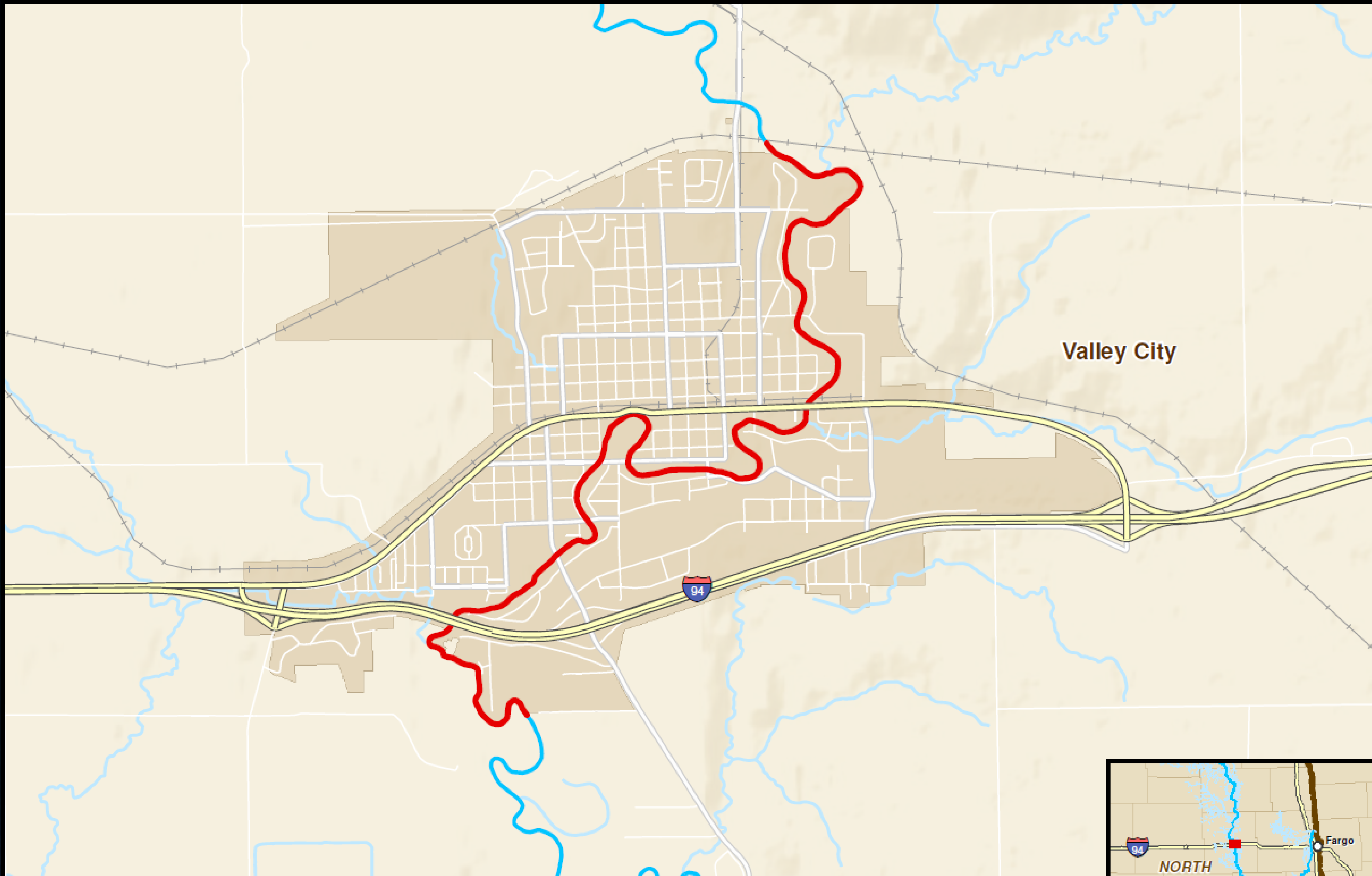
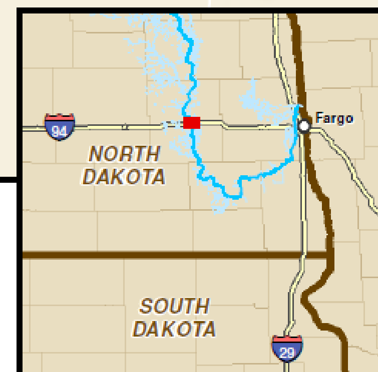
Sheyenne River Comprehensive Bank Stability and Restoration Study

VALLEY CITY, ND
2013

North Dakota Water Quality Monitoring Conference
March 4-6, 2014
Bismarck State College
National Energy Center of Excellence
Sponsored by the North Dakota Water Quality Monitoring Council





Study Area

Sheyenne River Bank Restoration Study
Valley City, ND

JOB NO. 31811365

URS

Legend

Study Limits

Sheyenne River

Sheyenne Basin Stream

Map Scale
1:35,000

0 1,400 2,800
Feet

Purpose and Need

- The Sheyenne River plays a vital role both to the aesthetics and economics of Valley City.
- The City of Bridges boasts a walking tour of many of the eleven historic bridges that cross back and forth along the Sheyenne River.
- A combination of recent extreme flooding and increased summertime low flows have accelerated streambank retreat throughout the study reach.

Project Goals

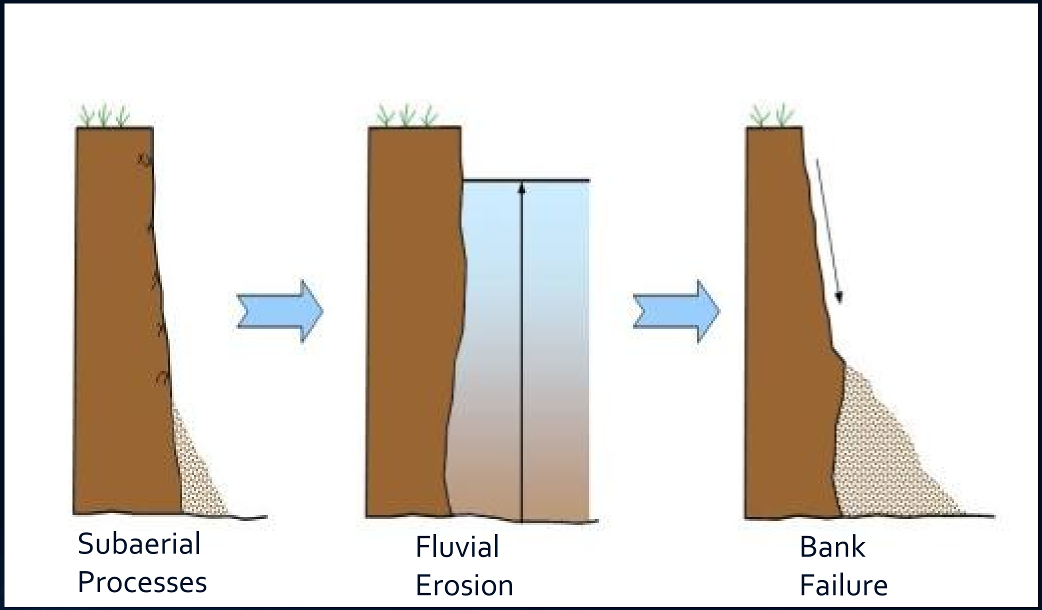
1. Evaluate the hydraulic and erosive properties under a wide range of discharge scenarios,
2. collect and evaluate data on bank erodibility and geomorphic stability,
3. predict sections of the channel that will continue to be at risk for channel degradation and streambank retreat, and
4. where conditions permit, focus on natural streambank restoration techniques also known as bioengineering.

Background – Hydrology/Hydraulics

- Flood waters in the Sheyenne River were at or near the 100-yr flood in both 2009 and 2011.
- Summertime low flow values have increased as the result of discharge from Devils Lake outlets.
- USACE conducted a Sheyenne River Flood Risk Management Feasibility Study in Valley City. Phase 1: updated hydrology and hydraulics, completed in December 2012.
- Updated HECRAS model represents significant cost saving to project.

Background - Geomorphology

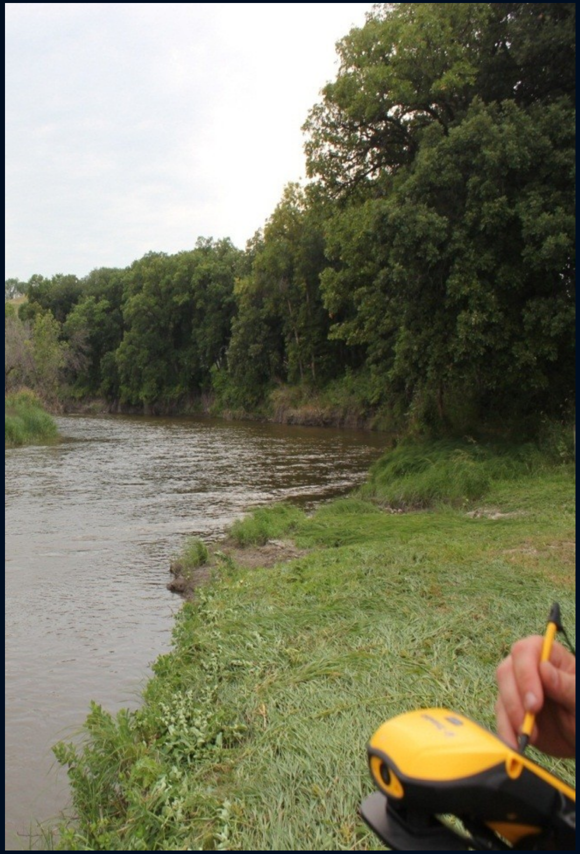
- Subaerial processes: Tension cracks caused by frost heave or the freeze/thaw cycle will increase the susceptibility of the banks of the Sheyenne River to erosion at higher flows.
- Fluvial erosion: At higher discharge rates, flowing water will possess enough energy to entrain and remove bank material. Fluvial erosion typically removes material from the toe of the bank leaving bank faces near vertical to overhanging.
- Bank Failure: Bank failure or mass wasting takes place when the weight of the bank is greater than the shear strength of the bank material. Mass wasting or bank failures tend to take place as floodwaters recede.



Wynn, T.M. 2006. Streambank Retreat: A Primer. AWRA Hydrology and Watershed Management Technical Committee, Watershed Update January – March 2006, Volume 4, No.1.

Methods – Data Collection

- 216 bank elevation points.
- 212 photographs taken from 89 different locations.
- 19 sediment samples from 10 different SSURGO soil mapping units.
- Rapid Geomorphic Assessment (RGA) was completed on 43 individual stream reaches.
- Notes on geomorphology and the presence or absence of artificial revetment were recorded throughout.



Bank Failure and Artificial Revetment

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Legend
- Bank Failure
- Artificial Revetment
- Stream Bank

N

Map Scale 1:4,000

0 160 320
Feet

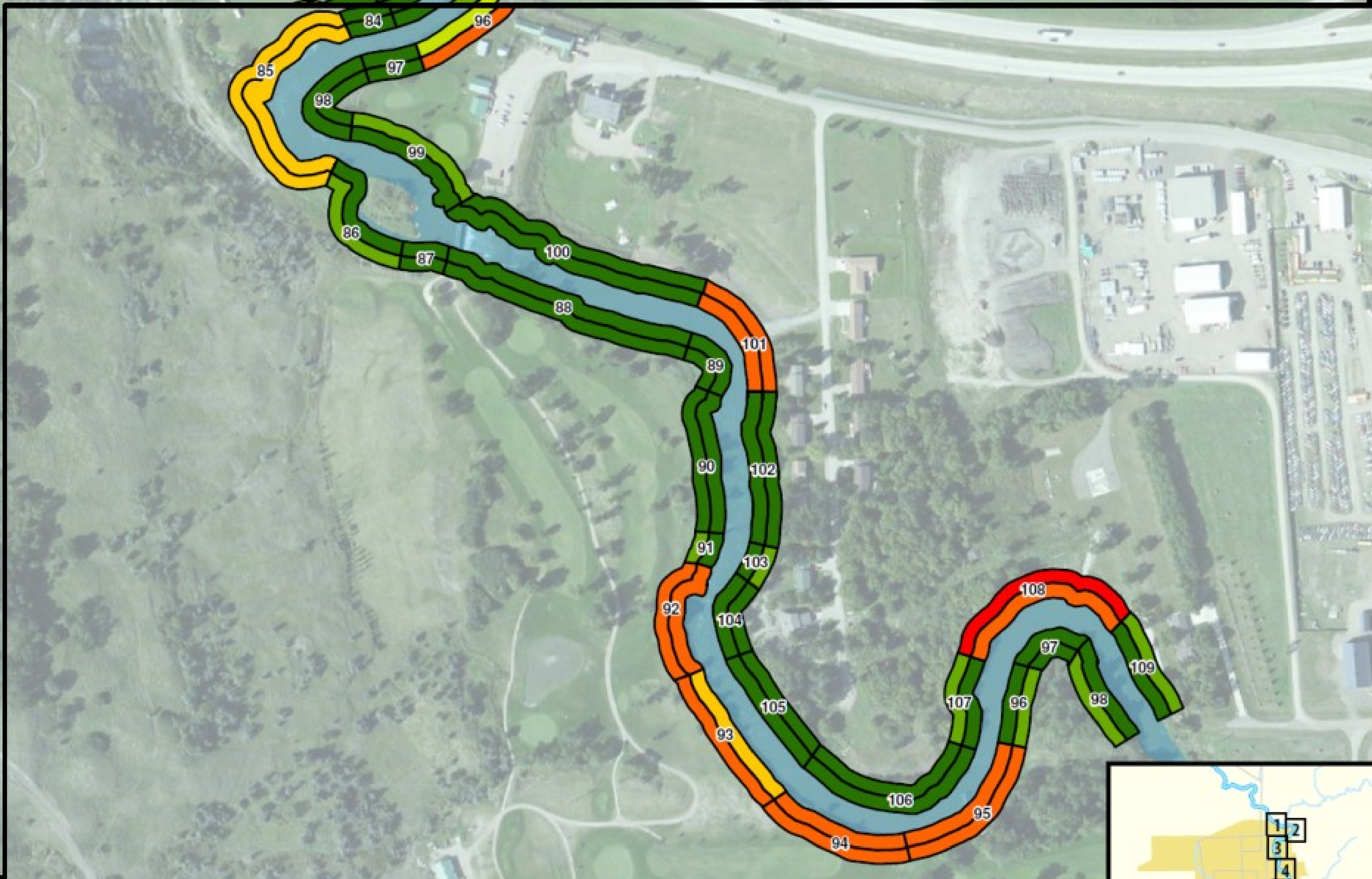
Methods – Sediment Production

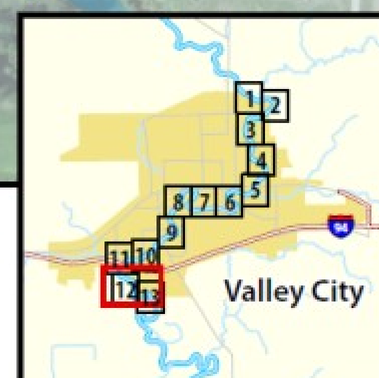
- $\varepsilon = 8.64x10^6 * k_d(\tau_a - \tau_c)^a$
  - ε = erosion rate (cm/day)
  - k_d = erodibility coefficient (cm_3/N-s)
  - τ_a = applied shear stress on soil boundary (Pa)
  - τ_c = critical shear stress (Pa)
  - a = exponent typically assumed to be 1

- $\tau_c = 0.16(I_w)^{0.84}$
  - I_w = plasticity index (dimensionless)

- $k_d = 0.2\tau_c^{-0.5}$
  - k_d = erodibility coefficient (cm_3/N-s)

- $K_b = 3.2135(R_c/T_w)^{-0.2657}$
  - K_b = ratio of shear stress in an outer meander to the straight channel approach shear stress (dimensionless)
  - R_c = radius of curvature of the bend to the channel centerline (feet)
  - T_w = main channel top width (feet)





20-Year and 100-Year Flood Erosion Rates

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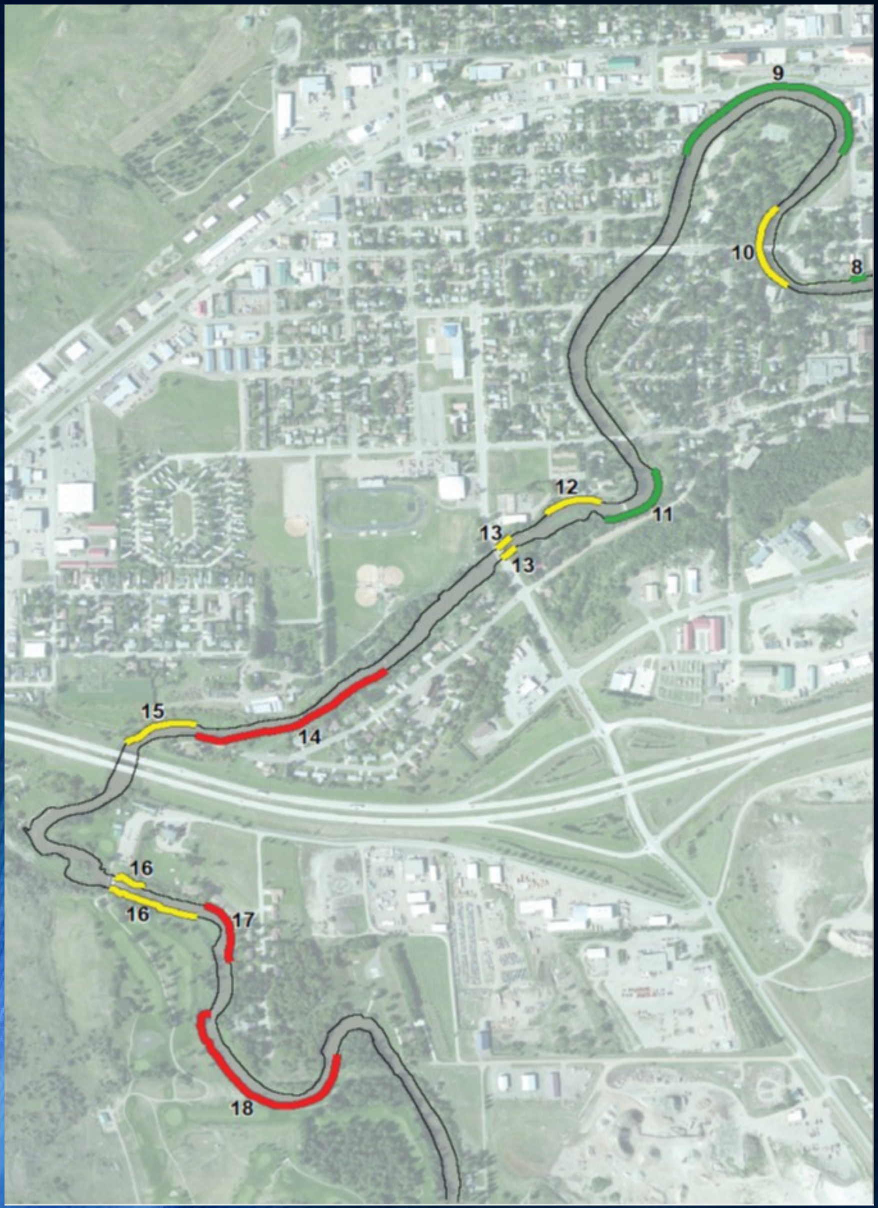
Erosion Rate (cm/day)

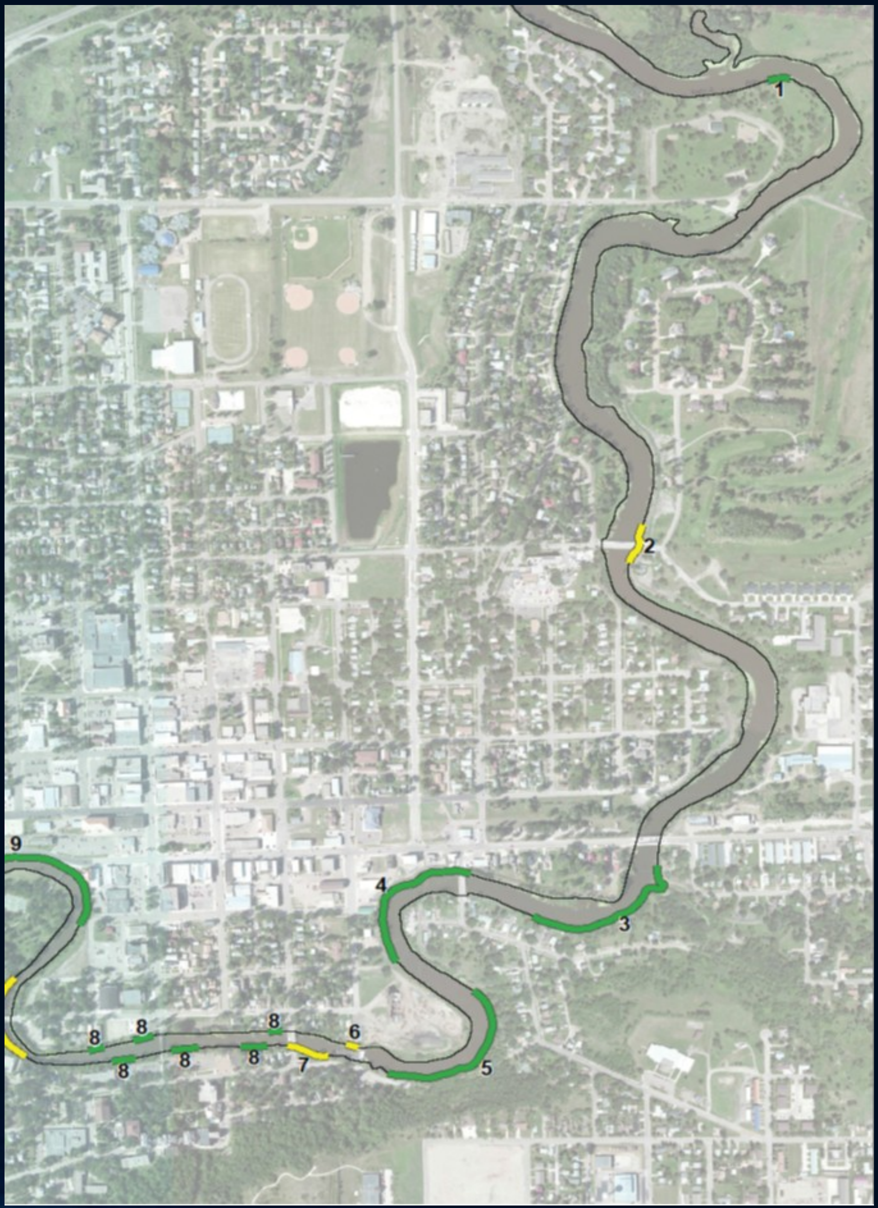
- 0 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 35
- 36 - 51

Map Scale 1:4,000

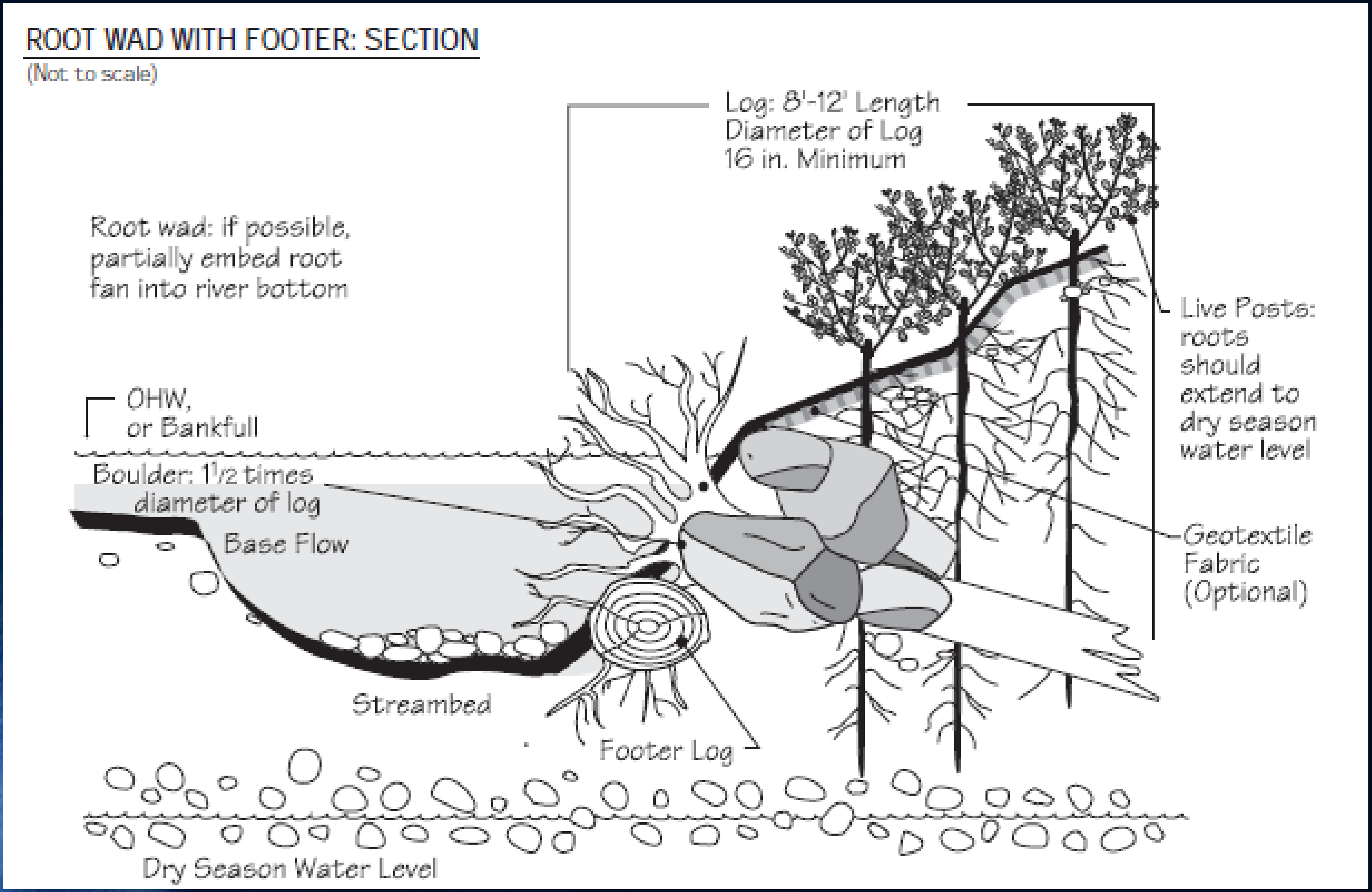
0 160 320
Feet

Priority Management Areas



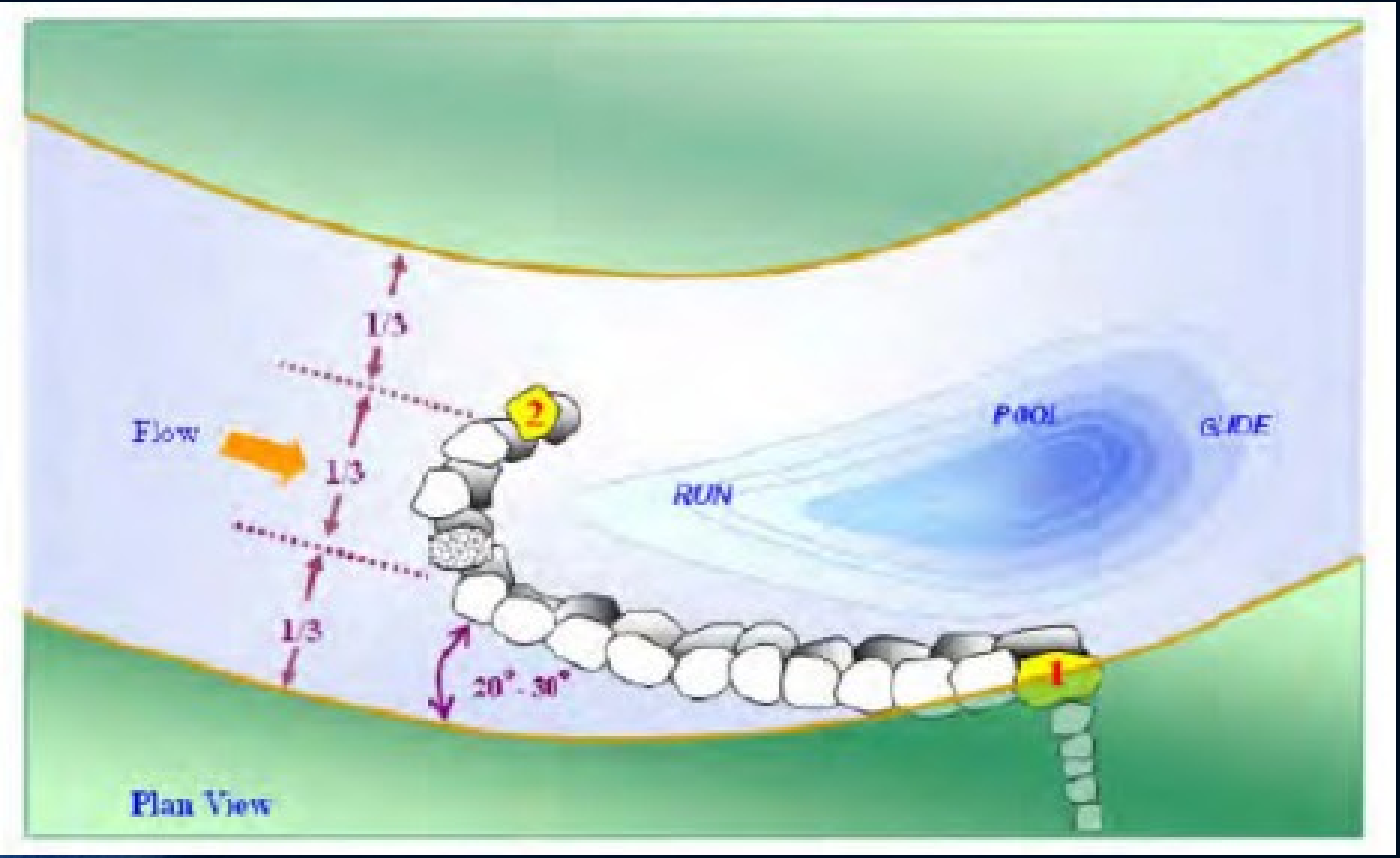


Bioengineering Toolbox – Toe Protection



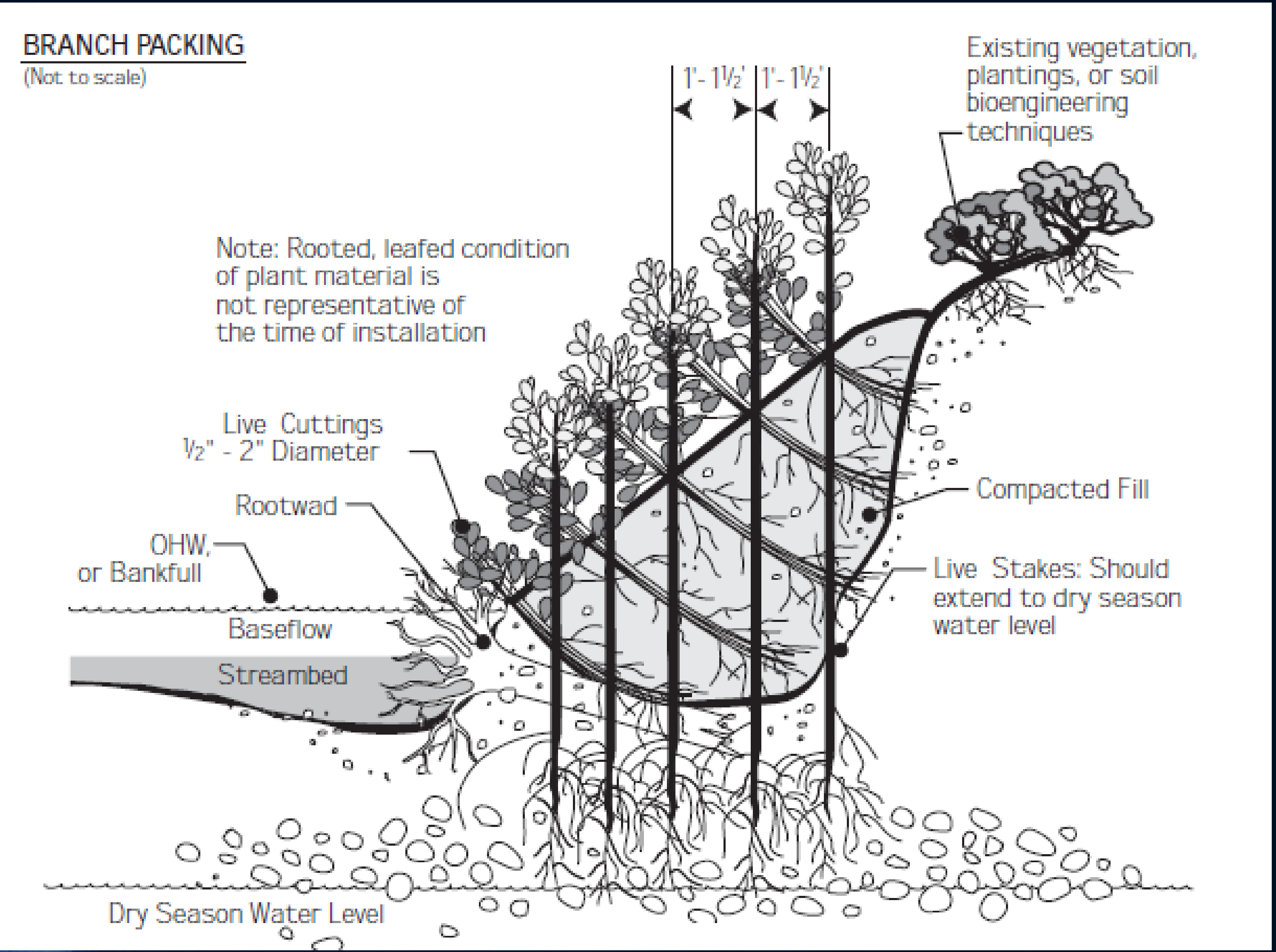
US Department of Agriculture Forest Service. 2002. A soil Bioengineering Guide for Streambank and Lakeshore Stabilization. October, 2002.

Bioengineering Toolbox – In-stream Deflection



Natural Resources Conservation Service (NRCS). 2007. Rosgen Geomorphic Channel Design. Part 654 Stream Restoration Design. National Engineering Handbook. Chapter 11.

Bioengineering Toolbox – Bank Stabilization



US Department of Agriculture Forest Service. 2002. A soil Bioengineering Guide for Streambank and Lakeshore Stabilization. October, 2002.

Next Steps

1. The study prioritized restoration areas based solely on geomorphology. It is a tool for the community to use in determining next steps.
2. Valley City formed an Erosion Committee containing private landowners, City officials, and the Soil Conservation District.
3. Projects will be prioritized by both severity of risk but also the presence of significant Valley City infrastructure.
4. Work done on any potential projects will need to coordinate with current permanent flood protection efforts.
5. Community focus is on both identifying projects and finding potential sources of funding.

Questions?