Drift Filled Hollows – Examples from Crossrail

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The Crossrail route in Central London
Crossrail route with the northern Thames Tributaries & some major geological structures
Crossrail Drift Filled Hollows

- Liverpool St Moorgate Box
- Limmo
- Thames River Crossing
Crossrail Ground investigation data

> 1000 Crossrail Boreholes
≈ 34000m of data

≈ 650 3rd Party Boreholes
≈ 25000m of data

1,200,000+ line AGS database
Drift Filled Hollow at Liverpool Street / Moorgate Box

Context

Crossrail

Hackney

Taplow

Fleet

Blackfriars

R. Thames

Cannon St

Walbrook
Drift Filled Hollow at Liverpool Street / Moorgate Box
Drift Filled Hollow at Liverpool Street /Moorgate Box
Contours on the base of the Taplow Fm
Liverpool Street Moorgate Box Hollow
Contours on the base of the Taplow Terrace in m above Tunnel datum

Lowest recorded elevation of the base of the hollow = 96m
Liverpool Street / Moorgate Box Hollow: Dimensions, Strata & Shape

- ‘Normal’ strata sequence = Alluvium / Taplow Fm / LC
- Hollow strata sequence = Alluvium / Taplow Fm / LC
- Shape - broadly conical, diameter = approx 70m
- Natural thickness of Taplow Fm away from the Hollow = approx 4m
- Thickness of LC away from the Hollow = approx 30m
- Natural thickness of Taplow Fm in the Hollow = approx 15m
- Thickness of LC remaining below the Hollow = approx 20m
Liverpool Street / Moorgate Box Hollow
Geological context

- Broadly coincident with the upper reaches of a recent minor Walbrook tributary.
- Located close to the current Fleet / Walbrook watershed.
- Located at the back edge of the Taplow Terrace.
- Surrounding Taplow Fm is thin & flat.
- No evidence of channels in the adjacent & higher sub Hackney Terrace surface.
- Slightly thicker Alluvium/Peat above than elsewhere locally
- No obvious vertical component of faulting at depth.
- Very small Lambeth Group Sand Channels are present.
- Not in an area of reduced LC thickness
• The infill is variable, but dominated by Sands and Gravels.

• Broadly speaking there is more Gravel at higher levels than at lower levels.

• The boundary between the Gravelly and less Gravelly is approximately coincident with the base of the Terrace away from the Hollow.

• At lower levels the infill is dominated by Sands with less Gravel. Also present are ‘inclusions’ of Clay, often with London Clay like descriptions.

• The data tentatively suggests the overlying Alluvium may be slightly thicker & have a slightly lower base within the Hollow compared to just outside it.

• The maximum Hollow slope angle is approximately 1V:2.5H.
Moorgate Hollow Bh Log extracts

Medium dense to dense light orange brown SAND AND GRAVEL. Sand is fine to coarse. Gravel is subangular to rounded fine to coarse of flint. (RIVER TERRACE DEPOSITS)

Soft light brown grey very sandy slightly gravelly CLAY. Sand is fine to coarse. Gravel is subangular to rounded fine to medium of flint. (RIVER TERRACE DEPOSITS)

Very dense becoming medium dense light orange brown SAND AND GRAVEL. Sand is fine to coarse. Gravel is subangular to rounded fine to coarse of flint. (RIVER TERRACE DEPOSITS)

Soft light brown grey very sandy slightly gravelly CLAY. Sand is fine to coarse. Gravel is subangular to rounded fine to medium of flint. (RIVER TERRACE DEPOSITS)

Medium dense becoming medium dense light orange brown SAND AND GRAVEL. Sand is fine to coarse. Gravel is subangular to rounded fine to coarse of flint. Rare coarse gravel sized pockets of soft grey brown sandy clay. (RIVER TERRACE DEPOSITS)

Very stiff indistinctly fissured dark grey and dark greyish green CLAY.

9.35 - 9.45m: Greyish brown and orangish brown fine to medium sand.
Greyish brown silty fine SAND/fine sandy SILT.
Greyish brown and orangish brown fine to medium SAND.
Greyish brown gravelly fine to coarse SAND. Gravel is fine to coarse sub-angular to sub-rounded of flint.
Firm grey silty CLAY.

Greyish brown gravelly fine to coarse SAND. Gravel is fine to coarse sub-angular to sub-rounded of flint.
Stiff indistinctly laminated grey CLAY with partings of grey and greyish brown fine sand.
Greyish brown and orangish brown gravelly fine to coarse SAND. Gravel is fine to coarse sub-angular to sub-rounded of flint.
Grey locally black fine sandy SILT/silty fine SAND
Stiff to very stiff indistinctly laminated grey and greyish brown slightly fine sandy/silt CLAY.

12.60m: Fine to coarse gravel sized claystone noted in SPT recovery.
Moorgate Hollow Bh Log extracts

Pockets of soft brown mottled orange brown fine to coarse sandy clay.
(MADE GROUND)

(Firm) black slightly clayey fibrous and amorphous PEAT with occasional shells and shell fragments and rare subangular fine to coarse gravel of flint.
(ALLUVIUM)

Brown fine to coarse sandy subangular to rounded fine to coarse GRAVEL of flint.
(TERRACE GRAVEL)

Yellowish brown fine to medium SAND with some becoming a little by 8.50m subangular to rounded fine coarse gravel of flint and occasional pockets (to 50mm size) of soft greyish brown slightly clayey silt.
(TERRACE GRAVEL)
Drift Filled Hollow at the Lea/Thames confluence (‘Limmo’)
Drift Filled Hollow at Limmo

Context

Contours in maTD on the Base of the Kempton Park Terrace

River Lea / Bow Creek

River Thames

Faults are picked on the base of the London Clay
Drift Filled Hollow at Limmo
Drift Filled Hollow at Limmo  Strata & Shape

- ‘Normal’ strata sequence = Alluvium / Kempton Park Gravel / LC
- Hollow strata sequence = Alluvium / Kempton Park Gravel / LC
- Shape – complex, unknown to the SW.
- Natural thickness of Kempton Park Gravel away from the Hollow = approx 2m (but Alluvium is thick)
- Thickness of LC away from the Hollow - max 37m (but faulted)
- Natural thickness of Kempton Park Gravel in the Hollow = approx 23m
- Thickness of LC remaining below the Hollow = approx 1.5m
- Maximum known width = approx 450m, maximum known depth 20m
- Close to, but entirely different to the Blackwall Tunnel Hollow

Berry shows a small shallow hollow just west of the Bow Creek / Thames junction
BGS Sheet 256 doesn’t show a hollow here.
Drift Filled Hollow at Limmo
Drift Filled Hollow at Limmo

Section 1

1V:4H
Drift Filled Hollow at Limmo

1V:2H approx

Section 2
Drift Filled Hollow at Limmo - Features

- Multiple coalescing hollows
- Elevation at the top = 95maTD
- Deepest elevation at the known base = 75maTD
- Strata below known base = London Clay (<2m thick)
- Infill materials: Sandy Gravel & Gravelly Sand
- No record of clay layers or large ‘inclusions’
- There is some evidence of fault control over the shape and location of the hollows.
- Max slope angle = approximately 1V:2H
- All strata adjacent to the Hollow to the North, including the London Clay, show a tidal response.
Drift Filled Hollows at Blackwall & Limmo
Comparison with the Blackwall Hollow

The section suggests the maximum Blackwall slope angle is approaching 1:1
The Blackwall Hollow has much thinner impermeable cover to the lower aquifer.
The Blackwall Hollow has evidence of diapirism.

The known data suggests the Limmo Hollow is entirely contained within much thicker London Clay just to the east.
### Limmo Hollow Bh Log extracts

**Medium dense orange brown gravelly SAND.** Sand is fine to coarse. Gravel is subangular to rounded, fine to coarse of flint. Occasional pockets (up to 40mm) of brown clay.

(RIVER TERRACE DEPOSITS)  

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**Dense to very dense brown grey sandy GRAVEL.** Gravel is subangular to rounded, fine to coarse of flint. Sand is fine to coarse. Occasional pockets (up to 50mm) of grey clay.

(RIVER TERRACE DEPOSITS)  

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**Very stiff fissured grey CLAY.** Fissures are extremely closely spaced, randomly orientated, smooth and mottled. Occasional foraminifera (up to 2mm) infilled with white silt. Rare burrows infilled with light grey clay.

(LONDON CLAY FORMATION - A2)  

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**Very stiff grey slightly sandy CLAY.** Occasional shell fragments (up to 20mm).

(HARWICH FORMATION - SWANSCOMBE MEMBER)  

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**Very dense grey silty fine SAND.** Occasional to frequent shell fragments.

(HARWICH FORMATION - OLDHAVEN MEMBER)  

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**EXPLORATORY HOLE ENDS AT 32.50 m**
Drift Filled Hollow at the Thames River Crossing
Drift Filled Hollow at the Thames River Crossing
Context
Thames River Crossing Hollow

- Reported in Lenham et al Proc. ICE, Civil Engineering 2006

- Entirely within the current River course & elongated parallel to it
- Sub-parallel to the structure axes
- Presence of minor faulting of the Chalk
- Elev at top 90m
- Elev at known base 80m
- Approx 400m long & 200m wide
- Strata below base = Chalk
- Infill materials = Kempton Park RTD & Alluvium
- No record of clay layers or large ‘inclusions’ – but data limited.

- Limited thickness of weathered Chalk in the base?
- Scour?

- This location was outside the scope of Berry’s paper.
Thames River Crossing Hollow

Fig. 15. Three-dimensional model of chalk bedrock under Woolwich and Gallions Reaches was constructed using interpreted seismic data and borehole records.
Thames River Crossing Hollow

Fig. 16. Cross-section along the proposed tunnel alignment showing the riverbed bathymetry, borehole stratigraphy, approximate boundaries of the filled-basin feature and the base of the weak comminuted chalk.

Taken from Lenham et al Proc. ICE, Civil Engineering 2006
Thames River Crossing Hollow
## Comparison

<table>
<thead>
<tr>
<th>Feature</th>
<th>Moorgate</th>
<th>Limmo</th>
<th>Thames River Crossing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terrace ?</td>
<td>Edge of Taplow</td>
<td>Kempton Park</td>
<td>Kempton Park</td>
</tr>
<tr>
<td>Modern watercourse ?</td>
<td>Yes but minor</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Faulting ?</td>
<td>No</td>
<td>Yes</td>
<td>Yes but minor</td>
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<tr>
<td>Depth ?</td>
<td>10m</td>
<td>20m</td>
<td>10m</td>
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<tr>
<td>Max width ?</td>
<td>70m</td>
<td>≈ 450m</td>
<td>400m x 200m</td>
</tr>
<tr>
<td>Infill ?</td>
<td>Alluvium, Gravel, Sand with large Clay inclusions</td>
<td>Alluvium, Sand and Gravel</td>
<td>Alluvium, Sand and Gravel</td>
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<tr>
<td>Area of thick LC ?</td>
<td>Yes</td>
<td>Yes, located in a faulted syncline</td>
<td>N/A</td>
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<tr>
<td>LG Sand Channel ?</td>
<td>Yes but minor</td>
<td>Yes</td>
<td>N/A</td>
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<tr>
<td>Max Slope angle</td>
<td>1V:2.5H</td>
<td>1V:2H</td>
<td>1V:6H</td>
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<tr>
<td>Clay layers or large inclusions ?</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>
Thankyou !

MOVING LONDON FORWARD