Measuring urban stream restoration success: processes, goals, monitoring, and regulations confound "ecological lift"

Chimarra spp.

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Department of Public Works and Environmental Services
Working for You!

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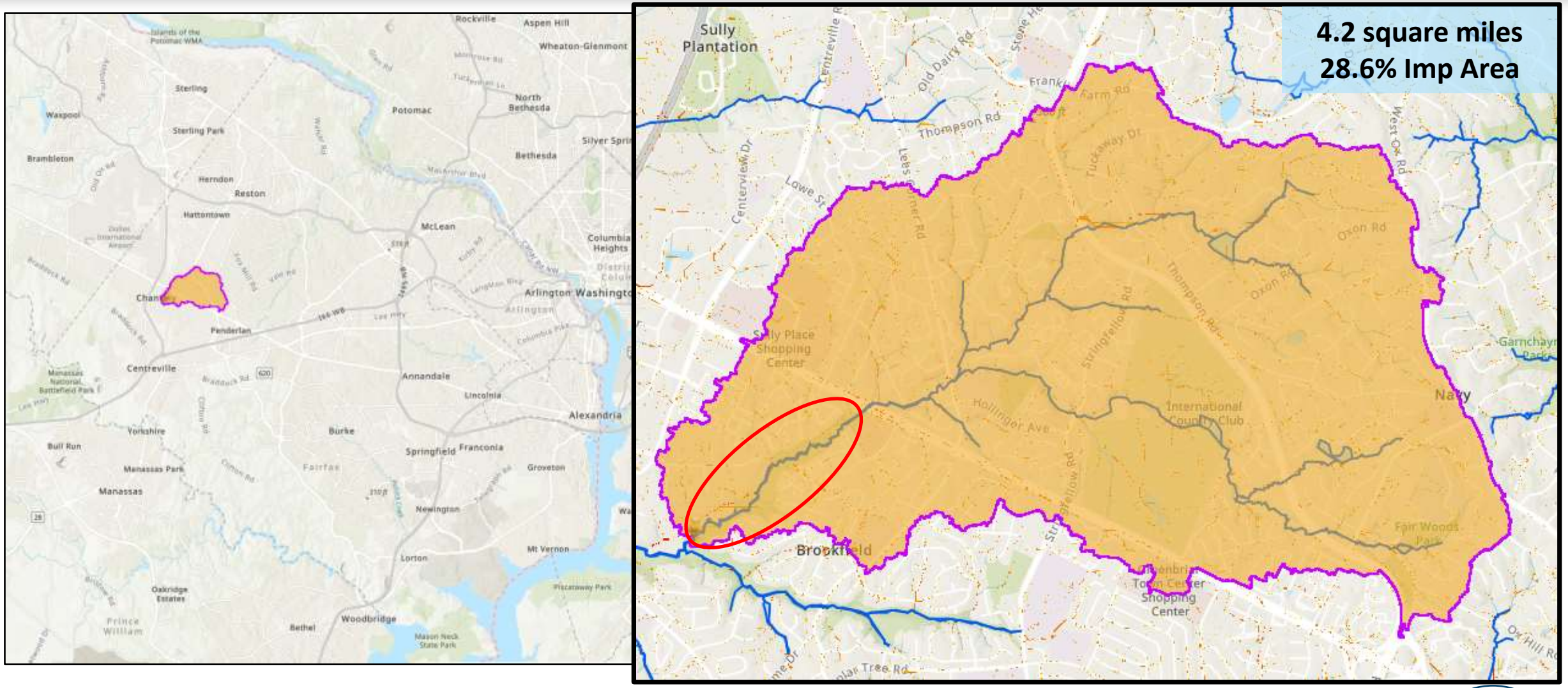
Outline

- Landscape setting & impairments
- Regulatory & policy drivers
- Goals
- Design approach / practices used
- Monitoring – **this is very different from most!**
- Outcomes & applicability to future work

Thanks:

- Neely Law (Fairfax County)
- Aaron Porter (USGS)
- Fairfax County ecologists

Flatlick Branch Watershed, Fairfax County, VA

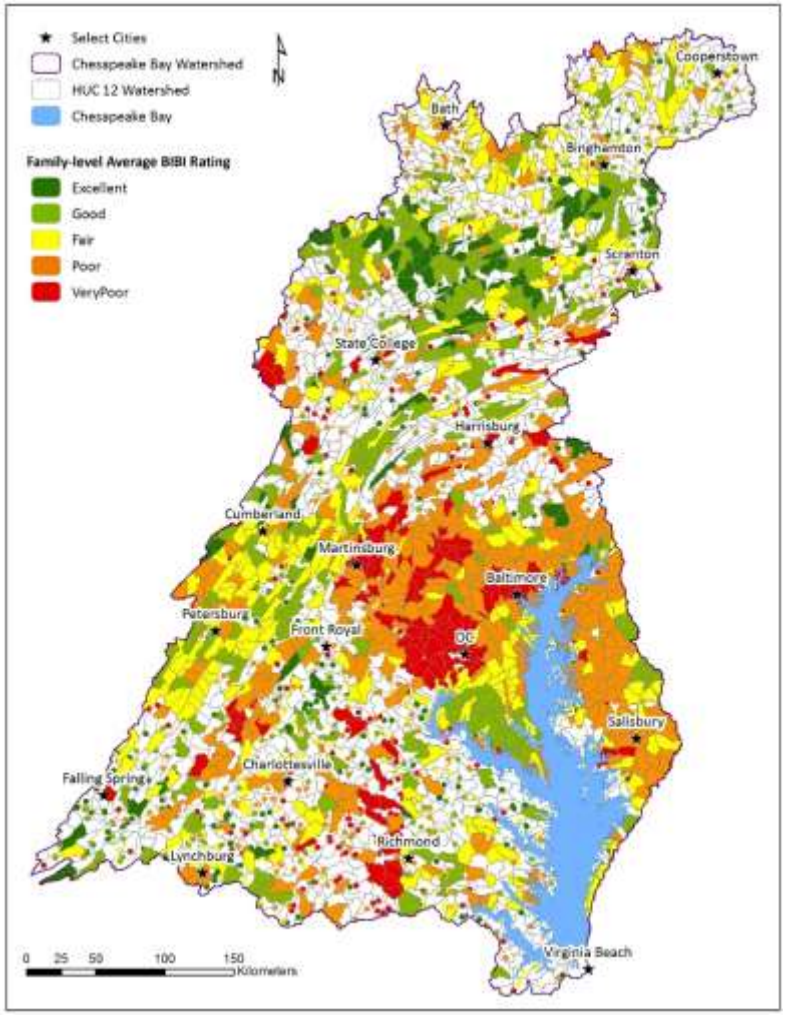


Flatlick Stream Restoration – Post-restoration aerial image

Regulatory Policy & Restoration Drivers

Desired/Regulated Outcomes

- Water quality improvement – Ches Bay TMDL
  - Nitrogen, phosphorus and sediment reduction targets
  - Stream restoration is a key management action to reduce nutrient loads in the agricultural and urban land use sectors
- Continually improve *stream health and function* throughout the watershed.
  - Not explicitly defined
  - Stream health measured and tracked by the “Chessie BIBI” (Biology)



Restoration Goals

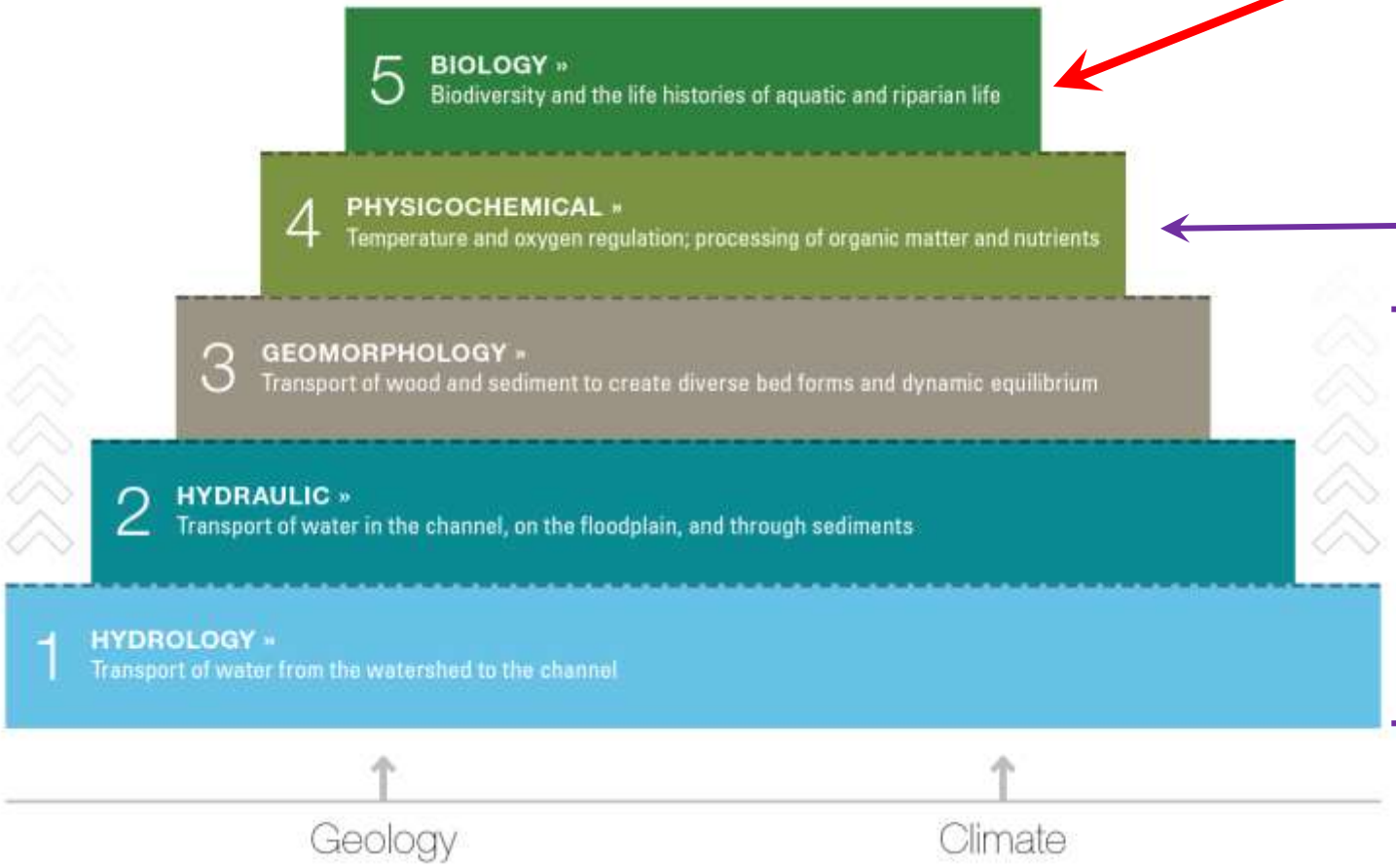
1. N, P and Sediment (Ches Bay TMDL)
2. Stability
3. Flood less/more frequently, connect to FP
4. Creation of habitat for biological improvement

Unusual for Fairfax County

- Longer than most projects
- Larger stream (order/size) than typical

Design Approaches & Practices

What we are looking for…



Hard to control – "these are watershed issues"

Assumed we can control "somewhat" through urban stream restoration

Flatlick Branch Stream Restoration (Phases 1 & 2)

- Stressors Addressed through design
  - Geomorphology & (Sediment)
  - Flow regime
  - Nutrients
- Restoration Length
  - Phase 1 – 1772 lf
  - Phase 2 – 4275 lf
- Phase 1 & 2 are credited with the following reductions (default rate) using Ches Bay Protocols 1 and 2:
  - P – 506 lbs/yr
  - N – 4,221 lbs/yr
  - Sediment – 66.3 tons/yr

Over 1.0 mi

Monitoring

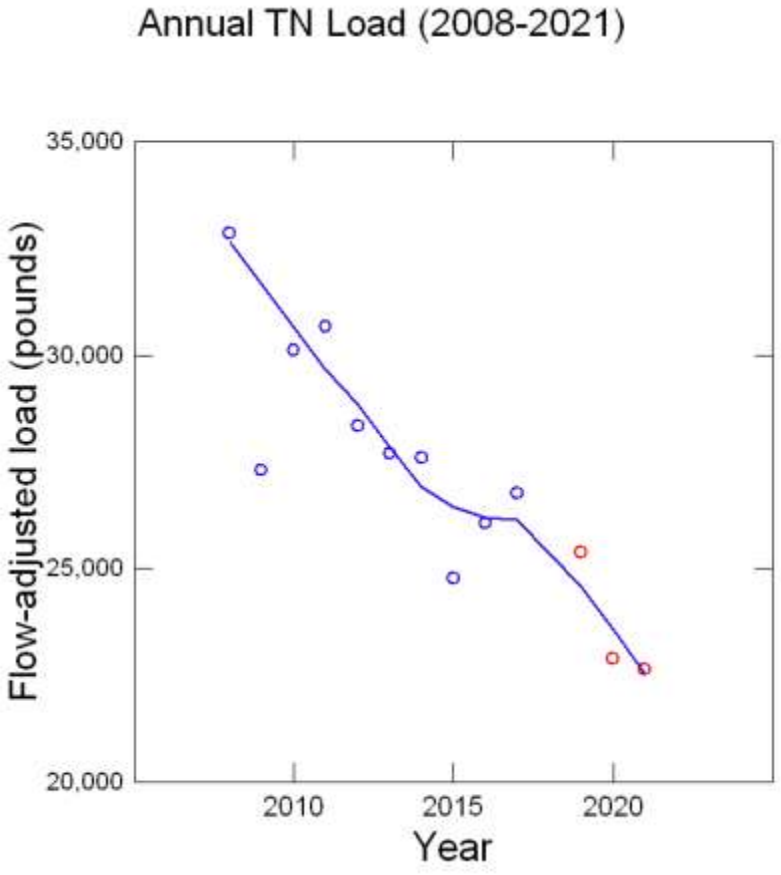
- Ongoing partnership w/ USGS since 2007
- Comprehensive monitoring
  - **Continuous** temp, flow, stage, pH, DO, SPC, and turbidity
  - Every sampling event (below) temp, pH, DO & SPC
  - **Monthly** grabs (N, P, TSS, Turbidity)
  - **Storm collections** (3-6 per year) of N, P, Sediment
  - **Bi-monthly** (Bacteria, Ions)
  - **Annual** benthic macroinvertebrate surveys
  - **Triennial** (every 3rd year) fish monitoring (started 2016)

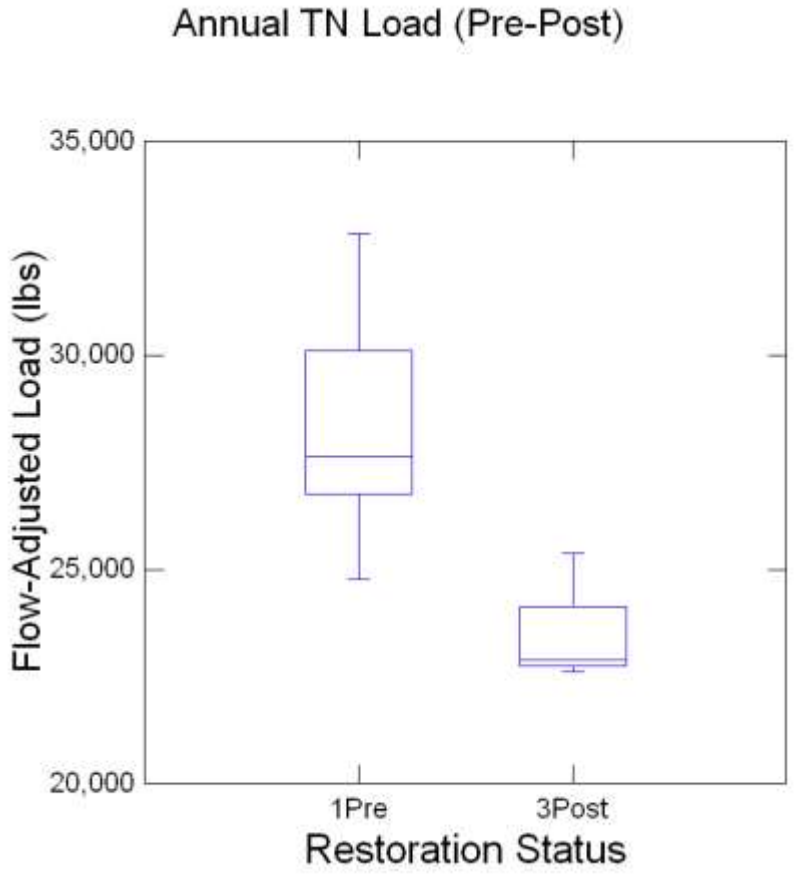
Past regulatory-required monitoring

[USGS Fairfax County, VA Surface Water Monitoring Network]

Flatlick Branch, Goal #1, TMDL Reductions (Total Nitrogen)

Total Nitrogen = GOAL ACHIEVED





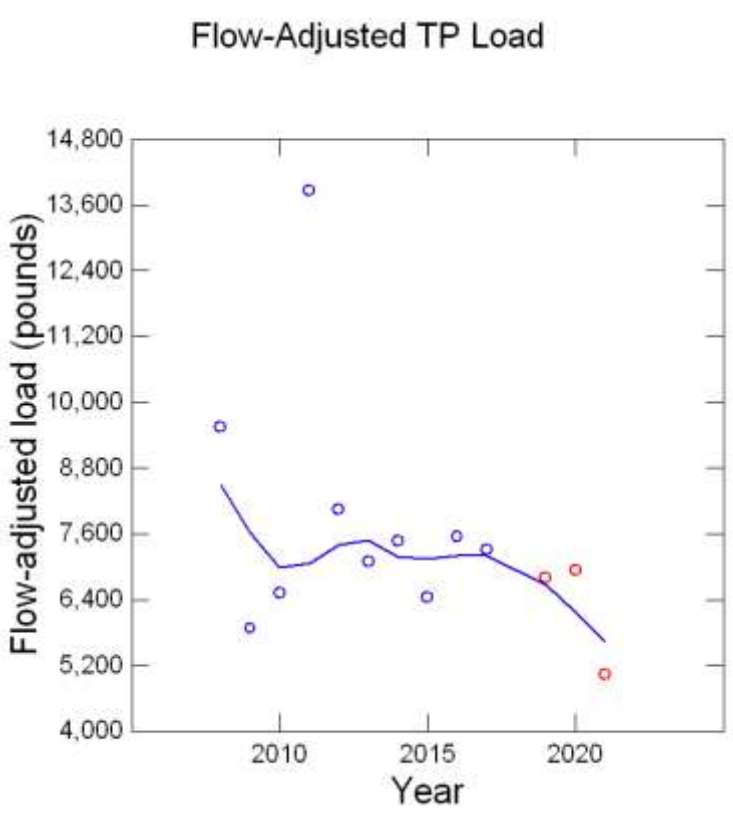
Pre-Restoration / **Post-Restoration**

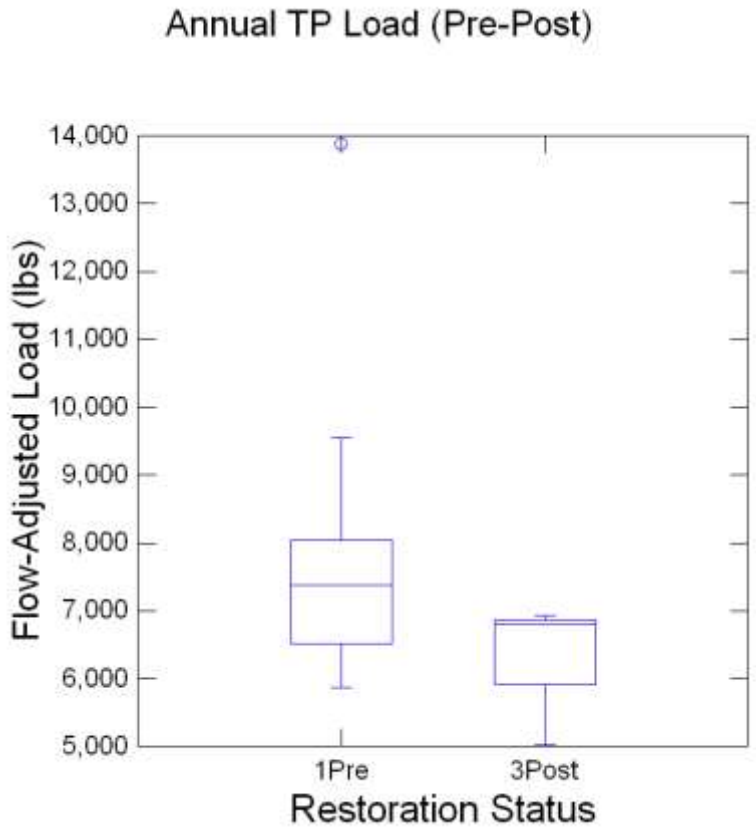
Kolmogorov-Smirnov, p <.0001
Mann-Whitney, p = 0.018

Annual Nitrogen Reduction	Pounds/Yr
Gage Measured (Flow-Adjusted Mean)	4585
TMDL Credited from Restoration	4221
Excess Removed	364

Flatlick Branch – Goal #1, TMDL Reductions (Total Phosphorus)

Total Phosphorus = GOAL ACHIEVED





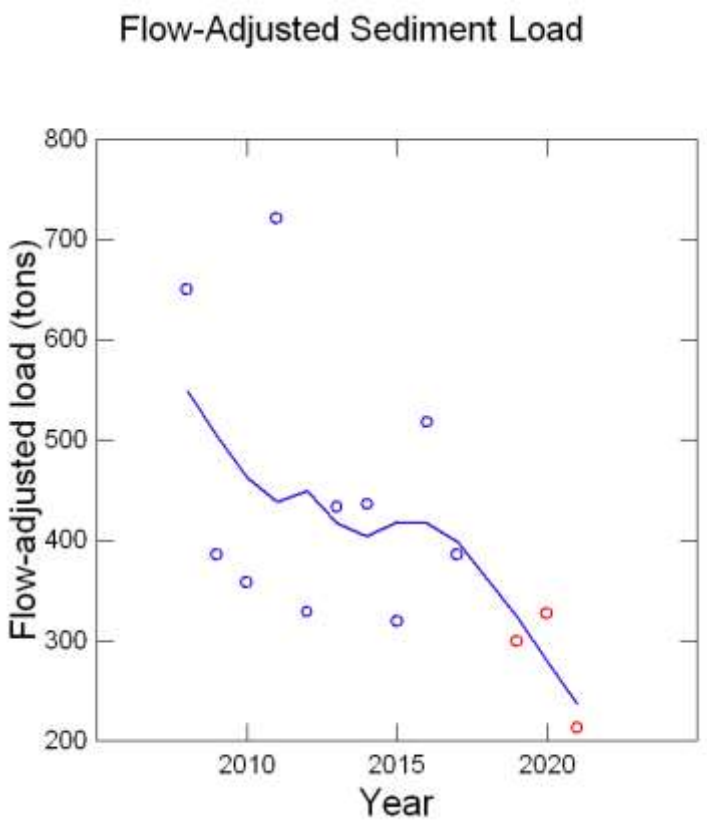
Pre-Restoration / **Post-Restoration**

Kolmogorov-Smirnov, p = 0.001
Mann-Whitney, p = 0.128

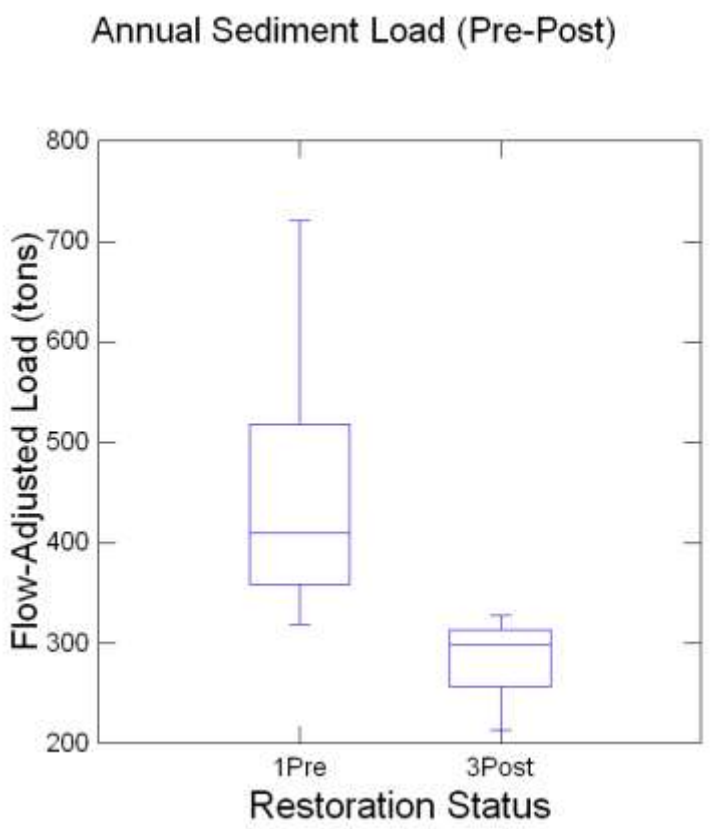
Annual Phosphorus Reduction	Pounds/Yr
Gage Measured (Flow-Adjusted Mean)	1714
TMDL Credited from Restoration	506
Excess Removed	1208

Flatlick Branch – Goal #1, TMDL Reductions (Total Suspended Sediment)

Total Suspended Sediment = GOAL ACHIEVED



Pre-Restoration / Post-Restoration



Kolmogorov-Smirnov, p = 0.020
Mann-Whitney, p = 0.018

Annual Sediment Reduction	Tons/Yr
Gage Measured (Flow-Adjusted Mean)	174
TMDL Credited from Restoration	66
Excess Removed	108

Flatlick Branch – Goal #2, Stability

Stability = GOAL ACHIEVED

1. Maintain annual credits
2. Reduce maintenance / corrective action
3. 5-yr inspection cycle

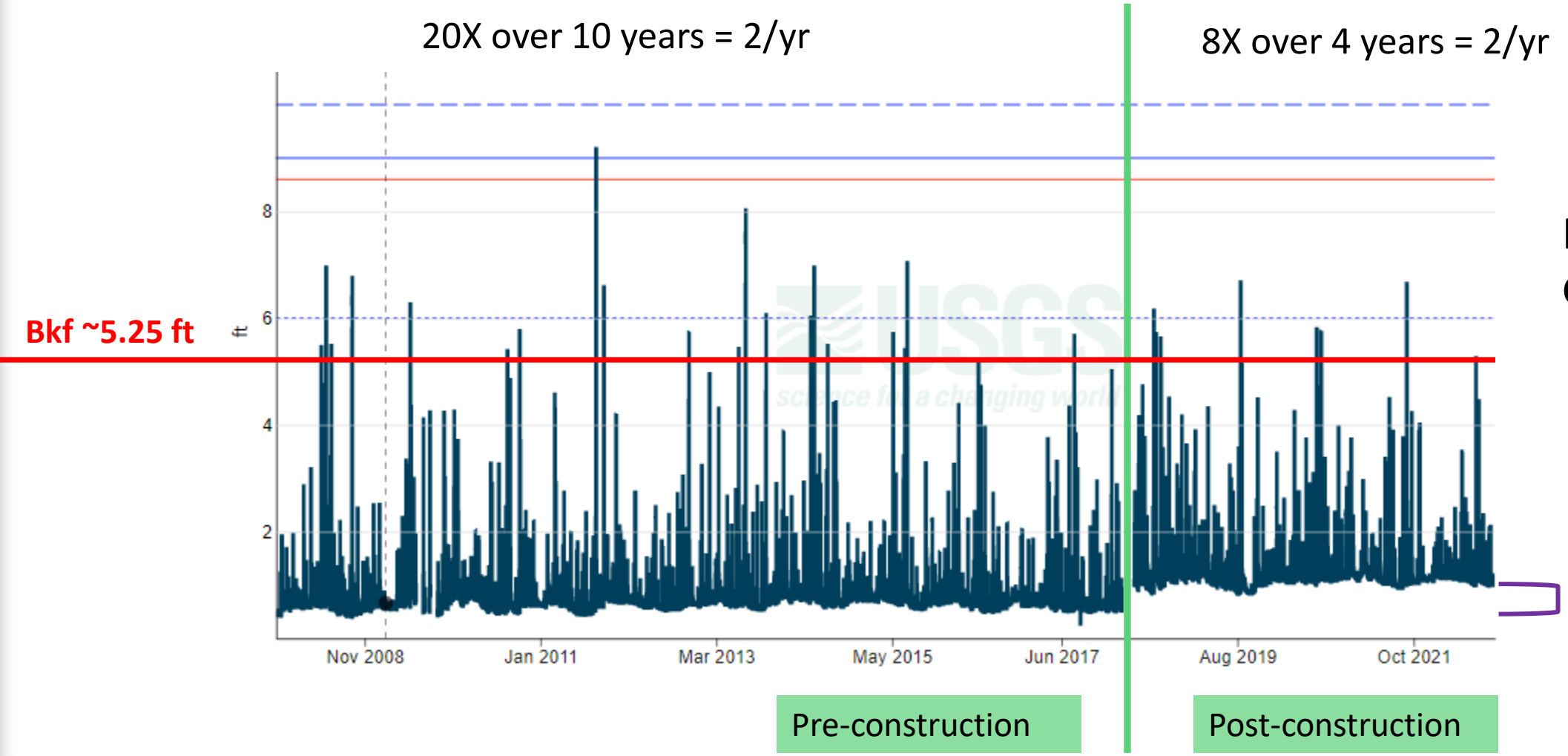
POST – 1st summer

POST – 3rd winter

Flatlick Branch – Goal #3 - Floodplain connectivity

20X over 10 years = 2/yr

8X over 4 years = 2/yr



FP Connection= GOAL ACHIEVED

Raised streambed, widened stream

Flatlick Branch – Goal #4, Habitat and Biological Improvements

RBP Habitat = GOAL ***PROBABLY*** ACHIEVED?

Modified from EPA's Rapid Bioassessment Protocol (RBP)

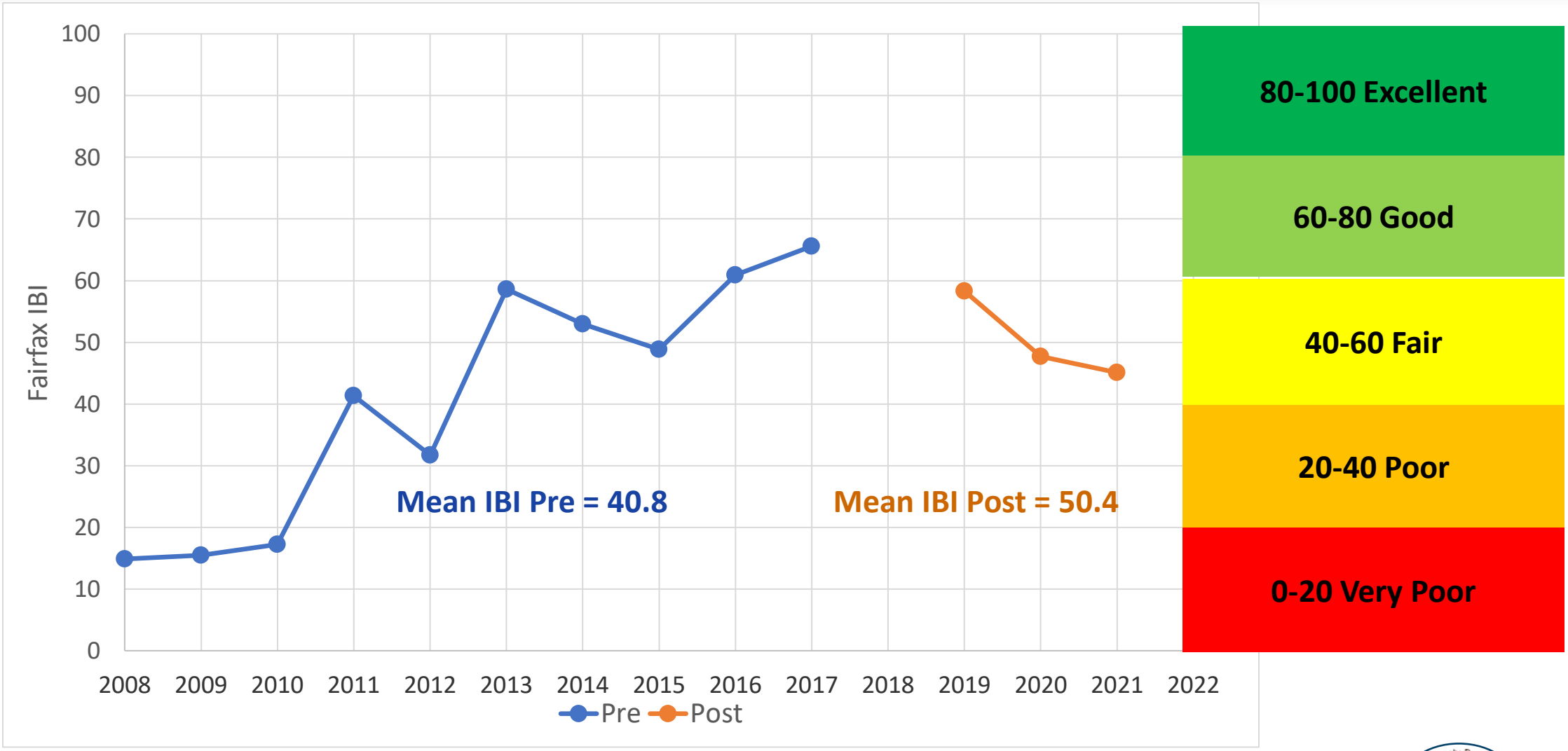
10 metrics, 0-20 scale

Semi-quantitative

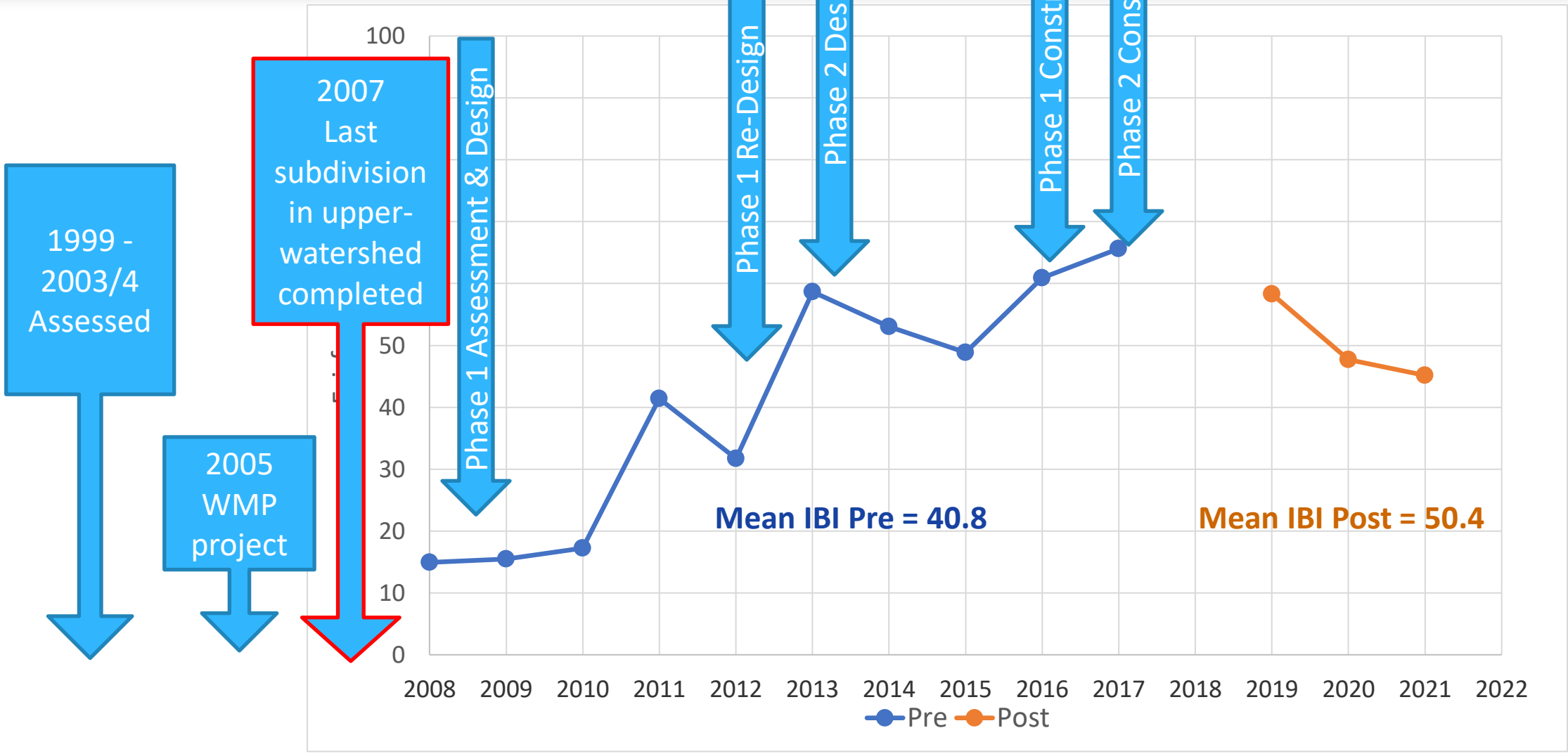
Goal of "improve habitat to support biology" assumes if you build it...

RBP Metric	Trend
Total Habitat Score	↑
Epifaunal Substrate / Available Cover	↑
Sedimentation (In-Channel Deposits)	↑
Bank Stability	↑
Channel Alteration (Man-Made Alteration)	↓
Velocity/Depth Regime (Flow Variability)	↓

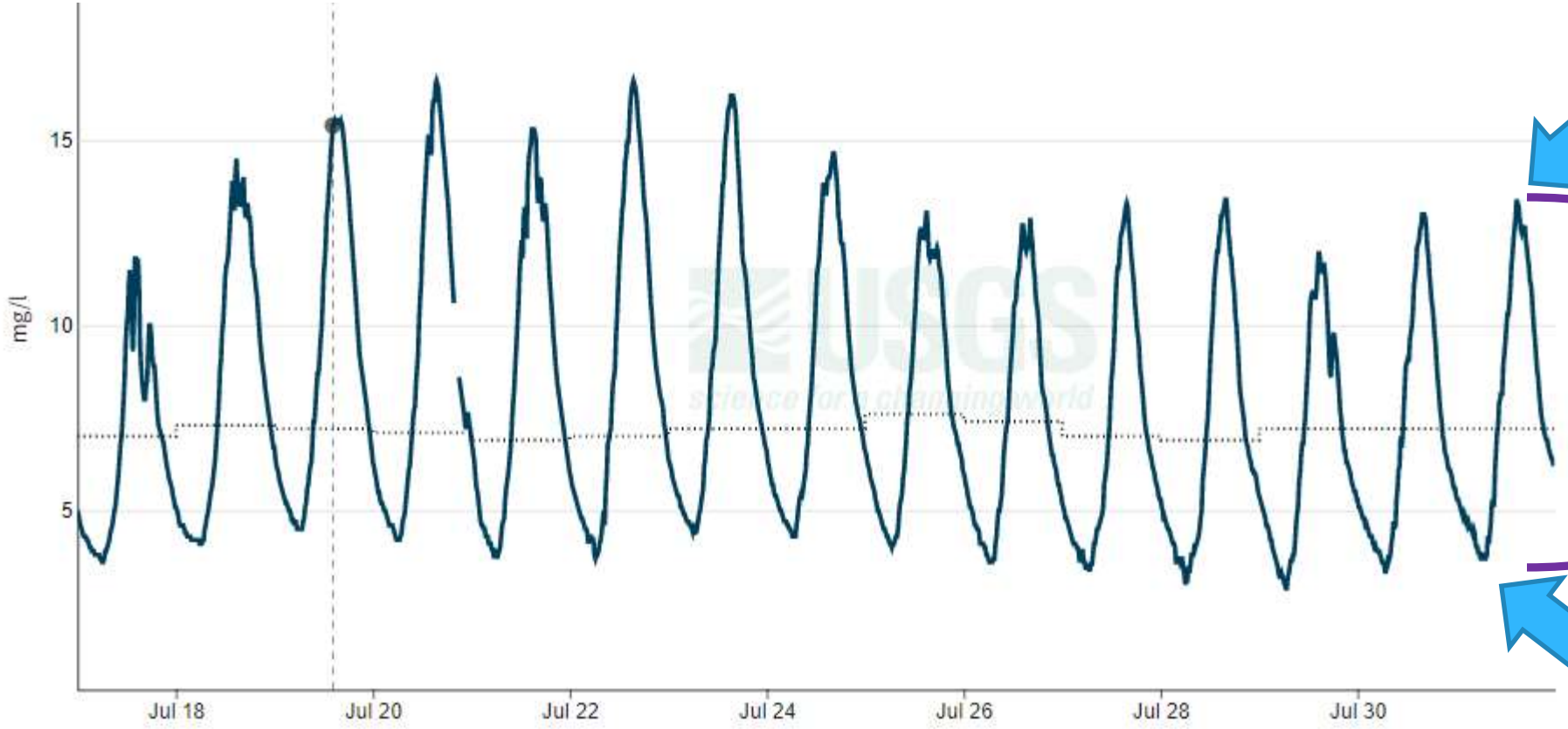
Flatlick Branch – Benthic Macroinvertebrate Assemblage



Flatlick Branch - Project Planning and Implementation



Diurnal cycle of dissolved oxygen



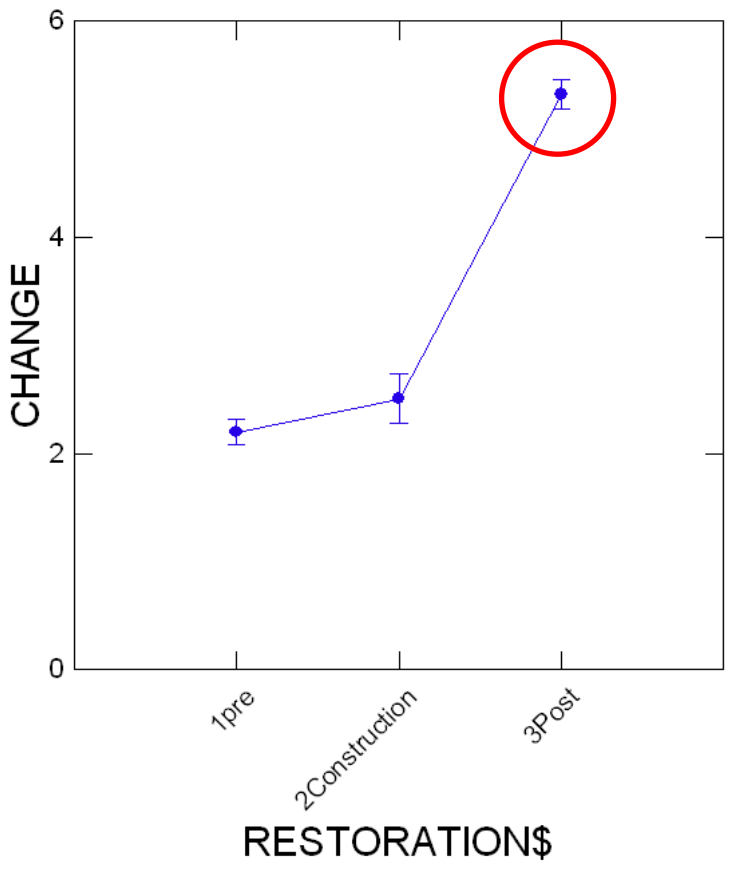
Peak photosynthetic activity minus active respiration

Daily shift in DO from ~4mg/L to ~13.5 mg/L

Respiration only, no photosynthetic activity

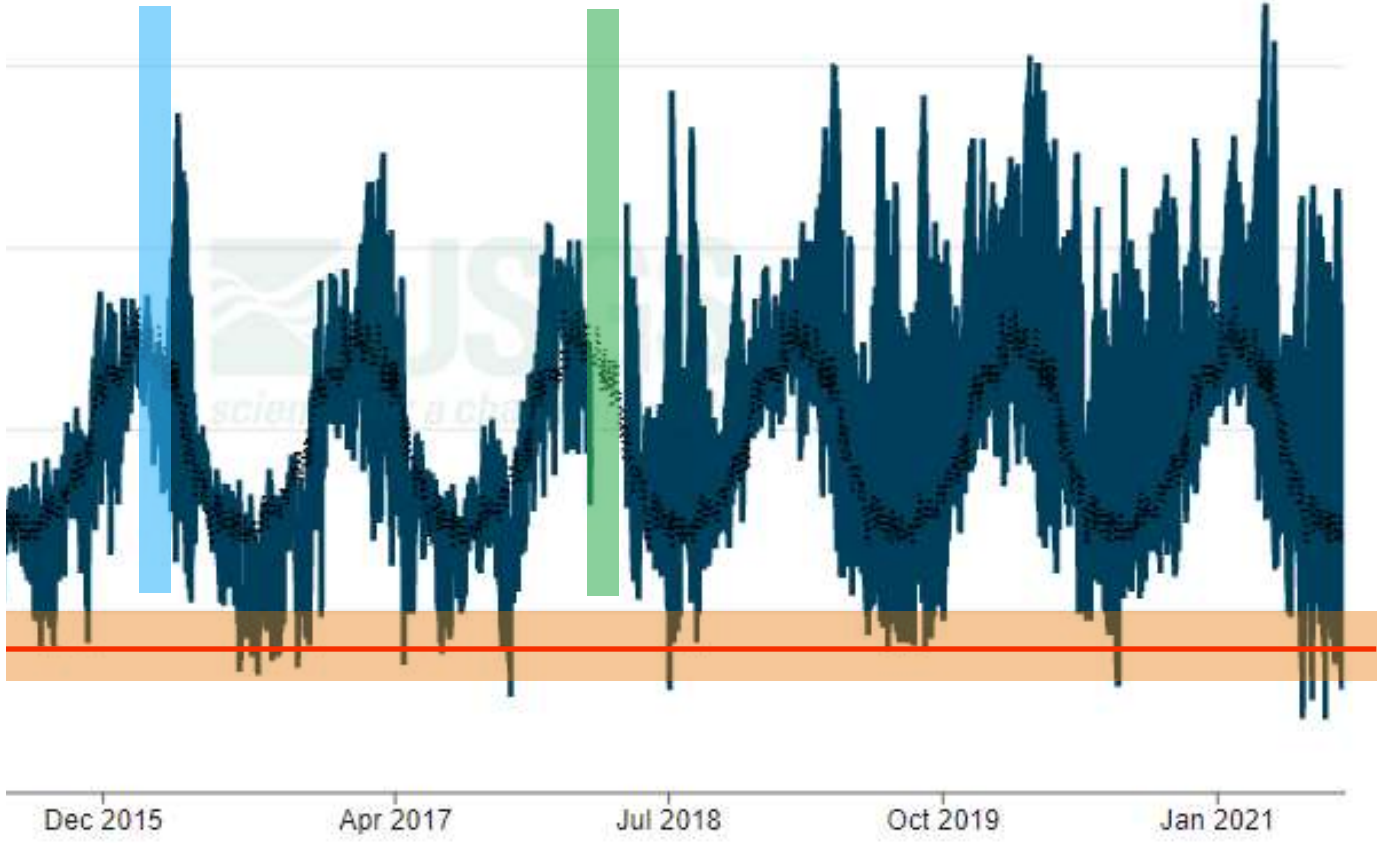
Dissolved Oxygen – large diurnal changes in DO (mg/L)

Significant increase in daily DO fluctuation (ANOVA, $p < 0.001$)



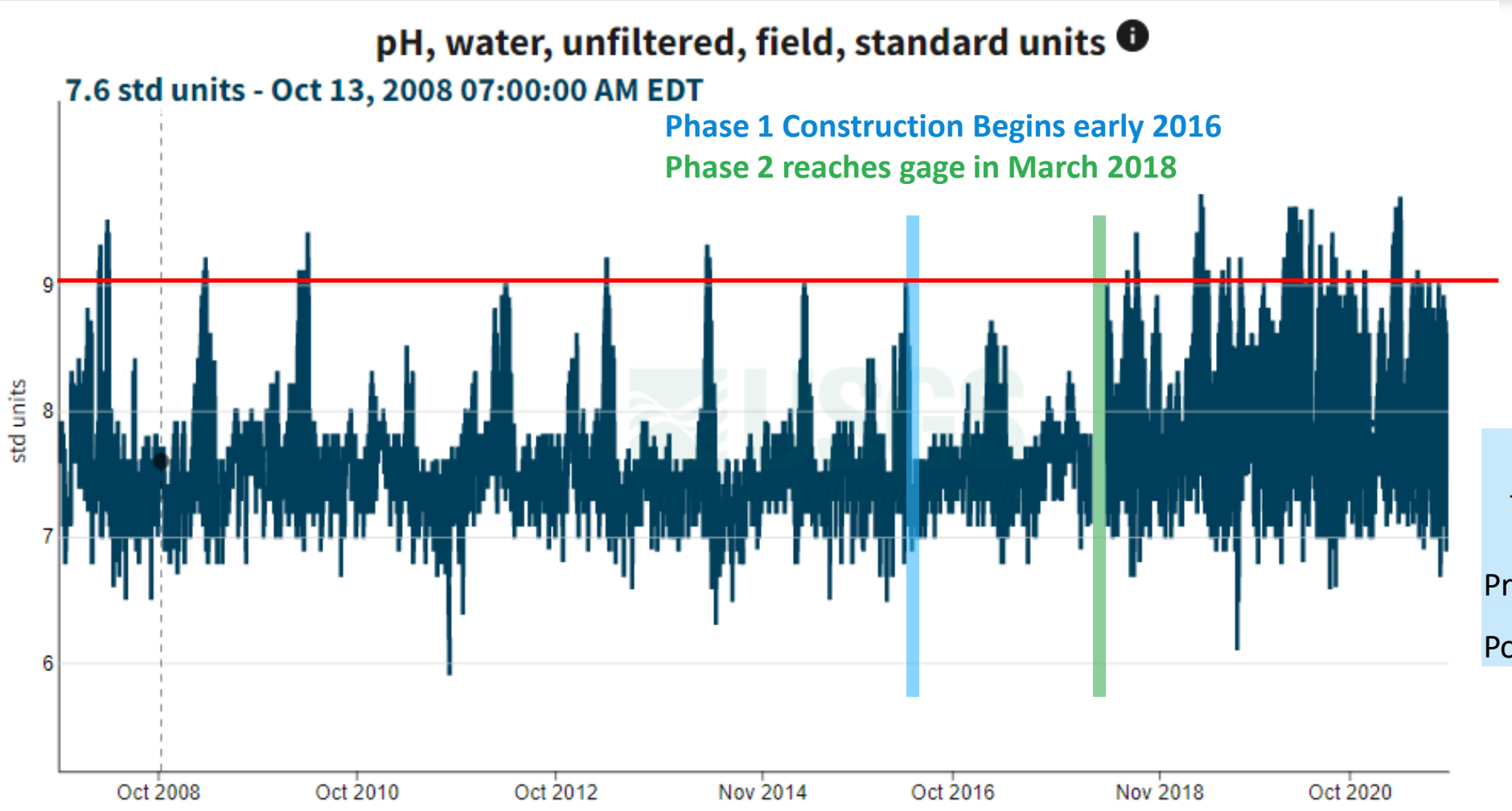
Phase 1 Construction Begins early 2016

Phase 2 reaches gage in March 2018



State Std 4mg/L

pH



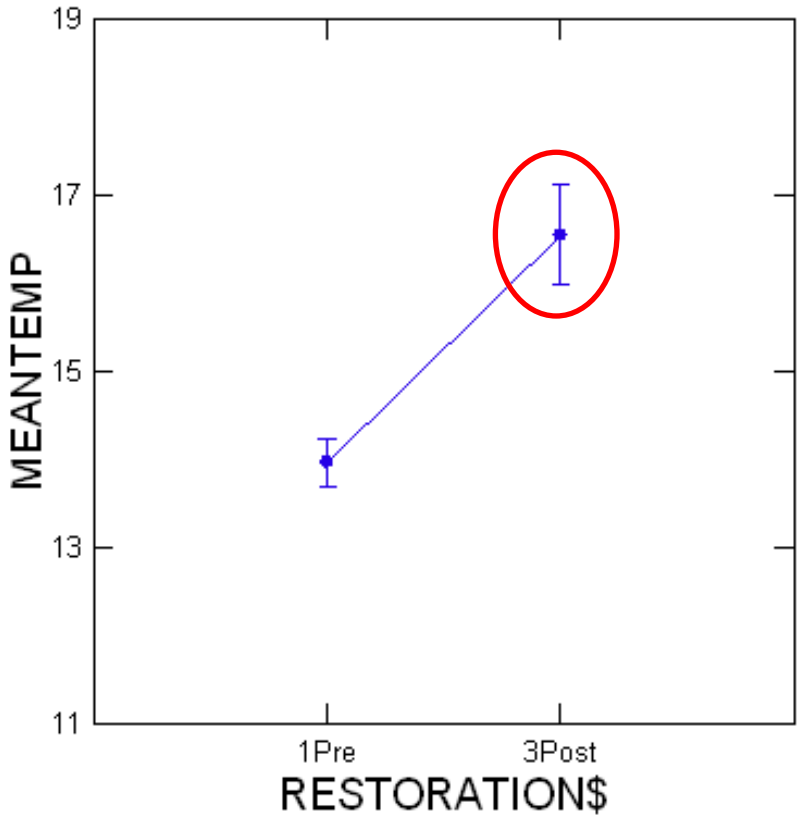
State Std
pH = 9.0

Exceedances (pH > 9.0)	N	Percentage of Days
Pre-Restoration	34	0.93%
Post-Restoration	112	10.23%

Changes in Stream Temperature (Pre- and Post-Construction)

Dulles Airport mean daily Air Temp increased 0.6 deg C over the same period

Over 2.5 deg C increase in the mean daily stream temperature (ANOVA, p<0.001)



Stream Temperature – Max Temps, shifting baselines

Pre-construction (2007-2017)

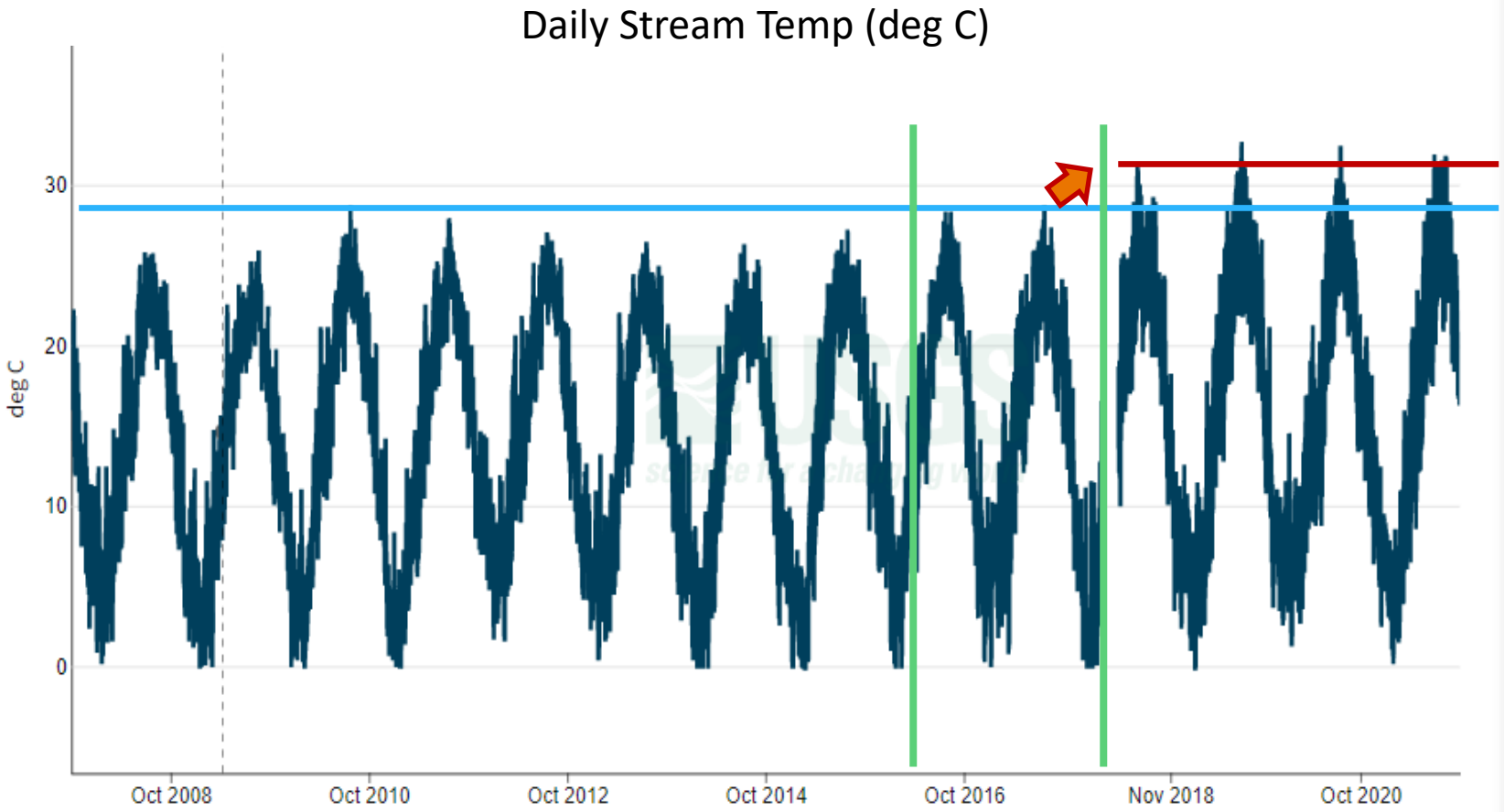
- Daily Max Temp: 28.7 deg C
- That's 83.7 Fahrenheit!!!

Post-Construction (2018-Sept 2021)

- Daily Max Temp: 32.7 deg C

  State Std 32 deg C

- Exceeded 28.7 deg C = **105 times**
- Exceeded 30.0 deg C = **41 times**



Stressors - Fish Thermal Tolerance/Restoration Response

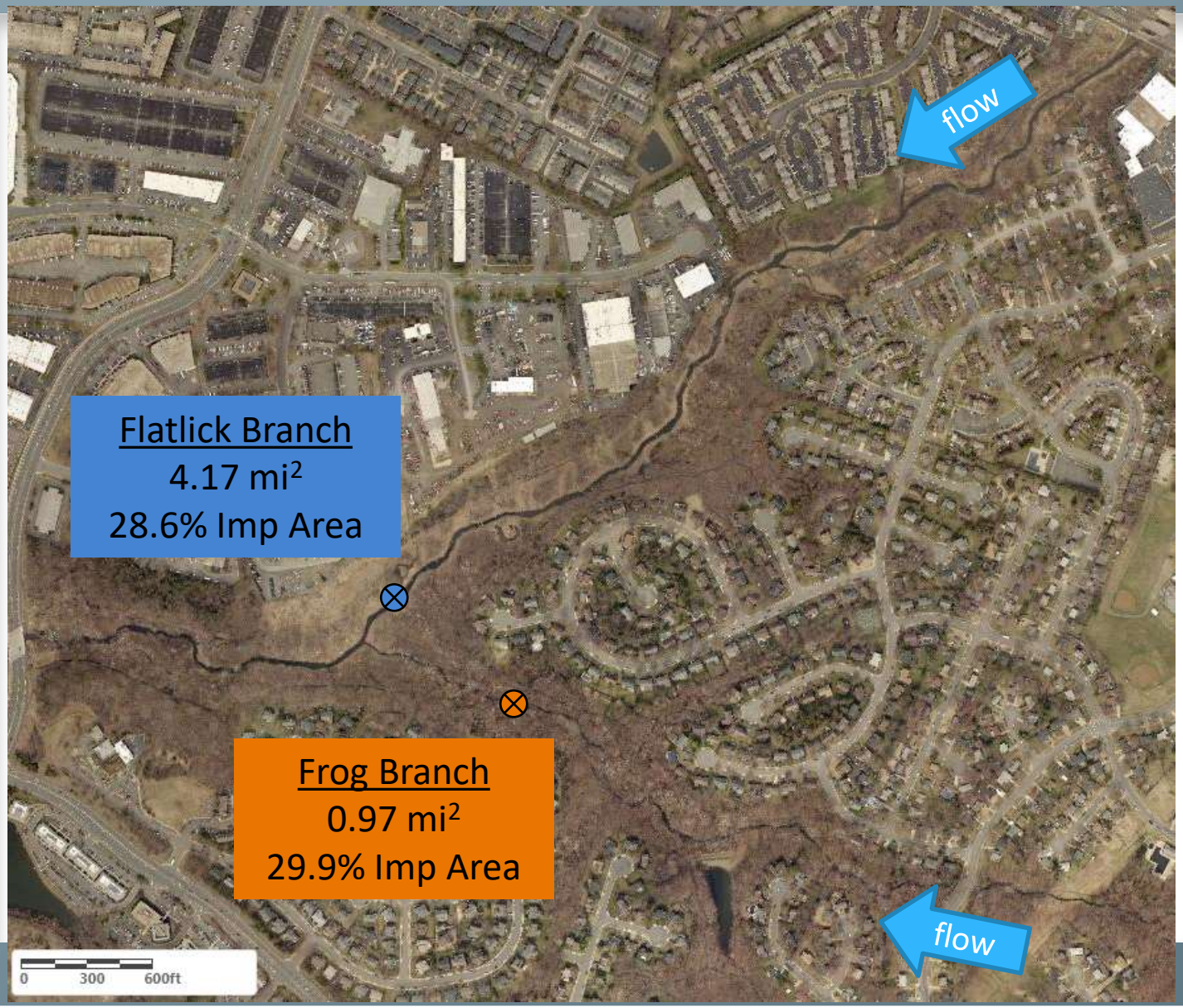
Physiochemical Stressors for Fish (measured on most water quality sondes)

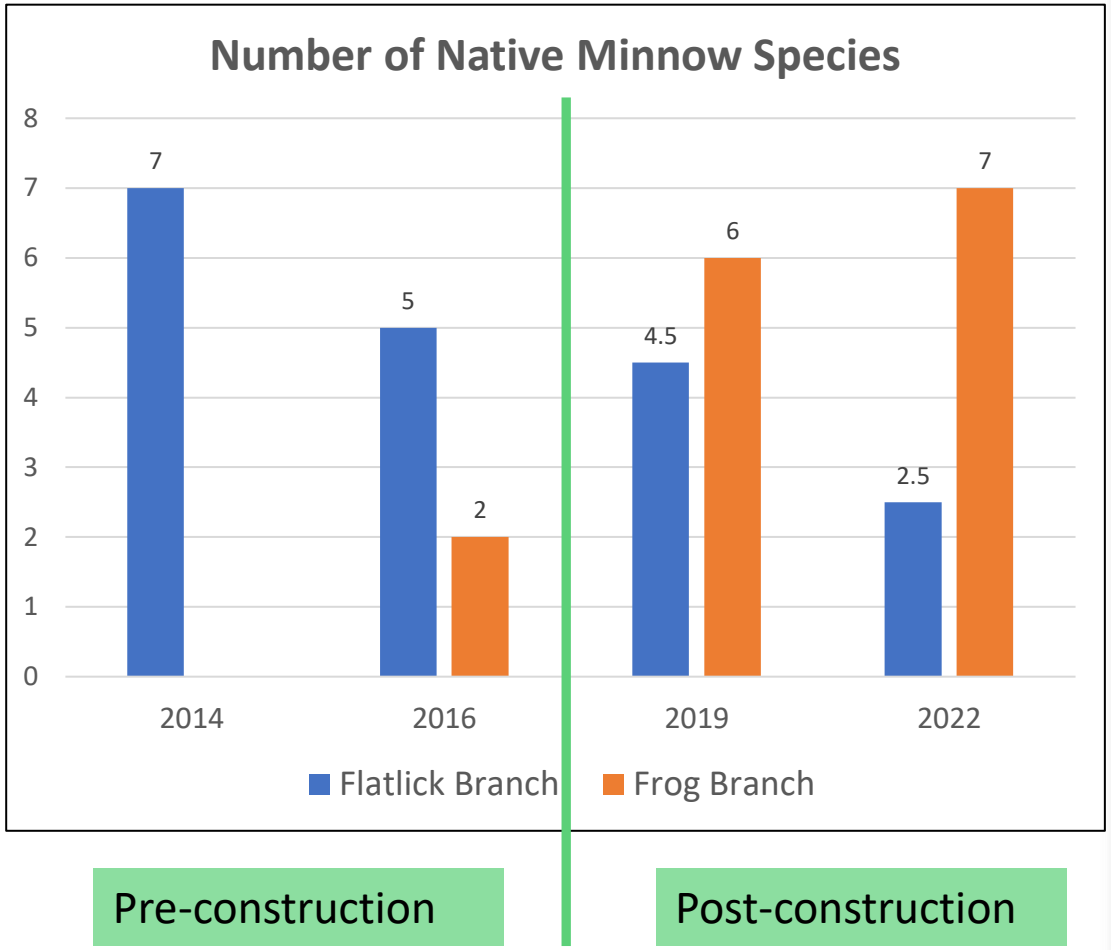
- DO
- pH
- Conductivity (TDS)
- **Temperature**

Each species has different tolerances for each of these stressors
These can change with life stage (egg, juvenile, adult, etc.)

Many minnows with a native range in Fairfax, Virginia have thermal tolerance at 28-30 deg C

Fish Assemblages (restoration reach and adjacent stream)





Shift in fish assemblage

Median Percent Abundance in Fish Families

	Centrarchidae (Sunfishes)			Cyprinidae (Minnows)		
Stream	Pre	Post	Trend	Pre	Post	Trend
Flatlick Branch	39.0%	65.4%	↑	34.8%	5.7%	↓
Frog Branch*	4.7%	21.3%	↑	92.3%	63.3%	↓

Sunfishes

Minnows

Restoration Outcomes

Restoration Goal	Measurable	Outcomes
1. Credits toward Chesapeake Bay TMDL	Nitrogen	↑
	Phosphorus	↑
	Total Suspended Sediment	↑
2. Stability	repeated visual inspections	↑
3. Floodplain connectivity	USGS stage data	↑
4. Habitat for biological recovery	RBP habitat metrics	▭ ↑
Other - Physiochemical	Temperature	↓
	Conductivity	▭
	pH	↓
	Dissolved Oxygen	↓
Other - Biology	Benthic macroinvertebrates	↑ ▭ ↓
	Fish assemblage	↓

Where we are…

- Lag times from project identification to completion affect outcomes
- Management practices that focus on singular impairments/sources/stressor may limit holistic restoration outcomes
  - Multiple stressors impacting stream health
- Regulatory and non-regulatory drivers of stream restoration impact restoration approach
- Need for robust monitoring, particularly linked expected restoration outcomes
- Modifying stream ecosystems require trade-offs limiting or delaying lift

<u>Next steps</u>

- Add stressors/factors to monitor or add to analyses (suggestions?)
- Dive into life history data regarding key critters (fish, benthics, others?)

Additional Information

For additional information, please contact

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