WORKING WITH NATURE TRAINING SERIES

NOV. 17, 2021

Designing with nature-based solutions in rural areas and open space

LOUISIANA
WATERSHED
INITIATIVE

working together for sustainability and resilience

AGENDA

- Nature-Based Solutions Program overview
- Natural channel design
- Mollicy Farms case study
- Questions

NATURE-BASED SOLUTIONS PROGRAM OVERVIEW

MAXIMIZE NATURAL FUNCTIONS OF THE FLOODPLAIN

- Fund projects that harness natural features to reduce flood risk and improve water quality
- Provide training and technical resources to advance understanding and adoption of nature-based solutions
- Prioritize nature-based solutions across state programs and projects
- Use tools to quantify benefits and measure performance of nature-based projects

NATURAL CHANNEL DESIGN

Lee Forbes

NATIONAL DIRECTOR | SWCA ENVIRONMENTAL CONSULTANTS

Lee Forbes has more than 33 years of experience as a civil and environmental engineer, serving as project manager/lead design engineer for numerous projects involving fluvial geomorphological assessment, natural channel design, ecologically enhanced channel design, wetland restoration and hydrodynamic modeling.

Presentation overview

- Traditional rural land use and drainage practices related to river system functions
- Natural channel design
- Case study: Cypress Creek at Meyer Park in Houston

Traditional rural land practices that affect river system functions

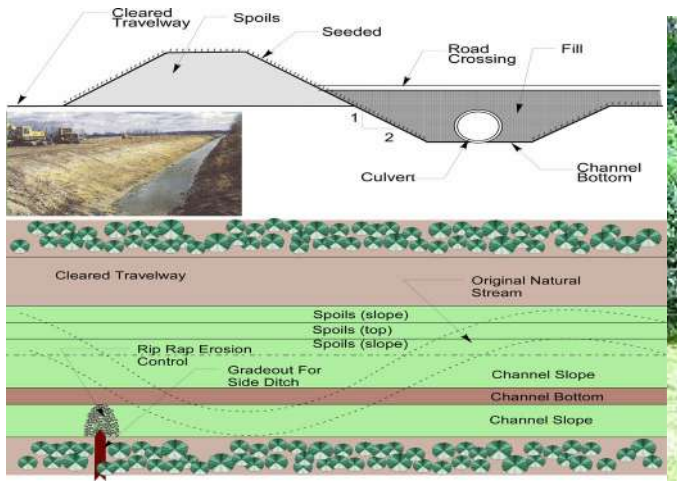
Traditional rural and suburban drainage practices that affect river system function

Maximum conveyance

- Straightening
- Channelization (constant x-sect & slope)
- Oversizing (10- to 100-year storm)

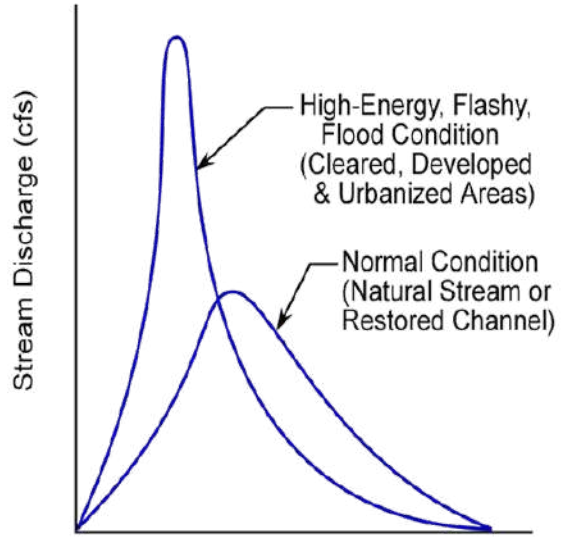
Minimal floodplain footprint

- Prescribed incision (floodplain disconnection)
- Buried storm sewer pipes
- Regional stormwater detention



Results of rural practices: hydromodification

- Increased flash flows
- Reduced base flows
- Increased sediment loads
- Increased channel erosion



Photos courtesy of HCFCD

Stormwater BMPs

Now we attempt to correct hydromodification through stormwater **Best Management Practices** in the watershed.

- Site sediment controls (silt fences, hydromulching and sodding, sediment capture ponds)
- Regional and onsite detention/retention
- Low-impact development and pre-development hydrology

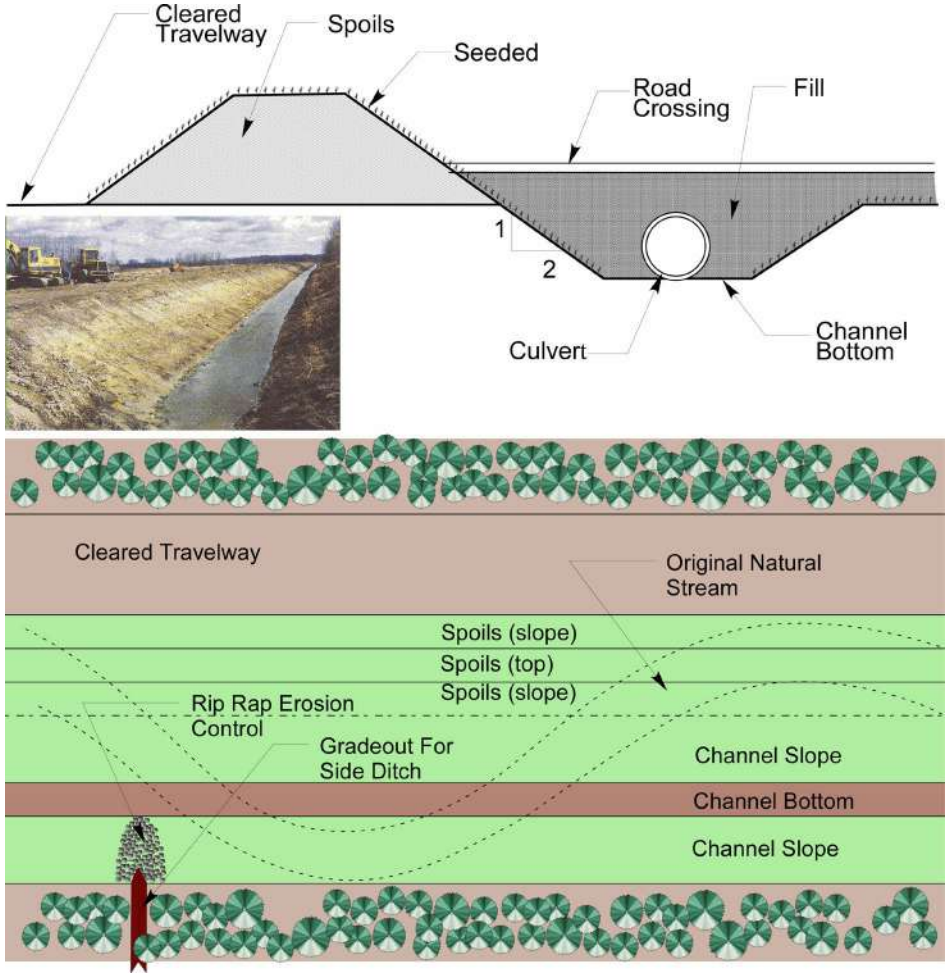
Sounds good…so what's the problem?

Problems with stormwater BMPs

Stormwater BMPs deal only with the watershed and not the channel, meaning they don't address **in-channel processes**, such as:

- Continued channel rectification
- Continued channel response to past and ongoing watershed hydromodification

Continued channel rectification



Channel response to past and ongoing hydromodification

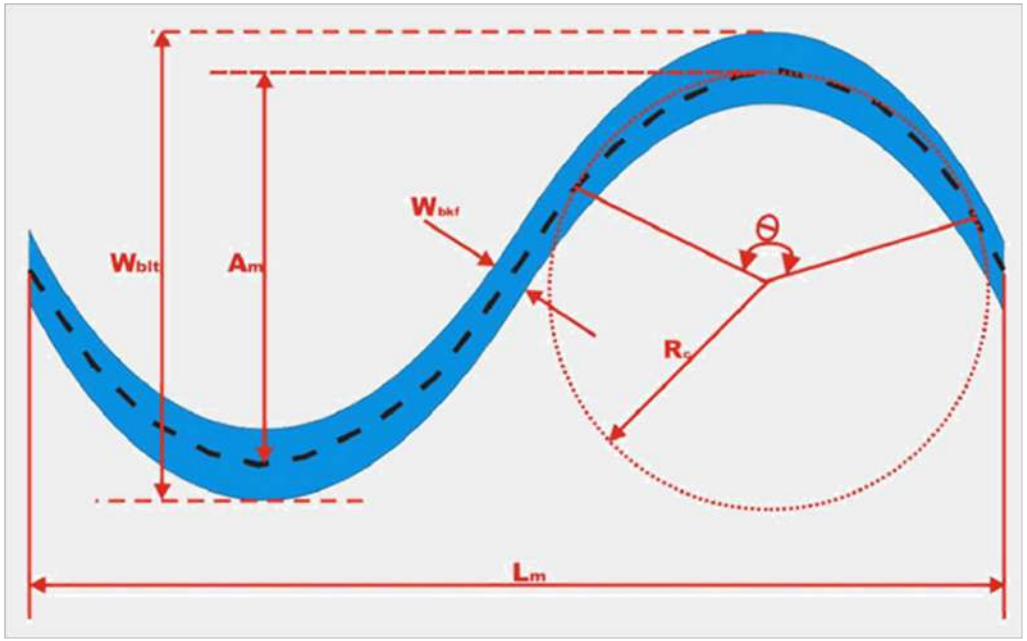
"When the works of man run contrary to the natural, stable tendencies of the river, the river eventually dominates."

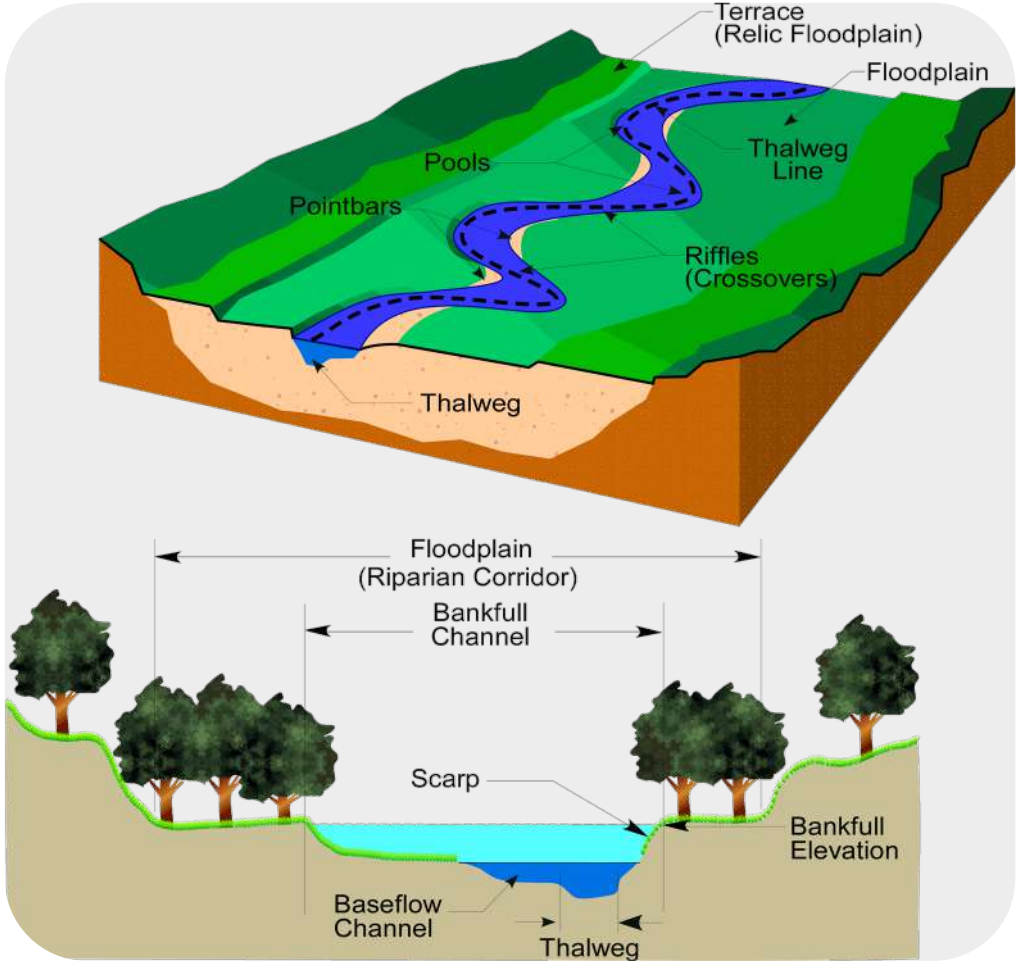
– *Dave Rosgen, 1996*

Photos courtesy of NRCS

Fluvial geomorphology

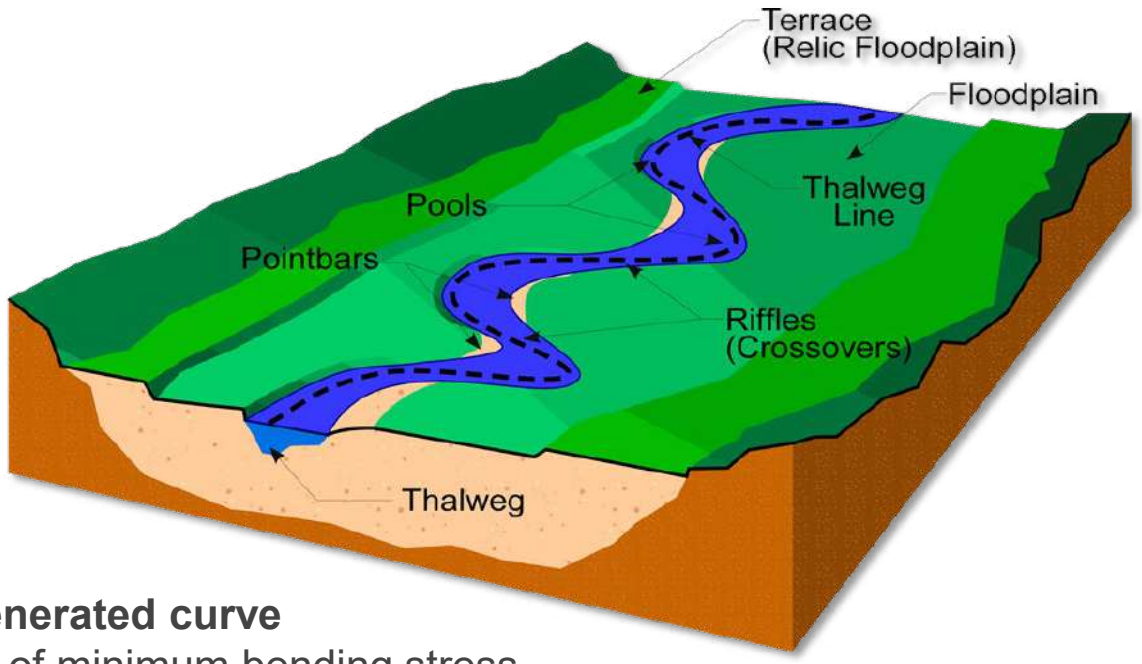
THE SCIENCE OF THE FORMATION OF RIVERBEDS, FLOODPLAINS AND STREAMS BY WATER





Optimized natural channel forms

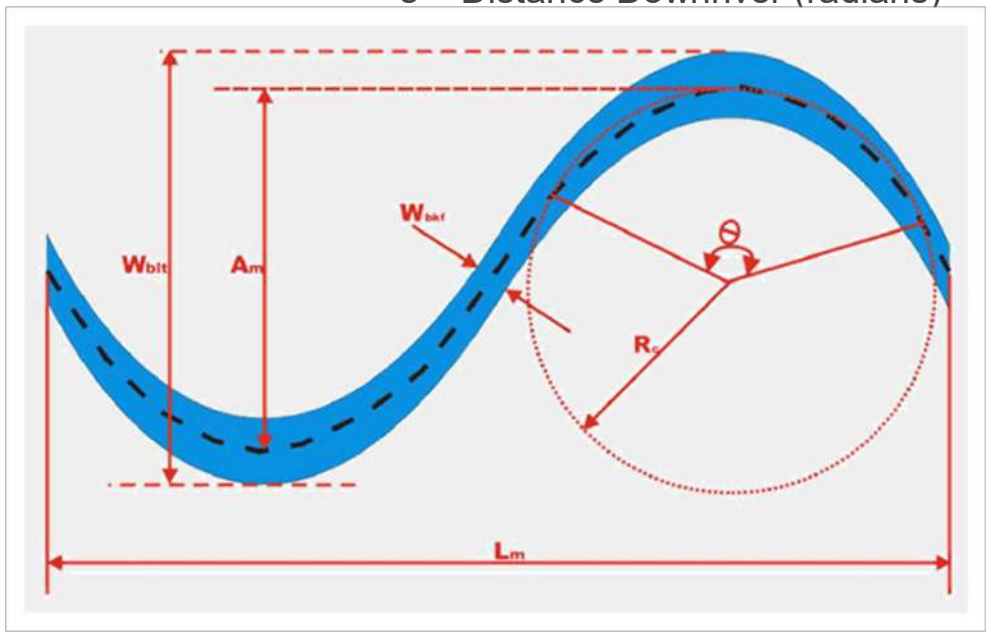
LATERAL (PLANFORM) DYNAMIC EQUILIBRIUM



Sine-generated curve

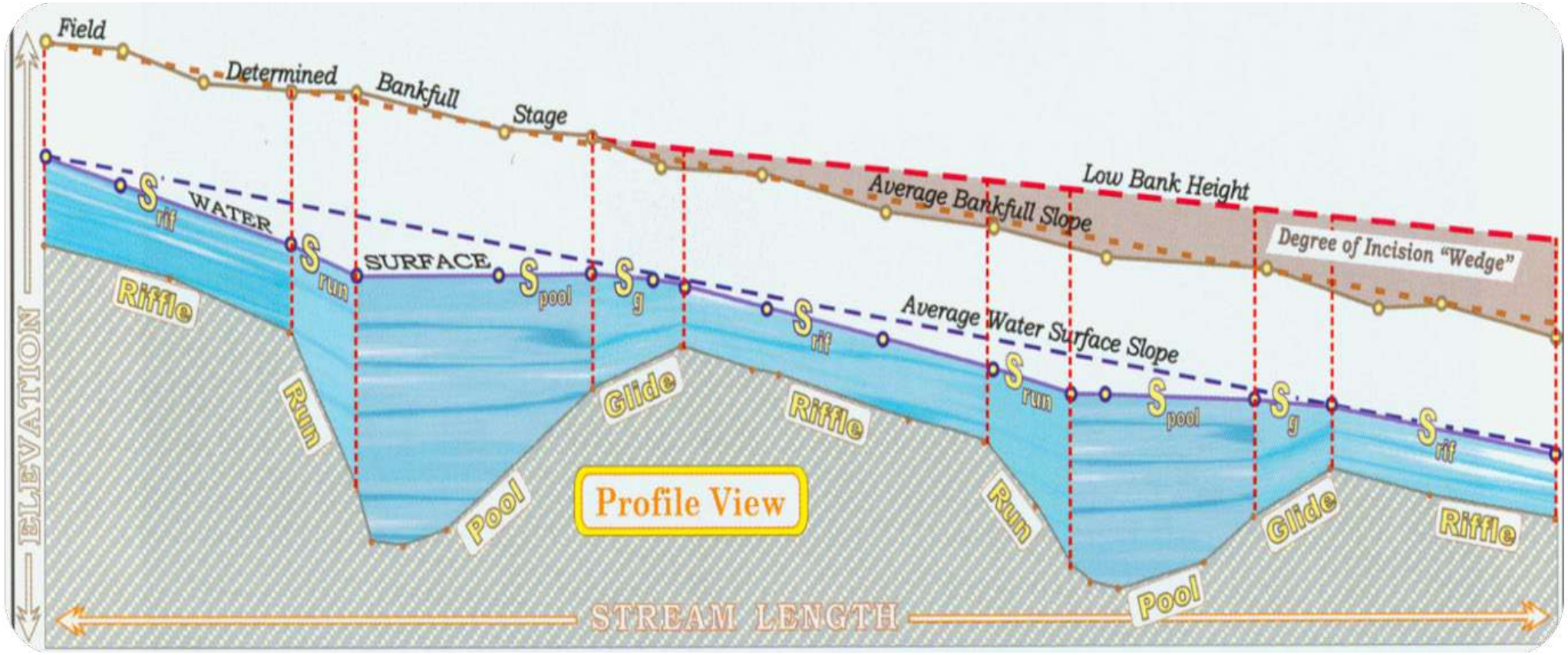
- Path of minimum bending stress
- Path of minimal directional variance
- Path that represents the most-likely random walk

Heading Angle $\Psi = c\sin(s)$
s = Distance Downriver (radians)



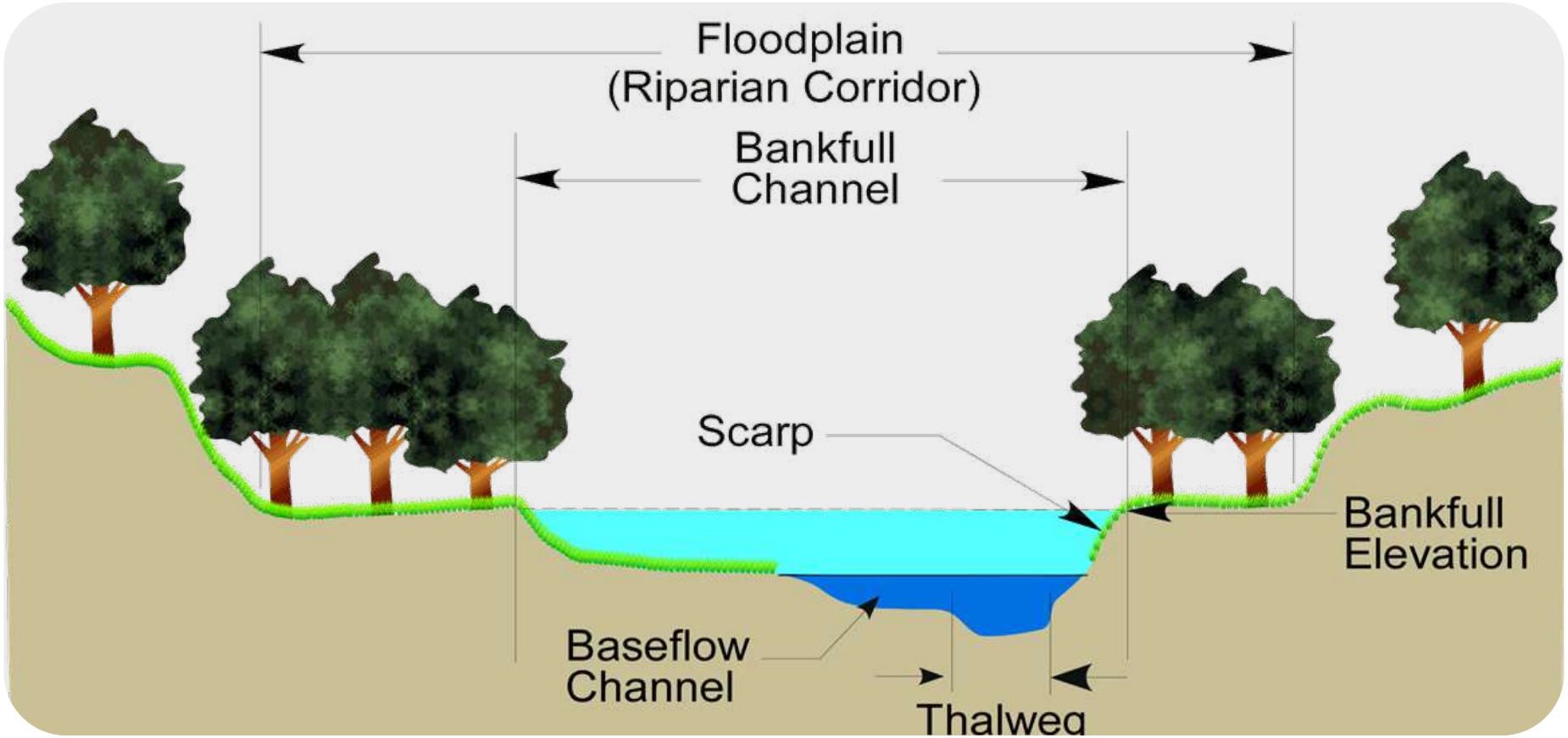
Optimized natural channel forms

LONGITUDINAL VERTICAL DYNAMIC EQUILIBRIUM



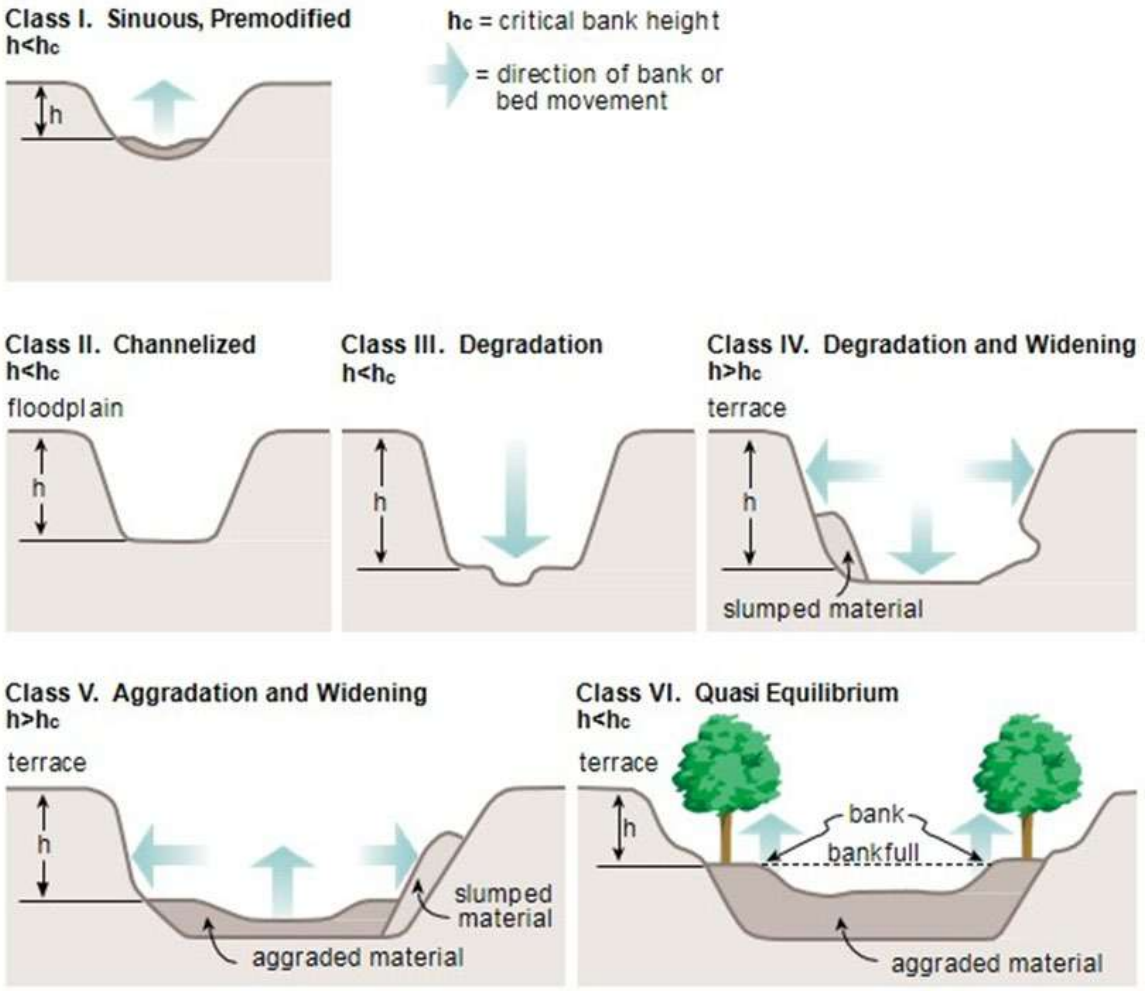
Optimized natural channel forms

CROSS-SECTIONAL AND TEMPORAL DYNAMIC EQUILIBRIUM



Alluvial channel response to hydromodification

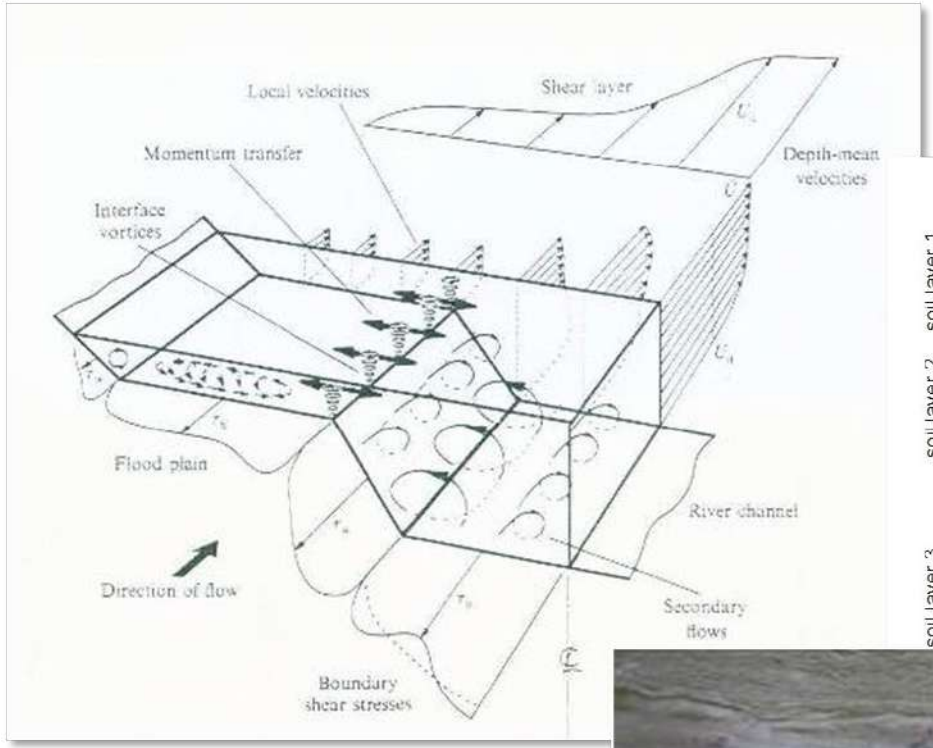
- Alluvial streams form both the stream channel **and** their adjacent floodplain.
- All alluvial streams respond in this same fashion in response to disturbance.

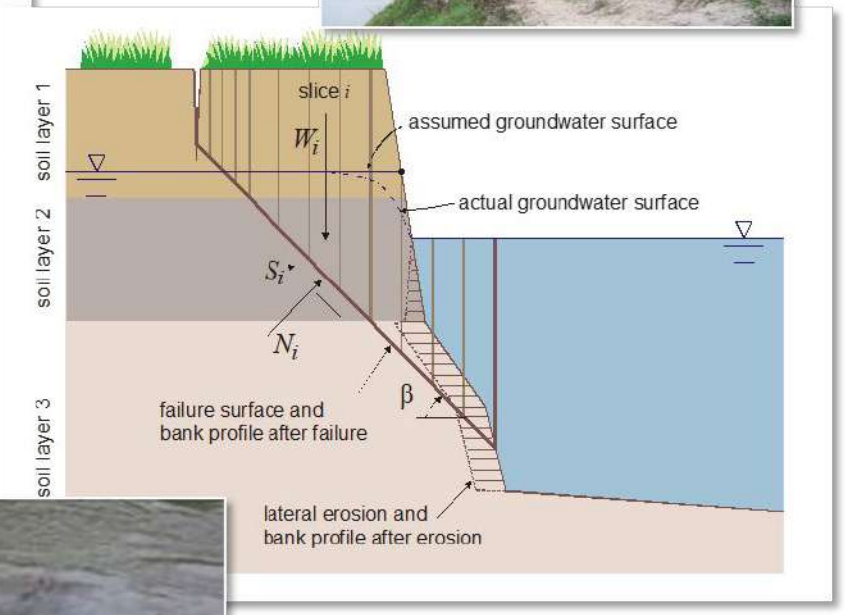


Simon's (1989) model of channel response in disturbed alluvial channels

Bank failure mechanism in incised channels

COMBINATION OF EXCESS SHEAR STRESS AND MASS FAILURE





Upland/hillslope vs. in-channel sediment loads

Sediment from stream channels account for as much as 85% of watershed sediment yields, and streambank retreat rates as high as 24 feet per year have been documented (Simon, A. et al, 2000).

1 acre x 2” erosion over 1-year period = 270 cubic yards x 1.1 tons/cy = 295 tons/year

210’ long x 15’ tall eroding failing/retreating channel bank (12’ over 6 months) = 1,400 cubic yards = 1,540 tons = 3,080 tons/year

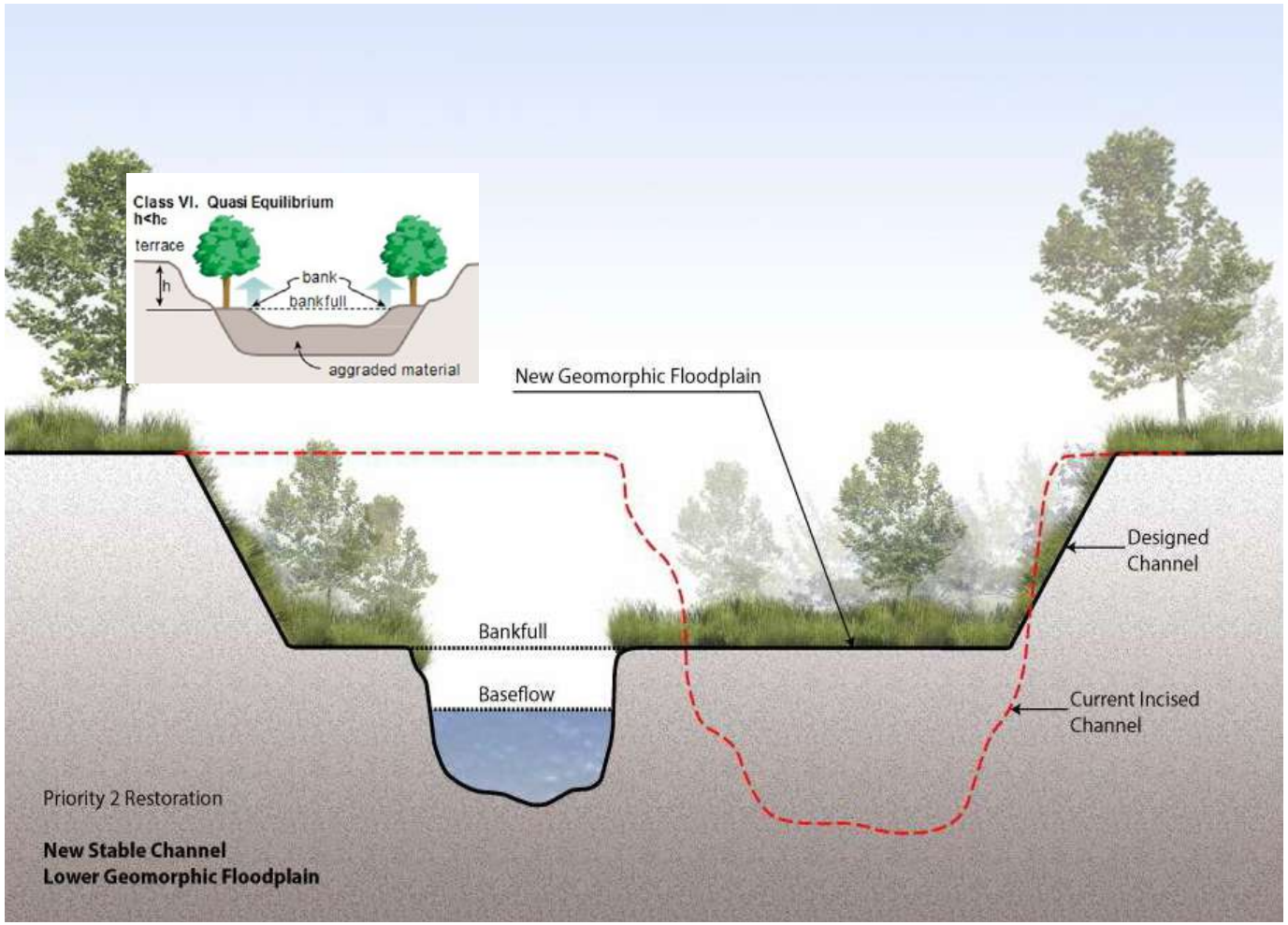
Sediment load (10 cubic yards)

X 140

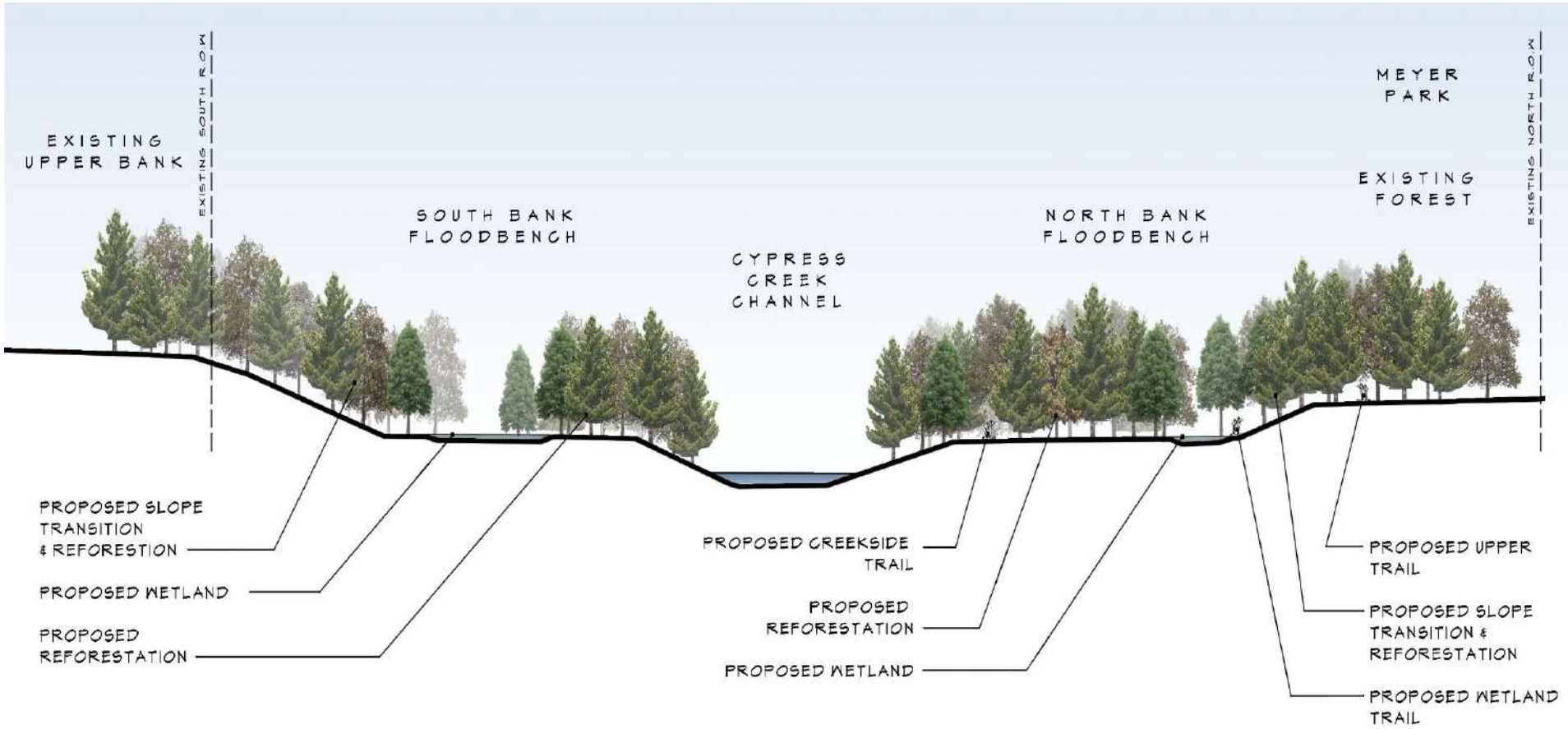
Priority 2 restoration

STREAM WITHIN A FLOOD CONTROL CHANNEL

Establish equilibrium at lower elevation

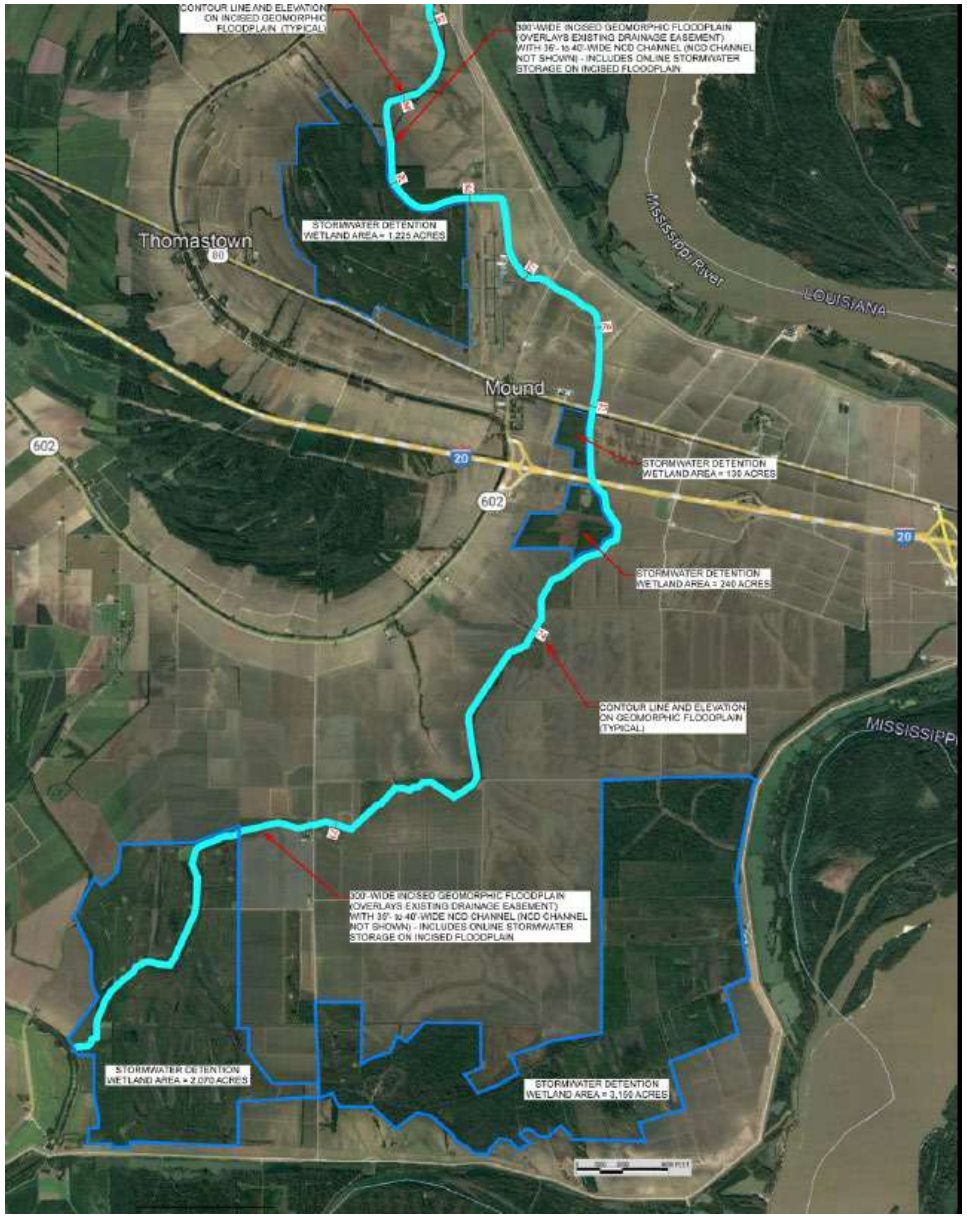


Priority 2 restoration components



Nature-based solutions for agricultural areas

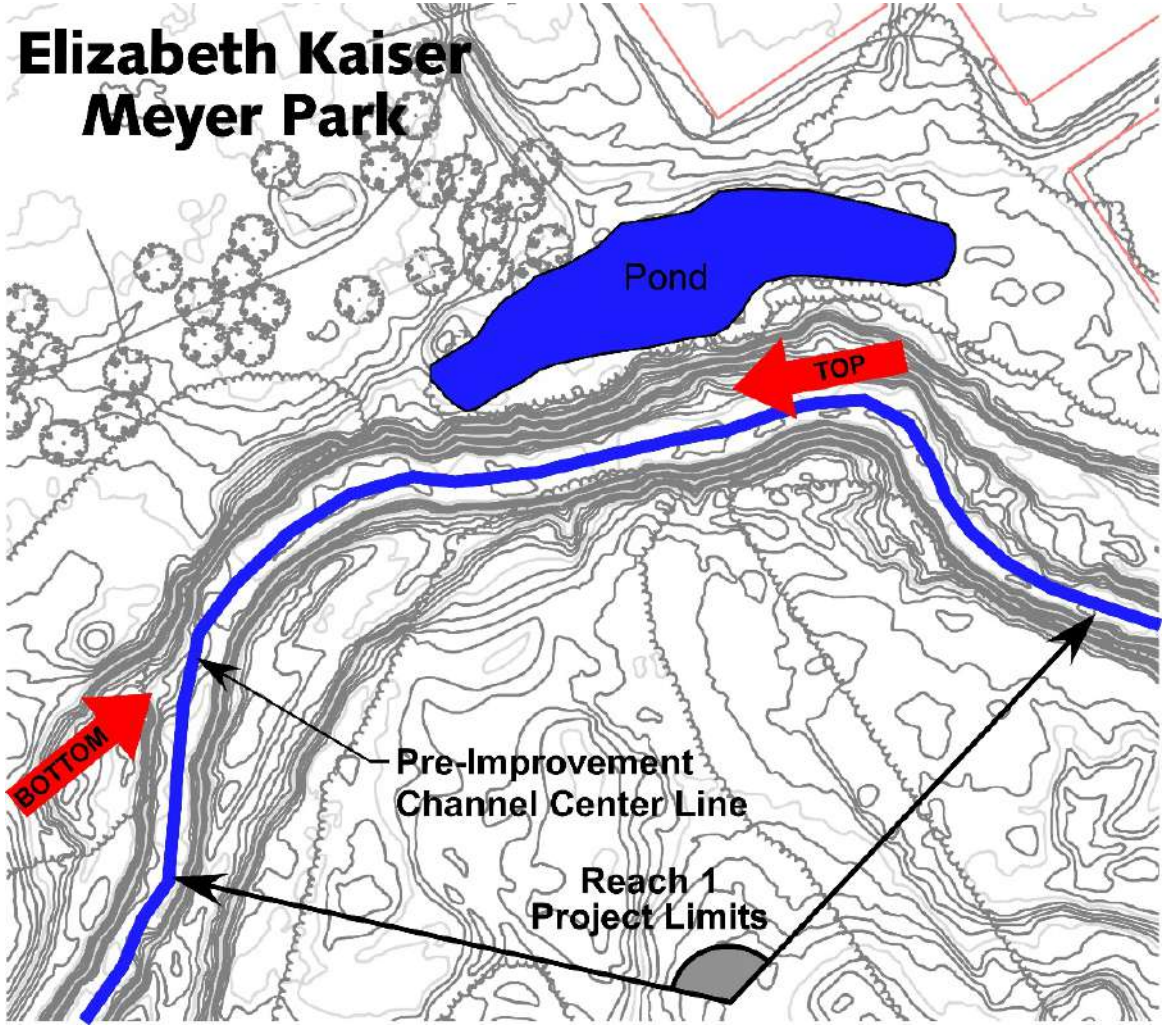
- Priority 1 stream restoration where possible, Priority 2 where the floodplain prohibits
- Maximize out-of-production areas for stormwater detention/retention water quality wetlands
- NRCS Conservation Easement Programs
- NRCS Watershed Assistance & Emergency Watershed Programs



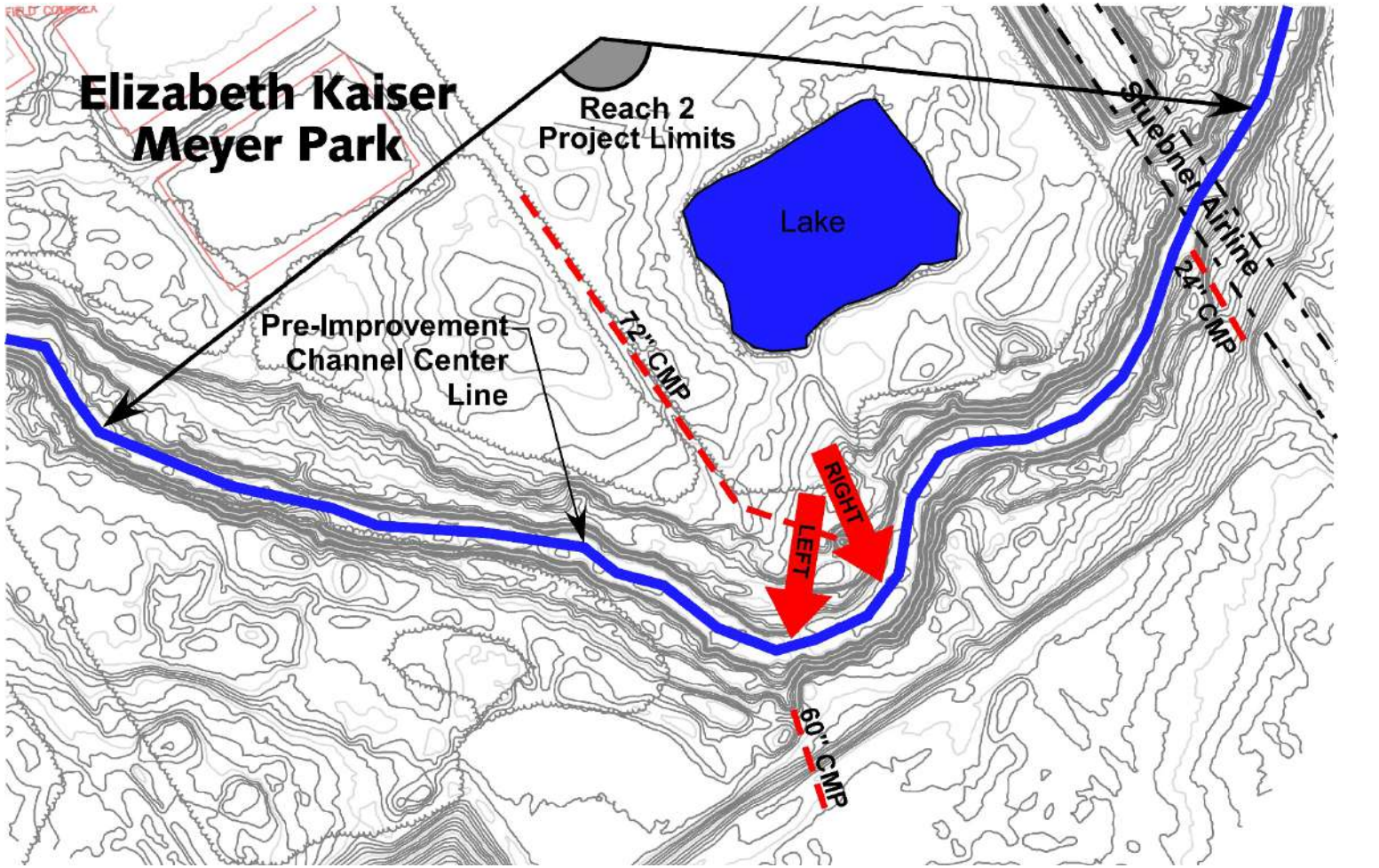
Case Study: Cypress Creek at Meyer Park, Houston

- 189 miles^2 drainage area
- Sand bed and banks with stiff marine clay outcroppings acting as natural, slowly melting grade control
- Natural, but majority of reaches in area were dredged in the past
- Unstable reaches upstream sending large sediment loads through project reach
- Over-widening threatens park infrastructure and storm sewer outfalls

Reach 1: Pre-improvement

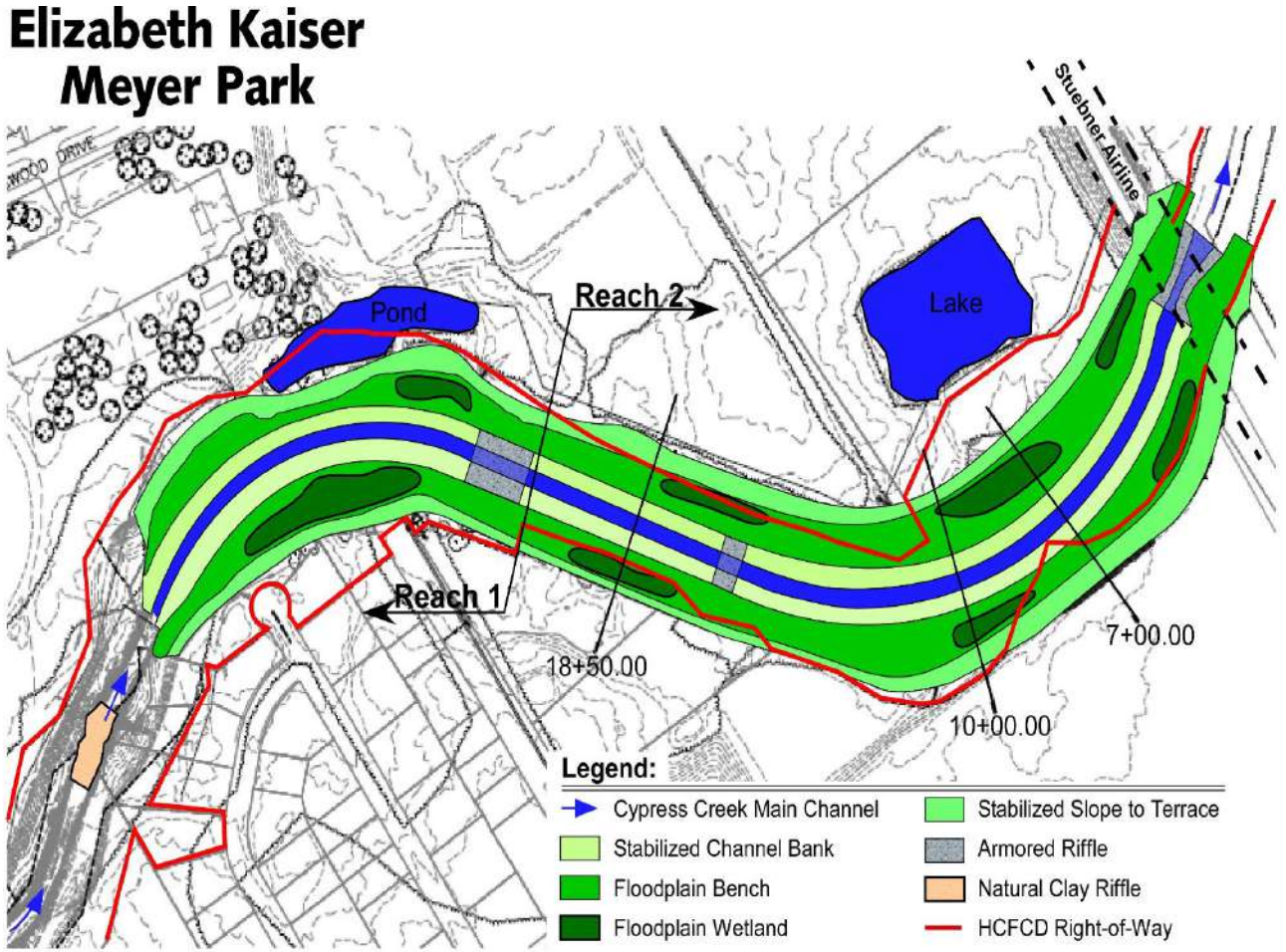


Reach 2: Pre-improvement



Natural channel design and nature-based improvements

- New Priority 2 NCD channel
- Constructed boulder riffles
- Geomorphic floodplain bench
- Stabilized slopes
- Geomorphic floodplain wetlands
- Grass and tree plantings
- Armored storm sewer outfalls
- Greenway and park trail alignments



During construction

Before and after (2006)

Before and after (2009)

STABLE AND SELF-IMPROVING AFTER 8 BANKFULL EVENTS

11 years later (2017)

STABLE AND SELF-IMPROVING AFTER MEMORIAL DAY FLOOD (2016), TAX DAY FLOOD (2016) AND HURRICANE HARVEY (2017)

MOLLICY FARMS CASE STUDY

Chris Rice

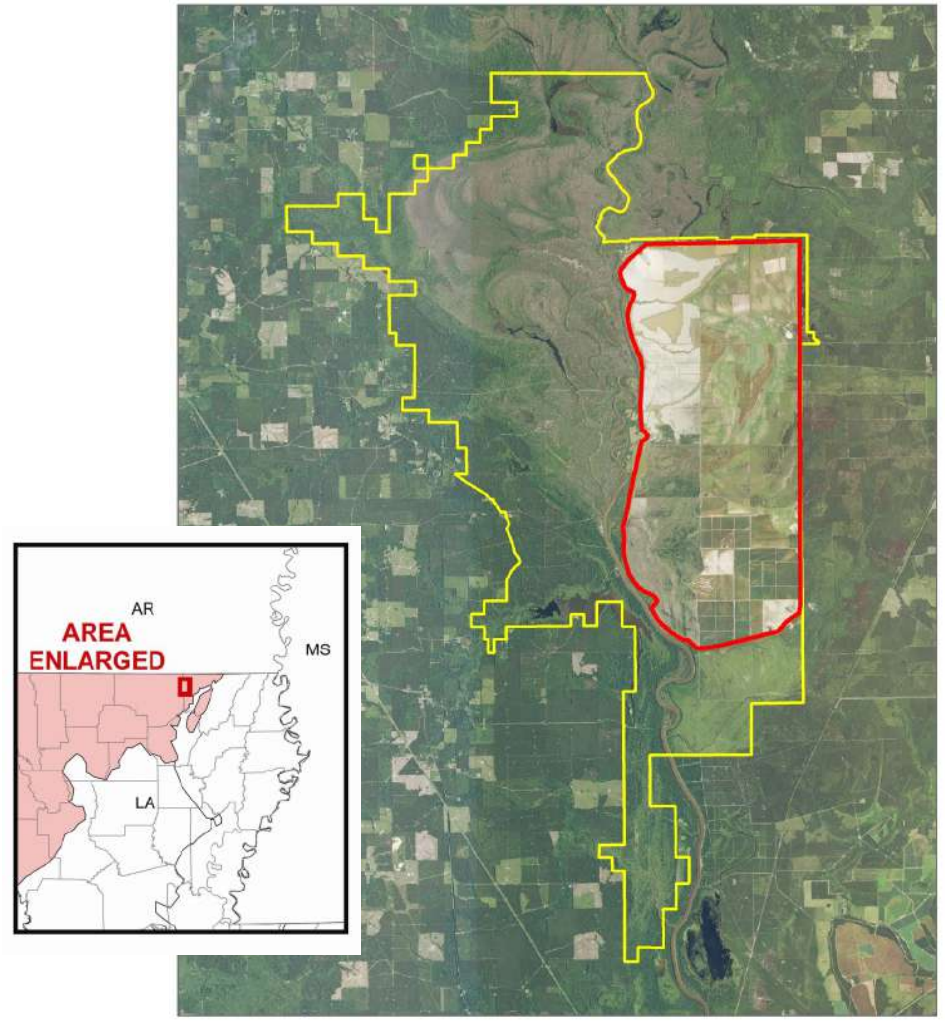
BIOLOGIST | THE NATURE CONSERVANCY

Chris Rice serves as the project manager for the Mollicy Farms restoration project. His expertise includes floodplains and bottomland hardwood/longleaf pine forests restoration and management.

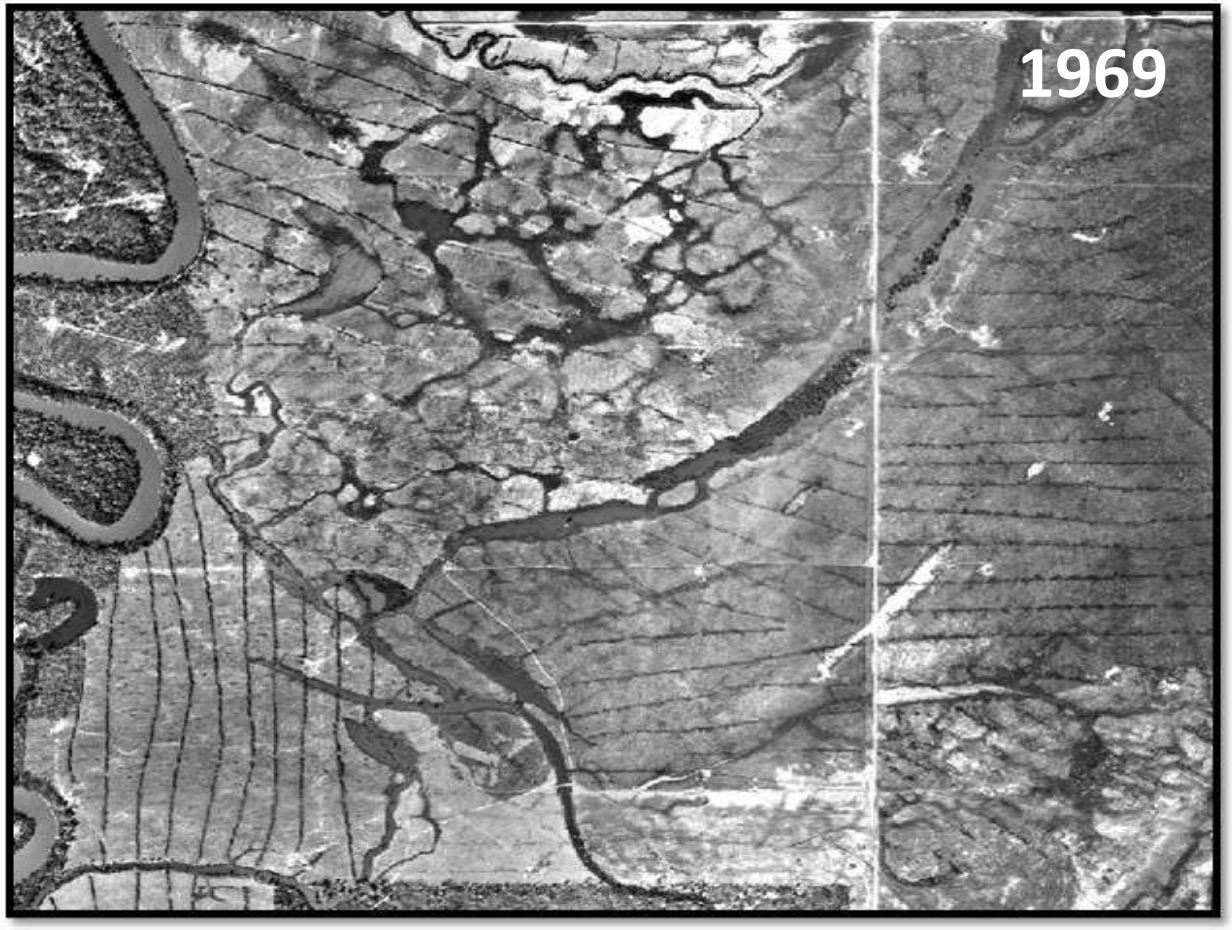

Ouachita
River
Basin
Merged Panchromatic
And Multispectral
Satellite Imagery

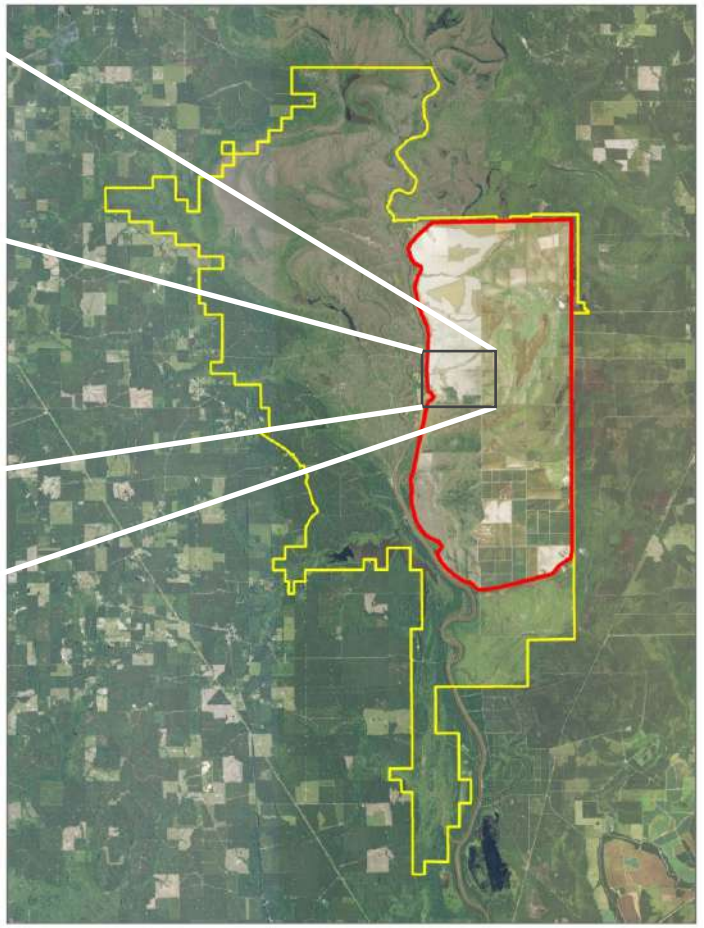
Upper Ouachita National Wildlife Refuge

- Mollicy Farms is part of the U.S. Fish and Wildlife Service Upper Ouachita National Wildlife Refuge.
- USFWS purchased it from one landowner.
- Mollicy Farms unit is 20,000 acres.
  - 16,000 acres within boundary levee and 4,000 acres outside boundary levee
- About 11,000 acres have been reforested, and about 3 million trees have been planted.



Interior hydrologic modification





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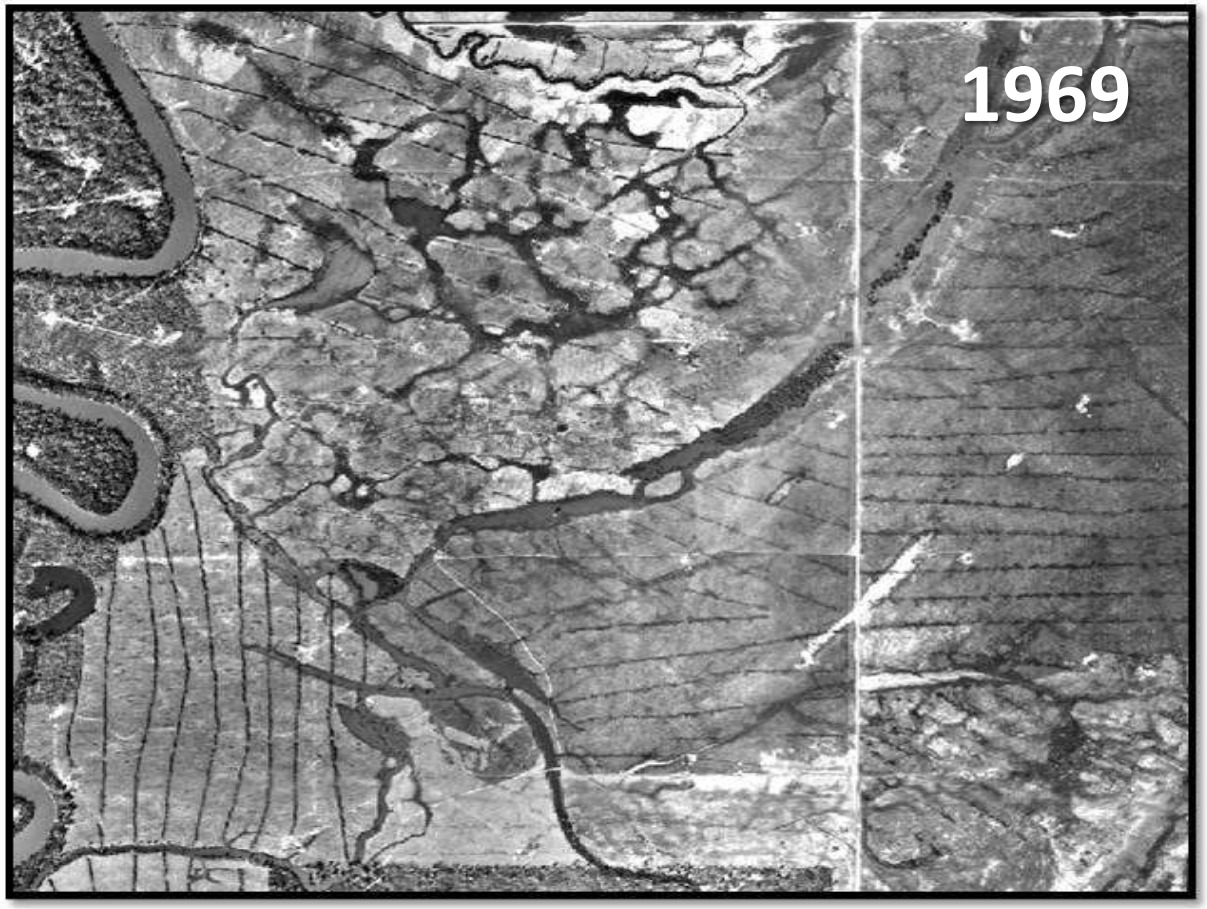
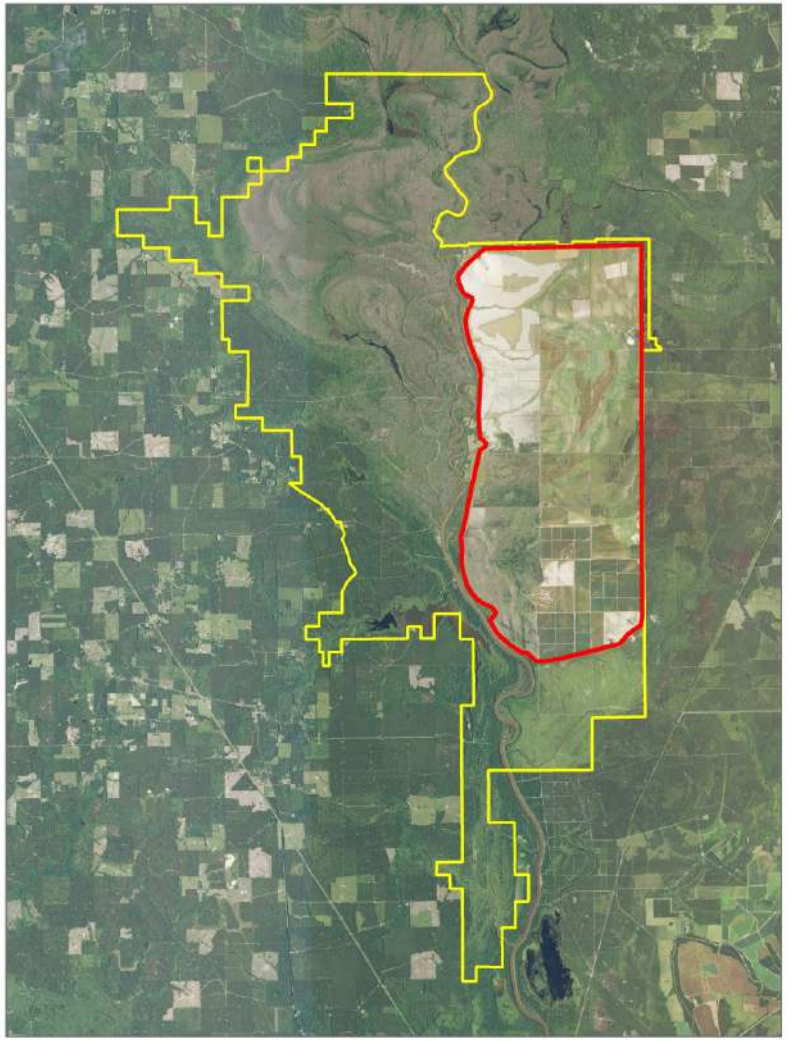


Mollicy Levee

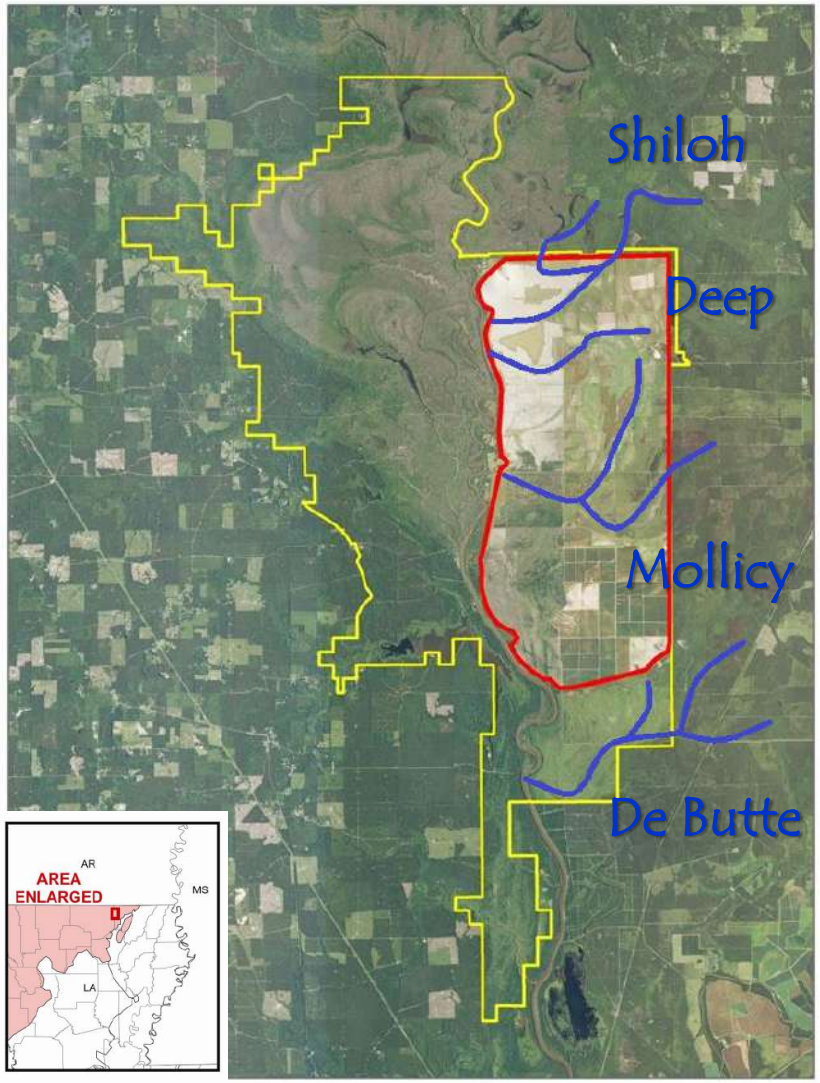


The Nature Conservancy


The Nature Conservancy

Mollicy Farms watersheds

- Significant watersheds: Shiloh Creek, Deep Slough, Mollicy Bayou and Bayou de Butte
- Increasing restoration footprint from 16,000 acres to 76,000 acres of combined uplands and bottomlands



Upper Ouachita impairments

- Total Maximum Daily Load from 2002 found organic enrichment, low dissolved oxygen and high nutrients and called for a 30% non-point reduction.
- Upper Ouachita River Watershed Implementation Plan cited Mollicy Farms tract as contributing significant sedimentation.

Funding and partnerships

- 2009 federal stimulus money
- Louisiana Department of Environmental Quality
- U.S. Fish and Wildlife Service
- Caterpillar
- Entergy
- Yellow Springs Instruments
- Private donations to The Nature Conservancy

Benefits of floodplain reconnection and restoration at Mollicy Farms

- Creates 25 square miles of floodwater storage for the Ouachita River
- Improves water quality of the Ouachita River
- Significantly decreases the chances of levees breaking near downstream communities during historic flood events
- Provides aquifer recharge
- Provides habitat for wildlife

Project objectives

- Reconnect remnant streams to Ouachita River flood pulse
- Conduct extensive water quality and biological monitoring
- Restore internal hydrology

Levee breach plan

- A design of the location and dimensions of the breaches was created to minimize the potential of scour and head-cutting during flood recession.
- The breaches were positioned to facilitate floodplain flow and water exchange between the Ouachita River and Mollicy Farms.
- The U.S. Army Corps of Engineers granted a permit to the USFWS for the breach design.

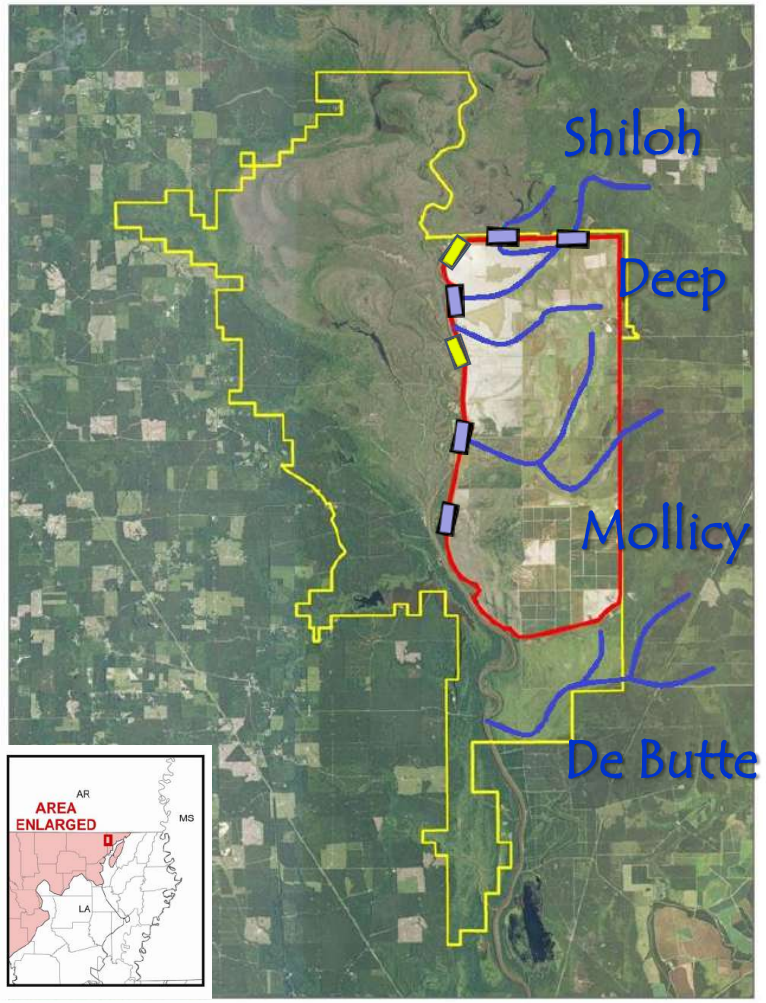
The Nature Conservancy

The Nature Conservancy

The Nature Conservancy

2009 flood aftermath

2010 floodplain restoration



Shiloh Creek

Shiloh Creek

Mollicy Bayou

Mollicy Bayou

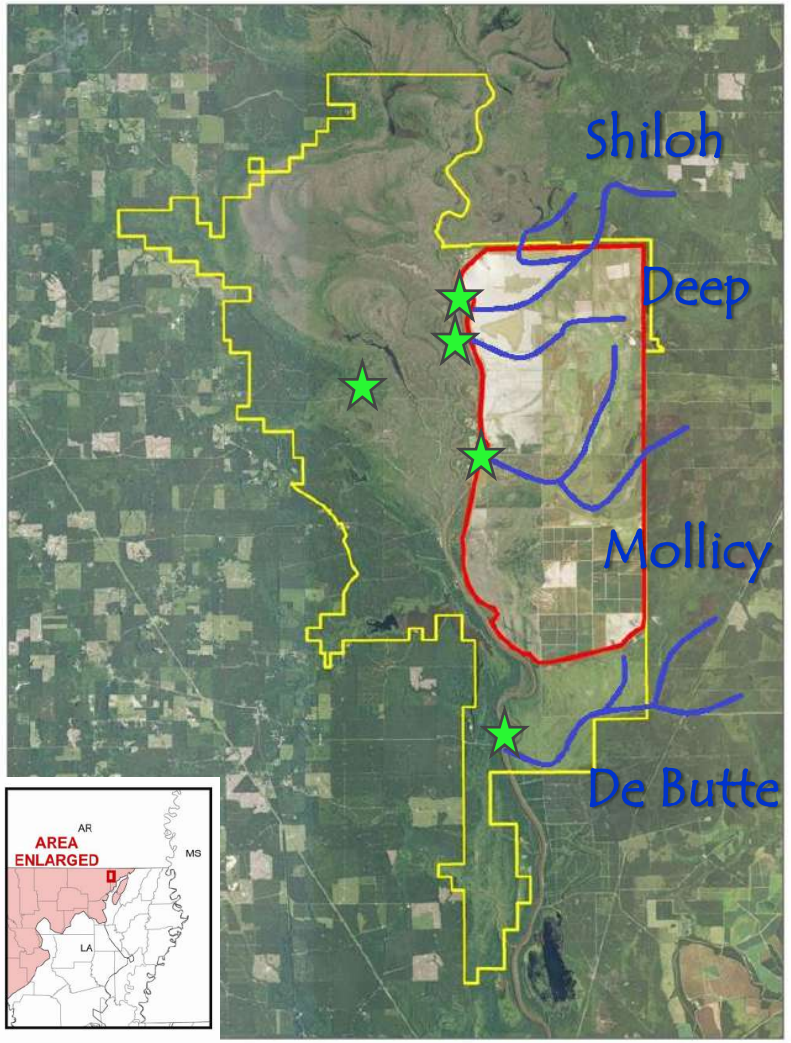
Biological monitoring

Aquatic invertebrate surveys

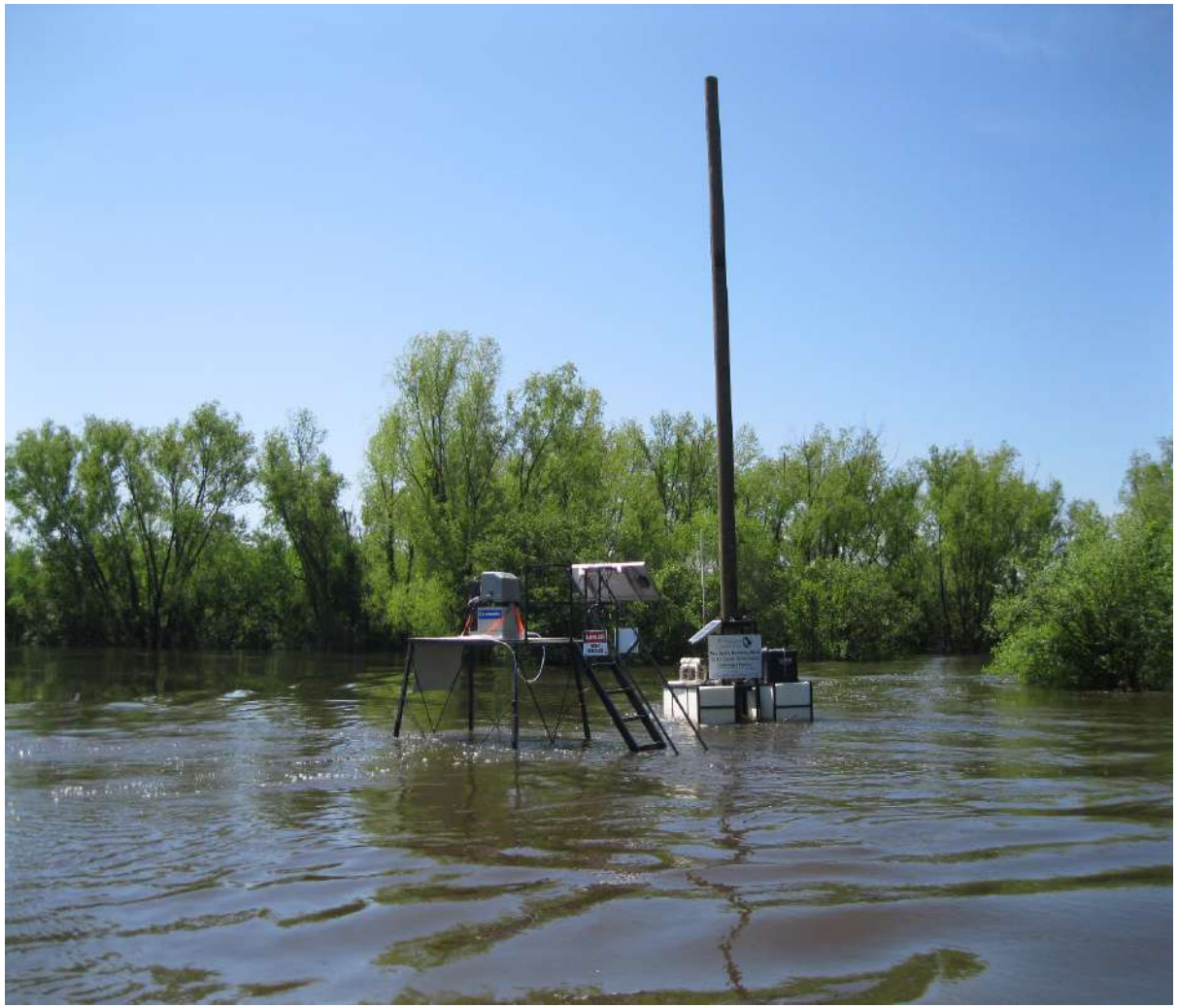
Herpetological surveys

Water quality monitoring

Water monitoring stations



Water monitoring stations



Water monitoring stations

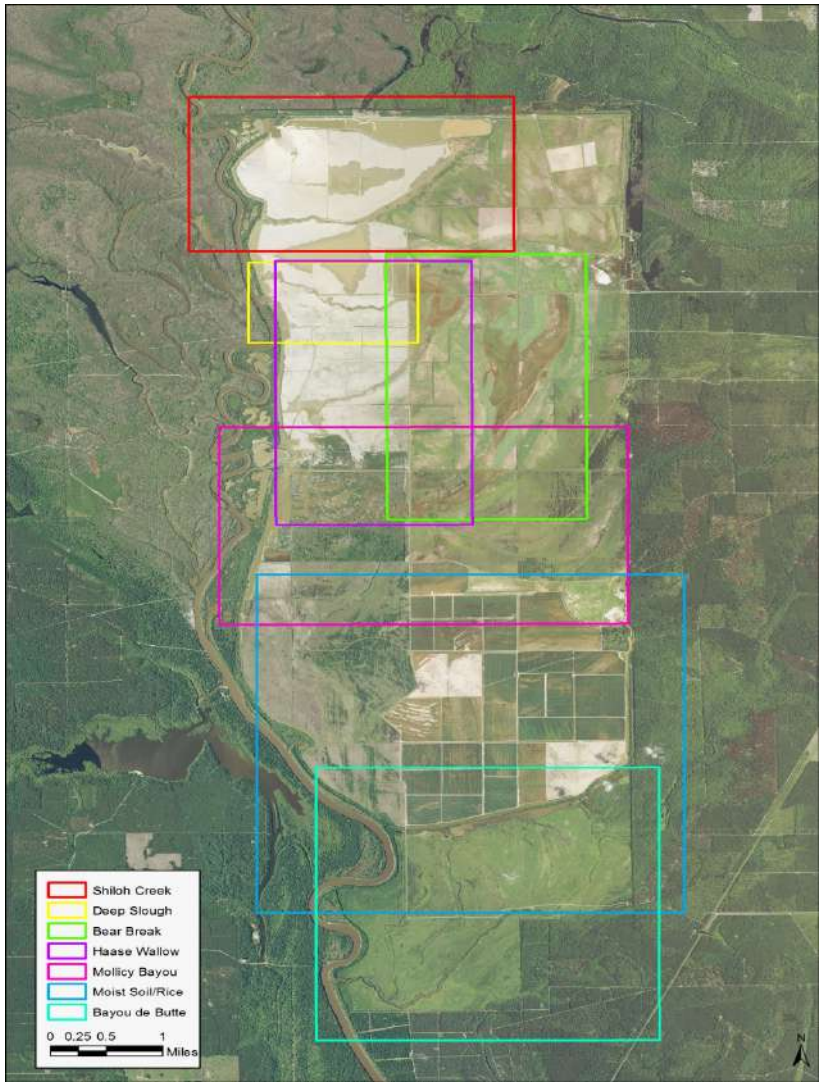
Parameters measured:

ISCO	YSI
TSS	DO
TKN	pH
TOC	Conductivity
Ortho-P	Turbidity
Nitrate-Nitrite	Chlorophyll
Turbidity	Temperature
pH	
Conductivity	

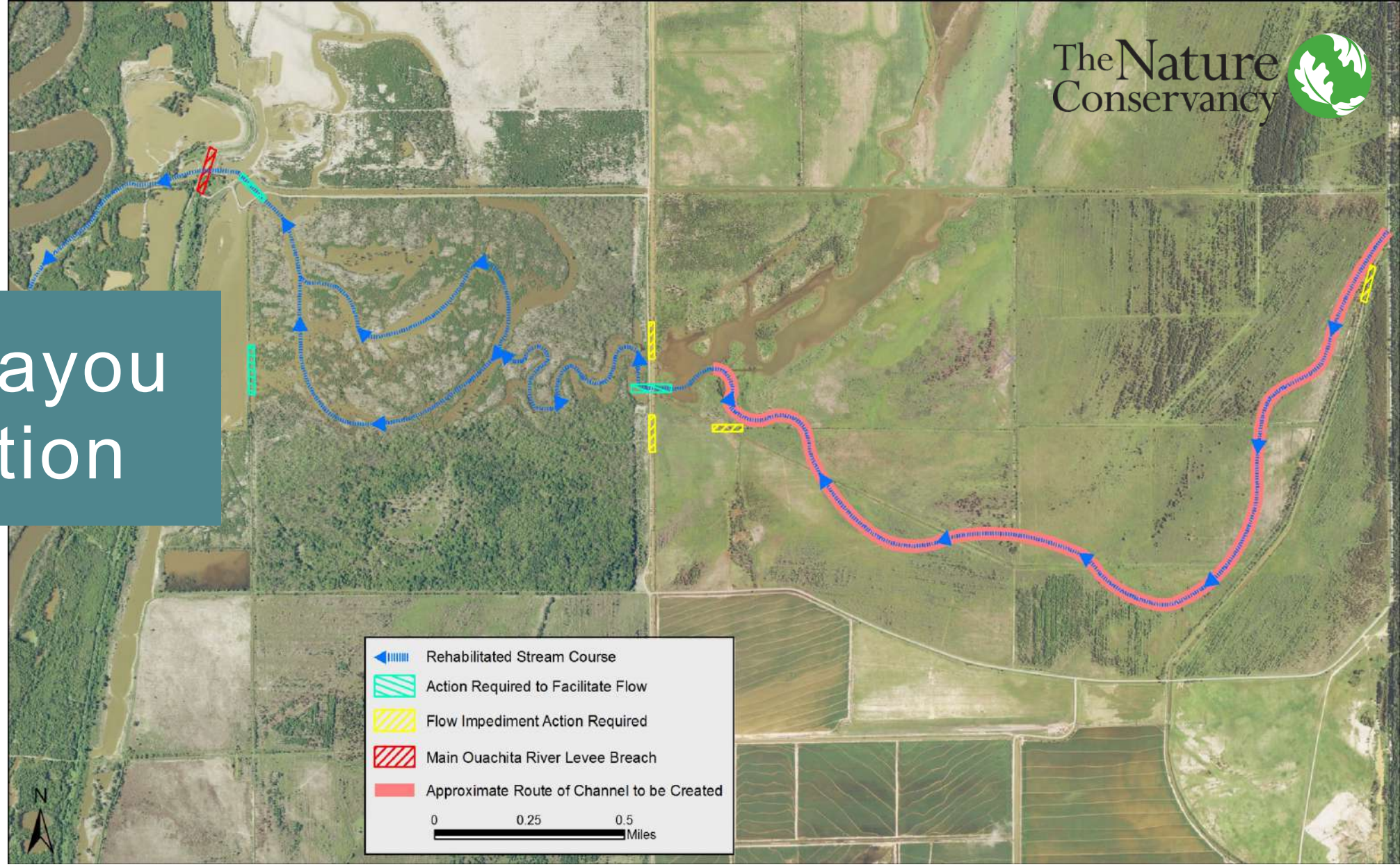
Sediment plume discharge: Mollicy Bayou

Internal hydrology restoration

- The restoration plan was broken down into drainage-based sections.
- It focused on restoring functionality to the floodplain, not historic conditions.
- TNC developed the design and supervised the construction of all interior hydrological restoration work.



Mollicy Bayou Restoration



Mollicy Bayou Restoration

Mollicy Bayou Restoration

Mollicy Bayou Restoration

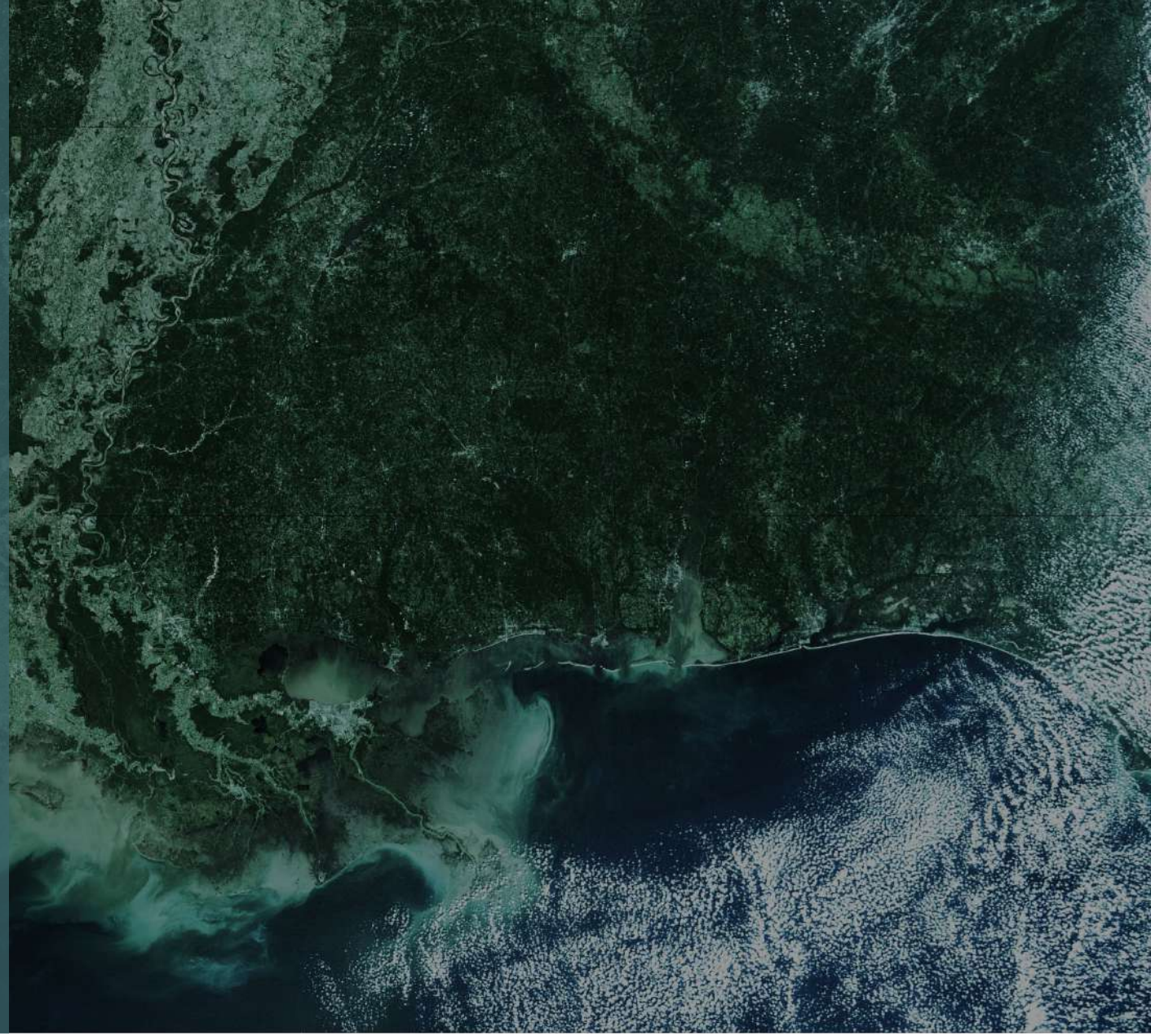
Mollicy Bayou Restoration

Mollicy Bayou Restoration

The Nature Conservancy

Finding more places like Mollicy

QUESTIONS



CONTACT INFORMATION

lforbes@swca.com
crice@tnc.org

@LAWATERSHEDINITIATIVE

@LAWATERSHED

@LAWATERSHED

LOUISIANA WATERSHED INITIATIVE

WATERSHED@LA.GOV

THANK YOU

WATERSHED.LA.GOV