ANCIENT MONUMENTS LABORATORY

REPORT

2832

SERIES/No CONTRACTOR

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TITLE Recent sediments of the Wensum Valley at Norwich; and Interim report

RECENT SEDIMENTS OF THE WENSUM VALLEY AT NORWICH: AN INTERIM REPORT

Introduction

The level of the local water-table in the valley floor, with its effects on the suitability of riverside sites for settlement,on mean river levels and on the extent of valley fen, was obviously an important factor influencing the location of early settlement and the main lines of communication at Norwich. This report is an attempt to draw together the available information about the character and extent of recent valley sediments and to discuss the existing evidence for changes in the local water-table. The information is derived from an examination of commercial bore-logs and from archaeological excavations.

Geological Background

The Upper Chalk is partly overlain by Lower Pleistocene marine sands and gravels, the Norwich Crag, which have been exposed on the lower slopes of the valley, for example in the 19th century during the construction of the gasworks and in the Lollards Pit (Woodward 1881, 73). Overlying these marine sediments are glacial deposits: the Norwich Brickearth and 'Plateau Gravels'. The Plateau gravels have recently been interpreted as the dissected remains of a glacial outwash plain or sandur extending to the N.E. in the direction of Salhouse and Ranworth (Funnell 1976), associated with the buried glacial channel beneath the present Yare Valley (Funnell 1958). The modern east-west drainage pattern of the Wensum was essentially established in the late Wolstonian (Phillips 1976), when the Wensum Valley was incised across this outwash plain, down into the chalk, leaving steep slopes leading down from Mousehold Heath facing gentler slopes on the southern and western valley sides. Subsequently valley gravels and sands were deposited. Phillips (idem) describes Ipswichian terrace deposits in the central section of the Wensum Valley between North Elmham and Ringland, but the valley gravels at Norwich have not, so far as the writer is aware, produced organic deposits which would permit dating.

Close to the present channel are deposits interpreted as 'River Brickearth', notably at the King Street Brewery site and along Riverside

Road. Catt (1978) suggests that such deposits may have been derived by fluvial erosion from areas of loess on the upland. This erosion and redeposition is thought to have taken place in the late Devensian or earliest Flandrian, before the development of forest stabilised the soil surface.

Overlying these deposits in the valley floor are the Flandrian peats and floodloams with which this report is concerned.

The Boreholes

Borehole logs recorded since the 1870s have been examined. The quality of sediment recording in these logs is variable, and in some cases sediment descriptions defied interpretation. Nevertheless these logs do give an overall picture of the valley deposits. Five main categories are distinguished in the accompanying plan.

(1) "Made Ground" directly overlying the Upper Chalk, often described as "Putty Chalk" or "Rotten Chalk". These exposed upper layers of the chalk have evidently been modified by periglacial processes.

(2) "Made Ground" over gravel. Layers of "gravel", "shingle" or "ballast" are frequently recorded. Glacial gravels and river gravels cannot be distinguished from the data supplied by the bore logs but the elevation of these gravel deposits indicates that most are Valley Gravels.

(3) "Made Ground" or topsoil on sediments described as "brown or buff sandy clays and sands", interpreted as River Brickearth. At the King St. Brewery (Borehole 4a) a 4m. thick layer of "Glacial Loam: Compact brown or buff coarse to fine silty sand with fine gravel and layers of firm very sandy clay or silt" is recorded, resting on an Upper Chalk surface. Apparently similar layers of "brown loamy sandy clay" up to 1m. thick are recorded along Riverside Road.

(4) "Made Ground" over thin, somtimes organic, "silt" layers on gravel. These can tentatively be interpreted as Flandrian floodloams in most cases.

(5) "Made Ground" over peat, peaty loam or floodloam. Most boreholes adjacent to the river encountered alluvial deposits, commonly very variable in composition and often including gravel layers.

The River Valley

1. Wensum Park - New Mills

The eastern edge of the river valley in this area is marked by a gravel slope along the line of Oak Street. The gravel was encountered in several boreholes, and formed the 'subsoil' at site 351N. To the north, gravel is absent: Upper Chalk was found beneath modern topsoil in St. Martin's Close and Wensum Park. Closer to the river, peat deposits, up to 3.7m. thick are present.

On the western bank several borehole logs record the presence of 'silt' layers (0.5m. thick at the Westwick Depot 22550930, beneath 3.1m. of 'Made Ground'). A possible flood deposit of 14th/15th century date was also recorded during excavations at Heigham Street (283N); this was a brown (10YR 5/3) loam with chalk and flint pebbles up to 2cm. and containing charcoal and mollusc shell fragments, but no freshwater molluscs.

The Heigham/Oak Street area has often been subject to flooding after rapid increases in freshwater run-off caused by heavy rains or sudden thaws, impeded by the presence of the New Mills dam. This mill, thought to have been one of the Domesday Mills, was rebuilt in 1430 by the City, and the result was immediate flooding. (Hudson and Tingey, I, 350). Historical evidence for flooding, both as a result of increased run-off and, less frequently, after tidal surges, is summarised by Woodward (1881, 149).

2. New Mills - Fye Bridge

Between the New Mills and Coslany Bridge no borehole records have been located. However, the placename Coslany is thought to refer to Cost's Long Island' (A. Carter, pers. comn.) and Blomefield's map of the City shows two large and several smaller islands. The course of the river at this point thus appears to have been braided. The five borehole logs from Hoppers Yard record 'silt' layers 1.0-1.5m. thick, over gravel, in the northern part of the site and thicker layers (1.6m - 2.75m.) of 'organic silt' to the south. A North-South section across this site (166N) revealed similar sediments resting on the gently-sloping gravel surface (Carter et al 1973, 463).

Peat deposits, approximately 1.7m thick are present on either side of Duke's Palace Bridge. At the Car Park site between St. Andrew's Street and the river layers of 'silt' and 'decomposed wood' are recorded in several bores. The central bore at this site is typical:

0 - 2.4m.	Made Ground
2.4 - 3.7m.	Decomposed wood and silt
3.7 - 4.0m.	Sand and gravel
4.0 - 4.9m.	Peat
4.9 - 5.8m.	Sand and gravel
5.8 - 9.1m.	Chalk.

A pipe-trench running the length of Elm Hill revealed Upper Chalk just beneath the modern surface (M. Atkin pers. commn.), but at the foot or Elm Hill, at its junction with Wensum Street, valley peat resting on gravel is present.

Medieval occupation on the reclaimed marsh surface has been investigated at several sites along this stretch of river (Carter et al 1973; Roberts et al 1975). North of Westwick Street and west of Coslany Street (159N) the earliest extensive colonisation of the marsh took place in the late 12th - early leth century, when insubstantial structures were erected directly on the peat surface.* In a second, mid-13th century phase of development, these buildings were demolished and the site level raised by dumping 20-40cm. of silt and clay before rebuilding. This might be interpested as evidence for a rising water-table during the 13th century, though other explanations are, of course, possible. At 166N, (mentioned above), the earliest occupation, industrial in character, was again of the 13th century; at the Duke's Palace (169N) a thick layer of 16th century and later make-up was dumped on the marsh surface to raise its level before building*; and the northern part of the Dominican Friary was built on the reclaimed river marsh after 1258.

*Macroscopic plant remains from these peats are described elsewhere (see report: 'Macroscopic Plant Remains from Norwich').

Small streams or 'cockeys' emptied into the Wensum along this stretch of river (Green and Young 1964; Carter 1972, Fig. 1). In addition to these streams, there were numerous minor rivulets; at 159N, for example, a stream bed was seen some 20m south-west of, and parallel to, the river. The probable courses of the major streams within the city, deduced from topographical and place-name evidence are shown by Campbell (1975).

3. Fye Bridge

In 1896 a complete section across the recent valley deposits was recorded (Hudson 1898). A 5ft. (1.52m) thick layer of 'peaty bog' (in fact an eutrophic valley peat) extended across the valley for a distance of 364 ft. (110.9m) between the foot of Elm Hill and the junction of Fye Bridge Street and Fishergate. The peat rested on layers of 'bog-stained ballast' and 'bright ballast' over chalk. The chalk rose to the surface at the foot of Elm Hill, but on the northern side of the valley, gravel layers continued, covering the chalk, beyond the limit of excavation.

Driven through the peat into the upper part of the gravel were oak piles, which, together with transverse planking made a causeway over the river and marsh. The 1974 excavation at 22 Wensum Street (171N) revealed a second level of transverse planking 1m. beanth the recorded level of the pile tops (Roberts et al 1975). The excavator suggested that these lower planks represent a late Saxon causeway, and that the 1896 finds were of a later reconstruction necessitated by rising water levels.

Samples taken during the excavation have been examined principally in an attempt to provide palaeoecological evidence for this suggested water-level rise but also for more general information about local conditions. The samples, mostly approximately 1 kg. in weight, are described in Table and a sketch section is given in

Macroscopic biological remains were extracted from these samples as follows:

1. Disaggregation (hot water /H_2O_2)
2. Flotation, collecting flot in 250μ mesh sieve
3. Non-floating residue washed through 1 cm. sieve to extract large wood fragments

4. Fine non-floating residue dried and sorted

As one would expect, the slowly-accumulating organic loams produced far more material than the dumped deposits.

1. Fruits, seeds etc.

The plant remains identified(excluding wood and mosses) are listed in Table . They can be divided into seven groups, although several of these species can be found in more than one habitat.

(1) Cultivated plants. Hordeum (barley), Avena (oats), Linum (flax), Juglans (walnut).

(2) Aquatic species. Alismataceae, Potamogeton (pondweed), Batrachium sp. (crowfoot).

(3) Meadow, marsh and reed-bed species. Ranunculus c.f. repens (buttercups), Lychnis c.f. flos-cuculi (ragged robin), Polygonum persicaria (redshank), Polygonum lapathifolium (persicaria), Polygonum c.f. hydropiper (water-pepper), Menyanthes (bogbean), Mentha (mint), Achillea (yarrow), Juncus (rushes), Typha (reedmace), Eleocharis (spike-rush), Carex (sedges), Phragmites (reed).

(4) Heath and dry grassland species. Pteridium (bracken), Rumex acetosella (sheep's sorrel), Calluna (heather)

(5) Scrub and hedgerow species. Rubus (bramble), Prunus (sloe), Anthriscus (hedge-parsley), Betula (birch), Corylus (hazel), Sambucus (elder)

(6) Arable weeds. Papaver rhoeas and P. argemore (poppies), Brassica sp. (cabbage-type), Raphanü (wild radish), Agrostemma (corn-cockle), P. convolvulus (black bindweed), Solanum (black nightshade), Galeopsis (hemp-nettle), Anthemis (stinking mayweed), Centaurea (cornflower?) Lapsana (nipplewort)

(7) Plants of disturbed and nutrient-rich soils Reseda (mignonette), Cerastium (mouse-ear), Chenopodium (fathen), Atriplex (orache), Conium (hemlock), P. aviculare (knotgrass), Rumex (dock)

Urtica urens (small nettle), U. dioćica (nettle), Sonchus (sowthistle).

Although the samples taken by the excavator were small, and the seed assemblages recovered consequently restricted, it is possible to make an outline interpretation of the sequence of events represented by these deposits, from their statigraphy and plant macrofossils.

(1) The basal layer of peat, 93, contains no seeds of fully aquatic plants. Permanent standing water was apparently absent during its formation. The peat obviously contains some plant remains derived from terrestrial habitats (crop weeds, flax, bracken and sheep's sorrel), but reed culm nodes are common, along with fruits and seeds of sedges, rushes and reedmace. These indicate a local environment of marsh and reed-swamp.

(2) The level of the area was raised by dumping soil, gravel and chalk on the marsh surface (layers 92, 77). 92 is relatively 'clean' chalk rubble, whilst 77 apparently includes more organic occupation refuce.

(3) The plank causeway (90) was laid on this higher surface. The presence of seeds of wetland plants in the peaty deposit around the planks indicates that conditions remained damp.

(4) A peaty loam layer (68) formed over the planks. The two species of nettle (Urtica dioica and U. urens) are extremely common in this deposit. They indicate soil disturbance and nutrient enrichment, perhaps reflecting the churned-up miry conditions developing on the causeway with use, after periodic flooding and the accumulation of mineral soil, plant detritus, horse-dung etc.

(5) 32, a clay loam layer, was dumped over 68. Very few plant remains were recovered from this layer, which suggests rapid deposition.

(6) Layer 64 represents renewed accumulations of organic debris. 31 is a dumped layer of ~~floodloam,~~ sandy loam, similar to 32 in that it contains very few plant remains. 65 is similar to 64.

Though the overall interpretation of this sequence seems straightforward enough, its significance in terms of the local water-table is less clear. The repeated cycle of dumping to raise the level does suggest however that the water-table was rising. The fruits and seeds from these layers show no clear trend towards wetness or dryness, which may be interpreted as indicating that this dumping maintained the area in a consistently damp, but passable, state.

2. Wood

The horizontal plank surface of the causeway, (90), exposed in Trench A was of oak (Quercus sp.). Marsh deposits in Trench C (94) produced a pointed stake of hazel (Corylus sp.) in addition. Three of the contexts discussed above produced identifiable wood fragments:

93 Quercus sp. (oak: adzed or axed chips), Corylus sp. (hazel; wood fragments), Alnus sp. (alder; wood fragments), Crataegus-type (hawthorn-type; wood fragments).

90 Quercus sp. (oak; large axed or adzed chips), Crataegus-type (hawthorn-type; wood fragments), Unidentified twigs.

77 Quercus sp. (oak; wood fragments), unidentified wood fragments.

3. Land and freshwater mulluscs.

The samples examined produced only a few shells, insufficient for ecological reconstruction. Samples were also sent by the excavator to Dr. J. Evans; it is hoped that these samples will prove more productive.

TABLE 1: DETAILS OF SAMPLES FROM 171N

93	Sandy peat, very dark brown (10YR 2/2) to black; flints up to 18mm., chalk fragments up to 12mm; 1 scrap pottery; charcoal fragments; wood and bark fragments; reed, moss; insects, fish-bone, bird-bone, chips mammal bone (some burnt); oyster, mussel shell fragments.
92	Crushed chalk lumps up to 80mm. in a light brownish-grey (10YR 6/2) clay loam matrix; few small flint chips; small fragments charcoal and wood; fish-bone; land and freshwater molluscs.
77	Irregularly laminated deposit: Sandy peat (10YR 2/2 to black) with flint pebbles up to 15mm; 5mm. lenses of brown (7.5YR 5/2) clay loam containing chalk pebbles; some flint pebbles up to 45mm; charcoal, wood and bark fragments; moss, reed; fish-bone, scrapps of mammal bone; small fragments of oyster and ? mussel shell; land and freshwater molluscs.
90	Sandy peat, 10YR 2/2 to black; chalk pebbles up to 15mm. flints up to 20mm; large wood fragments; moss, reed; fish-bone, mammal-bone fragments; small fragments of oyster and mussel shell; freshwater molluscs.
68	Friable very dark greyish brown (10YR 3/2) organic loam; chalk fragments up to 15mm; angular flints up to 30mm; pottery, daub; charcoal, small wood scraps; moss; fish-bone, bird-bone, mammal bone fragments (some burnt); entire valves of oyster, mussel fragments.
32	Compacted light yellowish-brown (10YR 6/4) clay loam: rounded chalk pebbles up to 40mm and flints up to 3mm; some iron-panning; few charcoal scraps.
64	Firm, partly cemented organic loam, very dark brown (10YR 2/2) with thin (1mm.) pale laminations; occasional 10mm. flints scraps of wood; moss, few reed fragments; fish-bone, bird-bone, mammal-bone scraps; oyster and mussel shell fragments.
31	Organic sandy loam, dark greyish-brown (10YR 3/2.5); some chalk pebbles up to 20mm. and rounded and angular flints up to 4cm; one fragment pottery; charcoal flecks; fish-bone, mammal-bone fragments; oyster, mussel & cockleshell fragments.
65	Organic loam, very dark greyish-brown (10YR 3/2); rounded and sub-angular flints up to 15mm. pottery, charcoal flecks, fish-bone, oyster and mussel shell fragments; land mollusc.

Site Datum (c. 4m.)

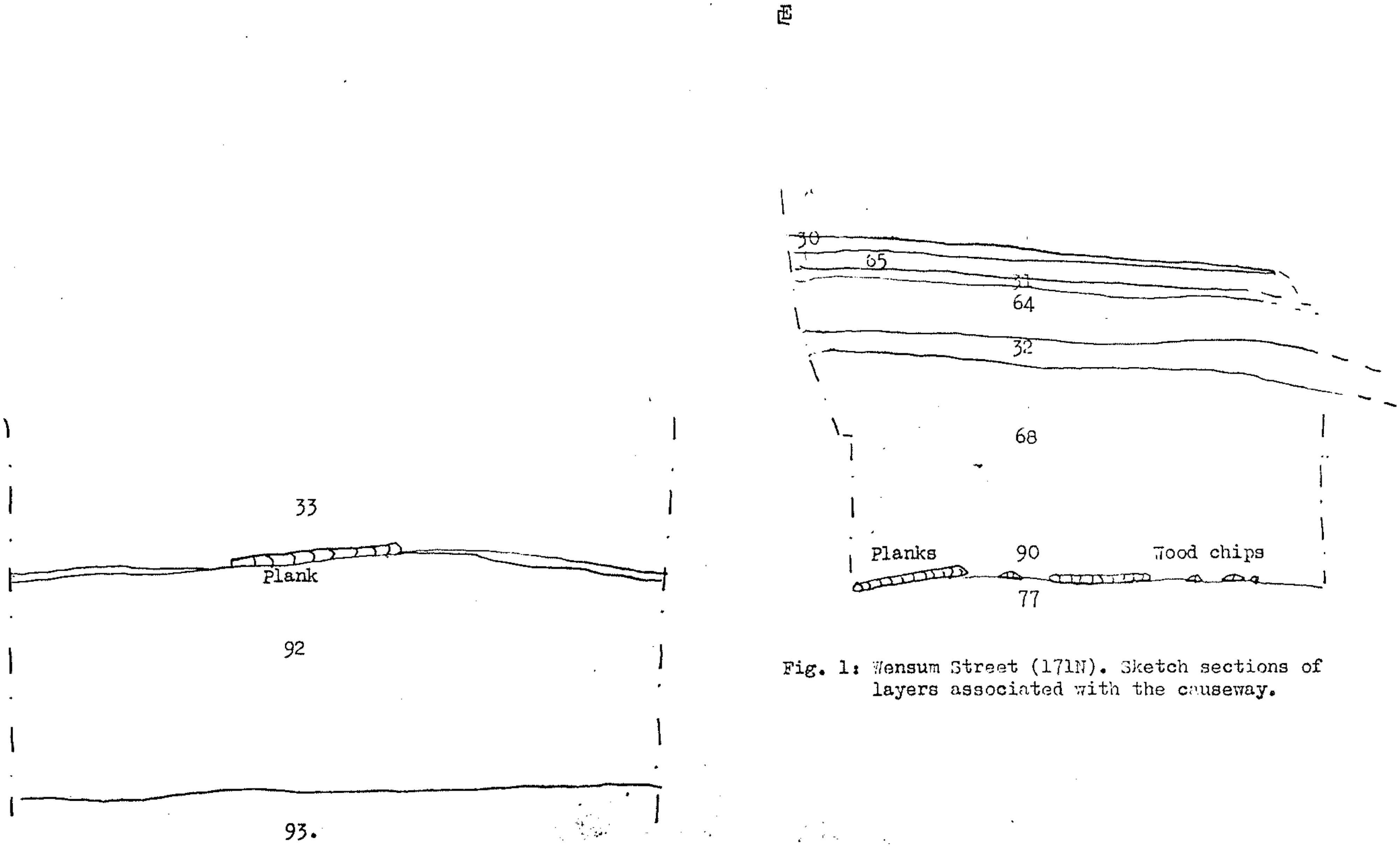

Fig. 1: Wensum Street (171N). Sketch sections of layers associated with the causeway.

Context No.	93	92	77	90	68	32	64	31	65
Hordeum sp.	-	-	-	-	-	-	-	-	1
Avena sp.	-	-	-	-	-	-	-	-	5
Linum usitatissimum L.	1	-	-	-	-	-	-	-	-
Juglans regia L.	-	-	-	-	-	-	+	-	-
Pteridium aquilinum (L) Kuhn (1)	+	-	-	+	-	-	-	-	-
Ranunculus subg. *Batrachium* sp.	-	-	-	-	-	-	1	-	-
Ranunculus c.f. *repens* L.	-	1	-	4	-	-	1	-	-
Papaver rhoeas L.	1	-	-	-	-	-	-	-	-
Papaver argemone L.	1	-	-	-	3	-	4	-	4
Papaver sp.	-	-	-	-	-	-	-	1	-
Brassica sp.	-	-	1	1	2	-	1	-	1
Raphanus raphanistrum L.	1	-	-	1	-	-	-	-	-
Reseda luteola L.	-	-	-	2	-	-	-	-	-
Reseda sp.	1	-	-	-	-	-	1	-	-
Lychnis c.f. *flos-cuculi* L.	-	-	-	1	-	-	-	-	-
Agrostemma githago L.	-	-	1	2	-	-	4	-	-
Cerastium c.f. *holosteoides* Fr.	1	-	-	1	-	-	1	-	-
Stellaria media (L) Vill.	-	-	1	-	3	-	3	-	-
Caryophyllaceae indet.	3	-	-	-	-	-	1	-	-
Chenopodium album L.	3	-	2	8	5	1	16	1	2
Atriplex patula/hastata L.	-	-	1	1	1	-	2	-	-
Chenopodiaceae indet.	-	-	-	-	1	-	5	2	8
Rubus fruticosus agg.	-	-	-	-	1	-	-	2	-
Potentilla sp.	-	-	-	-	1	-	-	-	-
Prunus spinosa L.	1	-	-	-	-	-	-	-	-
Anthriscus sylvestris (L) Hoffm.	-	-	-	3	-	-	-	-	-
Conium maculatum L.	-	-	-	-	4	-	-	-	-
Umbelliferae indet.	-	-	-	-	-	-	1	-	-
Polygonum aviculare agg.	3	-	-	3	1	-	1	-	-
Polygonum persicaria L.	5	-	-	2	-	-	-	-	-
Polygonum lapathifolium L.	-	-	1	2	-	-	-	-	-
Polygonum c.f. *hydropiper* L.	-	-	1	-	-	-	-	-	-
Polygonum convolvulus L.	3	-	2	2	-	-	-	-	-
c.f. *Rumex acetosella* agg.	10	-	-	3	1	-	13	1	-
Rumex sp.	1	-	-	2	-	-	-	-	-
Urtica urens L.	-	-	-	1	97	-	-	-	1
Urtica dioica L.	3	1	1	1	82	1	-	-	2
Betula sp.	-	-	1	-	-	-	-	-	-
Corylus avellana L.	+	+	+	+	+	-	+	-	+
Menyanthes trifoliata L.	-	-	-	-	1	-	-	-	-
Solanum nigrum L.	-	-	-	-	-	-	1	-	-
Mentha arvensis/aquatica L.	-	-	-	-	-	-	1	-	-
Galeopsis tetrahit L.	1	-	-	1	-	-	-	-	-

Labiatae indet.	-	-	-	-	1	-	-	1	-
Sambucus nigra L.	3	-	-	2	2	-	-	-	1
Anthemis cotula L.	6	3	3	8	-	-	9	-	2
Achillea millefolium L.	-	-	-	1	-	-	-	-	-
Centaurea sp.	-	-	-	2	-	-	-	-	-
Lapsana communis L.	-	-	-	1	-	-	-	-	-
Sonchus oleraceus L.	-	1	-	-	-	-	-	-	-
Compositae indet.	-	-	-	1	-	-	5	-	-
Alismataceae indet.	-	-	-	-	-	-	1	-	-
Potamogeton sp.	-	-	-	-	-	-	1	-	-
Juncus sp.	+	-	+	+	+	+	+	+	+
Typha sp.	-	1	2	-	-	-	-	-	1
Eleocharis sp.	-	-	-	-	9	1	4	-	4
Carex sp.	5	-	-	3	7	-	1	-	-
Cyperaceae indet.	-	-	-	1	-	1	-	-	3
Phragmites australis (Cav)Steudl.(2)	+	-	+	+	-	-	+	-	-
Bromus sp.	-	-	1	-	-	-	-	-	-
Gramineae indet.	7	4	2	9	3	-	12	1	2
Indeterminate	10	-	4	3	3	-	6	5	3

Table : Plant remaine from layers associated with the Fyebridge Causeway.

Taxa are represented by fruits or seeds unless otherwise indicated.

(1) Leaf segment (2) Culm fragments

* Sample 64 also produced leaves of Calluna vulgaris.

4. <u>The Cowgate/Whitefriars area</u>

Two shallow bores in this area show peat extending for at least 250m. north of the river. At the north end of St. Paul's Terrace the following sediments are recorded:

0 - 0.6m.	Coarse fill
0.6 - 1.5m.	Loamy, with stones
1.5 - 2.1m.	Peat
2.1 - 2.3m.	Sandy ballast

and at the corner of Charlton Road/Cowgate, the deposits were:

0 - 0.2m.	Topsoil
0.2 - 0.8m.	Coarse fill
0.8 - 1.5m.	Clay and chalk
1.5 - 2.1m.	Clay, with traces of peat.

The western margin of this peat was seen in contractors' excavations west of Paradise Street. Further south, on Whitefriars Street, a peat layer with a minimum thickness of 70cm. was exposed in contractors' and archaeological excavations (318N). Fruits and seeds recovered from this peat by Andrew Jones included marsh, grassland and weed species with some cereals (see seed report for details). Artefactual material from the deposits suggests that refuse was being dumped on the peat during the 13th-14th centuries. The shallower excavations at 36N did not reach this peat but probable flood deposits were present. These were firm, finely laminated sediments, consisting of thin bands (in the order of 5mm. thick) of sandy loam and silt loam varying in colour from greyish-brown to brownish-yellow (10YR 5/2: 6/6) with fine (1mm. thick) bands of crushed chalk or mortar. A similar laminated loam deposit was seen resting on an early floor level at St. James Pockthorpe.*

Evidently the Cowgate/Whitefriars area was largely marsh, prone to periodic flooding, in the early medieval period. This area was known as the 'Cows-Croft', a stretch of wet meadow drained by the Dalimund stream on which St. Paul's Church and Hospital were built in the 12th century (Blomefield 1806, iv, 429).

* For details of these sediments see report by Richard McPhail.

5. Barrack Street - Prince of Wales Road

On the north bank, facing the Cow Tower, peat and 'peaty clay' layers extend nearly as far north as Barrack Street (23910928), but immediately to the east (around 240920) a cluster of boreholes shows gravel and chalk immediately beneath 'Made Ground'. In the line of bores along Riverside Road no Flandrian river sediments are present; the river channel is incised into the slope running up to Mousehold Heath.

On the west bank extensive peat deposits are present, however. In a bore between Bishopgate and the Cow Tower, the sequence is:

0 - 1.5m.	Made Ground
1.5 - 2.7m.	Silty clay, sand and gravel
2.7 - 5.2m	Peat
5.2 - 6.4m	Sand and gravel
6.4m. +	Chalk

Closer to the line of Bishopgate, sand and gravel layers are only 1.2 - 2.0m. Beaneath the present surface, overlain by topsoil and 'made ground', and in one bore by 1.2m of 'soft grey clay/silt'. Undoubtedly the location of Bishop Bridge and of earlier crossing-places has been influenced by the presence of this gravel ridge close to the surface, bounded by deep peat to the north and south.

Peat deposits 1.5m. thick are present at the Water Gate (23920879) and these probably extend towards Bishopgate. It is interesting to note that peat development continued after the construction of the gate; the bore log records a layer of large flints (presumably building rubble) in the peat. Further south, in the Foundry Bridge area, peat layers up to 1.7m. thick are present close to the river, and these peats extend westwards for at least 90m.

This land between Foundry Bridge and Bishopgate was formerly known as 'Cowholme' and, as in the Cowgate area, was used as wet pasture in the medieval period (Blomefield 1806, iv, 50).

6. Foundry Bridge - Carrow

Layers of silt and peat with gravel and clay lenses up to 2m. thick, are present under the eastern part of the King Street Brewery (New Building) but further west, and all along the length of King Street the

Upper Chalk is present immediately beneath 'Made Ground'. The extent of marsh deposits on the west bank of this stretch of the river is clearly very restricted, a fact which made the construction of staithes during the medieval period relatively straightforward. No bores close to the river have been located on this bank.

On the east bank, however, along Riverside, several bore logs record deep marsh and river sediments. The bore opposite the City Flour Mills (23840783) is typical:

0 - 0.6m.	Topsoil
0.6 - 2.1m	Peat
2.1 - 2.4m	Well-graded gravel
2.4 - 4.0m	Peat
4.0 - 5.8m.	Gravel
5.8m +	Chalk

It is not clear, however, how far east these deposits extend.

Discussion and conclusions

The two main factors affecting the water-table and river levels, and hence the extent of valley fen are thought to have been changes in base-level and in freshwater run-off.

Stratigraphic evidence from Great Yarmouth has been interpreted as suggesting that the Yarmouth area stood some 13ft. (4.1m.) higher in relation to the sea towards the end of the 13th century than it does today. (Green and Hutchinson 1960, 140). However Akeroyd (1972, 159) observes that Yarmouth is the only place in the country where there is any evidence of a marked marine regression during the early medieval period. Elsewhere there appears to have been a slow eustatic rise with minor fluctuations of some 0.5 - 2.0m.; an oscillation in relative land-sea levels of over 4m. would be quite anomalous. More recently Coles (1977, 303) has suggested that a slighter emergence, in the order of 1.0 to 1.5m. may have been involved. The size of base-level changes is thus still a matter of dispute, but there is no doubt that base levels were slightly lower in the Saxo-Norman period than in the later medieval period, before the postglacial eustatic rise had reached modern levels. In the valleys this would have meant slightly steeper river gradients than those present today, probably leading to the incision of the channel. This would have improved drainage during the early medieval period. The extent of tidal influence may also have been affected.

Climatic deterioration would have had marked effects on the water-table of the river valley. There is evidence (summarised by Evans 1976) for deteriorating weather conditions with increased rainfall during the 13th century at the beginning of the so-called 'Little Ice Age'. The river valleys would have become wetter with the increase in rainfall.

Variations in the proportion of woodland to open country within the catchment area of the river would also have had effects on freshwater run-off, which would not necessarily be distinguishable from the effects of climatic deterioration. Limbrey (1978) discusses the differences between the forest hydrological regime and that of arable land and pasture. Essentially the removal of forest cover reduces losses by evapo-transpiration and exposes the soil surface to direct rainfall. The rates of leaching and surface flow then increase. This leads to increased freshwater run-off and also, in the case of arable land and poorly-managed pasture, to an increase in the sediment load of nearby streams.

Overall it may be suggested that relatively dry conditions would have prevailed before about 1300, but the combined effects of higher base-level and higher rainfall would have caused the local water-table to rise after this date, though the effects of woodland clearance and of variations in the arable/pasture ratio during the medieval period are less clear. Where the valley floor was not artificially drained, or the surface raised with layers of dumped material there would have been a spread of valley fen.

There is, unfortunately, little direct evidence at present to support this suggestion. The repeated dumping of material to raise the level at 171N can be interpreted as indicating rising water-levels. Similarly at 159N the earliest (late 12th/early 13th century) buildings were constructed directly on the peat surface, but before the second phase (mid-13th century) the site level was raised by dumping some

20-40cm. of material. This evidence is obviously by no means conclusive. Unfortunately, in the present series of excavations the most important riverside sites - the presumed Saxon waterfront at Palace Plain and the medieval staithes along King Street - have not as yet been examined. It is from these sites that unequivocal evidence for changing water-table and river levels can be expected (c.f. Willcox 1975) and consequently the excavations on the waterfront at Whitefriars, planned for the near future will be of some importance.

The bore logs examined serve to give an overall picture of the sediments of the valley floor. Peat covers extensive areas, notably around the Cow Tower, in the Cowgate area and between Foundry Bridge and Bishopgate. All three areas are known to have been used as wet pasture during the medieval period. Although 'river silts' are recorded in many bore logs, few of these can be definitely identified as flood deposits. The laminated sediments at 36N are, perhaps, the best example.

ACKNOWLEDGEMENTS

I am grateful to P. D. Holman, Esq. (City Engineer's Department), to Messrs. Feilden and Mawson, to Jarrolds Ltd. and to Watney Mann Ltd. for allowing me to inspect bore logs in their possession.

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