Culvert Design Process

Hydrology

↓

Site Assessment

↓

Alignment and Profile

↓

Bed and Banks

↓

Structure

↓

Sediment Mobility & Stability

Some low gradient bed and bank design options

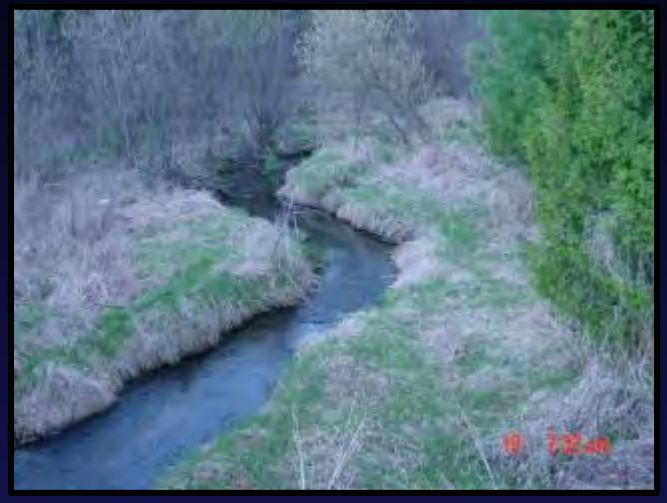
- BFW, tailwater control, no structure
- A few structural elements
- Rock bars for thalweg development
- Rock banks and bars

Can structures be too wide?

- Maybe - in sand bed streams with low flows
- Without structure to create banks or a thalweg
- Sand spreads out to create a flat, uniform bed
- Shallow water may impede passage of some sp.

Example of an open-bottom arch from Michigan.

Can structures be too wide?



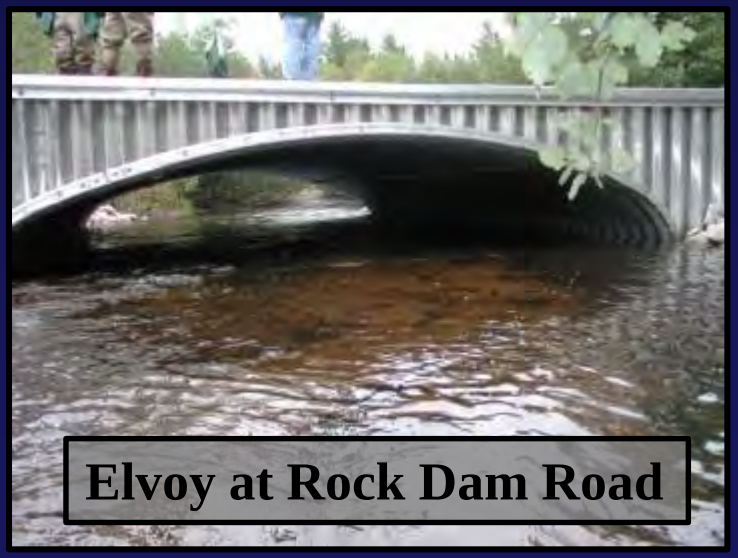
Example of bridge on Spring Cr near Durango in SW WI.

BFW, tailwater control, no structure

Drainage Area = 10.6 sq mi
BFW Est (E Reg) = 16.5'
Min BFW Graph = 12'

Simpson at FR 2386

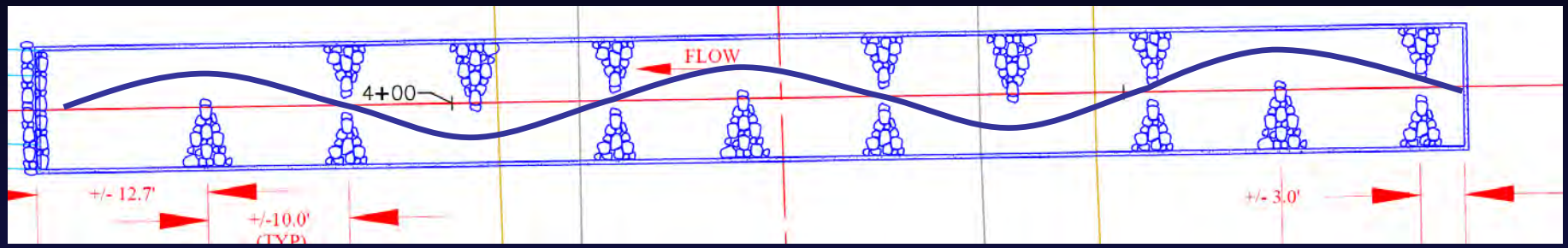
Brule at FR 2193



Elvoy at Rock Dam Road

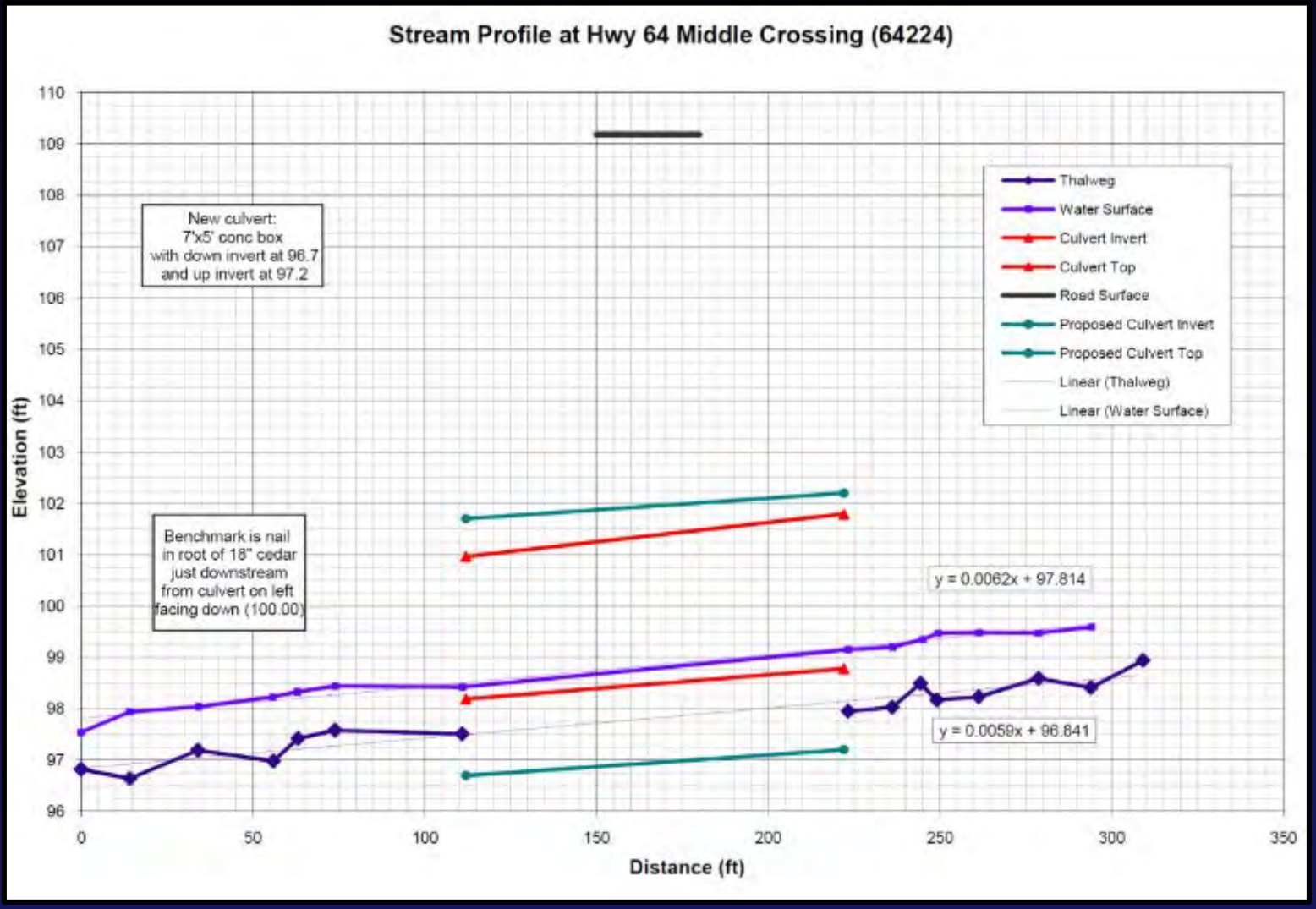
Rock bars for thalweg development

NB Oconto Middle Trib at Hwy 64



Rock bars for thalweg development

NB Oconto Middle Trib at Hwy 64



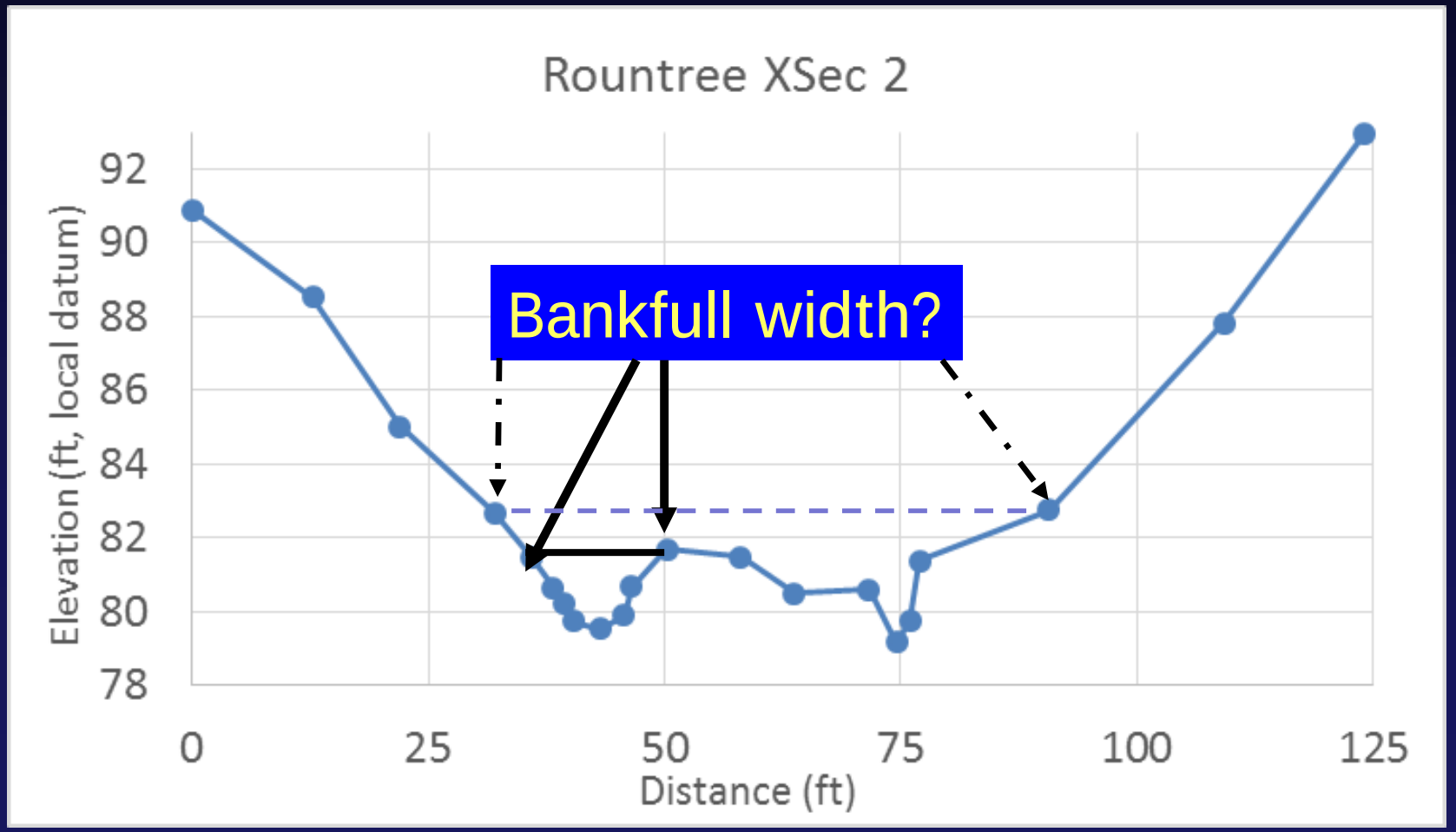
Rock banks and bars

Torpee Cr at Hwy 32

Bed design objectives

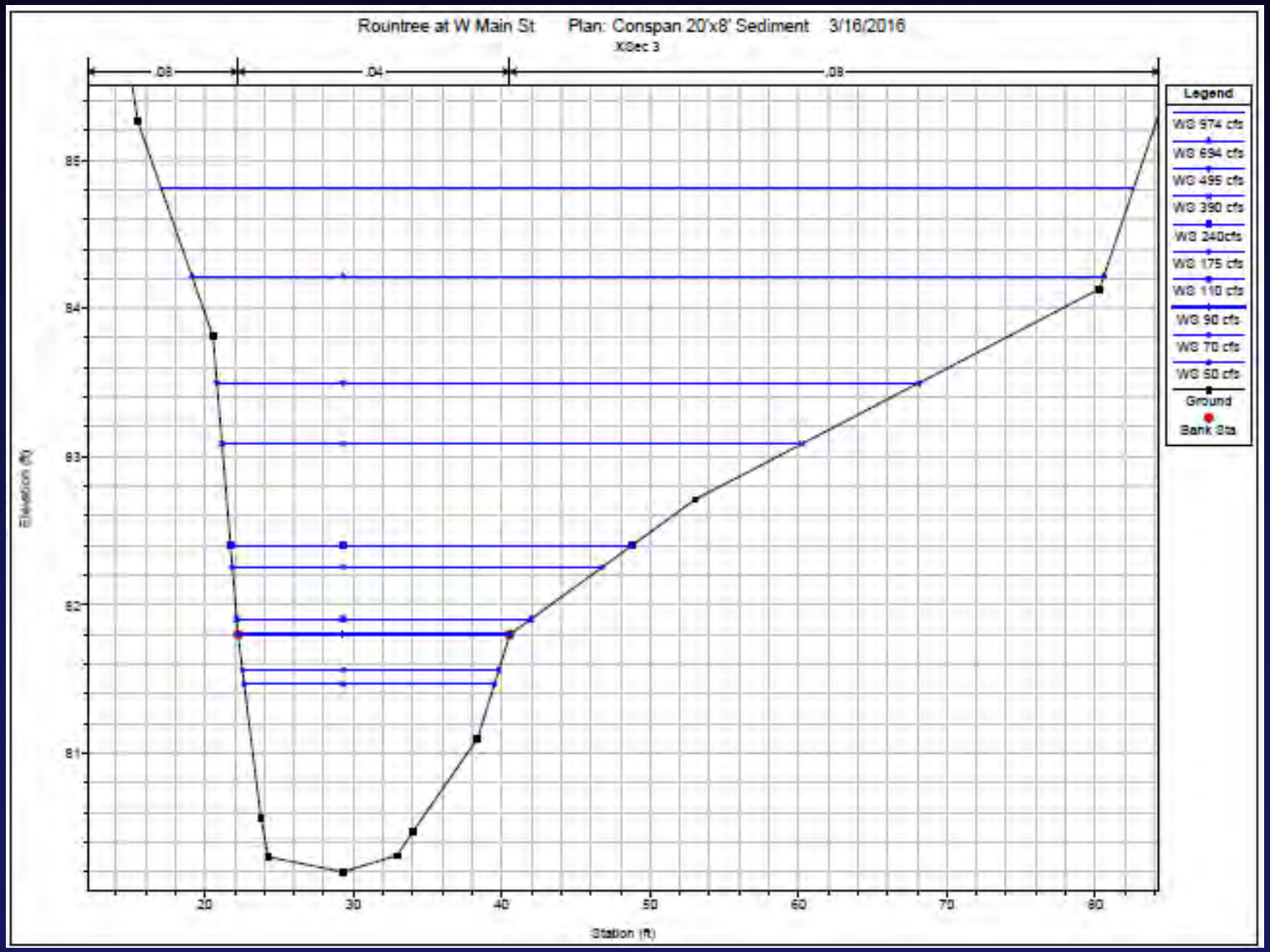
- Simulate natural bed
  - shape
  - diversity
  - roughness
  - mobility
  - permeability

Bed shape

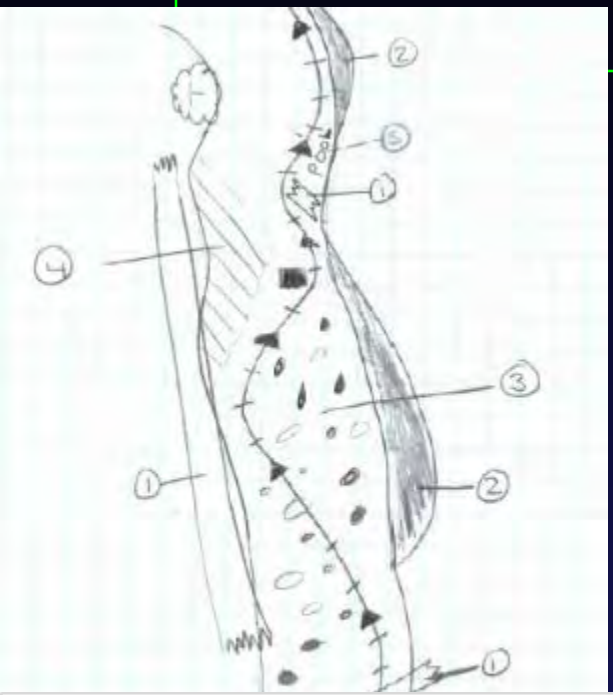

Rountree XSec 2
Elevation (ft, local datum)
92
90
88
86
84
82
80
78
0
25
50
75
100
125
Distance (ft)
Bankfull width?

Bankfull?

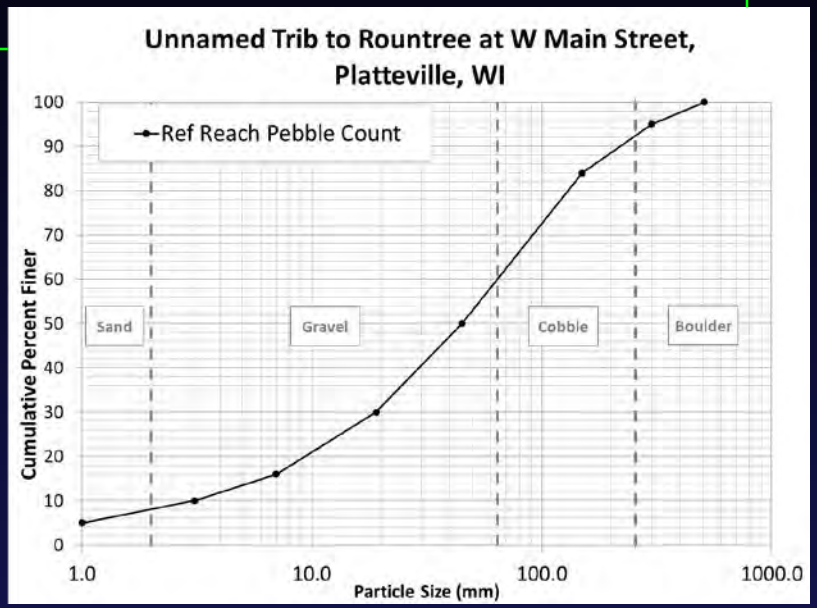
HEC-RAS output

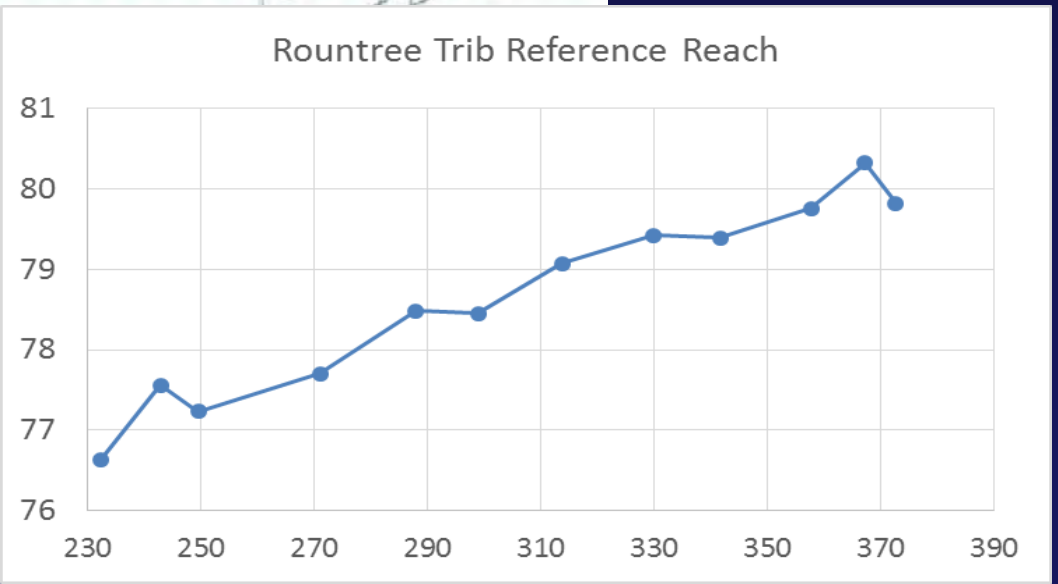


Diversity and roughness



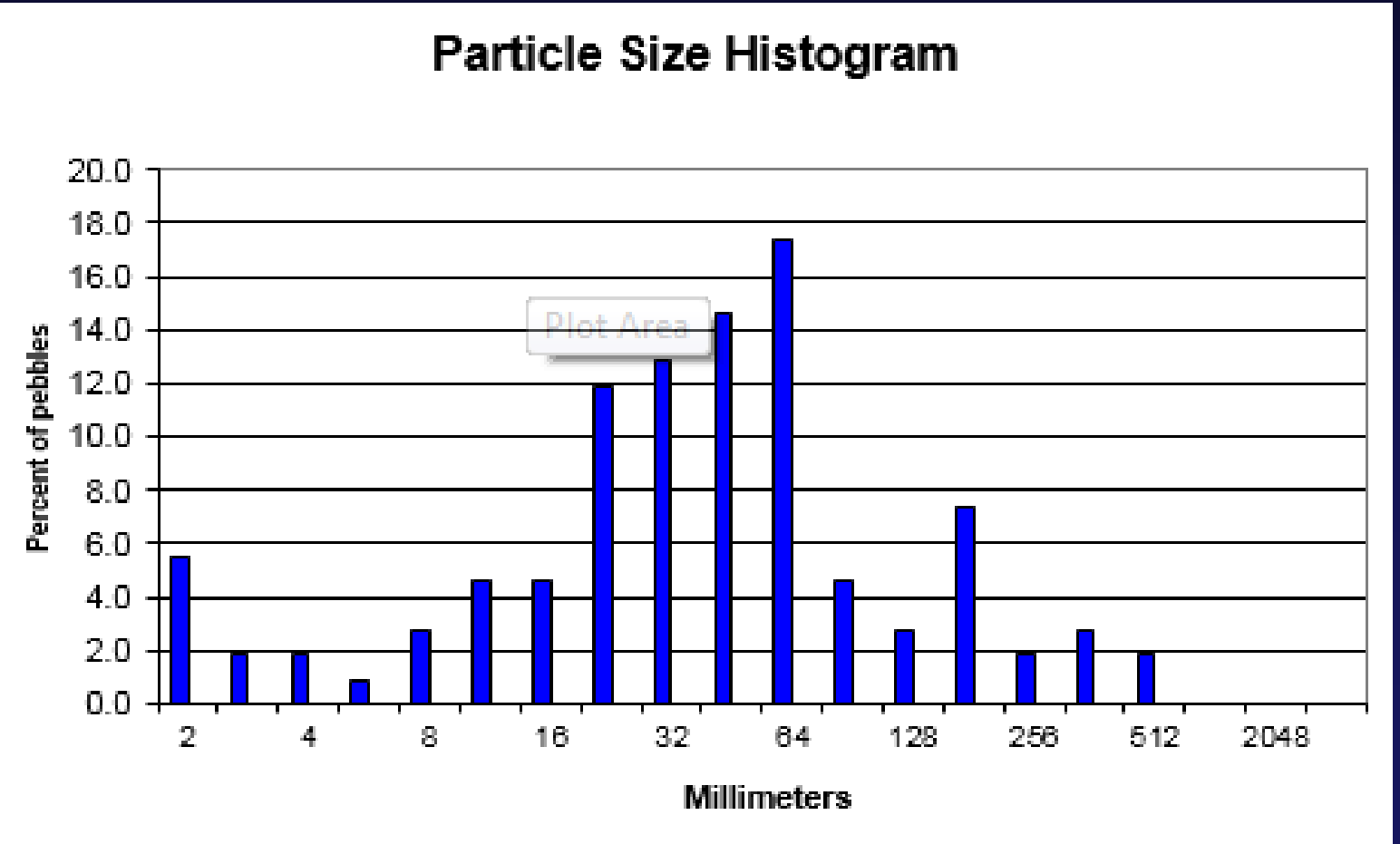
From site sketch, photos, profile, pebble count & key pieces



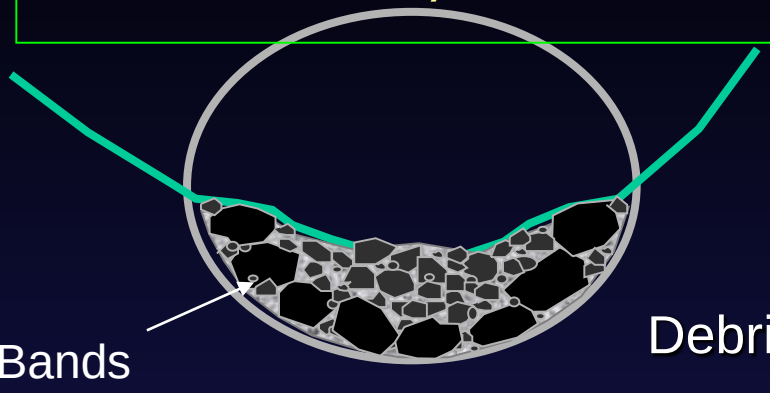


Mobility and permeability

- Depends upon well-graded bed materials (pebble count)



Banks, bands


Bands
Debris

Bank

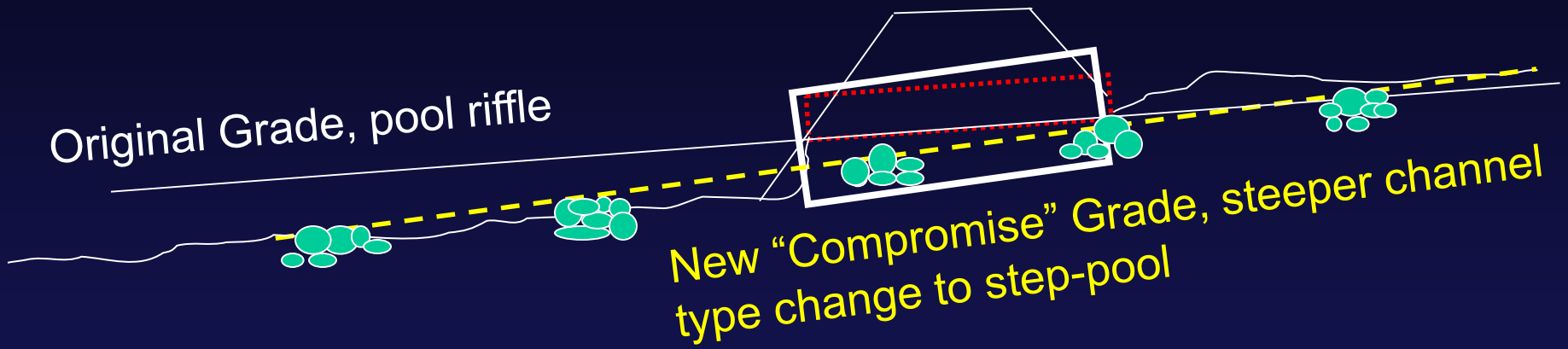
Design channel shape

Reference channel shape

Key pieces

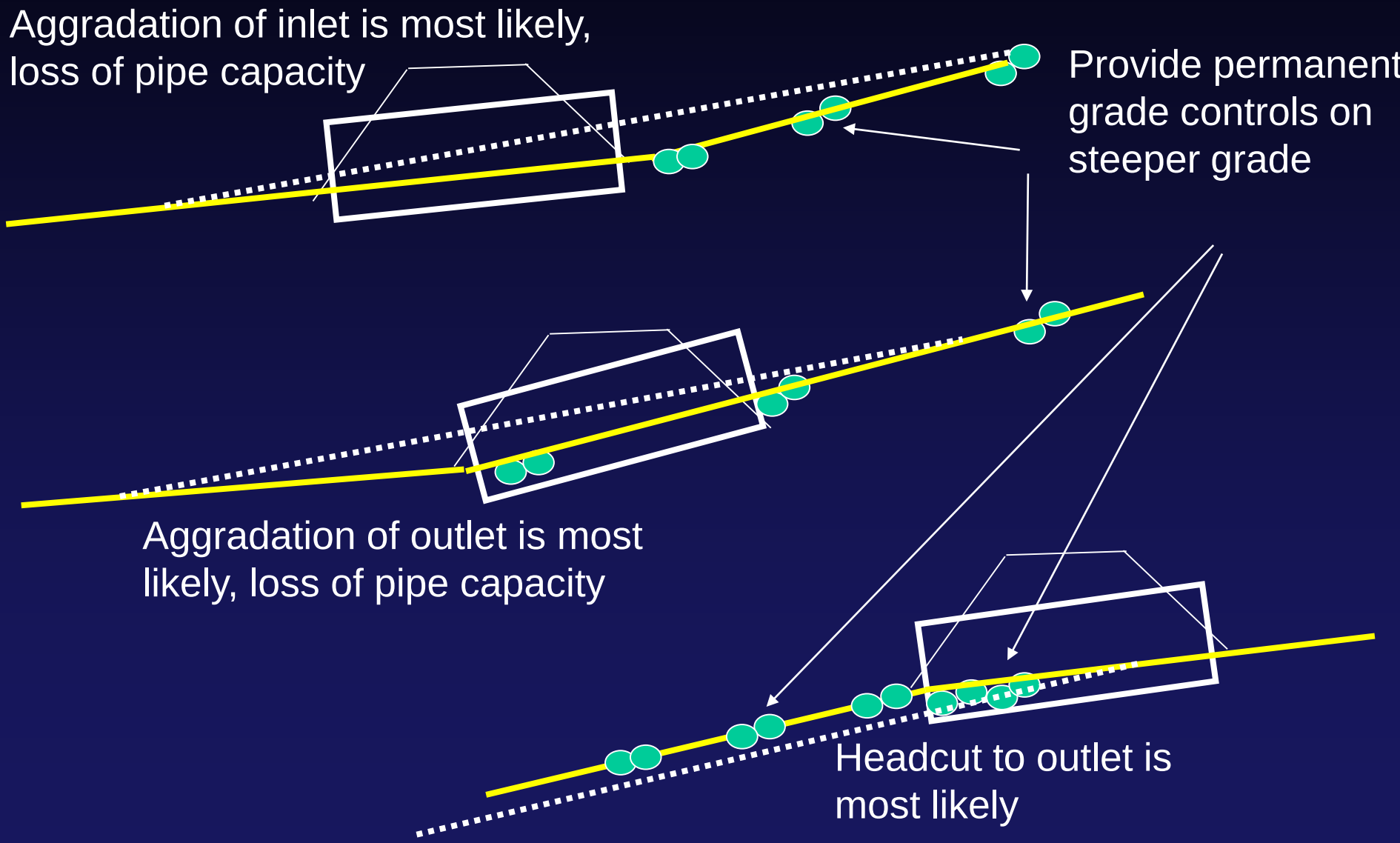
- Largest size materials in the reference reach
- Measure A, B, and C dimensions
- Stable pieces that maintain channel form
- Provide hydraulic and habitat diversity

Profile control options
grade controls – rock bands

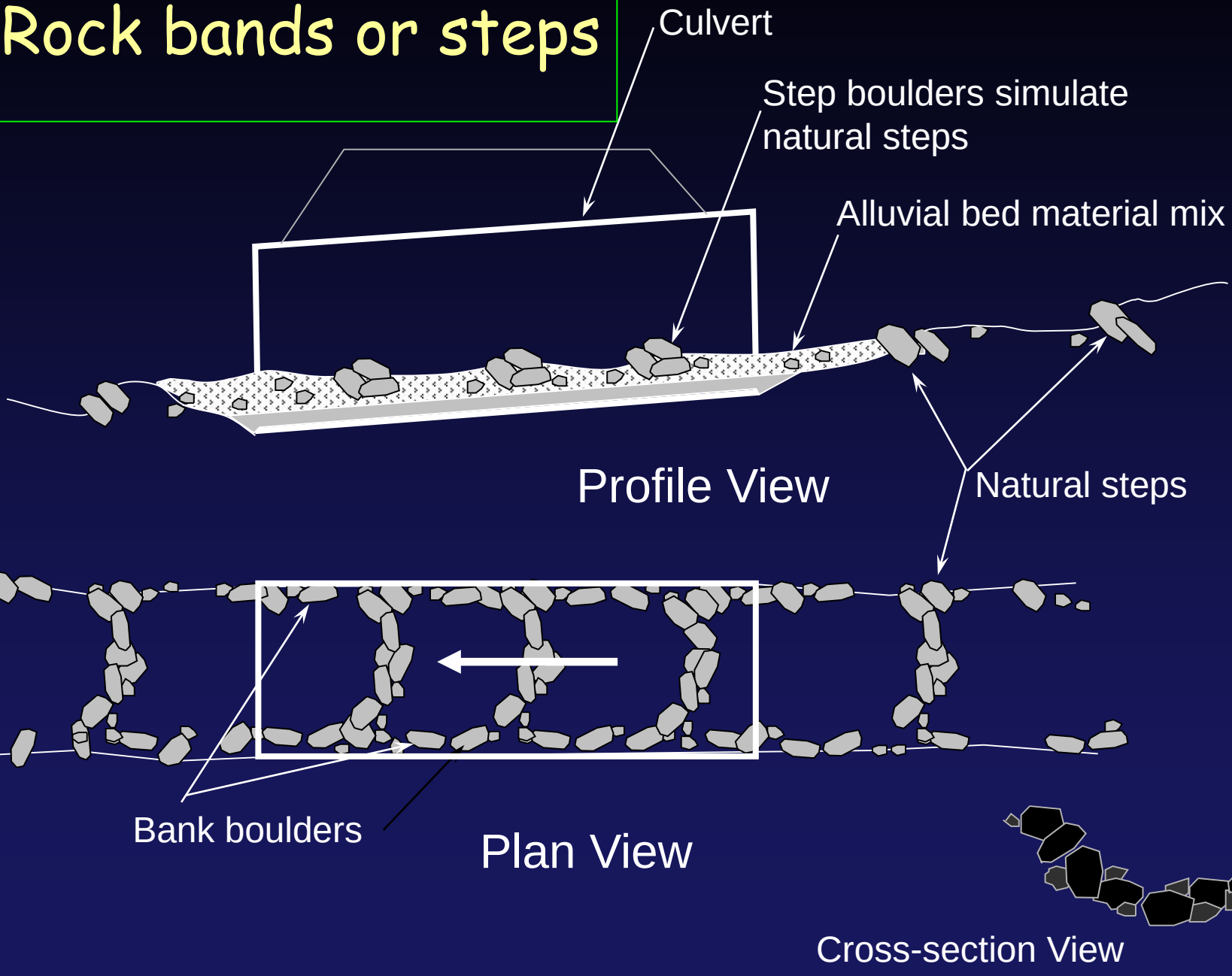


- Riffle or riffle/step structures
- Constructed with a band of primarily larger (D84-D100) size unsorted rocks.
- They help form channel cross-section and profile shape.

Natural compound profiles & channel disturbance scenarios

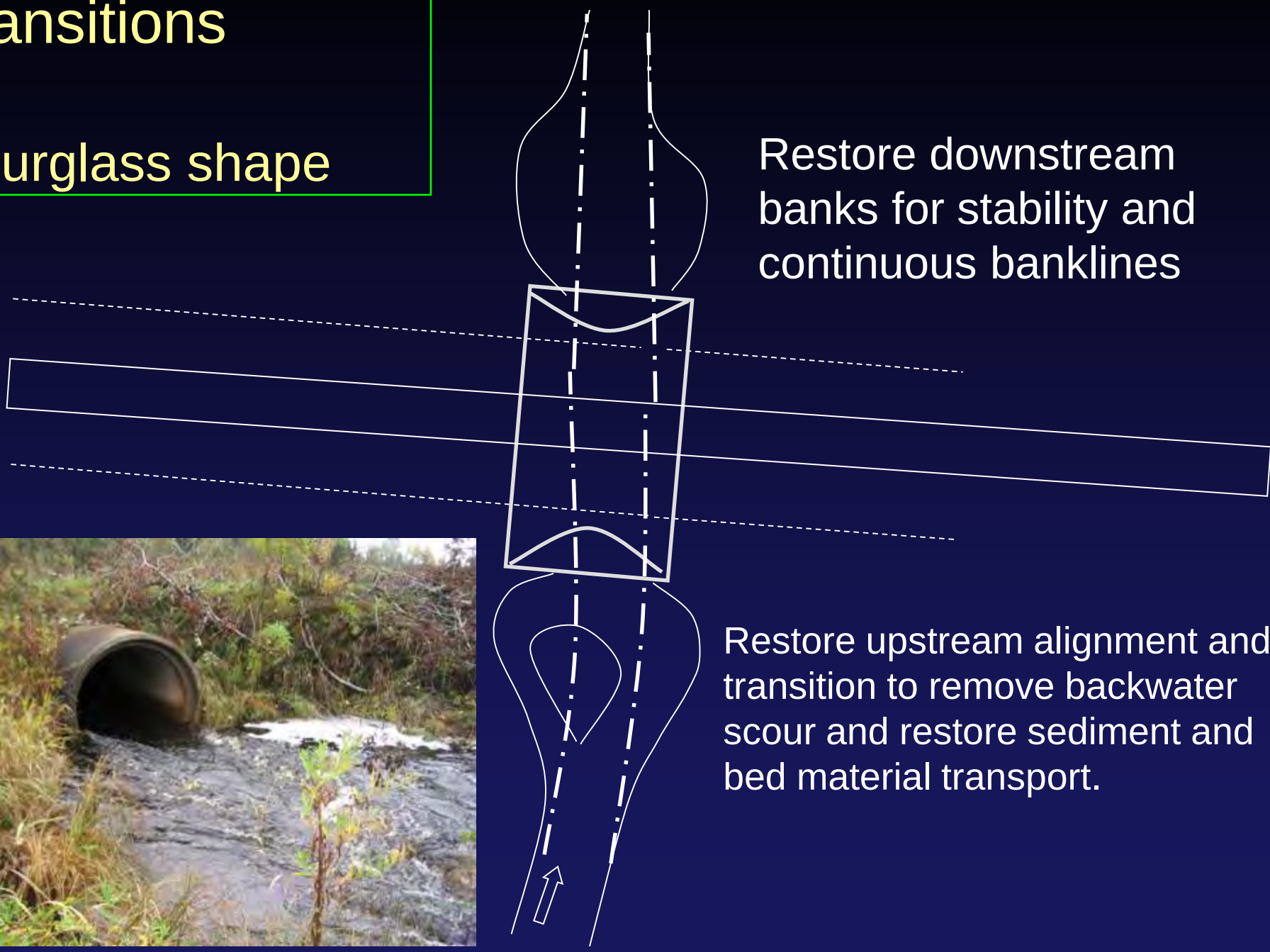


Rock bands or steps



Transitions

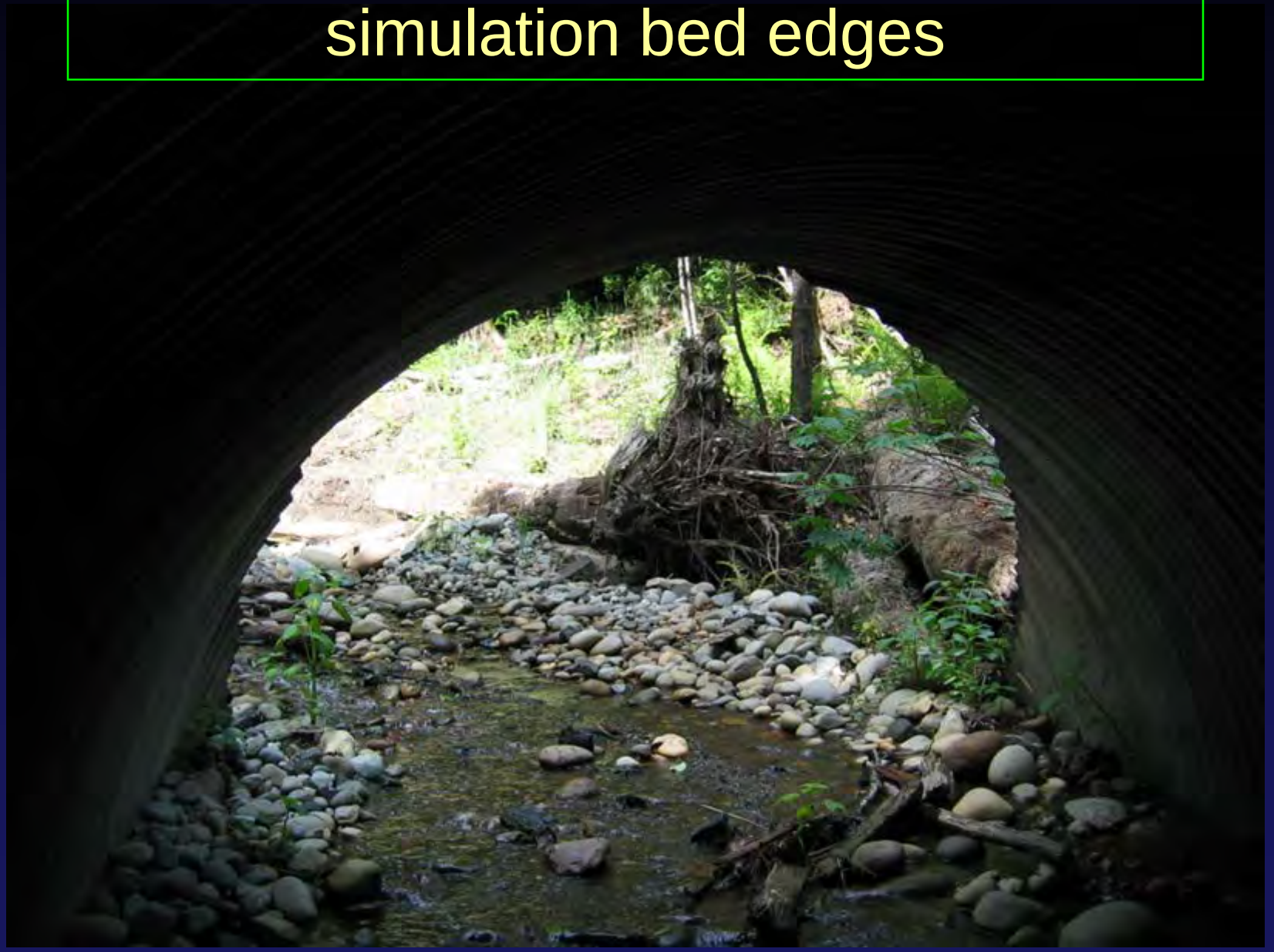
Hourglass shape



Restore downstream banks for stability and continuous banklines

Restore upstream alignment and transition to remove backwater scour and restore sediment and bed material transport.

Tie channel edges to stream simulation bed edges



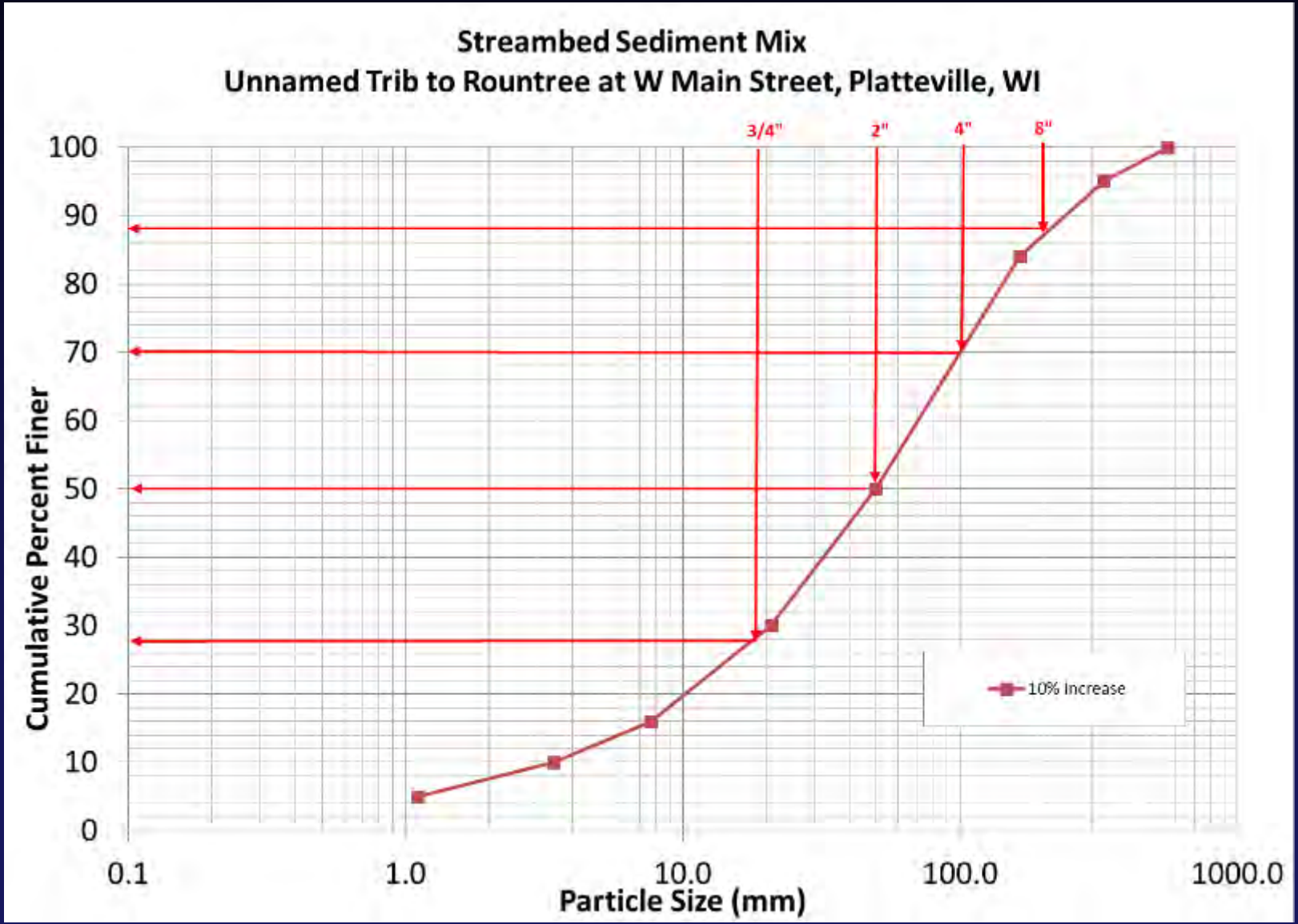
Bed material design

Use reference reach gradation

- Pebble count of reference channel for D_{100}, D_{84} and D_{50}
- Account for large roughness features
- Make sure you have at least 5% fine materials
- Can use Fuller-Thompson equations to adjust fine portion of the bed mix (see Stream Sim. Manual, chapt. 6.2.1 and Appendix E)

Pebble count interpretation exercise

Rountree Trib. pebble-count



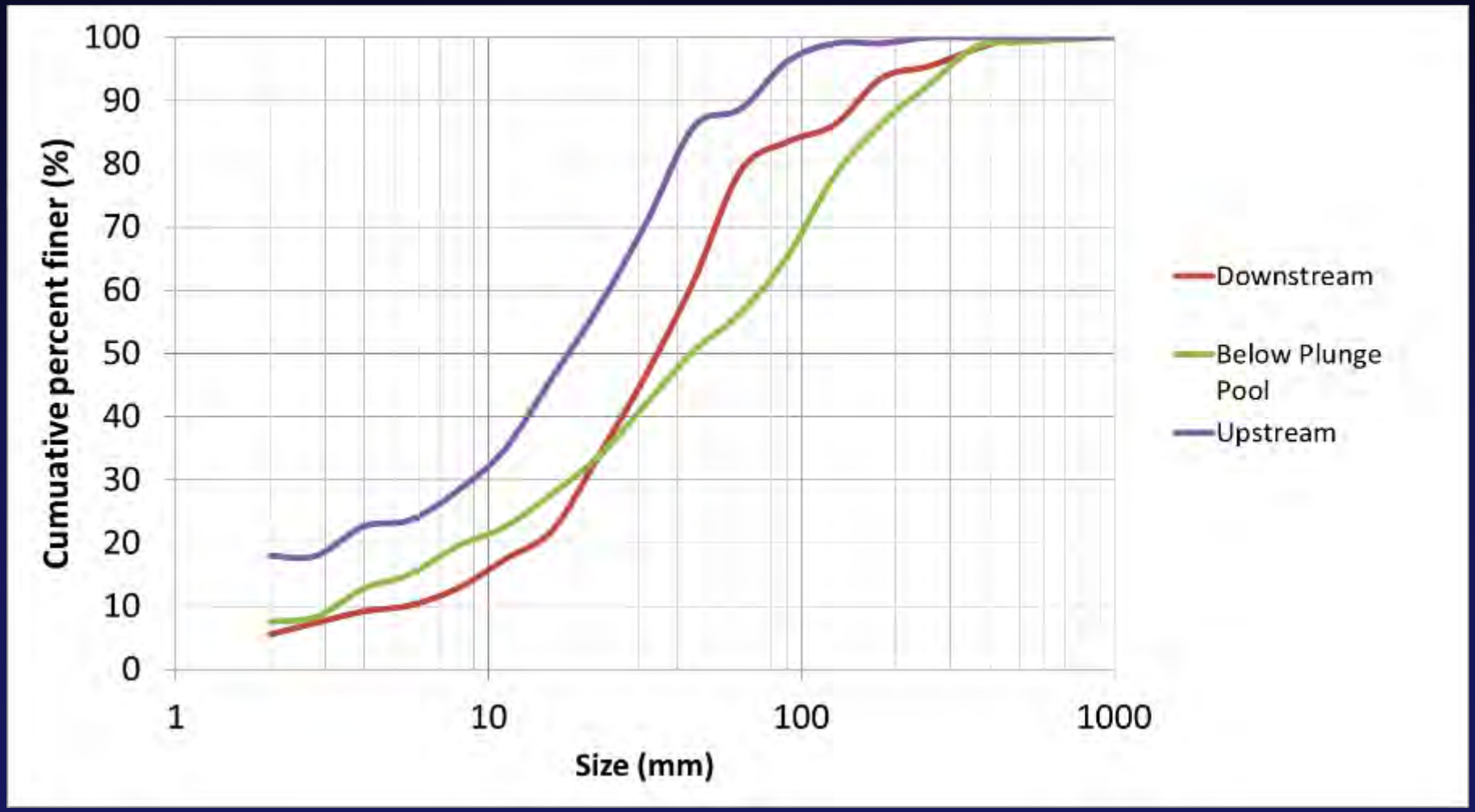
Bed material example
Rountree Trib

Size class	Reference (in)
D100	22
D84	6.5
D50	2.0
D16	0.3
D5	sand

Bed mix composition

% Composition	Nominal Category
7	Boulder (8-20 in)
17	Large Cobble (4-8 in)
20	Sm. Cobble (2-4 in)
22	Gravel (3/4-2 in)
28	< Gravel (<3/4 in)

Rountree Trib. pebble count



Bed material examples

- Walk-behind Bobcat to install materials
- Fan for air quality in confined space
- Sheet piling to divert water

Example, continued