



September 26<sup>th</sup> & 27<sup>th</sup>, 2016  
Marriott Gateway on the Falls  
Niagara Falls, Ontario

NATURAL CHANNELS Linking Processes to Practice

# NCS Design Approach

## Biology/Ecology Primer

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# Biology/Ecology

- Key biological principles that are applied
- Need to speak the same language
- Link between geology, watershed dynamics, the channel and aquatic habitat
- How fish use channel morphology and hydrology for their life stages
- Importance of the stream corridor to aquatic habitat



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# Biological Processes – Points to Remember

- Animals are intrinsically linked to the physical, abiotic and biotic system they live in
- Simple cause:effect relationships are rare
- Temporal conditions and specific channel features play a significant role in biotic life cycles



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Temporal = related to a length of time. Can be over years, seasons, months etc...

# Comparing Two Major Types Of Ecologists

- Bio-ecologists;
  - Perceive and define an ecosystem based upon the use by the organism (bio-centric);
- Geo-ecologists
  - Perceive and define an ecosystem based upon the geo-physical system that defines the opportunities for an organism (geo-centric)



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# Using Different Language

- Aquatic Biologist Parameters
  - Species, length, weight, scale count, velocity, food composition, substrate size, instream cover, spawning substrate composition, maximum/minimum/optimum temperatures
- Geomorphologist Measurement Parameters
  - Width:depth ratio, bankfull discharge, radius of curvature, meander geometry, amplitude, stream slope,  $D_{50}/D_{84}$ , bedload transport
- Engineers Measurement Parameters
  - Hydraulic radius, Reynolds Number, Froude Number, stream power, shear stress, flow frequency, magnitude, etc.



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# BUT.....

ALL THESE VARIABLES CAN APPLY TO THE SAME  
STREAM!.....

And all could be relevant in the management and  
restoration of a particular stream....

therefore we must create context in order to link  
these variables



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Geology  
provides the  
rock and  
structure



Climate  
creates the  
weather,  
weathering  
and water



Vegetation modifies  
water flow over and  
through the  
watershed



The site creates the channel  
form that provides habitat and  
stability

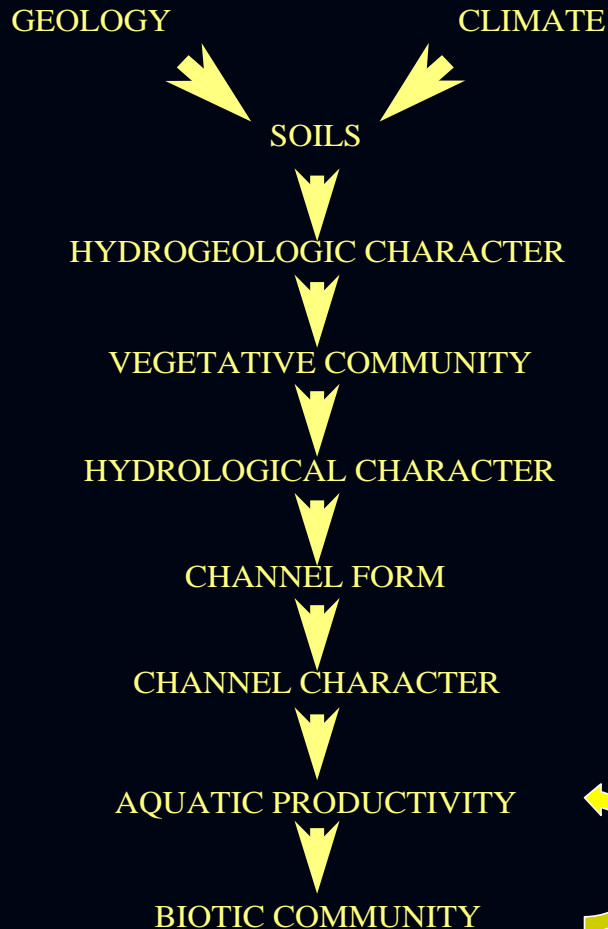
The valley directs and concentrates  
surface and groundwater

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# Driving our Aquatic Ecosystems

## RELATIONSHIP OF GEOLOGY, CLIMATE AND STREAMS



- At various spatial scales, there are drivers that exert direction and control
- These control conditions at finer scales that ultimately provide for the life of animals in our watersheds



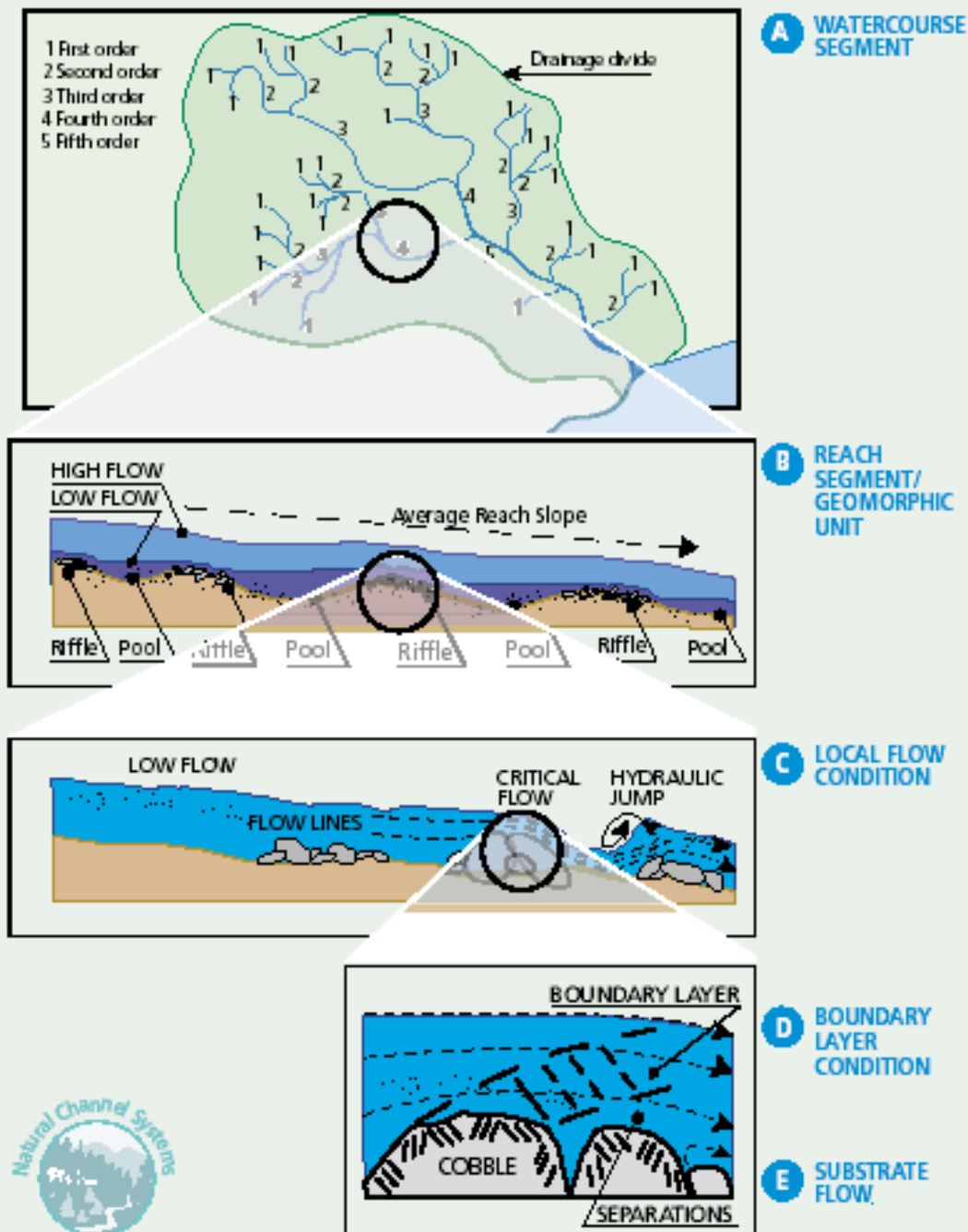
# FROM FISH SCALES TO TEMPORAL & SPATIAL SCALES

- **The Role of Geology**

- Conditions the potential for movement of water over and through the watershed
- Conditions the chemical make-up of the water
- Conditions the potential for sediment composition to the river and watershed
- Conditions the potential fish community distribution
- Creates the opportunities for various communities of animals and plants



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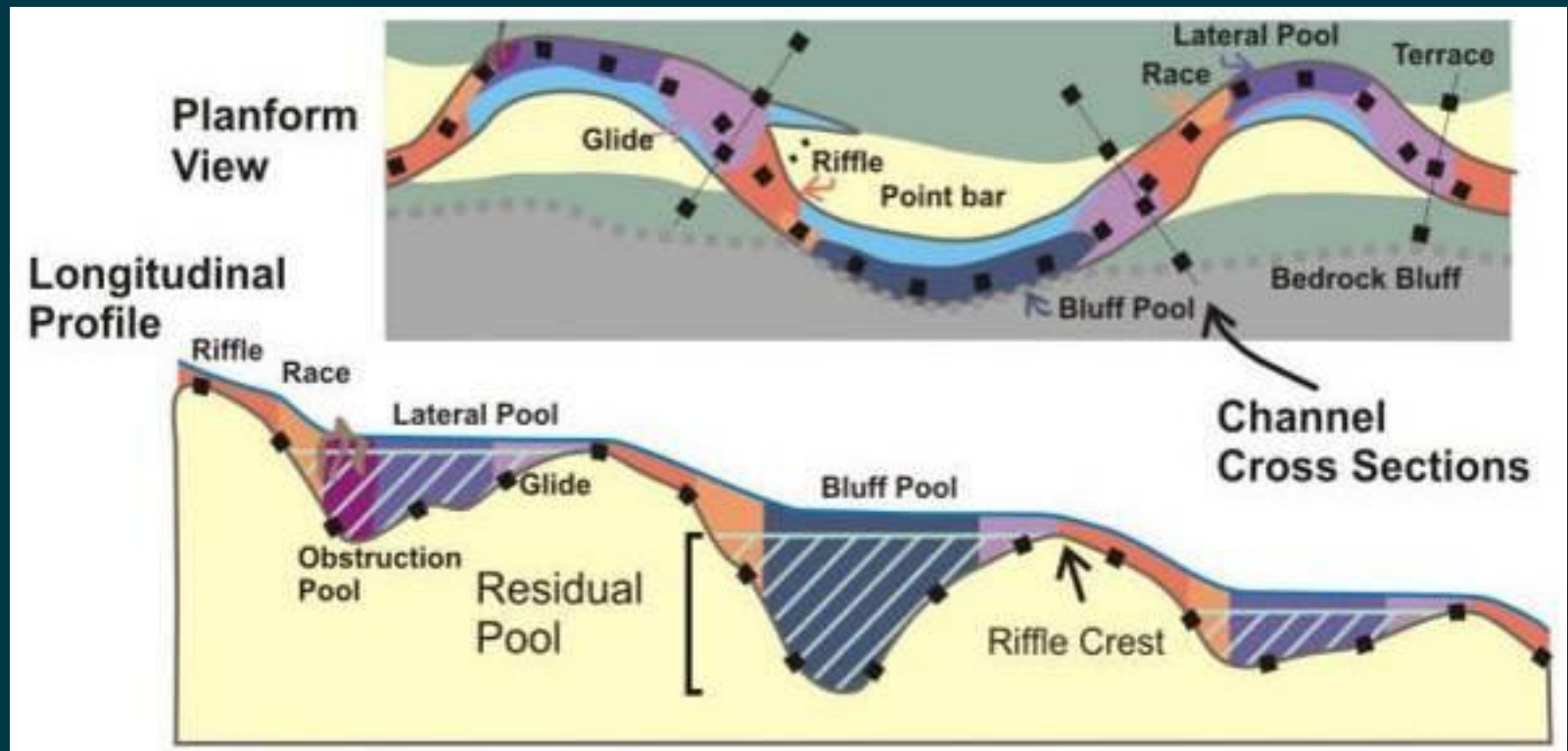
**Animals operate at multiple scales (e.g. migration, feeding, reproduction).**

At a site or local level, look upscale to understand the reach and location in the watershed and downscale to examine the specific hydraulic features

**From: Newbury and Gaboury 1993**



# Species Use Habitat In Four Dimensions And Often Specific To The Species

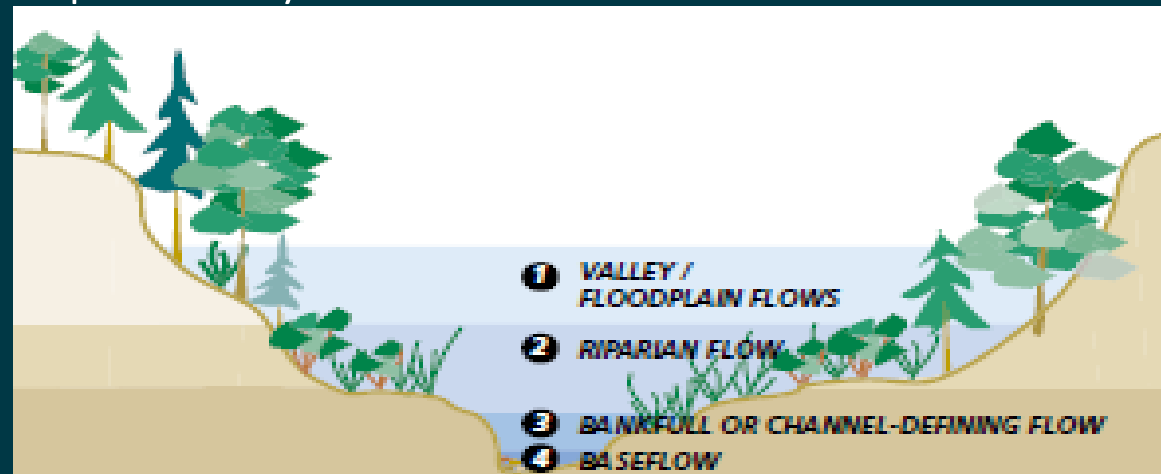


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# Flow Stages and Ecological Interactions

1. Baseflow Flow – Minimum living space and limits annual productivity
2. Bankfull Flow – Channel forming flow that creates baseflow channel structure
3. Riparian/Floodplain Flow – Helps influence bankful channel forming flow
4. Valley Flow – Sculpts valley form and function



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# Habitat Use In Rivers

- There are general elements important to a fishes survival in rivers:
  - Water Quality and Quantity (including temperature)
  - Food
  - Shelter (from water current, predators, etc.)
  - Space (watershed and channel structure and connectivity)

For each element we must understand the habitat requirement of the species or community



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# All Habitats Are Not Created Equal:

Defined as locations (in space and/or time) which structure or control life cycle dynamics of a community or species (e.g. pike spawning in floodplains)

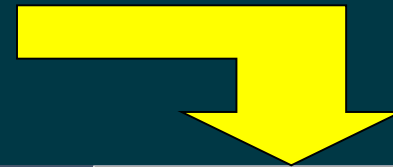


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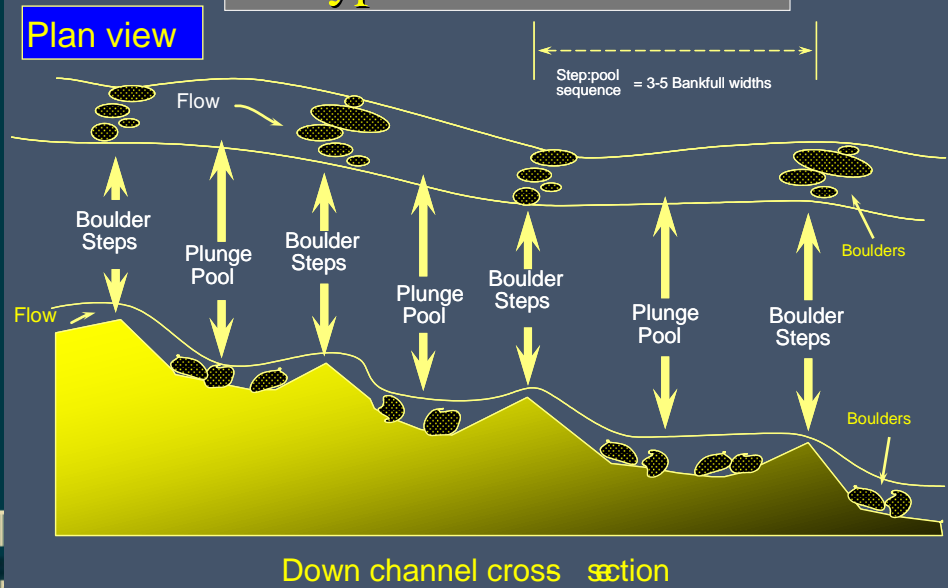


Higher Gradient, “B” Channels  
provide extensive cover for  
juvenile and adult fish,  
especially trout



These channel forms dissipate energy, mostly vertically, creating “pocket water”. One main limitation is that they do not provide reproductive habitat for most species of fish.

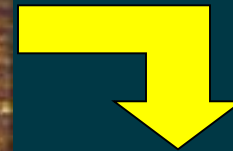
### Form and Characteristics of Typical “B” channels



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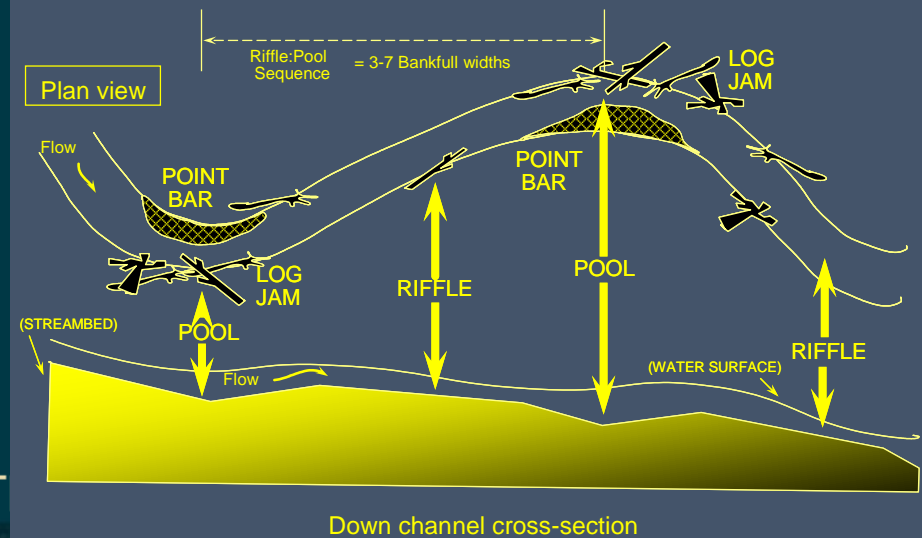


“C” channel forms are our typical Riffle:Pool streams, providing shallow, long riffles, deep pools with wood debris and diverse habitat



### Form and Characteristics of Typical “C” Channels

These stream types dissipate energy in two major directions, vertically and horizontally. Therefore the repeat sequence is longer. These are the most typical forms around the world. Most freshwater fish likely evolved in these types.

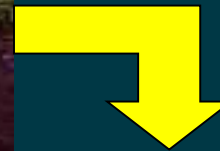


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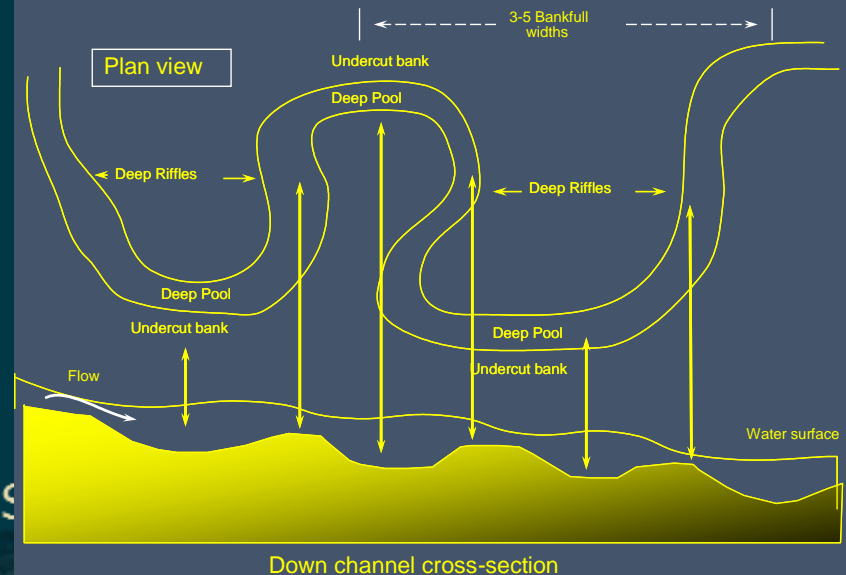


“E” Channels are extremely narrow and deep creating enormous amounts of habitat for juvenile and adult fish



Found in flat bottomed valleys in wetlands. Dissipate energy purely through lateral roughness at high flows. The channel is held together by the deep roots of wetland shrubs and grasses. Ideal for a few specialized fish species (e.g. brook trout or northern pike).

### FORM AND CHARACTERISTICS OF TYPICAL "E" CHANNELS



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# Land:Water Linkages

Healthy riparian zones encourage the river to develop a narrower, deeper profile creating excellent channel heterogeneity (i.e. deep pools; shallow riffles)



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TABLE 9-1: STEP 4

STEP 4

## ASSESSMENT OF CHANNEL RESPONSE: Functional assessment: what are the current channel dynamics and ecological functions?

### PURPOSE

- detailed assessment of processes and channel dynamics affecting conditions
- determine if any aspects of disturbance are controllable
- to gather information of existing flow regime and sediment transport dynamics
- determine present conditions of fish communities
- determine physical, chemical and/or biological processes that are inhibiting distribution and abundance of expected community types
- determine the extent of habitat available to the aquatic communities both within and amongst contiguous reaches (and watershed)

### DATA SOURCES

- information on cross-sectional form
- planform / survey - mapping information
- characteristics of bank and sediments
- geophysical assessment (borehole into bed)
- type of sediment on floodplain
- flow measurements and quality of water
- future infrastructure plans, routs
- any information of existing problems and their causative processes
- invertebrate sampling and riparian zone analysis (flow regimes, bank characteristics, riparian zone characteristics, community and habitat)

### ANALYSIS *(click in discipline's area to view related appendix: extended technical analysis)*

#### Engineering

- hydrologic analysis of channel conditions
- bank stability
- geotechnical information

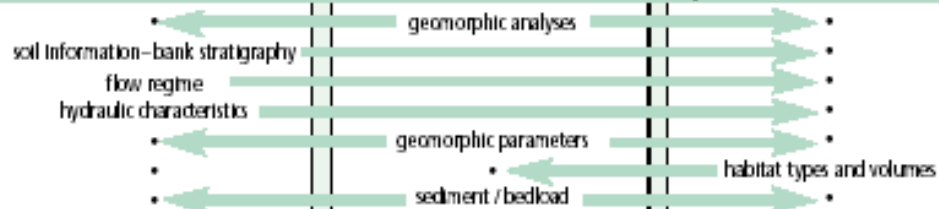
#### Geomorphology

- analysis of channel dynamics (hydraulic analyses)
- hydraulic geometry
- regime analysis
- sediment / discharge
- energy gradients
- identify sediment sources

#### Biology/Ecology

- assess aquatic health of various reaches (study, contiguous, reference)
- characteristics contiguous - plan and cross-section form
- sediment characteristics
- community and habitat availability

### LINKAGES: *flow of information between disciplines*



### OUTPUT

- define scale of effect and channel sensitivities
- nature of channel conditions and potential for change or response to disturbance
- will be able to consider potential changes to form and resulting problems or impacts
- identify any design implications
- specific information on rate of change
- an understanding of physical processes in reference reach and role of study reach in supporting biological community

### SCALE

reach to site

### DURATION

several weeks to 5 years (depending on data needs and availability)

Development of specific design methods for each discipline and an example for each step on how they interact.