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LAND DRAINAGE SURVEY — II

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ABSTRACT

The results of a 4-year countrywide land drainage survey are presented. The survey was designed to collect information on the problems which made drainage necessary and on the techniques used in solving those problems. The methods used for data collection, storage and analysis are outlined. Detailed information was collected from 16,336 schemes (120,952 acres). The main drainage problems encountered were seepage and springs (37.8%), impervious subsoil (31%) and water-table (23.8%). Old broken drains were found on 43.2% of the area surveyed.

Tile drains were used on 71% of the total acreage, open drains on 15% and stone drains on 11.7%. Topsod or topsoil was used as first backfill on 80% of all tile drains, except those used as mole catchments, 99.1% of which received some form of porous fill.

INTRODUCTION

A countrywide land drainage survey has been in progress in Ireland since 1964 (1). It was designed to collect information on land in need of drainage. The results are used to establish the major drainage problems in the country and to isolate individual problems at local level. A considerable amount of information has been collected on the drainage techniques used, and, since data are stored on punched tape, the information is readily available at all times.

The survey was planned and organised by the Soil Physics Department of An Foras Talúntais and carried out with the co-operation of the field officers of the Land Project. This project was set up within the Department of Agriculture in 1949 to improve the productive potential of agricultural land by providing state grants for drainage and reclamation. Details of the grants available and of progress since 1949 are available in the annual reports of the Minister for Agriculture and Fisheries.

The Land Project provides a comprehensive drainage service to the farmer. Its field officers survey the land, design drainage schemes, prepare estimates of cost (on which the grants payable are based) and supervise the schemes during the course of installation. Since almost all agricultural drainage in the country is carried out under the Land Project, it was decided that a short-term survey of all schemes in the course of installation should provide a reasonably accurate assessment of drainage conditions generally.

TABLE 1: Variability (expressed as an acreage percentage) of subsoil permeability, new outfall, occurrence of broken drains, drainage problem, type of drain, drainage depth, first backfill and second backfill for different subsoil types

		Subsoil type		All subsoils
		Mineral	Peat	
Occurrence on area surveyed		93.9	6.1	
Subsoil permeability	Low	20.9	12.2	20.4
	Medium	71.9	68.9	71.7
	High	7.2	18.9	7.9
New outfall	Good	84.7	75.7	84.2
	Fair	14.7	21.8	15.1
	Bad	0.6	2.5	0.7
Occurrence of broken drains		44.4	24.1	43.2
Drainage problem	Water-table	21.6	57.3	23.8
	Seepage and springs	38.5	26.4	37.8
	Cemented layer	0.9	0.3	0.9
	Iron pan	0.2	0.1	0.2
	Imperv. subsoil	32.5	7.1	31.0
	Imperv. topsoil	2.0	2.5	2.0
	Imperv. layer	1.8	0.5	1.7
	Hollows	1.6	5.0	1.8
	Flooding	0.9	0.8	0.8
Type of drain	Open	14.3	24.1	15.0
	Tile	52.6	35.9	51.5
	Tile + mole	13.5	0.2	12.7
	Tile + subsoiling	7.2	—	6.8
	Stone	11.6	13.2	11.7
	Sod	0.3	21.1	1.5
	Bush	0.1	5.3	0.4
	Mole	0.3	—	0.2
	Subsoiling	0.1	—	0.1
	Plastic pipes	—	0.2	0.1
Drainage depth (inches)	Up to 21	3.2	0.9	3.1
	24	15.8	10.6	15.4
	27	24.6	10.5	23.7
	30	21.5	20.7	21.5
	33–39	14.0	32.4	15.2
	42–54	18.2	20.4	18.3
	57–81	2.7	4.5	2.8
First backfill	None	14.4	24.1	15.1
	Subsoil	0.4	2.8	0.6
	Topsod and topsoil	52.4	57.6	52.7
	Organic	2.3	6.7	2.5
	Clinker	0.9	0.4	0.9
	Loose stones	6.8	3.8	6.6
	Broken stones	8.3	3.0	7.9
	Chips	2.6	0.1	2.5
	Screened gravel	7.5	0.3	7.0
	Naturally occurring gravel	4.4	1.2	4.2
Second backfill	None	14.4	24.1	15.1
	Subsoil	53.9	49.6	53.6
	Topsod and topsoil	31.0	15.0	30.0
	Organic	0.4	11.1	1.0
	Misc. porous fills	0.3	0.2	0.3

PROCEDURE

A pilot survey was first undertaken (1), and the survey proper was begun on a country-wide basis in June 1964. This survey set out to provide an overall picture of drainage conditions and practices in the country. Drainage survey cards (Appendix 1) and an explanatory memorandum (Appendix 2) were issued to each Land Project field officer. Meetings were held locally with groups of field officers at which the memorandum and the survey card were explained and discussed. The survey card was designed a) to provide information on the drainage problem and relevant factors before drainage was undertaken and b) to collect details of the drainage techniques employed. The procedure adopted in the survey was that a card was completed for every scheme in progress in an officer's area. This ensured that the field officer had the full facts available to him when completing the card and that the information supplied was accurate. The completed cards were checked quarterly in the Soil Physics Department and the data transferred to punched tape.

An interim analysis was undertaken after 18 months (1). Another analysis of all cards submitted over the 4-year period, ended June 1968, has now been completed. The analysis covers a total area of 120,952 acres. The number of cards involved was 16,336, from each of which 17 items were transferred to punched tape. From these data two-way tables, with acreage accumulated, were produced by digital computer analysis. The figures obtained were converted to percentages of the total acreage involved and tables were then constructed using these percentages. The 35 tables that are most pertinent to drainage conditions and techniques have been selected for further comment. Sixteen of these tables correspond with those already presented in the interim report (1) and have been up-dated to include the results of the total 120,952 acres.

In presenting the data, two different sets of tables are used. In the first set (Tables 1 to 7) particular aspects of the survey are taken and compared with other relevant aspects. In the second set (Tables 8 to 10) the particular aspects are broken down on a county basis. By comparing the appropriate tables, the relevance of figures presented in the first set of tables to any particular county can be readily ascertained.

RESULTS

Table 1 shows the variability for different *subsoil types* of subsoil permeability, new outfall, occurrence of broken drains, drainage problem, type of drain, drainage depth, first backfill and second backfill. Table 8 shows the distribution of subsoil type in different counties. Peatland drainage averaged 6.1% of the total, and ranged from 20.9% in Westmeath to zero in Waterford. The peat drained was generally more

TABLE 2: Variability (expressed as an acreage percentage) of occurrence of broken drains, type of drain, drainage depth, first backfill and second backfill for different subsoil permeabilities

		Subsoil permeability			All subsoils
		Low	Medium	High	
Occurrence on area surveyed		20.4	71.7	7.9	
Occurrence of broken drains		30.1	46.2	50.0	43.2
Type of drain	Open (only)	6.5	16.0	26.7	15.0
	Tile	36.5	54.4	63.3	51.5
	Tile + mole	30.3	9.1	0.1	12.7
	Tile + subsoiling	9.8	6.6	1.1	6.8
	Stone	14.2	11.7	5.0	11.7
	Sod	1.5	1.6	2.6	1.5
	Bush	0.1	0.4	0.9	0.4
	Mole	0.8	0.1	—	0.2
	Subsoiling	0.2	0.1	—	0.1
	Plastic pipes	0.1	—	0.3	0.1
Drainage depth (inches)	Up to 21	3.4	3.3	0.5	3.1
	24	23.1	14.5	4.2	15.4
	27	33.4	22.1	13.4	23.7
	30	22.2	21.7	17.4	21.5
	33–39	10.3	15.4	25.8	15.2
	42–54	7.2	20.1	30.5	18.3
	57–81	0.4	2.9	8.2	2.8
First backfill	None	6.7	16.1	26.7	15.1
	Subsoil	0.5	0.5	1.4	0.6
	Topsod and topsoil	35.2	56.9	59.8	52.7
	Organic	2.3	2.5	3.7	2.5
	Clinker	1.7	0.8	0.2	0.9
	Loose stones	10.5	5.9	2.7	6.6
	Broken stones	15.5	6.4	1.8	7.9
	Chips	5.0	2.0	0.3	2.5
	Screened gravel	15.3	5.3	1.0	7.0
	Naturally occurring gravel	7.3	3.6	2.4	4.2
Second backfill	None	6.7	16.1	26.7	15.1
	Subsoil	38.1	57.5	59.4	53.6
	Topsod and topsoil	54.1	25.1	12.4	30.0
	Organic	0.9	1.0	1.5	1.0
	Misc. porous fills	0.2	0.3	—	0.3

permeable than the mineral subsoil. Almost 19% of peat was placed in the high permeability category whereas the corresponding figure for mineral subsoil was 7.2%. As might be expected, the outfalls provided for schemes on mineral subsoil were better than those for peatland schemes, and the incidence of broken drains on mineral subsoil was very much greater than on peat.

TABLE 3: Variability (expressed as an acreage percentage) of subsoil permeability, occurrence of broken drains, type of drain, drainage depth, first backfill and second backfill for different drainage problems

		Drainage problem									
		Water-table	Seepage & springs	Cemented layer	Iron pan	Imperv. subsoil	Imperv. topsoil	Imperv. layer	Hollows	Flooding	All problems
Occurrence on area surveyed		23.8	37.8	0.9	0.2	31.0	2.0	1.7	1.8	0.8	
Subsoil permeability	Low	10.9	7.2	28.7	38.2	43.4	43.5	18.7	6.3	3.7	20.4
	Medium	76.8	81.5	71.0	61.8	56.6	55.9	79.8	75.1	70.6	71.7
	High	12.3	11.3	0.3	—	—	0.6	1.5	18.6	25.7	7.9
Occurrence of broken drains		38.5	57.2	48.7	47.8	29.7	36.4	47.6	46.1	37.2	43.2
Type of drain	Open	28.8	14.2	6.1	—	3.8	7.1	5.3	29.0	81.9	15.0
	Tile	51.1	66.5	56.2	40.5	35.4	33.7	59.4	52.0	16.0	51.5
	Tile+moles	1.2	1.9	0.7	8.4	34.8	32.7	12.4	0.5	—	12.7
	Tile+subsoiling	6.0	4.7	21.9	23.0	9.4	7.2	11.2	5.1	1.7	6.8
	Stone	6.8	11.8	15.0	22.7	15.5	15.8	11.3	9.9	0.4	11.7
	Sod	4.0	0.9	—	—	0.5	2.6	—	1.9	—	1.5
	Bush	1.4	—	—	—	—	—	—	1.2	—	0.4
	Mole	0.3	—	—	0.7	0.5	0.3	0.3	—	—	0.2
	Subsoiling	0.3	—	0.1	4.7	0.1	0.6	0.1	—	—	0.1
	Plastic pipes	0.1	—	—	—	—	—	—	0.4	—	0.1
Drainage depth (inches)	Up to 21	3.4	1.1	0.4	9.7	5.6	2.3	0.7	1.3	0.2	3.1
	24	8.0	10.7	9.0	20.1	26.9	25.5	11.3	17.2	3.5	15.4
	27	18.9	14.5	33.8	25.0	37.3	43.2	32.2	18.7	7.1	23.7
	30	25.7	22.8	20.5	19.4	18.2	14.1	18.1	16.2	3.1	21.5
	33–39	15.4	21.5	11.7	24.3	8.1	6.5	11.8	12.2	16.9	15.2
	42–54	23.4	26.1	22.5	1.5	3.5	8.4	25.9	29.1	55.6	18.3
	57–81	5.2	3.3	2.1	—	0.4	—	—	5.3	13.6	2.8
First backfill	None	29.1	14.2	6.1	4.5	3.8	7.7	5.3	29.0	81.9	15.1
	Subsoil	0.7	0.7	0.6	—	0.2	0.7	1.5	2.6	—	0.6
	Topsod & topsoil	53.6	65.2	70.6	62.9	37.7	37.4	60.1	54.6	14.7	52.7
	Organic	2.9	3.2	—	3.4	1.6	1.5	4.1	2.6	0.5	2.5
	Clinker	0.7	0.9	0.3	3.4	1.2	0.8	—	0.3	—	0.9
	Loose stones	2.7	5.4	9.7	15.0	11.1	6.9	6.2	3.4	2.6	6.6
	Broken stones	1.6	3.4	4.3	3.7	18.3	21.4	5.5	1.3	—	7.9
	Chips	2.1	0.6	3.2	2.2	4.1	10.4	10.0	3.9	—	2.5
	Screened gravel	2.8	2.7	2.6	4.9	16.1	7.7	7.0	1.4	0.1	7.0
	Naturally occurring gravel	3.8	3.7	2.6	—	5.9	5.5	0.3	0.9	0.2	4.2
Second backfill	None	29.1	14.2	6.1	4.5	3.8	7.7	5.3	29.0	81.9	15.1
	Subsoil	54.1	66.5	73.3	64.0	38.5	38.2	63.0	55.7	14.7	53.6
	Topsod & topsoil	13.9	18.5	20.1	31.5	56.8	53.2	30.5	14.2	3.3	30.0
	Organic	2.7	0.6	0.5	—	0.5	0.6	0.3	1.0	—	1.0
	Misc. porous fills	0.2	0.2	—	—	0.4	0.3	0.9	0.1	0.1	0.3

TABLE 4: Variability (expressed as an acreage percentage) of drainage depth, first backfill, second backfill and occurrence of broken drains for different types of drain

		Type of drain										
		Open (only)	Tile	Tile+ mole	Tile+ sub-soiling	Stone	Sod	Bush	Mole	Sub-soiling	Plastic pipes	All drains
Occurrence on area surveyed		15.0	51.5	12.7	6.8	11.7	1.5	0.4	0.2	0.1	0.1	
Drainage depth (inches)	Up to 21	—	4.6	0.4	—	4.7	—	—	23.1	21.8	—	3.1
	24	0.2	16.4	6.9	2.1	50.2	0.9	1.3	3.1	9.7	39.1	15.4
	27	0.2	21.8	70.0	31.4	9.6	7.9	6.7	28.2	8.0	—	23.7
	30	1.2	25.9	22.6	31.6	19.8	24.8	23.8	45.6	8.9	4.7	21.5
	33–39	11.2	16.9	0.1	34.0	10.5	59.9	68.2	—	12.1	56.2	15.2
	42–54	69.4	14.0	—	0.9	5.2	6.5	—	—	39.5	—	18.3
	57–81	17.8	0.4	—	—	—	—	—	—	—	—	2.8
First backfill	None	100.0	—	—	—	—	—	—	7.0	63.8	—	15.1
	Subsoil	—	0.7	—	—	0.7	6.0	0.4	—	—	—	0.6
	Topsod & topsoil	—	80.7	0.9	79.7	33.3	80.5	86.0	23.7	14.4	23.4	52.7
	Organic	—	3.6	—	0.3	3.5	12.5	13.6	3.1	2.1	—	2.5
	Clinker	—	1.3	1.6	0.1	0.2	—	—	—	—	32.8	0.9
	Loose stones	—	0.6	4.0	0.1	48.5	0.9	—	10.3	15.1	—	6.6
	Broken stones	—	2.0	40.5	2.3	13.3	0.1	—	25.6	4.6	4.7	7.9
	Chips	—	1.8	10.8	2.5	0.1	—	—	4.7	—	32.8	2.5
	Screened gravel	—	4.5	32.6	7.8	0.1	—	—	19.5	—	6.3	7.0
	Naturally occurring gravel	—	4.8	9.6	7.2	0.3	—	—	6.1	—	—	4.2
Second backfill	None	100.0	—	—	—	—	—	—	7.0	63.8	—	15.1
	Subsoil	—	82.8	1.3	81.5	34.1	59.9	67.4	23.9	14.4	23.4	53.6
	Topsod and topsoil	—	16.5	98.0	18.5	63.1	11.3	7.4	67.2	21.1	76.6	30.0
	Organic	—	0.5	0.3	—	2.0	28.8	25.2	1.9	0.7	—	1.0
	Misc. porous fills	—	0.2	0.4	—	0.8	—	—	—	—	—	0.3
Occurrence of broken drains		45.1	50.4	30.0	53.9	23.3	13.7	0.7	11.8	16.9	32.3	43.2

TABLE 5: Variability (expressed as an acreage percentage) of the condition of new outfall for different conditions of existing outfall

		Existing outfall				All outfalls
		Good	Fair	Bad	Inadequate	
Occurrence on area surveyed		44.0	33.2	17.1	5.7	
New outfall	Good	100.0	67.3	81.0	72.6	84.3
	Fair	—	32.6	15.5	27.1	15.0
	Bad	—	0.1	3.5	0.3	0.7

TABLE 6: Variability (expressed as an acreage percentage) of the occurrence of broken drains and installation of open drains for different drainage depths

		Drainage depth (inches)							All depths
		Up to 21	24	27	30	33–39	42–54	57–81	
Occurrence on area surveyed		3.1	15.4	23.7	21.5	15.2	18.3	2.8	
Broken or choked old drains	Yes	44.3	27.9	36.4	43.8	52.8	54.9	49.3	43.2
	No	55.7	72.1	63.6	56.2	47.2	45.1	50.7	56.8
Open drains	Yes	27.4	38.6	58.4	68.8	74.0	82.6	100.0	64.6
	No	72.6	61.4	41.6	31.2	26.0	17.4	0.0	35.4

The major differences between mineral and peat subsoils in the drainage problem section occurred with water-table, seepage and springs, and impervious subsoil. High water-tables were encountered on 57.3% of the peat drained. The corresponding figure for mineral subsoil was only 21.6%. Seepage occurred on 38.5% of the mineral subsoil and on 26.4% of the peat. Impervious subsoil was found in 32.5% of mineral soil and in only 7.1% of peat soil. Sod and bush drains were confined almost exclusively to peatland whereas mole drainage and subsoiling were scarcely ever used on peat. Percentagewise, drains were deeper in peat than in mineral soil. For drains less than 30 in. deep, higher percentages were recorded for mineral subsoil than for peat; at the 30-in. depth the figures were almost equal but for the deeper drains the figures for peat were higher than those for mineral subsoil. The backfill sections show that the percentage of drains receiving porous fill as a first backfill was much higher for mineral subsoil than for peat.

Table 2 shows the variability for different *subsoil permeabilities* of the occurrence of broken drains, type of drain, drainage depth, first backfill and second backfill.

TABLE 7: Variability (expressed as an acreage percentage) of second backfill for different first backfill materials

		First backfill										
		None	Subsoil	Topsod and topsoil	Organic	Clinker	Loose stones	Broken stones	Chips	Screened gravel	Naturally occurring gravel	All materials
Occurrence on area surveyed		15.1	0.6	52.7	2.5	0.9	6.6	7.9	2.5	7.0	4.2	
Second backfill	None	100.0	—	—	—	—	—	—	—	—	—	15.1
	Subsoil	—	35.5	98.3	15.0	4.6	2.0	2.0	18.9	3.6	5.9	53.6
	Topsod & topsoil	—	64.5	0.3	78.1	95.0	94.4	96.5	80.9	96.4	93.5	30.0
	Organic	—	—	1.2	6.2	0.4	2.9	0.7	—	—	0.1	1.0
	Clinker	—	—	—	0.5	—	—	—	—	—	—	—
	Loose stones	—	—	—	0.2	—	0.2	0.4	—	—	—	0.1
	Broken stones	—	—	0.1	—	—	0.5	0.4	0.2	—	—	0.1
	Chips	—	—	0.1	—	—	—	—	—	—	0.3	0.1
	Screened gravel	—	—	—	—	—	—	—	—	—	—	—
	Naturally occurring gravel	—	—	—	—	—	—	—	—	—	0.2	—

TABLE 8: Variability (expressed as an acreage percentage) of subsoil type, occurrence of broken drains and drainage problem for different counties

County	Subsoil type		Occurrence of broken drains	Drainage problem								
	Mineral	Peat		Water-table	Seepage & springs	Cemented layer	Iron pan	Imperv. subsoil	Imperv. topsoil	Imperv. layer	Hollows	Flooding
Carlow	98.2	1.8	77.0	0.7	99.2	—	—	0.1	—	—	—	—
Cavan	96.8	3.2	26.4	3.6	10.7	—	0.3	75.6	4.9	3.7	0.8	0.4
Clare	90.3	9.7	30.9	22.2	27.0	0.5	—	45.3	3.3	0.7	1.0	—
Cork	95.2	4.8	71.9	21.8	57.0	2.8	0.4	9.5	1.9	2.9	2.7	1.0
Donegal	82.6	17.4	57.0	20.6	30.4	0.4	0.5	37.9	6.1	1.2	2.8	0.1
Dublin	99.9	0.1	52.0	8.7	56.9	—	0.3	31.1	1.1	—	1.8	0.1
Galway	87.9	12.1	23.3	39.9	50.8	1.0	—	6.0	1.1	0.8	0.4	—
Kerry	85.1	14.9	28.7	32.0	29.9	1.2	0.9	28.9	2.0	2.1	2.8	0.2
Kildare	90.4	9.6	38.9	50.7	17.1	2.4	—	26.8	0.1	1.4	0.2	1.3
Kilkenny	98.7	1.3	61.0	22.4	47.5	0.6	—	25.1	0.3	1.9	0.6	1.6
Laois	97.3	2.7	47.1	66.2	19.4	—	0.4	7.9	1.3	2.5	—	2.3
Leitrim	86.3	13.7	3.4	11.4	6.4	—	—	80.7	0.5	0.2	0.8	—
Limerick	98.3	1.7	55.7	31.2	15.3	0.1	0.1	49.4	0.8	0.1	0.6	2.4
Longford	94.1	5.9	6.9	14.2	1.4	0.1	—	79.9	2.7	1.7	—	—
Louth	95.7	4.3	4.5	3.3	5.9	—	—	75.2	—	7.3	8.3	—
Mayo	80.1	19.9	14.2	26.8	54.7	2.3	0.7	11.8	1.9	0.9	0.3	0.6
Meath	98.9	1.1	67.2	26.7	16.1	0.3	2.1	43.6	6.9	1.5	1.6	1.2
Monaghan	98.9	1.1	5.9	2.3	8.6	0.2	0.5	80.1	3.0	4.4	0.9	—
Offaly	83.5	16.5	23.2	12.7	57.4	0.2	—	18.2	0.5	0.6	10.0	0.4
Roscommon	80.7	19.3	17.0	13.9	28.3	2.9	0.1	46.9	1.7	3.6	2.1	0.5
Sligo	80.6	19.4	3.2	32.3	17.3	1.2	0.7	42.2	2.7	1.1	2.5	—
Tipperary	98.5	1.5	26.0	5.1	67.8	2.6	—	16.2	1.1	1.2	3.1	2.9
Waterford	100.0	—	86.2	4.7	66.5	3.8	0.2	4.5	0.4	11.0	5.8	3.1
Westmeath	79.1	20.9	12.4	59.2	27.7	—	—	11.4	0.7	—	1.0	—
Wexford	99.8	0.2	49.0	21.5	45.3	0.2	—	30.1	1.4	0.4	1.0	0.1
Wicklow	99.0	1.0	66.5	11.9	73.6	—	1.6	11.2	—	1.2	0.5	—
All counties	93.9	6.1	43.2	23.8	37.8	0.9	0.2	31.0	2.0	1.7	1.8	0.8

TABLE 9: Variability (expressed as an acreage percentage) of type of drain and first backfill for different counties

	Type of drain							First backfill					
County	Open	Tile	Tile+ mole	Tile+ sub-soiling	Stone	Sod	Misc.	None	Sub-soil	Topsod + topsoil	Organic	Loose stones	Misc. porous fills
Carlow	—	99.8	—	—	0.2	—	—	—	0.2	78.5	0.1	0.2	21.0
Cavan	—	40.7	49.3	0.1	9.5	0.1	0.3	—	—	38.3	0.4	1.6	59.7
Clare	22.4	29.2	9.6	4.1	34.2	0.5	—	22.4	0.4	19.2	2.2	20.8	35.0
Cork	6.3	78.2	0.1	2.2	13.2	—	—	6.3	1.1	70.7	2.9	5.9	13.1
Donegal	—	45.4	0.9	—	45.9	7.8	—	—	1.8	48.0	15.1	21.5	13.6
Dublin	43.6	23.7	29.8	0.8	—	—	2.1	44.7	—	15.7	—	3.8	35.8
Galway	3.3	43.4	3.3	11.2	33.2	5.6	—	3.3	2.5	61.7	0.2	7.0	25.3
Kerry	13.6	53.7	4.5	0.7	24.5	1.8	1.2	13.6	1.1	49.9	4.2	14.7	16.5
Kildare	17.0	72.0	0.5	10.2	0.1	—	0.2	17.0	1.4	64.7	4.7	0.4	11.8
Kilkenny	13.0	74.9	1.3	3.1	7.7	—	—	13.0	0.5	73.6	7.4	2.3	3.2
Laois	78.7	15.9	1.9	—	1.8	—	1.7	79.0	0.2	18.0	0.3	0.2	2.3
Leitrim	—	26.0	30.5	—	40.8	2.1	0.6	—	0.1	20.2	—	32.6	47.1
Limerick	13.3	77.7	4.8	—	3.9	0.1	0.2	13.3	0.1	70.9	—	2.3	13.4
Longford	1.3	45.7	8.4	—	41.1	2.8	0.7	1.3	0.5	41.3	1.3	34.2	21.4
Louth	—	17.4	68.5	6.9	4.3	—	2.9	—	1.1	20.9	2.2	4.1	71.7
Mayo	1.2	29.2	—	1.0	50.1	18.2	0.3	1.5	0.1	59.4	5.2	25.8	8.0
Meath	8.9	32.0	48.9	8.4	0.5	1.3	—	8.9	0.4	30.2	—	1.1	59.4
Monaghan	—	7.4	68.0	3.6	19.7	0.2	1.1	—	—	7.4	5.3	8.7	78.6
Offaly	63.6	36.1	—	—	0.3	—	—	63.6	0.3	36.1	—	—	—
Roscommon	2.4	32.2	2.9	—	50.9	11.6	—	2.4	1.5	57.7	1.4	31.3	5.7
Sligo	1.2	29.8	—	—	53.4	11.3	4.3	1.2	0.1	32.0	15.0	38.0	13.7
Tipperary	27.0	62.5	3.8	0.6	5.8	—	0.3	27.0	0.1	50.9	2.3	1.5	18.2
Waterford	6.3	90.1	—	1.9	1.7	—	—	6.3	1.6	89.5	1.9	0.7	—
Westmeath	13.7	69.9	0.5	3.8	4.2	—	7.9	14.0	0.6	74.0	0.7	—	10.7
Wexford	2.9	48.7	13.9	34.3	—	—	0.2	3.0	—	73.1	—	1.7	22.2
Wicklow	—	100.0	—	—	—	—	—	—	3.7	73.2	13.0	—	10.1
All counties	15.0	51.5	12.7	6.8	11.7	1.5	0.8	15.1	0.6	52.7	2.5	6.6	22.5

TABLE 10: Variability (expressed as an acreage percentage) of drainage depth, subsoil permeability and land-use for different counties

	Drainage depth (inches)							Subsoil permeability			Land-use		
County	Up to 21	24	27	30	33–39	42–54	57–81	Low	Medium	High	Grass-land	Till-age	Horti-culture
Carlow	—	—	—	0.5	3.1	96.4	—	0.6	79.6	19.8	52.7	47.3	—
Cavan	0.7	56.6	42.2	0.4	0.1	—	—	41.0	57.5	1.5	98.2	1.8	—
Clare	3.8	47.7	18.7	3.4	19.0	7.4	—	33.9	63.9	2.2	99.6	0.4	—
Cork	0.2	7.7	7.5	52.9	22.0	9.2	0.5	10.1	84.2	5.7	92.4	7.6	—
Donegal	1.2	67.0	13.3	11.8	6.7	—	—	25.7	71.4	2.9	49.2	50.6	0.2
Dublin	—	0.7	2.0	42.8	7.8	19.9	26.8	22.4	69.2	8.4	63.4	36.6	—
Galway	—	2.5	8.3	54.1	28.9	5.3	0.9	16.1	80.0	3.9	95.0	5.0	—
Kerry	0.8	40.2	15.8	23.0	9.8	10.4	—	23.8	68.7	7.5	95.2	4.8	—
Kildare	—	3.0	41.3	29.4	7.8	16.7	1.8	18.9	68.5	12.6	90.0	9.7	0.3
Kilkenny	—	14.1	26.6	14.7	31.8	11.9	0.9	21.3	69.4	9.3	94.5	4.7	0.8
Laois	1.4	1.7	3.6	7.1	8.0	73.8	4.4	6.6	78.8	14.6	95.0	5.0	—
Leitrim	30.0	29.9	36.5	2.7	0.9	—	—	44.0	55.3	0.7	99.1	0.9	—
Limerick	51.7	25.1	6.6	0.7	4.3	9.8	1.8	13.0	85.1	1.9	100.0	—	—
Longford	0.4	69.4	22.4	3.0	3.2	1.3	0.3	35.1	63.5	1.4	98.4	1.6	—
Louth	0.1	0.7	94.2	4.8	0.2	—	—	44.2	49.0	6.8	54.0	46.0	—
Mayo	0.3	5.4	1.3	27.3	45.1	19.6	1.0	13.9	79.9	6.2	96.4	3.6	—
Meath	—	0.3	79.8	7.1	3.6	3.5	5.7	20.7	72.2	7.1	81.3	18.7	—
Monaghan	2.0	11.3	78.0	8.7	—	—	—	16.2	82.2	1.6	96.5	3.5	—
Offaly	—	12.6	15.4	8.3	2.9	57.0	3.8	11.3	85.0	3.7	96.9	3.1	—
Roscommon	1.4	11.9	19.4	44.9	19.8	1.7	0.9	31.9	56.3	11.8	96.3	3.4	0.3
Sligo	0.2	73.5	3.3	18.0	4.3	0.7	—	11.2	87.1	1.7	94.8	5.2	—
Tipperary	0.4	9.9	36.2	12.4	6.6	31.3	3.2	19.4	75.7	4.9	97.2	2.8	—
Waterford	—	1.1	0.8	4.6	25.4	68.1	—	9.3	79.6	11.1	97.0	3.0	—
Westmeath	0.3	—	35.4	31.2	15.9	3.0	14.2	10.4	74.4	15.2	98.9	1.1	—
Wexford	—	0.4	15.2	48.0	32.6	3.8	—	25.6	62.6	11.8	73.7	26.3	—
Wicklow	—	4.0	—	14.9	51.9	29.2	—	22.1	69.0	8.9	89.8	10.2	—
All counties	3.1	15.4	23.7	21.5	15.2	18.3	2.8	20.4	71.7	7.9	86.9	13.0	0.1

Table 10 shows the permeability breakdown for different counties. The average overall incidence of low permeability was 20.4%. This figure was much higher in Louth (44.2%), Leitrim (44%), Cavan (41%), Longford (35.1%) and Clare (33.9%). The average figure for high permeability was 7.9%. This in turn was exceeded in Carlow (19.8%), Westmeath (15.2%), Laois (14.6%) and Kildare (12.6%).

The most striking feature in Table 2 is the trend established across each line of the table. The values recorded either rise or fall as the permeability category changes from low through medium to high, in other words the figure appropriate to medium permeability always falls between the figures appropriate to the high and low permeabilities. The difference between the figures quoted for 'open drains (only),' in the type of drain section and 'none' in the first and second backfill sections, is explained by the fact that on a limited area subsoiling schemes were installed without catchment drains. These schemes, having no drainage channel, had no backfill and the percentage of 'none' in the backfill sections was raised accordingly. Topsod or topsoil was used to a large extent as a first backfill material. Even on the 'high' permeability subsoils, 59.8% of all drains, *i.e.*, 81.6% of the drains requiring backfill, received topsod as a first backfill.

Table 3 shows the variability for different *drainage problems* of subsoil permeability, occurrence of broken drains, type of drain, drainage depth, first backfill and second backfill. Table 8 shows the distribution of drainage problems within different counties. The three major problems were seepage and springs (37.8%), impervious subsoil (31%) and water-table (23.8%). The other six problems combined accounted for only 7.4% of the total. However, these countrywide averages were not maintained at county level. Seepage problems were to the fore in Carlow (99.2%), Wicklow (73.6%), Tipperary (67.8%) and Waterford (66.5%). Impervious subsoil was most common in Leitrim (80.7%), Monaghan (80.1%), Longford (79.9%), Cavan (75.6%) and Louth (75.2%), whereas problems due to high water-table occurred most frequently in Laois (66.2%), Westmeath (59.2%), Kildare (50.7%) and Galway (39.9%). Subsoiling (without drainage catchments), as already pointed out, accounts for the differences between figures quoted for 'open drains' and 'no backfill.'

Table 4 shows the variability for different *types of drain* of drainage depth, first backfill, second backfill and the occurrence of broken drains. Table 9 gives information on the types of drain installed in different counties. Laois (78.7%), Offaly (63.6%) and Dublin (43.6%) returned the highest figures for 'open drains only.' Tile drains were used most frequently in Wicklow (100%), Carlow (99.8%), Waterford (90.1%), Cork (78.2%), Limerick (77.7%) and Kilkenny (74.9%). Mole drainage with tile catchments was most prevalent in Louth (68.5%), Monaghan (68%), Cavan (49.3%) and Meath (48.9%). The highest percentages for stone drains were recorded in Sligo (53.4), Roscommon (50.9), Mayo (50.1) and Donegal (45.9). Wexford returned the highest figure (34.3%) for subsoiling followed by Galway (11.2%) and Kildare (10.2%). Mayo reported a figure of 18.2% for sod drains. Other high percentages for this category were Roscommon (11.6) and Sligo (11.3). Almost 70% of 'open

drains (only)' were installed at depths ranging between 42 and 54 in. The percentage of tile catchments for mole drains installed at the 27-in. depth was exactly 70. Topsod or topsoil was used as a first backfill on over 80% of all tile drains, except those used as mole catchments. On mole catchments some type of porous fill was used on 99.1% of the tiles. However, on subsoiling catchments 79.7% of the tiles received topsod or topsoil, 0.3% organic backfill and only 20% porous fill as first backfill.

Table 5 shows the variability of the condition of new outfall for different conditions of the existing outfall. Table 6 analyses the occurrence of broken drains and the installation of open drains for different *drainage depths*. The percentage occurrence of broken drains and the variation of drainage depth in different counties are shown in Tables 8 and 10 respectively. Limerick (51.7%) and Leitrim (30%) recorded the highest figures for drains at depths of 21 in. or less. Sligo (73.5) had the highest percentage of drains at the 24-in. depth, followed by Longford (69.4), Donegal (67) Cavan (56.6), Clare (47.7) and Kerry (40.2). The highest percentage of 27-in. drains was recorded in Louth (94.2) followed by Meath (79.8), and Monaghan (78). In the 30-in. category, Galway (54.1%), Cork (52.9%) and Wexford (48%) returned the highest figures. High percentages in the 33- to 39-in. category were recorded in Wicklow (51.9) and Mayo (45.1) while in the 42- to 54-in. range the highest percentages were returned in Carlow (96.4), Laois (73.8), Waterford (68.1) and Offaly (57). Dublin (26.8) had the highest percentage of drains at depths greater than 57 in.

The countrywide average for the occurrence of broken drains was 43.2%, but this was exceeded in Waterford (86.2%), Carlow (77%), Cork (71.9%), Meath (67.2%) and Wicklow (66.5%). Below average percentages were recorded in Sligo (3.2), Leitrim (3.4), Louth (4.5), Monaghan (5.9), Longford (6.9), Westmeath (12.4), Mayo (14.2) and Roscommon (17). Table 6 shows an above average incidence of broken drains at depths greater than 30 in. whilst below average figures were recorded at the 24-in. and 27-in. depths. It also shows that the percentage of open drains used increases steadily with drainage depth, rising from 27.4% at the 21-in. depth to 100% at depths greater than 57 in.

Table 7 shows the variability of second backfill for different first backfill materials, and Table 9 the distribution of first backfill within the different counties.

DISCUSSION

The most widespread drainage problems in the country are seepage and springs (37.8%), impervious subsoil (31%) and water-table (23.8%). These figures differ only slightly from those produced in the interim analysis (1). The percentages emerging on that occasion were seepage and springs 36.7, impervious subsoil 34, and water-table 21.8. Tile drains, stone drains and subsoiling with tile catchments were used on all drainage problems. In the disruption and drainage of cemented layers and iron pans,

tile drains were used on over half the area affected and only a relatively low percentage of subsoiling was undertaken.

Permeability measurements were not made. When the survey was being planned the omission of the permeability section from the card was considered, on the grounds that the basis for its determination might be rather subjective. However, since permeability is a key property of the soil in drainage design, some effort to judge it could not be avoided in the absence of facilities to measure it. Hence the Project Officer based his assessment on his impression of the texture, colour and structure of the soil in the excavated trenches coupled with the rate of water flow into the trenches, in the light of his experience of soils which in his judgment drained similarly. The data show that 71.7% of soils were placed in the medium permeability range, and this seems to indicate that only the extremes of high and low values were allotted to their respective categories. A further breakdown of the medium range and a more objective basis for permeability determination would be most desirable, and it is hoped to develop means of providing these in the near future.

The interim analysis (1) was carried out after 18 months' survey on approximately 39% of the eventual total area surveyed. The results of this analysis correspond very well with the final analysis figures. In fact almost 80% of the figures calculated in the interim analysis varied by less than 3% from the corresponding final analysis figures. The larger differences were found in the low acreage categories of some sections where small acreage variations could give rise to relatively large percentage differences. This verifies the accuracy of the results obtained in the drainage survey and indicates that a well-organised countrywide short-term survey can be used to provide an accurate assessment of drainage conditions and practices.

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REFERENCE

1. Galvin, L. F., *Ir. J. agric. Res.* **5**: 79, 1966.

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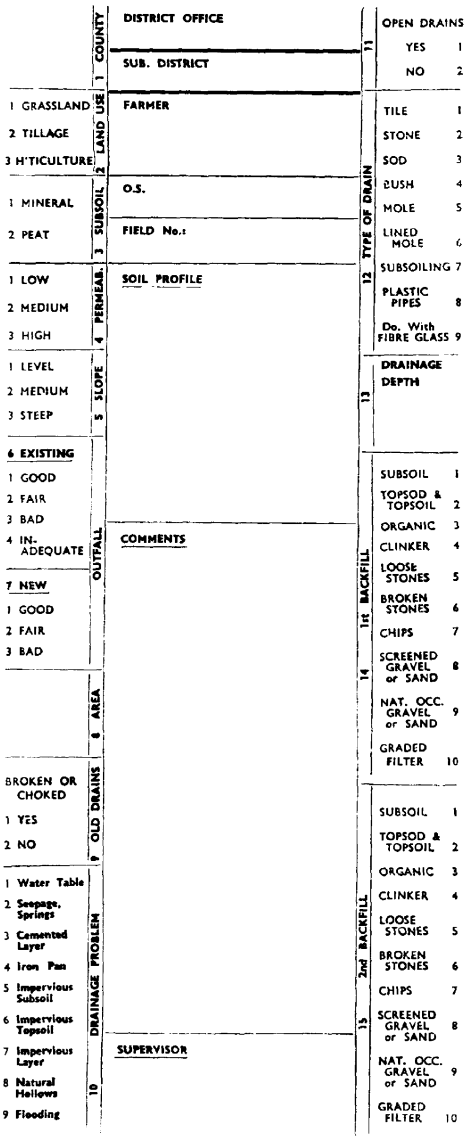
APPENDIX 1: Drainage survey card



APPENDIX 2: Explanatory memorandum issued to the field officers

Notes for the guidance of supervisors on the filling of the survey cards

Introduction: A 'drainage survey' card should be completed for each scheme on which drainage work is being carried out. The survey is expected to produce as complete and general a picture of drainage conditions in the country as is possible to achieve. It is, of course, appreciated that land which has been allowed to deteriorate will manifest a number of the drainage problems. In such cases, the predominating problem(s) only or those that originally gave rise to the condition should be indexed. The indexing system is devised so that in most cases one card will suffice for each scheme. However, on occasions, for example when peat and mineral subsoil, or two drainage problems requiring completely different treatments, occur on the same scheme, it will be necessary to split the area into two sections and fill a card for each section.

The following explanatory notes indicate the type of data that should be recorded on the survey cards.

1. *Farmer:* Give name, application number and townland in which drainage is being done.
   O.S. 6 in. and 25 in. sheet no.
   Field no.: Insert field no., as on sketch plan, of the area being drained and to which a particular card applies.
   Soil profile: A simple description of the soil profile, *i.e.*, the depth and type of each layer from ground surface to the bottom of the drain.
2. *Land-use:* Indicate the probable major potential use of the land on *completion of the scheme* (mark *one* use only).
   (1) *Grassland:* Where permanent pasture will be the predominating use.
   (2) *Tillage:* Where tillage will predominate, even though a grass lea may be grown for a few years, in the course of a rotation.
   (3) *Horticulture:* Where the soil, after drainage, is potentially suitable for fruit trees or some other special horticultural crop. (From the drainage point of view, if horticulture is a 'use potential,' it may be necessary to provide adequate drainage to greater than normal depths.)
3. *Subsoil:* Indicate whether the subsoil is mineral or peat.
   Note: Where a scheme contains both mineral and peat soils then a card should be completed for each area.
4. *Permeability:* Place the land in *one* of the categories listed on the card.
5. *Slope:* Note the general gradient of the area.
   Level: up to 1/300
   Medium: 1/300 to 1/30
   Steep: > 1/30
6. *Existing outfall:* Indicate the condition of the main outfall *before the drainage scheme commences,* under the following terms of reference.
   (1) *Good:* A 'good' outfall readily discharges all water reaching it under all conditions.
   (2) *Fair:* A 'fair' outfall operates effectively over most of the year but may require occasional maintenance.
   (3) *Bad:* A 'bad' outfall requires continual maintenance or has a very minimum gradient necessary. If an existing stream is used as an outfall and is flooded for some time to a level over that of the drains, it could merit the term 'bad' outfall depending on the duration of the high-water level.
   (4) *Inadequate:* An 'inadequate' outfall is one that in its present condition prevents drainage.
7. *New outfall:* Indicate into which category the main outfall will fall on completion of the drainage scheme, using the terms of reference at no. 6 on index card.
8. *Area:* Give actual area being drained to which card refers.
   Note: Acreage need only be given to the nearest unit. Cards need not be completed for areas of less than ½ acre.
   If only a portion of the total area of a field is being drained, an estimate of that portion should be inserted.

9. *Old drains:* Where the condition of an existing system of old drains has given rise to a drainage problem on the area, mark 'yes.' If there are no old drains, or if present and in good repair, and at a proper depth, mark 'no.'
Note: If on deepening a watercourse, a number of drainage outlets from an existing system are uncovered with a consequent benefit to the land, then 'yes' should be marked.

10. *Drainage problem:* In some schemes, more than one drainage problem may occur. Where one of these is predominant and the other(s) of a very minor nature, *only* the predominant one should be marked. If two problems of equal importance occur then both should be marked.
Note: (a) Only two problems may be marked on any one card. If more than two occur, then a second card must be filled to cater for those other problems.
(b) If two problems that require completely different drainage treatments occur on a scheme a separate card should be filled to cover each problem and its solution, *e.g.*, (i) water-table and (ii) seepage and springs should not appear on the same card.

(1) *Water-Table:* The general level of water is so high that drains must be laid to lower it.
(2) *Seepage and springs:* Outbursts of water over a wide area generally near the bottom of a slope (seepage) or at particular points (springs).
(3) *Cemented layer:* A layer of bonded subsoil giving an impervious pan.
(4) *Iron pan:* Thin high-iron layer.
(5) *Impervious subsoil:* The whole subsoil has such low permeability that it prevents the passage of water.
(6) *Impervious topsoil:* When the topsoil is so impermeable that it prevents the ingress of water.
(7) *Impervious layer:* When a soil layer, which is not cemented, prevents the passage of water because of its low permeability.
(8) *Natural hollows:* Refers to old lake beds or large depressions that require deep cuts to drain.
(9) *Flooding:* Refers to land that is often covered by water due to its low level position, *e.g.*, beside a stream, river, sea, etc. This item should be marked *only* when embankments are to be built or repaired or sluices provided in the course of a drainage scheme.

11. *Open drains:* If open drains are used to trap seepage or relieve an existing system of underdrains mark 'yes.' If the open drains are just 'carriers' and apart from that do not function as drains mark 'no.'

12. *Type of drain:* Only two types may be marked on any card. If a scheme has more than two of the types mentioned the area should be divided up and two cards filled.
(1) Tile
(2) Stone: gullets, flags, etc.
(3) Sod
(4) Bush
(5) Mole
(6) Lined mole
(7) Subsoiling
(8) Plastic pipes
(9) Plastic pipes wrapped in fibre glass

13. *Drainage depth:* Give the 'minimum graded depth' of the scheme in inches, *e.g.*, 21, 27, 48, etc.

14. *First backfill:* Note the material that is placed immediately on top of the pipes (mark *one* only).
(1) *Subsoil:* If the original subsoil or a mixture of subsoil and topsoil is used.
(2) *Topsod and topsoil:* If either or both used.
(3) *Organic:* If straw, rushes or other organic material is used.
(4) *Clinker:* Cinders, broken pipes, etc.

(5) *Loose stones:* Refers to small loose stones, usually used as a backfill on 'stone drains.'
(6) *Broken stones:* Quarry broken 1-in. nominal size or greater.
(7) *Chips:* Quarry broken less than 1-in. nominal size.
(8) *Screened gravel or sand:* Where used.
(9) *Naturally occurring gravel or sand:* Covers either pit-run, seashore or river gravel, or sand.
(10) *Graded filter:* A material specifically designed to counteract the silting of drains in a particular instance.

15. *Second backfill:* Mark the material next placed in position.