

Red River Biotic Impairment Assessment



June 2009

water | ecology | community



CHAPTER 5.3 - isolated from above document

5.3 SOUTH BRANCH BUFFALO RIVER CASE STUDY: ASSESSMENT OF GEOMORPHIC TOOLS

A geomorphic assessment was completed on the South Branch of the Buffalo River (SBBR) in order to evaluate the applicability of the WARSSS approach in the RRV. The detailed stream survey methodology used in WARSSS provides useful information on channel morphology variables that are critical to biotic integrity. Bed materials, width-

depth ratio, and pool measurements are all directly relevant to the habitat features required by different fish for different life support functions (spawning gravel, food supply, cover, suitable temperature, etc.).

The USDA-ARS approach was also applied to the SBBR and the technique is discussed here. However, results from that analysis were not available at the time of this report.

5.3.1 Applicability to TMDLs

Geomorphic methods are critical for the development of biotic TMDLs, given that excess sediment is one of the main pollutants in streams nationwide.

5.3.2 SBBR Site Characteristics

The study site, the South Branch Buffalo River (SBBR), is representative of RRV streams in terms of geology, climate, hydrology, land use, and channel materials. The hydrology of the SBBR is dominated historically by a rapid rise in water level and peak flow in early April, followed by declining streamflow through September, typical of the RRV. Geomorphically, the SBBR is positioned in the RRV from the mid lake plain position to the beach ridge. It does not drain directly to the main branch of the Red River as many major tributaries such as the Wild Rice, Buffalo, Red Lake River, and others where severe streambank erosion is occurring in some streams.

The SBBR also lacks larger tributaries in the upper glacial till regions above the steeply rising Lake Agassiz ridge. Most of the SBBR tributaries originate at or downstream of that point, minimizing the potential for headcutting and massive channel incision, which occurred in the upper reaches of the Wild Rice River, for example.

The SBBR was found to be more stable than most of the major RRV tributaries according to the RGA method and preliminary data collection done by the USDA-ARS group (SIMON ET AL. 2008). Other tributaries in the RRV have been the target of streambank erosion control projects funded by the U.S. Army Corps of Engineers, including the Wild Rice River and Hay Creek in the northern RRV. Therefore, while streambank erosion and mass-wasting may be less important in the SBBR, it is a major source of sediment in other parts of the RRV.

In terms of aquatic biota, the SBBR, as all RRV streams, has lower diversity than the Mississippi River Basin that borders to the east and therefore has lower IBI categories (Niemela et al. 1998). The SBBR is fairly representative of other SBBR tributaries in terms of biota. In watershed area it falls within the small (<200 mi²) and medium size (200-1500m²) categories laid out in the Red River IBI study (Niemela et al. 1998).

5.3.3 US EPA WARSSS Assessment

The Watershed Assessment of River Stability and Sediment Supply (WARSSS) procedure was developed by Dave Rosgen for the U.S. EPA as an assessment tool for

characterizing relationships between watershed hydrology, sediment supply, and stability of streams. It provides a comprehensive framework for quantifying this relationship, primarily in the form of semi-quantitative worksheets. The procedure has three main parts: the Reconnaissance Level Assessment (RLA), the Rapid Resource Inventory for Sediment and Stability Consequence (RRISSC), and the Prediction Level Assessment (PLA). After first eliminating stable watersheds from further assessment and then ranking the relative risk of channel instability in the remaining watersheds, the procedure predicts sediment load from the most unstable stream reaches.

5.3.3.1 Introduction

Excess sediment has been a leading cause of water quality impairment across the nation for years. While numerous methods have been proposed to assess sediment problems and plan solutions they have often not been very user-friendly to the average resource manager.

Watershed Assessment of River Stability and Sediment Supply (WARSSS) is a procedure developed by Dave Rosgen and the U.S. Environmental Protection Agency for scientists to use in evaluating the causes of excess sediment in streams and rivers. WARSSS is a technical framework of methods for assessing suspended and bedload sediment in rivers and streams in three separate phases. WARSSS is a watershed-based approach to sediment assessment that focuses on linkages between the watershed and stream:

- Natural variability in sediment dynamics
- Geologic versus anthropogenic sediment sources
- Erosional and depositional processes
- Prediction of sediment loads
- Streamflow changes
- Stream channel stability and departure from reference condition

The U.S. Environmental Protection Agency 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, develop sediment TMDLs (total maximum daily loads), and other uses.

Given that excess sediment is theorized to be a primary impairment of streams of the RRB, the WARSSS assessment is thought to be a possible tool for developing sediment TMDLs in this region and other parts of the state where excess sediment is a stressor. In an effort to evaluate the value and applicability of WARSSS to the RRB, a WARSSS analysis was undertaken as part of this project for the impaired reach of the South Branch of the Buffalo River and its tributaries.

5.3.3.2 Scope of Work

WARSSS is a three step process designed to screen out areas based on their limited risk of significant sediment yield and provide finer level of analysis to the higher risk areas. The three steps of WARSSS, illustrated in Figure 21, are: Phase 1 - Reconnaissance Level Assessment (RLA); Phase 2 - Rapid Resource Inventory for Sediment/Stability Consequences (RRISSC), and lastly Phase 3 - Prediction Level Assessment (PLA). **It is important to note that due to project budget constraints, a full WARSSS assessment was not completed as part of this project. Each step of the WARSSS methodology was carried out up to step 10 (flow/sediment relations) and through step 9 (stability analysis) of the PLA for the South Branch of the Buffalo River.** Continuing the analysis further would yield the most insightful results from the WARSSS process, however time (multiple seasons of monitoring necessary to complete) and budget precluded the work from being completed at this time.

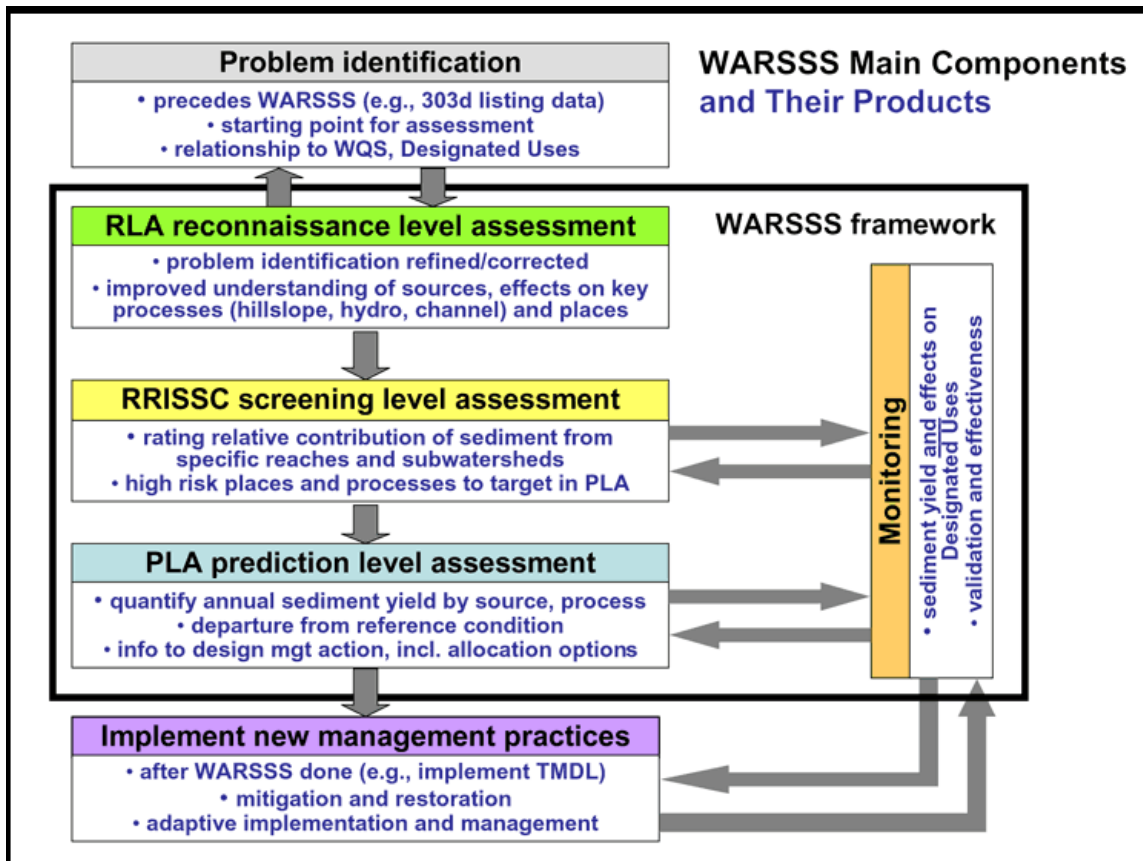
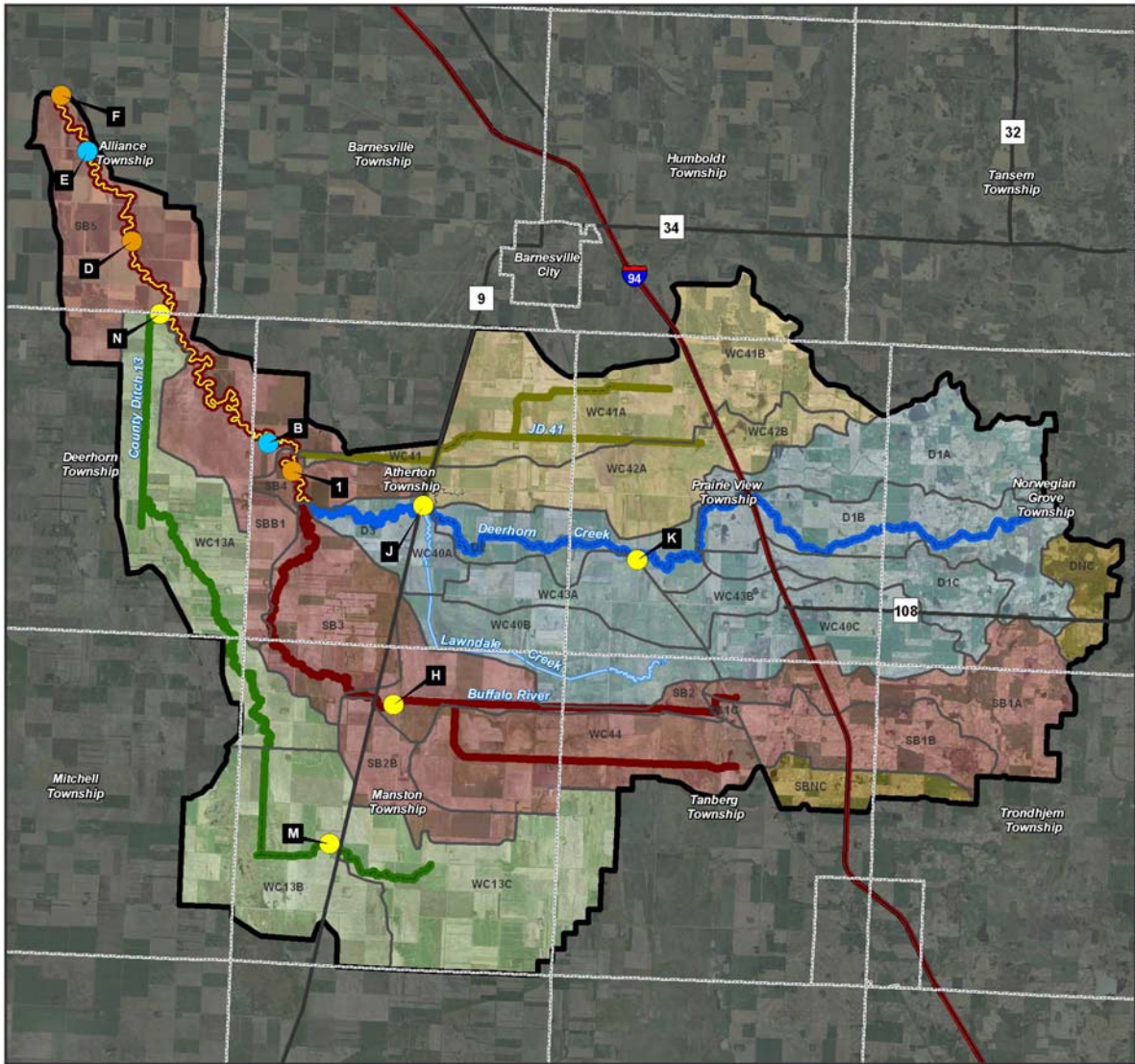


Figure 21. Main components of WARSSS

Since WARSSS is a watershed approach to sediment assessment, the entire 164 square mile drainage basin of the impaired reach of the South Branch of the Buffalo River (SBBR) was analyzed. This predominately rural, well-drained agriculture landscape, illustrated in Figure 22, was thoroughly assessed.



Study Area

March 13th, 2009

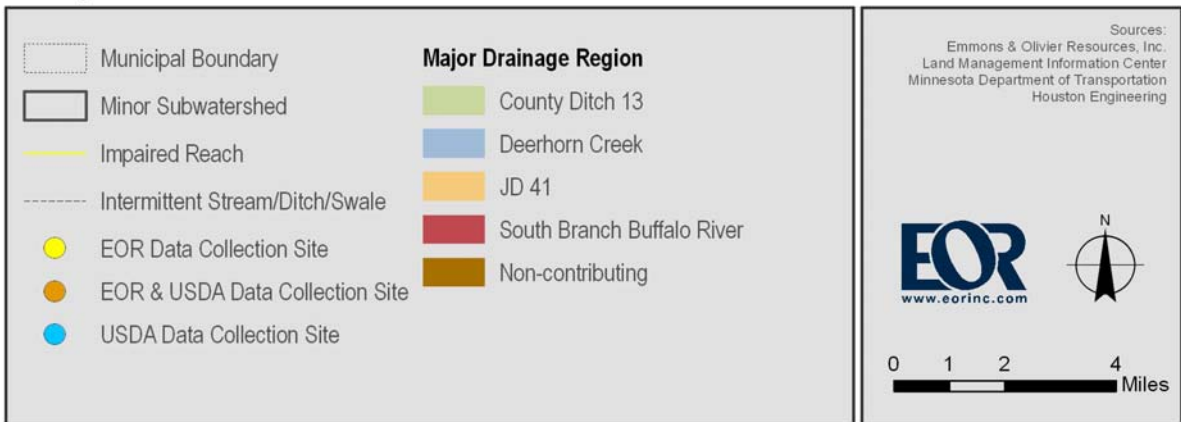


Figure 22. SBBR Study Area

The primary focus of this exercise was an evaluation of WARSSS and its applicability to biotic TMDLs in the Red River Valley. Therefore, the focal point of this section is not necessarily the results yielded, but an evaluation of the methodology. A subset of the culminating WARSSS process worksheets can be found in Appendix 2. User guidance instruction, developed out of this evaluation but not inherently expressed in the WARSSS methodology, can be found in Appendix 3. The response to questions of applicability and value as a TMDL tool are addressed herein. The synthesis of the WARSSS findings and comparison to the United States Department of Agriculture assessment completed by Andrew Simon et al. can be found in *Section 5.3.5*.

5.3.3.3 Methodology

The WARSSS methodology was strictly followed through step 9 of the PLA. As discussed previously, the WARSSS assessment was halted at this step due to budget and time constraints.

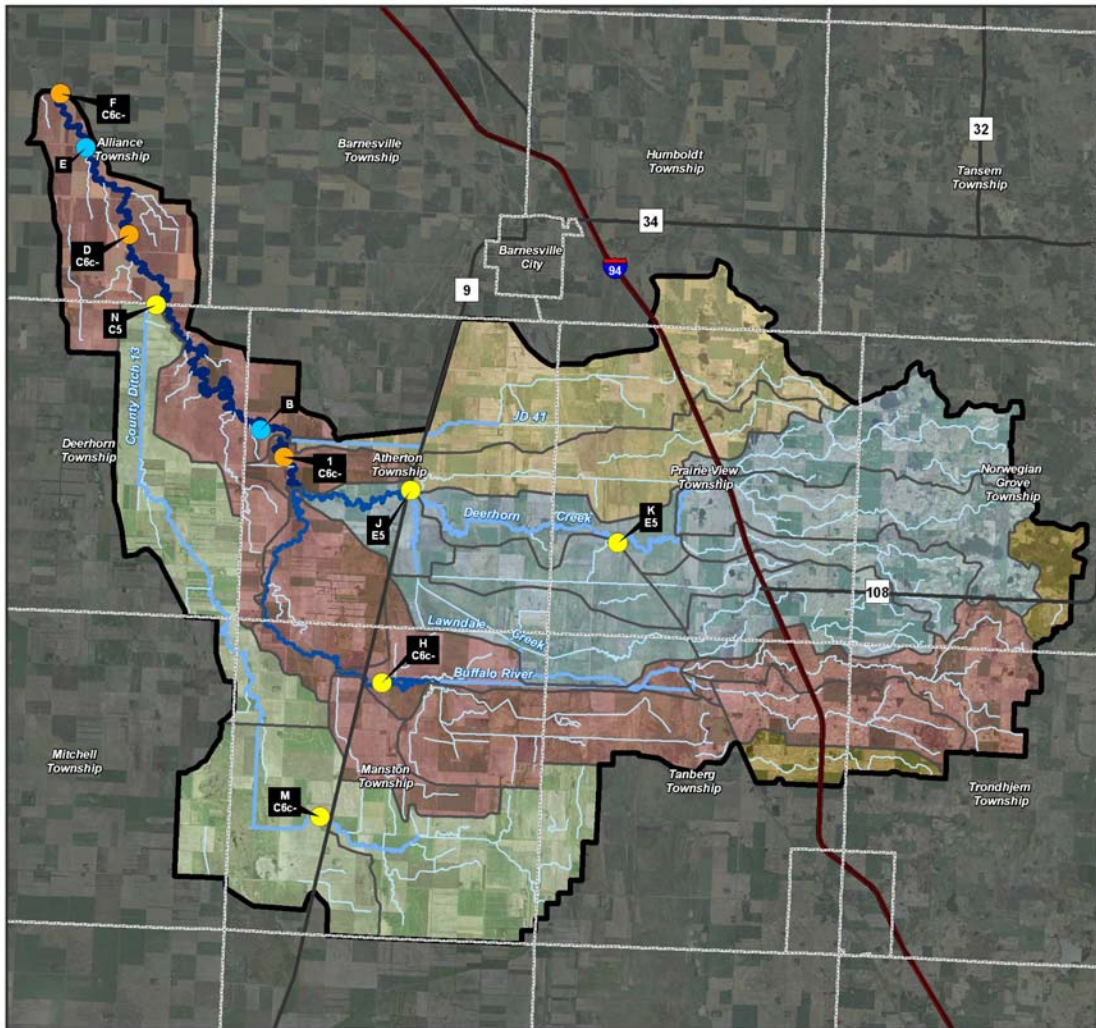
Methodology – Reconnaissance Level Assessment (RLA)

This first and most general phase is meant to identify sites in the watershed that represent likely sediment sources and channel stability problems, thereby limiting the effort and costs of the more intensive phases. RLA is meant to be a rapid, qualitative review of likely sediment sources and problem spots in the watershed. The EPA's online WARSSS tool estimates the level of effort to complete RLA for a third-order watershed to be a few days. This was found to be an underestimate of the time required to do RLA for the project study area. Because of its reliance on quick observation and expert judgment, RLA is best done by technical personnel very familiar with sediment sources, processes, and effects. Assessors working on this phase should be experienced in relating observations from topographic maps, land cover, soils, geologic maps, aerial photographs, and field reconnaissance to effects on flow, hillslope erosion, and channel processes and the identification of sediment sources and effects.

Methodology – Rapid Resource Inventory for Sediment/Stability Consequences (RRISSC)

The RRISSC inventory is a more detailed stream assessment process than the RLA, again aimed at prioritizing the stream reaches so that only the land and stream systems with poor conditions and other variables advance to the PLA. The RRISSC process inventories the reaches identified in the RLA stage as requiring further analysis.

Field data collection, necessary for RRISSC and PLA (due to pending freeze conditions), were collected on various dates over September and October 2008. A storm event producing near bankfull flows (verified by gauge station and historic return) occurred approximately three weeks prior to the initial site work, and provided key temporal bankfull indicators that correlated with other bankfull indicators. Site data were collected at eight different sites, identified in Figure 22 as Sites 1, D, F, H, J, K, M, and N. The Mecklenburg spreadsheets were used to organize the 800 profile and 1200 cross-section data points shot for this exercise.



Valley Type, Classification & Order

March 13th, 2009

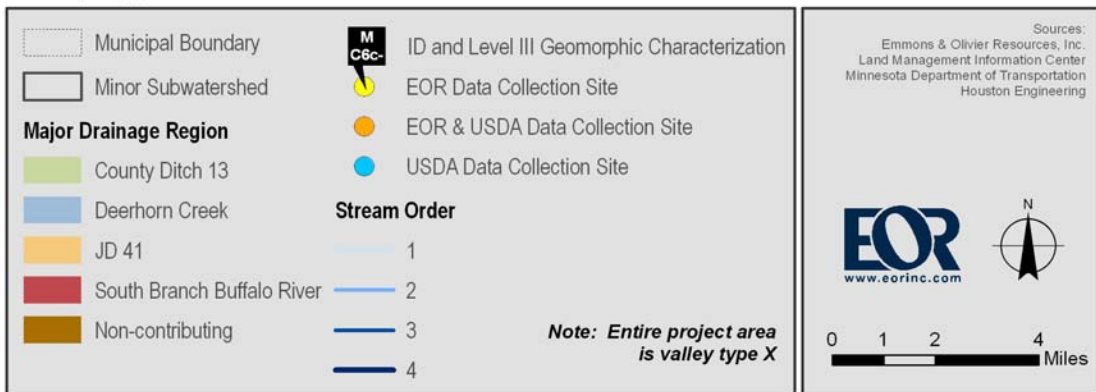


Figure 23. SBBR valley type, stream classification and order

Methodology – Predictive Level Assessment (PLA)

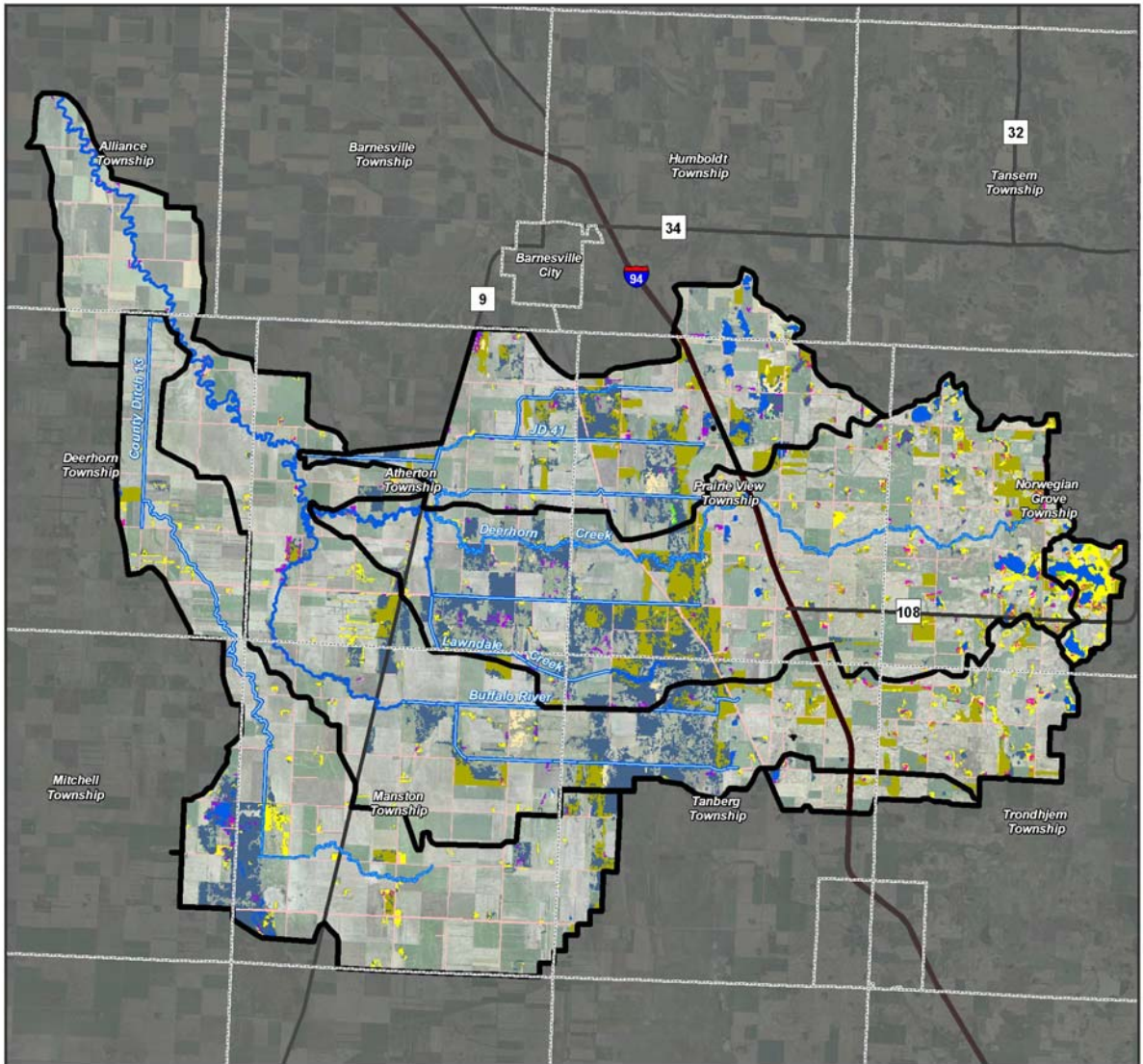
The PLA is the most detailed level of assessment within WARSSS. It is only applied to subwatersheds or stream reaches that require further assessment after being examined by the RLA and RRISSC processes. The following are the objectives of the PLA, as described in WARSSS:

- 1) Locate and quantify sediment sources
- 2) Link sediment sources to various land uses
- 3) Identify disproportionate sediment supply
- 4) Evaluate sediment impacts on river channels
- 5) Integrate hydrology, river morphology and river stability with land use impacts by specific location
- 6) Determine departure and degree of impairment due to sediment sources, watershed hydrology and riparian impacts
- 7) Provide sufficient detail to design site- and process-specific mitigation

5.3.3.4 Results

Results – Reconnaissance Level Assessment (RLA)

The process of eliminating subwatersheds, reaches, or areas within the watershed that do not contribute excessive sediment (the primary goal of the RLA phase) was challenging and did not produce definitive results for the study area. The general geomorphic and land use characteristics of the SBBR watershed, as illustrated in Figure 22, Figure 24, and Figure 25, are very homogenous with subtle topographic changes, which prevent the RLA evaluation criteria from differentiating subwatersheds. Thus, all subwatersheds were advanced to the next stage. As an example, one of the first WARSSS steps is to apply broad-level stream and valley type delineation, but little information is gained from this step as the entire study area is composed of one valley type (type X). Often the entire watershed is advanced to RRISSC by one particular metric, thus not serving its purpose of limiting the number of reaches or watershed areas for the more intensive phases. For example many of the WARSSS evaluations hinge on the identification of recent obvious disturbances, such as logging or construction of forest roads. However, minor attention is paid to the ubiquitous agriculture transformation that occurred over the past 150 years. Further difficulties were posed by the intricate surface and subsurface drainage network of the SBBR, which WARSSS does not directly address.

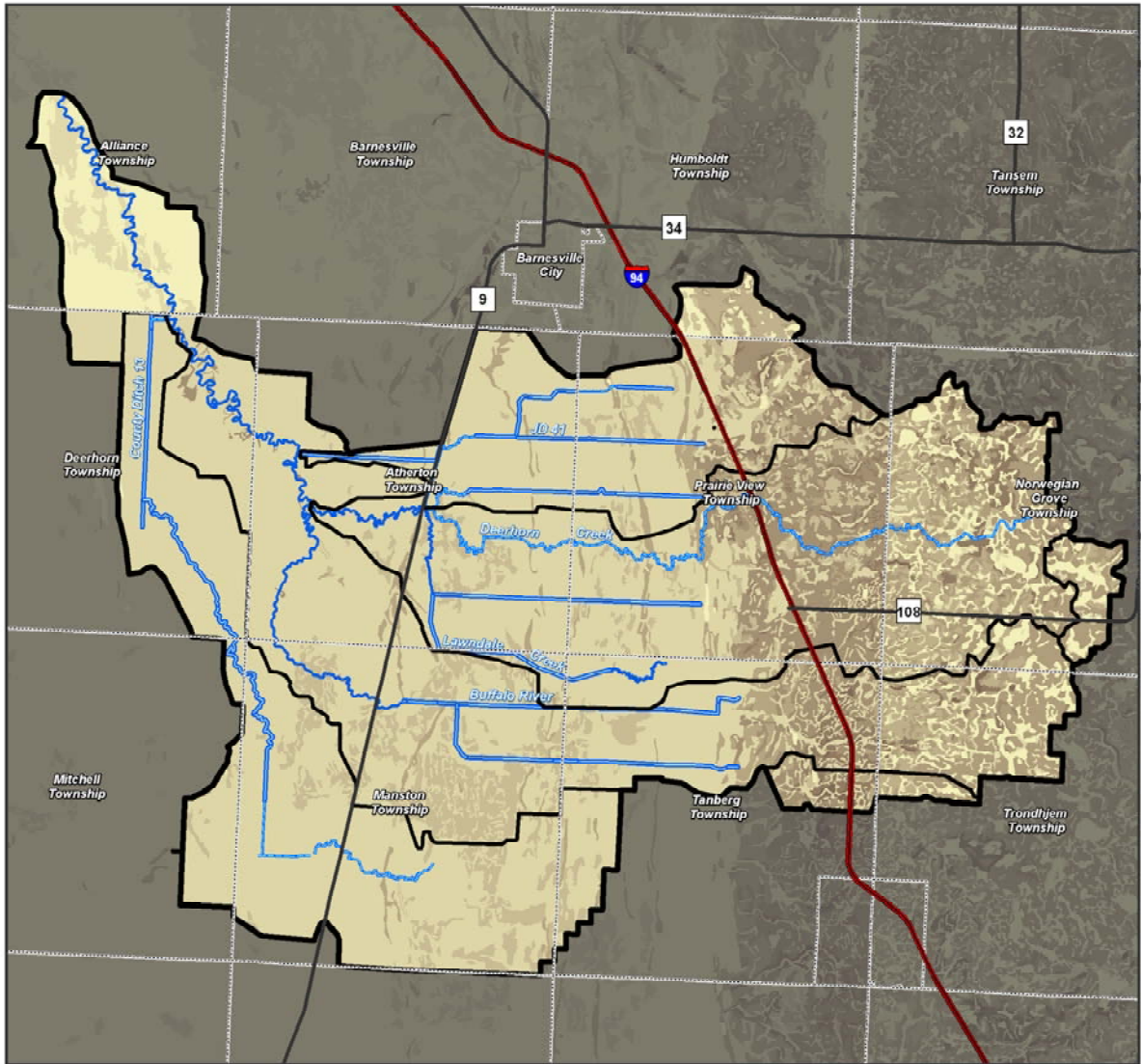


Existing Land Cover

March 13th, 2009



Figure 24. SBBR land cover



SLOPE

March 13th, 2009

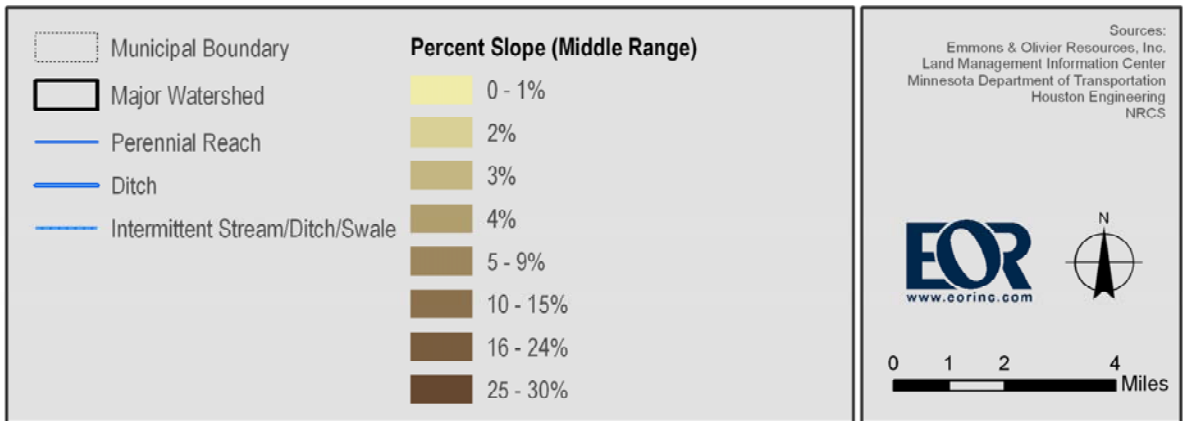


Figure 25. SBBR geomorphic features

The process of identifying these unique subwatersheds, reaches, or areas within the watershed posed similar challenges. Absent of distinct characteristics, less obvious qualifiers were used to break the study area into focus areas. The geomorphology of the former Lake Agassiz, apparent in Figure 25, was used to pair the subwatersheds of the SBBR into like study areas. The unique drainages of SBBR were divided into the outwash plains (primarily east of Interstate 94), beach ridge (immediately west of Interstate 94), and lake basin (remaining landscape west of the beach ridge). The watersheds making up the eleven study areas are identified in Worksheet 3-1 of Appendix 2.

Worksheet 3-1, summarized in Table 32, illustrates the separate subwatershed evaluations for advancement to the RRISSC phase. Per the WARSSS methodology any single inclusion advances that focus area to the next phase. Each focus area or subwatershed of the SBBR assessment advanced on multiple evaluations. For example the *streamflow change* and *channel processes* evaluations triggered multiple evaluations.

Table 32. RLA summary of results for SBBR

Subwatershed / Reach ID		Surface Erosion	Mass Erosion	Flow Change	Channel Processes	Direct Channel Impacts	Advancement to RRISSC	Selected for RRISSC Analysis
1	Lake Basin - SBBR	Single		Multiple	Multiple		√	√
2	Lake Basin - JD 41	Single		Multiple	Multiple	Single	√	
3	Lake Basin - Deerhorn	Single		Multiple	Multiple	Single	√	√
4	Lake Basin - CD 13	Single		Multiple	Multiple	Single	√	
5	Beach Ridge - SBBR	Single		Multiple	Multiple	Single	√	√
6	Beach Ridge - JD 41	Single		Multiple	Multiple	Single	√	
7	Beach Ridge - Deerhorn	Single		Multiple	Multiple	Single	√	√
8	Beach Ridge - CD 13	Single		Multiple	Multiple	Single	√	√
9	Outwash Plain - SBBR	Single		Multiple	Multiple		√	
10	Outwash Plain - JD 41	Single		Multiple	Multiple		√	
11	Outwash Plain - Deerhorn	Single		Multiple	Multiple		√	

The culmination of RLA, Worksheet 3-1, did not eliminate areas for further study. All eleven study areas advanced to the RRISSC. Due to time and budget limitations, two study areas, beach ridge and lake basin, were selected for RRISSC analysis. Five reaches were selected because they provided the most diversity of conditions and would likely be the least duplicative in assessment. The outwash plains study areas primarily contain ephemeral gullies or grassed-water ways without a defined channel and therefore were indirectly limited to WARSSS hillslope processes evaluation.

Results – Rapid Resource Inventory for Sediment/Stability Consequences (RRISSC)

The Environmental Protection Agency’s online WARSSS tool estimates the time required to assess a third order watershed using the RRISSC procedure as a few weeks (rather than days or months), depending on availability of land cover maps, aerial photographs, soils information, and access to land use history. Approximately 60 hours were logged to complete the selected study areas for the RRISSC.

Worksheet 4.2 summarizes the results of the RRISSC assessment. All study areas rated fairly similar in risk assessment by category. Steps 6 and 7 indicated that risk of mass erosion and road impacts were minimal (score of 1 on a scale from 1 to 5) for all study areas. In steps 8 and 10, surface erosion and streamflow change were found to rank as very high risk (score of 5, on scale 1-5). In steps 13, 17, and 18, streambank erosion, aggradation, and channel evolution were rated as moderate (score of 2-4, on scale of 1-5). In steps 14, 15, 16, and 19, in-channel mining, direct channel impacts, channel enlargement, and degradation ranked as very high for risk assessment. It should be noted that within the in-channel mining worksheet, ditching was assessed as “in-channel” mining despite the difficulty in determining the appropriateness of this categorization.

Worksheets 4-2 (RRISSC Summary), 4-5 (Surface Erosion), and 4-9 (Direct Channel Impacts) of the RRISSC are attached in Appendix 2 as they are the most pertinent worksheets to the RRV. Worksheets 4-1 through 4-13 were completed and the results of these worksheets can be found in Worksheet 4-2. The following specific user comments pertain to the applicability of the RRISSC to the Red River of the North Basin. More detailed user guidance can be found in Appendix 3.

Channel Type – In a watershed with a high density of drainage features, such as the SBBR, where streams are highly altered via direct manipulation and/or indirect degradation, it is unclear how well the Rosgen Classification system (Rosgen 1994) applies. WARSSS considers 80 years sufficient time for full hydrologic recovery from vegetative conversions similar to those in this region. Yet, due to the evolving crop regime of the region and continuing drainage intensities this recovery has not occurred for most systems within the SBBR. The question of classification applicability and current state versus stable state is a recurring issue through the RRISSC assessment. Assessment tools specific to ditches, such as MADRAS, may be useful in this setting.

Reference Reach – an ideal reference reach that has not been impacted by ditching or agricultural activities was not located within the 164 square mile SBBR watershed or in surrounding watersheds. Although not ideal, Site J on Lawndale Creek was used as a surrogate reference reach. Given the importance of the reference reach to the WARSSS methodology, it is clear that a less than ideal reference reach will yield poor results.

Mass Erosion Sediment Delivery – Due to the flat topography of the SBBR watershed and the Red River Basin, mass erosion as defined in

WARSSS has less applicability to the Red River of the North Basin. Mass erosion is outlined in WARSSS as:

The processes associated with mass erosion include two primary types: 1) shallow, fast movements of debris avalanche / debris torrents and mudflows that generally move in response to a major precipitation event, and 2) slow, deep-seated slump / earthflow erosional processes that move intermittently over a wide range of time scales in response to infrequent events and / or disturbance factors (Rosgen, 2006; WARSSS, page 4-14).

Road Sediment Delivery - The risk from roads comes primarily from frequent crossings, steep gradient, or areas where road fill intersects the stream. Because these are not the primary concern for this portion of the Red River of the North Basin, this entire worksheet (which consumes considerable time to complete) could be reduced to 3-4 check boxes and then skipped if none of the boxes are checked. In addition, in the “Adjustments for construction, design and age of road” for areas with stable (concrete, asphalt, or gravel) roads, all assessments will be reduced by two risk rating levels, thus lowering the risk level out of the PLA advancement range, no matter what the analysis to that point had indicated. This assessment could likely be skipped in future analyses, however it was completed as part of this analysis to gage applicability.

In-Channel Mining - Per worksheet instructions, in-channel mining is not applicable to the Red River of the North Basin. However, the impacts of significant agricultural activities may have an impact similar to that of in-channel mining. Activities such as irrigation, channel straightening, and ditch maintenance likely result in an impact similar to that of in-channel mining. These activities are not addressed elsewhere in the RRISSC, making this the most logical point for addressing these often negative stream impacts. However, the mining impact is measured in acres, rather than stream length impacted, making the transition from true mining to ditching difficult.

Streamflow Changes - Many of the streamflow change columns are based on current stream type/bankfull characteristics. If the current stream is or has been degraded, should it be compared to unaltered or existing condition? Additionally, a reduction in bankfull discharge may be beneficial for some streams; however, the worksheet may categorize a reduction in bankfull as a negative.

Results – Predictive Level Assessment (PLA)

The Environmental Protection Agency’s online WARSSS tool estimates time required to assess a third order watershed using the PLA is measured in months (rather than days or weeks), depending on availability of basic data, maps, photographs, soils mapping, size

of watershed, miles of stream length, experience of observer, and access to the site. We found that estimate to be a slight underestimate of the effort needed for the project study area. Approximately 50 hours were logged to complete the PLA through step 9.

Worksheets 5-1, 5-2, 5-3, 5-4, 5-8 (multiple), 5-9, and 5-10 for each reach analyzed are provided in Appendix 2 for reference. The following specific user comments pertain to the applicability of the PLA to the Red River of the North Basin. More detailed user guidance can be found in Appendix 3.

Reference Reaches - The PLA process is highly dependent on utilizing reference reaches to set benchmarks and target ideal parameters/ characteristics for streams. However, the vast majority of streams in the Red River of the North Basin, have been significantly altered over the past 125+ years by agricultural practices. Unimpacted (natural) stream reaches can only be found hundreds of miles away where precipitation, soils, development levels, etc. may be considerably different.

In a highly manipulated watershed, such as the RRV, a reference reach may be difficult to identify. It may be possible that monitoring data, in conjunction with Manning's equation and other stream metrics may be sufficient to interpret a sustainable stream type in such an agricultural setting. Alternatives to reference reaches are not addressed in WARSSS. Although not a pristine reach, Site J on Lawndale Creek was used as a surrogate reference reach.

Manning's Coefficient - The PLA process uses a number of different methods to determine the roughness of the stream by computing n-values from different equations. One method that is noticeably absent from consideration is the impact of vegetation. Vegetation can play a particularly prominent role in the roughness of RRV streams where the vegetation can be quite dense and have a large impact on stream flow rates.

The culmination of step 9 of the PLA yields a prediction for instream erosion rates (tonnage per linear feet per year). The assessment of watershed (referred to in WARSSS as hillslope) sediment contribution, likely a major contributor in the SBBR watershed, is completed in later steps and is not included here. Furthermore, these rates are not put into a context of transport continuity (i.e. is aggradation or degradation the dominant process in the reach).

Table 33 includes the final values yielded by this assessment in units of tons/yr-ft. See Appendix 2 for the detailed worksheets and WARSSS output.

Table 33. PLA summary of results for SBBR

Site ID	Stream	Classification	Valley Type	Annual streambank erosion estimates (tons/yr-ft)
1	SBBR (upstream to downstream)	C6c-	X	0.086
D		C6c-	X	0.061
F		C6c-	X	0.058
J	Lawndale	E5	X	0.105
K	Deerhorn	E5	X	0.007
M	County Ditch 13	C6c-	X	0.036

Table 33 shows that rates of channel erosion varied by a factor of 3, excluding Deerhorn Creek, which was less than 10% of the rate estimated for Lawndale Creek. Lawndale Creek, at 0.105 tons/yr-ft had a surprisingly high sediment load, as it was also one of the healthiest streams in terms of habitat diversity and lack of fine sediment accumulation. However, BEHI scores are based on the most erosive outer bank. Much of the eroded bank sediment is likely transported out of the reach, impacting flatter downstream reaches where the sediment aggrades. Deerhorn Creek had the lowest estimated erosion rate at 0.007 tons/yr-ft. (Total sediment loads for the entire South Branch Buffalo River were not calculated for this exercise.)

If the PLA section were entirely completed, additional information such as total annual bedload sediment yield, total annual suspended sediment yield, total annual suspended sand sediment yield, and total annual sediment yield increase or decrease from a reference condition due to changes in streamflow magnitude, timing, and duration would be estimated from steps 10-15 (FLOWSED modeling procedure). Flow-related changes in annual sediment yield would be estimated in steps 16 and 17 using the FLOWSED model. The POWERSED modeling, steps 18-19, would output a flow duration curve and bedload and suspended sand sediment rating curves for upstream and impaired reaches. However, bedload data are not available or very sparse in most rivers, making completion of the PLA impossible for most managers.

The estimation of sediment delivery from hillslope processes in PLA steps 20-21 is very useful given the importance of field erosion in the RRV. *Due to the widespread agricultural land use in the RRV and results obtained during the RRISSC, the hillslope contributions are expected to be significant.*

The overall sediment supply rating for the reach will be estimated in step 28 as the culmination of steps 24-27. Steps 29-31 are the PLA summary sheets and provide the final output for the process, indicating total sediment yield, broken down by bedload and

suspended sediment. They also present the difference of this yield to the baseline and the consequence of this for overall stability (stable/aggradation/degradation).

5.3.3.5 *Summary of Findings for SBBR*

RLA

In the Reconnaissance Level Assessment, all eleven subwatershed/reach focus areas were advanced to the RRISSC phase for further investigation due to the widespread impacts of field erosion, channelization, and hydrologic alteration.

RRISSC

Hillslope Processes

The RRISSC showed that hillslope processes contributed significantly to the sediment impairment of the SBBR. Surface erosion was determined to contribute the greatest amount of sediment of all of the hillslope processes, with mass-wasting the least. The agricultural landscape with a high percentage of bare soils during runoff periods is a key indicator highlighted through the WARSSS analysis as an element of concern for sediment contribution. The other components, mass erosion and road impacts, were not considered to be significant sources of sediment in the watershed.

Hydrologic Processes

The primary metric for impacts on hydrologic processes is the percentage of acres cleared compared to the total acres, indicative of increased runoff and subsequent stream impacts. Ubiquitous agricultural activity resulted in a very high percentage of clearing and indicated that additional assessment was needed in the PLA phase because of the impacts of increased runoff and sediment delivery. It is likely that the Hydrologic Processes category would yield the same result for other rural portions of the RRV since agriculture covers 90% of the basin (Figure 11).

Channel Processes

The assessment of channel processes (steps 11-15 of the RRISSC) indicated that channel processes had less of a negative impact than either hillslope or hydrologic processes on streams because of the high degree of landscape alteration. The main channel process leading to channel instability and sediment production was identified as agricultural ditching and channelization of streams in addition to lack of vegetated buffers or riparian vegetation. All stream types surveyed were either types E5 or C6, with the small, narrow, highly sinuous E types found in headwater reaches and C6 types occurring in the SBBR main branch and some ditches. These stream types are indicative of channel processes as increases in runoff tend to cause widening of E type streams (width-to-depth ratio of < 12) into C stream types (width-to-depth ratio >12) (Rosgen 1996).

PLA

The PLA was carried out to step 9, providing estimates of streambank erosion rates. Estimates of streambank erosion rates varied by a factor of 15, ranging from 0.007 to

0.105 tons/ft-year. Though streambank sediment contributions are thought to be small compared to field erosion, the sediment load from streambank erosion was still substantial.

No reference reaches were surveyed in this study, so comparisons to the “reference” condition were not possible. Given that many of the streams in the RRV are unstable (Simon et al. 2008), they are likely contributing more than the natural background rate of channel erosion.

5.3.3.6 Assessment of WARSSS

In the case of the SBBR and many tributaries of the RRV, excess sediment is thought to be the main cause of water quality impairments. Excess sediment has been a leading cause of water quality impairments across the nation for years, but success in controlling excess sediment has been limited (Waters 1995). While the focus of this discussion has been the evaluation of WARSSS as an assessment of sediment problems and solutions to the RRV, perhaps the first question that should be addressed is whether excess sediment is in fact the main cause of biological impairment. Due to its focus on sediment supply, users of WARSSS need to remember that chemical and biological stressors are also important. The WARSSS analysis may aid watershed stakeholders in identifying or correcting non-sediment impairments, but it is clearly a sediment driven process and not meant to shed light on other compounding stressors, such as chemical pollution or historic channelization of streams.

The WARSSS analysis provides a useful tool for assessing stream-watershed relationships and the impact of adjacent land manipulation on the stream at a theoretical level. The difficulties in applying WARSSS are derived from the lengthy assessment process required even for small sections of stream. The time and cost to conduct such an analysis, including monitoring, data collection, and filling out worksheets may limit its usability for many small government units. The result of the RLA and RRISSC analyses identified the key issue for streams to be agricultural practices. Agricultural practices, primarily ditching and vegetation clearing, led to indications that surface erosion, in-channel mining, direct channel impacts, and channel degradation were the primary stream issues requiring further assessment (more specific stressors for the Red River valley are listed in *Section 5.2.2.2: Geomorphic and Hydrologic Stressors in the RRV*). Due to the homogeneity of this agricultural landscape, the RLA and RRISSC phases of WARSSS advanced all study areas to the PLA assessment. No single disturbance was determined to be the sole reasoning of instability, rather it is thought to be the compounding effect of land use across the watershed. Although not quantifiable, this insight could possibly have been predicted.

Perhaps the primary difficulty in applying WARSSS to streams in the RRV is the lack of supporting documentation describing the intent and precise meaning of each column in each worksheet. For example, the in-channel mining worksheet (4-18) attempts to assess the channel impacts, noted as “lowering local baseflow level, causing headcuts, incising channels, changing dimension, pattern and profile, and accelerating streambank erosion.”

This is problematic in the RRV, because in-channel mining is only one of many activities that would contribute to these impacts. Agricultural drainage ditching, irrigation ditches, ditch straightening, drain tiling, and other activities could have negative impacts similar to those of in-channel mining. However WARSSS does not provide guidance on how to account for these agricultural impacts. It does not specify whether in-channel mining for sand and gravel supply is considered the only form of channel dredging with significant stream impacts.

Another challenge to consider when implementing WARSSS is the lack of supporting documentation outlining the intent of each worksheet and process. When the analysis is under way, there are a number of stream issues that arise that do not fit succinctly into the WARSSS parameters. Additionally, the scope of WARSSS is very large; therefore, tailoring the worksheets to specific ecoregions would produce more useful results. The procedure does not differentiate between the relative importance of parameters for sediment load, turbidity, or impaired biota. Finally, the RRISSC requires completion of numerous worksheets that are not always directly used in later stages of WARSSS, thus creating unnecessary paperwork.

The three-phased WARSSS process for identifying subwatersheds of the RRV that represent likely sediment sources and channel stability problems was not useful in narrowing down the investigation's scope since no subwatersheds were eliminated for further analysis. Furthermore, the most valuable data are likely yielded in the later PLA steps that predict sediment yield, which take multiple seasons of monitoring and evaluation to truly implement.

WARSSS quantifies physical hillslope, hydrologic, and channel processes that are broadly applicable to any watershed. Yet, in different ecoregions or physiographic provinces, the relative importance or intensity of the different processes will vary. The RLA and RRISSC phases of WARSSS are not tailored to a flat glacial landscape with intensive agricultural drainage, making them less useful to the RRV. These phases are often centered on the more obvious disturbances of the western United States with greater topographic variation and less altered landscapes. The impacts of logging and grazing are apparent, but the common agricultural practices and more subtle geomorphic gradients found in the Midwest are not adequately quantified. The most useful information from a sediment or nutrient TMDL perspective is found in the PLA stage. Therefore if the main stressors are already known, it is advisable to spend less time on the first two stages and spend more time on the PLA activities.

5.3.4 Mechanistic approach to channel erosion prediction: USDA-ARS approach

The USDA-ARS geomorphic approach uses numerous tools (Table 34) for quantifying the stability of stream channels and modeling the transport and deposition of sediment within the channel via the BSTEM and CONCEPTS models.

Table 34. USDA-ARS Tools for Sediment and Biota TMDLs

Tool	Application	Reference
Channel Evolution Model	Describe channel stability status and trend in six stages: pristine, constructed, degrading, widening, revegetation, quasi-equilibrium	Simon 1989a; Schumm 1984
RGA	Rapid geomorphic assessment – a worksheet to rank the stability of a channel based on bed and bank characteristics	Unpublished by Andrew Simon
BSTEM	Bank stability and toe erosion model	Simon et al. 2003
CONCEPTS	Models erosion of channel materials and routing of sediment downstream	Langendoen 2006
CSM meter	Measures critical shear strength of soils	
Iowa BST meter	Measures cohesive strength of soils	
Reference suspended sediment levels	Identify normal or average rates of suspended sediment transport for specific ecoregions (including the Lake Agassiz plain)	Simon et al. 2008, Simon et al. 1989b

The USDA’s geotechnical approach of quantifying streambank and bed erosion using process-based physical models provides technically accurate information, but is time and labor intensive. The USDA-ARS approach may be best used with pilot studies to accurately quantify rates of bank erosion in specific subwatersheds or geomorphic regions of the RRV. Findings from these studies could then be applied to locations where similar channel conditions and channel materials exist. Once this information is obtained across a range of different geomorphic regions or subwatersheds, the data can be applied to other streams in the region, using the BSTEM model or Rosgen’s BEHI to more accurately predict stream bank erosion sediment loads.

5.3.5 Geomorphic Assessment Tools: Synthesis of Findings

There are many watershed and geomorphic assessment tools (WARSSS, CONCEPTS, WEPP, SWAT, AnnAGNPS, etc.) available for use, yet none are geared specifically at diagnosing causes of impaired biota. Most of these tools only predict sediment load and provide minimal information on bedded sediment characteristics that are critical to fish and invertebrates. Given the wide variety of methods, it is necessary to tailor assessment techniques to a specific region or watershed, as discussed in the *Tailored Integrated Watershed Assessment* (MRB 2008). For the RRB, an integrated approach is recommended incorporating the watershed assessment framework of WARSSS with the focused quantification of streambank material properties of the USDA-ARS in combination with other tools.

5.3.5.1 WARSSS

The WARSSS procedure provides a framework for addressing watershed-scale and fluvial processes to determine the origins of sediment and stability issues in streams. However, WARSSS, and the Rosgen approach more generally, were heavily criticized in Simon et al. (2007). Numerous problems with the Rosgen approach were cited, including

1) a lack of process-based science linking channel classification types to physical channel processes; 2) difficulties in identifying the bankfull elevation in the field; 3) multiple channel evolution endpoints resulting from the same initial channel type; 4) lack of predictive power because of qualitative channel stability assessment; and 5) lack of distinction between sediment erosion, transport, and deposition processes in different hydrologic or geomorphic regions.

For application to the RRV, the lack of specificity to different hydro-geomorphic regions was found to be the most problematic. Some aspects of WARSSS are not relevant to the flat, tree-less agricultural landscape of the Red River Valley, particularly the worksheets on instream mining, forestry, and logging road impacts. WARSSS needs to be tailored to specific regions of Minnesota and condensed to be practically useful at the local government level, where most TMDL studies and management plans are implemented. For the RRV, WARSSS needs to better address issues involving flat intensively drained, agricultural watersheds. Worksheets that are not relevant to the region should be eliminated (forest roads, in-channel mining, etc).

WARSSS examines more processes at the watershed scale than the USDA-ARS approach and provides a more holistic investigation of watershed-channel relations (Table 35). However WARSSS provides less detail and less precise quantification of streambank and bed erodibility that allows for more accurate prediction of channel erosion rates. In order for the two to be comparable, the WARSSS procedure would need to be carried all the way through the PLA stage, which may be time and cost prohibitive for many local and state agencies and/or consultants.

Table 35. Comparison of the scope of methods used in WARSSS-EPA approach and the USDA-ARS geomorphic assessment approaches

Type	Watershed-based tools (WARSSS)		Mechanistic models: USDA- ARS	
	Inclusion of assessment?	Tool or approach	Inclusion of assessment?	Tool or approach
Reconnaissance level assessment	Yes	RLA	Yes	RGA
Hillslope processes	Yes	worksheets	No	x
Surface erosion	Yes	worksheets	No (but model may be added on)	AnnAGNPS model
Sediment delivery	Yes	Stiff diagram	No	x
Hydrologic processes	Yes	worksheets	No	x
Streamflow change (bankfull)	Yes	Stream gage records	No	x
Streamflow change (low or mean flow)	No	x	No	x
Channel processes	Yes	worksheets	Yes	CONCEPTS
Bed processes	Yes	FLOWSED, POWERSED	Yes	CONCEPTS
Materials	No	Pebble Count	Yes	Field measurements
Bank processes	Yes	BEHI	Yes	BSTEM
Materials	Yes	BEHI	Yes (measured values)	Field measurements
Sediment transport and deposition	Yes (RIVERMorph)	FLOWSED, POWERSED	Yes	CONCEPTS
Stream Classification	Yes	Rosgen Level 1 (Types A1-F6)	Yes	Channel Evolution Model (types I-VI)
Comparison to reference state	Yes	'stable' channel	Yes	suspended sediment levels

5.3.5.2 Mechanistic Models of Streambank Erosion

The USDA-ARS method likely provides more precise estimates of channel erosion. (Note: USDA-ARS channel data from the SBBR is not yet available.) One problem with this methodology is that extensive data collection requirements may prevent extensive use by local government units (LGUs), the organizations responsible for TMDLs. Secondly the equipment used to measure streambank erodibility, the Cohesive Strength Meter (CSM) and the Iowa Borehole Shear Tester (BST), are expensive and not easily available for purchase. As a result, the USDA-ARS approach is not as user-friendly to the typical local or state government resource manager.

The Rapid Geomorphic Assessment (RGA) developed by Andrew Simon provides a useful preliminary assessment of channel stability. If RGA scores could be linked to channel erosion rates on a regional basis, this would be quite useful for TMDL studies. The USDA (2008) report on reference suspended transport rates for different ecoregions of Minnesota may be quite useful in establishing normal or average suspended sediment loads for a given region. This study described long-term suspended sediment transport in the Lake Agassiz Plain. The reference sediment load approach poses some problems however; the reference period established is the past 50 years or less since little or no sediment sampling was done before the 1950s. Therefore it is not possible to know what pre-European sediment loading conditions were in RRV streams.

5.3.5.3 Development of Minnesota-specific channel erosion graphs

At the PLA level, the final stage of WARSSS, predictions of sediment yield using the BANCS model combining BEHI and near-bank shear stress (NBS) are very useful for TMDL studies. However, the bank erosion charts were developed from data collected in Colorado and Yellowstone National Park (Figure 26). Development of BEHI graphs for Minnesota streams would be very useful in developing turbidity TMDLs in the state of Minnesota. The Minnesota DNR and the University of Minnesota have BEHI data from various streams across the state and are working to make this tool more accurate and applicable across the state.

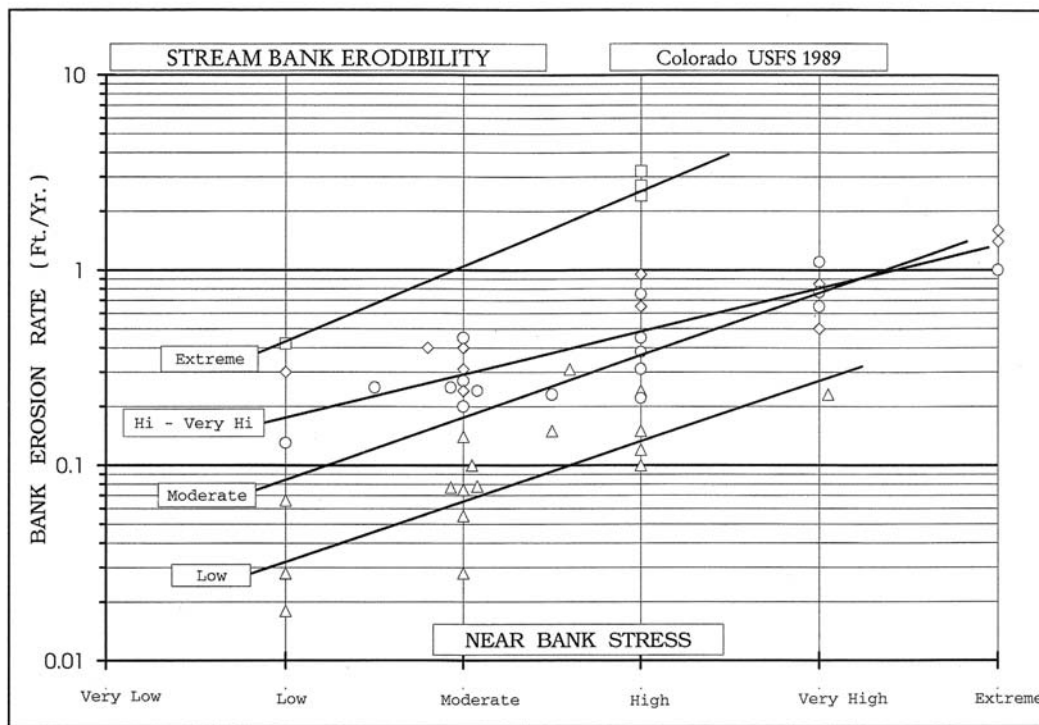


Figure 26. Relationship of BEHI and NBS to predict annual streambank erosion rates.
Colorado data, 1989 (Rosgen 1996, 2001)

The same region-specific erosion graphs could be developed for the RRV using the physical channel data collected in the USDA-ARS approach. Quantification of physical channel properties (streambank erodibility and cohesive strength) provides a more scientific, process-based tool for predicting streambank erosion rates than BEHI. The drawback is that data collection is more time-consuming and costly. Currently the tools needed to make these measurements (the CSM and Iowa Borehole Shear Tester) are expensive and not readily available to most natural resource managers. However if enough data on the critical shear stress and cohesive strength of streambanks could be collected and correlated with stream characteristics such as channel evolution stage or Rosgen Type, then more reliable estimates of channel sediment yield could be easily obtained by local government units implementing TMDL studies.

5.3.5.4 Other Assessment Tools

Sediment yield and transport are not the only causes of biotic impairment. The causes of biotic impairments need to inform the selection of geomorphic techniques and other assessment procedures, rather than letting the geomorphic assessment techniques dictate the design of the study in order to maximize the benefit of geomorphic investigations. While sediment load and transport are critical to biota, specific geomorphic and structural components needed by fish and invertebrate species need to be identified in order to address the biotic impairment. For example, simple lithophilic spawners require gravel beds in order to survive in a river. Measures of embeddedness (Sylte and Fischenich 2002) and aggradation (Lisle and Hilton 1992) on the stream bed are critical links to the biotic impairment problem.

Historic geomorphic investigations help to better understand what a “stable” stream channel is like. Long-term estimates of bank erosion by repeat surveys or aerial photo measurement are needed to place current rates of bank erosion in perspective (Eagan and Howell 2002). The concepts of channel stability and excess sediment load are only comprehensible in comparison to some “reference” condition.

Recommendations: Assessment of Geomorphic Tools

- Do not use “canned” approaches that are generic to all watersheds; rather use a suite of methods tailored to individual watersheds or ecoregions.
- Develop a Minnesota graph for BEHI/BANCS for ease of calculating sediment load from streams.
- Develop a table of physical channel properties (cohesive strength, shear strength, soil particle size) and their relationship to channel erosion rates.
- Results from the geomorphic assessments will help identify appropriate implementation options