Explanation of My Issues with:
1. Snapping Points to Lines
2. Extracting Physical Details by Means of Elaborated Multi-Ring Buffers

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Introduction

- Natural streams are characterized by changes in **cross-section geometry**, **bed-slope**, and **geophysical properties** (bed roughness, hydraulic slope, etc.) along their reaches. So their morphological patterns and cross-sectional shapes will be different and changeable in different regions and is dependent on many physical aspects

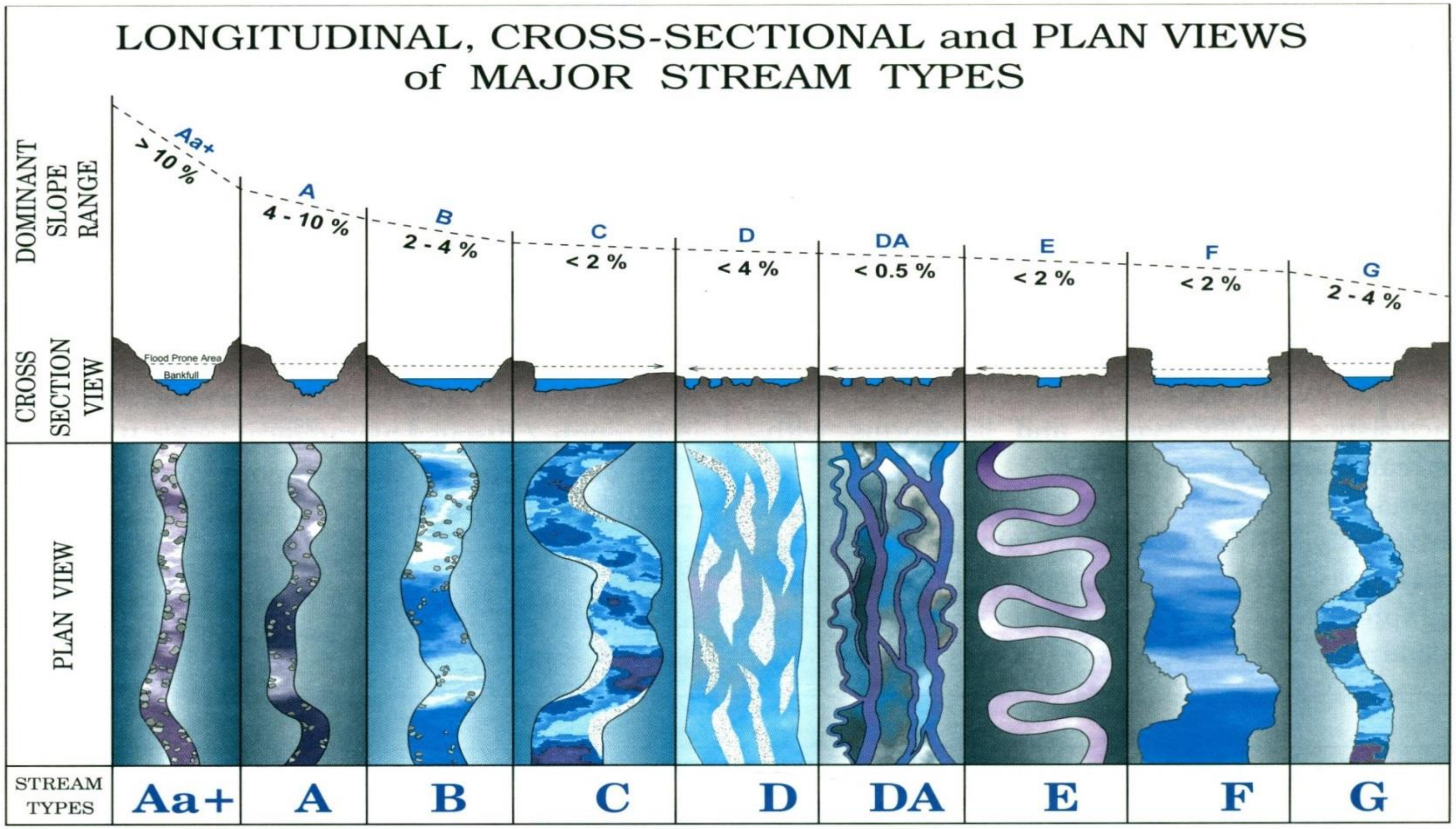
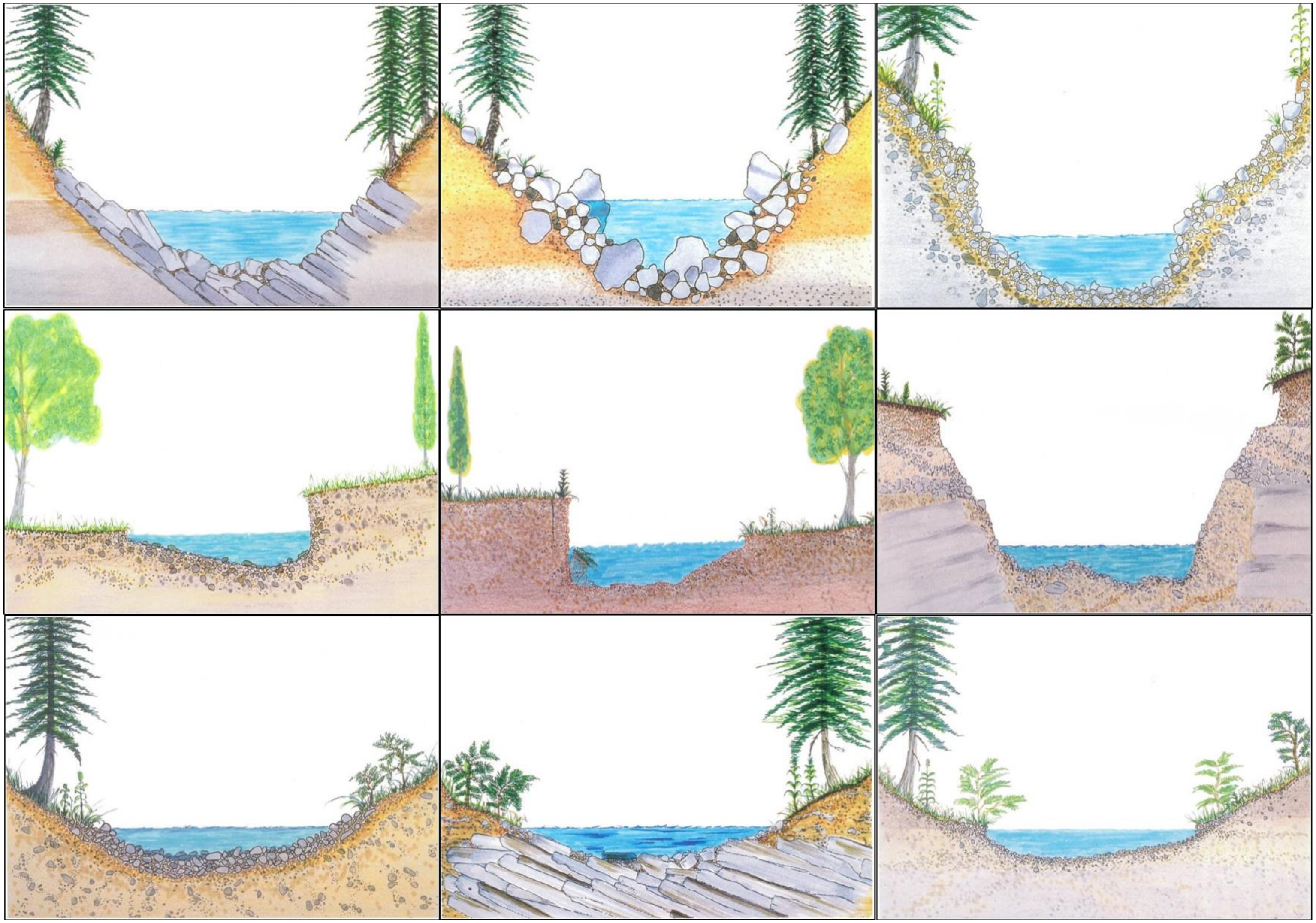


Figure was adopted from *Dave Rosgen*, (1996), *Applied River Morphology,* page 4-4.

Introduction

- Different River Morphology and Natural Riverbed Geometry



Figures are adopted from *Dave Rosgen*, (1996), *Applied River Morphology*.

Introduction

- Variations in the shape and size of the alluvial channel bed geometry result from several interacting features of the river system including effect of different flow regimes, bed-slope, sediment load, etc.

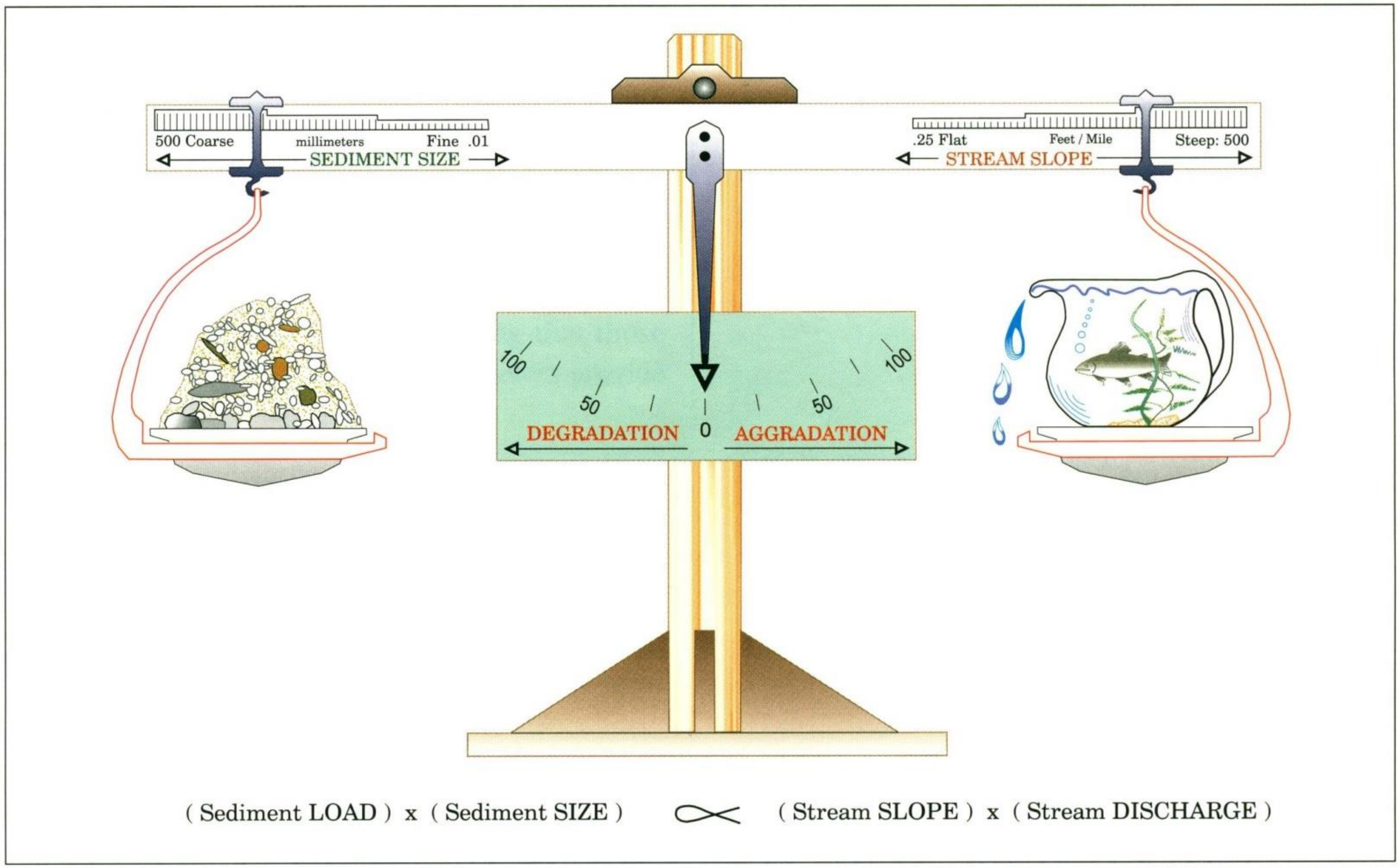
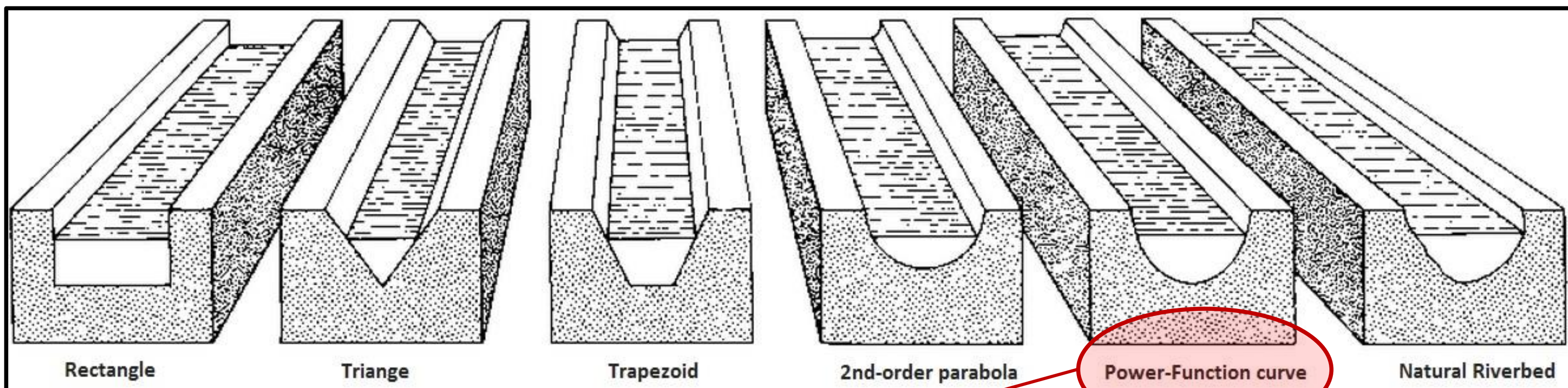


Figure is adopted from *Dave Rosgen*, (1996), *Applied River Morphology*, page 2-2.

Improving Riverbed Geometry

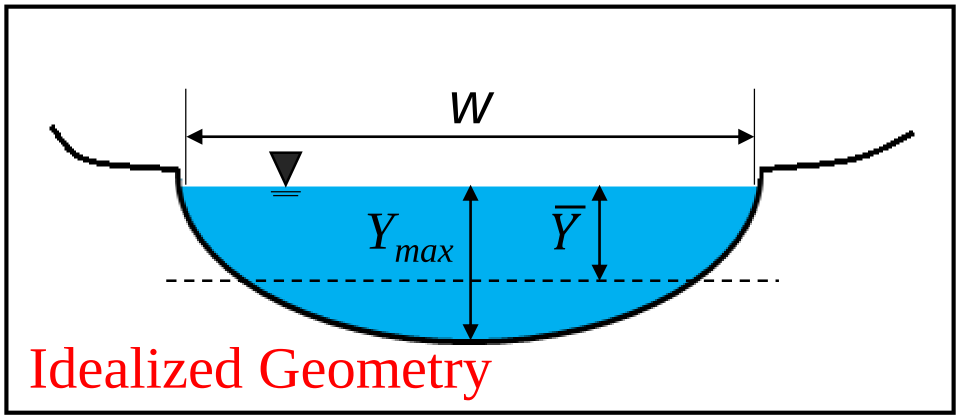
- Simplifying the river bed geometries could reduce the burden of assembling the required data.
- Implementing less detailed flow routing procedures could lower the computational burden.



- **Developing idealized power-law-shaped riverbed geometries only based on streamflow information, and employing them in flow routing schemes and river network models.**

Improving Riverbed Geometry; Hydraulic Geometry

- Average conditions over longer river reaches are more uniform and predictable based on flow and topography consideration.
- Average flow conditions expressed as power-law "**at-a-station**" hydraulic geometry (or AHG) relationships between key channel components, (i.e. water depth, top-width, flow velocity, flow area against discharge) have been studied since 50's.



discharge (Q)

mean depth ($\bar{Y}$)

water surface width (W)

flow velocity (U)

$\boxed{\bar{Y} = cQ^f}$ $\boxed{W = aQ^b}$ $\boxed{U = kQ^m}$

$$\boxed{Q = \bar{Y}\,W\,U = c\,a\,k\,Q^{f+b+m}} \longrightarrow \left.\begin{matrix} f+b+m \\ c\times a\times k \end{matrix}\right\} = 1$$

Idealized Geometry:

$$\bar{Y} = \left(\frac{r}{r+1}\right)\alpha W^{r}$$

Improving Riverbed Geometry; Hydraulic Geometry

$$z = Y_m^* \cdot \left(\frac{2}{W^*}\right)^r \cdot x^r, \quad 0 \leqslant x \leqslant W^*/2$$

where ***z*** is height of the bed above the lowest channel elevation (assumed to occur at the channel center), and ***x*** is horizontal distance from the center (Fig. 1).

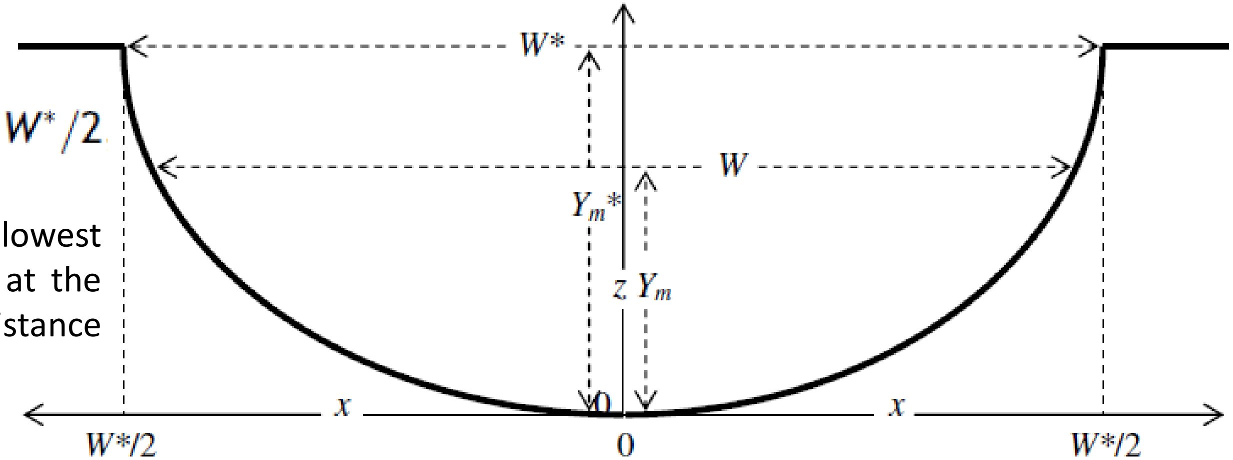


Figure 1 Definitions of terms used to model cross-section geometry.

A triangle is represented by **r = 1**, a parabola by **r = 2**, and forms with increasingly flatter bottoms and steeper banks by increasing values of **r**; in the limit as **r → ∞** the channel is rectangular (Fig. 2).

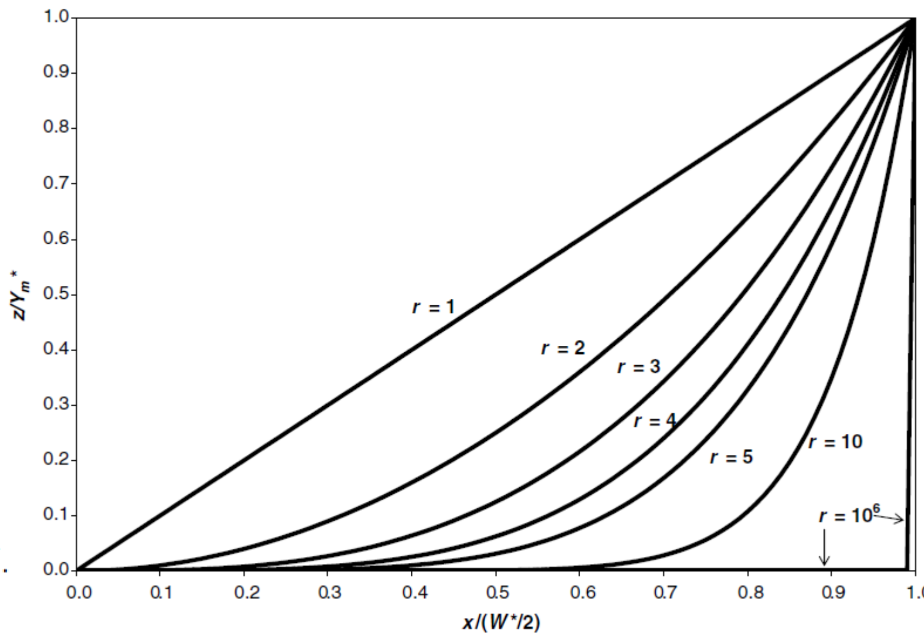


Figure 2 Channel shape as a function of the shape exponent r. Channels are assumed to be symmetrical with bankfull width W^* and bankfull maximum depth Y_m^* $\cdot$ $r = 1$ represents a triangle, $r = 2$ a parabola, and $r \to \infty$ a rectangle.

It can be shown that, given bankfull width W* and bankfull maximum depth Y^*_m, average depth, Y, and water-surface width, W, are related to maximum depth, Y_m, as

$$Y = \left(\frac{r}{r+1}\right) \cdot Y_m, \quad Y_m = \left(\frac{r+1}{r}\right) \cdot Y;$$

$$W = W^* \cdot \left(\frac{Y_m}{Y_m^*}\right)^{1/r} = W^* \cdot \left(\frac{1}{Y_m^*}\right)^{1/r} \cdot \left(\frac{r+1}{r}\right)^{1/r} \cdot Y^{1/r}.$$

Figures were adopted from S. L. Dingman, 2007, *Journal of Hydrology, Vol. 334, p 17-27*

Literatures Assessment over b, f, and m exponents distributions

- Park C. (1977) collected and assessed variations of power-law exponents of AHG relations derived from 139 stations reported in literature. Histograms of b, f, and m exponents of AHG relations associated with Park's study is shown below.
- These distributions have been found to be universal in all rivers where power-law hydraulic geometry relations were calculated.

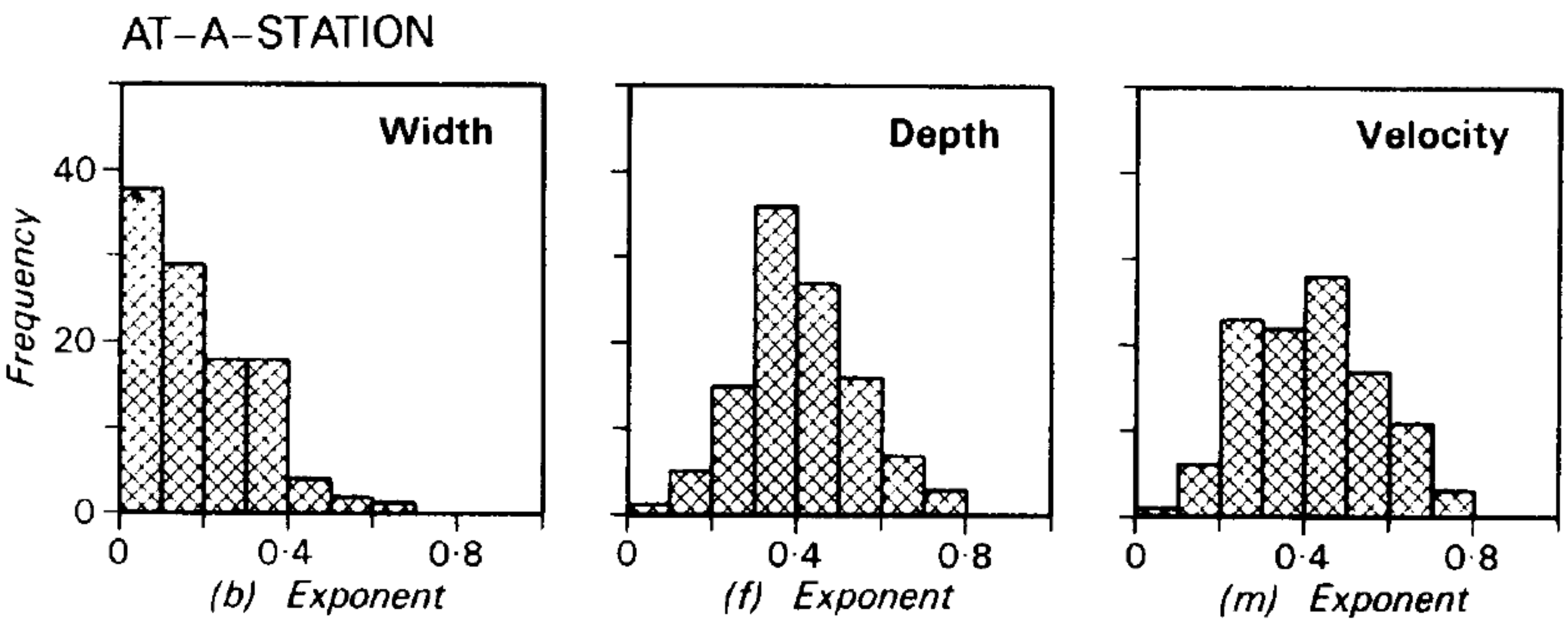
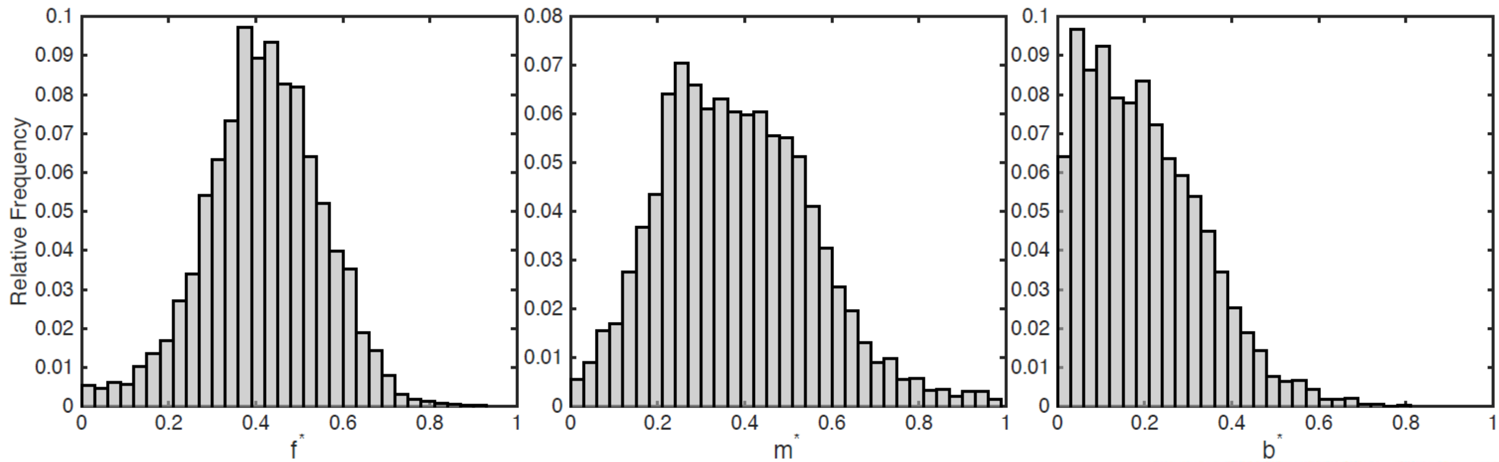


Figure was adopted from *C.C. Park, 1977, Journal of Hydrology, Vol. 33, p 133-146*

My Assessment over b, f, and m exponents distributions

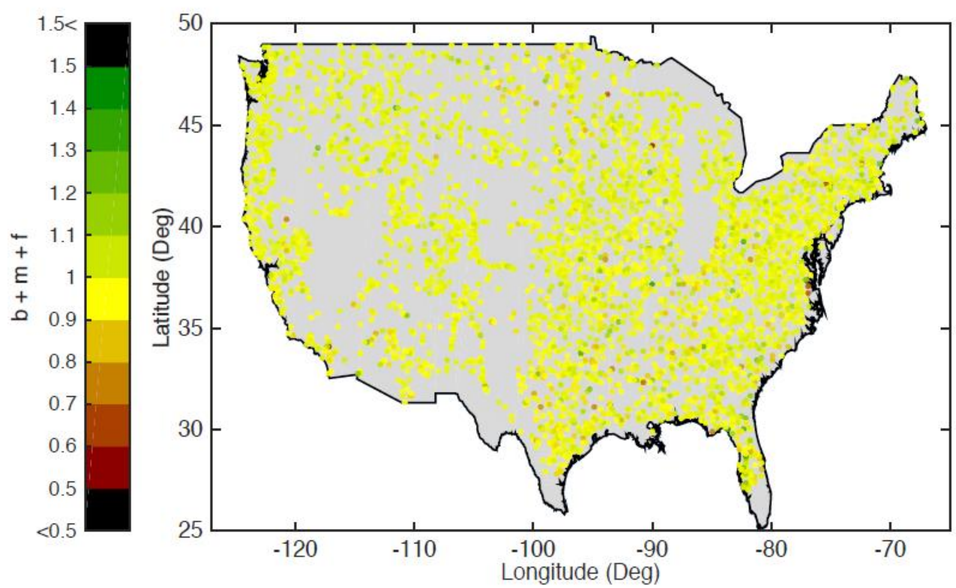
- I collected and assessed variations of power-law exponents of AHG relations derived from 4289 stations reported in literature. Histograms of b, f, and m exponents of AHG relations associated with my study is shown below.

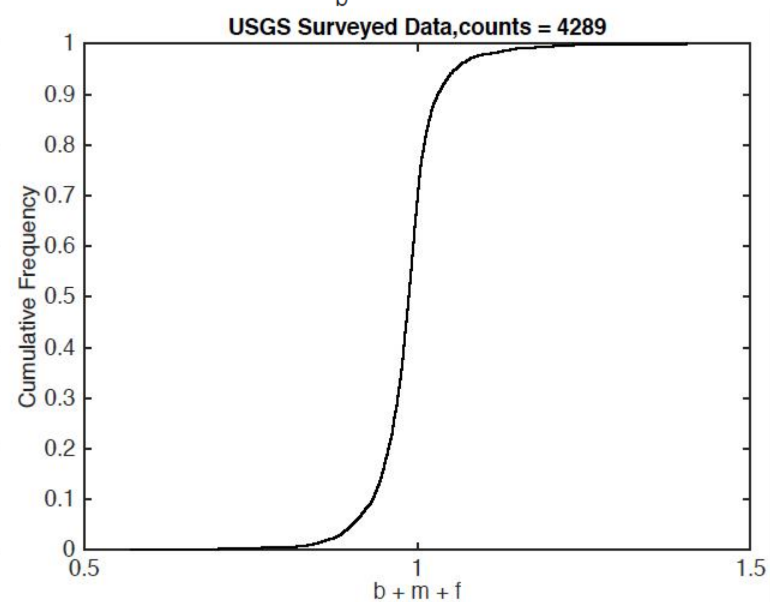


$$b^* = \frac{b}{b+m+f}$$

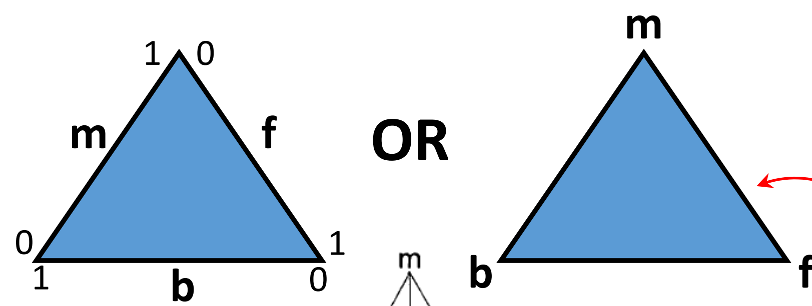
$$f^* = \frac{f}{b+m+f}$$

$$m^* = \frac{m}{b+m+f}$$





Literatures Assessment over b, f, and m exponents distributions



$$\bar{Y} = cQ^{f}$$

$$U = kQ^{m}$$

$$W = aQ^{b}$$

- b-f-m diagram below is produced by *D.D. Rhodes, 1977* where he assembled results of studies made by different researches on different rivers.
- It is based upon **315** sets of at-a-stations hydraulic geometry exponents
- This diagram illustrate some general relationship such as clusterings of points and the range of values.
- The usefulness of the plot, and the possible inferences derived from it, may be increased by meaningful division of the diagram.

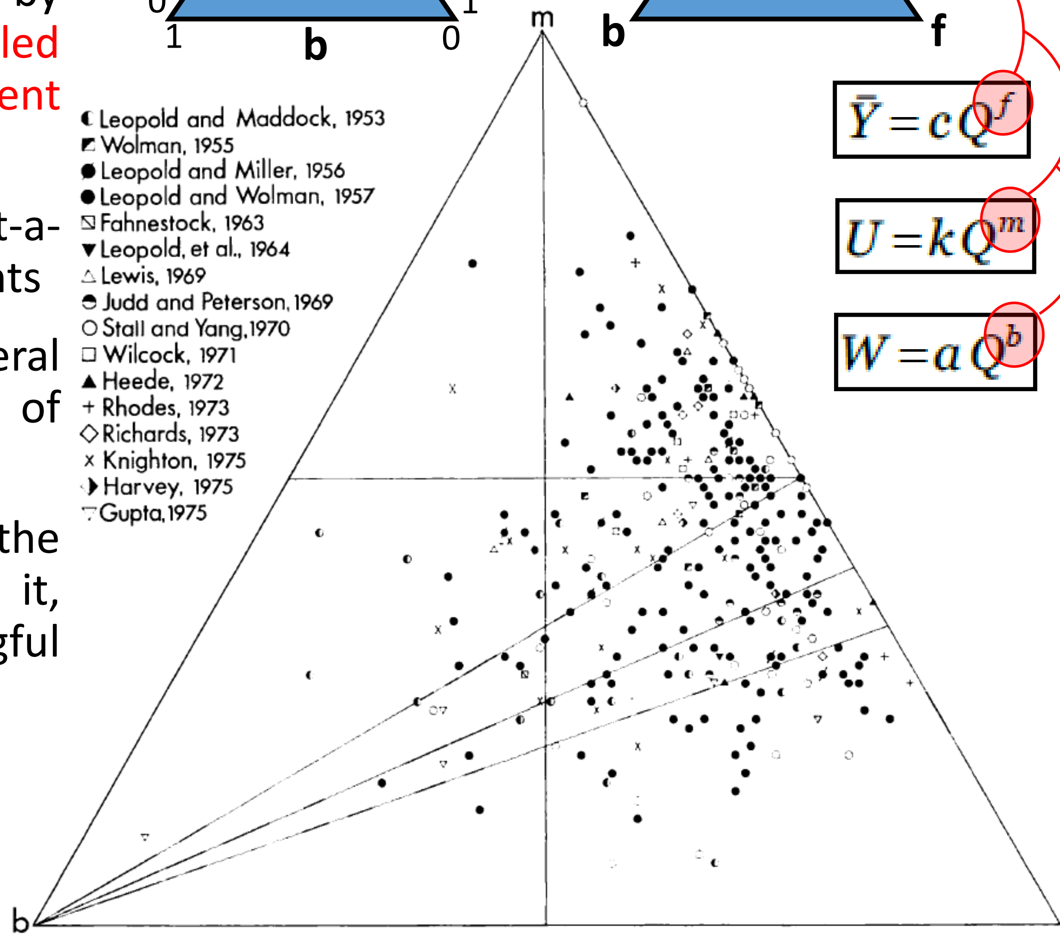


Fig. 1. The b-f-m diagram showing plotting position of 315 sets of at-a-station hydraulic geometry exponents. Some points represent more than one station.

Figure was adopted from *D. D. Rhodes, 1977, American Journal of Science, Vol. 227, p 73-96*

Literatures Assessment over b, f, and m exponents distributions

Expected direction of change of morphologic and hydrodynamic parameters with increasing discharge for different channel types

Channel type	Width-depth ratio (w/d)	Competence	Froude number	Velocity-area ratio (v/A)	Slope-roughness ratio ($s^{1/2}/n$)
1	Increases	Increases	Increases	Increases	Increases
2	Decreases	Increases	Increases	Increases	Increases
3	Increases	Increases	Increases	Decreases	Increases
4	Decreases	Increases	Increases	Decreases	Increases
5	Increases		Increases	Decreases	Increases
6	Decreases		Increases	Decreases	Increases
7	Increases		Increases	Decreases	Decreases
8	Decreases		Increases	Decreases	Decreases
9	Increases		Decreases	Decreases	Decreases
10	Decreases		Decreases	Decreases	Decreases

Table was adopted from *D. D. Rhodes, 1977, American Journal of Science, Vol. 227, p 73-96*

Division of the diagram by 5 criteria

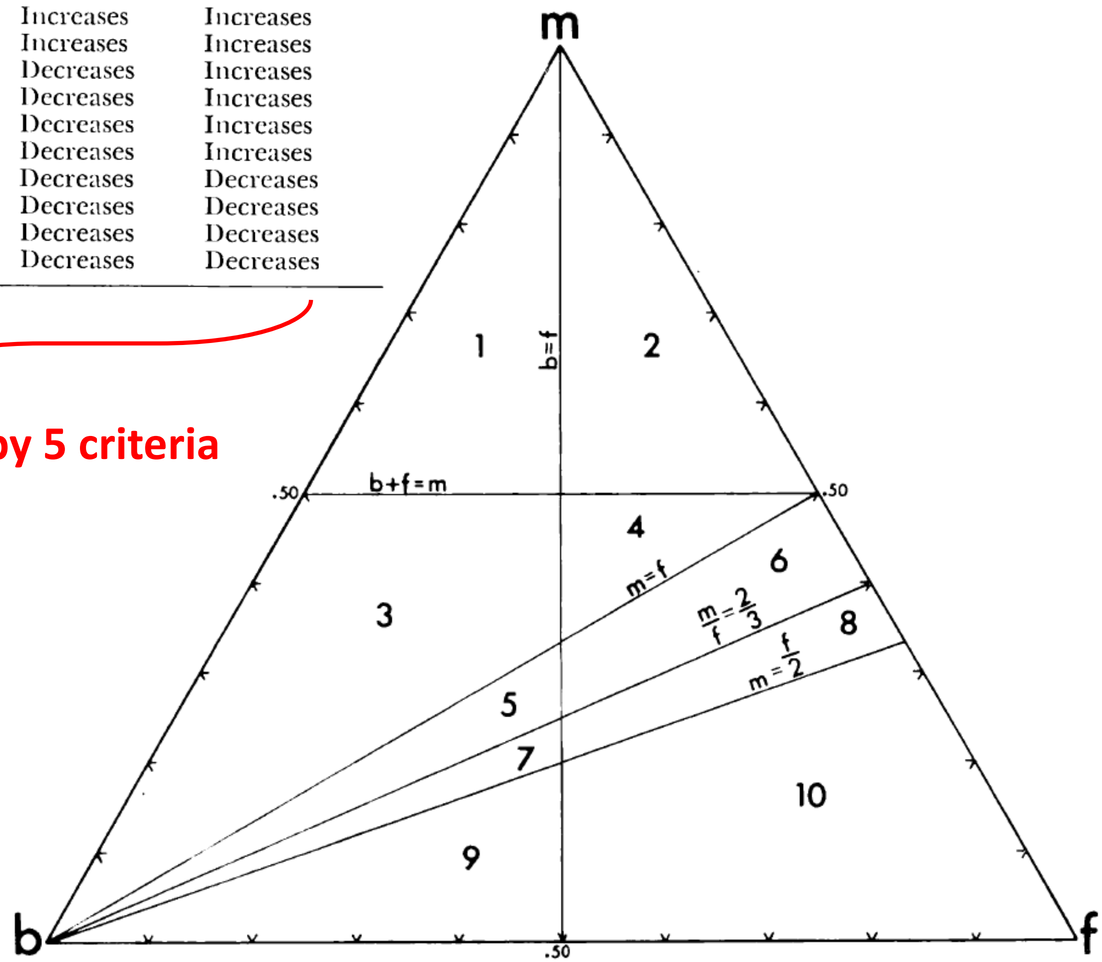


Fig. 2. Divided b-f-m diagram showing numbered areas that delineate channel types.

Figure was adopted from *D. D. Rhodes, 1977, American Journal of Science, Vol. 227, p 73-96*

Literatures Assessment over b, f, and m exponents distributions

Expected direction of change of morphologic and hydrodynamic parameters with increasing discharge for different channel types

Table was adopted from *D. D. Rhodes, 1977, American Journal of Science, Vol. 227, p 73-96*

Channel type	Width-depth ratio (w/d) $w/d \propto Q^{b-f}$	Competence $v/d \propto Q^{m-f}$	Froude number $F = \frac{kQ^m}{\sqrt{gcQ^f}}$	Velocity-area ratio (v/A)	Slope-roughness ratio ($s^{1/2}/n$)
1	Increases	Increases	Increases	Increases	Increases
2	Decreases	Increases	Increases	Increases	Increases
3	Increases	Increases	Increases	Decreases	Increases
4	Decreases	Increases	Increases	Decreases	Increases
5	Increases		Increases	Decreases	Increases
6	Decreases		Increases	Decreases	Increases
7	Increases		Increases	Decreases	Decreases
8	Decreases		Increases	Decreases	Decreases
9	Increases		Decreases	Decreases	Decreases
10	Decreases		Decreases	Decreases	Decreases

s: slope

n: Manning's roughness

$m <=> f + b$

- " **The simple b-f-m diagram gives little information about the sets of hydraulic data**...Division of the diagram by 5 criteria into various fields supplies much additional information about **similarities** and **relationships** between the various data." *C.C. Park, 1977*

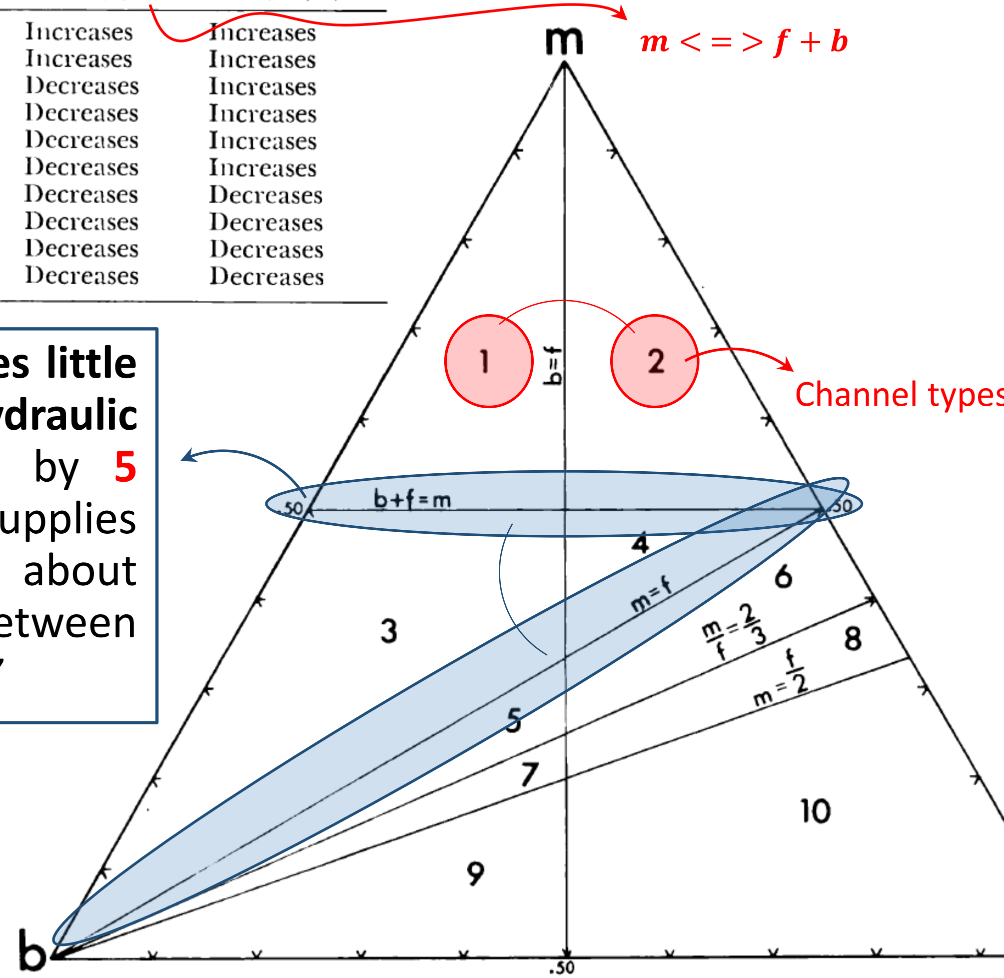


Fig. 2. Divided b-f-m diagram showing numbered areas that delineate channel types.

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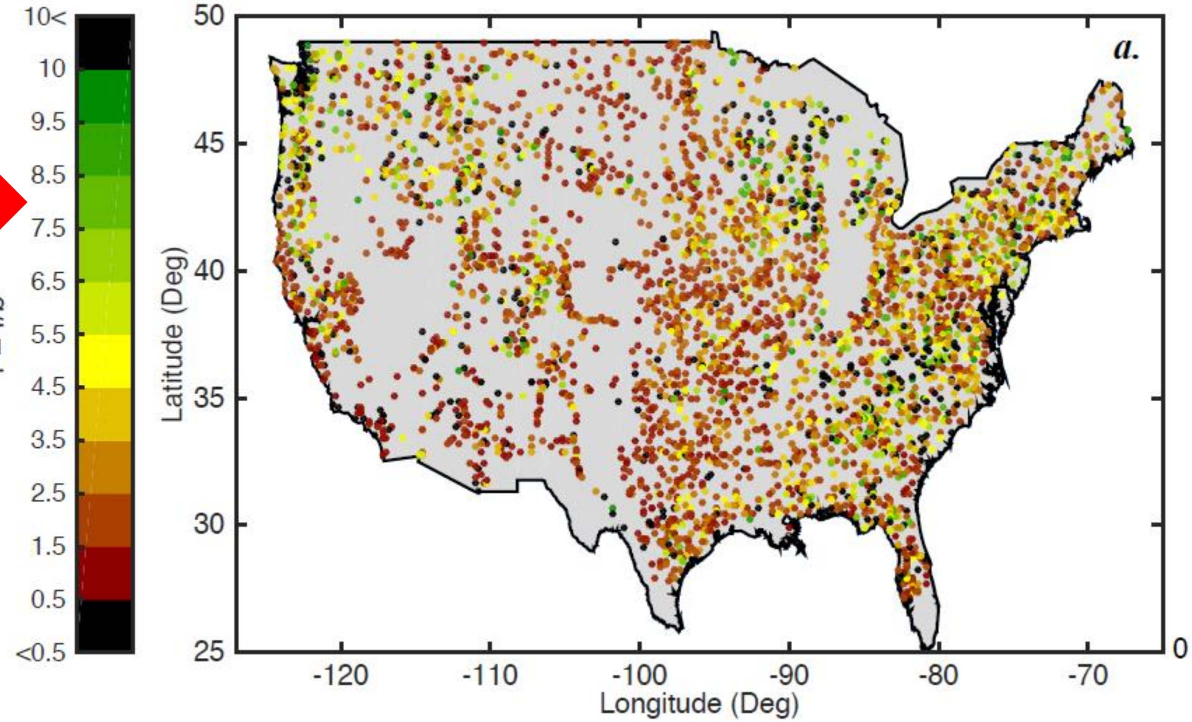
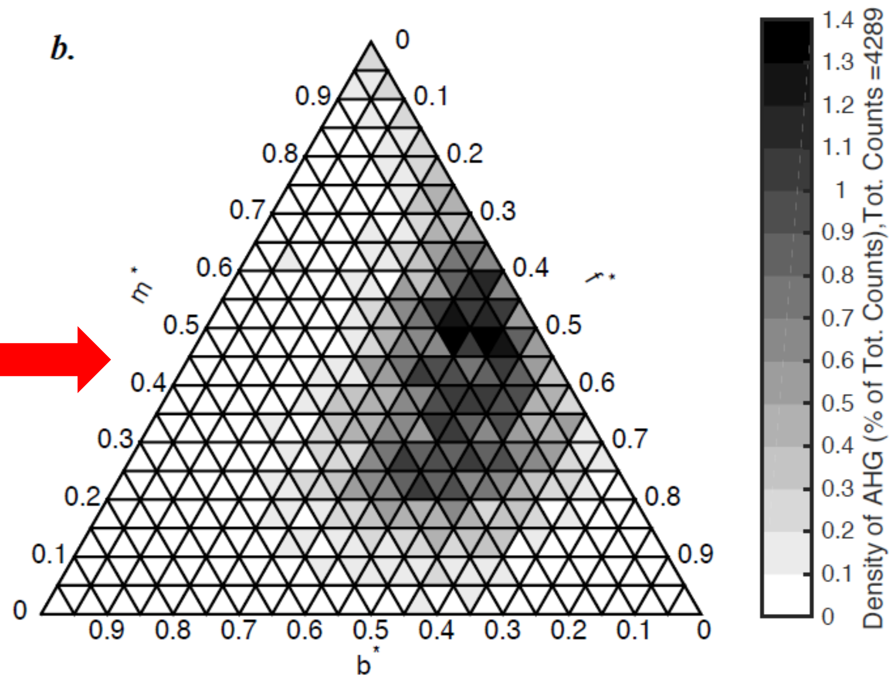
What I derived...

- I computed an estimate for geometrical shape of riverbed assuming a power-law relation for **4289 USGS monitoring stations** as following:

$$z = Y_m^* \cdot \left(\frac{2}{W^*}\right)^r \cdot x^r, \quad 0 \leqslant x \leqslant W^*/2$$

- I demonstrated the inter-relations of **b**, **f**, and **m** exponents of tri-axial diagram.
- Due to large counts of points clustering at particular regions of the diagram and/or overlaying at top of each other, I elaborated the original types of displaying them by showing the density of points which lay at particular domain of the tri-axial plot.
- **Classification of the diagram into 10 regions same as previous studies but based on larger counts of observation is demanded.**





$$b^* = \frac{b}{b+m+f}$$

$$f^* = \frac{f}{b+m+f}$$

$$m^* = \frac{m}{b+m+f}$$

Is there any correlation between b-f-m and following physical and topographical features of the environment?

- Elevation; rivers at high altitude lands
- Landcover and soil type
- Types of climate: humid temperate, semi-arid, tropical, etc.

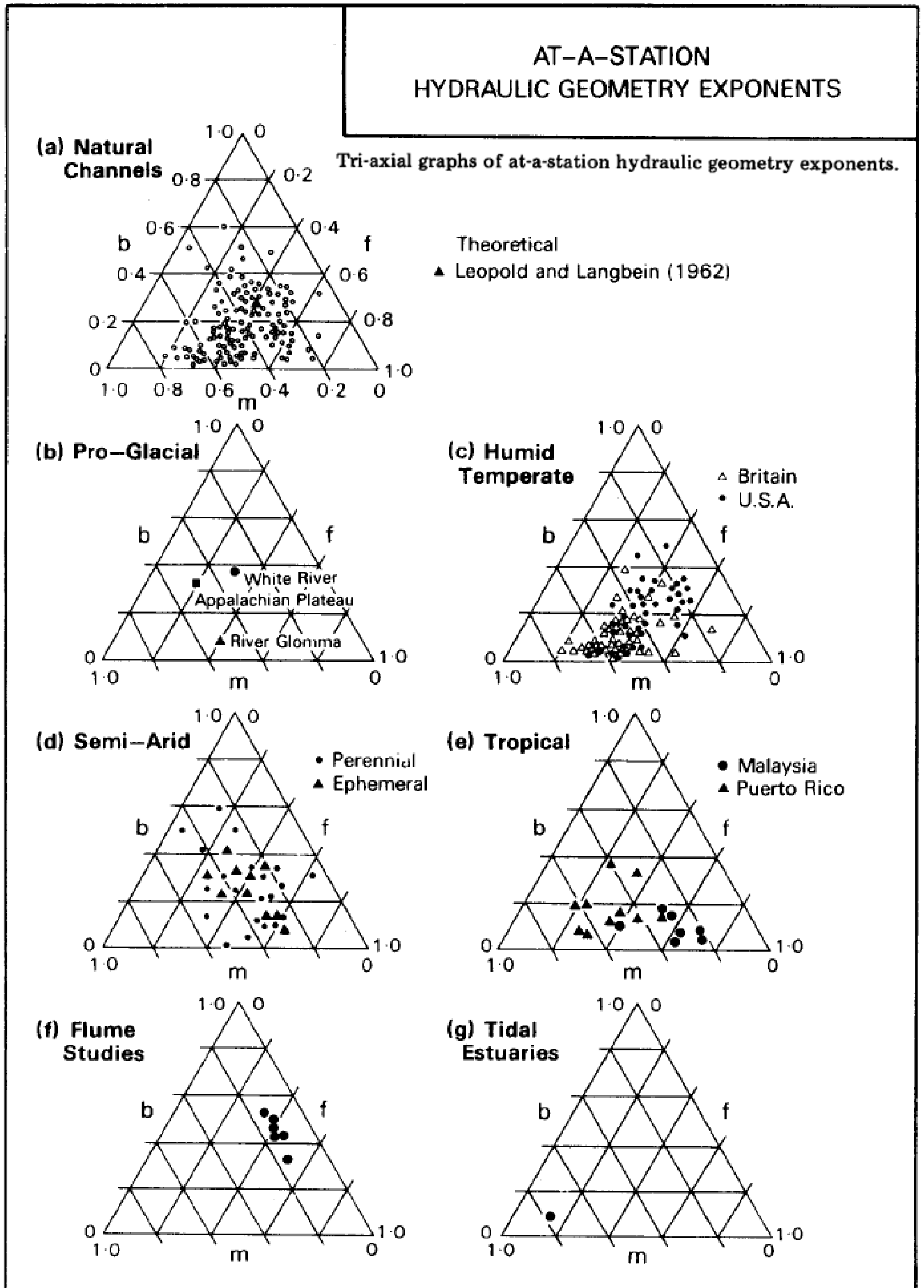


Figure was adopted from C.C. Park, 1977, *Journal of Hydrology*, *Vol. 33, p 133-146*

- Is there any correlation between b-f-m river planforms (e.g. straight, meandering, and braided)?

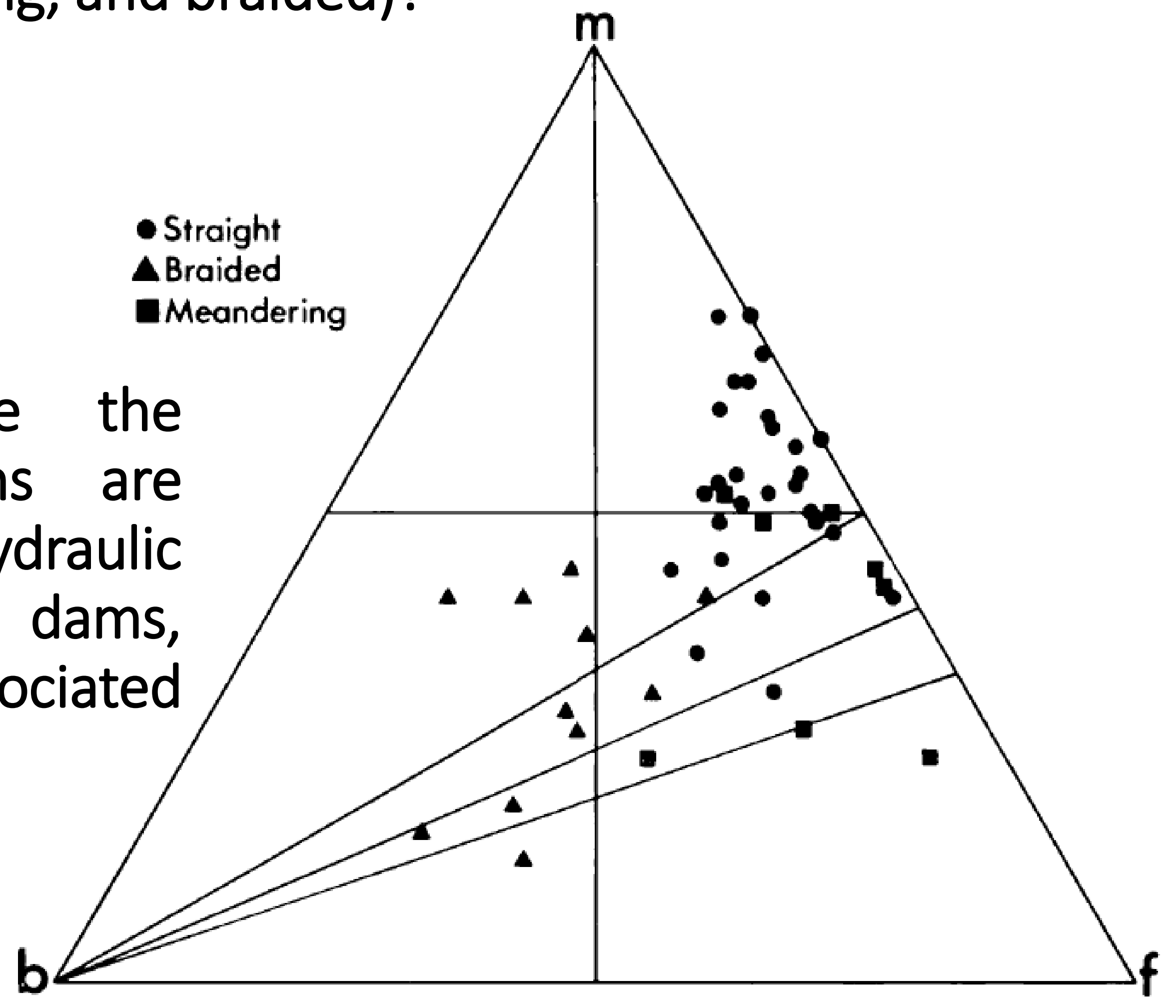


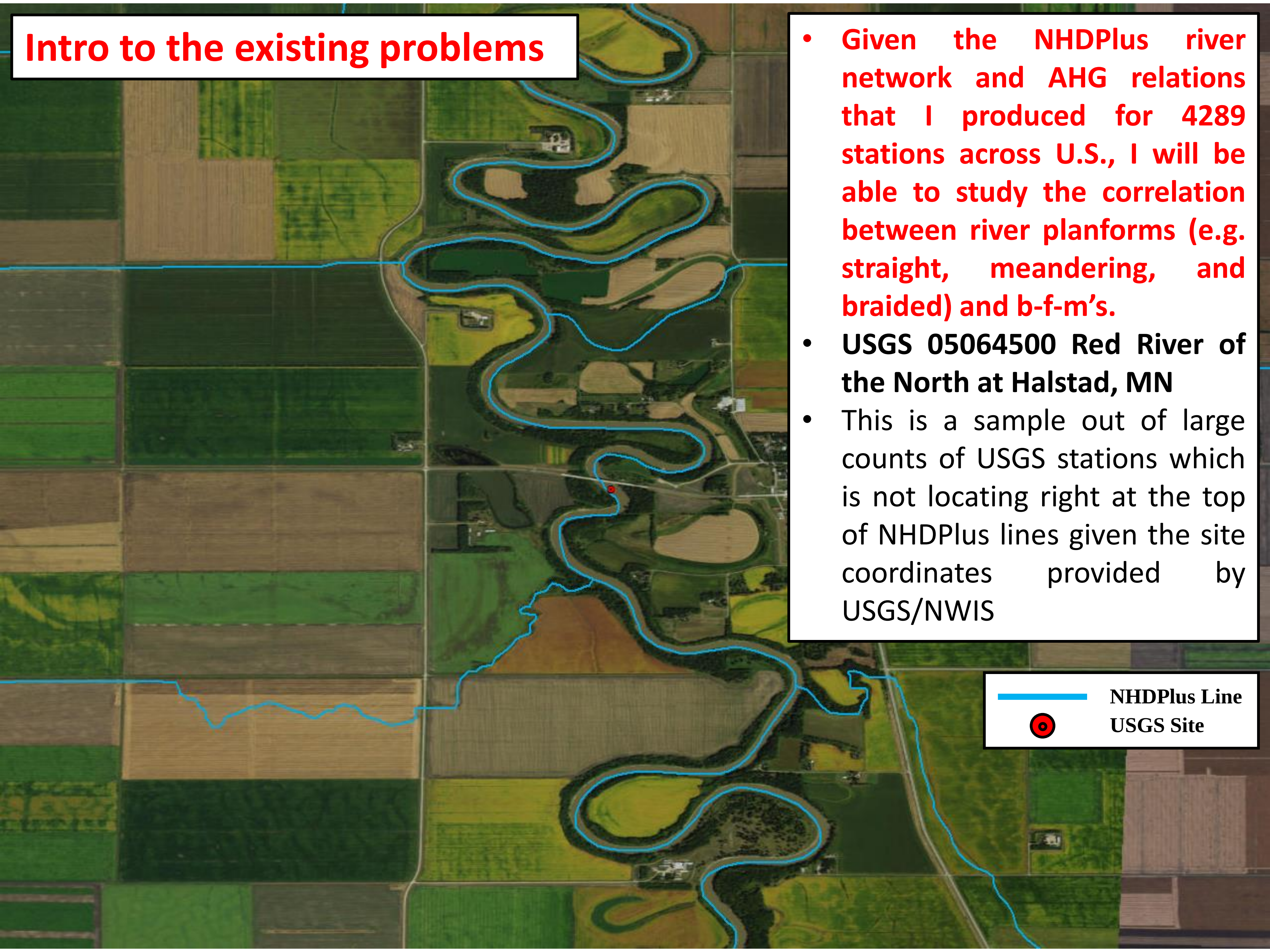
Fig. 5. Relation of channel pattern to plotting position on b-f-m diagram.

- For cases where the monitoring stations are located right at a hydraulic infrastructures (e.g. dams, weirs, etc.), how associated b-f-m's behave?

Figures were adopted from *D. D. Rhodes, 1977, American Journal of Science, Vol. 227, p 73-96*

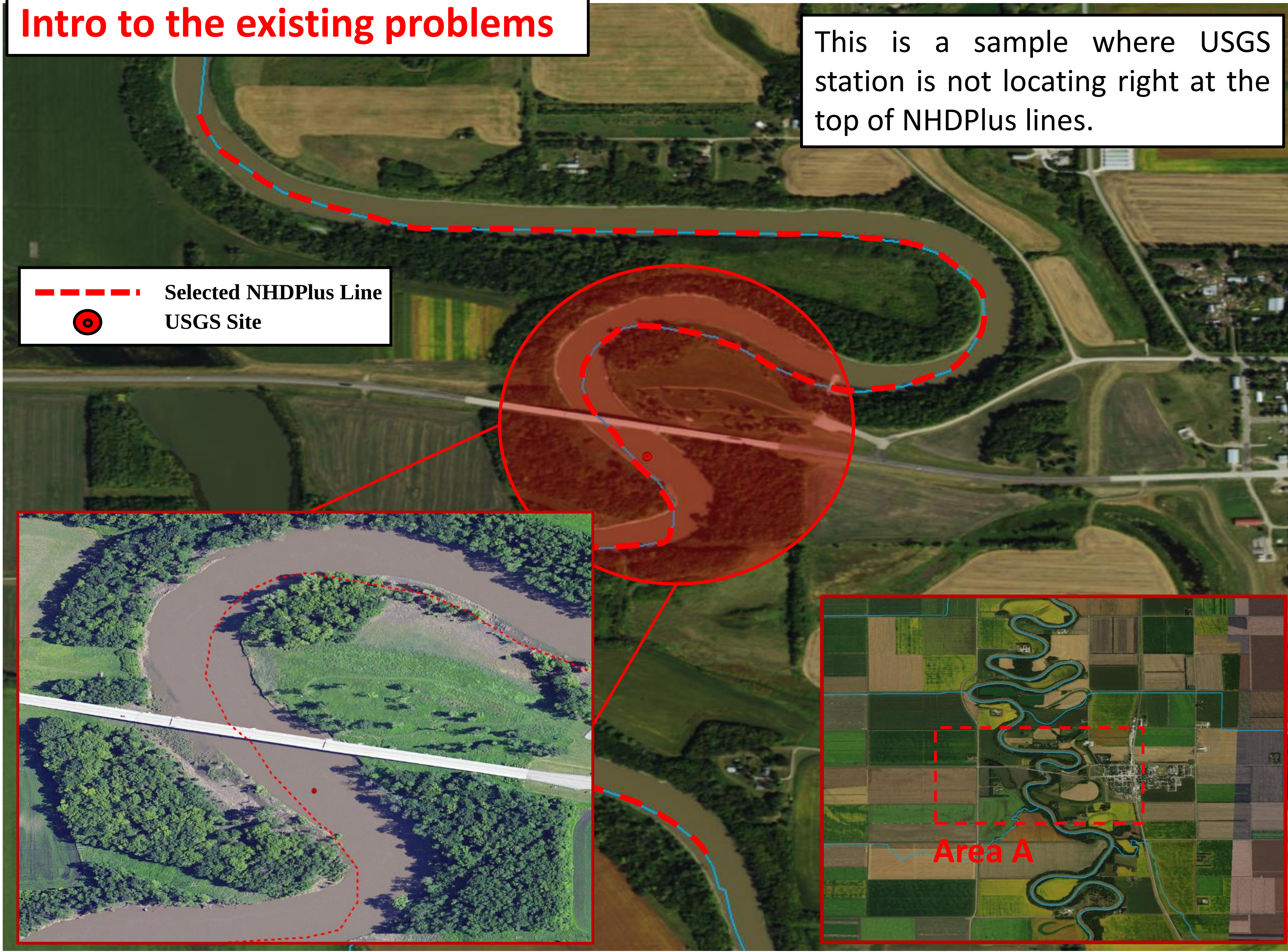
Intro to the existing problems

- **Given the NHDPlus river network and AHG relations that I produced for 4289 stations across U.S., I will be able to study the correlation between river planforms (e.g. straight, meandering, and braided) and b-f-m's.**
- **USGS 05064500 Red River of the North at Halstad, MN**
- This is a sample out of large counts of USGS stations which is not locating right at the top of NHDPlus lines given the site coordinates provided by USGS/NWIS



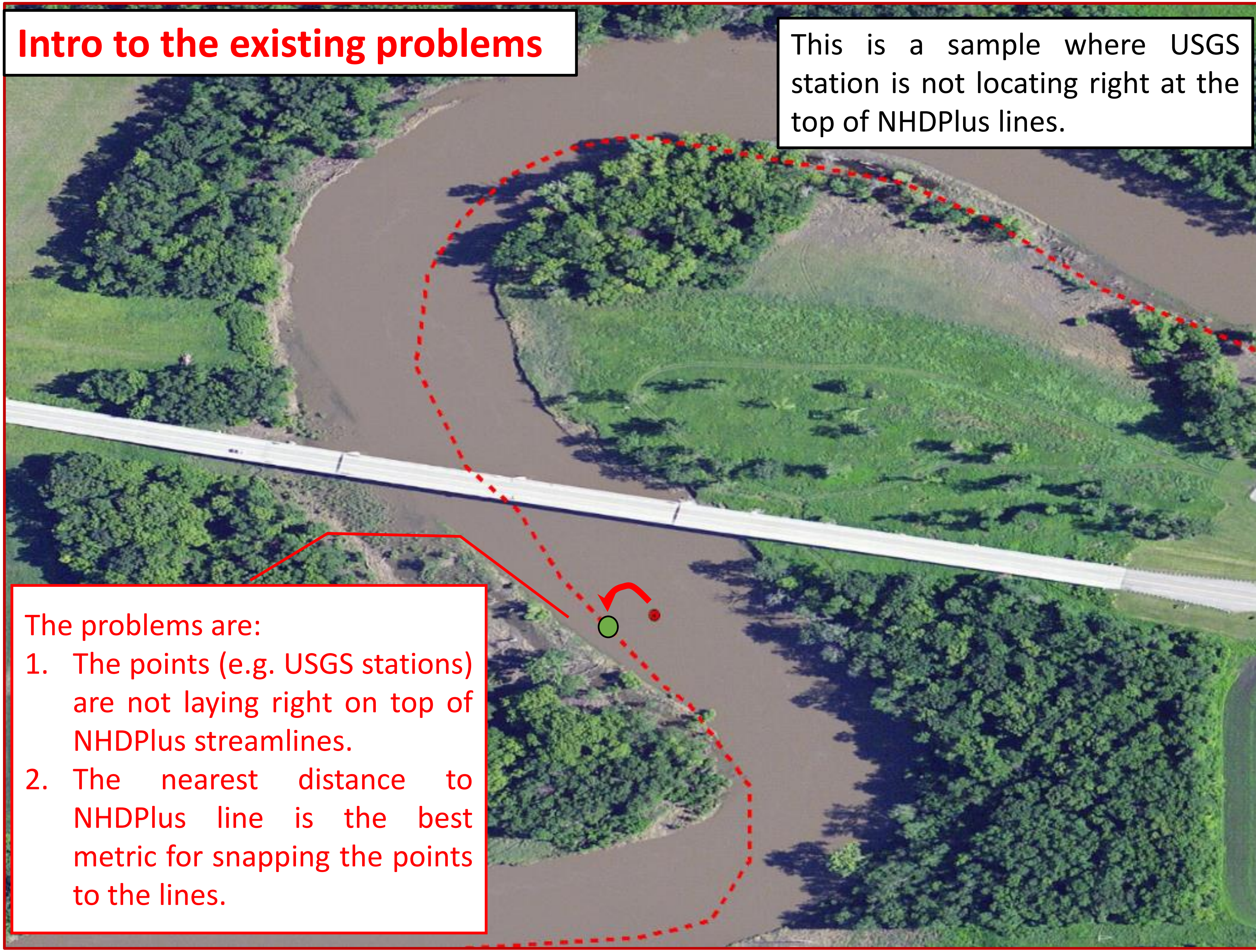
Intro to the existing problems

This is a sample where USGS station is not locating right at the top of NHDPlus lines.



Intro to the existing problems

This is a sample where USGS station is not locating right at the top of NHDPlus lines.

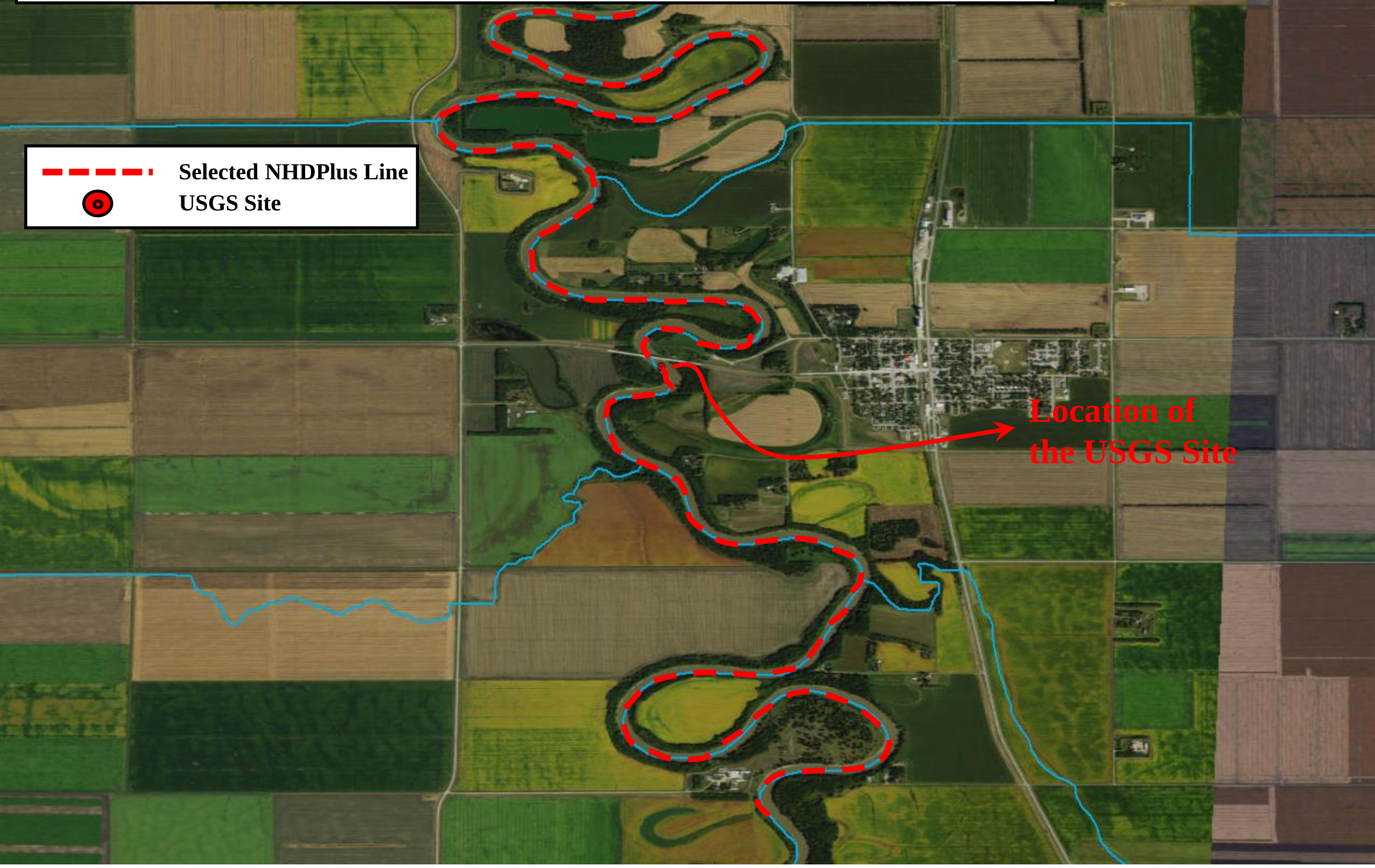


The problems are:

1. The points (e.g. USGS stations) are not laying right on top of NHDPlus streamlines.
2. The nearest distance to NHDPlus line is the best metric for snapping the points to the lines.

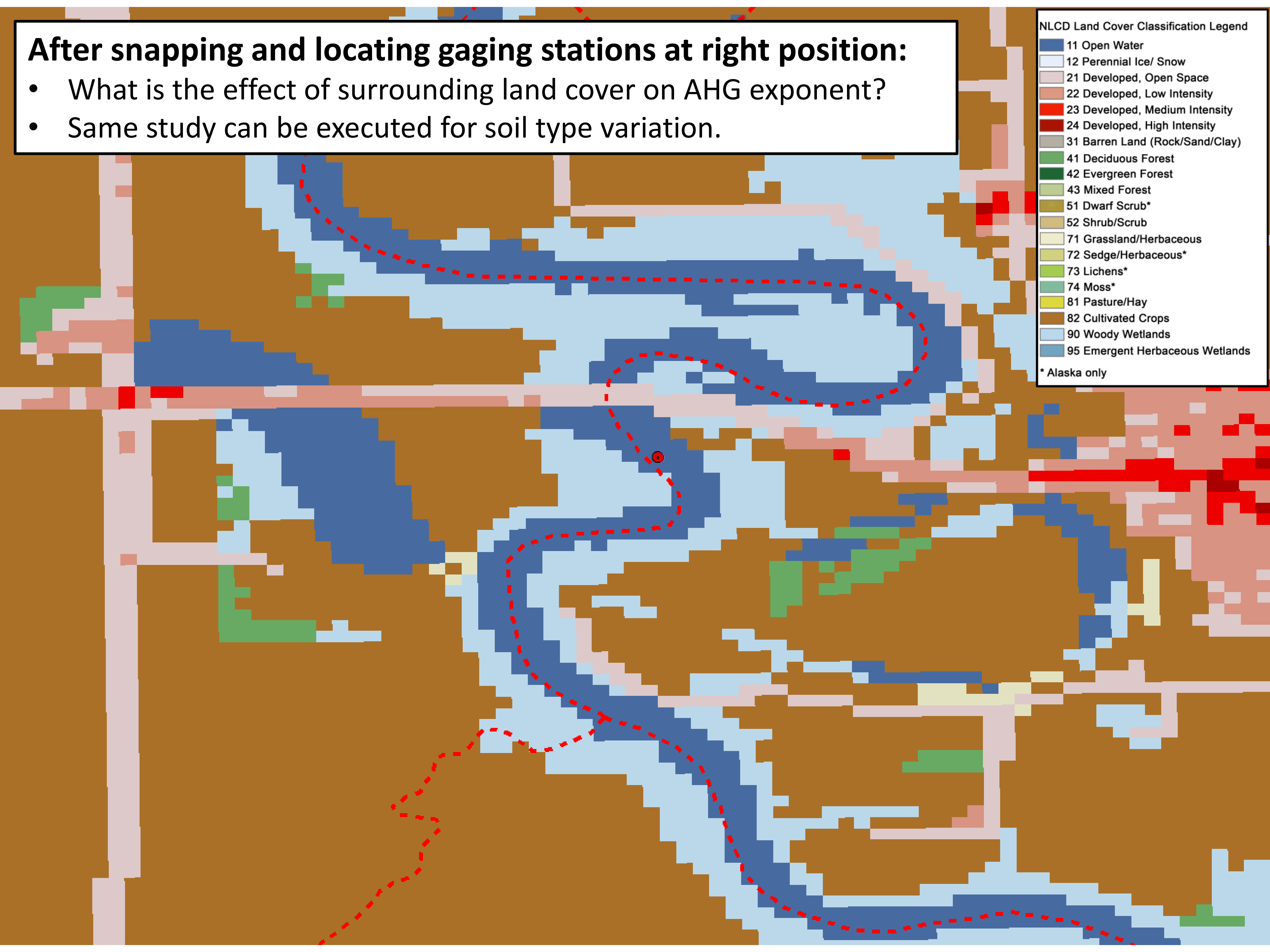
After snapping and locating gaging stations at right position:

- What is the sinuosity metric of the river?
- What is the planform of the river? Meandering, Straight, or Braided?

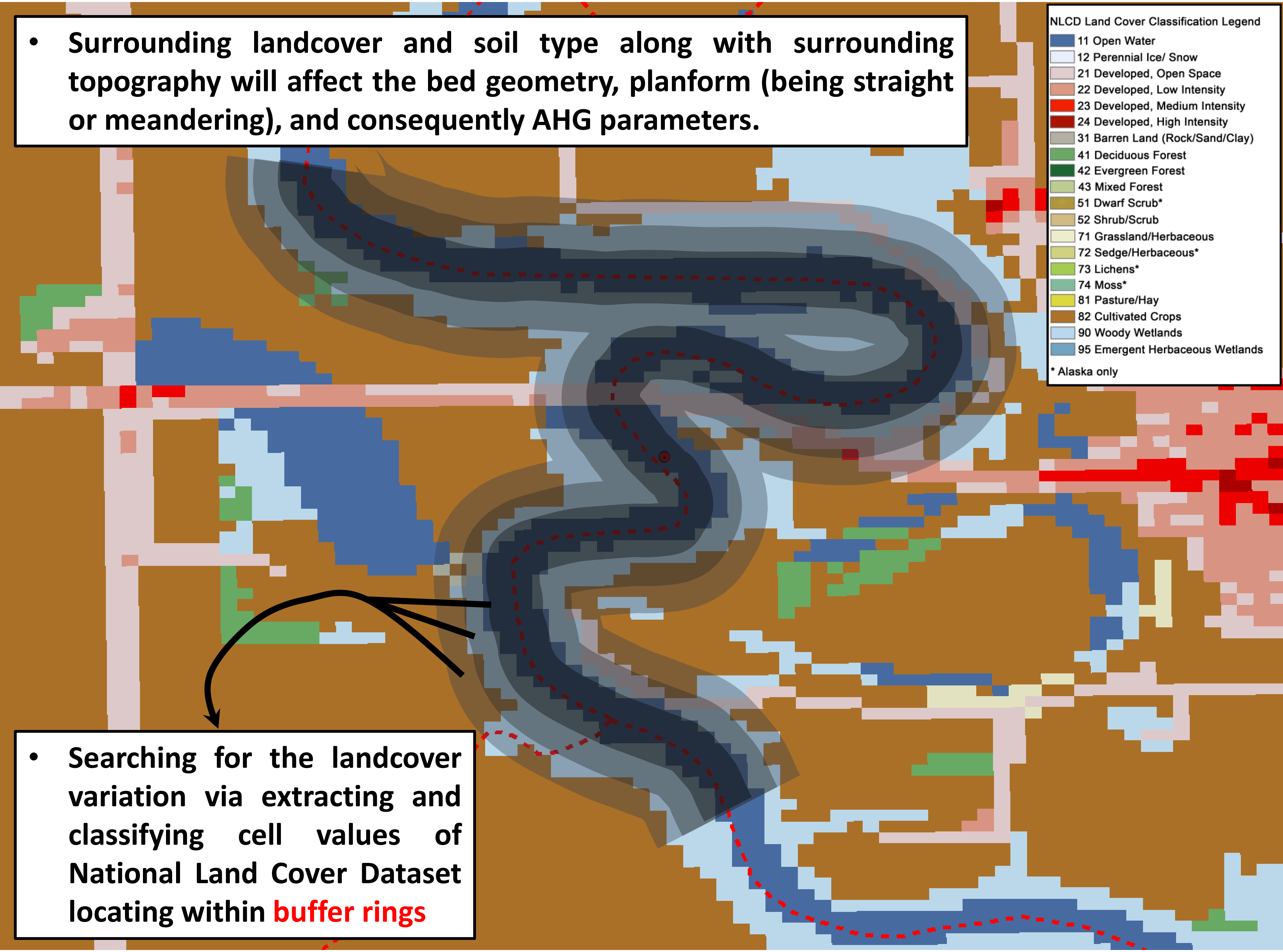


After snapping and locating gaging stations at right position:

- What is the effect of surrounding land cover on AHG exponent?
- Same study can be executed for soil type variation.



- Surrounding landcover and soil type along with surrounding topography will affect the bed geometry, planform (being straight or meandering), and consequently AHG parameters.



- Searching for the landcover variation via extracting and classifying cell values of National Land Cover Dataset locating within buffer rings

References

1. Dingman, S. L. (2007). Analytical derivation of at-a-station hydraulic geometry relations. *Journal of Hydrology, 334*, 17-27.
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