Hydrograph Modification: An Introduction and Overview

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Stormwater Regulation

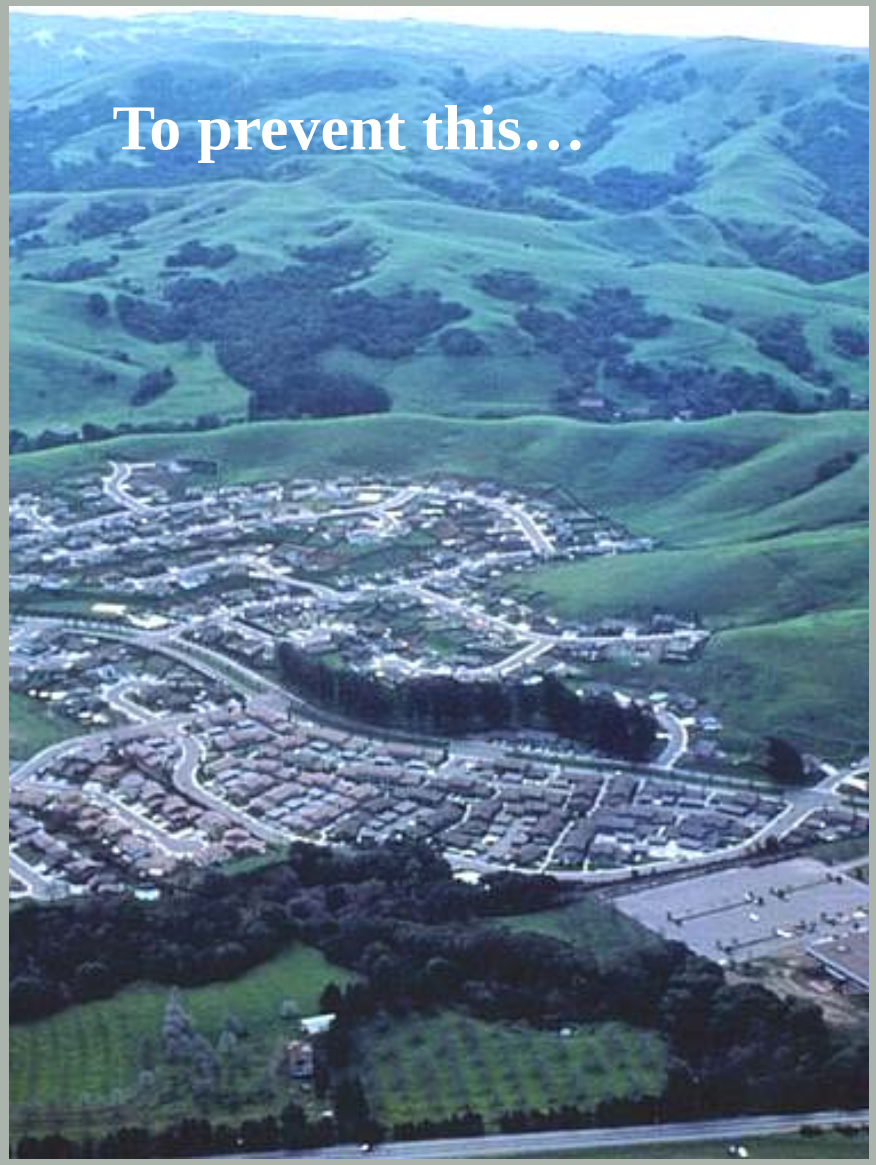
- **Flood Management**
  - Large, infrequent events (quantity)
- **Stormwater Quality**
  - Small, frequent events (quality)
- **Hydrograph Modification Management**
  - Small, frequent events
    (quantity --> quality)

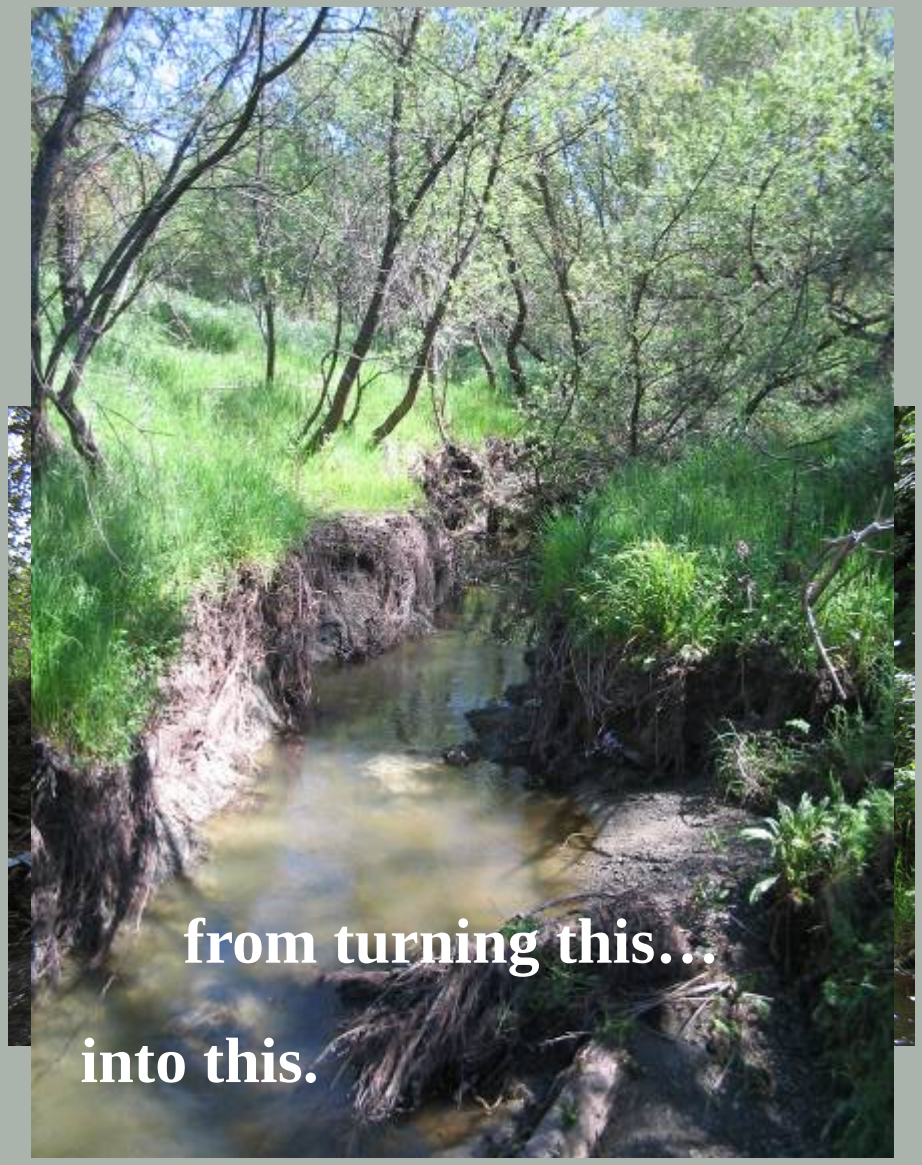
What's the problem?

Altered hydrology can cause channel erosion.

- Higher, more erosive peak flows
- Longer duration of lower, but still erosive, flows

Why regulate Hydro Mod?

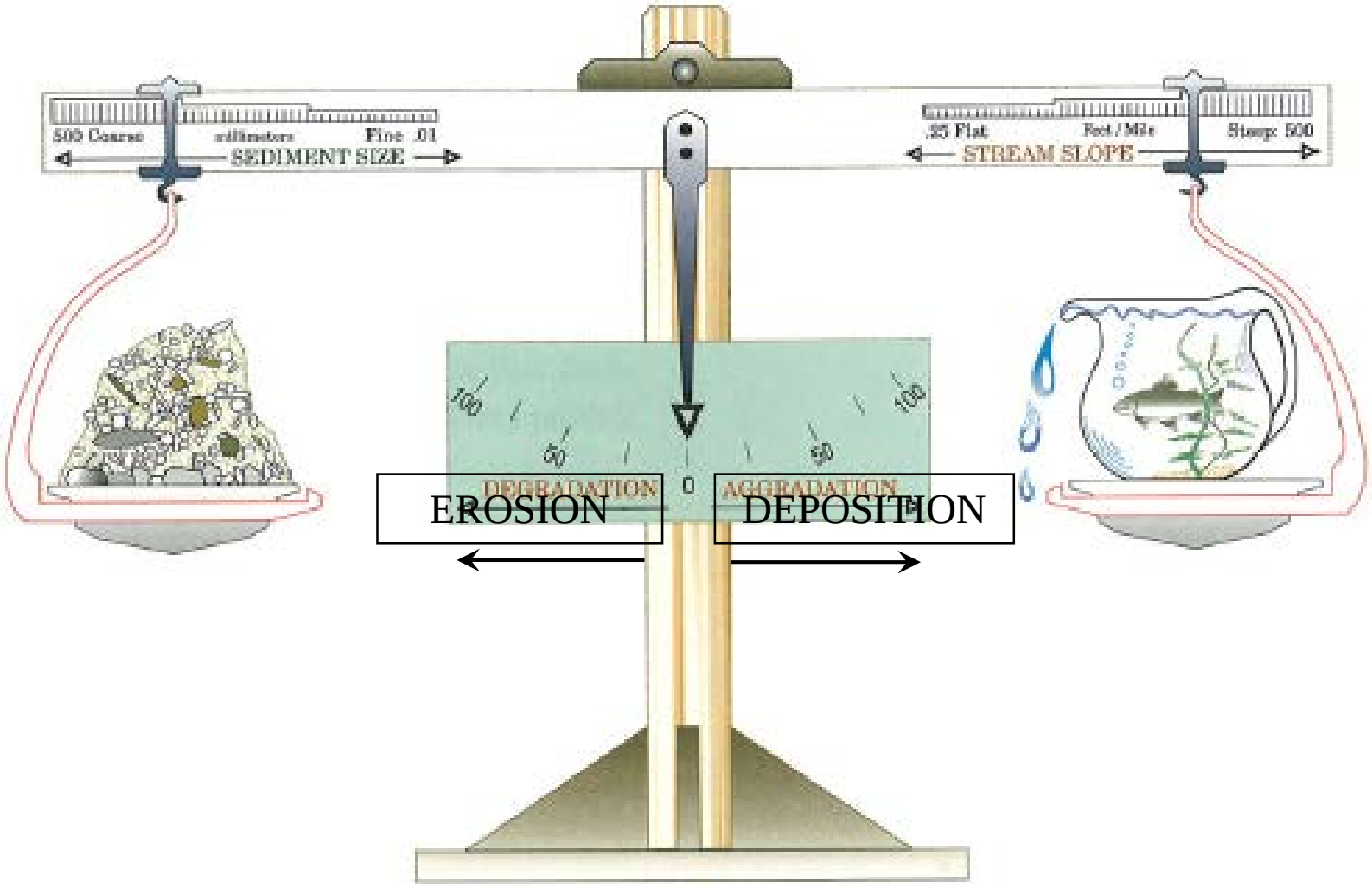




What's the problem?

- Channel morphology is a response to the watershed delivery of water and sediment
- In a stable creek channel, water and sediment are in balance:
  - no net erosion or deposition over time
- Changes in watershed hydrology & sediment supply can upset the balance
- Watershed impacts of development tend to cause channel erosion/degradation

What's the problem?

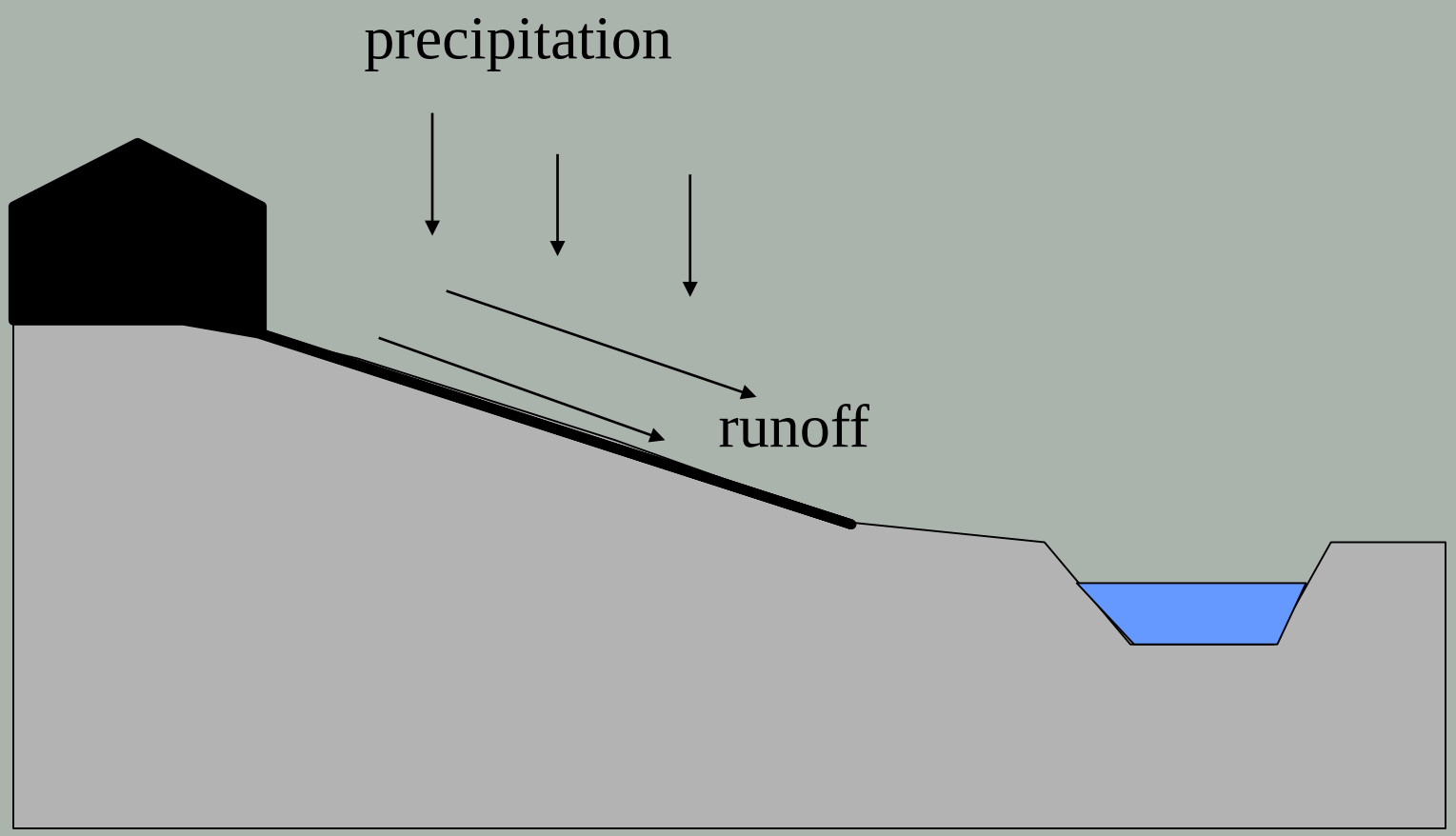


What's the problem?

Channel erosion can cause:

- Reduced water quality (sediment load, turbidity) = regulatory "hook"
- Damage to adjacent property & infrastructure
- Loss of riparian habitat
- Loss of aquatic habitat
- Downstream sediment delivery/deposition

How does it happen?



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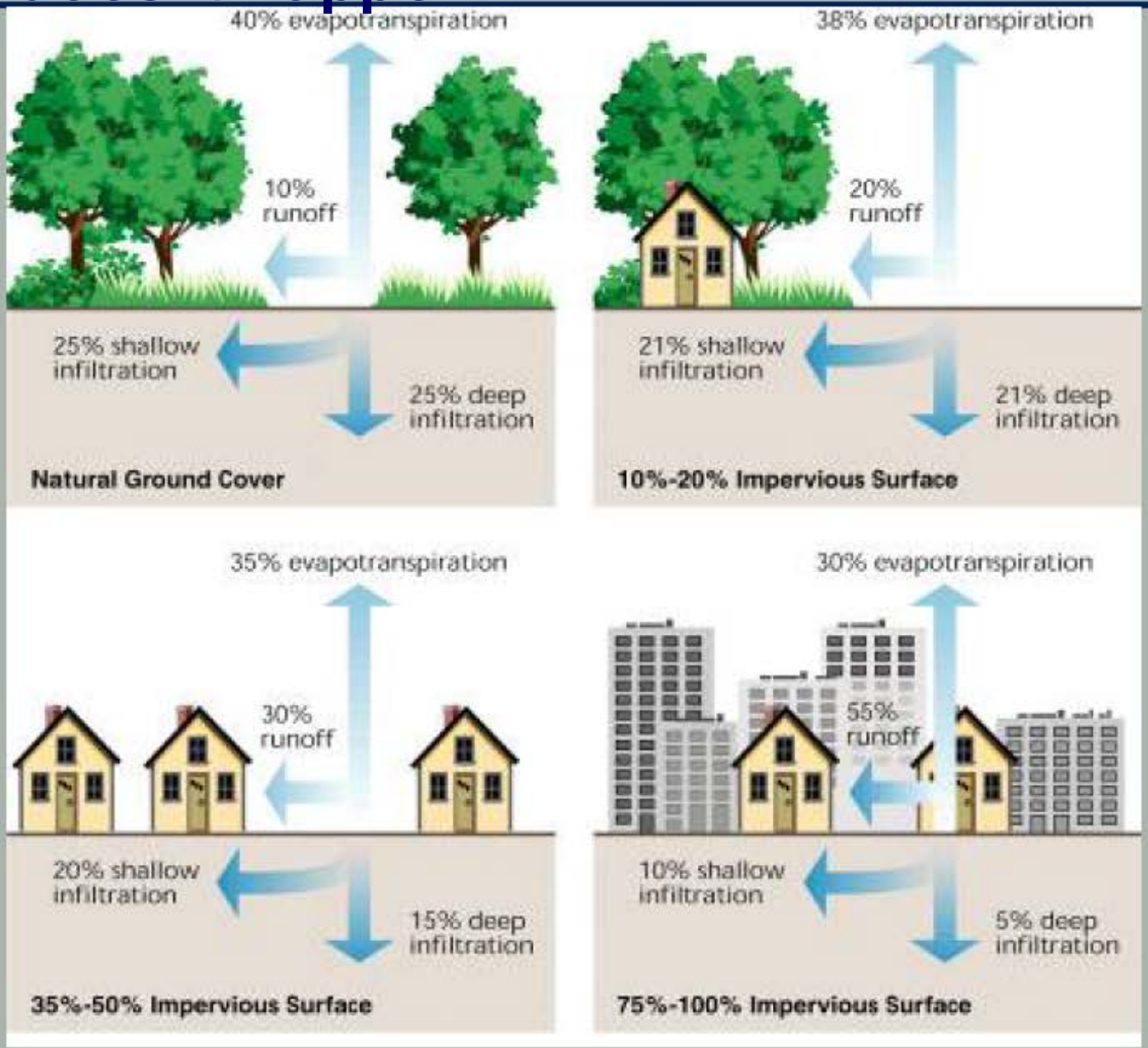
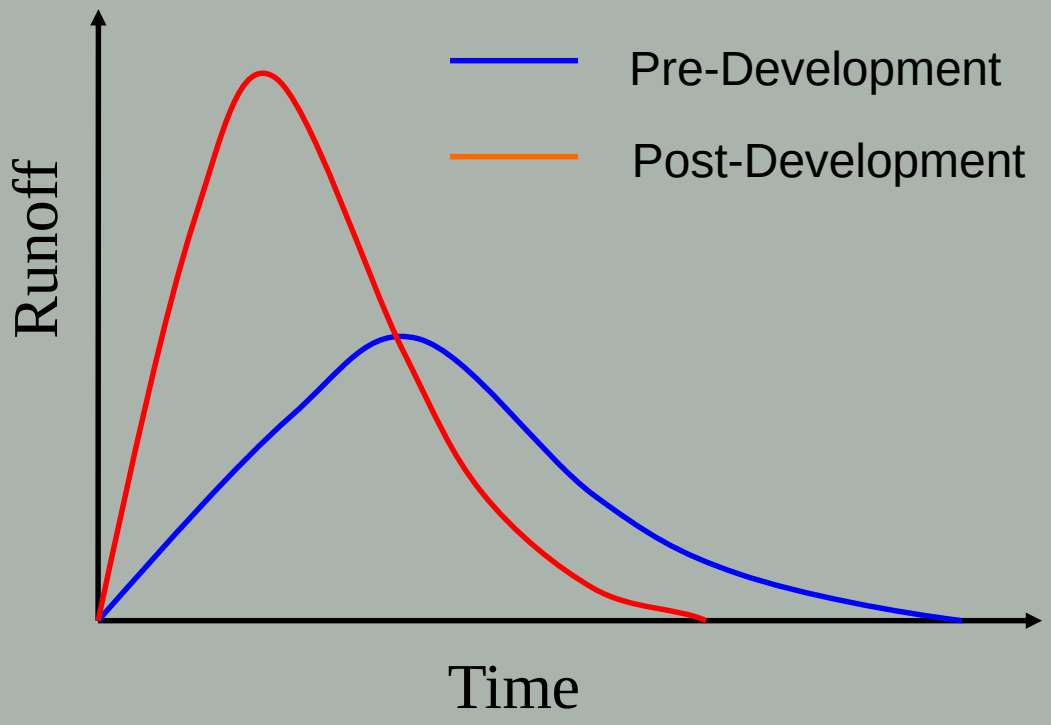


How does it happen?

Urbanization tends to increase stormwater runoff:

- peak flows
- volume
- frequency



Hydrograph Modification Management

Bay Area standard:

Post-project runoff peaks and durations must not exceed pre-project levels if an increase could cause erosion or other significant effects on beneficial uses.

How do you measure it?

- Quantifying potential hydrograph modification impact (and mitigation) is a challenge
- Analysis requires
  - Rainfall-runoff modeling
  - Comparison of pre- and post-project conditions

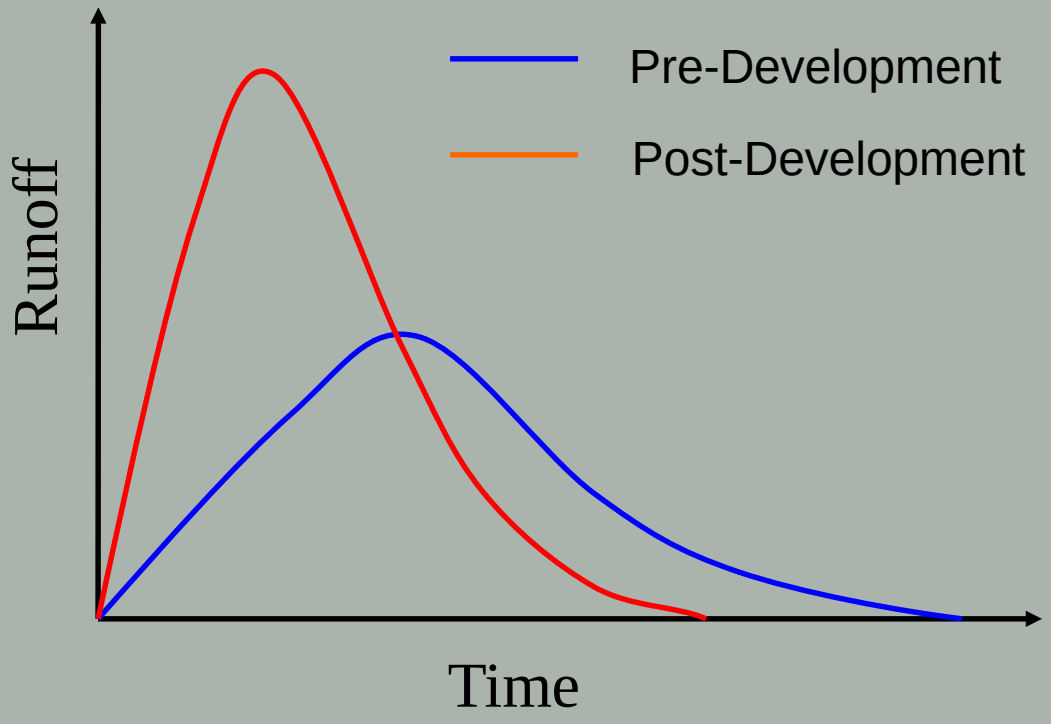
How do you measure it?

- Single event “design storm” models (e.g. Q100):
  - Common tools for flood analysis, but
  - Not effective for analyzing smaller, more frequent events

How do you measure it?

- Event-based models predict runoff response for a particular storm event

- Don’t reflect cumulative runoff response over time

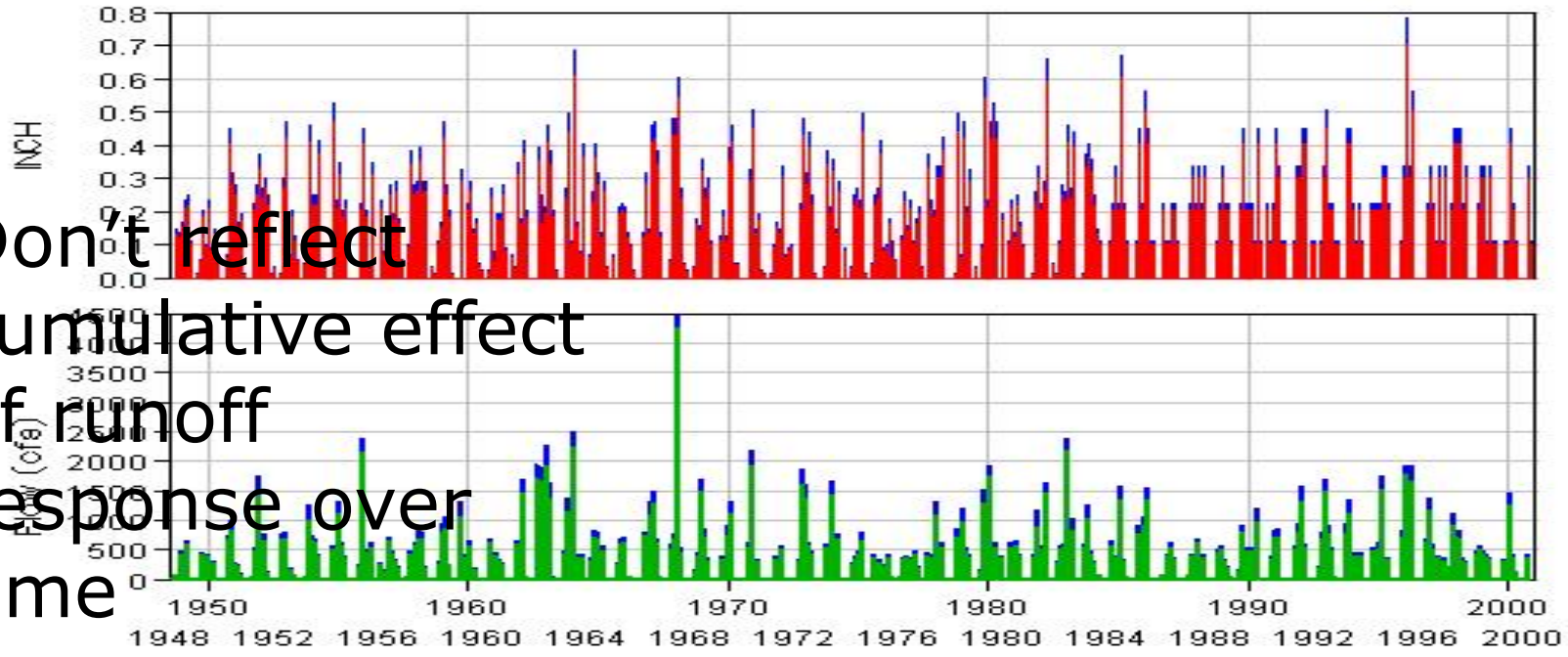


How do you measure it?

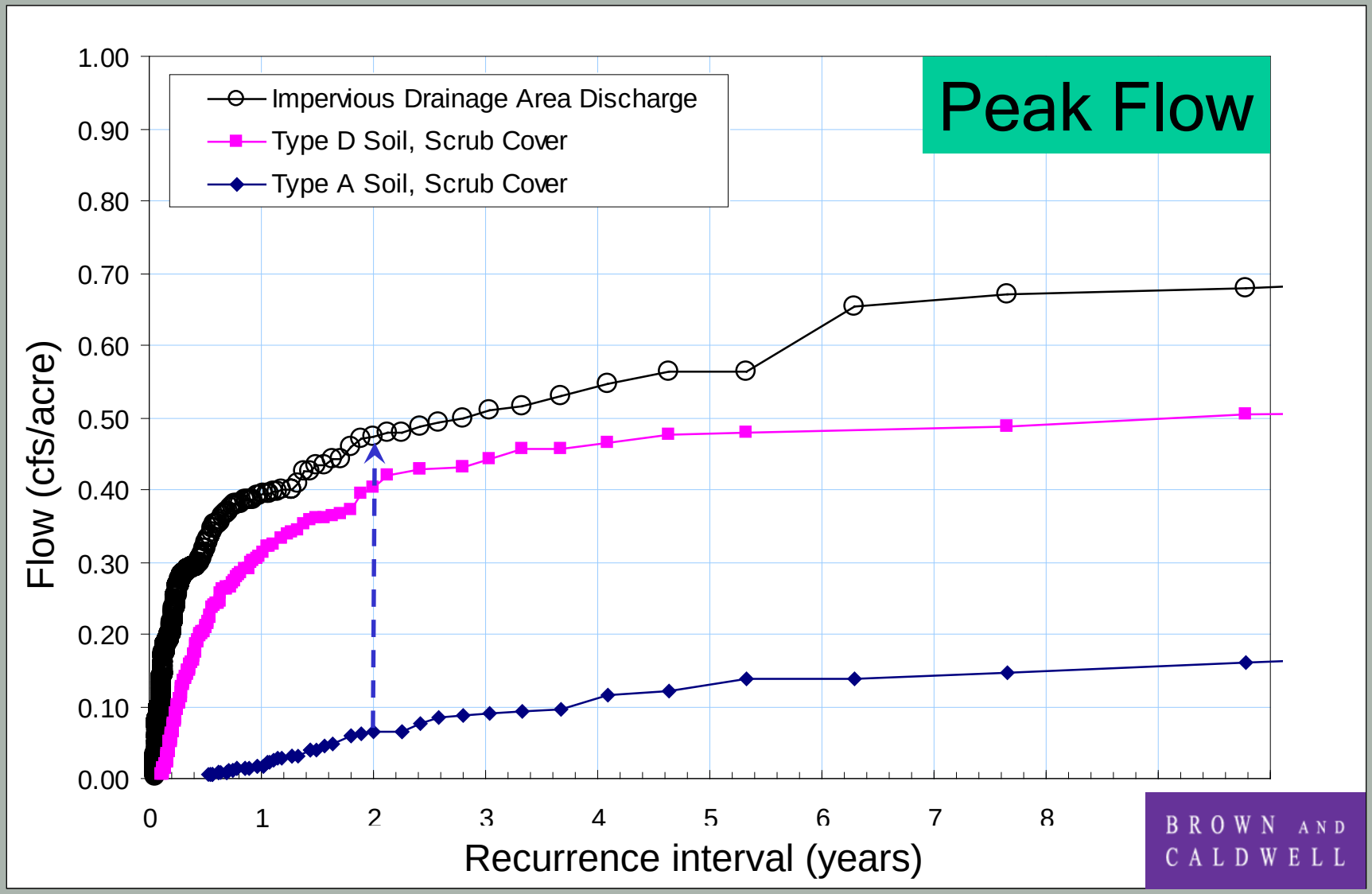
- Continuous hydrologic models:
  - Can evaluate flow peak and duration over full range of flows, but
  - Require specialized expertise, onerous for smaller projects

How do you measure it?

- Continuous simulation models use a long-term rainfall record (30+years)
- Statistical analysis of runoff response to all events
- Don't reflect cumulative effect of runoff response over time



How do you measure it?



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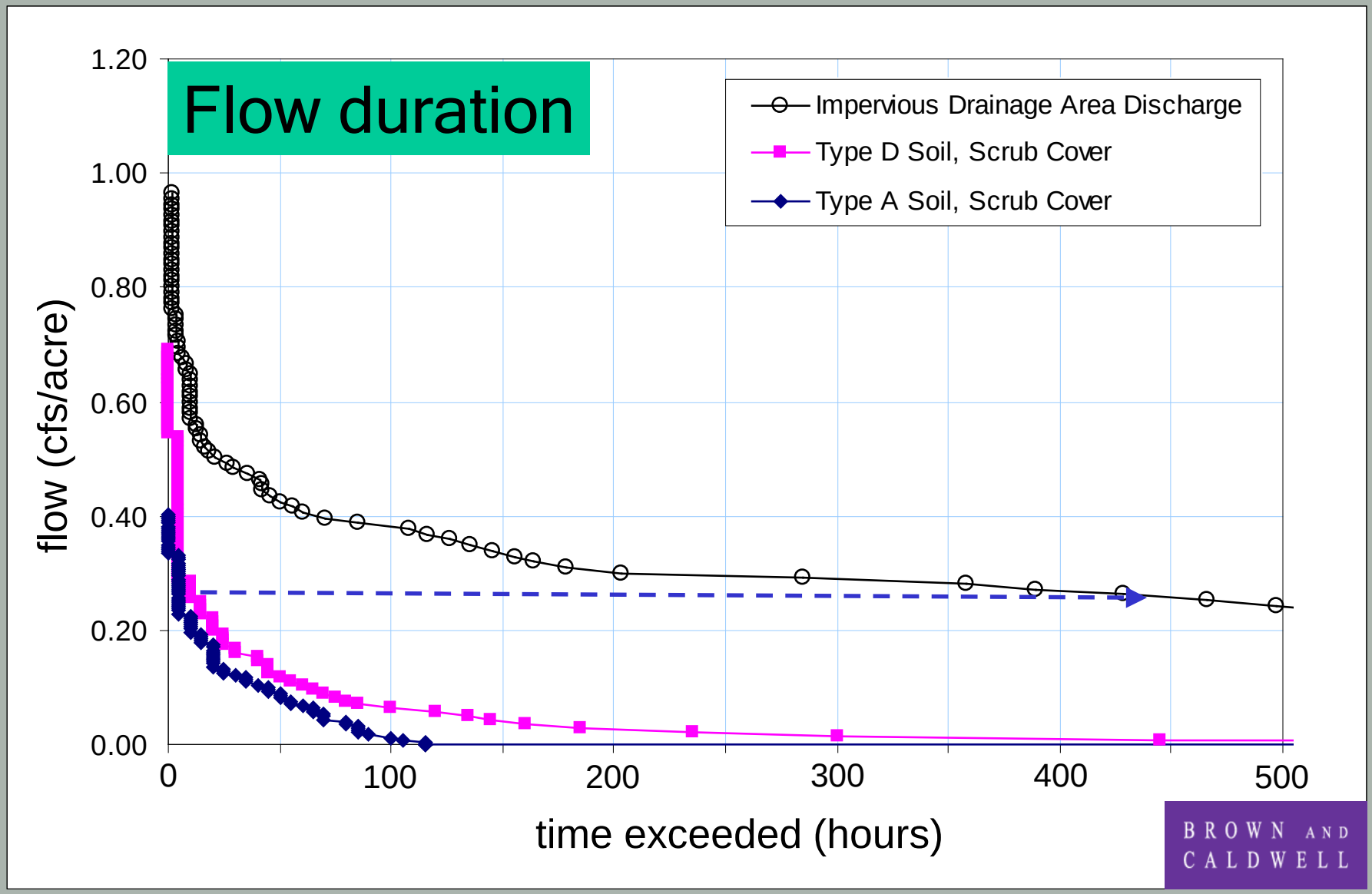


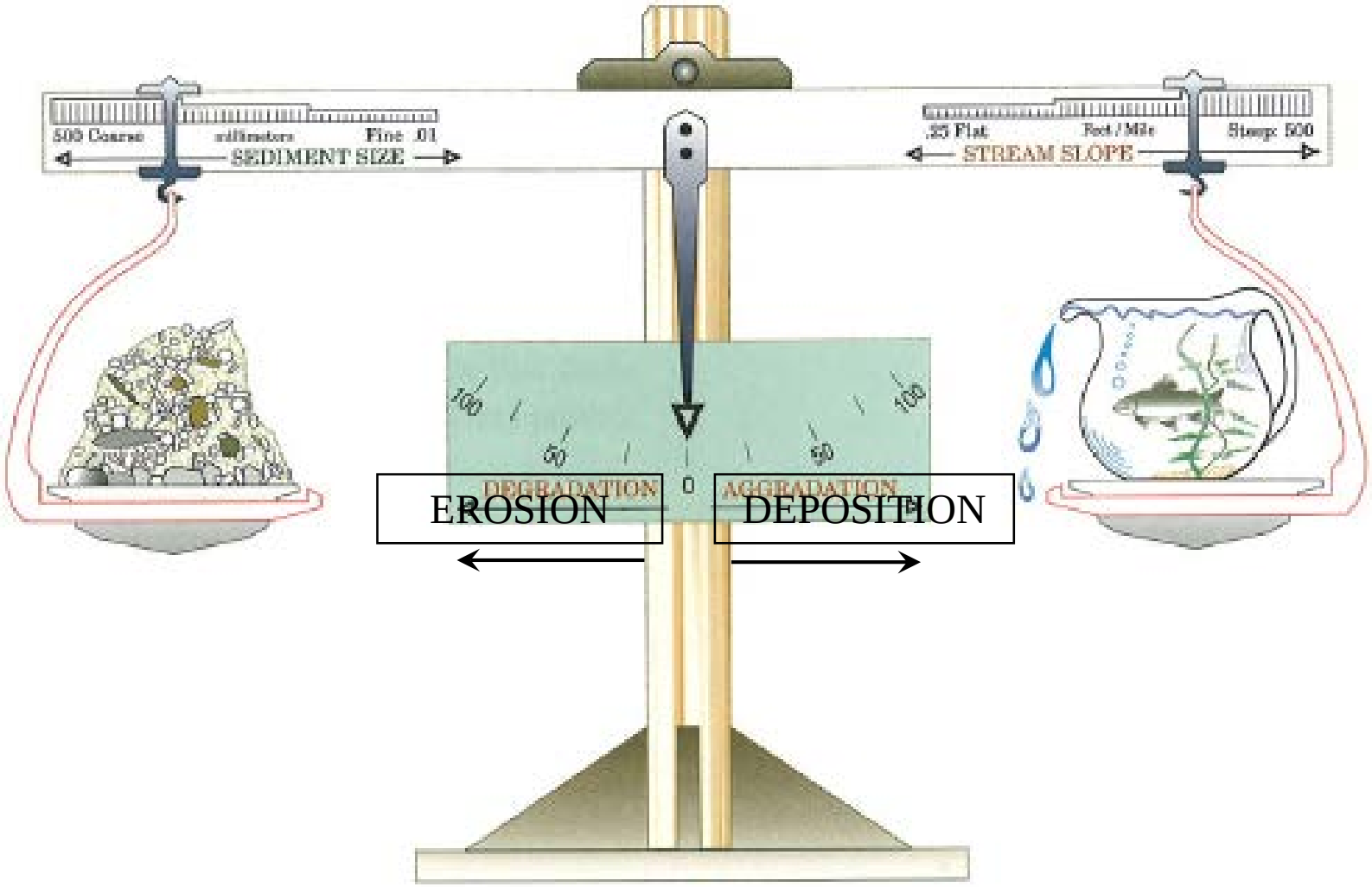
What's the result?

Altered hydrology can cause channel erosion.

- Higher, more erosive peak flows
- Longer duration of lower, but still erosive, flows

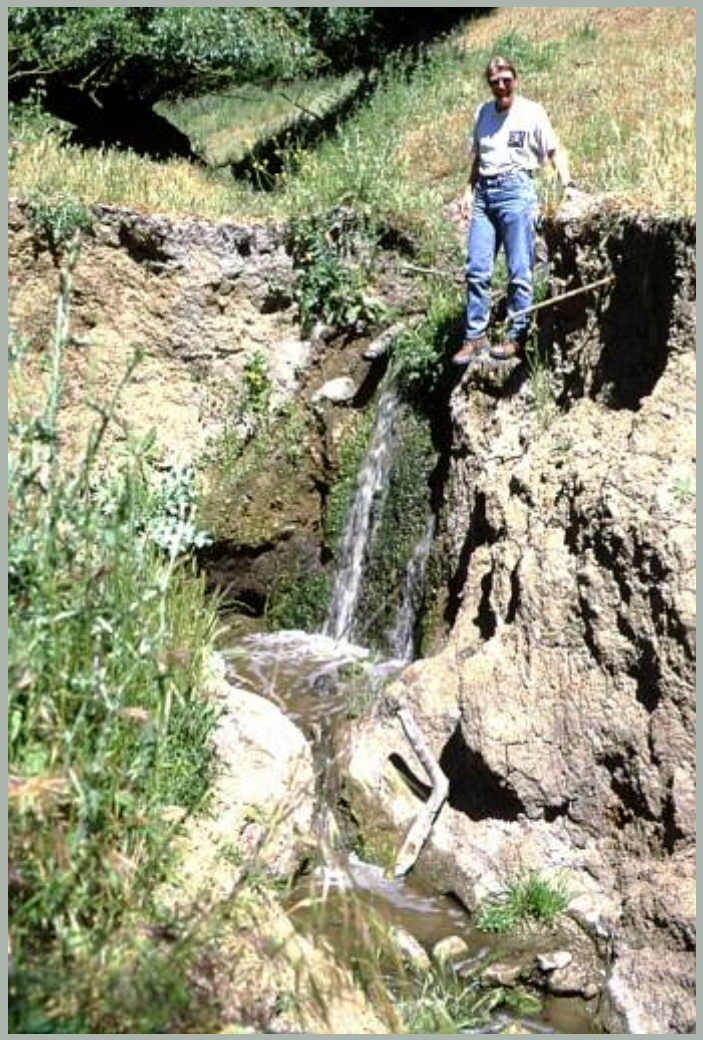
Urbanization also tends to reduce the natural sediment supply:

- land development
- detention basins

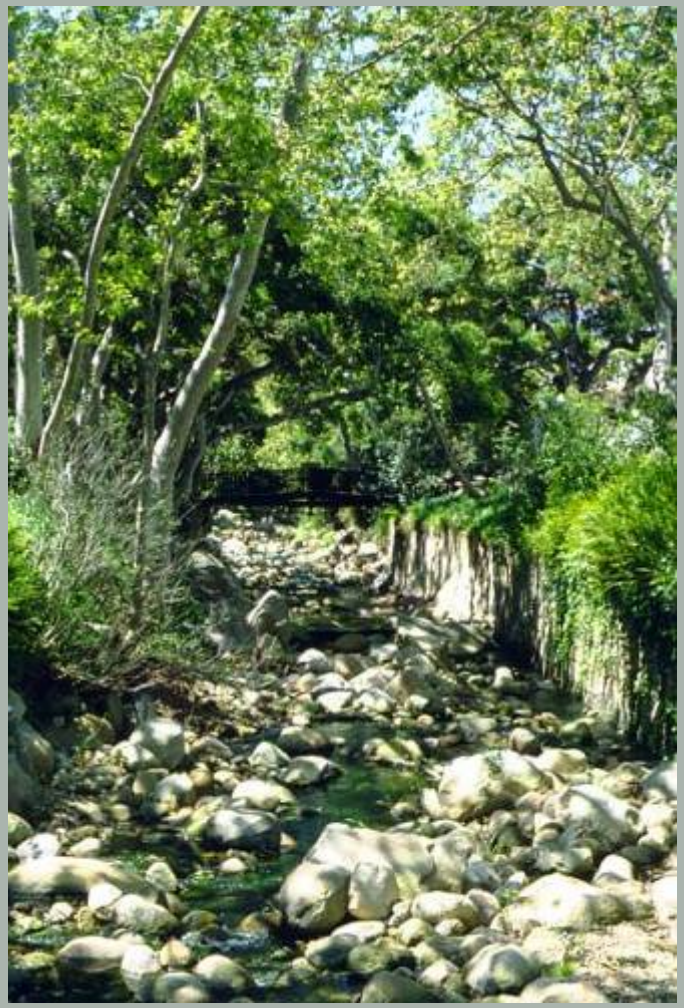

SEDIMENT SIZE
STREAM SLOPE
DEGRADATION
AGGRADATION
EROSION
DEPOSITION
(Sediment LOAD) x (Sediment SIZE)
(Stream SLOPE) x (Stream DISCHARGE)

Channel Response

Response of the stream is complex, depends on channel and watershed characteristics …



Channel Response



… but we have simple models to predict potential impacts from development.

Pre-project erosion along Miller Creek

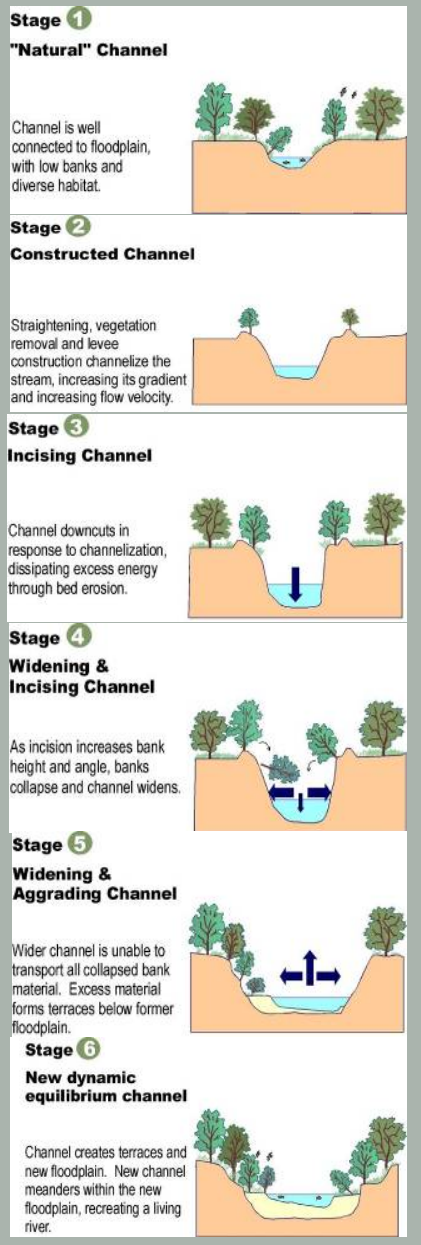
Channel Response

After Schumm, and Simon & Hupp

Stage 6

New dynamic equilibrium channel

Channel creates terraces and new floodplain. New channel meanders within the new floodplain, recreating a living river.



Restoration often seeks to accelerate this natural process to achieve new dynamic equilibrium.

Stable Channel

Channel Incision

Channel Incision

Bank Erosion / Collapse

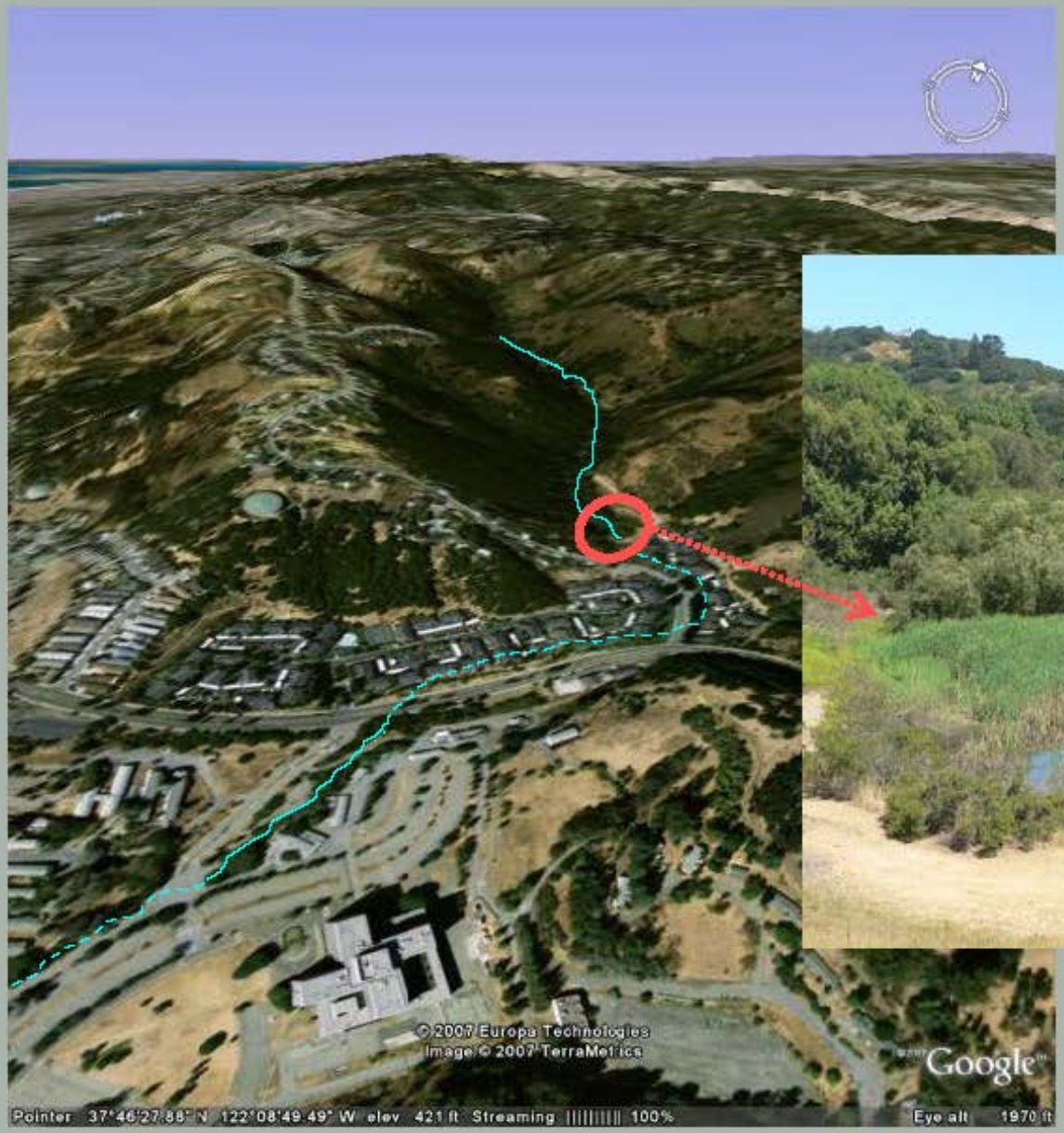
Bank Erosion / Collapse

Channel Widening

Channel Widening

New dynamic equilibrium

Example: Rifle Range Creek, Oakland



Example: Rifle Range Creek, Oakland

higher creek flows

+ lower sediment supply

erosion

Summary

- In a stable creek channel, water and sediment are in balance:
  - no net erosion or deposition over time
- Watershed impacts of development tend to cause channel degradation
- Specific channel response depends on complex interaction of watershed and channel characteristics

Conclusion

- The goal of hydrograph modification regulation is to manage water quantity to preserve water quality and stream function

- Challenge is to develop a regulatory scheme that is simple enough to apply but sophisticated enough to be effective

Questions?