UKOPA

Acknowledgements

Slide 5. Diagrams taken from:
Landsliding In Great Britain
Jones, D.K.C. & Lee, M.
HMSO. 1994.

Slide 6. Images taken from:
Geology of Britain viewer
http://www.bgs.ac.uk/discoveringgeology/geologyofbritain/viewer.html?src=topNav

Slide 7. Landslide domain map reproduced from:
Dashwood, C., Hobbs, P., & Harrison, A.
'National Grid Landslide Assessment'
Presented at a meeting in Keyworth on 15th May 2014.

Slide 9. One map image reproduced from:
Landslide Assessment GeoReport
Fenny Bentley
Near Ashbourne, Derbyshire.
Report GR_999999/1
British Geological Survey. 23rd June 2011.
http://shop.bgs.ac.uk/GeoReports/info.cfm?STD_REP=S009

Slide 23. Landslide susceptibility map reproduced from:
Foster, C.
Landslide Susceptibility Mapping – The GB perspective
British Geological Survey.
Presented at Expert Meeting on Harmonised Landslide Susceptibility Mapping for Europe, JRC, Ispra, Italy. 26-27th May 2010.

PIPELINE FAILURE RATES DUE TO INLAND NATURAL LANDSLIDING

G Leach

NIA_NGGD0019

October 2015

1 December 2015

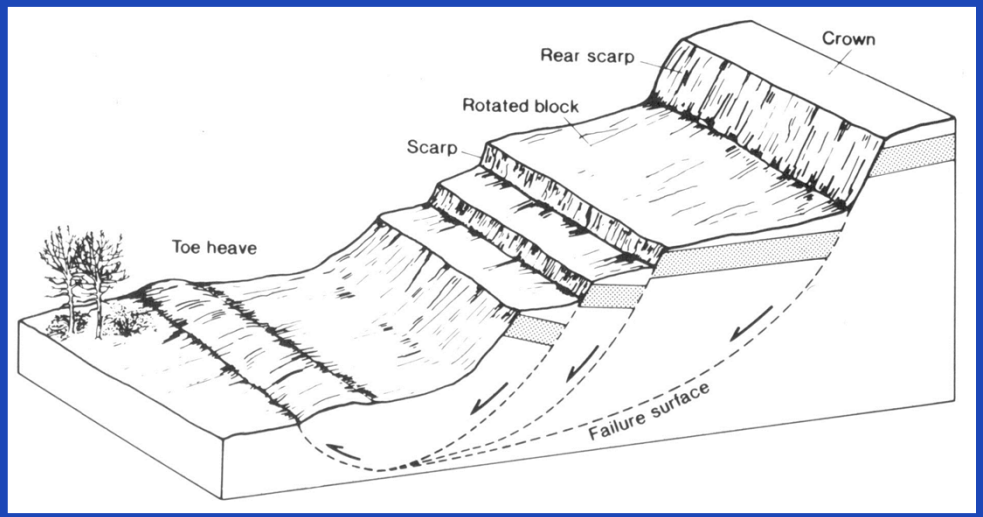
Background

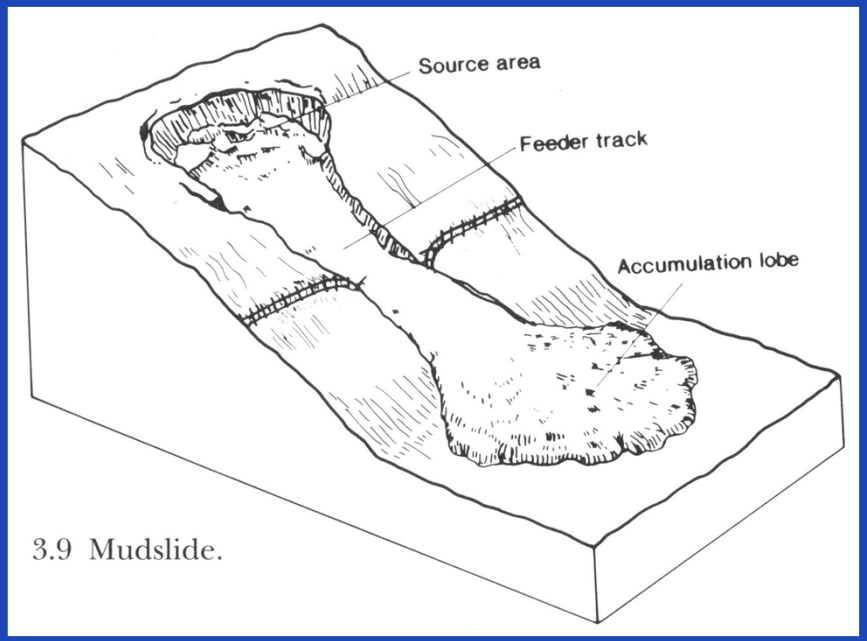
- **2003 – Transco**
  - BGS 6-tier landslide susceptibility (5, 4, 3, 2, 1, 0)
- **2005 – Transco**
  - BGS - 334 landslide deposits on HP network (zone 5)
- **2005 – Transco**
  - Weighted average failure rates
- **2013 – UKOPA [TD/2 & PD 8010-3]**
  - Rupture & Leak
  - Failure rates by WT & Weld Quality
  - 3-tier landslide susceptibility (BGS 2010)
- **2012 – National Grid**
  - BGS 5-tier landslide susceptibility
- **2014 – National Grid - NIA**
  - BGS – landslide domains
  - BGS – revised landslide dataset
- **2015 – NIA**
  - Failure rates by WT for Domains & GeoSure classes

Natural Landslides

Natural Landslides

- Gravity induced mass movements
  - Slides (~88%)





3.9 Mudslide.

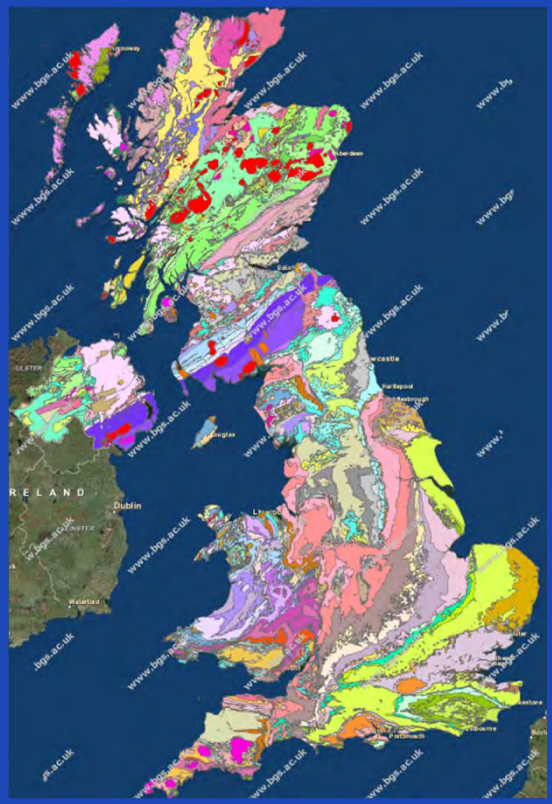
Landslide Domains

PIE

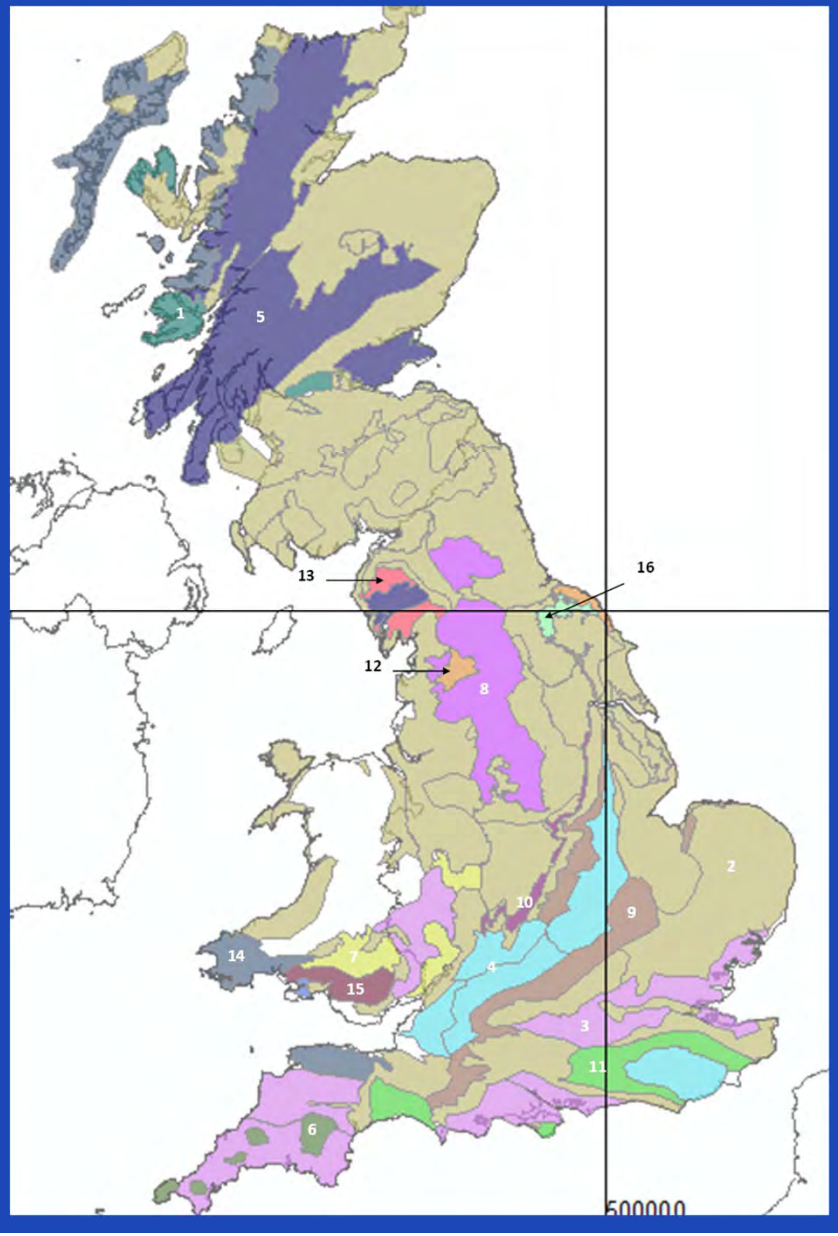
Physical Relief

Superficial Deposits

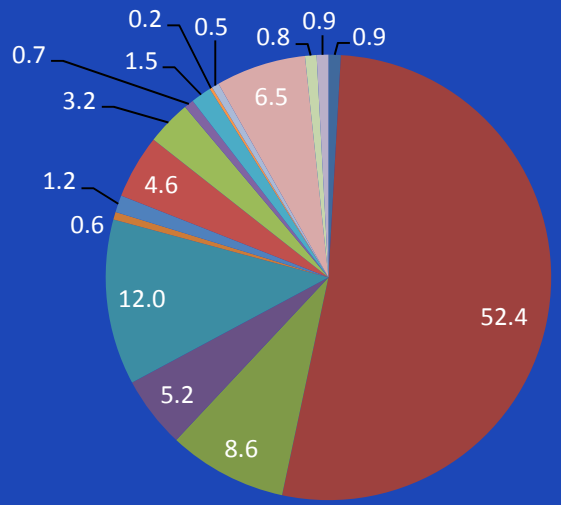
Bedrock Geology



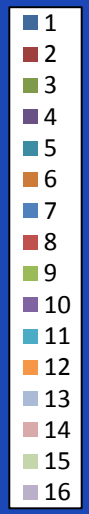
Landslide Domains

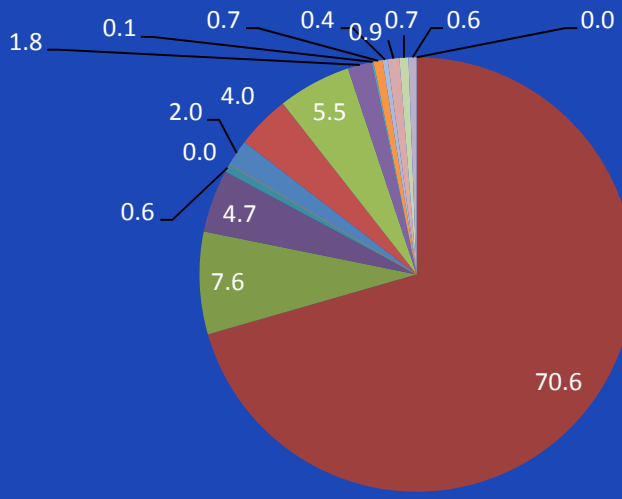


Landslide Domains



Land Area

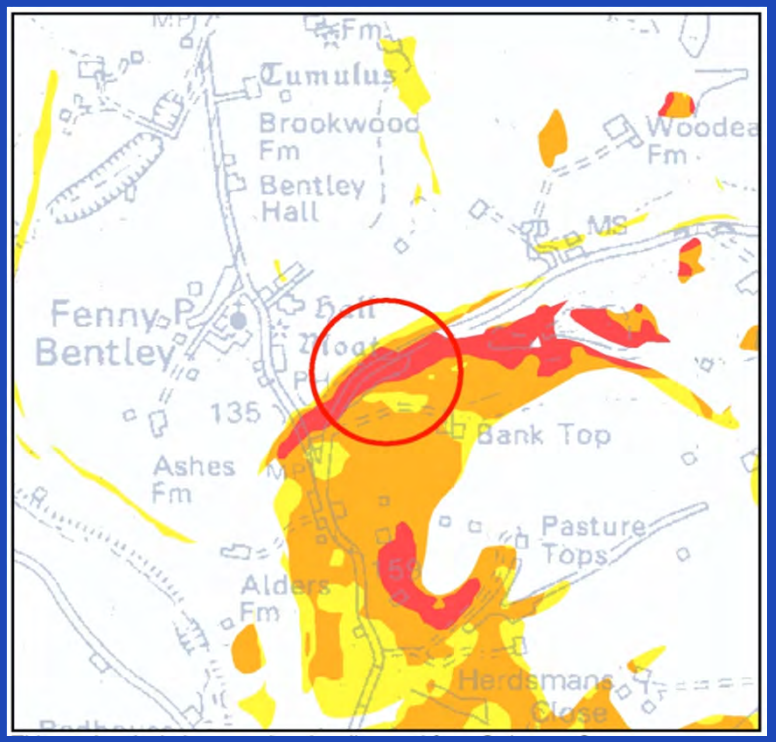




Pipeline Length

Susceptibility Zones [GeoSure]

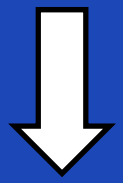
Class	Description
E	Slope instability problems almost certainly present and may be active.
D	Slope instability problems are probably present or have occurred in the past.
C	Slope instability problems may be present or anticipated.
B	Slope instability problems are not likely to occur but consideration to potential problems of adjacent areas impacting on the site should always be considered.
A	Slope instability problems are not thought to occur but consideration to potential problems of adjacent areas impacting on the site should always be considered.



Class	Spatial Extent in GB (%)	Notes
E	~0.2	~10% prone to landsliding
D	~1.1	
C	~8.5	
B	~81.6	~90% not prone to landsliding
A	~8.7	

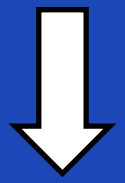
Domains & GeoSure Classes

Domain



Landslide Hazard

GeoSure Class



Landslide Frequency

BGS Work Elements

- **Domain map**
  [NG network]
- **Review of large landslide deposits**
  [for size attributes]
- **Landslide density (no/km^2)**
  [By Domain & GeoSure class]

PIE Work Elements

- Quantify landslide hazard
- Develop software for automated numerical probabilistic analysis
- Develop girth weld fragility curves
- Rationalise ~12600km network for analysis
- Perform calculations
- Provide results & procedure

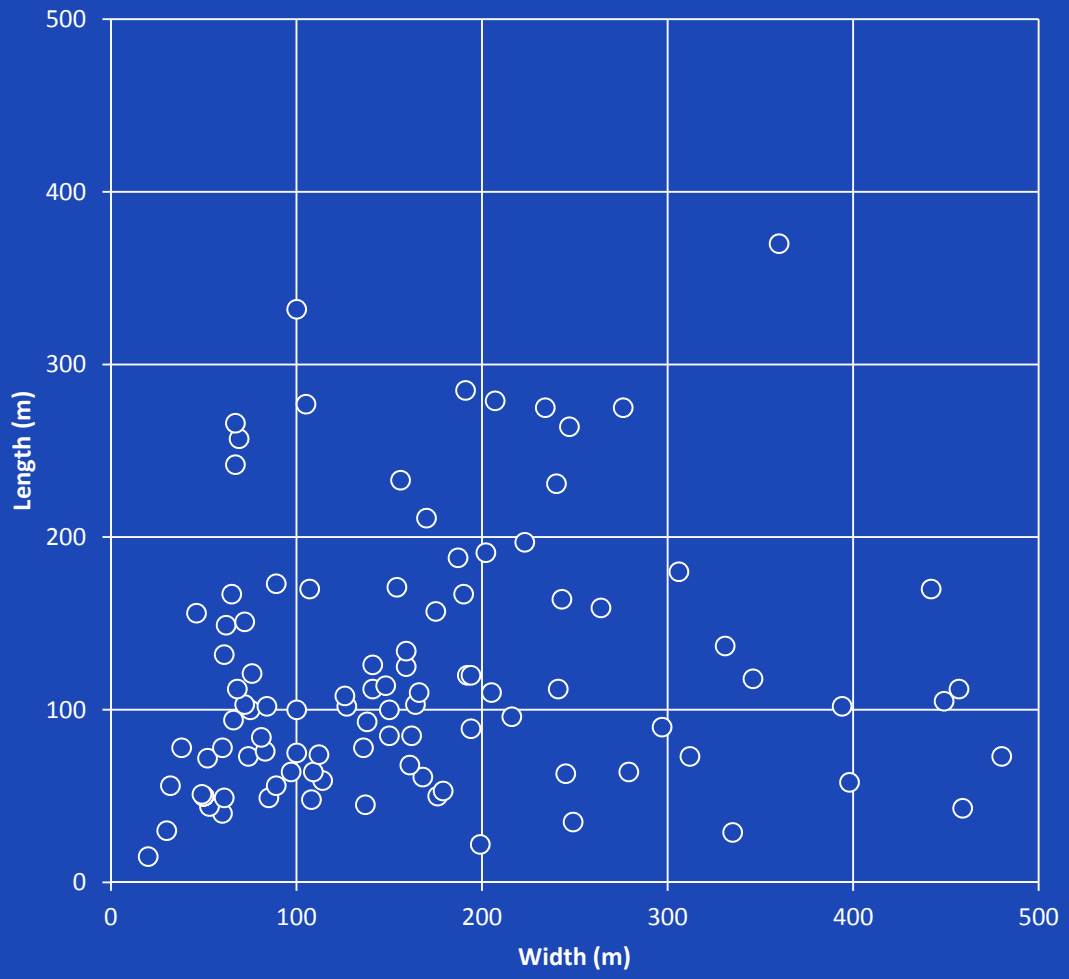
Landslide Hazard

- Size [width & length]
- Movement Level [magnitude]
- Ground Strength
- Pipeline Alignment

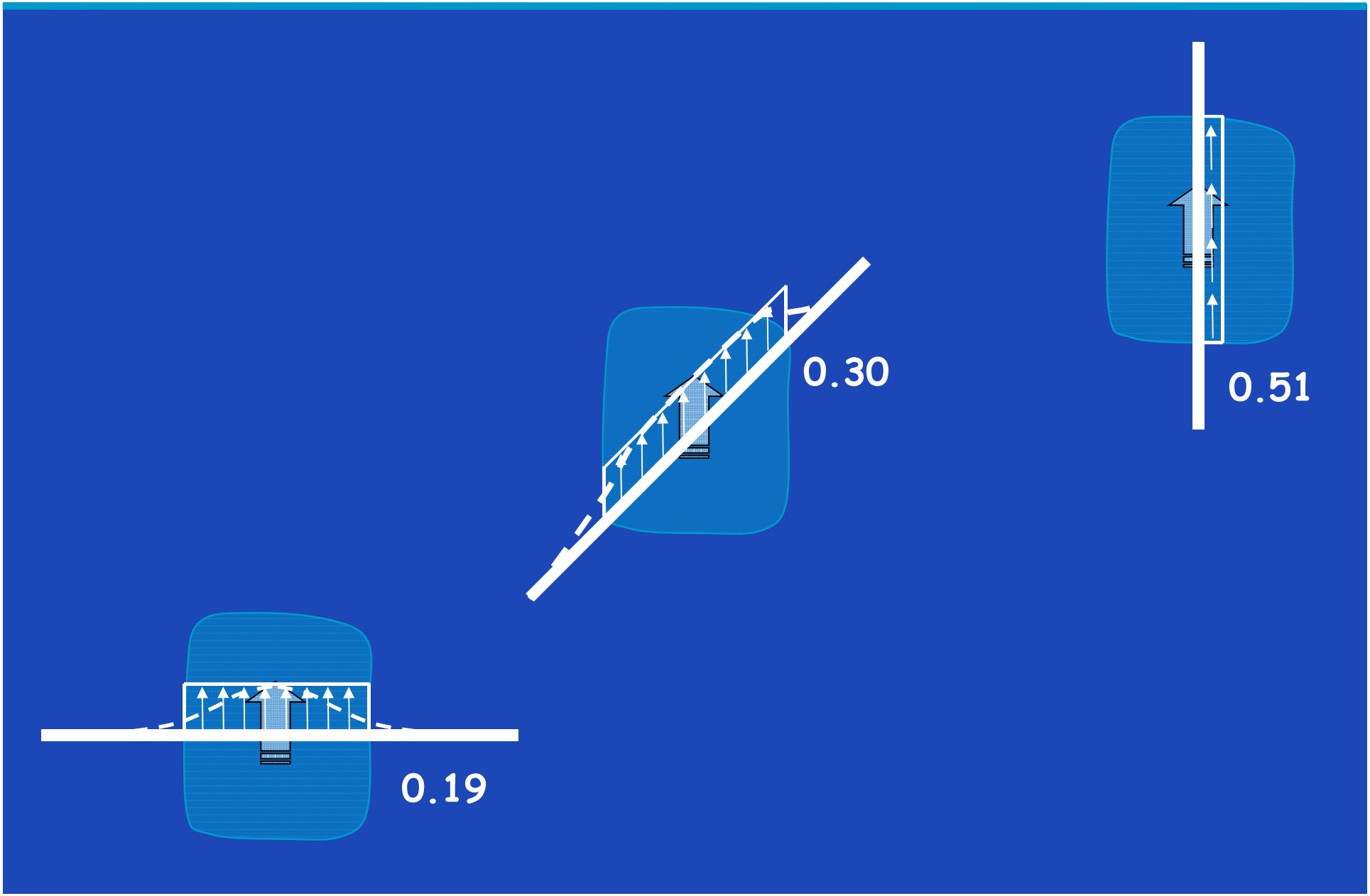
- Values expressed as probability density distributions

Landslide Hazard by Domain

Domain 2 – Landslide Size



Alignment



Method [Vulnerability]

15 landslides (Across slope alignment)

15 landslides (Down slope alignment))

60 landslides (45 degree alignment)

8 movement levels

---

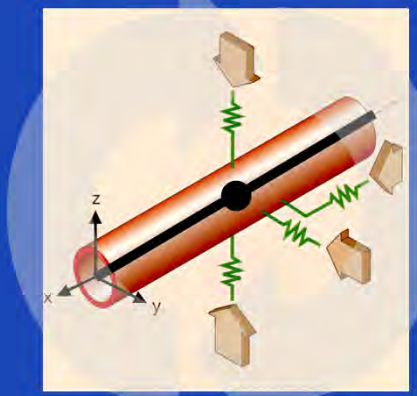
5 ground strength conditions

PIPELINE ATTRIBUTES

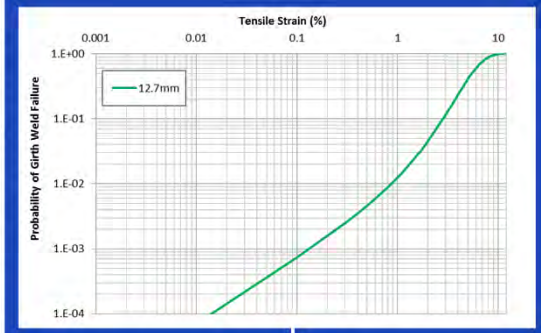
- Diameter
- Wall Thickness
- Grade
- Operating Pressure
- Weld Quality

Number of load cases
= 15 x 8 x 5 +15 x 8 x 5 + 60 x 8 x 5 = 3600

Probability of Each Condition
$= P_{Alignment} \times P_{Landslide\_Size} \times P_{Movement\_Level} \times P_{Ground\_Strength}$



Strain Outputs to Fragility Curve to Obtain Probability of Failure



$PoF_{Rupture}$ x hit rate

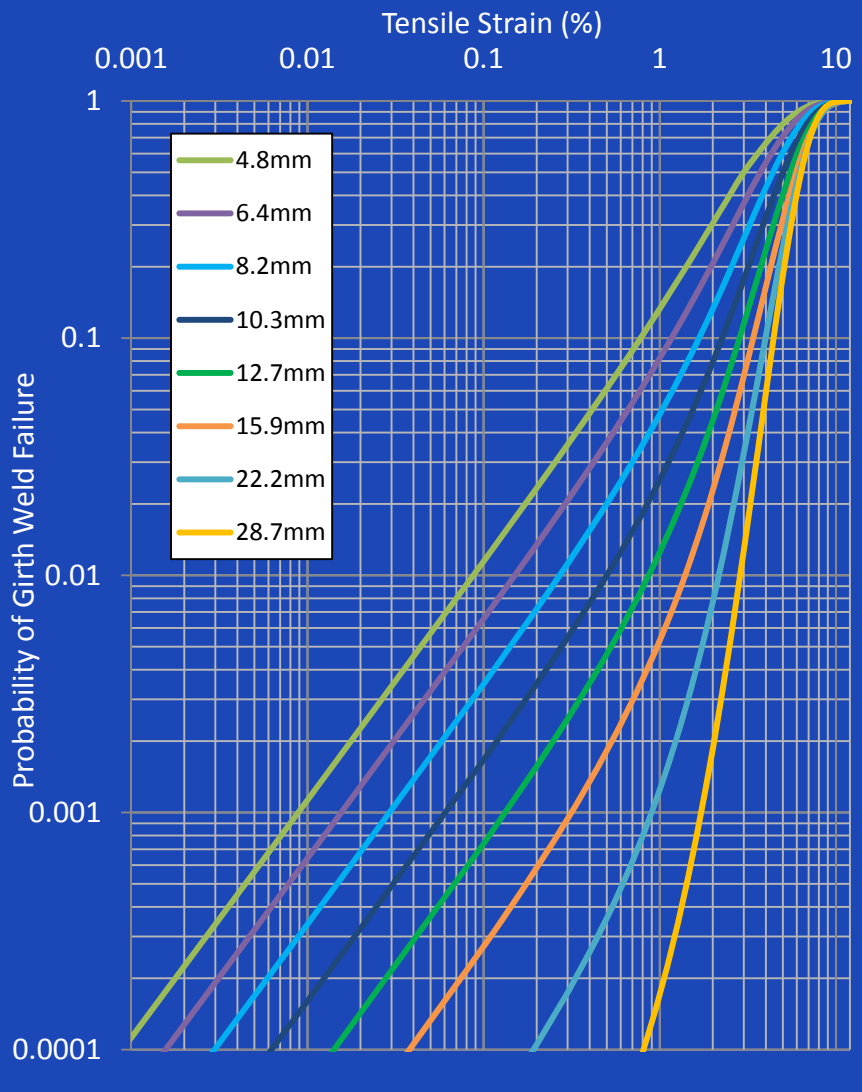
PoF_{Leak} x hit rate

Summation over load cases

Vulnerability factor = $\sum_{1}^{Cases} PoC.PoF.hit\ rate$

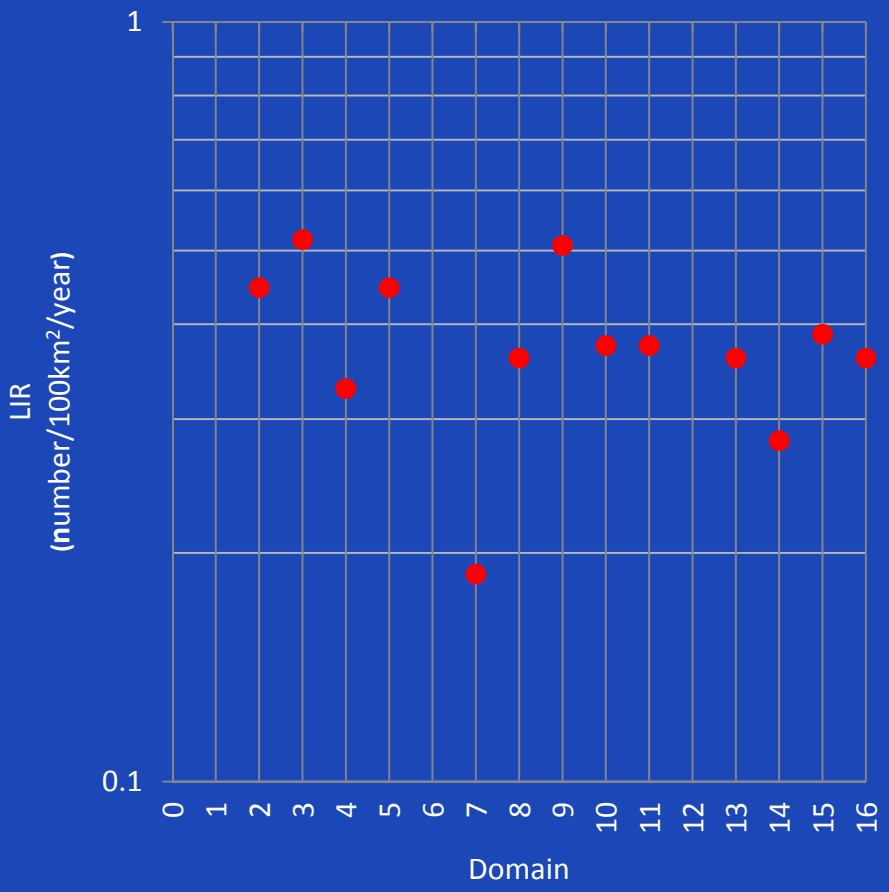
[probability of failure/km/(landslide/km^2)]

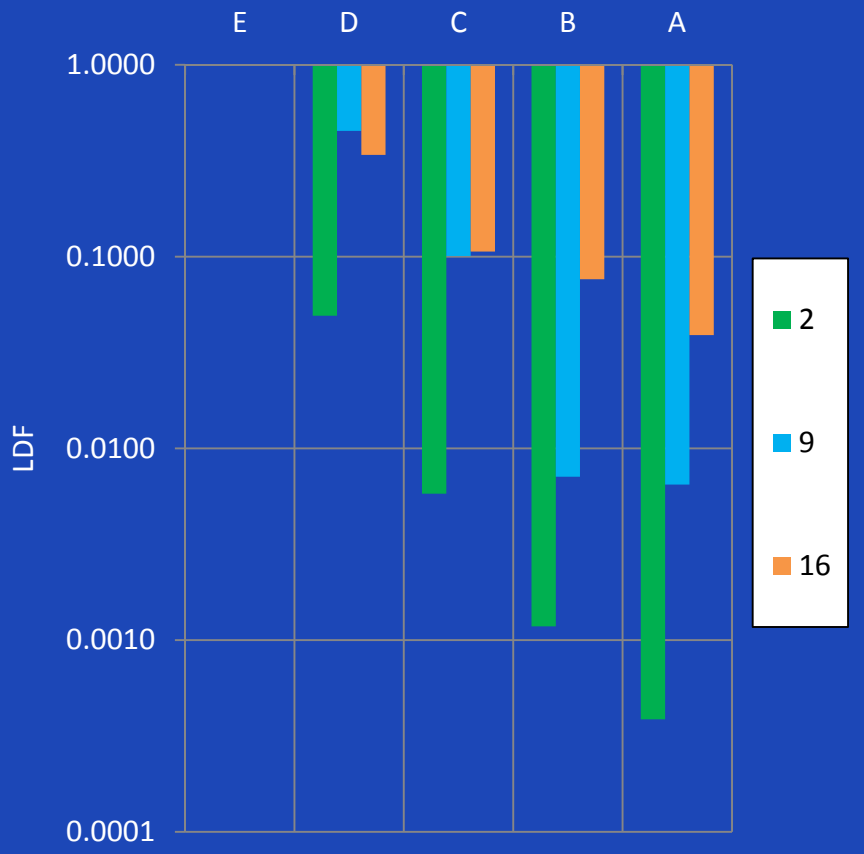
Method [Fragility Curves]



Method [Failure Rate]

$$F = VF.LIR.LDF$$

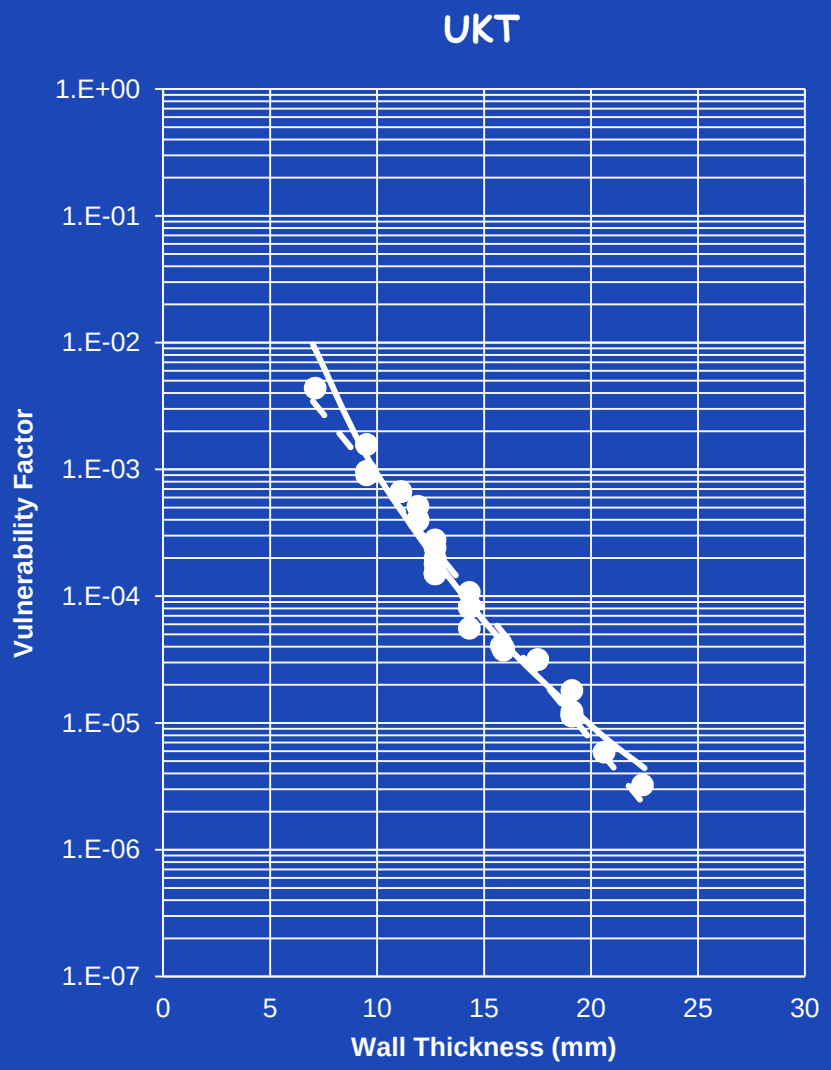


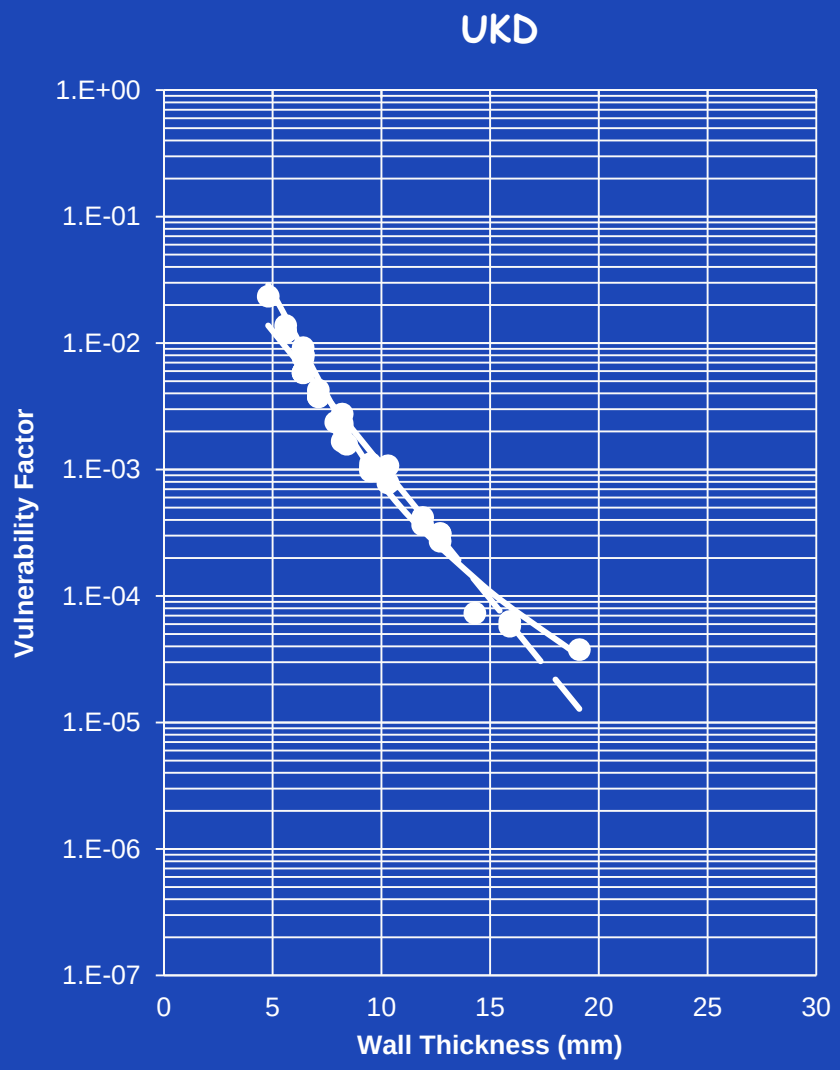


Calculations

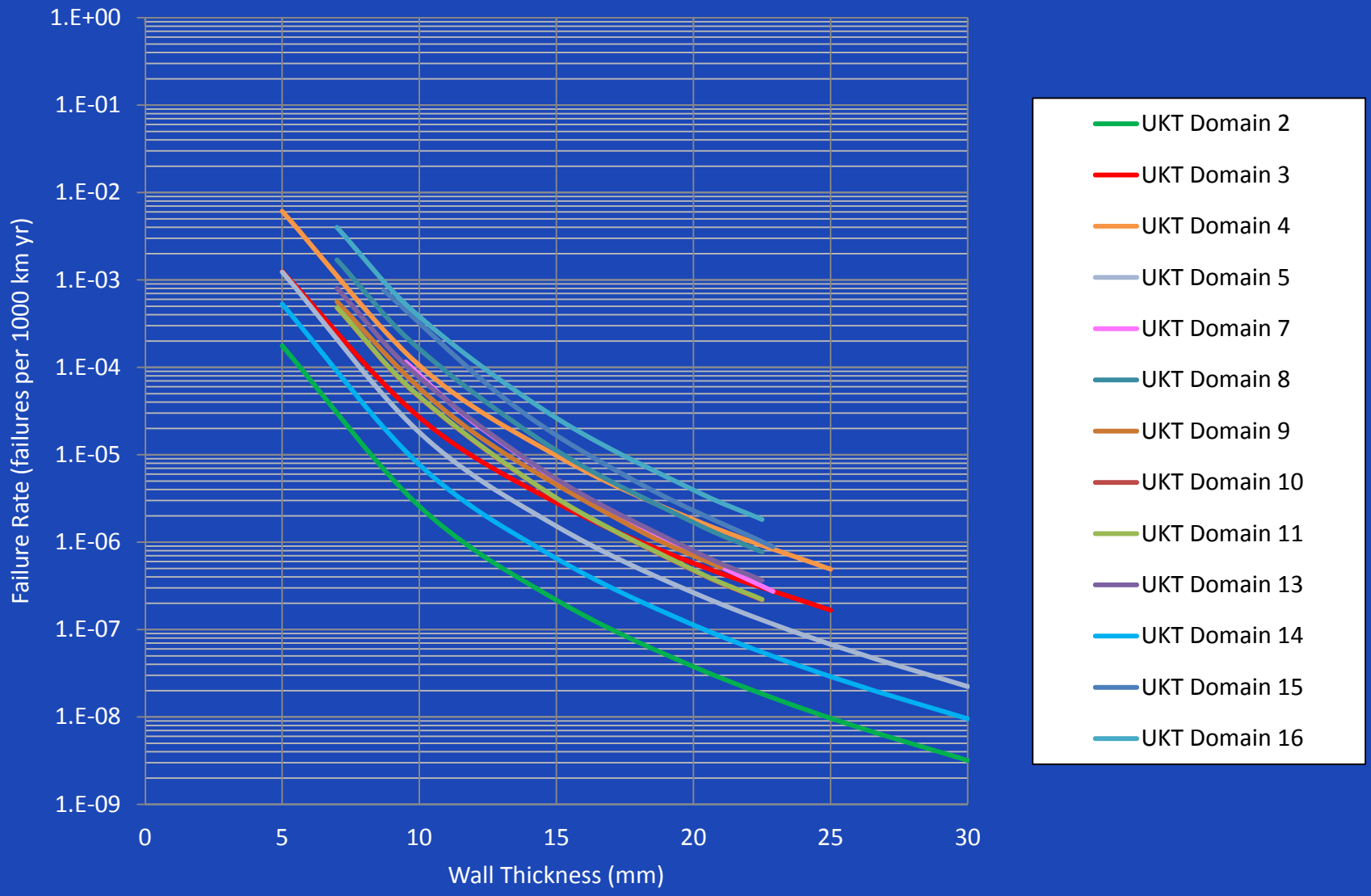
- Attribute Influence
  - Diameter
  - Grade
  - Internal Pressure
- 286 pipe groups – [12692 km]
  - ~70% in domain 2, ~90% in class B
  - 114-1219mm
  - 3.6-28.7mm
  - B-X80
  - 9-94 bar (76 bar UKT & 34 bar UKD)

Results


UKT
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
Vulnerability Factor
0
5
10
15
20
25
30
Wall Thickness (mm)


UKD
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
Vulnerability Factor
0
5
10
15
20
25
30
Wall Thickness (mm)

Results


1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
Failure Rate (failures per 1000 km yr)
0
5
10
15
20
25
30
Wall Thickness (mm)
UKT Domain 2
UKT Domain 3
UKT Domain 4
UKT Domain 5
UKT Domain 7
UKT Domain 8
UKT Domain 9
UKT Domain 10
UKT Domain 11
UKT Domain 13
UKT Domain 14
UKT Domain 15
UKT Domain 16

Implied Events

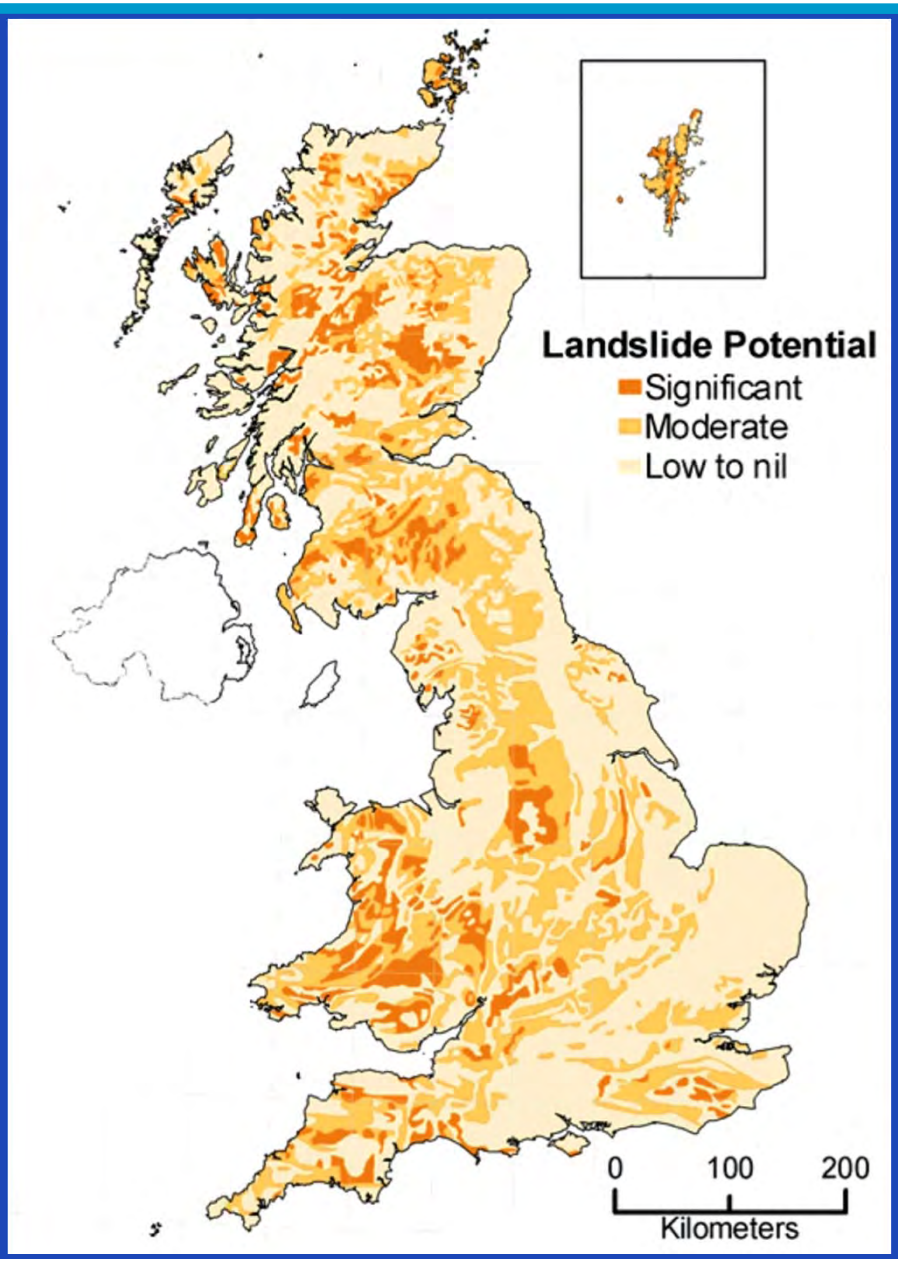
Landslides	Retained Network	National Network
	~6	~9

Failure Mode	Retained Network	National Network
Severance	~0.1	~0.2
Leak	~0.2	~0.4

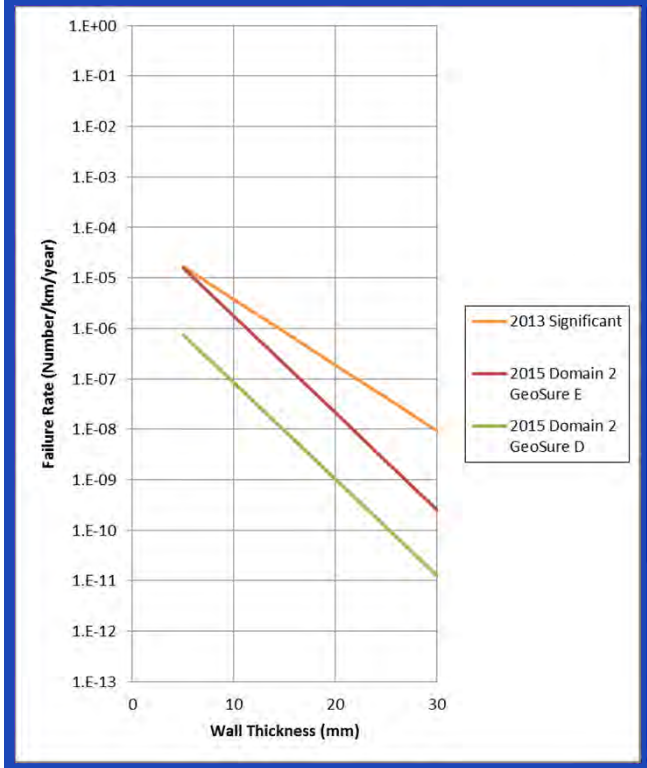
2005		National Network
Severance or Leak		~0.2

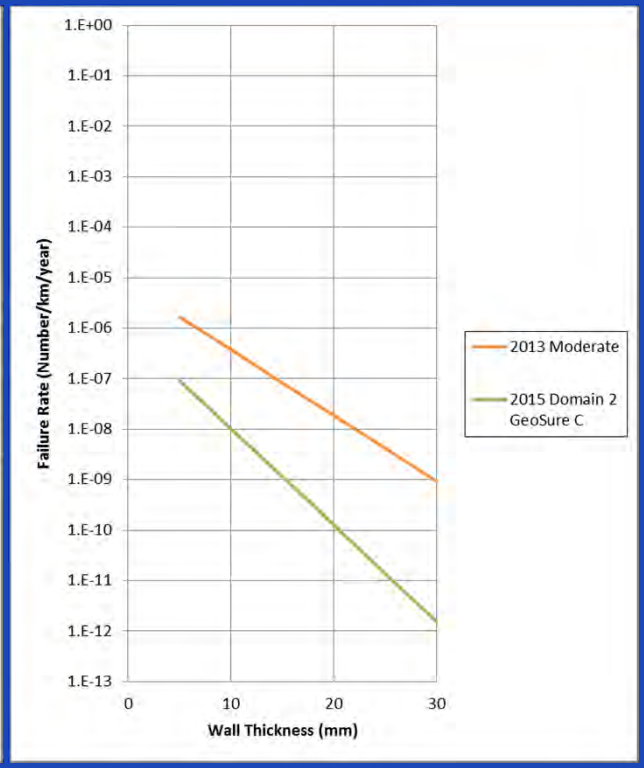
2005	2.1E-07 failures/km/year	
2013	3.8E-07	4.3E-06
2015	1.6E-07	4.4E-07

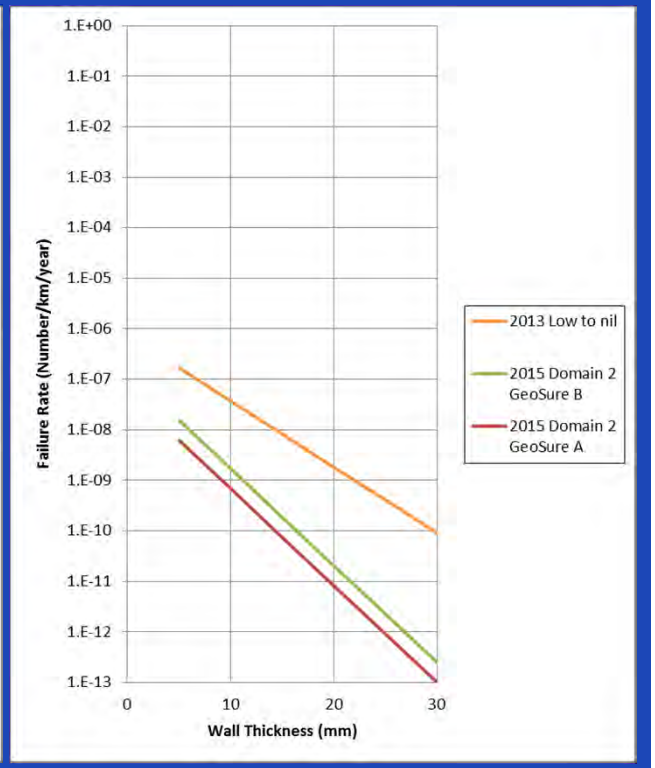
Landslide Susceptibility



Comparison







Example based tensile severance of 24 inch pipeline with standard quality girth welds