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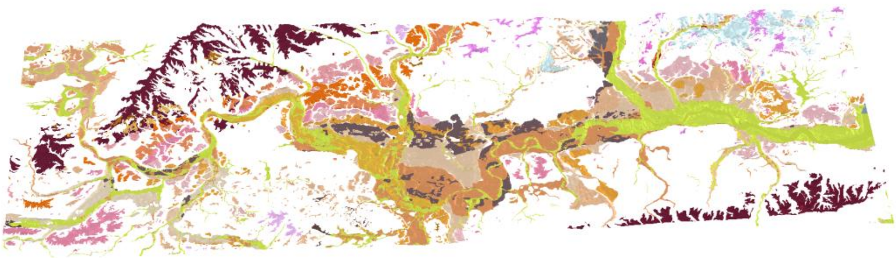
Metadata report for the Superficial LithoFrame 50 London Basin Model (Areas 1-12)

Geology and Landscape Programme

Open Report OR/12/77



BRITISH GEOLOGICAL SURVEY

GEOLOGY and REGIONAL GEOPHYSICS PROGRAMME

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Metadata report for the Superficial LithoFrame 50 London Basin Model (Areas 1-12)

H. Burke, S. Mathers, S Thorpe, J Ford and R Terrington

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3D view of Superficial LithoFrame 50 London Basin model

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Foreword

This report is the published product of a National Capability project by the British Geological Survey (BGS) to create a regional digital 3D model of the London Basin in south-east England.

Thanks are extended to Don Aldiss and Ben Wood and for their advice and technical assistance.

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Summary

This report describes the methodology and datasets used in constructing the 3D superficial geology LithoFrame 50 resolution model of the London Basin.

The London Basin project area was divided into twelve 20 x 20 km tiles, with construction of the first tiles beginning in 2006 and completion of the Areas 1-12 combined model in 2012. This time period coincided with the ongoing development of GSI3D software used to construct the model; therefore several versions of GSI3D were used in the model building process.

The model complements the corresponding DigMap GB-50 tiles and consists of 65 modelled superficial and artificial geological units.

A Glossary of technical terms used in this report is included at the end of this report.

1 Introduction

The Areas 1-12 1:50,000 scale 3D superficial geology model covers a total area of 4,800 km^2 in the London Basin of south east England, from easting 450,000 to 570,000 and from northing 160,000 to 200,000. Because of the size of the project area, the model construction was divided into twelve 20 x 20 km tiles (Figure 1). A separate 3D geological model was constructed for each tile using GSI3D so only data specific to each tile was used during the tiled model construction (boreholes, DTM, DigMapGB-50 polygons, etc.). The twelve model tiles were later merged into a unified model. This report summarises the metadata compiled during the construction of the individual tiles and combined model.

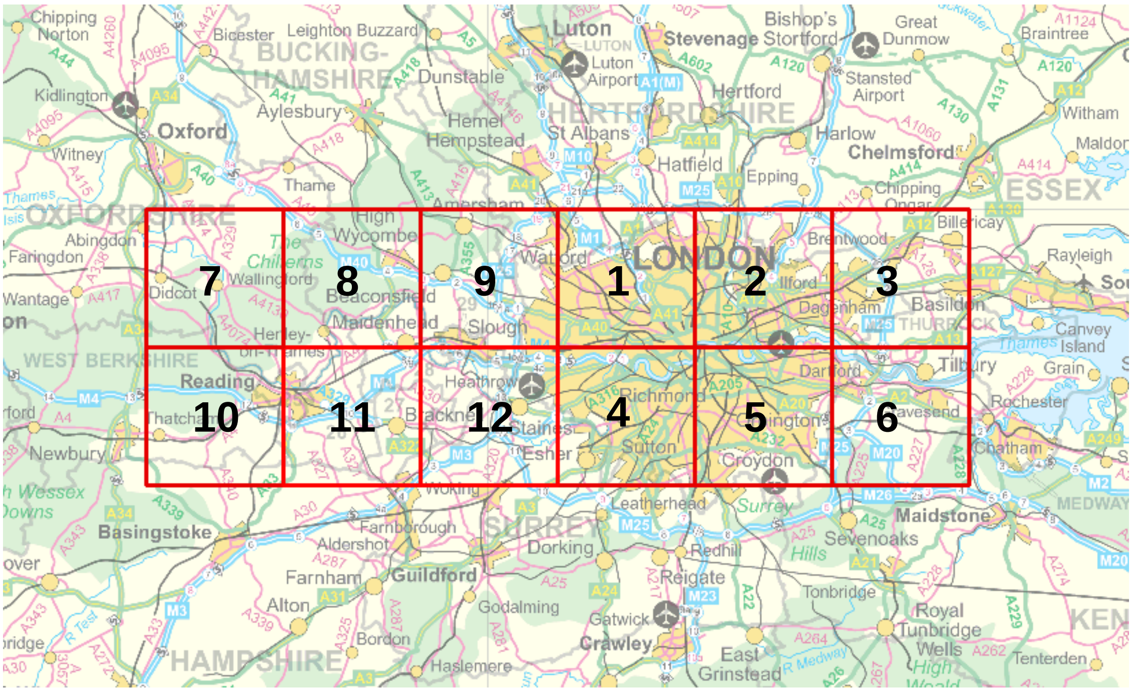


Figure 1 Location of model and areas 1-12

2 Model purpose and scale

Using National Capability funding, work began on this model in 2006, starting with Areas 1 to 6, and the individual model tiles were completed in 2010. All twelve tiles were amalgamated into a single superficial model in 2012. In total, 922 cross-sections were constructed, using 7174 borehole records. 59 superficial units have been modelled, along with Landslips and artificial ground, subdivided into Worked, Made, Worked & Made, Disturbed and Landscaped Ground. Head deposits are also drawn into the cross-sections where present, but are excluded from the model calculation because their coverage pattern is complex. Bedrock units are also correlated in the cross-sections as it was originally intended to publish a combined bedrock and superficial London Basin 3D model. However, the GSI3D bedrock engine was unable to calculate the faulted bedrock units, hence a superficial only version of the model is now released. A bedrock version is currently being prepared in GOCAD.

In section construction, discrepancies noted between boreholes and the geology indicated by the DigMap dataset were resolved in favour of the boreholes. The model therefore supersedes the DigMapGB-50 version 6 dataset.

A framework of cross-sections was constructed for each tile, with docking sections added along the margins of completed tiles, used for guidance when work began on an adjoining area. On completion of all twelve tiles, the derived surfaces were merged together and checked for artefacts, such as artificial ridges or trenches at boundaries due to the merging process. These were smoothed out in the combined model.

The model is intended to complement the corresponding 1:50,000 scale geological map sheets used during model construction, with minor amendments based on the assessment of borehole data and insights gained from the modelling process. These sheets are listed in the bibliography together with the accompanying memoirs/sheet explanations and the London and Thames Valley BGS Regional Guide (Sumbler, 1996).

Additional 1:50,000 scale artificial ground polygons were added to the Areas 1-12 model to address inconsistencies in the representation of artificial ground on different geological map sheets. Instances of artificial ground (Made, Worked, Landscaped and Worked & Made Ground) not already in DigMapGB-10 or -50 were identified and captured in a 2D GIS before being added to the 3D model. These artificial deposits, however, have not been modelled in 3D, so their distribution remains indicated by the 2D polygons at the surface, from which 3D volumes cannot be calculated.

3 Modelled surfaces/volumes

In total 65 superficial and artificial geological units were modelled. These range in age from pre-Anglian through to Anglian, Devensian, Holocene-Flandrian and Recent deposits, including five categories of artificial ground. Table 1 lists the units modelled in broad stratigraphic order in the model. Note that Head and Clay with Flints are known to be polycyclic deposits, and in the case of Clay with Flints are likely to have started formation as far back as the Pliocene.

Table 1 Stratigraphic table of geological units modelled

Inferred age	BGS LEXICON	Full name	Lithology
Recent	slip	Landslip	Mass movement deposits; variable composition, dependent on the nature of the upslope material
	wgr	Worked Ground	Artificially lowered area, or void, through man-made excavation, e.g. a gravel pit
	mgr	Made Ground	Artificially raised areas, variable composition
	wmgr	Worked & Made Ground	Area of artificial cut and fill, e.g. a backfilled quarry, variable composition
	ddgr	Disturbed Ground	Area of disturbance associated with surface or near-surface collapse
	lsgr	Landscaped Ground	Extensively remodelled areas where it is difficult to delineate zones of Made, Worked or Disturbed Ground. Variable composition
Holocene-Flandrian	tfd	Tidal Flat Deposits	Intertidal deposits, composed of silt, clay, gravel and peat
	peat	Peat	Humic deposits, consisting of wet dark brown partially decomposed vegetation
	tufa	Tufa	Inorganic calcium carbonate or silica deposited at or near springs and seepages
	alv	Alluvium	Fluvial deposits, consisting of clay, silt, sand and peat

Late Anglian – Devensian river terraces and overbank deposits, various catchments	rtdu	River Terrace Deposits (undifferentiated)	Sand and gravel deposits directly beneath alluvium
	head	Head	Solifluction or hillwash deposit, composition dependent on source material. Usually gravelly sandy clay
	cwf	Clay With Flints Formation	Residual deposit formed through the dissolution of Chalk bedrock. Typically orange-brown and red-brown sandy clay with flint nodules and pebbles
	rtdo	Pleistocene River Terrace Deposits (unclassified)	Exposed river terrace deposits (not below alluvium). Composed of sand and gravel
	igd	Interglacial Deposits	Composed of silty clay
	lasi	Langley Silt Member	Varies from silt to clay, usually yellow brown and massively bedded
	shgr	Shepperton Gravel Member	Gravel with clay and sand
	no1a	Northmoor Sand and Gravel Member	Sand and gravel
	no1b		
	no		
	rosi	Roding Silt Member	Varies from silt to clay, usually yellow brown and massively bedded
	esi	Enfield Silt Member	Varies from silt to clay, usually yellow brown and massively bedded
	cfsi	Crayford Silt Member	Varies from silt to clay, usually yellow brown, often contains wind-blown sand
	kpgr	Kempton Park Gravel Formation	Sand and gravel, with local lenses of silt, clay or peat
	bggr	Beenham Grange Gravel Member	Sandy clayey gravel
	sura	Summertown-Radley Sand and Gravel Member	Sand and gravel
	rtd2	2nd river terrace deposit	Sand and gravel
	ilsi	Ilford Silt Member	Sandy clay and silt
	tpgr	Taplow Gravel Formation	Sand and gravel, locally with lenses of silt, clay or peat
	thgrl	Lower Thatcham Gravel, subdivision of Beenham Grange Gravel Member	Sandy clayey gravel
	wv	Wolvercote Sand and Gravel Member	Sand and gravel
	rtd3	3rd river terrace	Sand and gravel
	hagr	Hackney Gravel Member	Sand and gravel, locally with lenses of silt, clay or peat
	lhgr	Lynch Hill Gravel Member	Sand and gravel, locally with lenses of silt, clay or peat
	han	Hanborough Gravel Member	Sand and gravel

	rtd4	4th river terrace deposits	Sand and gravel
	dasi	Dartford Silt Member	Varies from silt to clay, usually yellow brown, often contains wind-blown sand
	figr	Finsbury Gravel Member	Sand and gravel, locally with lenses of silt, clay or peat
	bht	Boyn Hill Gravel Member	Sand and gravel with possible lenses of silt, clay or peat
	rtd5	5th river terrace deposits	Sand and gravel
	bpgr	Black Park Gravel Member	Sand and gravel with possible lenses of silt, clay or peat
	rtd6	6th river terrace deposit	Sand and gravel
	sigr	Silchester Gravel Member	Clayey, sandy gravel

Anglian glaciation	loft	Lowestoft Formation	Till containing chalk and flint clasts
	gfdu	Glaciofluvial deposits	Sand and gravel
	gstc	Glacial silts and clays	Composed of silt and clay

Pre- and Early Anglian terraces, various catchments	wihg	Winter Hill Gravel	Clayey, sandy gravel
	dhgr	Dollis Hill Gravel Member	Sandy, clayey gravel, with some laminated silty beds and local silt, clay or peat lenses
	wogr	Woodford Gravel Formation	Sand and gravel, locally with lenses of silt, clay, or peat and organic material
	rtd7	7th river terrace deposits	Sand and gravel
	bsgr	Beenham Stocks Gravel Member	Clayey, sandy gravel
	wlgr	Westmill Gravel Member	Gravel and sand, with local lenses of silt, clay or peat and organic material
	gcgr	Gerrards Cross Gravel	Gravel and sand, with local lenses of silt, clay or peat and organic material
	bygr	Bucklebury Common Gravel Member	Clayey, sandy gravel
	swgr	Satwell Gravel Formation	Sand and gravel
	rtd8	8th river terrace deposit	Sand and gravel
	stgr	Stanmore Gravel Formation	Flint-dominated gravel with a clay and sandy clay matrix
	whgr	Well Hill Gravel Formation	Gravel and sandy gravel
	cwgr	Chorleywood Gravel Formation	Sand and gravel
	cagr	Cold Ash Gravel	Sand and gravel
	bdgr	Beaconsfield Gravel	Sand and gravel
	suhg	Surrey Hill Gravel Member	Flint-dominated gravel

	chgr	Chelsfield Gravel Formation	Sandy flint-dominated gravel
	wggr	Westland Green Gravel	Sandy, clayey gravel
	sgao	Sand and gravel of uncertain age and origin	Sand and gravel

3.1 KEY TO GEOLOGICAL UNITS

Standard BGS map colours have been used for all units in the model. Figure 2 is the key to the superficial units, in the approximate stratigraphic order used in the model and listed in Table 1. This should be referred to when viewing images of the model in section 6.

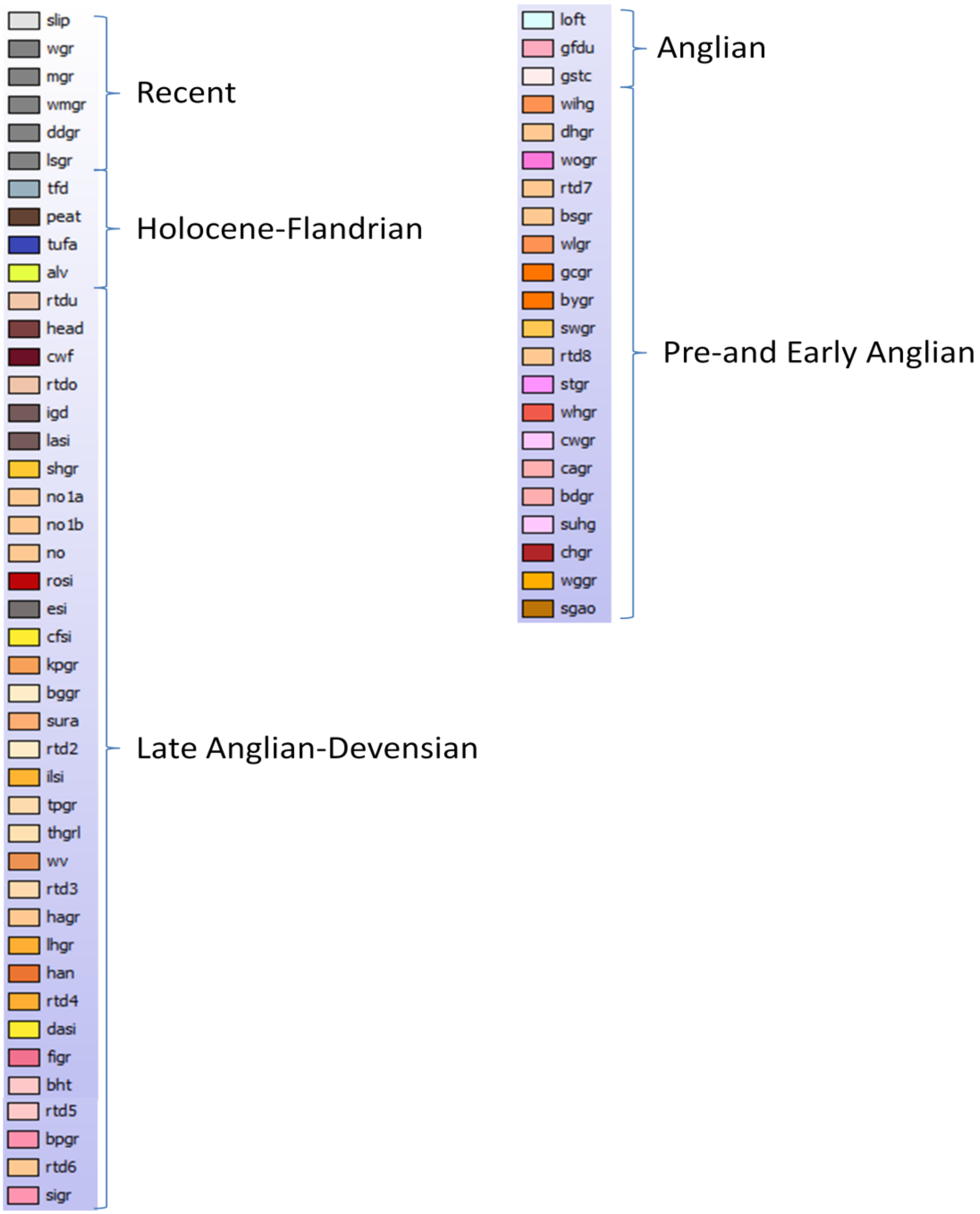


Figure 2 Key to geological units in the model

4 Model datasets

4.1 GEOLOGICAL MAP DATA

The model covers eight 1:50,000 scale England & Wales series geological map sheets: 254 (Henley-on-Thames), 255 (Beaconsfield), 256 (North London), 257 (Romford), 268 (Reading), 269 (Windsor), 270 (South London) and 271 (Dartford); with thin small portions of a further 14 1:50,000 scale map sheets: 238 (Aylesbury), 239 (Hertford), 240 (Epping), 241 (Chelmsford), 253 (Abingdon), 258-259 (Southend and Foulness), 267 (Hungerford and Newbury), 272 (Chatham), 283 (Andover), 284 (Basingstoke), 285 (Guildford), 286 (Reigate), 287 (Sevenoaks) and 288 (Maidstone). These 1:50,000 scale map sheet areas are named and their extents are shown in blue in Figure 3, with the Area 1-12 tiles outlined in red.

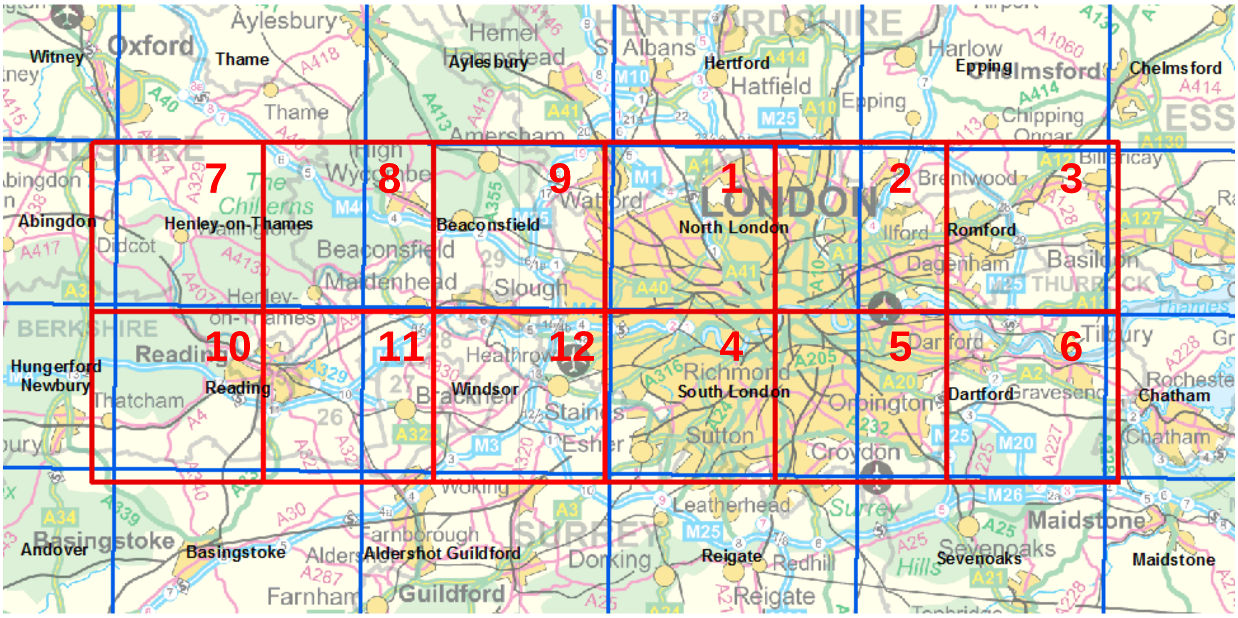


Figure 3 1:50,000 scale geological map sheets used in the model

DigMapGB-50 geology polygons were selected from the national DigMapGB-50 dataset with a buffer of 1-2 km for each tile using a GIS. Polygons that were split at 1:50,000 scale sheet boundaries were merged into a single polygon in the GSI3D project. The DigMapGB-50 extract was checked for inconsistencies, such as polygons terminating at sheet boundaries, which were addressed in the model. If the mapping/nomenclature on one 1:50,000 scale map sheet was more recent to that on an adjacent map, precedence was given to the more recent survey. This London Basin 3D model therefore supersedes the geology of the DigMapGB-50 version 6.

Because the model was constructed over a number of years, several versions of DigMapGB-50 were used. Table 2 lists the DigMapGB-50 version used for each model tile.

Table 2 List of DigMapGB-50 versions used in the model tiles

Area	DigMap version and date	Area	DigMap version and date	Area	DigMap version and date	Area	DigMap version and date
1	V3, 2006	4	V 3, 2006	7	V5, 2008	10	V5, 2008
2	V3, 2006	5	V3, 2006	8	V5, 2008	11	V5, 2008
3	V3, 2006	6	V3, 2006	9	V4, 2007	12	V5, 2008

4.2 BOREHOLES

Borehole information was downloaded from the BGS Intranet Data Portal, which automatically generates GSI3D-ready files. The *bid* file contains the location information of each borehole (easting, northing and start height) and the *blg* file holds the downhole information recorded in the BGS Borehole Geology (BoGe) database. Bid and blg files were downloaded on a tile by tile basis, on completion of additional borehole coding in preparation for the tile being modelled.

As the Intranet Data Portal retrieves every entry in the Borehole Geology database for a given borehole, the blg file contained duplicates where the same borehole had been coded for different purposes. For example, a borehole coded for the production of a national Rockhead (base of Quaternary) model may have been re-coded for use in the London Basin 3D model, but both interpretations appear in the BGS borehole geology database. To address this, the blg file was processed to remove multiple coding entries on a priority basis, using the Content Code (which indicates the purpose of coding) and the initials of the coder. The order of priority was revised for each model tile because different projects had carried out borehole coding in different areas

London Basin wide master bid and blg files incorporating the best available interpretation of the geology were produced, covering Areas 1-12 and beyond. These files also include some the reinterpreted borehole records coded in the recent, detailed HS2 route model, which crosses Areas 1 and 9. A separate metadata document details how these bid and blg files were assembled (*Metadata_Area1-22_BID-BLG_construction*).

4.3 DTM

All individual model tiles used a DTM in ASCII grid format, subsampled from the superseded 5 m resolution CEH DTM or the later, also superseded, 5 m NextMap DTM. These DTM extracts were downloaded via the BGS Intranet Data Portal and were converted to TINs within the GSI3D project to cap each model. Areas 1-6 used a DTM with a cell size of 25 m, and areas 8-12 were constructed using a 50 m DTM.

The combined model is capped by a BGS produced Bald Earth DTM with a 100 m cell size. This DTM is based on a NextMap DTM with an Ordnance Survey Landform Profile DTM inserted for extensive wooded areas as the NextMap DTM was not sufficiently reliable in these areas.

4.4 LEGACY 3D MODEL DATA

4.4.1 Thames Gateway models

Areas 2, 3, 5 and 6 overlap with the pre-existing LithoFrame 10 Thames Gateway 3D models (overlap shown as the blue hatched area in Figure 4). In Areas 2, 3, and 5, Thames Gateway model data was not incorporated into the London Basin model due to mismatches at the boundary.

In Area 6, Thames Gateway cross-sections and envelopes (unit coverages) were retained and extended to the edge of the tile, with the correlation lines reassessed, matched to the 1:50,000 scale mapping and previously completed London Basin tiles. The Thames Gateway cross-sections were simplified to fit the London Basin model, including the removal of subdivisions within the alluvium. Thames Gateway borehole coding was used throughout the overlap area between the two models, with decisions on whether to accept the borehole interpretations decided in context in the cross-sections.

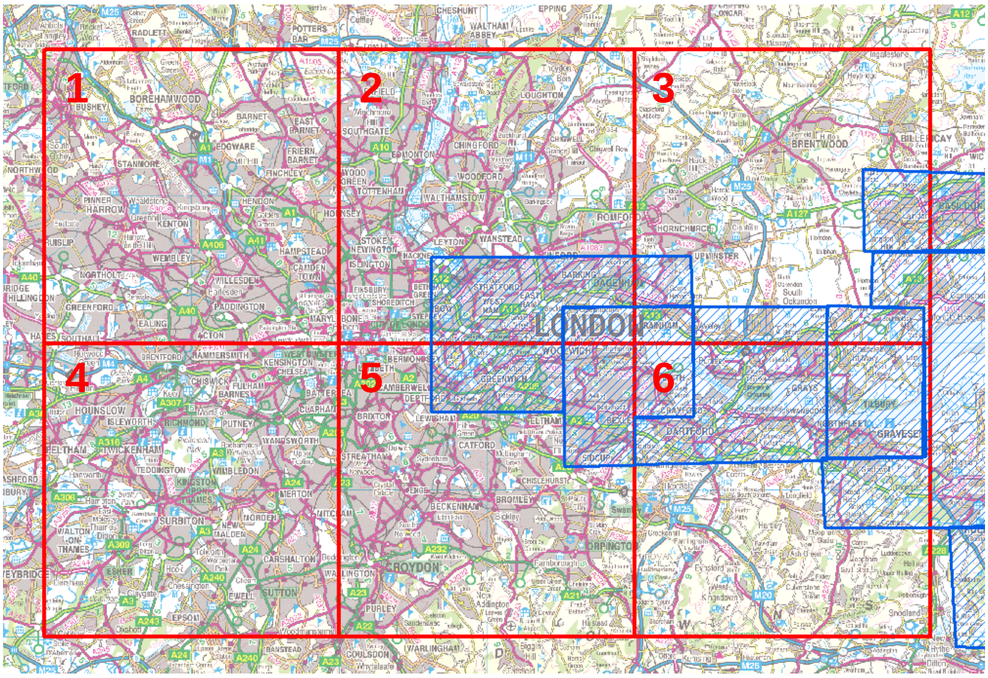


Figure 4 The Thames Gateway models, shown in blue hatching

4.4.2 HS2 route model

The 1:10,000 scale HS2 route model was commissioned by HS2 Ltd and adds more detail to the pre-existing London Basin LithoFrame 50 regional model. This involved a reinterpretation of borehole data within the HS2 project area (shown in blue shading in Figure 5), which was then incorporated into the London Basin combined borehole files. Extra cross-sections were added into the HS2 area, which were then incorporated into the London Basin regional model.

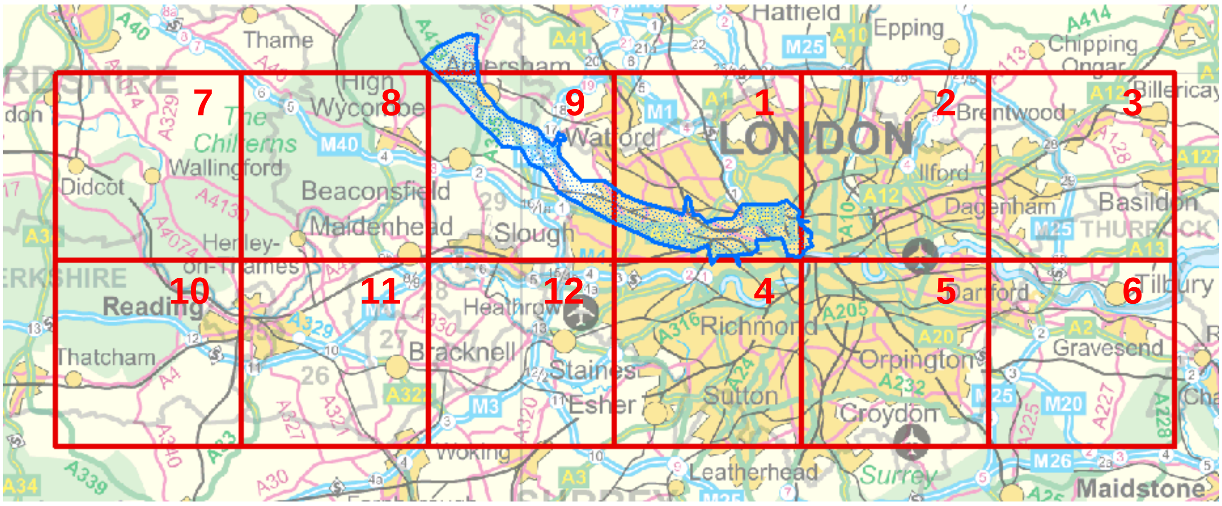


Figure 5 The LithoFrame 10 HS2 route model area, shown in blue stipple

In the HS2 route model, sand and gravel underlying alluvium is named Shepperton Gravel (shgr), corresponding with the geological maps, whereas, in the London Basin model, the sub-alluvial gravel is labelled as River Terrace Deposits Undifferentiated (rtdu).

The construction of the 3D model was carried out on a tile by tile basis by the geologists listed in Table 3. A Metadata diary recorded the modelling process for each individual tile, with this overall metadata summary document prepared for the combined model.

Table 3 Allocation of model construction work

Tile	Modeller	Start date	Completion date
Area 1	H Burke/S Mathers	2006	2008
Area 2	H Burke	2007	2008
Area 3	J Ford/H Burke	2006	2008
Area 4	S Mathers	2007	2007
Area 5	S Mathers	2007	2008
Area 6	J Ford/H Burke	2007	2008
Area 7	H Burke	2010	2011
Area 8	H Burke	2009	2011
Area 9	S Thorpe	2009	2011
Area 10	S Mathers	2009	2009
Area 11	S Mathers	2009	2009
Area 12	H Burke	2009	2010
Combined model	R Terrington	2012	2012

A standard GSI3D workflow (Kessler & Mathers 2004; Kessler, Mathers & Sobisch, 2009) was followed for constructing the cross-sections and geological unit distributions (outcrop and/or subcrop).

4.5 BOREHOLE CODING

7174 borehole logs were used in cross-section construction (Figure 6), comprising both confidential and open access borehole data, plus geotechnical boreholes that were absent from the BGS Single Onshore Borehole Index (SOBI). Using a GIS to ensure an even distribution of coded boreholes where possible, additional boreholes were selected for coding from the BGS Borehole Geology database to infill data poor areas. Selection criteria were drilled depth, borehole location and level of detail in the borehole log. Deeper boreholes were selected preferentially to constrain the deepest geological units, such as the top Chalk surface; and the borehole location was considered to ensure an even spread of borehole data across the project area. The quality of the logs themselves was also important. For example, a recently drilled borehole with a detailed log was selected preferentially over an old log conveying scant information. Old water wells were particularly difficult to use as they would often prove the depth of the top Chalk surface, but provide no information on the thickness or composition of overlying units (London Clay, superficial deposits etc.).

Boreholes were coded in the BGS Borehole Geology database using the content code 'LS' (London Strategic Model), which identifies coding specific to this project. To standardise the borehole coding, the superficial deposits coding scheme (Cooper et al. 2006) was used, where single letter codes represent the main lithologies (boulders are represented by the letter B, L is for cobbles, V for gravel, S for sand, C for clay, Z for silt and P for peat). For mixed compositions, the main lithology is coded first, with other lithologies added to the right in order of decreasing proportion. An example of how the codes can be applied to increasingly mixed lithologies is shown in Table 4. In this scheme, almost any combination of the letter codes is permissible.

Table 4 An example of the superficial deposits coding scheme

Clay	Silty clay	Sandy, silty clay	Gravelly, sandy, silty clay	Gravelly, sandy, silty clay with cobbles	Gravelly, sandy, silty clay with cobbles and boulders
C	CZ	CZS	CZSV	CZSVL	CZSVLB

Where a Borehole Geology database entry already existed for a borehole, it was not re-coded if the level of detail was sufficient for modelling. However, where a borehole only conveyed the depth of Rockhead, it was re-coded to maximise the data available for the 3D model. A selection of borehole logs were coded in areas with a high borehole density because of the sheer number of them, and only the deepest or most detailed logs were selected for coding where clusters occurred.

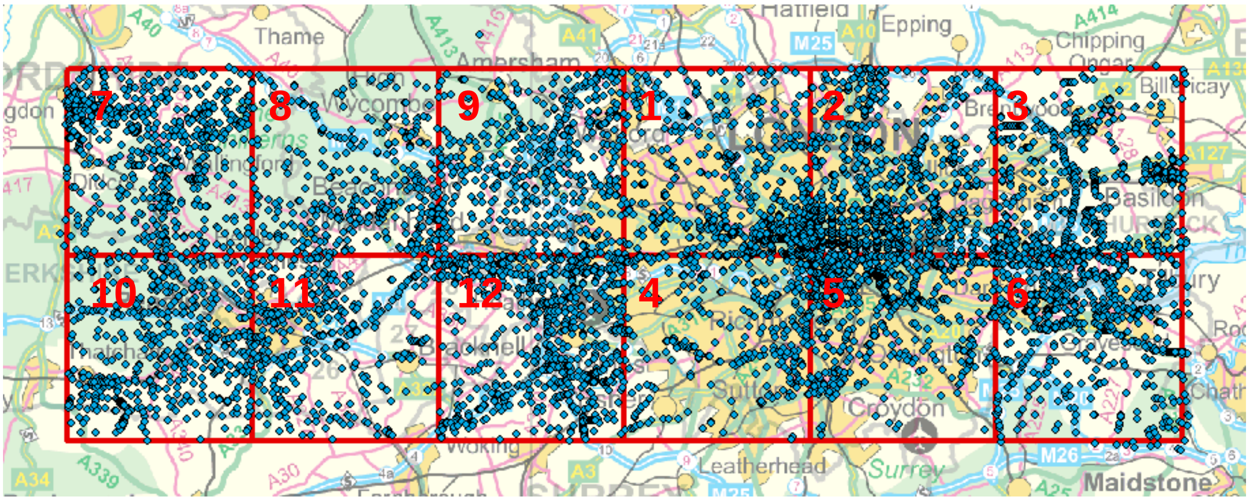


Figure 6 Location of borehole logs used in model construction

4.6 DATA COLLATION

A GSI3D project workspace was set up for each of the Area 1-12 tiles, which only contained data relevant to that particular area. This included clipped national DigMapGB-50 polygon data, a DTM with a cell size of 25 m to cap the model, and the relevant borehole data. The boreholes, DTM and DigMapGB-50 polygons were buffered to include data from slightly outside the project area. This buffered area helped constrain the depth of geological units in the absence of data at the edge of a tile.

4.7 CROSS SECTION CONSTRUCTION

A framework of 922 cross-sections was constructed in the modelled area (Figure 7). This includes helper sections, added to aid the calculation of particular units. Helper sections are especially needed along the length of alluvium and through polygons that fall between sections to provide extra depth constraint during calculation. On completion of a tile, docking sections were constructed along all the bounding grid lines, which were used as a starting point when work began on modelling the adjacent tile.

If the borehole evidence in Area 2, for example, contradicted the modelled geology in the docking section from the adjacent Area 1 tile, the docking section was adjusted in the Area 2 project workspace and returned to the Area 1 model, which then required reassessment. In some cases several stages of iteration were required before the two model tiles were forced to be compatible with a single shared docking section.

For guidance, the 1:50,000 scale geological map polygons were rendered to the DTM and displayed during section construction. However, where borehole evidence contradicted the mapped linework, precedence was given to the borehole. During borehole coding for the project, the borehole start height was entered when recorded on the log, or taken from the DTM in the absence of a start height. Thus, true borehole start heights were honoured where possible during cross-section construction.

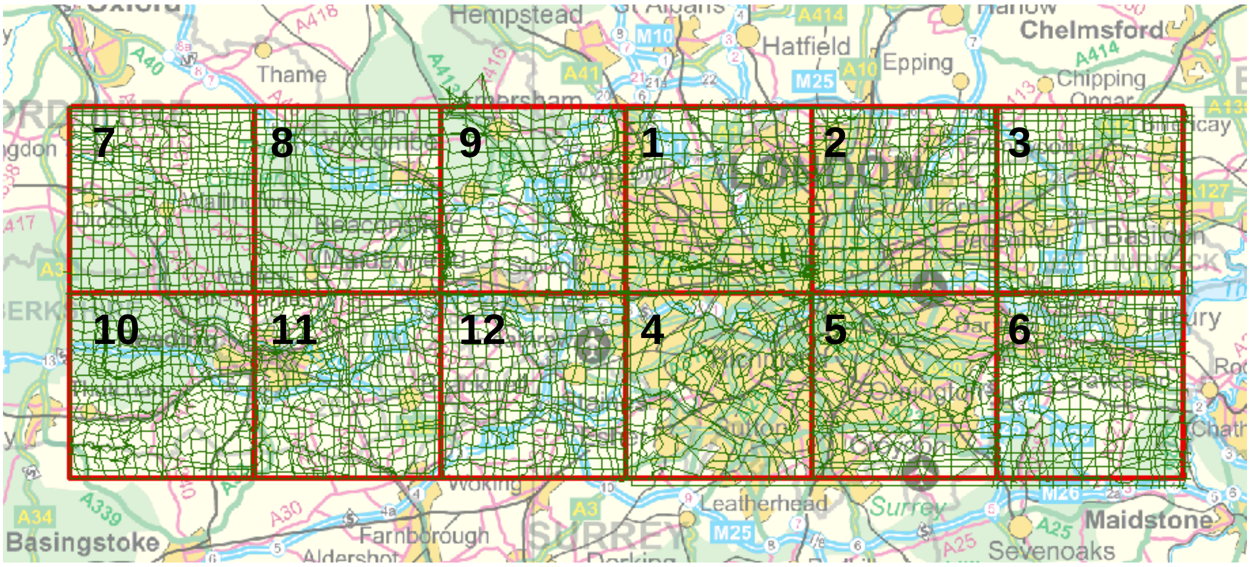


Figure 7 Framework of cross-sections used to construct the model

4.8 ENVELOPE CONSTRUCTION

When the cross-sections for a particular tile were completed, the envelopes (coverages) of each geological unit were added, starting with the youngest and progressing through to the oldest. DigMapGB-50 polygons were used to delineate the outcrop extent of the geological units, and where necessary, were combined with the subcrop as defined by the cross-sections. Using borehole evidence, some DigMapGB-50 polygons were modified in the model tiles.

4.9 ARTIFICIAL GROUND CAPTURE

Artificial ground was mapped on some 1:50,000 scale map sheets in the model area, but not others. To address these inconsistencies across the modelled area a GIS-based desk study was carried out to identify instances of artificial ground that were not originally in DigMapGB-50 or -10. This involved examining modern 1:10,000 scale topographic maps for areas where the ground surface has been artificially modified, such as embankments and cuttings along transport routes, reservoirs, etc. At the same time, the existing DigMap artificial ground data was validated, such as identifying mismatches across original map sheet boundaries, which were corrected in the GIS before being added to the 3D model. Artificial Ground is excluded from the model calculation because, although it has a coverage, no additional cross-sections were constructed to constrain the base of artificial ground polygons that fall between the sections. At present, this updated artificial ground information has not been incorporated into DigMapGB-50.

4.10 COMBINING THE TILES

To create the Areas 1-12 model, all envelopes from each tile were exported as polygon shape files using the ArcGIS tools for GSI3D. A single shape file was then created for each geological unit using the ArcGIS *merge* tool on polygons with the same model code/stratigraphy (e.g. merge all ‘alv’ polygons). Next, the *dissolve* function was used to remove any overlaps in each unit to make a continuous polygon. All cross-sections from the modelled areas were then loaded into an empty GSI3D project and the newly merged/dissolved geological unit shape files were imported into their corresponding *geological unit*.

Several checks were carried out at this stage, such as ensuring that only one version of each cross-section was loaded into the GSI3D project, and sections with the same name were verified to avoid duplicates. Particular attention was paid to the original area boundaries, where duplicate versions of docking sections were removed if they occurred in more than one tile. The imported polygon shape file for each unit’s distribution was also checked to ensure that ‘holes’ within polygons had been preserved following GIS processing. The polygon data was also checked for inconsistencies at area boundaries, such as thin slivers and straight edges.

The 25m DTM files used in the original model tiles are far too large for the Areas 1-12 combined model to process. Therefore, a more generalised DTM with a 100m cell size was used.

Once calculated, the surfaces generated for the Areas 1-12 model were checked for artefacts, especially along docking sections between adjoining tiles. These inconsistencies were addressed by checking the boreholes either side of the docking sections and editing the correlation lines in the affected cross-sections.

4.11 MODEL PROJECT FILES

The latest version of the Areas 1-12 combined superficial model is *LL50k_Area1_to_12_v39.gsipr.*

4.12 GVS

A regional GVS (stratigraphic sequence file) was used for all individual model tiles and the Area 1-12 combined model for continuity. The ‘London’ GVS was based on the pre-existing Thames Gateway GVS, but was adapted to generalise the level of detail, particularly in the alluvium. The code Alvg (an abbreviation of alluvium general) was used in the London GVS to define the base of all alluvium deposits, whereas the Thames Gateway model separated out individual peat horizons and intervening silt and clay layers, these were not included in the Areas 1-12 model.

Progressive versions of the GVS were created when new geological units were added as they were encountered with the expansion of the modelled area. On completion of the model, a new GVS was created that lists only the artificial and superficial geological units used in the model. The revised GVS used in the model is named *Areas1_12_Quaternary_GVS.*

4.13 GLEG

As with the London GVS, the London legend file applies to the region as a whole, and is also based on the Thames Gateway gleg. To match the geological map sheets, the DigMapGB-50 colours were used in the London gleg. A legend file specifically for the superficial model was created, named *Areas1_12_Quaternary_GLEG*.

4.14 ATTRIBUTION

Each geological unit in the model is attributed with stratigraphy, lithology and age, but the stratigraphy was the basis for modelling.

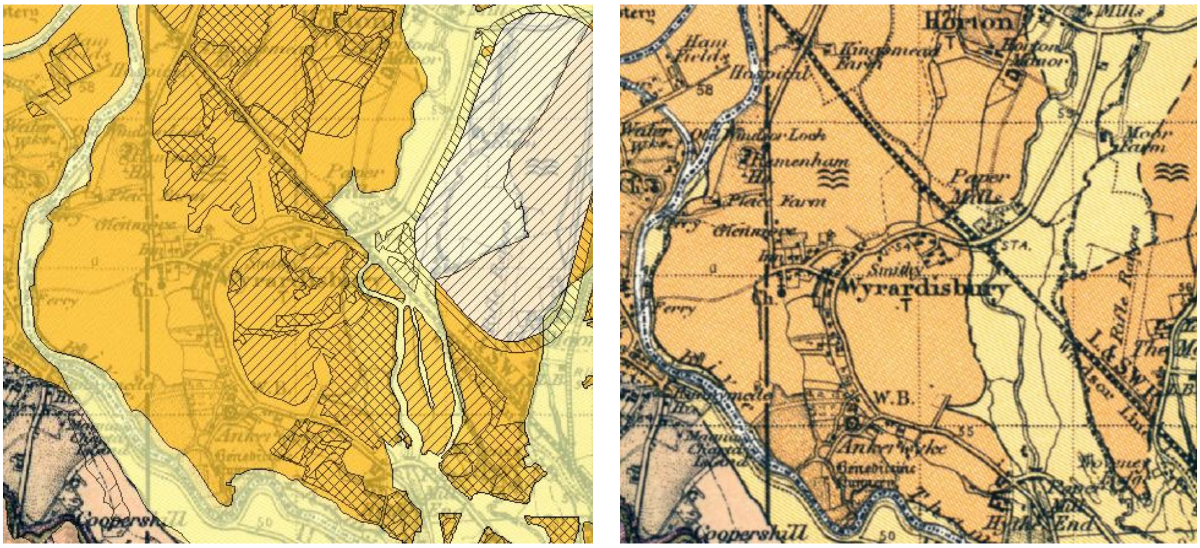
5 Model assumptions, geological rules and limitations

5.1 ASSUMPTIONS AND RULES

Wherever possible, this model matches the corresponding 1:50,000 scale geological map sheets. However, where mismatches occurred between boreholes and the geological mapping along cross-sections, the borehole was used in preference to the map polygons. Therefore, the vast majority of the model matches DigMapGB-50, but with minor amendments, these have not been carried over into an updated DigMapGB-50 version at this stage.

The artificial ground layer was updated specifically for the model and has not been incorporated DigMapGB-50 at present. This was carried out as a desk study using modern Ordnance Survey topographic maps and aerial photographs for the model area, with priority given to cuttings and embankments along major transport routes. Backfilled workings were not included, unless indicated on the published maps.

River Terrace Deposits Undivided (rtdu) were modelled where a sand and gravel deposit was proven beneath alluvium. Having a similar extent to the alluvium, the code rtdu was used to distinguish between sub-alluvial river terrace gravel and named or numbered terrace units that crop out at the surface. The code rtdu was also used in areas of gravel extraction where the gravel that originally lay beneath the alluvium was not completely worked out; often this deposit appears as Shepperton Gravel (shgr) on the published geological maps. In Area 12, for example, the Thames floodplain has been modified to such an extent that it was almost impossible to ascertain the original edge of the alluvium (Figure 8a). The 1901-2 Drift edition of One Inch scale geological map sheet 169 pre-dates the sand and gravel workings and shows the original extent of alluvium (Figure 8b). This was scanned, geo-referenced, and imported into the Area 12 GSI3D workspace for guidance in cross-section and envelope construction.



(a) DigMapGB-50 Artificial and Superficial (b) New Series One Inch Drift map sheet 269

Figure 8 Modification of the floodplain through sand and gravel extraction

The model sections include bedrock units, but these are excluded from the calculation of the superficial model.

5.2 MODEL LIMITATIONS

Whilst every effort was made to ensure accuracy, as the model was constructed using a framework of cross-sections according to standard GSI3D workflow and procedures, not every available borehole was used in the model. Some variation may therefore occur between the depth of units modelled and depths recorded in boreholes that fall between sections.

Where mismatches occurred at 1:50,000 scale geological sheet boundaries, precedence was given to the most recently mapped sheet, with older linework matched to the newer edition. For example, a polygon of Head with an artificial cut-off at a sheet boundary was carried over onto the adjacent sheet if the Head deposit was present on a more recently revised map. Current BGS LEXICON codes were used where the most recent edition of a map used old nomenclature.

Artificial ground, mass movement deposits (slip), tufa and head were drawn in cross-sections but have been excluded from the final model calculation because sections provide insufficient information to calculate these units due to their distribution, size and shape.

As noted earlier, the bedrock geology is present in cross-sections, but is excluded from the calculated model

This model is intended for use at around 1:50,000 resolution, in line with the corresponding DigMapGB-50 geological map data, and is not recommended for site specific use.

6 Model images

Figures 9 through to 11 are 3D views of the fully calculated model. Figure 9 shows all the units modelled, Figure 10 shows just the post-Anglian units and Figure 11 focuses on the pre-Anglian units, the alluvium is displayed in each for geographic orientation. The legend is as in Figure 2.

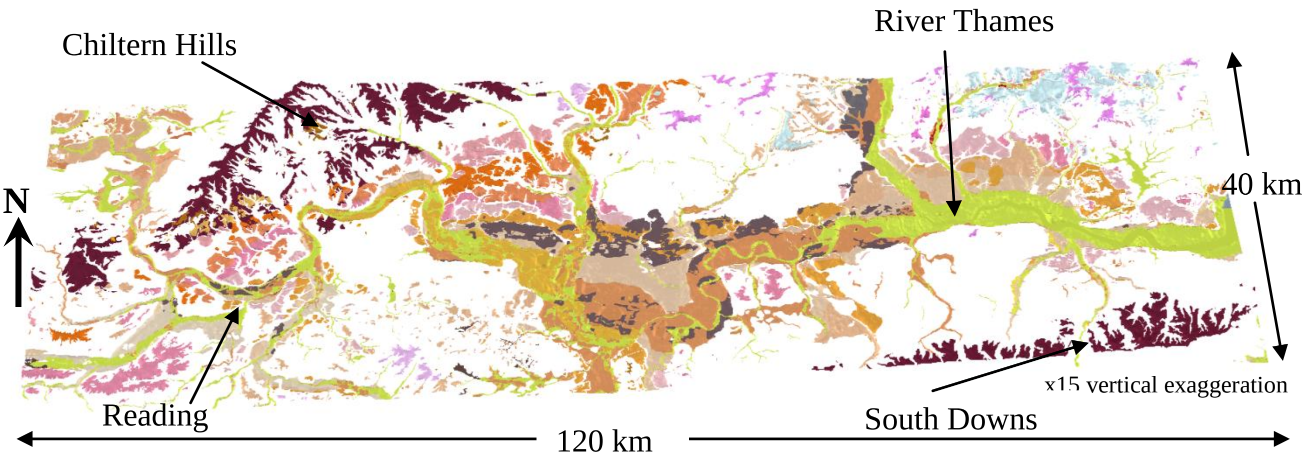


Figure 9 3D view of the model, looking north

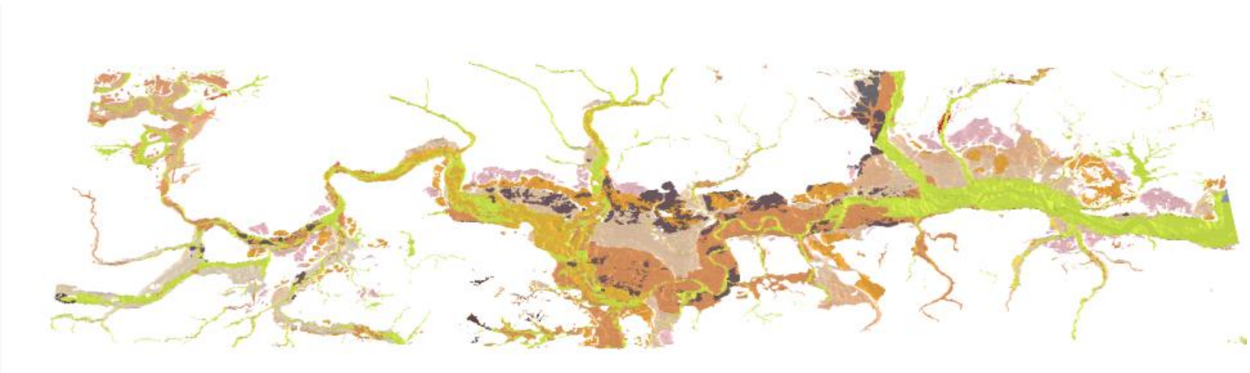


Figure 10 3D view of late and post-Anglian river terraces and overbank deposits

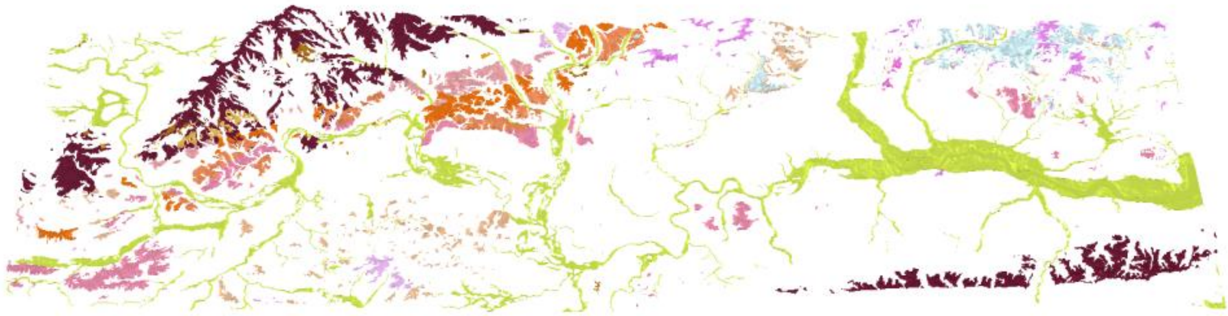


Figure 11 3D view of Anglian and pre-Anglian deposits (alluvium shown for spatial reference only)

7 Rockhead elevation model

A rockhead surface was derived from the combined base of all the modelled units (excluding head, artificial deposits and landslips). In areas where superficial deposits were absent or excluded, the rockhead surface corresponds to the DTM. This rockhead surface will form a cap for the upcoming bedrock version of the Areas 1-12 model.

A 3D view of the 100 m cell size rockhead surface is displayed in Figure 12, represented as contour lines with a 2m interval. This clearly shows the considerable incision along river valleys and the broad flat floodplains.

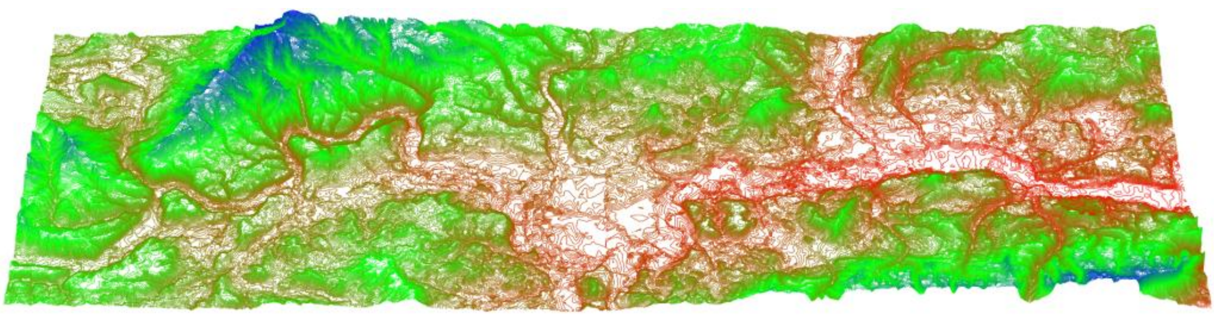


Figure 12 3D view of the calculated rockhead surface contour plot the highest contours are in blue, the lowest in red

8 Uncertainty

The fence diagram is not easy to assess for uncertainty because the borehole data, reference material and geological knowledge that went into the model are difficult to represent. The borehole data used in the model is displayed in Figure 6. However, whilst showing the distribution of boreholes, it does not convey the depth of the borehole, the quality of the log itself or the quality of the borehole coding.

9 Amending the combined model

The London Basin Areas 1-12 superficial model supersedes the individual Area 1 to 12 model tiles and includes additional cross-sections created for the HS2 project. The bedrock correlation lines in the London Basin model sections have been amended to fit the HS2 model in the area of overlap between the two models. However, the superficial correlation remains unchanged.

Glossary

BGS LEXICON	The Lexicon of Named Rock Units is a list of geological units that appear on all BGS geological maps, with details on their lithologies. This is accessible via the BGS website at: http://www.bgs.ac.uk/Lexicon
Bid file	GSI3D borehole file derived from the SOBI database (see below), which stores the locations of boreholes as eastings, northings and start heights
Blg file	GSI3D borehole file, which stores the interpretation downloaded from the Borehole Geology database
BoGe	BGS Borehole Geology database for the standardised entry of data recorded on borehole logs
DigMapGB-50	Digital 1:50,000 geological map data
DTM	Digital Terrain Model – a model of surface of the solid Earth (generally the boundary between geosphere and atmosphere or hydrosphere). This is traditionally derived from OS contours and spot heights and should therefore exclude all buildings, trees, hedges, crops, animals etc. Sometimes also referred to as 'bald earth' models
Envelope	Defined here as the extent, or coverage, of a geological unit in plan view, forming a 2D distribution map of the particular unit, or presence/absence map
Fence Diagram	The completed framework of cross-sections
GDI	Geoscience Data Index, an ArcGIS platform for displaying BGS data, including boreholes, with links to scans, and geological map polygons
Georeferenced	ArcGIS process where a scanned image is registered to British National Grid
GOCAD	3d geological modelling package utilised mainly for bedrock modelling. GoCad Consortium web site: http://www.gocad.org/w4/index.php/consortium/consortium
GSI3D	Geological Surveying and Investigation in 3D, a geoscience modelling software package. GSI3D Research Consortium web site: http://www.gsi3d.org.uk
SOBI	Single Onshore Borehole Index, a database where location details of borehole logs are stored, giving positional information in x, y and z with respect to British National Grid
TIN	Triangular Irregular Network – a digital elevation surface with triangle-shaped cells, rather than grid squares

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