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INSTITUTE OF TERRESTRIAL ECOLOGY
(NATURAL ENVIRONMENT RESEARCH COUNCIL)

PROJECT T02003d1
Interim Report to Severn-Trent Water Authority

ESTABLISHING LOW MAINTENANCE SWARDS WITH WILD FLOWERS ON RIVER BANKS

T C E WELLS

Monks Wood Experimental Station
Abbots Ripton
HUNTINGDON
Cambs PE17 2LS

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1 INTRODUCTION

Newly constructed river banks or main flood banks are sown with a grass or grass clover mixture in order to stabilise the bank and to help create a structure which will withstand flooding and occasional inundation. In general, banks within the area covered by the Severn-Trent Water Authority have seaward slopes of 1:2, landward slopes of 1:2.5 and crest widths of about 2 m. Much attention has been given in the past to the use of grass on these banks (see CIRIA Technical Note 71) although it is conceded that regarding the hydraulic engineering aspect "information of practical use is based on ad hoc tests on specific grasses, and development of a general theory is still at an early stage".

In the past, and until very recently, most grass mixtures used on river and flood banks were based on perennial rye grass and clover, occasionally with small amounts of other grasses. The standard seeding mixture was recommended by the grassland officer of the Ministry of Agriculture, Fisheries and Food. Well managed banks were grazed by cattle and sheep, creating a short, dense sward. With the decline in livestock farming in Eastern England, management of the banks has changed. Banks were firstly cut with an Allen scythe, usually twice or more times a season, but this has now been replaced by cutting with flail mowers at intervals of three to four weeks during the summer months. The number of times the banks are cut in a season varies according to weather conditions, but in an average year, the banks may be cut five times. This is clearly costly and the Severn-Trent Water Authority have been looking at ways of reducing the cost for some years.

In 1985, Mr J Pursglove, Senior Landscape Architect with the Water Authority, visited Monks Wood Experimental Station to discusss the possibility of introducing wild flowers onto flood and river banks with the objective of increasing their wildlife interest. Subsequent discussion with staff of the Water Authority established that they were interested in using low maintenance vegetation on flood banks in order to make savings in the cost of grass cutting. If at the same time it was possible to increase and enhance the value of banks for wildlife, by introducing wild flowers into the mixtures, so much the better, particularly in view of the Water Authorities statutory obligation under the Wildlife and Countryside Act, 1981.

Following these meetings, a contract was agreed between the Severn-Trent Water Authority and the ITE with the following objectives:

1. To investigate the establishment of low maintenance grass mixtures on a selected flood bank at Gainsborough, Lincs, by sowing various mixtures into prepared seed beds.

2. To monitor the establishment and subsequent performance of selected forbs (dicotyledons) sown with some of the grass mixtures.

3. To estimate the cost of cutting these mixtures once, twice or three times a year and to assess the most economic combination of mixture and cutting regime required to maintain a given level of appearance and sward quality.

The experiment was planned to have a duration of three years, with a review after that to see if a further two years was necessary to detect changes in floristic composition.

2 METHODS

2.1 Site details and experiment layout

The site chosen for the trial was selected in conjunction with staff of the Severn-Trent Water Authority as representative of the flood banks which they have to protect and manage. It is situated on the west bank of the River Trent in the parish of Beckingham, Nottinghamshire, at NGR43/805906, on the opposite bank to Gainsborough in Lincolnshire (Figure 1). The bank is constructed from a silt-like material, presumably derived from material dredged from the river, or brought in from other sources. In profile, it appears as a steep-sided west-facing bank, 7 m wide, sloping down to an arable field, a flat top, about 5 m in width, and a gently sloping east-facing bank, 8 m wide, which abuts on a flat track which provides vehicular access along the flood bank. To the east of the track is a narrow band of osier (Salix viminalis), with occasional patches of a tall herb community, occupying the zone immediately above the Trent. In winter, and at times of flood, the osier beds and the lower parts of the east facing bank may be inundated.

The grassland on the flood bank, which is currently kept short (<5 cm) by mowing about five times a year, consists principally of perennial rye grass (Lolium perenne), red fescue (Festuca rubra) and a variety of forbs (Table 1). The soil is a silty-loam, with a pH of 7.20 (mean of six readings, taken from the 0–10 cm zone, determined electrometrically in a 1:2½ soil/water paste).

The grassland on a 125 m length of the bank was sprayed with glyphosate on 7 August 1986 to kill the existing vegetation. Two weeks later, the area was cultivated to prepare a seed-bed, but a fine seed-bed was not produced because of the presence of clods and the dead remains of grass roots and other plant debris.

Four blocks, each 30 x 20 m, were marked out on the flood bank on 24 September 1986, the long axis of the plots running north/south. Within each block, six plots, each 5 x 20 m were marked out, the long axis of each plot extending over the steep west facing slope, across the flat top, and down the east facing slope. Six grass mixtures (Table 2) were allocated at random to the six plots within each block. Each plot was divided in half, one half being sown with a wild flower mixture (Table 3) as well as the grass mixture, the other half sown with only the grass mixture.

Detailed plans of the experimental layout are given in Appendix I.

Plots were sown by hand on 24-25 September 1986, followed by a light raking to cover the seed. Grasses were sown at 15 g m^{-2}. The 19 forbs in the wild flower mixture were sown at 0.319 g m^{-2}, which was calculated to provide ten seed of each species per m^{-2}. The amounts of seed of each species of forb used are given in Table 3.

2.2 Vegetation recording

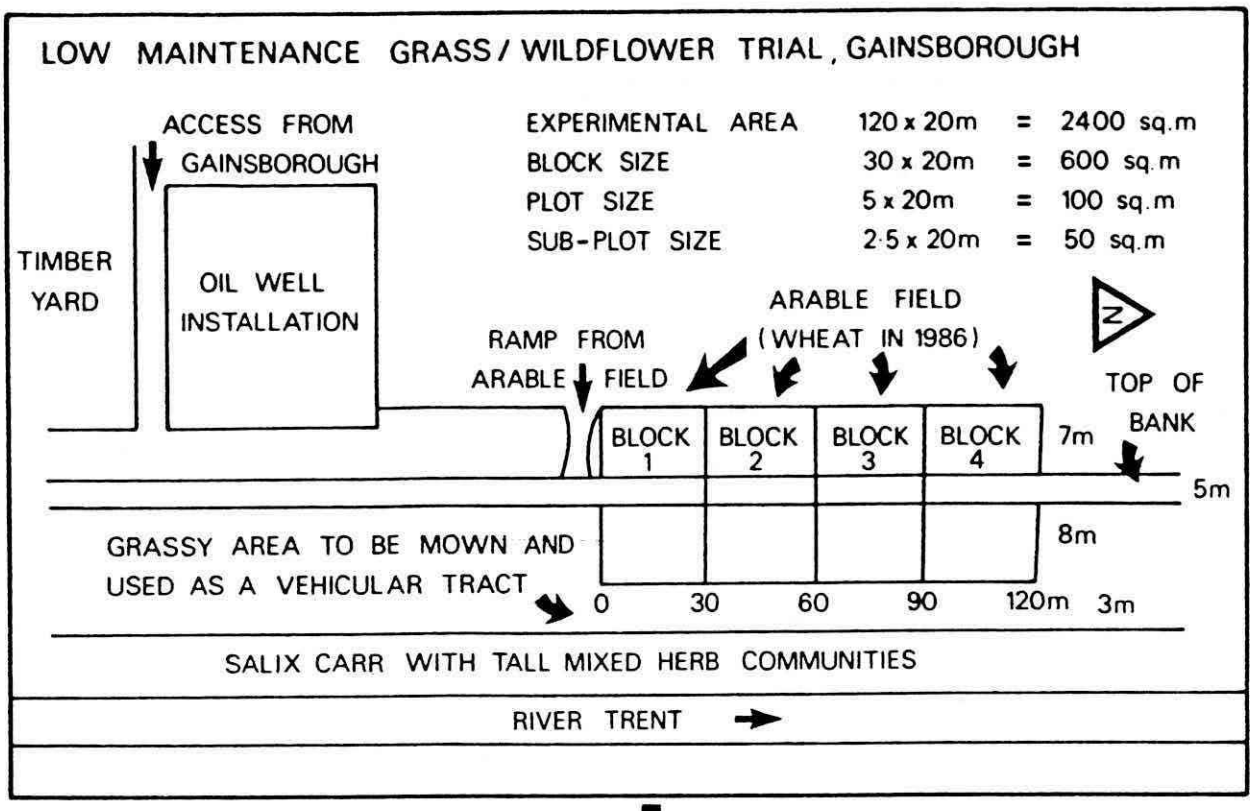
General notes were made on the state of the plots, on the cover and height of vegetation, and of the germination of sown and unsown species on 6 November 1986, 26 November 1986, 24 April 1987 and 17 July 1987. Photographs were also taken on some of these occasions when weather conditions permitted, to supplement the notes. (Plates)

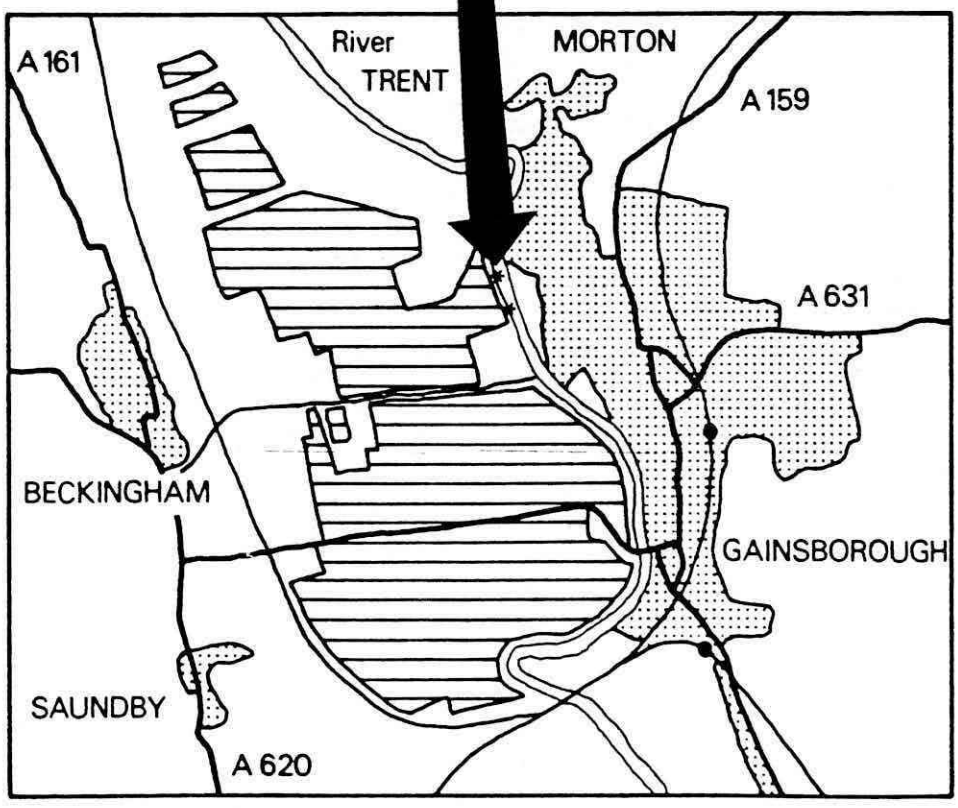
A detailed botanical analysis was made of all plots on the west facing slope in the period 17-20 August 1987. Four, 40 x 40 cm quadrats were located in each sub-plot using a table of random numbers. The percentage cover of all species within a quadrat was estimated by comparison with areas of white card of known cover values. Species occurring within a circle of radius of 0.5 m from the centre of each quadrat, but not within the quadrat were also noted. The mean height of the vegetation was estimated by placing a metre ruler vertically at four places in each quadrat and estimating the height of the canopy.

2.3 Germination tests on grasses and wildflower seeds

It is important to know the viability of seeds sown in this trial. This is especially important in the case of wildflower seeds, as most of these are not presently covered by the Fodder Plant Seeds Regulations 1976 and unlike the grass seeds, do not come with a test certificate, with details of quality, purity and germination. The germination of all wild flower seeds and of all grass seed mixtures (except for the standard Severn-Trent mixture) was tested using a standard test. Five replicates, each of 20 seeds were sown on a water-agar medium in small plastic pots and incubated at 20°C in a germination cabinet, with a 18 h light, 6 h dark daily cycle. The tests were run for 60-70 days. Pots were examined at intervals and those seeds which had germinated were removed. Results are expressed as total germination after 60-70 days and the rate of germination as t_{50}, the time (in days) for 50% germination to be achieved.

Fig. 1. Location and sketch map of trial.





late 1: Flood bank at Beckingham, Notts. 5 Aug 1986, before the sward was sprayed with glyphosate. Note the short turf maintained by flail mowing.

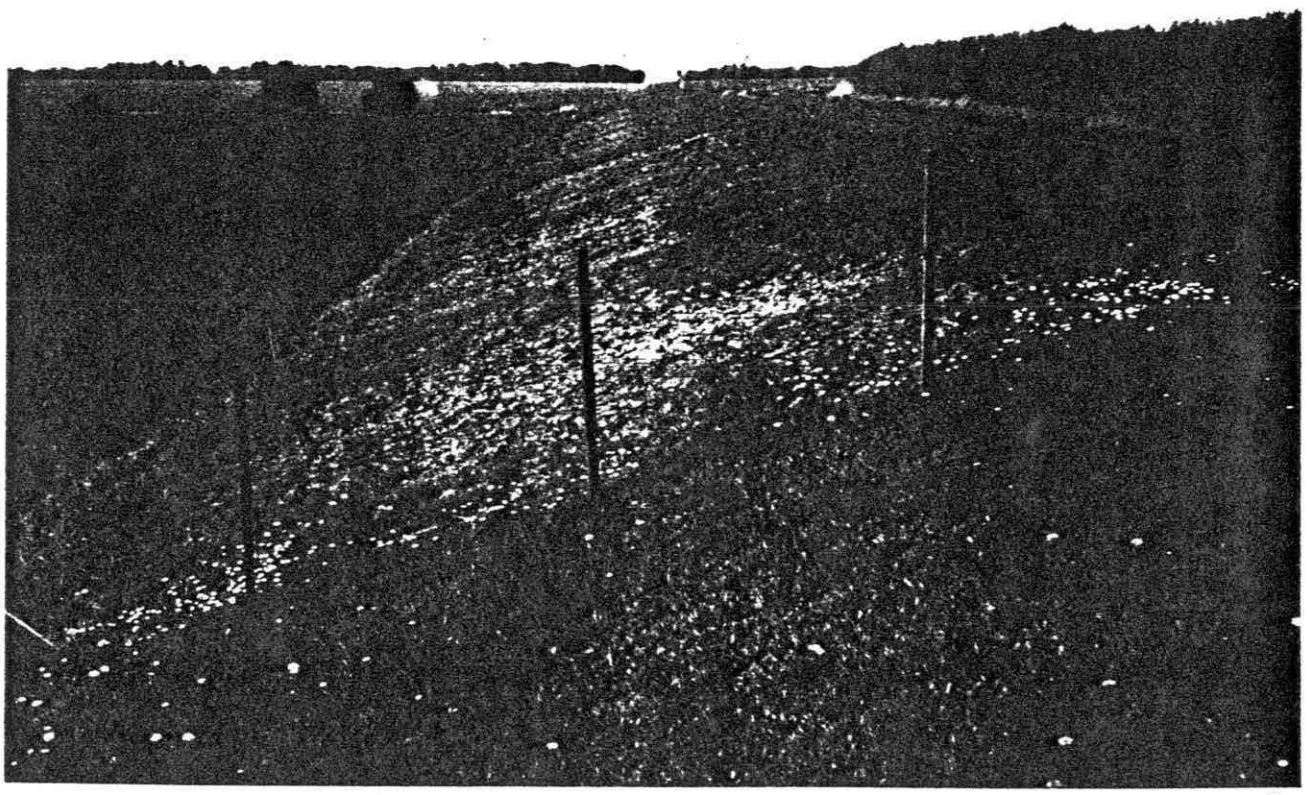


Plate 2: The same bank, 24 April 1987, 7 months after the trial began. Note the high proportion of bare ground on the west facing slope and the bright green plots of Treatment 6 showing the best establishment and cover.

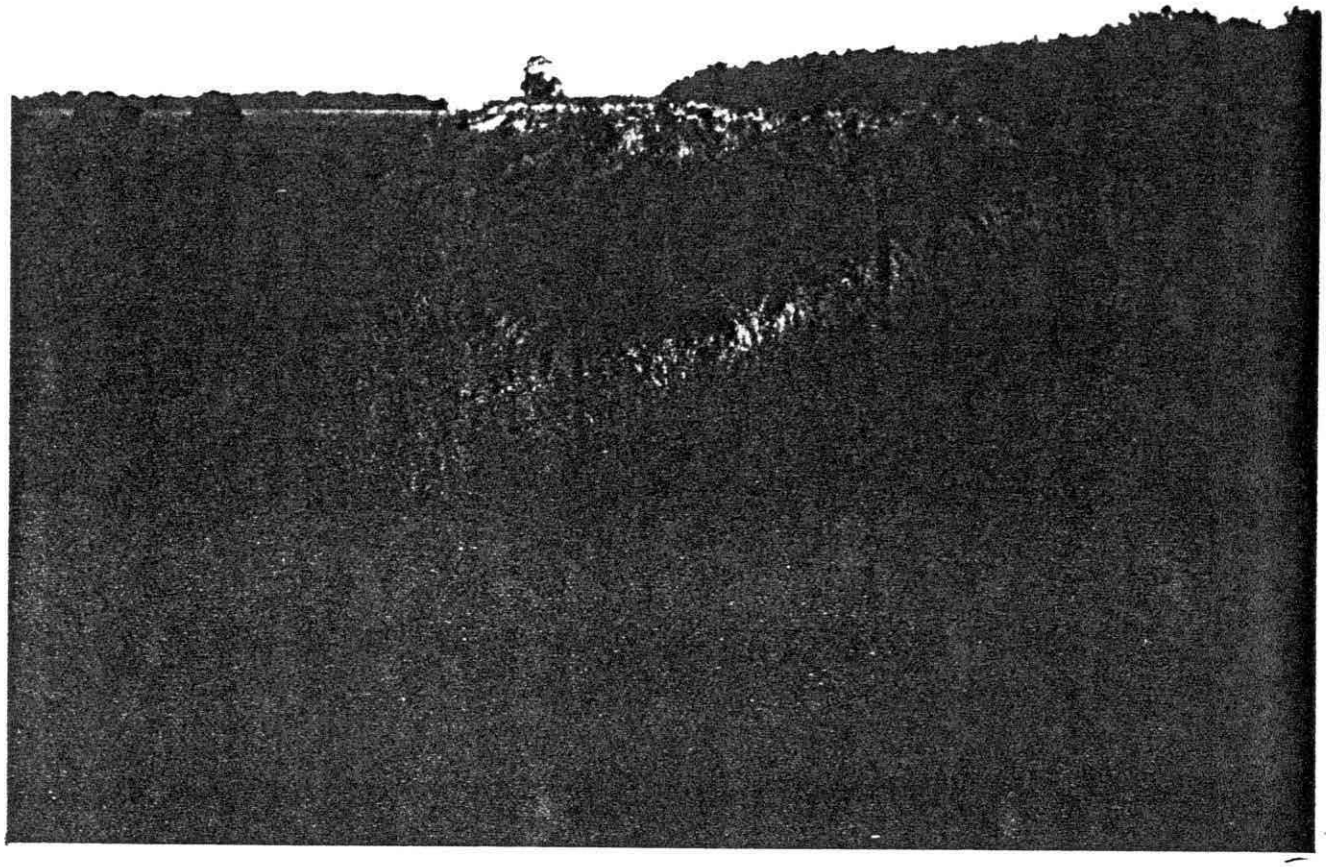


Plate 3: The same bank, 17 July 1987, 10 months after sowing. Note the dense growth of grasses in some plots and the presence of arable weeds, notably Papaver rhoeas, Sonchus asper and Cirsium spp.

Plate 4: Close up on one plot, 24 April 1987 to show hoof prints of horses and damage to establishing grassland by trampling. Note the coarseness of the seed bed and the capped surface.

3 RESULTS

3.1 Initial germination and establishment

Germination of all species after sowing on 24-25 September was extremely slow, probably as a result of dry soil conditions at sowing followed by dry, cool weather during the first half of October. Only 7 mm of rain fell in September (all meteorological data taken from Wiseton, Notts, at NGR43/715 898, 8 km west of Beckingham) and in October, the 41 mm of rain which fell was only 77% of the long term average. When the plots were visited on 11 November 1986, germination of grasses had just begun, but the emerging leaves were less than 2 cm high in all plots, except for those in the Severn-Trent mixture, where some leaves of Lolium perenne reached 4 cm.

Three weeks later, and 62 days after sowing, all plots appeared visibly green when viewed from a distance, with the Severn-Trent mixture standing out bright green and with a higher cover of grasses than in the other mixtures. Mixture two, consisting of Festuca longifolia "Biljart" and F. tenuifolia "Barok" was least satisfactory, with low cover and with leaves still only reaching about 2 cm. A few forbs, at the cotyledon or first true leaf stage were present, but no attempt was made to identify them at that stage.

From the end of November to the end of March, the mean daily air temperature was well below 6°C, and little or no growth occurred in the plots. During this period, the surface of many of the plots on the west facing slope was severely disturbed by horses, but whether they actually grazed the plots is not known. During the winter months, the areas of bare soil became quite badly 'crusted', and there may have been some loss of seed during this period by soil wash down the slope.

When visited on 24 April 1987, 212 days after sowing, vegetation cover in all mixtures on the west facing slope was only between 5 and 10%, except for the Severn-Trent mixture, where cover varied from 30 to 50%. Seedlings of Capsella bursa-pastoris, Taraxacum officinale and Bellis perennis, which had germinated during the winter months, had formed small rosettes, in contrast to the sown forbs which were still at the first or second true leaf stage. The following sown forbs were noted, mostly in small quantity: Leucanthemum vulgare, Medicago lupulina, Sanguisorba minor and Trifolium dubium.

The vegetation on the flat top of the bank was 10-20 cm, and consisted mostly of perennial rye grass which had regenerated from pieces of vegetative material that had not been killed by the herbicide, and numerous rosettes of "weed" species, particularly Sonchus asper, Papaver rhoeas and Rumex obtusifolius. The east facing bank was covered with flotsam deposited when the River Trent flooded during the winter months. The underlying vegetation consisted mostly of species derived from vegetative material not killed by the earlier herbicide sprays and it was decided that all future recording would be restricted to the west facing bank.

3.2 Sward development

Considerable growth of both sown and unsown species occurred between 24 April and 17 July 1987, when the plots were next visited. Cover varied from 67% in mixture 2, to 98% in mixture 6, the other 4 mixtures having cover values of greater than 80% (Table 4). Arable weeds, especially Sonchus asper, Papaver rhoeas and Crepis taraxacifolia were conspicuous and contributed considerably to total cover. Within the general matrix of grasses, and beneath the canopy of grasses and weeds, sown forbs were present but never in any quantity. Fifteen of the 19 sown forbs were found (Table 4) as established plants in the experiment but the number of species in each mixture varied from 4 in mixture 6, to 11 in mixture 1. The plots were cut by the Severn-Trent Water Authority on 1 August, using a tractor mounted flail. The cut material was raked off and deposited at the bottom of each bank.

The results of the detailed botanical recording, made from 17-20 August, two and a half weeks after the plots were cut, are presented in Tables 5 to 7.

There were no significant differences in total vegetation cover, total sown grass cover and total sown forb cover between the different mixtures. Total vegetation cover ranged from 69.4% to 84.2%, total sown grass cover from 45.4% to 71.6%. There were considerable differences between some mixtures which is not apparent from the cover values. Plots containing Lolium perenne (mixtures 1 and 6) were a bright green compared with plots containing Festuca longifolia and Poa spp. (Mixtures 2 and 5). The plots sown with Poa trivialis, which has narrow, prostrate leaves appeared different from species with a more upright habitat of growth, for example Lolium perenne. The fescues, with their more needle-like leaves produced a turf which was structurally different from other species, and it is expected that these differences will be expressed more strongly as the sward develops.

Sown forbs contributed little to total cover. Nevertheless, 17 of the 19 sown species established in at least one mixture; the two species which have yet to be found, Rhinanthus minor and Pimpinella saxifraga may yet still appear, but it is possible that they were washed away before they could germinate, both species requiring vernalisation (a winter cold treatment) before they germinate.

Unsown species ("weeds") originating in the soil seed bank were numerous. 25 species were recorded but most were present in small quantity, except for Taraxacum officinale (mean cover 5.1%), Leontodon taraxacoides (mean cover 2.1%) and Ranunculus repens (mean cover 1.0%) whose rosettes occupied space which might otherwise have been used by sown forbs.

As might be expected, the mean number of species (both sown and unsown) was significantly higher ($p < 0.05$) in plots to which forbs had been added (mean 22±1.09), compared with plots which had been sown with grasses only (mean 14.8±0.91).

3.3 Laboratory seed germination tests

It should be stressed that the germination tests made at Monks Wood are not made under exactly the same standard conditions as carried out by the Official Seed Testing Station at Cambridge. Nevertheless, there are no grounds for believing that our tests are in any way less meaningful than

those made at Cambridge - indeed, the use of alternating 24 hour light/dark cycles, which is more like the conditions seeds receive in the field, may actually enhance germination.

3.3.1 Grass seeds

All 11, of the 13 grass cultivars sown, which were covered by the Fodder Plant Seeds Regulations 1976, reached or exceeded the minimum germination requirement (Table 2). Festuca tenuifolia "Barok" and Agrostis castellana "Highland", not presently covered by the Regulations, had germination percentages of 56 and 68 respectively, which was considerably less than the germination reached by the other 11 cultivars.

With the exception of "Barok", which took 11 days to reach 50% germination, all other cultivars achieved 50% germination or more in 3-5 days and there were no significant differences between them in the rate of germination as measured under standard conditions.

3.3.2 Forbs (wild flower seeds)

Of the 19 forbs included in the mixtures, only two, namely birdsfoot trefoil (Lotus corniculatus) and black medick (Medicago lupulina), are covered by the Fodder Plant Seeds Regulations 1976. Even allowing for the maximum hard seed content (40% for Lotus, 20% for Medicago), neither species reached the minimum germination required under the 1976 Regulations (Table 3).

Eleven of the 19 forbs tested had a percentage germination greater than 70% (Table 3). Of these 11, Leucanthemum vulgare (93%), Prunella vulgaris (98%), Ranunculus acris (97%) and Sanguisorba minor (90%) germinated exceptionally well, as they have done in previous tests.

Three species, hoary plantain (Plantago media), hardheads (Centaurea nigra) and betony (Stachys officinalis) had percentage germination of 40-47%, which is within the range experienced in tests made on other batches of seed in previous years.

Cowslip (Primula veris), yellow rattle (Rhinanthus minor) and burnt saxifrage (Pimpinella saxifrage) are known to require vernalisation before they are able to germinate, a view which is supported by the zero or very low germination achieved in the standard test at 20°C.

4 DISCUSSION

The quick establishment of a vegetation cover on a newly made flood or river bank is of prime concern to the river engineer. Without vegetation, the bank will be eroded by the weather and will be more likely to be breached when flooding occurs. In the Gainsborough trial, establishment initially was slow in all mixtures, whether sown with wild flowers or as simple grass mixtures, and there was an unacceptable period when the bank was exposed and without an adequate cover of vegetation. This applies equally to the plots sown with the standard Severn-Trent mixture, as well as to the other low maintenance mixtures. Poor establishment was probably caused by a number of factors: (i) late sowing, coinciding with a period of low rainfall, followed by low temperatures in October and November, leading to poor germination; (ii) sowing grass seed at 15 g m^{-2}, which is at the lower end of the range of 10-35 g m^{-2} recommended in "Civil engineering specification for the water industry", 2nd edition, 1984; (iii) by not using a general purpose fertilizer (5:15:15) prior to seeding and a post establishment fertilizer (40% area) as is normal practice. Fertilizers were not used as these tend to promote the growth of grasses which in turn would suppress the slow germinating and slower growing forbs. A possible solution to the problem of establishing vegetation quickly would be to use a nurse crop of Westerwolds rye grass, sown at about 10 kg. ha^{-1}, controlling this in spring by early cutting.

It is too early to comment on whether there are differences in the performance of the low maintenance cultivars which could lead to savings in the cost of cutting. The various mixtures have been down for only 12 months and, after a slow start, have achieved a turf which will 'fill out' in the coming months. Differences in performance and height should become apparent by next spring (1988), when it will be possible to compare the growth of the low maintenance cultivars with the standard Severn-Trent mixture.

Despite poor conditions for growth and germination, 17 of the 19 sown forbs have established in at least one plot. At present their contribution to the total cover is small, but this is expected to increase now that competition from unsown ("weed") species has decreased following cutting in August 1987. Some sown species such as Leucanthemum vulgare and Prunella vulgaris are expected to flower in 1988, and provided they are allowed to seed, are likely to spread.

Weeds, originating from both seed in the soil seed bank and from vegetative material not killed by the pre-sowing herbicide treatment were a serious problem during the mid-summer period. These were controlled to some extent by cutting, but would have posed a less serious problem to the developing sward if they had been cut earlier. Many were annuals, and are unlikely to be a problem next year, but the perennials, especially Rumex obtusifolus and Taraxacum officinale will persist and may give cause for concern next year.

The establishment phase of grasslands is always the most difficult and subject to the vagaries of the climate, as well as the special conditions of the site, such as the unknown soil seed bank. Management, particularly the cutting regime will have a profound effect on subsequent floristic and structural development of the sward, and it will be necessary to monitor and record the trial for at least another two years, if meaningful results are to be obtained.

5 ACKNOWLEDGEMENTS

Mr A Frost and Mr R Plant marked out the plots and were responsible for sowing the mixtures. Miss R Cox assisted with the detailed botanical recording, while Mrs E Leeson made the germination tests. Staff of the Severn-Trent Water Authority, under the supervision of Mr D Woodcock sprayed the site and prepared the seed bed, and were responsible for cutting the plots. To all I am most grateful.

6 REFERENCES

Civil engineering specification for the water industry (second edition). 1984. Water Research Centre.

Whitehead, E. 1976. A guide to the use of grass in hydraulic engineering practice. Technical Note No. 71, CIRIA London.

Table 1: The floristic composition of the grassland on the experimental plots before spraying with glyphosate (recorded on the Tansley r, o, f, a scale).

Bellis perennis (common daisy)	o
Cerastium holosteoides (mouse-eared chickweed)	r
Cirsium arvense (creeping thistle)	r
Festuca rubra (red fescue)	o
Leontodon taraxacoides (hairy hawkbit)	f
Lolium perenne (rye grass)	a
Medicago lupulina (black medick)	r
Plantago lanceolata (ribwort plantain)	o
Prunella vulgaris (selfheal)	f
Ranunculus repens (creeping buttercup)	a
Rumex obtusifius (broad-leaved dock)	o
Taraxacum officinale (dandelion)	f
Trifolium dubium (yellow suckling clover)	r
Trifolium pratense (red clover)	r
Trifolium repens (creeping white clover)	o

Table 2: Composition and laboratory germination of 6 grass mixtures sown at Beckingham, Notts on 24 September 1986.

Mixture No.	Species Composition	Amount of seed sown (g) in each $50m^{-2}$ plot	% germination*	t_{50}+ (days)
1	British Seed Houses Low Maintenance Mixture A22			
	Lolium perenne "Lorina"	450.0	95 (80)	4
	Festuca rubra "Logro"	262.5	74 (75)	5
	Agrostis castellana "Highland"	37.5	68	5
2	Festuca longifolia "Biljart"	375.0	87 (75)	4
	" tenuifolia "Barok"	375.0	56	11
3	Festuca rubra "Barfalla"	225.0	90 (75)	4
	Festuca rubra "Frida"	225.0	89 (75)	4
	Festuca rubra "Waldorf"	225.0	90 (75)	4
	Agrostis castellana "Highland"	75.0	68	5
4	Festuca rubra "Merlin"	300.0	84 (75)	4
	Festuca rubra "Artist"	300.0	89 (75)	5
	Agrostis tenuis "Bardot"	150.0	91 (75)	3
5	Poa trivialis "Dasas"	337.5	81 (75)	5
	Poa pratensis "Sobra"	300.0		
	Festuca tenuifolia "Barok"	112.5	56 (75)	11
6	Severn-Trent Standard Mixture			
	Lolium perenne)	412.5)		
	Phleum pratense) Cultivars not	187.5)		
	Poa trivialis) specified	75.0) not tested		
	Cynosurus cristatus)	37.5)		
	Festuca rubra)	37.5)		

* Tested in laboratory at a constant 20°C, in a 18 h light/6 h dark daily cycle.
\+ Time (in days) for germination to reach 50%.
( ) Minimum germination required by the Fodder Seeds Regulation 1976.

Table 3: Composition and laboratory germination of wild flower mixture sown at Beckingham, Notts on 24 September 1986.

Latin Name	English Name	Amount of seed (g)* sown in each 50 m^{-2} plot	% germination+ after 50 days
Achillea millefolium	Yarrow	0.10	81
Bellis perennis	Daisy	0.05	86
Centaurea nigra	Common knapweed	1.00	44
Galium verum	Lady's bedstraw	0.40	74
Leontodon hispidus	Rough hawkbit	0.60	80
Leucanthemum vulgare	Oxeye daisy	0.20	93
Lotus corniculatus	Common bird's-foot-trefoil	1.00	28
Medicago lupulina	Black medick	1.50	12
Pimpinella saxifraga	Burnet-saxifrage	0.35	1
Plantago media	Hoary plantain	0.30	40
Primula veris	Cowslip	0.70	4
Prunella vulgaris	Selfheal	0.60	98
Ranunculs acris	Meadow buttercup	1.10	97
Rhinanthus minor	Yellow rattle	2.00	0
Rumex acetosa	Common sorrel	1.30	76
Sanguisorba minor	Salad burnet	2.30	90
Silene dioica	Red campion	0.40	86
Stachys officinalis	Betony	0.90	47
Trifolium dubium	Lesser trefoil	0.40	76
Total		15.95	

* Calculated to provide about 10 seed per m^{-2}.

\+ Tested in laboratory at a constant 20°C, in a 18 h light, 6 h dark daily cycle.

Table 4: Mean vegetation (%) and number of forbs established in 6 grass/wildflower mixtures on 17 July 1987, 296 days after sowing.

Grass Mixture	1	2	3	4	5	6
% cover	85	67	91	94	80	98
No. of forbs*	11	7	8	8	9	4

* Forbs recorded: Achillea millefolium, Bellis perennis, Centaurea nigra, Galium verum, Leontodon hispidus, Leucanthemum vulgare, Lotus corniculatus, Medicago lupulina, Prunella vulgaris, Plantago media, Ranunculus acris, Rumex acetosa, Sanguisorba minor, Silene dioica, Stachys officinalis.

Table 5: Mean cover (%) of sown and unsown species in 6 grass/forb mixtures, sown on a west-facing flood bank at Beckingham, 24 August 1986. Recorded 17-20 August 1987.
✓ = not in quadrat, but seen elsewhere in plot. - = not sown.
0 = not present.

	Mixture No.					
	1	2	3	4	5	6
Sown Species						
Agrostis castellana	1.30	-	0.75	-	-	-
Cynosurus cristatus	-	-	-	-	-	0
Festuca longifolia	-	45.4	-	-	-	-
Festuca rubra	6.90	-	69.2	67.8	-	0
Festuca tenuifolia	-	-	-	-	2.7	-
Lolium perenne	47.80	-	-	-	-	64.4
Phleum pratense	-	-	-	-	-	5.1
Poa trivialis	-	-	-	-	51.9	0
Achillea millefolium	0.12	0.37	0.25	0.06	✓	tr
Bellis perennis	0.06	0.18	0.06	0.50	0.19	0.06
Centaurea nigra	0.06	✓	✓	0	✓	0
Galium verum	0	0	0	0	0	✓
Leontodon hispidus	0.81	0.37	0.31	0.93	0	0.5
Leucanthemum vulgare	✓	1.25	0.06	✓	0.31	✓
Lotus corniculatus	0.06	0.06	✓	0	✓	0.19
Medicago lupulina	0.37	0	tr	0.06	0.06	✓
Pimpinella saxifraga	0	0	0	0	0	0
Plantago media	0	✓	tr	0	0.12	0
Primula veris	0	0	0	0.06	0	tr
Prunella vulgaris	0.81	0.50	0.56	0.62	0.56	0.12
Ranunculus acris	0.37	0.43	0.31	0.38	0.37	0.19
Rhinanthus minor	0	0	0	0	0	0
Rumex acetosa	0.31	3.00	0.69	1.06	1.12	0.44
Sanguisorba minor	0.06	0.19	0.12	0.37	0.12	0.12
Silene dioica	0.12	0.68	0	0	✓	0
Stachys officinalis	0	0	0	0	0	0.12
Trifolium dubium	tr	✓	0.06	✓	tr	tr

continued

Table 5: (Continued)

	Mixture No.					
	1	2	3	4	5	6
Unsown Species						
Agropyron repens	0.25	0.37	0.19	0.19	0.06	0.06
Agrostis stolonifera	0	0.06	0	0	0.50	0
Cerastium holosteoides	0.12	0.19	0.25	0.25	0	0.12
Chenopodium album	tr	0	0	0	0	0
Chenopodium polyspermum	0	0	0	0	0.12	0
Cirsium arvense	0	0	0	0	0.31	0
Crepis capillaris	tr	0	0	0	0	0
Festuca arundinacea	0	0	0	0.31	0	0
Heracleum sphondylium	0	0	0.06	0	✓	0
Holcus lanatus	0	0	0.06	0.12	0	0
Leontodon taraxacoides	1.69	3.81	0.44	1.12	1.56	0.31
Lolium perenne	0	0.43	0.19	0.62	1.25	0
Phleum pratense	0	tr	0	tr	✓	0
Picris echioides	0	0	✓	✓	0	0
Plantago lanceolata	0	tr	0	0.06	0.06	0
Poa pratensis	✓	0.19	0.75	0.06	0	0
Polygonum aviculare	0.06	0.62	✓	0	✓	0
Ranunculus repens	0.75	1.06	1.81	1.12	1.75	✓
Sonchus asper	0.19	0.25	0.06	0.68	tr	✓
Taraxacum officinale	8.12	12.21	5.18	3.44	6.44	1.56
Trifolium repens	0	tr	0	0	0	✓
Tripleurospermum maritimum	0	0	✓	0.06	0	0
Total No. Species	24	24	23	23	21	17
Bare Ground (%)	29.5	29.7	19.8	20.7	29.0	26.4
Height (cm)	8.9	5.9	9.6	10.9	6.2	12.8

Table 6: Mean cover (%) of sown and unsown species in 6 grass mixtures, sown on a west-facing flood bank at Beckingham, 24 August 1986. Recorded 17-20 August, 1987.
✓ = not in quadrat but seen elsewhere in plot. 0 = not present.
– = not sown.

	Mixture No.					
	1	2	3	4	5	6
Sown Species						
Agrostis castellana	0	–	1.62	0.69	–	–
Cynosurus cristatus	–	–	–	–	–	0.31
Festuca longifolia	–	54.7	–	–	–	–
Festuca rubra	10.40	–	70.0	65.62	–	0
Festuca tenuifolia	–	–	–	–	13.93	–
Lolium perenne	50.0	–	–	–	–	58.4
Phleum pratense	–	–	–	–	–	8.94
Poa trivialis	–	–	–	–	39.12	0
Unsown Species						
Agropyron repens	0.43	✓	0.5	✓	0.06	0.31
Agrostis stolonifera	0.06	1.37	0	0	0.68	0.18
Anthriscus sylvestris	✓	0	0	0	0	0
Atriplex hastata	0	0	✓	0	0	0
Bellis perennis	0.5	0.31	0.5	0.25	0.50	0.06
Cerastium holosteoides	0.13	0.37	0.5	tr	0.06	0.37
Chenopodium polyspermum	0	0	0	0	✓	0
Cirsium arvense	0	0.18	0	0	0	0
Crepis capillaris	✓	✓	✓	0	0.56	0
Heracleum sphondylium	0	0	0	0	✓	0
Holcus lanatus	0.12	✓	0	0	0	0
Leontodon taraxacoides	1.31	2.25	3.0	1.69	7.37	0.68
Lolium perenne	0	0.37	0.62	0.94	0.31	0
Medicago lupulina	tr	0	0.06	0	0.12	0
Papaver rhoeas	0	0	0	0	✓	0
Phleum pratense	0	0	0	✓	tr	0
Picris echioides	0	0	0.31	✓	0	0

Table 6: (Continued)

	Mixture No.					
	1	2	3	4	5	6
Unsown Species (continued)						
Plantago lanceolata	tr	✓	0	✓	✓	✓
Plantago major	0	0	0.12	tr	✓	0
Poa pratensis	tr	tr	0.12	0	0.31	0
Poa trivialis	0	1.87	0	0	0	0
Polygonum aviculare	✓	0.31	✓	0.06	✓	0
Polygonum persicaria	tr	0	0	0	0	0
Prunella vulgaris	0.87	0.25	0.5	0.19	0.93	tr
Ranunculus repens	1.37	1.62	2.06	0.62	0.12	0.19
Rumex crispus	0	0	0	✓	✓	✓
Senecio jacobae	0	✓	0	0	0	0
Sinapis arvensis	0	0	✓	✓	0	0
Sonchus asper	0.25	0.12	0.18	0	3.18	0
Stellaria media	0.06	0	0	0	10.06	0
Taraxacum officinale	3.87	8.06	4.62	5.56	✓	1.87
Trifolium dubium	tr	✓	0	✓	✓	✓
Trifolium pratense	0	0	0	✓	✓	✓
Trifolium repens	✓	0	0	0.12	0	0
Tripleurospermum maritimum	0	✓	0.12	0	0	0.06
Veronica arvensis	0	✓	0	0	0	0
Vicia sp.	0	0	0	0.06	0	0
Total No. Species	18	14	16	13	16	12
Bare Ground (%)	30.7	24.2	16.3	24.7	23.9	28.4
Height (cm)	10.2	6.7	10.8	11.3	6.09	13.5

Table 7: Mean cover (%) of grasses and forbs in 6 grass mixtures, sown with and without wildflower forbs on a west-facing flood bank at Beckingham, 24 August 1986. Recorded 17-20 August 1987.

	1		2		3		4		5		6	
With(+) or without(-) forbs	+	-	+	-	+	-	+	-	+	-	+	-
Sown Species												
Total grasses (%)	56.0	60.4	45.4	54.7	69.9	71.6	67.8	66.3	54.6	53.0	69.5	67.6
Total forbs (%)	3.15		7.03		2.42		4.04		2.85		1.74	
Total sown species (%)	59.15	60.4	52.43	54.7	72.32	71.6	71.84	66.3	57.45	53.0	71.24	67.6
Unsown Species												
Total grasses (%)	0.25	0.61	1.05	3.61	1.19	1.12	1.30	0.94	1.81	1.36	0.06	0.49
Total forbs (%)	10.93	8.36	18.14	13.47	7.80	11.44	6.73	8.55	10.24	22.9	1.99	3.23
Total unsown species (%)	11.18	8.97	19.19	17.08	8.99	12.56	8.03	9.49	12.05	24.26	2.05	3.72
Total sown and unsown species (%)	70.33	69.37	71.62	71.78	81.31	84.16	79.87	75.79	69.50	77.26	73.29	71.32

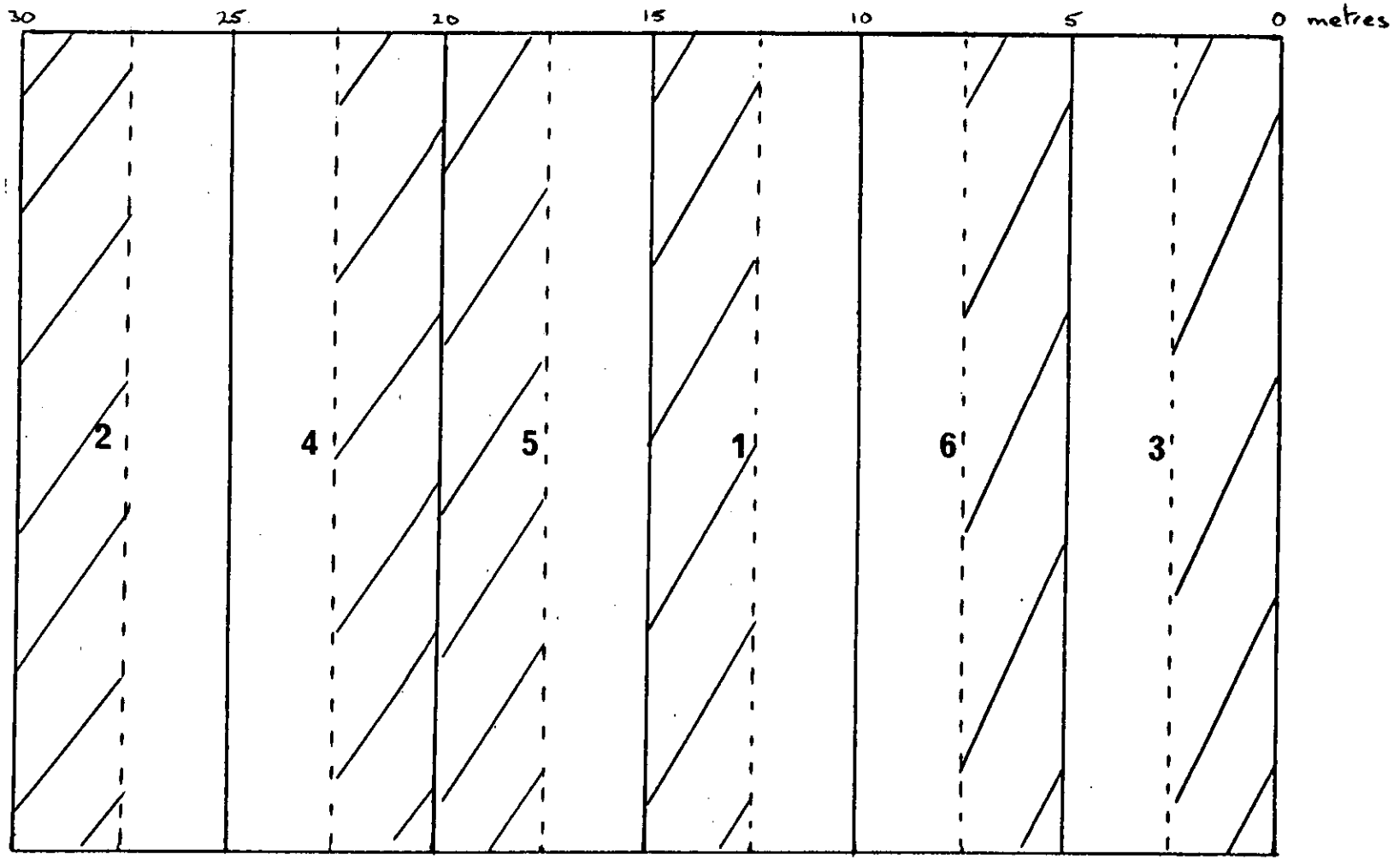
Appendix 1a. Detailed plans of low maintenance grass/wildflower trial, Gainsborough.

Block: 1

N ← RIVER TRENT

① to ⑥ Main Treatments (Grass Mixtures)

Sub-treatments (Wild Flower Mixtures)



ARABLE FIELD.

TREATMENTS

① B.S.H. A22 Low Maintenance Mixture

② 50% F. longifolia "Biljart"
50% F. longifolia "Barok"

③ Festuca/Agrostis mixture (1)
30% F. rubra "Barfalla"
30% F. rubra "Frida"
30% F. rubra "Waldorf"
10% A. castellana "Highlight"

④ Festuca/Agrostis mixture (2)
40% F. rubra "Merlin"
40% F. rubra "Artist"
20% A. tenuis "Bardot"

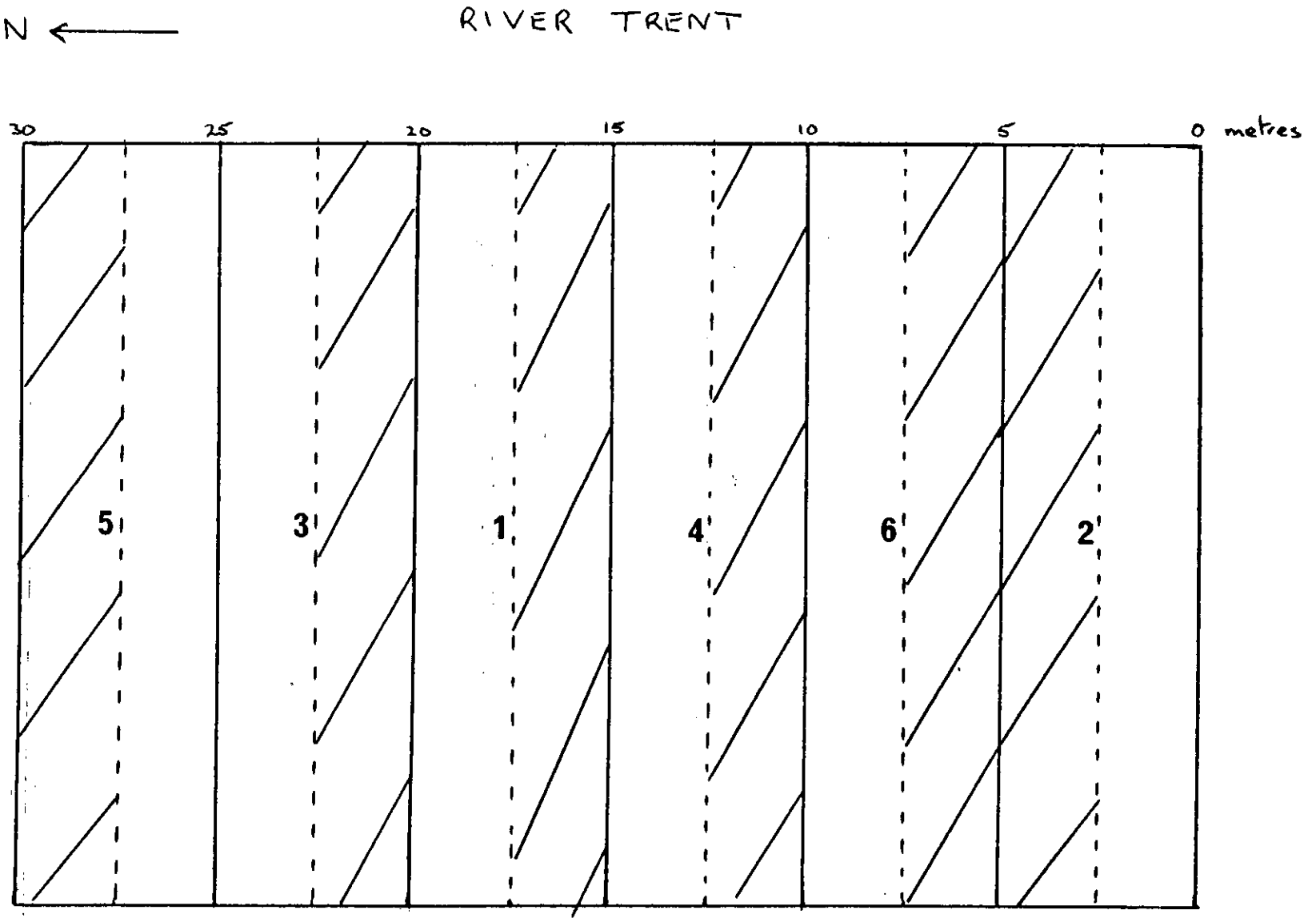
⑤ Poa/Festuca mixture
45% P. trivialis "Dasas"
40% P. trivialis "Sabre"
15% F. tenuifolia "Barok"

⑥ Severn-Trent Standard Mixture
55% Lolium perenne 10% Poa trivialis
25% Phleum pratense 10% Cynosurus/F. rubra.

T.C.E.W.
Aug 1986.

Appendix 1b. Detailed plans of low maintenance grass/wildflower trial, Gainsborough.

Block: 2



① to ⑥ Main Treatments (Grass Mixtures)

Sub-treatments (Wild Flower Mixtures)

TREATMENTS

1) B.S.H. A22 Low Maintenance Mixture

2) 50% F. longifolia "Biljart"
50% F. longifolia "Barok"

3) Festuca/Agrostis mixture (1)
30% F. rubra "Barfalla"
30% F. rubra "Frida"
30% F. rubra "Waldorf"
10% A. castellana "Highlight"

4) Festuca/Agrostis mixture (2)
40% F. rubra "Merlin"
40% F. rubra "Artist"
20% A. tenuis "Bardot"

5) Poa/Festuca mixture
45% P. trivialis "Dasas"
40% P. trivialis "Sabre"
15% F. tenuifolia "Barok"

6) Severn-Trent Standard Mixture
50% Lolium perenne 10% Poa trivialis
25% Phleum pratense 10% Cynosurus/F. rubra.

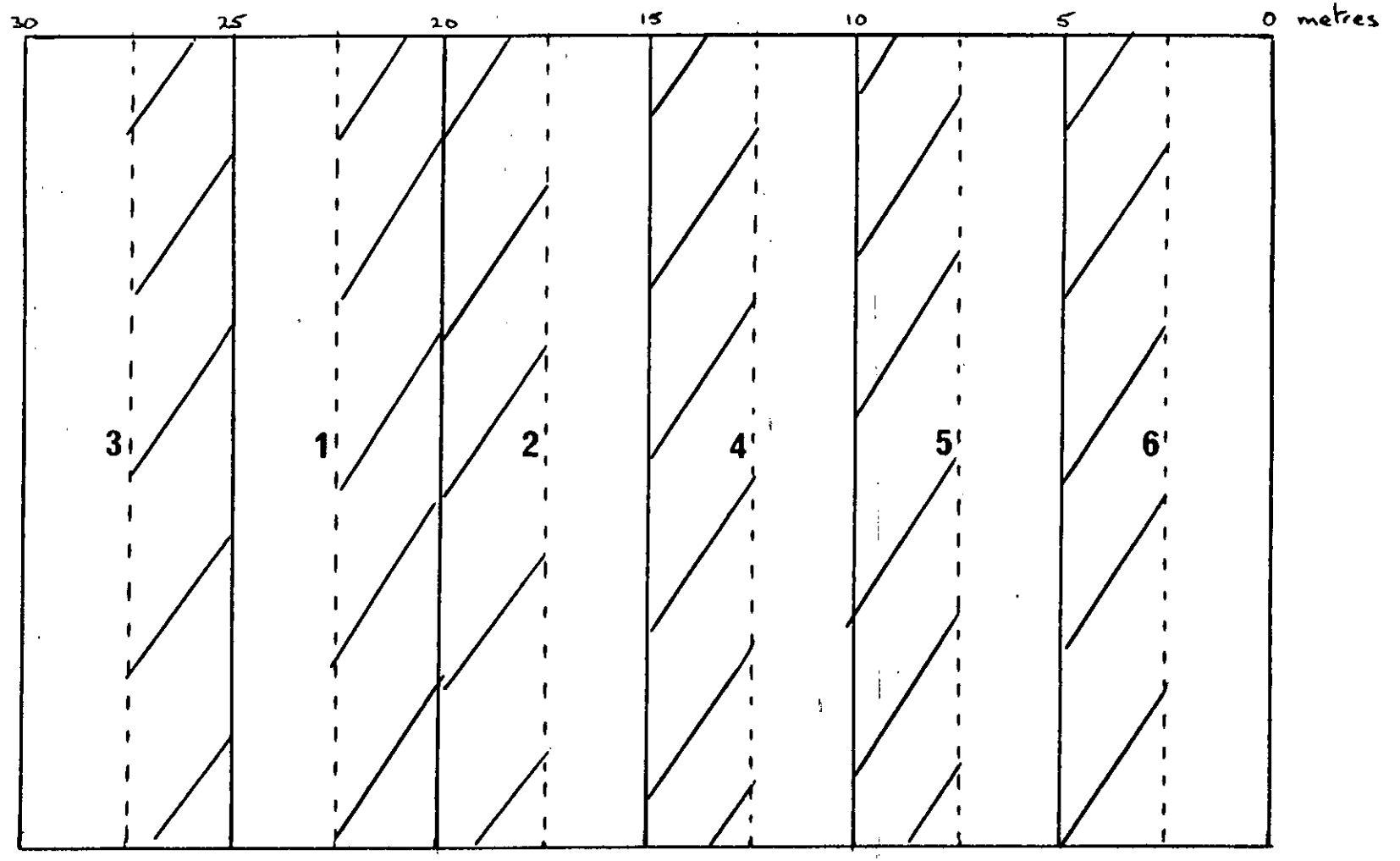
T.C.E.W
Aug 1986.

Appendix 1c. Detailed plans of low maintenance grass/wildflower trial, Gainsborough.

Block: 3

N ←

RIVER TRENT



ARABLE FIELD.

① to ⑥ Main Treatments (Grass Mixtures)

▨ Sub-treatments (Wild Flower Mixtures)

TREATMENTS

① B.S.H. A22 Low Maintenance Mixture

② 50% F. longifolia "Biljart"
50% F. longifolia "Barok"

③ Festuca/Agrostis mixture (1)
30% F. rubra "Barfalla"
30% F. rubra "Frida"
30% F. rubra "Waldorf"
10% A. castellana "Highlight"

④ Festuca/Agrostis mixture (2)
40% F. rubra "Merlin"
40% F. rubra "Artist"
20% A. tenuis "Bardot"

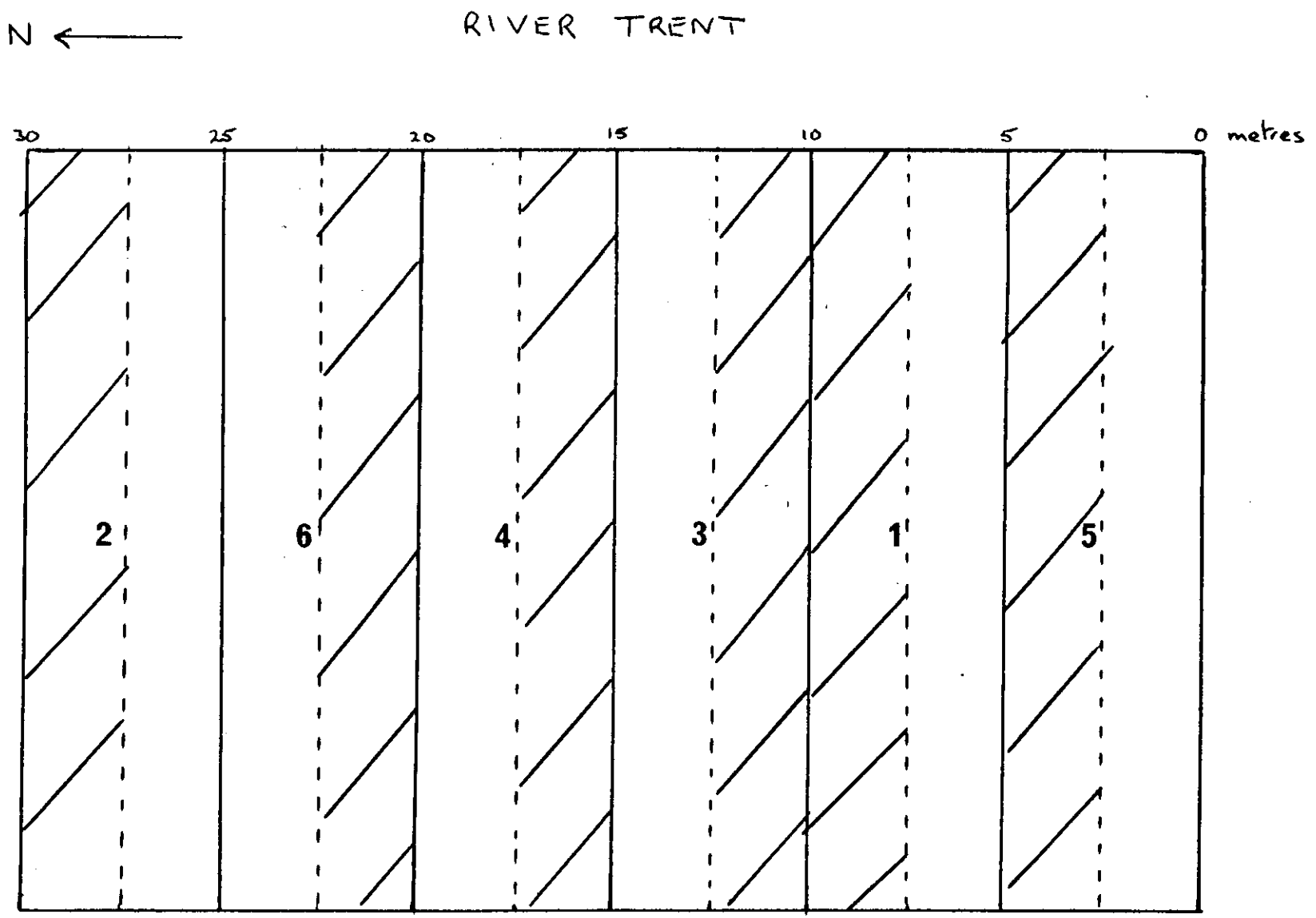
⑤ Poa/Festuca mixture
45% P. trivialis "Dasas"
40% P. trivialis "Sabre"
15% F. tenuifolia "Barok"

⑥ Severn-Trent Standard Mixture
50% Lolium perenne 10% Poa trivialis
25% Phleum pratense 10% Cynosurus/F. rubra.

T.C.E.W.
Aug 1986.

Appendix 1d. Detailed plans of low maintenance grass/wildflower trial, Gainsborough.

Block: 4



① to ⑥ Main Treatments (Grass Mixtures)

Sub-treatments (Wild Flower Mixtures)

REATMENTS

1) B.S.H. A22 Low Maintenance Mixture

2) 50% F. longifolia "Biljart"
50% F. longifolia "Barok"

3) Festuca/Agrostis mixture (1)
30% F. rubra "Barfalla"
30% F. rubra "Frida"
30% F. rubra "Waldorf"
10% A. castellana "Highlight"

4) Festuca/Agrostis mixture (2)
40% F. rubra "Merlin"
40% F. rubra "Artist"
20% A. tenuis "Bardot"

5) Poa/Festuca mixture
45% P. trivialis "Dasas"
40% P. trivialis "Sabre"
15% F. tenuifolia "Barok"

6) Severn-Trent Standard Mixture
50% Lolium perenne 10% Poa trivialis
25% Phleum pratense 10% Cynosurus/F. rubra.

T.C.E.W.
Aug 1986.