MDOT Riprap Criteria

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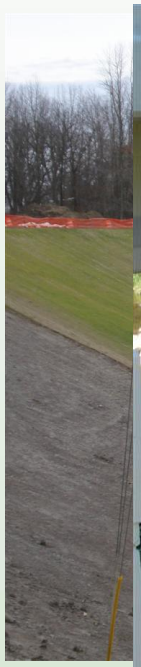
MDOT Hydraulics

Riprap Uses



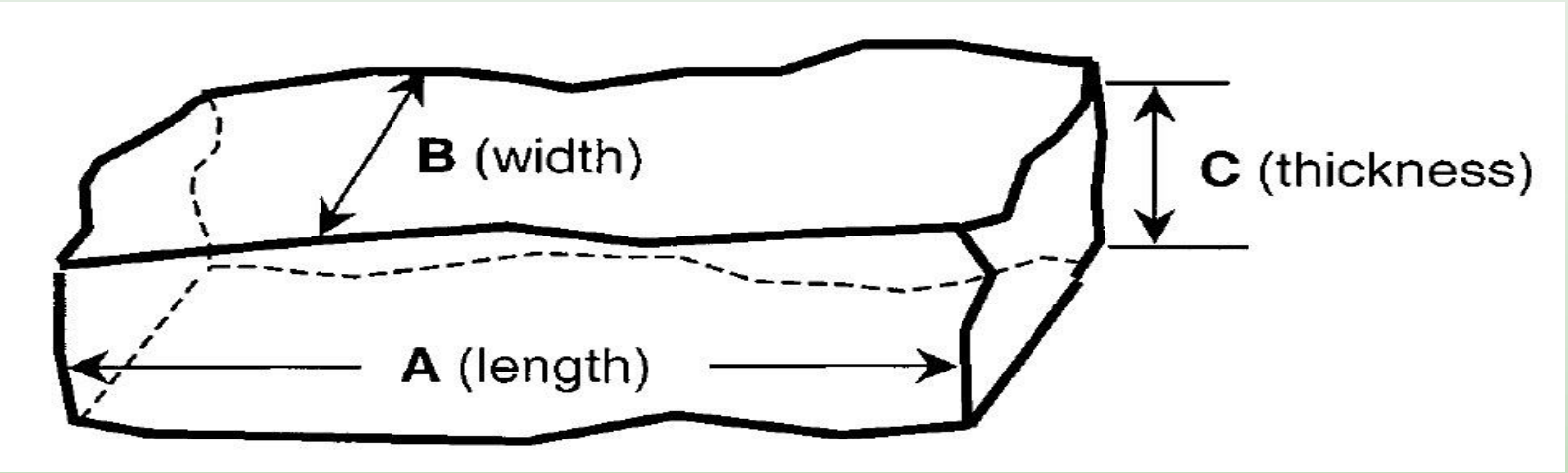
What Makes Good Riprap?

HEC- 23

- FHWA publication that MDOT uses to design riprap.
- Equations vary depending on how riprap is to be used and what is being protected.
- MDOT has adopted the requirements of this guide into our design specification.

What Makes Good Riprap?

- Hard, angular, and durable.
- Properly graded/sized to design condition.
- Proper shape: $A/C \leq 3$



What Makes Good Riprap? (cont'd)

- Properly keyed in edges
- Proper thickness of layers
- Geotextile fabric
- Proper construction methods

Abutment Riprap Design

- Riprap size at abutments affected by velocity, depth, Froude Number, and specific gravity of riprap.
- $\frac{D_{50}}{y} = \left[\frac{K}{S_s - 1}\right]\left[\frac{V^2}{gy}\right]$
- *Generally*, 6 ft/s & 6 ft depth = D_{50} of 8”
- Larger numbers require heavy or well graded riprap mixtures.

Well Graded Riprap

Example: D_{50} = 16”

Stone Size Range	Computed Stone Size	% Gradation Smaller Than
1.7 D_{50}	27.2”	100
1.4 D_{50}	22.4”	85
1.15 D_{50}	18.4”	50
0.6 D_{50}	9.6”	15

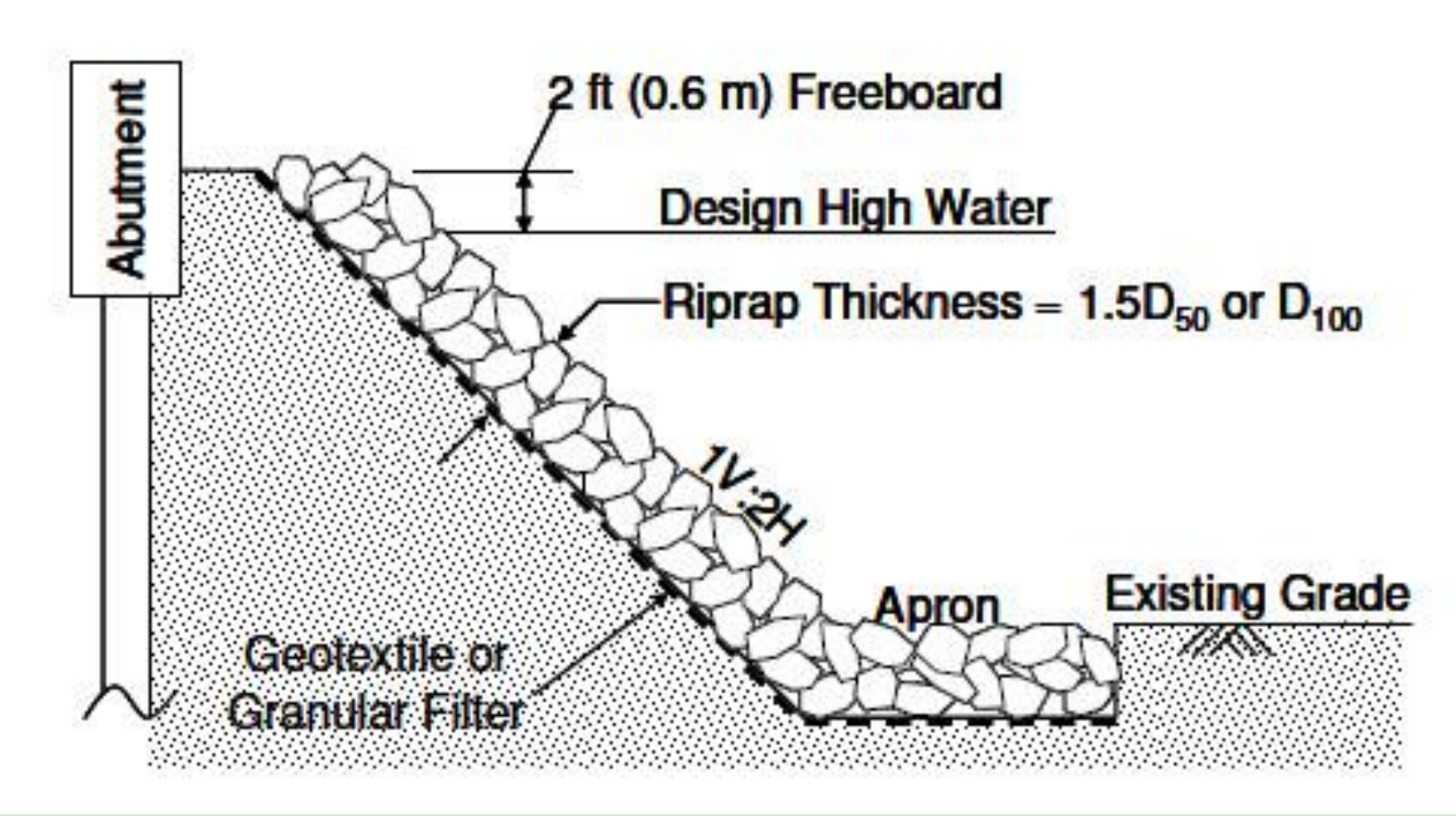
- D_{50} based on “B” dimension
- Particle sizes range from 10” to 28”

Pier Riprap Design

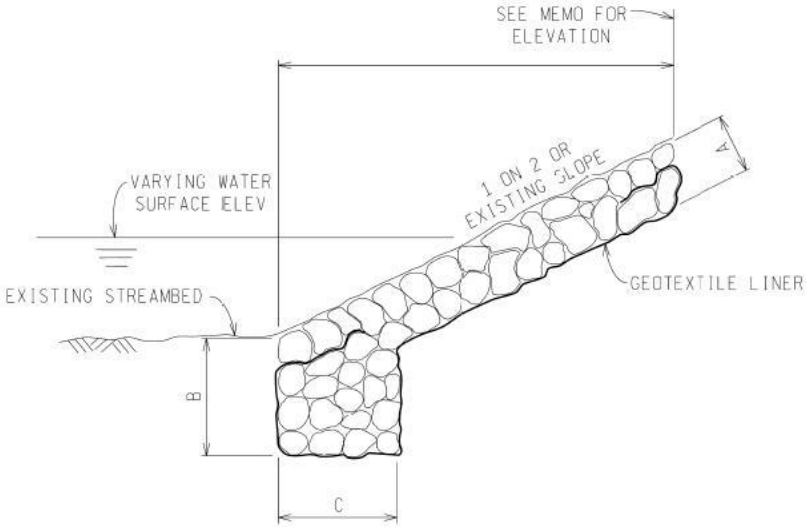
- Riprap at piers depends on **local** velocity
- $d_{50} = \frac{.692(V_{des})^2}{(S_s - 1)2g}$
- If **average** velocity is used, pier shape and location correction factors must be used.
- < 6 ft/s usually D_{50} = 8” (MDOT plain riprap)

Pad dimensions

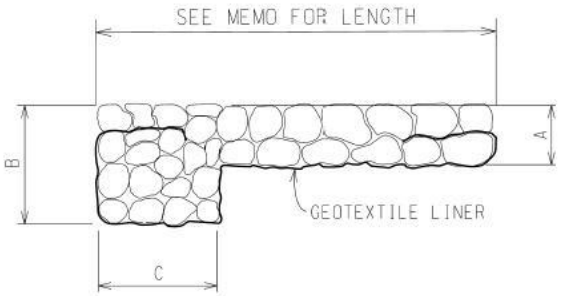
- Abutments
  - 2’ above design high water
  - Extend from abutment into the waterway twice the flow depth or 25’.
  - Extend upstream and downstream twice the flow depth or 25’, whichever is larger.
  - Mat thickness 1.5 D_{50}
  - If in water, increase thickness by 50%.



- http://mdotcf.state.mi.us/public/specprov/index.cfm?sy=439690



TOE HEADER



SIDE HEADER

RIPRAP HEADER DETAILS

TOP OF RIPRAP MUST BE AT OR BELOW EXISTING STREAMBED/ SLOPE ELEVATION.

AN APPROPRIATE METHOD OF WATER DIVERSION FOR PLACING RIPRAP SHALL BE PROPOSED BY THE CONTRACTOR AND APPROVED BY THE ENGINEER. IF WATER IS SHALLOW (LESS THAN TWO FEET), TEMPORARY CONCRETE BARRIERS OR SANDBAGS MAY BE USED TO DIVERT FLOW.

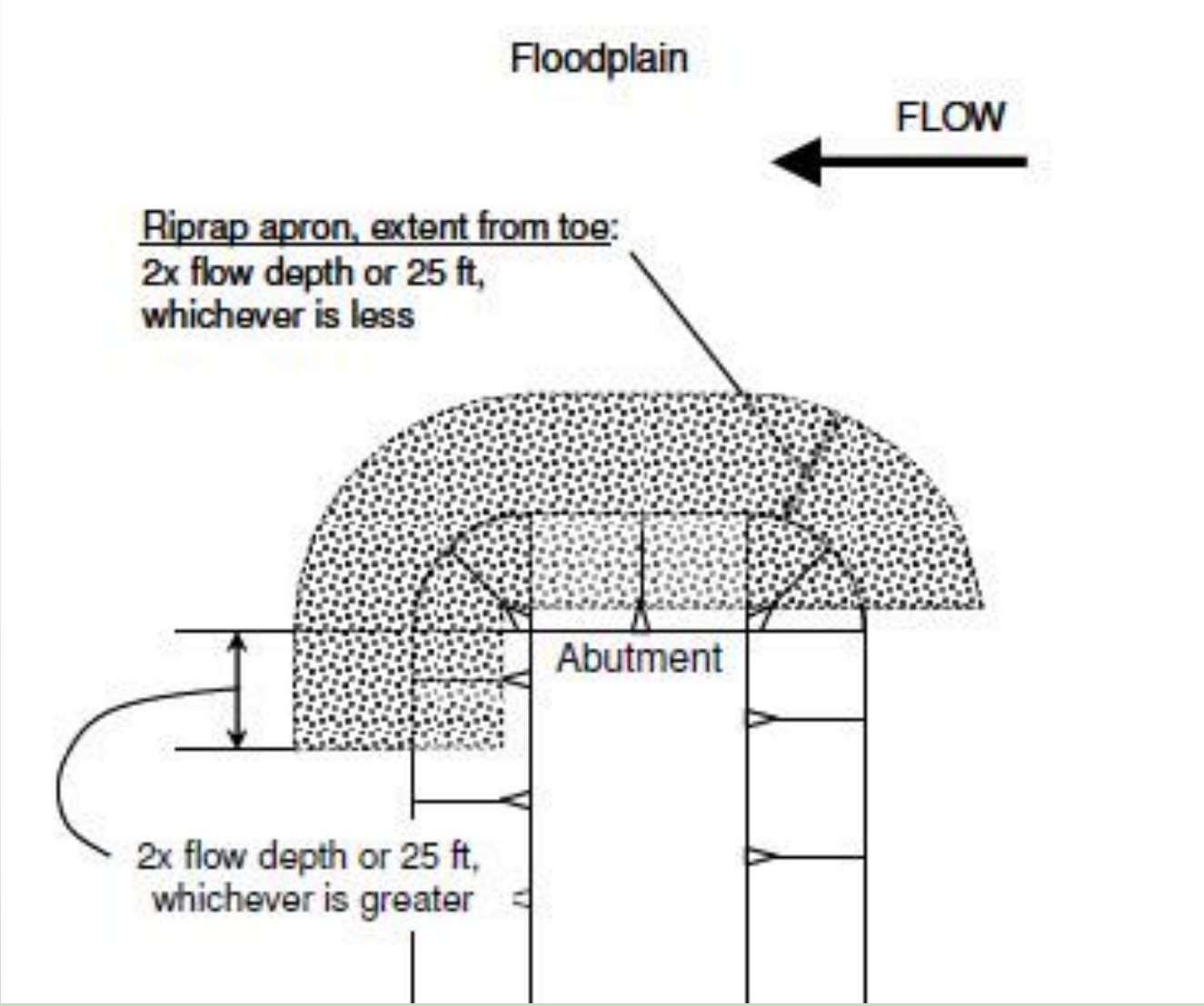
THE RIPRAP SCHEME SHOWN IS A MINIMUM REQUIREMENT FOR SCOUR.

*NOTE:
DIMENSION "A" FOR HEAVY/WELL GRADED RIPRAP SHALL BE PLACED IN A MINIMUM OF TWO LAYERS. MINIMUM THICKNESS FOR THIS DIMENSION SHALL BE TWICE THE D50 STONE INDICATED IN THE RIPRAP SPECIAL PROVISION GRADATION.

SEE MEMO FOR RIPRAP TYPE

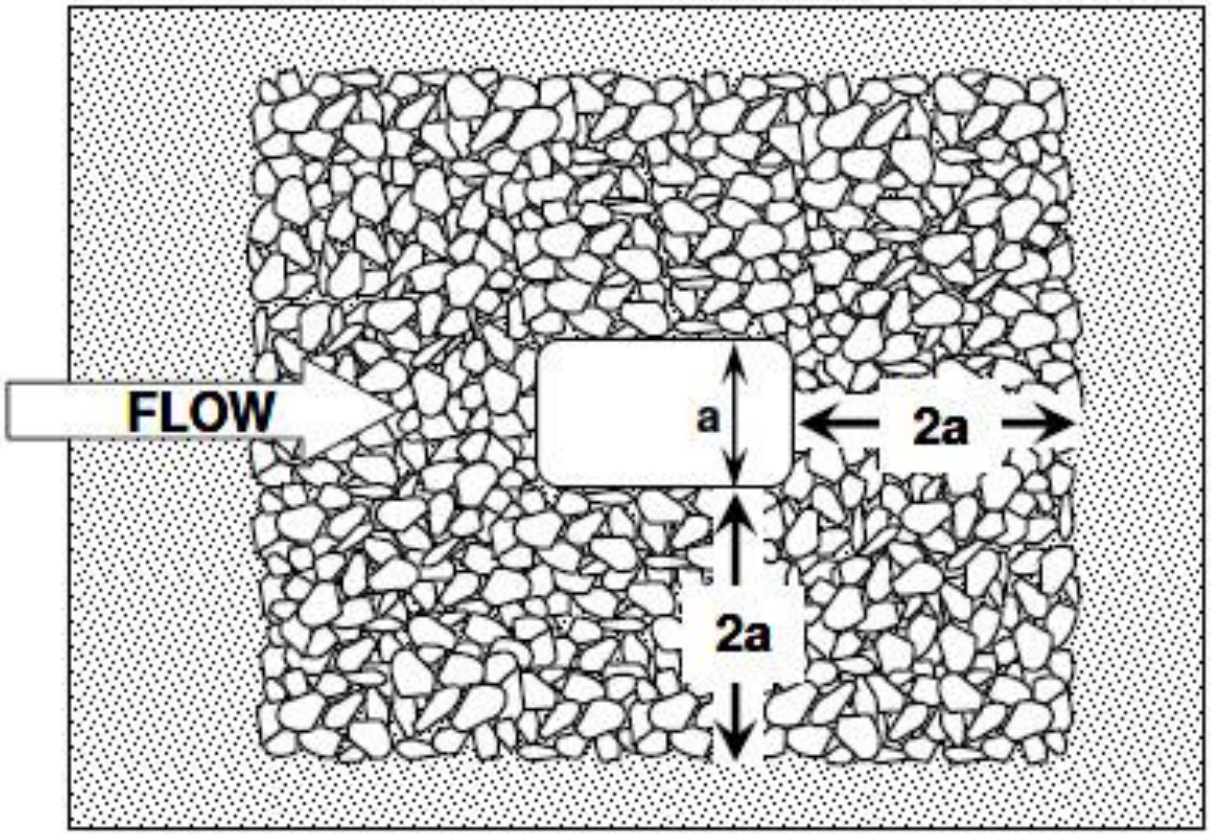
MINIMUM DIMENSIONS		
DIM.	PLAIN	HEAVY/ WELL-GRADED
A	1'-6"	*SEE NOTE
B	3'	DIM.(A) + D50
C	3'	DIM.(A)

MDOT | TYPICAL CROSS SECTIONS


Floodplain
FLOW
Riprap apron, extent from toe:
2x flow depth or 25 ft,
whichever is less
Abutment
2x flow depth or 25 ft,
whichever is greater

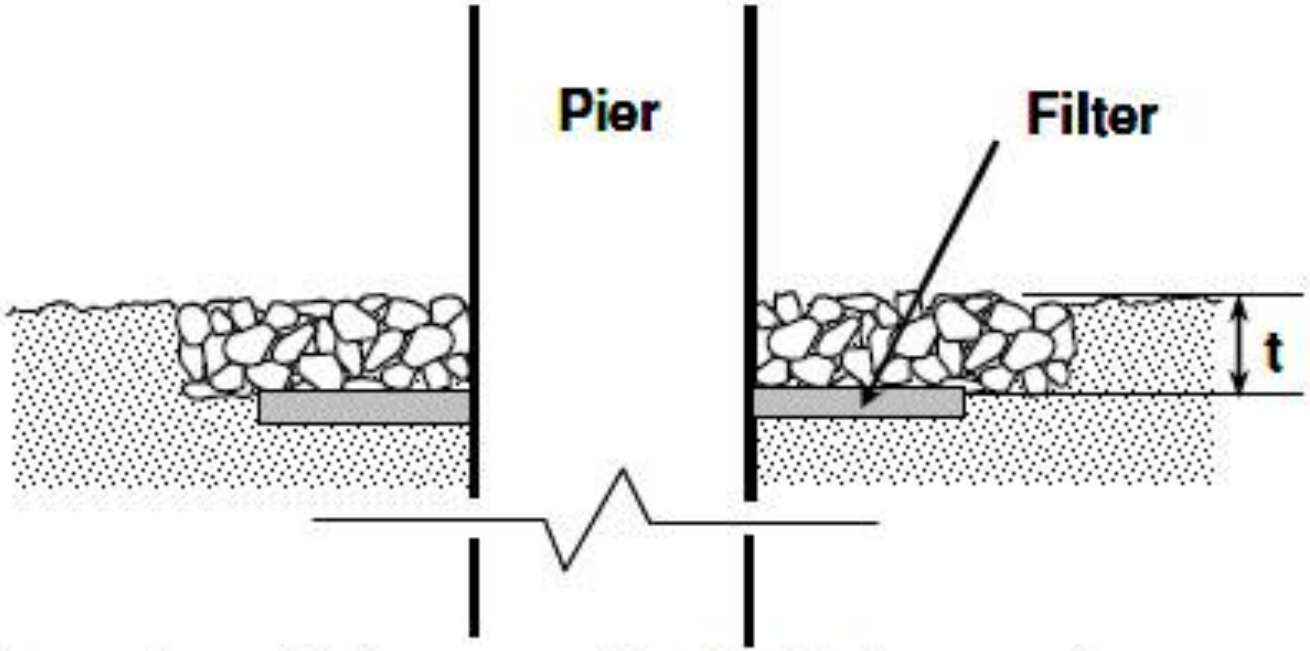
Pad Dimensions

- Piers
  - Extend twice the pier width in all directions.
  - If in water, increase thickness by 50%.



Pier width = "a" (normal to flow)
Riprap placement = 2(a) from pier (all around)

a. Plan View



Minimum riprap thickness $t = 3d_{50}$, depth of contraction scour and long-term degradation, or depth of bedform trough, whichever is greatest

Filter placement = 4/3(a) from pier (all around)

Physical Site Limitations

Part 31

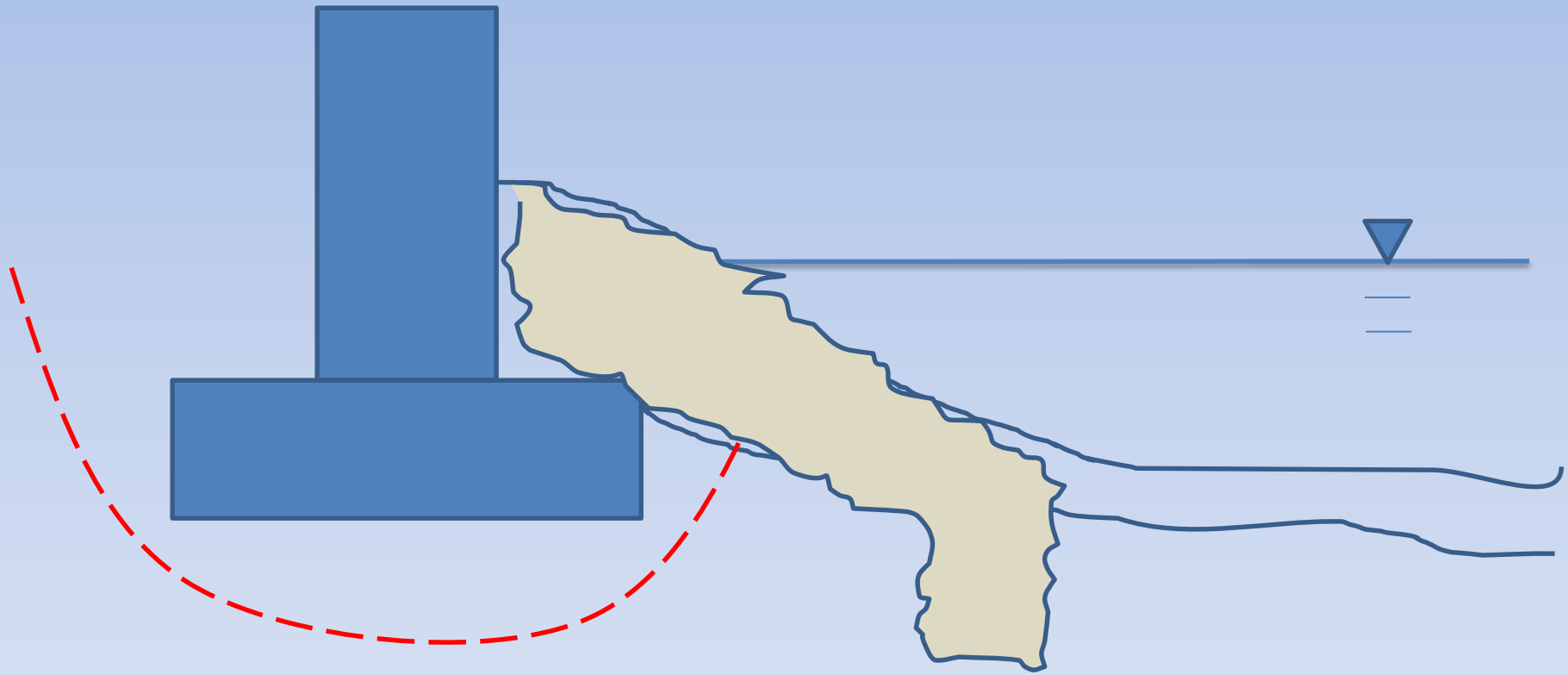
- No harmful interference – Can't increase backwater more than 0.01' (0.00'in some cases) outside of ROW

Geotechnical

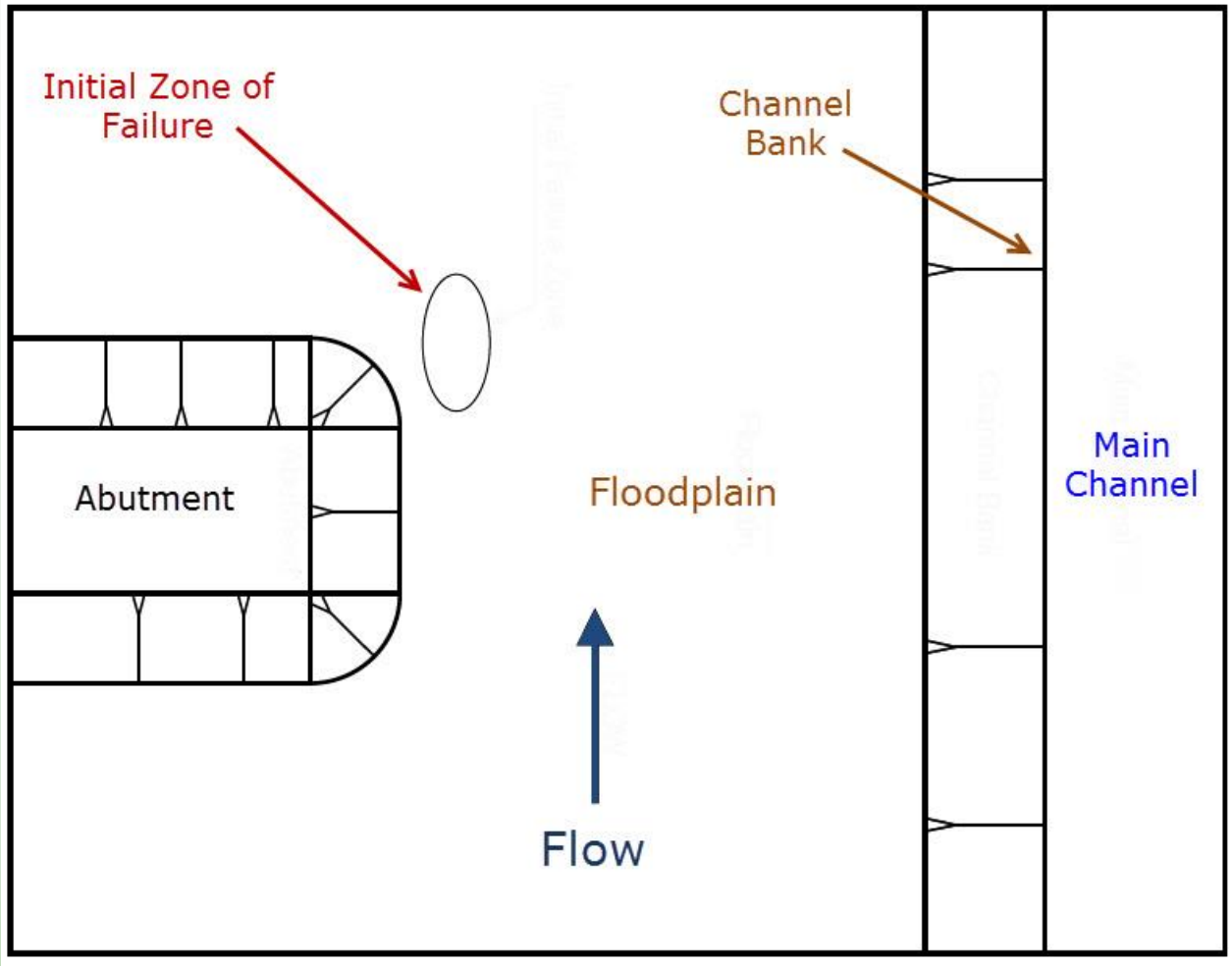
- No driving or vibrating of material within 25' of spread footings
- No excavation below top of footing within 25'

County Drains

- Drain elevations may have been lowered through structure



Riprap Failure Modes



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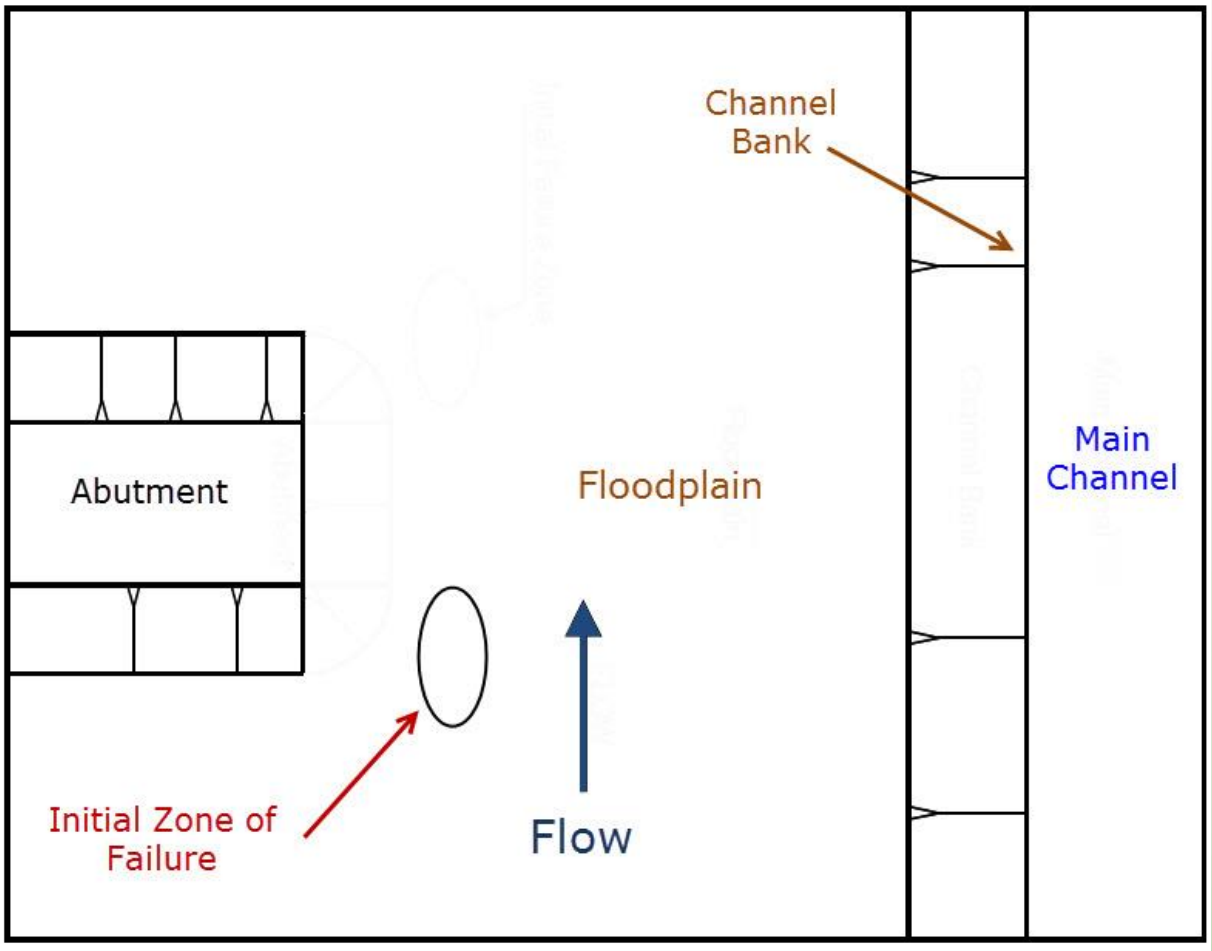

Constructability

- How will work be isolated from water?
- Will a causeway be needed?
- Machinery or hand place?
- T & E impacts?
- Construction inspection/documentation


CATERPILLAR
D5C

Alternatives?

- Articulated concrete blocks (ACB)
- Gabions blocks or mats
- Grout bags
- Grout filled mattresses

- Cost vs. Permit vs. Constructability

Questions???