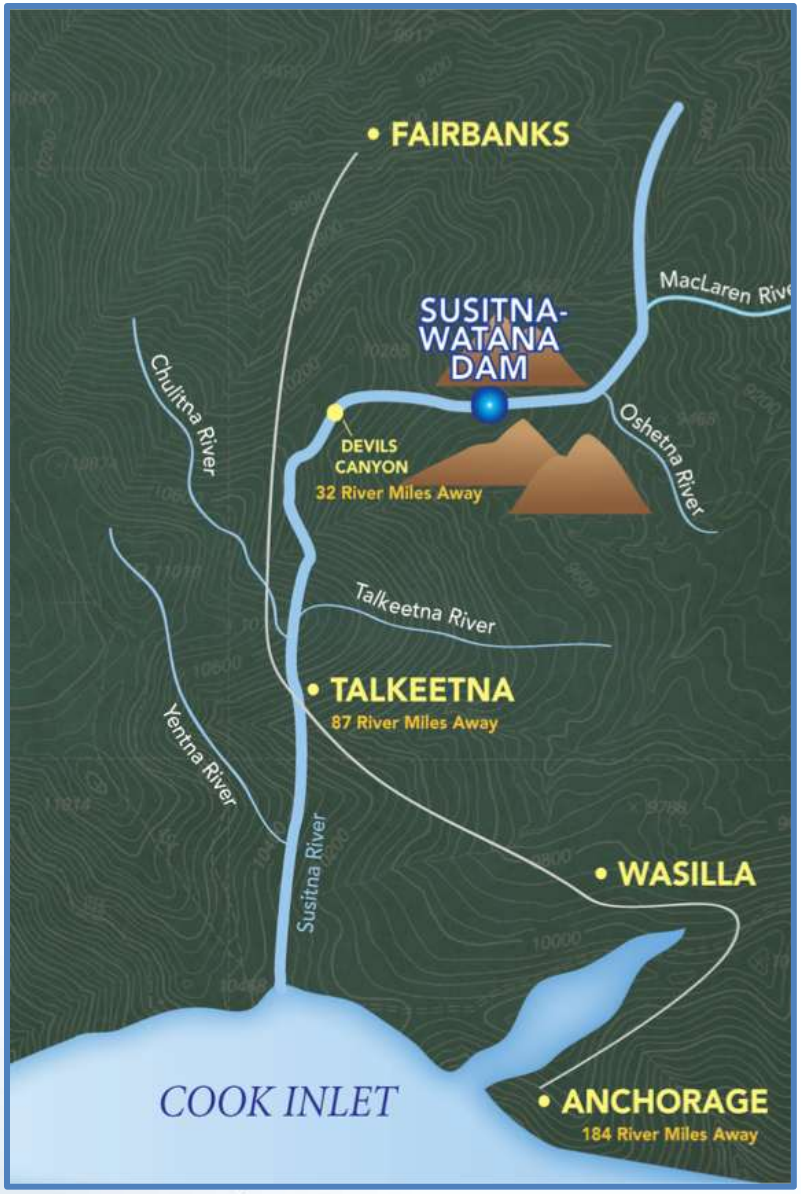


SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Technical WorkGroup Meeting

Riparian Instream Flow

Riparian Process Domain Delineation and Riparian Vegetation Sampling, including Focus Areas

14-15 February 2013

Prepared by

R2 Resource Consultants & ABR, Inc.

Road Map for Today's Presentation

1. Riparian Process Domains – Susitna River floodplain stratified sampling approach
2. Cluster Analysis: delineation of riparian process domains
   a. Methods
   b. Results
3. Floodplain Vegetation Sampling Approach
   a. Methods
   b. Results

Riparian Process Domain Concept

(after Montgomery 1999)

- Riparian (floodplain) process domains are distinct areas of the active valley within which similar suites of geomorphological processes govern floodplain habitat type, structure and dynamics.
- Geomorphic processes and elements may be mapped.
- Approach to stratify the river network for sampling floodplain vegetation variability and modeling
- Primary Susitna River geomorphic processes:
  - Hydroregime
  - Sediment transport
  - Channel migration (erosion and deposition)
  - Beaver dams (biogeomorphic process)
  - Ice processes: ice damming and associated flooding, sediment and vegetation disturbance (shear forces)

Riparian Process Domain Framework

- Primary objective to use a quantitative method based upon repeatable geologic and geomorphic variables to delineate similar channel / floodplain river segments.
- Geomorphic variables reflect influence of systematic geologic and geomorphic processes.
  - Valley geometry: channel/floodplain confinement
  - Channel gradient
  - Channel type

How to Stratify the Susitna River Floodplain, Delineate Riparian Process Domains & Select Riparian Vegetation Sample Sites?

Formal statistical or subjective approach?

- Multivariate statistical analyses
  - Cluster analysis
  - Ordination techniques
- Best professional opinion
- Riparian Instream Flow Study will use both approaches

Riparian Process Domain Delineation Cluster Analysis

What is cluster analysis:

statistically grouping objects similar in the same group and also identify distinctions or separations between groups of objects (Legendre 2012,Numerical Ecology)

- There are various types of cluster analyses

Cluster Analysis

- Spatially Constrained Agglomerative Clustering (Legendre and Legendre, 2012)
  - Begins with each transect as one cluster
  - In spatial sequence, the process Iteratively joins transects that are "closest" to adjacent transects
  - Final number of clusters selected based on minimizing *cross-validation residual error,* a comparison between within-cluster and among-cluster differences

Legendre, Pierre, and Louis Legendre. 2012. Numerical Ecology. Third English Edition. Elsevier, Amsterdam, The Netherlands.

Cluster Analysis

- Multivariate distance, or dissimilarity, based on Gower Coefficient of Similarity (1971)
  - For continuous variables (channel slope and confinement ratio) distance is scaled difference $|X_i - X_j|$/max(difference)
  - Ordered factors (channel type; values 1 to 9 with increasing complexity) are treated the same
- Multivariate distance is simply the average of the distances for the three variables.

Gower, J.C. 1971. A general coefficient of similarity and some of its properties. Biometrics 27:857-871.

Riparian Process Domain Delineation Cluster Analyses

Iterative Process conducted Q1 & Q4 2013

- First Run (Q1 February 2013)to preliminarily delineate riparian process domains and provide quantitative basis for selecting Focus Areas
- Second and Third Runs Q4 2013
  - Additional 2013 field data
  - Ice processes
  - Beaver Complexes

Cluster Analysis: Geologic and Geomorphic Variables

I Confinement-entrenchment ratio
  - $CR=W_{floodplain}: W_{channel}$
    - Is a contiuum
    - Confined (CR<2) vs. Moderate (2≤ CR ≤4) vs. Unconfined (CR > 4)

II Channel Type (general channel planform)

III Channel Slope

- To-be-included in Q4 2013 Analyses:
  - Beaver dam complex areas
  - Ice−floodplain interaction field survey data

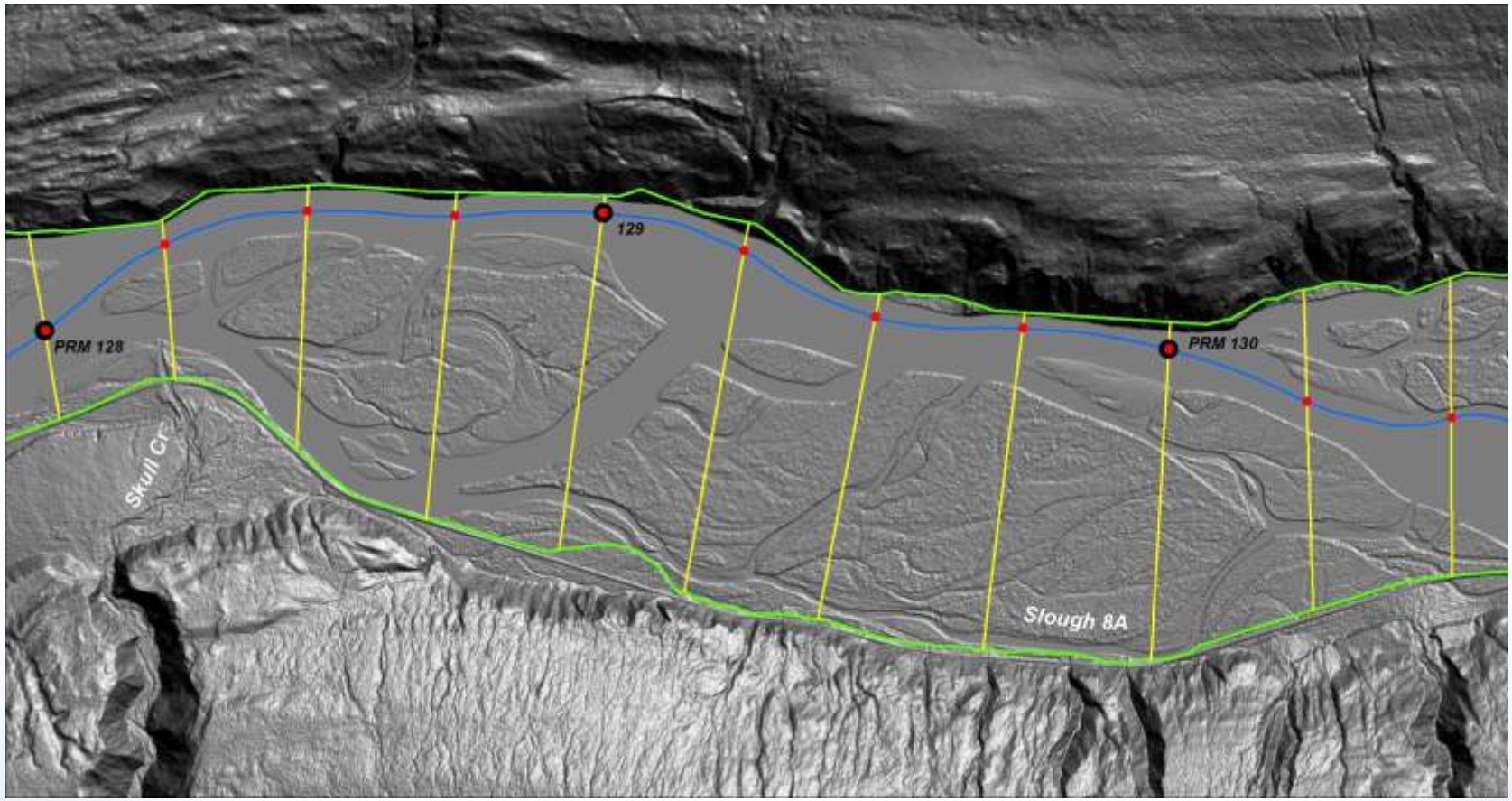
Spatial Extent of Process Domain Analysis

- Susitna River Floodplain
- Susitna River PRM 187-31
  - PRM 187.1 (proposed Susitna Dam)
  - PRM 31.0 (Yentna River)

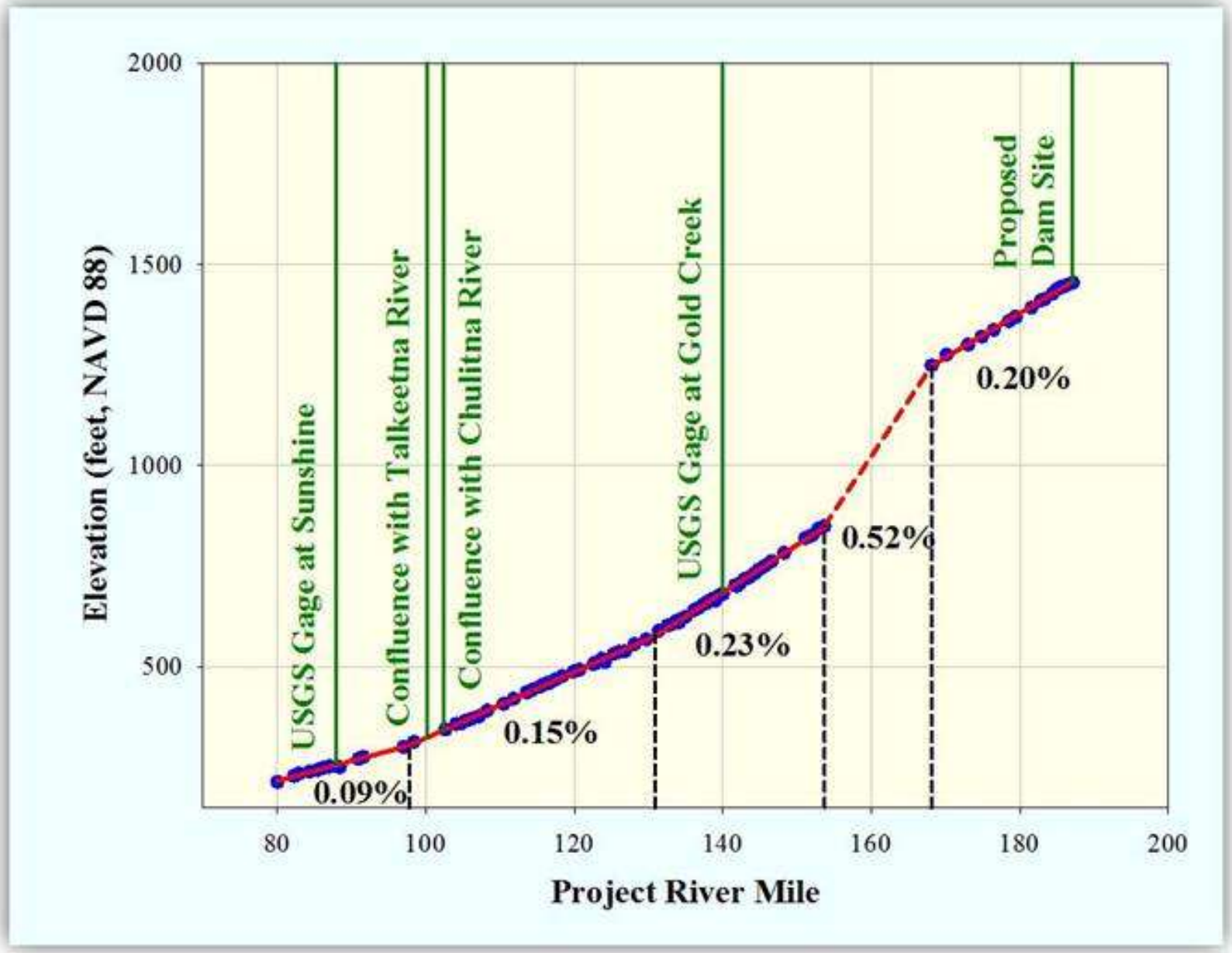
Project River Mile (PRM) System

Transect Generated Every ¼ Mile

DEM Floodplain Draft Determination & Transects



Susitna River Channel Slope (2012 survey data)



Middle & Lower River Channel Typing

1 MR Main Channel Single dominant channel

2 MR Split Main Channel, Three or fewer distributed dominant channels

3 MR Multiple Main Channel, Greater than 3 distributed dominant channels

4 LR Single Channel Type A , Single Channel with no off-main channels

5 LR Single Channel Type B, Single Channel with side channel complexes (multiple islands and smaller channels)

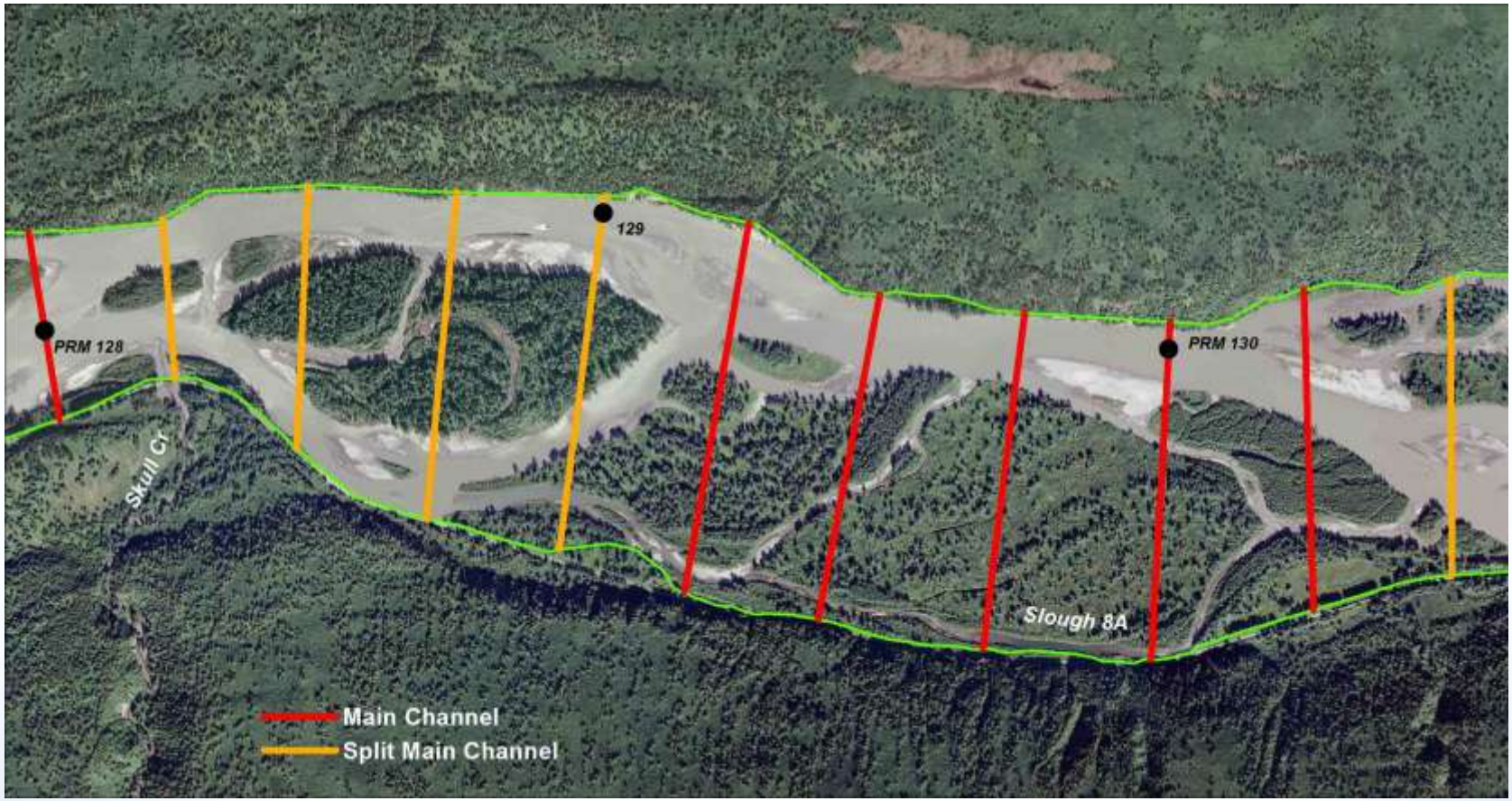
6 LR Single Channel Type C, Single Channel with lateral floodplain with a single channel that runs for mile(s)

7 LR Braid Plain Type A , Braid Plain with no off-main channels

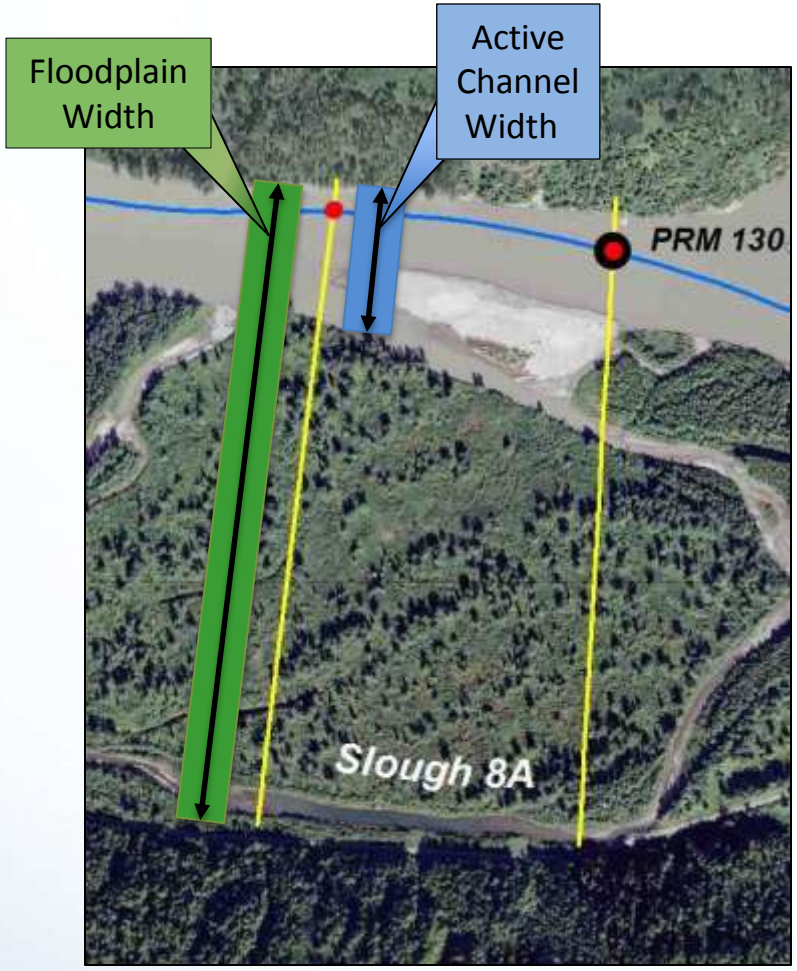
8 LR Braid Plain Type B, Braid Plain with side channel complexes (have multiple islands and smaller channels)

9 LR Braid Plain Type C, Braid Plain with lateral floodplain with a single channel that runs for mile(s)

Channel Typing



Confinement Ratio



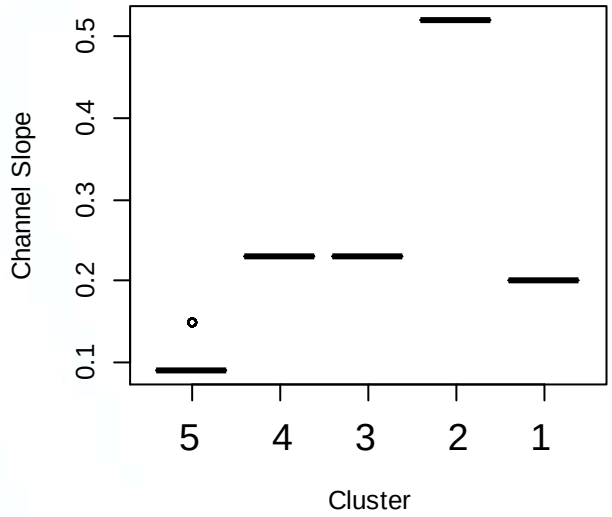
Confinement Ratio

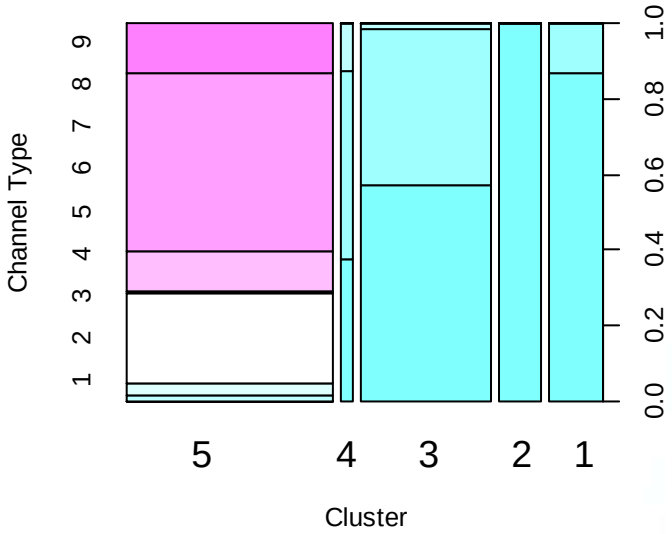
$$= \frac{\text{Floodplain Width}}{\text{Active Channel Width}}$$

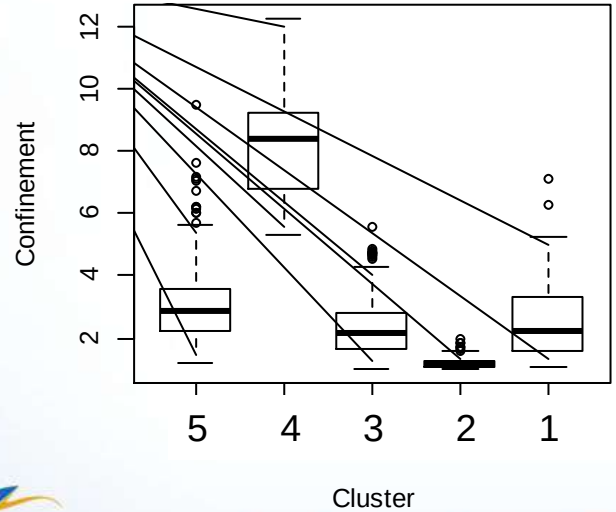
Riparian Process Domain Cluster Analysis Results

- Numerical Results
- River Network Projection
- Comparison and Contrast with Geomorphic Channel Classification

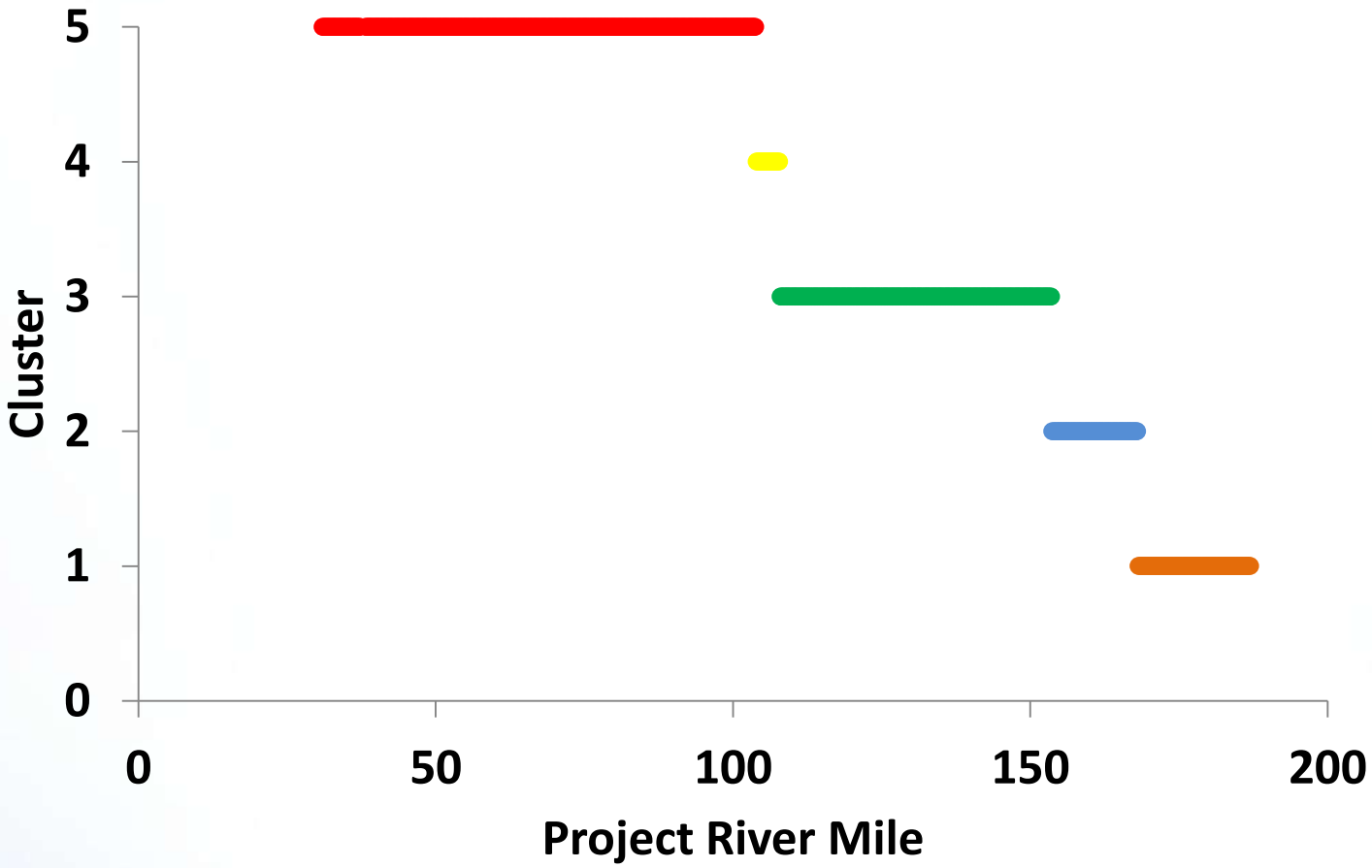
Constrained Cluster Analysis Results



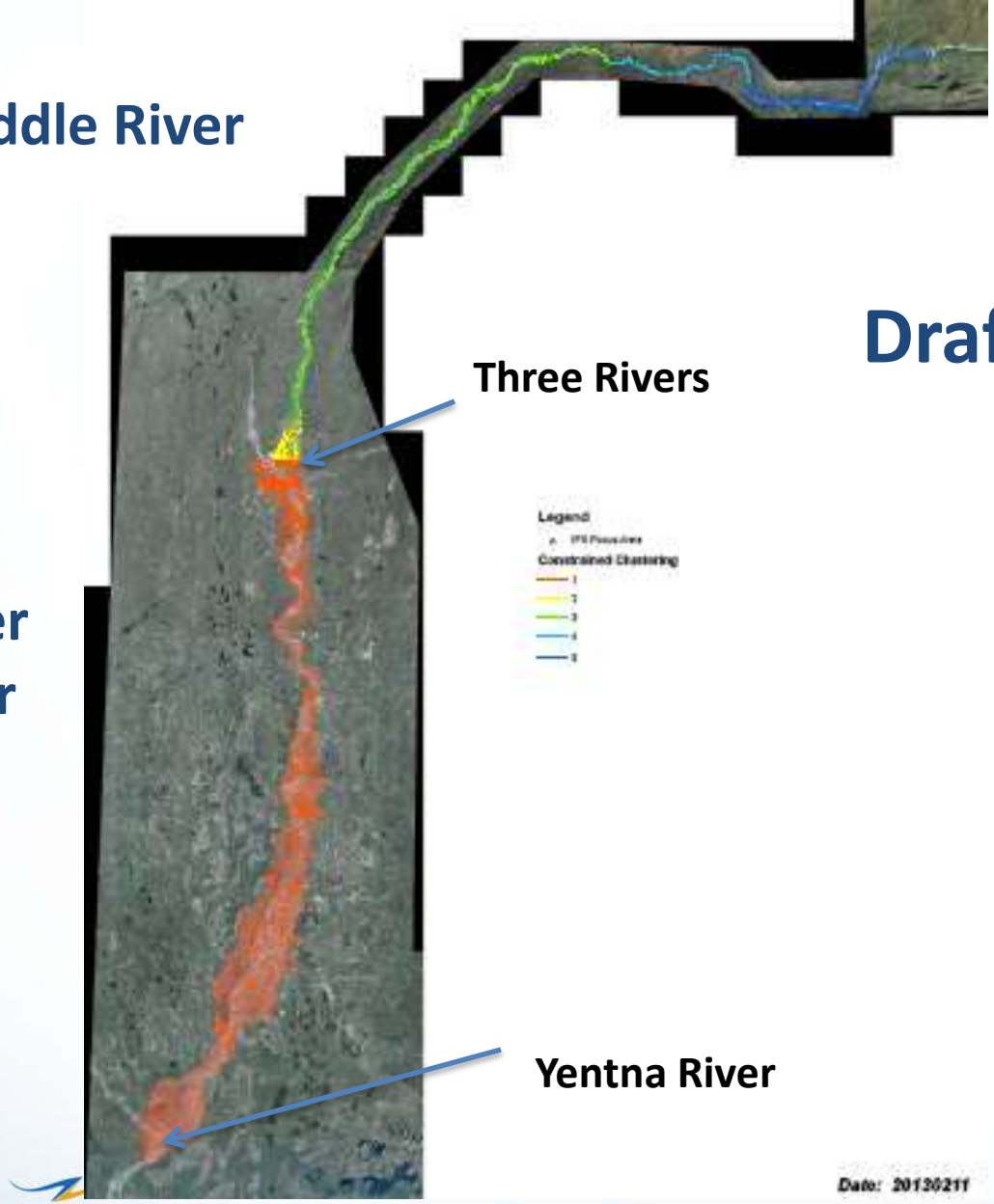




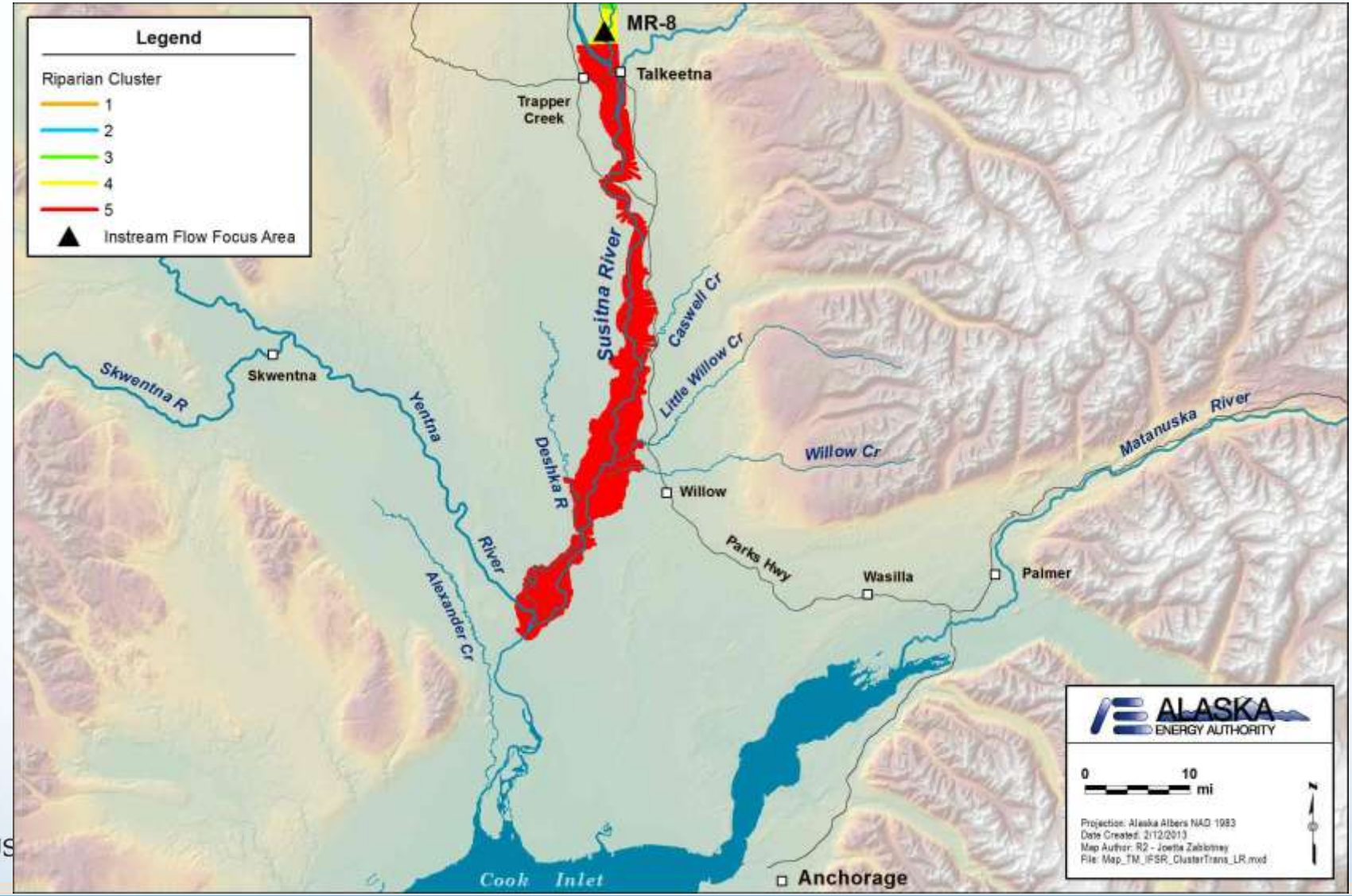
Constrained Cluster Analysis Results



Draft Cluster Analysis Results

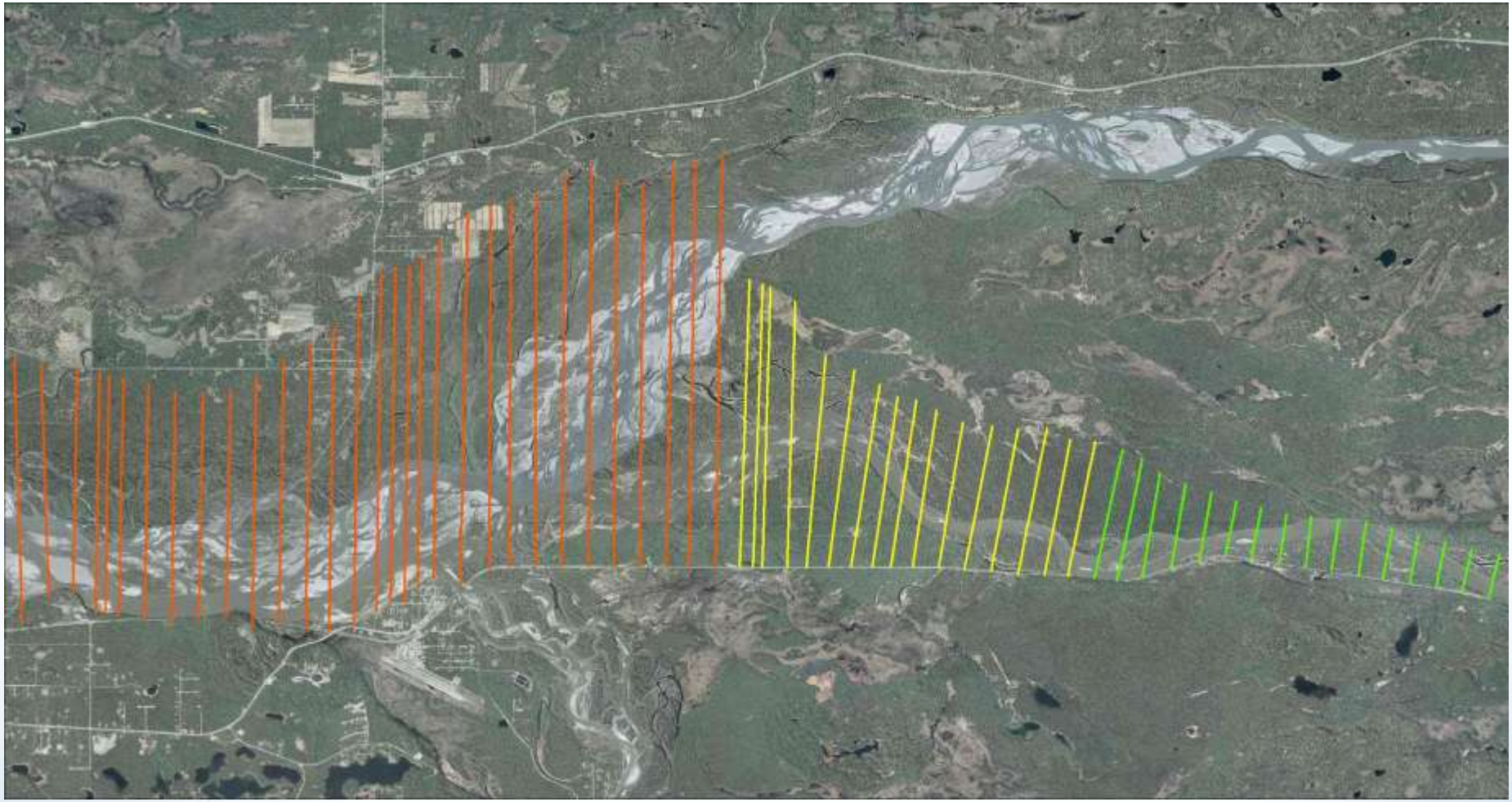


Lower River Riparian Process Domains: Cluster Analysis

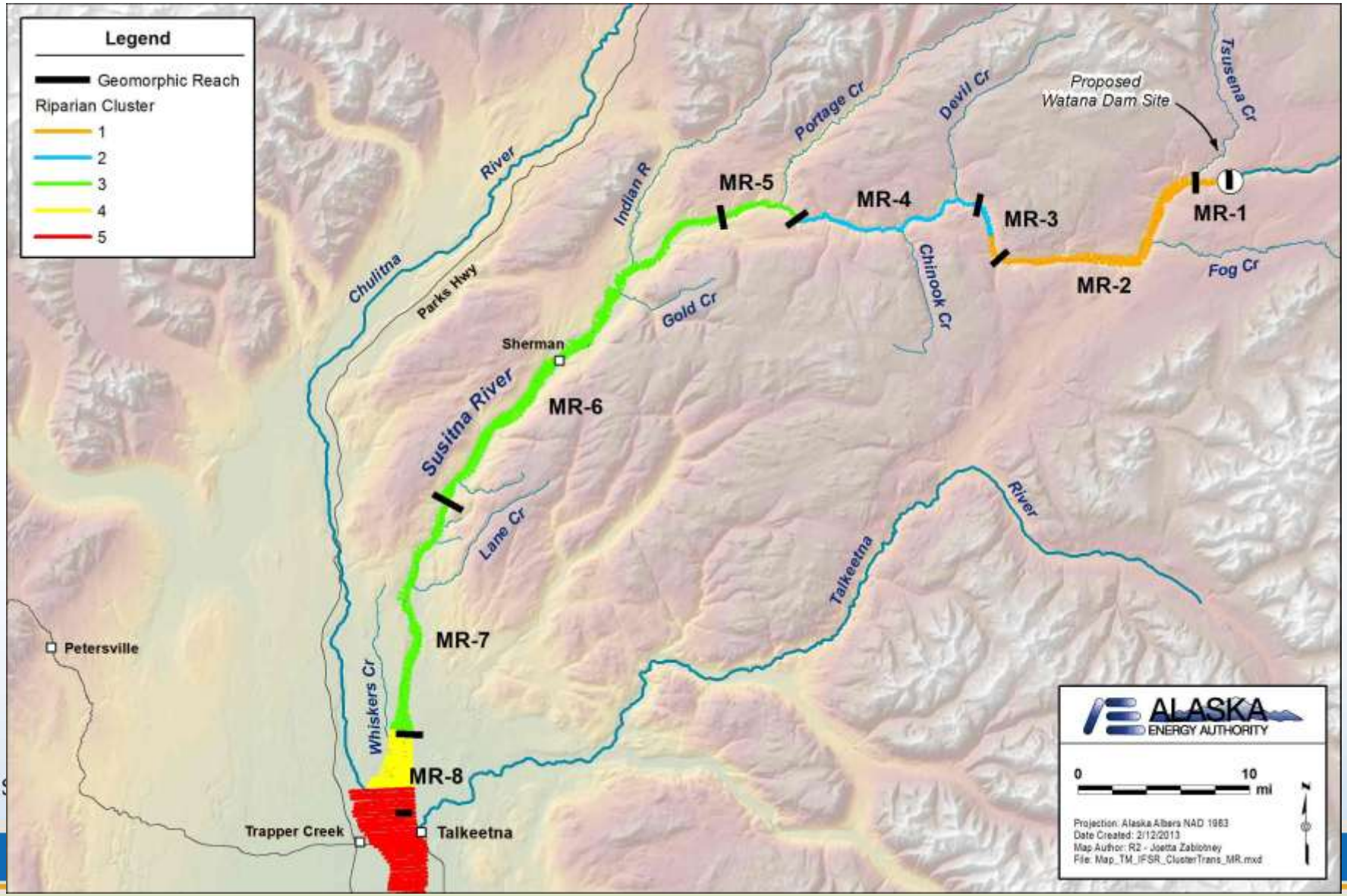


Cluster 2 to 3 Transition
(Devils Canyon Highly Constrained to Moderately Constrained channel)

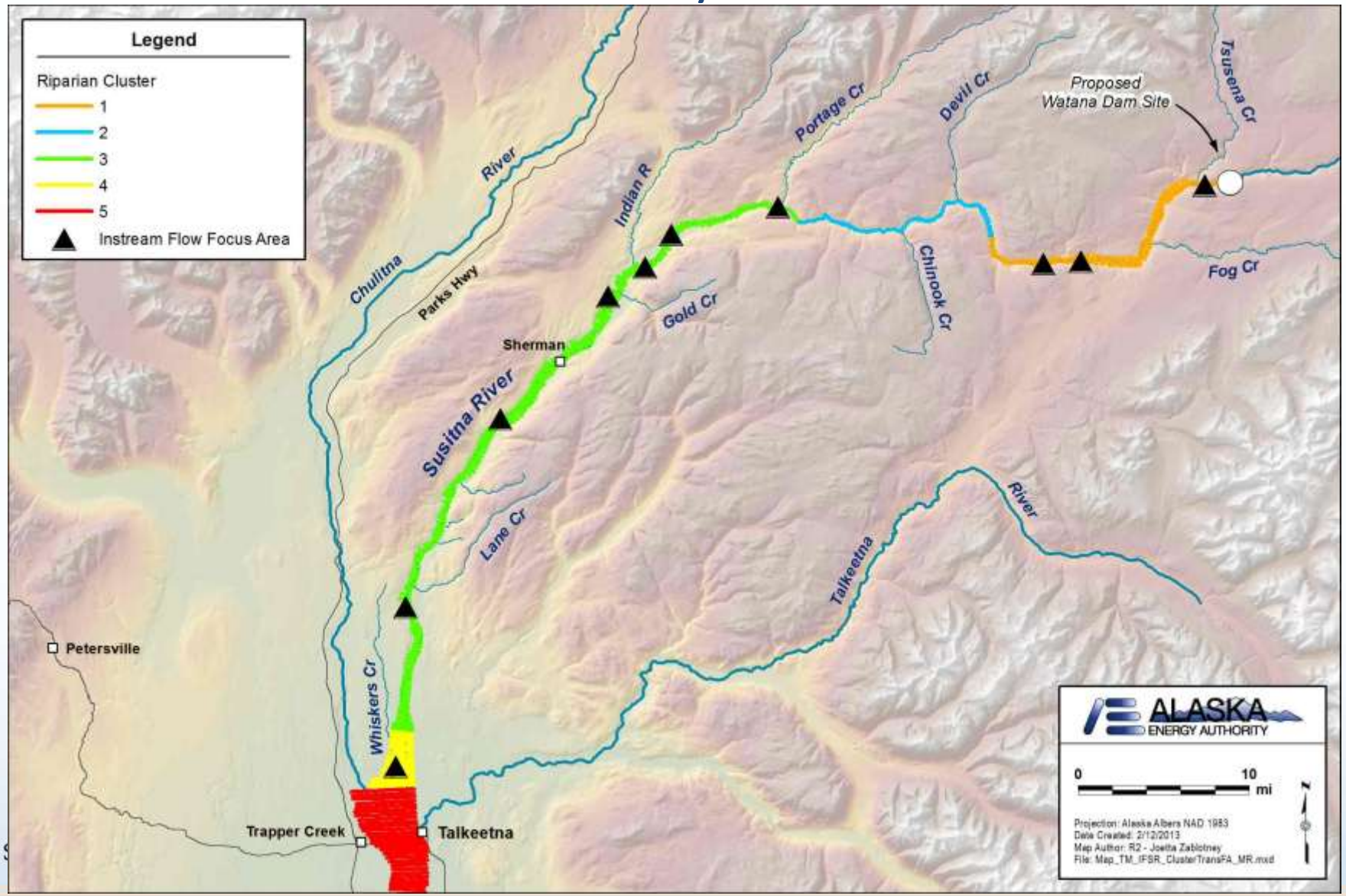
Three Rivers Confluence: Clusters 3, 4, 5 Transitions



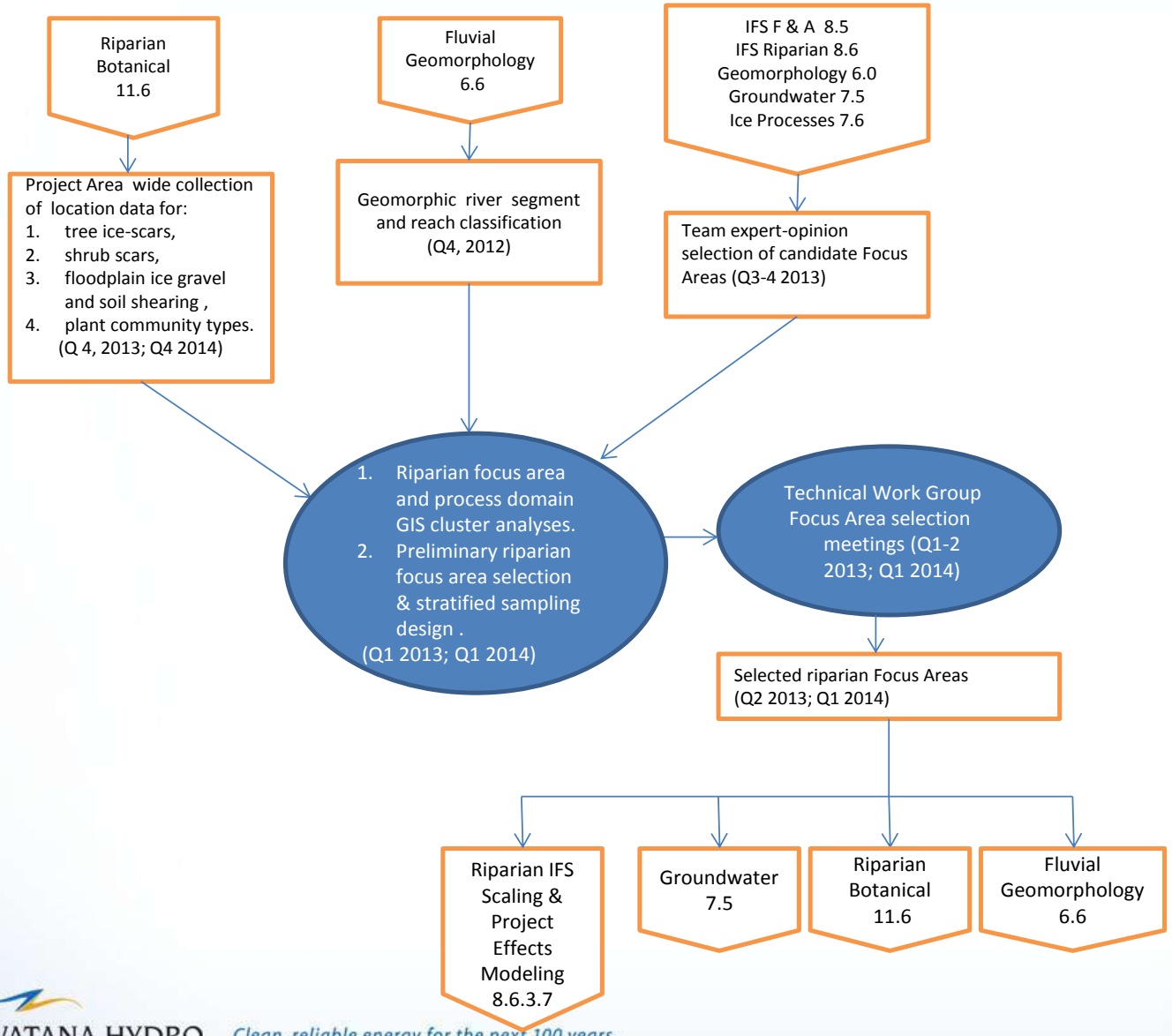
Geomorphic Reach Classification & Cluster Analysis Results



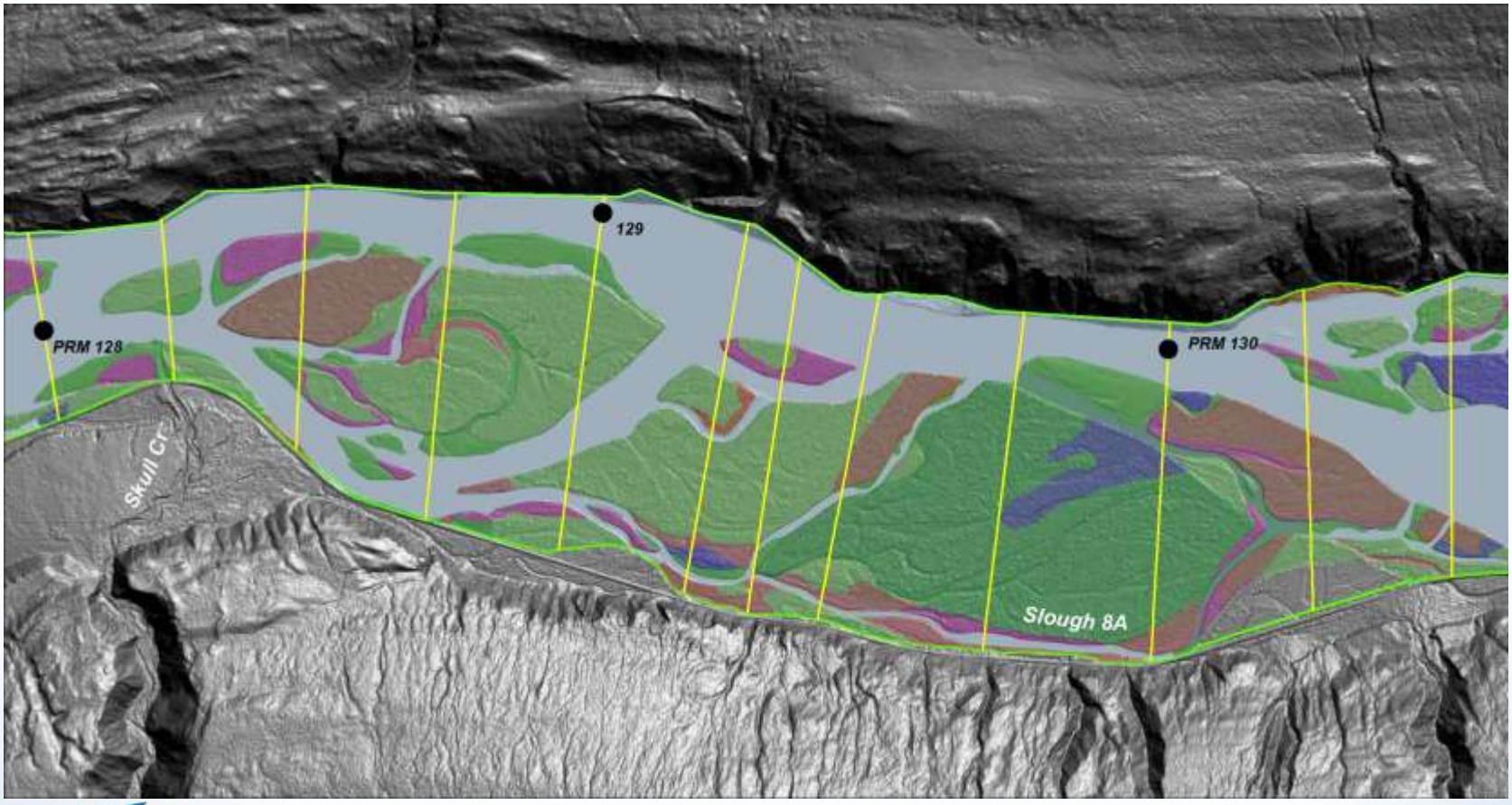
Middle River Riparian Process Domains: Cluster Analysis



RIPARIAN FOCUS AREA SELECTION 8.6.3.2



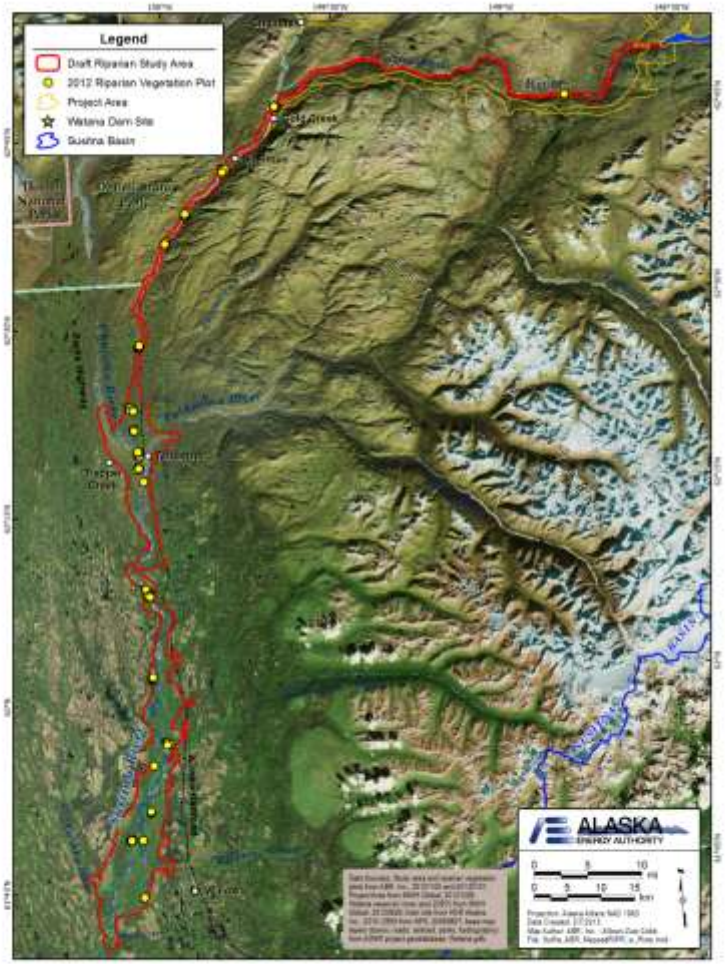
ABR Integrated Terrain Unit (ITU) Mapping



Field Protocols

- Geo-referenced plot locations
- Plot photographs
- Vegetation
  - Composition, structure, and age (trees and shrubs)
- General environmental descriptors
- Describe soils in shallow (~50 cm.) pit or cut bank

Draft Riparian Study Area and 2012 Field Plots



Oblique aerial view of plot V09_04 on gravel bar, Susitna River, Alaska, 2012.

Ground view plot V09_04 showing tall alder-willow-poplar vegetation.

Ground view of plot T09_01 showing open spruce-birch vegetation, Susitna River floodplain, Alaska, 2012.

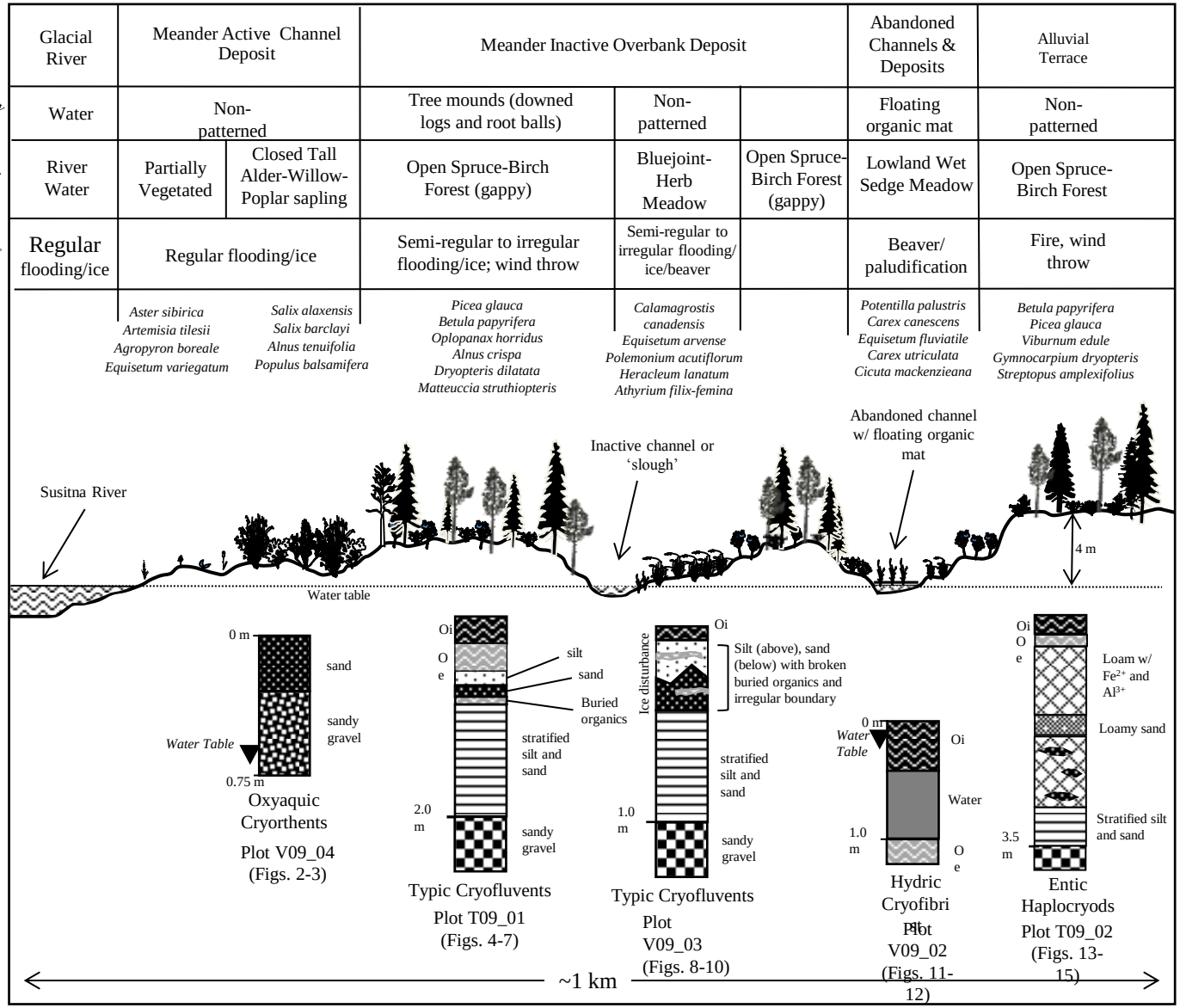
Soil pit view of plot T09_01 showing Typic Cryofluvents with multiple buried organic horizons (dark layers indicated by red arrows) interbedded with riverine silt (grayish layers indicated by black arrows), Susitna River floodplain, Alaska, 2012.

Oblique aerial view of plot T09_02 on an older terrace of Susitna River, Alaska, 2012.

Ground view of plot T09_02 showing open spruce-birch vegetation, Susitna River, Alaska, 2012.

Soil pit view of plot T09_02 showing Entic Haplocryods with an E-horizon (whitish, highly leached) and spodic horizon with reddish accumulations of iron indicating an older, well-developed soil, Susitna River, Alaska, 2012.

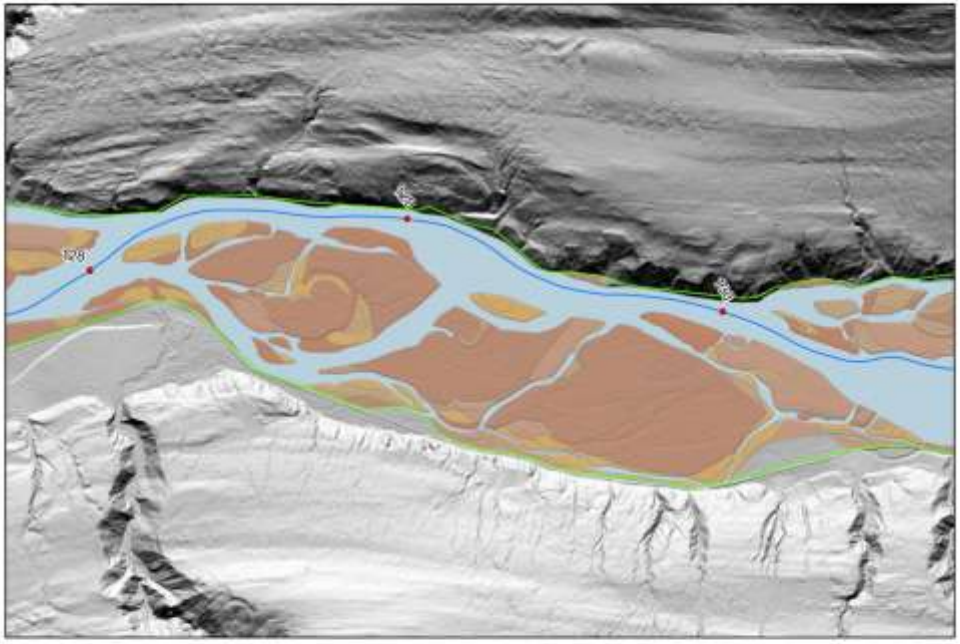
Toposequences – Pattern and Process



Integrated Terrain Unit (ITU) mapping

- An integrated, multivariate mapping approach (Jorgenson et al. 2003)
- Terrain unit map boundaries are adjusted so that there is increased coincidence between the boundaries and occurrences of interdependent variables
- e.g., geomorphology, vegetation, poplar size class
- Mapping conducted by hand-digitizing over high-res (≤1-m) aerial or satellite imagery at 1:3,000 to 1:5,000 scale.
- Verified by field data

ITU Geomorphology



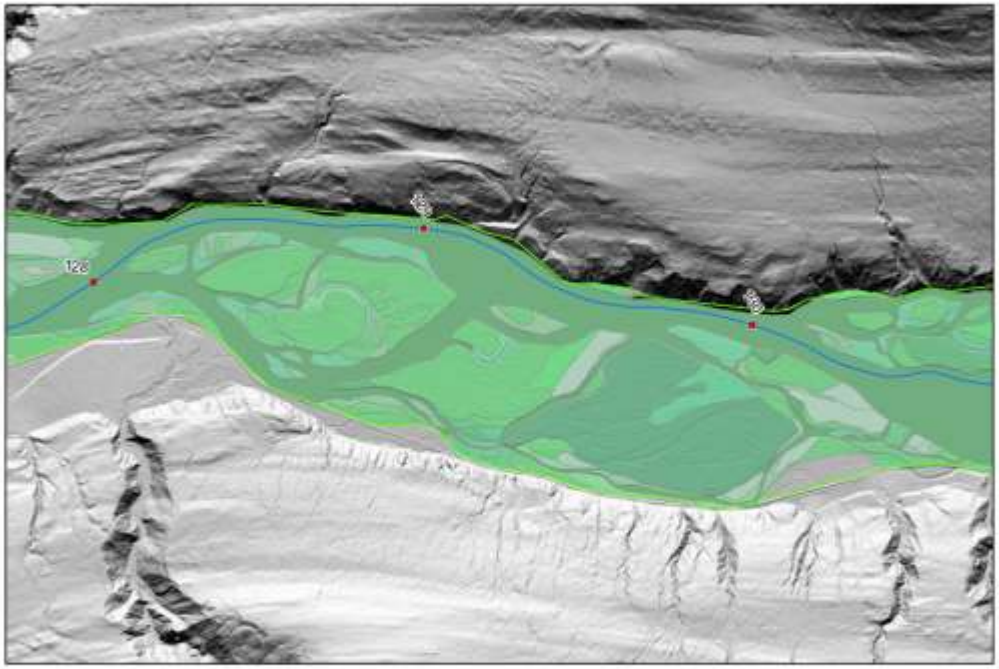
Legend

ITU Mapping

Geomorph

- Fboa:Braided Active Overbank Deposit
- Fbraf:Braided Fine Active Channel Deposit
- Fmraf:Meander Fine Active Channel Deposit
- Fmrif:Meander Fine Inactive Channel Deposit
- Fto:Old Alluvial Terrace
- He:Excavation
- Hfg:Gravel Fill
- Ofc:Channel Fen
- Wlscv:Shallow Connected Beaver Pond
- fbob:Braided Abandoned Overbank Deposit
- fboi:Braided Inactive Overbank Deposit
- fbrac:Braided Coarse Active Channel Deposit
- fbrif:Braided Fine Inactive Channel Deposit
- fmoa:Meander Active Overbank Deposit
- fmob:Meander Abandoned Overbank Deposit
- fmoi:Meander Inactive Overbank Deposit
- fmrac:Meander Coarse Active Channel Deposit
- ob:Bogs
- wldcr:Deep Connected Riverine Lake
- wldir:Deep Isolated Riverine Lake
- wlscr:Shallow Connected Riverine Lake
- wlsir:Shallow Isolated Riverine Lake
- wrlg:Lower Perennial Glacial River
- wrug:Upper Perennial Glacial River

ITU Vegetation



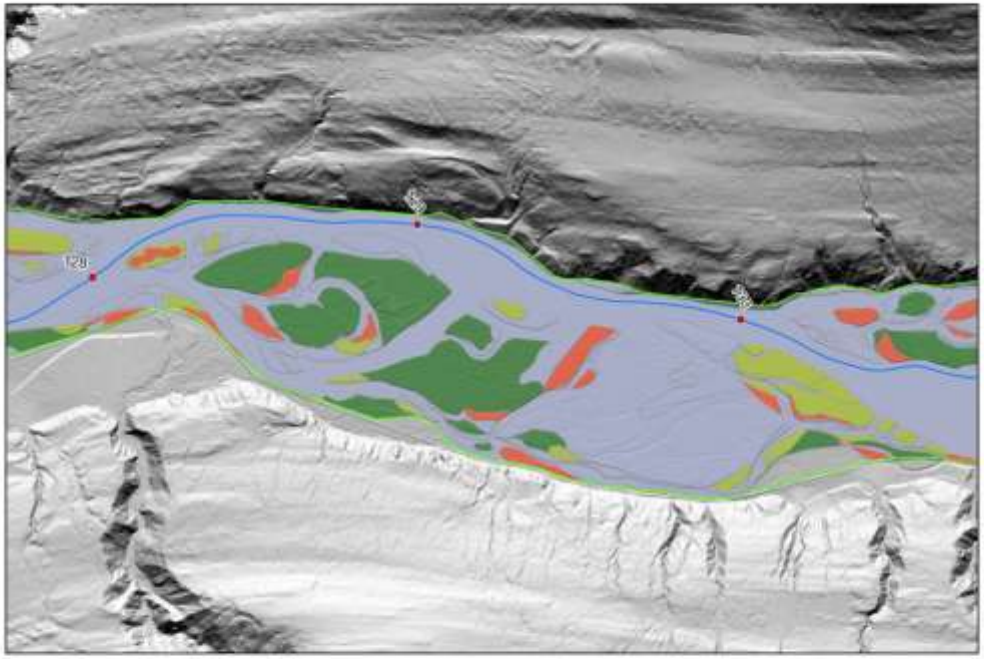
Legend

ITU Mapping

Vegetation

- Fbcp:Closed Balsam Poplar
- Fmosp:Open Spruce–Balsam Poplar Forest
- Fmwsp:Spruce–Balsam Poplar Woodland
- Sfcpa:Closed Poplar Woodland–Alder Tall Shrub
- Sfopaw:Open Poplar Woodland–Alder-Willow Tall Shrub
- Slcr:Closed Low Rose Shrub
- Slor:Open Low Rose Shrub
- Xr:Riverine Complex
- bpv:Partially Vegetated
- fbcb:Closed Paper Birch
- fbob:Open Paper Birch
- fbop:Open Balsam Poplar Forest
- fbwb:Paper Birch Woodland
- fbwp:Balsam Poplar Woodland
- fmosb:Open Spruce–Paper Birch
- fmwsb:Spruce–Paper Birch Woodland
- fnows:Open White Spruce Forest
- hfmc:Ferns
- hfmu:Large Umbel
- hfw:Wet Forb Meadow
- hgmb:Bluejoint Meadow
- slow:Open Low Willow
- stcw:Closed Tall Willow
- wf:Fresh Water

ITU Poplar Size Class

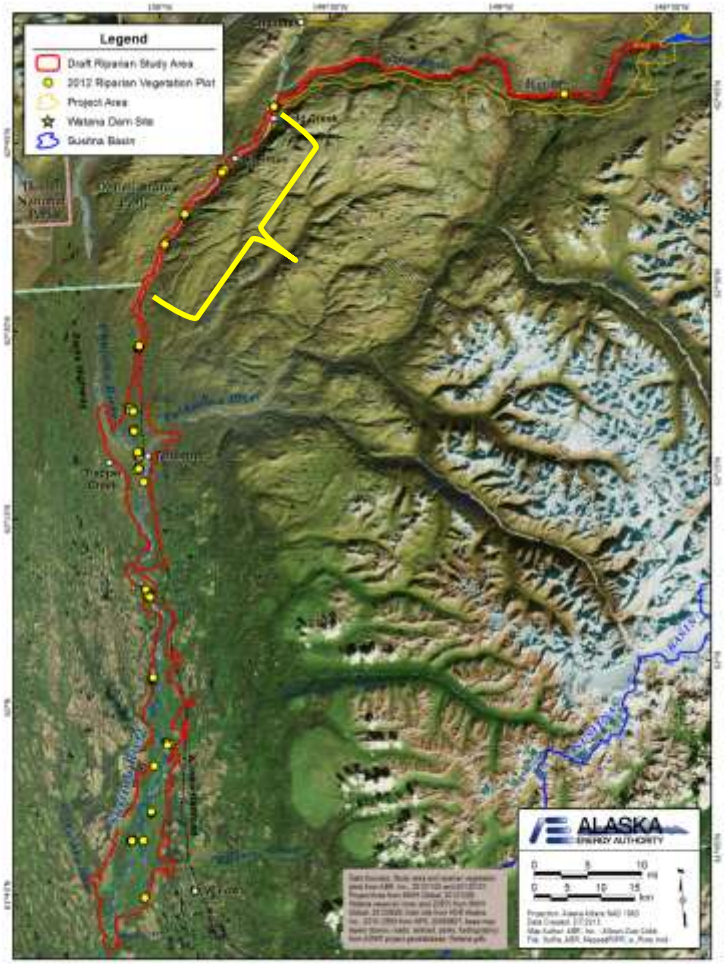


Legend

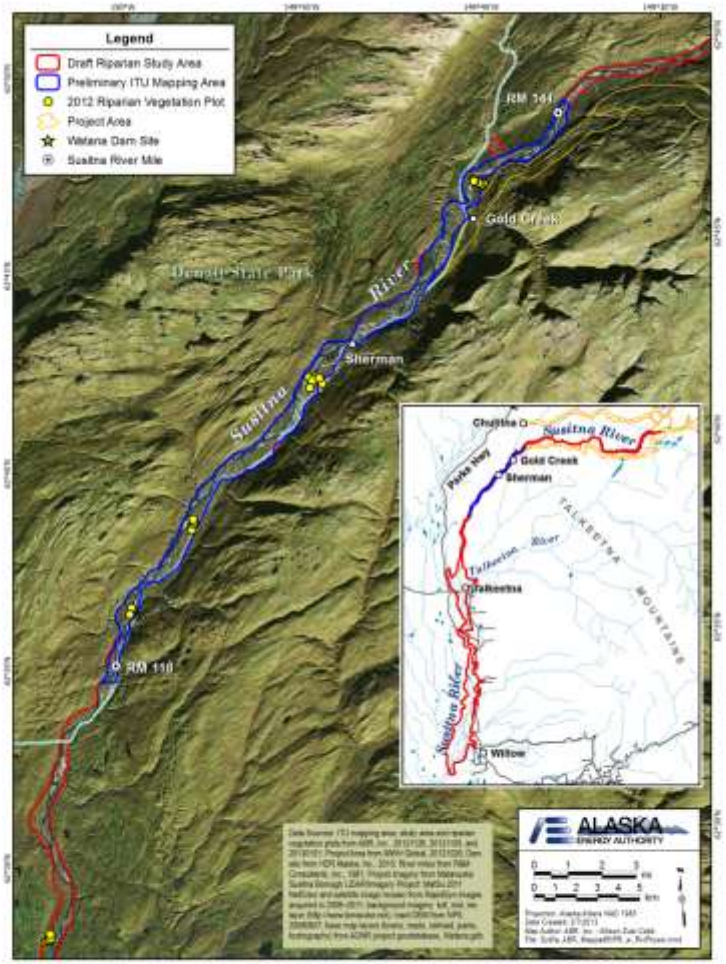
ITU Mapping

- No poplar
- Large Timber (>30 cm DBH)
- Pole (5-15 cm)
- Timber (15-30 cm)

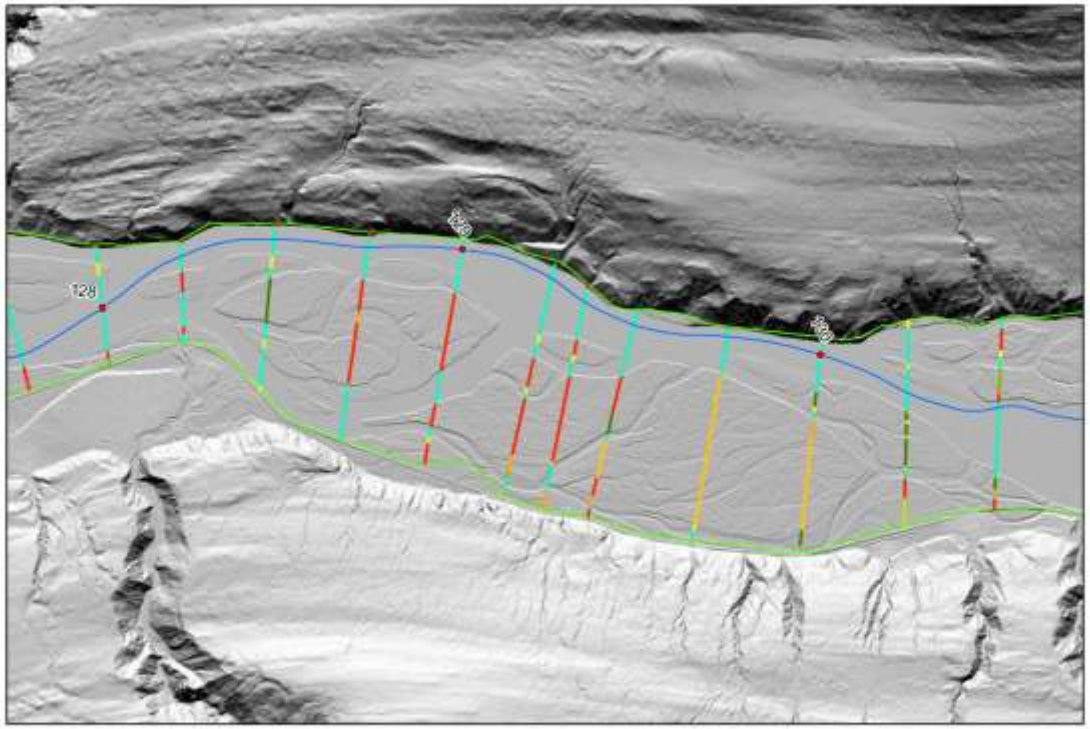
Draft Riparian Study Area and 2012 Field Plots



ITU mapping extent as of February 2013



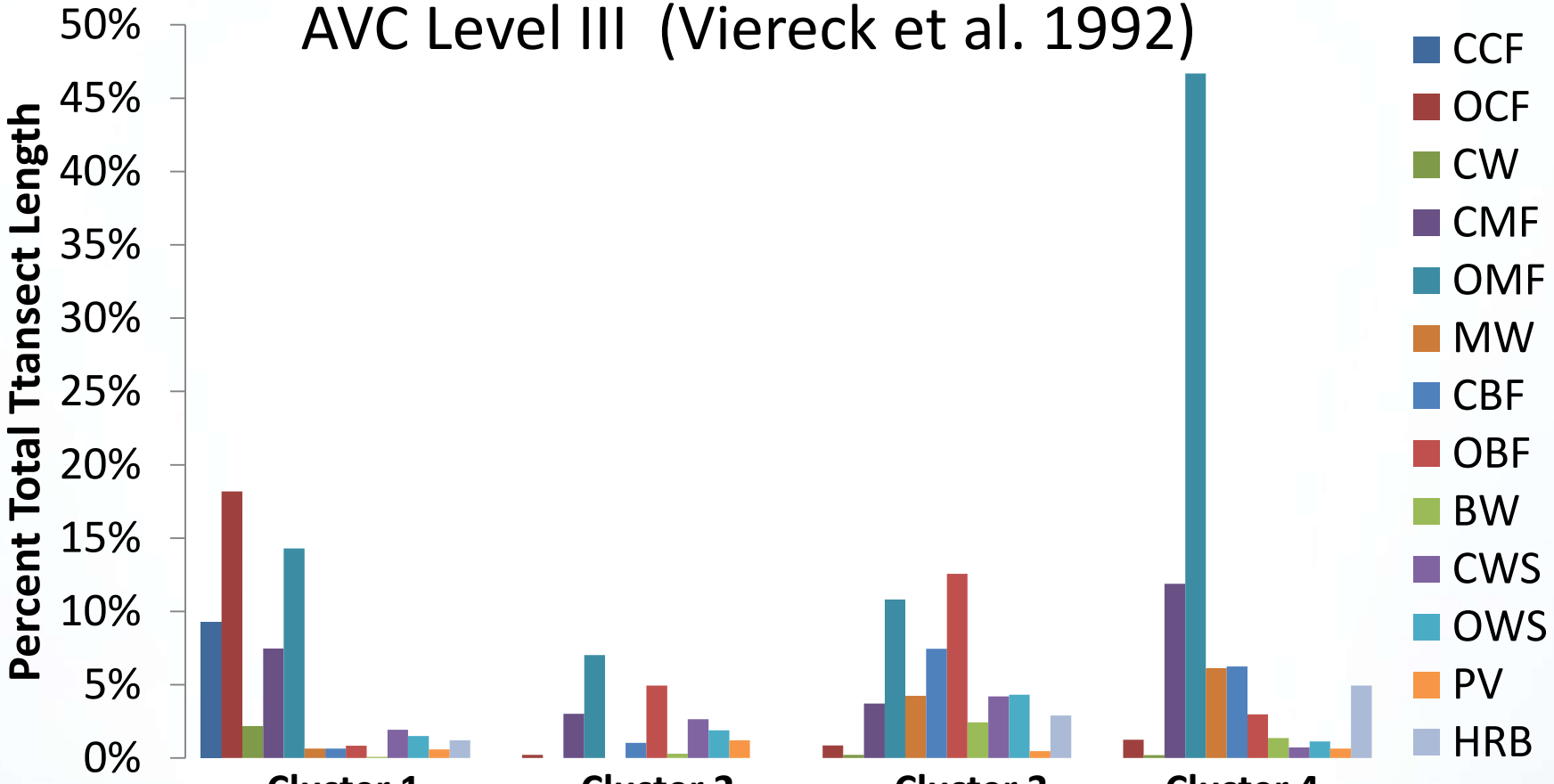
Vegetation Transects: AVC Level III Veg Class



Legend

- Aquatic Habitats
- BP: LR - Braid Plain
- BW: Broadleaf Woodland
- CBF: Closed Broadleaf Forest
- CCF: Closed Conifer Forest
- CMF: Closed Mixed Forest
- CW : Conifer woodland
- CWS: Closed Alder/Willow Shrub
- HM: Human Modified
- HRB: Herbaceous
- MW: Mixed Woodland
- OBF: Open Broadleaf Forest
- OCF: Open Conifer Forest
- OMF: Open Mixed Forest
- OWS: Open Alder/Willow Shrub
- PV: Partially Vegetated
- RD: Road
- UNK: Unknown
- WTR: Other Water Features

Vegetation Communities by Cluster
AVC Level III (Viereck et al. 1992)



	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Veg Types	13	9	12	12
Segments	n = 317	n = 96	n = 1180	n=205
Total Length	38945 m	8920 m	142856 m	44461 m

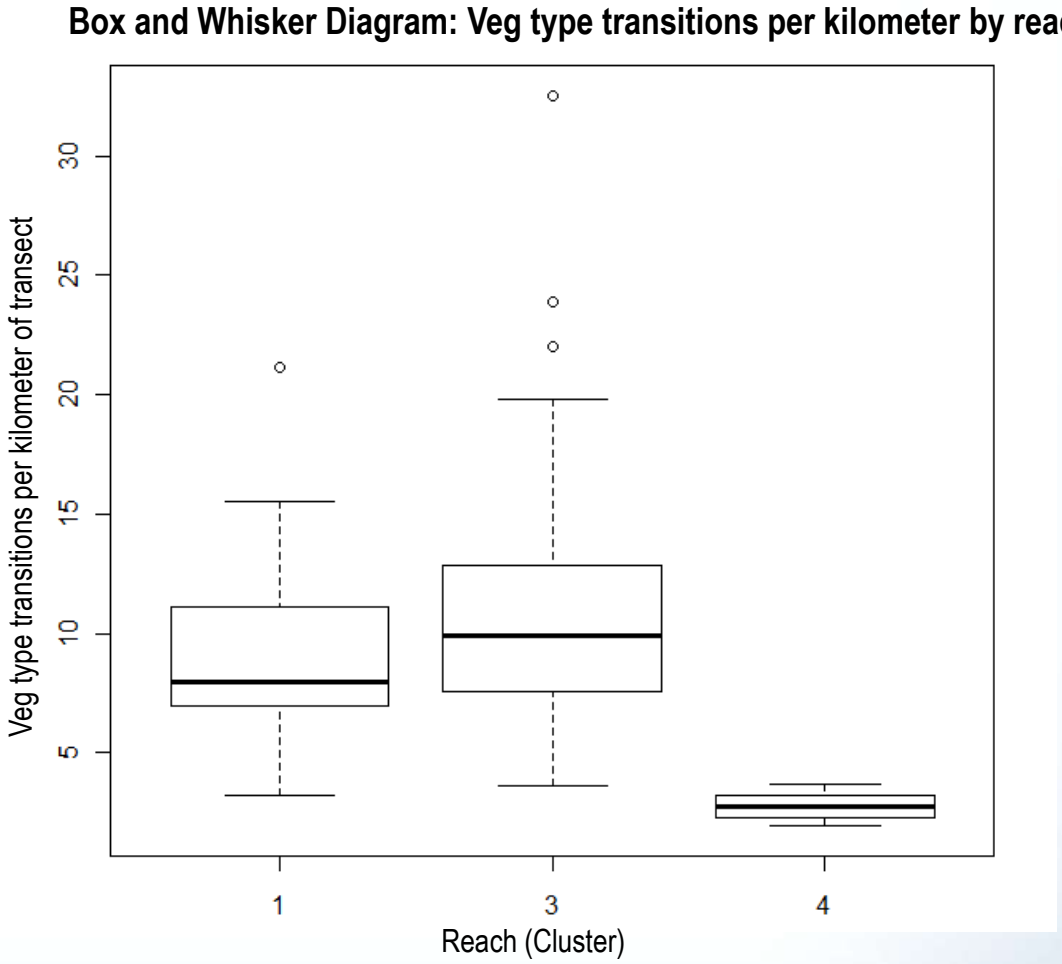
Vegetation transects, ITU mapping, and 2013 Study Design

- ITU vegetation mapping represents strata for use in developing the stratified random sample design within each focus area.
- Number and location of focus areas based on variability and abundance of vegetation types (from veg transects) within each process domain.
- Vegetation transects will be used to select focus areas representative of each process domain as a whole.
- Number of plots per focus area determined from a combination of number and area of veg classes (from ITU) and veg transect complexity in each focus area

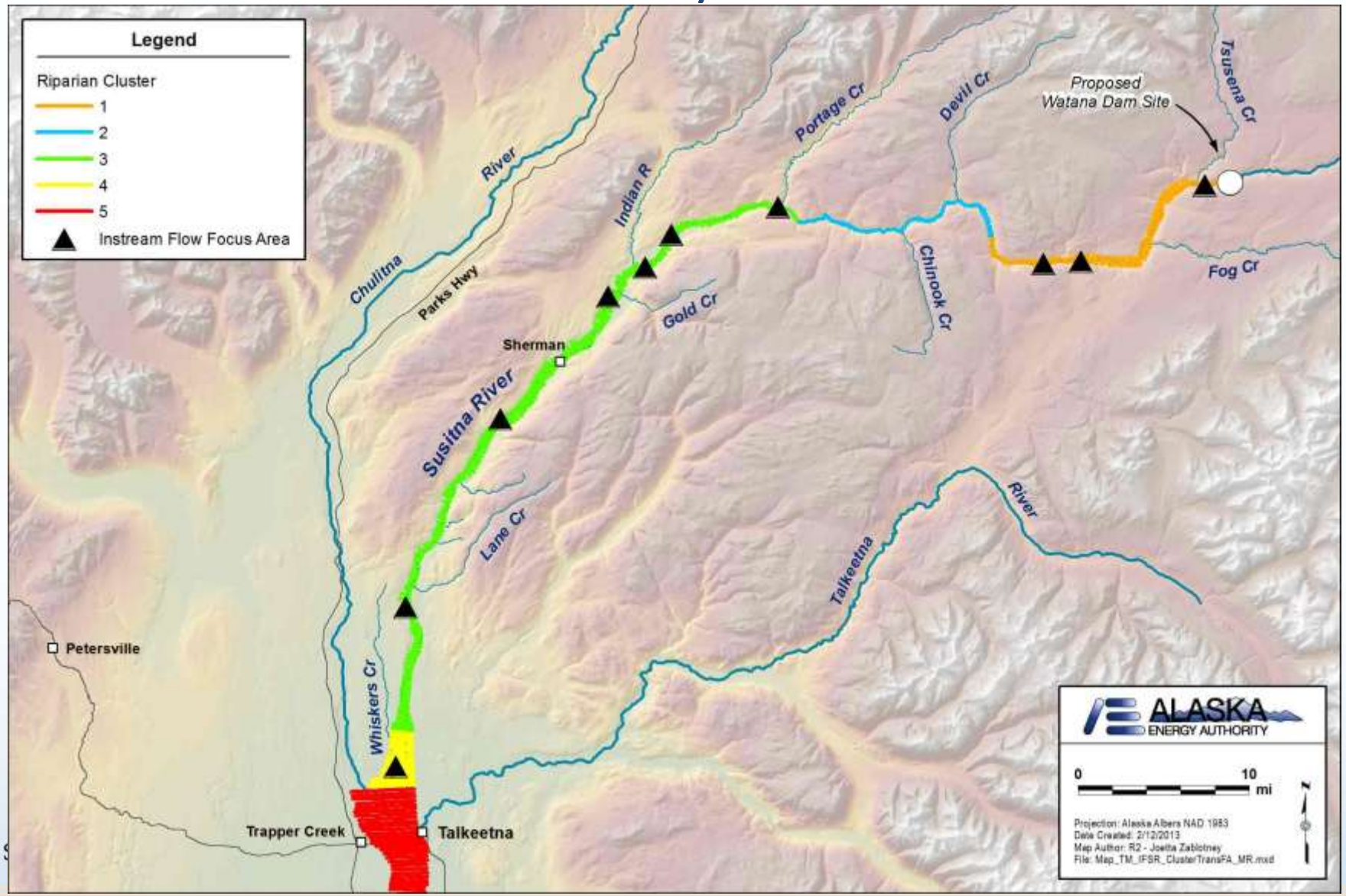
Vegetation Complexity

Each vegetation transect:

- Remove all transects less than 0.2 km total length
- Number of vegetation type transitions per transect (veg)
- Total length of each transect (km)
- Calculate # of veg type transitions per kilometer of transect as veg/km
- Summarize across all transects in each reach



Middle River Riparian Process Domains: Cluster Analysis



Riparian Instream Flow & Vegetation Study Team

- Thanks to the Riparian IFS Team!
  - Joetta Zablotney, R2 GIS Lead
  - Kate Knox, R2 Remote Sensing and Ecological Analyses
  - Alice Shelly, R2 Environmental Statistician
  - Tracy Christopherson, ABR Soil Scientist & Remote Sensing
  - Ellen Trainor, ABR Botanist
  - Allison Zusi-cobb, ABR GIS Lead