Institute of Geologists of Ireland

Peat Stability Seminar

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DETERMING THE STABILITY OF PEAT SLOPES

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Contents

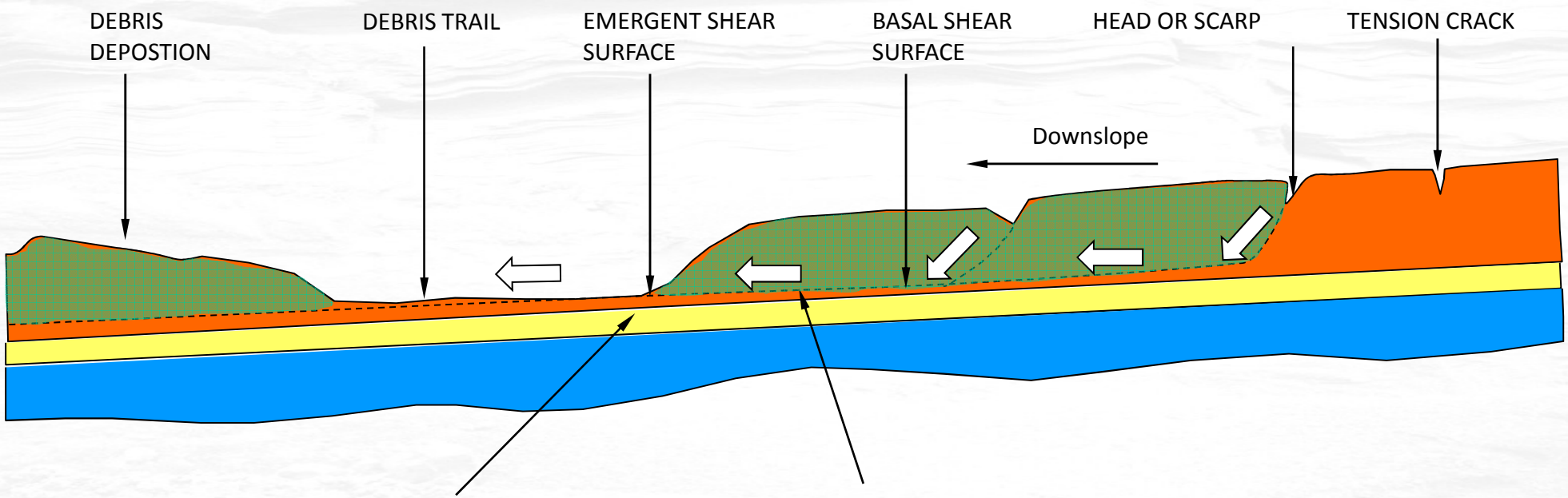
- Definition of Peat Failure
- Types of Peat Failures
- Approaches to Determining Stability
  - Geomorphological
  - Qualitative (judgement)
  - Index/Probabilistic (probability)
  - Deterministic (factor of safety) ..... Most common
- Deterministic Approach
  - Basic models
  - Short and long term conditions
  - Shear strength
  - Potential shear surfaces
- Summary

Definition of Peat Failure

Peat

Mineral Soil

Rock



SOME REPORTED 'PEAT FAILURES' HAVE INVOLVED BASAL SHEAR FAILURE IN THE UNDERLYING MINERAL SOIL

BASAL FAILURE SURFACE IN PEAT OR AT INTERFACE OF PEAT AND UNDERLYING MINERAL SOIL

Basal shear surface – on peat

Basal shear surface – on mineral soil

Basal shear surface – on rock

Emergent shear surface (at base of peat)

Emergent shear surface (in mineral soil)

Debris trail - multiple

Debris trail

Debris trail

Debris trail (close-up)

Debris deposition

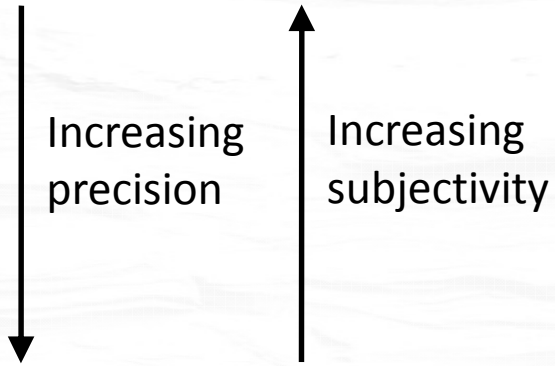
Types of Peat Failures

- **Peat failures -** classified as follows (Hutchinson, 1988)
- **Peat slides**
  - Mass of intact peat moves down slope
  - Failed peat moves on discrete sliding plane
  - Generally affects blanket bogs
- **Peat flows or 'bog bursts'**
  - Peat and water flow down-slope
  - Generally behaves as a viscous fluid
  - Generally affects raised bogs

Approaches to Determining Stability

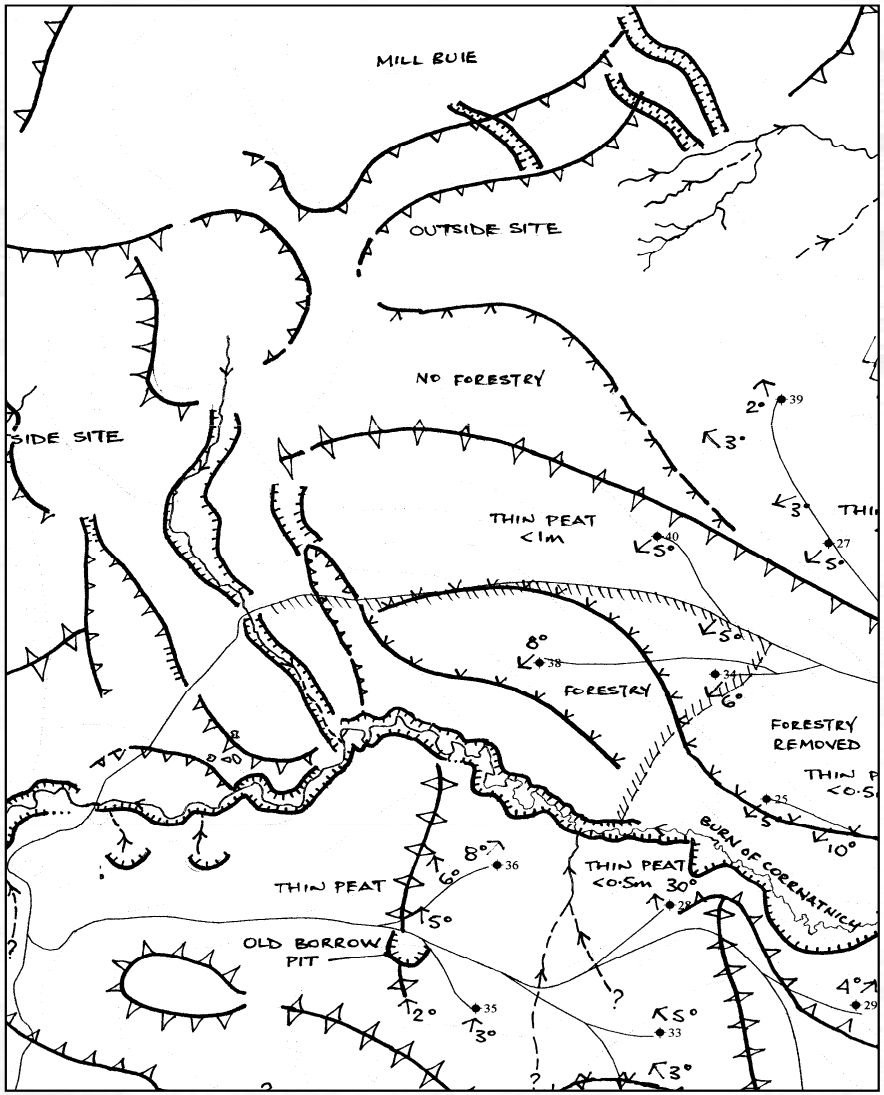
Main Approaches

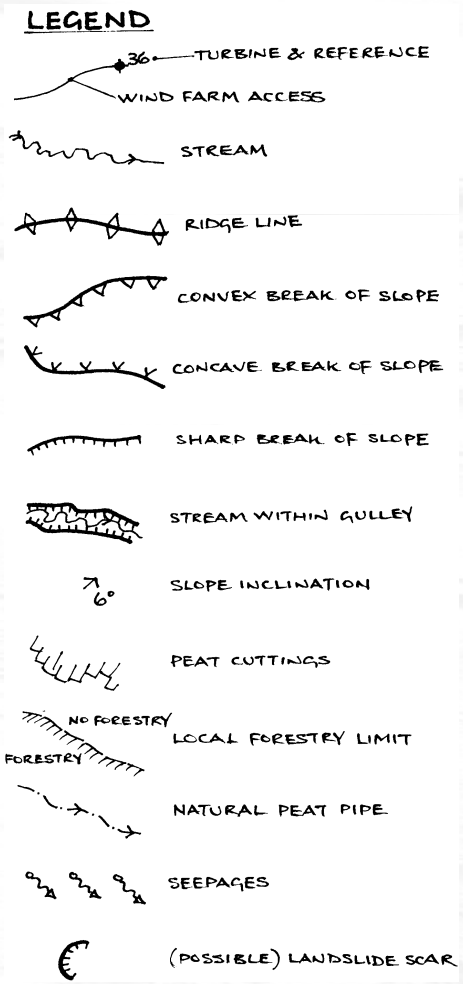
- Geomorphological
- Qualitative (judgement)
- Index/Probabilistic (probability)
- Deterministic (factor of safety)



Approaches to Determining Stability

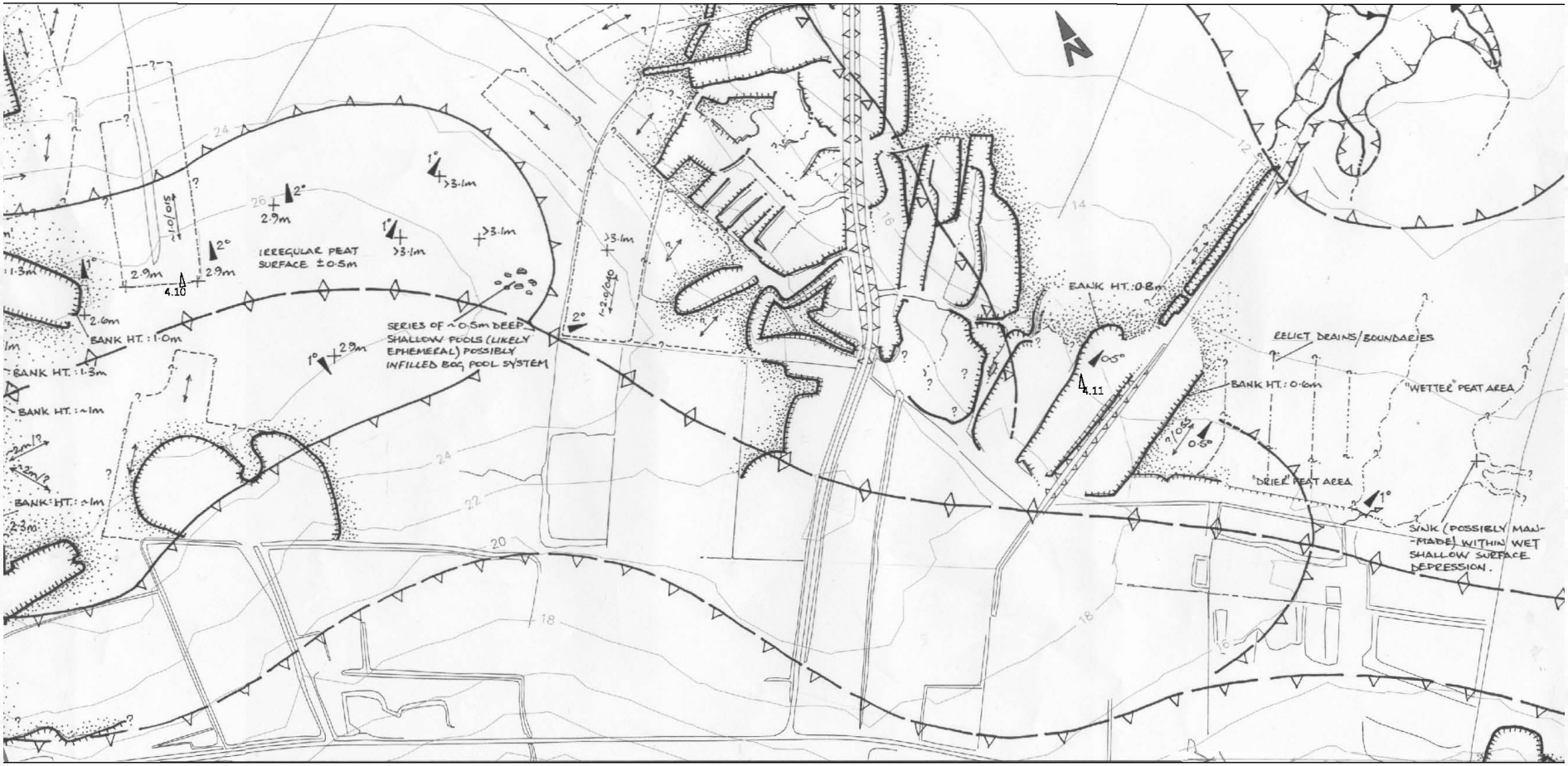
Geomorphological Approach





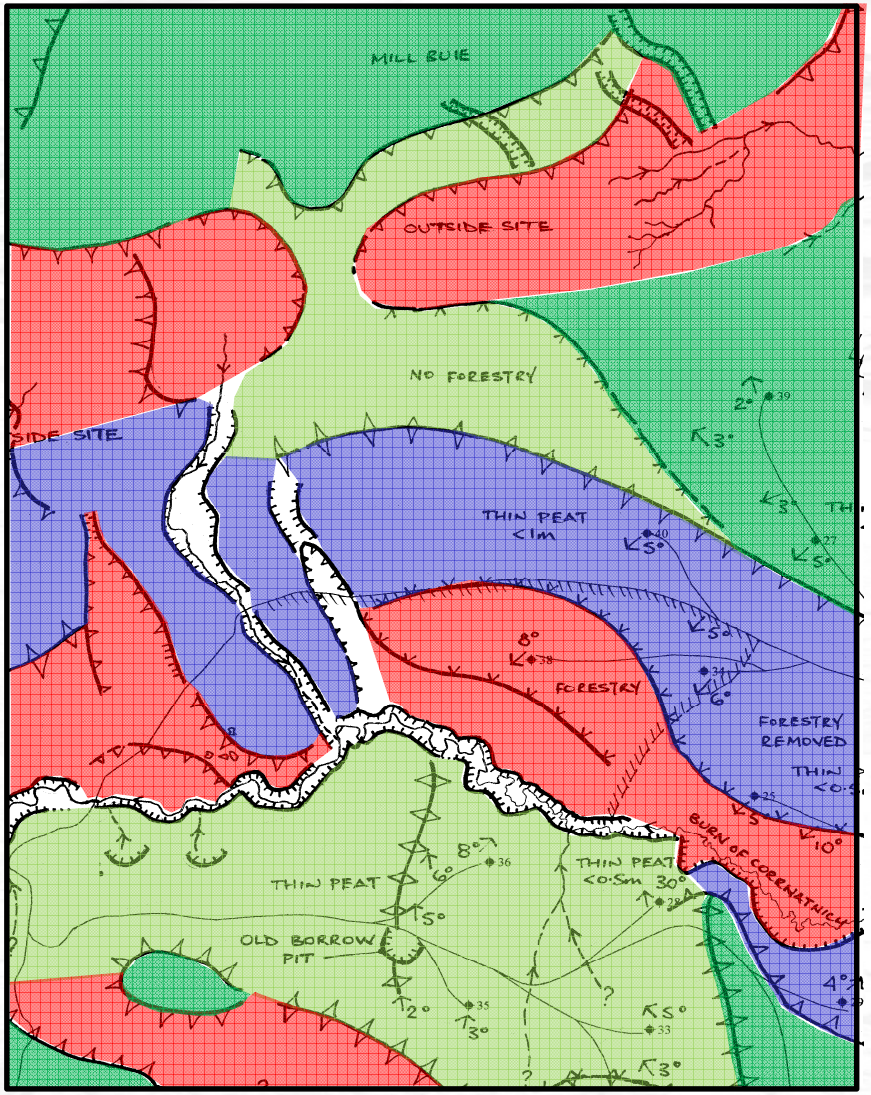
Approaches to Determining Stability

Geomorphological Approach



Approaches to Determining Stability

Qualitative Approach



Stability Hazard

- Negligible
- Low
- Medium
- High

Approaches to Determining Stability

Index/Probabilistic Approach

- Relies on compilation of a number of salient factors
- Typical factors include

Topography

Ground slope angle, surface slope angle at base of peat, slope profile (convex/concave/straight), proximity to convex break in slope (upslope/downslope)

Peat

Peat depth, water content, shear strength (peak, residual, drained, undrained) peat classification (von Post)

Underlying soil/rock

Soil at base (granular/cohesive), rock type, strength, permeability

Hydrology/hydrogeology

Springs, seepage, sub-surface piping, man-made water courses, natural water courses, permeability contrasts, concentrated surface/sub-surface flow

Vegetation

Type of vegetation, stunted growth vegetation, propensity for aquatic species

Previous slides

Evidence of previous slides, tension cracks , hummocky/disturbed terrain

Land use

Peat workings , drained peat, forestry, agriculture (rough grazing)

Approaches to Determining Stability

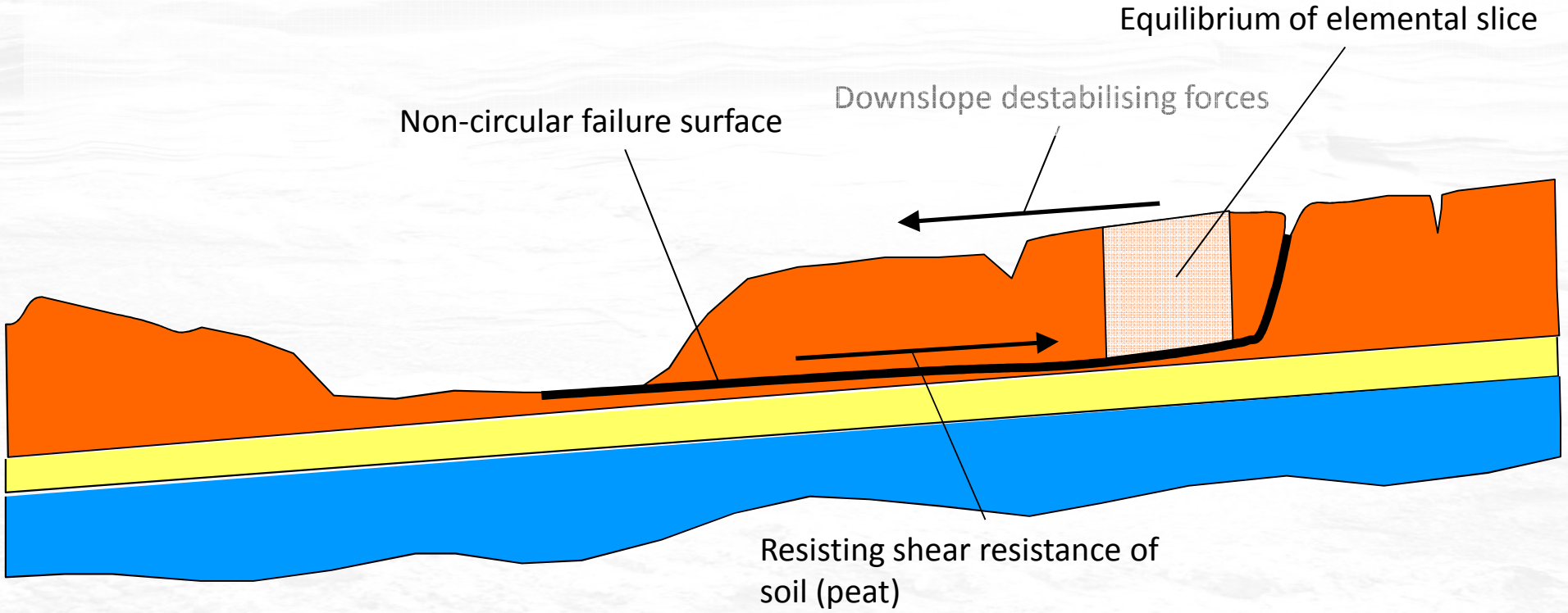
Index/Probabilistic Approach

- Index approach scores factors/uses weighting and combines
- eg $W_1.F_1 + W_s.F_2 + W_3.F_3 + ...$ (simple summation)
- eg $100(W_1.F_1/W_s.F_2) \times W_3.F_3.....$ (algorithm)
- Probabilistic approach uses factors with statistical techniques
- eg multiple regression, discriminant analysis
- Index approach commonly used (but not optimised)
- Probabilistic approach not commonly used (better optimised)
- Neither approach provides a definitive indication of stability

Approaches to Determining Stability

Deterministic Approach

- Numerical analysis (FEM)
- Classic factor of safety approach
- Analysis using non-circular or infinite slope



Deterministic Approach

Infinite Slope

- Sliding (translational) dominant failure mechanism
- Sliding (shear) surface generally at/near base of peat
- Models available to determine sliding stability
- Infinite slope readily applicable to translational slide

$$F = \frac{c_u}{\gamma z \sin \alpha \cos \alpha}$$

Where,

F =	Factor of Safety
cu =	Undrained cohesion
γ =	Bulk unit weight of soil (peat)
z =	Depth to failure plane (usually base of peat)
α =	Slope angle

Deterministic Approach

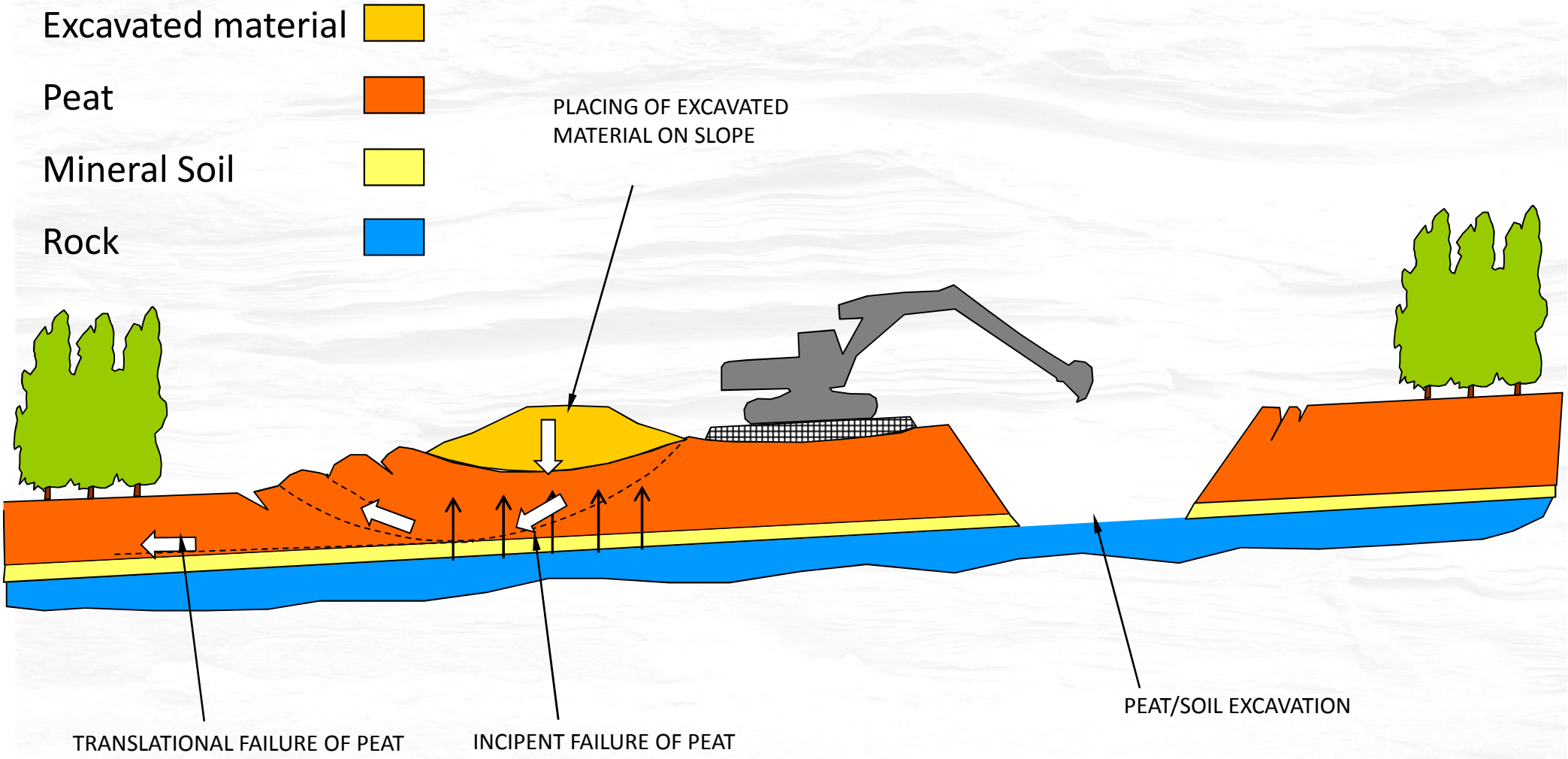
Analytical considerations

- Short and long term conditions

  (eg failure triggered by loading or ingress of water)

- Shear strength

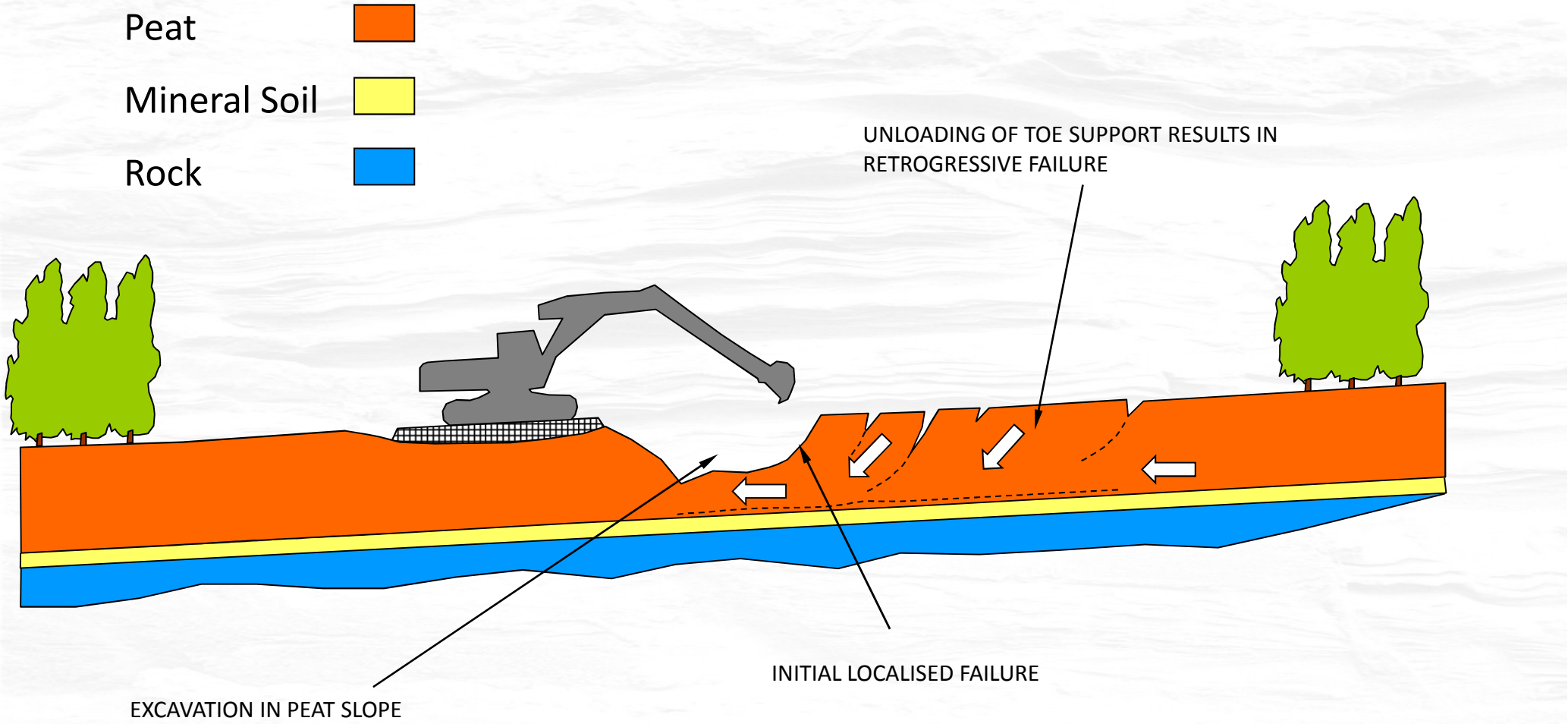
- Potential shear surfaces



Short term failure - loading

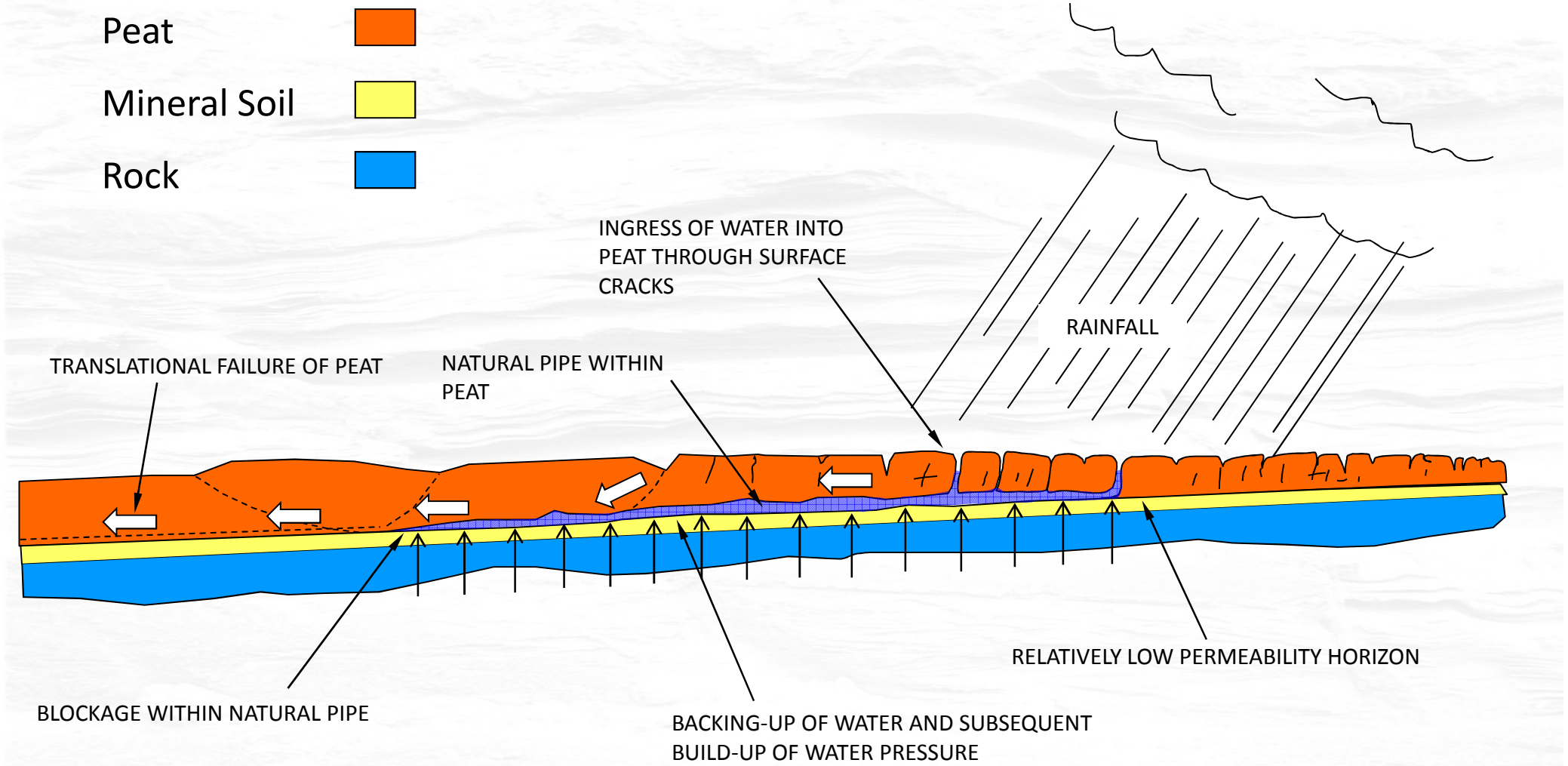
Anaholty Bog, Nenagh Bypass, Co Tipperary

Ref: Raven, K & Assinder, P. (2008).Use of Geotextiles in Construction over Soft Ground. Thames Valley Geological Society/International Geosynthetic Society, Royal Holloway College



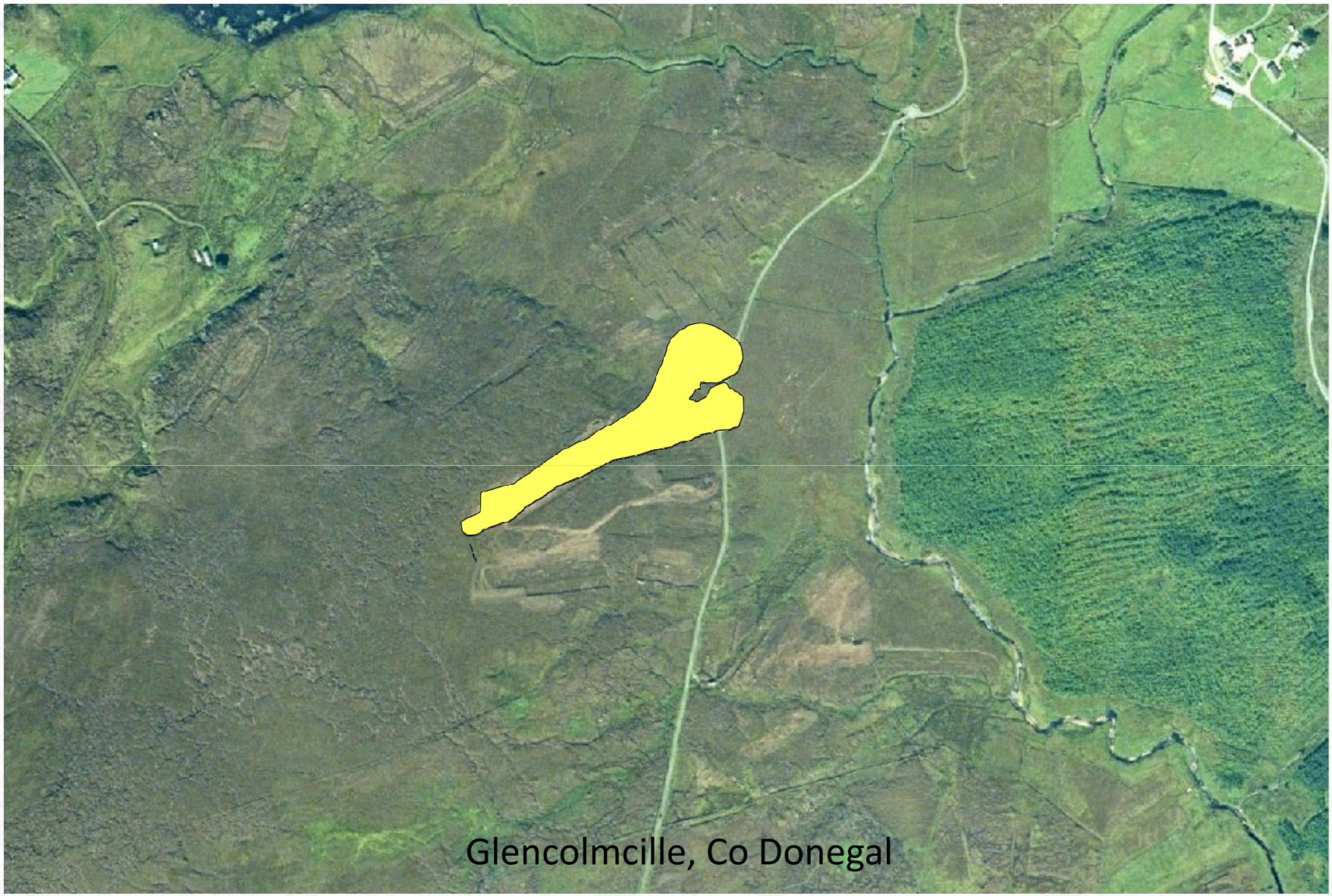
Short term failure - unloading

Wind farm site



Long term failure - ingress of water

Typical natural sub-surface pipe


Glencolmcille, Co Donegal

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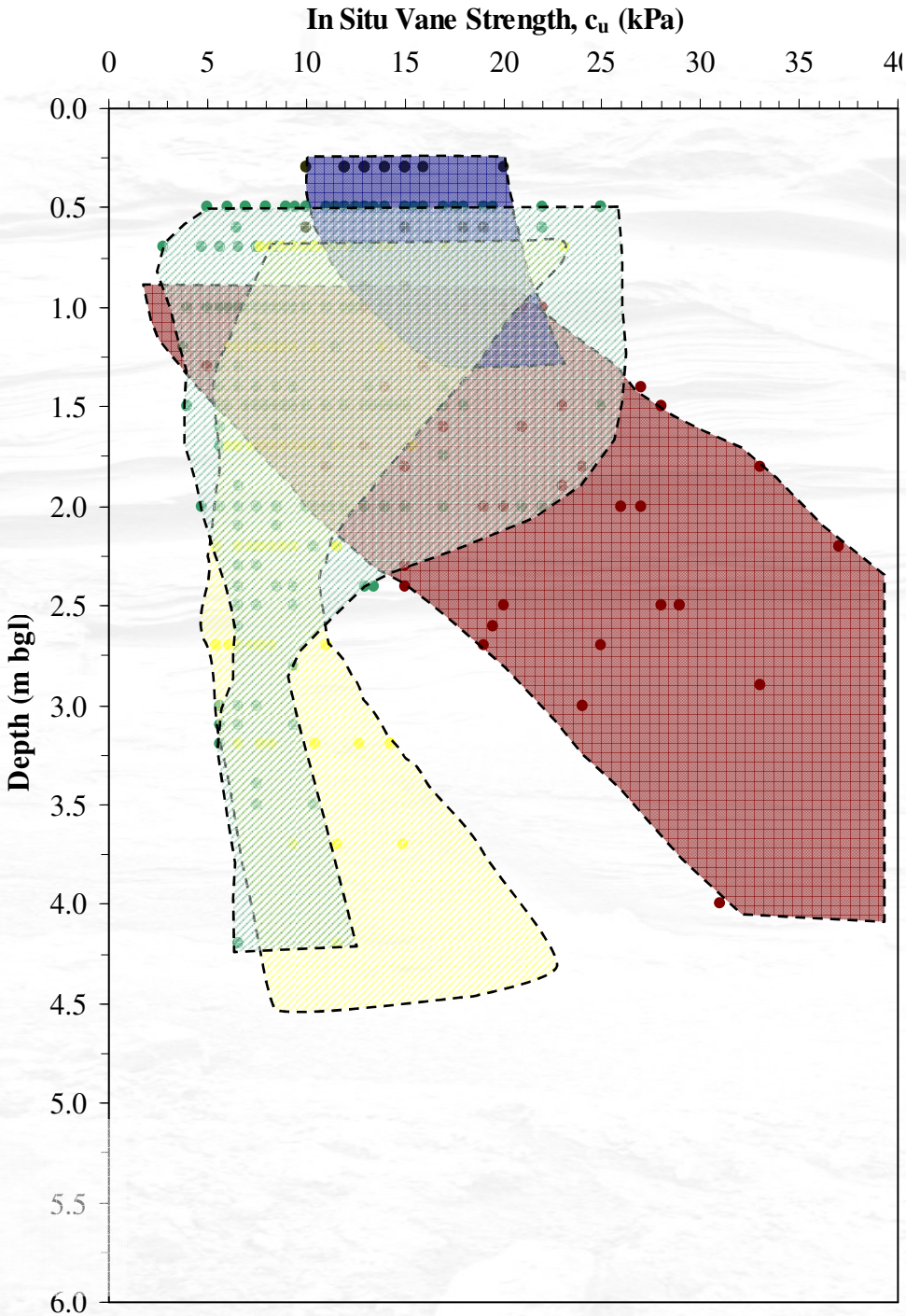

Shear strength - undrained

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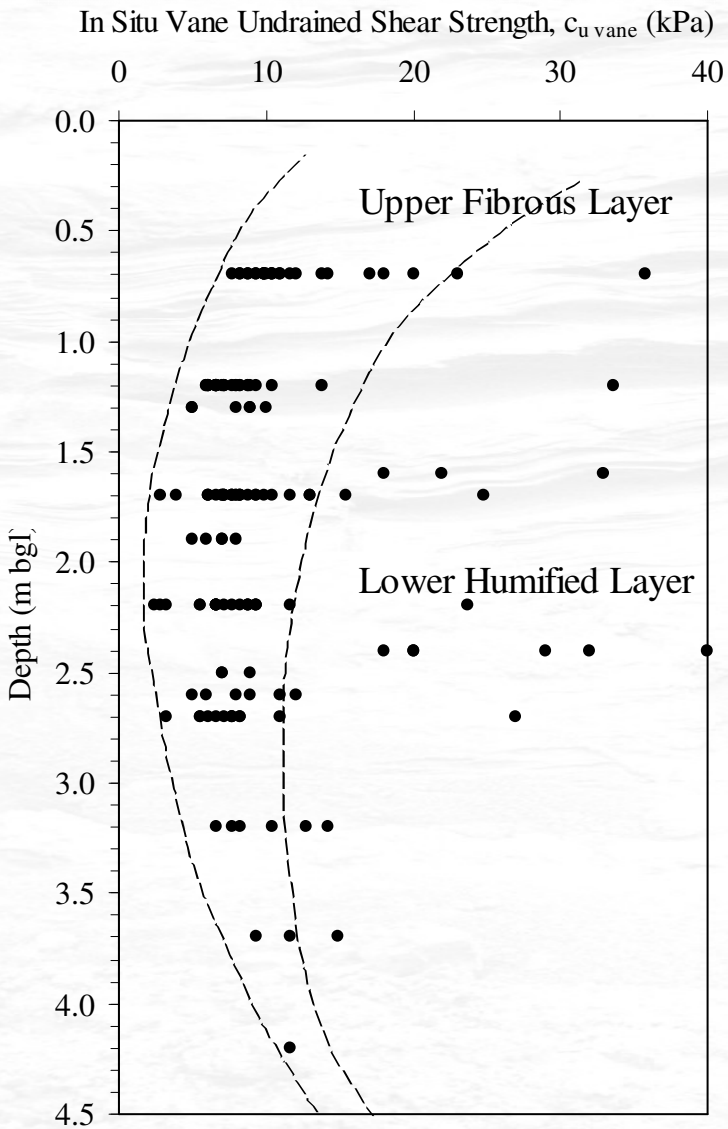
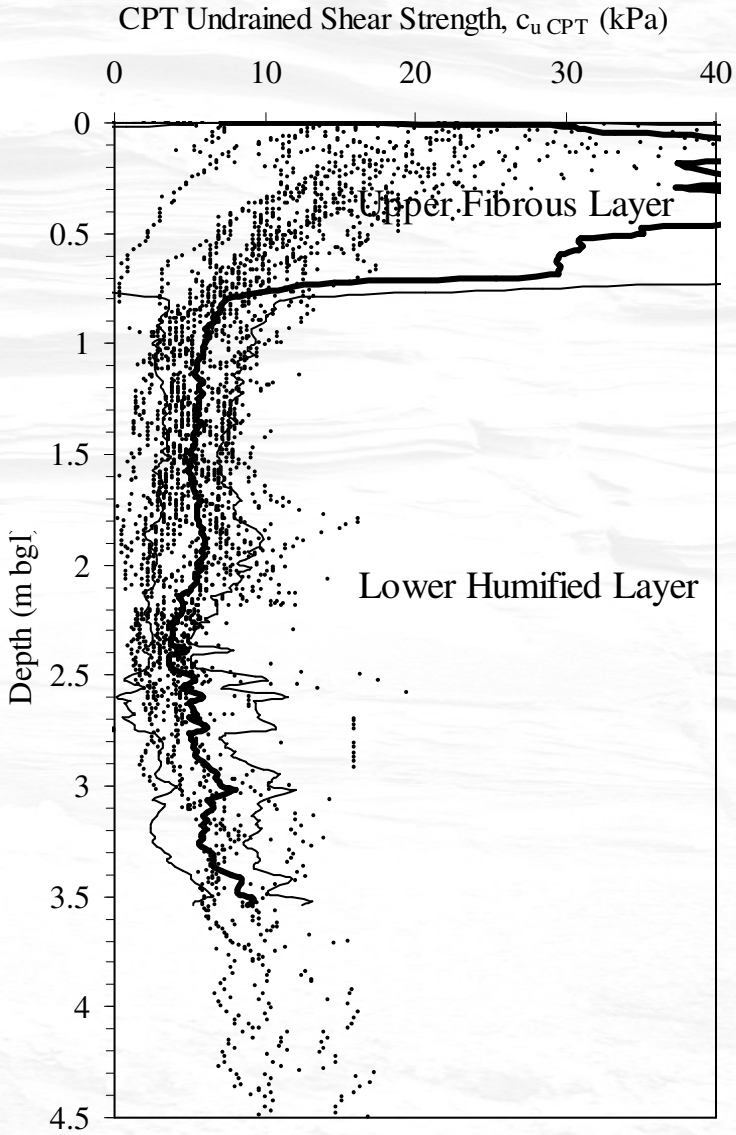
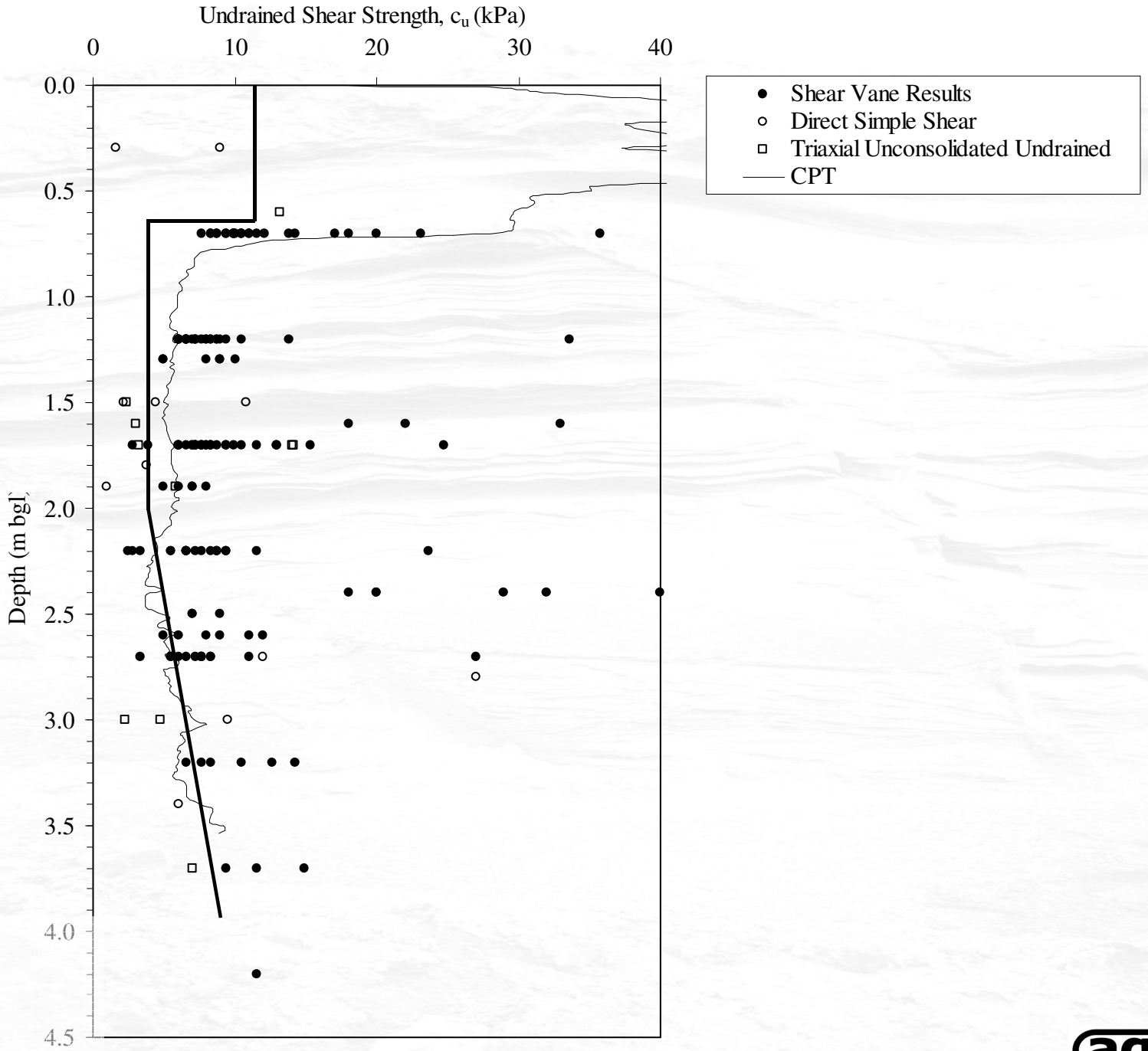
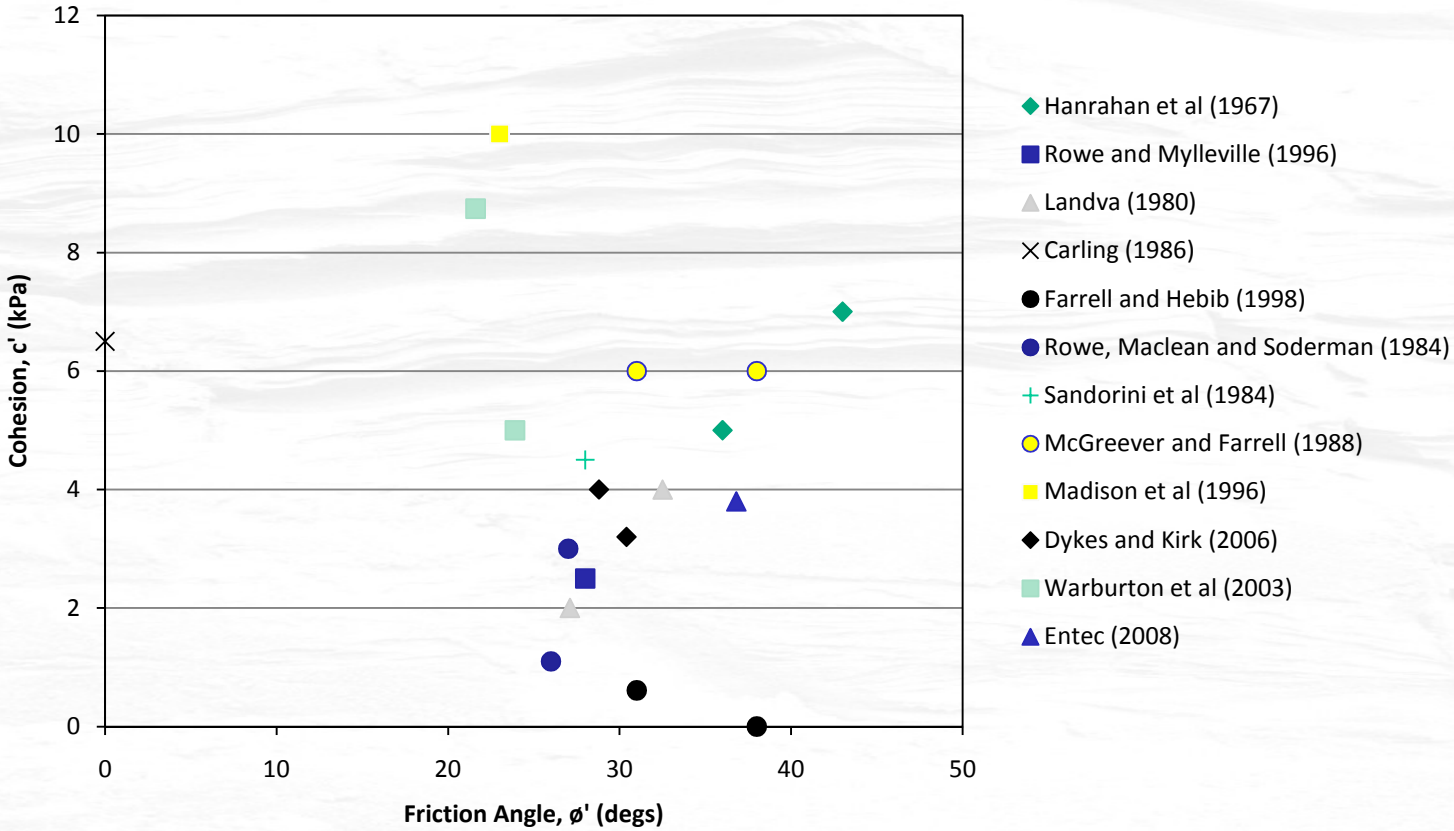


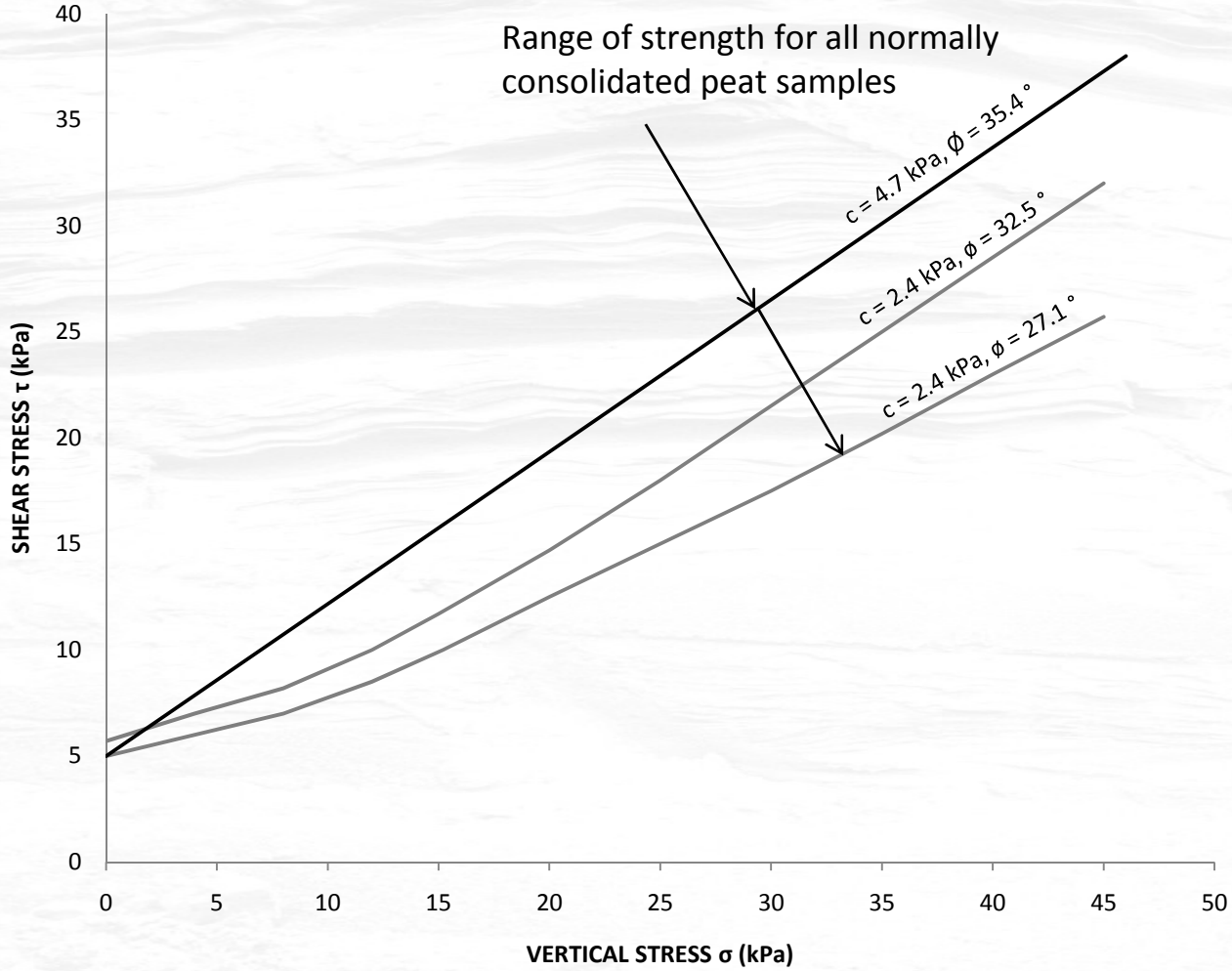




Shear strength - undrained

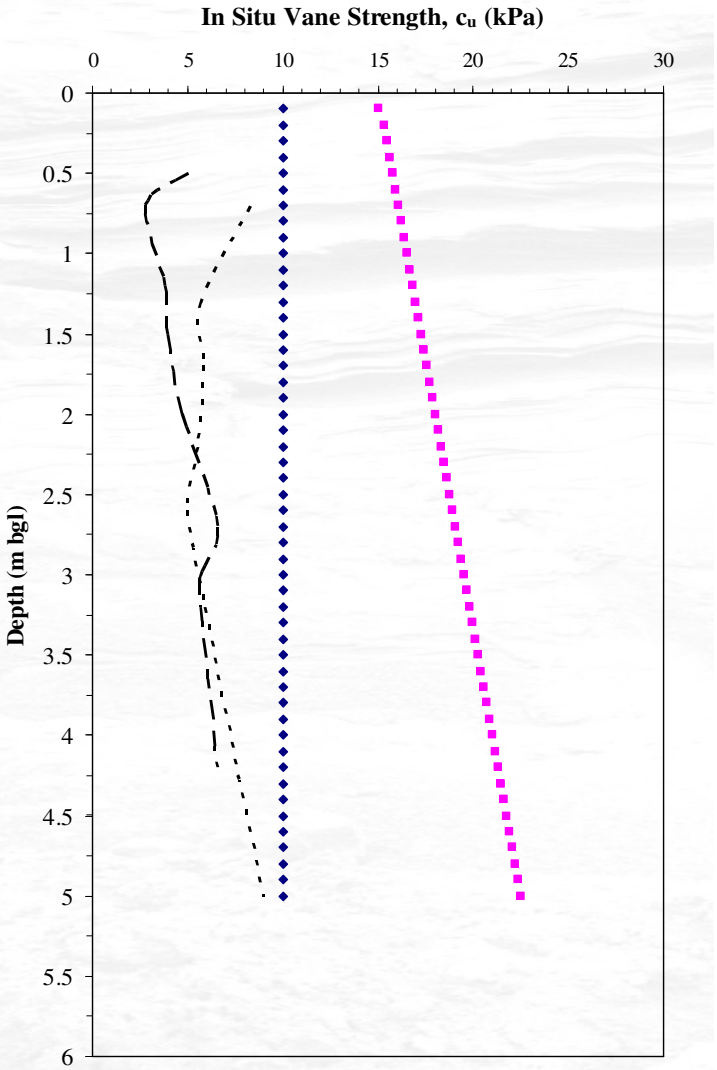


Shear strength - drained



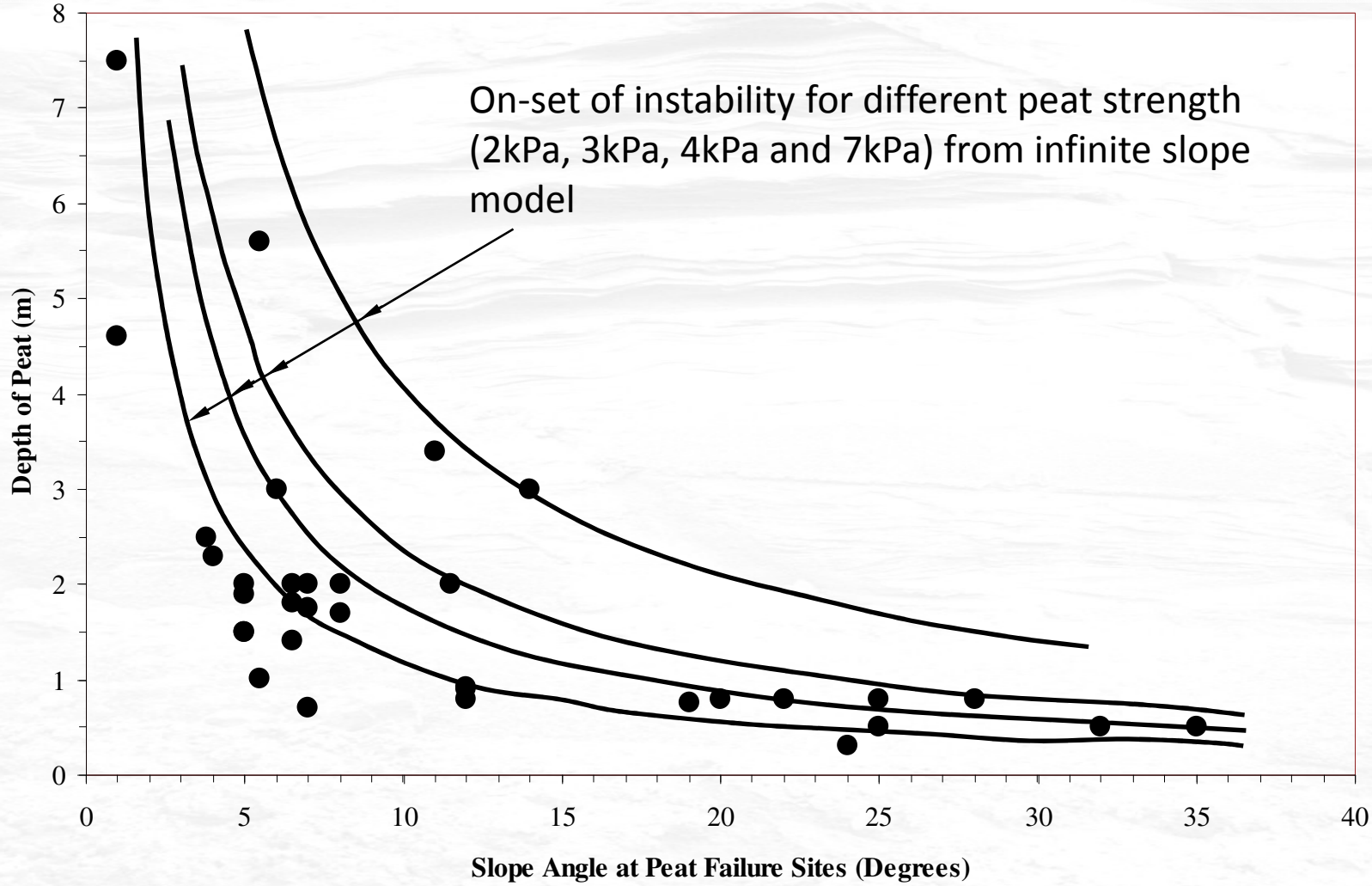
Shear strength – drained (Landva, 1980)

Potential failure surfaces - depth



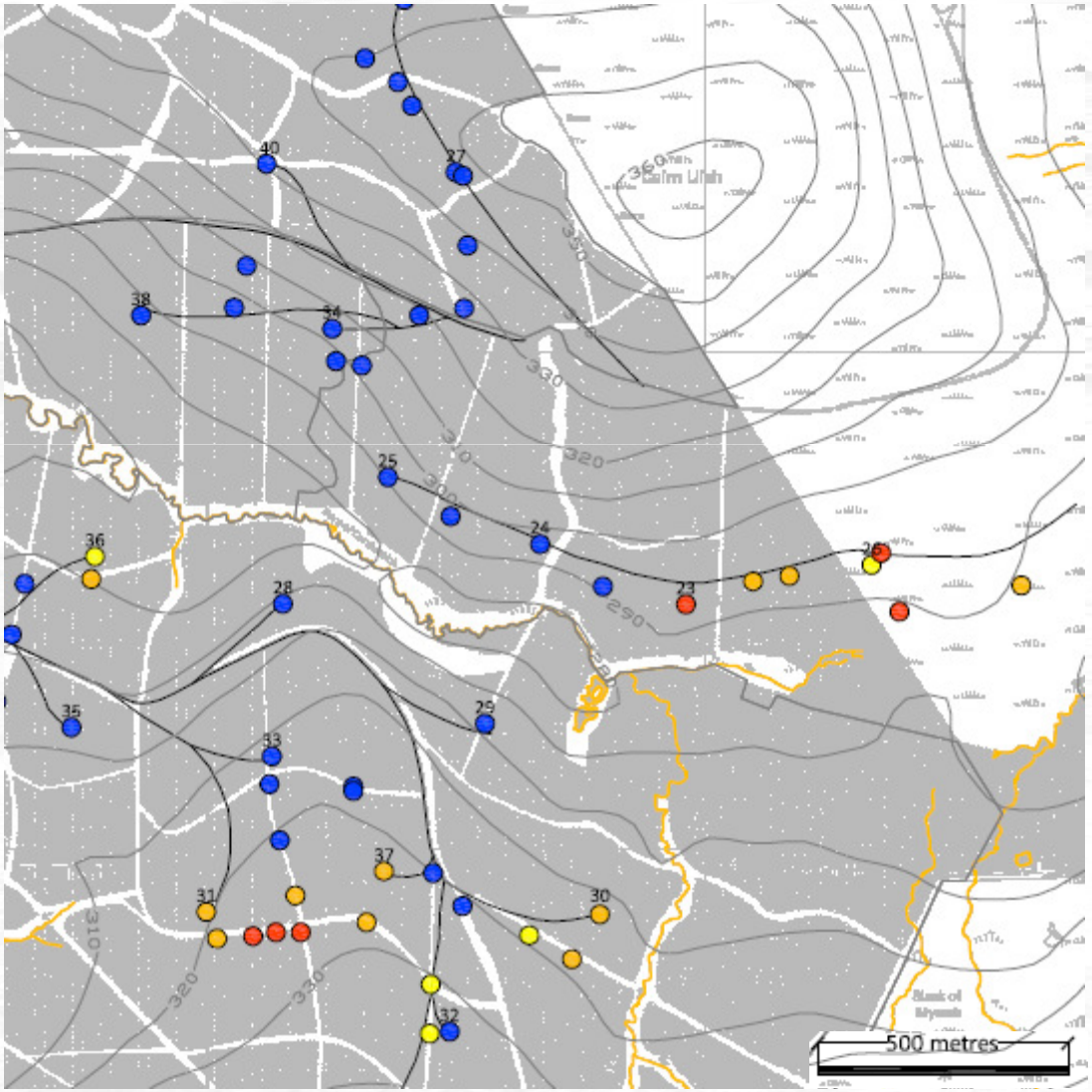
Deterministic Approach

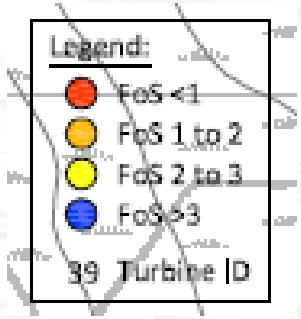
Analysis Results - chart showing slope angle vs. peat depth for various c_u



Deterministic Approach

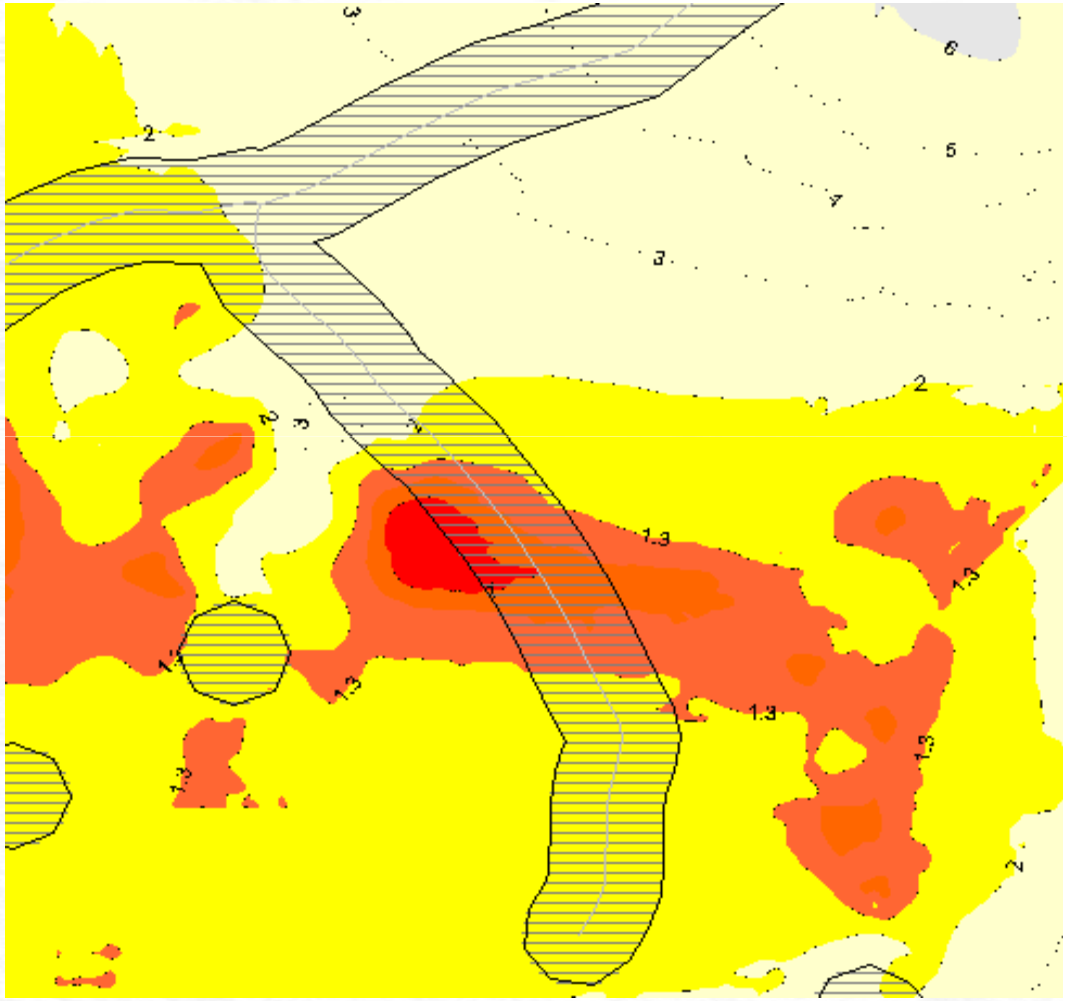
Analysis Results - factor of safety approach at spot locations





Deterministic Approach

Analysis Results - factor of safety approach using multiple locations



Factor of Safety	Hazard Category	Description	Likely Ground Conditions
< 1.0	Very High	Combination of adverse factors present that indicate that the peat is weak and is susceptible to failure.	Localised to more extensive areas of weaker peat present
1 to 1.3	High	Combination of some adverse factors present that indicate	Localised area of weaker peat present
>1.3 to 2	Moderate	Combination of factors present that indicate that the ground has a moderate susceptibility to failure	Possible areas of weaker peat present.
>2 to 6	Slight	Combination of factors present that indicate that the ground has a slight susceptibility to failure	Possible areas of weaker peat present. Peat is generally thin where ground is on slope. Thicker peat present on flatter ground.
>6 to 10	Marginal	Combination of factors present that indicate that the ground has a marginal susceptibility to failure	Areas of weaker peat unlikely to be present. Peat is generally thin where ground is on slope. Thicker peat present on flatter ground.
>10	Minimal	Combination of factors present that indicate that the ground has a minimal susceptibility to failure	Peat is generally thin or of minimal thickness where ground is on slope. Thicker peat present on flatter ground.

Summary

- Main approaches
  - Geomorphological
  - Qualitative
  - Index/Probabilistic
  - Deterministic

- Provide valuable insight and allow informed decisions
- Can include numerous useful predictive factors

But

- High level of judgement/experience required
- Difficult to relate score/probability results to real conditions

- Deterministic
  - Most common/accepted engineering approach
  - Sliding (translational) dominant failure mechanism
  - Models available include – non-circular, infinite slope
  - Provides ‘direct’ measure of stability
  - Not all parts of failure mechanism fully understood
  - Uses limited number of factors
  - Determining operational shear strength is difficult

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SITE OF
MOVING BOG
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Gníomh go Leith
GNEEVEGUILLA
An Rath Mhor
RATHMORE
KILLARNEY
09/12/2005

Finish

Thank You