

THE BABINGLEY RIVER CATCHMENT

Links between geodiversity and landscape

- A resource for educational and outreach work -

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1.0 INTRODUCTION

The Babingley River is a chalk river, of which there are more in England than any other country in the world. Chalk rivers are fed from groundwater sources, producing clear waters. Most of them have 'winterbourne' stretches in their headwaters, with intermittent or absent flow in summer. They have characteristic plant communities, and their gravelly beds, clear waters and rich invertebrate life support important populations of brown trout, salmon and other fish. The Babingley is the best example of a chalk river in west Norfolk.

This report explains the links between geodiversity and the biological and cultural character of the river catchment. It provides a digest of information for education and interpretive outreach about this precious natural resource. Some specialist words are marked in blue and appear in the Glossary (section 5).

2.0 LANDSCAPE PORTRAIT

2.1 Topography and geology

The Babingley River is a river in north-west Norfolk with a length of 19.6 km (12 miles). The river falls some 25 m (82 ft) from its headwaters at Flitcham to where it meets the sea at Wootton Marshes. This represents a mean fall of approximately 1.27 m (4.2 ft) per km. However this fall is mostly accomplished over a distance of 7.7 km upstream of Babingley Bridge (Castle Rising), at a steeper gradient of 3.24 m per km.

The Babingley river has its headwaters in a series of springs. Water in all its forms has played a vital role in forming the topography of the valley we see today. The erosive and depositional power of flowing water, glacial ice and ground ice acting on local bedrock has shaped the land over hundreds of thousands of years, through many climatic phases.

The valley's landscape setting is the [escarpment](#) topography of west Norfolk. A succession of eastward-dipping, early [Cretaceous](#) rocks presents an eroded, westward-facing scarp slope overlooking the Fenland basin. Comparatively resistant rocks of the Cretaceous Dersingham Beds, Carstone and Chalk are interbedded with softer rocks of the Leziatite Beds, Snettisham Clay and Gault. The Babingley river has its headwaters along the foot of the escarpment.

The most important landscape forming event here was the [Anglian](#) glaciation during the [Pleistocene](#) epoch, some 450,000 years ago, when thick a thick ice sheet arrived from the north-west. It eroded the pre-existing landscape and deposited a variety of sands, gravels and clays in the valley. It pushed the line of the chalk escarpment The most recent cold period, the [Devensian](#) also left its mark on the Babingley [catchment](#) through modifying aspects of local relief. An ice sheet reached as far south as Snettisham, and possibly even Sandringham. Everything we see in today's post-glacial, [Holocene](#) landscape is a footnote to these scene-setting episodes in local Earth history. Human influence on the landscape is most evident in deforestation, taming of rivers and wetlands, shaping of biodiversity, planting of crops, the development of buildings, settlements and roads, and the results of earth-moving activity such as embankments and quarries.



Chalk bedrock exposed in the West Norfolk Lime Co chalk pit at Hillington, 1966. The nodular rock above the hammer is the hard Melbourn Rock horizon, used locally for 'clunch' building stone. Photo courtesy British Geological Survey, Geoscientific P210724.

2.2 Headwaters

The Chalk forms the high ground overlooking the headwaters of the catchment. These uplands have the gently rounded hillsides and dry valleys characteristic of the chalk landscape of south-eastern England. Arable farming has now developed in place of historic sheep pasture on the thin, chalky soils of the Newmarket 2 [Association](#). The bedrock contains horizons of varying hardness, including the Melbourn Rock, Nettleton Stone and Totternhoe Stone (harder) and Plenus Marls, Nettleton Marl and Chalk Marl (softer). Locally these give rise to subtle changes in topography, visible as slight undulations in the ground, and to spring-lines where groundwater emerges above the harder or more impermeable layers, as at the Redhole and Denbeck springs. Water also emerges from wet flushes where the watertable is intercepted by the ground surface, as in the catchment's perennial headwaters near Flitcham Abbey Farm and Hillington Carr.

The Babingley River has multiple sources in its catchment, and the abundant flow of chalk-rich water generated by these sources imparts its character to the whole river. The Babingley is thus officially characterised as a Chalk River for the 6 km (3¾ miles) of its length between Flitcham and Castle Rising; this gives rise to the river's distinctive [biodiversity](#). However, the chalk landscape is mostly a dry one, as soils are permeable and surface water quickly soaks away underground. The higher ground in the catchment is marked by a series of broad dry valleys; the largest of these extends for over 4 km (2.4 miles) from Harpley towards Flitcham. These were created in past climatic periods when groundwater levels were higher in the chalk or river base levels were higher, or snow-melt was greater, or when the ground was permanently frozen by [permafrost](#) and thus prone to erosion by flowing water. Temporary streams known as 'winterbournes' may occasionally flow in dry valleys today, at times of high rainfall when soils are saturated, notably in the valley extending towards Harpley. In the 19th century, the source of the river was considered to lie in this valley, at Springhead Meadow a mile east of Flitcham. The nearby pumping station has since lowered the water table such that it has now run dry.



Spring-fed ponds in the headwaters at Abbey Farm, Flitcham.



The former source of the river at Springhead Meadow, Flitcham. It is now a 'winterbourne'.

The Chalk is the area's most important source of drinking water - it is the region's major aquifer, holding many millions of gallons of water in its joints, fissures and pores. The water works at Hillington supplies King's Lynn, Hunstanton and local villages, and organic farming at Flitcham Abbey Farm near helps maintain water quality in the surrounding catchment. In the 19th century, the spring at Denbeck Wood was the main source of water for Sandringham House.

Chalk rock has been extracted for building purposes (clunch and builders' lime), hardcore (for making up roads) and agricultural use (liming) in several quarries in the catchment, most notably today at Hillington. Flint nodules sourced from the Chalk and from surface deposits are a local source of building stone visible in walls.

2.3 Middle reaches

West of Hillington, the middle reaches of the catchment are underlain by early Cretaceous sandstones of the Leziate Beds, Dersingham Beds and Carstone. They underlie the higher

ground flanking the valley around Castle Rising and West Newton, and give rise to sandy soils of the Newport 4 Association, upon which areas of heathland and conifer forest are developed. The valley floor is broad, and contains a variety of surface deposits of glacial and periglacial origin. These include glacial till, sand and gravel, and head (a layer of mixed slumped material). These give rise to the variety of clayey, sandy and peaty soils found on the floor of the main valley and its tributaries, comprising the Isleham 2 and Blackwood Associations. The land use here is mostly arable and pasture.

The glacial deposits were laid down during the Anglian glaciation when ice sheets, perhaps over a ½ mile thick, moved over the land. They ground down the rocks over which they passed, reshaping and reducing the hills of the Chalk escarpment, depositing the variety of sands, gravels and clays, and carving out meltwater channels in the land beneath the ice.

The periglacial deposits were formed during the last glacial period, the Devensian. The ground was typically permanently frozen except for the summer time, when the top metre or so of the subsoil thawed and became mobile. This area close to the margin of an ice sheet which is thought to have reached as far south as Snettisham. A proglacial meltwater lake may have extended some way up the Babingley valley. Also, desiccating winds blew clouds of silt and dust into the air. These processes led to the formation of mixed sandy, solifluction and wind-blown deposits which mantled the ground with a mixture of head and coverloam, thus influencing the composition of soils. In some places blisters of ground ice formed over seasonally wet areas, leading to the formation of distinctive 'hummocky ground' and pingos. At that time, the river drained to a lower base level, as sea level in the North Sea was over 100 m (328 ft) lower than today. Evidence of the former river channel lies buried beneath the valley floor in its middle and lower reaches.

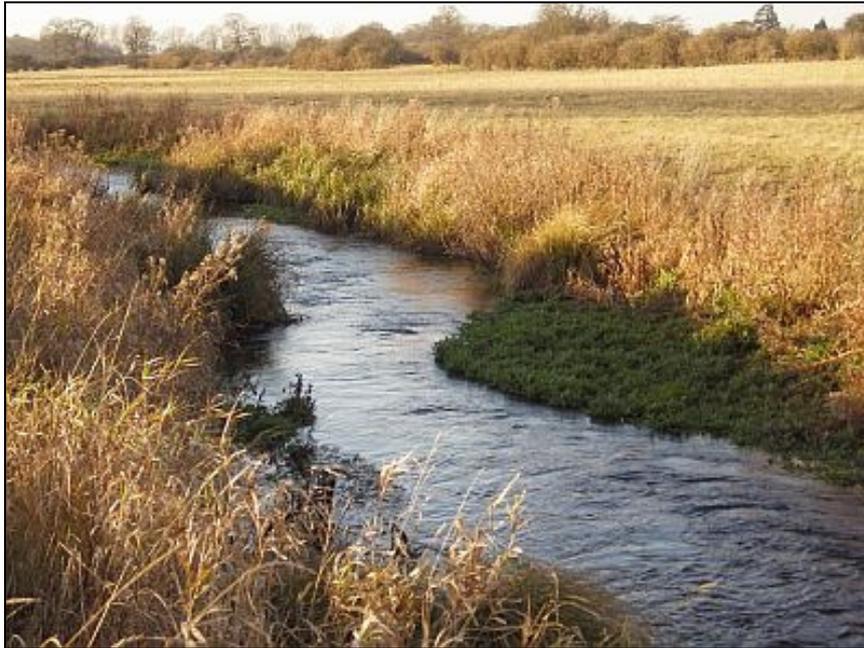


Surviving relict pingo topography at Babingley Meadow, Appleton; 1988. Image courtesy Norfolk Heritage Explorer.

Over the last few years, work has begun to improve the ecology of the middle reaches of the Babingley River through river restoration work. The nature of the river channel has been altered in past centuries for land drainage purposes, and its flow has been harnessed to create a series of water mills. The mills are no longer active, but the river remains constrained by the effects of channel deepening and straightening, and by low water flows. A century ago the river corridor was lined by damp grazing meadows, and the river was in closer contact with its floodplain; today agricultural land-use has encroached right up to the river in many places. Although flow is maintained in the river throughout the year, the quantity has been reduced by groundwater abstraction for public water supply in the headwaters.

Although the river's fall is relatively steep in this section (approx 3.24 m / km) its bed is prone to being clogged by silt, so affecting fish spawning and plant life. It is no longer in a living connection with its floodplain, so affecting the valley's biodiversity and also flood control measures. A programme of river restoration has been undertaken to mitigate some of these negative effects on river life. Small changes to the river's profile have been made in the stretch between West Newton Mill and Castle Rising Mill, including creating gravel riffles and ramps, channel chicanes and debris dams. The aim is to harness natural

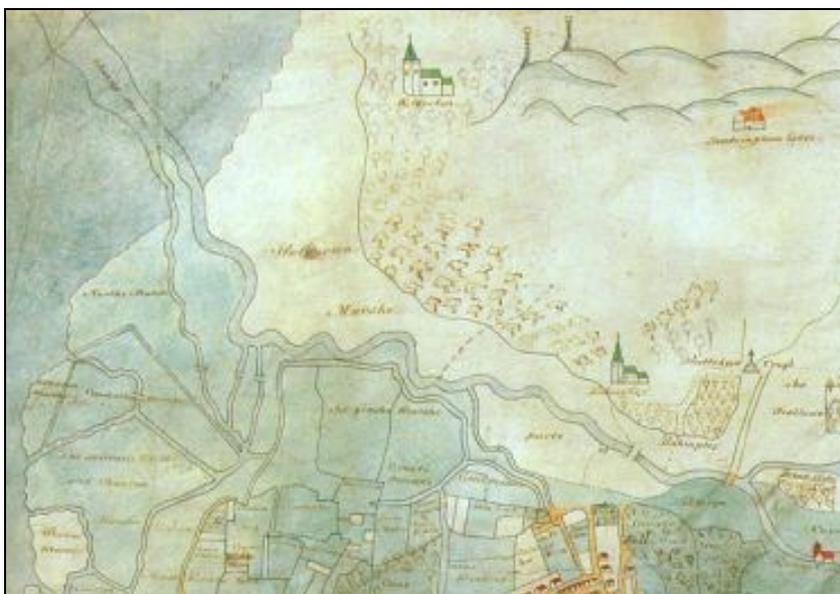
geomorphological processes to kick-start natural channel behaviour, in order to create more habitat diversity.



Recreated meanders and bank reprofiling add variety to river flow dynamics, enhancing available wildlife habitat above and below the water level.

2.4 Marshland

The valley opens out west of the A149 road at Castle Rising bridge. It was formerly part of a navigable estuary, but is now an expanse of reclaimed marshland underlain by the recent marine **alluvium** of the Terrington Beds. Here, silty soils of the Blacktoft Association make rich arable land. The land reclamation story here began in late Saxon times, when a sea bank (confusingly called the 'Roman Bank') was constructed to enclose **saltmarshes** fronting the Wash in Norfolk. At that time the Babingley River discharged directly into The Wash near Wolferton through a complex of saltmarshes and tidal creeks. In Mediaeval times Babingley and Castle Rising could be reached by ship, but further land-takes in the post-Mediaeval period distanced the quays from the sea and the access channels eventually silted up. In the 1850s the course of the Great Ouse was diverted into the Lynn Channel at King's Lynn, and tracts of former saltmarsh at North Wootton and South Wootton were reclaimed. The waters of the Babingley River were then diverted some 6.75 km (4 miles) southwards into the Lynn Channel via a drain known as the Marsh Cut.



A map showing the Babingley River estuary, 1588, showing the river directly entering The Wash. A canal links Castle Rising (lower right) with the river channel.

Image courtesy Castle Rising History - <http://www.castle-rising-history.co.uk>

2.5 Future scenario

Rising sea levels due to human-induced global warming may well see tidal influence extending up the Babingley valley once more. Norfolk County Council estimates that sea levels are likely to rise by up to 0.88 m this century, so the river could become tidal almost as far upstream as West Newton Bridge (located at the 10 m contour). If so, the river will be grading to a rising base level, which could raise freshwater levels upstream in the catchment. Set against this, all future scenarios suggest that climate change is likely to lead to lower groundwater and river flows in summer. To add to the uncertainty, unstable weather patterns are likely to lead to episodes of more intense rainfall alternating with drought, all of which have implications for river, floodplain and water management, and biodiversity in the catchment. The Babingley River valley is clearly still evolving.

3.0 FEATURES TO VISIT

The following natural and cultural features have potential to communicate the contribution of geodiversity (geology, landforms and processes, soil and water) to the natural and cultural character of the Babingley River and its catchment. For details see section 4 below.

3.1 Water mills

The river's abundant flow has been harnessed since the Middle Ages to power water mills processing various raw materials at:

- Flitcham (flax? mill);
- Congham ('oil mill');
- Castle Rising (the paper mill, the corn mill, ye Babingley Myll).

With the co-operation of the owners, there is potential to arrange mill visits to see surviving evidence. Congham Lodge Mill or West Newton Mill (Rising Mill) have the best above-ground remains.

3.2 River restoration

Following ecological degradation, work has started to restore aspects of the river's ecology and flow dynamics through channel enhancements at:

- Hillington Park, where the artificial lake called Broadwater has been restored to river;
- A 1.25 km stretch between West Newton Mill and Castle Rising Mill.

The results of river restoration can be seen via a public footpath routed along the river bank between West Newton Mill and Castle Rising Mill, and by arrangement with the owner of Hillington Park. Aerial photographs and old maps show the shape of the river's former meandering channel; some old channel remnants can still be seen on the floodplain, e.g. the wet area north of Old Sovereigns Wood.

3.3 Groundwater and the aquifer

Rain falling on the chalk hills round Flitcham, Harpley & Hillington recharges the aquifer and occasionally flows overground as 'winterbournes', as at Flitcham Springhead Meadow. The chalk bedrock itself can be seen exposed in chalk pits at Harpley Dams, Hillington and on Flitcham Abbey Farm. It can also be seen as fragments in the topsoil.

Groundwater is pumped from the aquifer into the public water supply from the Anglia Water borehole at Hillington Water Works (and also from a private pumping station in Hillington Park).

Groundwater emerges from springs and wet flushes at Flitcham Abbey Farm, Hillington Carr, Redhole, Denbeck). Flitcham Abbey Farm has areas of permissive public access where natural springs can be seen, and a bird hide from which water birds can be observed.



The river at Hillington Park, following restoration work by the Environment Agency, 2007. Photo courtesy Environment Agency

3.4 Water during the Ice Age

Water sculpted the dry valleys in the chalk hills in times when there was more surface water or the subsoil was impermeable. A good example of dry valley topography can be seen at Anmer Road, Flitcham.

Evidence of higher groundwater or surface water flows in the past can be seen at Springhead Meadow, Flitcham, where there are incised meanders.

Evidence of blisters of ground ice (pingos) can be seen at Babingley Meadow County Wildlife Site (CWS), Appleton. Areas of 'hummocky ground' can be seen north of the river east of the A149 (Rising Common) and along the valley floor near Gatton Waters.

A buried tunnel valley is present beneath the valley floor in the area of West Newton Bridge. This was carved out by water under pressure beneath the Anglian ice sheet, but can only be detected in borehole records.

3.5 Evidence of changing sea levels

In Roman, Saxon and Mediaeval times an estuary extended as far east as Castle Rising, and it was navigable as far as Castle Rising and Babingley (as witnessed by the story of St Felix landing there to evangelise Norfolk). Blocks of grey quartzite stone ('silver carr') were exported from here in Roman times to build the Roman fort at Brancaster; examples can be seen at the church and dotted around the parish. Port facilities at Castle Rising were accessible via a minor tributary of the river, with staithe and a ship canal; the best place to appreciate this is Night Marsh Lane. Permission from the Castle Rising Estate is needed to visit the staithe site.

3.6 Evidence of saltmarsh reclamation

The Babingley River once flowed directly into The Wash near Wolferton, and was fringed by natural saltmarshes. North Wootton is the best place to see aspects of saltmarsh reclamation over the last 1000 years or more. A seawall called the 'Roman Bank' was constructed in Saxon times across its outlet; evidence of its course can be seen north of Marsh Common beside the railway line. A saltern mound (of Mediaeval date?) can be seen here, also the meandering courses of former saltmarsh creeks, also a cutting through the saltmarsh alluvial deposits underlying the Common, possibly deposited in Roman times. The diversion of the Great Ouse at King's Lynn in the 1850s and the creation of the Lynn Channel led to a major phase of saltmarsh reclamation, the results of which are visible in the landscape of flat, open farmland intersected by drainage ditches created in the 1860s at Marsh Road.

3.7 Chalk river biodiversity

Distinctive species present include:

- water crowfoot, fool's watercress, watercress;
- water vole;
- brown trout, bullhead, dace and stone loach.

Mediaeval stories suggest that beavers were present in the valley in Saxon times. Other notable water-related species recorded from the river include heron, kingfisher, otter, marsh harrier, grey wagtail.

(The native white crayfish is a typical chalk river species, but has not been recorded from the Babingley, although it may formerly have been present.)



Clear flowing waters and submerged plant life in the river between West Newton Mill and Castle Rising Mill. Fool's Watercress *Apium nodiflorum* bedded with Soft Hornwort *Ceratophyllum submersum*.



The waters of the Babingley River enter The Wash at Point Green. This interpretive panel explains saltmarsh ecology and the history of land reclamation.



A reclaimed saltmarsh landscape in North Wootton, looking west. The dyke marks the probable line of the 'Roman Bank' seawall of late Saxon date which enclosed the mouth of the Babingley River estuary. The land to the right was reclaimed at some time before the 17th century.

4.0 LOCAL DETAILS

Supporting in-depth information about environmental features of the Babingley River valley.

Chalk topography

Glacially eroded scarp with dry valley development, notably visible from up Anmer Road, Flitcham, towards Bircham.

Soils are 343g Newmarket 2 Association: calcareous, loamy rendzinas.

Groundwater quality and quantity

The chemical quality and quantity of the groundwater in the chalk bedrock in Flitcham, Hillington and West Newton is classified as 'poor'. This is due to nitrate pollution from agriculture and over-abstraction for drinking water purposes. The groundwater in these areas is designated as 'vulnerable'. See groundwater information in the River Basin Management Plans on the Environment Agency's website at <http://maps.environment-agency.gov.uk>.

Ecological quality

The ecological quality of the whole Babingley River is assessed as 'moderate'. See river water information in the River Basin Management Plans on the Environment Agency's website at <http://maps.environment-agency.gov.uk>.

Harpley Dams Chalk Pit - TF774253

Turonian Chalk close to the Lower/Middle Chalk boundary, showing periglacial disturbance to flint bands. Overlying Pleistocene chalk-rich gravels of presumed Anglian age (Lowestoft Formation) are cut by a notable channel feature filled with pebbly sand.

Hillington Pumping station, north of Field Farm - TF743263

Source of water for Freebridge & Lynn Rural District Council, borehole created 1947. Hit Chalk at 5 ft 6" (1.65 m) and is over 99 ft (30 m) deep. Yielding 72,000 gallons (327,320 litres) per hr at test in 1975, so judged adequate to supply King's Lynn and local needs. BoreholeScan -

http://scans.bgs.ac.uk/sobi_scans/boreholes/510279/images/14780104.html.

Quality report -

http://scans.bgs.ac.uk/sobi_scans/boreholes/510279/images/14780110.html .

Site map - http://scans.bgs.ac.uk/sobi_scans/boreholes/510279/images/14780126.html.

Owned by Anglian Water. They say the Hillington Water Treatment Works are being currently upgraded to meet European Union Drinking Water Directive re. Cryptosporidium protozoan and lead content.

Flitcham Church - TF725266

Local people suggest that St Felix used to live at Flitcham [based on name of village]. A note in the church says that Camden's 'Britannia' c.1500 says that the hills thereabouts were known as the 'Christian Hills'. Geological building materials include chalk clunch and flint, and other rocks sourced from local fields.

Flitcham Church Pit - TF724266

An overgrown chalk pit is next to the church and can be seen over the churchyard wall. It is completely degraded now, but from its position and shape it is likely to have worked the hard Totternhoe Stone and beds above and below it as a source of clunch. (See Gallois 1994 p.134)

Hillington Chalk Pit - TF723245

An active quarry. It is a regionally important exposure of the Cenomanian Chalk of the Lower to Middle Chalk Transition, exposing a full sequence between the Nettleton Stone and Melbourn Rock horizons. Evidence of glacial tectonism is present e.g. in Plenus Marls. (See Gallois 1994 p.134)

The British Geological Survey has 4 publicly available photos of the pit in its online GeoScenic collection.

Flitcham Abbey Farm - TF736266

A farm with organic output, part of the Royal Sandringham Estate. Presumably organic farming helps maintain groundwater quality in the river's headwaters.

The house is listed as Norfolk HER record 3942. An Augustinian Priory (St Mary's) founded in 1217 as a dependant cell of the Priory at Walsingham, and dissolved in 1538. The buried remains of the Mediaeval monastic buildings, rectangular earthworks, and the remains of the medieval water management system of the Priory (spring, sluices, ditches) surround the 19th century farmhouse which now stands on the site. See

<http://www.heritage.norfolk.gov.uk/record-details?MNF3492-Flitcham-Abbey-or-St-Mary's-Priory>.

The farm has an annual open day, and has permissive access to parts of its land holding.

There is a permissive access bird hide overlooking spring-fed meadows with ponds at c.TF737266. Parking space for c. 6 cars near hide. List of species and visitors' record book present. Seating for c. 10 people, space for c.15 people (max).

There is permissive public access to 25 acres of rough grassland and unimproved pasture with spring-line features south of Flitcham village at c. TF 730265. Access to large parking area near village sports field from village street.

There is permissive public access to rough grassland at Springhead Meadow TF743263, with a seasonal (winterbourne) stream flowing over chalk bedrock and incised meandering channel feature as evidence of former higher-energy Devensian flow regime. No parking available (though 1 or 2 cars max perhaps on roadside verge).

Contact: Edward Cross, R S Cross & Son, Abbey Farm, Flitcham, King's Lynn, Norfolk PE31 6BT; tel: 01485 609094).

Flitcham Carr - TF730262

Fine Spring is marked as the 'source' of the Babingley River on Faden's map, 1793. Not publicly accessible.

Denbeck Wood - TF713275

The site of a spring feeding a north bank tributary of the Babingley. The spring emerges where Lower Chalk rests on impermeable Gault mudstone. Not publicly accessible.

"In a tributary-valley on the northern side strong springs rise from the junction of the

Chalk with the underlying marl (Gault) in Denbeck Wood, eastward of Appleton (Appleton Hall of the newer map, 146, in the parish of Flitcham?). They are used for the supply of Sandringham House, etc. and F. R. Beck, writing in 1894, stated that the water is excellent and that the supply never failed until 1893, when the quantity decreased seriously in August and failed altogether at the end of October, the deficiency being got over by pumping water from a shallow spring at the northern end of Sandringham House. The water began to flow again in the beginning of December, and the estate was again wholly supplied from the regular source on the 14th of that month." See Whitaker 1921: The water supply of Norfolk; HMSO p32

Flitcham Bridge Mill - TF728262

The site of a small mill in the C18th (possibly for flax). No traces remain. Signs of C19th culverting and iron pump visible near east side of bridge.

Hillington Park - TF725255

The site is listed as Norfolk HER 30512. See <http://www.heritage.norfolk.gov.uk/record-details?mnf30512>

Numerous water features are visible in the Park, as much of it is founded on impermeable glacial clays of the Lowestoft Till, also periglacial head deposits. There is peat and alluvium on the valley floor.

Ice was stored in a C19th ice house at TF 7279 2571, sited on a hill top.

A pumping station to supply the Hall is sited at TF724263.

The Environment Agency carried out a river restoration programme in 2007 at impounded lake known as the 'Broadwater'. The aim of the project was to revert 420m of lake back to river in order to improve the water quality, remove barriers to fish and eel passage and provide additional spawning habitat for wild brown trout (*Salmo trutta*). Sluice boards (1.15m high) at the downstream extent of the site were removed resulting in the lowering of the water level. This concentrated the flow and enabled the river to cut a new channel that would be more sustainable in the long term. Deflectors were installed in the downstream extent of the reach (where gradient and flow velocities were less) to concentrate flow further and enable the river to continue cutting a channel into the newly exposed silt. Improvements in water quality as a result of the work created better habitat and spawning grounds and the removal of the sluice boards allowed free passage for fish to access these areas. However, lowering the water level created a barrier at the upstream weir, which had to be addressed using a pool and traverse fish easement created with rock rolls (at bridge). See

[http://riverwiki.restorerivers.eu/wiki/index.php?title=Case_study: Babingley River at Hillington](http://riverwiki.restorerivers.eu/wiki/index.php?title=Case_study: Babingley_River_at_Hillington).

Not publicly accessible.

Hillington parish

Mentioned in the Domesday book 1086 : A freeman, villagers, smallholders, slaves, ploughs, meadow, pigs, sheep, mills and salthouses were recorded. The presence of salthouses might suggest that tidal conditions may have extended at least 7km inland along the Babingley River. See <http://www.heritage.norfolk.gov.uk/record-details?TNF268>.

Congham, Redhole Spring - TF721242

The spring emerges at the base of the Lower Chalk where it overlies the Gault Clay. It is marked on Faden's map 1797, and there are other springs in the vicinity. They are the source of a south bank tributary leading to Congham Lodge Mill. No public access, But visible from road.

Congham Lodge Mill - TF714248

Listed as Norfolk HER 14997. See <http://www.heritage.norfolk.gov.uk/record-details?mnf14997>

Marked as 'Oil Mill' on Faden's map 1897, called Whale Mill locally, now called Congham Lodge. The machinery was powered by one of the few overshot wheels in the county. The mill said to have produced oil from whale blubber brought in from Kings Lynn docks (last whale landed 1812). The resultant whale bones were then taken by road to Narborough

Bone Mill where they were ground into fertiliser. Some of the whale bones remain, positioned like posts at each end of the brick parapets of a bridge. There are legitimate doubts as to whether whale oil was ever processed here, so perhaps 'oil' refers to linseed (flax) oil? See <http://www.norfolkmills.co.uk/Watermills/congham.html>. See also: [http://en.wikipedia.org/wiki/River_Cong_\(Norfolk\)](http://en.wikipedia.org/wiki/River_Cong_(Norfolk))

Mills, general

The Domesday Book records that the parishes of Castle Rising and Babingley shared at least five watermills, between the sea and the eastern part of the parish. All must have been upstream from that part of the river which was used for navigation. The Babingley River was one of the few rivers in West Norfolk suitable for milling. It was relatively fast flowing and larger than at present with a gentle gradient which made it possible to build low dams which provided a head of water. Leat streams, to divert part of the river's flow to the mill wheel, could be easily dug in the soft glacial or alluvial deposits. Inventories taken in the 14th and 15th centuries mentioned five water mills used for both corn milling and fulling cloth and the sites of four of these can be identified today. See <http://www.castle-rising-history.co.uk/mills.html>.

Gatton Bridge (B1440) - TF711258

A BGS borehole (TF72NW11, 1992) recorded over 43 m deep of glacially-derived, buried valley fill deposits. This suggests that meltwaters were active beneath the ice here, carving out a tunnel valley in the underlying bedrock. There is no surface expression. NB there is no evidence for estuarine deposits to confirm the hypothesis that an estuary extended up the valley as far as Hillinton in Saxon times.

Babingley Meadow pingo site - TF 705261

A cluster of ramparted depressions, some holding water, are considered to be examples of relict periglacial pingo/palsa or hummocky ground microrelief of late Devensian age. See Walmsley 2009.

The site is County Wildlife Site CWS 263 Babingley Meadow; described as ungrazed neutral and marshy grassland together with patches of tall ruderal vegetation and a small mesotrophic pond.

The site is adjacent to a straight road dating from the early C19th Enclosures road called New Road (Hodskinson's map, 1826) or Common Road (1st ed OS map). The site is thus possibly a relict area of common land.

Soils are the 861b Isleham 2 Association - sandy & peaty soils formed in glaciofluvial sands with thin layer of wasted peat on top, on low-lying land affected by groundwater; often have periglacial hummock & hollow 'hills & holes' micro-relief.

West Newton Mill (Rising Paper Mill or Upper Mill) - TF695256

The site of a possible Saxon mill. Documentary sources record a mill here from 1588 (two mills, Rising Corn Mill and Rysinge Fulling Mill) and the shape of the parish boundary suggests it may have been here earlier in the Saxon period. First known mention of the mill in 1588 relates to a fulling mill. Fulling mill converted to a paper mill and was actually the subject of the first reference to a paper mill in Norfolk. It was burnt down in 1722 and was rebuilt several times. For many years the mill was in the estate of the Viscount of Andover - the Howard family. When papermaking ceased in 1845, the machinery was converted to corn milling and its 14' 6" wheel ran 3 pairs of stones. It went out of use in 1845 and the present buildings are now used as a house. Interestingly situated at the end of an arm of Castle Rising parish that extends up the river. See

<http://www.norfolkmills.co.uk/Watermills/west-newton.html>

The Upper Mill was a Fulling Mill until 1691. Here rather loosely woven cloth was scoured, sometimes in urine then in water and fuller's earth to remove the grease. It was then pounded with wooden mallets or stocks to consolidate the fibres. The stocks were powered by the water wheel. The 1588 Map shows not only the Upper Mill but also the tenter frames nearby, on which the cloth was eventually dried and stretched. After 1691 the mill was converted into a Paper Mill, the first one ever recorded in Norfolk. It seems likely that the initiative came from the new Lords of the Manor, the Howards of Ashted. The raw material for paper making at that time was rags which having been stripped of buttons and

clasps etc were cut up, soaked and washed and then pounded by wooden mallets into a pulp from which the paper was made. The sheets of paper were usually hung to dry in drying sheds at a distance from the mill because of the danger of fire. Fire in fact was a problem but in the form of arson when in 1722 the miller from the Lower Corn Mill, on finding that the paper mill was also grinding corn, burnt it down. He was "committed to the castle". The mill was rebuilt in 1746 for the miller John Parrott and all went well for a while until Parrott, perhaps as the result of an illness began to threaten the life of William Fawssett, the agent for the estate, who was responsible for collecting the annual rent. Despite these setbacks the mill continued to make paper until the 1847 by which time wood pulp and esparto grass were being used for paper making and modern mills were built near to ports. The Upper Mill was then converted into a corn mill and worked as such for almost a hundred years until it closed in the 1950s. William Rye and his son Jimmy were the last millers and some of the older residents of the village remember taking grain, which they had gleaned from the fields, to be ground at the mill. After being empty for some time the upper storey of the mill was removed in the 1960s or 70s and the mill was converted into a residence. See <http://www.castle-rising-history.co.uk/mills.html>

Gatton Waters - TF704254

A small gravel pit was present on the valley floor here in the late C19th and enlarged by 1946. Strangely, not marked on the OS map 1" :1 Mile 1963. Extraction heyday probably in the 1970s, as a lake was present by 1988, with a camp site. See <http://www.gattonwaters.co.uk/>.

The lake is surrounded by a caravan and camp site, with an 8 acre lake stocked with tench, carp, roach, rudd, perch and bream. See <http://www.gattonwaters.co.uk/index.html>
The geology is mapped by the BGS as an outcrop of glacial sand and gravel (the Briton's Lane Sand & Gravel Formation) of Anglian age, with adjacent river terrace deposits.

The river at 'Rising Common', between West Newton Mill (TF695256) and Castle Rising Mill (TF677251)

Faden's map 1797 marked 'Rising Common', suggesting the area was formerly common land (fen or grassland?). It shows the river had a meandering pattern then. Parts were straightened and meanders removed in the C19th. Vestiges of an old chopped-off meander can be seen in a marshy woodland at TF697253.

This stretch of the river has recently been subject to an Environment Agency river restoration project to enhance biodiversity value:

- Many whole log woody debris dams laid across the whole channel;
- Several hinged tree deflectors emplaced;
- Many pool and upstream run habitats created from a combination of bed and bank re-profiling;
- Lowering of right bank where possible, using sedge etc. from the banks to locally narrow the channel and form shallow edge habitat.

For more information contact Dr Nigel Holmes n.holmes3@btinternet.com.

Characteristic Chalk River biodiversity present include:

- water crowfoot, fool's watercress, watercress;
- water vole;
- brown trout, bullhead, dace and stone loach.

Mediaeval stories (see St Felix's Church entry below) suggest that beavers were present in the valley in Saxon times.

Other notable water-related species recorded from the river include heron, kingfisher, otter, marsh harrier, grey wagtail. (The native white crayfish is a typical chalk river species, but has not been recorded from the Babingley.)

There is public access via footpaths from either end of the valley.

The valley here includes three different soil types. Hummocky ground visible north of the river is developed on 861b Isleham 2 Association. Land to the south (White Hills Wood) is sandy soils (551g Newport 4). Land flanking estuary and up towards West Newton is 821b Blackwood (sandy or loamy over drift). These reflect the underlying geology.

Castle Rising Corn Mill (Lower Mill) - TF 677251

Castle Rising watermill was one of Norfolk's smallest mills in later years, although in 1868

the mill had a four storey steam mill alongside the watermill running up to twelve pairs of stones between them. The mill site and the surrounding farm complex as can be seen on the 1888-89 O.S. map below. Eventually most of the mill complex was demolished and a new cut was made for the river to bypass the mill. See

<http://www.norfolk Mills.co.uk/Watermills/castle-rising.html>

By 1891, probably suffering from the completion of large modern coastal mills using imported corn, the mill and the farm ceased to function. The river was diverted, the mill pond drained, the wheel house bricked up and the mill pulled down. The farm buildings have since fallen into disrepair. The Mill House and cottages remain tucked away in the woods beside the Babingley River beyond the by-pass. See <http://www.castle-rising-history.co.uk/mills.html>

Babingley Bridge, Castle Rising - TF673256

The site of mill a mentioned in a 16th century document as having been recently abandoned was "unto a place where sometime Babingley Myll did stand being west of the Stone Bridge of Rysing a furlong and a half" The Stone Bridge is the one on the Old Hunstanton Road; rebuilt of concrete in 1929. The site is marked on Faden's map 1797 as the landward limit of estuarine influence.

The site is accessible via footpath (the old main road). St Felix's Church ruins at Babingley can be seen in the distance.

The Environment Agency has a monitoring point here, for assessing water biology, chemistry and flow.

The river banks are accessible upstream by footpath. The former West Newton Brook (now a drainage ditch) enters the river, bringing acidic water from the sandy soils in the area of the former Newton Common to the north-east (now forested).

Babingley village - TF6626

Babingley is a lost Mediaeval village lying to the north of an area of reclaimed marshland, at one time a navigable estuary about 3km inland from the Wash. Babingley today comprises St Felix's church and Hall Farm with a moat.

Many archaeological finds have been made - see

<http://www.heritage.norfolk.gov.uk/record-details?MNF3257-Babingley-deserted-medieval-settlement-and-multi-period-finds>.

There is an access track to Hall Farm, but it is not public.

St Felix's Church, Babingley - TF665261

The ruins of the church can be seen but not visited (owned by Royal Sandringham Estate).

Listed as Norfolk HER 55921 - see <http://www.heritage.norfolk.gov.uk/record-details?mnf55921>. Carstone and Sandringham sandstone with limestone dressings. Ivy clad ruins survive. Dedication to St Felix suggests the possibility of a pre-Conquest church on or near the site. Said to be on site of earliest church in Norfolk founded by St Felix of Burgundy who landed in Babingley river estuary c.631 acc to tradition. Mediaeval legendary story about the arrival of the saint guided to his landing place by beavers. The ruins of the church can be seen across the valley from Castle Rising.

Castle Rising port - TF 6615 2555

Local stories say that there was a port here before King's Lynn.

See the website 'Castle Rising and the Sea' - [http://www.castle-rising-](http://www.castle-rising-history.co.uk/Book%20Chapter-)

[history.co.uk/Book%20Chapter-%20CR%20and%20the%20Sea%20Website%20version%20Sept%202012.pdf](http://www.castle-rising-history.co.uk/Book%20Chapter-%20CR%20and%20the%20Sea%20Website%20version%20Sept%202012.pdf)

The Babingley formerly had two channels - north is the Babingley proper; south was a lesser tributary; linked to the Babingley by a channel [in Saxon times when Babingley Corn Mill was built]. Castle Rising port may have lain at a staithe beside the south channel.

Access was via Nightmarsh Lane, which has a wide ditch beside it which may have been an access canal to staithe closer to the village when water levels were higher in the valley.

'Silver carr' stone can be seen at the base of St Lawrence's Church tower; this was extracted from the Sandringham Sands Formation locally and exported in Roman times to build the fort at Brancaster (*Branodunum*). The port was used for importing Caen stone to build the church and Castle, also for other goods in Mediaeval times. A 1946 aerial photo

shows areas of Mediaeval cultivation at TF660255 in the form of a ridge & furrow open field cultivation system. An old track between Night Marsh and Babingley church was swept away by the 1953 sea flood.

St Felix's Church ruins at Babingley can be seen in the distance. The land to westward is flat and used for arable; 200 years ago it was grazing land.

Babingley Marshes and saltmarsh reclamation

The Babingley estuary formerly reached as far east as Babingley Bridge, and perhaps beyond. It had its outlet to the sea near Wolferton. Its legacy can be seen in the marshland soils of the 532a Blacktoft Association (calcareous silts from marine alluvium) in the lower reaches of the valley.

The 'Roman Bank' enclosed the mouth of the estuary of presumed late Saxon age, as elsewhere in Fenland. Its course can be seen close to the disused railway line north of Marsh Common, North Wootton (open access land). Areas of saltmarsh were reclaimed and turned into grazing marshes behind this embankment. Such reclamations are likely to have lost during C13th during a period of relatively high sea level (see Gallois 1994, pp.173 & 4). Later, in the C17th a further land-take happened with an embankment contemporary with the Wolferton Bank. Faden's map shows the extent of the late C18th saltmarsh and sea walls.

The waters of the Babingley were diverted south-westwards in the 1850s via the 'Marsh Cut', after the Norfolk Estuary Company re-routed the Great Ouse into the new Lynn Channel in 1853. They enter the sea at Point Green (King's Lynn). The results of this are visible at Marsh Road and Marsh Common, North Wootton. This ushered in an era of major phase of successive saltmarsh reclamations (most recently 1965).

Saltmaking was carried out on the saltmarshes in Saxon or Mediaeval times, and there is a presumed saltern mound of industrial waste product visible on Marsh Common at TF638250. Aerial photos show the meandering courses of former saltmarsh creeks on the Common; these can be traced on the ground. A drainage canal was constructed across the Common sometime in the mid to late C19th, and was recut in WW2 as an anti-tank defence.

A geological exposure in a cutting at TF641257 shows a section through 1 m+ of brown saltmarsh alluvium underlying the Common. The geology of North Wootton marshes is explained in BGS borehole TF62NW5.

An IDB pumping station for controlling water flow is present at TF644257.

Point Green is a surviving remnant of upper (high) saltmarsh lost elsewhere round The Wash, supporting a distinctive flora of club rushes and reeds. It shows what the Babingley estuary once looked like. It is part of The Wash National Nature Reserve. It can be accessed by the footpath network and a long, very bumpy public road, and has a boardwalk and interpretive panels explaining local saltmarsh ecology and reclamation history.

Global warming impacts

See Norfolk Climate Change Strategy [2009] and also Local Climate Impacts Profile at <http://www.norfolkambition.gov.uk/consumption/groups/public/documents/article/ncc095340.pdf> -

- Increased winter rainfall, combined with a likely increase in the quantity of rainfall from intense events in winter, will result in a greater risk of flooding.
- Acute temperature events such as heat waves are extremely likely to increase. The longest summer heat wave duration is likely to grow by up to 10 days over the 21st century.
- Summers are also likely to be drier. Future summer average daily rainfall is likely to significantly decrease. In partnership with this summer dry periods are likely to increase in duration, more likely than not increasing by up to 10 days.
- Sea levels are likely to rise by up to 0.88m, rising at rates faster than present (IPCC, 2007), having a major impact on coastal erosion and coastal flooding. Recent scientific findings find this estimation to be very conservative.

Re. impact of climate change on groundwater and river flows, "almost all scenarios suggest lower summer flows" - see Prudhomme et al 2012 at <http://nora.nerc.ac.uk/15039/>

5.0 RESOURCES

5.1 BOOKS AND REPORTS

- Gallois, R.W.: *Geology of the Country around King's Lynn and The Wash*; British Geological Survey, 1994
- Purseglove, J.: *Taming the Flood: History and Natural History of Rivers and Wetlands*; Oxford University Press, 1988
- *The State of England's Chalk Rivers – A report by the UK Biodiversity Action Plan for Chalk Rivers*; Environment Agency, 2004
- Walmsley, A.: *The Norfolk 'Pingo' Mapping Project 2007 – 2008*; Norfolk Wildlife Trust, 2009

5.2 ONLINE RESOURCES

- British Geological Survey Borehole Scans - <http://mapapps.bgs.ac.uk/boreholescans/boreholescans.html>.
- British Geological Survey Lexicon of Named Rock Units - <http://www.bgs.ac.uk/lexicon/>.
- Castle Rising History – <http://www.castle-rising-history.co.uk>, notably the 'Landscape and Geology' section including 'Castle Rising and the Sea'.
- Norfolk Historic Environment Record, via Norfolk Heritage Explorer – <http://www.heritage.norfolk.gov.uk/simple-search>.
- Case study of river restoration at Hillington, via the RESTORE website: http://riverwiki.restorerivers.eu/wiki/index.php?title=Case_study:Babingley_River_at_Hillington.
- Soil Associations in England and Wales, via The Soils Guide (Cranfield University, 2014) – http://www.landis.org.uk/services/soilsguide/mapunit_list.cfm.
- UK Biodiversity Action Plan: Rivers Habitat Action Plan – http://jncc.defra.gov.uk/pdf/UKBAP_BAPHabitats-45-Rivers2011.pdf.

5.3 GLOSSARY

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| Alluvium | Unconsolidated, water-lain sediments of terrestrial origin deposited in a non-marine setting, for example a floodplain or an estuary. |
| Anglian | A major glacial period during the middle Pleistocene Epoch, about 450,000 years ago. Norfolk was covered by ice sheets from the north and north-west, one of which extended as far south as Hornchurch in Essex. When it retreated it left behind thick deposits of till or 'boulder clay', and also beds of outwash sands and gravels deposited by meltwater. |
| Aquifer | A water-bearing geological formation. |
| Association | A term used for classifying and mapping soils. Associations are composed of several soil types (series), and each is named after its principal series and these bear the location name from where they were first described (e.g. Isleham). |
| Biodiversity | The variety / diversity of life forms; the totality of genes, species, and ecosystems of a region. |
| Catchment | The land area from which a river or stream gathers its water. |
| Coverloam | Deposits of wind-blown silt. |
| Cretaceous | A period of Earth history between 145 and 65 million years ago; it followed the Jurassic period. It was characterised by widespread shallow shelf seas in which calcareous planktonic organisms were abundant; their remains were deposited to form chalk and the silica mineral flint. |

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|--------------|--|
| Escarpment | A linear slope landform fronting a plateau, often formed by erosion or faulting and may include a steep component such as a cliff. |
| Head | Mixed superficial deposits of periglacial origin on slopes, mobilised by solifluction. |
| Holocene | An Epoch of Earth history, between about 10,000 years ago to the present day. Its beginning corresponds with the onset of warming conditions at the end of the last glacial period (the Devensian stage). It is characterised by increasing human impacts on the Earth system. There is current debate about whether we have now entered a new Epoch, the Anthropocene, characterised by visible impacts of human life in the geological record. |
| Permafrost | Permanently frozen ground. |
| Pingo | A mound of earth-covered ice formed in regions of permafrost (qv); they typically form over artesian springs or in former lake beds; in the Arctic they can reach up to 70m in height and up to 600m in diameter. See also entry for palsa. |
| Periglacial | In the vicinity of a glacial environment, with conditions dominated by freeze-thaw processes. |
| Pleistocene | An Epoch of Earth history, between about 2.5 million and 10,000 years ago. Its ending corresponds with the end of the last glacial period (the Devensian Stage). It is characterised by cyclical shifts in the Earth's climate between cold (glacial) and warm (interglacial) periods, driven by variations in planetary orbit round the sun. |
| Proglacial | A term referring to deposits or landforms situated at or beyond the margins of an ice sheet or glacier, for example a meltwater lake. |
| Saltmarsh | An area of marshy ground periodically inundated with seawater, and often having creeks and pools of salt or brackish water; it has characteristic salt-resistant vegetation. |
| Solifluction | The slow movement of an active layer of waterlogged sediment down-slope, over impermeable material such as permanently frozen ground (permafrost). It occurs in periglacial environments where surface layers melt in summer. |
| Till | Unsorted, unstratified material deposited directly by glacial ice; sometimes called boulder clay. |

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 Version 1, February 2014



The Norfolk Geodiversity Partnership is a forum for conserving Norfolk's Earth heritage
<https://sites.google.com/site/norfolkgeodiversity/>