Enlargement and Instability of Stream Channels in Austin, Texas: When to Restore?

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STABILIZATION AND RESTORATION

What type of restoration is most appropriate?

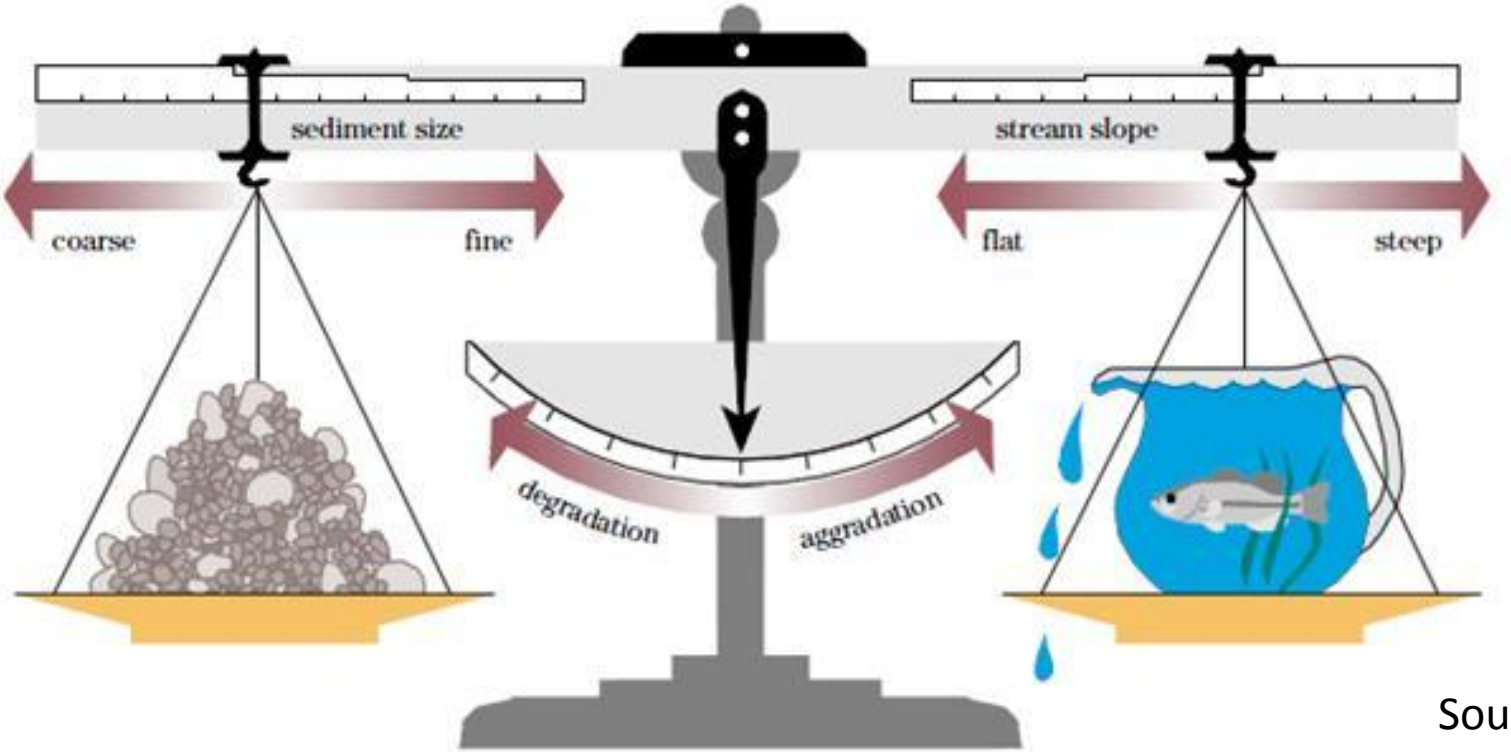
A STREAM IN EQUILIBRIUM

Lane's Balance:

$$Q_s \times D_{50} \propto Q_w \times S$$

Q_s	D_{50}	Q_w	S
Sediment Discharge	Particle Size	Flow Discharge	Stream Slope

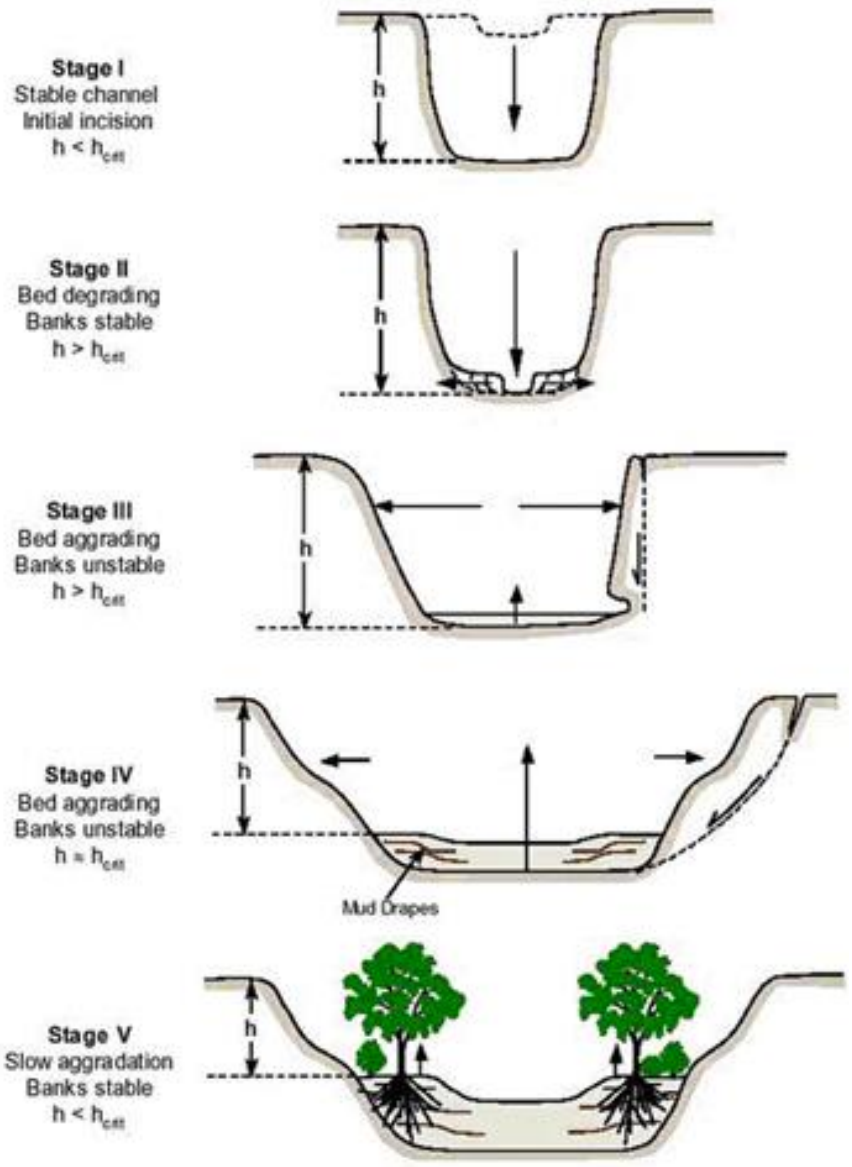
Sediment Load **Stream Power**



Source: ASCE

CHANNEL EVOLUTION MODEL (CEM)

- Understanding a stream's stage in channel evolution helps select appropriate restoration techniques
- Passive vs. active restoration
- "Watershed restoration" another approach



INITIAL STABLE CHANNEL

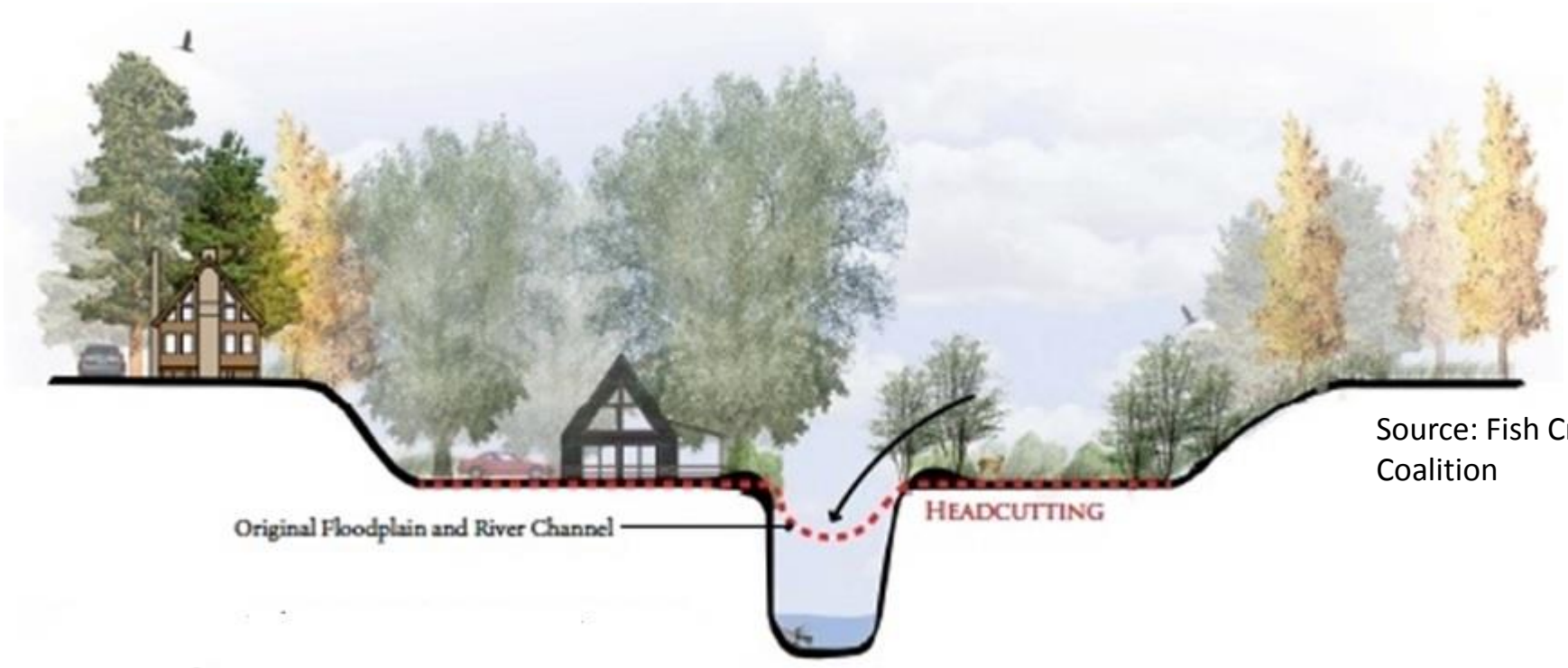
Source: Fish Creek Coalition

- Original stable channel: sediment load and stream power are in equilibrium
- Typically channel is vegetated and well-connected to floodplain

Restoration Method:

- Passive
- Active

STAGES I AND II: DISTURBANCE AND INCISION



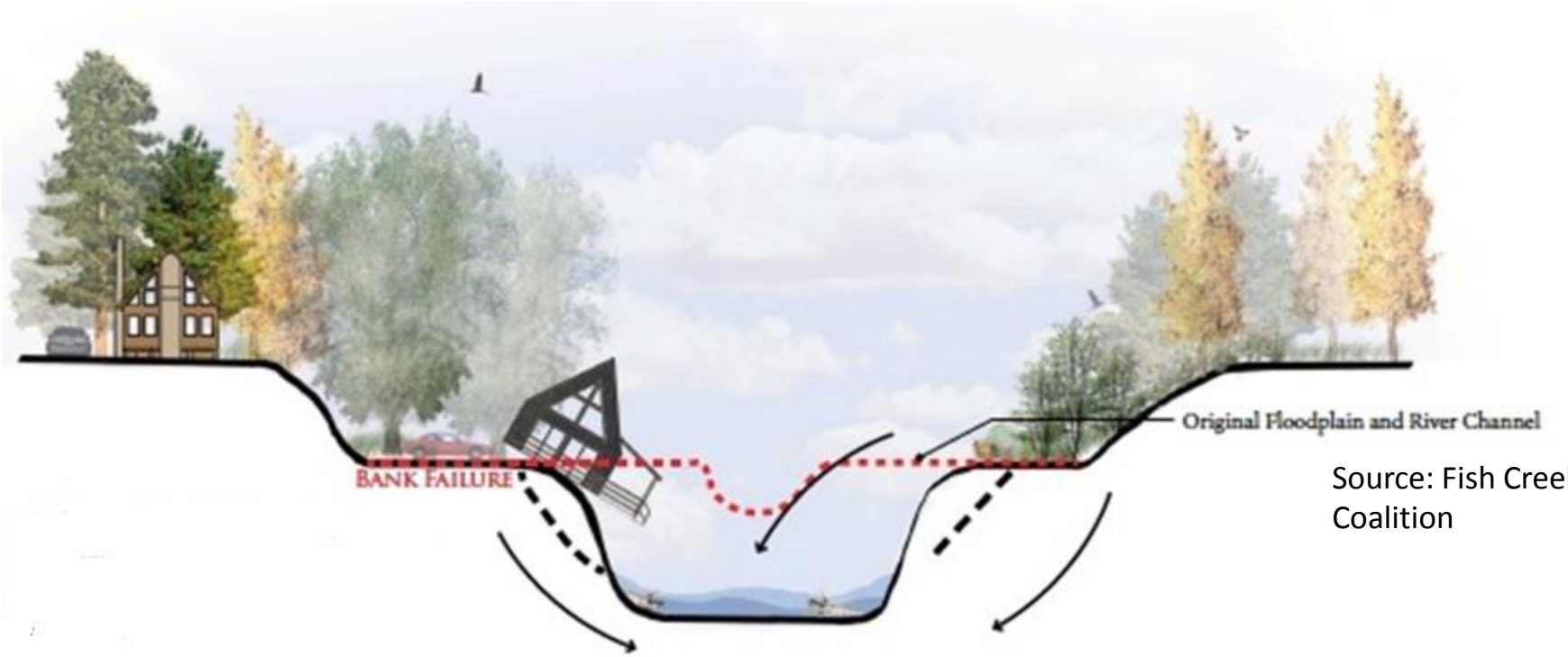
Source: Fish Creek Coalition

- Watershed development (ΔQ_w) or channelization (ΔS) typically increases stream power, interrupts equilibrium
- Response: Incision and headcutting

Restoration Method:

- Passive
- Active

CEM STAGE III: WIDENING



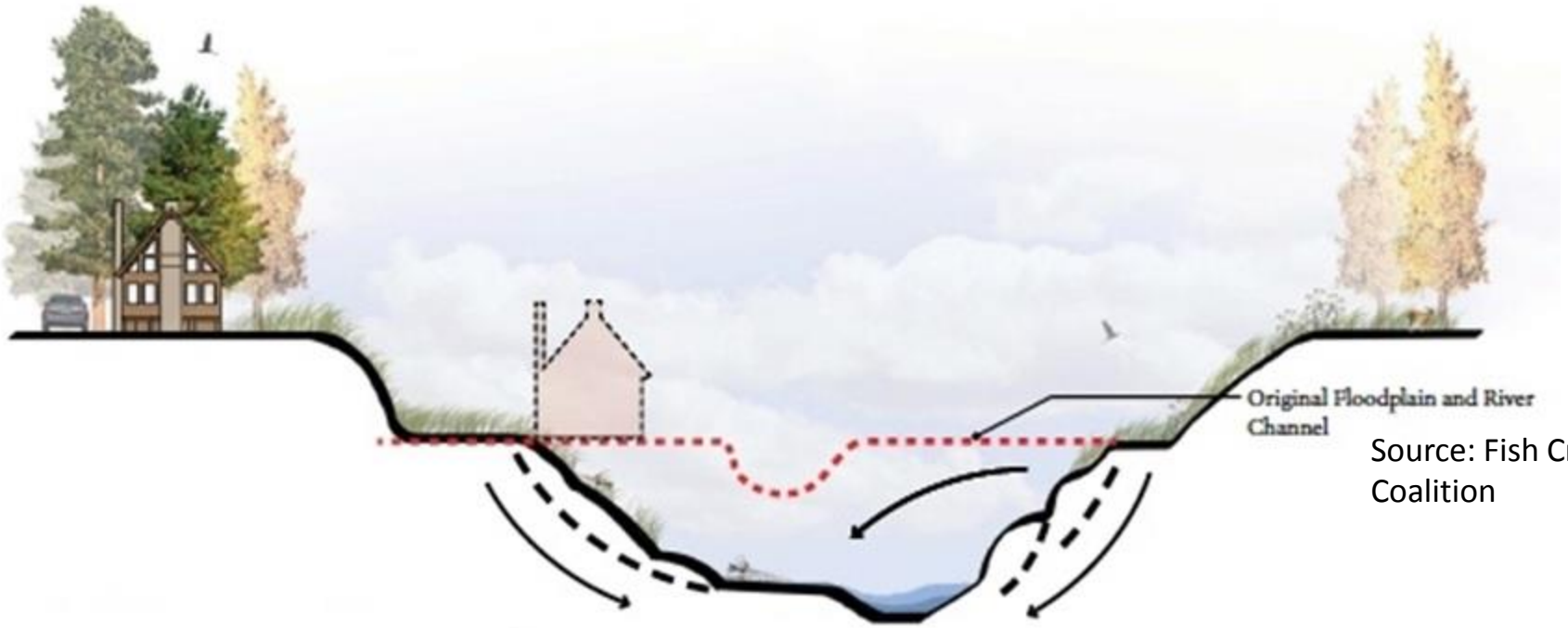
Source: Fish Creek Coalition

- Incision leads to steep, overly high banks
- Altered hydrology increases shear forces on banks
- Result: Bank failures, erosion, widening

Restoration Method:

- Passive
- Active

CEM STAGE IV: AGGRADATION AND PLANFORM ADJUSTMENT



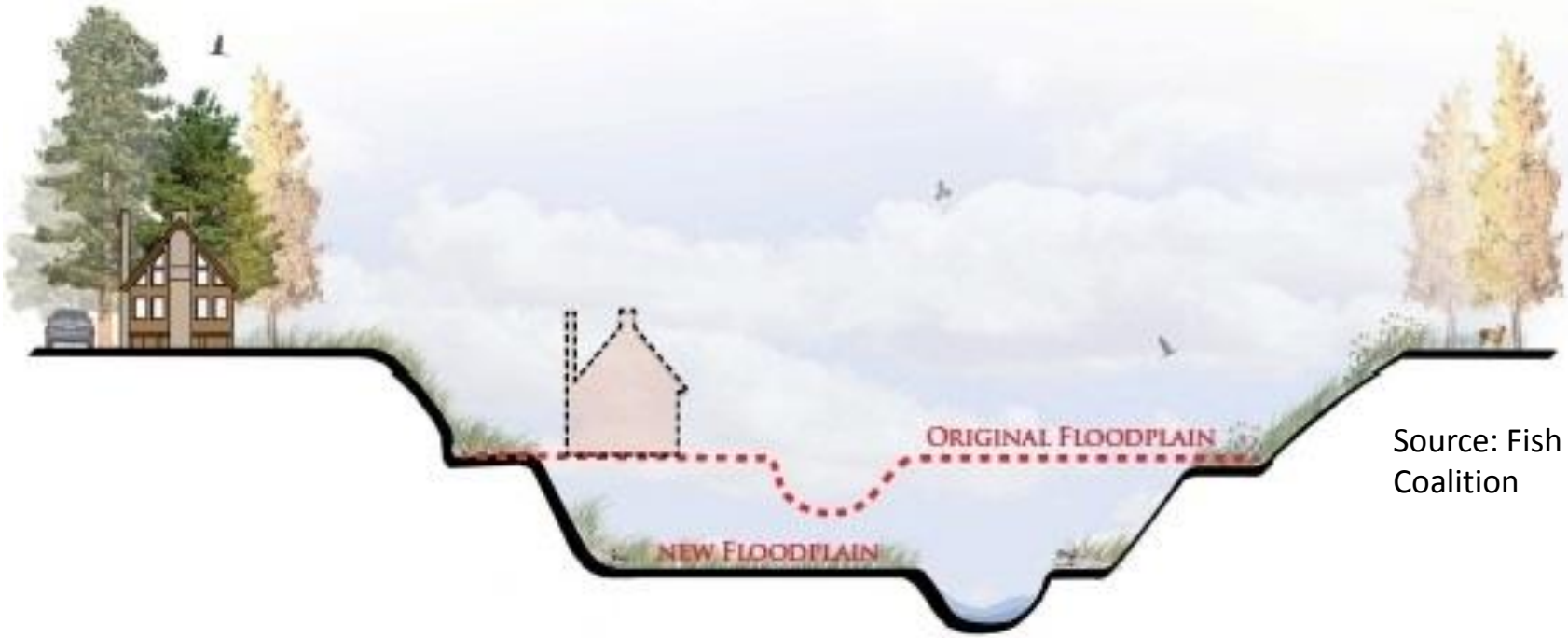
Source: Fish Creek Coalition

- Decrease in stream power due to widening
- Deposition of sediment carried from upstream degrading reaches causes aggradation, formation of bars

Restoration Method:

- Passive
- Active

CEM STAGE V: QUASI-EQUILIBRIUM



Source: Fish Creek Coalition

- A new inset floodplain and bankfull channel forms in the aggraded channel
- Evolution process takes many years, even after disturbance in the watershed has stabilized
- Stable does not imply static flowpath

Restoration Method:

- Passive
- Active

HOW HAVE AUSTIN'S CREEKS EVOLVED?

Tannehill Creek at Givens Park in 2015

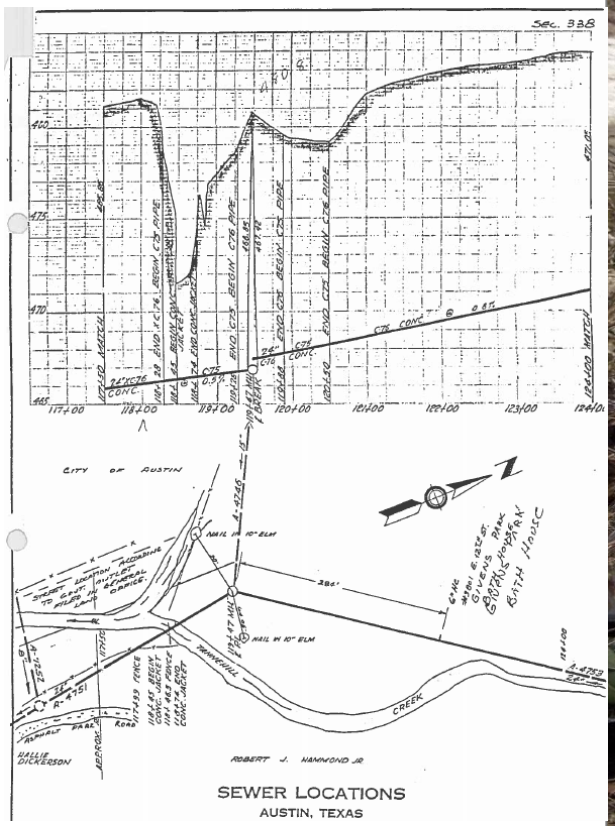
Channel Enlargement Study

- 1 to 3 cross sections at 45 sites in Austin watersheds
- Sites were re-surveyed in 2015 (in progress)

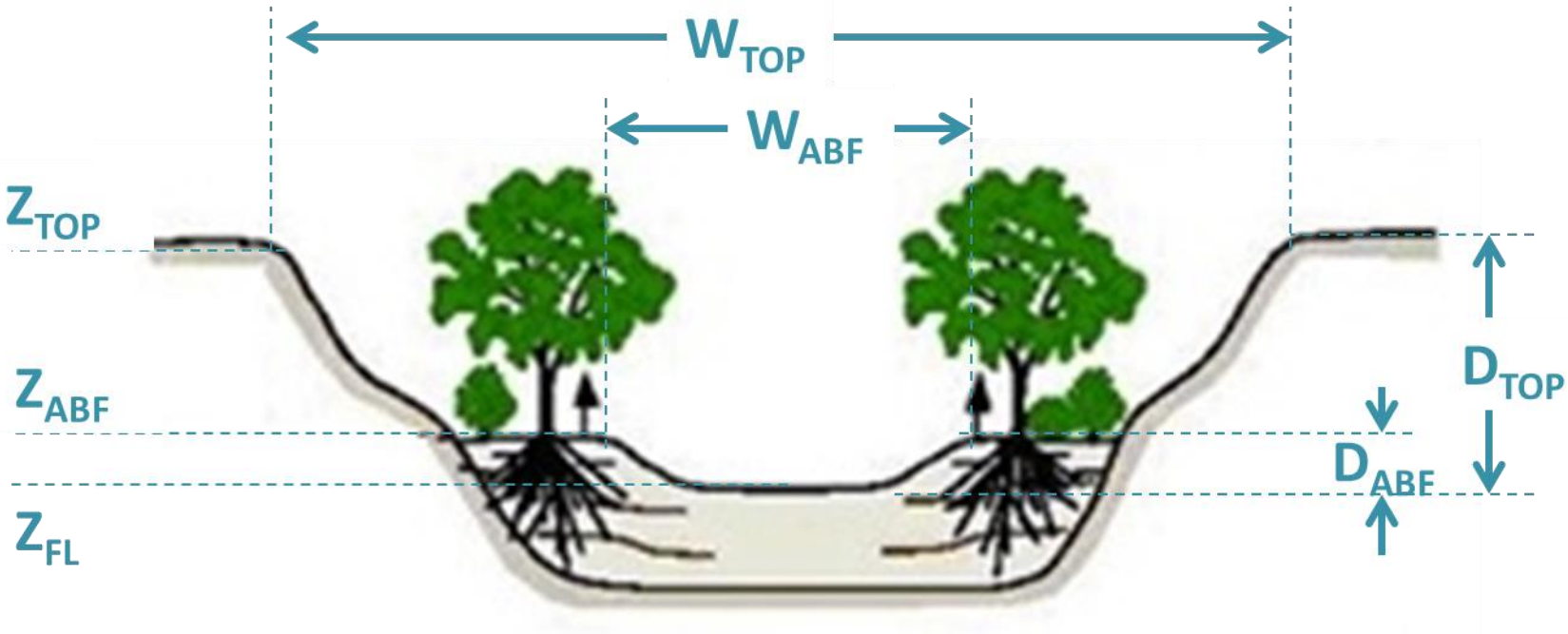
WATERSHED EROSION ASSESSMENT GEOMORPHIC SURVEYS

Survey Procedure

- Select cross section location at wastewater lines
- Survey cross sections in 1997 and 2015
    1. Wastewater line alignment
    2. Perpendicular & downstream of wastewater line
- Note locations of flowline, active bankfull channel, top of banks
- Observe channel type, channel features



DEFINING CHANNEL GEOMETRY



WATERSHED EROSION ASSESSMENT GEOMORPHIC SURVEYS

Calculations

Channel Geometry

- Active Bankfull Elevation, z_{abf}
- Top of Bank Elevation, z_{top}
- Cross Sectional Area, A
- Top Width, W
- Flow Depth, D
- Hydraulic Depth, D_{Hyd}
- Width : Depth Ratio, W/D_{Hyd}

Change over Time

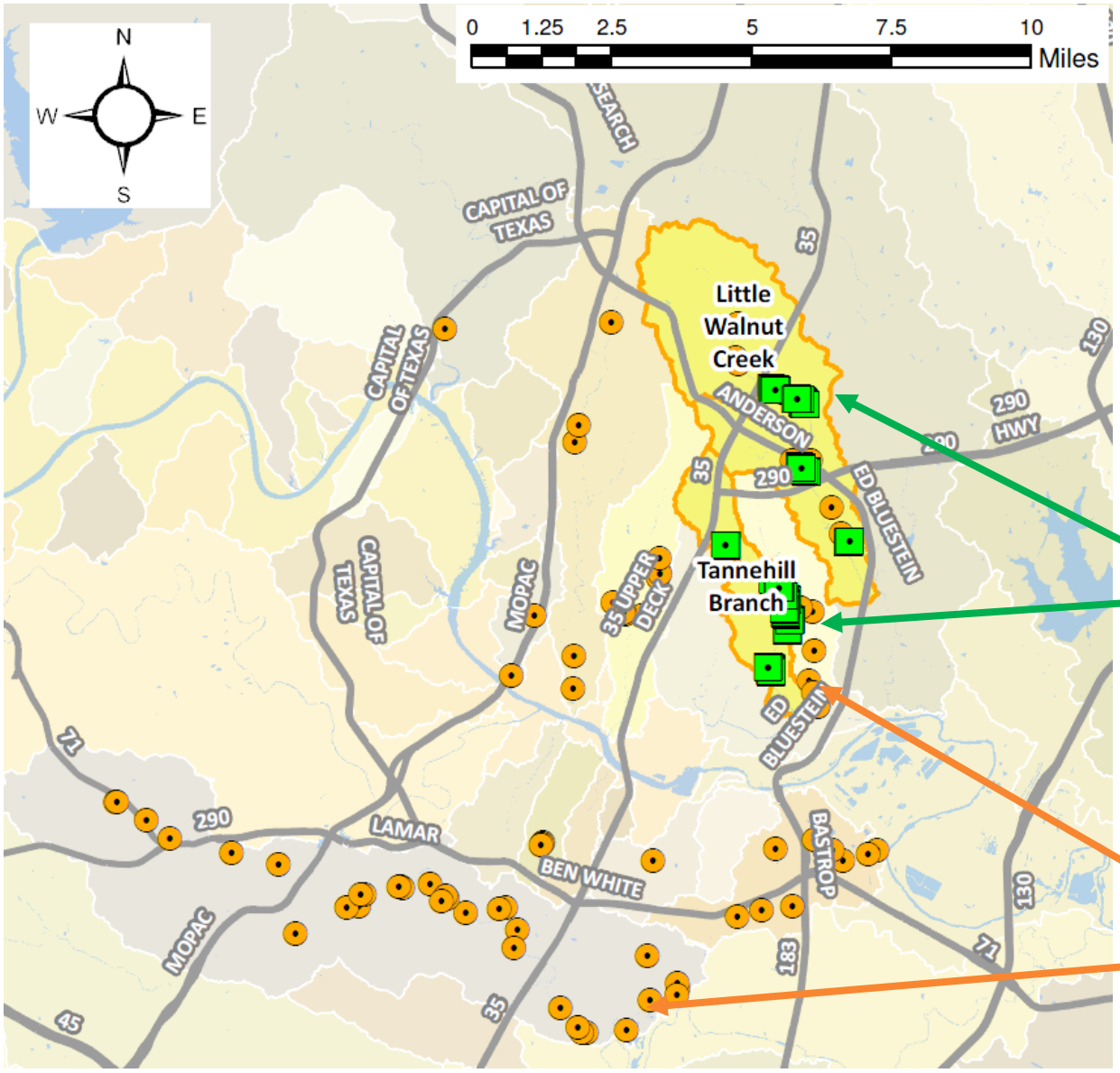
- Enlargement Ratio, Re
- Normalized Enlargement Rate, $\dot{Re}$
- Incision Factor, IF

$$Re = \frac{A_t}{A_{t_0}}$$

$$\dot{Re} = \frac{Re_t - Re_{t_0}}{t - t_0}$$

$$IF = \frac{D_t}{D_{t_0}} \qquad IF_{Hyd} = \frac{D_{Hyd,t}}{D_{Hyd,t_0}}$$

2015 SURVEYS



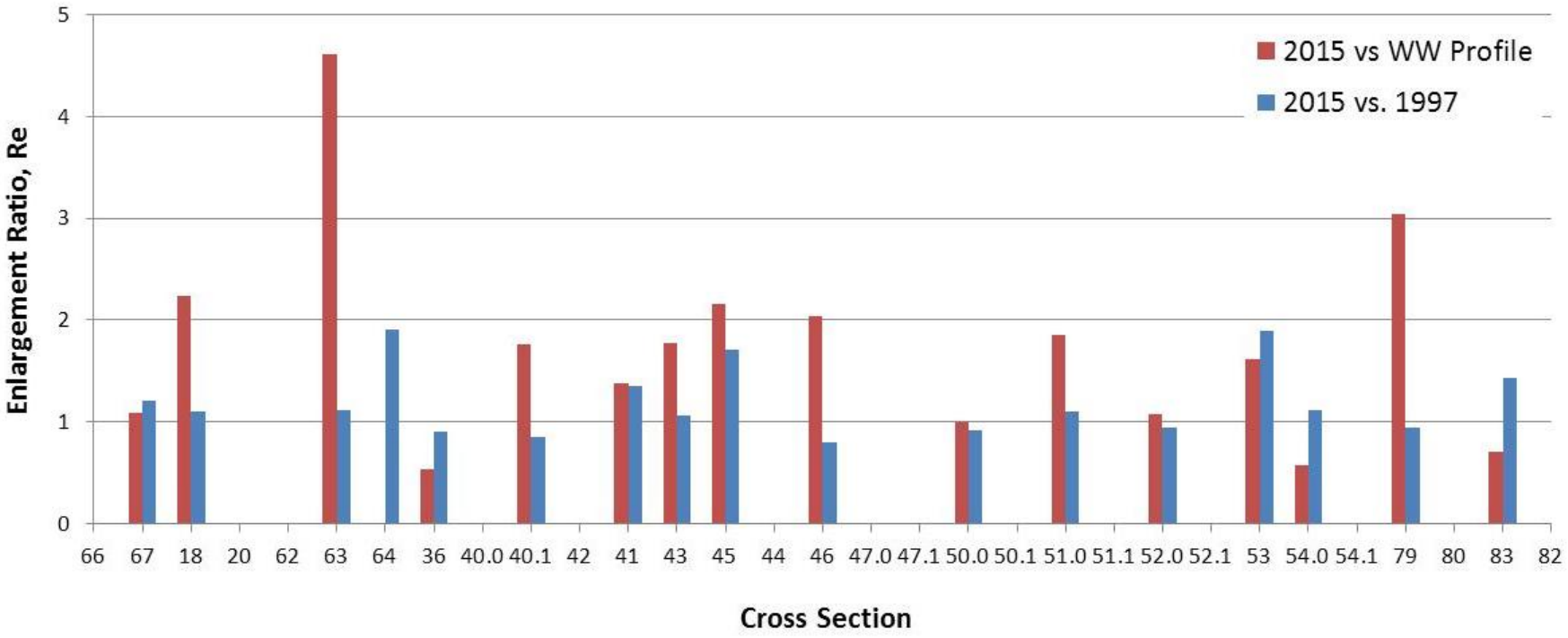
2015 Survey Locations (So Far)

1997 Survey Locations

PRELIMINARY RESULTS

Enlargement Ratio over Time

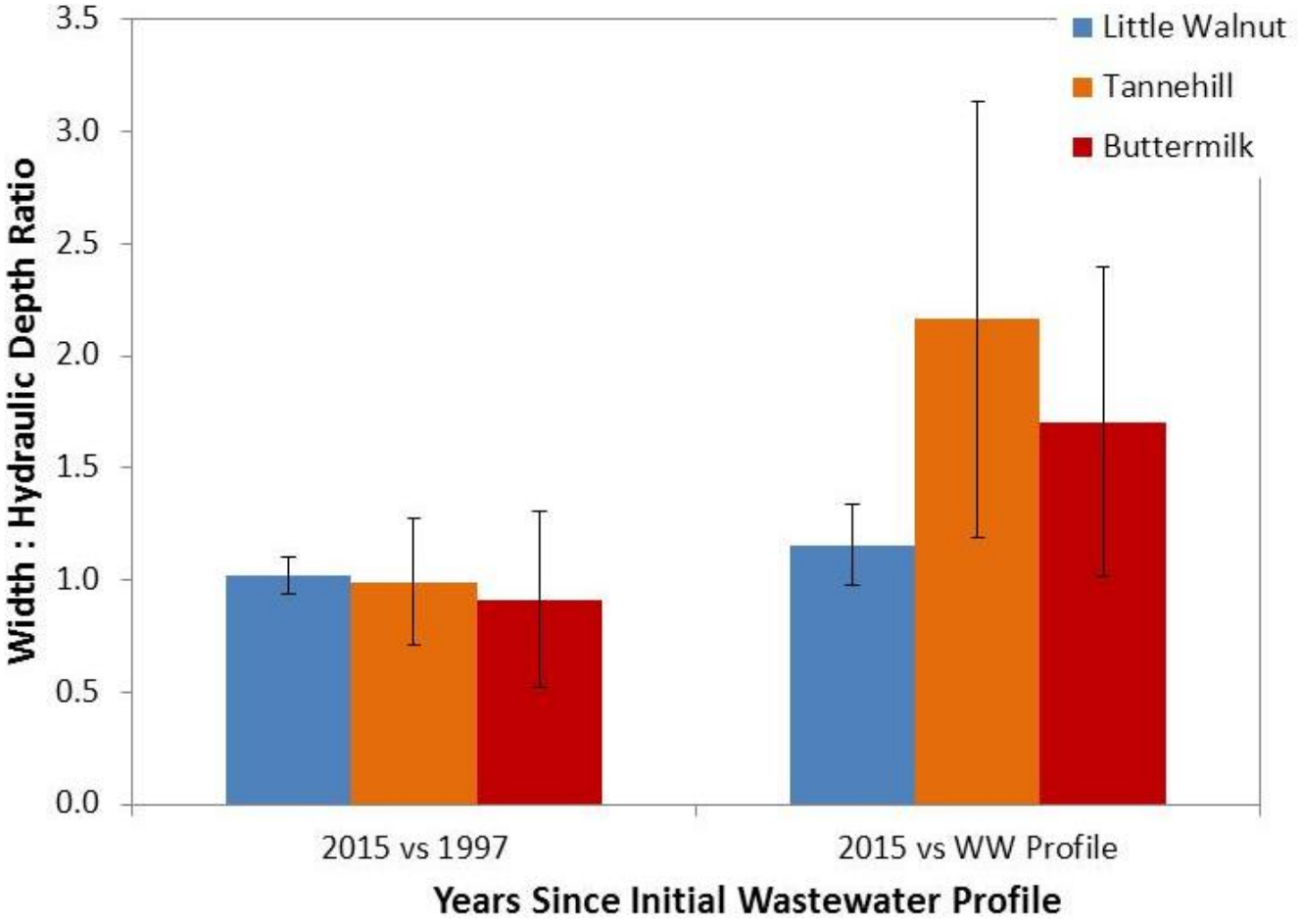
(Reference: Active Bankfull)



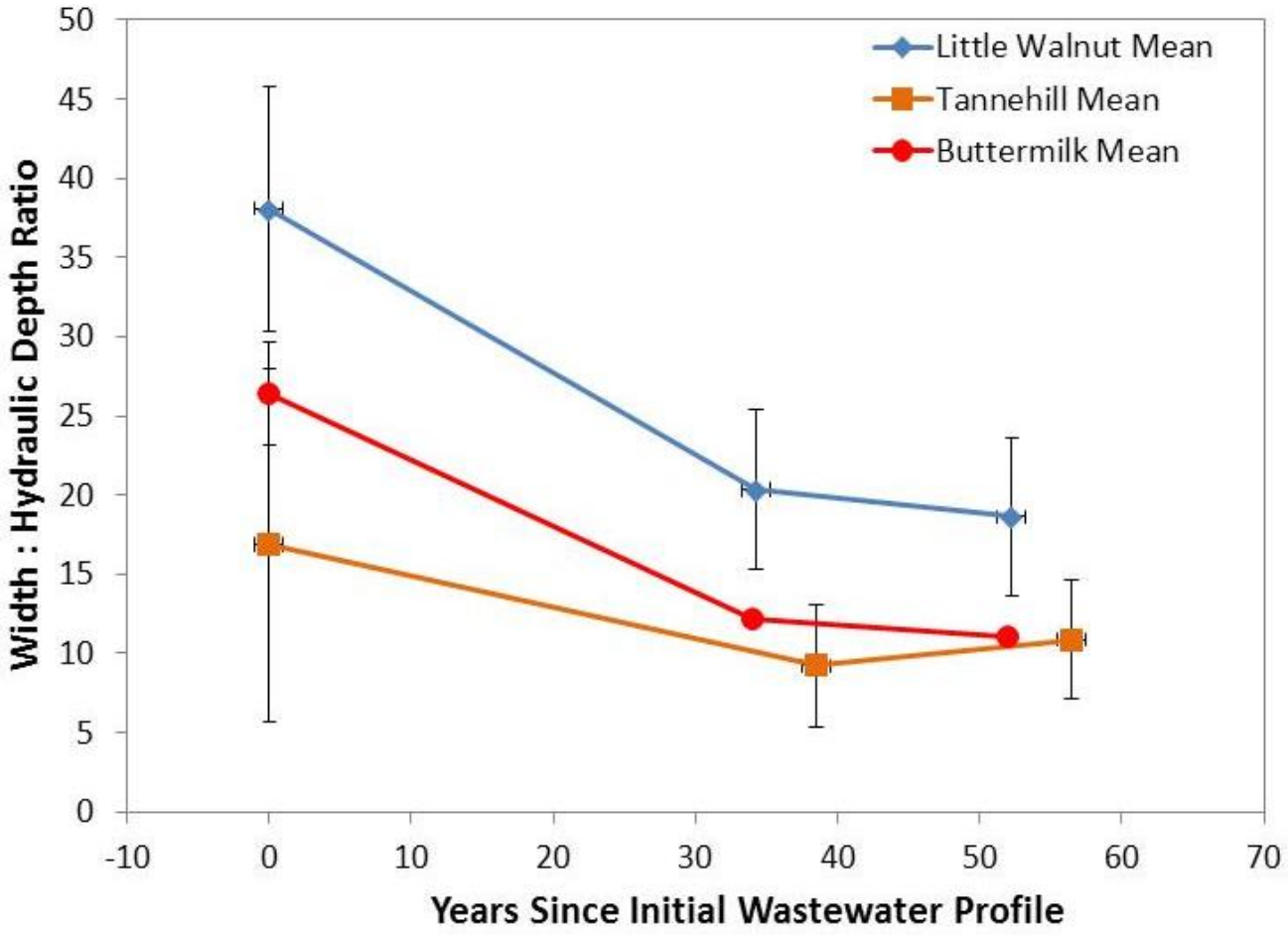
PRELIMINARY RESULTS

Incision Factor (Hydraulic depths taken from geometric top of bank)

By Watershed



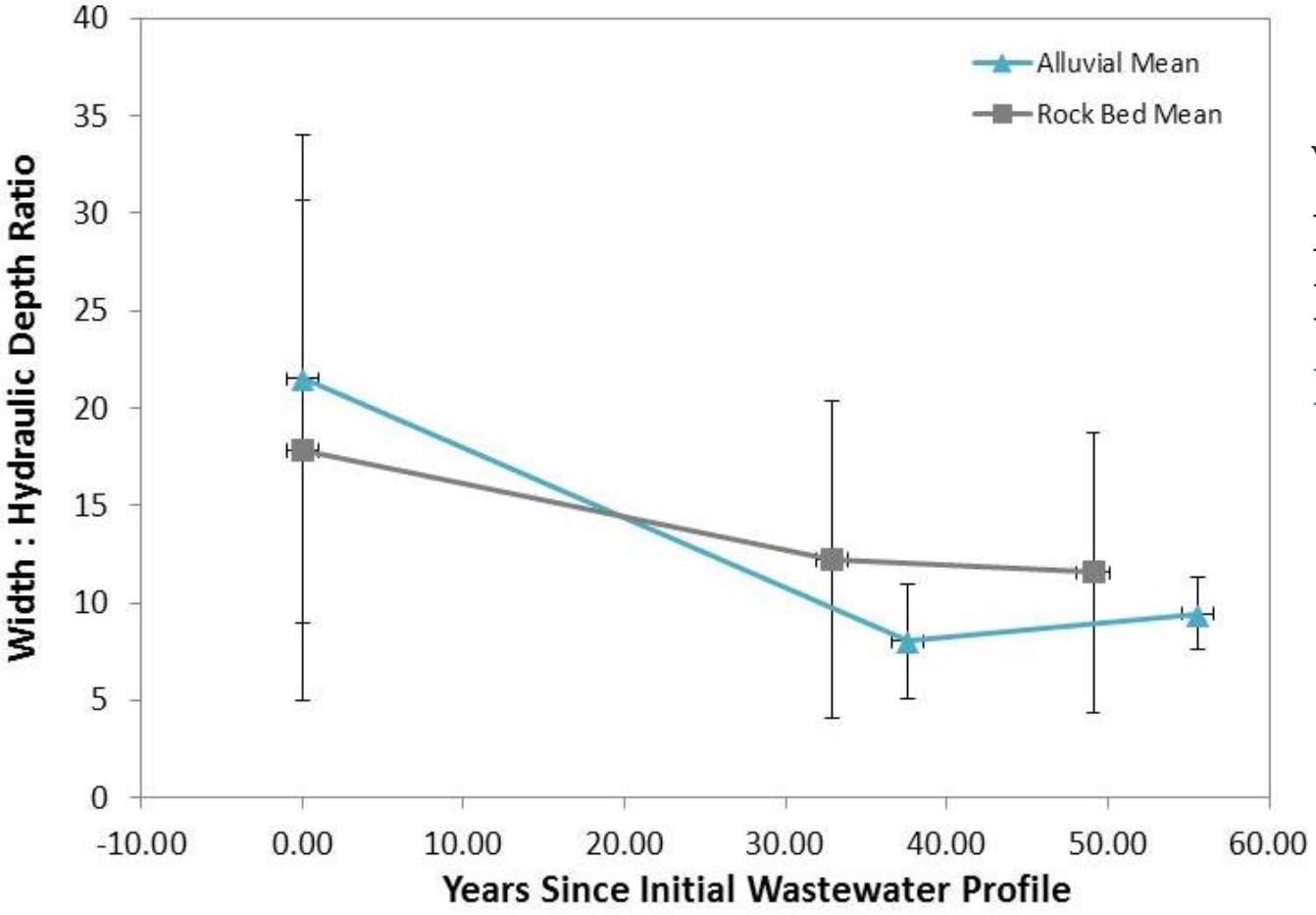
PRELIMINARY RESULTS



Width : Hydraulic Depth Ratio over Time

By Watershed

PRELIMINARY RESULTS



Width : Hydraulic Depth Ratio over Time

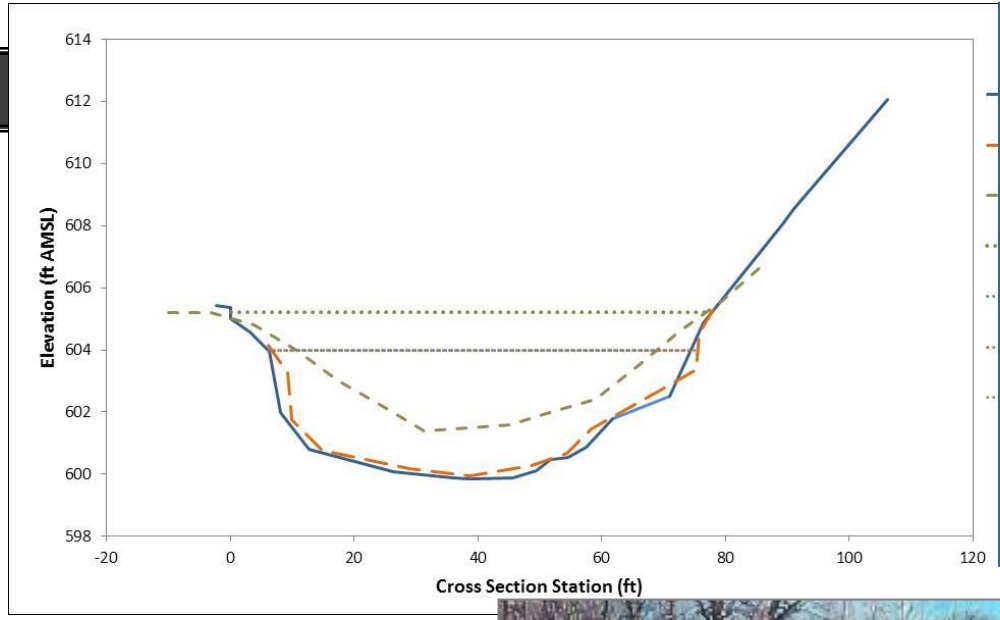
By Channel Type

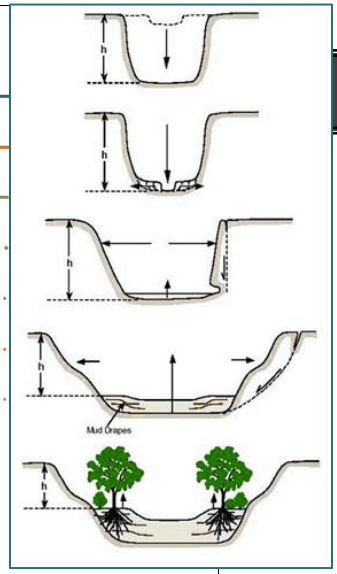
LITTLE WALNUT CREEK EXAMPLE SECTION

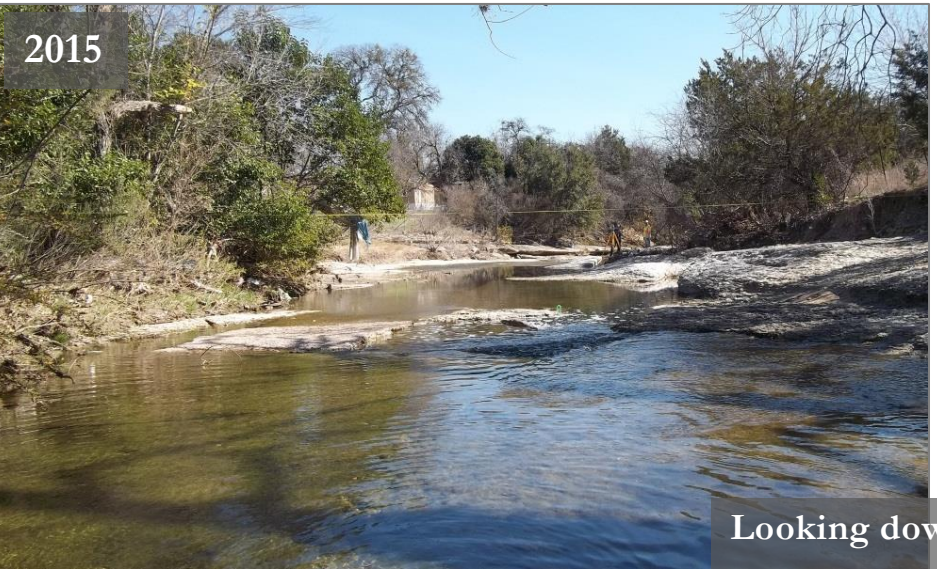
Section 18

Approx. 2500 ft upstream of Cameron Road

- Bedrock bottom channel
- Mowed on left side, natural on right







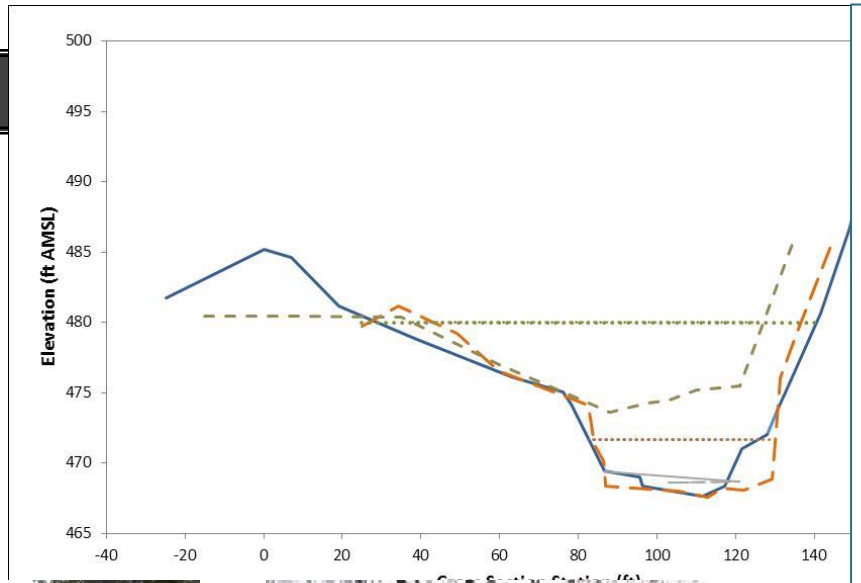
Looking downstream through section

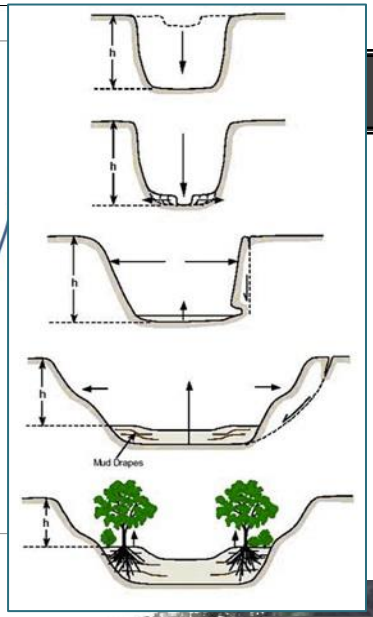
TANNEHILL BRANCH EXAMPLE SECTION

Section 54

50' D/S of Confluence with Tannehill Tributary in Givens Park

- Initial downcutting and widening
- Erosion of steep bluff on right bank
- Reestablishment of inset channel





2015

1997

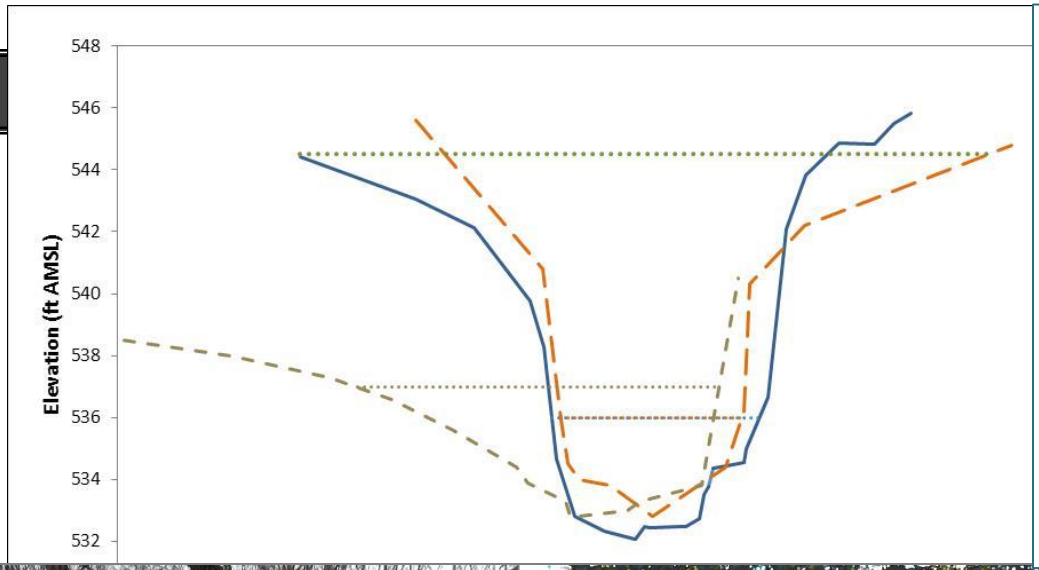
Looking downstream through section

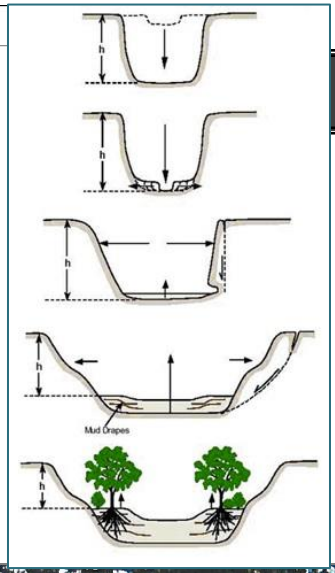
BUTTERMILK CREEK EXAMPLE SECTION

Section 83

Behind Lot 110 off of England ROW

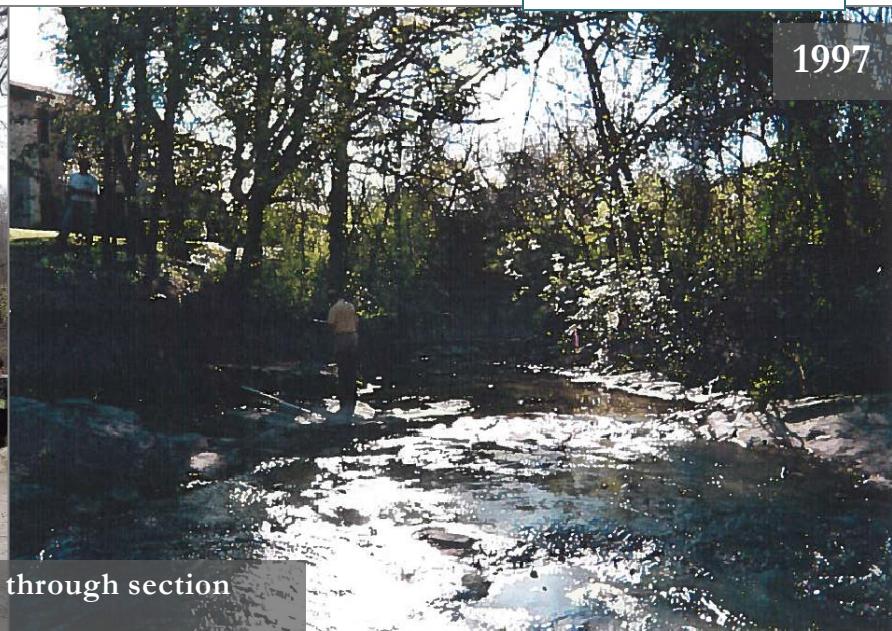
- Clearing of banks
- Widening
- Possible meandering of bend
- Stormwater infrastructure





2015

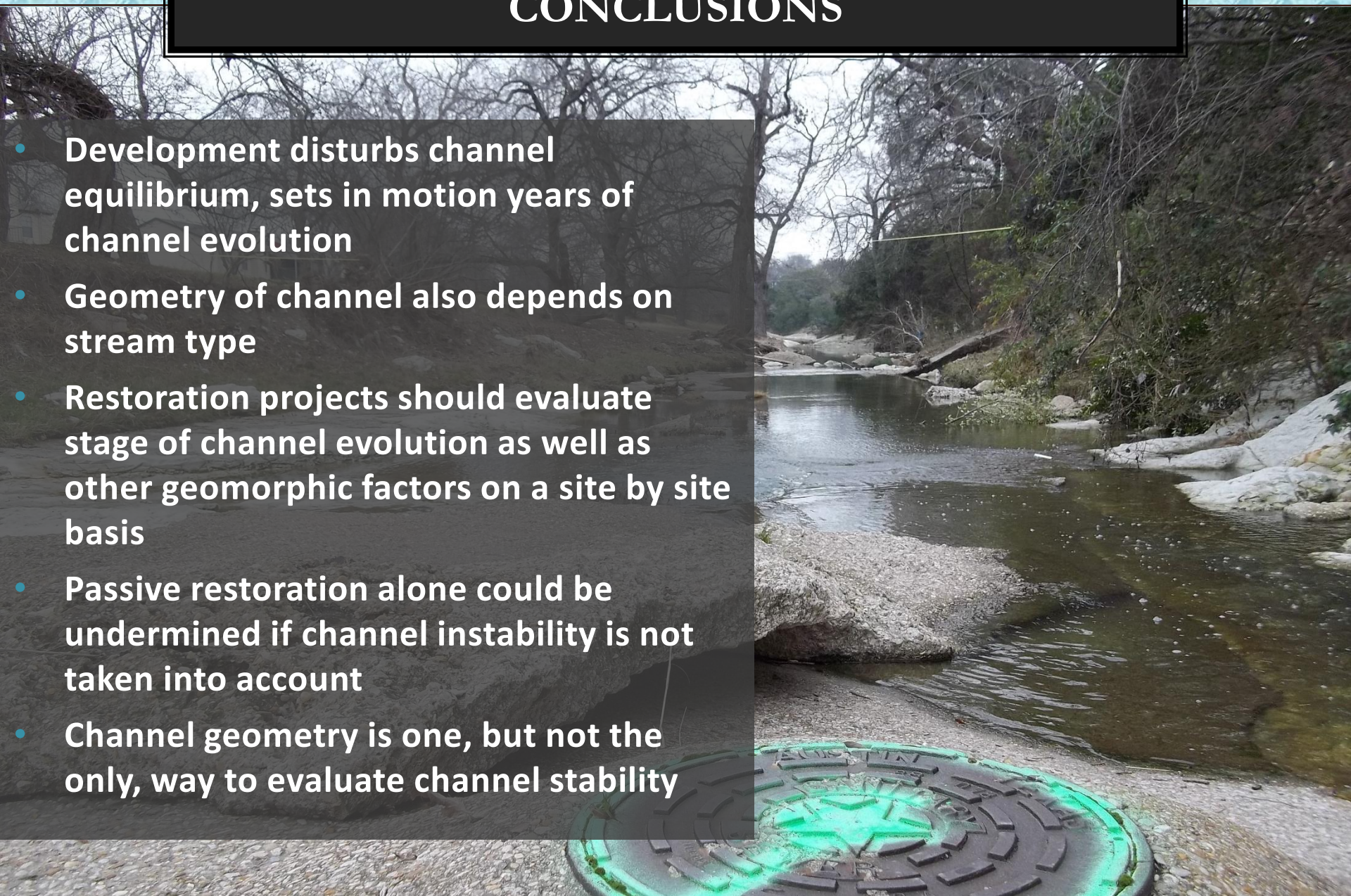
1997



Looking upstream through section

CONCLUSIONS

- Development disturbs channel equilibrium, sets in motion years of channel evolution
- Geometry of channel also depends on stream type
- Restoration projects should evaluate stage of channel evolution as well as other geomorphic factors on a site by site basis
- Passive restoration alone could be undermined if channel instability is not taken into account
- Channel geometry is one, but not the only, way to evaluate channel stability



THANK YOU

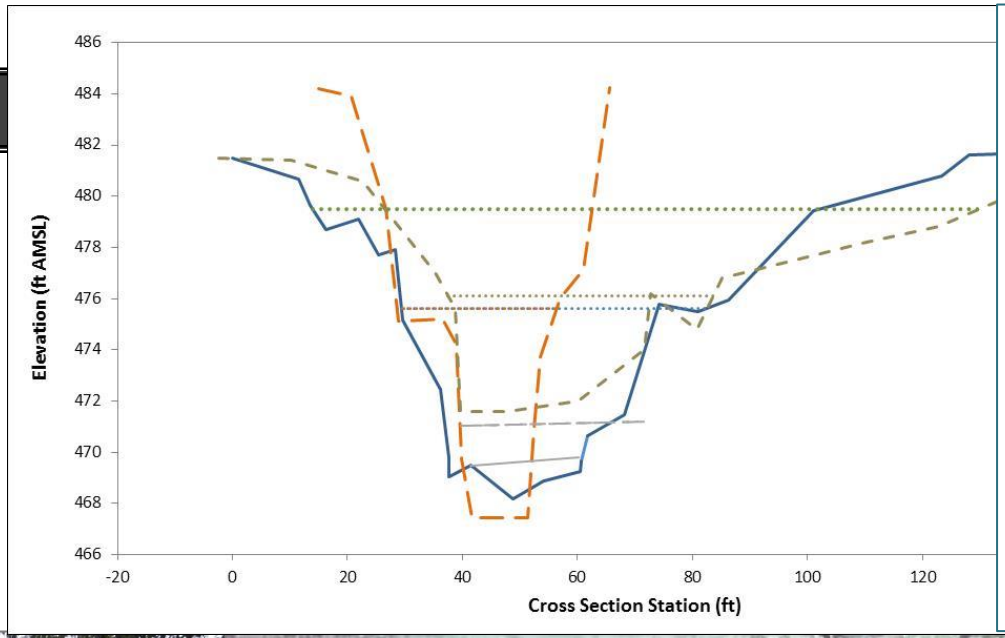
Clayton Ernst
Sean Thompson
Chris Adams
Morgan Byars
Stephen Davis

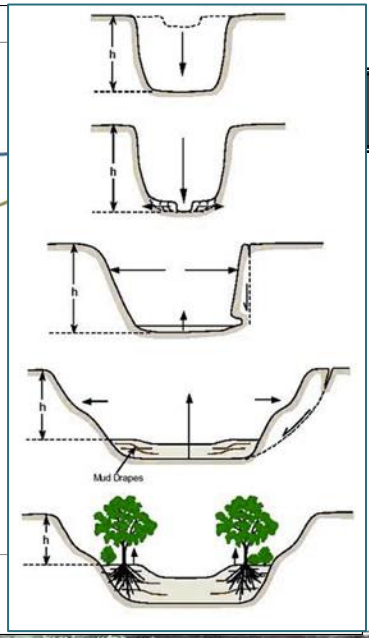
TANNEHILL BRANCH ENLARGING SECTION

Section 53

Givens Park upstream of confluence with tributary

- Outside of bend
- Mowed to top of bank
- Informal trail





Looking downstream through section