A Cinderella River

The River Glaven Conservation Group (RGCG) in river habitat improvement 2006.

Introduction

The River Glaven is a small chalkstream in north Norfolk. The headwaters are at Lower Bodham and Baconsthorpe. The river flows for some 17km, first in a south-westerly direction, then turning to the north before finally entering the sea at the tidal sluice at Cley. The gradient is steep for a lowland river. Historically there were 11 water mills on the Glaven. Today 5 mill structures remain and that at Letheringsett is still in operation. The RGCG undertook a river restoration project upstream of Letheringsett Ford, between TG 060383 and TG 057376. Most of the practical work took place in October 2006, but there was a spread of tasks through September to November.

The project had a long gestation period. The concept of what we wanted to develop followed an Wild Trout Trust advisory visit by Simon Johnson in September 2003. The finance required to make it happen was granted in May 2006 through the newly formed Cinderella Chalk Rivers Project (CCRP). The CCRP is a joint project undertaken primarily with the Wild Trout Trust and the Environment Agency. The Wild Trout Trust helped initiate the project and provided technical support, with generous funding through the CCRP, which aims to initiate partnerships to improve the conservation status of lesser known chalk rivers

This report sets out the main steps as the concept, preparation work and the implementation. The concept section includes the characteristics of the river, the proposed improvements, and the thinking behind these. The part on implementation sets out in some detail how the work was done: logistics and materials; construction work for riffles, river narrowing, mid stream islands, large woody debris deflectors and bank spoil removal and protection; project costs and control; and the follow-through.

This was the first major project to be undertaken by the RGCG. A short companion report, which is based on our experience here, highlights key points to consider in the planning and implementation a river restoration project. Other conservation bodies in a similar situation might find that the companion report gives them some additional useful pointers

A TYPICAL SECTION OF THE UPPER RIVER.

The concept

The River Glaven is set in most attractive countryside, and the closer the examination the more we realise how valuable it is as a wildlife habitat and the range of species dependent on it; including a number of protected or featuring in national and local Biodiversity Action Plans.

Nevertheless for a variety of reasons the river as a whole has suffered over past decades through changes in farming and land management practices, and policies for flood risk management; a principal reason for the existence of the RGCG to work with those concerned to make changes which are beneficial to the river and the wider catchment.

Even within the relatively short stretch of river concerning this project, there are considerable differences in the river landscape and wildlife habitat. There are broadly four reaches along "our" stretch.

The upper reach is thickly wooded on both sides, with mature alder and some fine ash, with a fair amount of ivy on many trees. The river here is on a steep gradient and fast flowing, and retains natural bank formations. There are variations in the river course, with bends and deep pools, and areas where it races over the gravel bed. These characteristics make it good for brown trout, invertebrates in the river, and for the wildlife chain as a whole. The trees add some leaves and light woody debris to the river, which add to the value by nurturing insect life. We planned to do no work here other than in a short section where we would clear a few sycamore trees which would permit sunlight on the river beside footbridge 2; the rest of this reach would remain heavily shaded.

The upper-middle reach is similar in most respects but almost all the trees are confined to the west bank. Again this is a "good" stretch of river for trout, a marker species for much wildlife; and

WATER CROWFOOT GROWING ON A SHALLOW GRAVEL RIFFLE.

FORD CROSSING OF THE RIVER.

with the additional light the appearance of water crowsfoot in the river bed. It is also a part of the river frequented by the kingfisher.

It suffers however from the 70s and 80s legacy of dredging of the river with a subsequent lowering of the river bed; and a resulting high bank of spoil on the open side facing a meadow, and where there are just two trees. Thus the natural progression of the degree of wetness between the river and meadow, and the characteristic species of plants and insects which depend on this, is lost to a high and dry spoil bank.

We have been keen to select a place such as this where the spoil bank could be removed and the natural regeneration that follows could be studied by the RGCG. The Environment Agency was supportive in principle for another reason. They favour, where appropriate, the re-connection of river and natural flood plain. In severe rain events flood water may be "held-up" in areas where there are no houses which could be affected. So spoil bank removal, and the formation of a more natural profile, was introduced into our programme. Our plan for this would involve the removal of hundreds of tonnes of spoil off-site, and recovery of the gravel and flint in the spoil, and disposal of the separated soil on arable land.

The lower-middle reach of the river runs diagonally across the meadow, with high spoil banks on each side and no trees. The gradient of the river remains quite steep, so that the flow is fast over a generally good gravel bed. It is however rather uniform in nature, and the plan is to introduce some flow deflector measures, to be created by "large woody debris"; a good "natural" example, a tree which had fallen across, was shown in the article "Let Sleeping Logs Lie" in our April 2006 Newsletter.

The lower reach of the stretch runs from footbridge 1 down to the Ford. Here the river profile has flattened. The flow is slower, and a sand silt deposit over the gravel dominates. The flow is also slowed by the river being too wide in places. The emphasis here is to carry out some narrowing in places, and also to introduce some gravel riffles. The riffles are beneficial to trout and invertebrates as noted above; and we would hope that they extend the amount of habitat available to four species all recorded in the vicinity of the Ford; bullhead, stone loach, brook lamprey and white-clawed crayfish.

So while the stretch of river has a great deal to offer in terms of its wildlife, the RGCG project aims to make improvements to the river habitat

as a whole, and to the micro-habitats so important to the wide range of wildlife that the river supports.

We looked to close some circles in how we would implement the works. The felled sycamore trees would supply the trunk sections required for the large woody debris. But also we estimated a need for some 120 faggots for river narrowing works, and some 200 wood stakes; a portion of this would come from these trees, and the remainder from hazel and alder growing close by.

The plan for the spoil from the river bank was to sieve off-site on an arable field nearby, using a grading machine to give two "cuts" of stone material. These were to be a spawn gravel in the size range 10-50mm, and larger stone, to be used in the construction of the riffles. The recovered soil will be spread over arable land.

Finally we would have the potential for flood risk reduction in the removal of the spoil bank as well as the conservation (and landscape) benefits where we make a re-connection between river and flood plain.

COPPICING UNDERTAKEN TO REDUCE SHADING OF THE CHANNEL.

The funding and preparation work

The RGCG received in March 2006 a grant of £1,500 from the Cinderella Project, administered by the Wild Trout Trust and the Environment Agency. This is a national initiative, and aims to promote improvements to the less well known chalk streams in England. We planned to use this grant to obtain the services of a consultant to "work up" our concept proposals in the detail of what would be done, and how it should be done, to comply with the licence consent required from the Environment Agency.

In May we heard that the Biodiversity team of the Anglian Region of the Agency was prepared to fund the proposed works to the tune of £7,000, plus a further £1,500 to carry out a Demonstration Day on behalf of the Cinderella Project. The money was for this financial year only. We were on a very tight time schedule from the start, as will be seen below, but the RGCG very much welcomed the opportunity to take the project forward.

Within the RGCG we had discussed and refined the concepts for what we wanted to do over many months previously, but we were very much aware the implementation is as important as the ideas in making a successful project.

First was the need to obtain a licence of consent to carry out the works from the Environment Agency engineering development control. In our case this was for a complex and interacting series

of measures. The Agency considerations are, as they must be, thorough and detailed and involve a number of staff in various disciplines. The time it would take to prepare the necessary documentation and hopefully receive approval was going to be absolutely crucial to the timing of the programme.

We were fortunate in having Vaughan Lewis, a nationally respected consultant, to see us through this process. He visited the site for an initial familiarisation. Also for the pre-application site visit, when RGCG members discussed our proposals with the Agency, who fielded the Norfolk Development Control Engineer, and colleagues in flood protection and conservation.

This visit took place on the 13th July 2006, and was invaluable in helping an interactive discussion on the general principles and approaches to be taken. Following this the extensive documentation was prepared and submitted to the Agency by the end of July. The Agency worked to see approval by mid-September. This involved, under the rather special circumstances, giving a high priority to the application. No work affecting the river could take place before the approval of the licence.

In progressing the actual work we faced a variety of constraints and some logistical considerations; plus working within the money available. The natural constraints include conservation issues. We had to ensure that in doing what we planned we would not have an inadvertent adverse impact on wildlife. In particular this included a very detailed survey of water vole sites, and looking for the presence of the otter. This was carried out by committee member Steve Henson of the Norfolk Wildlife Trust (NWT) in June, and the report formed part of the licence application. In addition a survey of vascular plants on the spoil bank to be removed, to make sure that there were no significant plants that might have to be moved.

One important reason to complete the bulk of the work quickly was that water voles tend to hold to their burrows from November for the winter, and trout start to spawn. But the nature of the terrain was another pressing reason to start the work by mid-September and finish by end October, certainly all the “heavy” work. The meadows are peaty, wet and soft. Heavy plant can cause “cut-up” even without vehicles getting stuck and literally becoming “bogged down”.

RED AND WHITE TAPE MARKING THE LOCATION OF WATER VOLE BURROWS.

FELLED TIMBER READY FOR INTRODUCTION INTO THE RIVER.

With the long time farmer we discussed how best this could be avoided, and also how to cross the side stream to get off the meadows in removing spoil from the bank of the river at the upper middle reach. The chosen route was for the heavy plant to travel close to the raised spoil banks on the east side of the river. This in turn dictated the felling and removal of the sycamore trees as the first piece of work; to be followed next by the removal of the selected section of spoil river bank, working from the upstream part to the downstream end. We wanted the timber for large woody debris and other work, and a key aim was to reclaim gravel and stone form the spoil.

The offer by the flood protection wing of the Agency to take out the designated spoil bank section would clearly be a huge help to the project on time-scale and project costs. It would involve a caterpillar tracked digger, with two 2.5 tonne tracked dumpers working alongside, to take the spoil away and place in heaps along the arable field adjacent to the meadows. It was estimated that there were 700-1,000 tonnes of spoil to be removed and 5 working days would be required.

The bank removal was scheduled to take a week in the second half of September. As soon as this was done, the off-site riddling operation was to be completed for the w/c 2nd October. Vaughan Lewis was scheduled to return then to supervise and work with RGCG volunteers to carry out the implementation of much of the in-river work in a three day work spell, with another 2 days pencilled in a week later. The same volunteers would carry out some preparation work in the second half of September, namely the making of the faggot bundles and stakes. There were other important tasks to be done then, in particular a survey and the “flagging up” of the water vole sites that we need to work around, as mentioned above. The felling and trimming of six sycamore trees, not a part of the licence application, took place in August. In early September we posted notices around the site to inform the public that the work was about to take place, which enabled local people to ask for more information. Our September Newsletter set out the work aims and plan for members and others.

The main programme of works was planned for completion by the end of October, but we realised that will not be the end of the story. We would need to follow through by monitoring to see how the measures bed down, and observe the broad changes in the river and wildlife over time. The whole project would be a steep learning curve experience for the RGCG, which we felt would undoubtedly benefit future projects that we expect to undertake.

Implementation of the work

1. Summary of main works

The main works carried out in the river were the introduction of:

- 6 riffle areas, two of which were combined with a cattle crossing/drinking of total length about 64 metres
- two lengths of river narrowing, lengths 10 metres and 13 metres
- the creation of 3 mid-stream islands
- 9 lengths of tree trunk as large woody debris (LWD) at a spread of points.

Work proceeded from downstream to upstream to take account of any water level changes and interactions between the various measures.

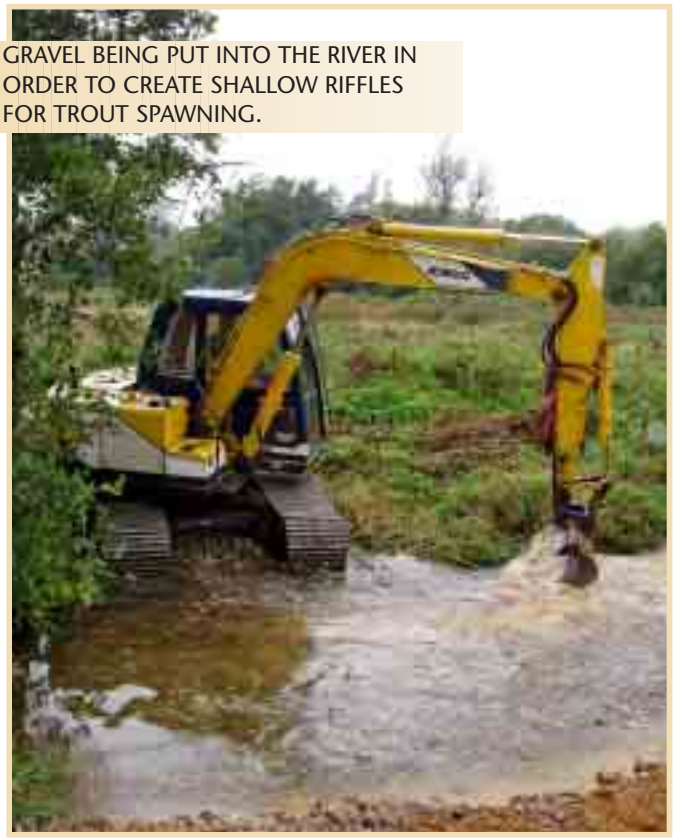
The placing of the stone and gravel in the river to form the riffles, and the setting of the LWD, were the most intensive parts of the works. These required the use of a tracked digger and a 3.5t dumper truck, with our consultant Vaughan Lewis directing the operations and driving the dumper. This work was carried out on the 5th October, and on the 11th and 12th October; but with subsequent much hand labour to form the upper cattle crossing/riffle, and re-instate the cattle crossing across the side channel.

Vaughan was also with us on the 3rd and 4th October. The work carried out then was the bank narrowing and island creation work, working with hazel materials. This used no heavy machinery but was labour intensive.

Running parallel to the in-river work, the spoil was removed along the bank length of some 120 metres of the upper middle reach meadow. This was a separate exercise carried out by Environment Agency staff and machinery working with their tracked digger feeding two 2.5t tracked dumper trucks. Some 700-1,000 tonnes of spoil were taken off-site to an adjacent arable field. This took 7 working days to move in the period from the 6th to the 16th October.

2. Logistics and materials

The meadow terrain can withstand heavy plant operating on the strip between the east side of the river and side channel and the hedge running between the meadow and the farm track (see map 2) in reasonably dry weather conditions. When operating to the west side of the side channel, heavy plant has to move material close to the river bank, which through the deposition of dredged material over the years is higher and dryer that the meadows as a whole.



GRAVEL BEING PUT INTO THE RIVER IN ORDER TO CREATE SHALLOW RIFFLES FOR TROUT SPAWNING.

We were fortunate that there was little rain in the first three weeks of October and ground conditions were drier that they could have been. However after one mid-afternoon shower on the 10th October the approaches to the side channel started to churn up very quickly with the continuous passage of the two spoil removal tracked dumpers. Work was stopped to put in a temporary bridge of sleepers the next morning. Up until then the dumpers had crossed through the side channel, whose bed had been protected by putting down some 8t of large flint, destined for later use further upstream as part of that needed for the cattle crossing 3/riffle work.

A gap in the hedge, an old entry point, gave a direct access to a corner of the arable field with hard standing, next to the farm track. This route was used by the tracked dumpers to get the spoil to the arable field with minimum distance on the meadow. This made for both quicker dumper turnaround time and less wear on the meadows. The hard standing area was the delivery area for 20t loads of stone and gravel coming from a local quarry.

Sampling at two of the highest areas of spoil had indicated that there was sufficient stone and gravel present to make it worthwhile to carry out a machine riddling (grading) operation off-site at the arable field work station. However once the top six inches of nettle cover and soil was removed across much of the area it was clear that the yield would be small and this approach was abandoned.

However some 10t of larger stone was recovered by hand from the spoil, either at the river bank area, or where it was heaped and then later spread over the field. A local Cemex (RMC) quarry, less than 3 miles away, supplied 60t of reject flint; and 40t of 20-40mm gravel, all that was used. This was obtained at a favourable price through the NWT. Another 40t of reject flint came from a small disused pit on the Bayfield estate, also a journey of 2-3 miles, and no charge was made for this material; and another 5t came from a stock adjacent to the site.

So in all we used some 115t of reject flint and 40t of gravel over six areas on the main river, 4 riffles and two cattle crossings serving a dual purpose also a riffle. The total length of these was some 62 metres. The plan had been to make more and longer riffle areas and use some 300t of reject flint and 100t of gravel but when costed out it was clear that we would exceed budget if we bought in more reject flint and gravel.

The other material requiring heavy plant to move about, a tracked digger with lifting chains, was sections of tree trunk of 5-6 yards in length and

LARGE STONE BEING INTRODUCED INTO THE CHANNEL.

between 1 and 2 feet in diameter. These were used as flow deflectors and one end set in the bank with an up-stream angle of about 30*. Eight sections were required, and all were drawn from the 6 sycamores that had been felled in the preparation stage.

The main wood material used was hazel, and in the plan was to be designated for bank narrowing, with a smaller amount for the island work. As part of the preparations leading up to the work in the second half of September 120 hazel faggots were made from material cut from trees on the Bayfield estate. The bundles were some 7 feet long and 1 foot in diameter.

It was estimated that we would need some 200 stout stakes for river narrowing. Chestnut was not available so we bought 200 hazel, which in fact were a mix (in decreasing thickness) of stakes, and baton and peg material. We also purchased 30 long round posts with pointed ends, mainly to secure the tree trunk sections. In terms of our budget these materials were costly to buy as opposed to having access to hazel at no charge and cutting and producing with voluntary labour.

Once much of the spoil was removed from the bank of the upper middle reach meadow it was clear that the re-profiled bank would have to be protected against higher river flows and any major flood event. The bank would be vulnerable to breaking off until such time the whole area has time to develop vegetation and bind the bank soil. This could have been foreseen, but not to the extent of the overall requirement. This was because the river at this point was revealed as far more sinuous, and with some sharp bends, than could be appreciated with the spoil bank in place.

This 122 yard length of meadow frontage, increased to some 130 yards by the winding course of the river, was protected by the same revetment technique as used for river narrowing, but the outer line of stakes were set much closer to the bank. It required 97 stakes, and the same number each for bank side pegs and the batons to be set at a diagonal to stakes and peg. The river "facing" to the revetment required about 70 hazel

HAZEL FAGGOTS READY FOR USE.

faggots; about 20 remained from the Bayfield 120, leaving another 50 to be made up.

These 50 faggots, the stakes, batons and pegs, and the soft filling brash, were obtained by coppicing 10 hazel trees on the lower part of meadows. The temporary bridge across the side channel proved its worth again as it enabled the movement of the bulky material to be done with a Land Rover and trailer. There was zero wastage of material in this exercise.

Seven of the hazel trees were 13 years old, grown from saplings, and this was the first coppicing. The other three were mature trees. The river is shallower here than downstream, and the stakes were around some 4-5 feet in length and 2-3" in diameter, the batons and pegs about 2" in thickness.

3. Construction work

Riffles

Reject flint from Cemex stacked at the hard surface area was loaded by a digger into a 3t dumper which ferried to the various areas of river bank where it was to be used, and similarly for the gravel. The stone was placed by digger in the river bed to a depth to around 75% of the final level of stone and gravel required. The lengths of the riffles were a compromise between the ideal (15 metres or more) and what could be contained within the project costs, and the material spread by the digger bucket. The stone was followed by the upper layer of 20-40mm gravel, a compromise between what was best for spawning brown trout and the habitat for the white-clawed crayfish. The weight ratio of stone to gravel was around 3 to 1, but varied with water depth.

The first and last (sixth) riffles were formed to serve as both a riffle and a cattle crossing. The other four riffles were set so as leave a narrow and deep run along the side of the far bank for the benefit of larger trout. Best estimates of the amounts of stone in gravel in each are shown below.

The deeper the river section, the more reject flint required.

The licence plan submitted to the Environment Agency was for up to 10 small riffles (including the two with dual function as cattle crossings/drinks) from the screened gravel, with a length of riffle at 15m or more in length. The riffle would increase the retained head by 15-30 cm. The depth of gravel in each riffle should exceed 50cm for the benefit of macro invertebrate. For the optimisation for brown trout to spawn the water depth should be between 25cm and 60cm; and water velocity between 25cm/sec and 75cm/sec.

There is an option over time to extend the length of the riffles by hand labour should more stone and gravel material become available and experience indicated this would be beneficial. In fact, cattle crossing 3 was done by hand, after the other riffles were done by heavy plant work. Local sourced reject flint was barrowed in and the gravel gleaned by rake and shovel from the digger spill on the bank side of the other riffles.

The need to build a bridge over the side channel at cattle crossing 2 required that the stone that had been placed there was supplemented by spoil to give a firm base on which to place the sleepers. The crossing here was about a yard wide with a bed of small stone and gravel bed in shallow water. After the bridge was removed, the digger then cleared the stream, and levelled the stone and spoil over the approaches. This was followed by 4 days of digging by hand to recover the large stone that had been placed there and the material that had formed the channel bed. With some

	Length	Gravel	Total
CC1/Riffle 1	8m	17t	22t
Riffle2	13m	24t	31t
Riffle3	15m	27t	35t
Riffle4	10m	18t	27t
Riffle5	12m	21t	31t
CC3/Riffle6	4m	8t	9t
Total	62m	115t	155t

additional replenishment the bed of the stream was enhanced and extended on completion of this work, with a length of small stone and gravel extended from 3 yards to 10 yards.

River narrowing

The licence agreement was for the extension of the present bank into the channel to be no more than 1.5m at any point, and the total length of river narrowing over the whole stretch of the river would not exceed 50m. Faggot bundles would be woven between the stakes, driven to a depth of 600mm into the river bed. The area created between the new and original bank lines will be "soft-filled" with woody brash in order to promote the accumulation of fine sediment. The structure would be keyed into the bank to reduce the risk of erosion.

Two sections of river narrowing revetment were built. One was 10m long, in line with 2 willow trees facing on the opposite bank. The revetment required 15 stakes set in an arc from either bank end to a maximum width of 1m at the central point The stakes were "faced" with hazel faggots pushed down over the stakes, and back filled with faggots and brash, the latter mainly hazel but containing some willow coppiced from one of the trees opposite. The filling was held in place by battens fixed (wire nails) to the stakes and pegs set in the bank.

The second length of river narrowing took place over 13m of bank and took 18 stakes. Again the maximum (mid-point) of extending into the river was 1m. At the mid-way point on the opposite bank was a mature alder. In both cases the river was about 3m wide, representing a narrowing when the revetment consolidates as mature bank of about one third. Within two or three weeks of building (5th October) it was clear that silt and leafy debris was being accumulated.

Map 2 shows the position of the two constructions. The plan for a third stretch of river narrowing just upstream from the ford was abandoned as the river bed proved to be just too hard to drive in the stakes, even though a two-handled heavy metal post "thumper" (drivall) was being used for this task.

In general the river bed was found to be very hard, making if difficult to drive stakes in to 18" or more. An old heavy metal fencing post, rectangular in cross section and with a pointed dagger end, was found to be very useful in penetrating the bed and loosening up to make way for a stake.

DRIVING STAKES INTO THE BED OF THE RIVER AND WEAVING HAZEL RODS IN ORDER TO CONSTRUCT MID-STREAM ISLANDS.

Mid-stream islands

Three mid-stream islands were constructed near footbridge 1 (see map 2). The method of construction was the same as the river narrowing work, and in time the structures would develop as islands with vegetation. The top level of the islands were planned to be 150-200mm above water level.

Following the construction of the two upstream islands they were surrounded with flint reject topped with gravel as part of riffle 3. The braided flow over the riffle provides a juvenile trout habitat within the spawning area created. The backwater effect also improves access for spawning fish to the side channel which enters the river immediately upstream from the islands.

Each of the islands formed a point at the upstream end, but set at a slight angle to the river flow. They were 2-3m long and some half metre wide. Each was built around a frame of 7 stakes driven into the river bed. The third island was in a metre of water, and as noted above the other two had been set where riffle 3 was to be placed. The islands quickly collected silt, leaves and much water cress.

COMPLETED MID-STREAM ISLAND.

Large Woody Debris deflectors

Sections of tree trunk were placed in 9 different parts of the river, all in or close to the lower middle reach. The purpose of these is to promote the scouring of the river bed in relatively homogeneous areas, and create high physical diversity within the channel. Past practice of removing all naturally occurring woody debris has an adverse impact on juvenile and adult trout. LWD create simple flow deflectors and provide deeper pools used by adult fish, and smaller pools and shelter areas also. The tree section is orientated to reduce bank erosion and secured by staking and wiring. All sections point upstream.

All nine sections of tree trunk were secured by setting the “downstream” end into the bank to a depth of 2 to 3 feet. The exposed in-river lengths for six of the nine ranged between 1.5 and 2.5m, at an upstream angle of about 55* to the bank. Six were set on the river bed and submerged by the flow. Three were set across riffles 4 and 5 and broke the surface of the water. One of the trunk sections (LWD 7, 3m) was set in a diagonal from

STAKED AND WIRED LARGE WOODY DEBRIS GROYNE.

bank to bank, all the rest fell short of this. Two other 3m sections were set in place upstream of this, LWD 8 at an acute angle to the bank, and LWD 9 at a diagonal and stopping just short of reaching bank to bank.

In addition to anchoring into the bank all sections of LWD were secured by at least two stakes in stream, and the stakes and trunk wired together with fencing wire held by heavy duty staples

GROYNE DURING HIGHER FLOW. NOTE SCOUR PATTERN DOWNSTREAM.

Bank spoil removal:
Upper Middle Reach Meadow

Some 700-1,000 tonnes of spoil were removed along a meadow width about 122m. with a tracked digger and two 2.5t tracked dumper trucks, as described in the Logistics section above. The work revealed the sinuous character of this stretch of river, the frontage of the river bank itself extending to some 130m. The re-profiled bank was taken to about 18" above the water line, and 2metres further back it was stepped up another 9" or so to bring the profile to the level of the meadow as a whole.

HYDRAULIC EXCAVATOR REMOVING OLD FLOOD BANK FROM ALONGSIDE THE GLAVEN.

The spoil had been piled to the highest level close to the river and it fell away gradually to meadow level. When all was cleared it showed that in the main the buried area stretched back some 9-11metres from the river. However where the river swung away in two bends the area of coverage with spoil had extended to 14 metres immediately downstream of tree 2, and similarly to 19 metres at tree 1, the old alder. The restoration of the site not only re-connects the river with the floodplain meadow, but completely transforms the visual impact. One can now see the whole stretch of the river on this meadow, instead of peering down a high bank to see just a few yards to left and right.

The spoil was principally a good rather peaty soil, probably coming from river widening in the past which some bank removal over a much wider area of river frontage. Within this were some areas of sandy soil containing stone and gravel. Presumably this came from dredging of the river bed. It was these spots, where we had cut two of the three sampling sections with a digger, that had lead us to believe that it would be worth riddling the spoil to recover stone and gravel.

EXCAVATED SPOLI DEPOSITED IN AN ADJACENT ARABLE FIELD AWAITING PLOUGHING INTO THE FIELD BY THE FARMER.

The spoil was covered with dense nettle growth, with some other vascular plants present. The vegetation was stripped off to make a separate heap on the arable field, where it would be allowed to rot down. The major part of the spoil removed was heaped on the field and later spread over about 2,500 square metres to a depth of 6"or so. Some 10t of larger stone was recovered by hand at both ends of the operation, the river bank and heaping and then spreading on the arable field. The stone recovered at the river end was used to create two areas of larger stone on the river bed there.

As described above in Logistics and Materials, the 130 yards of bank required protection with a hazel buffer structure to protect the bank from higher and stronger flow levels. Areas of sharp turn would be the most vulnerable. The same technique was used as described under bank narrowing. In addition coir matting was used to give additional protection. The matting came in rolls 2 metres wide and some 30 metres long. This was spread over the top of the revetment and the first level of bank, and additional pegs were fixed to hold the bank edge of the matting in place.

For the final 30 yards the matting was put down first before the hazel revetment work was done. This is not expected to make any difference to the final result as regards how well the bank is stabilised and the regeneration of vegetation, but this will be monitored. The plant species that grow from the bare soil, and the succession stages, will be an important part of the follow through studies on the whole bank of the upper middle reach meadow.

The removal off-site of the spoil to the field was carried out under a waste disposal exemption licence. This necessitated the analysis of soil samples taken from the spoil bank and the arable field for which it was destined. A wide range trace metals and other elements were measured. In all cases there was a lesser amount of trace constituents in the spoil bank material than there was in the arable field. This could reflect a generally "cleaner" environment dating from the 60s or 70's; or more likely the fact that the rivers and meadows have not borne an application of agrichemicals that can compare with arable land over the past decades. It would have taken a third analysis, that of the meadow itself as well as the spoil on it, to be sure on this point.

NEWLY EXCAVATED SHELF.

NEW BANK LINE MARKED WITH DRIVEN STAKES.

BRUSHWOOD FAGGOTS INSTALLED TO PROTECT THE BANK FROM SCOURING.

COIR GEOTEXTILE INSTALLED TO REDUCE EROSION OF EXPOSED SOIL. INSET: ROLL OF COIR GEOTEXTILE.

4. Project costs

The project Cinderella funding was set with £7,000 for the practical implementation of the planned programme. As the RGCG have no significant funds it was imperative to stay within budget. The breakdown of costs incurred are set out below.

In addition to the above budget and costs for the implementation there was a cost of £1,760 for work by the consultant in detailing the measures planned to be done, and for the processing of this into a document for the Environment Agency for the licence approval. In addition to the £1,500 grant for this stage there was another £1,500 for mounting a Cinderella Demonstration Day on the 23rd October; under-spend on the latter meant the total costs were contained within the overall budget of £10,000.

Chargeable item	Units/activity	Cost
Heavy plant, with operator.	Tracked digger, equivalent to 8 days. Includes tree felling 1 day, 0.75 consult.	£2,055
Reject stone, gravel. Cemex (RMC).	Reject flint 60t, gravel 40t; £9.50t + VAT. 50% discount via NWT.	£1,135
Coir matting.	4 rolls of 2m x 33m.	£315
Dumper 3t hire.	£103 for 5th Oct., £145 for 11th/12th.	£250
Reject flint and other transport costs.	5 times 8t deliveries of stone, woody and other materials.	ca£400
Hazel stakes purchase.	200, mixed material, incl. £50 transport.	£200
Long stake posts	Purchase of 30.	£70
Misc. supplies.	Fencing wire, wire nails, staples, etc.	£70
TOTAL		**ca£7,140**

Non-charged item	Units/activity	Cost
Spoil bank removal. Environment Agency	I tracked digger, 2x2.5t tr dumpers; 7 days. (cost includes transport of machines, loos).	£4,500
Spoil disposal	Waste disposal exemption licence, internal EA	£800
Water vole survey	Field survey/report; and otter survey. NWT	£400
Reject flint, 55t.	40t ex Bayfield, 15t local to site; market cost.	£1,230
10 hazel trees site, plus trees from Bayfield.	Pollarding for stakes, faggots and brash. Material value estimate.	?£400
Practical work.	Ca. 50 man days; plus 10 project co-ordinate. £8/hour for 8 hours/day = £64 a day.	£3,840
TOTAL		**ca£11,000**

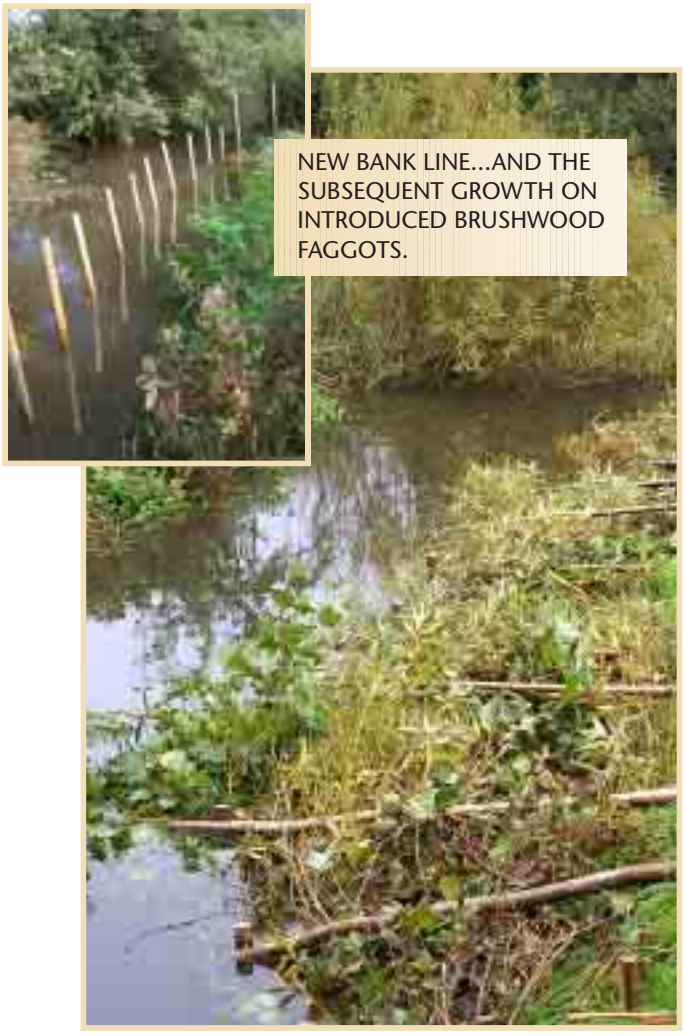
The follow-through

The post-works visit of the Environment Agency will discuss a number of monitoring and management issues as regards the completed works. One will be the placing of water level gauges at locations to be decided, and the measuring regime for these. Some depth measurements were indicated by "flagged" stakes before work started, but it would have been useful to have had a longer and more systematic study beforehand.

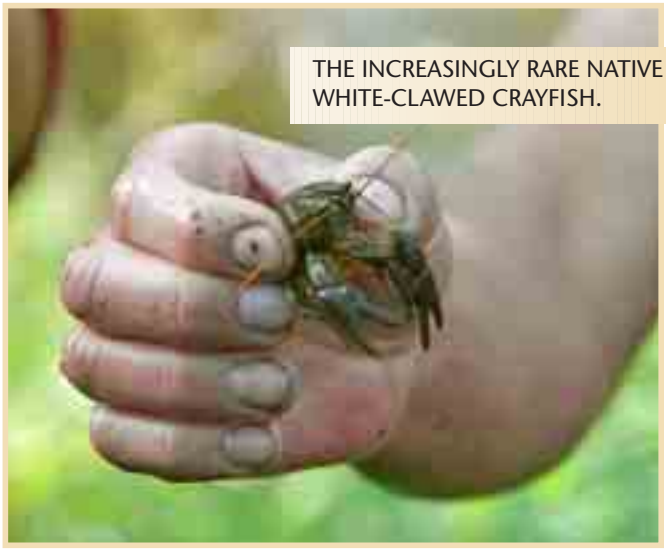
Physical changes will be noted, as will be changes in wildlife. We have as a "baseline" the distribution of water vole burrows and latrines along the whole length of river and the side stream, which was documented in a detailed report before the work started. Similarly the type and distribution of aquatic plants such as water crowsfoot has been examined and recorded.

The biomass of fish has been recorded at intervals in the past by the Agency just upstream of Letheringsett Ford, so this provides another baseline for this section of river. The presence of brown trout above this area will be more qualitative but any change year on year noted.

A specialist survey for the white-clawed crayfish was carried out on the upper and upper middle reaches before any in-river work was started there, and this will also be periodically continued in the future for the section worked on and we hope the river as a whole.



NEW BANK LINE...AND THE SUBSEQUENT GROWTH ON INTRODUCED BRUSHWOOD FAGGOTS.



THE INCREASINGLY RARE NATIVE WHITE-CLAWED CRAYFISH.

A very important exercise will be the monitoring of the upper middle reach meadow where the spoil has been removed from the bank. In particular how the exposed soil regenerates with vegetation, and the succession pattern of the re-colonisation by plants and insects. There may also be some changes or additions to birdlife, such as the presence and possible breeding of grey wagtails.

Finally of course, we study the physical integrity of the work carried out and take any remedial measures should these be necessary. We shall follow the rate of maturation of the protected bank, the development of extended (river narrowing) bank and the islands to permanent vegetation and solidity.

Acknowledgements

The RGCG wishes to acknowledge the help of those who have supported this project. These include the land ownership interests; the Wild Trout Trust and Environment Agency at Peterborough through the Cinderella Project for a grant total of £8,500 for the work. Also the local officers of the Environment Agency for their pre-application site visit and processing our licence application with all speed; and the time and skilled machine work required for the spoil bank removal. We also thank Cemex for the supply of reject flint and gravel at a favourable price; and others who were part of the project team and supplied additional stone and the hazel requirements at no materials cost. The Norfolk Wildlife Trust for the considerable time and expertise through a committee member. Our consultant provided a very necessary technical expertise to the project, combined with his hard work and good humour on site. Finally, a warm thanks to those RGCG members who made a vital contribution in time and effort to the evolution and implementation of the project.

River Glaven Conservation Group,
December 2006.

PARTICIPANTS AT THE OPEN DAY ORGANSIED BY THE RGCG.