



**British
Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

Geoscience for our changing Earth



European Cooperation in
Science and Technology



From geological maps to 3D and 4D models - transforming the delivery and relevance of geological knowledge for practitioners

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With particular thanks to BGS colleagues Steve Mathers, Hugh Barron, Helen Bonsor, Alison Monaghan, and many others

Evolution of the Geological Map

The mission has remained constant



1815



1874



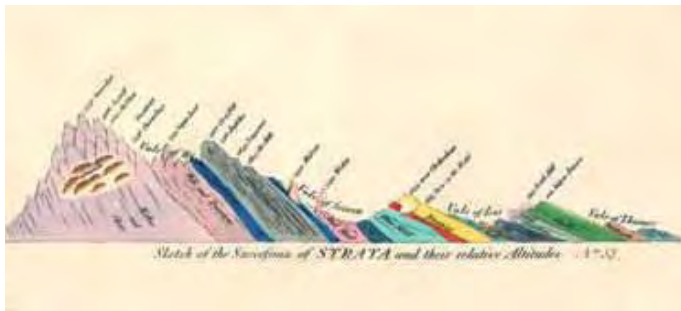
1939



2007

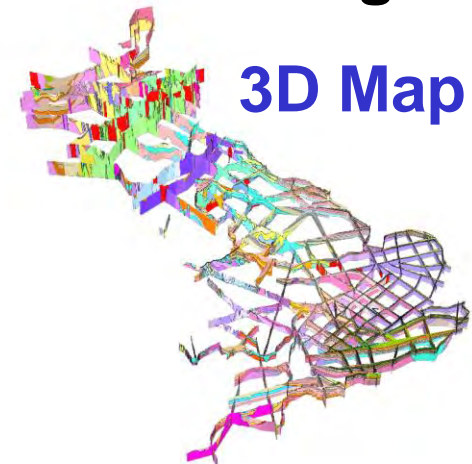


2012



Step
change

3D Map



Shaping a new culture

The National Geological Model (NGM)

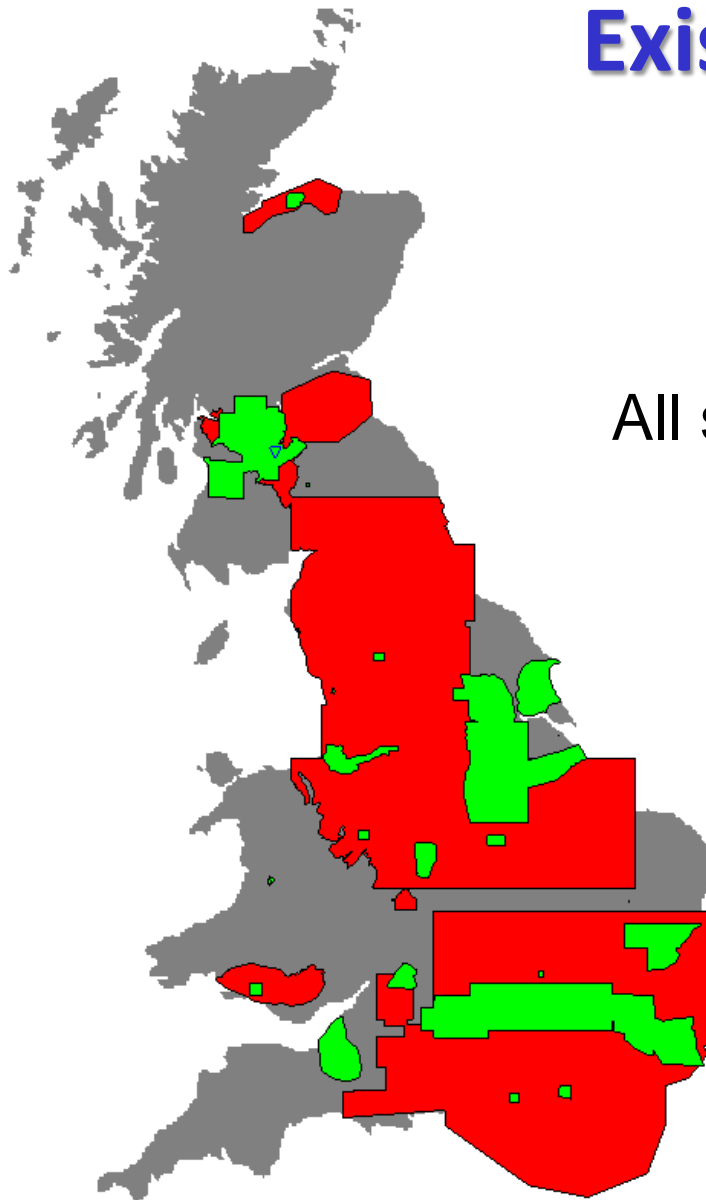
- **Tools for 3D Mapping (fit for any purpose)**
- **GOCAD Framework models** especially basin scale
- **GSI3D Framework models** Quaternary & Anthropocene
- **Petrel** Stochastics, Groundwater flow (4D)
- **Isatis** Statistics
- **Geovisionary** Fly through and visualisation
- **GIS** Data conditioning



Existing Framework Models

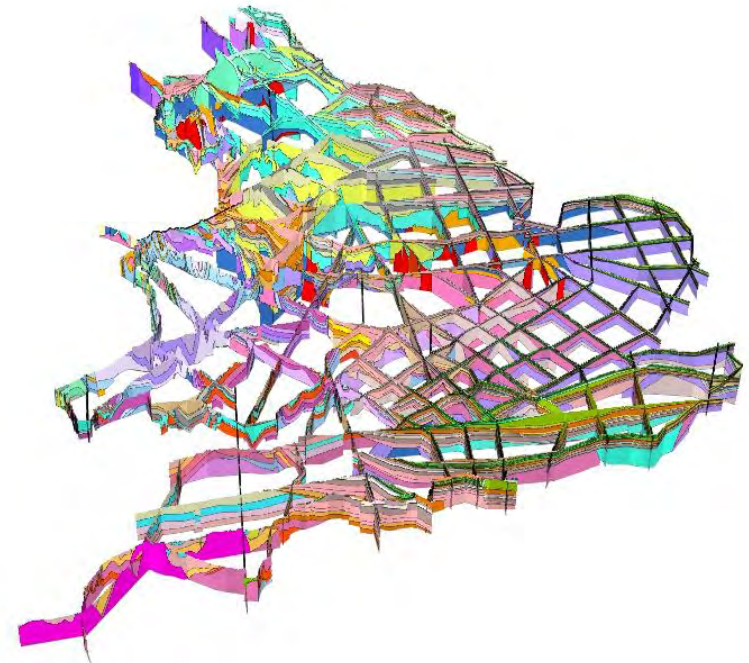
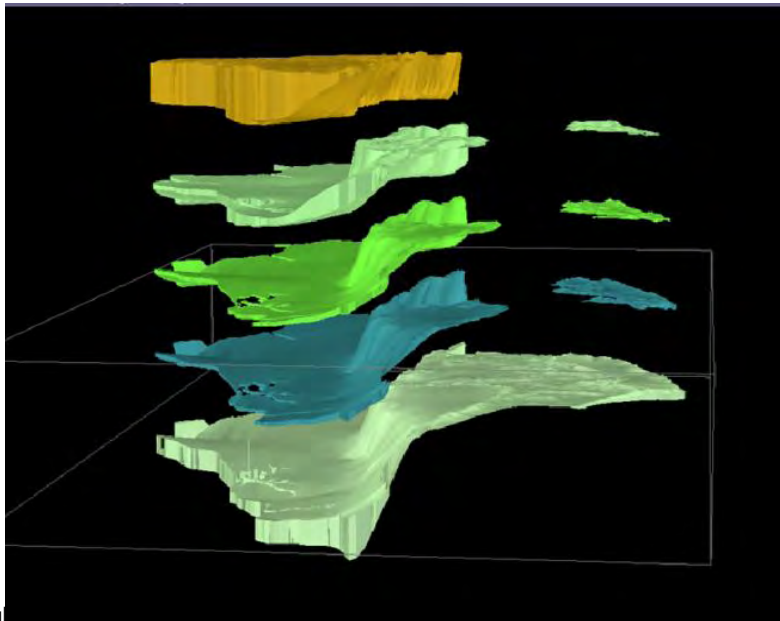
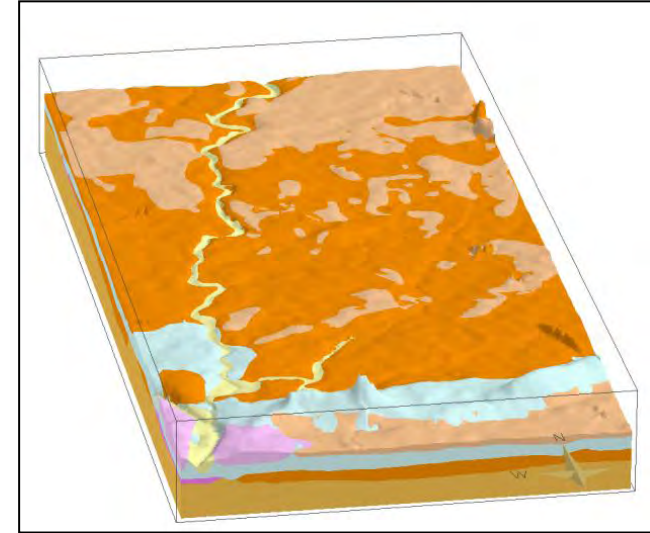
GS13D & GoCAD

All sizes, shapes, depths and drivers

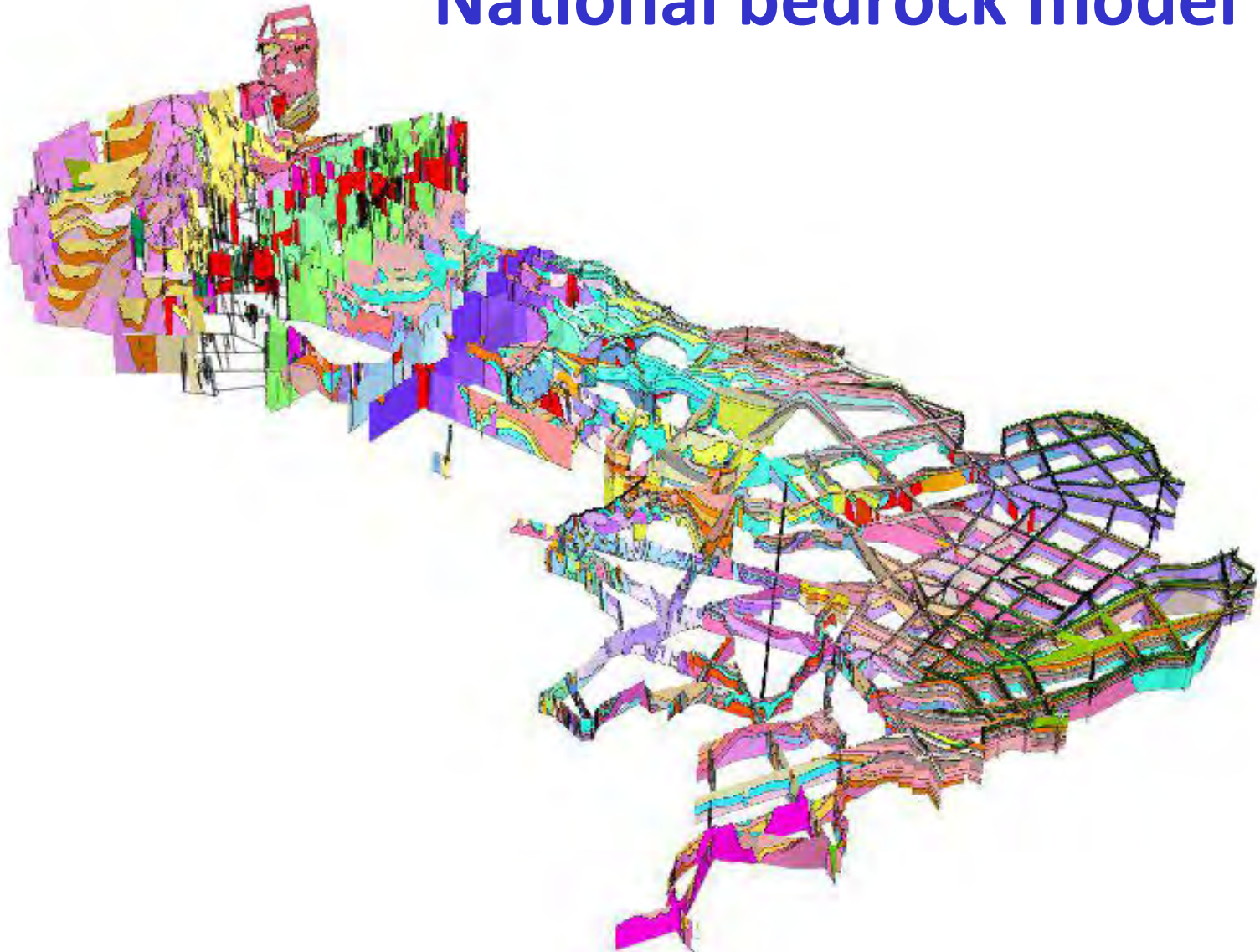


The Models

- **National** bedrock
- **National** crustal
- **National** Quaternary & Anthropocene
- Educational
- Collaborative
- Commercial



National bedrock model

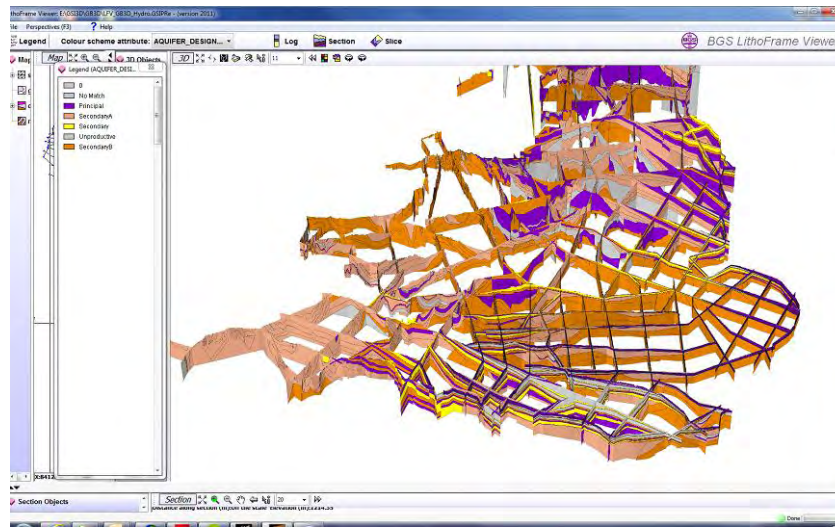


“Sharing our understanding”

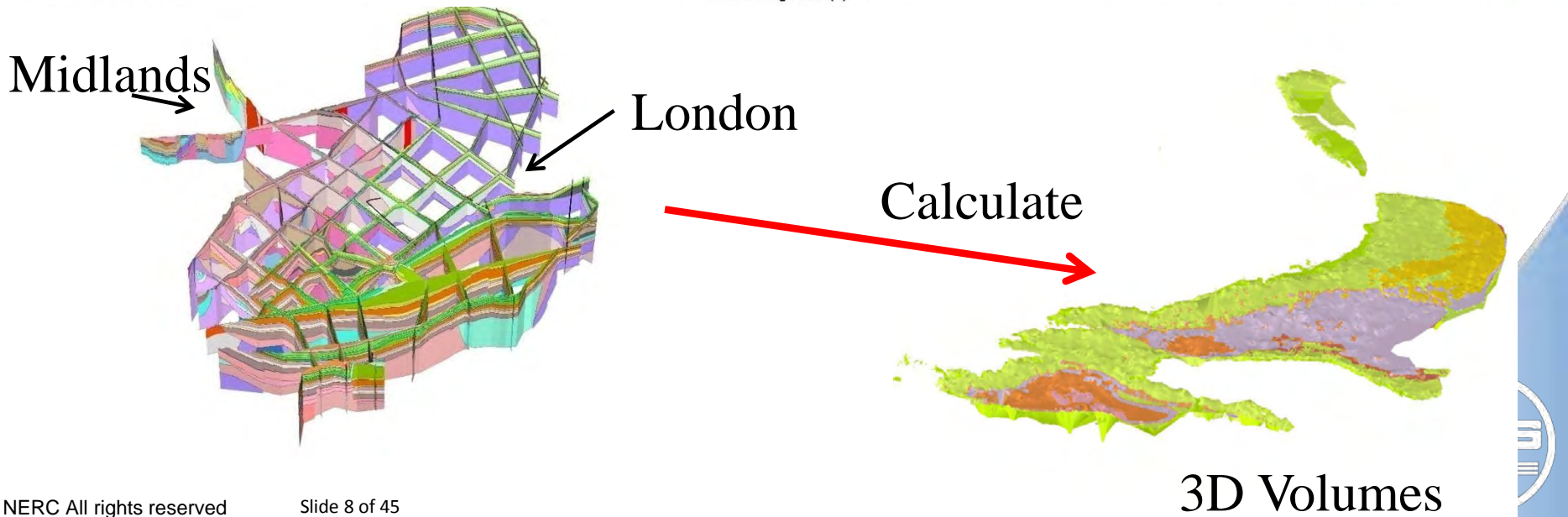
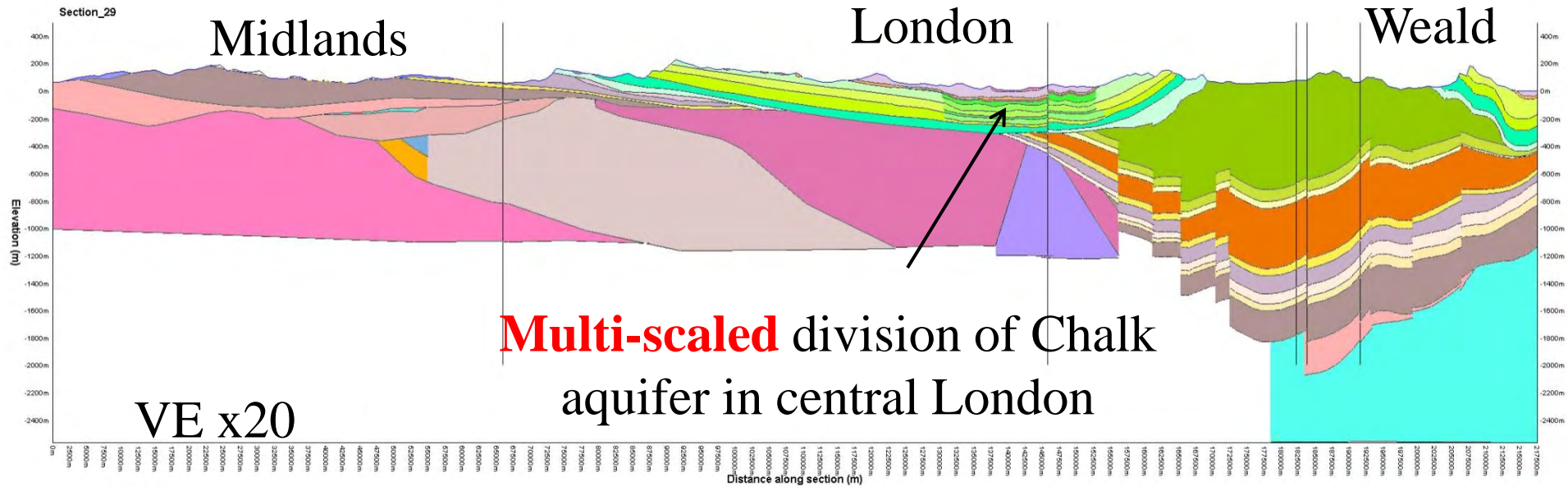
NGM- Key elements

- These 125 sections are intelligent, **utilising c. 20 existing models, 100's of existing sections contour and isopach maps**
- Measure 21,365 linear km's
- Based loosely on 625K maps & schema of 341 units,
- 14 expert regional geologists plus 3 data managers
- Already used for national and regional assessments, e.g.: Groundwater, Radwaste storage, Shale Gas, Geoscience Education (free download)
- Average **depth 2km**

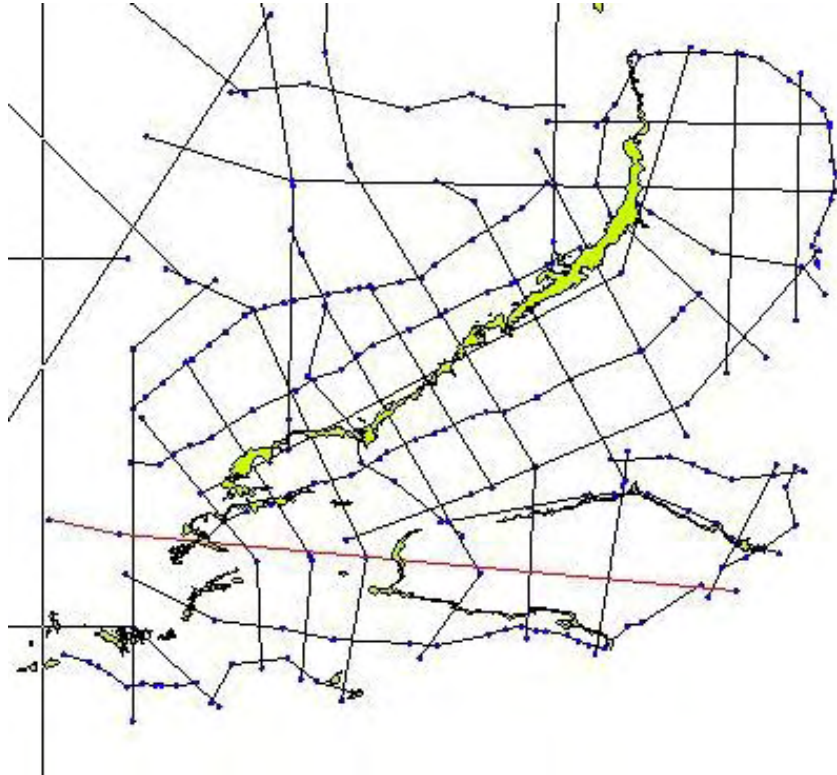
Parameterized
(e.g. aquifer type)



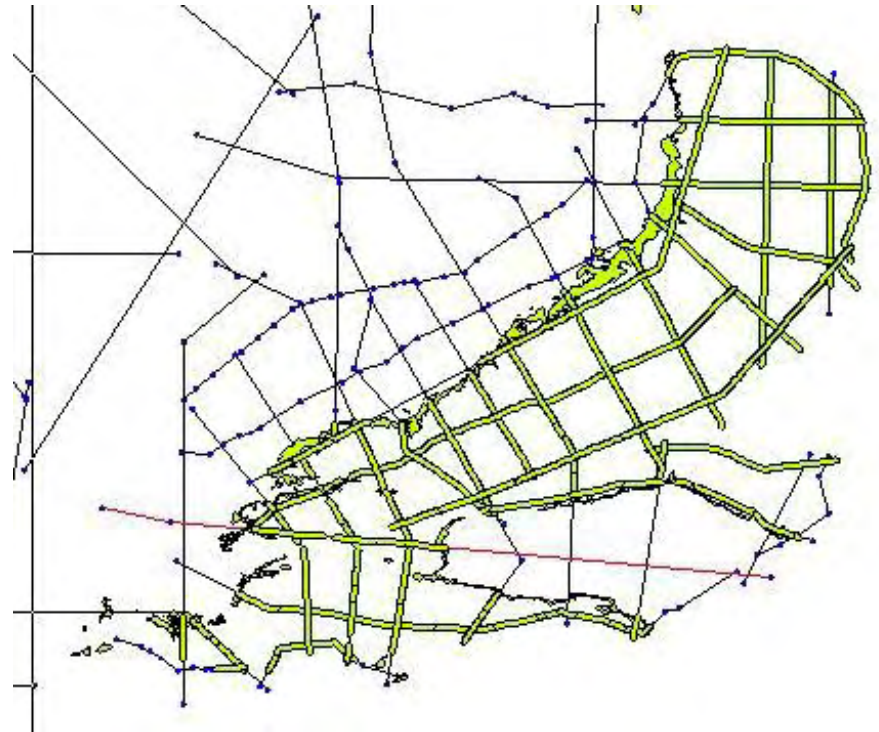
Regional context



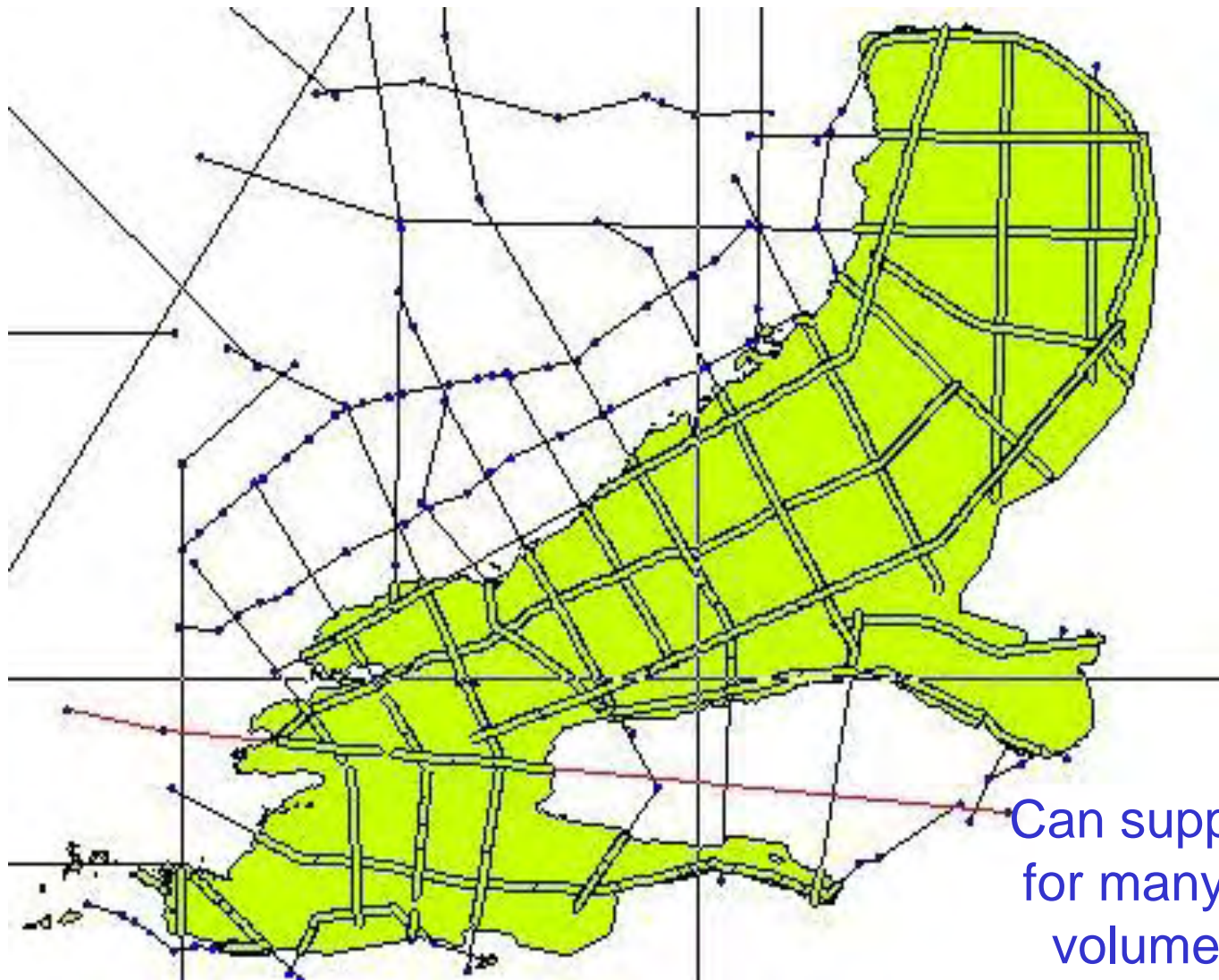
What can the NGM be used for



Outcrop Grey Chalk
From shp file attribute table



Distribution in sections
(defines subcrop)

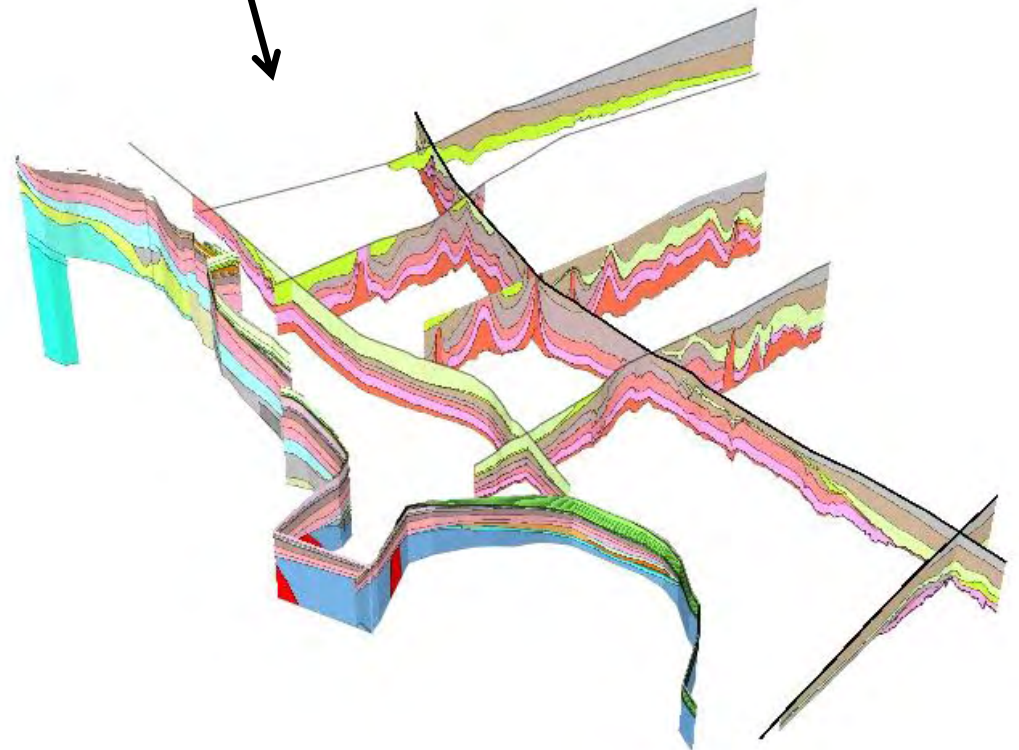
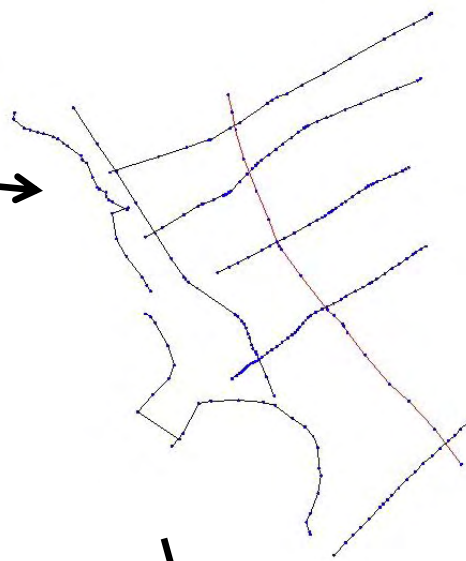
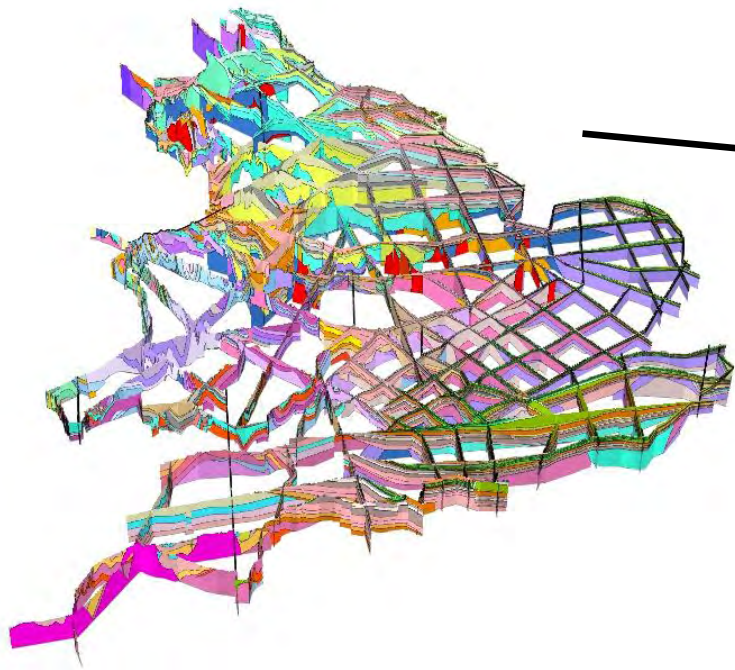


Can supply on demand
for many units and 3D
volumes for simpler
bedrock

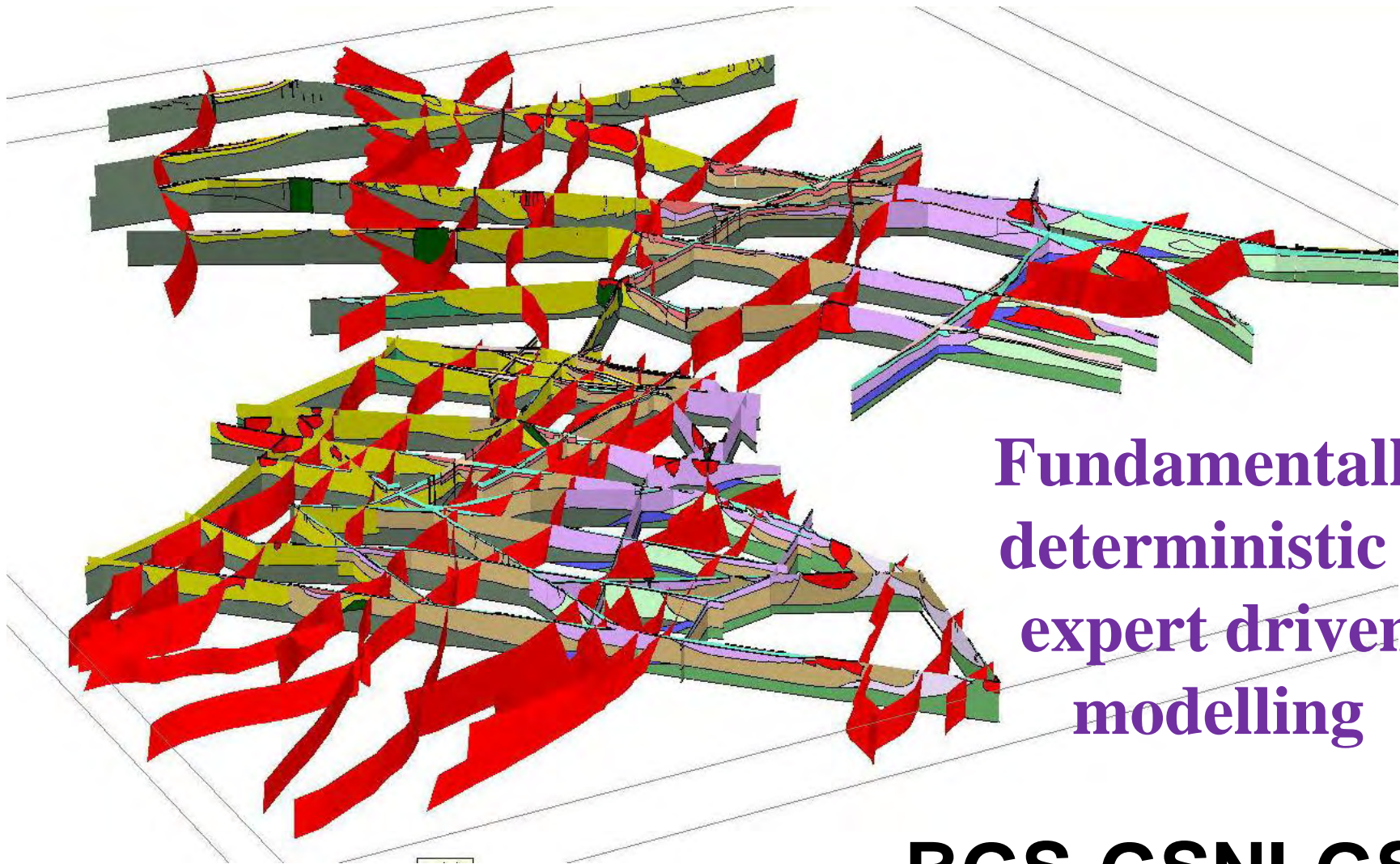
Outcrop and subcrop combined = **envelope** (unit distribution)

Recent **EA Shale gas study** used these





Moving offshore



**Fundamentally
deterministic –
expert driven
modelling**

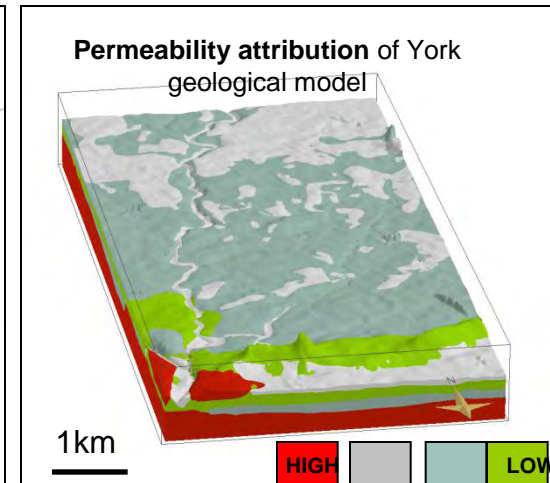
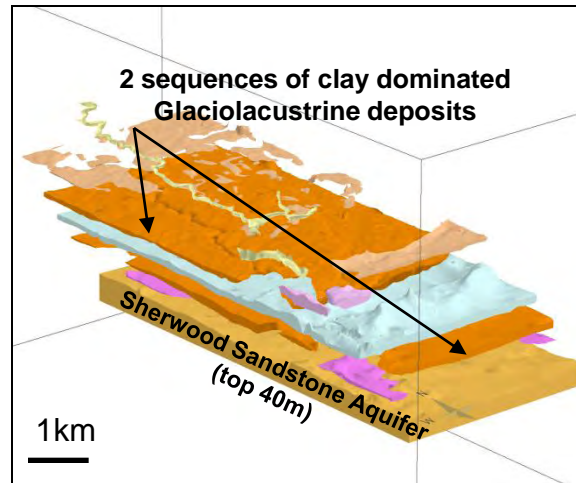
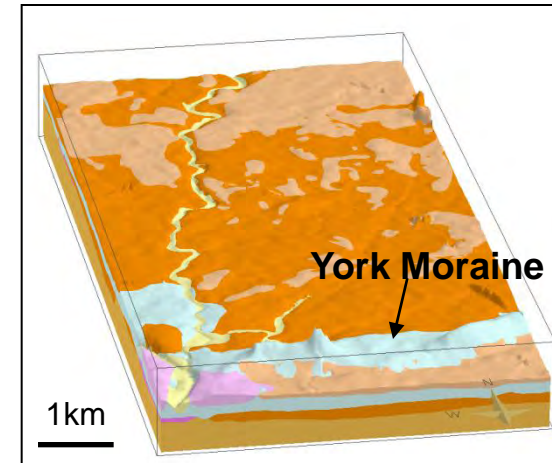
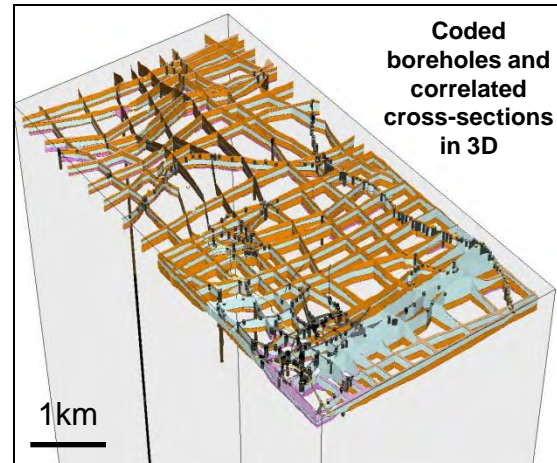
BGS-GSNI-GSI

National Crustal Model

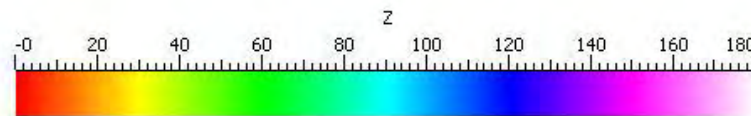
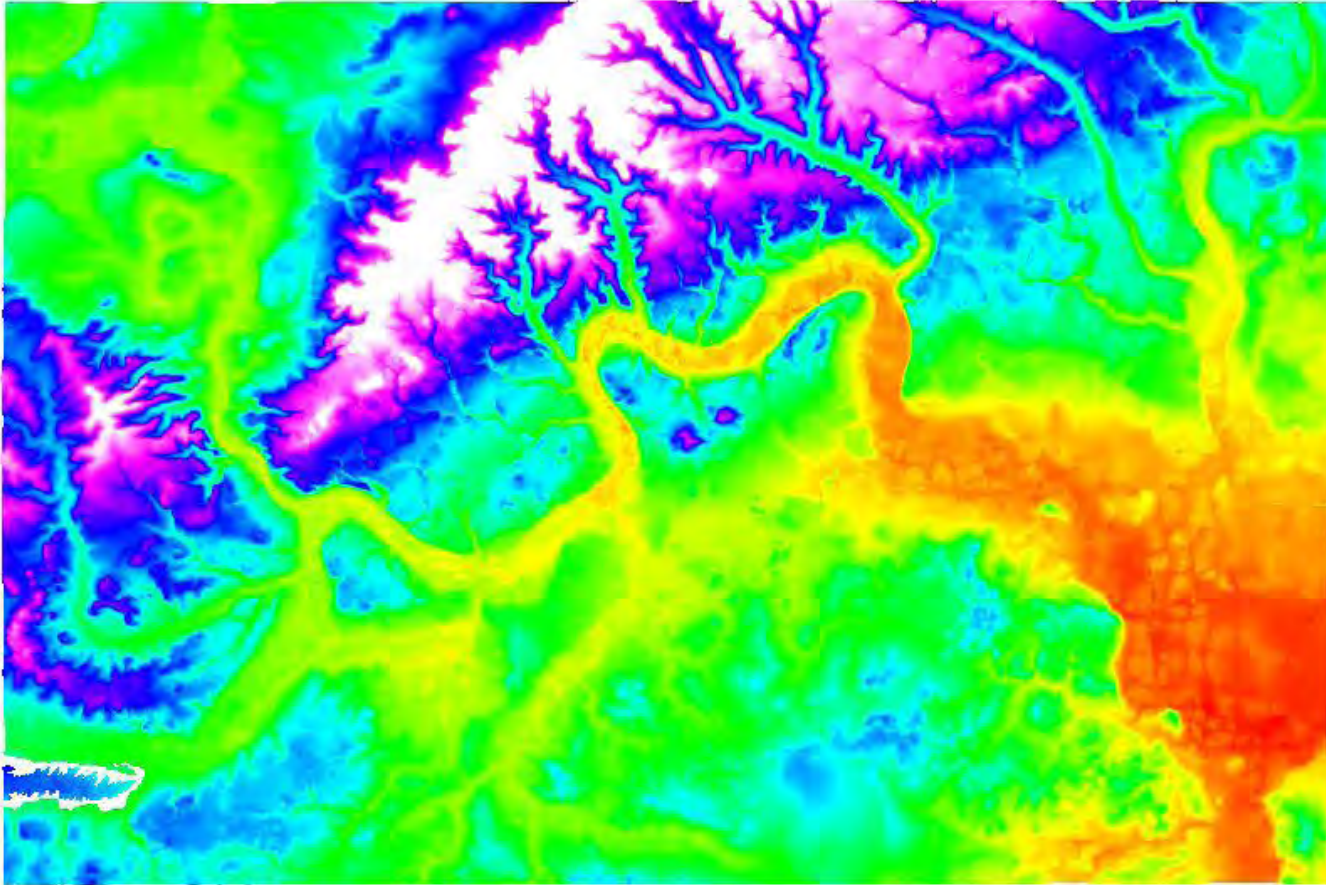


National 3D Quaternary & Anthropocene

- Unified 3D geological models of natural and artificial Quaternary deposits and landforms
- To develop 3D modelling methodologies for natural and man-made Quaternary deposits
- To build a common Quaternary 3D lithostratigraphic framework through model integration and 'arterial' cross-section construction along major infrastructure routes

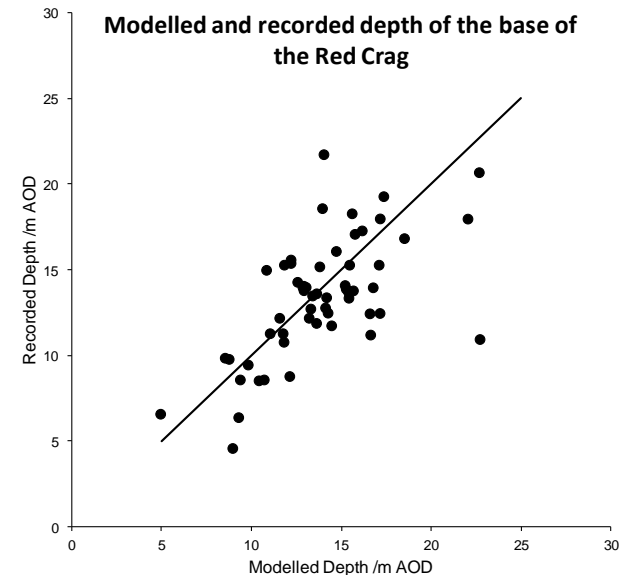
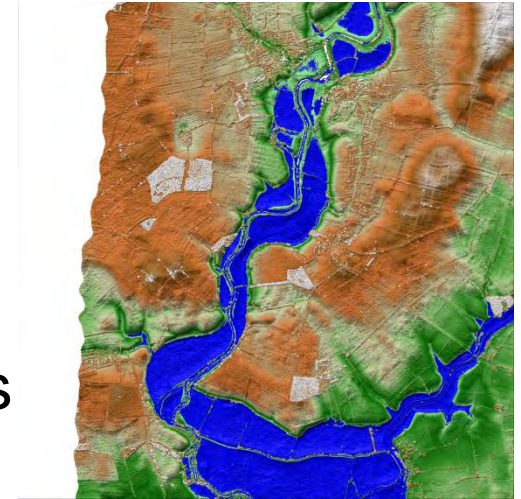


Base Quaternary surface

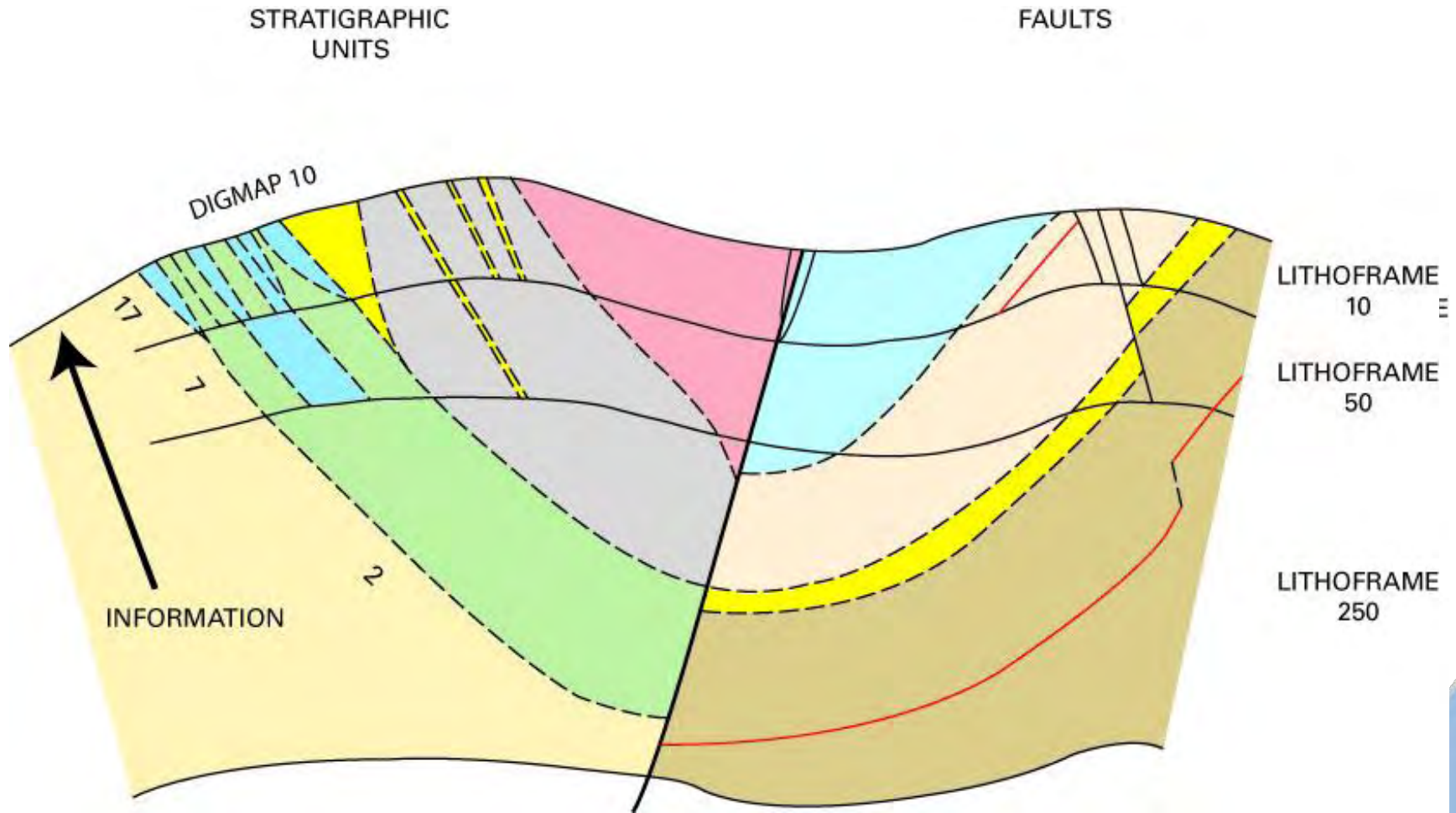


Generic issues and resources

- Model integration **multiscalar**
- DTM's
- 3D National library
- Model metadata & QA
- Uncertainty studies
- Property models, voxels and stochastics
- Model delivery
- Corporate workflow



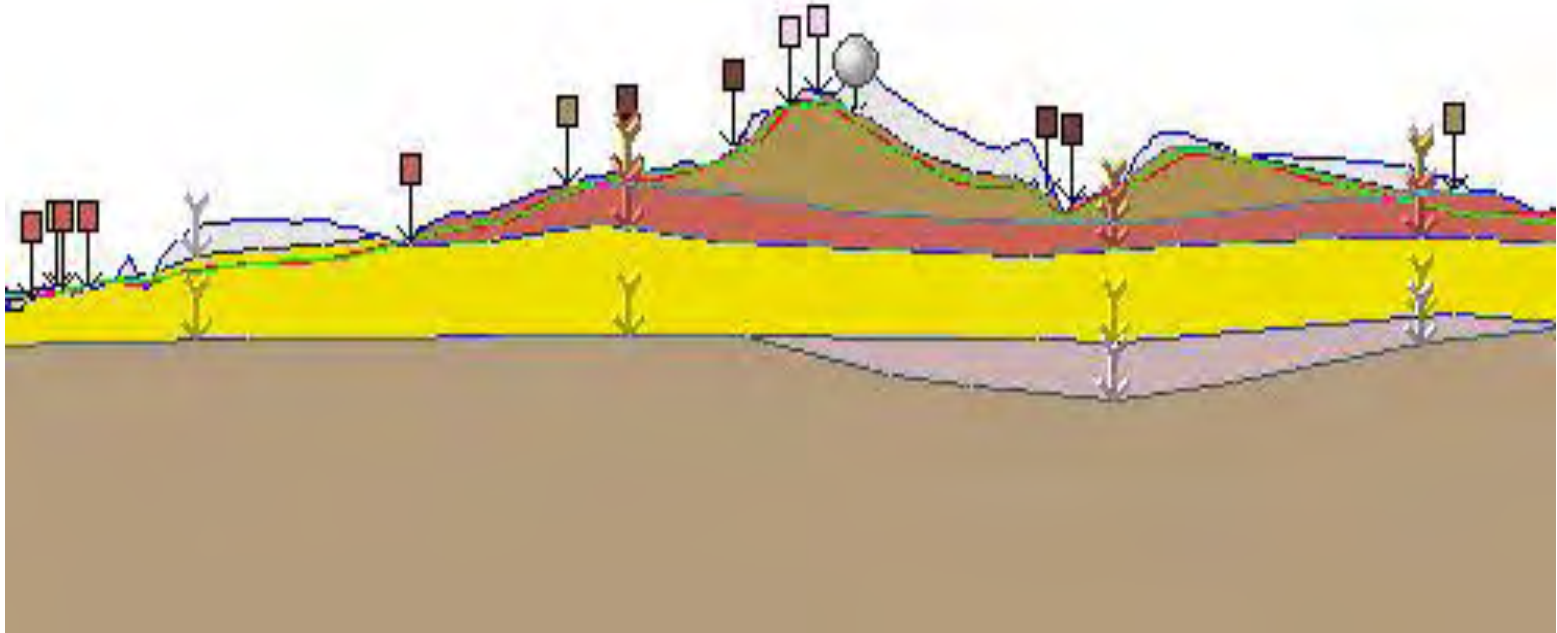
Nesting stratigraphies, compromises will be necessary



**Easiest to do for Stratified rocks –
stratigraphers permitting**

The Search for the holy grail

Bald Earth dtm and multi-patches



Blue = NextMap with woods included

Green = OS Panorama

RED = Merged BGS Bald Earth Model

Aspiration a perfect high resolution seamless dtm-dbm

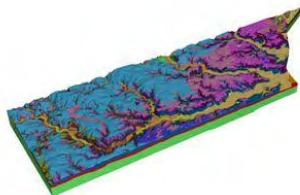


“We are passionate about metadata!!!”



Model summary report for the Ipswich-Sudbury model

Geology and Landscapes Programme
Internal Report XX/00/00



The National Grid and other Ordnance Survey data are used with the permission of the Controller of Her Majesty's Stationery Office. License No: 100017897/2012.

Keywords:
Ipswich, Keyworth.

Natural Grid Reference
EW 55000 210000
NS 44000 210000

Files created/forming part
Coverage of the selected block model of the Ipswich-Sudbury area. Files include but are not limited to the following:

Bibliographical reference
MATHERS, S.J. 2012. Model summary report for the Ipswich-Sudbury model. British Geological Survey, Internal Report XX/00/00.

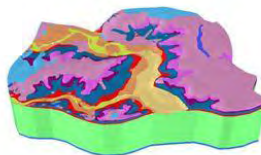
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BRITISH GEOLOGICAL SURVEY
WHATEVER PROGRAMME
INTERNAL REPORT XX/00/00

Model summary report for the Ipswich-Sudbury model.

S. Mathers



Keyworth, Nottingham British Geological Survey 2012

Summary Metadata & Model Approval Form



This form will comprise an important part of the model metadata. On completion it should be forwarded to the TL NGM with all the other model files and documentation for incorporation into the National Geological Model.

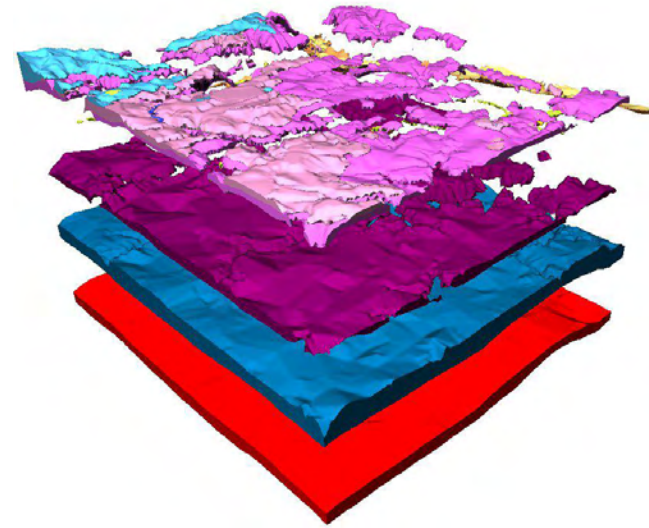
Model name		
Model file name including version		
Link to model folder		
Link to model internal report		
Lead modeller (name or code)		
Model resolution		
Scale of use		
Grid <small>(NSG to be ordered default and should be used in future where possible)</small>		
Datum used <small>(DD NAD83 to be ordered default wherever possible)</small>		
DEM - Capping surface		
Cell size used for calculation (in metres)		
Geology (select all that apply)	Bedrock <input type="checkbox"/>	Artificial <input type="checkbox"/>
	Superficial <input type="checkbox"/>	Mass Movement <input type="checkbox"/>
Extent	BOTTOM LEFT X COORDINATE <input type="text"/>	TOP RIGHT X COORDINATE <input type="text"/>
	Y <input type="text"/>	Y <input type="text"/>
Depth range (in metres from highest surface point)		
Purpose		
Intended Output (select all that apply)	TINs-Grids <input type="checkbox"/>	Viewer Model <input type="checkbox"/>
	3D PDF <input type="checkbox"/>	Groundhog <input type="checkbox"/>
	Other (please specify) <input type="text"/>	
Software(s) used including version		
Other Models fitted to, superseded or included		
IPR status		
Confidentiality status		
Signed signatures required:		
1. Lead Modeller	<input type="text"/>	<input type="text"/>
2. Project Leader (responsible for final checking of model)	<input type="text"/>	<input type="text"/>
3. IPR Manager (as required)	<input type="text"/>	<input type="text"/>
4. Team Leader/Chief Geologist	<input type="text"/>	<input type="text"/>
5. HOS (for high profile or sensitive models when referred by the TL NGM)	<input type="text"/>	<input type="text"/>

Models published as citable reference

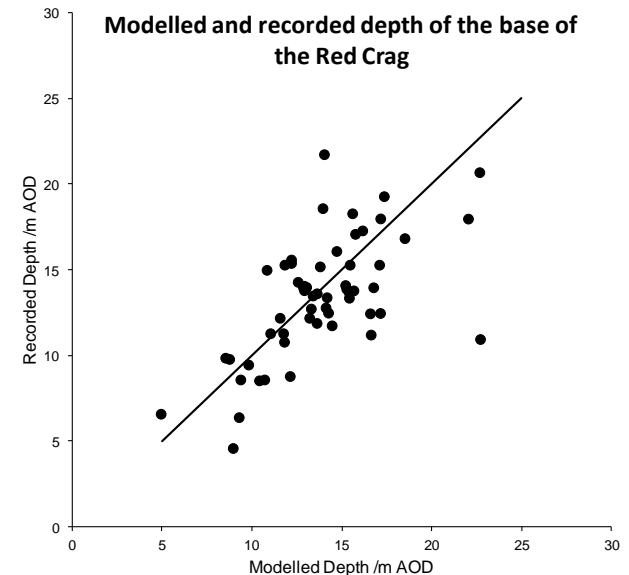


Uncertainty studies

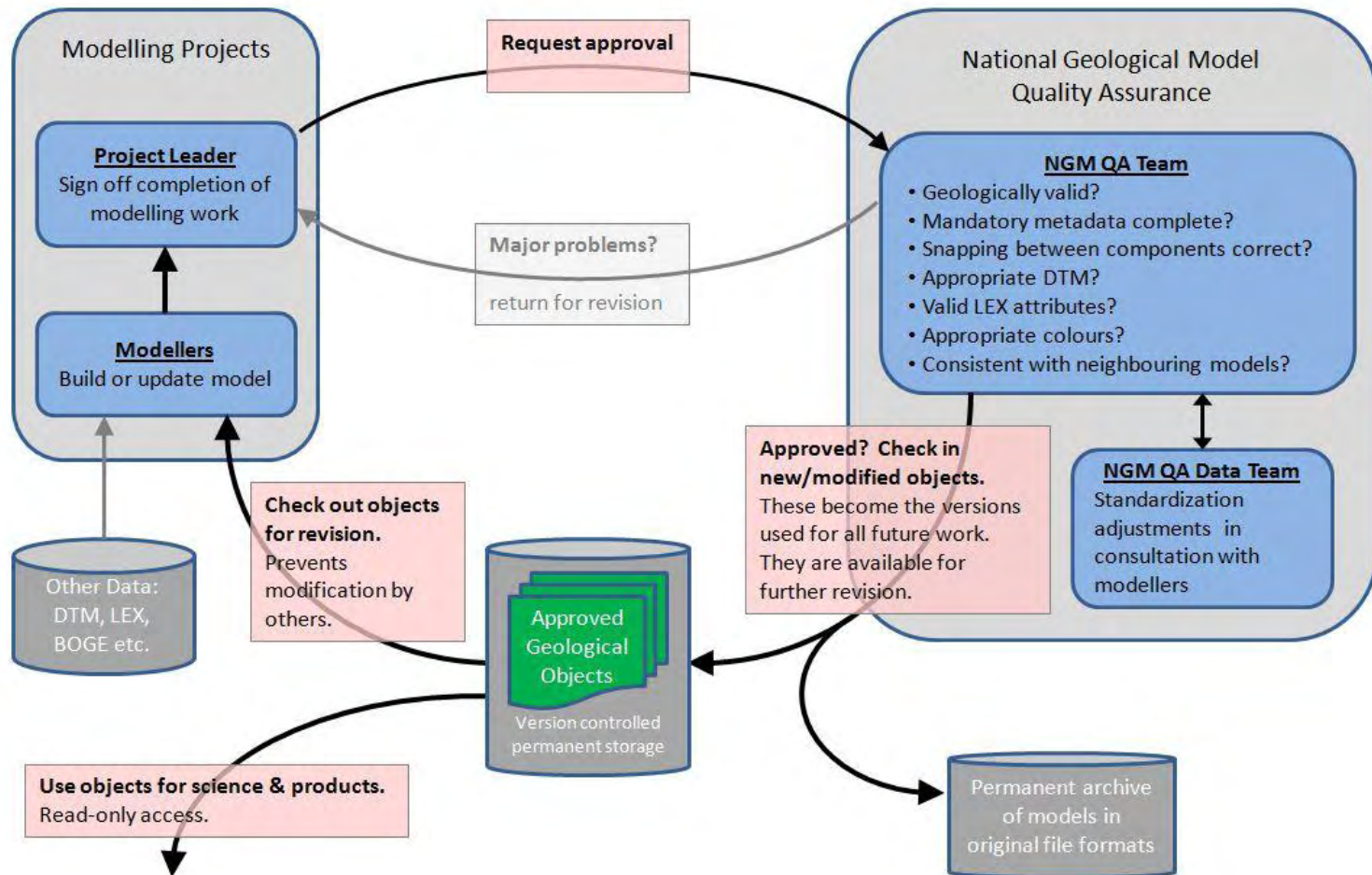
$$y_b(\mathbf{X}) - y_{m,i}(\mathbf{X}) = \mu_B + a_i(\mathbf{X}) + \varepsilon_i(\mathbf{X})$$

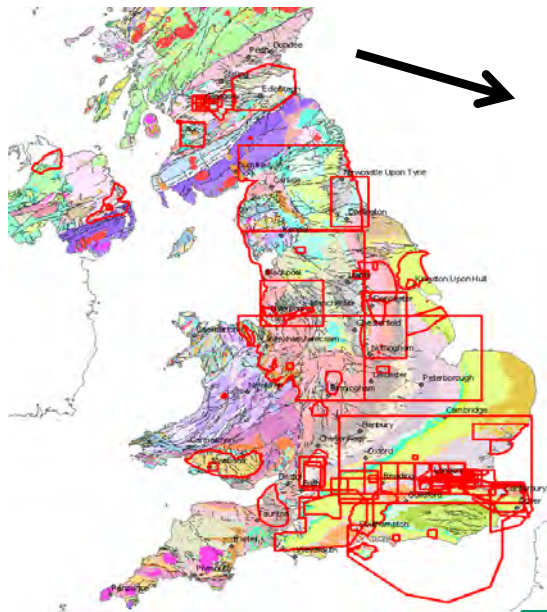


- 5 modellers modelled 6 formations in test area each using a unique subset of available boreholes from which a test set was withheld
- Each model can be compared with its test boreholes, to provide an overall data set on discrepancies between the model prediction and the corresponding observations.
- Analysis of these data enable us to quantify the overall model error, and contributions made to it by variation between modellers and how model uncertainty varies with factors such as depth and distance to boreholes.



Model build & storage workflow





Existing models



Jumble of
Lego bricks



Assembly instructions & QA

The National Geological Model



Frozen models



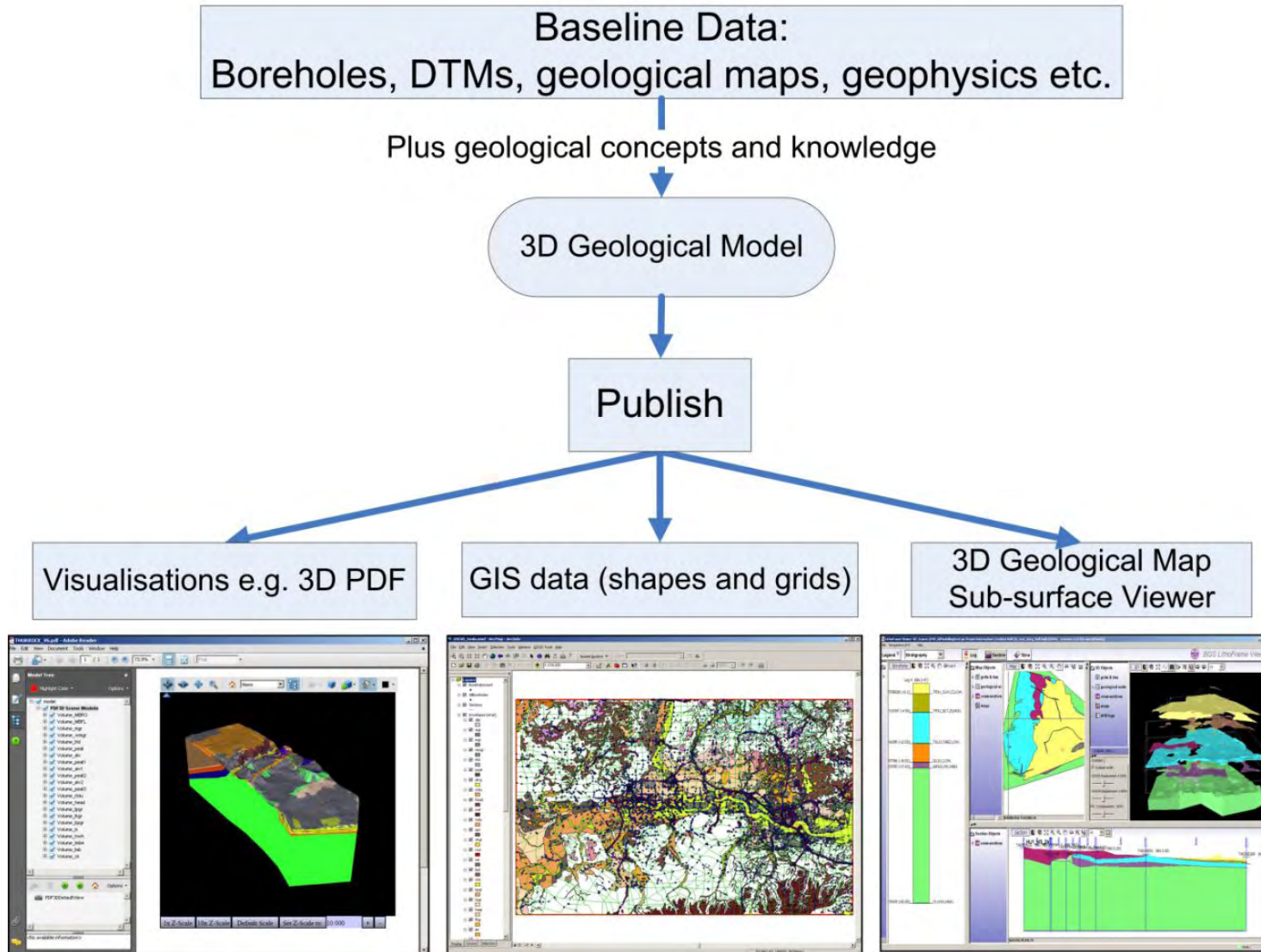
Objects Datastore



New models



Model Delivery



BGS's Urban Strategy

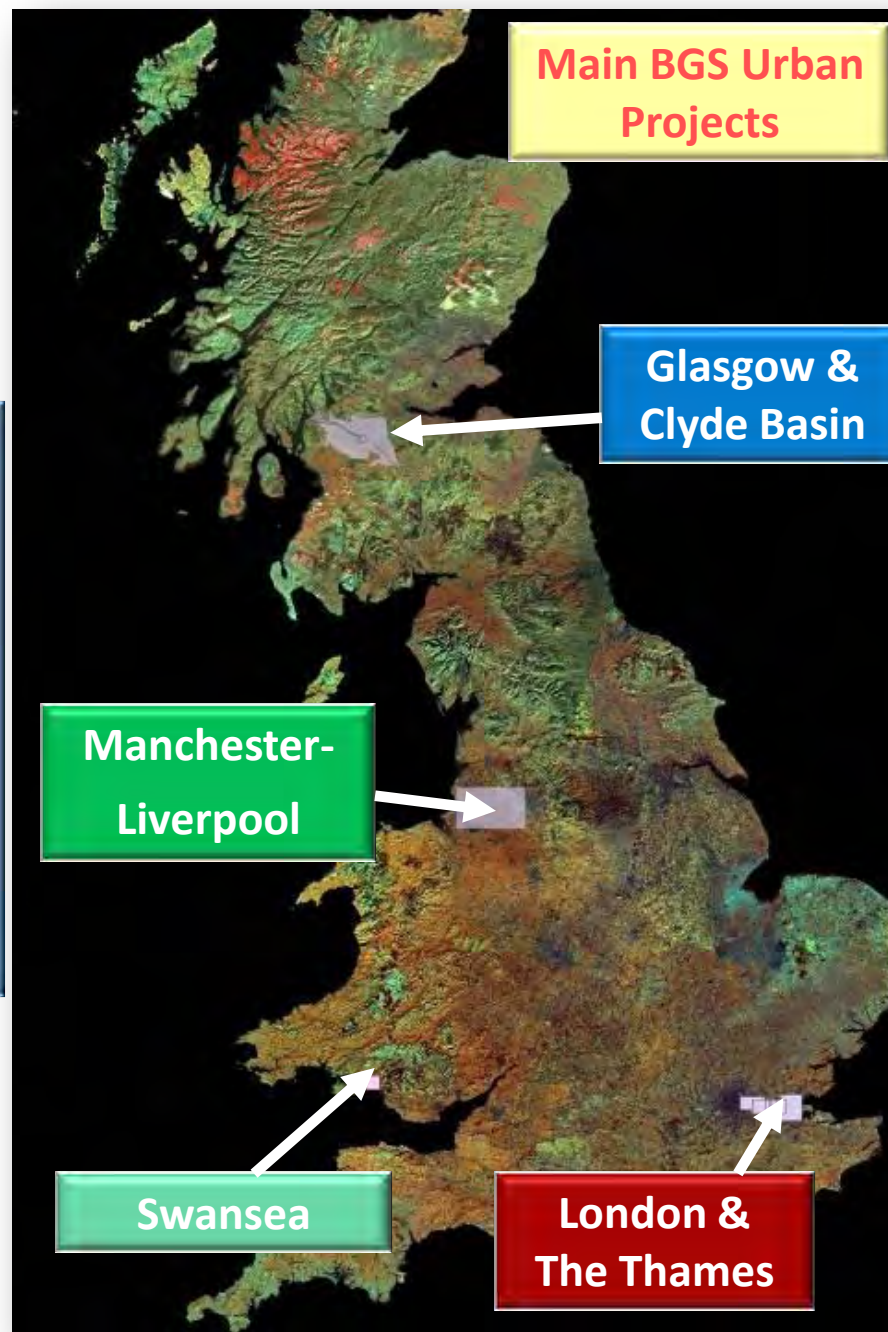
Why?

>80% UK population

Environmental impacts

Abundant subsurface data

Ideal test bed for **predictive** 3D/4D modelling



Key drivers (Glasgow)

Glasgow regeneration

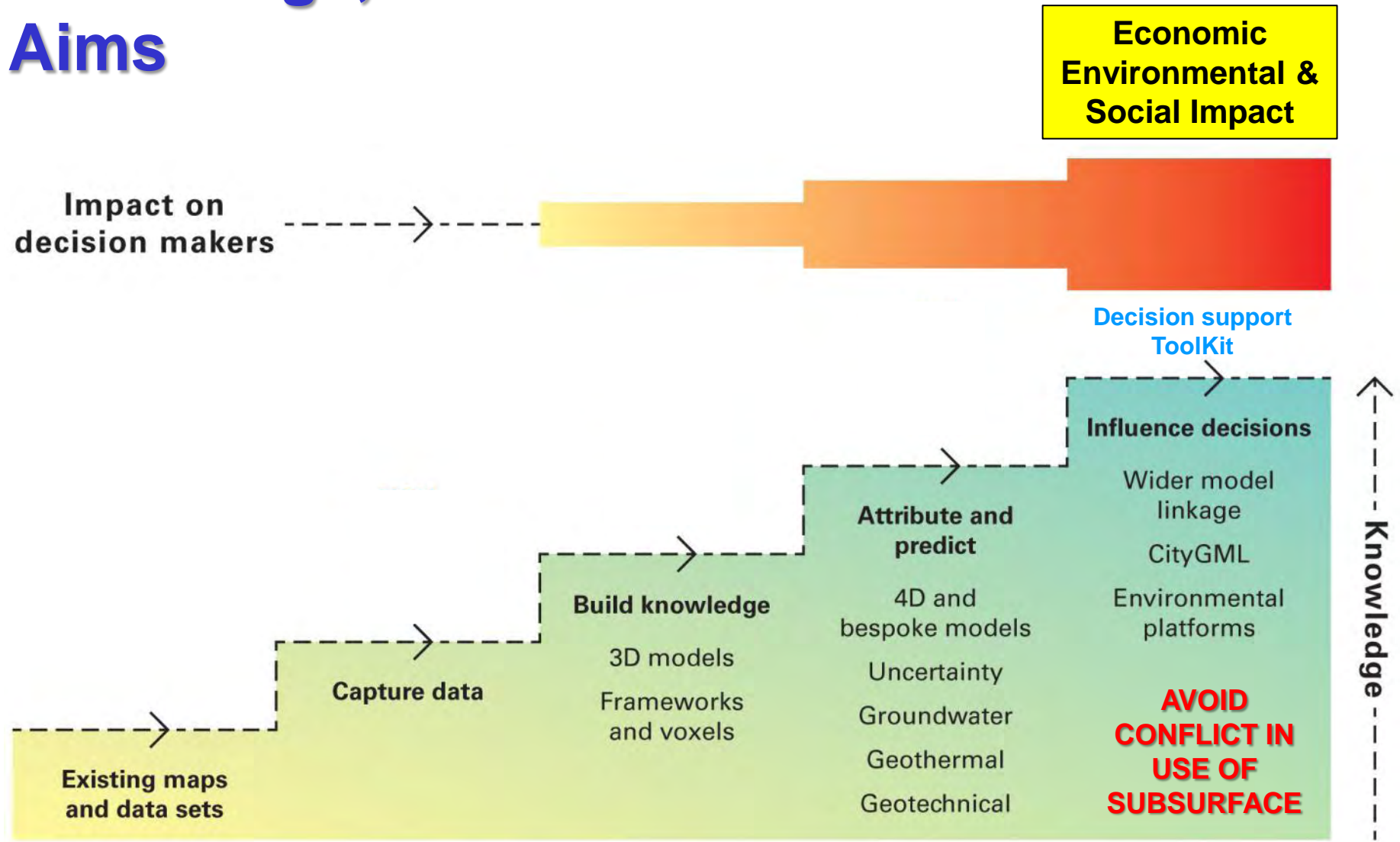
BGS data & knowledge can support needs

Local partners – Glasgow CC etc

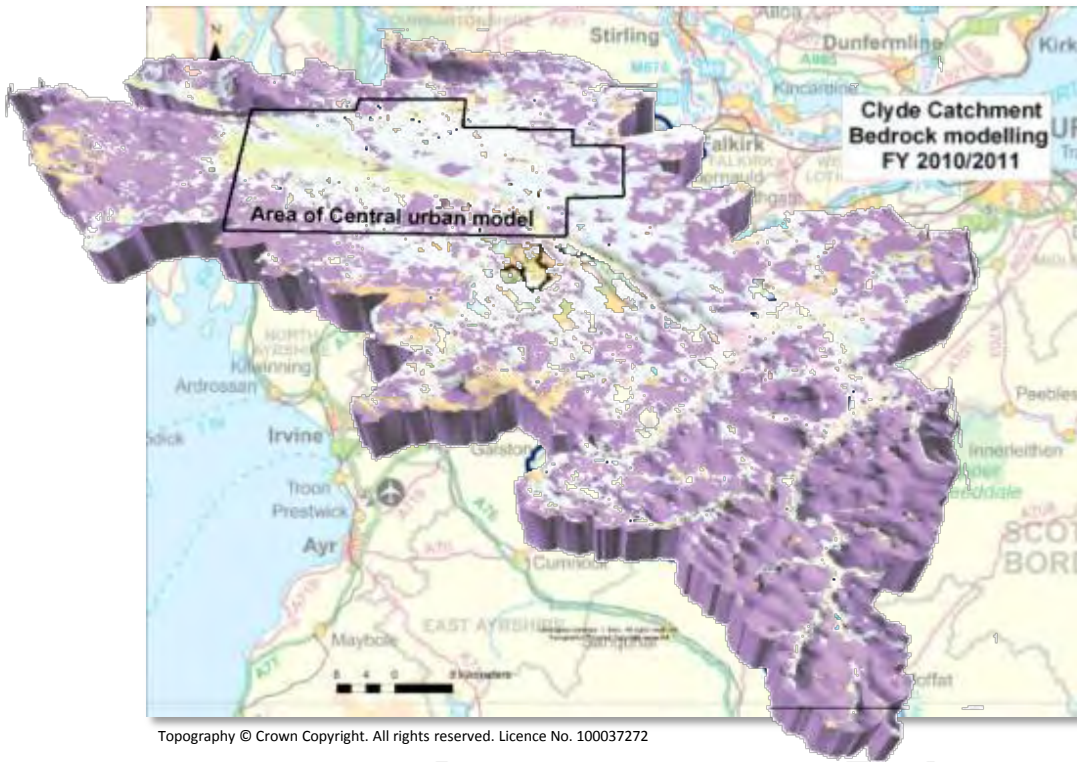
Complex industrial legacy



Urban Sub-Surface Knowledge, Needs and Aims



BGS's Clyde / Glasgow Project - CUSP



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3D geological models to help address:

Ground conditions

Contaminated Land

Land Use change impacts

Flooding

Sustainable drainage (SuDS)

Ground Source Heat resource

**Clyde Catchment
Glasgow conurbation
Development & Regeneration areas**



Clyde Gateway and 2014 Commonwealth Games

Multi-agency project regenerating east Glasgow and S Lanarkshire

Budget: £2.5 billion over 25 years



Targets: 10,000 new houses, 400,000 sq m business/commercial property
50,000 sq m retail outlets, M74 extension and new roads.

Sports arena, velodrome and athletes village
COMMONWEALTH GAMES 2014



Glasgow 3D models



synthesis of current
knowledge of Glasgow's
subsurface

most ambitious yet
completed in the UK

conurbation-wide

multi scalar
multi-attributed

>50,000 coded
boreholes used

Models used by GCC
and for groundwater
research

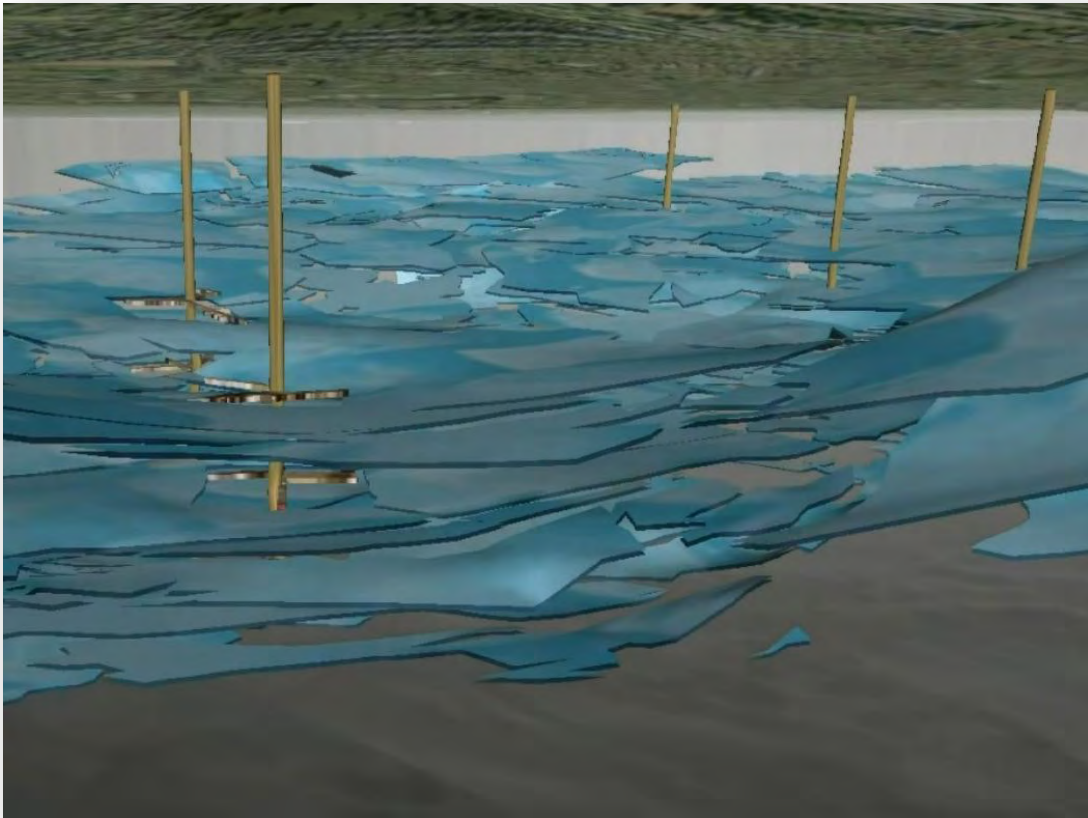


full potential is yet to be realised
by the wider community

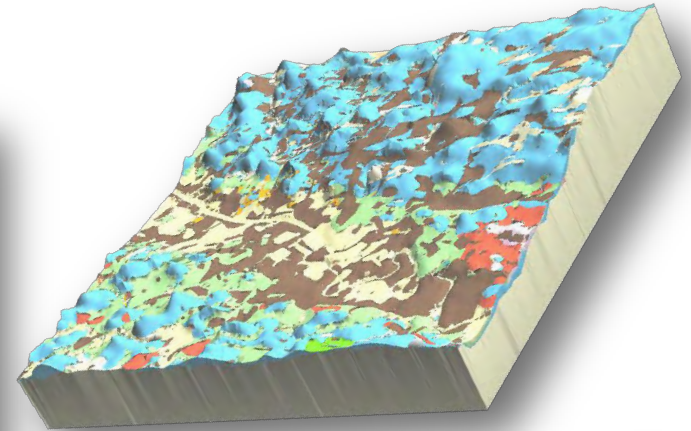


A range of 3D models

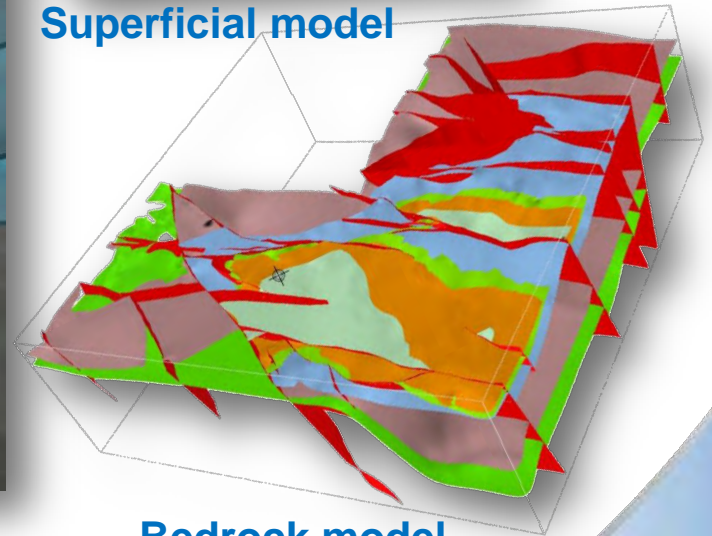
3D geological framework models



Coal seam model



Superficial model



Bedrock model

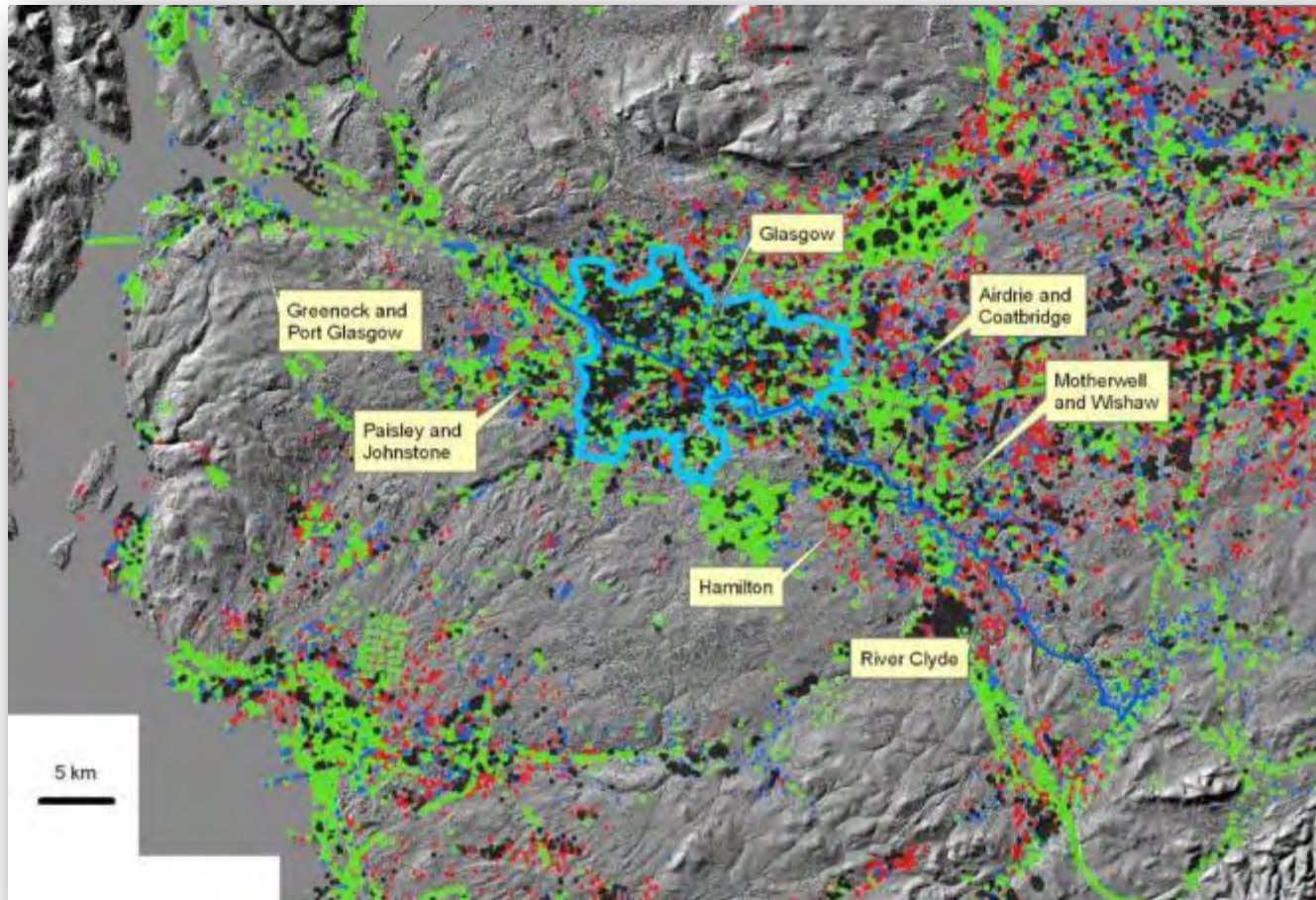
Key Glasgow 3D model requirements



Detailed ground height data
(Digital Terrain Model)

Ground investigation data
and information

Boreholes
provide most
depth
information
36,000 in BGS
archives for
Glasgow City

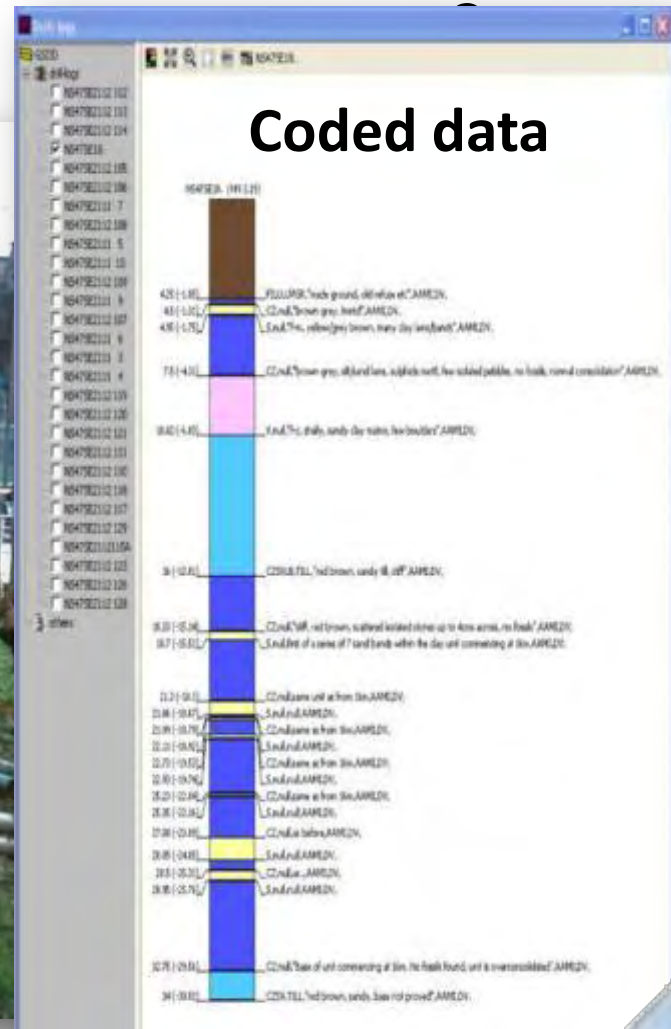


Borehole
locations
(green, red,
black, blue)
with
archived
data

NEXTMap DTM (Intermap Technologies Inc)



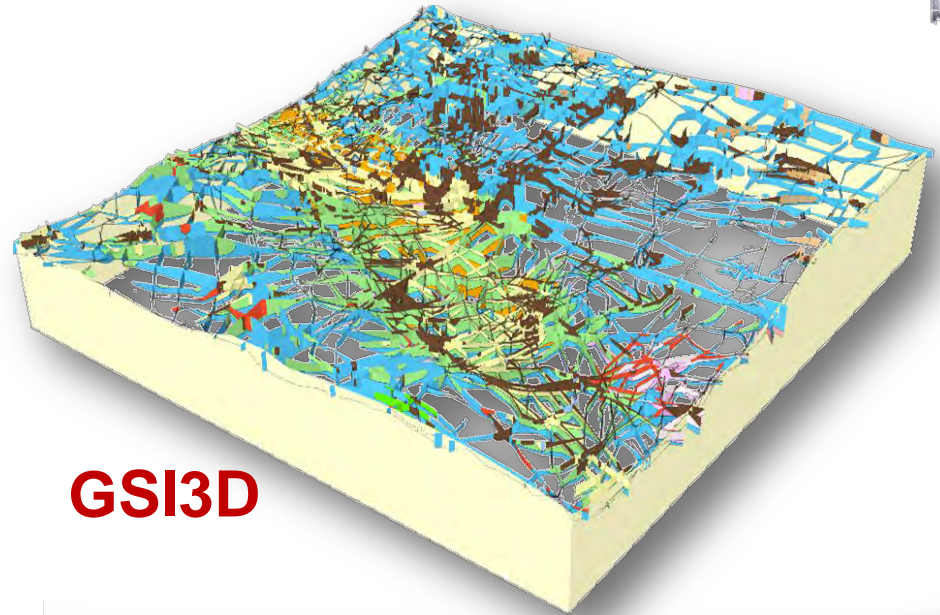
Information from boreholes



Glasgow 3D geological modelling

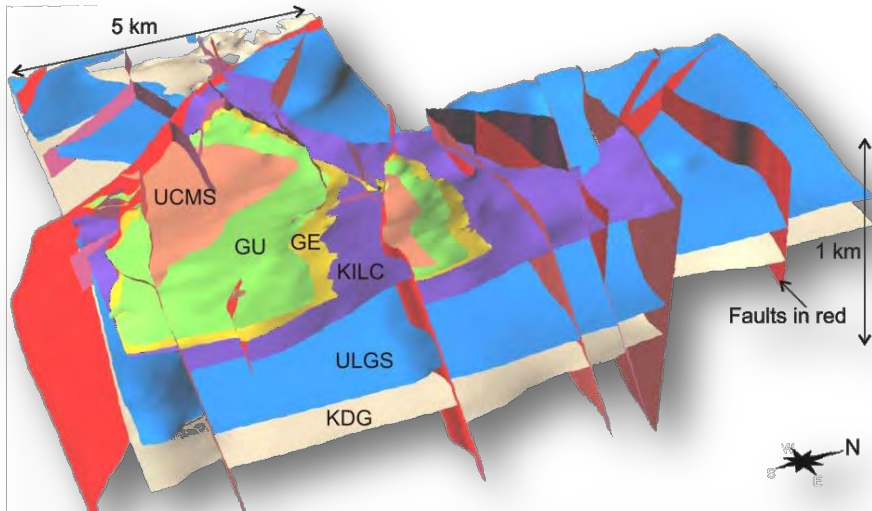


variety of methods and software depending on local geology and information available

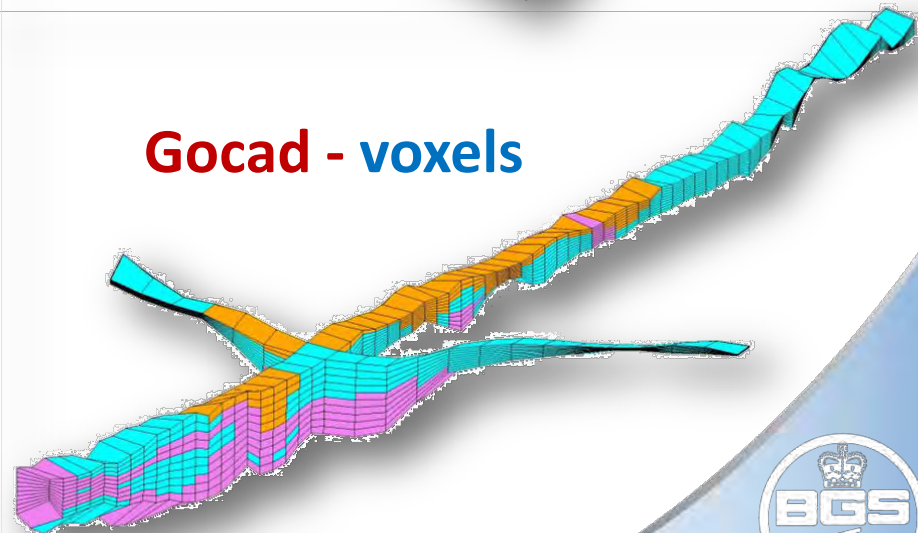


GSI3D

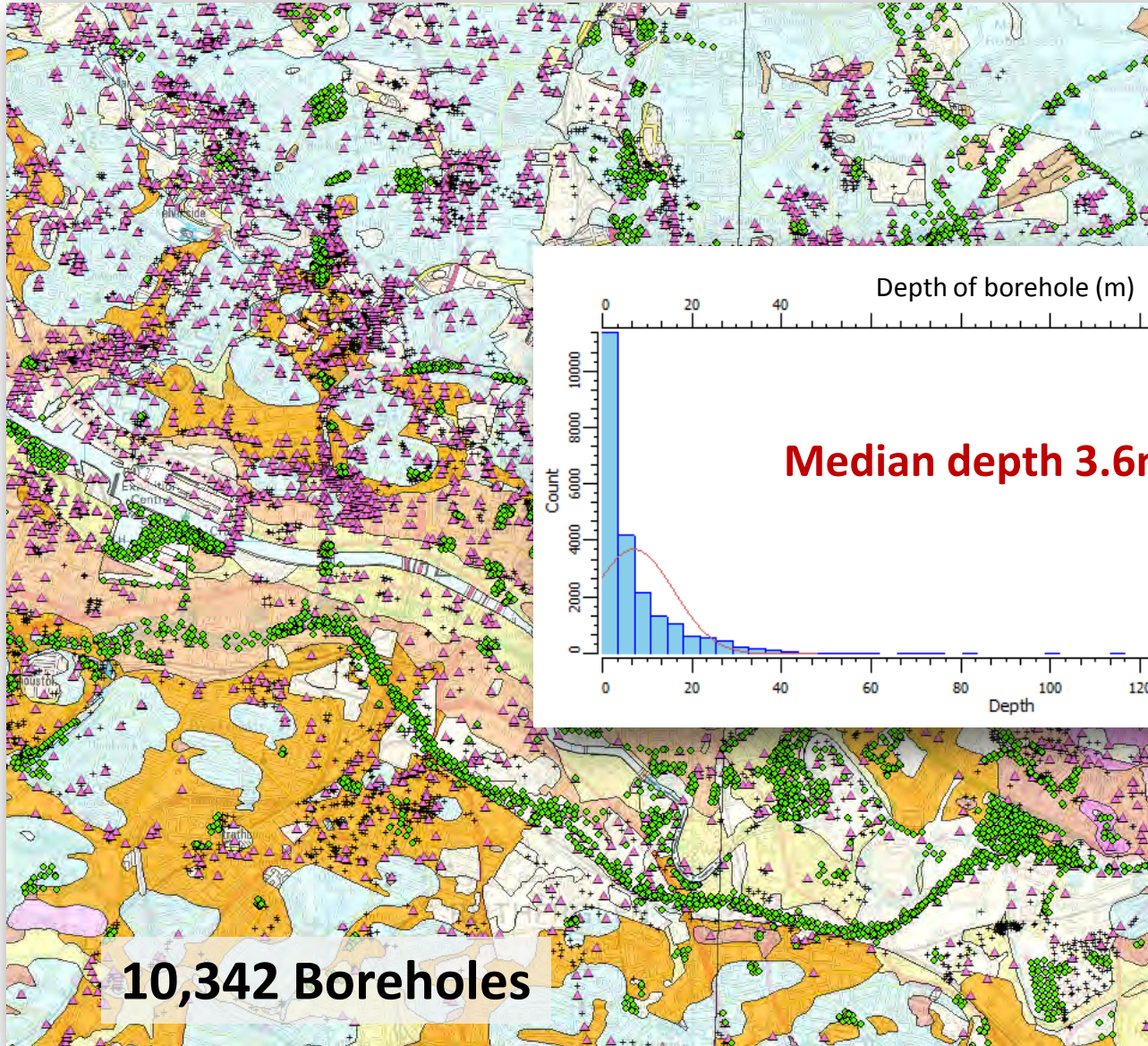
Gocad - surfaces



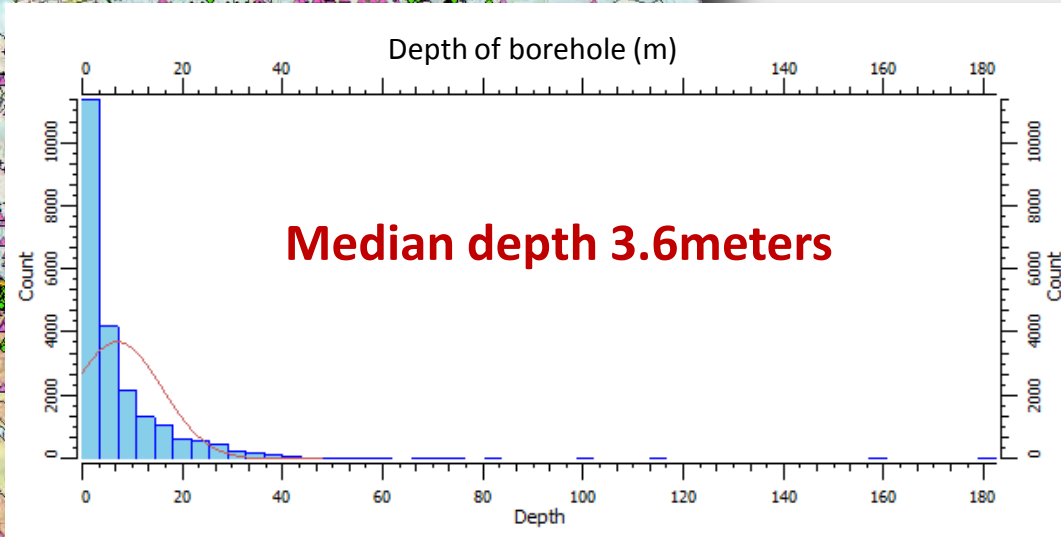
Gocad - voxels



Central Glasgow superficial deposits



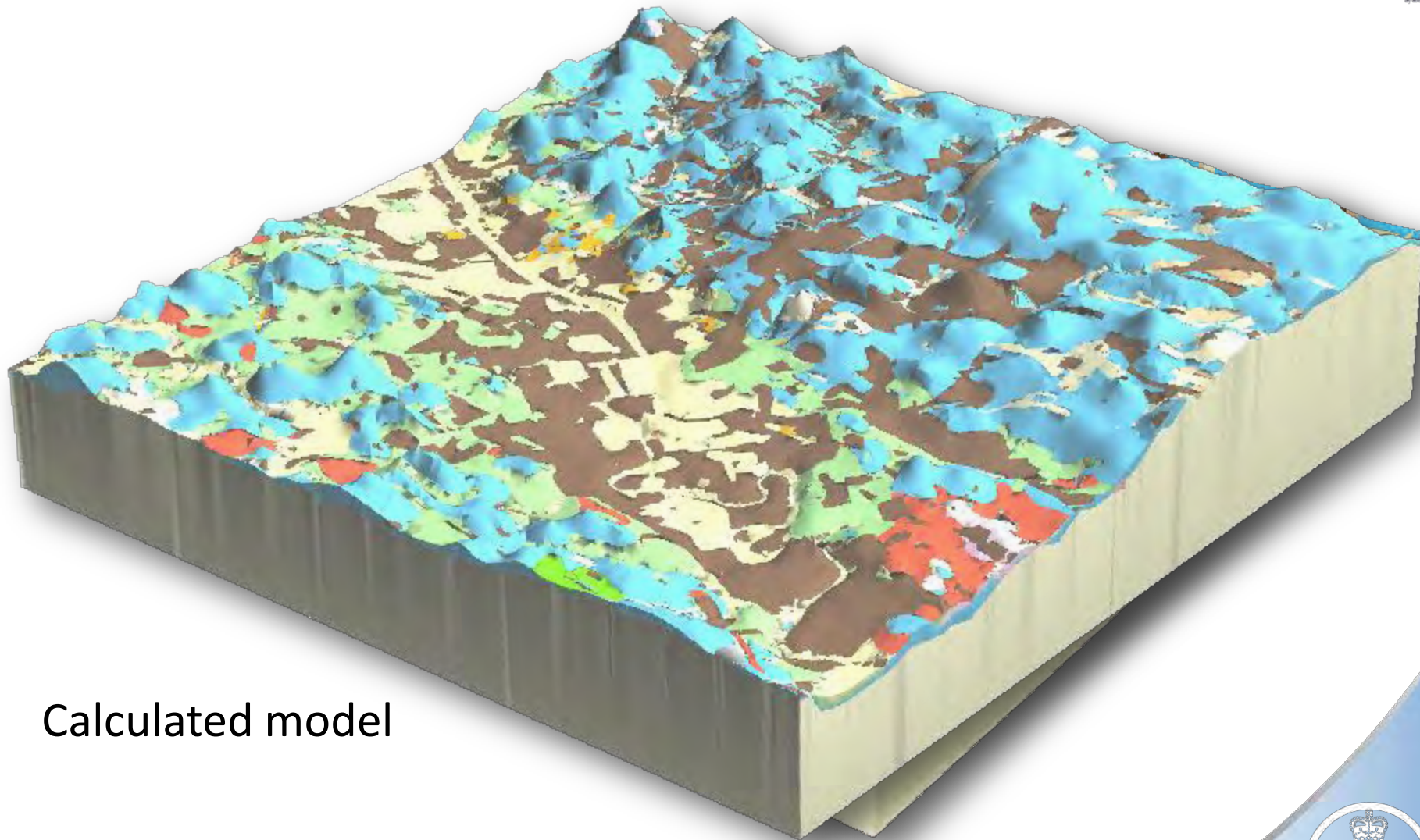
10,342 Boreholes



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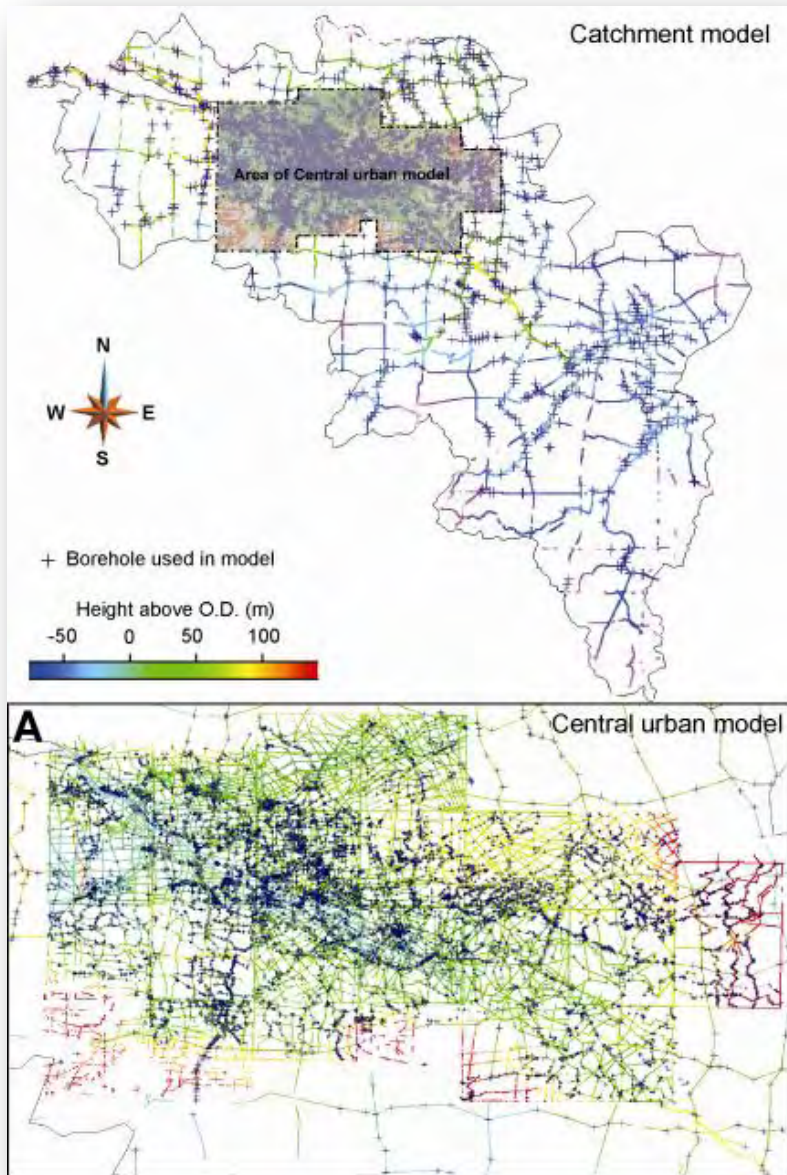
GSI3D Modelling process



Calculated model



Superficial Deposits model



Catchment model

85 cross sections

1066 boreholes

41,727 surface control points

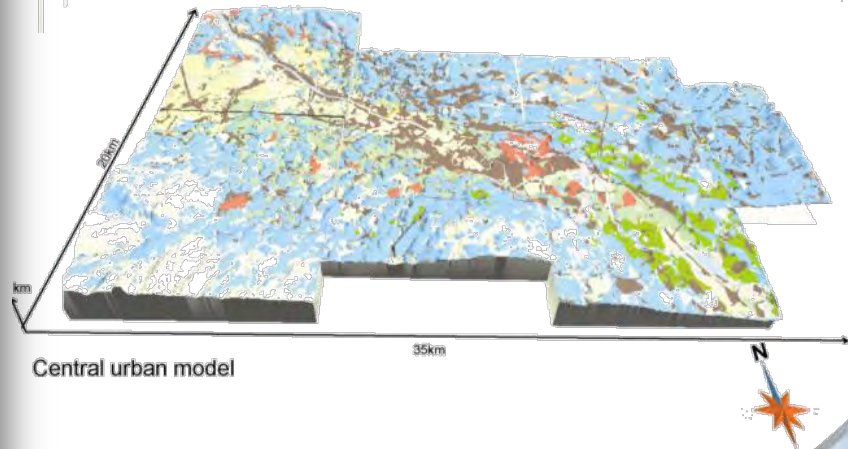
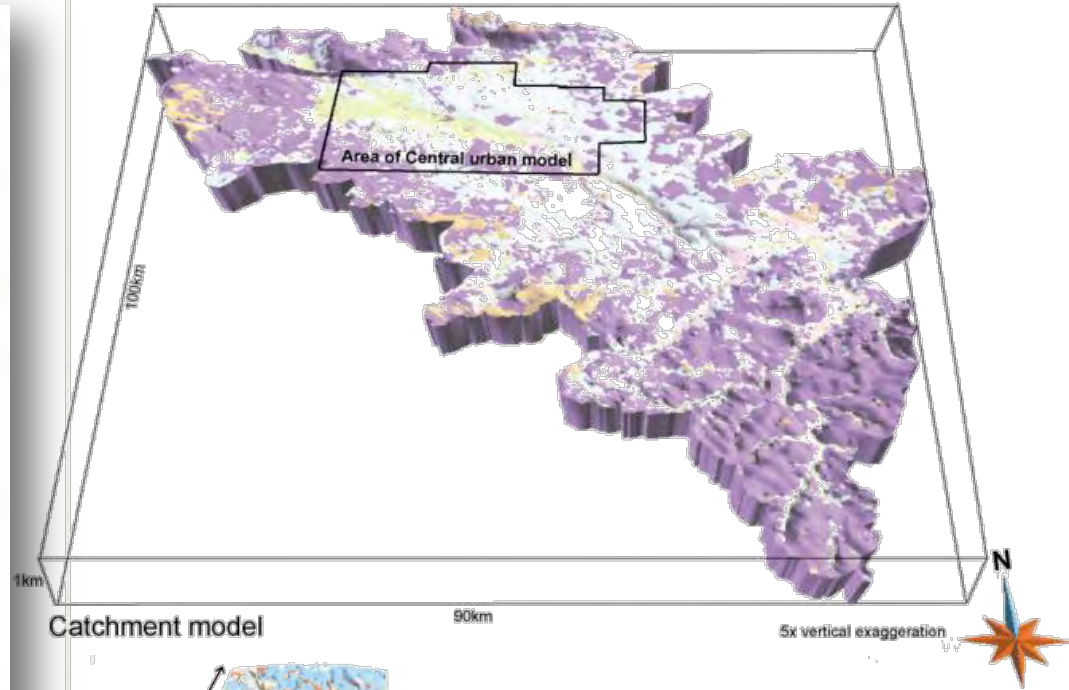
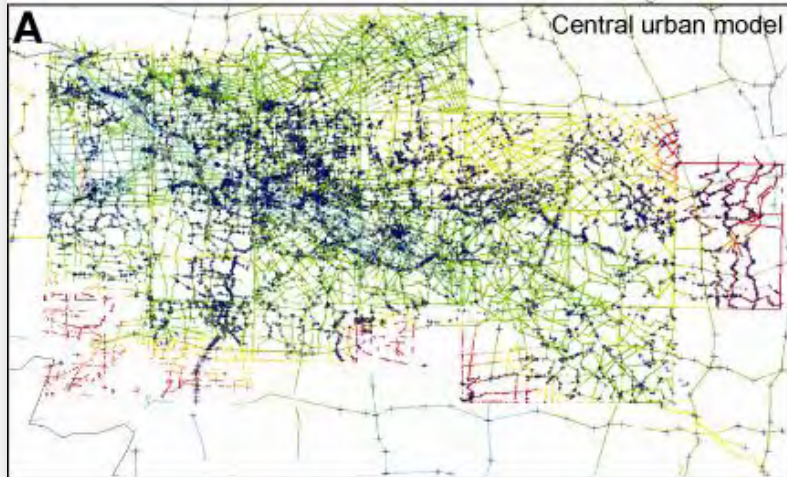
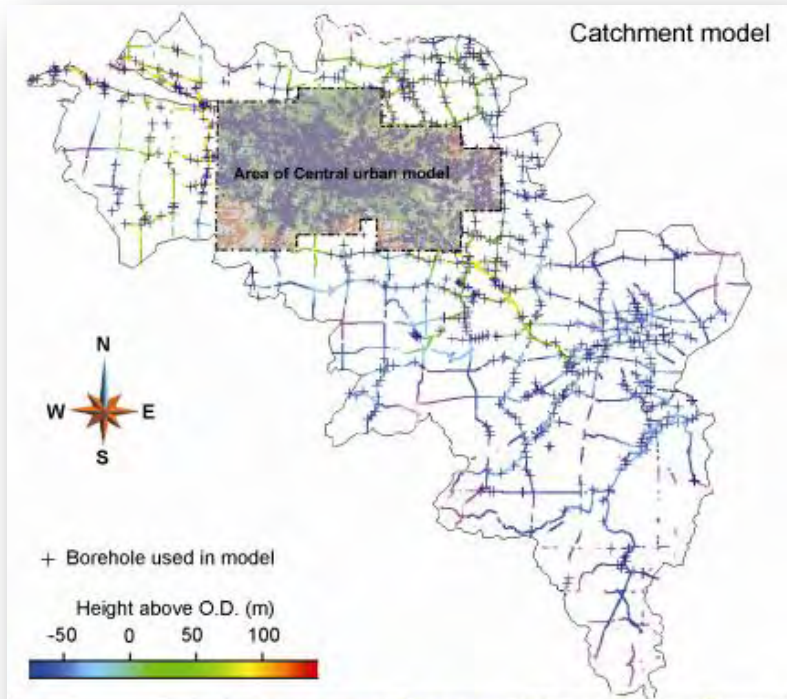
Conurbation model

1167 cross sections

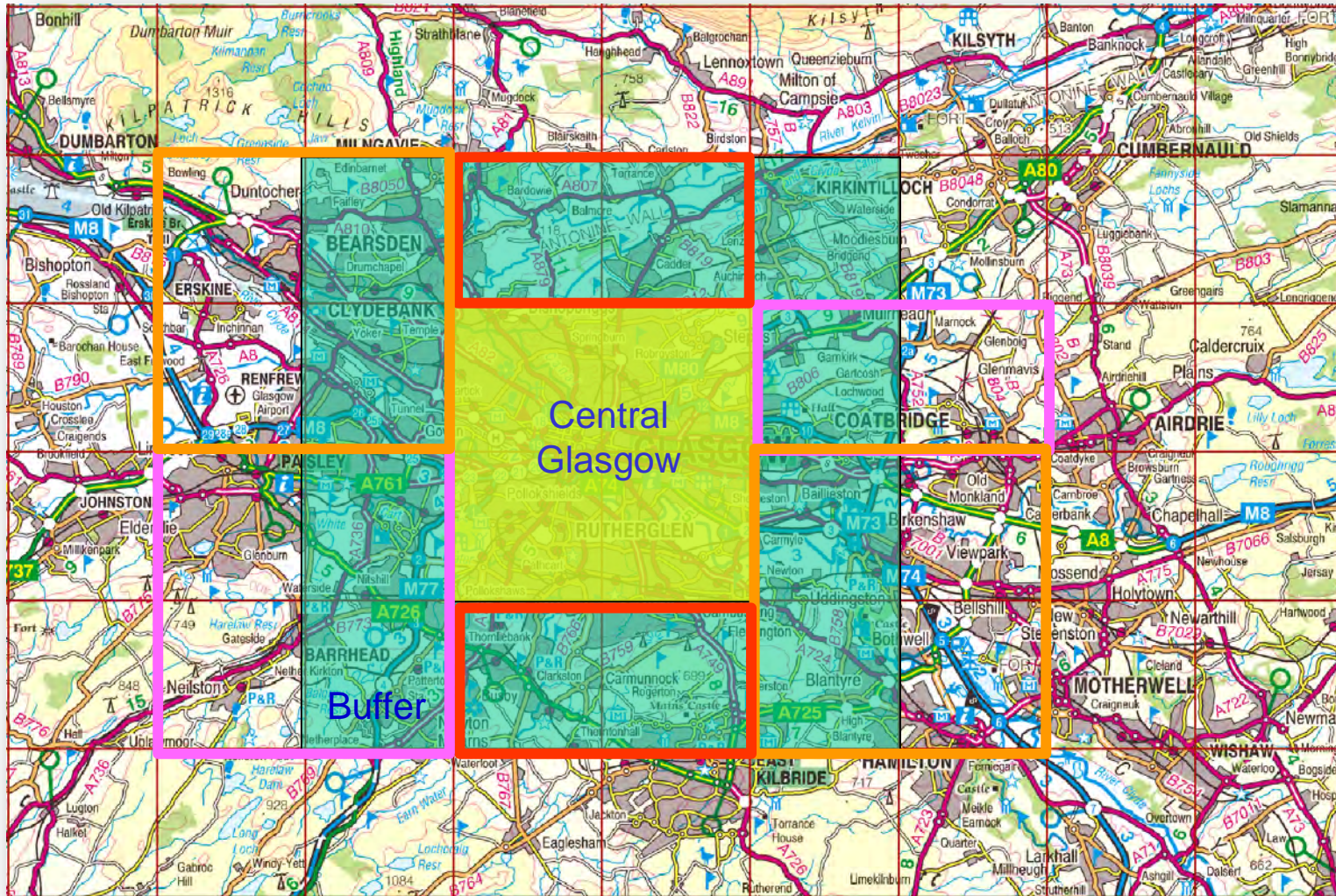
11,570 boreholes

326,942 surface control points

Superficial Deposits model



ASK Superficial Deposits model (s)

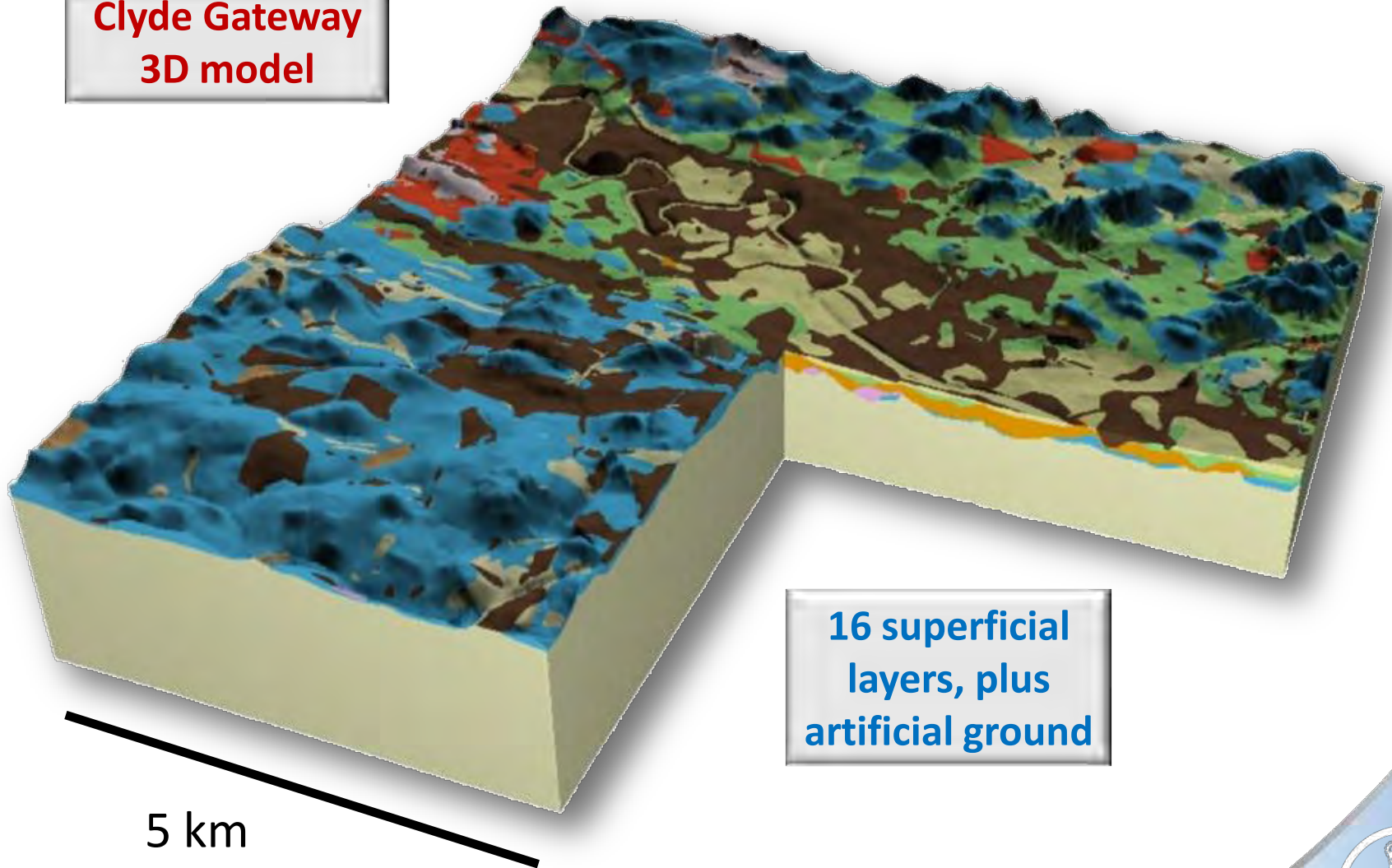


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Superficial Deposits model

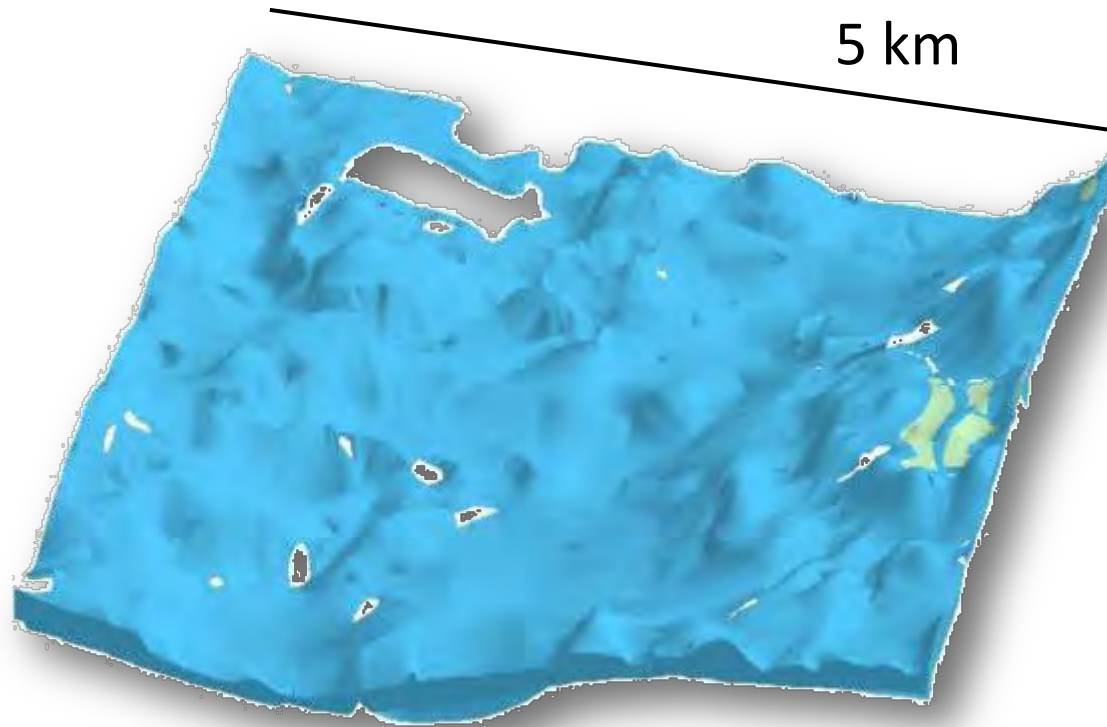
Clyde Gateway
3D model



16 superficial
layers, plus
artificial ground

5 km

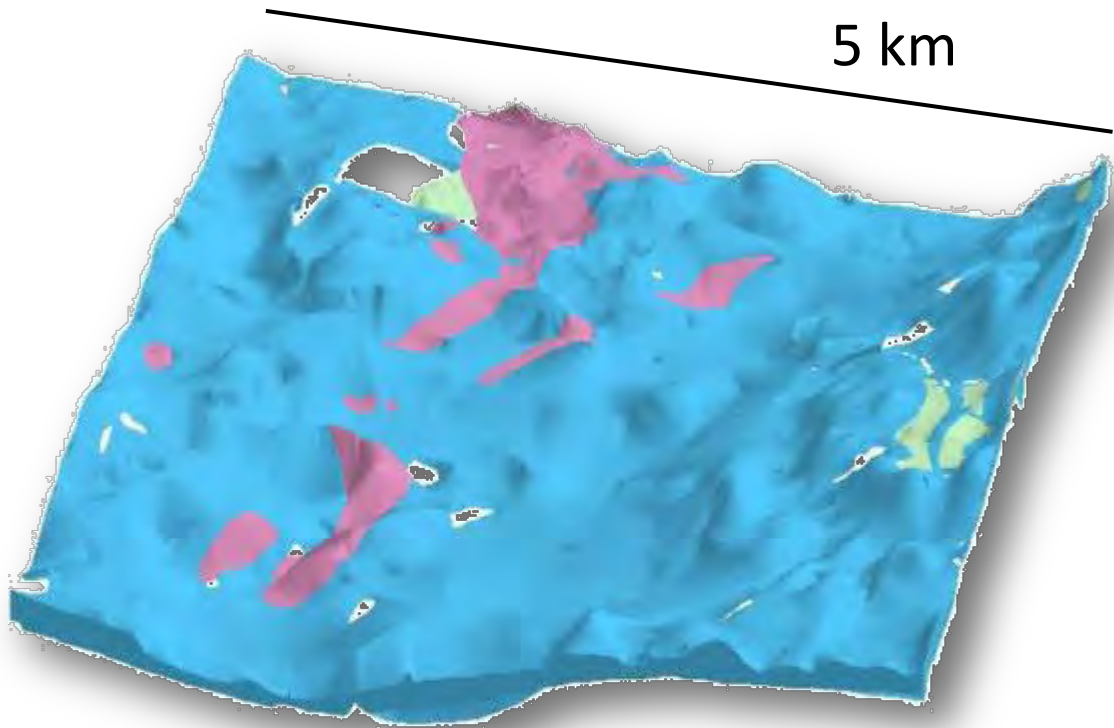
Engineering property attribution



e.g. **STRENGTH** (or texture, grainsize, SPT, permeability)
Firm to stiff laminated CLAY and SILT



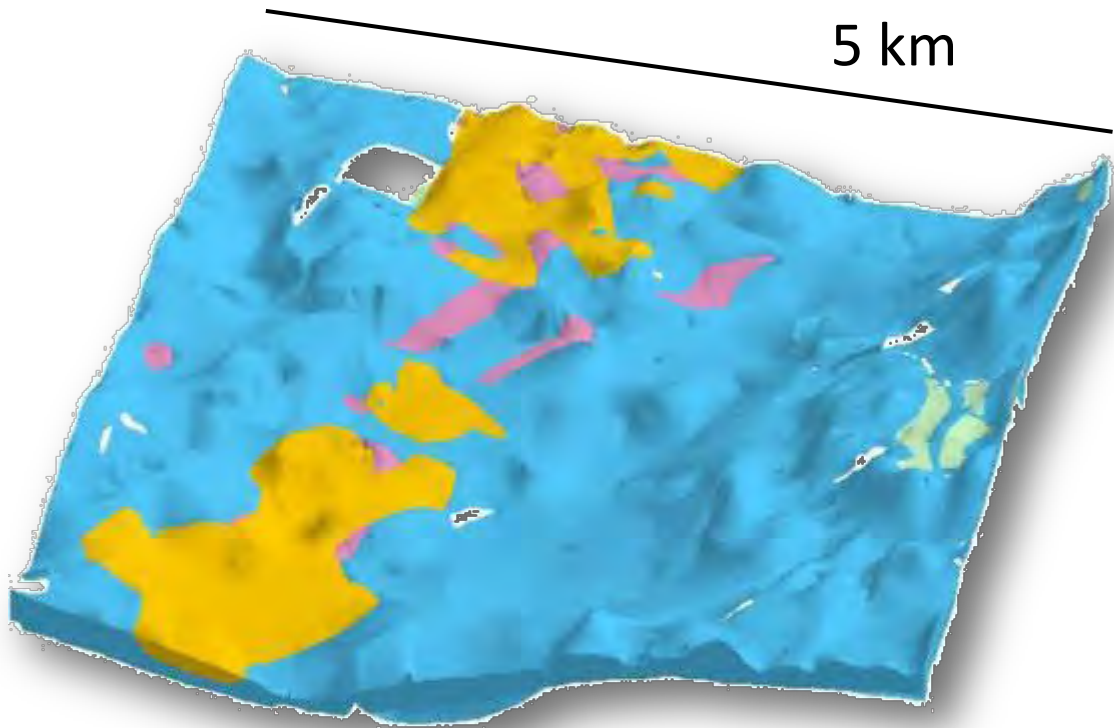
Engineering property attribution



Medium to very dense silty SAND and GRAVEL with coarser particles



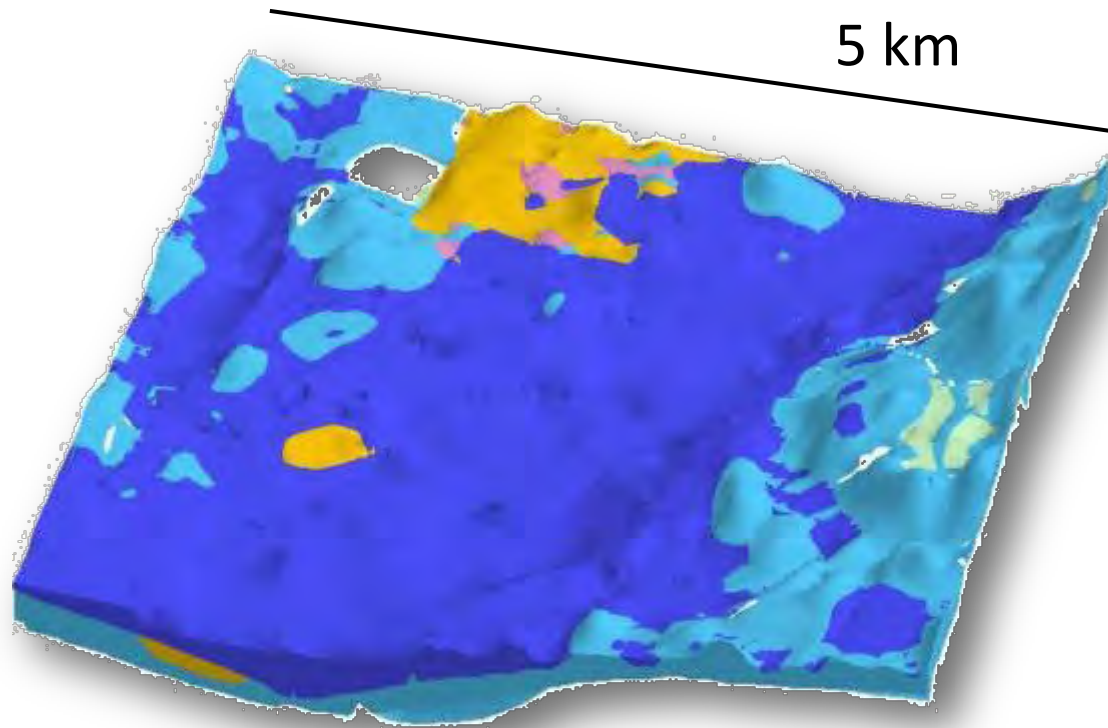
Engineering property attribution



Loose to medium dense silty SAND and SAND



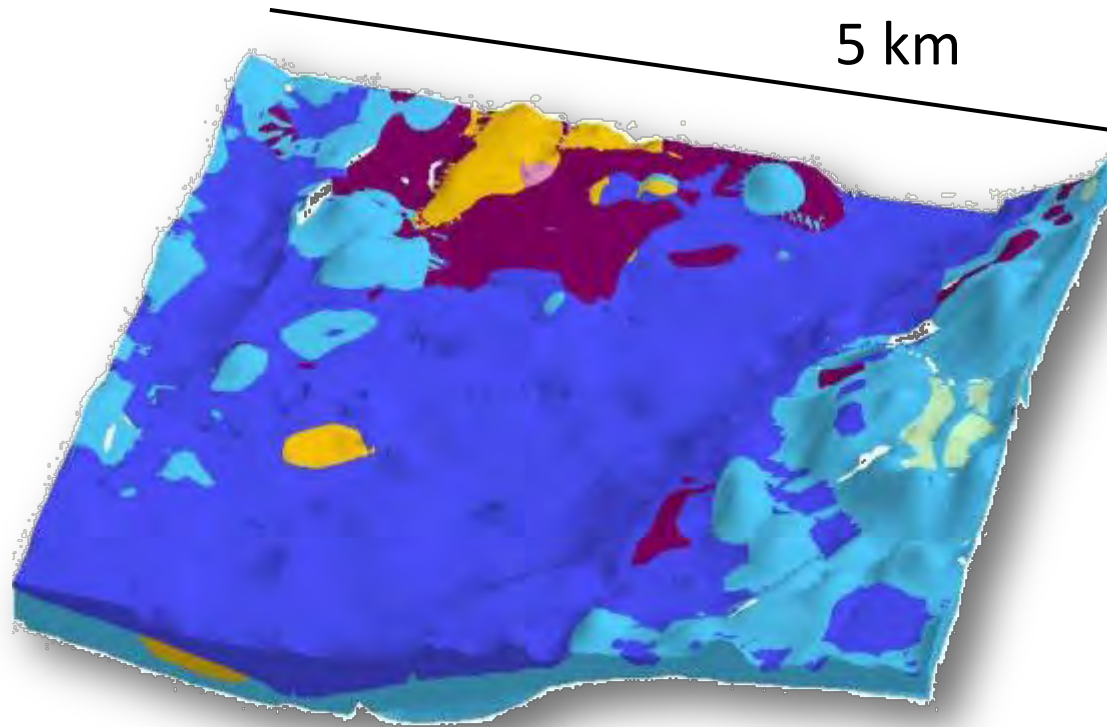
Engineering property attribution



Very soft to firm laminated CLAY and SILT some local sand beds



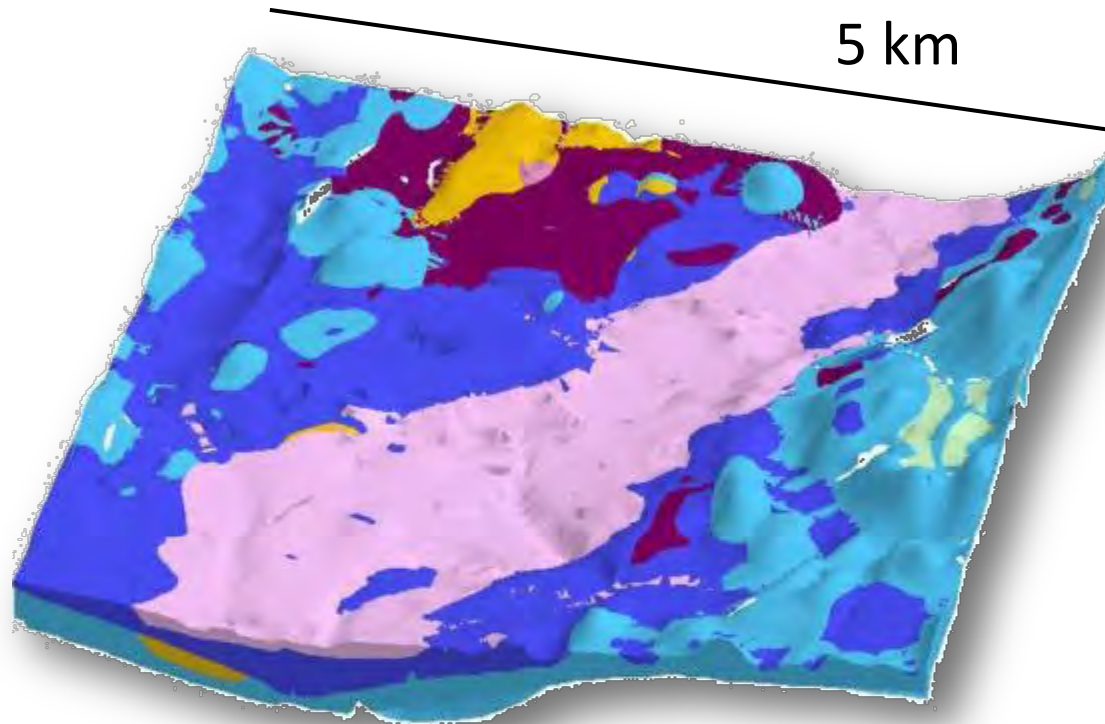
Engineering property attribution



Loose to medium dense silty sand and sand



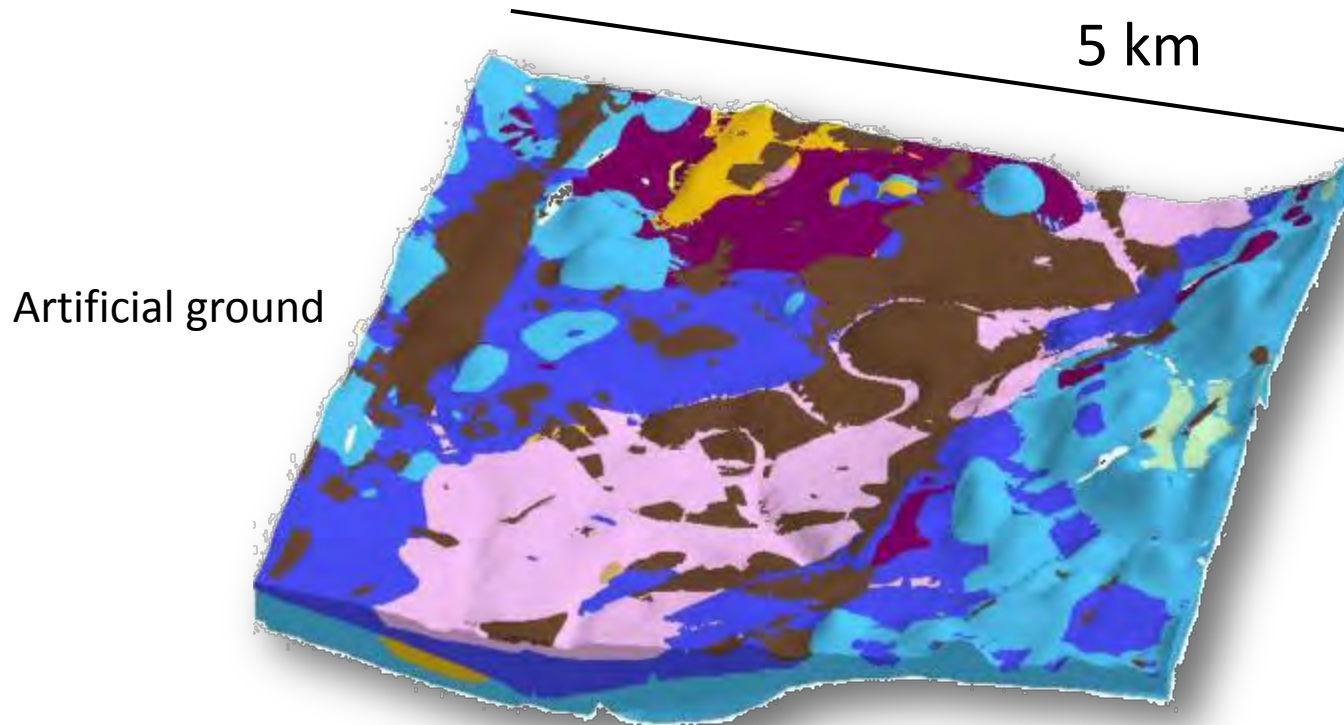
Engineering property attribution



Upper part very soft to very stiff CLAY and SILT occasional peat
Lower part loose to medium dense SAND and GRAVEL,



Engineering property attribution



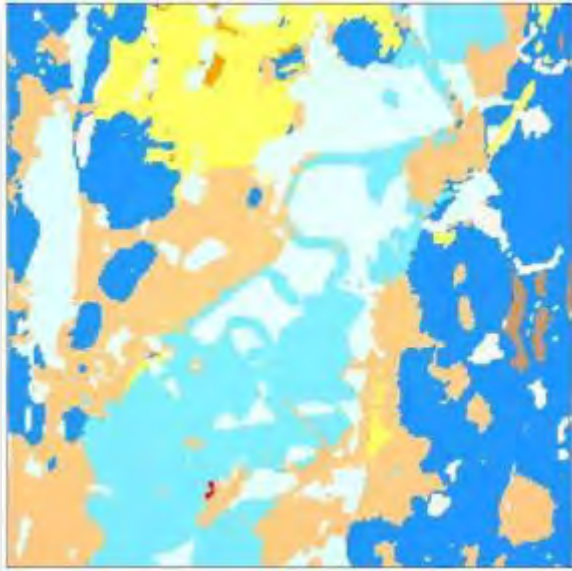
Highly variable, very loose to very dense sand and gravel or very soft to stiff CLAY and SILT, natural or man-made materials



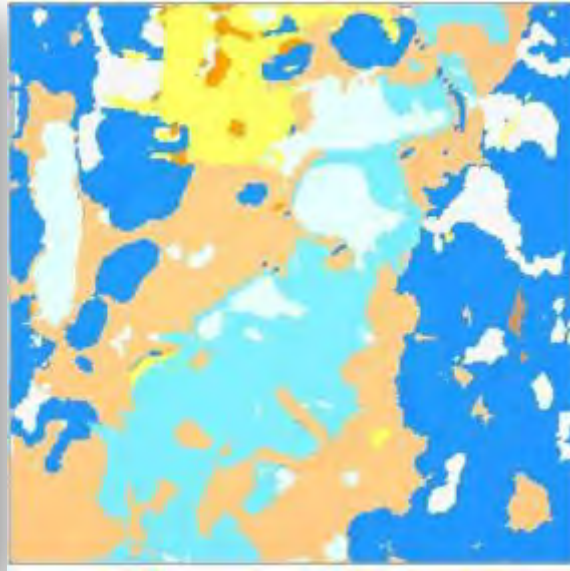
Predicting conditions below ground



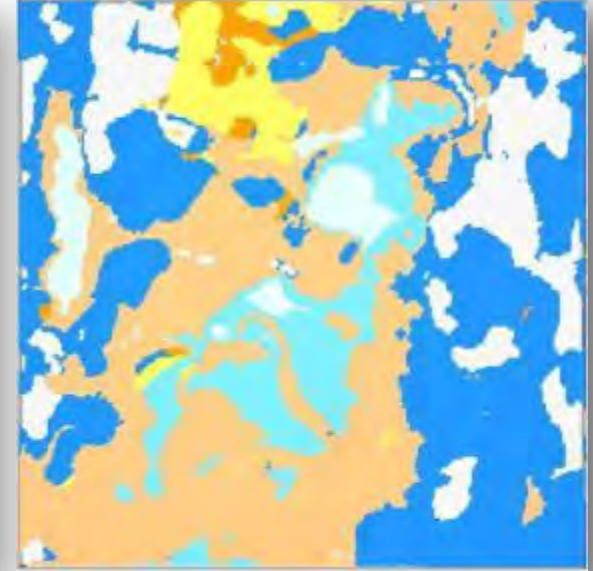
Horizontal slices from 3D Model of south-east Glasgow attributed with strength properties – e.g. for foundations



Ground level




2 m depth




5 m depth


Organic

 Organic, Highly compressible (Peat)


Mixed fine and coarse

 Very soft to very stiff/ loose to very dense

 Very soft to very stiff/loose medium dense


 Firm to stiff/dense very dense


Mostly fine grained

 Very soft to firm (loose) laminated (sand) SILT and CLAY

 Firm to stiff laminated SILT and CLAY

Mostly fine grained

 Loose to medium dense silt SAND and SAND

 Medium to very dense silty gravelly SAND and/or GRAVEL:

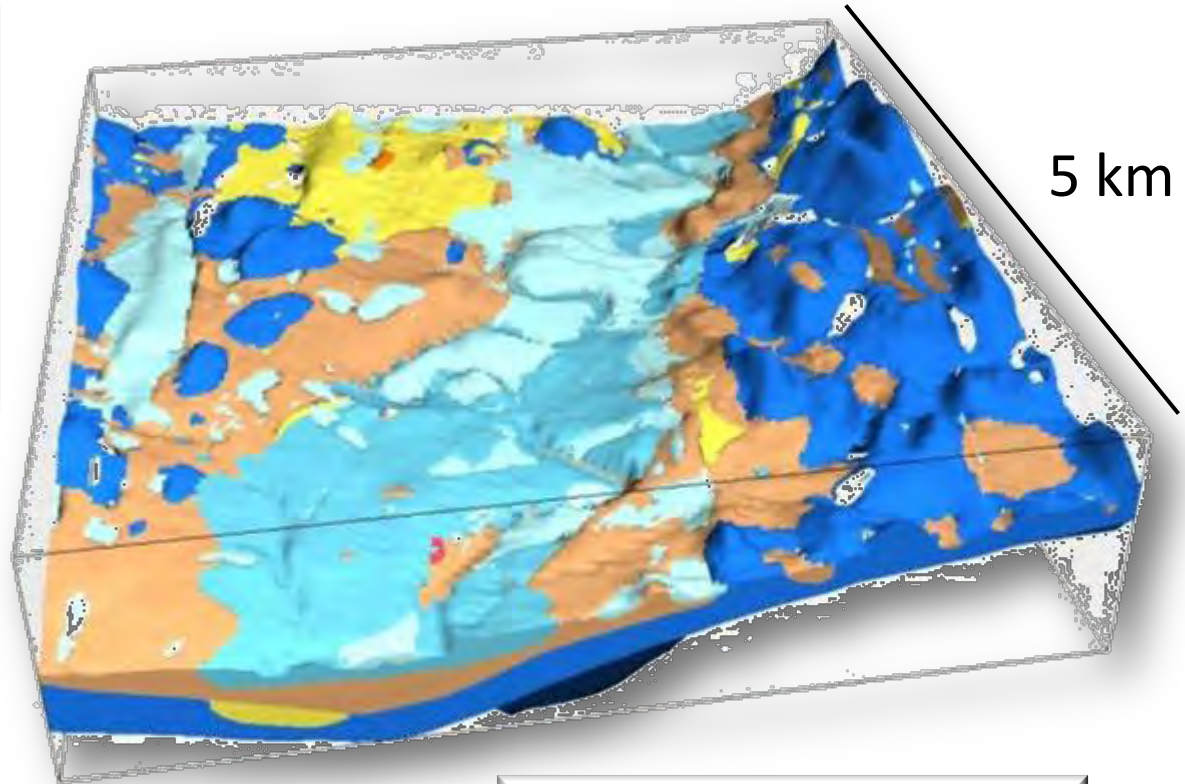
Rock

 Coal Measures

3D Engineering geology model



**Valuable
predictive tool
but not substitute
for ground
investigation**



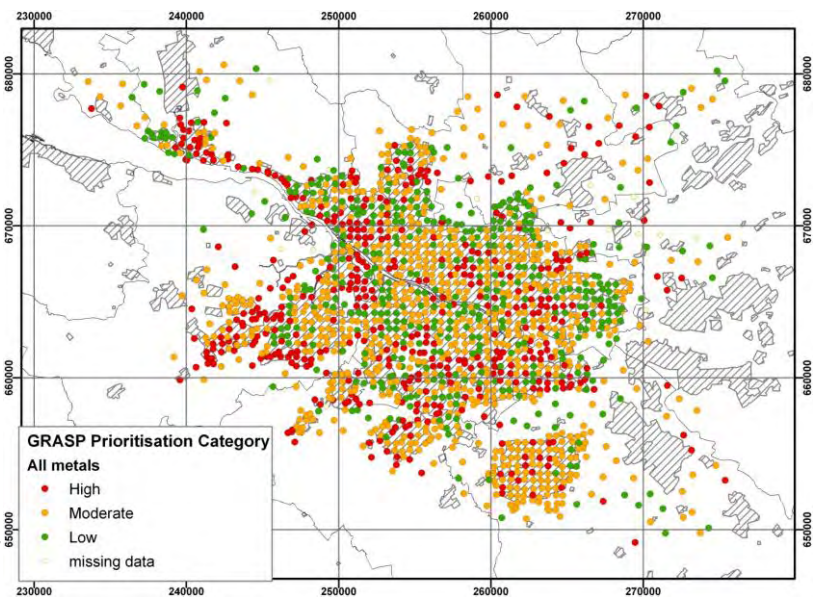
attributed with strength properties



Groundwater monitoring

Aim – *develop pilot urban groundwater monitoring network in East End area of Glasgow, utilising existing monitoring boreholes*

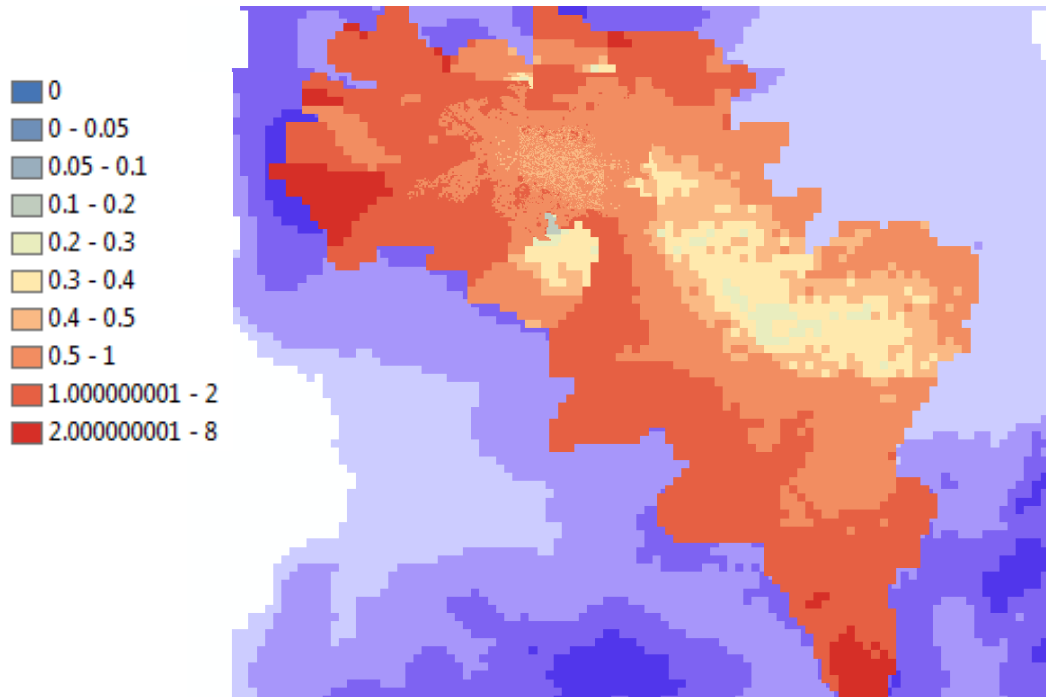
- Drivers**
- Need for baseline urban groundwater data
 - Sustainable urban development & management – SuDS, flooding, soil contamination
 - Assist stakeholders to meet future legislation of the EU Water Framework Directive



Slide 47

Groundwater Recharge Model

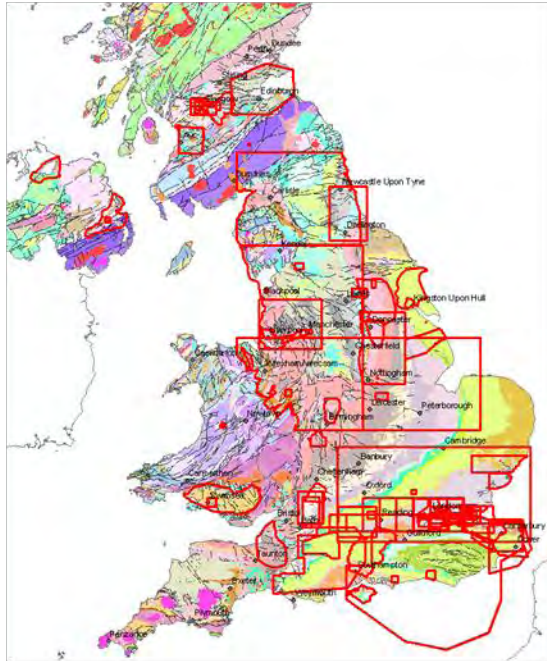
TOTAL WATER BALANCE						
			% of Total Inflows		Average daily	Average Yearly
Total Rainfall	17847486 MI		100 %	5400.637 mm	3.696535 mm	1350.159323 mm
Total Evaporation	5884994 MI		33 %	1780.795 mm	1.218888 mm	445.1988336 mm
Total Runoff	7041304 MI		39 %	2130.694 mm	1.45838 mm	532.6734741 mm
Total Recharge	4955857 MI		28 %	1499.639 mm	1.026447 mm	374.9097794 mm
Total Outflows	17882156 MI		100 %	5411.128 mm	3.703716 mm	
Net water	-34670 MI		0 %	-10.4911 mm	-0.00718 mm	



- Calibrated simulated surface flows to observed records
- Finally arrived at estimated recharge distribution which feeds into the groundwater model



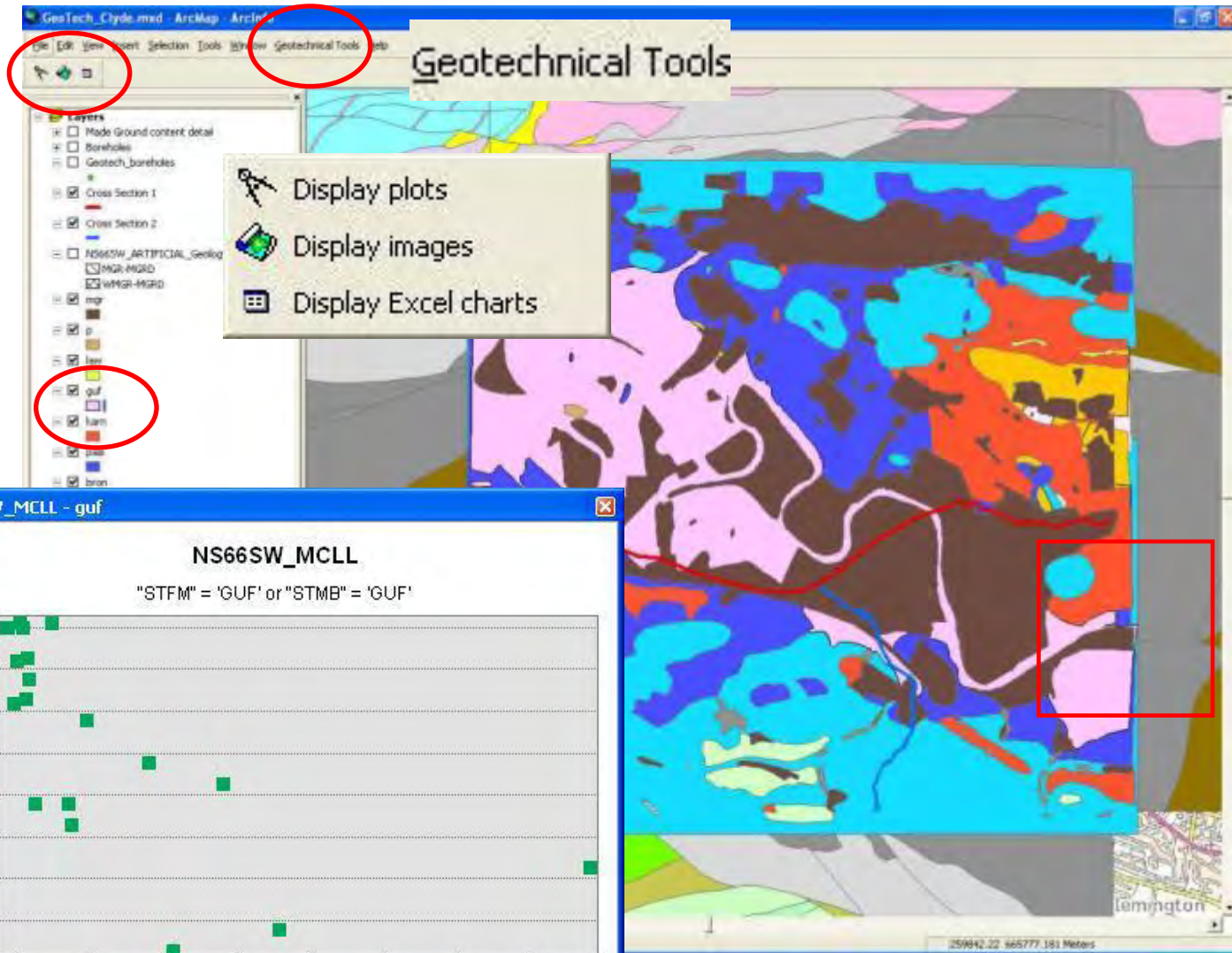
Limitations of 3D geological modelling



- Powerful tool but:
 - No consideration of intra-unit heterogeneity
 - Time consuming to undertake in dense borehole fields
 - Transects determined by borehole locations not lines of interest
 - Not always well suited to process model integration
 - Other modelling technologies are required in addition to fully understand UK geology



Engineering data GIS



Topography © Crown Copyright. All rights reserved. Licence No. 100037272

Glasgow Stochastic Modelling

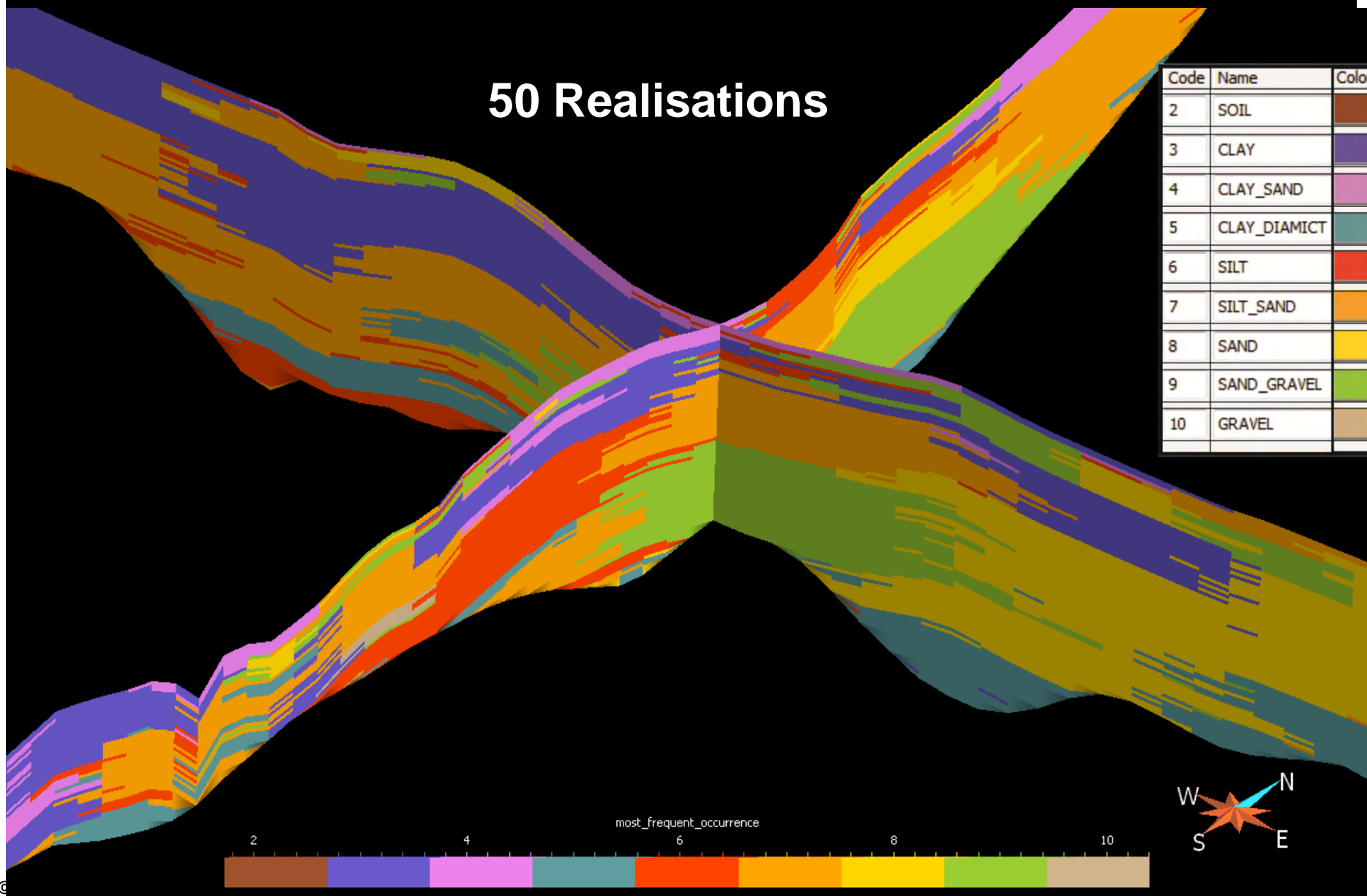
- Limits to capabilities of deterministic modelling at resolving complex superficial deposits
- Stochastic models using voxels a possible alternative
- Glasgow superficial deposits geology provides ideal test for new modelling techniques
 - Dense borehole field spanning city area
 - Major redevelopment projects means high resolution property data derived from geotechnical testing
 - Close cooperation between BGS and Glasgow City Council
- Apply standard oil industry reservoir modelling techniques to shallow unconsolidated sediments
- Simulation methods derive statistical information from boreholes and develop models of how these vary spatially
- Analyse vertical and horizontal spatial patterns of variance and populate a 3-D grid statistically using the variograms



Compilation of most likely lithology

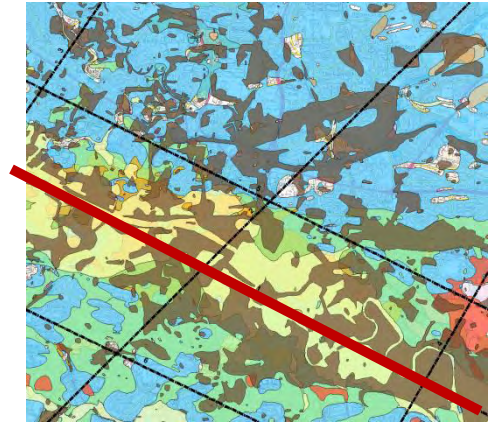
50 Realisations

Code	Name	Color
2	SOIL	Brown
3	CLAY	Dark Purple
4	CLAY_SAND	Pink
5	CLAY_DIAMICT	Teal
6	SILT	Red
7	SILT_SAND	Orange
8	SAND	Yellow
9	SAND_GRAVEL	Light Green
10	GRAVEL	Tan

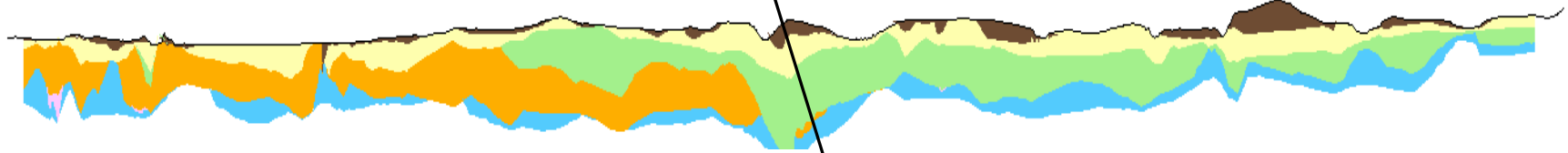


Comparing deterministic & stochastic models

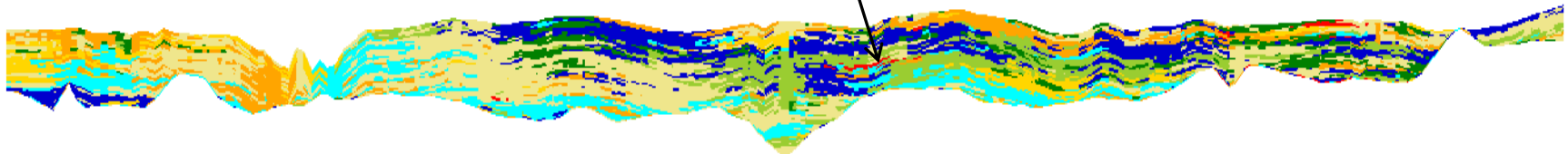
Captures greater lithological variability than the stratigraphy



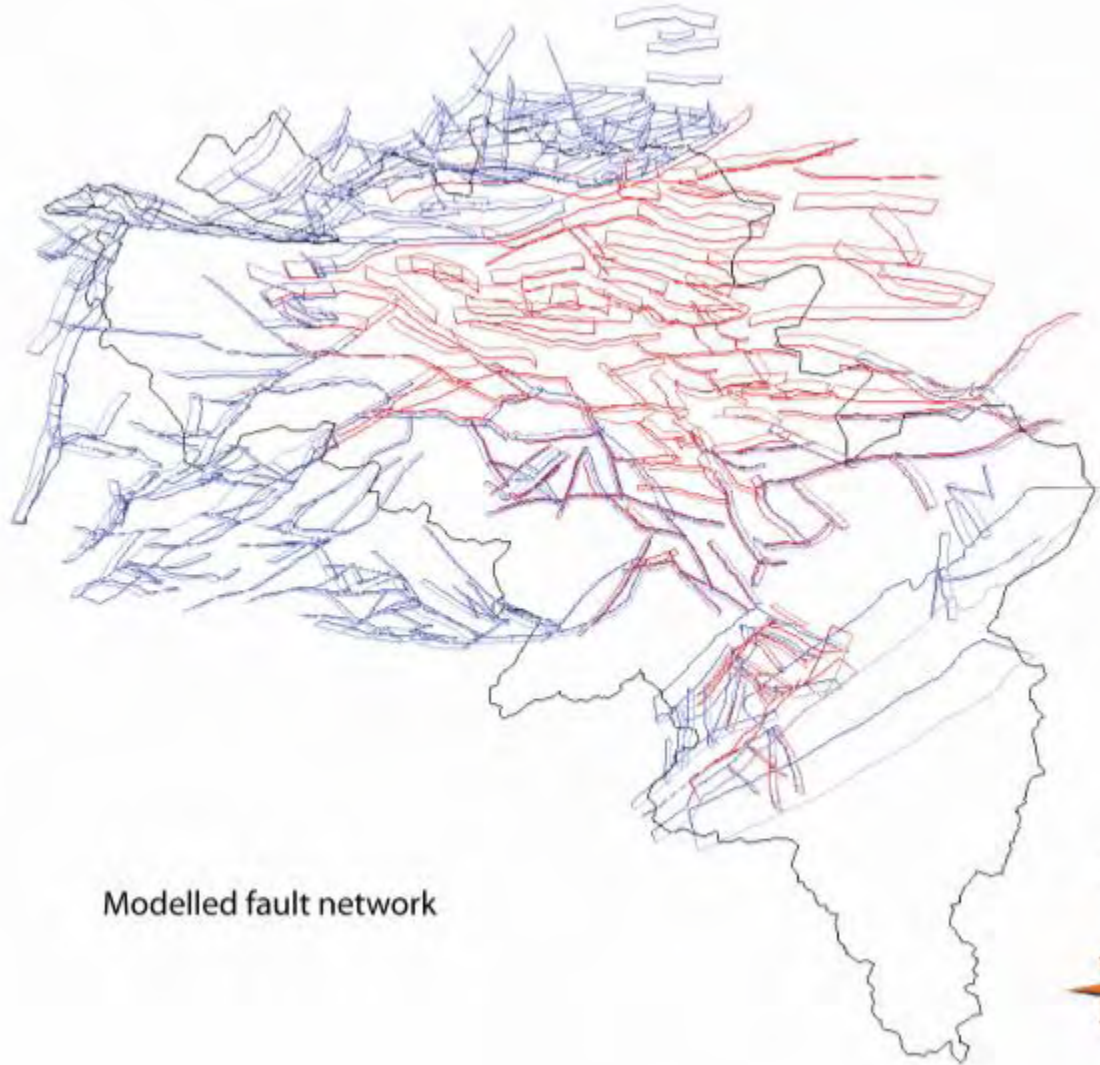
Deterministic



Stochastic



Bedrock model

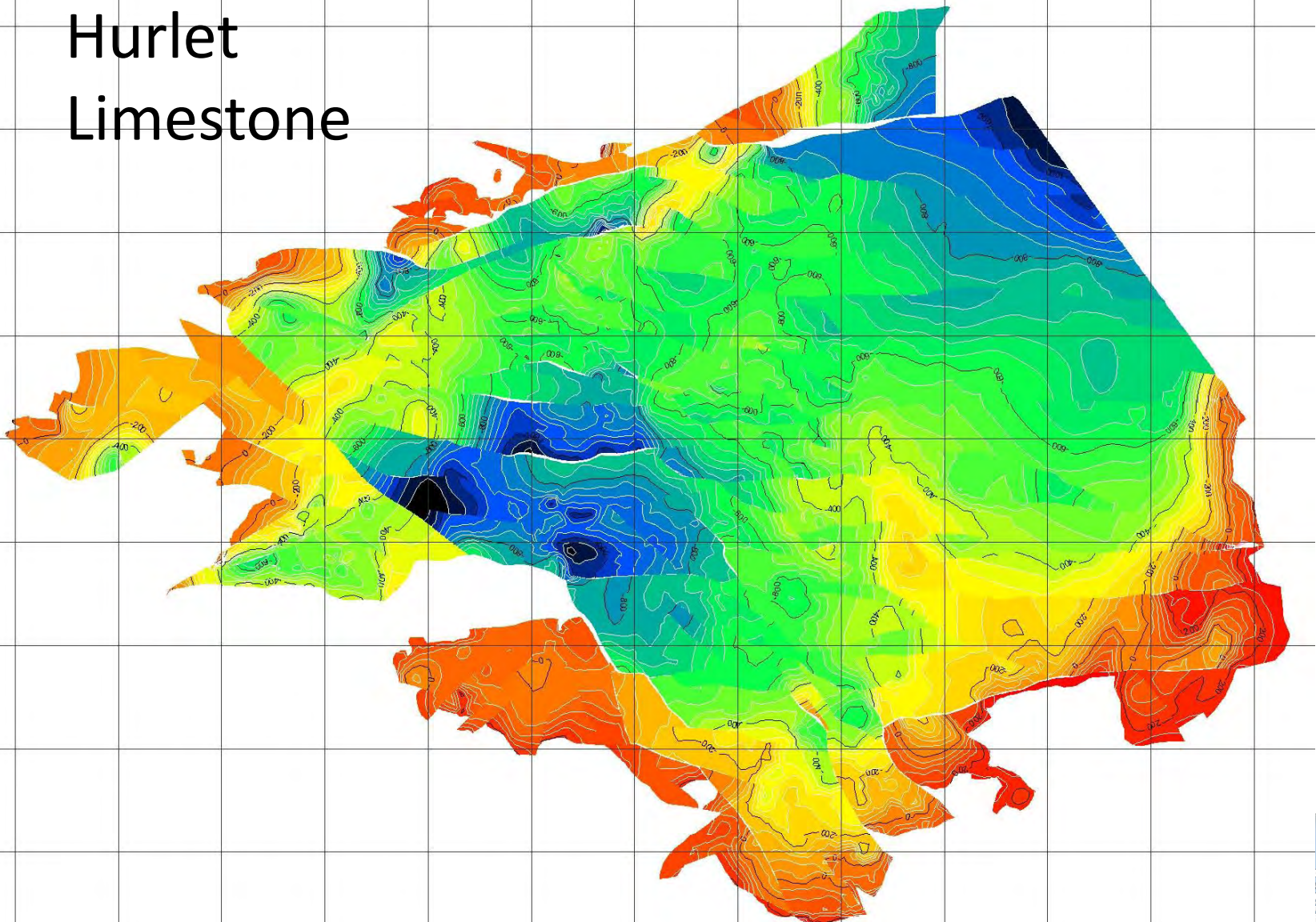


85 cross sections
1066 boreholes
>106,000 control points
Extends to 1.39km depth
794 faults
47 stratigraphic surfaces

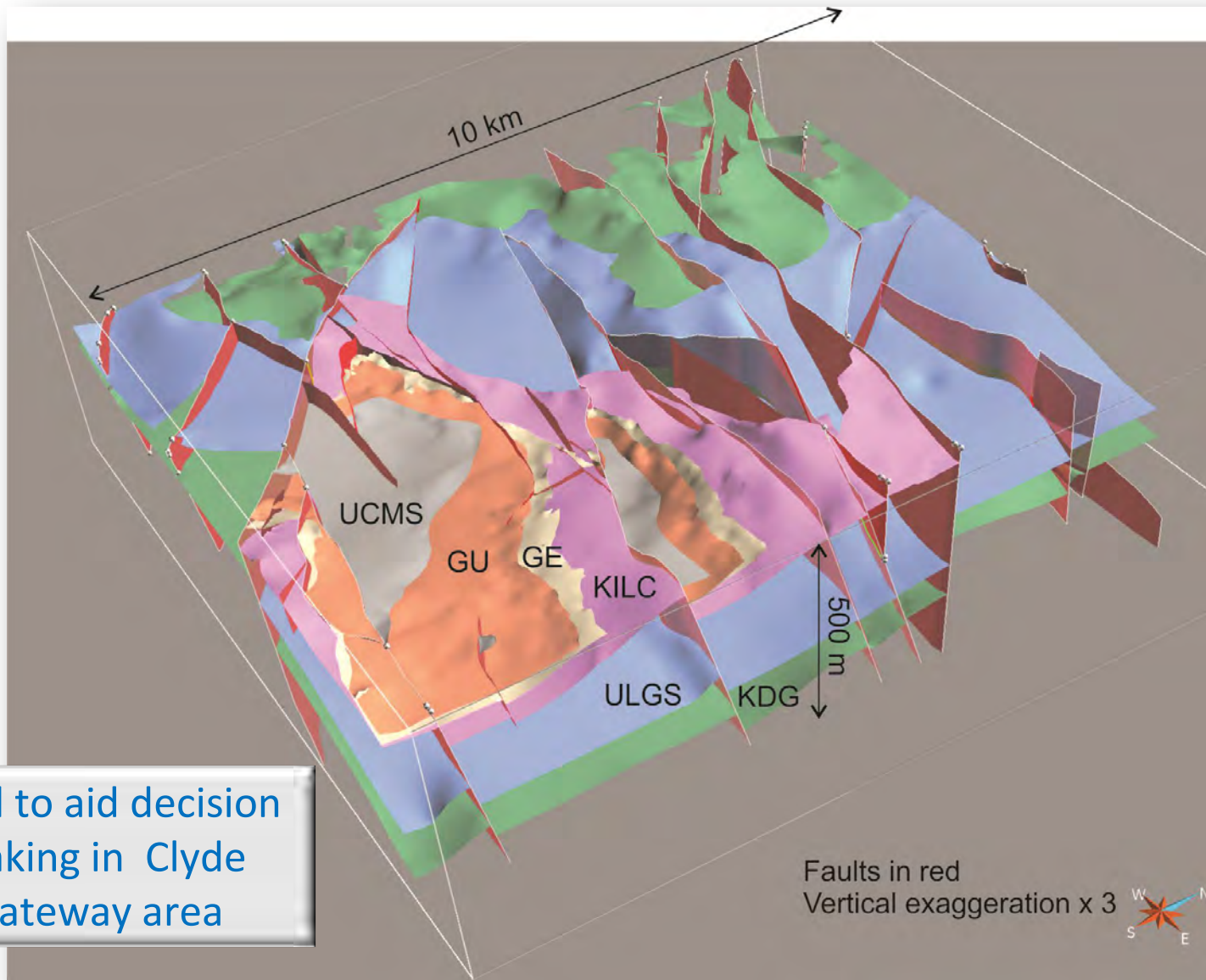


Mine plans

Hurlet Limestone

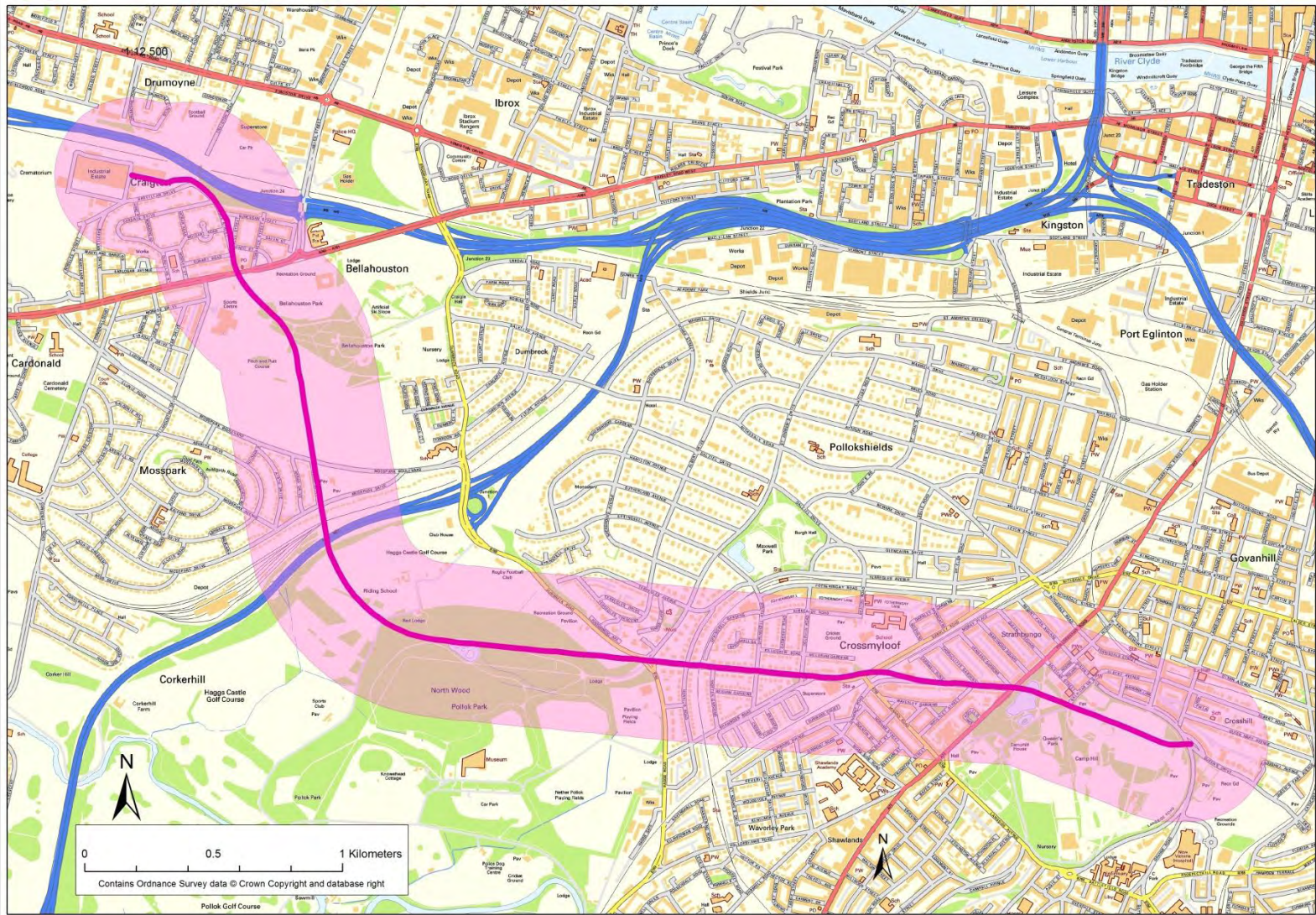


Central Glasgow bedrock model



Used to aid decision making in Clyde Gateway area

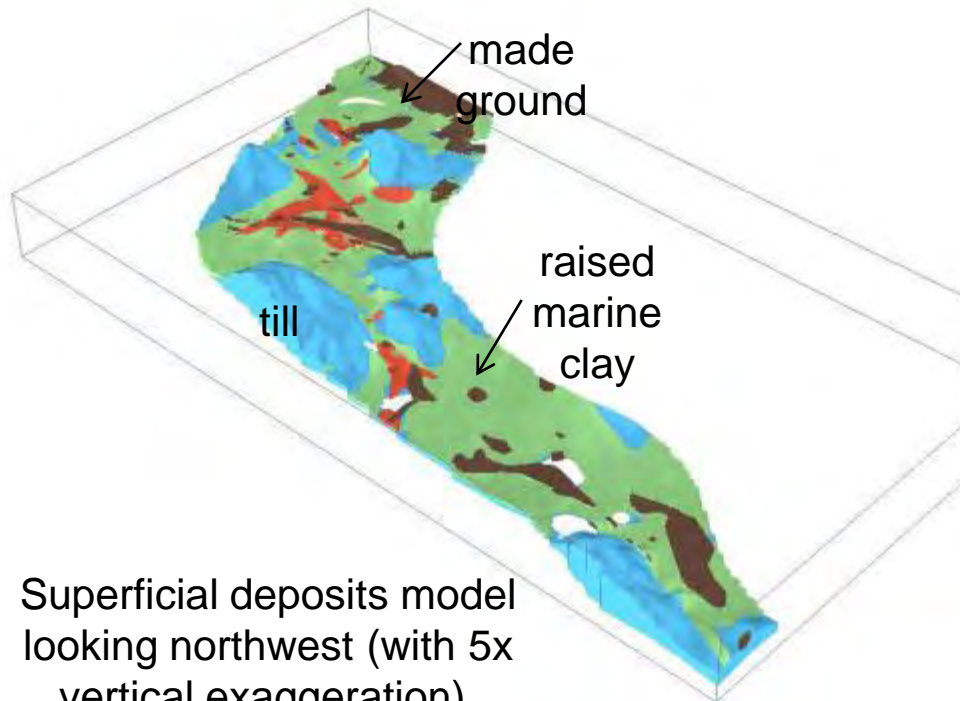




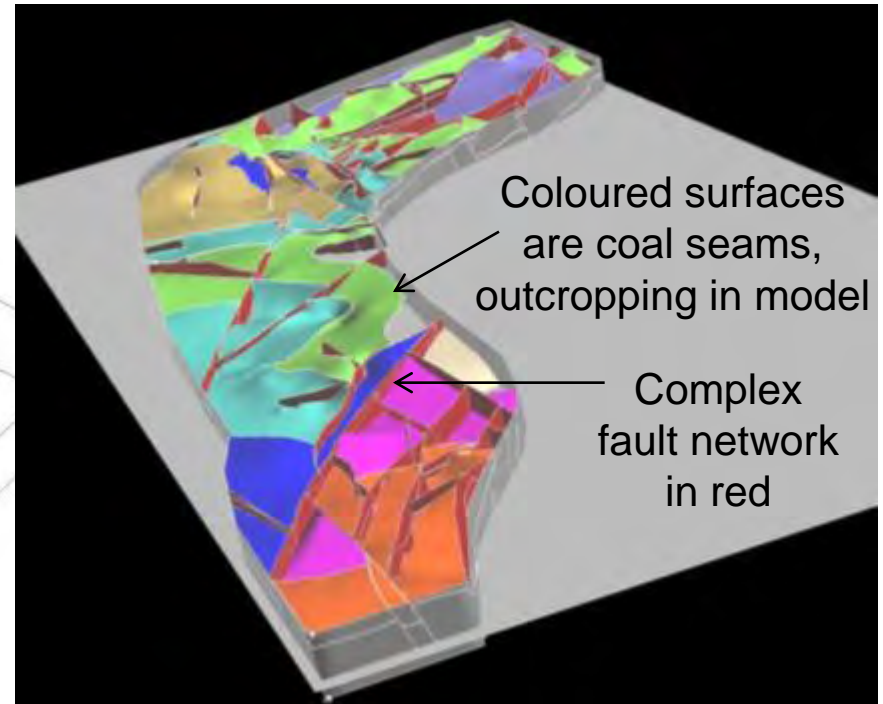
Bespoke Modelling for Linear Route Assessment



SW Glasgow – superficial and bedrock linear route model



Superficial deposits model looking northwest (with 5x vertical exaggeration).

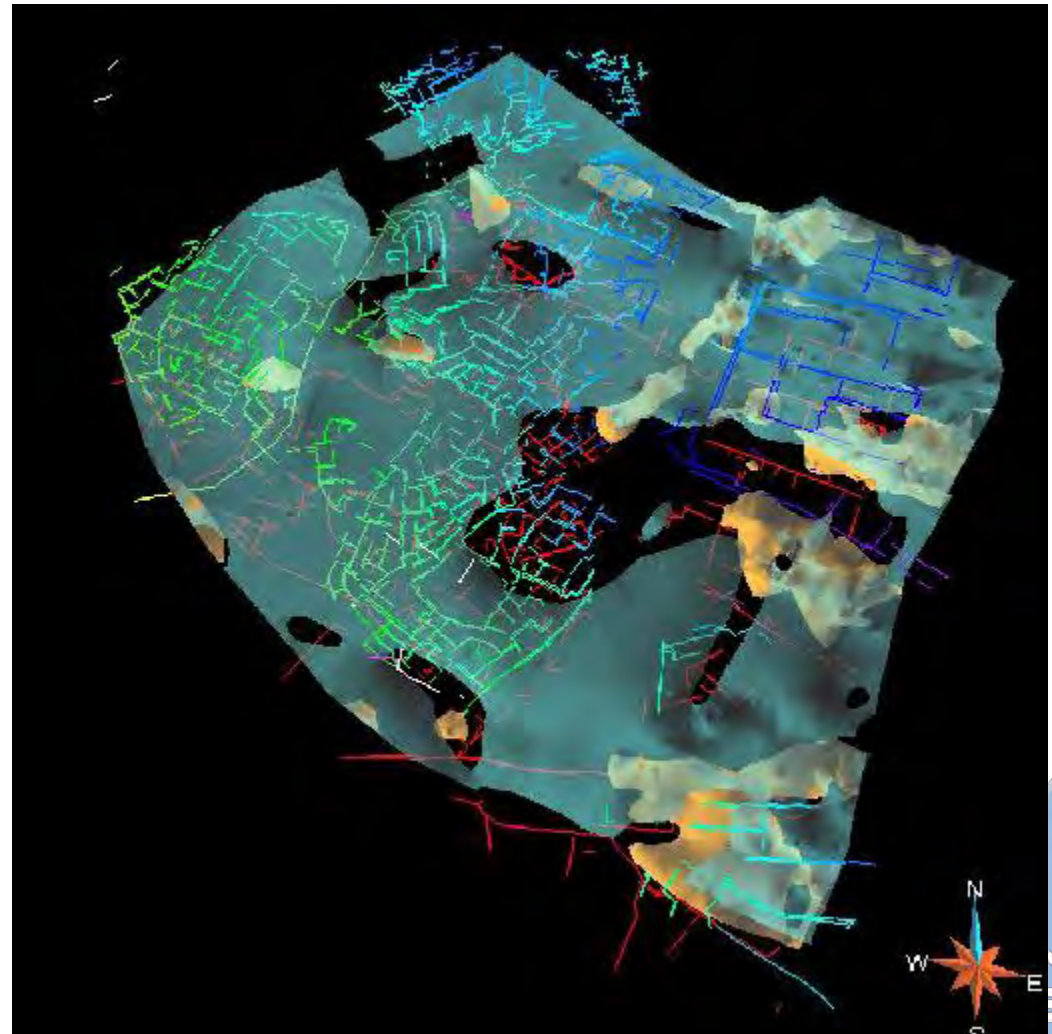


Faulted bedrock model looking northwest (with 2x vertical exaggeration).

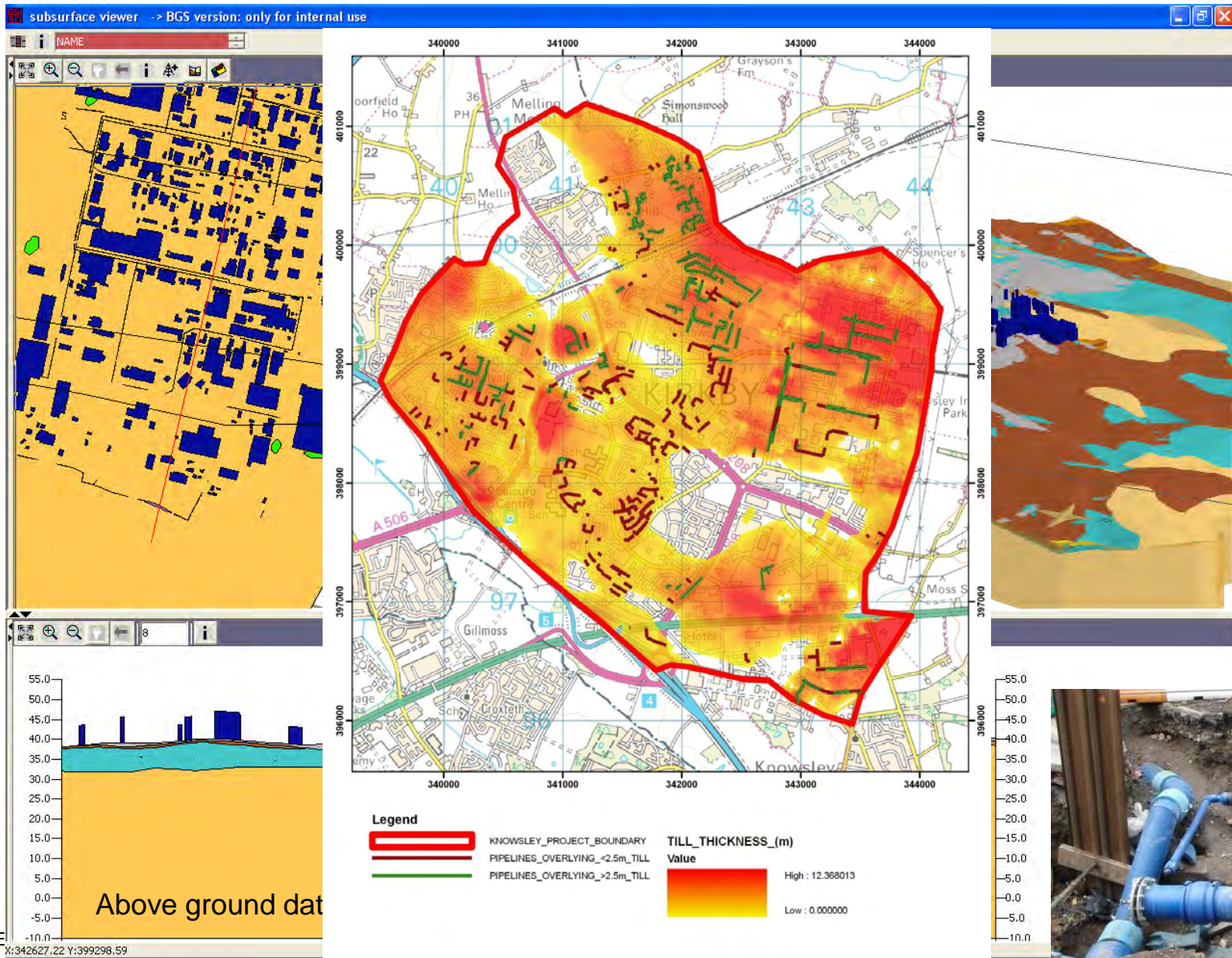
- ‘High resolution’ model used to inform a linear route assessment – complex faulting, mined strata

Buried Infrastructure

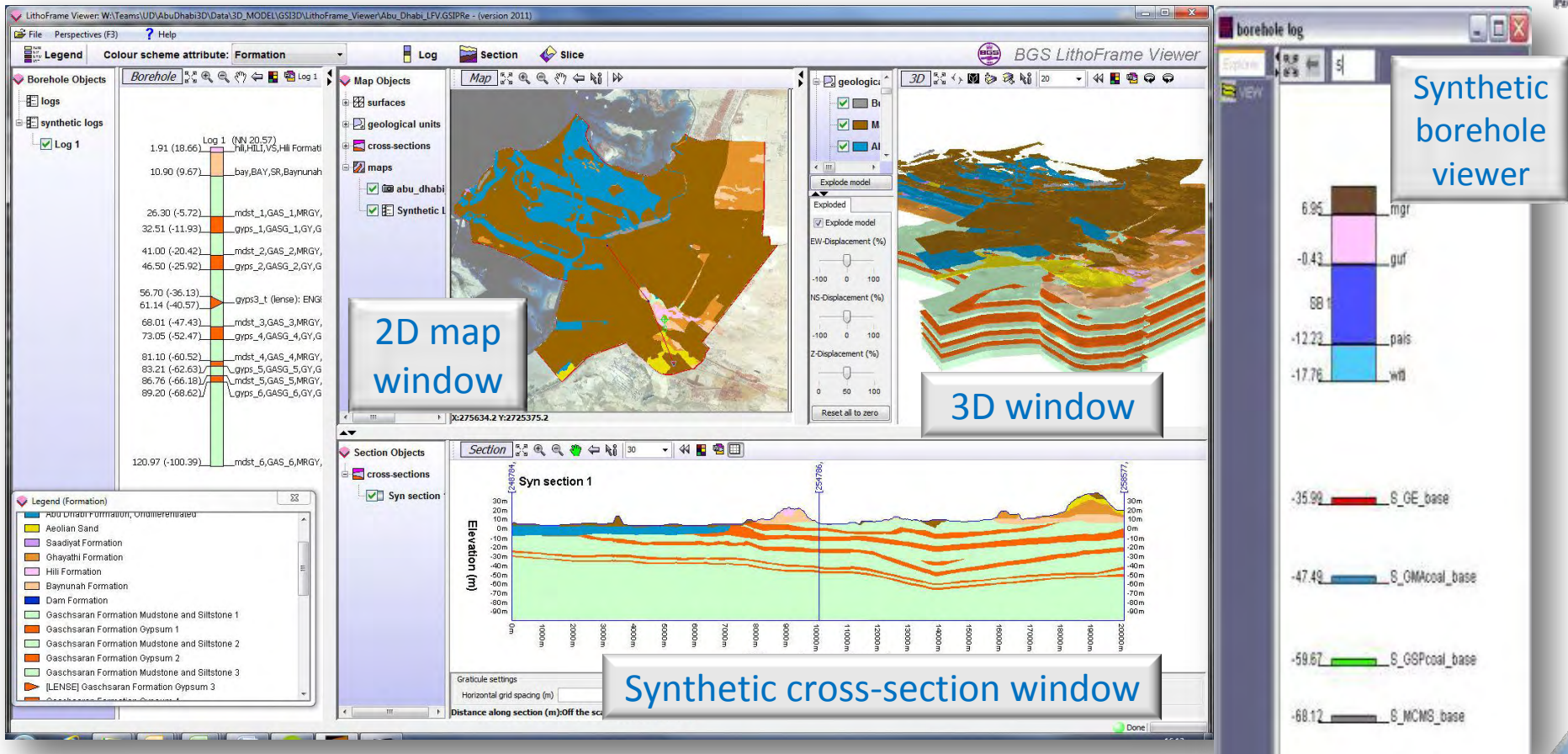
- Industrial park in North-West England
- Understand relationship between subsurface infrastructure (drain pipes) and geology
- Provide customer-focussed decision support tools
- 3D modelling to address real world problems



Urban Geology – integration of infrastructure



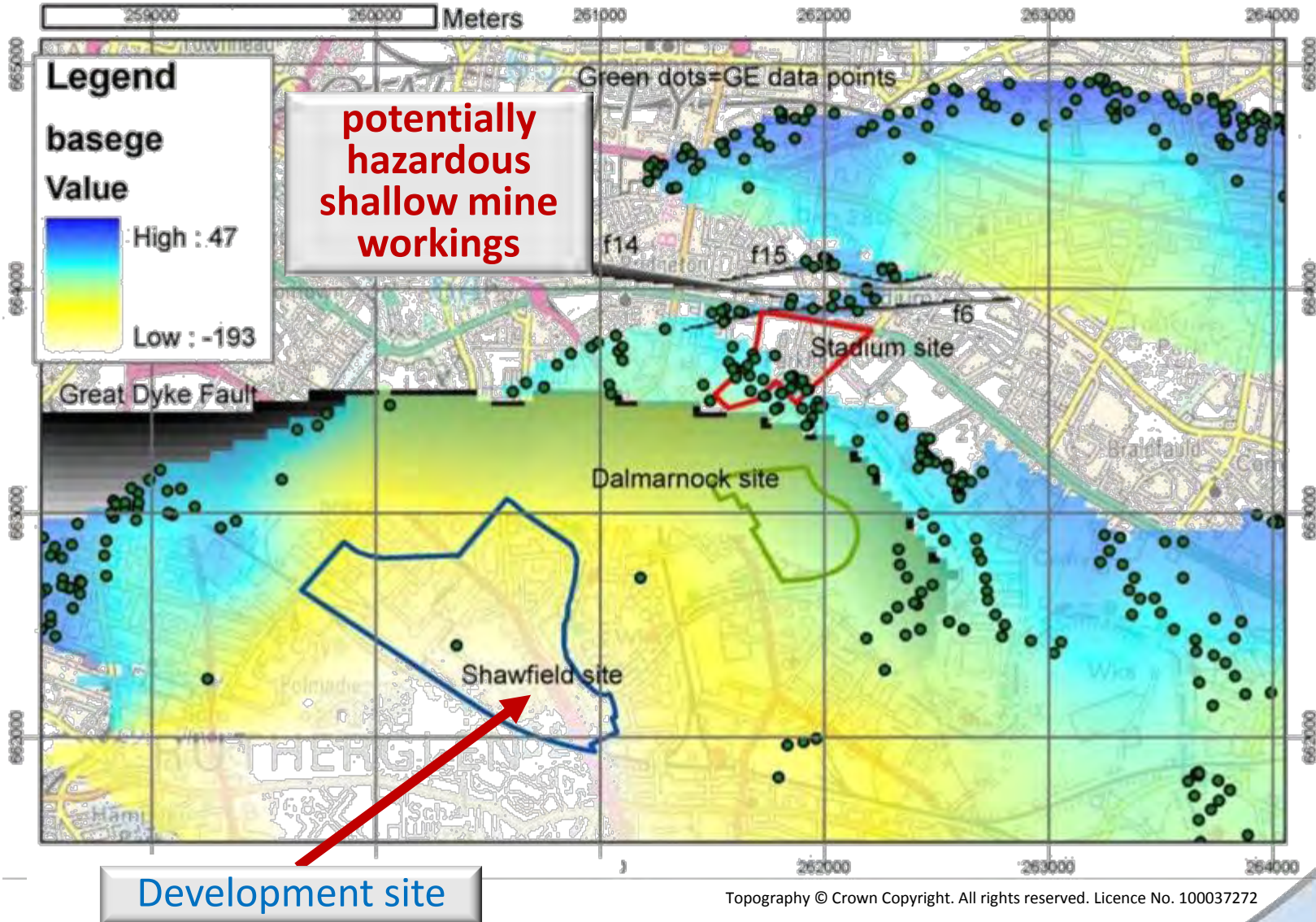
Model delivery: LithoFrame Viewer



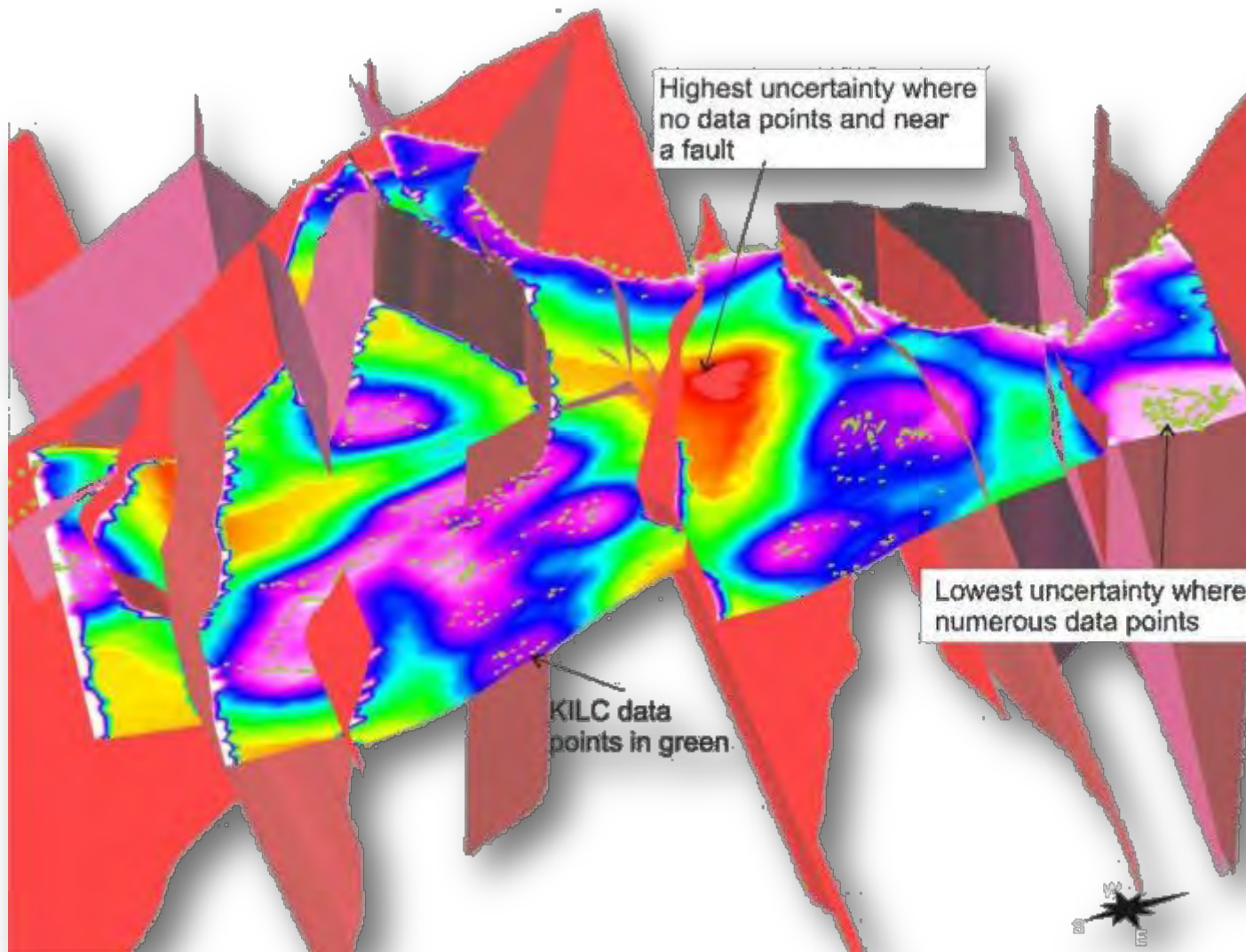
Custom output to: 3D PDF; 2D GIS; other software applications as layers or themes



Model delivery: GIS output



Model delivery: uncertainty



Calculated from data density and geological complexity

High uncertainty up to 10s m in XYZ

Low uncertainty c.<10m in XYZ



Model delivery: 3D PDF



Douglas Coalfield Geological 3D Model
(Version 1 - Dated 22nd June 2012)

Geological 3D model prepared by A Monaghan, interactive 3D PDF by C Ritchie.

This model is derived from a GOCAD® model prepared by A Monaghan based on BGS held borehole data, along with mine plan information and BGS mapping data. For further details and a more complete key see BGS report IR/12/03.

Surfaces Legend

- Topography / Aerial Photography
- Topo Aerial Photo
- Transparent
- National Grid
- Rockhead
- Transparent
- Douglas Seven Foot Coal
- Scottish Middle Coal Measure Formation
- Douglas Main Coal
- Scottish Lower Coal Measure Formation
- Upper Limestone Formation
- Big Drum Coal
- Kenno Nine Foot Coal
- Limestone Coal Formation
- Lower Limestone Formation

Major Faulting

Transparent

Individual Fault Control

Only the significant faults observed are shown; additional faults and fractures are known to be present.

Free Rotate OFF

Preset Views

-
-
-
-
- View looking north with cross section SW to NE and foreground removed

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

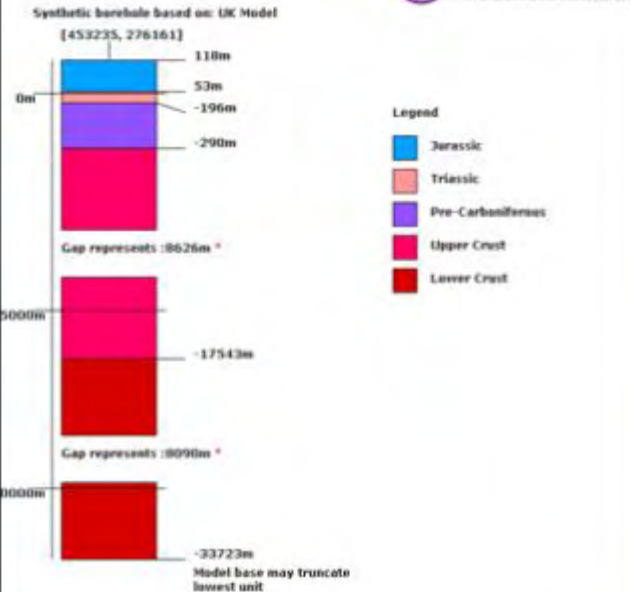
This product includes mapping data licensed from Ordnance Survey. © Crown copyright and database right 2012. All rights reserved.
BGMMap™ British Geological Survey / Intermap Technologies
Aerial photography © UK Perspective/DeLorme Licence No. UKP200501

Geological Model © NERC 2012. All rights reserved



GeologyViewer3





Lithology at ground surface: MUDSTONE, SILTSTONE, LIMESTONE AND SANDSTONE
Lithostratigraphy at ground surface: LIAS GROUP

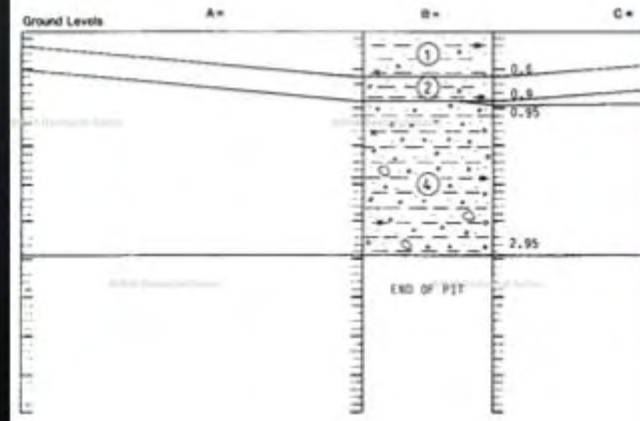
This virtual borehole log does not represent the complete geological view
It should not be used for any site specific purposes.

* Layer slicing is done where thickness is greater than 3000m

Close

TRIAL PIT RECORD

Project	PROPOSED WAREHOUSE EXTENSION	Client	MEDICAL MAILING COMPANY
Location	SCHMERS ROAD, RUGBY	Engineer	TAPSELL WADE
Location Plan			
	Bearing	Date	13.10.87
		Plant	CASE 5806
		Shoring	None
		Stability	Stable during
		Water	No seepages

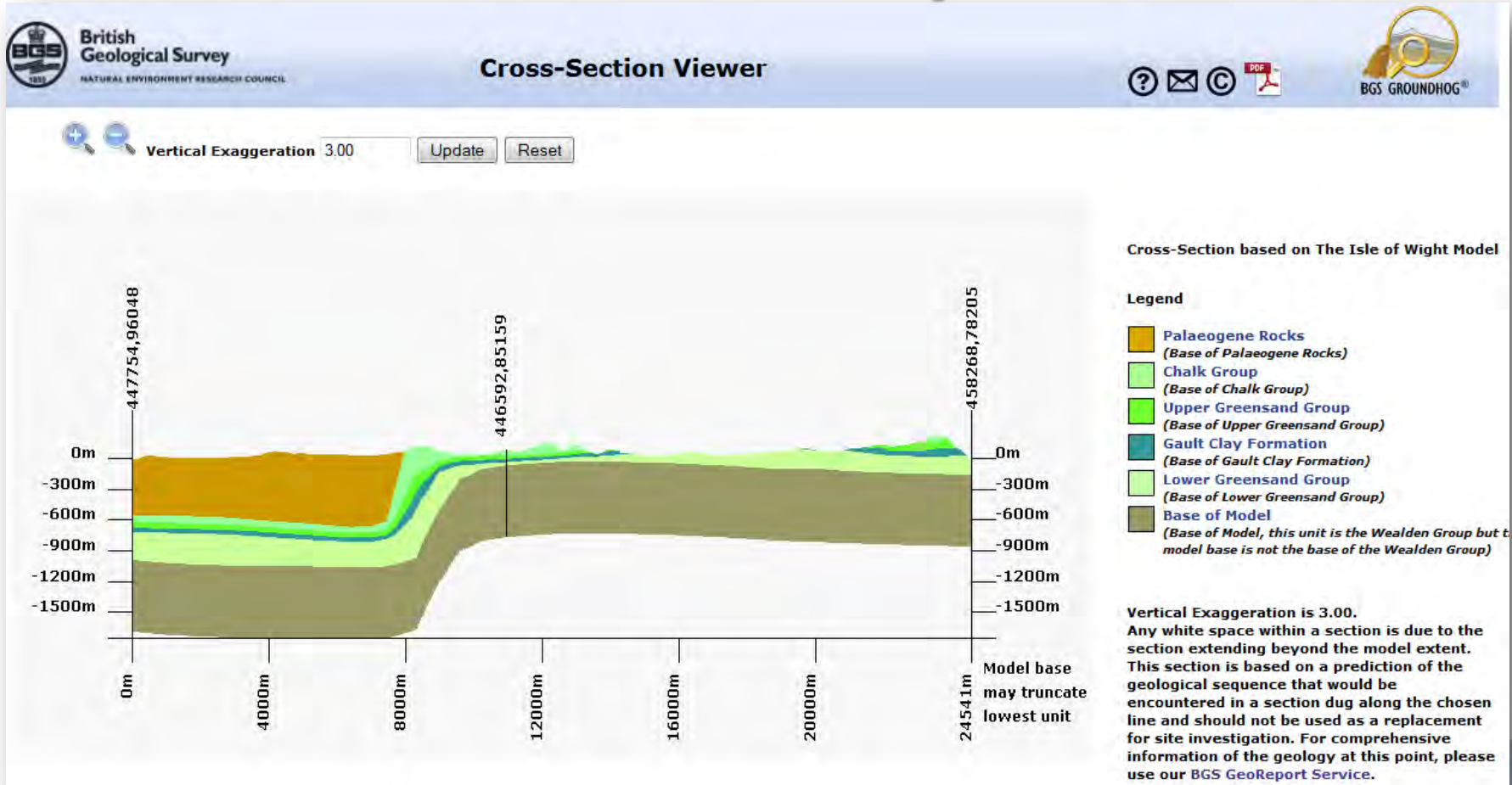


Samples and Tests			Strata	
Depth	Type	Strength	Reference	Description
0.50	HP	220	1	Fine to stiff extremely close
0.60	HP	230		sandy silt CLAY, some fine to
0.70	HP	200		softened at top. WILSTON CLAY.

Close



Groundhog Web/Mobile tools for virtual cross-sections/boreholes



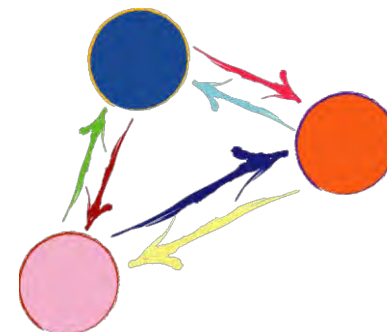
www.bgs.ac.uk/services/3Dgeology/virtualBoreholeViewer.html



Model Delivery via ASK

Accessing Subsurface Knowledge

ASK – a knowledge exchange network for public & private sectors



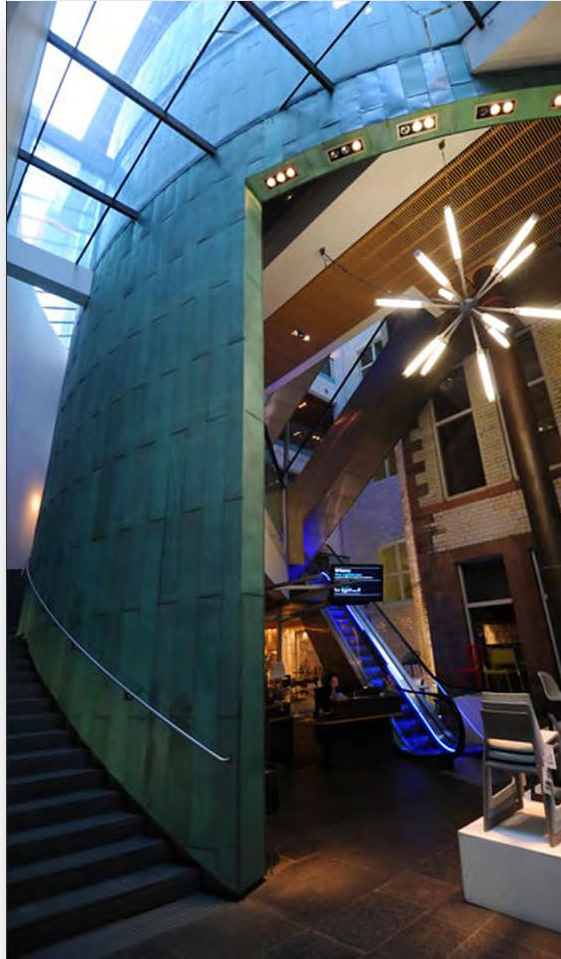
Aims

- foster free-flow of subsurface data and knowledge
- improve efficiency of ground investigation

Breaking news.....

Glasgow wins the UK TSB “future city demonstrator”
ASK Network is part of this £24 million award

ASK Network Partnership



launched at The Lighthouse,
Glasgow on 16 November 2012

Hosted by



**British
Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL



With support from



Organisations represented

AECOM

ARUP

Atkins

Atmos consulting

BAM Ritchies

Buchanan Laird Ltd Cookegan

Craighall Energy

Dougall Baillie Associates

ERM Fairhurst

Grontmij Halcrow

HydroLogic Services

Jacobs

Johnson, Poole & Bloomer

Mott MacDonald

Parsons Brinkerhoff

Scottish Coal

Scottish Power

Soilutions Ltd

URS Scott Wilson

Raeburn Drilling and Geotechnical

**Glasgow & Clyde Valley Structure
Plan Committee, incorporating:**

Glasgow City Council

Inverclyde Council

North Ayrshire Council

North Lanarkshire Council

South Lanarkshire Council

West Dunbartonshire Council

Scottish Water

Transport Scotland

Glasgow Caledonian University

Glasgow University

Newcastle University

University of Strathclyde

University of the West of Scotland

Those in bold have joined or are
in the process of joining

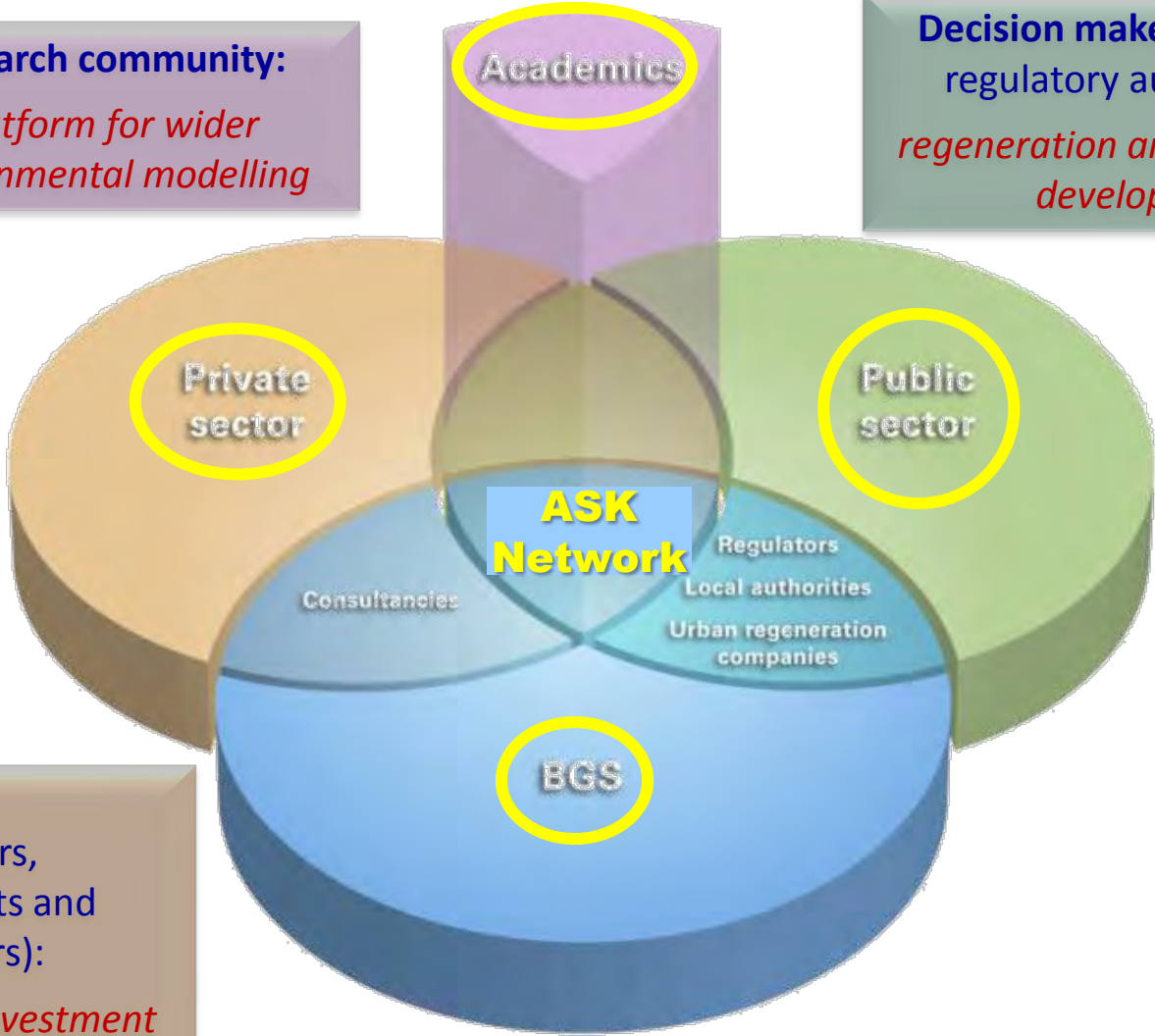


ASK Knowledge Exchange opportunity



Research community:
platform for wider environmental modelling

Decision makers (local and regulatory authorities):
regeneration and sustainable development



BGS - transforming user relationships:

- *providing archival data*
- *3D models for planning, development & decision making*
- *receive new data more efficiently from end-users*

Industry
(developers, consultants and contractors):
support investment and construction



Why we need the network?



High quality models produced by BGS but only limited use of models

Data often in unsuitable format for immediate use



Planning and engineering decisions are based on local, self contained datasets – not seen in context of 3D models or all potentially available data

Newly acquired data not routinely fed into models

Functioning well

Beginning to function

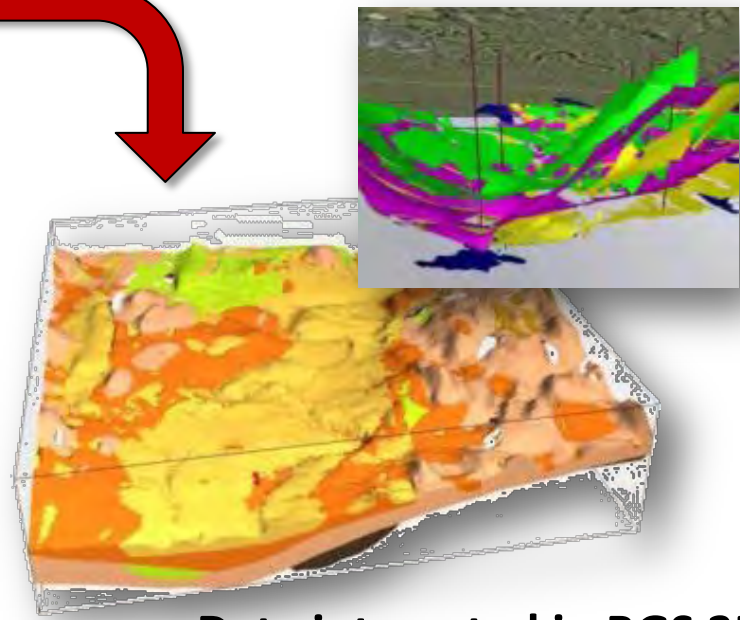
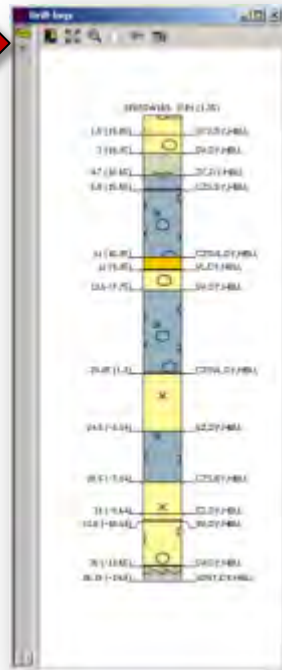
Functioning less well



The Glasgow experience.....



RECORD OF BORROWHOLE 120	
Name of Borrowhole	
Date of boring	
Name of borer	
Name of observer	
Name of contractor	
Depth	Description of soil
0.00	Surface soil
0.10	Dark brown loam with 10% sand
0.20	Dark brown loam with 10% sand
0.30	Dark brown loam with 10% sand
0.40	Dark brown loam with 10% sand
0.50	Dark brown loam with 10% sand
0.60	Dark brown loam with 10% sand
0.70	Dark brown loam with 10% sand
0.80	Dark brown loam with 10% sand
0.90	Dark brown loam with 10% sand
1.00	Dark brown loam with 10% sand
1.10	Dark brown loam with 10% sand
1.20	Dark brown loam with 10% sand
1.30	Dark brown loam with 10% sand
1.40	Dark brown loam with 10% sand
1.50	Dark brown loam with 10% sand
1.60	Dark brown loam with 10% sand
1.70	Dark brown loam with 10% sand
1.80	Dark brown loam with 10% sand
1.90	Dark brown loam with 10% sand
2.00	Dark brown loam with 10% sand
2.10	Dark brown loam with 10% sand
2.20	Dark brown loam with 10% sand
2.30	Dark brown loam with 10% sand
2.40	Dark brown loam with 10% sand
2.50	Dark brown loam with 10% sand
2.60	Dark brown loam with 10% sand
2.70	Dark brown loam with 10% sand
2.80	Dark brown loam with 10% sand
2.90	Dark brown loam with 10% sand
3.00	Dark brown loam with 10% sand
3.10	Dark brown loam with 10% sand
3.20	Dark brown loam with 10% sand
3.30	Dark brown loam with 10% sand
3.40	Dark brown loam with 10% sand
3.50	Dark brown loam with 10% sand
3.60	Dark brown loam with 10% sand
3.70	Dark brown loam with 10% sand
3.80	Dark brown loam with 10% sand
3.90	Dark brown loam with 10% sand
4.00	Dark brown loam with 10% sand
4.10	Dark brown loam with 10% sand
4.20	Dark brown loam with 10% sand
4.30	Dark brown loam with 10% sand
4.40	Dark brown loam with 10% sand
4.50	Dark brown loam with 10% sand
4.60	Dark brown loam with 10% sand
4.70	Dark brown loam with 10% sand
4.80	Dark brown loam with 10% sand
4.90	Dark brown loam with 10% sand
5.00	Dark brown loam with 10% sand
5.10	Dark brown loam with 10% sand
5.20	Dark brown loam with 10% sand
5.30	Dark brown loam with 10% sand
5.40	Dark brown loam with 10% sand
5.50	Dark brown loam with 10% sand
5.60	Dark brown loam with 10% sand
5.70	Dark brown loam with 10% sand
5.80	Dark brown loam with 10% sand
5.90	Dark brown loam with 10% sand
6.00	Dark brown loam with 10% sand
6.10	Dark brown loam with 10% sand
6.20	Dark brown loam with 10% sand
6.30	Dark brown loam with 10% sand
6.40	Dark brown loam with 10% sand
6.50	Dark brown loam with 10% sand
6.60	Dark brown loam with 10% sand
6.70	Dark brown loam with 10% sand
6.80	Dark brown loam with 10% sand
6.90	Dark brown loam with 10% sand
7.00	Dark brown loam with 10% sand
7.10	Dark brown loam with 10% sand
7.20	Dark brown loam with 10% sand
7.30	Dark brown loam with 10% sand
7.40	Dark brown loam with 10% sand
7.50	Dark brown loam with 10% sand
7.60	Dark brown loam with 10% sand
7.70	Dark brown loam with 10% sand
7.80	Dark brown loam with 10% sand
7.90	Dark brown loam with 10% sand
8.00	Dark brown loam with 10% sand
8.10	Dark brown loam with 10% sand
8.20	Dark brown loam with 10% sand
8.30	Dark brown loam with 10% sand
8.40	Dark brown loam with 10% sand
8.50	Dark brown loam with 10% sand
8.60	Dark brown loam with 10% sand
8.70	Dark brown loam with 10% sand
8.80	Dark brown loam with 10% sand
8.90	Dark brown loam with 10% sand
9.00	Dark brown loam with 10% sand
9.10	Dark brown loam with 10% sand
9.20	Dark brown loam with 10% sand
9.30	Dark brown loam with 10% sand
9.40	Dark brown loam with 10% sand
9.50	Dark brown loam with 10% sand
9.60	Dark brown loam with 10% sand
9.70	Dark brown loam with 10% sand
9.80	Dark brown loam with 10% sand
9.90	Dark brown loam with 10% sand
10.00	Dark brown loam with 10% sand



BGS recoding of logs – very resource intensive

Data integrated in BGS 3D models for GCC & others – maximise benefit of past investment, but resource intensive to produce and update

Site investigation
Data
Poor accessibility

Consultants
contractors

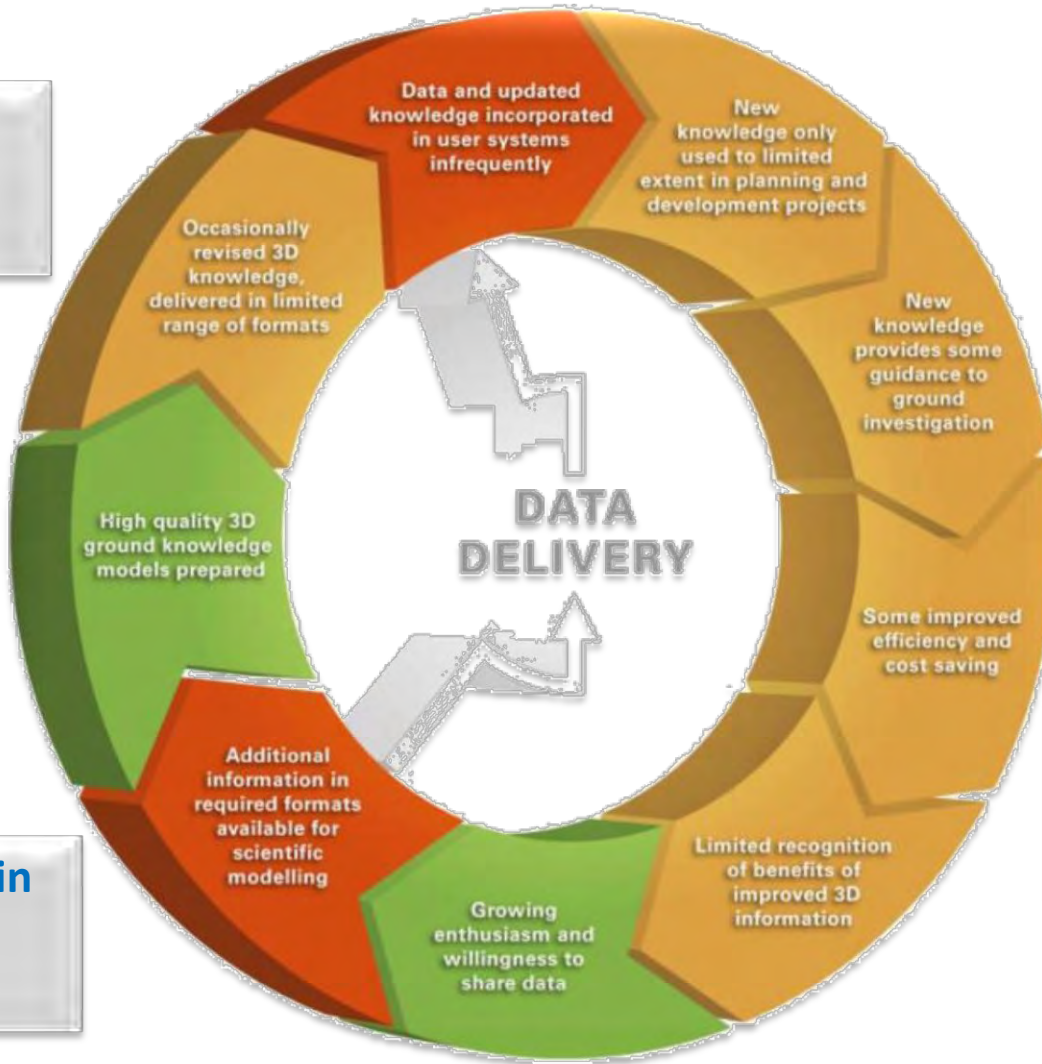


Current Glasgow situation



Limited revision of models

GCC and others use knowledge contained in 3D models



Data still in multiple formats

Greater willingness to share data

Functioning well

Function improving

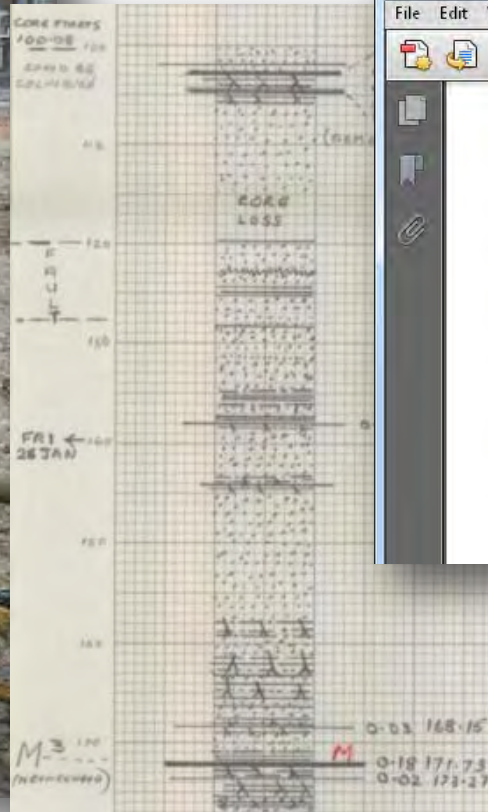
Beginning to function



Wealth of subsurface data unaccessed

Large amount of high quality ground investigation data only used once

Key access issues:
data reporting and storage



Area 1 - Groundwater Results.pdf - Adobe Reader

File Edit View Window Help

1 / 1 75%

Area 1 - Groundwater Results

Sample Identity	NH4/OP	NH4/OP Analyte (g)	CP01	CP01	CP01	CP01
			09 07 08	06 10 08	27 01 08	05 02 08
Arsenic (Soluble)	ug/l	10	1.2	1	1	1
Boron (Soluble)	ug/l	1000	170	130	71	120
Boron (Soluble)	ug/l	1000	170	170	170	180
Cadmium (Soluble)	ug/l	5	0.5	0.11	0.18	0.1
Calcium (Soluble)	mg/l	-	270	180	330	240
Chromium (Soluble)	ug/l	20	2	30	1	1
Copper (Soluble)	ug/l	26	8	7	1	1
Lead (Soluble)	ug/l	10	1	0.5	0.9	2.3
Mercury (Soluble)	ug/l	1	-	-	0.3	0.3
Nickel (Soluble)	ug/l	50	20	5.3	9.9	5.9
Selenium (Soluble)	ug/l	10	1.8	1.4	7.6	1.8
Sulphur (Total Ch. Water)	mg/l	0.01	50	11	24	38
Vanadium (Soluble)	ug/l	20	10	2.1	6.1	1
Zinc (Soluble)	ug/l	75	12	18	6	9
Chromium (Hexavalent)	ug/l	20	40	10	10	10
Cyanide (Free)	mg/l	0.05	0.05	0.05	0.05	0.05
Cyanide (Total)	mg/l	0.05	0.05	0.05	0.05	0.05
Sulphate as SO4	mg/l	250	150	130	35	120
Thiocyanate as CN	mg/l	0.05	0.05	0.05	0.05	0.05
Ammonia as N	mg/l	15	0.23	1	NDS	1
Sulphide as S	mg/l	0.0005	0.01	0.09	0.01	0.01
pH	pH units	-	7.1	8.4	8.3	8.7
PCB #28	ug/l	0.1	NDS	NDS	NDS	0.1
PCB #52	ug/l	0.1	NDS	NDS	NDS	0.1
PCB #701	ug/l	0.1	NDS	NDS	NDS	0.1
PCB #118	ug/l	0.1	NDS	NDS	NDS	0.1
PCB #153	ug/l	0.1	NDS	NDS	NDS	0.1
PCB #139	ug/l	0.1	NDS	NDS	NDS	0.1
PCB #180	ug/l	0.1	NDS	NDS	NDS	0.1
Total Phenol	ug/l	0.5	0.5	0.5	0.5	0.5
MTBE (Method-Only-Exec)	ug/l	10	NDS	10	10	10



GSPEC: Glasgow SPECification for data Capture



Stems from GCC led project funded by Local Authorities Research Councils Initiative (LARCI)



Developed by BGS in partnership with GCC to address shared needs



Data deposited as raw digital data in standardised AGS forms (not PDFs)

Key metadata (e.g. grid reference, borehole ID, borehole construction) reported with all associated data

Full compliance and completeness of AGS format files



GSPEC: facilitating improved knowledge exchange

GCC now require all ground investigation data to comply with GSPEC protocols

Data submitted to BGS for validation, confirmed to GCC if standards met

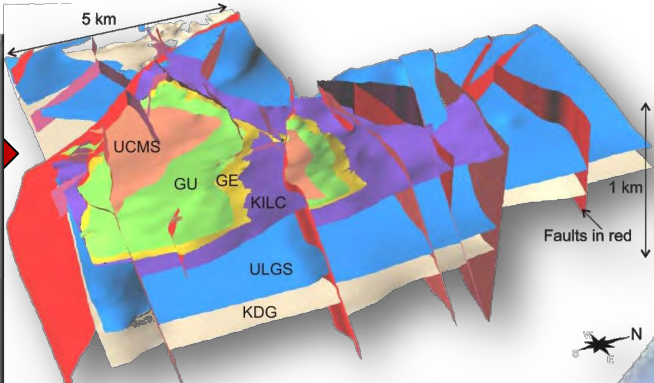
**Web portal for submission and validation under development
SG e-Planning portal involved**

Other parties can submit GI data to BGS on a voluntary basis



Data accessible for long term re-use, and efficiently transferred between:

- Consultants**
- contractors**
- GCC**
- BGS**



Future Glasgow – a Virtuous Circle based on **ASK**



ASK Network: how members join


Sign an Innovation Agreement

Allows BGS to supply 3D geological models and other information to Network members free of charge

In return BGS would like:

- feedback from members on how models are used,
- what could be improved, and
- willingness to help establish a *“virtuous circle of data and knowledge exchange”*
- *GSPEC use encouraged, but not compulsory*



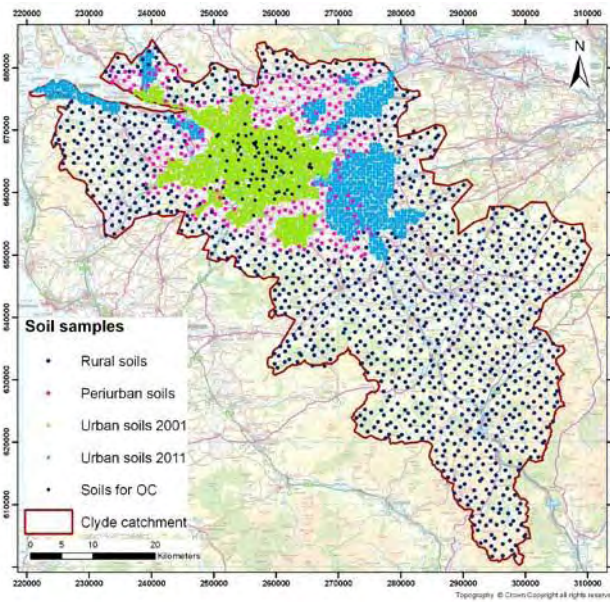
The background of the slide is a detailed 3D architectural model of a city. The buildings are rendered in a light blue-grey color, and the streets and infrastructure are visible. The model is viewed from an elevated perspective, showing the layout of the city blocks and the surrounding environment.

**Our ultimate objective
fully integrated surface-
subsurface environmental
models interoperable
in BIM systems**

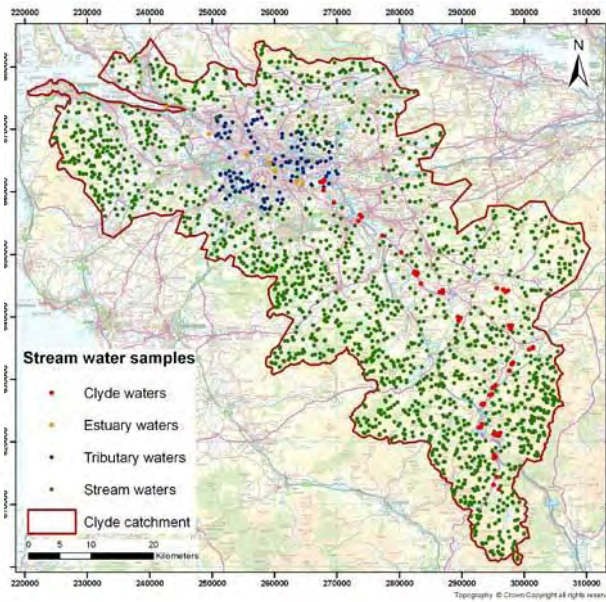




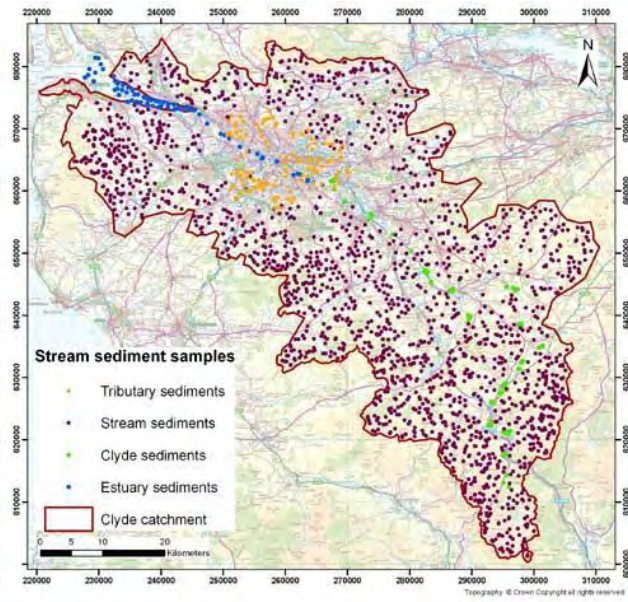
Clyde Geochemistry



Soil



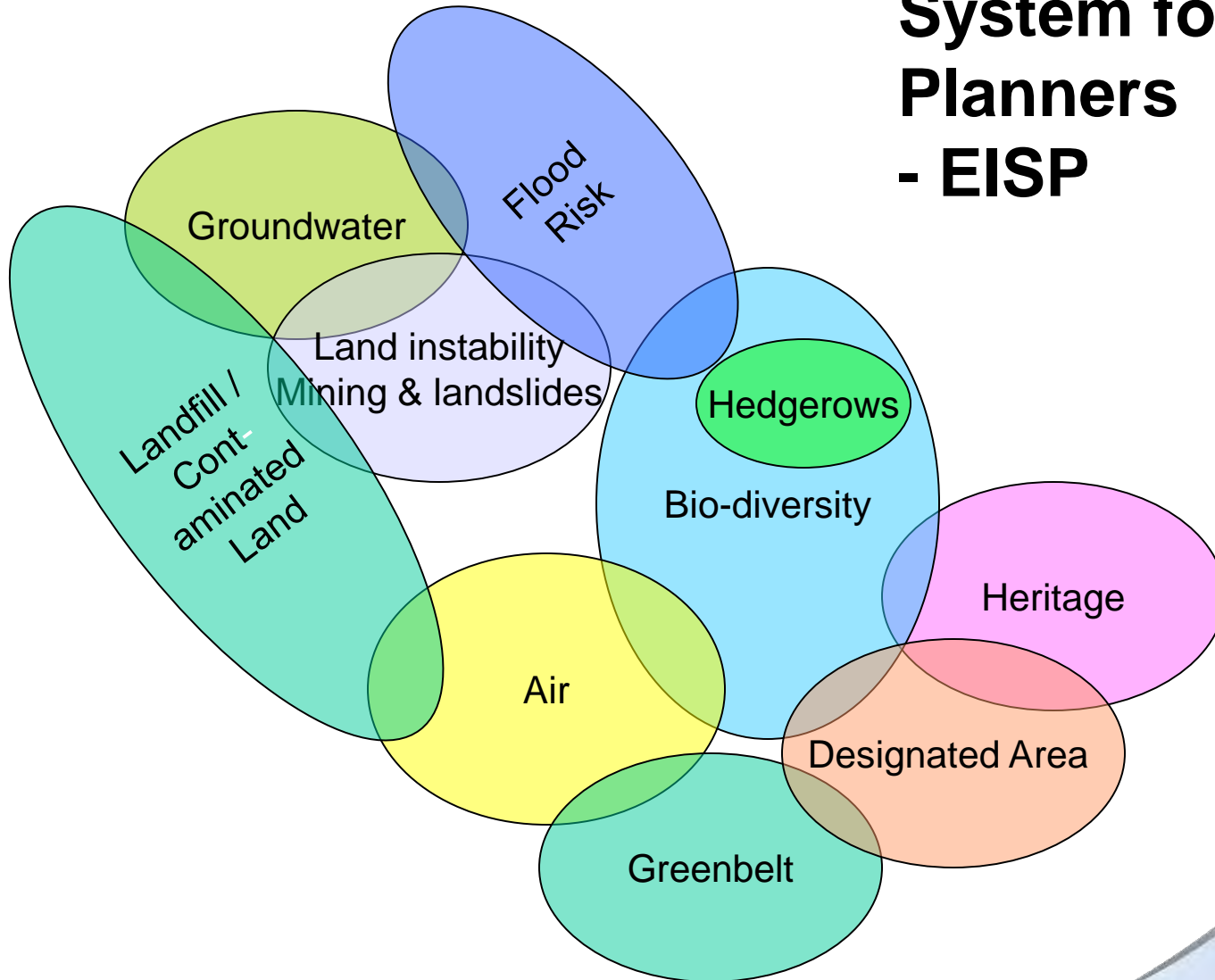
Stream Water



Stream Sediment

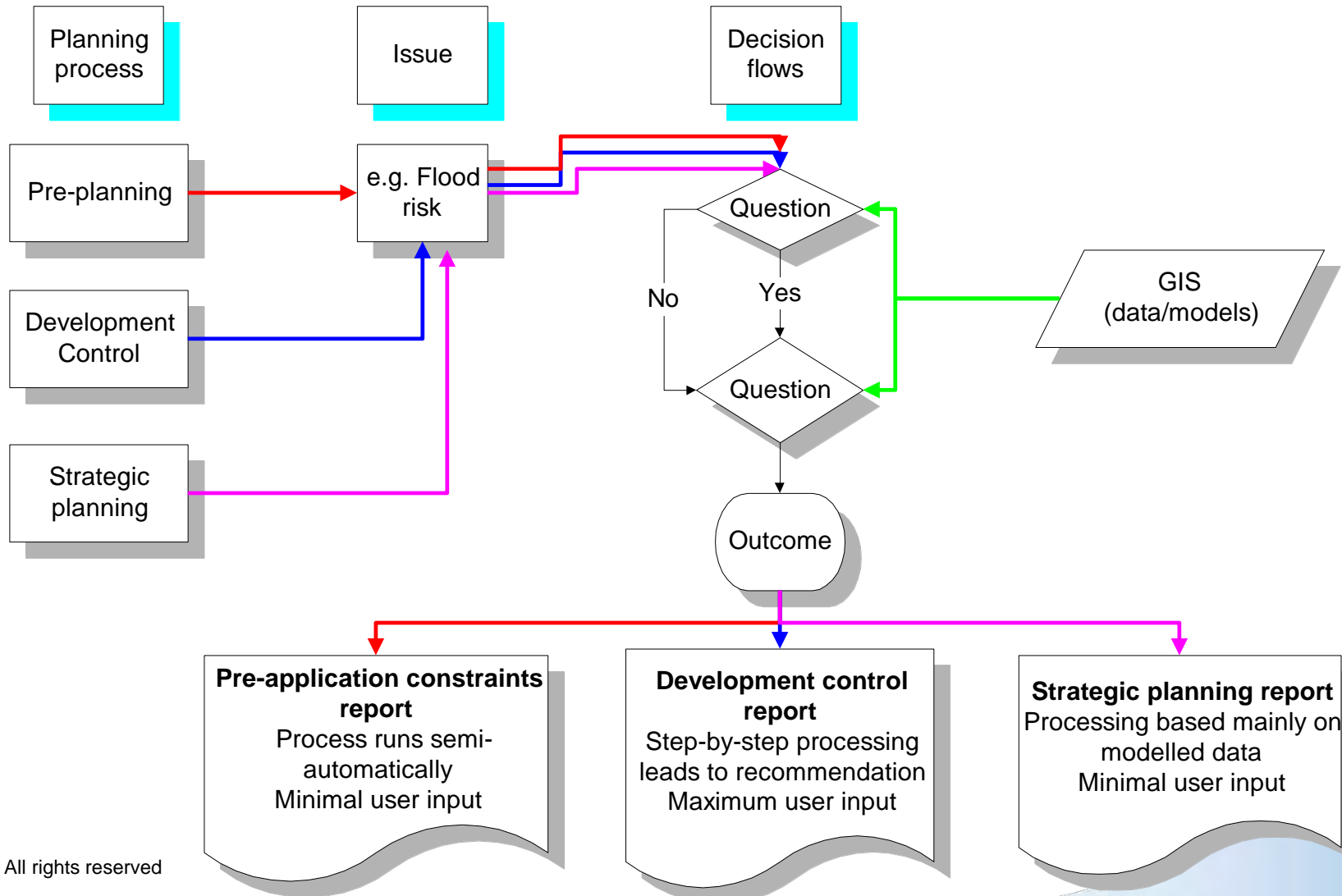
Which environmental issues?

Environmental Information System for Planners - EISP



EISP

Design overview: the system



EISP

Application determination



Defining conditions

[Show Guidance Notes](#)

Shallow undermining has been identified as a constraint.

Shallow undermining has been identified as a constraint. Please refer to the linked condition.

[Show Conditions](#)

Defining Conditions - Shallow undermining

No. Additional measures against shallow undermining are not necessary.

Any relevant mining reports and ground stability reports should be passed to a geotechnical engineer for their consideration.

Is there adequate information to assess mining issues identified in geotechnical brief?

Yes - 1. Advise negligible risk of subsidence. Proceed without special precautions.

Application Result

Following the guidance, procedures and local authority practices represented here, EISP determines that in the absence of all other factors to be taken into consideration, normal practice would be to:

1. Grant Permission

Grant Permission.

Model integration

