



Reference:

Loren R. Anderson. 2554. เอกสารประกอบการอบรม "การวิเคราะห์เพื่อออกแบบและประเมินความปลอดภัยเขื่อน", ระหว่างวันที่ 5,7 และ 8 เมษายน 2554, จัดโดย ศูนย์วิจัยและพัฒนาวิศวกรรมปฐพีและฐานรากมหาวิทยาลัยเกษตรศาสตร์ ร่วมกับ Thai Geotechnical Society (TGS), ณ โรงแรมมิราเคิล แกรนด์ คอนเวนชั่น, กรุงเทพฯ.

Internal Erosion Best Practices Toolbox – Initiating Mechanisms

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Risk and Reliability DX

14 May 2009



Internal Erosion “Best Practices” Toolbox

Risk Analysis for Dam Safety

A Unified Method for Estimating Probabilities of Failure of
Embankment Dams by Internal Erosion and Piping
Guidance Document
Version: Delta, Issue 2
August 2008

Reclamation Document:
Corps of Engineers Document:
URS Document:
UNSW Document:

Risk Analysis Methodology – Appendix E
UFC
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INTERNAL EROSION TOOLBOX

A Method for Estimating Probabilities of Failure of
Embankment Dams due to Internal Erosion

Best Practices Guidance Document

13 May 2009



Generic Internal Erosion Event Tree

↳ Initiation (28 mechanisms)

- Flaw Exists
- Erosion begins

↳ Continuation

- Unfiltered or inadequately filtered exit exists

↳ Progression

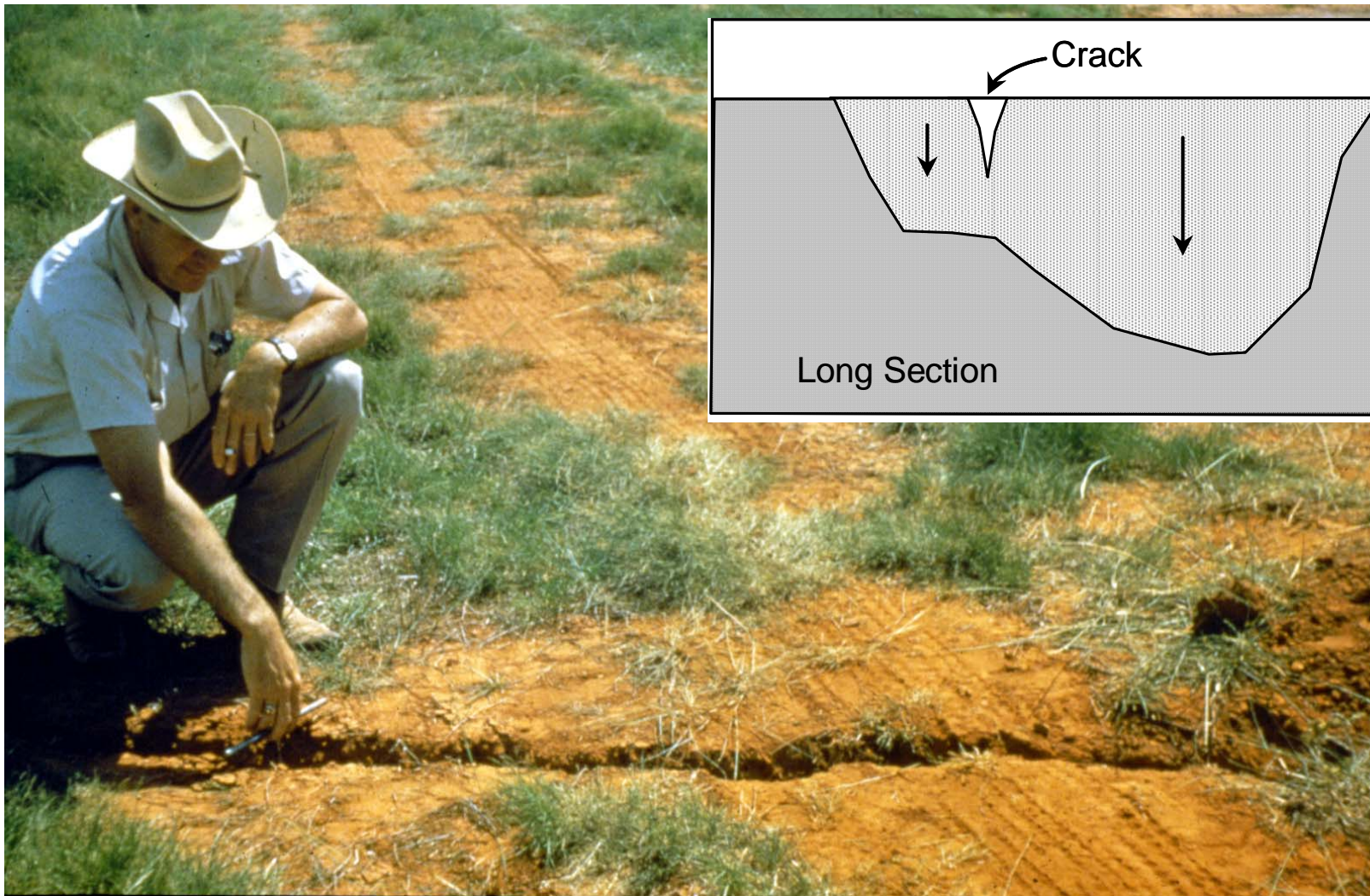
- Roof forms to support a pipe
- Upstream zone fails to fill crack
- Upstream zone fails to limit flows

↳ Intervention fails (omit from SRP)

↳ Dam breaches (4 mechanisms)

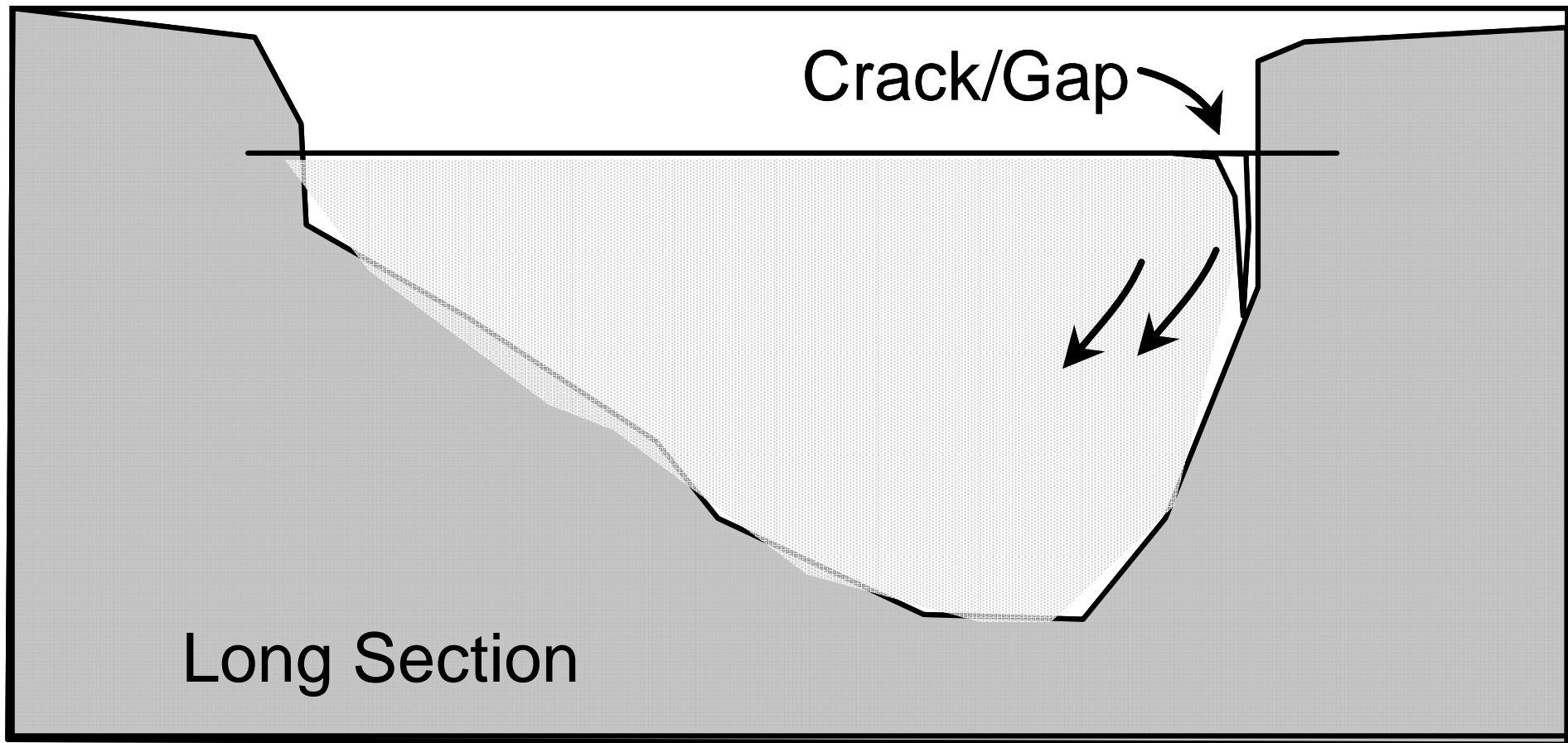


IM1 – Transverse Cracks in the Embankment due to Cross Valley Differential Settlement



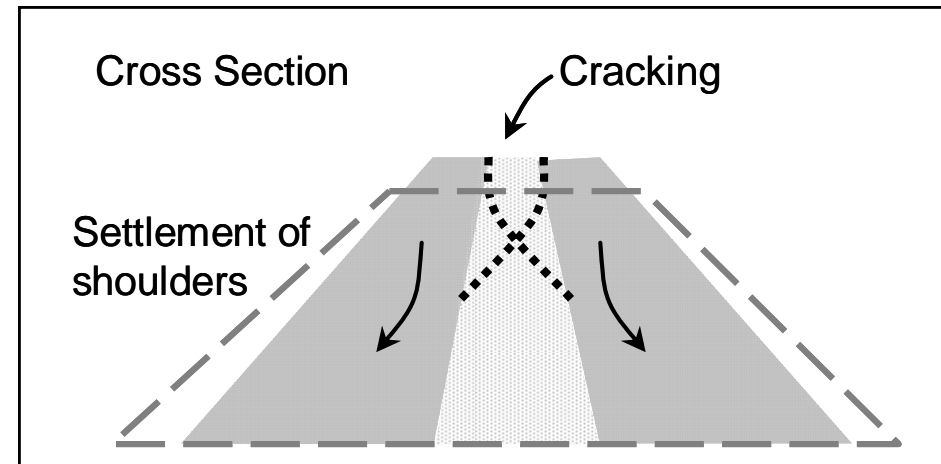


IM2 – Transverse Cracks in the Embankment due to Differential Settlement adjacent to a Cliff at the Top of the Embankment





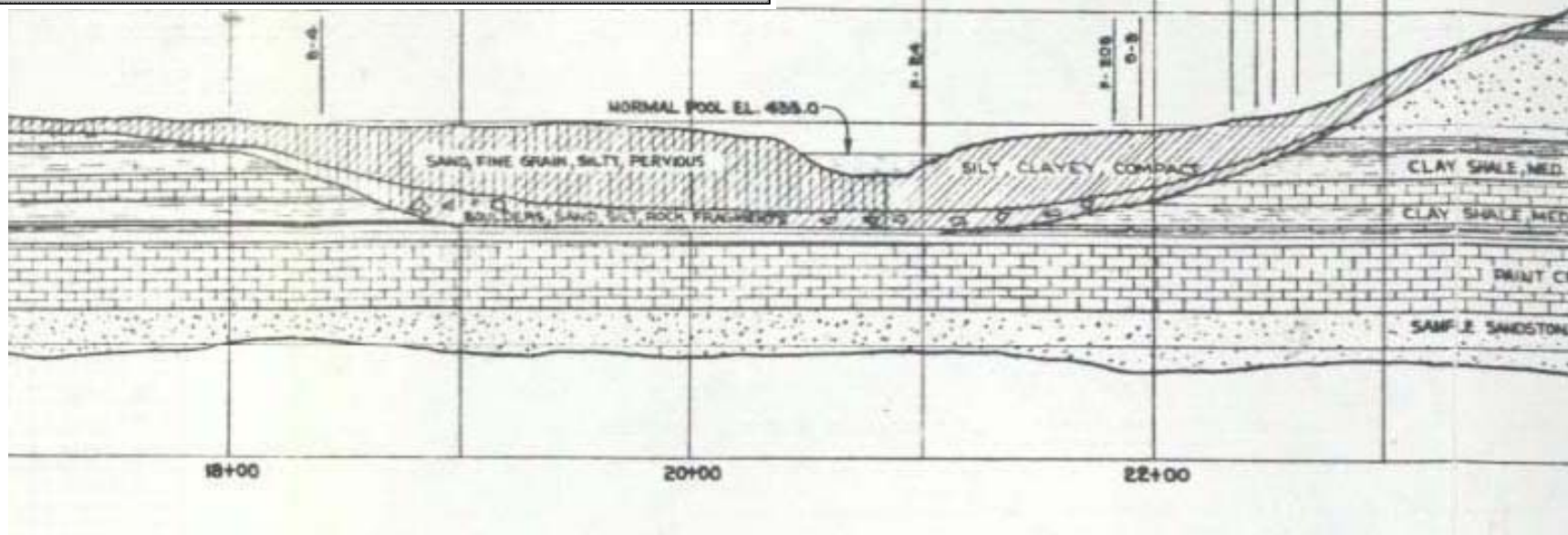
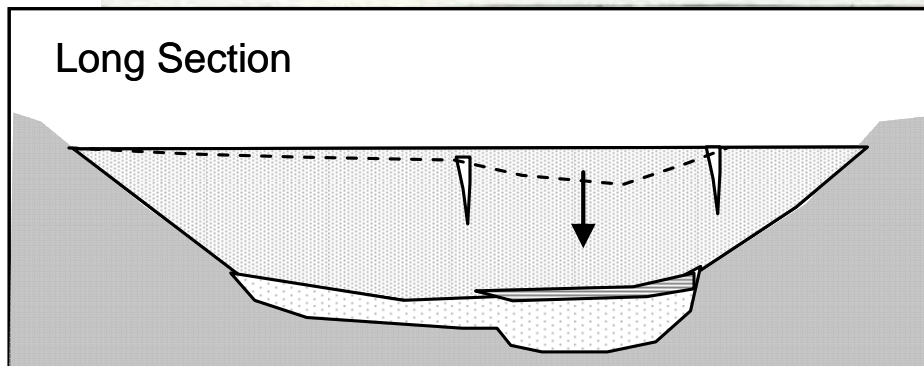
IM3 – Transverse Cracks in the Embankment due to Cross Section Settlement due to Poorly Compacted Shoulders



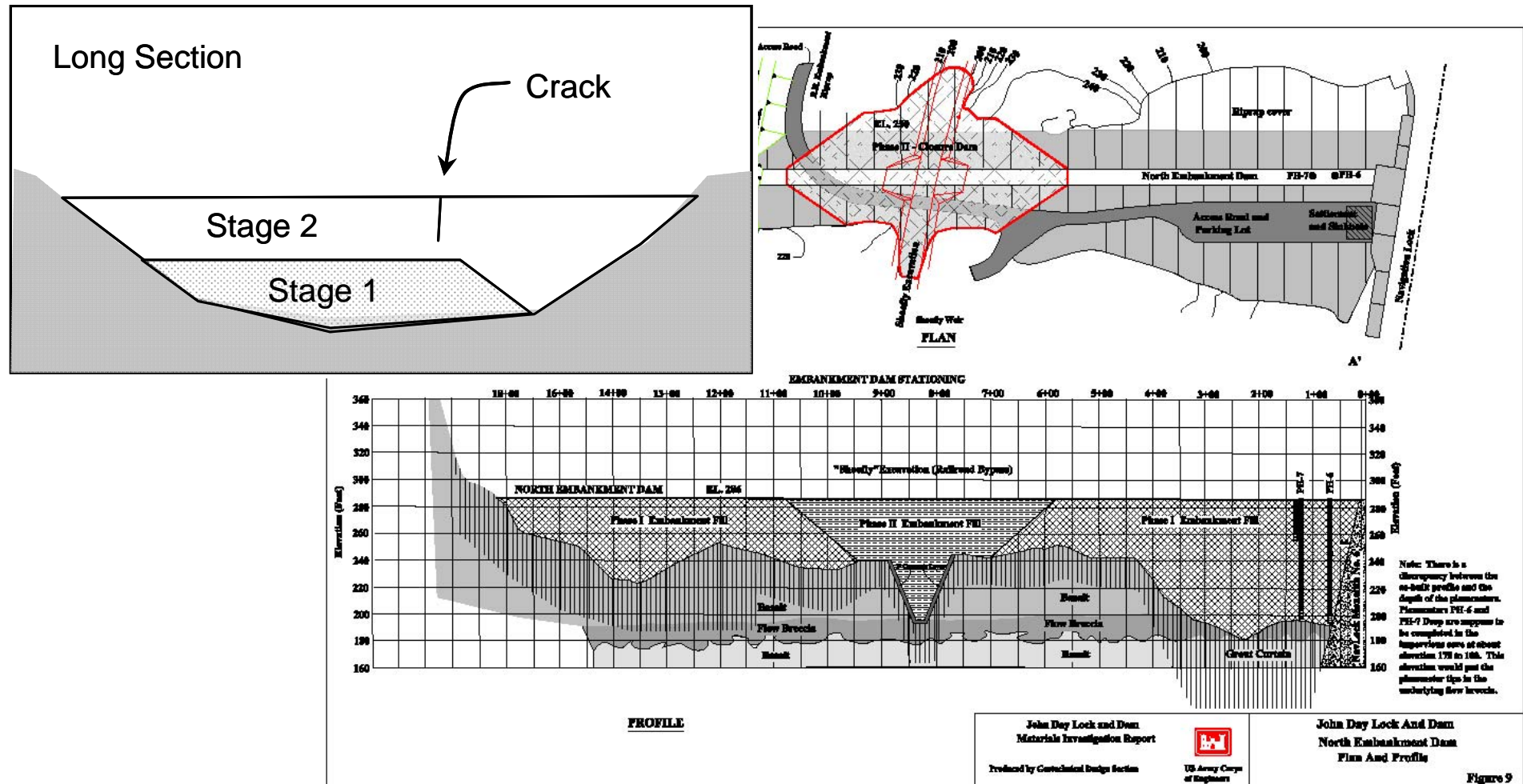
- Note: The longitudinal cracks on both shoulders must intersect to provide a “transverse” crack from upstream to downstream across the core.



IM4 – Transverse Cracks in the Embankment due to Differential Settlement in the Soil Foundation beneath the Core

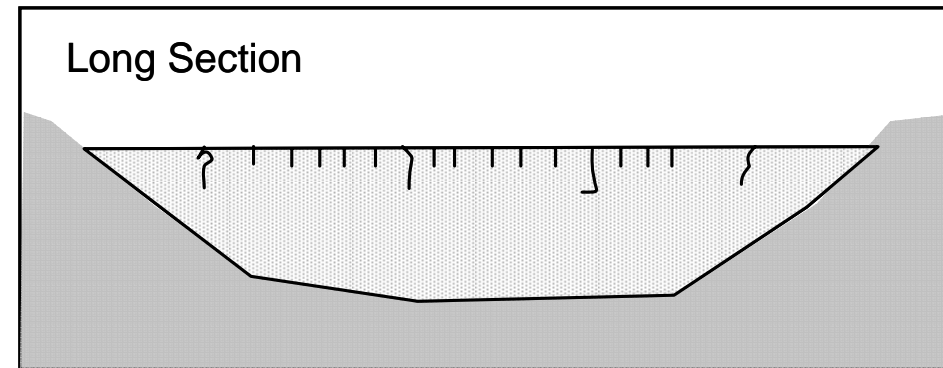


IM5 – Transverse Cracks in the Embankment due to Differential Settlement due to Embankment Staging





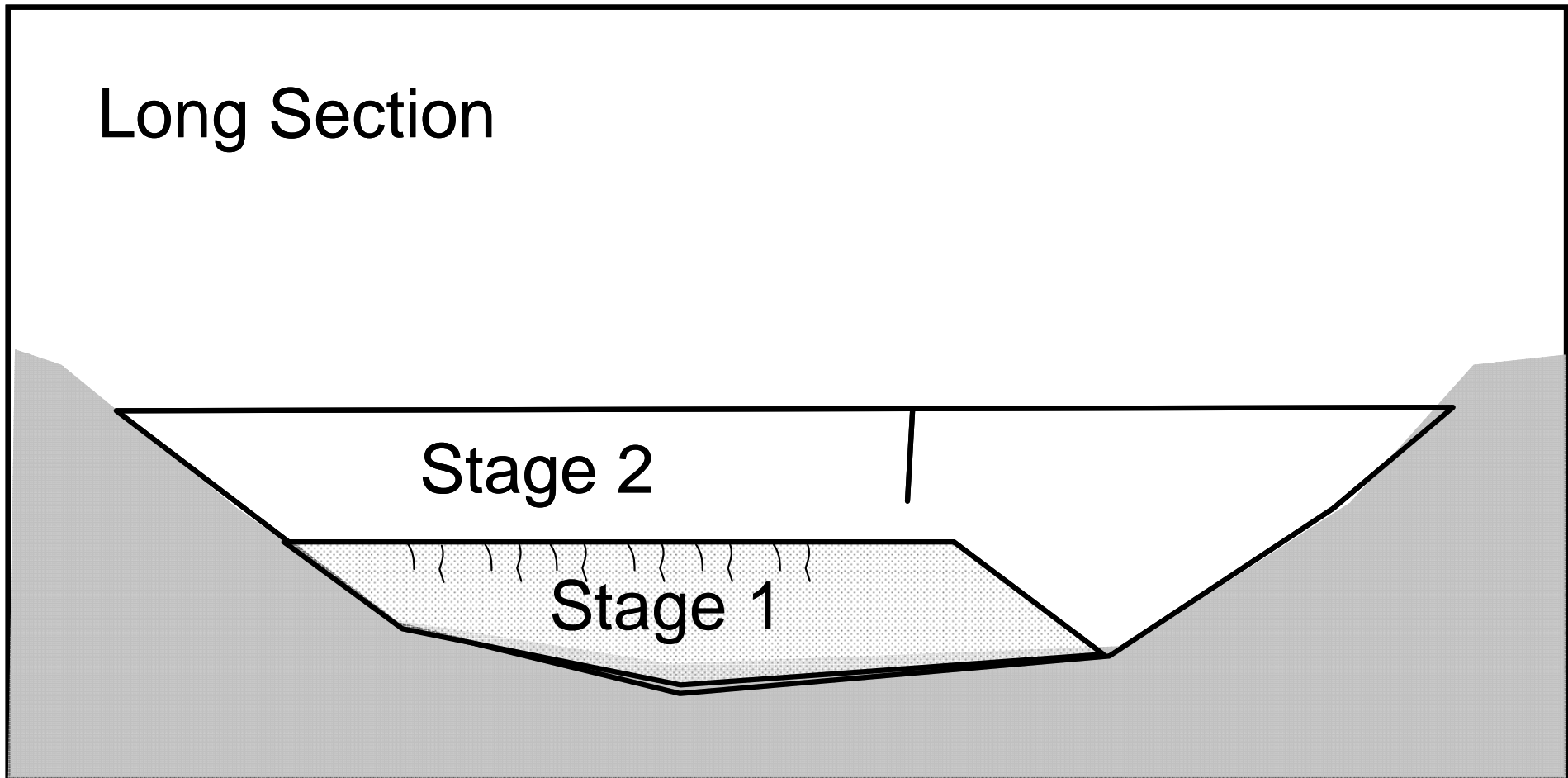
IM6 – Transverse Cracks in the Embankment due to Desiccation at the Crest of the Embankment





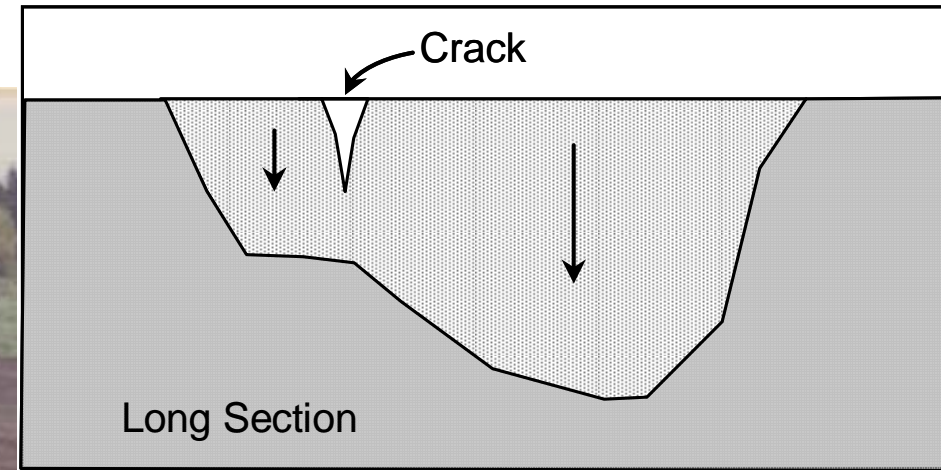
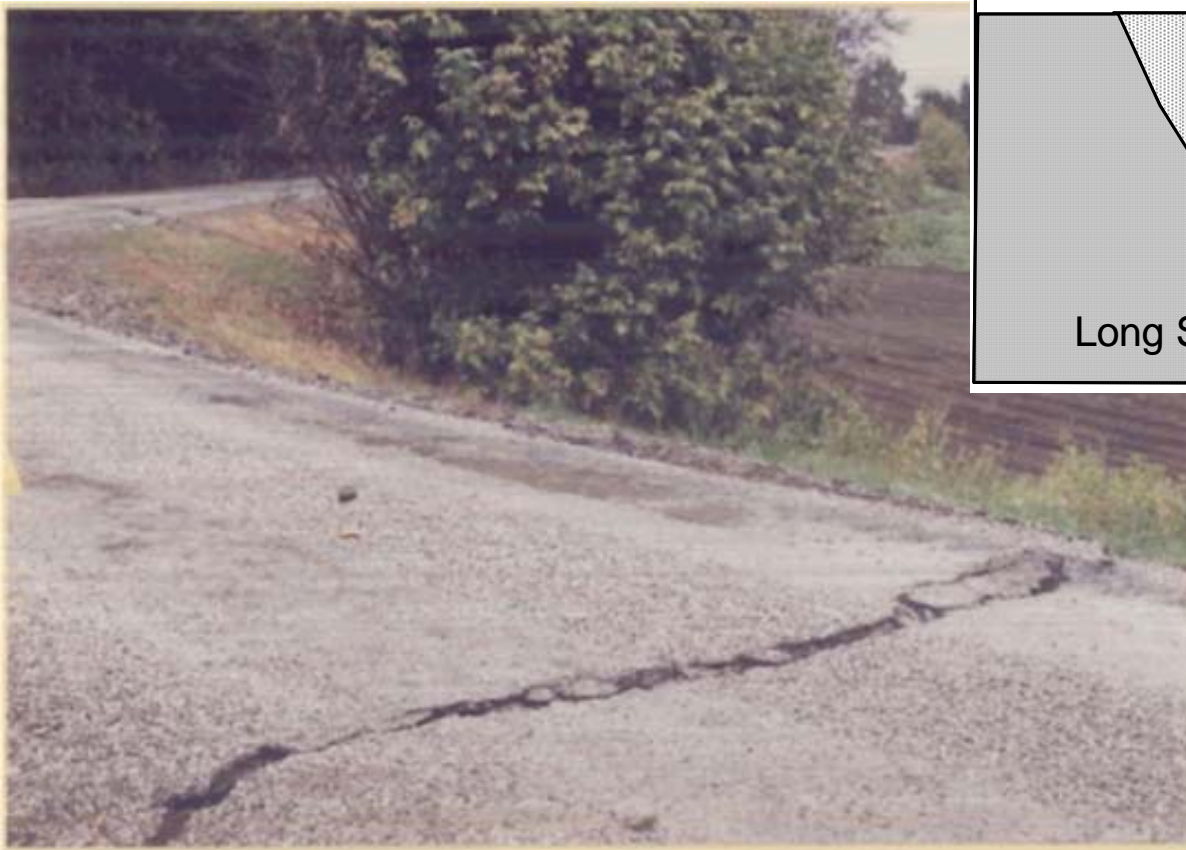
IM7 – Transverse Cracks in the Embankment due to Desiccation at Seasonal Shutdown Layers or Staged Construction Surfaces

Long Section



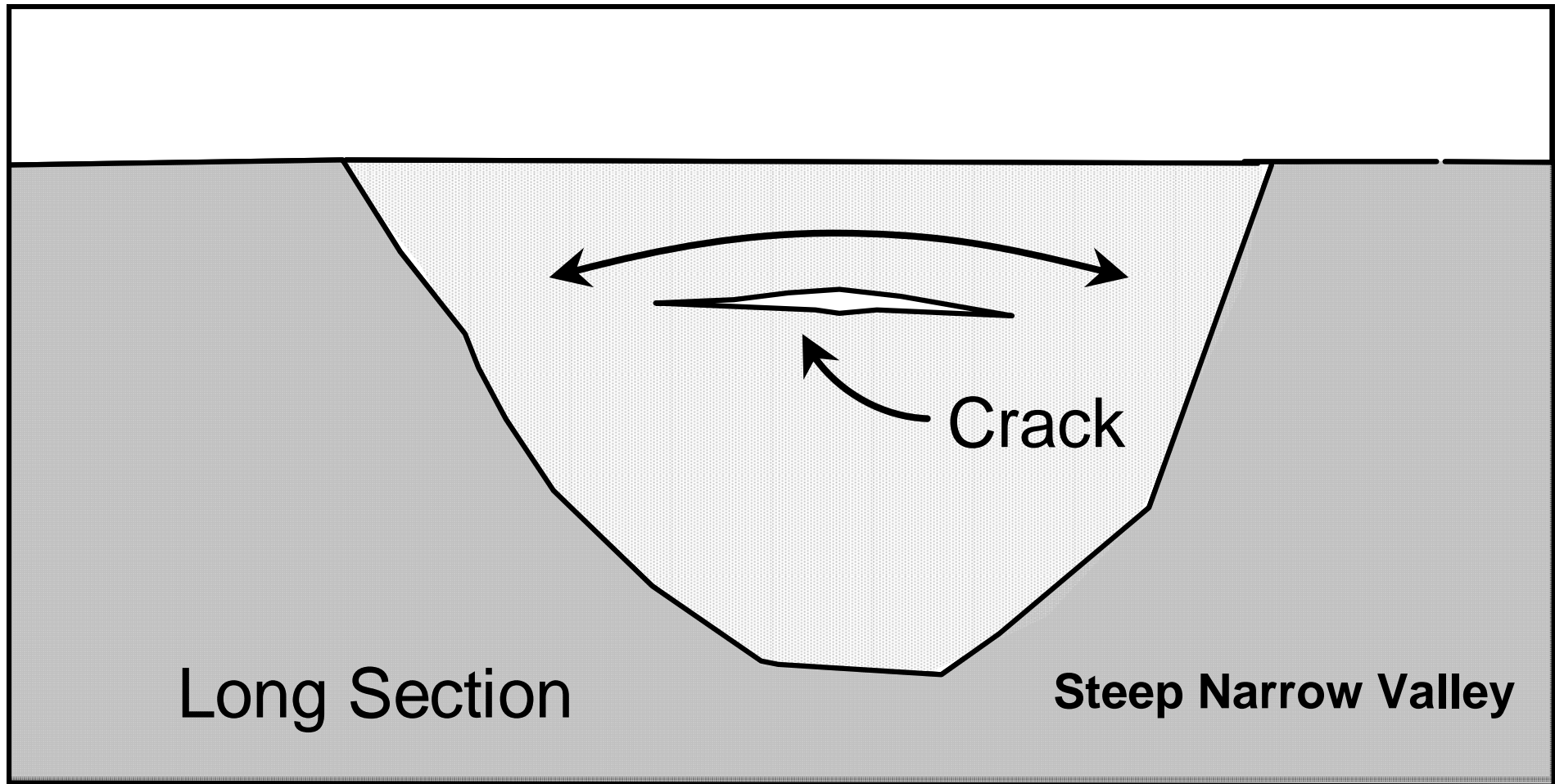


IM8 – Transverse Cracks in the Embankment due to Earthquake



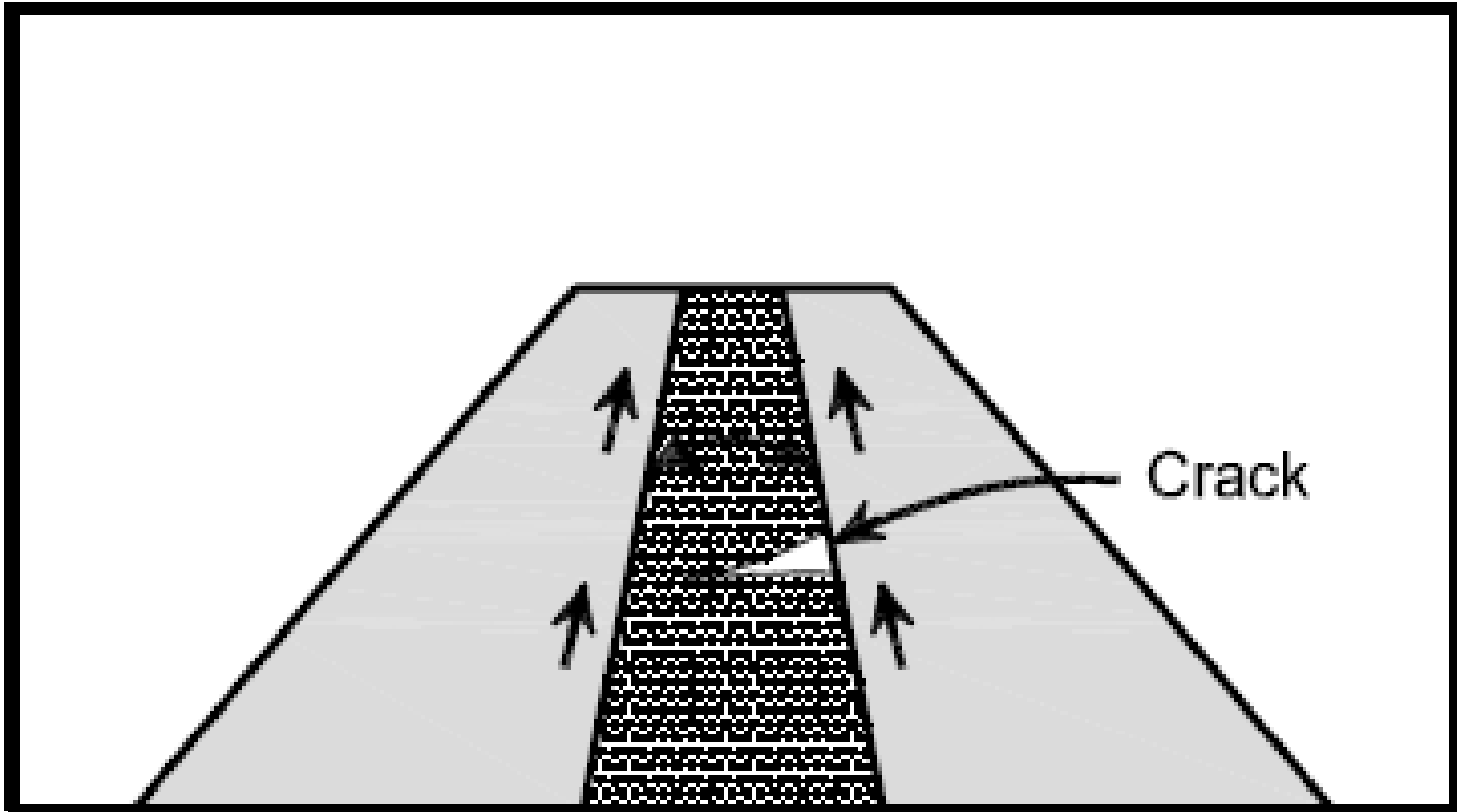


IM9 – Hydraulic Fractures in the Embankment due to Cross Valley Arching



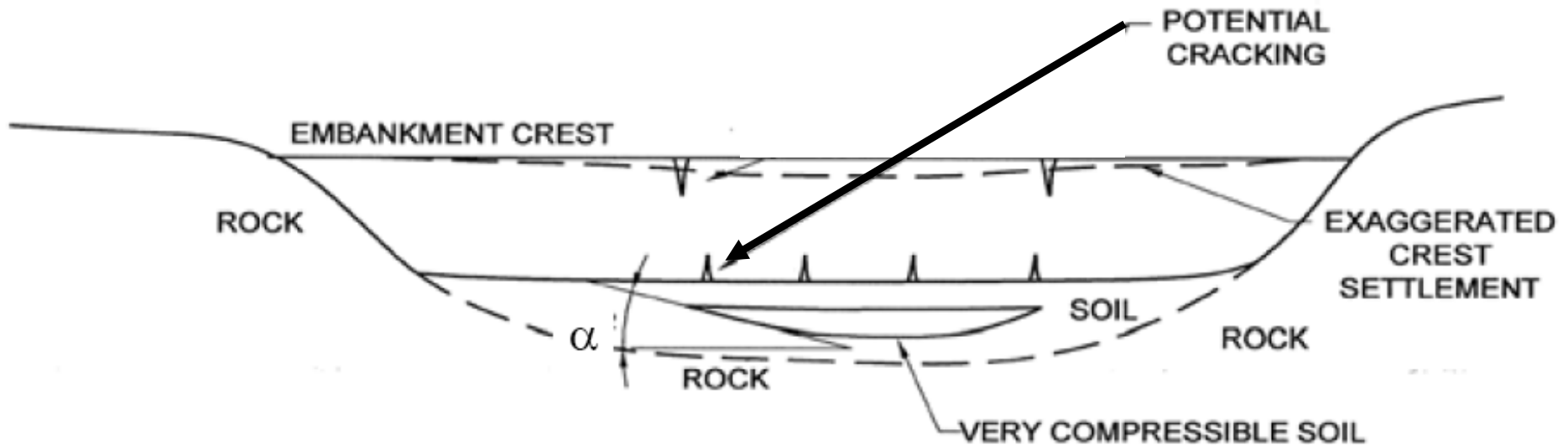


IM10 – Hydraulic Fracture in the Embankment due to Differential Settlement Causing Arching of the Core onto the Shoulders



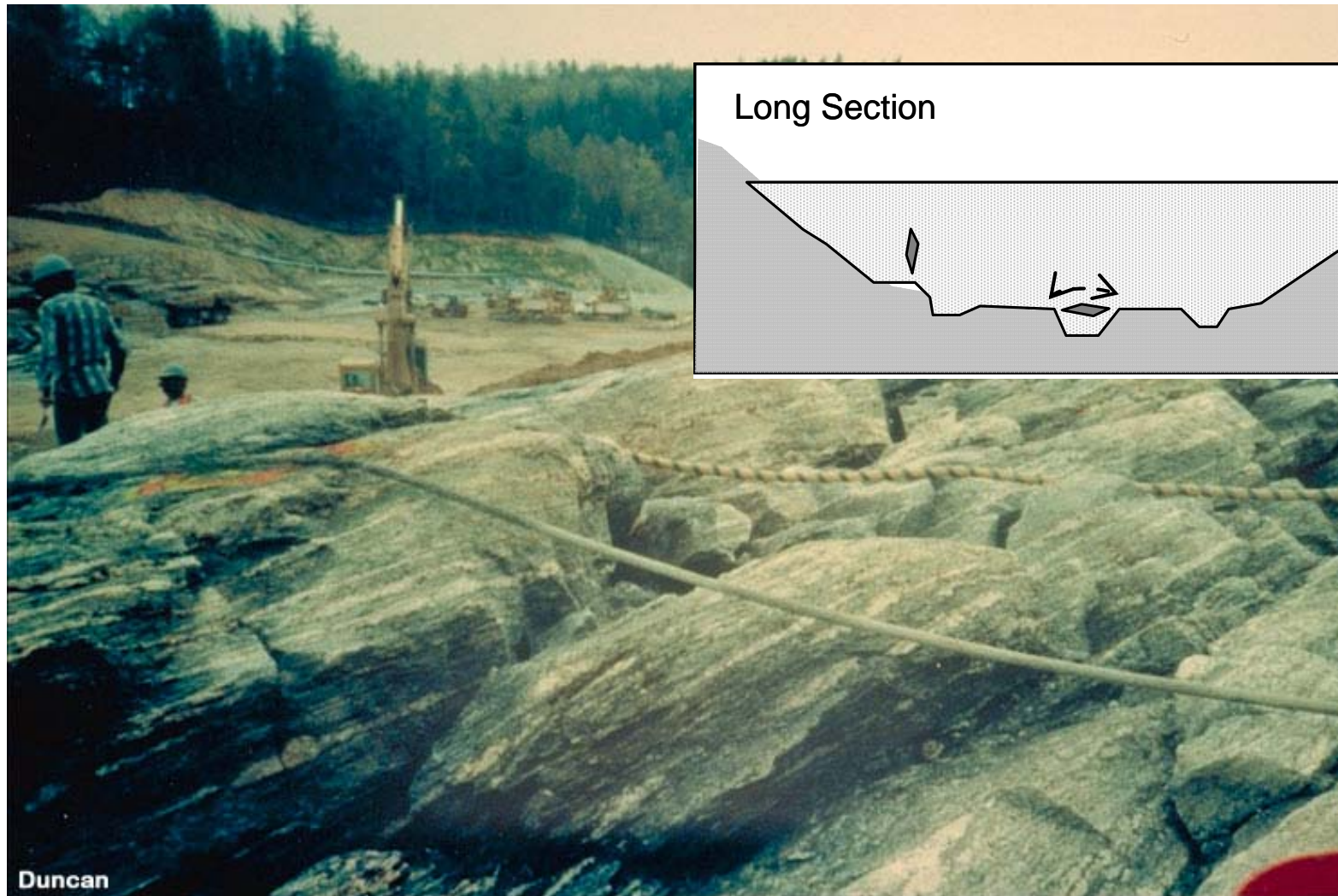


IM11 – Hydraulic Fractures in the Embankment due to Differential Settlement in the Soil Foundation



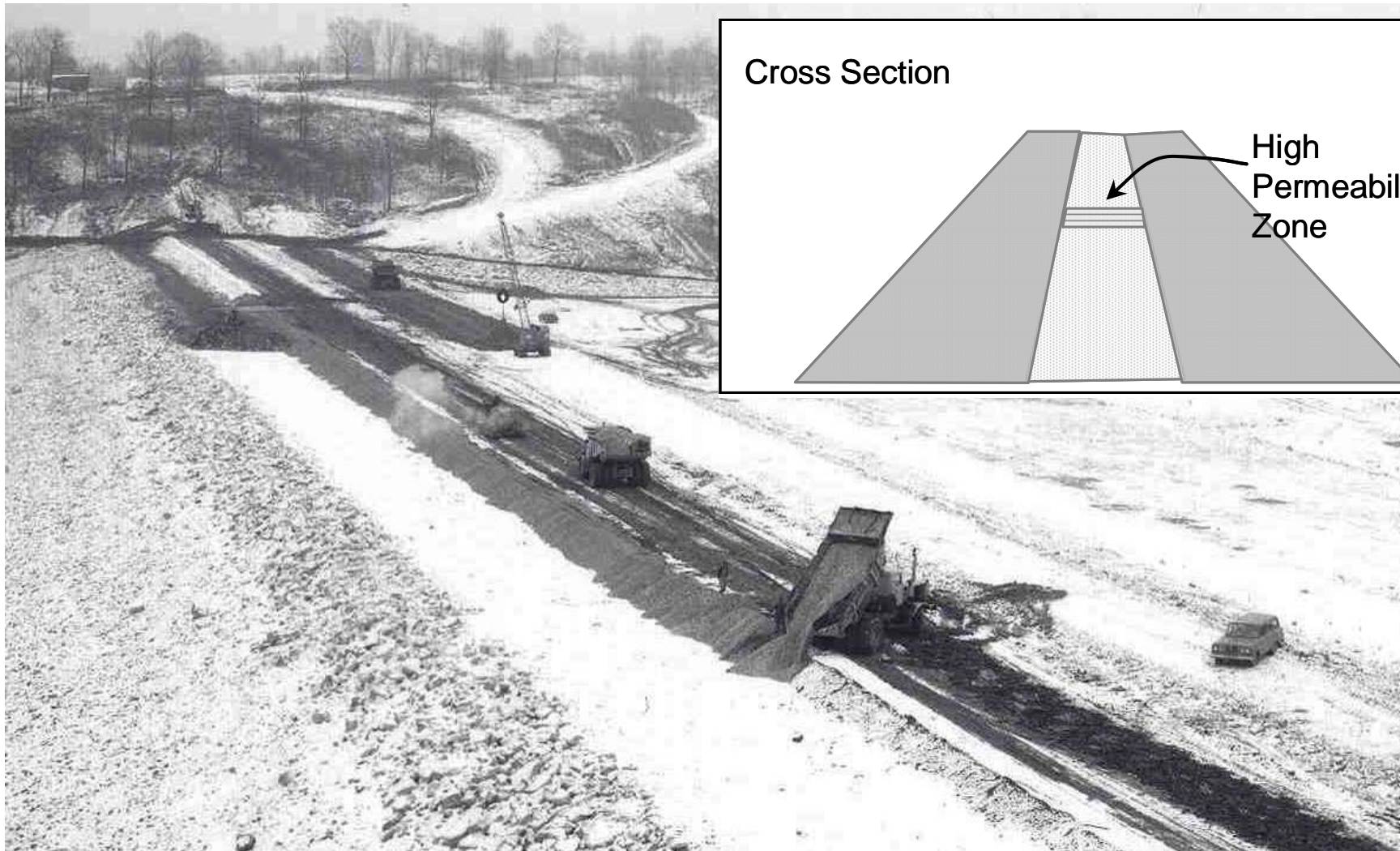


IM12 – Hydraulic Fractures in the Embankment due to Small-Scale Irregularities in the Foundation Profile beneath the Core

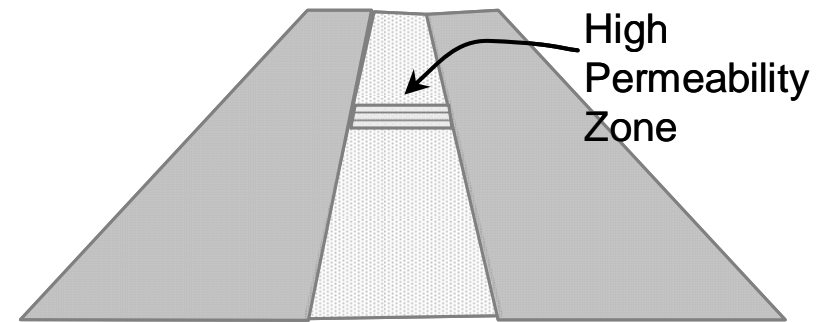




IM13 – Poorly Compacted or High Permeability Zones within the Embankment Core

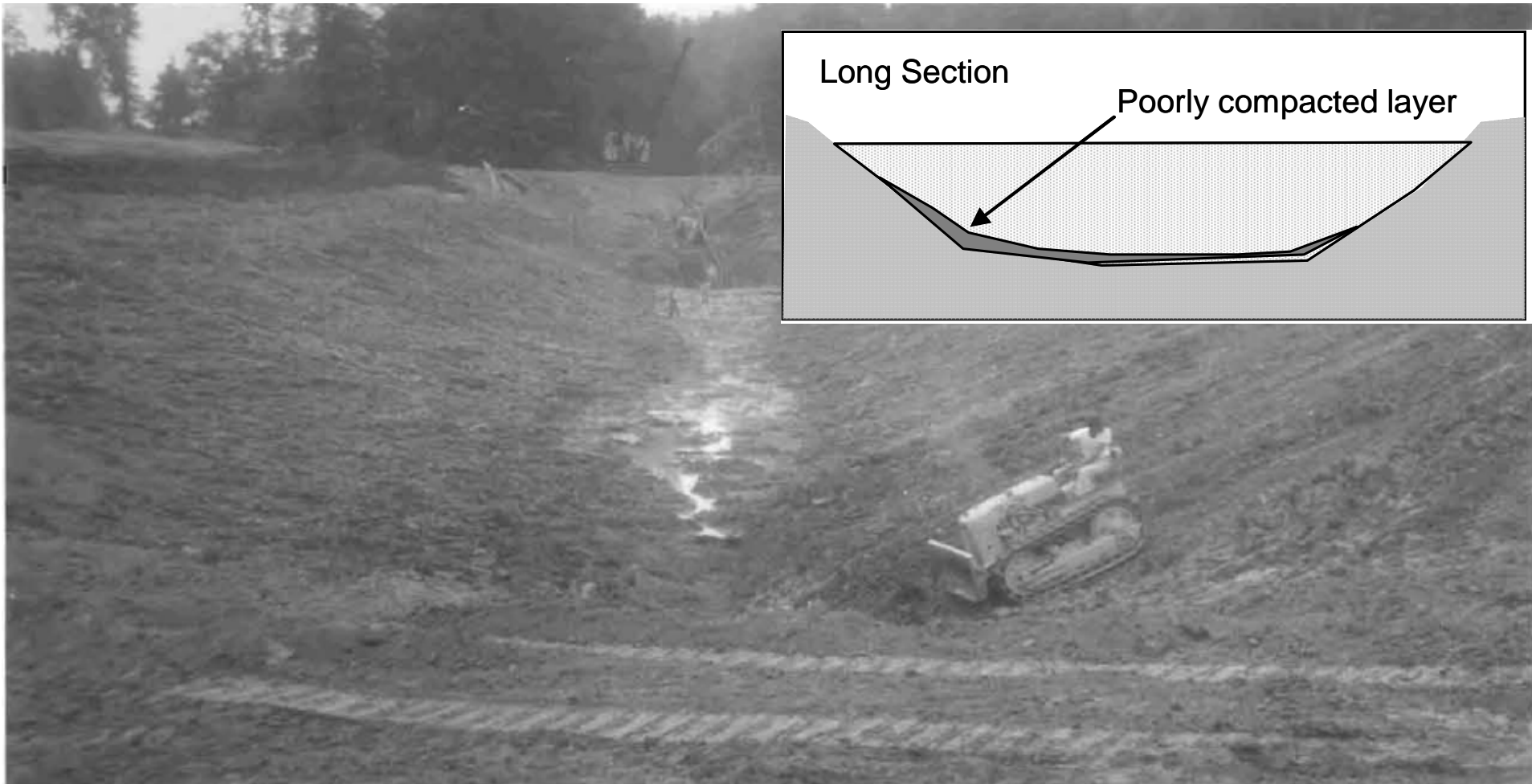


Cross Section



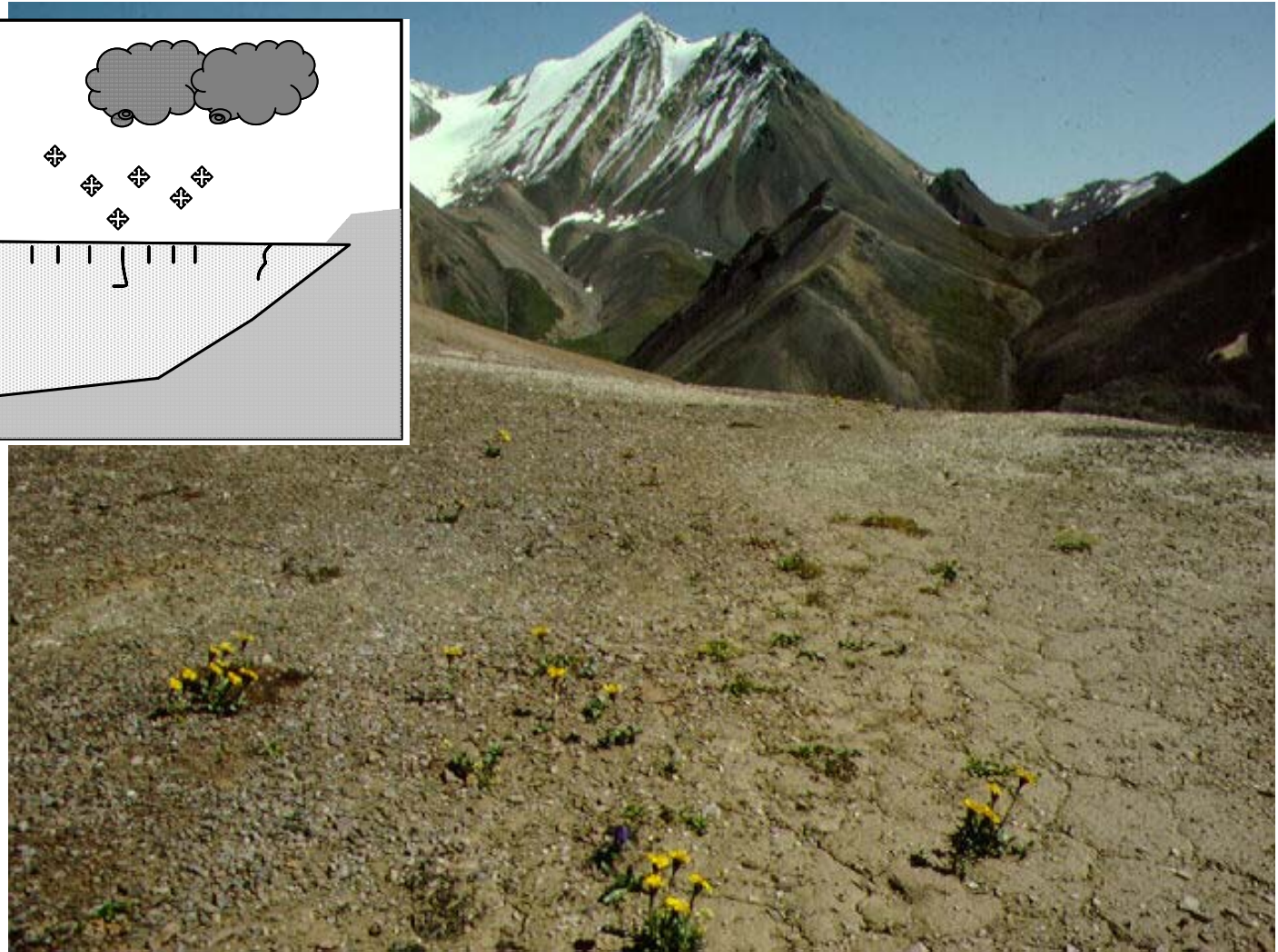
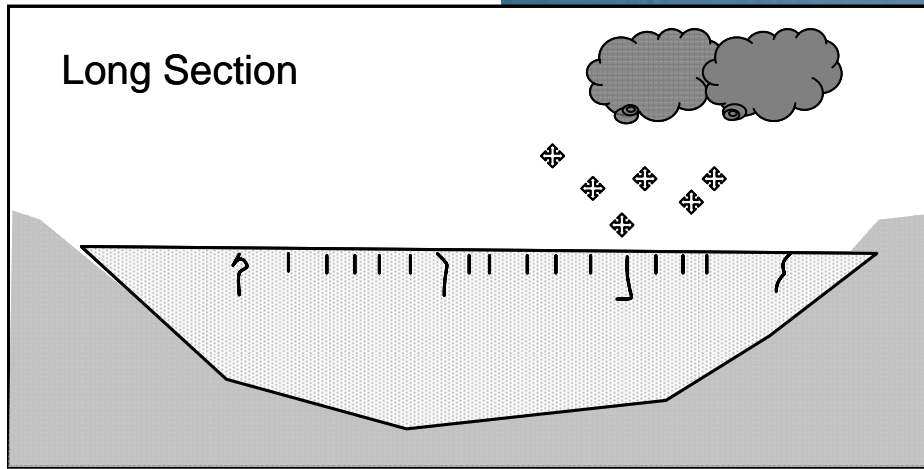


IM14 – Poorly Compacted or High Permeability Zones on the Core-Foundation/Abutment Contact



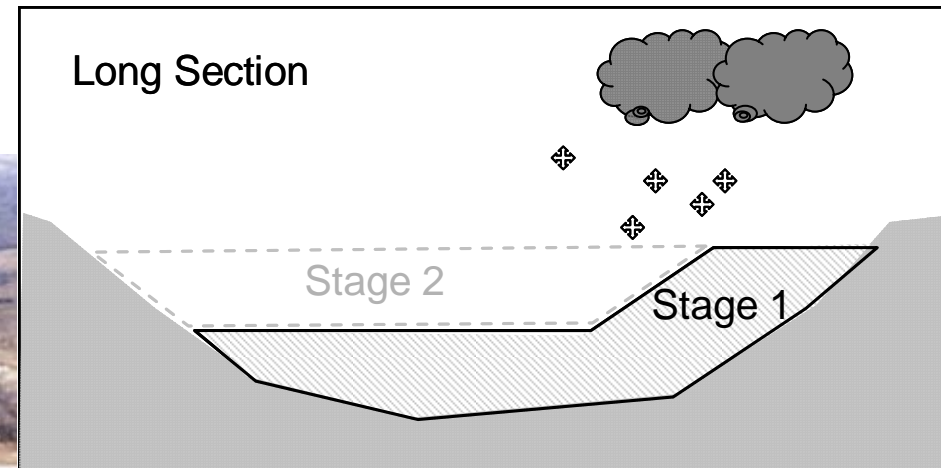


IM15 – High Permeability Zones due to Freezing at the Embankment Crest



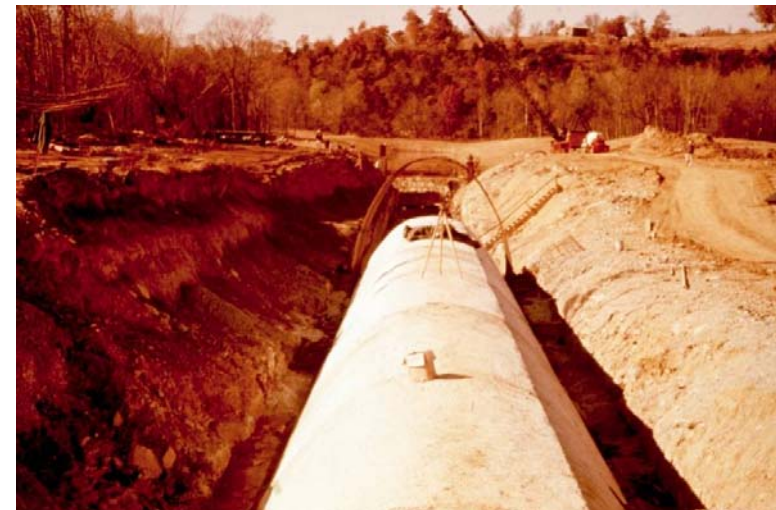
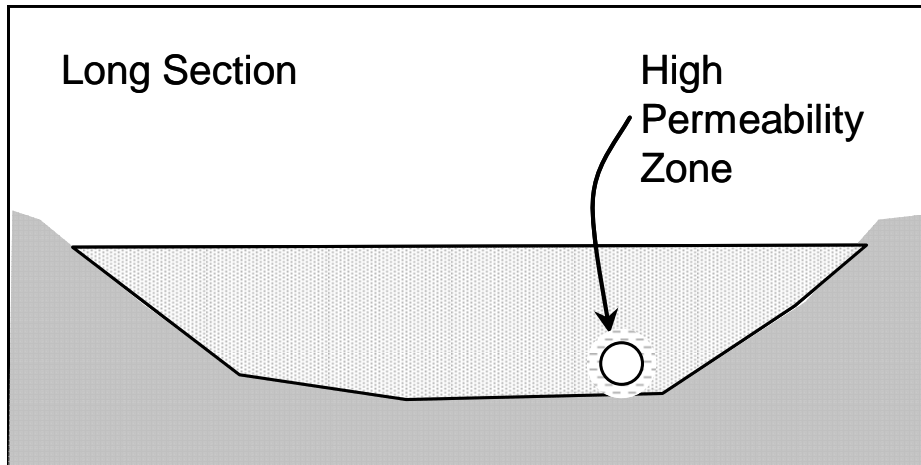


IM16 –High Permeability Zones due to Freezing on Seasonal Shutdown Layers or Staged Construction Surfaces



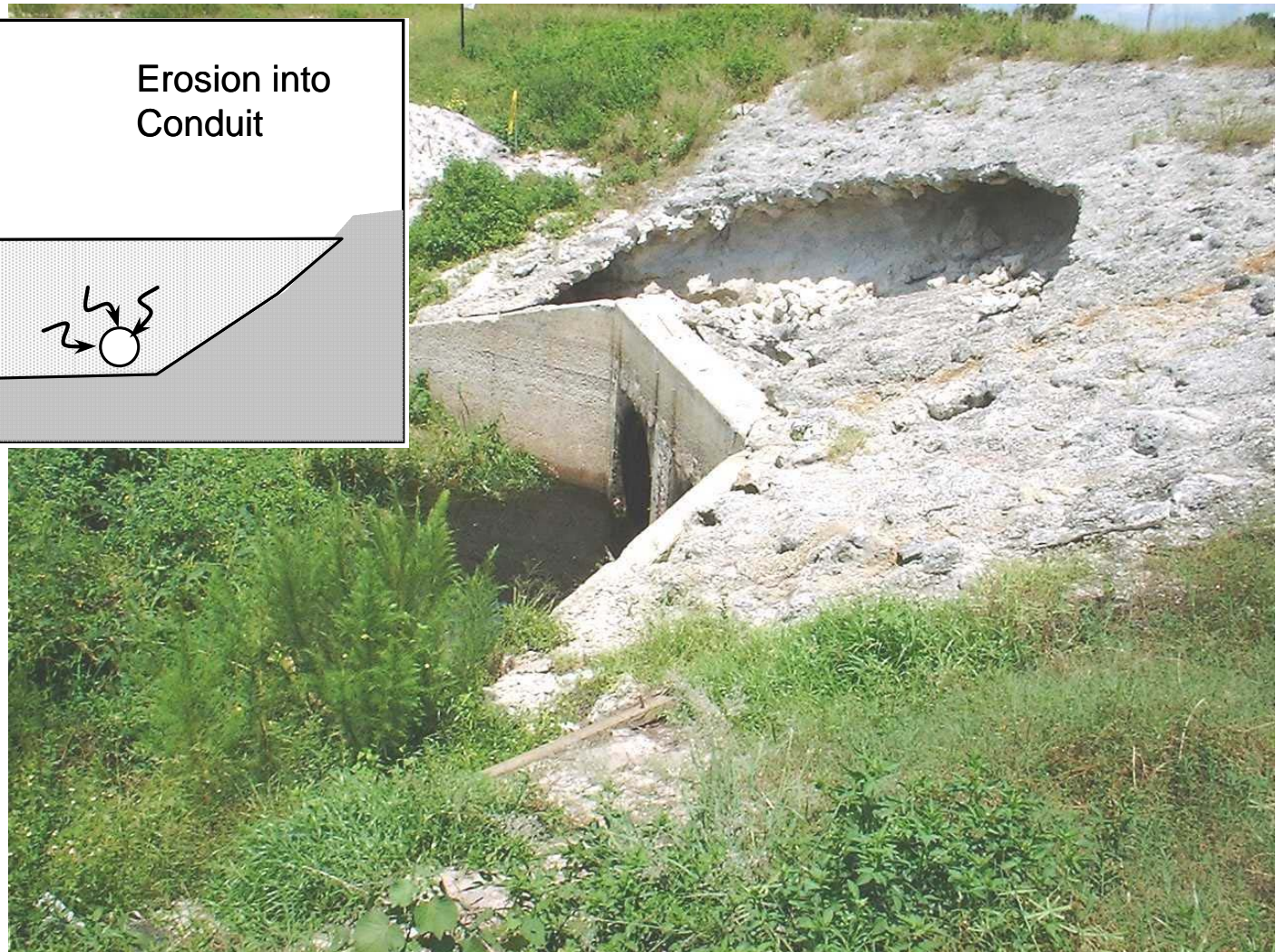
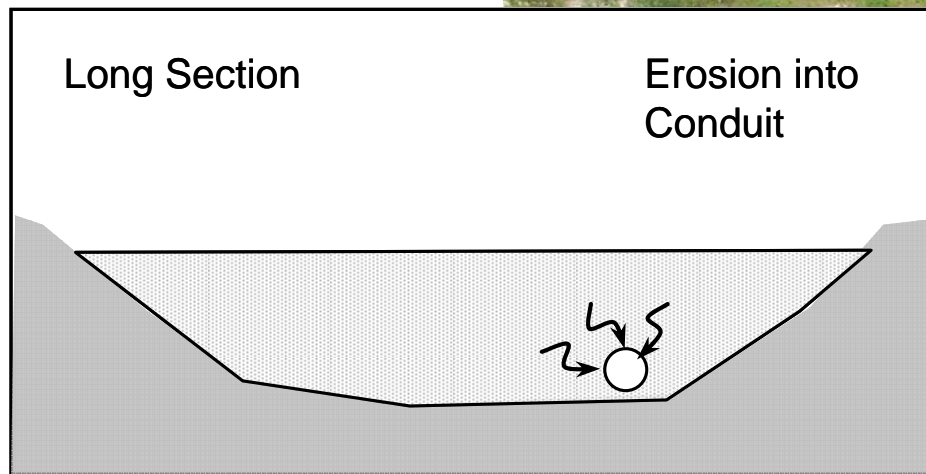


IM17 – Poorly Compacted or High Permeability Zones adjacent to a Conduit through the Embankment



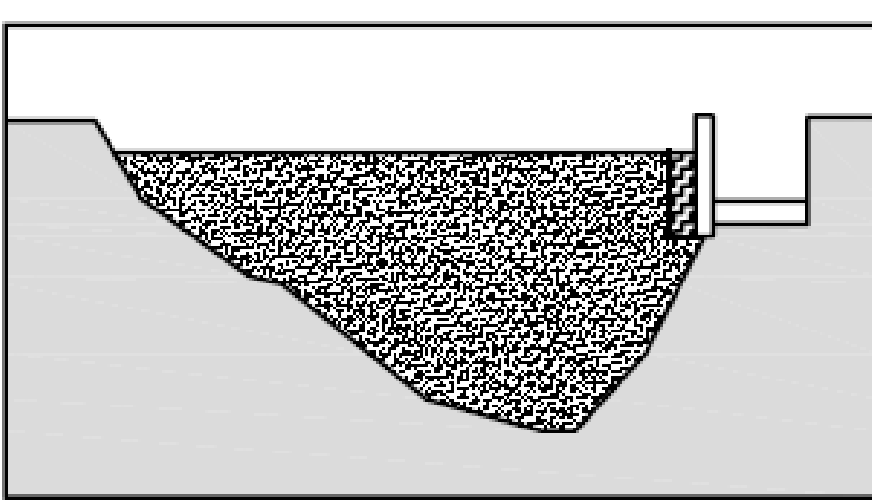


IM18 – Features Allowing Erosion into a Non-Pressurized Conduit



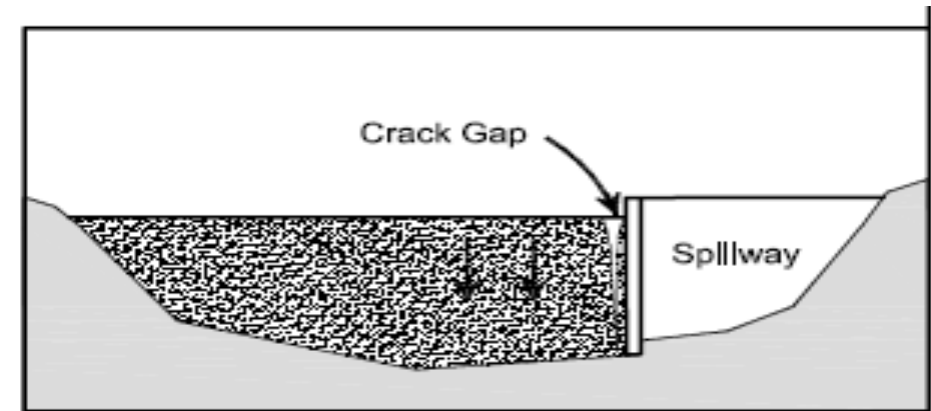
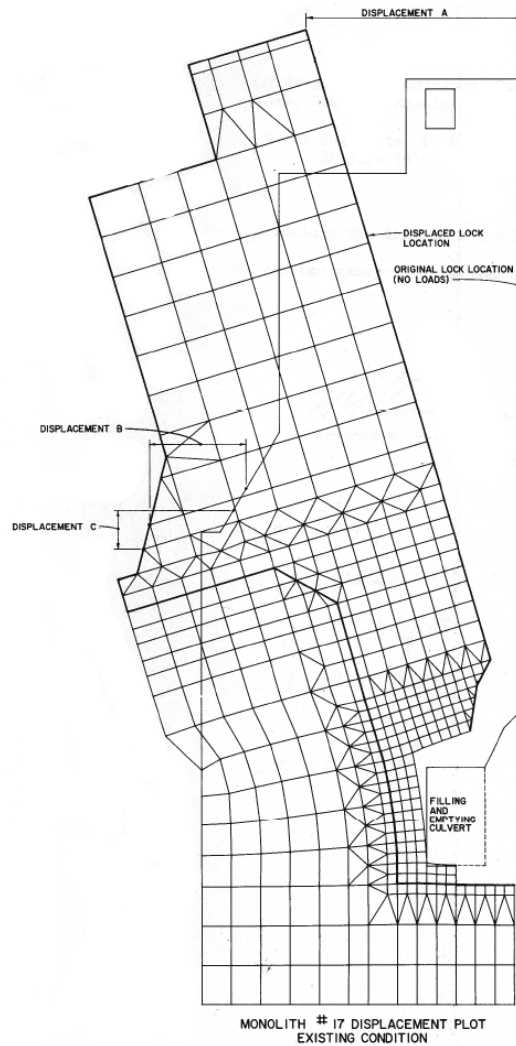


IM19 – Poorly Compacted or High Permeability Zones adjacent to a Spillway or Abutment Wall



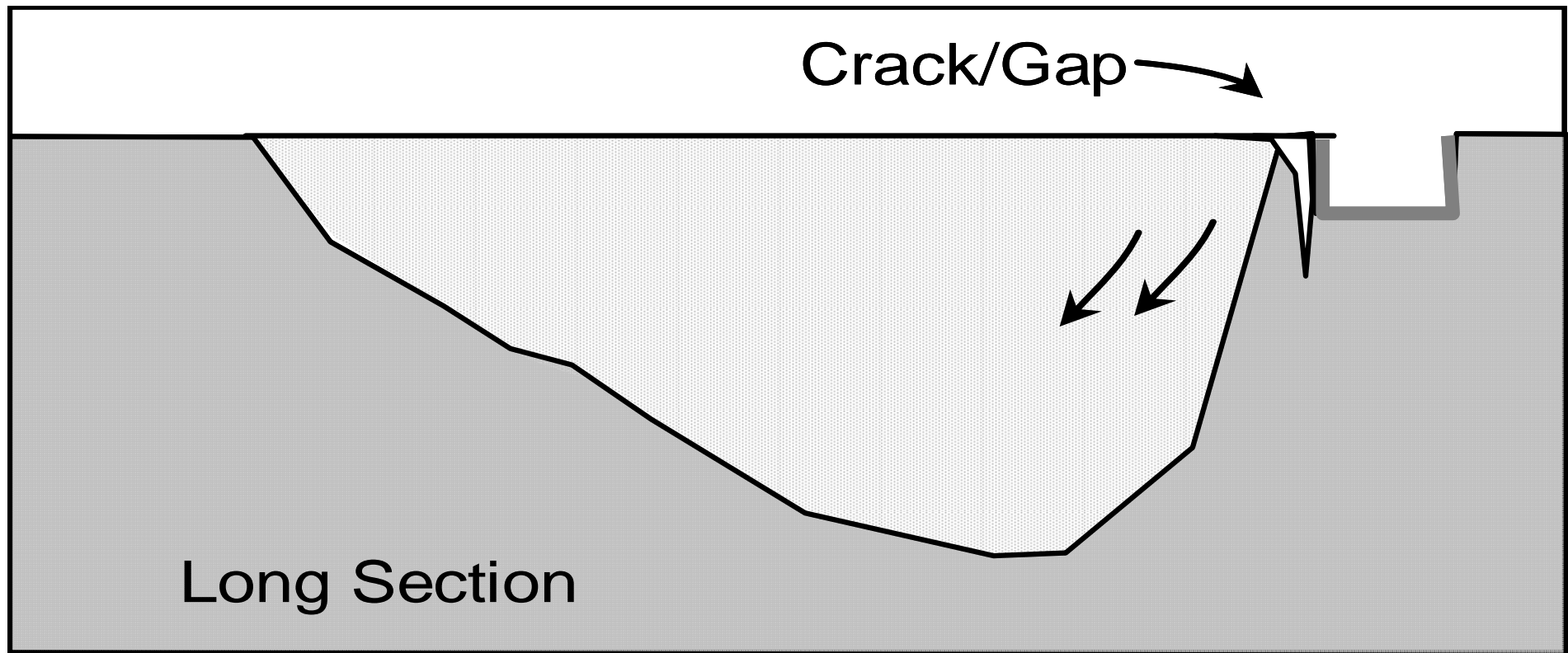


IM20 – Transverse Cracks in the Embankment due to Crack or Gap adjacent to a Spillway or Abutment Wall



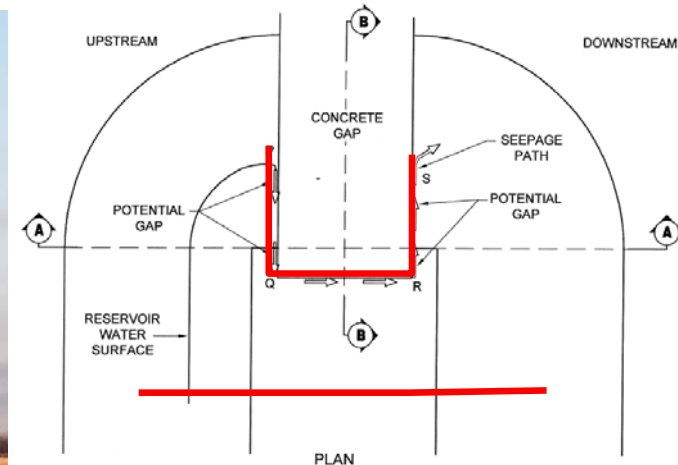


IM21 – Transverse Cracks in the Embankment due to Differential Settlement adjacent to a Spillway or Abutment Wall



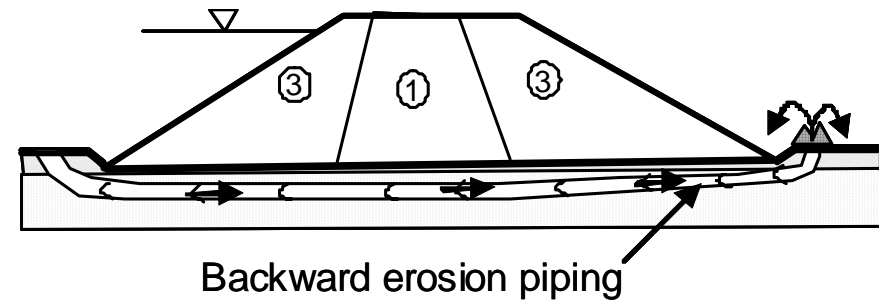


Special Considerations for Wrap-around Details for Connection of Embankment Dam to Concrete Gravity Dam (IM19 and IM21)



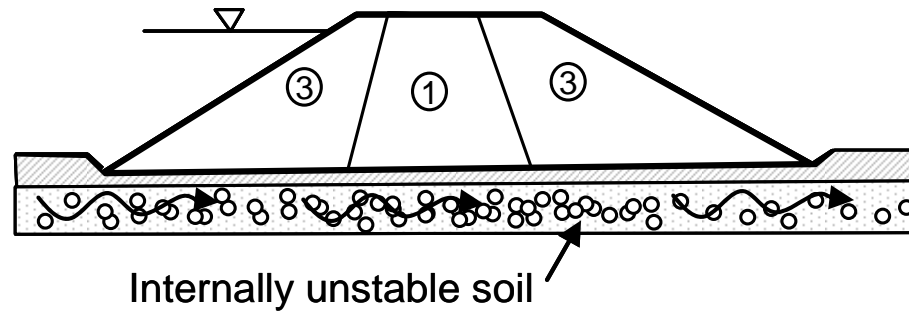


IM22 – Backward Erosion Piping in Cohesionless Soil Foundations



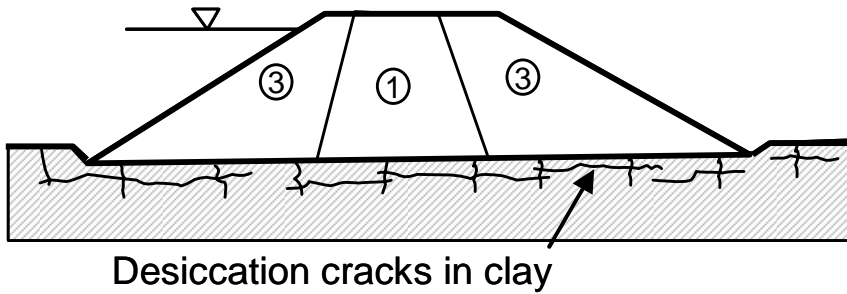


IM23 – Suffusion in Cohesionless Soil Foundations



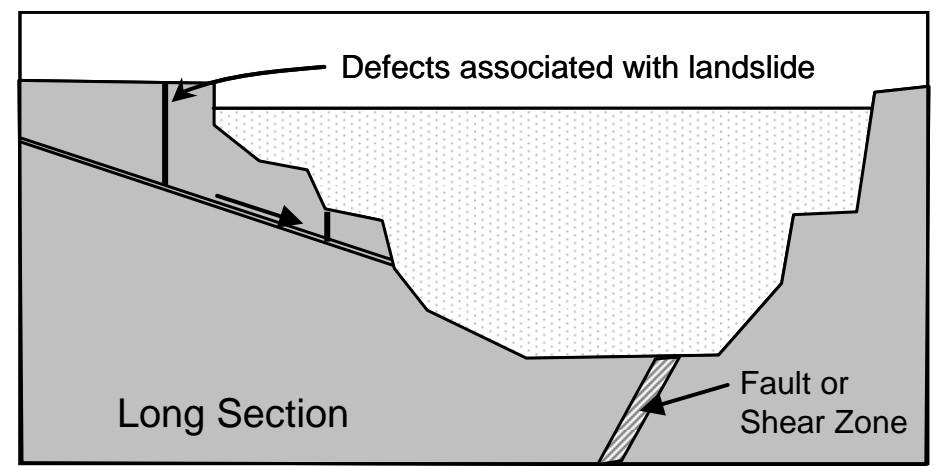
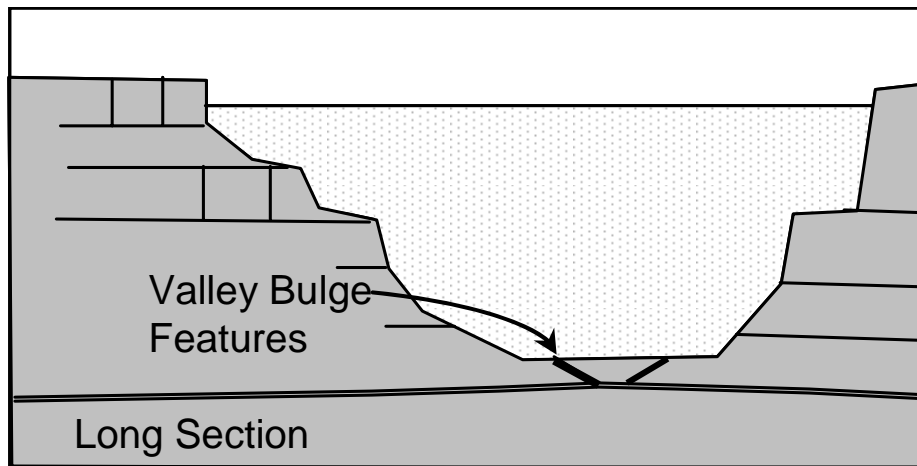
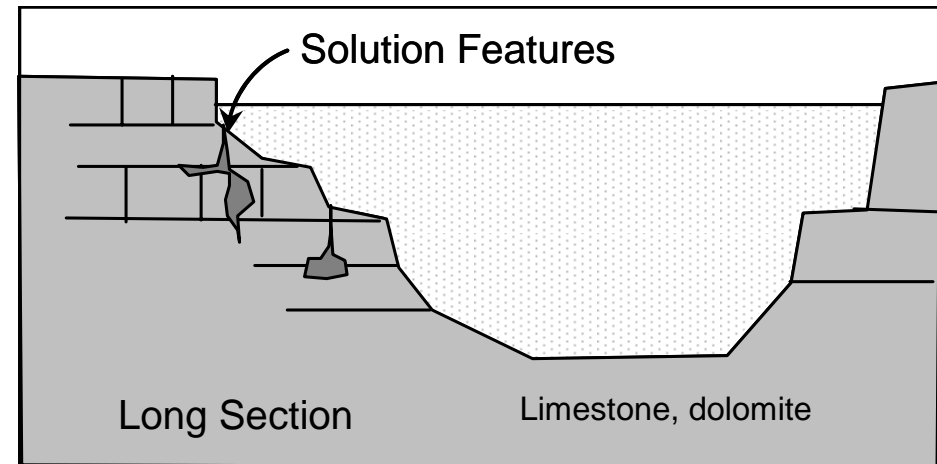
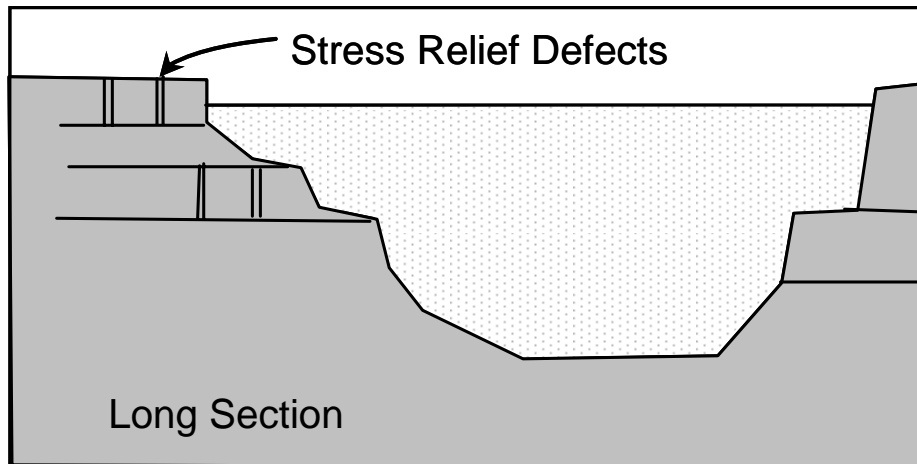


IM24 – Scour in a Crack in Cohesive Soil Foundations due to Differential Settlement or Desiccation Cracking



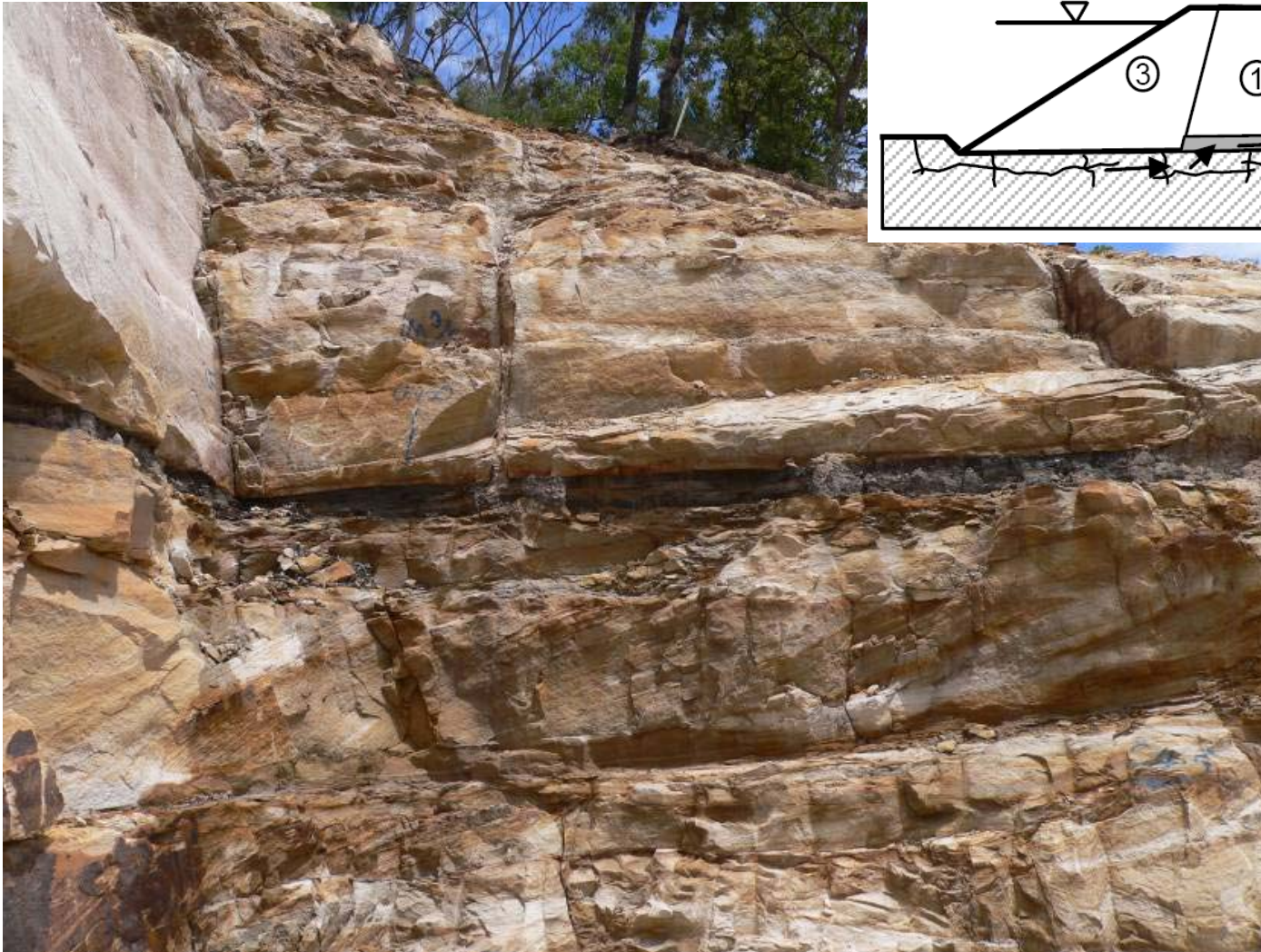


Geological Processes which can Lead to the Formation of Open Defects in Rock Foundation



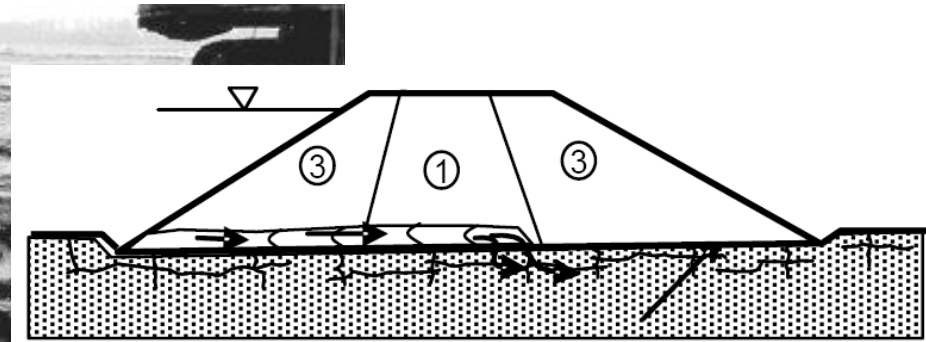
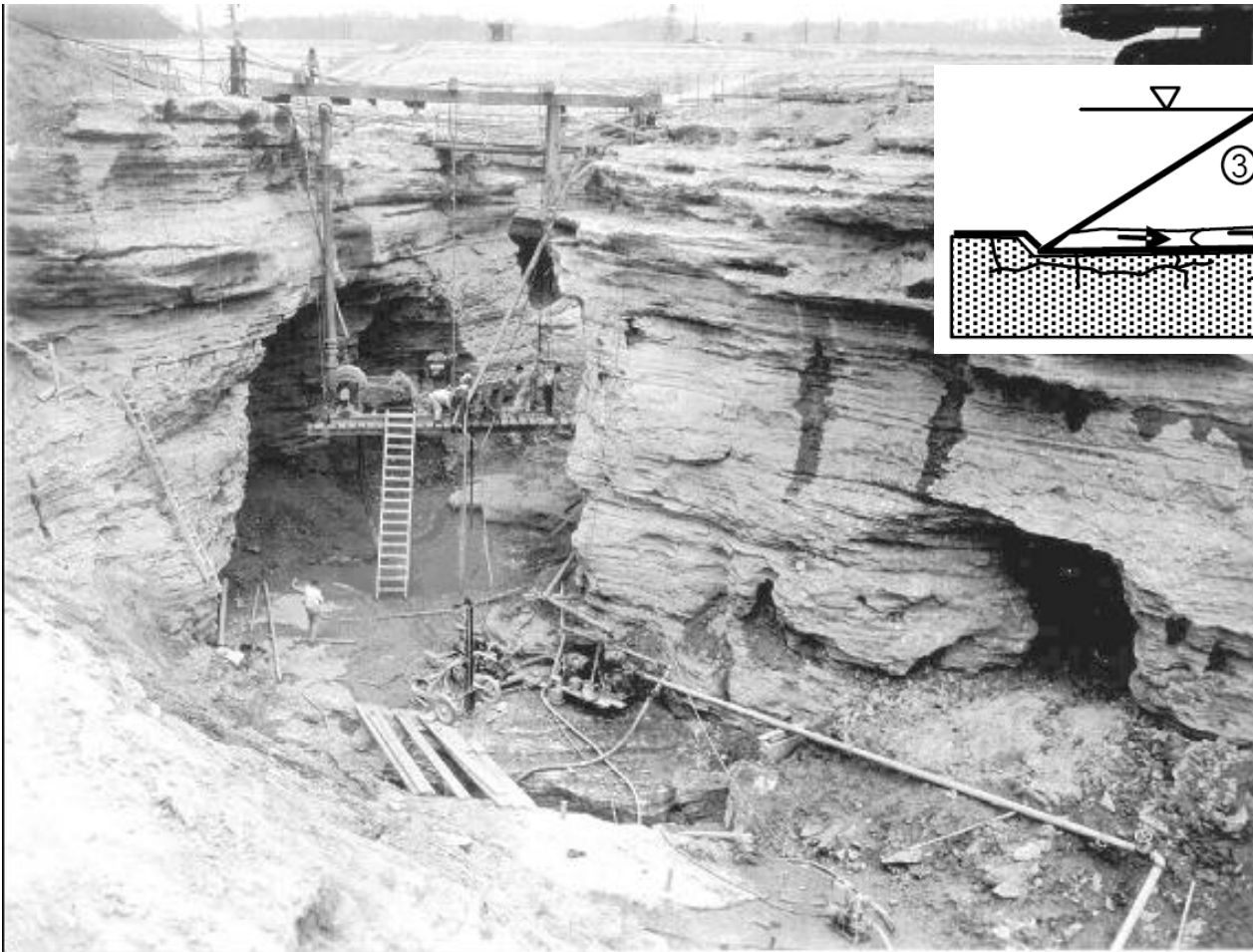


IM25 – Scour along Rock Defects < 25 mm



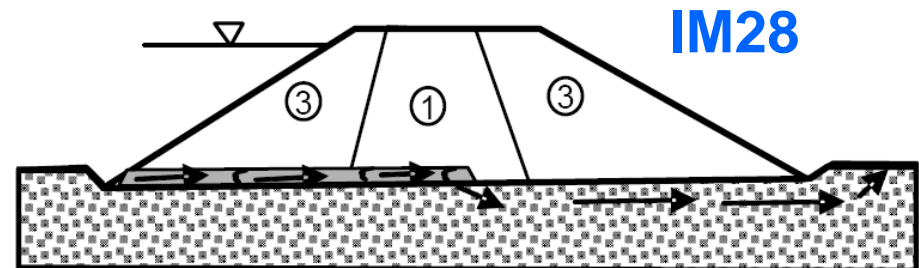
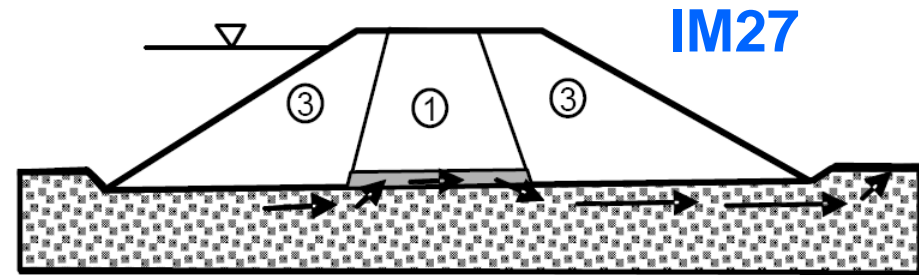


IM26 – Erosion into Rock Defects > 25 mm





IM27 – Scour along contact with Open-Work Granular Foundation IM28 – Erosion into Open-Work Granular Foundations





Questions, Comments, or Discussion?