

# Long-Term Monitoring of Fish Populations from NCD Project Sites



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ELI Webinar Series  
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# Limiting Factors & Ecological Function

Biology

Physicochemical

Geomorphology

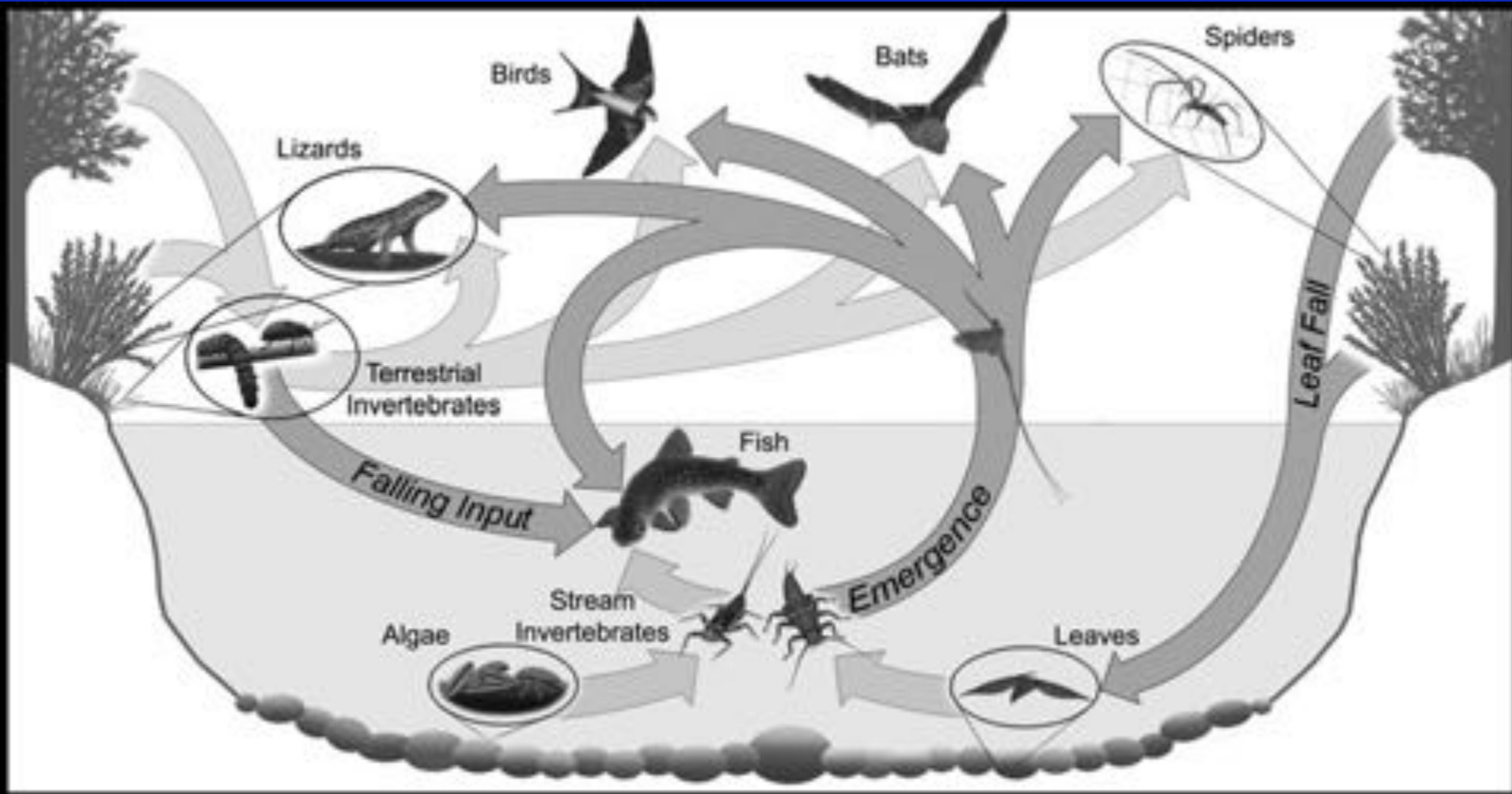
Hydraulics

Hydrology

Courtesy Will Harmon, USFWS



# Fish populations= Ecological Indicator



# How do you improve a fish population?

## Stocking

# How do you improve a fish population?

**Stocking**

**Regulations**

# How do you improve a fish population?

**Stocking**

**Regulations**

**Habitat**

# Basics of Stream Habitat



Modified from Schlosser and Angermeier 1995









# Basics of Stream Habitat



Modified from Schlosser and Angermeier 1995





# Basics of Stream Habitat



**Spawning  
Habitat**

**Refuge  
Habitat**



**Feeding  
Habitat**



Modified from Schlosser and Angermeier 1995

















# Basics of Stream Habitat

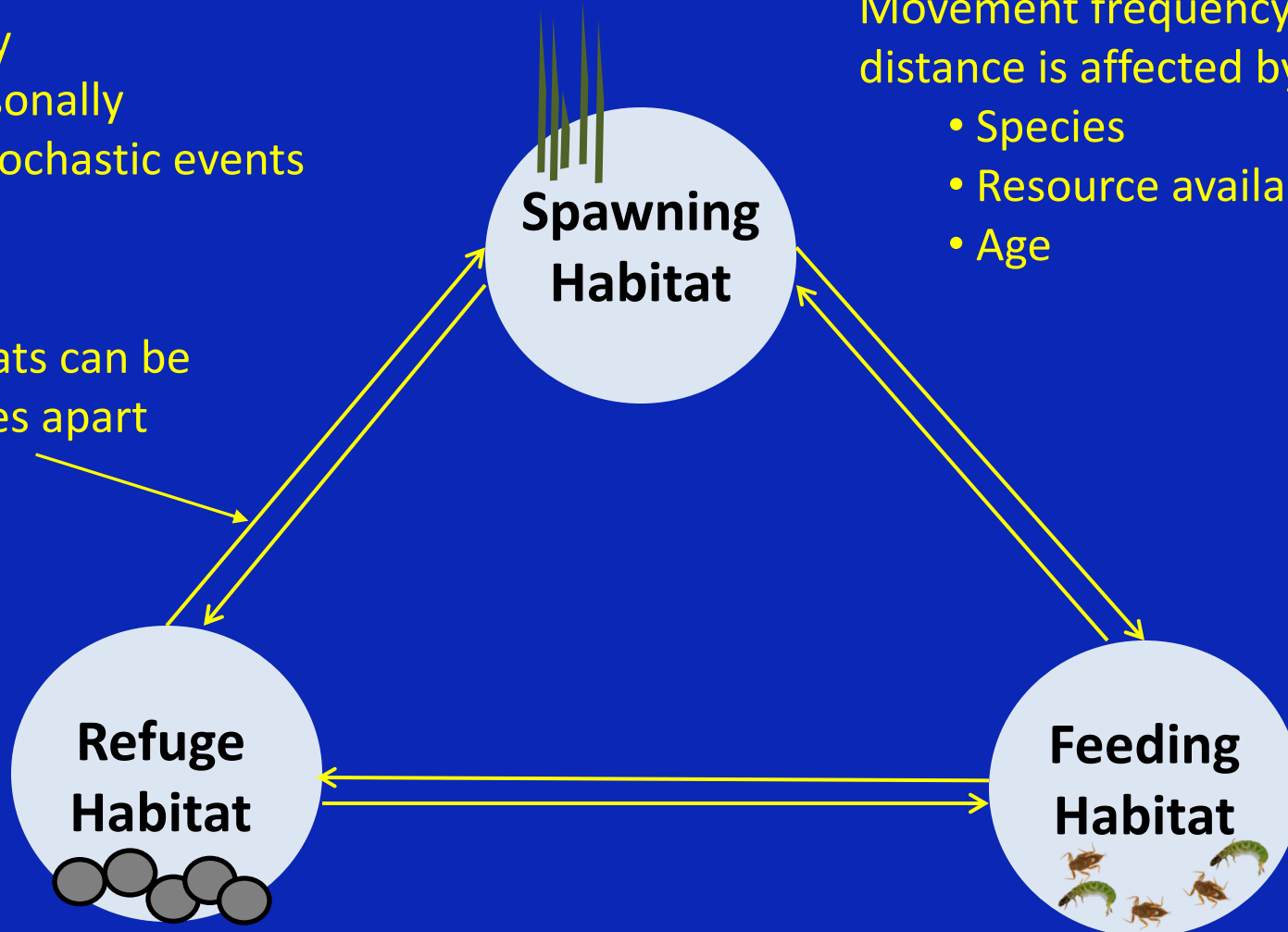
Fish move:

- Daily
- Seasonally
- In stochastic events

Movement frequency and distance is affected by:

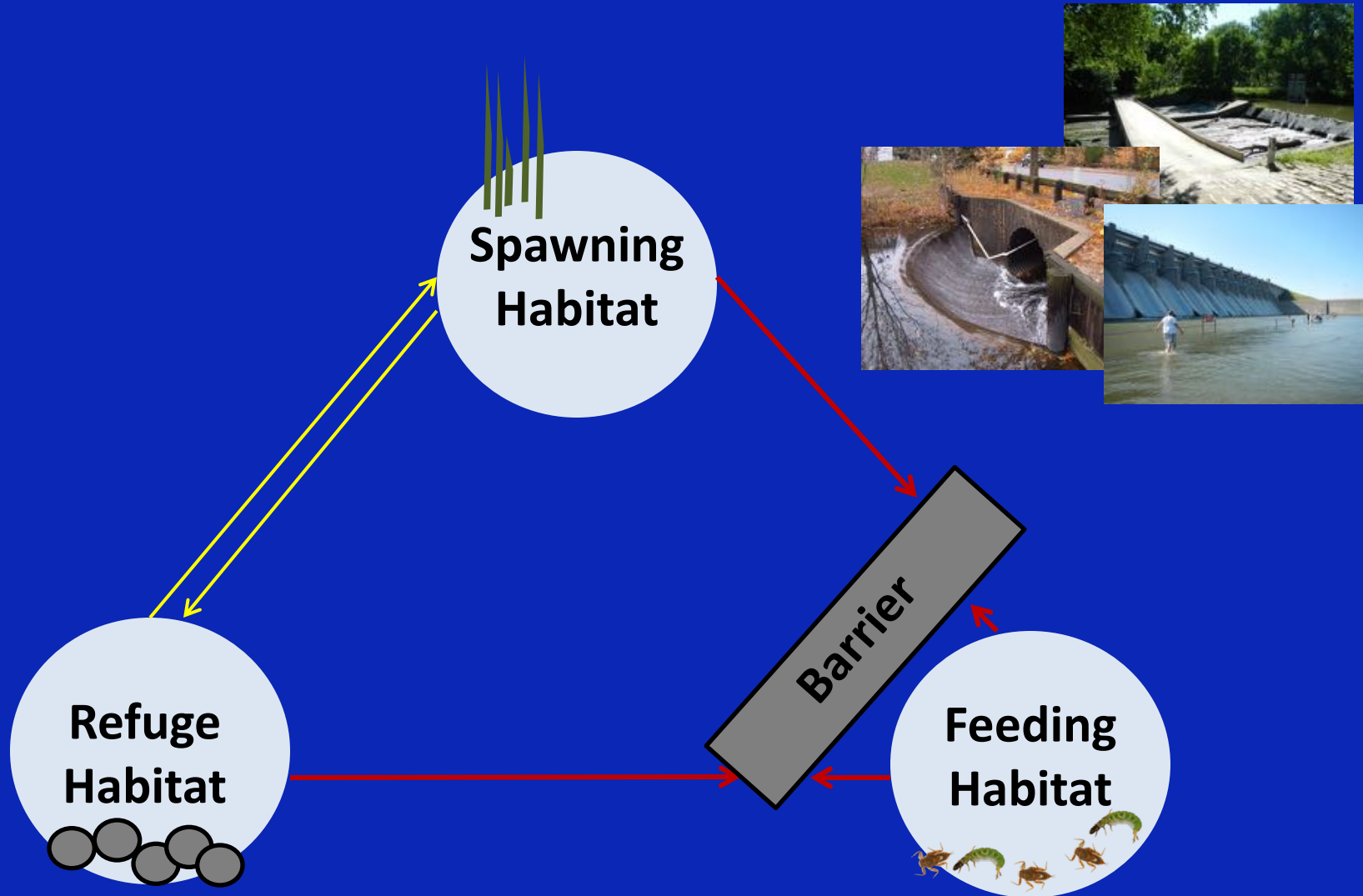
- Species
- Resource availability
- Age

Habitats can be miles apart



Modified from Schlosser and Angermeier 1995

# Basics of Stream Habitat

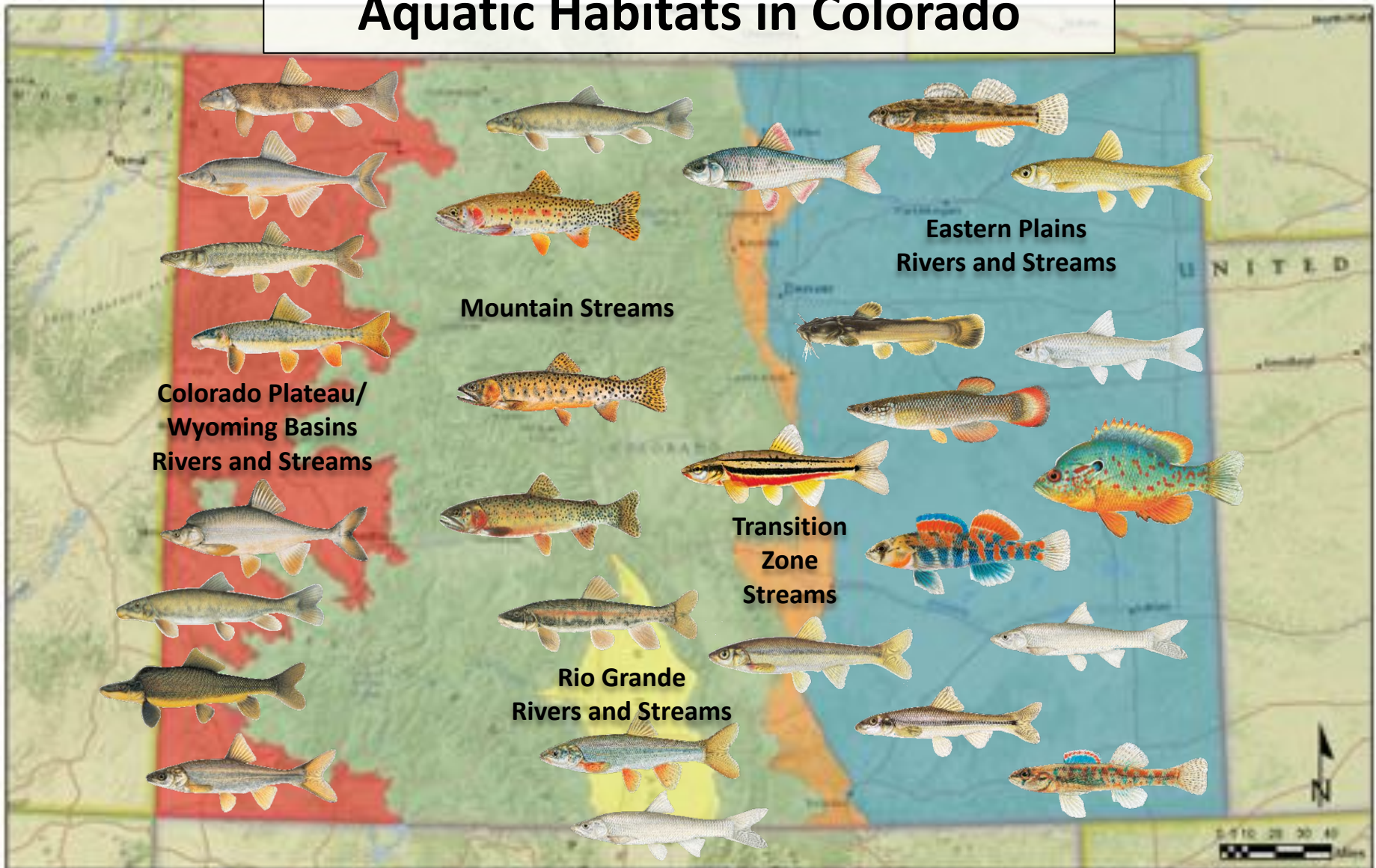


# Scale





# Aquatic Habitats in Colorado



**Colorado Plateau/  
Wyoming Basins  
Rivers and Streams**

**Mountain Streams**

**Eastern Plains  
Rivers and Streams**

**Transition  
Zone  
Streams**

**Rio Grande  
Rivers and Streams**



- Eastern Plains
- Mountain Streams
- Rio Grande
- Transition Zone
- Wyoming Basin/Colorado Plateau

**AQUATIC ZONES**

DRAWN BY/CHKD	6/15/2017
CHECKED:	
APPROVED:	

SHEET 1 OF 1

STATE OF COLORADO  
DEPARTMENT OF NATURAL RESOURCES  
COLORADO PARKS AND WILDLIFE  
FORT COLLIER, COLORADO

**COLORADO STATE WILDLIFE  
ACTION PLAN 2015-2018**



# Critical Trout Habitat Functions

7) Connectivity

- 1) Salmonid Forage Production Areas
- 2) High Flow Refugia
- 3) Low Flow & Winter Refugia
- 4) Spawning Habitat
- 5) Rearing Habitat
- 6) Adult Cover



# Natural Channel Design: Reference Reach





# Natural Channel Design: Fundamentals

Existing



# Natural Channel Design: Fundamentals

Existing



Reference



# Natural Channel Design: Fundamentals

Existing



Reference

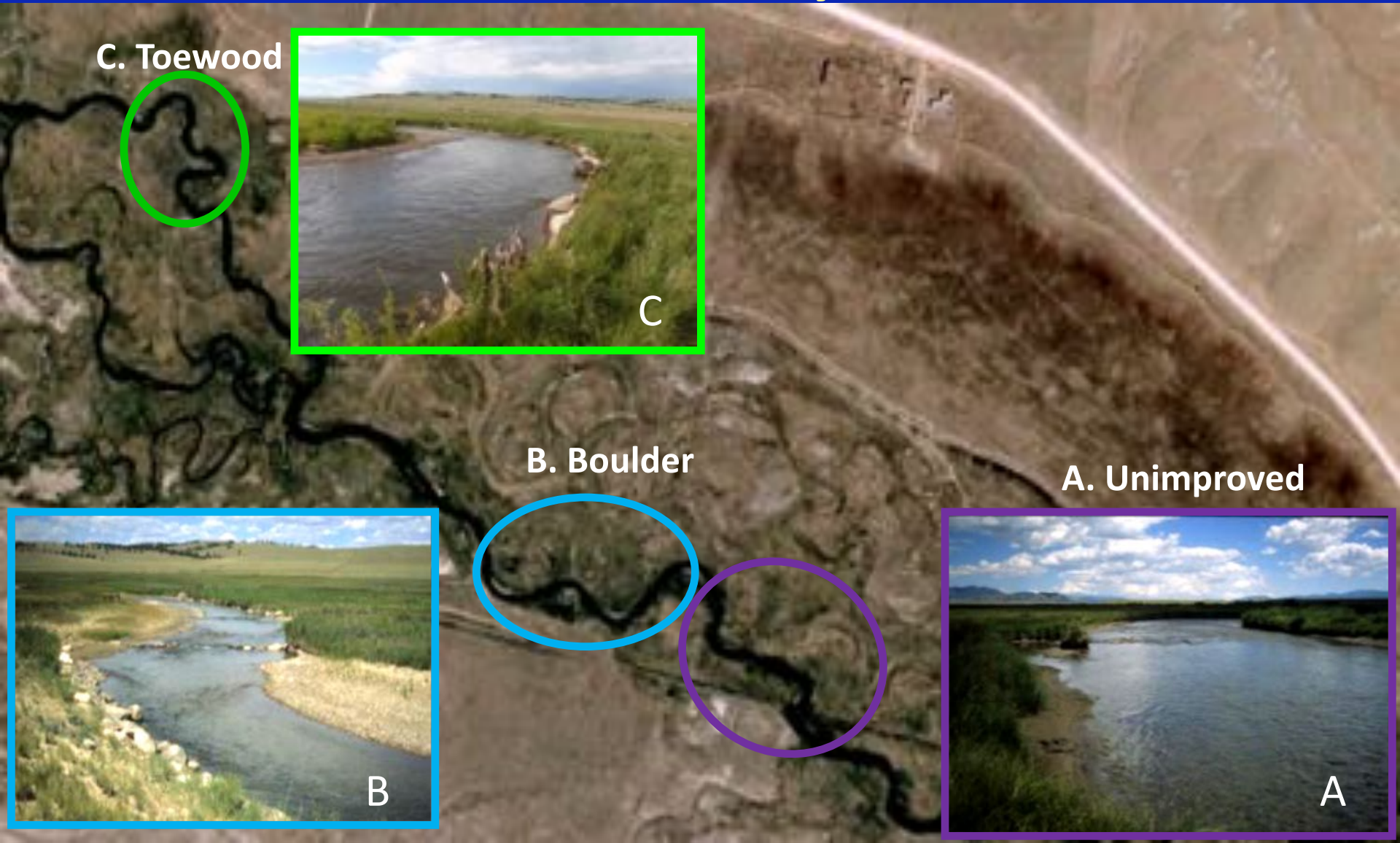


Proposed



# Monitoring Results: Buckley Ranch

## BACI study





# Control-Untreated

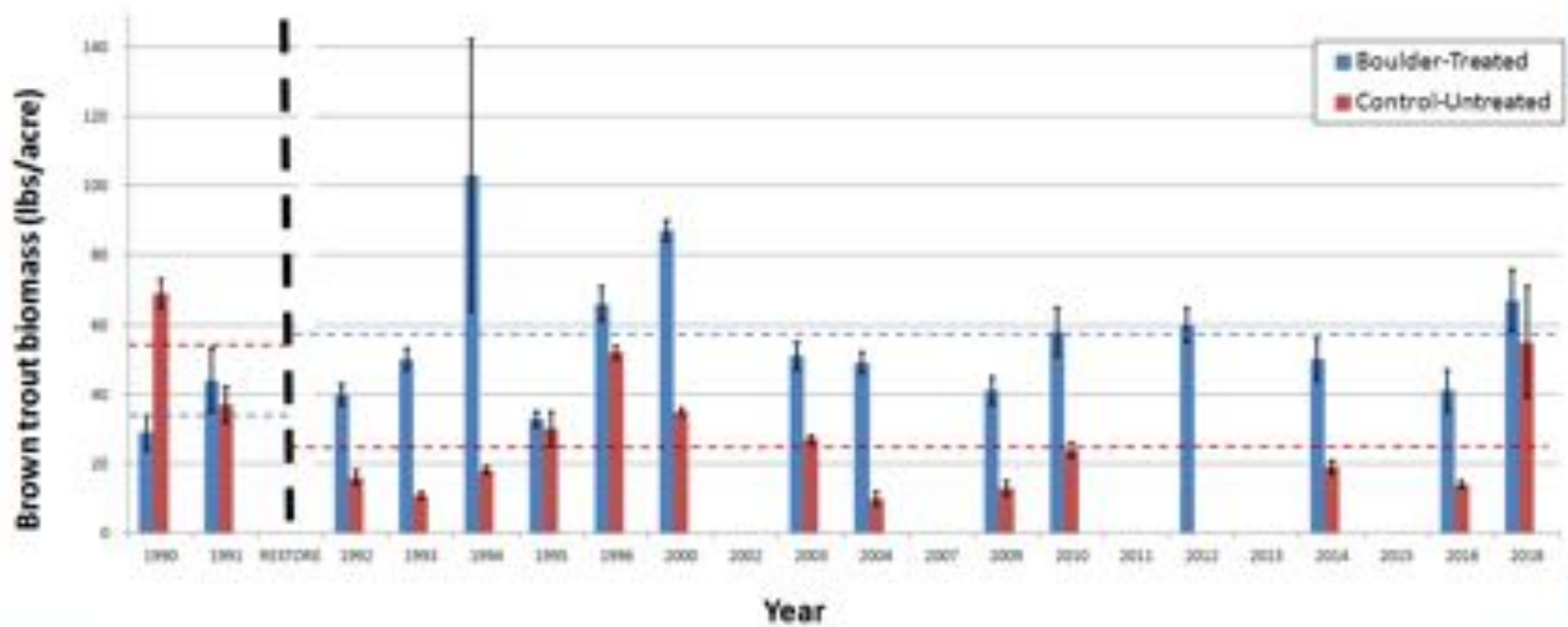


# Boulder-Treated





# Boulder-Treated Vs Control-Untreated



# Boulder-Treated Vs Control-Untreated

## Monitoring Period:

**1990-2018: 28 YEARS!**

## Pre- vs Post:

- Boulder-Treated: Brown Trout biomass increased 56% compared with pre-project baseline.
- Control-Untreated: Brown Trout Biomass declined 53% over the same time 26-year post-monitoring period.



# Boulder-Treated Vs Control-Untreated

## Monitoring Period:

**1990-2018: 28 YEARS!**

## Boulder vs Control:

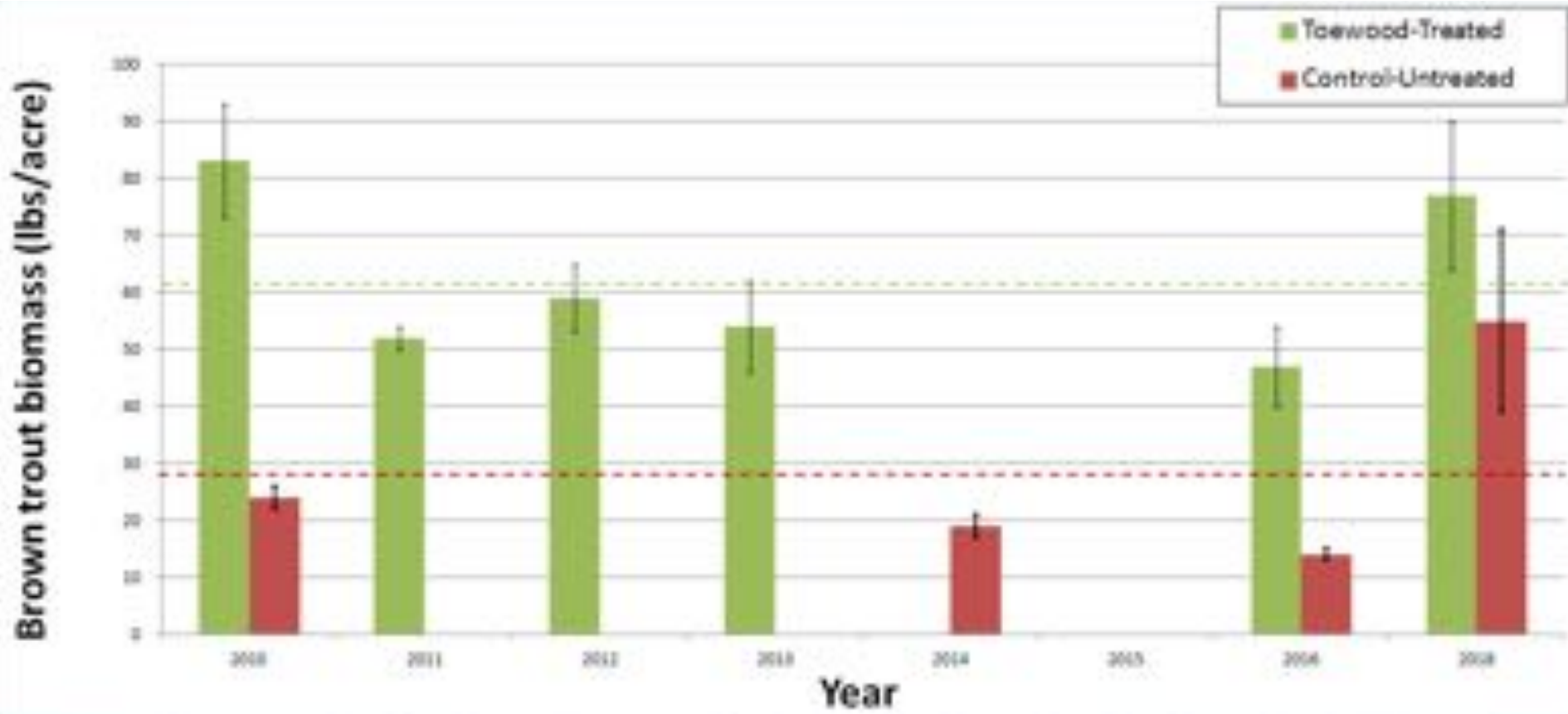
- Brown Trout biomass in the boulder -treated averaged 32% higher over the control-untreated reach for entire monitoring period
- Average difference in biomass (within year) was 183% (range 10-472 %) boulder over control



# Toewood-Treated



# Toewood-Treated Vs Control-Untreated



# Toewood-Treated Vs Control-Untreated

## Monitoring Period:

**2010-2018: 8 YEARS**

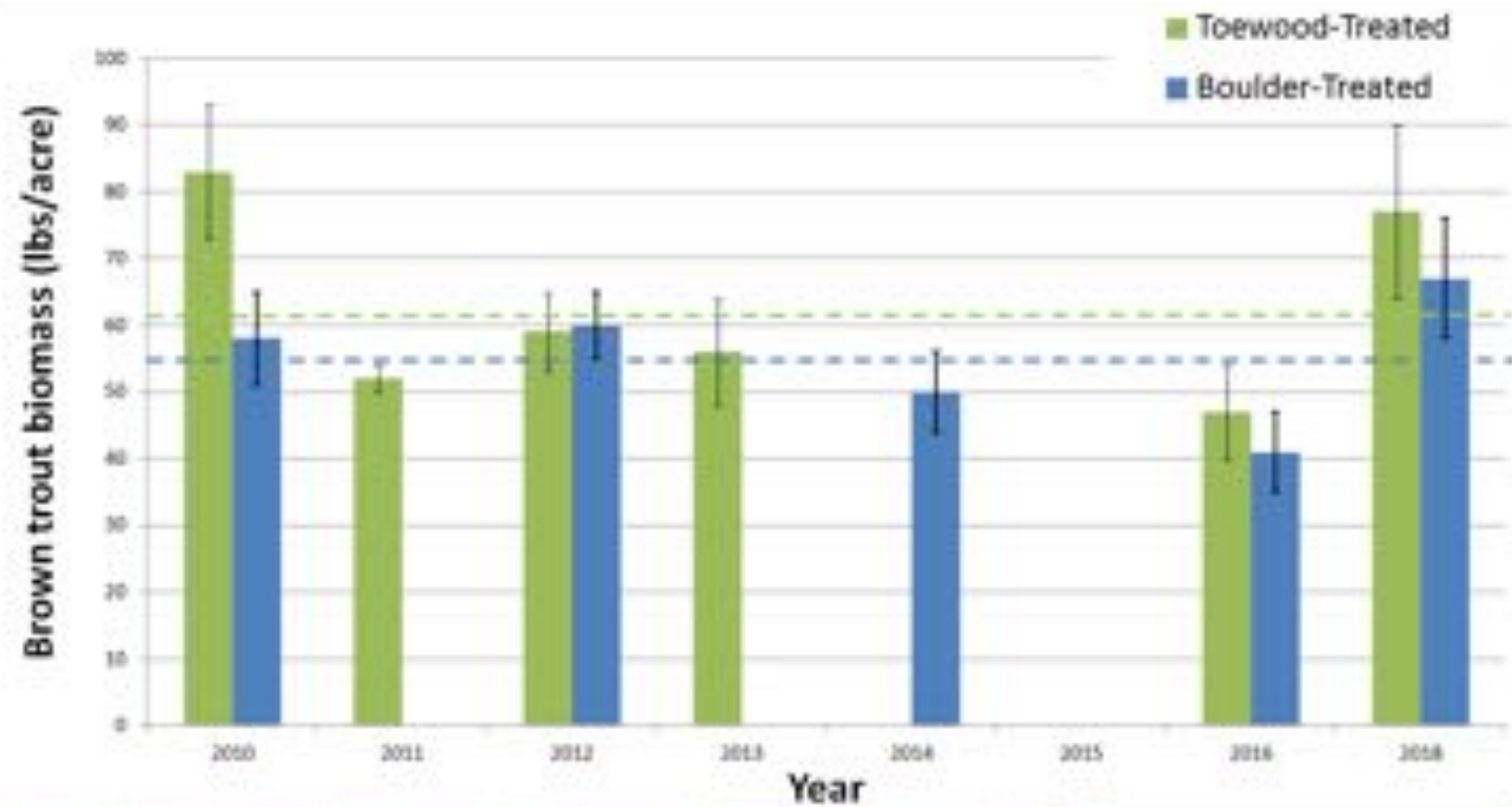
## Toewood-Treated vs Control:

- Brown Trout biomass in the toewood -treated reach averaged 34% higher over the control-untreated reach for entire monitoring period
- Average difference in biomass (within year) was 173% (range 40-245 %) toewood over control





# Toewood-Treated Vs Boulder-Treated



# Toewood-Treated Vs Boulder-Treated

## Monitoring Period:

**2010-2018: 8 YEARS**

## Toewood-Treated vs Boulder-Treated:

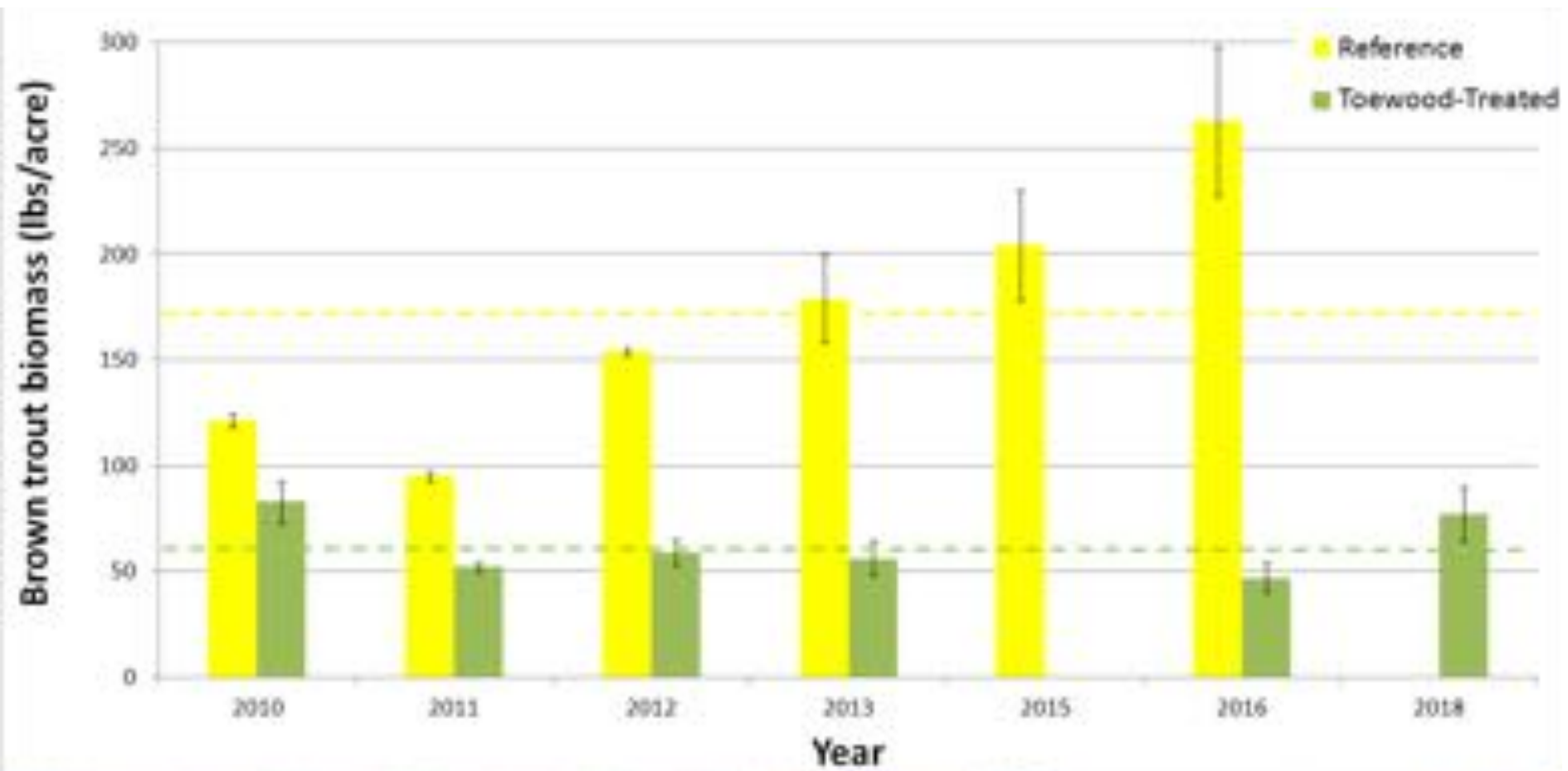
- Brown trout biomass in the toewood-treated reach averaged 7% higher over the boulder-treated for entire monitoring period
- Average difference in biomass (within year) was 18% (range -2-43 %) toewood over boulder



# Reference



# Toewood-Treated Vs Reference



# Toewood-Treated Vs Reference

## Monitoring Period:

**2010-2018: 8 YEARS**

- Brown trout biomass in the reference reach averaged 107% higher over the toewood-treated for entire monitoring period
- Average difference in biomass (within year) was 194% (range 46-460%) reference over toewood



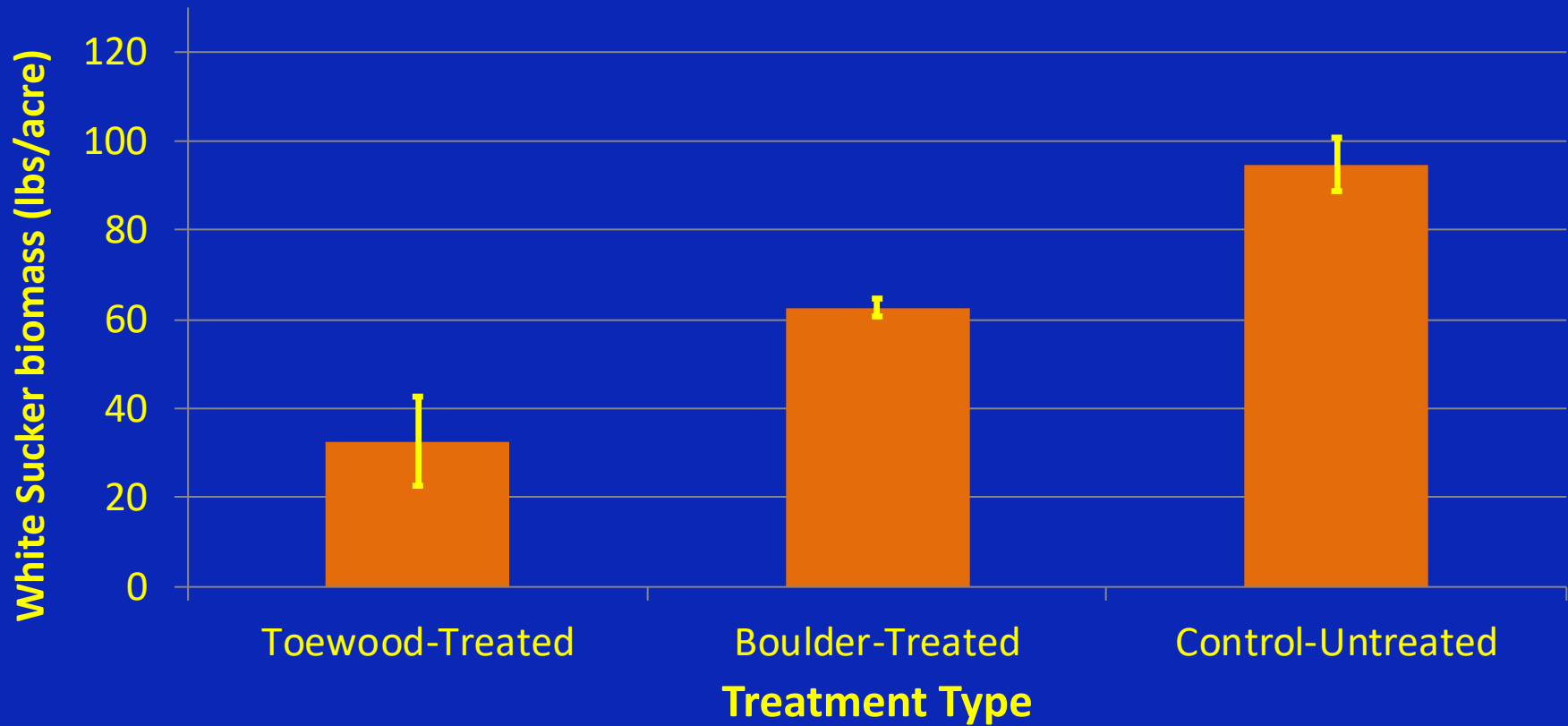


# Does Toewood Create More Sucker-Holes?





# Does Toewood Create More Sucker-Holes?



# Species Composition

## Toewood-Treated

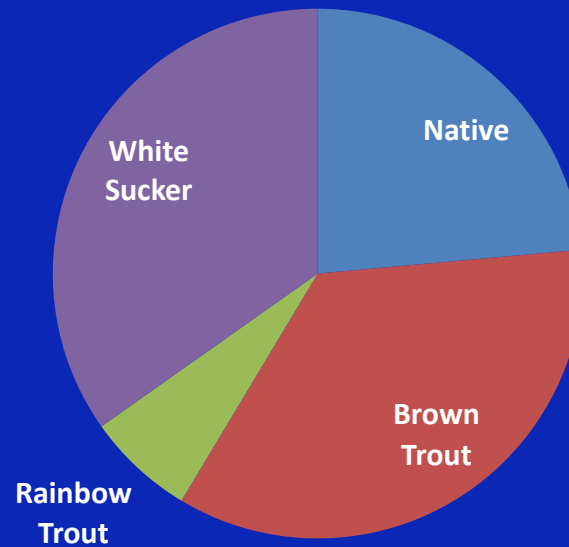


# Species Composition

## Toewood-Treated



## Boulder-Treated

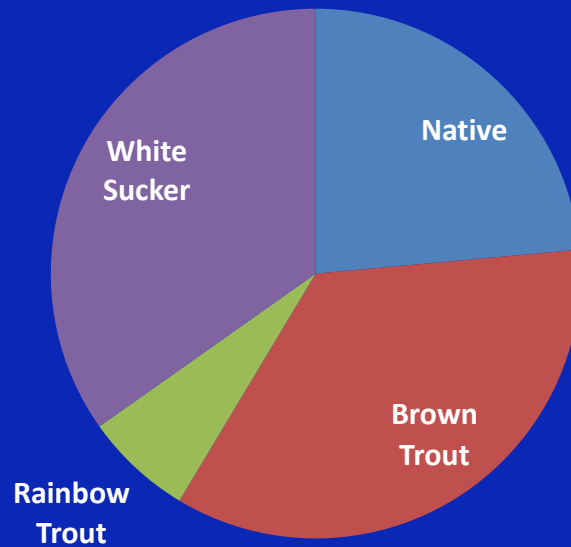


# Species Composition

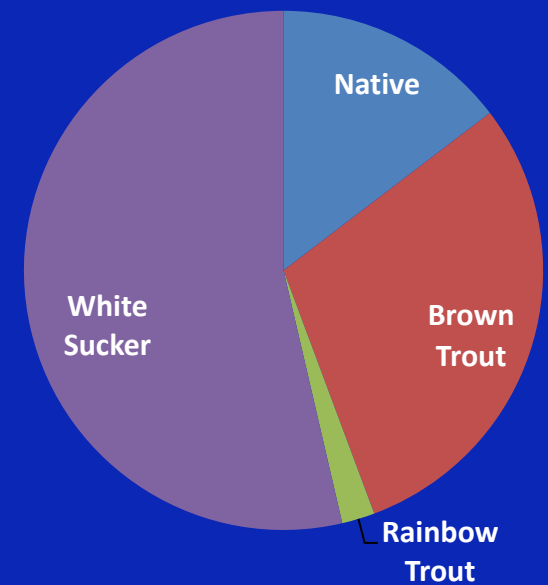
## Toewood-Treated



## Boulder-Treated



## Control-Untreated





# Clear Creek

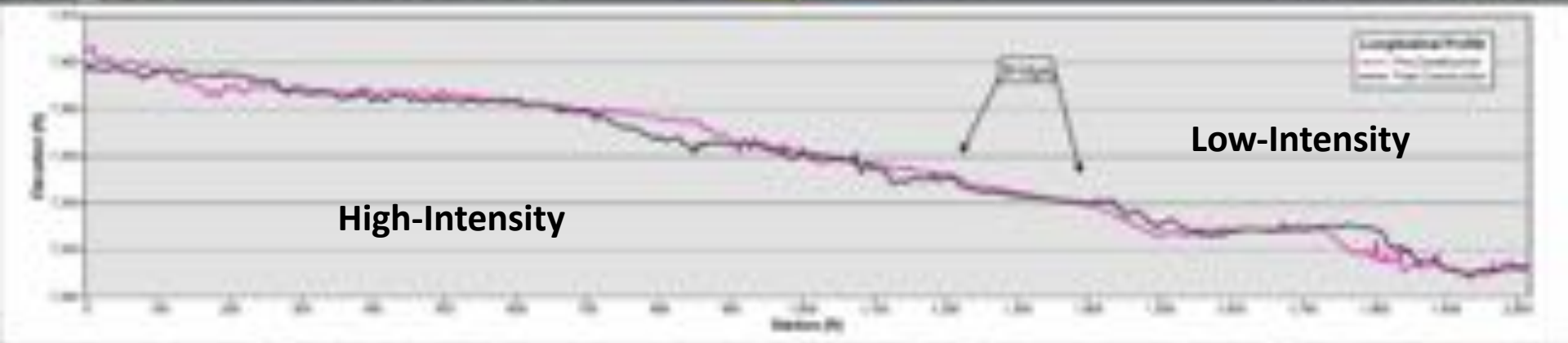
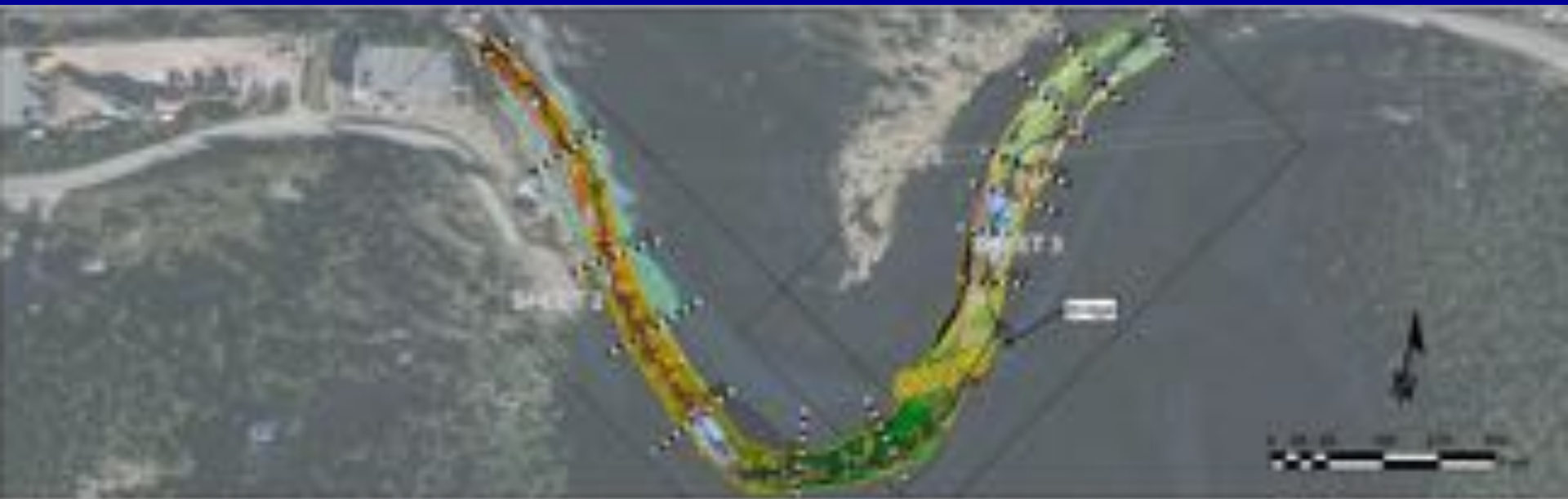


# Goals

- 1) Remove armored rip rap
- 2) Improve floodplain connectivity
- 3) Convert single stage to three-stage
- 4) Establish riparian vegetation
- 5) Enhance in-channel bedform features (i.e. spawning area development and depth cover)



# Overview



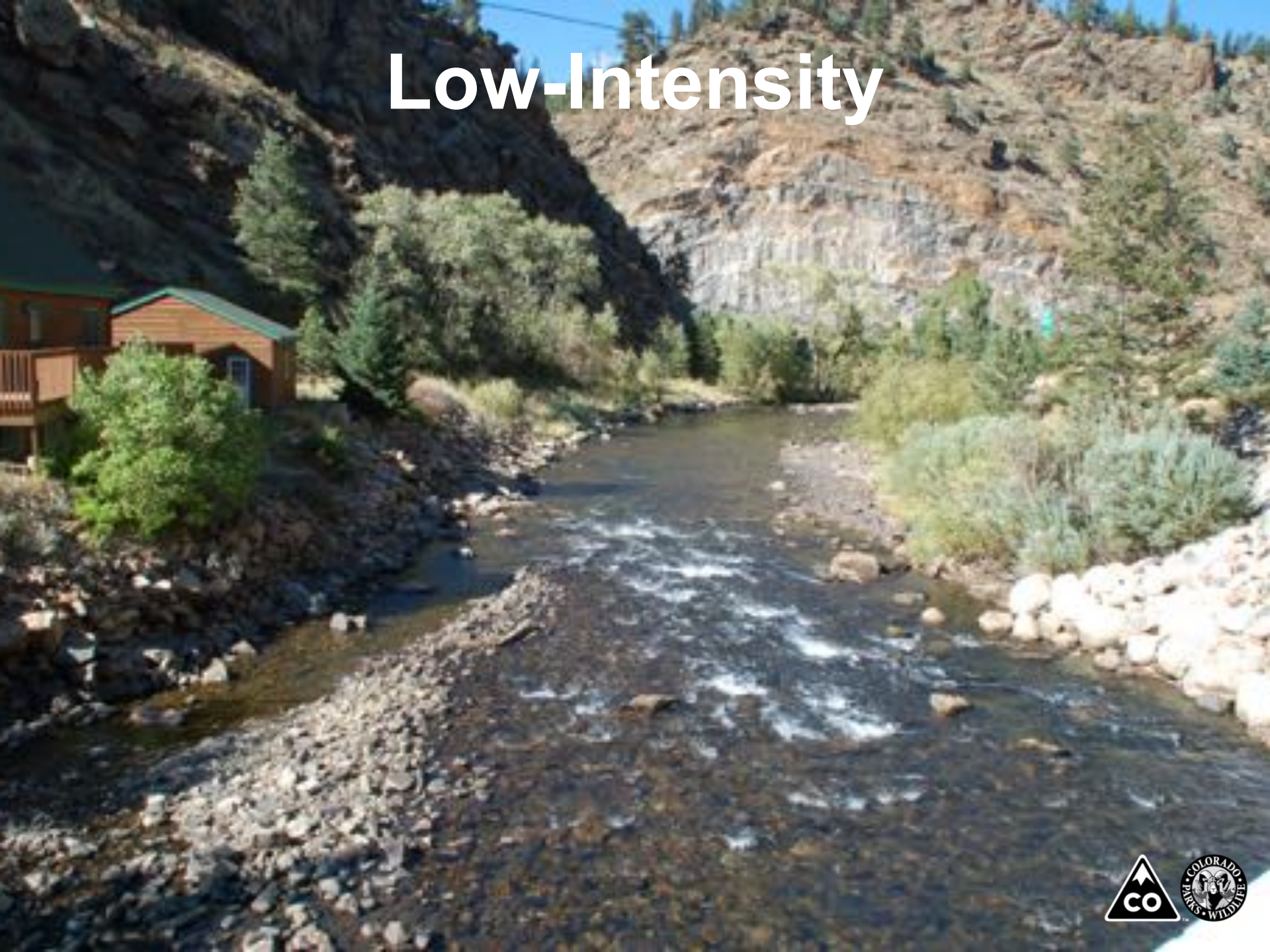
 	1. Headbox Drain (Yellow) 2. Floor Drain (Orange) 3. Manhole (Grey)	4. Headbox Drain (Yellow) 5. Floor Drain (Orange) 6. Manhole (Grey)	7. Manhole (Blue) 8. Manhole (Green) 9. Manhole (Grey)	10. Manhole (Yellow)
	11. Existing Profile (Dashed Pink) 12. Proposed Profile (Solid Pink)	13. Clear Creek (Black)	14. Headbox Drain (Blue) 15. Manhole (Green) 16. Manhole (Grey)	17. Manhole (Yellow)

TUNNELS	
DRINKING WATER	\$1,000,000
SEWERAGE	\$1,000,000
TOTAL	\$2,000,000

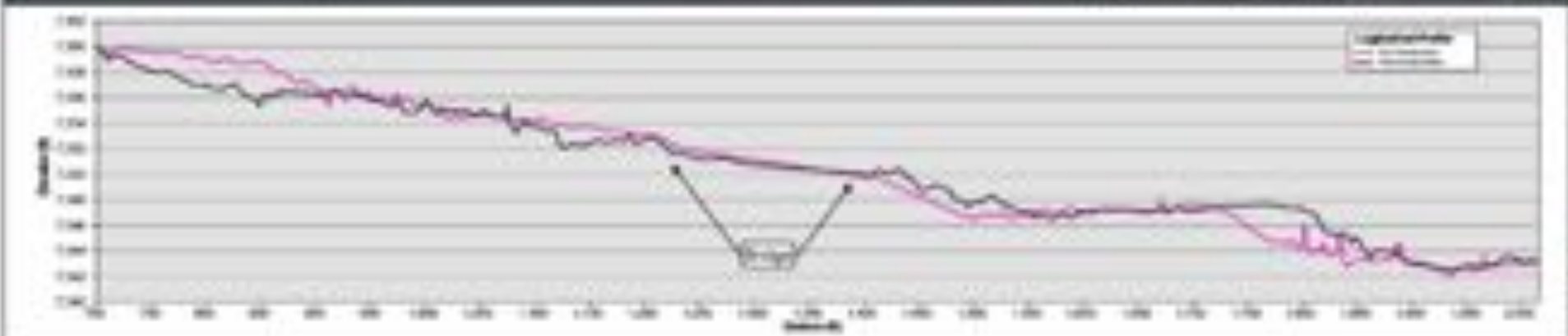
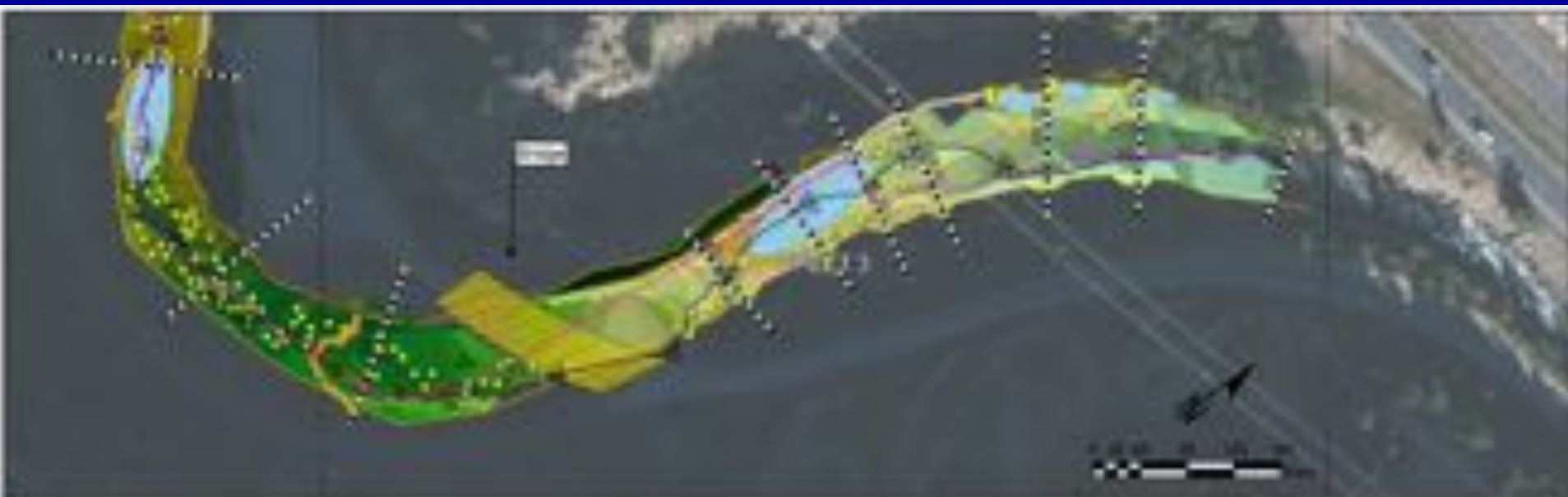
DATE: 12/15/2010  
 PROJECT: CLEAR CREEK TWIN TUNNELS  
 AS-BUILT DRAWINGS



# Low-Intensity







 	<p>--- Existing Top Contour --- Existing Top Contour --- Existing Elevation --- Tunnel Center</p>	<p>Yellow: Middle Section Orange: Middle Section Grey: Middle Section</p>	<p>Blue: Road Development Green: Right-of-Way Grey: Existing Development Yellow: Bridge</p>	<p><b>LONGITUDINAL PROFILE</b></p> <p>DATE: 10/15/11 PROJECT: CLEAR CREEK SHEET: 1 OF 1</p>	<p>STATE OF COLORADO DEPARTMENT OF TRANSPORTATION CLEAR CREEK TWIN TUNNELS AS-BUILT DRAWINGS</p>
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# Low-Intensity

Before  
Single-stage  
Confinement=1.2  
F-stream type

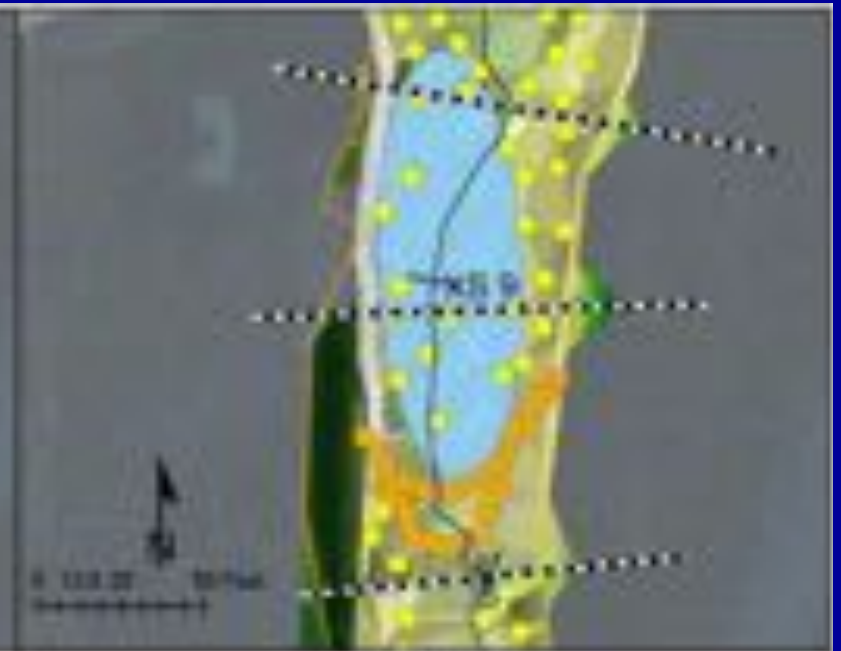
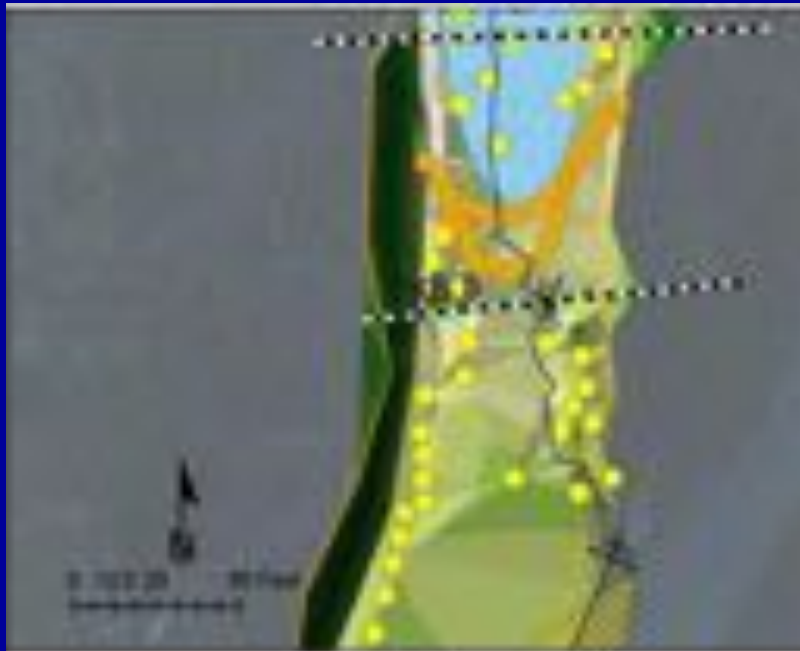




# Low-Intensity

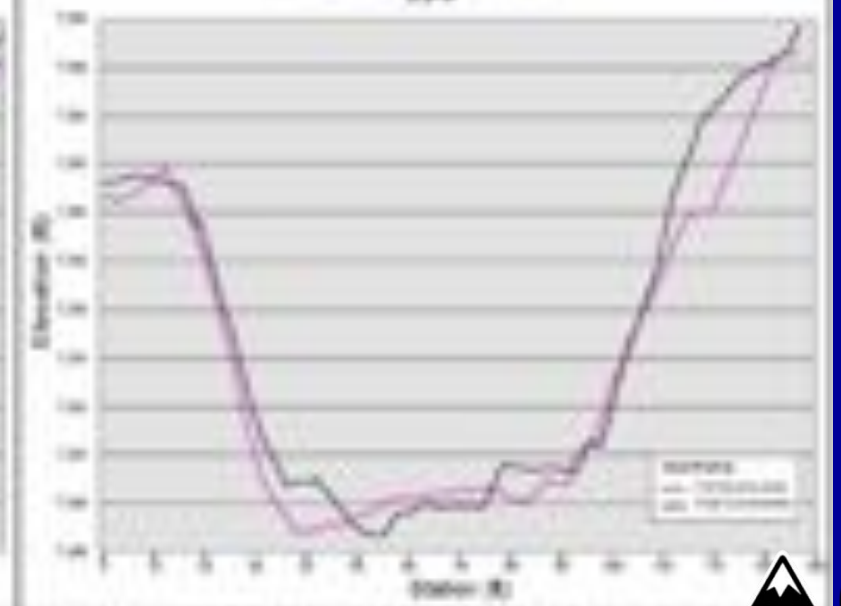
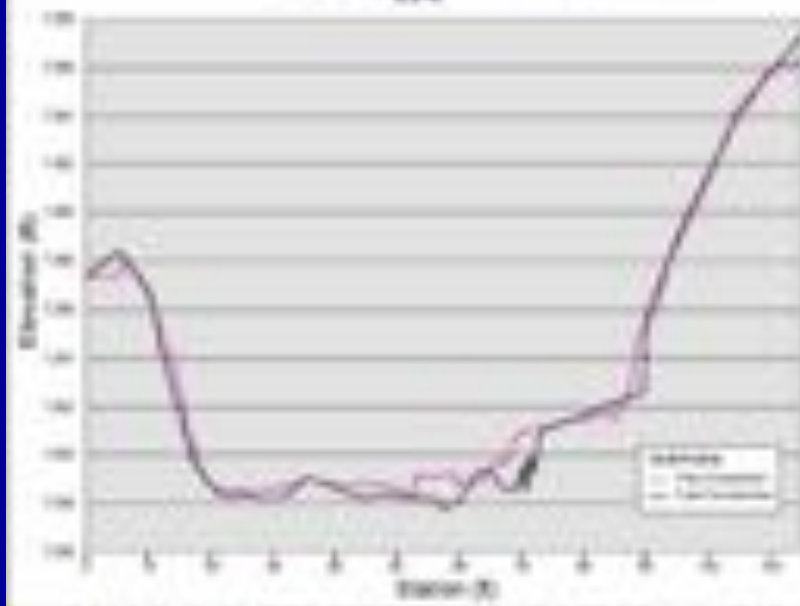
After  
Single-stage  
Confinement=1.2  
F-stream type





05-0

05-0





# Low-Intensity

Treatment	Quantity	Units	Total	% of Total Project
Habitat Boulder	81	Each	234	35%
Boulder Structure	1	Each	9	11%
Boulder Toe	250	LF	2,708	9%
Pool Development	4	Each	14	29%
Point-Bar Development	0	SF	5,420	0%
Floodplain Development	0	SF	18,775	0%

# Low-Intensity Treatment: Trout Density (#/mile)

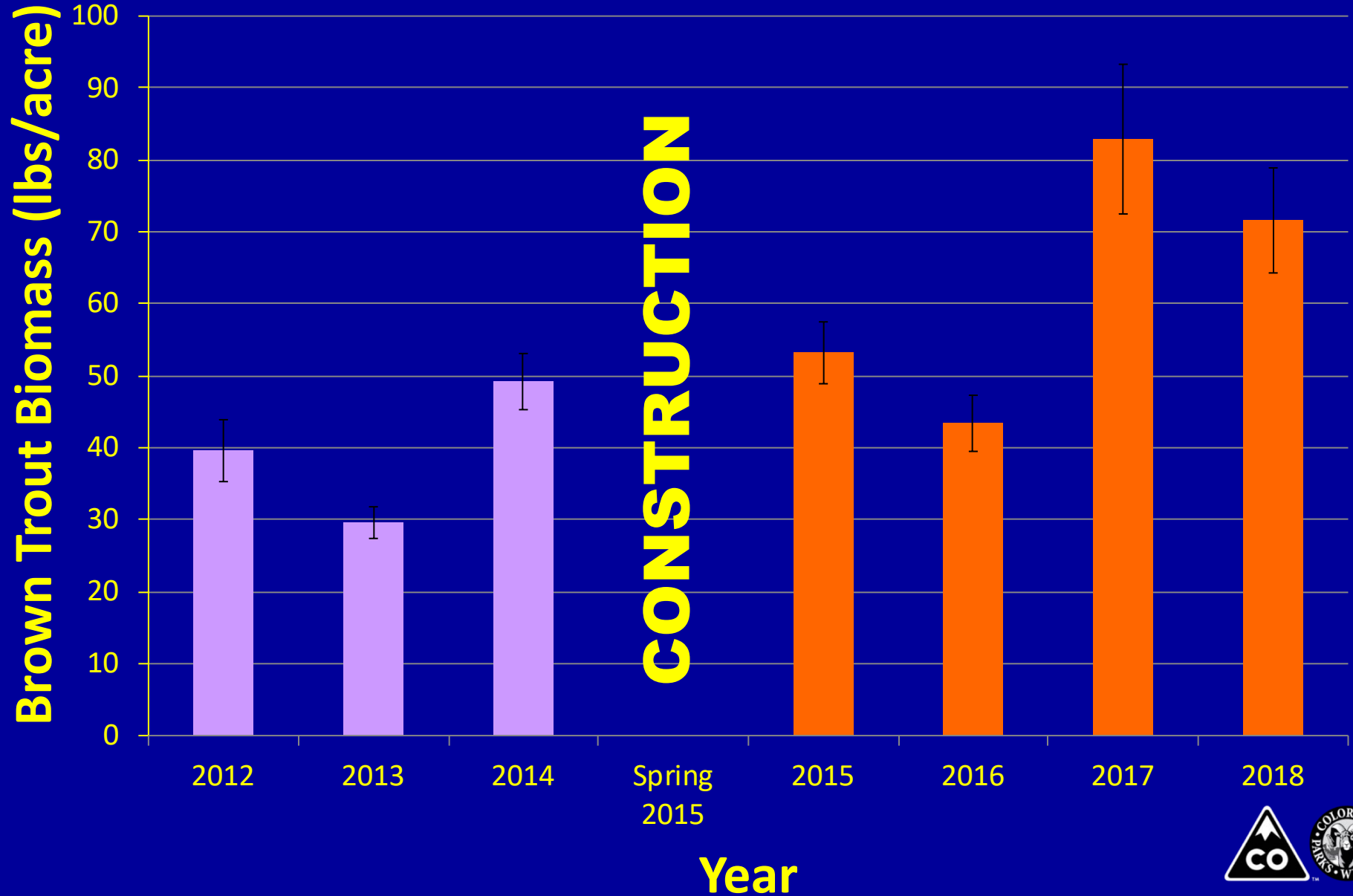


# Low-Intensity Treatment: Trout Density (#/mile)

**77% increase**



# Low-Intensity Treatment: Trout Biomass (lbs/acres)





**Low-Intensity Treatment: Trout Density (#/mile)**

**77% increase**

**Low-Intensity Treatment: Trout Biomass (lbs/acres)**

**59% increase**



# High-Intensity

Before  
Single-stage  
Confinement=1.2  
F3/2-stream type

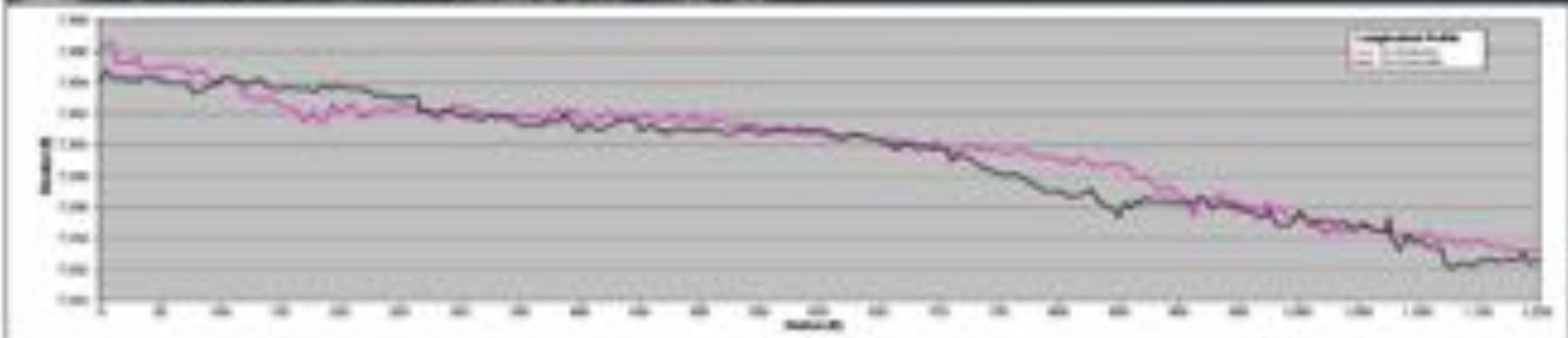




# High-Intensity

After  
Three-stage  
Confinement=2.0  
Bc3/2 -Stream Type








----- Existing Ground Surface

----- Existing Pipe Construction

----- Tunnel Alignment

◆◆◆ Construction

Yellow Swallow

Light Green

Orange Swallow

White Top

Blue Swallow

Green Swallow

Grey Swallow

White

CONSTRUCTION WORK	
CONSTRUCTION	2024
CONSTRUCTION	2024
CONSTRUCTION	2024
PAGE 2 OF 4	

STATE OF COLORADO  
DEPARTMENT OF NATURAL RESOURCES  
CITY OF PUEBLO  
PUEBLO, COLORADO

**CLEAR CREEK  
TWIN TUNNELS  
AS-BUILT DRAINAGE**



# High-Intensity

Before





# High-Intensity

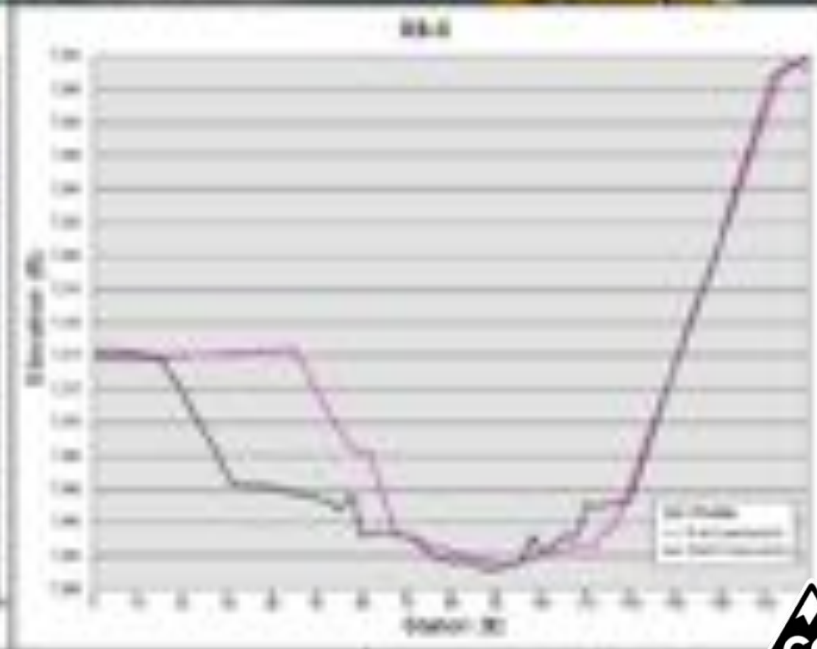
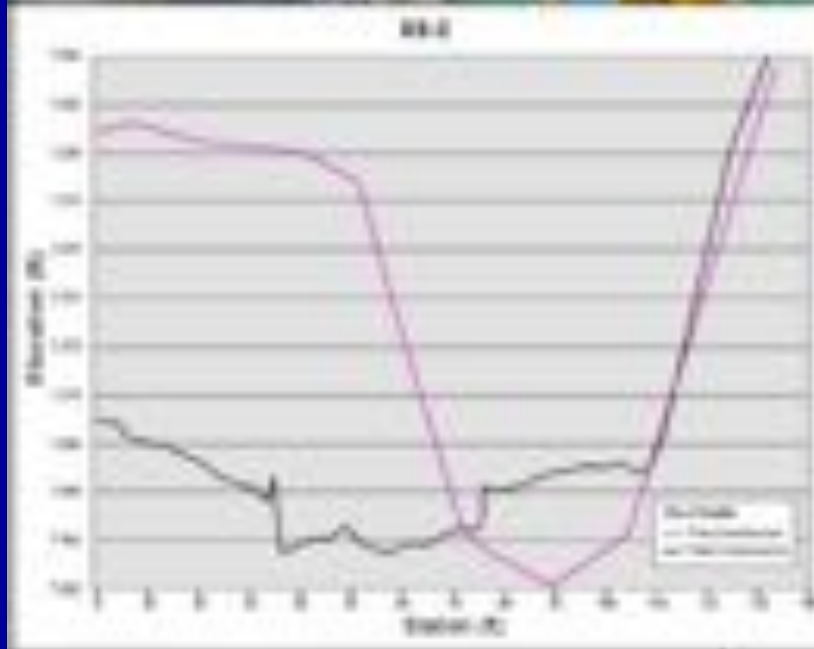
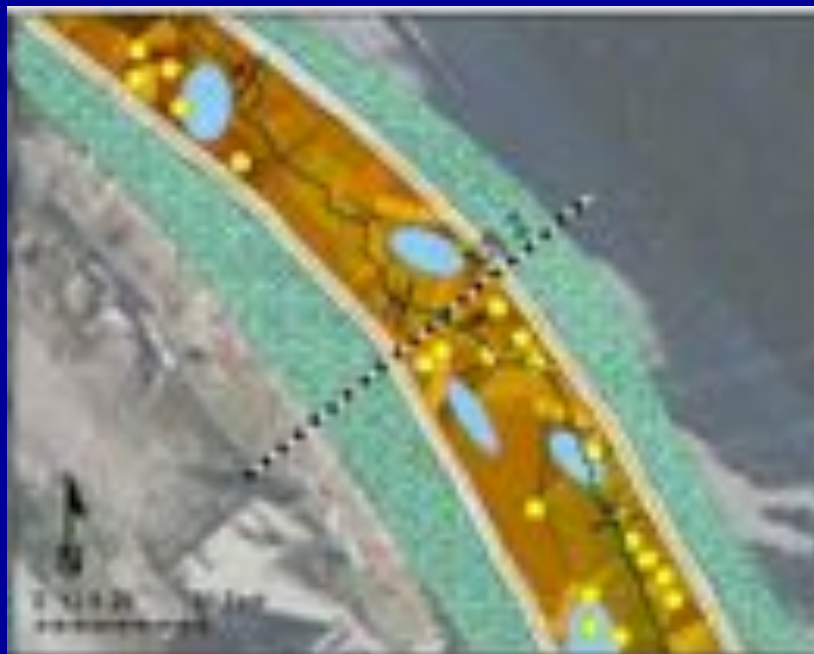
After





After



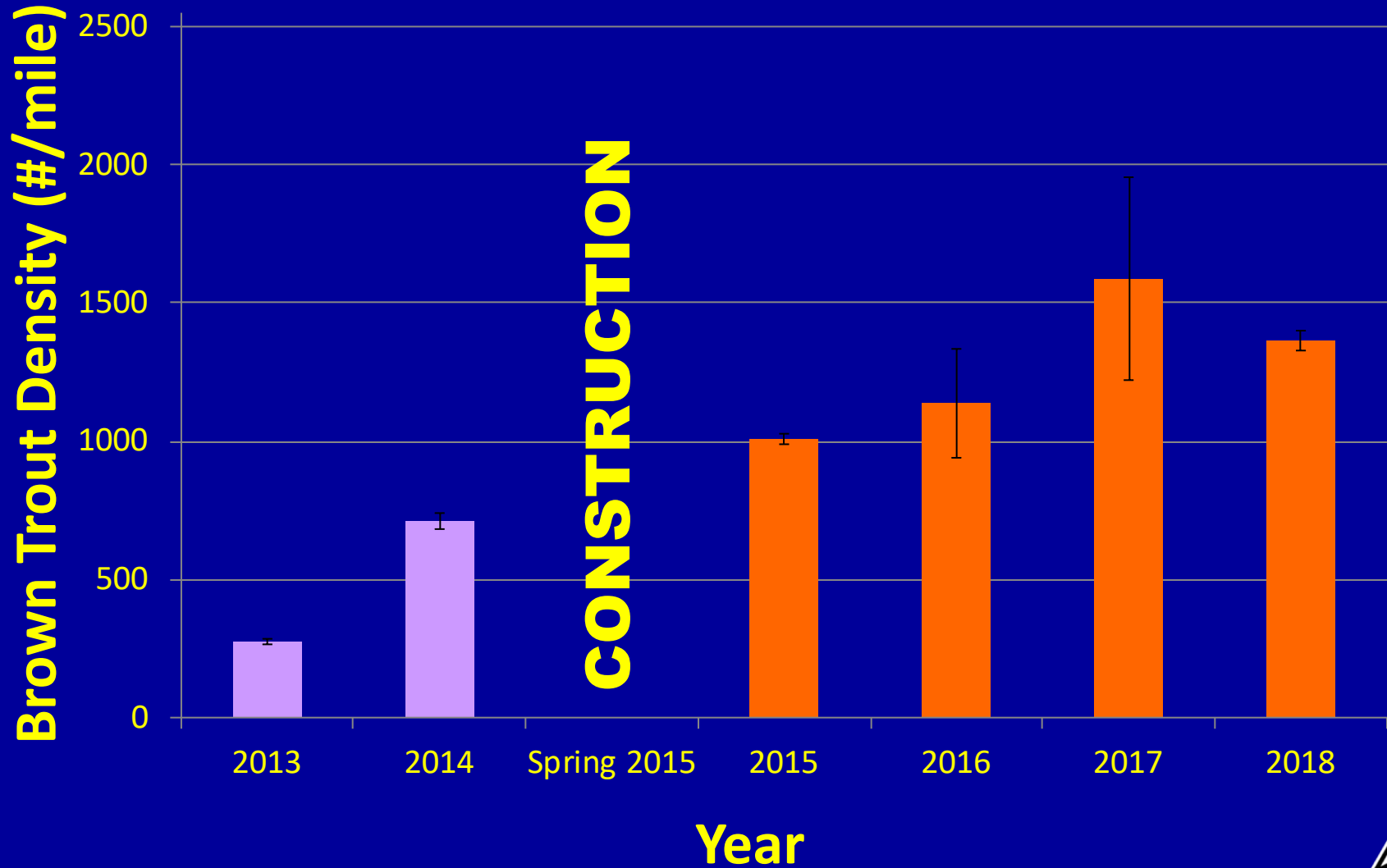




# High-Intensity

Treatment	Quantity	Units	Total	% of Total Project
Habitat Boulder	153	Each	234	65%
Boulder Structure	8	Each	9	89%
Boulder Toe	2,458	LF	2,708	91%
Pool Development	10	SF	14	71%
Point-Bar Development	5,420	SF	5,420	100%
Floodplain Development	18,775	SF	18,775	100%

# High-Intensity Treatment: Trout Density (#/mile)

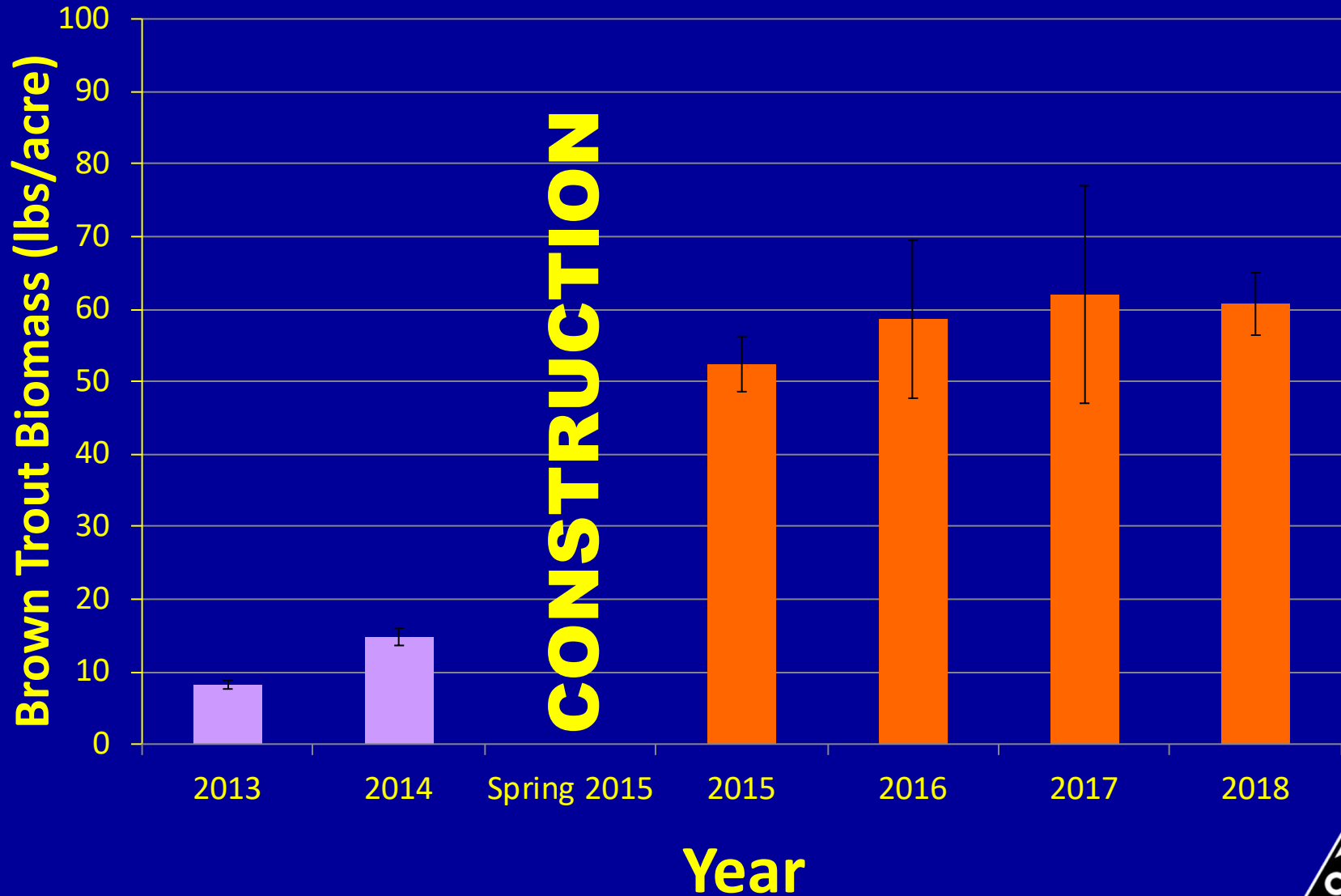


# High-Intensity Treatment: Trout Density (#/mile)

**160% increase**



# High-Intensity Treatment: Trout Biomass (lbs/acres)





**High-Intensity Treatment: Trout Density (#/mile)**

**160% increase**

**High-Intensity Treatment: Trout Biomass (lbs/acres)**

**408% increase**





# Summary






Restoration of natural stream forms (NCD) may restore natural habitats that provide the functions necessary for improving fish populations over time

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-  Departure from reference conditions may have negative consequences to fish populations that may not recover without physical intervention



# Summary



-  Restoration of natural stream forms (NCD) may restore natural habitats that provide the functions necessary for improving fish populations over time
-  Departure from natural conditions may have negative consequences to fish populations that may not recover without physical intervention
-  Assess limiting factors that may occur outside of geomorphology (channel forms) including departures from natural hydrologic regimes, hydraulics, physicochemical properties, and barriers

# Summary



Not all treatment alternatives are equal. Some treatments will accomplish a “bigger bang for the buck”

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-  Not all treatment alternatives are equal. Some treatments will accomplish a “bigger bang for the buck”
-  Carefully consider selection of reference reaches for biological monitoring. Use an average of multiple reference sites if possible

