Geomorphic Assessment using the Watershed Assessment of River Stability and Sediment Supply (WARSSS)

Macatawa Watershed
Ottawa and Allegan Counties, Michigan

MDEQ Tracking Code: 2008-0016

Prepared for:
Macatawa Area Coordinating Council
Holland, Michigan

April 27, 2011
Project No. G100240

Fishbeck, Thompson, Carr & Huber
engineers • scientists • architects • constructors

fTC&h

Geomorphic Assessment using the Watershed Assessment of River Stability and Sediment Supply (WARSSS)

Macatawa Watershed
Ottawa and Allegan Counties, Michigan

MDEQ Tracking Code: 2008-0016

Prepared for:
Macatawa Area Coordinating Council
Holland, Michigan

April 27, 2010
Project No. G100240

Fishbeck, Thompson, Carr & Huber, Inc. Engineers • Scientists • Architects • Constructors
1515 Arboretum Drive, SE, Grand Rapids, MI 49546 Telephone: 616-575-3824

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLOTS

LIST OF APPENDICES

LIST OF ABBREVIATIONS/ACRONYMS

AWRI	Annis Water Resources Institute
BEHI	Bank Erosion Hazard Index
BMPs	Best Management Practices
FTC&H	Fishbeck, Thompson, Carr & Huber, Inc.
fps	feet per second
GIS	Geographic Information System
HUC	hydrologic unit classification
MACC	Macatawa Area Coordinating Council
MDNRE	Michigan Department of Natural Resources and Environment
NHD	National Hydrography Dataset
RLA	Reconnaissance Level Assessment
RRISSC	Rapid Resource Inventory for Sediment Stability Consequence
TMDLs	Total Maximum Daily Loads
TP	total pressure
TSS	total suspended solids
USEPA	Environmental Protection Agency
WARSSS	Watershed Assessment of River Stability and Sediment Supply

INTRODUCTION

Accelerated erosion from land use practices and destabilized streambanks commonly release excess sediment, causing turbid water, nutrient enrichment, and sediment deposits that can harm aquatic life, reduce recreational uses of our waters, and, in some cases, lead to property damage. Excess sediment impairments are among the most common river and stream water quality problems reported by state monitoring programs.

The Watershed Assessment of River Stability and Sediment Supply (WARSSS) is a technical procedure developed by Dr. David L. Rosgen for use in evaluating streams and rivers impaired by excess sediment. WARSSS is a three-phase technical framework of methods for assessing the cause and effect of watershed inputs and channel processes in rivers and streams. The U.S. Environmental Protection Agency (USEPA) supported the development of WARSSS because there is limited guidance on assessing sediment impairments. WARSSS can be used to analyze known or suspected sediment problems, develop sediment remediation and management components of watershed plans, and develop sediment Total Maximum Daily Loads (TMDLs), among other uses.

The method is broken down into a series of worksheets available online at the USEPA website http://www.epa.gov/warsss/index.htm or incorporated into the textbook entitled *Watershed Assessment of River Stability and Sediment Supply (WARSSS)* by David Rosgen (Rosgen 2006).

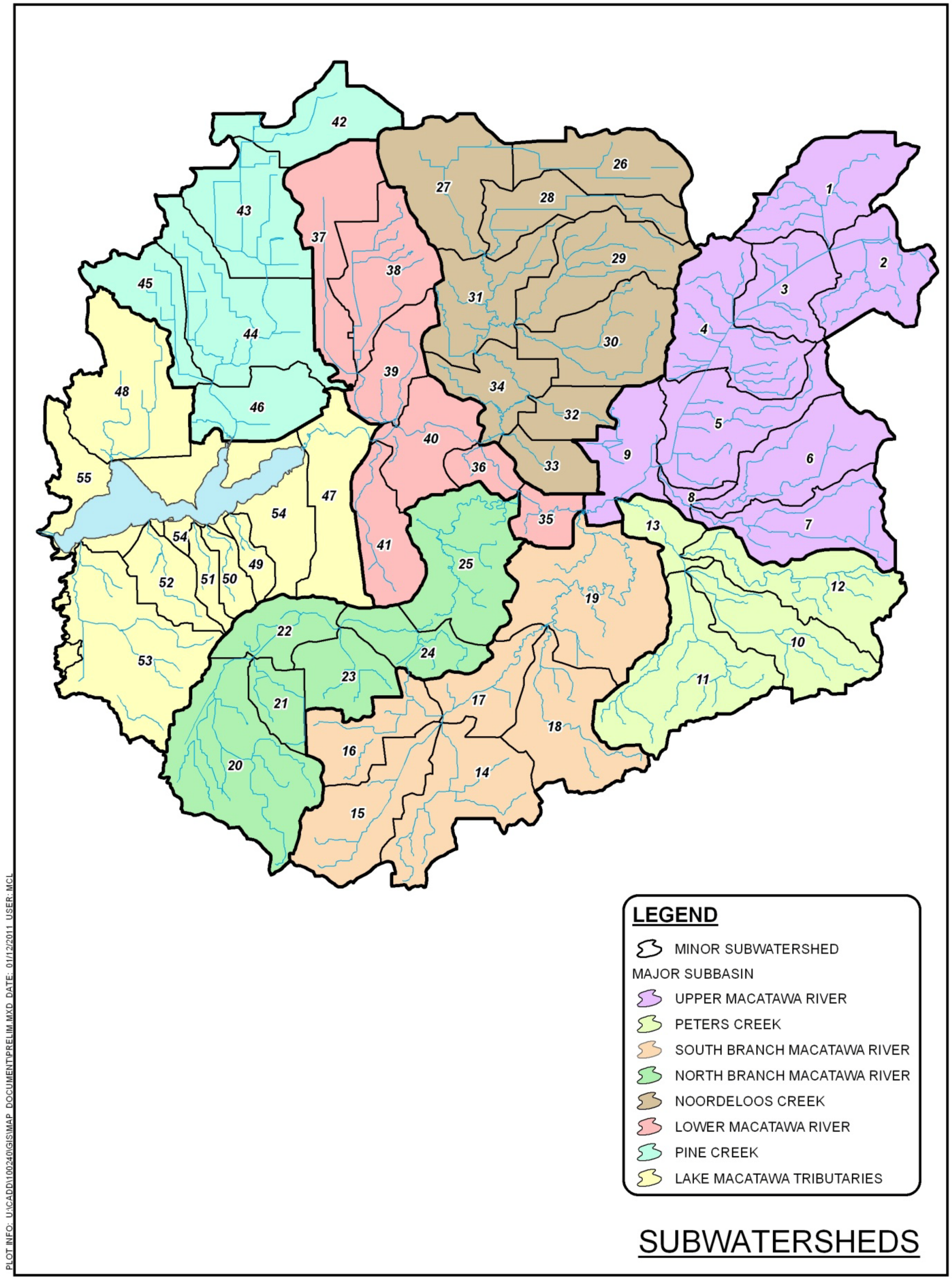
WARSSS was selected for use in the Macatawa Watershed located in Ottawa and Allegan Counties, Michigan, since Lake Macatawa has a phosphorus TMDL, and one source of phosphorus input into Lake Macatawa is from sediments carried to the lake by tributary drains and watercourses, many of which are experiencing instability in terms of excessive bank erosion and channel widening.

Two phases of the WARSSS process were employed for this study:

- Reconnaissance Level Assessment (RLA) – Identifies “stressors” (contributors of disproportionate sediment supply or stream instability) by subwatershed.
- Rapid Resource Inventory for Sediment Stability Consequence (RRISSC) – Evaluates impact of “stressors” on stream stability/channel evolution.

The Macatawa Watershed encompasses an area of approximately 175 square miles, which was divided into 55 subwatersheds grouped into 8 major subbasins based on Michigan Department of Natural Resources and Environment (MDNRE) hydrologic unit classification (HUC). A subwatershed map is shown in Figure 1.

Figure 1 – Subwatershed Map



WATERSHED BACKGROUND

WATERSHED CONCERNS

The Lake Macatawa phosphorus TMDL was approved by the USEPA in April 2000. The TMDL mandates a reduction in the amount of phosphorus entering Lake Macatawa from 138,500 lbs per year (1997 level) to 55,000 lbs per year (a 60% reduction). While phosphorus is the pollutant of concern, total suspended solids (TSS) must also be considered since phosphorus, as an element, does not easily dissolve in water and instead tends to travel through the watershed bound to soil particles. Therefore, soil erosion and sediment transport were targeted as watershed concerns.

LANDSCAPE HISTORY

Ottawa and Allegan Counties and the majority of Michigan's Lower Peninsula experienced extensive lumbering of the pine and hardwood forests in the middle to late 19th Century. This activity would have resulted in a large increase in sediment load due to the disturbed understory landscape. Another significant increase in stream discharge would have also resulted due to the loss of interception, uptake, and evapo-transpiration provided by the trees. Logical channel adjustments include widening to handle the increased flow and sediment load, aggradation in certain reaches due to increased sediment load from both hill slope erosion and channel widening, and avulsion (meander cutoffs resulting in a steeper channel gradient) to balance the excessive sediment load.

Agriculture and improved drainage systems followed the lumbering era during the latter part of the 19th century and into the middle of the 20th century. It is likely that a majority of wetlands were lost during this time period. These activities would have resulted in a large increase in stream discharge resulting in additional channel widening. The majority of studies performed since the mid 1960s indicate that Lake Macatawa and its tributaries have struggled for decades with high levels of sediment and nutrients, indicating highly trophic (hypereutrophic) conditions.

Much of the land use in the watershed is still agricultural, but significant growth in urban land use has occurred over the last 30 years, as seen clearly in the Land Cover maps (Figures 13 and 14) in the *Macatawa Watershed Hydrologic Study* (MDNRE, 2009). Urban land use increased by over 15% to claim 30% of the watershed total, while agriculture declined by the same percentage, reducing the total agricultural land use to 50%. The remaining 20% is comprised of open space (woods, etc.) and water/wetlands.

RECONNAISSANCE LEVEL ASSESSMENT (RLA)

The RLA phase of the assessment is meant to be a very quick, qualitative review of likely and unlikely sediment sources and problem spots in the watershed to guide the user in selecting the most critical subwatersheds to proceed to the RRISSC phase.

PROCESS

This narrative provides a step-by-step process for completing the RLA phase of the WARSSS based on the modifications made for the Macatawa Watershed project. The modification process focused on adapting the RLA to provide for prioritization of three subbasins as outlined in the scope of work for the Macatawa Watershed 319 Implementation Grant (Tracking No. 2008-0016). Rosgen's overall concept of determining stream stability and sediment supply and screening of subwatersheds for advancement to RRISSC was not altered. The revised approach included a numerical qualification system to rank the subwatersheds. The process used to complete the WARSSS RLA for the Macatawa Watershed included:

- **Data Collection –** Geographic Information System (GIS) layers (soils and land-use), aerial photographs, hydrology and related maps (*Macatawa Watershed Hydrologic Study*, MDNRE, 2009), and condition inventories (*Summary of Bank Erosion Hazard Index and Road Stream Crossing Assessment*, Macatawa Area Coordinating Council [MACC], 2009), (*Summary of Macatawa River Watershed Assessment,* MDNRE 2004) and related studies of pollutant loads (*Macatawa Watershed Modeled Pollutant Loads,* MDNRE 2009).
- **Watershed Background –** Understand watershed concerns and the landscape history of the watershed.
- **Data Evaluation** – Divide the watershed into major subbasins and further into subwatersheds, and identify stressors for each in terms of surface erosion, stream flow change, channel processes, and direct channel impacts (Worksheets 1a-1d).
- **Subwatershed/Subbasin Ranking** – Numerically rank 55 subwatersheds (Worksheets 1a-1d) and 8 subbasins. A ranking system is used here in lieu of the go/no-go approach proposed by Rosgen.
- **Subwatershed/Subbasin Prioritization** – Determine final prioritization (Worksheets 2 and 3) and produce a map of the prioritized subwatersheds and major subbasins.
- **Results –** Summarize results of data evaluation.
- **Priority Subbasins –** Summarize understanding of factors leading to priority selection for each subbasin.

METHODOLOGY

The metrics used to prioritize subbasins within the Macatawa Watershed for advancement to the RRISSC assessment were selected based on methods prescribed by Rosgen in the WARSSS. Each metric is related to either the hill slope (surface erosion), hydrologic (stream flow change), or channel (including direct channel impact) process which affects the overall stability of the watershed. A detailed description of each metric and how it relates to assessing the stability of the watershed is provided below.

TIME-TREND ANALYSIS

The time-trend analysis conducted by the MDNRE (*Macatawa Watershed Hydrologic Study*, MDNRE 2009) was used to assess land use and flow changes over a time span of 27 years (1978 MIRIS and 2005 MDNRE). The rationale behind identifying changes within a 20- to 50-year time span is based on the assumption that stream channels in rain-dominated temperate climates like Michigan take longer than 20 years to adjust to changes in hydrology (Rosgen 2006).

SURFACE EROSION

RANKING FACTOR: PERCENT HIGH RISK LAND USES WITH HIGH ERODIBILITY K FACTOR

The potential for surface erosion from hill slope processes was determined using the GIS 2009 land cover (Annis Water Resources Institute [AWRI]) and querying the intersection of high risk non-urban developed land use (cropland, confined feeding, orchards, other agricultural, and permanent pasture) with soil types having a high erodibility factor (K > 0.2). The erodibility factor (K) takes into account land slope, which is identified as another risk factor by Rosgen. A map of non-urban developed land with highly erodible soils is included in Appendix 1.

Nonpoint source pollutant modeling predictions for TSS in pounds per acre based on 2005 land use are presented in the report *Macatawa Watershed Modeled Pollutant Loads* (MDNRE, 2009). The modeling calculates TSS from both urban and non-urban land covers based on Water Quality Trading Rule Event Mean Concentrations for a given land cover type. Results show the highest TSS loads from those subwatersheds with a high percentage of urban land use located within the Cities of Holland and Zeeland. Figure 11 in the MDNRE Report indicates that the closest modeled results to monitored data (for total pressure [TP], assuming parallel results for TSS) were in non-urban subwatersheds (10, 11, 12, 13, 14, 18, and 19) and that the model appeared to overestimate pollutant (TP and TSS) loads in urban areas.

The standard metric, described in the first paragraph, was selected to estimate the potential for surface erosion from hill slope processes in lieu of the modeled TSS results, which, given their high variability from monitored data in urban areas, would likely overestimate (inflate) the subwatershed risk ranking in urban areas.

Ranking Factor: Percentage of Stream Miles with Poor Riparian Buffers

A review of the 2009 aerial photography was used to identify areas of poor riparian buffer along the stream corridor. 'Poor' buffers were those reaches of watercourse that did not have trees or filter strips visible from the aerial photographs. Buffers were counted as 'good' if woods or filter strips, regardless of width, existed inside of a 200-foot GIS 'filter.' This metric was used as an indicator of where sediment would have a greater probability of entering of stream channel. A map of riparian buffers is included in Appendix 1.

Stream Flow Change

Ranking Factor: Percentage of 2nd and 3rd Order Streams (By Stream Mile)

Percentage of stream miles of 2nd and 3rd order streams per subwatershed was quantified using the MDNRE Institute for Fisheries Research and the USGS Great Lakes Gap GIS steam order layer developed from the 1:100,000 National Hydrography Dataset (NHD). The stream order layer was used to determine which subwatershed could potentially have the most hydrologic impact due to efficient and extensive open channel drainage networks. In other words, the percentage of 2nd and 3rd order streams is used to estimate the density of tributaries within each subwatershed, and indirectly assess the probability of an adverse impact to the natural hydrology of the subwatershed through channelization and other efforts to improve drainage. Conversely, this metric is an indicator of which subwatersheds have the greatest number of watercourses that may be impacted. A map of 2nd and 3rd order streams is included in Appendix 1.

Ranking Factor: Percent of Natural and Wetland /Subwatershed

Wetlands were not specifically considered in the USEPA RLA, yet they play a critical role in watershed hydrology in Michigan. Wetlands were added as a land cover type in addition to woods, open, agricultural, and urban. Open water is not counted since it is not "land" cover.

Percentages of all major land cover types (urban, agriculture, natural [open/woods] and wetland) were taken from the *Macatawa Watershed Hydrologic Study* (MDNRE 2009) to provide a complete picture of present land uses and land use changes. Land cover rankings were computed based on the percentage of natural and wetland areas in each subwatershed. The assumption is that land uses in the natural state (as opposed to a developed condition such as urban or agriculture) contribute to stable stream flow and are an indicator of the overall hydrologic stability of the subwatershed. Figure 14 – 2005 Land Cover (from the MDNRE Study) is included in Appendix 1.

Ranking Factor: Percent Increase in Runoff Volume/Area

The percent change in natural and wetland land cover in the last 30 years was omitted in favor of using runoff volume changes for a 2-year, 24-hour rainfall from the *Macatawa Watershed Hydrologic Study* (MDNRE 2009), since woods and wetland changes account for only a very small percentage of the watershed area. The changes in runoff reflect for the most part increases in urbanized areas. Figure 31 – Change in Runoff Volume/Drainage Area from the MDNRE study is included in Appendix 1.

Ranking Factor: Percent Water Withdrawals and Reservoirs

No water withdrawals or reservoirs were large enough or in critical locations to impact channel stability through alterations in stream flow (except under failure conditions as when the Ottogan Dam, located in Subwatershed 49, washed out in June 2009). In addition, a flood control dam that has been in place and operating for many years may actually contribute to stream channel stability. Therefore, this metric was eliminated as a ranking factor.

Channel Processes

Ranking Factor: Percent Medium and High BEHI Sites

An indication of channel stability was based on the number road crossings with moderate or high erosion risk documented in the Bank Erosion Hazard Index (BEHI) survey performed by the MACC staff in lieu of stream departure from a stable condition as observed from aerial photography. Sixteen of the 55 subwatersheds did not have any crossings evaluated using the BEHI. Many of these areas were reviewed during a separate windshield assessment by FTC&H. Most of the undocumented subwatersheds were determined to be fairly stable and given a risk ranking value of 1 indicative of a low BEHI score. Subwatersheds, not included as part of the BEHI assessment, which showed signs of instability, were given a risk ranking value of 25 (one above the number of subwatersheds with a BEHI score of “Low”). It should be noted that relying on the BEHI information to perform this metric is only as reliable as the BEHI, which is not necessarily representative of overall channel conditions throughout the Macatawa Watershed because it was only conducted at road crossings. A map of BEHI sites is included in Appendix 1.

Ranking Factor: Percent Stream Miles of Departure within Last 30 Years

Stream departure was estimated by reviewing 2009 aerial photography and documenting locations with abandoned channels, ox-bows, or other obvious signs of channel modifications. The extent of stream departure, in terms of impacted channel length, was recorded and scored as a percentage of the entire stream length. No distinction was made between historic stream departure and stream departure within the last 30 years due to the lack of quality historic aerial photography (high resolution, leaf off conditions). Therefore, this metric was not included in the overall prioritization scoring.

DIRECT CHANNEL IMPACTS

RANKING FACTOR: PERCENT ROAD/STREAM CROSSINGS (BY TOTAL IN WATERSHED)

The number of road/stream crossings in each subwatershed as a percentage of the total road/stream crossings in the entire watershed was determined using GIS and used as an indicator of potential sources of sediment, increased surface runoff, and direct channel impacts in terms of realignment, grade changes, channel widening and scour. A map of road/stream crossings is included in Appendix 1.

RANKING FACTOR: PERCENT STREAM MILES IMPACTED BY GRAZING/ANIMAL OPERATIONS

The percentage of stream miles impacted by livestock access and grazing was evaluated by review of the 2005 aerial photographs using the "confined feeding and animal operations" category in the 2009 land cover (AWRI) and the report *Summary of Macatawa River Watershed Assessment* (MDNRE 2004) as guides. A map of grazing and animal operations is included in Appendix 1.

RANKING FACTOR: PERCENT STREAM MILES WITH CHANGE IN RIPARIAN BUFFER WITHIN LAST 30 YEARS

Changes to riparian buffer within the last 30 years were determined through GIS queries using 1978 and 2005 land cover layers and a 200-foot buffer width. A map of land cover change in riparian buffers is included in Appendix 1.

RANKING FACTOR: PERCENT STREAM MILES IMPACTED BY FLOOD CONTROL / LAND DRAINAGE PROJECTS

No ranking was performed based on this metric because of the difficulty in discerning high risk when a majority of the watercourses have been altered. Channelized drains (inherently a high risk ranking) may or may not be stable. Natural sections of river/streams that have not been altered (inherently a low risk ranking) may more appropriately receive a high risk ranking if they are at risk of being impacted (i.e., headcuts, meander cutoffs) by upstream or downstream reaches of channel that have been modified. Because of this ambiguity, this metric was eliminated as a ranking factor.

SUBCATCHMENT RANKING

This is an entirely new task added to the USEPA RLA process. A ranking system was used in lieu of the go/no-go approach proposed by Rosgen. Ranking was performed at both the subwatershed and major subbasin levels. The data in Worksheets 1a-1d were ranked in numerical order from 1 to 55 (i.e., the number of subwatersheds). A ranking of 1 represents the lowest risk of change, and a ranking of 55 represents the highest risk or change. "Tied" results are given the same ranking value with the next ranking value skipping over the number of tied results (i.e., if three results are tied at a ranking value of 10, the next ranking value would be 13).

The only drawback to this approach is that the consecutive ranking does not account for the closeness of results that a High/Medium/Low (H/M/L) ranking system may account for. The consecutive ranking system was still selected over the H/M/L ranking, as the H/M/L limits would need to be adjusted for each category using statistical analysis or introducing a heavy reliance on judgment.

Also, all metrics were given the same “weight” to avoid adding another level of judgment to the numeric process. Again, the RLA is simply meant to identify sediment sources and channel stability problems to be able to quickly locate problem areas within a large watershed that require more detailed level of assessment. Judgment is introduced in selecting the metrics themselves and in the final prioritization.

At the subbasin level, data given in Worksheets 1a-1d was averaged over each of the major subbasins. This averaging was weighted based on the relative size of the subwatersheds involved. A 0-1 ranking was then established for each of the indicators where a zero value indicates the lowest risk of change, and a 1 value indicates the highest risk of change. These ranking values were then summed for the nine different metrics resulting in a total rating score that could potentially range from 0 to 9.

SUBWATERSHED PRIORITIZATION

The rankings in each of the categories were totaled, and the subwatersheds/subbasins were prioritized based on the total ranking score using Worksheets 2 and 3. The subwatershed/subbasin with the highest ranking score was prioritized as number 1 and so forth.

Subwatersheds are shown in Figure 2 by 20-percentile ranking categories, which were then given the labels of ‘very high,’ ‘high,’ ‘medium,’ ‘low’ and ‘very low.’

Major subbasins are shown in Figure 3 by ranking score.

Figure 2 – Priority Ranking by Subwatershed

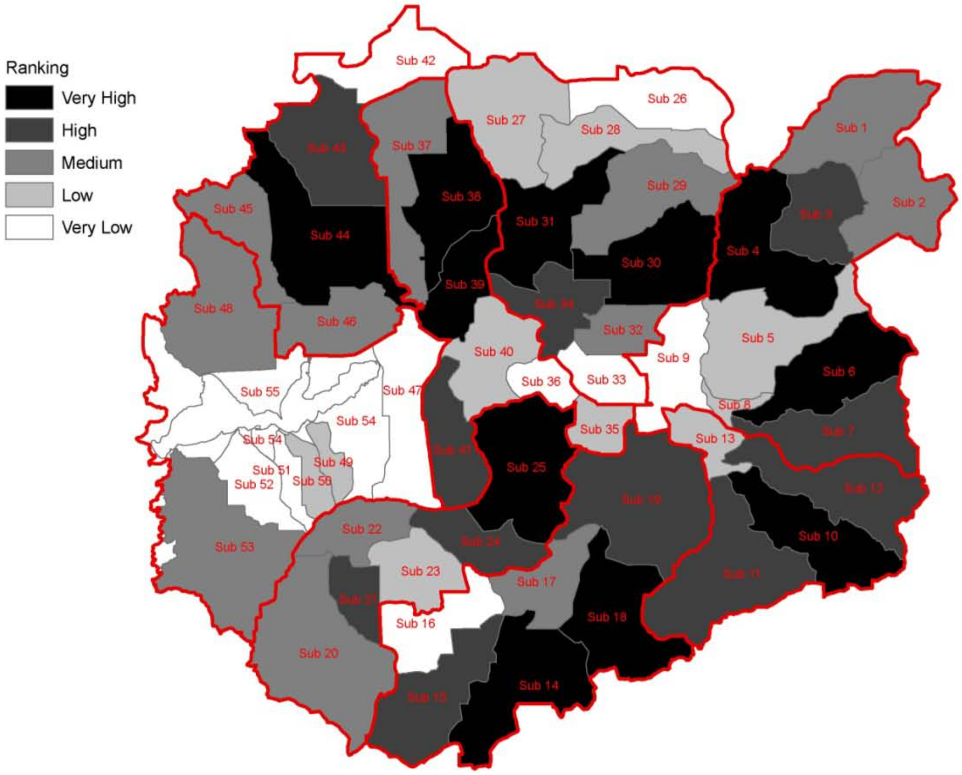
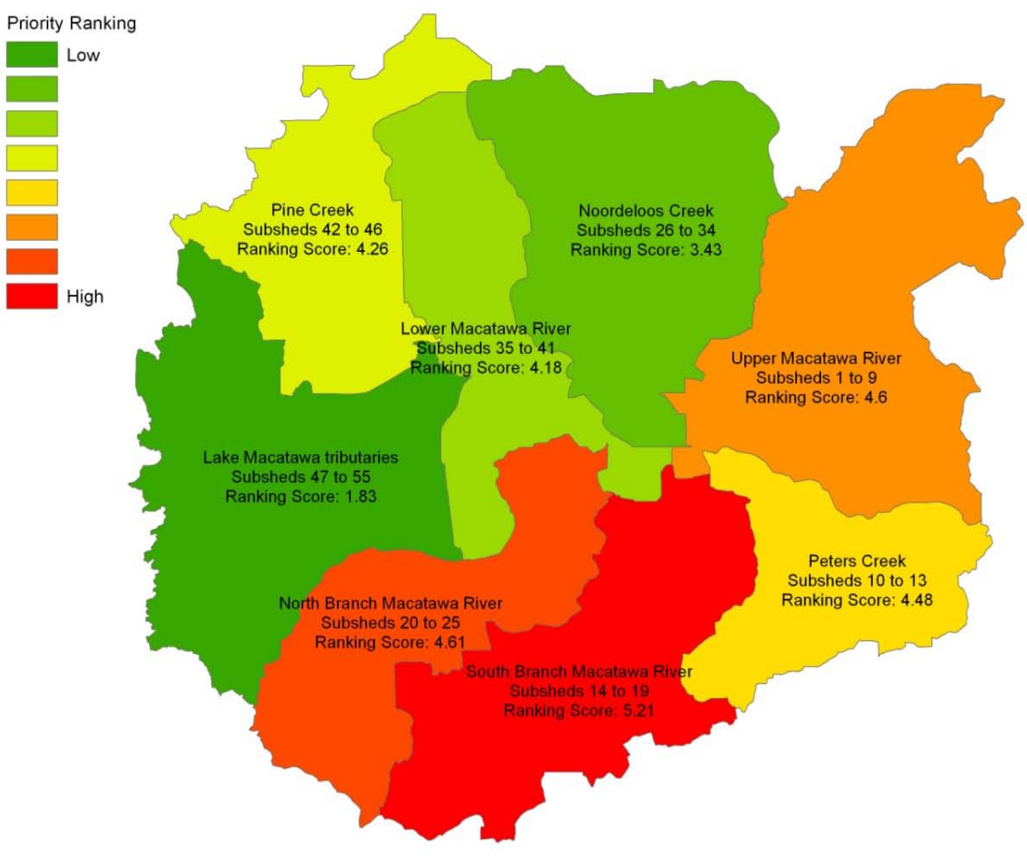


Figure 3 – Priority Ranking by Major Subbasin



Priority subbasins were selected based on numerical ranking scores and consideration of other factors not included in the ranking, such as the presence of coldwater streams, TMDLs, other monitoring data or inventory/known information. A review can then be made of the conditions, activities, or land changes that caused a subwatershed/subbasin to be selected as a priority.

RESULTS

SURFACE EROSION

The Peters Creek, South Branch, and Upper Macatawa River subbasins showed the highest risk ratings for surface erosion from hill slope processes from non-urban land uses. These areas tend to have siltier soils, steeper topography, and prevalent agricultural land use.

While the Noordeloos Creek subbasins were rated at the median for surface erosion potential, it was rated highest for largest percentage stream miles with poor riparian buffers, which are an indicator of increased sediment load delivery. Peters Creek and South Branch subbasins were in the top quartile for poor riparian buffers.

STREAM FLOW CHANGE

The Peters Creek, South Branch, and North Branch subbasins have the greatest percentage of second and third order streams per stream mile. These areas have an extensive drainage network. Many of the tributaries and upstream headwaters consist of open channel drains constructed to facilitate agriculture production.

According to the *Macatawa Watershed Hydrologic Study* (MDNRE, 2009), the greatest increase in runoff volume between 1978 and 2005 was in Lower Macatawa and Pine Creek Subbasins with three or more subwatersheds showing increases in the North Branch, Noordeloos Creek, and Lake Macatawa Subbasins.

CHANNEL PROCESSES

The greatest percentage of stream departure based on the BEHI conducted by the MACC is located in the South Branch and Upper Macatawa (including Peters Creek) Subbasins.

DIRECT CHANNEL IMPACTS

Direct channel impacts were found to be most concentrated in the Pine Creek Subbasins.

The percentage of road/stream crossings was greatest in the Pine Creek, Upper Macatawa, and Lower Macatawa Subbasins.

The North Branch and Upper Macatawa Subbasins were the most impacted by grazing.

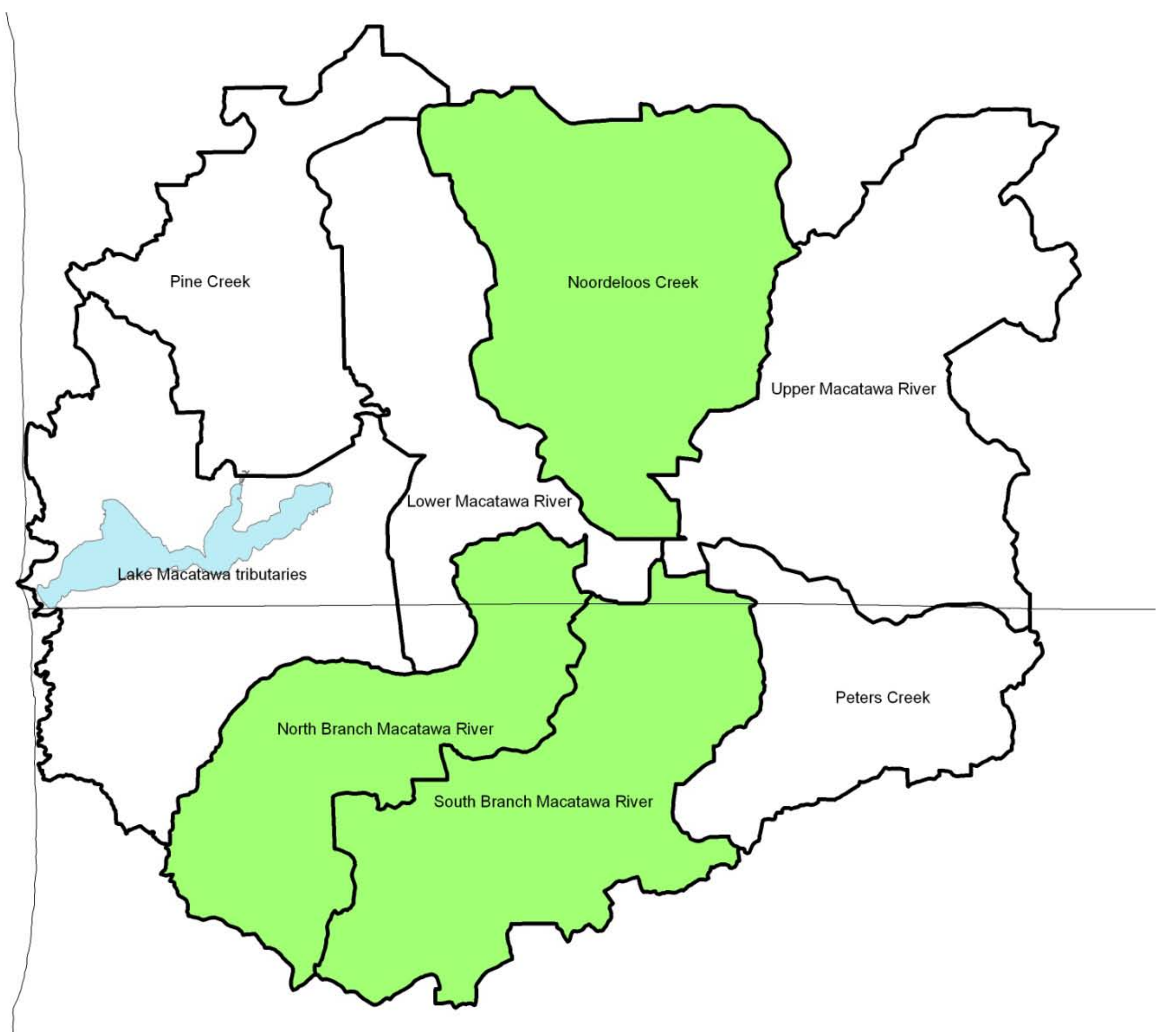
The Pine Creek, Lower Macatawa, and Lake Macatawa Subbasins all located in the lower portion of the watershed had the greatest change in riparian buffer in the last 30 years.

PRIORITY SUBBASINS

The following three subbasins are recommended for advancement to the Level II RRISSC Assessment as Shown in Figure 4:

- South Branch Macatawa River.
- North Branch Macatawa River.
- Noordeloos Creek.

Figure 4 – Recommended Subbasins for RRISSC Assessment



A validation procedure was used to determine the final three subbasins recommended for advancement as listed above, since the following three subbasins received the highest ranking scores from the RLA:

- South Branch Macatawa River.
- North Branch Macatawa River.
- Upper Macatawa River.

Keeping in mind that the primary pollutant of concern in the Macatawa Watershed is phosphorous, validation of priority subbasins was done using the phosphorous monitoring data and an understanding of the phosphorous/sediment relationship. Sands and loams are the soil types most susceptible to erosion. Loamy soils, which contain significant amounts of silt and clay, adsorb and concentrate phosphorous to a greater extent than sandy soils. This can result in the transport of phosphorous adsorbed to these sediment particles by river and stream channel processes. Therefore, the dunes and sandy soils found in the Lake Macatawa Tributaries and Pine Creek Subbasins do not present as high of a risk in terms of the Phosphorous TMDL as the heavier soils found in the middle and upper watershed. Subsequently, these two subbasins (ranking eighth and fifth), were not considered for further assessment as part of this study.

Phosphorous monitoring data from October 1, 1999, through September 30, 2001, indicates the highest concentrations (in pounds per square mile) measured in the South Branch Macatawa River, Lower Macatawa River, Noordeloos Creek, and Peters Creek Subbasins. The South Branch was identified as a priority Subbasin (ranking first) through the RLA process and was selected to remain one of the priority subbasins.

The North Branch of the Macatawa River (ranking second) has the steepest gradient of all the major subbasin tributaries. While this subbasin was not identified as a contributor of high concentrations of phosphorous based on the monitoring data, it does differ from the South Branch in land use (more impervious). The North Branch is also known to have channel stability issues in erodible loamy soils. Therefore, this subbasin was selected to remain on the priority list.

The Upper Branch of the Macatawa River (ranking third) was eliminated from the list of priority subbasins due to the absence of high concentrations of phosphorous load in the monitoring data and for the reason that much of the flood flows that would carry phosphorous-laden sediment would settle out in the broad, flat floodplains adjacent to this low-gradient reach of river. Historically, over 600 acres of cropland were once located in the floodplain “flats” of the Black River valley south of Byron Avenue in Sections 20 and 21 of Zeeland Township. Phosphorous-carrying sediments would have naturally tended to settle out during overbank flood conditions and contributed to the fertility of the flats. At present, almost all of this area has been converted to wetland as part of the Upper Macatawa Natural (Conservation) Area, so removal of fine sediments (and phosphorous) continues to "treat" watersheds 1 through 5. This fact is not reflected well in the RLA metrics (only to the extent of a change in riparian buffer in the last 30 years).

Peters Creek (ranking fourth) was eliminated from the list of priority subbasins because the topography, soils, land use, and stream types are very similar to those of the South Branch and lower two subwatersheds from the Upper Macatawa Subbasin (that are not routed through the Natural Area). It was felt that conducting further in-depth evaluation in Peters Creek would result in "more of the same" findings from the South Branch assessment.

The remaining two subbasins are the Lower Macatawa River (ranking sixth) and Noordeloos Creek (ranking seventh). Either of these subbasins would be a good candidate for the final priority list and provide a measure of diversity for the RISSC Level II Assessment. Both were identified in the non-point source monitoring as delivering some the highest concentrations of phosphorous. Both have mixed land use with an urban center, suburban areas, and agricultural in the upper reaches. Politically, both are located in Ottawa County, which provides for some equity in study funds allocated among project partners. In the end, Noordeloos Creek was selected for the priority list based on previous selection as a priority subbasin for phosphorous. In addition, Noordeloos Creek had a greater percentage of medium and high BEHI sites, indicating more possible issues with stream stability.

RAPID RESOURCE INVENTORY FOR SEDIMENT AND STABILITY CONSEQUENCE (RRISSC)

The Rapid Resource Inventory for Sediment Stability Consequence (RRISSC) phase of the WARSSS builds upon the data collected during the RLA to provide a finer level of analysis in regard to the affects that hill slope, hydrologic, and channel process have on a watershed. While the overall concepts of the RRISSC have been employed, the actual worksheets and graphs provided in the USEPA WARSSS (Rosgen 2006) were abandoned in favor of a more rapid assessment method as described in the *Stream Stability Assessment Guidelines for NPS Grant Applications* (MDNRE 2008). Employing these principles, an in-depth geomorphic assessment was conducted for the Noordeloos Creek, North Branch, and South Branch subbasins to answer the following questions:

- What is the stable stream type / dimension for the watershed?
- Is the current stream stable or if not, how far has the stream departed from its stable form?
- Where is the stream headed in terms of channel evolution and what are the potential consequences?
- Why is the stream unstable and is the instability localized or systemic?
- How can we improve the stability and water quality of the stream?

PROCESS

The process used to complete the WARSSS RRISSC includes:

- **Aerial Photography/Field Inspection** – Detailed review of watercourses within critical subbasins using 2009 aerial photography and ground data from field inspection to confirm BEHI results, document areas of stream instability, and identify stable reference reaches.

- **Geomorphic Assessment** – Detailed channel survey at representative (both reference and altered) locations within the watershed to document channel properties such as slope, substrate, bankfull channel dimensions, width to depth ratio, entrenchment ratio, etc. Classify each stream by Rosgen stream type. Utilize geomorphic stream data to determine stable stream form and/or assess the degree of departure from the stable condition.

- **Sediment / Pollutant Load Calculations** – Estimate the instream sediment load. Identify areas of instability and assess the degree of departure from the stable channel form.

- **Conclusion** – Summarize results of RLA and RRISSC and determine potential causes of instability within the watershed.

- **Recommendations** – Identify and prioritize potential BMPs and provide specific recommendations for restoration/monitoring efforts within the watershed.

AERIAL PHOTOGRAPHY / FIELD INSPECTION

A widespread review of the entire watershed was conducted using aerial photography and by field inspection, including a windshield survey of road/stream crossings. The intent of this work was to develop a broader feel for the watershed, identify potential areas of instability, stable reference reaches, and verify BEHI data from previous studies by the MACC.

High quality, leaf-off aerial imagery was provided by Ottawa County. These photographs were valuable in identifying potential areas of instability including channel bank erosion, sediment deposition (point bars and mid-channel bars), and log jams. Below is an example of how aerial imagery was used to identify areas of instability. The photographs are taken along the main-stem of the Noordeloos Creek in Section 14 (Subwatershed 34) of Holland Township between Chester Drive and Meadow Drive.

Aerial Photograph of Noordeloos Creek (Left) compared to Photograph of Site from Field Inspection (Right)

The same high quality level of aerial imagery could not be obtained for Allegan County. The available aerial photographs were limited for assessment purposes; however, they did provide enough detail to determine channel sinuosity for stream classification purposes.

Due to the limited availability of aerial photography, the assessment of each subbasin relied heavily on field inspections. Road/stream crossings were inspected throughout the watershed and notes regarding the extent and severity of instream erosion were recorded. In addition, previously established BEHI sites were reviewed to confirm individual rankings in terms of severity of erosion.

Most of the upstream reaches and first order “streams” in the watershed consist of fairly linear, trapezoidal ditches constructed to facilitate drainage of agricultural lands. While the extent of riparian buffer varies, the banks of most of these channels are well vegetated and fairly stable as documented by the primarily low BEHI scores.

The majority of natural streams appear to be "C" type streams according to classification by Rosgen (1994) with relatively high width to depth ratio, riffle/pool profile, meandering pattern, and varying degrees of incision. Approximately five potential reference reach sites were identified along the main branch and tributaries within the Noordeloos Creek, North Branch, and South Branch subbasins.

GEOMORPHIC ASSESSMENT

Detailed geomorphic stream surveys were conducted at eight locations within the Noordeloos Creek, North Branch, and South Branch subbasins to assess overall stream stability and variability between reaches (drainage area). Five sites were classified as "reference reaches," reflecting the stable stream potential. Geomorphic stream surveys were also conducted along three altered reaches to reflect channelized (dredged) sections of stream. The locations of the geomorphic stream surveys are shown in Figure 5.

At each site, the channel cross section was surveyed at a riffle. The bankfull elevation was identified and a longitudinal (profile) survey was completed, which included elevations of the channel bottom, water surface and top of bank (bankfull). Pebble counts were made throughout the entire reach and at the surveyed riffle cross section to classify the substrate and assess the stability of the streambed. Field data from the geomorphic survey is provided in Appendix 3.

Bankfull discharge was calculated for each site using Manning's Equation. Channel roughness (Manning's "n") was estimated using Limerinos Equation, which relates the channel bed particle size (D84) to hydraulic resistance. Calculated channel roughness coefficients were then compared to published Manning's "n" values to confirm their validity.

Relative bed stability was evaluated in terms of sediment competence (ability of a channel to move the largest particle made available from the upstream sediment supply). Sediment competence was determined by comparing the measured D50 and D84 particle sizes, obtained by pebble count in the field, to the predicted bed material grain size diameter. The bed material grain size was predicted using Shields' equation, which relates the calculated critical (bankfull) shear stress to grain diameter.

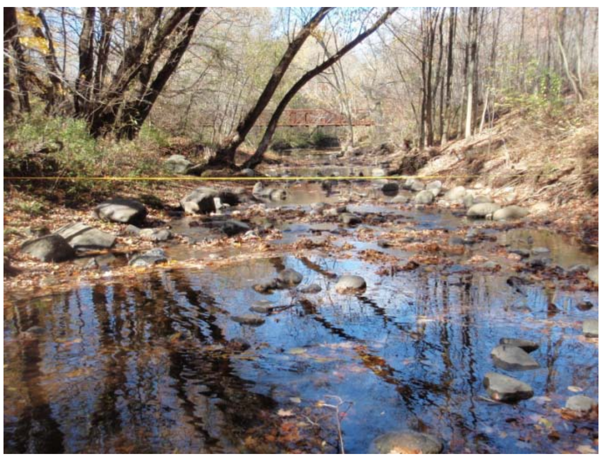
STREAM CLASSIFICATION

Consistent with the observations made during the field inspection, the stable natural channel form for the watershed appears to be a "C" type stream with gravel substrate and a bankfull width to depth (w/d) ratio between 11 and 16. The reference reaches have a well-connected floodplain with corresponding entrenchment ratio greater than 2.2. At all locations except for the E. Fillmore Drain, downstream of 144th Avenue (ID No. 3), the bankfull elevation is equivalent to the top of low bank. The geomorphic relationships pertaining to stream classification for the five reference reach sites are summarized below in Table 1.

Table 1 – Reference Reach Stream Classification

Subbasin	ID	Stream / Location	Ent. Ratio	w/d Ratio	Sin. (k)	Slope	Substrate	Stream Type
N. Branch	1	Main upstream of 146th Avenue	>2.2	11.2	>1.2	NA	Gravel*	C4
N. Branch	2	Main upstream of Country Club Road	>2.2	12.7	>1.2	0.78%	Gravel	C4
S. Branch	3	East Fillmore Drain downstream 144th Avenue	>2.2	15.8	>1.2	0.13%	Gravel	C4
S.Branch	4	Main downstream of 46th Street	>2.2	15.6	>1.2	0.62%	Gravel	C4
Noordeloos	5	Main near confluence with Black River	>2.2	12.5	>1.2	NA	Gravel*	C4

Substrate type estimated by visual observation (no pebble count performed).



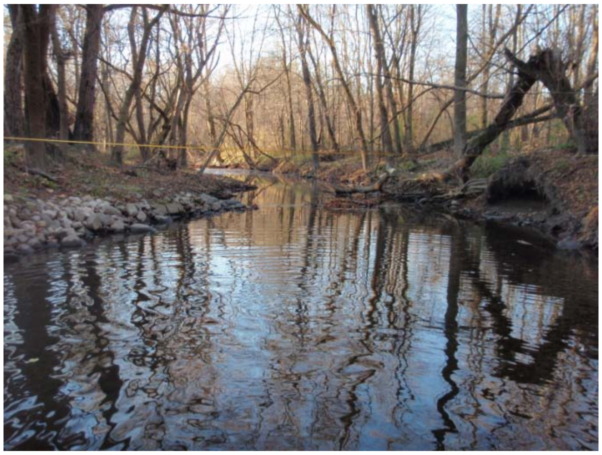
N. Branch – Upstream of Country Club Road

N. Branch – Upstream of 146th Avenue

Comparative geomorphic measurements were made along altered sections of stream, including channelized (dredged) reaches of stream as shown in Table 2. A well-defined bankfull shelf has developed along the surveyed section of the North Branch of the Macatawa River (Tulip Intercounty Drain), downstream of US-31 (ID No. 6). At the other two locations, the bankfull elevation is equivalent to the top of low bank. In general, the altered channels have a lower width to depth ratio, primarily due to the higher degree of channel incision (mean bankfull depth). While the altered channels are somewhat incised, higher flows (twice the mean bankfull depth) are still able to access the floodplain as indicated by the entrenchment ratio being greater than 2.2. Similar gravel substrates were found at all locations except for the Macatawa River (Tulip Intercounty Drain), downstream of M-40 (ID No. 7), which has a coarse sand bottom that is consistent with the extremely flat gradient.

Table 2 – Altered Stream Comparison

Subbasin	ID	Stream / Location	Ent. Ratio	w/d Ratio	Sin. (k)	Slope	Substrate	Stream Type
N. Branch	6	Main downstream of US-31	>2.2	10.1	<1.2	0.56%	Gravel	NA
N. Branch	7	Main downstream of M-40	>2.2	8.7	<1.2	0.04%	Sand	NA
Noordeloos	8	Main upstream of Riley St.	>2.2	9.0	>1.2	NA	Gravel	NA



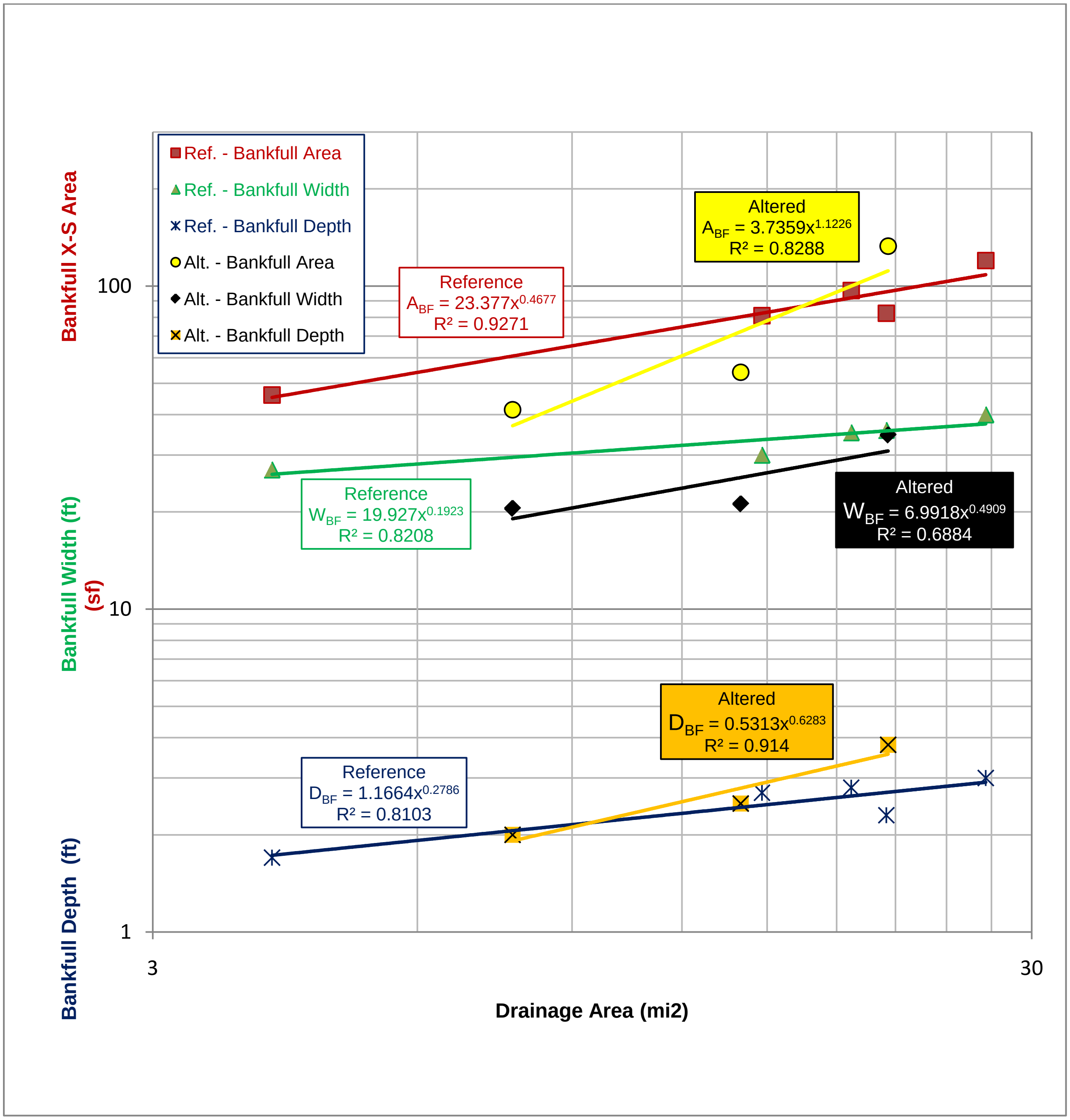
Noordeloos Creek – Upstream of Riley Street ***N. Branch – Downstream of US-31***

CHANNEL DIMENSION

For comparative purposes, geomorphic channel dimensions such as bankfull area, bankfull width, and bankfull mean depth were plotted versus drainage area for both the reference and altered reaches as shown in Plot 1. A non-linear regression was used to generate power-function equations relating bankfull cross-sectional area, width, and mean depth to drainage area.

As shown in Plot 1, a fairly strong relationships exist between bankfull cross sectional area, width, and depth versus drainage area for the reference reaches as indicated by the relatively high coefficients of determination (R^2), which are all greater than 0.8. Given their altered (dredged) condition, it is not surprising that the relationship between bankfull dimensions, most notably bankfull width, and drainage area are not as strong for the channelized reaches.

Plot 1 – Relationship between Bankfull Dimensions and Drainage Area

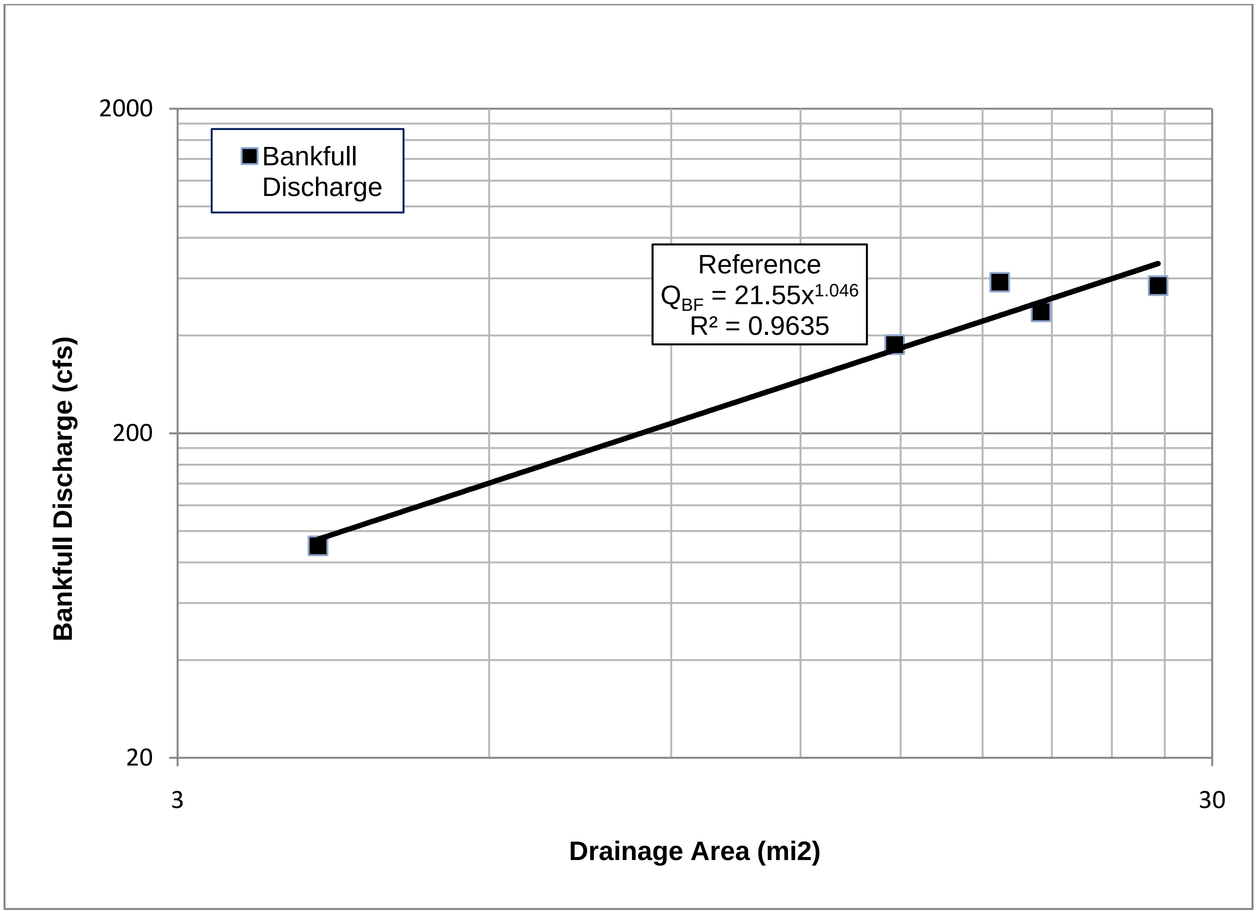


In general, the reference reach bankfull width is greater and the mean bankfull depth is less than the altered channel, which is consistent with the lower bankfull width to depth (w/d) ratio of the altered reaches. The greater bankfull depth of the altered reaches is indicative of a higher degree of channel incision, which is reasonable given these sections of channel have been historically dredged.

BANKFULL DISCHARGE

Estimates of bankfull discharge were made utilizing the cross sectional and longitudinal profile survey information along with pebble count data as previously described. The relationship between bankfull discharge and drainage area for the reference reaches is shown below in Plot 2. A non-linear regression was used to generate a power-function equation relating bankfull discharge to drainage area.

Plot 2 – Relationship between Reference Reach Bankfull Discharge and Drainage Area



As shown in Plot 2, a fairly strong relationship exists between bankfull discharge and drainage area for the reference reaches as indicated by the high coefficient of determination (R^2), which is greater than 0.96.

Estimated bankfull discharges were then compared to MDNRE discharges to determine the frequency at which bankfull events occur. Bankfull discharge and reoccurrence frequency for each reference reach site are summarized below in Table 3.

Table 3 – Reference Reach Bankfull Discharge and Reoccurrence Frequency

Subbasin	ID	Stream / Location	Drainage Area	Bankfull		
				Velocity	Discharge	Frequency
N. Branch	1	Main upstream of 146th Avenue	14.8 mi2	4.6 fps*	367 cfs*	1 year
N. Branch	2	Main upstream of Country Club Road	18.7 mi2	6 fps	584 cfs	1.6 year
S. Branch	3	East Fillmore Drain downstream 144th Avenue	4.1 mi2	2 fps	90 cfs	1.9 year
S.Branch	4	Main downstream of 46th Street	20.5 mi2	5.7 fps	473 cfs	1.3 year
Noordeloos	5	Main at confluence with Black River	27+ mi2	4.4 fps*	565 fps*	1.7 year

*Bankfull Velocity and Discharge estimated assuming a channel slope of 0.25%.
fps feet per second

Consistent with the typical return period for bankfull discharge, the bankfull discharge of the surveyed reference reaches varies between 1 and 2 years with an average return period of 1.5 years. While the bankfull discharges appear to be consistent with the current hydrologic regime, the associated bankfull velocities are relatively high (near 5 fps or more) and sufficient enough to result in bank erosion and streambed scour depending on soil and vegetation conditions. It should be noted that most of the reference reaches are located in areas with well vegetated clay/loam banks and gravel substrates capable of withstanding higher stream velocities.

SEDIMENT COMPETENCE

Aside for the East Fillmore Drain, downstream of 144th Avenue (ID No. 3), it appears as though the reference reaches have the ability to move the size of sediment particle being supplied (competence). The predicted particle sizes which can be mobilized at the bankfull discharge are just very close to or within the range of the actual D50 and D84 as determined by riffle pebble count, thereby indicating the streambed is relatively stable. Table 4 provides a comparison between calculated movable particle size and the measured D50 and D84 particle sizes. Detailed longitudinal profiles and pebble counts were not performed along the North Branch of the Macatawa River (Tulip Drain) upstream of 146th Avenue (ID No. 1) or along the Noordeloos Creek upstream of the confluence with the Black River (ID No. 5).

Table 4 – Sediment Competence

Subbasin	ID	Stream / Location	Slope	Mean Depth	Shear Stress	Predict Particle	Measure D50	Measure D84
N. Branch	1	Main upstream of 146th Avenue	NA	2.7 ft	Gravel Substrate, Detailed Pebble Count or Channel Profile Not Conducted			
N. Branch	2	Main upstream of Country Club Road	0.78%	2.8 ft	1.26 psf	62 mm	74 mm	140mm
S. Branch	3	E. Fillmore Drain downstream 144th Avenue	0.13%	1.7 ft	0.13 psf	6 mm	37 mm	80 mm
S.Branch	4	Main downstream of 46th Street	0.62%	2.3 ft	0.85 psf	42 mm	29 mm	75 mm
Noordeloos	5	Main at confluence with Black River	NA	3.0 ft	Gravel Substrate, Detailed Pebble Count or Channel Profile Not Conducted			

SEDIMENT/POLLUTANT LOAD CALCULATIONS

Sediment (pollutant) loads from instream (streambank) erosion throughout the entire watershed were estimated based on the methods prescribed in the MDNRE *Pollutants Controlled Calculations and Documentation for Section 319 Watersheds Training Manual* (MDEQ 1999). Together with pollutant loads calculated by the MDNRE from hill slope processes presented in the *Macatawa Watershed Modeled Pollutant Loads* 2009 report, these estimates will provide a more complete picture of the annual sediment load delivered to the Macatawa River.

Critical areas in terms of channel instability and potential sediment loading were identified for in-depth field assessment and inventory based on review of aerial imagery, windshield survey, and BEHI data from the *Summary of Bank Erosion Hazard Index and Road Stream Crossing Assessment* completed by the Macatawa Area Coordinating Council in 2009. Critical reaches of stream channel within the North Branch, South Branch, and Noordeloos Creek subbasins include:

- North Branch of Macatawa River (Tulip Intercounty Drain) between M-40 and Ottogan Road (32nd Street).
- South Branch of Macatawa River between 144th Avenue and Macatawa River.
- Noordeloos Creek between Quincy Street and Macatawa River.

Over 18 miles of stream channel were assessed by means of field inspection along the critical reaches. Locations of bank erosion were recorded using a GPS Unit. Bank height, length, severity of erosion, composition (soil and vegetation) and potential cause of instability were recorded and are documented in Appendix 4. Erosion rates between 0.01 and 0.5 feet per year were estimated qualitatively based severity of erosion (very low to very high), in accordance with the *Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual* (MDEQ 1999). Pollutant loading calculations from critical reaches are provided in Appendix 5. Locations of log jams, some severe and contributing to areas of localized erosion, were also recorded as shown in Appendix 4. In addition, rough estimates of low bank height were made in the field and compared to reference reach data to estimate degree of channel incision and departure from the stable condition. Photographs of each site were taken and are included in the enclosed CD.

Sediment loads from all other watercourses within the watershed (non-critical areas) were estimated by correlating erosion rates to BEHI scores from previous MACC studies and/or qualitative observations made during the windshield survey by FTC&H. In general, the severity of erosion along these reaches was much lower than the critical reaches. Unless identified otherwise in the windshield survey, reaches with a low BEHI score were considered to be stable and therefore excluded from sediment loading calculations. Aside from the Kuipers Drain (tributary to the North Branch of the Macatawa River) and Kelly Lake Intercounty Drain (Lake Macatawa Tributary) in Allegan County, erosion rates between 0.05 feet per year and 0.1 feet per year were assumed for impaired reaches based on observations from the windshield survey and BEHI scores. The length of erosion was assumed to occur along a single bank throughout the entire reach (stream length), typical of bank erosion found along outside bends of a meandering stream, and was calculated using GIS maps. Unless measured in the field, the height of erosion for each reach was estimated as the mean bankfull depth for the given drainage area based on the relationship established from the reference reach survey data, where the mean bankfull depth (D_{BF}) is approximately equal to 1.1664 x (drainage area in square miles)$^{0.278}$. Sediment load calculations from non-critical reaches are provided in Appendix 5.

The estimated annual instream sediment load from the entire watershed is approximately 5,571 tons per year. A breakdown of estimated annual instream sediment load by major subbasin is shown in the map provided in Appendix 5. Areas of channel instability categorized by degree of impairment (sediment load in cubic feet per year per linear foot of channel) are shown in Figure 6.

NORTH BRANCH OF MACATAWA RIVER (TULIP INTERCOUNTY DRAIN)

The upper (southern) portion of the North Branch subbasin consists of fairly linear, dredged trapezoidal drains through agricultural lands. While the dredged channels are generally deeper than a natural stream, the banks are quite stable due to the dense vegetative covering and fairly cohesive underlying soils. As indicated by the MACC study, the BEHI scores are generally low and contribute very little in terms of sediment loading. The exception appears to be the Kuipers Drain in Section 24 of Laketown Township, Allegan County, which is severely incised and actively eroding (in terms of both the channel bottom and banks) as documented in a recent study by FTC&H conducted on behalf of the Allegan County Drain Commissioner. Preliminary estimates indicate that the Kuipers Drain has some of the highest in-stream erosion rates in the watershed and is generating as much as 500 tons of sediment annually from streambank and streambed erosion.

N. Branch of Macatawa Upstream of Lincoln Avenue

Headcut along Kuipers Drain

The degree of channel instability increases in the downstream receiving streams, especially along the North Branch of the Macatawa River itself. Erosion along meander bends and valley walls, channel degradation, tributary head-cuts, log jams, and mid-channel bars are common along the North Branch of the Macatawa River, especially downstream of the M-40 corridor, which has undergone extensive industrial and commercial development over the past few decades.

Mid-Channel Bar downstream of M-40

Erosion along Valley Wall downstream of 147th Street

The severity of bank erosion and channel instability is most severe between M-40 and 32nd Street (Ottogan Road) as shown in Figure 6. The majority of the North Branch of the Macatawa River is deeply incised along this stretch, resulting in higher flows and associated shear stresses being confined to the channel. Low bank heights of 5 to 7 feet are common in areas where the mean bankfull depth should be approximately 2.5 feet. The related Bank-Height ratios (lowest bank height to maximum bankfull depth) are greater than 1.5, indicative of a stream that is lowering its local base level (degrading) and capable of contributing a disproportionate amount of sediment from stream bank (and bed) erosion.

Incised Channel downstream of M-40

Incised Channel upstream of 32nd Street

The most severe erosion in terms of degree and extent (sediment loading) along the North Branch of the Macatawa River is between M-40 and 32nd Street (Ottogan Road). Over 86% of the channel along this stretch is experiencing some level of bank erosion. On average, this reach is contributing an estimated 0.6 cubic feet per linear foot or 385 tons of sediment annually from in-stream erosion. Overall, the North Branch sub-basin is estimated to contribute approximately 1,235 tons of sediment annually from bank erosion, the second highest of all eight major subbasins. A detailed breakdown of pollutant loading by stream reach is shown below in Table 5. Pollutant loading calculations are provided in Appendix 5.

Table 5 – North Branch of Macatawa River – Pollutant Loading

Location	Reach Length (ft)	Annual Sediment Volume (cft/yr)	Erosion Rate (cft/yr/lf)	Annual Pollutant Load		
				Sediment (tons/yr)	Phosphorous (lbs/yr)	Nitrogen (lbs/yr)
Kuipers Drain – 60th to I-196	8,800	8,800	1.00	440	440	880
Kuipers Drain – I-196 to US-31	6,100	1,281	0.21	64	64	128
North Branch – Washington to Lincoln	6,500	1,495	0.23	67	67	134
North Branch – Lincoln to M-40	6,700	804	0.12	36	36	72
*North Branch – M-40 to 146th	6,100	3,557	0.58	173	173	346
*North Branch – 146th to 147th	3,500	1,967	0.56	89	89	178
*North Branch – 147th to 32nd (Ottogan)	4,650	2,760	0.59	124	124	248
North Branch – 32nd (Ottogan) to Black River	20,700	5,382	0.26	242	242	484
Total	63,050	26,046	0.41	1,235	1,235	2,470

*Entire Reach Assessed in the Field

SOUTH BRANCH OF MACATAWA RIVER

While a majority of the dredged tributaries are fairly stable, erosion along the main stem of the South Branch of the Macatawa River is quite extensive. Of the three subbasins analyzed, the South Branch subbasin ranked highest in terms of annual pollutant loading. The dominant BEHI scores are moderate, although some of the tributaries were determined to be fairly stable based on the windshield survey. Erosion at the toe of banks and along meander bends and valley walls was common. Signs of channel degradation, including increased channel incision and tributary head-cuts, were noted. Extensive log jams causing localized scour and erosion were also prevalent.

Erosion of Valley Wall between 146th & 46th Streets

Log Jam downstream of 46th Street

The most severe erosion along the South Branch of the Macatawa River is downstream of 46th Street. On average, this reach is contributing an estimated 0.8 cubic feet per linear foot or 620 tons of sediment annually from in-stream erosion. Nearly the entire stretch is deeply incised with low bank heights between 5 and 7 feet in areas where the bankfull mean depth should be less than 3 feet. The related Bank-Height ratios (lowest bank height to maximum bankfull depth) are greater than 1.5, indicative of a stream that is lowering its local base level (degrading) and capable of contributing a disproportionate amount of sediment from stream bank (and bed) erosion.

Incised Channel between 46th St. and Ottogan St.

Incised Channel near Black River

The South Branch sub-basin is estimated to contribute approximately 1,242 tons of sediment annually from bank erosion, which is the highest of all eight major subbasins. A detailed breakdown of pollutant loading by stream reach is shown below in Table 6. Pollutant loading calculations are provided in Appendix 5.

Table 6 – South Branch of Macatawa River – Pollutant Loading

Location	Reach Length (ft)	Annual Sediment Volume (cft/yr)	Erosion Rate (cft/yr/lf)	Annual Pollutant Load		
				Sediment (tons/yr)	Phosphorus (lbs/yr)	Nitrogen (lbs/yr)
Tributary – 46th to 47th	5,060	253	0.05	11	11	23
Tributary – 50th to 52nd	9,760	586	0.06	26	26	53
Jaarda Drain – 56th to M-40	18,640	1,584	0.08	71	71	143
South Branch – M-40 to 144th	8,180	1,881	0.23	85	85	169
*South Branch – 144th to 146th	10,200	3,907	0.38	165	165	330
*South Branch – 146th to 46th	18,000	5,935	0.33	264	264	527
*South Branch – 46th to Ottogan	7,760	6,547	0.84	295	295	589
*South Branch – Ottogan to Black River	9,300	7,226	0.78	325	325	650
Total	86,900	27,918	0.32	1,242	1,242	2,484

**Entire Reach Assessed in the Field*

NOORDELOOS CREEK

In general, the dredged open channel drains through agricultural lands in the upper part (north and east) of the Noordeloos Creek subbasin tend to be fairly stable. This is most likely due to the lower channel gradients (and associated shear stresses), more cohesive soils, and well-vegetated banks.

Tributary at 96th Street and Van Buren Street

Tributary near 104th Avenue and Quincy Street

While the altered (dredged) agricultural drains may be fairly stable, the receiving natural channels show classic signs of instability from altered hydrology (both agricultural and urban development/ channelization). Erosion along meander bends and valley walls, channel degradation, tributary head-cuts, fallen trees and log jams, mid channel bars, transverse riffles, and meander bends (pools) with steep gradients (and associated high near-bank shear stresses) are common along the main branch of the Noordeloos Creek.

Mid-Channel Bar downstream of I-196 BL

Severe Log Jam downstream of Riley Street

The severity of bank erosion and channel instability tends to increase in a downstream direction along Noordeloos Creek as shown in Figure 6. The majority of the main branch of Noordeloos Creek downstream of Riley Street is deeply incised, resulting in higher flows and associated shear stresses being confined to the channel. Low bank heights of 5 to 7 feet are common in areas where the mean bankfull depth should be less than 3 feet. The related Bank-Height ratios (lowest bank height to maximum bankfull depth) are greater than 1.5, indicative of a stream that is lowering its local base level (degrading) and capable of contributing a disproportionate amount of sediment from stream bank (and bed) erosion.

Incised Channel downstream of Riley Street

Incised Channel with debris downstream of I-196 BL

Not surprisingly, the most severe erosion in terms of degree and extent (sediment loading) is along Noordeloos Creek, downstream of Riley Street. On average, this reach is contributing an estimated 0.6 cubic feet per linear foot or 660 tons of sediment annually from in-stream erosion. Overall, the Noordeloos Creek subbasin is estimated to contribute approximately 951 tons of sediment annually from bank erosion, the fourth highest of all eight major subbasins. A detailed breakdown of pollutant loading by stream reach is shown below in Table 7. Pollutant loading calculations are provided in Appendix 5.

Table 7 – Noordeloos Creek Subbasin – Pollutant Loading

Location	Reach Length (ft)	Annual Sediment Volume (cft/yr)	Erosion Rate (cft/yr/lf)	Annual Pollutant Load		
				Sediment (tons/yr)	Phosphorous (lbs/yr)	Nitrogen (lbs/yr)
Tributary to Noordeloos Creek – Perry to 106th	1,889	123	0.07	6	6	11
Tributary to Brower Drain – Fairview to Centennial	2,491	324	0.13	15	15	29
Brower Drain – 100th to Riley	2,746	233	0.08	10	10	21
Brower Drain – Riley to 104th	1,342	114	0.08	5	5	10
Northwest of Zeeland Drain – 100th to Brower Drain	5510	468	0. 08	21	21	42
Bower Drain –104th to Noordeloos Creek	3,724	782	0.21	35	35	70
Bosch & Hulst Drain – Van Buren to 112th	5,164	491	0.10	22	22	44
Bosch & Hulst Drain – 112th to Noordeloos Creek	6,139	614	0.10	28	28	55
Noordeloos Creek – Bosch & Hulst Drain to Quincy	4,058	893	0.22	40	40	80
*Noordeloos Creek – Quincy to Riley	9,855	2,353	0.24	106	106	212
*Noordeloos Creek – Riley to 106th	16,915	9,959	0.59	447	447	895
*Noordeloos Creek – 106th to Black River	8,025	4,776	0.59	215	215	430
Total	67,858	21,090	0.31	951	951	1,902

**Entire Reach Assessed in the Field*

CONCLUSIONS

As noted in the geomorphic assessment, the stable natural channel form for the Macatawa Watershed is that of a “C” type stream. In general, “C” type streams are highly susceptible to shifts in both lateral (bank erosion) and vertical (bed degradation or aggradation) stability caused by direct channel disturbance (channel processes), changes in hydrology (hydrologic processes) and/or changes in sediment regime (hill slope processes) of the contributing watershed.

In terms of the hill slope (landscape/land use), hydrologic and channel processes affecting the Macatawa Watershed, the following conclusions can be drawn based on the results of the RLA and RRISSC analysis.

HILL SLOPE PROCESSES

The upper portions of the North Branch, South Branch, and Noordeloos Creek subbasins consist of predominately agricultural lands with extensive drainage networks (dredged open channels). While the channels themselves are generally stable with well vegetated banks, the surrounding landscape is not. Agricultural practices combined with highly erodible soils and poor riparian buffers results in a high potential for generating and delivering a disproportionate amount of sediment and nutrients to nearby waterways. Not surprisingly, some of the highest monitored levels of phosphorus in the watershed are located in the upper reaches of the South Branch and Noordeloos Creek subbasins, where agricultural land use is dominate, soils are highly erodible, and riparian buffers are poor. In general, monitored phosphorous levels tend to decrease in a downstream direction. Therefore, it appears as though a majority of the phosphorous (nutrient) loading in the watershed is being generated from upland sources as opposed to in-stream processes.

Poor Buffer – South Branch Tributary near 138th St.

Poor Buffer – Noordeloos Tributary near 96th Street and Barry Street

HYDROLOGIC PROCESSES

The systemic nature of bank erosion and degree of channel incision provides evidence that much of the stream instability within the Macatawa Watershed is due to altered hydrology, most significantly from increased urbanization and loss of wetlands.

While USGS gage data (04108801, Macatawa River near Zeeland) do not show an increase in hydrologic flashiness since 1960, it does indicate that the Macatawa watershed is highly flashy. The flashiness of the watershed is likely due to the highly developed landscape (both agricultural and urban), extensive drainage network and heavier, more poorly drained soils that dominate the area. Although the hydrology of the watershed appears to have stabilized, the river and its tributaries may still be adapting to hydrologic changes which occurred in the watershed prior to the collection of hydrologic data (1960).

While land use along the South Branch subbasin has not changed much in the past 30 years, data from the *Macatawa Watershed Hydrologic Study* (MDNRE, 2009) indicates that imperviousness along portions of the North Branch and Noordeloos Creek subbasins has increased by as much as 23% since 1978. Imperviousness along the Noordeloos Creek has increased along the tributaries immediately upstream of Riley Street and along the main stem of Noordeloos Creek, downstream of Riley Street. Development and imperviousness near the M-40 corridor of the North Branch has increased as well. Not surprisingly, the most extensive bank erosion and channel instability were recorded along these reaches of stream.

CHANNEL PROCESSES

Direct impacts to channels within the watershed, including channelization (dredging) have been primarily limited to the upper end of the main-stems and tributaries within the North Branch, South Branch, and Noordeloos Creek subbasins. Most of the channelized watercourses appear fairly stable with well vegetated banks and in some instances low flow channels are developing within the larger dredged channel. The most significant impact of channelization efforts in the watershed has been on hydrology (decreasing wetland storage volumes and increasing peak flow rates).

In terms of overall stability, results of the RLA and RRISSC analysis indicate that the upper reaches of the North Branch, South Branch, and Noordeloos Creek subbasins are relatively stable. However, the potential sediment load from the upland landscape may be too much for the stream to transport, resulting in aggradation of the channel bottom (raising of streambed through sediment deposition). Reduced conveyance capacity, sedimentation of drainage tile outlets, increased flooding, and higher maintenance (dredging) costs are potential consequences of channel aggradation.

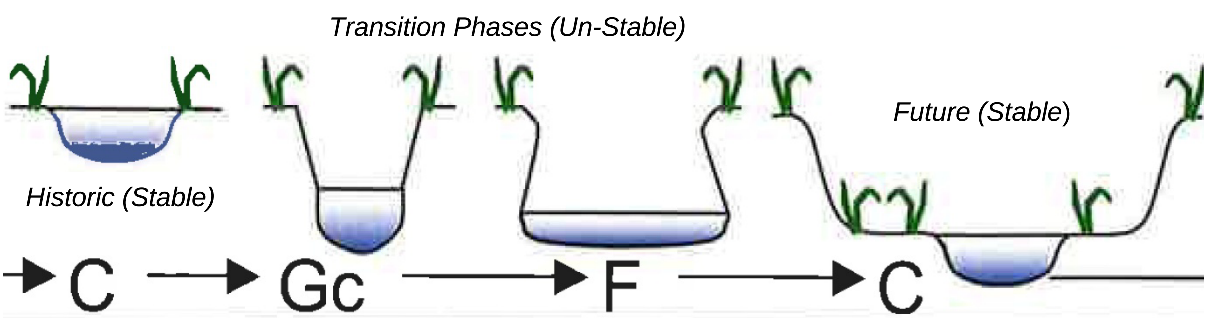
The main-stems of the North Branch, South Branch, and Noordeloos Creek subbasins appear to be adapting to altered hydrologic flow regimes through the channel evolution process. Scouring of the stream bottom due to an increase in the intensity and frequency of the channel forming (bankfull) flow has resulted in channel degradation (lowering of the channel bottom) and incision. The increased channel incision results in higher flows with associated higher shear stresses being confined to the channel, eroding banks and causing a lateral expansion of the channel. Fallen trees and log jams from eroded banks are prevalent. The lowering of the streambed of the main-stems also appears to have resulted in head-cuts along some directly connected tributaries, thereby causing degradation and increased channel incision and erosion along these tributaries.

Not surprisingly, the reference reaches selected for geomorphic assessment are located along riffle (grade control) areas with gravel/cobble substrates that are capable of withstanding the increased channel forming (bankfull) flow of the altered hydrology (as indicated by sediment competence analysis conducted as part of the geomorphic assessment) and therefore able to maintain relatively stable.

South Branch - Incised Channel with Sand Substrate

South Branch – Ref. Reach with Gravel/Cobble Substrate

Left unchecked, channel degradation and bank erosion will continue along the main-stem and directly connected tributaries until the channel profile, dimension, and pattern have completely adjusted to the altered hydrologic regime. The most probable channel evolution will result in the channel down-cutting to a lower stable gradient and the dimension increasing laterally (through bank erosion) until sufficient width has been provided to allow for a new stable channel and connected floodplain to be formed. An illustration of the predicted channel evolution for the Macatawa Watershed is shown below.



Predicted Channel Evolution of C-Type Stream in Macatawa Watershed

RECOMMENDATIONS

Efforts to reduce pollutant loads (both sediment and nutrients) and improve stream stability within the Macatawa Watershed should focus on the following:

- Stabilizing hydrology / reducing storm water runoff.
- Reducing sediment input from upland areas.
- Holistic restoration / stabilization of existing water courses.

STABILIZE HYDROLOGY

Given the sensitivity of the types of streams found in the Macatawa Watershed to changes in hydrology, preventing large increases in the frequency and magnitude of flow rates and runoff volumes and restoring a more stable hydrology to in developed areas will be critical to ensure that channel restoration initiatives are successful. Recommended Best Management Practices (BMPs) to stabilize hydrology include:

- Wetland Restoration/Floodplain Reconnection to attenuate peak flows.
- Adopt low impact development rules for stream protection (and water quality) at the county level and incorporate criteria into storm water ordinances at the city/township level. Ensure that new developments and redevelopments adhere to established storm water rules and criteria.

Subwatersheds (both urban and agricultural) targeted for BMPs to stabilize hydrology are shown in Figure 7.

REDUCE UPLAND SEDIMENT INPUT

Upland efforts to reduce pollutant loading should focus on reducing surface erosion and direct sediment input into nearby watercourses. Specific BMPs for upland areas include:

- Riparian Buffer/Filter Strips.
- Windbreaks.
- Conservation Tillage.
- Cover Crops.
- Bio-Swales to Treat Urban and Agricultural Runoff.
- Wetland Restoration and Treatment.
- Nutrient Management/Ordinances/Public Education.

Reaches of stream targeted for upland BMPs are shown in Figure 8.

HOLISTIC STREAM RESTORATION

Efforts to reduce instream erosion and associated pollution should focus on both attenuating hydrology and working with natural processes to create a stable channel dimension, pattern and profile. A holistic approach to restoration using the principles of natural channel design is recommended as opposed to “patch-in-place” stabilization measures. While specific BMPs will require additional data collection for design purposes, potential preliminary BMPs to address instream stability issues include:

- Woody debris management, conducted in accordance with the *"clean and open method"* as advocated by the MDEQ, to remove log jams and other obstructions that may create flooding hazards or promote localized streambank erosion (see Appendix 4 for log jam locations).

- Channel Restoration using principles of natural channel design to create a stable channel dimension, pattern and profile. Additional geomorphic data should be collected along reference reaches within the larger watershed to develop a more robust set of data for generating regional curves, which may be used for natural channel design purposes.

- Channel Relocation in sensitive areas, such as adjacent to severely eroding valley walls near property which may be adversely impacted by erosion.

- Grade Control Stabilization to halt advancing head-cuts.

- In-stream structures such as cross vanes and j-hooks to reduce shear stresses against eroding channel banks.

- Bank stabilization using native plantings, bio-engineering and/or hard armoring.

- Replacement of undersized or poorly aligned culverts with adequately sized, clear span structures with a natural bottom.

- Roadway runoff stabilization BMPs at stream crossings.

Reaches of stream targeted for restoration and prioritized based on severity of erosion and/or proximity to improved property (commercial, residential or active agricultural) are shown in Figure 9.

REFERENCES

Rosgen 2006. *Watershed Assessment of River Stability and Sediment Supply (WARSSS)*. Wildland Hydrology, Pagosa Springs, CO.

Macatawa Watershed Hydrologic Study, MDNRE 2009.

Macatawa Watershed Modeled Pollutant Loads, MDNRE 2009.

Stream Stability Assessment Guidelines for NPS Grant Applications, MDNRE 2008.

Summary of Macatawa River Watershed Assessment, MDNRE 2004.

Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual, MDEQ 1999.

Summary of Bank Erosion Hazard Index and Road Stream Crossing Assessment, Macatawa Watershed. The Macatawa Area Coordinating Council, Mary Fales. 9/29/2009.

Tulip Intercounty Drain Geomorphic Maintenance Assessment, Fishbeck, Thompson, Carr and Huber, Inc. (FTC&H). 9/27/2010.

Figures

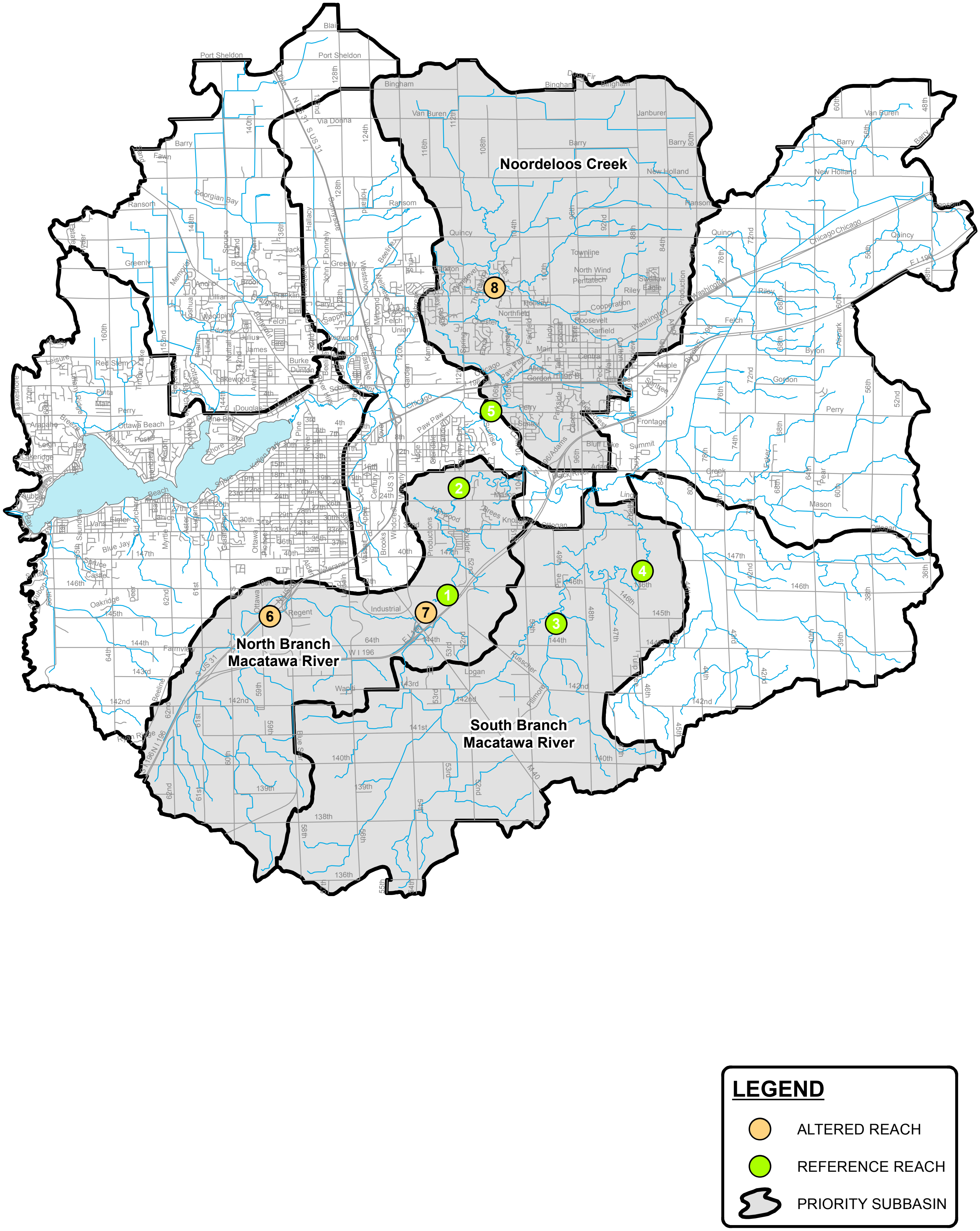


FIGURE 5 - STREAM SURVEY LOCATION

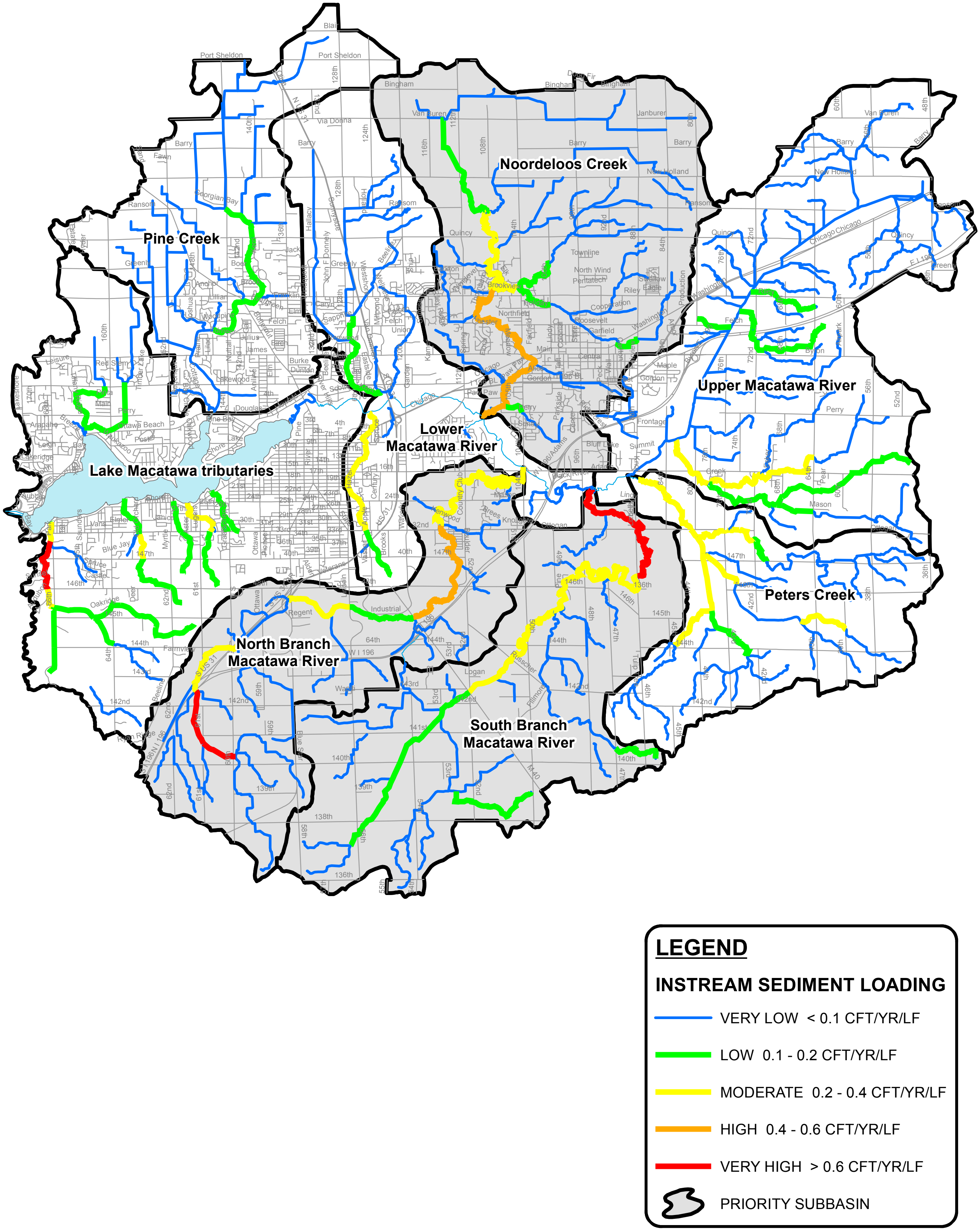
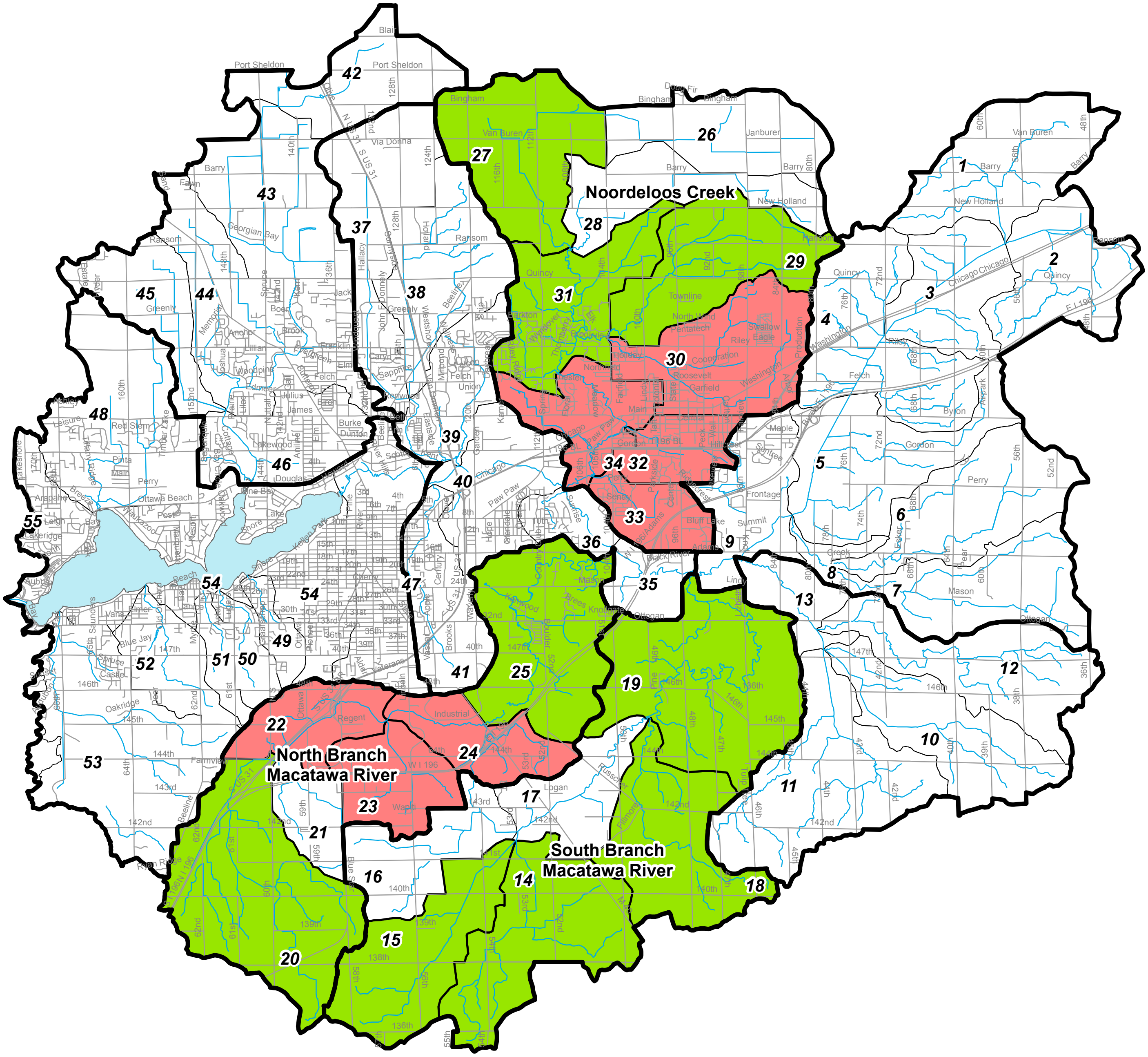


FIGURE 6 - INSTREAM SEDIMENT LOADING



LEGEND

HIGH PRIORITY SUBWATERSHEDS

- URBAN (> 20% IMPERVIOUS)
- AGRICULTURAL

FIGURE 7 - HYDROLOGIC BMP PRIORITIZATION

PLOT INFO: U:\CADD\100240\GISMAP DOCUMENT\FIGURE 7 - STABILIZE HYDROLOGY BMP PRIORITIZATION DATE: 04/26/2011 USER: MB2

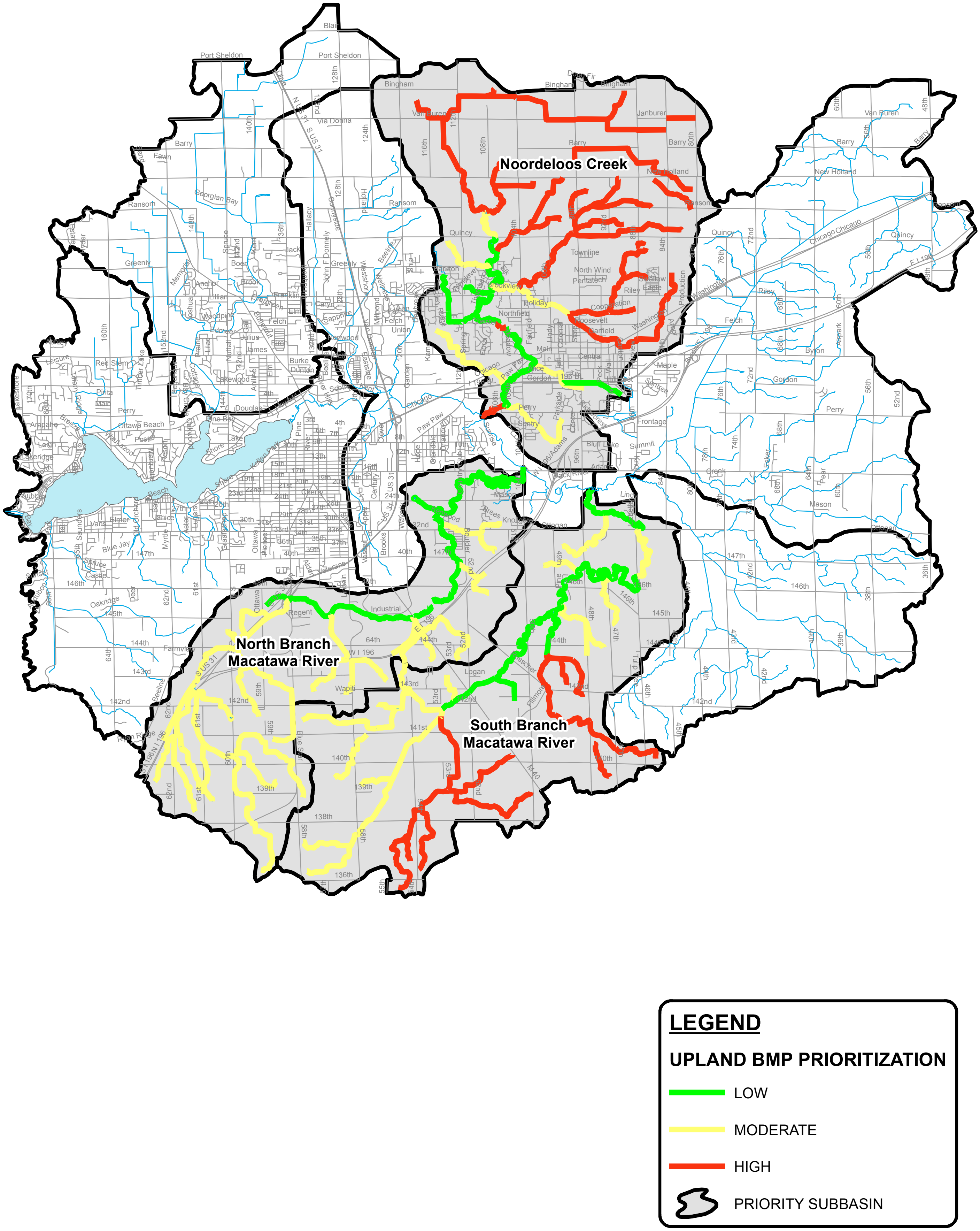


FIGURE 8 - UPLAND BMP PRIORITIZATION

PLOT INFO: U:\CADD\100240\GIS\MAP DOCUMENT\FIGURE 8 - UPLAND BMP PRIORITIZATION.MXD DATE: 04/25/2011 USER: MB2

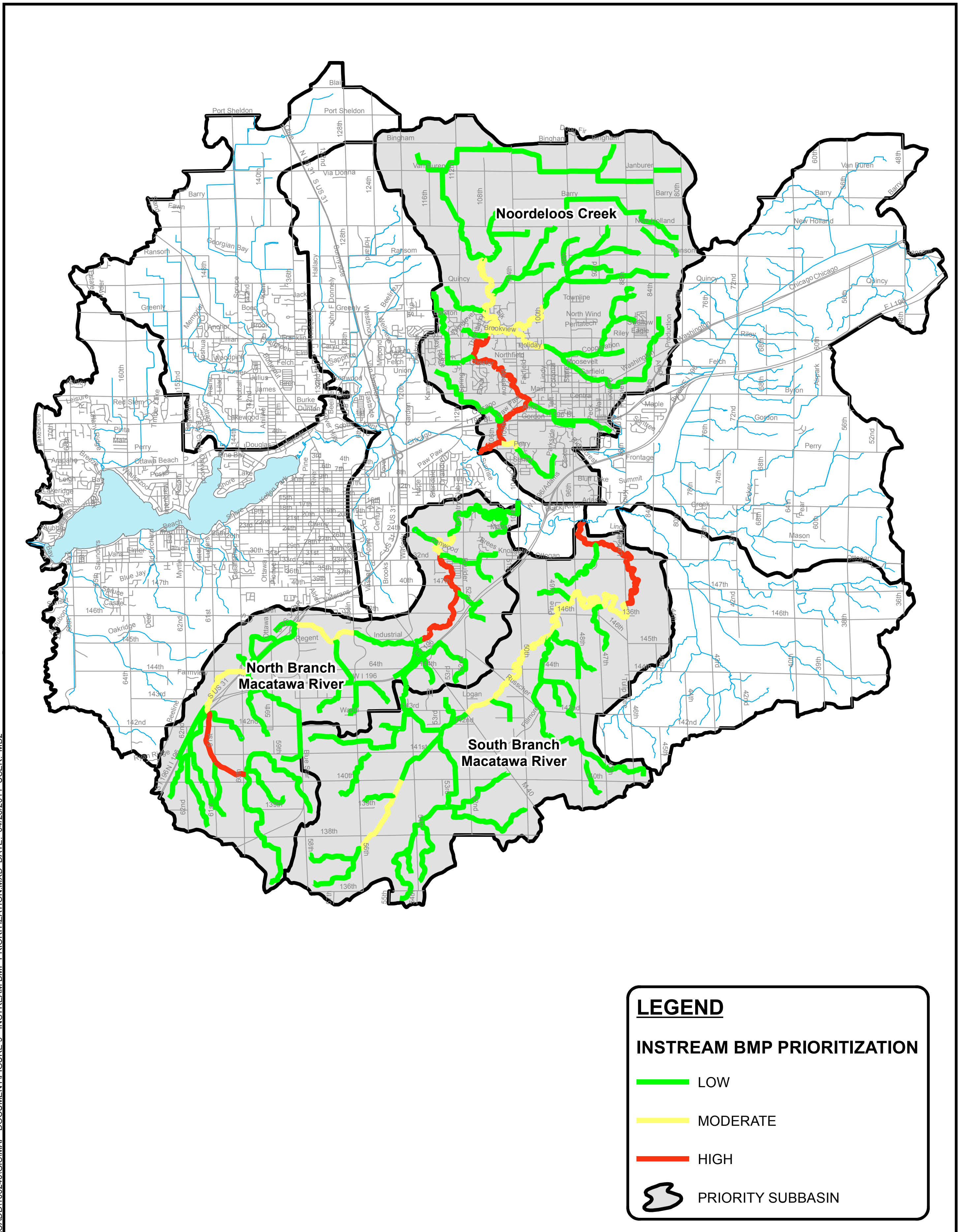


FIGURE 9 - INSTREAM BMP PRIORITIZATION

PLOT INFO: U:\CADD\100240\GIS\MAP DOCUMENT\FIGURE 9 - INSTREAM BMP PRIORITIZATION.MXD DATE: 04/26/2011 USER: MB2

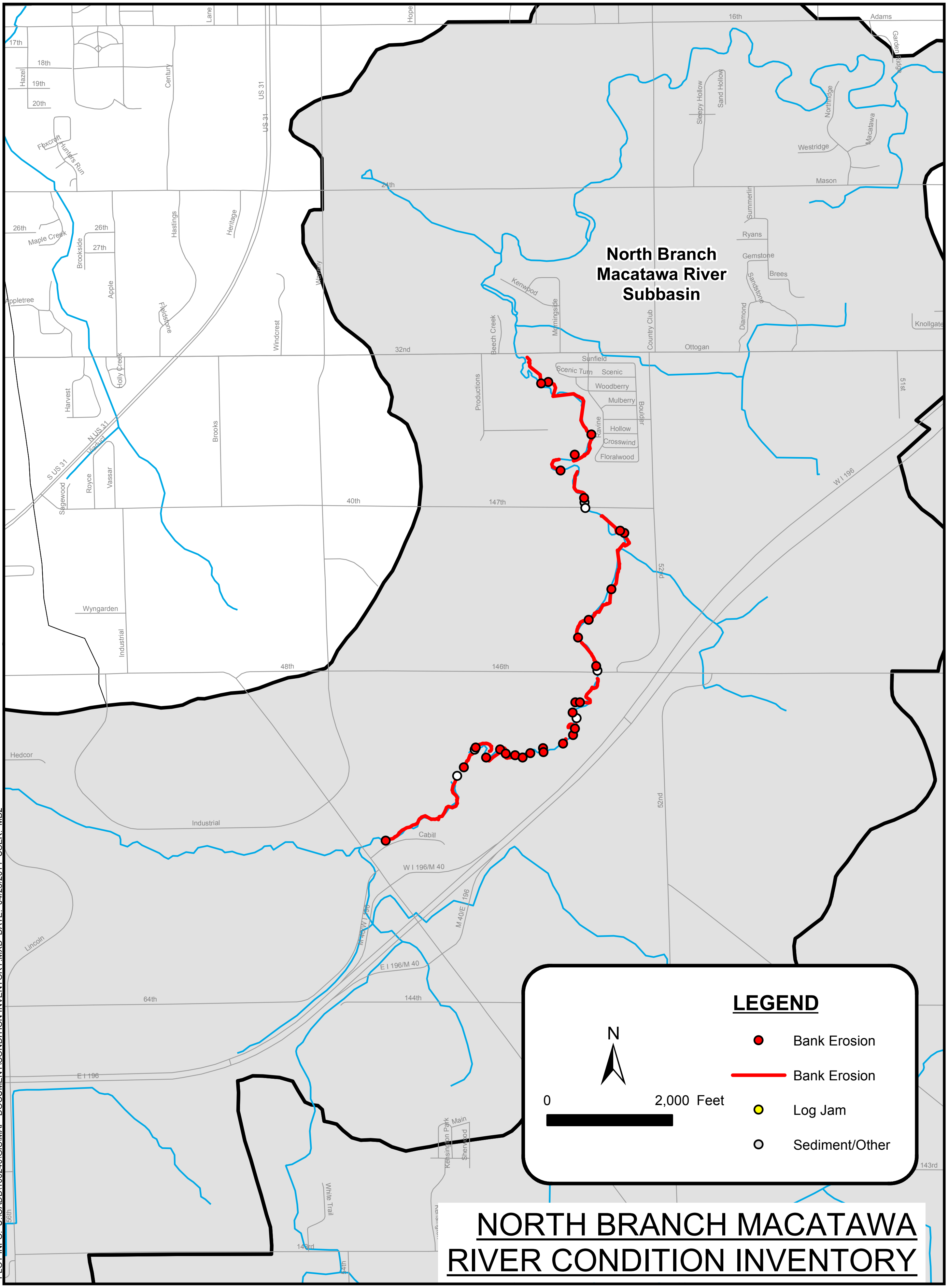
Macatawa Watershed Geomorphic Assessment

Appendices 1, 2 and 3

Available Upon Request

mfales@the-macc.org

Appendix 4



NORTH BRANCH MACATAWA RIVER CONDITION INVENTORY

PLOT INFO: U:\CADD\100240\GIS\MAP_DOCUMENT\CONDITION INVENTORY.MXD DATE: 04/25/2011 USER: MB2

Project: Macatawa - WARSSS
Job No: G100240
Date: 11/12/2010
Engineer: DF2

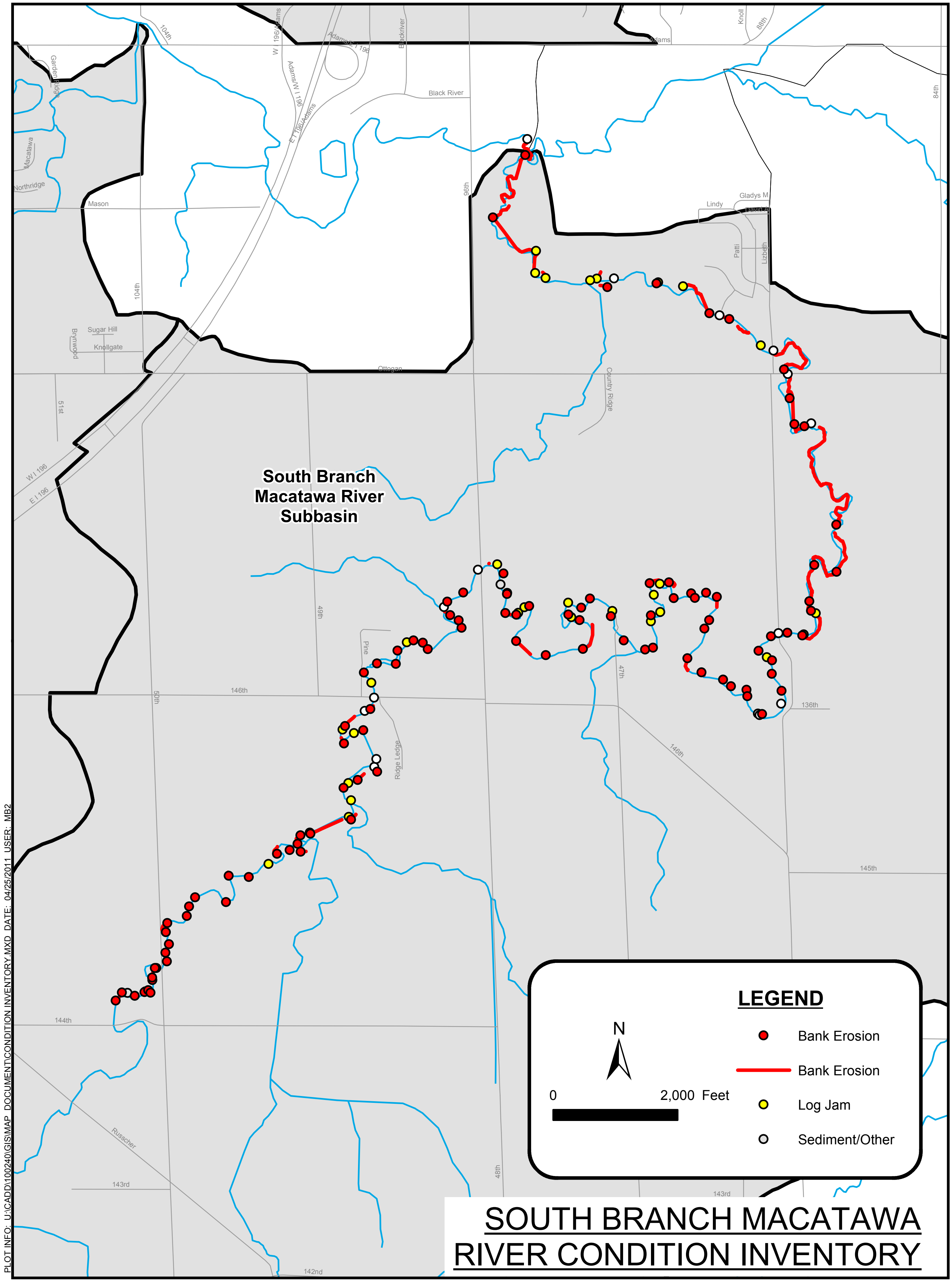
FISHBECK, THOMPSON,
CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

North Branch of Macatawa River - Condition Inventory

Weather: Mostly Cloudy, 55 F
Location: M-40 to 32nd Street
Inspectors: Dan Fredricks, P.E. - Fishbeck, Thompson, Carr & Huber, Inc.

Location ID Number	NAD 83 Northing (D.MS)		NAD 83 Easting (D.MS)		Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Priority	Photo ID Number(s)	Additional Comments
1	42.74738	N	86.07365	W	Bank Erosion	3	2030	clay/loam	low	0.01	60.9	low	418-428	3'-5' minor erosion along toe fo channel from M-40 to RR Bridge
3	42.75022	N	86.06938	W	Other								428-429	RR Bridge
5	42.75062	N	86.06900	W	Bank Erosion	5	370	clay/loam	low	0.01	18.5	low	429-432	5' Minor Eroson
6	42.75138	N	86.06834	W	Other								433-434	Ford Crossing
7	42.75148	N	86.06828	W	Bank Erosion	6	410	sand/loam	high	0.4	984	medium	435-436	5'-7' Heavily Eroding Banks & Incised Channel
9	42.75103	N	86.06766	W	Bank Erosion	5	340	clay/loam	medium	0.06	102	low	437-438	5'-7' Erosion
11	42.75140	N	86.06680	W	Bank Erosion	7	190	sand/loam	high	0.4	532	medium	439-440	5'-7' Heavily Eroding Banks & Incised Channel
13	42.75122	N	86.06649	W	Bank Erosion	5	210	clay/loam	medium	0.1	105	medium	441-442	5' Erosion
15	42.75113	N	86.06595	W	Bank Erosion	6	50	sand/loam	high	0.4	120	medium	443	
16	42.75103	N	86.06548	W	Bank Erosion	5	100	clay/loam	medium	0.1	50	medium	444	
17	42.75124	N	86.06504	W	Bank Erosion	4	75	clay/loam	medium	0.1	30	medium	445	
18	42.75144	N	86.06427	W	Bank Erosion	6	75	sand/loam	high	0.4	180	medium	446	
19	42.75127	N	86.06425	W	Bank Erosion	5	100	clay/loam	medium	0.1	50	medium	447-449	
20	42.75165	N	86.06308	W	Bank Erosion	6	100	sand/loam	high	0.4	240	medium	450	5' Heavy Erosion
22	42.75202	N	86.06249	W	Bank Erosion	5	140	sand/loam	high	0.4	280	medium	451	5' Heavy Erosion
24	42.75231	N	86.06238	W	Bank Erosion	5	300	clay/loam	medium	0.1	150	medium	452	Tight Radius of Curvature (Typical)
26	42.75276	N	86.06227	W	Other								453-454	Reference Reach Upstream of 146th - 30+/- Width, <3' Depth
27	42.75301	N	86.06251	W	Bank Erosion	5	50	clay/loam	medium	0.1	25	medium	455	
28	42.75345	N	86.06235	W	Bank Erosion	6	75	sand/loam	high	0.4	180	medium	456	
29	42.75347	N	86.06207	W	Bank Erosion	5	300	clay/loam	high	0.3	450	low	457-460	5' Moderate to Heavy Bank Erosion
31	42.75483	N	86.06103	W	Other									146th Avenue
32	42.75505	N	86.06111	W	Bank Erosion	5	470	clay/loam	medium	0.1	235	medium	461	5' Erosion
34	42.75630	N	86.06219	W	Bank Erosion	8	440	clay/loam	medium	0.2	704	high	462-463	5'-10' Erosion along Bend / Valley Wall (Proposed Floodplain Restoration).
36	42.75709	N	86.06156	W	Bank Erosion	5	750	clay/loam	medium	0.1	375	medium	464-466	5'-7' Erosion (Some Heavy) and Incised Channel,
38	42.75843	N	86.06020	W	Bank Erosion	4	1200	clay/loam	medium	0.06	288	low	467-474	3'-5' Minor Erosion at Toe, Relatively Straight Channel (Less Meandering)
40	42.76090	N	86.05943	W	Bank Erosion	12	50	clay/loam	medium	0.2	120	high	475	Stabilize Bluff (Valley Wall)
41	42.76100	N	86.05969	W	Bank Erosion	5	490	clay/loam	medium	0.1	245	medium	476-477	5' Erosion & Incised Channel
43	42.76200	N	86.06175	W	Other								478-479	147th Avenue
44	42.76224	N	86.06181	W	Sediment Bar							low	480	75' Long / 20' Wide / 1' Deep - Overwidened Channel DS 147th Avenue
45	42.76243	N	86.06184	W	Bank Erosion	4	550	clay/loam	medium	0.06	132	low	481-483	4'-5' Erosion, Incised Channel, Some Rock along Toe
47	42.76364	N	86.06324	W	Bank Erosion	4	370	clay/loam	medium	0.06	88.8	low	484	3'-5' Erosion at Toe of 15' +/- Valley Wall
49	42.76422	N	86.06243	W	Bank Erosion	8	860	clay/loam	medium	0.2	1376	high	485-489	3'-15' Erosion along 10'-25' Valley Wall
51	42.76523	N	86.06140	W	Bank Erosion	5	1450	clay/loam	medium	0.1	725	medium	490-493	3'-7' Erosion and Incised Channel
53	42.76752	N	86.06398	W	Bank Erosion	7	120	clay/loam	medium	0.2	168	high	494	7' Erosion and Incised Channel
55	42.76749	N	86.06445	W	Bank Erosion	5	540	clay/loam	medium	0.1	270	medium	495	5'-7' Erosion and Incised Channel

Total Length of Erosion 12205 LF — 8284 CF
Total Length of Water Course 14242 LF — 307 CY
86% of Channel is Eroding — 0.6 CF of erosion per LF



SOUTH BRANCH MACATAWA RIVER CONDITION INVENTORY

Project: Macatawa - WARSSS
Job No: G100240
Date: 11/10/2010
Engineer: DF2

FISHBECK, THOMPSON,
CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

South Branch of Macatawa - Condition Inventory

Weather: Mostly Sunny, 60 F
Location: 144th to 46th
Inspectors: Dan Fredricks, P.E. - Fishbeck, Thompson, Carr & Huber, Inc.

Location ID Number	NAD 83 Northing (D.MS)		NAD 83 Easting (D.MS)		Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Priority	Photo ID Number(s)	Additional Comments
1	42.74125	N	86.03956	W	Bank Erosion	10	355	clay	medium	0.1	355	medium	1-5	Erosion along Valley Wall
3	42.74161	N	86.03918	W	Bank Erosion									End Erosion
4	42.74159	N	86.03885	W	Sediment Bar						0	low	6	30' long, 15' wide, 1' deep Upstream of 104th
5	42.74146	N	86.03842	W	Bank Erosion	7	230	clay/loam	medium	0.1	161	medium	7	
7	42.74163	N	86.03783	W	Bank Erosion									End Erosion
8	42.74166	N	86.03778	W	Sediment Bar						0	medium	8	25' length, 7' width, 1' depth
9	42.74171	N	86.03759	W	Bank Erosion	8	50	clay/loam	medium	0.1	40	medium	9	
10	42.74160	N	86.03747	W	Bank Erosion	15	300	clay/loam	medium	0.2	900	high	10-12	
13	42.74216	N	86.03737	W	Bank Erosion									End Erosion
14	42.74227	N	86.03737	W	Bank Erosion	7	170	clay	medium	0.1	119	medium	13-15	
16	42.74268	N	86.03721	W	Bank Erosion									End Erosion
17	42.74269	N	86.03713	W	Sediment Bar						0	low	16	50' length, 15' width, 1' depth
18	42.74299	N	86.03649	W	Bank Erosion	15	50	clay	medium	0.1	75	medium	17	
19	42.74336	N	86.03658	W	Bank Erosion	7	150	clay/loam	medium	0.1	105	medium	18	
22	42.74374	N	86.03637	W	Bank Erosion	7	50	clay/loam	low	0.01	3.5	low	19-20	
23	42.74427	N	86.03655	W	Bank Erosion	7	240	clay/loam	medium	0.1	168	medium	21-22	5'-7' Bank Erosion
25	42.74467	N	86.03647	W	Bank Erosion	10	150	clay	medium	0.1	150	medium	23-24	
26	42.74498	N	86.03530	W	Bank Erosion	5	50	clay/loam	medium	0.06	15	low	25-26	
27	42.74541	N	86.03156	W	Bank Erosion	5	50	clay/loam	medium	0.06	15	low	27	
28	42.74581	N	86.03458	W	Bank Erosion	10	50	clay/loam	medium	0.06	30	low	28	
29	42.74559	N	86.03294	W	Bank Erosion	15	140	clay/loam	medium	0.1	210	medium	29	10'-15' Bank Erosion
31	42.74675	N	86.03279	W	Bank Erosion	15	240	clay/loam	low	0.01	36	low	30	10'-20' Bank Erosion
33	42.74671	N	86.03159	W	Bank Erosion	5	75	sand	low	0.01	3.75	low	31	
34	42.74728	N	86.03041	W	Log Jam						0	high	32	
35	42.74773	N	86.02990	W	Bank Erosion	5	190	clay/loam	medium	0.06	57	low	33	5' Bank Erosion
37	42.74790	N	86.02914	W	Bank Erosion	5	75	clay/loam	medium	0.06	22.5	low	34	
38	42.74782	N	86.02848	W	Bank Erosion	5	220	clay/loam	medium	0.1	110	medium	35-37	5' Bank Erosion
40	42.74817	N	86.02867	W	Bank Erosion	7	120	clay/loam	medium	0.1	84	medium	38	7-20' Bank Erosion
42	42.74853	N	86.02850	W	Bank Erosion	15	200	clay/loam	medium	0.1	300	medium	39	
43	42.74866	N	86.02794	W	Sediment Bar						0	low	40	50' long, 10' wide, 1' depth
44	42.74862	N	86.02790	W	Bank Erosion	7	610	clay/loam	low	0.01	42.7	low	41	5-7' Bank Erosion
46	42.74936	N	86.02561	W	Log Jam						0	medium	42-44	
47	42.74935	N	86.02559	W										Floodway
48	42.74924	N	86.02547	W	Bank Erosion	7	120	clay/loam	medium	0.1	84	medium	45	7' Bank erosion
50	42.75009	N	86.02546	W	Log Jam						0	high	46	
51	42.75064	N	86.02591	W	Bank Erosion	8	200	clay	medium	0.1	160	medium	47	8' bank erosion
53	42.75085	N	86.02563	W	Log Jam						0	high	48	
54	42.75096	N	86.02508	W	Bank Erosion	5	220	clay/loam	medium	0.1	110	medium	49	5' Bank Erosion
56	42.75154	N	86.02409	W									50-51	Floodway 50
57	42.75135	N	86.02391	W	Bank Erosion	15	200	clay/loam	medium	0.1	300	medium	52	10-30' Bank Erosion
59	42.75191	N	86.02396	W									53-54	Floodway
60	42.75319	N	86.02474	W	Bank Erosion	15	50	clay/loam	medium	0.06	45	low	55	
61	42.75306	N	86.02530	W	Log Jam						0	high	56	
62	42.75260	N	86.02589	W	Bank Erosion	8	110	clay/loam	medium	0.06	52.8	low	57-58	7-30' Bank 7-10' Erosion

Location ID Number	NAD 83 Northing (D.MS)		NAD 83 Easting (D.MS)		Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Priority	Photo ID Number(s)	Additional Comments
64	42.75320	N	86.02599	W	Log Jam						0	low	59	
65	42.75337	N	86.02584	W	Bank Erosion	5	250	clay/loam	low	0.01	12.5	low	60	5' Bank Erosion
67	42.75403	N	86.02464	W									61	Gully Erosion
68	42.75411	N	86.02430	W	Bank Erosion	10	140	clay/loam	medium	0.1	140	medium	62-63	10-20' Bank Erosion
70	42.75462	N	86.02409	W										146th Ave.
71	42.75528	N	86.02425	W	Log Jam						0	low	64-65	
72	42.75572	N	86.02469	W	Bank Erosion	5	80	clay/loam	medium	0.06	24	low	66	5' Bank Erosion
74	42.75612	N	86.02392	W	Bank Erosion	7	170	clay/loam	medium	0.06	71.4	low	67	7' Bank erosion
76	42.75611	N	86.02279	W	Bank Erosion	7	230	clay/loam	high	0.5	805	high	68-70	7' bank erosion with concrete
78	42.75671	N	86.02269	W	Bank Erosion	10	270	clay/loam	medium	0.06	162	low	71	10' Bank Erosion
80	42.75706	N	86.02213	W	Log Jam						0	high	72	
81	42.75715	N	86.02173	W	Bank Erosion	10	75	clay/loam	low	0.01	7.5	low	73-74	
82	42.75704	N	86.02118	W	Bank Erosion	8	100	clay/loam	high	0.5	400	high	75	8' bank erosion
84	42.75678	N	86.02089	W	Bank Erosion	8	50	clay/loam	medium	0.06	24	low	76	
85	42.75746	N	86.01964	W	Bank Erosion	5	50	clay/loam	low	0.01	2.5	low	77	
86	42.75770	N	86.01885	W	Bank Erosion	3	25	clay/loam	low	0.01	0.75	low	78	
87	42.75803	N	86.01903	W	Bank Erosion	7	50	clay/loam	medium	0.1	35	medium	79-80	
88	42.75826	N	86.01953	W	Bank Erosion	5	270	clay/loam	medium	0.1	135	medium	81-82	5-7' Erosion
90	42.75862	N	86.01990	W									83	Gully Erosion
91	42.75886	N	86.01971	W	Bank Erosion	4	180	clay/loam	low	0.01	7.2	low	84-85	3-5' Bank Erosion
93	42.75926	N	86.01875	W	Bank Erosion	4	50	clay/loam	low	0.01	2	low	86	
94	42.76026	N	86.01787	W									87	48th Street
95	42.76055	N	86.01722	W	Bank Erosion	4	50	clay/loam	low	0.01	2	low	88	3-5' Bank Erosion
97	42.76050	N	86.01672	W	Log Jam							very high	89	
98	42.76009	N	86.01635	W	Bank Erosion	4	50	clay/loam	low	0.01	2	low	90	
99	42.75961	N	86.01651	W	Sediment Bar						0	high	91-94	50' long, 20' side, 4' depth
100	42.75923	N	86.01612	W									95-96	End of Split Bar
101	42.75919	N	86.01613	W	Bank Erosion	3	50	clay/loam	low	0.01	1.5	low	97	
102	42.75836	N	86.01623	W	Bank Erosion	10	120	clay/loam	medium	0.1	120	medium	98	10' Bank Erosion
104	42.75828	N	86.01557	W	Bank Erosion	8	25	clay/loam	medium	0.06	12	low	99	
105	42.75836	N	86.01546	W	Log Jam							extreme	100-101	
106	42.75860	N	86.01509	W	Log Jam							very high	102-103	
107	42.75866	N	86.01480	W	Bank Erosion	10	25	clay/loam	low	0.01	2.5	low	104-105	
108	42.07571	N	86.01559	W	Bank Erosion	10	570	clay/loam	low	0.01	57	low	106-108	20' valley wall 10' bank erosion
110	42.75649	N	86.01382	W	Bank Erosion	7	600	clay/loam	low	0.01	42	low	109	5-7' Bank Erosion incised
112	42.75676	N	86.01158	W	Bank Erosion	10	490	clay/loam	medium	0.06	294	low	110	20' valley 5-15' bank erosion
114	42.75804	N	86.01179	W	Bank Erosion	7	25	clay/loam	low	0.01	1.75	low	111	
115	42.75816	N	86.01229	W	Log Jam							very high	112	
116	42.75829	N	86.01245	W	Bank Erosion	5	25	clay/loam	medium	0.06	7.5	low	113	
117	42.75881	N	86.01247	W	Log Jam							very high	114	
118	42.75859	N	86.01169	W	Bank Erosion	8	100	clay/loam	medium	0.1	80	medium	115	7' Bank Erosion
120	42.75899	N	86.01116	W	Bank Erosion	10	100	clay/loam	medium	0.1	100	medium	116	10' Bank Erosion
122	42.75843	N	86.00982	W	Log Jam						0	high	117	
123	42.75822	N	86.00992	W	Bank Erosion	5	290	clay/loam	low	0.01	14.5	low	118	5-7' Bank Erosion incised
125	42.75714	N	86.00915	W	Bank Erosion	7	75	sand	high	0.4	210	medium	119	
126	42.75674	N	86.00786	W	Bank Erosion	4	75	clay/loam	low	0.01	3	low	120	
127	42.75682	N	86.00739	W	Bank Erosion	10	30	clay	low	0.01	3	low	121	
128	42.75798	N	86.00752	W	Log Jam							extreme	122-123	
129	42.75825	N	86.00752	W	Bank Erosion	7	50	clay/loam	high	0.4	140	medium	124	
130	42.75840	N	86.00696	W	Log Jam						0	medium	125	
131	42.75915	N	86.00734	W	Log Jam						0	high	126	
132	42.75966	N	86.00760	W	Bank Erosion	3	240	clay/loam	low	0.01	7.2	low	127	3' Bank Erosion
134	42.75964	N	86.00698	W	Log Jam						0	high	128-129	
135	42.75970	N	86.00644	W	Bank Erosion	6	210	clay/loam	high	0.4	504	medium	130	6' bank Erosion
137	42.75901	N	86.00615	W	Bank Erosion	10	90	clay	high	0.4	360	medium	131	15' Valley 10' Erosion

Location ID Number	NAD 83 Northing (D.MS)		NAD 83 Easting (D.MS)		Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Priority	Photo ID Number(s)	Additional Comments
139	42.75922	N	86.00511	W	Bank Erosion	7	50	clay/loam	medium	0.1	35	medium	132	
140	42.75901	N	86.00488	W	Bank Erosion	8	50	clay/loam	medium	0.1	40	medium	133	
141	42.75925	N	86.00422	W	Bank Erosion	5	50	clay/loam	medium	0.1	25	medium	134	
142	42.75906	N	86.00357	W	Bank Erosion	8	190	clay/loam	low	0.01	15.2	low	135	20' valley 5-10' erosion
144	42.75804	N	86.00402	W	Bank Erosion	5	25	clay/loam	low	0.01	1.25	low	136	
145	42.75767	N	86.00428	W	Bank Erosion	6	25	clay/loam	medium	0.06	9	low	137	
146	42.75635	N	86.00534	W	Bank Erosion	10	390	clay/loam	medium	0.1	390	medium	138-140	20' Valley 10' erosion
148	42.75574	N	86.00450	W	Bank Erosion	10	220	clay/loam	medium	0.1	220	medium	141	30' Valley 10' erosion
150	42.75542	N	86.00320	W	Bank Erosion	4	210	clay/loam	medium	0.06	50.4	low	142	4' bank erosion
152	42.75512	N	86.00273	W	Bank Erosion	8	140	clay/loam	medium	0.1	112	medium	143	7' incised bank erosion
154	42.75496	N	86.00179	W	Bank Erosion	8	100	clay/loam	medium	0.1	80	medium	144	8' bank erosion
156	42.75468	N	86.00175	W	Bank Erosion	8	200	clay/loam	medium	0.1	160	medium	145	30' Valley 8' erosion
158	42.75389	N	86.00107	W									146	Trib outlet incised & erosion
159	42.75392	N	86.00111	W	Sediment Bar						0	high	147	50' long, 15' wide, 2' deep
160	42.75389	N	86.00086	W	Bank Erosion	10	690	clay/loam	medium	0.1	690	medium	148	30' Valley 10' erosion
162	42.75435	N	85.99973	W									149	Gulley from road
164	42.75491	N	85.99968	W	Bank Erosion	7	75	clay/loam	medium	0.06	31.5	low	150	
165	42.75567	N	86.00027	W	Bank Erosion	6	75	clay/loam	medium	0.06	27	low	151	
166	42.75627	N	86.00026	W	Bank Erosion	6	50	clay/loam	medium	0.06	18	low	152	
167	42.75640	N	86.00057	W	Log Jam						0	high	153	
168	42.75668	N	86.00107	W	Bank Erosion	10	320	clay/loam	medium	0.1	320	medium	154	30' Valley 10' erosion
170	42.75734	N	86.00023	W	Bank Erosion	7	100	clay/loam	medium	0.1	70	medium	155	
171	42.75746	N	85.99988	W										46th Street

Project: Macatawa - WARSSS
Job No: G100240
Date: 11/12/2010
Engineer: DF2

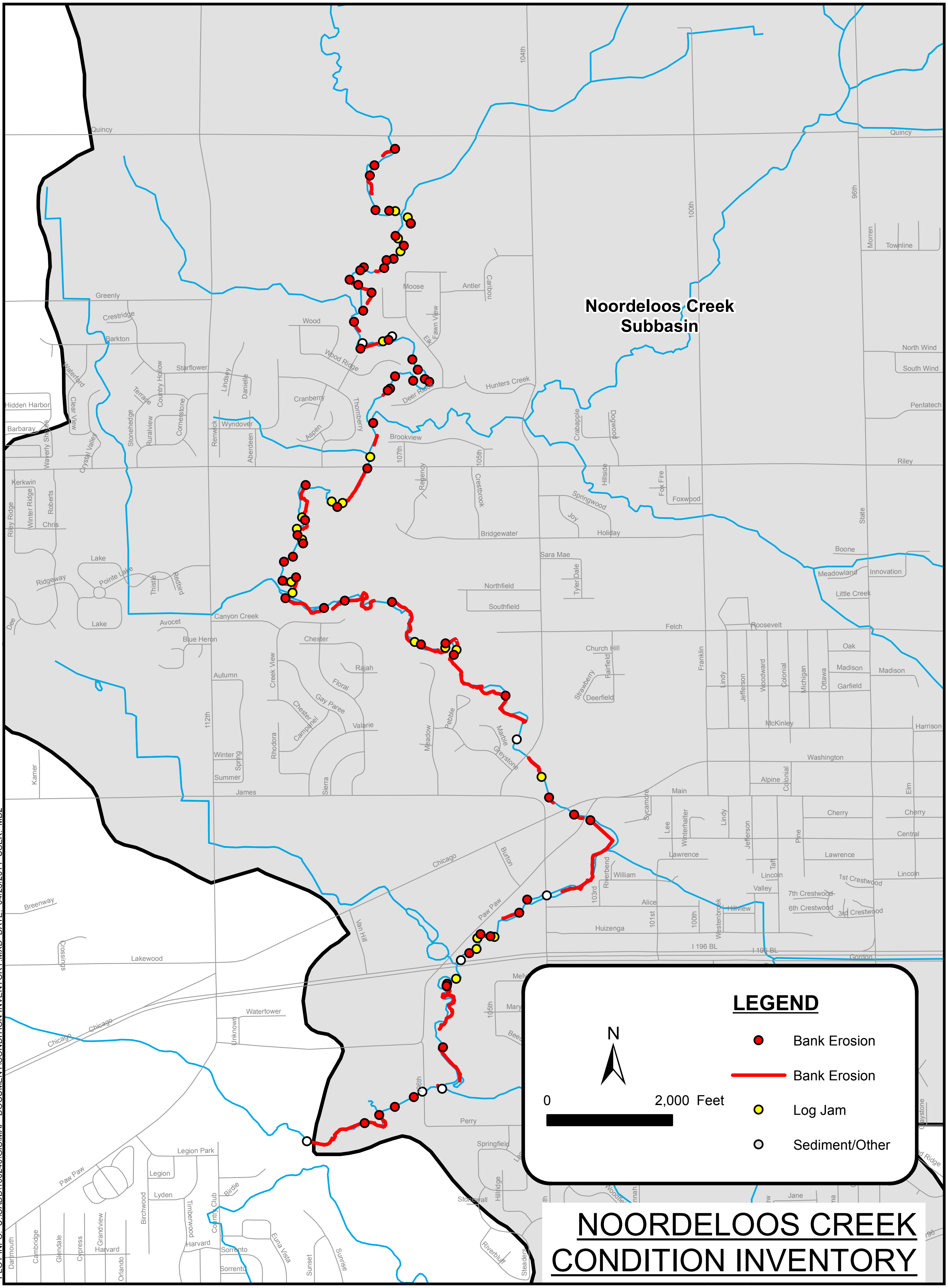
FISHBECK, THOMPSON,
CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

South Branch of Macatawa River - Condition Inventory

Weather: Mostly Cloudy, 55 F
Location: 46th to Mouth
Inspectors: Dan Fredricks, P.E. - Fishbeck, Thompson, Carr & Huber, Inc.

Location ID Number	NAD 83 Northing (D.MS)		NAD 83 Easting (D.MS)		Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Priority	Photo ID Number(s)	Additional Comments
172	42.75750	N	85.99936	W	Bank Erosion	5	100	clay/loam	medium	0.06	30	low	307	
173	42.75741	N	85.99836	W	Log Jam						0	medium	308	
174	42.75735	N	85.99847	W	Bank Erosion	7	800	clay/loam	medium	0.1	560	medium	309-312	7' bend erosion trib head cut 312
176	42.75834	N	85.99765	W	Log Jam							extreme	313-314	
177	42.75844	N	85.99792	W	Bank Erosion	7	200	clay/loam	medium	0.1	140	medium	315-316	up to 20' valley 5-7' erosion
179	42.75887	N	85.99803	W	Bank Erosion	6	680	clay/loam	medium	0.06	244.8	low	317-318	5-7' erosion & incised
181	42.76047	N	85.99772	W	Bank Erosion	7	850	clay/loam	high	0.5	2975	high	319-325	5-7' erosion & incised cont 326
183	42.76017	N	85.99640	W	Bank Erosion	3	770	clay/loam	low	0.01	23.1	low	326-329	3' erosion at toe gc some stabilization
185	42.76224	N	85.99641	W	Bank Erosion	5	2690	clay/loam	medium	0.1	1345	medium	330-339	3-7' erosion & incised
187	42.76671	N	85.99791	W									340-343	Irrigation Pond
188	42.76660	N	85.99832	W	Bank Erosion	7	310	clay/loam	medium	0.2	434	high	344-346	7' erosion incised
190	42.76668	N	85.99892	W	Bank Erosion	5	410	clay/loam	medium	0.06	123	low	347	5-7' erosion & incised
192	42.76783	N	85.99921	W	Bank Erosion	7	480	clay/loam	medium	0.2	672	high	348-350	7' erosion & incised & debris
194	42.76889	N	85.99931	W									351-352	Ottogan
195	42.76909	N	85.99954	W	Bank Erosion	8	1380	clay/loam	medium	0.1	1104	medium	353-358	7-9' heavy erosion & incised
197	42.76992	N	86.00016	W									359-360	Elizbeth
198	42.77016	N	86.00093	W	Log Jam						0	high	361	
199		N		W									362	Min Toe Erosion Connect Floodplain 2-4' bank
200	42.77132	N	86.00282	W	Bank Erosion	5	190	clay/loam	medium	0.06	57	low	363	15' valley 5' toe erosion
202	42.77149	N	86.00340	W									364-366	Abandoned twin box
203	42.77158	N	86.00401	W	Bank Erosion	5	720	clay/loam	medium	0.1	360	medium	367-370	5-7' erosion & incised & debris
205	42.77277	N	86.00558	W	Log Jam						0	high	371	
207	42.77294	N	86.00709	W	Log Jam						0	medium	372-373	
208	42.77290	N	86.00717	W	Bank Erosion	6	200	clay/loam	medium	0.1	120	medium	372-373	5-7' erosion incised debris
210	42.77312	N	86.00973	W									374-375	x-ing 374ds 375 us
211	42.77273	N	86.01013	W	Bank Erosion	5	2140	clay/loam	medium	0.1	1070	medium	376-378	5-7' erosion incised
213	42.77308	N	86.01077	W	Log Jam						0	high	379-381	
215	42.77303	N	86.01114	W	Log Jam							extreme	382	
217	42.77315	N	86.01379	W	Log Jam							very high	386	
219	42.77336	N	86.01444	W	Log Jam						0	high	387-388	
221	42.77433	N	86.01439	W	Log Jam						0	high	389	
223	42.77580	N	86.01697	W	Bank Erosion	7	1850	clay/loam	medium	0.2	2590	high	395-397	7' Heavy erosion & debris
226	42.77854	N	86.01502	W	Bank Erosion	7	550	clay/loam	high	0.5	1925	high	407-415	7' heavy erosion jam near be
228	42.77927	N	86.01491	W									416-417	Black River 416 us 417 ds

Total Length of Erosion 27225 LF — 23614 CF
Total Length of Water Course 45260 LF — 875 CY
60% of Channel is Eroding — 0.5 CF of erosion per LF



PLOT INFO: U:\CADD\100240\GIS\MAP_DOCUMENT\CONDITION INVENTORY.MXD DATE: 04/25/2011 USER: MB2

Project: Macatawa - WARSSS
Job No: G100240
Date: 11/11/2010
Engineer: DF2

FISHBECK, THOMPSON,
CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Noordeloos Creek - Condition Inventory

Weather: Mostly Sunny, 65 F
Location: Quincy to Mouth
Inspectors: Dan Fredricks, P.E. - Fishbeck, Thompson, Carr & Huber, Inc.

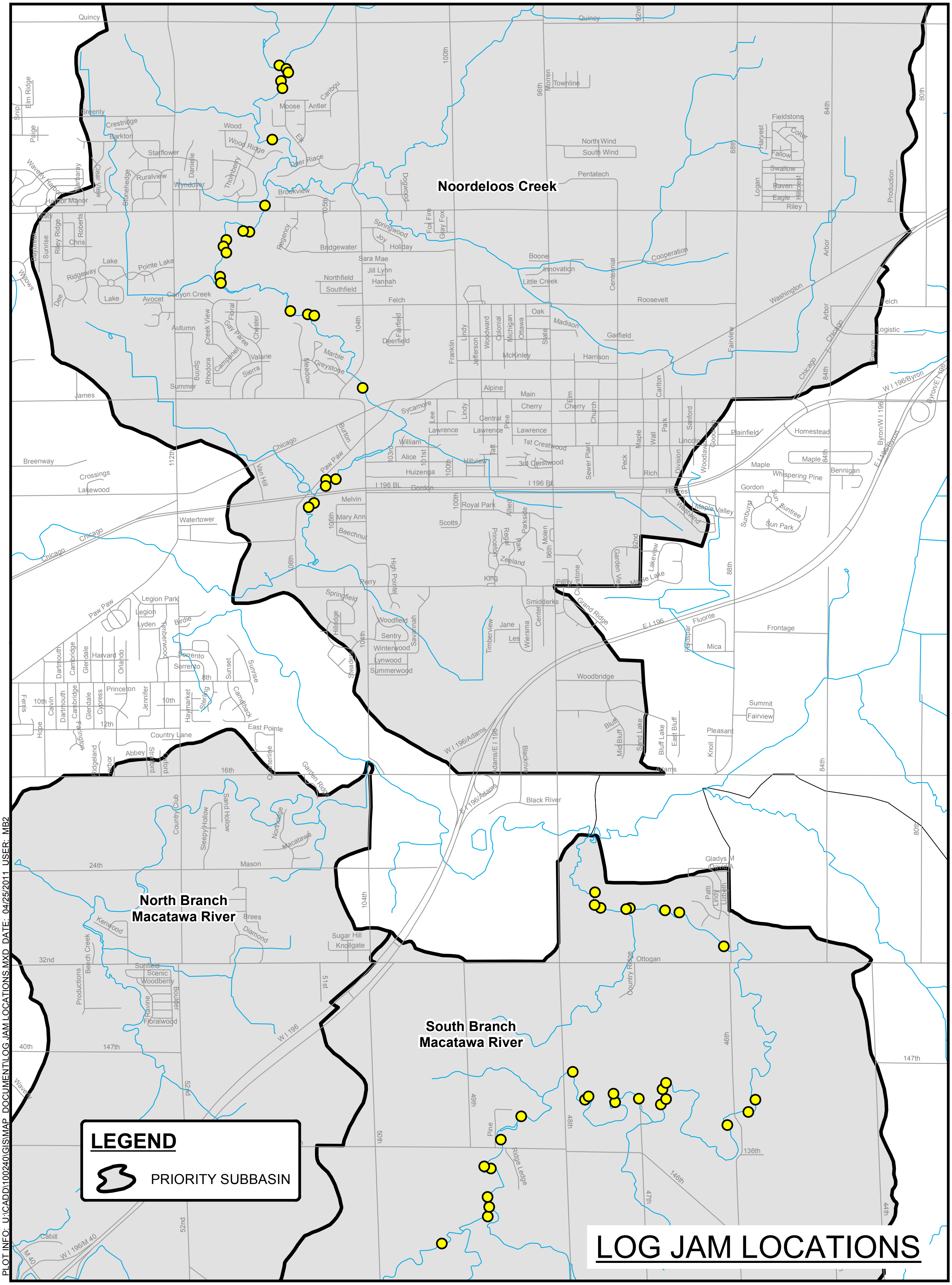
Location ID Number	NAD 83 Northing (D.MS)		NAD 83 Easting (D.MS)		Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Priority	Photo ID Number(s)	Additional Comments
1	42.84076	N	86.04744	W	Bank Erosion	10	270	clay/loam	medium	0.06	162	low	156	5'-10' Erosion along 25' Valley Wall
3	42.84005	N	86.04866	W	Bank Erosion	5	50	clay/loam	medium	0.06	15	low	157-158	
4	42.83960	N	86.04894	W	Bank Erosion	5	380	clay/loam	medium	0.1	190	medium	159-162	5'-7' Erosion, Sediment Bars and Woody Debris
6	42.83807	N	86.04861	W	Bank Erosion	3	30	clay/loam	medium	0.1	9	medium	163	
7	42.83805	N	86.04779	W	Bank Erosion	5	50	clay/loam	medium	0.1	25	medium	164	
8	42.83804	N	86.04742	W	Log Jam							high	165	
9	42.83777	N	86.04667	W	Log Jam							medium	166	Remove by Hand
10	42.83751	N	86.04650	W	Log Jam							very high	167	
11	42.83751	N	86.04650	W	Bank Erosion	10	100	clay/loam	medium	0.1	100	medium	167-168	
12	42.83696	N	86.04740	W	Bank Erosion	8	25	clay/loam	medium	0.06	12	low	169	
13	42.83684	N	86.04726	W	Log Jam							medium	170	Remove by Hand
14	42.83651	N	86.04691	W	Bank Erosion	5	50	clay/loam	medium	0.1	25	medium	171	
15	42.83627	N	86.04712	W	Log Jam							medium	172	Remove by Hand
16	42.83594	N	86.04753	W	Bank Erosion	7	75	sand	medium	0.1	52.5	medium	173	
17	42.83588	N	86.04794	W	Bank Erosion	4	50	clay/loam	medium	0.06	12	low	174	
18	42.83554	N	86.04808	W	Bank Erosion	5	200	clay/loam	medium	0.1	100	medium	175	5' Erosion along Valley Wall
20	42.83557	N	86.04929	W	Bank Erosion	8	60	clay/loam	medium	0.06	28.8	low	176	8' Erosion 20' valley
22	42.83543	N	86.04952	W	Bank Erosion	4	50	clay/loam	medium	0.1	20	medium	177	
23	42.83503	N	86.05015	W	Bank Erosion	10	175	clay/loam	medium	0.2	350	high	178	15' valley 10' erosion high priority
25	42.83479	N	86.04961	W	Bank Erosion	5	315	clay/loam	medium	0.06	94.5	low	179	Incised Channel 5-7' bank erosion
27	42.83446	N	86.04884	W	Bank Erosion	10	230	clay/loam	medium	0.1	230	medium	180	15' valley 8-10' bank erosion
29	42.83366	N	86.04933	W	Bank Erosion	7	50	clay/loam	medium	0.06	21	low	180	
30	42.83317	N	86.04988	W	Bank Erosion	5	280	clay/loam	medium	0.1	140	medium	181	5' erosion valley & incised channel
32	42.83223	N	86.04937	W	Log Jam							high	182-183	split flow log jam
33	42.83199	N	86.04949	W	Bank Erosion	5	270	clay/loam	medium	0.1	135	medium	184	15' valley 5' erosion
35	42.83231	N	86.04815	W	Log Jam							very high	185	Remove with machine (>18" diam.)
36	42.83238	N	86.04782	W	Bank Erosion	5	240	clay/loam	medium	0.1	120	medium	186	5' Bank erosion incised tight radius of curvature
38	42.83254	N	86.04761	W	Perched Outfall								187	
40	42.83150	N	86.04640	W	Bank Erosion	4	50	clay/loam	medium	0.06	12	low	188	
41	42.83111	N	86.04617	W	Bank Erosion	4	50	clay/loam	medium	0.06	12	low	189	
42	42.83066	N	86.04566	W	Bank Erosion	4	50	clay/loam	medium	0.1	20	medium	190	
43	42.83055	N	86.04540	W	Bank Erosion	15	50	clay/loam	high	0.5	375	high	191-192	20' valley 5-15' erosion
45	42.83059	N	86.04635	W	Bank Erosion	6	10	clay/loam	medium	0.06	3.6	low	193	5-7' erosion incised
47	42.83078	N	86.04743	W	Bank Erosion	4	50	clay/loam	medium	0.06	12	low	194	
48	42.83025	N	86.04773	W	Bank Erosion	4	50	clay/loam	medium	0.06	12	low	195	
49	42.83016	N	86.04787	W	Bank Erosion	5	130	clay/loam	medium	0.1	65	medium	196	5' erosion along valley & incised
51	42.82874	N	86.04878	W	Bank Erosion	6	30	clay/loam	medium	0.1	18	medium	197	5-7' erosion incised *(Downstream of Riley Street)*
54	42.82724	N	86.04892	W	Log Jam							high	198	Remove by Hand
55	42.82674	N	86.04909	W	Bank Erosion	5	720	clay/loam	medium	0.06	216	low	199	5-7' erosion DS of Riley incised
57	42.82521	N	86.05056	W	Log Jam							medium	200	Remove with machine (>18" diam.)
58	42.82504	N	86.05087	W	Bank Erosion	5	60	clay/loam	medium	0.1	30	medium	201	5' erosion
60	42.82528	N	86.05122	W	Log Jam							very high	202	Remove with machine (>18" diam.)
61		N		W	Log Jam							extreme	203	Remove with machine (>18" diam.)
62	42.82601	N	86.05277	W	Bank Erosion	5	780	clay/loam	medium	0.1	390	medium	204	5-7' erosion & incised

Location ID Number	NAD 83 Northing (D.MS)		NAD 83 Easting (D.MS)		Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Priority	Photo ID Number(s)	Additional Comments
64	42.82459	N	86.05297	W	Log Jam							extreme	205-206	Remove by Hand
65	42.82448	N	86.05281	W	Bank Erosion	5	200	clay/loam	medium	0.1	100	medium	207	5-7' erosion
67	42.82409	N	86.05328	W	Log Jam							very high	208-209	Remove with machine (>18" diam.)
68	42.82381	N	86.05324	W	Bank Erosion	6	275	clay/loam	medium	0.1	165	medium	210	5-7' incised Heavy woody debris
70	42.82363	N	86.05303	W	Log Jam							extreme	211	Remove with machine (>18" diam.)
71	42.82343	N	86.05291	W	Bank Erosion	10	20	clay/loam	high	0.4	80	medium	212	
72	42.82285	N	86.05354	W	Bank Erosion	8	25	clay/loam	medium	0.06	12	low	213	
73	42.82262	N	86.05408	W	Bank Erosion	7	150	clay/loam	medium	0.1	105	medium	214	
74	42.82180	N	86.05415	W	Bank Erosion	7	130	clay/loam	medium	0.1	91	medium	215-216	7' erosion
76	42.82177	N	86.05361	W	Log Jam							high	217	Remove with machine (>18" diam.)
77	42.82195	N	86.05334	W	Bank Erosion	6	200	clay/loam	medium	0.1	120	medium	216	5-7' erosion incised
79	42.82127	N	86.05354	W	Log Jam							very high	219	Remove with machine (>18" diam.)
80	42.82103	N	86.05396	W	Bank Erosion	6	500	clay/loam	medium	0.1	300	medium	220	5-7' erosion
83	42.82061	N	86.05167	W	Bank Erosion	8	75	clay/loam	high	0.4	240	medium	222	
85	42.82093	N	86.05042	W	Bank Erosion	7	1100	clay/loam	high	0.4	3080	medium	224	7' heavy erosion & incised
87	42.82087	N	86.04762	W	Bank Erosion	7	1020	clay/loam	high	0.4	2856	medium	225-226	7' incised high erosion trib hc
89	42.81912	N	86.04627	W	Log Jam							high	227	Remove with machine (>18" diam.)
90	42.81911	N	86.04586	W	Bank Erosion	6	610	clay/loam	medium	0.1	366	medium	228	5-7' erosion incised channel
92	42.81887	N	86.04445	W	Log Jam							high	229	Remove with machine (>18" diam.)
93	42.81905	N	86.04442	W	Bank Erosion	6	370	clay/loam	medium	0.1	222	medium	230-231	5-7' erosion & incision riffle
95	42.81876	N	86.04376	W	Log Jam							high	232	Remove with machine (>18" diam.)
96	42.81855	N	86.04393	W	Bank Erosion	7	1500	clay/loam	medium	0.1	1050	medium	233-235	5-7' erosion & incision trib hc
98	42.81677	N	86.04085	W	Bank Erosion	7	740	clay/loam	medium	0.1	518	medium	236	7' erosion incised
100	42.81483	N	86.04017	W										End Erosion Near 104th
101		N		W	Bank Erosion	5	640	clay/loam	low	0.01	32	low	243	7' bank 3-5' minor erosion debris
103	42.81318	N	86.03871	W	Log Jam							very high	244-245	Remove with machine (>18" diam.)
104	42.81228	N	86.03824	W	Bank Erosion	5	150	clay/loam	medium	0.06	45	low	246	5-7' bank erosion
106	42.81153	N	86.03675	W	Bank Erosion	9	180	clay/loam	high	0.5	810	high	247	8-10' bank erosion
108	42.81128	N	86.03580	W	Bank Erosion	5	2030	clay/loam	medium	0.1	1015	medium	248-253	5-7' bank erosion 30+ bankfull width
111	42.80780	N	86.03955	W	Bank Erosion	5	50	clay/loam	low	0.01	2.5	low	255	
112	42.80722	N	86.04002	W	Bank Erosion	6	350	clay/loam	medium	0.1	210	medium	256-259	5-7' bank erosion buried trunk
114	42.80615	N	86.04150	W	Log Jam							high	260	Remove with machine (>18" diam.)
115	42.80619	N	86.04174	W	Bank Erosion	3	180	clay/loam	low	0.01	5.4	low	261	5' bank min toe erosion & valley
117	42.80628	N	86.04233	W	Bank Erosion	8	115	clay/loam	medium	0.1	92	medium	262	7-10' erosion up to 15' valley
119	42.80611	N	86.04252	W	Log Jam							high	263	Remove with machine (>18" diam.)
120	42.80610	N	86.04252	W										Better Connected Floodplain width 25-30' depth 3'
121	42.80563	N	86.04257	W	Log Jam							high	264-265	Remove with machine (>18" diam.)
122	42.80545	N	86.04301	W	Bank Erosion	5	150	clay/loam	medium	0.06	45	low	266	5' bank erosion (Distance may be greater than 150'; all the way to I-196)
124	42.80514	N	86.04350	W										Business I-196
125	42.80432	N	86.04379	W	Log Jam							medium	267	
126	42.80410	N	86.04433	W	Bank Erosion	4	100	clay/loam	medium	0.06	24	low	268	
127	42.80397	N	86.04433	W	Log Jam							high	269	Remove with machine (>18" diam.)
128	42.80401	N	86.04436	W	Bank Erosion	6	1320	clay/loam	medium	0.1	792	medium	270-276	5-7' erosion incised mid channel bars debris
130	42.80131	N	86.04456	W	Bank Erosion	7	750	clay/loam	medium	0.1	525	medium	277-282	5-7' erosion up to 15' valley
132	42.79949	N	86.04462	W	Bank Erosion	4	100	clay/loam						Survey Location 283; 4' minor erosion
134	42.79936	N	86.04580	W										106 284
135	42.79912	N	86.04631	W	Bank Erosion	6	75	clay/loam	medium	0.06	27	low	285	
136	42.79870	N	86.04744	W	Bank Erosion	6	100	clay/loam	medium	0.06	36	low	286	
137	42.79834	N	86.04837	W	Bank Erosion	7	550	clay/loam	medium	0.1	385	medium	287-290	5-10' erosion
139	42.79798	N	86.04924	W	Bank Erosion	6	1150	clay/loam	medium	0.1	690	medium	291-301	GC 5-7' bank slough toe stabilize
141	42.79719	N	86.05268	W									302-303	Confluence with Black

Total Length of Erosion 19885 LF 17048 CF

Total Length of Water Course 34795 LF 631 CY

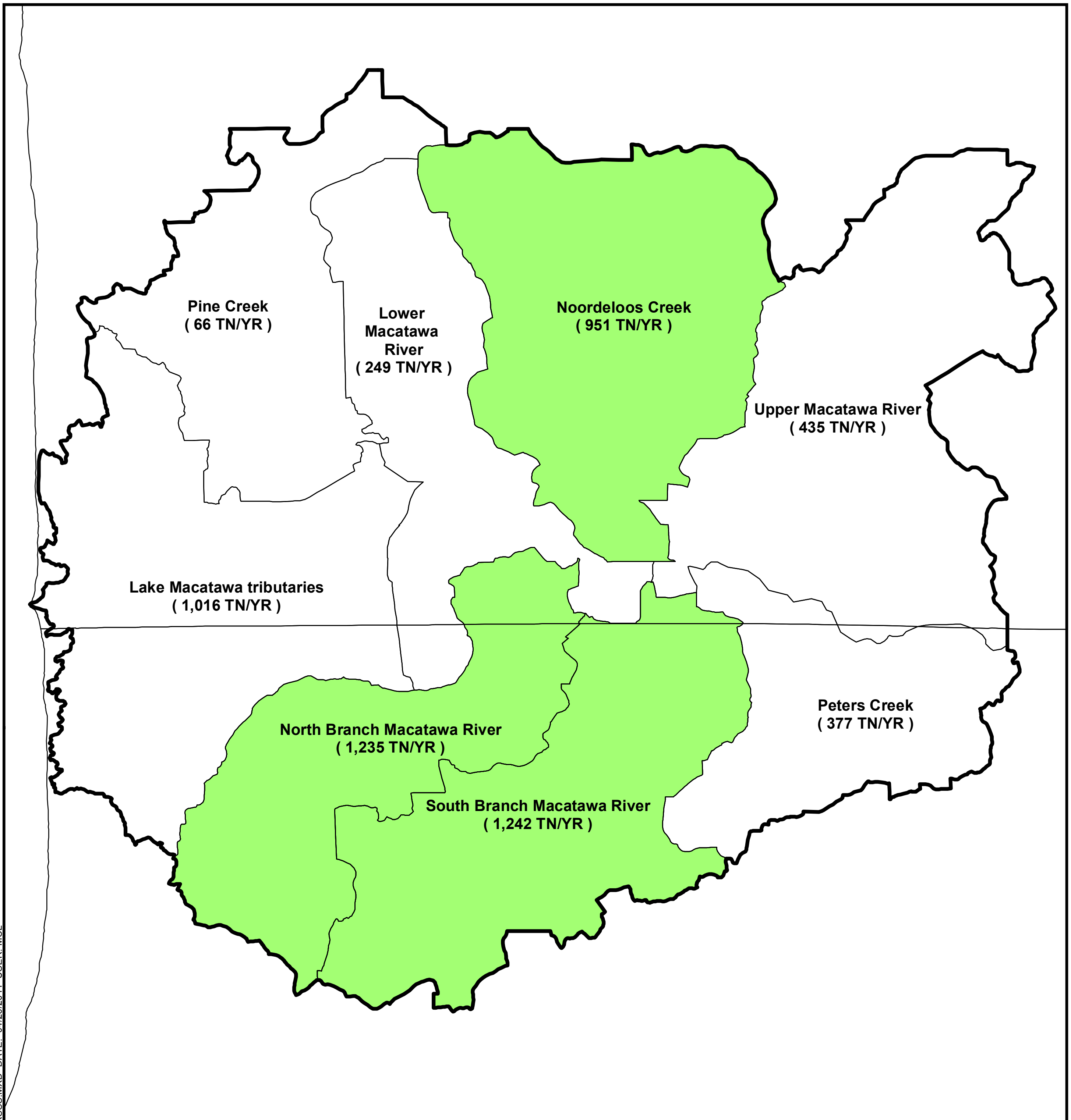
57% of Channel is Eroding 0.5 CF of erosion per LF



LOG JAM LOCATIONS

PLOT INFO: U:\CADD\100240\GIS\MAP DOCUMENT\LOG JAM LOCATIONS.MXD DATE: 04/25/2011 USER: MB2

Appendix 5



PLOT INFO: U:\CADD\100240\GIS\MAP DOCUMENT\MACATAWA WARSSS.MXD DATE: 04/26/2011 USER: MCL

MACATAWA WATERSHED ANNUAL INSTREAM SEDIMENT LOAD

Project: Macatawa - WARSSS
Job No: G100240
Date: 11/12/2010
Engineer: DF2

FISHBECK, THOMPSON,
CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

North Branch of Macatawa River - Pollutant Load Calculations (Critical Reach)

Weather: Mostly Cloudy, 55 F
Location: M-40 to 32nd Street
Inspectors: Dan Fredricks, P.E. - Fishbeck, Thompson, Carr & Huber, Inc.

Location ID Number	NAD 83 Northing (D.MS)		NAD 83 Easting (D.MS)		Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Priority	Sediment (lbs.)	Sediment (tons)	Phosphorus (lbs.)	Nitrogen (lbs.)
1	42.74738	N	86.07365	W	Bank Erosion	3	2030	clay/loam	low	0.01	60.9	low	5481	3	3	5
3	42.75022	N	86.06938	W	Other											
5	42.75062	N	86.06900	W	Bank Erosion	5	370	clay/loam	low	0.01	18.5	low	1665	1	1	2
6	42.75138	N	86.06834	W	Other											
7	42.75148	N	86.06828	W	Bank Erosion	6	410	sand/loam	high	0.4	984	medium	98400	49	49	98
9	42.75103	N	86.06766	W	Bank Erosion	5	340	clay/loam	medium	0.06	102	low	9180	5	5	9
11	42.75140	N	86.06680	W	Bank Erosion	7	190	sand/loam	high	0.4	532	medium	53200	27	27	53
13	42.75122	N	86.06649	W	Bank Erosion	5	210	clay/loam	medium	0.1	105	medium	9450	5	5	9
15	42.75113	N	86.06595	W	Bank Erosion	6	50	sand/loam	high	0.4	120	medium	12000	6	6	12
16	42.75103	N	86.06548	W	Bank Erosion	5	100	clay/loam	medium	0.1	50	medium	4500	2	2	5
17	42.75124	N	86.06504	W	Bank Erosion	4	75	clay/loam	medium	0.1	30	medium	2700	1	1	3
18	42.75144	N	86.06427	W	Bank Erosion	6	75	sand/loam	high	0.4	180	medium	18000	9	9	18
19	42.75127	N	86.06425	W	Bank Erosion	5	100	clay/loam	medium	0.1	50	medium	4500	2	2	5
20	42.75165	N	86.06308	W	Bank Erosion	6	100	sand/loam	high	0.4	240	medium	24000	12	12	24
22	42.75202	N	86.06249	W	Bank Erosion	5	140	sand/loam	high	0.4	280	medium	28000	14	14	28
24	42.75231	N	86.06238	W	Bank Erosion	5	300	clay/loam	medium	0.1	150	medium	13500	7	7	14
26	42.75276	N	86.06227	W	Other											
27	42.75301	N	86.06251	W	Bank Erosion	5	50	clay/loam	medium	0.1	25	medium	2250	1	1	2
28	42.75345	N	86.06235	W	Bank Erosion	6	75	sand/loam	high	0.4	180	medium	18000	9	9	18
29	42.75347	N	86.06207	W	Bank Erosion	5	300	clay/loam	high	0.3	450	low	40500	20	20	41
31	42.75483	N	86.06103	W	Other											
32	42.75505	N	86.06111	W	Bank Erosion	5	470	clay/loam	medium	0.1	235	medium	21150	11	11	21
34	42.75630	N	86.06219	W	Bank Erosion	8	440	clay/loam	medium	0.2	704	high	63360	32	32	63
36	42.75709	N	86.06156	W	Bank Erosion	5	750	clay/loam	medium	0.1	375	medium	33750	17	17	34
38	42.75843	N	86.06020	W	Bank Erosion	4	1200	clay/loam	medium	0.06	288	low	25920	13	13	26
40	42.76090	N	86.05943	W	Bank Erosion	12	50	clay/loam	medium	0.2	120	high	10800	5	5	11
41	42.76100	N	86.05969	W	Bank Erosion	5	490	clay/loam	medium	0.1	245	medium	22050	11	11	22
43	42.76200	N	86.06175	W	Other											
44	42.76224	N	86.06181	W	Sediment Bar							low				
45	42.76243	N	86.06184	W	Bank Erosion	4	550	clay/loam	medium	0.06	132	low	11880	6	6	12
47	42.76364	N	86.06324	W	Bank Erosion	4	370	clay/loam	medium	0.06	88.8	low	7992	4	4	8
49	42.76422	N	86.06243	W	Bank Erosion	8	860	clay/loam	medium	0.2	1376	high	123840	62	62	124
51	42.76523	N	86.06140	W	Bank Erosion	5	1450	clay/loam	medium	0.1	725	medium	65250	33	33	65
53	42.76752	N	86.06398	W	Bank Erosion	7	120	clay/loam	medium	0.2	168	high	15120	8	8	15
55	42.76749	N	86.06445	W	Bank Erosion	5	540	clay/loam	medium	0.1	270	medium	24300	12	12	24
						Sub-Total	**12205** LF				**8284** CF		**770738**	**385**	**385**	**771**
						Total Length of Water Course	14242 LF				307 CY					
							86% of Channel is Eroding									

Project: Macatawa - WARSSS
Job No: G100240
Date: 10/12/2010
Engineer: DF2

**FISHBECK, THOMPSON,
CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824**

North Branch of Macatawa River - Pollutant Load Calculations (Non-Critical Reach)

Weather: Mostly Cloudy, 55 F
Location: Tulip Watershed
Inspectors: Dan Fredricks, P.E. - Fishbeck, Thompson, Carr & Huber, Inc.

Windshield Survey ID Number	Location	Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Erosion Rate (cf per lf per yr)	Priority	Sediment (lbs.)	Sediment (tons)	Phosphorus (lbs.)	Nitrogen (lbs.)
19-21	Tulip 32nd to Black River	Bank Erosion	2.6	20700	clay/loam	Moderate	0.1	5382	0.26	Moderate	484380	242	242	484
28	Tulip Lincoln to M-40	Bank Erosion	2.4	6700	clay/loam	Low	0.05	804	0.12	Low	72360	36	36	72
-	Tulip Washington to Lincoln	Bank Erosion	2.3	6500	clay/loam	Moderate	0.1	1495	0.23	Moderate	134550	67	67	135
-	Kuipers Drain - I-196 to US-31	Bank Erosion	2.1	6100	sand/loam	Moderate	0.1	1281	0.21	Moderate	128100	64	64	128
-	Kuipers Drain - 60th to I-196	Bank Erosion	2	8800	sand/loam	High	0.5	8800	1.00	High	880000	440	440	880
			Sub-Total	**48800** LF				**17762**	**0.4**		**1699390**	**850**	**850**	**1699**
						TOTAL (Critical and Non-Critical)		**26046** CF **965** CY			**2470128**	**1235**	**1235**	**2470**

Project: Macatawa - WARSSS
Job No: G100240
Date: 11/10/2010
Engineer: DF2

FISHBECK, THOMPSON,
CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

South Branch of Macatawa - Pollutant Load Calculations (Critical Reach)

Weather: Mostly Sunny, 60 F
Location: 144th to 46th
Inspectors: Dan Fredricks, P.E. - Fishbeck, Thompson, Carr & Huber, Inc.

Location ID Number	NAD 83 Northing (D.MS)		NAD 83 Easting (D.MS)		Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Priority	Sediment (lbs.)	Sediment (tons)	Phosphorus (lbs.)	Nitrogen (lbs.)
1	42.74125	N	86.03956	W	Bank Erosion	10	355	clay	medium	0.1	355	medium	23075	12	12	23
3	42.74161	N	86.03918	W	Bank Erosion											
4	42.74159	N	86.03885	W	Sediment Bar						0	low				
5	42.74146	N	86.03842	W	Bank Erosion	7	230	clay/loam	medium	0.1	161	medium	14490	7	7	14
7	42.74163	N	86.03783	W	Bank Erosion											
8	42.74166	N	86.03778	W	Sediment Bar						0	medium				
9	42.74171	N	86.03759	W	Bank Erosion	8	50	clay/loam	medium	0.1	40	medium	3600	2	2	4
10	42.74160	N	86.03747	W	Bank Erosion	15	300	clay/loam	medium	0.2	900	high	81000	41	41	81
13	42.74216	N	86.03737	W	Bank Erosion											
14	42.74227	N	86.03737	W	Bank Erosion	7	170	clay	medium	0.1	119	medium	7735	4	4	8
16	42.74268	N	86.03721	W	Bank Erosion											
17	42.74269	N	86.03713	W	Sediment Bar						0	low				
18	42.74299	N	86.03649	W	Bank Erosion	15	50	clay	medium	0.1	75	medium	4875	2	2	5
19	42.74336	N	86.03658	W	Bank Erosion	7	150	clay/loam	medium	0.1	105	medium	9450	5	5	9
22	42.74374	N	86.03637	W	Bank Erosion	7	50	clay/loam	low	0.01	3.5	low	315	0	0	0
23	42.74427	N	86.03655	W	Bank Erosion	7	240	clay/loam	medium	0.1	168	medium	15120	8	8	15
25	42.74467	N	86.03647	W	Bank Erosion	10	150	clay	medium	0.1	150	medium	9750	5	5	10
26	42.74498	N	86.03530	W	Bank Erosion	5	50	clay/loam	medium	0.06	15	low	1350	1	1	1
27	42.74541	N	86.03156	W	Bank Erosion	5	50	clay/loam	medium	0.06	15	low	1350	1	1	1
28	42.74581	N	86.03458	W	Bank Erosion	10	50	clay/loam	medium	0.06	30	low	2700	1	1	3
29	42.74559	N	86.03294	W	Bank Erosion	15	140	clay/loam	medium	0.1	210	medium	18900	9	9	19
31	42.74675	N	86.03279	W	Bank Erosion	15	240	clay/loam	low	0.01	36	low	3240	2	2	3
33	42.74671	N	86.03159	W	Bank Erosion	5	75	sand	low	0.01	3.75	low	375	0	0	0
34	42.74728	N	86.03041	W	Log Jam						0	high				
35	42.74773	N	86.02990	W	Bank Erosion	5	190	clay/loam	medium	0.06	57	low	5130	3	3	5
37	42.74790	N	86.02914	W	Bank Erosion	5	75	clay/loam	medium	0.06	22.5	low	2025	1	1	2
38	42.74782	N	86.02848	W	Bank Erosion	5	220	clay/loam	medium	0.1	110	medium	9900	5	5	10
40	42.74817	N	86.02867	W	Bank Erosion	7	120	clay/loam	medium	0.1	84	medium	7560	4	4	8
42	42.74853	N	86.02850	W	Bank Erosion	15	200	clay/loam	medium	0.1	300	medium	27000	14	14	27
43	42.74866	N	86.02794	W	Sediment Bar						0	low				
44	42.74862	N	86.02790	W	Bank Erosion	7	610	clay/loam	low	0.01	42.7	low	3843	2	2	4
46	42.74936	N	86.02561	W	Log Jam						0	medium				
47	42.74935	N	86.02559	W												
48	42.74924	N	86.02547	W	Bank Erosion	7	120	clay/loam	medium	0.1	84	medium	7560	4	4	8
50	42.75009	N	86.02546	W	Log Jam						0	high				
51	42.75064	N	86.02591	W	Bank Erosion	8	200	clay	medium	0.1	160	medium	10400	5	5	10
53	42.75085	N	86.02563	W	Log Jam						0	high				
54	42.75096	N	86.02508	W	Bank Erosion	5	220	clay/loam	medium	0.1	110	medium	9900	5	5	10
56	42.75154	N	86.02409	W												
57	42.75135	N	86.02391	W	Bank Erosion	15	200	clay/loam	medium	0.1	300	medium	27000	14	14	27
59	42.75191	N	86.02396	W												
60	42.75319	N	86.02474	W	Bank Erosion	15	50	clay/loam	medium	0.06	45	low	4050	2	2	4
61	42.75306	N	86.02530	W	Log Jam						0	high				
62	42.75260	N	86.02589	W	Bank Erosion	8	110	clay/loam	medium	0.06	52.8	low	4752	2	2	5

Location ID Number	NAD 83 Northing (D.MS)		NAD 83 Easting (D.MS)		Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Priority	Sediment (lbs.)	Sediment (tons)	Phosphorus (lbs.)	Nitrogen (lbs.)
64	42.75320	N	86.02599	W	Log Jam						0	low				
65	42.75337	N	86.02584	W	Bank Erosion	5	250	clay/loam	low	0.01	12.5	low	1125	1	1	1
67	42.75403	N	86.02464	W												
68	42.75411	N	86.02430	W	Bank Erosion	10	140	clay/loam	medium	0.1	140	medium	12600	6	6	13
70	42.75462	N	86.02409	W												
71	42.75528	N	86.02425	W	Log Jam						0	low				
72	42.75572	N	86.02469	W	Bank Erosion	5	80	clay/loam	medium	0.06	24	low	2160	1	1	2
74	42.75612	N	86.02392	W	Bank Erosion	7	170	clay/loam	medium	0.06	71.4	low	6426	3	3	6
76	42.75611	N	86.02279	W	Bank Erosion	7	230	clay/loam	high	0.5	805	high	72450	36	36	72
78	42.75671	N	86.02269	W	Bank Erosion	10	270	clay/loam	medium	0.06	162	low	14580	7	7	15
80	42.75706	N	86.02213	W	Log Jam						0	high				
81	42.75715	N	86.02173	W	Bank Erosion	10	75	clay/loam	low	0.01	7.5	low	675	0	0	1
82	42.75704	N	86.02118	W	Bank Erosion	8	100	clay/loam	high	0.5	400	high	36000	18	18	36
84	42.75678	N	86.02089	W	Bank Erosion	8	50	clay/loam	medium	0.06	24	low	2160	1	1	2
85	42.75746	N	86.01964	W	Bank Erosion	5	50	clay/loam	low	0.01	2.5	low	225	0	0	0
86	42.75770	N	86.01885	W	Bank Erosion	3	25	clay/loam	low	0.01	0.75	low	67.5	0	0	0
87	42.75803	N	86.01903	W	Bank Erosion	7	50	clay/loam	medium	0.1	35	medium	3150	2	2	3
88	42.75826	N	86.01953	W	Bank Erosion	5	270	clay/loam	medium	0.1	135	medium	12150	6	6	12
90	42.75862	N	86.01990	W												
91	42.75886	N	86.01971	W	Bank Erosion	4	180	clay/loam	low	0.01	7.2	low	648	0	0	1
93	42.75926	N	86.01875	W	Bank Erosion	4	50	clay/loam	low	0.01	2	low	180	0	0	0
94	42.76026	N	86.01787	W												
95	42.76055	N	86.01722	W	Bank Erosion	4	50	clay/loam	low	0.01	2	low	180	0	0	0
97	42.76050	N	86.01672	W	Log Jam							very high				
98	42.76009	N	86.01635	W	Bank Erosion	4	50	clay/loam	low	0.01	2	low	180	0	0	0
99	42.75961	N	86.01651	W	Sediment Bar						0	high				
100	42.75923	N	86.01612	W												
101	42.75919	N	86.01613	W	Bank Erosion	3	50	clay/loam	low	0.01	1.5	low	135	0	0	0
102	42.75836	N	86.01623	W	Bank Erosion	10	120	clay/loam	medium	0.1	120	medium	10800	5	5	11
104	42.75828	N	86.01557	W	Bank Erosion	8	25	clay/loam	medium	0.06	12	low	1080	1	1	1
105	42.75836	N	86.01546	W	Log Jam							extreme				
106	42.75860	N	86.01509	W	Log Jam							very high				
107	42.75866	N	86.01480	W	Bank Erosion	10	25	clay/loam	low	0.01	2.5	low	225	0	0	0
108	42.07571	N	86.01559	W	Bank Erosion	10	570	clay/loam	low	0.01	57	low	5130	3	3	5
110	42.75649	N	86.01382	W	Bank Erosion	7	600	clay/loam	low	0.01	42	low	3780	2	2	4
112	42.75676	N	86.01158	W	Bank Erosion	10	490	clay/loam	medium	0.06	294	low	26460	13	13	26
114	42.75804	N	86.01179	W	Bank Erosion	7	25	clay/loam	low	0.01	1.75	low	157.5	0	0	0
115	42.75816	N	86.01229	W	Log Jam							very high				
116	42.75829	N	86.01245	W	Bank Erosion	5	25	clay/loam	medium	0.06	7.5	low	675	0	0	1
117	42.75881	N	86.01247	W	Log Jam							very high				
118	42.75859	N	86.01169	W	Bank Erosion	8	100	clay/loam	medium	0.1	80	medium	7200	4	4	7
120	42.75899	N	86.01116	W	Bank Erosion	10	100	clay/loam	medium	0.1	100	medium	9000	5	5	9
122	42.75843	N	86.00982	W	Log Jam						0	high				
123	42.75822	N	86.00992	W	Bank Erosion	5	290	clay/loam	low	0.01	14.5	low	1305	1	1	1
125	42.75714	N	86.00915	W	Bank Erosion	7	75	sand	high	0.4	210	medium	21000	11	11	21
126	42.75674	N	86.00786	W	Bank Erosion	4	75	clay/loam	low	0.01	3	low	270	0	0	0
127	42.75682	N	86.00739	W	Bank Erosion	10	30	clay	low	0.01	3	low	195	0	0	0
128	42.75798	N	86.00752	W	Log Jam							extreme				
129	42.75825	N	86.00752	W	Bank Erosion	7	50	clay/loam	high	0.4	140	medium	12600	6	6	13
130	42.75840	N	86.00696	W	Log Jam						0	medium				
131	42.75915	N	86.00734	W	Log Jam						0	high				
132	42.75966	N	86.00760	W	Bank Erosion	3	240	clay/loam	low	0.01	7.2	low	648	0	0	1
134	42.75964	N	86.00698	W	Log Jam						0	high				
135	42.75970	N	86.00644	W	Bank Erosion	6	210	clay/loam	high	0.4	504	medium	45360	23	23	45
137	42.75901	N	86.00615	W	Bank Erosion	10	90	clay	high	0.4	360	medium	23400	12	12	23

Location ID Number	NAD 83 Northing (D.MS)		NAD 83 Easting (D.MS)		Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Priority	Sediment (lbs.)	Sediment (tons)	Phosphorus (lbs.)	Nitrogen (lbs.)
139	42.75922	N	86.00511	W	Bank Erosion	7	50	clay/loam	medium	0.1	35	medium	3150	2	2	3
140	42.75901	N	86.00488	W	Bank Erosion	8	50	clay/loam	medium	0.1	40	medium	3600	2	2	4
141	42.75925	N	86.00422	W	Bank Erosion	5	50	clay/loam	medium	0.1	25	medium	2250	1	1	2
142	42.75906	N	86.00357	W	Bank Erosion	8	190	clay/loam	low	0.01	15.2	low	1368	1	1	1
144	42.75804	N	86.00402	W	Bank Erosion	5	25	clay/loam	low	0.01	1.25	low	112.5	0	0	0
145	42.75767	N	86.00428	W	Bank Erosion	6	25	clay/loam	medium	0.06	9	low	810	0	0	1
146	42.75635	N	86.00534	W	Bank Erosion	10	390	clay/loam	medium	0.1	390	medium	35100	18	18	35
148	42.75574	N	86.00450	W	Bank Erosion	10	220	clay/loam	medium	0.1	220	medium	19800	10	10	20
150	42.75542	N	86.00320	W	Bank Erosion	4	210	clay/loam	medium	0.06	50.4	low	4536	2	2	5
152	42.75512	N	86.00273	W	Bank Erosion	8	140	clay/loam	medium	0.1	112	medium	10080	5	5	10
154	42.75496	N	86.00179	W	Bank Erosion	8	100	clay/loam	medium	0.1	80	medium	7200	4	4	7
156	42.75468	N	86.00175	W	Bank Erosion	8	200	clay/loam	medium	0.1	160	medium	14400	7	7	14
158	42.75389	N	86.00107	W												
159	42.75392	N	86.00111	W	Sediment Bar						0	high				
160	42.75389	N	86.00086	W	Bank Erosion	10	690	clay/loam	medium	0.1	690	medium	62100	31	31	62
162	42.75435	N	85.99973	W												
164	42.75491	N	85.99968	W	Bank Erosion	7	75	clay/loam	medium	0.06	31.5	low	2835	1	1	3
165	42.75567	N	86.00027	W	Bank Erosion	6	75	clay/loam	medium	0.06	27	low	2430	1	1	2
166	42.75627	N	86.00026	W	Bank Erosion	6	50	clay/loam	medium	0.06	18	low	1620	1	1	2
167	42.75640	N	86.00057	W	Log Jam						0	high				
168	42.75668	N	86.00107	W	Bank Erosion	10	320	clay/loam	medium	0.1	320	medium	28800	14	14	29
170	42.75734	N	86.00023	W	Bank Erosion	7	100	clay/loam	medium	0.1	70	medium	6300	3	3	6
171	42.75746	N	85.99988	W												

Project: Macatawa - WARSSS
Job No: G100240
Date: 11/12/2010
Engineer: DF2

FISHBECK, THOMPSON,
CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

South Branch of Macatawa River - Pollutant Load Calculations (Critical Reach)

Weather: Mostly Cloudy, 55 F
Location: 46th to Mouth
Inspectors: Dan Fredricks, P.E. - Fishbeck, Thompson, Carr & Huber, Inc.

Location ID Number	NAD 83 Northing (D.MS)		NAD 83 Easting (D.MS)		Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Priority	Sediment (lbs.)	Sediment (tons)	Phosphorus (lbs.)	Nitrogen (lbs.)
172	42.75750	N	85.99936	W	Bank Erosion	5	100	clay/loam	medium	0.06	30	low	2700	1	1	3
173	42.75741	N	85.99836	W	Log Jam						0	medium				
174	42.75735	N	85.99847	W	Bank Erosion	7	800	clay/loam	medium	0.1	560	medium	50400	25	25	50
176	42.75834	N	85.99765	W	Log Jam							extreme				
177	42.75844	N	85.99792	W	Bank Erosion	7	200	clay/loam	medium	0.1	140	medium	12600	6	6	13
179	42.75887	N	85.99803	W	Bank Erosion	6	680	clay/loam	medium	0.06	244.8	low	22032	11	11	22
181	42.76047	N	85.99772	W	Bank Erosion	7	850	clay/loam	high	0.5	2975	high	267750	134	134	268
183	42.76017	N	85.99640	W	Bank Erosion	3	770	clay/loam	low	0.01	23.1	low	2079	1	1	2
185	42.76224	N	85.99641	W	Bank Erosion	5	2690	clay/loam	medium	0.1	1345	medium	121050	61	61	121
187	42.76671	N	85.99791	W												
188	42.76660	N	85.99832	W	Bank Erosion	7	310	clay/loam	medium	0.2	434	high	39060	20	20	39
190	42.76668	N	85.99892	W	Bank Erosion	5	410	clay/loam	medium	0.06	123	low	11070	6	6	11
192	42.76783	N	85.99921	W	Bank Erosion	7	480	clay/loam	medium	0.2	672	high	60480	30	30	60
194	42.76889	N	85.99931	W												
195	42.76909	N	85.99954	W	Bank Erosion	8	1380	clay/loam	medium	0.1	1104	medium	99360	50	50	99
197	42.76992	N	86.00016	W												
198	42.77016	N	86.00093	W	Log Jam						0	high				
199		N		W												
200	42.77132	N	86.00282	W	Bank Erosion	5	190	clay/loam	medium	0.06	57	low	5130	3	3	5
202	42.77149	N	86.00340	W												
203	42.77158	N	86.00401	W	Bank Erosion	5	720	clay/loam	medium	0.1	360	medium	32400	16	16	32
205	42.77277	N	86.00558	W	Log Jam						0	high				
207	42.77294	N	86.00709	W	Log Jam						0	medium				
208	42.77290	N	86.00717	W	Bank Erosion	6	200	clay/loam	medium	0.1	120	medium	10800	5	5	11
210	42.77312	N	86.00973	W												
211	42.77273	N	86.01013	W	Bank Erosion	5	2140	clay/loam	medium	0.1	1070	medium	96300	48	48	96
213	42.77308	N	86.01077	W	Log Jam						0	high				
215	42.77303	N	86.01114	W	Log Jam							extreme				
217	42.77315	N	86.01379	W	Log Jam							very high				
219	42.77336	N	86.01444	W	Log Jam						0	high				
221	42.77433	N	86.01439	W	Log Jam						0	high				
223	42.77580	N	86.01697	W	Bank Erosion	7	1850	clay/loam	medium	0.2	2590	high	233100	117	117	233
226	42.77854	N	86.01502	W	Bank Erosion	7	550	clay/loam	high	0.5	1925	high	173250	87	87	173
228	42.77927	N	86.01491	W												
						Sub-Total	27225 LF				**23614** CF		**2096875**	**1048**	**1048**	**2097**
					Total Length of Water Course		45260 LF									
							60% of Channel is Eroding									

Project: Macatawa - WARSSS
Job No: G100240
Date: 10/12/2010
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

South Branch of Macatawa River - Pollutant Load Calculations (Non-Critical Reach)

Weather: Mostly Cloudy, 55 F
Location: South Branch Watershed
Inspectors: Dan Fredricks, P.E. - Fishbeck, Thompson, Carr & Huber, Inc.

Windshield Survey ID Number	Location	Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Erosion Rate (cf per lf per yr)	Priority	Sediment (lbs.)	Sediment (tons)	Phosphorus (lbs.)	Nitrogen (lbs.)
40-43	SBM M40 to 144th	Bank Erosion	2.3	8180	Clay/Loam	Moderate	0.1	1881	0.23	Moderate	169290	85	85	169
30-31,37-38	Jaarda Drain 56th to SBM	Bank Erosion	1.7	18640	Clay/Loam	low	0.05	1584	0.08	Low	142560	71	71	143
34	Trib to Trib to SBM 50th to 52nd	Bank Erosion	1.2	9760	Clay/Loam	low	0.05	586	0.06	Low	52740	26	26	53
47	Trib to Trib to SBM 46th to 47th	Bank Erosion	1	5060	Clay/Loam	low	0.05	253	0.05	Low	22770	11	11	23
			Sub-Total	**41640**	LF			**4304**	**0.1**		**218070**	**194**	**194**	**387**
					TOTAL (Critical and Non-Critical)			**27918**	CF		**2314945**	**1242**	**1242**	**2484**
								1034	CY					

Project: Macatawa - WARSSS
Job No: G100240
Date: 11/11/2010
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Noordeloos Creek - Pollutant Load Calculations (Critical Reach)

Weather: Mostly Sunny, 65 F
Location: Quincy to Mouth
Inspectors: Dan Fredricks, P.E. - Fishbeck, Thompson, Carr & Huber, Inc.

Location ID Number	NAD 83 Northing (D.MS)		NAD 83 Easting (D.MS)		Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Priority	Sediment (lbs.)	Sediment (tons)	Phosphorus (lbs.)	Nitrogen (lbs.)
1	42.84076	N	86.04744	W	Bank Erosion	10	270	clay/loam	medium	0.06	162	low	14580	7	7	15
3	42.84005	N	86.04866	W	Bank Erosion	5	50	clay/loam	medium	0.06	15	low	1350	1	1	1
4	42.83960	N	86.04894	W	Bank Erosion	5	380	clay/loam	medium	0.1	190	medium	17100	9	9	17
6	42.83807	N	86.04861	W	Bank Erosion	3	30	clay/loam	medium	0.1	9	medium	810	0	0	1
7	42.83805	N	86.04779	W	Bank Erosion	5	50	clay/loam	medium	0.1	25	medium	2250	1	1	2
8	42.83804	N	86.04742	W	Log Jam							high				
9	42.83777	N	86.04667	W	Log Jam							medium				
10	42.83751	N	86.04650	W	Log Jam							very high				
11	42.83751	N	86.04650	W	Bank Erosion	10	100	clay/loam	medium	0.1	100	medium	9000	5	5	9
12	42.83696	N	86.04740	W	Bank Erosion	8	25	clay/loam	medium	0.06	12	low	1080	1	1	1
13	42.83684	N	86.04726	W	Log Jam							medium				
14	42.83651	N	86.04691	W	Bank Erosion	5	50	clay/loam	medium	0.1	25	medium	2250	1	1	2
15	42.83627	N	86.04712	W	Log Jam							medium				
16	42.83594	N	86.04753	W	Bank Erosion	7	75	sand	medium	0.1	52.5	medium	5250	3	3	5
17	42.83588	N	86.04794	W	Bank Erosion	4	50	clay/loam	medium	0.06	12	low	1080	1	1	1
18	42.83554	N	86.04808	W	Bank Erosion	5	200	clay/loam	medium	0.1	100	medium	9000	5	5	9
20	42.83557	N	86.04929	W	Bank Erosion	8	60	clay/loam	medium	0.06	28.8	low	2592	1	1	3
22	42.83543	N	86.04952	W	Bank Erosion	4	50	clay/loam	medium	0.1	20	medium	1800	1	1	2
23	42.83503	N	86.05015	W	Bank Erosion	10	175	clay/loam	medium	0.2	350	high	31500	16	16	32
25	42.83479	N	86.04961	W	Bank Erosion	5	315	clay/loam	medium	0.06	94.5	low	8505	4	4	9
27	42.83446	N	86.04884	W	Bank Erosion	10	230	clay/loam	medium	0.1	230	medium	20700	10	10	21
29	42.83366	N	86.04933	W	Bank Erosion	7	50	clay/loam	medium	0.06	21	low	1890	1	1	2
30	42.83317	N	86.04988	W	Bank Erosion	5	280	clay/loam	medium	0.1	140	medium	12600	6	6	13
32	42.83223	N	86.04937	W	Log Jam							high				
33	42.83199	N	86.04949	W	Bank Erosion	5	270	clay/loam	medium	0.1	135	medium	12150	6	6	12
35	42.83231	N	86.04815	W	Log Jam							very high				
36	42.83238	N	86.04782	W	Bank Erosion	5	240	clay/loam	medium	0.1	120	medium	10800	5	5	11
38	42.83254	N	86.04761	W	Perched Outfall											
40	42.83150	N	86.04640	W	Bank Erosion	4	50	clay/loam	medium	0.06	12	low	1080	1	1	1
41	42.83111	N	86.04617	W	Bank Erosion	4	50	clay/loam	medium	0.06	12	low	1080	1	1	1
42	42.83066	N	86.04566	W	Bank Erosion	4	50	clay/loam	medium	0.1	20	medium	1800	1	1	2
43	42.83055	N	86.04540	W	Bank Erosion	15	50	clay/loam	high	0.5	375	high	33750	17	17	34
45	42.83059	N	86.04635	W	Bank Erosion	6	10	clay/loam	medium	0.06	3.6	low	324	0	0	0
47	42.83078	N	86.04743	W	Bank Erosion	4	50	clay/loam	medium	0.06	12	low	1080	1	1	1
48	42.83025	N	86.04773	W	Bank Erosion	4	50	clay/loam	medium	0.06	12	low	1080	1	1	1
49	42.83016	N	86.04787	W	Bank Erosion	5	130	clay/loam	medium	0.1	65	medium	5850	3	3	6
51	42.82874	N	86.04878	W	Bank Erosion	6	30	clay/loam	medium	0.1	18	medium	1620	1	1	2
54	42.82724	N	86.04892	W	Log Jam							high				
55	42.82674	N	86.04909	W	Bank Erosion	5	720	clay/loam	medium	0.06	216	low	19440	10	10	19
57	42.82521	N	86.05056	W	Log Jam							medium				
58	42.82504	N	86.05087	W	Bank Erosion	5	60	clay/loam	medium	0.1	30	medium	2700	1	1	3
60	42.82528	N	86.05122	W	Log Jam							very high				
61		N		W	Log Jam							extreme				
62	42.82601	N	86.05277	W	Bank Erosion	5	780	clay/loam	medium	0.1	390	medium	35100	18	18	35

Location ID Number	NAD 83 Northing (D.MS)		NAD 83 Easting (D.MS)		Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Priority	Sediment (lbs.)	Sediment (tons)	Phosphorus (lbs.)	Nitrogen (lbs.)
64	42.82459	N	86.05297	W	Log Jam							extreme				
65	42.82448	N	86.05281	W	Bank Erosion	5	200	clay/loam	medium	0.1	100	medium	9000	5	5	9
67	42.82409	N	86.05328	W	Log Jam							very high				
68	42.82381	N	86.05324	W	Bank Erosion	6	275	clay/loam	medium	0.1	165	medium	14850	7	7	15
70	42.82363	N	86.05303	W	Log Jam							extreme				
71	42.82343	N	86.05291	W	Bank Erosion	10	20	clay/loam	high	0.4	80	medium	7200	4	4	7
72	42.82285	N	86.05354	W	Bank Erosion	8	25	clay/loam	medium	0.06	12	low	1080	1	1	1
73	42.82262	N	86.05408	W	Bank Erosion	7	150	clay/loam	medium	0.1	105	medium	9450	5	5	9
74	42.82180	N	86.05415	W	Bank Erosion	7	130	clay/loam	medium	0.1	91	medium	8190	4	4	8
76	42.82177	N	86.05361	W	Log Jam							high				
77	42.82195	N	86.05334	W	Bank Erosion	6	200	clay/loam	medium	0.1	120	medium	10800	5	5	11
79	42.82127	N	86.05354	W	Log Jam							very high				
80	42.82103	N	86.05396	W	Bank Erosion	6	500	clay/loam	medium	0.1	300	medium	27000	14	14	27
83	42.82061	N	86.05167	W	Bank Erosion	8	75	clay/loam	high	0.4	240	medium	21600	11	11	22
85	42.82093	N	86.05042	W	Bank Erosion	7	1100	clay/loam	high	0.4	3080	medium	277200	139	139	277
87	42.82087	N	86.04762	W	Bank Erosion	7	1020	clay/loam	high	0.4	2856	medium	257040	129	129	257
89	42.81912	N	86.04627	W	Log Jam							high				
90	42.81911	N	86.04586	W	Bank Erosion	6	610	clay/loam	medium	0.1	366	medium	32940	16	16	33
92	42.81887	N	86.04445	W	Log Jam							high				
93	42.81905	N	86.04442	W	Bank Erosion	6	370	clay/loam	medium	0.1	222	medium	19980	10	10	20
95	42.81876	N	86.04376	W	Log Jam							high				
96	42.81855	N	86.04393	W	Bank Erosion	7	1500	clay/loam	medium	0.1	1050	medium	94500	47	47	95
98	42.81677	N	86.04085	W	Bank Erosion	7	740	clay/loam	medium	0.1	518	medium	46620	23	23	47
100	42.81483	N	86.04017	W												
101		N		W	Bank Erosion	5	640	clay/loam	low	0.01	32	low	2880	1	1	3
103	42.81318	N	86.03871	W	Log Jam							very high				
104	42.81228	N	86.03824	W	Bank Erosion	5	150	clay/loam	medium	0.06	45	low	4050	2	2	4
106	42.81153	N	86.03675	W	Bank Erosion	9	180	clay/loam	high	0.5	810	high	72900	36	36	73
108	42.81128	N	86.03580	W	Bank Erosion	5	2030	clay/loam	medium	0.1	1015	medium	91350	46	46	91
111	42.80780	N	86.03955	W	Bank Erosion	5	50	clay/loam	low	0.01	2.5	low	225	0	0	0
112	42.80722	N	86.04002	W	Bank Erosion	6	350	clay/loam	medium	0.1	210	medium	18900	9	9	19
114	42.80615	N	86.04150	W	Log Jam							high				
115	42.80619	N	86.04174	W	Bank Erosion	3	180	clay/loam	low	0.01	5.4	low	486	0	0	0
117	42.80628	N	86.04233	W	Bank Erosion	8	115	clay/loam	medium	0.1	92	medium	8280	4	4	8
119	42.80611	N	86.04252	W	Log Jam							high				
120	42.80610	N	86.04252	W												
121	42.80563	N	86.04257	W	Log Jam							high				
122	42.80545	N	86.04301	W	Bank Erosion	5	150	clay/loam	medium	0.06	45	low	4050	2	2	4
124	42.80514	N	86.04350	W												
125	42.80432	N	86.04379	W	Log Jam							medium				
126	42.80410	N	86.04433	W	Bank Erosion	4	100	clay/loam	medium	0.06	24	low	2160	1	1	2
127	42.80397	N	86.04433	W	Log Jam							high				
128	42.80401	N	86.04436	W	Bank Erosion	6	1320	clay/loam	medium	0.1	792	medium	71280	36	36	71
130	42.80131	N	86.04456	W	Bank Erosion	7	750	clay/loam	medium	0.1	525	medium	47250	24	24	47
132	42.79949	N	86.04462	W	Bank Erosion	4	100	clay/loam	medium	0.1	40	medium	3600	2	2	4
134	42.79936	N	86.04580	W												
135	42.79912	N	86.04631	W	Bank Erosion	6	75	clay/loam	medium	0.06	27	low	2430	1	1	2
136	42.79870	N	86.04744	W	Bank Erosion	6	100	clay/loam	medium	0.06	36	low	3240	2	2	3
137	42.79834	N	86.04837	W	Bank Erosion	7	550	clay/loam	medium	0.1	385	medium	34650	17	17	35
139	42.79798	N	86.04924	W	Bank Erosion	6	1150	clay/loam	medium	0.1	690	medium	62100	31	31	62
141	42.79719	N	86.05268	W												
						Sub-Total	**19885** LF				**17088** CF		**1538472**	**769**	**769**	**1538**
					Total Length of Water Course		34795 LF				633 CY					
							57% of Channel is Eroding									

Project: Macatawa - WARSSS
Job No: G100240
Date: 10/12/2010
Engineer: DF2

FISHBECK, THOMPSON,
CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Noordeloos Creek - Pollutant Load Calculations (Non-Critical Reach)

Weather: Mostly Sunny, 65 F
Location: Noordeloos Drainage District
Inspectors: Dan Fredricks, P.E. - Fishbeck, Thompson, Carr & Huber, Inc.

Windshield Survey ID Number	Location	Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Erosion Rate (cf per lf per yr)	Priority	Sediment (lbs.)	Sediment (tons)	Phosphorus (lbs.)	Nitrogen (lbs.)
1	Trib to Brower Drain Washington to Fairview	Bank Erosion	1.3	2491	Clay/Loam	Moderate	0.1	324	0.13	Low	29160	15	15	29
18	Trib to Noordeloos Creek Perry to 104th	Bank Erosion	1.3	1889	Clay/Loam	low	0.05	123	0.07	Low	11070	6	6	11
5	Brower Drain 100th to Riley	Bank Erosion	1.7	2746	Clay/Loam	low	0.05	233	0.08	Low	20970	10	10	21
16	Brower Drain Riley to 104th	Bank Erosion	1.7	1342	Clay/Loam	low	0.05	114	0.08	Low	10260	5	5	10
6	Northwest of Zeeland Drain	Bank Erosion	1.7	5510	Clay/Loam	low	0.05	468	0.08	Low	42120	21	21	42
15	Bower Drain 104th to Noordeloos Creek	Bank Erosion	2.1	3724	Clay/Loam	Moderate	0.1	782	0.21	Moderate	70380	35	35	70
10	Bosch & Hulst Drain Van Buren to 112th	Bank Erosion	1.9	5164	Clay/Loam	low	0.05	491	0.10	Low	44190	22	22	44
11	Bosch & Hulst Drain 112th to	Bank Erosion	2	6139	Clay/Loam	low	0.05	614	0.10	Low	55260	28	28	55
14	Bosch & Hulst Drain to Quincy	Bank Erosion	2.2	4058	Clay/Loam	Moderate	0.1	893	0.22	Moderate	80370	40	40	80
			Sub-Total	**33063** LF				**4042**	**0.1**		**363780**	**182**	**182**	**364**
					TOTAL (Critical and Non-Critical)			**21130** CF **783** CY			**1902252**	**951**	**951**	**1902**

Project: MACC Erosion Assessment
Job No: G100240
Date: 4/5/2011
Engineer: KJV

**FISHBECK, THOMPSON,
CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824**

Pine Creek - Pollutant Load Calculations

Weather: Mostly Sunny - 45 F
Location: Lake Macatawa Tributaries Watershed
Inspectors: Dan Fredricks, P.E. - Fishbeck, Thompson, Carr & Huber, Inc.

Location ID Number	Location	Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Erosion Rate (cf per lf per yr)	Priority	Sediment (lbs.)	Sediment (tons)	Phosphorus (lbs.)	Nitrogen (lbs.)
PC-5	Harlem Drain at 144th (north)	Bank Erosion	1.5	4100	Sand/Loam	low	0.05	308	0.08	low	30800	15	15	31
PC-6	Pine Creek at Quincy	Bank Erosion	1.5	6700	Sand/Loam	low	0.05	503	0.08	Low	50300	25	25	50
PC-7	Pine Creek at Butternut	Bank Erosion	1.5	1600	Sand/Loam	low	0.05	120	0.08	Low	12000	6	6	12
PC-9	Pine Creek at 144th	Bank Erosion	1.5	5200	Sand/Loam	low	0.05	390	0.08	Low	39000	20	20	39
			TOTAL	**17600 LF**				**1321 CF**			**132100**	**66**	**66**	**132**
								49 CY						

Project: MACC Erosion Assessment
Job No: G100240
Date: 4/5/2011
Engineer: KJV

FISHBECK, THOMPSON,
CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Lake Macatawa Tributaries - Pollutant Load Calculations

Weather: Mostly Sunny - 45 F
Location: Lake Macatawa Tributaries Watershed
Inspectors: Dan Fredricks, P.E. - Fishbeck, Thompson, Carr & Huber, Inc.

Location ID Number	Location	Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Erosion Rate (cf per lf per yr)	Priority	Sediment (lbs.)	Sediment (tons)	Phosphorus (lbs.)	Nitrogen (lbs.)
Kelly Lake Drain	Kelly Lake to 146th Ave.	Bank Erosion	5	1500	Sand/Loam	low	0.05	375	0.25	low	37500	19	19	38
Kelly Lake Drain	146th Ave. to 1000' DS 147th Ave.	Bank Erosion	5	5250	Sand	high	0.5	13125	2.50	high	1312500	656	656	1313
Kelly Lake Drain	1000' DS 147th to Lake Macatawa	Bank Erosion	5	1800	Sand/Loam	low	0.05	450	0.25	low	45000	23	23	45
14	S Trib to Kelley Lake Drain at 64th	Bank Erosion	2	3300	Sand/Loam	low	0.05	330	0.10	low	33000	17	17	33
15	Kibbie Drain 144th & 66th	Bank Erosion	2	2500	Sand/Loam	low	0.05	250	0.10	low	25000	13	13	25
16	Kibbie Drain 145th & 66th	Bank Erosion	2	3500	Sand/Loam	low	0.05	350	0.10	low	35000	18	18	35
17	Kelly Lake Drain 145th West of 64th	Bank Erosion	2	3700	Sand/Loam	low	0.05	370	0.10	low	37000	19	19	37
18	US of Kelly Lake Drain at 64th	Bank Erosion	3	3000	Sand/Loam	low	0.05	450	0.15	low	45000	23	23	45
19	US of Kelly Lake Drain at 145th	Bank Erosion	1.5	4200	Sand/Loam	low	0.05	315	0.08	low	31500	16	16	32
20	US of Kelly Lake Drain at 62nd	Bank Erosion	1	4600	Sand/Loam	low	0.05	230	0.05	low	23000	12	12	23
21	Ottogan ICD 62nd North of 146th	Bank Erosion	1.5	7000	Sand/Loam	low	0.05	525	0.08	low	52500	26	26	53
22	Ottogan ICD 147th	Bank Erosion	2	2500	Sand/Loam	medium	0.1	500	0.20	medium	50000	25	25	50
23	Wildwood SG 32nd near Plasman	Bank Erosion	2	1400	Sand/Loam	low	0.05	140	0.10	low	14000	7	7	14
24 DS	Weller 32nd West of Graafschap	Bank Erosion	2.5	4000	Sand/Loam	medium	0.1	1000	0.25	medium	100000	50	50	100
24 US	Weller 32nd West of Graafschap	Bank Erosion	1.5	2700	Sand/Loam	low	0.05	203	0.08	low	20300	10	10	20
25	Unnamed Trib 32nd near Pinegrove	Bank Erosion	2	2700	Sand/Loam	low	0.05	270	0.10	low	27000	14	14	27
26	Ottogan ICD 32nd near Old Orchard	Bank Erosion	1.5	3000	Sand/Loam	low	0.05	225	0.08	low	22500	11	11	23
30	Wildwood SG at Graafschap	Bank Erosion	2	3600	Sand/Loam	low	0.05	360	0.10	low	36000	18	18	36
31	Unnamed Trib S Shore E of Mrtyle	Bank Erosion	1	300	Sand/Loam	low	0.05	15	0.05	low	1500	1	1	2
32	Ottogan ICD at South Shore Drive	Bank Erosion	1	800	Sand/Loam	low	0.05	40	0.05	low	4000	2	2	4
37	No. 20 & 53 James East of 160th	Bank Erosion	1	7800	Sand/Loam	low	0.05	390	0.05	low	39000	20	20	39
38	No. 23 James West of 160th	Bank Erosion	1	8000	Sand/Loam	low	0.05	400	0.05	low	40000	20	20	40
			TOTAL	**77150 LF**				**20313 CF**			**2031300**	**1016**	**1016**	**2031**
								752 CY						

Project: MACC Erosion Assessment
Job No: G100240
Date: 4/5/2011
Engineer: KJV

FISHBECK, THOMPSON,
CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Lower Macatawa River - Pollutant Load Calculations

Weather: Mostly Sunny - 45 F
Location: Lake Macatawa Tributaries Watershed
Inspectors: Dan Fredricks, P.E. - Fishbeck, Thompson, Carr & Huber, Inc.

Location ID Number	Location	Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Erosion Rate (cf per lf per yr)	Priority	Sediment (lbs.)	Sediment (tons)	Phosphorus (lbs.)	Nitrogen (lbs.)
33	Maplewood ICD 32nd	Bank Erosion	2	5000	Sand/Loam	Low	0.05	500	0.10	Low	50000	25	25	50
34-36	Maplewood ICD 32nd to Macatawa R	Bank Erosion	2	17800	Sand/Loam	Moderate	0.1	3560	0.20	Moderate	356000	178	178	356
LMT-6	No. 40 at James	Bank Erosion	1.5	12200	Sand/Loam	Low	0.05	915	0.08	Low	91500	46	46	92
			TOTAL	**35000 LF**				**4975 CF**			**497500**	**249**	**249**	**498**
								184 CY						

Project: MACC Erosion Assessment
Job No: G100240
Date: 4/5/2011
Engineer: KJV

FISHBECK, THOMPSON,
CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Upper Macatawa River - Pollutant Load Calculations

Weather: Mostly Sunny - 45 F
Location: Lake Macatawa Tributaries Watershed
Inspectors: Dan Fredricks, P.E. - Fishbeck, Thompson, Carr & Huber, Inc.

Location ID Number	Location	Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Erosion Rate (cf per lf per yr)	Priority	Sediment (lbs.)	Sediment (tons)	Phosphorus (lbs.)	Nitrogen (lbs.)
UMT-10	Felch & 80th	Bank Erosion	1	3400	Clay/Loam	Moderate	0.1	340	0.10	Moderate	30600	15	15	31
UMT-8,9,13	Trib flows S to N across I-196	Bank Erosion	1	16500	Clay/Loam	Moderate	0.1	1650	0.10	Moderate	148500	74	74	149
UMT-7	Trib to Trib to SBM 50th to 52nd	Bank Erosion	1	4200	Clay/Loam	Low	0.05	210	0.05	Low	18900	9	9	19
UMT-27	Upper Macatawa River at 84th	Bank Erosion	2	900	Clay/Loam	Moderate	0.1	180	0.20	Moderate	16200	8	8	16
UMT-26	Drenthe Creek at Adams	Bank Erosion	2	6000	Clay/Loam	Moderate	0.1	1200	0.20	Moderate	108000	54	54	108
60	North Trib at 76th	Bank Erosion	2	5900	Clay/Loam	Moderate	0.1	1180	0.20	Moderate	106200	53	53	106
60	North Trib at 76th	Bank Erosion	2	500	Clay/Loam	Moderate	0.1	100	0.20	Moderate	9000	5	5	9
UMT-21	Trib at 64th	Bank Erosion	2	10900	Clay/Loam	Moderate	0.1	2180	0.20	Moderate	196200	98	98	196
UMT-19	Drenthe Creek at 76th	Bank Erosion	2	7400	Clay/Loam	Low	0.05	740	0.10	Low	66600	33	33	67
UMT-15	Drenthe Creek at 64th	Bank Erosion	2	4000	Clay/Loam	Low	0.05	400	0.10	Low	36000	18	18	36
UMT-17	Hunderman Creek at 64th	Bank Erosion	2	14900	Clay/Loam	Low	0.05	1490	0.10	Low	134100	67	67	134
			TOTAL	**74600 LF**				**9670 CF**			**870300**	**435**	**435**	**870**
								358 CY						

Project: MACC Erosion Assessment
Job No: G100240
Date: 4/5/2011
Engineer: KJV

FISHBECK, THOMPSON,
CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Peters Creek - Pollutant Load Calculations

Weather: Mostly Sunny - 45 F
Location: Lake Macatawa Tributaries Watershed
Inspectors: Dan Fredricks, P.E. - Fishbeck, Thompson, Carr & Huber, Inc.

Location ID Number	Location	Inventory Category	Height of Erosion (feet)	Length of Erosion (feet)	Soil Type	Erosion Severity / Rate (feet/year)		Annual Volume of Sediment (cubic feet)	Erosion Rate (cf per lf per yr)	Priority	Sediment (lbs.)	Sediment (tons)	Phosphorus (lbs.)	Nitrogen (lbs.)
UMT-44	Peters Drain near Adams	Bank Erosion	2	1300	Clay/Loam	Moderate	0.1	260	0.20	Moderate	23400	12	12	23
UMT-44	Peters Drain near Adams	Bank Erosion	2	3500	Clay/Loam	Moderate	0.1	700	0.20	Moderate	63000	32	32	63
UMT-43	Peters Drain at 84th	Bank Erosion	2	7100	Clay/Loam	Moderate	0.1	1420	0.20	Moderate	127800	64	64	128
62	N trib to Peters at 76th S of Ottagon	Bank Erosion	2	6200	Clay/Loam	Moderate	0.1	1240	0.20	Moderate	111600	56	56	112
62	N trib to Peters US 42nd S of Ottagon	Bank Erosion	2	3100	Clay/Loam	Low	0.05	310	0.10	Low	27900	14	14	28
UMT-35	Trib to Peters at 147th	Bank Erosion	2	4300	Clay/Loam	Moderate	0.1	860	0.20	Moderate	77400	39	39	77
UMT-34	Trib to Peters at 146th	Bank Erosion	2	4100	Clay/Loam	Moderate	0.1	820	0.20	Moderate	73800	37	37	74
UMT-28	Peters Drain at 44th	Bank Erosion	2	10600	Clay/Loam	Moderate	0.1	2120	0.20	Moderate	190800	95	95	191
UMT-29	Peters Drain at 43rd	Bank Erosion	2	6500	Clay/Loam	Low	0.05	650	0.10	Low	58500	29	29	59
			TOTAL	**46700 LF**				**8380 CF**			**754200**	**377**	**377**	**754**
								310 CY						