THE NORFOLK RIVERS TRUST

RESTORING NORFOLK'S RIVERS

THE RIVER INGOL

A WATER FRAMEWORK DIRECTIVE LOCAL CATCHMENT PLAN

DEVELOPED IN PARTNERSHIP WITH

Environment Agency

CONTENTS

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THANKS

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INTRODUCTION

This plan has been produced by Norfolk Rivers Trust in consultation with relevant agencies, landowners, farmers and residents in the Ingol Catchment. The catchment is thought to be an appropriate scale to consider because it encompasses the entire area which drains towards the river so can involve even distant sources of pollution which could affect the river. The aim of the plan is to provide an outline for improvement of the ecological status of the Ingol, guided by the Water Framework Directive (WFD). Setting ecological restoration objectives should be undertaken with community consultation, and Norfolk Rivers Trust is very keen for local people to participate in setting objectives for an environmentally sustainable solution for their area. Delivery of the actions outlined in the plan will lead to improved water quality, ecosystem health, and should encourage economically valuable fish species.

The plan begins by providing an audit of the current state of the catchment. This information is then used to identify ecological pressures. In the final stages of the plan, solutions to these pressures are identified, costed and prioritised.

THE WATER FRAMEWORK DIRECTIVE

The Water Framework Directive (WFD) was introduced in 2000 and commits European Union member states to improving the physical and ecological quality of their rivers, lakes and groundwater areas. The quality of these waters is measured using a range of indicators outlined below which combine to give a picture of a river's health. Using this combination of indicators a river (or groundwater unit or lake) is then graded on its overall "ecological status", and designated as either bad, poor, moderate, good or high. Each member state is required to bring its water bodies to good status by 2015. Where this is not possible, good status must be achieved by 2021 or 2027, depending on the severity of the barrier to good status. The majority of Britain's rivers fail to attain good status due to a wide variety of pressures. In England, the Environment Agency is responsible for WFD delivery.

The current report is informed by an existing technical Waterbody Report undertaken by the Environment Agency, but also draws together information from other sources, and is written with stakeholders as the intended audience.

Water Framework Directive Status	Current river Status (2009)	Predicted by 2015
Bad		
Poor	**Invertebrates** **Fish** **Phosphate**	**Invertebrates** **Fish** **Phosphate**
Moderate	**Overall status**	**Overall status**
Good		
High	**Dissolved oxygen** **Ammonia** **pH**	**Dissolved oxygen** **Ammonia** **pH**
	Heavily Modified Water Body for wider environment	**Heavily Modified Water Body for wider environment**
	Hydrology supports good status	**Hydrology supports good status**

Table 1. Results of detailed water body investigations undertaken by the Environment Agency to determine the status of the River Ingol. A prediction about the status at the next "waypoint" in the WFD schedule (2015) also shown.

A CHOICE FOR THE FUT URE OF OUR RIVERS…

RIVER INGOL STATISTICS

Approximate river length:	10.3 km
Catchment area:	35.3 km^2
Protected areas:	Snettisham RSPB Nature Reserve and the coastline – SSSI, SAC, Ramsar site, SPA.
Legal designations:	Natura 2000 (Habitats and/or Birds Directive), Nitrates Directive, Shellfish Water Directive

WHY RESTORE RIVERS?

Britain's rivers generally fail to reach "good" ecological quality. This is both a problem in itself and a sentinel of trouble.

A well-functioning river system is an inseparable combination of good water quality, distinctive physical processes and diverse wildlife. These factors interact to provide benefits. A naturally functioning river has a floodplain with sufficient capacity to absorb inundation and to act as a store for silt carried by high flows. The river channel is also self-scouring. This reduces flood risk and the need for expensive management. Headwater forests reduce surges of water into the system by increasing drainage and removal of water. Moreover, the vegetation, microbes and invertebrates in the river corridor also absorb and process pollutants. This enhances water quality within limits. However, very polluted rivers have less wildlife and in turn a reduced capacity to provide such benefits. This leads to a downward spiral. Wildlife itself has an intrinsic value and is enjoyed by groups such as fishermen, ramblers and bird watchers.

If any of the three pillars of the river system are damaged (water quality, physical processes, ecosystem), then the value of the entire interconnected system is reduced. Arguably, we also have a responsibility to repair our damaged natural heritage for future generations. Thus, ecological restoration aims to enhance the functioning, as well as the intrinsic value of our beautiful rivers.

SECTION 1 THE CATCHMENT

The Ingol is a chalk stream in North Norfolk which runs from its source in Shernborne through a predominantly rural catchment until its mouth close to Snettisham RSPB Nature Reserve. Towards the headwaters of the stream, agriculture is represented by low intensity grazing by cattle and captive red deer, with arable fields at a distance from the stream. A section of the river passes through Ingoldisthorpe and Snettisham providing scenic nature walks for the community. Below Snettisham, intensive arable agriculture borders the stream and the Ingol has been modified to such an extent that it has almost no ecological value.

THE COMMUNITY

It is part of the Norfolk Rivers Trust's mission to gain the active participation of the community. Stakeholders help us to set objectives, keep us informed about issues on the ground such as pollution and actively volunteer to make many more worthwhile projects possible.

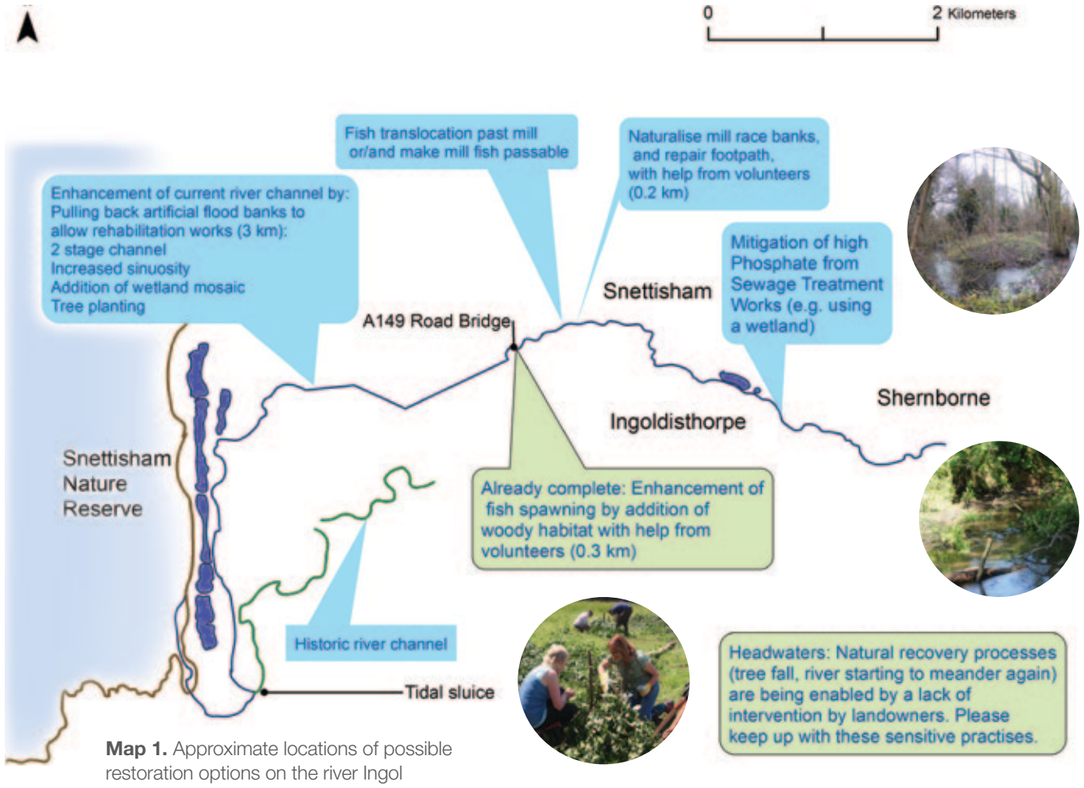
Norfolk Rivers Trust have recently started to work in the Ingol catchment, and we were very pleased to receive over 100 people at our latest event. The River Ingol is a rural catchment, containing the towns and villages of Shernborne, Dersingham, Ingoldisthorpe and Snettisham.

An opportunity to restore a section of the River Ingol by improving habitat has already been identified, and this project will be greatly aided by the help of volunteers. Norfolk Rivers Trust are grateful for the help which landowners have given to make this project happen, and hope that more projects will be initiated in the near future.

A Norfolk Rivers Trust event in Snettisham in March 2014 which was attended around 100 people.

OVERVIEW OF RESTORATIONS OPTIONS

Summary of possible restoration options on the river Ingol. These proposals will greatly enhance the water quality and wildlife value of the river. It is stressed that these are subject to landowner consent and are only outline ideas at this stage.



Map 1. Approximate locations of possible restoration options on the river Ingol

GEODIVERSITY OF THE RIVER INGOL

Introducing Chalk Rivers

Chalk rivers are a distinctive and valuable part of England's landscape. There are more to be found here than anywhere else in the world. They are located wherever rivers flow across chalk bedrock or chalk-rich superficial deposits, in a tract of land stretching from East Yorkshire, Norfolk and the Chilterns to Wiltshire and Dorset. There are 12 such rivers in Norfolk. They are fed principally from groundwater rather than surface water, and flow is gradually released through springs or directly up through the river bed. Chalk rivers have a distinctive flow regime: their springheads tend to have steady flow, although some headwater valleys may be dry in summer when groundwater levels fall. They tend to have more stable temperature regimes than other rivers due to a constant baseflow component. Their waters are highly alkaline, which gives rise to a distinctive ecology and suite of plants and animals. High quality chalk streams are prized by anglers because they support abundant brown trout populations, which shelter and feed amongst characteristic water plants such as water crowfoot.

The Heacham River: a Norfolk chalk stream, having clear, lime-rich water flowing over flint and chalk gravel.

GEODIVERSITY OF THE INGOL VALLEY

The headwaters

The Ingol has its headwaters in the chalk uplands in the parish of Shernborne. It is nominally 11 km (8 miles) long, but it is a chalk river for less than 3.5 km (2¼ miles). It owes this status to the lime-rich springs which provide much base flow in its upper reaches.

In wet years the river begins as a winterbourne with its source near the church, generated from the Chalk Marl bed at the base of the Lower Chalk. The most important and more regular source is located a short distance away down the valley, at Hall Farm Meadows. Here, the valley has been incised to a level below the Chalk, and a complex of springs is present where the Red Chalk and Carstone form relatively impermeable layers beneath the valley floor. These have been harnessed to form a series of ponds. Further springs are located in an area of carr (wet woodland) near Shernborne Hall. Another winterbourne spring was formerly active west of the Hall, where relict evidence of its channel can be seen in the contours of the valley floor; it is likely that lowered water levels in the aquifer have reduced perennial groundwater flows here.

A spring fed pond and wet flushes at Shernborne Hall Meadows. Permeable Lower Chalk bedrock underlies the fields in the background, which are developed on permeable chalky soils.

Photograph: © Tim Holt-Wilson

The middle reaches

The river becomes defined by a managed channel where it passes Shernborne Hall. The floodplain widens out downstream of here, and the river flows in a straightened course through damp meadows developed on calcareous, loamy soils. Its flow is augmented by springs between here and Ingoldisthorpe: water percolating down through the joints and fissures in the Chalk, Red Chalk and Carstone meets an impermeable layer of Snettisham Clay, and emerges along the valley side in a series of sapped embayments along the springline. The river is also augmented by the discharge of Ingoldisthorpe sewage water treatment works, which has been identified as a source of phosphorus pollution. Approaching St Thomas's Bridge and just beyond it, the springline is found at higher levels above the valley floor; it follows the upper boundary of the Snettisham Clay. The result is a zone of wet flushes, artificial ponds, rivulets and small landslips on the valley side. The river flows along the southern side of the valley until diverted towards the northern side at Snettisham. This diversion is likely to be associated with water management for milling purposes, and may have taken place in the 11th century or earlier, as seven mills were recorded here in the Domesday Book. This stretch of the river was formerly controlled by a sequence of weirs and sluices. The river is canalised where it passes through woodland and a housing area and then widens out as it enters the pond at Snettisham Mill.


Photograph: © Tim Holt-Wilson

Groundwater emerging from an outcrop of ochre-coloured Carstone in the valley side between Shernborne and Ingoldisthorpe.


Photograph: © Tim Holt-Wilson

A dissected spread of sandy river terrace or slope-derived deposits occupies the valley floor near St Thomas's Bridge; these supply the river bed with sands and gravels. In-stream vegetation includes watercress.

The coastal flatlands

The former westward course of the River Ingol where it entered the coastal plain is followed by the parish boundary. Evidence of the palaeochannel can be seen on the ground near Ingoldisthorpe, though the landform soon loses definition westwards. The inland margin of the flatlands is developed on a sheet of sandy superficial deposits which may represent the bed of a proglacial lake of Devensian (last glacial) age; these overlie a glacially eroded platform of early Cretaceous Sandringham Sands. The soil here is sandy and permeable. The river flows over a bed of coarse flint gravel and fluid drifts of sand, between banks of thick sandy alluvium; its course meanders slightly, showing that it has enough energy periodically to erode its banks, probably due to periodic releases of water upstream at Snettisham Mill. Beyond Paper Hall Farm, however, the river pursues a course which was straightened and canalised in the 19th century; it passes onto thick layers of silty marine alluvium, representing former areas of saltmarsh reclaimed as far back as the 17th century. The Ingol is essentially a fenland drainage channel between here and its outlet to the sea at Wolferton Creek (formerly Snettisham harbour), and its bed is dominated by silt. It is a ponded river, that is to say its exit to the sea is controlled by a sluice which only opens at low tide, and prevents the river from becoming tidal.


Photograph: © Tim Holt-Wilson

The River Ingol flows through a landscape of former saltmarshes near Shepherd's Port. The land here was reclaimed in 1878.

Tim Holt-Wilson Norfolk Geodiversity Partnership

WILDLIFE SURROUNDING THE INGOL

Despite the many challenges which the wildlife in the Ingol valley faces, the catchment supports a diversity of organisms which benefit from the river.

Species profile: Riffle Beetle

The riffle beetles (family Elmidae) are small beetles between 1.25-4.75 mm in length, have long legs and claws relative to their body size and are generally dark brown to black in colour. The long claws help them to keep hold of the substrate and plants on the river bed to stop them from getting washed downstream. This is very important as they are not able to swim. There are a small number of species in the family, some of which are very common and some that are Red Data Book species. Most common in the North West Norfolk rivers are *Elmis aenea* which are found in rivers and streams where 'riffle' features are present. One of the regionally notable species found is *Riolus subviolaceus* which inhabits base-rich streams and rivers with good flow velocities.

Contribution: Nina Birkby, Environment Agency


Riffle beetle and larvae (Elmis aenea)

Photograph: © APEM©


Kingfisher

Photograph: © Jonathan Lewis.

Species profile: River Kingfisher, *Alcedo atthis*

When walking down a gurgling river, one is sometimes lucky enough to be graced by the teal blue flash of a kingfisher speeding on urgent business. This incredible little bird feeds on small fish and invertebrates at a voracious rate, consuming its entire body weight each day. During the mating season, the kingfisher will catch 5,000 small fish to sustain itself and its young. Kingfishers do not have a beautiful song to match their striking colours, but they do have a variety of calls with different meanings. In fact, one call signifies to their mate and young: "I'm home!"

In the winter, when some of the kingfishers' feeding spots freeze over, the birds migrates towards coastal estuaries where the warming effect of the sea, and the salt water prevent freezing. Most of the time, however, kingfishers stick to a particular territory and will be seen in the same spot routinely.

Species profile: The Eurasian Otter, *Lutra lutra*

The otter is a predatory mammal which uses its excellent swimming ability and specialised teeth to feed on a variety of prey such as fish but also amphibians and occasionally birds. They have even been shown to be capable of eating toads despite their poisoned skins. They corral the amphibians into groups before proceeding to skin them and eat the nutritious innards. Otters hold territories against the same sex, and this stops their numbers building up into high densities, especially when food is scarce. This beautiful and reclusive animal is wide ranging and can be seen around ponds, lakes, rivers and marine habitats.


Otter

Photograph: © Jack Perks

Wildlife profile:
River plants

The benefits of aquatic plants for lowland river systems are threefold: they reduce pollution, they improve river structure and they are a vital habitat for other wildlife.

Scientific studies have shown that plants remove excess nutrients caused by sewage effluent or agriculture. Their sinuous fronds create a large surface area for colonisation by algae, bacteria and invertebrates which process nutrients and organic matter within the river. Their roots directly remove nutrients. They also stabilise sediment and thus prevent movement of toxins which may be bound to sediment particles. Water plants' physical role is also vital. They narrow the channel in places and cause water to accelerate, as well as holding water up in other places. This allows differential scour and deposition of sediment, which helps river channels to remove and store sediment. Together with trees, they are nature's architects of channel structure, helping rivers which have been artificially straightened to recover to a more meandering form. Water plants are also a rich habitat for invertebrates which feed the larger animals in the river system. Last, but not least, their delicate greens and subtle white flowers are also one of the wonders of the British countryside.

Ten years ago this section of stream was absolutely straight and featureless. Growth of plants and sediment deposition around dead plants has caused a return to a more natural meandering form, which in turn has started to cause pools and riffles to develop. (Photo: Olly van Biervliet, Fox's Beck, Norfolk. With thanks to John Dowland)

Water crowfoot in flower.

Water plants cause flow variation which also encourages sediment storage and scour.

Varied water plants represent shelter and food for a diversity of other wildlife.

A HISTORY OF HUMAN MANAGEMENT

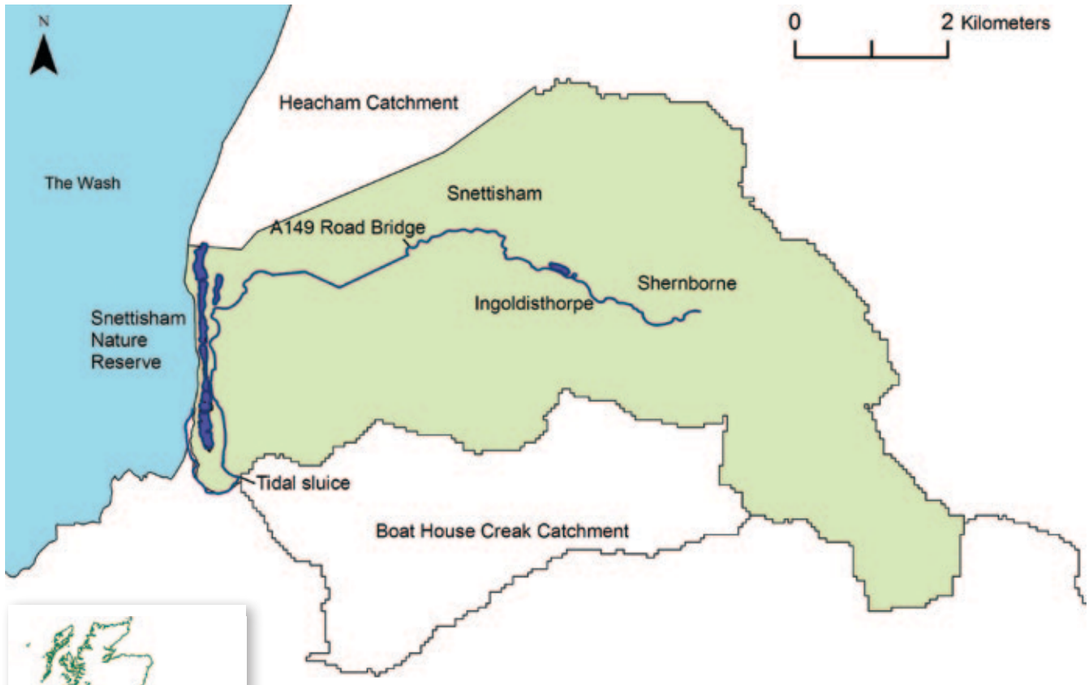
The first Neolithic settlers arrived on the North Norfolk coast about 4-6,000 years ago. They brought with them agriculture and this innovation represented a means by which humanity would gradually alter the entire landscape.

By the middle ages, Norfolk rivers were exploited by local communities to provide fresh fish, watercress, watering for animals, and irrigation for crops. Osier (willow -*Salix viminalis*) coppices were exploited for weaving baskets of all sizes, hazel coppices for hurdle production and alder for clog soles. Moreover, the fish ponds were an ingenious way to increase the productivity of river margins.

The Enclosure movement involved significant changes to agriculture in Norfolk: common pasture was turned to plough and marshland to grazing. From the late Nineteenth century to this day, the mechanisation of farming, large-scale land-drainage and afforestation of wet ground has brought about an inexorable reduction in marshes and floodplains. Modern post-war agriculture has continued to intensify the production of food in the Ingol Catchment.

Looking back on the interaction between the River Ingol and humans over millennia, man has greatly benefitted from the production furnished by the river and its margins. We have changed the Ingol catchment, completely altering vegetation cover, the extent of marshes, tidal influence and have moved the river itself into a totally different course in its lower reaches. Nevertheless, the river remains an important feature of the landscape and a useful asset for irrigation, drainage, and the removal of sewage effluent. The Ingol is also still home to a variety of beautiful wildlife, and perhaps this can be increasingly reconciled with the functions of the river as we move forward into the future.

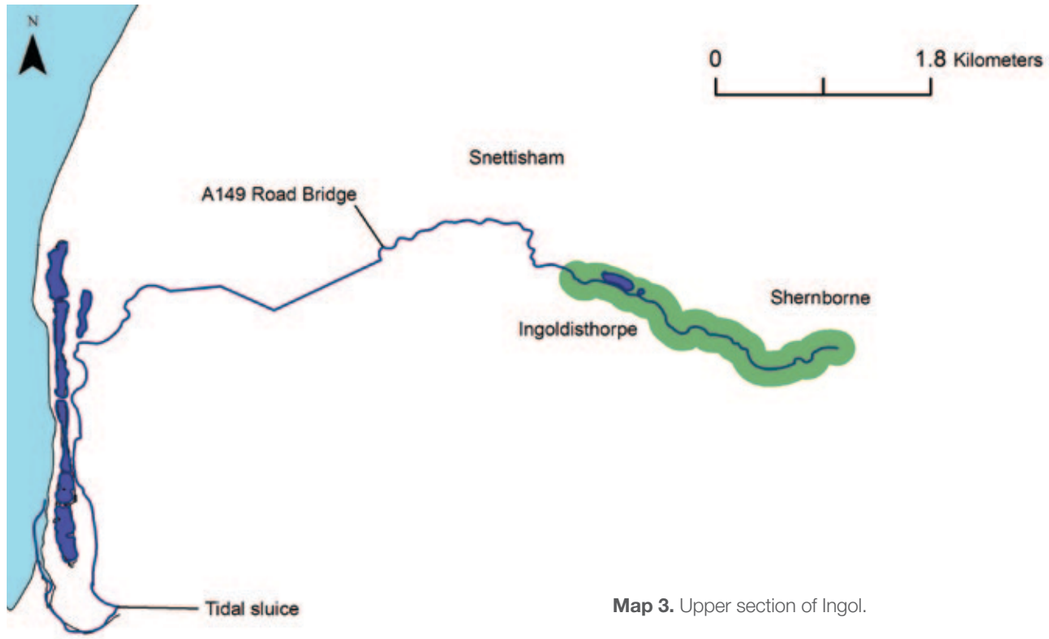
THE INGOL FROM SOURCE TO MOUTH



Map 2. Overview of the Ingol Catchment

Section 1 – Source at Shernborne to Ingoldisthorpe (St Thomas' Lane)

The exact position of the source of the Ingol varies depending on the height of the water table, but the most permanent source appears to be springs which rise in ponds close to Shernborne. The stream enters a dense area of wet woodland after this point and then flows into the moat of Shernborne Hall, where levels are maintained by a small weir. Thereafter, the stream flows through a shallow valley with varying degrees of tree cover alternating with dense wetland plants where the aspect is more open. Cattle and deer graze meadows surrounding the stream. The buffering vegetation and lack of agricultural pollution in this section are generally conducive to promoting a healthy ecosystem. The only exception to this is the high nutrient effluent discharged from Ingoldisthorpe Sewage Treatment Works which contains concentrations of phosphorus which are of particular concern.The Environment Agency can address this issue through the enviroment permitting regime.



Map 3. Upper section of Ingol.

Photo 1. The Ingol flows through the moat at Shernborne Hall.

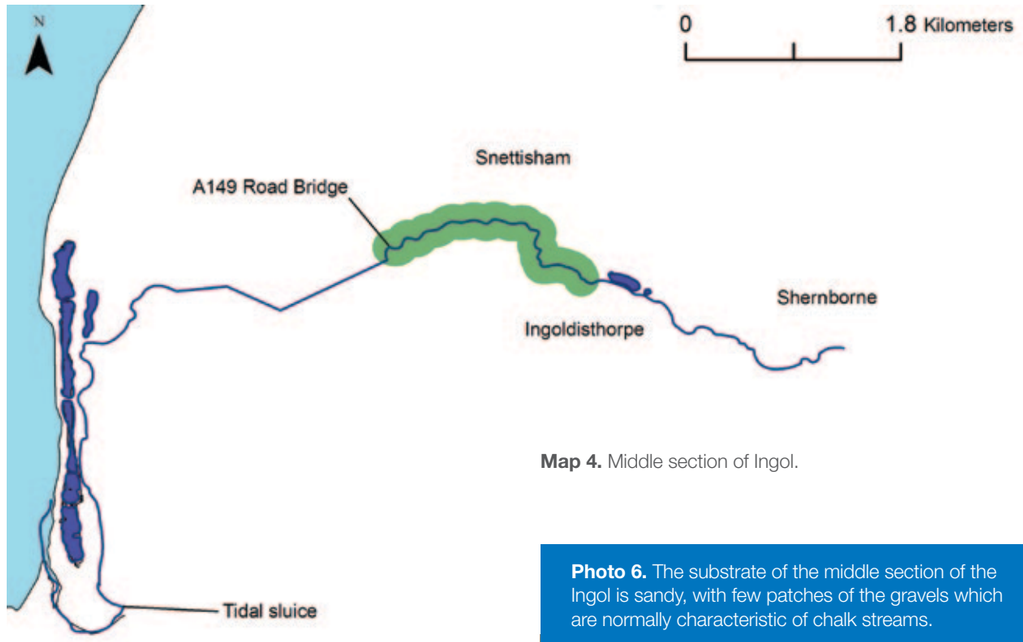
Photo 2. A representative stretch of the upper Ingol.

Photo 3. Photos showing excellent river habitat with the river overflowing into historical meander bends and flow variation produced by large woody debris.

Photo 4. Outfall of Ingoldisthorpe Sewage Treatment Works.

Section 2 – Ingoldisthorpe (St Thomas' Lane) to A149

At the upstream end of this section, the river flows past Ingoldisthorpe through grazed grassland and some arable. The river is sheathed in a buffer of varied vegetation including tree cover alternating with abundant growth of scrubby vegetation and wetland plants. The nature of the stream changes when it crosses the Lynn Road in Snettisham, where it enters the mill pond of Snettisham Watermill and is embanked with a footpath on one side and gardens on the other (Photo 10). The mill pond has collapsing banks, which are of concern to residents, and muddy substrate with an accumulation of rubbish probably thrown in from the road bridge over time. The mill is a barrier to fish passage, and no fish apart from eels (which can traverse dry ground) are found upstream of this point. Below the mill, the River Ingol flows more rapidly once more through a section shaded by tree cover. The river channel just above the A149 road bridge provides some of the most important fish habitat in the lower river with dace *(Leuciscus leuciscus)* in particular depending on this section for spawning.



Map 4. Middle section of Ingol.

Photo 5. A representative section of the middle Ingol.

Photo 6. The substrate of the middle section of the Ingol is sandy, with few patches of the gravels which are normally characteristic of chalk streams.

Photo 7.

Photo 8.

Photo 9. Mill bypass channel has almost no water in it except for during extremely wet conditions.

Photo 10. Snettisham Mill Pond.

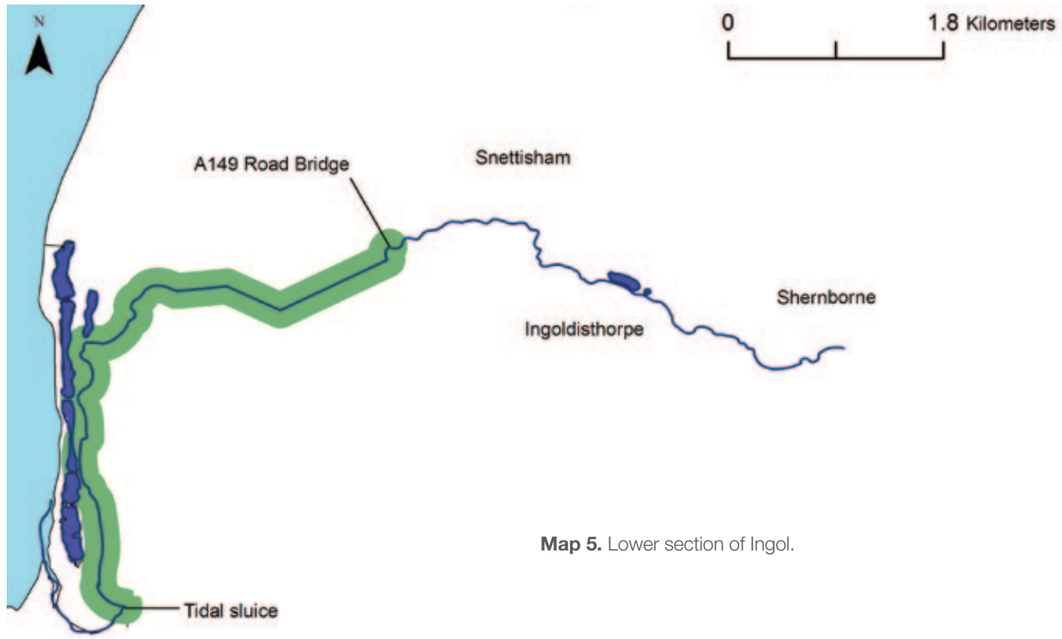
Photo 11. Main path of water through Snettisham Watermill

Photo 12. Ingol just above A149 road bridge.

Section 3 – A149 to Source to tidal sluice

Below the A149 road bridge the Ingol runs through intensive arable fields and has been re-directed throughout the rest of its length. It starts off relatively narrow and fast flowing but becomes wider, deeper and more sluggish as it approaches the sea wall (Photo 17). Near the road bridge, a temporary weir is used for seasonal abstraction, and this impoundment causes a barrier to fish passage (Photo's 13 and 14). The entire section is characterised by a very straight channel with very few trees to provide shading or woody debris which would enhance the river habitat. At one point, the river flows in a straight line for 1.4 kilometres with only a single sharp corner to change the orientation (Photo 15). This current channel is perched above the adjacent farmland and surrounded by earth banks in places, and the implications of this are discussed in the Action Plan section. The old course of the river is evident about 500m to the south of the existing river course.

The invertebrate and fish communities in this section of the river are designated as poor and are impacted by nutrient enrichment from sewage effluent and by the poor state of the habitat. A new fish pass has been fitted on the tidal sluice. If complemented by efforts to improve water and habitat quality, this could hopefully enable migratory fish to return to the river Ingol in the future.



Map 5. Lower section of Ingol.

Photo 13.

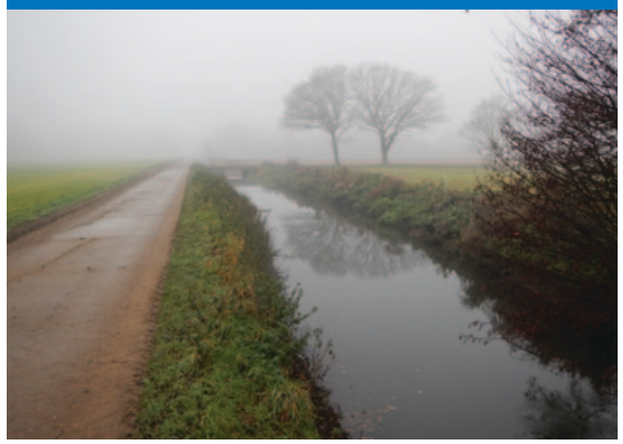


Photo 14.

Photo 15.

Photo 16.

Photo 17.

Photo 18. Sluice at tidal outlet.

SECTION 2 THE PROBLEMS AND SOLUTIONS

The Ingol is a river of 2 halves.

Above the A149 road bridge, some excellent habitat is available, and natural processes such as tree fall are causing a steady recovery from historic damage to the river's structure. Sensitive land-use and undisturbed vegetation around the river reduce the risk of diffuse pollution. The only significant problems stem from nutrient enrichment due to the sewage treatment works and the barrier to fish passage posed by the mill.

Below the A149 road bridge, centuries of modification have led to a situation where the river has very little ecological value. The invertebrate community seems to be repressed by poor water quality and the fish community is restricted to the low quality downstream section of the river. It is unfortunate that the fish community cannot benefit from potentially excellent habitat in the river's headwaters. The surrounding land use is intensive and the habitat represented by the vegetation in the river corridor could hardly be of lower value to wildlife.

HOW CONNECTED IS THE RIVER ALONG ITS COURSE AND TO ITS FLOODPLAIN?

In a natural, highly productive stream, there is seasonal connectivity between the river and its floodplain and unimpaired movement of fish species along the river.

Above the A149 road bridge, the Ingol connects to historic meander bends during high flows, giving valuable seasonal inundation similar to that which occurs in floodplains. However, below this point the Ingol does not connect to its floodplain, even during periods of high flow. This greatly reduces the river's marginal habitat, and prevents the rich ecological interchange between the stream and its river corridor which would occur during natural inundation.

There are a few key impoundments along the river which isolate the fish community to the lowest part of the river. The fish community has been assessed to be "poor" by the Environment Agency.

Overall, the stream ecosystem in the lower reaches would benefit from increased re-connection to the floodplain where possible. Fish passage past key impoundments would also be desirable.

Naturally river floodplains contain a diversity of plants and yield a variety of benefits including sediment storage.

WATER QUALITY

Phosphorus

Chalk stream ecosystems have evolved to function with relatively low levels of the nutrient phosphorus. In low nutrient conditions, chalk streams will adopt their characteristically beautiful vegetative form with clear water running over abundant submerged plants such as *Ranunculus sp*. growing within the channel and a gradient of emergent vegetation such as the yellow flag iris appearing at the edge of the channel.

The lower Ingol is failing the requirements of the Water Framework Directive for excessively high levels of the nutrient phosphorus. The vast majority of this phosphorus comes from a single point (the sewage treatment works), so is known as point source pollution. There are several implications of this for the stream ecosystem. The first is that dominant forms of water plants and algae will grow very rapidly. This results in the disappearance of the chalk stream plants which are adapted to compete well in low nutrient levels. Moreover, when the algae dies off it decomposes, greatly reducing oxygen in the channel, thus causing physiological stress or death to fish and invertebrates. It is likely that the impoverishment of the invertebrate community in the Ingol recorded by the Environment Agency is due to nutrient enrichment.

Diverse water plant growth on the upper River Leach facilitated by good water quality.

DIFFUSE POLLUTION

Point source pollution is by far the greatest polluting factor on the Ingol. Nevertheless, if this is ever mitigated, the lower river is likely to be at risk from diffuse pollution due to the proximity of intensive arable agriculture to the river channel. A long term strategy for the river should acknowledge this.

ENVIRONMENTAL FLOWS AND ABSTRACTION

There are 4 licenced abstractions from the River Ingol, and the Environment Agency have undertaken an analysis to determine the impact. It appears that the river can support this level of abstraction, and perhaps slightly more, in a sustainable way which does not impact upon river wildlife.

RIVER STRUCTURE

Above the A149 road bridge, the river has some sinuosity and approximates its natural flow path. Below the road, the river is straightened, cut deep below ground level and embanked in several places. A lack of meandering channel, and few trees to provide woody debris means that there is very little habitat variation, and no chance of natural recovery.

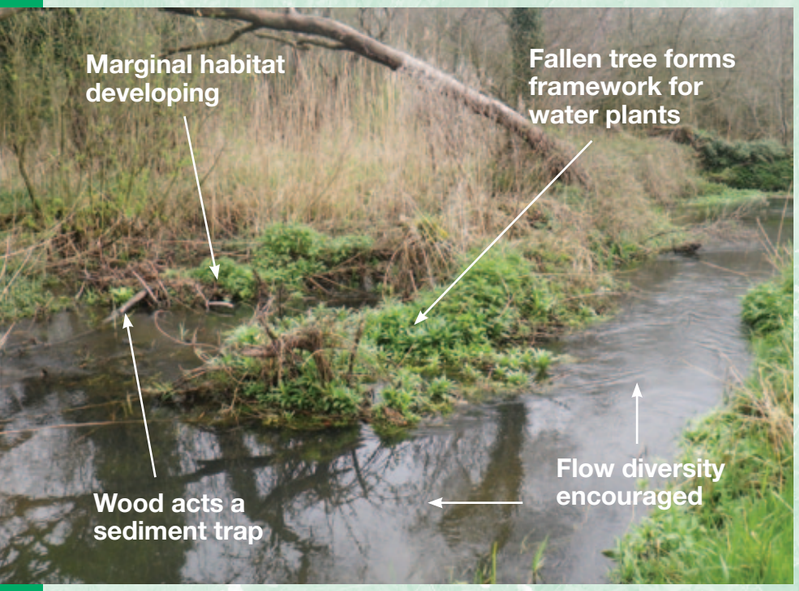
TREES AND WOODY HABITAT

Over the past two decades the importance of trees bordering rivers has become increasingly apparent. Recent research has highlighted the threat that climate change poses to aquatic ecosystems through changing water temperatures. As water warms the oxygen levels decrease in water and this can cause death of aquatic organisms. Small streams such as the Ingol are especially vulnerable. The recent Environment Agency project "Keeping Rivers Cool" highlights the importance preventing dangerous temperature increases in the water by shading.

Trees also intercept and modulate agricultural nutrients and sediment. They can increase infiltration, thus reducing flooding.

Trees are vital as "architects" of river structure. Live trees act as hard points, stabilizing banks and helping meanders to develop. Tree roots in banks provide vital habitats for a multitude of species, notably native crayfish, otters and eels. Dead trees in the river are equally important. They are a key habitat. Moreover, large dead wood (especially entire trees) initiate the natural recovery of rivers from straightening and cause flow diversity. In fact, tree planting and addition of large woody material are the most cost effective and among the most beneficial measures which Norfolk Rivers Trust undertake.

The Ingol is desperate need of more trees and woody debris in the lower sections to accrue all the benefits described above. However, due to the unnatural state of the lower river channel (which is perched above the surrounding landscape in places) such measures will need to be considered carefully.



Natural tree fall has several benefits for habitat creation, channel structure and sediment modulation.

Growing trees have changed this former straightened drainage channel into a river with a more natural structure and in-stream islands (*anastonising* channel).

Tree acts as a hard point and has caused a meander to develop.

Tree acts as a hard point and has caused the development of a pool. Submerged tree roots are also excellent habitat for brown trout.

Natural tree fall has caused a great range of microhabitats and greatly increased in-stream surface area for a diversity of river invertebrates.

SNETTISHAM WOODY HABITAT PROJECT

Easy, fast, and beneficial to fish, insects and birds!

In this pilot project Norfolk Rivers Trust worked in partnership with the Environment Agency and were helped by volunteers to enhance the habitat of the Ingol at Snettisham. The first stage of this project was undertaken in June 2014, and we have gained permission from the Environment Agency to continue this project in the Autumn.

There were 2 objectives of this project. The first was to enhance the wildlife value for groups such as fish, aquatic birds and insects. A family of ducks has already been seen sheltering in the extra cover! Dace spawning relies on this stretch of the river and will also be enhanced by this project. The second aspect of the project was to use alder faggots (as seen below) to protect banks which were eroding due to unnatural causes (variously unnaturally high flows and water plant removal from banks).

Construction of alder faggots

Before project – eroding banks

After project – protected banks, flow variation produced which will lead to increased marginal habitat

As seen in the Woody Habitat section, great benefits accrue from woody habitat. Perhaps the greatest of these is that woody habitat can trigger the re-stating of natural river recovery processes which were very much needed in this straightened section of river which had no pools and little flow variation previously to the project.

Before project

After project - "hinging" of live trees is a good way to ensure stability over time.

INVASIVE SPECIES

No invasive species were noted as part of a Norfolk Wildlife Trust survey of the river which involved a botanical survey. Some Himalayan balsam was reported to Norfolk Rivers Trust by residents in Snettisham and was destroyed with the help of volunteers in June 2014. No invasive crayfish have been reported in the river. However, giant hogweed have been found in the adjacent Heacham catchment. Norfolk Rivers Trust always appreciate it when people can report the presence of invasive species, and can often mobilise volunteer groups or relevant authorities to deal with the problem. Moreover, the link below can be used to report invasive species from your smart phone and trigger the local authority into action:
http://www.rinse-europe.eu/smartphone-apps

Giant hogweed

Photograph: © Olaf Booy

Photograph: © Mike Sutton-Croft

Himalayan Balsam (Impatiens glandulifera).

ECOSYSTEM

The river corridor in the upper sections of the river Ingol contains varied wetland vegetation and a mosaic of trees and meadows (Photo 19). Whilst a survey by the Norfolk Wildlife Trust did not find any plant species of great rarity, the structure that this variation produces is very valuable because it represents habitat for species which thrive in riparian environments such as grey wagtails, water voles and kingfishers. However, natural recovery processes in the lower river will be impaired by poor water quality, little riparian vegetation and degraded river structure.

The fish community is restricted to the lower sections of the Ingol with the exception of eels. It is thought that water quality problems in the past have destroyed the fish community in the upper river, and impoundments have prevented them from recolonizing the headwaters. This is very unfortunate because the headwaters of the Ingol provide the best habitat. Similarly to the fish, the aquatic invertebrate community is classified as "poor". As aforementioned, the poor water quality in the lower stream is likely to be responsible for this, and the homogenous sandy substrate may also contribute to the lack of diversity.

Below the A149 road bridge, the riparian vegetative corridor is generally of very low ecological quality. However, the Norfolk Wildlife Trust report shows that the semi-improved grassland towards the RSPB reserve on the West side of the river towards the sea wall has some botanical value.

In general terms the Ingol's ecosystem has patches of good quality which have the potential to make the Ingol a productive and diverse system with high conservation value. However, poor water quality, degraded habitat in the lower reaches, and a lack of hydrological connectivity prevent natural recovery processes from restoring the river.

Photo 19. Wetland vegetation and lightly grazed meadows provide varied habitat for a variety of species in the river corridor of the Ingol.

SECTION 3 AN ACTION PLAN

Despite attractive sections of the river, what we know of the River Ingol's aquatic and riparian ecosystem indicates that is it in a poor state. Nevertheless, there is scope for the Ingol to be a river which flows through a corridor of diverse vegetation, supporting a community of dynamically interacting wildlife. The in-stream habitat and water quality of the upper sections could become high quality with a good density of submerged vegetation and woody debris sheltering diverse assemblages of invertebrates and modest populations of fish. In an ecologically ideal situation, the lower section of the river could be restored from a straight-sided ditch to a meandering, tree-lined channel supporting varied wildlife and a high-value migratory fish population. If this ambitious solution to the lower river is not desirable to stakeholders, then mitigation of some aspects of the channel's worst features could greatly improve the habitat.

SECTION 1 – SOURCE AT SHERNBORNE TO INGOLDISTHORPE (ST THOMAS' LANE)

This section of stream has potential to support a high quality aquatic and riparian ecosystem. Landowners are commended on their sensitive approach to the river, which has given the river generous buffering strips of vegetation and has allowed a natural stream structure to develop. Measures to mitigate the damage caused by effluent from the Sewage Treatment Works would confer great benefits on the downstream sections of the river.

SECTION 2 – INGOLDISTHORPE (ST THOMAS' LANE) TO A149

This section would benefit from "light touch" addition of woody habitat into the channel in appropriate places to improve habitat. The variation in velocity which would result from channel constriction could help to scour gravels making places where gravel-spawning fish such as dace and trout could breed. Fish passage past the Snettisham Mill would allow the re-colonisation of over 3km of high-quality stream which currently has no fish population.

Norfolk River's Trust do not usually advocate stocking of fish populations due to the potential for transport of disease and risk of genetic outbreeding depression which this can lead to. Nevertheless, an interim measure might be to introduce fish from local populations to the upper river. For instance, introduction of trout caught in the River Heacham or Babingley, and appropriate course fish from the lower Ingol could be considered.

SECTION 3 – A149 TO SOURCE TO TIDAL SLUICE

As aforementioned, there are two restoration options for the lower part of the Ingol.

The first option, and that which seems preferable, is to modify the existing channel by taking back the flood banks either side of the river. This would allow greater channel sinuosity and the production of greater lower-lying marginal habitat by the river's edge. Within this enlarged river corridor, a two-stage channel and some shallow wetland habitats and reeds would encourage species such as wading birds. Tree planting to provide shade and woody habitat would certainly also be beneficial. If retreat of flood banks is not possible, then some increase in habitat variation could still be achieved by the "dig and dump" technique, thus producing some pool-riffle sequences. The danger of such an approach in isolation is that without fundamentally changing the straightened nature of the channel, geomorphic process are likely to reverse any work attempted. Pools would be likely to silt up over time, and the already over-widened channel would probably accrete sediment. Therefore any plan should emulate natural processes. It should be noted that adaptations to the existing channel would be restricted by the perched channel and the low-level pipes which drain water underneath the river (see Figure 2). Nevertheless, careful planning could lead to a dramatic improvements.

Another solution which might work with natural processes to reduce maintenance and enhance the ecosystem would be a reconnection to the historic channel which is shown in Photo 21. This could clearly have implications for stakeholders and would need to be discussed in detail to determine whether it was acceptable. The historic channel is largely still existing as can be seen in Figures 1 and 2. However, there is a risk that the historic channel would be more exposed to diffuse agricultural pollution because, unlike the perched current channel which flows above the landscape like an aqueduct, the historic channel drains the surrounding farmland. Moreover, the historic channel has very little gradient and was formed under estuarine conditions which are quite different to how the river currently functions due to the one-way sluice at the bottom of the river.

If properly executed, the result of either scheme could be a dramatic increase in the productivity of the river's fishery and conservation value.

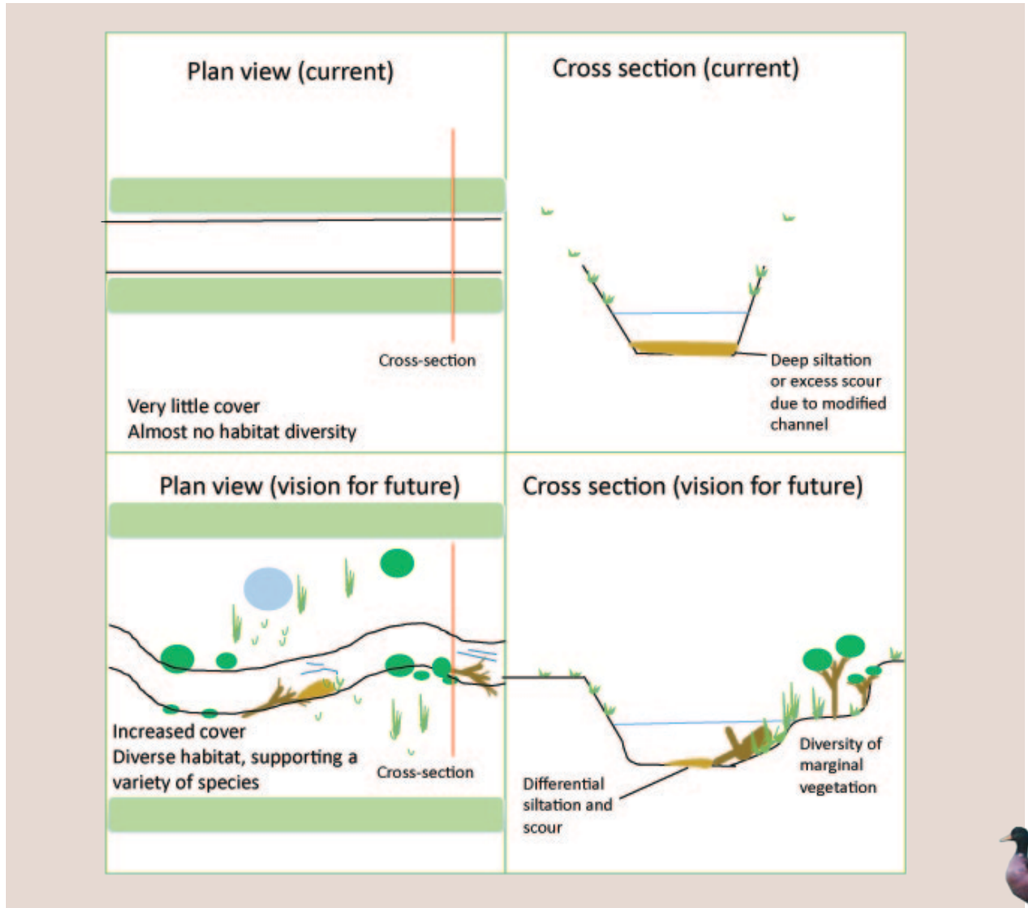


Photo 21. Sections of historic course of the Ingol with riparian trees, vegetation and river channel still in-tact.

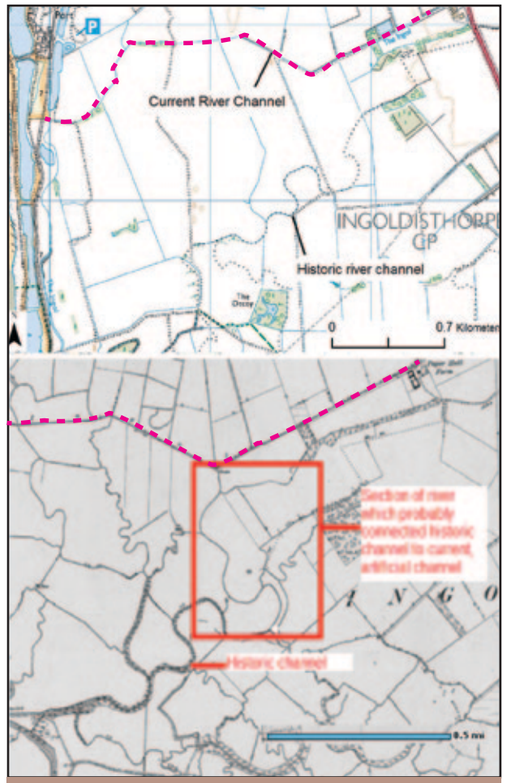
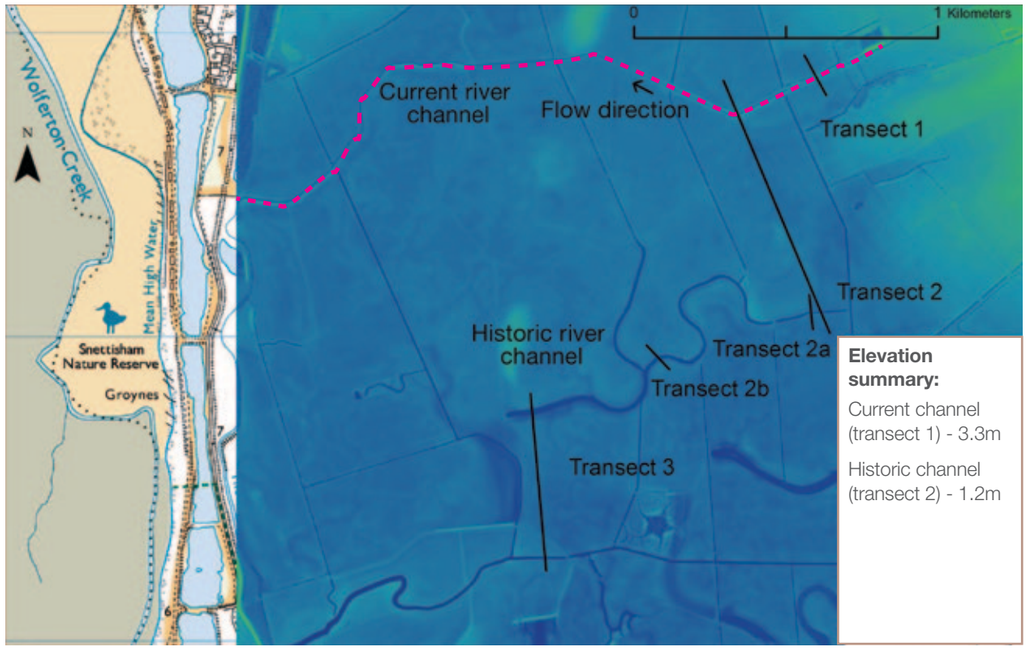


Figure 1. Images showing position of probable position of contemporary course of river is straightened channel. Historic course of the Ingol (from the first series of OS maps which were produced in the late 19th century; image courtesy of Norfolk County Council http://www.historic-maps.norfolk.gov.uk/mapexplorer/).



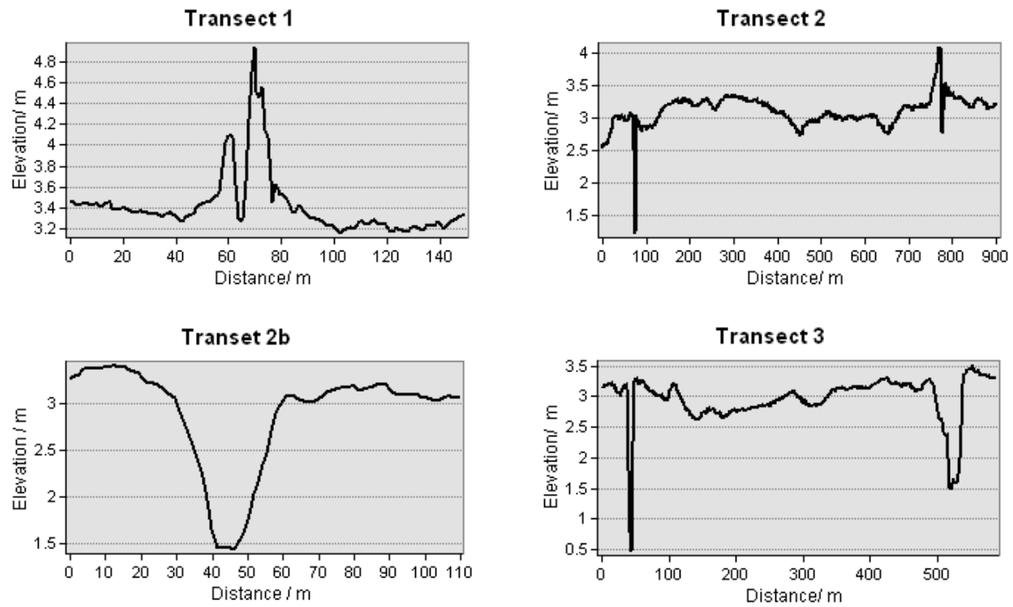


Figure 2. Elevation analysis of current and historic channel of lower Ingol. Green shows higher ground and darker blue shows progressively lower areas. Transects are taken from left to right looking downstream as is standard practice. In summary, the historic channel has a lower channel bed, less steep banks and has a greater capacity to carry water. In its upstream reaches, the current channel is actually perched high in the landscape and kept from flooding by earth banks as shown in Transect 1. Lower level drains pass underneath the river, so it acts almost like to an aqueduct. Much of the historic channel is much wider and lower as shown in Transect 2b. This means that its capacity to carry unusually high flows would be greater. With reference to water quality, it should be noted that the historic channel probably receives more agricultural diffuse pollution than the current channel because the perched current channel does not drain much of the surrounding farmland.

COSTS AND TIMELINE

The Water Framework Directive objective for the Ingol is to reach Good Ecological Potential by 2027, and each of the actions set out in this report will assist in achieving that goal.

The river is approximately 10.3 km long with good quality and naturally recovering habitat in the 4.5 km of the river upstream of the A149 road bridge. Below this point the remaining 5.8 km of the river represents very degraded habitat which will not naturally recover to good status in the foreseeable future. Due to the scale of the challenge posed by restoring the river Ingol, future actions will need to be prioritised according to both cost and importance.

Allowing a healthy fish community to thrive in the headwaters is relatively cost effective and is an important step in the context of the Water Framework Directive. Improving water quality in the Ingol and restoring the habitat in the lower section of the river are very important steps, but they are also far more costly.

Overall, the order of priorities for the river are as follows:

1. To improve fish passage, or/and transplant appropriate species of fish from the lower river to the higher river. Stocking trout from adjacent rivers could also be considered, if a strain can be obtained with regionally distinctive genetic characteristics.
2. To improve water quality, specifically by phosphate reduction. This could entail wetland construction, phosphate stripping, or piping of Ingoldisthorpe Sewage Treatment Works' effluent to sea.
3. To improve habitat in the lower river. This may be achieved by tree planting and channel morphology work along the existing channel, or by utilising the historic channel.

Measures to improve fish passage should be investigated as soon as possible. The appropriateness of transplanting fish is being investigated with the relevant authorities. Moreover, some ecological restoration work to improve the very limited habitat which is available to fish in the lower river is ongoing.

Improvements to the water quality of the river would benefit downstream users, allow wildlife to recover and enable Water Framework Directive objectives to be met. This is the responsibility of Anglian Water and is subject to financial decisions taken by the company.

Habitat improvements in the lower river need to be considered strategically due the scale of the task. Significant funding will be required if any worthwhile improvements are to be made.

Action	Number of kilometres / sites	Predicted cost	Achievable timeline	Responsibility / capability
Mill bypass	1	£75,000	2021	Norfolk Rivers Trust (NRT), /Internal Drainage Board (IDB)
Improvements to Mill race and public footpath	0.2 km	£2,000	2015	NRT in partnership with the Environment Agency (EA) and volunteers
Bypass of other significant impoundments	1	Good will agreement	2015	NRT/EA/IDB
Ongoing project to improve fish habitat with woody debris	0.6 km	Phase 1: £3,318 Phase 2: £500	Phase 1 complete	Volunteers with guidance from NRT and EA
Fish transplants	1	£1000	2021	NRT/EA
Phosphate reduction: phosphate stripping at Sewage Treatment Works	1	£ 1,000,000 Thereafter: £500,000 pa	2021	Anglian Water
Phosphate reduction: wetland construction	1	£60,000	2021	Anglian Water / With support from NRT
Phosphate reduction: Piping of effluent to sea	1	To be determined by Anglian Water	2021	Anglian Water
Option 1: Downstream of A149 Road Bridge: Rehabilitate existing channel	Channel morphology work at £100 pounds a metre for 3 km	£330,000	2027	NRT/EA/IDB
Option 1: Downstream of A149 Road Bridge: Rehabilitate existing channel	Tree Planting for 4 km	£ 1,325	2027	NRT/EA/IDB
Downstream of A149 Road Bridge: Wetland mosaic to emulate habitats which have been lost.	3 km	£11,358	2021	NRT/EA/IDB
Option 2: restore historic channel	Channel morphology work at £100 pounds a metre for 3 km	£330,000	2027	NRT/EA/IDB
Option 2: restore historic channel	Tree Planting for 1.8 km	£596	2027	NRT/EA/IDB

* Note: costs include another 10% for monitoring where appropriate and always include VAT.

FURTHER INFORMATION

Environment Agency - Keeping Rivers Cool report
Rivers by Design - rethinking development and river restoration
World Wildlife Fund - Why are chalk streams special?
River Restoration Centre manual of river restoration techniques
Norfolk Wildlife Trust
River Rehabilitation for Eastern England Rivers
Environment Agency homepage
Introduction to the Water Framework Directive

THE RIVER INGOL A WATER FRAMEWORK DIRECTIVE LOCAL CATCHMENT PLAN

www.norfolkriverstrust.org

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