Peat Slide
Susceptibility Assessment
for
Windfarm Developments

Robert Bone
Principal Engineer

Setting the context…

- **Mouchel's involvement with windfarms**
  - Peat stability is only one aspect of Environmental Impact Assessment *(Appendix to Soils and Water Chapters)*
  - Related issues: CAR, Stream crossings, Borrow pits
  - Hydrology / topography / peat constraint mapping
- **An overview of peatslide assessment techniques**
- **Mouchel's approach to peatslide assessment**

A Generic View of Peatslide Assessment Techniques

- **Common to all approaches**
  - Desk studies
  - Site walkovers
  - Ground investigation
- **But different types of analysis**
  - Statements of opinion
  - Scoring schemes based of physical attributes
  - Modelling based on physical characteristics

Attribute or Factor Scoring Schemes

Attribute	Values	Range
Peat Depth (first instance)	4	0 - 2
Relief	3	1 - 2
Exposure	4	1 - 3
Slope	5	0.05 - 2
Grade	4	1 - 2
Surface Loading	1	1
Peat strength	1	1
Peat stratification	1	1
Rainfall	1	1
Drainage	4	0.5 - 3
Subsurface hydrology	1	1
Peat Depth (second instance)	4	0 - 2
Evidence of instability	3	1 - 5

- **12 attributes or factors but 5 greyed out**
- **Greyed out factors recognised, but do nothing in assessment**
- **Each factor assigned a range of values**
- **Attributes combined through multiplication and 'score' can range from 0 – 288**
- **About 46,000 permutations, but hundreds give same score eg 6 = fn(240 permutations)**
- **Are all like scoring permutations really the same?**

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‘Guideline’ Method: The Process

Hazard over Lifetime		
Scale	**Likelihood**	**Probability**
5	Almost certain	> 1:3
4	Probable	1:10 – 1:3
3	Likely	$1{:}10^2$ – 1:10
2	Unlikely	$1{:}10^7$ – $1{:}10^2$
1	Negligible	< $1{:}10^7$

X

Exposure over Lifetime		
Scale	**Exposure**	Impact as % of total project cost or time
5	Extremely high impact	> 100% of project
4	Very high impact	10% - 100%
3	High impact	4% - 10%
2	Low impact	1% - 4%
1	Very low impact	< 1% of project

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Insignificant				**Significant**						**Substantial**						**Serious**								

Hazard Ranking

‘Guideline’ Method: Conceptual Conundrums

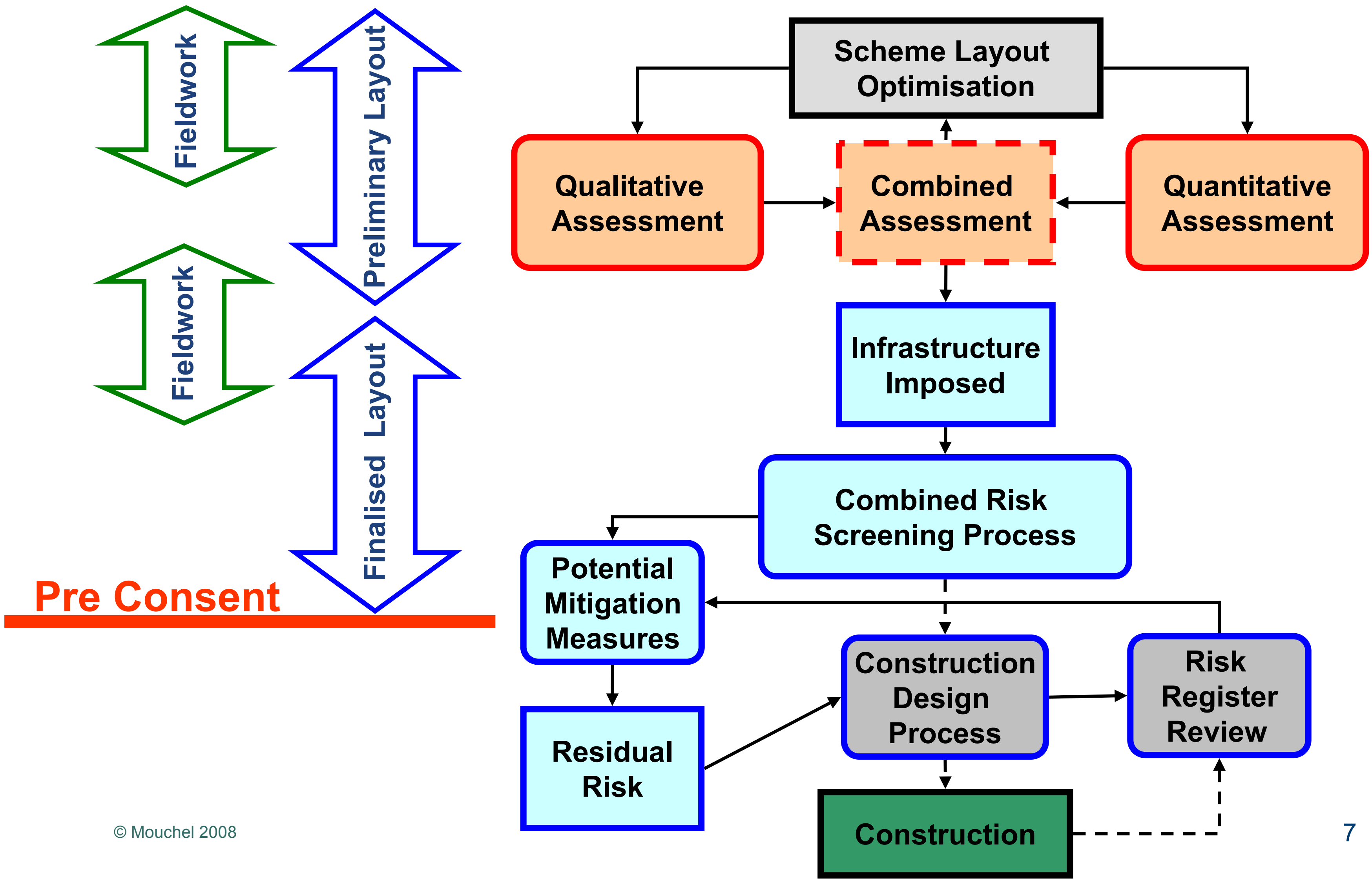
- Assessment process for ‘Hazard’ & ‘Exposure’ values not defined - left to ‘technically competent persons’
- Impact (as %) disadvantages smaller schemes
- Scoring scheme has numerical gaps – implications?
- Commutative arithmetic and equivalent scores

Hazard	Exposure	H x E	Question
4 Probable	1 Very Low	4	Are these really all the same either conceptually or when evaluated numerically?
1 Negligible	4 Very High	4	
2 Unlikely	2 Low	4	

Project Risk = Hazard (Likelihood) x Exposure (Impact %)

= different values in all cases !

Mouchel's Risk Assessment Process



Philosophy of Qualitative – Quantitative Assessment

	Qualitative	Quantitative
Area Covered	wide area - whole site	small area – localised feature
Techniques	causative factors in combination	mathematical formulae based model
Parameters	topography, hydrology, geology, photography, vegetation, judgement	material properties, problem geometry, loadings
Output	relative risks displayed in a spatial context	factor of safety for a specific cross-section
Applications	risk zone avoidance layout planning mitigation planning	embankment design excavation stability check road cutting stability check
	"JUDGEMENT"	"ENGINEERING"

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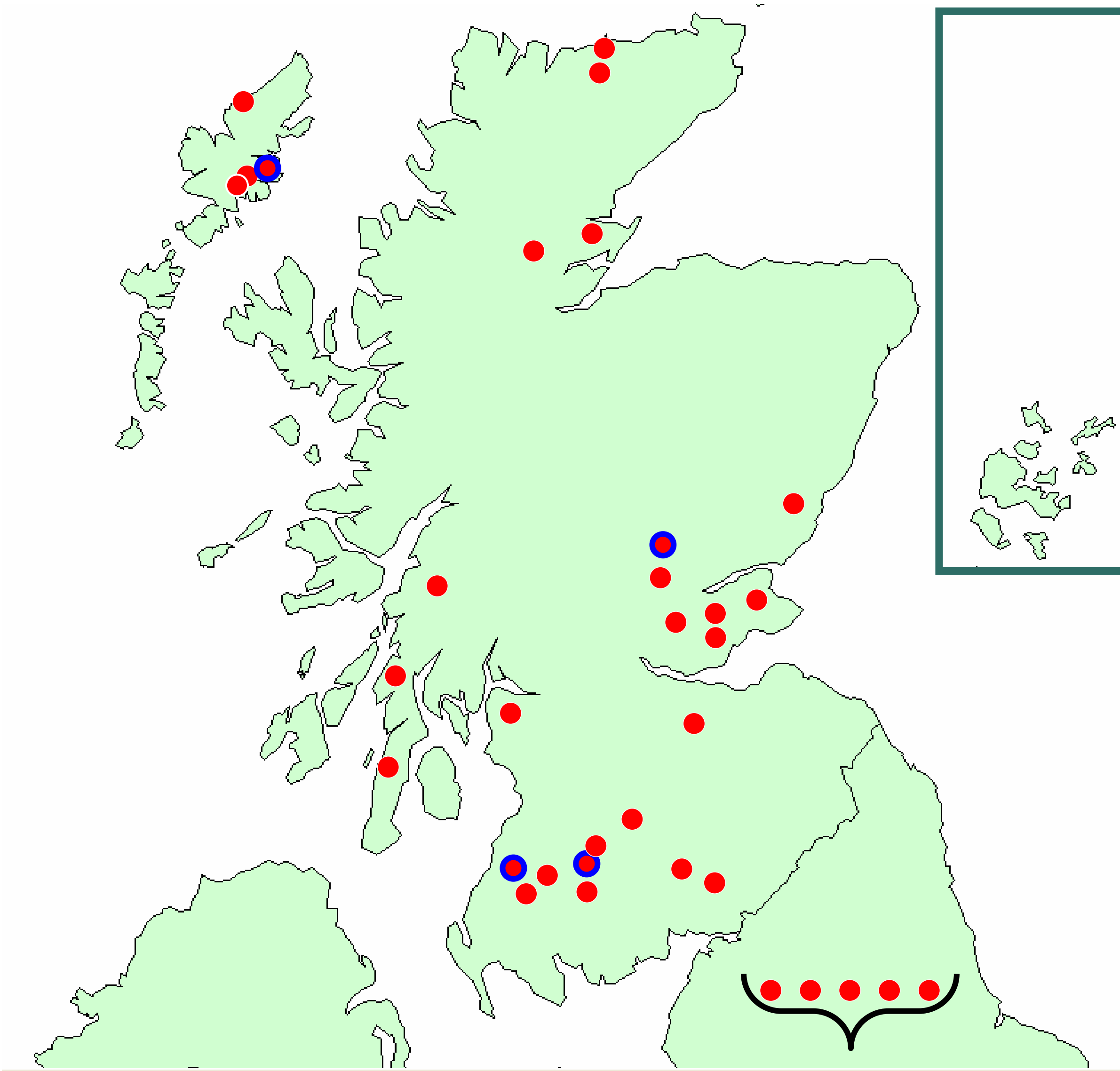
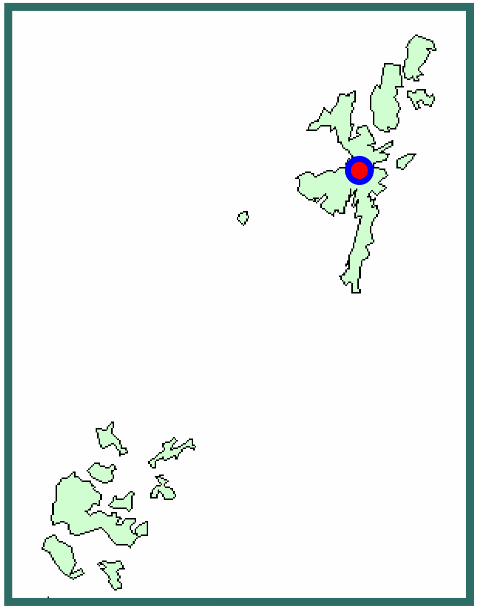
Geographical spread of projects…





Preliminary Processes

- **Desk Study**
  - Acquire OS / BGS / DTM mapping etc and load into GIS
  - Acquire aerial photography and load into GIS
  - Generate ‘grid’ (c.50-100m) across whole site
  - Undertake slope mapping from DTM
  - Plan reconnaissance and initial fieldwork
- **Undertake Fieldwork**
  - Peat depth probing (location, depth, surface, substrate)
  - Take peat cores (Von Post, M/C, bulk density)
  - Note surface and drainage features
  - Note morphology and signs of instability
- **Process Fieldwork Information**
  - Create indicative peat depth map
  - Geo-reference photos, observations etc

Qualitative Process - Overview

- **For each grid cell determine:**
  - Surface slope from DTM
  - Peat depth from indicative map (or actual)
  - Surface classification (from aerial photography)
- **Determine peatslide susceptibility**
  - Assess combined effect of above attributes
  - Consider over-riding factors (eg historic slide, cracks)
- **Display analysis as thematic map**
  - Provide feedback into windfarm design layout
  - Undertake supplementary fieldwork as necessary

Qualitative Assessment – Factor Combination

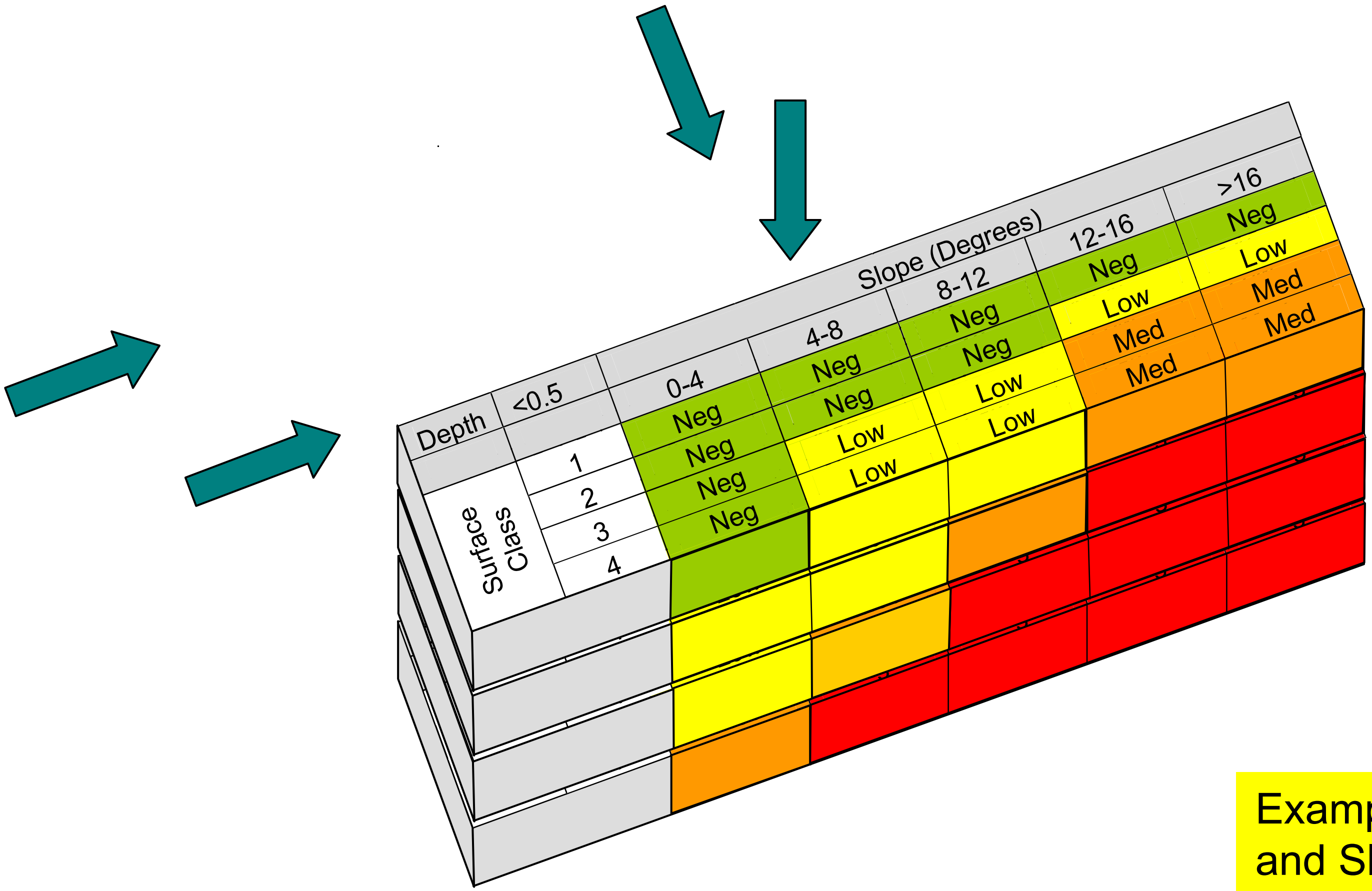
- **How to combine attributes to make an assessment?**
- **Logical Operations**
  - ‘and’ / ‘or’ / ‘not’

If case A and B and (C or D) then Susceptibility is X

- **Algebraic Operations**
  - Basic operators: addition / multiplication etc
  - Transformation: powers, weightings

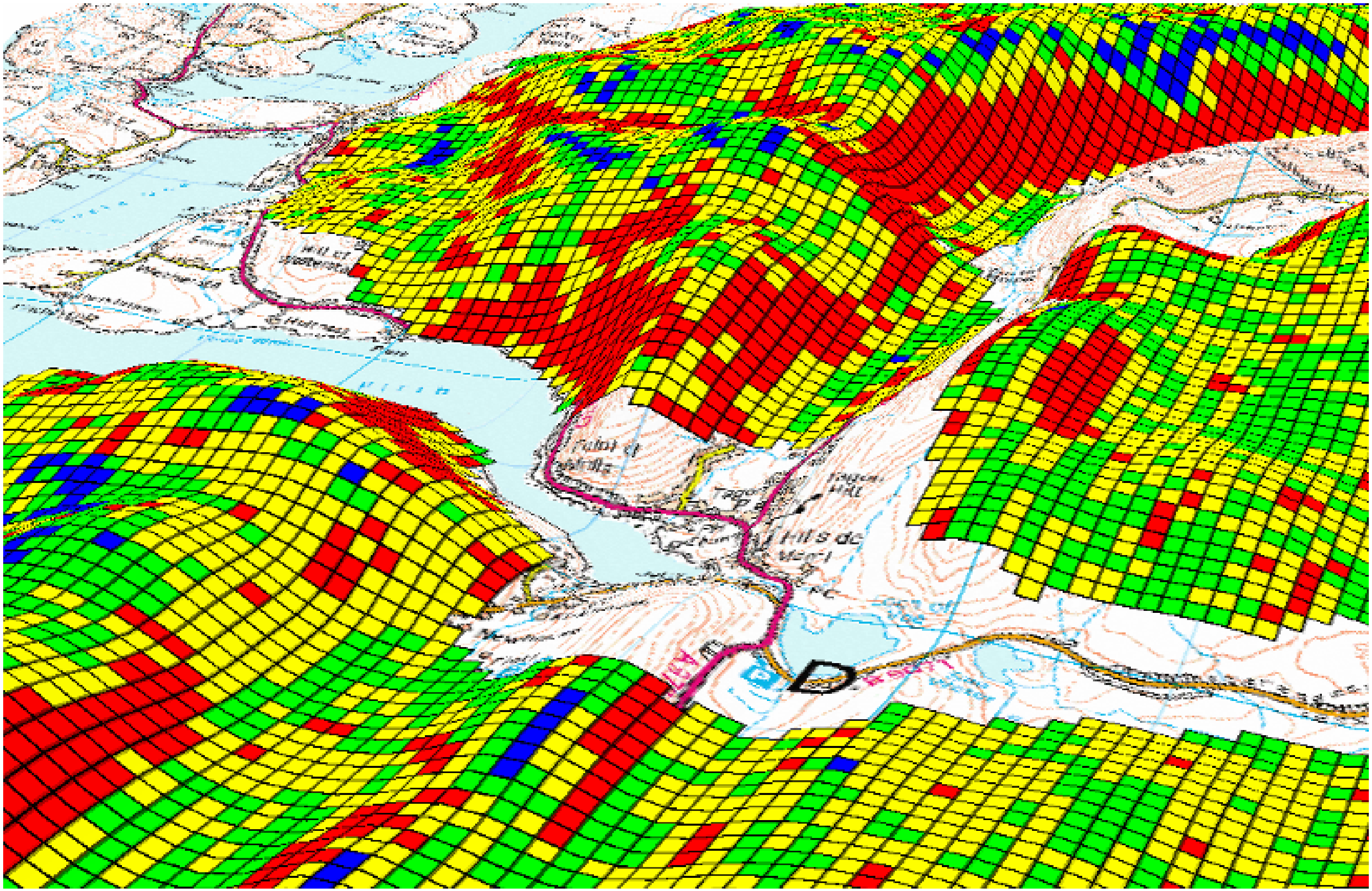
Susceptibility Score = $A \times B \times (C+D)^{0.5}$

Qualitative Assessment Matrix – In Practice

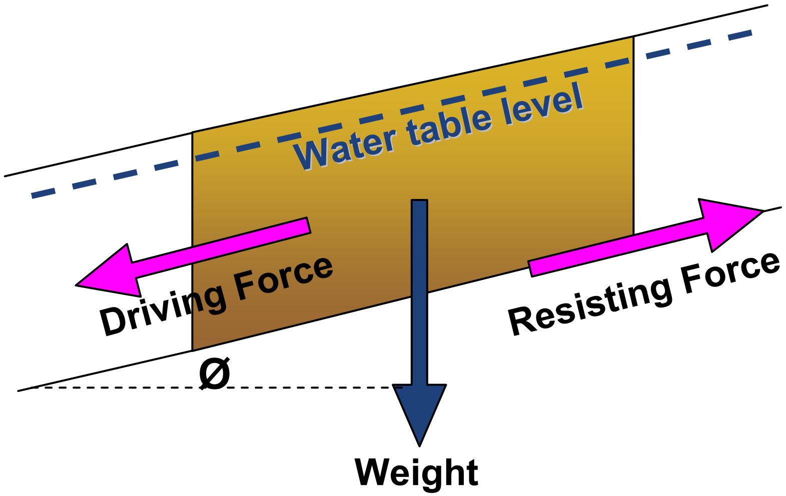


Example: If Depth 0.5-1.5 and Slope 8-12 degrees and Surface Class 3 then Medium Susceptibility

Qualitative Assessment – Pictorial Output



Quantitative Assessment - Infinite Slope Model



Factor of Safety = Resisting Force / Driving Force

Resisting Force = (c' + (γ - mγw) z cos2β tanǿ)

Driving Force = (γ z sinβ cosβ)

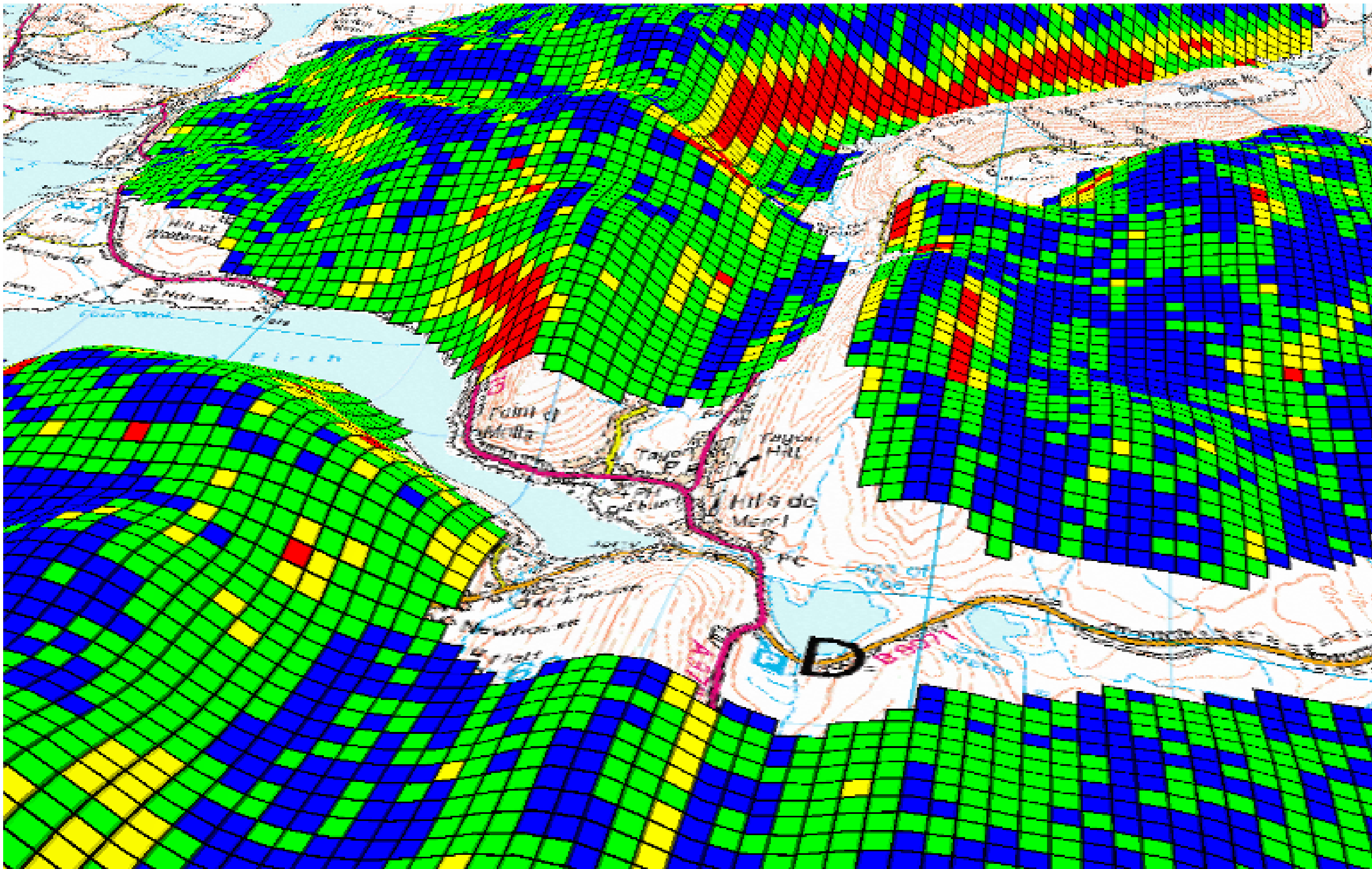
Where:

c’	(cohesive) shear strength [kN/m2]
γ	bulk density of peat [kg/m3]
γw	bulk density of water [kg/m3]
m	water table elevation as a ratio of peat depth [m]
z	peat depth perpendicular to slope [m]
β	slope angle [Degrees]
ǿ	angle of internal friction [Degrees]

Quantitative Assessment - Overview

- **Based on Infinite Slope Model**
- **Determine characteristic shear strength**
  - Back calculate (*lower bound*) shear strengths from peat probing
  - Adjust strength on basis of observation
- **For each grid cell determine:**
  - Surface slope from DTM
  - Peat depth from indicative map (or actual)
  - Calculate Factor of Safety (FoS)
- **Display FoS as thematic map**
  - Provide feedback into windfarm design layout
  - Undertake supplementary fieldwork as necessary

Quantitative (FoS) Assessment – Pictorial Output



Combined Assessment Matrix

Qualitative Assessment	Quantitative (FoS) Assessment			
	> 2.5	1.3 – 2.5	1.0 – 1.3	< 1.0
Negligible				
Low				
Medium				
High				

Combined Key:	
Neg.	Low
Medium	High

- In general the qualitative assessment is more conservative than the quantitative assessment
- Combined assessment provides a cross check for anomalous results

Combined Assessment Matrix – Post Layout

Qualitative Assessment	Area	Total	Quantitative Assessment Factor of Safety			
			>2.5	1.3 – 2.5	1.0 – 1.3	<1
Neg.	Grid Area	1312	1312			
	Tracks	271	271			
	Turbines	91	91			
Low	Grid Area	2785	2781	4		
	Tracks	685	684	1		
	Turbines	197	197			
Medium	Grid Area	215	191	19	5	
	Tracks	57	49	7	1	
	Turbines	16	13	3		
High	Grid Area	11	1	3	2	5
	Tracks	2		2		
	Turbines	3		1	1	1
Totals	Grid Area	4323	4285	26	7	5
	Tracks	1015	1004	10	1	
	Turbines	307	301	4	1	1

Combined Key:

Neg.	Low
Medium	High

Final Steps: Exposure, EIA context, Risk Register

- Combined Assessment Matrix has identified the areas of highest susceptibility
- Reject grid cells not relevant to windfarm footprint
- For candidate grid squares:
  - estimate potential slide direction, volume, distance and receptor
  - possibly undertake further localised fieldwork
- For each potential incident consider impact in ‘EIA language’:

  not significant OR significant

- For each potential incident consider mitigation measures and reassess impact post mitigation
- Tabulate details in the form of a Risk Register and summarise findings.

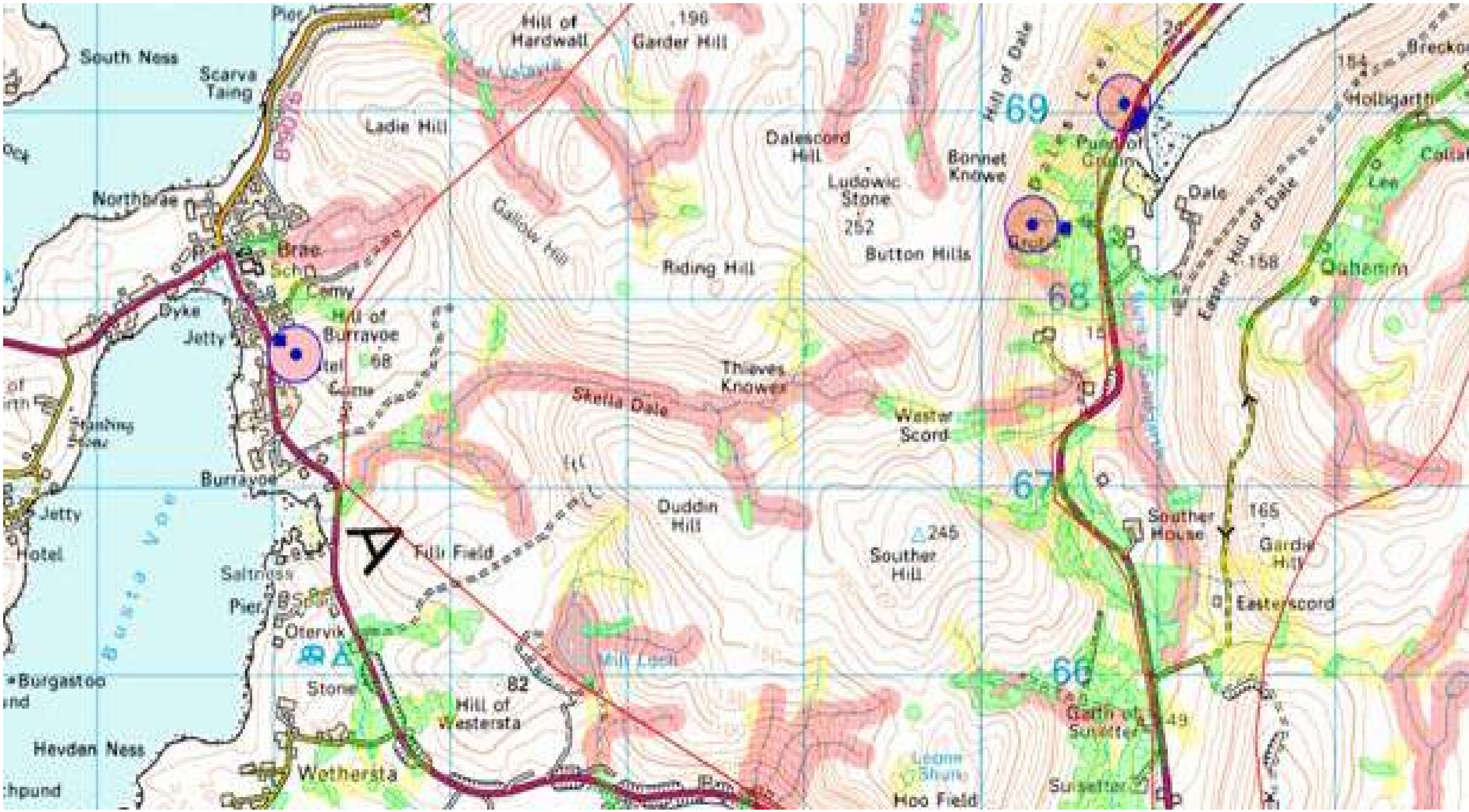
Any Questions ?

An Environmental Impact Assessment

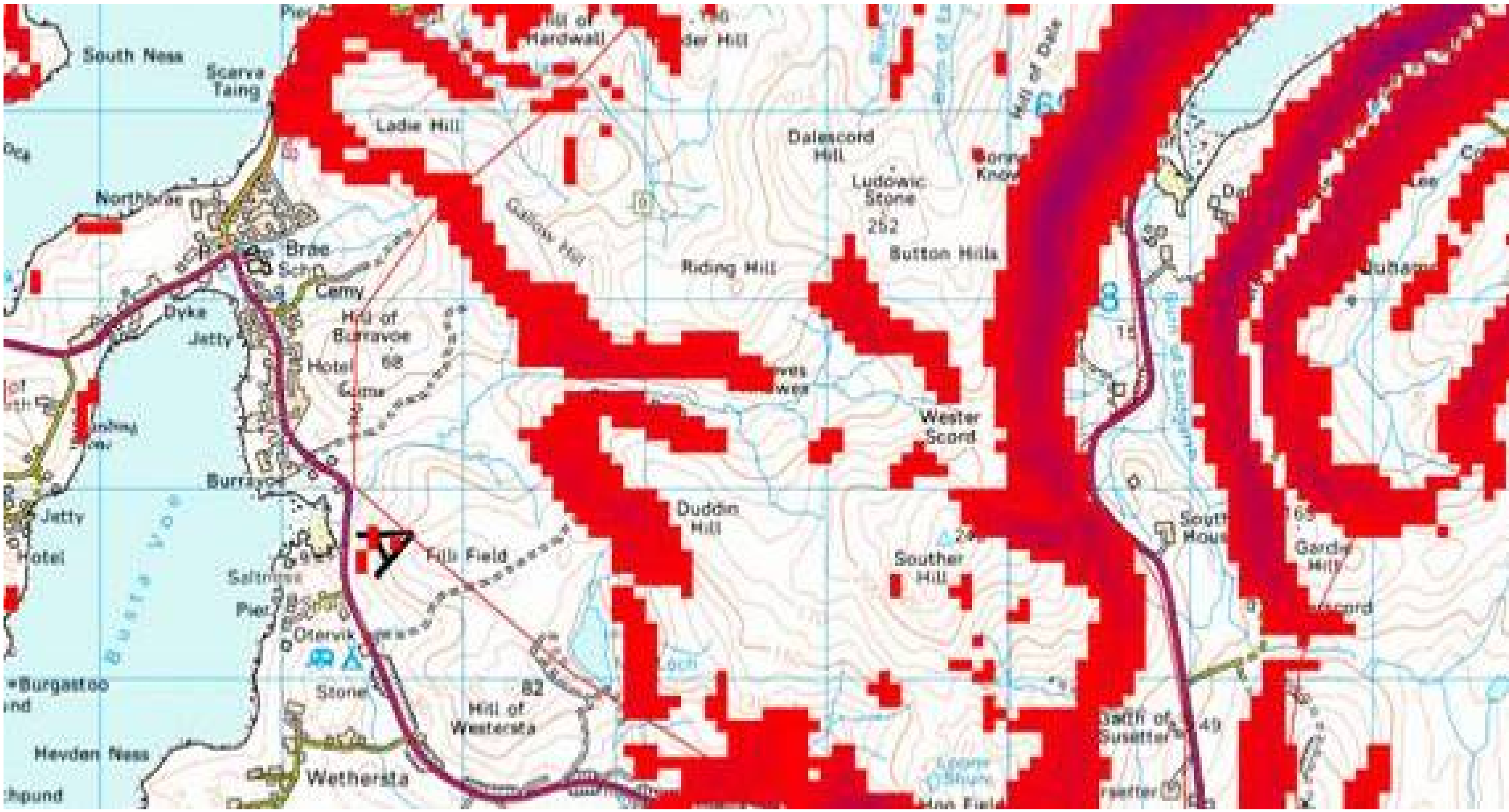
is…"a means of drawing together, in a systematic way, an assessment of a project's likely significant environmental effects. This helps to ensure that the importance of the predicted effects, and the scope for reducing them, are properly understood by the public and the relevant competent authority before it makes its decision."

Para. 6 of Circular 15/1999

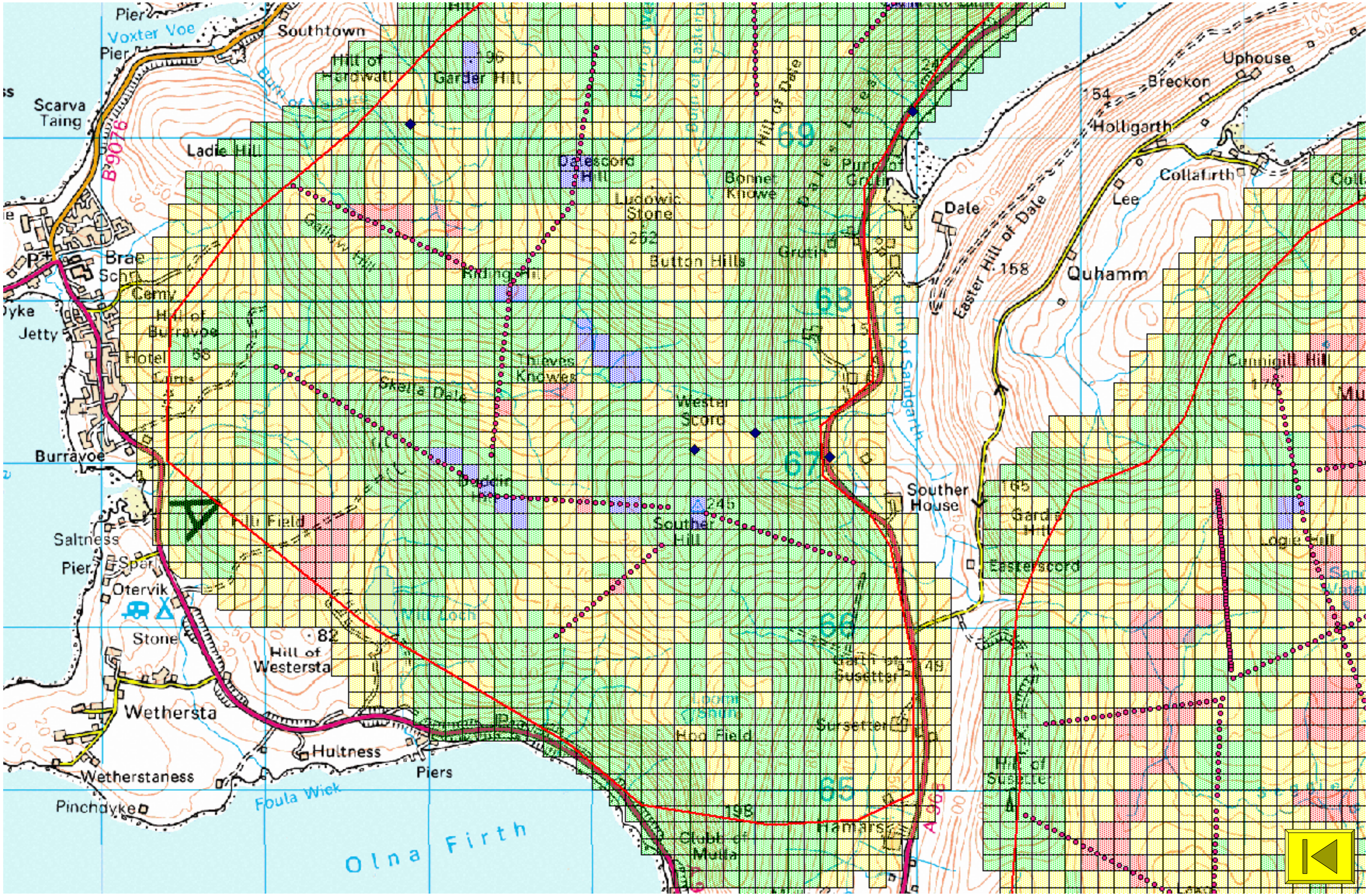
Constraint: Buffers round water features



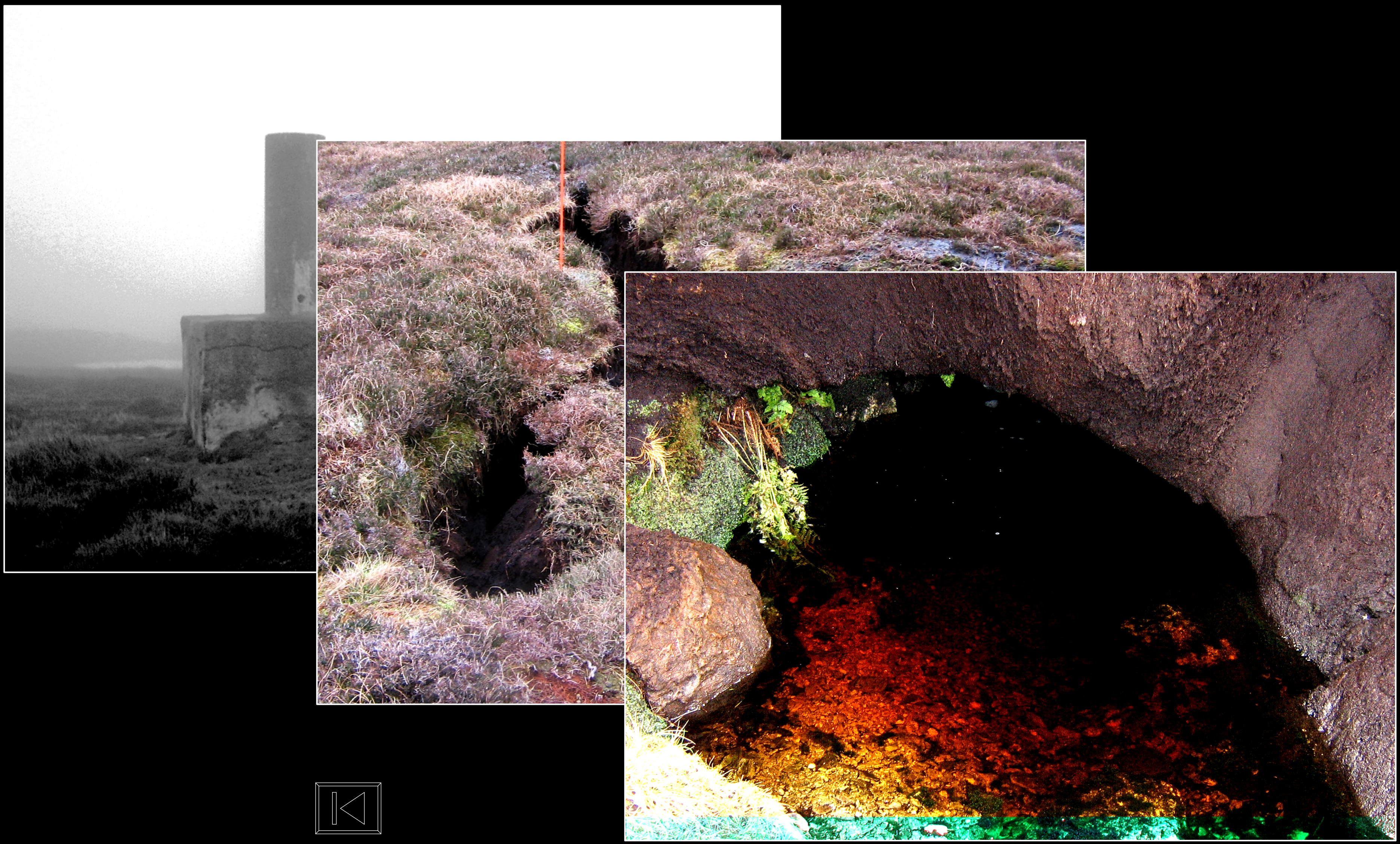
Constraint: Slopes > 10 Degrees



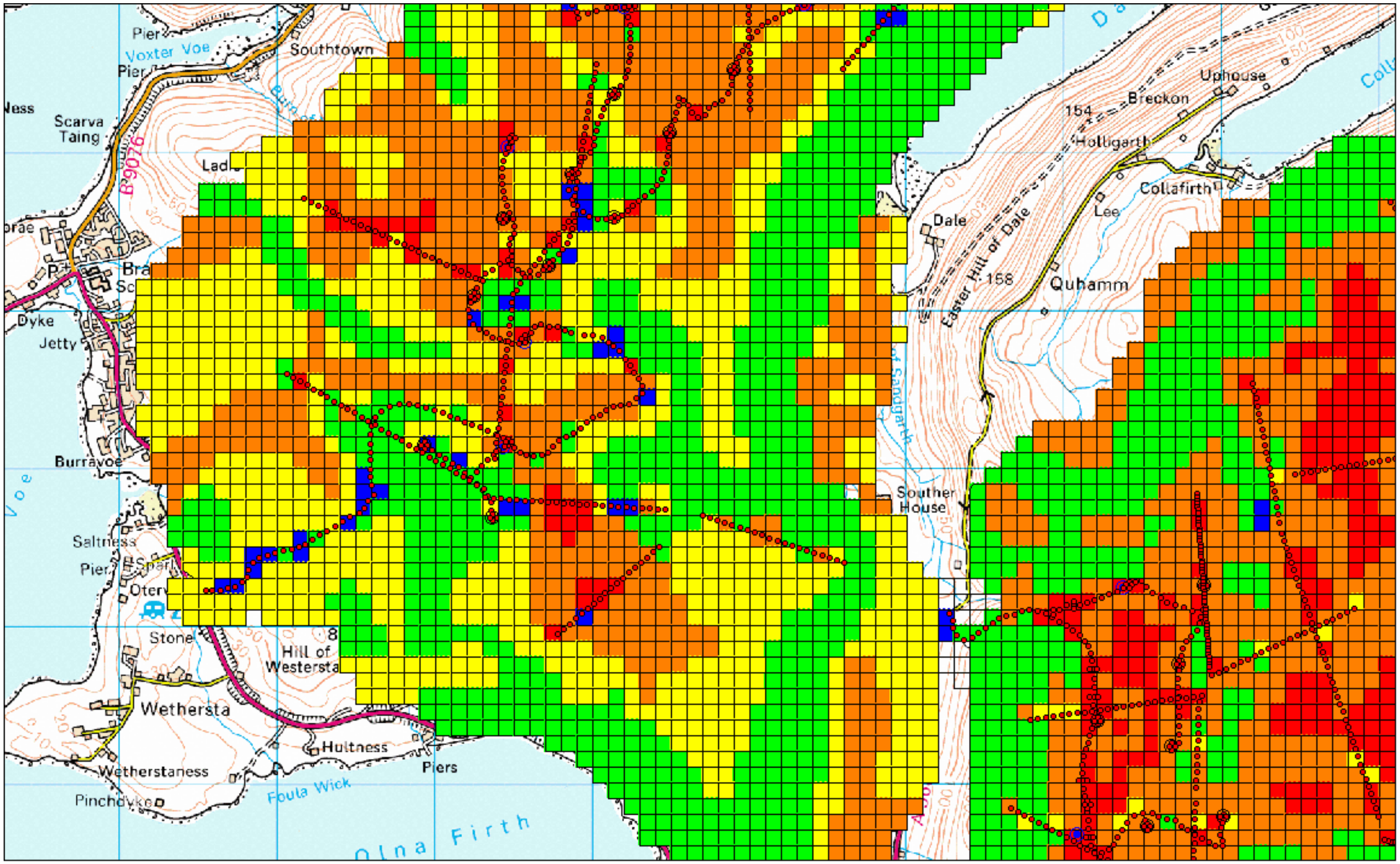
Constraint: Peat Depths



Telltale Signs: Erosion, Tension cracks, Peat pipes



Indicative Peat Depth Maps



Depth (m)	1	2
0.0 - 0.5		
0.5 - 1.0		
1.0 - 1.5		
1.5 - 2.5		
> 2.5		

Surface Classification

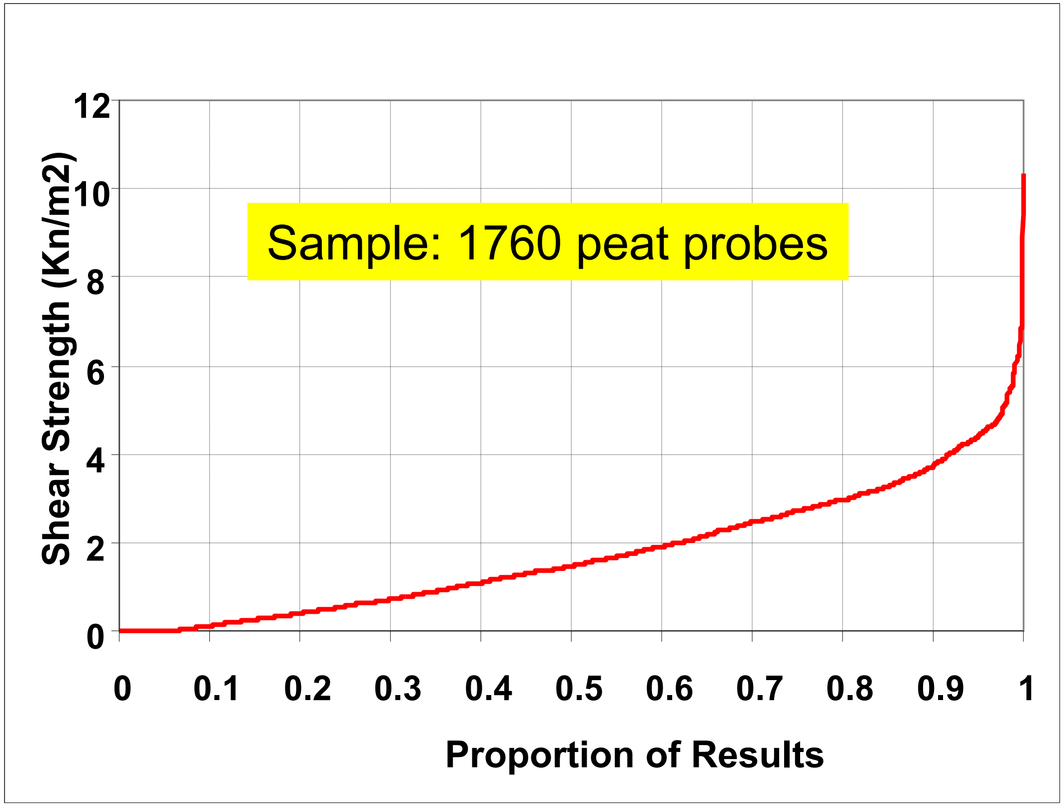
Class 1

Class 2

Class 3

Class 4

Shear Strengths – back calculated values



Seven variables in Infinite Slope Equation:

- Some values fixed

- Some can be inferred

-Some vary with location

So can rearrange Eqn to calculate Shear Strength

All values are estimates of minimum strength required for stability at that location.

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Detailed location specific assessment

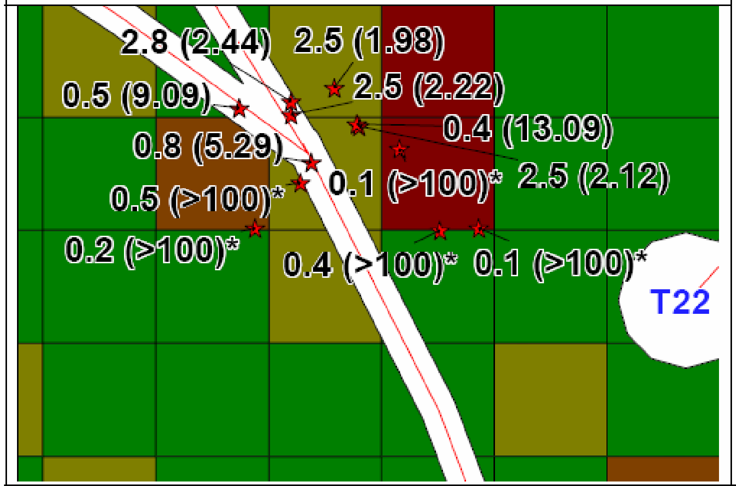
Detailed Assessment Area 2

See Drawing 5 for site location

Location: NN 91860 44107 – near junction to TA21

1^{st} **Assessment:** Combined Risk Assessment - Moderate

2^{nd} **Assessment:** Reduced to Low Risk



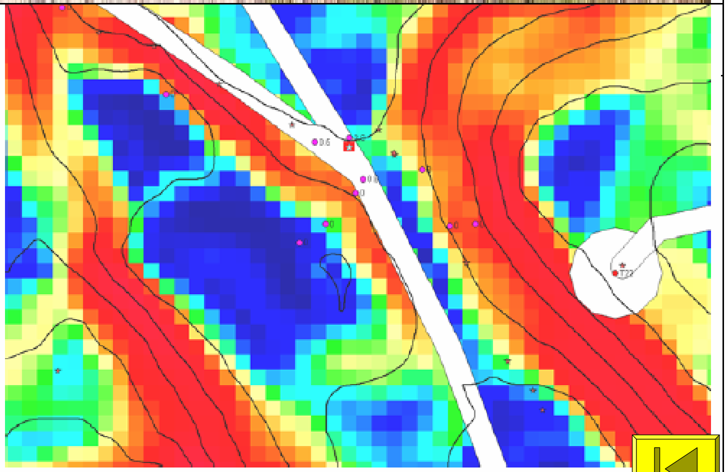
The cells are coloured according to the 1st assessment of FoS, the numbers show peat depth and FoS from the 2nd assessment (in brackets)

** Calculations performed for soil, where peat depth is zero.*

Discussion:

This area lies towards the northwest end of a saddle between two hill tops about 450m apart. The high risk cells (above) are at the base of the northeast top where the hillside is steep (as illustrated in photo) and this strongly influences the mean slope for the grid cells used in the initial FoS calculations. However, at the deepest peat location (2.8m) the ground has little slope and on the slopes there is only shallow soil and no peat. In summary, the deeper peat is very fibrous, localised and constrained by topography. It is possible that short lengths of floating road may be used over the deeper peat. The FoS calculations do not suggest any risk of a peat slide developing.

The steep slopes are indicated by red and the flat areas by blue. This is also shown by the 5m interval contour lines. The access track and junction to TA21 lies in a saddle. The steeper slopes have a cover of shallow soils about 0.2m deep.



Ayrshire: Hill grazing, shallow soils, limited peat in hollows

Galloway: Coarse grasslands, extensive shallow peat

Perthshire: Forestry, traversed with roads, extensive peat

Shetland: Uniform blanket bog, deep generally, intact

Hebrides: Lochans, rocky outcrops, areas of deep peat