Thursday 4 August 2022 Review Cub R Exercise
Today’s exercise: estimate sediment transport from data, calculate effective discharge

Study Motivation: can we detect the impact of flow diversion on a stream channel?
What is the critical discharge? 
??Calculate from Shields Curve??
??Discharge producing reference stress??
??Tracers??
What if I asked you to estimate critical discharge on Cub R Site 1?
You could calculate it, with at least factor of two uncertainty

Site 1

Qc: 90% within factor of 2
Σ qs: 90% within factor of 10
Then I tap you on the shoulder and mention that some sediment transport measurements have been made.

You observe that measurable transport occurs at $Q$ as low as $7 \text{ m}^3/\text{s}$ and that a trend through the data hits the reference transport rate ($W^* = 0.002$ “a surrogate for incipient motion”) at $Q = 11 \text{ m}^3/\text{s}$.

$Q$ at onset of measurable transport $\sim 7 \text{ m}^3/\text{s} = 250 \text{ cfs}$

$Q$ at reference transport rate $= 11.1 \text{ m}^3/\text{s} = 392 \text{ cfs}$
Given $\tau_r$, what is the associated discharge $Q_r$?

$$\tau' = 17 \left( SD_{65} \right)^{1/4} U^{3/2}$$
$$U = k Q^m$$

$$\tau' = 17 \left( SD_{65} \right)^{1/4} \left( k Q^m \right)^{3/2}$$

$$Q = \left[ \frac{1}{k} \left( \frac{\tau'}{17 \left( SD_{65} \right)^{1/4}} \right)^{2/3} \right]^{1/m}$$

- For Cub River:
- Slope $S = 0.02$
- $D_{65} = 90 \text{ mm}$
- Mean velocity $U = 0.46 Q^{0.42}$
Finally, I reveal to you that pointed rocks had been placed in the bed over the 2007 snowmelt runoff, with peak $Q = 12.7$ m$^3$/s.

This is a “real” answer, if limited to a single peak flow. If one wanted to know the flow at which half the bed surface is mobilized, 12.7 m$^3$/s is close (presuming the coarser sizes are largely immobile). If one wanted to know the flow at which the bed is 90% mobilized, it would be larger.

At $Q = 12.7$ cms (449 cfs) peak flow, median sizes on bed surface are partially mobile.
Bankfull = 17 cms (600 cfs)

At $Q = 12.7$ cms (449 cfs) peak flow, median sizes on bed surface are partially mobile.

$Q$ at onset of measurable transport $\sim 7 \text{ m}^3/\text{s} = 250$ cfs
$Q$ at reference transport rate $= 11.1 \text{ m}^3/\text{s} = 392$ cfs

Note how the recurrence interval for a flood greater than or equal to a particular flow (e.g. 12.7 m$^3$/s) decreases if the peak flow each year were reduced by 70 cfs or 160 cfs.

Note too (below), how a reduction in peak flow makes the stream more vulnerable to ‘streaks’ of multiple years with flow below a specified value.
Site 1

Effective Discharge 17-18 cms
Main findings from Grams et al. report:

Diversions cause a substantial fraction of supplied sediment to deposit in the reach.

However, the sediment supply in this system is quite small, so it would take many years for this deposition to produce clearly measurable channel change.

Biggest changes in reach are related to vegetation establishment in the former wider, more open channel.