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Fluvial System Concepts and Their Application in Greenfield Stream Corridor Realignment

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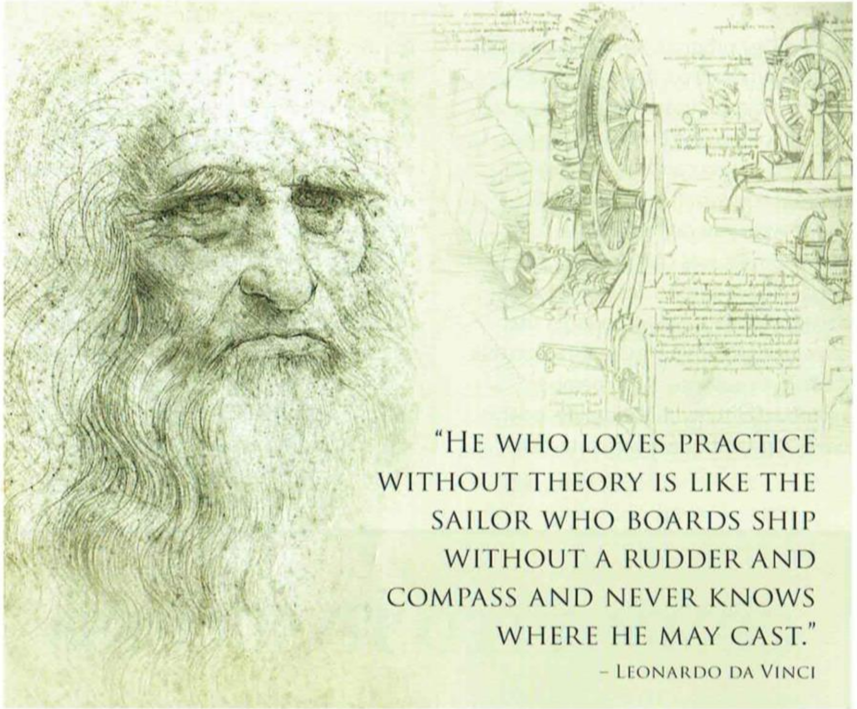
GEO Morphix Ltd.

Overview

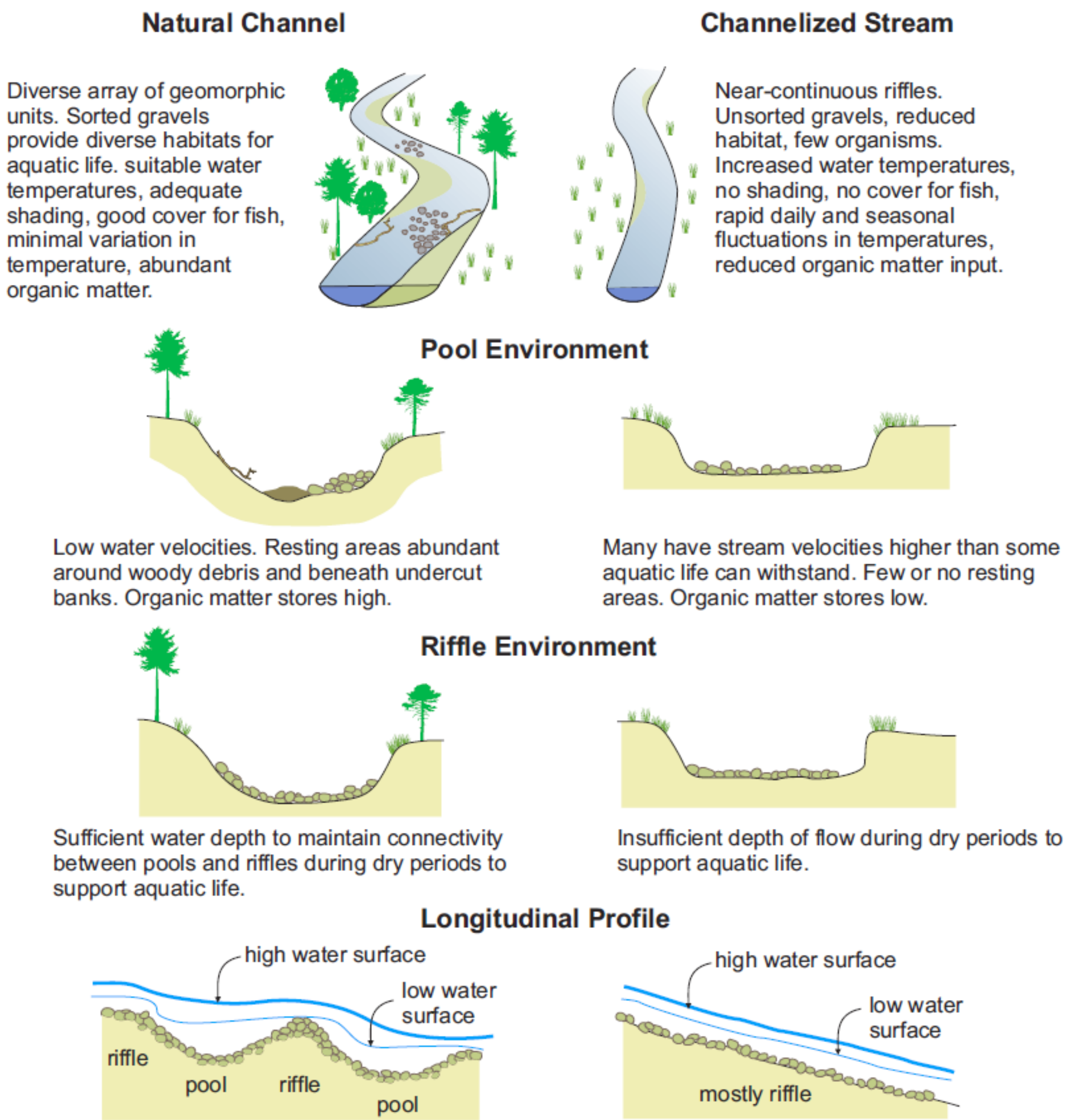
- Major realignment of valley corridors to facilitate development is an evolving applied science
- Realignments provide a unique opportunity to reset systems and address more substantive impacts to watershed function and the fluvial system
- Unlike restoration and erosion mitigation projects in confined urbanized systems, these projects can result in dynamic, self-maintaining landscapes



APEGM, The Keystone Professional, Spring 2015

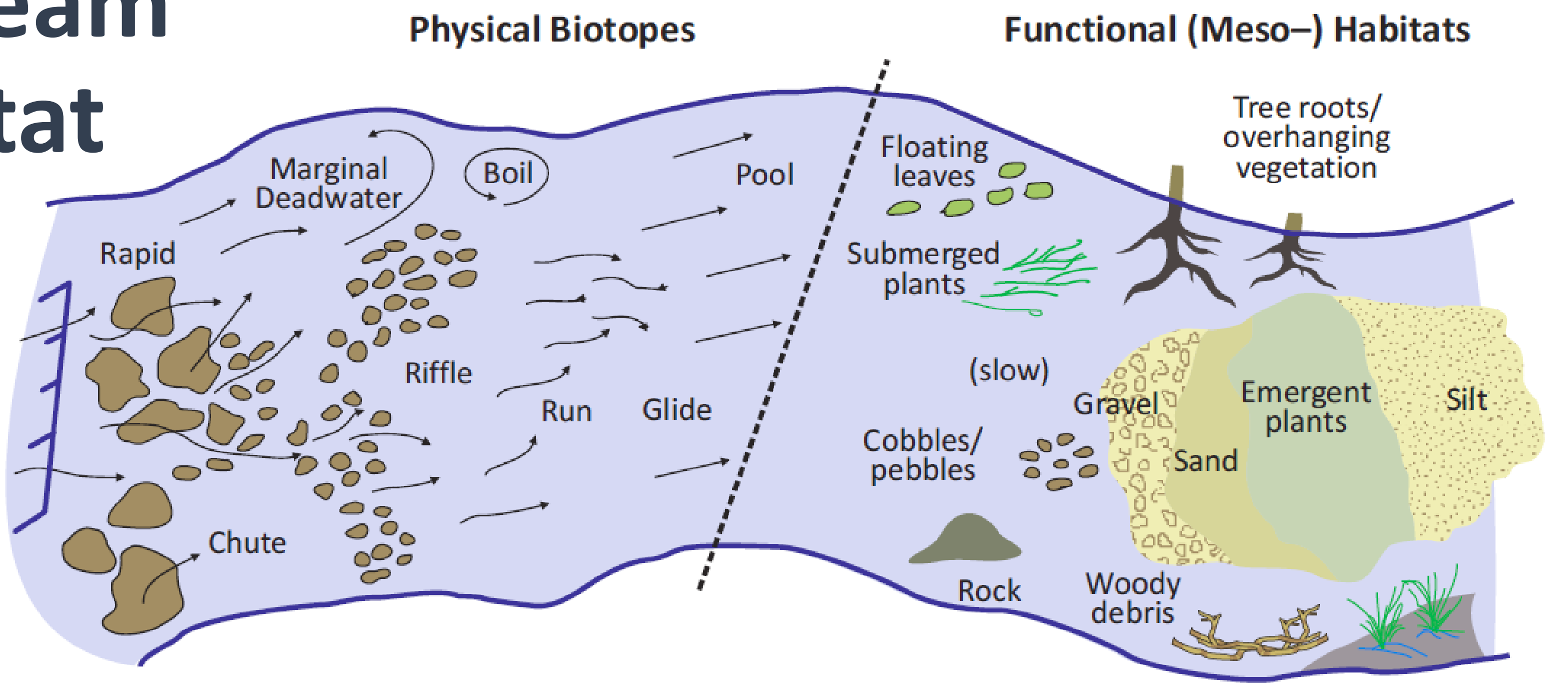
Large Scale Realignment Designs Focus

- Bankfull conditions, instream sediments
- Instream habitat
- Naturalized planting plans
- A level of complexity in the floodplain
- Addressing bedrock when it is encountered
- Flood and erosion hazard

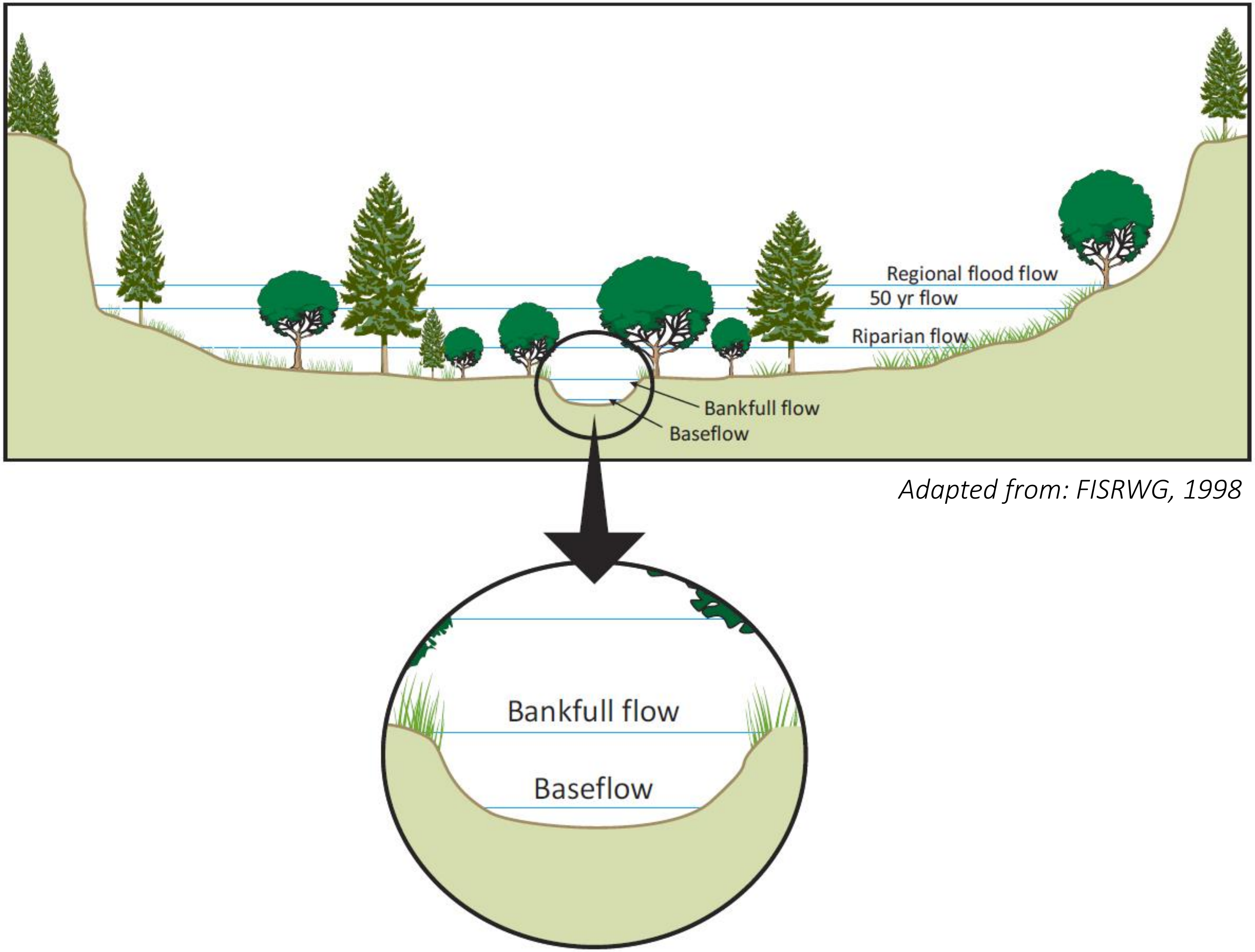


Adapted from: Brierley and Fryirs, 2005

Instream Habitat



Adapted from: Newson and Newson, 2000



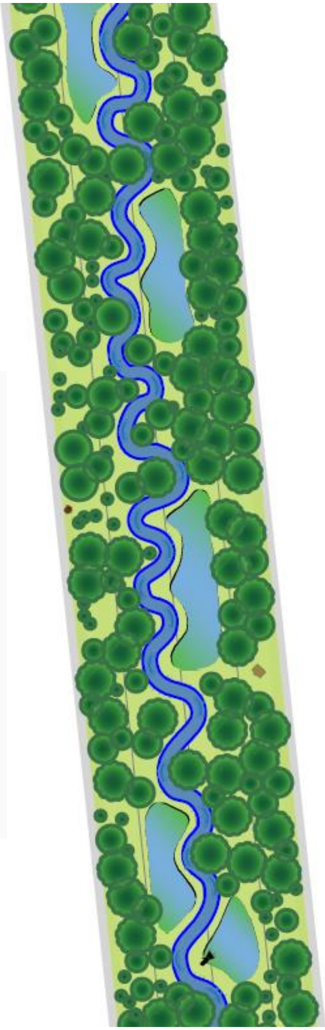
Adapted from: FISRWG, 1998

Meander Belt Width

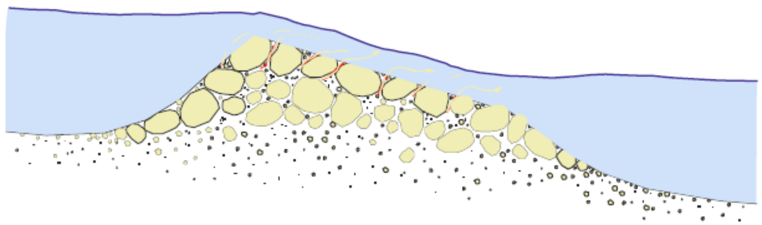
- We rely heavily on analogies from natural fluvial systems to guide design
- Early on the need to provide opportunity for the river to move freely in the corridor was understood
- Resulting in application of the concept of the meander belt width



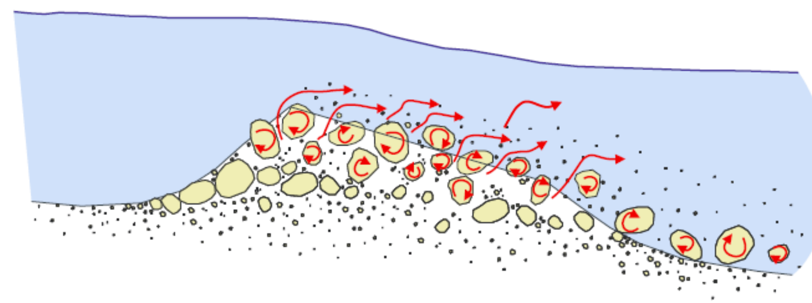
Valley Corridor and Meander Belt Width



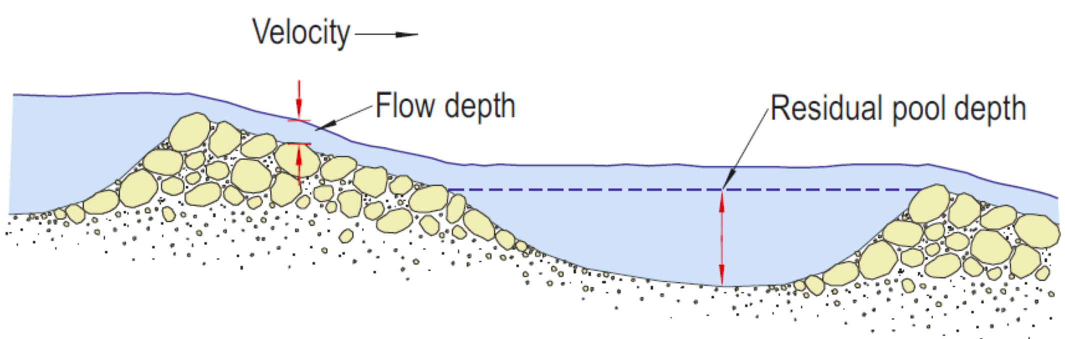
When Does Sediment Move in Our Natural Systems?



Flushing flows



Mobilizing flows



Aquatic habitat related flows

Adapted from: Villard and Ness, 2006

Bankfull, Mobilizing, and Flushing Flows

Bankfull shear stress:

$$\tau_B = \rho g D_B s$$

where *r* is density of water, *g* is gravity, D_B is bankfull depth, and s is bankfull slope.

Miller et. al.'s (1977) to define the shear stress associated with a mobilizing flow:

$$\tau_m = 0.045(\rho_s - \rho_w) g d_{50}$$

where r_s is the density of the sediment, r_w is the density of water, *g* is gravity and d_{50} is the median grain size. In fine cohesive sediments a critical shear stress of 4.5 N/m^2 was applied.

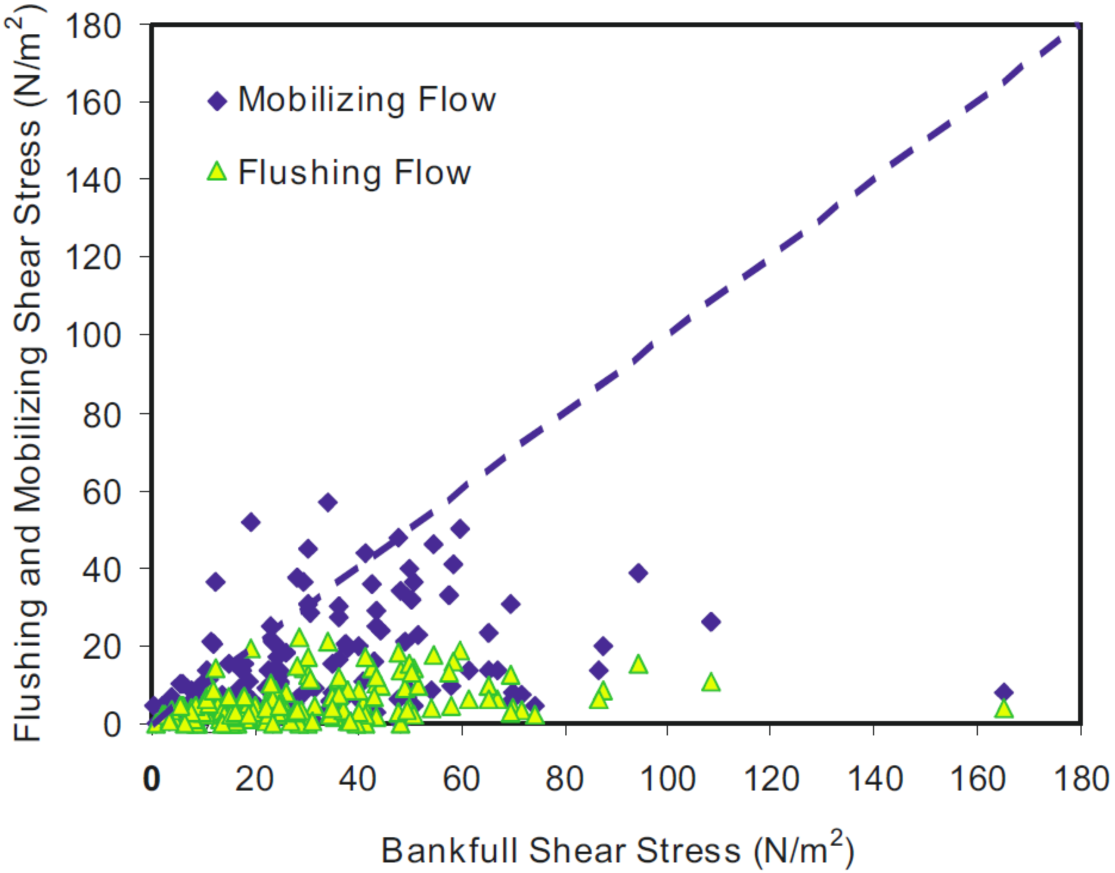
During flushing flows it is expected that the fine sediments are mobilized, but not necessarily the coarser sediments. A hiding function corrects for the protection of the fines (Hey 2001):

$$\tau_f = 0.0375 \left(\frac{d_i}{d_{50}} \right)^{-0.872} (\rho_s - \rho_w) g d_i$$

where d_i is the grain size fraction of interest.

When Does Sediment Move in Natural Systems?

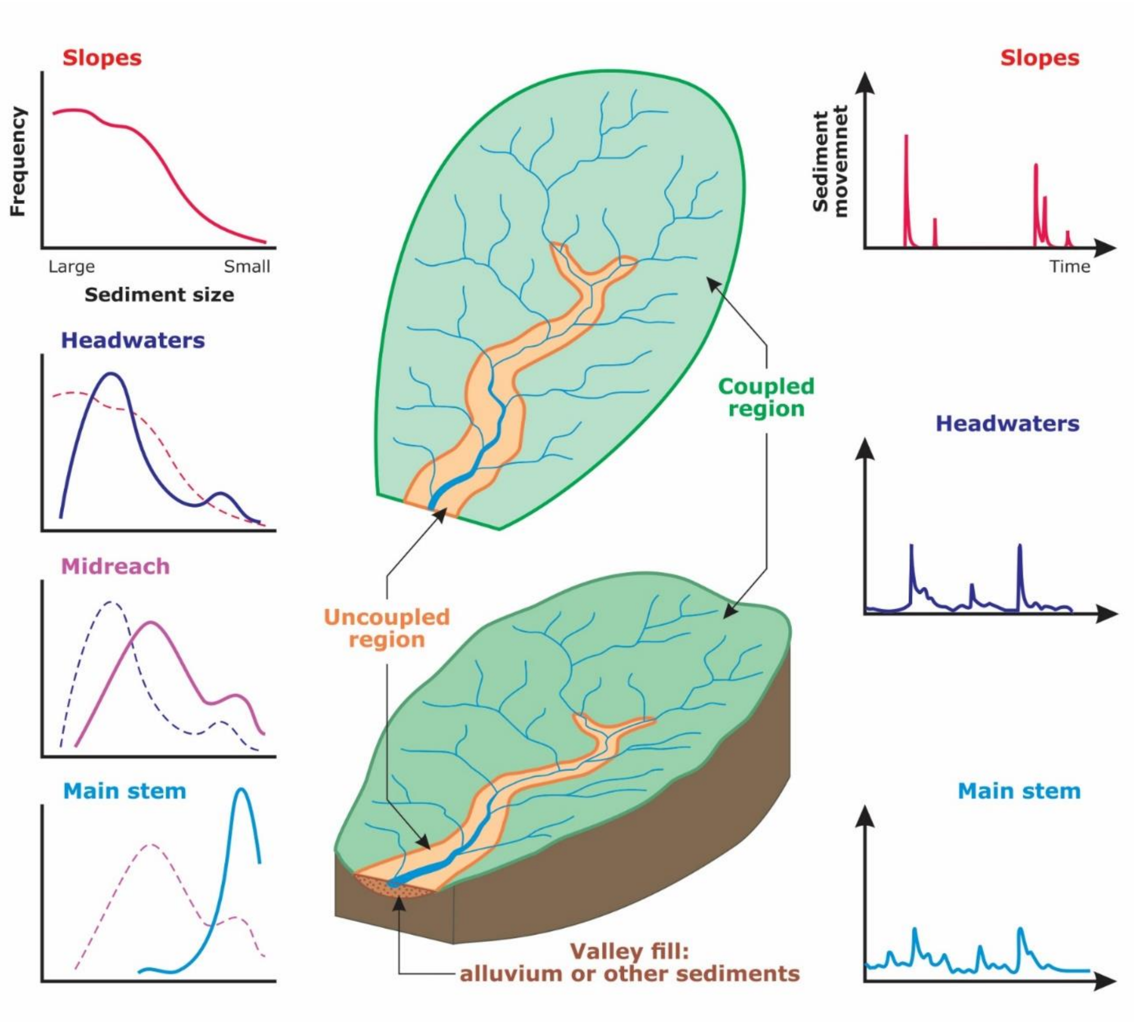
- Analysis based on detailed geomorphological sites throughout TRCA's watersheds
- Shows that mobilizing flows and flushing flows are well below bankfull
- Our design channels are usually meant to be stable to bankfull



Adapted from: Villard and Ness, 2006

Drainage Basin

- Slope and headwater sources supply sediment periodically
- Moves in jumps and not directly fed to the main stem
- Decoupling within the main stem – a lot of sediment stored only a portion being activated at any time
- Sediment size difference between channel and floodplain and headwaters and main stem



Adapted from: Church, 2002

Slopes and Headwaters – Production Zone

Main Stem and Floodplain Alluvium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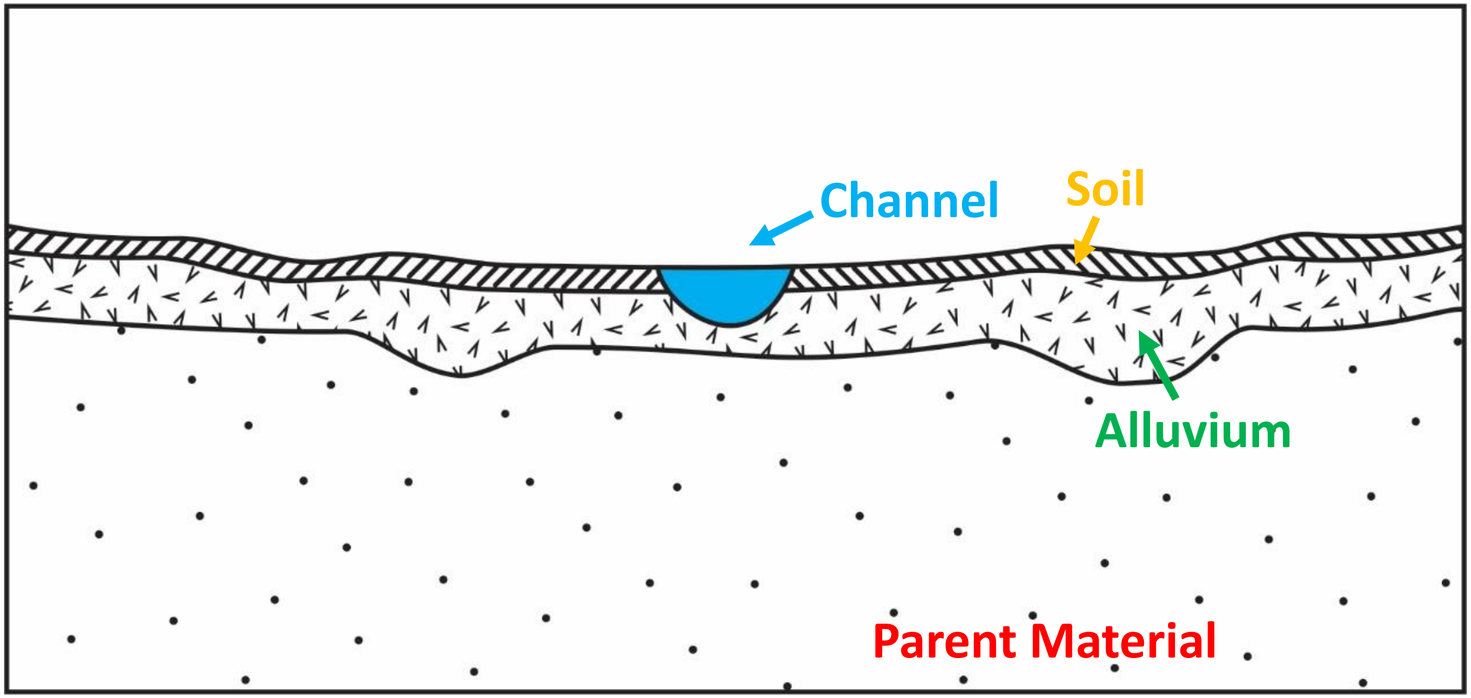
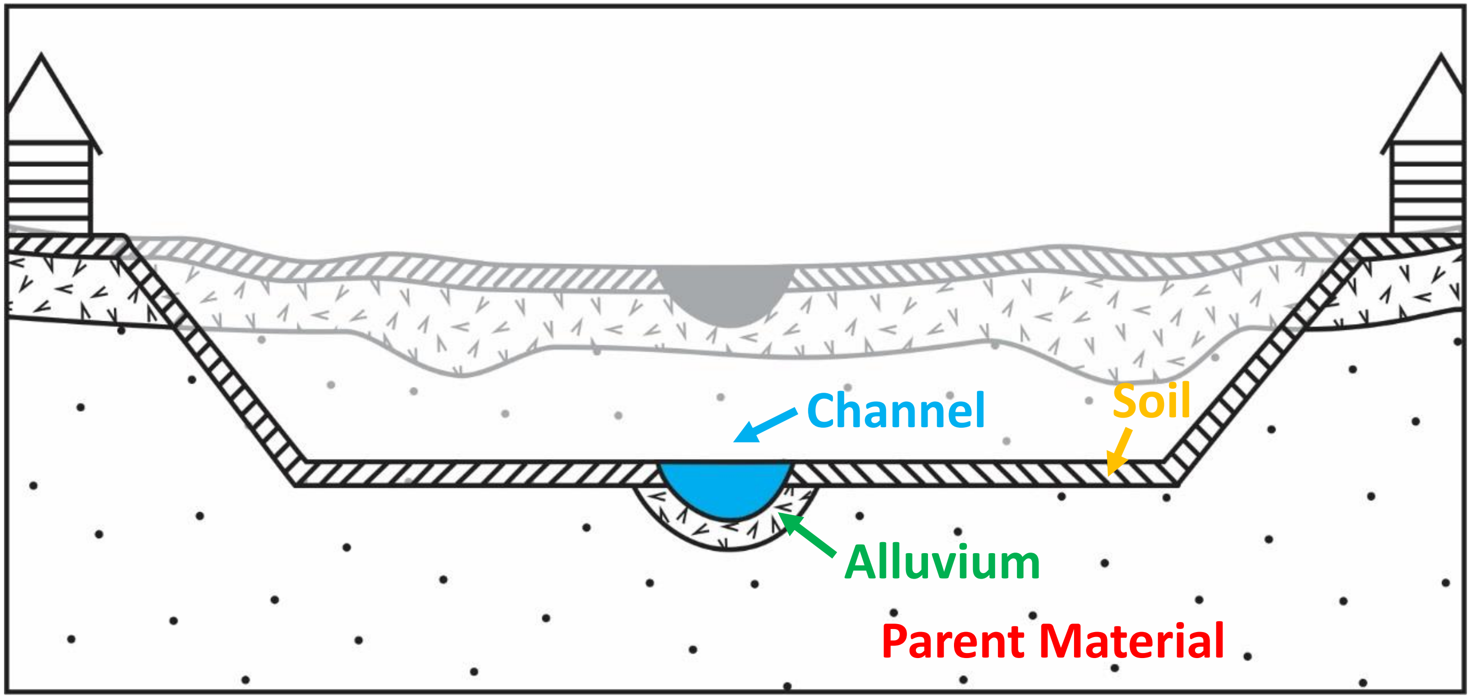
Geology of Southern Ontario

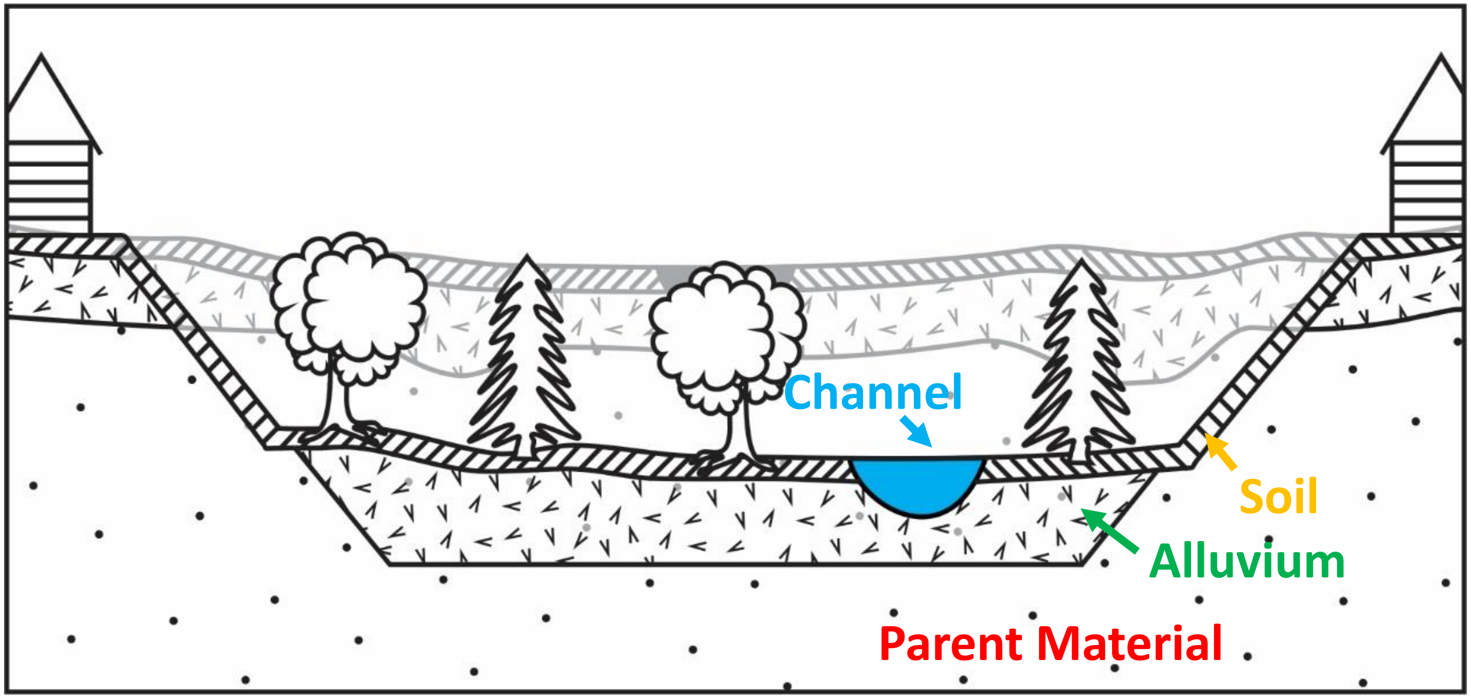
Impacted Agricultural Channel



Traditional Lowering Method



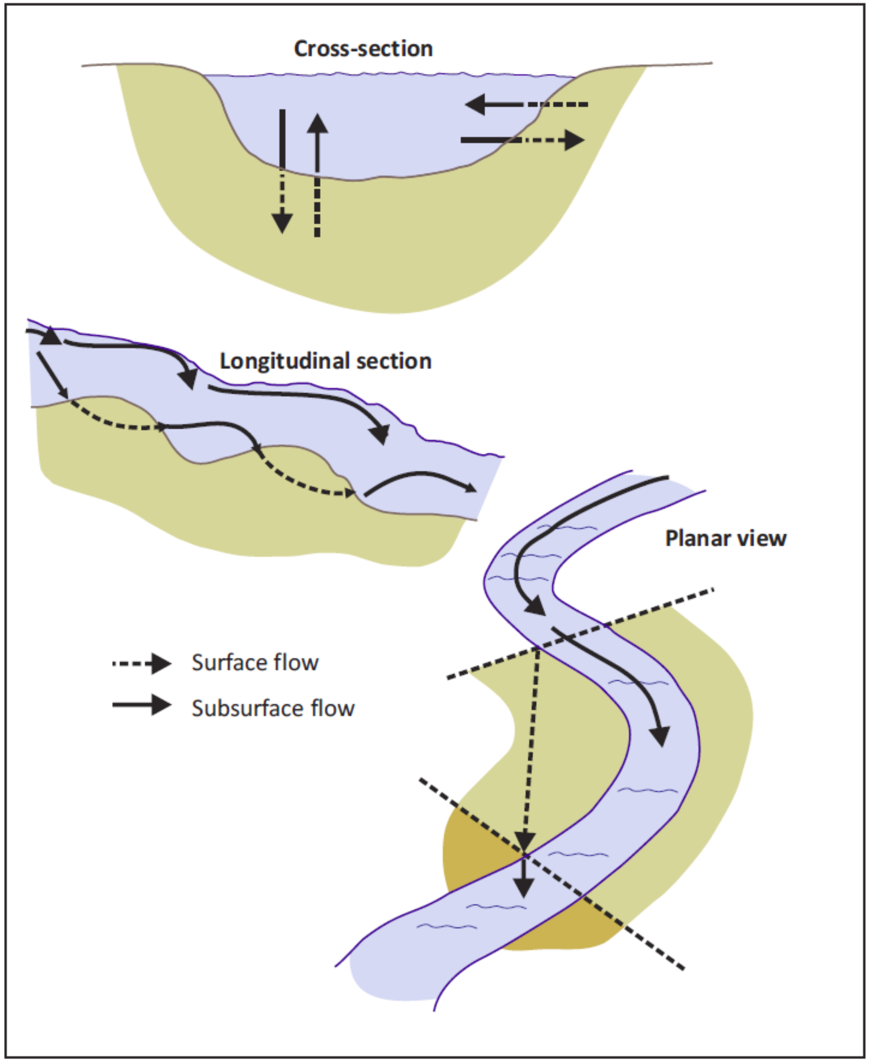
Respect for Alluvium



Communication within the Floodplain

- Communication between the channel and floodplain is important
- Focusing in terms of flooding alone results in systems that have limited exchanges between the terrestrial and aquatic components of the system
- Think soil, sediment and floodplain morphology


Hyporheic Zone



Adapted from: Findlay, 1995

Conclusions

- Focus on the stream as part of a system within a larger corridor
- Allow for more dynamic channels
- Maintain sediment supply, sediment sources, and replace floodplain sediments
- Focus on replication of soils and sediment profiles
- Focus on communication between the floodplain and channel – biological inputs, groundwater and sediments
- An adjustment in our focus would result in more resilient, self-maintaining systems that better mimic natural systems