Red Lake River Watershed

ONE WATERSHED ONE PLAN
How did we get here?

Nothing GREAT was ever achieved without enthusiasm.

- Emerson
BWSR Guidance

- Plan with **prioritized, targeted, and measurable** implementation actions
- Plan will strive for **systematic, watershed-wide**, science-based approach to watershed management, driven by the participating **local** governments
- Plans will embrace the concept of **multiple benefits** in the development and prioritization of implementation **strategies** and actions
- Planning and implementation efforts will recognize **local commitment** and contribution
BWSR Guidance

- MN 8410 - Integrated Comprehensive Plan with public and agency involvement
- Surface water & ground water quality protection, restoration, & improvement, including prevention of erosion and soil transport into surface waters
- Restoration, protection, & improvement of surface water & groundwater storage and retention systems
- Promotion of groundwater recharge
- Flood damage reduction, especially to minimize future public expenditures needed to correct flooding problems
- Wetland enhancement, restoration, & establishment
- Shoreland and riparian zone management & buffers
- Protection and enhancement of fish and wildlife habitat & water recreational facilities
One Watershed, One Plan
Plan Content Requirements

January 27, 2015

Purpose: This document outlines plan content requirements for developing comprehensive watershed management plans as per Minnesota Statutes §103B.801.

Introduction
This document contains specific content requirements for drafting a comprehensive watershed management plan through the One Watershed, One Plan program. Full operating procedures for developing the plan - including initiating the planning process through review, approval, and adoption - are contained in the One Watershed, One Plan Operating Procedures document.

The following Guiding Principles provide sideboards and direction in the plan content requirements outlined in this document:

- One Watershed, One Plan will result in plans with prioritized, targeted, and measurable implementation actions that meet or exceed current water plan content standards.
- One Watershed, One Plan will strive for a systematic, watershed-wide, science-based approach to watershed management, driven by the participating local governments.
- Plans developed within One Watershed, One Plan should embrace the concept of multiple benefits in the development and prioritization of implementation strategies and actions.
- One Watershed, One Plan planning and implementation efforts will recognize local commitment and contribution.
- One Watershed, One Plan is not intended to be a one-size-fits-all model.

The requirements in this document are also supported by the vision of the Local Government Water Roundtable that future watershed-based plans will have sufficient detail that local government units can, with certainty, indicate a pollutant of concern in a water body, identify the source(s) of the pollutant, and provide detailed projects that address that particular source. This vision also includes a future of limited wholesale updates to watershed-based plans; a streamlined process to incorporate collected data, trend analysis, changes in land use, and prioritization of resource concerns into the watershed-based plan; and an emphasis on watershed management and implementation through shorter-term work plans and budgeting. This vision includes acknowledging and building off of existing plans and data (including local and state plans and data), as well as existing local government services and capacity.
The Process

- Early Steps
  - Issues
  - Resources
  - Planning Zones
  - PTMApp Pour Points
  - Plan Outline
  - Priority Statements

- Later Steps
  - Rank Priority Statements
  - Assignment of Resources to Priority Statements
  - Measurable Goals for each Resource
Basic Plan Layout

- Executive Summary
- Key Terms
- Introduction
- Planning Zones
- Issues and Resources
- Prioritization and Goals
- Targeting and Implementation Programs
- Figures and Tables
- Appendices
Executive Summary

Plan will have an Executive Summary. The purpose of the executive summary is to provide a brief look into the contents of the plan. The summary includes:

- A general map and description of the planning boundary and smaller planning units
- A summary of the priority issues and goals that are addressed in the plan
- A summary of the implementation actions and programs
- A brief description of the process used to identify the measurable goals and targeted implementation actions
- An outline of the responsibilities of participating local governments
Introduction

3. Introduction

3.1. 1W1P Background

Minnesota has a long history of water management by local government (BWSR 2015). One Watershed, One Plan (1W1P) is rooted in this history and the idea that the local governments responsible for water management should organize and develop focused implementation plans on a watershed scale. Recent legislation (Revision of Statutes 2015) permits the Board of Water and Soil Resources (BWSR) to adopt methods that allow comprehensive plans, local water management plans, or watershed management plans to serve as substitutes for one another, or to be replaced with one comprehensive watershed management plan. Legislation is referred to as One Watershed, One Plan (1W1P). The Red Lake River 1W1P was developed to consolidate existing policies, programs and implementation strategies from multiple stakeholders to provide a single, concise, and coordinated approach to watershed management.

BWSR’s vision for 1W1P is to align local watershed planning with state strategies towards prioritized, targeted and measurable implementation plans. BWSR has developed several guiding principles for the development of the Red Lake River 1W1P:

- The Red Lake River 1W1P will prioritize, target, and outline how to measurable implementation actions that meet or exceed current water plan content standards.
- The Red Lake River 1W1P is not an effort to change local governance.
- The Red Lake River 1W1P strives for systemic, watershed-wide, science-based approach to watershed management; driven by the participating local governments.
- The Red Lake River 1W1P uses the state’s delineated major watersheds (Etiquette Hydrologic Unit Codes or EUHUC) as the starting point for defining the preferred scale for local watershed management planning.
- The Red Lake River 1W1P involves a broad range of stakeholders to ensure an integrated approach to watershed management.
- The Red Lake River 1W1P embraces the concept of multiple benefits in the development and prioritization of implementation strategies and actions.
- The Red Lake River 1W1P implementation will be accomplished through formal agreements among participating local governments on how to manage and operate the watershed.
- The Red Lake River 1W1P planning and implementation efforts recognize local commitment and contributions.
- The Red Lake River 1W1P is not intended to be a one size fits all model.

The Red Lake River 1W1P was developed under a Memorandum of Agreement (Appendix A) between project partners. These included:

- Red Lake, Pembina and Polk Counties
- Pembina, Red Lake County and West Polk Soil and Water Conservation Districts, and
- The Red Lake Watershed District.

The following resulted from the Red Lake River 1W1P:
Analysis & Prioritization of Issues
Planning Zones
Issues, Resources, Measurable Goals and Targeted Implementation Plan

Resources

<table>
<thead>
<tr>
<th>Management Class</th>
<th>Class Description</th>
<th>Management Strategy</th>
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<tbody>
<tr>
<td>High Quality</td>
<td>Un-impaired stream segments greater than 5% from the impairment listing standard for any given parameter</td>
<td>Maintain</td>
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<tr>
<td>Needs Protection</td>
<td>Un-impaired stream segments within 5% of the impairment listing standard for any given parameter</td>
<td>Protection</td>
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<tr>
<td>Restorable</td>
<td>Impaired stream segments within 5% of the impairment listing standard for any given parameter</td>
<td>Restoration</td>
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<tr>
<td>Low Quality</td>
<td>Impaired stream segments greater than 5% from the impairment listing standard for any given parameter</td>
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<tr>
<td>Not Assessed</td>
<td>No monitoring data available at the time of plan writing</td>
<td>Assess</td>
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</table>
greatest risk of becoming impaired by targeting implementation in subwatersheds with highest export.

**PRIORITY:** Inventory, evaluate and assign management classes to stream and river reaches and prioritize those most susceptible to altered hydrology effects on bank and bed stability.

**PRIORITY:** Reduce runoff-driven sediment transport to other impaired waters by targeting implementation in subwatersheds with highest export.

**ISSUE: Altered Hydrology**

**PRIORITY:** Reduce runoff rates by targeting implementation in subwatersheds with high runoff.

**PRIORITY:** Identify ideal locations for flood control structures that include multifunctional design.

**PRIORITY:** Protect disconnected, non-contributing drainage areas from future altered hydrology leading to a connection to water resources downstream.

**PRIORITY:** Restore or modify natural water course morphology where feasible to promote adequate drainage as well as channel equilibrium.

**PRIORITY:** Promote infiltration, retention, extended detention practices in new and existing urban developments based on current stormwater best management practices.

**ISSUE: Drainage System Management**

**PRIORITY:** Utilize information collected from the drainage ditch inventories to prioritize and install side water inlets and buffer strips to ensure adequate support of agriculture without negative downstream ecological and economic impacts.
Planning Zones
Issues, Resources, Measurable Goals and Targeted Implementation Plan

- Management Areas

  1W1P Boundary
  (Red Lake River & Grand Marais Outlet Watersheds)

  - Upper Planning Zone
    Management Areas 14, 22, 23, 24, 25

  - Middle Planning Zone
    Management Areas 2, 3, 4, 6, 7, 9, 10, 16, 18, 19

  - Lower Planning Zone
    Management Areas 1, 2, 7, 11, 13, 17
Priority Statements – Lead to Resource alignment and Measurable Goals development

Priority Statement
“Improve water quality within river and stream reaches designated as Restorable by establishing appropriate best management and conservation practices in the watershed that ensure restoration of its designated use classification.”

Resources
1. Red Lake River Segment XX
2. Grand Marais Creek Segment XX
3. County Ditch XX

Measurable Goals
1. Reduce TP delivery by XX% within 10 years
2. Reduce TSS delivery by XX% within 5 years
3. Reduce Fecal Coliform by XX% in 10 years
Setting Measurable Goals
### Table 6. PTMApp non-urban management strategies and their respective best management practices considered for the Red Lake River One Watershed, One Plan

<table>
<thead>
<tr>
<th>Source Reduction</th>
<th>Storage</th>
<th>Infiltration</th>
<th>Filtration</th>
<th>Protection</th>
<th>Bioinfiltration</th>
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<td>Alternative Tile Intake - Perforated Riser Intake</td>
<td>Alternative Tile Intake - Dense Pattern Tilling</td>
<td>Alternative Tile Intake - Gravel Inlet</td>
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<td>Bioretention Basin</td>
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<td>Contour Farming</td>
<td>Constructed Wetlands</td>
<td>Infiltration Trench</td>
<td>Alternative Tile Intake - Blind Intake</td>
<td>Grade Stabilization Structure</td>
<td>Saturated Buffer</td>
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<td>Forage and Biomass Planting</td>
<td>Culvert Sizing Lined Waterway or Outlet</td>
<td>Alternative Tile Intake - Perforated Riser Intake</td>
<td>Channel Bed &amp; Stream</td>
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<td>Drainage Management</td>
<td>Strip Cropping</td>
<td>Contour Buffer Strips</td>
<td>Tree/Shrub Establishment</td>
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<td>Streambank</td>
<td></td>
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<td>Pennington</td>
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</table>
11.5. Assessment and Evaluation

The Assessment and Evaluation of plan implementation will be made by the Planning Group at quarterly meetings. The planning group will continue to meet after the adoption of the Red Lake River 1WIP. One member of the planning group will be responsible for organizing and hosting the quarterly meetings on a rotating annual basis. New programs, laws, funding, projects, and duties of LGUs can change quickly and needs may be amended in the 1WIP. A more detailed evaluation and assessment will need to be discussed that meets the measurability requirement stated in the targeted implementation schedule.

5.1.5.1. ANNUAL EVALUATION

Annual evaluation of progress be made by the planning group at quarterly meetings. The planning group will report to the combined TAC/Policy Committee at the annual meeting. The planning group will prepare a summary of progress and projects completed or in progress for the watershed. Monitoring data may be used to show reductions in pollutants.

5.1.5.2. BIENNIAL EVALUATION

Same process as annual evaluation.

5.1.5.3. FIVE YEAR EVALUATION

Same process - Evaluation of progress and goals made by planning group with recommendation to TAC/Policy Committee. Completed projects can be checked off. Include input from BWSR and other state agencies? Re-run PTMAp? Are the initial goals set realistic or do they need to be changed. Determine if there are new models available to include in the plan. Possible project tours.

5.1.5.4. REPORTING

Various forms of reporting were discussed by the Planning Group. LGUs are required to submit annual reports to BWSR and there is a requirement to include information from EPA.
Appendices

- Appendix A: Land and Water Resources Inventory
- Appendix B: State and Regional Plan Summaries and Relevance to the Red Lake River 1W1P
- Appendix C: Manually entered public survey results relative to priority issues
- Appendix D: Priority statement ranking within each planning zone by relevant issues
- Appendix E: Resources of Concern
- Etc.
Lessons Learned

- Evaluate People Styles and personality of core team
- Maintain an active website and communications plan
- Anticipate level of effort, budget, and timeline...plan for challenges
- Facilitate with an end-goal in mind
Lessons Learned

- Involve planning group early on with definition of implementation schedule and measurable goals
- Involve planning group and TAC early on in reviewing sections of the draft plan
## Work Plan

<table>
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<tr>
<th>ID</th>
<th>TASK</th>
<th>SCOPE ID</th>
<th>DESCRIPTION</th>
<th>COMPLETION</th>
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<td>19</td>
<td>Stakeholder agreement on Priority Statements</td>
<td>3.2.2</td>
<td>TAC meeting(s): Ahead of meeting, provide initial examples of priority statements (derived from existing plans). May require 2 meetings.</td>
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<td>Measurable Goals for each Resource Of Concern</td>
<td>3.2.2</td>
<td>CONSULTANT: Develop Draft Resources-Measurable Goals and Timelines</td>
<td>October 2</td>
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<td>Stakeholder agreement on #20 and #21</td>
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<td>TAC: Draft Resources-Measurable Goals and Timelines review and comments CONSULTANT: Incorporate comments</td>
<td>October 16</td>
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<td>23</td>
<td>Targeted and Measurable Implementation Plan and Schedule</td>
<td>3.2.3</td>
<td>CONSULTANT: Build out Draft Targeted and Measurable Implementation Plan and Schedule section</td>
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<td>24</td>
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<td>TAC: Targeted and Measurable Implementation Plan and Schedule review and comments CONSULTANT: Incorporate comments</td>
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<td>Implementation Programs</td>
<td>3.2.4</td>
<td>TAC: Draft Implementation Programs section</td>
<td>October 16</td>
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</table>
Lessons Learned

- Clearly outline process expectations and define editing and review processes, # of reviews, and timeline
- Adapt. It’s a great plan!
QUESTIONS
Implementing the PTMapp GIS Toolset at Smaller Watershed Scales: Results and Lessons Learned

Presented by: Joe Pallardy, Biologist & Jason Ulrich, Hydrologist
From: Emmons & Olivier Resources, Inc. (EOR) / www.eorinc.com
Watershed Planning: Nearshore vs. Landscape has Emerged as a “Key Issue”

Incremental increases in runoff volume and/or intensity over time is the crux of the problem
Occam’s Razor
“The simplest explanation for the condition of a waterbody and consequently implementation priority should be considered correct until proven otherwise.”

Hickam’s Dictum
“A waterbody can have as many diagnoses as it darn well pleases”. Multiple ailments are likely accounting for the symptoms being expressed.
Watershed Models

- Are **NOT** substitutes for the collection of field data

- Allow us to change watershed characteristics in **space and time** in ways that support prioritization and planning efforts.
PTMapp Overview

GIS Inputs
- LiDAR (Conditioned DEM)
- DNR Travel Time
- RUSLE
- SSURGO Soils Data
- MLCSS Land Cover
- Curve Number Grid
- Landlocked Basins
- Depressional Watersheds
PTMapp: Landscape Yield vs. Delivery

Sediment Yield-RUSLE

- K-Factor – (SSURGO Values)
- R-Factor – (NRCS Value)
- LS-Factor – (LiDAR Value)
- P-Factor – (Existing BMPs)
- C-Factor – 2011 MLCCS Layer

Landscape Yield Raster (High Resolution)
Sediment Delivery Ratio (SDR)

SDR is a function of drainage area and distance from each raster cell to channelized flow.

In-channel transport correction factor follows an exponential decay function

- *Travel time & diameter of sediment*
PTMapp: Source Load Identification

Legend
PTMapp
Sediment Loads- FL (Tons/Acre)
0.00 - 0.34
0.35 - 1.03
1.04 - 2.05
2.06 - 4.88

Wetlands
Landlocked Basins

Sediment Analysis
Catchment Loading
PTMapp: Refinement – Landlocked Basins

Depressions in DEM

Depressions Removed

Legend

PTMapp Stream

Corrected DEM Value

High: 306.982
Low: 276.918

Land Locked Basins

CMSCWD BMP Targeting
DEM Extraction

Legend

0 250 500 1,000 Feet

Map of PTMapp showing refinements in landlocked basins with before and after comparisons of depressions in DEM.
PTMapp: Refinement – SDR Adjustment

Depressions in DEM

SDR Adjustment

Legend
- Land Locked Basins
- Overland SDR (Adjusted): High: 1, Low: 0.000019564
- Impaired Waterbody
- PTMAp Stream

CMSCWD BMP Targeting
SDR Adjustment

Legend:
- Land Locked Basins
- Overland SDR (Adjusted): High: 1, Low: 0.000019564
- Impaired Waterbody
- PTMAp Stream

Map showing depressions in DEM and SDR Adjustment.
PTMapp: Refinement – Wetland Analysis

Depressions in DEM

Predicted Load = 9914 kg/yr

Depressions Removed

Predicted Load = 4741 kg/yr

Legend

Sediment Mass

Red Network

Improved Waterbody

Land Locked Basins

CMSCWD BMP Targeting

DEM Extraction
Sediment Sources Budget - Brown’s Creek

Total Sediment Load (WOMP station) = Landscape Sediment Load (PTMapp) + Near-channel Sediment Load

\[ 1,140,000 \text{ kg/yr} \approx 473,000 \text{ kg/yr} + \text{Near-channel Sediment Load} \]

- Gullies/Ravines
- Streambanks
- Streambed
- Bluffs

Therefore, an estimate of average near-channel sediment load ≈ 667,000 kg/year (60% of total average load)
Landscape Loads

Legend
PTMAp
Sediment Loads- FL (Tons/Acre)
0.00 - 0.34
0.35 - 1.03
1.04 - 2.05
2.06 - 4.88
Wetlands
Landlocked Basins

Sediment Analysis
Catchment Loading

Landscape – 40%
Near Channel Loads

Near Channel – 60%
Field Verification

- Active Near Channel Source
- Ownership
- Convey Landscape Load Directly to Brown’s Creek
- Feasibility of Implementation
- Magnitude of Landscape Load
- Affected Resource
- Source of Erosion
- Potential Cost
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<th>Desktop Aerial/ LIDAR Review</th>
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<td>Y</td>
<td>Moderate</td>
<td>Low</td>
<td>Both H</td>
</tr>
<tr>
<td>61</td>
<td>Moderate SPI</td>
<td>No visible signature</td>
<td>Private Agri.</td>
<td>Y</td>
<td>Y</td>
<td>Watershed only</td>
<td>Moderate</td>
<td>Both M</td>
</tr>
<tr>
<td>59</td>
<td>Moderate SPI</td>
<td>Visible on LiDAR</td>
<td>Public -DNR</td>
<td>Y</td>
<td>Y</td>
<td>Good</td>
<td>Moderate</td>
<td>Both M</td>
</tr>
<tr>
<td>51</td>
<td>Converge Two Moderate SPI</td>
<td>No visible signature</td>
<td>Private Res.</td>
<td>N</td>
<td>Y</td>
<td>Good</td>
<td>Moderate</td>
<td>Landscape M</td>
</tr>
<tr>
<td>41</td>
<td>Moderate SPI</td>
<td>No visible signature</td>
<td>Private Res.</td>
<td>Y</td>
<td>Y</td>
<td>Good</td>
<td>Low</td>
<td>Both M</td>
</tr>
<tr>
<td>54</td>
<td>Moderate SPI</td>
<td>No visible signature</td>
<td>Private Res.</td>
<td>N</td>
<td>Y</td>
<td>Good</td>
<td>Low</td>
<td>Landscape L</td>
</tr>
</tbody>
</table>
Results

6 Priority Sites **Within**
Direct Drainage to Brown’s Creek

- 5 Locations Recommended in St. Croix River Assoc. Grant Application (see black circles)
  - 2 High Priority Locations
    - 59/59b
    - 51/52

8 Secondary Sites **Outside**
Direct Drainage to Brown’s Creek
### BMP Project ID: 52

<table>
<thead>
<tr>
<th>BMPID</th>
<th>BMP Description</th>
<th>Total Load (kg/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>52</td>
<td>Ravine stabilization w/ check dams</td>
<td>14,716</td>
</tr>
</tbody>
</table>

- Steep ravine immediately downstream of BMP 51.
- Active erosion/unstable, un-vegetated soils
- Bank sluffing
<table>
<thead>
<tr>
<th>BMPID</th>
<th>BMP Description</th>
<th>Total Load (kg/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>59</td>
<td>Gully stabilization at ravine downstream of Oak Glen Golf Course cart washing facility or retention basin to capture runoff from cart washing facility.</td>
<td>170.79</td>
</tr>
</tbody>
</table>
### BMP Project ID: 59B

<table>
<thead>
<tr>
<th>BMPID</th>
<th>BMP Description</th>
<th>Total Load (kg/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>59B</td>
<td>Ravine stabilization w/ potential SW pond upgrades</td>
<td>2,563.6</td>
</tr>
</tbody>
</table>
### Take Home Messages

#### 1.

**Occam! Hickam! Fight!**

#### 2.

[Image of equipment setup in a field]

#### 3.

<table>
<thead>
<tr>
<th>ID</th>
<th>Initial Prioritization Criteria</th>
<th>Desktop Aerial/LIDAR Review</th>
<th>Ownership</th>
<th>Active Near Channel</th>
<th>Hydrologic Connectivity</th>
<th>Implementation Accessibility</th>
<th>PTMapp Magnitude</th>
<th>Source</th>
<th>Priority</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>59b</td>
<td>Moderate SPI Signature</td>
<td>Visible signature on aerial photograph</td>
<td>Public -DNR</td>
<td>Y</td>
<td>Y</td>
<td>Good</td>
<td>Moderate</td>
<td>Both</td>
<td>H</td>
<td>Active gully, field verified, storm water pond upstream, flashy nature from residential runoff, yard waste</td>
</tr>
</tbody>
</table>
Thank you!
This script creates a raster whose cells measure the length of time in seconds that it takes water to flow across it and then accumulate the time from the cell to the outlet of the watershed. Water velocity is calculated as a function of hydraulic radius, Manning's N and slope using a DEM as a source, flow direction, flow accumulation and slope (percent) is calculated. Using flow accumulation, each cell is assigned one of three flow regimes. Slopes are processed so that there are no cells with zero slopes.

Landcover is used to assign flow N and R values to non-channelized cells. Users can use various landcover sources but these must be matched to the N and R table that is stored in the /data folder in this distribution. The N and R table must contain one record for each of the raster values in the landcover grid and there must be the same fields in that table for the program to work. R and N values are assigned based on landcover and flow regime.

*Hydraulic Radius is calculated using:*

\[(X)a + Y\]

where:

- \(X\) = hydraulic radius factor 1 (User setting, 0.0032 default)
- \(a\) = drainage area in square miles (calculated from Flow Accumulation)
- \(Y\) = hydraulic radius factor 2 (User setting, 1.7255 default)

*Velocity is calculated as:*

\[\text{vel(feet/second)} = (1.49 \times \text{Hydraulic Radius}^{0.667} \times \text{slope}^{0.5}) / \text{Mannings N}\]
Once the sediment yield leaving the landscape is estimated for a cell, the sediment reaching a channel or flowline within a catchment is estimated using a sediment delivery ratio. The estimated sediment delivery ratio (SDR) for the catchment is a function of area (see Handbook of Hydrology, DATE).

\[
\text{Overland SDR} = 0.41 \times \text{catchment drainage area (sq. km)}^{-0.3}
\]

The SDR for each cell within a catchment raster is estimated as a function of the catchment SDR adjusted by the distance from a cell to the flowline.

\[
\text{Overland SDR Adjustment Factor} = 1 - \frac{\text{Flow Length}}{0.75 + \frac{\text{Maximum Flow Length in Catchment}}{\text{Flow Length}}} - \frac{\text{Maximum Flow Length in Catchment}}{\text{Flow Length}}
\]

Therefore, the SDR for each cell is computed as Overland SDR (for the catchment) * Overland SDR Adjustment Factor (for the cell).
The sediment transported downstream from each cell to the subwatershed and watershed pour points is further reduced using a first-order transport function.

In-channel downstream transport and loss follows a simple exponential decay function (i.e., first order loss) using travel time and median diameter of sediment (Williams 1977):

$$SY = Y_0 e^{-\beta T \sqrt{d_{50}}}$$

Where $Y$ is sediment yield from sub-basin, $\beta$ is transport coefficient, $T$ is travel time, $d_{50}$ is mean sediment diameter. The channel routing will occur between pour points. The user can insert known transport coefficients and median sediment diameters if available. Default values of 0.2 and 0.1 are used for $\beta$ and the $d_{50}$, respectively.

Essentially, four products are produced for each cell in the raster: 1) sediment yield leaving the landscape; 2) sediment yield reaching the catchment pour point; 3) sediment yield delivered to a user defined downstream subwatershed pour point; and 4) sediment yield reaching the watershed pour point. Mass reaching the watershed pour point can be adjusted using the calibration factor to achieve the interquartile range yield (e.g., assuming 50% washload and 50% in channel process) for the ecoregion as computed by Klemitz and Simon (2009).
Nutrients (Total Phosphorus and Total Nitrogen)

Annual Yield

Nutrient annual yields leaving the landscape are estimated using a method similar to sediment (i.e., they are computed for each cell in the raster). However, different methods are used to compute yield leaving the landscape and reaching the catchment outlet point. TP and TN annual yields are estimated using the values in Table 2 and Table 3 applied to each National Land Cover Dataset (NLCD) land use class.

Table 2: Total Phosphorus Loading Lookup Table for NLCD Land Use Classification

<table>
<thead>
<tr>
<th>NLCD #</th>
<th>Description</th>
<th>TP Loading [kg/ha/yr]</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Open Water</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Developed, Open Space</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Developed, Low Intensity</td>
<td>0.91</td>
<td>LimnoTech 2007</td>
</tr>
<tr>
<td>23</td>
<td>Developed, Medium Intensity</td>
<td>1.15</td>
<td>LimnoTech 2007</td>
</tr>
<tr>
<td>24</td>
<td>Developed, High Intensity</td>
<td>1.5</td>
<td>LimnoTech 2007</td>
</tr>
<tr>
<td>31</td>
<td>Barren Land</td>
<td>1.35</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>Deciduous Forest</td>
<td>0.075</td>
<td>LimnoTech 2007</td>
</tr>
<tr>
<td>42</td>
<td>Evergreen Forest</td>
<td>0.075</td>
<td>LimnoTech 2007</td>
</tr>
<tr>
<td>43</td>
<td>Mixed Forest</td>
<td>0.075</td>
<td>LimnoTech 2007</td>
</tr>
<tr>
<td>52</td>
<td>Shrub/Scrub</td>
<td>0.075</td>
<td>LimnoTech 2007</td>
</tr>
<tr>
<td>71</td>
<td>Grassland/Herbaceous</td>
<td>0.17</td>
<td>LimnoTech 2007</td>
</tr>
<tr>
<td>81</td>
<td>Pasture/Hay</td>
<td>0.17</td>
<td>LimnoTech 2007</td>
</tr>
<tr>
<td>82</td>
<td>Cultivated Crops</td>
<td>0.38</td>
<td>LimnoTech 2007</td>
</tr>
<tr>
<td>90</td>
<td>Woody Wetlands</td>
<td>0</td>
<td>LimnoTech 2007</td>
</tr>
<tr>
<td>95</td>
<td>Emergent Herbaceous Wetlands</td>
<td>0</td>
<td>LimnoTech 2007</td>
</tr>
</tbody>
</table>
The nutrient mass loss from the location of the cell to the flow line and as transported downstream is represented using a first order loss equation, as a function of travel time:

\[ W = \exp(-kT) \]

where \( W \) is the portion of the yield leaving the landscape and delivered to the catchment pour point, \( k \) is the decay rate and \( T \) is travel time from one location to the next (e.g., cell to a catchment pour point). The default values for \( k \) are 0.1 for travel to the flowline and 0.4 for in-channel transport. The delivery raster \( (W_{\text{raster}}) \) is created using the travel time raster\(^2\) to determine the portion of the mass leaving the landscape which reaches the catchment pour point. The portion of mass reaching downstream pour points is also computed using the above equation.

Default values are used when creating the nutrient yield (Tables 1 and 2) and when applying the decay functions to delivery rasters. However, the users can modify these including the data shown in Table 1 and Table 2, when creating the products.

**Post-Processing of the Data**

A variety of products can be developed using the enhanced geographic information system water quality data products. For example, the cell values comprising a raster for a catchment or subwatershed can be summed, providing total yields at the catchment or subwatershed pour points. The yield data can be
Grid-Cell SWAT Modeling Breaks New Ground on Isolating Pollutant Source Areas and Quantifying BMP Benefits

Minnesota Water Resources Conference
Greg Wilson and Evan Christianson, Barr Engineering
October 19, 2016
Project overview

- Watershed-scale models normally lump input parameters
  - Landscape interactions unaccounted for
  - Response unit loads individually routed
  - Non-specific relationship to stream network or conveyances

- Planning tools/terrain analysis can target sites, but don’t explicitly simulate pollutant fate/transport or account for BMPs in series
Project goals

• Produce feasible modeling scenarios
  – Small-scale GIS output for discussions with farming community
• Account for
  – Current crops/rotations
  – Tillage and residue
  – Fertilization
  – Conservation drainage
  – Grassed waterways/filter strips
  – Wetland restoration
SWAT Model

- Continuous, distributed water quality simulation model—predicts effects of land management changes and BMPs
- Physically-based
Modeling scales

30-meter pixels
Sediment yield
Sediment transport
Sediment flow-weighted mean concentration
Otter Creek sediment concentration
Otter Creek nitrate
Model Results

• Sediment loads significantly reduced by
  – Conservation tillage, drainage water management and strategic application of grassed waterways/filter strips

• Phosphorus reductions from conservation tillage

• Nitrate loads significantly reduced by
  – Drainage water management, agronomic fertilization rates and strategic application of wetland restoration
Overall conclusions and recommendations

• Model performed well for what was intended
• Future efforts could
  – Define critical timeframes
  – Evaluate how multiple conservation practices can be combined to optimize water quality benefits for all pollutants
  – Better account for volume loss from DWM
Mitigating Bridge Scour
Case Study from the I–90 River Bridge and Interchange Reconstruction

Nicole Bartelt and Petra DeWall, MnDOT
Lisa Goddard, SRF
Project Need

- Aging bridge with worsening structural deficiencies
  - Fracture critical design
- Narrow shoulders
  - Stalled vehicles caused lane closures
- Adjacent I–90 / US 61 interchange with geometric deficiencies
  - Locations with higher than average accident rates
Project issues

- Wide floodplain
- Limestone bedrock overlain with
  - Topsoil and granular soils of varying thickness
  - Coarse alluvium
- West approach = very dramatic elevation change in narrow corridor
  - Resulted in very tall walls and terraced walls
  - Global stability analysis
Birds Eye View
Constructing in a floodplain

Photo Credit: Dustin Thomas
Scour numbers

- Over 40–ft of scour computed at Pier 1
  - 43–ft for the 100–yr
  - 45–ft for the 500–yr
- Width of scour hole = 2 * Scour Depth
- Piers are designed to be stable for the computed scour
Scour Issues

- Pier 1 close to west river bank, toe of the abutment slope
- Scour from Pier 1 potentially undermines the retaining walls and west abutment slope
- Velocity and depth of river makes placement of filter and riprap difficult
West Abutment

Credit: Project Website
Pier 1 proximity to West Bank

Photo Credit: Dustin Thomas
Toe of West Bank

Photo Credit: Dustin Thomas
West Abutment Stability

Critical Location
West Abutment Stability

Example Failure Surfaces

Could we neglect the piles?
West Abutment Stability

- Embankment/walls were **not stable** on their own for each and every case (e.g. floods, scour)
- Our analyses showed West Abutment was stable (FS>1.2) if piles were neglected, but it was not found to be stable enough (needed FS>1.5); hence **could not neglect piles in analysis**
Example 3-Part Wedge SLOPE/W Analysis (including lateral pile contribution)

Scour protection by riprap

LL surcharge = 250 psf

New Sand Fill

Existing Sand Fill

Fine Alluvium

Upper Coarse Alluvium

Middle Coarse Alluvium

Lower Coarse Alluvium

16-in. CIP piles spaced per foundation plan

12-in. CIP piles spaced per pile plan
Final Design – staging & instrumentation
West embankment construction

Photo Credit: Dustin Thomas
Solution

- Protect Pier 1 so scour doesn’t happen
  - Geobags
  - Riprap layer
  - Scour monitoring
Geobags

Photo Credit: Solomon Woldeamlak
Filling

Photo Credit: Solomon Woldeamlak
Placing

- 3_Geobag_placement.mp4
Scour monitoring

- Fixed–Sonar
- Tilt meters (during construction)
- Float–outs
Fixed Sonar
Tilt meters

Photo Credit: Dustin Thomas
Float-outs
Size
Float-out placement
Project Completion

Credit: Project Website
Drainage Dilemmas in Bluff Country

Case Studies from the I-90 River Bridge and Interchange Reconstruction

Jeremy Nielsen, P.E.
October 19, 2016
Project Background

Looking Southeast
Project Participants

- **Owners**
  - MnDOT
  - WisDOT

- **Stakeholders**
  - FHWA
  - US FWS
  - MnDNR
  - WisDNR
  - Mn Office of Tourism
  - USACE
  - US Coast Guard
  - FAA
  - BWSR
  - MPCA
  - Cities of LaCrosse, Onalaska and La Crescent
  - Counties of Houston, Winona and LaCrosse
  - LAPC
  - LaCrosse Area Chamber of Commerce
  - LaCrosse Area Convention and Visitors Bureau
Consultant Team

- SRF Consulting Group
- Parsons Transportation Group
- Kimley-Horn and Associates
- American Engineering Testing
- Widseth Smith Nolting and Associates
- Isthmus Engineering
- Project Information Services
- Design Center
- Karl Weissenborn
- Goliath Hydro-Vac
- Visu-Sewer
- M-P Consultants
- FIGG (River Bridge)
Project Timeline and Cost

- Final Design 2011-2012
- Construction Began 2013 (Ames Construction)
- Ribbon Cutting Ceremony – October 21, 2016
- Construction Cost - $188M
  - Bridges - $105M
Project Constraints
Complex Design

- 7 Inland Bridges plus River Bridge
- 3 miles of Retaining Walls (MSE and CIP)
- 5 miles of Storm Sewer
Bridge Deck Drainage
Bridge Deck Drainage
Bridge Deck Drainage
Wall Coordination
Wall Coordination
Bluff Flume Analysis
Bluff Flume Analysis
Bluff Flume Analysis
Bluff Flume Analysis
Analysis of Existing Pipe Conditions
Analysis of Existing Pipe Conditions
Analysis of Existing Pipe Conditions
Analysis of Existing Pipe Conditions

- Pipe condition
- Cover depth
- Difficulty of replacement
- Peak flow
- Velocity
- Energy dissipation options
- Connection to RR drainage system
## Analysis of Existing Pipe Conditions

### I-90/US Hwy 61/14 Interchange

**Existing Storm Sewer, Pipe Lining and Energy Dissipation Recommendations**

<table>
<thead>
<tr>
<th>No.</th>
<th>Approximate Location</th>
<th>Material</th>
<th>Length (ft)</th>
<th>SBA/CLA</th>
<th>Condition</th>
<th>Location in Existing Pipe</th>
<th>Recommendations for Project Work</th>
<th>Recommendation for RR Work</th>
<th>Energy Dissipation Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>160-245</td>
<td>300 CMP</td>
<td>46-12</td>
<td>24</td>
<td>Root with sett cement &amp; rock ballast in pipe from bottom to end of pipe north.</td>
<td>Crosses under RR (does not daylight upstream), buried (3) of west of tracks (in RR R/W), crosses under existing retaining wall west of tracks (in RR R/W)</td>
<td>Clean debris from pipe, close pipe to remain (meets under RR and retaining wall, includes bend)</td>
<td>Remove debris from pipe, insulate pipe to remain (meets under RR and retaining wall, includes bend)</td>
<td>Shower of debris upstream of tracks and adjust to surface (OR) Absence of debris (pipe lining will go through RR)</td>
</tr>
<tr>
<td>2</td>
<td>4 upstream of 3</td>
<td>None</td>
<td>160-95</td>
<td>24</td>
<td>Root with tile &amp; rock ballast in pipe from bottom to end of pipe north.</td>
<td>Crosses under RR, end is in RR R/W, crosses under small existing retaining wall west of tracks (in RR R/W)</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Remove debris from pipe, insulate pipe to remain (meets under RR and retaining wall, includes bend)</td>
<td>Shower of debris upstream of tracks and adjust to surface (OR) Absence of debris (pipe lining will go through RR)</td>
</tr>
<tr>
<td>3</td>
<td>All</td>
<td>160-95</td>
<td>21&quot; CDP/21&quot; HCP/28&quot; Cast Iron</td>
<td>24</td>
<td>Piperlass pipe, gusset type transitions, small joints offsets at transitions</td>
<td>Crosses under RR, not connected to pipe from roadway</td>
<td>Align joints/replace pipe if necessary under RR, seal joints (OR) Rebar pipe</td>
<td>Remove debris from pipe, insulate pipe to remain (meets under RR and retaining wall, includes bend)</td>
<td>Shower of debris upstream of tracks and adjust to surface (OR) Absence of debris (pipe lining will go through RR)</td>
</tr>
<tr>
<td>4</td>
<td>4 upstream of 3</td>
<td>None</td>
<td>160-95</td>
<td>24</td>
<td>Root with tile &amp; rock ballast in pipe from bottom to end of pipe north.</td>
<td>Crosses under RR, end is slightly outside of RR R/W</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Remove debris from pipe, insulate pipe to remain (meets under RR and retaining wall, includes bend)</td>
<td>Shower of debris upstream of tracks and adjust to surface (OR) Absence of debris (pipe lining will go through RR)</td>
</tr>
<tr>
<td>5A</td>
<td>All</td>
<td>672-96</td>
<td>48&quot; RCP</td>
<td>24</td>
<td>Minor debris in sewer, significant area with root exposure and rusting, aggregate exposed on interior, possible cracks</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Remove debris from pipe, insulate pipe to remain (meets under RR and retaining wall, includes bend)</td>
<td>Shower of debris upstream of tracks and adjust to surface (OR) Absence of debris (pipe lining will go through RR)</td>
</tr>
<tr>
<td>5B</td>
<td>All</td>
<td>673-12</td>
<td>48&quot; RCP</td>
<td>24</td>
<td>Minor sediment in sewer, significant area with root exposure and rusting, spalling area</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Remove debris from pipe, insulate pipe to remain (meets under RR and retaining wall, includes bend)</td>
<td>Shower of debris upstream of tracks and adjust to surface (OR) Absence of debris (pipe lining will go through RR)</td>
</tr>
<tr>
<td>6</td>
<td>4 upstream of 7</td>
<td>44-132</td>
<td>54&quot; CDP/84&quot; RCP Cast Iron</td>
<td>24</td>
<td>Minor sediment in sewer, sign. in sewer near center, deformation on pipe (loss of 4 in. high 3 ft wide), not on an eroded pipe.</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Remove debris from pipe, insulate pipe to remain (meets under RR and retaining wall, includes bend)</td>
<td>Shower of debris upstream of tracks and adjust to surface (OR) Absence of debris (pipe lining will go through RR)</td>
</tr>
<tr>
<td>7</td>
<td>All</td>
<td>675-A</td>
<td>48&quot; CDP/84&quot; RCP Cast Iron</td>
<td>24</td>
<td>Minor sediment in sewer, sign. in sewer near center, deformation on pipe (loss of 4 in. high 3 ft wide), not on an eroded pipe.</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Remove debris from pipe, insulate pipe to remain (meets under RR and retaining wall, includes bend)</td>
<td>Shower of debris upstream of tracks and adjust to surface (OR) Absence of debris (pipe lining will go through RR)</td>
</tr>
<tr>
<td>8A</td>
<td>None</td>
<td>488-15</td>
<td>56&quot; CDP</td>
<td>24</td>
<td>Minor rust, piping/ends around upstream eaves, downstream sediment (below upstream grade)</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Remove debris from pipe, insulate pipe to remain (meets under RR and retaining wall, includes bend)</td>
<td>Shower of debris upstream of tracks and adjust to surface (OR) Absence of debris (pipe lining will go through RR)</td>
</tr>
<tr>
<td>9</td>
<td>155-240</td>
<td>201-25</td>
<td>48&quot; CDP/48&quot; RCP Cast Iron</td>
<td>24</td>
<td>Rooting pipe (possible)</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Remove debris from pipe, insulate pipe to remain (meets under RR and retaining wall, includes bend)</td>
<td>Shower of debris upstream of tracks and adjust to surface (OR) Absence of debris (pipe lining will go through RR)</td>
</tr>
<tr>
<td>9a</td>
<td>None</td>
<td>200-92</td>
<td>48&quot; RCP</td>
<td>24</td>
<td>Rooting pipe (possible)</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Shower of debris upstream of tracks and adjust to surface (OR) Absence of debris (pipe lining will go through RR)</td>
</tr>
<tr>
<td>10</td>
<td>8 upstream of 12</td>
<td>204-12</td>
<td>24&quot; RCP</td>
<td>24</td>
<td>Rooting pipe, strong pipe (upstream portion to be removed has numerous holes and voids in interior)</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Shower of debris upstream of tracks and adjust to surface (OR) Absence of debris (pipe lining will go through RR)</td>
</tr>
<tr>
<td>11</td>
<td>None</td>
<td>204-12</td>
<td>24&quot; RCP</td>
<td>24</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Replace pipe from highway (significant portion remaining after replacement due to connections and connected velocity)</td>
<td>Shower of debris upstream of tracks and adjust to surface (OR) Absence of debris (pipe lining will go through RR)</td>
</tr>
</tbody>
</table>
Pipe Lining
Pipe Lining
Pipe Lining

54"  Top

I-90 RIVER BRIDGE AND INTERCHANGE RECONSTRUCTION
Pipe Lining
Energy Dissipation
Energy Dissipation

ENERGY DISSIPATION BAFFLE ELEVATION
NOT TO SCALE

ENERGY DISSIPATION BAFFLE - DESIGN SPECIALS 5 & 6
NOT TO SCALE

NOTES:
1. PIPE SUPPLIER TO PROVIDE INSERTS IN MH WALL TO ACCEPT BOLTS.
2. HOT DIP GALVANIZE ALL PIECES AFTER FABRICATION.
3.PIPES WILL BE PAID FOR SEPARATELY.
4. MANHOLE SHALL BE A WSDOT 4020 STRUCTURE.
Energy Dissipation
Unique Project
US 53 Virginia to Eveleth
Minnesota Water Resources Conference
October 19, 2016

Jonathan Libby, PE
Water Resources Engineer
Kimley-Horn & Associates, Inc
Project Background

- **1960**
  - MnDOT acquired an easement that allowed US 53 in Virginia to operate on land that has significant mineral resources. This easement could be terminated on 3 years notice.

- **May 2010**
  - RGGS (land owner) and United Taconite (UTAC) (lessee) gave notice that the US 53 easement would terminate in 3 years

- **Fall 2017**
  - In 2012 RGGS, UTAC, and MnDOT negotiated this as the new termination date, based on project development requirements for a highway relocation project
Project Overview

New Alignment

Rouchleau Pit

Active United Taconite Mine
Final Alignments in DEIS
Alternative M-1

EXISTING US 53

US 53

MIDWAY DRIVE

MN-135

VIRGINIA, MN
Alternative E–1A – Alignment (Fill)
Alternative E-1A – Alignment Bridge

PRELIMINARY – Bridge Type and Pier Location TBD
Alternative E-2

Looking North
The project includes:

- 3.2 mi of new four-lane highway construction
- 1,132 ft. bridge across a former mine pit now filled with water
  - The bridge will be the tallest in Minnesota (204’)
- A new interchange at Highway 53/Highway 135
- Utility and trail relocation
- The total project cost of $240 million
- Construction cost of $156 million
Water Resources Components

- Stormwater Management
  - Water Quality BMPs
  - Diversion Swale
- Rouchleau Pit
- East Bridge Abutment
Stormwater Management

- Water Quality Overview
  - Designed to Minimal Impact Design Standards (MIDS)
  - • Removed Impervious = 34.06 ac
  - • Proposed Impervious = 46.61 ac
  - • Net Increase in Impervious = 12.55 ac

- Exceeds requirements of MPCA Construction General Permit
Stormwater Management

- Best Management Practices:
  - Wet Sedimentation Basin – 1
  - Dry Detention Basins – 2
  - Filtration Basins – 3
  - Infiltration Basins – 39

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>BOTTOM ELEV.</th>
<th>NORMAL WATER ELEV.</th>
<th>OUTLET CONTROL</th>
<th>HIGH WATER ELEV.</th>
<th>POND TYPE</th>
</tr>
</thead>
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<tr>
<td>POND 1</td>
<td>NB TH53 STA 143+00 RT</td>
<td>1578.00</td>
<td>1584.50</td>
<td>CULVERT</td>
<td>1588.03 TYPE 1 WET POND</td>
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<tr>
<td>POND 2</td>
<td>SB TH53 STA 194+00 LT</td>
<td>1531.00</td>
<td>NA</td>
<td>FILTER BERM</td>
<td>1533.00 DRY BIO-DETENTION BASIN</td>
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<tr>
<td>POND 3</td>
<td>NB TH53 STA 194+00 RT</td>
<td>1533.00</td>
<td>NA</td>
<td>FILTER BERM</td>
<td>1533.00 DRY BIO-DETENTION BASIN</td>
</tr>
<tr>
<td>POND 4</td>
<td>SB TH53 STA 197+00 LT</td>
<td>1520.00</td>
<td>NA</td>
<td>DRAIN TILE, OUTLET CTRL STR</td>
<td>1522.00 FILTRATION BASIN</td>
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<tr>
<td>POND 5</td>
<td>NB TH53 STA 197+00 RT</td>
<td>1520.00</td>
<td>NA</td>
<td>DRAIN TILE, OUTLET CTRL STR</td>
<td>1522.00 FILTRATION BASIN</td>
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<tr>
<td>POND 6</td>
<td>NB TH53 STA 215+00 LT</td>
<td>1472.00</td>
<td>1476.00</td>
<td>BERM, OUTLET CTRL STR, DRAIN TILE</td>
<td>1478.74 WET SEDIMENTATION BASIN, FILTRATION BASIN</td>
</tr>
</tbody>
</table>
Infiltration – Modified Filter Berm
Rouchleau Pit

- Drinking Water Source for City of Virginia
  - Best management practices to prevent water quality impacts to Rouchleau Pit
- No deck drains in new bridge
- Treat water prior to discharge
- No infiltration within 500’ due to bedrock and geologic concerns
Diversion Swale

- 36.8 acre drainage area tributary to highway
- Divert water away from highway and east bridge abutment
- Capacity for 100-year design event
- Difficult to access
- Minimal maintenance needs
Diversion Swale

EX. GROUND LINE

COMPACTED EMBANKMENT

2' MIN.

DIVERSION SWALE LIMITS

1 1/2

MATCH INPLACE GROUND LINE

ROCK FACE

10' MAX.

1 1/2 OR

DIVERSION SWALE
STA 182+00 TO 194+00
PAID BY LINEAL FOOT AS "CONSTRUCT DRAINAGE DITCH"
East Abutment Outfall
East Abutment Drainage Path
East Abutment Outfall

- Waterfall Test
  - March, 2016 – 2500 gallons released in 10 minutes
East Abutment Waterfall Test

Abutment

Upper Bench

Middle Bench/Attenuator Bench

Outfall location

Abutment Pad

Upper Bench

Middle Bench

Un-named Bench

Fault contact
East Abutment Outfall – Initial
East Abutment Outfall – Initial

- Upper Channel Design
  - Energy dissipation using St. Anthony Falls Laboratory design research
  - Stilling basin, weirs and baffle blocks
东端接头出水口 – 最终

- 上部通道设计
  - 出水口过落石网
  - 落石锚之间的位置
  - 防水以防止渗透
  - 100年流量率容量
East Abutment Outfall

- Lower Channel Design
  - Waterproof bottom, prevent infiltration
  - Freeze-thaw concerns
  - Impact from falling rock
Construction Schedule

- November 2015: Start of Construction
- November 2017: Open to traffic and vacate existing easement
  - Currently on track for September 2017
- The project is now 60% complete
- June 2018: Final Completion and Landscaping
Girder Fabrication 4/12/16
Project Website

- Google “MnDOT Highway 53”
- Updated information on construction
- Updated photos
- Webcam
- Project Hotline: (218)820–8532
Mitigating Geyser Events in the Minneapolis Tunnel Systems

Minnesota Water Resources Conference
October 19, 2016

Brandon Barnes, PE
Greg Fransen
Lulu Fang
Christian Frias, PhD
Omid Mohseni, PhD, PE
overview

- Case studies for two stormwater tunnel systems
- Hydraulic evaluation
- Structural modifications to tunnel connections
- Conclusions
- Numerous stormwater tunnels located in Minneapolis
- Stormwater directed to Mississippi River
- Increased stormwater runoff
- Rapid pressurization can result in geyser events
Minneapolis stormwater tunnels

geyser – rapid upward movement of an air/water mixture through a tunnel connection

August 1, 2011 geyser event at Como Ave SE and 24th Ave SE
(Source: https://www.youtube.com/watch?v=eO8TP-erR4k)

June 24, 2010 geyser event at 24th Street East and Snelling Avenue
(Source: https://www.youtube.com/watch?v=GIlt4AekMWBM)

May 19, 2013 geyser event at Como Ave SE and 25th Ave SE
(Source: https://youtu.be/eeItLdLUA-g)
two case studies

St. Mary’s stormwater tunnel system

Como Avenue stormwater tunnel system
hydraulic evaluation

- XP-SWMM used for hydrologic calculations
- ITM used for hydraulic analysis
- OpenFOAM used for two-phase flow analysis

*Depth of water does not reach zero because pressure transducers were positioned above tunnel invert by approximately 1.5 feet*
hydraulic evaluation

- simulation results used to define boundary conditions for OpenFOAM simulations
- measured pressure simulated with XP-SWMM and Illinois transient model
- Illinois Transient Model identified potential air pocket locations
sample OpenFOAM simulation

hydraulic design criteria
- vertical force
- chamber volume
- open area
surge chamber schematic
surge chamber construction
conclusions

• hydraulic evaluation can identify design criteria for surge chambers

• surge chamber construction based on hydraulic evaluation allows pressure release without geyser events

• monitoring of existing tunnels is critical to identify issues
thank you.

Brandon Barnes, PE
Barr Engineering
bbarnes@barr.com
952-832-2737
sample OpenFOAM simulation
Development of Planning Toolsets using XP-SWMM and GIS Systems

October 19, 2016

Presented by
Ed Matthiesen, P.E.
Bryce Cruey, P.E., C.F.M.
Introduction to The System
Developing a Watershed Model
Data Management and Workflow
Developing Practical Management Tools
Q & A
Introduction to the System

- Coon Creek Watershed
- 107 Sq. Mile Watershed
- 134 Miles of Public Ditches

- Floodplain
  - Zero net loss policy
  - Property Damage and Public Safety

- Surface Water Safety

- Water Quality

- Floodplain

- Wildlife Habitat
Model Development

In 2013 and 2014, Wenck Associates worked with the District to update its XP-SWMM model.

Cross Section Surveys

Datum Conversion

LiDAR

City Cooperation

- Storm Sewer Data
- New Bridge Crossings
- As-built data

NOAA Atlas 14

Precipitation-Frequency Atlas of the United States

October 19, 2016
Cross Section Surveys

- Replace large storage areas with cross sections
- Improve floodplain hydraulics
LiDAR

October 19, 2016
City Data

- Link storm sewer information into the model for urbanized areas
- Account for rate control projects within the District.
Challenge
How to best manage a large collection of data and incorporate it into a stormwater model??
Geodatabase

Management of an Organized Collection of Data

CCWD Data
City Data
Geometry Inputs
Hydrology Inputs
Model Outputs
Workflow

- Data Collection & Organization
- QA/QC
- Geodatabase
- Mapping
- Model Runs & Calibration
- XP-SWMM Inputs
Developing Practical Management Tools

- Floodplain Management
- Development Projects
- Asset Management
Developing Practical Management Tools
Questions

Contact Information
Bryce Cruey, P.E. (MN, CA), C.F.M.
Water Resources Engineer, Associate
bcruey@wenck.com
D – 763.479.4241
C – 612.418.0565
OUTLINE

• Purpose of Stream Crossing Guidelines
• New Culvert Legislation
• Stream Impacts from Culverts
• Overall Inventory Process
• Review of Ranking Parameters
• Watersheds Applying Ranking Guidelines
• Next Steps
• Culvert Training
• Summary
STREAM RESTORATION - SYSTEMS PERSPECTIVE

• 5 Components
  • Hydrology
  • Connectivity
  • Water Quality
  • Geomorphology
  • Biology

• Used for ranking restoration projects

• All 5 can be affected by stream crossings (culverts)
PURPOSE OF STEAM CROSSING INVENTORY

- Inventory All Stream Crossings
- Assign Culverts with a Barrier Ranking
- Use assigned Barrier Rankings to prioritize culverts for replacement or restoration
Sec. 91. Minnesota Statutes 2014, section 103G.245, subdivision 2, is amended to read:

Subd. 2. Exceptions. A public waters work permit is not required for:

(1) work in altered natural watercourses that are part of drainage systems established under chapter 103D or 103E if the work in the waters is undertaken according to chapter 103D or 103E; or

(2) a drainage project for a drainage system established under chapter 103E that does not substantially affect public waters; or

(3) culvert restoration or replacement of the same size and elevation, if the restoration or replacement does not impact a designated trout stream.
MN STREAM PRACTITIONERS
WHITEPAPER

• DRAFT – In Review
  • Road crossings as barriers
  • Types of barriers
  • Documented impacts
  • Endangered species
  • Sediment impacts
  • Advances in culvert design
  • Cost effectiveness of properly designed culverts
• Intended for the public, DNR Management and Legislators

Written by:
Minnesota Stream Practitioners
September 2016

A Response to Minnesota Statutes 6459, Section 547.689, Subd. 2. Exceptions. A public waters work permit is not required for: (3) culvert restoration or replacement of the same size and elevation, if the restoration or replacement does not impact a designated trout stream.

Upholding Minnesota Statutes 2015, Section 103G.245, subdivision 2, (CHAPTER 4-S.F.No. 5., page line 153.20 – 153.28) will have the unintended consequence of perpetuating existing and future negative impacts to Minnesota streams due to improper culvert design. This statute creates an exception to the need for a Department of Natural Resources (DNR) Public Waters Work Permit for culvert restoration and replacement (on non-trout streams) when replaced with a culvert of the same size and elevation. Eliminating the need for a permit ensures that ecological damage caused by improper culvert placement in the past will persist. The loss of oversight provided by permitting could lead to further degradation of these biological systems. The perpetuation of ecological damage supported by this statute is counter to the mandate set by Minnesota (MN) voters when they approved the Clean Water, Land and Legacy Amendment to protect, enhance and restore fish, game and wildlife habitats; and to protect, enhance and restore rivers and streams.

Road-stream crossings have the potential to negatively affect the physical and biological function of our streams if designed and installed improperly. Methods used in the past for sizing and installing stream crossings were based on a less complete understanding of these potential impacts. Currently, many of the culverts dispersed throughout our watersheds are negatively impacting the biological and physical function of these stream networks. DNR Public Waters Work Permits can mitigate harmful impacts and provide a tool for education that influences future culvert designs.
MESBOAC – A GUIDE FOR CULVERT PLACEMENT

- Match culvert and bankfull width
- Extend culvert length through side slope toe
- Set culvert slope same as stream slope
- Bury culvert 4” to 2’
- Offset Multiple culverts
- Align culverts with the stream (riffle)
- Check headcuts with grade control (below and/or above)
MAJOR DESIGN MISTAKES

- Setting the culvert too high
- Improper sizing of culvert
- Poor alignment
- Not aligning slope with stream slope
STREAM IMPACTS FROM IMPROPERLY DESIGN CULVERTS

- Fish Migration Barrier
  - Jump, Velocity, Depth, Turbulence, Lack of substrate and Debris
- Alter aquatic habitat assemblages
- Geomorphological Impacts
  - Alter sediment transport dynamics
- Alter flow regimes
  - Velocity
  - Depths
- Alter water quality
  - Turbidity
  - Water temperatures
INVENTORY PROCESS

• Overall Inventory Process
  • Digitizing Site Locations
  • Photo documentation
  • Data Collection
  • Onsite Barrier Assessment
PHOTO DOCUMENTATION

Structure

River

Downstream

Upstream
Figure 13: General locations of survey points (elevations and water depths). Measurements include: headwater surface (HWS), tailwater surface (TWS), upstream (US) and downstream (DS) invert elevations, US and DS stream bed elevations, DS hydraulic control, US and DS water depths in the deepest part of each opening, and vertical scour water depth.

- Site information
- General crossing information
- Culvert dimensions
- Degree of perching
ONSITE BARRIER RANKING

- Determine if site is a fish barrier
  - Outlet drop
  - Velocity
  - Depth
  - Substrate

- Determine if site has an impact of geomorphic stream stability
# BARRIER RANKING PARAMETERS

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Degree of Barrier</th>
<th>Parameters Characterizing Barrier Type</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Complete</td>
<td>&gt;2.0 ft perched (Aadland, personal communications, September 9th, 2014)</td>
</tr>
</tbody>
</table>
| 2       | Significant       | 0.5-2.0 ft perched (WDFW, USFS et al. 2011)  
<0.8 sizing width ratio (constricted)  
Not countersunk and one or both:  
- Water/Culvert Slope >1% (WDFW 2000)  
- Headloss of >1.0 ft |
| 3       | Partial/Seasonal  | Water depth <0.2 ft (USFS et al. 2011)  
Upstream Pool or evidence of backwatering (USFS et al. 2011, Verry 2011)  
Downstream scour pool (USFS et al. 2011)  
>2.0 sizing width ratio (overwide) |
| 4       | Passable          | No parameters exceed set limits |
| 5       | Dry               | No data collected at dry crossings |
WATERSHEDS IMPLEMENTING THESE GUIDELINES

- Nemadji
- Root River
- Buffalo
- Cottonwood
- Snake Otter Tail
- Kettle
- St. Croix
- Miss R La Crescent
- Miss R Reno
- Upper Iowa
- Upper Wapsipinicon
ROOT

Root River Watershed Non-Bridge Crossings
Ranking Summary

Legend
- Root River
- Non-Bridge Crossings
- Ranking
  - 1
  - 2
  - 3
  - 4
  - 5
- DAM
- UND
- Perennial Streams
5.6% of sites are complete barriers
- Ranking Level 1
- Dams
75.5% of sites (Levels 1, 2 and 3) were a barrier of some degree
Only 5.9% of sites were ranked as passable
48.2% of crossings were bridges
### BUFFALO RIVER
### NUMBER OF SITES IN EACH RANKING

<table>
<thead>
<tr>
<th>Ranking Level</th>
<th>Number of each Rank</th>
<th>% of Non-bridge Crossings</th>
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</thead>
<tbody>
<tr>
<td>Rank 1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Dam</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Rank 2</td>
<td>38</td>
<td>31</td>
</tr>
<tr>
<td>Rank 3</td>
<td>27</td>
<td>22</td>
</tr>
<tr>
<td>Rank 4</td>
<td>39</td>
<td>32</td>
</tr>
<tr>
<td>UND</td>
<td>8</td>
<td>7</td>
</tr>
</tbody>
</table>
BUFFALO WATERSHED RANKINGS
SITE 14-0001

- June 2014
- DS most site of watershed
- Assumed it was a bridge
SITE 14-0001 OCTOBER 2015

- Entire watershed is draining through 2 pipe-arch culverts
- Culverts are cemented in place
- Sizing width ratio: 0.5
SITE 14-0100

- Sizing Width Ratio: 0.54
SITE 3-0116

- Water slope: 6.3%
- Headloss: 3.51 ft
- Culvert Slope: 2.5%
- Perched >2.0 ft
- Large DS Scour Pool
CULVERT TRAINING

• Attendees
  • Local Fisheries Staff
  • Local Hydrologists
  • SHP

• In office training for about 1 hour
  • Datasheets
  • Measurement locations
  • Culvert Issues
  • Ranking

• Field data collection on-site

• Others interested in a similar type of training?
NEXT STEPS

• Continue with watershed culvert inventories
• Develop prioritization methods
• Culvert remediation funding package
• Seek out other groups to consolidate/collect data
• Training
SUMMARY

- Methodology can be replicated
  - assign each crossing a barrier ranking
- A complete statewide inventory is needed
- Necessity for
  - improved culvert design and
  - permitting regulation
- CONTACT INFORMATION:
  - Amanda Hillman
  - Amanda.hillman@state.mn.us
  - 218-739-7576 ext. 276
Flocculation BMPs for Reducing the Sediment in Construction Water Discharges

Nazli Yilmaz Wodzinski, PhD
Stephen J. Druschel, PhD, PE
Construction Waters

Sources

• Stormwater
• Dewatering fluids
• Tremie slurries

BMPs

• Prevent run-on / erosion
• Trap and settle
• Filter
But: What If Not Enough Site Room, or Sediments Won’t Settle?
Sediments = Dead Critters or No Critters

- Sediments entomb stream bottom animals
- Habitat loss
- Disruption to food chain
- Sterile, muddy waters
Flocculation Treatment

Make particles bigger to settle faster & filter better.

“Chemical Velcro”

- Reduces settlement time from days to minutes (performance)
- Move from big basins to small tanks (space saving)
Flocculation for Water Treatment

- Inject flocculant chemical into turbid water
- Flash mix – blend chemical throughout water
- Slow mix – “caress” water to slowly form flocs
  - Mixing too much at this stage can break flocs up
- Gravity clarify water – sedimentation
  - Sediment becomes sludge (bottom mud)
- Possibly: filter water
  - Sand or geotextile
Previous Work: Jar Testing of 21 Flocculant Chemicals on 57 Soil Sources

- Jar Testing: Bench scale beaker tests
  - Effectiveness
  - Reaction timing – basis for treatment facility size

- Phase I: Effects screening
  - Every soil-chemical combination done twice

- Phase II: Dose assessment
  - Optimization with selected flocculant chemicals & all soils

- 4500 total determinations
Flocs Capture Colloidal Particles
Bench Scale Mixing Tests

- **How best to flash mix on a construction site?**
  - Blending in flocculant
  - Evenly disperse throughout water
  - Reduce “fish eyes”, over treatment, or under treatment

- **How best to slow mix on a construction site?**
  - Cause particles to bump into each other
  - Form flocs big enough to settle
  - Aggregate flocs for quicker cleaning

- **How best to use gravity to clear water?**
  - Will flocs drop fast enough?
Flocculation Treatment BMPs for Construction Water Discharges
Experiment Setup
Preparing the river silt – water mix by air lance
Flash mixing by air lance
Different flumes used for slow mixing

- 9 ft. flume with 1.0 in. diameter cylinders arranged as obstacles.
Different flumes used for slow mixing

- 9 ft. flume with 6 ft. of pea rocks and 3 ft. of 1.0-1.5 in. river washed rocks used as obstacles.
Different flumes used for slow mixing

- 9 ft. flume with 9 ft. of 1.0-1.5 in. river washed rocks used as obstacles.
Clarification in a sedimentation “Pond”
Clarification in a sedimentation “Pond”
Experiment Results:
Experiment Results:
Experiment Results: 95% removal av. (35 – 50 NTU)
Experiment Results: 94% removal av. (40 – 140 NTU)
Experiment Results: 93% removal av. (40 – 100 NTU)
Experiment Results: 94% removal av. (32 – 120 NTU)
Experiment Results: 95% removal av. (29 – 60 NTU)
Experiment Results: 98% removal av. (NTU < 25)

Mankato Topsoil - 6 ft. pea rock - 3 ft. 1"-1.5"- 9 ft

![Graph showing turbidity over time for Sedimentation Tank L and Sedimentation Tank R.](image-url)
Experiment Results: 99% removal av. (NTU < 25)

Mankato Topsoil - 9 ft. 1"-1.5"- 9 ft

Minneapolis State University Mankato
Implementation:
250 gpm = 1 acre foot / 24 hours

- Flow rate of 250 gpm can be managed on construction site
  < Diaphragm pumps run by an air compressor (noise?)
  < Bigger flow rates may need ductile iron piping and a crane...

- Chemical and dose rate
  < Use ferric chloride for Minnesota soils – broadly effective
  < Mixes well – quickly and uniformly
  < Dose rate of 0.2 mL/L = 65 gal/acre foot
Implementation:
250 gpm = 1 acre foot / 24 hours

- Mixing and clarification in three stages:
  - Flash mix – 6 seconds & a lot of energy
    - 25 gal volume at 250 gpm – outboard motor in 55 gal drum?
  - Slow mix – 20 minutes & slow pulsing/turning
    - 5,000 gal vol at 250 gpm – 25 cy roll off with air injection?
  - Gravity clarify – 60 minutes of quiet, peaceful time
    - 15,000 gal vol at 250 gpm – sedimentation pond forebay?

- In channel mixing – effectiveness likely to slip over time
  - Channel likely to smooth over due to sediment deposition
  - Needs further evaluation on site
Implementation:
250 gpm = 1 acre foot / 24 hours

- **Sediment sludge collection**
  - Likely 5 – 10% solids
  - Can calculate likely volumes using TSS tests
  - E.g., at 100 mg/L TSS, 12 cy sediment sludge per ac-ft treated

- **Sediment sludge disposal**
  - Need to dry out before excavate and haul?
  - Will contain flocculant constituents
    - Ferric chloride = “salty iron”
  - Use for soil improvement?
    - Will add water holding capacity when blended in
Acknowledgements

- Minnesota Department of Transportation
- Research Contract 00734
- City of Mankato Waste Water Treatment Plant
- Minnesota State University
  - Center for Transportation Research and Implementation
  - Undergraduate Students:
    - Jenna Lepper, Julia LaGuardia, Thu (Amy) Nguyen, Eric Benson, Jeremy Stalcar, Jeffrey Her, Mary Kloos, and Tyler Bache