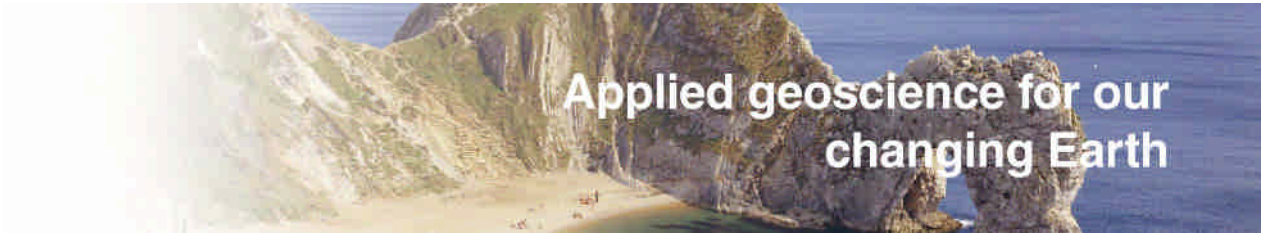
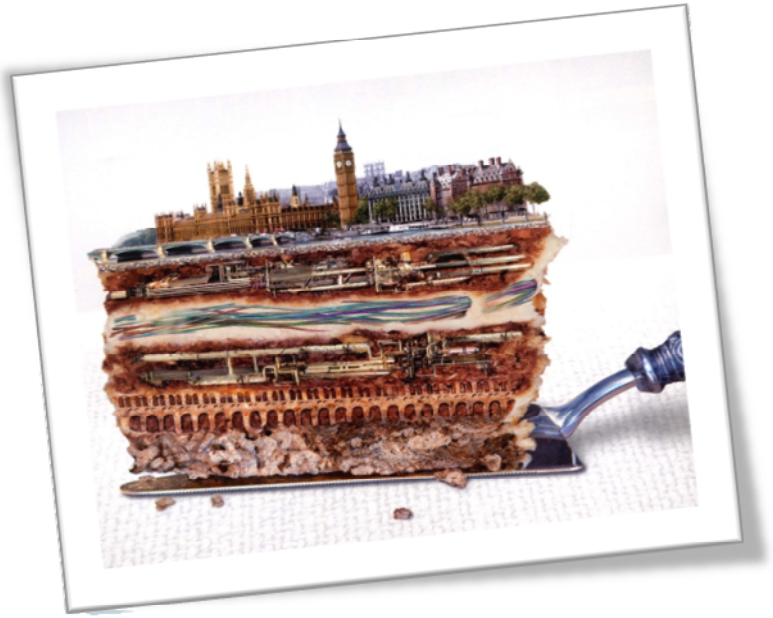
British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL



The use of 3D modelling and GIS technologies in understanding and predicting anomalous ground conditions in London



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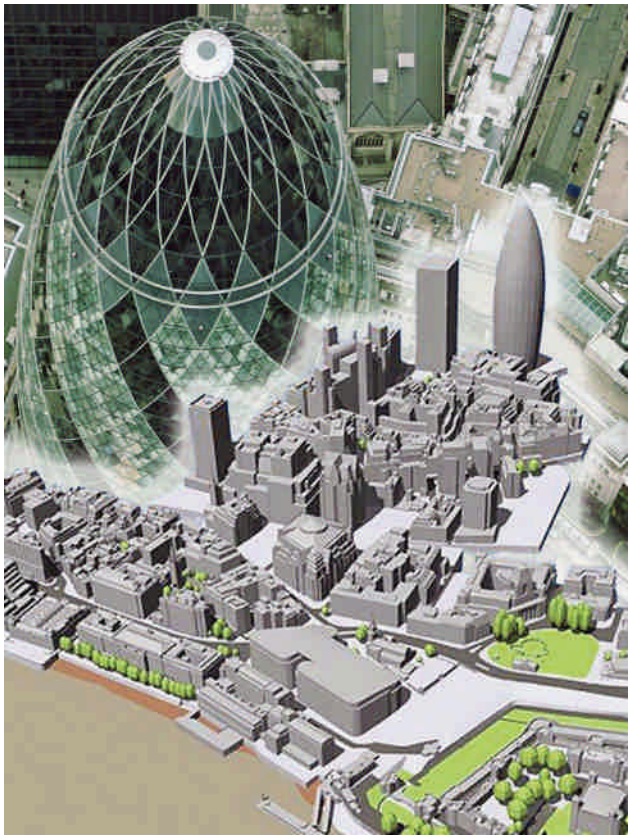
Outline

- Why use 3D modelling and GIS in London ?
- The use of 3D models and GIS technologies in:
    - understanding the distribution of lithofacies in the Lambeth Group
    - indentifying ‘Drift Filled Hollows’ beneath the River Terrace Gravels

Why Study the London Basin ?



7.5 million people, Greater London

14 million people, London Basin

urbanised – 80% live in 14% of area

300 years of industrial exploitation of geological resources

highly diverse geology in a small area

extensive exploitation of the shallow subsurface ‘zone of human influence’

The urban environment has dramatically expanded

This results in traffic congestion, higher levels of air pollution, lack of green space and insufficient water supplies

Development of sustainable cities…..but how?

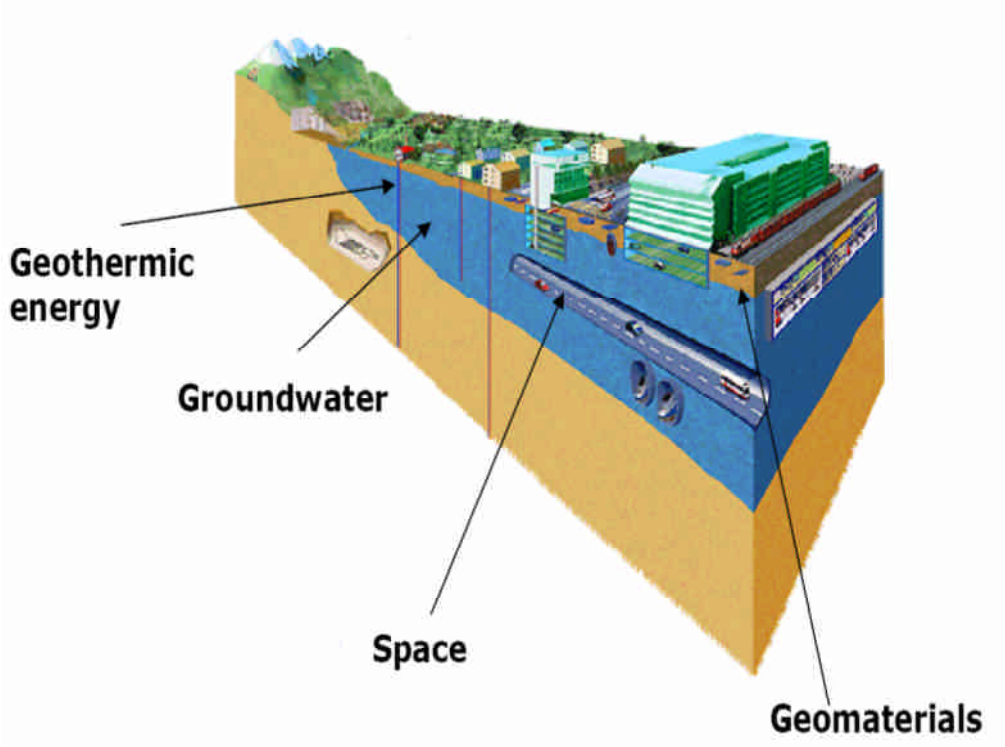
One solution is to develop more compact cities. We can do this by utilising underground space

But space is not the only resource underground e.g. groundwater, geo-materials and geothermal energy

Could the underground be better utilised ?

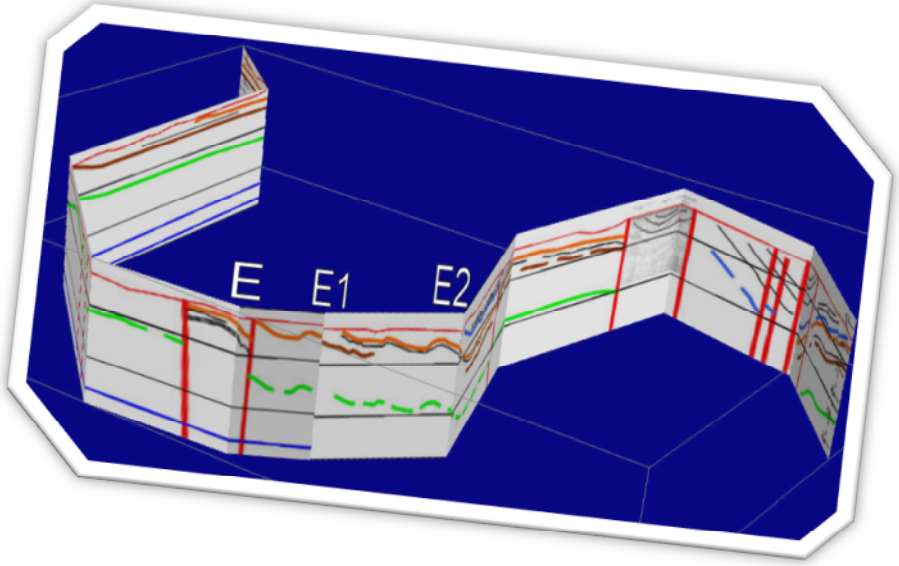
- Most of the investigations in the urban underground are done only at the **building scale**
- **Specialists** in the different aspects of urban underground development (e.g. geologists, engineers, hydrologists, environmental scientists etc) do not collaborate enough
- Geological structures are often **heterogeneous and complex**
- Planner and developers usually only have **partial access** to the information and don't have the ability to interpret and exploit it

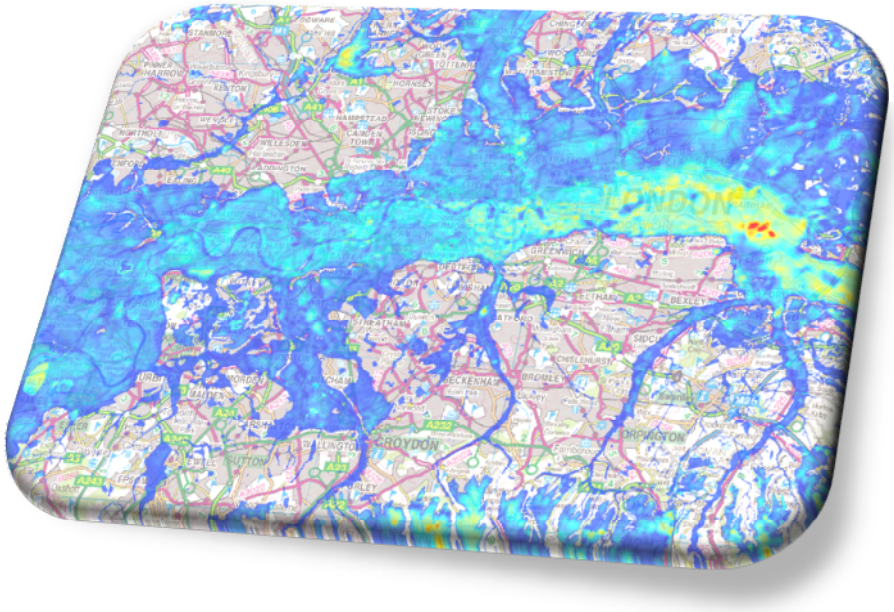
Solution: Detailed 3D models characterised with geotechnical and hydrogeological information



How well do we understand the geology in London?

Recent engineering projects (CTRL, CrossRail, Tideway, and DLR) suggest that the structure under London does **not fit the simple layer cake model**

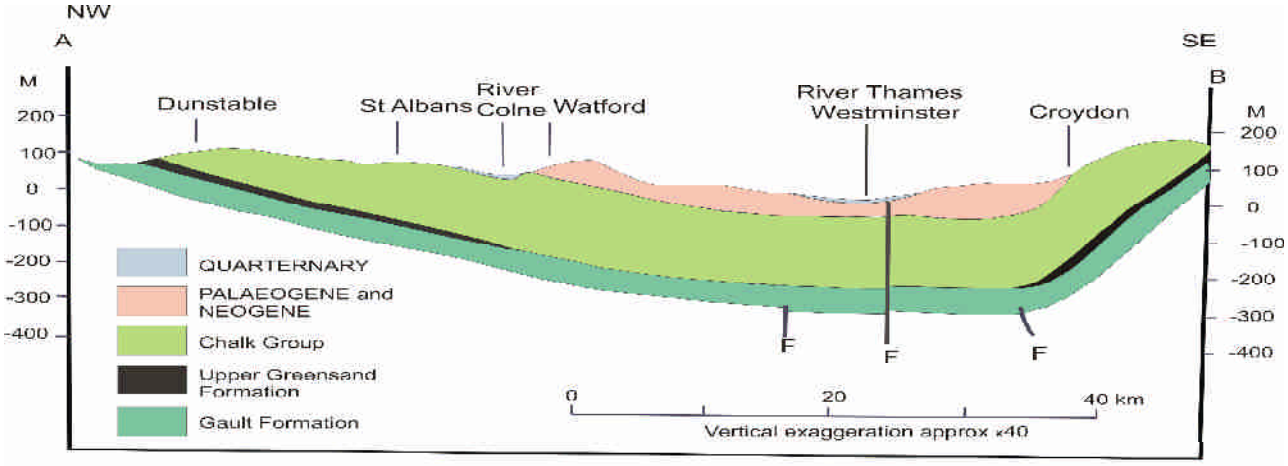




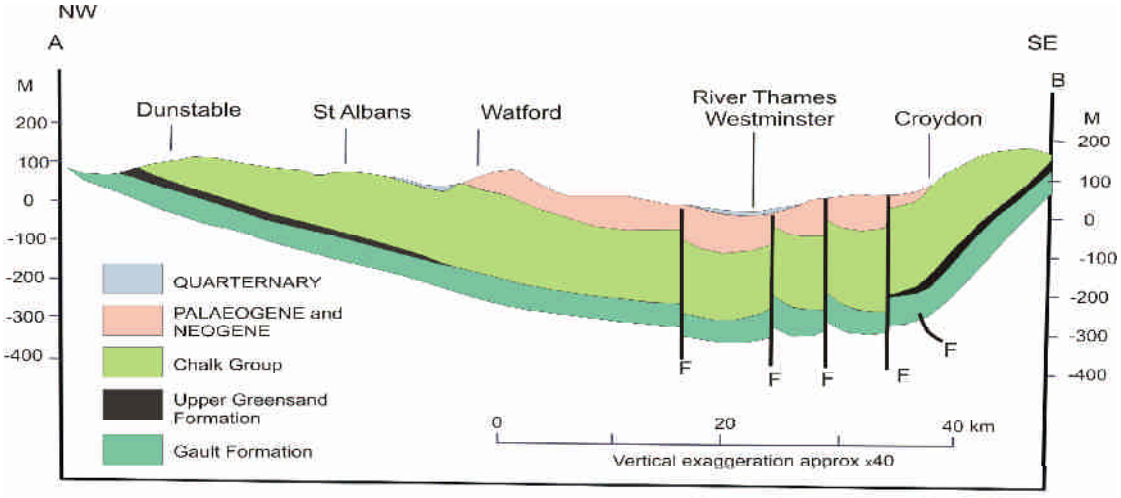
BGS have over 80,000 borehole records for Central London

The **Geology** is largely **unexposed** and covered by either the **built environment** or **superficial deposits**

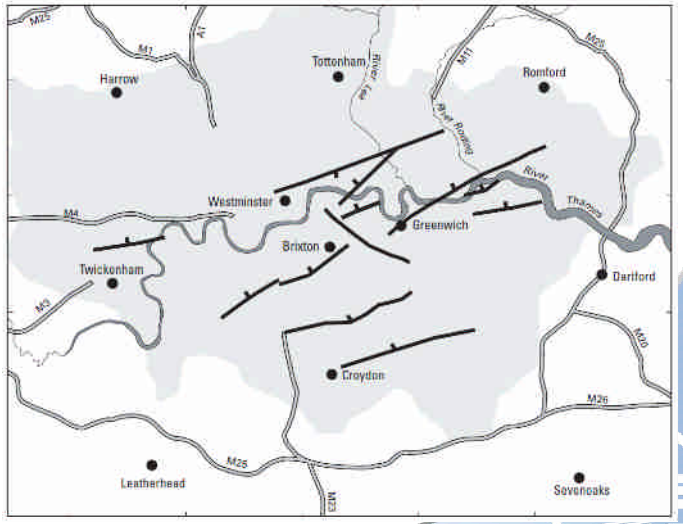
Are there faults in London ?



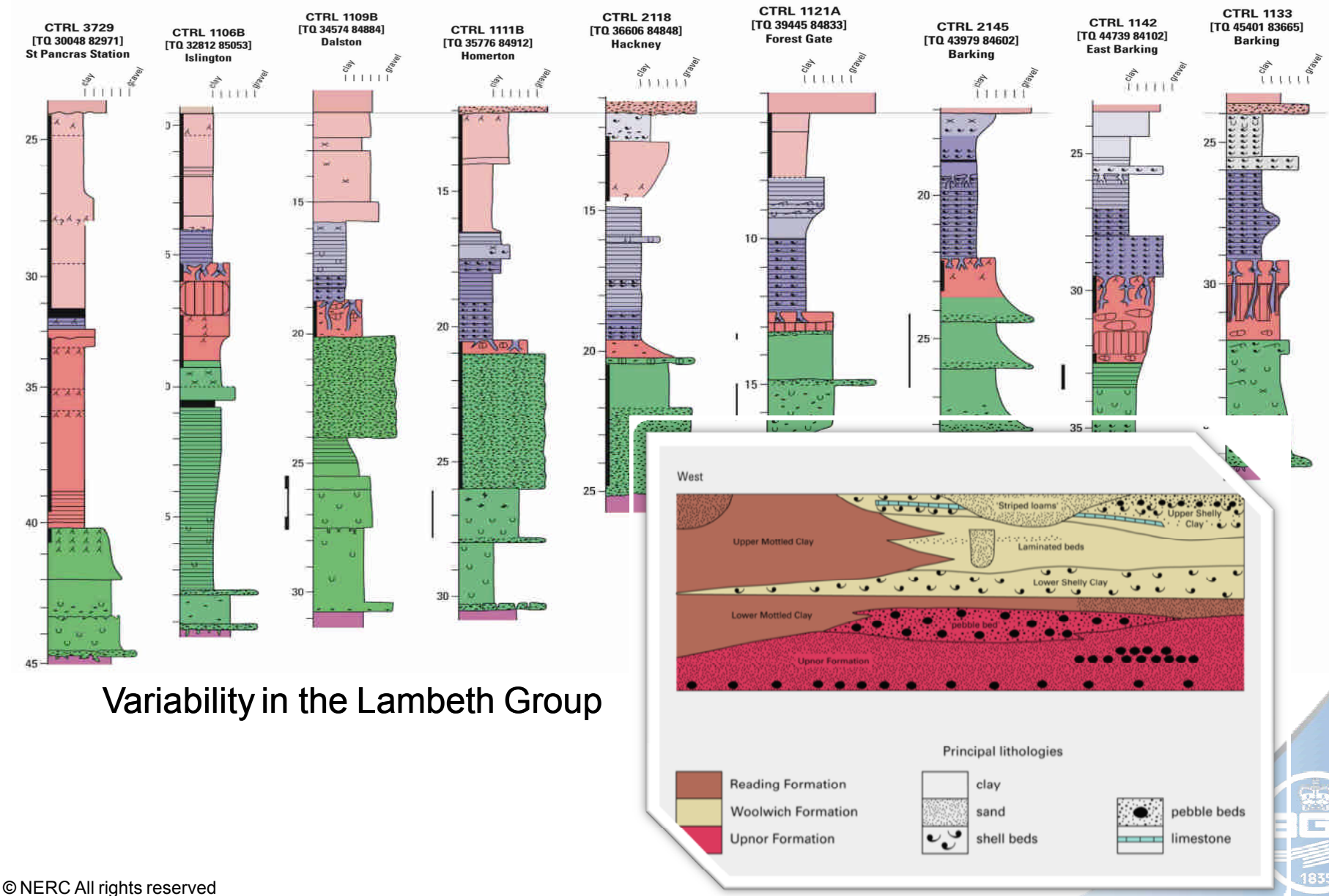
This is what the geological maps would suggest



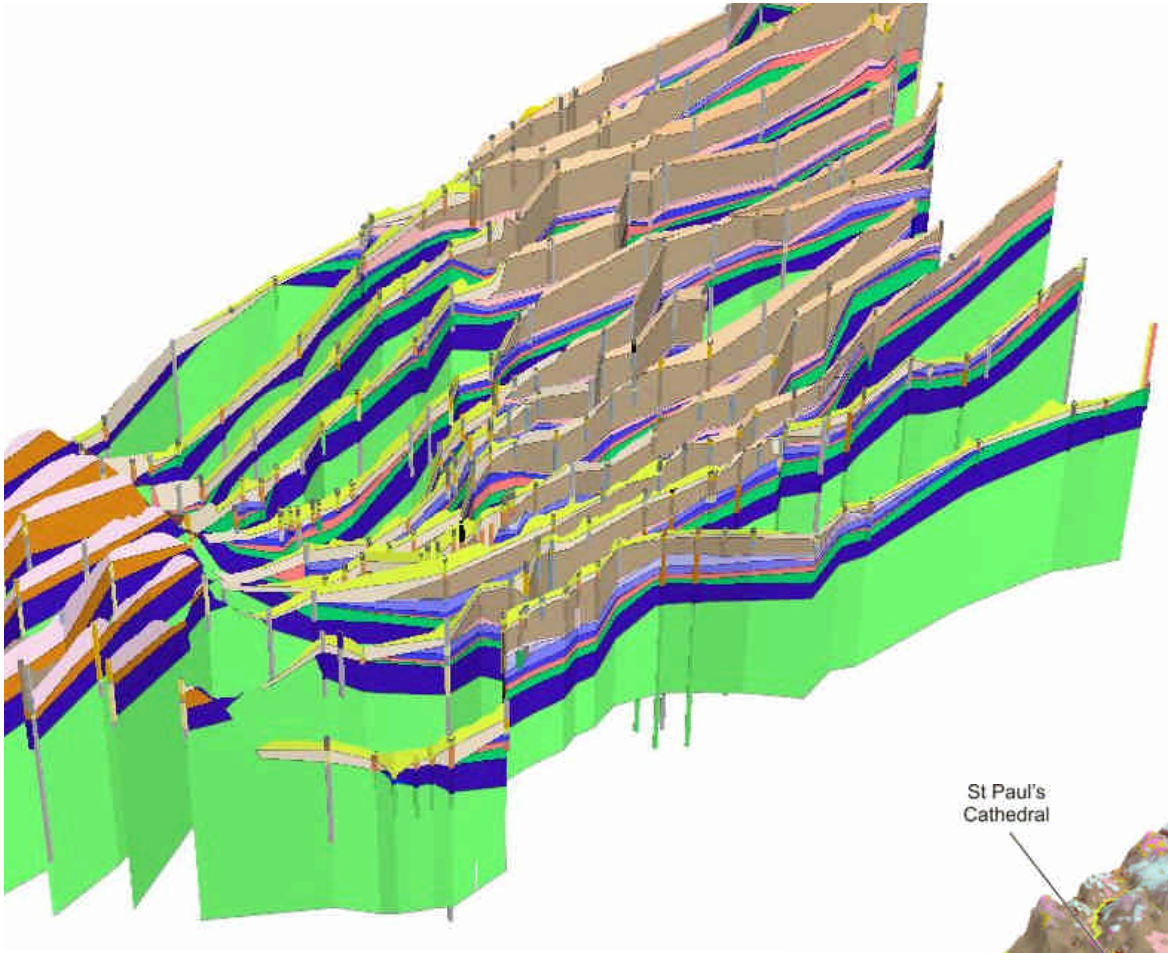
This is closer to reality

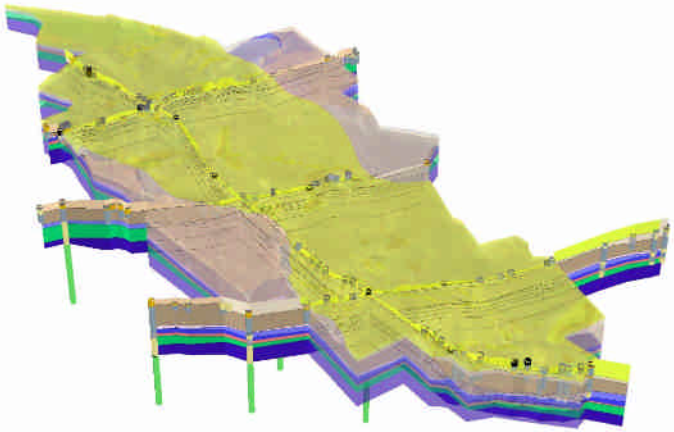


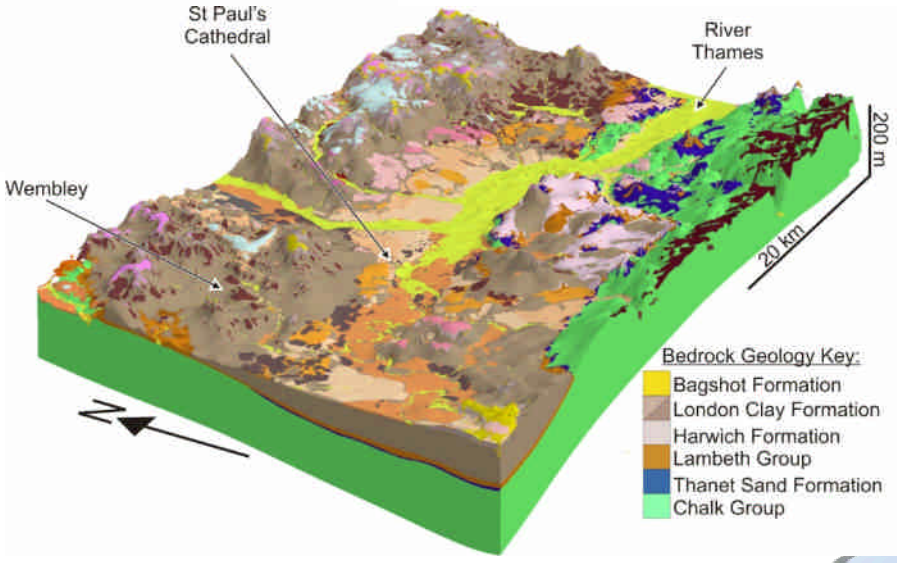
Lambeth Group



Variability in the Lambeth Group

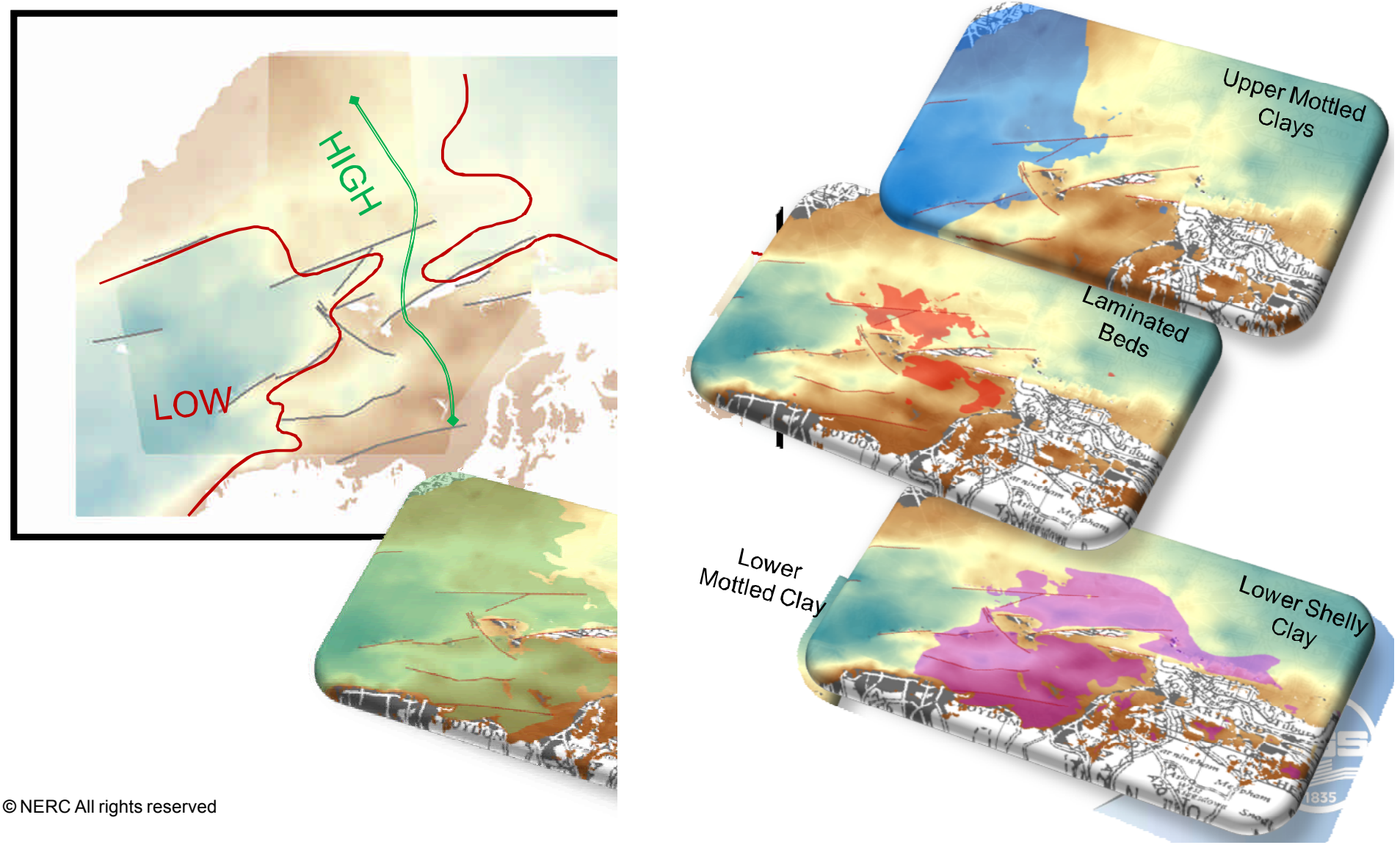


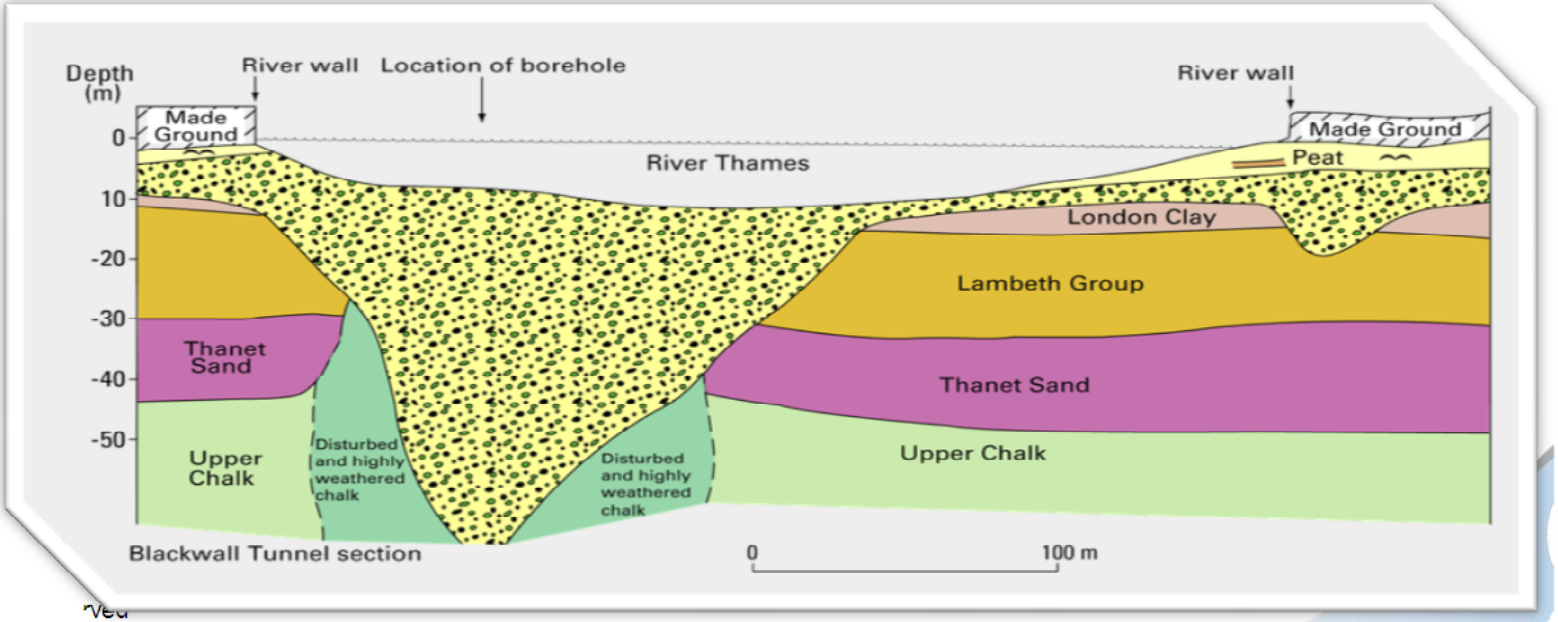




3D lithofacies models of the Lambeth group

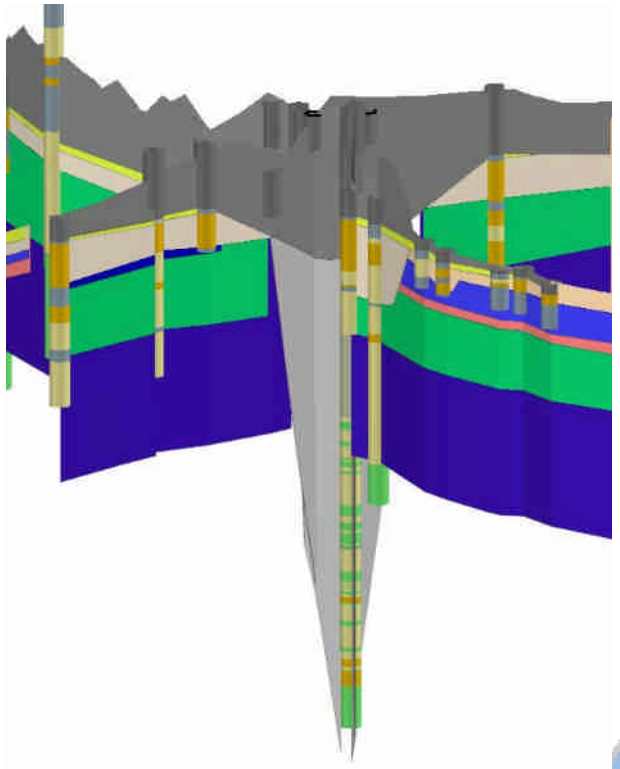
Tectonic control on the distribution of the Lambeth Group




Depth (m)
River wall
Location of borehole
River wall
Made Ground
0
River Thames
Made Ground
Peat
10
London Clay
-20
Lambeth Group
-30
Thanet Sand
-40
Thanet Sand
-50
Upper Chalk
Disturbed and highly weathered chalk
Disturbed and highly weathered chalk
Upper Chalk
Blackwall Tunnel section
0
100 m

Why produce a Susceptibility map for ‘Drift Filled’ Hollows?

- Engineering works carried out in central London have unearthed a number of features which exhibit curious characteristics.
- DFH extend deep into the bedrock geology and are in-filled with disturbed superficial deposits and highly weathered bedrock.
- Can be up to 500m wide and more than 60 m in depth.
- This map will provide planners with a broader awareness of the potential location of difficult ground conditions associated with these features thereby reducing the potential for unforeseen ground conditions through effective site investigation design.



Factors Contributing to the GIS Layer

Criteria	Justification	GIS layer
i. Proximity to river drainage network	DFH tend to be situated within valley locations, close to valley floor.	A buffer of 300m applied to the river drainage network.
	Unloading of overburden material by scouring facilitating pressure release.	
ii. Artesian groundwater levels	DFH are associated with a source of groundwater near to ground surface occurring under an upward hydraulic gradient.	Zone of HMV artesian groundwater conditions.
iii. Kempton Park Gravel Member	DFH occur most frequently beneath the Kempton Park Gravel member.	Distribution of the Kempton Park Gravel member with BGS digital geological map (1:50k)
iv. London Clay thickness	DFH are associated with the feather edge of the London Clay where overburden pressures are present but restricted.	Zone where the London Clay is less than 35m thick.
v. Lambeth Group clay layers	Clay layers within the Lambeth Group may also serve to restrict overburden pressures and the movement of groundwater to ground surface.	Zone where the Lambeth Group is dominated by clay-rich horizons.

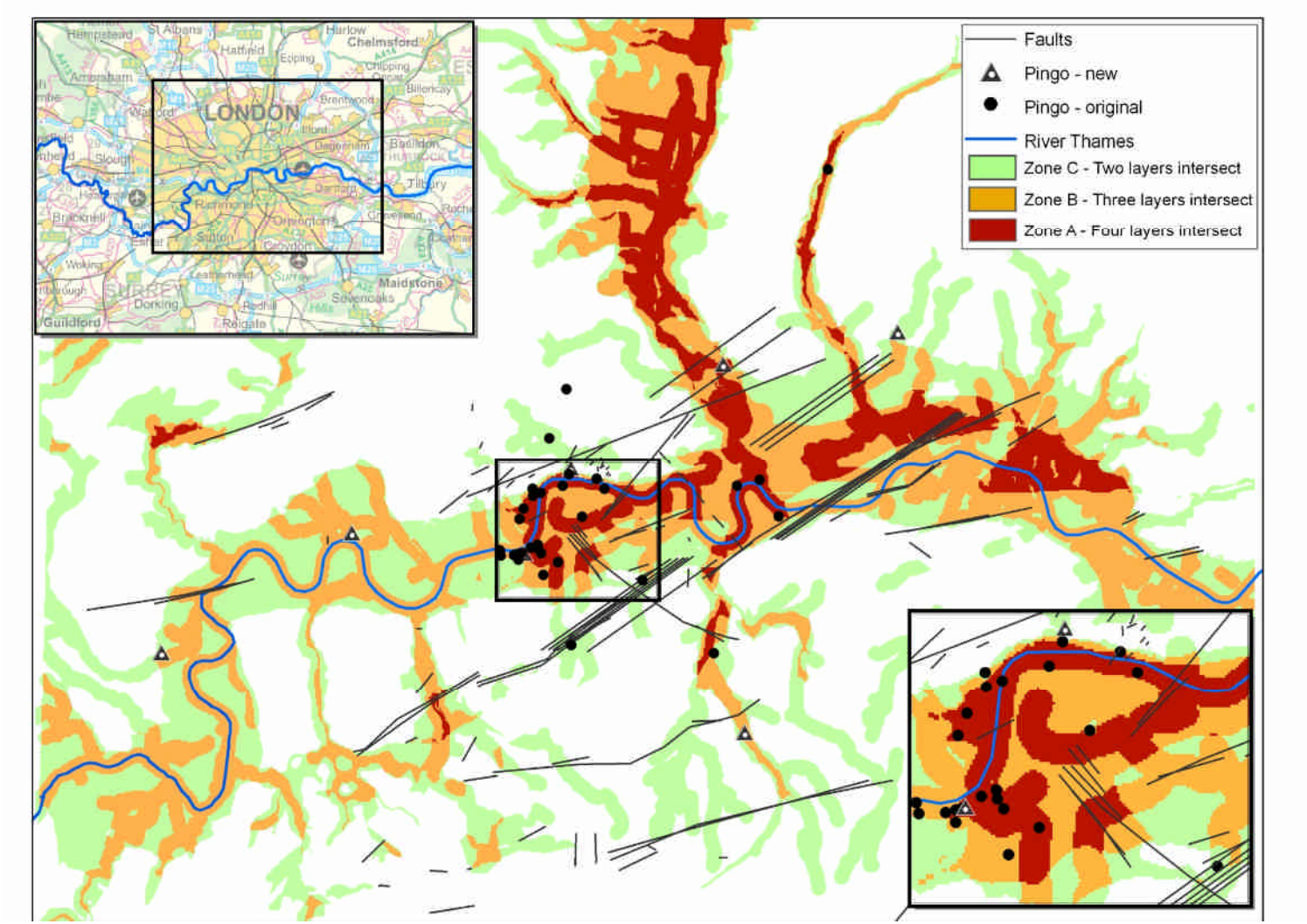
Criteria analysis

1. All Occurrences should occur where all the criteria are satisfied
2. Interrogation of the layers showed this not always to be the case
3. We therefore developed 3 zones :

   A = 4 criteria
   B = 3 criteria
   C = 2 criteria
4. 81% of DFH occurred within Zones A and B

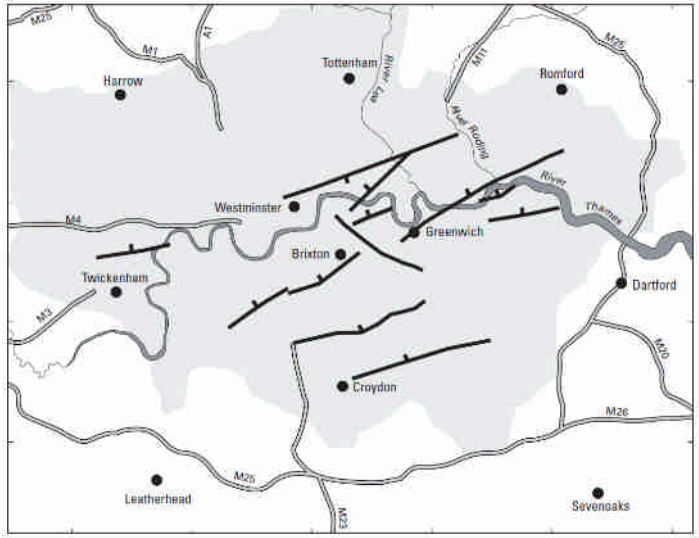
Original 'Drift-filled hollows'			Newly identified 'Drift-filled hollows'	
	No.	%		No.
Zone A	18	56	Zone A	2
Zone B	8	25	Zone B	2
Zone C	4	13	Zone C	3
Outside zones	2	6	Outside zones	0

Hazard Susceptibility map



‘Drift Filled’ Hollows Association with Faults

- Of the 32 drift-filled hollows originally identified, 9 lie within 500 m of a mapped fault and a further 6 lie within 1000 m.
- It is likely to be more than coincidental that the majority of the *DFH* fall within the between the Northern boundary fault to the north and the Streatham and Greenwich faults to the south, where the chalk is downthrown by some 50 m
- The chalk within this zone is expected to be highly deformed with a greater propensity for fracturing and faulting.
- An area of preferential groundwater discharge for DFH development may have developed within this faulted zone and may explain the clustering of drift-filled hollows locally.
- Potential for structural control of groundwater upwelling



Conclusions

- 3D Geological models provide a **framework or platform** whereby the **integration and visualisation** of data from many different sub-disciplines can be achieved
- The use of 3D modelling in the London Basin is resulting in an **improved understanding** of the development and evolution of the basin.
- The development of a **susceptibility map for 'Drift Filled' Hollows** will provide planners with a broader awareness of location of difficult ground conditions associated with these features.