British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Metadata report for the Knowsley 3D geological model

Engineering Geology Programme

Open Report OR/15/020

BRITISH GEOLOGICAL SURVEY

ENGINEERING GEOLOGY PROGRAMME

OPEN REPORT OR/15/020

Metadata report for the Knowsley 3D geological model

S Thorpe

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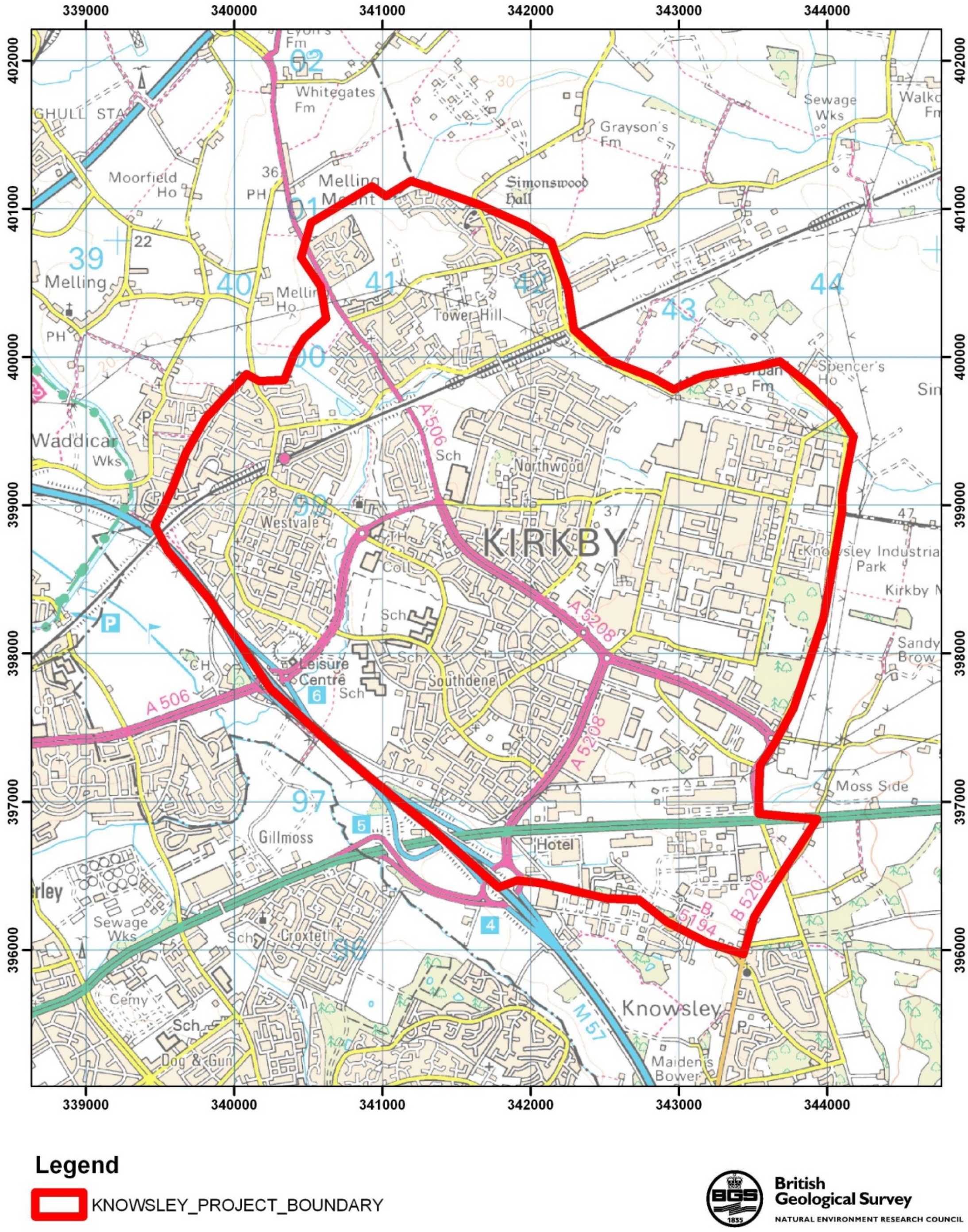
Summary

This report describes the metadata generated during the creation of a 3D geological model for the Environment Agency (EA) in the Knowsley area in NW England. Knowsley Industrial Park, NW England and its buried sewerage network presents a potential source of pollution to the underlying Triassic Sherwood Sandstone Group aquifer. Weakly permeable superficial deposits beneath the site may provide a barrier to potential pollution of groundwater in the aquifer. The aim of the study was to develop and apply a 3D model of the superficial deposits beneath the park to a qualitative assessment of the vulnerability of the underlying aquifer to potential pollution. The study also aimed to devise a method for the integration of the 3D geological model of the shallow sub-surface with the buried utility network.

The 3D model revealed 7 superficial units. Glacial till, comprising clay and silt, was the only weakly permeable deposit identified. Other deposits were interpreted as permeable. The underground utility network was integrated in 3D with the geological model. Those utilities overlying less than 2.5 m of till were interpreted to represent the most vulnerable parts of the underlying aquifer. The greatest relative vulnerability to the aquifer occurred in the south and south-west of the project area.

The study identified a novel method for the integration of a 3D geological model and a buried sewerage network. The identification of these utilities prioritised the areas of highest relative vulnerability of the Sherwood Sandstone aquifer to potential pollution from utility leakage. This approach enabled the development of a hazard identification and prioritisation scheme for future improvements to the buried sewerage network serving Knowsley Industrial Park.

1 Modelled volume, purpose and scale



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Environment Agency

Figure 1 Modelled area (in red)

The model incorporates the town of Kirkby and the Knowsley Industrial Park located in the northwest of the project area. This industrial area lies on a sequence of superficial deposits comprising glacial, post-glacial and artificial deposits overlying the Sherwood Sandstone Group, that in places are deeply weathered to form loose sand (Price et al., 2008). The Sherwood

Sandstone Group is an important source of groundwater and identifying the vulnerability of the aquifer to potential pollution from the buried sewerage network was the driver for the project. United Utilities supplied the pipeline network for foul and surface water drainage, and the EA provided new boreholes which the project incorporated into the BGS systems. Using this additional borehole data, a detailed 3D geological model of superficial and artificial deposits was created. Once the model surfaces were created, they were interrogated in a GIS against the sewerage network data. This spatial data assessment was used to highlight the relative spatial vulnerability of the underlying Sherwood Sandstone Group aquifer to potential pollution based on the thickness and distribution of permeable and weakly-permeable superficial deposits.

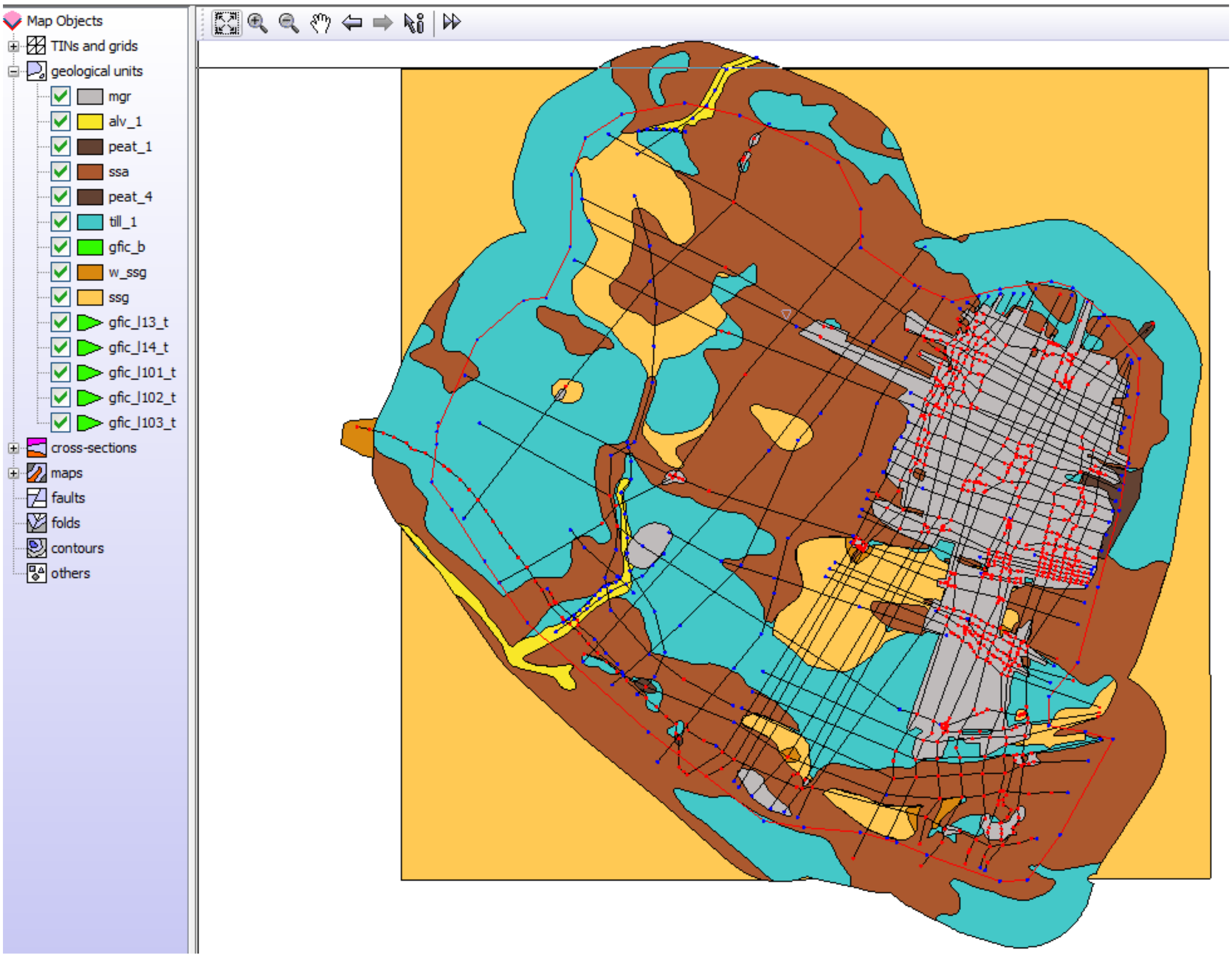


Figure 2 - Distribution of cross-sections and geological units at outcrop viewed in GSI3D

2 Modelled surfaces/volumes

7 superficial geological units and 5 glacial lenses were modelled and volumes generated for each. The interpreted weathered top of the Sherwood Sandstone Group was modelled as a separate unit. The base of the Sherwood Sandstone Group represents the base of the model corresponding to an elevation of approximately -10 mOD. The geological model comprises the following units:

- Madeground (mgr)
- Alluvium (alv_1)
- Surface Peat (peat_1)
- Shirdley Hill Sand (ssa)

- Buried Peat (peat_4)
- Till (till_1)
- Glaciofluvial Ice-Contact Deposits (gfic_b)
- Weathered Sherwood Sandstone Group (w_ssg)
- Sherwood Sandstone Group (ssg)
- Lens of Glacial Deposits (gfic_l13_t)
- Lens of Glacial Deposits (gfic_l14_t)
- Lens of Glacial Deposits (gfic_l101_t)
- Lens of Glacial Deposits (gfic_l102_t)
- Lens of Glacial Deposits (gfic_l103_t)

NB: The abbreviations in brackets after each unit correspond to named units within the geological model (Figure 2) and generalised vertical section (GVS) described further in this report.

3 Model datasets

DTM

The DTM source was NEXTMap (Intermap Technologies Inc) at a 25m cell size resolution. The date of the DTM extraction was not recorded but it is assumed to be the date that modelling commenced – Sep 2007

Borehole data

Borehole information was taken from the current BGS corporate databases – Single Onshore Borehole Index. Additionally, over 300 paper borehole records were provided by the Agency from previous environmental site investigations carried out in the industrial park and incorporated into the BGS databases. In total, 1279 coded boreholes were used in the study. Of these, 733 were used to construct 58 geological cross-sections (Price et al., 2008). One site investigation containing 11 boreholes has subsequently been found to contain boreholes whose start height was based on a local survey. These boreholes sit approximately 26m above the model DTM, and in these cases the boreholes were hung from the DTM in order to use their data in drawing the sections.

Map data

The 1:50 000 DigMapGB-50 digital geological data (natural superficial deposits and bedrock) which was used to guide the cross-section drawing and creation of the geological unit distributions was extracted from version 4.16 in 2008 and was derived from the 1930s survey of the Wigan sheet which did not include artificially modified ground. Although modelling then took place approximately concurrently with resurvey of the district (1999-2010) any consequent revisions from the latter were not fed into the shapefiles that were utilised within the model. In addition, the Made Ground envelope drawn for the model differs in detail from the survey. Thus there are discrepancies from the final map data published in the Wigan 1:50 000 sheet in 2013 (and to be included in DiGMapGB-50 v8) which are only partly due to generalisation. Incorporating the updated natural superficial deposits and bedrock data into the model and the Made Ground into DiGMapGB-50 would require further intervention that for the moment cannot be justified [A J Mark Barron and S Thorpe, 09/03/2015]

GVS data

See appendix

Geological Legend (GLEG) data

See appendix

4 Software Used and Model workflow

4.1 SOFTWARE USED

- GSI3D V2.6
- ArcGIS 9.3
- MS Excel

4.2 MODEL WORKFLOW

The standard GSI3D workflow was used to create the 3D model. (Kessler and Mathers, 2004) The interrogation of the pipeline data with the modelled surfaces was then completed using a series of spatial queries in ArcGIS (for more details see (Price et al., 2008))

A review of the model by Barron in Feb 2015 prompted further investigation into some small modelling errors that came to light. These included a Site Investigation whose boreholes had been entered into the BGS corporate system using a site datum without being converted to the correct level above Ordnance Datum (SI 44928 – corrected on 9th March 2015 by Sally Stolworthy) and a borehole that looked at odds with the rest of the cross-section (Figure ? below show Knowsley_NS_17 and Knowsley_WE_09).

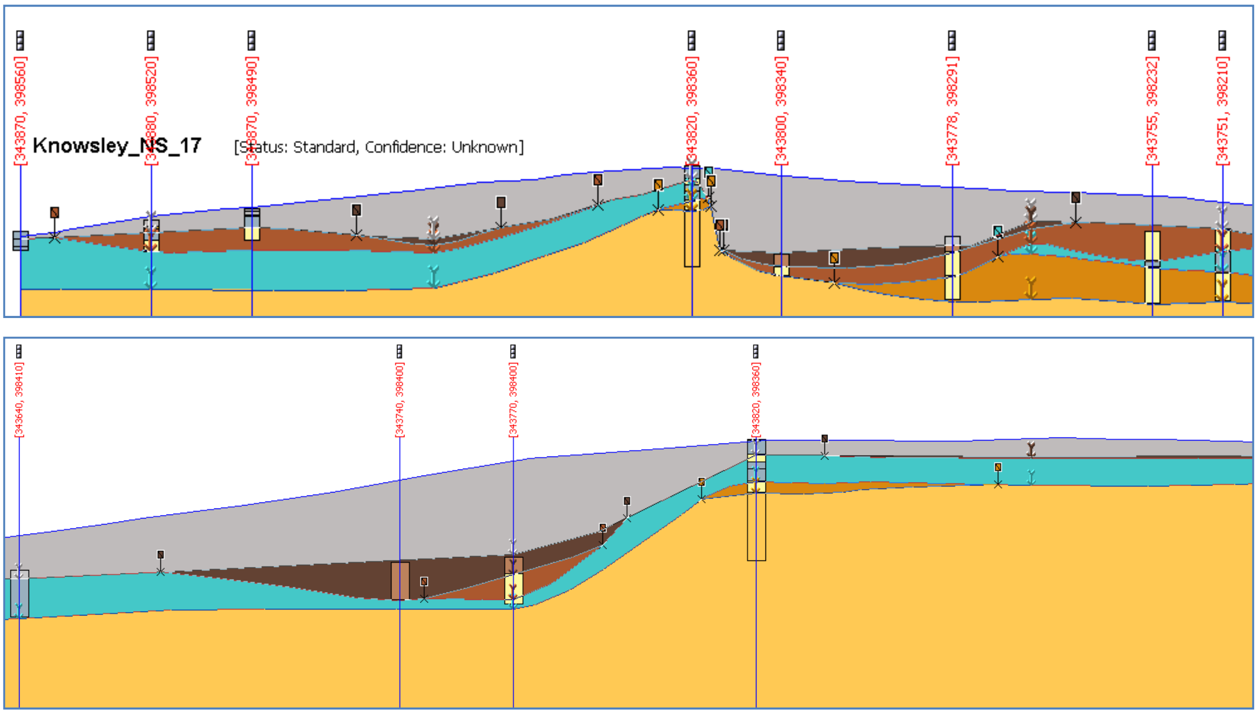
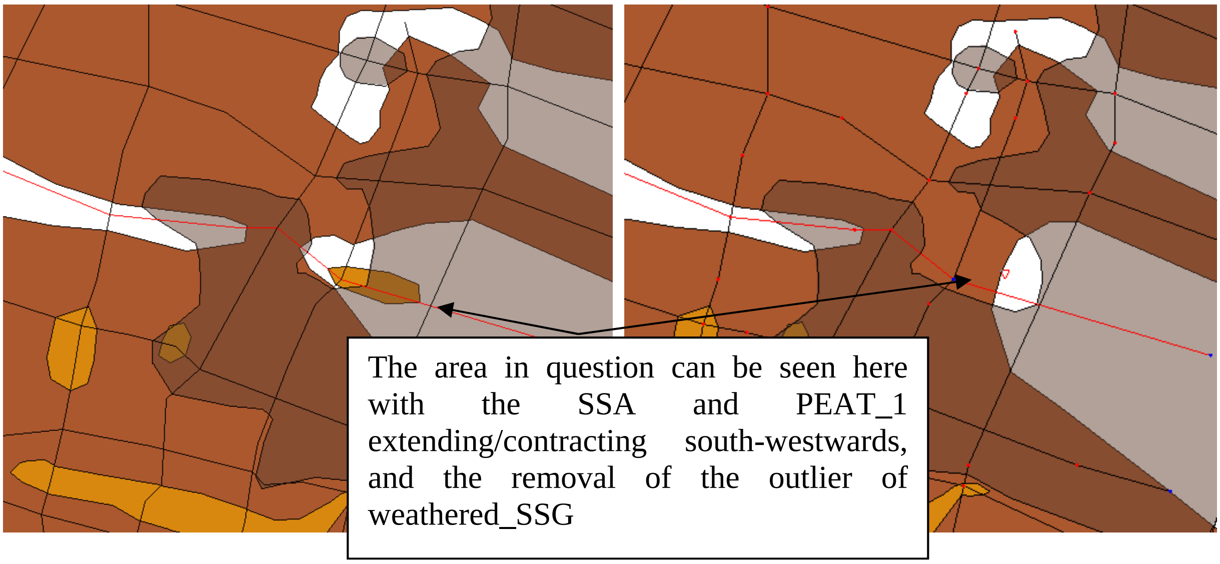


Figure 3 - Sections showing erroneous borehole

As is clear, the borehole in question (SJ49NW1122.) appears to 'force' the superficial geology to a higher elevation than the surrounding correlations. Upon investigation it was revealed that this borehole isn't located in the correct position by at least 1000m. The cross-sections were amended to exclude this false borehole information and this in turn altered the geological envelopes for the Peat_1 (dark brown – but transparency is set to 50% which allows the other units to show through), Shirdley Hill Sand (in dark orange) and the Weathered Sherwood Sandstone (in orange). The original project is shown on the left, and the amendments are shown on the right.



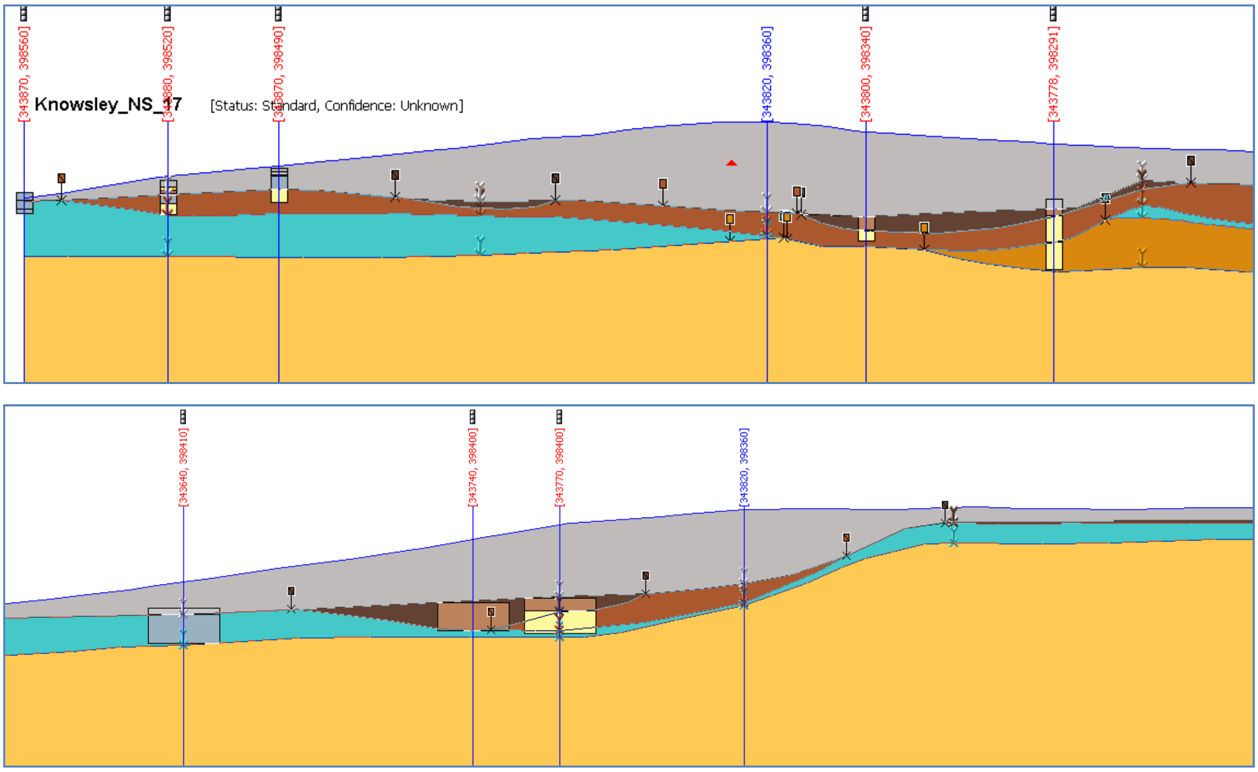
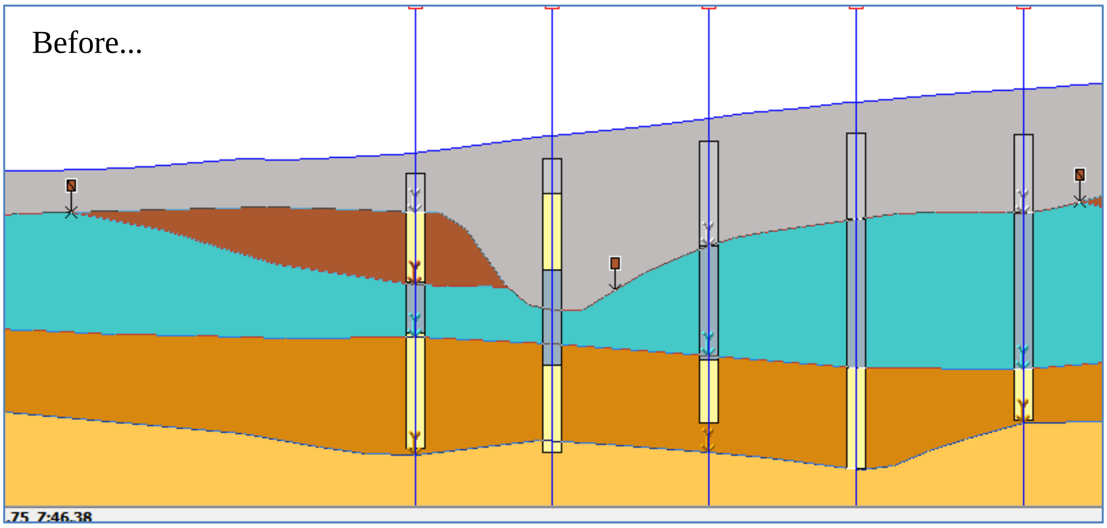
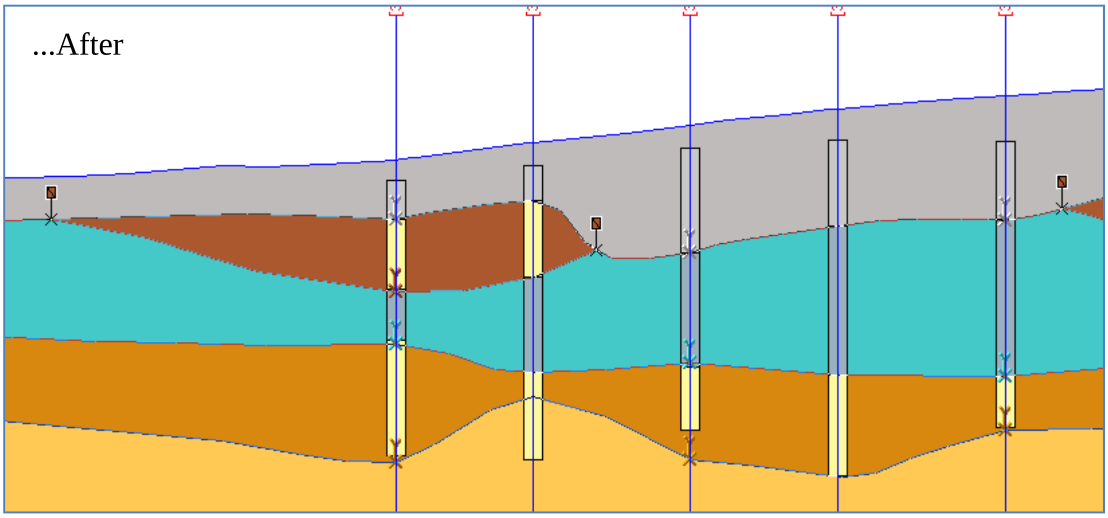


Figure 4 - Corrected sections after removing erroneous borehole

Cross-section WE_12 also had a borehole at odds with the section. After reviewing the borehole and finding out that the start height had been input into the system incorrectly on loading the borehole appears fit the geology better as shown in the before and after view of the section.



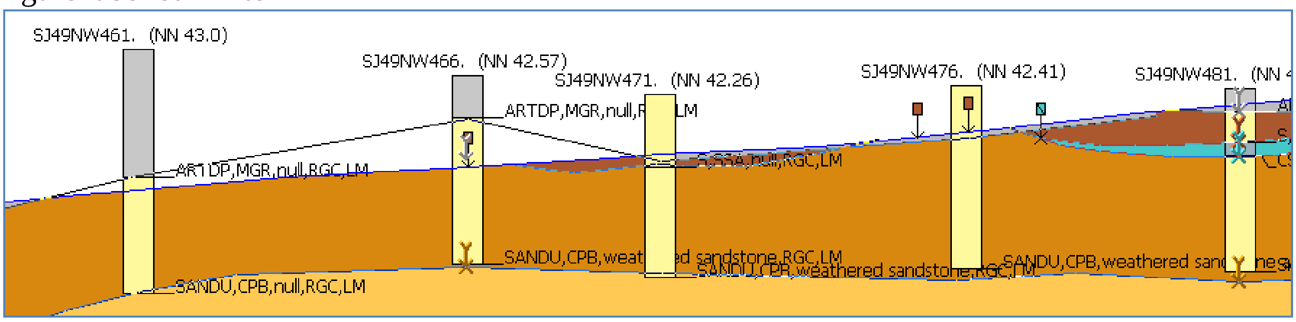


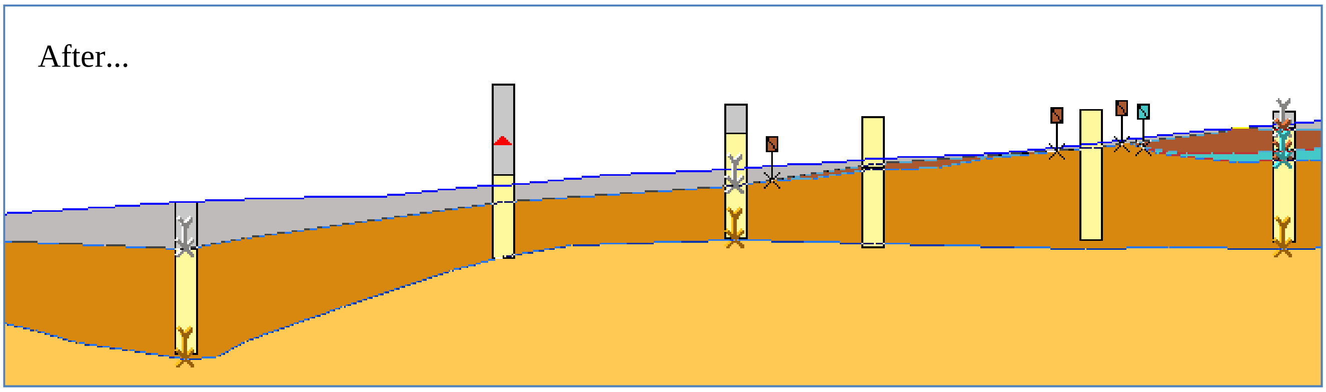
Some cross-sections show correlation lines that appear to be above the DTM. S Thorpe believes that this is because the original model was produced using a version of GSI3D which didn't store the DTM. Therefore when the NGM checks were completed a new DTM was introduced which was slightly different (due a more recent flying date). This is unfortunate, but the sections have been modified to represent a better fit to this more recent DTM (derived from the BaldEarth DTM model).

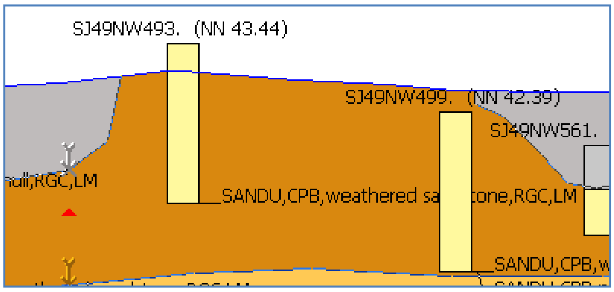
Below is a specific example of the changes made:

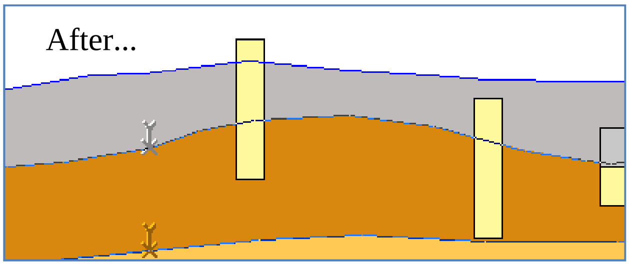
<u>Knowsley_WE_16</u>

This section shows the MGR line floating above the DTM, the corrective action is shown in the figure labelled "After"

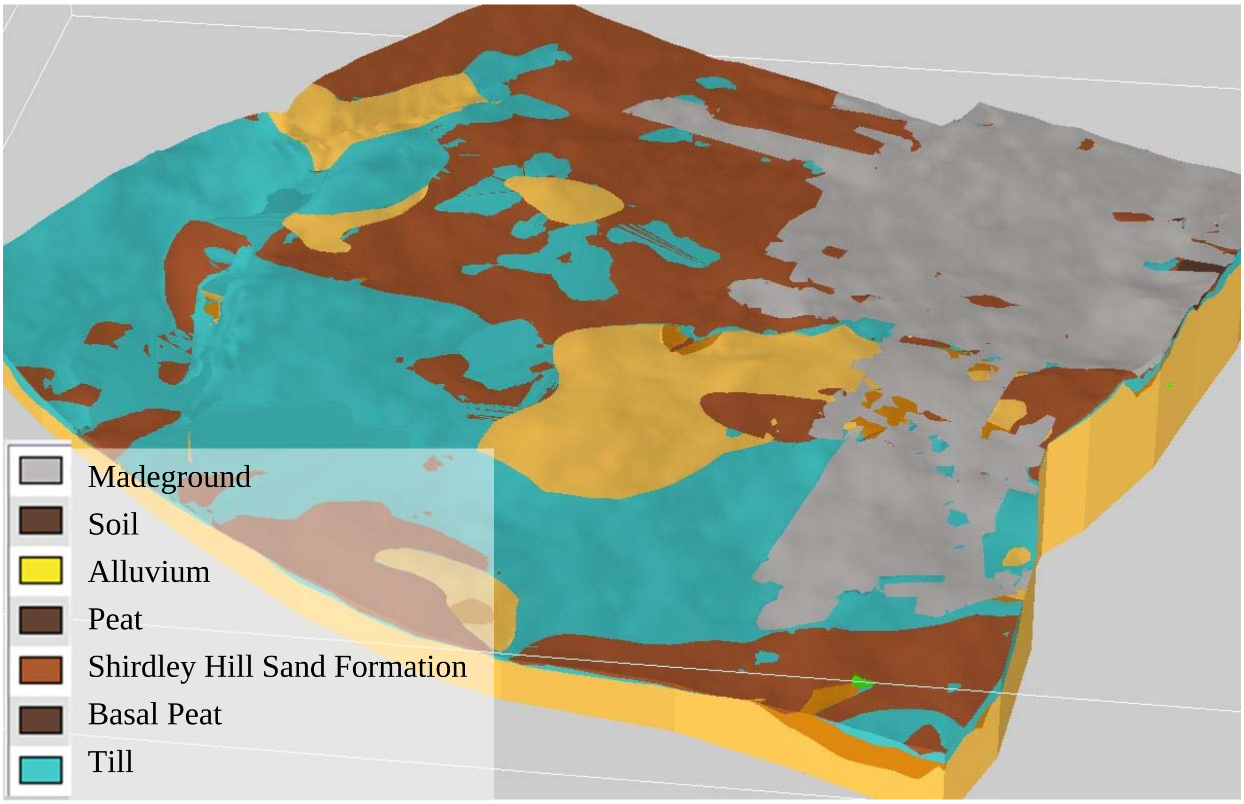



After...


SJ49NW493. (NN 43.44)
SJ49NW499. (NN 42.39)
SJ49NW561.
SANDU,CPB,weathered sa
tone,RGC,LM
SANDU,CPB,w


After...

5 Model image



6 Reference List

KESSLER, H, and MATHERS, S. 2004. GSI3D - The software and methodology to build systematic near-surface 3-D geological models - Version 1.5.

PRICE, S J, CROFTS, R G, TERRINGTON, R L, and THORPE, S. 2008. A 3D geological background for Knowsley Industrial Park and surrounding area, NW England. *Commisioned Report*.

Appendix

GVS file

name	id	Stratigraphy	LEX_RCS	RCS	Age	Description
mgr	10	MGR	MGR-ARTDP	ARTDP	Holocene	Made Ground (Undivided). Includes colliery spoil and industrial and commercial waste
soil	31	SOIL	SOIL-SOIL	SOIL	Holocene	Soil
alv_1	33	ALV	ALV-ZCV	ZCV	Holocene	Alluvium. East of tidal sluice river dominated processes depositing mainly silt, clay and sand. West of sluice active channel comprising mainly sand and gravel.
peat_1	45	PEAT	PEAT-P	P	Holocene	Main peat deposit at surface
ssa	70	SSA	SSA-S	S	Devensian	Shirdley Hill Sand Formation
peat_4	72	PEAT	PEAT-P	P		
till_1	100	TILL	TILL-CZSV	CZSV	Devensian	Main till sheet
gfic_b	105	GFIC	GFIC-SV	SV	Devensian	Subtill Glaciofluvial Ice Contact lens
w_ssg	123	W_SSG	W_SSG-SV	SV		Weathered Sherwood Sandstone Group. Sand and Gravels
ssg	125	SSG	SSG-SDST	SDST		Sherwood Sandstone Group. Sandstone
gfic_l13_t	-713	GFIC	GFIC-SV	SV	Devensian	Intratill Glaciofluvial Ice Contact lens, base above 35m OD. In EA Knowsley Model
gfic_l13	713	GFIC	GFIC-SV	SV	Devensian	Intratill Glaciofluvial Ice Contact lens, base above 35m OD
gfic_l14_t	-714	GFIC	GFIC-SV	SV	Devensian	Intratill Glaciofluvial Ice Contact lens, base above 35m OD. In EA Knowsley Model
gfic_l14	714	GFIC	GFIC-SV	SV	Devensian	Intratill Glaciofluvial Ice Contact lens, base above 35m OD
gfic_l100_t	-800	GFIC	GFIC-SV	SV	Devensian	Intratill Glaciofluvial Ice Contact lens, base above 25m OD. In EA Knowsley Model
gfic_l100	800	GFIC	GFIC-SV	SV	Devensian	Intratill Glaciofluvial Ice Contact lens, base above 25m OD
gfic_l101_t	-801	GFIC	GFIC-SV	SV	Devensian	Intratill Glaciofluvial Ice Contact lens, base above 40m OD. In EA Knowsley Model
gfic_l101	801	GFIC	GFIC-SV	SV	Devensian	Intratill Glaciofluvial Ice Contact lens, base above 40m OD
gfic_l102_t	-802	GFIC	GFIC-SV	SV	Devensian	Intratill Glaciofluvial Ice Contact lens, base above 40m

						OD. In EA Knowsley Model
gfic_l102	802	GFIC	GFIC-SV	SV	Devensian	Intratill Glaciofluvial Ice Contact lens, base above 40m OD
gfic_l103_t	-803	GFIC	GFIC-SV	SV	Devensian	Intratill Glaciofluvial Ice Contact lens, base above 41m OD. In EA Knowsley Model
gfic_l103	803	GFIC	GFIC-SV	SV	Devensian	Intratill Glaciofluvial Ice Contact lens, base above 41m OD

GLEG file

ALV	DESCRIPTION	248	231	40	255	TEXTURES\black.jpg
ARTDP	DESCRIPTION	200	200	200	255	TEXTURES\black.jpg
CZSV	DESCRIPTION	153	176	190	255	TEXTURES\CZV.jpg
GFIC	DESCRIPTION	50	250	0	255	TEXTURES\black.jpg
MGR	DESCRIPTION	191	187	187	255	TEXTURES\black.jpg
P	DESCRIPTION	188	130	92	255	TEXTURES\P.jpg
PEAT	DESCRIPTION	188	130	92	255	TEXTURES\P.jpg
S	DESCRIPTION	255	249	158	255	TEXTURES\S.jpg
SDST	DESCRIPTION	255	201	84	255	TEXTURES\SV.jpg
SSA	DESCRIPTION	171	88	46	255	TEXTURES\black.jpg
SSG	DESCRIPTION	255	201	84	255	TEXTURES\black.jpg
SV	DESCRIPTION	255	249	158	255	TEXTURES\SV.jpg
TILL	DESCRIPTION	68	200	200	255	TEXTURES\black.jpg
W_SSG	DESCRIPTION	217	136	15	255	TEXTURES\black.jpg
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