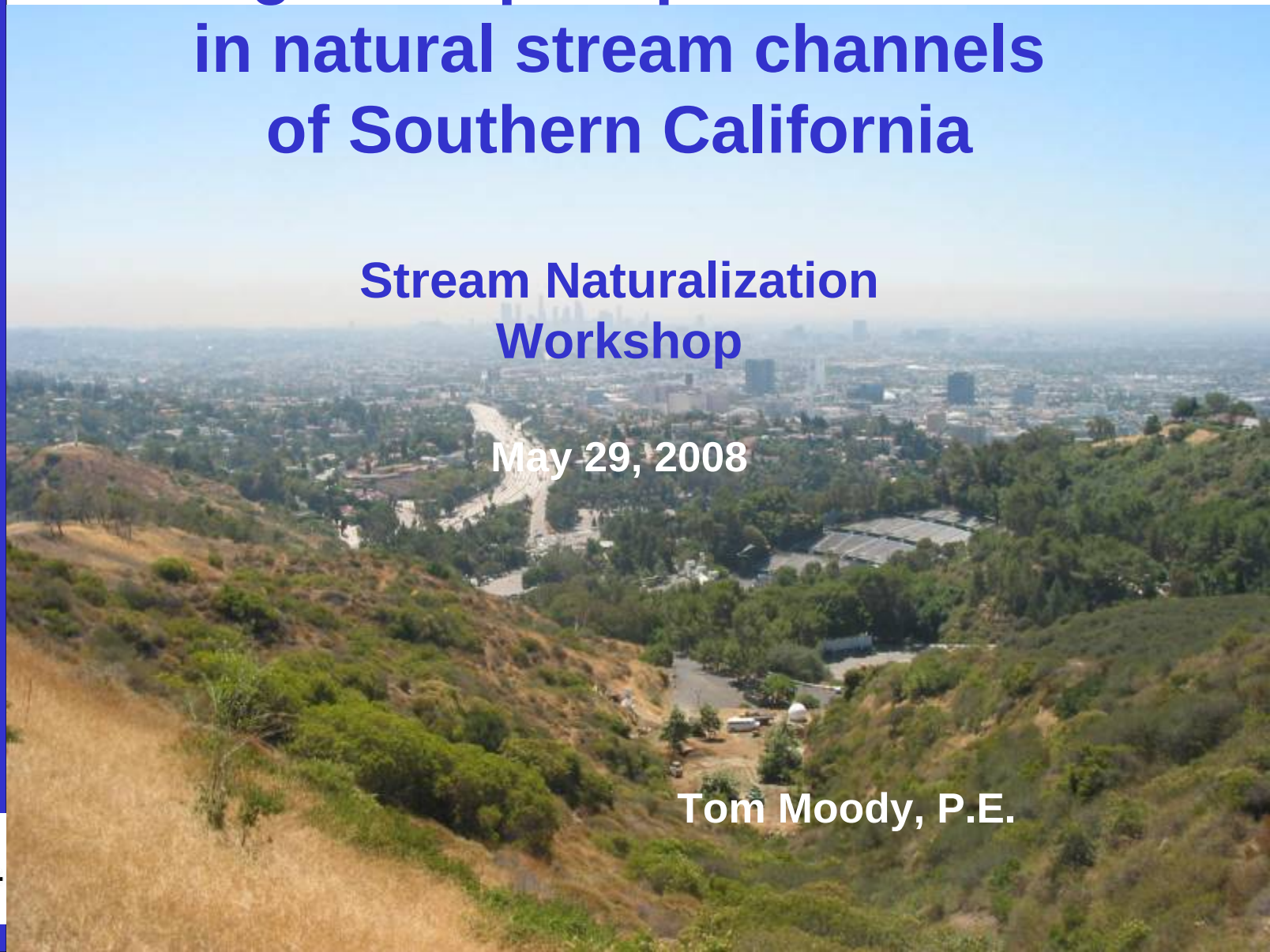
Introduction to geomorphic processes in natural stream channels of Southern California

Stream Naturalization Workshop

May 29, 2008

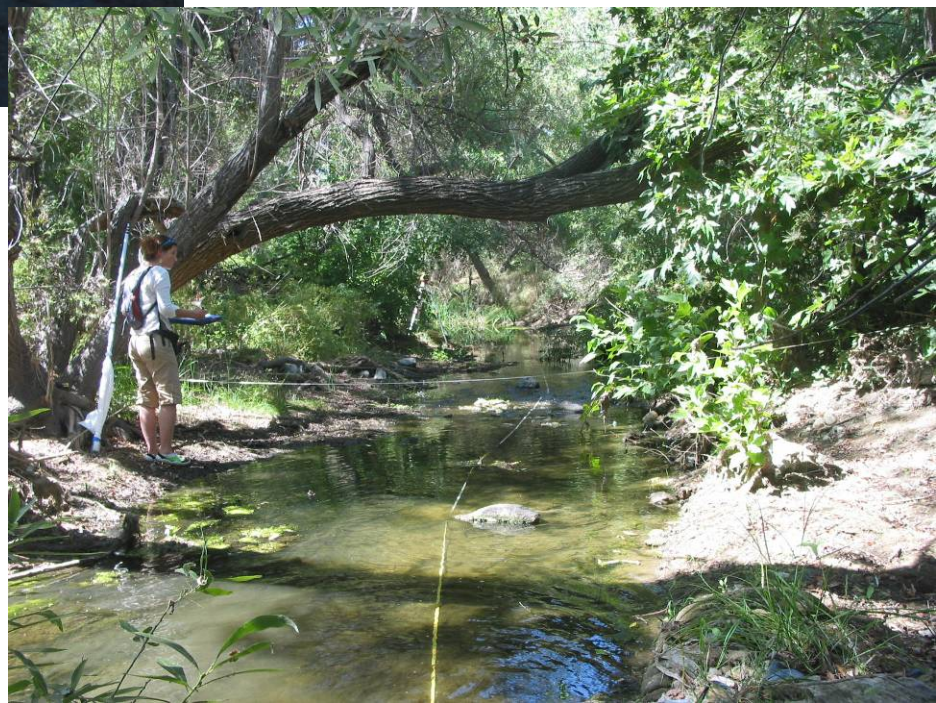


Tom Moody, P.E.

THE QUESTION…

How do we get from this…

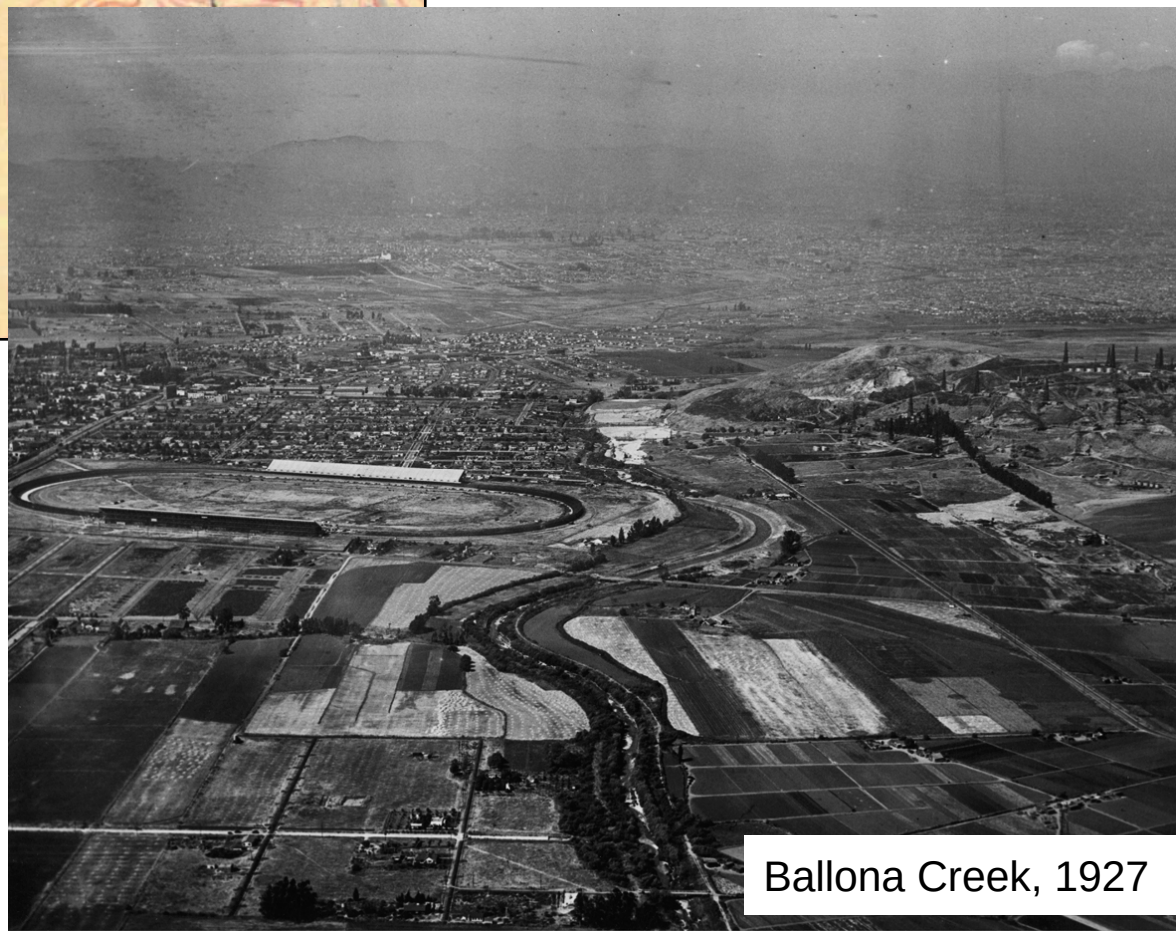
…to this?



HISTORIC CONDITIONS

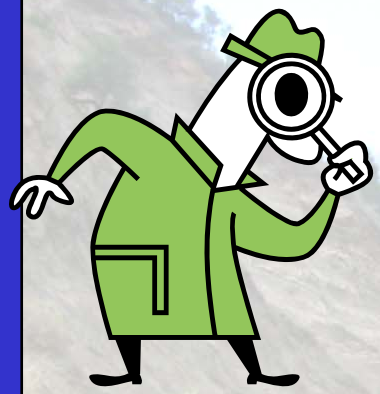
Maps, photos, anecdotal evidence, some field data; Useful for trends and causes

May not be applicable in today's climate, hydrology, development



Ballona Creek, 1927

ANALYTICAL APPROACHES



Quantifying/modeling fluvial processes

HEC-RAS

$Q = VA$

$R = A/WP$

$V = 1.486/n\ R^{2/3}\ S^{1/2}$

SAM

$\tau = \omega RS$

$Q = CLH_e^{1.5}$

$V = (8g/f)^{1/2}\ (R\ S)^{1/2}$

HEC-FFA

$V_1 = (2g\ (Z + H_a + y_1))^{1/2}$

$y_1/y_2 = ½\ (1+8F_1^2)^{1/2} - 1)$

HEC-6

$\rho_1/\gamma + x_1\ V_1^2/2g + z_1 = \rho_1/\gamma + x_2\ V_2^2/2g + z_2 + h_L$

$S_f = S_0 - \partial y/\partial x - V/g\ \partial V/\partial x - 1/g\ \partial V/\partial t$

The value of computer models is insight, not numbers.

Useful assessments….but where do we begin?

A VIEW OF THE RIVER

An empirical approach:

Natural stream channels are created and maintained by the water and sediment of their watersheds.

Stream Functions:

- Convey flood flows
- Transport sediment
- Dissipate energy

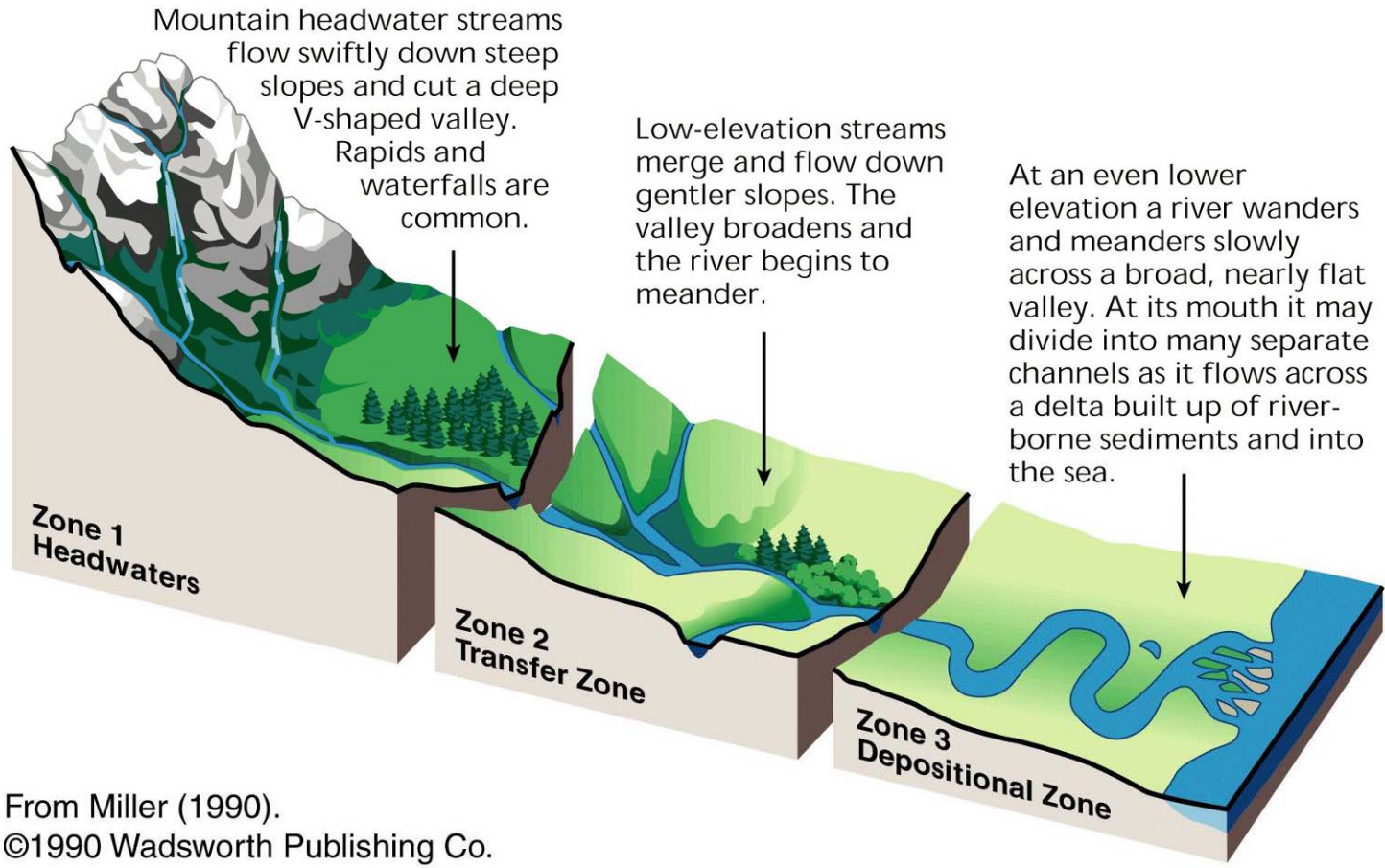
THE NATURE OF RIVERS

Channels are constantly adjusting to changes in sediment and water inputs.

FORM ⟷ FUNCTION

Stream channel form depends on:

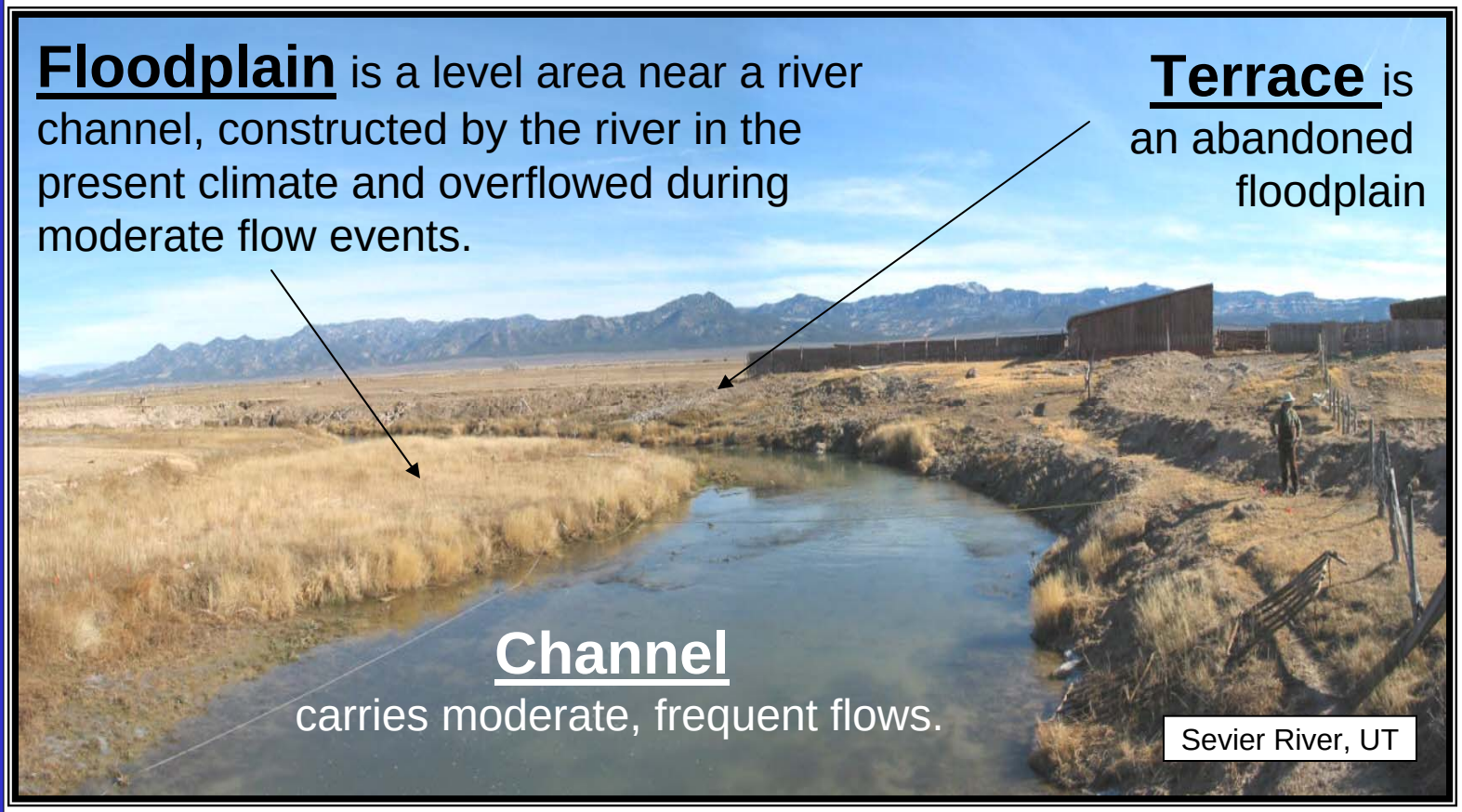
Watershed size
Landscape (valley, slope)
Geology
Climate

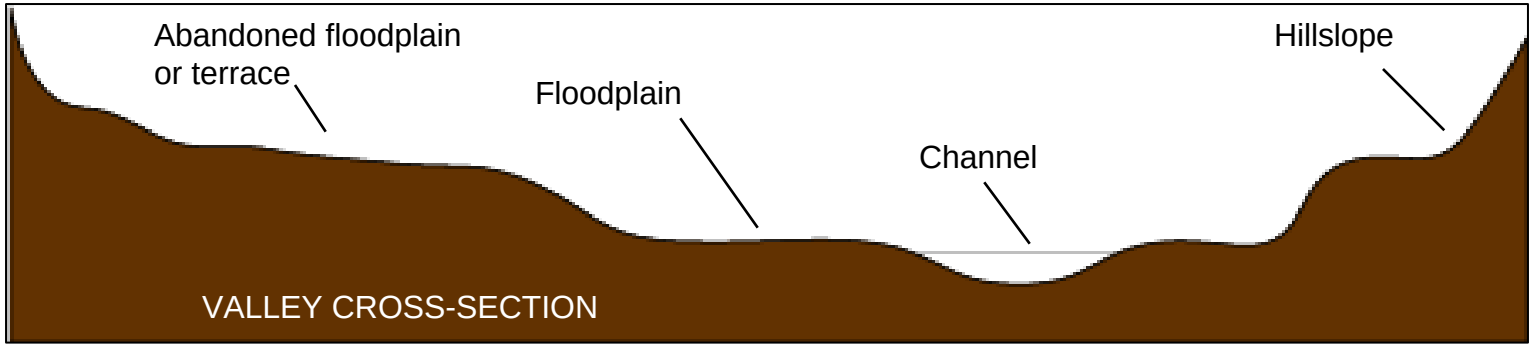


From Miller (1990).

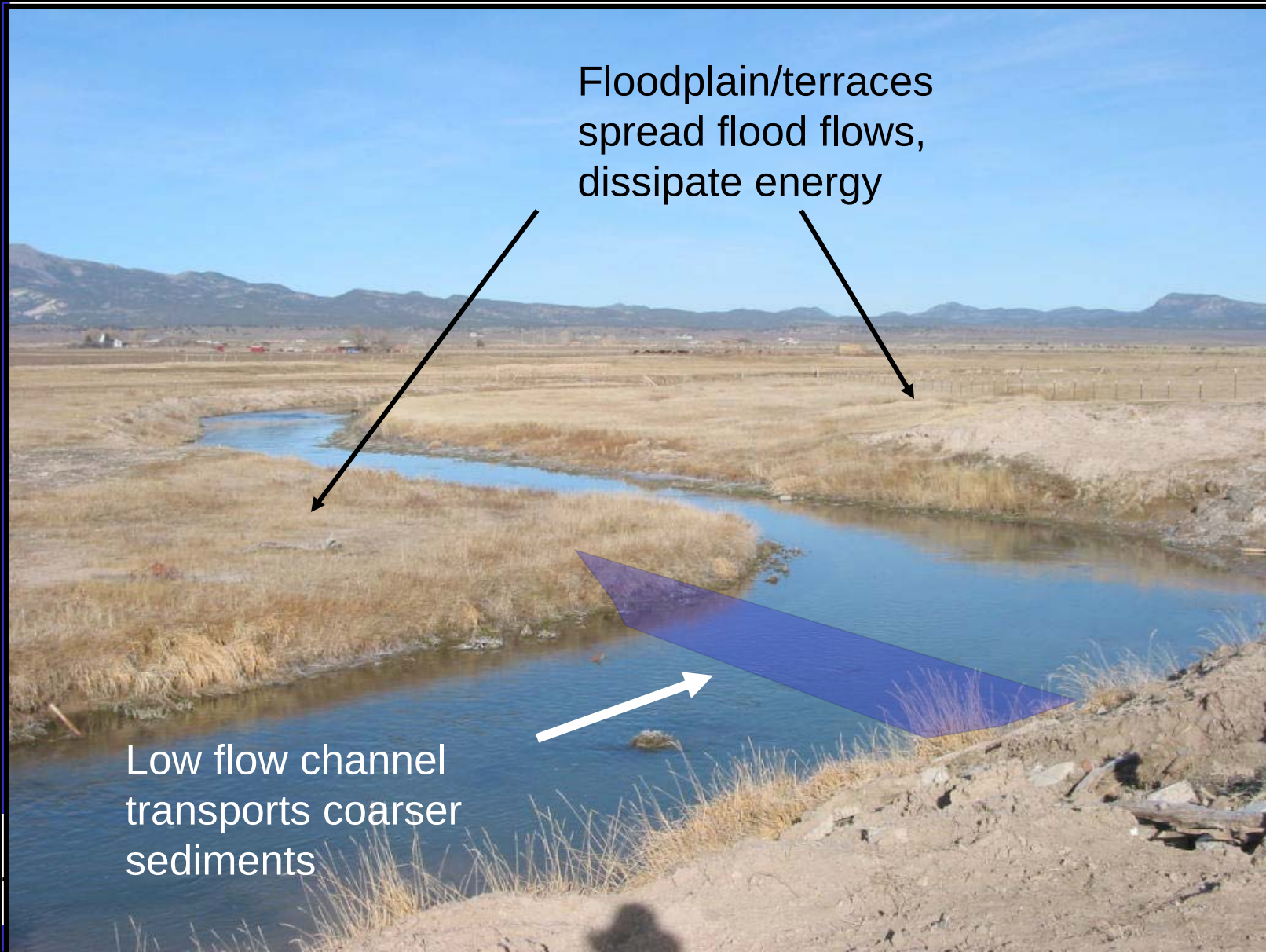
Stream Corridor Restoration: Principles, Processes, and Practices, 1998

CHANNEL DIMENSION





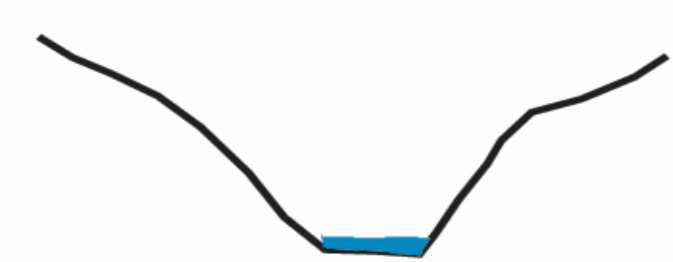
ALLUVIAL FEATURES



STEEP VALLEYS

Steep stream slopes (>4%)

V-shaped channels



MODERATELY STEEP VALLEYS

Steep stream slope (2- 4%)

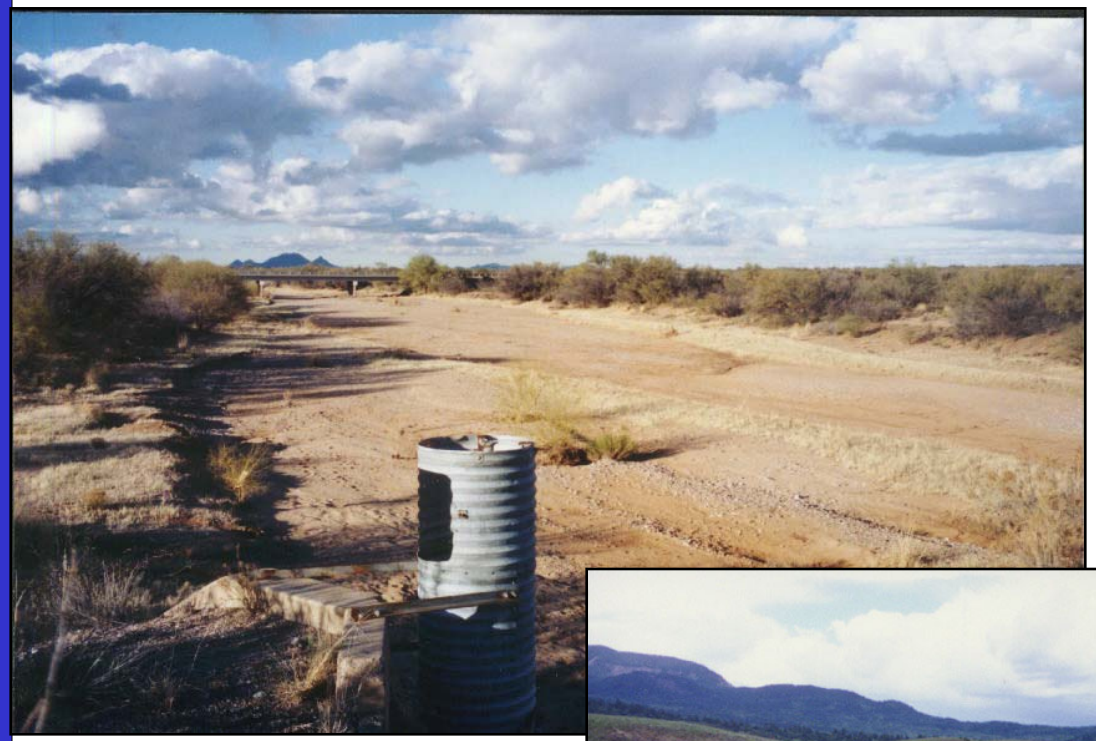
U-shaped channel

BROAD, LOW-GRADIENT VALLEYS

Gentle stream slopes

Broad overbank zones

SEDIMENT SUPPLY



Wide, shallow channels: greater sediment supply, weaker banks.

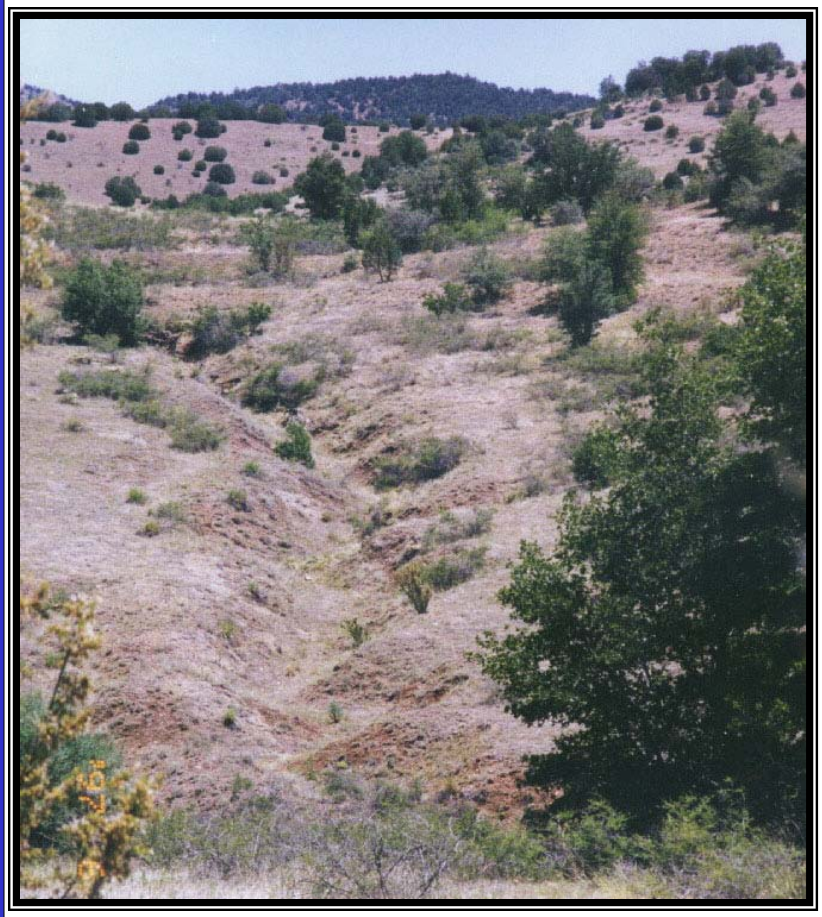
Narrow, deep channels: Lower sediment supply, stronger banks

CHANNEL PATTERN

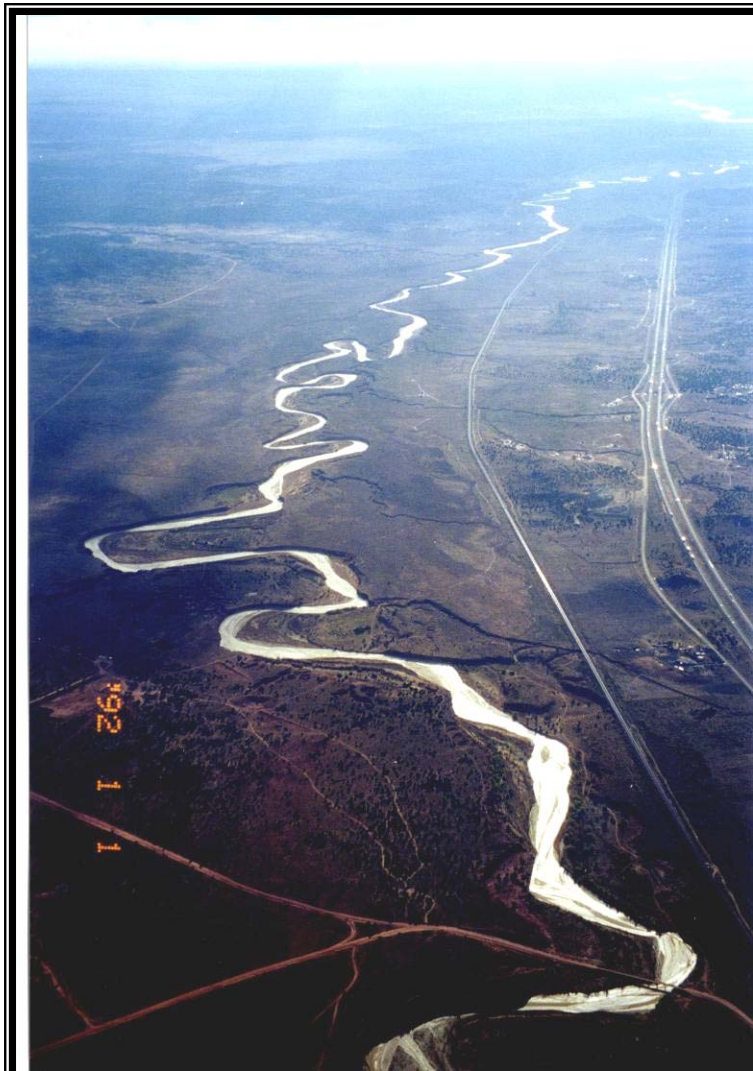
Channel meander dissipates energy.

Meander is inversely proportional to slope.

MEANDER & SLOPE



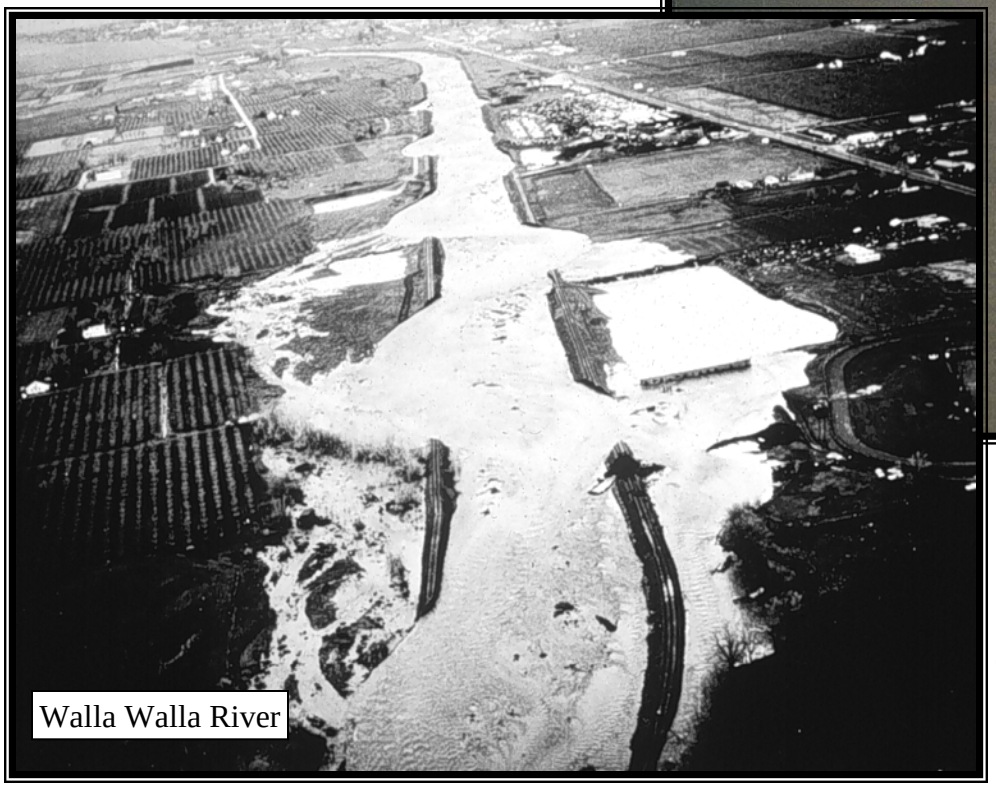
Steep channels;
little meander.



Low gradient channels;
More meander.

CHANNEL MEANDER

MEANDERING IS COMMON TO ALL STREAM CHANNELS

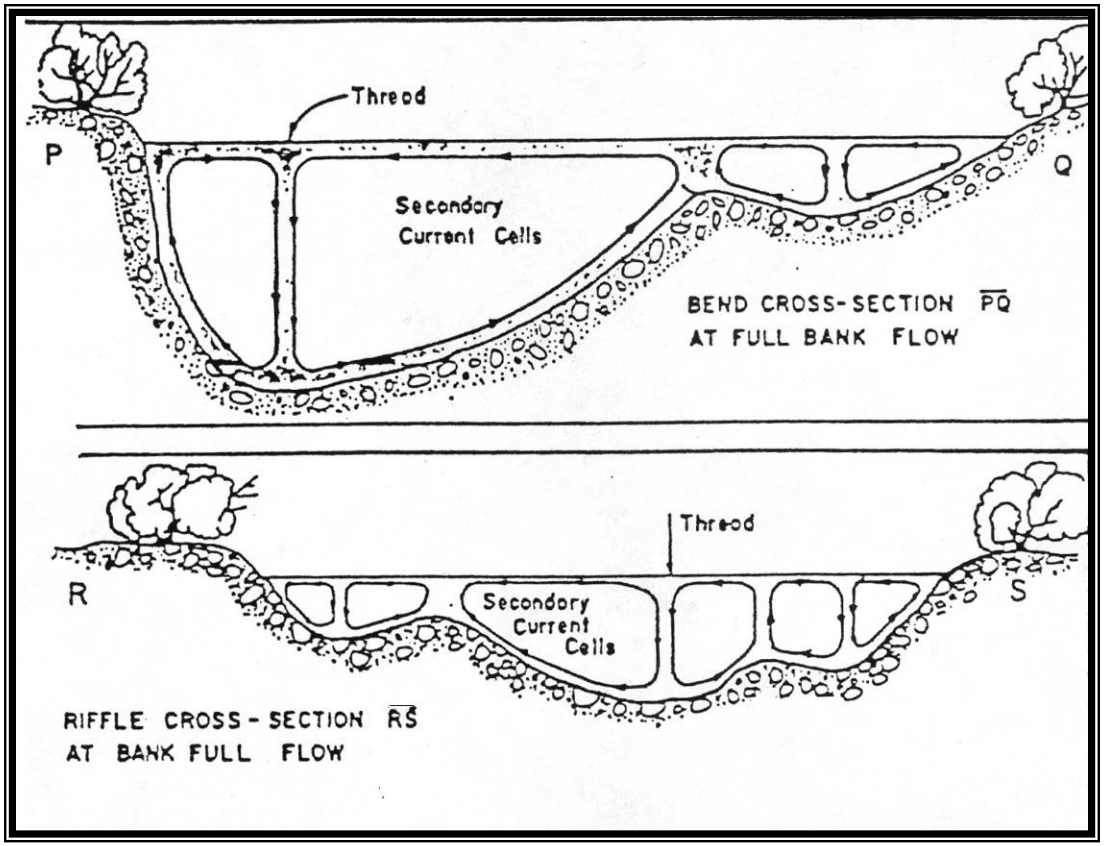


Walla Walla River

STRAIGHT CHANNELS WORK TO CREATE MEANDER

SECONDARY CELLS

These currents are responsible for scour and deposition along the channel.



(Leopold, Wolman, & Miller, 1964)

ALLUVIAL FEATURES

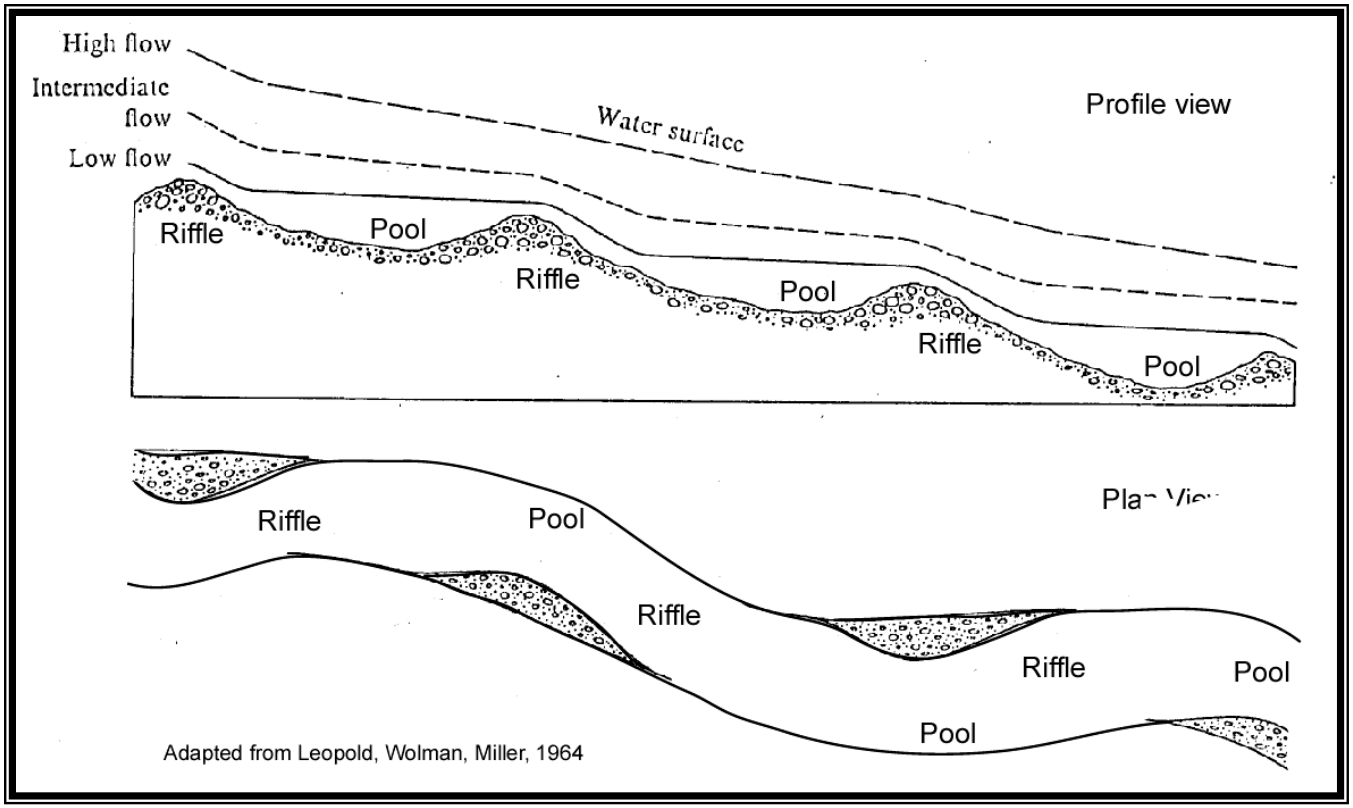
Point bars form on inside of meanders
Riffles located between meanders


Animas River, CO

Channels with less meander;
Less well-developed point bars.

CHANNEL PROFILE

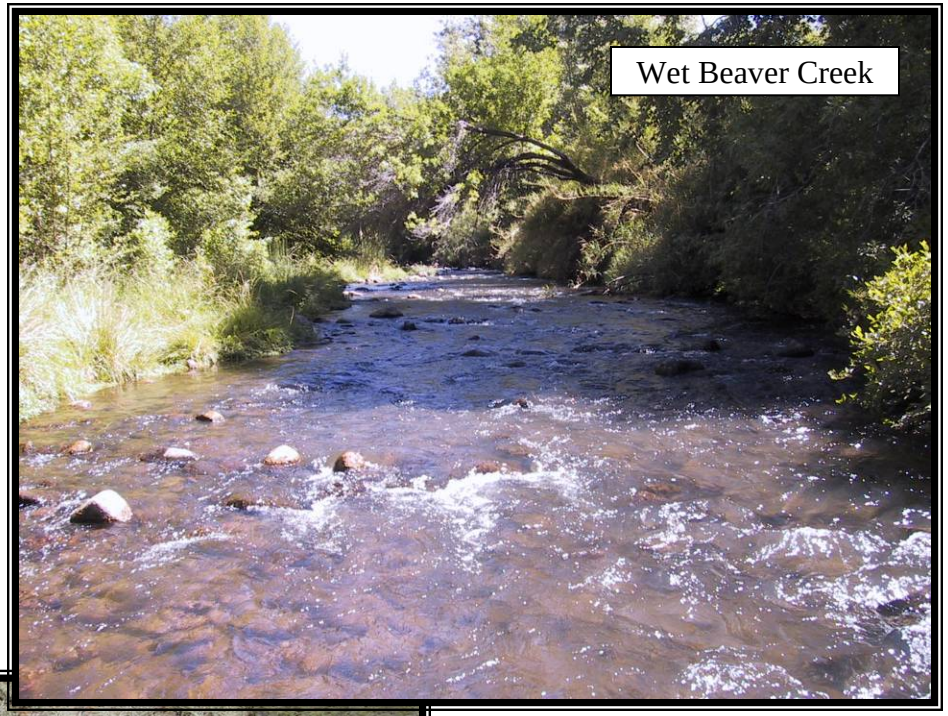
Channel profile is related to channel meander pattern.



CHANNEL BEDFORMS

Riffles, runs, & drops dissipate energy;

provide natural grade control

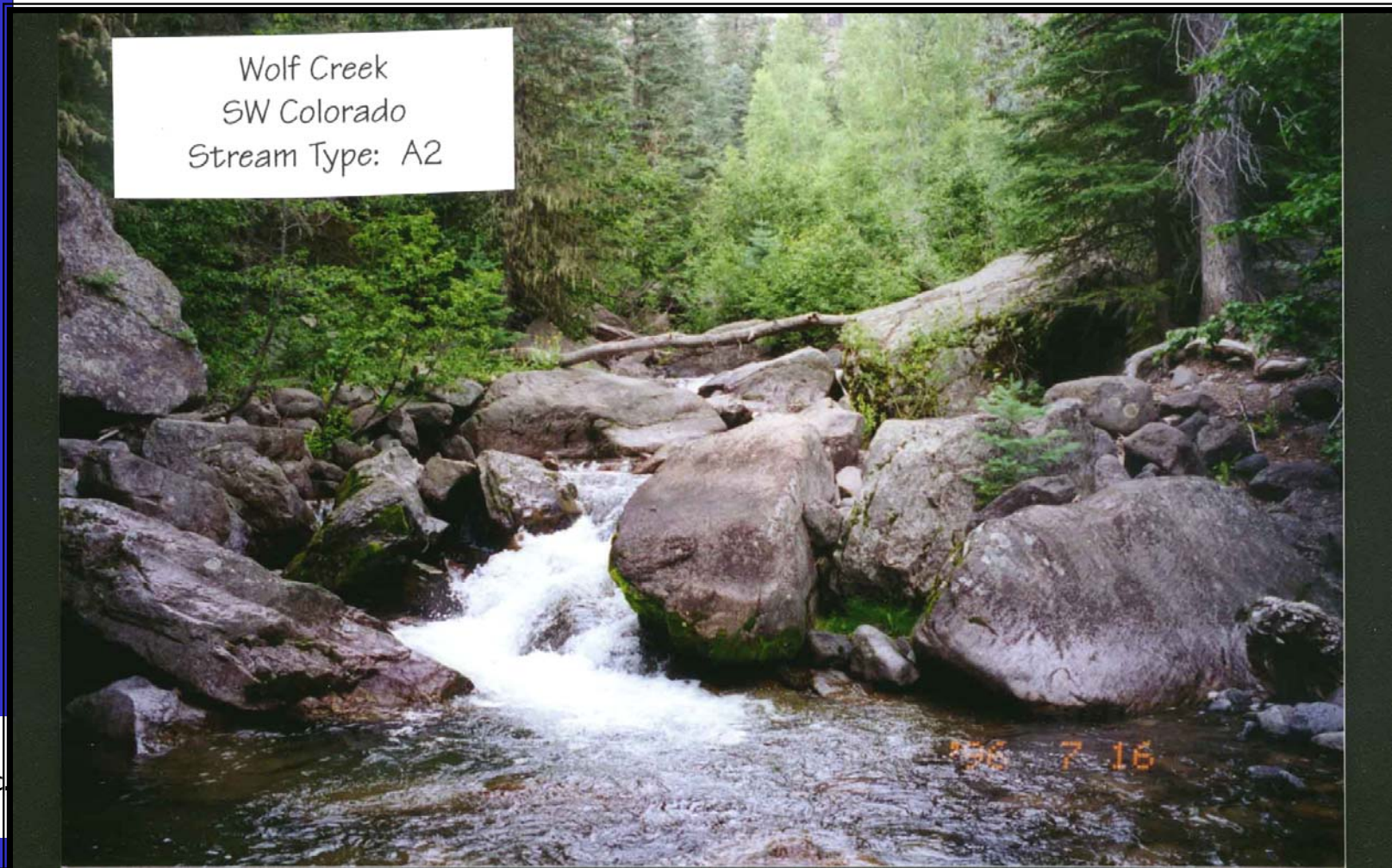


Runs and pools dissipate energy through turbulence

BEDFORMS & SLOPE

Step-pools in steep channels.

Slope > 4 %



Bear Wallow Creek

Continuous riffles in moderately steep channels.

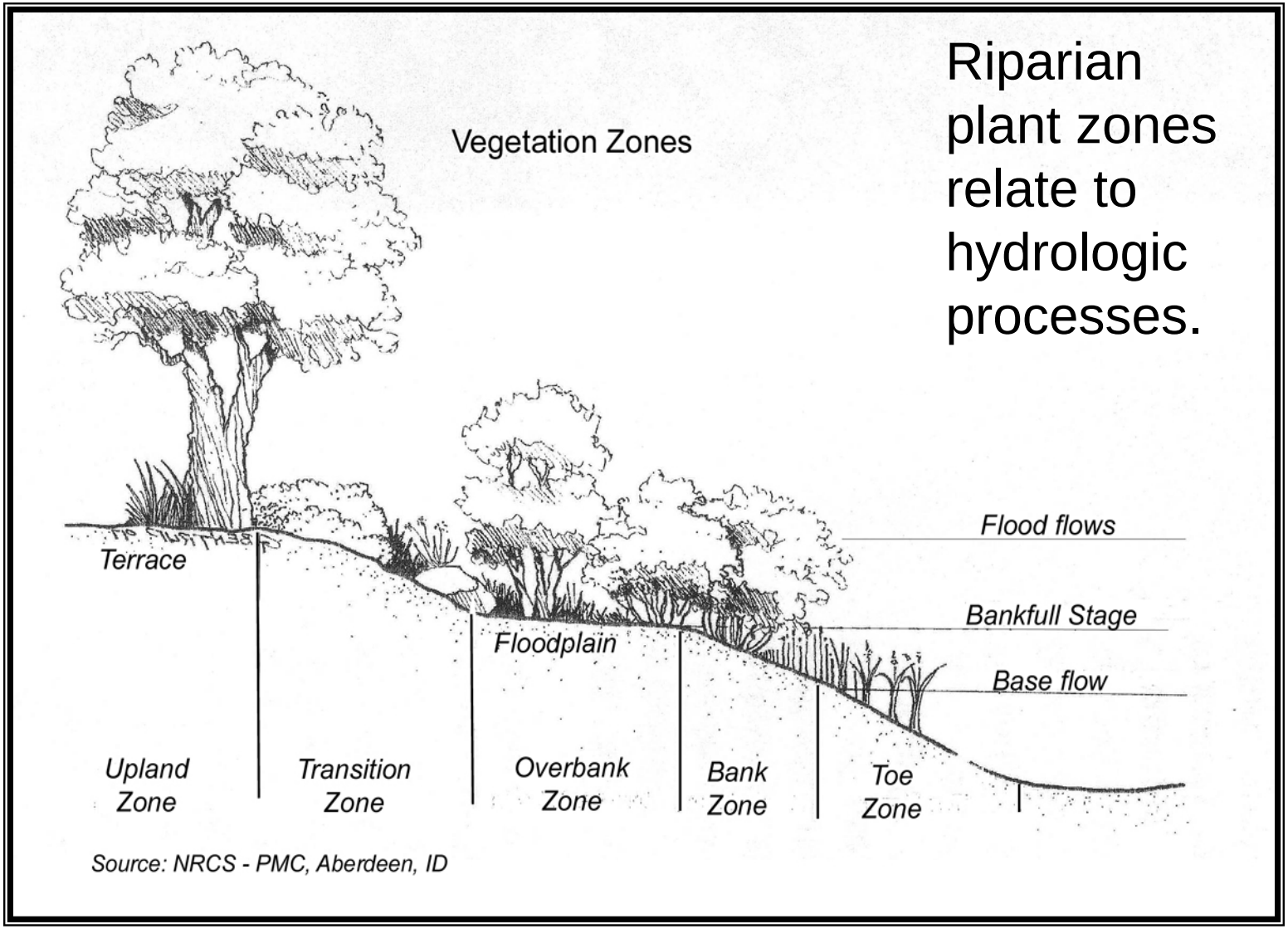
Slope 2 - 4 %

Riffle-pools in low-gradient meandering streams.

Slope < 2 %

In many regions, channel beds are dominated by sand.

RIPARIAN VEGETATION



Riparian plant zones relate to hydrologic processes.

PHYSICAL & BIOLOGICAL COMPONENTS

- Strengthens stream banks to reduce erosion.
- Enhance water quality
- Aesthetics/recreation
- Dissipates energy during high flows.
- Provides habitat for fish and wildlife.

GEOMORPHIC APPROACH

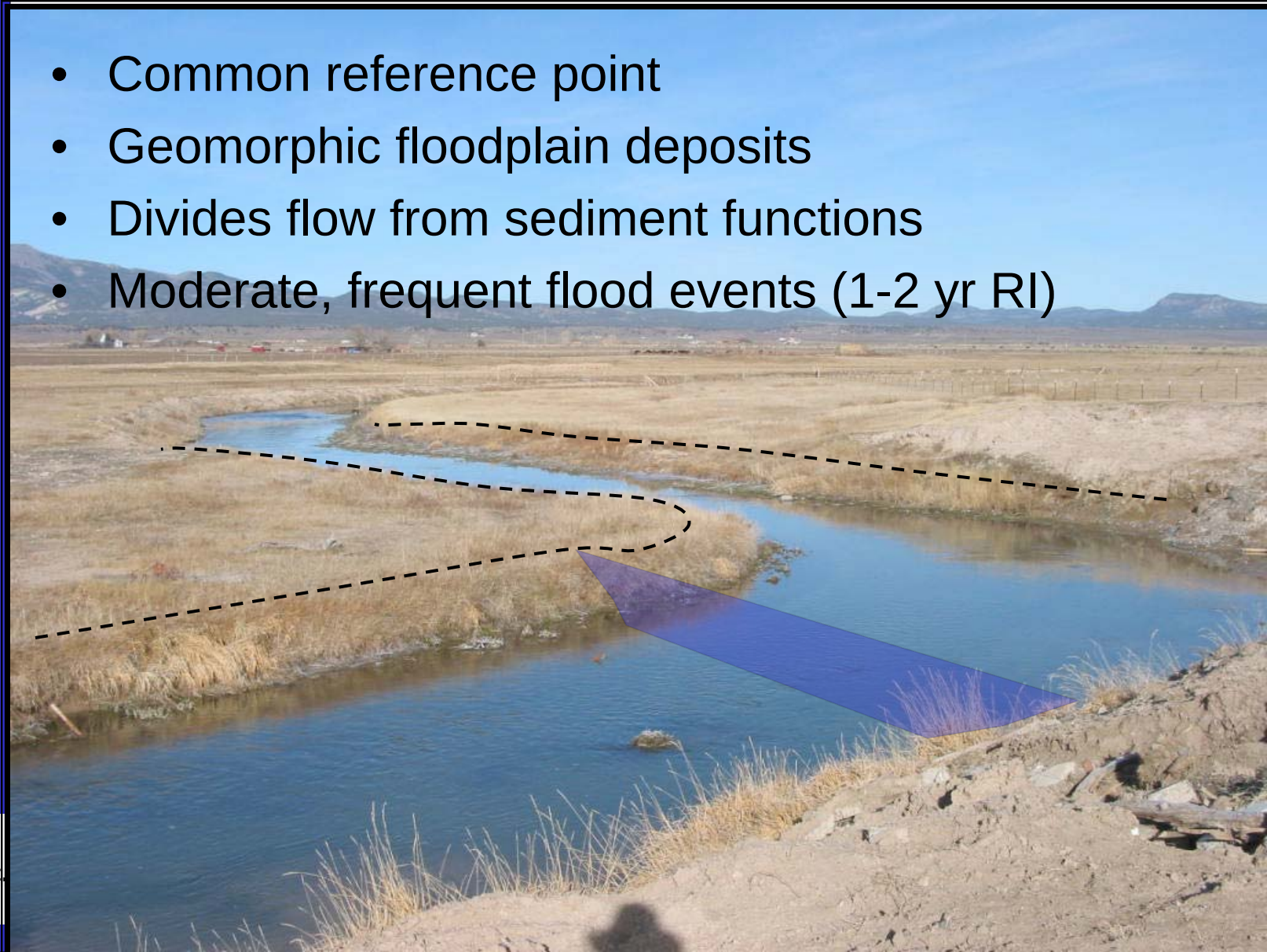
How can we quantify stream processes?

A rigorous empirical process for identifying and quantifying channel patterns to assess and predict present and future form and function.

Systematic research began with USGS scientists in 1950s

BANKFULL STAGE

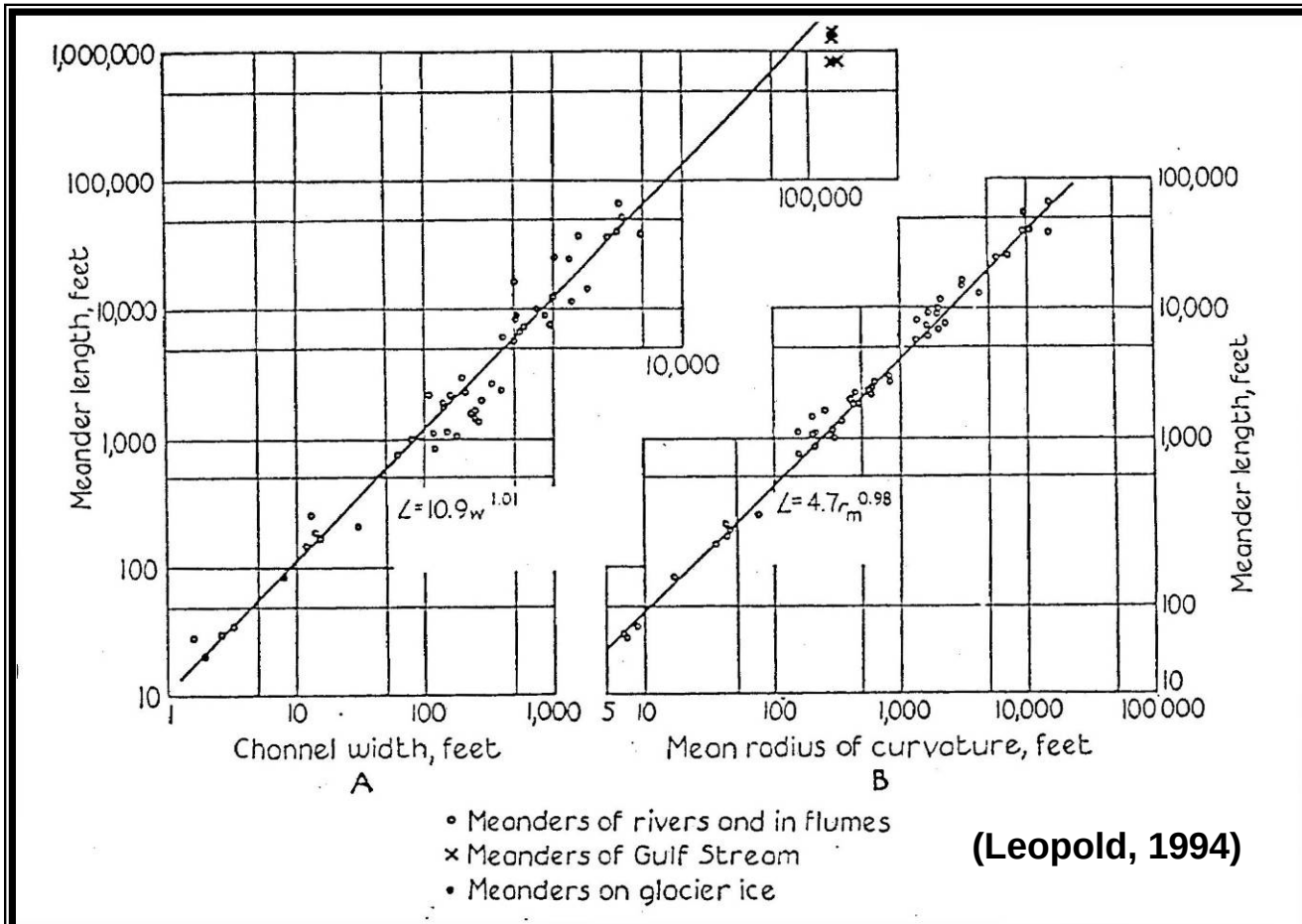
- Common reference point
- Geomorphic floodplain deposits
- Divides flow from sediment functions
- Moderate, frequent flood events (1-2 yr RI)



GEOMORPHIC PATTERNS

Meander length ~ 10.9 channel widths

Meander length ~ 4.7 Mean radius of curvature

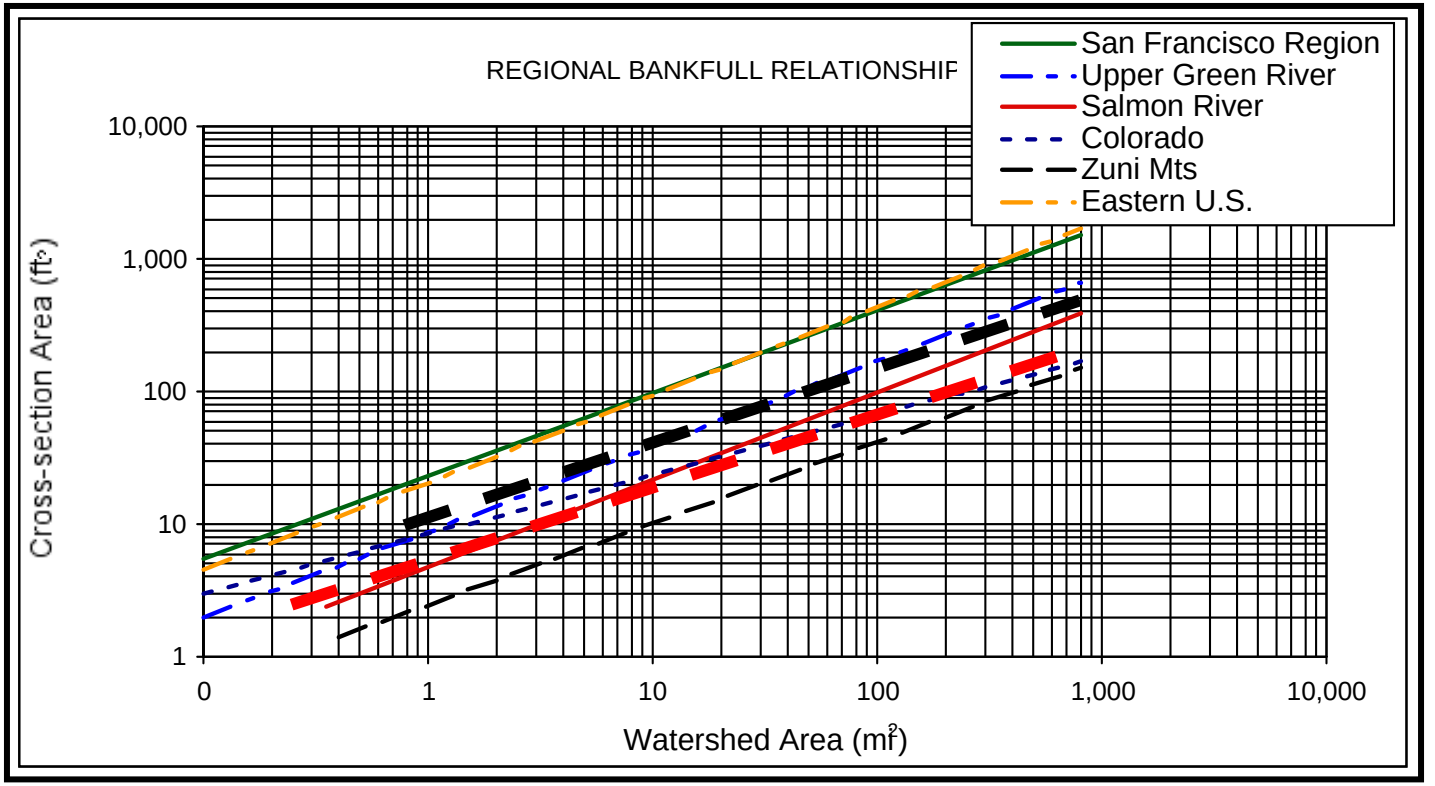


(Leopold, 1994)

GEOMORPHIC PATTERNS

Common reference point allows:

- Quantify channel dimensions
- Compare stream channels
- Identify regional patterns (250+ sites in Arizona, Utah, New Mexico)

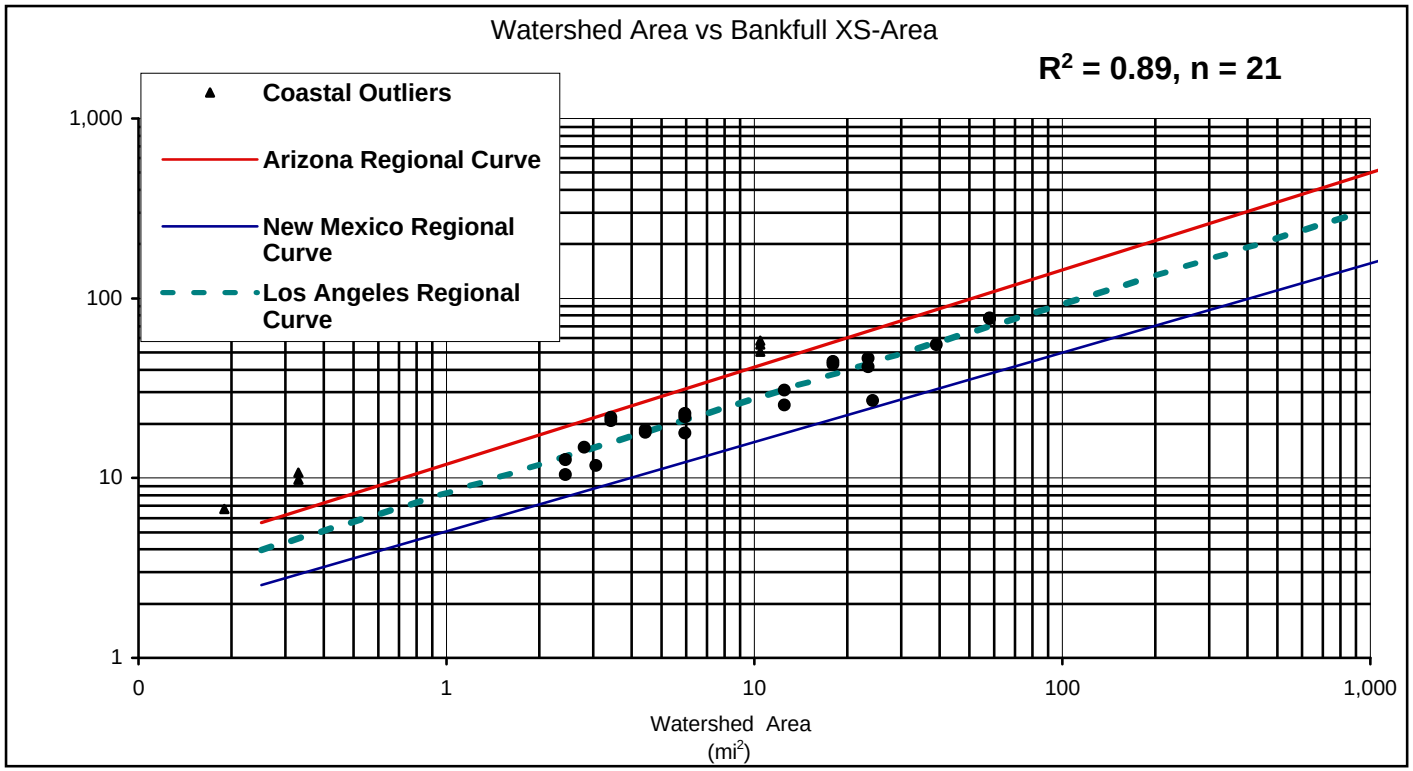


Source: Leopold, et al, 1964; Emmett, 1975; Jackson, 1994

SO CALIFORNIA STREAMS

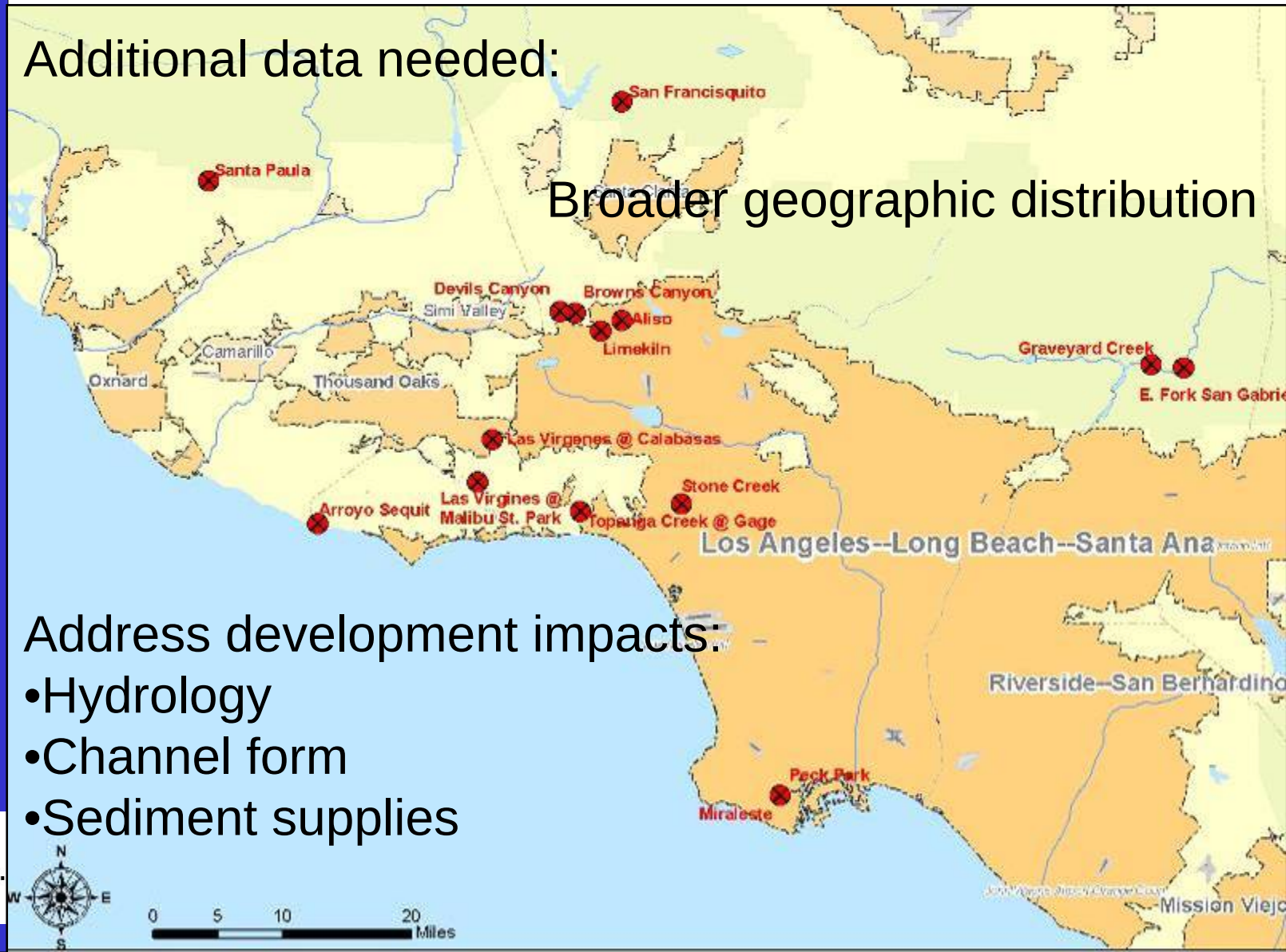
Are they unique? **No!**

Stream forms are similar to others
Data creates useful geomorphic patterns
Additional information needed.



Courtesy: Santa Monica Bay Restoration Commission

So California Sites



Natural Channel Design, Inc.

THE QUESTION…again

How do we fix this…

…or this?

EFFECTIVE APPROACHES

1. Historic photos, maps, anecdotes suggest changes and trends;
2. Regional geomorphic patterns suggests initial channel/floodplain dimension, pattern, & profile
3. Analytical modeling tests hypotheses and tests alternatives

Las Virgenes Creek, Courtesy Questa Engineering

WHERE TO START?

Regional geomorphic patterns can estimate:

- Size and shape of channel
- Width and height of floodplains
- Meander pattern
- Type and spacing of bedforms

So we don't end up with this!

DAYLIGHTING STREAMS

Gently meandering low-gradient streams with broad overbanks and robust riparian vegetation

Centinella Creek

Lafayette Park

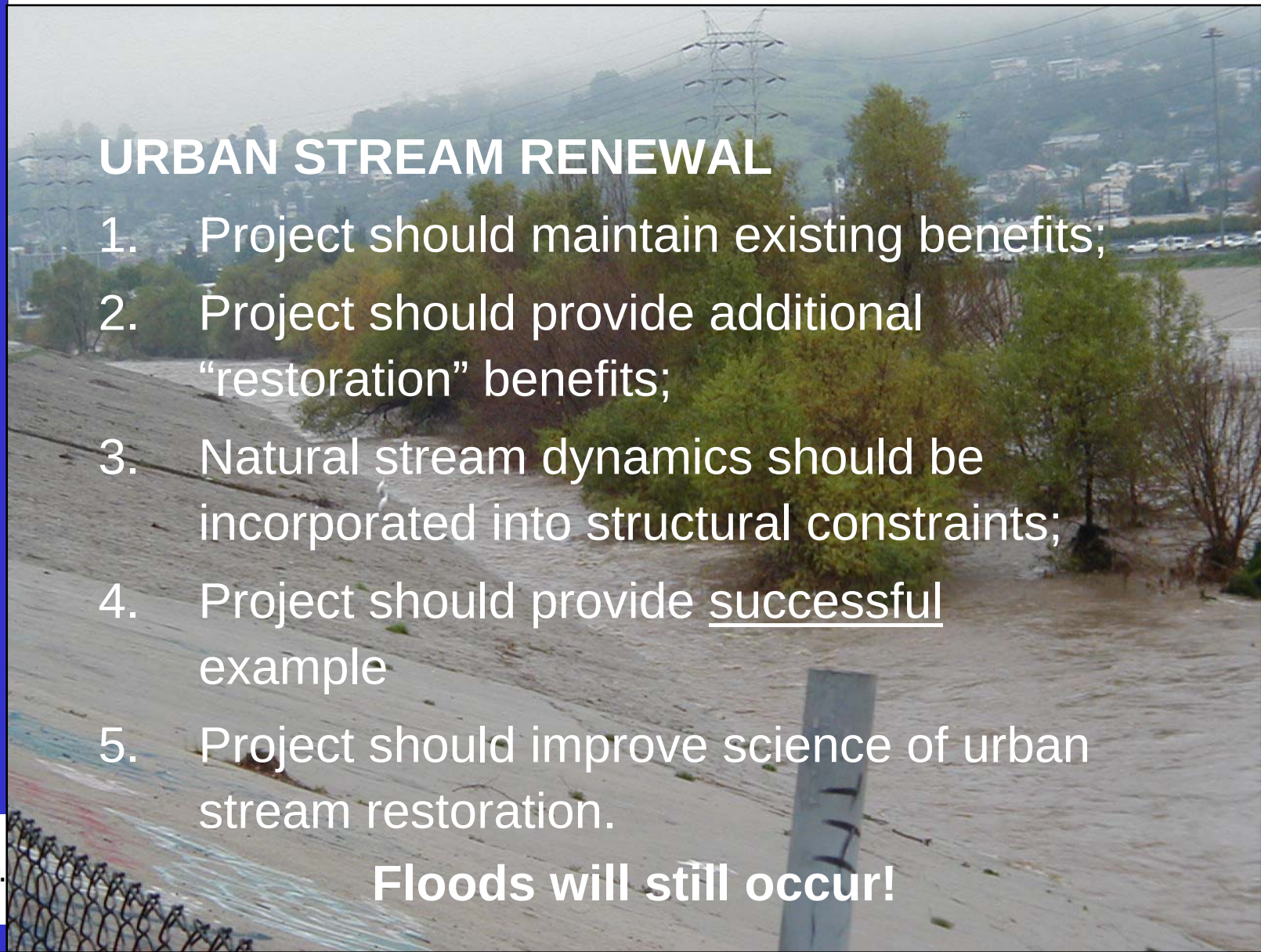
BALLONA CREEK

Provide sufficient width for flood protection;

Vegetation for habitat, aesthetics, water quality, energy dissipation

Graphic courtesy J. Hall, SMBRC

PRINCIPLES

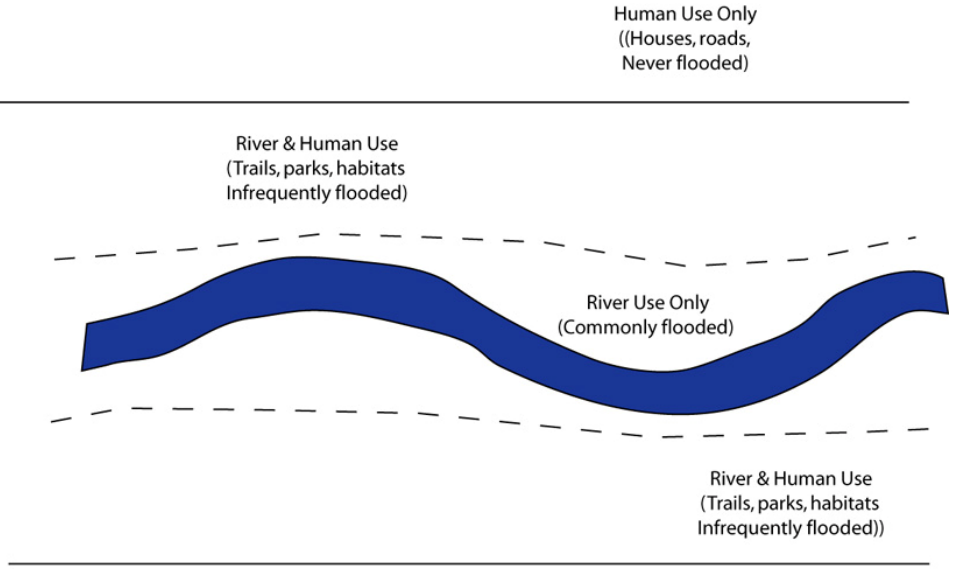


URBAN STREAM RENEWAL

1. Project should maintain existing benefits;
2. Project should provide additional "restoration" benefits;
3. Natural stream dynamics should be incorporated into structural constraints;
4. Project should provide successful example
5. Project should improve science of urban stream restoration.

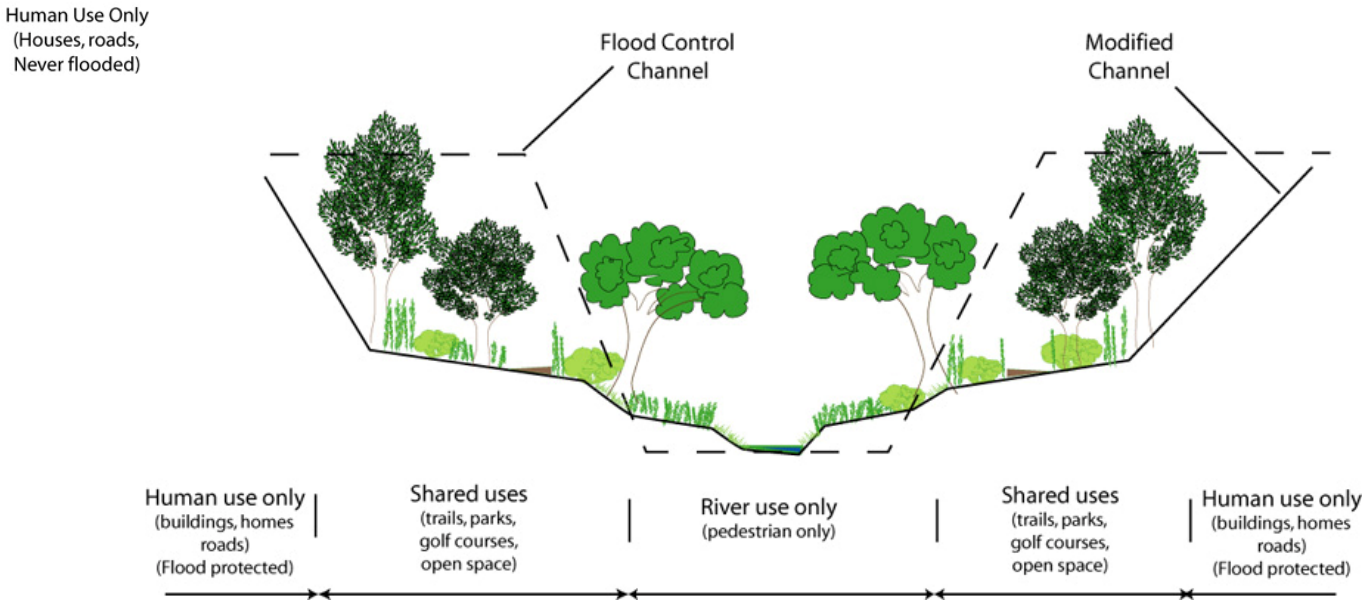
Floods will still occur!

PRINCIPLES



LIVING WITH A RIVER

Areas along a river can be shared



NATURAL CHANNEL PROCESSES

Stream channels are created and maintained by watershed processes.

Stream functions:

- –convey flood flows,
- –transport sediment,
- –dissipate energy

Alluvial forms adjust to changing watershed conditions

Riparian vegetation is essential to stream function

QUESTIONS?

There's always hope!

Tom Moody, P.E.

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