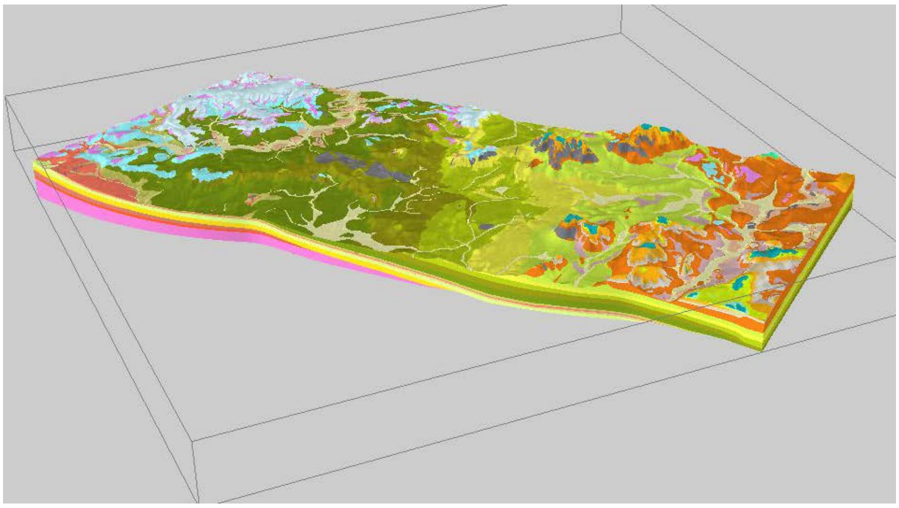
Model metadata report for HS2 Area 2 (Aylesbury to Newton Purcell)

Geology and Regional Geophysics Programme
Open Report OR/16/003



BRITISH GEOLOGICAL SURVEY

GEOLOGY AND REGIONAL GEOPHYSICS PROGRAMME

OPEN REPORT OR/16/003

Model metadata report for HS2 Area 2 (Aylesbury to Newton Purcell)

C Cripps

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Metadata report; High Speed 2; HS2; Area 2; 3D Model.

Front cover

View of the HS2 Area 2 3D Model looking from the SW corner

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Summary

This report describes the 3D geological model of HS2 (High Speed 2 rail link) Area 2 (Aylesbury to Newton Purcell), created by C. Cripps with support from S. Thorpe. The model was created as part of a set of nine geological models that cover the proposed HS2 rail route from the end of the HS2 London model to Birmingham and the West Coast Main Line near Lichfield. The models were funded from the NERC/BGS Science Budget to promote BGS modelling and geological interpretation services to this important infrastructure project and to test methodologies and procedures for creating geological models by multiple compilers.

The report describes the model construction and purpose, with spatial limits and scale, sources of information, data processing, workflow, decisions, assumptions, rules and limitations, together with images of the model.

1 Modelled Volume, Purpose and Scale

The model purpose was to model the bedrock, superficial, mass movement and artificial ground following the proposed High Speed Rail link between London and Birmingham (HS2). The model area covers a 25km section of the route from Aylesbury in the southeast to Newton Purcell in the northwest and 5km either side of the route (Figure 1). The bedrock geology of the model area comprises strata of Lower Jurassic to Lower Cretaceous in age. In addition, superficial deposits were modelled, which are glacigenic and fluvial in origin. This is one of an initial group of nine models along the planned route. Area 1 to the south-east was modelled by Dr A Farrant and Area 3 to the north-west was modelled by A J M Barron. All of these models have been matched to ensure integrity across the project as a whole. This model is suitable for use at scales between 1:100,000 and 1:10,000 to a depth of 30 m below Ordnance Datum (OD).

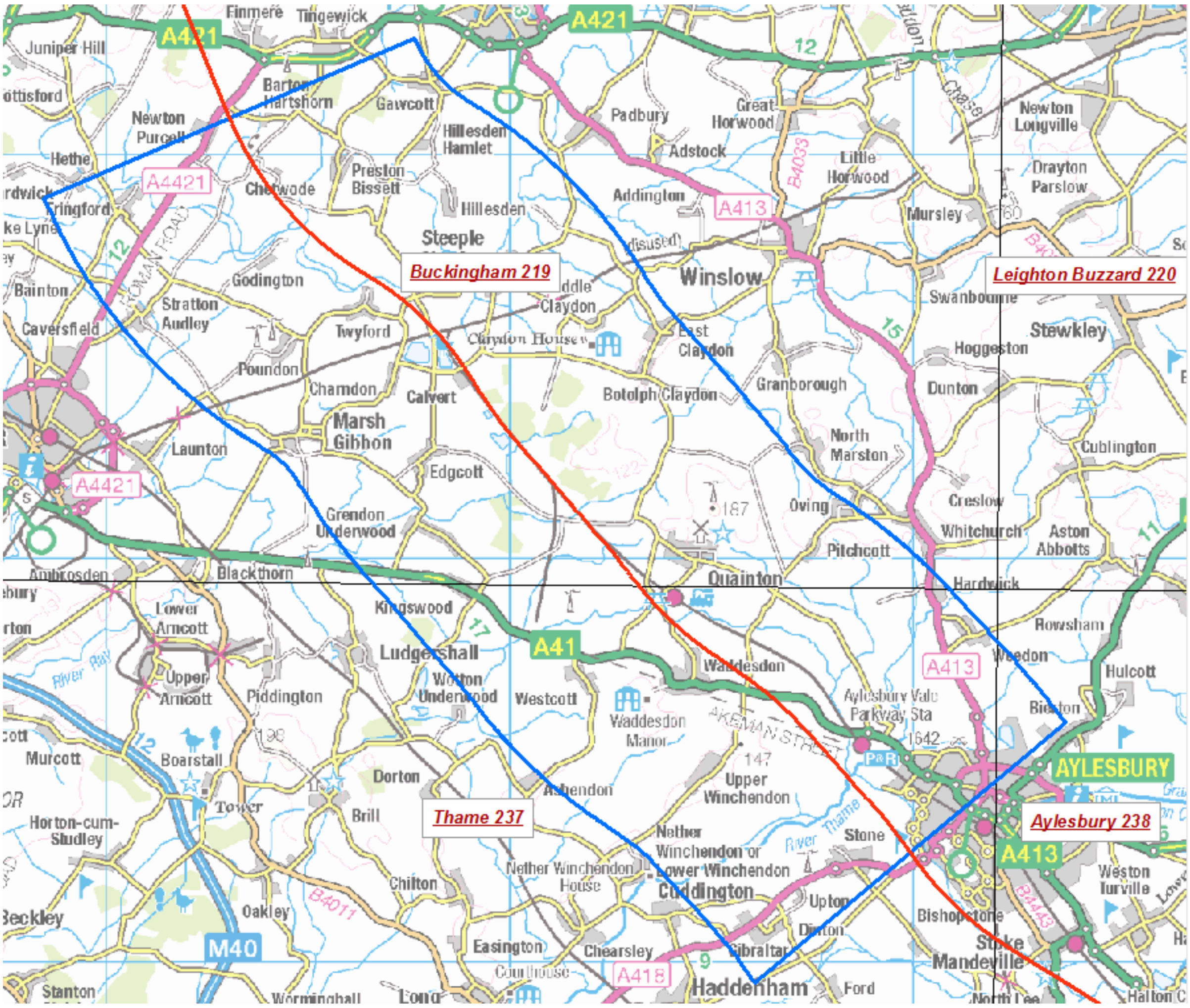

Figure 1. Location of the model area outlined in blue, proposed route shown in red. 1:50,000 scale geological map sheet areas shown by black outlines and red labels. Contains Ordnance Survey data © Crown copyright and database rights 2014.

2 Modelled Surfaces/Volumes

The modelled bedrock, superficial, artificial and landslip deposits are listed in Table 1 in the relative stratigraphic order used in the model. Brief descriptions of the geological units are given here, but more detail can be found in the BGS Lexicon of Named Rock Units. The level of detail and extent of the natural geology in the model may differ from that shown in other BGS datasets.

Artificial ground and landslips were modelled according to the corresponding 1:50,000 scale geological maps. Table 1 should be used as the legend for viewing images of the model in this report.

Table 1 List of geological units modelled

LEX-RCS code	Lex Description	Composition
WMGR-ARTDP	Worked and Made Ground	Variable
MGR-ARTDP	Made Ground	Variable
WGR-VOID	Worked Ground	Variable
LSGR-UKNOWN	Landscaped Ground	Variable
DDGR-UKNOWN	Disturbed Ground	Variable
SLIP-UKNOWN	Landslip Deposits	Variable
ALV-XCZSV	Alluvium	Clay, silt, sand and gravel
HEAD-XCZSV	Head	Clay, silt, sand and gravel
PEAT-P	Peat	Peat
RTD1-XSV	River Terrace Deposits, 1	Sand and gravel
RTD2-XSV	River Terrace Deposits, 2	Sand and gravel
RTD3-XSV	River Terrace Deposits, 3	Sand and gravel
RTDU-XSV	River Terrace Deposits (Undifferentiated)	Sand and gravel
TUFA-CATUFA	Tufa	Calcareous tufa
GFDMP1-XSV	Glaciofluvial Deposits, Mid Pleistocene (added For Area2 Buckingham Sheet)	Sand and gravel
TILMP1-DMTN	Till, Mid Pleistocene (added For Area2 Buckingham Sheet)	Till
GFDMP-XSV	Glaciofluvial Deposits, Mid Pleistocene	Till
TILMP-DMTN	Till, Mid Pleistocene	Till
LOFT-DMTN	Lowestoft Formation	Till
GDU-XCZS	Glacial Deposits	Clay, silt and sand
GLT-MDST	Gault Formation	Mudstone
LGS-SDST	Lower Greensand Group	Sandstone
WHS-SDST	Whitchurch Sand Formation; Sandstone	Sandstone
WHS-MDST	Whitchurch Sand Formation; Mudstone	Mudstone
PB-LMAR	Purbeck Group	Interbedded limestone and argillaceous rocks
POST-LMST	Portland Stone Formation; Limestone	Limestone
POSA-LMCS	Portland Sand Formation	Limestone and calcareous sandstone
POSA-CALSST	Portland Sand Formation	Calcareous sandstone
PL-LMCS	Portland Group	Limestone and calcareous sandstone
KC-SISD	Kimmeridge Clay Formation	Siltstone and sandstone
KC-MDST	Kimmeridge Clay Formation	Mudstone
AMC-MDST	Ampthill Clay Formation	Mudstone
WWB-MDST	West Walton Formation	Mudstone
WEY-MDST	Weymouth Member	Mudstone
SBY-MDST	Stewartby Member	Mudstone
PET-MDST	Peterborough Member	Mudstone
KLB-SDSM	Kellaways Formation (includes Kellaways Sand Member)	Siltstone and sandstone with subordinate mudstone
CB-LMST	Cornbrash Formation	Limestone
FMB-LSMD	Forest Marble Formation	Interbedded limestone and mudstone
WHL-LMST	White Limestone Formation	Limestone
GOG-LMAS	Great Oolite Group	Interbedded limestone, argillaceous rocks and subordinate sandstone
NS-SDLI	Northampton Sand Formation	Sandstone, limestone and ironstone
WHM-MDST	Whitby Mudstone Formation	Mudstone
MRB-FLIR	Marlstone Rock Formation	Ferruginous limestone and Ironstone
DYS-SIMD	Dyrham Formation	Interbedded siltstone and mudstone
CHAM-MDST	Charmouth Mudstone Formation	Mudstone

3 Modelled Faults

A number of mapped geological faults occur in the Area 2 model area, which are modelled with less than 10m of vertical displacement. These normal faults are modelled as steps in the bases of the affected geological units. Several of these fault traces occur the south of the model area at Dinton. Cross-section *HS2_Area2_Rung1_SW_NE_CCRIPPS* runs approximately perpendicular to two mapped faults in this area, which are modelled as steps in the geological unit bases (Figure 2).

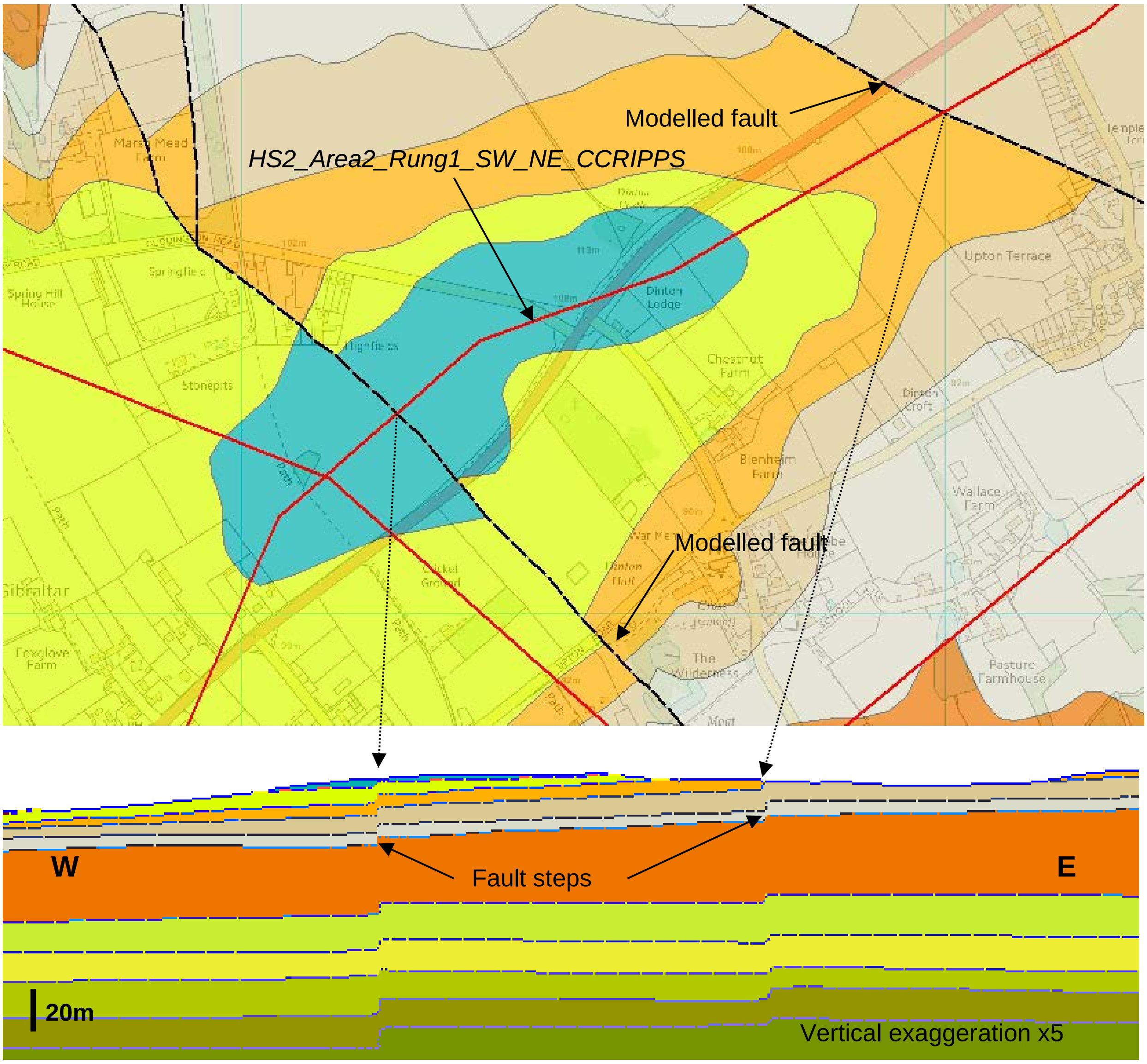

Figure 2. An example of fault modelling in map view (top) and cross-section (bottom). Cross-sections are shown as red lines in the map, faults are dashed black lines. Key to geological units as per Table 1. Contains Ordnance Survey data © Crown copyright and database rights 2014. 1km grid squares shown.

4 Model Workflow

The standard GSI3D modelling workflow was followed for this project. GSI3D software utilises a range of data such as boreholes, digital terrain models (DTM) and geological linework to enable the geologist to construct a series of interlocking cross-sections. Borehole data is represented in GSI3D by two proprietary files: a borehole identification file (.bid), that contains 'index'-level information including location and start-heights; a borehole log file (.blg), that contains the borehole interpretation. Constructing cross-sections is intuitive and flexible, combining borehole and outcrop data with the geologist's experience to refine the interpretation.

Using both the information from the cross-sections and the distribution of each unit a calculation algorithm creates the triangulated surfaces for the top and base of each unit. In order to control the relative vertical ordering of the calculation, a generalised vertical section file (.gvs) is established. A proprietary legend file (.gleg) is created to control symbolisation of the cross-section and model. The modeller can view all the units in 3D and iteratively return to the cross-section to make amendments or add further cross-sections to refine the model. This process is a standard methodology within BGS for modelling Quaternary and simple bedrock horizons and is fully documented in Kessler *et al* (2009).

5 Model Datasets

5.1 GVS AND GLEG FILES

The generalised vertical section (.gvs) and geological legend (.gleg) files were assembled using Notepad or Excel and iterated as the model expanded and new units were encountered. The GVS was based on DiGMapGB-50 data by identifying all those geological units that are within a 5km area of the HS2 route. However some units occur only in subcrop, so additional units in the GVS had to be appended as modelling progressed. The GLEG files were created using the standard BGS colours from DigMap-50. Overall GVS and GLEG files were created for the whole HS2 route, rather than for each individual model area. Thus the units used in this model are only a subset of those available in the overall HS2 GVS file.

5.2 GEOLOGICAL LINEWORK

The majority of the model area is covered by 1:50 000 scale map sheets 219 (Buckingham) and 237 (Thame), with the south-east corner covered by sheet 238 (Aylesbury) (Figure 1). The entire model uses DiGMap 1:50 000 scale map data due to the lack of more detailed 1:10 000 scale geological mapping in the majority of the model area (Figures 3 and 4).

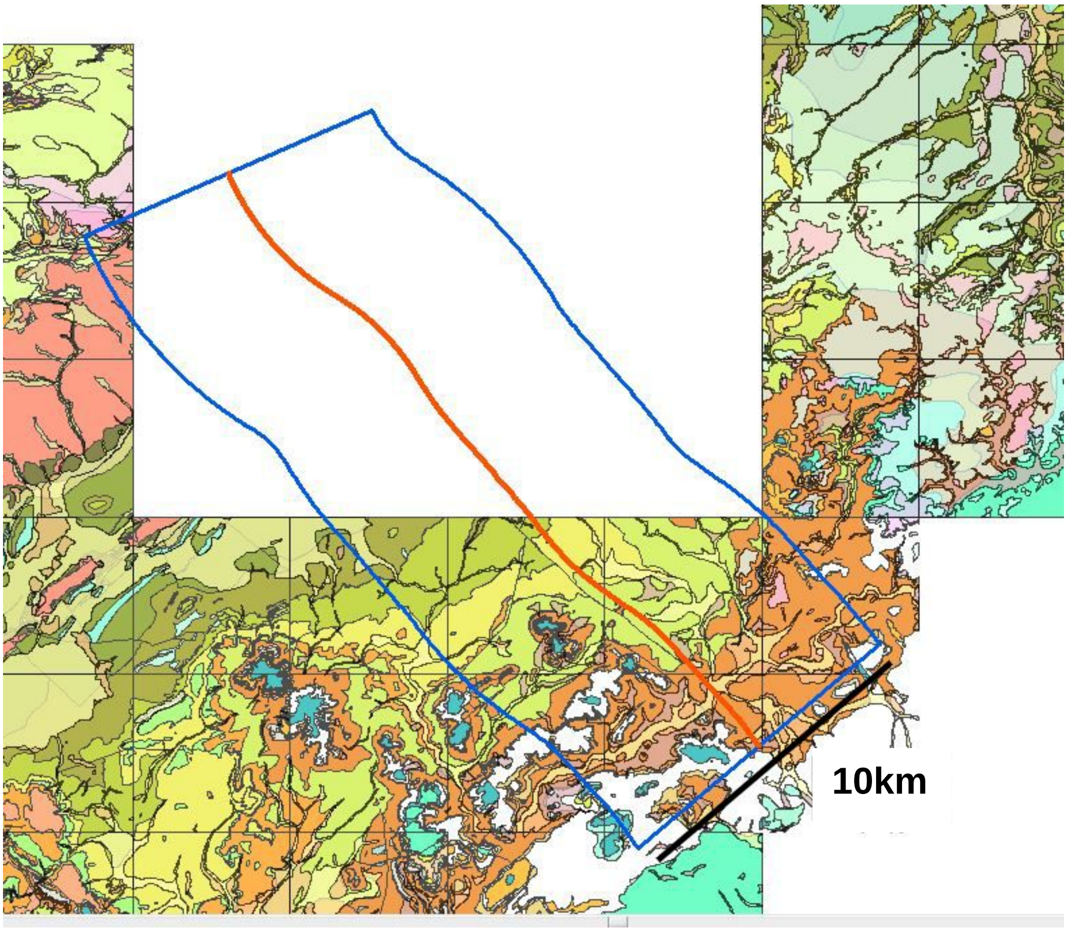

Figure 3. 1:10 000 scale geological linework coverage. Area 2 in blue, HS2 route in red

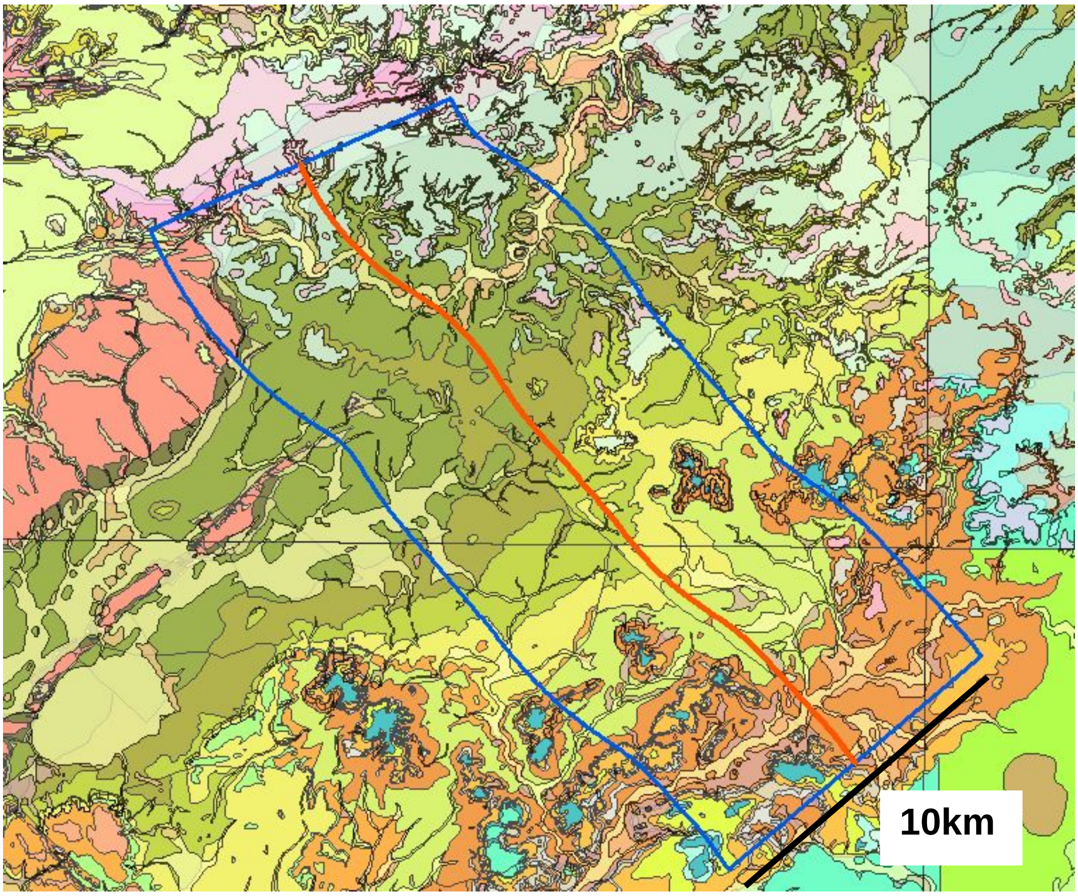

Figure 4. 1:50 000 scale geological linework coverage. Area 2 in blue, HS2 route in red

5.3 DIGITAL TERRAIN MODEL

The terrain model used in this model was the BGS Bald Earth 20 m DTM obtained from the BaldEarth model and trimmed to the project area (5 km buffer of the route shapefile). A NextMap DTM was also included, but not used for modelling.

5.4 BOREHOLE DATA

Borehole records examined included both Keyworth and Wallingford held logs. Closely clustered sets of boreholes were not all coded but the deepest and most representative were included. Any significant local variation in sequence was also recorded by coding. Entries were all made directly into the corporate BGS *Borehole Geology* database (BoGe). However, many of the boreholes were either very shallow and thus did not provide any data on the bedrock geology, or did not contain sufficient information to be coded in any meaningful way.

After borehole coding was completed, the boreholes were extracted from the BGS *Single Onshore Borehole Index* (SOBI) database using a set of queries. The borehole log file (.blg) needed to be deduplicated and a borehole filter tool was used to address this. A set of priorities were applied to borehole records that were coded by more than one project. Figure 6 shows the distribution of the boreholes that were coded, represented by pink stars. A total of 729 boreholes were considered, 81 of which were already coded, and an additional 77 that were coded for this project (Figure 5).

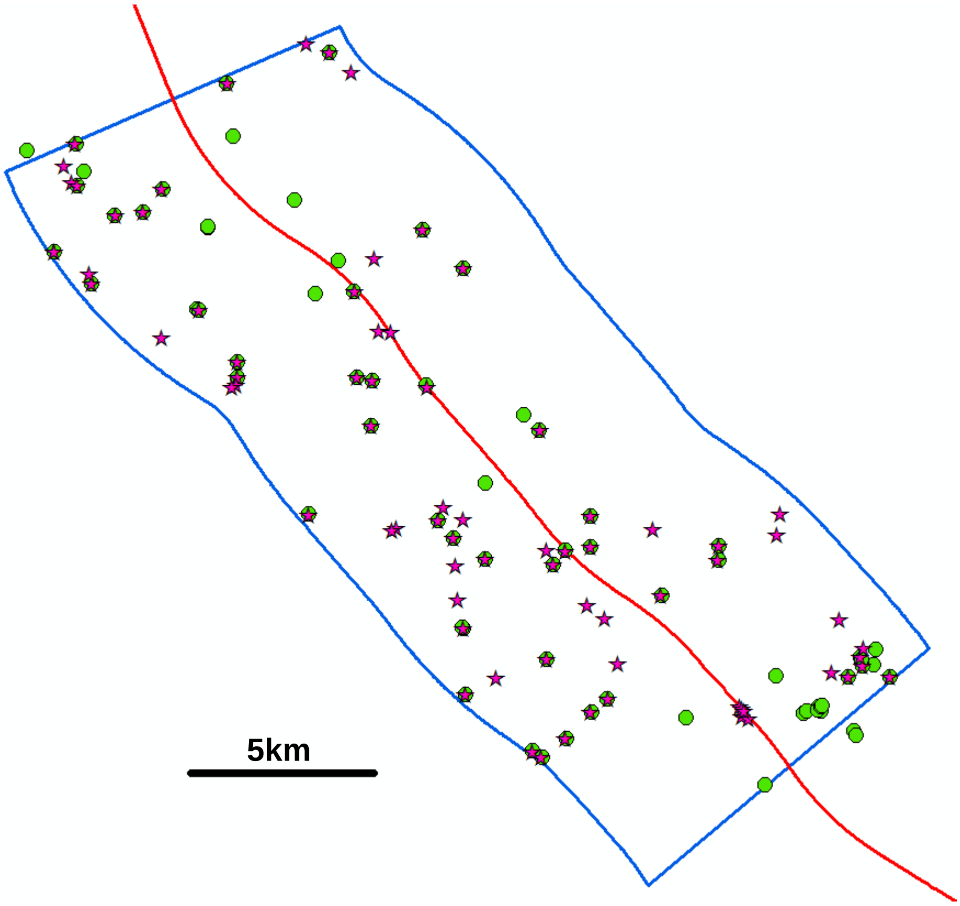

Figure 5. Distribution of boreholes used in the HS2 Area 2 model (green dots). Pink stars represent boreholes coded by the modeller/report author. Model area outlined in blue, proposed HS2 route shown in red.

5.5 RASTER IMAGES

A cross section illustrated on the printed Buckingham 1:50,000 scale geological map sheet was imported into the 3D modelling software and lines of correlation were digitised from it. Named *HS2_Area2_Helper_15_NW-SE_CCRIPPS* in the model, the trace of this cross-section is shown as a blue line Figure 6 with the the cross-section image and correlated lines underneath.

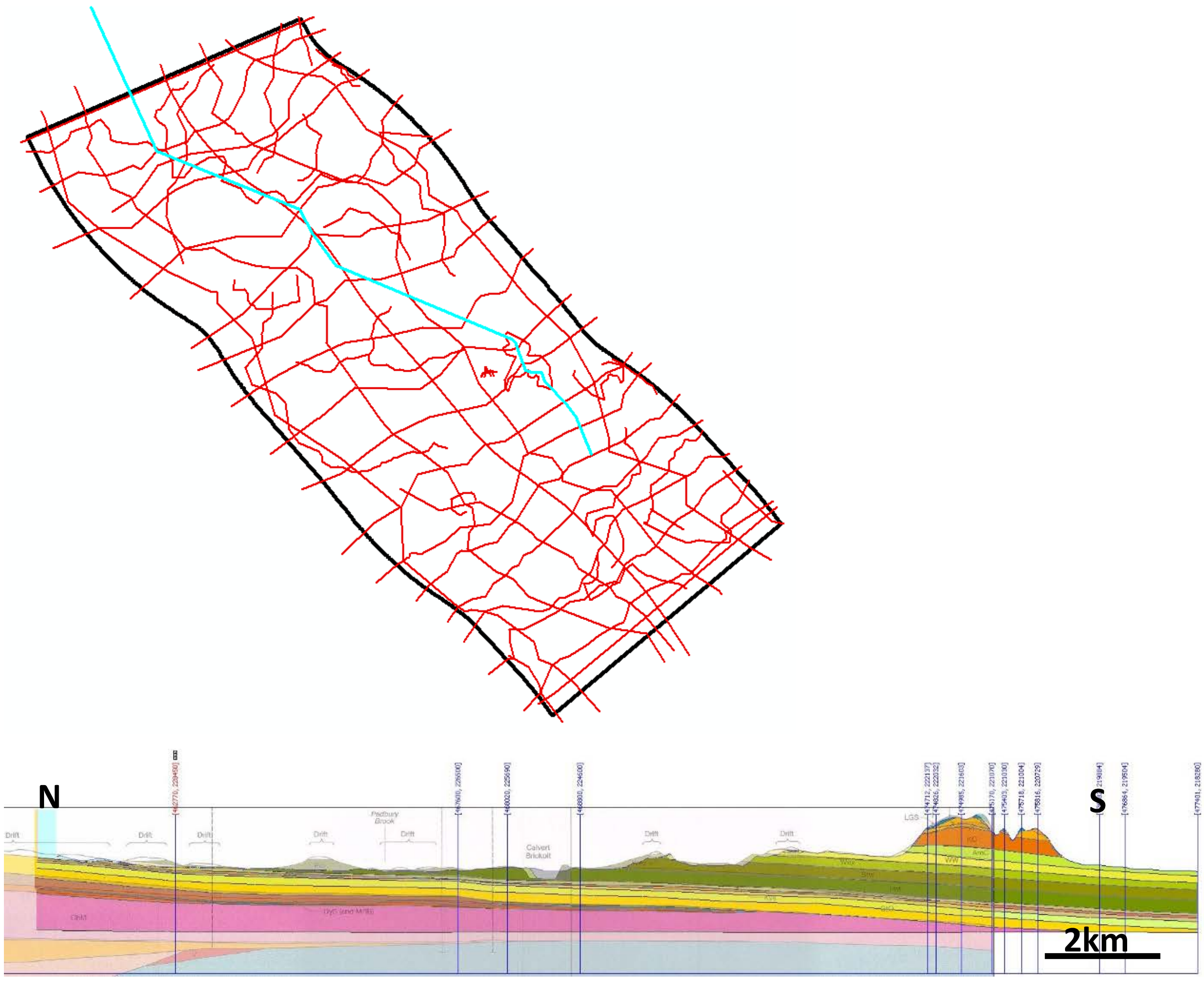

Figure 6. Top: Map view showing Buckingham cross-section trace highlighted in blue. Model area outlined in black. Bottom: correlated section lines with the Buckingham sheet raster cross-section as a backdrop in GSI3D.

6 Model Development Log

During the course of the modelling, the modeller kept a running log of the development, changes and decisions made for their designated modelling areas (Figure 7). These records are kept as part of the model storage and metadata (QA) process and can be accessed as needed.

HS2_Rung1_SW_NE_CCRIPPS – All fault throws match 50K map (Thame). No changes made
HS2_Area2_-2_NW-SE_CCRIPPS – small fault at W: 24366 (NGR: 473910 212950) not modelled. 50K map (Thame) shows downthrow to the west. Added to section/all bedrock units. 50K map (Thame) shows downthrow to the west. Added to section through all bedrock units.
*HS2_Area2_Rung3_SW-NE_*CCRIPPS – small fault at W: 1323 (NGR: 437897 213000) not modelled. Same fault as previous section, added to section through all bedrock units.
Area2_3D_Model_V1_158_ilc9_hbu3_caip6_HBU2.gsipr

Figure 7 Extract from Area 2 Model Development Log

7 Model Assumptions, Geological Rules Used etc.

Normal geological principles were assumed, such as the laws of superposition. In addition, several model specific assumptions were made:

- Units were correlated by the youngest unit first based on current stratigraphy; this meant that, for example, ALV would downcut into HEAD deposits.
- The geological maps of the area show one till unit (TILMP) and a single glaciofluvial sand and gravel deposit (GFDMP). However, borehole logs used in the model reveal that the glacigenic sequence is actually more complex. Four glacigenic deposits were modelled, comprising alternating layers of till and glaciofluvial sand and gravel (Figure 8). These are listed in their relative stratigraphic order from youngest to oldest below:
    - GFDMP1-XSV
    - TILMP1-DMTN
    - GFDMP-XSV
    - TILMP-DMTN

  During modelling it became apparent that GFDMP and TILMP were the most extensive of the glacial units, with GFDMP1 and TILMP1 assumed to occupy the areas of highest relief. Isolated patches of the glacial deposits are not constrained by cross-sections for time reasons, but were assumed to be GFDMP and TILMP. Additional cross-sections were constructed in areas deemed more geologically complex and where clarification was needed.

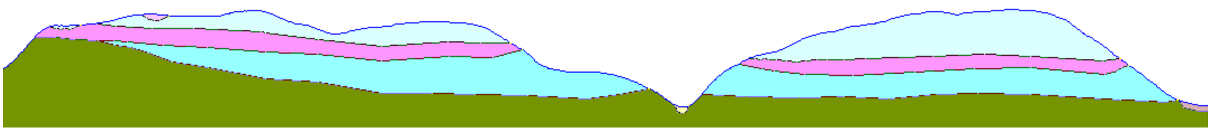

Figure 8. Cross-section *HS2_Area2_Rung15_SW-NE_CCRIPPS* shows how topography was useful in determining glacigenic unit characterisation. GFDMP1 is coloured light pink, TILMP1 is light blue, GFDMP is dark pink and TILMP is turquoise.

- Small area of PL-LMCS has been modelled as POST-LMST in adjoining Area 1 (see diagram).

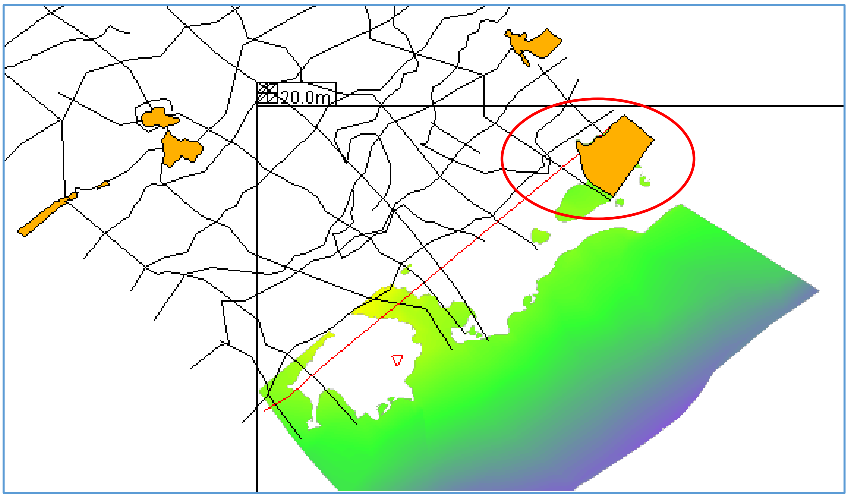

Figure 9 Extent of PL-LMCS and adjoining extent in Area 1

- Kellaways Sand Member is only separated from the Kellaways Formation in the north-west margin of the model area on the geological maps, forming two small polygons shown in blue below. The Kellaways Sand Member was combined with the Kellaways Formation and modelled as the unit KLB (Figure 9).

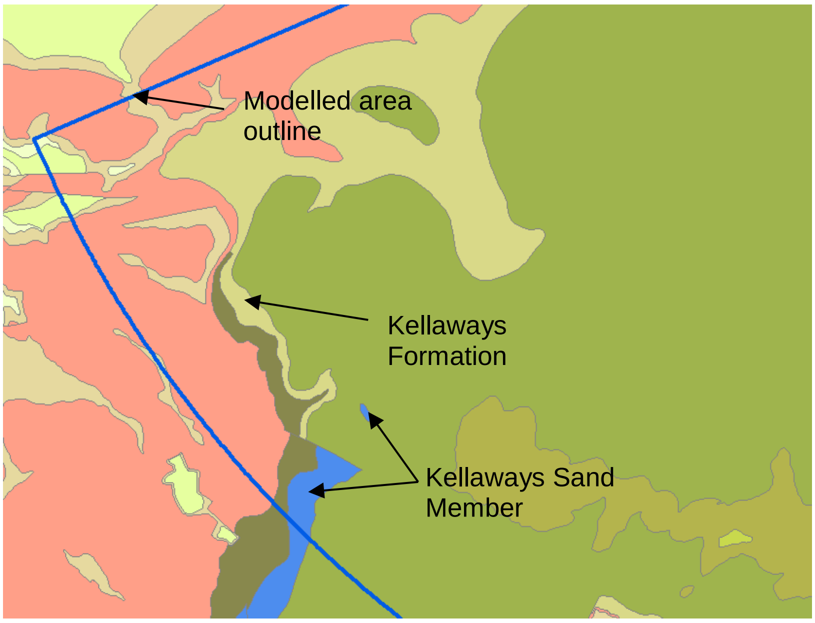

Figure 10 Kellaways Sand Member (blue) is modelled as Kellaways Formation

- Weymouth, Stewartby and Peterborough Members have been modelled, but in adjoining Area 1 these have been modelled at group level as KLOX-MDSS

8 Model Limitations

8.1 MODEL SPECIFIC LIMITATIONS

- Artificial ground and landslips are modelled according to the corresponding 1:50,000 scale geological maps. Additional cross-sections were constructed to aid the calculation of landslip deposits, but it was not possible to constrain every occurrence of artificial ground with a cross-section because of its patchy nature.

- The superficial glacigenic sequence is laterally and stratigraphically complex, and its representation in the model is a simplification of reality.
- The alluvium linework was simplified in order to aid the model calculation.
- As mentioned in Section 3, faults are not modelled as objects. Using the GSI3D methodology described in this report, faults are represented as 'steps' in the model rather than clean breaks in the succession. Only faults that intersect the cross-sections are represented in the model.

8.2 GENERAL MODELLING LIMITATIONS

- Geological interpretations are made according to the prevailing understanding of the geology at the time. The quality of such interpretations may be affected by the availability of new data, by subsequent advances in geological knowledge, improved methods of interpretation, improved databases and modelling software, and better access to sampling locations. Therefore, geological modelling is an empirical approach.

- It is important to note that this 3D geological model represents an individual interpretation of a subset of the available data; other interpretations may be valid. The full complexity of the geology may not be represented by the model due to the spatial distribution of the data at the time of model construction and other limitations including those set out elsewhere in this report.

- Best endeavours (detailed quality checking procedures) are employed to minimise data entry errors but given the diversity and volume of data used, it is anticipated that occasional erroneous entries will still be present (e.g. boreholes locations, elevations etc.) Any raw data considered when building geological models may have been transcribed from analogue to digital format. Such processes are subjected to quality control to ensure reliability; however undetected errors may exist. Borehole locations are obtained from borehole records or site plans.

- Borehole start heights are obtained from the original records, Ordnance Survey mapping or a digital terrain model. Where borehole start heights look unreasonable, they are checked and amended if necessary in the index file. In some cases, the borehole start height may be different from the ground surface, if for example, the ground surface has been raised or lowered since the borehole was drilled, or if the borehole was not originally drilled at the ground surface.

- Borehole coding (including observations and interpretations) was captured in a corporate database before the commencement of modelling and any lithostratigraphic interpretations may have been re-interpreted in the context of other evidence during cross-section drawing and modelling, resulting in occasional mismatches between BGS databases and modelled interpretations.

- Digital elevation models (DEMs) are sourced externally by BGS and are used to cap geological models. DEMs may have been processed to remove surface features including vegetation and buildings. However, some surface features or artefacts may remain, particularly those associated with hillside forests. The digital terrain model may be sub-sampled to reduce its resolution and file size; therefore, some topographical detail may be lost.

- Geological units of any formal rank may be modelled. Lithostratigraphical (sedimentary/metasedimentary) units are typically modelled at Group, Formation or Member level, but Supergroup, Subgroup or Bed may be used. Where appropriate, generic (e.g. alluvium – ALV), composite (e.g. West Walton Formation and Ampthill Clay Formation, undifferentiated – WWAC) or exceptionally informal units may also be used in the model, for example where no equivalent is shown on the surface geological map. Formal lithodemic igneous units may be named Intrusions or Dykes or may take the name of their parent (Pluton or Swarm/Centre or Cluster/Subsuite/Suite), or if mixed units Complex may be used. Highly deformed terranes may use a combined scheme with additional rank terms. Artificially Modified Ground units (e.g. Made Ground (undivided) – MGR, Landscaped Ground (undivided) – LSGR) are currently regarded as informal.

- The geological map linework in the model files may be modified during the modelling process to remove detail or modify the interpretation where new data is available. Hence, in some cases, faults or geological units that are shown in the BGS approved digital geological map data (DiGMapGB) may not appear in the geological model or vice versa. Modelled units may be coloured differently to the equivalent units in the published geological maps.

9 Model QA

In order for a geological model to be approved for publication or delivery to a client a series of QA checks is carried out. This includes visual examination of the modelled cross-sections to ensure that they match each other at cross-section intersections and fit the borehole and geological map data used. The model calculation is checked to ensure that all units calculate to their full extent within the area of interest and the modelled geological surfaces are checked for artefacts such as spikes and thickness anomalies. The naming convention of the modelled geological units is checked to ensure that recognised entries in the BGS Lexicon of Named Rock Units (http://www.bgs.ac.uk/lexicon/home.html) and the BGS Rock Classification Scheme (http://www.bgs.ac.uk/bgsrcs/) are used as far as possible. Any issues found in the QA checking process are recorded and addressed before delivery/publication of the model.

10 Model Images

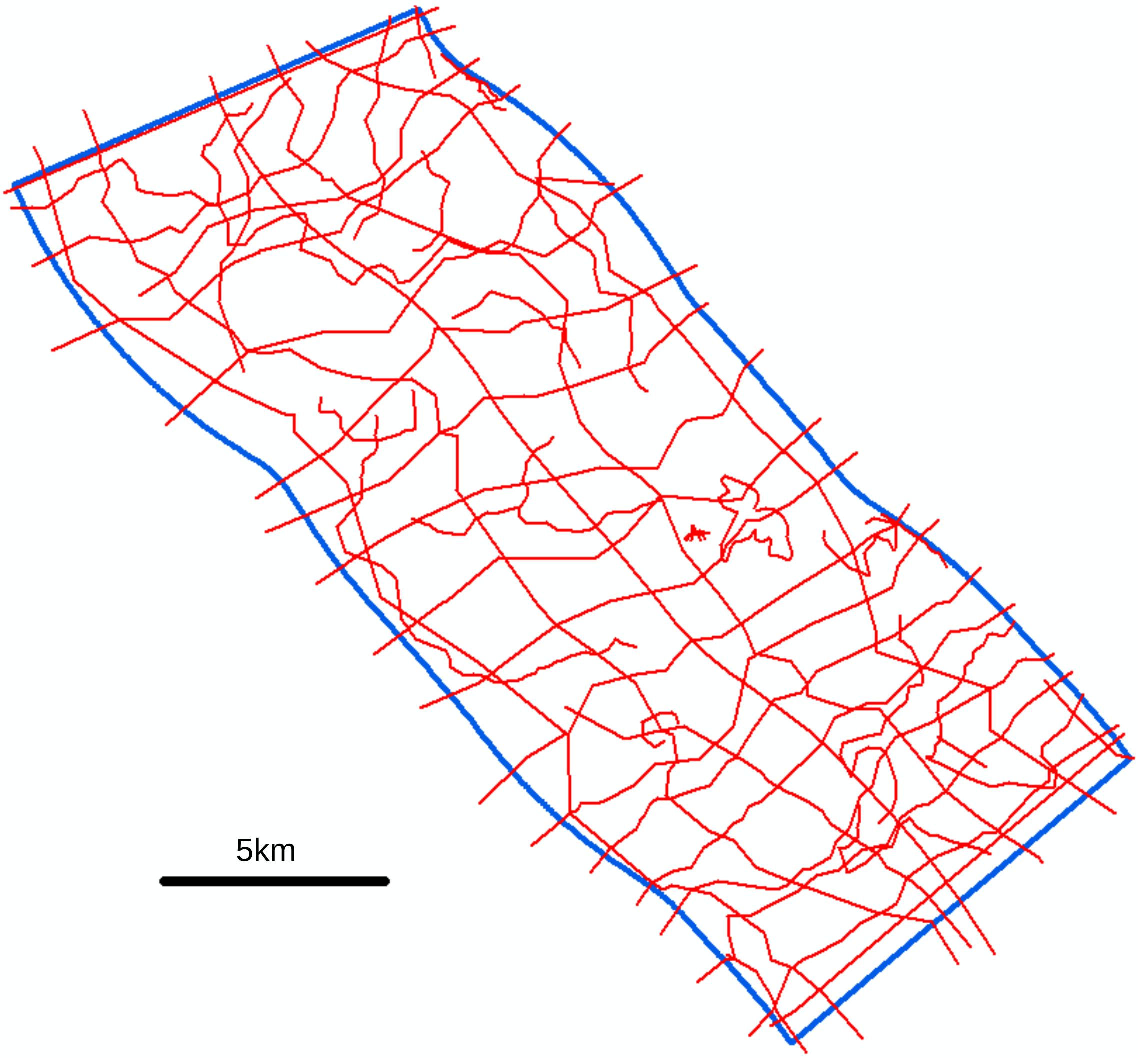

Figure 11. Plot of all 52 cross-sections (red) constructed to constrain the model (model area outlined in blue).

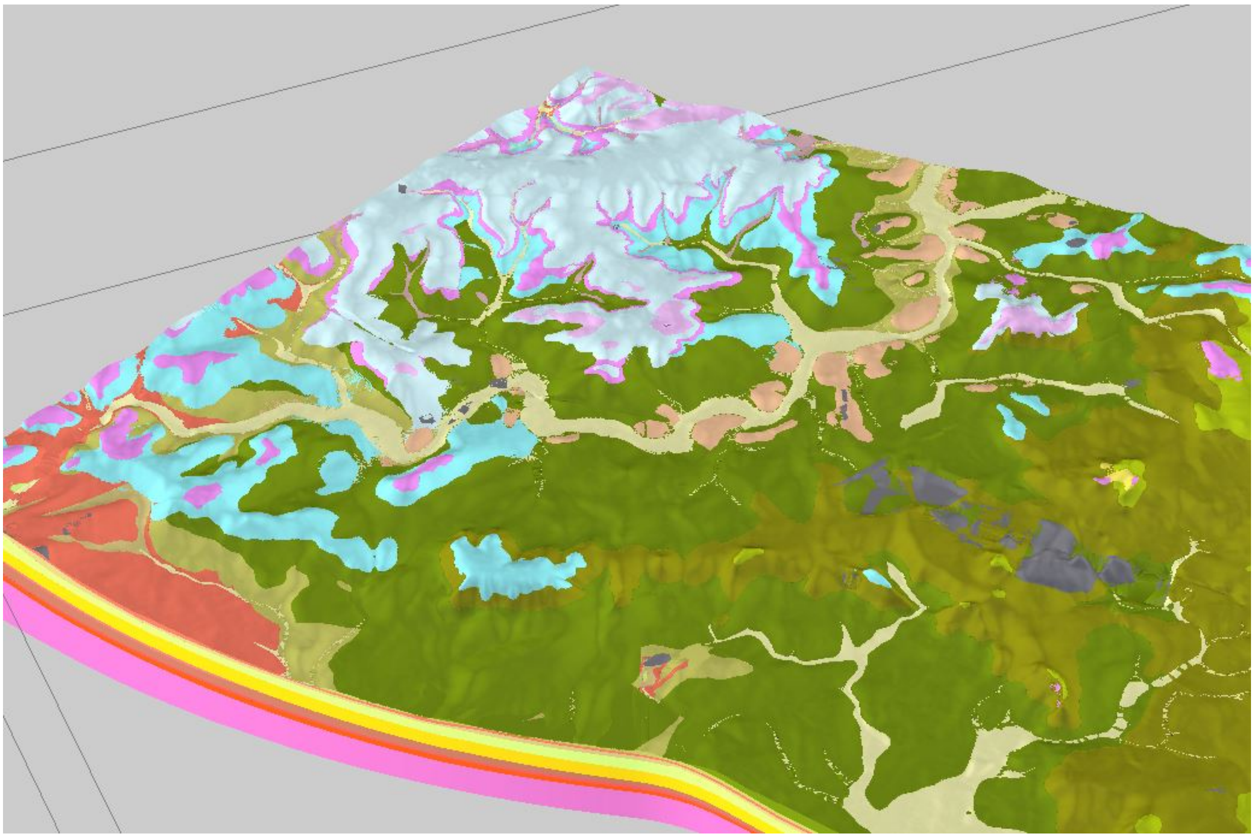

Figure 12. Close-up 3D view of the north-west quadrant of the model with all units shown, looking to the north-east. Key to geological units as per Table 1. Vertical exaggeration x10.

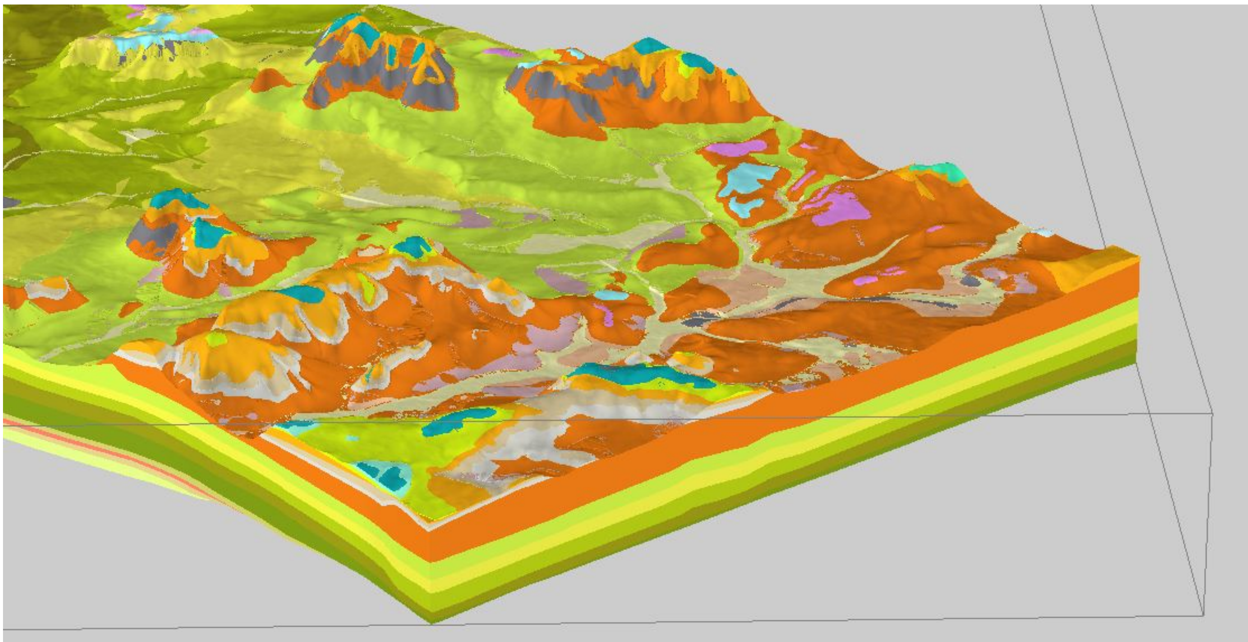

Figure 13. Close-up 3D view of the southern part of the model with all units shown, looking to the north-east. In this view, mapped landslip deposits (grey) can be seen on steep slopes. Key to geological units as per Table 1. Vertical exaggeration x10.

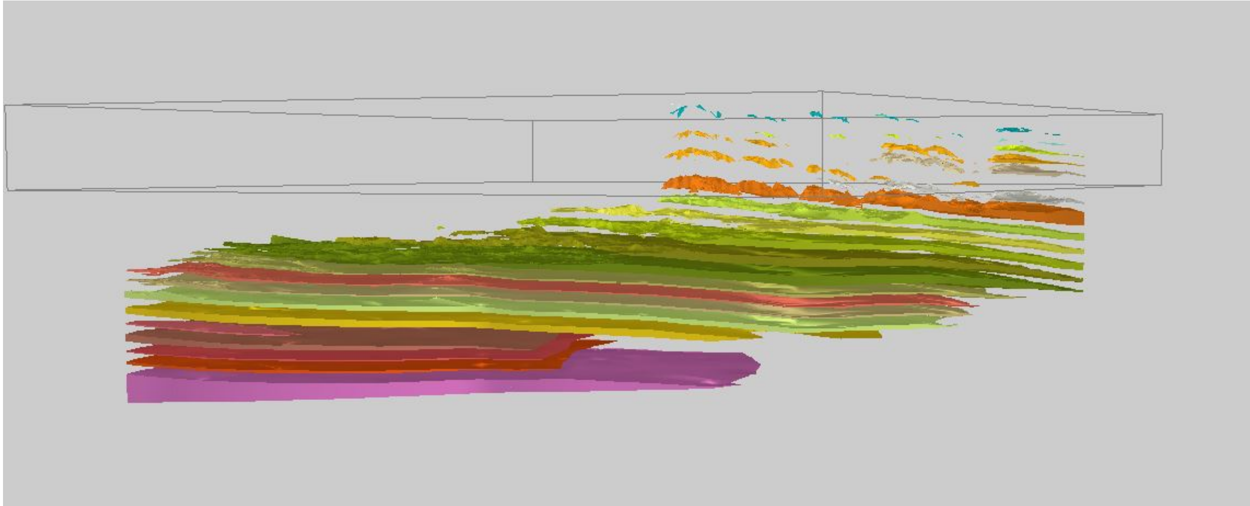

Figure 14. 3D 'exploded' view of the bedrock units, looking North Eastwards. Key to geological units as per Table 1. Vertical exaggeration x10.

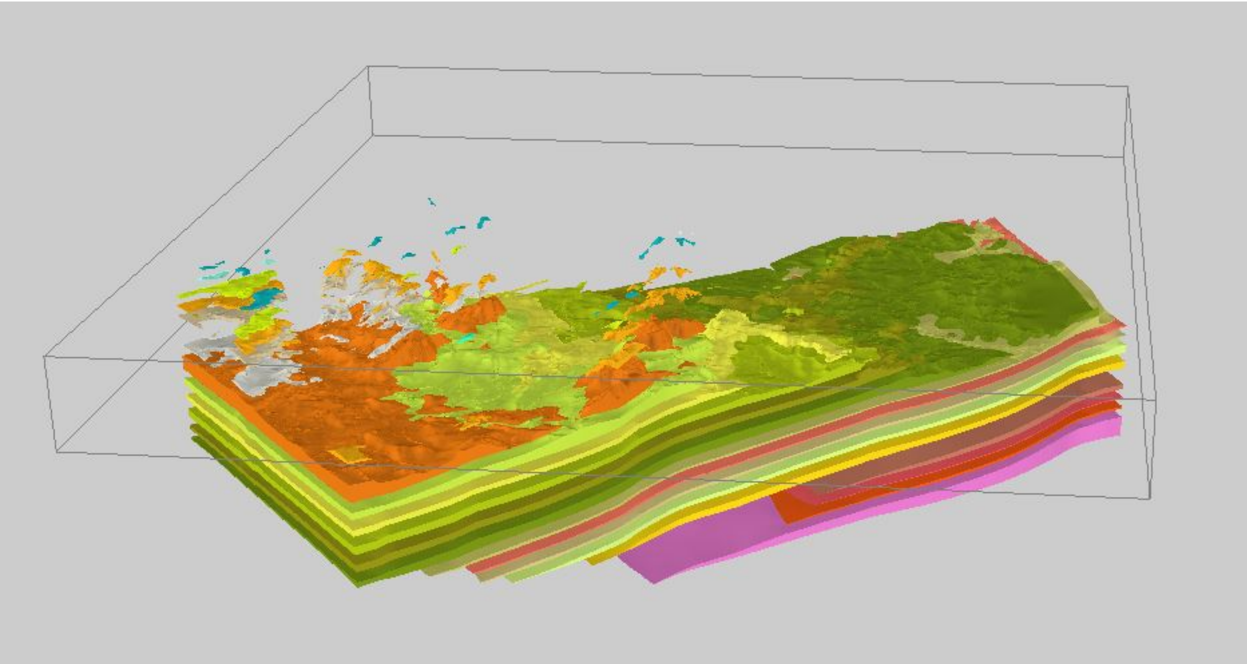

Figure 15. 3D 'exploded' view of the bedrock units, looking towards the North West. Key to geological units as per Table 1. Vertical exaggeration x10.

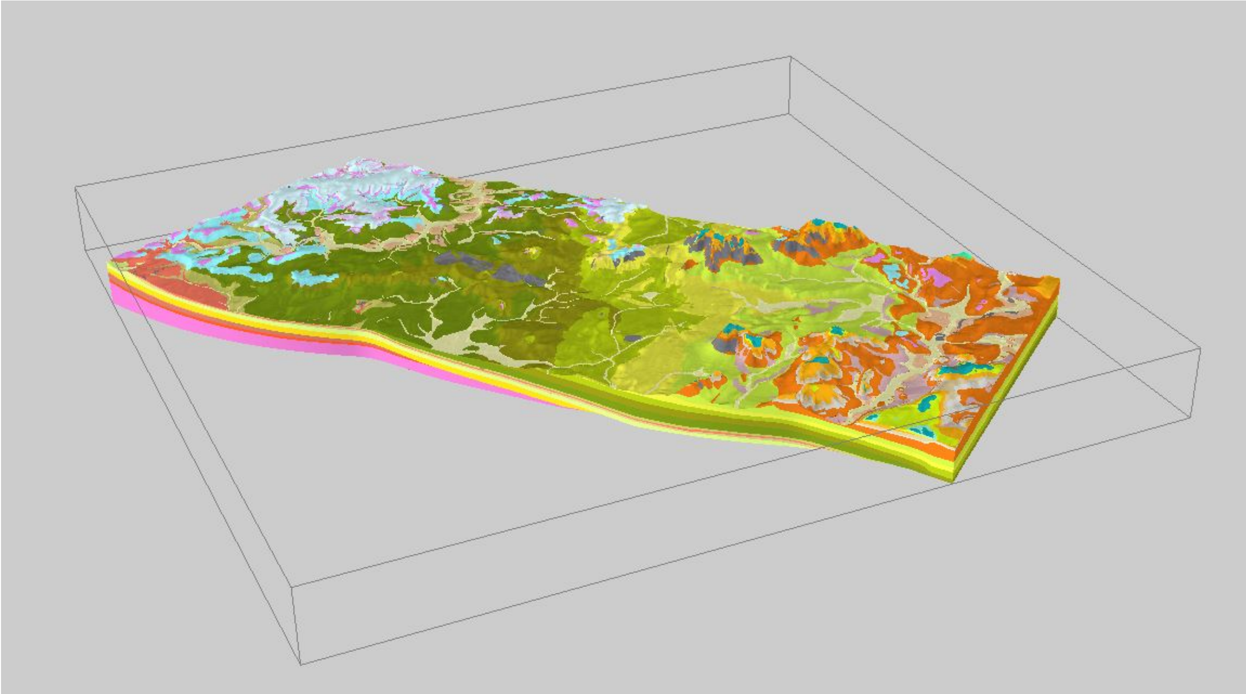

Figure 16. 3D view of all modelled bedrock, superficial, landslip deposits and artificial units. Key to geological units as per Table 1. Vertical exaggeration x10.

11 References

British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details). The library catalogue is available at: http://geolib.bgs.ac.uk.

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