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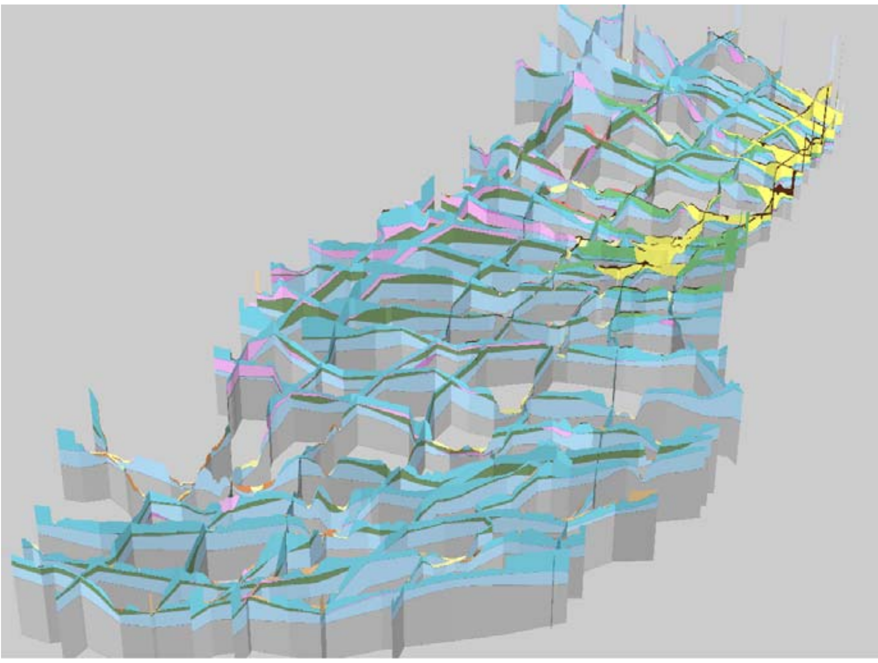
Model metadata report for the EA Tees 3d Model

LAND USE PLANNING AND DEVELOPMENT Programme

Open Report OR/14/035



BRITISH GEOLOGICAL SURVEY

LAND USE PLANNING AND DEVELOPMENT PROGRAMME

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Model metadata report for the EA Tees 3d Model

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Keywords

GSI3D; Environment Agency; 3d modelling; Tees; Superficial;

National Grid Reference

SW corner 425360,502230
Centre point 999999,999999
NE corner 455730,533040

Map

Sheet 27, 33 & 42, 1:50 000 scale, Durham; Stockton & Northallerton

Front cover

Cover picture details, delete if no cover picture.

Bibliographical reference

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Foreword

This report is the published product of a study by the British Geological Survey (BGS). It describes the data and information used for the completion of the study into the superficial deposits within the Teesside 3d model.

Contents

FIGURES

TABLES

Summary

This report describes the creation of a 3d model developed by the British Geological Survey (BGS) for the Environment Agency (EA) covering the area around Middlesbrough and the Tees river valley. The model describes the superficial deposits of the area, and was used to define hydrogeological domains in the Tees catchment area.

1 Modelled volume, purpose and scale

The model area is 414km^2 and covers the area along the Tees valley, from Middlesbrough in the north-east, at the mouth of the Tees, in a roughly south-west direction to Darlington and Dalton-on-Tees. Figure 1 shows the model extent, together with the cross-sections used to construct the model.

A set of five framework sections consisting of one north-east – south-west oriented section and four east-west sections were produced initially. As well as forming the core sections of the 3D model, these framework sections have been delivered separately to the client to provide an overview of the distribution and form of the main lithostratigraphic units in the study area. The section lines were selected to link to previously produced cross-sections of the Durham area to the north and to include sufficient high quality boreholes to constrain the subsurface geology.

A further seven north-south trending and seventeen east-west trending model sections were then constructed to create the cross-section network for the model. The exact lines of these sections were chosen through inspection of borehole data with the highest quality boreholes included. Borehole selection criteria include the borehole depth (especially whether the bore reaches rockhead) and the detail and quality of the description of the strata. A number of helper sections were also generated in order to check the geological interpretation and to represent small and/or complex deposits more accurately in the final model.

Figure 1 - Map showing project area and cross-sections used in model construction

2 Modelled surfaces/volumes

A list of the units modelled is given in table 1.

There was no defined regional stratigraphy for the Teesside area prior to modelling. The lithostratigraphy used to define the modelled geological units was defined following a literature review and initial borehole inspection. The nomenclature for the stratigraphic units, particularly the Quaternary Deposits, was chosen for consistency with previous work for the Environment Agency in the Durham area to the north (Price et al. 2007). It should be noted that the lithological consistency of the units in Teesside with type-sections from the Durham area is assumed based on borehole records and has not been verified in the field.

name	id	Strat_text	LEX_code	Lith_code	Description	Age	Permeability
water	1	water	water	water	water	Recent	Aquifer
mgr	10	Made ground	MGR	UNKNOWN	Artificial and man-made deposits	Recent	Aquifer
bsa	20	Blown Sand	BSA	S	Fine grained sand	Recent	Aquifer
peat1	30	Upper Peat	PEAT1	P	Organic peat	Recent	Aquitard
bchd	40	Marine beach deposits	BCHD	SV	Sand and gravel	Recent	Aquifer
alv	100	Alluvium	ALV	CZSV	clay silt sand and gravel	Flandrian	Aquifer
mea	120	Marine or Estuarine alluvium	MEA	SZC	sand silt and clay	Holocene	Aquitard
lde	130	Lacustrine deposits	LDE	CZ	clay and silt	Holocene	Aquitard
rtdu	160	River terrace deposits undifferentiated	RTDU	SV	sand and gravel	Holocene	Aquifer
peat2	170	Lower Peat	PEAT2	P	Organic peat	Holocene	Aquitard
alv2	180	Holocene alluvial gorge fill	ALV2	CZSV	alluvial gorge fill	Holocene	Aquifer
tssg	200	Teeside Sand and Gravel Formation	TSSG	SV	marginal sand and sand and gravel	Devensian	Aquifer
tsdc	210	Teeside Clay Formation	TSDC	CZ	laminated clay Glacio-lacustrine	Devensian	Aquitard
gfdu1	230	Glaciofluvial deposits-upper	GFDU1	SV	sand and gravel Glacio-fluvial	Devensian	Aquifer
hnti	300	Horden Till Formation	HNTI	DMTN	red-brown diamiction	Devensian	Aquitard
clay_sub_till	335	Sub-Horden Till laminated clay	GLLD	C	laminated clay Glacio-lacustrine	Devensian	Aquitard
gfdu2	340	Glaciofluvial deposits-middle	GFDU2	SV	sand and gravel Glacio-fluvial	Devensian	Aquifer
dctf	350	Darlington Clay Formation	DTCF	CZ	laminated clay Glacio-lacustrine	Devensian	Aquitard
gfdu3	370	Glaciofluvial deposits-lower	GFDU3	SV	sand and gravel Glacio-fluvial	Devensian	Aquifer
bhti	380	Blackhall Till Formation	BHTI	DMTN	grey to dark brown diamicton	Devensian	Aquitard
sagr	410	Basal sand and gravel	SAGR	SV	Sand or sand and gravel	Devensian	Aquifer
base model	510	Model base	base model	NULL	Model base	None	Aquifer

Table 1 - Generalised vertical section (GVS) used in the Teesside 3d Model.

Surface water, including the River Tees, offshore areas and parts of the Tees Estuary that fall within the model area have been modelled as a pseudo-stratigraphic unit. Information on the geometry of the water bodies, including water depth was taken from OS topographic maps and Hydrographic Office Nautical Charts.

Made ground, including artificial man-made ground observed in boreholes and inferred from features recorded on topographic maps, has been included in the model.

A ‘Base Model’ surface has been modelled to define the lower limit of the modelled ground. This surface lies well below the base of the superficial deposits but does not include details of the bedrock geology.

Also included in the model are several Sand, Sand and Gravel, Till, Peat and Clay lenses found within various units but the majority occur within the Till sequences.

3 Model datasets

The following primary datasets were used in the construction of the Teesside 3D model:

- DTM – the BGS derived BaldEarth digital terrain model (DTM) was used as the capping surface and was resampled to give a cell resolution of 50m
- Rockhead model – this was extracted from the corporate rockhead model dataset (V5) at the start of the project (01/08/2012).
- Borehole data – Boreholes were coded by H Burke and C Horabin using the BGS Superficial Deposits Coding Scheme (Cooper et al, 2005), and content code “DU”. All coded boreholes were extracted from SOBI/BoGe using an access query to create BID/BLG files for import into GSI3D software. The Borehole Filter Tool was used to prioritise and deduplicate the borehole records using the following priority order:

1	CB	best coding, full breakdown of lithologies in superficial and bedrock with some attempt at Lithostrat - good description text
2	WM	good coding, full breakdown of lithologies in superficials and bedrock with some attempt at Lithostrat - good description text
3	DU	Lithologies for superficials, not lithostrat. Some descriptions input, appears patchy
4	DV	as above
5	G	Midas coding. Lith and Strat coded. Good descriptions. Old coding system used
6	AR	full lithological coding with some lithostrat for superficial attempted
7	GX	Geotechnical Database Logs: interpretations copied from the National Geotechnical Database.
8	NR	Good descriptions but uses the old style of coding lithologies and in places no entries are given for lith. No attempt at lithostrat made
9	LO	No bedrock details (input as ROCK), but good lithological breakdown. No descriptions. No Lithostrat attempted
10	L	little detail in coding, useful only for base of superficials
11	R	no details of superficials

Table 2 – Borehole interpreter coding scheme used to prioritise the selection of borehole records for modelling.

- Map data – the surface distribution of the modelled lithostratigraphic units is based on the distribution of lithogenetic units depicted in DiGMap50. The model included the breakdown of the mapped Till unit into an upper (Horden Till) and lower (Blackhall Till) and this required some added delineation in 2D to enable these units to be drawn in cross-section.
- Previous GSI3D models– this model is an extension of work in the Durham area to the north completed in 2007 by (Price et al. 2007) and several sections from the earlier work were utilised in the construction of the Teesside model.
- Other datasets – a shapefile outlining the known extent of moraines was created by A Cooper to provide a guide as to the extent of Till units, particularly the upper Till. A limit of laminated clay (also created by A Cooper) was used to guide the extent of sub-glacial clays.

4 Model development log

This section outlines the initial set-up of the project GIS, Borehole coding and extraction to GSI3D and the 3d modelling of the EA Tees 3d Model. A detailed modelling progress log can be found in appendix 1.

4.1 PHASE 1: DATA COMPILATION AND GIS ASSESSMENT

The project area was defined following meetings with the client (EA). An initial project area shapefile was drawn by ST to include the full extent of Sherwood Sandstone outcrop between West Hartlepool in the north-east and Darlington in the south-west.

Boreholes recorded in SOBI were queried for the project area, with a total of 7066 borehole records, of which 5431 fall directly within the outcrop of the Sherwood Sandstone. In order to prioritise deep boreholes, that record the full sequence of superficial deposits, for coding, a method was derived to identify boreholes that penetrate to rockhead using ARC GIS tools. This process should be viewed carefully, as it can include or exclude some boreholes that may prove useful.

1. Clip the SOBI borehole shapefile and the superficial thickness (BSTM) models to the outline of the Sherwood sandstone (derived from the 250k map)
2. Using the extract values to points function add the total superficial deposits thickness from the BSTM (basic sediment thickness) model to the borehole file
3. Open the dbf file in Excel and used the IF function to select only those boreholes with total length (LengthC) greater than the sediment thickness from the BSTM model, and create a new dbf file.
4. Create a 'boreholes to rockhead' shapefile from the new dbf.

The following is a list and description of shapefiles created or viewed within the project GIS (EA_Tees_Superficial.mxd):

EA_Tees_NotCoded_Boreholes_alongSections.shp
– boreholes within 200m buffer of section (39)

EA_Tees_NotCoded_Boreholes_below_RH.shp
– shows all boreholes which penetrates the RHEM surface from the superficial thickness model (487)

EA_Tees_CodedBoreholes_26-06-12.shp
– records extracted from SOBI/BoGe database on this date (2216). This file shows unique borehole (i.e. only id, easting and northing) the majority of these boreholes have multiple coding schemes and so need to be looked at in more detail. Prioritisation tool from ST?

XYTess_Sherbore_ToRock.shp
– supplied by Katie Whitbread. Boreholes that penetrate Rockhead using the above procedure

EA_Tees_Sobi_overSSG.shp
– all boreholes that overly the outcrop of SSG (5431)

EA_Tees_Sobi.shp
– all boreholes within project area (7066)

Borehole_imau.shp
– Mineral Assessment borehole records (no strata)

EA_Tees_Sectionlines.shp

– shapefile of cross-sections drawn for proposal, these may be subject to slight adjustment

Durham_south, Durham_Permian, Durham_North.shp

– three files containing sections from Durham EA model

EA_Tees_Projectarea.shp

– currently agreed project area

SSG_outcrop.shp

– outcrop pattern of SSG, supplied by KW and VB

Boreholes layer from GDI

Geology layer from GDI

Topo base maps from GDI

EA_Tees_25m_DTM_ascii.asc

– grid generated in GSI3D using Baldearth Model

Superficial Thickness layer from GDI

4.2 PHASE 2: BOREHOLE PROGNOSIS AND CODING

A review of the level of coding by ST:
Of the 9 categories of borehole records shown in Table 2, all but 2 of them provided very useful data to the project (a total of 3566 records). The top 4 codes provided 1407 boreholes of "best coding".

ST performed a narrowing down exercise: from the list of boreholes coded a switch selection was made to select those that hadn't been coded. From these 2307 the DTM value, BSTM value and borehole total depth (TD) were used to determine which boreholes penetrated the Rockhead surface. This created a file of 2472 boreholes. These boreholes were inspected to assess the quality of the borehole logs (currently some of these are not logged in the SOBI database) and were prioritised using the lines of framework sections specified by the client. The framework section lines were used to create a list of non-coded boreholes within 200m of the lines of section (280 Boreholes). Priority was given for coding of boreholes along these section lines, and to deep boreholes with high quality logs dispersed throughout the model area. Approximately 750 coded boreholes were used in the model cross-sections and many more were used to help delineate the spatial extent of units (envelopes).

4.3 PHASE 3: LITHOSTRATIGRAPHY AND THE GVS SET UP

The GVS presented in table 1 was developed through a literature review with guidance from A Cooper. The lithostratigraphic succession is described in detail in Whitbread et al. (2013). The published geological 50k map for Stockton (Sheet 33), a range of published papers and unpublished reports were consulted to develop this regional lithostratigraphy and these sources are also recorded in Whitbread et al. (2013). Descriptions of the main modelled units are also included in the detailed model development log in Appendix 1.

4.4 PHASE 4: MODEL DEVELOPMENT (SUMMARY)

This section provides a summary of the modelling procedure and stages of model development. A detailed log of the modelling process produced by the modelling team during model construction is included in Appendix 1. This detailed log includes information relating to individual modelling decisions (both geological and technical), as well as model checking and amendments.
The project files are located in W:\Teams\UD\TeesSuperficialGeology\Data\GSI3D_Modelling at the time of writing. Borehole and DTM data files used in the modelling are:

- Ea_tees_bid.bid

- EA_Tees_BLG_v2.blg (prioritised to remove duplicates)
- DTM: EA_Tees_DTM_25

Stage 1: Framework section construction

Five framework section lines were requested by the client, one aligned along the length of the model (roughly north-south) and four aligned roughly east to west. These sections were constructed as continuations of cross-sections drawn for the Durham (south) area in previous work for the EA (Price et al. 2007). In the initial stage of the modelling, these five framework sections were correlated by modellers Helen Burke (HB), Steve Thorpe (ST) and Katie Whitbread (KW) working in conjunction with A Cooper to ensure consistent interpretation of the lithostratigraphy was applied across the model area.

Stage 2: Model development

- 6 Framework sections
- 21 Model sections
- 54 Helper sections

The model was constructed in three stages by modellers working consecutively on three model sub-sections; north, middle and south. These model segments were divided by the east-west orientated framework section lines. 17 regularly spaced model cross-sections were constructed to utilise the best available borehole records on an approximate grid pattern between the framework section lines and 4 boundary sections were constructed at the model edges. A further 54 helper sections were constructed during the modelling development and calculation checking.

4.5 PHASE 5: QA

The Tees Model was reviewed by M Barron following standard BGS model checking procedures (W:\Teams\NGM\Models\Documents\QA & Approval Docs\NGM QA Checklists\GSI3D_model_corp_check_8-3-13_TEMPLATE.docx). From this review it was noted that the river, although defined by the OS topographic maps, didn't fit the DTM surface, but showed some of the 'thalweg' sections rising and fall across the hills. This is due in part to the resolution of the DTM held at BGS (5m grid) but more likely to the resampling of the DTM to 50m. Following discussions with V Banks and S Thorpe it was decided that the river polygon and water-lines in relevant cross-sections should be removed from the model, and the underlying geology reviewed and amended where necessary. Water was retained in the estuary and off-shore areas at the north end of the model. The removal of the river polygon was undertaken by S Thorpe.

4.6 PHASE 6: MODEL DELIVERY

Following final approval, the model, together with digital images of the five framework cross sections were prepared for delivery to the client.

The final version of the GSI3D model was encrypted into the Lithoframe viewer using standard procedures.

GIS exports – envelopes (Shapefiles), grid thicknesses were also derived and formed the basis for hydrogeological domain assessment performed by V Banks and M Garcia-Bajo.

5 Model workflow

The standard GSI3D workflow for superficial geological models was followed (Mathers et al 2011).

6 Model assumptions and geological rules used

The model covered the superficial deposits overlying the Sherwood Sandstone and the underlying bedrock was not modelled in detail. Instead a 'base model' was constructed with an arbitrary cut-off point at -35m. The area of bedrock shown in the model is coloured grey so as not to be confused with other modelled units.

7 Model limitations

- More borehole interpretations are needed to give the model more reliability.
- The deep topography, particularly the valleys, has proved difficult to model. The thin units associated with these valley areas mean that more cross-sections are needed to help constrain the base of such units. Given the time constraints for this model, this was unachievable and as a result there are areas (most notably the alluvial channel fills, and thin clay outcrops) where the model under-represents the geology.
- The separation of the Horden Till, Blackhall Till and the intervening Darlington Clay Formation are in some areas of the model, over-simplified. Not enough borehole data was used (given the time constraints on the modelling process) to allow a thorough investigation into the thicknesses of these units.
- There are vagaries between the height distributions of both the Darlington Clay Formation and Tees Clay Formation. These could be further investigated with more borehole coding, targeted site investigations and subsequent further revision of the model.
- The relationship between the Lake Deposits and Alluvium is poorly described and the large scale of the model means that this distinction could not be fully resolved in all areas of the model.

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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Appendix 1 Detailed model development log

1st and 2nd Aug

HBU and STHORPE correlated Section 1

Surface glacial lake deposit correlated as TSDC for now, but may need to add another lake clay to separate it from the large area of lake clay near the coast, or use LDE?

Tills separated out where boreholes indicate a layer of lake clay below the surface, but not based on colour etc. of tills in log descriptions

Basal till carried through where only one till type is described in boreholes

Difficult to know where to put the boundary between Darlington Clay FM and Tees

Need a basal gravel adding to the GVS

RHEM used as a guide where no borehole data exists, and boreholes honoured where differences occur

6th Aug:

KWHI Modelled sections 4 and 5 (the northern most E-W framework sections, named EA_Tees_EW_4 and 5).

File name: EA_Tees_Model_KW_v6.GSIPR *(Starting file was EA_Tees_Model_V1_9)*

Changes to section 1: i) added water to coastal end of section; ii) amended relationship between lde and river terrace deposits at southern end; iii) added area of Teesside sand and gravel mid section and; iv) added some Horden till where section crosses section 4 to agree with crossing section.

8th Aug HBU
Plotted Sections E_W_1 and E_W_2 ready for correlating

Section Tees_Framework_2
BH NZ20NE 9 records sand & gravel where ALV is mapped. Broken the ALV line to allow this to be correlated as RTDU

Boreholes NZ30NW 1 and 38 record approx 18m of sand at surface where till is mapped. Correlated this as GFDU.

Section 1 finished
EA_Tees_Model_HB_v2.GSIPR

8-9th Aug
Section E_W_2
Sand unit between the two tills in BH NZ41SW 20 correlated as Glacial Sand & Gravel rather than Darlington Clay Fm.

SUPNM polygon at BH NZ40NE 34 correlated as RTDU
EA_Tees_Model_HB_v4.GSIPR

Questions:
Should the GVS/Gleg need to match the previous Durham work?

Section checking, Tony C, 14th Aug

Corrections:

Section 1 looks good; I appreciate that the Blackhall Till Fm will crop out in the valley whereas on the rest of the section it will be concealed by the Howden Till Formation so I think it should be postulated from NZ42SW95 to the north-east of the section line. If we don't do that we will have lots of windows in addition to the valleys down into the underlying Blackhall Till.
HB 15/8/12: Done

Section 2: I think the Howden Till Fm should be joined up at the surface, especially between NZ30NE7 and NZ30NE20. I think it will also exist on the other parts of the section except in the valley areas and the SE end outside of the main moraines.
HB 15/8/12: Done, but still carved out by thick sand & gravel at BHs NZ30NW 1 and 38

Section 3: I wonder if the Howden Till Formation should go right across the area, this will involve postulating it being in the area of NZ31SE16 and splitting it off from the Blackhall Till Formation.
HB 15/8/12: Done, except at river at BH NZ31SE 27

Section 4: Looks good especially with respect to the Howden Till Fm covering the area.

Section 5: Looks good to me with the Howden covering the area except for the middle of the estuary.

I think that the Howden Till Formation should cover most of the area since it is that formation that forms the moraines. It may be missing from the middle of the Tees estuary where the ice probably sat while the moraines were formed. I think the Howden Till Formation needs to be extended and joined up on the other sections i.e. 1, 2 and 3. This will involve postulating that it will be in boreholes where only till has been recorded, but there may also be other hints of the boundary if there are any colour changes in the clay tills etc.

NB: Marieta will remodel bedrock when we have produced the sections. We will continue to use the existing rockhead surface to guide where we place the bottoms of our sections. Marieta will then incorporate the modelled section nodes and re-digitised borehole logs in the dataset to produce a new rockhead model.

Tees Model North
Modeller: Katie Whitbread

15th and 16th Aug 2012
Correlating sections Tees_Model_EW_1 and Tees_Model_NS_1

NB: section Tees_Model_EW_1 will form the southern limit of the 'North' model area

Sections drawn to utilise coded bores, but also include non-coded bores to increase information along section lines. Borehole logs for non-coded bores, and for many coded bores (especially IMAU bores), consulted via the GDI.

Coding of IMAU bores is not detailed and units are commonly lumped together. In places my interpretation of a unit boundary, based on the log description, may fall within a coded unit.

Water in tidal and estuarine areas of the Tees has been modelled with reference to Admiralty charts.

Minor amendments to framework sections where crossed by model sections

<u>17th August</u>

Correlating sections Tees_Model_EW_2, EW_3 and EW_4
Latest GSIPR: EA_Tees_Model_KW_v18

Some changes to Tees_Framework_1 (NS) due to correlation of crossing sections.

Correlation utilises non-coded bore logs as well as logs of IMAU and other coded bores that have more detail in the log that has not been coded.

Note in section Tees_Model_EW_3, some bores dated 1973 in Seal sands area now under Teesside Jetty oil terminal are assumed to have had start heights just below OD (as suggested by historic OS maps). In jetty area, water depth is now c. 18-14m due to excavation, this is assumed to have occurred post 1973 as bores will have been drilled prior to dock construction. Correlation of bores is thus based on an assumed start height of OD minus 0.5m when bore was drilled.

<u>27th August</u>

Correlating sections: Tees_Model_EW_5, NS_2 and NS_3
Latest GSIPR: EA_Tees_Model_KW_v24

Correlation utilises non-coded bore logs as well as logs of coded LOIS bores and other coded bores that have more detail in the log that has not been coded.

Substantial thickness of marine and estuarine alluvium in the Tees basin is mainly sand, but silty clay is also present in many bores. Sand and clay parts of this unit have not been distinguished as yet but could possibly be differentiated by adding a code to the GVS (?).

<u>28th August</u>

Correlating sections: Tees_Model_EW_6 and NS_4
Latest GSIPR: EA_Tees_Model_KW_v26

Correlating boundary section: Tees_boundary_west
Latest GSIPR: EA_Tees_Model_KW_v27

<u>29th August</u>

Correlated sections: Tees_Model_EW_7 and Tees_boundary_east
Created envelopes for BSA, BCHD and MEA.

Modified water envelope to crop to low tide mark so that model matches the extent of the DiGMapGB polygons and simplified the channel margin along the River Tees.

Latest GSIPR: EA_Tees_Model_KW_3v1

Note: boundary sections correlated from tie lines with crossing sections, but nearby borehole information also utilised through the ‘project near-by boreholes’ function with a buffer distance of less than ~50m.

<u>30th and 31st August</u>

Correlated a series of Helper sections (Tees_Helper_KW_1 to 10) to help delineate till and sand and gravel units in the north of the model area. Partially constructed HNTI envelope to capture the modelled distribution of the till in this complicated area, but the envelope is not completed and still needs editing in other areas.

Final GSIPR: EA_Tees_Model_KW_39

Tees North - Modelling notes
4 NS sections (in addition to the Framework section) have been started in the north area to be extended south as required. We are contracted to produce 10 in total so there are more available to be started in the south where the model is wider.

I have constructed 7 EW sections in addition to the framework sections, and 10 helper sections.

I have also constructed boundary sections along the east and west edges of the model and have correlated them for the north.

I have used as many coded bores as possible, but have also used non-coded bores and correlated on the basis of the scanned log downloaded from the GDI. Obviously this is more time consuming but the data in the non-coded bores was very useful as the stratigraphy is relatively complicated. Also, some of the pre-existing coding of IMAU bores is very basic and there is a lot more information – especially about laminated vs. unlaminated clay in the logs so it was worth referring to them.

I have print outs of most of the scans (marked with my lithostrat interpretations and lists (currently hand-written) of the coded and uncoded bores used in each section.

Tees North - Geology notes Katie Whitbread 31/8/2012
<u>Basal sand and gravel:</u> isolated pockets or spreads under Blackhall Till, mostly found in apparent depressions in the rockhead surface.

<u>Blackhall Till:</u> virtually complete cover. Small areas where BHTI is not found are associated with minor bedrock highs (Tees_Model_NS_3) and areas where the till may have been locally eroded to bedrock buy subsequent process e.g. by river excavation in the Tees Estuary (Tees Model_NS_3) or by channels cut by glaciofluvial streams (Tees Model_EW_2, Tees_Model_NS_4 and Tees Helper_KW_3). The till is thickest in the north and west of the area (up to c. 60m) and thins into the Tees lowlands, where it is overlain by a considerable thickness of younger deposits. Some boreholes indicate that it contains sand, sand and gravel or clay lenses. These have been modelled where observed in boreholes but lithological variations within the Blackhall Till are likely to be considerably under-represented in the model.

GFDU3: Glaciofluvial sand and gravel deposit directly overlying the Blackhall Till and found underlying relatively thick laminated clay deposits interpreted as the Darlington Clay Formation have been termed GFDU3. This unit is found as mounds, relatively thin spreads or occupies hollows, possibly channels, in the underlying till. Where developed in hollows/channels boreholes indicate the unit may contain thin beds of till and laminated clay. These sand and gravels are likely to have formed during the retreat of the ice responsible for the deposition of the Blackhall Till.

Darlington Clay Formation: A relatively thick laminated clay unit is seen between the two tills across much of the area. It is absent in the very north of the model where a relatively extensive sheet of sand and gravel has been interpreted between the two tills. The lack of DCTF in this area may be due to the thick development of underlying till which may have formed an area of higher ground, or may be related to the ice margin responsible for the damming of the earlier glacial lake.

The Darlington Clay also appears to be absent in much of the Tees lowlands where it may have been eroded by the ice associated with the deposition of the overlying Horden till advancing from the east, and later dissected in places by the erosion by the (tidal) River Tees. The Darlington Clay appears to reach elevations of up to c. 50m in the north of the model area but the possibility that erosion by ice that deposited the overlying Horden Till has affected the distribution means that this may not relate directly to a former lake level.

GFDU2: Glaciofluvial deposits found in between the Darlington Clay and the overlying Horden Till have been termed GFDU2. In areas where the Darlington Clay is absent, distinguishing between the GFDU2 and GFDU3 is essentially arbitrary. The convention used has been to model sand and gravel or sand deposits found between the two tills as GFDU2 when no laminated clay is present.

Where overlying the Darlington Clay, this unit appears to form fairly extensive 'moundy' sheets and may be locally channelized, with glaciofluvial channels possibly having eroded into the Darlington Clay and Blackhall Till in places. These deposits are likely to have formed during the advance of the ice responsible for the deposition of the overlying Horden Till.

In the north of the model area, where no laminated clay is present, a fairly extensive sheet of sand and gravel is found between the two tills. The irregular topography of the region is thus characterised by substantial exposures of sand and gravel in along the flanks of hills and valleys. This sand and gravel has been interpreted as GFDU2 and it is assumed that the overlying till is the Horden Till with the Blackhall Till below. This interpretation means that the Horden till is fairly thin in this area. However, it should be noted that there is a possibility that the sand and gravel layer occurs within the Horden Till which is actually a thicker unit. This latter explanation is not supported by borehole evidence for a change in till characteristics below the sand and gravel hence the former interpretation has been assumed here.

Note: issues with the relationship of sand and gravel and till units in the north have been resolved using 10k standards and a number of helper sections – the key issue was determining the lateral extent of the Horden till (only general 'till' shown in DigMap...) and the distribution of the sand and gravel (GFDU2) – which is not present in some of the boreholes but is indicated by the geology map and boreholes in some areas.

Horden Till: The Horden till is extensive but relatively thin over much of the area, especially in the north where it overlies the sand and gravel sheet and in the Tees Lowlands where it has been partially eroded by the River Tees in the Tees estuary.

GFDU1: Sand and gravel units overlying the Horden Till (and not deemed to be associated with the lake shoreline...) are interpreted as GFDU1. These form moundy deposits or infilled hollows, and in the Tees lowlands are draped with the overlying Teesside clay. More extensive deposits have been modelled along the valley of Billingham Beck where the glaciofluvial deposits shown on DigMap have been interpreted as a valley-infill, i.e. glaciofluvial terraces (rather than an outcrop of GFDU2).

Teesside Clay: This overlies the Horden till in the Tees estuary, and has been modelled up to an elevation of ~15-20m above OD, largely coincident with the mapped extent (DigMap). The unit is overlain by marginal sand deposits and Holocene estuarine and beach deposits. Along the lines of the main rivers (Tees, Billingham Beck, Hartburn Beck) the Teesside Clay (and some of the underlying deposits) appears to have been eroded.

Teesside Sand and Gravel: Interpreted as overlying the Teesside Clay, and generally found near the margins of the TSDC outcrop. Along the lines of major streams, notably Billingham Beck, the relationship between this unit and adjacent glacio-fluvial deposits is difficult to decipher. This is in part due to miss-labelled or oversimplified polygons in DigMap and the relationships are clearer in the 10k standards. The sand and gravel is described in the literature as occupying a bench feature located c. 15-20m above OD. This is consistent with the mapping in the north of the outcrop area, but in the region of Billingham Beck, the outcrop of Teesside S&G extends up to c. 25-35m above OD. In this area, the original 50k standard showed glaciofluvial deposits which have been re-interpreted as lake marginal sands in DigMap to be consistent with the southern half of the Stockton sheet. Considered in the context of the borehole data, the revised mapping implies that the TSSG directly overlies the Darlington Clay formation in the region of Billingham Beck. This means that the Horden till and any glaciofluvial deposits are absent from the succession. While possible, an alternative explanation in which some of the sand deposits (especially those above~20m OD) are actually glacio-fluvial may be more likely. For the moment, the modelling is consistent with the current DigMap.
Further modelling of the margin of the TSDC and TSSG deposits may help to assess this, and we may need to reassess the extent of the TSDC and TSSG units once the full outcrop area has been modelled.

Marine and Estuarine Alluvium: contains both laminated clay/silt and sand units but is distinguished from underlying units (TSSG or DCTF) as it may contain shells, peat and plant remains and is generally soft to firm.

HBU 3/9/12 to 4/9/12

Tees (Middle) Modelling Notes

Extended sections NS1, NS2, NS3 and NS4 southwards as far as Framework section 3
Added sections Tees_Model EW_8, EW_9, EW_10, EW11, EW12, EW13
plots only for now, not correlated

The following boreholes were coded in BoGe and EA_Tees_BLG.blg to add data to sections:
NZ32SE 12, NZ41NE 785, NZ41NE 806, NZ41NW 673, NZ41NW 675, NZ41NW 676, NZ41NW662, NZ41NW 657, NZ41NE 45, NZ41NE 264, NZ41NE 266, NZ41NE 782, NZ41NE 784, NZ41NE 783, NZ41NE127, NZ41NE 125, NZ41NE 181, NZ41NE 182, NZ41NE 122, NZ41NE 117, NZ41NE 114, NZ41NE 106, NZ41NE 103, NZ41NE 97, NZ41SE 13716/J15, NZ41SE 13716/J16A, NZ41NW 56, NZ41NE 948, NZ41NE 15022/7, NZ41NE 15022/4, NZ41E 919, NZ41NE 47, NZ41NE 316, NZ41NE 310, NZ31NE 9, NZ41NE 102, NZ41NE 137, NZ31NE 46, NZ31NE 55, NZ31NE 44, NZ31NE 45, NZ31NE 59, NZ31NE 124, NZ41NW 13592/19, NZ41NW 728, NZ41NW 417, NZ41NE 13523/7, NZ31SE 75, NZ41SW 108, NZ31SE 75, NZ41SW 108, NZ41SE 133776/6, NZ41SW 47, NZ41NE 116, NZ41NE 480, NZ41NE 863, NZ41NE 120, NZ41NE 116, NZ41NE 480, NZ41NE 863, NZ41NE120, NZ41NE 837, NZ41NE 247, NZ41NW 34, NZ41NW 33, NZ41NW 18, NZ41NW 278, NZ41SW 333, NZ41NW 456

5-9-12
Correlated N-S sections as far as Framework 3 section

Section NS1:
Added DCTF to Framework Section 4 where it crosses NS1 – present in boreholes either side of crossing point
Complete as far as crossing point with Framework Section 3

NS 2
Unsure where to put the boundary between MEAS and Gorge Fill. Used the clay, sand and gravel dominated lithologies for gorge fill and silty lithologies for MEAS.

Section NS4:
Small patch of HEAD at NGR: 440241, 520728 correlated as GFDU1
Borehole NZ31SW 7 records sand & gravel down to c.45m, with till to c.47m. The gravel is correlated as GFDU1, with till lenses within it and BHTI as the basal till unit (at rockhead).

Added more DTCF to section Framework 3 after checking scanned BH logs for laminated clay. Also added it to the Blg file in some cases.

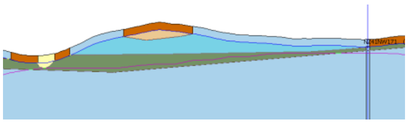
6-9-12
EW8
Thick Darlington Clay in BH, re-examined Framework 4 boreholes and added DCTF to Framework 4 due to presence of laminated clay

Unsure about interpretation of BH NZ41NW 53 in section Framework 1, whether the whole log records alluvium or whether there's some lake clay at the bottom. Kept it as alluvium for now.

EW9
Boreholes NZ31SW11 and NZ31SW 12 record 'very clayey sand' beneath silty or laminated clay. Should this be picked out as GFDU or can it be part of the DTCF?

SUPNM appear to be landslips on the 50K map. Does this need adding to the GVS?

EW10
GLLD mapped at NGR 440215 151610 is on a too high up to be the Darlington Clay, so have correlated LDE instead.



Modelling Notes

Not easy to represent the Cleveland Dyke without bedrock. Is it worth adding it to the GXS to get the superficial right?
LDE is younger than ALV in the GVS. This should be the other way round?

**Concerned that the MDAS coding isn't detailed enough, laminated clay is not recorded.
7-9-12
EW 11
Borehole NZ41SW 108 shows a thin cover of till over sand, whereas the mapping indicates lake clay exposed in a valley side. Drill log given precedence over the mapping.

EW12
Borehole NZ31NE120 records peat in what appears to be Darlington Clay. Would peat be expected in there?

Correlated EW13
Added NS 4 and NS5 where the model widens out
Added a helper section for LDE

LDE
Small patches of LDE are correlated using DigMap 50 as a guide. Additional areas of LDE are correlated using the borehole logs as a guide. Borehole NZ31NE 17 (used in section NS4) records clayey silt (interpreted as LDE) underlain by sand and gravel (correlated as GFDU1) with till underneath.

GFDU1
This forms an overdeepened channel structure just south of the crossing point between Framework Section 3 and NS4, indicated by borehole NZ31SW7 (used in NS4). As this borehole records a sequence dominated by glacial sand and gravel with minor amounts of till, the whole sequence is correlated as GFDU1 in line with boreholes either side, and the thin bands of tills are recorded as lenses. It is worth noting that there is good borehole coverage in this part of Section NS4.

Darlington Clay Formation
Borehole NZ42SW 44 in section NS4 records a basal clay unit described as 'stiff, brown, structureless, with rare limestone cobbles and pebbles'. This has been interpreted as BHTI, due to lack of lamination to indicate a typical lake clay origin. If this interpretation is correct, the Darlington Clay Formation becomes patchy in this area, with the HNTI and BHTI separated by glacial sand and gravel only. However, few boreholes in this section reach Rockhead.

Tills
Till subdivided where boreholes indicate a change of colour, or forced through when a deep borehole gives a general description of till. Horden Till present across the whole area, carved out in valleys, exposing the underlying Darlington Clay lake clay and/or Blackhall Till, as indicated by the mapping.

10th September – STHORPE

Renamed Tees_Model_NS4 to "Tees Model_NS_6" to be more consistent with other sections

Extended NS_6 southwest to edge of model area
Extended NS_4 southwest to edge of model area
Extended NS_1 southwest to edge of model area
Extended NS_5 southwest to edge of model area
Extended NS_2 southwest to edge of model area
Extended NS_3 south to edge of model area

Model saved - EA_Tees_Model_ST_V1_2.gsipr
11th September

Added cross-sections
EW_14
EW_15

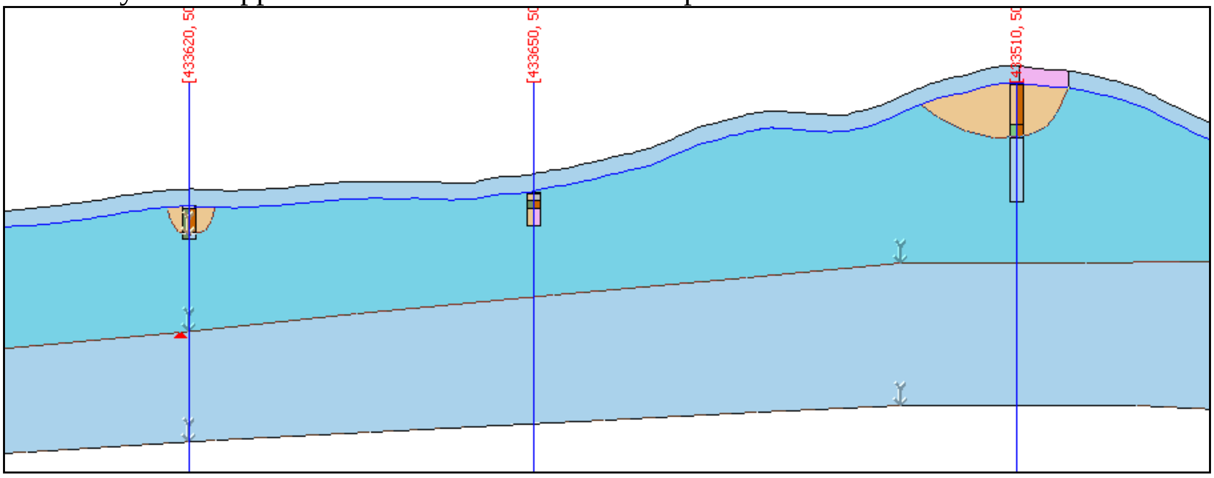
EW_16

12th September

NS_1 - completed

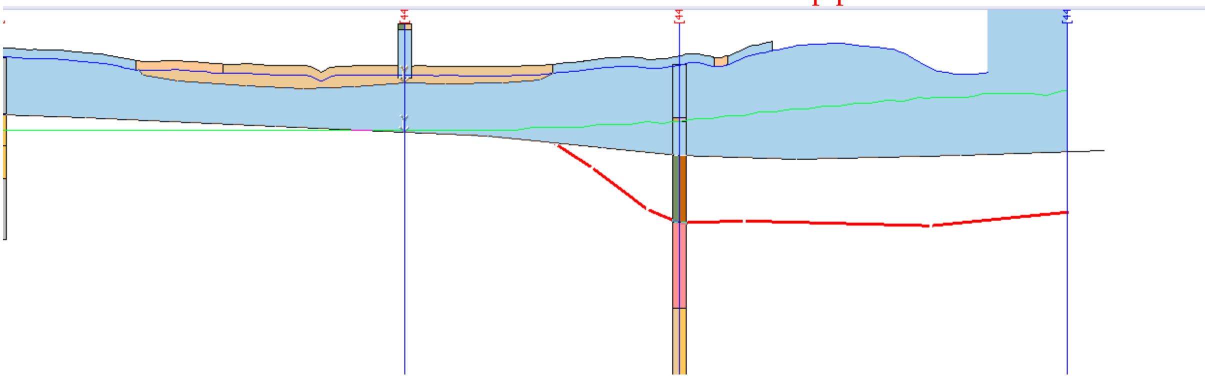
Borehole NZ31SE20 shows a silty brown pebble-free layer 2.2-3.2 interpreted as DCTF on cross-section.

Boreholes NZ30NW42 & NZ30NW19 show laminated clay at top of borehole. This doesn't match any unit mapped and therefore have been interpreted as below:



Tees_Model_NS_2 - completed

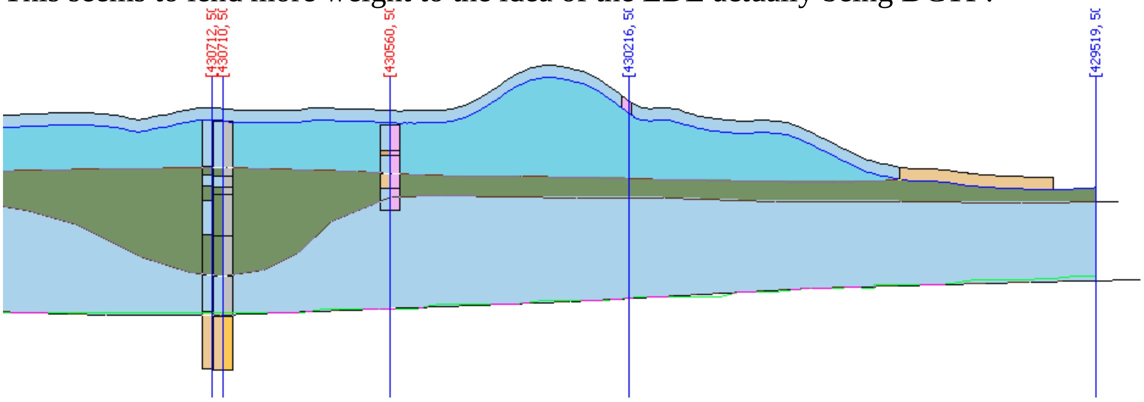
Unknown unit below BHTI? Could this be sandier reworked top part of MMG?



Tees_Model_NS_3 – completed

Tees_Model_NS_4 – completed

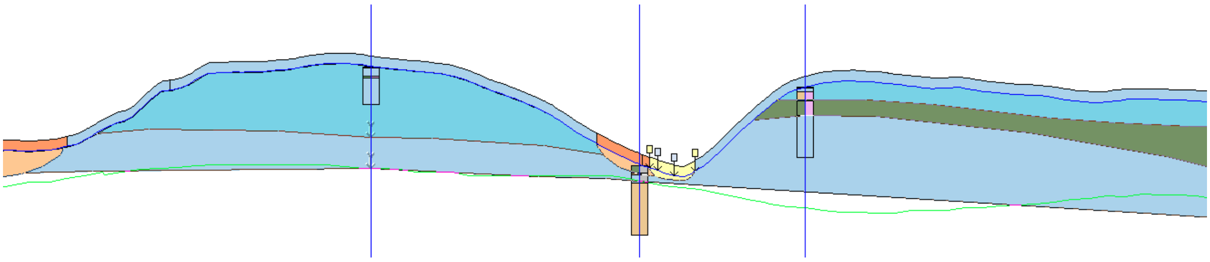
This seems to lend more weight to the idea of the LDE actually being DCTF?



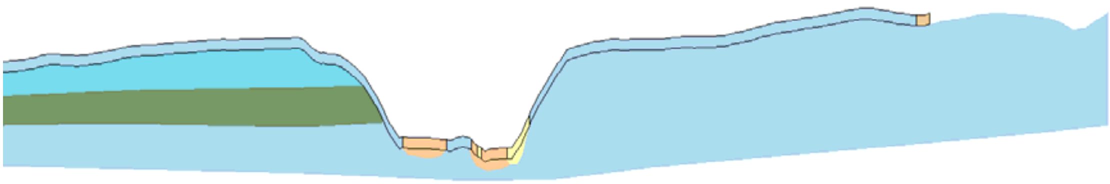
Tees_Model_NS_5 – completed

Tees_Model_EW_14 – completed

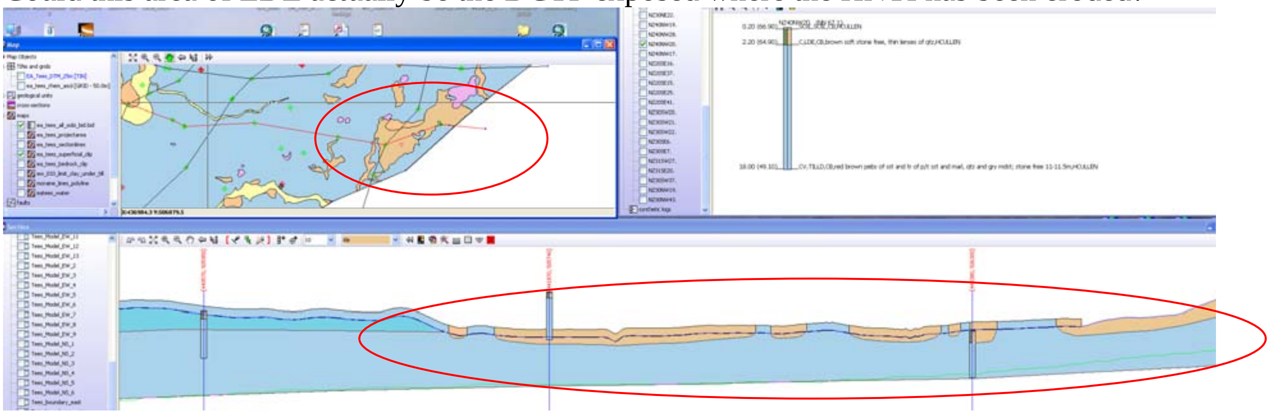
Unsure whether HNTI should be at the level correlated or match the adjacent hill?



And also at the eastern end of the section?



Tees_Model_EW_15 - completed
Could this area of LDE actually be the DCTF exposed where the HNTI has been eroded?



Tees_Model_EW_16 - completed

Envelope Construction – STHORPE 12th September
Envelopes begun to give more constraint to cross-sections. These obviously all need checking as the modelling process is iterated, as the calculation has shown that much more work needs to be done along the river valleys in particular.

Water - complete
BSA – Complete
LDE - Complete
BCHD - Complete
ALV - Complete
MEA - Complete
TSSG – Complete
TSDC – Complete. Amended EW_13 to force break in this unit to match the higher reaches where the ALV has cut down to the BHTI.
BHTI - complete

Latest version EA_Tees_Model_ST_V1_12.gsipr

Review Process of Cross-section up to 18th September 2012 with Cooper, Burke, Thorpe, and Banks

Tony Cooper reviewed the current cross-sections and compiled the list below. This list then formed the basis of an informal meeting in which TC explained his findings to HB and ST to help better understand the geological vagaries. In these discussions however it became obvious that there were significant mismatches with the Durham South Model (particularly in terms of GVS/GLEG and the development of the glacial history of the two convergent ice sheets). ST agreed that he would append any legend entries from the Durham South Model to the Tees GVS and then reconvene the meeting to further discuss how the Durham sections can be revisited and ameliorated.

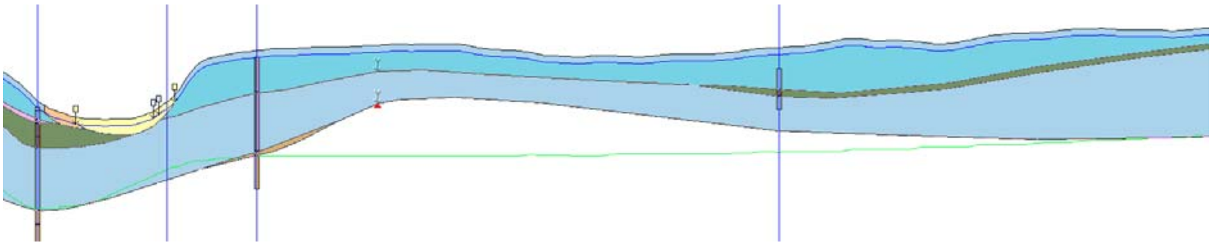
Tony Cooper's main findings were:

Section NS_1 Need to consider the moraines and whether the Horden Till extends to the southern part of the section.
Section NS_2 has some strange geometrical relationships between the laminated clays and the over and underlying till units. This is especially so where the section runs alongside the meanders in the Tees and south from here. On the south part of the section it looks like the Horden Till should be present. Need to consider the moraines around here.
Section NS_3 Looks OK, but I wonder about the Darlington DTCF going as far to the south uphill, borehole NZ41NE101 shows gravelly clayey silt at this level. Ok for the contact between the two tills, but I think without the laminated clay. In fact the majority of this clay is outside of the area where it is shown on the Stockton 33 sheet.
Section NS_4 Looks OK
Section NS_5 Looks OK
Section NS_6 Looks OK, but what evidence for DTCF at base in the left (north-east) of the section?
Tees_boundary_east Looks OK
Tees_boundary_west Looks OK
Section EW_1 Looks OK
Section EW_2 Looks OK
Section EW_3 Looks OK, but need to determine the envelope for the Darlington Clay Formation DTCF to ensure that it fits with all the sections.
Section EW_4 Looks OK does not have DTCF as much as EW3
Section EW_5 Looks OK
Section EW_6 Looks OK
Section EW_7 Looks OK
Section EW_8 not checked
Section EW_9 not checked
Section EW_10 bit worried about the dip in the boundaries at borehole NZ41NW721, it does not appear required, possibly better to make the laminated clay around here much thinner to fit with the geological lines on the map so that the Blackhall Till crops out in the bottom of the valley. The big dip in the laminated clay and till boundaries to the east also looks strange. This needs to be looked at along with NS_2 which has intersection cross marks here.
Section EW_11 looks OK
Section EW_12 looks OK
Section EW_13 looks OK, we need to decide whether any Horden Till exists in the low area of the Tees cf Section 12.
Section EW_14 – Questions about the extent of the laminated clay it looks like it should go across the valley in the west and then die out, this is suggested from the published map and the limit of laminated clay. In the east it looks like the laminated clay is far too extensive and the Horden Till should be more extensive.

Section EW_15 looks OK, but need to consider whether the Horden Till continues to the SE to edge of area – the moraines lines should help
Section EW_16 looks OK

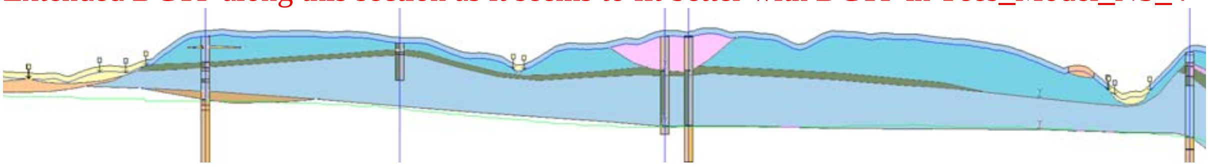
Areas for further investigation (as these are discovered I am adding them to this section of the metadata – STHORPE)

Tees-Framework_2
Correlated section doesn't fit with RHEM model



Crossing section Tees Framework 1 has a borehole that reaches sandstone at 23m OD (depth of ~20m) within 350m of the crossing point suggesting rockhead model is significantly out in this area (at c. 2m OD) – KWHI 17/10/12

Tees-Framework_2
Extended DCTF along this section as it seems to fit better with DCTF in Tees_Model_NS_4



HBU 21-9-12 to 24-9-12
Amended EA Tees sections using comments from Tony C after checking.
Checked boreholes used in framework sections and edited blg file where laminated clay is recorded
Added and correlated sections Tees_Model_NS_7 and Tees_Model_EW_17

HBU 26-9-12
Matched Durham South sections to Tees model following advice from AHC. Changed Durham South sections to (b) to distinguish from originals. Durham sections matched to 50m DTM
EA_Tees_Model_HBU_V1_19.gsipr

HBU 12-10-12
EA_Tees_Model_HBU_V1_40.gsipr
Envelopes constructed for all units in the model
Sections correlated, except for the eastern boundary section, which is half finished.
Alluvial fan deposits not correlated (on advice of AHC) due to their small extent

KWHI 16-10-12
EA_Tees_Model_KWHI_V1_41.gsipr
Correlated eastern boundary section:

Stopped DCTF at the eastern end of EW_10 short of the model edge to correlate with the boundary section which contains no DCTF in this area.
Moved boundaries at east end of EW_12 to rockhead.

Minor changes to NS_3 and EW_12 near their intersection to include peat containing units in overlying alluvium.

Raised level of HNTI at east end of Tees_Framework_3
Lowered level of BNTI to rockhead at east end of Framework_3 (no bores to suggest otherwise) and slightly lowered HNTI base too – as more consistent with adjacent sections.

Stopped GFDU2 short of east boundary in section EW_17 and slightly raised HNTI base

Created and correlated Tees_boundary_south:

Extended DCTF at south end of NS_1 to agree with adjacent sections

Created and correlated Tees_boundary_north:

Created and correlated Tees_Helper_KW_11

Created Tees_Helper_KW_12 to help sort distribution of TSSG in Billingham area (not finished)

Envelope edits:

Edits to DCTF envelope near east boundary.
Expanded BNTI envelope so that it fully covers the southern edge of the model
Edited HNTI in north of model
Edited BNTI in north of model
Edited DCTF in north and east of model

KWHI 17-10-12
EA_Tees_Model_KWHI_V1_44

Issue with extent of TSSG, GFDU1 and GFDU2 in Billingham Beck area:
Details from DigMap and 1:10k sheet are not clear as to the extent of the TSSG sands along Billingham Beck. There is a rather abrupt break between the TSSG in the lower part of the valley and GFDU 1 in the upper part. Both of these deposits may effectively line the valley, and local boreholes suggest that there are substantial thicknesses of GFDU2 and DCTF underlying relatively thin HNTI in the surrounding area which may also outcrop in the valley sides. The existing mapping has a head unit mapped in the valley sides. We are not modelling head – but inspection of the local boreholes suggests that the mapped 'head' may actually be outcrop of the Darlington Clay in the valley sides. The outcrop of TSSG is mapped on DigMap as extending up a series of tributary gullies. However, these extend up to c. 35-40m above OD. The TSSG is interpreted to be a lake-marginal deposit formed at the edge of the latest Tees glacial lake – the laminated lake deposits are restricted to areas below c. 20m OD, so high elevation TSSG is unlikely. What is more likely is that the gullies are cut into the till and expose the sheet of glacio-fluvial sand beneath (GFDU2).
TSSG has been modelled up to c. 25m OD up Billingham Beck (see Nirex report ref giving lake limit c. 24m).
TSSG 'beaches' along the margins of Billingham beck thin upstream and eventually peter out where the floor of the valley reaches c. 25m OD. It is interpreted that TSSG in the floor of the valley has been eroded by the stream and replaced with alluvium.
The upstream area of the Beck is partially flanked with GFDU1 sand and gravel
The sequence of HNTI, GFDU2 and DTCF are exposed in the valley sides where the flanking GFDU1 and TSSG are not present and tributary gullies cut into HNTI exposing GFDU2.

This interpretation suggests that the Glacio-Fluvial sheet (GFDU2) separating the upper and lower tills in the north of the model area is effectively continuous along the western edge of the model and has been dissected by Billingham Beck.

Modified GFDU1, GFDU2, GFDU3, TSSG and DCTF units in region of Billingham Beck – new helper sections; Tees_Helper_KW_12, 13, 14, and 15 created, crossing sections locally modified and TSSG, GFDU1, HNTI, GFDU2, DCTF and GFDU3 envelopes modified.

Issue with ALV 2:
Created ALV2 envelope

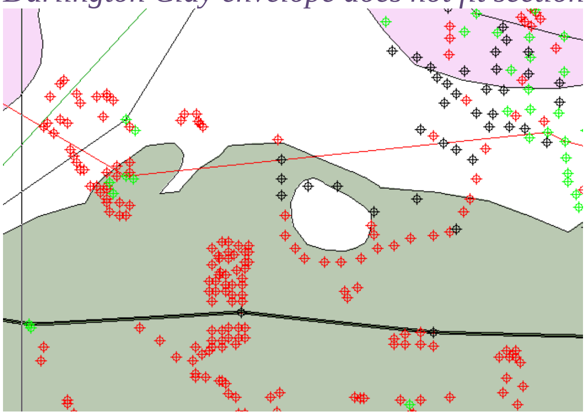
ALV2 is a possible channel fill deposit in valley excavated into TSDC and underlying deposits during period of lower sea level immediately following the drainage of the last glacial lake. The existence of this deposit has been suggested in the literature on the basis of boreholes showing a thick gravel sequence going to bedrock in the area of the Newport Bridge over the Tees.

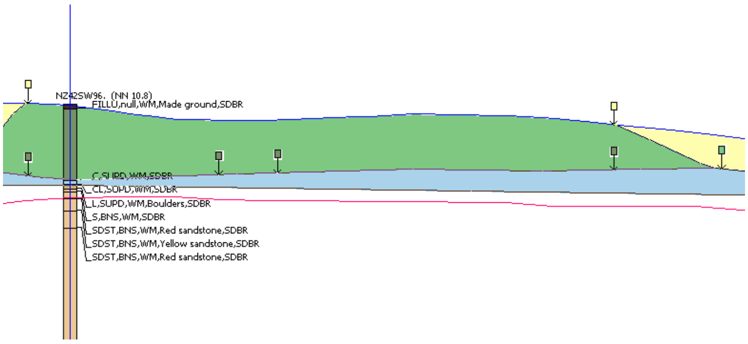
Some boreholes in this area do suggest that there is a gravel sequence, overlain by Holocene marine/estuarine deposits that contacts bedrock or basal till – but it is difficult to trace the lateral extent. This is because: 1) many of the bores are not coded, 2) it is difficult to identify the clay and till units in many of the logs as they could be MEAS, TSDC or HNTI – if the latter two overlie the gravel then it can't be classed as ALV2 but must beGFDU2 or GFDU3... But the boreholes that have been coded do suggest that it does not continue northward as suggested in the literature.

A helper section (Tees_Helper_KW_16) was drawn to attempt to delineate the ALV2 unit better – the section highlights the problem distinguishing ALV2 and GFDU2.

Consequently ALV2 is currently interpreted as a localised deposit and does not form an elongate channel fill as may have been expected. It may be simpler to re-interpret this unit as MEAS and/or GFDU2 or 3 .... (?)

Issue Highlighted:
Tees_Model_EW_13
Darlington Clay envelope does not fit section



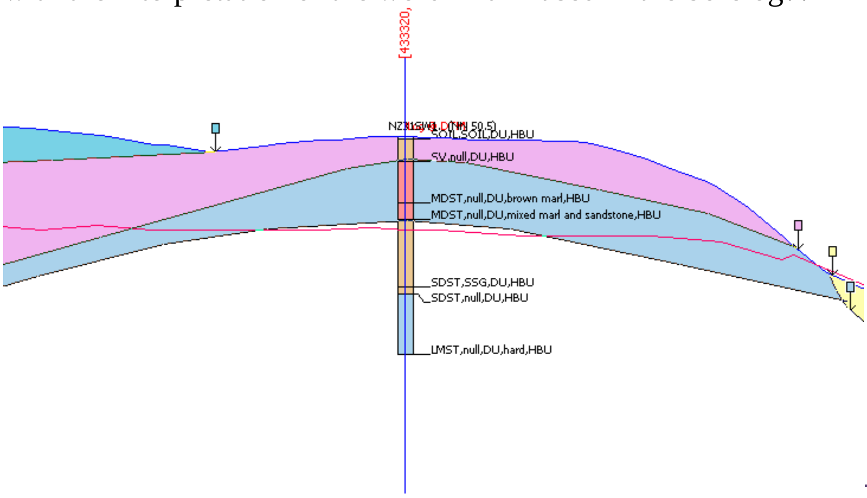


<u>17/10/12 STILL TO DO LIST:</u>
Sort made ground (how are we doing this?? – boreholes, landuse??)
Add bedrock (weathered vs. unweathered SST; Cleveland Dyke)?
Check snapping of all sections and envelopes
Model calculation: check + iterate with helper sections.

18/10/12
KWHI checking sections: details of issues arising:

Moraine near Sockburn – adjacent sections (NS_4 and NS_1) crossing the moraine show different thicknesses of HNTI and only one contains DCTF.
– Constructed Helper section Tees_Helper_KW_17 along the line of the moraine ridge to check the interpretation: I have thinned HNTI in NS_1 and EW_14 (and some crossing sections) and added a thin unit of DCTF in between that and the underlying BHTI where a sandy silt is seen in borehole NZ30NW 13. This means that the DCTF continues across the valley to the west and then dies out – as suggested by Tony for EW_14.

Issue in section NS_4:
BNTI till unit has been drawn through MDST in borehole NZ31SW1 (pic below) – is this to do with the interpretation of the word 'marl' used in the borelog??



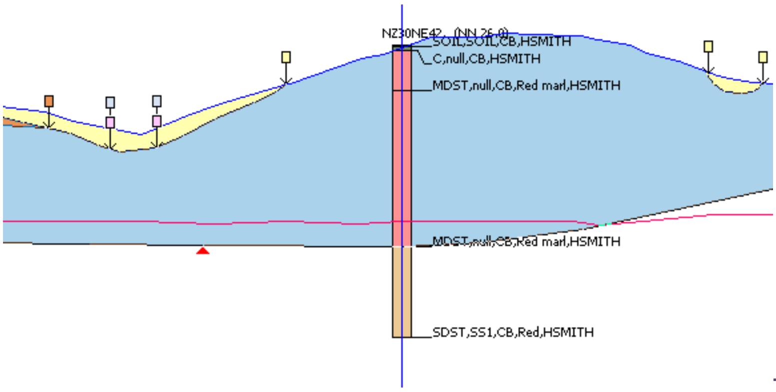
- Current interpretation.

This bore log is from 1953 and contains only the info included in the coding. As we are close to the (DigMap) contact between the Roxby Formation (calcareous mudstone) and the SSG it is possible that 'marl' here refers to the Roxby Formation... especially as the lower 'marl' is mixed with sandstone, and then is underlain by a sandstone that directly overlies the Permian limestone. I'd prefer to pinch out the BHTI against a rock high at this bore.... Any thoughts??? – KWHI

Similar issue in section NS_6:

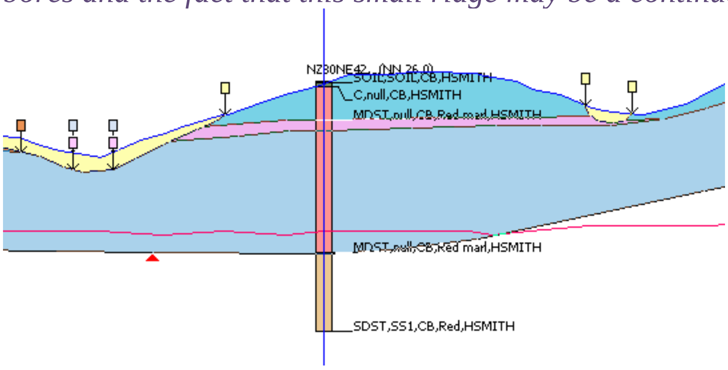
Borehole NZ31SW17048/5 in section NS_6 has till interpreted through SST recorded in the base of the log – this has been amended to pinch out BHTI before the borehole. KWHI-18/10/12

Similar issue also in *Tees_Framework_1*:



- Original interpretation.

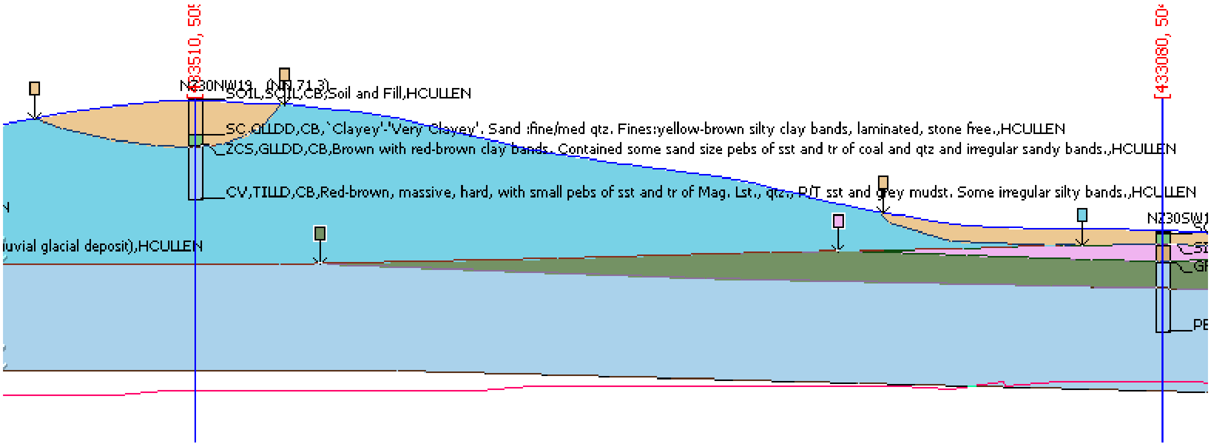
The bore log is from a 2006 water bore and contains no more info than the coded log except a 3m thick sand and gravel has not been coded between the two units of "red marl" recorded as mudstone. On the basis that we are right in the middle of the Sherwood sandstone subcrop and surrounding bores record red-brown till, I agree with the interpretation of till in this bore. But the presence of the sand and gravel probably marks the boundary between the two tills so I have added HNTI (and GFDU2) in the section. This latter interpretation is consistent with adjacent bores and the fact that this small ridge may be a continuation of the Sockburn moraine.



- Revised interpretation – KWHI 18/10/12

Envelopes edited following these amendments: ALV, BNTI, DCTF, GFDU2, HNTI

Noted that small lakes have been modelled on top of the moraine ridge near Great Smeaton (e.g. south end of NS_1, borehole NZ30NW 19 – see below)
The log describes a laminated, "stone free" sandy clay so this fits – but the position at the top of the ridge, and that fact that the descriptions of till in other boreholes along the moraine suggest that weak laminations are common indicates that this is probably part of the moraine deposit which is likely to have had minor ice marginal lakes and channel systems and/or some chunks of the underlying laminated clay sliced in with it. I haven't changed the interpretation as it highlights that there is a laminated clay but we could remove these minor lakes to simplify things and restrict lde to clear topographic hollows... Thoughts??



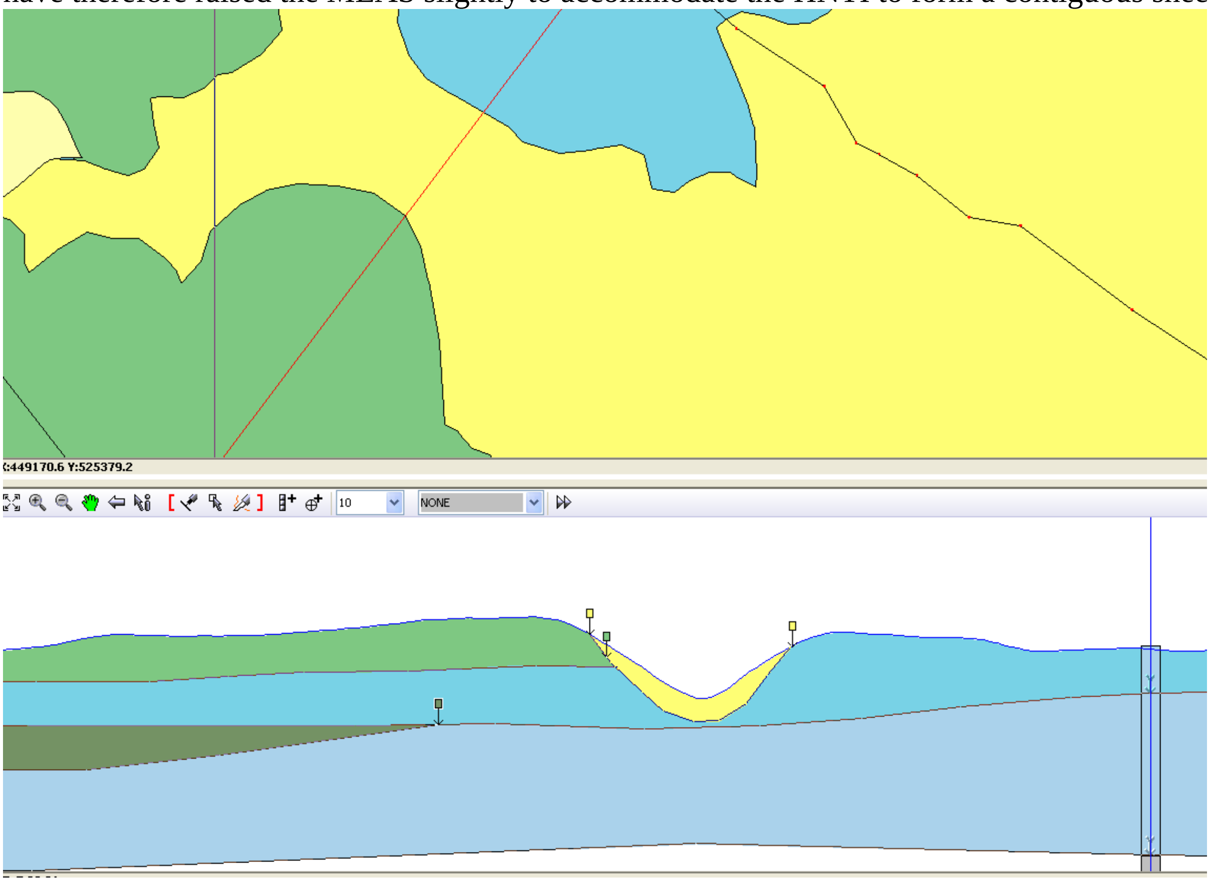
Current interpretation

Latest GSIPR:
EA_Tees_Model_KWHI_V1_45

S Thorpe – Checking snapping, calculation and adding any envelopes as necessary. Begun 23rd October 2012. Amended DTM to 25m project area (since previous versions had been using the overall DTM at 50m)

Helper_1_HBU – This section defines the base of the LDE and needed to be densified to calculate correctly. Snapped the GFDU2 lines and corrected in crossing section EW10.

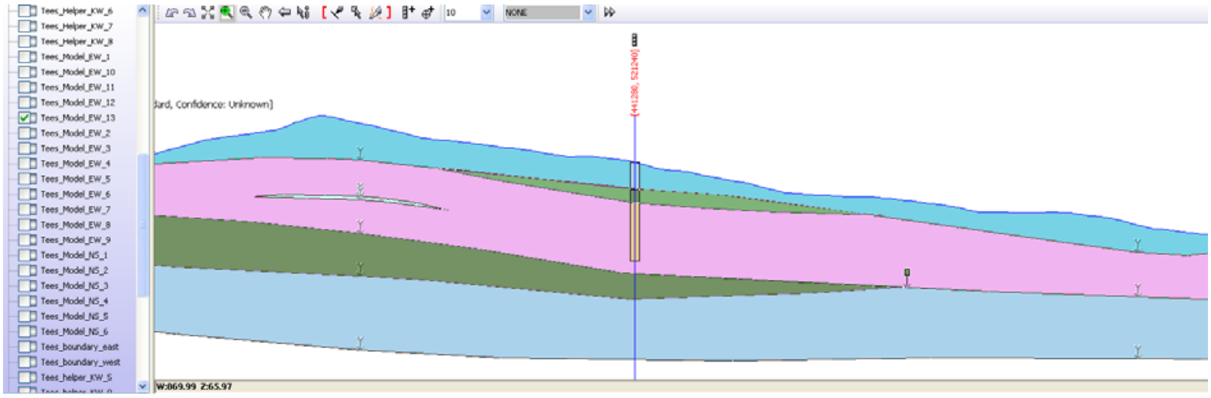
Tees-Framework_1 – At 449642,526010 where MEAS forms a channel-like feature the MEAS cut down through HNTI into BHTI underneath. This was not replicated in the envelope and I cannot rationalise it as it would mean that the HNTI is not a continuous sheet under the MEAS. I have therefore raised the MEAS slightly to accommodate the HNTI to form a contiguous sheet.



All units snapped.

25th Oct 2012
Rationalised the lens entries in the GVS. There were some hiccups in the numbering (and some spelling errors too) with the lenses for sand, till and clay. These were corrected in GVS, numbered correctly, and input back into the cross-sections.

Tees_model_EW_13
Cross-section shows a small area of laminated clay (proved in borehole) and has been coded as a lens. I am a bit sceptical as to whether this will work in the calculation, as the lens top is coincident with the base of HNTI. It may be better to create a clay unit that sits underneath the HNTI?

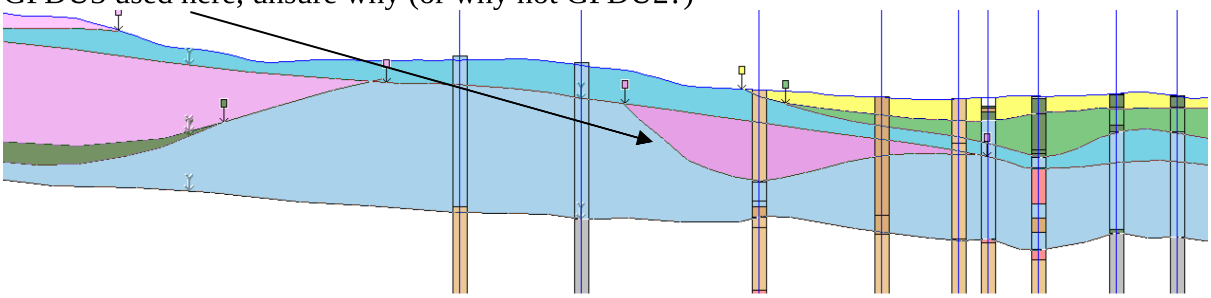


Tees_Framework_5
Amended thickness of DCTF in crossing section to match this one, it appeared far too thick.

All Lenses completed – drawn arbitrarily as circular objects as none of these have been sufficiently defined in cross-section to be drawn with any great knowledge about their structure.

Saved as V1_49.gsipr

EW_4
GFDU3 used here, unsure why (or why not GFDU2?)



Need to amend envelope for NS_4 - GFDU1!!!

Need way of representing the DYKE in cross-section. Along with bedrock adding.

26th Oct 2012
25m DTM is unworkable!! Taking in excess of 10mins to update in 3D window. Will resort back to a trimmed version of the 50m DTM.

Tees-Framework_2
All snapped and envelopes amended for HNTI and BHTI in east where RTDU cuts down.
Saved as V1_51.gsipr

Tees_Framework_3
All snapped

Tees_Framework_4
All snapped

Tees_Framework_5
All snapped

Tees_Helper_KW_1
All snapped and envelopes amended for GFDU1 along valley where RTDU cuts down through (as above in NS_4)

Tees_Helper_KW_10
All snapped

Tees_Helper_KW_2
All snapped

Tees_Helper_KW_3
All snapped – suggest extending the cross-section across the rest of the model to avoid truncating section mid-model (bad practice!) *(– Section extended by KW – see below*)

Tees_Helper_KW_4
All snapped

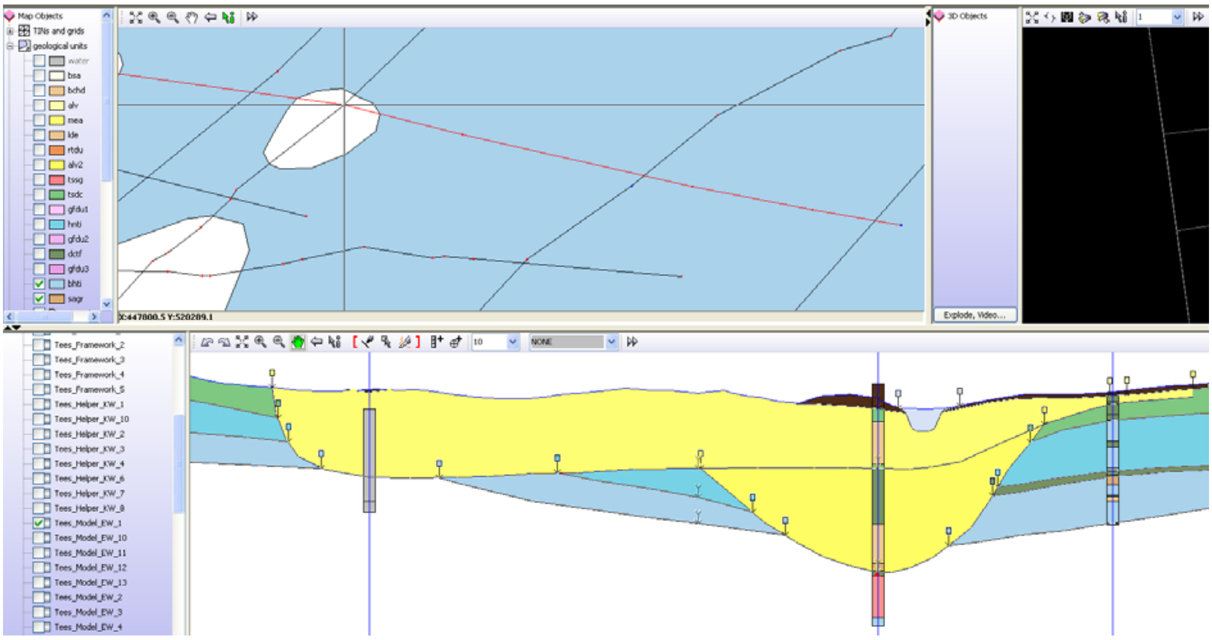
Tees_Helper_KW_6
All snapped

Tees_Helper_KW_7
All snapped

Saved as V1_53.gsipr

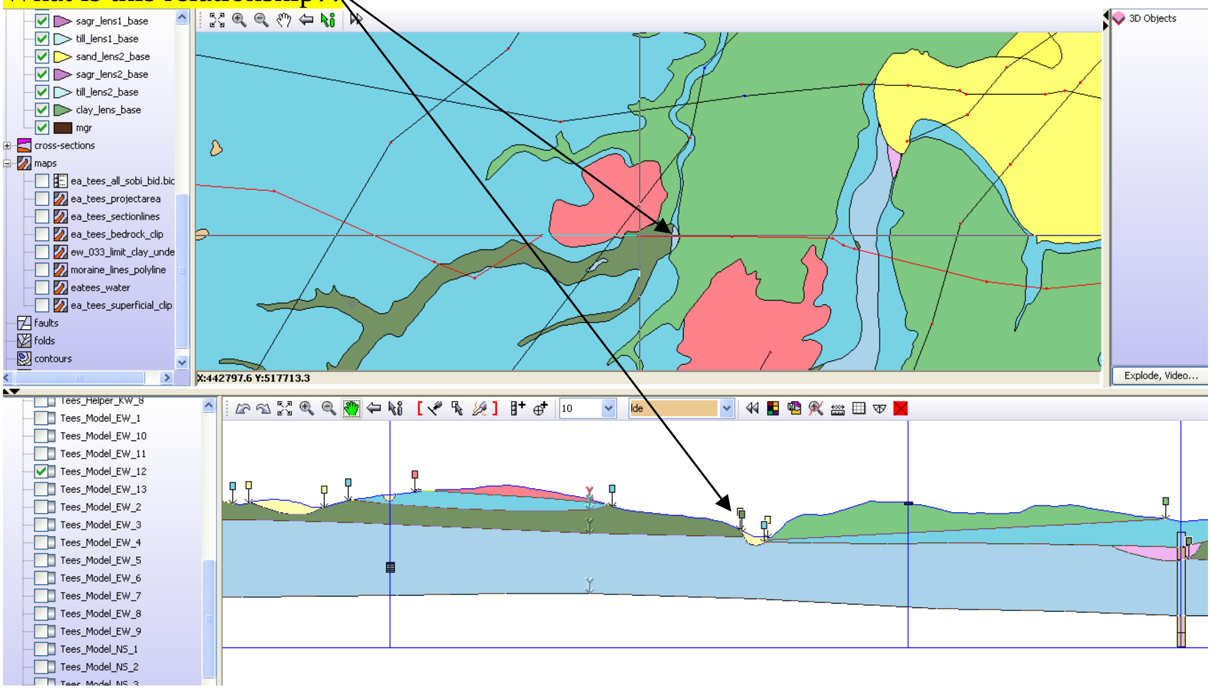
12th November 2012 – S Thorpe
Tees_Helper_KW_8
All snapped

Tees_Model_EW_1
All snapped
Amendment made to the BHTI where it meets with the ALV2 lines. Previously the BHTI was shown to pass through this borehole.



Tees_Model_EW_10
All snapped

Tees_Model_EW_11
All snapped
Tees_Model_EW_12 *(Issue addressed – see below. KW)*
What is this relationship??



All snapped

Tees_Model_EW_13
Added Peat1 envelope
Added clay_sub_till to GVS_V3 to allow input of laminated clay deposit in borehole NZ42SW45. This was drawn as a lens but is actually a stratified unit.
All snapped

Tees_Model_EW_2

Amended LMST colour in legend to be greeny-blue to differentiate from TILLs overlying limestone.
All snapped

Tees_Model_EW_3
All snapped

Tees_Model_EW_4
All snapped

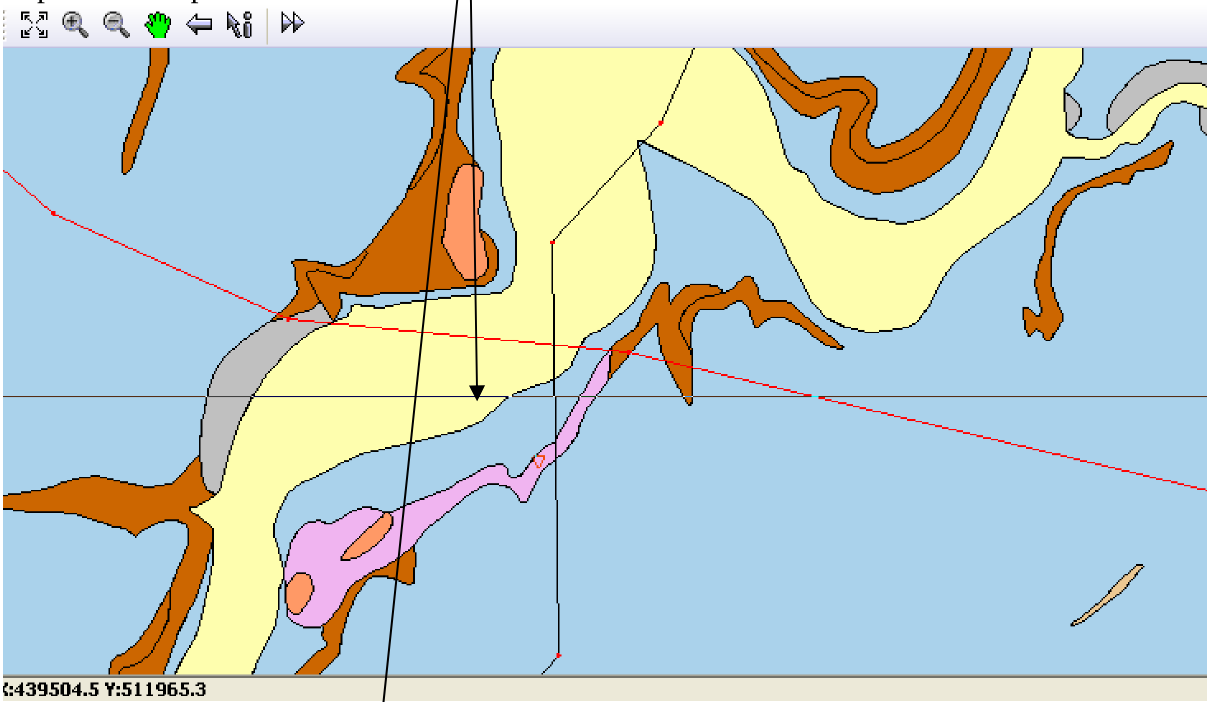
Tees_Model_EW_5
All snapped
BHTI taken underneath ALV in Tees valley, no evidence to show that it is cut out by river

Tees_Model_EW_6
All snapped

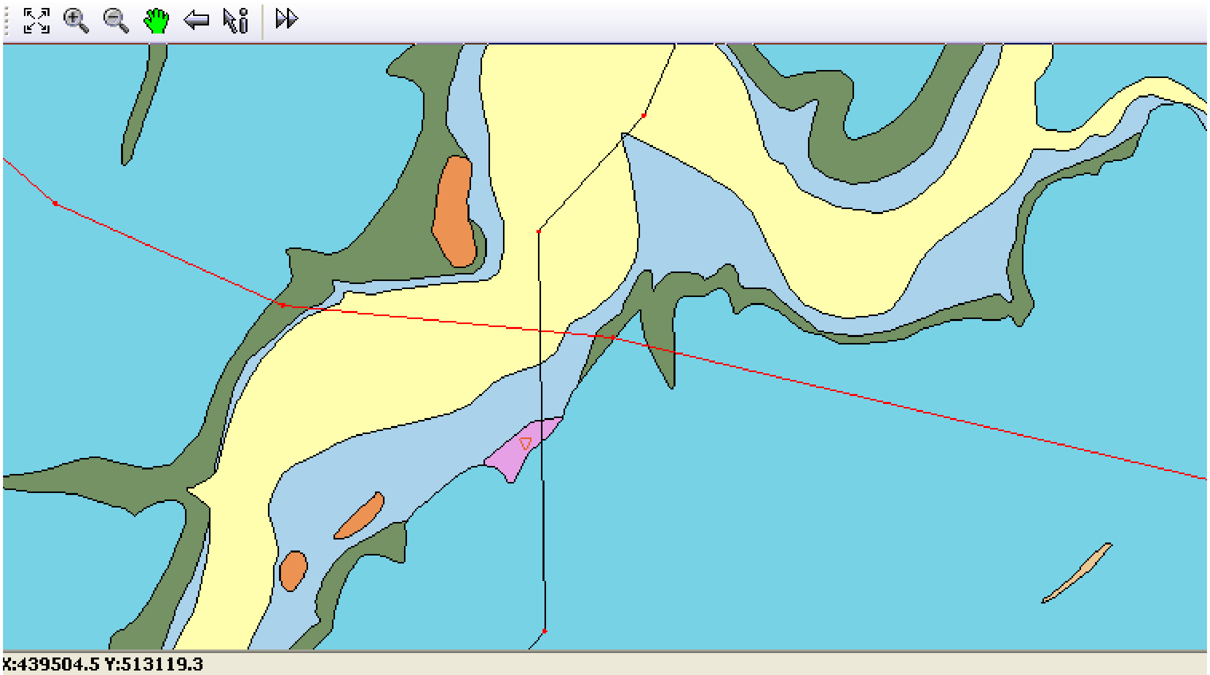
Tees_Model_EW_7
All snapped

Tees_Model_EW_8
All snapped
Tees_Model_EW_9
All snapped

This geological situation doesn't seem to have been honoured in the model? - *(Issue dealt with by construction of helper section (Tees_Helper_KW_18) and expansion of GFDU3 unit. See below - KW)*
Superficial map view



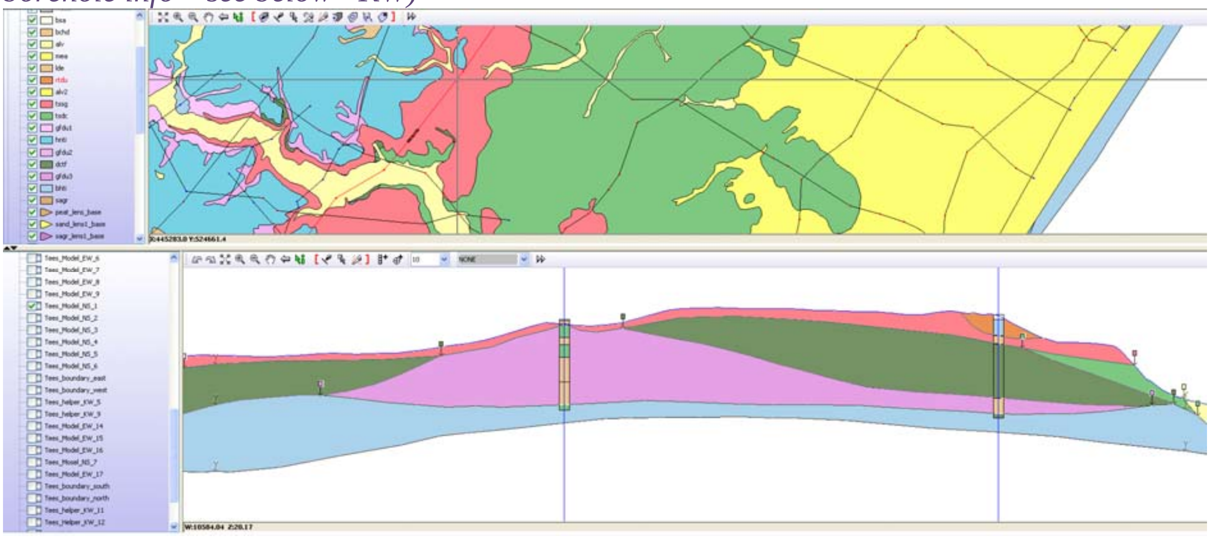
Model 2d map View



Model doesn't show the gfdu(?) between the two till units, and further east the DCTF can be seen between the two till units whereas the map doesn't show any separation.

Tees_Model_NS_1

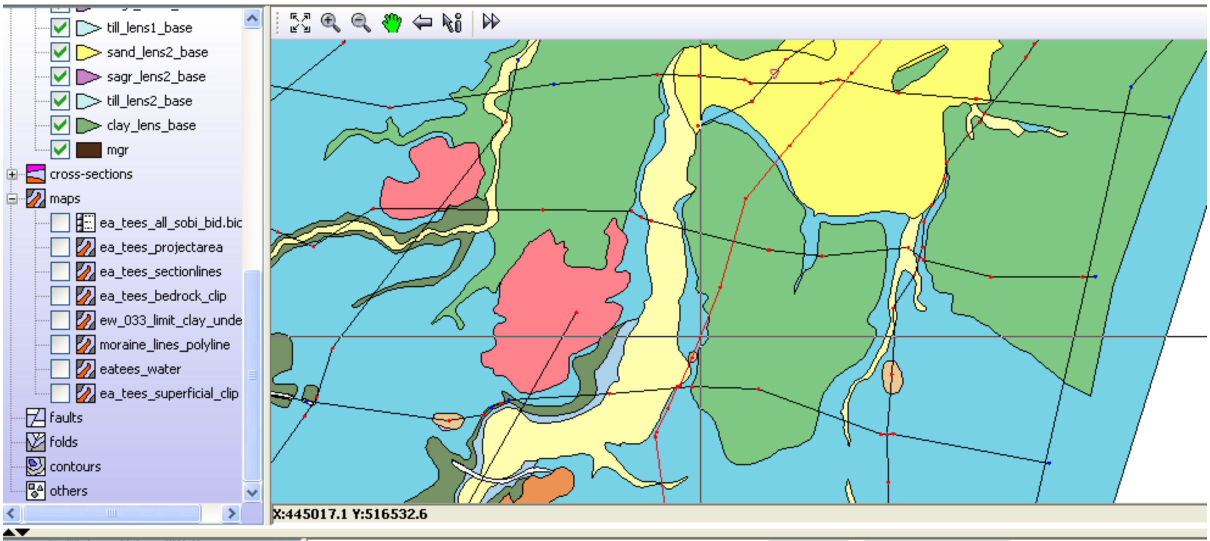
Confused by this one? RTDU and the GFDU/DCTF interface don't get confirmed by the borehole evidence. - *(Sections Tees_Model_NS_1 and EW_5 amended to simplify and honour borehole info – see below - KW)*

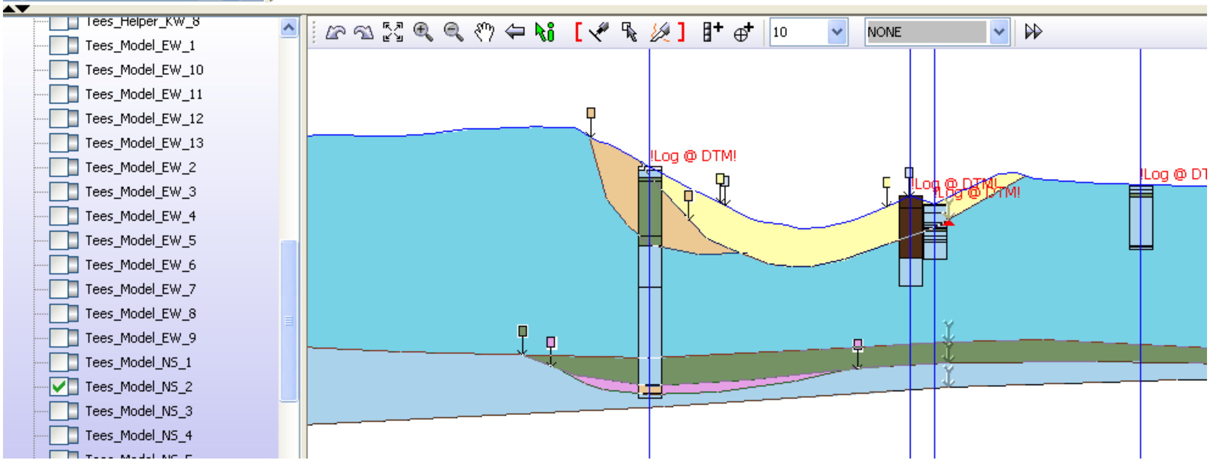


All snapped

Tees_Model_NS_2

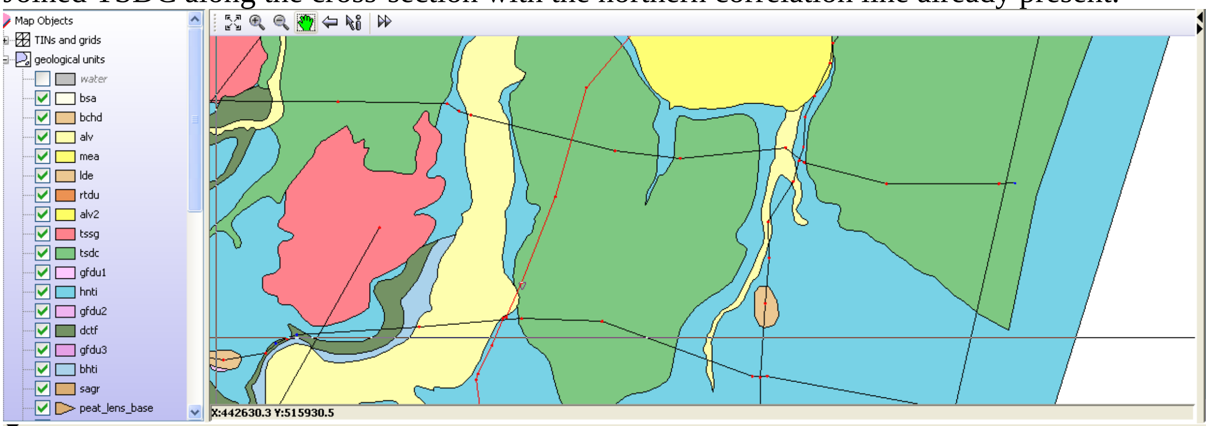
Unhappy about ALV and underlying clays relationship here:

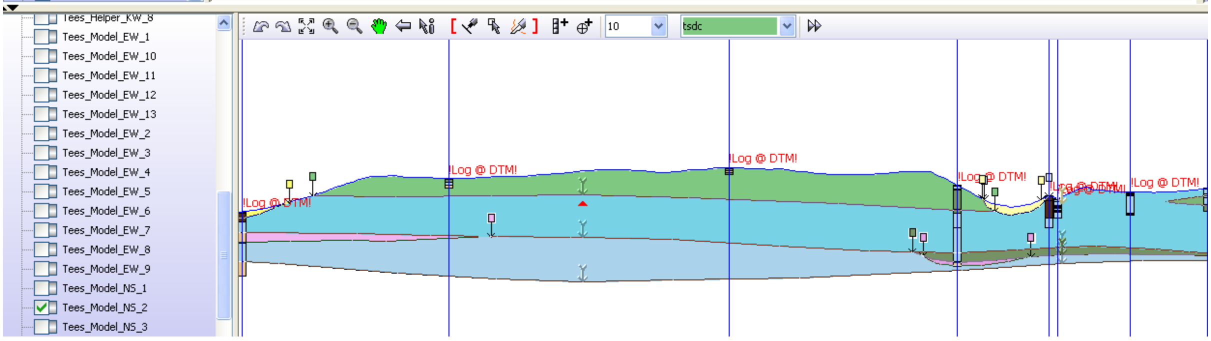




ALV seems too thick for such a tangential line across the edge of the polygon. And the laminated clays in green at the top of the borehole could be interpreted as TSDC extension.

Joined TSDC along the cross-section with the northern correlation line already present.





Tees_Model_NS_3

All snapped

Tees_Model_NW_4
All snapped

Tees_Model_NW_5
All snapped

Tees_Model_NW_6
All snapped

Tee_helper_KW_5
All snapped

Tees_helper_KW_9
All snapped

Tees_Model_EW_14
All snapped

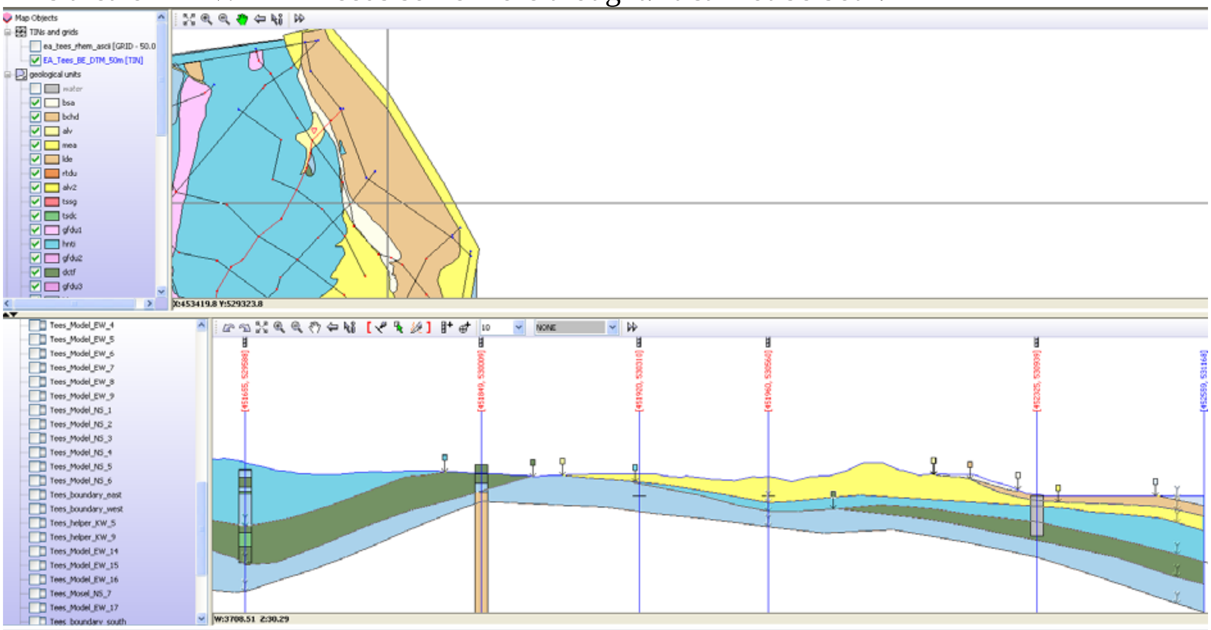
Tees_Model_EW_15
All snapped

Tees_Model_EW_16
All snapped

Tees_Model_NS_7
All snapped

Tees_Model_EW_17
All snapped

Tees_helper_KW_11 *(Section amended to deal with ALV –MEA issue – see below. KW)*
All snapped.
This area of ALV/MEA needs some more thought. It cannot be both.



Tees_helper_KW_12

All snapped

Tees_helper_KW_13
All snapped.

Tees_helper_KW_14
All snapped.

Tees_helper_KW_15
All snapped.

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19 Nov 2012 - Katie Whitbread
Summary: Section checking for snapping and dealing with issues raised by Steve Thorpe.

Tees_Helper_KW_16
Made substantial changes to this section as relationships between units were not structurally consistent with those in nearby sections. Need to amend envelopes and make minor changes to adjacent sections as a result:

Envelopes amended: BNTI, GFDU2, ALV2, HNTI, MEA, DCTF, GFDU3
Sections amended:
Tees_Model_EW_8 – ALV2 amended - checked and snapped to envelopes
Tees_Framework_4 – some sand and gravel modelled as GFDU2 reinterpreted to ALV2 as it appears to be a continuation of the early Holocene channel fill deposit –snapped to envelopes

Tees_Model_EW_13 – extended east to join Tees_Model_EW_8 so that the section end is not hanging – snapped to envelopes

Tees_Model_NS_2 – added in made ground and water (missing from area of borehole NZ41NE 981) – snapped to envelopes

Tees_Model_EW_1 – snapped to envelopes

Tees_Helper_KW_17
Added two till lenses where Tees_Model_NS_4 intersects. Snapped.

Tees_boundary_south
Not checked as it is now mostly outside the DTM – has a new DTM been cut since it was drawn??

Tees_boundary_north
Amended MEA distribution (MEA envelope also edited) – snapped

Tees_boundary_east
Some areas of section now off the DTM.
Snapped.

Tees_boundary_west
Some areas of section now off the DTM (around Billingham Beck) – these not checked.
Snapped – in places it looks as if the DTM is different to the one used to model the section lines – ties with envelope outcrop lines are off in a number of places. Tied to current DTM.

Dealing with problem areas identified by Steve T -

Tees_Helper_KW_3

Section extended to model boundary as suggested by Steve – GFDU3 unit added - envelope amended. Section snapped.

Tees_Model_EW_12
Section amended where it crosses Hartburn Beck to address issue with DCTF and TSDC apparently outcrop on opposite sides of the stream. Having check log for nearby borehole NZ41NW 18 I have thinned the TSDC and HNTI and added DCTF to the east of the stream. This is more consistent with modelling in adjacent areas. Snapping checked in region of the amendments.

Tees_Helper_KW_18
New helper section constructed to assess nature of relationship between till and sand and gravel units and delineate SAGR issue noted by Steve above. Resolved by expanding GFDU3 with is locally present so that it outcrops in the lower part of the incised valley wall.

Tees_Model_NS_1 and Tees_Model_EW_5
Checking the interpretation of RTDF, TSDC and DCTF in section. Amended to simplify the stratigraphy modelled as these is limited evidence for some relationships from the borehole data. RDTU removed from section Tees_Model_NS_1.

Tees_helper_KW_11
Amended MEA – ALV issue in north of section. Kept ALV unit to be consistent with mapped units.

Latest File: EA_Tees_Model_KW_V1_70.gsipr

Other key issues to be addressed:
Can’t complete the boundary section checking due to the excessively trimmed DTM – there should be a small buffer zone at the model edge

Has water been taken out of some of the sections? It is still in others so how will this affect the calculation??

What are we doing about the made ground?? – envelope is unfinished but MGR has been modelled in many sections.

4th December HBU
Water added to cross-sections where it was missing
Doesn’t always match alluvium or the DTM – sometimes sits on top of hills

Two River Tees sections added, one following the path of the river, and the other through the middle of the alluvium, ready to correlate.

5th December HBU
Correlated section Tees_Thalweg_1

Section: Tees_Thalweg_2 Does this affect the domains?
Borehole NZ30NW 24 records sandstone bedrock directly below alluvium and gravel, but till envelopes carry on. Edited the till envelopes to fit the borehole.
NZ30NW 12: RTD recorded but no ALV. ALVl, BHTI, HNTI and RTD envelopes edited

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5th/6th Dec - KWHI

Deleted existing MGR envelope (only one polygon in it)
Imported 10k MRG and MWGR polygons from DigMap into new MGR envelope
Derived borehole shapefile showing all coded bores with FILLU and ARTDP in them.
Created topo map jpegs for key areas from 1:25k OS maps
Extended and simplified 10k DigMap MGR polygons to include areas surrounding boreholes containing made ground and/or to account for obvious features on 1:25k topo e.g. large road embankments. Non-coded bores also consulted (via scans linked to the GDI) to constrain extensions to MGR.
Deleted most small MGR polygons except where crossed by a section containing a borehole that indicates MGR.
Added MGR to all sections where needed. Standard depth of 1-2m used except where boreholes indicate otherwise.
Created four helper sections to cross larger MGR polygons (not fully correlated)

Final file: EA_Tees_Model_KW_V1_83.gsipr

Calculation Checking Process – S Thorpe 7th Dec 2012
First pass calculation checking attempted by checking all sections for synthetic polygon errors.
Cross-sections checked-
DS_1 – “base_model” added where model exists
DS_3b – “base_model” added where model exists
DS_5b – “base_model” added where model exists
DS_7b – “base_model” added where model exists

Lenses don’t seem to be calculating? Will investigate further.
Helper_1_HBU
Tees-Framework_1
Tees-Framework_2
Tees-Framework_3
Tees-Framework_4
Tees-Framework_5
Tees-Helper_KW_1
Tees_Helper_KW_2
Tees-Helper_KW_3
Tees_Helper_KW_4
Tees_Helper_KW_6
Tees_Helper_KW_7
Tees_Helper_KW_8
Tees-Helper_EW_1
Tees-Helper_EW_10
Tees-Helper_EW_11
Tees-Helper_EW_12
Tees-Helper_EW_13
Tees-Helper_EW_2
Tees-Helper_EW_3 – base model took a bit of a blip here
Tees-Helper_EW_4
Tees-Helper_EW_5
Tees-Helper_EW_6 – added PEAT-2 unit and envelope
Tees-Helper_EW_7

Tees-Helper_EW_8
Tees-Helper_EW_9
Tees-Helper_NS_1
Tees-Helper_NS_2
Tees-Helper_NS_3
Tees-Helper_NS_4
Tees-Helper_NS_5
Tees-Helper_NS_6
Tees_Boundary_East
Tees_Boundary_west
Tees_Helper_KW_5
Tees_Helper_KW_9
Tees_Model_EW_14
Tees_Model_EW_15
Tees_Model_EW_16
Tees_Model_NS_7
Tees_Model_EW_17
Tees_boundary_south
Tees_boundary_north
Tees_Helper_KW_11
Tees_Helper_KW_12
Tees_Helper_KW_13
Tees_Helper_KW_14
Tees_Helper_KW_15
Tees_Helper_KW_16
Tees_Helper_KW_17
Tees_Helper_KW_18
Tees_MGR_Helper_1
Tees_MGR_Helper_2 – if enough time left, then go back and correlate other units
Tees_MGR_Helper_3 – if enough time left, then go back and correlate other units
Tees_MGR_Helper_4 – if enough time left, then go back and correlate other units
Tees_thalweg_1
Tees_thalweg_2

10th Dec 2012 -
Tees_thalweg_3 - created to guide geology beneath Billingham Beck
Tees_Helper_KW_14 – extended to eastern boundary to help correlate ALV and constrain lower units. Also extended along alluvial tract to western boundary.

11th Dec 2012 –
Tees_MGR_Helper_4 – extended to the southern boundary to help a number of units correlate better.

12th Dec 2012 –
Completed Tees_MGR_Helper_4 from yesterday.
Created Tees_ALV_Helper_1 to help correlate the Alluvium and LDE units in the south of the model.

13th Dec 2012 –
DS_3b extended eastwards to help RTDU/ALV calculation
Tees_RTDU_Helper_1 constructed to help terrace calculation across the sharp bend in the river mid-model.
Tees_TSSG_Helper_1 constructed to constrain broad sheet across north of model.

Tees-helper_KW_13 extended to northeast corner
Tees_TSSG_Helper_2 constructed for Billingham Beck valley.
Tees_TSSG_Helper_3 constructed for Billingham Beck valley.
Tees_TSSG_Helper_4 constructed for Billingham Beck valley.
Tees_TSSG_Helper_5 constructed for Billingham Beck valley, along the valley rather than perpendicular.

18th Dec 2012 –
Tees_Helper_1_STHORPE constructed to help with correlation of ALV/TSSG
Tees_Thalweg_4 constructed to help alluvium along Greatham Creek/Beck

19th December –
HB constructed helpers (Tees_RTDU_Helper_2 to Helper_13) across the higher reaches of the valleys to constrain the RTDU.

20th December –
ST checked all sections from yesterday calculated correctly, made amendments where necessary.
Tees_RTDU_Helper_14 + Helper_15 constructed
Tees_LDE_Helper_1 constructed
Tees_LDE_Helper_2 constructed
Tees_TSSG_Helper_6 constructed
Tees_thalweg_5 constructed
Tees_ALV_Helper_2 constructed

DTM along north coast was found to be extending into the sea further than the northern boundary section, therefore ST amended it to fit with section distribution.

2nd Jan 2013 STHORPE
Tidying up of lenses now. Lenses don’t seem to calculate so it has been agreed that I can remove them from the calculation in order to create the grids, but that a copy of their distribution be put into the report. Therefore the current GSIPR has been saved as V1_129_with_lenses and the lenses then removed and saved as subsequent version from V1_130_without_lenses onwards.

Cross-section Tees_MGR_helper_2 completed correlations

3rd Jan 2013 STHORPE
Lenses removed from all cross-sections and saved as V1_133.GSIPR. Calculated and exported grids as ASCII files and saved here:

W:\Teams\UD\TeesSuperficialGeology\Data\GSI3D_Modelling\Exports_STHORPE_03_01_13_without_lenses

Rockhead level created using the “create DTM from combined unit bases” tool inside GSI3D. Saved in latest project file and also exported as an ASCII grid here:

W:\Teams\UD\TeesSuperficialGeology\Data\GSI3D_Modelling\Tees_RHEM_from_modelling_03-01-13.asc

Lens envelopes removed from Geological unit list and saved as V1_135.GSIPR (STHORPE)

Removal of Water polygons (by S Thorpe) following QA

Deleted Helper_1; Helper_2 and Helper_3 (these were imported from the Durham South model) as they fell outside the project area and didn't have any influence on the modelling.

BHTI was investigated further with respect to the two 'holes through to bedrock and ST found no evidence to support these. The BHTI made more geological sense with these holes removed and allowed a more consistent base to flow through the model.

Thalweg_1 – completed
Tees_ALV_Helper_2 – completed
Thalweg_2 – completed
Thalweg_3 – completed
Thalweg_4 – completed
Thalweg_5 – completed

Tees_Helper_KW_10 extended to help North-west corner calculate better

Week beginning 14/10/2013 - Ian Cooke completed a Technical Check as part of the NGM Model Approval Procedure and highlighted a few minor errors that needed to be corrected. The document can be found here:

W:\Teams\UD\TeesSuperficialGeology\Data\GSI3D_Modelling\EATees_ILC_Modelchecking_document.docx

Tony Myers then completed a check on the file using FME. This highlighted errors in the GVS including:

1) GVS codes not found in Lexicon - GFDU1 (2 & 3), PEAT2 were not standard lexicon codes, and as such should not be used to colour the units. This doesn't affect the name of the unit (these have to be specifically numbered to indicate their stratigraphical position) but refers to the code used by the GLEG file to colour the units. GFDU/PEAT was replaced in each case and an entry for the GLEG file was added. This makes all GFDU the same colour which is contrary to the Sections already delivered to the EA.
2) GVS codes not in GLEG – two units were indicated as not being present in the GLEG file but these units were not used in the model so nothing was done with this information.
3) Inconsistent code in GVS – this indicated that two units had inconsistent name versus code (clay_sub_till / GLLD & dctf / DTCF). The first unit 'clay_sub_till' was defined by STHORPE (see earlier entry in this file) but the dctf/DTCF is a typographical error. This was corrected by STHORPE on 17/10/13. This doesn't affect the Sections delivered to the EA as the shortened codes are not used.

These were corrected and commented by STHORPE and saved out as: EA_Tees_Model_ST_V1_153_ilc_checked.gsipr