

# PEN 1 & PEN 2

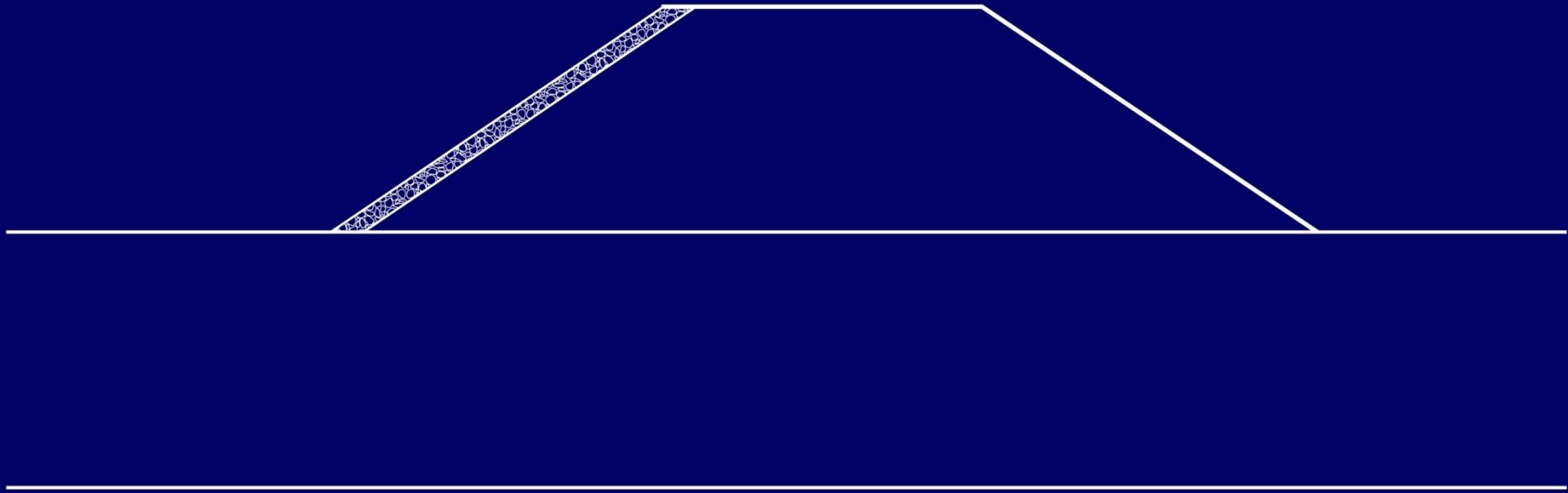
## Levee Engineering Assessment

- Following 44 CFR 65.10 (FEMA)
- Standard: US Army Corps Manuals
- Roles:
  - Cornforth: Seepage, Stability, Settlement
  - WEST: Freeboard, Scour Protection
  - MCDD: Interior Drainage
  - Group Mackenzie: As-Builts

# 44 CFR 65.10 CERTIFICATION REQUIREMENTS

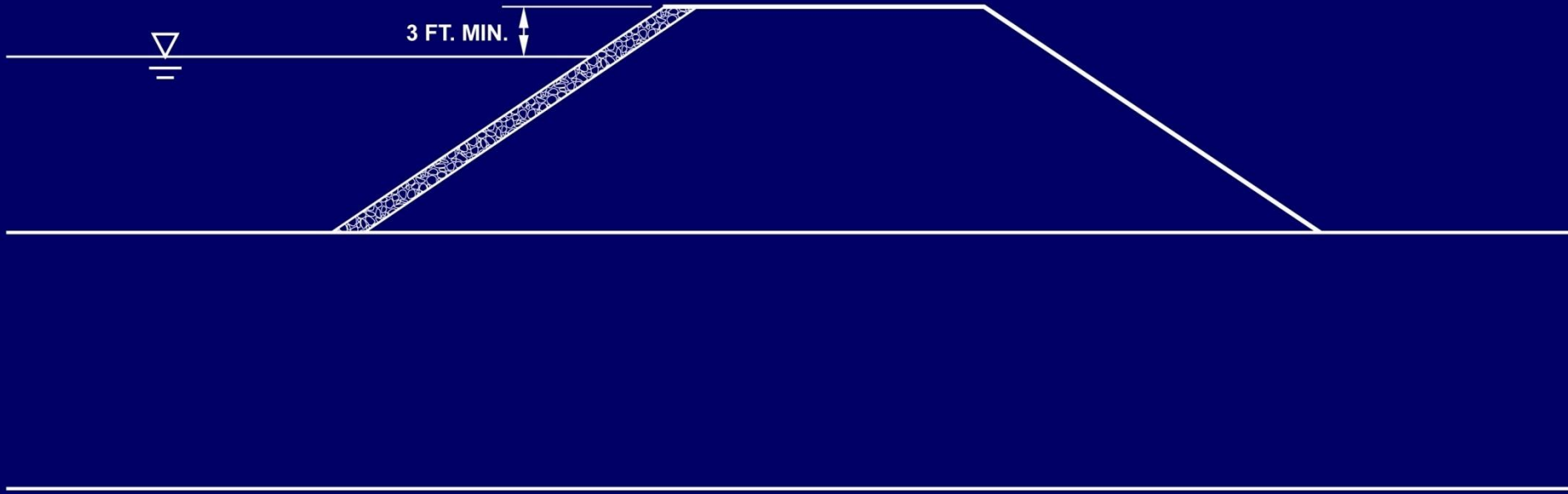
RIVER SIDE

LAND SIDE



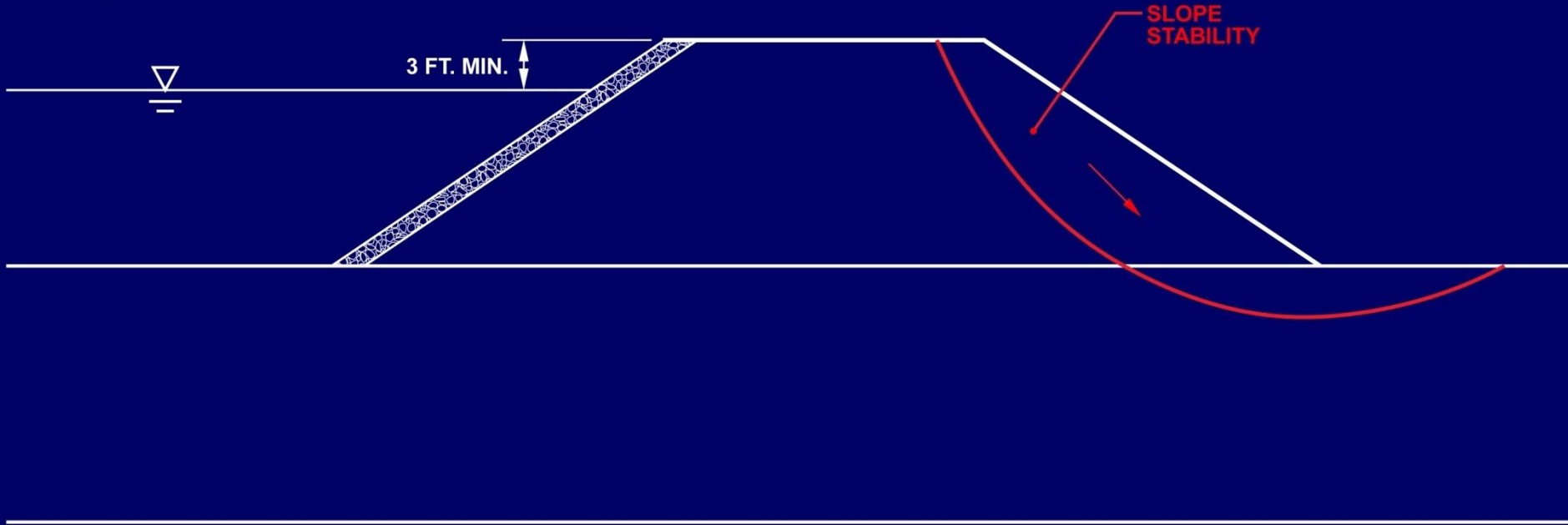
# 44 CFR 65.10 CERTIFICATION REQUIREMENTS

HYDRAULIC ANALYSES  
(FLOOD LEVELS)



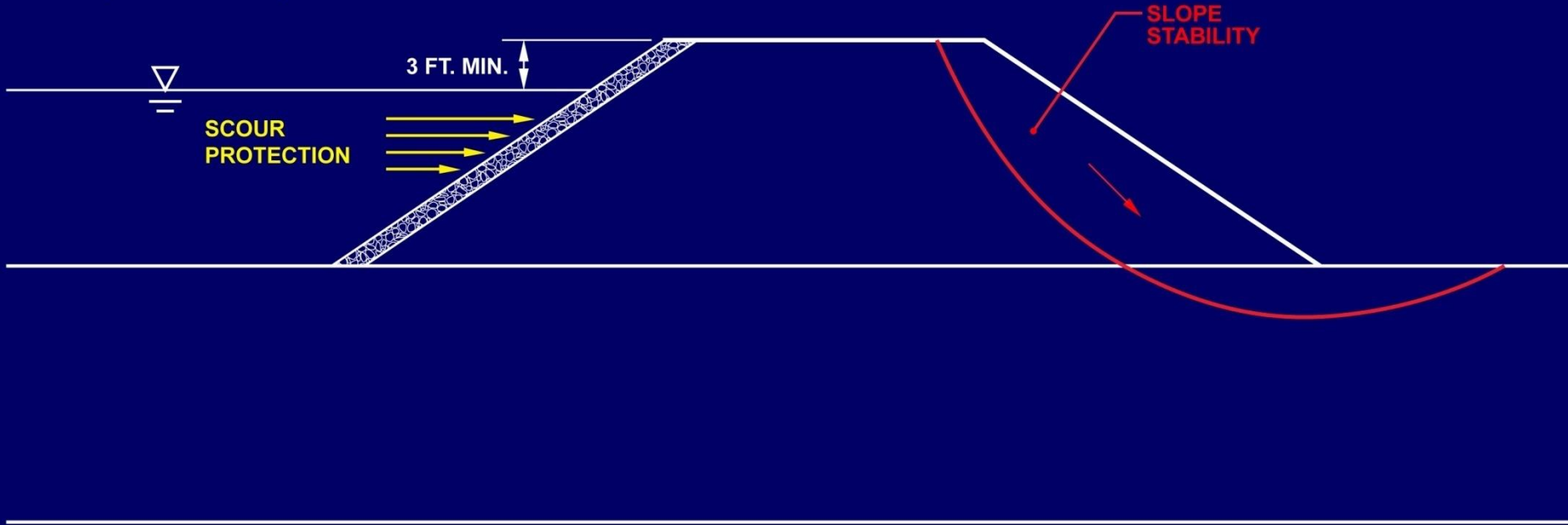
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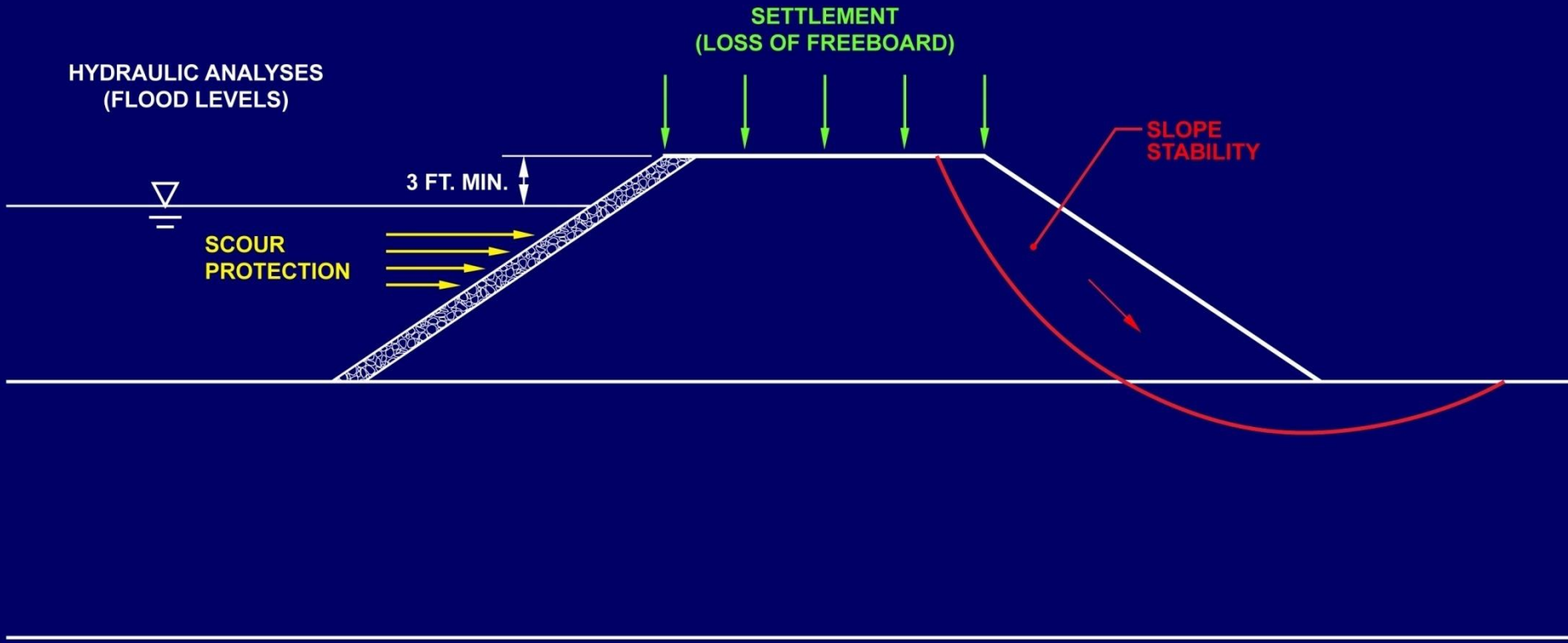


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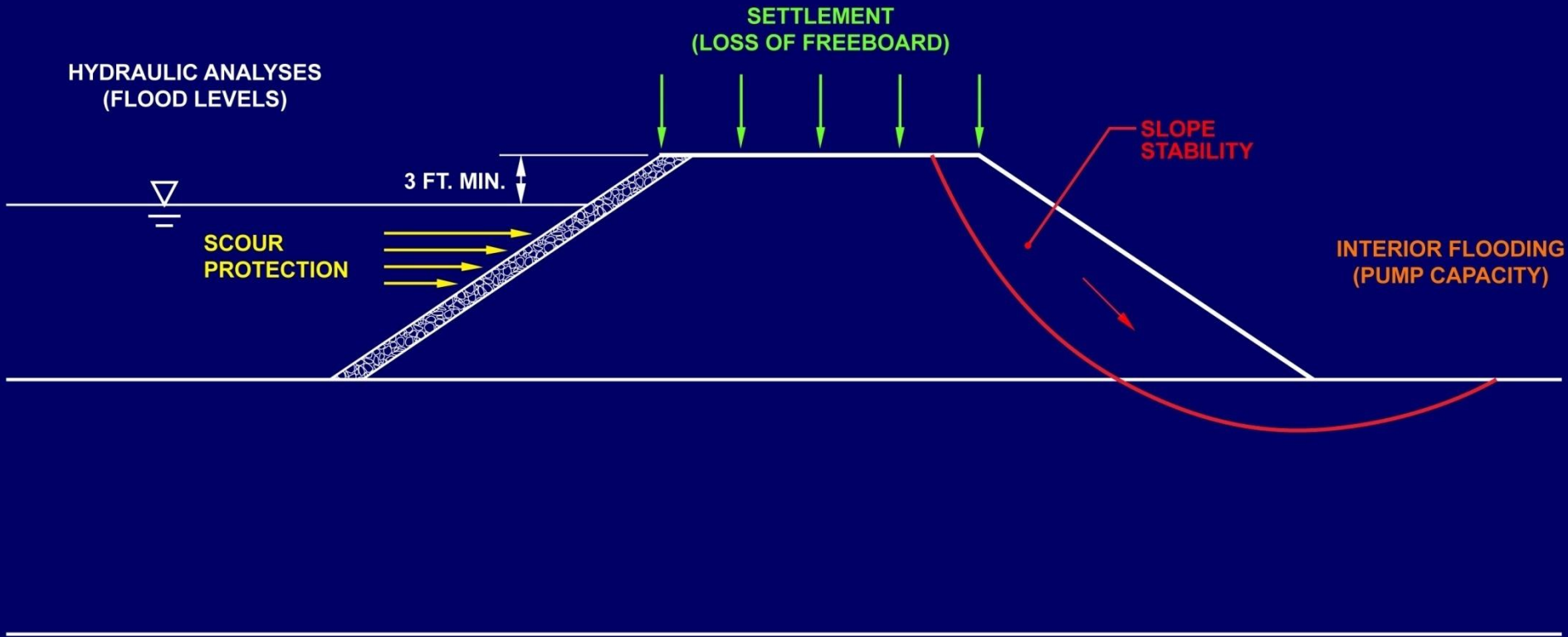
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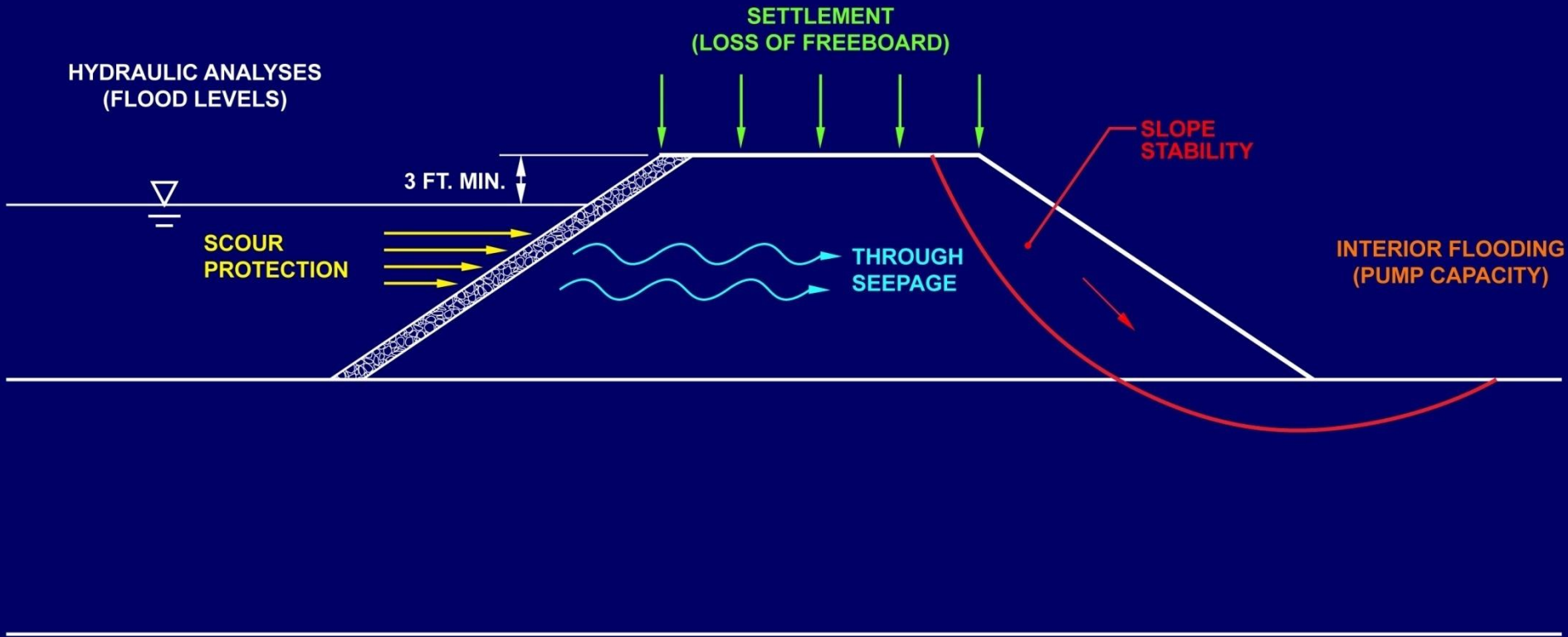
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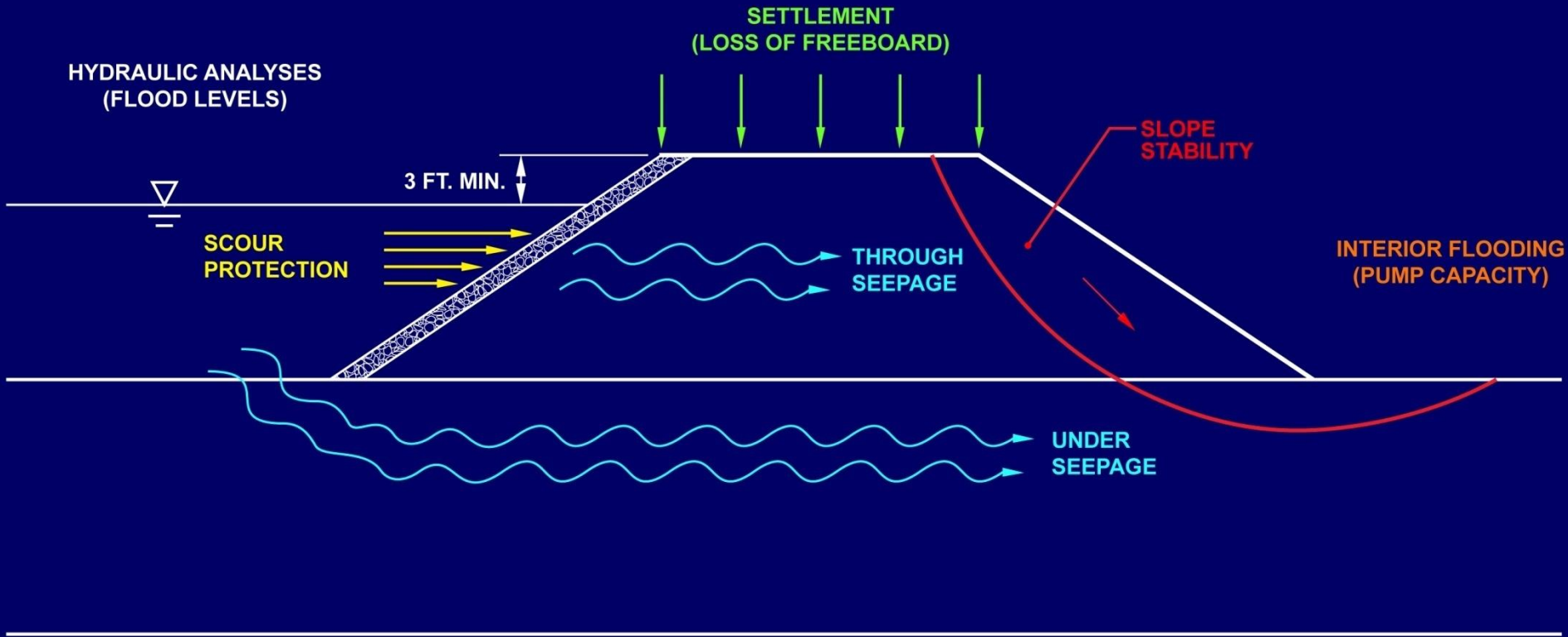


# 44 CFR 65.10 CERTIFICATION REQUIREMENTS





# 44 CFR 65.10 CERTIFICATION REQUIREMENTS



# PEN 1

## Site Investigation

- 57 Borings Total
- Crest, riverward and landward side toes
- Set of borings every ~1,000 feet
- 44 borings on land, 13 over water
- Depths ranged from 20 to 100 feet
- Falling head permeability tests
- SPT's and undisturbed samples every 5 ft
- Not able to access railroad embankment



02/25/2014

# PEN 2

## Site Investigation

- 74 Borings Total
- Crest, riverward and landward side toes
- Set of borings every ~1,000 feet
- 51 borings on land, 23 over water
- Falling head permeability tests
- Depths ranged from 20 to 90 feet
- SPT's and undisturbed samples every 5 ft





OREGON MARINE CONSTRUCTION

OR 276 178

# Site Geology

- Embankment fill underlain by Columbia River Alluvium
- Fill: Loose sandy silt/silty sand, to soft clayey silt
- Fill Sources: Dredged, railroad cuts, district interior
- Alluvium: Loose, interlayered, sandy silt/silty sand, and soft, clayey silt
- Dense gravels under soft alluvium

# Lab Testing Program

- Natural water content
- Grain size and plasticity (Atterberg limits)
- Unit weights
- Consolidation
- Strength tests – TxCU & Direct Shear (levee fill)
- Strength tests – TxCU (foundation soils)



# PEN 1 Soil Parameters

- Embankment Fill
  - Unit Weight: 102 to 119 pcf
  - Coef. of Consolidation: 2,600 ft<sup>2</sup>/yr
  - Strength:  $\phi' = 32$  degrees to 36 degrees
- Alluvium
  - Unit Weight: 94 to 121 pcf
  - Coef. of Consolidation: 2,400 ft<sup>2</sup>/yr
  - Strength:  $\phi' = 32$  degrees,  $c' = 50$  psf

# PEN 2 Soil Parameters

- Embankment Fill
  - Unit Weight: 107 to 116 pcf
  - Coef. of Consolidation: 2,700 ft<sup>2</sup>/yr
  - Strength:  $\phi' = 33$  degrees to 37 degrees
- Alluvium
  - Unit Weight: 93 to 118 pcf
  - Coef. of Consolidation: 2,400 ft<sup>2</sup>/yr
  - Strength:  $\phi' = 30$  to 32 degrees,  $c' = 50$  psf