Changes In The Riparian Water Table With Channel Incision

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Stream Incision, part II
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Following stream incision:

- What happens to the riparian water table?
  - How much does it change?
  - At what rate does it change?

- What happens to the channel?
- What happens to floodplain/channel interaction?
- What happens during and after storms?
What happens to the channel following incision?
Changes in channel shape and size

upstream of knickpoint

just downstream of knickpoint

further downstream of knickpoint

farthest downstream of knickpoint
What happens to floodplain/channel interaction following incision?

stilling well

staff gauges
Correlation between stilling well and stream stage of transect B

\[ y = 0.5023x - 2.8714 \]

\[ R^2 = 0.9582 \]
Changes in flooding frequency

- far upstream
- upstream
- downstream
- far downstream
- farther downstream

% of storms that stream overflows its bank

- negligible
- small
- medium
- large

size of storm
What happens to the water table when it storms?
Wells with pressure transducers installed

Transect B

Transect E

Knickpoint
Time – precipitation occurs from hour 3 to 5

upstream

downstream
Comparative affect of a large storm on upstream and downstream water tables
Upstream, near-stream response to a large storm

Downstream, near-stream response to a large storm
Groundwater/stream interactions during and following a large storm in an unincised channel

Specific discharge, based on Darcy’s Law:

\[ q = -K \frac{dh}{dl} \]
Channel incision contributes to exacerbating the “urban” hydrograph:

• Channel volume increases significantly
  • Storm flow contained within channel – floodplain inundation rare

• Lowered groundwater levels allow for significant storage of storm water – but this storage is only for the short term
Effects of Urbanization

Natural vs. Urban Stream Response

Discharge vs. Time

- Precipitation
- Natural Discharge
**Effects of Urbanization**

- Increased impervious surface
  - Higher peak flow
  - Reduced lag time
  - Reduced base flow

**Natural vs. Urban Stream Response**

Greater discharge often leads to channel incision
What Are The Effects Of Channel Incision?

1.) How is the riparian water table effected? How much does it change? At what rate?

2.) Effects on channel geometry?

3.) Changes in the floodplain/channel interaction?

4.) Storm response?
The Watershed at Eastern State

Area = 1.5 km²
- 1.3 km² upstream of knickpoint
- ~15% impervious

Area of Study

Unincised (above the knickpoint)

Incised (below the knickpoint)
Methods

- 34 Wells installed in 6 transects
- Surveyed all wells, floodplain, and stream
- Wells measured with water level meter ~3 times a week
Well Field at Eastern State

Direction of Water Flow

Knickpoint
Typical Water Table Levels

- Close to surface
- Low Gradient

Transect B (above knickpoint)

- 7/21/2004
- Water Table
- Floodplain

Transect E (below knickpoint)

- 7/21/2004
- Water Table
- Floodplain

- Lowered
- Higher Gradient
Transect A

Transect B
Summary of Measured Water Table Levels

Upstream/unincised regions show:
- Water table close to surface
- Little variance in head
- Low Gradient

Downstream/incised regions show:
- Lowered water table
- Greater variance in head
- Steeper gradient

Water table lowers near stream first then slowly propagates out
- Wells farthest from stream lowered the least
Analytical Model

Boussinesq Equation

\[
\frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial y^2} = \frac{Sy}{Kb} \frac{\partial h}{\partial t}
\]

One Dimensional

\[
\left(\frac{\partial^2 h}{\partial x^2} \frac{Kb}{Sy}\right) \frac{\partial t}{\partial t} = \partial h
\]

- **h** = head
- **t** = time
- **x** = distance
- **K** = hydraulic conductivity
- **b** = aquifer thickness
- **Sy** = specific yield

- Hydraulic conductivity found by conducting slug tests
  - Values range from: 0.03-0.1 m/day
- Aquifer thickness estimated to be 2 meters
- Specific yield estimated to range from .10-.18
Model Results

Original Water Table based off of transect B

$K = 0.08 \text{ m/day}$

$Sy = 0.15$

$b = 2\text{m}$
Summary of Model

- Quick Response near the stream
- As gradient is reduced lowering of the water table is slowed
- Areas further from stream have a minimal and delayed response
Conclusions

- Channel incision lowers the riparian water table, and increases variance.

- This lowering is most dramatic near the stream and propagates inland through time as the gradient is reduced.
Further Work

- Continue to monitor wells
- Calibrate model to more accurately simulate real conditions
- Use model to predict future changes and to understand what conditions were like in the past