Hydrology Homework

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9/25/2021

The following data was used to calculate flow at the three cross sections. No time values were provided for the Deer Creek pygmy meter measurements, so it was assumed that all counts were taken over 40 seconds.

Site	Position	Distance (m)	Depth (ft)	Revolutions	Time (s)
Deer Creek Left	1	0.3	0.20	52	40
Deer Creek Left	2	0.6	0.15	27	40
Deer Creek Left	3	1.4	0.15	13	40
Deer Creek Right	1	0.2	0.70	31	40
Deer Creek Right	2	0.6	0.40	27	40
Deer Creek Right	3	0.8	0.50	36	40
Deer Creek Right	4	1.2	0.40	29	40
Deer Creek Right	5	1.5	0.30	16	40
Snake River	1	0.6	0.60	23	40
Snake River	2	1.1	0.30	106	55
Snake River	3	2.0	0.20	42	40
Snake River	4	2.6	0.15	18	40
Confluence	1	0.6	0.15	44	40
Confluence	2	1.0	0.35	35	40
Confluence	3	1.3	0.40	47	40
Confluence	4	1.9	0.50	75	40
Confluence	5	2.8	0.60	25	40
Confluence	6	5.1	0.50	17	40
Confluence	7	6.0	0.60	50	40

Calculating discharge:

$$Q_n = V_n * w_n * d_n$$

where

$$w_n = \frac{l_n - l_{n-1}}{2} + \frac{l_{n+1} - l_n}{2}$$

and

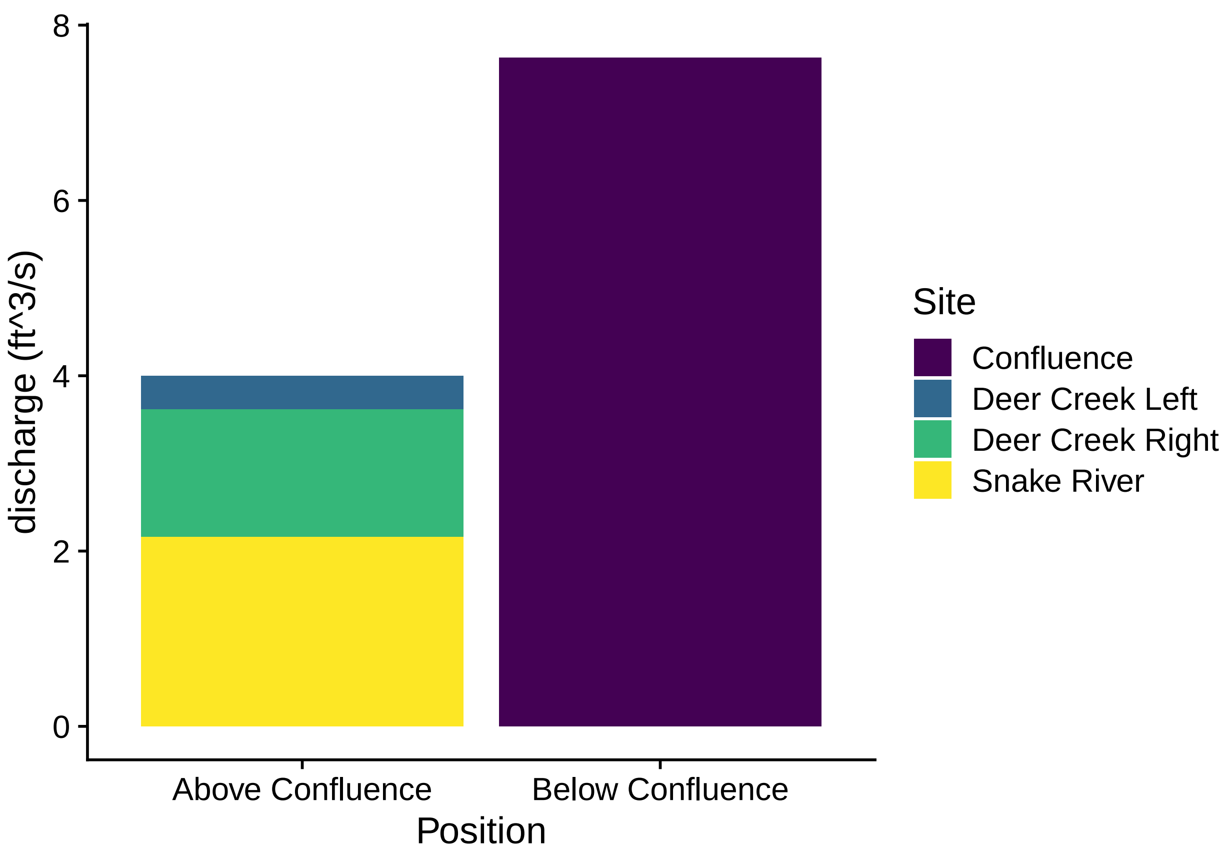
$$V_n = 0.9604 * \frac{rev}{sec} + 0.0312$$

```
flow_data <- flow_data %>%
  group_by(Site) %>%
  mutate(Position = as.integer(Position)) %>%
  mutate(final_position = max(Position)) %>%
  mutate(`width (m)` = case_when(`Position` == final_position ~
                                   (`Distance (m)` - lag(`Distance (m)`))/2,
                                 `Position` == 1 ~
                                   (lead(`Distance (m)` ) - `Distance (m)`)/2,
```

```
                                 TRUE ~
                                   (`Distance (m)` - lag(`Distance (m)`))/2 +
                                   (lead(`Distance (m)` ) - `Distance (m)`)/2)) %>%
  mutate(`Velocity (ft/s)` = 0.9604*(Revolutions / `Time (s)`) + 0.0312) %>%
  mutate(`width (ft)` = `width (m)` * 3.281) %>%
  mutate(`discharge (ft^3/s)` = `Velocity (ft/s)`*`width (ft)`*`Depth (ft)`) %>%
  summarise(`discharge (ft^3/s)` = sum(`discharge (ft^3/s)`)) %>%
  mutate(`discharge (ft^3/s)` = round(`discharge (ft^3/s)`, 2))
```

Site	discharge (ft^3/s)
Confluence	7.63
Deer Creek Left	0.38
Deer Creek Right	1.46
Snake River	2.16

1. According to these calculations, total discharge above the confluence was $4.00 ft^3/s$, a full $3.63 ft^3/s$ lower than the value measured downstream of the confluence. One reason for this discrepancy could be inaccuracies in measurement—the USGS recommends 25-30 measurements while 3-7 were used here. Snake River may also be a gaining stream, although the contribution from groundwater would likely be minimal over the distances between the sampling sites.



2. The measurements taken on the USGS stream gauge range from $28.5 ft^3/s$ to $30.4 ft^3/s$.

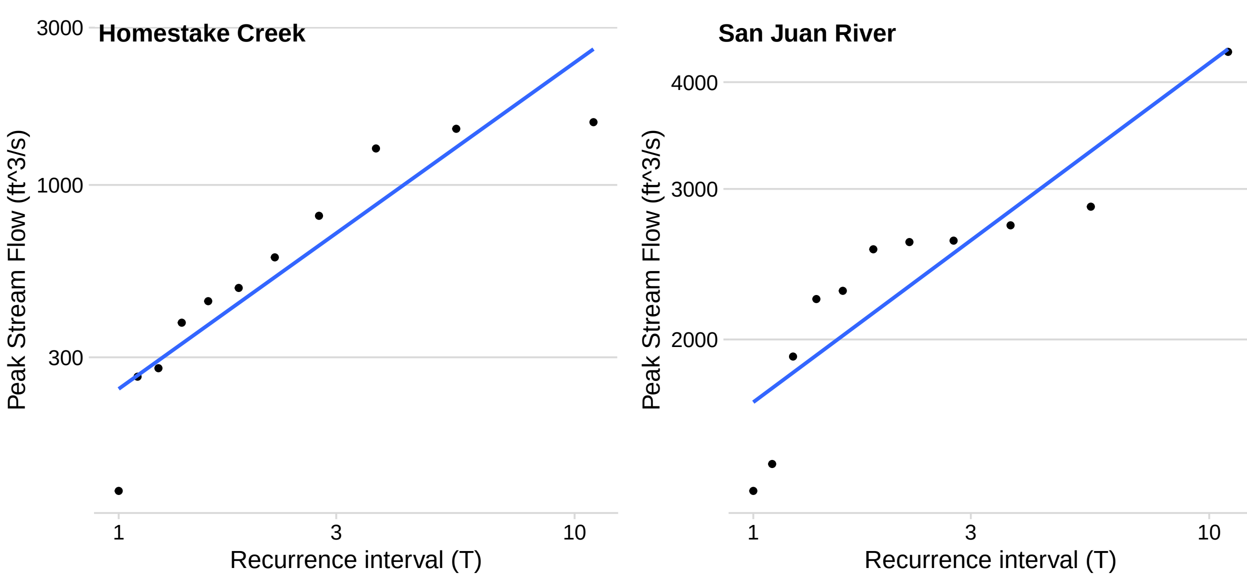
3. Recurrence interval (T) is calculated using equation 2.6 from Allan and Castillo (2007):

$$T = \frac{n+1}{m}$$

This calculation is performed for Homestake Creek at Gold Park, CO (USGS 09064000) and the San Juan River at Pagosa Springs, CO (USGS 09342500) for the years 2010-2020.

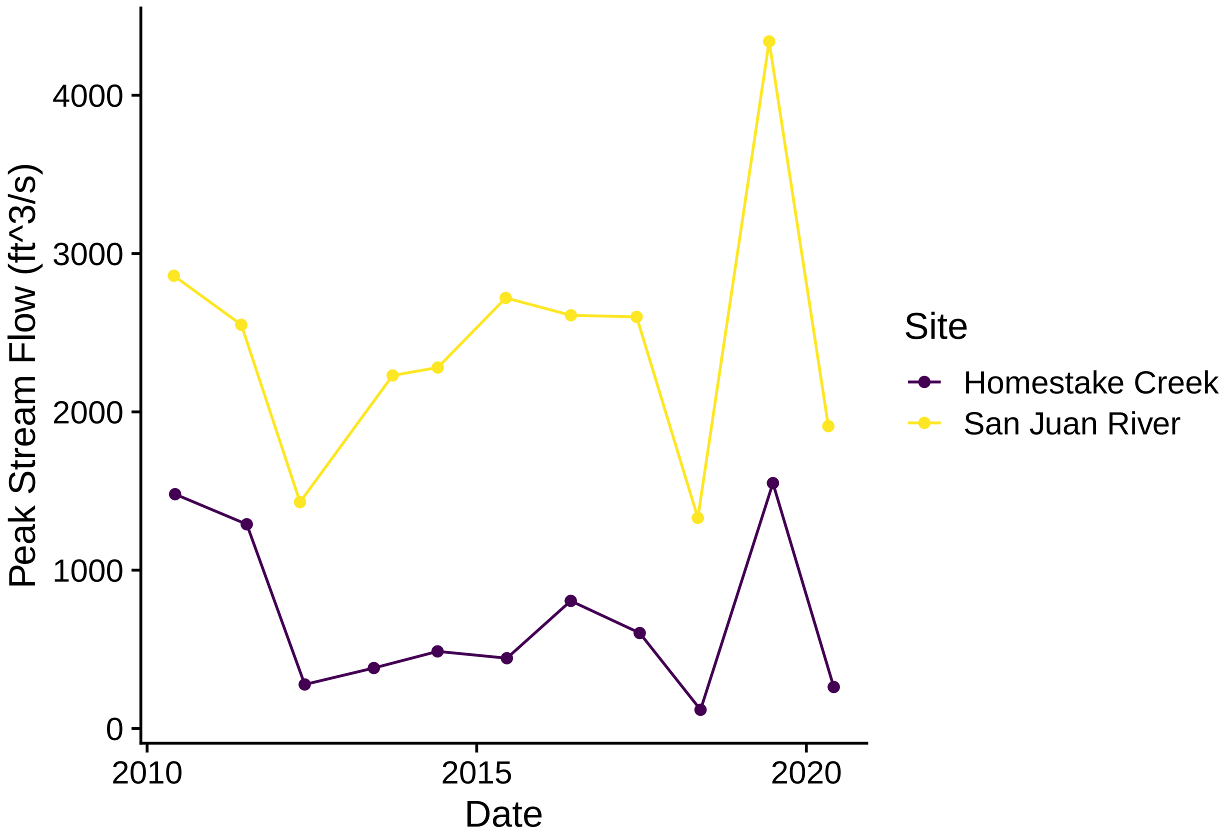
```
homestake_creek <- read_csv("peak_homestake_creek.csv", show_col_types = FALSE) %>%
  mutate(Site = "Homestake Creek")

peak_stream_flow <- read_csv("peak_san_juan_river.csv", show_col_types = FALSE) %>%
  mutate(Site = "San Juan River") %>%
  rbind(homestake_creek) %>%
  mutate(Date = as_date(peak_dt),
         `Peak Stream Flow (ft^3/s)` = peak_va) %>%
  mutate(Year = year(Date)) %>%
  filter(Year >= 2010) %>%
  group_by(Site) %>%
  mutate(`Rank Magnitude (m)` = rank(-`Peak Stream Flow (ft^3/s)`)) %>%
  mutate(`Recurrence interval (T)` = 11/`Rank Magnitude (m)`)
```

```
homestake_recurrence <- ggplot(data = peak_stream_flow[peak_stream_flow$Site ==
  "Homestake Creek", ], aes(x = `Recurrence interval (T)`,
  y = `Peak Stream Flow (ft^3/s)`)) + geom_point() + geom_smooth(method = "lm",
  se = FALSE, formula = "y ~ x") + theme_minimal_hgrid() +
  scale_x_continuous(trans = "log10") + scale_y_continuous(trans = "log10")

san_juan_recurrence <- ggplot(data = peak_stream_flow[peak_stream_flow$Site ==
  "San Juan River", ], aes(x = `Recurrence interval (T)`,
  y = `Peak Stream Flow (ft^3/s)`)) + geom_point() + geom_smooth(method = "lm",
  se = FALSE, formula = "y ~ x") + theme_minimal_hgrid() +
  scale_x_continuous(trans = "log10") + scale_y_continuous(trans = "log10")

plot_grid(homestake_recurrence, san_juan_recurrence, labels = c("Homestake Creek",
    "San Juan River"))
```

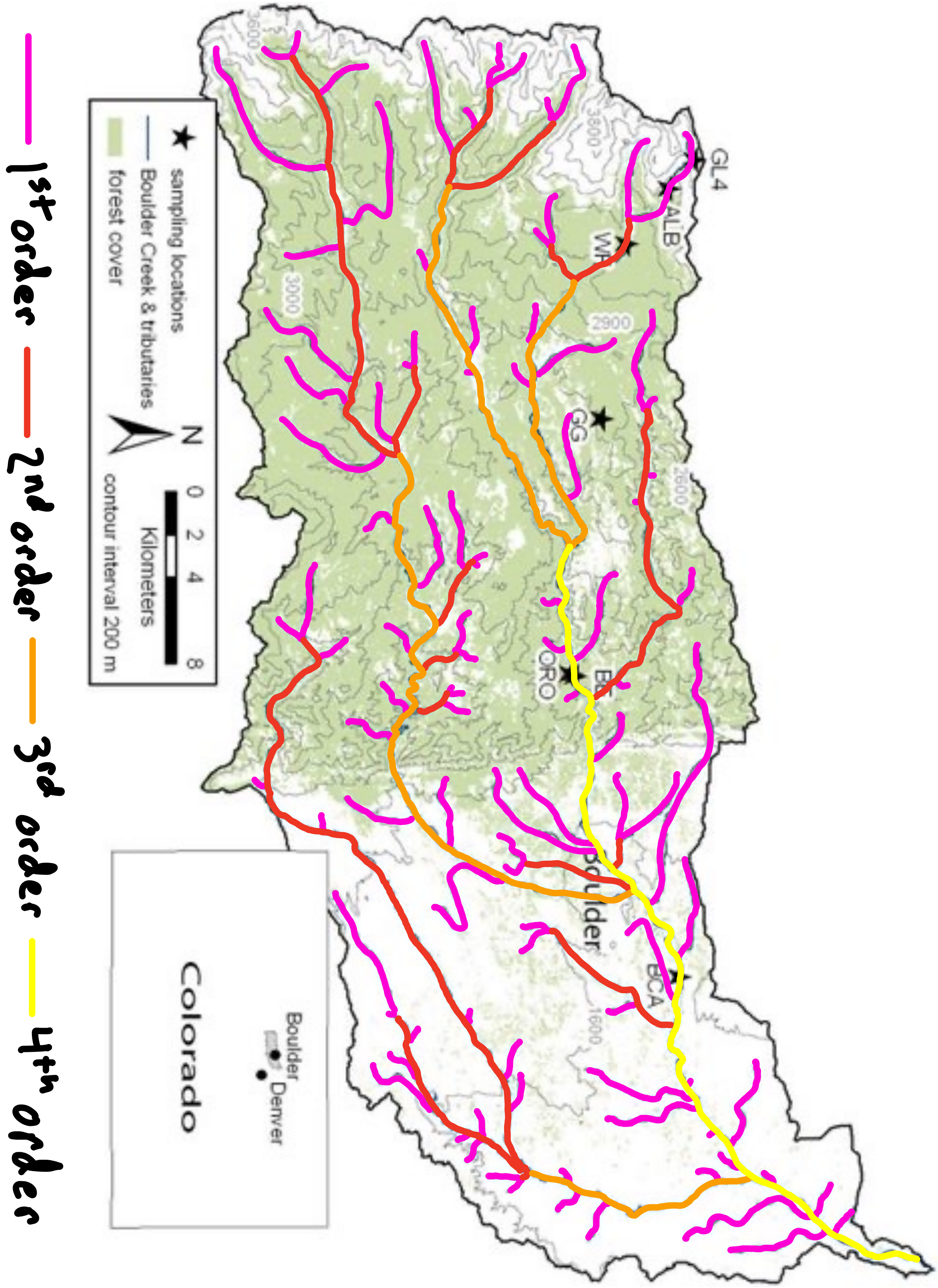


One watershed is not clearly more flashy than another on the recurrence interval graph. The San Juan River has much higher average discharge than Homestake Creek, but the slopes on each graph is relatively similar. On a graph of discharge over time, it seems that there is slightly more variability on the San Juan River.

```
ggplot(data = peak_stream_flow, aes(x = Date,
  y = `Peak Stream Flow (ft^3/s)`, color = Site)) + geom_point() + geom_line() +
  scale_color_viridis_d() + theme_cowplot()
```




```
knitr::include_graphics("Boulder_Creek_Annotated.pdf")
```



1st order
2nd order
3rd order
4th order
sampling locations
Boulder Creek & tributaries
forest cover
N
Kilometers
0 2 4 8
contour interval 200 m
GL4
ALB
WR
GG
BC
ORO
Boulder
BCA
3600
3800
3000
2900
2600
1600
Colorado
Boulder
Denver