Stabilization-Structure Impact on Non-Point Source Pollution in the Unglaciated Area of Wisconsin

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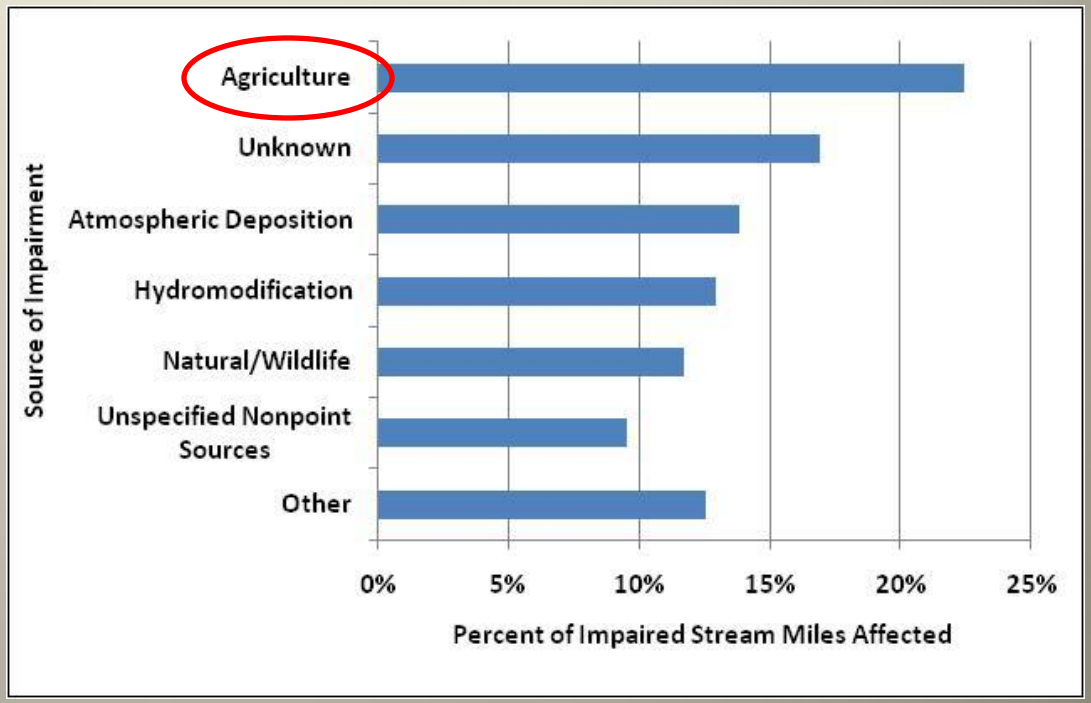
Major Contributor of Non-Point Source Pollution

- 3,533,205 miles of streams and rivers in the US
- 26% (934,799 miles) assessed by the EPA for impairment
  - 50% of all assessed streams were found to be impaired
    - Agriculture primary cause



http://iaspub.epa.gov/waters10/attains_nation_cy.control#prob_source

EPA 2010

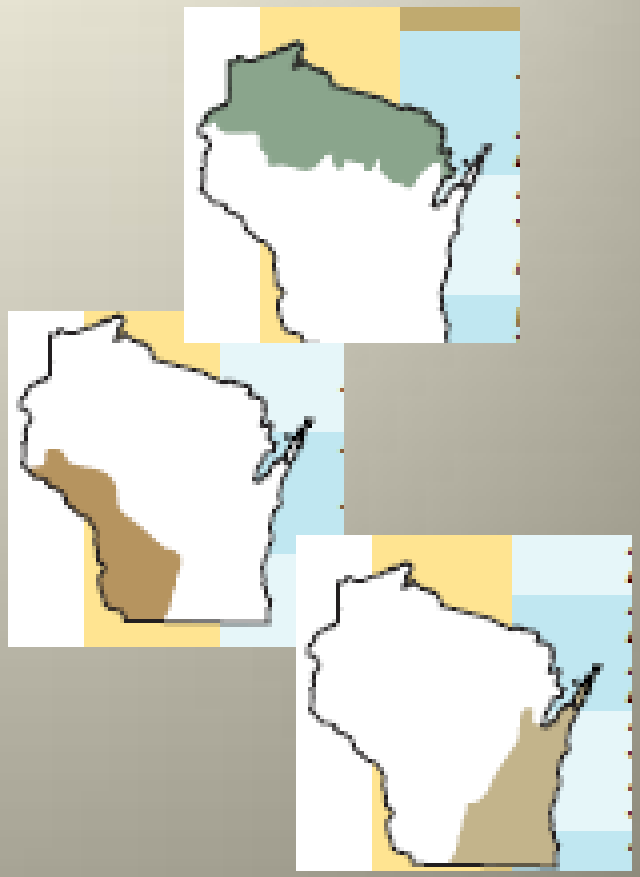
Soil Loss

- 1930 annual soil loss
  - 33.4 metric tons ha^{-1} (14.9 tons $acre^{-1}$)
- 1933 Soil Conservation Service
  - Coon Creek Watershed project
- 1992 annual soil loss
  - 14.1 metric tons ha^{-1} (6.3 tons $acre^{-1}$)

(Helms et al 1996)
Pictures from (Trimble & Lund 1982)

Current Problem

- Driftless Area Unit-area loads
  - 73 mt km^{-2} (209 t $mile^{-2}$) of suspended sediment
    - 88% higher then state average
  - 153 kg km^{-2} (875 lbs $mile^{-2}$) of total phosphorus
    - 35% higher then state average

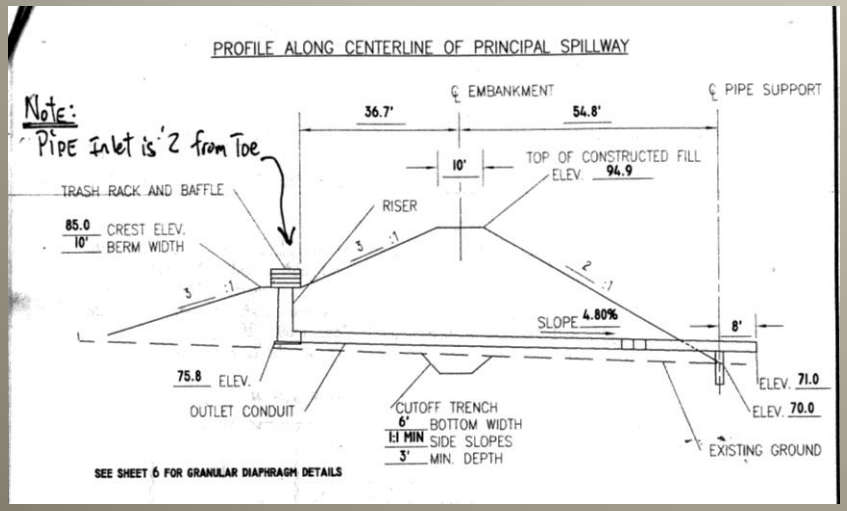


- Annual total suspended sediment from storm-runoff
  - Driftless area 93-95%
  - Southeast WI till plains 59-66%

Corsi et al. 1997

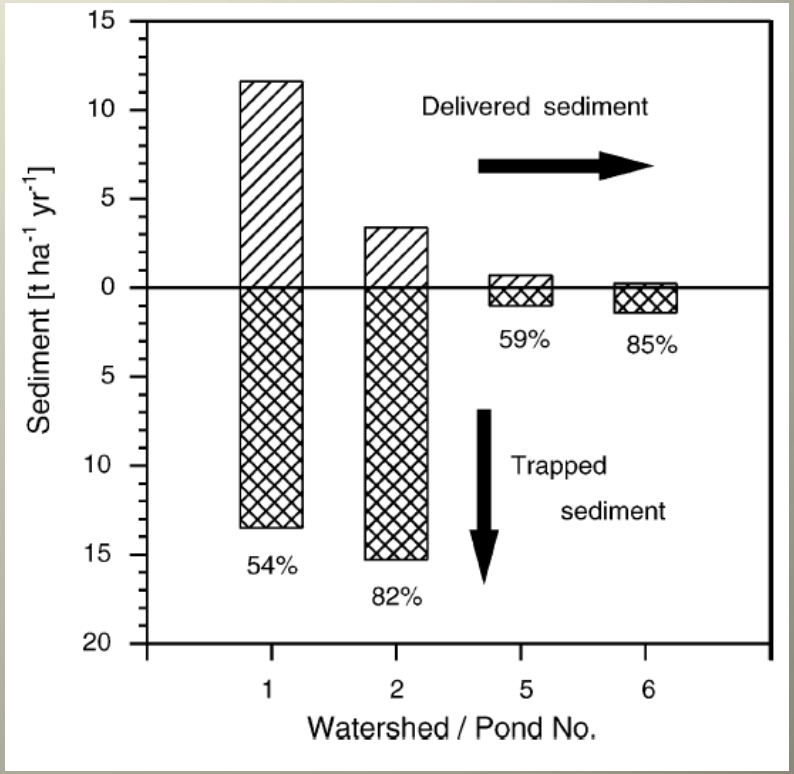
At-Grade-Stabilization-Structure

- Located at base of forested hill slope
- Similar to a sedimentation basin



Sedimentation Basin Research

- Edwards et al. (1999)
  - Trapping efficiencies of simulated agricultural runoff
    - Suspended sediment
      - 87.5 to 97.0%
    - Total Phosphorus
      - 32.2 to 65.8%
    - Total Nitrogen
      - 72.5 to 80.7%
- Fiener et al. (2005)
  - Basins trapped 54-85% of incoming suspended sediments



Conservation Practice Comparisons

Practice	Runoff	Soil erosion/Sediment yield	Total water and soil losses (lb ac^{-1})	
	(in)	(t ac^{-1} $year^{-1}$)	N	P
Moldboard plow	5.2	15.0	55.6	21.0
Typical tillage	4.8	7.8	35.8	13.1
No tillage	4.2	1.0	9.7	3.1
Contour farming	4.4	3.9	15.9	5.3
Strip cropping	4.4	2.9	12.9	4.2
Terraces surface-drained	4.4	2.3	11.0	3.4
Water and sediment control basins	3.9	0.4	6.5	1.6

Estimated annual soil and nutrient losses under various erosion control practices. Central Iowa climate, average over 10 Iowa soils, and a 72.6 foot long slope of 9% and a 300 foot long slope of 5%.

(Czapar et al 2005)

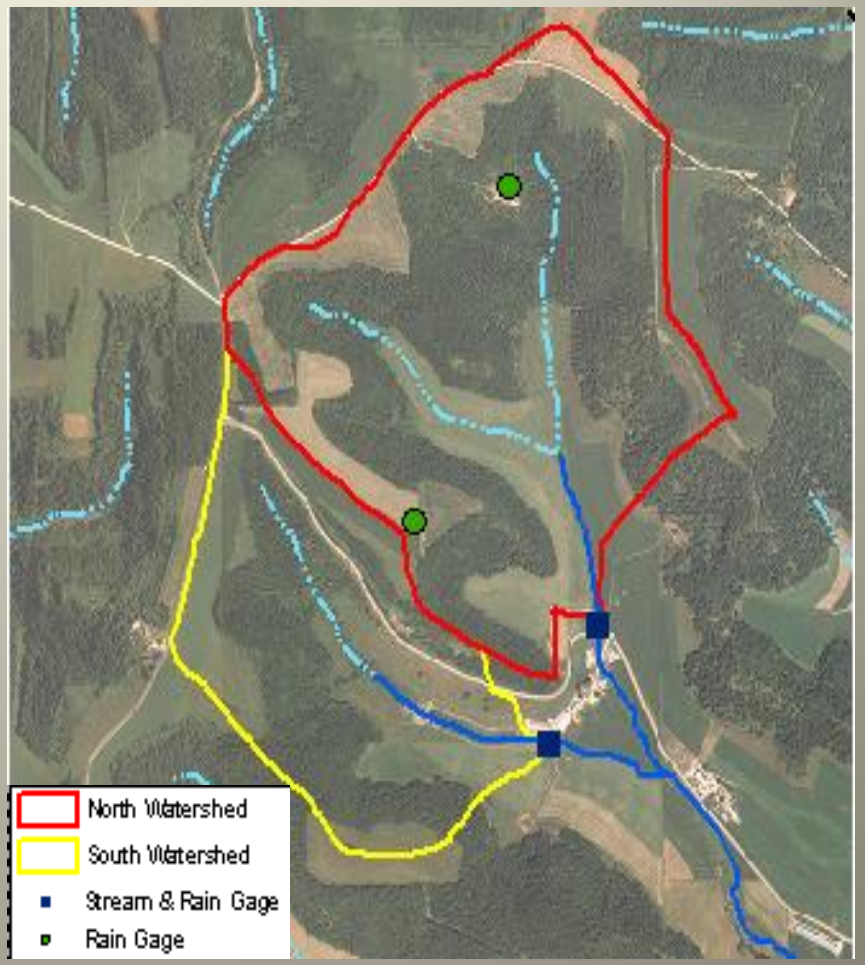
Research Purpose

- To determine if installing an At-Grade-Stabilization-Structure (AGSS) improved runoff water quality

- Objectives
  1. A comparison of precipitation, runoff volumes, and suspended sediment concentrations before and after installation of an AGSS.
  2. A comparison of phosphorus and nitrogen concentrations before and after installation of an AGSS.
  3. An analysis to determine the trapping of sediments by the AGSS.

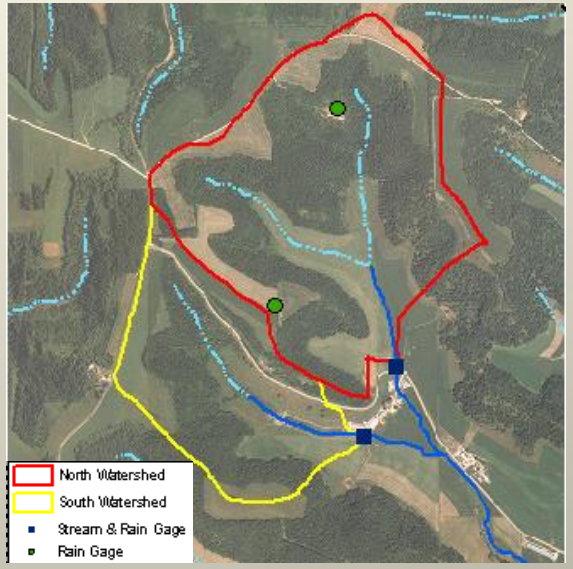
Study Site Location

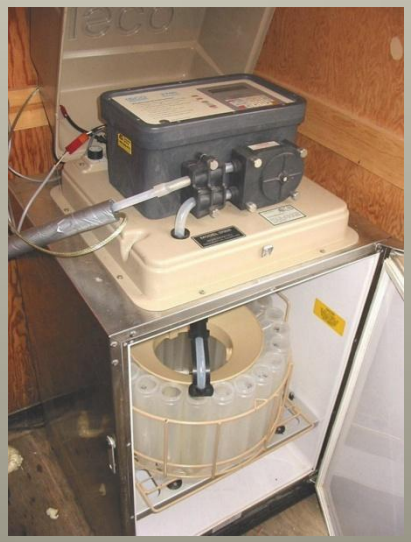
- Two paired watersheds
  - South (control)
    - 87 ha (215 ac)
    - 47% forested
    - 18% agriculture
    - 34% hay/pasture or CRP
  - North (treatment)
    - 174 ha (430 ac)
    - 59% forested
    - 39% agricultural
    - 5% hay/pasture of CRP



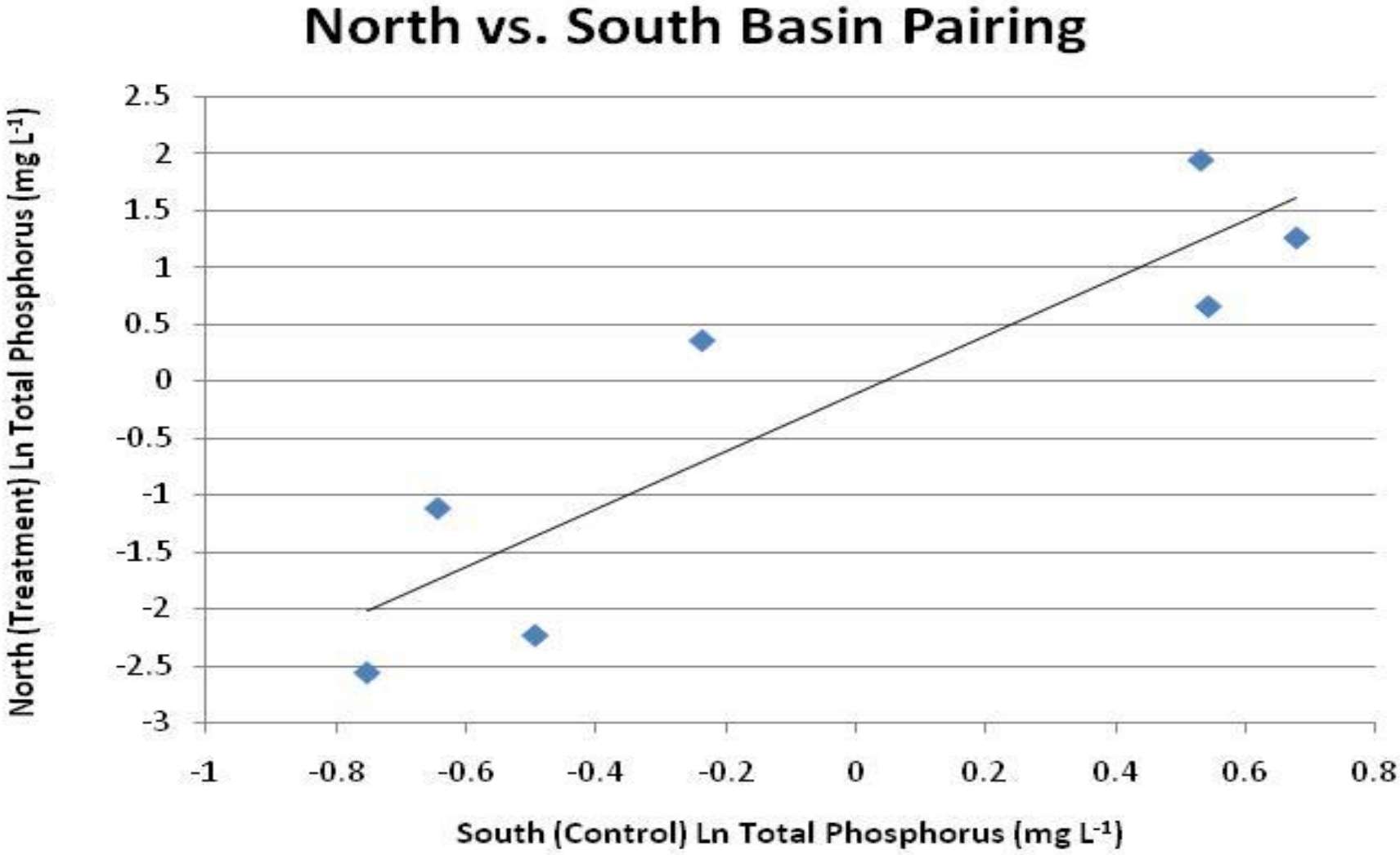
Monitoring

- Data collected from
  - Oct 2001 - Sept 2008
  - USGS monitoring equipment
    - Stream gauging stations
    - Meteorological stations
    - Soil temperature probes





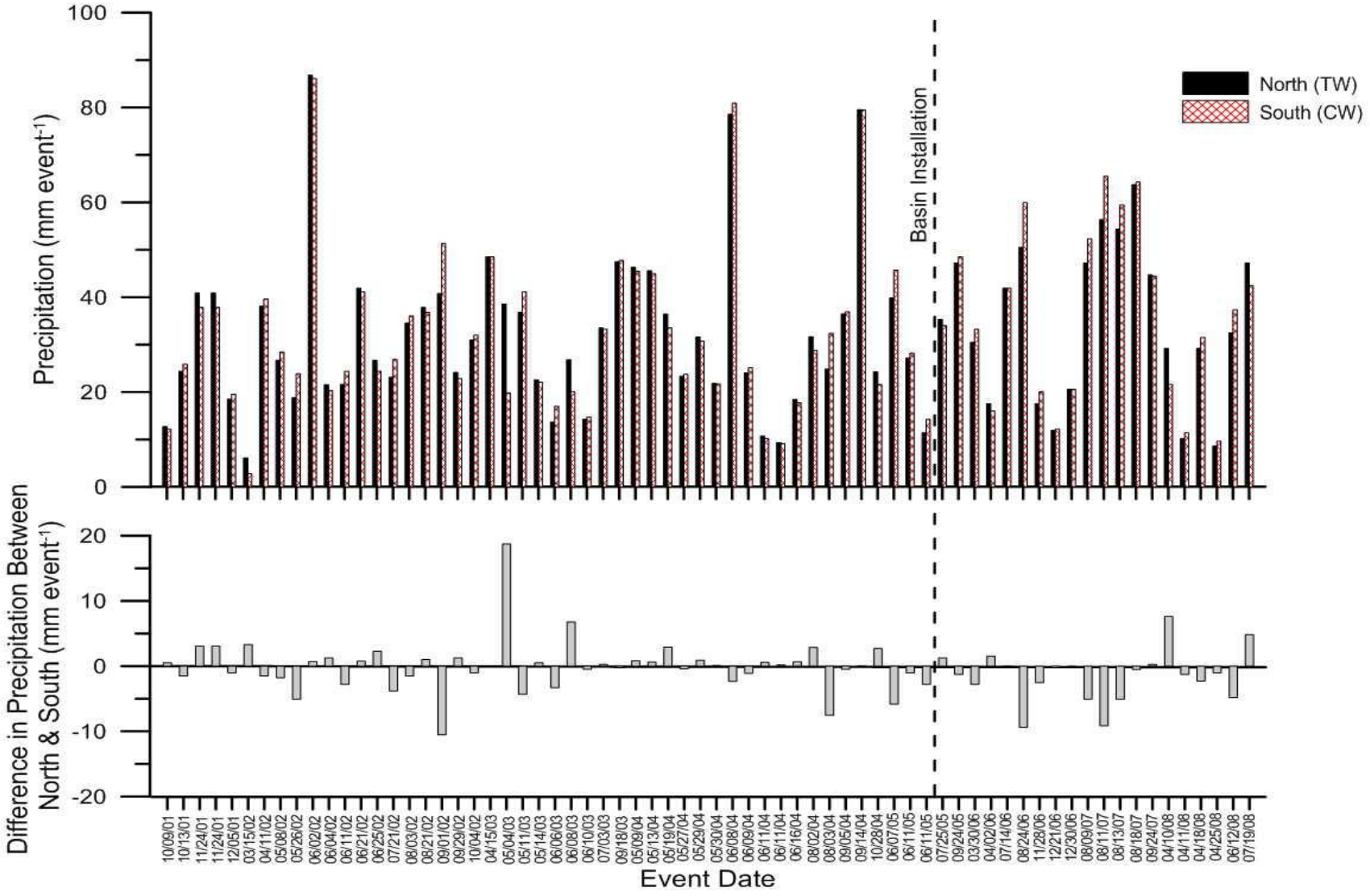
Watershed Pairing



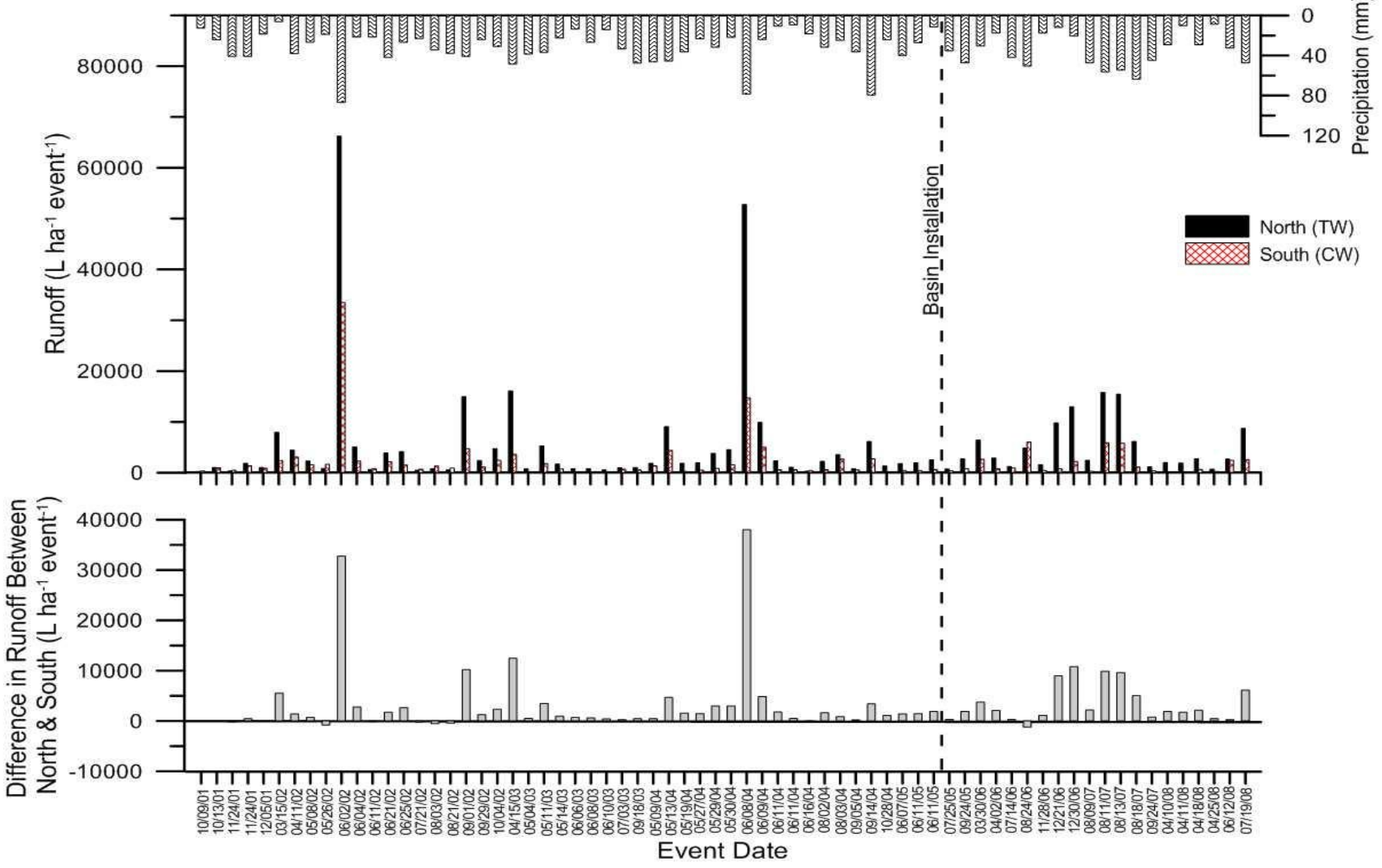
Evaluation

- Compare north and south
  - Non-frozen ground
  - Paired storm runoff events
  - Before installation of the AGSS to after
- Pre installation time period
  - Oct 2001-June 2005
- Post installation time period
  - July 2005-Sept 2008
- Parameters being compared
  - Precipitation
  - Runoff
  - Suspended Sediment
  - Phosphorus
  - Nitrogen
- Evaluate for changes within each watershed using a linear mixed effects (LME) model
  - SAS 9.2

Precipitation



Runoff


Runoff (L ha-1 event-1)
80000
60000
40000
20000
0
Precipitation (mm)
0
40
80
120
Basin Installation
North (TW)
South (CW)
Difference in Runoff Between North & South (L ha-1 event-1)
40000
30000
20000
10000
0
-10000
10/09/01
10/13/01
11/24/01
11/24/01
12/05/01
03/15/02
04/11/02
05/08/02
05/26/02
06/02/02
06/04/02
06/11/02
06/21/02
06/25/02
07/21/02
08/03/02
08/21/02
09/01/02
09/29/02
10/04/02
04/15/03
05/04/03
05/11/03
05/14/03
06/06/03
06/08/03
06/10/03
07/03/03
09/18/03
05/09/04
05/13/04
05/19/04
05/27/04
05/29/04
05/30/04
06/08/04
06/09/04
06/11/04
06/11/04
06/16/04
08/02/04
08/03/04
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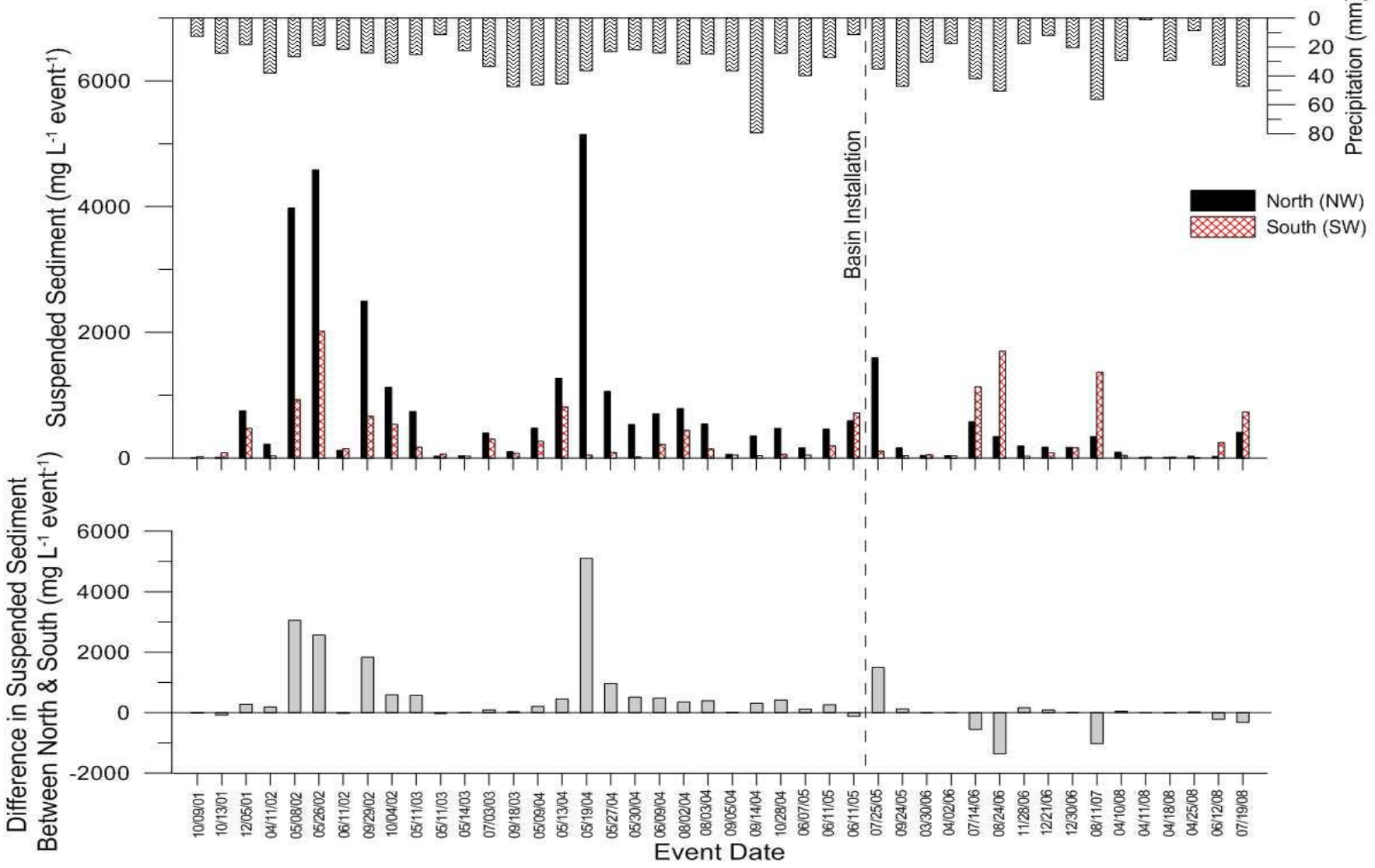
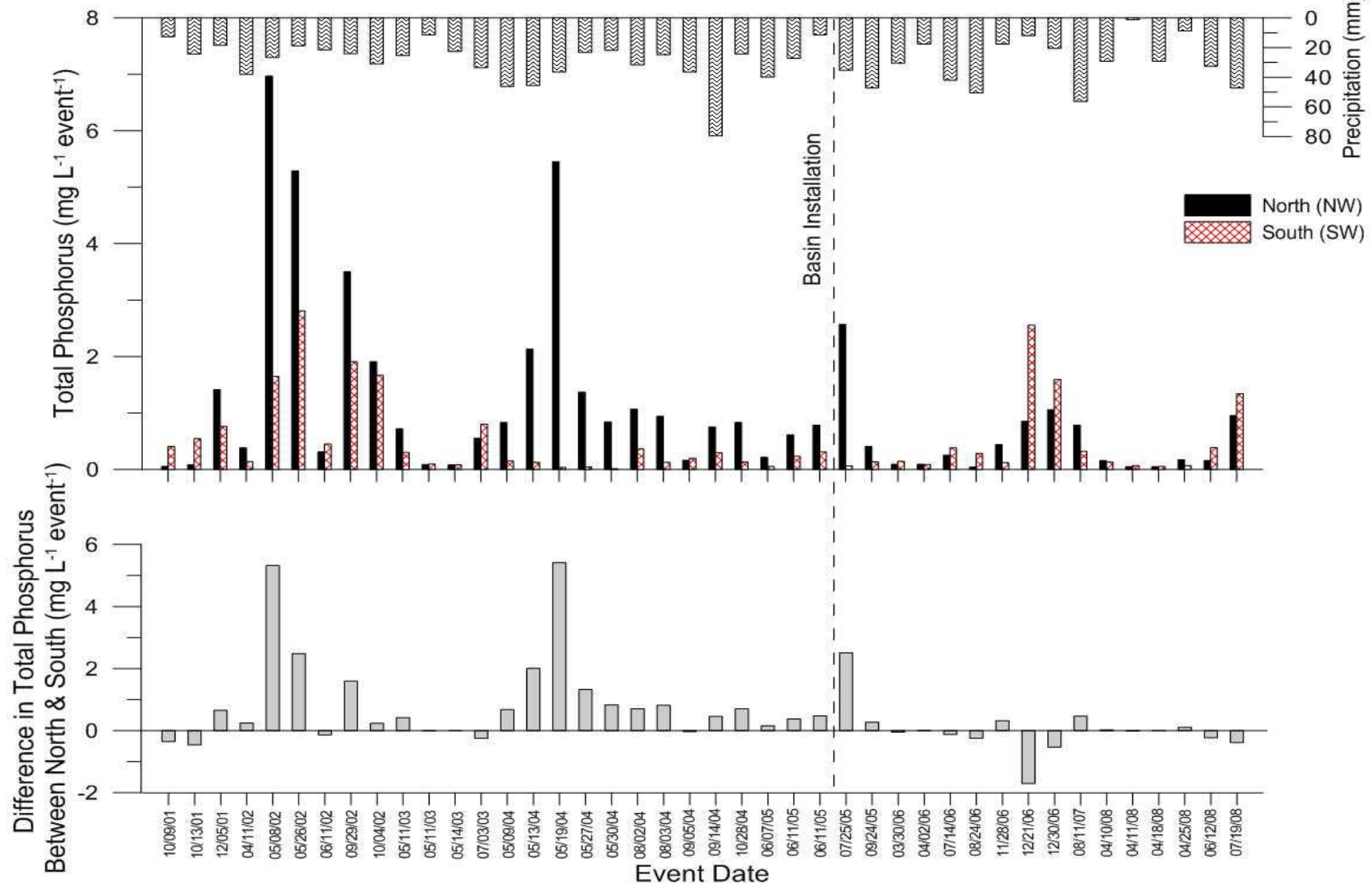
03/30/06
04/02/06
07/14/06
08/24/06
11/28/06
12/21/06
12/30/06
08/09/07
08/11/07
08/13/07
08/18/07
09/24/07
04/10/08
04/11/08
04/18/08
04/25/08
06/12/08
07/19/08
Event Date

Suspended Sediment



Total Phosphorus



Phosphorus

Total dissolved phosphorus

- Average concentration (mg L^{-1} $event^{-1}$)
  - North
    - Before=0.21
    - After=0.19
  - South
    - Before=0.18
    - After=0.40
- No significant differences

Phosphorus components

- Total phosphorus =

  Dissolved Phosphorus

  +

  Particulate Phosphorus

- Total Phosphorus has significant difference, total dissolved phosphorus does not
  - Particulate phosphorus reduced

Nitrogen Components

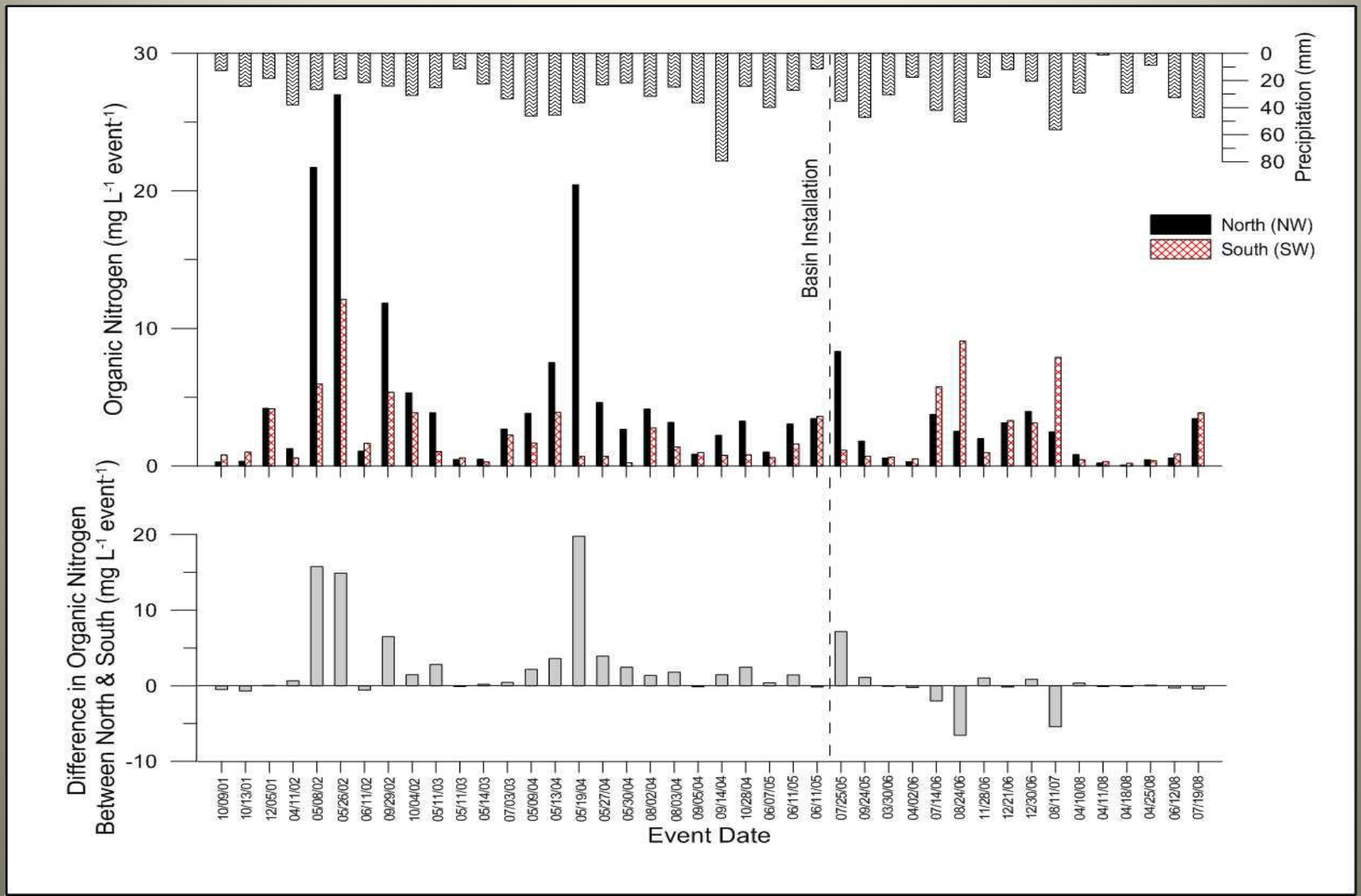
Total nitrite + nitrate

- Average concentration (mg L^{-1} $event^{-1}$)
  - North
    - Before=0.30
    - After=-0.08
  - South
    - Before=0.01
    - After=1.04
- No significant differences

Total ammonium

- Average concentration (mg L^{-1} $event^{-1}$)
  - North
    - Before=0.48
    - After=0.10
  - South
    - Before=0.09
    - After=0.10
- No significant differences

Total Organic Nitrogen

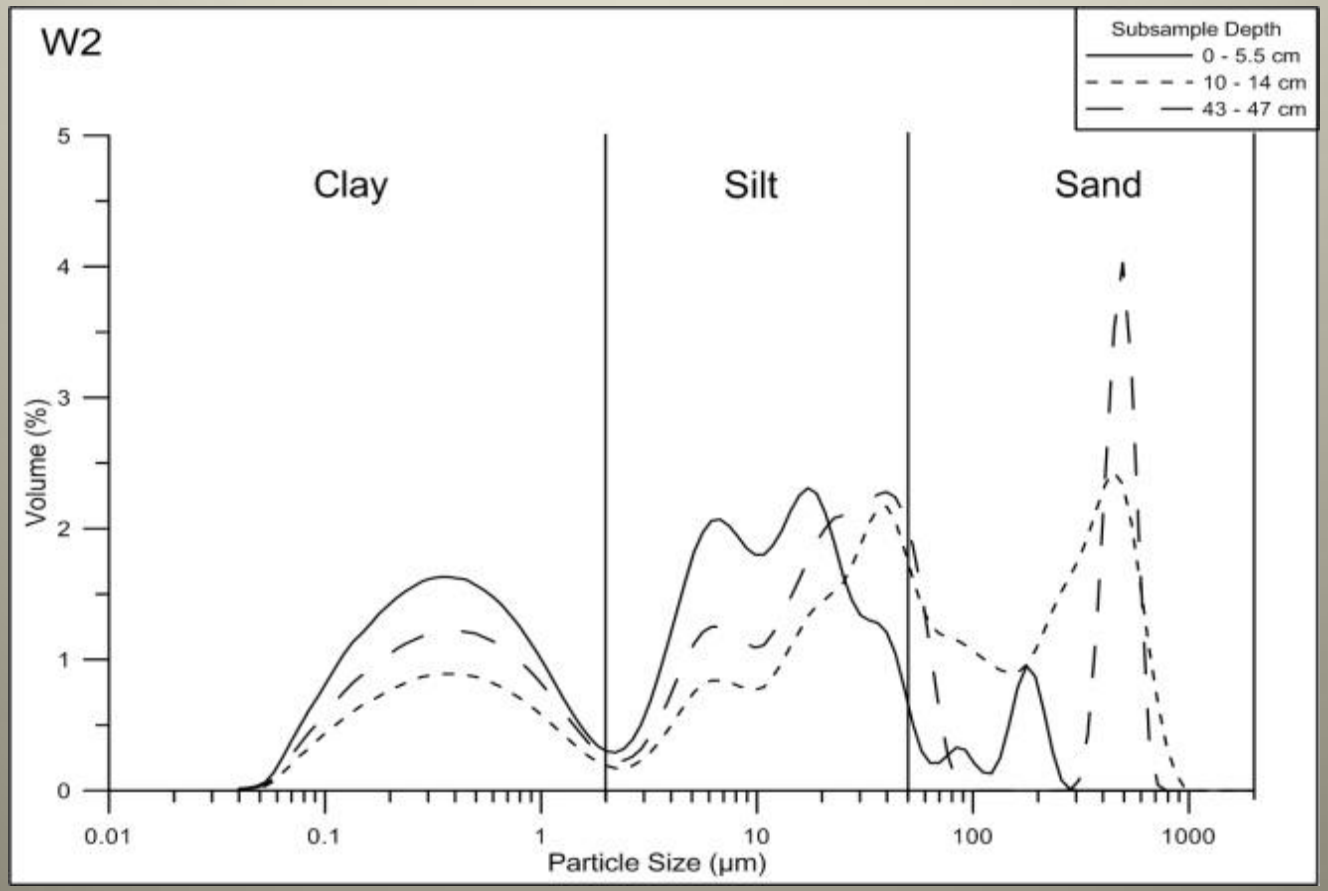


AGSS Sedimentation Evaluation

- Within the AGSS
  - Extraction of eight soil cores
  - Two to three soil subsamples removed from each core
  - Particle size analysis to determine sediment deposition
- Surface soil (0-5.5 cm) comparison
  - Particle size analysis on
    - Eight samples within the AGSS
    - Six samples from adjacent valley
    - Three samples from ridge top
  - Evaluate statistical differences in the amount of sand, silt, and clay at each location.

Within the AGSS Evaluation

- As depth increases
  - Amount of clay and silt decreases
  - Amount of sand increases



Sedimentation Evaluation

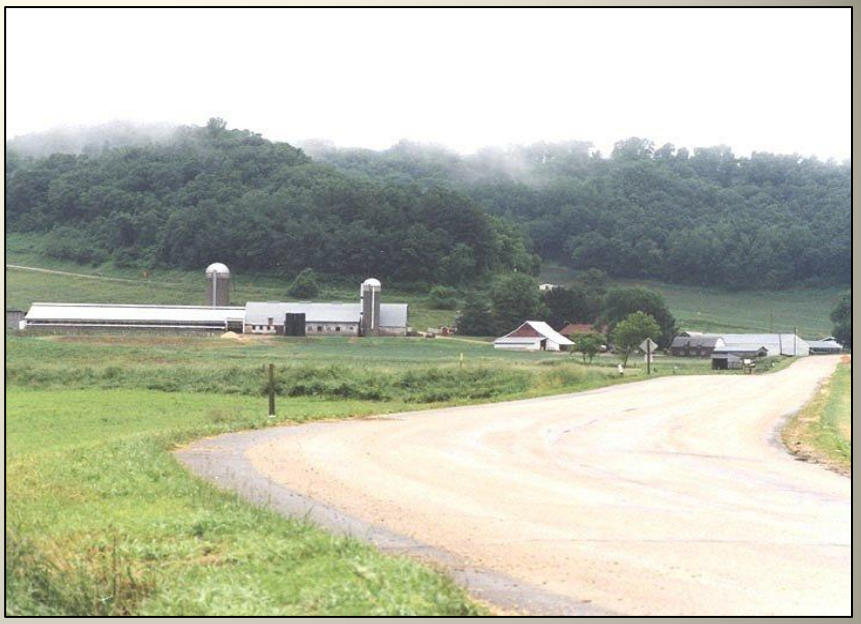
Average Soil Texture (0-5.5 cm) at Each Sampling Location			
Location	**Sand (%)**	**Silt (%)**	**Clay (%)**
AGSS (8)	12	51	37
Valley (6)	29	47	29
Ridge (3)	5	62	32

() indicates number of soil samples

- Significantly different at $P<0.05$
  - Valley vs. AGSS
    - Significantly more clay in the AGSS
    - Significantly more sand in the valley
  - Ridge vs. AGSS
    - Significantly more clay and sand in the AGSS
    - Significantly more silt in the ridge

Conclusion

- At-Grade Stabilization Structure reduced
  - Suspended sediment concentrations
  - Total particulate phosphorus concentrations
  - Organic nitrogen concentrations
- The At-Grade Stabilization Structure also contained surface soil samples with significantly greater clay content then the surrounding landscape.
- At-Grade Stabilization Structures are inexpensive to construct (<$2000), and occupy a relatively small land area (1-2 acres).



Questions?