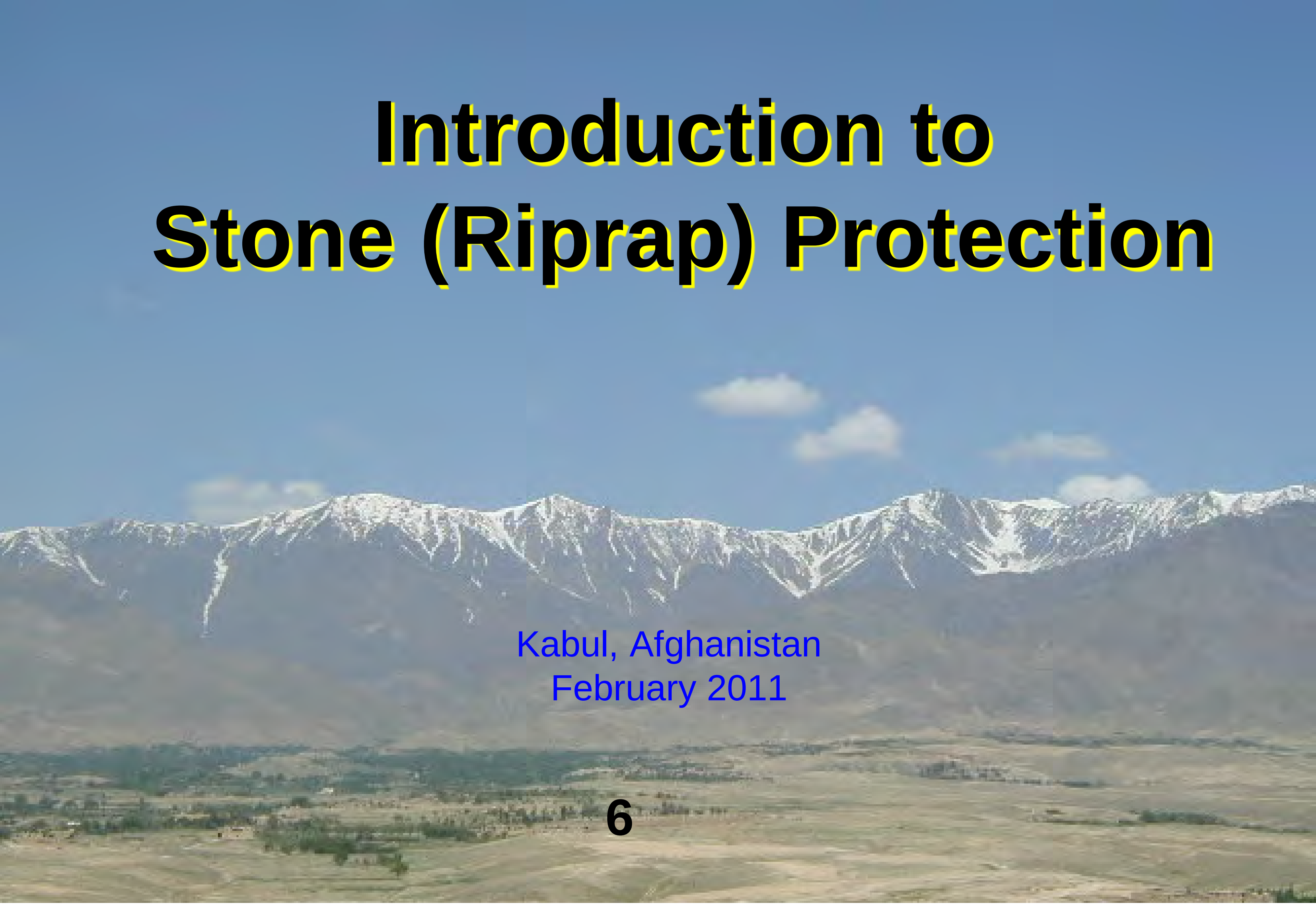
Introduction to Stone (Riprap) Protection



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Module Topics:

- **Why use stone to protect stream banks**
- **Design calculations**
- **Examples**

Stone (Ripprap) Protection

•Usually Used in Transport Zone
•Can Also be used in the Collection Zone
•Strengthens the banks of the stream
•Hard Protection

What is Riprap and why do we use it? Answer: Riprap is the use of large stone to protect a stream or river bank

Designing a riprap protected area can be complicated and is often done by an engineer

Advantages of Riprap

- **Stops streambank erosion**
- **High level of confidence**
- **Low chance of failure if designed correctly**

Riprap Design Criteria

- Rock Size
- Rock Durability
- Extent of Protection
- Depth of Protection
- Location
- Filter

Design often requires and engineer
This introduction is going to cover the basics
You may want to get more detailed training

Rock Size

- Streams and rivers have power
- This power can move stones that are in the stream or river
- The size of the stone that we use in the riprap protection must be larger than what this power can move
- So row big does the riprap stone have to be to resist the stream or river?

Several Ways to Calculate the Required Stone Size are Available.

Simple Formula for Calculating Required Riprap Stone Size to Resist River Power

Stone size (cm) = 15.6 x maximum water depth (cm) x slope

Assume straight channel, flat side slopes

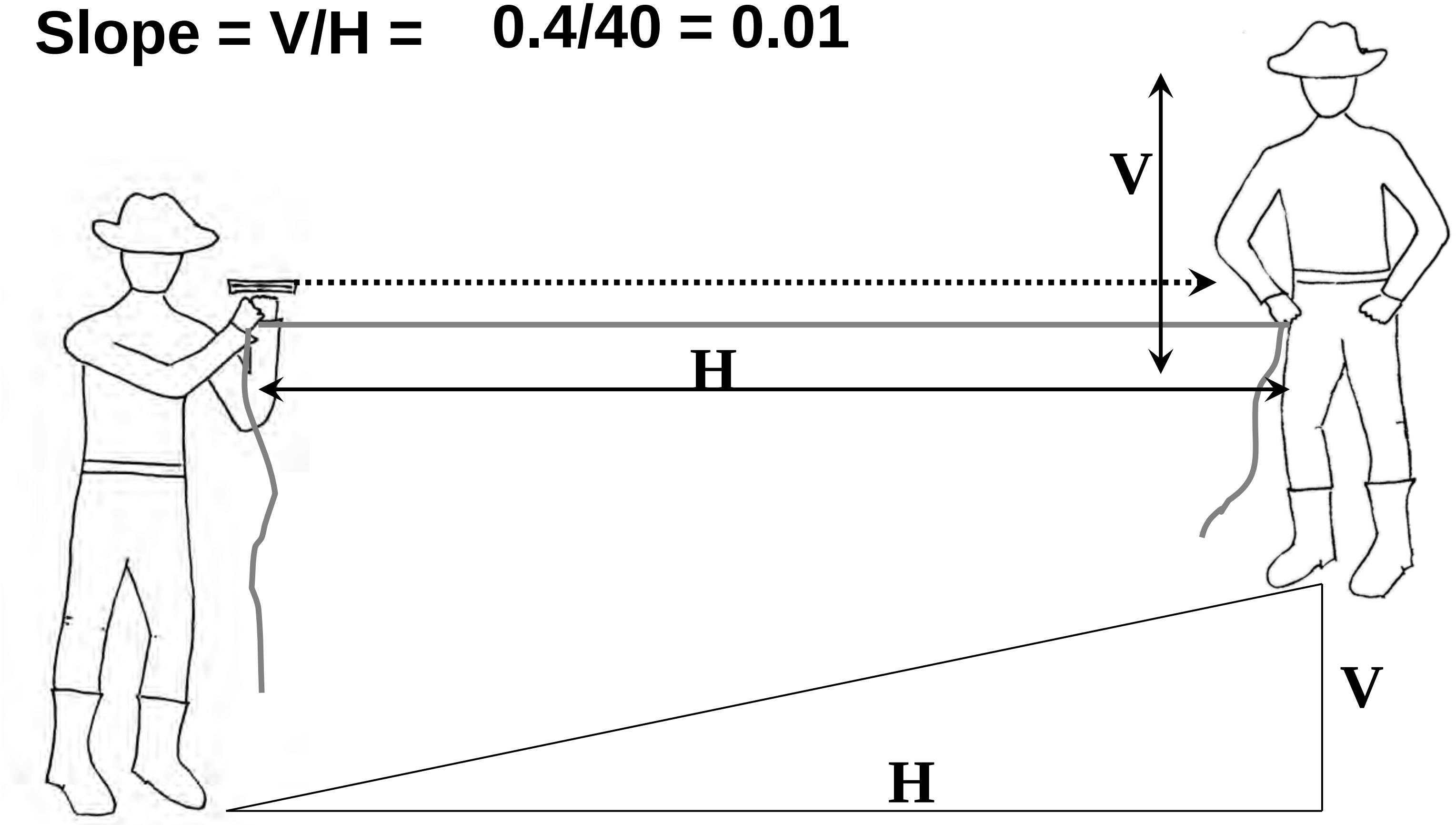
Sample Calculation

<u>Measure then calculate the slope</u>

V = 0.4 meter

H = 40 m

Slope = V/H = 0.4/40 = 0.01



Sample Calculation

<u>Measure the maximum depth</u>

D = 120 cm

Sample Calculation

Calculate the Smallest Riprap Stone Size

Stone size (cm) = 15.6 x maximum water depth (cm) x slope

Stone size (cm) = 15.6 x 120 (cm) x 0.01 = ***19 cm***

Check your calculation

- Compare what you calculate with the size of stones that you see in the stream
- If the stones in the stream are allot bigger than what you calculated, you may be wrong

LANE'S Far West States Method

Far West states (FWS)—Lane's Method

Vito A. Vanoni worked with the Northwest E&WP Unit to develop the procedure from the ASCE paper entitled "Design of Stable Alluvial Channels" (Lane 1955a). The equation is:

$$D_{75} = \frac{3.5}{C \times K} \times \gamma_w \times D \times S_f \qquad \text{(eq. TS14C–19)}$$

where:

D_{75} = stone size, (in)
C = correction for channel curvature
K = correction for side slope
S_f = channel friction slope (ft/ft)
d = depth of flow (ft)
γ_w = density of water

Note: this equation allows designer to account for bends in channel and different side slopes

Note: this is in inches

LANE'S Far West States Method

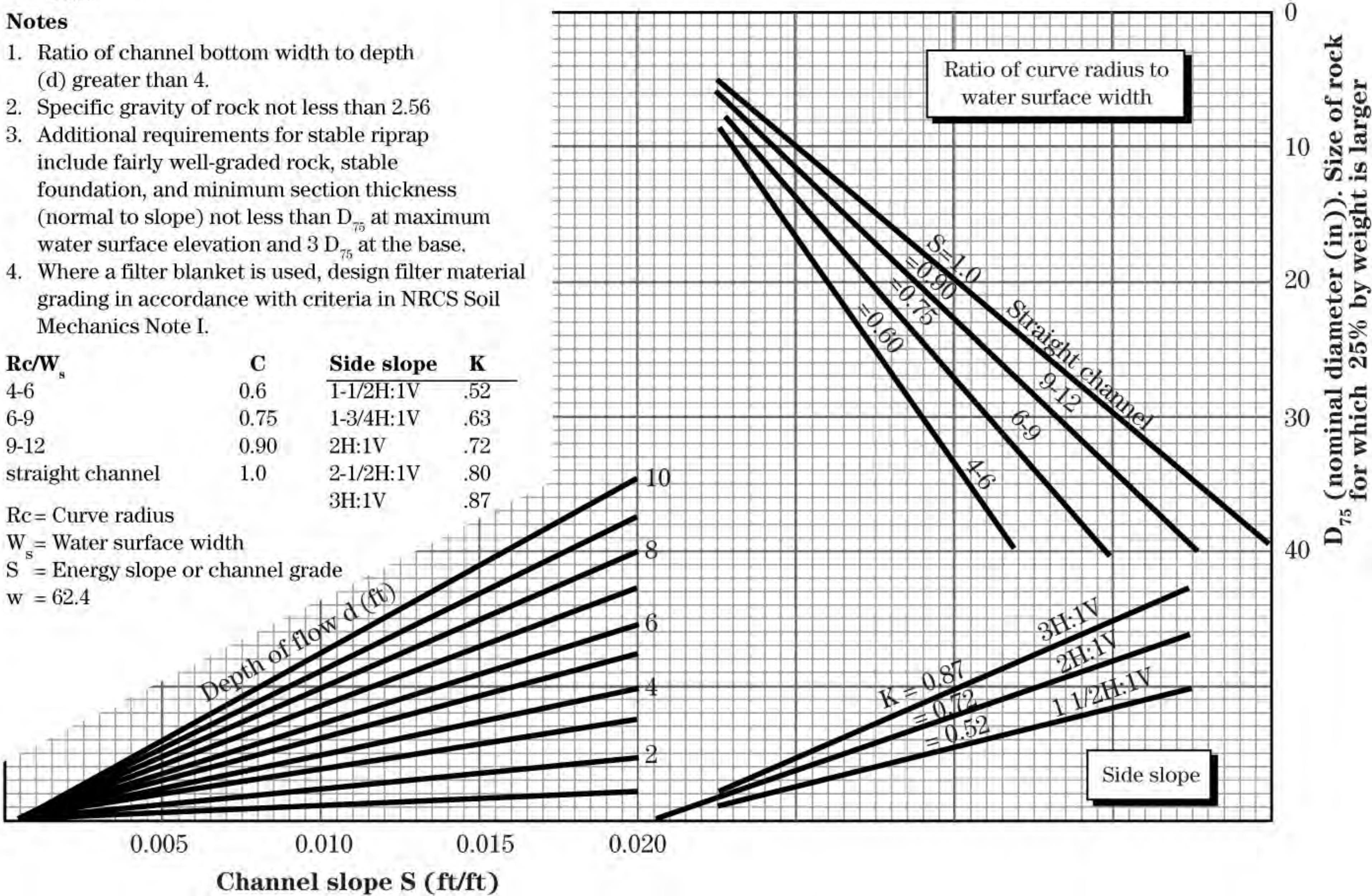
$$D_{75}=\frac{3.5}{C\times K}\times\gamma_w\times d\times S$$

Notes

1. Ratio of channel bottom width to depth (d) greater than 4.
2. Specific gravity of rock not less than 2.56
3. Additional requirements for stable riprap include fairly well-graded rock, stable foundation, and minimum section thickness (normal to slope) not less than D_{75} at maximum water surface elevation and 3 D_{75} at the base.
4. Where a filter blanket is used, design filter material grading in accordance with criteria in NRCS Soil Mechanics Note I.

Rc/W_s	C	Side slope	K
4-6	0.6	1-1/2H:1V	.52
6-9	0.75	1-3/4H:1V	.63
9-12	0.90	2H:1V	.72
straight channel	1.0	2-1/2H:1V	.80
		3H:1V	.87

Rc = Curve radius
W_s = Water surface width
S = Energy slope or channel grade
w = 62.4



Example Problem

Given:

$G_S = 2.6$

Bend Radius = 350 ft

Channel width = 50 ft

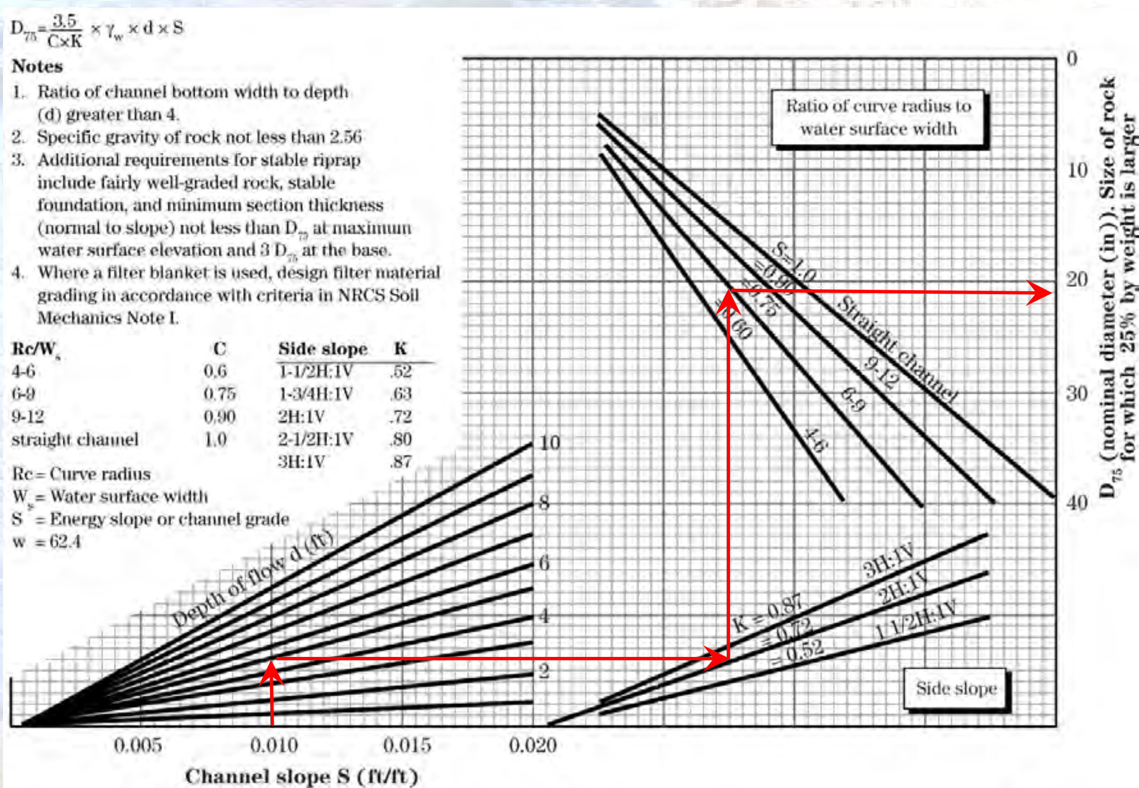
Side slope = 2:1

Slope = 0.01 ft/ft

Depth = 5 ft

Find:

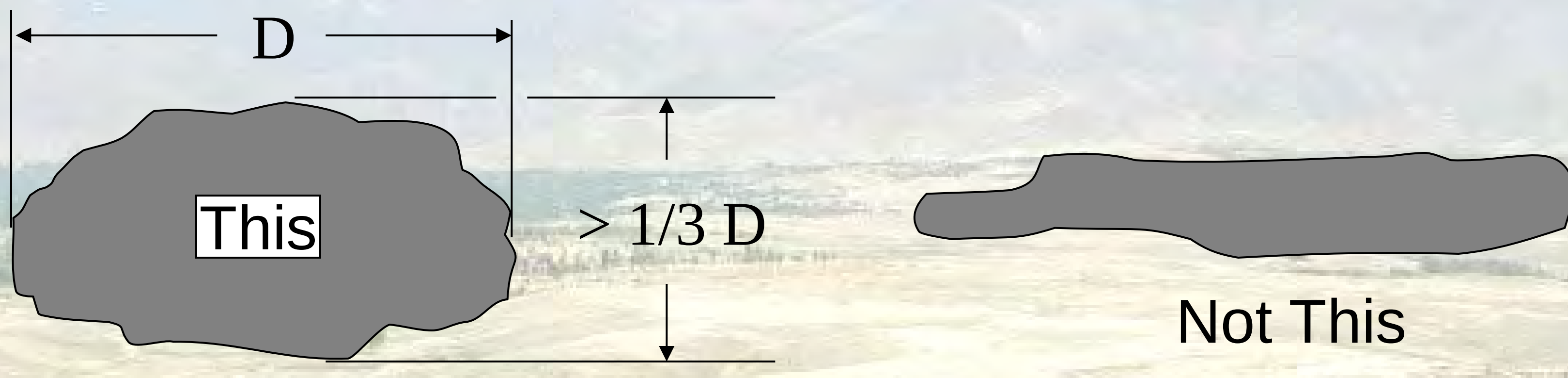
Appropriate rock size using Lane's FWS technique



Rock Shape

Shall be angular to sub-rounded.
The least dimension of individual rock shall not be less than 1/3 the greatest dimension.

Rocks need to be rock shaped. Thin or ‘slab’ rock can break, slip or slide down, lift or raft off the placed location in high flows.

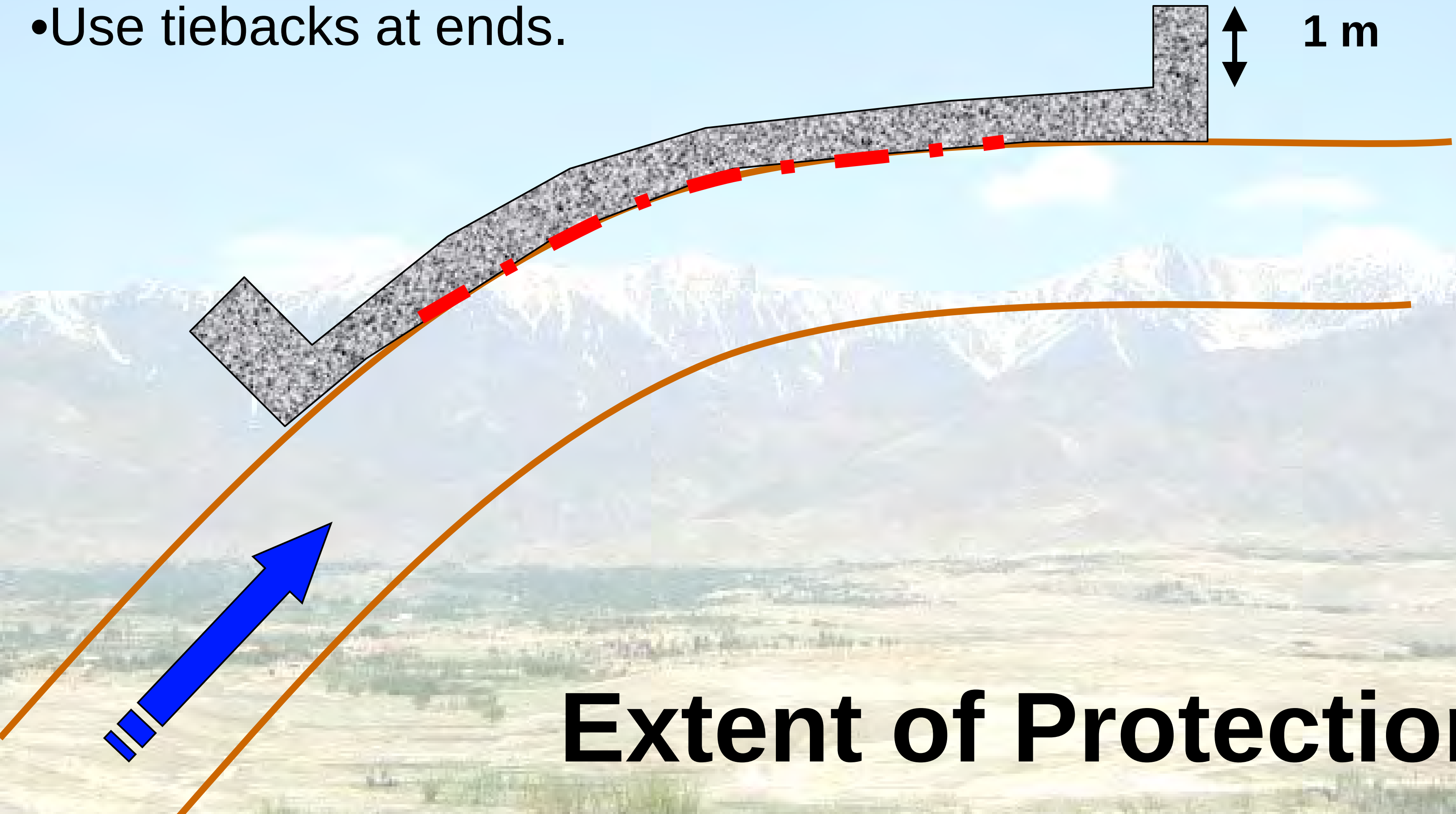


Rock Durability

Be sure to use rock that will stay the size that you want it to be

Longitudinal Extent of Riprap Protection

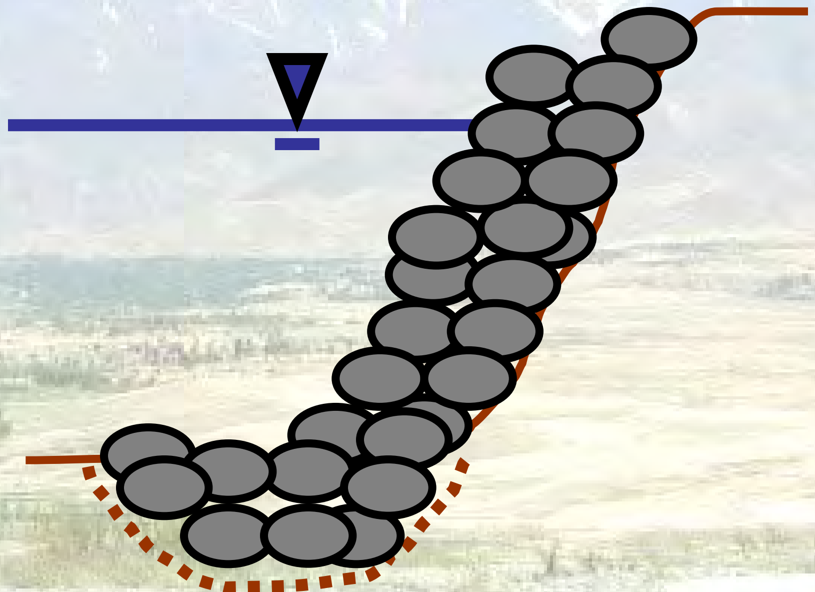
- The outer bend gets more force than the inside of a bend. So concentrate the riprap along the outer bend.
- Continue riprap beyond the area that is eroding
- Use tiebacks at ends.



Extent of Protection

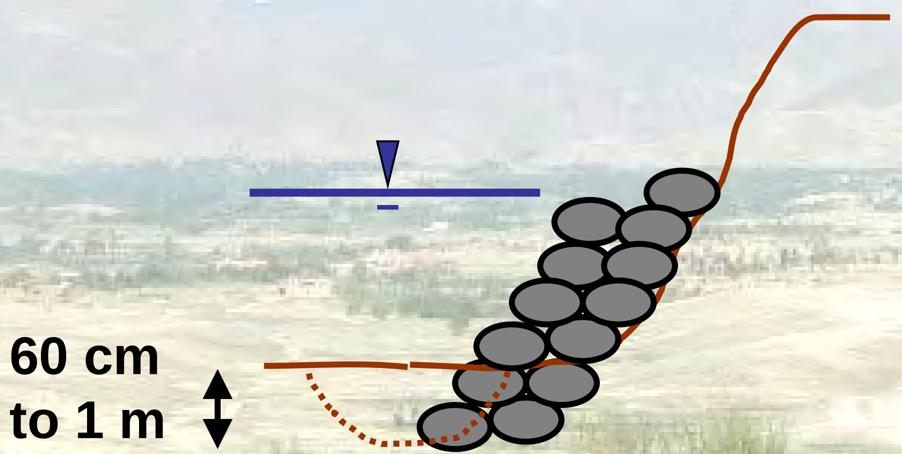
Depth Of Protection

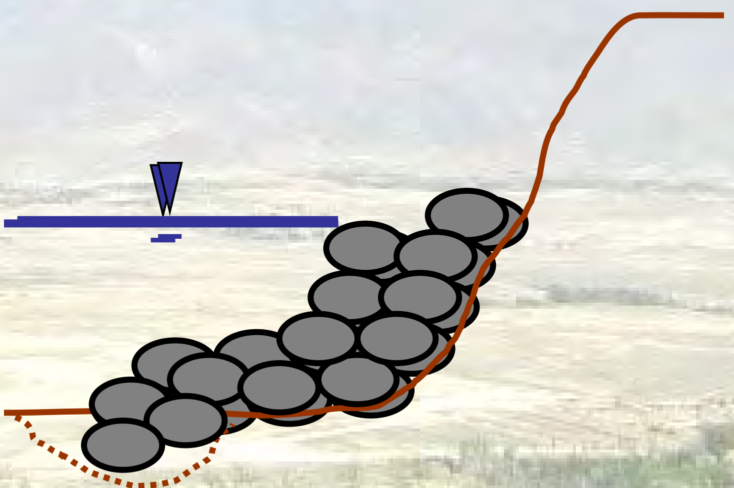
- May have erosion at the base of a river bank (the toe) during a storm
- The riprap will fall in this hole
- The stream bank will no longer be protected



Two techniques to prevent damage from toe erosion

- Continue depth below possible erosion (60 cm to 1 m)
- Provide extra stone riprap at toe of slope to fall into scour hole (60 cm to 1 m)





Bend **Scour**

Can also be calculated for high risk projects

$$\frac{y_{max}}{y} = 1.5 + 4.5\left(\frac{W_i}{Rc}\right) \qquad \text{(eq. TS14B–34)}$$

where:

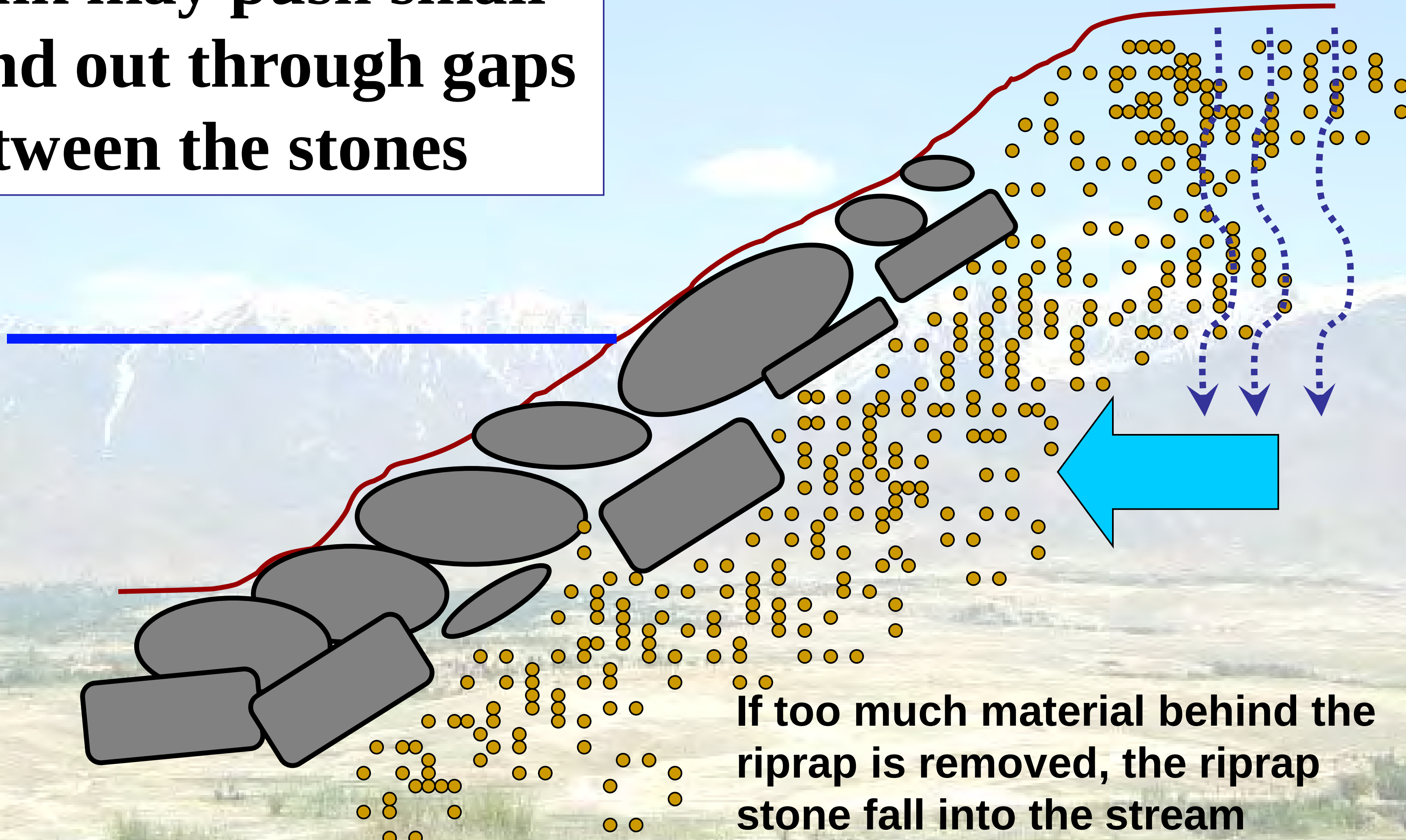
W_i = channel width at bend inflection point, ft (m)
Rc = bend radius of curvature, ft (m)

y = average flow depth in the bend, ft (m)
y_{max} = maximum flow depth in the bend, ft (m)

Many formulas are available
Other types of scour may need to be considered

Filter

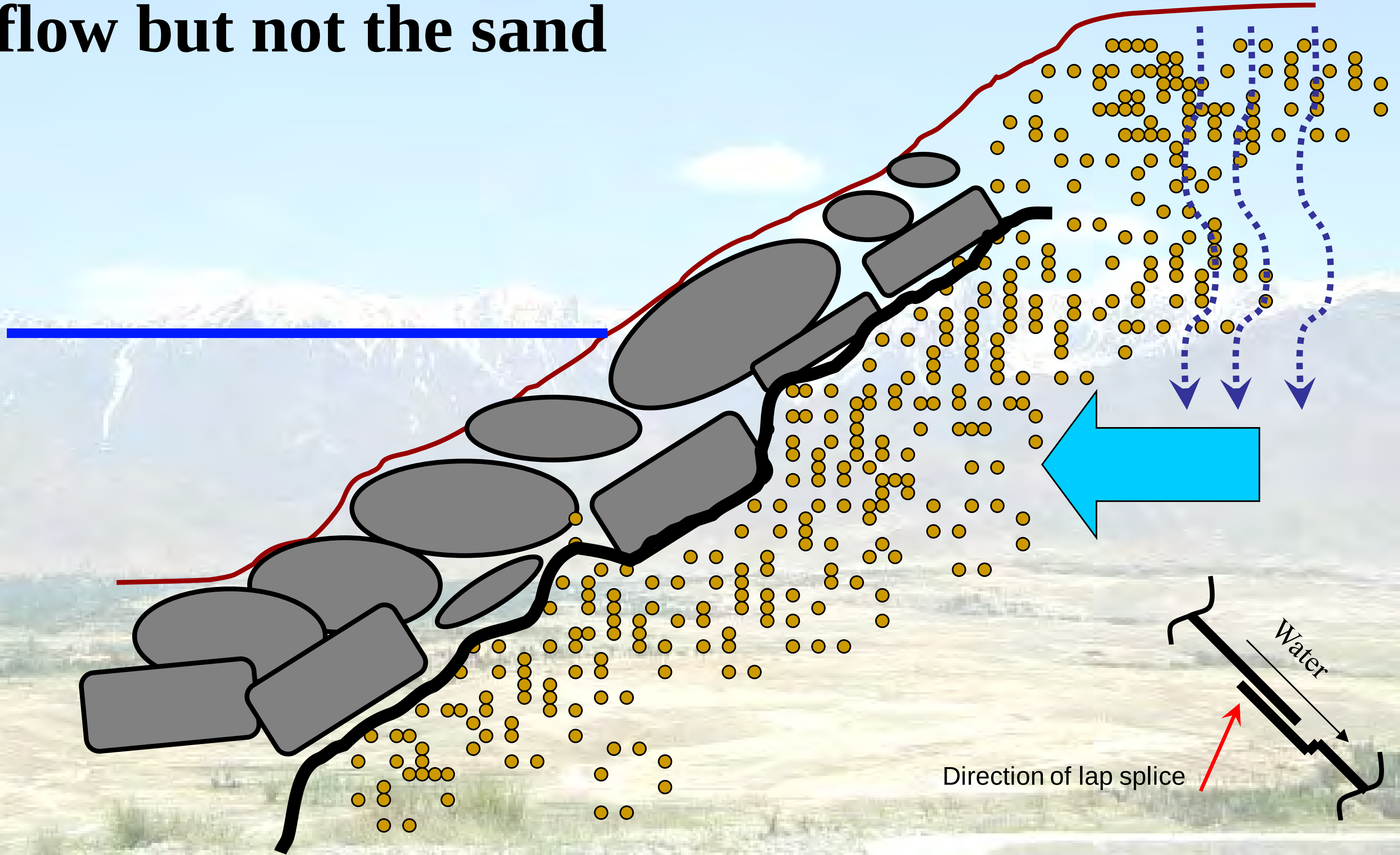
Water flowing out of bank may push small sand out through gaps between the stones



If too much material behind the riprap is removed, the riprap stone fall into the stream

•Place a filter fabric (rice bag, feed sack, etc) between the riprap stone and soil

•The opening in the fabric must allow water to flow but not the sand



A filter layer is not needed if the bank soil has clay in it

If you can make a rope with a handfull of soil, you do not need a filter

You need an engineer to help with the design if:

- The river has high velocities
- The river is large
- The erosion is significant
- The river system is unstable
- There is something very important on the bank
- The project will cost a lot of money
- Laws state you must have an engineer

Disadvantages of Riprap Hard Armor

- Usually very expensive
- Can fail dramatically
- Can cause negative downstream impacts
- Can have low aesthetic quality
- Can have negative ecologic impacts
- Once started, difficult to end

Rock size too small
Failed project
Problems downstream

Questions?