# River morphodynamics

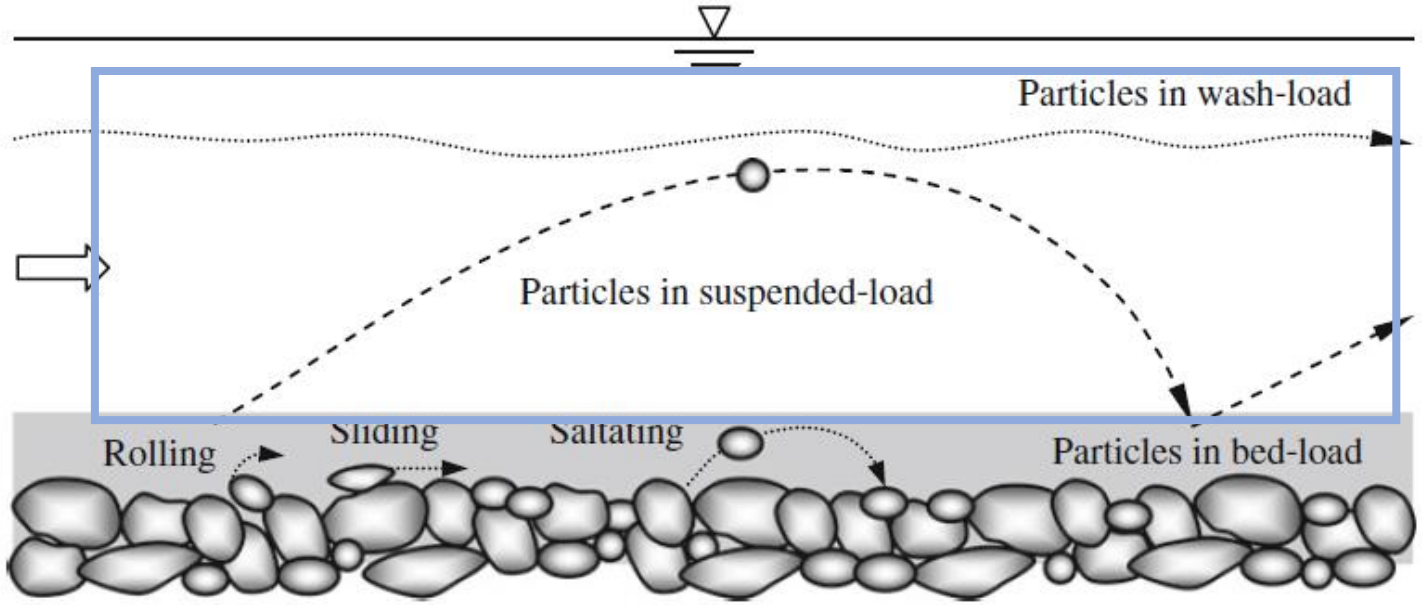
Part 3.2: Suspended load

Institute of Geophysics
Polish Academy of Sciences

Michael Nones
mnones@igf.edu.pl

# Introduction

**Suspended load** is constituted by fine particles transported within the flow. The particle is lifted up to a height of the order of the water depth, and before returning to the bed it flows along a trajectory, the length of which can be compared to the water depth (and is often many times higher).




Suspended load (Dey, 2018)

# Sediment rating curve

To compute the (long-term) suspended load, frequently a suspended sediment rating curve is adopted.

suspended sediment transport [$m^3/s$]

water discharge [$m^3/s$]

$$Q_{s,s} \propto Q^m$$

The suspended sediment rating curve is based on an *empirical correlation* between sediment concentration (transport) and water discharge.

Examples of sediment rating curves from Hickin (2001)

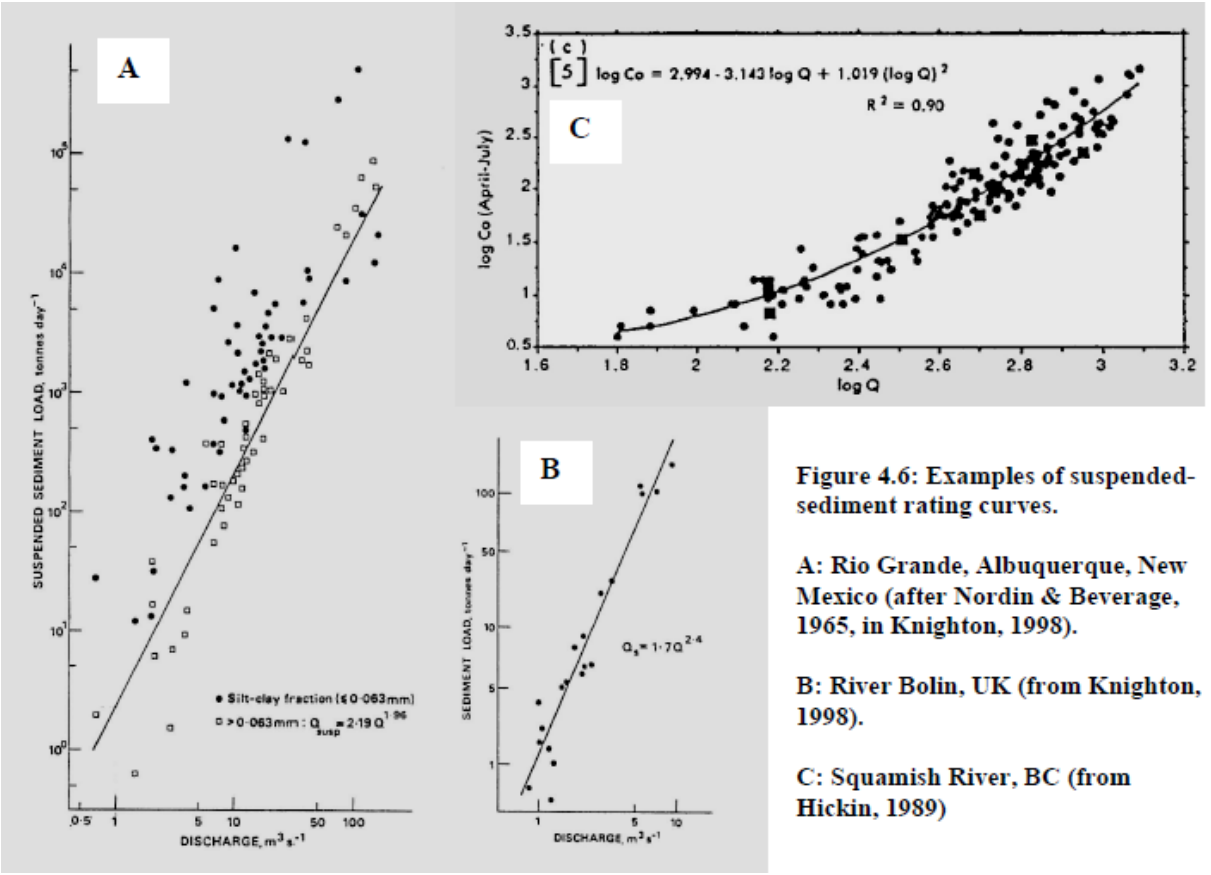



**Figure 4.6: Examples of suspended-sediment rating curves.**

**A: Rio Grande, Albuquerque, New Mexico (after Nordin & Beverage, 1965, in Knighton, 1998).**

**B: River Bolin, UK (from Knighton, 1998).**

**C: Squamish River, BC (from Hickin, 1989)**

# Sediment rating curve

**Hypotheses**

- direct correlation between concentration and discharge (not physically-based)
- real forces involved: shear stress (or stream power) function of the flow turbulence
- capacity-limited suspended sediment concentration/load

The curve fails to represent the suspended load if:

- there are complex relationships between sediment and water discharges (e.g., discontinuities in fluid mechanics due to bedforms, sudden changes in the flow structures due to channel constrictions, rapids, etc.
- most rivers are sediment-supply limited, and we are not able to quantitatively predict the amount and timing of sediment delivery from tributaries, hillslopes and channel banks.

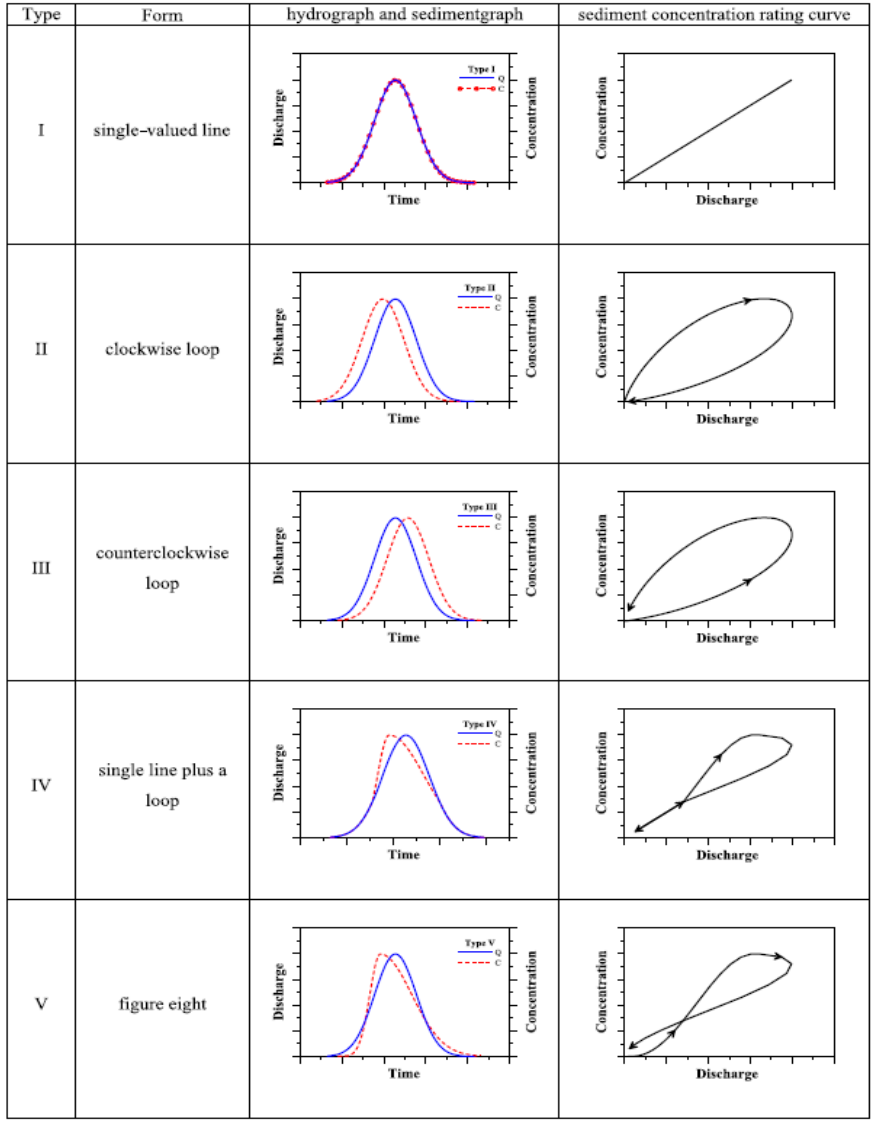
# Sediment load: hysteresis

External sediment-supply variations control the amount of suspended sediment being transported in a river.

Hysteresis refers to the fact that each single event's rating-curve (rating curve based on a single discharge event like a storm or a single seasonal cycle), instead of being a single-valued function, is better described as a loop.

→ the suspended sediment concentration on the rising discharge is different from the loads at the corresponding discharges in the falling limb.

Depending on the river, hysteresis can have many causes generally related to the season (variable accumulation of sediment, snow melt, rainfall, etc.).




adapted from Yang and Lee, IJSR 2018

# Total load formulas

**Ackers & White formula** (1973)

- total transport formula
- developed for flume data having relatively uniform gradations ranging from sand to fine gravel
- fitting of data covering bed configurations like ripples, dunes and plane bed conditions
- no consideration of grain shear partition

**Engelund-Hansen formula** (1967)

- total transport formula
- developed for flume data having relatively uniform sand sediments (0.19-0.93 mm)
- simplest transport equation
- explicit function of channel velocity, bed shear and $d_{50}$
- its application is restricted to sand-dominated systems