A Detailed Summary of the WRWI-PAC Reaches: Hydrologic and Geomorphic Aspects

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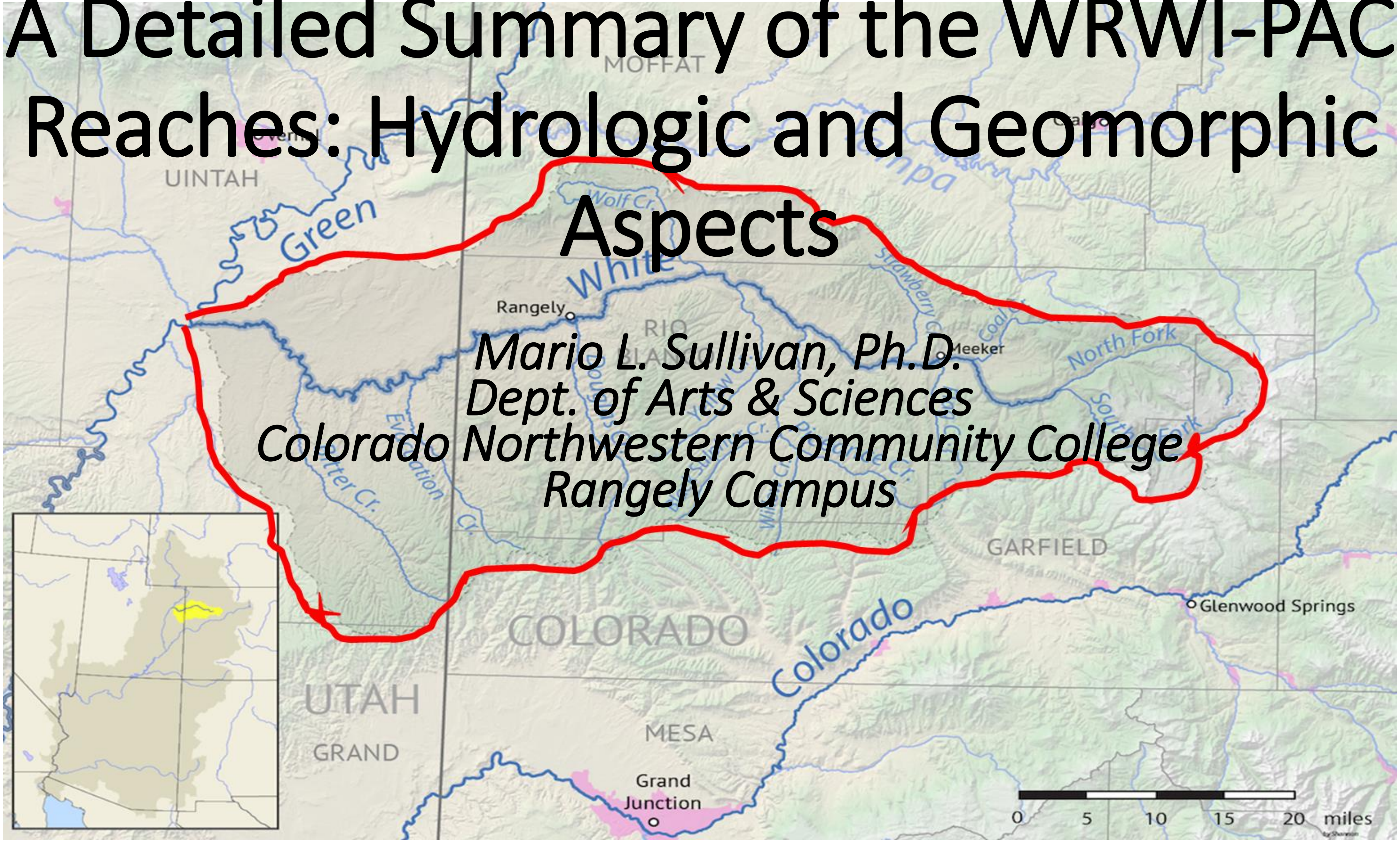


Objectives…

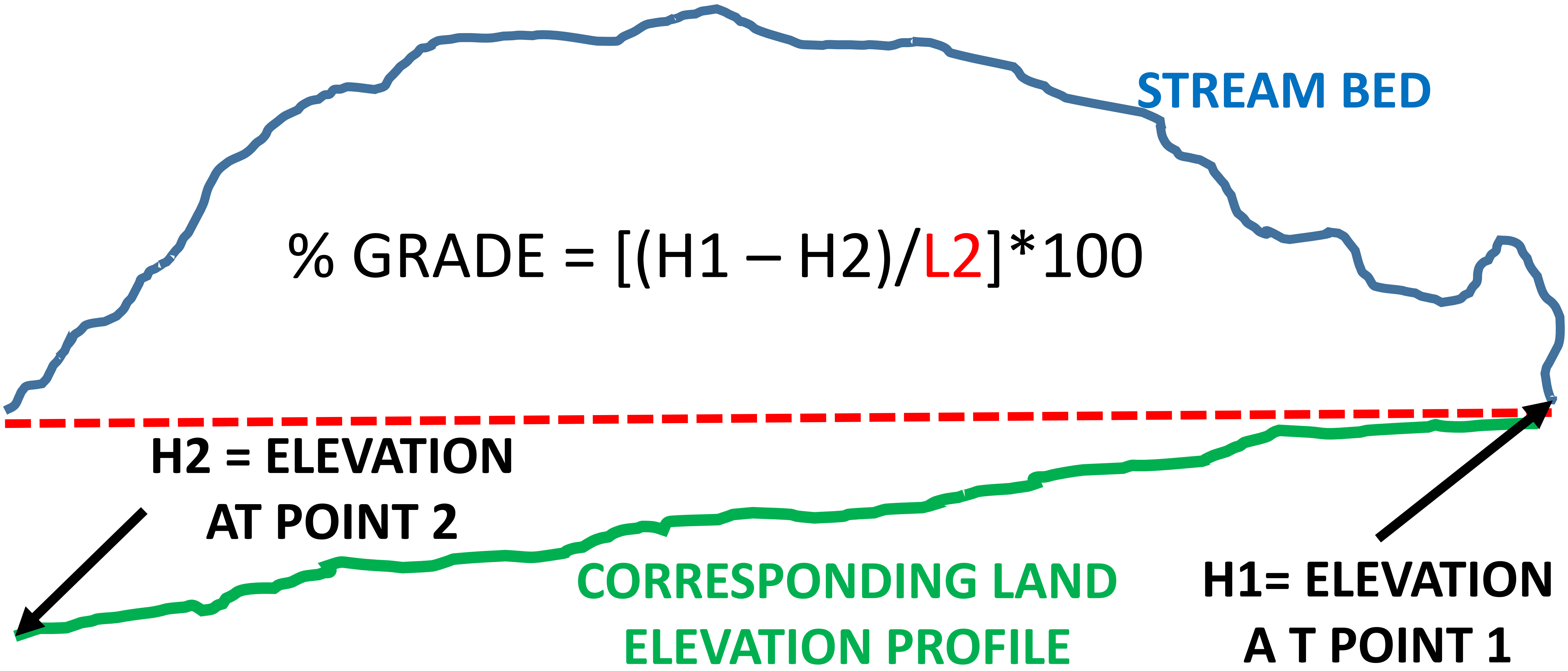
- Summarize the important hydrological, geological, and relevant sub-surface aspects of each reach (particularly with respect to the middle reach) for usage in PFC assessment, etc…
- Aid in prioritizing reaches or locations for riparian assessment
  - For each reach, have four to five sections of sufficient length (or whatever we can get)
- Begin to apply the Rosgen (1994) stream classification model as it pertains to the PFC riparian assessment

Summary of Contents…

- Measurements and Methods
- General descriptions of each reach
- For each reach, the following factors are explored as they will relate to the PFC assessment and the associated Rosgen (1994) classifications…
  - Sinuosity and gradient
  - Hydrology
  - Surface geology
  - A few notes on water quality and forest cover
  - Rosgen classifications

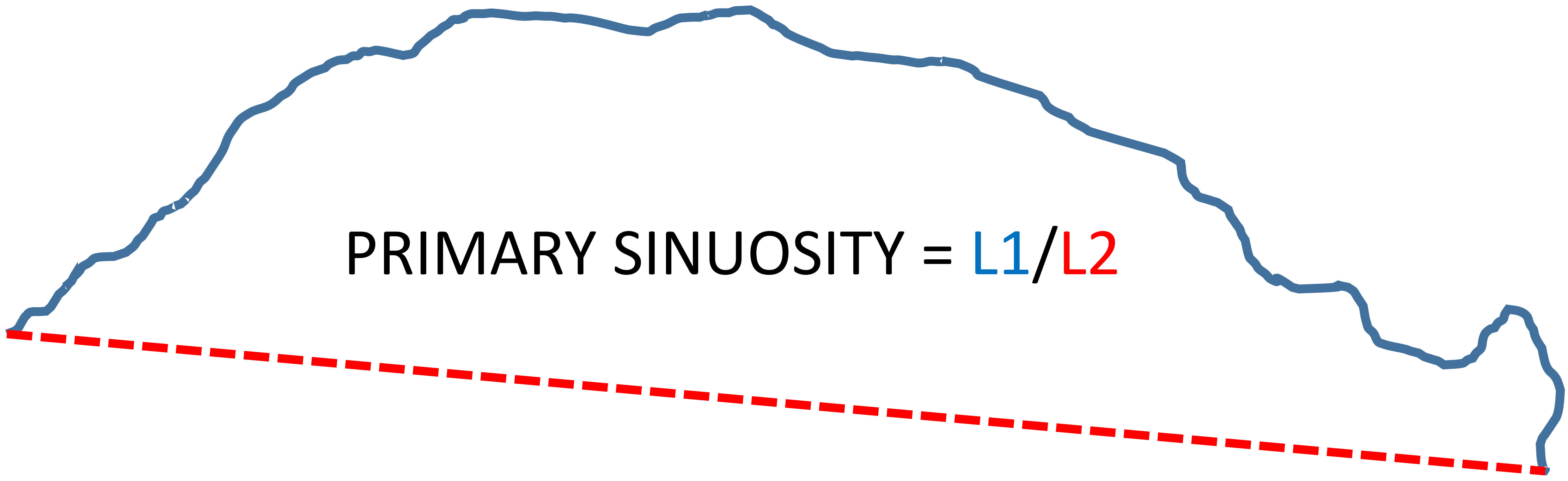
Measurements and Methods: Channel Morphology: Elevation Gradient (Steepness)…

% GRADE = [(H1 – H2)/L2]*100

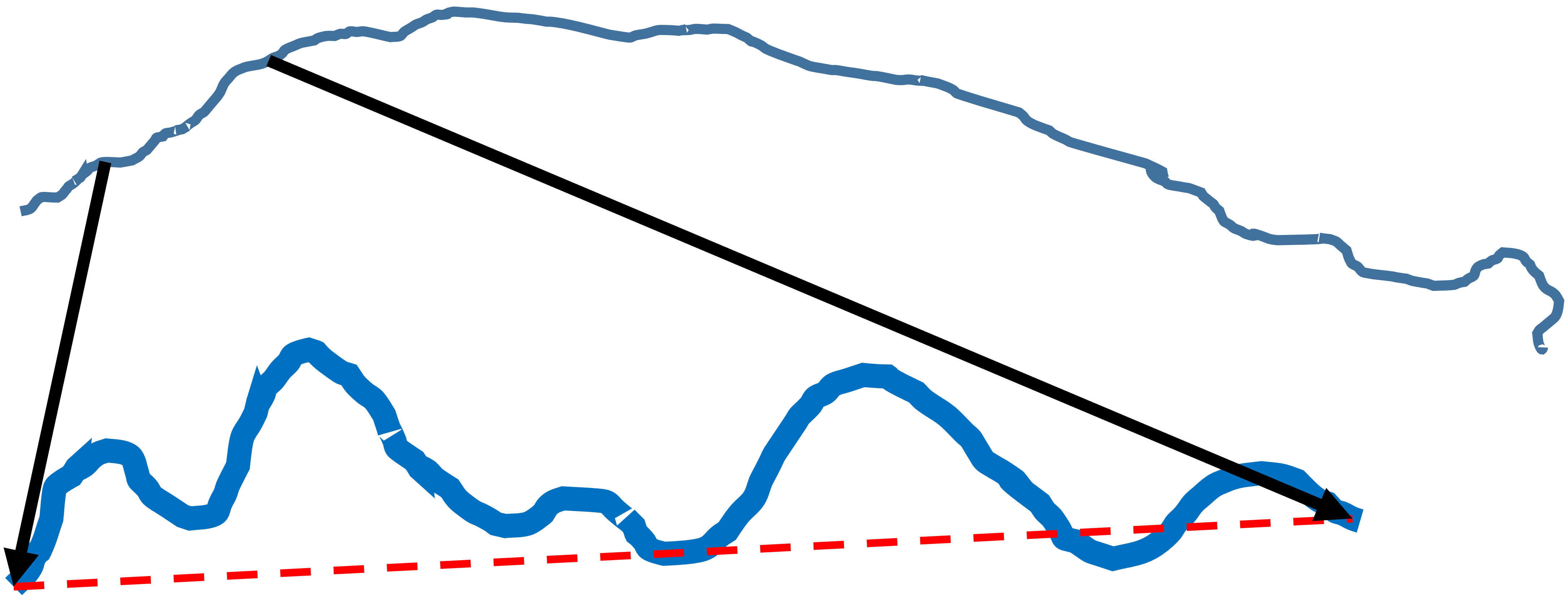


Measurements and Methods: Channel Morphologies: Sinuosity…

- Indicator of channel complexity and habitat
  - Cut banks, mesohabitat structure (riffles, runs, pools), bank stability
- Sinuosity broken up into primary and secondary…



Measurements and Methods: Sinuosity and Channel Morphologies…

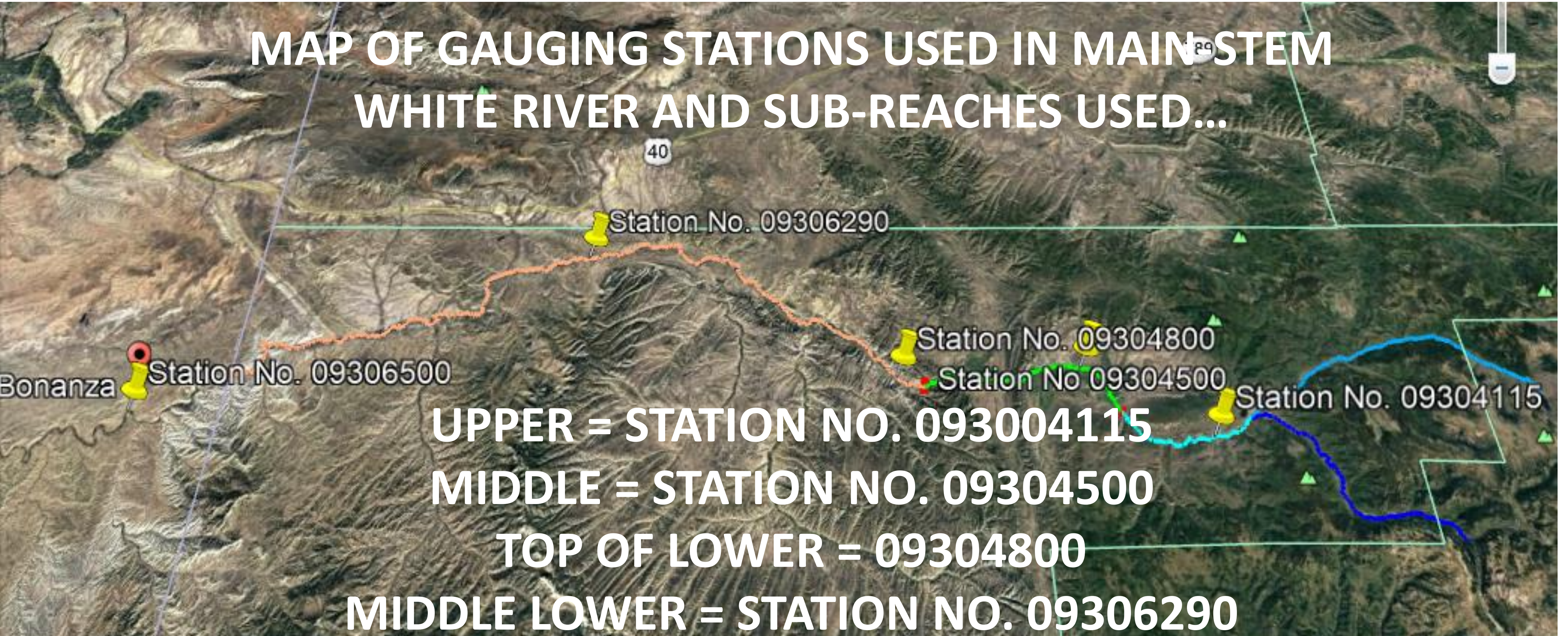


SECONDARY SINUOSITY = L1/L2

Measurements and Methods: Geologic Characteristics…

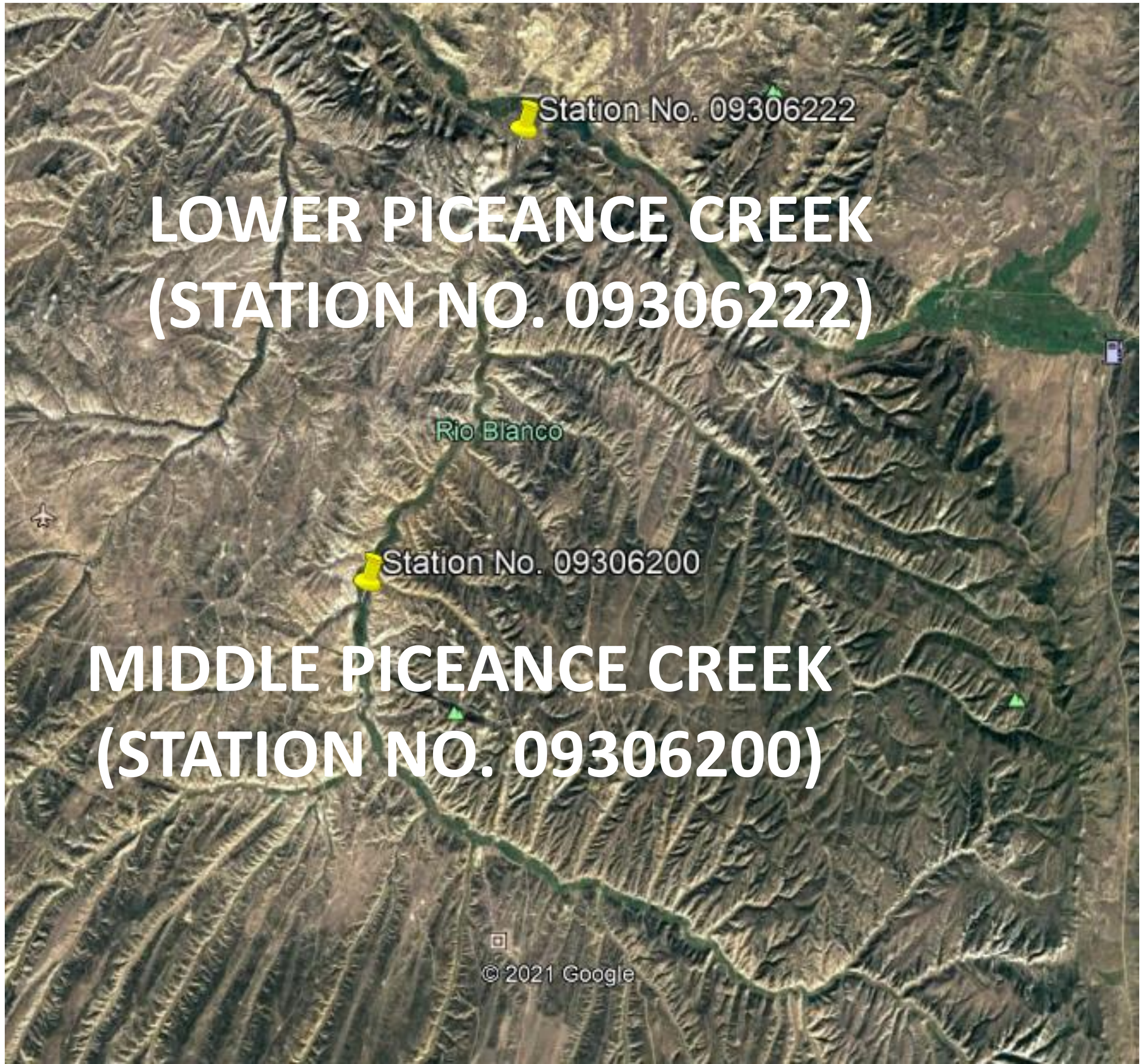
- Used the interactive mapping service from the USGS
  - https://ngmdb.usgs.gov/mapview/?center=-106.759,39.547&zoom=8
  - Link is uploaded to our database
  - Individual quad maps can be downloaded; not necessarily same scale or color scheme
  - All aerial views are taken from Google Earth

Measurements and Methods: Hydrological Data Analysis and Summaries…



Measurements and Methods: Hydrological Data Analysis and Summaries…

MAP OF UPPER AND MIDDLE STATIONS ON PICEANCE CREEK…



Measurements and Methods: Hydrological Data Analysis and Summaries…

- Summary of USGS stations used in analyses; goal was a full 20 years of *recent* daily flow data but that period was not available; stations with more recent data were chosen over those with older data…
  - **Upper:**
    - **Station No. 09304115 White River below N. Elk Creek near Buford, CO. Period of record available 01/09/2003-12/31/2009**
  - **Middle:**
    - **Station No. 09304500 White River near Meeker, CO. Period of record available 01/1902-12/2019**
    - **Primarily used 01/01/1998-12/31/2018**
  - **Lower:**
    - ***Top Lower:*** **Station No. 09304800 White River below Meeker, CO. Period of record available 01/1962-12/2019**
    - ***Mid Lower:*** **Station No. 09306290 Whiter River below Boise Creek near Rangely, CO. Period of record used 01/01/1998-12/31/2018**
    - **Station No. 09306500 White River near Watson, UT. Not used: *appears to be identical to 09306290***
  - **Piceance Creek:**
    - ***Lower PC*: Station No. 09306222 01/1990-12/2019**
    - ***Middle PC*: Station No. 09306200 01/2000-12/2019**

- The software program "Indicators of Hydrologic Alteration V7" and the USGS interactive StreamStats map available at https://streamstats.usgs.gov/ss/
  - Used to generate graphs for mean monthly discharge across multiple years
  - Provides threshold values for high and low flows

Measurements and Methods: Variables Used to Analyze Flow from Gauging Stations:

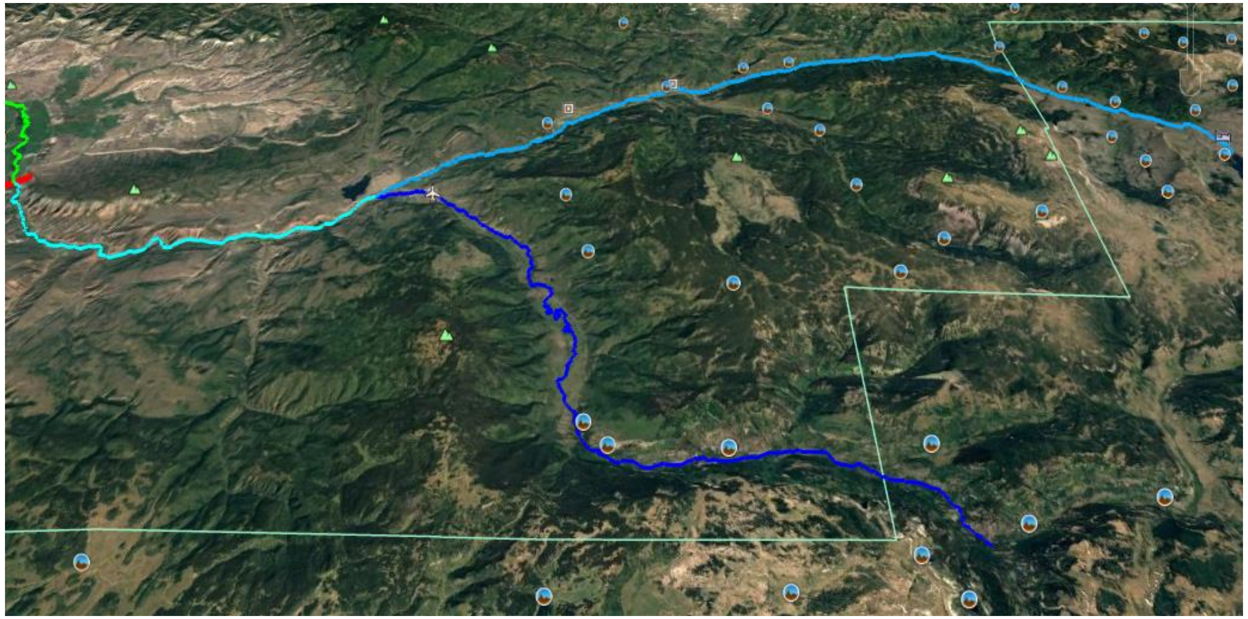
- Average annual discharge (cubic feet per second, CFS)
- Average monthly discharge (cubic feet per second, CFS)
- Coefficient of variation (aka CV) on average monthly and average annual discharge
  - Coefficient of variation is the percentage of the standard deviation (SD) from the average: CV = (SD/Average)*100
  - This statistic standardizes or calibrates flow so reaches with very different raw discharges can be compared directly
  - This statistic also summarizes, on average, how much a particular month or year varies from the average value and can reveal the “behavior” of flow as it compares to a long-term average

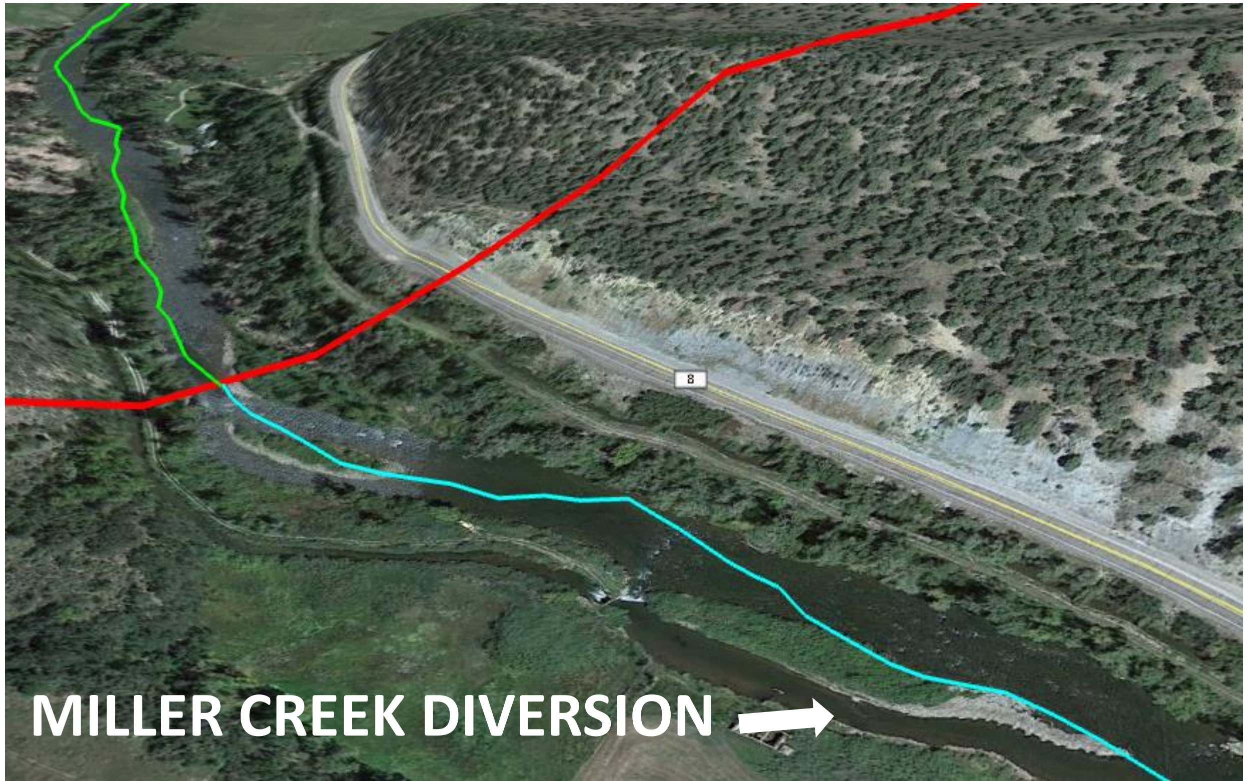
General Description of the White River

- Appx. 195 river miles (314 km) in length
- Drains appx. 5,120 mi^2 (13,300 km^2)
- Change in elevation (Green River confluence up to Trapper's Peak = appx. 7,338') over 675,840 linear ft. appx = 1.0% grade
- Sinuosity generally increases downstream
  - Primary and secondary curvature
- Major impoundments/diversions:
  - Miller Creek Ditch diversion (middle)
  - Rio Blanco Lake and Taylor Draw Dam (lower)
- In general, snow-melt driven hydrograph
  - Colluvium aquifer influence in PAC middle reach that hydrologically links middle and lower reach
  - Flashy contributions from tributaries
- Path primarily a result of uplift and faulting

Description of Upper Reach…

- The North and South Forks of the White River and the main stem of the White River to the confluence of Miller Creek diversion
- Approximately 12 river miles of the main stem White River.
- The North Fork is taken from Trapper’s Lake to the confluence with the South Fork
- The South Fork is taken from the confluence of Nichols, Fawn, and Buck Creeks below Elk Knob and Triangle Mountain.
- In general, the upper reach is characterized by a steeper average gradient (1.2% along the entire reach, closer to 2.0% along the gradients of the North and South Forks)
- It is the gateway to the major irrigation ditches of he middle reach.





Description of Middle Reach…

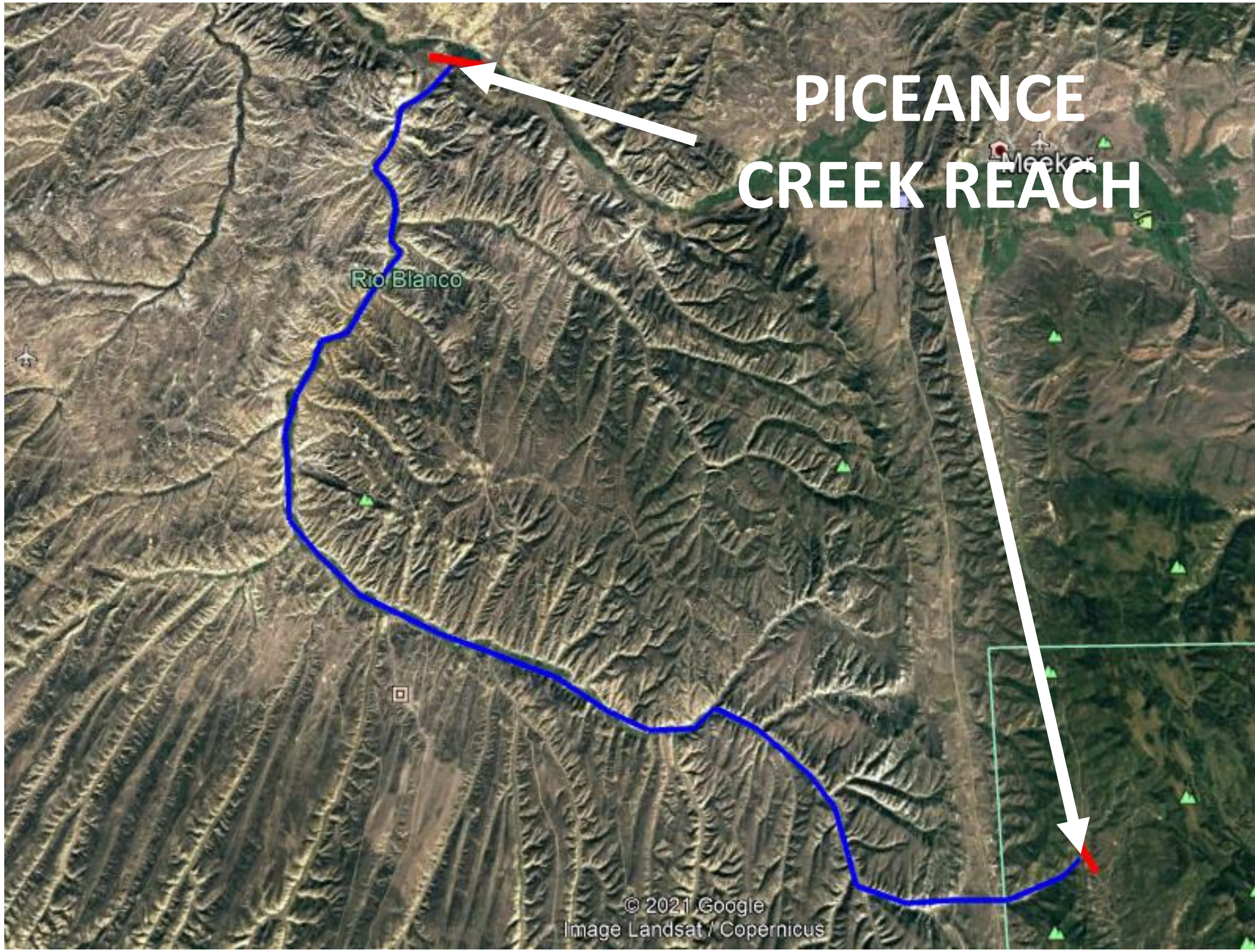
- Includes the main-stem White River from the Miller Creek diversion inlet to a "pinch point" appx. three linear miles west of Powell Park (based upon the conversation at the July 6th meeting)
- The intent of this reach is to enclose the "driving reach" of the river despite its relatively short length of appx. 23.90 river miles
- Both geologic and hydrologic evidence suggests that there is a very close connection between the middle and lower reach that will be explored in later sections

Description of the Lower Reach…

- Includes the main-stem White River from the proposed “pinch point” west of Powell Park to the CO-UT state line
- This reach is approximately 92.3 river miles which makes it the longest reach
- With respect to geology, geomorphology, temperature and discharge (with some minor influence by Kenney Reservoir), this is perhaps the most generalizable reach
- This reach receives some of the more substantial tributaries such as Douglas Creek, Yellow Creek, and Piceance Creek which in part will explain its greater average variability
- In terms of flow variability, there is a tight linkage between the upper lower, middle lower, and upper reaches

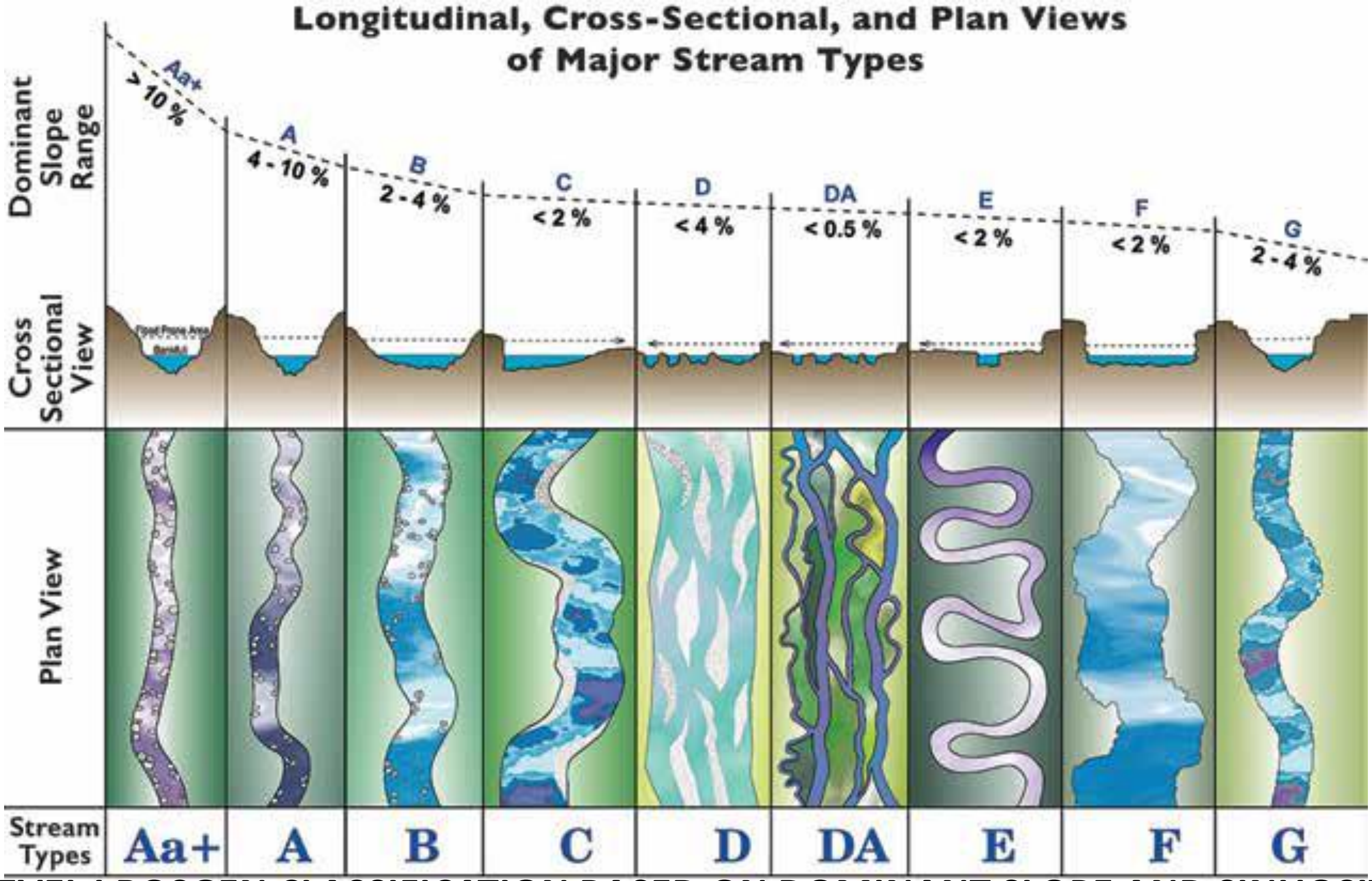
Description of the Piceance Creek Reach

- The Piceance reach constitutes the entire Piceance Creek basin to the confluence of the mainstem White River
- Piceance Creek is approximately 58 river miles in length and has an average sinuosity of 1.3 which is similar to the middle and lower reaches of the mainstem White River (average sinuosity 1.3 and 1.4, respectively)
- Piceance Creek is unique in that it is relatively small when compared to the drainage areas of the other reaches but is utilized by the many agricultural and energy extraction operations that occur along its length.



Geomorphic Aspects of Each Reach: *Elevation Gradients and Sinuosity*

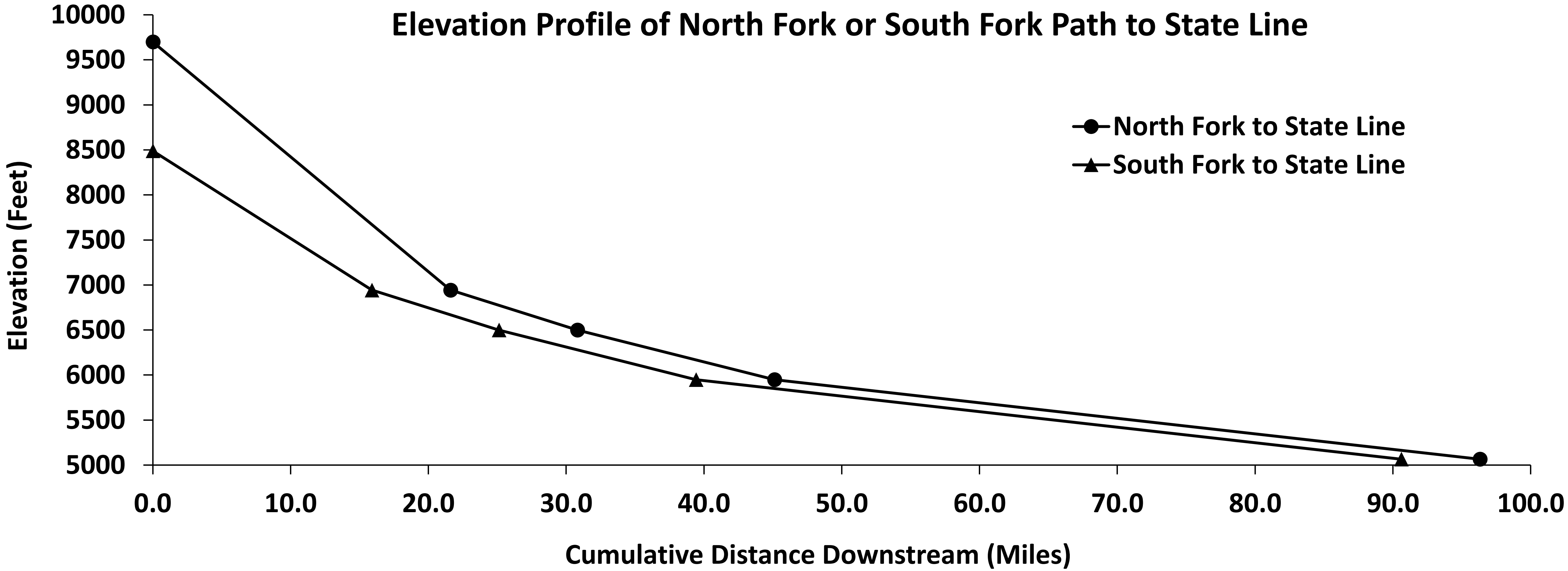
- The Rosgen (1994) classification system we'll use in the riparian assessment relies heavily on the shape and underlying geology of streams



LEVEL I ROSGEN CLASSIFICATION BASED ON DOMINANT SLOPE AND SINUOSITY

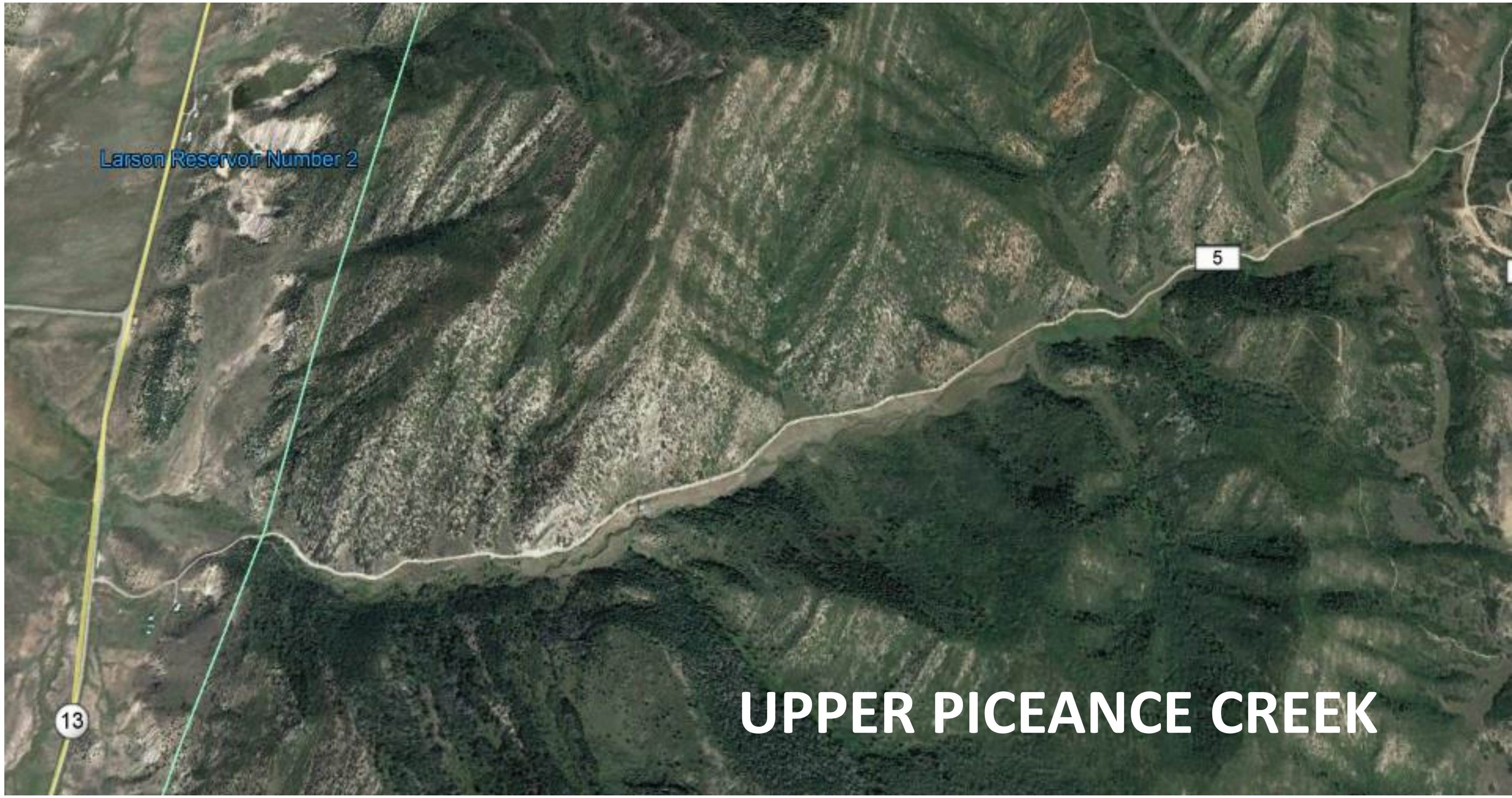
Geomorphologic Aspects: *Elevation Gradients White River*…

	Segment Length (ft)	Change in Elevation (ft)	% Grade
SF → Confluence	84,111	1,547	1.84
NF → Confluence	114,256	2,757	2.41
Confluence → top of middle	48,771	443	0.91
Top of middle → bottom of middle	75,667	552	0.73
Bottom of middle → state line	270,779	882	0.33



Geomorphologic Aspects: Elevation Gradients *Piceance Creek*…

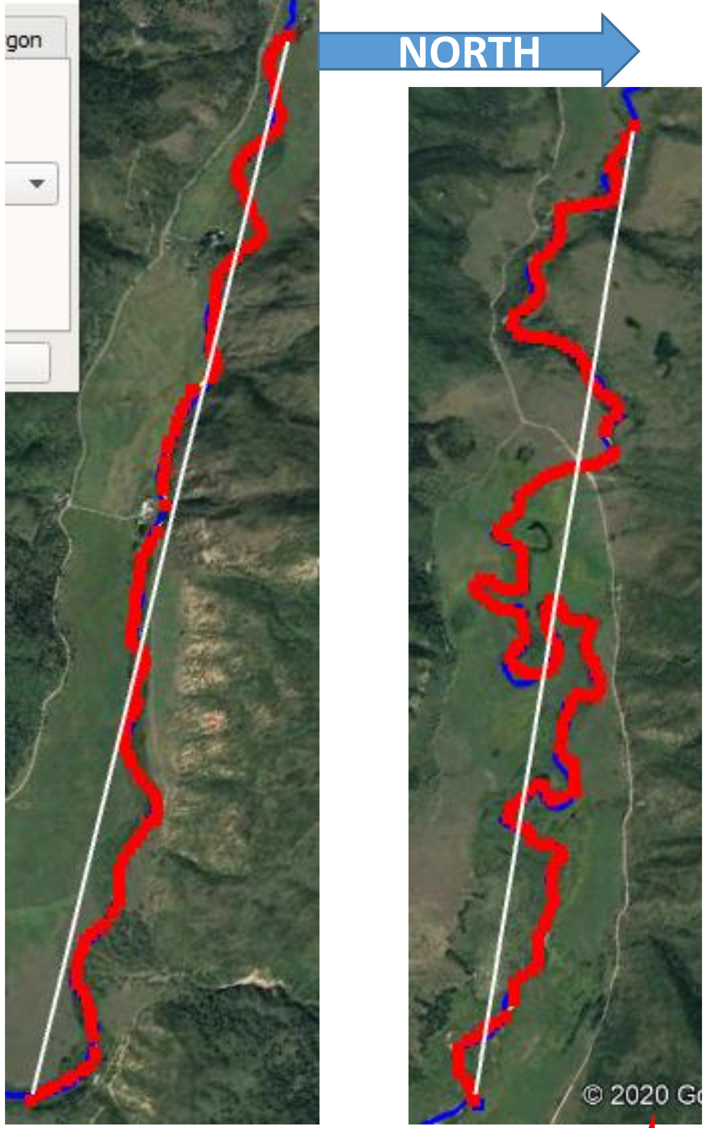
- Headwaters = 7,588' to confluence = 5,712'
- Length = 158,700 Linear Feet (30.0 Linear Miles)
- Overall average % gradient = 1.2
  - Range 0.5% to 2.6% in uppermost reach (11,141 LF over a 285' change in elevation)
  - Most of the stream ranges between 0.4 and 0.6%



Geomorphic Aspects: *Sinuosity of Upper Reach*…

- South Fork
  - 1° sinuosity = 19 RM/16 LM = 1.2
  - Average 2° sinuosity = 3.6/3.0 = ≤ 1.2 (low sinuosity)
    - Range = 1.1 – 1.6
    - > 1.5 ***meandering*** reach

1° Sinuosity



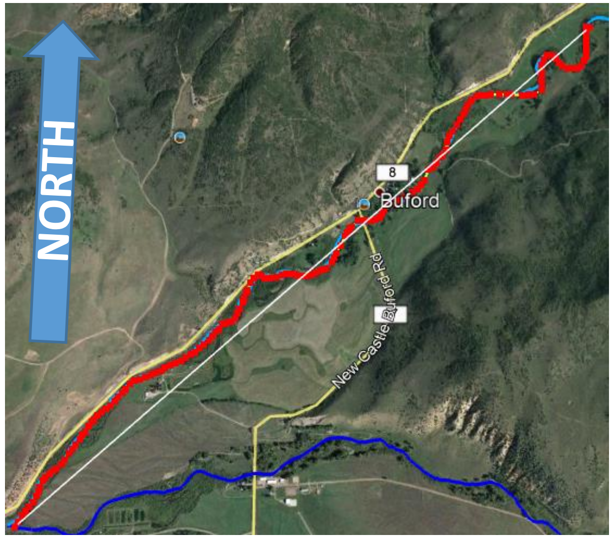
2° Sinuosity

Upper Reach Sinuosity; South Fork

- Meandering Stretch and Oxbow Lakes

Geomorphic Aspects: *Sinuosity of the Upper Reach*...

- North Fork
  - 1° sinuosity = 25.0 RM/22.0 LM = 1.1
  - Average 2° sinuosity = 1.1 (low sinuosity)
    - Range = 1.1



2° Sinuosity

1° Sinuosity

Geomorphic Aspects: *Sinuosity of the Upper Reach*...

- Lower End of Upper Reach (NF-SF confluence to Miller Creek diversion)
  - 1° sinuosity = 11.1 RM/9.4 LM = 1.2
  - Average 2° sinuosity = 1.2 (low sinuosity)

2° Sinuosity

1° Sinuosity

Geomorphic Aspects: *Sinuosity of the Middle Reach*…

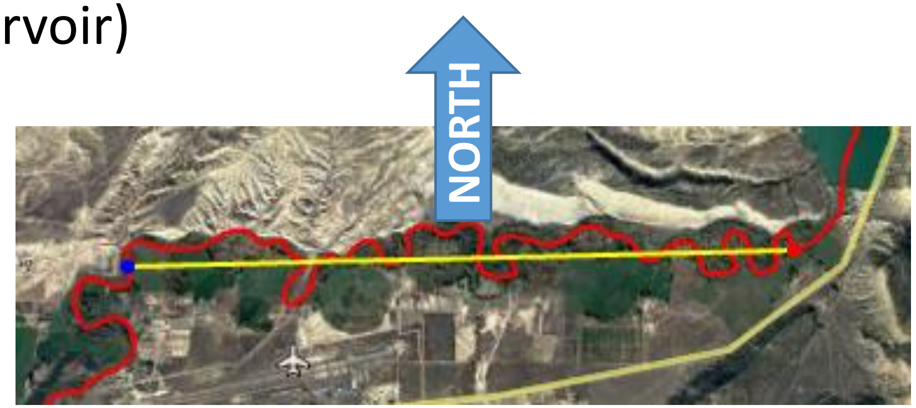
- 1° Sinuosity 17.0 RM/14.35 LM = 1.2
- Average 2° Sinuosity = 1.3
  - Range = 1.2 – 1.5 (moderately sinuous)

2° Sinuosity

1° Sinuosity

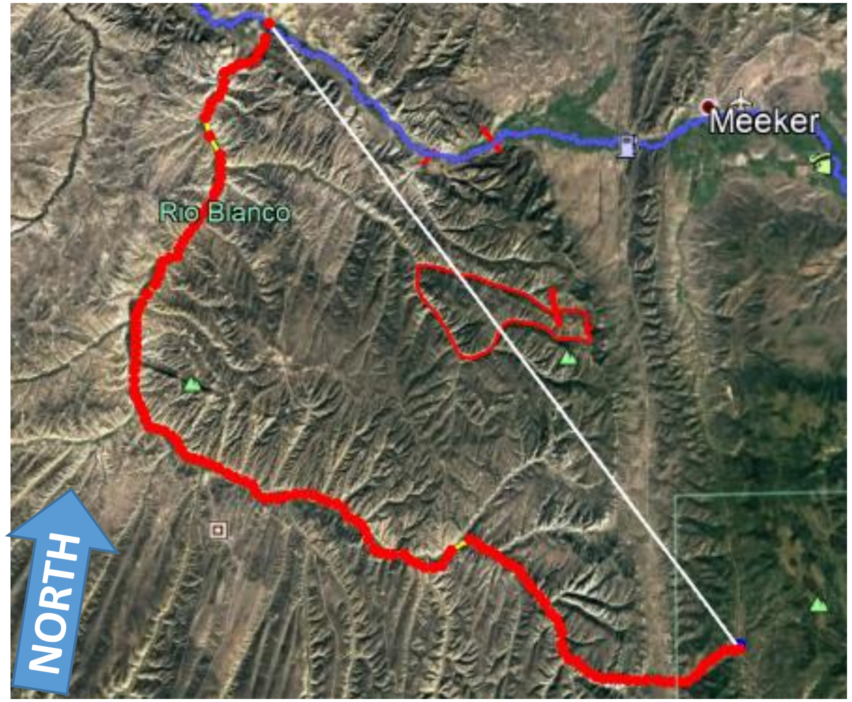
Geomorphic Aspects: *Sinuosity of the Lower Reach*…

- Primary sinuosity = appx. 76 river miles/52 linear miles = 1.5
- Average Secondary sinuosity = 1.3
    - Range = 1.1-1.7 (more sinuous downstream of Kenney Reservoir)



Geomorphic Aspects: *Sinuosity of Piceance Creek*…

- Primary sinuosity = 1.4
- Average secondary sinuosity = 1.3
  - Range = 1.1 – 1.4



Hydrologic Summaries of Each Reach…

- All reaches demonstrate snow-melt driven hydrographs; peak flows in May to June

- Greatest variability in flow was observed in May (Piceance Creek), June (upper White River) and July for main-stem White River
  - Piceance Creek is incredibly variable during spring and summer; the percent deviation far exceeds 100% for May in both the lower and middle reaches

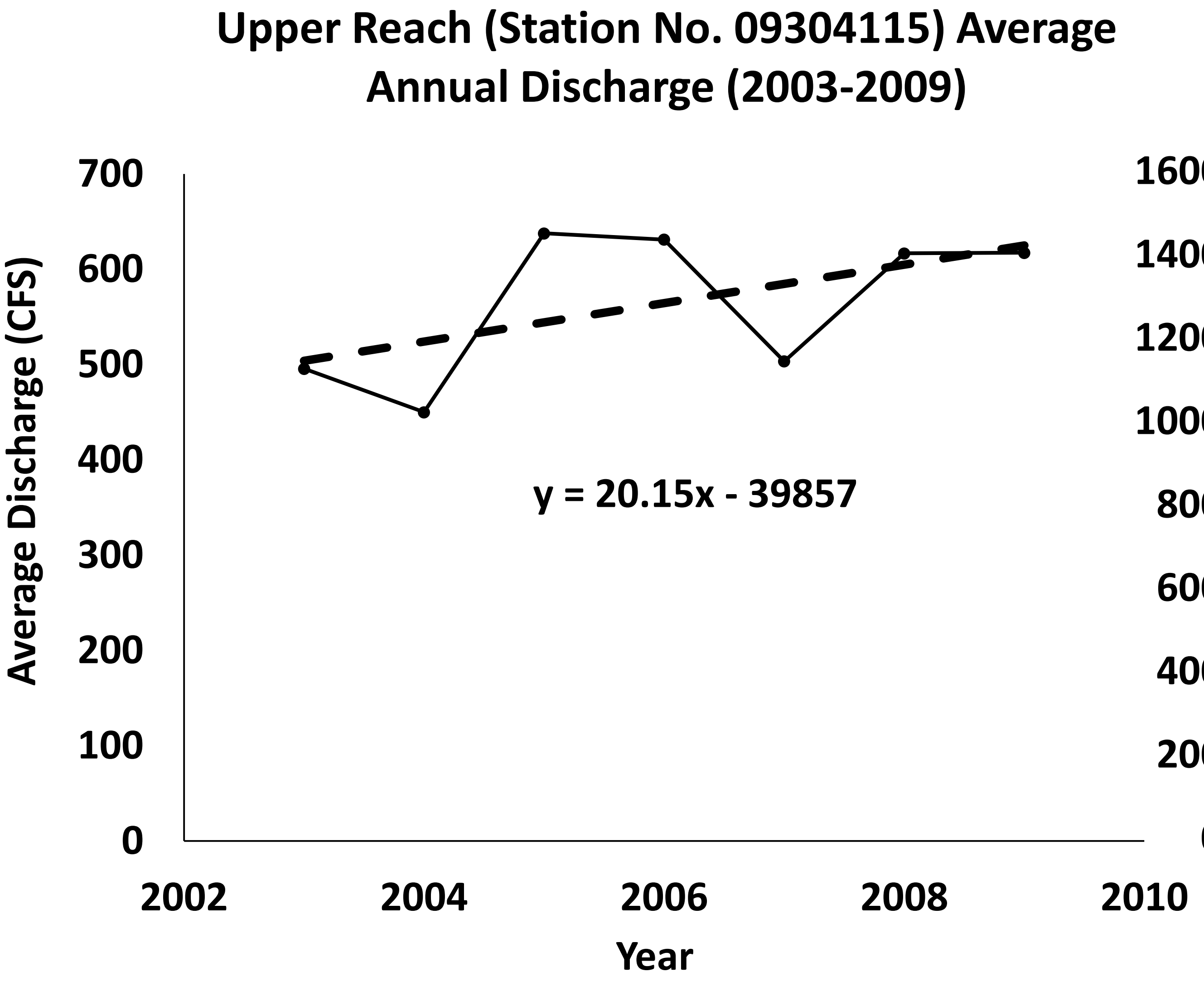
- The least variability observed occurred in winter months for all reaches (December-February)
  - Piceance Creek appears to be more variable in winter than other reaches

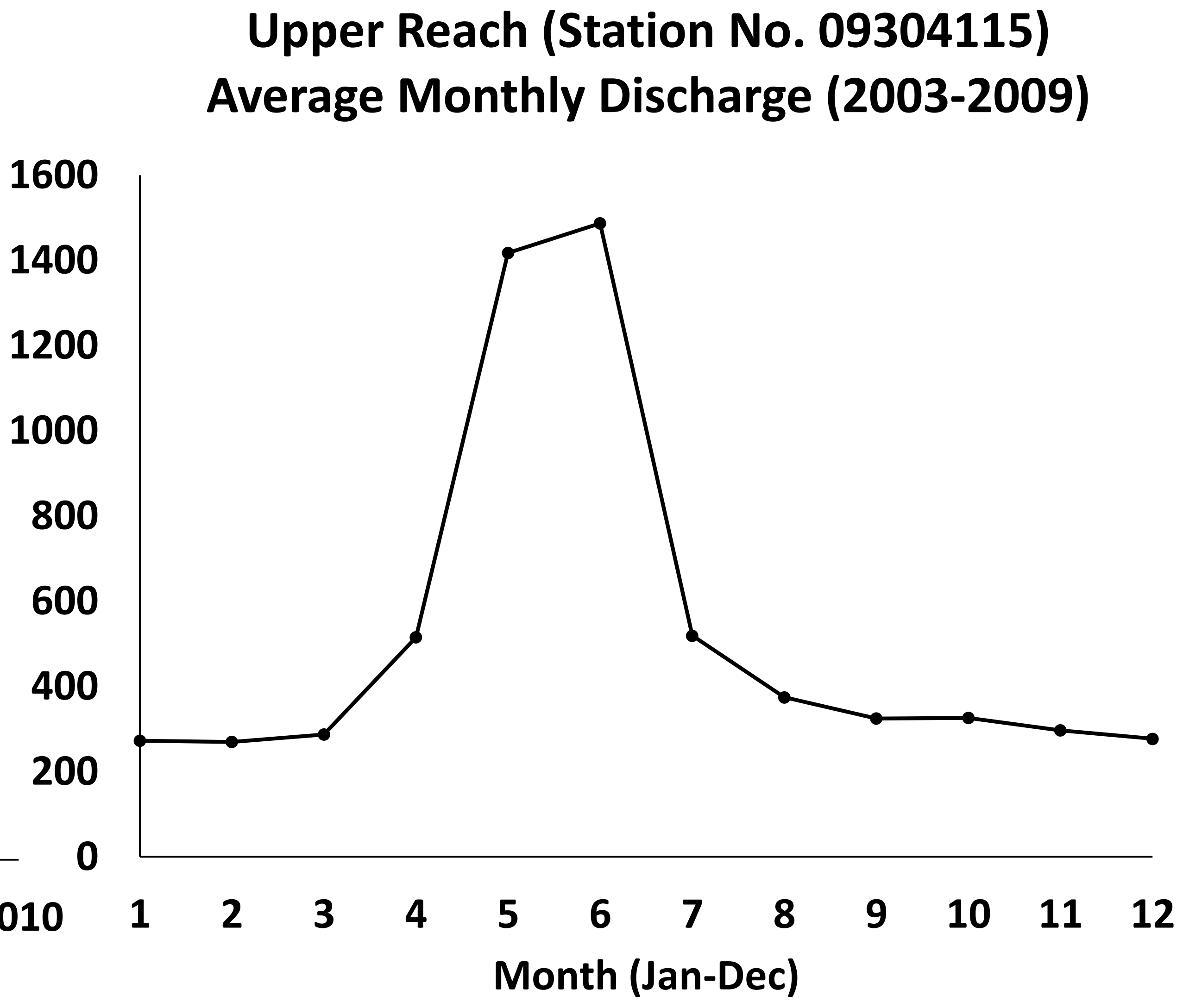
- Variability in flow of main-stem White River increases downstream due to influence of substantial and independent tributaries

- Flow variability between the middle reach and lower reach is highly correlated; much more so than between the upper and middle or the upper lower

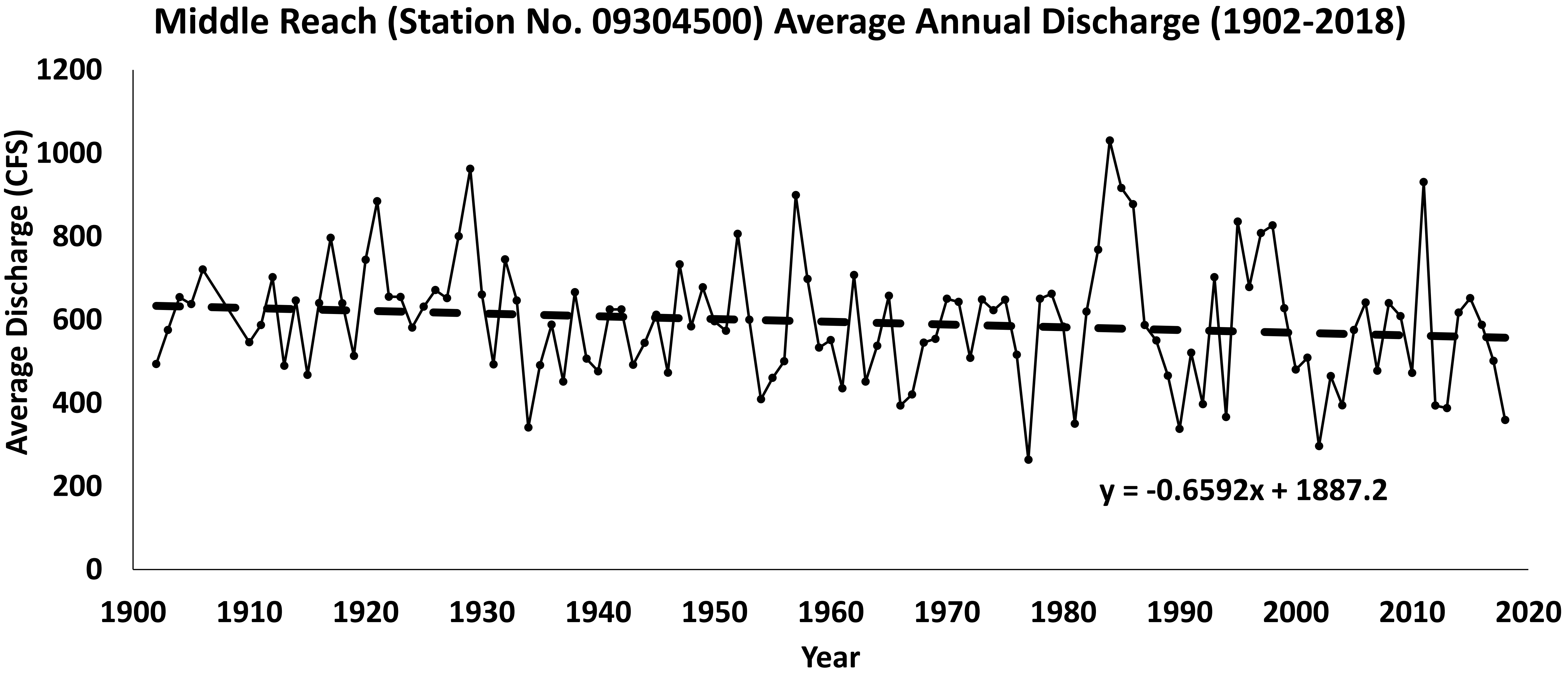
- On average, the seasonal flow variability in Piceance Creek appears to be greater than that of the White River
  - Smaller drainage basin and more rain (versus snow) in winter?

Hydrologic Summaries: Flow Variation of *<u>Upper Reach</u>*

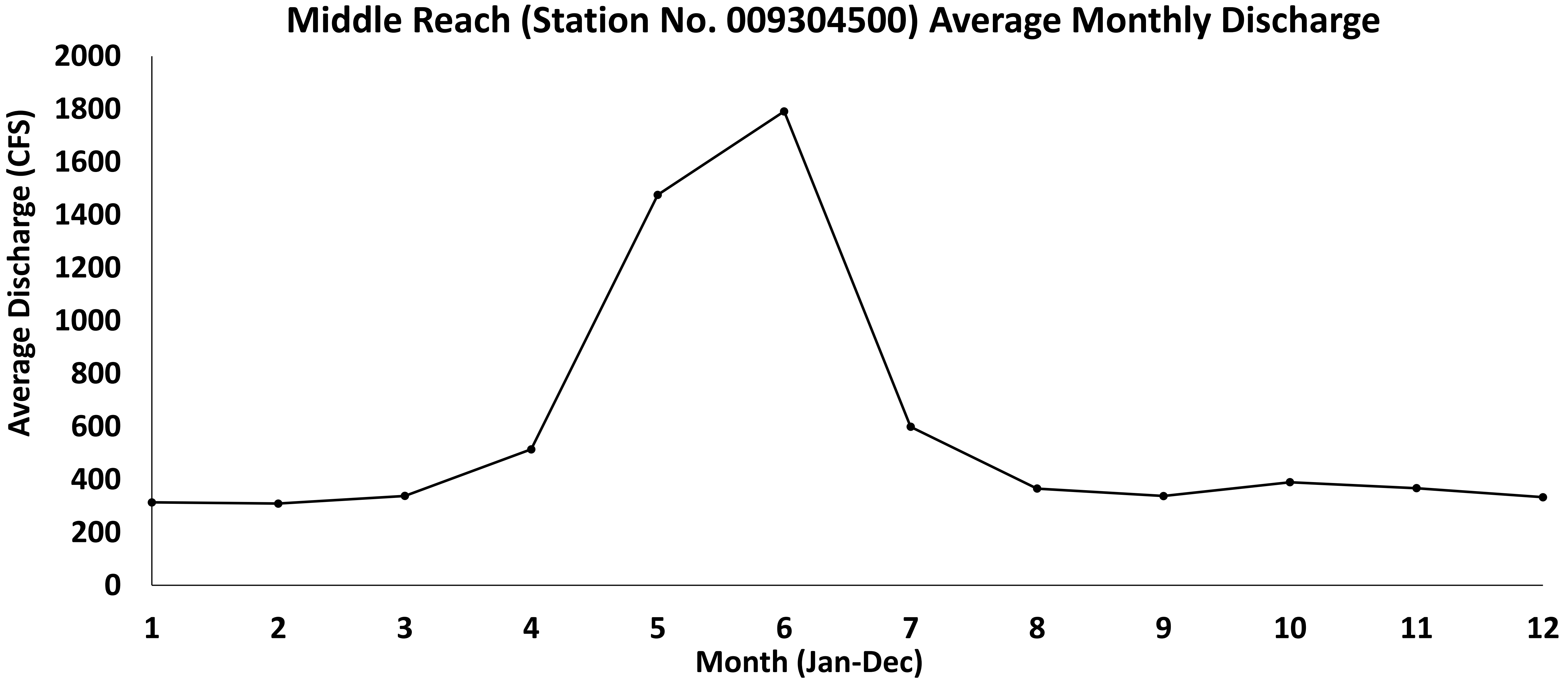




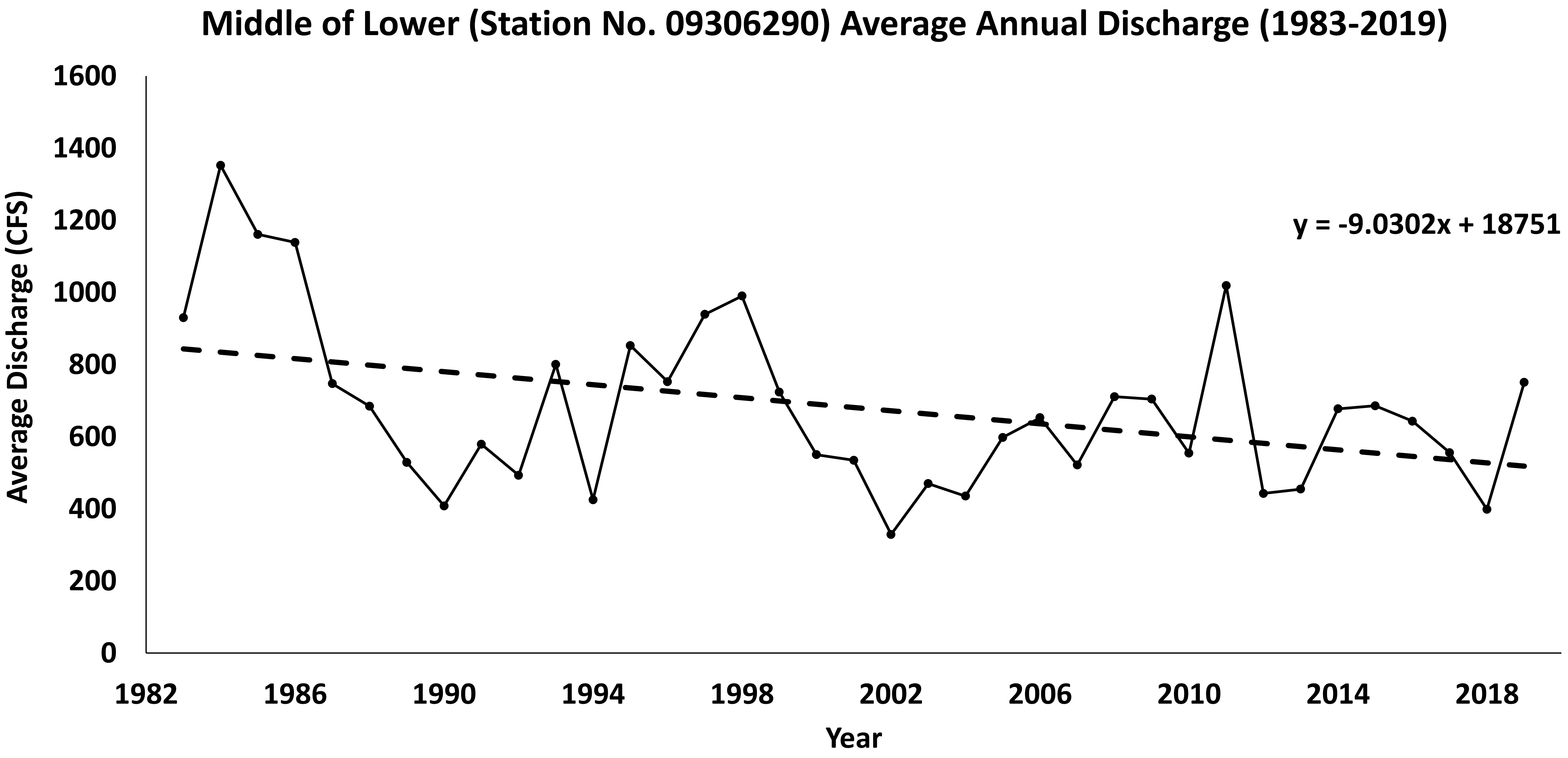
Hydrologic Summaries: Flow Variation of *Middle Reach*



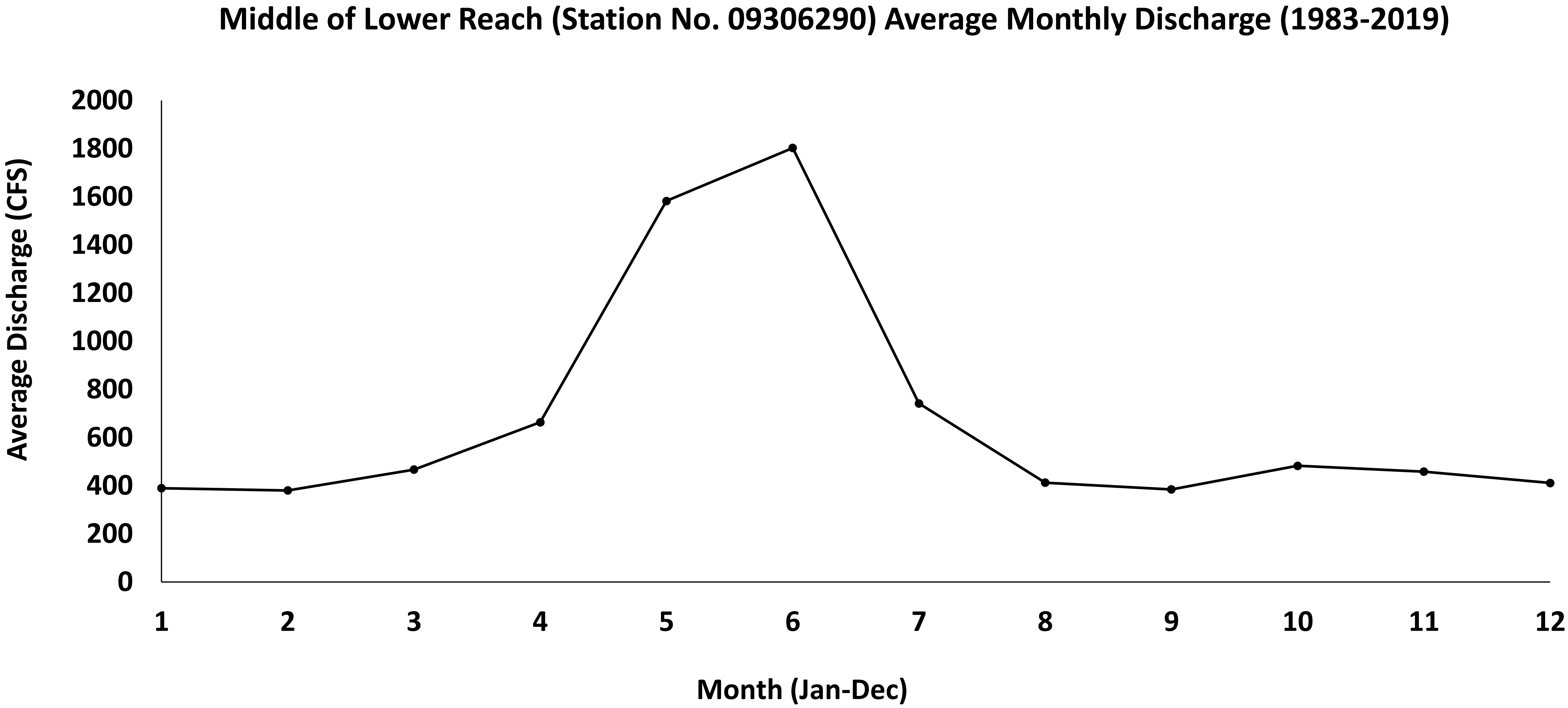
Hydrologic Summaries: Flow Variation of ***Middle Reach***



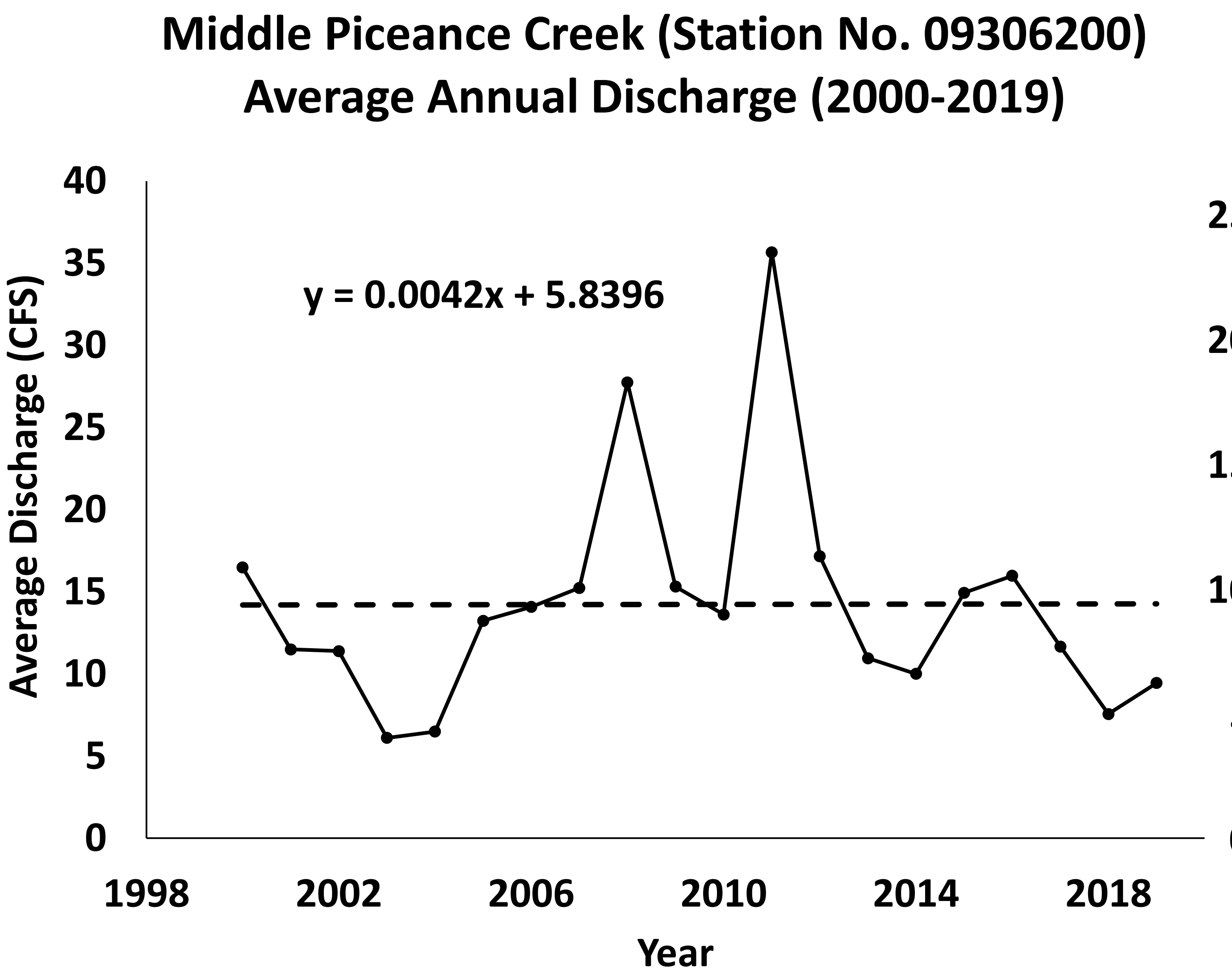
Hydrologic Summaries: Flow Variation of *Middle of Lower Reach*

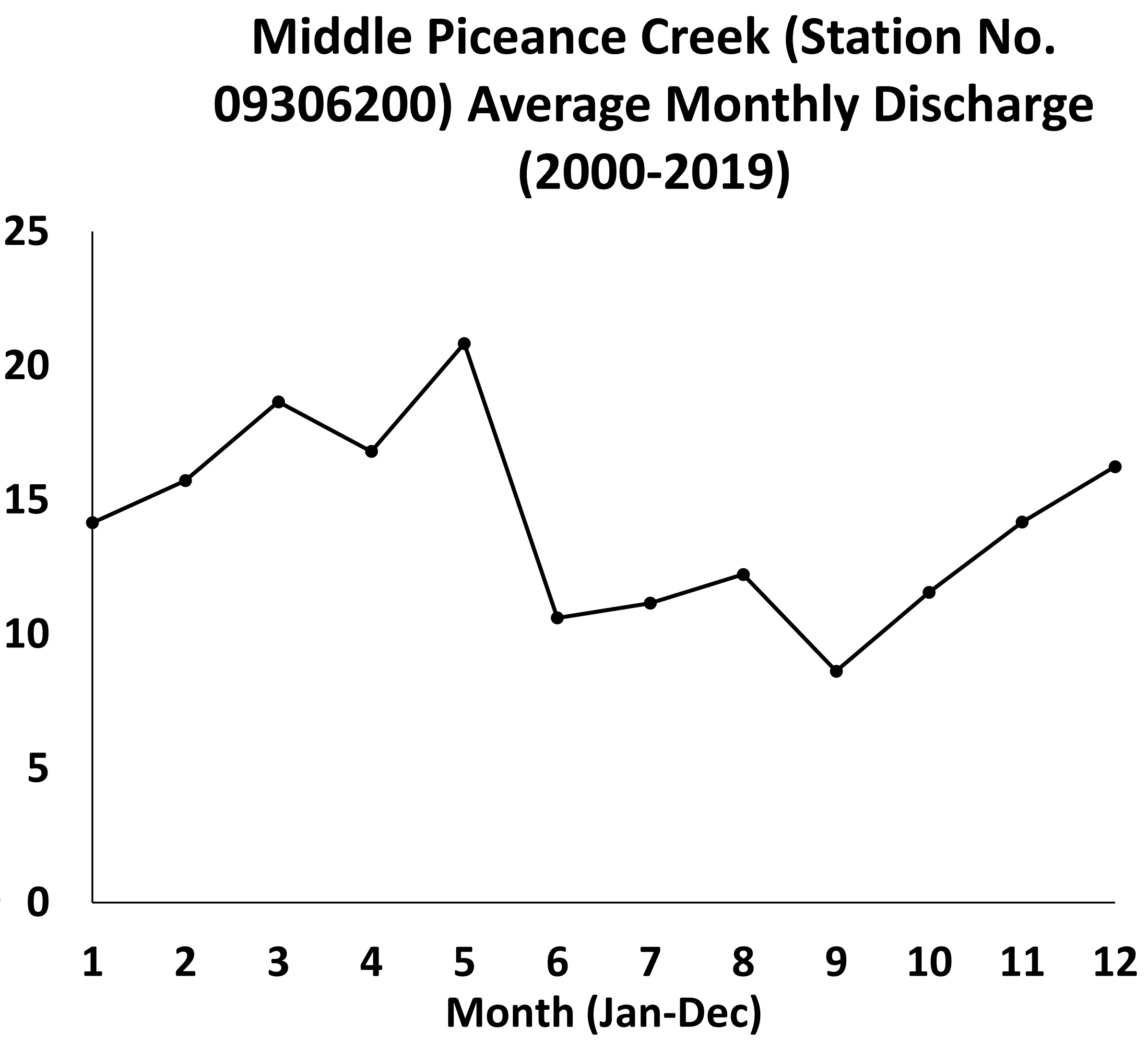


Hydrologic Summaries: Flow Variation of *Middle of Lower Reach*

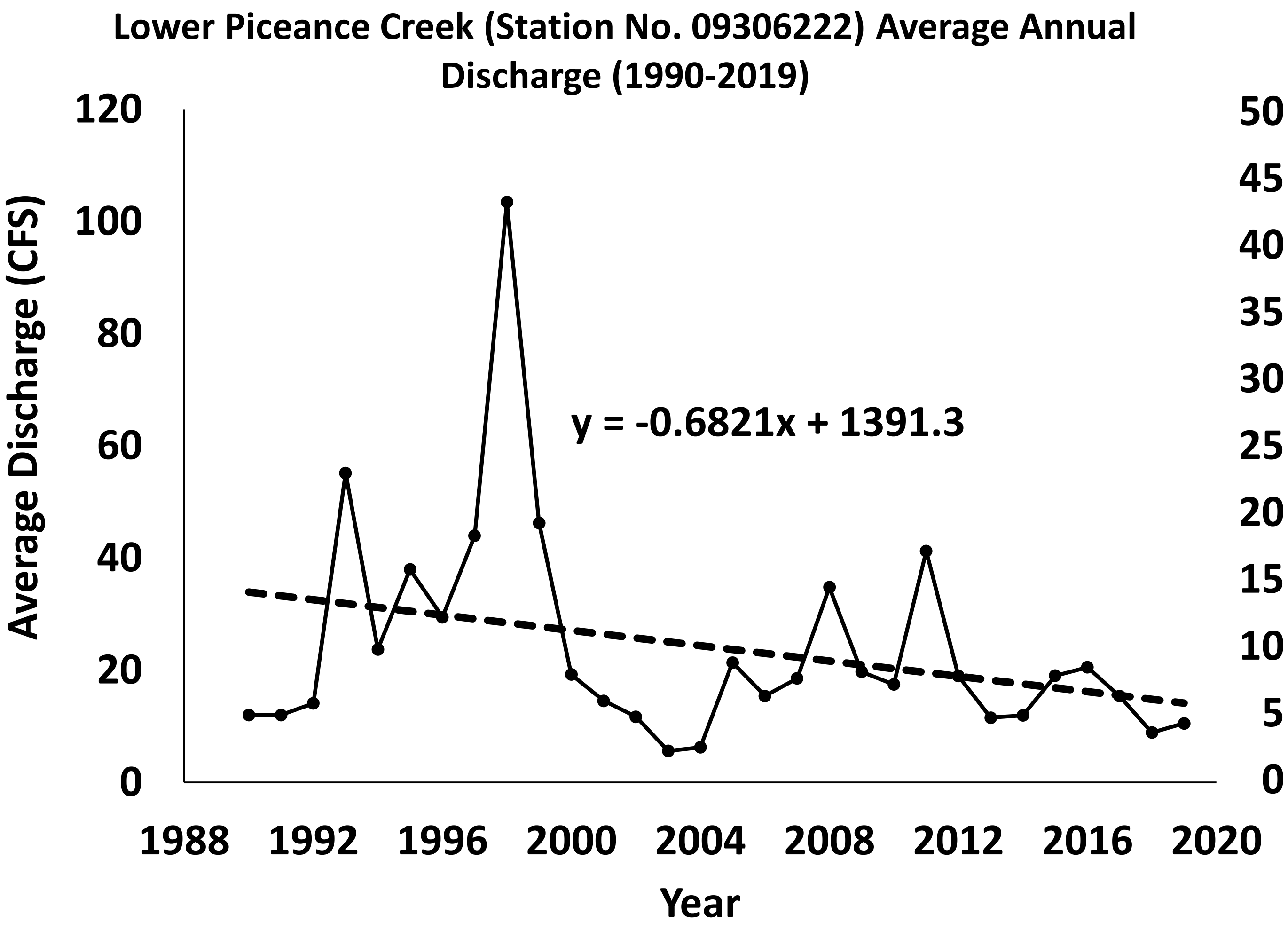


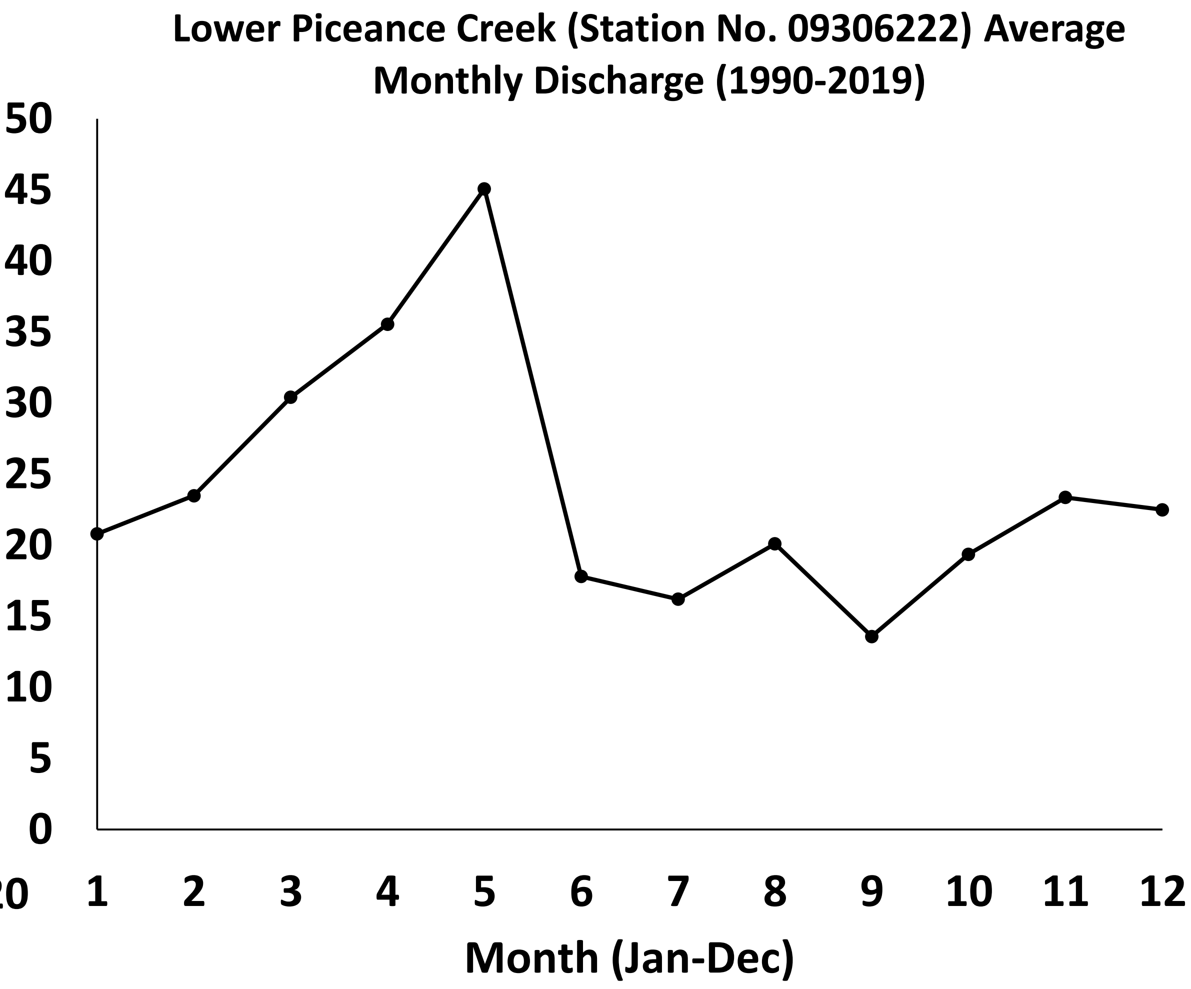
Hydrologic Summaries: Flow Variation of *Middle Piceance Creek*



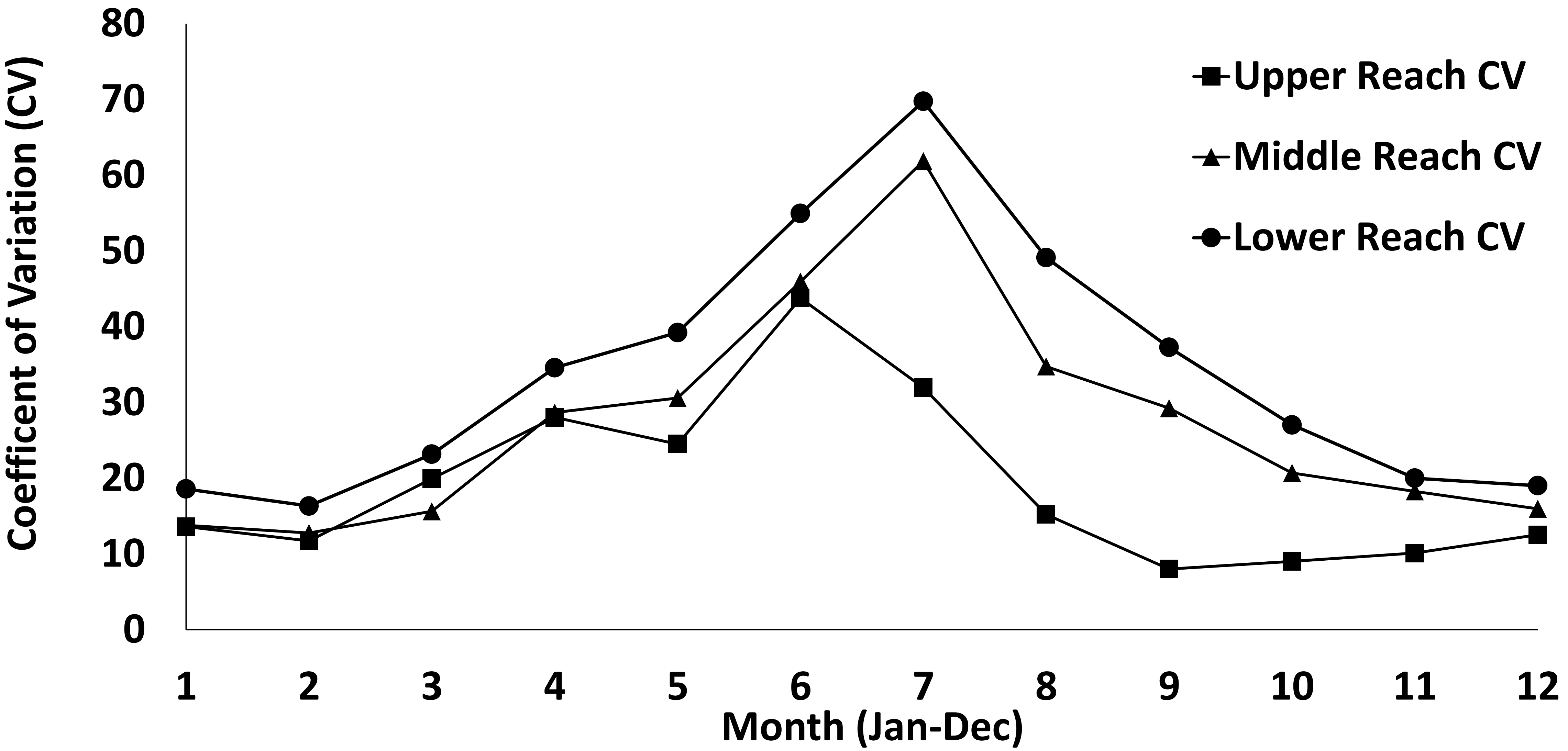


Hydrologic Summaries: Flow Variation of *Lower Piceance Creek*



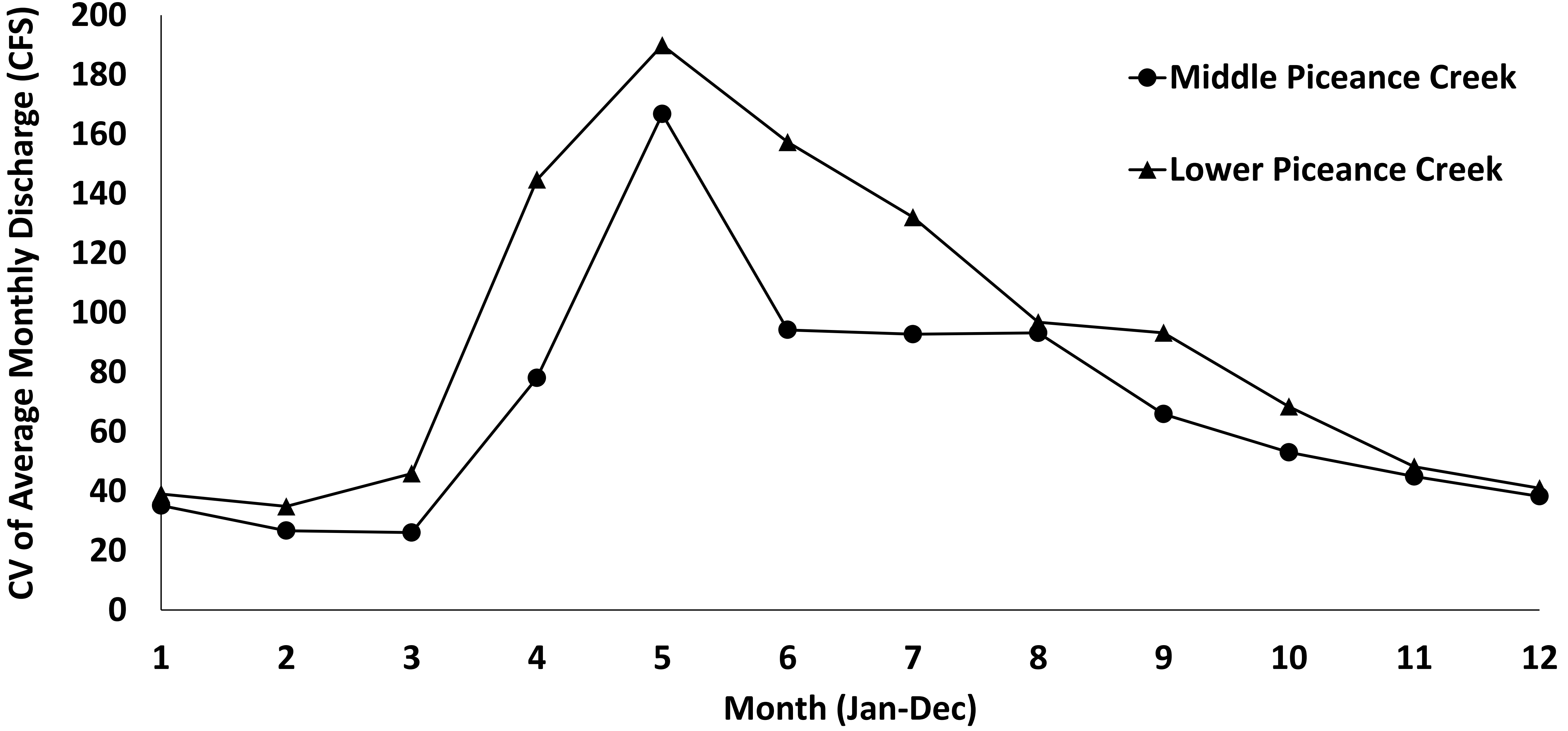


Variability (CV) for Average Monthly Flows *Main-stem White River*



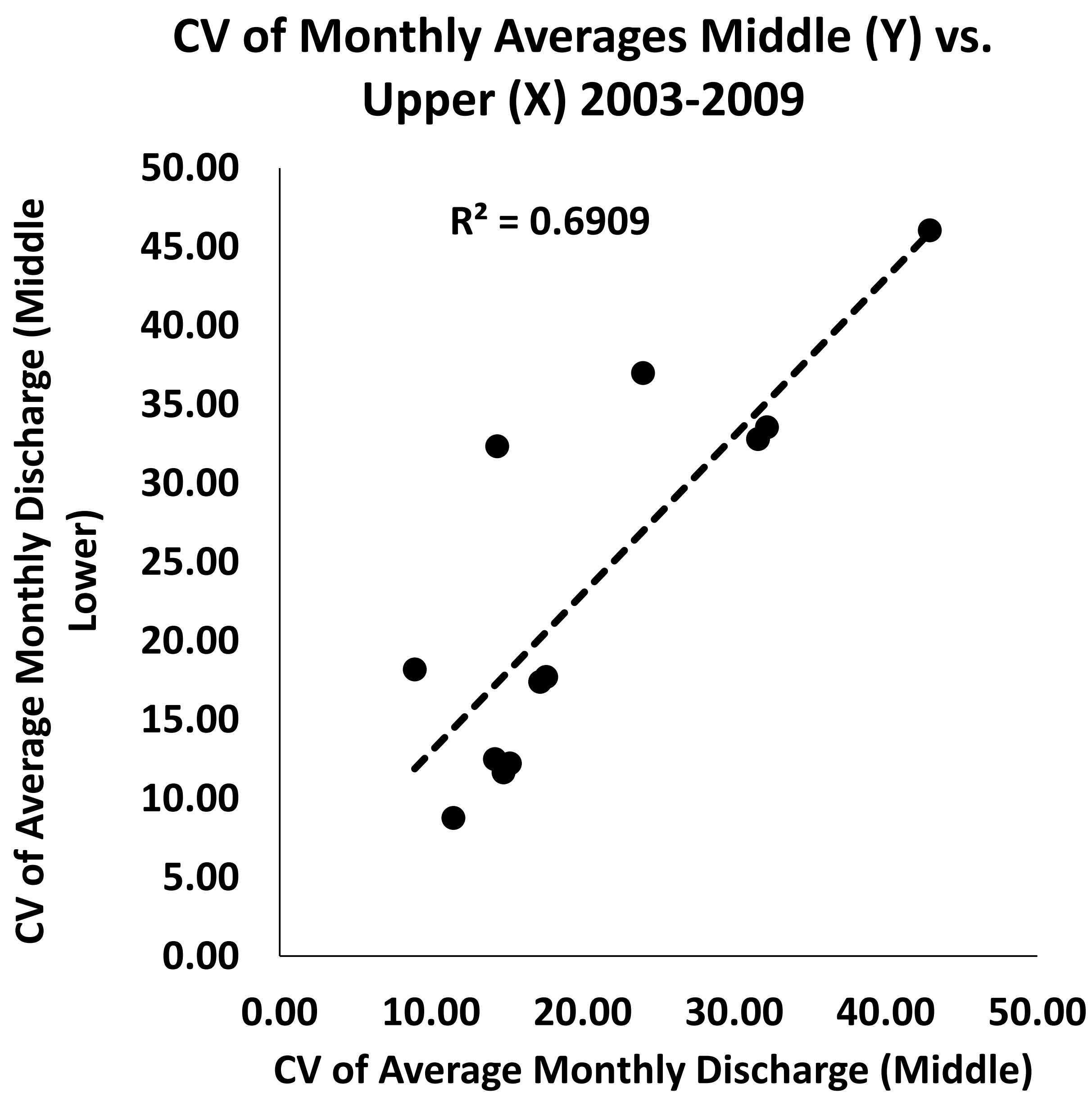
CV = (Std. Dev. of Monthly Discharge/Average Monthly Discharge) x 100

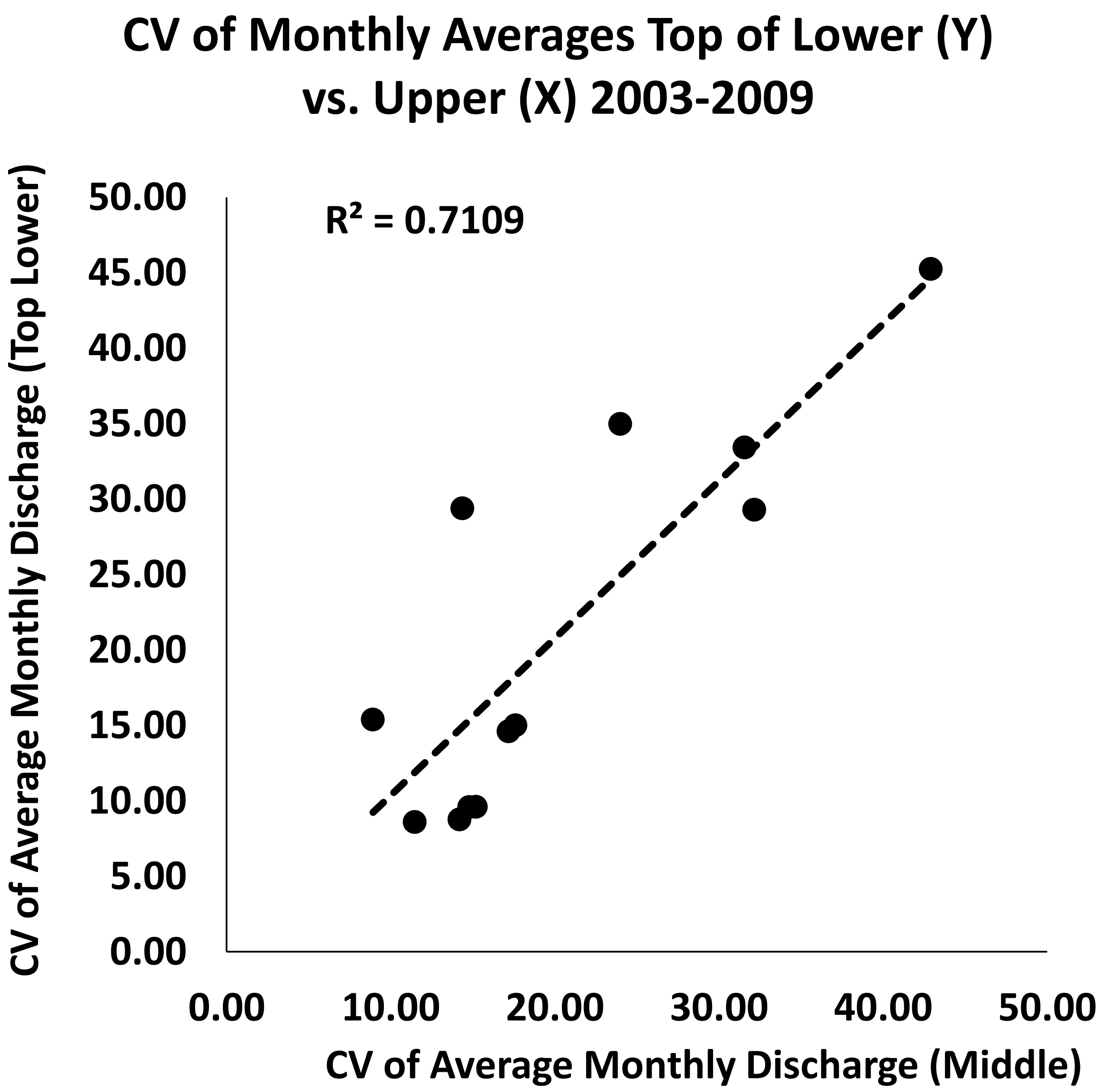
Variability (CV) for Average Monthly Flows *Piceance Creek*



CV = (Std. Dev. of Monthly Discharge/Average Monthly Discharge) x 100

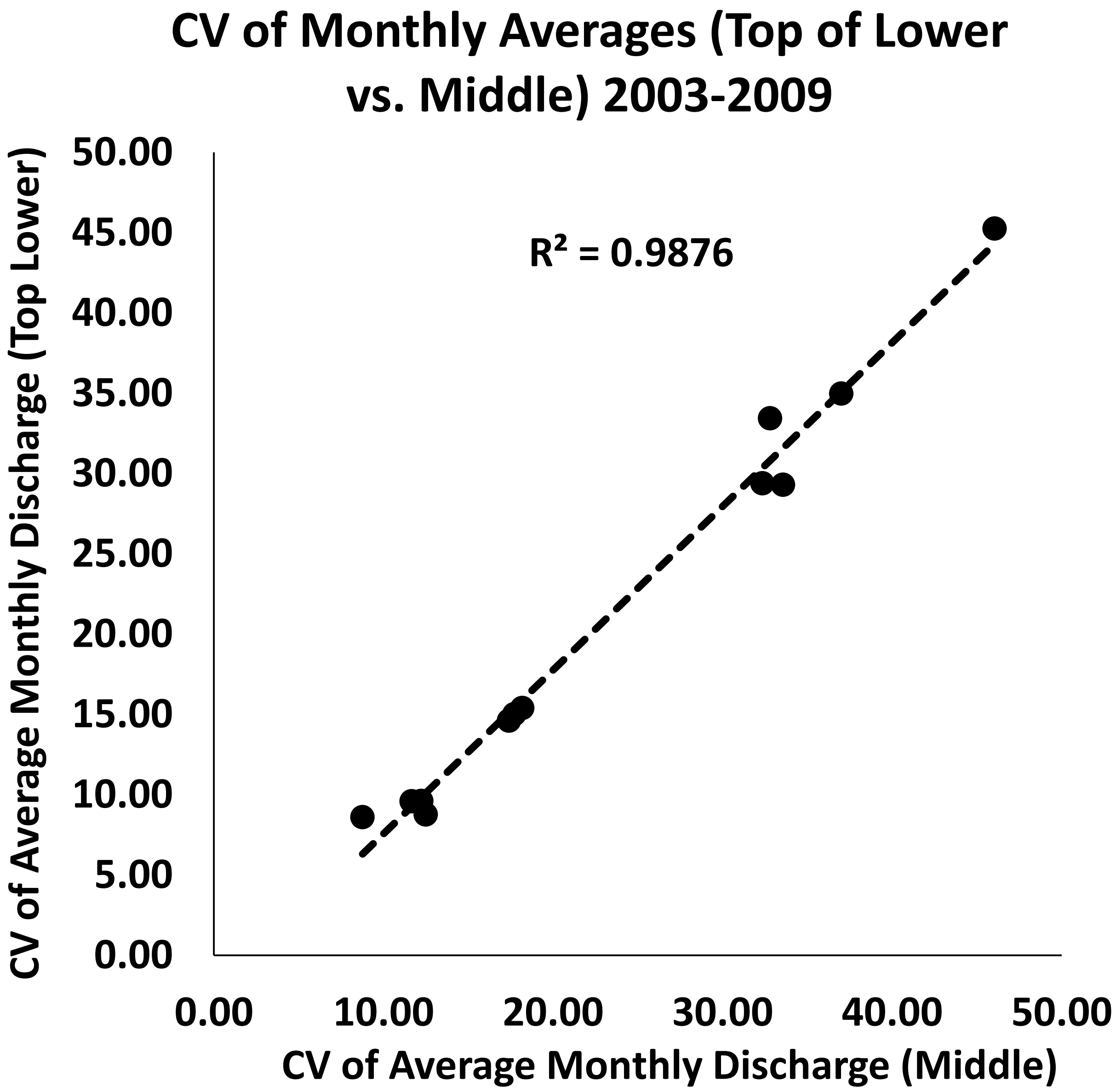
Hydrologic Summaries: Correlations of Variability Around Average Monthly Discharge Among Reaches…

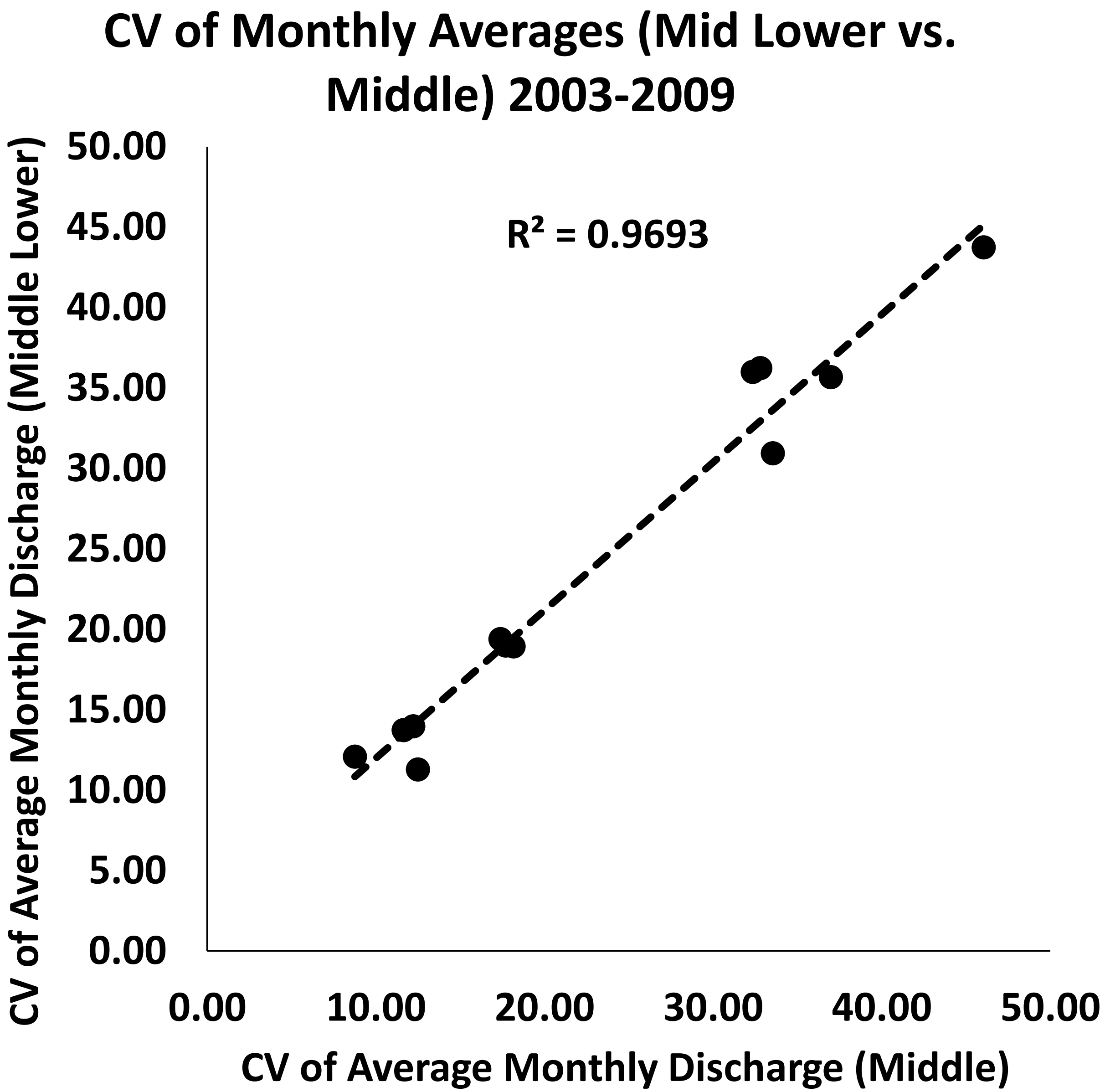




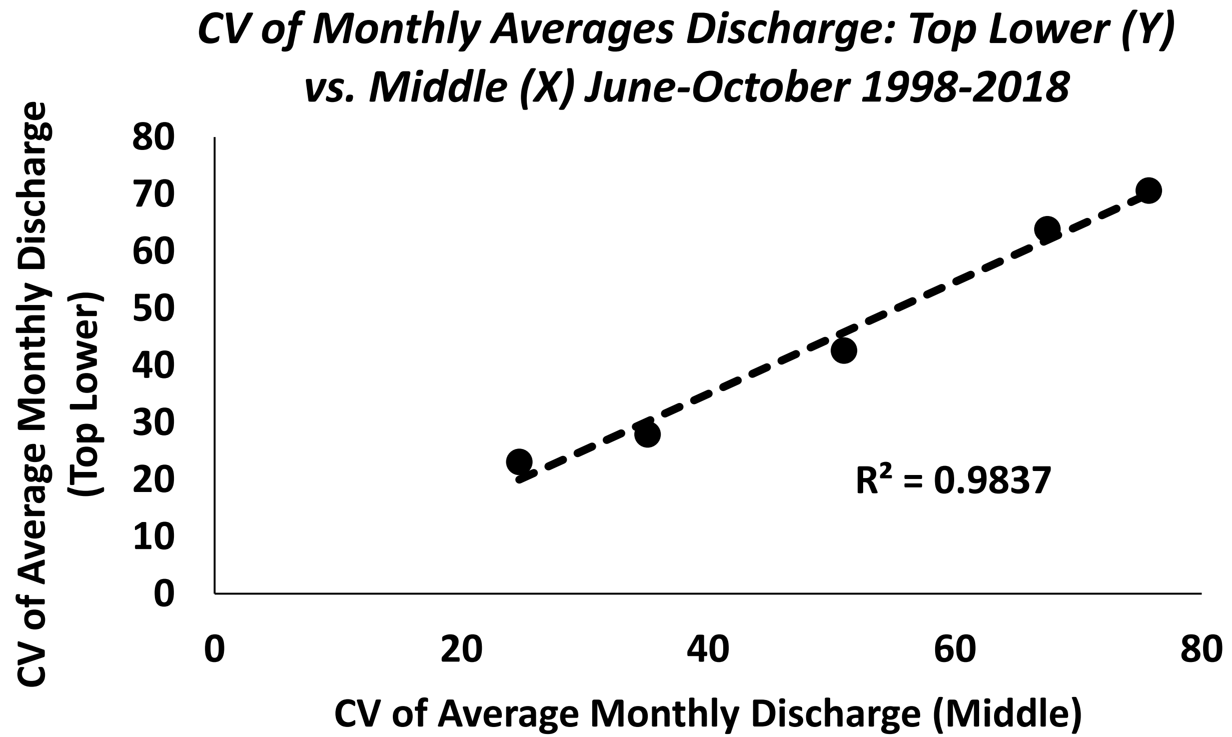
CV = (Std. Dev. of Monthly Discharge/Average Monthly Discharge) x 100; R^2 = % change in Y explained by change in X

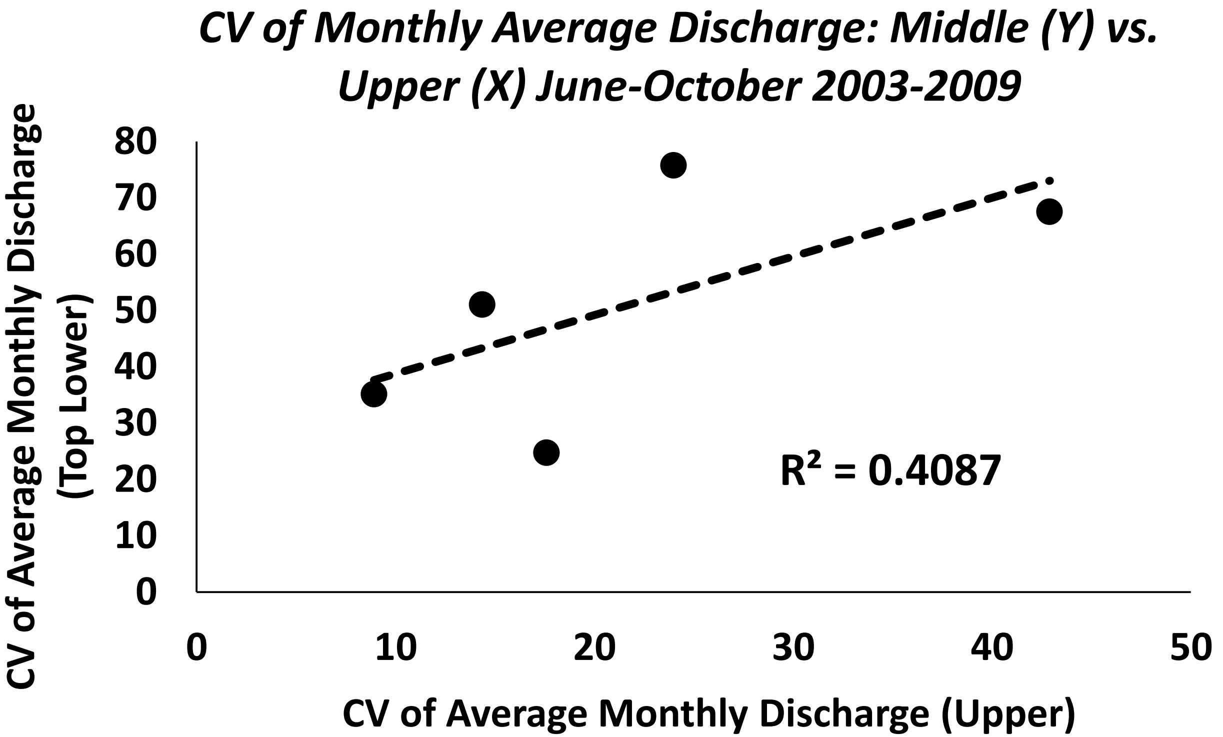
Hydrologic Summaries: Correlations of Variability Around Average Monthly Discharge Among Reaches…

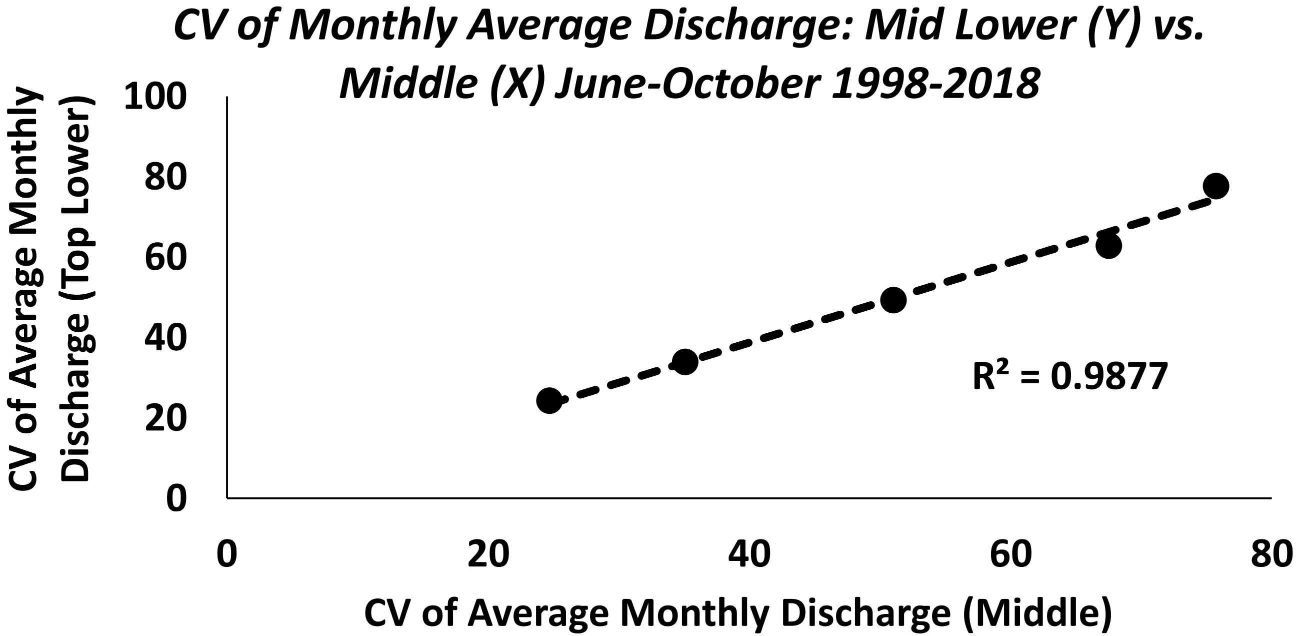




CV = (Std. Dev. of Monthly Discharge/Average Monthly Discharge) x 100; R^2 = % change in Y explained by change in X


CV of Monthly Averages Discharge: Top Lower (Y) vs. Middle (X) June-October 1998-2018
CV of Average Monthly Discharge (Top Lower)
CV of Average Monthly Discharge (Middle)
$R^2 = 0.9837$
0
10
20
30
40
50
60
70
80
0
20
40
60
80

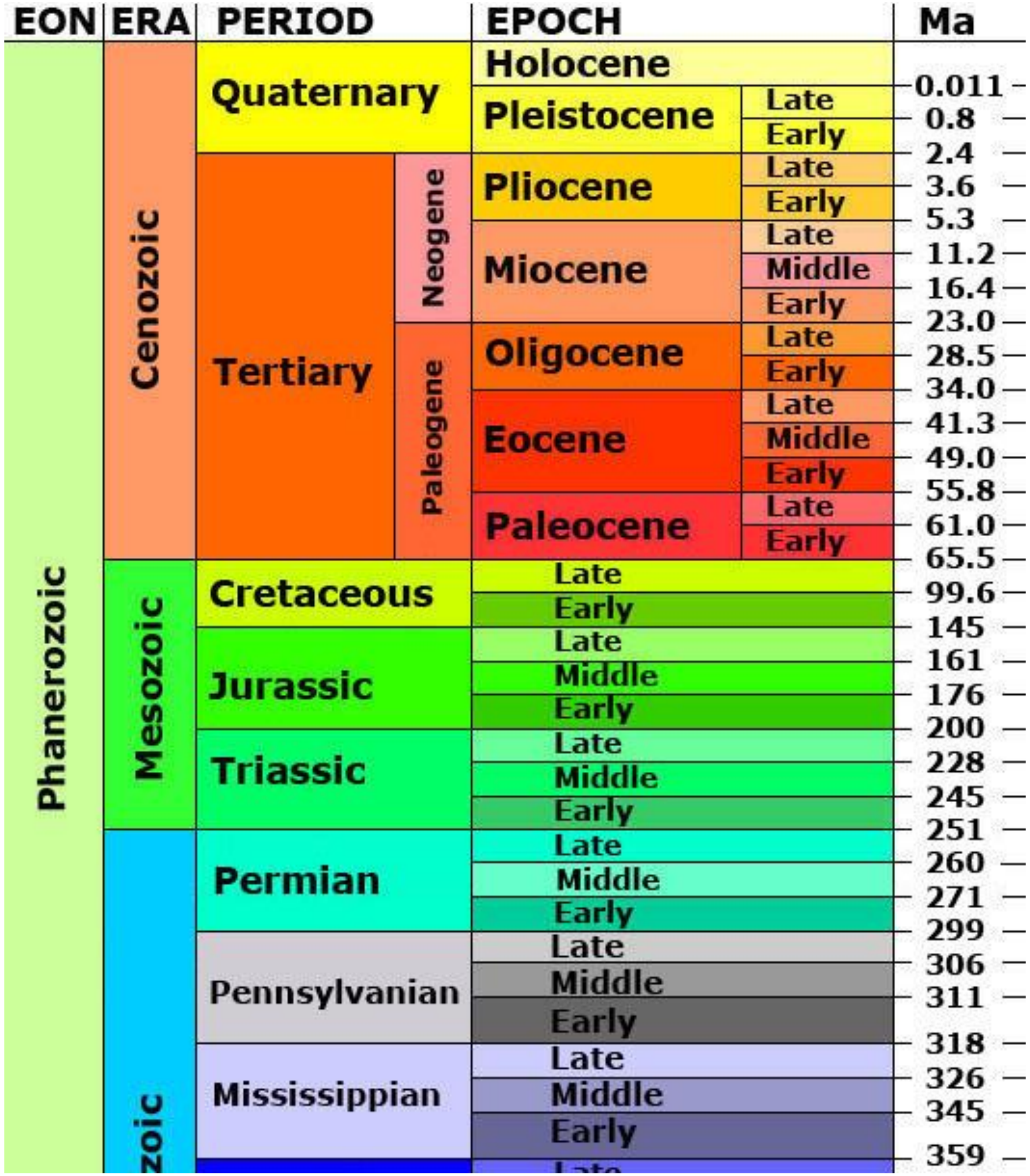

CV of Monthly Average Discharge: Middle (Y) vs. Upper (X) June-October 2003-2009
CV of Average Monthly Discharge (Top Lower)
CV of Average Monthly Discharge (Upper)
$R^2 = 0.4087$
0
10
20
30
40
50
60
70
80
0
10
20
30
40
50


CV of Monthly Average Discharge: Mid Lower (Y) vs. Middle (X) June-October 1998-2018
CV of Average Monthly Discharge (Top Lower)
CV of Average Monthly Discharge (Middle)
$R^2 = 0.9877$
0
20
40
60
80
100
0
20
40
60
80

Geologic Aspects of Each Reach

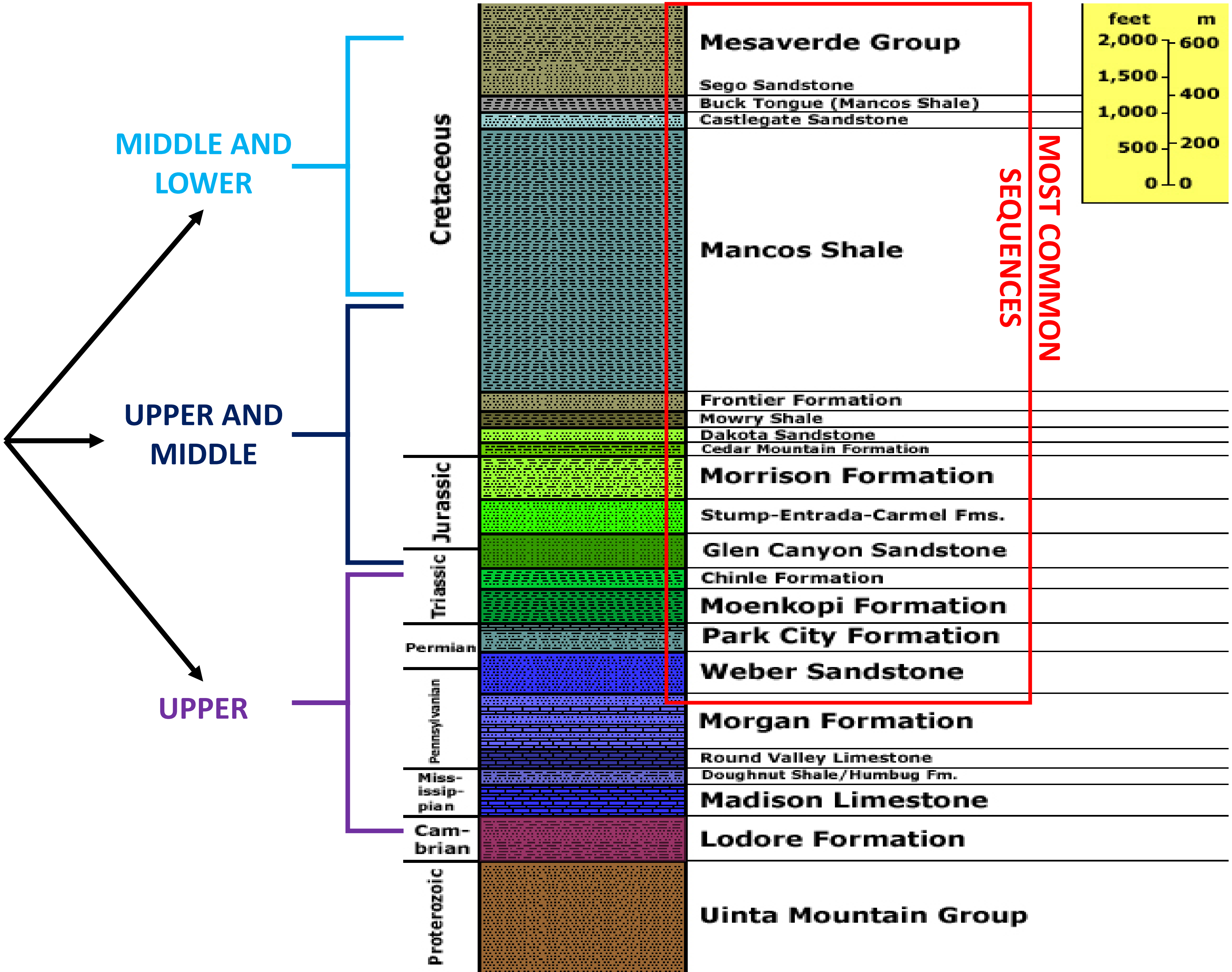
Geologic Aspects of the White River in General…

- The bed of the main-stem White River consists of relatively young, unconsolidated Quaternary deposits
  - Water, wind, and glaciers to an extent in the upper reaches
- The tops of the upper reach drain older rocks; Cambrian quartzite and limestone
- The most relevant geologic time span is on the figure to the right…
  - Some rocks in the upper reaches are older (Cambrian)

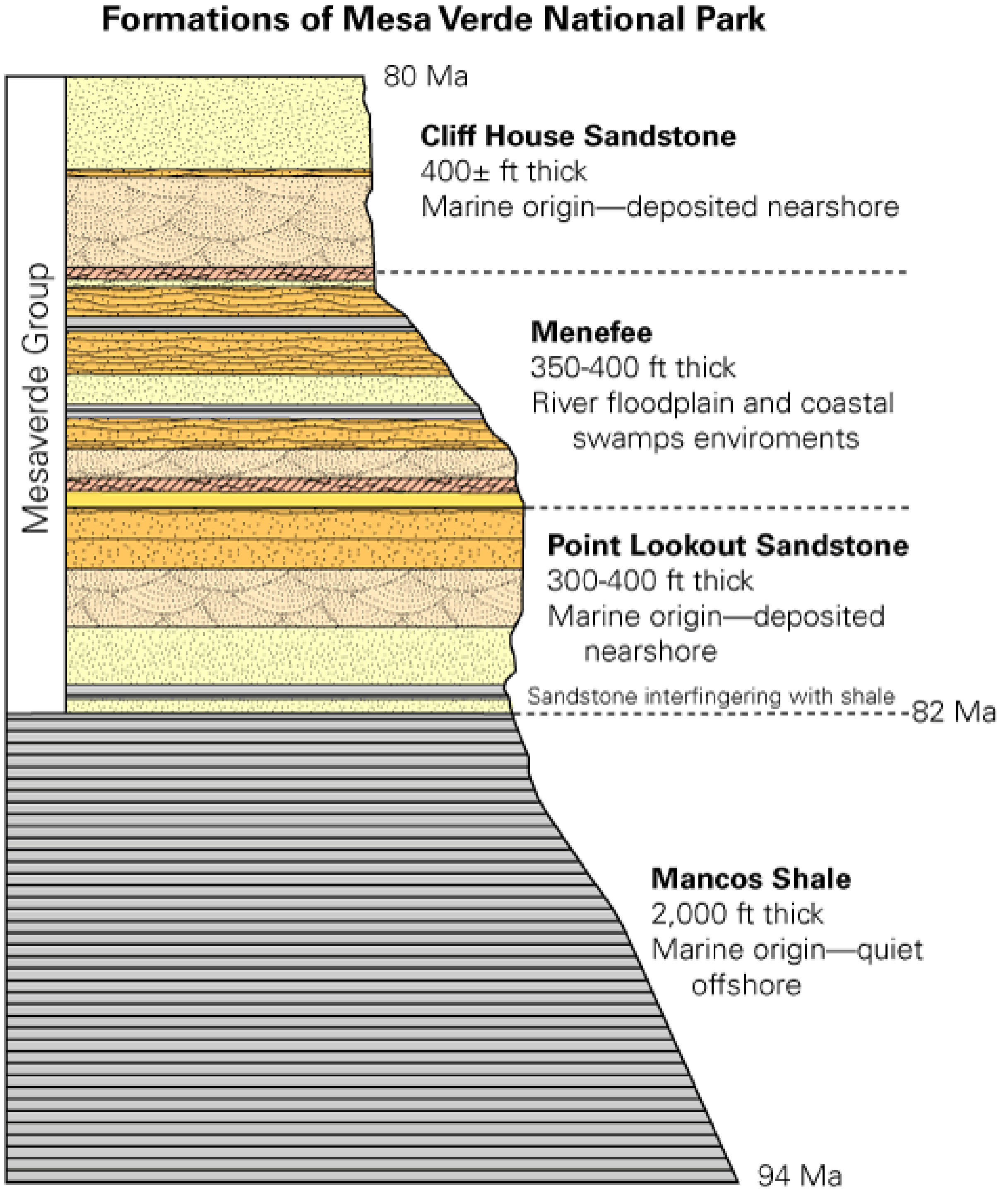


STRATIGRAPHY OF DINOSAUR NATIONAL MONUMENT

APPROXIMATE TIME PERIODS THAT OUR REACHES DRAIN (*PARTICULAR SEQUENCES AND FORMATIONS MAY DIFFER*)



MESA VERDE FORMATION + MANCOS SHALE; *DOMINANT GEOLOGICAL FEATURE IN LOWER REACH*



Geologic Aspects of Each Reach; *The Upper Reach*

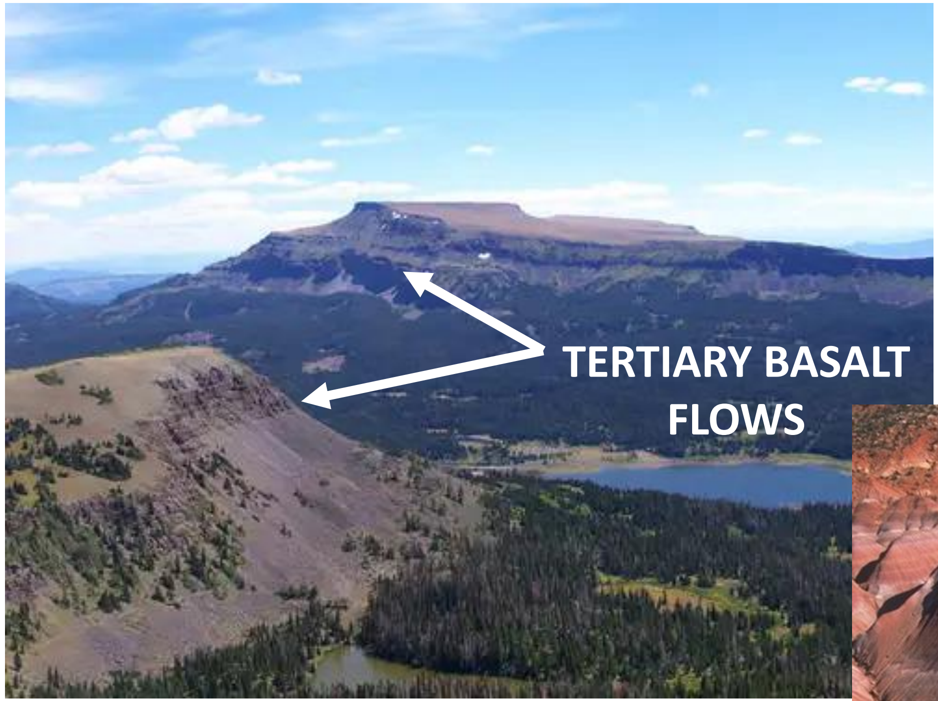
- The tops of the North and South Fork, in general, drain more consolidated metamorphic and sedimentary rocks capped by basalt (lava flows)

- As both the North and South Fork progress, they quickly cut into more sedimentary features that produce silts and clays (Chinle formation for example)
  - Sediment load buffered by vegetation

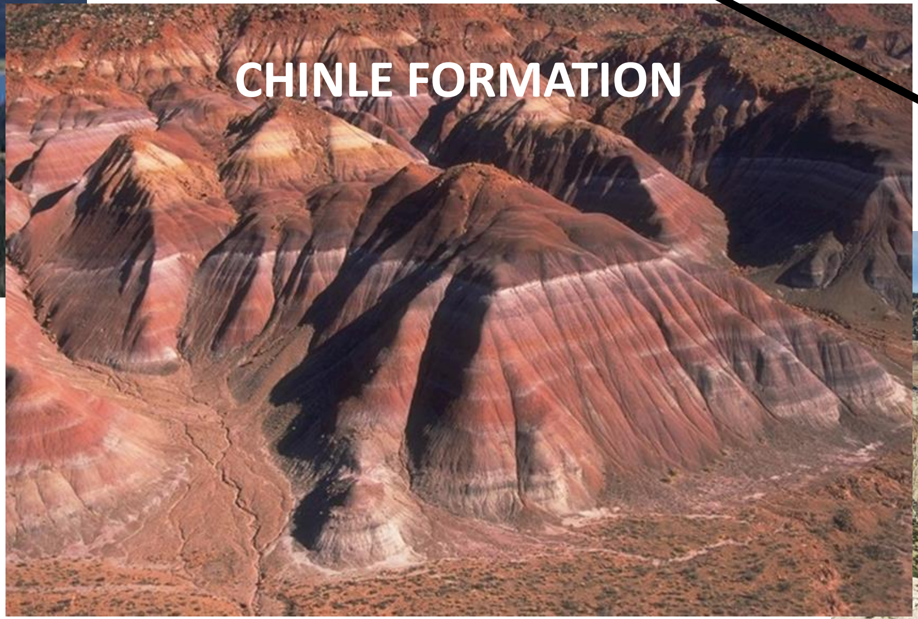
- In the North Fork, this transition has certainly occurred by the time Cty. Rd. 8 climbs out of the river valley

- In the South Fork, this transition occurs at the "valley floor"

EXAMPLES OF GEOLOGIC FEATURES OF THE *UPPER REACH*…

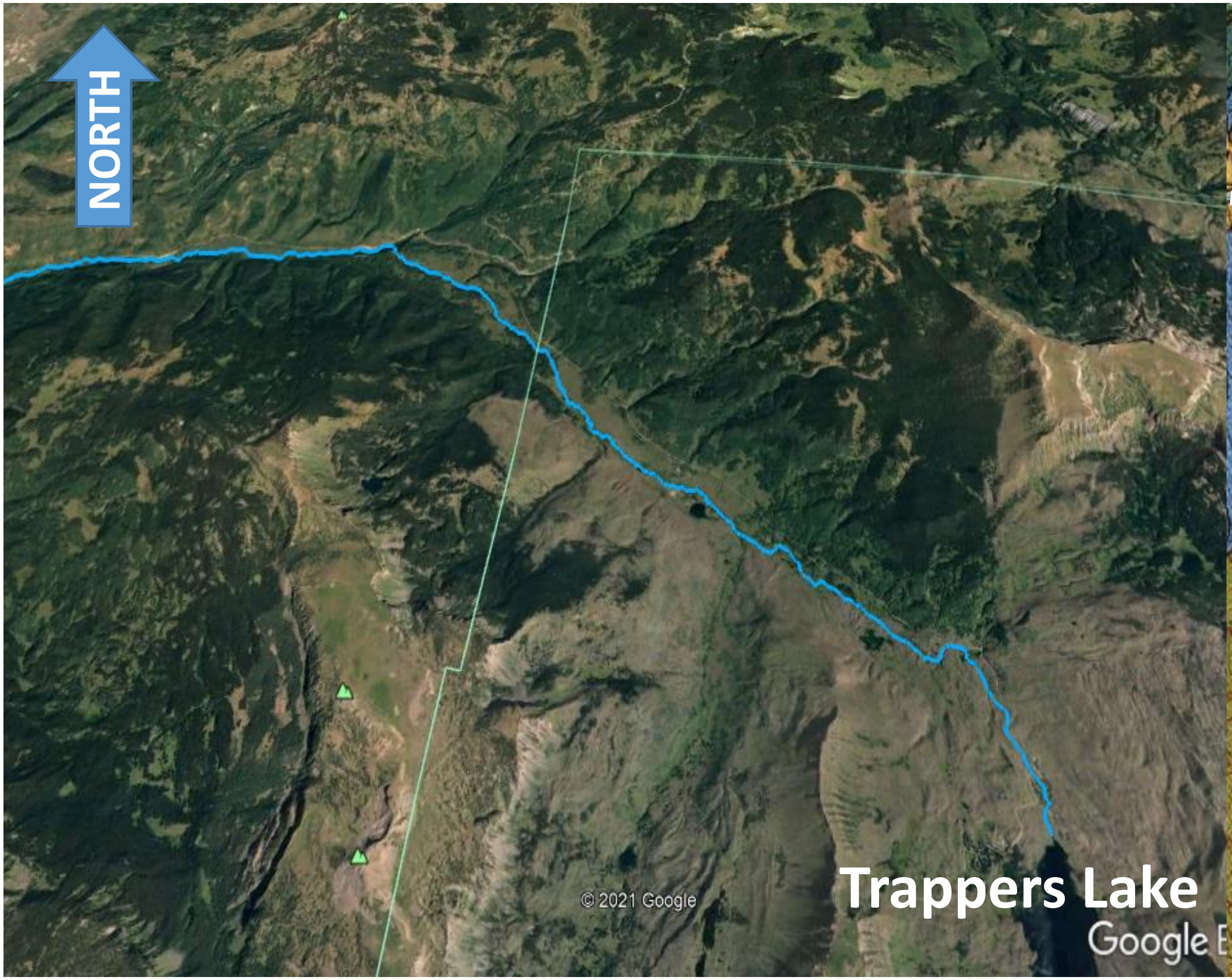


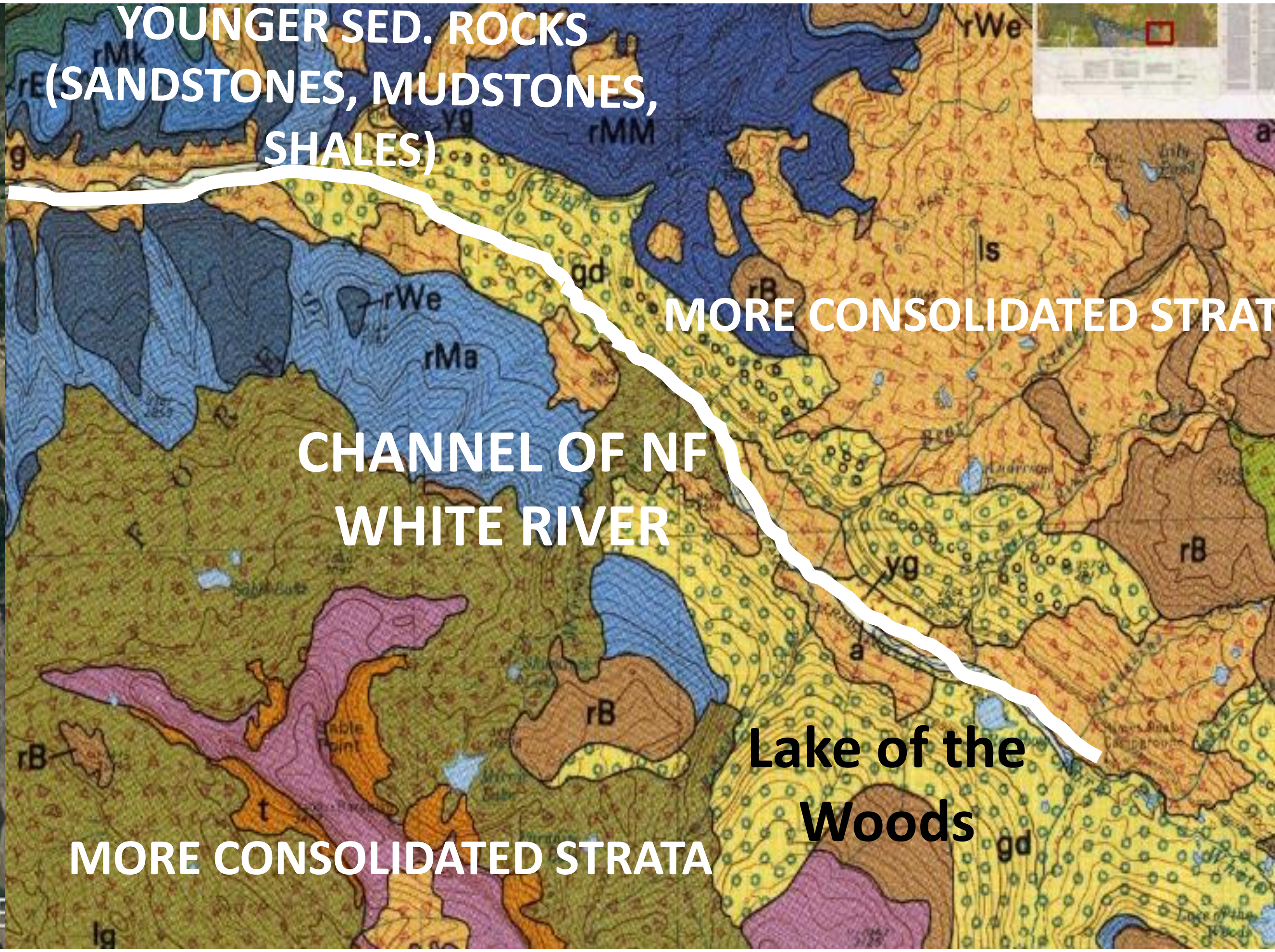
Very old sed. and met. rocks (uplifted) and capped by relatively young igneous rocks at top…



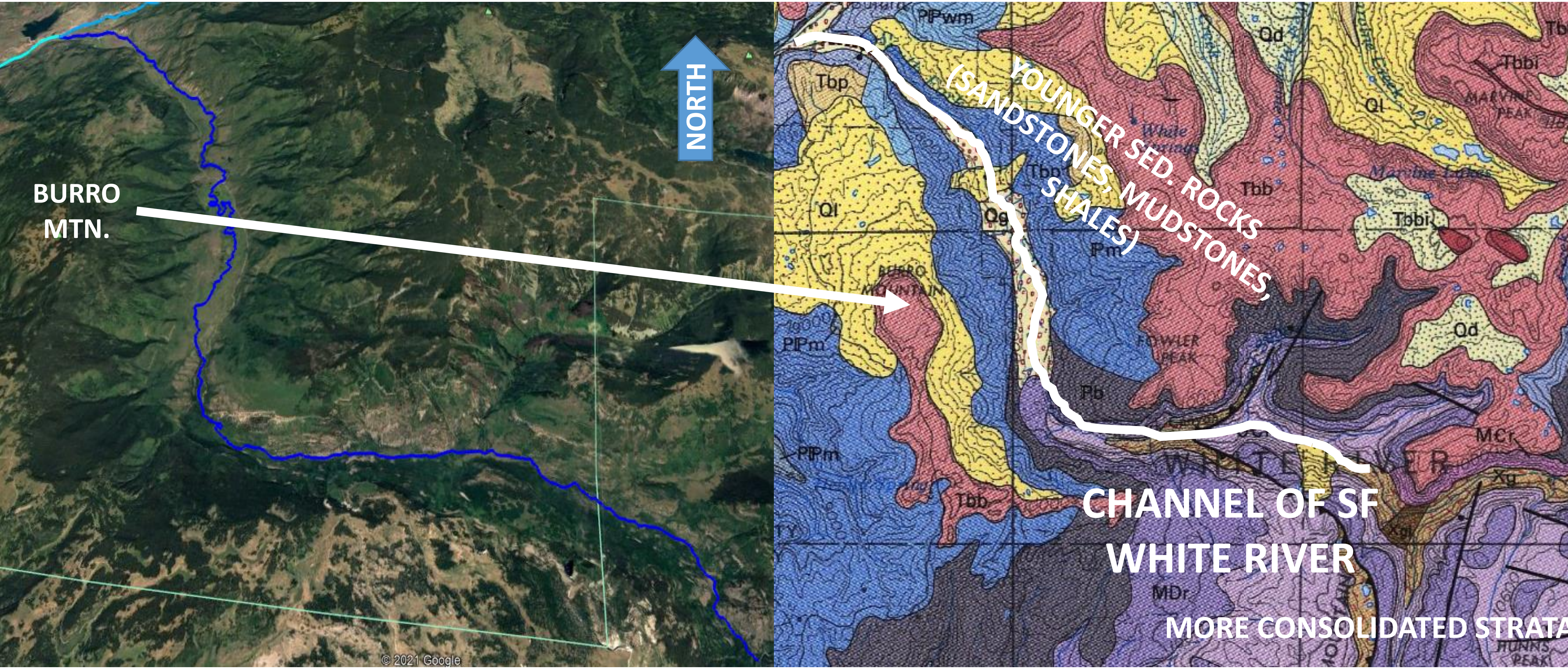
Lay uncomformitably atop "middle aged" sed rocks at bottom

Geologic Features of Each Reach (Upper): *The North Fork Geologic Transition…*





Geologic Features of Each Reach (Upper): *The South Fork Geologic Transition…*

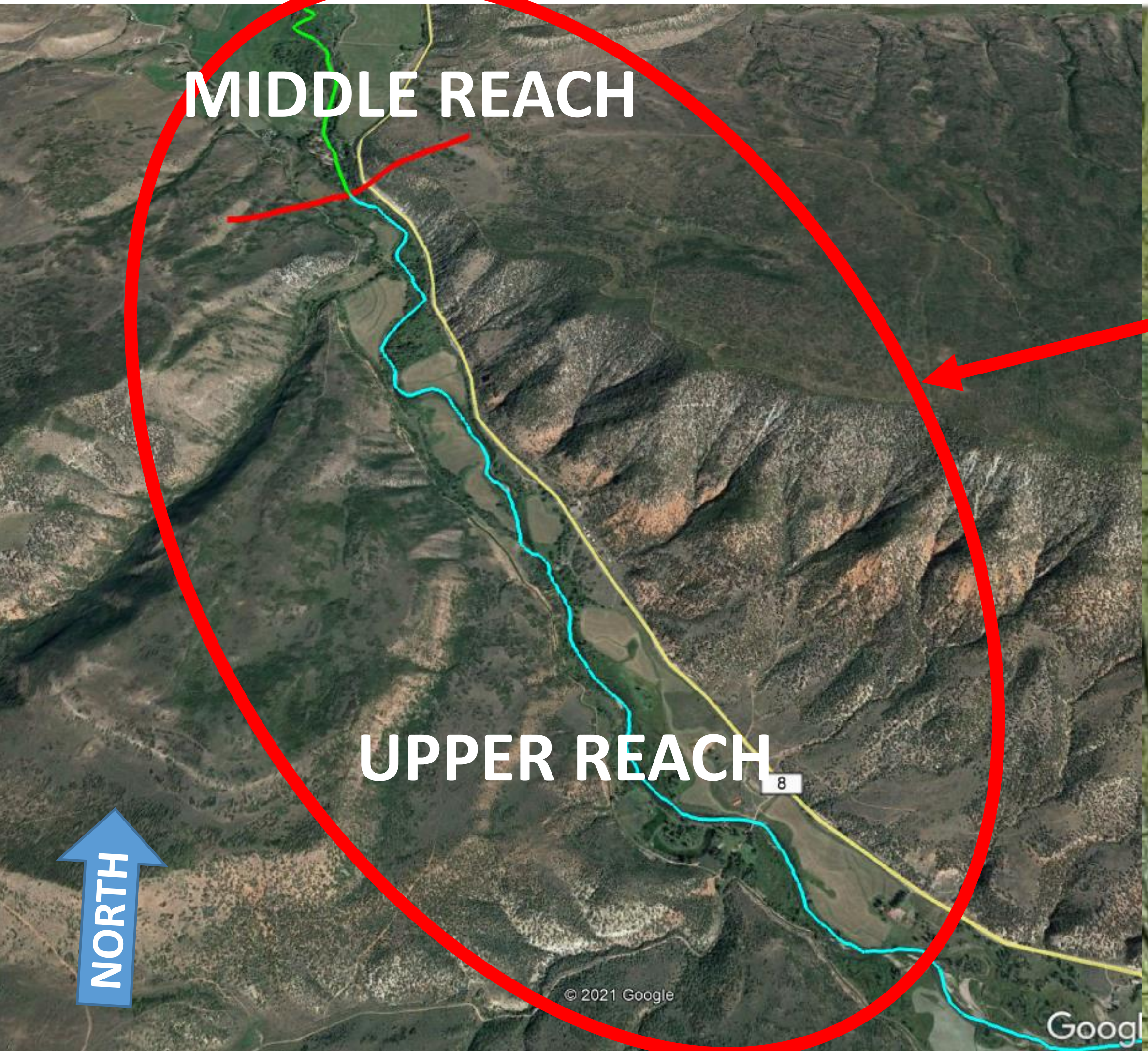


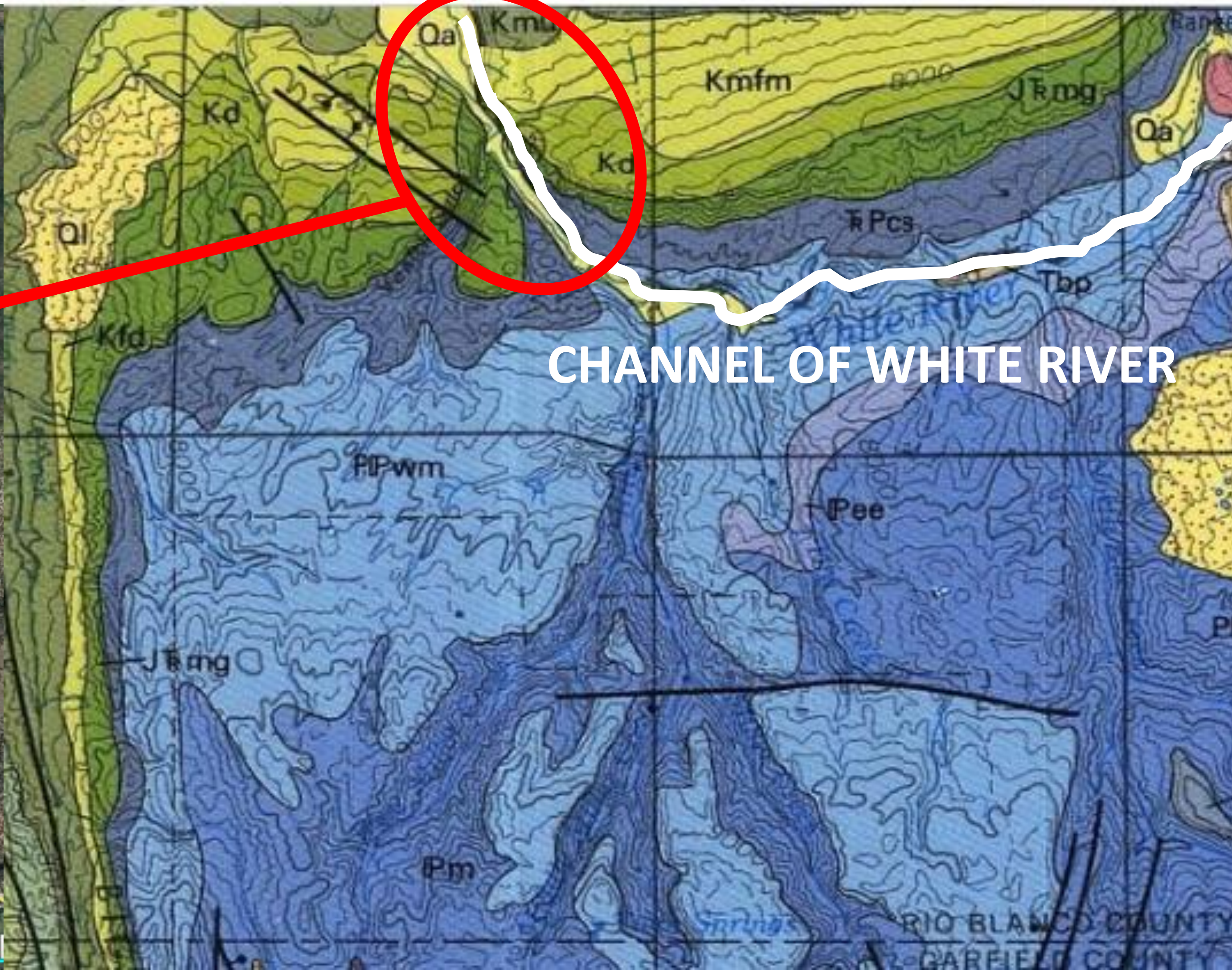
Geologic Features of Each Reach; *The Middle Reach*

- The transition into the middle reach reflects a transition into different geological strata
  - Hillslopes generally drain younger Mancos shale (fine grained and unconsolidated)
  - Enters a wider river channel with ample sand and gravel valley fill (Quaternary fill)
  - The upper end of the middle reach contains several well-heads
  - The surficial and underlying fill could allow water to permeate; also note the aspect of the adjacent drainages and their fill pattern
  - White River cuts through Grand Hogback just west of Meeker
    - HWY 13 parallels Grand Hogback

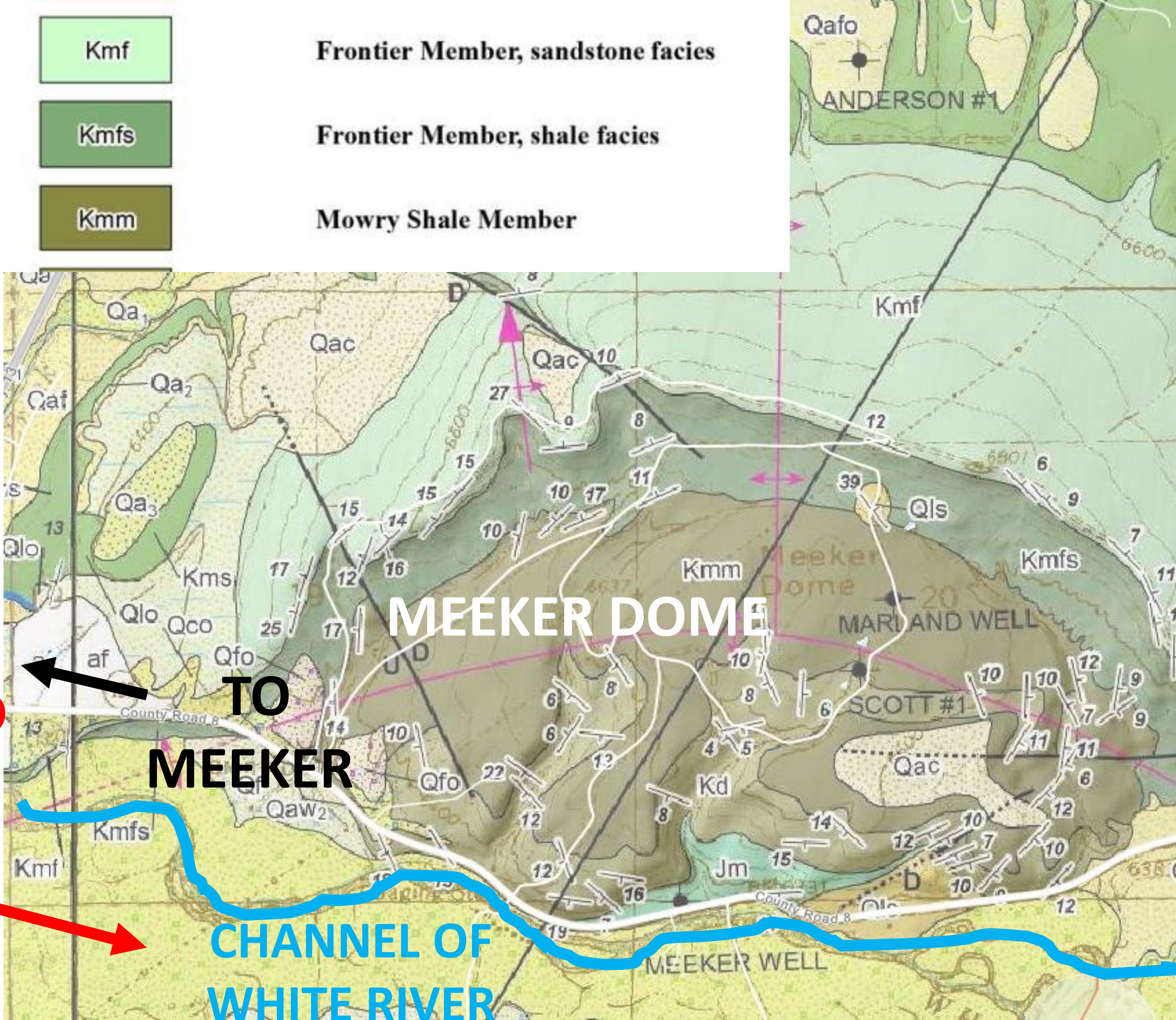
Geologic Features of Each Reach (*Upper to Middle Transition*): The geologic transition from the upper reach into the middle reach shifts from primarily Paleozoic sed. rocks (upper) to Mesozoic sed. rocks. (middle) from the lower Cretaceous

→Sandstones, mudstones, and shales



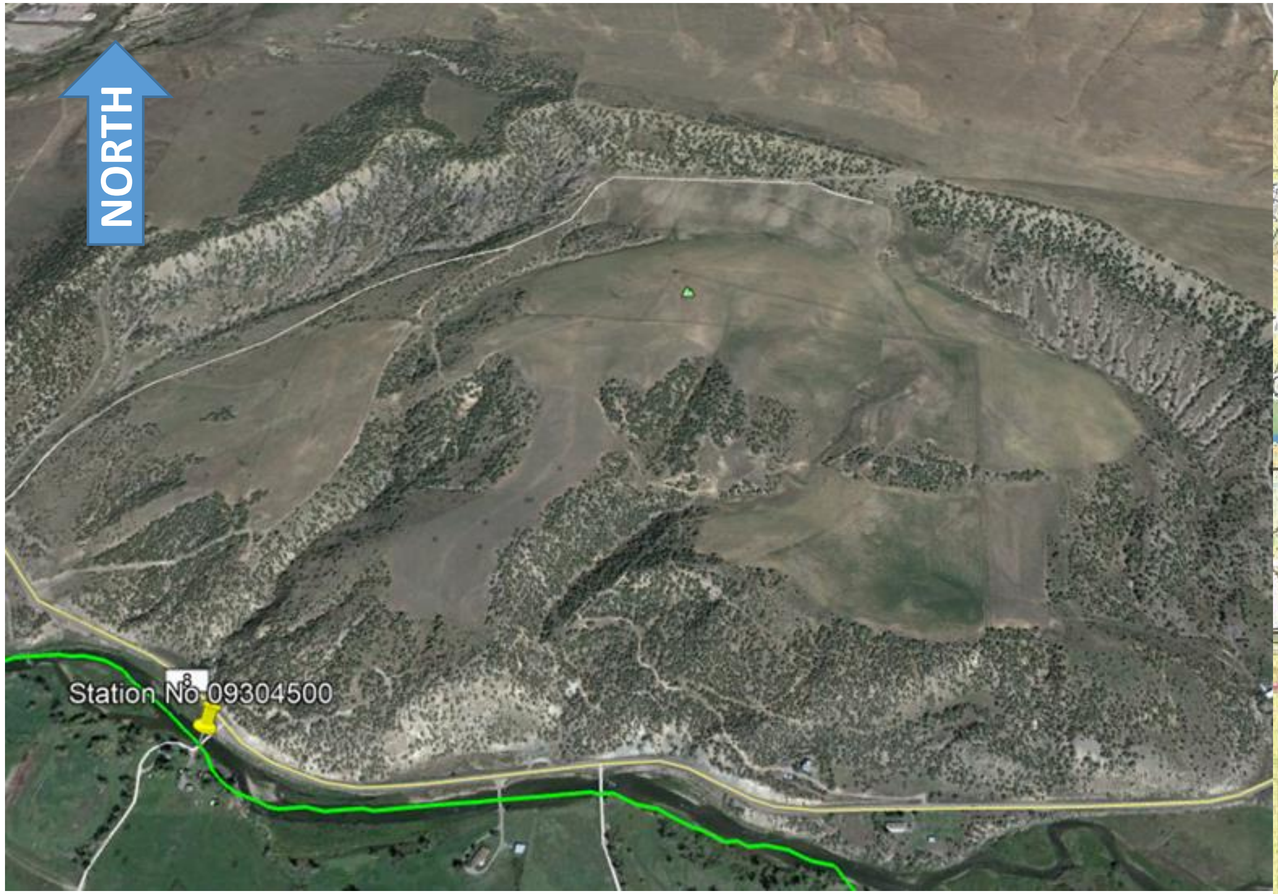


Wells in the upper portion of the middle reach…"**<u>MEEKER DOME</u>**"

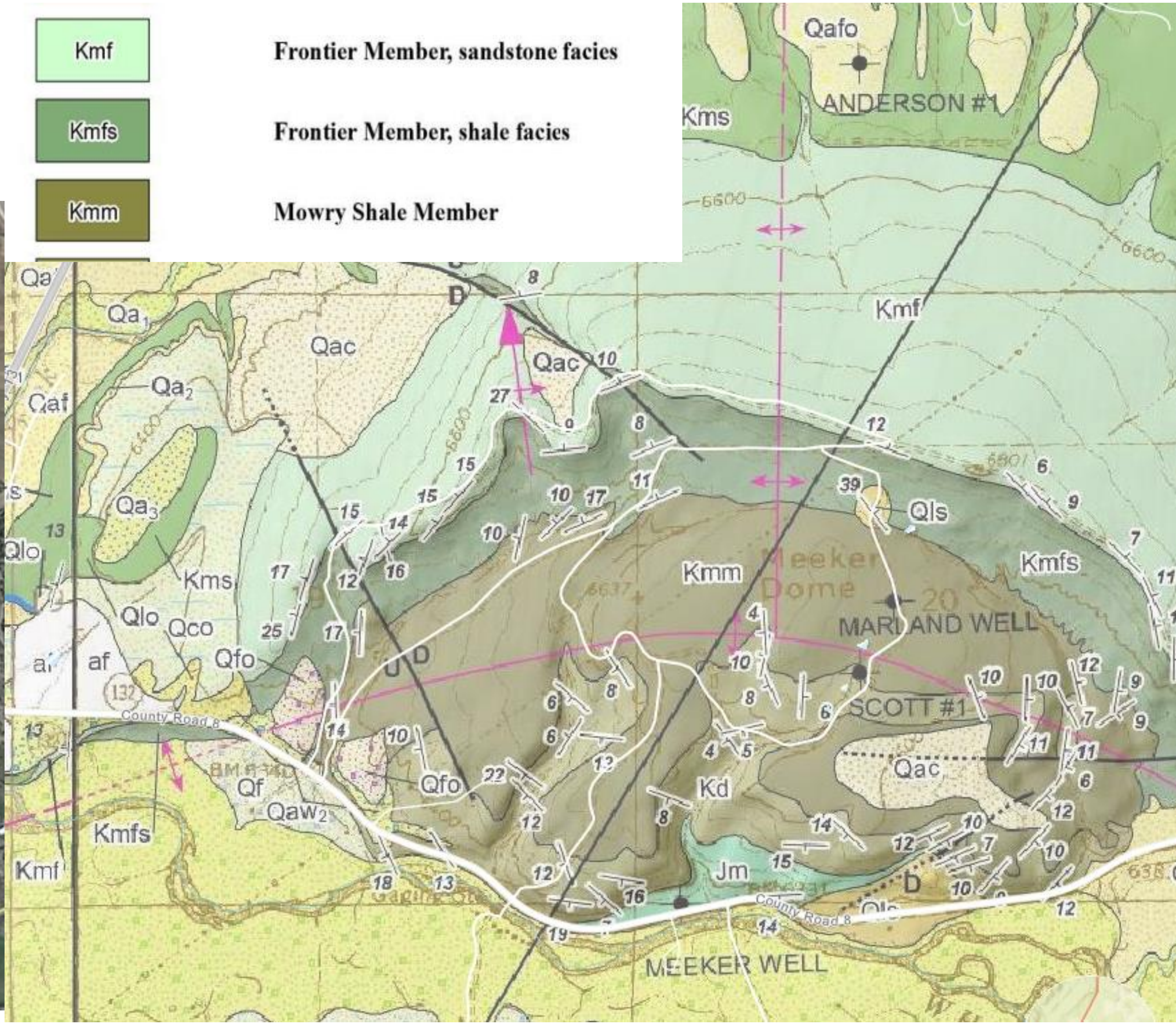


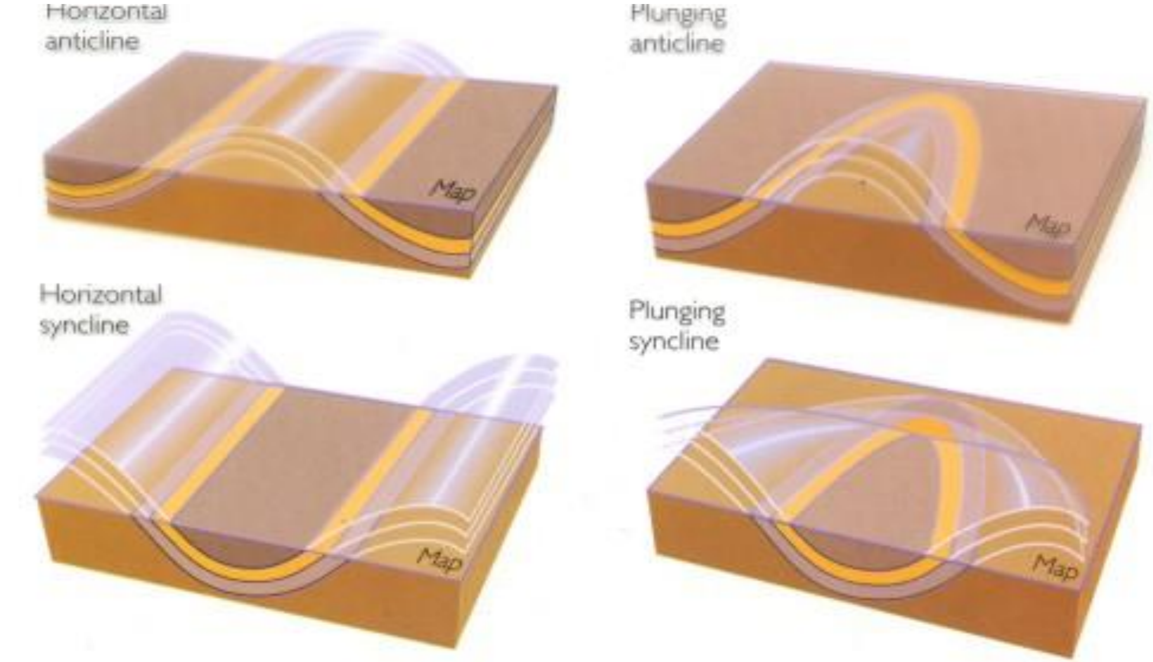
QUATERNARY SAND AND GRAVEL VALLEY FILL

The Middle Reach; *Meeker Dome*



Kmf	Frontier Member, sandstone facies
Kmfs	Frontier Member, shale facies
Kmm	Mowry Shale Member





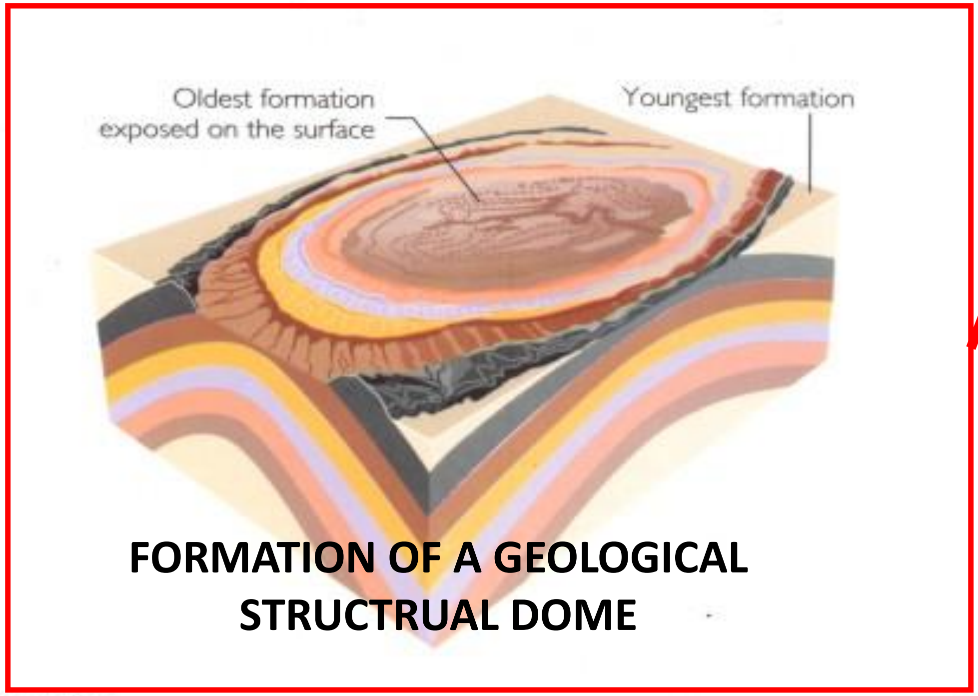
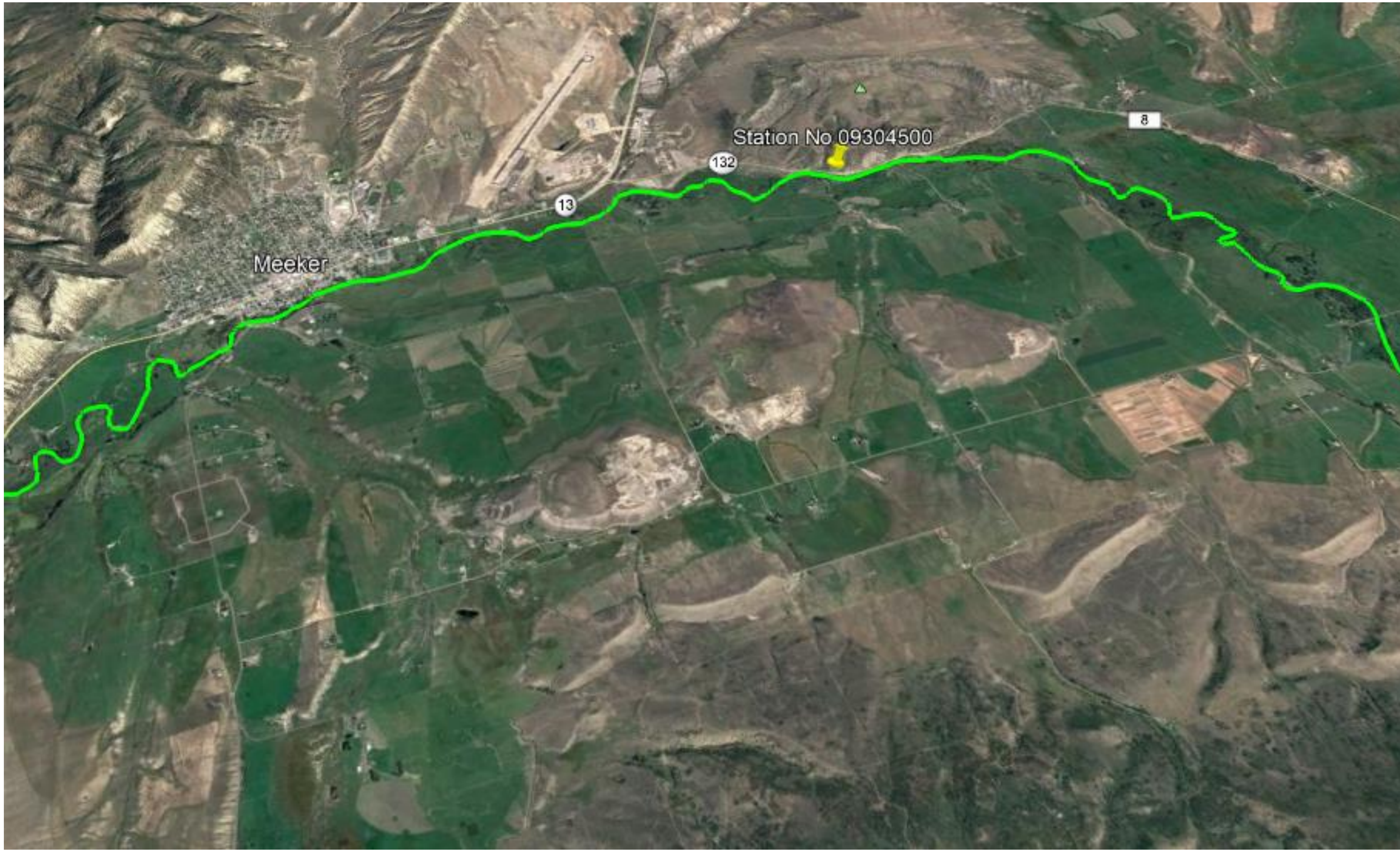


Figure 10.14, 10.16 OHT 53

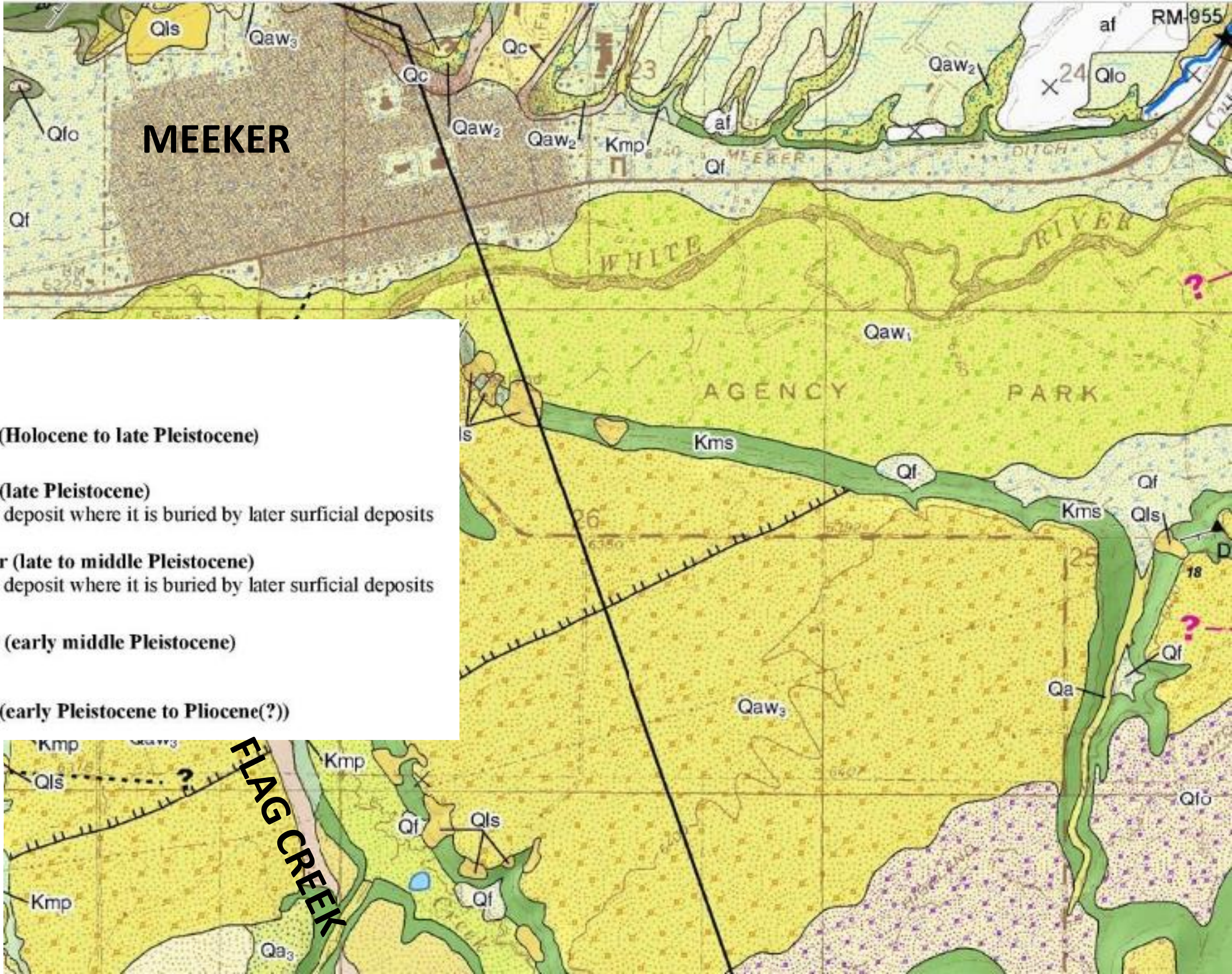
Press and Siever: *Understanding Earth*

Geologic Features of Each Reach; ***The Middle Reach***

- Downstream of Meeker Dome, the river valley broadens into a series of young (Quaternary) deposits that are primarily sand and gravel
  - In some cases, these deposits are buried by more recent fill material



Geologic Features of Each Reach; *The Middle Reach*



ALLUVIAL DEPOSITS

Alluvial Deposits of the White River

Qaw_1	**Alluvium one of the White River (Holocene to late Pleistocene)**
Qaw_2	**Alluvium two of the White River (late Pleistocene)** Line indicates trace of gravel deposit where it is buried by later surficial deposits
Qaw_3	**Alluvium three of the White River (late to middle Pleistocene)** Line indicates trace of gravel deposit where it is buried by later surficial deposits
Qaw_4	**Alluvium four of the White River (early middle Pleistocene)**
Qaw_5	**Alluvium five of the White River (early Pleistocene to Pliocene(?))**
Kms	**Smoky Hill Member**

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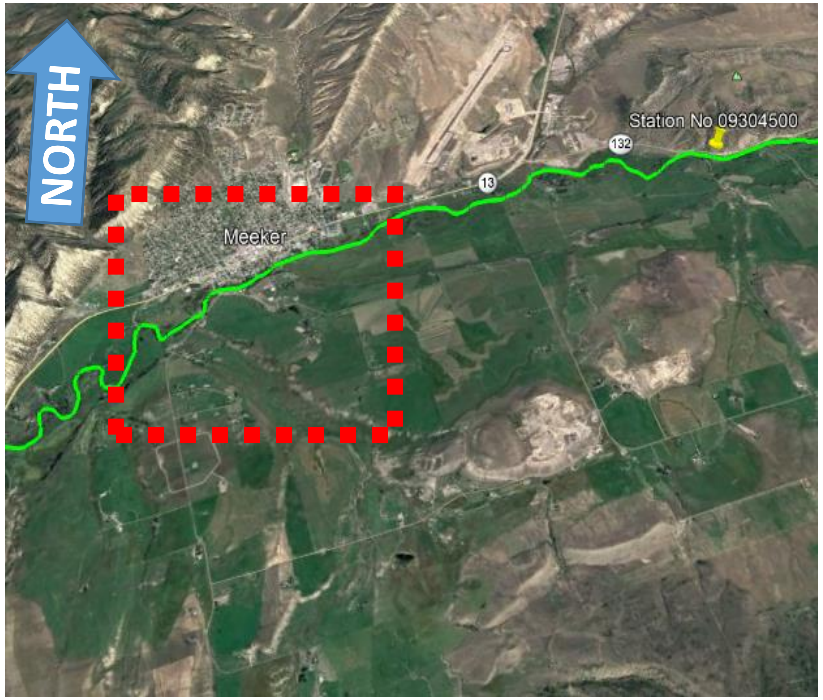
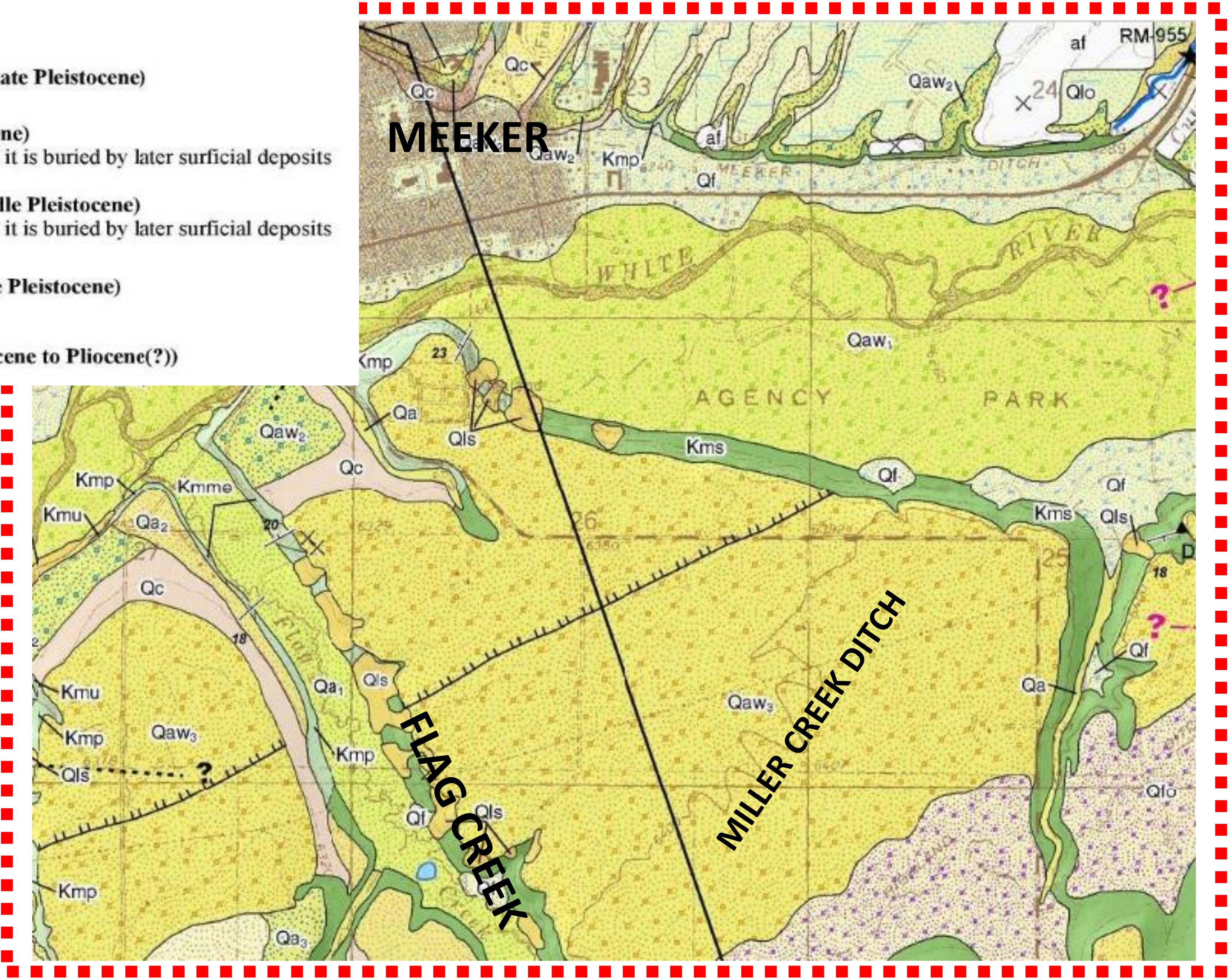
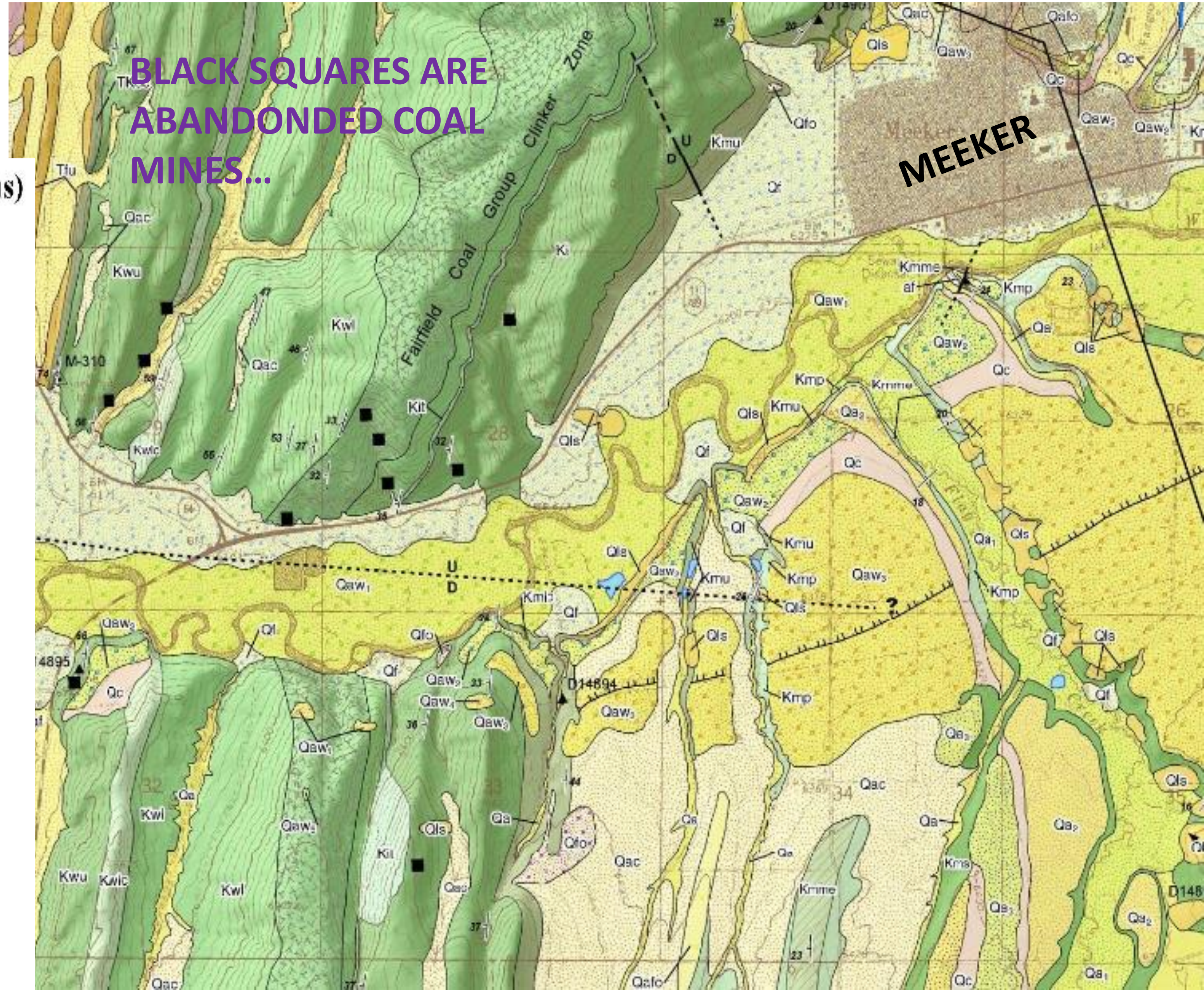


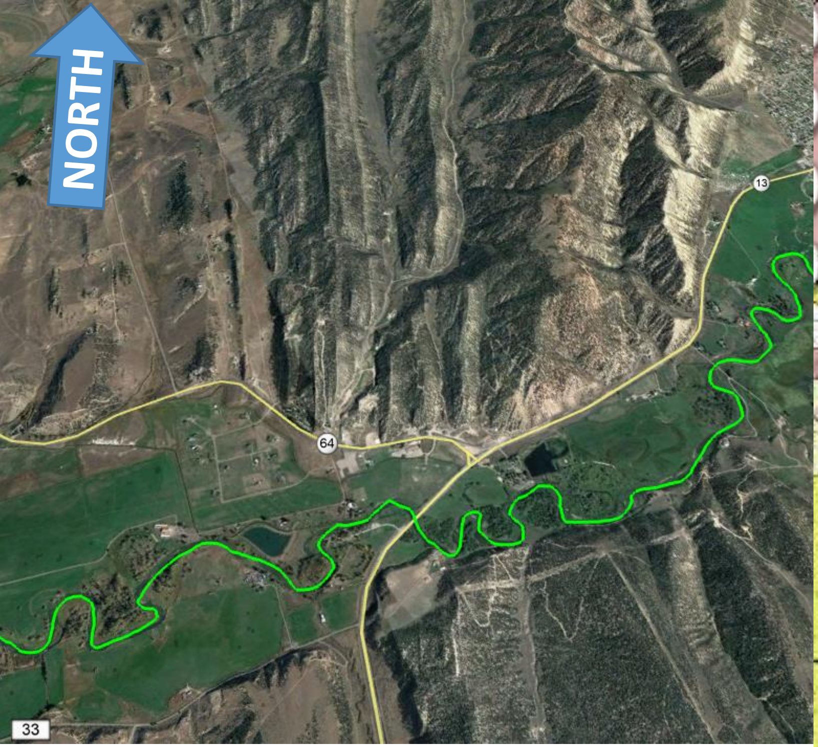


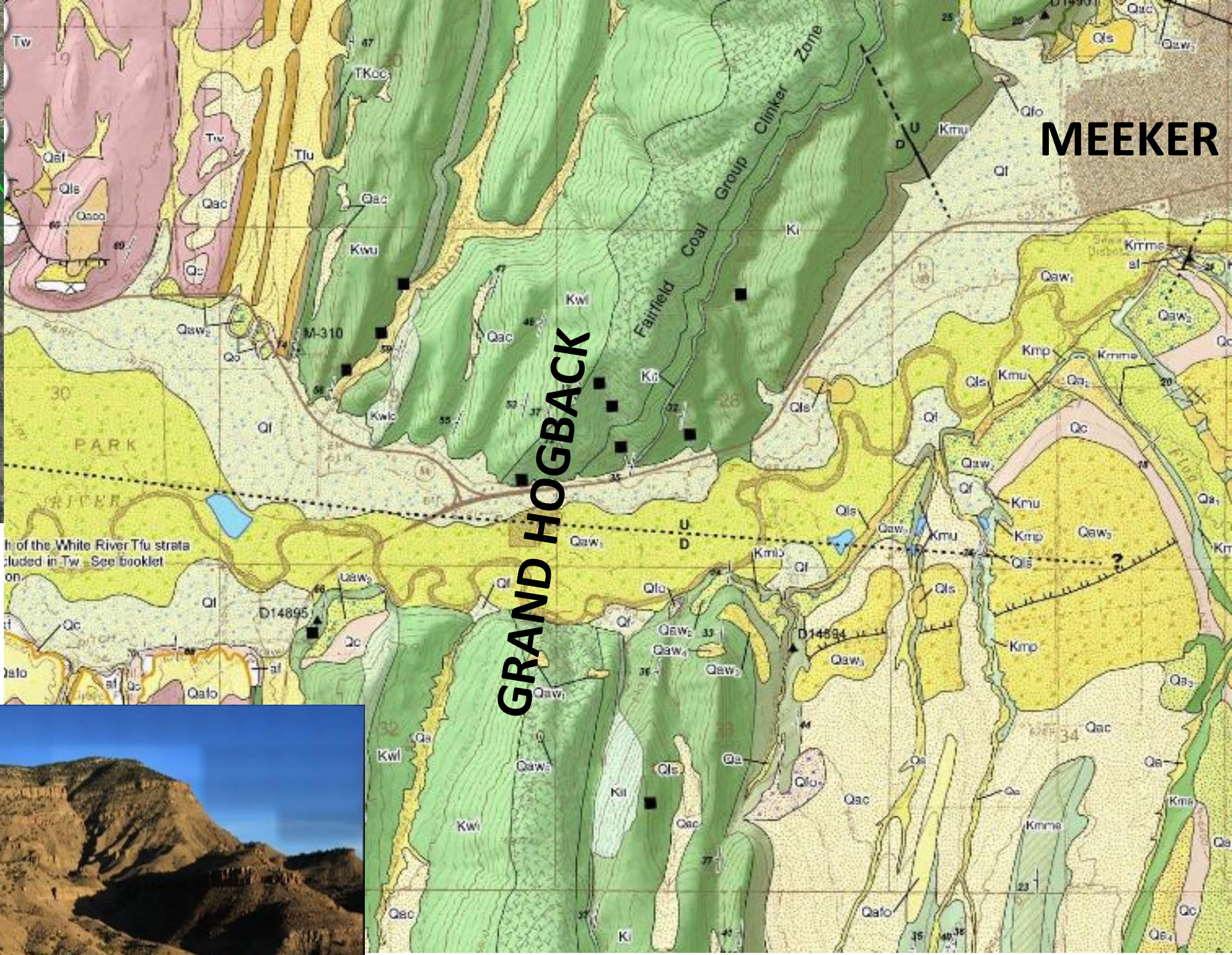
Geologic Features of Each Reach; *The Middle Reach*

NOTCH THROUGH GRAND HOGBACK SEPARATES POWELL PARK (WEST) AND AGENCY PARK (EAST)

	Williams Fork Formation (Upper Cretaceous)
Kwu	Williams Fork Formation, upper unit
Kwlc	Lion Canyon Sandstone Member
Kwl	Williams Fork, lower unit
Ki	Iles Formation (Upper Cretaceous)
Kit	Trout Creek Sandstone Member
	Mancos Shale (Upper Cretaceous)
Kmu	Mancos Shale, upper unit







ESSENTIAL WILLIAMS FORK FORMATION

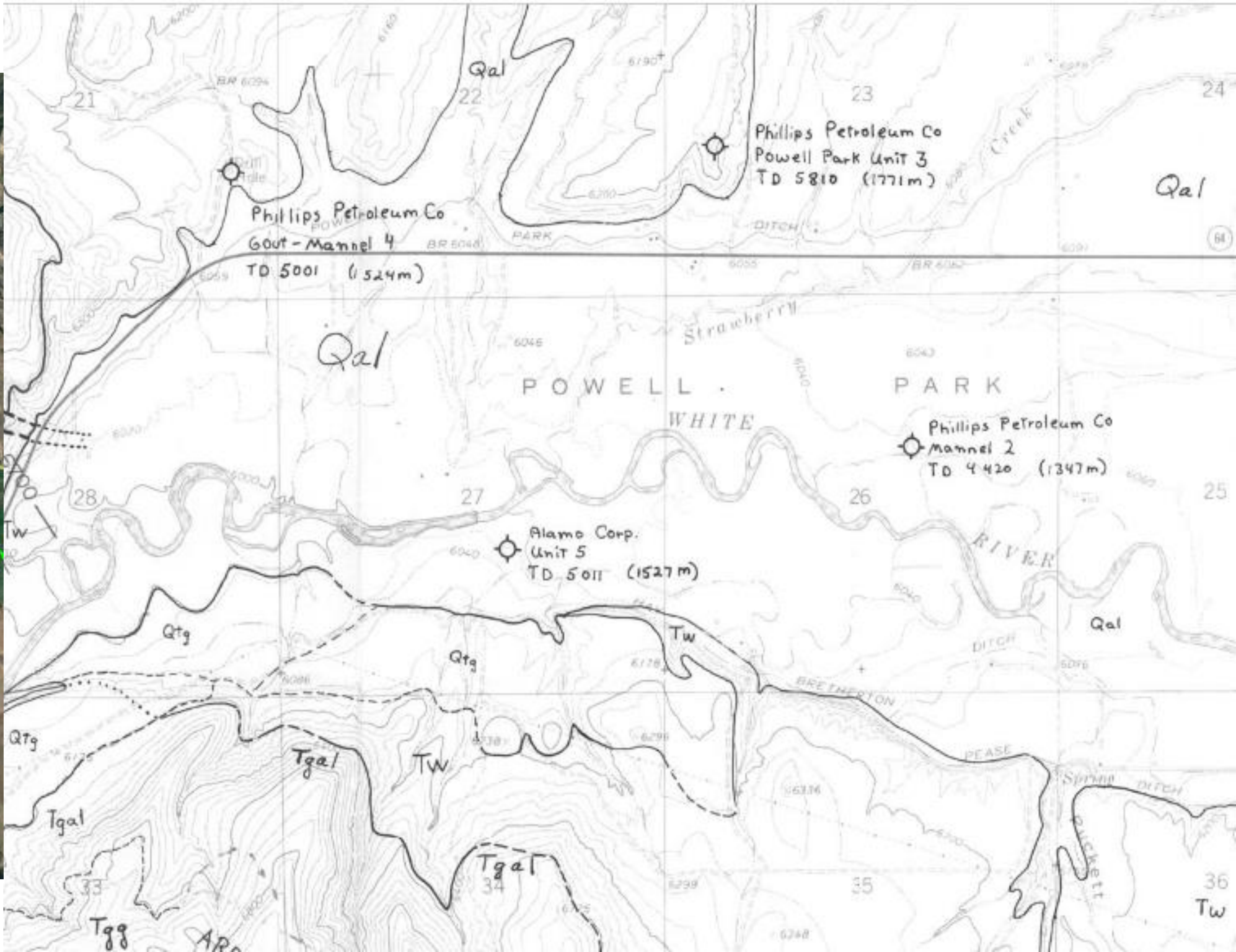
Geologic Features of Each Reach; *The Middle Reach*

- After the White River cuts through the Grand Hogback and enters Powell Park, it drains a younger (Eocene) strata called the Wasatch Formation

- Powell Park has similar underlying Quaternary fill as Agency Park

- The Wasatch Formation consists of mudstones, siltstones, sandstones, and conglomerates deposited in a large alluvial plane
  - Mobile, silty sediments


WASATCH FORMATION
NORTH
WASATCH FORMATION


Qal
Phillips Petroleum Co
Powell Park Unit 3
TD 5810 (1771m)
Phillips Petroleum Co
Gout-Mannel 4
TD 5001 (1524m)
Qal
Strawberry
POWELL PARK
WHITE RIVER
Phillips Petroleum Co
Mannel 2
TD 4420 (1347m)
Alamo Corp.
Unit 5
TD 5011 (1527m)
Qal
Qtg
Tw
Qtg
Qtg
Tgal
Tw
Tgal
Tgal
Tgg
Tw
21
22
23
24
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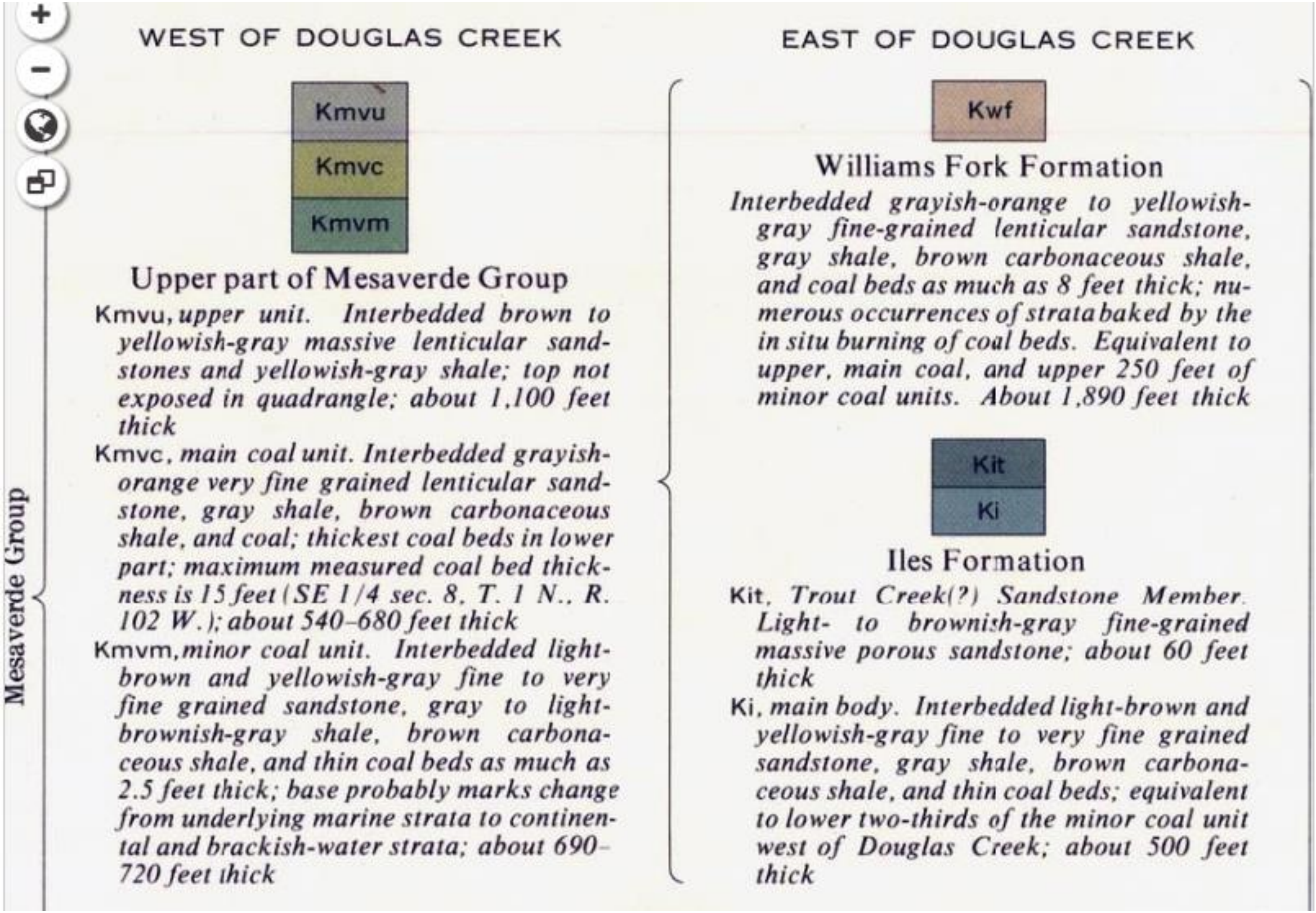
36

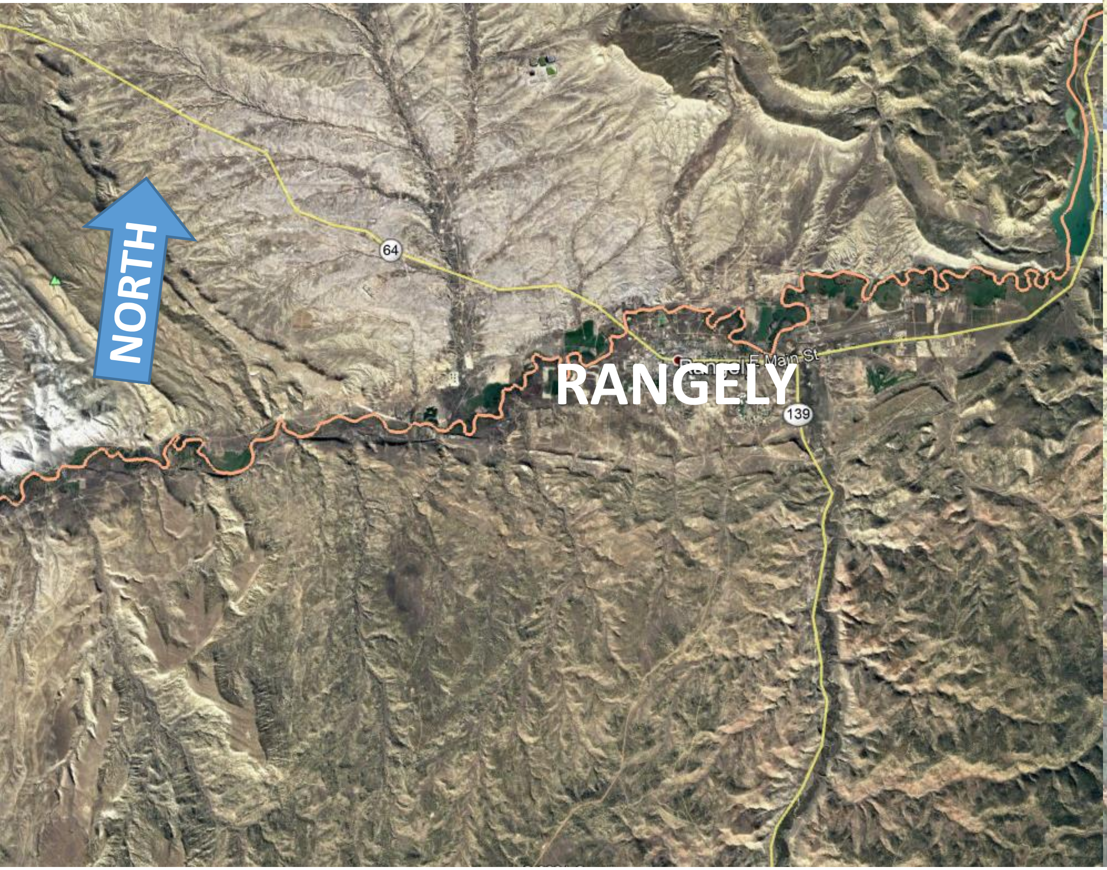
Geologic Features of Each Reach; *The Lower Reach*

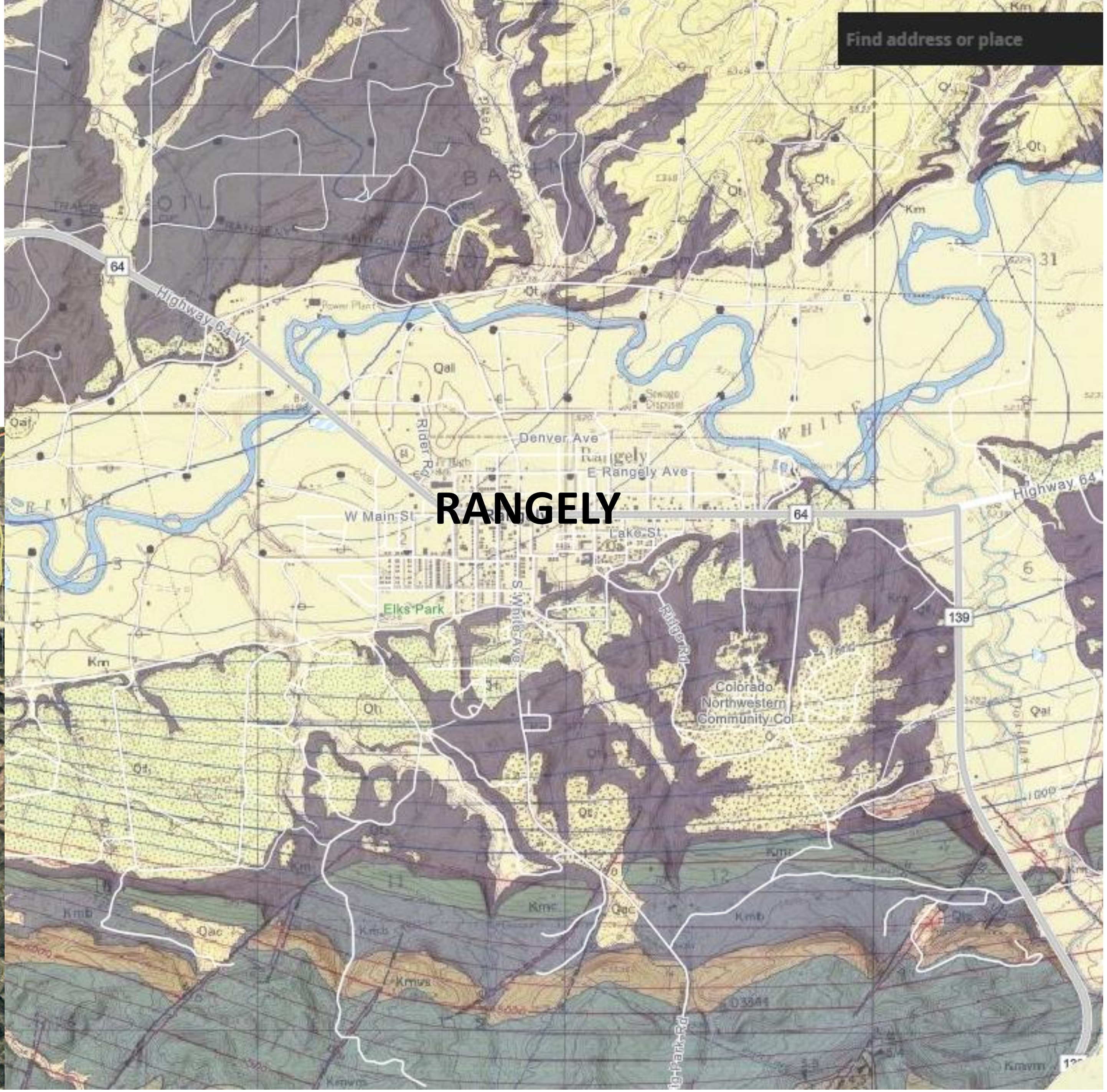
- Once the White River enters the lower reach, it primarily drains the main body of the Mancos Shale until West of Rangely

- Downstream of Rangely (just east of the UT border), there is another geologic transition into even younger Eocene strata
  - Green River Formation
    - Shales, limestone

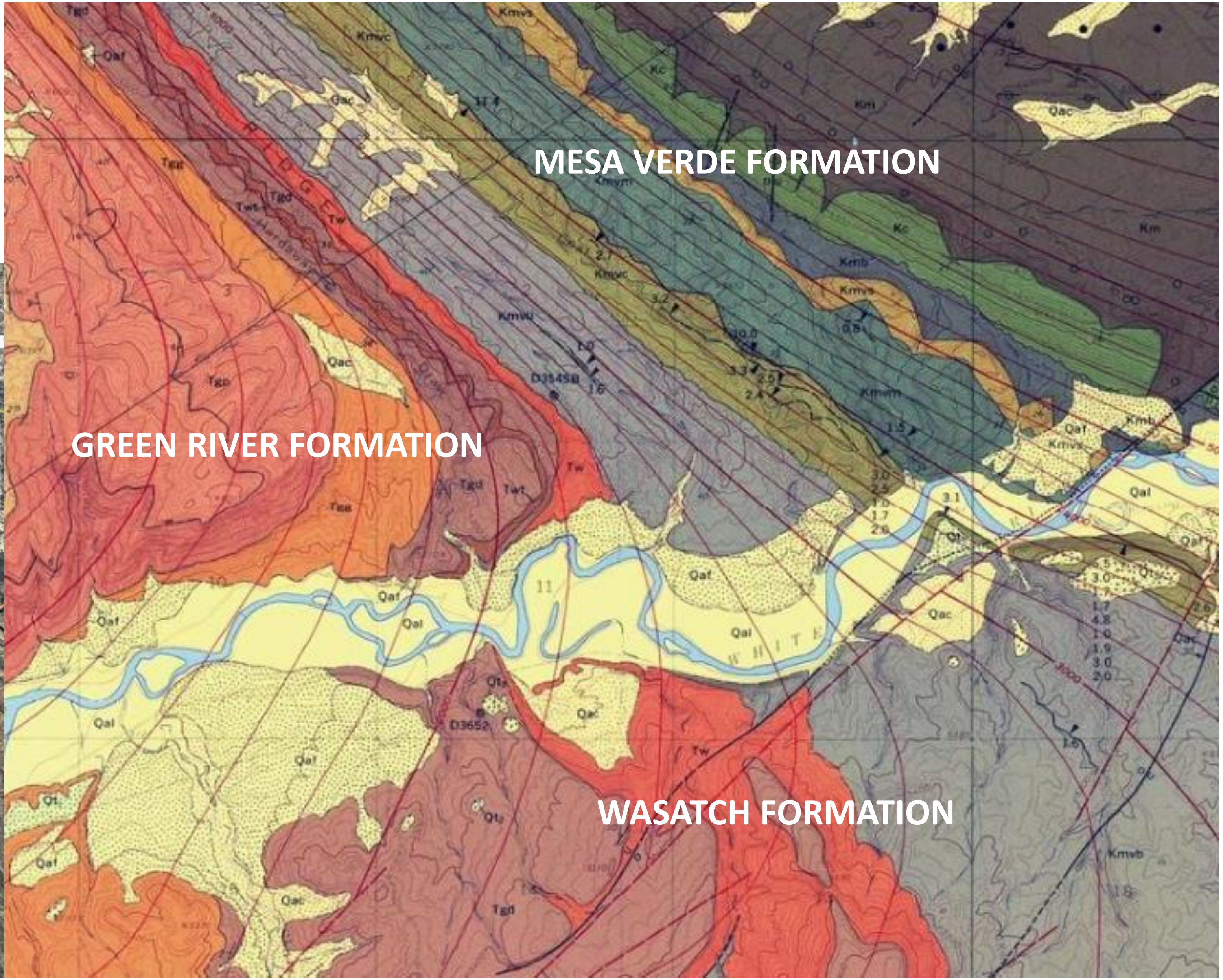


Geologic Features of Each Reach; *The Lower Reach*





Geologic Features of Each Reach; *The Lower Reach*



Geologic Features of Each Reach; *Piceance Creek*

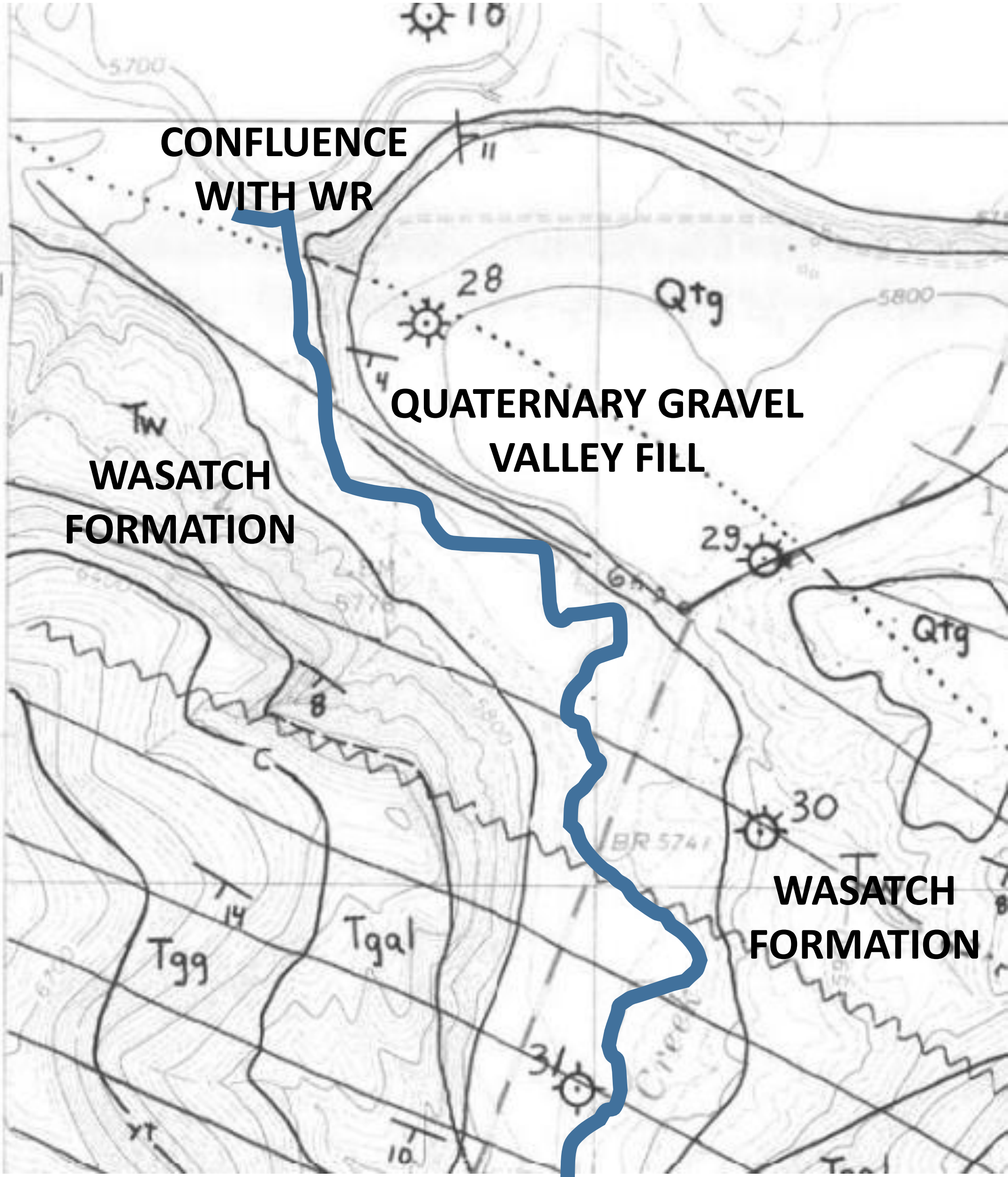
- The upper most reaches of Piceance creek drain hillslopes with older Jurassic and Cretaceous deposits

- The middle to upper middle reaches drain hillslopes with relatively young Tertiary deposits (e.g. Green River and Uinta Formations) as Piceance cuts through the edge of the White River uplift

- Toward the lower reaches, it cuts through older Tertiary deposits (e.g. Wasatch Formation)

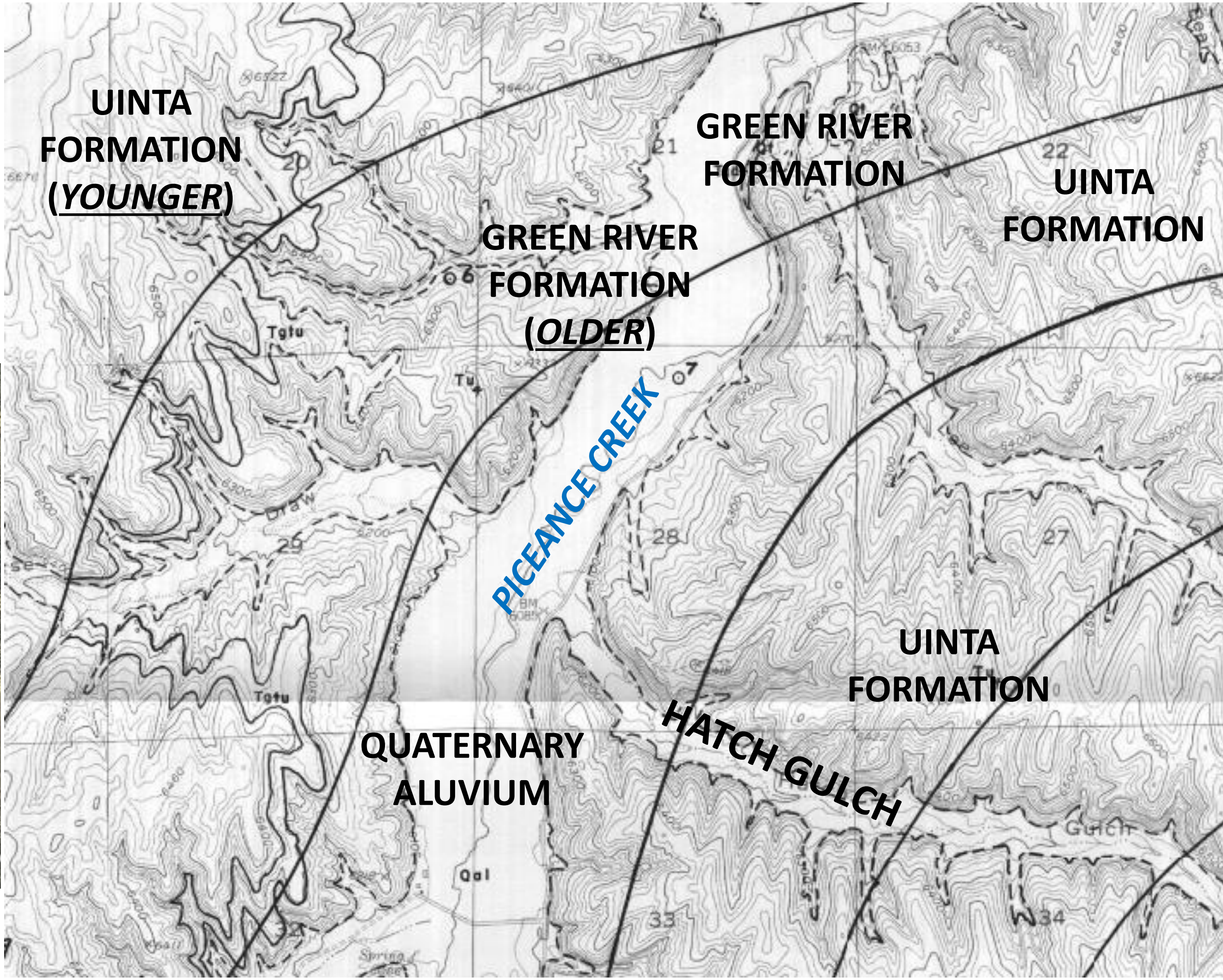
Geologic Features of Each Reach; *Piceance Creek*

LOWER PICEANCE CREEK



Geologic Features of Each Reach; ***Piceance Creek***

MIDDLE PICEANCE CREEK

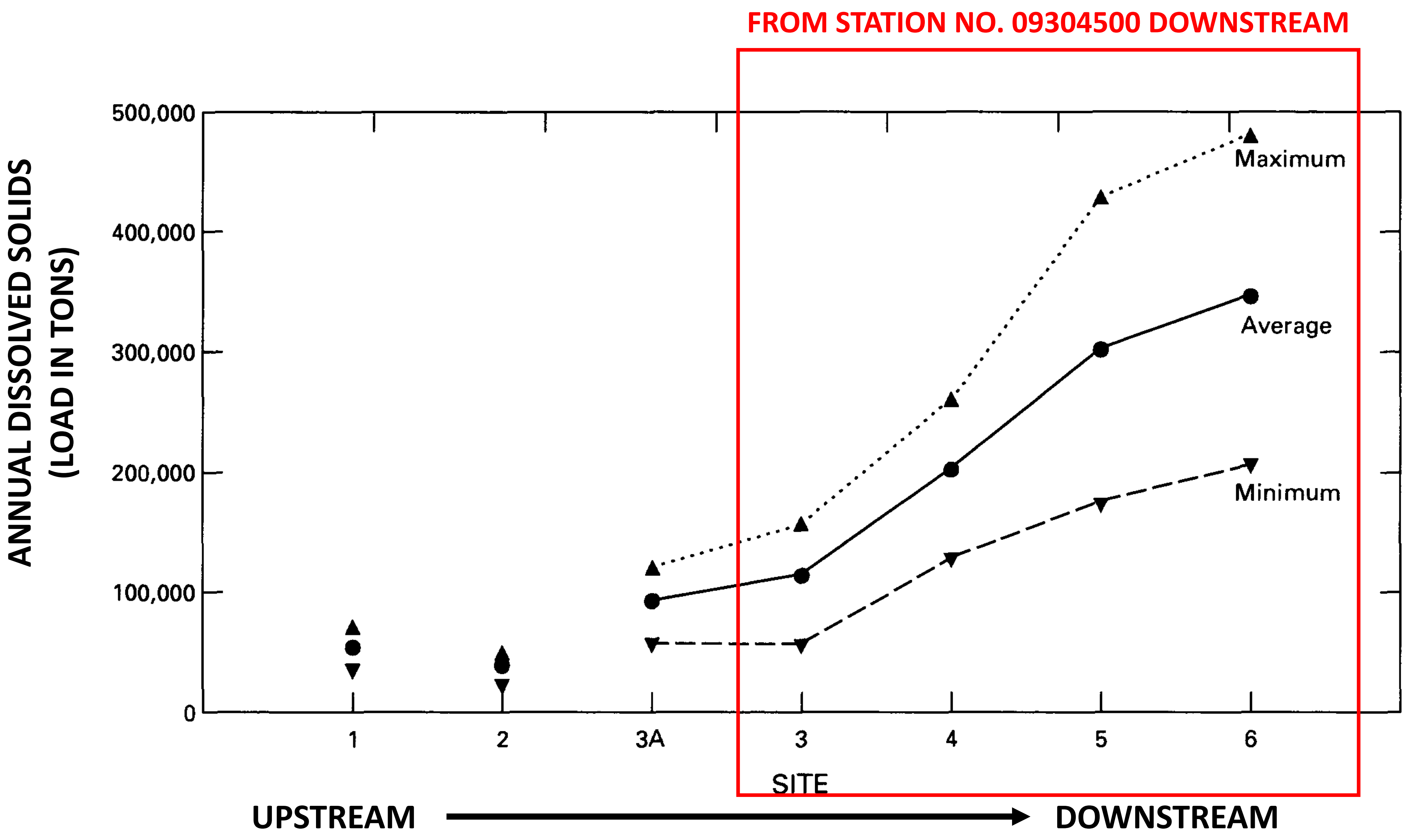


Geologic Features and Water Quality Trends for Main-Stem White River:

TOBIN (1993) SITES

Site number from figure 1	U.S. Geological Survey station number	Name
		PRIMARY SAMPLING SITES
1	09303000	North Fork White River at Buford
2	09304000	South Fork White River at Buford
3	09304200	White River above Coal Creek near Meeker
4	09304800	White River below Meeker
5	09306224	White River above Crooked Wash near White River City
6	09306290	White River below Boise Creek near Rangely
		SECONDARY DATA SITES
3A	--	White River at confluence of North Fork and South Fork
--	09304500	White River near Meeker
--	09306222	Piceance Creek at White River
--	09306255	Yellow Creek near White River
--	09306300	White River above Rangely (discontinued)

ANNUAL DISOLVED SOLID LOAD FOR MAINSTEM WHITE RIVER MODIFIED FROM: TOBIN (1993)



Rough Percentages of Forest Cover along *Main-stem White River* (Note that some stations were not used in hydrologic analysis)

- **Station No. 09304200; White River above Coal Creek = 76% forested**

- **Station No. 09304500; White River near Meeker = 72% forested**

- **Station No. 09304800; White River below Meeker = 67% forested**

- **Station No. 09306395; White River near state line (in Utah) = 73% forested**

% Forested Area Taken from https://streamstats.usgs.gov/ss/

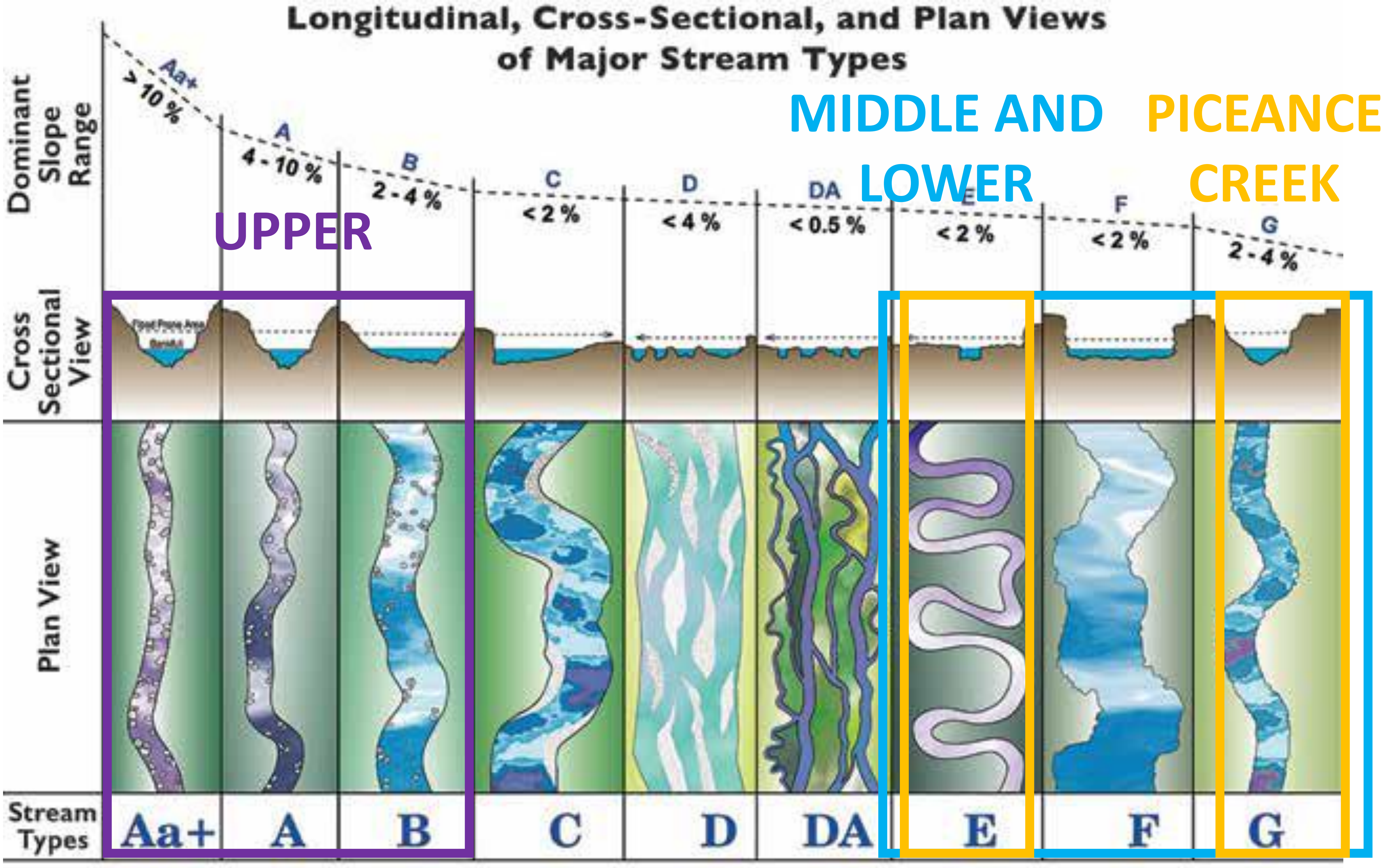
Rough Percentages of Forest Cover along *Piceance Creek*
(Note that some stations were not used in hydrologic analysis)

- Station No. 09306222 (Lower PC) = 80%
- Station No. 09306200 (Middle PC) = 80%
- Station No. 09306007 (Upper PC) = 83%

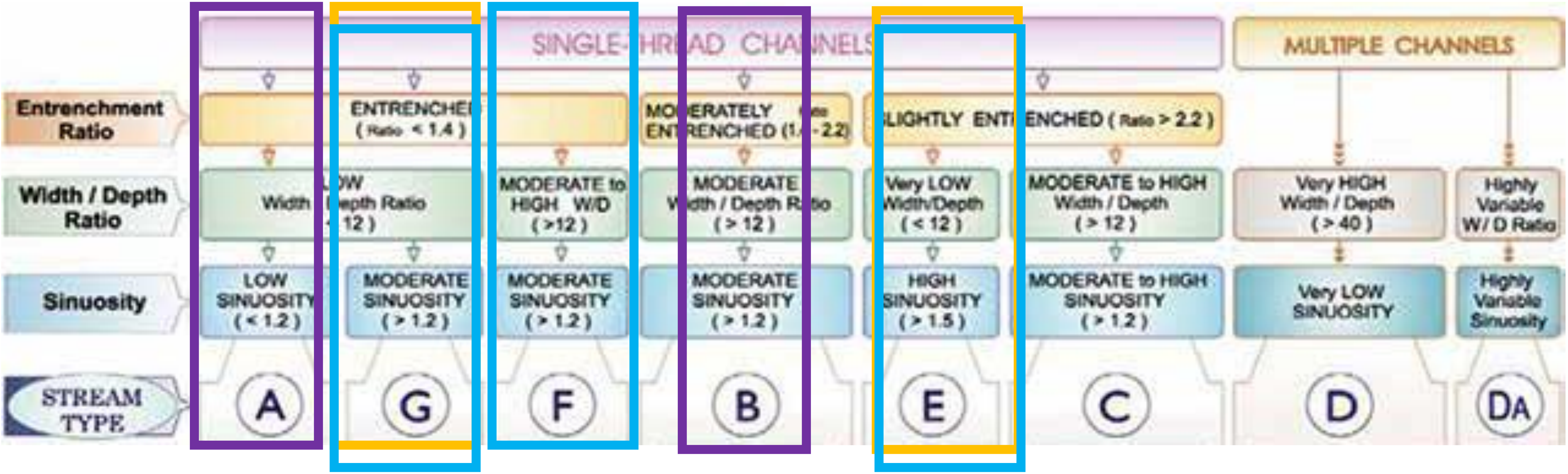
% Forested Area Taken from https://streamstats.usgs.gov/ss/

Predicted Rosgen 1994 Classification Predictions…

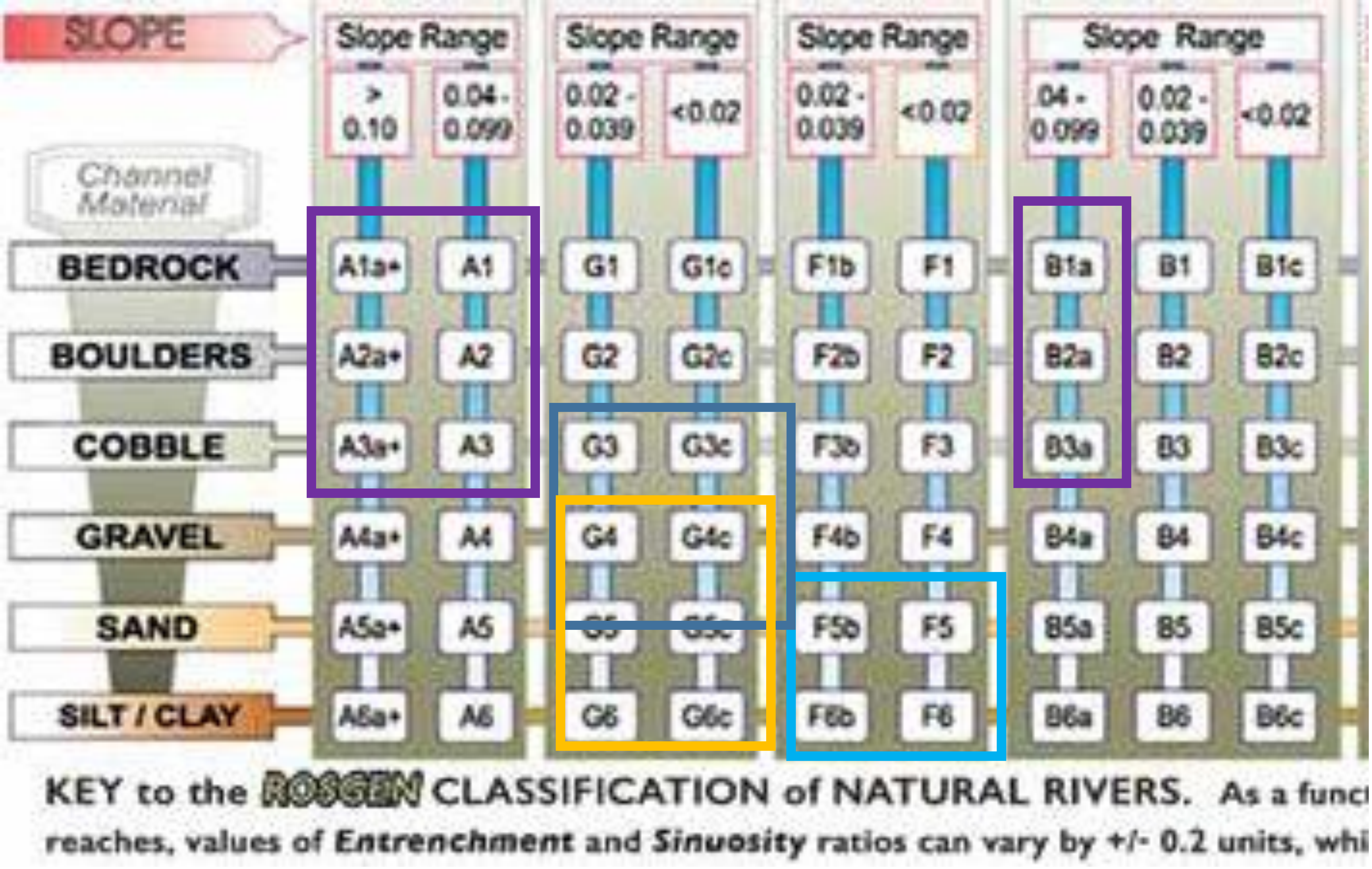
- UPPER
- MIDDLE
- LOWER
- PICEANCE



Longitudinal, Cross-Sectional, and Plan Views of Major Stream Types
Dominant Slope Range
Aa+
> 10 %
A
4 - 10 %
B
2 - 4 %
C
< 2 %
D
< 4 %
DA
< 0.5 %
E
< 2 %
F
< 2 %
G
2 - 4 %
Cross Sectional View
Plan View
Stream Types
Aa+
A
B
C
D
DA
E
F
G
UPPER
MIDDLE AND LOWER
PICEANCE CREEK



SINGLE-THREAD CHANNELS
MULTIPLE CHANNELS
Entrenchment Ratio
Width / Depth Ratio
Sinuosity
STREAM TYPE
ENTRENCHED (Ratio < 1.4)
MODERATELY ENTRENCHED
SLIGHTLY ENTRENCHED (Ratio > 2.2)
LOW Width / Depth Ratio (< 12)
MODERATE to HIGH W/D (>12)
MODERATE Width / Depth Ratio (> 12)
Very LOW Width/Depth (< 12)
MODERATE to HIGH Width / Depth (> 12)
Very HIGH Width / Depth (> 40)
Highly Variable W/ D Ratio
LOW SINUOSITY (< 1.2)
MODERATE SINUOSITY (> 1.2)
MODERATE SINUOSITY (> 1.2)
MODERATE SINUOSITY (> 1.2)
HIGH SINUOSITY (> 1.5)
MODERATE to HIGH SINUOSITY (> 1.2)
Very LOW SINUOSITY
Highly Variable Sinuosity
A
G
F
B
E
C
D
DA



UPPER

MIDDLE

LOWER

PICEANCE

References…

- Dickard, M., M. Gonzalez, W. Elmore, S. Leonard, D. Smith, S. Smith, J. Staats, P. Summers, D. Weixelman, S. Wyman. 2015. Riparian area management: Proper functioning condition assessment for lotic areas. Technical Reference 1737-15. U.S. Department of the Interior, Bureau of Land Management, National Operations Center, Denver, CO.

- Rosgen, D.L. 1994. A classification of natural rivers. Catena (22) 169 – 199.

- https://ngmdb.usgs.gov/mapview/?center=-107.845,40.039&zoom=14

- https://maps.waterdata.usgs.gov/mapper/index.html

- https://waterdata.usgs.gov/co/nwis/sw