Doing what rivers do

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20100202

1) Pre-restoration fluvial system—incised, single-thread, meandering, high banks, narrow gravel bars

   (a) Historic sediment, black Holocene hydric soil, blue-gray Holocene hydric soil, Pleistocene periglacial rubble

   (b) Gravel bars, bed load transport

   (c) Base flow and high flow conditions

   (d) Channel cross sections and bank erosion monitoring

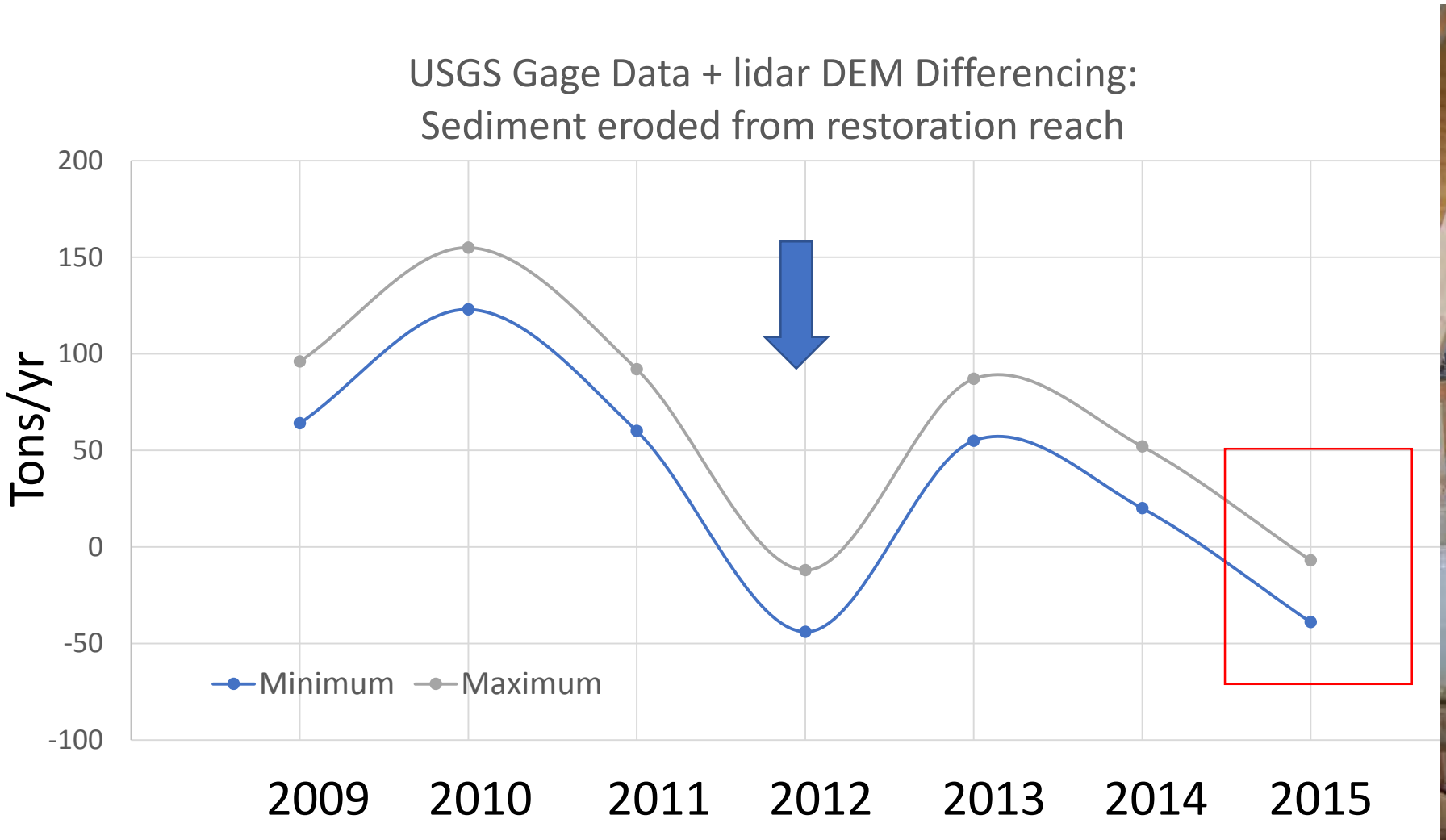
2) Post-restoration fluvial system-- shallow multi-thread channels, low banks, no gravel bars, wide floodplain

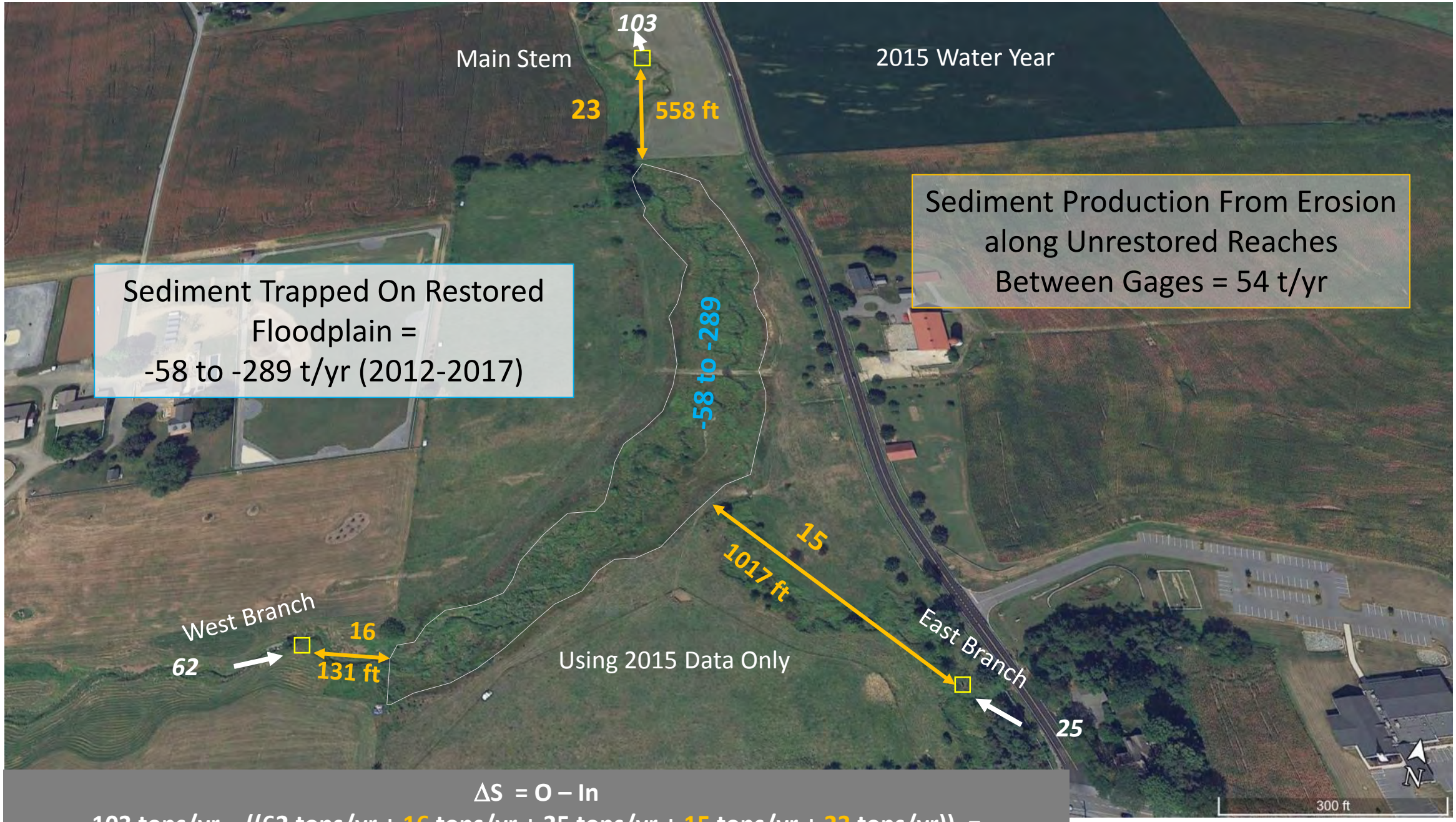
   (a) Vegetated floodplain and channels

   (b) Little bed load transport, small particle size (D_{50} <10 mm)

   (c) Surface and groundwater connected at base flow

   (d) Valley cross sections and floodplain-channel erosion and deposition monitoring

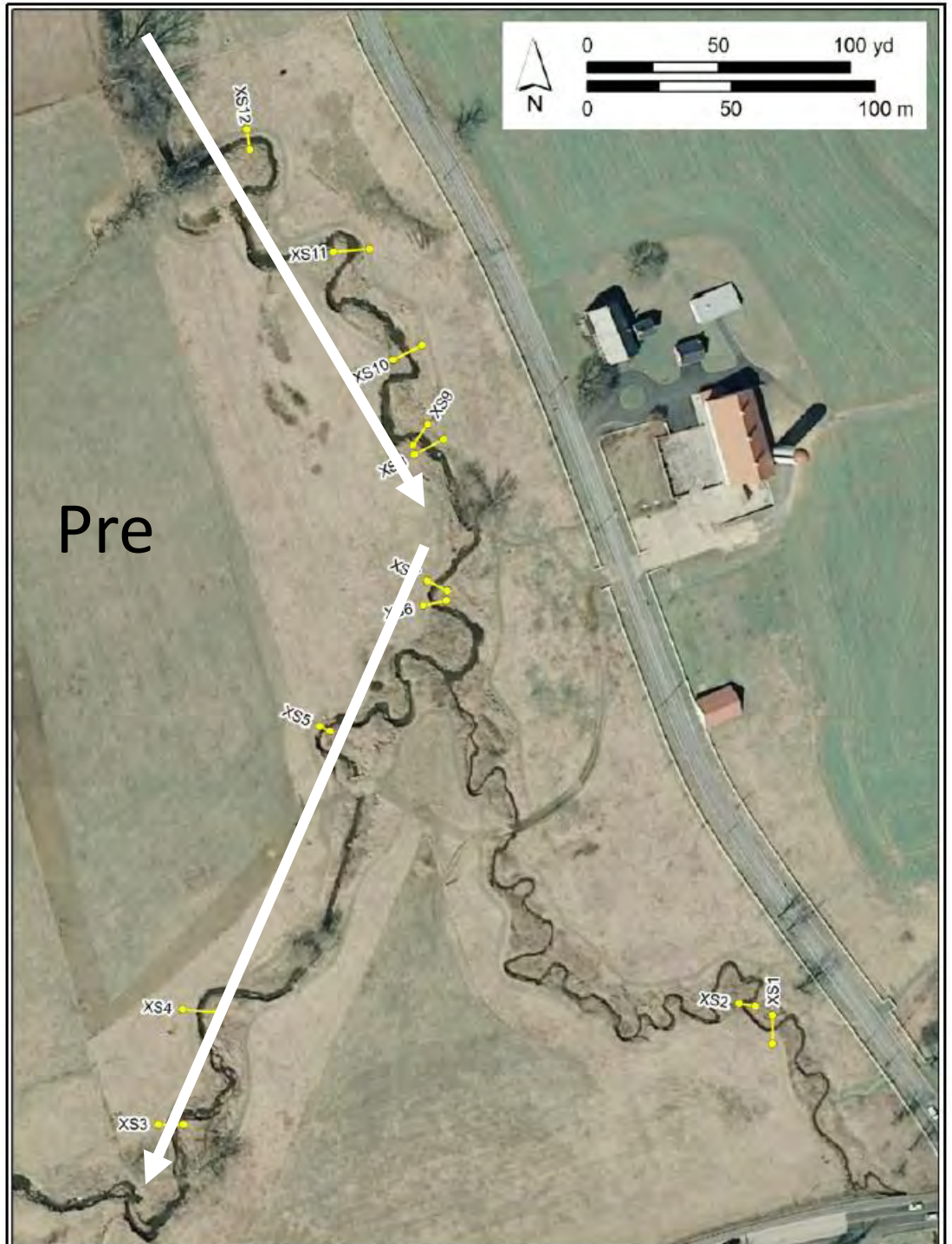

USGS Gage Data + lidar DEM Differencing:
Sediment eroded from restoration reach
Tons/yr
200
150
100
50
0
-50
-100
Minimum
Maximum
2009
2010
2011
2012
2013
2014
2015

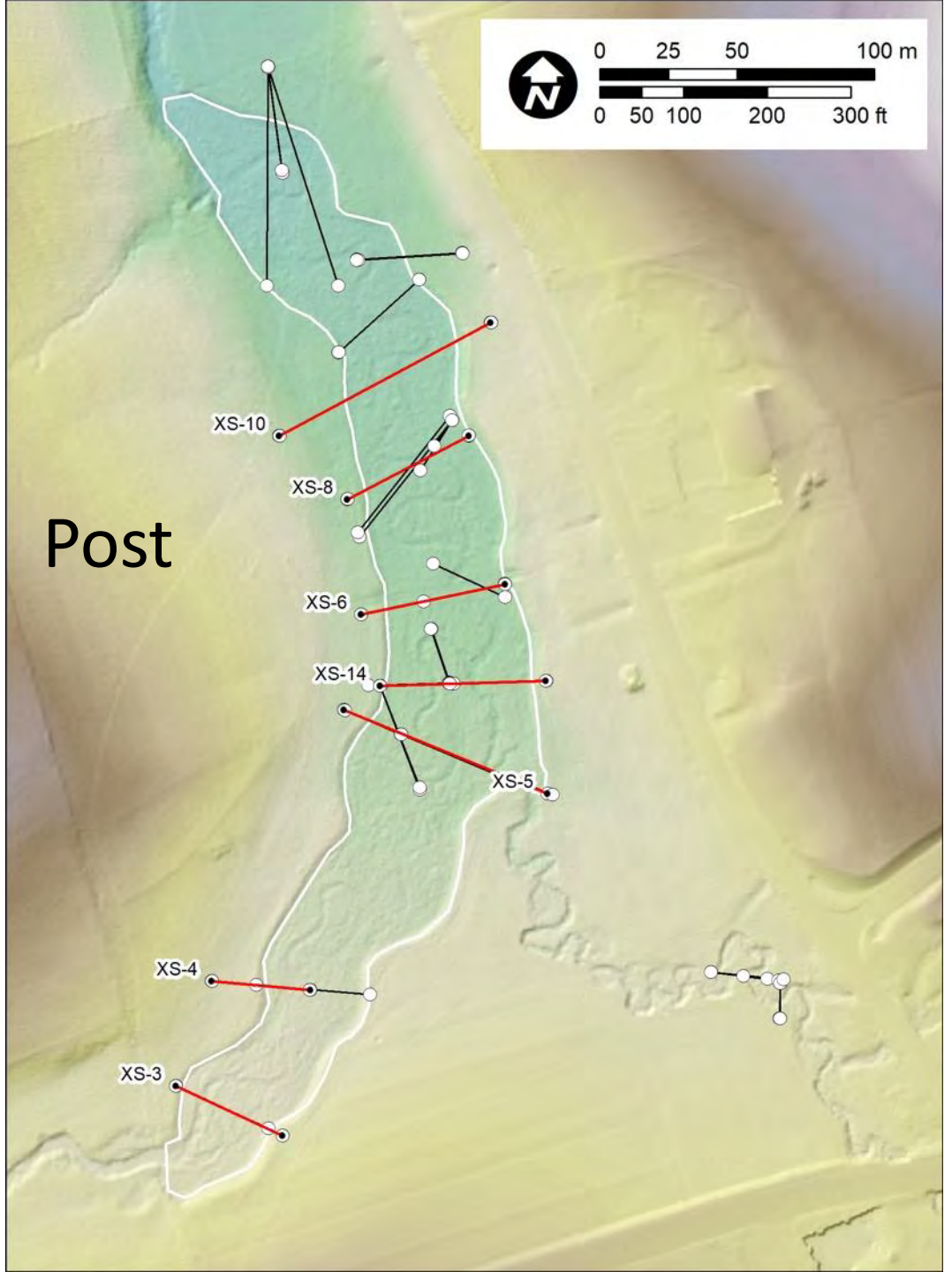


$\Delta S = O - In$

103 tons/yr – ((62 tons/yr + 16 tons/yr + 25 tons/yr + 15 tons/yr + 23 tons/yr)) =

ΔS = 103 - 141 = -38 tons/yr (i.e., deposition)

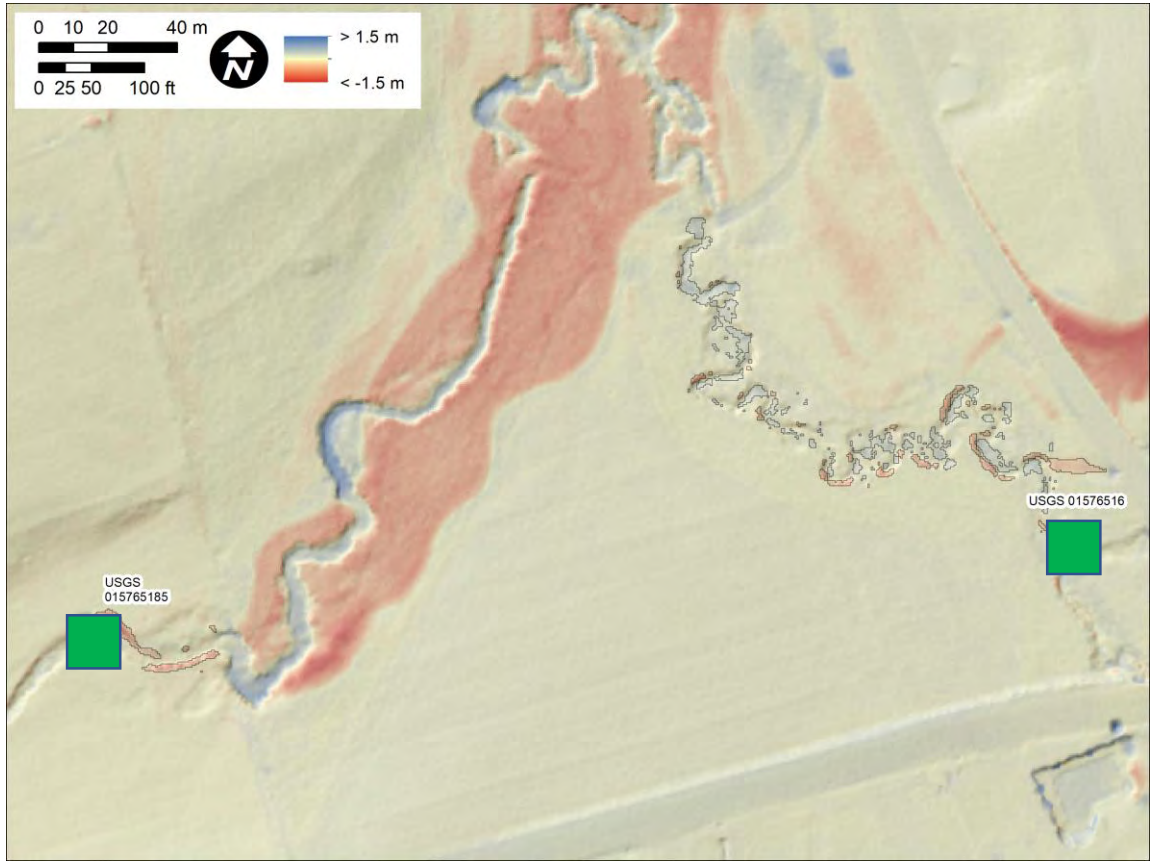

Pre
N
0 50 100 yd
0 50 100 m
XS12
XS11
XS10
XS9
XS5
XS4
XS3
XS2
XS1


Post
0 25 50 100 m
0 50 100 200 300 ft
XS-10
XS-8
XS-6
XS-14
XS-5
XS-4
XS-3

20100121

04242016

Lidar DEM Differencing, 2014 - 2008



USGS gage station identifier	Location	Distance to restoration reach, ft
01576516 (In)	Eastern tributary	1017
015765185 (In)	Western tributary	131
015765195 (Out)	Main stem	558

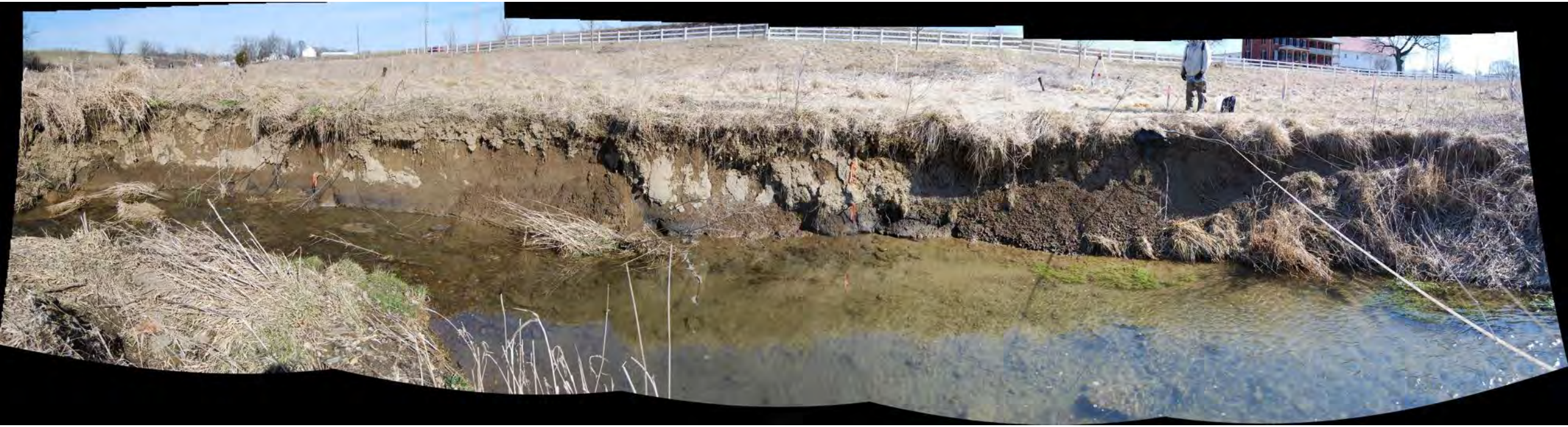
~80 to 100 tons/yr per km of stream bank

Location	Minimum net change, tons/yr	Maximum net change, tons/yr
Western tributary	-7.8	-16.0
Eastern tributary	-5.2	-15.2
Main stem	-10.2	-23.4
Total	-23.2	-54.6

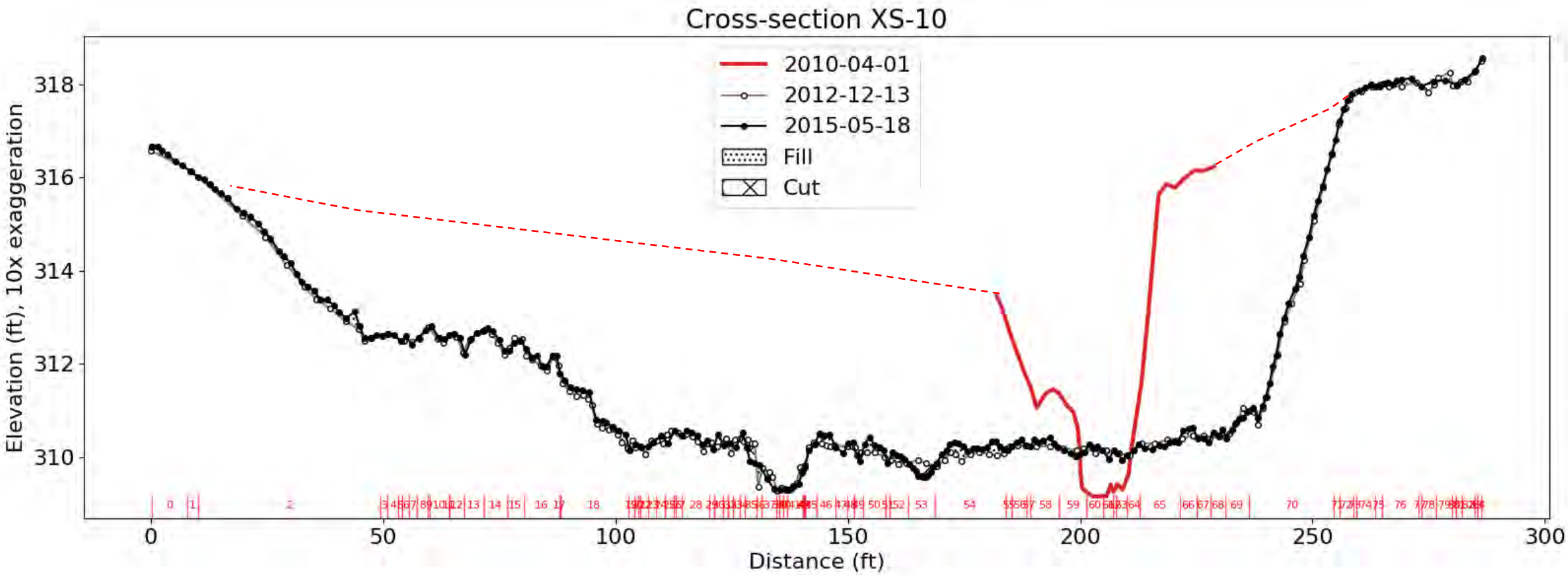
20100205


20100205

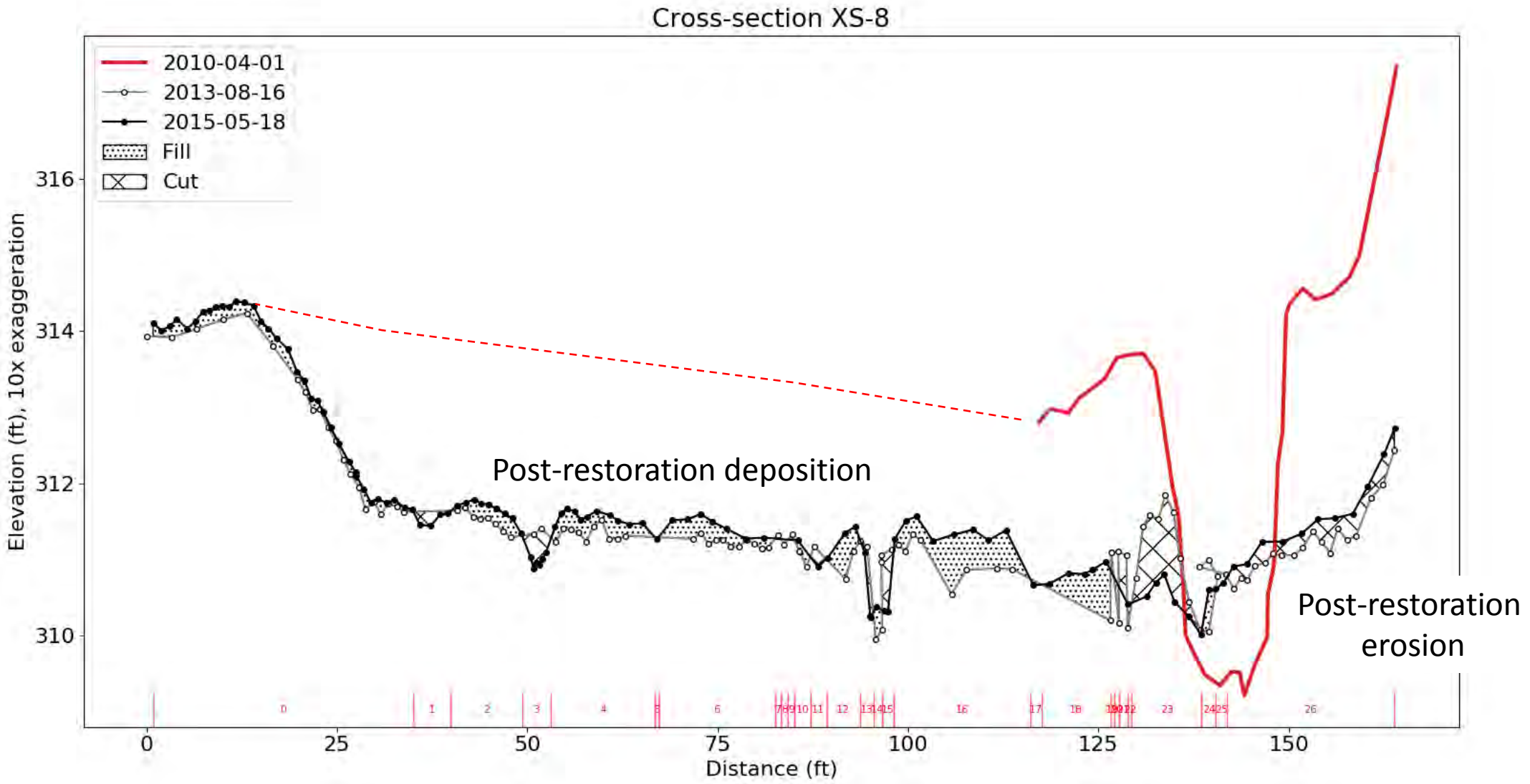
20090217



Repeat RTK-GPS Surveying



Repeat RTK-GPS Surveying



Repeat RTK-GPS Surveying

Section number	Installation date	2nd survey date	Monitoring period yrs	Length ft	Deposition ft^2	Erosion ft^2	Net area change ft^2	Deposition rate ft/yr	Net change rate ft/yr
XS-3	5/14/13	6/9/17	4.07	113.3	43.85	-1.81	42.04	0.10	0.09
XS-4	5/14/13	6/9/17	4.07	55.4	14.55	-0.32	14.23	0.06	0.06
XS-5	5/14/13	5/12/15	1.99	210.1	38.80	-2.34	36.47	0.09	0.09
XS-14	5/18/13	8/4/15	2.21	172.8	14.02	-10.49	3.54	0.04	0.01
XS-6	1/20/14	5/12/15	1.31	145.6	16.04	-1.10	14.94	0.08	0.08
XS-8	8/16/13	5/18/15	1.75	163.0	30.78	-8.52	22.26	0.11	0.08
XS-10	12/13/12	5/18/15	2.43	244.4	17.23	-6.76	10.47	0.03	0.02
Average			2.55	157.8	25.04	-4.48	20.56	0.07	0.06
1 S. D.					12.58	4.04	14.03	0.03	0.03

20090226

2009 04 17

2010 02 05

20090403

04242016

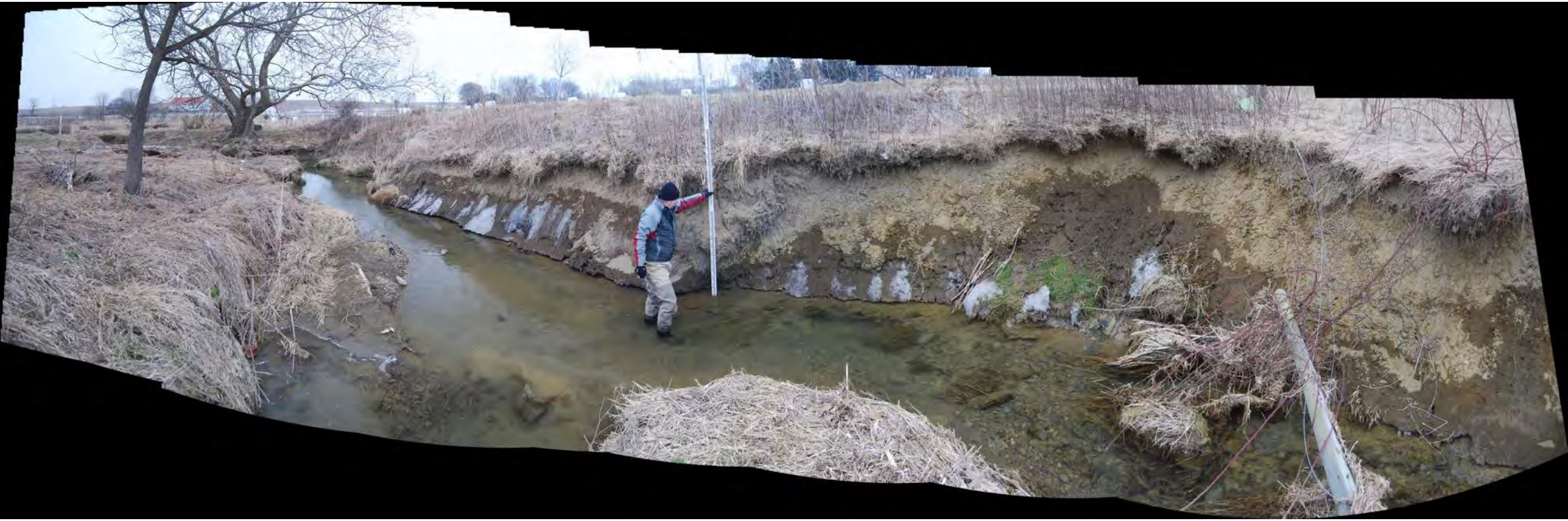
20160424

20100202


200904179

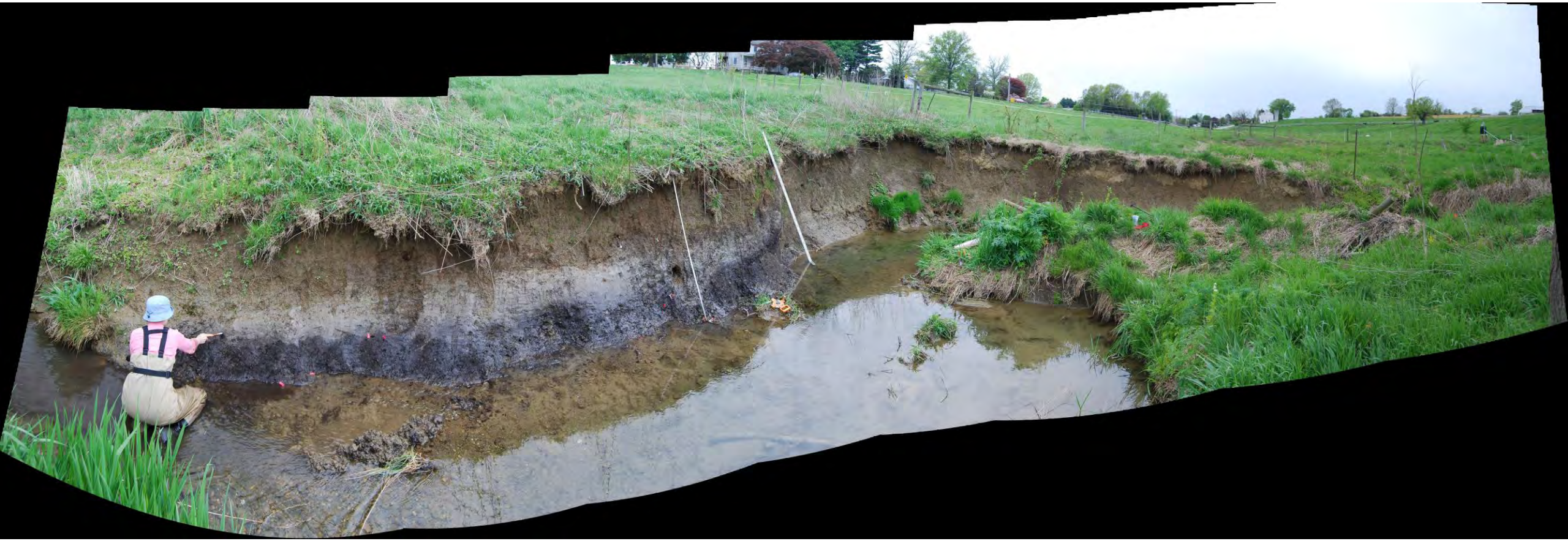
20090310

20100202

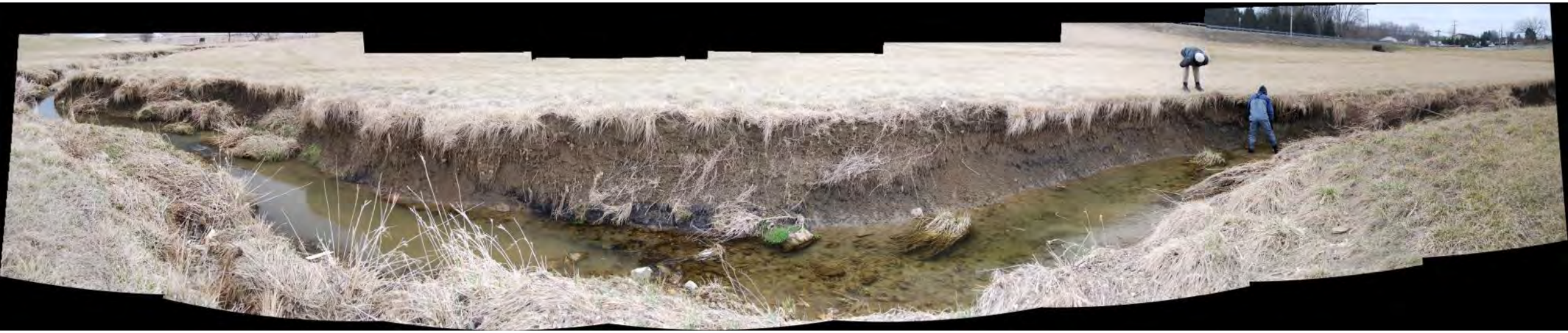


20100424

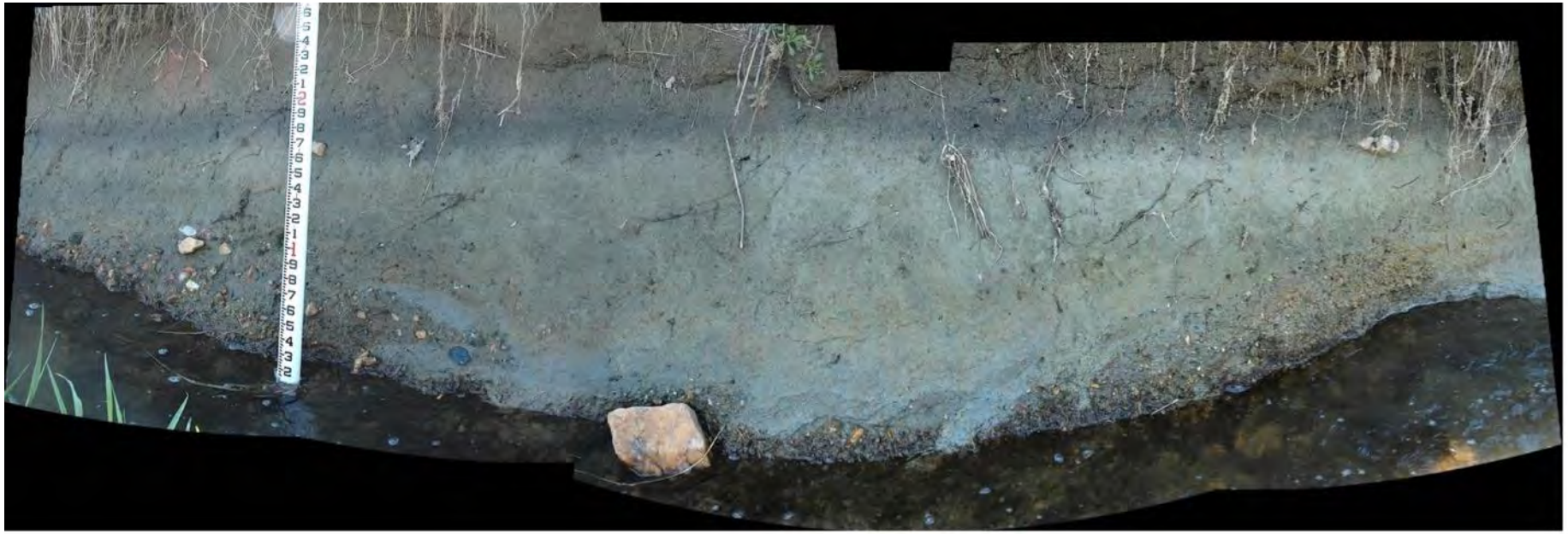
20100424

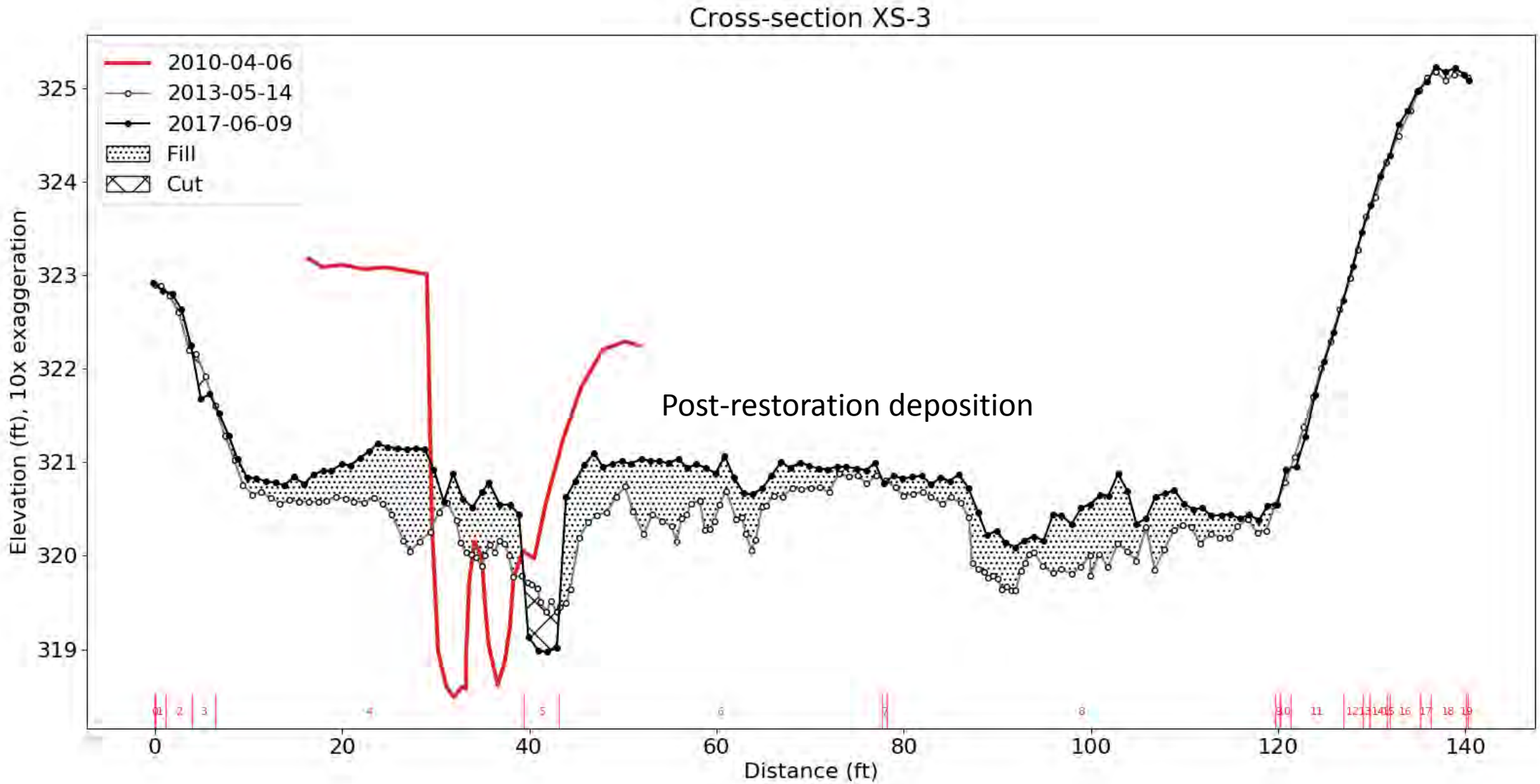


20090310



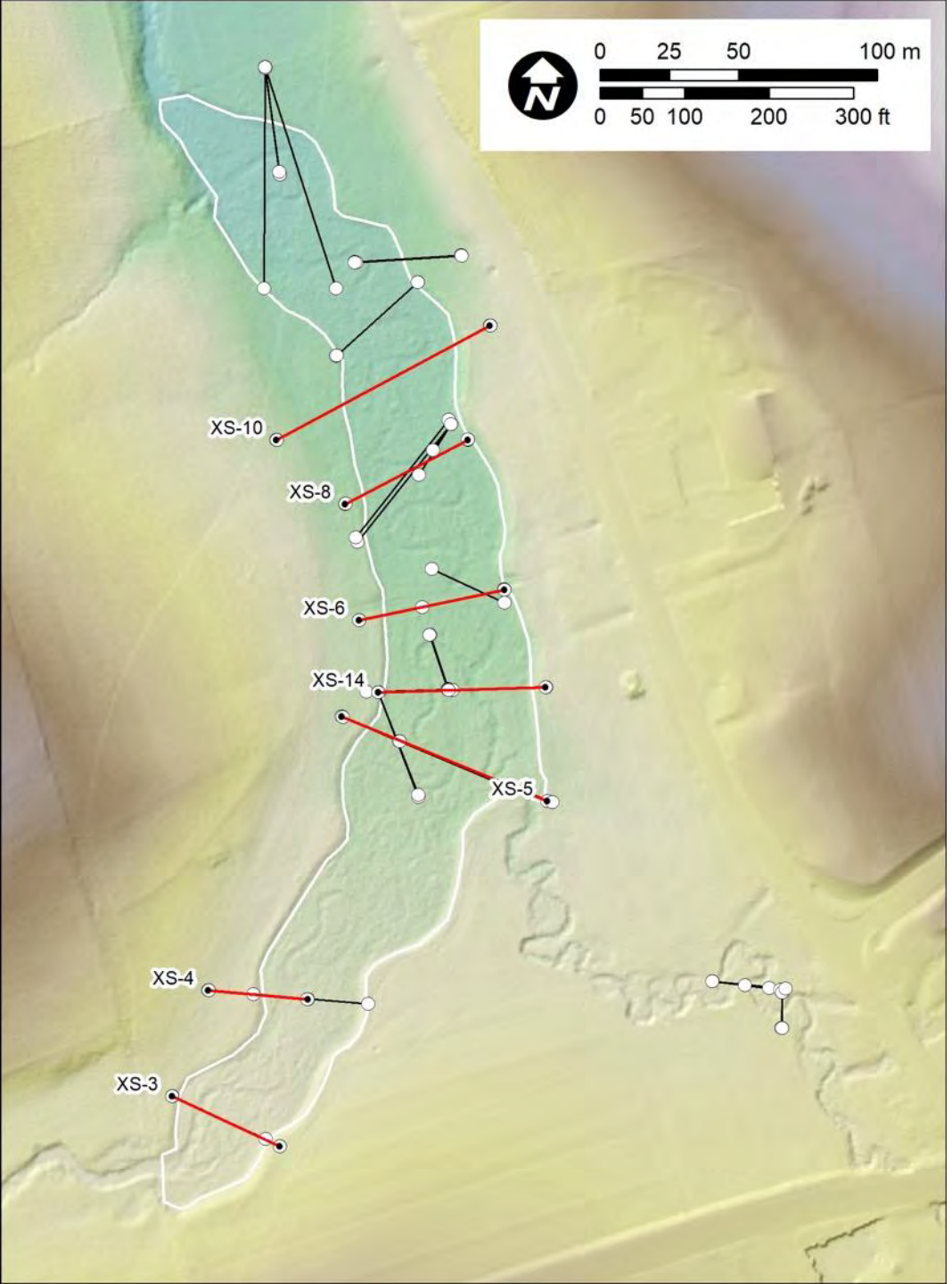
20090424

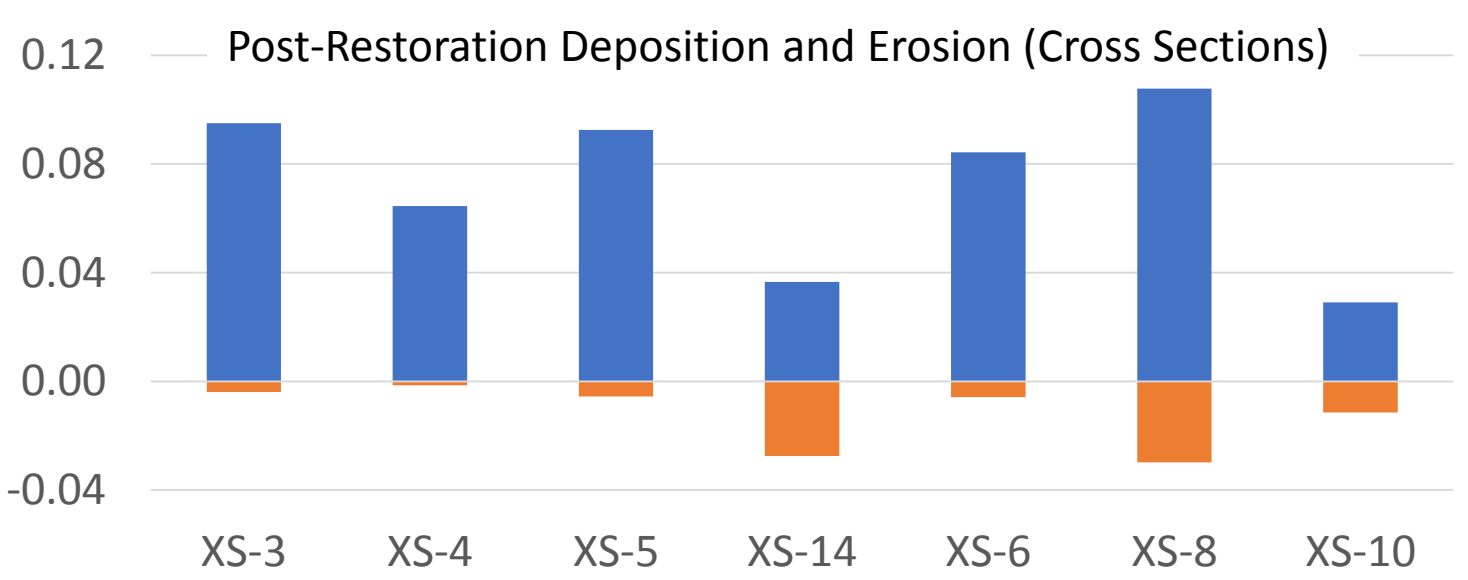


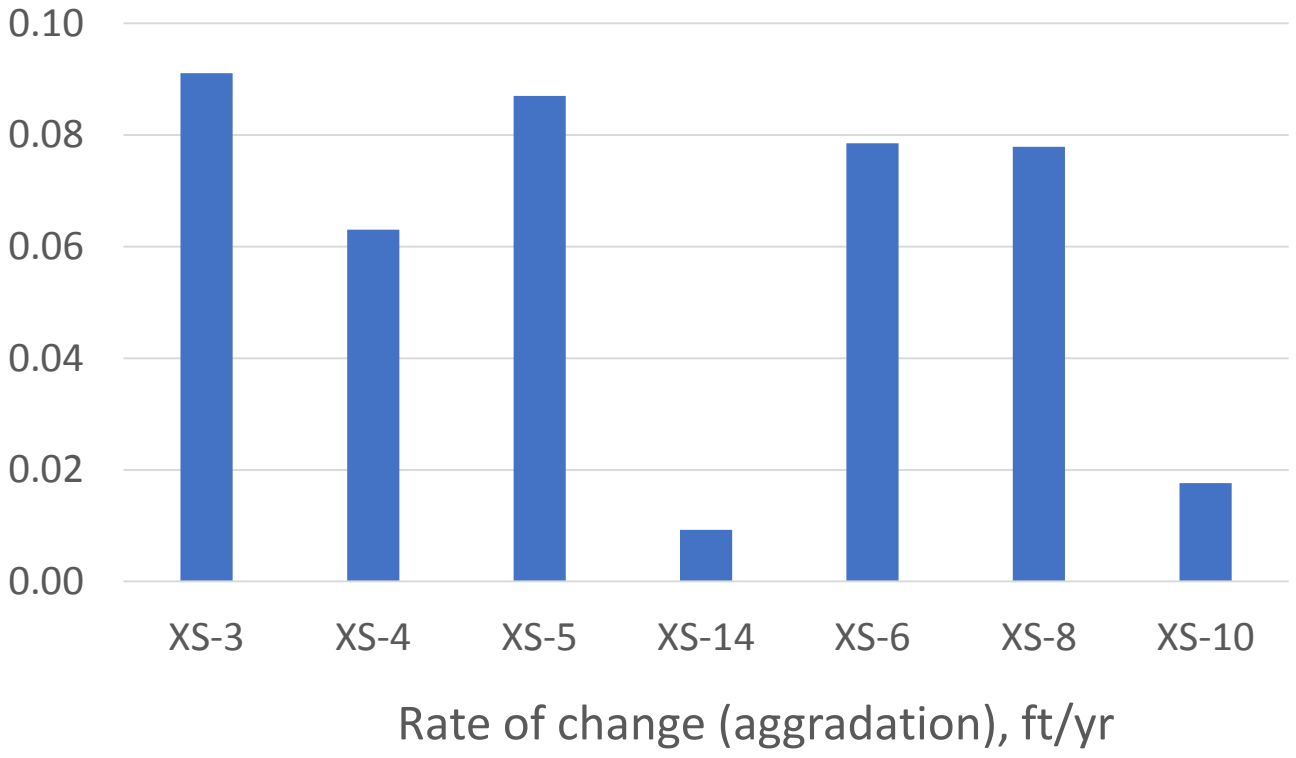

Cross-section XS-3
2010-04-06
2013-05-14
2017-06-09
Fill
Cut
Post-restoration deposition
Elevation (ft), 10x exaggeration
Distance (ft)
325
324
323
322
321
320
319
0
20
40
60
80
100
120
140

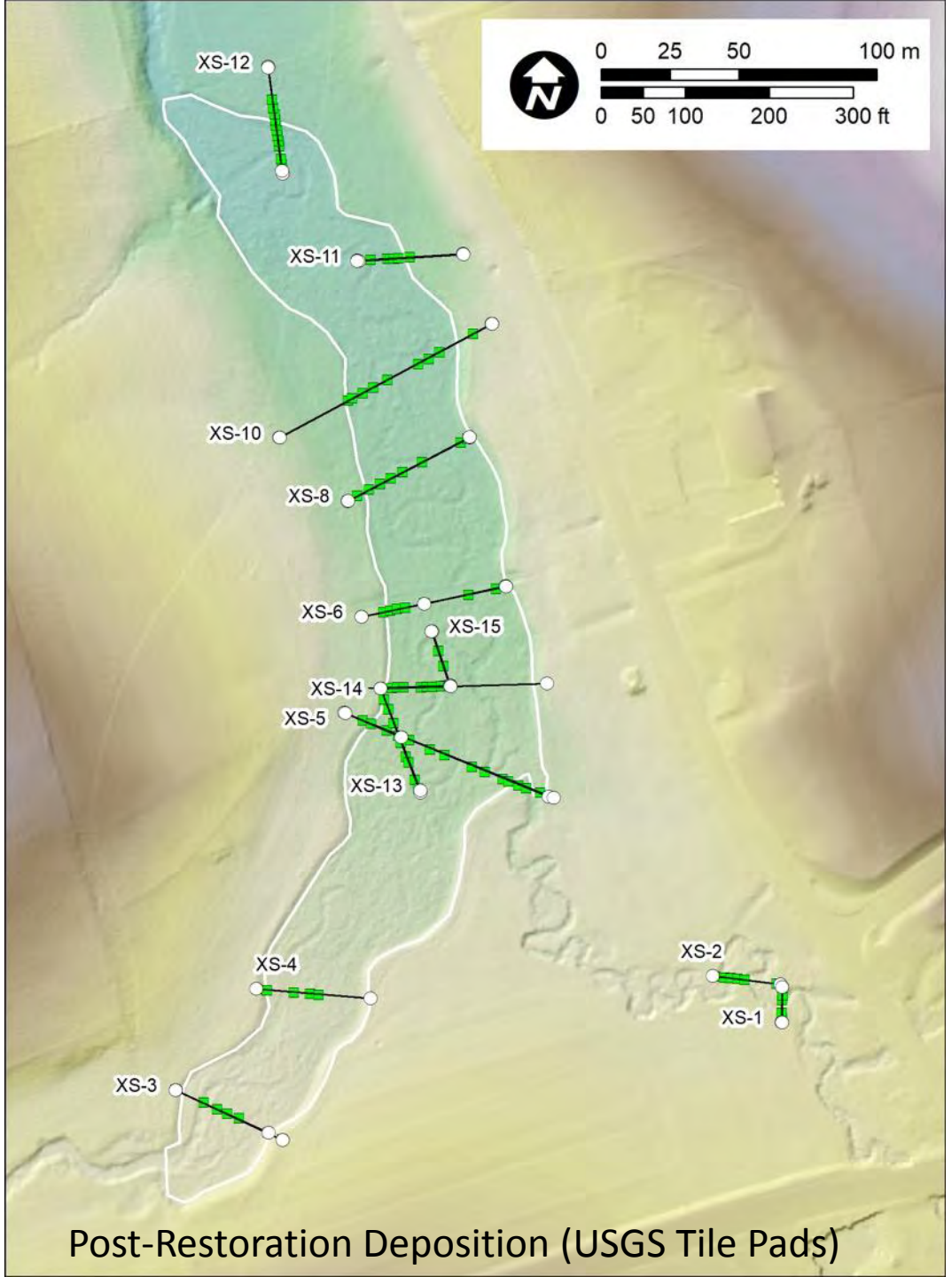
Post-restoration deposition

20160424

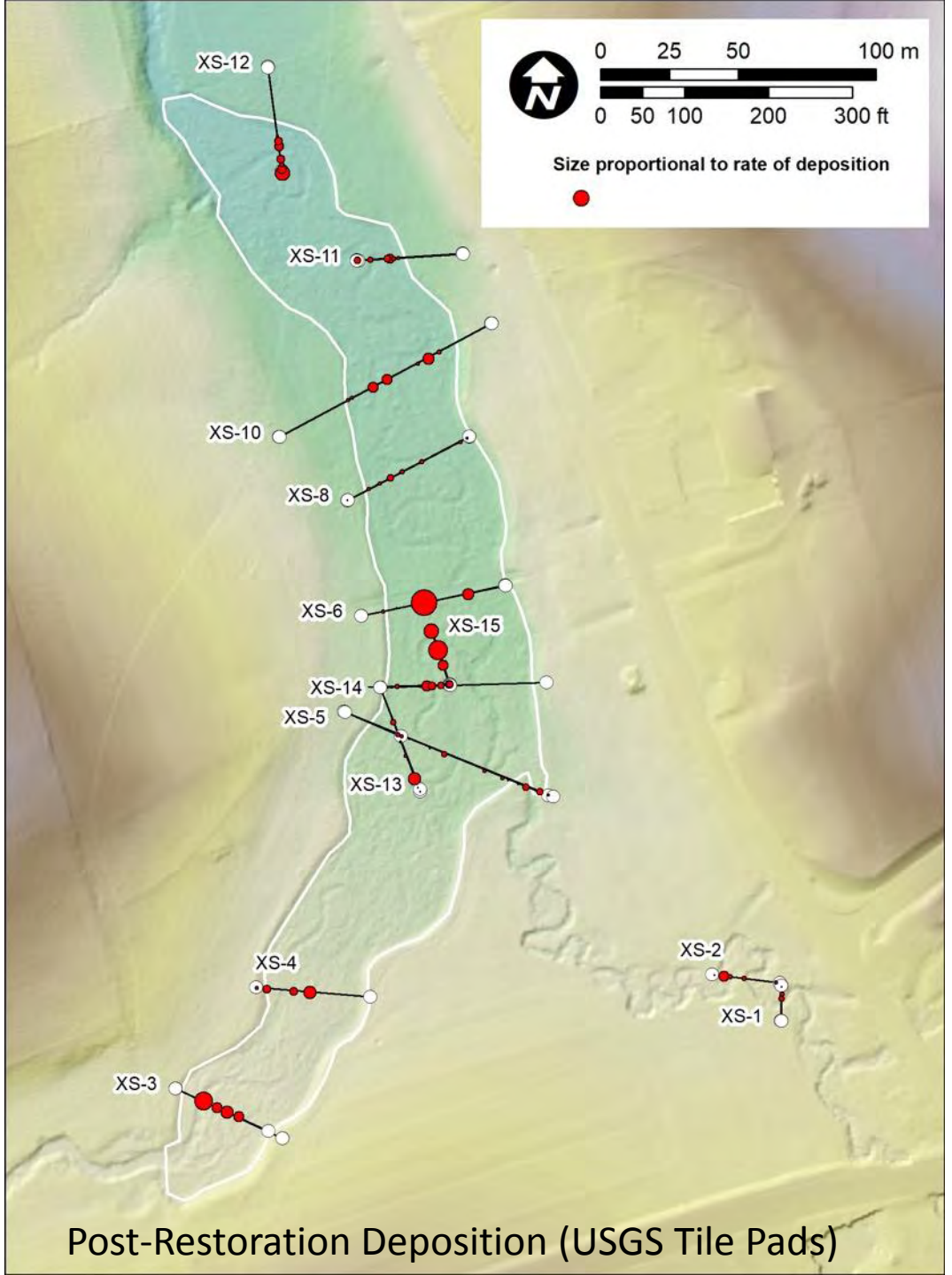

0 25 50 100 m
0 50 100 200 300 ft
XS-10
XS-8
XS-6
XS-14
XS-5
XS-4
XS-3


Post-Restoration Deposition and Erosion (Cross Sections)
0.12
0.08
0.04
0.00
-0.04
XS-3
XS-4
XS-5
XS-14
XS-6
XS-8
XS-10
Deposition rate ft/yr
Erosion rate ft/yr


0.10
0.08
0.06
0.04
0.02
0.00
XS-3
XS-4
XS-5
XS-14
XS-6
XS-8
XS-10
Rate of change (aggradation), ft/yr



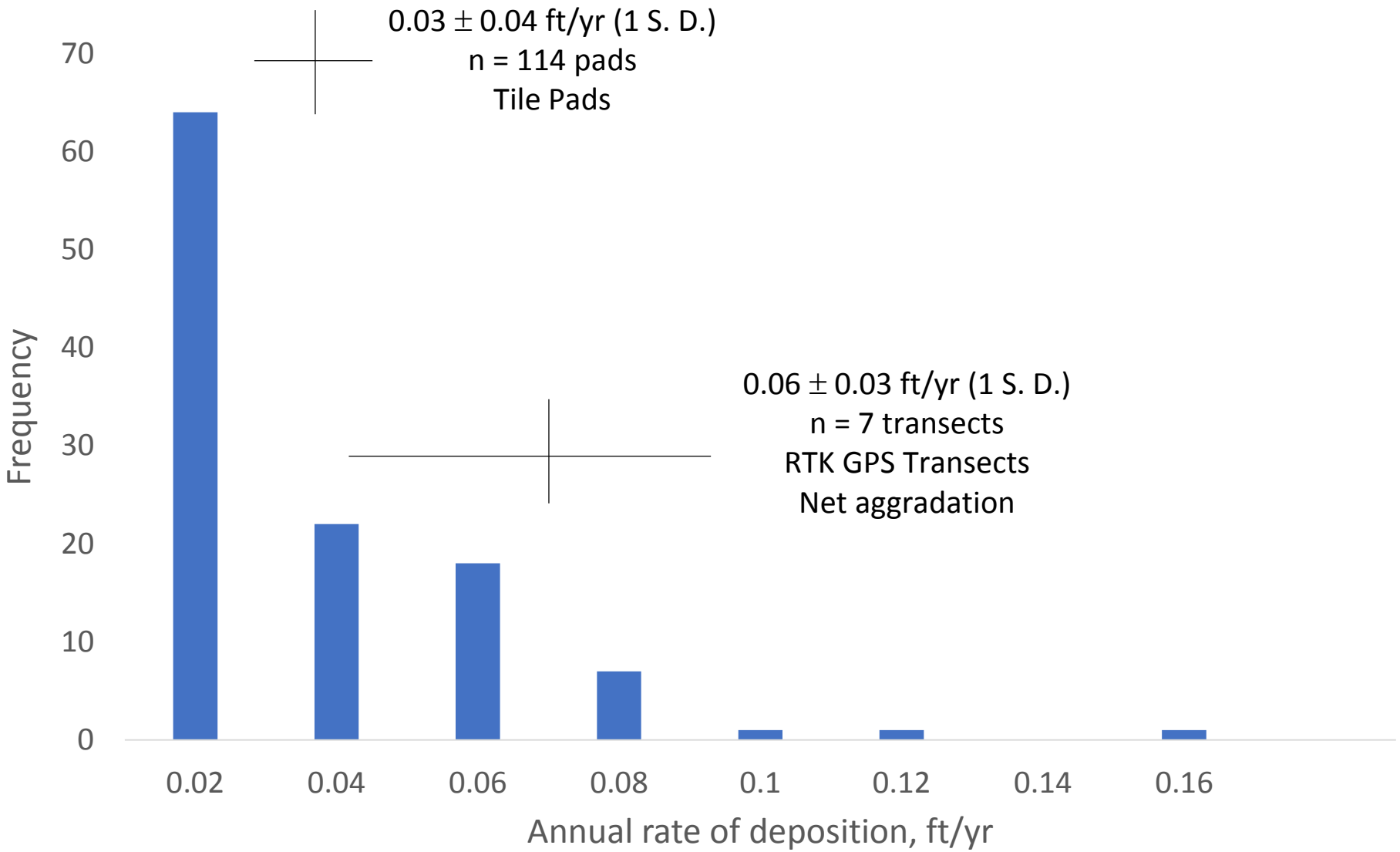
Post-Restoration Deposition (USGS Tile Pads)

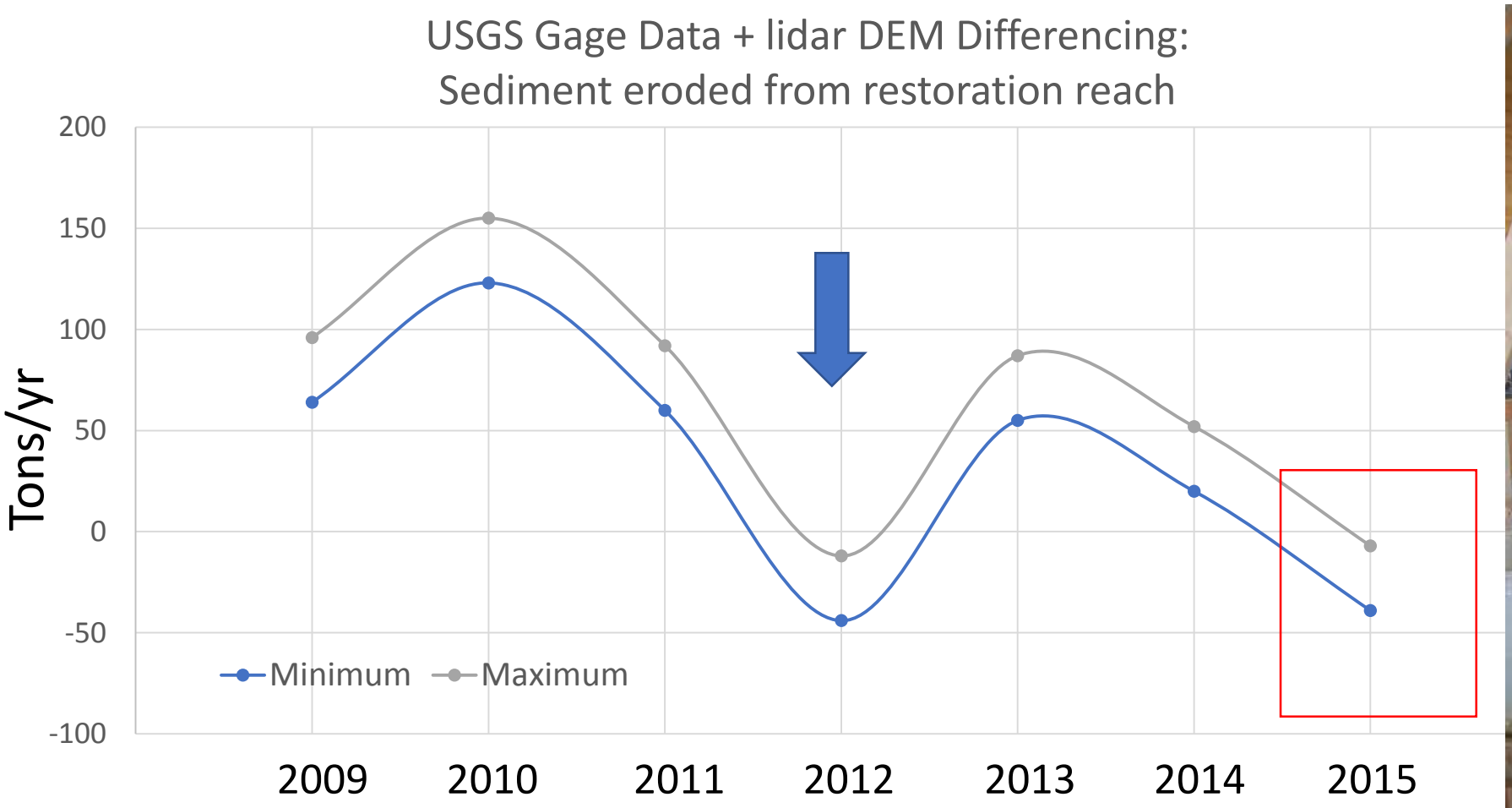


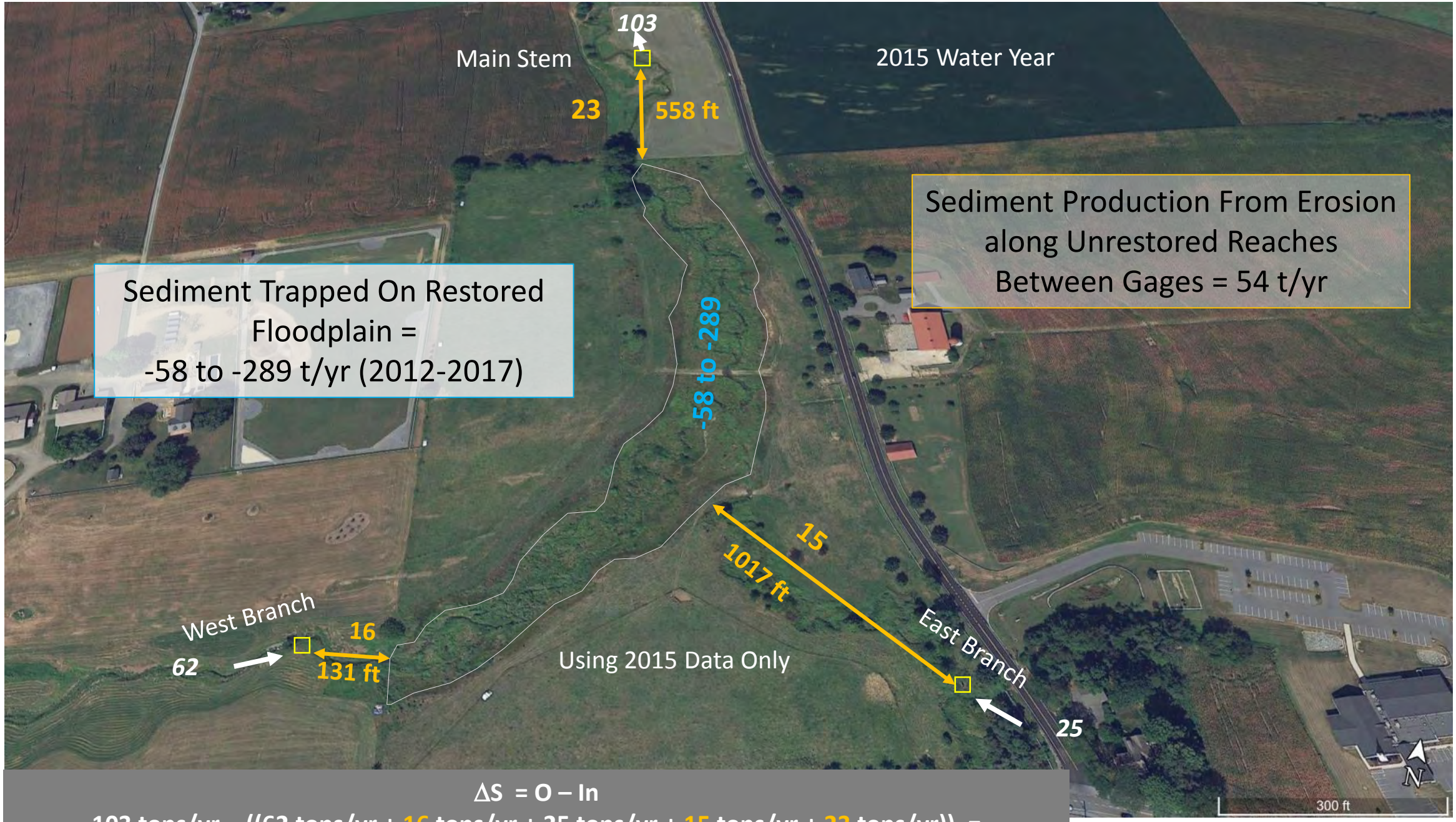
Post-Restoration Deposition (USGS Tile Pads)

			Post-Restoration Deposition (USGS Tile Pads)						
	Cross section	Install date	Most recent measurement	Time between measurements, yrs	Distance from end to end, ft	Number of pads	Average deposition rate (weighted by distance), ft/yr	1 S.D. average deposition rate, ft/yr	Deposition rate from RTK GPS surveys, ft/yr
	XS-3	1/24/13	4/24/16	3.25	138.8	8	0.02	0.005	0.09
	XS-4	1/24/13	4/24/16	3.25	134.8	9	0.04	0.008	0.06
	XS-5	1/24/13	6/12/17	4.38	238.7	18	0.01	0.015	0.09
	XS-14	12/12/12	6/6/17	4.48	82.5	10	0.02	0.001	0.01
	XS-6	12/12/12	6/12/17	4.5	142.7	8	0.08	0.023	0.08
	XS-8	12/12/12	6/6/17	4.48	187.3	10	0.02	0.003	0.08
	XS-10	12/12/12	4/20/16	3.36	205.3	14	0.04	0.006	0.02
	XS-11	12/12/12	4/20/16	3.36	61.7	7	0.03	0.006	
	XS-12	12/12/12	4/20/16	3.36	121.6	15	0.03	0.003	
	XS-13	12/12/12	5/8/14	1.4	126.5	11	0.02	0.003	
	Average			3.58	143.99	11	0.03	0.01	0.06

Post-Restoration Deposition (USGS Tile Pads)



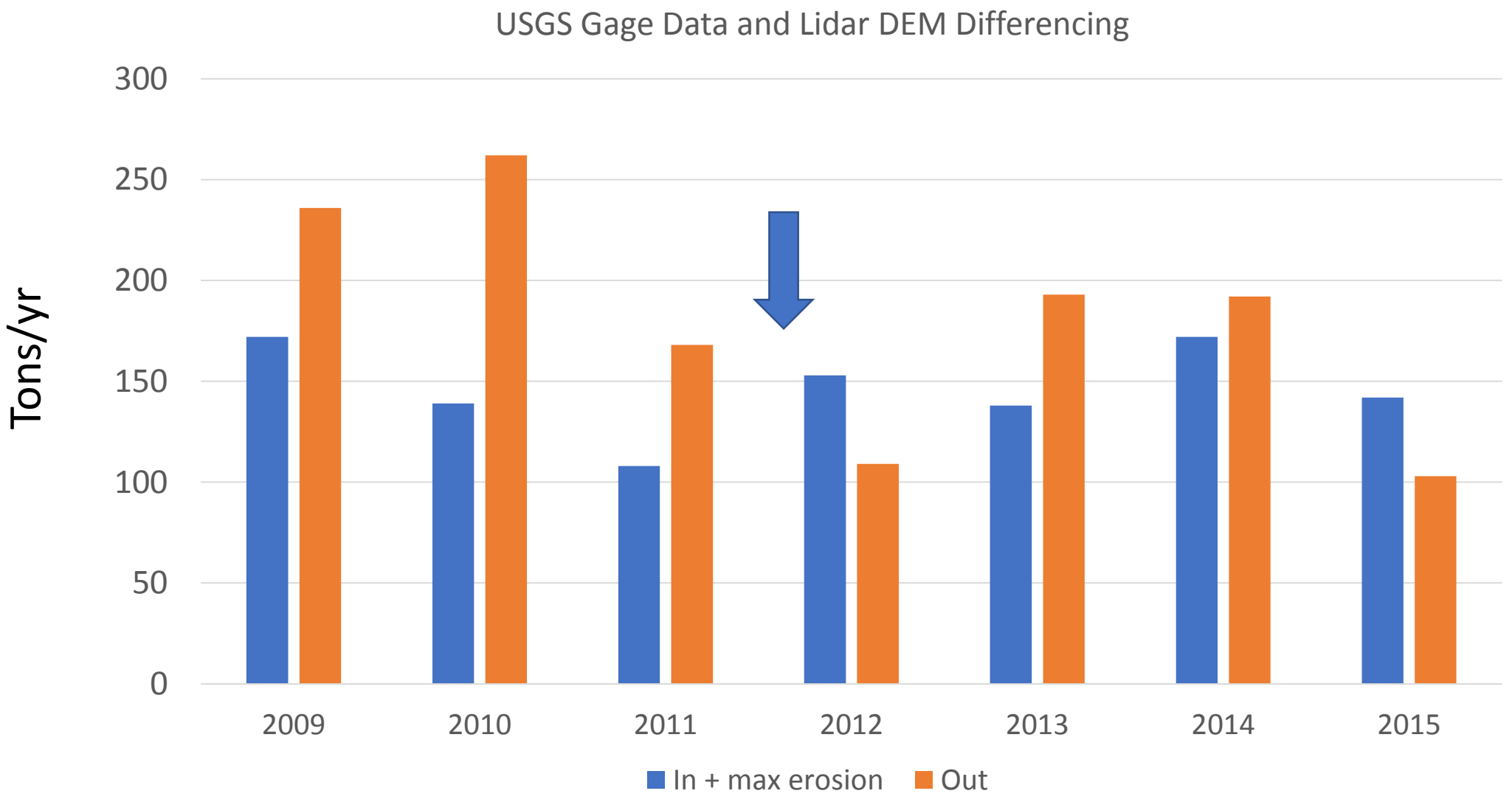

USGS Gage Data + lidar DEM Differencing:
Sediment eroded from restoration reach
Tons/yr
200
150
100
50
0
-50
-100
Minimum
Maximum
2009
2010
2011
2012
2013
2014
2015



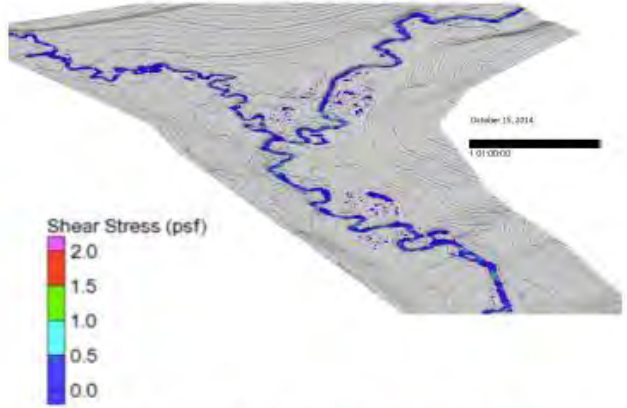
$\Delta S = O - In$

103 tons/yr – ((62 tons/yr + 16 tons/yr + 25 tons/yr + 15 tons/yr + 23 tons/yr)) =

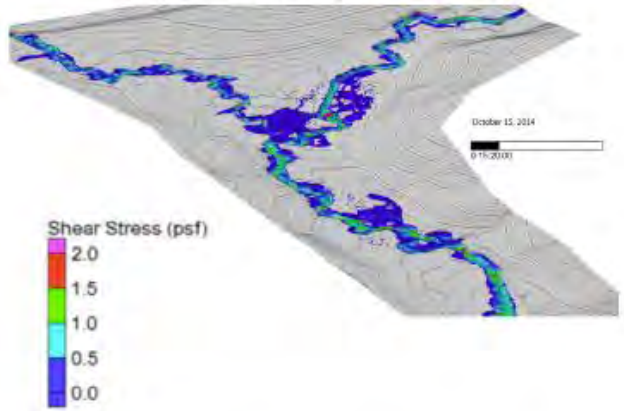
ΔS = 103 - 141 = -38 tons/yr (i.e., deposition)


USGS Gage Data and Lidar DEM Differencing
Tons/yr
300
250
200
150
100
50
0
2009
2010
2011
2012
2013
2014
2015
In + max erosion
Out

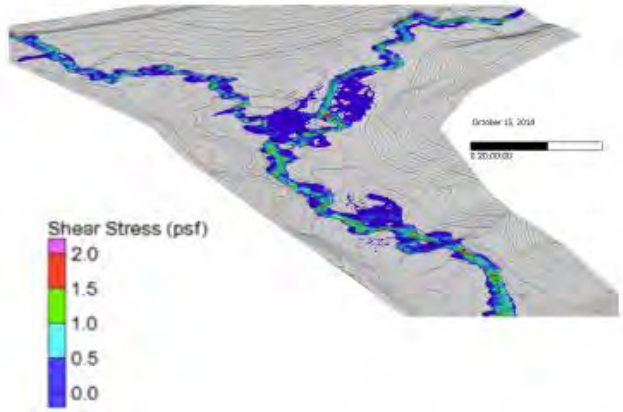
Pre-Restoration 2-D Hydraulic Modeling

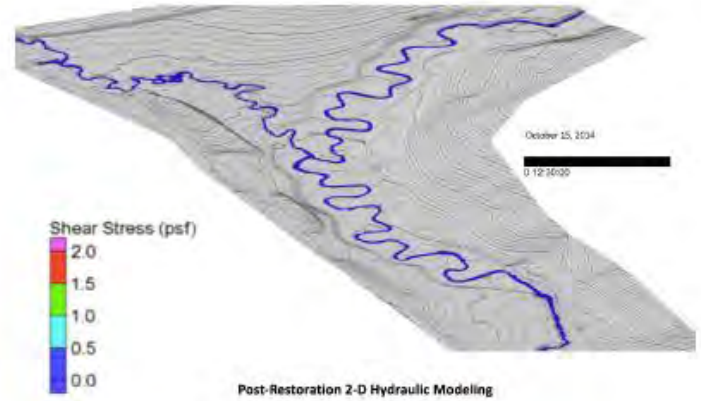


Pre-Restoration 2-D Hydraulic Modeling

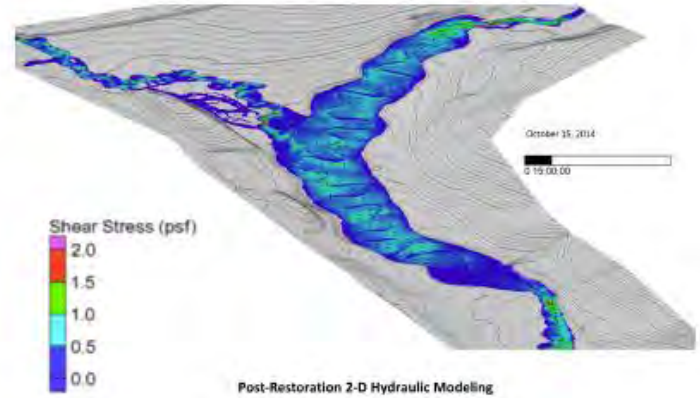


Pre-Restoration 2-D Hydraulic Modeling

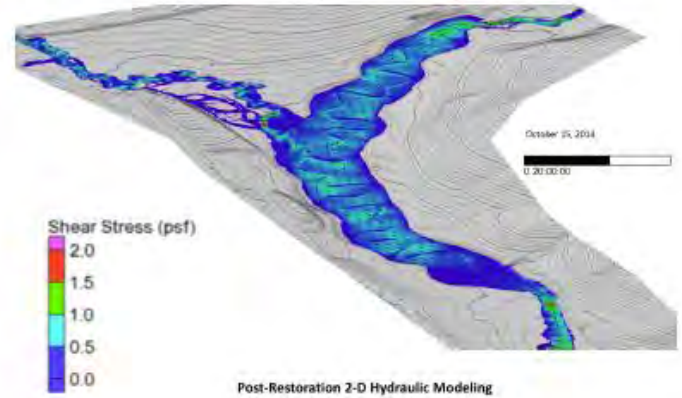




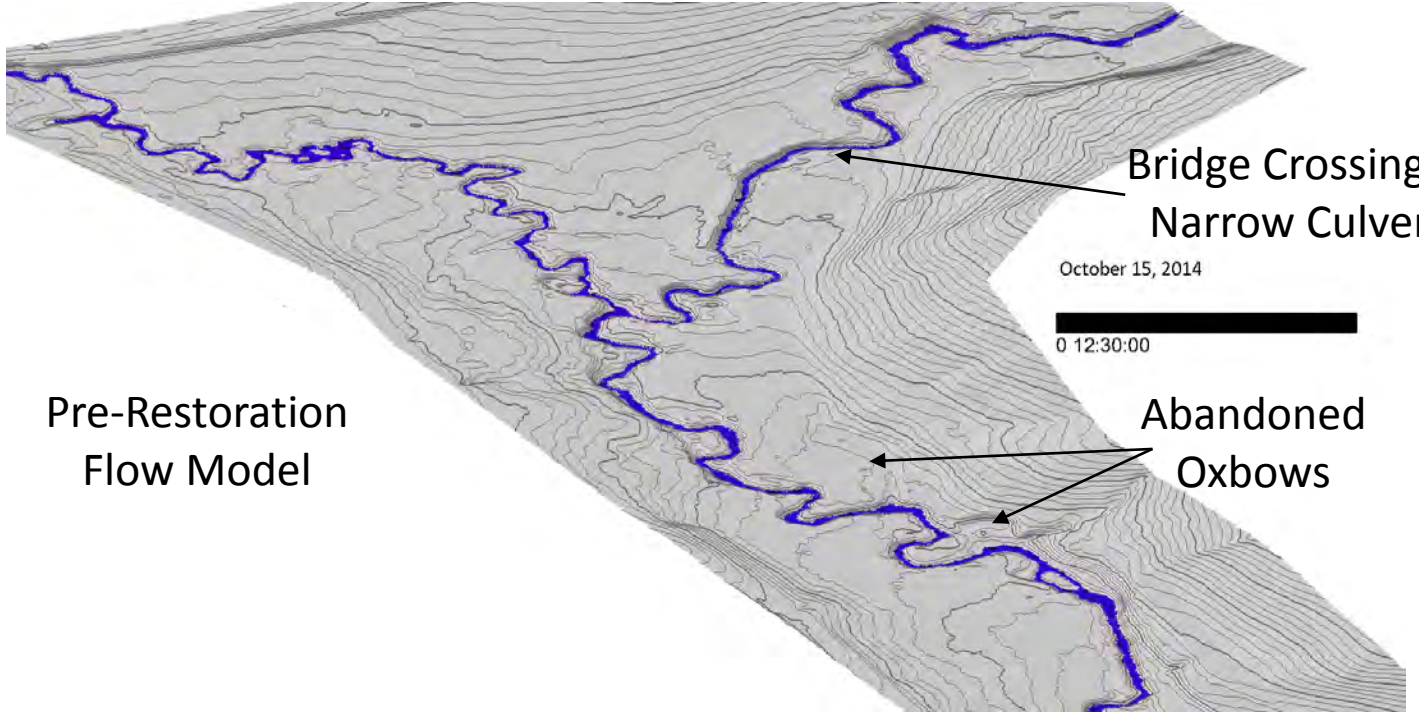
Post-Restoration 2-D Hydraulic Modeling



Post-Restoration 2-D Hydraulic Modeling

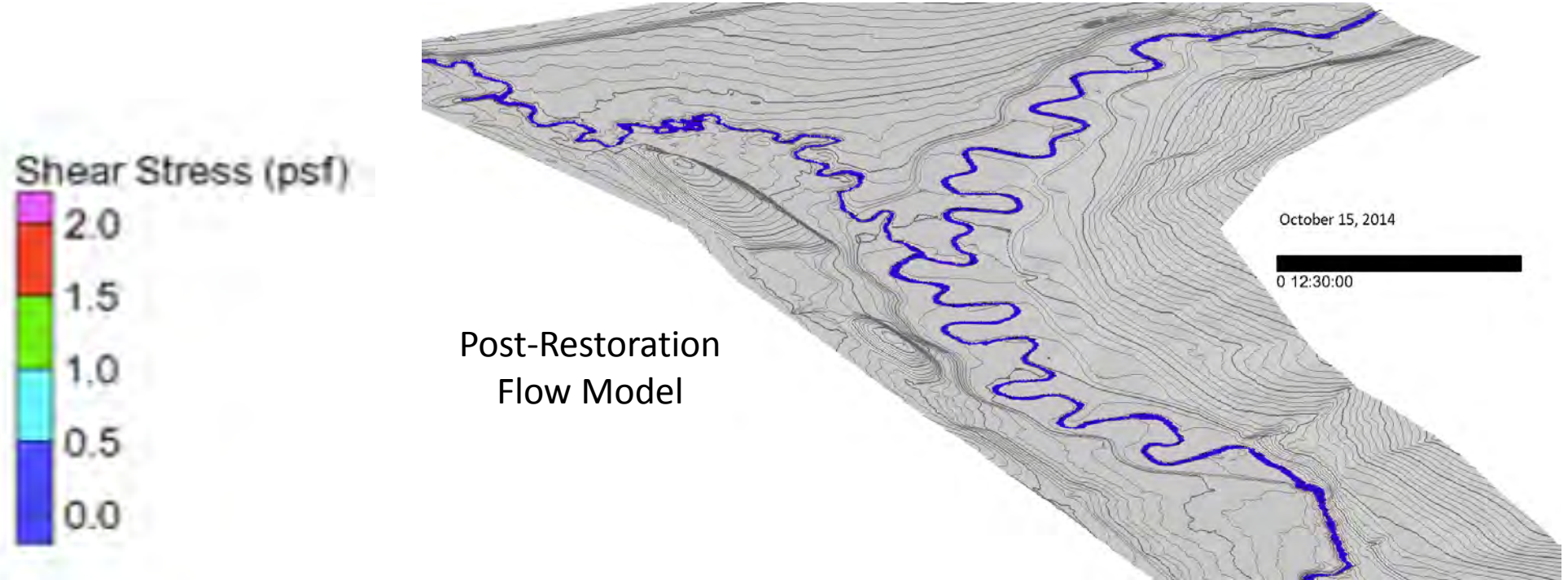


Post-Restoration 2-D Hydraulic Modeling



Pre-Restoration
Flow Model

Art Parola, Univ. Louisville
Dorothy Merritts, F&M



Post-Restoration
Flow Model


0
35
70
140
Meters
Gravel Samples
May 2016
D50
1.0 - 1.4
1.4 - 4.1
4. 1 - 7.9
7.9 - 11.5
11.5 - 16.5
Small Streams

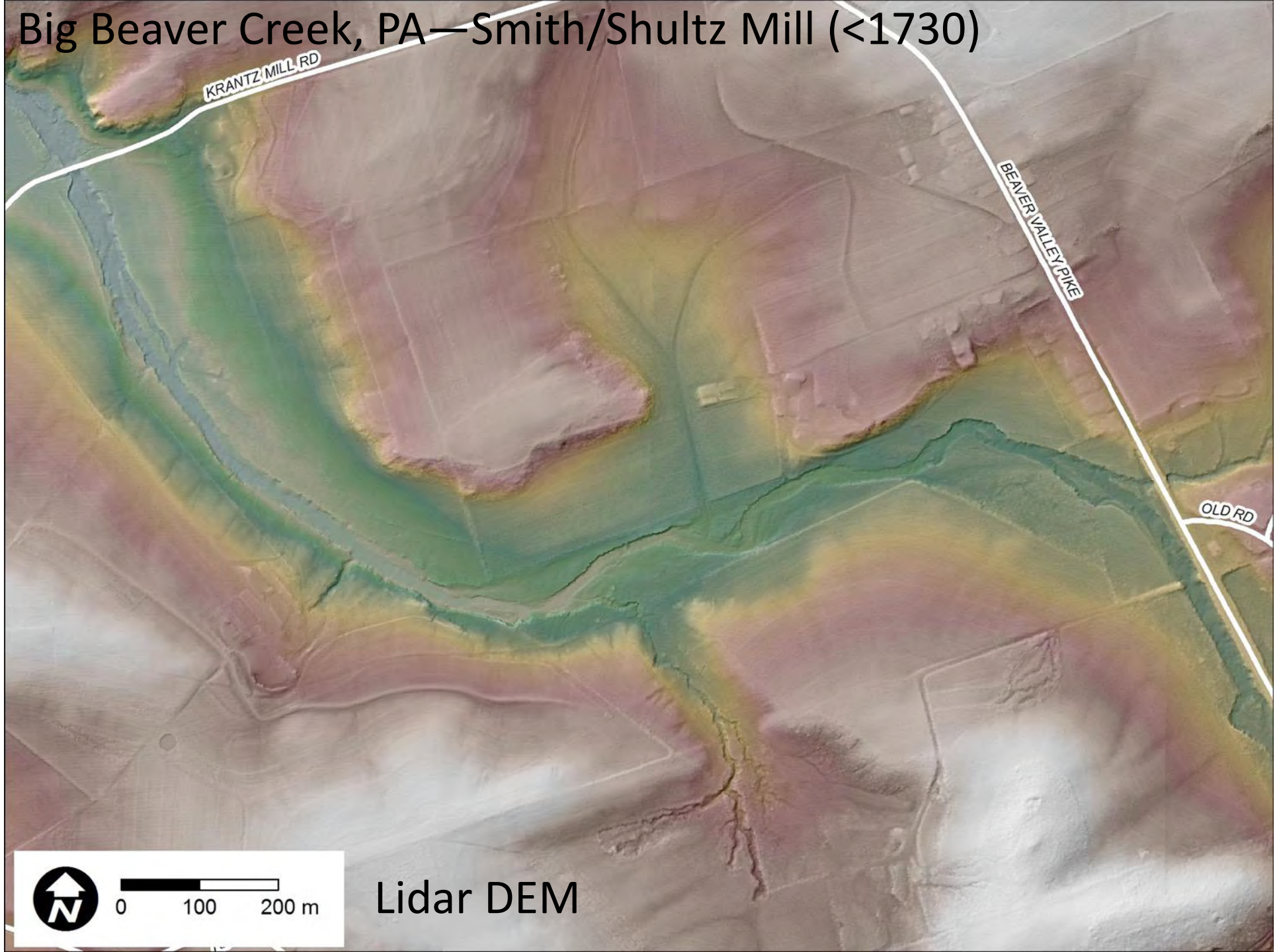
Big Beaver Creek, PA – Smith/Shultz Mill (<1730)

Big Beaver Creek, PA – Smith/Shultz Mill (<1730)

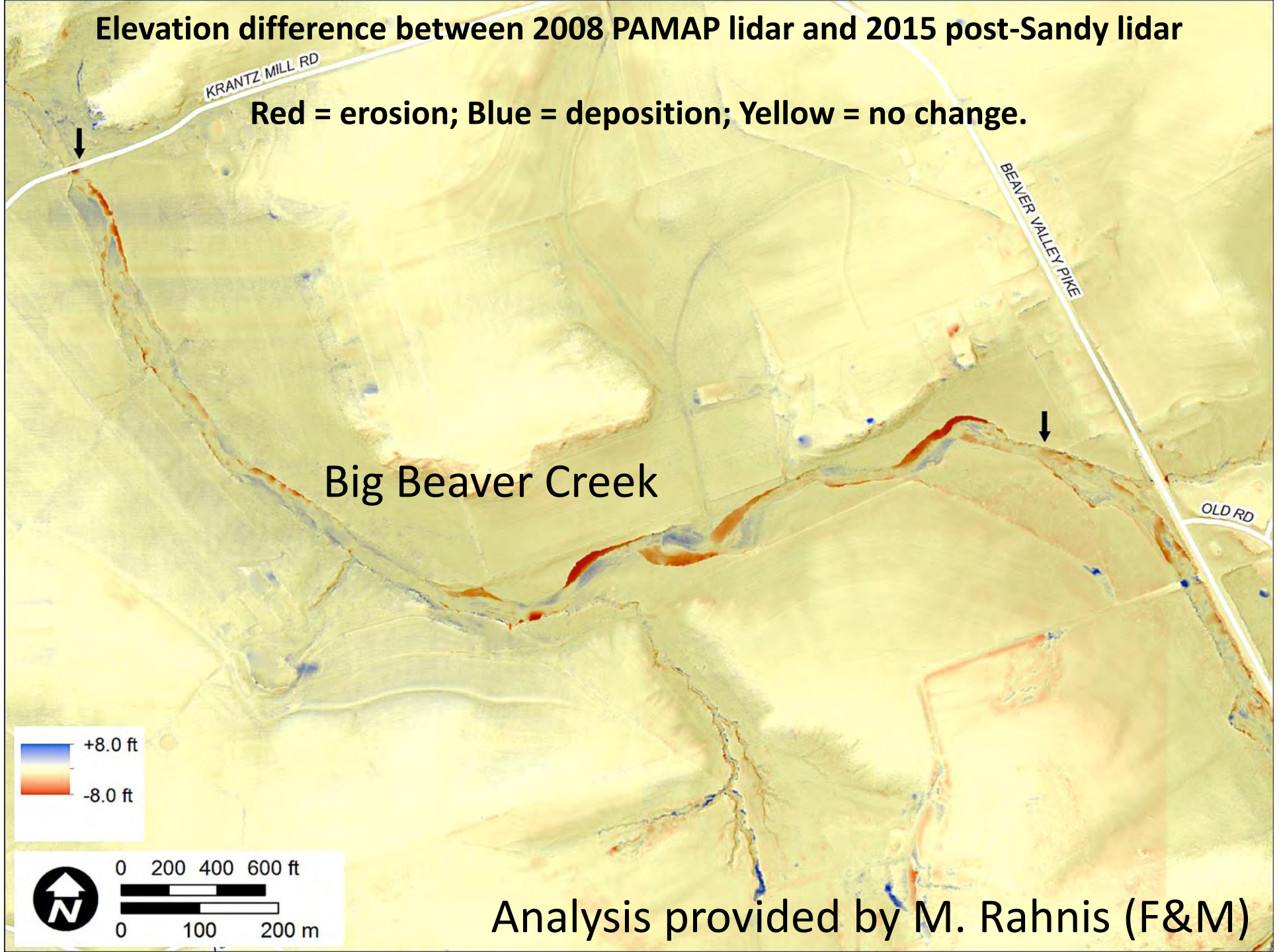
Photo taken in April 2009. Note apron of sediment from winter freeze-thaw.

Big Beaver Creek, PA – Mills, dams, inset dams, and incised streams

Big Beaver Creek, PA—Smith/Shultz Mill (<1730)



Lidar DEM


Elevation difference between 2008 PAMAP lidar and 2015 post-Sandy lidar
Red = erosion; Blue = deposition; Yellow = no change.
KRANTZ MILL RD
BEAVER VALLEY PIKE
OLD RD
Big Beaver Creek
+8.0 ft
-8.0 ft
0 200 400 600 ft
0 100 200 m
Analysis provided by M. Rahnis (F&M)