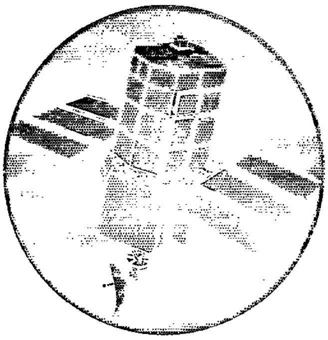
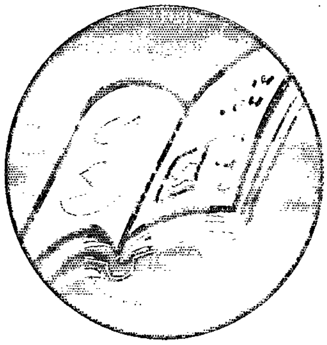
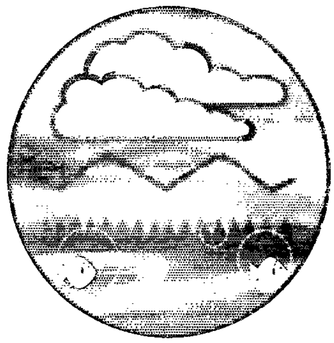
Management of Vegetation on Raised Embankments







Research and Development

Technical Report
W133

ENVIRONMENT AGENCY

Management of Vegetation on Raised Embankments

R&D Technical Report W133

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Research Contractor:

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Statement of use

This report will be of use to Flood Defence and Conservation staff in formulating options for the management of vegetation on raised embankments.

Research contractor

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1. EXECUTIVE SUMMARY

1.1. Background to the project

The Environment Agency has a commitment to the management of vegetation on both fluvial and tidal embankments. The Agency aims to ensure that the management regimes implemented are operationally, financially and environmentally sound. The Environment Agency maintains 36,000 km of main river defences nationally and 800 km of sea defences, protecting over two million people and over 850,000 properties from flooding. The protection is provided by earth embankments in the main.

1.2. The remit of the project

The overall project aims are to identify the significance of vegetation type and growing environment on the effectiveness of vegetation management on raised embankments in both fluvial and tidal situations. The project is approached in two stages, the second dependent on the findings from the first stage. This report covers the findings of the first stage only.

In the first instance, the range of vegetation established on raised embankments, including both designed grass mixtures and natural generation, was identified. The range of vegetation was related to information about the site and management practices in order to confirm the likely response of the vegetation in place to the management regimes currently practised. The remit included an assessment of changes that could be instigated to increase the effectiveness of the management and to lead to beneficial variations in plant species. The scope for developing a modified standard seed mix for use with new and repaired raised embankments was also considered. If the first stage of the project identified that there are likely to be benefits from modifications to existing management practice the project would proceed to a second stage comprising trials to evaluate particular management operations.

1.3. The approach to the project

Information was sought from managers in the form of a questionnaire (Appendix 1). This helped to determine the choice of sites visited (Appendix 2). The aim was to visit both fluvial and tidal locations, sown with 'standard mixes' and with other mixes, and to assess the effects of the method of control on the vegetation. Individual studies of species present are shown at Appendix 3. At each location, a species list was compiled. A record of relative abundance according to a DAFOR scale was made.

1.4. The main findings from the project (Stage 1)

The project showed that there are variations in the botanical composition of species on raised embankments, from 8 to 40 species identified on individual sites. Most embankments were seeded with a 'standard mix' which was considered by managers to be perennial ryegrass and clover, but in fact there have been several broadly similar standard mixes used in EA regions for many years, see section 4.6. The uniformity of the vegetation on the embankment has become ameliorated with time. Only 3 out of 25 embankment sections observed had fewer than 10 species. Six embankment sections had over 30 species recorded. These differences did not relate simply to management but to the interaction of the non-management and management factors present at each location.

The project showed that the botanical composition of the vegetation was very dependent on the location, topography and materials used in the construction of the raised embankment. The choice of seeding mixture or use of natural regeneration affected the range of species on the embankment. Several sites had been sown to low maintenance mixes and these mixes, in combination with lack of fertiliser or low-fertility soils, had allowed a range of species to flourish.

There are wide variations in the methods used to manage the vegetation. These ranged from apparently no maintenance (in a nature reserve) to very frequent maintenance (up to 5 mowing cuts per year). The most common was four to five mowings per year. This achieved the standards of the flood defence requirement (100 per cent green cover, a tightly knit root network for bank stability, ease of visual inspection for rapid anticipation of problems to the flood defence). From the project, it was ascertained that the same high standard of maintenance could be achieved from fewer mowings but that this depended on the natural fertility of the soil used to construct the embankment and on seed mix used. In some locations, very few mowings and no mowings were the operational practice. The vegetation had become long and rank in places and this low maintenance approach may compromise the standards of flood defence service required. It was noted that grazing was used as the vegetation control method in many locations visited. Although this is not favoured by all managers nationally there did not appear to be any compromise to the standards of service required. This method of control was beneficial in terms of biodiversity of plants on the embankment.

The management affected greatly the changes in species composition with time. On sites where the species composition was considered 'species rich' or 'interesting' it was concluded that past management had influenced this.

1.5. Recommendations for management in the future

The project showed that changes in vegetation composition have occurred over time from the time of establishment and these can now influence the chosen method of management. There are recommendations for modifications to existing management which include a reduction in frequency of mowing on sites (omitting some cuts) where wildflowers have developed, varying the timing from year to year of the cuts, and any omitted cuts, to allow for the different flowering and seeding times of wildflower species.

There is scope to tailor frequency of cut to the fertility of individual sites. Some sites are more fertile and require more frequent cutting. Other sites, where low maintenance mixes have been seeded and which have low soil fertility, require fewer cuts per season, and the application of these cuts could be varied to increase diversity of species.

The choice of soil for construction of an embankment will affect the subsequent management requirement. Fertile loam for topsoil, over a fertile subsoil will allow rapid establishment of a green cover, but there is a need to match this with a suitable seeding mix (perhaps a low-maintenance mix) that does not call for intensive management subsequently.

It was concluded that future management should take into account the botanical composition of sites, leading to 'management prescriptions' for individual sites, particularly those which have become valuable from the conservation point of view. Some diverse sites were visited in the course of Stage 1, but there are other sites which should be considered for siting trials in Stage 2 (for example, the grass seed trials at Beckingham, the Ouse Washes barrier banks seed trials, and the wildflower trials on the Lower Clone, from personal communication with V Holt, A Bullivant and A Driver respectively).

In terms of operational efficiency, there may be scope to reduce the frequency of cut so reducing costs. It is suggested that this be approached in the light of investigations into a) the effects of reduced frequency of cut on damage to vegetation when cuttings are left *in situ*, b) the effects on soil fertility of different cutting intervals and c) the effect of removal of cut vegetation when compared with leaving it *in situ*.

Management by grazing was an effective regime in most cases, except where some (unpalatable) species were left which produced scrub vegetation which could hinder close inspection of the floodbank. Such sites could benefit from the occasional mowing to control scrub vegetation growth. There was little evidence of excessive poaching from stock. Severe grazing from rabbits was noted on one site, but the problem was controlled before the visit.

Many floodbanks were used by the public (even where public access was denied). This caused excess wear and tear at the top of the bank with poor vegetation cover and some signs of soil erosion and lowering of the bank. The use of different seed mixes (or turfed grass) on the top and sides of the floodbank was not observed in the study, but could be considered for future evaluation.

In some cases, there was minimal management of the embankments, and in these cases it seemed appropriate to instigate a greater degree of management. The choice of management to re-instate the embankment is important. The first cut would prove a problem as there would be considerable vegetation causing a litter problem. It may be appropriate to graze the vegetation first, to mow twice in rapid succession to shred the vegetation, or to consider removal of the vegetation from the first cut off the site.

Although the move towards site-specific management will require additional costs at the outset, once a database of the soil type, fertility, seeding mix and past management has been set up, there will be savings in terms of management in the medium and long term.

1.6 Choice of seeding mix

The standard seed mixes used achieved the vegetation cover required. Some suggestions are made to include additional herbs which will increase the diversity and palatability without reducing its success in terms of rapid and reliable establishment. There is scope to increase the use of low maintenance mixes, but their ability to ensure good cover in all situations requires further investigation. Some of the sites observed had developed a wildflower landscape by chance, but it is known there are other sites which have been sown to wildflower mixes.

A short-list of preferred mixes to fulfil criteria for specific locations is available from EA conservation officers. The aim is to ensure reliable full cover and to serve specific requirements for landowners (for example, for grazing). There has been a move towards targeting the mix to reduce the long-term maintenance load. This may be combined with the opportunity to maximise the conservation value of embankments. It is important to take care when procuring seed. There is a National Seed Contract which is awarded to a company on an annual basis. The company must adhere to certain criteria for sourcing its seed(Copas, 1996-Appendix 6). Environment Agency engineers should ensure that they use seed sources outside the National Contract for a good reason.

The effects of management regimes on these should be investigated as part of Stage 2.

It is likely that at the end of the Stage 2 investigation there will be clearer recommendations towards achieving the 'best environmentally practicable option' for raised embankments.

KEY WORDS

Embankments, flood embankments, floodbank, vegetation management, mowing, grazing, grass embankment, seeding mixes, grass seeds, wildflowers.

2 RECOMMENDATIONS

Recommendations for changes to existing management

- Reduce cutting frequency on sites containing wildflowers.
- Vary timing (from year-to-year) of the omission of cut.
- Tailor cutting frequency to fertility of individual sites.
- Target management aimed at encouraging species-rich flora on low-moderate fertility sites.
- Consider using poorer soil on new embankments where sowing wildflowers is planned.
- On grazed embankments, ensure that certain areas are not avoided altogether (e.g. by fencing stock onto slopes for certain periods at sites where this has been a problem although the increased risk of erosion by stock must be considered).
- Encourage diversity of vegetation types at particular sites.
- Make use of berm areas for hay making with aim of reducing fertility over time, and graze aftermath where possible.
- Reconsider whether using fertilisers to speed establishment is worth the subsequent need for frequent cutting.
- Consider using a greater variety of species in 'standard' and 'low-maintenance' mixes.

2.1 Recommendation for trials work

To determine the differences in management that are needed for newly established embankments and those where the vegetation has become stablilised after a few years. This may require more frequent cutting or hard grazing to establish the preferred sward, but a reduction in intensity of management thereafter.

To investigate the effects of variations in cutting frequency and timing on the number of species both flowering and able to set seed at species-rich sites. This may require missing out one of the standard cuts.

To investigate the optimum cutting regime for nutrient offtake, by measuring yield and nutrient composition of cut vegetation on fertile and moderately fertile sites.

To determine the optimum cutting interval to minimise damage to vegetation when cuttings are left *in situ* as influenced by soil fertility, using two contrasting sites.

To determine the effect of removal of vegetation at cutting on subsequent vegetation growth both within the same season and in following years.

To evaluate the role of growth regulators in maintenance of embankments, and include the economic and environmental implications of their use.

To undertake seed mix trials using wet and dry mixes, and compare existing standard and low maintenance mixes with alternatives for speed of establishment and growth.

There are trials sites already established which could be evaluated as part of this (Appendix 7).

To determine the effect of establishing seed of low maintenance and wildflower mixes on new embankments.

To determine the best management strategy for a neglected embankment with rank vegetation.

To undertake an economic appraisal of the reduction in management that will be possible by adopting the best environmental practice for a range of sample sites.

To determine the role, if any of judicious use of growth regulators (those approved for use near watercourses), taking into account the number of annual applications permitted.

3. SUMMARY OF DECISIONS FOR CHOICE OF MANAGEMENT OF A FLOOD EMBANKMENT

The following is a general guideline for managers. There may be a need for site-specific advice from conservation officers.

There are particular requirements for some species if there is a desire to modify management to encourage them. An example is that of Yellow Rattle which will not establish if mown or grazed in the first year after sowing (from Emorsgate catalogue). Some species flower early and others late. A move toward more varied management for sites and site-specific prescriptions will improve the diversity of flood embankments.

3.1. Choice of seeding mix

The choice of seeding mix is influenced by nutrient status of the soil used in the construction of the embankment, by its pH (acidity/alkalinity), by proximity to water, by location of the site, and by the method of management of the site.

<u>Nutrient status</u>
Is soil nutrient status rich, medium of poor?

If poor:
Few embankments are constructed of poor fertility soils but if the topsoil is shallow and the subsoil has poor fertility this will affect the tolerance of the species in the sowing mix. Some fertiliser may be needed to establish the seed mix. Use a standard mix, at higher density 2-4 g/m^2.

If rich:
Most flood embankments are constructed from fertile soils.
Do not apply fertiliser to establish, use a low maintenance mix, low density (1-2g/m^2).

If medium:
Do not apply fertiliser, a low maintenance mix but a nurse crop is useful in this situation, use 1.5-3 g/m^2.

<u>The acidity/alkalinity</u>
What is the pH?
The acidity or alkalinity of the soil affects the growth and development of species. There are mixes which suit chalky/limestone or acid soils.

<u>Is the site to be grazed or mown?</u>
If grazed the choice of seed mix will include herbs and clover.
If mown, the management will be affected by both seed mix and base soil nutrient status (see nutrient).

<u>Is the site near to an ESA of SSSI?</u>
If Yes:

Seeds from outside the area should not be used on National Nature Reserves or Sites of Special Scientific Interest.

If No:
Seeds catalogue listed mixes.

Will be plants be near or in water
There are species which tolerate occasional wet conditions which could be used on the section of the embankment that is flooded at high water levels. This area should be managed as for the higher section of the embankment. Any areas under water and boggy should be sown to an aquatic mix (if sown at all) and left uncut.

3.2. Management choices

Time of sowing
Seed may be sown in the autumn, winter or spring. If a mix with flowers is sown in the autumn there may be flowers in the next summer. If sown in the winter, there may not be flowering until the second summer.

Time of cutting
When establishing the new seed mix, the cutting or grazing in the first year should be quite intensive. This is to help control weeds in the soil seedbank. In the following year, the sown mixes will start to flower and cutting needs to take into account the timing to allow flowering to complete. Two cuts in March and late July will allow species to flower.

On more fertile soils, several cuts or hard grazing during late summer and autumn may be needed. Perennial weeds such as docks and thistles may be spot sprayed to remove (with an approved herbicide for use near watercourses). The hard grazing may serve this purpose equally well.

Varying timing of cut and frequency will improve diversity as some species are early flowering and others later.

It is likely that if the seed mix could be matched to the soil type and method of management, there would be a reduction in the number of annual cuts needed once the establishment phase is completed and the species composition on the bank has stabilised.

The site contains wildflowers
These may have developed by chance and there is scope to reduce the frequency and vary the cutting of the sites.

Has the vegetation become worn?
If so, if small patches leave to regenerate naturally.

For larger patches use native (local origin)seed to regenerate the areas before coarse weeds develop.

Is the embankment unmanaged?

Return to management by ensuring no fertiliser, patching up as described at 10, cutting regularly

Is the area an SSSI or AONB?

Unmanaged areas will provide cover for animals. This will not be acceptable on embankments with risk of flooding. The site needs to be managed to a certain degree. Consider removal of cuttings.

Do you want to introduce more species into an existing sward?

Most species sown into grass will establish best if the grass if kept short by close mowing or tight grazing for the first 12 months after sowing. Then the mowing intervals should be reduced to allow the newly introduced plants to flower and spread.

4. INTRODUCTION

4.1. Flood defence in England and Wales

The Ministry of Agriculture, Fisheries and Food (MAFF) has policy responsibility for flood defence and coastal protection work in England and Wales. The improvement and construction of flood and sea defence is undertaken by The Environment Agency through regional flood defence committees, local councils and by 250 Internal Drainage Boards. The Environment Agency has statutory authority to exercise general supervision over all matters relating to flood defence throughout the country. The Environment Agency maintains 36,000 km of main river defences nationally and 800 km of sea defences, protecting over two million people and over 850,000 properties from flooding. The protection is provided by earth embankments in the main.

All schemes are required to be technically sound, economically viable and environmentally sympathetic. Within the Environmental Procedures for Inland Flood Defence works managers are charged 'to consider opportunities for environmental enhancement'.

4.2. Best environmental practice

The Environment Agency is committed to achieving best environmental practice for all its activities including the specification and purchase of wildflower and grass seed. The Environment Agency is bound by its statutory obligation towards sustainable development under the Environment Act of 1995. A key aspect of sustainable development is the need to halt 'the loss of animal and plant species and genetic resources' and 'to save and enhance biodiversity' (from Copas, 1996).

4.3. Maintenance of flood embankments

The flood embankments must be assessed regularly and for this visual inspection is used, which to be efficient implies a standard of service on the embankment. The standard of service is affected by the following factors:

- potential risk posed by failure of the structure
- potential for erosion or damage that may result in deterioration of the structure
- type and condition of the structure
- competence and experience of the inspector
- the speed with which observed changes will lead to failure of the structure
- adequate warning of flood events
- the frequency of maintenance

4.4. Vegetation on raised embankments

Raised embankments are constructed with gradients from 30 to 70%. These embankments, often up to 6m high, are exposed to weathering and are liable to suffer soil erosion in the absence of a cover of vegetation. The vegetation has to be established immediately at the end of the construction operation to minimise this risk. The seeding mixes used have typically been those which have a record of establishing rapidly and reliably on embankments in a range of conditions. It is important to maintain the embankments hydrologic 'smoothness', i.e. the vegetation should not provide excessive resistance to flowing water, as would be the case with scrub invasion or the establishment of trees. Rank or tall grass and herb vegetation may not be excessively 'rough', but this type of vegetation often precedes or accompanies scrub invasion. Secondly, tall, dense vegetation makes it difficult to inspect banks for damage and signs of burrowing animals. Furthermore, whilst rank vegetation can provide suitable habitats for certain small mammals and invertebrates, and may contain tall herbs of conservation interest, in general better managed vegetation is of wider conservation value.

4.5. General features of grass-covered embankments

All embankment grasses require management to maintain them as grassland. There are three methods grazing, burning and cutting. Burning is not considered a suitable method as full green cover is required at all times. Grazing involves the removal of vegetation, whereas cut vegetation is either removed or left *in situ*.

The following are features of grass covered embankments summarised by Fletcher and Marshall in 1997.

- withstand some overtopping,
- vulnerable to disturbance and lowering of bank level from sheep and cattle which pierce and wear the turf (there are Environment Agency by-laws to prevent damage to floodbanks caused by excessive poaching)
- cannot be covered with debris, as this damages the vegetation and causes points of weakness in the grass covering where erosion can occur. The extent of this erosion will be dependent upon soil type,
- rabbit holes provide a point of weakness in the grass cover and this initiates erosion (there are Environment Agency by-laws to cover vermin damage to floodbanks),
- animals tunnelling through the bank can lead to seepage ('piping') which undermines the bank structure.

4.6. Establishing vegetation on embankments

Sowing a standard mix

The main method used in the past (to the mid 1990s) was to sow a 'standard mix'. This has been suggested as perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*). However, there are a range of standard mixes, and examples are given in Table 1

This practice has evolved due to the following factors:

- ease of obtaining
- reliability of establishment
- rapid establishment to give a quick green cover
- competitive species to swamp 'weeds'
- lack of knowledge on alternative mixes
- price
- vigorous tetraploid varieties of ryegrass to increase competitiveness

In recent years, there has been a trend towards using other specified mixes (for examples, see Appendix 4). The mixes must conform to British Standard BS4428.

The seed germination is subject to quality control and there is a list for the blend for each mixture.

Table 1 Examples of standard seed mixes used

Species	common name	% content
Severn Trent		
Lolium perenne	perennial ryegrass	55
Poa trivialis	rough meadow grass	10
Phleum pratense	timothy	25
Cynosaurus cristatus	crested dogs'-tail or	10
Festuca rubra	red fescue	
Anglian		
Lolium perenne	perennial ryegrass Magella and Marcour	25
Phleum pratense	timothy Motim	25
Festuca rubra	slender creeping red fescue. Smooth stalked red fescue	
Agrostis spp	browntop bent Highland	
Trifolium repens	white clover Kent Wild White	
Yorkshire region		
Lolium perenne	perennial ryegrass Melle	50
Festuca rubra	creeping red fescue	25
Phleum pratense	timothy S48	15
Trifolium repens	white clover Grasslands Huia	10

A report on the 'Wildflower and Grass Seed Policy for the Environment Agency' (Copas, 1996), see Appendix 6, gives details of the procurement and use of wild flower and grass seed, specifically with regard to biodiversity and the effects of the use of non-native seed. The report states that the Best Environmental Practice for specification of wild flower and grass seed is to use wild flower and wild grass seed of local provenance, of the appropriate vegetation type within the National Vegetation Classification (NVC) and from as close as possible to the site. If such seed is not available, then seed from the appropriate NVC from elsewhere in the UK should be sought. For the specification for grass seed only Copas reported that it had not been possible to identify a seed supplier of UK only provenance. It is an application for seed use that needs to be developed as current best practice relies on the use of hybrids of part non-native origin. The use of native mixes of grass only is the primary requirement to provide immediate vegetative cover on embankments. There may be scope to review the source of supply of native grass seed mixes towards achieving the best practice option. The suppliers of wild flower and grass seed to the EA must be accredited. Copas gave criteria for accreditation as a commitment to supply only 100% native wild flower seed in wild flower and grass seed mixes and a commitment to supply the maximum proportion of wild grass seed in grass only mixes in addition to other quality criteria.

Low maintenance mixes
The aim with this type is to use plants which root well but with a shorter sward.
An example is given in Appendix 4.

Sowing a Grazing mix
There may be a requirement for the bank to be sown with a grazing mix where the landowner wishes to keep livestock. There are alternative mixes that EA. personnel suggest which have advantages for grazing animals (Appendix 4). These are:

- faster growing
- more vigorous
- provide nutrients for the animals
- withstand the wear of hoofs

Sowing a conservation mix
There is a move towards ensuring native grass seed and wildflowers mixes are used and concern by EA conservationists that the widespread use of standard mixes with non-native species is contributing to a loss of biodiversity. There has been an increase in input from the conservation specialists within the EA and the adoption of a range of mixes. Guideline documents have been produced (Copas, 1996).

Laying turf
This method was not observed in the project, but is practised.
- Turf grass
- Turfed topsoil used in some areas
- Sources of turf mixes

This method is controlled according to specification of type, size and thickness and shelf life.

Transplants
This is a specialised method of putting vegetation onto embankments. Techniques include:
- Transplants of nearby native plants
- Transplanted coastal grasses e.g. Marram
- Transplantation of native species

An example is that at North Heacham beach whereby the EA has transplanted coastal grasses from a donor site to the transplant site on the beach. The aim of the transplant operation was to retain the ecological features of the transplant site, to reinforce the sand and shingle faces of part of the embankment and to help to control wind-blow of fine sand particles. The recovery of the donor site was also assessed.

Other methods
Some novel methods include:
- seeded coir and straw mats with a polymer mesh for near vertical banks
- tyre mats with soil interspersed in-between the tyres

4.7. Choice of seeding mix

The EA is amenable to this input from landowners choosing their own mixes, provided the seed mix meets the overall needs.

5. THE OBJECTIVES OF THE PROJECT

5.1. The overall objective

The specific remits of the project reported here were as follows:

To identify the significance of vegetation type and growing environment on the effectiveness of vegetation management on raised embankments in both fluvial and tidal situations.

5.2. The specific objectives of phase 1

- To identify the range of vegetation established on raised embankments, including both designed grass mixtures and natural regeneration

- To confirm the likely response of the vegetation in place to the management regimes currently practised, based on the ecology of the grasses/ plants and their susceptibility or resistance to control

- To advise on the effectiveness of the management regime and what changes could be introduced to increase the effectiveness, including changes to enhance the conservation value

- To identify and develop seed mixes or mixtures for providing an optimum engineering habitat vegetated surface to sections of new and repaired raised embankments over a range of growing situations

6. METHODOLOGY

6.1. The range of vegetation types

The first remit of the project was to identify the range of vegetation types established on raised embankments, including both designed grass mixtures and natural regeneration. Information was sought from managers in the form of a questionnaire (Appendix 1). This helped to determine the choice of site visit (Appendix 2). The aim was to cover both fluvial and tidal locations, sowing with the 'standard mixes' and those with other mixes, and different methods of control of the vegetation. Individual studies of species present are shown in Appendix 3. At each location, a species list was compiled. A record of relative abundance according to a DAFOR scale was made, where D = 'dominant', A = 'abundant', F = 'frequent, O = 'occasional', and R = 'rare'.

7. SURVEY RESULTS

Summary of details from individual sites (Appendices 2 and 3)

Site 1- Shardlow on The Trent and Mersey Canal
A recent embankment (1995), formed using loam topsoil, managed as a grazed site with a sown grazing mix chosen by the farmer. The mix comprised four types of ryegrass (*Lolium* spp.), two types of timothy (*Phleum pratense*) and white clover (*Trifolium repens*). At assessment two years later there were few species and ryegrass was dominant with clover and timothy present. The management had affected the vegetation in that where two cuts for silage were taken in 1997, thistles and nettles were absent in this location.

Site 2 - Misterton Soss on River Idle
This embankment was constructed in 1981 using soil from the Idle Stop area. There were differences in the amount of topsoil used along the stretch. In one section (C) very little topsoil was used and there was less disturbance of the bank. Downstream of this there was more topsoil added and the area seeded with a 'standard' ryegrass mix. Both sections are managed by frequent mowing, cut every 5 weeks from late May-early June to October, although one of these cuts is unintentionally omitted in some years. At assessment on 21 July there were marked differences in botanical compositions with length C much more species-rich with many wild flower species. Length D was dominated by a few grasses with few broad-leaved species, and this length appeared to be much more fertile. Some areas of the berm in length D were managed for hay and receive fertilisers. These areas were completely grass-dominated, with only three species recorded, *Bromus* spp. (Brome grass) *Alopecurus pratensis* (Meadow Fox-tail) and *Arrhenatherum elatius* (Tall Oat-grass).

An additional embankment on the adjacent Mother Drain was assessed. This bank was constructed and seeded in 1981. It has been managed by cutting once a year for hay without the use of fertilisers The origin and content of the seed mixture is not known, but the landowner guessed that it was probably a standard maintenance mix.

For assessment, the embankment was divided into two sections A and B, since these sections showed marked differences in botanical composition. Twenty-five species were recorded in Section A (over a length of about 200m), including a number of wild-flower species such as *Geranium pratense* (Meadow Crane's-bill), *Centaurea nigra* (Black Knapweed) and *Dipsacus fullonum* (Teasel). However, the vegetation in this section was dominated by a dense growth of *Arrhenatherum elatius* (Tall Oat-grass),and *Dactylus glomerata* (Cocksfoot), with species such as *Convolvulus arvensis* (Field bindweed), and *Anthriscus sylvestris* (Cow Parsley) also prominent, indicating a combination of low disturbance and moderate-high fertility. Section B was much more species rich, containing 38 species (over *c.* 30m) with a greater abundance of less competitive, more stress-tolerant species not recorded in section A, e.g. *Leontodon hispidus* (Rough Hawkbit), *L. taraxacoides* (Lesser Hawkbit), *Lotus corniculatus* (Bird's-foot Trefoil),and *Primula veris* (Cowslip). These differences were attributed to the low fertility of underlying stony soil in this section, which had been spread onto the embankment during the construction of a culvert in the Mother Drain soon after the embankment itself was constructed.

Site 3 - West Stockwith on the River Trent
This embankment was constructed in 1973 and sown in the same year. The topsoil was dredged river material (silt).

This embankment is mown five times a year from May to October and, in common with most cut sites, the cuttings remain *in situ*. A total of 27 species were recorded, although all but 7 were only occasional or rare in occurrence at the site.

This site showed differences between the two sides of the embankment with more vegetation cover on the SW facing slope (side 2, ie. the side facing away from the river) than on the NE facing side 1. In common with most other sites, species of ryegrass and *Poa pratense* were more prominent on the top footpath section. Also in common with several other sites, there was a unmown marginal strip which showed development of scrub (*Rubus* and *Salix*). The overall dominant species was perennial ryegrass (*Lolium perenne*), with dandelion (*Taraxacum officinale*) dominating some areas.

Site 4 - Sturton on the River Trent
This embankment was constructed from 1963, but appears to have had part added later. The soil was obtained from the Borrow Pits upstream of Sturton Pumping Station. It is grazed by cattle and has a sward typical of improved grassland, with fertilisers probably applied at least to the lower slope and the berm on side 1. There were differences in species composition reflecting position on the bank and possibly differential use of fertiliser. *Geranium molle* (Dove's -Foot Crane's-bill) was common on the south-facing slope (side 2), but was not recorded elsewhere.

Site 5 - Bottesford Beck on the River Trent at East Butterwick
The embankment was constructed in 1974 and re-profiled in 1993. The site had been established with a 'low frequency maintenance mix' in 1974 and a new seed mix was sown in 1993 after re-profiling. The embankment soil was a light sandy silt.

The site was very species rich (38 on side 1 (south-facing)and 28 on side 2). There were no dominant species. Side 1 was heavily grazed by rabbits and there was bare ground and rabbit holes, reflecting the light soil. Stress-tolerant and ruderal species (i.e. those typical of soil disturbance) were common on side 1, e.g. *Erodium circutarium* (Common Stork'sbill), *Geranium dissectum* (Cut-leaved Crane's-bill), *Polygonum lapathifolium* (Pale Persicaria), and *Rumex acetosella* (Sheep's Sorrell).

Site 6 - River Torne at Acomb Bridge
The embankment was constructed and sown in 1980 with a low maintenance mix. Vegetation is cut four times per year May-September. The soil is an apparently fertile peaty loam. When assessed on 2 September 1997, there were 32 species along a 100m length. *Lolium multiflorum* (Italian or 'annual' Ryegrass) and *Taraxacum officinale* (dandelion) were the most common species, the former presumably Westerwolds ryegrass sown in the original mix, with *Arrhenatherum elatious* and *Cirsium arvense*

(Creeping thistle) also abundant. The embankment had not recently been cut and the growth was lush

There was an unmown marginal area of berm dominated by *Phragmites communis* (Common Reed)and *Glyceria maxima* (Reed Sweet-grass), with *Urtica dioica* (Stinging nettle), *Rumex obtusifolius* (Broad-leaved dock) and *Typha latifolia* (Common Reedmace) abundant. The remainder of the berm was wet in places, but the only other species reflecting this was *Polygonum amphibium* (Amphibious bistort). The two sides of the embankment had mostly similar species, although side 1 (south facing) supported a greater number of broad-leaved species.

Site 7- River Trent at Amcotts

This embankment was constructed in 1972 and sown in that year. The soil was dredged river material (silt). It is managed by five cuts per year from May to October. This river is tidal in this area, but no saline influence was seen in the vegetation. The vegetation is species-poor, with only 11 species recorded over several hundred metres of embankment. The grasses *Lolium perenne, Dactylus glomerata* and *Phleum pratense* (timothy) are dominant over most of the embankment; but with poorer grass cover at the village end where *Taraxacum officinale* is dominant.

Site 8 - Sea wall on the Humber Estuary at Easington

The embankment had a sea-facing and land-facing side. There were marked differences in the vegetation. The land-facing embankment was well established and contained a mixture of grasses and interesting broad-leaved species, although none uncommon. The top of the bank and the extreme edge adjacent to the sea had an obvious saline influence as indicated by the present of *Agropyron pungens* (Sea Couch) *Spergularia media* (Greater Sea-spurrey), *Atriplex littorlis* (Grass-leaved Orache); *Plantago maritima* (Sea Plantain), *Plantago coronopus* (Buck's-horn Plantain) and *Halimone protulacoides* (Sea Purslane).

The top of the bank was affected by trampling from vehicle access and pedestrians resulting in some bare ground.

Site 9- Monk Dyke in Yorkshire

This embankment lies adjacent to arable fields on one side and the watercourse on the other. There is a public footpath along the top of the bank but it is not used regularly. The vegetation comprised rank coarse grasses with tall weeds such as docks and nettles. The bank was uniform along its length. The majority of the vegetation was not cut at the time of the assessment but it had been mown adjacent to the arable field, probably by the farmer. The species present indicate that the bank may have been left to regenerate naturally dominated by *Elytrigia repens* (Couch-grass).

Site 10 - Dovefields Farm on the River Dove

The embankment was c.30-50m from the river, about 1m high at the point of assessment, with a gradient of 50%. It was constructed in 1969-70 and sown in 1970. The topsoil was from the immediate location, subsoil from local gypsum mine.

This site bisects a grazed field (cattle). It had been sown by hand with (apparently) a ryegrass/clover mix. The vegetation cover was complete. The vegetation was uniform along the embankment. There were no differences in vegetation between the north and south facing slopes. There were few other broad-leaved species. Other than those associated with trampled ground and bare ground caused by poaching. Bare ground was more prevalent on the bank top. Although clover was rare on the bank itself, it was more common in the field.

Site 11 - Branston Golf Course on the River Trent
This embankment was constructed in the early 1960s and re-seeded in 1970s. The topsoil was from the immediate location. It has a gradient of 50%. Although sown to a mix, probably including perennial ryegrass (*Lolium perenne*), it has many other species. This embankment is adjacent to a golf course, housing and school. It protects the houses and school from flooding but not the golf course. The first attempt at seeding the bank was not successful. After the second attempt, it still has not achieved full cover. It is not well established in terms of grass species but there is a varied mixture of broad-leaved species which tend to give it a 'weedy' appearance. Overall there were 40 different species, none dominant. Some species were only present on the side of the embankment adjacent to the river (*Reseda luteola*(Weld), *Rubus fruiticosus* (Bramble), *Convolvulus arvensis* (Field Bindweed), *Sambuscus nigra* (Elder), *Tanacetum vulgare* (Tansy), *Rumex obtusifolius* (Broad-leaved Dock), *Artemesia vulgaris* (Mugwort). This side was generally grassier with much less bare ground. There was a lot of dead vegetation straw and litter which may have originated from mowing. Many of the plants were drought stressed (possibly due to the source of the subsoil - fly ash from Drakelow power station).

There is access along the bank which is causing soil to erode, due to lack of stability of the vegetation.

Site 12 - River Tame at Tamworth
The embankment was at a distance of c. 100m from the River Tame. It was constructed in 1960s using local topsoil. It was sown to perennial ryegrass (*Lolium perenne*) and clover (*Trifolium* spp). It is adjacent to a main road and is mown four times a year. The bank top has eroded due to access by vehicles and pedestrians. Both sides of the bank had similar vegetation although the bank adjacent to the road was more grassy. There were 28 species, including a varied mixture of grasses, herbs and legumes, suggesting soil of low-moderate fertility.

Site 13 - Dendon on Endon Brook
This embankment was established in 1982 and sown in that year. The topsoil was from the immediate location. This embankment was adjacent to a car park and Endon Brook with a grass field on the other side. It was probably originally sown to ryegrass and clover as both species were present but at low frequency. The vegetation comprised a grass (couch) dominated bank with a few dandelions and docks. The bank was supposed to be managed by mowing 4 times per year, but appeared to be unmanaged at the time of assessment.

Site 14 - Sea embankment at Heacham
There were two sites assessed at Heacham:

14A The embankment was 200-300m from the sea and did not show the coastal influence at this distance.. This is with the exception of knotted hedge parsley (*Torilis nodosum*) which tends to be associated with dry grassy banks especially close to the sea. The embankment was very weedy although there was a significant amount of grass underneath the tall herbs, especially couch (*Elytrigia repens* - no sea couch). The embankment had adjacent land seaward as grazing (by cattle), and arable on the landward, south side. The embankment itself was not grazed by the animals presumably due either to the steep slope or to the availability of sufficient vegetation on level ground. Vegetation cover was uniform, apparently not influenced by adjacent land use or orientation. There were 25 species identified, with no obvious evidence of seed mix having been used.

14B This embankment was similar to 14A but some 50m further inland. It is mown annually in September. Again, there was little/no evidence of saline plants. The embankment was dominated by grasses with some broad-leaved species and scrub encroachment. A caravan park is situated on both sides of the embankment which is used by the public.. On one side there was a thick hawthorn hedge providing with the bank itself a useful habitat. The vegetation was shorter. There were 22 species recorded, again with no evidence of a seed mix having been used.

There were notable differences in vegetation between these two sites, probably attributable to differences in management. Although site A did not appear to be grazed regularly, the greater abundance of hedgerow species and scrub encroachment at site B presumably reflect lack of defoliation compared to site A.

Site 15 - Brandon Creek on the Ten Mile River

The species composition on the two banks was quite different.

15A This embankment is adjacent to Ten Mile River with a busy road on one side bordered by arable fields on the other. The vegetation is mown annually in October. The vegetation was rank and dominated mainly by grasses at the time of assessment in August. There were few broad leaved species except where the bank met the waters' edge.

The opposite bank was not easily accessible. However, it was similar to a bank located on the other side of the A10 which was assessed, 15B. There, the land was grazed giving short vegetation except for the less palatable species. The original seed mix was probably ryegrass (*Lolium perenne*) which remained dominant and White Clover (*Trifolium repens*) which was frequent. There were also substantial areas of bare ground caused by poaching by livestock (cattle), and this had created opportunities for many less competitive species to become established.

Site 16 - River Hull at Watton Beck

The embankment was adjacent to the River Hull. The vegetation appears to have been sown with a ryegrass and clover mix but has become species-rich in time. The grass-dominated banks are grazed by sheep which keep the sward short. The steep banks level off into flatter inundation zones (berms) and species tolerant of wetter conditions, such as *Agrostis stolonifera* (Creeping Bent) and *Alopecurus geniculatus* (Marsh Foxtail), have invaded. Where sheep did not have access (part of the area is a nature reserve) the vegetation was rank and much taller. There was a well-used pathway on the top of the embankment and different species were noted here, including *Trifolium pratense* (Red Clover), *Lotus corniculatus* (Bird's-foot Trefoil), and *Festuca rubra* (Red Fescue).

8. IDENTIFICATION OF FACTORS AFFECTING THE VEGETATION

8.1. Salinity

The effects of salinity were only noticeable in locations immediately adjacent to the coast. The top of the sea wall at Easington on the Humber Estuary (Site 8) showed a significant saline influence with *Agrypyron pungens, Spergularia media, Atriplex littorlis. Plantago maritima, Plantago coronopus* and *Halimone protulacoides* which were not present on the landward side. The landward side had a diverse mix of grasses and broad-leaved species associated with non-saline conditions. The effects of seaward-facing embankments on vegetation were dependent upon distance from the shore, with the embankments at Heacham (Sites 14A and B) not showing this influence at distances of 200-300m from the sea. The saline effect on plant communities depended on wind direction in addition to the proximity to the sea. This was noted in observations of plants typical of saline conditions on the road-side verges at Heacham. Vegetation on the estuarine embankment of the Trent, away from the coast at Amcotts (Site 7), showed no saline influence, presumably because its contact with estuary water would be infrequent and only at times when the river was filled with flood water.

8.2. Age of the embankment

Newly sown embankments reflected the species used in the seed mix (e.g. Site 1 at Shardlow on the River Trent) whereas longer-established embankments reflected management practice to a greater extent (e.g. Site 16 Watton Beck on the River Hull). Some were well-established and grazed but were still dominated by the species used in the seed mix (e.g. Site 10 Dovefield Farm on the River Trent, where the embankment bisected an improved field grazed by cattle and received management treatments as part of the field). The benefits of grazing (poaching and trampling) on species diversity were often observed where grazed and mown/unmanaged embankments were located together (e.g. Site 15 Brandon Creek on the Ten Mile River, where the apparently grazed embankment appeared to have been sown with *Lolium perenne* (Perennial ryegrass) and where there is now a reasonably diverse sward). It was usually possible to determine the likely species sown (where this information was not available) but the relative abundance of species (assessed using a DAFOR scale) is likely to be affected by management over the intervening years.

8.3. Source and fertility of soil

The specifications for watercourse maintenance work-construction of embankments refer to the use of 'suitable material' and refer to topsoil as 150-400 mm depth of soil which is to be stripped and stored. There are details on the management of this fraction during the construction process.

The type of topsoil had a large bearing on the species on an embankment. The sown standard and grazing mix species tended to predominate where the topsoil was a fertile loam (e.g. Site 2D, Misterton Soss on the River Idle, Site 4 Sturton on the Trent, and Site 6 River Torne at Acomb Bridge). Where the sown species did not become established well, possible due to lack of soil fertility, other species suited to low fertility or the pH of the soil were able to compete more effectively. This appeared to be the case at Site 11 at Branston Golf Course on the River Trent where the site was acidic with species such as *Sedum acre, Rumex acetosella* and *Campanula rotundiflora.* The majority of the vegetation was dominated by *Crepis cap/versicaria* so overall it appeared very weedy.

The subsoil can also affect plant survival and vigour, e.g. Site 11, where subsoil was sourced from fly ash from local power station caused apparent drought stress, with several species present which are typical of dry grasslands, sand dunes etc., e.g. *Sedum acre*, *Campanula rotundiflora*.

8.4. Slope

The gradient of the embankments varied from 30 to 70%. Generally, the sown species established on the banks. The tops of the banks were used by pedestrians and vehicles causing differential wear and tear. Steep slopes appeared to deter grazing animals where more level grazing was abundant (e.g. Site 14A, sea wall at Heacham) but such slopes were grazed elsewhere (e.g. Site 4, Sturton on the Trent). In general, cattle are less keen to climb steep embankments than sheep.

8.5. Orientation

The orientation of the slope affected species present. This was marked in the coastal locations where salinity was a factor (e.g. Site 8 Sea wall at Easington on the Humber Estuary), but also noted in inland areas (e.g. Site 3 West Stockwith on the River Idle, Site 5 Bottesford Beck, and Site 6, River Torne at Acomb Bridge) where slopes with a southerly orientation were more species-rich with more flowering plants. Furthermore, in the sandy silt soil at Bottesford Beck, the southerly facing slope also proved more attractive to rabbits than the other side of the bank. This influenced vegetation composition due to the amount of bare ground and the short vegetation resulting from rabbit grazing . There were several examples where orientation made little difference to the species present (as recorded using the DAFOR system-other methods may show up the slight differences in species composition better).

8.6. Adjacent land use

The berm itself was used for cropping in some locations (e.g. Site 2D, at Misterton Soss on the River Idle) and was grazed along with the embankment at others (e.g. Site 4, Sturton on the River Trent). However, the effect of different cropping of adjacent land on the vegetation of the embankment itself was not noticeable. A more obvious effect was that of periodic inundations on the vegetation at the bottom of the bank (berm in some cases) which was noted at Site 6, River Torne, and Site 16 at Watton Beck.

8.7. Seed mix

There were many examples of standard seed mixes used on embankments. For example, at Site 16 Watton Beck on the River Hull, there was a mixture of vegetation types. Where access was possible, sheep were used to maintain the sward and this resulted in a very closely grazed sward. Most of the embankment was steep sided but in some places there were inundation areas and the vegetation varied accordingly. Part of this embankment was not accessible to grazing animals and vegetation here was tall comprising a large riparian component.

At Site 10 (Dovefields Farm on the River Dove) there was minimal modification to the seeding mix (e.g. Site 10 Dovefield Farm on the River Trent), in spite of grazing of a long-established embankment) and this may be associated with the presence of fertile topsoil and competitiveness of the sown species.

The use of a nurse crop sown alongside a low maintenance mix was evident at Site 6, River Torne at Acomb Bridge. *Lolium multiflorum* (Italian ryegrass 'Westerwolds') was present 17 years after establishment. Low maintenance mixes were used on several sites and these tended to have an abundance of species present and generally to have good cover. For example, site 6 River Torne at Acomb Bridge and site 5 Bottesford Beck on the River Trent.

9. EFFECT OF THE MANAGEMENT REGIMES

9.1. General findings

The effect of management by either mowing or grazing was sometimes difficult to determine, due to the overriding influence of some of the factors noted above, e.g. soil type, saline influence. Caution must be adopted when drawing conclusions from sites which differ in their management, since underlying differences in factors such as soil type and fertility may not always be clear. To disentangle these influences accurately would require either detailed experimentation at different sites, or surveys of a very much larger number of sites involving the collection of samples for soil analysis in addition to the botanical assessments. Neither of these two approaches fell within the scope of the work undertaken here.

Nevertheless, some broad generalisations are possible from the information collected, and the following points give some indication of the effects of the various management practices.

9.2. Management by mowing

Compared with grazing this is a sudden and unselective form of vegetation removal giving a uniform height and structure and uniform species composition with no bare ground areas. The cuttings are normally left *in situ*. Where mowing is frequent or the soil is infertile, the cuttings are short and have little physical effect on the underlying vegetation, although leaving the cuttings *in situ* will allow fertility to be maintained by returning nutrients to the soil.

In some cases, mowing was done annually in the autumn and on these sites the vegetation was rank and overgrown at the time of assessment in August. Mowing at this time would do little to enhance the conservation interest of the vegetation. There are benefits to ground nesting birds in this practice.

There were large differences between grazed and 'mown' sides of an embankment (e.g. Site 15 Brandon Creek on the Ten Mile River, Sites 14A and 14B Sea walls at Heacham).

9.3. Frequency of mowing

Within the constraints described above it was possible to make basic conclusions about the frequency of mowing.

On several sites, the mowing was infrequent (once a year, e.g. Site 2 A at Misterton Soss). The vegetation here tended to be of lower diversity than at more frequently cut sites, although some interesting plants might be present. Vegetation tended to be dominated by *Arrhenatherum elatius* (Tall Oat Grass) and sometimes *Elytrigia repens* (Common couch), often with large patches of nettles (*Urtica dioica*) and thistles (*Cirsium arvense*), these species having largely replaced the sown species. Where vegetation was cut 4-5 times per year, these species were less common and sown species such as *Lolium* persisted. This was even the case at Site 6 on the River Torne, where the management (4 cuts per year) had apparently allowed the persistence (presumably through seedling regeneration) of the normally short-lived Westerwolds ryegrass (*Lolium multiflorum*).

9.4. Management by grazing

Several embankments were grazed, ranging from the recently-established embankment at Site 1, Shardlow, to the older and more established sites at Brandon Creek (site 15) and Watton Beck (Site 16). Sown species such as *Lolium perenne* and *Trifolium repens* were dominant or abundant at both sites, and although grazing had allowed ingress of other species at both sites, the vegetation had become more diverse at Watton Beck than at Brandon Creek. On the former site, sheep grazing kept the sward shorter than at Brandon where the vegetation was grazed by cattle. However, it was not possible to say to what extent these differences accounted for differences in botanical composition between the two sites, since there were no marked differences in the abundance of species associated with frequent defoliation.

The effects of no management were noted only at the ungrazed area at Watton Beck. There a nature reserve was fenced off from sheep grazing. The vegetation had become tall and rank, dominated by tall herbs and reed-grasses, and was apparently left unmanaged.

10. THE EFFECTIVENESS OF THE MANAGEMENT REGIME

10.1. General findings

Sites cut only once a year or grazed very infrequently supported very rank vegetation of low plant species diversity, and in the case of grazed embankments at least, this would lead to scrub invasion. One exception to this was at Site 2B Misterton Soss, where the infertile, stony soil allowed a species-rich plant community containing several low-growing plants, despite a single cut management. Such sites do not require more frequent cutting, but are probably rare, since the aim when constructing new embankments is normally to provide an adequate depth of loam soil.

10.2. Grazing

Sites which were grazed generally supported a good ground cover, and the sown species appeared to have persisted. At least one of these sites, site 16 Watton Beck, a species-rich vegetation had resulted, presumably facilitated by low-moderate soil fertility. However, where grazing animals were excluded at this site, and also at site 14 Heacham where animals appeared to avoid the slope due to the ample availability of grazing on more level ground, the vegetation was more rank with fewer flowering plants. It may also be significant that Heacham was grazed by cattle, which may be more reluctant to graze steeply sloping ground than the sheep at Watton Beck. By contrast, at site 4 Sturton on the Trent, where, apart from a fairly small berm area, grazing cattle had access only to the embankment, the vegetation was well managed.

There was no significant evidence of damage to the embankments by grazing animals at the sites surveyed. Some small bare areas had been created by poaching, and whilst these allowed ingress of a greater variety of plants, the surface area involved was unlikely to be great enough to increase the danger of erosion.

10.3. Mowing

a. Cutting frequency

Regular mowing also maintained a good ground cover in most cases, a notable exception being at site 5 Bottesford Beck where there was excessive rabbit damage. It is not certain whether this damage was exacerbated by regular mowing, and it is unlikely that vegetation management can prevent rabbit burrowing. However, where the vegetation is already kept short by rabbit grazing it seems unnecessary to cut so regularly. A reduction in the amount of exposed bare ground would allow a more stable plant community to develop, less dominated by ruderal species, encouraging a close turf to develop.

As noted above, at Site 2B on the Mother Drain at Misterton Soss, a single cut each year was sufficient to maintain the conservation interest of the vegetation and to contain the limited growth supported by the poor soil. A 5-cut system was maintained at both Sites 2 C and D (at the same location, though on the river embankment as opposed to the Mother Drain), although there were obvious differences in soil fertility between C and D. This was confirmed by information supplied by local sources. who stated that although section D had received a good covering of topsoil, very little had been applied to section C; also that a standard seed mix had been sown on section D but none on section C. Regular mowing was evidently required to maintain the vegetation on section D, and vegetation cover was good on this section. However, section C supported markedly less growth than D, though ground cover was also good, and there were a large number of flowering plants present on 21 July when the embankment was just about to be cut. It seems unlikely that the same frequency of cutting was necessary on both these sections, and indeed, the presence of so many wild-flower species on section C was probably related to the fact that one of the 5 cuts per season was often omitted, allowing species to set seed. Since access to this section was via section D and at some distance, it is possible that the omission of a cut occurred more often in section C than D.

These observations suggest that the regulation of cutting frequency should be site-specific, with less frequent cutting at some sites feasible and attractive both from the point of view of economy and conservation interest.

b. Removal of cuttings

Cuttings were left *in situ* at all the mown sites surveyed.. Where cutting frequency was high, the resultant litter was insufficient to cause physical problems to the vegetation. However, large amounts of litter were seen at least one site (Site 11 at Branston Golf Course). Leaving cuttings *in situ* can be beneficial from the ecological point of view since it allows greater seed shedding to occur than when cuttings are removed. On the other hand, this practice allows soil fertility to be maintained, since nutrients taken up in herbage are ultimately returned to the soil. This is a disadvantage, since soil fertility appeared to be the most common impediment to increasing species-richness and also perpetuates the need for frequent cutting to control the vegetation.

The presence of large amounts of cuttings may also be a disadvantage, particularly in the autumn, since this can lead to pollution of the watercourse and possible inconvenience caused by floating material.

11. DISCUSSION AND CONCLUSIONS

11.1. The characteristics of embankment vegetation

Most embankments are a form of 'mesotrophic grassland' as categorised by Ausden and Treweek (1995), comprising plant species with a preference for soils that are *circum*-neutral. Seeded swards on such soils are typically dominated by a small number of highly productive and nutritious species such as *Lolium perenne* with other often highly selected strains of grasses and clover (*Trifolium* spp). Well-maintained grasslands such as this maintain the dominance of these species and suppress others so that the vegetation tends to be uniform and floristically poor. The associated invertebrate fauna will be common and widespread species of little conservation value. Early and repeated cutting destroys the nests and young of ground-nesting birds (Green, 1986). Both the frequency and timing of cuts have been amended to allow for ground nesting birds. An example of this is the tidal reaches of the River Trent.

11.2. Scope for modification of management

Cutting, grazing, and soil fertility,

A major overriding factor in determining the vegetation on these embankments was the underlying fertility of the soil. When grass cuttings are left *in situ*, soil fertility is retained, since no nutrients are removed. And when vegetation is left uncut for several years, fertility can build up, due to the invasion of deeper rooting tall herbs and shrubs which can forage at greater depth for nutrients, transferring these to the surface layers in the form of litter (Grime, 1979).

Grazing animals return a very high proportion of the nutrients they consume in the form of excreta (During *et.al.*, 1973; Jarvis *et.al.*, 1989). This can increase or maintain the heterogeneity of nutrient supply in the soil, which generally allows the co-existence of a larger number of species (Crawley, 1986). However, vegetation of conservation interest is unlikely to develop where soil fertility is moderate to high, even under grazing, since this will allow fertility-demanding, grazing-resistant species like *Lolium perenne* to dominate at moderate-high stocking rates (Tallowin *et. al., 1990*), or lead to selective grazing and rank vegetation at low stocking levels.

Repeated removal of cuttings will eventually lead to depletion of soil nutrients. This will not only tend to increase species diversity in the vegetation, but should reduce the need for frequent cutting. However, this seems unlikely to be economical in most situations, particularly as soil nutrient depletion is a slow process and removing cuttings is labour-intensive. Nevertheless , it may be worthwhile as a means of improving the conservation interest of specifically targeted sites of marginal (moderate) fertility. Further work is needed to determine what is the optimum frequency of cutting for maximal nutrient removal.

High soil fertility may be the result of compound fertilisers applied at sowing, or may reflect the source of the soil used to construct the embankment. Phosphorus is particularly persistent in the soil (Tallowin *et.al.*,in press), is commonly applied to aid grass establishment, and is often present at high levels in river sediments (Thomas, 1970; Cooke, 1976), from which several of the embankments in this study were constructed. This element is increasingly thought to be a major impediment to the restoration of floristic diversity in grasslands (Tallowing *et. al.*, in press) and ex-arable areas (Gough and Marrs, 1990). It seems unlikely to be worthwhile adopting managements aimed at improving conservation interest where soil fertility is high. On embankments with lush growth indicative of high soil fertility, management should probably concentrate on hydrologic and maintenance considerations, rather than enhancement of conservation interest, except in specific situations where there are faunal interests (e.g. otters).

Grazing at low intensity is probably the most cost-effective strategy for maintaining floristic diversity at species-rich sites. However, where grazing is not practicable, species-richness can be maintained by cutting, although timing and frequency of cutting will be important.

Application of fertiliser
The application of fertiliser is considered acceptable to EA managers where the floodbank is to be grazed as a 'managed sward'. The fertiliser is applied to encourage establishment of the vegetation and is applied at 45 to 90 kg/ha of Nitrogen, Phosphate and Potassium. The fertiliser is applied only when wet weather is forecast to prevent scorching of young seedling (C Essery, EA at Willerby in memo to engineers).

Application of pesticides
The only suggested use of pesticides is that of seed treatments such as metalaxyl +, thiabendazole + thiram as Apron Combi FS (from Ciba Agric.) or fonofos as Fonophos Seed Treatment (from Zeneca). These are applied by the seeds companies. Growth retardants, such as maleic hydrazide, which can be used near water, have been evaluated in trials, but have not been taken up widely due to their high cost. There is scope to evaluate these further.

Timing and frequency of cutting
It has been said that mown banks typically have minimal ecological interest (Holmes and Hanbury, 1995). The same authors point out that banks which are mown just once a year allow herbs and grasses to reach full height and flowers to set seed, and that this can lead to increases in species-richness. However, the findings of the survey reported here suggested that these generalisations need qualifying. Some species-rich embankments were found which were managed by cutting, at least one of which (Site 2C at Misterton Soss) was cut 4-5 times per year.

Cutting 4-5 times per season, from late May to October, was the most common management regime practised at the sites surveyed. On the face of it, this would seem a rather too intensive programme to allow plants to flower and set seed. Both flowering and seed setting are important for conservation interests, in order to both attract pollinating and nectar-feeding insects and seed-eating birds, and to allow seedling regeneration. (The latter is important not only for annual and biennial species, but also for a large number of perennials which rely on regeneration from seed to maintain a turnover of new plants, a requirement which is often underestimated). However, the cutting regime was not always rigidly adhered to, and at one of the most species-rich sites (Misterton Soss on the River Idle) one of the planned 5 cuts per season was apparently often omitted. This would allow an interval of some 8 weeks for species to flower and set seed, and may well have been a contributory factor to the species-richness at that site.

Flowering times (phenologies) vary greatly between different species (Kirkham, 1997a; Smith and Jones, 1991), so that if this 8-week window of opportunity occurred at the same time each year, this might not be sufficient to allow all species to set seed. An optimum strategy might be to vary both the timing and frequency of cutting from year-to-year, in order to encompass the requirements of a larger number of species over a sequence of years. However, care would be needed with this strategy, since annual species, particularly those which do not form a persistent soil seed bank, can easily be eliminated from plant communities by cutting before they have set seed.

This is a subject area in which insufficient work has been done, and experiments investigating optimum cutting strategies for species-rich or moderately species-rich embankments would be well worthwhile. Whilst it should be recognised that leaving cuttings in place will allow greater seed return than removal of the vegetation (Kirkham, 1997b), including measurements of potential nutrient offtake at different cutting timings and frequencies would also be a useful component of these studies.

11.3. Variations in management at a site

Waterside margins

High biodiversity in a habitat can often be promoted by encouraging heterogeneity of vegetation structure and composition on a medium scale. Examples of this were seen where the waterside margins of the embankments were left unmown, either because the ground was too wet or because the mower arm did not extend to the bottom of the embankment from the tractor positioned at the top. This provided a greater variety of plants and habitat niches at the site than would have been produced by a uniform mowing or grazing regime. However, this often led to the development of scrub, willows and alder, which might provide excessive resistance to water flow during flood events.

Berms

The berm could be managed in a pro-active way to enhance its value. The vegetation on the berm is often distinct from that on the bank. It can be botanically interesting and often requires management different from the rest of the bank (Whereas removal of vegetation from embankments is often difficult, berms are often mown for hay or silage. In the example seen at Misterton Soss (section D), the berms received inorganic fertilisers and were very species-poor. However, since the vegetation is removed as hay in at least one cut per year, their is scope for reducing soil fertility if fertiliser use is abandoned, eventually producing areas of very species-rich vegetation. The most species-rich meadows are those which are grazed following hay cutting, so that this management should be encouraged also. These management strategies are out with the remit of Flood Defence Engineers.

11.4. Changes in management

Sites which have been managed consistently in a similar way for many years may have developed plant communities of high conservation interest. It is important to continue to manage in the same way. If new management is to be introduced, it should ideally be done on part of the site and the effects monitored. Furthermore, introducing sheep or cattle to a site which has previously been undermanaged and which contains rank vegetation can lead to further deterioration due to selective grazing. Nevertheless, use can be made of the different feeding habits of different breeds and types of animal, for example by using goats which tend to select shrub plants which cattle and sheep reject.

Introducing grazing to previously mown embankments may run the risk of reduction in vegetation cover through poaching and sward death, unless the vegetation already contains an abundance of species which can withstand grazing, such as *Lolium perenne*, *Trifolium repens*, *Poa* spp. etc. Species such as *Arrhenatherum elatius*, characteristic of mown grassland, can quickly die out under heavy grazing. Thus the smoothest transitions are likely to occur in situations where the vegetation has previously been mown regularly rather than infrequently, since both the abundance of species suited to grazing and their overall tiller density are likely to be higher, leading to less poaching damage with less consequent risk of erosion.

11.5. Sowing seed

Standard and low-maintenance mixes, fertiliser application

Generally, engineers opt for a rapidly establishing sward, associated with subsequent prolific growth, requiring regular maintenance. Speed of establishment may be enhanced by adding compound inorganic fertilisers with the aim of achieving a rapid vegetation cover before the onset of inundation. This will not only inhibit the ingress of native species of conservation interest, but will perpetuate the need for frequent mowing, since even small amounts of phosphorus can persist in the soil and contribute to enhanced growth. Lower maintenance mixes are associated with slower establishment (Donaldson *et al*, 1988). A compromise between rate of establishment and subsequent demand for maintenance may need to be reached.

Using a nurse crop

This is a annual crop, not necessarily native, which establishes very quickly and is cut before it has chance to flower and set seed. It provides rapid green cover whilst the desired species are establishing. It should not remain as part of the species composition longterm, although there was evidence on one site of persistence of annual ryegrass 'Westerwolds'. It is possible to use other species of a native origin but there is likely to be a cost implication.

Using wildflower mixes

As has already been made clear, the establishment and maintenance of wildflowers is dependent upon low soil fertility, coupled with sensitive mowing or grazing management. The use of wildflower mixes will need to be targeted at low fertility sites, and the use of fertile loam topsoil should probably be avoided on those new embankments where it is intended to sow wild flowers. Since establishment of this type of vegetation cover will be slow, it will be best to target these on embankments, or parts of the embankment, where inundation is likely to be least frequent and/or where the danger of erosion is least.

11.6. Development of seed mixes

There are a range of seed mixes recommended for use in different circumstances by the Environment Agency Some of these are listed in Appendix 4. The existing standard and low maintenance mixes serve the purpose well, although there are other species which could be added to improve the diversity. Species which could compete reasonably well with the vigorous ryegrass include chicory and plantain which would add palatability to grazing mixes and improve the conservation value.

Some of the seed mixes used in the farm-scale demonstration at ADAS Bridgets and ADAS Boxworth Research Centres could be considered for this purpose (Appendix 5).

The following species can be considered

11.6.1. Grass

Yorkshire fog
Timothy
Meadow foxtail ***could add variety, especially for cutting***
Cocksfoot *may be aggressive in some locations*
Native Perennial ryegrass
Sweet vernal-grass ***low-moderate fertility situations, especially for sites that are. cut***
Crested dogs'-tail - ***low-moderate fertility only***
Rushes ***not likely to need sowing where conditions suitable!***
Sedges - *very specific situations low fertility, most spp. in wet conditions*
Tufted hairgrass
Rushes
Tall fescue *for dry situations on exposed banks*
Meadow fescue *for dry situation on exposed banks*

11.6.2. Broad-leaved

Yellow rattle ***an annual with only transient seed dormancy, very. susceptible to early cutting (before late June-July), whole population can be completely eliminated by a single cut !***
Oxeye daisy
Red clover ***often occurs in natural swards with grasses***
White clover

11.6.3. Legumes for grazing mixes

White clover *high digestibility, sheep and cattle grow faster with this than on grass alone. There are new varieties with better winter survival and spring growth such as* AberCrest *and* AberHerals. *The NIAB has a classified list of varieties. The establishment is by spreading by stolons to cover gaps in sward. There is a large stolon network for relatively few plants. Hard grazing gives many compact stolons with small leaves on short stalk whilst less dense grazing gives fewer longer stolons with large leaves on long stalks.*

Birds foot trefoil *for low fertility locations when white clover may not do so well.*

Red clover *tends to use less nutrients, has poor persistence and is susceptible to pests and diseases, it and may cause bloat, it affects sheep fertility (as contains natural oestrogens), now used in 'sustainable farming systems' as it performs satisfactorily in poor soil fertility and shallow soils.*

11.6.4. Herbs for grazing mixes

Chicory
Yarrow
Plantain
These have been shown to improve the nutrient composition of swards in research by IGER. They reduce leaching losses. Due to the high cost, it is suggested that they are used for particular situations such as on areas where leaching is predominant where there is animal excreta concentrated.

Grazing animals often prefer herbs to grass and clover. It is considered that herbs are beneficial to swards but there is not scientific evidence to support this. It is difficult for herbs to survive in a grass and clover mix and with hard grazing and in rotational pastures. In permanent pastures, herbs can prosper either if indigenous or sown.

11.6.5 Grassland wildflower Species to encourage on embankments

Wet locations
Cowslip *often difficult to establish*
Ragged robin
Meadow sweet
Great burnet

Dry locations
Daisy
Plantain
Lady's bedstraw
Sorrel *can be rather tall, which may not be acceptable to EA managers*
Yarrow
Cats'ear

Herbs
Betony
Knapweed

Poor soil
Grass
Quaking grass
Cocksfoot
Sheeps fescue
Red Fescue
Meadow Oat

Poor soil broad-leaved
Salad burnet
Lady's bedstraw

Dwarf thistle
Plantains

12 SUMMARY OF RECOMMENDATIONS

12.1 Recommendations for changes to existing management

- Reduce cutting frequency on sites containing wildflowers
- Vary timing (from year-to-year) of the omission of cut
- Tailor cutting frequency to fertility of individual sites
- Target management aimed at encouraging species-rich flora on low-moderate fertility sites
- Consider using poorer soil on new embankments where sowing wildflowers is planned
- On grazed embankments, ensure that certain areas are not avoided altogether (e.g. by fencing stock onto slopes for certain periods at sites where this has been a problem although the increased risk of erosion by stock must be considered)
- Encourage diversity of vegetation types at particular sites
- Make use of berm areas for hay making with aim of reducing fertility over time, and graze aftermath where possible
- Reconsider whether using fertilisers at establishment to speed establishment is worth subsequent need for frequent cutting (Elaborate on this)
- Consider using a greater variety of species in 'standard' and 'low-maintenance' mixes
-

12.2 Recommendation for trials work

To investigate the effects of variations in cutting frequency and timing on the number of species both flowering and able to set seed at species-rich sites. This may require missing out one of the standard cuts.

To investigate the optimum cutting regime for nutrient offtake, by measuring yield and nutrient composition of cut vegetation on fertile and moderately fertile sites.

To determine the optimum cutting interval to minimise damage to vegetation when cuttings are left *in situ* as influenced by soil fertility, using two contrasting sites.

To determine the effect of removal of vegetation at cutting on subsequent vegetation growth both within the same season and in following years.

To evaluate the role of growth regulators with reference to the work by the Centre for Aquatic Plant Management. This would need to take into account the efficacy (already shown) and the economic and environmental implications of using such a material.

To undertake seed mix trials using wet and dry mixes, and compare existing standard and low maintenance mixes with alternatives for speed of establishment and growth. There are trials sites already established which could be evaluated as part of this (Appendix 7).

To determine the effect of establishing seed of low maintenance and wildflower mixes on new embankments.

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Water Maintenance specification 4 Grass Cutting (Midland Region of the Environment Agency)

APPENDIX 1 QUESTIONNAIRE

ENVIRONMENT AGENCY W5A (96) 01 MANAGEMENT OF VEGETATION ON RAISED EMBANKMENTS

Management information needed (please complete for individual sites, separate forms for different management or orientation etc)

1. Location
a. OS Reference
b. Access details for assessors
c. Contact for permission

2.Topography
a. Flood embankment
By watercourse
At a distance

b.Coastal
Riverine

c. Saline
Not saline

d. Adjacent land use
Side 1 (1.e. towards watercourse/sea)
Side 2

e. Orientation of slope (North/West etc)
Side 1
Side 2

f. Gradient of slope (1 in 3 or 33% of angle to vertical)
Side 1
Side 2

3. Recent History
a.When was the embankment built?
b. When was the embankment sown?
c. Do you know the origin of the soil? (topsoil/subsoil)

4.Vegetation
a. What technique was used to establish the vegetation?
Sown
Mix used.

Turf
Source

Planted species
Type

Natural regeneration

b. Establishment of the vegetation

Is the cover 100%

Is the cover apparently uniform?

Has introduced seed/turf taken well, partially or not at all?

Are weeds dominant?

Any comments

c. Management of the vegetation
Main method
Mowing
Herbicide
Growth regulator
Grazing
Other

Other method used

Any experience of other methods tested or trialled

d. Have there been any surveys done on the vegetation?

If so, please give details and contacts if possible

APPENDIX 2 INFORMATION SPREADSHEET

Site No	OS Ref No	Location	1 top	2 date	3 soil	4 est	5 man	6 seed	Assessed	Species	Comments
1	SK438303	R Trent Shardlow	f,w	1995	ic=s il=t	s	g	gm	21/07/97	11	sown plants present
2A	SK773956	Mother Drain Misterton	f,w	1981	lo	s	h	s?	21/07/97	25	dense (uncut)
2B	"	"	f,w	1981	i/lo	s	h	s?	21/07/97	38	species rich
2C	"	River Idle Misterton	f,w	1981	i	s	m(f)	ng	21/07/97	39	little topsoil, species rich
2D	"	"	f,w	1981	i	s	m(f)	s	21/07/97	8	fertile, grass dominated
3	SK785950	R. Trent W. Stockwith	f,w	1973	rd	s	m(f)	s	03/09/97	27	better cover on S'face
4A	SK806858	R. Trent Sturton	f,w	1963	lo,c	s	g	s/gm	03/09/97	16	berm vegetation suggests previously hay?
4B	"	"	f,w	1963	lo,c	s	g	s/gm	03/09/97	18	
5A	SE840062	Bottesford Beck, Butterwick	f,w	1974/1993	lo		m		02/09/97	38	grazed by rabbits, wildflower mix?
5B	"	"	f,w	1974/1993	lo		m		02/09/97	28	species rich-wildflower?

Site No	OS Ref No	Location	1 top	2 date	3 soil	4 est	5 man	6 seed	Assessed	Species	Comments
6A	SE680034	R. Torne Acomb	f,w	1980	lo,rd	s	m (f)	lm	02/09/97	31	lush
6B	"	"	f,w	1980	lo,rd	s	m(f)		02/09/97	24	lush
7	SE855144	R. Trent Amcotts	t,w	1972	rd	s	m(f)		21/07/97	11	dominated by 2 spp
8A	TA335185	Humber	t	1980		s	m		19/08/97	25	landward side
8B	"	Humber	t	1980		s	m		19/08/97	6	sea wall, saline plants
9	TA108394	Monk Dyke	f,w			s		ng?	19/08/97	8	rank, coarse grass
10	SK161311	R Dove Sudbury	f,d	1969-70	lom/m =s lo/l=t	s	g-c	pr+c	21/08/97	14	uniform, improved grass
11	SK235028	R Trent Burton-on-Trent	f	1960	ia=s lo/l=t	s	m(f)	pr+c	21/08/97	40	poor grass cover, weedy
12	SK205034	R. Tame Tamworth	f,d	1960	lo/m=s l/lo=t	s	m(f)	pr+c	21/08/97	28	
13	SJ955535	Endon Brok Denford	f,d	1982	lo=t	s	mf	pr+c	21/08/97	18	
14A	TF664369	Sea Bank @ Heacham	f,d			s	g-c		30/08/97	25	little saline effect

Site No	OS Ref No	Location	1 top	2 date	3 soil	4 est	5 man	6 seed	Assessed	Species	Comments
14B	"	Sea Bank @ Heacham	f,d			s	m		30/08/97	21	little saline effect,good habitat
15A	TL610922	Brandon Creek	f,w	1960		s	m		30/08/97	19	rank, grasses
15B	"	"	f,w	1960		s	g-c		30/08/97	17	poaching, some interest
16	TA630473	River Hull Watton Beck	f,w				g-s	pr+c	19/08/97	40	species rich (management effect)

KEY					
1	f	fluvial	4	s	sown
	t	tidal		t	turf
	w	by watercourse		p	planted
	d	at a distance from watercourse	5	g	grazed c: cattle s: sheep
2	**Age of embankment**			m	mown
	o	old		m(f)	mown frequently
	n	new		n	no maintenance
3	**Subsoil/topsoil source**		6	**Seed mix**	
	rd	river dedging lo local		s	standard
	i	imported m marl (clay + lime mix)		lm	low maintenance
	c	clay a ash (paver station)		p r+c	perennial ryegrass & claver
	l	loamy		wf	wildflower mix

APPENDIX 3 CASE STUDIES

W5A (96) 01 Site vegetation survey Site 1

Location name	OS ref.	Date surveyed	Surveyed by:
Shardlow (Trent and Mersey Canal)	SK438303	21/07/97	F.W. Kirkham

Species	DAFOR	Species	DAFOR
Side 1:			
Lolium perenne	D		
Phleum pratense	F		
Taraxacum officinale	R		
Trifolium repens	F		
Side 2:			
Cirsium arvense	O/A	*Artemisia vulgaris*	O
Cirsium vulgare	O		
Lolium perenne	D		
Phleum pratense	F		
Taraxacum officinale	R		
Trifolium repens	O		
Urtica dioica	O		
Notes:			
Side 1 grazed with sheep autumn/winter after establishment, steers in 1996. Cut twice for silage so far in 1997. Side 2 ditto, but uncut in 1997			

W5A (96) 01 Site vegetation survey Sites 2A and B

Location name	**OS ref.**	**Date surveyed**	**Surveyed by:**
Misterton Soss (Mother Drain, Lengths A and B)	SK7759956-777955	2/9/97	F.W.Kirkham

Species	DAFOR		Species	DAFOR	
Length:	**A**	**B**	**Length:**	**A**	**B**
Achillea millefolium	F	F	*Knautia arvensis*	-	O
Agrostis capillaris	O	F	*Lapsana communis*	-	R
Agrostis stolonifera	A	F	*Leontodon hispidus*	-	O
Anthriscus sylvestris	O	-	*Leontodon taraxacoides*	-	R
Arrenatherum elatius	D	F	*Leucanthemum vulgare*	R	F
Bellis perennis	-	F	*Lotus corniculatus*	-	O
Centaurea nigra	R	F	*Lotus corniculatus*	-	O
Cirsium arvense	D/A	O	*Medicago lupulina*	-	A
Cirsium vulgare	R	O	*Phleum pratense*	O	-
Convolvulus arvensis	A	-	*Plantago lanceolata*	F	A
Crataegus monogyna	-	R	*Potentilla reptans*	R	A
Dactylus glomerata	D/A	A	*Primula veris*	-	R
Deschampsia caespitosa	-	R	*Prunus spinosa*	F	O
Dipsacus fullonum	O	O	*Ranunculus acris*	-	O
Elymus repens	F	-	*Ranunculus bulbosus*	-	O
Festuca pratensis	-	A	*Rosa canina*	-	O
Festuca rubra	O	A	*Rubus fruticosus*	-	R
Galium verum	-	R	*Rumex obtusifolius*	O	R
Geranium pratense	F	-	*Sanguisorba officinalis*	-	R
Glechoma hederacea	O	O	*Senecio jacobaea*	R	A
Heracleum spondylium	F	-	*Taraxacum officinale*	O	O
Hypericum perforatum	-	O	*Trifolium pratense*	-	R
			Vicia cracca	-	O

Notes: A = main length of bank (c. 200m); B = c. 30m length at W end

W5A (96) 01 Site vegetation survey Site 2C

Location name	OS ref.	Date surveyed	Surveyed by:
Misterton Soss (R. Idle, length C)	SK773956 - 778952	21/07/97	F.W. Kirkham

Species	DAFOR	Species	DAFOR
Achillea millefolium	F	*Lolium perenne*	A/D
Aethusa cynapium	O	*Lotus corniculatus*	F
Alchemilla vulgaris	O/A	*Medicago lupulina*	F
Allium scorodoprasum	R	*Plantago lanceolata*	F
Arrhenatherum elatius	A	*Poa pratensis*	R
Brachypodium pinnatum	O/A	*Potentilla reptans*	O
Centaurea nigra	F	*Primula veris*	R
Dryopteris filix-mas	R	*Ranunculus acris*	O
Festuca rubra	A	*Ranunculus bulbosus*	R
Filipendula ulmaria	F	*Rumex acetosa*	O
Galium mollugo	R	*Senecio jacobea*	O
Galium verum	O/F	*Rumex acetosella*	R
Geranium pratense	A	*Stachys palustris*	R
Helictotrichon pubescens	R	*Taraxacum officinale*	F
Holcus lanatus	O	*Thalictrum flavum*	R
Hypericum perforatum	A	*Trapogon pratensis*	R
Hypochaeris radicata	O/R	*Trisetum flavescens*	R
Lathyrus pratensis	R	*Urtica dioica*	O
Leontodon autumnalis	O	*Vicia cracca*	O
Leontodon hispidus	R		

Notes:

1. Length downstream managed similarly but sown with grass mix (length D): and
2. embankment adjacent to "Mother Drain" at same location (lengths A and B)

1. No distinction made in above list between side 1 (South facing) and side 2. Both looked similar, though side 2 more grass dominant, esp. *A. elatius.*
2. 5-8 ft marginal belt where mower does not reach, providing a different habitat/flora - this section not recorded
3. A section above the railway bridge (Eastern end) slightly different: less grass-dominated with some species not recorded in remaining area:

Briza media	O/F	*Sanguisorba officinalis*	O
Listera ovata	R		

W5A (96) 01 Site vegetation survey Site 2D

Location name	OS ref.	Date surveyed	Surveyed by:
Misterton Soss (R. Idle, length D)	SK778952-782950	21/07/97	F.W.Kirkham

Species	DAFOR	Species	DAFOR
Side 1			
Lolium perenne	D		
Arrhenatherum elatius	A		
Bromus spp.	F		
Rosa canina	R-		
Hordeum secalinum	F		
Alopecurus pratensis	O		
Arctium minus	R		
Alchemilla vulgaris	O		

Notes:

- This area adjacent (downstream) of the Misterton Soss stretch C
- Some areas where bends have been filled in with a flat birm area. These areas harvested for hay, receive fertilizers etc. Completely grass-dominated:

Alopecurus pratensis	F	*Bromus spp.*	D
Arrenatherum elatius	A		

- Marginal areas unmown (not reached by mower). No attempt to assess veg. in these areas, but commonest species =

Angelica sylvestris	O	*Rosa canina*	F
Crataegus monogyna	O	*Thalictrum flavum*	O
Chamaenerion angustifolium	A	*Urtica dioica*	A
Impatiens glandulifera	A		
Side 2			
Lolium perenne	D		
Arrhenatherum elatius	A		
Bromus spp.	O		
Hordeum murinum/secalinum	O		
Tussilago farfara	O		

W5A (96) 01 Site vegetation survey Site 3

Location name	OS ref.	Date surveyed	Surveyed by:
West Stockwith (Idle)	SK785940	21/07/97	F.W.Kirkham

Species	DAFOR	Species	DAFOR
Side 1			
Lolium perenne	D		
Arrhenatherum elatius	A		
Bromus spp.	F		
Rosa canina	R		
Hordeum murinum/secalinum	F		
Alopecurus pratensis	O		
Arctium minus	R		
Notes:			
• This area adjacent (downstream) of the Misterton Soss stretch • Some areas where bends have been filled in with a flat birm area. These areas harvested for hay, receive fertilizers etc. Completely grass-dominated:			
Alopecurus pratensis	F	*Bromus spp.*	D
Arrenatherum elatius	A		
• Marginal areas unmown (not reached by mower). No attempt to assess veg. in these areas, but commonest species =			
Angelica sylvestris	O	*Rosa canina*	F
Crataegus monogyna	O	*Thalictrum flavum*	O
Chamaenerion angustifolium	A	*Urtica dioica*	A
Impatiens glandulifera	A		
Side 2			
Lolium perenne	D		
Arrhenatherum elatius	A		
Bromus spp.	O		
Hordeum murinum/secalinum	O		
Tussilago farfara	O		

W5A (96) 01 Site vegetation survey Site 4

Location name	OS ref.	Date surveyed	Surveyed by:
Sturton P.S. R. Trent	SK 806 858	3/9/97	F.W. Kirkham

Species	DAFOR		Species	DAFOR	
Area (see note below):	**A**	**B**		**A**	**B**
Achillea millefolium	F	O	*Geranium molle*	F*	-
Agrostis stolonifera	R	O	*Heracleum spondylium*	-	R
Alopecurus pratensis	-	O	*Holcus lanatus*	O	F
Anthriscus sylvestris	R	O	*Lolium perenne*	D	A
Arrhenatherum elatius	R	F	*Phleum pratense*	-	O
Bellis perennis	R	-	*Rumex obtusifolius*	-	R
Bromus hordeaceus	F	-	*Sonchus oleraceus*	R	-
Cirsium vulgare	F/A	O	*Stellaria media*	F	F
Dactylus glomerata	O	A	*Taraxacum officinale*	O	O
Elymus repens	-	O	*Trisetum flavescens*	-	R
Festuca rubra	F	O	*Urtica dioica*	R	O

Notes:

1. The area chosen for assessment was a 200m length of embankment and birm area stretching eastwards from the fence surrounding the Sturton pumping station.

2. Embankment appears to have been added to (raised) at some time. There is a top portion (A), identifable by differences in profile, which is noticeably different in composition to the remainder (B). Area B consists of a flat birm area and the lower portion of slope on Side 1. Side 2 appears continuous in the upper and lower portions (i.e., there is an unbroken slope on that side, and was included in area A for the assessment.

3. Although the embankment is grazed by cattle, Side 1 contains a few scattered examples of typical hay meadow species (e.g. *Arrenatherum elatius, Trisetum flavescens*), suggesting a change of management. This may have been as long ago as when the embankment was built in 1963 (*was it added to later than this?*).

4. The current sward is, overall, typical of 'improved grassland and, the birm area at least, probably receives fertilizers.

* *Geranium molle* was frequent over the whole of Side 2, but absent from Side 1.

W5A (96) 01 Site vegetation survey Site 5

Location name	OS ref.	Date surveyed	Surveyed by:
Botteford Beck East Butterwick	SE 845063 (given 840062)	2/9/97	F.W. Kirkham

Species	DAFOR		Species	DAFOR	
Side:	S 1	S 2	Side:	S 1	S 2
Achillea millefolium	O	R	*Heracleum spondylium*	F	A
Agrostis capillaris	A	F	*Holcus lanatus*	R	F
Agrostis stolonifera	O	O	*Lamium album*	O	O
Anthriscus sylvestris	O	F	*Leontodon autumnalis*	O	-
Arctium minus	O	A	*Lolium perenne*	O	O
Arrhenatherum elatius	R	-	*Plantago lanceolata*	F	R
Bellis perennis	O	R	*Plantago major*	O	-
Bryophyta	F	O	*Poa pratensis*	A	F
Carex sp.	O	-	*Polygonum lapathifolium*	F	O
Cerastium fontanum	R	-	*Potentilla anserina*	-	O
Cirsium arvense	O	O	*Potentilla reptans*	F	-
Cirsium vulgare	O	O	*Ranunculus repens*	R	O
Dactylus glomerata	F	A	*Rumex acetosella*	F	R
Erodium circularium	O	-	*Rumex obtusifolius*	A	A
Festuca rubra	A	F	*Senecio jacobaea*	R	-
Geranium dissectum	R	-	*Senecio vulgaris*	O	O
Geranium molle	F	F	*Sonchus asper*	O	-
Glechoma hederacea	A	O	*Stellaria media*	O	R
			Taraxacum officinale	F	O
			Urtica dioica	O	F
			Veronica persica	R	-

Notes:
1. Area assessed is that contained between two fences, a length of about 70m
2. Sides 1 and 2 (S 1 and S 2) assessed separately because notably different.
3. Side 1 heavily grazed by rabbits. Much bare ground, and some rabbit holes

W5A (96) 01 Site vegetation survey Site 6

Location name	OS ref.	Date surveyed	Surveyed by:
River Torne Acombe Bridge	SE 680034	2/9/97	F.W. Kirkham

Species	DAFOR		Species	DAFOR	
Side:	**1**	**2**	**Side:**	**1**	**2**
Achillea millefolium	O	R	*Lolium perenne*	O	A
Anthriscus sylvestris	O	O	*Phleum pratense*	R	-
Arrhenatherum elatius	A	O	*Plantago lanceolata*	O	R
Centaurea nigra	R	-	*Plantago major*	R	-
Chaerophyllum temulentum	R	-	*Polygonum amphibium*	O	R
Chenopodium album	R	-	*Ranunculus repens*	O	O
Cirsium arvense	A	O	*Rumex obtusifolius*	F	F
Cirsium vulgare	O	R	*Senecio jacobaea*	O	-
Dactylus glomerata	O	O	*Senecio vulgaris*	F	O
Elymus repens	O	O	*Sonchus oleraceus*	O	O
Festuca rubra	F	R	*Stellaria media*	O	O
Geranium molle	O	R	*Taraxacum officinale*	F	D/A
Heracleum spondylium	-	R	*Trifolium pratense*	O	-
Holcus lanatus	R	R	*Trifolium repens*	F	R
Hypochaeris radicata	O	R	*Urtica dioica*	A	A
Lolium multiflorum/hybridum	R	A/D	*Vicia cracca*	R	-

Notes:
1. Area assessed about 100m long
1. Unmown marginal area of birm dominated by *Phragmites communis* and *Glyceria maxima,* with *Urtica dioica, Rumex obtusifolius* and *Typha latifolia* abundant.
2. Very lush growth on both birm and embankment (not cut recently)

W5A (96) 01 Site vegetation survey Site 7

Location name	OS ref.	Date surveyed	Surveyed by:
Amcotts (Trent - tidal)	SE855144	21/07/97	F.W.Kirkham

Species	DAFOR	Species	DAFOR
Alopecurus pratensis	O	*Phleum pratense*	D/O*
Anthriscus sylvestris	O	*Plantago lanceolata*	A/O
Arrhenatherum elatius	O	*Plantago media*	O
Dactylus glomerata	A	*Ranunculus repens*	O
Heracleum spondylium	R	*Taraxacum officinale*	A/D
Lolium perenne	D		

Notes:

- One area (opposite wharf on opposite bank) very dominated *by Ph. pratense/D. glomerata* (particularly on side 2). Mixture sown here?
- Flat birm area 10-15 ft wide, managed same as bank - even more grass dominated.
- Marginal strip/lower birm, not managed, dominated by *Phragmites communis*, *Elymus repens*, *Convolvulus arvensis*, *Cirsium arvense*, and occasional *Alnus glutinosa*
- Grass cover varies, poorer at village end where *T.officinale* dominant

W5A (96) 01 Site vegetation survey Site 8

Location name	OS ref.	Date surveyed	Surveyed by:
Easington Drain Humber Estuary	TA 3350-1850 & 2360-1880	19/08/97	AJSherwood

Species	DAFOR	Species	DAFOR
*Agropyron pungens**	O	*Cerastium fontanum*	R
Plantago lanceolata	F	*Cirsium arvense*	R
Trifolium repens	F	*Rumex acetosa*	R
Dactylis glomerata	A	*Tussilago farfara*	R
Potentilla reptans	O	*Elytriga repens*	O
Lolium perenne	F	*Cynosurus cristata*	R
Lotus corniculatus	O	*Vicia* spp	R
Bellis perennis	R	*Festuca rubra*	O
Plantago major	R	*Atriplex* sp	R
*Spergularia media**	O		
Trifolium pratense	R		
Vicia cracca/sativa	R		
Arrentherum elatius	R		
Picris echioides	R		
Trifolium dubium	R		
Festuca arundinacea	R		
Lathyrus pratense	O		
*Atriplex littoralis**	R		
Tripleurospermum inodoratum	R		
*Plantago maritima**	R		
*Plantago coronopus**	O		
*Halimone portulacoides**	R		

W5A (96) 01 Site vegetation survey Site 9

Location name	OS ref.	Date surveyed	Surveyed by:
Monk Dyke	TA 1080-3940 to 1080-4370	19/08/97	AJSherwood

Species	DAFOR	Species	DAFOR
Elytriga repens	D		
Urtica repens	F		
Arrenatherum elatius	A		
Dactylis glomerata	O		
Cirsium vulgare	R		
Galium aparine	R		
Anthriscus sylvestris	R		
Alopecurus pratense	R		

Notes: This embankment lies adjacent to arable fields on one side (at the point of assessment) and the water course on the, which was a slow moving stream/ditch. This water course was approximately 5m wide and was locally dominated by *Glyceria maxima* with *Phalaris arundinacea* and *Sparganium erectum*. There is a public footpath along this bank in both directions but it was obvious that it is not used regularly. The vegetation comprised rank , coarse grasses with tall weed species such as dock and nettles. I was advised by EA that the whole bank was similar. The majority of the vegetation was uncut at the time of my visit but it had been mown along the bank adjacent to the arable field, probably by the farmer. The species present indicate that the bank may have left to naturally regenerate.

W5A (96) 01 Site vegetation survey Site 10

Location name	OS ref.	Date surveyed	Surveyed by:
Dovefields Farm	SK 161311	21/08/97	AJSherwood

Species	DAFOR	Species	DAFOR
Lolium perenne	D		
Trifolium repens	R		
Dactylis glomerata	R		
Capsella bursa-pastoris	R		
Polygonum aviculare	R		
Stellaria media	R		
Taraxacum officinale Agg	R		
Cirsium arvense	R		
Poa annua	R		
Achillea millefolia	R		
Plantago major	R		
Potentilla reptans	R		
Senecio jacobae	R		
Elytriga repens	R		

Notes: This bank bisects a grazed field (grazed by cattle) which has been sown with a rye grass/ clover mix. There was very little else in the way of broad-leaved species, other than those associated with trampling and bare ground caused by poaching. Bare ground was more prevalent on the bank top. Although clover was considered rare on the bank itself, within the field it was more common. This bank was approximately 30-50m away from the river Dove at the point where the assessment took place and was probably about 1 metre high. The vegetation on the bank appeared fairly uniform throughout.

W5A (96) 01 Site vegetation survey Site 11

Location name	OS ref.	Date surveyed	Surveyed by:
Branston Golf Club	SK235208	21/08/97	AJSherwood

Species	DAFOR	Species	DAFOR
Lolium perenne	R	*Ranunculus bulbosus*	R
Trifolium pratense	R	*Senecio jacobae*	R
Dactylis glomerata	F	*Lactua serriola*	R
Festuca rubra	O	*Prunus* spp	R
Alopecurus pratense	R	*Senecio vulgaris*	R
Agrostis capillaris	A	*Campanula rotundifolia*	R
Taraxacum officinale Agg	O	*Reseda luteola**	R
Cirsium arvense	R	*Rubus fruticosus**	R
Arrenatherum elatius	R	*Lamium album*	O
Achillea millefolia	R	*Convolvulus arvensis**	O
Plantago lanceolata	O	*Sambucus nigra**	R
Rumex acetosa	R	*Tanacetum vulgare**	R
Rumex acetosella	F	*Rumex obtusifolius**	R
Elytriga repens	R	*Urtica dioica*	R
Galium verum	O	*Artemisia vulgaris**	R
Crepis capillaris/vesicaria	A	*Cerastium fontanum*	R
Lathyrus pratense	R	*Leucanthemum vulgare*	R
Lotus corniculatus	R	*Trisetum flavescens*	R
Poa pratensis	O		
Centurae nigra	R		
Vicia spp	R		
Cirsium vulgare	R		

Notes: This embankment is adjacent to the golf course, a housing estate and school playing fields for most of its length. On reaching the River Trent, the embankment bends round and at this point is approximately 10m from the river itself, thus providing flood protection for the housing estate, school and associated grounds but not the golf course. The embankment has not established well in terms of grass species but there is a varied mixture of broad-leaved species which tend to give it a 'weedy' appearance. Species marked by an asterix were only recorded on the embankment closest to the river. Generally this section of embankment was grassier with much less bare ground. There was a a lot of dead vegetation i.e. straw/litter which may have originated from mowing but not necessarily. I think many of the plants were drought stressed and / or suffering from components in the soil. There was also a good deal of bare ground giving the more ruderal species plenty of opportunity to become established. The presence of *Rumex acetosella* (Sheep's sorrel) and possibly *Campanula rotundifolia* (Harebell) indicated that the soil was acidic. This was borne out by the notes provided by EA where it states that the subsoil originated from power station fly ash. I suspect that this may also contain substances such as sulphur and possibly other contaminates which may help to explain why the vegetation has not established very well. The top of the bank was very bare and looked like it was made up of old ash/clinker. It is also used by pedestrians and this has caused erosion.

W5A (96) 01 Site vegetation survey Site 12

Location name	OS ref.	Date surveyed	Surveyed by:
Tamworth Borough Council	SK 205034	21/08/97	AJSherwood

Species	DAFOR	Species	DAFOR
Lolium perenne	F	*Leontodon hispidus*	R
Trifolium pratense	F	*Festuca arundinacea*	R
Dactylis glomerata	O	*Galium verum*	R
Festuca rubra	A	*Trifolium dubium*	R
Agrostis spp	A	*Vicia cracca/sativa*	R
Centurea nigra	F	*Deschampsia cespitosa*	R
Taraxacum officinale Agg	O	*Elytriga repens*	R
Cirsium arvense	R	*Lotus corniculatus*	O
Lathyrus pratense	R	*Crepis capillaris/vesicaria*	O
Achillea millefolia	O	*Medicago lupulina*	O
Plantago lanceolata	F	*Anthriscus sylvestris*	R
Potentilla reptans	R	*Bryophyte* spp	O
Senecio jacobae	R	*Tussilago farfara.*	R
		Holcus lanaus	R
		Poa pratensis	R

Notes: The river Tame is a long way from this embankment (100m+). The bank is adjacent to the A4091 Tamworth to Fazely road and is mown regularly. In fact the bank had been mown on the same day that I visited and this has resulted in a very short sward. The bank top has become eroded and is bare in places but this is due to access by vehicles and pedestrians. Both banks were generally similar in appearance, although the bank adjacent to the road was probably more grassy, however this bank side is protected from the road by a hedge. On the other side of the bank there is grass field/park sown to rye grass and clover and approximately 50m away is a large lake between the embankment and the river. There is also a small drain about 30m away from the embankment which contains a nice mixture of aquatic species. Overall this embankment has a relatively rich mix of grasses and herbs although none were particularly uncommon. The whole area comprised a varied mixture of grassland, open water and aquatic vegetation which provided a good habitat for a range of wildlife.

W5A (96) 01 Site vegetation survey Site 13

Location name	OS ref.	Date surveyed	Surveyed by:
Denford Endon Brook	SJ 955535	21/08/97	AJSherwood

Species	DAFOR	Species	DAFOR
Lolium perenne	F		
Rumex obtusifolius	F		
Elytriga repens	D		
Taraxacum officinale Agg	F		
Urtica dioica	O		
Trifolium repens	O		
Ranunculus repens	R		
Poa annua	R		
Plantago lanceolata	R		
Plantago major	R		
Sonchus asper	R		
Senecio jacobae	R		
Tripleurospermum inodoratum	R		
Dactylis glomerata	R		
Polygonum aviculare	R		
Festuca rubra	R		
Agrostis stolonifera	R		
Cerastium fontanum	R		

Notes: This embankment was adjacent to a pub car park (Holly Bush Inn) and Endon Brook was a good 5-10m below the height of the bank with a sttep grass field on the other side. The brook flows through a steep sided valley system. The vegetation compised a grass (couch) dominated bank with little else other than docks and dandelions. Probably originally sown to a rye grass / clover mix as both these species were present albeit at low frequency. It appeared to be unmanaged at the time of the visit although the documentation suggessted that it is mown 4 times a year. Maybe I was looking at the wrong bit! The landlady assured me that the short piece of embankment (approx 50-100m) was all there was and that the brook did flood. In fact the pub was flooded out two years ago. There is a canal on the other side of the pub A very uninteresting embamnkment.

W5A (96) 01 Site vegetation survey Site 14A

Location name	**OS ref.**	**Date surveyed**	**Surveyed by:**
Heacham A		30/08/97	AJSherwood SRRunham

Species	DAFOR	Species	DAFOR
Senicio jacobae	F	*Cirsium vulgare*	R
Elytriga repens	A	*Torilis nodosum*	R
Dactylis glomerata	O	*Malva sylvestris*	R
Plantago lanceolata	O		
Dipsacus fullonum	O		
Cirsium arvense	O		
Rumex obtusifolius	R		
Tussilago farfara	R		
Potentilla reptans	R		
Urtica dioica	O		
Phleum pratense	R		
Arrenatherum elatius	R		
Sysimbrium officinale	R		
Hordeum muralum	R		
Cerastuim fontanum	R		
Trifolium repens	R		
Lactua serriola	R		
Taraxacum officinale Agg	R		
Rubus fruticosus Agg	R		
Ranunculus repens	R		
Agrostis stolonifera	R		
Leontodon hispidus	R		

Notes: This embankment was very weedy in appearance although there was a significant amount of grass underneath these tall herbs, especially couch. The bank vegetation does not seem to be influenced by the proximity of the sea (within 200-300m) although knotted hedge parsley (*Torilis nodosum*) does tend to be associated with dry grassy banks especially close to the sea. The adjacent land use was arable on the south side and a grazed paddock on the north side. This appeared to be grazed by cattle which were able to access the bank but did not appear to have done so, presumably because of the steepness of the banks themselves.

W5A (96) 01 Site vegetation survey Site 14B

Location name	**OS ref.**	**Date surveyed**	**Surveyed by:**
Heacham B		30/08/97	AJSherwood SRRunham

Species	DAFOR	Species	DAFOR
Arrenatherum elatius	A		
Elytriga repens	D/A		
Dactylis glomerata	O		
Plantago lanceolata	O		
Rosa canina	O		
Cirsium arvense	R		
Rumex obtusifolius	R		
Tussilago farfara	R		
Hordeum muralum	R		
Urtica dioica	R		
Phleum pratense	R		
Crataegus monogyna	R		
Sysimbrium officinale	R		
Symphytum officinale	R		
Crepis vesicaria	R		
Trifolium repens	R		
Daucus carota	R		
Lolium perenne	R		
Festuca rubra	R		
Lotus corniculatus	R		
Agrostis stolonifera	R		
Trifolium pratense			

Notes: This embankment was dominated by grasses with some broad-leaved species together with some scrub encroachment. A caravan park is situated on both sides of the embankment. This was separated on one side by a thick hawthorn hedge, providing good habitat for wildlife. The top of the bank is regularly used by pedestrians and especially dog walkers. Here the vegetation tended to be shorter.

W5A (96) 01 Site vegetation survey Site 15

Location name	OS ref.	Date surveyed	Surveyed by:
Brandon Creek	TL 610922	30/08/97	AJSherwood SRRunham

Species	DAFOR	Species	DAFOR
Bank 1(A10/ship pub-west side)		Bank 2 (East side A10)	
Elytriga repens	A	*Lolium perenne*	D
Epilobium hirsuitum	O	*Senecio jacobae*	O
Arrenatherum elatius	A	*Plantago lanceolata*	O
Urtica dioica	R	*Trifolium pratense*	O
Heracleum sphondyllium	R	*Potentilla reptans*	O
Sambucus nigra	R	*Urtica dioica*	R
*Carex riparia**	R	*Trifolium repens*	F
Cirsium arvense	R	*Medicago lupulina*	R
Calystegia sepia	R	*Elytriga repens*	O
*Stachys palustris**	R	*Cirsium arvense*	O
Achillea millefolia	R	*Bryophyte* spp	O
Plantago lanceolata	R	*Carex hirta*	R
Polygonum persicaria	R	*Ranunculus repens*	R
Dactylis glomerata	R	*Ranunculus bulbosus*	O
Malva sylvestris	R	*Plantago major*	R
*Lycopus europaeus**	R	*Equisetum arvense*	R
*Filipendula ulmaria**	R	*Crepis capillaris/vesicaria*	O
Lamium album	R		
Sonchus asper	R		

W5A (96) 01 Site vegetation survey Site 16

Location name	OS ref.	Date surveyed	Surveyed by:
Watton Beck/River Hull	TA 0630-4730 to 0410-4890	19/08/97	AJSherwood

Species	DAFOR	Species	DAFOR
Lolium perenne	A	*Achillea millefolia*	R
Trifolium repens	A	*Bromus hordaceous*	R
Elytriga repens	F	*Galium aparine*	R
Urtica repens	F	*Glyceria maxima***	L D
Arrenatherum elatius	O	*Phragmites australis***	F
Dactylis glomerata	O	*Plantago lanceolata*	R
Deschampsia cespitosa	O	*Sonchus arvensis*	R
Cynosurus cristata	O	*Sonchus asper*	R
Phleum pratense	O	*Phalaris arundinacea*	R
Conium maculatum	F	*Tussilago farfara*	R
*Agrostis stolonifera**	L D	*Senecio jacobae*	R
*Alopecurus geniculatus**	L D	*Eupatorium cannabinum*	R
Cirsium vulgare	R	*Festuca arundinacea*	R
*Epilobium hirsuitum***	O	*Salix* sp	R
Anthriscus sylvestris	R	*Bryophyte* spp	O
Alopecurus pratense	R	*Trifolium pratense+*	O
Cirsium arvense	R	*Festuca rubra+*	R
Carduus nutans	R	*Lotus corniculatus+*	R
Agrostis capillaris	R		
Trifolium dubium	R		
Taraxacum officinale Agg	R		
Rumex obtusifolius	R		

APPENDIX 4
EXAMPLES OF SPECIES MIXES

Examples supplied by Environment Agency Severn Trent
Used on River Torne improvements, started in 1989

Low maintenance mix
Slender creeping red fescue Dawson
Hard fescue Biljart
Annual ryegrass
Chewings Fescue Koket
Fine-leaved sheeps fescue Festalia
Brown Bent Highland
(Seeding rate 100 kg/ha)

Low maintenance mix as provided by seed merchant
Creeping red fescue Boreal
Hard fescue Valda
Chewings Fescue Banner
Hard fescue Ridu
Brown top bent Highland
Annual ryegrass Elunaria Westerwolds

Cost in 1989 £52.50/25 kg

Examples supplied by EA Willerby

Seed mix 1 Sheep grazing only
Pernille (*Festuca rubra ssp Rubra)*
Montagne *(Lolium* perenne (tet))
Oriflamme (*Festuca rubra* ssp.*litorals*)
Wild White Clover (*Trifolium repens*)
Highland Bent (*Agrostic castellana*)
Condesa (*Lolium perenne* (tet))

Seed Mix 2 Cattle grazing only
Sovereign (*Lolium perenne* (dip))
Pernille (*Festuca rubra* ssp *rubra*)
Trani (*Lolium perenene* late Dip)
Alice Clover (*Trifolium* spp)
Tivoli (*Lolium perenne*)

Seed Mix 3 Cattle and Sheep grazing
Pernille (*Festuca rubra* ssp Rubra)
Sovereign *(Lolium perenne* (dip))
Montagne (*Lolium perenne* (tet))
Oriflamme (*Festuca rubra* ssp *litorals*)
wild White Clover (*Trifolium repens*)

Alice Clover (*Trifolium* spp)
Condesa (*Lolium perenne* (tet))
Trani (*Lolium perenne* late Dip)
Tivoli (*Lolium perenne* late tet)

Examples supplied by Anglian Region

<u>Standard deep rooting mix-Ely District</u>
Perennial ryegrass Sisa, Pergamo, Phantoom (one third each)

<u>Standard mix used for 40 years</u>
Perennial ryegrass Magella and Parcour (25% each)
Timothy Motim
Smooth stalked meadow grass
Slender creeping red fescue
Browntop Bent
White clover

<u>Low maintenance mix</u>
Crested dogstail
Perennial ryegrass
Annual ryegrass
Smooth stalked meadow grass
Creeping bent
Creeping red fescue
Timothy
Yorkshire fog
Meadow barley
Sweet vernal grass
White clover

Example supplied by Northumbrian region

Provisional specification for low maintenance mix
smooth stalked meadow grass
hard fescue or
sheeps fescue or
fine-leaved sheeps fescue
Browntop Bent highland
White Clover
Seeding rate 50-150 kg/ha (depending on seedbed conditions.

Example supplied by Northwest region
This region has a comprehensive table of advice entitled 'Table 1 Grass Seed mixes (choice by soil type of grass function)'

APPENDIX 5

COMPOSITION OF RECOMMENDED SEED MIXTURES, seed rates (kg/ha) used in Farm-scale setaside project at ADAS Research Centres. These could be adapted for use in appropriate embankment locations.

Common name	Scientific name	Seed rate (kg/ha) Boxworth	Bridgets
Basic grass mixture (A)	Approx. seed cost	£15/ha	£25/ha
Common bent	*Agrostis capillaris*		0.50
Crested dog's tail	*Cynosurus cristatus*	5.00	3.00
Red fescue	*Festuca rubra* var. *rubra*		5.00
Italian rye-grass	*Lolium multiflorum*		3.50
Late perennial rye-grass	*Lolium perenne*	5.00	
Smooth meadow-grass	*Poa pratensis*	5.00	3.00
	Total seed rate	15.00	15.00
Tussocky grass mixture (B)	Approx. seed cost	£17/ha	£34/ha
Cocksfoot	*Dactylis glomerata*	3.75	3.00
Tall fescue	*Festuca arundinacea*		4.00
Red fescue	*Festuca rubra* var. *rubra*	2.25	5.00
Late perennial rye-grass	*Lolium perenne*	7.50	
Timothy	*Phleum pratense*	1.50	3.00
	Total seed rate	15.00	15.00
Diverse grass mixture (C)	Approx. seed cost	£70/ha	£90/ha
Common bent	*Agrostis capillaris*	0.75	0.50
Sweet vernal-grass	*Anthoxanthum odoratum*		0.10
Quaking-grass	*Briza media*		0.10
Upright brome	*Bromus erectus*		0.10
Crested dog's tail	*Cynosurus cristatus*	3.00	2.00
Sheep's fescue	*Festuca ovina*	3.00	4.00
Red (chewings) fescue	*Festuca rubra* ssp. *commutata*	2.25	4.00
Slender red fescue	*Festuca rubra* ssp. *pruinosa*	3.75	
Small timothy	*Phleum pratense* ssp. *bertolonii*		1.70
Smooth meadow-grass	*Poa pratensis*	2.25	2.00
Yellow oat-grass	*Trisetum flavescens*		0.50
	Total seed rate	15.00	15.00

Mix C Heavy soils, clays, demolition and quarry affected soils
Low maintenance (0-3 cuts per year)
Creeping red fescue Boreal
Annual meadow grass Reptans
Chewings fescue Waldorf
Crested Dog's-tail
Brown-top bentgrass Highland
White clover
Seeding 100-140 kg/ha

Mix G top soil and reasonable subsoil
very hard wearing and rapid germination
requires regular cutting
Perennial ryegrass Sprinter
Smoothstalked meadow grass Julia
Creeping red fescue Waldorf
Browntop bent highland
Seeding rate 250-300 kg/ha

Mixtures used in Farm-scale setaside proj (contd.)

Common name	Scientific name		Seed rate (kg/ha) Boxworth	Bridgets
Grass + wildflower mixture (D)		Approx. seed cost	£300/ha	£262/ha
Diverse grass mixture			15.00	15.00
Yarrow	*Achillea millefolium*		0.24	0.05
Kidney vetch	*Anthyllis vulneraria*			0.03
Black knapweed	*Centaurea nigra*		0.42	0.05
Greater knapweed	*Centaurea scabiosa*			0.04
Basil	*Clinopodium vulgare*			0.02
Wild carrot	*Daucus carota*			0.05
Lady's bedstraw	*Galium verum*		0.42	0.15
Rough hawkbit	*Leontodon hispidus*			0.02
Ox-eye daisy	*Leucanthemum vulgare*		0.30	0.10
Bird's-foot-trefoil	*Lotus corniculatus*		0.42	0.05
Black medick	*Medicago lupulina*			0.05
Wild marjoram	*Origanum vulgare*			0.01
Ribwort plantain	*Plantago lanceolata*			0.10
Hoary plantain	*Plantago media*			0.02
Cowslip	*Primula veris*		0.30	0.03
Selfheal	*Prunella vulgaris*		0.45	0.06
Meadow buttercup	*Ranunculus acris*		0.45	
Salad burnet	*Sanguisorba minor*			0.15
Pepper saxifrage	*Silaum silaus*			0.02
		Total seed rate	18.00	16.00
Bee mixture (E)		Approx. seed cost	£35/ha	
Phacelia	*Phacelia tanecetefolia*		2.80	
Buckwheat	*Fagopyrum esculentum*		1.75	
White mustard	*Sinapsis alba*		0.49	
Coriander	*Coriandrum sativum*		0.42	
Field marigold	*Calendula officinalis*		0.35	
Black cudmin	*Nigella sativa*		0.35	
Red radish	*Raphanus sativus*		0.21	
Cornflower	*Centaurea cyanus*		0.21	
Common mallow	*Malva sylvestris*		0.21	
Dill	*Anethum graveolens*		0.14	
Borage	*Borago officinalis*		0.07	
		Total seed rate	7.00	
Wild bird mixture (F)		Approx. seed cost		£146/ha
Thousand headed kale	*Brassica napus*			3.00
Quinoa	*Chenopodium quinoa*			5.00
Sunflower	*Helianthus annua*			15.00
Buckwheat	*Fagopyrum esculentum*			8.00
Lucerne	*Medicago sativa*			2.00
		Total seed rate		33.00
Ley mixture (H)		Approx. seed cost		£31/ha
Italian ryegrass	*Lolium multiflorum* var Atalja			14.00
Italian ryegrass	*Lolium multi.* var Bartissimo			12.00
Inter. Perennial ryegrass	*Lolium perenne* var Merlinda			5.00
		Total seed rate		31.00

APPENDIX 6

WILDFLOWER AND GRASS SEED POLICY FOR THE ENVIRONMENT AGENCY

1.0 INTRODUCTION

1.1 This paper addresses the subject of wild flower and grass seed supply, specifically with regard to the issue of biodiversity and the effects of the use of non-native seed. It recommends improved environmental practice for specification and procurement.

1.2 It does not consider the many complex issues regarding the technical aspects of establishment and management of grass and wildflowers such as the type of site, previous use, site preparation, existing dormant seed, and the sowing and management, all of which are important. The provenance of trees and shrubs is also excluded from this paper as these are generally supplied from a different but related market.

2.0 ENVIRONMENTAL POLICY

2.1 The Environment Agency (EA) is committed to achieving best environmental practice for all its activities including the specification and purchase of wildflower and grass seed.

2.2 The EA is also bound directly by its statutory obligation towards sustainable development under the Environment Act 1995. A key aspect of sustainable development is the need to halt "the loss of animal and plant species and genetic resources" and "to save and enhance biodiversity" (1).

3.0 CURRENT PRACTICE IN THE ENVIRONMENT AGENCY AND IN THE U.K.

3.1 A survey of NRA/EA practice with regard to the procurement of seed mixes and shrubs was undertaken by E.A conservation staff in 1995. This survey was directed at Conservation staff and revealed a high level of awareness of the desirability of local or native provenance. Many staff however stated that when they attempted to actually obtain seed of local native provenance it was impossible due to lack of availability of the species required or the difficulty in obtaining it in the time available.

3.2 John Akeroyd's paper "Seeds of Destruction" (2) indicates that much of the wild flower seed utilised by the landscape industry and through the "wild flower" market by the public includes a proportion of seed material that is not strictly British native. He states "the species are correct, or they usually are, but few widespread species are at all uniform and many of the plants sold in Britain are just not the same genetic stock as our native wild flowers". The use of wildflower seed of non-native origin can cause the following problems (as stated by John Akeroyd (2)).

- Confusion as to the natural distribution of natural plants in Britain.
- Confusion of complex and ancient patterns in the landscape and creation of a facsimile of the countryside.
- Competition between native and perhaps more vigorous introduced strains of the same species.
- Crossing between native and introduced plants, leading to erosion of native genotype..

3.3 The key issue with regard to the specification and purchase of wildflower seed is that of crossing between native and introduced plants which could threaten Britain's biodiversity. In Britain the landscape has been so extensively managed and changed by man that few places remain where native plants and habitats exist. Hence it is even more important to maintain this diversity where it exists and if possible to extend the range of native wild flora.

3.4 There is considerable evidence from seed testing, seed suppliers and from direct observation by botanists, ecologists and other specialists that some of the 'wild flowers' being seeded or planted are of non-native origin. For instance Britain imports enormous quantities of seed each year from nearly 100 different countries and at least some of this is utilised in wildflower mixtures.

3.5 Wildflower seed mixtures when checked carefully on sites specifically sown as wild flower meadows have been found to contain variants or sub-species which originate from Southern and Central Europe or further away.

3.6 It is likely that a careful survey of sites where grass mixtures and/or wild flora mixtures have been used would reveal that the Environment Agency, through its use of the general seed supply industry, is contributing to the loss of the biodiversity of the U.K's wild flora.

3.7 Two examples confirm this conclusion:-

(a) the E.A's National Contract for the supply of grass seed and wild flora specifically states that it may not be possible to supply locally indigenous seed material. Four of the six sample mixes supplied with the contract information include a variant of white clover called 'Huia'. As native populations of white clover are hard to find it is likely that this variety is non-native and indeed this is confirmed by trade literature from the same company which states wild white clover may be supplied as an alternative to 'Huia' white clover.

(b) discussions with one of the seed suppliers that takes the greatest care with regard to the provenance of its seeds revealed that they have attempted to supply local seed to the NRA/EA. In view of the E.A's duties they had expected strong interest but this has not yet materialised. In one case they had seed available from a SSSI adjacent to an NRA scheme and contacted the NRA staff concerned but an alternative (non-local) supplier was used for the seed.

3.8 Plantlife has found that many wild flowers with a history of use in the agricultural industry are now found in wild flora mixtures. The varieties supplied tend to be taller than the wild plants as they are then easier to cut by scythe or machinery. Such plants include:-

Red Clover (*Trifolium pratense*)
White Clover (*Trifolium repens*)
Black Medick (*Medicago lupulina*)
Birds Foot Trefoil (*Lotus corniculatus*)
Kidney Vetch (*Anthyllis vulneria*)
Salad Burnet (*Sanguisorba minor*)
Ox-eye daisy (*Leucanthemum vulgare*)
Yarrow (*Achiliea millefolium*)
Corn Marigold (*Chrysanthemum segetum*)

3.9 Grasses are a greater problem than other wild flowers when it comes to genetic origin. Vast quantities of non-native material such as Chewings Fescue (*Festuca rubra subsp commutata*) from North America and New Zealand are utilised in the landscape and agriculture industries. Again the EA National Contract for grass seed is an example of this - the "Freshwater Mixture" contains 20% Chewings Fescue. Where grass seed is classified as an agricultural crop it has been subject to British Standard and EC Regulations on germination, purity and origin. EC Seed Certification aims to ensure that species such as Red Fescue and Crested Dogstail will germinate successfully and the species list has established defined varieties that are acceptable. This process therefore actively selects <u>against</u> genetic variation which would give less reliable germination rates. The EA Contract makes specific reference to this system of seed purity, quality etc.

4.0 BEST ENVIRONMENTAL PRACTICE

4.1 Research has indicated that current best practice with regard to the SPECIFICATION of wild flower and grass seed is as follows (in order of preference):-

(A) To use wild flower and wild grass seed of local provenance ie. of the appropriate vegetation type within the National Vegetation Classification (NVC) and from as close as possible to the site.

(B) If wild flower and wild grass seed of local provenance is not available then the source should be from the same Natural Area as defined by English Nature/Countryside Commission, and of the appropriate NVC type.

(C) If the wild flower and wild grass seed mix is not available from the same Natural Area then it should be of the appropriate NVC type and of U.K. origin.

(D) If wild flower and wild grass seed as required is not available from the U.K. then wild flora seed of the appropriate NVC type and of U.K. origin should be used in combination with the maximum available proportion of wild grasses of U.K. provenance; the remaining grasses may be of non-U.K. origin.

4.2 For the specification of grass seed only it has not yet been possible to identify a supplier able to provide wild grass seed of U.K. only provenance and no specific examples of this being used without wild flowers were found. It appears that this is an application for seed use that needs to be developed as current best practice relies on the use of hybrids of part non-native origin. The EA is likely to require grass only seed mixes to provide immediate vegetative cover on river banks, contractors working areas etc.

4.3 With regard to SUPPLIERS there are several able to meet the specification requirements set out above. The EA appears not to have utilised all possible sources of seed which meet these standards and best practice may currently be achieved more often in external organisations such as the Wildlife Trusts, Local Authorities and the Highways Agency.

4.4 The Wild Flower Seeds Working Group, the U.K. Biodiversity Action Plan Steering Group (3) and many other individuals and organisations have suggested that the sale of local and native provenance seed should be regulated through a National Certification Scheme in combination with a Native Provenance Symbol. So far such a scheme has not been set up and although the EA should support the idea it is likely to be some time before it is realised. In the meantime purchasers are independently monitoring the sources of seed they utilise by working closely with suppliers. It is suggested that pending a more organised National Certification System that the EA needs to take this approach.

5.0 IMPLEMENTATION OF BEST ENVIRONMENTAL PRACTICE IN THE ENVIRONMENT AGENCY

5.1 In order to improve the current practice of the EA the following actions are proposed:-

(A) Specification

The Specifications described above (see 4.1) should be adopted as the basis for the purchase of wild flower and grass seed.

(B) Supply

The suppliers of wild flower and grass seed to the EA should be required to achieve several criteria before being accredited suppliers to the Agency. Only accredited suppliers will be utilised.

The criteria for accreditation shall be:-

- a stated commitment to supply only 100% native wild flower seed in wild flower and grass seed mixes.
- a commitment to supply the maximum available proportion of wild grass seed in seed mixes.

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its remit and operational role the EA has the potential to have significant influence in this area but it has not fulfilled this yet.

The Conservation Technical Group members are therefore asked to nominate a Regional contact for this work(if not the CTG member) and 4-5 staff should be nominated to actively participate in a national working group. Please make your nominated person known at the meeting on 4th/5th September. The working group will conduct most of its business by correspondence/telephone and is likely to meet 3 times in the next 12 months. The working group will report to the Conservation Technical Group.

6.0 SUMMARY

6.1 The Conservation Technical Group is asked to:-

- endorse the proposed best practice as specification and supply of seed and accreditation of suppliers.
- endorse the idea of a National Certification Scheme for Seed Suppliers (to be implemented externally).
- nominate Regional contacts and Working Group members.
- endorse the request that the National Contract for Seed Supply is not re-tendered at the end of the current period (completion 31st December 1996).
- any further comments are invited.
- discuss and agree the process for national adoption.

RICHARD COPAS
Regional Landscape Architect
August 1996

Ref: CTG(96)7

REFERENCES

1. "U.K. Biodiversity Action Plan", HMSO (1995).

2. "Seeds of Destruction", Akeroyd, J. Plantlife (1994).

3. "Importation of Wild Flower Seed", Paper for U.K. Biodiversity Action Plan, Royal Botanic Gardens (1995).

APPENDIX 7
CURRENT TRIALS SITES ON RAISED EMBANKMENTS

1. River Wraysbury-Cambridge Kennels and Church Lammas Embankment
Three seed mixes from Johnsons Seeds were compared. These were:

Mix A
Broadleaved;Yarrow, Black knapweed, wild carrot, ladys bedstraw, meadow cranesbill, rough hawkbit, oxeye daisy, birdsfoot trefoil, ribwort plantain, cowslip,self-heal, meadow buttercup, yellow rattle, common sorrel, bladder campion
(20% in total by weight),

with Grasses (80%) comprising
browntop bent, meadow foxtail, crested dogstail, sheeps fescue, chewings fescue, slender red fescue, smooth meadow grass and yellow oat grass.

Mix B
Agrostis capillaris Highland 10% by weight
Festuca rubra commutata Banner 35% by weight
Festuca rubra Boreal 55% by weight

Mix C
Broadleaved:Sneezewort, black knapweed, meadow sweet, Square stem St Johnswort,
birdfoot trefoil, ragged robin, gypsywort, purple loosestrife, common fleabane,
meadow buttercup, yellow rattle, common sorrel, betony, devilsbit
scabious, common meadow rue (20%)

and grasses (80%) comprising
browntop bent, sweet vernal, meadow foxtail, crested dogstail,
tufted harigrass, sheeps fescue, chewings fescue,
slender red fescue, smooth meadow grass.

The wildflower seeds did not establish generally.

In addition wildflower plugs were planted in 1993. These included
chicory,
meadow sweet,
cranesbill,
ragged robin,
musk mallow and
cowslip.
These were chosen as recorded within the site location (Flora of the London area, Burton, 1983). The wild flower plugs did establish early on and 'some species have done well'.

Site 2
The Ouse Washes SSSI Barrier Banks trial in 1990
Standard WA seed mix used for 40 years (Mix 4)
Perennial ryegrass Magella

Perennial ryegrass Parcour
Timothy Motim
Smooth stalked meadow grass Ensema
slender creeping red fescue Estica
Browntop Bent highland
White Clover Kent Wild White

Low maintenance mix (Mix 1)
Crested dogs tail
Perennial ryegrass Bravo
Annual ryegrass Westerwolds
Smooth-stalked meadow grass Erte
Creeping bent-grass emerald
Creeping Red Fescue Tridano
timothy Motim
Yorkshire Fog
Meadwo Barley Sweet vernal grass
White clover Kent Wild White
12 wildflowers

Low maintenance mix (Mix 2)
Perennial ryegrass Magella
Perennial ryegrass Parcour
Annual ryegrass Westerwolds
Smooth stalked meadow grass Erte
Creeping bent-grass Cobra
Crested dog's-tail
Creeping red fescue 'Tridano'
Browntop Bent Highland
Yorkshire Fog
timothy Motim
White clover Kent Wild White
8 wild flowers

Low maintenance mix (Mix 3)
Perennial ryegrass 'Magella'
Perennial ryegrass'Parcour'
Annual ryegrass Westerwolds
Smoothstalked meadow grass Erte
Creeping bent-grass Cobra
Crested dog's-tail
Creeping red fescue Tridano
Browntop bent highland
Yorkshire Fog
Timothy Motim
White clover Kent Wild white
No wild flowers

APPENDIX 8

WATERCOURSE MAINTENANCE SPECIFICATION FOR THE MIDLAND REGION

Section 4 Grass cutting (reproduced with permission of P Coxhill, EA)

4.1. General

-The contractor shall carry out a preliminary assessment of the areas to be cut and clear items of debris which might damage plant or create a possible hazard to persons or property.

-All grassed areas shall be mowed with approved machines to produce a standard of finish appropriate to the particular area.

-The contractor shall work around existing trees, bushes and reeds at the waters' edge and avoid any obvious bird nesting sites.

-Obstructions to machine work, such as fencelines, bridges, pylons, land drains, outfalls etc. shall be finished off using appropriate means e.g. Strimmers, where specified.

-Cutters to all mowers shall be sharp, properly set and cut the sward cleanly and evenly.

-The contractor shall arrange his cutting patterns to prevent his machinery from crossing paths or driveways other than for reasons of access from completion of one area to the start of the next.

4.2. Floodbanks and berms

-Floodbanks and berms, where applicable, will be maintained over a 12 month period such that the maximum height of the grass is not greater than 250 mm. The grass shall not be re-cut until it has reached a minimum height of 150 mm and the approval of the Engineer has been obtained.

-All mowers shall be set to a cutting height of 75 mm or as directed by the Engineers, but at no time should the cutting height be set to allow 'scalping'.

-The grass on the landward side of a floodbank shall be cut down to a level of 6 metres below the top of the bank or down to land level whichever is the least. In addition a 2 metre wide horizontal strip shall be cut on the riverside berm.

-Where the section of floodbank can not be cut in one visit the top of the bank shall be cut before the slopes. The slopes must be completed within two weeks of the top.

4.3. Watercourse maintenance

-Where grass/vegetation is cut on any river bank it shall be cut to a height of between 100 and 125 mm.

-Where there is to be more than one cut per annum each cut must start and finish at the same point.

-Where the grass is to be cut once per annum the commencement date will be 1 August, completion 1 November after the grass has seeded.

-Where grass is to be cut twice per year within the channel:

1st cut

commencement date 1 June

completion date 1 August

2nd cut

commencement date 1 September

completion date 1 November

4.4. Disposal

-If grass is sufficiently chopped (i.e. by flail mowing or similar) during the grass cutting operations, then the cuttings may be left in situ. Where the density of grass clippings is deemed to be detrimental to the grass sward below the Engineer Representative may direct the grass clippings to be removed from the floodbank and disposed off site.

-Cut grass may be evenly spread on the adjoining land close to the top of the bank, embankment or rear of embankment with the Engineers approval and within any limitations defined in the Environmental appraisal.

-Cut vegetation must not be deposited in bulk so as to form silage. Silage liquor is a pollutant to watercourses.

APPENDIX 9

COMMON NAMES AND SCIENTIFIC NAMES OF PLANTS IN REPORT

Common name	Scientific name
Common bent	*Agrostis capillaris*
Crested dog's tail	*Cynosurus cristatus*
Red fescue	*Festuca rubra* var. *rubra*
Italian rye-grass	*Lolium multiflorum*
Late perennial rye-grass	*Lolium perenne*
Smooth meadow-grass	*Poa pratensis*
Cocksfoot	*Dactylis glomerata*
Tall fescue	*Festuca arundinacea*
Timothy	*Phleum pratense*
Sweet vernal-grass	*Anthoxanthum odoratum*
Quaking-grass	*Briza media*
Upright brome	*Bromus erectus*
Sheep's fescue	*Festuca ovina*
Red (chewings) fescue	*Festuca rubra* ssp. *commutata*
Slender red fescue	*Festuca rubra* ssp. *pruinosa*
Small timothy	*Phleum pratense* ssp. *bertolonii*
Smooth meadow-grass	*Poa pratensis*
Yellow oat-grass	*Trisetum flavescens*
Yarrow	*Achillea millefolium*
Kidney vetch	*Anthyllis vulneraria*
Black knapweed	*Centaurea nigra*
Greater knapweed	*Centaurea scabiosa*
Basil	*Clinopodium vulgare*
Wild carrot	*Daucus carota*
Lady's bedstraw	*Galium verum*
Rough hawkbit	*Leontodon hispidus*
Ox-eye daisy	*Leucanthemum vulgare*
Bird's-foot-trefoil	*Lotus corniculatus*
Black medick	*Medicago lupulina*
Wild marjoram	*Origanum vulgare*
Ribwort plantain	*Plantago lanceolata*
Hoary plantain	*Plantago media*
Cowslip	*Primula veris*
Selfheal	*Prunella vulgaris*
Meadow buttercup	*Ranunculus acris*
Salad burnet	*Sanguisorba minor*
Pepper saxifrage	*Silaum silaus*
Phacelia	*Phacelia tanecetefolia*
Buckwheat	*Fagopyrum esculentum*
White mustard	*Sinapsis alba*
Coriander	*Coriandrum sativum*
Field marigold	*Calendula officinalis*
Black cudmin	*Nigella sativa*
Red radish	*Raphanus sativus*
Cornflower	*Centaurea cyanus*
Common mallow	*Malva sylvestris*

Dill	*Anethum graveolens*
Borage	*Borago officinalis*
Thousand headed kale	*Brassica napus*
Quinoa	*Chenopodium quinoa*
Sunflower	*Helianthus annua*
Buckwheat	*Fagopyrum esculentum*
Lucerne	*Medicago sativa*
Italian ryegrass	*Lolium multiflorum* var Atalja
Italian ryegrass	*Lolium multi.* var Bartissimo
Inter. Perennial ryegrass	*Lolium perenne* var Merlinda
white clover	*Trifolium repens*
brome grass	*Bromus spp*
meadow foxtail	*Alopecurus pratensis*
Tall oat-grass	*Arrhenatherum elatius*
meadow crane's-bill	*Geranium pratense*
black knapweed	*Centaurea nigra*
teasel	*Dipsacus fullonum*
field bindweed	*Convolvulus arvensis*
cow parsley	*Anthriscus sylvestris*
rough hawkbit	*Leontodon hispidus*
lesser hawkbit	*Leontodon taraxacoides*
bird's-foot trefoil	*Lotus cornculatus*
dandelion	*Taraxacum officinale*
dove's-foot crane's-bill	*Geranium molle*
common stork's-bill	*Erodium circutarium*
cut-leaved crane's-bill	*Geranium disssectum*
pale persicaria	*Polygonum lapathifolium*
sheep's sorrell	*Rumex acetosella*
creeping thistle	*Cirsium arvense*
stinging nettle	*Urtica dioica*
broad-leaved dock	*Rumex obtusifolius*
sea couch	*Agropyron pungens*
greater sea-spurrey	*Spergularia media*
Grass-leaved orache	*Atriplex littorlis*
Sea plantain	*Plantago maritima*
buck's-thorn plantain	*Plantago coronopus*
sea purslane	*Halimone protulacoides*
couch-grass	*Elytrigia repens*
Weld	*reseda luteola*
bramble	*Rubus fruiticosus*
ekder	*Sambuscus nigra*
tansy	*Tanacetum vulgare*
Mugwort	*Artemesia vulgaris*
knotted hedge parsley	*Torilis nodosum*
creeping bent	*Agrostis stolonifera*
marsh foxtail	*Alopecurus geniculatus*
red clover	*Trifolium pratense*
red fescue	*Festuca rubra*