Field drainage in Scotland

R.J.F. Morris

North of Scotland College of Agriculture, Craibstone, Bucksburn, Aberdeen, Scotland

1 Introduction

Scotland is one of the four countries which make up the United Kingdom. It is a small country with a population of five million and a total land area of 7 715 000 ha occupying the Northern part of the British Isles. Of the total land area approximately 84% or some 6 500 000 ha is classified as agricultural land; the remainder largely being classified as forest, ungrazed uplands and urban areas. Most of the agricultural land is used only for extensive hill or rough grazing with only approximately 25% or 1 650 000 ha being classified as arable or improved grassland. The relative proportion of land in these categories is shown in Table 1.

Table 1 Agricultural land classification

Year	Total improved grass and arable land (1000 ha)	Improved grassland (1000 ha)	(%)	Arable land (1000 ha)	(%)
1963	1722.2	1118.6	65	603.6	35
1973	1645.3	1073.6	65	571.2	35
1983	1686.4	1051.6	62	634.8	38

Table 1 shows that grassland production and associated livestock enterprises form the mainstay of Scottish agriculture. Traditionally most farms were mixed enterprises with a combination of grass and crops. Over the last decade, however, there has been a shift away from traditional rotations in the drier Eastern areas with more emphasis being placed upon arable cropping. This is a reflection of the more favourable economics of arable farming over this period and is a trend that has accelerated since 1983.

In its topography, climate and land use Scotland is a country of marked contrasts. The mountainous nature and high rainfall of much of the Northern and Western parts of the country precludes all but the most extensive forms of agriculture. The arable cropping is concentrated along the drier Eastern coastal fringe where the annual rainfall is less than 900 mm. The main crops grown are barley, wheat, potatoes and oilseed rape. Livestock enterprises predominate in the wetter Western and Northern areas and principally involve dairying, beef cattle and sheep. Because of the adverse winter climate feed must be conserved for overwintered livestock which in the case of diary and beef animals are usually housed during this period. Pigs and poultry products

are another important facet of the Scottish agricultural economy with their production mainly being concentrated in intensive housed units.

2 Drainage requirement

Approximately half of the area devoted to improved grassland and arable crops is upon soils that are naturally freely drained. On the remaining area of some 825 000 ha some form of underdrainage is required for the full agricultural potential of the land to be realized. Scottish farmers have long realized the benefits that good drainage confers and there has been a long tradition of drainage improvements on these soils stretching back over the last few centuries. Most of the land in this category has therefore been drained at some time in the past. Unfortunately nothing lasts forever and no matter how well drainage schemes were designed and installed in the first instance, they eventually cease to function and have to be replaced. With an average life expectancy of 50 years, just to maintain the status quo or to ensure that drainage schemes are being replaced at the same rate as they are passing out of commission, the annual Scottish drainage requirement will be somewhere in the order of 16 500 ha. As indicated in Figure 1a, however, the statistics show that since 1955 this annual maintenance target has never been achieved. If the figure of 50 years is an accurate estimate of the life expectancy of drainage schemes it can only be concluded that at best, there

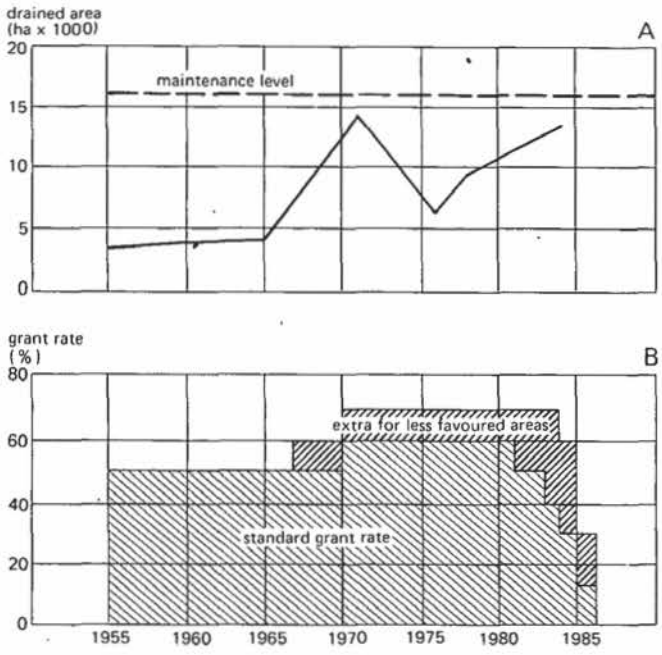

Figure 1 Area drained and grant rate in Scotland

is a substantial area of land where the drains are working at sub-optimum efficiency or at worst, the drains are completely defunct and are making no significant contribution to the drying out of the land.

3 Drainage problems

Most of the drainage effort is on mineral soils with less than 10% of the annual area drained being classified as peat. There are basically three types of drainage problems encountered under Scottish conditions namely surface water, high watertable and springs or seepage lines. Table 2 shows the classification of drainage problems into these categories for 1984.

Table 2 Dominant drainage problems (1984)

Drainage problem	% Area drained
Surface water	65
High watertable	20
Spring/seepage line	15

Although there are regional variations where the relative proportion of these problems differ in response to variations in dominant soil types, the above figures are typical of the overall annual distribution of drainage problems in Scotland.

Accounting as they do for two-third of the area drained, surface water problems are by far the dominant drainage problems under Scottish conditions. This is due to the fact that most of the soils are developed upon dense and slowly permeable glacial tills. The above problems are by no means mutually exclusive and are frequently found in combination.

4 Drainage systems

In all but the most extensive forms of land use in the hill farming and crofting areas field drainage is achieved by pipes. The geological and more recently the glacial and post glacial processes which have formed the Scottish landscape have ensured that there is an adequate network of rivers and streams throughout the country which form the arterial or main drainage outlets. These have been supplemented since the earliest land improvements by a network of man made canals and field ditches to transmit water to the main drainage channels. Another legacy of the natural land forming processes is that the landscape in the main agricultural areas is an undulating one. In most cases therefore drainage can be achieved by a gravity outlet and only in a few cases has recourse to be made to pumping.

5 Drainage criteria

In common with the rest of Britain the most widely used method for the design of piped drainage systems is that advocated by the Ministry of Agriculture, Fisheries and Food (MAFF 1983). In determining daily design rates this system takes account of the incident rainfall, proposed land use and the type of drainage system to be installed. The daily design rate is then used in conjunction with the slope on the land surface, the area served by the pipe and an assessment of soil permeability to calculate the design discharge. From this and the pipe gradient the appropriate size of pipe can be selected.

Because of the large variation in rainfall it would be unwise to adopt a single daily design rate for the whole country. For this and for other agricultural reasons the main agricultural areas have been subdivided into 17 agroclimatic areas (Meteorological Office 1981) for which appropriate meteorological data are available. This includes long-term rainfall data which are used in the determination of the daily design rates for drainage purposes.

6 Drainage materials

Since its introduction in the early 1960's corrugated plastic pipe has had a major impact upon the Scottish drainage scene and currently accounts for 75% of the drainage materials used. Traditional clayware tiles make up most of the remaining 25% with less than 1% being classified as other pipes (mainly concrete).

As indicated earlier the dominant drainage problem encountered in Scotland is the removal of surface water on dense glacial tills which have a slowly permeable subsoil. In response to an increasing number of drain failures and an intensified extension effort the use of permeable infill as a trenchline connection has become increasingly popular on such soils since 1970 and is at present used in 55% of the area drained. In the same context subsoiling and moling are presently practised as permeability aids on 12% and 1% respectively of the area drained.

7 Drainage machinery

Drainage work in Scotland is for the greater part undertaken on a large number of relatively small schemes. The 1984 statistics show that the average project size was 5 ha with the most frequently occurring size falling in the 1-1.9 ha range. This scale of operations limits the use of large capacity drainage machines. Consequently on just over half of the area drained in Scotland the drains are installed by backacting machinery. The remaining area is equally divided between trenchless and continuous trenching machines.

8 Drainage grants

Grants towards field and arterial drainage works were first introduced in the United Kingdom in 1921. Since then the rate of grant has varied between 15% and 70% but has mostly stood at the 50% level. Today, in an era of surplusses in most of the agricultural commodities within the European Economic Community (EEC) and less emphasis being placed upon home grown food production the rate of grant currently stands at 15% for low ground farms and 30% for farms in areas classified as less favoured (LFA) (Figure 1b). From Figure 1 it can be seen that the rate of grant has a bearing upon the amount of drainage done. There are other factors, however, principally the state of confidence of farming and climate. The records show that periods of high drainage activity have coincided with periods of relative prosperity within the agricultural community when the industry was in a confident mood, or have occurred in response to wet years.

9 Drainage costs

In 1984, without taking account of arterial works or ditch improvements and before grants, Scottish farmers spent £15.2 million on field drainage. In so doing 13 312 ha were drained at an average cost of £1.145 per ha. There were wide variations about this average with the lowest regional cost being £485 per ha and the highest just over 2 000 per ha. This variation is due to the variations in soil type and their associated drainage problems throughout the country and the different types of solutions adopted to combat them.

The development of average drainage costs over the last 25 years together with the corresponding values of the different types of agricultural land is shown in Figure 2. The sharp rise in both land values and drainage costs is in part due to the high inflation rate in the United Kingdom at this time. The continuing steep increase in land values during the 1970's and early 1980's was also due to a confident agricultural industry during this period and the fact that the acquisition of land was perceived by farmers and institutional investors as a good long-term investment and a hedge against inflation. In addition to the inflationary aspects the rise in drainage costs from 1970 is also due to the increasing use of permeable infill in drainage schemes which at current costs can account for more than half the total cost of a scheme.

Until 1984 the graphs show that even before grant if a project was based upon a sound financial footing, drainage and land improvements were an attractive economic proposition especially for arable land. Since then, however, there has been a sharp fall in agricultural land values especially in the more marginal LFA areas while drainage costs have remained constant. As a result the economics of drainage have to be much more carefully assessed before embarking upon major projects.

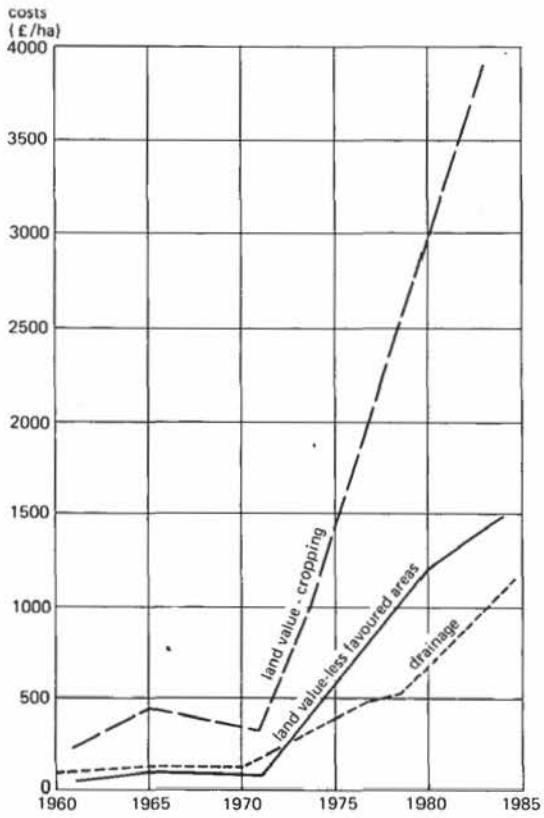

Figure 2 Drainage cost and land value in Scotland

10 Problem areas

In the preceding sections a brief description of the Scottish physical and agricultural background has been given together with an outline of the recent development and current state of the drainage industry. In the following sections attention will be focussed upon the main problem areas confronting the drainage industry in Scotland.

10.1 Standards of design and installation

At least as far as Scotland and indeed the rest of the U.K. is concerned field drainage is an area in which, in the majority of cases, the theory and science of the subject is far in advance of the practice. This is largely due to the structure of the industry and the nature of a large proportion of the servicing contracting industry. Because of the large number of relatively small schemes it is impractical and uneconomic for

most of the projects to have a major design input. Consequently in most cases the farmer and his chosen contractor are left to their own judgement and a large proportion of drainage schemes are installed without design guidance and often by untrained and inexperienced contractors. It is not surprising therefore that the final results are often disappointing. This was exemplified in a recent survey into the efficiency of recently installed drainage schemes in S.W. Scotland, carried out by Merrilees & Keer. The results of this survey are shown in Table 3.

Table 3 Farmer and surveyors assessment of drainage efficiency (% of schemes)

	Good	Sub-optimal	Poor	Total
Farmer	58	18	24	100
Surveyor	47	27	26	100

Further detailed investigations of the schemes showed that all the reasons for poor or sub-optimal drainage could and should have been avoided through good design and installation practices.

In an ideal world all drainage contractors should have undergone formal training and be licensed by the administrative authorities. Such a state of affairs is unlikely to occur at least in the forseeable future in Scotland. Under these circumstances the only method of combatting this problem is therefore through a continuing extension and education programme to the wider agricultural community.

10.2 Iron ochre

Almost one third of Scottish drainage schemes have a potential problem due to the presence of iron ochre. In most cases its presence only reduces the efficiency of the drains. In the worst cases, however, it can cause complete drain failure within a few months of installation. Two types of ochre formation have been identified by Kuntze (Kuntze 1982) namely Allochthonous (permanent) and Autochthonous (temporary). Both types are found in Scottish soils with the Allochthonous type presenting the most serious problems.

As yet no satisfactory and environmentally acceptable cure has been found for this problem. Promising work is currently in progress with the use of coniferous bark to absorb the iron from solution. At present, however, the only method of combatting the problem is through design factors to facilitate drain maintenance by rodding or jetting.

10.3 Drainage economics

In a reclamation situation where drainage is a prerequisite to any meaningful agricultu-

re, or where there has been a complete breakdown of an existing system, the benefits of drainage can be easily quantified and justified by economic analysis. For the reasons indicated, however, much of the drainage work undertaken in Scotland does not take place under these categories but is the replacement of sub-optimum drains which are unable to cope with the needs of modern agriculture. Under these conditions drainage economics is much more open to question. This is especially the case under Scottish circumstances where most of the drains are installed to deal with surface water and the drainage need and therefore responses can vary markedly from year to year in accordance with the vagaries of the climate. For U.K. conditions therefore it is a matter of urgency that work is undertaken in this area to allow any drainage improvements to be made on a sound basis.

11 The future

The outlook for the drainage industry in Scotland and the rest of the U.K. will mirror the fortunes of agriculture in general and the emphasis that will be placed upon home grown food production. This in turn will be determined by the priorities of the government of the day and the political sway that the agricultural lobby has with that government. As a member of the EEC any such policies will of course have to comply with the wider interest of the community.

At present both public and political opinion has been coloured by the increasing importance of the environmentalist lobby and the bad publicity targetted at agriculture and fuelled by the high cost of storing the agricultural surplusses produced within the EEC. In this climate it seems unlikely that on a national scale major emphasis will be placed upon increasing or even maintaining current production levels. On the contrary policies being advocated at present would suggest that a decrease in production levels is to be sought. In the future therefore it seems likely that drainage improvements will be concentrated in areas where the interests of the individual farmer are at variance with the national interest of lower production levels.

Against this background it is inevitable that there will be a reduction in the amount of drainage carried out and a corresponding reduction in the capacity of the ancillary industries. In response to this there will be a shift away from single purpose drainage machinery requiring large capital investment and an increasing reliance on the more versatile backacting equipment.

To maintain efficient agricultural production greater emphasis will be placed upon reducing drainage costs without a lowering of standards. The most likely ways of achieving this end for Scottish and U.K. conditions is through alternatives for gravel as permeable infill and the extension of mole drainage to a wider range of soil types. One method of reducing costs which is already gaining in popularity with farmers is 'do-it-yourself' drainage. This trend is likely to increase in importance in the future.

Finally it can only be concluded that within the U.K., agriculture in general and the drainage industry in particular is heading for uncertain times. Many changes will be required while the industry adjusts to the policies of the day and the consequent

market pressures. These changes in themselves will produce interesting and stimulating challenges across the whole spectrum of field drainage activities.

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