limited to 11 m, which involved an embankment of a maximum of 6 m in height. There were also geotechnical benefits in surcharging the foot of the slope; these enabled the embankment side-slopes to be drawn out to 1:10 and rounded out at the foot to blend out smoothly into the existing contours. With the gradient so slack, it was possible to return the slopes back to arable farming and the permanent fence has therefore been erected close into the motorway. The final touch of restoring the field boundaries has been achieved with off-site planting, which also has the advantage, in being placed laterally to the motorway, of helping to block oblique views.

16. At the Oxford Turn-off (Junction 8) intervisibility between the Oxford–London road link road and a parallel local road constructed alongside, has been restricted by the provision of a gentle mound between them, the benefits of which will be accentuated with planting. In order to extend the screening benefits of this mound, a wooden environmental barrier 700 m in length and 5 m above carriageway height has been constructed. Elsewhere within the interchange, areas between the various road elements have been gently shaped and mounded to achieve landforms with a natural appearance; these have also been planted in a way that is complementary to them.

17. Similar principles were applied within the A418 interchange, but in this case, ground sloping also enabled the embankment supporting the adjacent slip road to be blended into it. This makes it seem as if the slip road is running at natural ground level and thereby helps to settle that side of the interchange more comfortably into the landscape.

18. Other earthshaping outside the motorway has been carried out in private arrangements between landowners and the main contractor, some of which have been very successful visually, but in other cases quite the opposite.

19. Details are given in Paper 9950 about efforts to enhance the conservation of the seven flood storage reservoirs. In addition, a separate pond was excavated purely for conservation reasons.

20. When the Secretary of State officially opened the whole of the motorway extension be planted an oak tree in a small plantation south of the Wendlebury Interchange. In the same plantation many more oaks, wild cherry, field maple, blackthorn, dogwood, guelder rose, wild rose and wild service tree were planted. This is typical of the type of planting being carried out on this section and indeed all of the way through to Birmingham. The principle is that species indigenous to the particular locality have been used, both to associate visually with those already in the vicinity and also for their conservation value. At intervals there will be plants of a more eye catching nature to act as milestones. These features, although not literally that distance apart, at some season of the year will provide a pleasant incident for travellers, against which they might consciously or otherwise measure their progress along the motorway.

Conclusion

21. The millions of people who will use the motorway in the future should find it a pleasant route drive along, even if they are not conscious of how this came to be. Above all for those who live in the locality, it should not be too intrusive. It provides an excellent example of how environmental considerations have been sympathetically received and reacted on.

Acknowledgements


M40 Waterstock–Wendlebury: planning, protection and provision for wildlife

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The first of this series of two papers (Paper 9890) described the environmental planning of the M40, in particular the landscape aspects. This Paper considers nature conservation aspects. It describes how the scheme complies with the minimum requirements of species protection also to incorporate measures that further enhance wildlife interest. Such measures were integrated with the engineering and landscape design and include special crossing points for mammals, wetland features and areas for butterflies.

Introduction

The Department of Transport’s Manual of environmental appraisal requires that nature conservation issues are given due consideration within the highway design process. Statutory Instrument No 1341 Highways 2 also requires nature conservation matters to be addressed if the route is within 100 m of a site of special scientific interest (SSSI) or a national nature reserve. As described in the first paper of this series the original environmental assessment for the M40 took place before the advent of such documents. The M40 experience of having a mixed discipline team at the early stage of route optimisation and through the detailed design and construction process, has proved particularly successful for the implementation of the scheme. However, for ecological matters, timing of input is crucial. The description which follows concentrates on the design and implementation of nature conservation aspects for the Waterstock–Wendlebury section of the M40.

The countryside beside Waterstock and Wendlebury is relatively rich in sites of nature conservation interest, in particular areas of ancient woodland and traditionally managed meadows. Eight such areas have been designated SSSIs (Fig. 1), three of which were notified during the official environmental study period. The woodland sites mostly form part of the medieval Forest of Berrwood and have a rich associated invertebrate population. The meadow sites are generally related to the low-lying land associated with Otmoor and are noted also for their floristic diversity.

Route optimisation

3. The proposed route was just able to thread its way around all the designated sites, even though this resulted in a less than direct route. However, following the announcement of the route currently preferred, two of the farmers affected by it made representations to the Department of Transport requesting that the line be moved slightly further away from their homes. Such a move had the effect of extending the original proposal (Fig. 2) was duly considered by the Department of Transport and the then Nature Conservancy Council (now English Nature).

4. The then Nature Conservancy Council was particularly concerned about the effect of the route on the rare black hairstreak butterfly. The black hairstreak has a very restricted distribution in Britain, being mainly found in woods between Peterborough and Oxford. It was known to be present along certain sections of the hedges which bound Shabbington Wood. A detailed ecological investigation took place as to the vegetation and insect fauna that would be affected, in particular the rare black hairstreak butterfly. The survey found that, although the modified route would destroy some minor black hairstreak colonies, it would avoid locations with strong colonies. Within the interior of the wood the line would affect a plantation of conifer and oak of restricted nature conservation interest and relatively unimportant to the SSSIs.

5. Following this investigation, the then Nature Conservancy Council agreed to the modified route on the condition that an area of over 4 ha, comprising two severed fields between the route and the wood, were given over, planted and managed for nature conservation purposes (Fig. 3). The woodland boundary of these two fields contains strong black hairstreak colonies; these have a good chance of spreading providing the right conditions are created.

Habitat creation for butterflies

6. One of the fields was in arable production and the other was a grass ley. The black hairstreak is a relatively sedentary species, which spends most of its time around the canopy of sheltered bushes and trees, basking or feeding on honeysuckle. It only lays its eggs on blackthorn bushes. The design of the habitat creation area has taken account of the particular requirements of the black hairstreak and a series of irregular bands of trees and shrubs have been planted to provide a sheltered
habitats. The plant mix included large amounts of blackthorn, some of which has been propagated under contract from suckers of bushes known to be acceptable to the black hairstreak (it is believed that the butterfly is selective to this degree). Elms and willows were also incorporated in the mix to attract other relatively rare butterflies, including white-letter hairstreak and purple emperor.

7. Wildflower glades have also been created between the bands of trees and shrubs to encourage butterflies. This required the removal of the layer of rich topsoil from the arable field to create conditions more conducive to the establishment of a range of wild flowers. The wildflower seed source was provided from the hay crop of a nearby traditionally managed flower-rich hay meadow. Individual devils bit scabious plants were added to attract the marsh frill butterfly.

8. The whole site has been fenced to protect the establishing plants from browsing deer and rabbits. Swinging gates were installed across a stream to prevent deer entering under the fence at this point. To enable easy vehicle access for maintenance purposes a track was cut through the plantation woodland off the main forestry road (Fig. 4). The landscape contract still underway includes a three year maintenance period, after which time the site will be leased to English Nature and other arrangements will be made for long-term management.

9. Monitoring is an important aspect of any habitat creation scheme. It should enable management changes to be made and the success of the scheme to be assessed scientifically over a
period of time. Thanks to the interest and cooperation of the society Butterfly Conservation, the butterflies will be recorded regularly on the site. The recording method follows the procedures of the national Butterfly Monitoring Scheme and will enable comparisons to be made by the Institute of Terrestrial Ecology between records from the habitat creation area and the country as a whole. Thus, natural fluctuations in species numbers, due for instance to the weather, can be taken into account. In the new area the most exciting record so far is for the scarce brown hairstreak butterfly. It has also already laid eggs on some of the recently planted blackthorns.

As has been previously mentioned the route directly affected areas of blackthorn with associated minor black hairstreak colonies. Rather than let such colonies be destroyed by motorway site clearance works, a separate salvage operation was undertaken in advance of the main civil engineering contract. For this it was necessary to have early access and the voluntary agreement of the affected landowners. Movement of the blackthorn bushes took place in June, an ideal time for the black hairstreak because it is at the static pupal stage, but not the most desirable time of year in terms of the bushes themselves. The contract took place over a few days and the pupae remained attached to the transferred bushes. Butterflies subsequently hatched out in the new positions within the habitat creation area. Surprisingly the majority of the bushes have also survived.

11. Alongside much of the M40, the surrounding agricultural land with its neat hedges and cultivation is comparable to desert conditions for many invertebrates. The route also passes close to Shabbington Wood SSSI and another wood, Whiterose Green SSSI, (Fig. 1). Both important for their associated invertebrate populations including black hairstreak. In comparison to arable fields, motorway verges can provide valuable areas of semi-natural habitat for a range of wildlife including insects. With this in mind, an opportunity was taken to create a link along the verges between these two SSSI woods to encourage an interchange of invertebrate populations in the long term.

12. Within the motorway fence line the embankments have been sown with a special wildflower seed mix over a shallow depth (50 mm) of topsoil. The composition of the seed mix was based on species attractive to invertebrates and typically found in the locality. A meandering double line of trees and shrubs, including blackthorn for the black hairstreak have been planted to form the shrubby component of the link. It was also necessary to enhance two existing hedgerows between the motorway and each woodland in order to complete the link. In one case this was achieved by planting by agreement; in the other case planting was on land presently owned by the Department of Transport and on which a restrictive covenant will be placed when sold off. The full nature conservation benefits of the link could take around 50 years to achieve, but this was not seen as an obstacle to its implementation because it also has a screening effect.

Deer

13. In addition to invertebrates, mammals were considered in the highway planning process, not only because of the danger they can pose to motorists if they stray onto the carriageway but also to provide a safe passage for them across the motorway. Large populations of fallow and muntjac deer are present within and around the woodlands adjacent to the route. Information obtained on the distribution and movement pattern of the deer was used to plan both the length of deer fencing along the route and crossing points (Fig. 5). The 18 km (11.25 miles) of 2 m high tensile strained wire fencing has been provided to prevent deer gaining access onto the motorway and three of the scheme structures were modified to provide deer with safe crossings. One of these shares a large stream culvert with a public footpath underpass. In addition to passing under the width of the motorway embankment the culvert has to contend with a screening mound on one side. Deer, however, are deterred from using narrow, long, dark tunnels and at an early stage the original design was made more attractive for them by locally steepening the screening mound. This resulted in a broader, shorter underpass with plenty of light coming through at either end. On the two overbridges, a softer grass-covered surface was incorporated by the use of grasscrete.

Badgers

14. Badgers are also present in the general area of the motorway. With the help of the local badger conservation group a survey was undertaken to locate their sets within the vicinity of the route. This information was used to plan the length of special badger fencing along the motorway to direct the badgers to safe crossing points. One of the crossing points is a purpose-built badger tunnel. This comprises a 600 mm dia. pipe through the embankment. As there
was a deep ditch along one side of the embankment and a simple wooden bridge made of planks was installed where the tunnel emerges (Fig. 6). A badger flap was inserted in the agricultural fence beyond the ditch to prevent farm animals from gaining access to the tunnel. It did not take long for the badgers to learn to use the tunnel.

15. Deer and badger fencing were often required in the same places, therefore the badger fencing was specially designed so that it could be visually integrated with the deer fencing.

16. The badger fencing is constructed of 14 mm gauge mesh 1-4 m wide, the lower 0.5 m of which is buried and turned away from the highway to provide a barrier 0-9 m high. The locations for the original badger fencing were subject to the provision that some additional lengths might be required depending on the movement of the badgers following highway construction. Additional fencing has in fact proved necessary, and while negotiations are taking place with the landowners a temporary electric mesh fence has been erected along one length. This is regularly checked, for example, to ensure the batteries are fully charged.

Flood storage reservoirs

17. Over the 20-35 km length of this part of the M40 seven flood storage reservoirs were proposed by the then Thames Water Authority at a fairly late stage in the scheme design. Through close co-operation with Sir William Halcrow and Partners, the original engineering designs were modified to take advantage of the opportunities they offered for wildlife. Travers Morgan's ecologists, together with the Department of Transport's landscape architect on the scheme, asked for the pond areas to be over-provided in order to be of benefit to wildlife. To guarantee water retention it was initially suggested that the ponds should be lined artificially. However, in view of the underlying Oxford Clay in the area, this was decided to take a risk and not to use a liner. In the worst case, a boggy area and in the best case, an open body of water area with marginal aquatic vegetation would be established. This proved the right decision. Motorway construction is now complete and the reservoirs are holding water.

18. The geometrical engineering designs of the reservoirs were all rounded off and flattened to produce a more irregular natural-looking profile. In some cases land acquisition limited the extent to which this was possible. The flood storage reservoirs have been planted with the main highway planting contract, but in some cases natural colonisation by aquatics is already underway. One farmer was so impressed by the nature conservation potential of the flood storage reservoirs that, following a request, he was granted permission to retain ownership of the land in order to use it for educational purposes for parties of children who visit the farm. In addition to the flood storage reservoirs, an extra pond was created to serve as a replacement for the three small farm ponds affected by the scheme.

River crossing and realignment

19. The crossing of the River Thames was realigned with an approximately 300 m long approach to the channel to avoid a skewed bridge on an oblique angle. In this area the Thames is a slow flowing, gently meandering river. Regular floods and a relatively natural appearance with large old pollarded willows along the banks and fringes of vegetation, such as club rush, reed sweet grass, arrowhead and reed canary grass. Clumps of white and yellow water lily were present in the central part of the river. This particular length of the river was typical of the wider area, apart from white water lily which is locally uncommon in Oxfordshire.

20. It was desirable to amend the basic trapezoidal channel section to a form which would look more natural and encourage re-colonisation by aquatic vegetation. However, the subtleties of how this might be achieved were considered to be difficult to specify in such a major civil engineering contract. The problem was resolved by simply including a variable width submerged berm (0-3 m) either side within the channel to provide for shallower growing emergent vegetation. Roughness in the channel bed was achieved by allowing tolerance levels of plus or minus 0-05 m in the excavation. The cut off thumb end of the old channel (Fig. 7) was retained to develop as a back water area.
for emergent vegetation. To maintain some through flow, two 300 mm dia. pipelines connect between the back water and the re-aligned river.

21. Attention was also paid to retaining existing vegetation where possible. Thus here, as elsewhere along the route, a tree survey located and individually tagged all trees to be protected from the main contractor's works. Along the river old willows within the highway acquisition area have been repollarded under a landscape contract. Within the section of river channel filled by the motorway embankment a separate salvage operation of the aquatic vegetation took place on the basis that the common white water lily should be saved if possible. Other more commonly occurring aquatics were also salvaged to hasten the recolonization process in the re-aligned channel. In other circumstances, it is usually possible to undertake a direct transfer of the emergent vegetation from the existing river channel into the newly formed one. In the case of the bridge construction this could not be guaranteed due to the time lag between the two operations, with various temporary diversion channels being formed to aid bridge construction.

22. A system was devised to store temporarily the salvaged aquatics until the final diverted channel was completed. Thanks to the co-operation of the land owner, a specialist contractor (Thames Water Authority) was able to undertake this operation before the main civil engineering contract got underway.

23. A less interesting section of straight river channel just outside the works area was identified as a suitable storage area. Bank excavation formed two underwater platforms of different depths on which gabion baskets stood and which received vegetation originating from different depths of the affected sections of river (Fig. 8). The storage area was protected from river currents by the formation of a low bund on the main channel side. The best and most accessible stands of aquatic vegetation were identified for salvaging, together with all available stands of white water lily.

24. The vegetation was lifted from the river using a long-armed Hymac with a dredging bucket. Such an operation required a skilled driver to prevent damage to the vegetation and to judge the correct depth of underwater excavation. The excavated vegetation was placed directly into slot Myper sheeting and wrapped into manoeuvrable sized bundles ranging between 300 mm–600 mm across. A rope was tied around the heavier bundles to aid lifting at the time of relocation. Bundles were then loaded onto a trailer and taken to fill the gabion baskets. Two years later the vegetation was re-located into the new channel.

25. After explaining the reasons for this salvage operation to the sympathetic resident engineers, it was possible to arrange for the main contractor to move large lumps of more commonly occurring river vegetation to the temporary channel and then to the final channel. This added bonus demonstrates the value of explaining why certain operations have taken place.

Conclusions

26. Credit has been paid to the environmental achievements of the whole M40 extension with the award to the Department of Transport of the first ever Automobile Association's Green Award. In addition the Waterstock - Wendlebury Section has received an award from the Chilterns Branch of the Institution of Civil Engineers. Throughout the work attention has been paid to detail with the aim of integrating the motorway into the surrounding countryside. No longer a luxury, such detail is now considered to be an essential part of the highway design process, the aims of which will need to be consolidated through good maintenance in the coming years.

References