Nutrient Reduction Through Stream Restoration

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Stream Program
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History of the Cannonsville Reservoir

- **1994:** NYS DEC identified Cannonsville & West Branch Delaware River as priority water bodies in need of Total Maximum Daily Load (TMDL) for total phosphorus (TP)
  - ❖ *Phosphorus reduction efforts were successful!*
- **2002:** Cannonsville Reservoir was removed from the restricted list
- **2004:** West Branch Delaware River was removed from the NYS 303(d) impaired list
- **2019:** Records of elevated median annual TP concentration in West Branch Del River and Cannonsville Reservoir to near-eutrophic levels

Science-Based Data Collection

- It is hypothesized that severe streambank erosion is contributing substantially to the overall nutrient load of the Cannonsville Reservoir between 2009-2019.
- Three approaches were used to estimate sediment load volumes and nutrient load masses for streambank erosion at two case study sites;
    1. Analysis of the eroded land volume
    2. Soil nutrient concentrations and physical properties
    3. Estimate nutrient load masses that are introduced into the West Branch Delaware River.

Why Estimate Nutrient & Sediment Loads

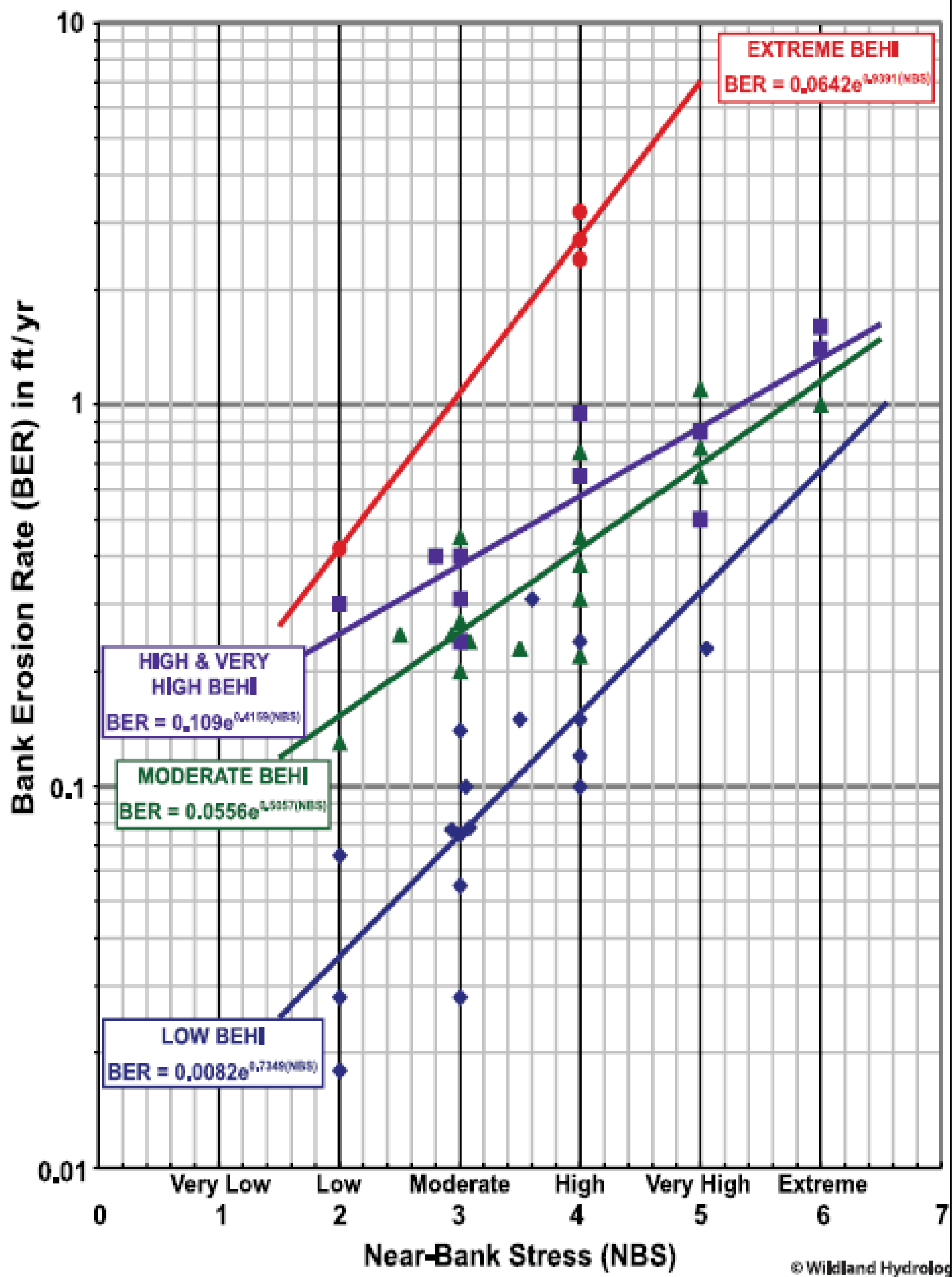
- Prioritize projects by nutrient load
- General water quality concerns
- Reservoir nutrient loading
- Chesapeake Bay nutrient loading
- Grant funding

How to Estimate Nutrient & Sediment Loads

- Steps:
  1. Measure eroded soil volume
  2. Measure physical soil properties and soil nutrient concentrations
  3. Estimate total phosphorous (TP) and total nitrogen (TN) mass loaded

Alternate Method

- Prediction of Annual Streambank Erosion Rates
  - Relationship of Bank Erosion Hazard Index (BEHI) and Near-Bank Stress (NBS) to predict annual streambank erosion rates
  - Data from streams found in sedimentary and/or metamorphic geology



Bank Erosion Hazard Index (BEHI)

Stream:	Location:	
Station:	Observers:	
Date:	Stream Type:	Valley Type:

BEHI Score (Fig. 3-7)

Study Bank Height to Bankfull Height (C)

Study Bank Height (ft) =	(A)	Bankfull Height (ft) =	(B)	(A) / (B) =	(C)	

Root Depth to Study Bank Height (E)

Root Depth (ft) =	(D)	Study Bank Height (ft) =	(A)	(D) / (A) =	(E)	

Weighted Root Density (G)

Root Density as % =	(F)	(F) x (E) =	(G)	

Bank Angle (H)

Bank Angle as Degrees =	(H)	

Surface Protection (I)

Surface Protection as % =	(I)	

Bank Material Adjustment:

- **Bedrock** (Overall *Very Low* BEHI)
- **Boulders** (Overall *Low* BEHI)
- **Cobble** (Subtract 10 points if uniform med. to large cobble)
- **Gravel or Composite Matrix** (Add 5–10 points depending on percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt/Clay** (No adjustment unless primarily clay, then subtract 20 points)

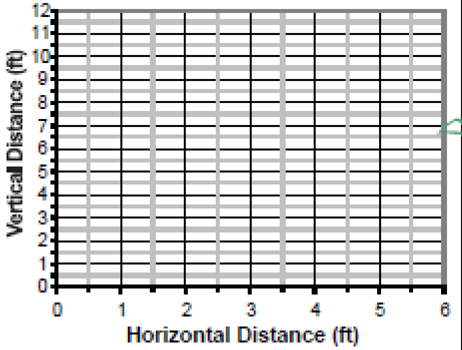
Bank Material Adjustment

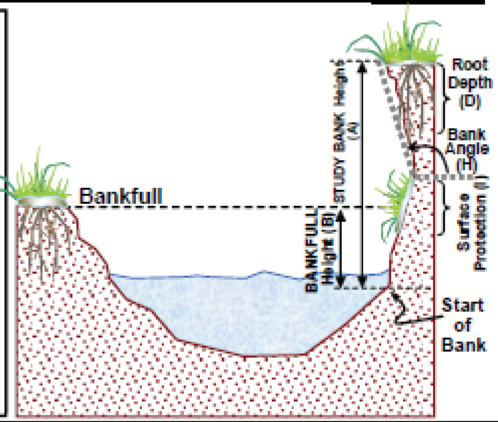
Stratification Adjustment

Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50	

Bank Sketch





Estimating Near-Bank Stress (NBS)

Stream:	Location:	
Station:	Stream Type:	Valley Type:
Observers:		Date:

Methods for Estimating Near-Bank Stress (NBS)

(1) Channel pattern, transverse bar, or split channel/central bar creating NBS......	Level I	Reconaissance
(2) Radius of curvature to bankfull width (R_c / W_{bkf})......	Level II	General Prediction
(3) Pool slope to average water surface slope (S_p / S)......	Level II	General Prediction
(4) Pool slope to riffle slope (S_p / S_{rif})......	Level II	General Prediction
(5) Near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})......	Level III	Detailed Prediction
(6) Near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})......	Level III	Detailed Prediction
(7) Velocity profiles / Isovels / Velocity gradient......	Level IV	Validation

Level I (1)

- Transverse or central bars - short or discontinuous...... NBS = *High / Very High*
- Extensive deposition (continuous, cross-channel)...... NBS = *Extreme*
- Chute cutoffs, down-valley meander migration, converging flow...... NBS = *Extreme*

Level II

(2)	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)	Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)	Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Dominant Near-Bank Stress

Level III

(5)	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV

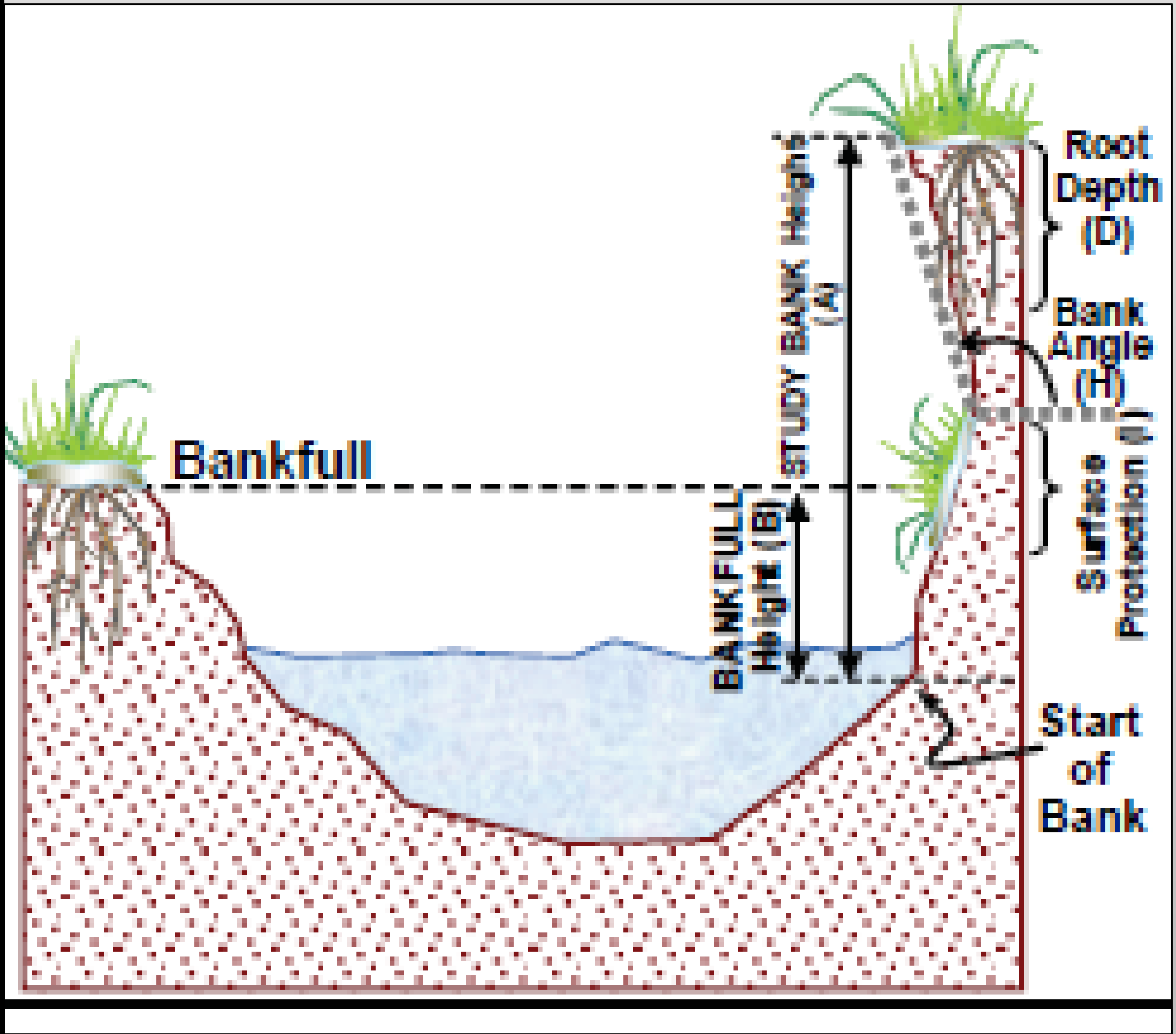
(7)	Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) Ratings	Method Number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40

Overall Near-Bank Stress (NBS) Rating

Bank Erosion Hazard Index



Bank Height at Bankfull vs Bank Height

Measurements Used

- Volume:

  square area * bank height = cubic volume

  $\mathbf{m^2 * m = m^3}$

- Mass:

  cubic volume * bulk density = mass

  $\mathbf{m^3_{soil} * g/cm^3 * (100\ cm/\ m)^3 * (\ kg\ /\ 1000\ g) = kg_{soil}}$

- Mass of fine-earth fraction:

  mass * fine-earth fraction = mass of fine-earth fraction

  - Exclude rocks from nutrient estimates
  - Use fine-earth fraction, or the fraction of particles <2mm in size (sand and smaller)

Nutrient Concentrations

- Soil Samples
  - Break into manageable segments by soil type and land cover
  - Segments sampled every 50 feet and made into composite
  - Analysis by environmental lab
  - Results returned in mg/kg (ppm)
    - Phosphorus Mass:

Soil mass * TP concentration = TP mass

$$kg_{soil} * (mg_{TP} / kg_{soil}) * (1\ kg / 1{,}000{,}000\ mg) = kg_{TP}$$

- Nitrogen Mass:

Soil mass * TN concentration = TN mass

$$kg_{soil} * (mg_{TN} / kg_{soil}) * (1\ kg / 1{,}000{,}000\ mg) = kg_{TN}$$

Soil Map
West Branch Delaware River Watershed
Delaware County, NY

Assumptions

- Constant floodplain elevation
- Constant streambed elevation
- Soil sample is an accurate representation

Estimating Nutrient Loads from Two Streambank Erosion Sites on the West Branch Delaware River, Delaware County, New York

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Case Studies

- Town of Hamden, NY
    1. Birdsong Farm

    2. River Haven Farm

Birdsong Farm
1995 Aerial
Image U.S. Geological Survey
508 ft
Google Earth
Tour Guide
1993
Imagery Date: 6/22/1993
18 T 502970.52 m E 4675543.60 m N elev 1284 ft
eye alt 3514 ft

Birdsong Farm
2015 Aerial

Birdsong Farm

2015 Aerial with 1995 Stream Alignment

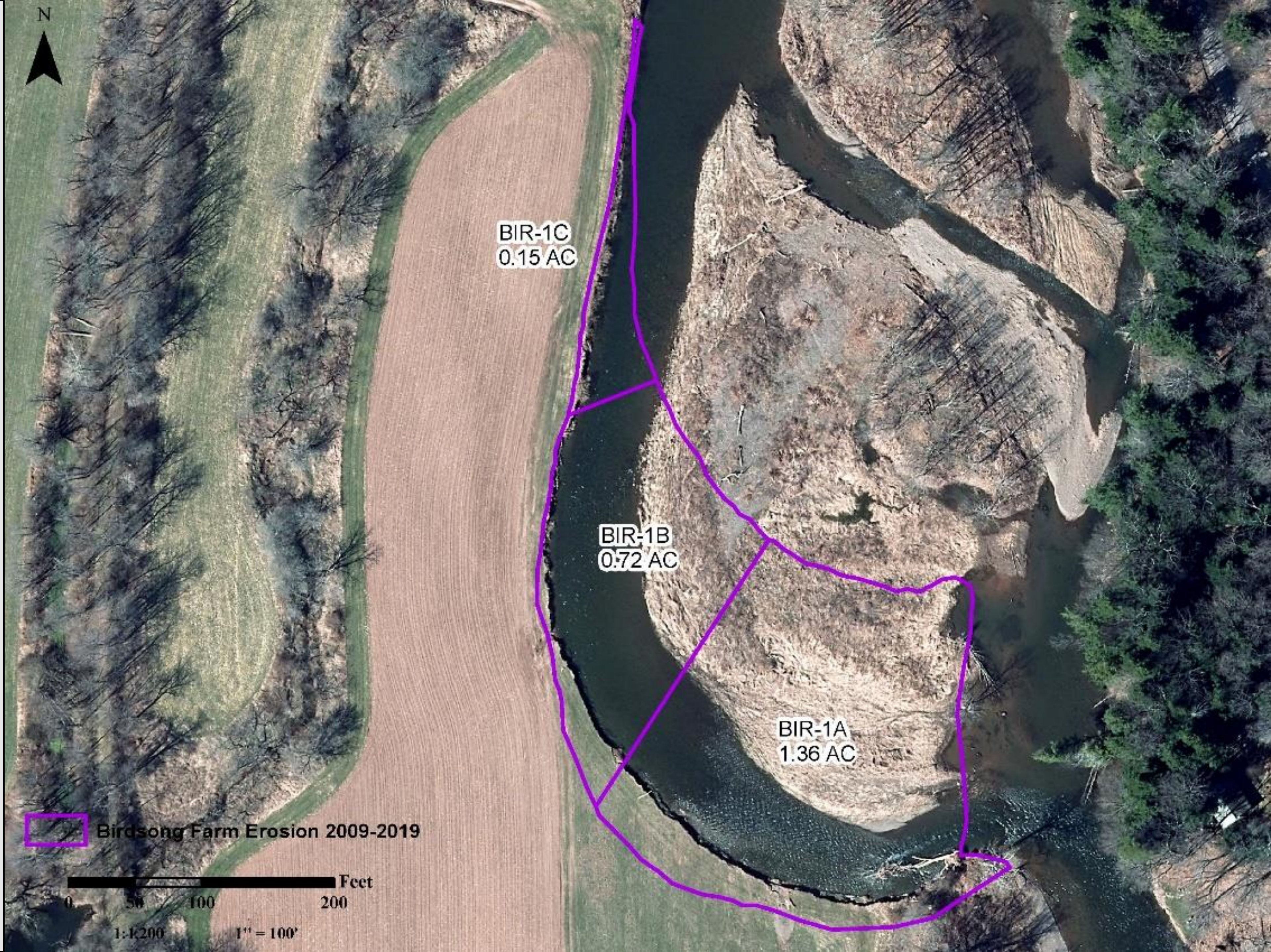
Birdsong Farm
2009 Aerial

2.23 acres of Erosion from 2009-2019

Birdsong Farm

2016 Aerial

2.23 acres of Erosion from 2009-2019



Waterbody Pollutant Load Estimates

2009-2019

Location	Sediment (tons/yr)	Phosphorus (lb/yr)	Nitrogen (lb/yr)
Birdsong Farm	1,900	1,300	8,200

2019-2022

Location	Sediment (tons/yr)	Phosphorus (lb/yr)	Nitrogen (lb/yr)
Birdsong Farm	2,500	1,800	11,000


River Haven Farm
1995 Aerial

River Haven Farm

2015 Aerial

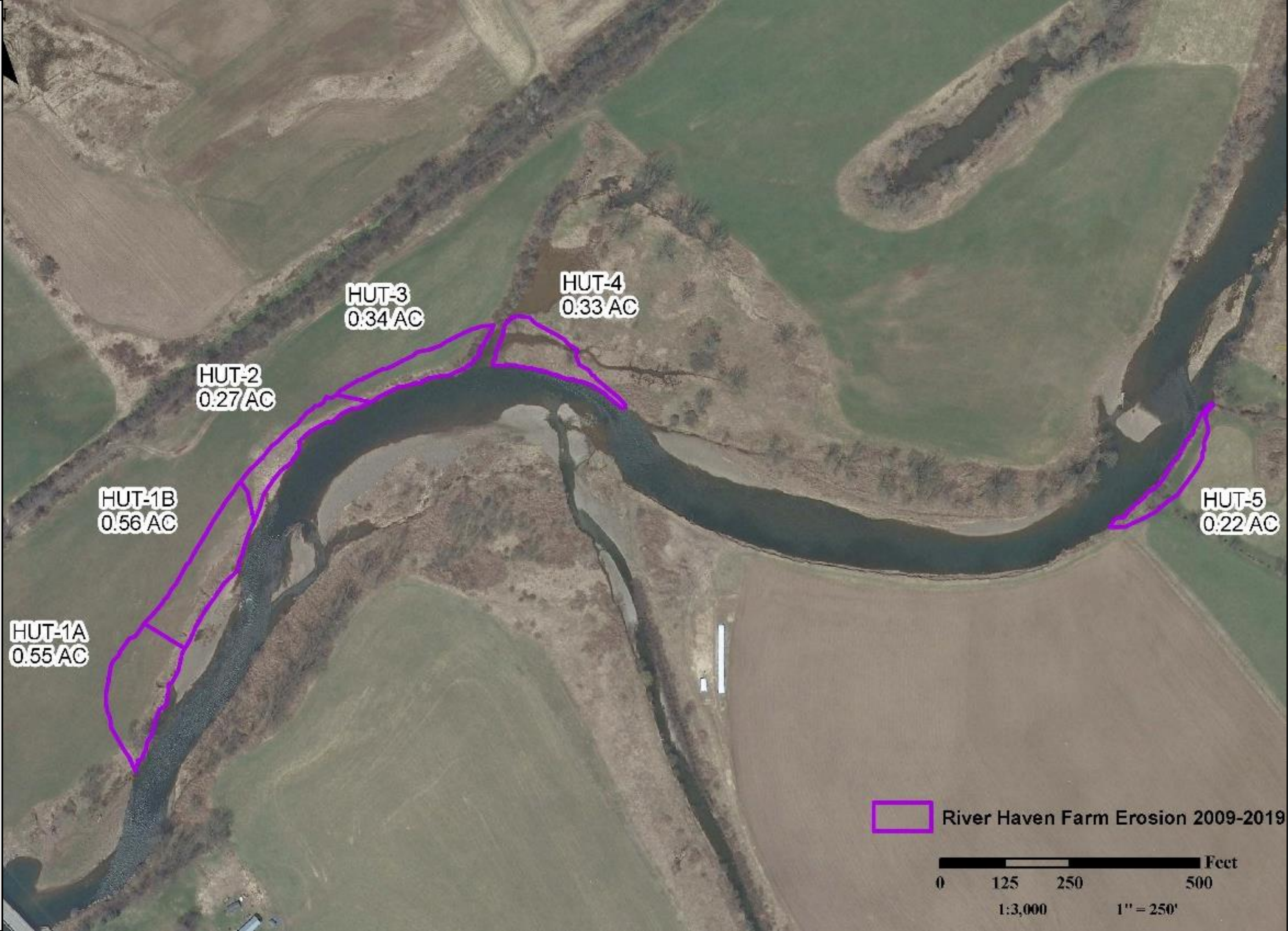
River Haven Farm

2015 Aerial with 1995 Stream Alignment

River Haven Farm

2009 Aerial

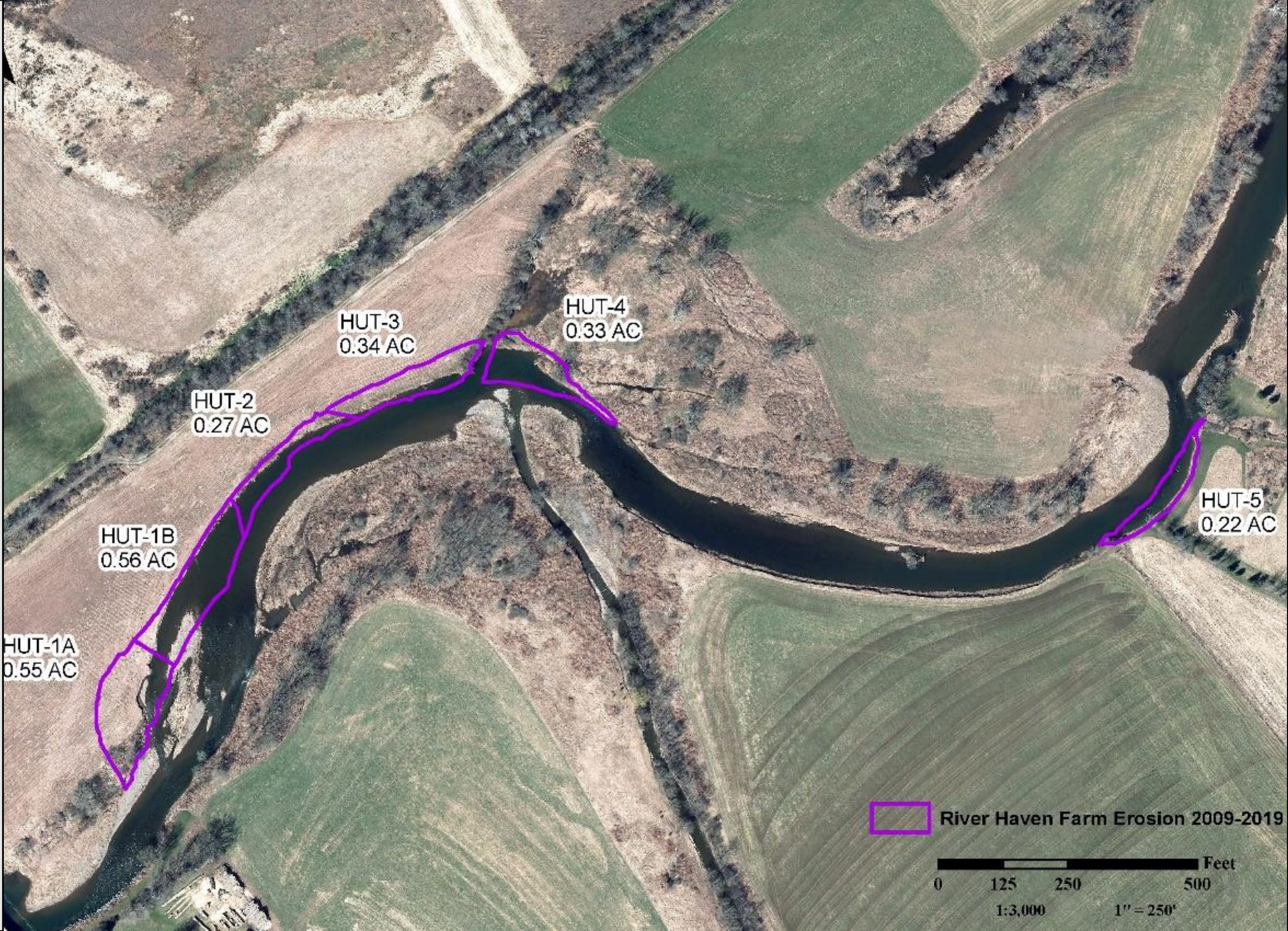
2.27 acres of Erosion from 2009-2019



River Haven Farm

2016 Aerial

2.27 acres of Erosion from 2009-2019



Waterbody Pollutant Load Estimates

2009-2019

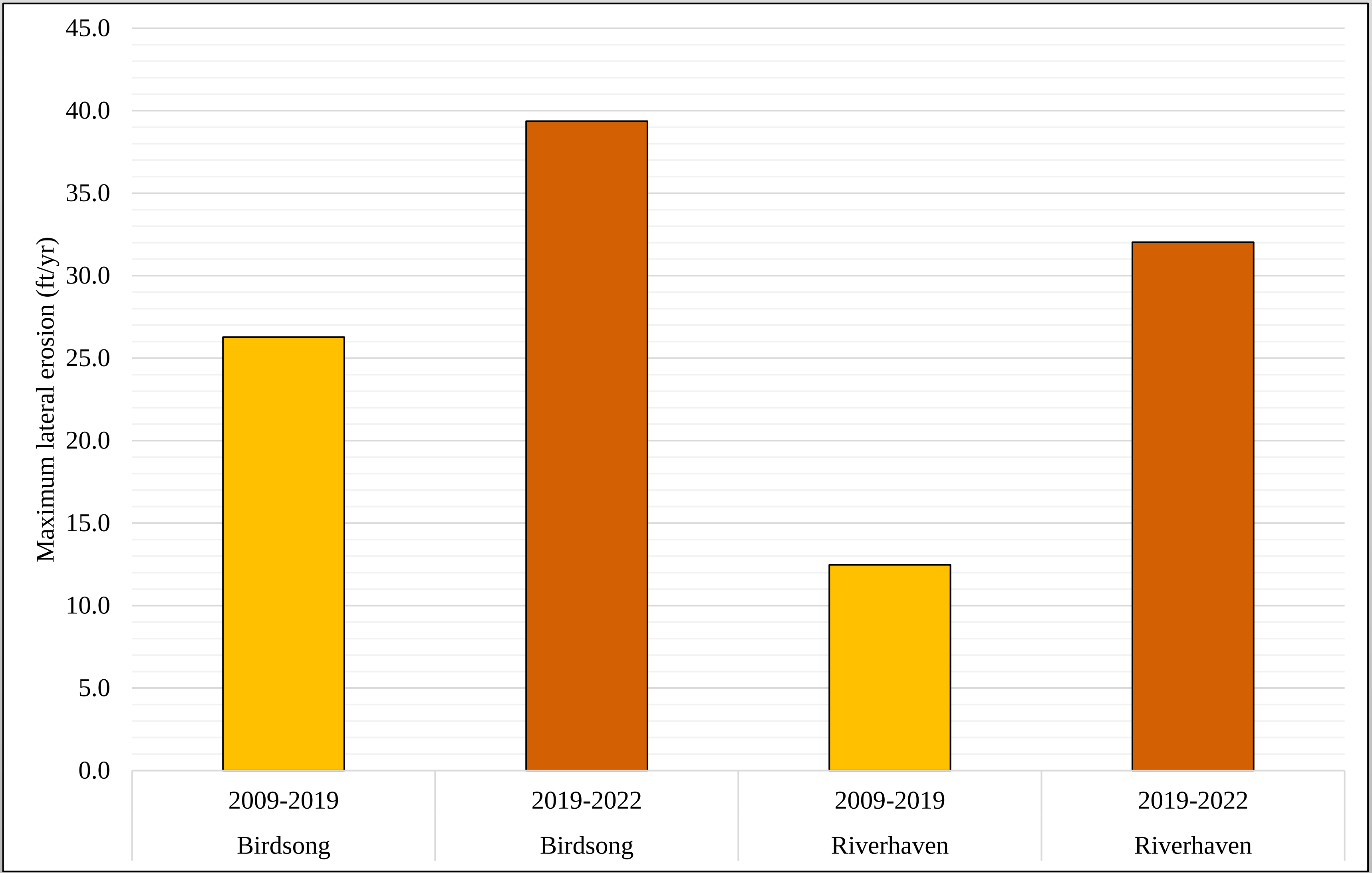
Location	Sediment (tons/yr)	Phosphorus (lb/yr)	Nitrogen (lb/yr)
River Haven Farm	1,800	700	2,600

2019-2022

Location	Sediment (tons/yr)	Phosphorus (lb/yr)	Nitrogen (lb/yr)
River Haven Farm	2,400	800	2,800

Case Studies Summary

Maximum Lateral Erosion Rates



Flows (at WBDR Walton)

Date	Discharge (cfs)	RI
3/9/2009	6690	1.34
1/25/2010	9380	2.04
3/23/2010	9330	2.03
10/1/2010	19700	15.82
3/6/2011	11100	2.81
3/11/2011	12300	3.55
8/29/2011	16000	7.34
9/8/2011	18500	12.36
3/12/2013	6360	1.29
5/30/2013	6990	1.4
2/25/2016	6400	1.29
2/25/2017	6960	1.39
8/18/2018	6840	1.37
1/25/2019	7420	1.49

Waterbody Pollutant Load Totals

2009-2019

Location	Eroded soil mass (tons)	Eroded TP mass (tons)	Eroded TN mass (tons)
Birdsong Farm	19,000	6.7	41
River Haven Farm	18,000	3.5	13
Total	**36,000**	**10**	**54**

2019-2022

Location	Eroded soil mass (tons)	Eroded TP mass (tons)	Eroded TN mass (tons)
Birdsong Farm	7,600	2.7	16
River Haven Farm	7,100	1.2	4.3
Total	**15,000**	**3.9**	**20**

Summary

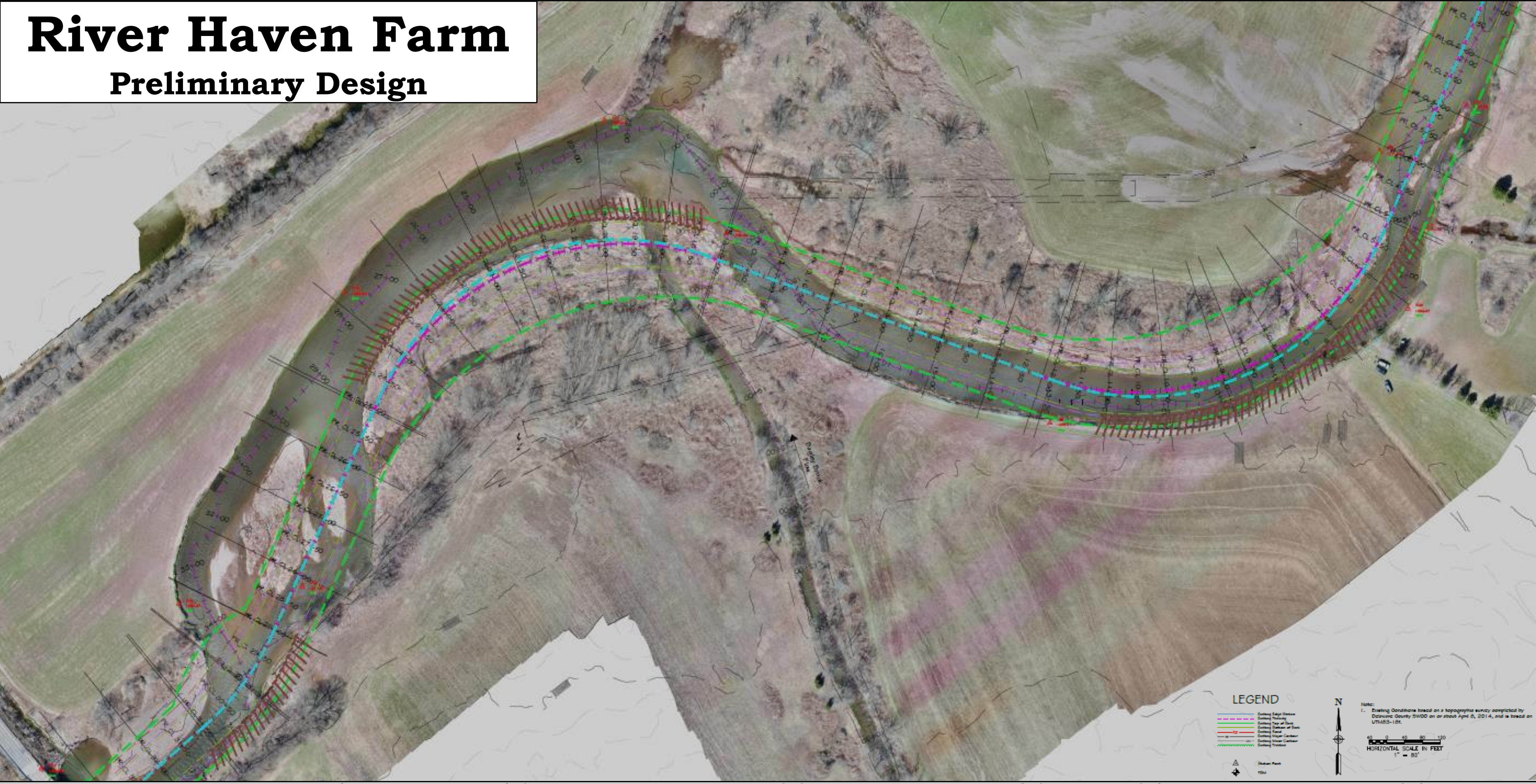
- Birdsong
  - Percentage of total eroded length = 18%
  - Percentage of total eroded area = 77%
- River Haven
  - Percentage of total eroded length = 40%
  - Percentage of total eroded area = 68%
- Cannonsville Reservoir has a 2000 TP TMDL
  - Birdsong and River Haven account for <u>1.7%</u> of the annual TP load
  - 2.1% of the annual non-point load
  - 353.5 mi^2 watershed

River Haven and Birdsong Streambank Stabilization Projects

Preliminary Designs

River Haven Farm

Preliminary Design



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BENJAMIN DATES

NYS P.E. LIC. NO. 095927-1 DATE

I HAVE REVIEWED THE DRAWINGS AND SPECIFICATION FOR THIS PROJECT. THE PROJECT HAS BEEN EXPLAINED TO ME FULLY, AND I AGREE WITH ALL TECHNICAL ASPECTS OF THE PROJECT.

TOWN SUPERVISOR DATE

Rev. #	Date	Description
Concept	1/8/2015	Concept Plan
30%	3/9/2015	30% Plan

DRAWN BY: ----
DESIGNED BY: B. Dates
CHECKED BY: ------
APPROVED BY: ----

XX-XX-XXXX
DATE CREATED

DIG SAFELY, NEW YORK
Call 811
BEFORE YOU DIG

Town of XXX
Delaware County
Project Name
Proposed Condtions

PAGE NO.
3 OF 6
PROJECT NO.
DE-O-PROJ-005

Birdsong Farm

Preliminary Design

More Streambank Stabilization Project


Project Reach
West Branch Delaware River
10
Google earth

Waterbody Pollutant Load Estimates

Location	Sediment (tons/yr)	Phosphorus (lb/yr)	Nitrogen (lb/yr)
More Farm	1,900	390	730

Conclusion

- Prioritize Stream Projects Based on Nutrient Load
- Stop the excessive lateral migration to reduce direct nutrient loading
- Establish riparian buffers
  - Reduces the nutrient loading
  - Reduces nutrient transport

Questions