

Geomorphology Update

Science Team Mtg January 2007

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Outline

- Bank Erosion Lidar Mapping Progress Report
- Historical Aerial Photo Progress Report
- Bank Erosion Modeling
 - “Bend-migration” modeling
 - “Bank profile erosion modeling”

Lidar Bank Surveys – Progress Report

- Goal – document bank morphology and patterns of bank migration
- Spatial scale - ~ 100 m
- Temporal scale
 - Annual
 - 1 site resurveyed $\sim$ monthly

Summary of Mapping Sites

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Number	From (RRM)	To (RRM)	Side of Channel	37-05	Presently Eroding?	Reach Type	Geologic Map Unit	Vegetation Type
1	1.55	1.65	Right	No (cutoff)	yes	bend	Alluvium	Forested
2	1.7	1.8	Right	No (cutoff)	yes	bend	Alluvium	Pasture
3	2.15	2.17	Right	Yes	yes (not mapped)	straight	Alluvium	Trees on bank
4	2.88	3	Left	No	yes	bend	Alluvium	Trees on bank
5	3.08	3.12	Left	Yes	? (not mapped)	bend	Alluvium	Trees on bank
6	3.47	3.52	Right	Yes	yes	bend	Alluvium	Trees on bank
7	4.7	4.8	Left	Yes	yes	confluence	Alluvium	Pasture
8	5.35	5.351	Left	No	yes	straight	Alluvium	Trees on bank
9	5.37	5.4	Right	No	yes	straight	Alluvium	Pasture
10	7.25	7.4	Left	Yes	no	bend	Alluvium	Trees on bank
11	7.7	7.8	Left	Yes	no	bend	Alluvium	Trees on bank
12	8.2	8.3	Left	Yes	yes	bend	Alluvium	Forested
13	8.5	8.53	Left	Yes	yes	bend	Alluvium	Forested
14	8.7	8.78	Left	Yes	yes	confluence	Alluvium	Pasture
15	8.8	8.9	Right	Yes	yes	island	Alluvial Fan!	Pasture
16	9.7	9.8	Left	Yes	Yes	bend	Alluvium	Forested
17	10.6	10.7	Right	Yes	Yes	bend	Terrace	Trees on bank
18	13.05	13.15	Right	Yes	Yes	island (bend)	Alluvium	Forested
19	15.3	15.4	Left	Yes	yes	bend (island)	Terrace	Forested
20	17.58	17.62	Left	Yes	yes	bend	Alluvium	Forested
21	20.7	20.8	Both?	Yes (right)	not mapped	straight	Alluvium	Forested
22	22.3	22.4	Right	No	Yes	bend (island)	Alluvium	Forested
23	22.42	22.6	Right	Yes	Yes	bend	Alluvium	Pasture
24	22.65	22.7	Right	Yes	yes	straight	Alluvium	Trees on bank
25	23.04	23.15	Right	Yes	not mapped	bend (island)	Alluvium	Forested
		Eco study sites						
		Survey completed						
		Benchmarks in place						

Survey Protocol

- Bank surveyed from at least 2 instrument locations at each site
 - Helps to “see behind” vegetation
- 2 permanent benchmarks in concrete at each site
 - Left level with ground, unobtrusive
- Photo panorama of each site
- Detailed descriptions of eroding bank sediments

Eroding Bank Near Dooms



RRM 22.58



Monthly Survey Site Near Dooms



HI Res GPS, Benchmarks



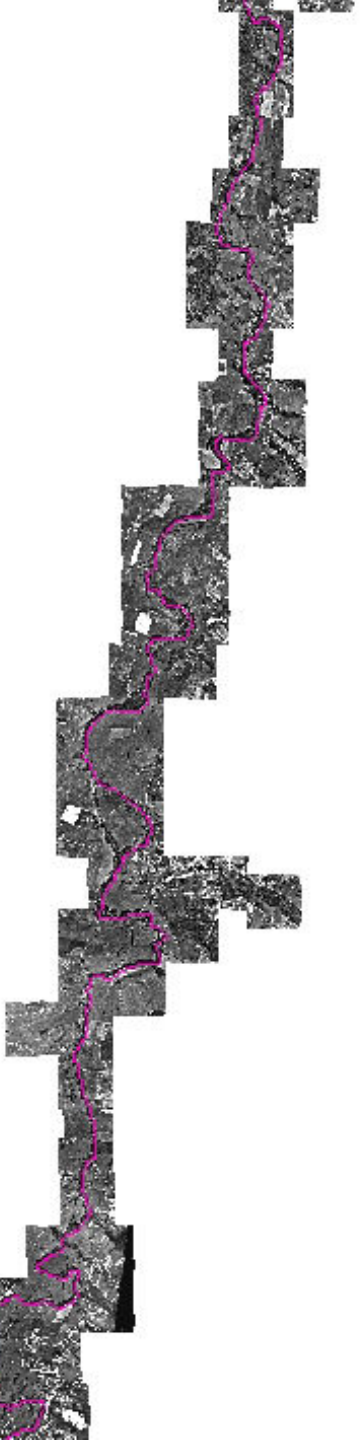
Some Example Benchmark Locations



Historical Aerial Photo Progress Report

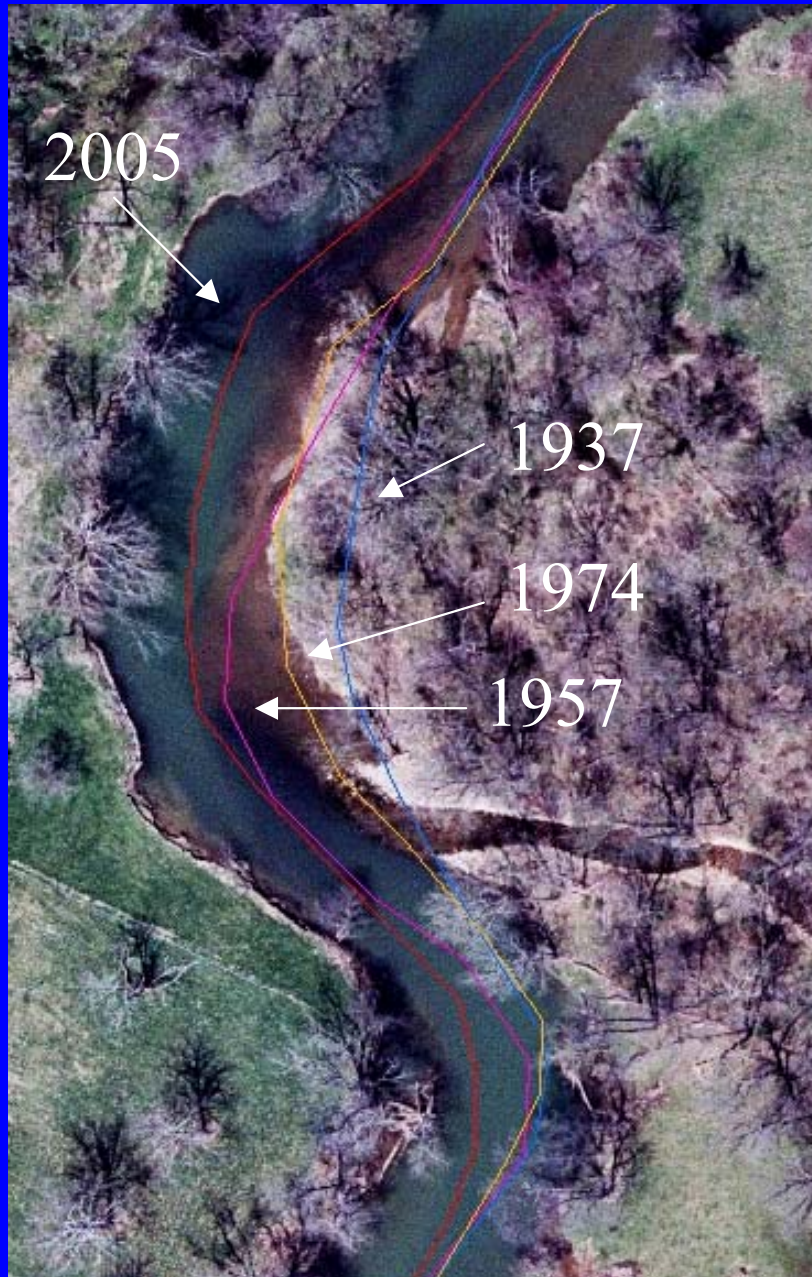
- Scanned large scale 1976 photos
- Rectified 1957, 1974 aerial photo set
- Future work
 - Analyze decadal changes to supplement 1937-2005 analysis completed last year
- Prognosis
 - Difficult to resolve decadal changes, but some useful and interesting results will emerge

1957, 1974 Rectified Photos



Channel Centerlines Nr Dooms

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Changes between 1957 and 1974 are not resolvable!

'37,'57,'74,'05 Centerlines RRM 8.8-8.9

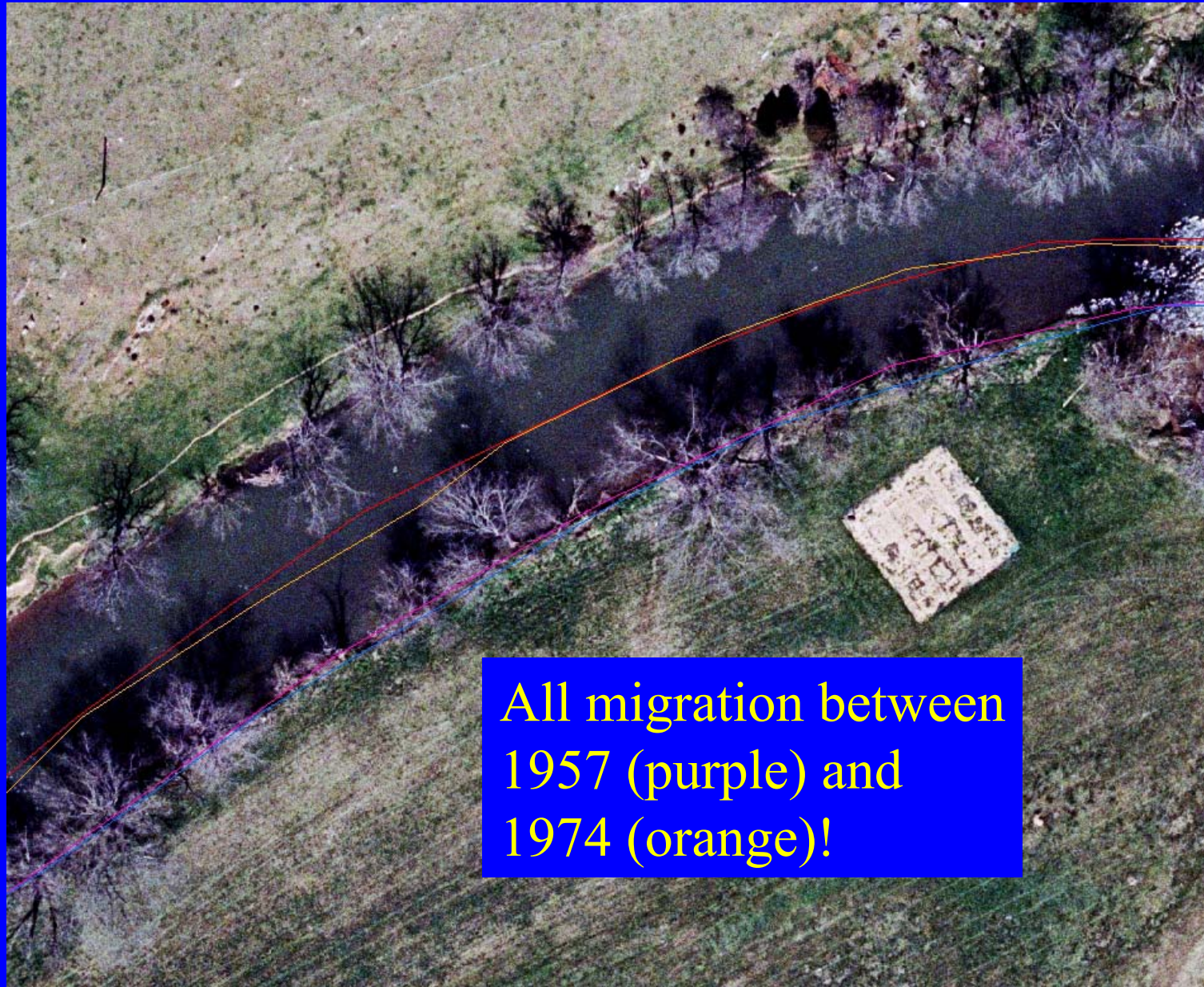
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Nearly all change occurred between 1974 (yellow) and 2005 (red)

More '37,'57,'74,'05 Centerlines

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All migration between
1957 (purple) and
1974 (orange)!

Cutoff – '37, '57, '74, '05¹⁶

Arrows show '74-'05 migration



'37, '57, '74, '05

Centerlines – Hopeman Pkwy

Two pulses of migration?
37 (blue)-74 (purple)
74-'05 (red)....
Or just noise?

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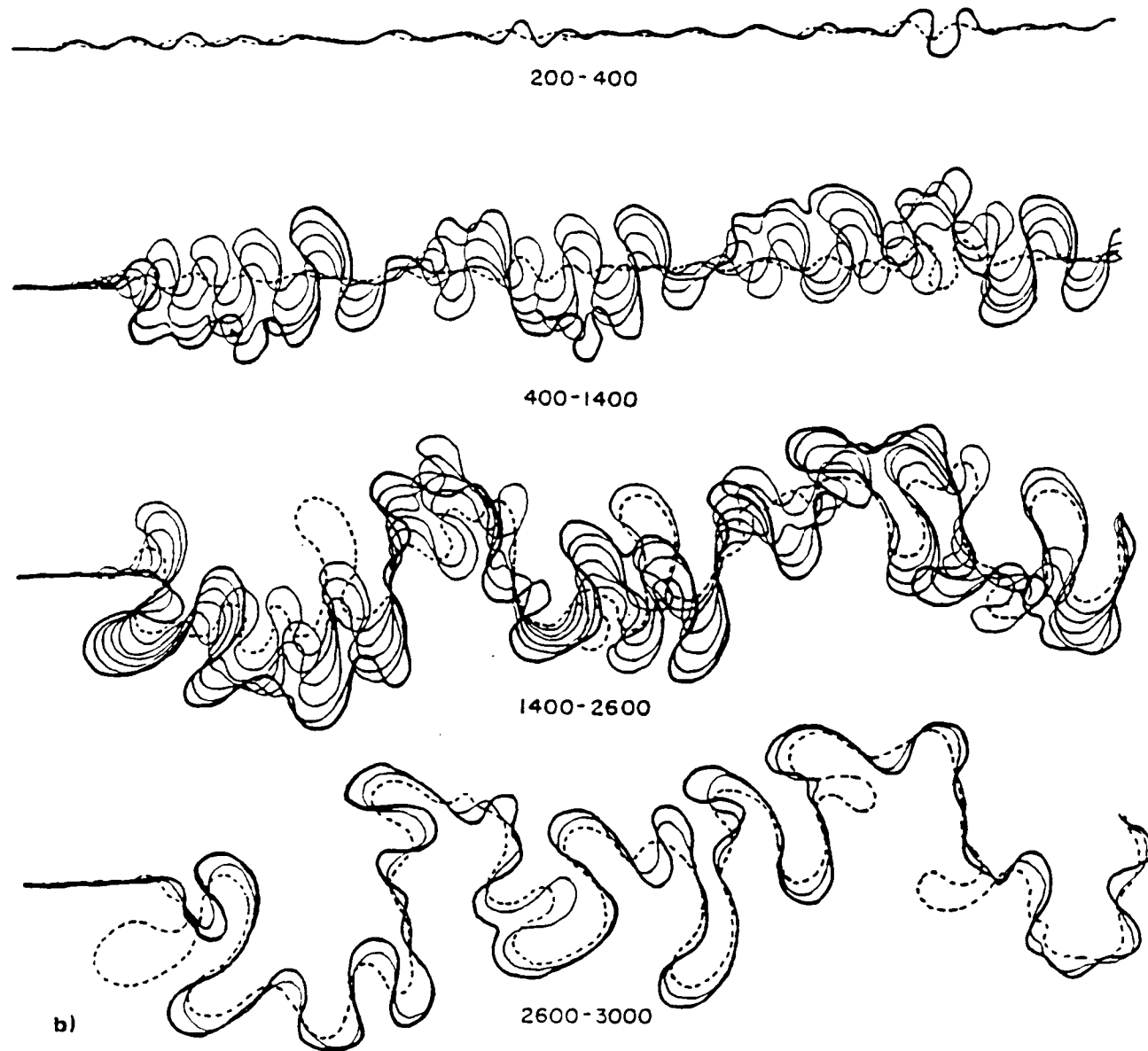


Bend Migration Modeling¹⁸

- Goal – Understand and predict 1937-2005 patterns of channel migration
- Assumptions:
 - Bend migration driven by “near-bank velocity”
 - Extent of migration also related to a coefficient that describes resistance of the bank to erosion

Predicted Channel Evolution From “Bend” Theory

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Approach

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- Apply analytical hydraulic theory to determine velocity field
- Determine erosion “coefficients” using 1937-2005 patterns of channel migration
 - Stratify observed erosion by
 - Vegetation
 - Bank material type
 - Other important variables
- Modify theory to account for:
 - Variable discharge
 - Influence of tributaries and islands

Status of Bend Migration Modeling

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- Programming of theory nearly complete
 - In testing phase
- Next steps:
 - Apply to actual South River bends where migration has been determined
 - Statistical methods used for model calibration

Bank Profile Erosion Modeling

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- Why?
 - Bend model does not determine location of erosion along the bank profile
 - Need to determine where erosion occurs to predict short term loading of Hg
 - Bend model not suitable for predicting erosion by:
 - “small events”
 - Any individual events

Bank Profile Erosion Modeling - Approach

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- Use data of Pizzuto and Meckelnburg (1989) and Mecklenburg (1989)
- Obtained from 3 year study of the Brandywine Creek at Chadds Ford, PA
 - Results of every “flow event” surveyed at 9 locations around the bend
 - Brandywine at Chadds Ford similar in size and floodplain materials to South River

The Eroding Bank At the Brandywine Creek near Chadds Ford

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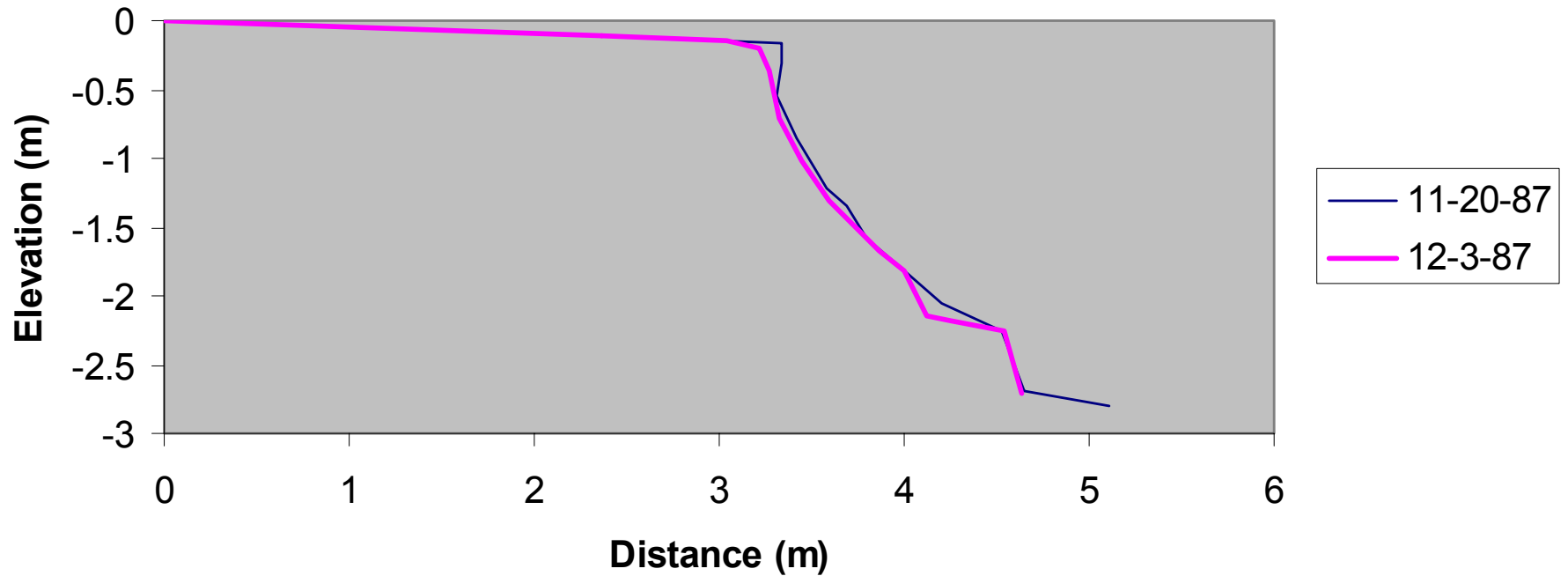
Surveys Documenting Erosion

11/20/87-12/3/87

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- High flow date – 11/30/87
- Water surface elevation: - 2.8 m (bankfull)
- High flow duration – 39 hours
- Since last high flow:
 - 19 days
 - 14 freeze-thaw events
- Total erosion – 0.107 square meters

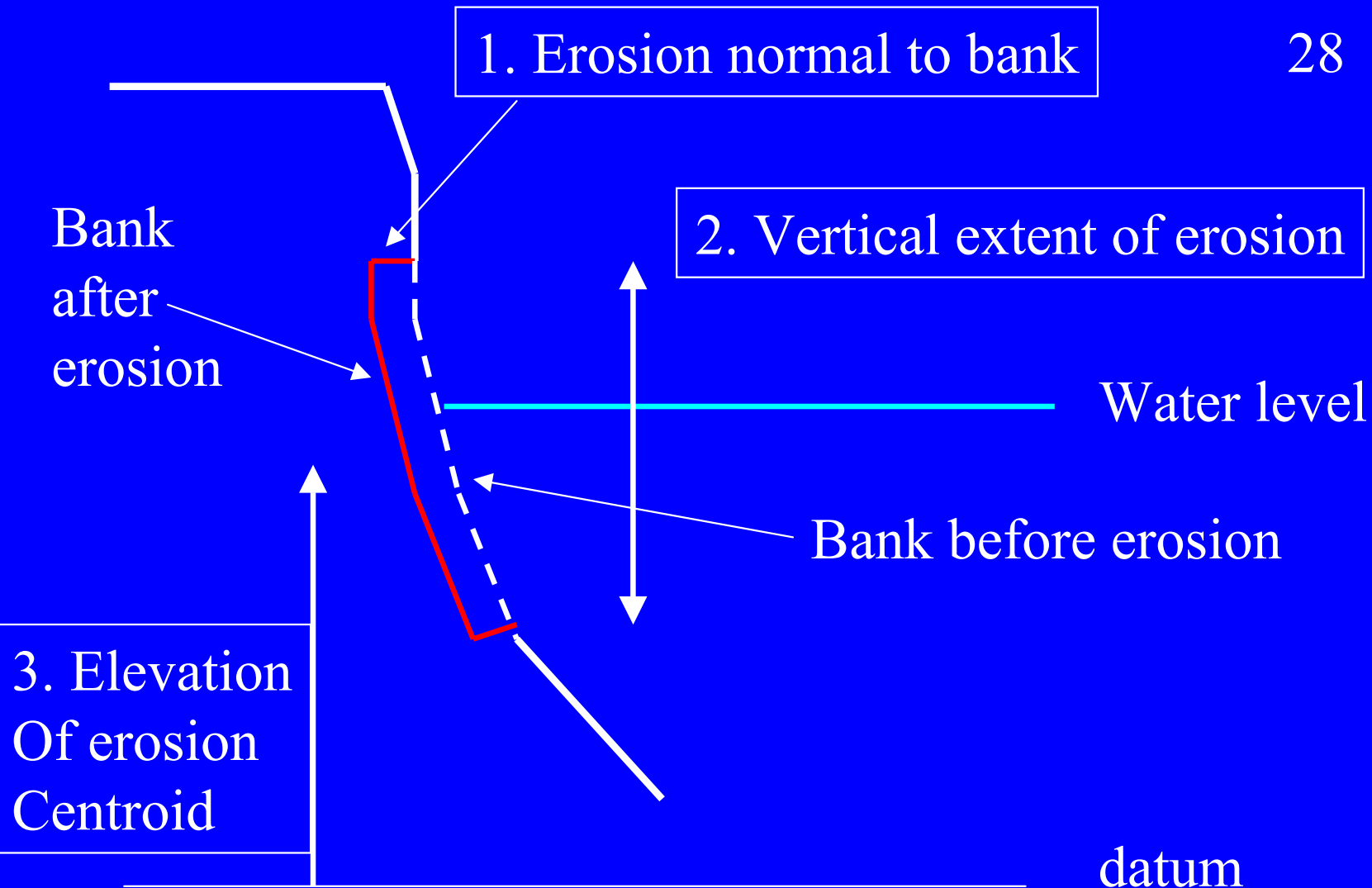
Site 5 - Erosion By 1 Bankfull Flow



Approach

- Create empirical model that includes the effects of:
 - Water level
 - Flow velocity “near the bank”
 - Implicitly includes protection of the bank by vegetation, since the sites have varying vegetation characteristics
 - Freeze-thaw
 - Time between surveys
 - Bank geometry (overhangs)

3 Variables Needed to Quantify Erosion by Water



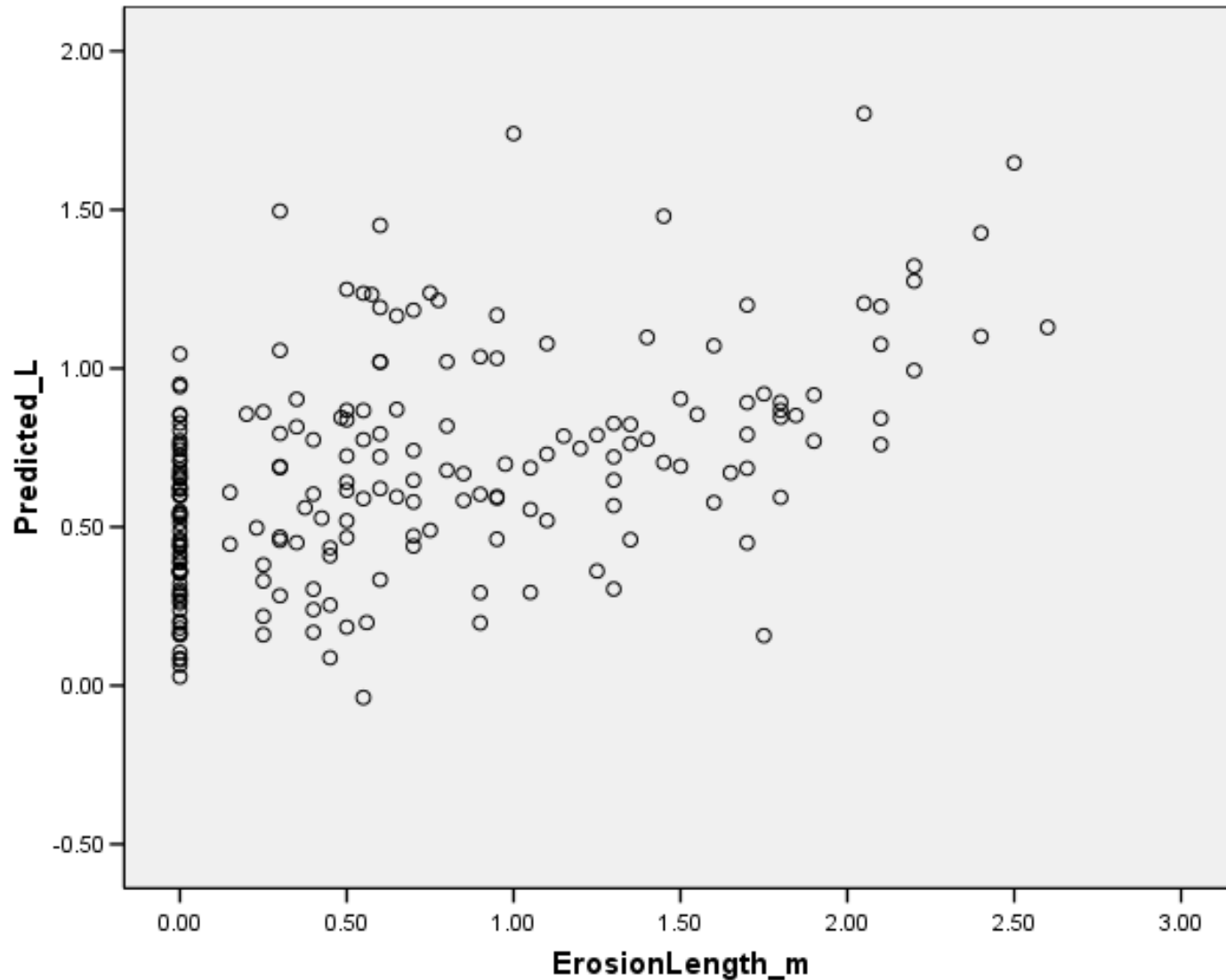
Summary of Controlling Variables

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- The length of erosion (L) is a linear function of
 - Near-bank velocity
 - Number of freeze-thaw “events” since last high flow
 - Water surface elevation
- Length of erosion normal to the bank (NE) depends on:
 - Near-bank velocity only
- Centroid Elevation of erosion depends on:
 - Water surface elevation
 - Duration of high flow event
 - $L * NE$

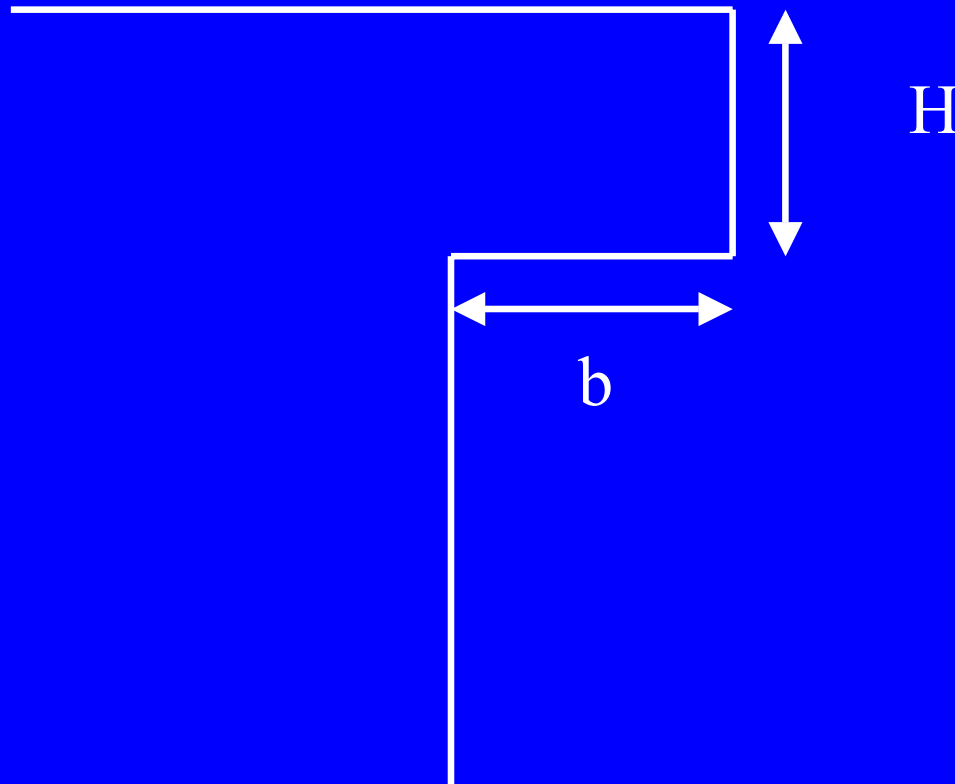
An Example of Predicted vs Measured Variables – Length of Erosion (in meters) (“noisy”, but statistically significant)

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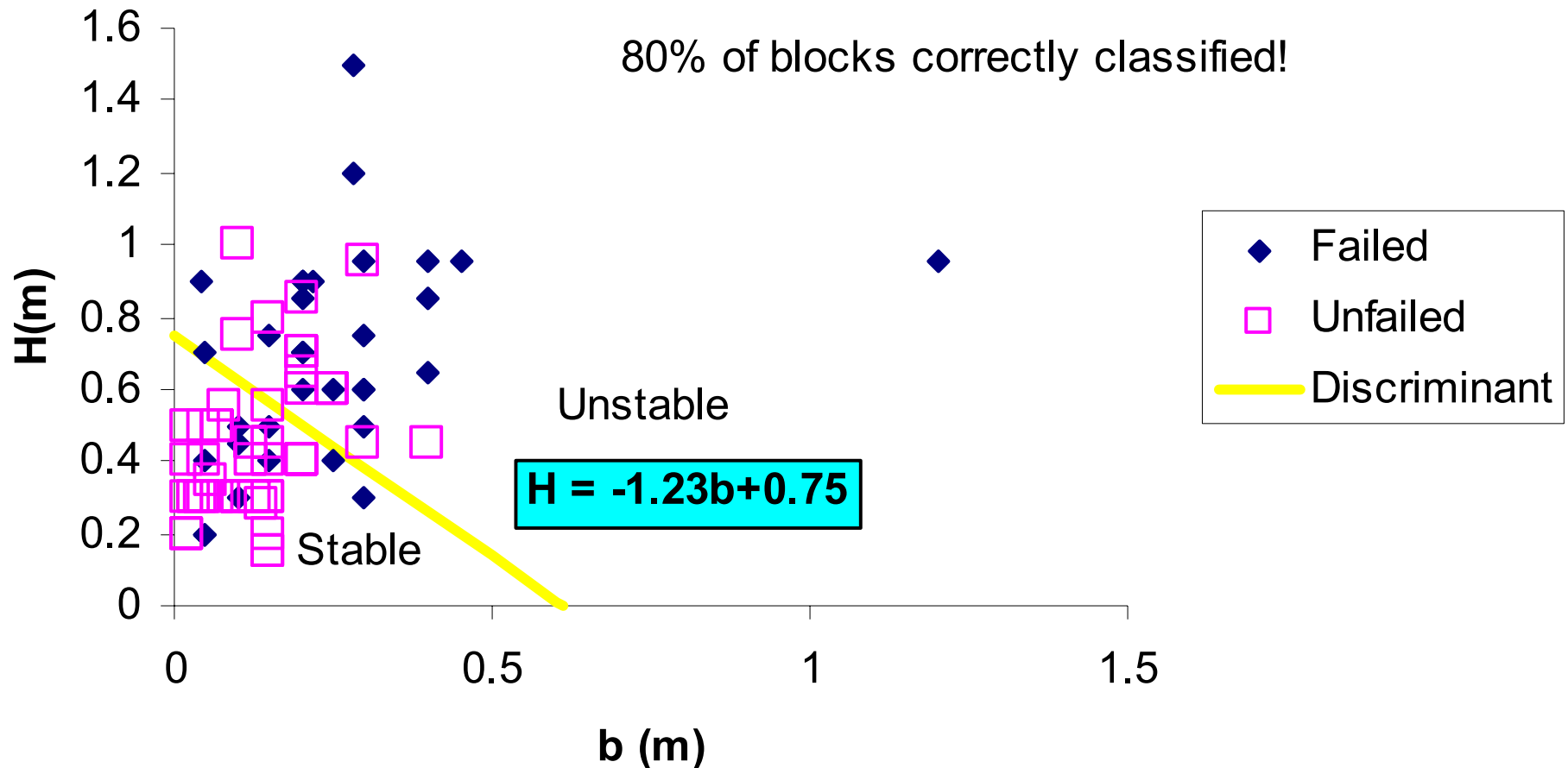
Predict Overhang Failure By Geometry

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Empirical Stability Field For Overhangs

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Predicted Bank Profiles for 19 Erosion Events, 4/16/86-3/5/88

Evaluation: algorithm overpredicts extent of erosion at this site!

