



# The Use of 3D models to manage the groundwater resources of the Lower Greensand Group aquifer, Hertfordshire and North London, England

Catherine Cripps

Sedimentary Geologist and Geological 3D framework modeler

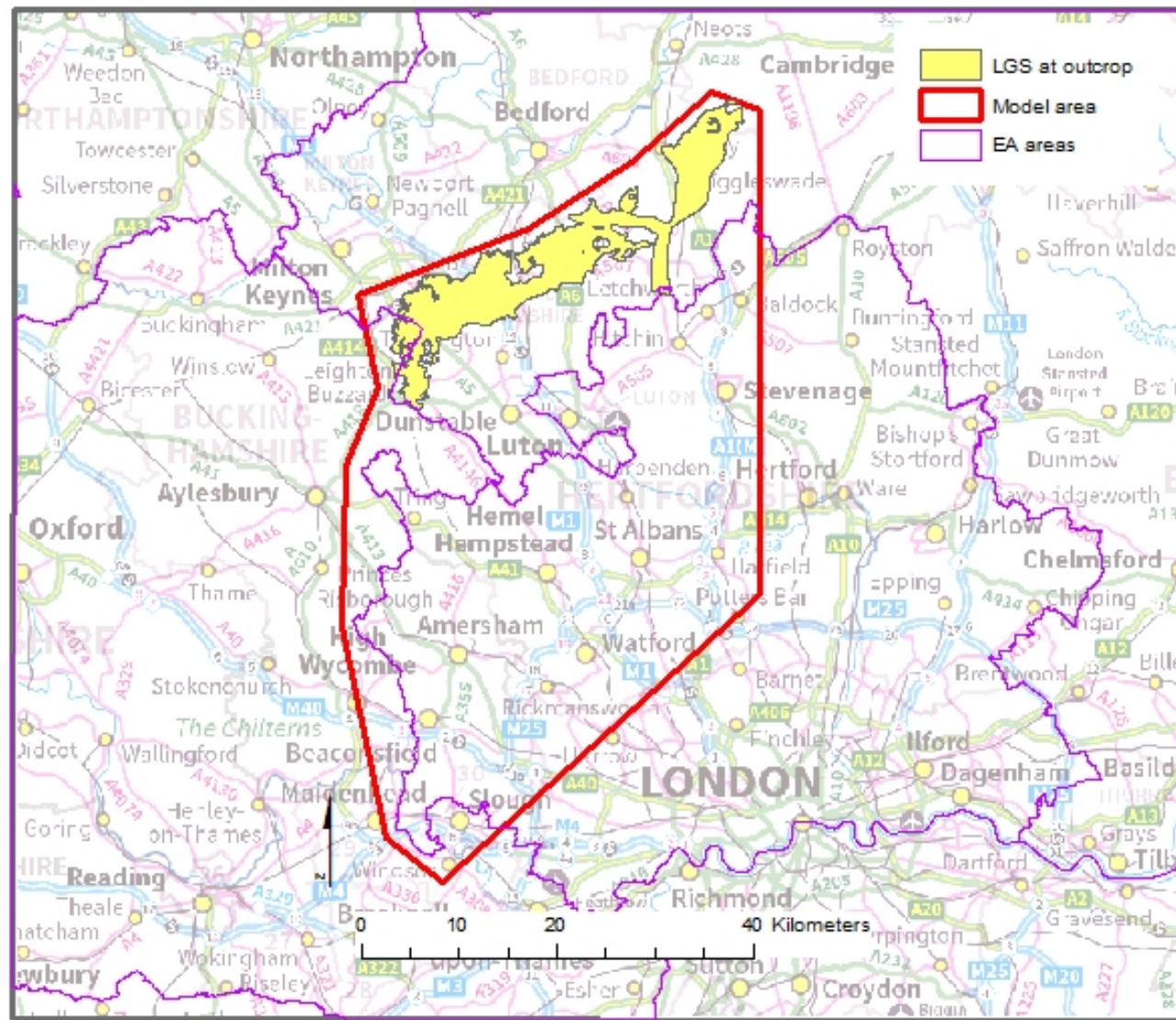
British Geological Survey

caip@bgs.ac.uk

Also: Melinda Lewis, Calum Ritchie, Marieta Garcia-Bajo

British Geological Survey



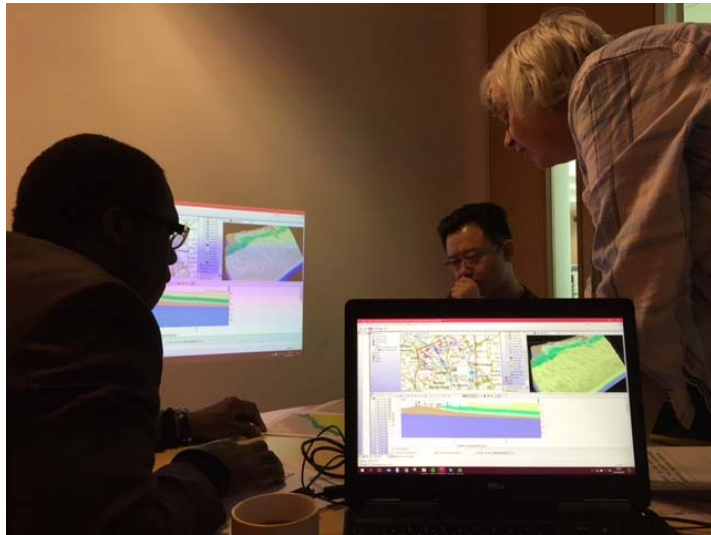




Dr Michael Kehinde FGS, CGeol • 2nd

Founder/Executive Director, Helpers of Destiny (influencing minds...transforming lives)

Environment Agency - Hertfordshire & North London Area • Christ The Redeemer College L...  
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# Our supply area

We are a water only supply company, however [click here](#) to find out services.



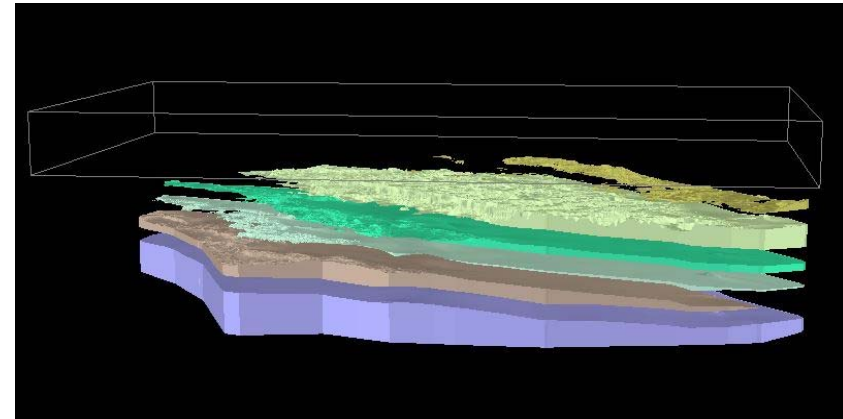
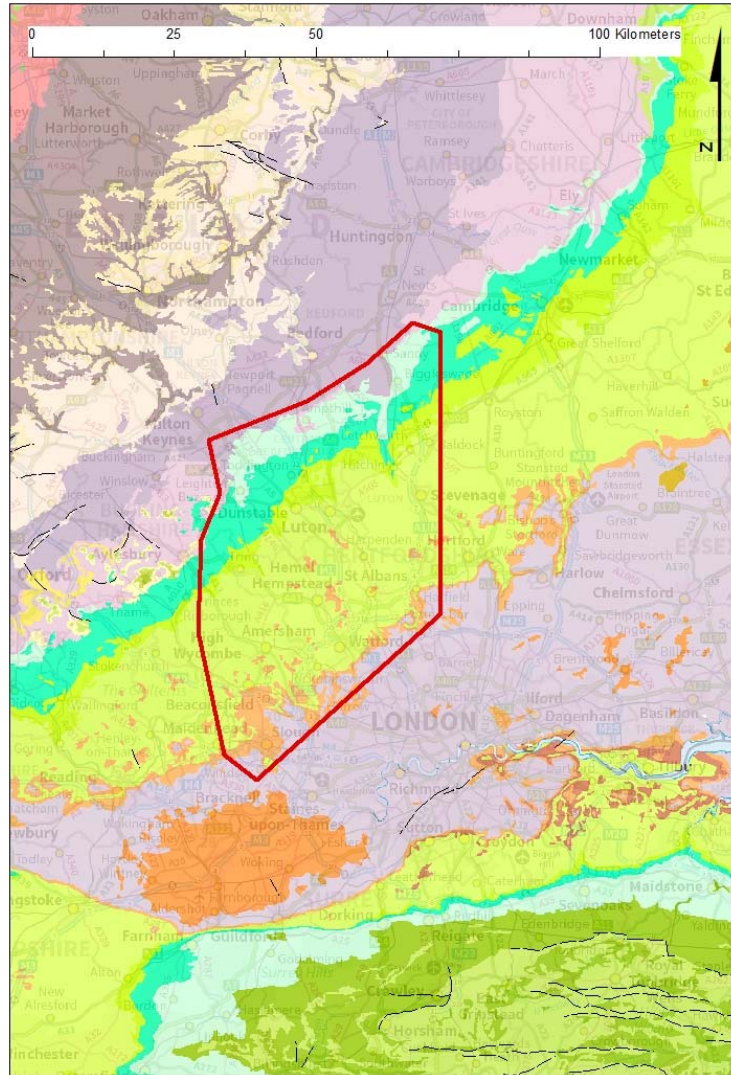

Water resources

Water levels are currently **BELOW AVERAGE.**

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# Lower Greensand Group



 LGS\_model\_area

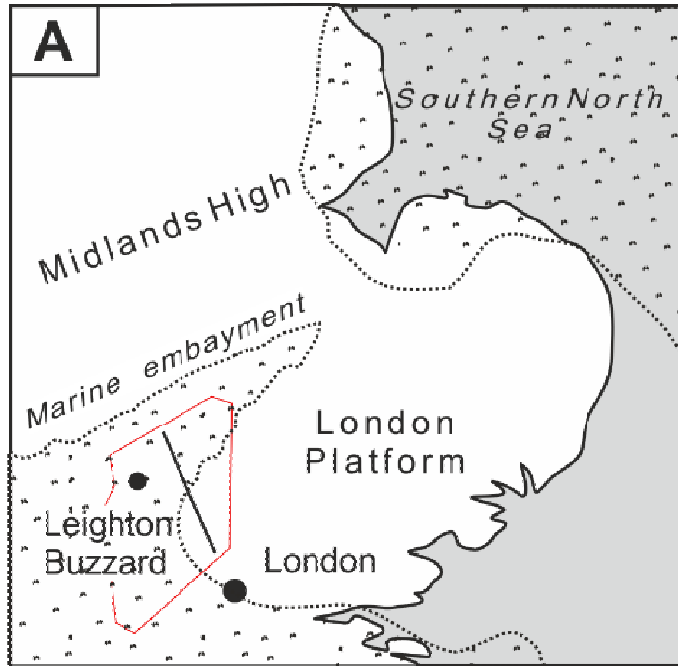
**625k\_V5\_BEDROCK\_Geology\_Polygons**

**LEX\_RCS\_I**

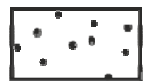
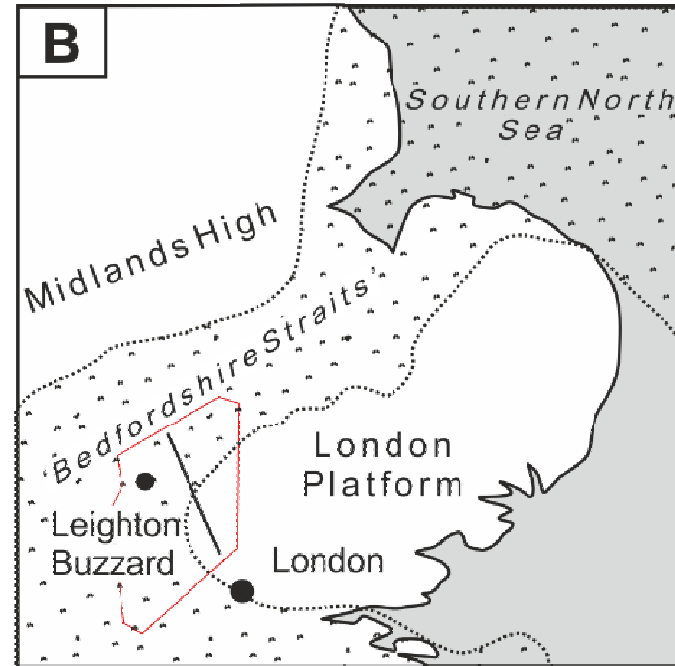
-  BRACKLESHAM GROUP AND BARTON GROUP (UNDIFFERENTIATED) - SAND, SILT AND CLAY
-  THAMES GROUP - CLAY, SILT, SAND AND GRAVEL
-  THANET SAND FORMATION - SAND, SILT AND CLAY
-  LAMBETH GROUP - CLAY, SILT, SAND AND GRAVEL
-  GREY CHALK SUBGROUP - CHALK
-  WHITE CHALK SUBGROUP - CHALK
-  GAULT FORMATION AND UPPER GREENSAND FORMATION (UNDIFFERENTIATED) - MUDSTONE, SANDSTONE AND LIMESTONE
-  LOWER GREENSAND GROUP - SANDSTONE AND MUDSTONE
-  WEALDEN GROUP - MUDSTONE, SILTSTONE AND SANDSTONE
-  WEALDEN GROUP - SANDSTONE AND SILTSTONE, INTERBEDDED
-  PURBECK LIMESTONE GROUP - LIMESTONE AND MUDSTONE, INTERBEDDED
-  PORTLAND GROUP - LIMESTONE AND CALCAREOUS SANDSTONE
-  CORALLIAN GROUP - LIMESTONE, SANDSTONE, SILTSTONE AND MUDSTONE
-  WEST WALTON FORMATION, AMPTHILL CLAY FORMATION AND KIMMERIDGE CLAY FORMATION (UNDIFFERENTIATED) - MU
-  KELLAWAYS FORMATION AND OXFORD CLAY FORMATION (UNDIFFERENTIATED) - MUDSTONE, SILTSTONE AND SANDSTONE
-  GREAT OOLITE GROUP - SANDSTONE, LIMESTONE AND ARGILLACEOUS ROCKS
-  INFERIOR OOLITE GROUP - LIMESTONE, SANDSTONE, SILTSTONE AND MUDSTONE
-  LIAS GROUP - MUDSTONE, SILTSTONE, LIMESTONE AND SANDSTONE



### Late Aptian - Early Albian



### Late Albian



Extent of shallow marine environment

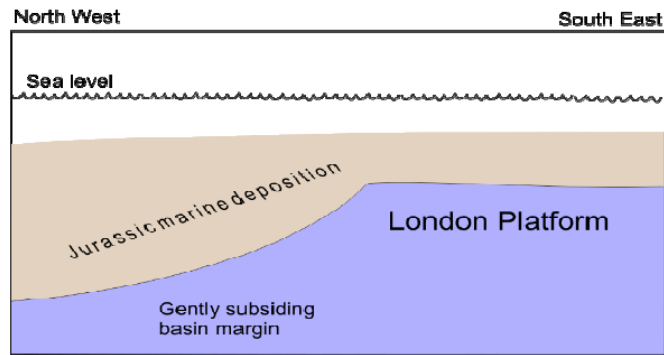


Approximate location of model area

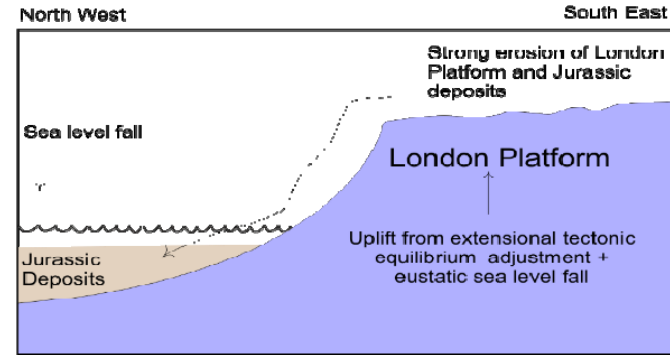


Approximate location of hypothetical cross-sections in Figure 3

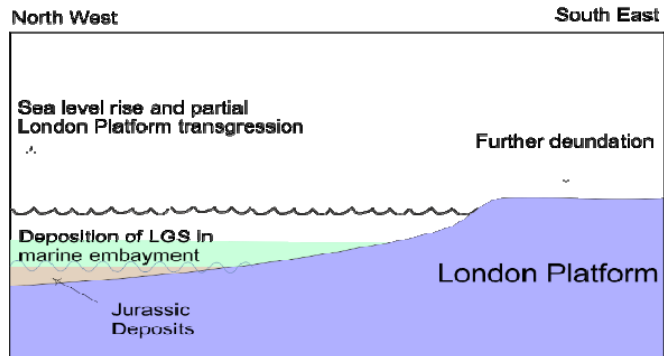
### A Jurassic



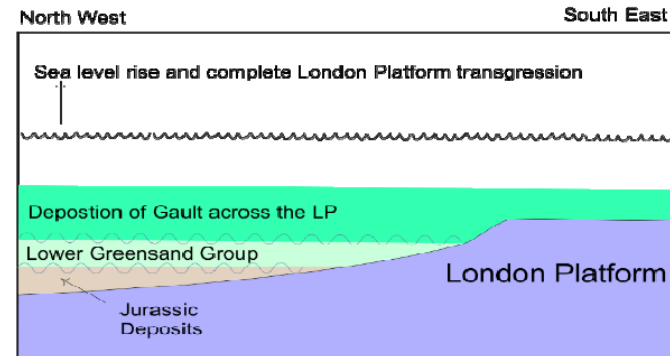
### B Late Cimmerian unconformity



### C Late Aptian - Early Albian



### D Late Albian



Unconformity LP = London Platform

Not to scale; conceptual sketches only; x 20 vertical exaggeration

Sketch conceptual cross-sections across the model area, NW to SE showing tectonic and eustatic events related to the deposition of Jurassic, Lower Greensand, and Gault strata.

# Modelled units

Name model	Description
PEAT-P	Peat
ALV-XCZSV	Alluvium
HEAD-XCZSV	Head
FELM-XSV	Felmersham Member
RTD1-XSV	River Terrace Deposits, 1
RTD2-XSV	River Terrace Deposits, 2
T1T2-XSV	River Terrace Deposits, 1 to 2
RTDU-XSV	River Terrace Deposits, Undifferentiated
GFDMP-XSV	Glaciofluvial Deposits, Mid-Pleistocene
LOFT-DMTN	Lowestoft Formation
ODT-DMTN	Oadby Member
GFDMP2-XSV	Glaciofluvial Deposits, Mid-Pleistocene 2
TILL1-DMTN	Unnamed Till 1
GFDMP3-XSV	Glaciofluvial Deposits, Mid-Pleistocene 3
GLDMP-XSC	Glaciolacustrine Deposits, Mid-Pleistocene
TILL2-DMTN	Unnamed Till 2
QUU-UKWN	Quaternary Deposits, undifferentiated

Name	Description
PGU-MDSD	Palaeogene Deposits, undifferentiated
CK-CHLK	Chalk Group
GLT-MDST	Gault Formation
LGS-SDST	Lower Greensand Group
JURA-MDLM	Jurassic rocks, undifferentiated
RZRU-MDSL	Palaeozoic rocks, undifferentiated



# Data Sources:

1. DigMap50k v8
2. Boreholes
3. UK3D sections



Runley Wood P.S. (New LGS Bore) TL 02 / 65 SC

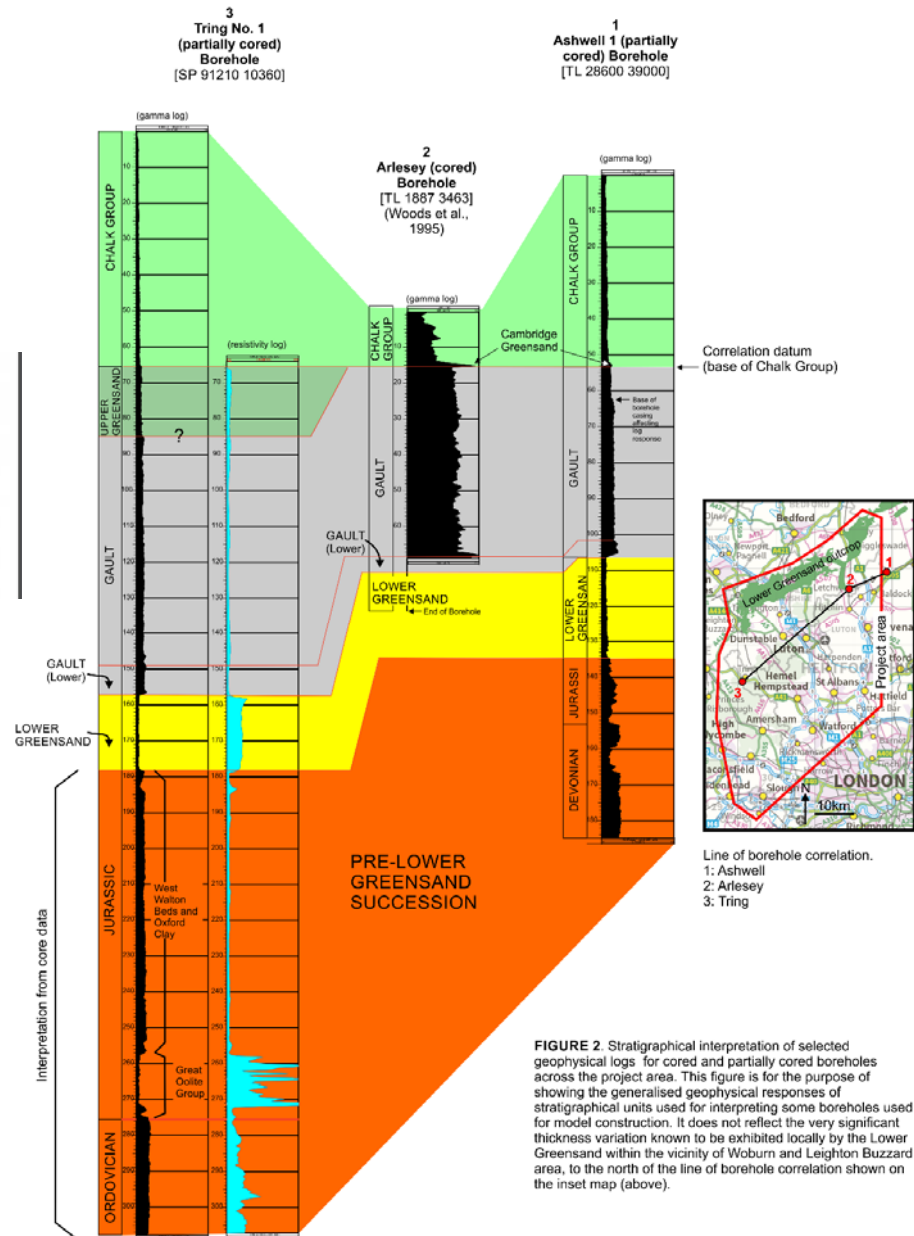
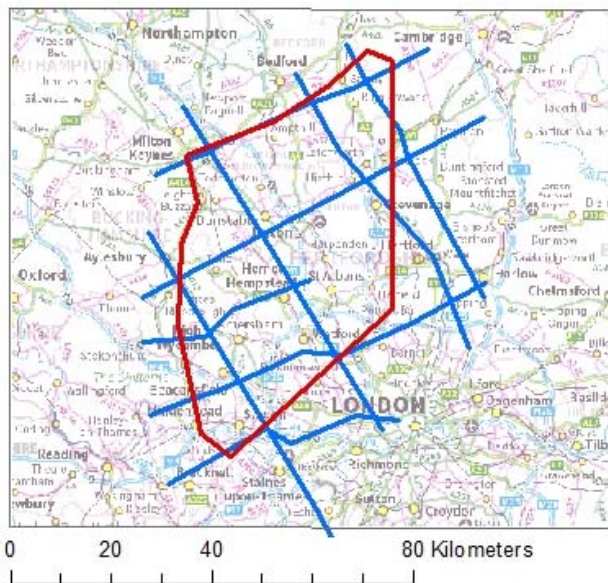
W. Valley W.C. Licence No 29/38/1/0

240m 275m 188-20m 180-50m 215-50m 215-99m

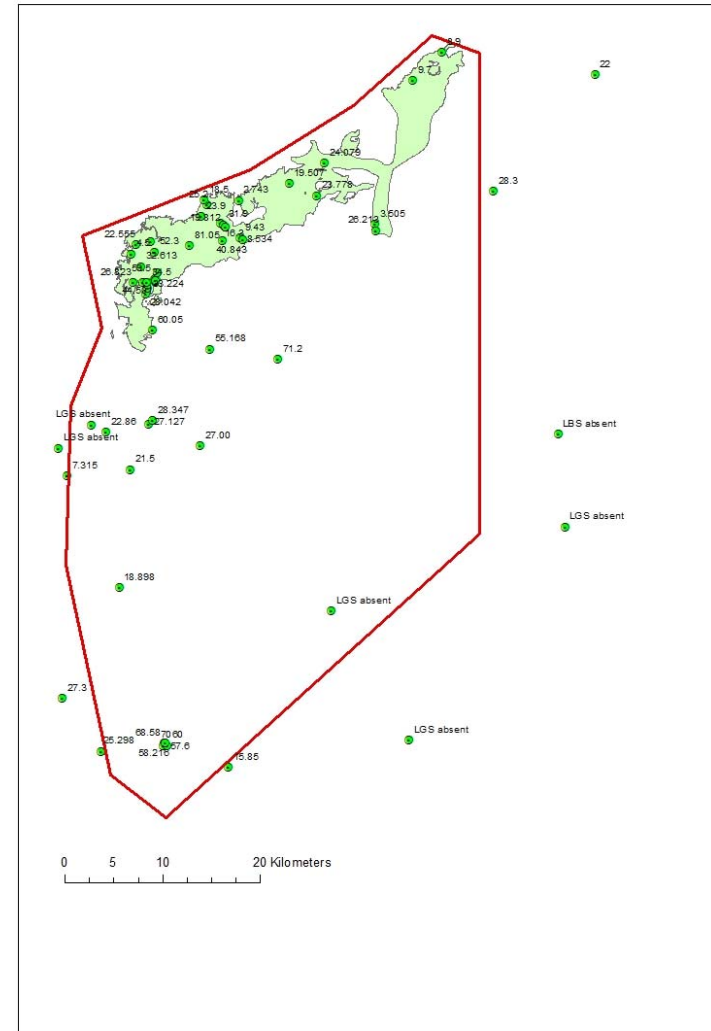
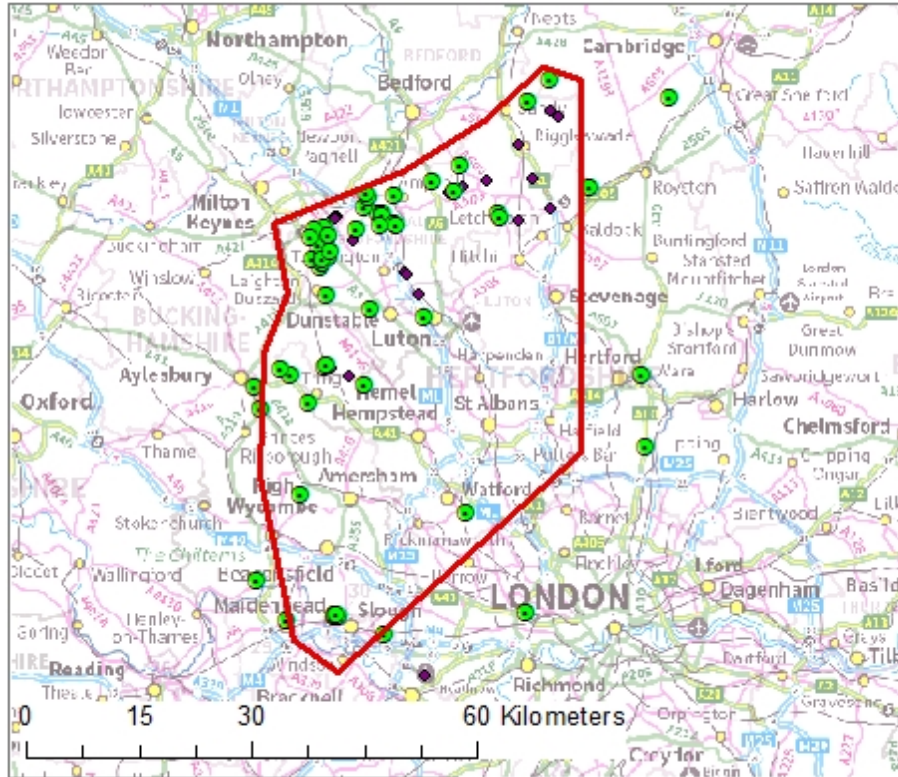
0.3 - 0.4m 0.5 - 0.6m 0.5 - 0.6m 0.5 - 0.6m

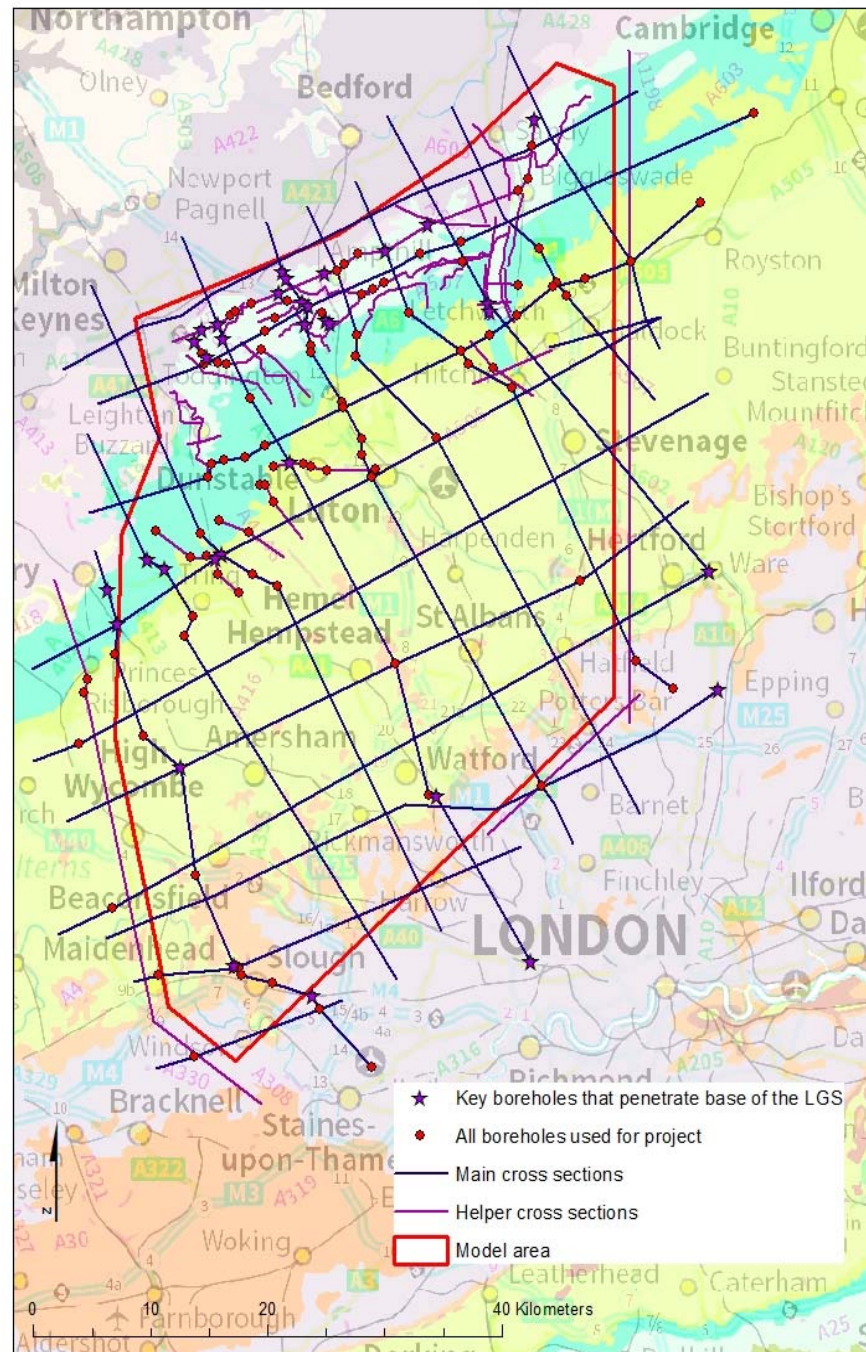
193-50 215-50 215-50 215-99

1.0 1.0 1.0 1.0

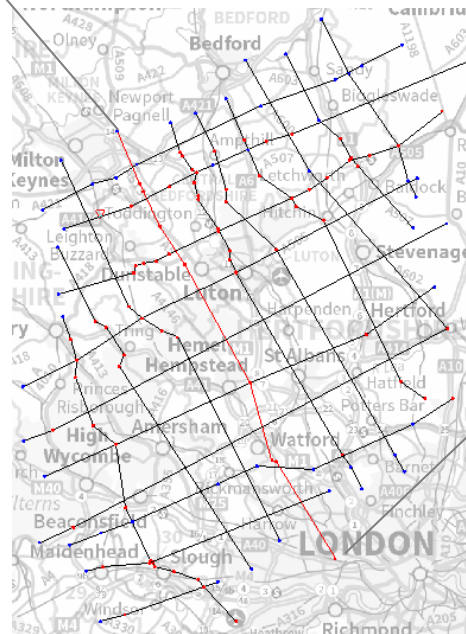
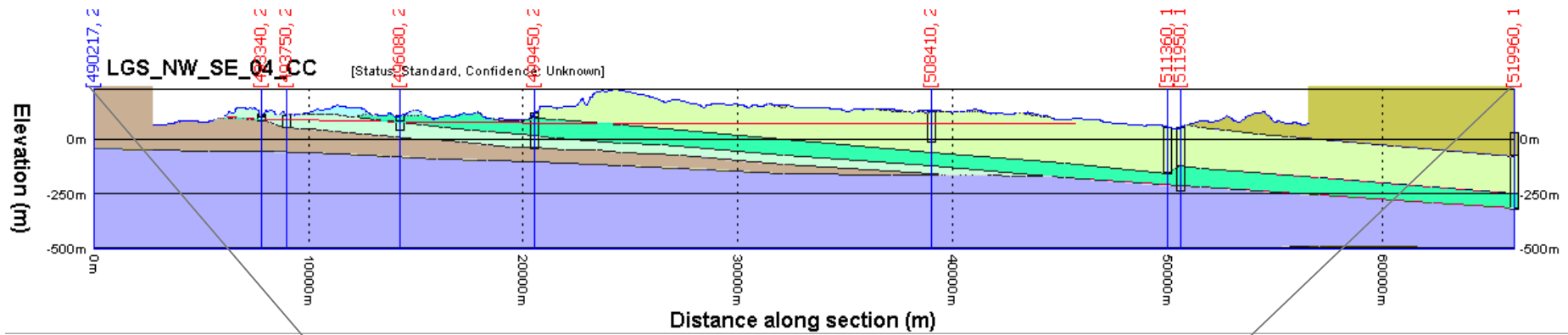


# Key borehole distribution:

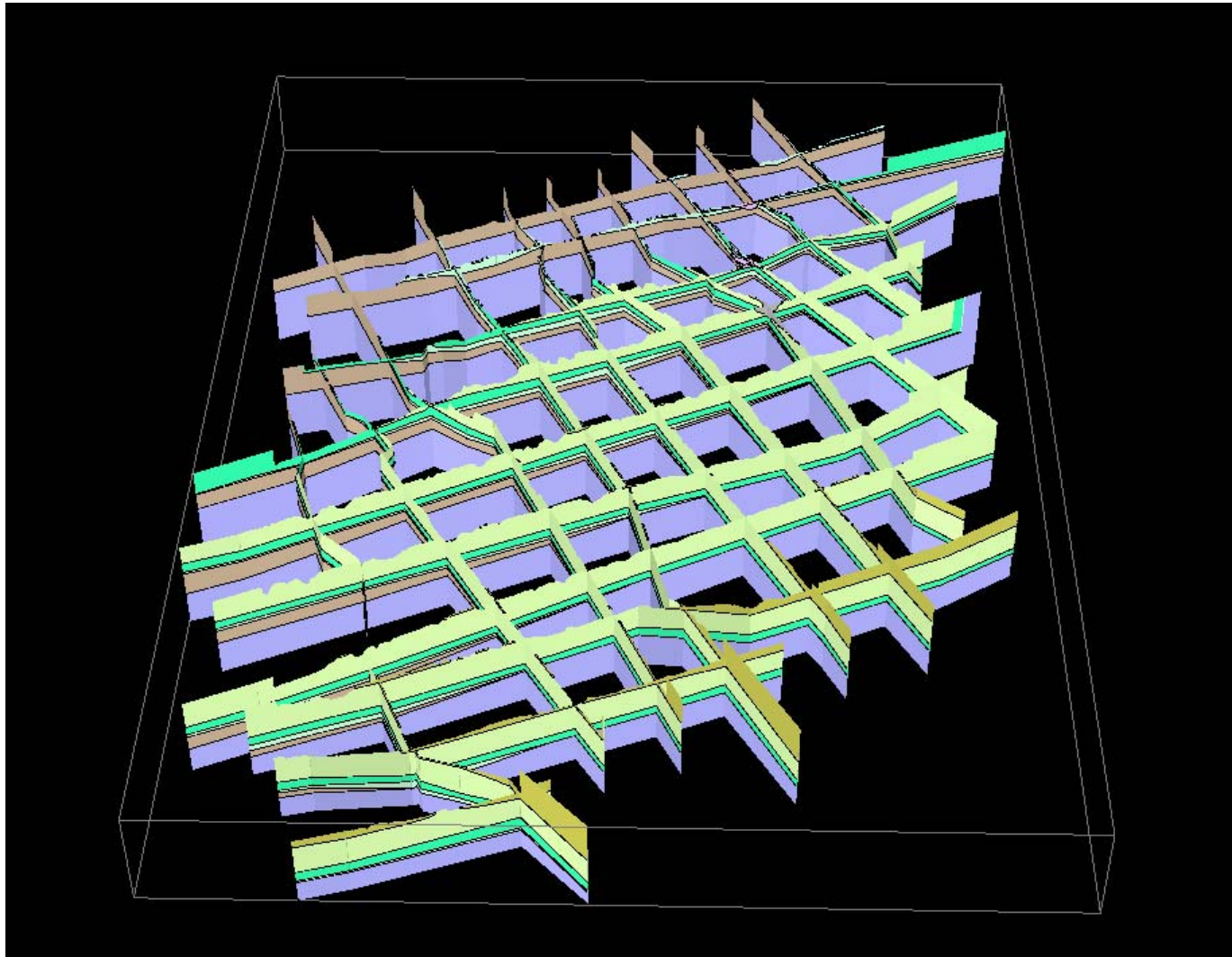


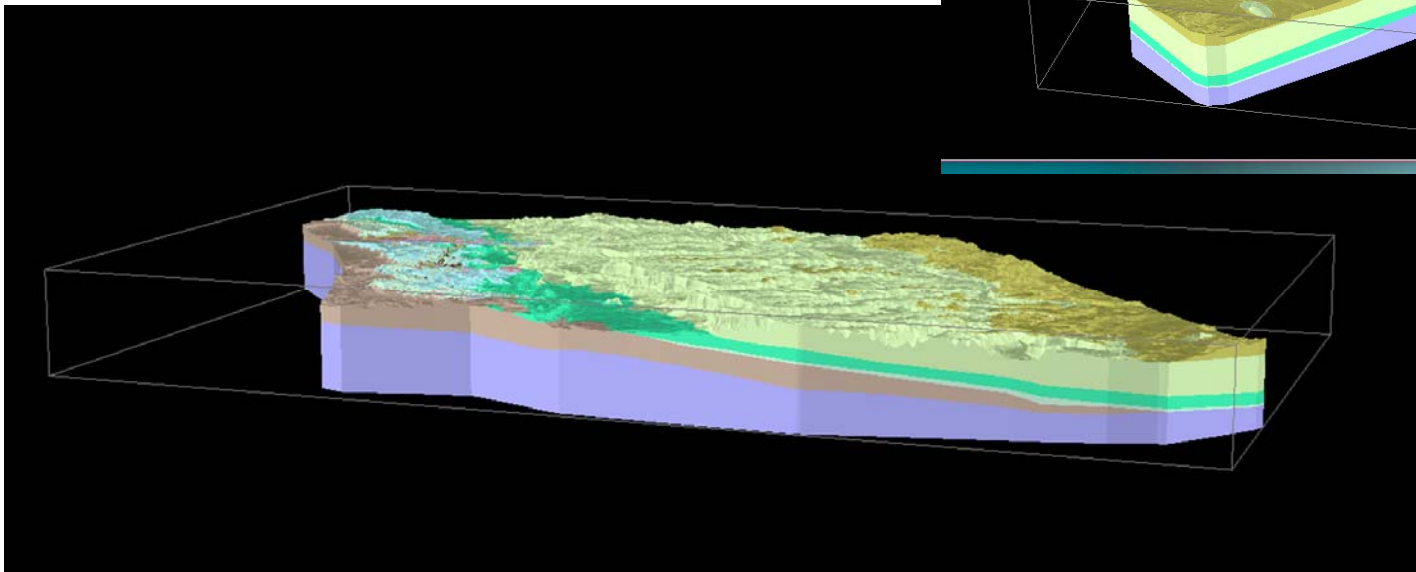
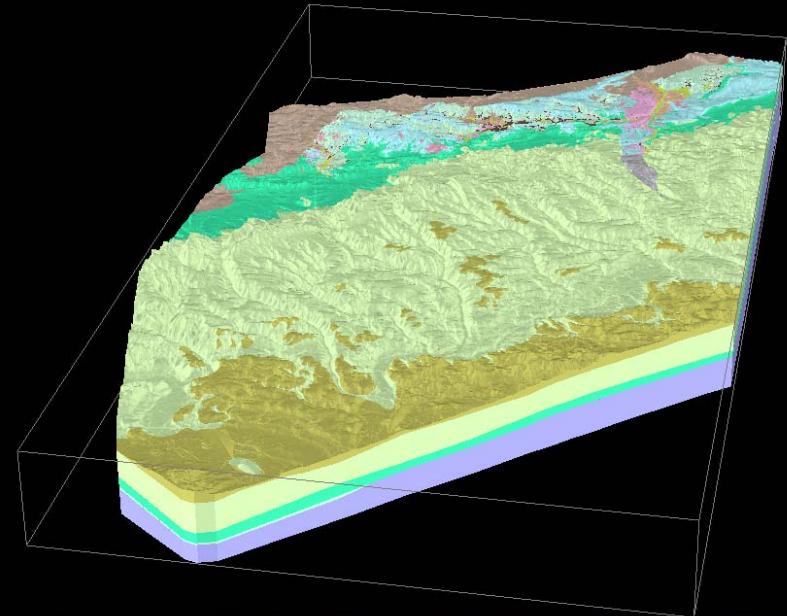
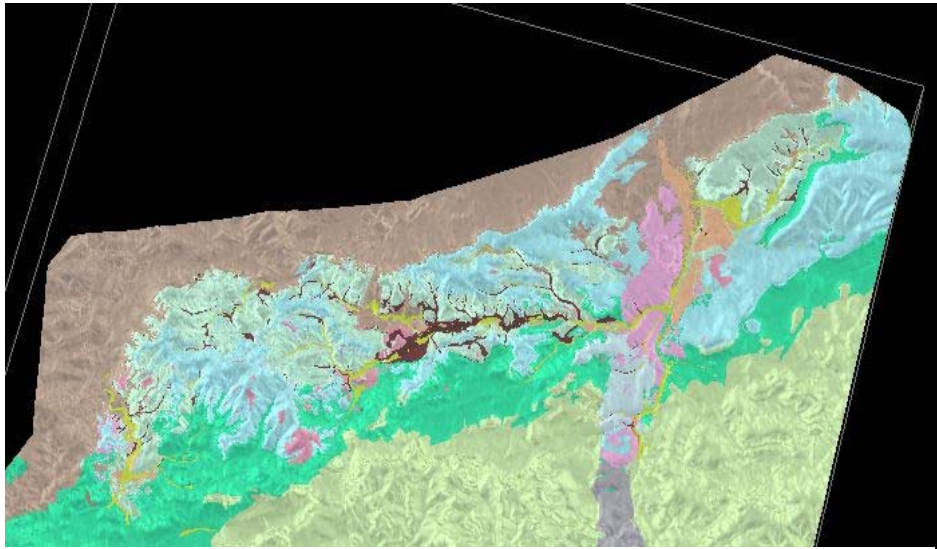


# Example cross section:



LGS\_NW\_SE\_04\_CC





# Hydrogeological Characterisation:

Melinda Lewis



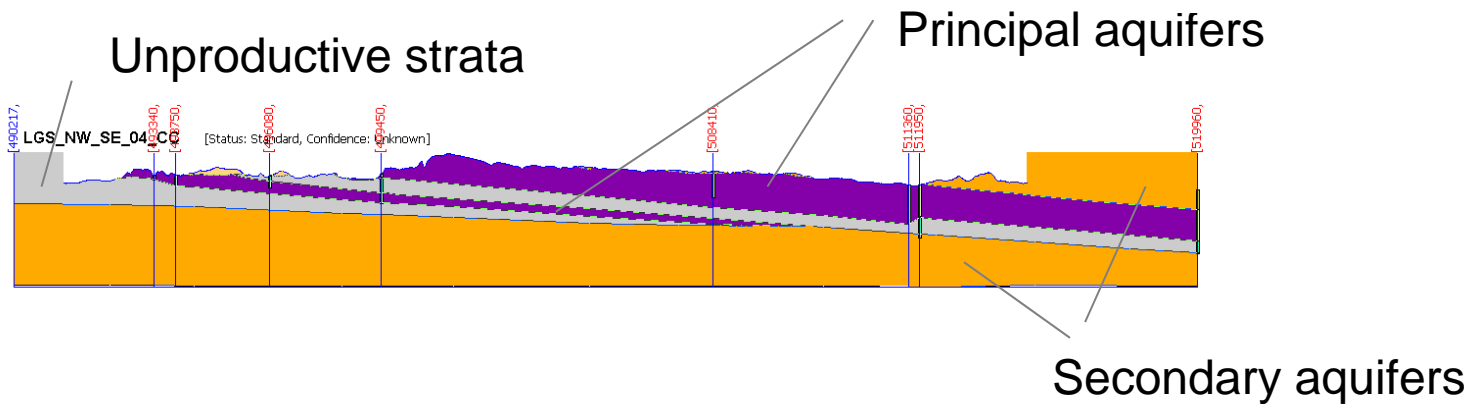
Senior Hydrogeologist

Location: Wallingford

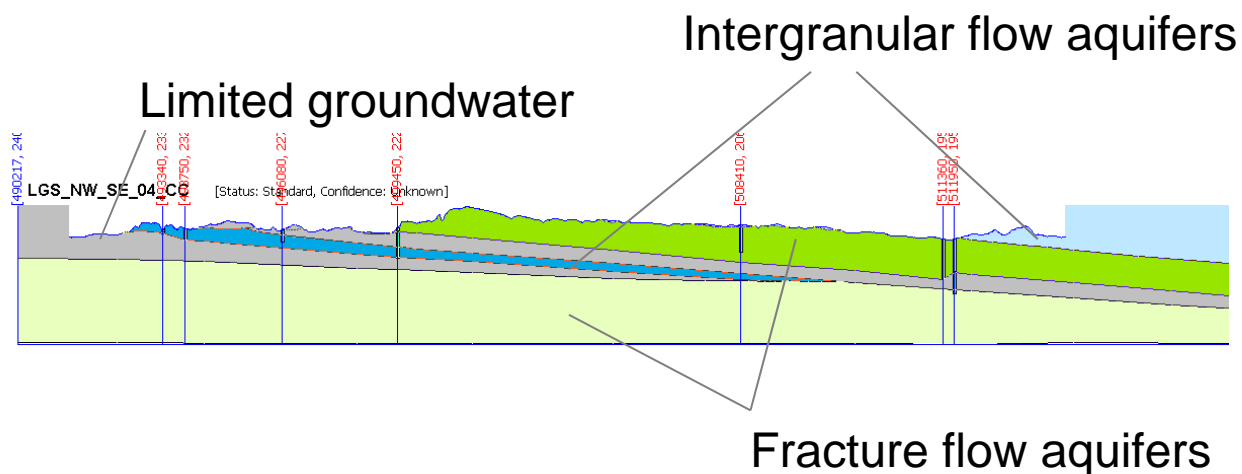
Tel: 01491 69 2459

E-mail Melinda Lewis

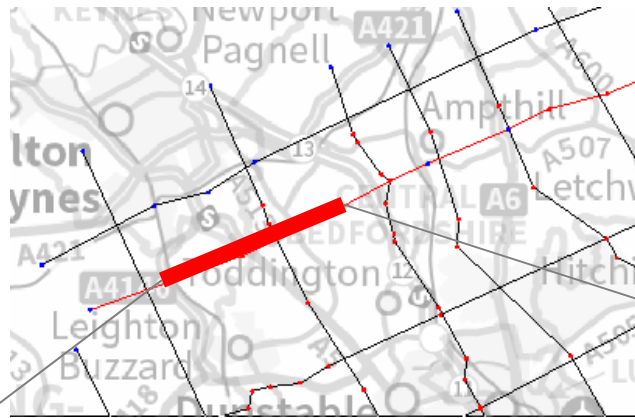
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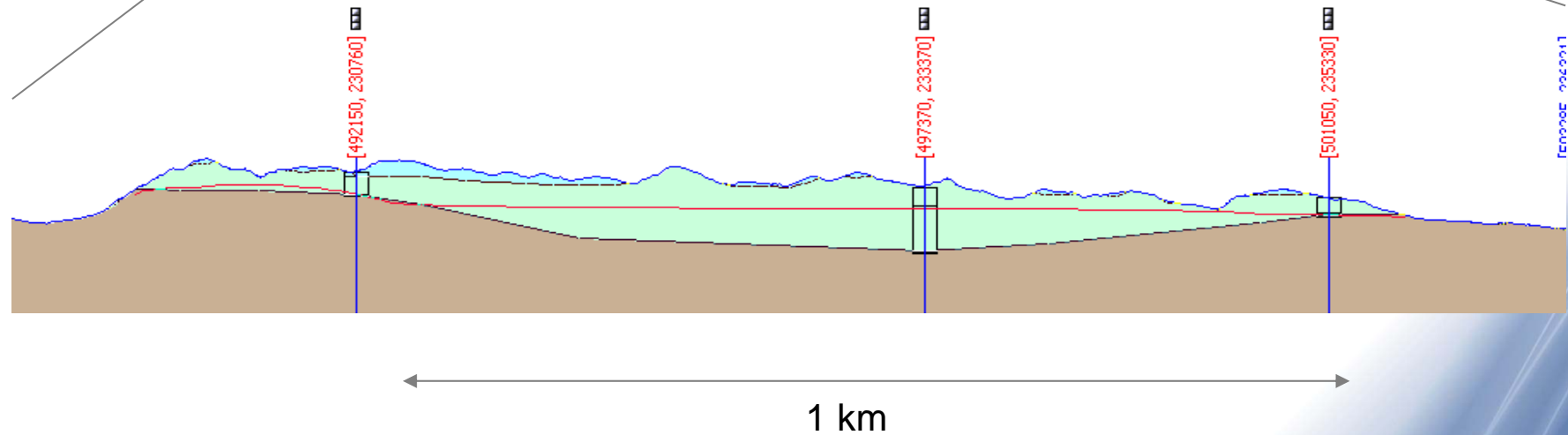
## Flow mechanism:



# Water Levels:

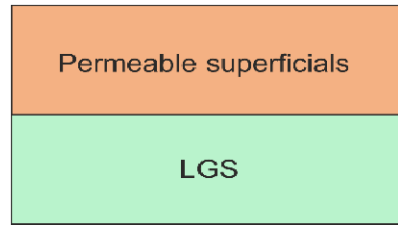


LGS\_SW\_NE\_09\_CC

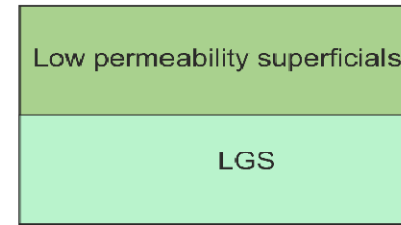




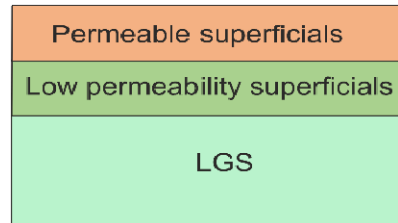
# Hydro- domains



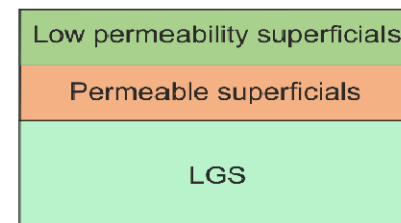
Domain 2



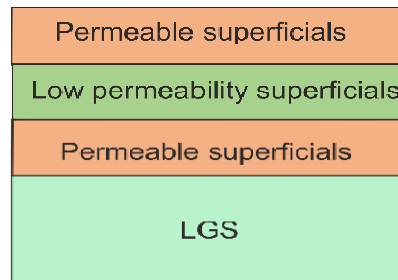
Domain 3



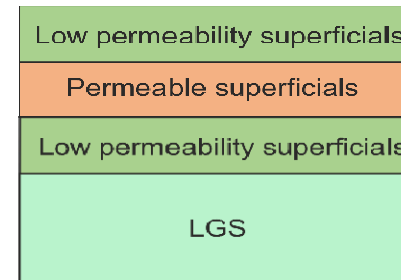
Domain 4



Domain 5



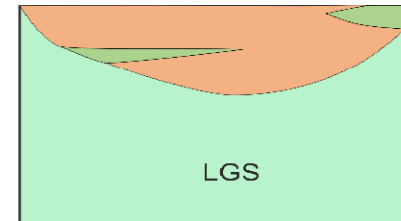
Domain 6



Domain 7



Domain 1

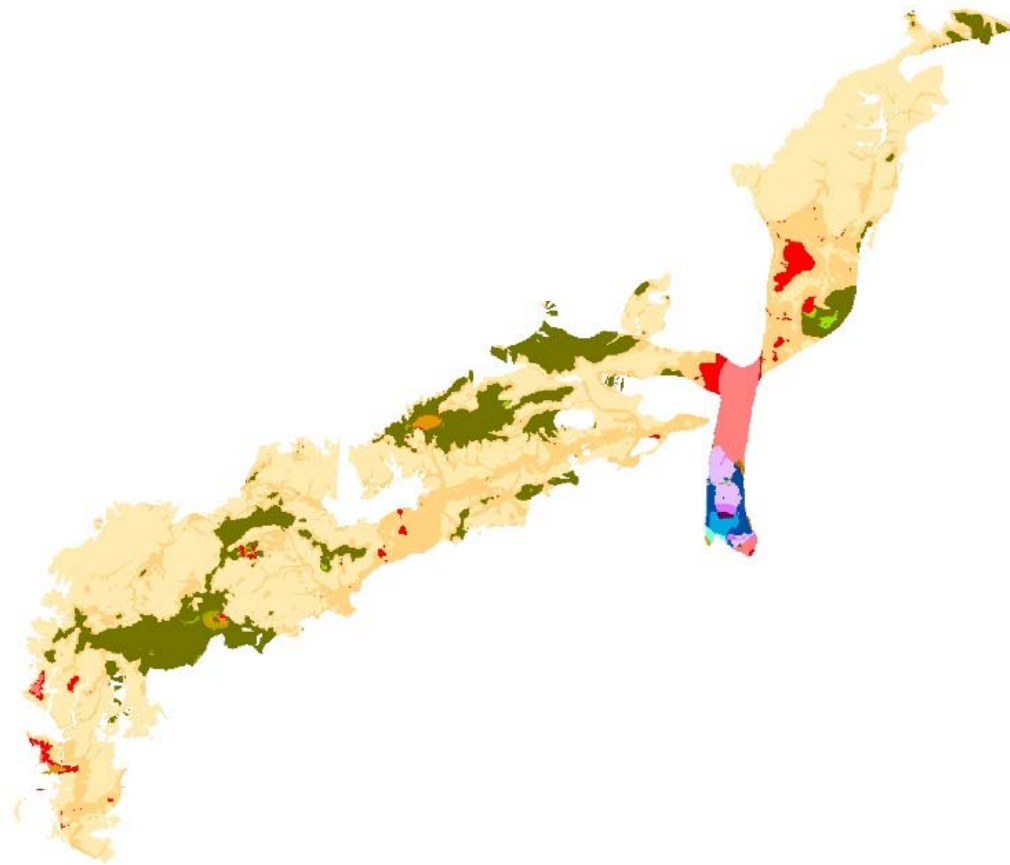


Domain 8

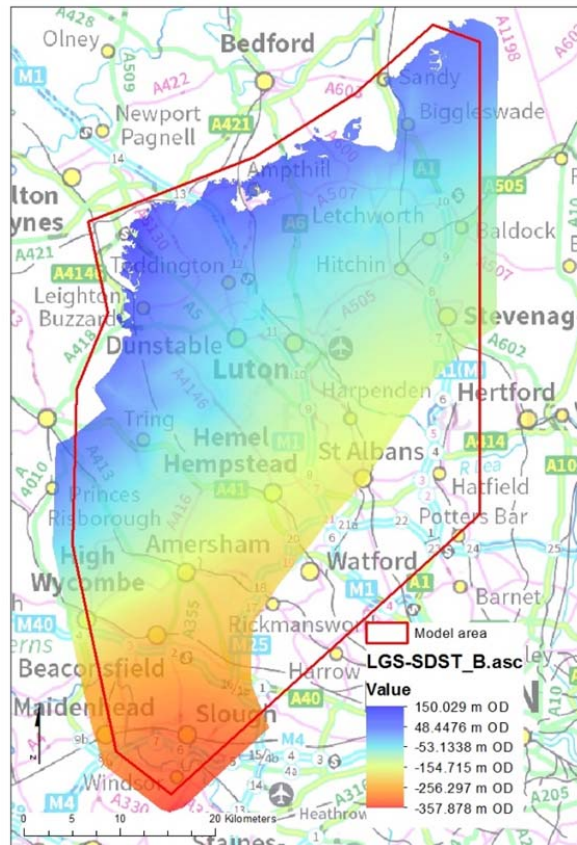
# Hydro-domains

hydrodomains  
 subdomains

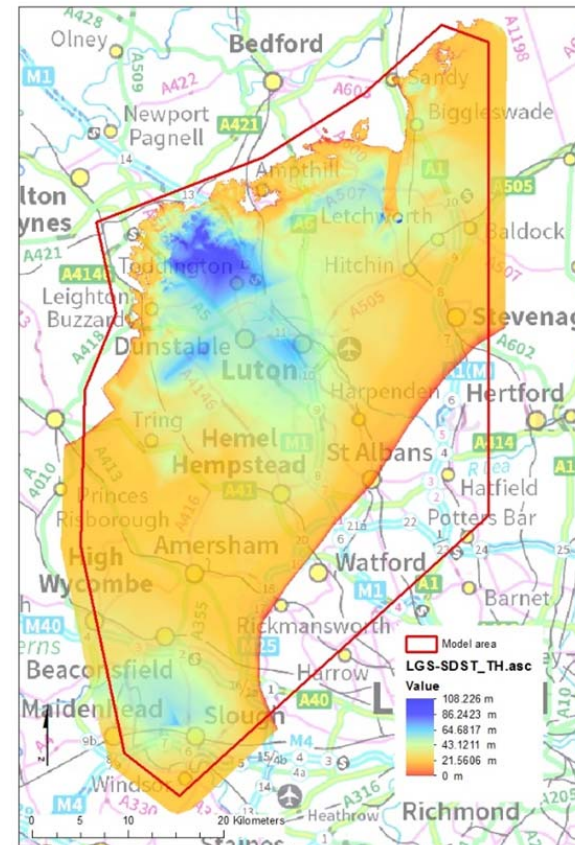
- 1a
- 1b
- 1c
- 2a
- 2d
- 4a
- 4b
- 5a
- 5b
- 6a
- 6b
- 15a
- 15b
- 16a
- 16b
- 17a
- 17b
- 18a




## LGS Base:



## LGS thickness:



# Lower Greensand Group Geological 3D Model; Hitchin to Slough



View from Dashed Hill looking NW over Fagbott towards Clapham, Lower Greensand (Woburn Sands Formation) is seen on the horizon.


This model allows a unique visualisation in three dimensions of the subsurface geology of the Lower Greensand Group in parts of Buckinghamshire, Hertfordshire and Bedfordshire. It is based on a commissioned model and report by the Environment Agency, undertaken by the British Geological Survey. For more information, please see:

Cripps, C., Lewis, M., Woods, M., Garcia-Bazo, M., 2017. Lower Greensand geological model and hydrogeological conceptualisation report (Hitchin to Slough). British Geological Survey Commissioned Report, CR17/072.

The model has been developed as an aid to help improve the understanding of the Lower Greensand aquifer and engagement with stakeholders by allowing them to visualise what lies below ground in a simplified manner that can be easily accessed.

This three-dimensional model covers the Environment Agency's Hertfordshire & North London administrative area, in addition to East Anglia to the north.

**Area of model**




Geological cross-sections based on model from Cripps et al. 2017. Surface topographical and bedrock mapping based on OSMap06, 1:50,000 scale data. British Geological Survey geological data © NERC 2017.

Topographic detail derived from Ordnance Survey OpenStreetMap.

Ordnance Survey © Crown copyright and database right 2017. All rights reserved.

Elevation detail derived from Ordnance Survey Digital Terrain Model with 5m resolution.

This publication forms part of an ongoing program to improve the understanding of the Lower Greensand Group in the Hitchin to Slough area. We welcome your comments on this publication via [enquiries@bgs.ac.uk](mailto:enquiries@bgs.ac.uk).



**British Geological Survey**  
Natural Environment Research Council

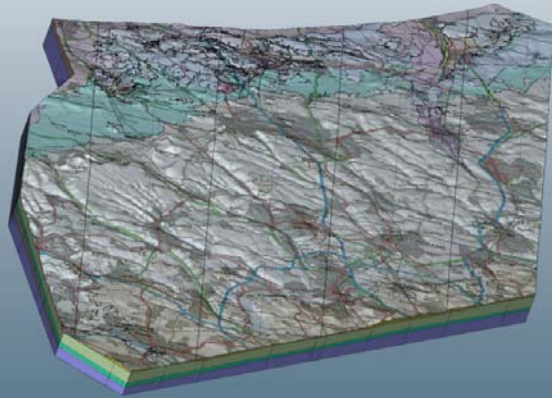
Produced by the British Geological Survey 2020 07/20/20

**Geological Model**

**Detailed Legend**

**Instructions**

## Key to geological units



**Quaternary**

- Peat
- Alluvium
- Head
- Floodplain Deposits
- River Terrace Deposits, 1
- River Terrace Deposits, 2
- River Terrace Deposits, T1 to 3
- Large Terrace Deposits, Sub-Pleistocene
- Coaly Member
- Unconformable Deposits, Sub-Pleistocene 1
- Unconformable TS 1
- Unconformable Deposits, Sub-Pleistocene 2
- Unconformable TS 2
- Quaternary Deposits, unstratified

**Paleogene**

- Paleogene Deposits (unstratified)

**Cretaceous**

- Chalk Group and Upper Greensand Formation
- East Formation
- Lower Greensand Group

**Jurassic**

- Assens beds (unstratified)

**Paleozoic**

- Paleozoic rocks (unstratified)

**Block display control**

Ground surface: All on

Subsurface units: All off

Subsurface surfaces: All off

Vertical cross sections: All off

**Vertical Exaggeration**

View Orientation

Direction: N Pitch: -07

Bearing: 37 Roll: 0

**Introduction**

**Detailed Legend**

**Instructions**

PERIOD	LEXICON CODES (LEX-ACB)	DESCRIPTION	COMMENTS
Quaternary	PS00A	Peat	Peat generated with the River Trent is assumed to be having an alluvial genesis (Cripps et al. 2017). The peat is assumed to have a Backwash of peat in a valley, but it can be used to seal a trench.
	AL002B0	Alluvium	Modern alluvial soils, with some (occasional) to (discrete) flows (1800s)
	HEAD002B0	Head	Head (Backwash) (subdivided in 6 (discrete) flows, 1800s)
	FL00A00	Floodplain Deposits	Fluvial deposits (subdivided in 6 (discrete) flows, 1800s)
	FT01A00	River Terrace Deposits, 1	River Terrace Deposits, 1st terrace
	FT02A00	River Terrace Deposits, 2	River Terrace Deposits, 2nd terrace
	FT03A00	River Terrace Deposits, 1 to 3	River Terrace Deposits, 1st to 3rd terrace
	FT04A00	River Terrace Deposits, unstratified	River Terrace Deposits, unstratified
	FT05A00	Coaly Member	Member of peat with the fluvial formation
	UP00A00	Unconformable Deposits, Sub-Pleistocene 1	Unconformable Deposits, Sub-Pleistocene 1
	UP01A00	Unconformable TS 1	Unconformable Deposits, Sub-Pleistocene 1
	UP02A00	Unconformable Deposits, Sub-Pleistocene 2	Unconformable Deposits, Sub-Pleistocene 2
	UP03A00	Unconformable TS 2	Unconformable Deposits, Sub-Pleistocene 2
Paleogene	PS00A00	Paleogene Deposits (unstratified)	Includes all Paleogene Formation found in the model area, e.g. Lutetian Clay Formation etc.
	CA00A00	Chalk Group and Upper Greensand Formation	Base of the Chalk, which includes Cambridge Greensand (includes pebbles, nodules, and some fossiliferous layers) and the top of the Chalk.
	SL00A00	East Formation	Pre-Pleistocene member.
Cretaceous	L00A00	Lower Greensand Group	In addition, this is known as the 'Lower Greensand Formation' (Pre-Pleistocene member). It includes the 1st and 2nd members of the Lower Greensand Group, the 'Lower Greensand Group' (1st and 2nd members) and the 'Lower Greensand Group' (3rd member). It also includes the 'Lower Greensand Group' (4th member) and the 'Lower Greensand Group' (5th member).
	JA00A00	Jurassic rocks (unstratified)	Includes beds of the Jurassic when in steady (maximum age (Present) to maximum age (Present))
Paleozoic	PS00A00	Paleozoic rocks (unstratified)	Includes Devonian and Permian rocks unstratified in the model area.

**Key to geological units**

The geological legend shows the rock units contained within the model in the form of a vertical column. This column is divided into the different geological units each identified within the model as a different colour. The sequence in the column also indicates the age of the rocks and the order they were formed with the youngest shown at the top and travelling back in time towards the oldest rocks at the base of the column.

**Stratigraphy (LEX)**

Stratigraphy is a list of the approved names given to the various map-scale geological units that are represented in the model. The terms Formation, Subgroup and Group refer to the hierarchical status of each unit in the UK stratigraphy. Rocks refer simply to the more generalised geological Period with which the units are identified.

**Lithology (RCS)**

Lithology or rock type refers to the general physical characteristics of a rock (what it's made of) its mineral composition, colour and texture.

**Lexicon Codes**

The BGS Lexicon of Named Rock Units provides a freely accessible definition of geological units of Great Britain, Northern Ireland and the associated continental shelf that appears on BGS maps, models and other publications. It is an online searchable database that can be found at [www.bgs.ac.uk/lexicon/](http://www.bgs.ac.uk/lexicon/)

**Introduction**

**Geological Model**

**Instructions**

## Instructions on orientating the 3D model and setting display controls

The initial model view looks north with the 1:625 000 scale bedrock geology draped over the land surface. The model is divided into a series of elements that can be controlled from the tools in the panels around the model. These controls enable the viewer to change the display of the ground surface, as well as breaking the model apart into different configurations of the thirteen component blocks that the model is constructed from.

**Key to geological units**

**Display of geological units**

Outcrop surface units

Sub-surface units

Vertical cross sections

**Block display**

This control is located in the middle of the lower panel. An expanded view shows each block and its individual display control. Click on each of the individual blocks to add or remove them from the main display. To the top left are two switching buttons. The user is 'sticky' from the display of all the blocks on or off at once.

**Geological Units Display**

The left hand panel contains a short legend of the geological units contained within the model. Controls for the display of the geological units are located on the left hand side of the legend table which have been grouped together based on the stratigraphic period they were formed. The Quaternary units have been grouped together for display purposes. The bedrock units can be controlled individually. Simply click on these controls to toggle on and off the display of the geological units and groups.

The three controls listed below also affect how the geological units are displayed. Simply click on these controls to explore the internal structure in more detail. Refer to the information below for more detail.

**Display of Geological Units**

These controls allow parts of the geological units to be hidden so the internal structure of the model can be viewed. They are divided into the geology at surface, the sub-surface unit boundaries and the vertical cross sections. Click on these to change how the geological unit display is applied to the model.

**Block display control**

Ground surface: All on

Sub-surface units: All off

Sub-surface surfaces: All off

Vertical cross sections: All off

**Vertical Exaggeration**

Located on the right hand side of the lower control panel is a control to change the vertical exaggeration shown on the model. The initial view of the 3D model is shown with five times vertical exaggeration but a factor from one to fifteen times the exaggeration of the vertical scale can be applied by using the controls. Click on the upper of the lower buttons to change the vertical scale up or down a factor of one.

**View Orientation**

Located on the right hand side of the lower control panel is a control to change the view orientation shown on the model. The initial view of the 3D model is shown with the bearing, pitch and roll set to 0, 0, 0. This gives a view of the viewing orientation, showing the direction, bearing, pitch and roll.

**Basic Navigation**

Basic view control is as follows: To rotate the model view hold the left mouse button and move the mouse in the direction of rotation. To move the model view around in the screen hold the 'control' key with the left mouse button and move the mouse. To zoom in and out hold the right mouse button and move the mouse back or forward or roll the mouse wheel or hold the 'shift' key with the left mouse button and move the mouse back or forward.

**Ground Surface Display**

On the lower panel are controls for the display of the ground surface. The master control, on the top, will turn on or off all ground surface features. Click on this to change the display state. The individual controls for the three ground features: OS national grid lines - Black 1:5 kilometre interval, gray 3 kilometre sub interval and topography based on OS data. The topography has control to change its display transparency. Click on these controls to reconfigure how the ground surface displays.

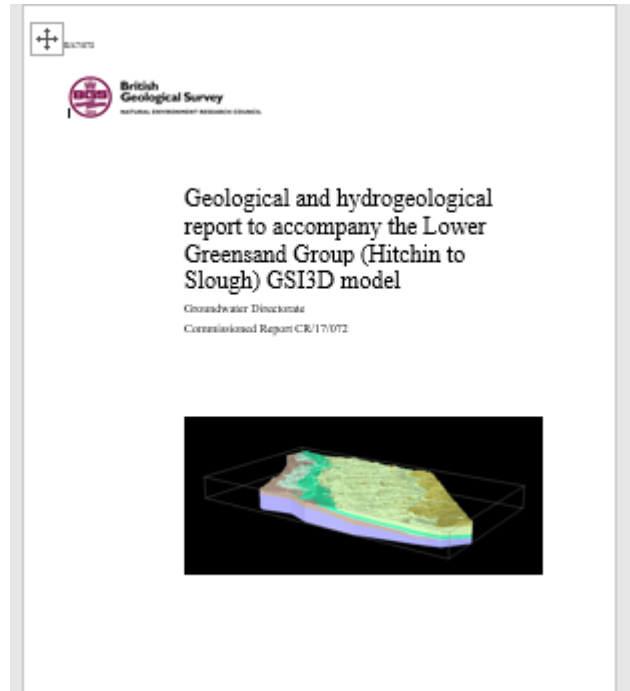
**Borehole Positions**

Located on the lower panel is the control for the display of the boreholes referenced in the construction of the geological model. Click on this control to show or hide the boreholes.

**Introduction**

**Geological Model**

**Detailed Legend**



Cripps, C., Lewis, M., Woods, M., Thorpe, S. 2017. Geological and hydrogeological report to accompany the Lower Greensand Group (Hitchin to Slough) GSI3D model. *British Geological Survey Commissioned Report, CR/17/072*. 118pp.

Further collaboration with the Environment Agency...



**British Geological Survey**  
NATURAL ENVIRONMENT RESEARCH COUNCIL



**Environment Agency**

