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

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What type of restoration is most appropriate?
A STREAM IN EQUILIBRIUM

Lane’s Balance:

\[
Q_s \times D_{50} \propto Q_w \times S
\]

- **Sediment Discharge** \(Q_s\) × **Particle Size** \(D_{50}\)
- **Flow Discharge** \(Q_w\) × **Stream Slope** \(S\)

Sediment Load
Stream Power

Source: ASCE
Understanding a stream’s stage in channel evolution helps select appropriate restoration techniques.

- Passive vs. active restoration
- “Watershed restoration” another approach
• Original stable channel: sediment load and stream power are in equilibrium
• Typically channel is vegetated and well-connected to floodplain

Restoration Method:
- Passive
- Active
Watershed development ($\Delta Q_w$) or channelization ($\Delta S$) typically increases stream power, interrupts equilibrium.

Response: Incision and headcutting.
CEM STAGE III: WIDENING

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

Source: Fish Creek Coalition

Restoration Method:
- Passive
- Active
CEM STAGE IV: AGGRADATION AND PLANFORM ADJUSTMENT

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

Source: Fish Creek Coalition

Restoration Method:
- Passive
- Active
CEM STAGE V: QUASI-EQUILIBRIUM

- 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

Source: Fish Creek Coalition
Channel Enlargement Study

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

Tannehill Creek at Givens Park in 2015
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, $W/D_{Hyd}$

\[ Re = \frac{A_t}{A_{t_0}} \]
\[ \dot{Re} = \frac{Re_t - Re_{t_0}}{t - t_0} \]
\[ IF = \frac{D_t}{D_{t_0}} \]
\[ IF_{Hyd} = \frac{D_{Hyd,t}}{D_{Hyd,t_0}} \]

Change over Time
- Enlargement Ratio, $Re$
- Normalized Enlargement Rate, $\dot{Re}$
- Incision Factor, $IF$
2015 SURVEYS

2015 Survey Locations (So Far)

1997 Survey Locations
PRELIMINARY RESULTS

Enlargement Ratio over Time
(Reference: Active Bankfull)
Incision Factor
(Hydraulic depths taken from geometric top of bank)
By Watershed
Width: Hydraulic Depth Ratio over Time
By Watershed
PRELIMINARY RESULTS

Width : Hydraulic Depth Ratio over Time
By Channel Type
Section 18

Approx. 2500 ft upstream of Cameron Road

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

Looking downstream through 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

Looking downstream through section
Section 83

Behind Lot 110 off of England ROW

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

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

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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