Battle Creek: Lessons Learned from Tinkering at a Confluence

Steven Yochum, PhD, PE
Hydrologist
U.S. Forest Service
National Stream and Aquatic Ecology Center
Fort Collins, Colorado
(formerly with the Natural Resources Conservation Service)

Presentation Overview

- Overview of stream condition, pre-implementation of stream project
- Summary of flow frequency
- Summary of stream project
- Response of streams to three years of high flows, with consequence to stream project
- Post-project evaluation
- Lessons learned

Battle Creek at Little Snake confluence

- Northwest Colorado, on Wyoming Border
- Average Annual Precipitation: 19 to 55 inches

Imagery: 2011

Battle Creek at Little Snake confluence

4/2012

- Battle Creek, in reach of concern

Battle Creek at Little Snake confluence

Battle Creek*:

- watershed area: 83 mi^2
- Q (2 year): ~ 650 cfs
- Q (10 year): ~ 1260 cfs
- Q (100 year): ~ 2140 cfs

Little Snake River**:

- watershed area: 252 mi^2
- Q (2 year): 2200 cfs
- Q (10 year): 3610 cfs
- Q (100 year): 4980 cfs

* values from USGS Streamstats

** values from USGS streamgage records (09253000) and log-Pearson Type 3 analysis

Pre-Project Condition

8/4/2004

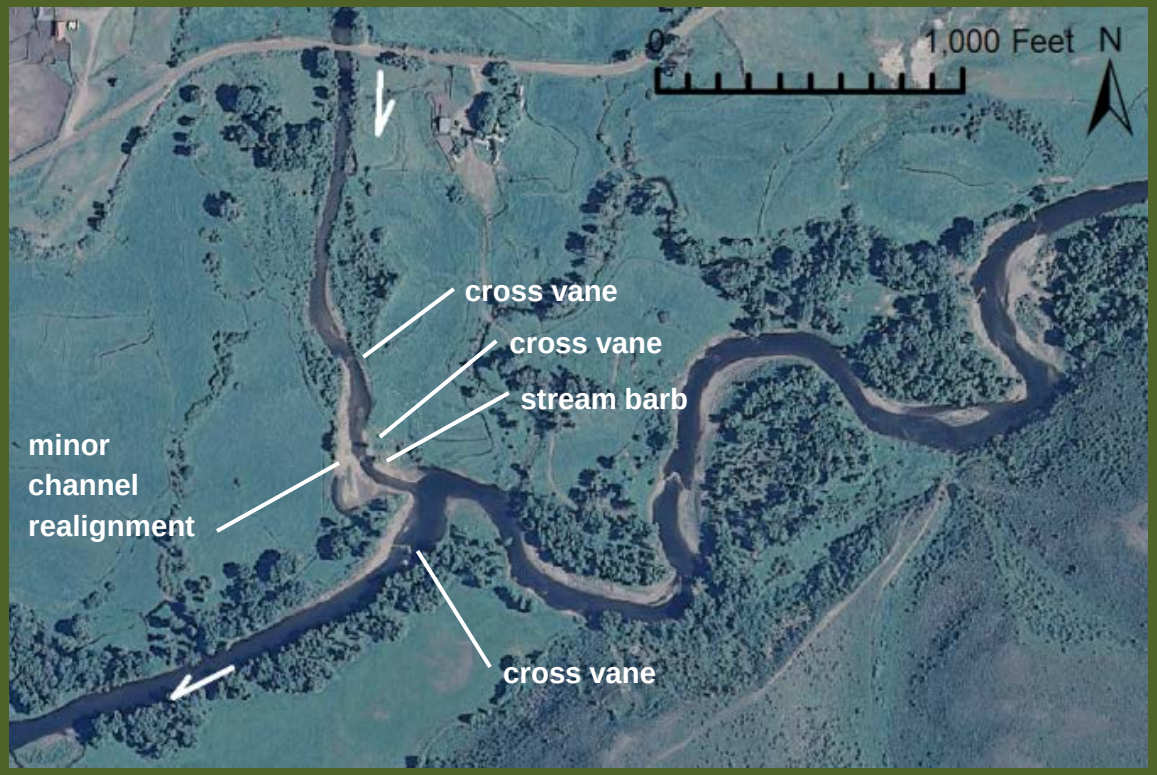
- Tight meander, with dense patch of cottonwood
- Battle Creek flowing into Little Snake with upstream orientation
- Bank erosion, in places
- Cattle grazing to channel edge

Pre-Project Condition

9/19/2006

- Tight meander was cutoff, presumably by heavy machinery, by landowner

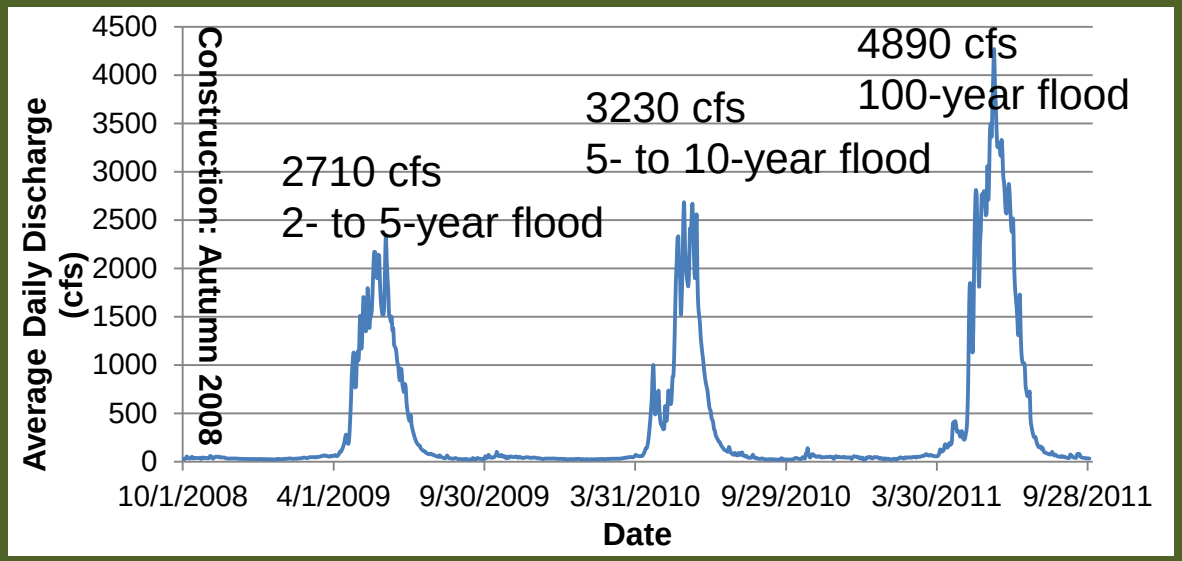
Construction (Autumn 2008)



7/23/2009

- Objectives: Unclear from documentation. Presumably:
  - bank protection
  - fish habitat improvement
- Cross vanes & barbs (Battle Creek)
- Cross vanes & barbs (Little Snake)
- <u>Minimal project planning</u>

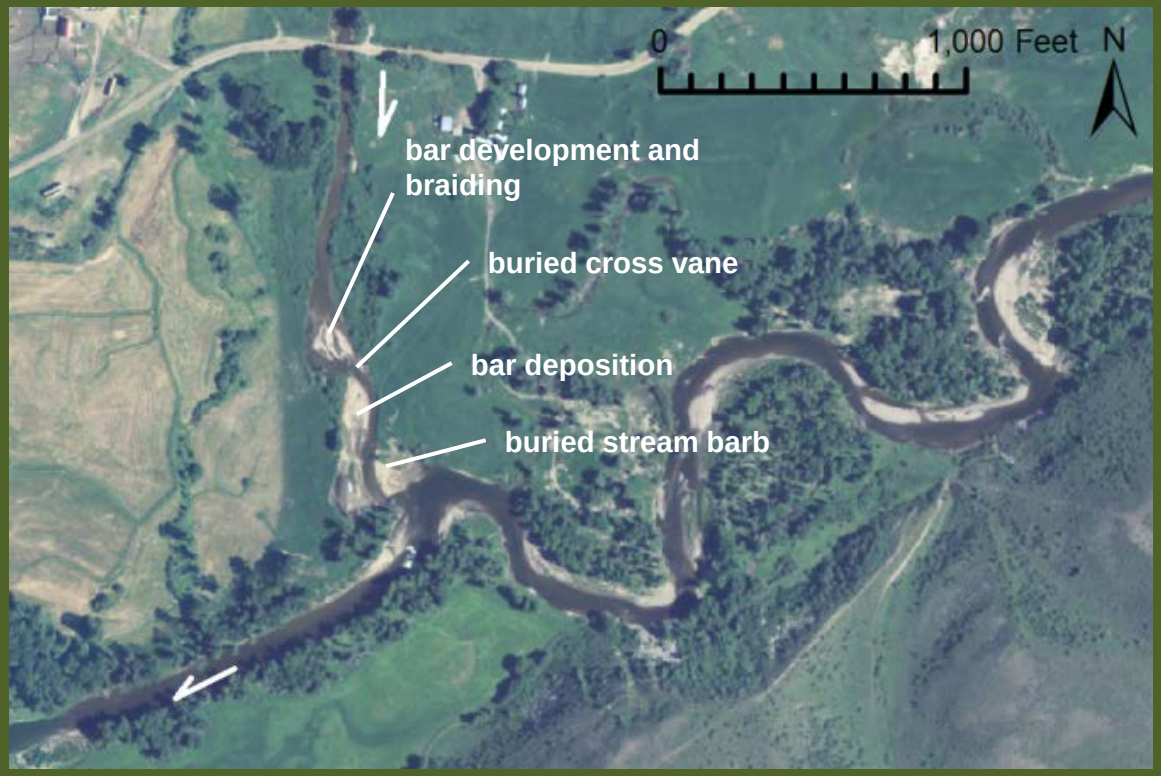
Post-Construction Flooding



Little Snake River near Slater (09253000)
~5 miles upstream of Battle Creek confluence

- During the next three years: Out-of-bank flow occurred each year:
  - 2- to 5-year flood
  - 5- to 10-year flood
  - 100-year flood

Flooding Ramifications



7/23/2011

- Avulsion, bar deposition, braiding in Battle Creek
- Bank erosion
- Pool filling
- Erosion, bar deposition at confluence
- Floodplain deposition
- Unhappy landowner, who blamed project

Post-Flood Condition

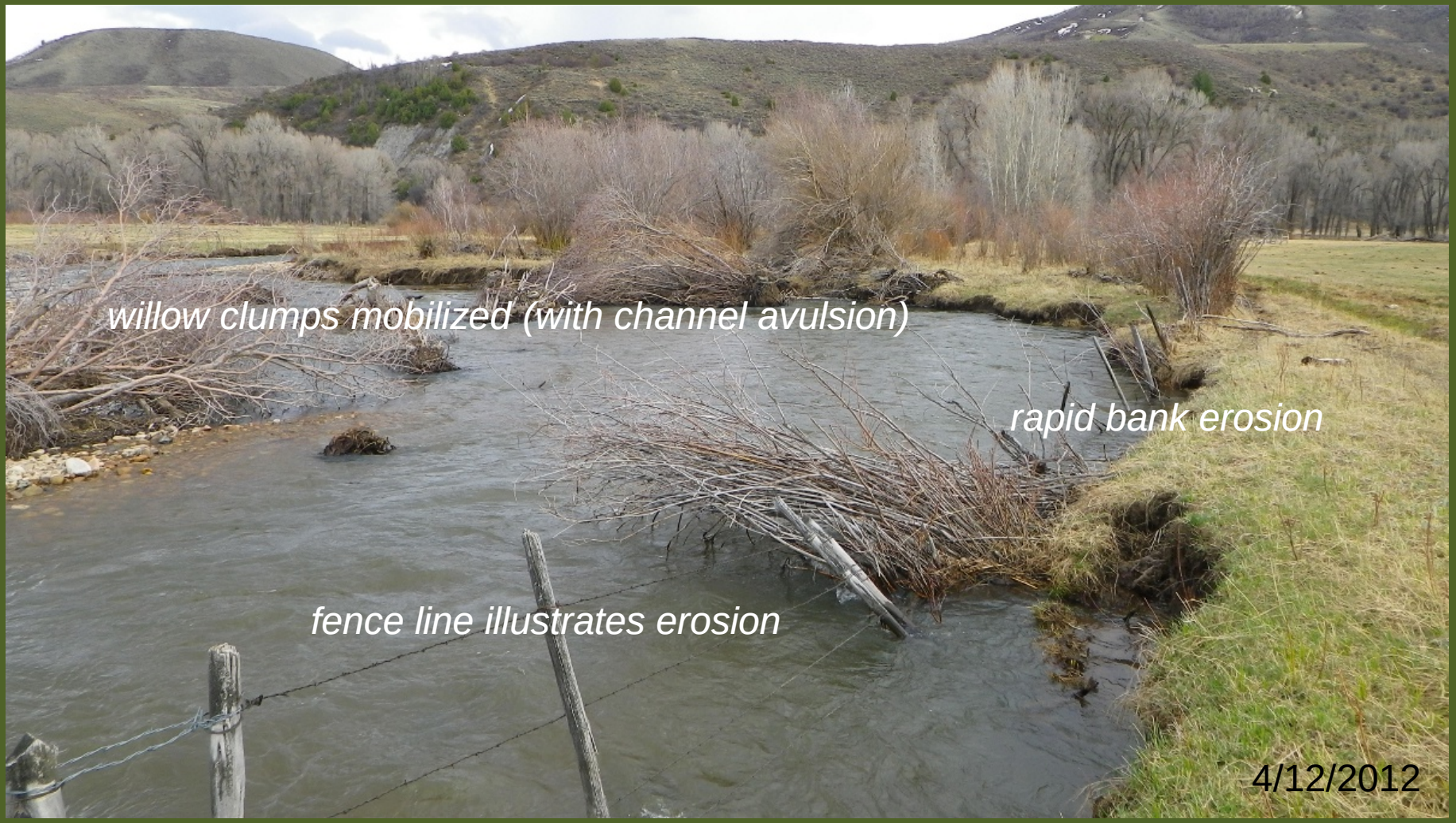
Post-Flood Condition

Post-Flood Condition

Post-Flood Condition

Post-Flood Condition

Post-Flood Condition



Post-Flood Condition

Post-Flood Condition

Post-Flood Condition

Post-Flood Condition

Key Questions

- What is the primary mechanism for the sediment deposition in the upper portion of the reach?
- What additional issues contributed to the bank erosion?
- Did the 2008 stream project contribute to the sediment deposition and bank erosion?
- What additional project features could have increased the resiliency of the stream project?
- In hindsight, was the stream project advisable?
- Could a thoughtful planning process avoided the pitfalls encountered at this site?

Historic Aerial Imagery

1953

- Upper depositional bar (amber oval)
  - At same location of recent deposition

1968

- Depositional bar has become well vegetated
- Avulsion across bar evident
- Enlarging bar, increased meandering (red circle)

Historic Aerial Imagery

1953

1968

Note: Down-valley meander migration of Little Snake

- Radius of curvature reduction at last meander bend
- Complicates flow dynamics at confluence

Historic Aerial Imagery

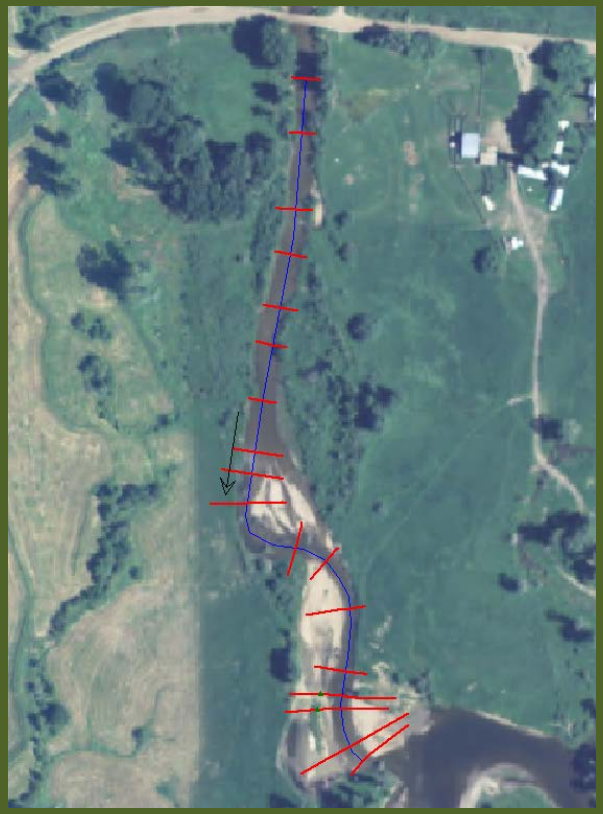
1980

- Left upper channel (streamwise) fully filled and vegetated
- Relatively strait channel in this reach, other than deposition and meandering at confluence

2004

- Slight tendency towards increased meandering upstream, with bars and bank erosion
- Lower portion has substantial meandering and short up-valley flow, forced by vegetated point

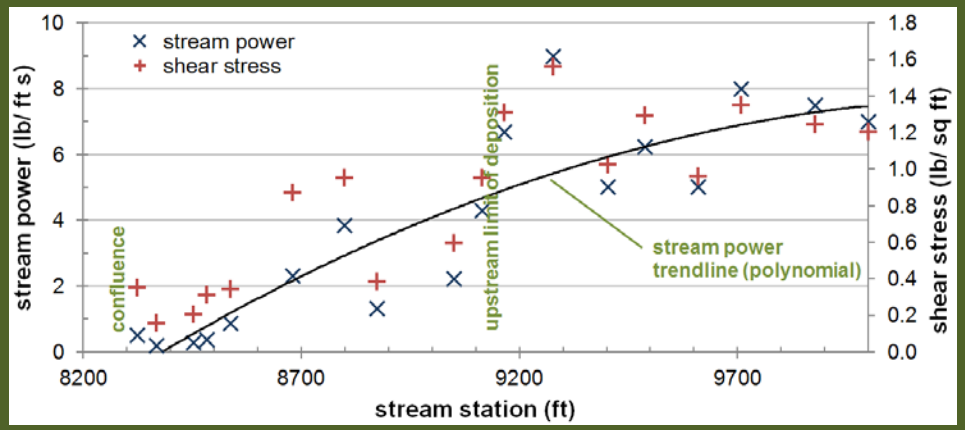
1-D Hydraulic Modeling



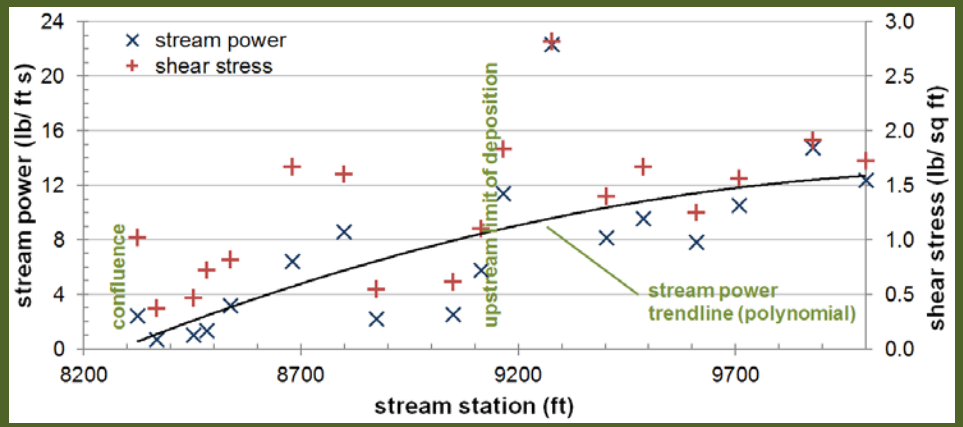
- Relatively-simple steady flow hydraulic model created
- Stream power and shear stress tallied, to assess sediment transport capacity
- ~Bankfull, 10-year, 100-year flows
- Boundary condition: peak water surface elevation in the Little Snake, as indicated by flood debris

1-D Hydraulic Modeling

10-year



100-year



- Stream power and shear stress (and hence sediment transport capacity) decrease substantially at the point where deposition occurred in 2010 and 2011.
- Sediment deposition likely the result of backwater from the Little Snake.

Some Answers

Backwater from the Little Snake is likely the primary cause of the periodic sediment deposition and increased bank erosion rates. Supported by:

- historical aerial imagery
- hydraulic model
- on the ground observations

Additional compounding issues:

- Poor grazing management
- Lack of sufficient plantings during 2008 construction
- Upstream orientation of confluence
- Meander migration of the Little Snake River

Primary Lessons Learned

- Structural measures should not have been installed on Battle Creek near the confluence. These measures provided little benefit since bank instabilities are primarily the result of:
  - Backwater-induced sediment deposition
  - Insufficient vegetative cover, due to grazing practices

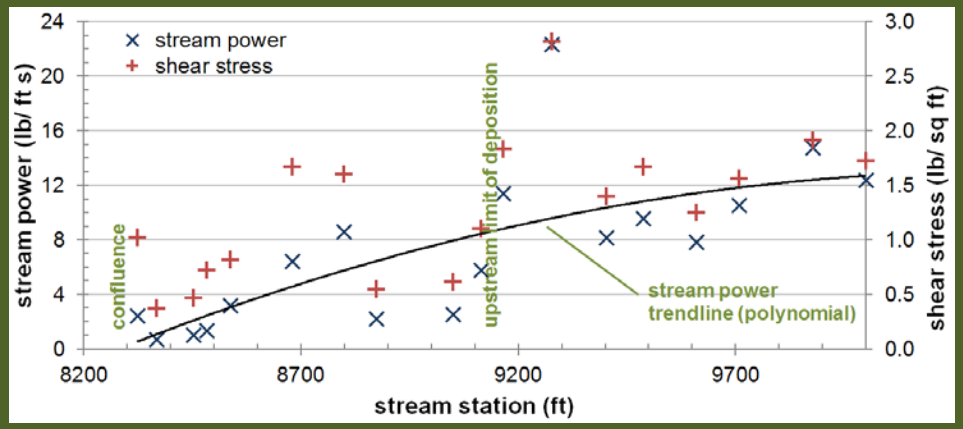
Primary Lessons Learned

- This project should have likely consisted of:
  - Riparian fencing and grazing management
  - Vegetative plantings
- More generally, structural streambank protection measures should always include sufficient vegetative plantings and livestock management components!

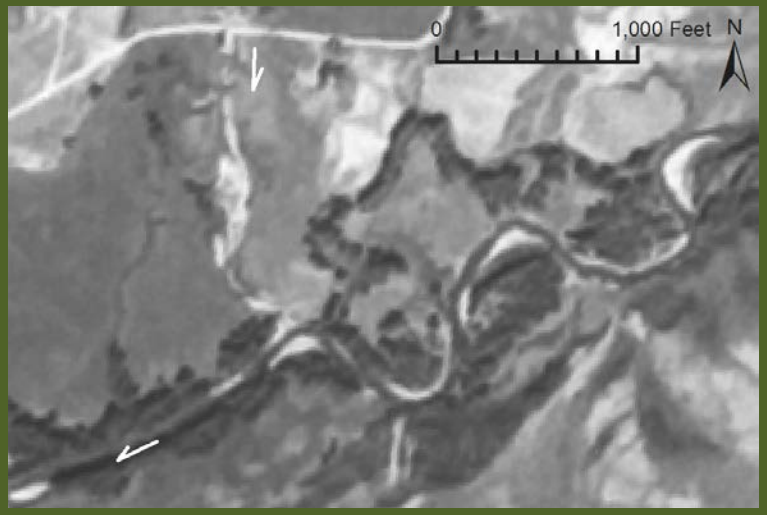
Primary Lessons Learned

- A proper planning process could have illuminated the potential problems long before construction. Planning should have included:
  - Historic aerial imagery interpretation
  - Hydraulic modeling, due to the inherent complexity at a confluence

100-year



1953



Primary Lessons Learned

- Qualified and experienced staff needed to be involved at project initiation, to avoid:
  - Waste of limited restoration funding
  - Repercussions associated with an unhappy politically-connected landowner

Battle Creek: Lessons Learned from Tinkering at a Confluence

Steven Yochum, PhD, PE
Hydrologist

Questions?