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SOILS of Co. WATERFORD

by

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National Soil Survey of Ireland

Teagasc
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PREFACE

This publication, Soil Survey Bulletin No. 44, presents the findings of the Soil Survey of County Waterford. It is the thirteenth in a series of county soil survey bulletins to be published by Teagasc; these surveys now cover about half the area of the State.

Although the scope and methodology of the survey of Co. Waterford conform broadly to that of previous counties, some changes and additions were introduced. As in the other counties, field mapping was carried out at a scale of 1:10,560 with a view to publication at 1:126,720; the publication scale, however, was increased to 1:100,000 to improve legibility. Map accuracy and quality were assessed in a sample area. Moisture retention characteristics of representative profiles were determined in the laboratory, and the hydraulic conductivities of lowland Gley soils were measured in the field.

Mr J. Diamond (Project Leader), Mr P. Feeney (Moorepark), Mr J. Hartigan, Mr P. Sills and Mr K. Sills performed the field mapping. Mr N. Kijp (Wageningen) and Mr S. Ormonde assisted in the fieldwork relating to the assessment of map accuracy. The laboratory staff of the Soil Survey Department, under the direction of Mr T. Shanley, provided the particle size and chemical analyses data. Mr E. McDonald and Mr P. Sills made the soil moisture retention, particle density, and bulk density determinations. The field measurement of hydraulic conductivity was performed by Mr J. Hartigan and Mr G. Ryan.

Mr V. Staples reduced the field sheets to 1:126,720 scale and calculated the areas of the map units. Mr E. McDonald prepared the digital version of the soil and soil suitability maps that accompany this bulletin; he also prepared the various figures that are in the bulletin. Ms M. Foley was responsible for word processing.

Assistance also came from some outside sources. In the assessment of soil suitability, especially that of hill land, Mr D. Ryan and Mr W. McCarthy of the Agricultural Advisory Service in Co. Waterford gave valuable assistance. Climatic data were abstracted from Met Éireann records. The Ordnance survey provided the topographic maps that were used in field mapping; it also prepared the modified digital topographic map that forms the base of the soil and soil suitability maps. The section on bedrock was based mainly on the Bedrock Geology 1:100,000 series compiled by the Geological Survey (Sleeman and McConnell, 1995; Tietzsch-Tyler and Sleeman, 1994). The description of Quaternary Geology in the county mainly follows that presented by Quinn and Warren (1989).

Permission to traverse the land of the county was freely given by farmers and landowners; their generous cooperation is gratefully acknowledged.

Grateful acknowledgement is made to all those contributors mentioned here and to others who helped in various ways.

Dr. Noel Culleton,
Head of Programme for Crops, Environment & Land Use, Teagasc.

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DISCLAIMER

CHAPTER 1

GENERAL DESCRIPTION OF THE AREA

Location and Extent

County Waterford is situated on the south west coast of Ireland between 6º 58' and 8º 11' west longitudes and between 51º 56' and 52º 21' north latitude. It is bounded on the west by County Cork, on the north by Counties Tipperary and Kilkenny, on the east by County Wexford and on the south by the Atlantic Ocean (Fig. 1.1). The principal towns are Waterford, Dungarvan, Tramore, Portlaw, Lismore, Tallow and Cappoquin.

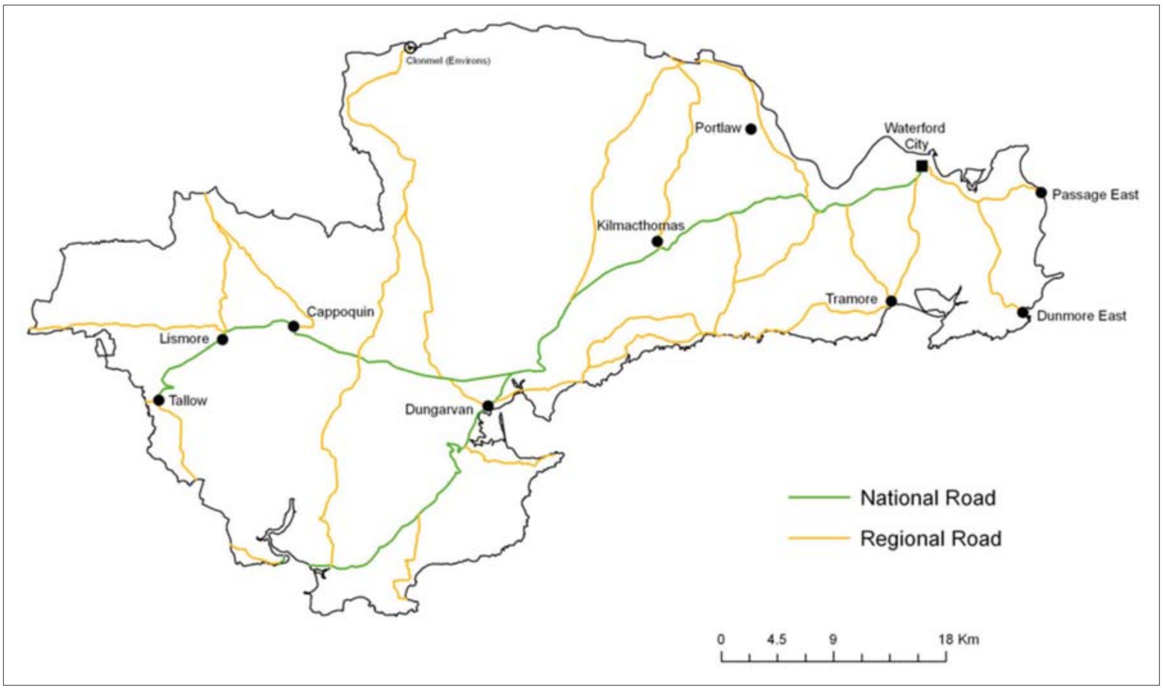

Figure 1.1: Major towns, villages, and roads, Co. Waterford.

The total area of the County and City of Waterford is 185,753 ha; this comprises 183,161 ha land, 618 ha freshwater and 1973 ha tidal water. Administrative units such as Townlands and District Electoral Divisions (DED's) consist of land and freshwater areas and amount to 183,779 ha. As land use data published by the Central Statistics Office (CSO) is based on DED's, the areas of soil map units and distinct freshwater areas were reconciled with the areas of DED's returned by the CSO.

Topography

Topography is an important factor in soil genesis and affects land use and performance. In the context of soil mapping, it pertains to the configuration of natural landscapes and excludes manmade features, such as roads and buildings. Topography includes elevation, gradient and concavity or convexity of slopes. These features remain virtually unchanged during the relatively short period of post Ice Age soil genesis in Ireland and define part of the ecosystem at the initial stage of soil development.

Topography modifies the regional climate; rainfall increases whilst temperature decreases with increases in elevation. Decades of experimentation have shown that rate of soil loss increases with gradient and slope length (Wischmeier and Smith, 1965). Topography also influences the soil hydrologic regime.

Co. Waterford reflects the general topographic pattern of Munster in having a larger proportion of uplands than the State. The proportion of land above the 76.2 m, 152.4 m, 304.8 m, and 609.6 m AMSL contours is greater in Munster and Co. Waterford than in the State (Table 1.1).

Table 1.1: Areas (%) above specified contours in Co. Waterford, Munster, and the State.

Contour m AMSL	D	76.2	152.4	304.8	609.6
Co. Waterford	100	63.48	30.47	8.91	1.04
Munster	100	63.31	29.73	7.21	0.42
State	100	58.84	21.91	5.1	0.29

The proportion of land above 152.4 m AMSL is about the same in Co. Waterford and Munster; above 304.8 m and 609.6 m AMSL the proportion is slightly greater in Co. Waterford.

In each of the contour intervals 152.4 to 304.8 m AMSL, 304.8 to 609.6 m AMSL, and above 609.6 m AMSL, the proportion of land in Co. Waterford and Munster is greater than in the State (Table 1.2). A distinctive feature of Co. Waterford and Munster is the relatively large proportion between 304.8 and 609.6 m AMSL (Table 1.2).

Table 1.2: Areas (%) between specified contours in Co. Waterford, Munster, and the State.

Contour m AMSL	D–76.2	76.2–152.4	152.4–304.8	304.8–609.6	>609.6
Co. Waterford	36.52	33.01	21.56	7.87	1.04
Munster	36.69	33.58	22.52	6.79	0.42
State	41.16	36.93	16.81	4.81	0.29

The county comprises two distinct major topographic regions, which are delimited by a line extending northwards from Ballyvoyle Head, 9 km east of Dungarvan, towards Kilsheelan along the flanks of the Monavullagh and Comeragh mountains. The major uplands of the county, comprising the Monavullagh, Comeragh, and Knockmealdown mountains and the Drum Hills, are situated in the western region. Towards the east, relief is less prominent, and elevation rarely exceeds 180 m AMSL (Fig. 1.2), except at the margin in the northeast.

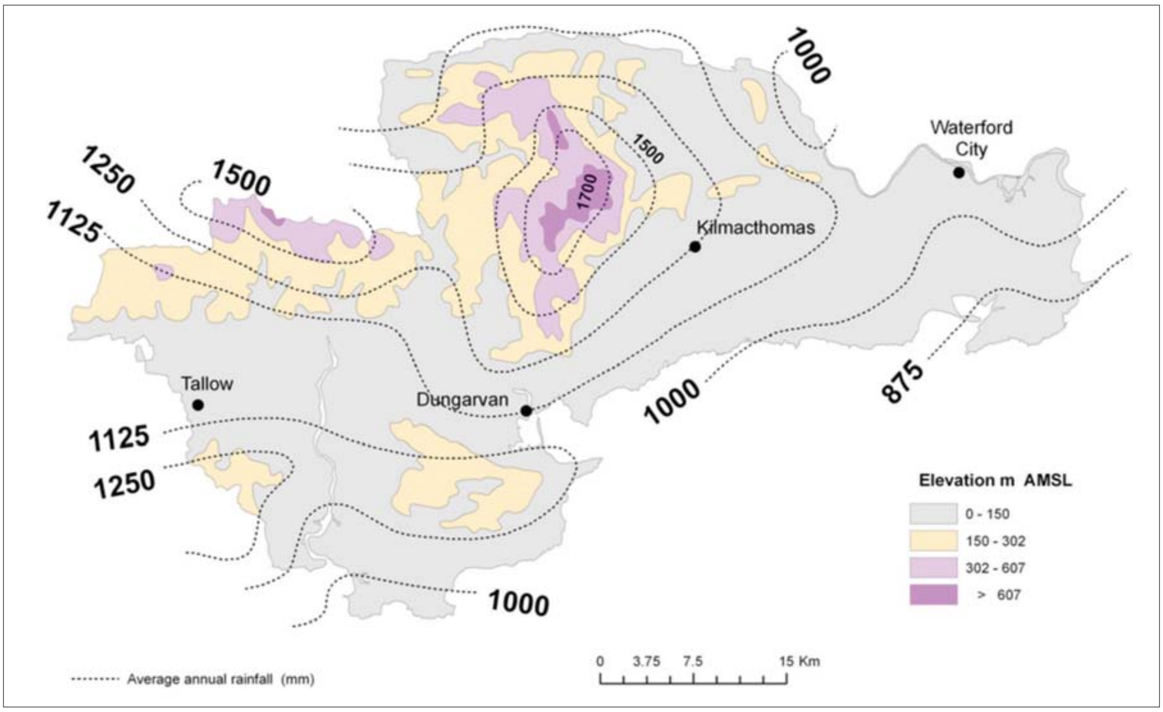

Figure 1.2: Isohyets and elevation, Co. Waterford (Met Éireann and OSI data).

The western region forms part of the ridge and valley province of southwest Ireland, which extends to the west coast in Co. Kerry. The topography is closely related to the structure and lithology of the underlying bedrock. The Variscan Orogeny, at the end of the Carboniferous period (290 Ma), formed a series of anticlines and synclines trending from east to west. Differential weathering of resistant Devonian sandstone and fragile Carboniferous limestone produced a landscape in which sandstone forms anticlinal uplands and limestone survives in the synclinal valleys. The floors of the valleys rarely exceed a height of 60 m AMSL. Along the margins of the valleys, an abrupt break of slope usually marks the boundary between limestone and sandstone; the valley sides are commonly steep or moderately steep. The height of the sandstone ridges varies considerably; the maximum height of the Tallowbridge–Dromana Wood ridge is 179 m AMSL, while north of the Lismore–Dungarvan valley, sandstone rises well over 600 m AMSL to form the Knockmealdown, Comeragh and Monavullagh mountains.

A widespread planation surface at 183 to 244 m AMSL on the southern uplands has long been recognised. Miller (1939) termed this surface the 'South Ireland Peneplane' and recognised a lower coastal peneplane. These he attributed to marine transgression, but Farrington (1953) suggested that these surfaces were formed by subaerial planation. Figure 1.3 shows the distribution of land area in relation to altitude for the Knockmealdown Ridge. Gradient is gentle between 122 and 244 m AMSL and increases between 244 and 274 m AMSL. The steepest slopes are above and below this range at the highest (274–427 m AMSL) and lowest (61–122 m AMSL) elevations. Farrington (op. cit.) concluded that the benching was most likely to be found between 183 and 244 m AMSL.

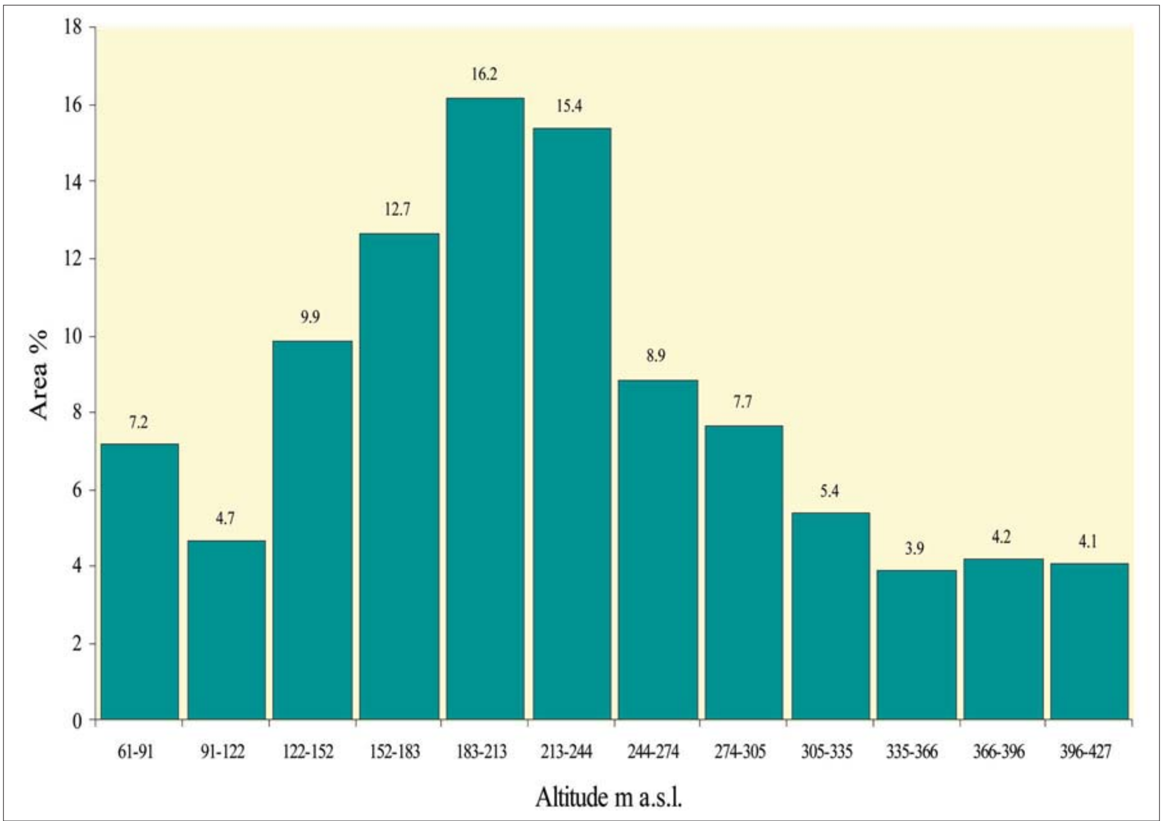

Figure 1.3: Distribution of land area in relation to altitude, Knockmealdown Ridge; [based on Farrington's data (1953) for seven sections across the ridge between 61 and 427 m AMSL].

The Drum Hills (Orme, 1964) rise sharply from the south side of the Dungarvan valley to form a little-dissected, 183 to 250 m AMSL upland plain; the upland falls gradually southward across a series of benches. The upland and adjacent benches are characterised by large areas of negligible slope. On the basis of detailed morphological mapping, Orme (op. cit.) found that slopes ranged from 2° to 6° interspersed with flats less than 2°. Between Helvick Head and Ardmore Bay, normally resistant Devonian sandstone carries planation surfaces at several distinct levels suggesting that land forms should not be attributed solely to differential weathering. Orme (op.cit.) concluded that the summit-plain was a largely base-levelled subaerial planation feature conforming closely to the theoretical conception of a peneplane. The upland plain was later submerged, at least partially, by a marine transgression.

The northeast region, which encompasses Rathgormuck and Kilmeadan, forms a lone plateau developed on lower Palaeozoic shales. Much of the area lies above 120 m AMSL. Topography is mostly undulating and slopes are generally smooth. The plateau falls away sharply to the north and east towards the Suir valley.

Elevation is less than 120 m AMSL in the southeast region, which lies south of the Waterford to Dungarvan road; although generally undulating, topography tends to be more rugged than in the northeast region. Outcrops of volcanic rock and to a lesser extent sandstone occur sporadically; they are common around the Ballyscanlan Hills. Throughout the county, flat areas occur in the river valleys principally around the major rivers, such as Blackwater and Suir, and along the smaller rivers and streams. These flat alluvial lands are estimated on the basis of the soil map to comprise about 4% of the county.

The relatively large amount of upland in the county is not matched by a corresponding large amount of rolling or steep land because of the extensive upland planation surfaces. Figure 1.4 shows the distribution of the dominant topographic class in soil mapping units; undulating and flat land predominates, comprising about 84% of the county, whereas moderately steep and steep land occupies only about 8%. These estimates do not represent the exact distribution of gradients in the county as some map units may consist of more than one topographic class.

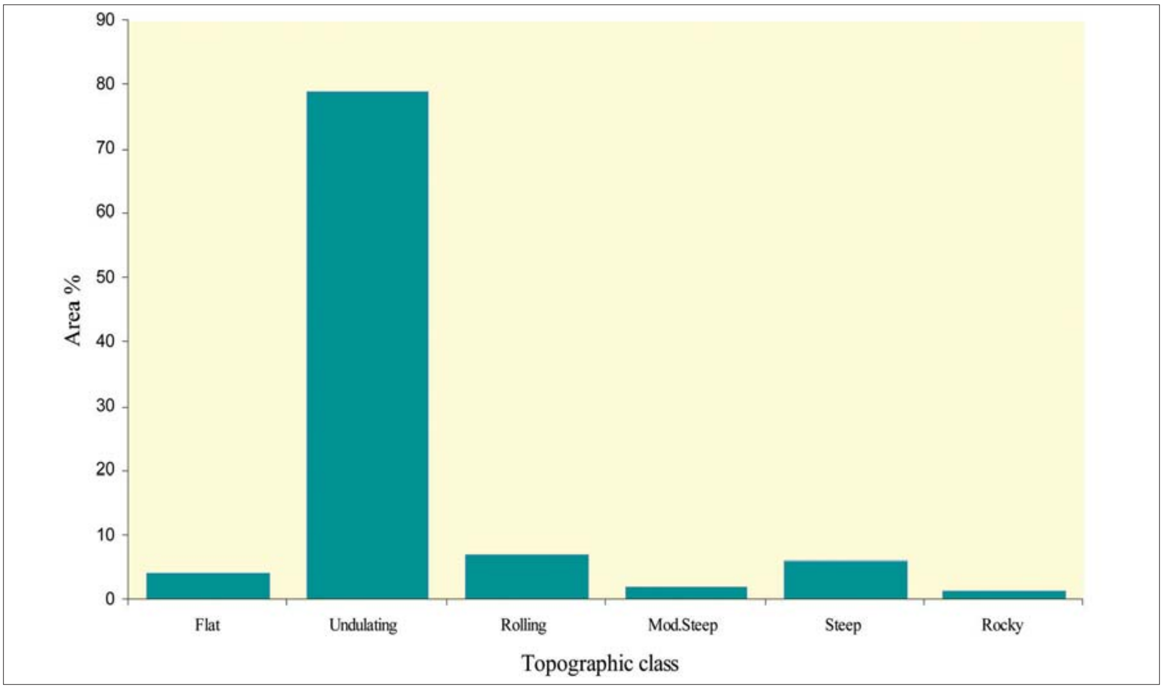

Figure 1.4: Distribution (%) of topographic classes, Co. Waterford (Dominant class in soil map units).

Rivers

The main rivers in the county (Fig. 1.5) are the Suir and Blackwater, which, after the River Shannon, have the largest catchments in the State. The area of the Shannon catchment (to Limerick) is 11,700 km^2, whilst the areas of the Suir and Blackwater catchments are 3600 and 3300 km^2 respectively. The Suir, including its estuary, forms the eastern boundary of the county and most of the northern boundary. It drains the northeast region, where the Clodiagh is the principal tributary, and part of the northwest region, where its principal tributaries are the westward flowing Nire and Glenary. The Blackwater drains the southwest region, except the coastal area, and part of the northwest region. It has many tributaries including the Bride, Glendine, and Licky on the south side, the Owenashad and Glenshelane to the north, and the Finnisk on the east side.

Except for the lower reaches of the Blackwater, the courses of the major rivers accord with the geological structure (Davies and Whittow, 1975). They follow the strike of synclinal valleys floored by Carboniferous strata. Within the valleys, the rivers tend to follow the shale bedrock, which commonly lies adjacent to sandstone bedrock, at the valley margins. Instead of continuing eastward along the limestone valley to the sea at Dungarvan, the Blackwater turns abruptly south at Cappoquin, cuts through four sandstone ridges and reaches the sea 30 km further south at Youghal. The steep gorges below Cappoquin form a marked contrast to the wide undulating valley above Cappoquin. Various explanations have been postulated to account for the discordant course of the lower Blackwater (Jukes, 1862; Davies and Whittow, 1975).

The Suir and Blackwater have extremely flat longitudinal profiles. The Suir is tidal for 55 km up to Carrick-on-Suir and the Blackwater is tidal to just above Cappoquin, a distance of 30 km (Miller, 1939). The distance from the tidal head to the 91.4 m AMSL contour is the same for both rivers, 91.7 km; this implies an average slope of only about 0.1%. Flat land beside the tidal parts of the Suir and Blackwater is protected from flooding by an extensive series of embankments and sluices. Arterial drainage has significantly lowered the water table in the catchment of the River Brickey, which flows into Dungarvan Harbour and drains the eastern part of the Dungarvan valley.

Numerous small streams drain the southern slopes of the Knockmealdown–Monavullagh Range into the River Blackwater and Dungarvan Harbour. These short rivers are deeply entrenched into a shelf in their lower reaches e.g. Owenashad and Glenshelane, forming steep-sided V-shaped valleys. The knick-points on the tributaries do not coincide with the Carboniferous/ORS junction, and Millar (1939) attributed their origin to rejuvenation. The Glanagad, Glenmore, Owenashad, Monavegga, Licky, and Glendine streams have reaches graded to 107–122 m AMSL level, and the Glenshelane, Glenmore, and Glendine streams have reaches graded to 61 m AMSL. Rejuvenation has not proceeded as far as the heads of the streams, and the upper portions of the valleys are often wide and open (Miller, op.cit.). The drainage of the low undulating plateau east of the Monavullagh Mountains follows a similar pattern; each river as it approaches the coast is rejuvenated, flows in a steep-sided trench and enters the sea between Ballyvoyle head and Tramore (Miller, op.cit.).

The River Clodiagh, which is the principal tributary of the River Suir in the county, passes across the Rathgormuck plateau in narrow valleys with short steep sides and drops across the sandstone boundary in a deep steep sided valley at Curraghmore/Guilcagh. The tributary streams of the Clodiagh generally begin in relatively wide small basins at elevations that are typically between 107 and 152 m AMSL.

The south and east flanks of the Drum Hills generate numerous independent coastal streams. They begin within broad shallow depressions but become deeply incised into the benchlands about 1.5 km from the coast (Orme, 1964).

The distribution of wet soils in the county is strongly related to the macro drainage pattern. Wet mineral soils with moderate soil profile development (Gleys) are concentrated in the depressions that surround the upper reaches of the tributary and coastal streams, but wet soils with weak soil profile development (Wet Regosols) are concentrated at lower elevations in the floodplains of the rivers Suir, Blackwater, Brickey and Bride.

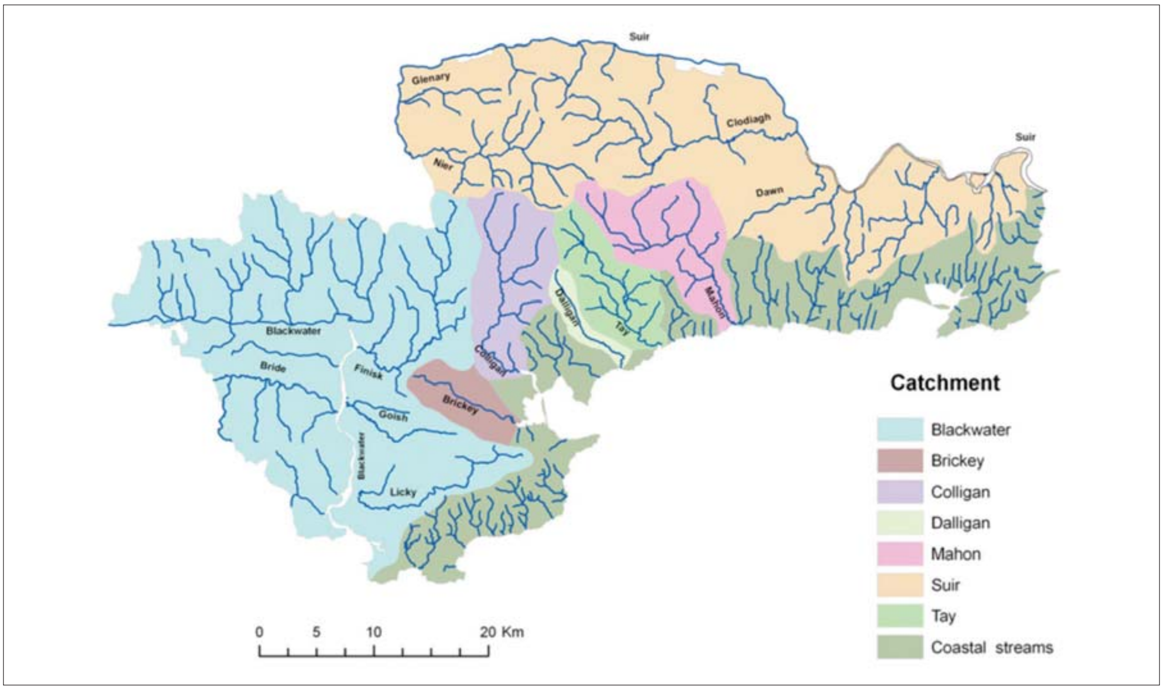

Figure 1.5: River catchments, Co. Waterford (after OSI).

Climate

Ireland, lying at mid-latitudes on the margin of the Atlantic Ocean, has a temperate oceanic climate The prevailing winds are from the southwest and bring moisture-laden air from the Atlantic Ocean. The warm water of the North Atlantic Drift (Gulf Stream) tends to moderate temperatures throughout the year, and consequently the country lacks the extremes of temperature experienced by many other countries at similar latitude. Winters are relatively mild and moist, but summers are relatively cool and cloudy. Many days are wet, and there is no distinct dry season. Average annual precipitation is greatest along the west and southwest coasts and in inland areas of high relief.

The principal factors that influence the climatic pattern in Co. Waterford are proximity to the south coast, and relief, especially the Knockmealdown, Comeragh, and Monavullagh mountains, which rise to 795 m AMSL in the northwest of the county.

The information presented here on the climate of Co. Waterford is based on the records of Met Éireann. There are no synoptic stations in the county; the nearest stations are at Cork Airport, Kilkenny and Rosslare. Climatological stations, which provide limited data, are at Dungarvan and Waterford City (Tycor). A comprehensive network of rainfall stations in the county provides long-term rainfall data.

Precipitation

Average annual rainfall increases twofold across the county from southeast to northwest; it ranges from about 975 mm in the southeast of the county around Dunmore East to over 1750 mm around the summit of the Monavullagh Mountains (Fig. 1.2). The range is smaller than the fourfold range across Ireland, which varies from 700 mm at Dublin to 3200 mm on Carrauntoohil. Over most of the county, the average annual rainfall exceeds 1000 mm; only the lowland coastal areas in the southeast, southwest, and a small area around Portlaw, have average annual amounts less than 1000 mm.

The rainfall distribution pattern is largely associated with elevation (Fig. 1.2). For example, those areas that have more than 1500 mm rainfall lie predominantly above 305 m AMSL, whilst areas with less than 1125 mm rainfall are generally below 152 m AMSL.

Monthly and annual averages of rainfall for rainfall stations in the county are in Table 1.3. On average, the wettest months are January, October, and December; the least amount of rainfall is in June, and July followed by April. The annual averages are influenced by the elevation of the recording stations ($R^2 = 0.53$).

Rainfall distribution: The number of rain-days (rainfall ≥0.2 mm day^{-1}) and the number of wet-days (rainfall ≥1.0 mm day^{-1}) are simple indices commonly used to describe the day-to-day pattern of rainfall. As the averages of rain-days and wet-days at rainfall stations in the county are not reliable, the estimates for the county are based on data for Cork Airport (Table 1.4) and Rosslare (Table 1.5), which are the nearest stations with this type of data.

Table 1.3: Monthly and annual averages of rainfall (mm) at rainfall stations in Co. Waterford.

Station	Grid ref.	Ht. m	Period yr	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
BALLYMACARBERY G.S.	S193128	59	63	148	106	98	75	79	67	70	90	99	122	108	134	1196
BELLE LAKE (FILTER STN.)	S668052	34	49	102	80	75	58	64	58	53	76	81	103	93	98	940
CAPPOQUIN (MT. MELLERAY)	S095041	213	62	166	123	115	94	95	86	83	117	116	145	124	154	1416
CAPPOQUIN HSE.	S102000	70	39	131	100	86	72	70	70	62	88	92	116	100	120	1108
DUNGARVAN (AGR. RES. STN.)	X235932	15	20	133	105	92	72	76	63	61	87	94	115	104	124	1126
GLENCAIRN (ST. MARY'S ABBEY)	W998989	52	62	134	100	87	67	71	63	60	86	86	114	96	121	1083
KILL G.S.	S456031	88	40	122	93	88	69	72	63	59	86	90	110	98	112	1061
KNOCKADERRY RESV. NO.1	S498067	71	120	119	95	91	69	76	65	62	90	95	112	104	115	1094
KNOCKADERRY RESV. NO.2	S494065	62	85	123	98	93	71	78	67	64	92	96	116	106	116	1119
KNOCKANORE	X075891	122	42	147	114	100	76	80	71	71	98	106	131	115	137	1245
LEAMYBRIEN G.S.	S327021	76	41	149	117	105	80	84	74	69	97	104	130	120	141	1268
MONATRAY EAST	X140766	55	31	103	82	72	57	60	53	51	77	77	93	86	96	907
PORTLAW (MAYFIELD)	S466152	8	153	136	103	93	69	78	64	58	84	93	113	104	121	1115
RATHGORMACK	S338174	160	56	162	124	108	84	95	72	68	92	104	134	116	141	1299
RING G.S.	X280884	47	56	129	104	94	70	75	65	65	93	100	122	110	125	1151
STRADBALLY G.S.	X370978	53	43	121	94	87	67	69	61	58	84	90	105	100	113	1050
TALLOW	X009944	15	54	134	101	87	66	73	63	59	86	85	107	102	122	1084
WATERFORD (TYCOR)	S594116	49	120	114	89	81	61	70	60	56	79	86	105	95	106	1002
YOUGHAL (GLENDINE W.W.)	X064839	107	42	137	107	96	73	78	71	67	96	104	126	110	129	1195

Source: Met Éireann

Table 1.4: Climatological data for Cork Airport, 1962–1991, Lat. 51º 5´N Long. 8º 29´W, 154 m AMSL.

TEMPERATURE (*degree Celsius*)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	**Year**
mean daily max.	7.6	7.5	9.3	11.3	13.8	16.6	18.5	18.2	16.0	13.1	9.9	8.5	**12.5**
mean daily min.	2.6	2.5	3.1	4.2	6.5	9.2	11.1	10.9	9.4	7.5	4.5	3.7	**6.3**
mean	5.1	5.0	6.2	7.7	10.2	12.9	14.8	14.5	12.7	10.3	7.2	6.1	**9.4**
absolute max.	12.6	13.5	15.5	20.5	23.6	25.7	28.7	27.5	24.7	19.0	15.9	13.6	**28.7**
absolute min.	-8.5	-8.6	-6.1	-2.4	-0.9	2.4	4.8	4.9	2.3	-0.4	-3.3	-5.9	**-8.6**
mean no. of days with air frost	6.7	5.6	3.4	1.8	0.1	0.0	0.0	0.0	0.0	0.0	2.4	3.9	**24.0**
mean no. of days with ground frost	15.0	12.7	12.0	9.4	2.9	0.2	0.0	0.0	0.4	2.6	9.5	12.2	**76.8**
RELATIVE HUMIDITY (*%*)													
mean at 0900UTC	90	90	88	83	81	81	83	86	88	91	90	90	**87**
mean at 1500UTC	84	80	75	71	71	72	72	73	76	82	83	86	**77**
SUNSHINE (*hours*)													
mean daily duration	1.70	2.28	3.51	5.21	6.02	5.73	5.40	5.14	4.13	2.80	2.16	1.56	**3.80**
greatest daily duration	7.3	9.3	11.8	13.8	15.4	15.9	15.4	14.2	12.8	9.9	8.5	6.7	**15.9**
mean no. of days with no sun	11	9	6	4	2	3	2	2	4	7	9	12	**69**
RAINFALL (*mm*)													
mean monthly total	138.3	115.6	98.7	67.7	83.4	68.8	66.4	88.7	96.4	125.4	111.1	133.8	**1194**
greatest daily total	55.1	48.2	39.3	44.9	49.3	43.3	83.8	64.8	51.8	86.7	69.9	52.2	**86.7**
mean no. of days with >= 0.2mm	20	17	18	14	16	15	14	16	16	19	19	20	**204**
mean no. of days with >= 1.0mm	16	13	13	10	12	10	9	11	12	15	14	16	**151**
mean no. of days with >= 5.0mm	9	8	6	4	6	5	4	5	6	8	7	8	**75**

Table 1.4: Climatological data for Cork Airport, 1962–1991, Lat. 51º 5´N Long. 8º 29´W, 154 m AMSL (cont'd).

WIND (*knots*)													
mean monthly speed	12.9	12.6	12.3	11.0	10.6	9.5	9.1	9.2	10.3	11.2	11.6	12.4	**11.1**
max. gust	94	83	70	63	60	51	57	54	64	75	66	68	**94**
max. mean 10-minute speed	58	54	44	41	41	36	40	38	45	48	46	46	**58**
mean no. of days with gales	3.2	2.2	1.7	0.7	0.4	0.1	0.1	0.2	0.7	1.2	1.8	2.5	**15.0**
WEATHER (*mean no. days with…*)													
snow or sleet	4.5	4.7	3.0	1.1	0.2	0.0	0.0	0.0	0.0	0.0	0.6	2.3	**16.4**
snow lying at 0900UTC	2.7	1.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	**5.6**
hail	1.0	1.1	1.9	1.9	1.1	0.3	0.1	0.1	0.1	0.4	0.3	0.6	**8.8**
thunder	0.4	0.1	0.1	0.2	0.4	0.5	0.8	0.5	0.2	0.4	0.1	0.1	**3.7**
fog	7.4	7.3	7.9	5.9	7.7	8.6	8.5	9.8	10.7	10.4	7.3	8.0	**99.5**

Source: Met Éireann

Table 1.5: Climatological data for Rosslare 1961–1990 Lat. 52º 15/ N Long. 6º 20/ W 26 m AMSL.

TEMPERATURE *(degrees Celsius)*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sep.*	*Oct.*	*Nov.*	*Dec.*	*Year*
mean daily max.	8.2	7.9	9.3	10.9	13.2	15.9	17.9	17.9	16.3	13.8	10.6	9.1	**12.6**
mean daily min.	3.9	3.8	4.3	5.6	7.9	10.4	12.1	12.2	10.8	9.0	5.9	4.8	**7.6**
mean	6.1	5.9	6.8	8.3	10.5	13.2	15.0	15.0	13.6	11.4	8.2	7.0	**10.1**
absolute max.	12.7	13.0	14.2	20.1	20.3	25.4	26.2	25.9	21.5	19.2	15.7	14.0	**26.2**
absolute min.	-4.4	-4.1	-2.5	-1.0	-0.3	4.7	5.2	6.2	2.6	0.7	-2.5	-3.1	**-4.4**
mean no. of days with air frost	2.4	2.0	1.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.6	**8.0**
mean no. of days with ground frost	11.0	8.6	7.2	4.4	1.3	0.0	0.0	0.0	0.1	0.8	5.6	8.5	**47.4**
RELATIVE HUMIDITY *(%)*													
mean at 0900UTC	86	85	84	82	81	82	82	84	84	86	85	86	**84**
mean at 1500UTC	81	79	76	76	77	78	77	78	77	80	79	82	**78**
SUNSHINE *(hours)*													
mean daily duration	1.94	2.47	3.87	5.74	6.88	6.59	6.29	5.86	4.79	3.27	2.50	1.75	**4.33**
greatest daily duration	8.2	9.8	11.8	13.4	15.4	15.8	15.9	14.0	12.8	10.2	8.6	7.3	**15.9**
mean no. of days with no sun	11	8	5	3	1	2	1	2	3	6	9	1	1 **61**
RAINFALL *(mm)*													
mean monthly total	94.8	69.9	67.8	55.7	55.8	50.6	50.7	68.7	73.3	94.9	97.1	97.8	**877.1**
greatest daily total	44.9	33.4	48.9	27.9	31.0	32.6	79.1	61.0	63.6	54.8	56.7	44.8	**79.1**
mean no. of days with >= 0.2mm	18	15	16	14	14	13	11	13	14	16	16	17	**176**
mean no. of days with >= 1.0mm	14	11	12	10	10	8	8	9	10	12	13	13	**129**
mean no. of days with >= 5.0mm	7	5	5	4	4	3	3	4	5	6	6	7	**59**

Table 1.5: Climatological data for Rosslare 1961–1990 Lat. 52º 15/ N Long. 6º 20/ W 26 m AMSL (cont'd).

WIND *(knots)*													
mean monthly speed	12.9	12.8	12.4	11.8	11.4	10.1	9.5	10.0	10.7	11.6	12.1	12.8	**11.5**
max. gust	76	76	66	75	57	51	50	56	72	87	71	80	**87**
max. mean 10-minute speed	46	44	42	52	35	38	35	37	47	50	45	50	**52**
mean no. of days with gales	2.5	1.5	1.1	1.3	0.3	0.2	0.1	0.2	0.5	0.9	1.3	1.9	**11.7**
WEATHER *(mean no. of days with)*													
snow or sleet	2.7	3.7	1.9	0.8	0.1	0.0	0.0	0.0	0.0	0.0	0.2	1.3	**10.7**
snow lying at 0900UTC	0.8	0.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	**1.8**
hail	1.8	1.1	2.5	2.1	1.0	0.3	0.0	0.0	0.1	0.4	1.2	1.2	**11.8**
thunder	0.4	0.2	0.1	0.4	0.8	1.0	1.0	0.7	0.6	0.5	0.7	0.3	**6.7**
fog	2.0	2.2	3.2	4.2	3.2	4.4	5.0	4.6	3.9	2.5	1.7	1.6	**38.5**

Source: Met Éireann

As in Ireland generally, rainfall in the county is distributed mainly in falls of low intensity over many days. The pattern in the west of the county, west of Dungarvan, is probably broadly analogous to that at Cork Airport, and the pattern in the east approaches that obtaining in Rosslare. This implies at least 204 rain-days and 151 wet-days in the west of the county; the wet-days increase to over 175 days around the mountain summits (Rohan, 1975). Rainfall is less frequent in the east of the county. Wet-days are estimated to increase from at least 129 days at the southeast periphery to about 151 days around Dungarvan; rain-days exceed wet-days in this region by about 50±3 days.

Rainfall intensity: At Waterford City, the rainfall intensities to be expected for periods between 0.5 and 100 years and durations ranging from 1 min to 2 days are in Table 1.6. This station is in the low rainfall region (1004 mm yr^{-1}), and events of a given intensity are possibly somewhat more frequent over most of the county. Extreme rainfall events are relatively infrequent, and rarely exceed the steady infiltration rate of free draining soils in summer. Most free draining soils in Ireland that have been assessed have steady infiltration rates in summer equal to or greater than 30 mm hr^{-1} and rainfalls of greater intensity can be expected only once in 30 years at Waterford City.

Table 1.6: Extreme rainfall return periods[1], Waterford City.

Duration	Return period (years)								
	1/2	1	2	5	10	20	30	50	100
1 min				1.8	2.0	2.4	2.6	3.0	3.4
2 min				3.0	3.5	4.1	4.6	5.1	5.9
5 min				5.4	6.3	7.5	8.3	9.3	10.7
10 min				7.8	9.1	10.9	12.1	13.7	15.9
15 min	4.9	6.2	6.9	9.4	11.5	13.9	15.4	17.7	21
30 min	6.7	8.4	9.4	12.7	15.4	18.5	20.5	23	27
60 min	9.0	11.2	12.5	16.7	20.0	24	26	30	35
2 hour	12.2	14.8	16.6	21.8	26	31	34	38	44
4 hour	17.0	20.5	22.5	29	34	39	42	47	54
6 hour	20.8	24.9	27	35	40	46	50	56	63
12 hour	27.4	33	35	45	52	59	64	71	80
24 hour	34	40	44	55	63	72	78	85	96
48 hour	43	50	55	68	77	88	94	103	116

[1] = *Maximum rainfall (mm) of indicated duration expected in the indicated return period.*

Source: Met Éireann

Temperature

Monthly and annual averages of maximum, minimum and mean temperatures for the climatological stations within the county at Dungarvan (Carriglea), Dungarvan (Ballygagin), and Waterford City (Tycor) are in Table 1.7. All these stations are at low altitude (15–49 m AMSL), and mean annual temperatures are virtually identical (10.0– 9.9°C). Mean monthly temperatures are very similar at Ballygagin and Carriglea, but they tend to be slightly (≈0.2°C) lower at Tycor from November to March (incl.). The amplitude is slightly less at Tycor, where the mean maximum is least in all months and the mean minimum is slightly greater in all months except February. These slight differences probably reflect the small difference in altitude (Table 1.7).

The annual average mean temperatures (1961–1990) at the three climatological stations in Co. Waterford were virtually the same as that at Rosslare, which reflects their proximity to the coast. Compared to the inland station at Birr, the annual average is warmer (0.7°C), and each month is warmer by amounts ranging from 0.5°C in April, May and June to 0.9–1.2°C in the November to January (incl.) period (Fig. 1.6).

Temperatures are likely to decrease northwards within the county as distance from the sea increases. Since virtually all the northern county boundary is less than 40 km from the sea, the influence of distance from the sea on temperature is small and is less than the effects of altitude. The average lapse rate of temperature with increase in altitude in Ireland is generally assumed to be 1°C per 150 m (McEntee 1976). On this basis it is estimated that the mean annual temperature at Birr equates to that at Dungarvan (Ballygagin) extrapolated to 122 m AMSL. The calculated values at 300 m and 500 m AMSL are 8.1°C and 6°C respectively. A mean annual air temperature of 9°C, which equates to a soil temperature of 8°C at 50 cm depth, is estimated to occur at 165 m AMSL.

Because soil temperature regimes control or influence soil formation, they are used in defining classes at various categoric levels in Soil Taxonomy (USDA, 1999). The lowlands in Co. Waterford have mean annual soil temperatures more than 8°C, and the difference between mean summer and mean winter soil temperatures is more than 6°C; they have a mesic temperature regime which is estimated to extend up to 165 m AMSL. At higher altitudes, the mean annual soil temperature is less than 8°C, but the difference between mean summer and mean winter temperatures remains above 6°C, and the temperature regime is termed frigid. The distinction between frigid and mesic temperature regimes pertains to lower levels of classification. Even at high altitude, a cryic regime, which is a criterion for classification at suborder level, is absent in Co. Waterford.

Table 1.7: Estimates of temperatures (°C), 1961-1990, at three stations in Co. Waterford (Met Éireann)

Station	Dungarvan (Ballygagin)			Dungarvan (Carriglea)			Waterford (Tycor)		
Latitude	52° 05'n			52° 05'n			52° 15'n		
Longitude	07° 39'w			07° 41'w			07° 08'w		
Grid Ref.	X 2493			X 2293			S 5912		
Height AMSL	15 metres			18 metres			49 metres		
Month	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean
Jan	8.6	2.6	5.6	8.6	2.0	5.4	8.0	2.6	5.3
Feb	8.4	2.9	5.6	8.7	2.5	5.6	8.0	2.7	5.3
March	10.2	3.4	6.8	10.6	3.0	6.8	9.9	3.4	6.6
April	12.2	4.6	8.4	12.9	4.1	8.5	12.1	4.6	8.4
May	14.8	6.9	10.9	15.3	6.4	10.8	14.7	7.0	10.9
June	17.8	9.6	13.7	18.4	9.2	13.8	17.6	9.9	13.8
July	19.8	11.5	15.7	20.3	11.2	15.6	19.5	11.6	15.5
Aug.	19.3	11.2	15.3	19.8	10.9	15.3	19.1	11.4	15.2
Sept.	17.1	9.4	13.3	17.6	9.2	13.4	16.9	9.7	13.3
Oct.	14.1	7.7	10.9	14.5	7.3	10.9	13.9	7.7	10.8
Nov.	10.7	4.4	7.6	11.1	3.9	7.5	10.3	4.5	7.4
Dec.	9.3	3.4	6.3	9.3	2.9	6.2	8.8	3.5	6.1
Year	13.5	6.5	10.0	13.9	6.1	10.0	13.2	6.6	9.9
Spring	12.4	5.0	8.7	12.9	4.5	8.7	12.2	5.0	8.6
Summer	19.0	10.7	14.9	19.5	10.5	14.9	18.8	10.9	14.8
Autumn	14.0	7.2	10.6	14.4	6.8	10.6	13.7	7.3	10.5
Winter	8.8	2.9	5.9	8.8	2.5	5.7	8.2	2.9	5.6

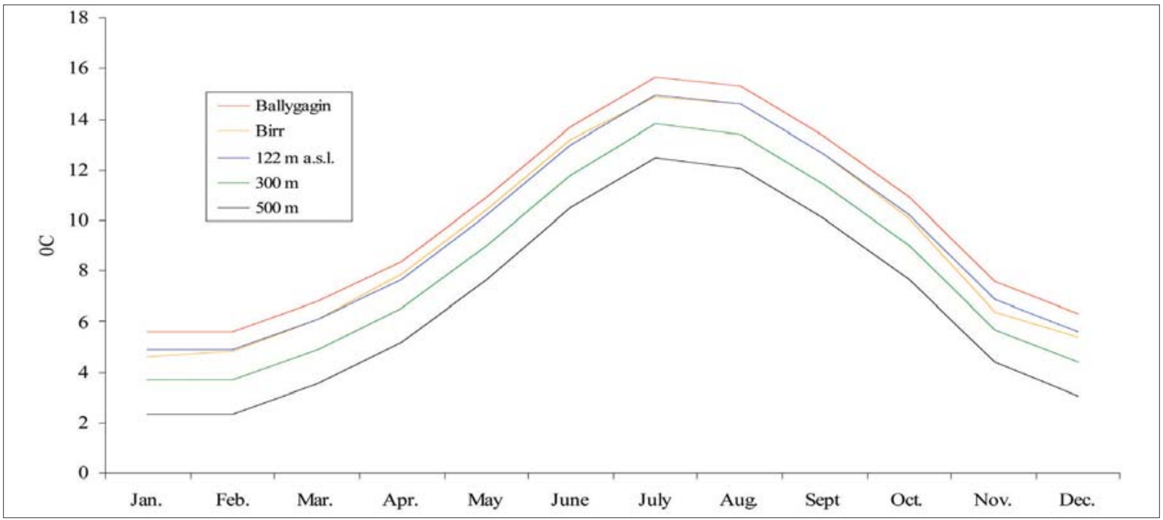

Figure 1.6: Mean monthly temperatures at Dungarvan (Ballygagin) and Birr (Met Éireann), and calculated values at various altitudes based on values at Ballygagin.

Sunshine

Duration of bright sunshine in Ireland exhibits a southeast-northwest trend; the largest amounts are recorded at Rosslare. The duration of sunshine at Carrick-on-Suir, which is close to the northern boundary of Co. Waterford, probably represents reasonably well the lower annual average limit for the lowland areas of the county. This amounts to 1434 hours per year (3.93 hr day^{-1}). Keane and Sheridan, (2004) indicate about 1500 hours along the coast of the county, which is about 80 hours less than that recorded at Rosslare (Table 1.5). Lowland areas in the county are estimated to have significantly more bright sunshine than the midlands and north midlands; Birr, for example, has 1215 hours, which is less than the coastal and northern parts of the county by 19% and 15% respectively.

The duration of sunshine is likely to decrease in uplands owing to increased cloudiness, especially on slopes facing the prevailing winds (Keane and Sheridan, 2004). The extent of the decrease is uncertain, but it means that sunshine in the mountainous areas may be reduced to less than 1200 hours, and may approach that estimated for parts of the Cork–Kerry region (Keane and Sheridan, op. cit.).

Growing season

The duration of the growing season in Ireland is determined principally by soil temperature. As the critical temperatures that determine the start and end of growth varies among different crops, the concept of growing season pertains to a specific crop. Grass, the predominant crop in the county, grows actively when soil temperature is consistently above 6°C (Brereton, 1985); this is the generally accepted critical temperature for grass growth. At the start of growth, the critical soil temperature equates to an air temperature of 5.6°C. The grazing season is usually shorter than the growing season as the bearing capacity of soil, influenced by rainfall and internal drainage, may be insufficient to permit grazing even when grass is available. The growing season, calculated, on the basis of a critical temperature, is a climatological model rather than an exact biological indicator (McEntee, 1978); nevertheless, it is useful for spatial comparisons,

Figure 1.7 shows the calculated length of the grass growing season in Ireland (Connaughton, 1973), and the mean air temperatures in January; both trend southwest to northeast with the highest values in the southwest. The map (Fig. 1.7) indicates that even in January, the coldest month of the year, the mean temperature in the coastal area of Co. Waterford, and for some distance inland, is above the critical air temperature, whilst in the north-midlands it is 1°C less than the critical temperature. At Ballygagin, the mean temperature in January is equal to the critical temperature, whilst it is slightly less at Carriglea and Tycor (Table 1.7).

The median length of the grass growing season is 300 days at sea level in the coastal area around Dunmore East in the southeast of the county; it is a little longer in the Ardmore area in the southwest, but does not reach, on average, the 330 days experienced in the coastal areas west of Cork City (Fig. 1.7b). The length of the growing season decreases northwards in the county; nevertheless, the lowlands of the entire county enjoy a significant advantage over the midland and east-midland areas of the country, where the growing season is shorter by 30 days or more.

The estimates given above relate to sea level. In oceanic climates, the annual temperature curve is relatively flat, and the growing season shortens much more rapidly with increase in altitude than in continental climates. Gloyne (1968) contrasted the decrease of 13 days 100 m^{-1} in the maritime climate of Northern England/Scotland with the 6.5 days 100 m^{-1} at Berne, Switzerland. On the basis of a decrement of 13 days 100 m^{-1} , the growing season at Ballygagin extrapolated to 300 m AMSL is estimated to be 273 days, which represents the upper limit of the midland region. Thus, based on climatic criteria, the potential grass growing season in the Drum Hills, which rise to 302 m AMSL, is equal to or greater than that obtaining in the midlands.

Accumulated temperatures, expressed as degree-days, integrate temperatures with reference to a base temperature. They are used mainly to predict maturity dates of crops, but they also provide a simple index that is useful in comparing conditions for plant growth at different locations. McEntee (1978), on the basis of data recorded at synoptic stations in Ireland, empirically derived equations that predict degree-day totals from positional parameters defined as latitude, altitude, and distance from the sea. The degree-day totals based on these equations (Table 1.8) refer to a base temperature of 6°C, which is the critical temperature for grass growth.

The decrease in degree-day totals across Co. Waterford from south to north is relatively small (3%) compared to the decrease due to altitude, which amounts to 11% at 100 m *AMSL*. As the locations used in deriving the equations were at or below 108 m AMSL, extrapolation to higher altitudes would be speculative.

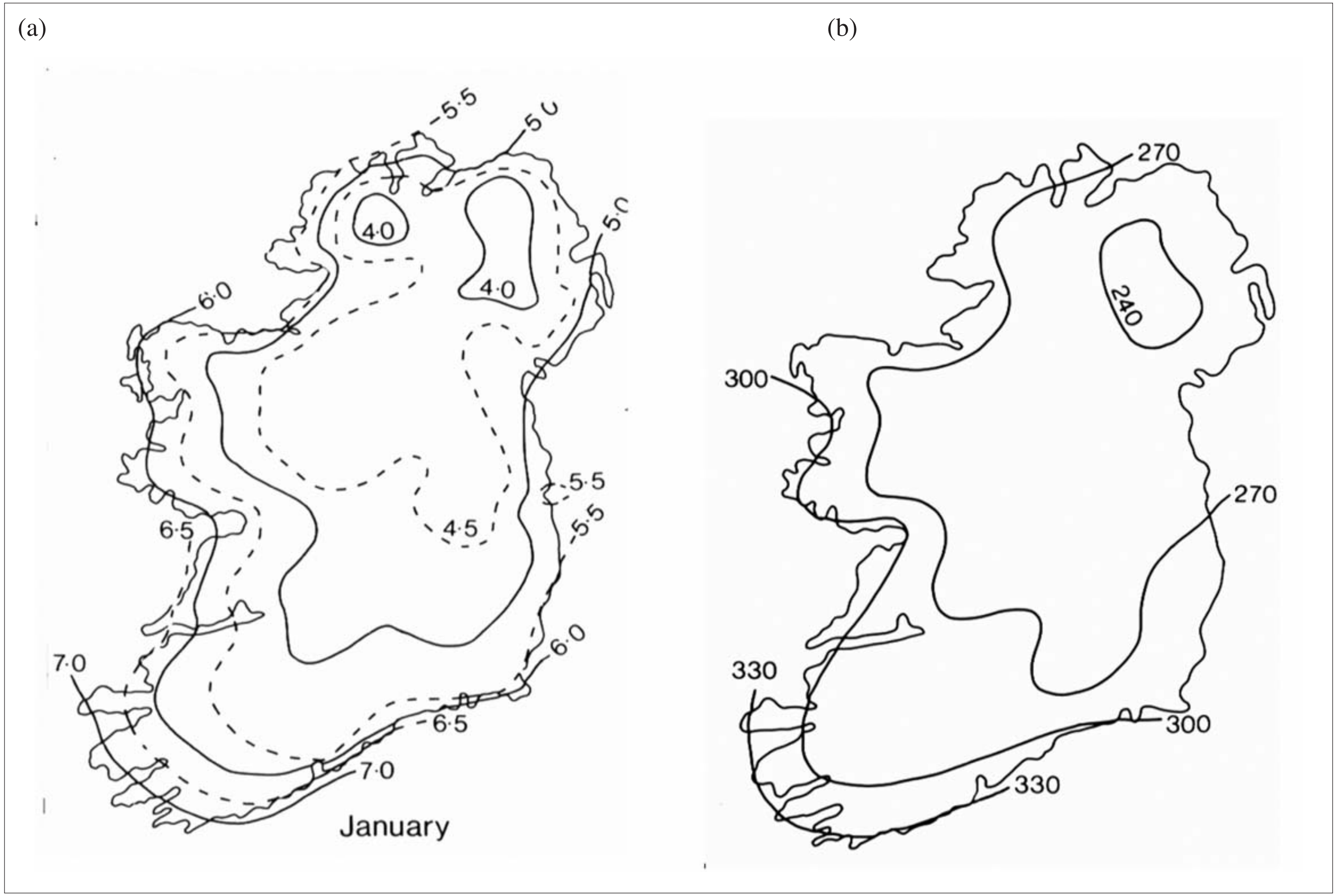

***Figure 1.7:* (a) Mean daily air temperature (°C), January, Ireland, 1931–1960, reduced to mean sea level, and (b) Median length (days) of grass growing season (1954–1968) (Met Éireann data).**

Table 1.8: Annual total of degree-days, base 6°C, by location (Based on McEntee, 1978).

Location	Latitude	Altitude m a.s.l	Degree-days	Ratio %
Co. Waterford North	52°–22’	0	1711	95
(Kilsheelan)		100	1516	84
Co. Waterford South	51° 56’	0	1761	98
(Ardmore)		100	1566	87
Midlands (Birr)	53° 05’	0	1650	92
		100	1455	81
Ireland South	51° 27’	0	1802	100
(Mizen)		100	1607	89

Moisture balance

Mean monthly evaporation from a water surface (ET_a), measured in a Class a pan at Dungarvan (Carriglea), is compared to mean monthly rainfall at the same station in Figure 1.8. On average, monthly precipitation exceeds evaporation (ET_a) from August to April (incl.); the excess ranges from 10 mm in August to 117 mm in January. Actual evaporation, however, is generally considerably less than that measured with a Class a pan, whilst values estimated by the Penman method (ET_P) are close to actual values. Actual evaporation is generally about 0.7 times pan evaporation, but there is significant seasonal variation. The ratio of ET_a (Class A pan) to ET_P (Penman) for each month at Rosslare was used to estimate monthly potential evapotranspiration (ET_P) at Dungarvan (Carriglea).

Based on potential evapotranspiration (ET_P), the average moisture deficits are very small, and range from 4 mm in June to 10 mm in July (Fig. 1.8). In normal years, moisture deficits have no significant effect on crop growth over most of the county where average rainfall is equal to or greater than the 1108 mm per annum received at Dungarvan (Fig. 1.2). Significant reductions in grass yield due to moisture deficits are confined to exceptional years or to the southeast coastal area of the county that has less than 1000 mm average annual rainfall (Fig. 1.2). In this area, the average annual herbage loss due to drought was estimated to be 1 DM t ha^{-1}, or more, at 250 N kg ha^{-1} yr^{-1} (Brereton, 1982); this loss represents about 7% of potential yield in the absence of drought.

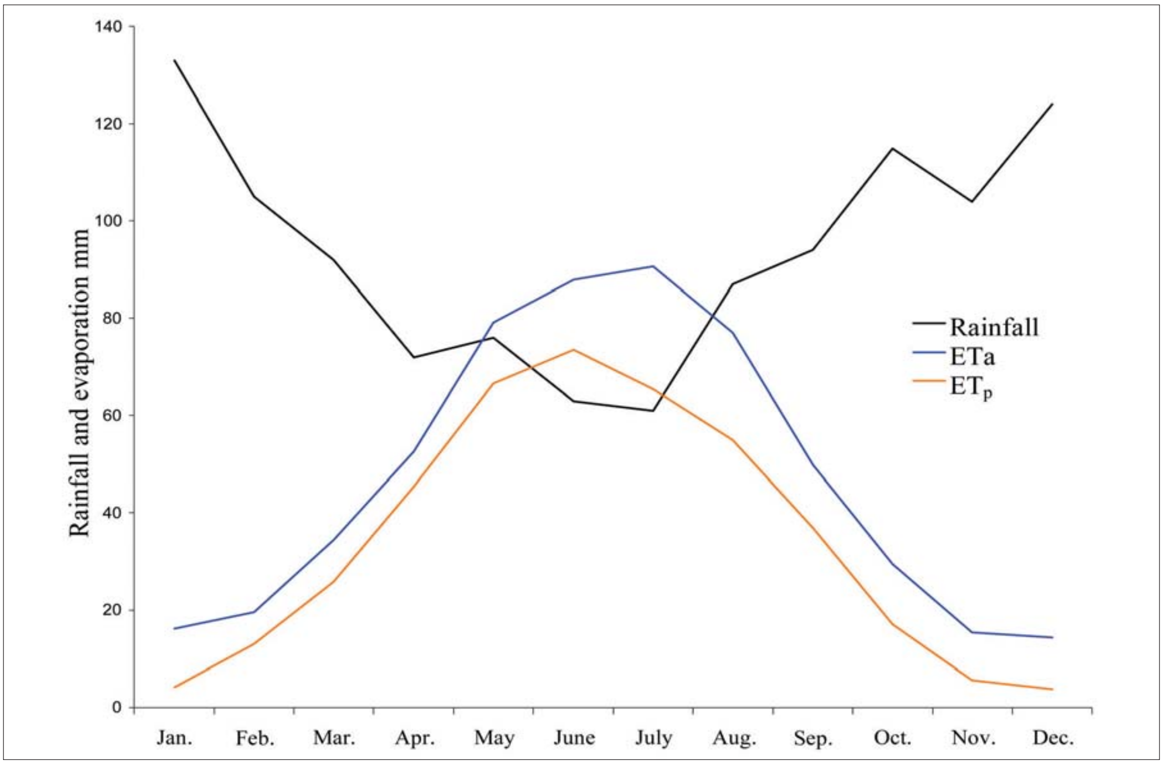

Figure 1.8: Rainfall, Class A pan evaporation (ET_a), and calculated potential evapotranspiration from grass (ET_p) at Dungarvan (Carriglea). (Met Éireann data).

Bedrock

The formation of bedrock in Co. Waterford extended from the early Cambrian Period to the early Carboniferous, an interval of about 200 Ma (Holland, 2001). The depositional environment alternated between marine and terrestrial. Tectonic activity generally accompanied the transitions but succeeded the transition in the case of the Carboniferous formations. In the southeast of the county, the transition was accompanied by prolonged and intermittent volcanism (Quinn and Warren, 1989).

Only part of the geological succession is evident in the county (Table 1.9). All of the Precambrian, parts of the Cambrian, most of the Devonian, all of the Upper Carboniferous and rocks of Mesozoic and Tertiary age are absent from the geological succession exposed in the county (Sleeman and McConnell, 1995). However, geological events during these intervals, principally erosion and mountain building, have contributed much to the geological structure.

Table 1.9: Bedrock, Co. Waterford (Based on Sleeman and McConnell, 1995; Tietzsch-Tyler and Sleeman, 1994).

Era	Period	Age Ma	Group	Formation	Symbol	Environment	Lithology
Upper Palaeozoic	Carboniferous	345		Walsortian Limestone	C4		Massive calcareous mudstone, packstone & wackestone
				Ballysteen	C3		Argillaceous micrite, packstone, wackestone & shale-chert banks
				Ballymartin	C2	Shallow tropical sea on North Munster Shelf	Muddy bioclastic limestone-calcareous shale
		359	Lower Limestone Shales	Porters Gate, Mellon House, Ringmoylan & Ballyvergin	C1		Sandstone, siltstone, calcareous shale & noncalcareous mudstone
	Devonian			Templetown-Harrylock	D4	Extra basinal-braided streams & sheet floods.	Conglomerate & siltstone
				Gyleen-Kiltorcan	D3	Nonmarine to marine transition. Fluvial coastal plain.	Sandstone & mudstone
				Carrigmaclea		Braided streams.	Conglomerate & sandstone
			Nier	Ballytrasna Knockmealdown Sandstown	D2	A thick sequence of fluviatile sediments accumulated in the subsiding Munster Basin; the coarser sediments, representing alluvial fans and braided streams, are mostly on the margins of the basin.	Medium grained sandstone & mudstone
			Comeragh		D1		Conglomerate & mudstone-sandstone
		416		Croghaun-Coumshingaun			Coarse conglomerate

Table 1.9: Bedrock, Co. Waterford (Based on Sleeman and McConnell, 1995; Tietzsch-Tyler and Sleeman, 1994) (cont'd).

Era	Period	Age Ma	Group	Formation	Symbol	Environment	Lithology
Lower Palaeozoic	Silurian	444		Ballindysert	S1	Turbidite currents flowing from continental margins into narrow basin as the lapetus Ocean closed.	Dark, grey slate, greywacke
	Ordovician		Duncannon	Campile-Bunmahon-Tramore Shale	O2	Submarine volcanic arc at continental margin.	Intermediate to acid volcanics in sedimentary successions of mostly shale & slate.
		488	Ribband	Kilmacthomas	O1	Turbidite currents in a deep marine basin.	Slate-siltstone
	Cambrian	542	Cahore	Booley Bay	B1	Distal turbidites on abyssal floor of lapetus Ocean.	Mudstone-siltstone & occasional sandstone.

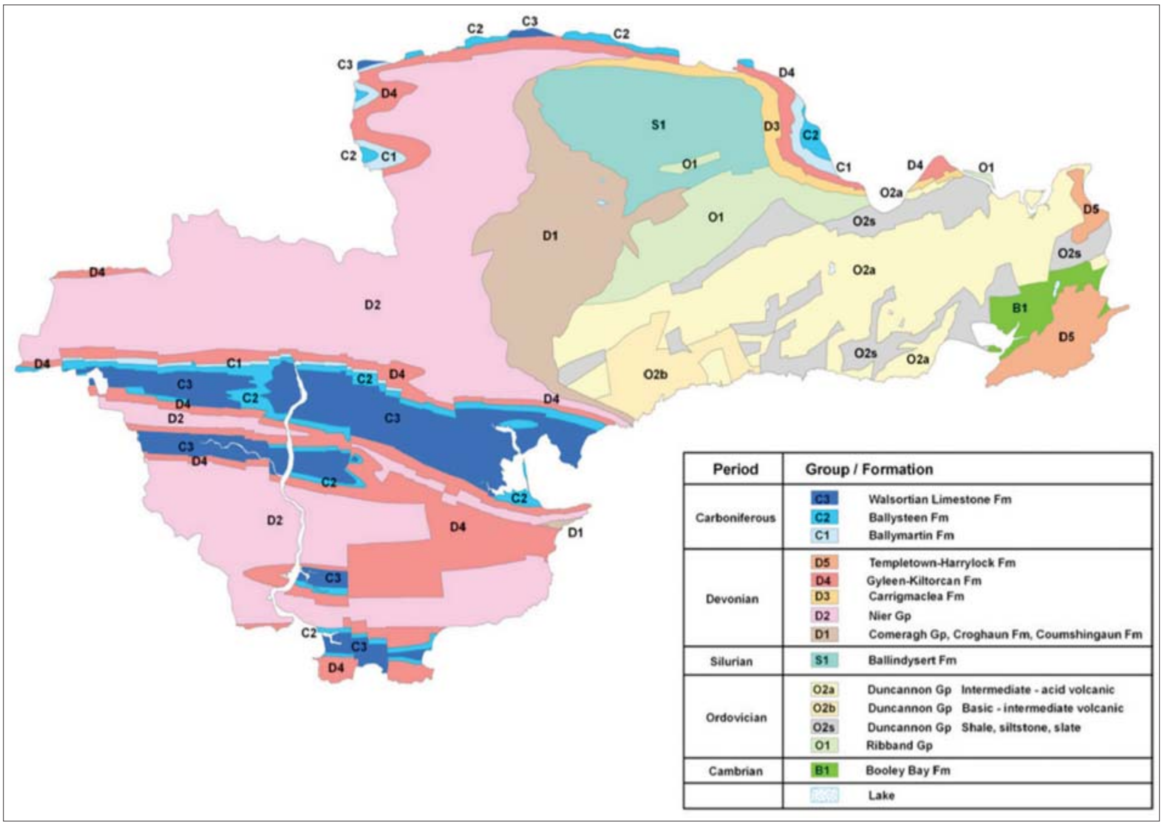

Figure 1.9: Map of bedrock, Co. Waterford.

The county comprises two broad geological regions. The eastern part forms the southwest extension of the Leinster Massif and consists predominantly of the older rocks in the county, which were formed during the Lower Palaeozoic Era. The western region includes the Comeragh–Monavullagh Massif, the Drum Hills, and intervening valleys. This region is composed of younger rocks deposited during the Upper Palaeozoic Era (Fig. 1.9).

Lower Palaeozoic

The opening of the Iapetus Ocean took place in the early part of the Era. Following rifting of an ancient land mass the crust stretched and thinned and sank below sea level (Tietzsch-Tyler and Sleeman, 1994). A deep basin was formed which continued to widen by sea-floor spreading up to the early Ordovician. The Iapetus Ocean separated the Laurentian Plate in NW Ireland from the Avalon Plate in SE Ireland (Phillips, 2001). As the ocean floor was subducted beneath chains of volcanic islands along the margin the ocean began to shrink. It continued to contract up to around the end of the Lower Palaeozoic when it finally closed. Virtually all the rocks exposed at the surface in east Co. Waterford were formed within the Iapetus Ocean.

The Lower Palaeozoic rocks of east Waterford form four tracts, which are probably bounded by major faults (Sleeman and McConnell, 1995). From south to north, the tracts comprise: (1) the Booley Bay Formation, a Cambrian sedimentary sequence; (2) Duncannon Group, a middle to late Ordovician sequence dominated by volcanic rock; (3) Kilmacthomas Formation, early Ordovician shale; (4) Ballindysert Formation, a Silurian sedimentary sequence.

Cambrian rocks

The oldest rocks that are exposed at the surface in the county form a belt about 3 km wide, which extends northeastward from Tramore Back Strand, through Clohernagh and Belle Lake, to the east coast around Woodstown. The rocks are part of the Cahore Group, which formed along the southeast margin of the Iapetus Ocean. The coarser grained components of the group lie to the east in Co. Wexford, but the part that is in Co. Waterford, the Booley Bay Formation, is generally finer grained. The formation consists of dark grey to black cleaved mudstone interbedded with thin pale grey siltstone and occasional greywacke, sandstone, and some conglomerate. The siltstone may be only a millimetre or two thick and closely spaced.

The Booley Bay Formation owes its origin to turbidity currents triggered by earthquakes. The preponderance of thinly bedded dark mudstone indicates that they were deposited at the furthest edge of turbidite sheets (distal turbidites) on the abyssal floor of Iapetus, whereas the coarse formations in Co. Wexford were deposited nearer to the shore (proximal turbidites). Occasional black mudstone, up to two metres thick, which occur throughout the succession, represents long quiescent intervals between periods of earthquake activity. Fossils, which are scarce in the group, imply Lower to Middle Cambrian age.

The Cahore Group, including the Booley Bay Formation, was first subjected to compressional stresses during the Monian Orogeny, shortly after deposition (Tietzsch-Tyler and Sleeman, 1994). This deformation caused large scale crumpling in the thinly bedded Booley Bay turbidites, producing large folds; numerous small thrust faults were also formed.

In common with the other Lower Palaeozoic rocks, except volcanics, in the South Wexford/East Waterford area, the Booley Bay strata are impermeable and considered aquitards (op. cit.). Groundwater flow is normally restricted to the top 30 m of rock or along faults. The overlying terrain is generally low-lying and relief is flat to undulating. Most of the soils on the formation are poorly drained, but some well drained soils are found on the upper slopes at elevations above 15 m to 50 m AMSL (Chapter 3).

Ordovician rocks

The Ordovician rocks reflect a complex interaction of sedimentation, volcanic activity and tectonism, which were associated with the margins of the Iapetus Ocean, which bisected Ireland. Ordovician sedimentary and volcanic rocks originally formed in belts roughly parallel to the Iapetus continental margins, which were aligned roughly NE-SW. Later deformation has commonly emphasised the original orientation. The Ordovician rocks exposed were formed in a marine environment, and many are fossiliferous (Graham, 2001).

According to Sleeman and McConnell, (1995) the oldest Ordovician rocks exposed at the surface in the county are the sedimentary rocks of the Kilmacthomas Formation. These were deposited in a deep marine basin by turbidity currents and by settling of hemiplegic sediment. During the Ordovician Period, the ocean began to close by subduction of the ocean floor under the continental margin on which the present area of Co.Waterford was situated. The result was volcanic activity on the overriding plate, which is preserved as basic to acid tuffs, lavas and minor intrusions of the Duncannon Group. Ultimately, a mature volcanic arc developed, but this did not emerge above sea level; the volcanic rocks were deposited under water interbedded with fine-grained sedimentary rocks.

The Kilmacthomas Formation outcrops over a large area between Croughaun Hill to the North and the main Waterford to Dungarvan Road (N25), which forms its southern limit. It also outcrops in a narrow strip on the north side of Croughaun Hill and another strip just south of Clonea. Penny (1980) distinguished a number of lithofacies within the formation:

- laminated green silky slate with trace fossils,
- very thin bedded laminated grey siltstone,
- homogeneous green purple and grey slate,
- thinly bedded, well laminated purple and green slate (variegated mudstone),
- acid tuffs, particularly in lower part of the formation.

The variegated mudstone, which Penney (op. cit.) interpreted as the deposits of low-density turbidites, is the most common facies in the formation. The purple colour is associated with small detrital grains of ilmenite and haematite; the green colour is associated with leucoxene, limonite and large amounts of green chlorite. The minerals containing iron account for the relatively large amounts of free iron found in soils derived from fine-grained sediments (Chapter 3).

Although fractured, the slate and shale generally have low permeability and are regarded as poor aquifers (Sleeman and McConnell, 1995). Yields of water to wells often depend on the permeability developed in the uppermost few metres of broken and weathered rock and the supply may be unreliable. Except in depressions, the overlying soils are well drained (Chapter 3).

The tract between the Waterford to Dungarvan road (N25) and the south coast is underlain predominantly by rocks of the Duncannon group. This is a complex group characterised by the abundance of intermediate to acidic volcanic rocks and rests uncomformably on rocks of the Ribband Group, which includes the Kilmacthomas Formation. The group forms a NE to SW trending belt from near Arklow although the prominent NE to SW trend is partly due to later deformation (Graham, 2001). This group was formed in Co. Waterford in the middle to late Ordovician; it comprises volcanic rocks, sedimentary successions, and near-surface intrusions, which together represent a submarine volcanic arc formed at the Avalonian continental margin above the subducting Iapetus Ocean.
The Campile Formation is the most extensive formation of the group in Co.Waterford. It consists of a variety of acid volcanic rocks and shale. Generally, the volcanic rocks are more tuffaceous in the lower part and mainly massive or brecciated rhyolite in the upper part. The rocky knolls, which give

the landscape its distinctive rugged appearance, especially in the eastern part, consist of rhyolite domes. Numerous horizons of shale occur between the volcanic deposits; only the more extensive areas of shale have been delineated on GSI sheets 22 and 23 e.g. the Ross Member to the north and the Tramore shale and Ballyhack Members to the southeast.

The Bunmahon Formation, which lies along the south coast and inland between Knockmahon and Stradbally, comprises basic to intermediate lavas with penecontemporaneous basic intrusions.

The permeability of rocks in the Duncannon Group depends on the degree of fracturing. The rhyolitic igneous rocks, the stronger rocks in the group, tend to be the most permeable. Wright (1997) classified the aquifers of the Campile volcanic rocks as regionally important with 'excellent' yields (>400 m^3 day^{-1}) but Sleeman and McConnell (1995) state that only moderate yields (270–400 m^3/day^{-1}) were abstracted from boreholes in the group covered by Sheet 22 in Co. Waterford. The sedimentary rocks in the Duncannon Group are probably similar to Lower Palaeozoic sediments in general; the aquifers are likely to be generally unproductive with moderately productive aquifers only in local zones. Nevertheless, the soils overlying the shaly rocks that are on the northern and southwest margin of the group (Ross and Ballyhack members, Tramore Shale Fm) are predominantly well drained (Chapter 3) and probably reflect the permeability developed within the top few metres of fractured or weathered rock. Most of the land overlying the area mapped as volcanic is well drained, but a significant amount of the land is poorly drained. Because of the intricate geological pattern, the relative influence of topography compared to shale inclusions in the bedrock on the genesis of poorly drained land is unclear.

Silurian rocks

These rocks occupy a large tract, which includes Clonea and Rathgormuck, to the north of Croughaun Hill. They were formed by much the same processes as the Kilmacthomas Formation to the south and represent filling of a narrow remnant of the Iapetus Ocean after closure by subduction was almost complete (Sleeman and McConnell, 1995). Turbidity currents flowed from both continental margins to the narrow basin; those from the south include material eroded from the older volcanic arc. The Silurian rocks in Waterford are assigned to one formation, Ballindysert (op. cit.); they comprise dark grey, generally massive, slate, and inclusions of greywacke turbidites.

Penny (1980) distinguished three lithofacies within the formation:
- grey, homogeneous slate
- grey, silty laminated slate
- grey slate and fine sand lenses.

The homogeneous slate is composed predominantly of fine silt and clay. There are occasional fine sand grains, which Penny interpreted as indicating hemi-pelagic settling. He attributed the silty laminated slate to turbidity currents. In addition, there are small areas of distinctly coarser rocks consisting of greywacke and conglomerate (Ballyhest Member).

The Silurian and earlier rocks were deformed during the Caledonian Orogeny (C. 405 Ma) which involved closure of the Iapetus Ocean and collision of the two blocks of continental crust. Although fractured, the Ballindysert Formation, in common with Lower Palaeozoic sediments generally, is regarded as a poor aquifer (Sleeman and McConnell, 1995), but may produce moderately productive aquifers in local zones (Wight, 1997). Nevertheless, the overlying soils are predominantly well drained (Chapter 3) and probably reflect rapid or moderately rapid permeability of fractured or weathered rock in the top few metres.

Upper Palaeozoic
The Upper Palaeozoic rocks in the county rest unconformably on folded and faulted Lower Palaeozoic rocks (Capewell, 1955). The unconformity reflects the Caldonian Orogeny, which involved closure of the Iapetus Ocean, the collision of blocks of continental crust, and subsequent erosion of uplifted crust (Phillips, 2001). The collision was a relatively mild event in the British Isles and did not create (Graham) large-scale uplift of mountain ranges. Deformation in the Leinster area took place during the Lower Devonian (405 ± 2 Ma). The Upper Palaeozoic rocks in the county are of Devonian, probably Upper Devonian, and Lower Carboniferous (Dinantian) age.

Devonian
The large landmass known as the Old Red Continent, which was produced by the final closure of the Iapetus Ocean, lay mainly to the north of Ireland and included present day Sweden and Greenland. Paleomagnetic reconstructions place Ireland about 20º south of the equator in the mid-Devonian.

The Devonian sediments accumulated in a large basin, the Munster Basin (Capewell 1965), which extended from the west coast south of the Dingle Peninsula to at least the eastern boundary of the Comeragh Mountains. The basin continued to subside resulting in a very thick, up to 6 km, sequence of sediments that were deposited by rivers (fluviatile). Grain size and colour varies; the rocks comprise conglomerate, sandstone, siltstone, and mudstone, and they are mostly red or green.

For the earliest sediments, Capewell (1955) deduced an eastern provenance that included volcanic and minor intrusive rocks. The large volume of sediments in the Munster Basin entails a large source area, and the most likely source is thought to be the metamorphic rocks in the north and west of Ireland (Graham, 2001).

The Devonian rocks in the west of the county (Comeragh–Monavullagh–Drum Hills) fall into two broad facies, a coarse marginal facies and a fluvial facies. The latter was subdivided (Graham, 2001a; Sleeman and McConnell, 1995) into coarse and fine subclasses, but as the distinction is not significant for soil development it is not retained here.

The coarse marginal facies crops out near the northern (Galty Mountains) and eastern margins of the Munster Basin. In the Comeragh Mountains it comprises the Croughaun and Coumshingaun formations and most of the Comeragh Group.

The Coumshingaun and Croughaun formations form the lowest parts of the Comeragh succession. The Coumshingaun Formation comprises dominantly coarse boulder, cobble and pebble conglomerate and breccia dominated by Lower Palaeozoic clasts. It rests unconformably on Lower Palaeozoic slate and has been interpreted as resulting from bed load transport (Penny, 1979). Outcrops of the Croughaun Formation are less extensive. It comprises predominantly quartz-rich pebbly conglomerate and coarse sandstone. It is lithologically similar to the Comeragh Group to the east except that the rocks are dominantly green. Its age is uncertain, but it may be the same as the Comeragh Group (op. cit.).

Outcrops of the Comeragh Group in the Monavullagh and central Comeragh mountains are represented mainly by the Treanearla and Sheskin formations and the less extensive Kilnafrehan Conglomerate Formation (Sleeman and McConnell, 1995). The Treanearla Formation comprises a thick-bedded sequence of conglomerate and conglomeratic sandstone. The conglomerate is generally greenish and contains pebble and cobble grade clasts dominated by rein quartz. The Sheskin Formation is a sequence of interbedded red and purple conglomeratic sandstone, sandstone and silty mudstone. The mudstone is dominant. The Kilnafrehan Formation consists of thickly bedded red, cobble grade conglomerate and conglomeratic coarse sandstone. The Treanearla Formation was deposited in braided streams, but the siltstone in the overlying Sheskin Formation was laid down in single channel streams and flood plains. The succeeding Kilnafrehan Formation was deposited on an alluvial braid plain (Boldy, 1982 as cited by Sleeman and McConnell, 1995).

The fluvial facies represented by the Nier Group outcrops extensively on the western part of the Comeragh–Monavullagh Massif, the Knockmealdown Mountains and on the Drum Hills including the western extension across the Blackwater. The group consists of the Knockmealdown and Ballytrasna formations (Sleeman and McConnell, 1995). As the difference between these formations is not significant for soil development, only the distribution of the group is shown in Figure 1.9. According to Capewell (1955), the group consists of purple fine silty sandstone. The Ballytrasna Formation comprises dusky red to purple mudstone and subordinate pale-red sandstone. The Knockmealdown Sandstone Formation is sandstone dominant (Boldy, op. cit.); it consists of pink to purple-red medium grained sandstone and conglomerate and conglomeratic sandstone near the base but dying out upwards.

The Ballytrasna Formation represents the sediments of a terminal alluvial fan system while the Knockmealdown Formation was formed in a sandy alluvial braid plain (Boldy, op. cit.).

The uppermost Devonian comprises the Kiltorcan and Gyleen formations. The Kiltorcan Formation has been mapped in the region north of the Dungarvan valley, and forms the northern and southern margins of the Comeragh and Knockmealdown mountains. The Gyleen Formation is confined to the south of the Dungarvan Valley, in the Drum Hills Region (Sleeman and McConnell, 1995). These formations are characterised by a significant amount of non-red rocks and the common presence of interbedded sandstone and mud rocks (Graham, 2001b). The Kiltorcan Formation represents a fluvial coastal plain facies (op. cit.), and the Gyleen Formation is its lateral equivalent (Sleeman and McConnell, 1995). The Kiltorcan Formation comprises coarse-grained white-yellow sandstone, mudflake conglomerate, red-yellow flaggy sandstone and green mudstone. This formation has been interpreted as the deposits of flood plains traversed by single channel river systems. The characteristic green and yellow rock colours indicate reducing conditions. The Gyleen Formation fines upwards; it consists of sequences of red sandstone and thinly bedded alternations of green and red sandstone, siltstone, and mudstone toward the top (Sleeman and McConnell, 1995).

The band of Devonian rocks on the margin of the county extending from near Kilsheelan on the north to Dunmore East represents an extrabasinal sequence. The Portlaw succession is north of Waterford City; it comprises the Carrigmaclea and Kiltorcan formations. The succession is different south of Waterford City including Dunmore East area and consists of the Templetown and Harrylock formations. The Carrigmaclea Formation generally lies at the bottom of the succession and is overlain by the Kiltorcan Formation. The Carrigmaclea Formation is red, brown, or pink and comprises a sequence of quartz-cobble conglomerate, pebbly sandstone and cross-stratified sandstone deposited by braided streams (Sleeman and McConnell, 1995). The succession at Dunmore East reflects localised sedimentation outside and on the edge of the Munster Basin. The lowest beds belong to the Templetown Formation and are predominantly quartz conglomerate with a small proportion of red sandstone. This formation represents deposition close to source by braided and sinuous streams and possibly sheet floods (Tietzsch-Tyler and Sleeman, 1994). The succeeding Harrylock Formation comprises quartz conglomerate fining up to red sandstone, siltstone and occasional grey mudstone. The coarse-grained rocks formed in river channels meandering over a flood plain represented by the finer grained siltstone and mudstone (Tietzsch-Tyler and Sleeman, 1994).

Hydrogeology and drainage: On the basis of QSC graphs, Wright (1997) concluded that Devonian sandstone, except the Kiltorcan Formation, typically produced locally important aquifers. Productivity varied widely, however; the coarser formations, conglomerate and coarse sandstone, may be more productive having aquifers that are generally moderately productive, whereas the finer grained formations may form poor aquifers that are only locally moderately productive. The Kiltorcan Formation is classified as a regionally important aquifer (Wright, 1997); high yielding boreholes are at Cappoquin and Portlaw (Sleeman and McConnell, 1995). The Carrigmaclea Formation is considered an aquitard.

Except in depressions and where pedogenic pans have developed, the soils on the Devonian rocks are predominantly well drained (Chapter 3). Gley soils are generally more common on the formations that consist of siltstone or mudstone, the Nier Group, but this may be due to topography. A large area of Gley soil also lies above the Gyleen Formation in the upper reaches of the Lickey catchment.

Carboniferous

Rocks of Carboniferous age form the floors of the Ardmore, Clashmore, Lismore–Dungarvan and Carrick-on-Suir synclinal valleys. They belong to the early Carboniferous Tournaisian series. They comprise a succession of "Lower Limestone Shales" and Carboniferous Limestone formations that were deposited in a shallow tropical sea on the North Munster shelf; at the same time, terrigenous sediments that formed mudstone and sandstone were deposited in the deeper South Munster Basin.

The "Lower Limestone Shales" represent the start of the Carboniferous marine flooding of the Old Red Sandstone continent. They generally form a thin band at the margin of the synclinal valleys. They have been subdivided into Porters Gate, Mellon House, Ringmoylan and Ballyvergin formations, which are generally too thin to delineate separately. These formations consist of sandstone, siltstone calcareous shale, crinoidal limestone and noncalcareous mudstone (Sleeman and McConnell, 1995).

The limestone succession in the county comprises the Ballymartin and Ballysteen formations and the Waulsortian Facies. The succession typically starts with the Ballymartin Formation overlying the "Lower Limestone Shales"; this is followed by the Ballysteen Formation and Waulsortian Limestone. The Ballymartin Formation, however, is absent from the Ardmore and Clashmore synclines, where the Ballysteen Formation rests conformably on the underlying shale. In the south of the county, including the Lismore–Dungarvan Syncline, the Waulsortian Facies is the most extensive limestone at the surface, whereas the Ballymartin and Ballysteen Formations are dominant in the Carrick-on-Suir syncline within the county.

The Ballymartin Formation is composed of muddy bioclastic limestone and interbedded calcareous shale. In the Carrick-on-Suir Syncline, the upper 300m of the Ballysteen Formation comprises dark-grey bedded argillaceous micrite, packstone and wackestone, and frequent thin shales and chert bands in the upper part. In the Lismore–Dungarvan Syncline, most of the Ballysteen outcrops appear to be from the upper part of the formation, which comprises mud-wisped calcilutite interbedded with very muddy bands. The Waulsortian limestone consists predominantly of massive calcareous mudstone, wackestone and packstone; the formation commonly contains original cavities filled with internal cements and sparry cements. The Waulsortian facies has been commonly referred to as "reef" limestone but they are not analogous to coral-algal reefs. This facies probably first developed as individual carbonate mudmounds on the seafloor surrounded by more muddy limestone of the Ballysteen type. The mounds contained crinoids and bryozoans and later coalesced.

Hydrogeology and drainage: On the basis of QSC graphs, Wright (1997) classified the Waulsortian Limestone in the county as a regionally important aquifer. Boreholes at Ballinamuck, Dungarvan yield 6300 m^3d^{-1}. The limestone is very permeable due to extensive karstification. The Variscan folding increased in intensity towards the south; it created extensive fractures that could be subsequently enlarged by karstification. The substantial fall in sea level during the Pleistocene also contributed to karstification by allowing drainage down to at least 100 m below present sea level (Sleeman and McConnell, 1995). The small proportion of poorly drained soils (Gleys) on relatively subdued topography partly reflects the rapid permeability of the underlying limestone.

Post-Carboniferous
Although there are no rocks in the county younger than the early Carboniferous (Tournaisian Series), events at the end of the Carboniferous and later Periods left a significant imprint on the bedrock and landscape.

Sedimentation ceased at the end of the Carboniferous with the onset of the Variscan Orogeny. The rocks of the Munster Basin were uplifted, folded and faulted. Structural deformation and dislocation are generally more intense south of the Dungarvan–Lismore valley and gradually decrease northwards (Naylor et al. 1981). According to Graham (2001b), deformation in the east of the county is markedly different; dips are low and the rocks generally lack cleavage.

The major folds in the west of the county have amplitudes and wavelengths of several kilometres (Graham, 2001b); the axes of the folds generally trend E-W. The alternating east-west trending ridges and valleys, the "Ridge and Valley Province", reflect the trend of the Variscan folds. Generally, the ridges are Devonian sandstone/shale cored anticlines, but the synclinal valleys are floored by Carboniferous limestone. This pattern reflects differential erosion of limestone that left the sandstone/shale exposed at the surface on higher ground.

After the Variscan Orogeny, the county remained above sea level until the late Cretaceous. In this interval, a thick cover of Silesian (Upper Carboniferous) rocks was probably eroded. In the late Cretaceous, most of the country was inundated by the "chalk sea". Any chalk deposited in the county was subsequently eroded, but Davies and Whittow (1975) suggested that there was never sufficient thickness of chalk to cover the Comeragh and Knockmealdown mountains.

Quaternary
The definition and rank of the Quaternary in the Geologic Time Scale is a topic of continuing debate. The International Commission on Stratigraphy (2005) recognised the Quaternary as a formal Sub-era of the Cenozoic time scale. The lower boundary was placed at the base of the Gelasian stage (2.6 Ma) in the late Pliocene. Hence, the Quaternary encompasses the Holocene and Pleistocene epochs and the late Pliocene (Table 1.10). It is an interval of oscillating climatic extremes comprising glacial and interglacial episodes.

Based on study of the glacial succession on land, the traditional chronology of the Quaternary in NW Europe consisted of four or five major glacial episodes that were separated by interglacial stages with climates broadly similar to that of the present day. Owing to erosion by subsequent glaciations, the stratigraphic record is likely to be fragmentary.

The oxygen isotope record preserved in marine sediments and ice cores provides a more comprehensive and detailed signal of the climatic record and indicates a far greater number of glacial and interglacial episodes in the Quaternary. The isotope stages range from one (MIS 1) for the present (Holocene) to 103 at the beginning of the Quaternary. The isotopic record suggests that the magnitude and frequency of the climatic cycles varied during the Quaternary. In the middle and late Pleistocene (<0.78 Ma) the cold stages occur over 100 ka intervals (Shackleton, 1976), whereas shorter cycles (≈41 ka) were predominant in the early Quaternary. The isotopic record suggests that intense cold cycles, which probably encompassed glacial stages, were more frequent in the middle and late Pleistocene than in the early Quaternary. As well as glacial stages — during which ice advanced — the cold stages contained interstadials during which the climate ameliorated for short periods (1–2 ka) rather than the 10–20 ka intervals characteristic of interglacials. The isotopic record indicates that in the last 0.78 Ma (Middle and Late Pleistocene) Ireland was affected by at least five major cold stages, but not all of these are evident in the terrestrial stratigraphic record (Coxon, 2001).

Table 1.10: Quaternary Time Scale (ICS 2005).

Sub-Era	Epoch	Stage	Age Ma	MIS
	Holocene		0.118	1–2
Quaternary		Late	0.126	5
	Pleistocene	Middle	0.781	21
		Early	1.806	64
	Pliocene	Gelasian	2.588	103

Stratigraphy

The traditional lithostratigraphic framework of the Middle and Late Pleistocene in Ireland is compared to that of NW Europe and the marine isotope stages in Table 1.11. The stratigraphic sequence in Ireland was traditionally viewed as reflecting two glaciations, the Midlandian and Munsterian, separated by a putative interglacial corresponding to the Eemian. As the actual periods of glaciation made up only a small part of their ≈100 ka length, the Midlandian and Munsterian are probably better termed cold stages. The Midlandian (Table 1.11) is currently thought to comprise three glacial stages with the maximum ice advance taking placing during the Glenavy Stadial (24 to 14 ka). The remainder of the Midlandian stage comprises warmer interstadials and cold phases e.g. Derryvree, Hollymount. The glacigenic sediments representing the Munsterian (Saalian) stage would be considerably older (198 or 302 ka) than those of the Glenavy Stadial and should produce significant differences in soil development on a stable landscape. This is particularly relevant in Co. Waterford, which, lying south of the south-Ireland End Moraine, is entirely within the Munsterian zone.

Table 1.11: Pleistocene sequence in Ireland and NW Europe.

Subseries	Quaternary Stage NW Europe	Quaternary Stage Ireland	MIS	Age ka	Irish substage	Glacial(G) Interglacial(I)
	Holocene	Littletonian		10		
				11	Nahangan Stadial	
				13	Woodgrange Interstadial	
			2	19	Glenavy Stadial – Drumlin Event	
				24	Glenavy Stadial – Main Event	
Late Pleistocene	Weichselian	Midlandian		48	Derryvree and Hollymount Cold Phase	G
			3	59	Aghnadarragh Interstadial	
			4	115	Fermanagh Stadial	
			5d/5c	120	Kilfenora Interstadial	
	Eemian	Last Interglacial	5e	132		I
	Saalian	Munsterian	6	198 (or 302)		G
	Holsteinian	Gortian	7 or 9	252 338		I
Middle Pleistocene	Elsterian		12	?		G
	Cromerian		13-21	780		G & I

The evidence used to assign the Munsterian deposits to a glaciation older than the Midlandian is weak (Coxon, 2001); it includes subjective features such as subdued relief and lack of 'fresh' glacial landforms and deep weathering profiles (Synge, 1968; Finch and Synge, 1966; Mitchell et al., 1973). Bowen (1973) stated that there was no stratigraphic evidence that the tills south of the End-Moraine were older than the last glaciation, and Warren (1979) interpreted the Gortian Interglacial as last interglacial in age. In the absence of stratigraphic evidence to suggest otherwise, Quinn and Warren (1989) regarded the entire Quaternary sequence in east Cork and Co. Waterford as the product of a single glacial event, which they assigned to the most recent (Midlandian) glaciation.

As the age of the Munsterian and the stratigraphic position of many deposits assigned to the Munsterian cold stage remain uncertain (Coxon, 2001), it is not possible to assign an age with any confidence to the soil parent materials in Co. Waterford. As will be seen below (Chapter 3) the soils of Co. Waterford are not highly weathered. With one possible but unlikely exception, the county lacks pelosols, or paeleo-argillic Brown Earths as are found in England south of the last glaciation (Devensian). This suggests that soil development is not inconsistent with the time scale proposed by Warren (1979).

Glacigenic deposits

Two major ice sheets affected the county (Quinn and Warren, 1989). Ice of inland origin advanced mainly southward (Fig. 1.10). Ice of Irish Sea origin seems to have reached the coast before the ice of inland origin. The two ice sheets were broadly contemporaneous. It seems likely that the Kerry/Cork ice sheet, advancing eastward, merged with the ice of northern provenance as it crossed the coast around Youghal. In addition, glaciers originating in the Comeragh Mountains advanced towards the east and west.

The glacigenic deposits in the county are generally shallow; thicknesses less than 10 m are common and thick deposits (>≈30 m) are found only in valleys, depressions, and in the lee of the 'preglacial' rock cliff at the coast (Quinn and Warren, 1989). In the ridge and valley terrain, which is predominant in the west of the county, the glacigenic sediments are thinly spread on the sandstone ridges and are thicker in the limestone valleys. In this region, the north-south movement of the ice sheets is significant as it results in the glacigenic sediments on the east-west trending limestone valleys containing a large proportion of sandstone, which was carried over from the sandstone ridges and mountains that lie north of the limestone valleys. This carryover of sandstone may largely account for the noncalcareous nature of the sediments in the valleys rather than weathering over a long time dating back to before the last Interglacial (Eemian). In the east of the county, however, the carryover is much less across the boundary between the shale and volcanic rocks, and the boundary between the shaly and volcanic deposits practically coincides with the bedrock boundary.

The Quaternary succession along the south coast (Wright and Muff, 1904) comprises a raised beach overlain by head (lower), till of Irish Sea provenance, till of inland origin overlain by head (upper). The upper till along the coast west of Youghal is associated with ice that spread eastward from the Kerry/Cork Mountains, whereas to the east in Co. Waterford the upper till is associated with a southerly moving ice sheet (Fig. 1.10). Warren (1985) formally named the stratigraphic units as follows:

Upper till	Kerry/Cork provenance	Garryvoe Fm
Upper till	Midland provenance	Bannow Fm
Shelly till with Irish Sea		
Basin erratics		Ballycroneen Fm
Lower head		Fenit Fm
Raised beach		Courtmacsherry Fm

Courtmacsherry Formation

This is a discontinuous feature along the south coast. It comprises clast-supported gravel that rests on a wave-cut platform at approximately 3 to 5 m AMSL. This raised beach has generally been regarded as an interglacial deposit. Traditionally it was assigned to the penultimate interglacial (Mitchell et al., 1973), but more recently Warren (1979, 1985) regarded it as an isochronous marker horizon belonging to the last interglacial.

Figure 1.10: Ice movements in County Waterford (After Quinn and Warren, 1989).

The Courtmacsherry Formation is generally overlain by a head/gelifluted unit; rarely, it is directly overlain by till. Hence, it does not directly form soil parent material. The significance of the formation rests on its use as a marker horizon.

Fenit Formation

This is the lower head deposit. In Co. Waterford, it comprises diamictons composed of angular clasts that are clast supported or in a clayey to sandy matrix (Quinn and Warren, 1989). It is often cryoturbated and occasionally contains ice wedge casts. The clasts are local in origin; occasional rounded clasts include erratics of eastern and northern provenance. The erratics are generally considered to have been derived from an underlying beach or from an earlier glaciation (op.cit.). The sediments have been interpreted as the products of gelifluction under periglacial conditions in an intensifying cold climate. The formation is generally overlain by drift and only rarely continues to the surface to form a soil parent material. As its lithology is generally similar to the local drift, it is not distinguished as a separate soil parent material.

Ballycroneen Formation

This formation consists of till of Irish Sea provenance. Typically, it consists of a brown, fine matrix and few or no stones. In the unweathered state it is calcareous. It has a characteristic suite of erratics comprising flints and shell fragments derived from the Irish Sea Basin (Warren 1985, Quinn & Warren 1989).

In the east of the county, the formation is generally thin; it is rarely more than one metre thick. It is invariably covered by drift, and the soils in this part of the county are unrelated to the Ballycroneen Formation.

Between Dungarvan and Youghal Harbour the Ballycroneen Formation is very different from that in the east of the county. Here it is tens of metres thick and occupies most of the stratigraphic column. Outcrops of the formation extend approximately 5 km inland; it forms the parent material of the Ardmore and Moord series, which occupy approximately 3000 ha (1.7% of the county). The upper limit of the formation is at 186 m AMSL on the flanks of the Drum Hills at the base of Ahaun Hill. This is much higher than the limit in Co. Wexford, where it is at about 80 m AMSL.

A blue-green laminated facies is exposed in Dungarvan Bay and Whiting Bay. It is overlain by the massive silty facies. The basal facies has been interpreted (op.cit.) as a sub-marginal melt out facies deposited in a shallow water column. The massive facies, which is extensive throughout this area, was formed by lodgement at the base of a temperate ice sheet advancing from the southeast.

Garryvoe Formation

This is a till unit composed of phenoclasts of Devonian sandstone and shale and Lower Carboniferous sandstone, shale and clast. It has a reddish brown matrix (Warren, 1985). In Co. Cork, it represents the upper till of Kerry/Cork provenance. It overlies the Ballycroneen Formation in places and is generally considered to relate to the Fenitian Stage (Midlandian). The Garryvoe Formation extends along the coast as far east as Youghal Harbour; it is possible that some of the upper till on the western margin of Co. Waterford belongs to this formation.

Bannow Formation

This formation includes the Ballyvoyle till (Wright and Muff, 1904) and the Bannow till (Synge, 1964). Typically, the Bannow till is composed mostly of shale and slate and erratics of Leinster granite, Carboniferous limestone, and occasionally Devonian sandstone (Warren, 1985). The Ballyvoyle till is typically stony; volcanic clasts predominate and sandstone clasts are common. In addition, it contains few chert and shale clasts and occasional fragments of flints and shells. The limestone and granite erratic content increases eastward toward the Waterford estuary. The Ballyvoyle till extends northward up to the Rathgormuck plateau; the shale and chert content increases in this direction.

The Bannow Formation is widespread in Co. Waterford and forms the predominant upper till.

Glaciofluvial deposits

These deposits are restricted to isolated kames. Mapped areas of soils derived from these gravels amount to only 0.4% of the county. They are mostly in the east of the county, mostly in the Suir Valley. Small parcels were found in the Dungarvan and Ardmore valleys (cf. Callaghane and Curragh soil series).

Periglacial features

Lewis (1985) records pingos in lowland areas in both the east and west of the county. These are all beyond the limits of the Midlandian glaciation as delineated by Synge. It is not clear when they were formed. Coxon (2001) suggests that some pingos may be of Nahangan stadial age; Mitchell (1977) suggests that all the periglacial features created during the Last Cold Stage in Ireland could have been formed in two cycles. The surface layer of drift in Co. Waterford is commonly cryoturbated (Quinn and Warren 1989). Small, sorted polygons on the summit plateau of the Comeragh Mountains reflect contemporary periglacial processes (Lewis, 1985). The larger stone polygons in the Comeragh and Knockmealdown regions are probably entirely remnant. Stone polygons, typically 3 m wide, are abundant in the Glenary Soil Series, which occupies 2790 ha, mostly in the Comeragh region, and lies between 244 m and 521 m AMSL. Stone polygons are found up to 570 m AMSL in the Knockmealdown region, and extensive block-field and stone-runs lie at higher elevations (Mitchell 1992). The latter features probably underlie much of the blanket peat in the Knockmealdown/ Comeragh region.

Holocene

Apart from the accumulation of alluvium, geological modification of the landscape was limited during this epoch, which dates from 10 ka and is designated The Littletonian in Ireland (Mitchell et al., 1973). However, substantial changes in climate and vegetation left an imprint on present day soils.

Alluvium covers about 7,000 ha, which represents nearly 4% of the county. It is mainly in the flood plains of the major rivers Suir, Blackwater, Bride, and Brickey, where it is generally thick (>2m), silty, and underlain by gravel in places. Alluvium also lies in strips along the numerous streams that flow directly to the sea and along tributaries of the major rivers; this alluvium is generally thin, and thickness is commonly less than 1.5 m are common.

The postglacial cycle began 10,000 years ago with a rapid rise in temperature. Species such as juniper, birch and hazel had to build up from small populations in Ireland or had to migrate from distant sources in which they had survived the climate of the Nahangan Stadial, and their increase in numbers lagged behind the rise in temperature (Watts, 1985). Between 9000 and 6000 years ago, mean temperatures were warmer than they are today in Ireland, and precipitation was possibly lower (Bradshaw, 2001).

Pollen analyses at Belle Lake (Watts, 1985) indicate the vegetation succession in a lowland area in the east of the county. The first response of the flora to warming was an increase in grass and Rumex followed by a brief reappearance of crowberry (Empetrum) and a peak of meadowsweet (Filipendula). These were followed by an expansion of juniper (Juniperus), which, at most sites in Ireland, became more abundant than in the earlier juniper expansion in the late glacial and probably formed continuous scrub. Peaks in tree willow (Salix) and tree birch (Betula) succeeded the juniper expansion. By about 9,100 BP hazel (Corylus) and oak (Quercus) were dominant; Pine (Pinus) began to increase and elm (Ulmus) had arrived. Alder (Alnus) arrived about 6300 BP and increased rapidly. As indicated by the pollen counts, the vegetation about 5000 BP was woodland composed dominantly of alder and hazel with moderate amounts of oak and pine and small amounts of birch, willow, elm, grass and sedge.

The vegetation succession in the uplands of Co. Waterford is probably analogous to that indicated by pollen analyses at Arts Lough, a high attitude lake in the Wicklow Mountains (Bradshaw, 2001). Tree pollen, broadly similar to that found at Belle Lake, dominates the early Holocene (Littletonian). Blanket peat development was underway by 4,500 BP and probably largely reflects the fall in summer temperatures that began about 4000 BP.

CHAPTER 2

SOIL DESCRIPTION CLASSIFICATION AND MAPPING

Although the soil mantle of the earth is far from uniform, all soils have certain features in common. Every soil consists of mineral and organic matter, living organisms, water and air. The relative proportions of these components vary among soils. As a small segment of the earth's surface, every soil extends downwards as well as laterally and must, therefore, be regarded as being three-dimensional, having length, breadth and depth.

The soil unit

A soil profile refers to a vertical section of the soil down to, and including, the geological parent material. The profile is the basic unit used in describing a soil. It usually displays a succession of layers that may differ in properties* such as colour, texture, structure, consistence, porosity, chemical composition, organic matter content and biological composition. They are known scientifically as soil horizons.

A soil pedon represents a three-dimensional extension of a soil profile. The surface of a pedon is roughly polygonal and ranges from 1 m^2 to 10 m^2 in area, depending on the extent of the cycle of variation of soil horizons and other properties.

The solum of a soil consists of a set of horizons formed by the same pedogenic processes. Horizons below the zone of major biological activity may be part of the solum. Conversely, layers that have not been affected by pedogenic processes, even where they are within the zone of biological activity, are not part of the solum.

The method used to describe soil profiles essentially follows that described in "Soil Survey Manual" (USDA, 1993); the main features are shown below.

Soil horizons

Definitions of soil horizons are based on the kinds of alterations produced by pedogenic processes. A horizon designation represents an interpretation of soil properties compared to the inferred parent material of that specific horizon. Commonly, the parent material is very similar to, or the same as, the soil material below the solum. A part of a soil profile that has not been affected by pedogenic processes is termed a layer.

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* *Texture, structure and porosity are defined and discussed in Appendix I.*

The master horizons and layers of soils are represented by the capital letters O, A, E, B, C, and R. Most horizons and layers are denoted by a single capital letter.

O horizons or layers: Layers dominated (v/v) by organic material. Some are saturated with water for long periods or were once saturated but are now artificially drained; others have never been saturated.

A horizons: Mineral horizons that formed at the surface or below an O horizon that show one or more of the following:

- an accumulation of humified organic matter intimately mixed with the mineral fraction and not dominated by properties characteristic of E or B horizons;
- properties resulting from cultivation, pasturing, or similar kinds of disturbance.

E horizons: Mineral horizons in which the main feature is loss of silicate clay, iron, aluminium, or some combination of these, leaving a concentration of sand and silt particles.

B horizons: Horizons that formed below an A, E, or O horizon and show one or more of the following:

- illuvial concentration of silicate clay, iron, aluminium, humus, carbonates, gypsum, or silica, alone or in combination;
- evidence of removal of carbonates;
- residual concentration of sesquioxides;
- coatings of sesquioxides that make the horizon conspicuously lower in value, higher in chroma, or redder in hue than overlying and underlying horizons without apparent illuviation of iron;
- alteration that forms silicate clay or liberates oxides or both and that forms granular, blocky, or prismatic structure if volume changes accompany changes in moisture content;
- brittleness.

C horizons or layers: Horizons or layers excluding hard bedrock, that are little affected by pedogenic processes and lack properties of O, A, E, or B horizons. The material of C layers may be either like or unlike that from which the solum presumably formed. The C horizon may have been modified even if there is no evidence of pedogenesis.

R layers: Hard bedrock.

A horizon whose properties are transitional between two master horizons is denoted by two capital letters. The first letter indicates the horizon whose properties are dominant. A CB horizon, for example, has properties of both the overlying B horizon and the underlying C horizon but is more like the C than the B.

Two capital letters separated by a virgule (B/C) denotes a horizon in which material characteristic of different master horizons occupies discrete parts of the horizon.

Specific kinds of master horizons are denoted by lower case letters used as suffixes. Those relevant to soils in Ireland are as follows:

a Highly decomposed organic material
This symbol is used with "O". The rubbed fibre content is less than about 17 per cent of the volume.

e Organic material of intermediate decomposition
This symbol is used with "O". Rubbed fibre content is 17 to 40 per cent of the volume.

g Strong gleying
This symbol is used to indicate either that iron has been reduced and removed during soil formation or that saturation with stagnant water has preserved a reduced state. Most of the affected layers have chroma of 2 or less and many have redox concentrations. If "g" is used with "B", pedogenic change in addition to gleying is implied. If no other pedogenic change in addition to gleying has taken place, the horizon is designated Cg.

h Illuvial accumulation of organic matter
This symbol used with "B" to indicate the accumulation of illuvial amorphous, dispersible organic matter-sesquioxide complexes. The sesquioxide component coats sand and silt particles. In some horizons, coatings have coalesced, filled pores, and cemented the horizon. The symbol "h" is also used in combination with "s" as "Bhs" if the amount of sesquioxide component is significant but value and chroma of the horizon are 3 or less.

i Slightly decomposed organic material
This symbol is used with "O" to indicate the least decomposed of the organic materials. Rubbed fibre content is more than about 40 per cent of the volume.

p Tillage or other disturbance
This symbol is used to indicate a disturbance of the surface layer by mechanical means, pasturing, or similar uses. A disturbed organic horizon is designated Op. A disturbed mineral horizon is designated Ap even though clearly once an E, B, or C horizon.

r Weathered or soft bedrock
This symbol is used with "C" to indicate root restrictive layers of soft bedrock, such as weathered igneous rock; partly consolidated soft sandstone; siltstone; and shale.

s Illuvial accumulation of sesquioxides and organic matter
This symbol is used with "B" to indicate the accumulation of illuvial, amorphous, dispersible organic matter-sesquioxide complexes if both the organic matter and sesquioxide components are significant and the value and chroma of the horizon is less than 3. The symbol is also used in combination with "h" as "Bhs" if both the organic matter and sesquioxides components are significant and the value and chroma are less than 3 or less.

t Accumulation of silicate clay
This symbol is used to indicate an accumulation of silicate clay that has formed and subsequently translocated within the horizon or has been moved into the horizon by illuviation, or both. At least

some part should show evidence of clay accumulation in the form of coatings on surfaces of peds or in pores, or as lamellae, or bridges between mineral grains.

w Development of colour or structure
This symbol is used with "B" to indicate the development of colour or structure, or both, with little or no apparent illuvial accumulation of material.

x Fragipan character
This symbol is used to indicate genetically developed layers that have a combination of firmness, brittleness, very coarse prisms with few to many bleached vertical faces, and commonly higher bulk density than adjacent layers. Some part is physically root restrictive.

Horizon designations for three common profiles are shown diagrammatically in Figure 2.1.

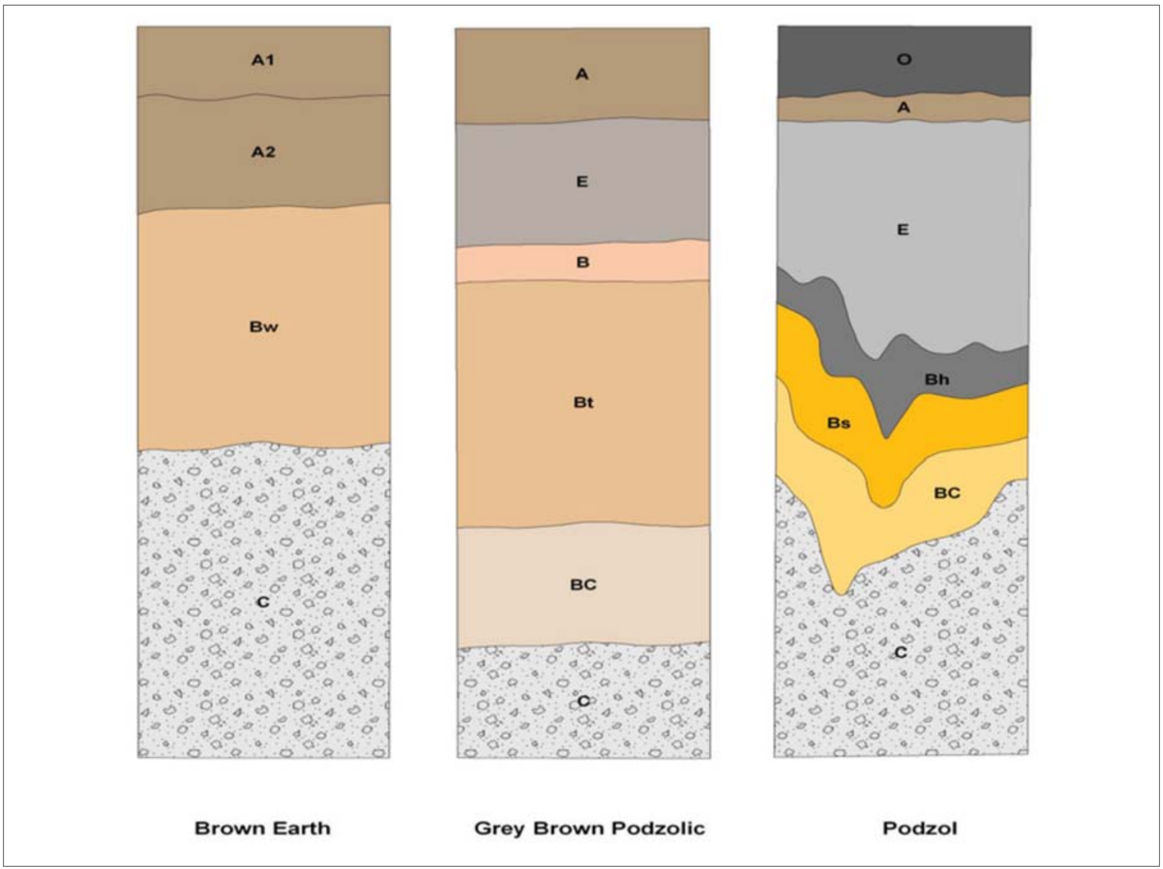


Figure 2.1: Diagrammatic representation of three common soil profiles.

A subdivision of a horizon or layer designated by a single letter or a combination of letters is indicated by Arabic numerals placed after all letters whatever the purpose of the subdivision. For example, a Bw horizon having evident differences in structure with depth is designated Bw1, Bw2, Bw3 and so on. A similar convention is used for horizons or layers that are morphologically homogeneous but are subdivided during sampling for laboratory analyses e.g. C1, C2, C3.

Factors of soil formation

The initial state of a soil is defined by its parent material and by its position in relation to the surrounding topography. Over time, climate and living organisms determine or condition the gains, losses and transformations that constitute pedogenic processes. Thus the properties of a natural soil are determined by the interaction of the five factors of soil formation, parent material, topography, climate, living organisms and time. Man may be regarded as a special case of the biotic factor or as a sixth factor which modifies natural soils.

Parent material

Parent material may be either solid rock which has weathered, or some superficial deposit such as glacial drift or alluvium that has been derived from weathered rocks and transported. Rocks vary greatly in composition, and such variation is reflected in the soils derived from them. For example, quartzite is highly resistant to weathering and during its slow weathering process little clay is formed and release of mineral nutrients is small. Besides being inherently poor, soils on such materials degrade easily as the leaching process outpaces the rate of weathering. Fortunately, most rocks are mixtures of many minerals, few of which are as resistant to weathering as quartz. Glacial drift, the most common parent material of Irish soils, varies considerably in structure and in geological composition, giving rise to many different soils. Calcareous materials buffer the effects of leaching and have a significant effect on soil development in a humid climate.

Topography

The influence of topography on the hydrologic regime is an important factor in soil development. Surface runoff and internal downslope flow contribute to the preponderance of poorly drained soils in low-lying areas. These areas are also more likely to be influenced by the regional groundwater. Soils of poor drainage, however, may also be found on relatively high ground or on moderate slopes where the lower soil horizons or parent material are slowly permeable, leading to retardation of water movement.

Elevation, slope, and aspect influence soil development by modifying the regional rainfall and temperature regimes. Rate of soil loss increases with increase in slope gradient and slope length (Wischmeier and Smith, 1965). Apart from its influence on soil formation, topography can be an important factor in determining the use of soils.

Climate

The role of climate in soil genesis is complex; not only does it influence soil formation directly but also indirectly through its effect on living organisms. An additional complication is that the postglacial climate in Ireland showed distinct variations over time; nevertheless, the current climate provides a broad indication of the spatial climatic pattern under which the soils developed. The excess of rainfall over evaporation and the temperature regime are the main elements of the climate that influenced soil development in Ireland.

Organic matter is probably the soil component that is most sensitive to climate. Soil carbon and nitrogen increase with rising rainfall and decrease exponentially with increases in temperature (Jenny, 1983). A decrease in temperature combined with an increase in rainfall produces a widening C/N trend (op.cit.). An increase in effective rainfall and a decrease in temperature with elevation retard the rate of microbial decomposition; consequently, organic matter accumulates as relatively undecomposed peat on the uplands in Co. Waterford.

Carbonates and exchangeable bases are susceptible to leaching where the rainfall surplus is large. The thickness of carbonate-free soil increases as the effective rainfall increases. The increased acidity produced by leaching may contribute to the accumulation of organic matter. The acid conditions and accumulations of raw humus stimulate podzolisation in an interdependent process.

The humid climate is also partially responsible for the extensive areas of wet-gley soils in the county.

Living organisms

Living organisms in the soil include plants, animals, insects, fungi, bacteria and other biological forms. These play an important role in soil development such as determining the kind and amount of organic matter that is incorporated in the soil under natural conditions. They also govern the manner in which organic matter is added, whether as leaves and twigs on the surface or as fibrous roots within the profile. The rate of organic matter decomposition is strongly influenced by the type and activity of organisms present. Plants can partly reverse the leaching process: roots take up calcium, potassium, phosphorus, and other elements from the lower horizons and return them to the surface on the decay of leaves, roots, and other plant remains

The nature of the vegetative cover is known to have a decided influence on soil development. Other factors being equal, a forest cover stimulates a different soil-forming process than either grass or cultivated crops. As natural grasslands are replaced by trees the lowering of the $CaCO_3$ boundary is accelerated, exchangeable bases decrease in the surface-horizon with a concomitant increase in exchange acidity (Jenny, 1983). When woody long living tree roots replace fine fibrous grass roots, the invertebrates and microbes deplete the humus reservoir within the soil, and the bases are washed away aided by acid leachates. The surface horizon tends to become greyer as the organic matter content decreases and may eventually become an albic horizon (op. cit). Trees differ in their influence on soil development; conifers are generally more conducive to soil degradation and podzol formation than broadleaf trees. In addition, certain forms of ground cover, e.g. heath, contribute to the formation of Podzols. Most soils in Ireland and Co. Waterford developed under deciduous forest during the Holocene Epoch (last ≈10,000 years); a large part of the forest was replaced by grassland in the late Holocene.

Time
Considerable time is needed for the accumulation of soil parent material and for the development of horizons in the soil profile. The degree of maturity of a soil depends largely on age, and on parent material and other factors. Soils developed on young deposits, such as alluvium, generally show less distinct horizons than those developed over a longer period on old materials. The ages of the glacigenic sediments that form the parent material of most of the soils in the county are uncertain. As earlier soils that formed south of the South Ireland End-Moraine were probably destroyed by periglacial processes (Mitchell, 1976), it is likely that present day soils began to form about 10,000 years ago. Radiocarbon dates obtained for blanket peat initiation in Ireland range from 7,100 BP (Doyle, 1982) to less than 1,000 BP (Edwards, 1985). Most of the blanket peat in Co. Waterford probably began developing later than 4,500 BP.

None of the above five factors of soil formation is universally uniform. There are many kinds of rocks, many types of climate, many combinations of living organisms, and great variation in topography and age of different land surfaces. Consequently, there are innumerable combinations of the factors of soil formation resulting in many different soils.

Although soils are spatially very variable, they are distributed with some degree of discernible order. Each soil reflects the environment in which it formed, occupies a definite geographic area and occurs in certain patterns with other soils. By recognising the main factors of soil formation and by distinguishing the reflected characteristics in the soils themselves, we can identify different soils and segregate them into geographic units. Thus, similarities and differences among soils can be recognised, and the various soils can be classified and their distribution depicted on maps.

Soil classification
Since there is great diversity among soils, it is necessary to group them into progressively higher categories so that the relationships among them may be understood and their properties more easily communicated and remembered.

The soil classification system used by the National Soil Survey in Ireland is a modification of the system established by the United States Department of Agriculture in 1938 and amended in 1949. This was a relatively simple, qualitative, inexact system based largely on the presence or absence of soil horizons. It was replaced in the USA and internationally by a comprehensive system (Soil Taxonomy) based on quantitative morphological criteria in which the limits of soil classes were defined (USDA, 1999). Despite its shortcomings, the older system is retained here and in the map legend to facilitate comparison with the maps of counties already published. As used in Ireland including Co. Waterford, the classification has two essential categories, Group and Series, and an optional third category, Phase. Each map unit was also classified at subgroup level according to the USDA (Soil Taxonomy) system. Some map units were assigned to more than one subgroup. This classification is summarised in Appendix II.

Soil groups
Groups are soils having the same kind, arrangement and degree of expression of horizons in the soil profile. They also have close similarity in soil moisture and temperature regimes. The characteristics of the Groups differentiated in Co. Waterford are described below.

Regosols
Regosols are very immature soils. They are distinguished by a lack of profile development apart from the presence of an A horizon which directly overlies the C horizon. In wet environments the C horizon commonly contains weakly decomposed organic material. Regosols are usually differentiated on the basis of factors such as origin and composition of parent material, texture, drainage, and base status.

Rendzinas
Rendzinas are shallow soils less than 50 cm deep, derived from parent material containing over 40% carbonates. The surface horizon is dark coloured with a well-developed structure and neutral or alkaline reaction. A calcareous B horizon may be present, but generally the A horizon directly overlies the calcareous parent material.

Brown Earths
These are well-drained soils possessing rather uniform profiles with little differentiation into horizons. The B horizon represents weathered parent material produced by physical and chemical alterations, and lacks accumulations of iron, aluminium or carbon translocated from the horizon above. Generally some leaching has taken place resulting in the translocation or removal of exchangeable constituents notably calcium and magnesium.

Grey Brown Podzolics
Grey Brown Podzolics have a significant increase in clay content in the B horizon relative to the overlying horizons. The B horizon (Argillic horizon) shows evidence of clay illuviation in the form of clay coatings on ped surfaces or clay linings on pores and cavities. The A horizons are usually light coloured and have medium or high base status. A subsurface E horizon, which has light colour and low organic matter or iron content, may form between the A and B horizons. The parent material generally has a high base status, or it is calcareous.

Podzols
The distinguishing feature of a Podzol is the presence of a subsurface horizon in which amorphous mixtures of organic matter, aluminium and iron have accumulated. Under natural or seminatural vegetation, a podzol profile usually has a distinct sequence of horizons. At the surface, an acid organic layer (O horizon) overlies a thin mineral layer (A horizon) that is succeeded by a thicker bleached layer (E horizon), which is grey or light grey similar to uncoated quartz. The underlying B horizon ranges from black to reddish/yellowish brown depending on the proportions of organic matter and iron.

Various kinds of Podzol are recognized. Peaty Podzols have a relatively thick (20 to 40 cm) organic horizon on the surface. Podzols that have a thin, black to dark reddish pan that is cemented by iron and organic matter and possibly by manganese (Placic horizon), are classified as Ironpan Podzols. Humus Podzols are distinguished by having part or all of the B horizon dominated by organic matter. Brown Podzolics have a surface layer in which organic matter is combined with mineral matter (A horizon), and any bleached eluvial material (E horizon) is weakly expressed or sporadic. Most of the soils classified as Brown Podzolics in Co. Waterford have remnants of E horizons or ironpans and represent Podzols that were reclaimed.

Gleys

Gleys are distinguished by the predominance of grey colours and/or ochreous mottling due to the effects of permanent or intermittent waterlogging. The waterlogging of the soil may be due to a high water table, to a 'perched' water table caused by the impervious nature of the soil itself, or to seepage or run-off from slopes. Where gley features are the result of a high water table, the soil is referred to as a Groundwater Gley; where they are due to a 'perched' water table, the soil is referred to as a 'Surface-water Gley'. Peaty gley soils have an organic horizon up to 40 cm thick. The presence of this horizon generally indicates wetter conditions than for mineral Gley soils.

Plaggen

Plaggen soils are characterised by a man-made surface horizon, 50 cm or more thick, that has been produced by long-continued manuring. In Ireland the manure generally comprises varying proportions of sea sand and seaweed.

Peats (Histosols)

Peat soils have at least 30% organic materials (w/w) that are at least 40 cm thick, or at least 60 cm thick if composed predominantly of moss fibres. The organic materials may be any depth if they directly overlie bedrock or stones. The peat soils mapped in Co. Waterford form two peatland landscape units, Blanket Bog and Fen (Hammond, 1981).

Blanket Peat

Blanket peat accumulates under conditions of high rainfall and humidity. In the west of Ireland, blanket bog, as the name suggests, covers the landscape from sea level to mountains. Drier climate at the lower elevations in Co. Waterford restricts blanket bog formation to the hills and mountains.

Climatic peats at the higher elevations vary from 1m to 2m deep and are usually characterised by an upper layer dominated by fibrous roots, a subsurface layer of pseudo-fibrous peat, and a basal layer of highly humified peat within which pine stumps may be found. The peat materials consist mainly of plants of cyperaceous origin embedded in a highly humified matrix. In the basal layer, variations may occur in botanical composition due to topographic and edaphic conditions influencing past nutrient status.

Fen

The fen peat materials that are within the lowland landscape of Co. Waterford developed where water tables were at, near, or above the land surface. The fens formed under the influence of base-rich groundwater, and the plant remains that comprise these peat materials are reed, sedges, non-sphagnum mosses, other semi-aquatic plants, and wood remains of trees (willow, alder etc.). The fen landscape unit is found in river flood plains and poorly drained hollows. The botanical composition of the organic materials ranges from relatively weakly humified-Carex-enriched peat to highly humified Phragmites reed-swamp peat.

It is possible that some of the areas mapped as fen peat in Co. Waterford represent areas in which the upper acid layers of raised bogs were cut away.

Soil series and phases

The properties of a Soil Series are more restricted than those of the related Group. A Series comprises a collection of pedons (polypedon) having essentially the same kind and arrangement of horizons, a limited and defined range of properties, and developed from lithologically similar parent materials. A Soil Series is usually named after a location in the first county in which it was mapped where the essential characteristics of the Series were well expressed.

Phases are units outside the taxonomic system but related to it (Smith, 1965). Soil Series that are not sufficiently homogeneous for practical purposes may be subdivided on the basis of single properties of the soil or site. In Co. Waterford, phase distinctions were based on differences in slope gradient and abundance of rock outcrops or stones.

Representative soil profiles

During the survey of Co. Waterford, one or more profiles having the essential morphological properties of each soil series were selected for special study. These profiles are designated "representative profiles", which replaces the term "modal profile" as the latter term had statistical connotations. Fresh profile pits were opened; the depth of pit varied according to soil depth but was usually about 1.3 to 1.6 m. Each horizon and subhorizon was described using the terms and methods in Soil Survey Manual (USDA 1961, 1993). Soil colours were described using Munsell Color Charts.

Soil profiles were described by first noting certain features of the soil's environment, followed by details of its general characteristics. The characteristics of the site include relief, slope, aspect, elevation and vegetation. Drainage conditions and the pattern of horizon development within the profile are considered next, and finally, properties of the individual soil horizons such as texture, structure, consistence, colour, mottling, amount of organic matter, stoniness, presence of hardpans, and root development are described.

A bulk sample (1–2 kg) was taken from each soil horizon and forwarded for mechanical and chemical analyses at the Soils Laboratory, Johnstown Castle. Where possible, undisturbed samples were taken for physical analyses. The analytical data for representative profiles of each Soil Series are included with the descriptions in Chapter 3. As the data for the representative profiles provide no indication of spatial variation, they are supplemented by data for a number of random and subsurface (ca 50 cm) bulk samples of the most extensive mineral soils (Chapter 3).

Soil mapping

Prior to systematic mapping, preliminary studies were performed in each of the major physiographic units in the county to prepare a mapping legend. Traverses and transects were made across topographic features in selected parts of the landscape. Soil morphology was observed using auger borings and a small number of soil pits. Observations in exposures, including road cuttings, quarries, drains and building sites, were particularly useful in determining the spatial variation to be expected in particular facets of the landscape. A grid scheme was used to assess the feasibility of mapping subsurface peat layers in the flood plain of the river Suir; a similar scheme was used in the sandstone region in the west of the county. The initial mapping legend was subsequently modified as systematic mapping progressed. A few map units were added, but most changes consisted of the elimination or amalgamation of map units that were small in area or could not be mapped consistently.

Mapping was performed by traditional "free" survey technique at a field scale of 1:10,560 with a view to reduction to 1:126,720 publication scale. In a "free" survey observations are made at irregular intervals and varying intensities that reflect the estimated intricacy and predictability of the soil pattern; this technique is generally more efficient than a grid survey which may contain redundant observations in relatively uniform areas. In areas that lacked field boundaries on the base map, mainly mountain and peatland areas, soil boundaries were drawn on aerial photographs and subsequently transferred to the base map.

Map units were normally differentiated at series level. Phases that were extensive and mappable at the intended publication scale were added to some series, but most map units contain undifferentiated phases. The soil series were named after the location where they were first mapped in the county; some were changed at the final correlation stage. Boundaries of map units were delineated by a combination of interpolation between auger borings and predictions based on changes in land form, vegetation, appearance on aerial photographs and geological information. Except those of mountain peats, boundaries were observed in the field throughout their length which is one of the definitive characteristics of detailed and semi-detailed surveys. Mountain peats were delineated by aerial photograph interpretation.

Map units are rarely homogeneous. Some soils are distributed in parcels that are too small to be accommodated at the given publication scale. Soil properties may be distributed in such an unpredictable or intricate pattern that they cannot be mapped economically. The soil continuum may merge gradually from one soil to another and the boundary that distinguishes between them is approximate. Map units are named after the dominant series, but it must be assumed that they normally contain inclusions of related soils and some inclusions of unrelated soils that perform differently. Where two or more series form an intricate pattern they are mapped as a complex and named after the two dominant series. As all map units are assumed to be heterogeneous to some extent, the number of map units in the county that were designated as complexes was kept to a minimum.

Soil maps at series level in Western Europe and USA generally range from 1:50,000 to 1:24,000 publication scales. It is unusual to attempt to map soil series at 1:126,720 scale. This means that, in landscapes of similar complexity in Co. Waterford, the soil series have to be defined more broadly or mapped with lesser accuracy.

Intensity

In addition to density of observations on the ground, intensity may also refer to the number of observations per unit area (cm^2) of the publication scale. Density of auger borings does not define or describe exactly the intensity or detail of a free survey since other sources of information are also used; nevertheless, it is a useful basis for comparison and provides a better measure of detail than map scale (Steur, 1961).

Mapping intensity was greater in an area comprising 4500 ha around Waterford City than in the adjoining area and provided an adequate basis for assessing suitability for urban residential use; here the density of field observations was 3 ha per observation (ha/obs.). Except for this area around Waterford City, the density of observations was not methodically assessed in east Waterford. The density is considered to be generally less in the west of the county, partly in response to the soil pattern and for economic reasons.

Nineteen one-quarter field sheets (1:10,560) distributed widely throughout the county in a systematic random sample were selected for assessment of observation density. The assessment area comprised 33,148 ha, which represents about 18% of the land area of the county, and included both lowland and mountainous areas.

As expected, the observation density varied widely, ranging from 0.35 to 121 ha/obs.–a 344 fold ratio. The lowest densities were in mountainous areas dominated by Peaty Podzols and Peats, which were delineated mainly by aerial photo interpretation. To facilitate presentation, densities less than 26 ha/obs. are excluded from Figure 2.2, which shows a modal density of about 8 ha/obs. The average and median densities based on all observations in the sample were 10.5 and 8.2 ha/obs. respectively. This implies that the total number of auger borings in the county was about 17,500. According to FAO (Smyth, 1981), an observation density of 8 ha/obs. represents a high intensity survey. However, the average observation density in Co. Waterford was much less than the 2.5 ha/obs. used at a larger publication scale (1:25,000) in Warwickshire (UK) (Beard, 1984).

The average observation density in Co. Waterford equates to 10 observations per cm^2 (obs./cm^2) of map at the revised publication scale of 1:100 000, whilst the density in the Warwickshire map (op.cit.) is 2.5 obs./cm^2. A wide range of densities has been suggested as an acceptable standard, ranging from 0.5 obs./cm^2 (Smyth, 1981) to 4–5 obs./cm^2 (Vink 1963, Burrough et al. 1971). At scales of 1:20 000 and smaller in Belgium and Holland, densities ranged from 4.4 to 8 obs./cm^2 (Western, 1979). Except that proposed by Smyth (1981), these densities refer to grid surveys which require a greater observation density than the free survey in Co. Waterford. The observation density of the Co. Waterford map was greater than any of these, which suggests that the map could be published at a larger scale than that originally intended; at 1:50,000 scale the map would have the same observation density as the Warwickshire map.

Figure 2.2: Frequency distribution of observation density, Co. Waterford.

Scale reduction

Ideally the ratio of field scale to publication scale is two fold and generally ranges from 1 to 5 (Western, 1979). In Ireland, because few adequate base maps are available, the reduction is twelve fold. In the reduction process map units are confused with each other owing to the elimination of map units smaller than the least size delineation (0.09 cm^2), and the adjustment of mapunit boundaries. Mapping confusion of soil classes and derived suitability classes was estimated on three sheets comprising 10,000 ha in southeast Waterford (Table 2.1).

Table 2.1: Mapping confusion (%) of soil maps and suitability maps at 1:126,720 scale.

Six inch sheet	Soil map	Suitability map
10	10	10
18	9	8
27	3	3
Mean	7	6

These sheets were mapped in the early stages of the survey. The area covered by Sheets 10 and 18 is near Waterford City; the underlying bedrock is mostly volcanic. Many small enclaves of outcropping rock shown on the O.S. sheets were delineated on the field sheets, and the confusion found in these sheets was probably well above the average for the county. The area represented by sheet 27 is underlain by sandstone and shale, and this sheet is considered to represent better the maps of the whole county. Mapping was generally somewhat less detailed in later stages of the survey particularly in west Waterford. It is unlikely that scale reduction is generally a major source of inaccuracy in the final map; increasing the publication scale to 1:50,000 would not substantially improve the accuracy of the map, as only part of the loss would be compensated.

Little or no difference in mapunit confusion was found between soil maps and suitability maps. Substituting a soil legend defined in terms of soil suitability instead of morphogenetic units would not increase the speed or accuracy of mapping.

Accuracy

Mapping success based on profiles has a rather limited value in appraising the quality of an inventory (Schelling, 1981). The soil profile is smaller than the soil unit, the pedon, which forms the basis of soil classification. Evaluation studies in the USA (McCormack, 1969) and the UK (Burrough et al., 1971) found impurities ranging from 30% to 60% in soil series. Some of the impurities, however, differed only in minor definitive features and not all the nonconforming profiles differed enough to require different management. Nevertheless, estimates of mapping success are useful as an objective basis for comparison.

To assess map accuracy, a random multi-stage sample of 100 sites was chosen in a selected 100 km^2 area (S5-0) in southeast Waterford. At each site two profiles were described and classified at series level. Mapping success was assessed in relation to the field map (1:10,560) and to the intended publication scale (1:126,720).The success rate was 78 per cent for the field map and 72 per cent for the publication scale. The success rate was lower than the objective of USDA surveys (85%) and corresponded to the standard for the Netherlands 1:50,000 maps. It was higher than that found in USA and UK evaluation studies (op. cit.).

The evaluation criteria in East Waterford were based on the combination of properties rather than single properties as employed in the USA and UK studies; profiles were assigned to the series which best fitted the total properties of the profile. The dominant series in the test area, a Brown Earth (Inceptisol), was allowed to contain weakly developed Podzols (Haplorthods). These were found to comprise 14% of the mapunit. If taxonomic principles were rigidly applied, the success rate of the published map would drop to about 60%, which is comparable to the success rate of the larger scale maps in the UK and USA.

Map characteristics

Eswaran (1981) proposed the map index of maximum reduction (IMR) as a basis for classifying maps. It is a measure of map texture, and it is based on the ratio between the average size delineation and the minimum size delineation of the published map. According to this classification scheme, the IMR ranges from 1 to 2 for very fine textured maps to more than 10 for very coarse textured maps. The number of delineations was determined on a 1:126,720 map of east Waterford, and the IMR of the area corresponding to each of fourteen field sheets was calculated (Table 2.2).

Table 2.2: Map Texture (East Waterford 1:126,720).

Sheet	Area	Delineations	Delineations per cm^2	Map index of maximum reduction	Area
	ha	no.	n	$(1/0.4n)^{1/2}$	%
10	902	17	3.0	0.9	2.1
18	4,868	47	1.5	1.3	11.4
27	3,932	33	1.3	1.4	9.2
9	1,104	21	3.0	0.9	2.6
17	6,093	47	1.2	1.4	14.3
26	4,029	45	1.8	1.2	9.4
4	1,495	29	3.1	0.9	3.5
8	2,064	41	3.2	0.9	4.8
16	6,242	60	1.5	1.3	14.6
25	5,329	41	1.2	1.4	12.5
3	1,051	13	2.0	1.1	2.4
7	1,823	10	0.9	1.7	4.3
15	1,873	15	1.3	1.4	4.4
24	1,825	8	0.7	1.9	4.3
All Sheets	42,619	323	1.2	1.4	100

The IMR ranged from 0.9 to 1.9 with an overall mean of 1.4. According to the classification of Eswaran, this is a very fine textured map. Sheets with an IMR of less than unity do not meet the minimum standard of legibility, and comprise 13% of the total map area. Values less than unity arise from the use of a least size delineation standard (0.09 cm^2) that is lower than the minimum size delineation (0.4 cm^2) recommended by Eswaran. On this basis, the map is very fine textured with part (13%) of the map being finer than the limits proposed by Eswaran.

It was concluded that the map of east Waterford was at or below the acceptable limits of legibility. Consequently, it was decided to enlarge the publication scale to 1:100,000, which is the scale currently used by the Geological Survey of Ireland for bedrock maps.

CHAPTER 3

SOILS

Soil Groups

Nine Soil Groups, distinguished mainly on the basis of the nature and degree of expression of soil horizons (Chapter 2) are represented in the county. The relative extent of the various groups, as represented on the 1:10,560 field sheets, is shown below (Fig. 3.1).

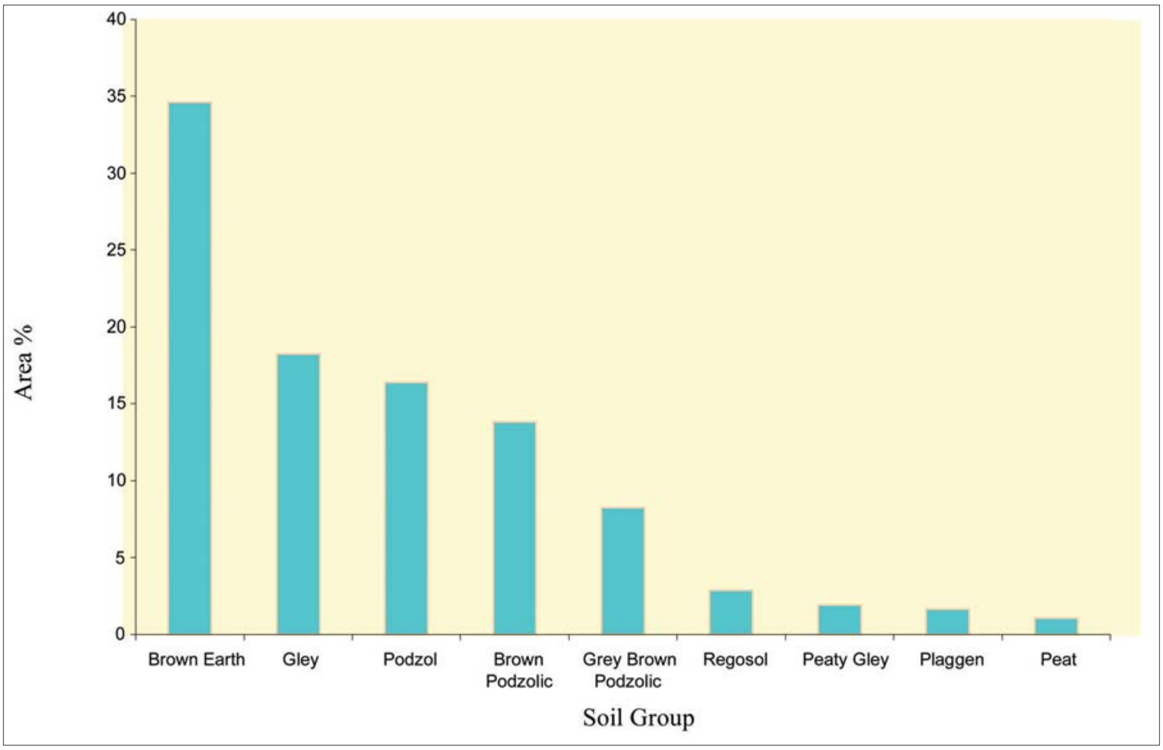


Figure 3.1: Relative extent of Soil Groups, Co. Waterford.

Brown Earths are the most extensive Group; Regosols, Peaty Gleys and Plaggen soils occupy relatively small areas (13%). The proportion of Peat (≈1%) shown in Figure 3.1 is an underestimate; an undetermined amount of Peats are interspersed among the Peaty Podzols. Combining the areas of Peats, Peaty Podzols and Peaty Gleys indicates that surface peaty layers, ranging in thickness from a few centimetres to a few metres, occupy about 15 per cent of the county. These groups, except Plaggen soils, were mapped previously in various counties; the Plaggen soils were mapped previously only in West Cork.

The spatial distribution of the Soil Groups in the county is shown in map form in Figure 3.2. Brown Earths predominate in the lowlands on shale, sandstone and volcanic materials. The elevation of the boundary between Podzols and Brown Podzolics varies with parent material. On sandstone and volcanic materials the Brown Earths extend up to about 130 m AMSL. On these materials, weakly developed spodic features are scattered among the Brown Earths down to near sea level. On shaly materials Brown Earths extend up to the boundary with podzolic soils at about 180 m AMSL, and spodic features fade out below about 150 m AMSL.

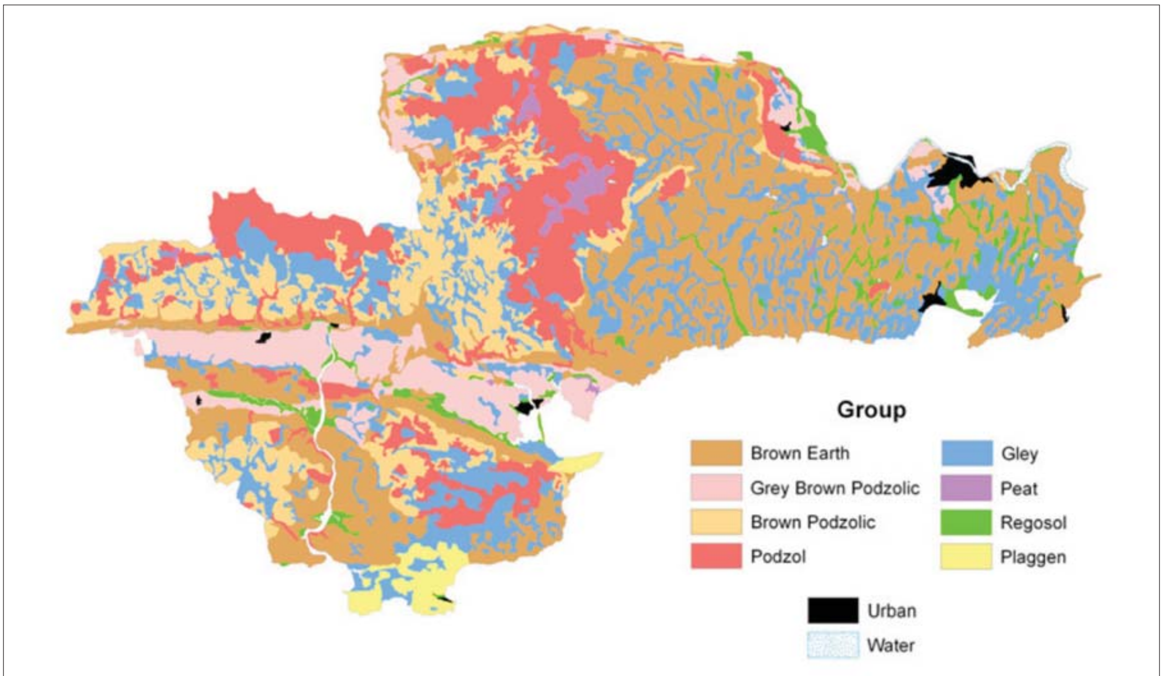


Figure 3.2: Map of Soil Groups, Co Waterford.

Gley soils developed on till mainly in depressions in the upper reaches of river valleys in both uplands and lowlands. They generally have slow permeability, but since they developed from the same parent materials as their freely drained associates it is likely that their poor drainage is primarily due to the influence of overland flow and inflow in addition to rainfall. Prolonged waterlogging impedes the development of structure resulting in slow permeability, which, by positive feedback, increases the duration of waterlogging. Poorly drained soils developed from alluvium were classified as Regosols. Excluding Peat and peaty soils in the uplands, the poorly drained land of the county is represented by Gleys and 'wet' Regosols, which amount to ca. 42,300 ha (23% of the county).

Podzolic soils (spodosols), composed of the Podzol and Brown Podzolic Groups, occupy about 30 per cent of the county (Fig. 3.1). They are the predominant groups on the sandstone uplands in the west of the county where they extend from about 130 m AMSL to the summits of the Monavullagh and

Knockmealdown mountains (≈795 m AMSL). Under woodland, they extend down to 20 m AMSL in places on sandstone parent material (Portlaw series). On shale parent materials, podzolic soils are found only at higher altitudes (>≈150–180 m AMSL); this probably reflects the higher base status of shaly materials which inhibits podzolisation. Only a small proportion (14%) of the soils in the intermediate to acid volcanic region has podzolic (spodic) features. As well as relatively low rainfall, this is probably also due to the influence of shale, which is interbedded among the volcanic rocks.

In the uplands in the west of the county, the Podzolic soils form a broad altitudinal sequence comprising Brown Podzolics, Podzols with a thin peaty surface layer, and Peaty Ironpan Podzols. The overlap in the altitudinal range of the different Podzolic soils is considerable, however, owing to variation in topography and reclamation history. Brown Podzolics are mainly between 130 and 210 m AMSL and extend up to 210 m AMSL in places. Podzols with a thin (<30 cm) surface peat layer and shallow ironpan occupy intermediate positions on the landscape between 150 and 380 m AMSL. Podzols that commonly have relative thick (30–50 cm) surface peat layers and deep ironpans (Peaty Ironpan Podzols) are on in the upper slopes of the Knockmealdown and Monavullagh Mountains at altitudes ranging from 275 to 795 m AMSL. Scattered remnants of thin peat layers (≈30 cm) in the intermediate podzol region suggest that the Brown Podzolics, which have a dark (umbric) surface horizon, were covered by thin peat prior to reclamation. Hence, virtually all the upland sandstone region above 130 m AMSL in the west of the county was probably covered by blanket peat of varying thickness in the natural or seminatural state.

Most (92%) of the peats consist of Blanket Peat, which accumulated under conditions of high rainfall and humidity. Virtually all the Blanket Peat is on uplands in the west of the county (Fig. 3.2); it belongs to the Montane sub-group. The remainder is Fen Peat which accumulated in areas with high water tables in the floodplains of rivers and streams and some estuaries. Fen Peat is mostly in the east of the county (Fig. 3.2). Some of the areas mapped as Fen Peat represent basin peats that were cutover.

Grey Brown Podzolics are found in the Dungarvan–Lismore and Fourmilewater–Kilmeadan (Suir) valleys, where limestone influences or dominates the parent material. The subsurface horizon of clay accumulation (argillic horizon), which is characteristic of the group, is commonly weakly expressed or intermittent, especially in the Dungarvan Valley, where the amount of limestone in the parent material is small. Albic horizons are sporadic. Argillic horizons appear to develop best where there are large seasonal moisture deficits; these are rare in the limestone valleys. The areas assigned to the Grey Brown Podzolic Group contain an unknown but significant proportion of Brown Earth inclusions; it is arguable that map units in the Grey Brown Podzolic Group would be better placed in the Brown Earth Group, especially those in the Dungarvan valley.

Wet soils derived from alluvium, in the flood plains of the major rivers, Suir, Blackwater, Brickey and Bride, and many small streams, are included in the Regosol Group. Peat layers, within the solum, that have undecomposed plant remains and a wide carbon to nitrogen ratio indicate little or no pedogenic development. Except in the A horizon, structure is generally massive; occasionally there is very weakly developed prismatic structure in the upper part of the C horizons. The well drained and moderately well drained alluvial soils lack peaty layers and commonly have blocky structure below the A horizon; on the basis of these features they are tentatively classified as Brown Earths.

Plaggen soils are near the coast in the south-west of the county. The soil profile was significantly altered by additions of sea-sand and seaweed over centuries. The topsoil, 40–60 cm thick, has rounded pebbles and shell fragments and is commonly calcareous. In the Ardmore Valley (<30 m AMSL), the texture of the topsoil is coarser than the subsoil which was derived from fine till. On higher ground, 30 to 100 m AMSL, on the east and west side of Whiting Bay, textural stratification is not as marked since the subsoil was derived from loamy sandstone till. Although the areas mapped as Plaggen soils are near (≈3 km) the coast, historical evidence shows that sea-sand was added much further inland. A land survey of the estate south of the River Bride, belonging to Richard Earle of Burlington, was carried out in the year 1716 (National Museum); several banks were recorded along the Blackwater and Bride rivers for landing "y^{e} manure sea-sand". For example, referring to a farm "bounded on y^{e} north by the River Bride" in Kilwinny, near present-day Tallow Bridge, the record states: "on y^{e} farm is a bank for landing sea-sand for y^{e} use of the neighbouring farms". This farm is estimated to be about 45 km, along the Bride and Blackwater rivers, from the south coast.

Map units

The map units were normally differentiated at series level; in some cases distinctions were made at phase level. The map units are identified by the name of the dominant series. The relationship between groups, parent materials and series are shown in Table 3.1. Forty series were delineated in the county; in addition three complexes, each consisting of two series, represent a relatively small part (≈0.2%) of the county. Most (33) of the series are new; the remainder were mapped previously in other counties and their names are retained in Co. Waterford. The large number of new series reflects the large area of sandstone and volcanic rock in the county. Differentiation at phase level produced an additional 52 map units. Thus, the entire county is represented by 105 map units; the approximate area and proportionate extent of each map unit are shown in Table 3.2.

Phases are based mainly on differences in slope and to a lesser extent rockiness, stoniness, depth, drainage, surface texture, or presence of a peaty surface layer. Cutover peats are differentiated as phases of the appropriate series. Delineation of phases was not an essential requirement of the survey; they were differentiated on an ad hoc basis mainly where they were extensive and could be readily observed or inferred from topographic maps or aerial photographs. The areas mapped at phase level amount to approximately 11 per cent of the county.

Table 3.1: Soil Groups, Parent materials and Soil Series.

Group	Parent material	Series
Regosol	Alluvium	Ballynabola
		Coolfinn
		Coolfinn-Sand
		Kilbarry
	Estuarine alluvium	Slob
	Blown sand	Sand
Brown Earth	Alluvium	Finisk
		Suir
	Sandstone till	Broomhill
		Clashmore
	Shale till	Clonroche
	Volcanic till/bedrock	Kill
Grey Brown Podzolic	Sandstone>limestone till	Dungarvan
	Sandstone>shale>limestone till	Kilmeadan
Brown Podzolic	Sandstone till	Knockboy
	Sandstone-limestone gravel	Callaghane
	Shale till and bedrock	Slievecoiltia
Podzol	Conglomerate rock and drift	Monavullagh
	Sandstone rock and drift	Knockmealdown
	Sandstone rock	Drumslig
	Sandstone till	Ahaun
		Ballycondon
		Glenary
		Knockalisheen
		Portlaw
	Volcanic rock	Ballyscanlan
Gley	Irish Sea till	Moord
	Sandstone till	Ballymacart
		Dodard
		Lickey
		Newport
	Sandstone>Limestone till	Killadangan
	Sandstone>Shale>Limestone till	Waterford
	Shale >volcanic-sandstone till	Clohernagh
	Shale>limestone-sandstone till	Mothel
	Volcanic till	Tramore
Peat	–	Aughty
	–	Fen
Plaggen	Irish Sea till	Ardmore
	Glaciofluvial sand	Curragh
	Sandstone till	Monatray

Table 3.2: Map unit areas, Co. Waterford.

	Mapunit	Area	
Series	**Phase**	**ha**	**%**
Ahaun	Typic	1588	0.86
	Rolling	60	0.03
Ardmore	Typic	705	0.38
Aughty	Typic	1339	0.73
	Cutover	316	0.17
Aughty	Cutover, Moderately steep	144	0.08
Ballynabola	Typic	1623	0.88
	Peaty	130	0.07
Ballycondon	Typic	6388	3.48
	Rolling	253	0.14
	Moderately steep	802	0.44
	Stony	696	0.38
	Rocky	305	0.17
	Very rocky	128	0.07
Ballymacart	Typic	1786	0.97
Ballyscanlan	Typic	106	0.06
Broomhill	Typic	2697	1.47
	Rolling	90	0.05
	Moderately steep	137	0.07
	Rocky	11	0.01
	Very rocky	18	0.01
Callaghan	Typic	624	0.34
Clashmore	Typic	15702	8.54
	Rolling	3032	1.65
	Moderately steep	447	0.24
	Steep	128	0.07
	Stony	20	0.01
	Rocky	100	0.05
	Very rocky	6	0.00
Clohernagh	Typic	3431	1.87
	Sandy	43	0.02
Clonroche	Typic	18559	10.10
	Rolling	116	0.06
	Moderately steep	193	0.10
	Steep	14	0.01
	Shallow	52	0.03
	Rocky	20	0.01
	Very rocky	9	0.00

Table 3.2: Map unit areas, Co. Waterford (cont'd).

	Mapunit	Area	
Series	**Phase**	**ha**	**%**
Coolfinn	Typic	1903	1.04
	Peaty	30	0.02
Coolfinn–Sand	Typic	44	0.02
Curragh	Typic	121	0.07
Dodard	Typic	3586	1.95
Drumslig	Typic	337	0.18
Dungarvan	Typic	11999	6.53
	Rocky	134	0.07
Fen Peat	Typic	151	0.08
Finisk	Typic	931	0.51
Glenary	Typic	2791	1.52
Kilbarry	Typic	1206	0.66
Kill	Typic	18677	10.16
	Moderately steep	99	0.05
	Rocky	597	0.32
	Very rocky	820	0.45
Killadangan	Typic	1922	1.05
Kilmeadan	Typic	2862	1.56
	Rolling	130	0.07
	Very rocky	2	0.00
Killmeadan-Callaghane	Typic	180	0.10
Killmeadan–Clashmore	Typic	199	0.11
Knockalisheen	Typic	1988	1.08
Knockboy	Typic	18900	10.28
	Rolling	2578	1.40
	Moderately steep	345	0.19
	Steep	6	0.00
	Stony	825	0.45
	Rocky	412	0.22
	Very rocky	29	0.02
	Brown	608	0.33
	Brown, rolling	218	0.12
	Brown, mod. steep	46	0.02
Knockmealdown	Typic	2767	1.51
Lickey	Typic	1280	0.70
Monatray	Typic	1858	1.01
	Rolling	325	0.18
	Shallow	60	0.03

Table 3.2: Map unit areas, Co. Waterford (cont'd).

Series	**Mapunit Phase**	**Area ha**	**%**
Monavullagh	Typic	7198	3.92
Moord	Typic	1701	0.93
	Poorly drained	609	0.33
Mothel	Typic	4664	2.54
	Peaty	188	0.10
Newport	Typic	9238	5.03
Portlaw	Typic	802	0.44
	Rolling	1480	0.81
	Moderately steep	1376	0.75
Portlaw	Steep	1088	0.59
Sand	Typic	127	0.07
Slievecoiltia	Typic	896	0.49
Slob	Typic	126	0.07
	Sandy	131	0.07
	Peaty	25	0.01
Suir	Typic	1142	0.62
Suir–Coolfinn	Typic	37	0.02
Tramore	Typic	6558	3.57
	Peaty	190	0.10
Waterford	Typic	1901	1.03
URBAN	Typic	1244	0.68
WATER	Typic	279	0.15

Ahaun Series

This series covers 1648 ha (0.90% of the county) in the southwest of the county. It is situated on the crest of the Drum Hills and generally lies next to and above the Lickey, Ballymacart, and Moord series. Elevation ranges from 122 to 213 m AMSL, and topography is undulating. The parent material is relatively thin drift, probably mostly till, composed predominantly of sandstone. The underlying bedrock consists mostly of the Gyleen Formation, which typically comprises mudstone and minor amounts of medium-grained sandstone; the Ballytrasna Formation, which also consists of mudstone and sandstone, underlies a small part of the series. The average annual rainfall is between 1125 and 1250 mm.

Typically, an Ahaun soil has an ironpan (Placic horizon) and gley features in at least part of the pedon. The pan is tortuous and can plunge from 0.3 m to 1.5 m depth within a short (<1 m) horizontal distance. The profile described below has two pans; one discontinuous pan lies directly under the topsoil at about 40 cm depth and another continuous pan lies at 80 to 110 cm depth. The horizon above the continuous pan is gleyed, has some dark patches, typically greyish brown, and has higher carbon content than the grey Eg horizon that lies above it in part of the pedon. In places, only traces of the pan are found; in some places the pan is absent probably due to incorporation of a shallow pan into the topsoil during land reclamation. Mostly, the material under the lower pan lacks mottles. Whether a pan is present or not, the abundance and intensity of gley features characteristically diminish with depth in the Ahaun series. A yellowish brown spodic horizon uncommonly lies under the pan in places. This series is classified as an Ironpan (Placic) Podzol. As most profiles lack spodic horizons under the ironpan, the series is classified as a Placaquept in the USDA system; since the placic horizon (ironpan) is intermittent, it is assigned to the Haplic subgroup. The Knockboy and Ballycondon series are found at similar elevation over sandstone drift, but they lack deep ironpans. It is likely that the Ahaun series had a relatively deep cover of blanket peat. Old pastures on the Ahaun series typically have thistles and lack rushes indicating relatively dry conditions, although the gley features in the profiles indicate frequent waterlogging. It is likely that the gley features reflect soil development under a peat cover. Following the removal of peat and disruption of the ironpan, drainage has improved substantially.

Textures of the soil profiles range from loam to sandy loam. On average, the content of individual size fractions, except clay, is very similar among different horizons; clay contents of the A and E horizons are slightly lower than that of the underlying B and C horizons. Structure is well developed in the topsoil (A horizon) but is typically massive in the lower solum and C horizon. In the representative profile, bulk density is moderate in the topsoil, high (>1.5 Mg m^{-3}) in the E and C horizons and moderately high in the B horizon. The E and C horizons are brittle. Roots are abundant in the topsoil; they extend down to the continuous pan but they are sparse in the lower solum. Rooting depth is very variable but may be up to about one metre where the ironpan is deep or broken.

The average carbon content of the A horizon is moderate; the carbon content ranges from very low to very high. The topsoil is organic in places. In general the ratio of carbon to nitrogen is high indicating a slow rate of decomposition. The cation exchange capacity of the A horizon is high and reflects the above average carbon content. The CEC is similar to other upland soils derived from sandstone (e.g. Knockboy) and higher than lowland sandstone soils (e.g. Clashmore). The reaction of the A horizon ranges from moderately acid to slightly acid; the C horizon is strongly acid in places. Free iron content is low on average in the A and E horizons and moderately high in the B and C horizons. In the representative profile, free iron is low throughout the profile. The distribution pattern of carbon and free iron in the profile is consistent with development under a peat cover.

Except for the top layer (0–10 cm), the air capacity of the topsoil of the representative profile is high or moderate; the air capacity of the remainder of the solum is high. This implies that if the ironpan is broken the profile would have at least moderately rapid permeability. The air capacity of the topsoil, which is 40 cm thick, is very high and the air capacity of the rest of the solum ranges from high to moderately high. The total available water in the profile to 1 m depth is very high (241 mm) and the soil is not droughty.

Soil suitability: The principal limitations are moderate to imperfect drainage and elevation. These limitations are additive and result in relatively short grazing and growing seasons. Inherent fertility is low but this can be remedied by fertilisation. Many of the locally wet patches can be improved by ripping to rupture the remaining ironpans. After reclamation, where necessary, the Ahaun series is estimated to be moderately suited to grassland (Class C) and poorly suited to arable crops (Class IV).

Representative profile description

Series:	Ahaun
Location:	Co. Waterford, Mweeling Td., Grid Ref. 220900 84200
Classification:	Ironpan Podzol (Placic Haplaquept)
Parent Material:	Grey and pink sandstone drift, ≈2 m thick, over sandstone bedrock.
Drainage:	Free below ironpan
Topography:	Undulating
Slope:	2^0 crest
Altitude:	165 metres AMSL
Land-use:	New pasture

Horizon	Depth (cm)	Description
Ap1	0–10	Very dark grey (10YR 3/1); sandy loam; few medium stones; moderately developed medium and coarse granular structure; moderately weak, semi-deformable consistence; moderately plastic (wet); abundant very fine roots.
Ap2	10–20	Same as next horizon above.
Ap3	20–40	Same as next horizon above except many roots; clear wavy boundary, abrupt over ironpan.
Bsm1	40	Ironpan, wavy discontinuous, extends to three-quarters of pedon.
Eg	40–70	Light brownish grey (10YR 6/2) to greyish brown (10YR 5/2); sandy loam; many medium and small stones; massive structure; moderately firm, brittle consistence; moderately plastic (wet); few medium macropores; very few roots; clear wavy discontinuous boundary; occupies half of pedon.
Bg	40–90	Light brownish grey (10YR 6/2) to greyish brown (10 YR 5/2) with many yellowish brown (10YR 5/8) medium to coarse mottles; loam; common small to medium stones; massive structure; moderately weak, semi- deformable consistence; very plastic (wet); very few roots; few medium macropores; abrupt wavy boundary.
Bsm2	90	Ironpan; wavy, continuous.
C	90+	Pale brown (10YR 6/3); loamy sand; many large and very large stones becoming abundant with depth; massive structure; very weak, brittle consistence; moderately plastic (wet); very few (<0.1%) very fine macropores; no roots.

Table 3.3: Particle size and chemical analyses, Ahaun Series.

Horizon	ApI	Ap2	Ap3	Eg	Bg	C
Depth cm	0–10	10–20	20–40	40–70(80)	40–90(110)	90(110)+
Particle size %						
Coarse sand 2000–200 μm	37	31	32	30	33	32
Fine sand 200–50 μm	20	22	22	19	21	23
Silt 50–2 μm	27	38	35	35	31	35
Clay <2 μm	16	9	11	16	15	10
T.N.V g kg^{-1}						
Ca cmol kg^{-1}	18	16.40	15.80	4.25	5.20	1.83
Mg cmol kg^{-1}	0.96	0.73	0.57	0.29	0.19	0.11
K cmol kg^{-1}	0.04	0.03	0.02	0.02	0.02	0.04
Na cmol kg^{-1}	0.20	0.18	0.15	0.08	0.02	0.03
T.E.B. cmol kg^{-1}	19.20	17.34	16.54	4.64	5.43	2.01
C.E.C cmol kg^{-1}	27	26.4	23.2	6.2	8.6	3.2
Base Sat. %	71	66	71	75	63	63
pH	5.8	5.9	6.2	6.6	6.6	6.8
C g kg^{-1}	47	41	33	6	18	2
N g kg^{-1}	3.30	2.70	2		0.40	
C/N	14.20	15.20	16.50			
Free iron g kg^{-1}	8	8	7	4	8	8

Table 3.4: Physical analyses, Ahaun Series.

Horizon	A	A	A	A	E	E	B	C
Sub-horizon	p1	p2	p3	p3	g	g	g	g
Depth cm	0–10	10–20	20–30	30–40	40–55	55–70	70–90	90–110
Particle density Mg m^{-3}	2.43	2.42	2.49	2.49	2.69	2.69	2.65	2.69
Bulk density at saturation Mg m^{-3}	1.03	1.09	1.18	1.17	1.64	1.72	1.44	1.74
Bulk density at -59 hPa Mg m^{-3}	1.03	1.09	1.18	1.17	1.64	1.72	1.44	1.74
Air capacity % vol.	6.8	7.7	12.5	9.5	12.0	14.2	12.4	8.3
Retained water % vol.:								
0 hPa	61.6	56.3	54.9	48.3	40.7	41.9	46.2	35.5
-2 hPa	57.8	52.8	49.1	43.3	32.1	30.7	36.8	30.5
-59 hPa	54.8	48.6	42.4	38.8	28.7	27.7	33.8	27.2
-137 hPa	52.3	45.9	38.4	35.4	26.8	25.5	31.3	25.4
-0.1 MPa	46.3	40.7	32.4	29.3	23.7	21.2	26.6	22.6
-1.5 MPa	19.1	17.0	14.5	13.7	7.3	7.1	14.3	7.3
Total available water % vol.	35.7	31.6	27.9	25.2	21.4	20.6	19.5	19.9
Total available water cm	3.6	3.2	2.8	2.5	3.2	3.1	3.9	4.0
Total available water cumulative cm	3.6	6.7	9.5	12.0	15.3	18.3	22.2	26.2

Table 3.5: Descriptive statistics, Ahaun Series.

	Depth/HOR cm	Count	Mean	Standard Deviation	Minimum	Maximum	Range
Clay	0–10	15	17.1	3.9	12	24	12
Clay	40–50	15	18.3	5.0	12	33	21
Clay	C[1]	6	17.0	3.0	14	22	8
Fine silt	0–10	15	20.8	4.1	16	30	14
Fine silt	40–50	15	20.5	4.7	14	33	19
Fine silt	C	6	23.5	2.2	20	26	6
Coarse silt	0–10	15	18.5	3.3	14	28	14
Coarse silt	40–50	15	17.9	3.1	14	23	9
Coarse silt	C	6	18.0	2.8	13	21	8
Very fine sand	0–10	15	11.1	2.6	8	18	10
Very fine sand	40–50	15	10.8	3.0	7	19	12
Very fine sand	C	6	10.0	1.7	8	13	5
Fine sand	0–10	15	13.8	3.7	9	22	13
Fine sand	40–50	15	13.6	2.9	7	18	11
Fine sand	C	6	11.8	2.3	9	14	5
Medium sand	0–10	15	10.0	1.6	7	12	5
Medium sand	40–50	15	10.3	1.8	7	14	7
Medium sand	C	6	9.5	2.2	7	13	6
Coarse sand	0–10	15	6.8	2.6	3	11	8
Coarse sand	40–50	15	6.7	2.3	3	12	9
Coarse sand	C	6	8.0	2.6	6	13	7
Very coarse sand	0–10	15	1.9	1.2	1	5	4
Very coarse sand	40–50	15	1.9	0.9	1	4	3
Very coarse sand	C	6	2.2	0.4	2	3	1
TNV g kg^{-1}	0–10	15	0.0	0.0	0	0	0

[1] C = C horizon

Table 3.5: Descriptive statistics, Ahaun Series (cont'd).

	Depth/HOR cm	Count	Mean	Standard Deviation	Minimum	Maximum	Range
TNV g kg^{-1}	40–50	15	0.0	0.0	0	0	0
TNV g kg^{-1}	C[1]	6	0.0	0.0	0	0	0
Ca cmol kg^{-1}	0–10	15	10.5	9.6	<0.1	34.8	34.8
Mg cmol kg^{-1}	0–10	15	0.9	0.7	<0.1	2.0	2.0
K cmol kg^{-1}	0–10	15	0.1	0.1	0.0	0.2	0.2
Na cmol kg^{-1}	0–10	15	0.1	0.1	0.0	0.3	0.3
TEB cmol kg^{-1}	0–10	15	11.6	10.2	0.2	36.7	36.5
CEC cmol kg^{-1}	0–10	15	28.6	23.3	1.8	97.4	95.6
Base Sat. %	0–10	15	32.8	18.7	3	57	54
pH	0–10	15	5.4	0.5	4.3	6.2	1.9
C g kg^{-1}	0–10	15	54.6	65.1	2	260	258
C g kg^{-1}	40–50	15	5.1	3.8	1	13	12
C g kg^{-1}	C	6	2.2	0.4	2	3	1
N g kg^{-1}	0–10	11	4.2	2.3	0.9	10	9.1
N g kg^{-1}	40–50	2	1.1	0.2	0.9	1.2	0.3
C/N	0–10	11	15.9	4.3	11.2	26	14.8
C/N	40–50	2	12.6	2.5	10.8	14.4	3.6
Free iron g kg^{-1}	0–10	15	11.3	7.4	1	24	23
Free iron g kg	40–50	14	20.0	6.9	9	34	25
Free iron g kg	C	6	15.7	10.1	3	27	24

[1] C = C horizon

Ardmore Series

This series is not extensive in Co. Waterford; it occupies 705 ha (0.38% of the county). It is situated in the southwest of the county in the Ardmore valley, mainly on the eastern side, where it is associated on the landscape with the Moord and Monatray series. Elevation is less than 30 m AMSL; topography is undulating, and slopes are commonly gentle (<3^{o}).

The Ardmore Series is closely related to the Moord Series and represents a man-modified variant of the Moord series. The lower solum was derived from material similar to that which forms the parent material of the moderate and imperfectly drained phases of the Moord series; the upper part of the solum, including the topsoil, was significantly altered by additions of sea sand and seaweed over centuries. The underlying till is very plastic; it is of Irish Sea Basin provenance and contains shell fragments and few stones composed of sandstone, volcanic material, limestone and chert. Most of the underlying bedrock consists of muddy limestone (Waulsortian and Ballysteen formations); a small part consists of sandstone interbedded with mudstone (Crows Point Formation). Average annual rainfall is close to 1000 mm.

The profile is characterised by topsoil that has sandy loam texture and small or very small rounded pebbles; shell fragments and carbonates are common, but they are absent in places. This horizon was formed by mixing sea sand and the topsoil of a Moord soil. The clay content of the surface layer (0–10 cm) varies widely (2–28%) and is 15% on average, whereas the average clay content of the corresponding layer of the Moord Series is 22%. A high fine sand (125–250µ) content is a characteristic feature; it is usually about 25% ,whereas it is normally about 15% in the Moord series and soils derived from sandstone till (e.g. Clashmore series). The topsoil is usually 50 cm thick and ranges from 40 to 60 cm; a stone layer marks the bottom of the topsoil in places. On the basis of 50 cm depth, and that the amount of material added is proportional to the difference in clay content between the Moord and Ardmore series, it is calculated that the Ardmore soil was raised by 16 cm. Similar soils are in the Ardfield area in West Cork; they are placed in the Plaggen group (Typic Plagganthrept; USDA, 1999).

A typical subsoil consists of a very plastic or extremely plastic clay loam with few small stones. Structure is weak coarse blocky, becomes very weak and very coarse with depth and extends down to the limit of observation at 1.5 m. Strong brown, or black manganiferous mottles, are found within peds; they are absent on ped faces. Roots penetrate as far as a stone layer at 1.2 m.

The carbon content in the surface layer (0–10) is low relative to Irish soils generally; cation exchange capacity (CEC) is moderate and pH ranges from slightly acid to alkaline.

The bulk density of the representative profile is high (>1.3 Mg m^{-3}) throughout the profile; it is not very high in any sub-horizon. Air capacity is moderate at 0–10 cm depth; it is low or very low below 10 cm depth. The available water capacity (AWC) decreases with depth in the topsoil from very high to moderate; some sub horizons in the fine textured subsoil have relatively high moisture contents at the wilting point (-1.5 MPa) and consequently have low or moderately low AWC. The total available water in the profile to 1 m depth is high (173 mm). Although the brown mottling in the subsoil indicates some degree of waterlogging, the absence of grey mottles on ped faces and the light texture of the relatively deep topsoil indicate that the soil is effectively well drained. Except where texture is very coarse, the soil is not normally droughty.

Soil suitability: Consisting of two contrasting textural layers, the Ardmore series combines ease of cultivation and harvesting with an adequate moisture supply. It is very suited to grass, cereals, root crops and horticultural crops including carrots and peas. The neutral to alkaline pH may induce nutrient deficiencies (e.g. manganese); as fertilisation or spraying can correct any such deficiency, it is not considered a significant continuing limitation, and the soil is assigned to suitability Class AI.

Representative profile description

Series:	Ardmore
Location:	Co. Waterford, Listeige Td., Grid Ref. 216400 78500
Classification:	Plaggen (Typic Plagganthrept)
Parent Material:	Plaggen sand over Irish Sea till composed of greywacke, red sandstone and quartzite.
Drainage:	Well
Topography:	Smoothly undulating
Slope:	2^0
Altitude:	20 m AMSL
Land-use:	Grassland

Horizon	Depth (cm)	Description
A1	0–10	Dark greyish brown (10YR 4/2); sandy loam; few very small and small rounded stones; moderate fine granular structure; moderately weak consistence, moderately plastic (wet); abundant very fine roots.
A2	10–20 (25)	Dark greyish brown (10YR 4/2); sandy loam; common very small and small rounded stones; moderately developed fine granular structure; moderately weak consistence; moderately plastic (wet); many very fine roots; clear smooth boundary.
A3	20–40	Brown (10YR 4/3); sandy loam; common very small and small rounded stones; weakly developed, fine granular structure; moderately weak consistence; moderately wavy boundary.
Bw	40–60	Brown (10YR 4/3) becoming brown (10YR 5/3) with depth, common fine black mottles; clay loam; few small stones; weakly developed, compound, coarse and fine subangular blocky structure; moderately weak semi-deformable consistence, very plastic (wet); common fine macropores; common very fine roots; gradual discontinuous boundary; horizon extends to 75% of pedon.

Bg	60 (40)–100	Pale brown (10YR 5.5/3) with very many coarse strong brown (7.5YR 5/5) mottles; clay loam; few small stones; weakly developed, coarse subangular blocky structure; moderately firm semi-deformable consistence, very plastic (wet); common fine and medium macropores; few very fine roots; gradual wavy boundary.
C1g	100–125	Pale brown (10YR 5.5/3), with very many coarse strong brown (7.5YR 5/5) mottles and common medium black mangans; clay loam; common small stones; very weakly developed, very coarse subangular blocky structure, with pale brown (10YR 5.5/3) ped faces; moderately firm semi-deformable consistence; extremely plastic (wet); common very fine macropores; very few roots.
C2	125–130	Many medium subangular stones.
C3	130+	Brown (10YR 5/3) with pale brown (10YR 5.5/3) ped faces and common medium black mangans; clay loam with few sand pockets; few small rounded stones; very weakly developed very coarse subangular blocky structure; moderately firm semi-deformable consistence; common very fine macropores; no roots.

Table 3.6: Particle size and chemical analyses, Ardmore Series.

Horizon	A1	A2	A3	Bw	Bg	C1g	C3
Depth (cm)	0–10	10–20 (25)	20–40	40–60	60(40) –100	100 –125	130+
Particle Size % :							
Coarse sand 200 μm –2 mm	23	25	22	12	11	16	9
Fine sand 50–200 μm	31	28	25	16	19	17	15
Silt 2–50 μm	29	29	33	41	40	35	42
Clay <2 μm	17	18	20	31	30	32	34
TNV g kg^{-1}	74	25	0	0	0	0	
Ca cmol kg^{-1}	10.5	10.5	9.42	8.3	7.8	8.45	9.51
Mg cmol kg^{-1}	1.17	0.72	0.44	0.2	0.23	0.22	0.33
K cmol kg^{-1}	1.2	0.3	0.1	0.08	0.12	0.11	0.19
Na cmol kg^{-1}	0.16	0.09	0.16	0.09	0.23	0.12	0.17
TEB cmol kg^{-1}	13.03	11.61	10.12	8.67	8.38	8.9	10.36

Table 3.6: Particle size and chemical analyses, Ardmore Series (cont'd).

CEC cmol kg^{-1}	17.6	15.4	12.8	11.6	11.6	12.4	13.6
Base Saturation %	74	75	79	75	72	72	76
pH	6.7	7.3	7.6	7.2	7.2	7.2	7.3
C g kg^{-1}	29	18	9	5	3	2	2
N g kg^{-1}	2.8	1.7	1				
C/N	10.4	10.6	9				
Free iron g kg^{-1}	14	15	18	23	23	26	26

Table 3.7: Physical analyses, Ardmore Series.

Horizon	A	A	A	A	B	B	B	C
Sub-horizon	1	2	3	3	w	g	g	g
Depth cm	0–10	10–20	20–40	30–40	40–60	60–80	80–100	100–125
Particle density Mg m^{-3}	2.79	2.43	2.51	2.51	2.56	2.57	2.57	2.58
Bulk density at saturation Mg m^{-3}	1.34	1.50	1.55	1.52	1.34	1.64	1.69	1.65
Bulk density at -59 hPa Mg m^{-3}	1.34	1.50	1.55	1.52	1.34	1.64	1.69	1.65
Air capacity % vol.	7.4	5.4	3.0	2.9	5.7	5.1	3.3	2.0
Retained water % vol.:								
0 hPa	51.8	43.6	37.1	38.1	48.3	39.0	38.1	36.7
-2 hPa	45.4	39.5	35.9	36.2	45.7	36.1	37.1	35.7
-59 hPa	44.4	38.2	34.1	35.1	42.6	33.8	34.9	34.7
-137 hPa	40.2	34.4	29.8	31.3	41.3	32.4	33.6	33.6
-0.1 MPa	32.8	29.3	24.3	26.0	38.7	29.4	31.1	31.2
-1.5 MPa	18.3	17.4	16.5	17.9	33.7	23.1	17.9	18.9
Total available water % vol.	26.1	20.9	17.6	17.2	8.9	10.8	17.0	15.8
Total available water cm	2.6	2.1	3.5	1.7	1.8	2.2	3.4	4.0
Total available water cumulative cm	2.6	4.7	8.2	9.9	11.7	13.9	17.3	21.2

Table 3.8: Descriptive statistics, Ardmore Series.

	Depth cm	Count	Mean	Standard Deviation	Minimum	Maximum	Range
Clay	0–10	11	15.5	6.1	2	28	26
Clay	40–50	10	22.8	9.2	11	40	29
Fine silt	0–10	11	14.6	4.1	7	24	17
Fine silt	40–50	10	19.8	5.9	8	29	21
Coarse silt	0–10	11	14.1	4.1	8	23	15
Coarse silt	40–50	10	14.9	3.1	7	18	11
Very fine sand	0–10	11	9.5	2.0	7	13	6
Very fine sand	40–50	10	10.4	2.0	7	14	7
Fine sand	0–10	11	25.6	7.6	9	41	32
Fine sand	40–50	10	17.7	9.8	5	40	35
Medium sand	0–10	11	13.4	3.9	4	18	14
Medium sand	40–50	10	9.3	4.8	2	18	16
Coarse sand	0–10	11	5.3	1.9	2	9	7
Coarse sand	40–50	10	3.8	1.8	1	7	6
Very coarse sand	0–10	11	2.0	1.3	1	5	4
Very coarse sand	40–50	10	1.3	0.5	1	2	1
TNV g kg^{-1}	0–10	11	46.7	66.4	0	205	205
TNV g kg^{-1}	40–50	10	41.1	77.9	0	242	242
Ca cmol kg^{-1}	0–10	11	16.66	5.27	7.9	24.52	16.62
Mg cmol kg^{-1}	0–10	11	0.64	0.42	0.18	1.52	1.34
K cmol kg^{-1}	0–10	11	0.26	0.36	0.06	1.22	1.16
Na cmol kg^{-1}	0–10	11	0.13	0.04	0.08	0.22	0.14
TEB cmol kg^{-1}	0–10	11	17.70	5.56	8.25	26.28	18.03
CEC cmol kg^{-1}	0–10	11	19.4	4.6	11.6	24.6	13
Base Sat. %	0–10	8	84.5	10.9	67	98	31
pH	0–10	11	7.2	0.5	6.1	7.7	1.6
pH	40–50	10	7.6	0.3	7.3	8	0.7
C g kg^{-1}	0–10	11	23.9	9.1	5	36	31
C g kg^{-1}	40–50	10	5.9	2.1	4	9	5
N g kg^{-1}	0–10	10	3.1	0.8	1.6	4.3	2.7
N g kg^{-1}	40–50	1	1.1		1.1	1.1	0
C / N	0–10	10	8.6	0.4	8	9.4	1.4
C / N	40–50	1		8.2	8.2	8.2	0
Free iron g kg^{-1}	0–10	11	12.8	3.9	9	24	15
Free iron g kg^{-1}	40–50	10	17.3	9.5	8	39	31

Aughty Series

Most of this series is on the plateau that lies at the top of the Monavullagh Mountains; a small part is lower down on a saddle around Moanyarha. The Aughty mapunit covers 1799 ha (0.98% the county); it includes a cutover phase, which occupies 460 ha (0.25% of county). Most of the cutover phase surrounds the original series in the Moanyarha area; a small part is found in the Ballysaggart area in the west of the county. In addition, significant amounts of the series occur as inclusions in the Knockmealdown and Monavullagh map units. Most of the series on the Monavullagh Mountain lies above 520 m and ranges up to 790 m AMSL, whereas in the Moanyarha area elevation is less than 440 m AMSL. Topography is undulating to rolling in both the Monavullagh and Moanyarha areas: these areas are separated by the Monavullagh series lying on steep slopes. Virtually all the Monavullagh Plateau has more than 1750 mm average annual rainfall and 175 rain-days (>1 mm), whereas average annual rainfall in the Moanyarha area is less than 1500 mm. Most of the peats in this environment belong to the Aughty series and its phases (Hammond, 2003).

The salient features and analyses of the surface and subsurface tiers of a monolith taken on the Monavullagh plateau are tabulated below. In addition, the morphological features and analyses of a profile representing the Aughty series in Co. Offaly (Hammond, 2003) are presented below. The surface tier of the Monavullagh profile consists of black greasy peat with dark brown fibrous pockets. The subsurface tier is black, greasy with indistinct plant remains. Rubbed fibre contents and SPEC values indicate that the subsurface tier is highly decomposed (sapric). The profile lacks evidence of soil development and is classified as a Haplosaprist (USDA, 1999) which, allowing for changes in terminology, is the same as the representative Aughty profile (Hammond, 2003). Peat depth varies from 0.8 to over 2 m. Most of the series belongs to the Typic subgroup, but the shallow parts are in the Terric subgroup.

The surface and subsurface tiers are strongly acid and have very low (≤5%) base saturation. There are small amounts (<1.28 cmol kg^{-1}) of exchangeable Ca above 40 cm depth; none was found below this depth. Relative to peat soils, the C/N ratio of both tiers is low (≈15), which indicates aerobic decomposition and that the nitrogen is potentially mineralizable (Williams, 1983).

Although both the rubbed fibre content and SPEC values indicate that virtually all the control section (≤90 cm depth) consists of highly decomposed sapric material, the average saturated water content (91.7% vol) is relatively high and lies within the range ascribed to typical fibric material (Boelter, 1969). Mean bulk density (0.12 Mg m^{-3}), however, is relatively low for sapric material and lies within the range found in hemic material by Boelter (1969). The air-filled porosity, estimated on the basis of laboratory measurement at –59 h Pa, is very large. It tends to decrease with depth and the average of the control section is 25% (vol). A large part of this is accounted for by macropores corresponding to potentials less than –20 hPa. As it takes a long time to empty the macropores (cf. Knockmealdown Series) and rainfall is frequent, it is likely that the actual air-filled pores in the field are much less than that indicated by the soil water retention data. The amount of water retained between –59 hPa and 1.5 MPa is very large (31.9–57.0% vol), and the actual available water capacity (AWC) is likely to be even greater than this due to disequilibrium between matric suction and soil water content.

Hydraulic conductivity, estimated on the basis of density, is slow to moderately rapid in the surface tier and moderately slow to moderately rapid in the subsurface tier. However, the high degree of decomposition in most of the surface tier (≤30 cm) and throughout the subsurface tier implies slow hydraulic conductivity (Boelter, 1969). The estimated hydraulic conductivity of the surface tier based on drainable porosity (Galvin, 1976), which is probably more accurate than the estimate based on density, is moderately slow to moderately rapid, whilst that of the subsurface tier is slow and tends to decrease with depth. This suggests that, under frequent high rainfall, the soil water regime is probably similar to the blanket bog investigated by Burke (1975), where the water table was perched, very shallow (<10 cm) in winter, and shallow (<20 cm) in summer (cf. Knockmealdown series).

Soil suitability: The principal inherent limitations are low nutrient status, weak bearing capacity, wetness, and short growing season due partly to climatic effects associated with high elevation. The combined effect of these limitations for agriculture is severe. It is likely that the soil contains some mineralizable nitrogen, but the status of other nutrients including bases and phosphorus, is very low. Exposure is an additional limitation for forestry. In its current condition the soil is poorly suited to agriculture or forestry. Its agricultural use is limited to extensive sheep grazing, and it is assigned to suitability Class EV. Poor access and a commonage system of land tenure preclude development. A small part of the series on the Comeragh–Monavullagh plateau is eroded. The Aughty series is predominantly intact and is included in the Comeragh Mountain Natural Heritage Area. The intensity of sheep grazing should be limited to that consistent with conservation requirements. It is technically feasible to establish grassland on the cutover and cutaway areas (CP) that are on the gently sloping lower plateau at about 455 m AMSL around Moanyarha. This could be accomplished either by fertilisation and surface seeding, which is a long process (Moloney, 1964), or by a faster process that includes deep ploughing or ripping. As in the surrounding Glenary series, large boulders are probably abundant under the peat layer which could add substantially to the reclamation cost. Wetness will be a continuing limitation, and with higher nutrient levels there is a serious risk of rush infestation (cf. Knockmealdown Series). Thus the potential suitability is severely limited and remains in Class EV.

Table 3.9: Chemical analyses and fibre content, Aughty Series, Monavullagh profile.

Horizon	Oa1	Oe1	Oe2	Oa2	Oa3	Oa4	Oa5	Oa6	Oa7
Depth cm	0–5	10–20	20–30	30–40	40–50	50–60	60–70	70–80	80–90
Ca cmol kg^{-1}	1.28	0.88	0.68	0.2	0	0	0	0	0
Mg cmol kg^{-1}	2.56	2.32	2.68	2.32	1.64	2.04	1.6	1.52	1.2
K cmol kg^{-1}	0.72	0.44	0.16	0.12	0.08	0.08	0.08	0.08	0.08
Na cmol kg^{-1}	0.76	0.6	1.08	0.8	0.52	0.8	0.52	0.72	0.6
T.E.B. cmol kg^{-1}	5.32	4.24	4.6	3.44	2.24	2.64	2.2	2.32	1.88
C.E.C cmol kg^{-1}	94.4	90.4	94.4	88.8	62.4	84.8	98.2	70.4	87.2
Base Saturation %	2	5	5	4	4	3	2	3	2
pH	4.1	4.3	4.6	4.6	4.9	4.7	4.8	4.9	4.8
Free iron g kg^{-1}	20	16	6	4	4	6	14	12	24
C g kg^{-1}	301	278	263	296	256	284	270	220	288
N g kg^{-1}	20	20.6	22.2	21.6	22.2	19.8	21.6	20.8	18.8
C/N	15.1	13.5	11.8	13.7	11.5	14.3	12.5	10.6	15.3
Loss on ignition g kg^{-1}	914	954	969	944	985	981	974	963	881
Ash O.D. g kg^{-1}	86	46	31	56	15	19	26	37	119
Fibre unrubbed % vol	40	44	40	56	58	40	44	44	44
Fibre rubbed % vol	16	20	14	10	12	10	8	8	4
SPEC[1] value/chroma	5/4	6/3	7/2	6/3	6/3	6/3	6/3	5/4	6/3

[1] Sodium Pyrophosphate Extract Colour

Table 3.10: Physical analyses, Aughty Series, Monavullagh profile.

Horizon	O	O	O	O	O	O	O	O	O
Sub-horizon	a1	e1	e2	a2	a3	a4	a5	a6	a7
Depth cm	0–10	10–20	20–30	30–40	40–50	50–60	60–70	70–80	80–90
Particle density Mg m $^{-3}$	1.47	1.45	1.37	1.38	1.31	1.25	1.19	1.18	1.09
Bulk density at saturation Mg m $^{-3}$	0.19	0.13	0.1	0.1	0.12	0.11	0.1	0.11	0.12
Bulk density at -59 hPa Mg m $^{-3}$	0.19	0.13	0.1	0.1	0.12	0.11	0.1	0.11	0.12
Air capacity % vol.	27.5	28.2	32.8	28.1	22.2	24.4	23.8	20.5	18.7
Retained water % vol.: 0 hPa	89.3	93.5	94.7	89.9	90.2	91.6	91.0	94.0	90.8
-2 hPa	66.2	70.2	68.3	71.1	74.9	74.1	73.4	79.5	76.9
-59 hPa	61.9	65.2	61.9	61.8	68.0	67.2	67.2	73.5	72.1
-137 hPa									
-0.1 MPa	42.7	44.3	39.4	38.5	48.7	43.1	48.6	48.3	55.7
-1.5 MPa	30.0	18.2	18.2	22.5	20.2	24.9	17.7	16.4	18.5
Total available water % vol.	31.9	47.1	43.7	39.3	47.7	42.3	49.5	57.0	53.5
Total available water cm	3.2	4.7	4.4	3.9	4.8	4.2	4.9	5.7	5.4
Total available water cumulative cm	3.2	7.9	12.3	16.2	21.0	25.2	30.1	35.8	41.2
Hydraulic conductivity[A] cm day $^{-1}$	14	17	41	24	8	11	9	5	4
Hydraulic conductivity[B] cm day $^{-1}$	2	18	55	55	26	38	55	38	26

[A] Estimate based on drainable porosity at -99 hPa (Galvin, 1976)
[B] Estimate based on density (Boelter, 1969)

Representative profile description: Aughty Series (After Hammond, 2003).

Location	Glenregan Td., Co. Offaly, Grid Ref. 226360 204157
Relief	Mountain plateau
Slope of site	Flat
Elevation	396 m O.D.
Vegetation and land use	Natural blanket bog vegetation
Drainage	Poorly drained
Parent material	Ombrotrophic peat of cyperaceous origin
Great Soil Group	Histosol (USDA Classification)
Sub-group	Medisaprist

Horizon	Depth (cm)	Description
Oal	0–25	Peat; black (5YR 2/1); cyperaceous plant remains in well-humified matrix; pasty residues, on squeezing, one third peat material passes through fingers; vPIII; clear, smooth boundary.
Oa2	25–80	Peat; dark reddish brown (5YR 3/2); many prominent long fine fibres in humified matrix vPII; on squeezing, little peat material passes through fingers; gradual smooth boundary.
Oa3	80–150	Peat; dark reddish brown (5YR 3/2); fine fibres embedded in highly humified matrix two thirds peat material passes through fingers on squeezing; abrupt, smooth boundary.
A1	150–158	Loam; greyish brown to light brownish grey (10YR 5/2–6/2); massive structure; wet sticky; many fine fossil roots; clear, smooth boundary.
A2	158+	Loam; light grey (10YR 7/2) massive structure; common fossil roots.

Table 3.11: Profile analyses, Aughty Series (After Hammond, 2003).

Horizon	Oa1	Oa2	Oa3
Depth (cm)	0–25	25–80	80–100
pH	3.6	3.5	3.6
SPEC	7	6	6
Bulk density Mg m^{-3}	0.109	0.093	0.096
Moisture field gravimetric, %	556	554	411
Ash, %	3.5	1.8	1.7

Ballycondon Series

This series is widely distributed in the county; including all phases, it occupies 8570 ha (4.68% of the county). It is situated predominantly in the uplands in the western part of the county; in addition, a very small proportion lies on the ridge that extends from Kilmeadan to Kilsheelan. This is the dominant soil under 'natural vegetation' on the South Ireland Peneplane; it occurs in association with its poorly drained counterpart, the Dodard series, and also with the Knockboy Series. Elevation ranges from 150 m AMSL in Bawnfune Td. about 3 km northeast of Cappoquin, to 380 m AMSL on the footslopes of the Comeragh mountains; most of the series lies between 215 and 305 m AMSL, whereas the Knockboy series predominates at lower elevations. Except where forest was planted, the Ballycondon series is under heath; it is likely that heaths dominated the landscape above about 135 m AMSL in the sandstone region prior to the reclamation that formed the Knockboy and Newport series. Topography is predominantly undulating, and most gradients are more than 3°. Some rolling and steep phases were mapped separately, mostly on the footslopes of the mountains; some of these phases were too small to separate, and it is likely that the normal undulating phase contains a greater proportion of rolling and steep inclusions than the reclaimed series (Knockboy). The parent material is loamy till composed predominantly of Devonian sandstone. The bedrock underlying the till is medium grained sandstone and mudstone of the Knockmealdown and Ballytrasna formations. Average annual rainfall is about 1250 mm over most of the area; it ranges from 1100 to 1500 mm over the entire series.

The surface horizon consists of dark brown to black highly decomposed peat, which ranges in thickness from about 10 to 30 cm. A mineral A horizon is generally absent and the organic layer is underlain directly by a strongly bleached E horizon, which is mostly 10 to 20 cm thick, but in places forms tongues which extend to 50 cm depth. The E horizon is composed of grey mineral matter, with some humus staining, and pockets of organic matter, which typically occupy about 15% of the horizon. Mottling is absent in the mineral matter, but the stones commonly have a yellowish surface zone, which indicates periodic waterlogging. The thin ironpan, which generally lies immediately below the E horizon, is wavy and continuous; the upper surface is black while the underside is reddish brown reflecting different moisture regimes above and below the pan. Accumulations of near horizontal roots lie above the pan. The underlying spodic horizon has a characteristic strong brown colour and is generally 10 to 20 cm thick; it passes gradually into the underlying brown to pinkish brown parent material. The series is classified as a podzol. In the USDA system, the series has features characteristic of both the wet Podzols (Aquods) and the 'dry' Podzols (Orthods). Although the peaty surface is too thin in some pedons to qualify as histic, and the redoximorphic features may be weakly expressed or absent, the soil is considered on balance to be a Typic Placaquod rather than a Placorthod. The low contrast mottles that are above the ironpan are characteristic of Placaquods; they probably reflect concentrations of organic matter (USDA, 1999).

Texture of the E and C horizons of the representative profile is sandy loam, while that of the spodic B horizon is loam. The silt content of all horizons is relatively high (41–48%); the clay content shows greater variation (6 to 25%). The high clay content of the spodic horizon is probably due partly to the inclusion of free iron in the clay fraction. Grid samples are not available for the Ballycondon series; it is likely that the spatial variation is similar to that of the reclaimed version, the Knockboy series. Large stones are common in the C horizon below 50 cm depth. Some stony phases, which have common to many large stones near the surface, were delineated on the footslopes of the Comeragh and Monavullagh mountains and on Carronadavderg Hill in the Drum Hills; these phases lie over both sandstone/mudstone and conglomerate bedrock. The consistence of the E and C horizons is friable to slightly firm, whilst the B horizon is invariably friable; all the mineral horizons are slightly brittle. The best developed structure is found in the spodic B horizon; it is weakly developed in the E and upper C horizon and becomes massive in the lower C horizon. Bulk density is not very high in any horizon in the representative profile; it is moderate to low in the spodic B horizon. Roots are common in the B horizon suggesting that the ironpan is permeable in places; few roots are found below 60 cm depth.

Cation exchange capacity (CEC) of the surface horizon is very high due to the high carbon content. The CEC of the B horizon is much higher than that of the E horizon although the organic carbon and clay contents are lower. Reaction is strongly acid in the surface layer (O and E horizons), and it is moderately acid throughout the subsoil; base saturation is very low ($\leq$13%) throughout the profile. The C/N ratio is high indicating slow rates of organic matter decomposition throughout the solum. The very high free iron content (53 g kg^{-1}) combined with the high CEC confirms the spodic nature of the B horizon.

The available water capacity of each horizon of the representative profile decreases regularly with depth and ranges from extremely high in the O horizon to high in the C horizon. Based on a relatively shallow rooting depth of 60 cm, the total available water in the representative profile is high (188 mm); it will vary substantially from site to site depending on the depth of the surface peat layer. Under the moderately high rainfall regime, the available water in the root zone is sufficient to ensure that the soil is non-droughty. The air capacity varies widely throughout the solum. It is very low in the albic (E) horizon, while it is moderate to high in the horizons below the ironpan. This indicates slow permeability in the mineral horizon above the pan and at least moderately rapid permeability below the ironpan. This is consistent with the morphological features, which lack evidence of prolonged saturation below the ironpan.

Soil suitability: The FAO Framework (FAO, 1976) distinguishes between Current Suitability and Potential Suitability, and it is arguable which is the most pertinent in relation to the Ballycondon series. Current suitability may include minor land improvements, which normally lie within the capacity of an individual farmer, whereas Potential Suitability includes a “large non-recurrent input in land improvement which causes a substantial and reasonably permanent change in the suitability and which cannot normally be financed or executed by an individual farmer”. Conry (1987) assessed the heathland on sandstone in the Slieve Bloom in the natural state and assigned the Conlawn and Rossmore Series to Suitability Class EV i.e. very poorly suited to grassland and arable crops. Owing to the very low nutrient status, relatively low bearing strength, and wetness, the Ballycondon series, without inputs, is limited to extensive grazing (Class EV). As the ironpan, which impedes drainage, is generally shallow, it can be broken relatively easily using hand tools or horse drawn implements. The nonplastic and somewhat brittle nature of the surface mineral horizon (E) permits shattering, which increases the permeability. Prior to mechanised agriculture, large areas of the Ballycondon series were reclaimed to form the Knockboy series which supports productive grassland. Large areas were reclaimed in the 1970s when the economic environment was particularly favourable for livestock production; in the last decade virtually none of this land has been reclaimed. Kiely (1985) described the reclamation and performance of a similar soil at Coolnakilla where, after copper, cobalt, selenium and sulphur deficiencies were alleviated, a grazing capacity of 2.5 L.U. ha^{-1} was attained. Thus the potential suitability of this series is Class BIII (cf. Knockboy Series).

Representative profile description

Series:	Ballycondon
Location:	Waterford, Kilwatermoy Mountain Td., Grid Ref. 203,000 088,000
Classification:	Podzol (Typic Placaquod)
Parent Material:	Sandstone till
Drainage:	Well drained below shallow ironpan
Topography:	Smoothly undulating
Slope:	3^0
Altitude:	184 m AMSL
Land-use:	Heath, mainly heather and furze

Horizon	Depth (cm)	Description
Oa	0–10	Very dark brown (7.5YR 2/1); highly decomposed peat, no fibres visible; weak fine granular structure.
E	10–20	Pinkish grey (7.5YR 5/2) sandy loam, and dark brown (7.5YR 3/2) organic material; many small and medium stones; mineral part has weak fine angular blocky structure, few very fine pores, slightly firm brittle consistence, and is moderately plastic (wet); organic part extends to about 15% of pedon and has weak fine granular structure; common fine roots; abrupt wavy boundary.
Bsm	20	Thin ironpan (4 mm thick) black upside and reddish brown underside; accumulations of roots lie above pan.
Bs	20–32	Strong brown (7.5YR 4/6) and very dark brown (7.5YR 2/2) coatings on root channels and ped faces; loam; common small and medium stones; weak to moderate fine subangular blocky structure, and medium granular around roots; friable, slightly brittle consistence; very plastic (wet); very abundant, very fine pores; common fine roots; gradual wavy boundary.
C1	32–60	Dark brown (7.5YR 4/4) and very dark brown (7.5YR 2/2) coatings on root channels and ped faces; sandy loam; common small and medium stones; weak coarse subangular blocky structure; friable, slightly brittle consistence; moderately plastic (wet); abundant very fine and fine pores; few roots; gradual wavy boundary.

C2	>60	Brown (7.5YR 5/2) and few, very dark brown (7.5YR 2/2) coatings on old root channels; sandy loam; common, small to large stones; very weak coarse subangular blocky structure becoming massive with depth; slightly firm, slightly brittle consistence; many very fine pores; few old roots.

Table 3.12: Particle size and chemical analyses, Ballycondon Series.

Horizon	Oa	E	Bs	C1	C2
Depth cm	0–10	10–20	20–32	32–60	60–80
Particle Size % :					
Coarse sand 200–2000 μm		23	20	21	20
Fine sand 50–200 μm		24	14	20	18
Silt 2–50 μm		47	41	48	46
Clay <2 μm		6	25	11	16
T.N.V g kg^{-1}	0	0	0	0	0
Ca cmol kg^{-1}	5.80	0.40	1.40	1.30	0.30
Mg cmol kg^{-1}	4.08	0.34	0.27	0.2	0.07
K cmol kg^{-1}	1.04	0.05	0.01	0.01	0.08
Na cmol kg^{-1}	0.6	0.012	0.2	0.08	0.06
T.E.B. cmol kg^{-1}	11.52	0.91	1.88	1.59	0.51
C.E.C cmol kg^{-1}	85.6	16.2	35.2	12.6	7.8
Base Saturation %	13	6	5	13	7
pH	4.2	3.9	4.8	5.6	5
C g kg^{-1}	256	28	20	6	2
N g kg^{-1}	11.2	1.4	1.2		
C/N	22.9	20	16.7		
Free iron g kg^{-1}	6	1	53	16	15
Loss on ignition g kg^{-1}	696				

Table 3.13: Physical analyses, Ballycondon Series.

Horizon	Oa	E	B	C
Sub-horizons				1
Depth cm	0–10	10–20	20–32	32–60
Particle density Mg m^{-3}	1.69	2.5	2.38	2.65
Bulk density at saturation Mg m^{-3}	0.28	1.23	0.94	1.66
Bulk density at -59 hPa Mg m^{-3}	0.28	1.23	0.94	1.66
Air capacity % vol.	18.9	3.2	13.7	8.6
Retained water % vol.:				
0 hPa	96.0	53.2	64.8	39.1
-2 hPa	81.3	51.1	55.3	32.5
-59 hPa	77.1	49.9	51.1	30.5
-137 hPa	74.2	47.4	48.7	29.2
-0.1 MPa	67.8	36.1	42.9	24.9
-1.5 MPa	18.1	12.9	22.4	9.9
Total available water % vol.	59.0	37.1	28.7	20.6
Total available water cm	5.9	3.7	3.4	5.8
Total available water cumulative cm	5.9	9.6	13.1	18.8

Ballymacart Series

This series is situated in the southwest of the county where it occupies 1746 ha (0.95% of the county). It lies principally on the lower, south-facing slopes of the Drum Hills, where it is associated with its freely drained counterpart the Clashmore series. In places it adjoins the Ahaun series, which is situated on the crests of the hills. Some small enclaves, which are surrounded by The Clashmore series, lie around the upper reaches of tributaries of the Blackwater and Bride rivers. Elevation is mostly between 61 and 122 m AMSL, but a small part has been mapped up to 183 m AMSL in the Drum Hill region. Topography is undulating. The parent material is similar to that of the Clashmore series and consists of loamy till composed predominantly of Devonian sandstone. The bedrock underlying the till is mudstone and sandstone of the Ballytrasna and Gyleen Formations. Average annual rainfall is 1100±50 mm.

A typical profile has dark (umbric) topsoil, up to 40 cm thick, underlain by a grey horizon (E) that has few or no yellowish mottles. The abundance of the mottles increases with depth, and eventually mottles become dominant. Stones are small to medium and have characteristic yellowish outer margins, unlike the stones in the Clashmore series, which retain their reddish or purplish hue. The soil is classified as a Gley (Humic Haplaquept).

Texture is a light loam throughout the solum and is similar to the Clashmore series. The average clay content is 19.7% in the surface layer (0–10 cm) and 18.6% at 40–50 cm depth. The clay content shown below for a representative profile appears to be anomalous and is probably due to sand pockets, which occur occasionally in the map unit in the Drum Hills region. Structure is typically weakly developed granular or fine blocky in the topsoil (A horizon) and becomes massive in the subsoil (E, B and C horizons). In the profile described below roots are absent in the subsoil.

The average carbon content of the surface layer (0–10 cm) is moderate and is substantially greater than in the Clashmore series. The cation exchange capacity (CEC), reflecting the higher carbon content, is also greater than in the Clashmore series. The ratio of carbon to nitrogen is also higher indicating slower rates of organic matter decomposition. Acidity is moderate in the surface layer and decreases with depth; both the surface and subsoil layers are more acid than the corresponding depths in the Clashmore series. Free iron content is low; it is about half the amount found in the free draining counterpart indicating reduction and removal under saturated conditions.

The A horizon (0–40 cm) of the profile described below has a very high available water capacity (AWC); the AWC is lower in the subsoil but remains moderately high or high throughout the profile. The total amount of available water in the profile, down to one metre depth, is very high (>200 mm). The amount exploitable by plants, however, is less due to limited root penetration in the subsoil. The air capacity is moderate to 20 cm depth; it is low in most of the profile and is lowest in the eluvial horizon (E) immediately under the topsoil. This horizon is brittle. The bulk density is moderate (<1.3 Mg m^{-3}) in the topsoil; it increases in the subsoil where it is high but slightly less dense than the corresponding horizons of the Clashmore series. Hydraulic conductivity data are not available for this soil; however, the low air capacity and massive structure of the subsoil indicates that it is slow. The Gley morphology indicates saturation with water for long periods and the soil is classified as poorly drained.

Soil suitability: The principal limitation is wetness, which will remain a continuing limitation after field drainage owing to the slow hydraulic conductivity. Subsoiling is likely to be beneficial only where the brittle horizon lies near the surface. Although root penetration is limited in the subsoil, drought is unlikely to be a significant limitation because of the high available water capacity and moderately high rainfall over most of the area. The soil is moderately suited to grassland and arable crops. Situated in the coastal region, the climate of the area favours a long growing season and high levels of grass production, but wetness reduces dry matter production and shortens the length of the grazing season. There is a risk of damage by poaching especially in those parts of the series that have high carbon content. Wetness reduces the number of workdays in spring and sowing date of spring-sown crops can be delayed. Winter cereals are the most suitable arable crops. The series is assigned to Suitability Class CIII.

Representative profile description

Series:	Ballymacart
Location:	Waterford, Gates Td., Grid Ref. 226000 83600
Classification:	Gley (Humic Haplaquept)
Parent Material:	Till composed predominantly of purple fine sandstone; some green sandstone.
Drainage:	Poor
Topography:	Undulating
Slope:	3^0
Altitude:	90 m AMSL
Land-use:	Old pasture. Rush and buttercup common.

Horizon	Depth (cm)	Description
A1	0–10	Very dark grey (10YR 3/1); loam; few small stones; weakly developed coarse granular structure; moderately weak and moderately firm semi-deformable consistence; moderately plastic (wet); abundant roots.
A2	10–20	Very dark grey (10YR 3/1); loam; few small stones, weakly developed medium granular structure; moderately weak semi-deformable consistence; moderately plastic (wet); abundant very fine roots.
A3	20–40	Very dark grey (10YR 3/1); loam; few small stones; weakly developed medium granular structure; moderately weak semi-deformable consistence; very plastic (wet); many very fine roots; abrupt smooth boundary.
Eg	40–60	Light brownish grey (10YR 6/2) and (25%) very dark greyish brown (10YR 3/2); sandy loam; common medium yellowish brown weathered stones; moderately firm brittle consistence; slightly plastic (wet); very few medium macropores; no roots; gradual wavy boundary.
Bg	60–100	Pale brown (10YR 5.5/3) and very many yellowish brown (10YR 5/8) coarse mottles and weathering stones; loam (silty) and some sand pockets; common small and medium stones mostly weathered; massive structure; moderately firm semi-deformable consistence; moderately plastic (wet); very few fine pores; no roots; gradual wavy boundary.
Cg1	100–125	Pinkish grey (7.5YR 6/2) (40%) and coarse strong brown (7.5YR 5/8) mottles (60%); clay loam; many small and medium stones; massive structure; moderately firm semi-deformable consistence; very plastic (wet); few fine pores; no roots; gradual boundary.
Cg2	125+	Yellowish brown (10YR 5/5) with common pinkish grey (7.5YR 6/2) coarse mottles with strong brown (7.5YR 5/8) rims; loam (silty) with many sand pockets; common small and medium stones; massive structure; moderately firm semi-deformable consistence, sandy pockets are brittle; very few, very fine macropores; no roots.

Table 3.14: Particle size and chemical analyses, Ballymacart Series.

Horizon	A1	A2	A3	Eg	Bg	Cg1	Cg2
Depth cm	0–10	10–20	20–40	40–60	60–100	100–125	125+
Particle Size % :							
Coarse sand 200–2000 μm	20	20	22	34	24	21	21
Fine sand 200–50 μm	27	26	25	33	35	24	25
Silt 50–2 μm	47	46	47	23	32	32	33
Clay <2 μm	6	8	6	10	9	23	21
TNV g kg^{-1}	0	0	0	0	0	0	0
Ca cmol kg^{-1}	9.7	10	10.28	3.35	1.8	4.3	2.95
Mg cmol kg^{-1}	0.79	1.06	0.71	0.39	0.24	0.51	0.34
K cmol kg^{-1}	0.23	0.74	0.14	0.08	0.07	0.18	0.06
Na cmol kg^{-1}	0.21	0.27	0.06	0.07	0.02	0.03	0.04
TEB cmol kg^{-1}	10.93	11.26	11.19	3.89	2.13	5.02	3.39
CEC cmol kg^{-1}	22.6	24	21.4	7.4	4.6	9	8
Base Saturation %	48	47	52	53	46	56	42
pH	5.5	5.7	5.7	6.3	6.3	6	5.7
C g kg^{-1}	55	45	41	8	3	4	2
N g kg^{-1}	3.9	3	2.6				
C/N	14.1	13.3	15.8				
Free iron g kg^{-1}	8	8	7	2	10	26	20

Table 3.15: Physical analyses, Ballymacart Series.

Horizon	A	A	A	A	E	E	B	B	C
Sub-horizon	1	2	3	3	g	g	g	g	g1
Depth cm	0–10	10–20	20–30	30–40	40–50	50–60	60–80	80–100	100–125
Particle density Mg m^{-3}	2.26	2.17	2.25	2.25	2.56	2.56	2.65	2.65	2.64
Bulk density at saturation Mg m^{-3}	1	1.08	1.22	1.23	1.69	1.53	1.51	1.63	1.5
Bulk density at -59 hPa Mg m^{-3}	1	1.08	1.22	1.23	1.69	1.53	1.51	1.63	1.5
Air capacity % vol.	11.8	7.7	4.6	4.1	3.6	6.1	9.1	5.9	7.3
Retained water % vol.:									
0 hPa	59.5	60.0	50.7	49.9	34.2	39.8	43.3	38.9	49.1
-2 hPa	52.8	56.5	48.7	47.8	32.4	36.5	37.5	35.4	43.6
-59 hPa	47.7	52.4	46.1	45.8	30.5	33.7	34.1	33.0	41.7
-137 hPa	45.4	50.1	45.1	44.8	29.5	32.4	32.6	31.4	40.8
-0.1 MPa	40.1	45.5	40.6	40.4	25.0	28.3	25.3	27.1	37.6
-1.5 MPa	21.3	18.9	19.4	18.8	11.1	14.4	10.3	9.5	25.8
Total available water % vol.	26.4	33.5	26.7	26.9	19.4	19.4	23.8	23.4	15.9
Total available water cm	2.64	3.35	2.67	2.69	1.94	1.94	4.76	4.69	3.99
Total available water cumulative cm	2.6	6.0	8.6	11.3	13.3	15.2	20.0	24.7	28.7

Table 3.16: Descriptive statistics, Ballymacart Series.

	Depth cm	Count	Mean	Standard Deviation	Minimum	Maximum	Range
Clay	0–10	10	19.7	3.3	15	26	11
Clay	40–50	10	18.6	2.3	16	23	7
Fine silt	0–10	10	18.0	4.1	8	23	15
Fine silt	40–50	10	19.3	4.3	11	26	15
Coarse silt	0–10	10	19.7	3.4	14	27	13
Coarse silt	40–50	10	18.6	4.4	13	28	15
Very fine sand	0–10	10	11.0	1.8	7	13	6
Very fine sand	40–50	10	11.4	1.6	9	13	4
Fine sand	0–10	10	12.3	1.6	10	15	5
Fine sand	40–50	10	11.6	2.2	7	15	8
Medium sand	0–10	10	11.0	1.6	9	13	4
Medium sand	40–50	10	10.3	3.1	6	16	10
Coarse sand	0–10	10	6.4	2.6	1	9	8
Coarse sand	40–50	10	7.7	3.0	4	14	10
Very coarse sand	0–10	10	1.9	0.9	1	3	2
Very coarse sand	40–50	10	2.5	1.5	1	6	5
TNV g kg^{-1}	0–10	10	0	0	0	0	0
TNV g kg^{-1}	40–50	10	0	0	0	0	0
Ca cmol kg^{-1}	0–10	10	5.75	3.46	1.62	11.91	10.29
Mg cmol kg^{-1}	0–10	10	1.02	0.38	0.65	2.02	1.37
K cmol kg^{-1}	0–10	10	0.19	0.10	0.09	0.32	0.23
Na cmol kg^{-1}	0–10	10	0.20	0.07	0.13	0.35	0.22
TEB cmol kg^{-1}	0–10	10	7.17	3.53	3	13.18	10.18
CEC cmol kg^{-1}	0–10	10	24.72	3.05	20.2	29.8	9.6
Base Sat. %	0-10	10	28	11	12	44	32
pH	0–10	10	5.2	0.3	4.7	5.7	1
pH	40–50	10	5.5	0.2	5.1	6	0.9
C g kg^{-1}	0–10	10	53.0	16.8	37	91	54
C g kg^{-1}	40–50	10	7.1	6.1	2	22	20
N g kg^{-1}	0–10	10	3.9	0.5	3	4.5	1.5
N g kg^{-1}	40–50	3	1.2	0.5	0.9	1.8	0.9
C/N	0–10	10	13.5	3.3	10.5	21.7	11.2
C/N	40–50	3	11.8	1.7	10	13.3	3.3
Free iron g kg^{-1}	0–10	10	9.3	5.3	3	21	18
Free iron g kg^{-1}	40–50	10	12.7	6.1	5	23	18

Ballynabola Series

This series is widespread in the county and occupies 1753 ha (0.95% of the county). It occurs mainly as narrow strips around the many small rivers that lead directly to the sea in the volcanic region and also around some tributaries of the major rivers. The series also forms unmapped minor inclusions in the Gley soils derived from till. The soil is related to the Coolfinn series, but it is generally derived from thinner alluvial deposits, occurs mainly at higher elevations and lacks the embankments and sluices characteristic of the Coolfinn series. Elevation is generally around 30 m AMSL; it ranges from 6 to 60 m AMSL. Most of the area liable to floods in the lower reaches of the Mahon River and Annestown Stream was separated as a peaty phase. The elevation of a parcel near Portlaw ranges from about 4 to 7 m AMSL; here, the alluvial deposit is thin (0.5 to 1 m).

Most of the alluvial parent material is derived from volcanic rocks; the remainder is derived from varying combinations of sandstone, shale, and to a lesser extent, limestone. The alluvium is generally 1 ± 0.5 m thick; topography is flat with minor undulations.

The soil profile is characterised by thin, dark greyish brown topsoil (A horizon) and light grey subsoil (C horizon) that has few to abundant yellowish mottles. In some profiles, the lower part of the subsoil lacks mottles, which indicates saturation with groundwater for long periods. Structure is generally very weakly developed coarse prismatic in the upper C horizon and becomes massive with depth. Texture is variable and mostly consists of silty clay loam, silt loam or silty clay. Peaty layers are at the surface in places; these soils are differentiated as a peaty phase. Peaty materials within the subsoil are sparse. As soil horizons are typically absent or very weakly expressed, this series is included with the Regosol group (Aeric or Humaqueptic Fluvaquent; USDA, 1999).

A stratified random sample of soil profiles in the volcanic region included eight profiles from the Ballynabola series. The distribution of particle size, some chemical properties, and mottle frequency at fixed depths, are shown below. All properties show a wide variation at any given depth. Overall, silt is the dominant size fraction. The mean silt content (48%) is about twice the clay content (25%), which is approximately similar to the ratio in the associated soils derived from till (Kill, Tramore), which form the source area. The amount of fine material (silt plus clay), however, is greater than in the associated soils and tends to decrease with depth. The amount of fine sand is generally small, and either clay, silt, or coarse sand may be the dominant fraction at a given depth.

The free iron content of the surface layer (0–10 cm) is low (1.0%) and is about half that of the corresponding layer in the Kill series (1.9%); it is also lower than that of the corresponding layer in the Tramore series. It increases with depth but may decrease in the lowest layer (80–100 cm). High free iron contents in the subsoil are associated with many or abundant mottles. The low free iron content, compared with the soils in the source area, is consistent with saturation with water for long periods and reduction and leaching of iron hydroxides.

Acidity ranges from strong to neutral; carbonates are absent. Acidity tends to decrease with depth; a strongly acid (pH 3.9) layer, which occurs below neutral layers in one profile, is most likely due to acidification by sulphides on exposure to air. Carbon content is high to very high in the surface layer (0–10 cm) and ranges from very low to high at lower depths. Roots are abundant in the surface layer; they are confined to ped faces and fissures in the subsoil and extend to about 85 cm depth.

The soil is poorly drained due mainly to the shallow groundwater. Structure of the subsoil is very weakly developed coarse prismatic, or massive. Hydraulic conductivities of the mineral and peaty phases are moderately rapid and are less than that of the corresponding phases of the Coolfinn series. .The average hydraulic conductivity of the peaty phase is faster than that of the normal mineral phase but the difference is not statistically significant; values for both phases are very variable (Appendix III). The high carbon content of the A horizon and generally high clay and silt contents of the subsoil imply high available water capacity.

Soil suitability: The main limitation of the soil is wetness due principally to shallow groundwater. Assuming moderately rapid hydraulic conductivity and adequate outfalls the soil should respond to field drainage. Wetness will remain a continuing limitation, which will vary depending on the hydraulic conductivity and depth of available outfall. The grazing season will remain short owing to delayed growth in Spring and risk of poaching. Shallow water tables are a limitation for winter cereals, and wetness reduces workdays and delays sowing in spring. The soil is considered moderate or poorly suited to grassland (Class C or D) and poorly suited to tillage (Class IV or V). The peaty phases that are in the lower reaches of some rivers and liable to flooding are very poorly suited to tillage and grassland (Class EV).

Representative profile description

Series:	Ballynabola
Location:	Co. Waterford, Ballyhoo Td., Grid Ref. 25800 10800
Classification:	Regosol (Aeric Fluvaquent)
Parent Material:	Alluvium
Drainage:	Poor
Topography:	Flat plain, micro undulations
Slope:	0.5^{o}
Altitude:	30 m AMSL
Land-use:	Pasture, many rushes (Juncus spp.)

Horizon	Depth (cm)	Description
Ag	0–10	Dark greyish brown (10YR 4/2) to 2 cm depth over greyish brown (10YR 5/2); common fine yellowish red (5YR 4/6) mottles; silty clay; no stones; weak to moderate fine granular structure to 2 cm depth over weak fine subangular blocky; slightly firm consistence; abundant very fine and fine roots; clear wavy boundary.

Cg1	10–20	Grey (10YR 6/1) with common fine yellowish red (5YR 4/6) mottles; silty clay loam; no stones; weak to moderate very coarse prismatic structure; very firm consistence; common very fine and fine pores; many very fine and fine vertical roots; clear wavy boundary.
Cg2	20–30	As next horizon above except many coarse strong brown (7.5YR 4/6) mottles and weak very coarse prismatic structure.
Cg3	30–50	Grey (10YR 6/1) with common to many coarse strong brown (7.5YR 4/6-5/6) mottles and abundant black mangans; silt loam; no stones; weak very coarse prismatic structure; very firm consistence; common very fine and fine pores; common very fine and fine, mainly dead, vertical roots; clear wavy boundary.
Cg4	50–80	Grey (10YR 6/1), and light grey (10YR 7/1) on ped faces; many coarse yellowish brown (10YR 5/6) mottles and black mangans; silt loam; no stones; very weak very coarse prismatic structure; firm consistence; common very fine and fine pores; few very fine and fine, mainly dead, vertical roots; clear wavy boundary.
Cg5	80–100	As next horizon above except clay loam.
Cg6	>100	Sand layer over silt loam.

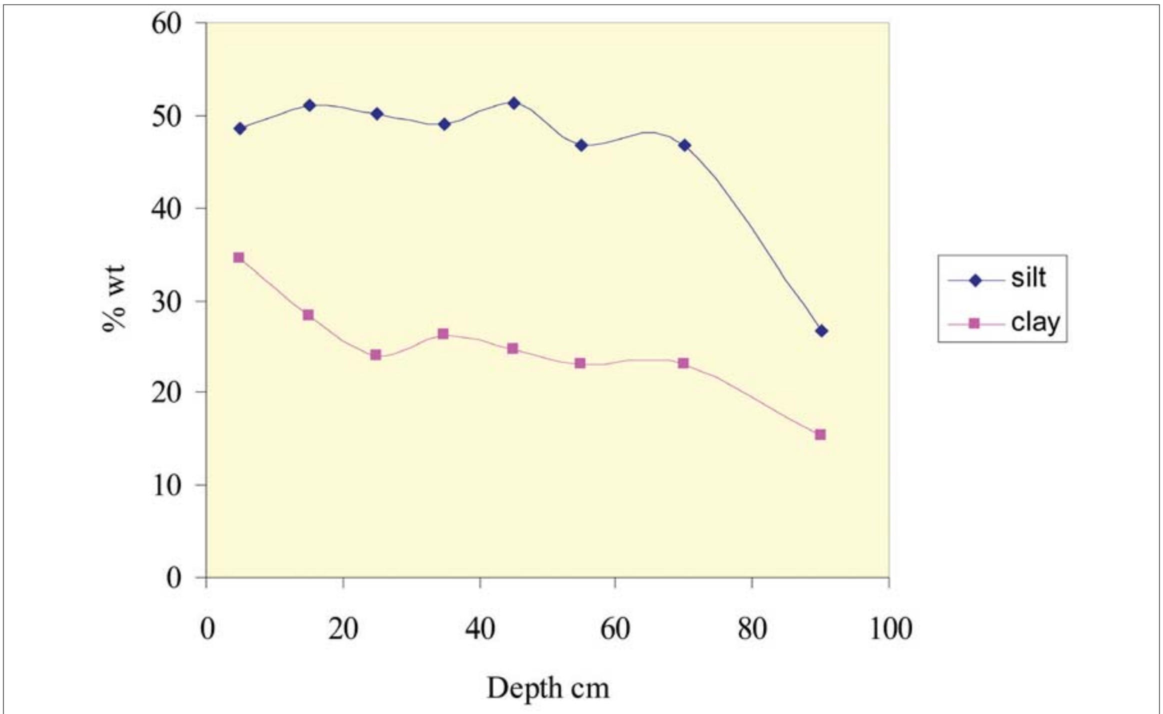


Figure 3.3: Mean clay and silt content by depth, Ballynabola Series.

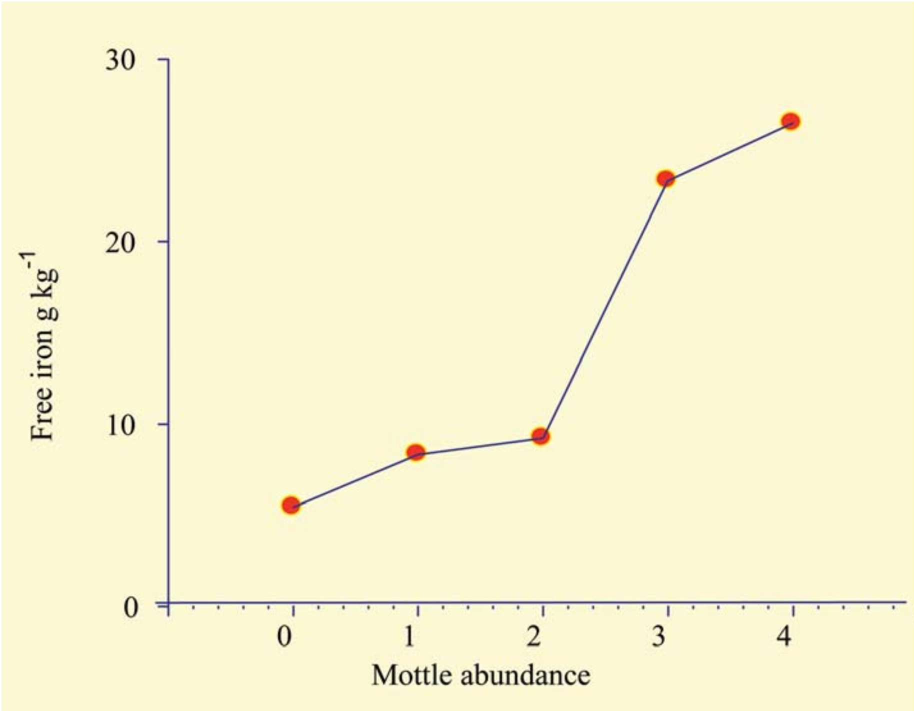


Figure 3.4: Free iron and mottle abundance, Ballynabola Series.

Table 3.17: Descriptive Statistics, Ballynabola Series.

	Mean	Standard Deviation	Minimum	Maximum	Range
Depth cm	5				10
Coarse sand 2000–200 μm %	9.3	7.4	1	17	16
Fine sand 200–50 μm %	7.5	5.2	1	13	12
Silt 50–2 μm %	48.7	9.4	39	62	23
Clay <2 μm %	34.5	12.5	22	56	34
TNV g kg^{-1}	0.0	0.0	0	0	0
CEC cmol kg^{-1}	61.3	27.5	35.8	119.2	83.4
Base Saturation %	31.0	13.0	16	56	40
pH	4.7	0.5	4.1	5.5	1.4
C g kg^{-1}	154	93.6	83	350	267
C/N	13.3	2.7	8.9	16.5	7.6
Free iron g kg^{-1}	10.6	3.6	6	17	11
Depth cm	15				10
Coarse sand 2000–200 μm %	11.9	9.2	2	26	24
Fine sand 200–50 μm %	8.9	3.5	3	13	10
Silt 50–2 μm %	51.0	6.8	41	59	18
Clay <2 μm %	28.3	7.8	22	44	22
TNV g kg^{-1}	0.0	0.0	0	0	0
CEC cmol kg^{-1}	43.7	35.2	18.6	125.6	107
Base Saturation %	23.9	12.1	9	43	34
pH	5.0	0.6	4.3	5.7	1.4
C g kg^{-1}	80.8	98.2	14	310	296
C/N	12.1	4.1	7	16.6	9.6
Free iron g kg^{-1}	11.4	4.1	5	16	11
Depth cm	25				10
Coarse sand 2000–200 μm %	14.3	10.8	4	34	30
Fine sand 200–50 μm %	11.6	3.3	6	16	10
Silt 50–2 μm %	50.3	6.0	39	56	17
Clay <2 μm %	23.9	7.5	11	35	24
TNV g kg^{-1}	0.0	0.0	0	0	0
CEC cmol kg^{-1}	42.7	37.5	12	119.2	107.2
Base Saturation %	23.9	12.9	4	38	34
pH	5.4	0.9	4.4	7.1	2.7
C g kg^{-1}	77.6	113.8	4	340	336
C/N	13.0	5.6	5	22.4	17.4
Free iron g kg^{-1}	13.6	10.7	4	33	29

Table 3.17: Descriptive Statistics, Ballynabola Series (cont'd).

	Mean	Standard Deviation	Minimum	Maximum	Range
Depth cm	35.0				10
Coarse sand 2000–200 μm %	11.9	7.2	2	21	19
Fine sand 200–50 μm %	12.8	6.6	2	19	17
Silt 50–2 μm %	49.1	7.5	35	61	26
Clay <2 μm %	26.3	14.8	14	61	47
TNV g kg^{-1}	0.0	0.0	0	0	0
CEC cmol kg^{-1}	35.1	38.7	4.4	122.4	118
Base Saturation %	29.8	19.3	4	54	50
pH	5.7	1.1	4.6	7.5	2.9
C g kg^{-1}	59.3	99.0	3	292	289
C/N	16.2	4.3	13	23.6	10.6
Free iron g kg^{-1}	13.6	8.2	4	28	24
Depth cm	45.0				10
Coarse sand 2000–200 μm %	12.0	7.7	1	22	21
Fine sand 200–50 μm %	12.0	5.8	1	18	17
Silt 50–2 μm %	51.4	5.7	44	59	15
Clay <2 μm %	24.6	12.9	14	54	40
TNV g kg^{-1}	0.0	0.0	0	0	0
CEC cmol kg^{-1}	21.3	20.4	3.8	64	60.2
Base Saturation %	38.9	25.9	3	70	67
pH	6.0	1.1	4.7	7.5	2.8
C g kg^{-1}	33.5	55.7	2	165	163
C/N	16.2	5.8	12.8	24.9	12.1
Free iron g kg^{-1}	14.8	8.6	6	27	21
Depth cm	55				10
Coarse sand 2000-200 μm %	17.6	12.4	2	37	35
Fine sand 200-50 μm %	12.9	5.3	5	20	15
Silt 50-2 μm %	47.6	8.7	35	60	25
Clay <2 μm %	21.9	10.5	11	44	33
TNV g kg^{-1}	0.0	0.0	0	0	0
CEC cmol kg^{-1}	16.1	13.7	0.4	42.8	42.4
Base Saturation %	44.8	33.5	3	100	97
pH	6.1	1.0	5	7.4	2.4
C g kg^{-1}	16.1	21.2	2	64	62
C/N	15.2	4.3	10.9	19.4	8.5
Free iron g kg^{-1}	17.8	16.4	2	52	50

Table 3.17: Descriptive Statistics, Ballynabola Series (cont'd).

	Mean	Standard Deviation	Minimum	Maximum	Range
Depth cm	70				20
Coarse sand 2000-200 μm %	18.9	16.2	4	53	49
Fine sand 200-50 μm %	11.6	5.0	5	17	12
Silt 50-2 μm %	46.9	13.1	27	63	36
Clay <2 μm %	23.0	5.3	12	30	18
TNV g kg^{-1}	0.0	0.0	0	0	0
CEC cmol kg^{-1}	10.1	5.5	0.2	15.2	15
Base Saturation %	54.6	31.9	3	100	97
pH	6.2	1.0	4.7	7.3	2.6
C g kg^{-1}	5.3	3.2	2	11	9
C/N	11.8	0.6	11.3	12.2	0.9
Free iron g kg^{-1}	17.3	15.7	1	46	45
Depth cm	90				20
Coarse sand 2000-200 μm %	46.0	34.1	8	74	66
Fine sand 200-50 μm %	12.0	6.2	5	17	12
Silt 50-2 μm %	26.7	18.9	12	48	36
Clay <2 μm %	15.3	10.1	9	27	18
TNV g kg^{-1}	0.0	0.0	0	0	0
CEC cmol kg^{-1}	6.8	5.8	0.1	10.4	10.3
Base Saturation %	55.0	39.7	25	100	75
pH	5.0	1.5	3.9	6	2.1
C g kg^{-1}	6.5	3.5	4	9	5
C/N					
Free iron g kg^{-1}	10.7	13.4	1	26	25

Ballyscanlan Series

This series is situated on the Ballyscanlan Hills in the southeast of the county; it covers only 262 ha (0.06% of the county). Topography is rolling to moderately steep and elevation ranges from 76 to 149 m AMSL. Parent material is Rhyolite bedrock, and rock outcrops are common. Vegetation is heath in which furze and heather are dominant, and coniferous plantations composed of pine and spruce.

This soil is related to the Kill series; it is distinguished from the Kill series by the presence of a spodic B horizon. The soil profile is characterised by a yellowish brown undulating B horizon, which extends down to depths varying from 40 to 80 cm; it may overlie bedrock or loamy weathered bedrock. There are many to very abundant stones in the B horizon. The nature of the surface horizons varies from place to place; fibric or sapric organic horizons (O) or dark mineral horizon (A) may be present. These may overlie a pale brown to grey albic horizon (E). The soil is classified as a Podzol (Typic Haplorthod). Texture of the A horizon is loam with relatively high silt content, similar to the Kill series. Texture becomes coarser with depth; the material lying between the stones in the C horizon is loamy sand with a predominant silt fraction. Because of the high stone content or shallow depth to bedrock, most of the series is excessively drained; some deep pockets are well drained. Available water capacity (AWC) was not assessed, owing to the difficulty of obtaining undisturbed samples due to the presence of abundant stones. The organic horizons are likely to have a high AWC; the mineral A horizon is comparable to the A horizon of the Kill series and is likely to have a very high AWC. However, the total available water in the profile is limited by stoniness and shallow depth to bedrock.

Soil suitability: The combination of rockiness, stoniness, shallow depth to bedrock on moderately steep slopes form severe or very severe limitations over most of the Ballyscanlan map unit. This soil is unsuited to cultivation and poorly suited to grassland: it is assigned to suitability Class DV.

Representative profile description

Series:	Ballyscanlan
Location:	Co. Waterford, Ballyscanlan Td., Grid Ref. 254700 102700
Classification:	Podzol (Typic Haplorthod)
Parent Material:	Rhyolite bedrock
Drainage:	Well
Topography:	Hill. Moderately steep upslope
Slope:	10^{o}
Altitude:	90 m AMSL
Land-use:	Norway Spruce plantation with bracken and grass undergrowth.

Horizon	Depth (cm)	Description
Al	0–10	Very dark greyish brown (10YR 3.5/2); loam; few stones; moderate medium granular structure; friable consistence; moderately plastic (wet); abundant diffuse fine and medium roots.
A2	10–20	Very dark greyish brown (10YR 3.5/2); loam; many medium and large stones; moderate to strong medium granular structure; very friable consistence; moderately plastic (wet); abundant fine and medium roots.
Bs1	20–35	Yellowish brown (10YR 5/4) discontinuous pockets which extend to 15% of pedon; similar to next underlying horizon.
Bs2	20–40	Yellowish brown (10YR 5/6 and 5/8); sandy loam; many medium and large stones; moderate fine granular structure; loose consistence; non plastic (wet); abundant diffuse roots.
Bs3	40–60	Similar to next horizon above.

Bs4	60–80	Yellowish brown (10YR 5/6); sandy loam; many medium and large stones; weakly developed fine granular structure; loose consistence; non plastic (wet); abundant fine diffuse roots; gradual wavy boundary.
C	80+	Yellowish brown (10YR 5/4); loamy sand; abundant very small to large stones; loose consistence; non plastic (wet); few roots.

Table 3.18: Particle size and chemical analyses, Ballyscanlan Series.

Horizon	A1	A2	Bs1	Bs2	Bs3	Bs4	C
Depth cm	0–10	10–20	20–35	20–40	40–60	60–80	80+
Particle Size % :							
Coarse sand 200 μm–2 mm	18	26	27	30	34	32	35
Fine sand 50–200 μm	13	11	13	12	14	14	13
Silt 2–50 μm	44	40	35	35	37	42	42
Clay <2 μm	25	23	25	23	15	12	10
TNV g kg^{-1}	0	0	0	0	0	0	0
Ca cmol kg^{-1}	0.5	0.4	0.3	0.1	0.3	0.3	0.3
Mg cmol kg^{-1}	0.21	0.1	0.1	0.1	0.1	0.1	0.1
K cmol kg^{-1}	0.06	0.25	0.09	0.01	0.01	0	0.04
Na cmol kg^{-1}	0.51	0.2	0.11	0.11	0.1	0.09	0.1
TEB cmol kg^{-1}	1.27	0.95	0.6	0.32	0.51	0.49	0.54
CEC cmol kg^{-1}	30.6	23.2	27.4	28.4	22	10.4	14.9
Base Saturation %	4	4	2	2	2	4	4
pH	4.4	4.8	5.1	5	5	5	5.1
C g kg^{-1}	48	32	24	22	14	8	6
N g kg^{-1}	3.1	2.2	1.8	1.9	1		
C/N	15.5	14.5	13.3	11.6	14		
Free iron g kg^{-1}	12	15	25	29	20	14	15

Broomhill Series

This series is in the southeast of the county in the areas around Dunmore East and Passage East. It occupies 2,953 ha (1.61 % of the county). Elevation ranges from 15 to 107 m AMSL. Topography is mostly undulating; a rolling phase occurs around Knockameelish Hill, and steep land on the east side of Waterford Harbour is included in the Broomhill map unit. This series overlies Old Red Sandstone bedrock consisting of the Templetown and Harrylock formations; the latter formation underlies the series in Co. Wexford. These formations consist of quartz conglomerate with subordinate sandstone and mudstone. The parent material is thin till composed predominantly of sandstone, which is derived from the local formations, and a small amount of volcanic material in places. Depth to bedrock may be more than that reported for the Broomhill series in Co. Wexford (Gardiner and Ryan, 1964); it ranges from 0.6 to over 2 m in Co. Waterford.

The reddish hue of the subsoil (B and C horizons) is distinctive. The solum consists of a brown A horizon and a reddish weathered B horizon. This series is classified as a Brown Earth (Dystric Eutrochrept). The representative profile shown below has a high base status, which probably results from applications of sea sand and lime. It is likely that the soil was more acid in the natural state and belonged to the Typic Dystrochrept sub-group; parts of the series still possibly belong to this subgroup. The soil is related to the Clashmore series, which is extensive in west Co. Waterford. These two series are derived from different rock formations, and spodic features are less developed in the Broomhill series, partly because of slightly lower rainfall. The texture of the Broomhill series is generally slightly finer than that of the Clashmore series.

The soil is well drained. Consistence of the A horizon is friable, and structure is moderate under grassland. The coarse blocks in the lower B horizon have abundant pores. Rooting depth is moderate to deep. The available water capacity of the solum is high to very high and the total available water in the profile varies from moderate to very high depending on rooting depth.

Soil suitability: The typical phase of the series is very suited to grassland and a wide range of arable crops. Because of the favourable climate, the potential grass yield is estimated to be very high, similar to the Kill series. Drought is a limitation in the shallower parts in exceptionally dry years. Poaching risk is low due to the free drainage resulting in high potential utilisation efficiency over a long grazing season. Consistence permits cultivation over a relatively long period in spring; the soil is very suited to both winter and spring sown crops. The limitation due to drought is generally slight.

Representative profile description

Series:	Broomhill
Location:	Co. Waterford, Knockanpaddin Td., Grid Ref. 266600 99300
Classification:	Brown Earth (Dystric Eutrochrept)
Parent Material:	Sandstone bedrock
Drainage:	Well
Topography:	Undulating to rolling
Slope:	3º
Altitude:	70 m AMSL
Land-use:	Reseeded pasture

Horizon	Depth (cm)	Description
Al	0–10	Dark brown (7.5YR 4/2); loam; common small stones; clods 5-10 cm diameter breading to weakly developed medium and fine granular structure; friable, slightly firm consistence in places; moderately plastic (wet); abundant very fine diffuse roots.
A2	10–20	Dark brown (7.5YR 4/2); loam; common small and medium stones; clods 5-10 cm diameter breaking to weakly developed medium and fine granular structure; friable consistence, slightly firm in places; moderately plastic (wet); abundant diffuse roots; clear wavy boundary.
A3	20–30	Dark brown (7.5YR 4/2); loam; common, small and medium stones; moderate medium granular structure; friable consistence; moderately plastic (wet); many roots; clear wavy boundary.
Bw1	30–40	Reddish grey (5YR 4.5/2); common, medium and yellowish red (5YR 4/6) mottles; loam; many small and medium stones; weak to moderate very fine blocky structure; friable consistence; moderately plastic (wet); common diffuse roots; abundant very fine pores; clear wavy boundary.
Bw2	40–60	Reddish grey (5YR 4.5/2); common, medium yellowish red (5YR 4/6) mottles, becoming few with depth; loam; many small to large stones; weakly developed subangular coarse blocky breaking to weakly developed fine subangular blocky structure; friable consistence; moderately plastic (wet); abundant very fine pores; few roots, gradual wavy boundary.
C	60–70	Reddish grey (5YR 5/2); coarse sand, very abundant large to small angular stones; single grain structure; loose consistence, non plastic (wet); few roots; irregular sharp boundary to bedrock.

Table 3.19: Particle size and chemical analyses, Broomhill Series.

Horizon	A1	A2	A3	Bw1	Bw2	C
Depth cm	0–10	10–20	20–30	30–40	40–60	60–70
Particle Size % :						
Coarse sand 200–2000 μm	25	30	29	24	26	60
Fine sand 50–200 μm	13	12	12	11	12	8
Silt 2–50 μm	36	34	36	38	36	13
Clay <2 μm	26	24	23	27	26	19
TNV g kg^{-1}	0	0	2	2	10	0
Ca cmol kg^{-1}	16.4	14.3	10.3	8.2	6.6	4
Mg cmol kg^{-1}	1.2	1.1	0.7	0.4	0.3	0.3
K cmol kg^{-1}	1.1	0.47	0.37	0.28	0.15	0.11
Na cmol kg^{-1}	0.45	0.3	0.19	0.17	0.14	0.11
TEB cmol kg^{-1}	19.15	16.17	11.56	9.05	7.19	4.52
CEC cmol kg^{-1}	27.4	30.6	17.2	12.2	10.6	6.4
Base Saturation %	70	53	67	74	68	71
pH	6.9	6.8	7.1	7.2	7.2	6.9
C g kg^{-1}	40	33	20	10	6	3
N g kg^{-1}	3.6	3.3	2	1.1		
C/N	11.1	10	10	9.1		
Free iron g kg^{-1}	22	20	23	30	28	18

Table 3.20: Physical analyses, Broomhill Series.

Horizon	A	A	A	B	B
Sub-horizon	1	2	3	w1	w2
Depth cm	0–10	10–20	20–30	30–40	40–60
Particle density Mg m^{-3}	2.45	2.45	2.51	2.58	2.63
Bulk density at saturation Mg m^{-3}	1.19	1.24	1.41	1.22	1.57
Bulk density at -59 hPa Mg m^{-3}	1.2	1.22	1.4	1.48	1.56
Air capacity % vol.	6.7	8.0	11.2	9.7	7.4
Retained water % vol.:					
0 hPa	54.7	51.1	46.5	45.5	41.4
-2 hPa	48.8	48.7	43.8	36.1	38.4
-59 hPa	48.0	43.1	35.3	35.7	33.9
-137 hPa	47.2	40.8	33.4	33.1	32.1
-1.5 MPa	17.1	16.3	15.2	15.0	13.0
Total available water % vol.	30.9	26.8	20.1	20.7	21.0
Total available water cm	3.1	2.7	2.0	2.1	4.2
Total available water cumulative cm	3.1	5.8	7.8	9.9	14.1

Callaghane Series

This series is small in extent; it covers 624 ha (0.34% of the county). It is distributed in many small parcels, mostly in the eastern part of the county. A small area is situated in the Dungarvan valley, about 5 km west of Dungarvan. About half of the series lies within and on the margin of the Suir valley, where it is associated with the Suir and Coolfinn series, which occupy the lower ground. This is the largest series in the county that is derived from glaciofluvial gravels and sands. The parent material is acid and consists predominantly of sandstone and small amounts of acid volcanic material or shale. In the northern part of the county, in the Suir valley, chert is common and indicates some limestone influence. Except for a small area that rises to 122 m on the flanks of the Monavullagh Mountains, elevation rarely exceeds 30 m AMSL. Topography is undulating and commonly consists of relatively smooth low hummocks. Average annual rainfall generally ranges from slightly less than 1000 mm in the east to about 1150 mm in the westernmost parcel; it is about 1500 mm in the parcel on the flanks of the Monavullagh Mountains.

Acid topsoil distinguishes the Callaghane Series from the Curragh Series, which is also derived from coarse materials. The brown topsoil is generally underlain by yellowish brown subsoil, about 20 cm thick, which has free iron content greater than the adjacent horizons and an index of accumulation that meets the requirement of a spodic horizon. This series is classified as a Brown Podzolic (Entic

Haplorthod; USDA 1999). The spodic B horizon is commonly intermittent. In some pedons where there was some limestone influence, especially in the Carrick-on-Suir–Kilsheelan area, the spodic B horizon is weakly developed or absent. These are Brown Earth inclusions and eventually may be distinguished as a separate series should such soils be extensive in south Co. Tipperary.

The topsoil of a representative profile has a sandy loam texture, friable consistence and strong granular structure. The solum is usually 30 to 40 cm deep and rarely exceeds 50 cm. The underlying parent material is grey coarse sand with single grain structure and loose consistence; layers that consist mostly of gravel and stones are common. Only very few roots extend into the C horizon, where they diminish rapidly with depth, and the rooting depth is taken as being equivalent to the solum depth (≈ 40 cm).

Though adequate, the carbon content of the surface layer of the representative profile is low relative to Irish soils generally. The representative profile overlies limestone bedrock but the reaction of the profile is moderate to slightly acid. Whilst the cation exchange capacity (CEC) is moderate in the topsoil, it is very low in the C horizon, where both carbon and clay contents are very low.

Data on physical properties of the representative profile are available only for the topsoil due to difficulty in obtaining undisturbed supplies in the gravelly subsoil. The air capacity of the topsoil is large (15.5%) and, in conjunction with the coarse gravelly texture of the subsoil, indicates rapid permeability. The available water capacity (AWC) of the topsoil is high, probably due to the strongly developed structure. As the contribution of the subsoil to the available water supply is assumed to be negligible, the total available water in the profile to normal rooting depth of about 40 cm is likely to be low (≈50 mm). Except in the high rainfall area, the soil is estimated to be generally slightly droughty (Thomasson, 1979).

Soil suitability: This soil is suited to grassland and very suited to some arable crops. Due to its widespread distribution, the length of the growing season varies; for example the median length of the grass growing season, based on climatic parameters, is estimated to vary from about 270 days per annum at the northernmost parcel to 300 days in the Dungarvan valley. The principal limitations are liability to drought, and in places, stoniness. Having free drainage and friable consistence, the soil is easily cultivated, except locally where it is stony. By analogy with the Baggotstown series (Conry, 1987), the soil is assigned to suitability Class 1 for tillage. Drought is likely to have a greater effect on crops that mature in late summer. On an analogous soil, winter cereals gave substantially better yields than spring cereals; spring wheat yields are generally uneconomic (Conry, 1987). The soils with stony topsoil belong to Class II, but differentiation of this phase would require detailed mapping. Due to free drainage and rapid permeability, there is little risk of poaching damage, and utilisation efficiency of grassland is potentially high. Drought, however, is likely to reduce the yield of grass in some years; by analogy with the Baggotstown series, the Callaghane series is assigned to suitability Class B (Conry, 1987; Hammond, 2003).

Representative profile description

Series:	Callaghane
Location:	Co. Waterford, Knocknaculla Td., Grid Ref. 220800 95300
Classification:	Brown Podzolic (Entic Haplorthod)
Parent Material:	Glaciofluvial sand, predominantly sandstone
Drainage:	Excessive
Topography:	Hummocky
Slope:	4°
Altitude:	20 m AMSL
Land-use:	Ryegrass-clover pasture

Horizon	Depth (cm)	Description
A1	0–10	Dark brown (7.5YR 3/1); loam; many small round stones; strong medium granular structure; friable consistence; moderately plastic (wet); abundant very fine roots.
A2	10–20	Similar to A1. Clear wavy boundary.
Bs	20–40	Light olive brown (2.5Y 5/6) and yellowish brown (10YR 5/6); loamy sand; extremely abundant large round stones; weakly developed fine granular structure; loose consistence; many very fine roots; gradual irregular boundary.
C	>40	Reddish grey (5YR 5/2); coarse sand; abundant large round stones to 70 cm; very few roots diminishing with depth.

Table 3.21: Particle size and chemical analyses, Callaghane Series.

Horizon	A1	A2	Bs	C
Depth cm	0–10	10–20	20–40	40+
Particle Size % :				
Coarse sand 200–2000 μm	42	45	57	82
Fine sand 50–200 μm	24	23	11	4
Silt 2–50 μm	18	16	20	6
Clay <2 μm	16	16	12	8
TNV g kg^{-1}	0	0	0	0
Ca cmol kg^{-1}	5.5	6.12	3.3	0.9
Mg cmol kg^{-1}	0.8	0.77	0.32	0.16
K cmol kg^{-1}	1.64	0.99	0.07	0.02
Na cmol kg^{-1}	0.06	0.1	0.01	0.01
TEB cmol kg^{-1}	8.0	7.98	3.7	1.09
CEC cmol kg^{-1}	22	21.4	11.2	2.8
Base Saturation %	36	37	33	39
pH	4.6	4.6	6.2	6.3
C g kg^{-1}	29	33	7	1
N g kg^{-1}	2.8	3.4		
C/N	10.4	9.7		
Free iron g kg^{-1}	19	17	24	13

Table 3.22: Physical analyses, Callaghane Series.

Horizon		A	A
Sub-horizon		1	2
Depth cm		0–10	10–20
Particle density Mg m^{-3}		2.47	2.51
Bulk density at saturation Mg m^{-3}		1.21	1.13
Bulk density at -59 hPa Mg m^{-3}		1.21	1.13
Air capacity % vol.		13.79	17.32
Retained water % vol.:			
	0 hPa	54.97	57.24
	-2 hPa	42.5	41.57
	-59 hPa	41.18	39.92
	-137 hPa	39.84	38.53
	-0.1 MPa	32.41	31.3
	-1.5 MPa	15.23	15.9
Total available water % vol.		25.95	24.02
Total available water cm		2.60	2.40
Total available water cumulative cm		2.60	5.00

Clashmore Series

This is one of the most extensive soils in the county and occupies 17,647 ha (9.6% of the county). It is situated mostly in the western part of the county; a small proportion lies on the ridge that forms the south side of the Suir Valley between Kilmeadan and Kilsheelan. This series is the dominant lowland sandstone soil in the county and occurs in association with its poorly drained counterpart the Ballymacart series. It commonly adjoins the Knockboy Series, which occupies the higher parts of the landscape. Elevation ranges from about 15 to 130 m AMSL. Topography is predominantly undulating; some rolling and steep phases lie along the sides of the major valleys. The parent material is dense brittle loamy till composed predominantly of Devonian sandstone. The bedrock underlying the till is mostly mudstone and sandstone of the Ballytrasna Formation; sandstone of the Knockmealdown or Gyleen formations underlies part of the series. Average annual rainfall is generally 1100±50 mm.

Brown topsoil with a reddish hue (7.5 YR) distinguishes the Clashmore series from the Knockboy series, which has dark (umbric) topsoil. The underlying subsoil (B horizon) is generally brown, but yellowish brown or pinkish grey pockets may be present in places. Free iron content of the representative profile shown below decreases with depth, but a small increase occurs in the profile that represents the Mine variant. These horizons do not meet the carbon or CEC criteria diagnostic of spodic horizons. The mean free iron contents of subsoils (40–50 cm depth) in both the Clashmore series and the Mine variant are higher than the contents in the topsoil (0–10 cm depth), which suggests some degree of podzolisation. It is possible that the yellowish brown and pinkish grey pockets represent the remnants of spodic or eluvial horizons that were incorporated in the topsoil during reclamation. Field evidence indicates that weathered B horizons are predominant in the series and that the spodic features are more common and better developed on the rolling and steep phases. The series is classified as a Brown Earth (Typic Dystrudept); it represents the transition between the Brown Earth and Brown Podzolic (Entic Haplorthod) groups, and the map unit contains inclusions of the Brown Podzolic group.

Texture is a light loam throughout the solum; the clay content of the surface layer is on average 18.2% (SD 2.3%) and varies very little with depth. The clay contents of the C horizons of the representative profiles are 19 and 23 per cent. The amount and size of stones tend to increase with depth. Stones in the subsoil are common to many, and large stones are generally confined to the subsoil. An exception is the Newport–Strancally area, where there are medium to large stones within the topsoil. The topsoil has well developed structure and friable consistence. Structural development decreases with depth and is very weak or massive in the C horizon. The bulk density of the solum, which generally extends to 60–90 cm depth, is moderate to high, but the density of the C horizon is very high. Roots are generally absent in the C horizon so that rooting depth in the Clashmore series is typically less than in deep well drained limestone soils derived from limestone till (e.g. Kilmeadan and Elton series).

The average carbon content of the surface layer (0–10 cm) is low, relative to Irish soils generally, and the cation exchange capacity (CEC) is moderate. The solum is slightly acid.

The available water capacities (AWC) of the A horizons of the representative profiles are high to very high; the AWC of the subsoil is moderate. The total available water in the profiles, down to the rooting depth limit at 85–90 cm, is high (151–165 mm). Although the air capacities of the representative profiles are low to moderate, the soils are considered to be well drained as the profiles lack morphological evidence of waterlogging.

Soil suitability: This soil is very suited to grassland and arable crops. Situated near the coast, the potential grazing season is long, and the free drainage permits high utilisation efficiency of grass. Due to the light texture and friable consistence, the soil is easily cultivated, and many days are suitable for cultivation in spring. Stoniness is a slight limitation in places. The series is very suited to both winter and spring cereals; it is also very suited to sugar beet due to the relatively high temperatures. Although the total available water may be limited in places due to moderately shallow rooting depth, drought is not a significant limitation owing to the moderately high rainfall. This series is assigned to suitability class A1.

Representative profile description

Series	Clashmore
Location:	Waterford, Kilmore Td., Grid Ref. 211900 085200
Classification:	Brown Earth (Typic Dystrudept)
Parent Material:	Till, mostly fine purple sandstone, some green greywacke
Drainage:	Well
Topography:	Undulating
Slope:	4º
Altitude:	80 m AMSL
Land-use:	Grass

Horizon	Depth (cm)	Description
A1	0–10	Dark brown (7.5YR 4/2); loam; common small and medium stones; moderately developed medium granular structure; friable consistence; very plastic (wet); abundant very fine roots.
A2	10–20	Dark brown (7.5YR 4/2); loam; common small and medium stones; moderately developed medium granular structure; moderate, friable consistence; very plastic (wet); many very fine roots.
A3	20–32	Dark brown (7.5YR 4/2); loam; common small and medium stones; weakly developed medium granular and fine blocky structure; friable consistence; very plastic (wet); many very fine roots; clear wavy boundary.
E	32–50 (80)	Pinkish grey (7.5YR 5.5/2); loam; many stones, mainly medium and large; weakly developed medium blocky structure; very friable consistence; very plastic (wet); many very fine macropores; common very fine roots; discontinuous clear boundary; horizon extends to about half of pedon.
Bw	50–90 (140)	Yellowish brown (10YR 5/4); loam; many stones, mainly medium and large; weakly developed medium subangular blocky structure; very friable consistence; very plastic (wet); many very fine macropores; few roots, decreasing to very few with depth; clear irregular boundary.
C	> 90 (140)	Brown (10YR 5/3); loam; common large to small stones; very weakly developed coarse subangular blocky structure; very firm consistence; very plastic (wet); very few, very fine macropores; no roots.

Table 3.23: Particle size and chemical analyses, Clashmore Series.

Horizon	A1	A2	A3	E	Bw	C
Depth cm	0–10	10–20	20–32	32–50	50–90(140)	>90(140)
Particle Size % :						
Coarse sand 200–2000 μm	21	22	22	18	23	22
Fine sand 50–200 μm	30	29	28	26	25	22
Silt 2–50 μm	31	31	31	37	35	33
Clay <2 μm	18	18	19	19	17	23
TNV g kg^{-1}	0	0	0	0	0	0
Ca cmol kg^{-1}	8.46	8.03	7.08	3.1	2.08	1.63
Mg cmol kg^{-1}	0.22	0.86	0.82	0.4	0.35	0.29
K cmol kg^{-1}	0.08	0.06	0.05	0.04	0.04	0.03
Na cmol kg^{-1}	0.2	0.07	0.05	0.12	0.08	0.01
TEB cmol kg^{-1}	8.96	9.02	8	3.66	2.55	1.96
CEC cmol kg^{-1}	16	15.2	13.6	8.4	6.2	3.4
Base Saturation %	56	59	59	44	41	58
pH	6.4	6.3	6.2	6	5.9	5.8
C g kg^{-1}	20	19	14	5	4	2
N g kg^{-1}	1.9	1.8	1.3			
C/N	10.5	10.6	10.8			
Free iron g kg^{-1}	19	18	17	17	16	15

Table 3.24: Physical analyses, Clashmore Series.

Horizon	A	A	A	E	E	B	B	C
Sub-horizon	1	2	3	1	2	w1	w2	
Depth cm	0–10	10–20	20–32	32–40	40–50	50–70	70–90	>90
Particle density Mg m^{-3}	2.41	2.49	2.59	2.67	2.67	2.68	2.68	2.73
Bulk density at saturation Mg m^{-3}	1.41	1.43	1.47	1.45	1.52	1.57	1.79	1.77
Bulk density at -59 hPa Mg m^{-3}	1.41	1.43	1.47	1.45	1.52	1.57	1.79	1.77
Air capacity % vol.	4.4	5.8	6.6	7.6	8.3	6.6	5.2	3.5
Retained water % vol.:								
0 hPa	49.7	46.8	46.6	44.1	42.8	39.6	33.6	33.1
-2 hPa	48.8	46.0	45.8	42.9	40.7	37.4	30.8	31.7
-59 hPa	45.3	41.1	40.0	36.5	34.5	33.0	28.5	29.6
-137 hPa	44.3	40.0	37.7	34.7	32.6	31.1	27.4	28.9
-0.1 MPa	38.9	38.4	30.1	32.1	29.2	26.0	24.8	26.8
-1.5 MPa	18.4	17.3	15.9	19.7	20.2	17.1	15.6	14.8
Total available water % vol.	26.9	23.8	24.1	16.9	14.3	15.9	12.8	14.8
Total available water cm	2.7	2.4	2.9	1.3	1.4	3.2	2.6	1.5
Total available water cumulative cm	2.7	5.1	8.0	9.3	10.7	13.9	16.5	18.0

Table 3.25: Descriptive statistics, Clashmore Series.

	Depth cm	Count	Mean	Standard Deviation	Minimum	Maximum	Range
Clay	0–10	25	18.2	2.3	14	23	9
Clay	40–50	25	20.7	4.5	10	31	21
Fine silt	0–10	25	18.5	3.7	11	25	14
Fine silt	40–50	25	19.1	3.3	14	30	16
Coarse silt	0–10	25	16.9	3.3	11	24	13
Coarse silt	40–50	25	16.8	2.4	13	22	9
Very fine sand	0–10	25	14.0	4.4	7	22	15
Very fine sand	40–50	25	10.4	2.9	5	17	12
Fine sand	0–10	25	16.4	4.6	10	25	15
Fine sand	40–50	25	12.8	3.2	7	21	14
Medium sand	0–10	25	8.4	1.3	7	12	5
Medium sand	40–50	25	9.4	2.2	6	17	11
Coarse sand	0–10	25	5.1	1.0	3	7	4
Coarse sand	40–50	25	6.7	2.3	4	14	10
Very coarse sand	0–10	25	2.1	1.1	1	5	4
Very coarse sand	40–50	25	3.8	2.1	1	10	9
TNV g kg^{-1}	0–10	25	3.1	13.6	0	68	68
TNV g kg^{-1}	40–50	25	0	0	0	0	0
Ca cmol kg^{-1}	0–10	25	8.09	3.64	2.84	16.18	13.34
Mg cmol kg^{-1}	0–10	25	0.69	0.31	0.22	1.23	1.01
K cmol kg^{-1}	0–10	25	0.20	0.18	0.01	0.92	0.91
Na cmol kg^{-1}	0–10	25	0.08	0.06	0.01	0.21	0.2
TEB cmol kg^{-1}	0–10	25	9.07	3.74	3.45	17.41	13.96
CEC cmol kg^{-1}	0–10	25	17.9	2.7	13.8	25.6	11.8
Base Sat. %	0–10	25	50	20	18	91	73
pH	0–10	25	5.9	0.7	4.8	7.4	2.6
pH	40–50	25	6.3	0.6	5	7.4	2.4
C g kg^{-1}	0–10	25	25	5	18	36	18
C g kg^{-1}	40–50	25	9	4	4	19	15
N g kg^{-1}	0–10	25	2.7	0.4	2	3.5	1.5
N g kg^{-1}	40–50	15	1.3	0.3	1	2.1	1.1
C/N	0–10	25	9.3	0.8	8	12	4
C/N	40–50	15	8.8	1.8	6.9	13.6	6.7
Free iron g kg^{-1}	0–10	25	17	4.2	12	30	18
Free iron g kg^{-1}	40–50	25	22	6.1	14	40	26

Profile description

Series:	Clashmore Series, Mine variant
Location:	Waterford. Ballinroad Td., Grid Ref. 225700 81900
Classification:	Brown Earth (Typic Dystrochrept)
Parent Material:	Till. Purple and green fine sandstone.
Drainage:	Well
Topography:	Smoothly undulating
Slope:	2^0
Altitude:	90 m AMSL
Land-use:	Pasture, grass-clover

Horizon	Depth (cm)	Description
A1	0–10	Brown (7.5YR 4/2) with few fine reddish brown (5YR 4/2) root mottles; loam; common small stones; weakly developed medium granular structure; friable to firm semi-deformable consistence; very plastic (wet); abundant very fine roots.
A2	10–20	Brown (7.5YR 4/2) with few fine reddish brown (5YR 4/2) root mottles; loam; common small stones; weakly developed medium granular structure; friable to firm semi-deformable consistence; very plastic (wet); abundant very fine roots.
A3	20–30/50	As above except no root mottles; clear wavy boundary.
Bw	30–60/70	Brown (10YR 5/3), and yellowish brown (10YR 5/6) in places at the top of horizon; loam; common medium to large stones; weakly developed medium, parting to fine, subangular blocky structure; friable semi-deformable consistence; very plastic (wet); many fine macropores; common very fine roots; clear wavy boundary.
C1	60–85	Brown (7.5YR 5/2); loam; many small to large stones; very weakly developed coarse blocky structure; very firm, brittle consistence; very plastic (wet); few fine macropores; very few roots.
C2	85–110	As above, except no roots; gradual wavy boundary.
C3	>110	Pinkish grey (7.5YR 5/2) with common coarse distinct strong brown (7.5YR 5/6) mottles; loam; many small to large subangular stones; massive structure; extremely firm brittle consistence; few fine macropores; no roots.

Table 3.26: Particle size and chemical analyses, Clashmore Series, Mine variant.

Horizon	A1	A2	A3	Bw	C1	C2	C3
Depth cm	0–10	10–20	20–30 (50)	30–60 (70)	60–85	85–110	>110
Particle Size % :							
Coarse sand 200–2000 μm	24	28	26	20	26	27	29
Fine sand 50–200 μm	22	21	22	18	18	19	18
Silt 2–50 μm	33	30	31	36	35	36	34
Clay <2 μm	21	21	21	26	21	18	19
TNV g kg^{-1}	0	0	0	0	0	0	0
Ca cmol kg^{-1}	13.9	8.81	6.28	5.98	2.67	2.49	2.6
Mg cmol kg^{-1}	0.83	0.51	0.51	0.57	0.37	0.29	0.3
K cmol kg^{-1}	0.1	0.05	0.04	0.05	0.04	0.04	0
Na cmol kg^{-1}	0.24	0.11	0.1	0.07	0.1	0.13	0
TEB cmol kg^{-1}	15.07	9.48	6.93	6.67	3.18	2.85	2.9
CEC cmol kg^{-1}	20	14.2	13.2	12.8	5	5.4	5
Base Saturation %	75	67	53	52	64	53	59
pH	6.6	6.5	6.5	6.5	5.9	6	6.1
C g kg^{-1}	32	18	10	8	3	2	2
N g kg^{-1}	2.9	2	1.2				
C/N	11	9	8.3				
Free iron g kg^{-1}	15	16	17	20	18	16	16

Table 3.27: Physical analyses, Clashmore Series, Mine variant.

Horizon	A	A	A	B	B	C	C	C	C
Sub-horizon	1	2	3	w	w	1	1	2	2
Depth cm	0–10	10–20	20–30	30–45	45–60	60–70	70–85	85–100	100–110
Particle density Mg m^{-3}	2.38	2.53	2.56	2.54	2.54	2.67	2.67	2.67	2.67
Bulk density at sat. Mg m^{-3}	1.13	1.37	1.45	1.39	1.25	1.84	1.85	1.88	1.87
Bulk density at -59 hPa Mg m^{-3}	1.13	1.37	1.45	1.39	1.25	1.84	1.85	1.88	1.87
Air capacity % vol.	7.2	7.3	11.5	12.3	10.3	5.9	7.5	5.1	6.9
Retained water % vol.:									
0 hPa	54.5	47.4	47.2	49.5	54.8	34.8	35.4	32.6	34.2
-2 hPa	52.3	46.3	44.5	43.9	52.7	32.6	31.3	29.5	30.0
-59 hPa	47.3	40.1	35.7	37.2	44.5	28.9	27.9	27.4	27.3
-137 hPa	45.1	37.3	33.4	35.2	41.1	27.4	26.7	26.5	26.4
-0.1 MPa	41.9	33.0	30.0	31.5	34.5	25.2	25.3	25.2	25.2
-1.5 MPa	20.0	18.6	19.3	20.1	22.4	18.3	16.7	16.6	16.0
Total available water % vol.	27.4	21.5	16.4	17.1	22.1	10.7	11.2	10.9	11.4
Total available water cm	2.7	2.1	1.6	2.6	3.3	1.1	1.7	1.6	1.1
Total available water cumulative cm	2.7	4.9	6.5	9.1	12.4	13.5	15.2	16.8	17.9

Table 3.28: Descriptive statistics, Clashmore Series, Mine variant.

Item	Depth cm	Count	Mean	Standard Deviation	Minimum	Maximum	Range
Clay	0–10	14	18.9	2.7	14	24	10
Clay	40–50	14	21.0	3.7	15	29	14
Fine silt	0–10	14	19.1	3.6	14	25	11
Fine silt	40–50	14	20.5	2.3	17	25	8
Coarse silt	0–10	14	17.0	3.4	11	24	13
Coarse silt	40–50	14	18.6	2.1	16	23	7
Very fine sand	0–10	14	9.2	1.6	7	12	5
Very fine sand	40–50	14	9.9	1.7	7	13	6
Fine sand	0–10	14	12.4	3.9	8	20	12
Fine sand	40–50	14	10.4	2.3	7	15	8
Medium sand	0–10	14	12.1	2.9	9	18	9
Medium sand	40–50	14	9.6	1.4	7	11	4
Coarse sand	0–10	14	8.6	1.9	6	12	6
Coarse sand	40–50	14	7.6	2.0	5	11	6
Very coarse sand	0–10	14	2.6	1.0	1	5	4
Very coarse sand	40–50	14	2.4	1.0	1	4	3
TNV g kg^{-1}	0–10	14	0	0	0	0	0
TNV g kg^{-1}	40–50	14	0	0	0	0	0
Ca cmol kg^{-1}	0–10	14	12.74	4.99	3.70	19.62	15.92
Mg cmol kg^{-1}	0–10	14	1.11	0.52	0.23	2.44	2.21
K cmol kg^{-1}	0–10	14	0.16	0.14	0.03	0.48	0.45
Na cmol kg^{-1}	0–10	14	0.13	0.07	0.03	0.32	0.29
TEB cmol kg^{-1}	0–10	14	14.13	4.87	5.07	21.25	16.18
CEC cmol kg^{-1}	0–10	14	22.4	4.1	17.4	29.8	12.4
Base Sat. %	0-10	13	61	20	24	97	73
pH	0–10	14	6.1	0.7	5	7.5	2.5
pH	40–50	14	6.5	0.9	5.1	7.7	2.6
C g kg^{-1}	0–10	14	32	8	23	51	28
C g kg^{-1}	40–50	14	11	3	7	17	10
N g kg^{-1}	0–10	14	3.31	0.71	2.4	5.2	2.8
N g kg^{-1}	40–50	11	1.31	0.25	1	1.7	0.7
C/N	0–10	14	9.7	1.9	8.1	15.5	7.4
C/N	40–50	11	8.8	2.1	6	13	7
Free iron g kg^{-1}	0–10	14	14.6	5.1	4	20	16
Free iron g kg^{-1}	B[1]	14	24.5	5.1	17	34	17

[1] B horizon

Clohernagh Series

This series covers 3,474 ha (1.89% of the county) in the southeast of the county, mainly between Tramore Bay and Woodstown; a small area extends northwards towards Passage East. It is predominant in the lower parts of the landscape at elevations that range down to near sea level. It occupies about two thirds of the landscape and extends in places over the crests of low ridges up to near 60 m AMSL. It generally lies south east of the volcanic region that stretches from Tramore to Passage East. Topography is undulating with gradients up to 6°. Cambrian mudstone and siltstone (Booley Bay Formation), Ordovician shale, siltstone, and slate (Tramore and Campile formations), and Devonian conglomerate and sandstone (Harrylock and Templetown formations) underlie the series. The parent material is thick till composed predominantly of shale and slate with an admixture of volcanic material, sandstone, and traces of limestone. The series lies in association with the Clonroche and Broomhill series, which are situated at higher elevations. The texture of the parent material is clay loam (33% clay) and is similar to that of the Bannow till, which forms the parent material of the western part of the Rathangan series in Co. Wexford. The Clohernagh series lacks the influence of Irish Sea Till which is dominant in the eastern part of the Rathangan series. Blown sand covers a small area (43 ha; 0.02 % of the county) around Crobally. This is separated as a sandy phase.

A typical profile has a greyish brown or brown loam (A horizon) that is underlain by a mottled, dense to very dense, B horizon of clay loam texture. Grey seams about 10 cm wide occur at about 1 m intervals at the top of the B horizon. They branch, become narrower and closer with depth, and extend down to about 2 m depth. At 1 m depth, in the representative profile, the seams are 1 cm wide at 25 cm intervals. The seams are generally bounded by yellowish brown margins. At the centre of the seam, a fine fissure follows the faces of coarse polyhedrons and prisms. The matrix between the seams is firm to very firm; it is very brittle in places with a high penetration resistance. The large polyhedrons are consistent with the development of fragipan features in an environment that lacks a marked dry season. Roots are mainly vertical and extend down to about 1 m depth. The soil is classified as a Gley. The mapunit comprises Typic Epiaquepts, which have weakly expressed or no fragic properties, and Fragic Epiaquepts.

Clohernagh soils are poorly drained. Hydraulic conductivity (Appendix III) is moderately slow (0.16 m day^{-1}) and reflects the poor structure, high density, and low porosity of the profile below the surface layer. The air capacity at all depths below 10 cm in the representative profile is low or very low (<5%). Although the available water capacity is very high in the surface layer, it is low in the B and C horizons owing to the large amount of water retained at high suction. Nevertheless, the total amount of available water retained in the profile is high. The extent to which the retained water can be exploited by roots is limited by the high resistance to root penetration in part of the profile. It seems that it cannot be assumed that all of the poorly drained Clohernagh series is necessarily less likely to be affected by drought than the deeper phases of the Kill and Clonroche series.

Soil suitability: Poor drainage is the principal limitation, and the soil is only moderately suited to grassland and arable crops. The moderately slow hydraulic conductivity limits the improvement that can be achieved economically by field drainage, and wetness will remain a continuing limitation after drainage. Soil loosening should be beneficial where the subsoil is brittle. Wetness delays grass growth in spring and there is a risk of poaching damage. The grazing season is likely to be about 3 to 4 weeks shorter than on the associated Clonroche and Broomhill series with a corresponding increase in the length of the winter feeding period.

Wetness reduces the number of days suitable for cultivation in spring and can delay sowing. The soil is therefore more suited to autumn or winter cereals than to spring cereals. This series is assigned to suitability Class C111. The sandy phase, owing to better drainage and friable consistence of the surface horizon, is assigned to suitability Class B11.

Representative profile description

Series:	Clohernagh
Location:	Waterford, Leperstown Td., S 660 017
Classification:	Gley (Fragic Epiaquept)
Parent Material:	Till, mostly shale, few sandstone
Drainage:	Poor
Topography:	Gently sloping
Slope:	3°
Altitude:	45 m AMSL
Land-use:	Old pasture

Horizon	Depth (cm)	Description
Al	0–10	Greyish brown (10YR 5/2); loam; few small stones; weakly developed fine granular structure becoming medium with depth; friable consistence, slightly firm in places; moderately plastic (wet); abundant very fine diffuse roots.
A2	10–20	Brown (10YR 5/3) loam; few small stones; weak to moderate medium granular structure; friable consistence; moderately plastic (wet); abundant very fine diffuse roots; clear wavy boundary.
Bg	20–40	Light grey (10YR 7/2) with abundant yellowish brown (10YR 5/8) coarse mottles; clay loam; common small stones; weakly developed coarse and very coarse subangular blocky structure; firm, semi-deformable consistence; moderately plastic (wet); common very fine pores; common vertical very fine roots; clear wavy boundary.
Cgx	40–67	Grey (2.5Y 6/0) with many strong brown (7.5YR 5/6) coarse mottles and common coarse black manganese mottles; grey (2.5Y 6/0) seams with many coarse strong brown (7.5YR 5/6) mottles are at 1 m intervals; clay loam; common small stones; very weakly developed coarse prismatic structure; very firm brittle consistence; moderately plastic (wet); few very fine pores; few very fine vertical roots; gradual wavy boundary.

Cg1	67–100	Grey (2.5Y 6/0) with abundant coarse strong brown (7.5YR 5/6) mottles; grey seams 1 cm wide occur at 25 cm intervals; clay loam; common small and medium stones; massive structure; firm, semi-deformable consistence; very plastic (wet); few very fine pores; very few vertical roots; diffuse boundary.
Cg2	100–150	Brown (10YR 5/3) with common medium grey (2.5Y 6/0) mottles and seams; massive structure; firm consistence; few pores; no roots; many small stones.
Cg3	150–180	Brown (10YR 5/3) with common (5%) medium grey (2.5Y 6/0) mottles, and, at 50 cm intervals, grey (2.5Y 6/0) seams, 1 cm wide with yellowish brown (10YR 5/6) rim 0.5 cm wide; clay loam; many small shaly stones, few large grey sandstone; massive structure; firm consistence; very plastic (wet); few fine pores; no roots.

Table 3.29: Particle size and chemical analyses, Clohernagh Series.

Horizon	A1	A1	Bg	Cgx	Cg1	Cg2	Cg3
Depth cm	0–10	10–20	20–40	40–67	67–100	100–150	150–180
Particle Size % :							
Coarse sand							
200–2000 μm	28	34	21	19	20	19	19
Fine sand 50–200 μm	12	11	11	11	9	10	10
Silt 2–50 μm	34	32	37	40	41	38	38
Clay <2 μm	26	23	31	30	30	33	33
TNV g kg^{-1}	0	10	2	3	5	3	7
Ca cmol kg^{-1}	16.9	14.8	7.5	9.1	9	6.3	6.3
Mg cmol kg^{-1}	0.9	0.3	0.1	0.4	1.6	2.2	2.1
Na cmol kg^{-1}	0.3	0.12	0.12	0.18	0.12	0.12	0.14
K cmol kg^{-1}	0.13	0.06	0.04	0.05	0.06	0.06	0.06
TEB cmol kg^{-1}	18.21	15.28	7.76	9.75	10.88	8.68	8.6
CEC cmol kg^{-1}	27	25.2	15	11.6	11	10.1	9
Base Saturation %	67	61	52	84	99	86	96
pH	6.5	7.3	7.9	7.8	8	8	7.9
C g kg^{-1}	47	24	4	3	2	2	3
N g kg^{-1}	4	2.4					
C/N	12	10					
Free iron g kg^{-1}	22	20	42	24	38	30	37

Table 3.30: Physical analyses, Clohernagh Series.

Horizon	A	A	B	C	C	C	C
Sub-horizon	1	2	g	gx	g1	g2	g3
Depth cm	0–10	10–20	20–40	40–67	67–100	100–150	150–180
Particle density Mg m^{-3}	2.38	2.49	2.63	2.66	2.67	2.68	2.68
Bulk density at saturation Mg m^{-3}	0.79	1.25	1.49	1.76	1.91	1.82	1.75
Bulk density at -59 hPa Mg m^{-3}	0.81	1.25	1.5	1.77	1.82	1.84	1.78
Air capacity % vol.	10.7	4.4	5.4	4.96	5.13	4.35	5.32
Retained water % vol.:							
0 hPa	64.7	52.4	44.9	38.2	36.5	37.0	42.4
-2 hPa	54.8	49.1	41.3	34.9	34.8	33.5	37.9
-59 hPa	53.9	47.9	39.5	33.2	31.3	32.7	37.0
-137 hPa	50.6	45.4	38.5	32.6	30.5	31.9	36.1
-1.5 MPa	12.3	14.3	18.6	19.4	20.0	19.5	19.1
Total available water % vol.	41.6	33.6	20.8	13.7	11.3	13.1	17.9
Total available water cm	4.1	3.3	4.1	3.7	3.7	6.5	5.3
Total available water cumulative cm	4.1	7.5	11.7	15.4	19.1	25.7	31.1

Clonroche Series

This is one of the major soils in the county; it occupies an area of 46,104 ha (10.2% of the county). It is extensive in the northeastern part of the county to the east of the Comeragh Mountains. Relief is characterised by a low plateau (60-120 m AMSL) with deeply incised valleys which follow Caledonian structural trends, such as the Clodiagh River valley. Elevation is about 60 m AMSL at its boundary with the volcanic region to the south and reaches about 180 m AMSL at the boundary with the sandstone formations to the north. The Clonroche series is associated with the Mothel series, which lies at lower elevations, and the Slievecoiltia series, which is generally at higher positions on the landscape.

Clonroche soils overlie both Ordovician (Kilmacthomas Formation) and Silurian (Ballindysert Formation) rocks. The Kilmacthomas Formation consists predominantly of green and purple shales and siltstones and minor volcanic tuffs; the Ballindysert Formation, which forms the northern tract, is characterised by dark grey slates, which are generally massive. No consistent difference was found in Co. Waterford between the soils on Silurian and Ordovician formations.

The typical parent material is medium textured noncalcareous till consisting predominantly of material derived from the local slate and shale. The till mantle is commonly thin, less than 5 m thick (Quinn, 1989), and contains abundant slate and shale fragments. Some profiles are derived from weathered bedrock.

The profile is characterised by a brown (ochric) A horizon and a weathered B horizon that lacks illuvial materials. The soil is classified as a Brown Earth; a representative profile is classified as a Typic Dystrudept (USDA, 1999), but a pH range from 6.2 to 7.5 in subsoil samples implies that Dystric Eutrudepts also occur in the Clonroche map unit. The soils are well drained. Texture is loam to clay loam; the mean clay content found in the topsoil (0–100 mm depth) was 29% and clay content ranged from 23% to 36%. At 400–500 mm depth, mean clay content was slightly less (25%), and the content ranged from 19% to 30%.

The free iron contents in the topsoil (0–100 mm depth) and subsoil (400–500 mm depth) are the highest for any series in the county; the mean contents are 3.0% (topsoil) and 3.1% (subsoil); a value of 5.0% was found in the B horizon of the representative profile shown below. It is likely that the high free iron content, and possibly other sesquioxides, contribute to the friable consistence and durable structure of the soil.

The solum is predominantly 300–600 mm deep. The available water capacity is very high and tends to compensate for the shallow solum. Although the air capacity of the representative profile is low, the soil is classified as well drained because it lacks morphological evidence of water logging and structure is durable and moderately well developed.

Soil suitability: Clonroche soils have a wide use range. They are very suited to tillage. Because of their friable consistence and durable structure, they are easily tilled and are among the best tillage soils in the country. The large available water capacity contributes to a high yield potential. These soils are analogous to the Clonroche soils of north Co. Wexford, where a wide range of crops including cereals, root crops and soft fruits are grown successfully. The potential yield of sugar beet is somewhat less than that obtained in south Co. Wexford because of lower temperatures. The soils are very suited to grass production. Ryan (1974) reported a 4-year mean dry matter yield of 12.3 t ha^{-1} on the Clonroche series in south Co. Wexford with an average application of 310 kg N ha^{-1}. The grazing season is long, and because of free drainage conditions there is no significant limitation to utilisation.

Representative profile description

Series:	Clonroche
Location:	Waterford, Feddans Td., Grid Ref. 237200 116000
Classification:	Brown Earth (Typic Dystrochrept)
Parent Material:	Till composed of shale
Drainage:	Well
Topography:	Gently sloping
Slope:	3°
Altitude:	120 m AMSL
Land-use:	Old pasture

Horizon	Depth (cm)	Description
A1	0–12	Brown (10YR 4/3); clay loam; common small and medium stones; weak and moderate coarse granular structure; friable consistence; moderately plastic (wet); abundant very fine diffuse roots; gradual wavy boundary.
A2	12–27	Brown (10YR 4/3); clay loam; common small and medium stones; weak and moderate coarse granular structure; friable consistence; moderately plastic (wet); many to abundant very fine diffuse roots; clear, wavy boundary.
Bw	27–32	Yellowish brown (10YR 5/5); loam; common small and medium stones; weak and moderate medium granular structure; friable consistence; very plastic (wet); many very fine diffuse roots; clear broken boundary.
C	32–105+	Pale brown (10YR 6/3); loam; many (≈20%) small and medium stones; massive structure; very firm, brittle consistence; moderately plastic (wet); common very fine pores; few roots.

Table 3.31: Particle size and chemical analyses, Clonroche Series.

Horizon	A1	A2	Bw	C
Depth cm	0–12	12–27	27–32	32–105
Particle Size % :				
Coarse sand 200–2000 μm	21	16	19	30
Fine sand 50–200 μm	10	10	10	12
Silt 2–50 μm	37	40	40	36
Clay <2 μm	32	34	31	22
TNV g kg^{-1}	0	0	0	0
Ca cmol kg^{-1}	11.7	11.9	7.5	2
Mg cmol kg^{-1}	0.2	0.11	0.09	0.09
K cmol kg^{-1}	0.18	0.11	0.1	0.09
Na cmol kg^{-1}	0.16	0.07	0.04	0.08
TEB cmol kg^{-1}	12.24	12.19	7.73	2.26
CEC cmol kg^{-1}	26.6	23.8	20.8	7.5
Base Saturation %	46	51	37	30
pH	6.3	6.5	6.7	6.3
C g kg^{-1}	29	25	14	3
N g kg^{-1}	3.2	2.9	1.4	
C/N	9.1	8.6	10	
Free iron g kg^{-1}	34	36	50	24

Table 3.32: Physical analyses, Clonroche Series.

Horizon	A	A	Bw	C
Sub-horizon	1	2		
Depth cm	0-12	12-27	27-32	32-105+
Particle density Mg m^{-3}	2.48	2.53		2.68
Bulk density at saturation Mg m^{-3}	1.17	1.17		1.83
Bulk density at -59 hPa Mg m^{-3}	1.18	1.17		1.83
Air capacity % vol.	6.2	6.0		3.2
Retained water % vol.:				
0 hPa	59.9	58.4		40.2
-2 hPa	54.5	53.2		36.4
-59 hPa	53.7	52.4		37.0
-137 hPa	51.3	49.3		35.3
-1.5 MPa	18.1	16.9		15.2
Total available water % vol.	35.6	35.6	30e	21.8
Total available water cm	4.3	5.3	1.5e	15.9
Total available water cumulative cm	4.3	9.6	11.1e	27.0

e = estimated

Table 3.33: Descriptive statistics, Clonroche Series.

Item	Depth cm	Count	Mean	Standard Deviation	Minimum	Maximum	Range
Clay	0–10	10	28.6	3.5	23	36	13
Clay	40–50	10	25.4	4.2	19	30	11
Fine silt	0–10	10	28.6	3.9	22	35	13
Fine silt	40–50	10	28.8	5.0	20	37	17
Coarse silt	0–10	10	14.6	3.2	9	19	10
Coarse silt	40–50	10	14.2	3.6	10	20	10
Very fine sand	0–10	10	6.0	1.2	4	7	3
Very fine sand	40–50	10	5.1	1.5	3	7	4
Fine sand	0–10	10	6.8	1.2	5	8	3
Fine sand	40–50	10	6.8	1.6	4	9	5
Medium sand	0–10	10	8.3	1.4	7	11	4
Medium sand	40–50	10	9.6	2.6	7	16	9
Coarse sand	0–10	10	5.9	0.9	5	7	2
Coarse sand	40–50	10	7.8	3.2	5	16	11
Very coarse sand	0–10	10	1.2	0.4	1	2	1
Very coarse sand	40–50	10	2.3	1.3	1	5	4
TNV g kg^{-1}	0–10	10	37	100	0	318	318
TNV g kg^{-1}	40–50	10	3	8	0	26	26
Ca cmol kg^{-1}	0–10	10	13.11	5.35	3.84	19.76	15.92
Mg cmol kg^{-1}	0–10	10	0.78	0.54	0.19	1.66	1.47
K cmol kg^{-1}	0–10	10	0.26	0.11	0.13	0.45	0.32
Na cmol kg^{-1}	0–10	10	0.10	0.07	0.03	0.25	0.22
TEB cmol kg^{-1}	0–10	10	14.23	5.15	5.54	20.15	14.61
CEC cmol kg^{-1}	0–10	10	23.4	2.3	19.2	25.6	6.4
Base Sat. %	0–10	10	61	22	23	90	67
pH	0–10	10	6.6	0.7	5.4	7.6	2.2
pH	40–50	10	6.8	0.4	6.2	7.5	1.3
C g kg^{-1}	0–10	10	32.8	5.1	25	39	14
C g kg^{-1}	40–50	10	9.8	4.8	4	19	15
N g kg^{-1}	0–10	10	3.7	0.5	3	4.4	1.4
N g kg^{-1}	40–50	5	1.7	0.3	1.4	2.1	0.7
C/N	0–10	10	8.9	0.7	8	10.3	2.3
C/N	40–50	5	8.0	0.7	7.1	9	1.9
Free iron g kg^{-1}	0–10	10	29.7	5.6	24	44	20
Free iron g kg^{-1}	40–50	10	30.9	6.9	17	38	21

Coolfinn Series

This soil is widespread in the county and occupies 1933 ha (1.06 % of the county). It lies in the flood plains of the major rivers, Suir, Blackwater, Bride, and Brickey. Most of the area included in the map unit is embanked and drained by a system of dykes and sluices. The river valleys are floored by limestone. The parent material is deep alluvium, which consists predominantly of material derived from varying proportions of sandstone and limestone till. Topography is flat; elevation ranges from 30 m AMSL to near sea level and is commonly around 10 m AMSL. Flooding is frequent in winter.

The profile is typically characterised by a dark grey to greyish brown surface horizon that has weak to moderate structure and grey subsoil with massive structure. Texture ranges from silty clay loam to silt loam, and there are no stones. Peaty layers are common; many layers have undecomposed plant remains, which indicate little or no pedogenic alteration; the soil is therefore classified as a Regosol. The distribution of peaty layers in profiles was examined in a grid survey of the areas denoted "*Coolfinn Marshes*" and "*Darrigal Marshes*" (OSI, Sheet 8). About 30% of the profiles lack peaty layers; in the remainder, peaty layers can occur at any depth, including the surface, and the thickness varies. It is not feasible to differentiate mappable areas on the basis of depth and thickness of organic materials. Hence the Coolfinn mapunit comprises Aeric Fluvaquents and Thapto-Histic Fluvaquents; the latter subgroup has one or more buried layers of organic material 20 cm or more thick (USDA, 1999).

In the natural state, the soil was poorly or very poorly drained due to the high groundwater level. Currently the drainage regime is strongly influenced by the artificial drainage system. The hydraulic conductivity is much higher than in soils derived from glacial till and is also more variable (Appendix III). Although the structure is massive, the average hydraulic conductivity of Coolfinn mineral soils is rapid (2.14 m day^{-1}). The sites that have peaty layers have higher values (mean 2.3 m day^{-1}). The available water capacity is very high in all horizons; it is closely related to the carbon content (r^2 = 0.91; Fig. 3.3). The air capacity is low to moderate and bulk density is low. Mineral horizons are generally very plastic when wet.

In the representative profile pH ranges from alkaline to strongly acid. The free iron content is low, especially below 1 m depth; this is consistent with saturation for long periods and reduction and leaching of iron from the profile. Depth to water table varies from about 20 cm in winter to over 1.5 metres in summer. Vertical fissures; 5–10 mm wide, occur at 0.5 metre intervals and extend down to 1.1 metres in the representative profile; these fissures contribute to the high hydraulic conductivity.

Soil suitability: Waterlogging due to the shallow groundwater and winter flooding are the principal limitations. The soil responds to field drainage owing to the high hydraulic conductivity, but the low bulk density and plastic consistence indicates that subsoiling would not be effective. The high clay and silt contents of the representative profile indicate high suitability for mole drainage; it is likely, however, that the soil is generally unsuitable for mole drainage, owing to the unpredictable distribution of peaty layers. Suitability for grassland is moderate (Class C). Wetness delays growth in Spring and combined with plastic consistence and a peaty surface in places causes a high risk of poaching. Hence grazing can commence late in Spring (Mid to late April). Cereals have been grown successfully, but the series is generally poorly suited to tillage crops. Winter flooding limits the suitability for winter cereals. Wetness and poor workability delays sowing date of cereals and root crops in Spring. The soil is assigned to the general Class IV for tillage; individual fields in some years may have a higher ranking – up to Class II.

Representative profile description

Series:	Coolfinn
Location:	Co. Waterford, Coolfinn Td., Grid Ref. 248500 114700
Classification:	Regosol (Aeric Fluvaquent)
Parent Material:	Alluvium >1 m deep
Drainage:	Poor
Topography:	Flat plain, micro undulations
Slope:	0.5°
Altitude:	5 m AMSL
Land–use:	Reseeded pasture

Horizon	Depth (cm)	Description
Al	0–10	Dark grey (10YR 4/1); silty clay loam; no stones; weak/moderate fine blocky structure; slightly firm consistence; very plastic (wet); abundant very fine diffuse roots.
A2	10–20	Greyish brown (10YR 5/2) with common medium reddish brown (5YR 4/3) mottles; silty clay loam; no stones; weak/moderate breaking to fine blocky structure; slightly firm consistence; very plastic (wet); many very fine diffuse roots.
Ag	20–34	Greyish brown (10YR 5/1.5) with common medium reddish brown (5YR 4/3) mottles; silty clay loam; no stones; weak to moderate very coarse prismatic breaking to weakly developed, fine, blocky structure; firm consistence; very plastic (wet); many fine pores; many very fine roots, mainly vertical; abrupt smooth boundary.
Cg1	34–50	Greyish brown (10YR 5/2) with common medium (7.5YR 5/8) mottles; silty clay loam; no stones; massive structure; friable, semi-deformable consistence; very plastic (wet); many very fine vertical roots; clear irregular boundary.
Cg2	50–80	Very dark grey (10YR 3/1) silty clay loam; no stones; massive structure; friable consistence; slightly plastic (wet); many very fine and fine pores; common vertical very fine roots; few very weakly decomposed very coarse plant remains; abrupt wavy boundary.
Cg3	80–100	Dark grey (10YR 4/1); humose silty clay loam; no stones; massive structure; friable, deformable consistence; moderately plastic (wet); common very fine and fine pores; few very fine roots; common, fine to coarse, very weakly decomposed plant remains; clear wavy boundary.

Cg4	100–120	Dark greyish brown (10YR 4/2) and very dark brown (10YR 2/2); humose silty clay; no stones; massive structure; moderately plastic (wet); common very fine pores, many fine to coarse; weakly decomposed, plant remains; abrupt wavy boundary.
Cg5	120–150	Greyish brown (10YR 5/2) humose silty clay loam; no stones; massive structure; moderately fluid consistence; slightly plastic (wet); common fine pores; no roots; many fine to very coarse weakly decomposed plant remains.

Table 3.34: Particle size and chemical analyses, Coolfinn Series.

Horizon	A1	A2	Ag	Cg1	Cg2	Cg3	Cg4	Cg5
Depth cm	0–10	10–20	20–34	34–50	50–80	80–100	100–120	120–150
Particle Size % :								
Coarse sand 200–2000 μm	0	0	0	0	0	0	0	0
Fine sand 50–200 μm	12	11	1	1	1	1	1	1
Silt 2–50 μm	54	54	55	60	61	63	53	64
Clay <2 μm	34	35	44	39	38	36	46	35
TNV g kg^{-1}	55	53	12	7			7	
Ca cmol kg^{-1}	34.2	23.7	25.3	35.2	25.3	21.8	46.8	37
Mg cmol kg^{-1}	1	0.33	0.41	1.2	1.7	2.57	5.48	5.62
K cmol kg^{-1}	0.09	0.12	0.11	0.12	0.13	0.11	0.07	0.15
Na cmol kg^{-1}	0.14	0.13	0.09	0.13	0.12	0.18	0.26	0.45
TEB cmol kg^{-1}	35.33	24.28	25.91	36.65	27.25	24.66	52.61	43.22
CEC cmol kg^{-1}	38	38.8	44.8	54.8	67.5	54.6	100.8	68.8
Base Saturation %	93	63	58	67	40	45	52	63
pH	7.1	7.3	6.9	6.7	5.2	4.5	4.8	5.2
C g kg^{-1}	63	46	53	64	116	110	138	118
N g kg^{-1}	5.7	4.7	4.8	4.8	7.6	7.2	9.6	6.8
C/N	11.1	9.8	11	13.3	15.3	15.3	14.4	17.3
Free iron g kg^{-1}	12	14	15	11	13	17	10	6

Table 3.35: Physical analyses, Coolfinn Series.

Horizon	A	A	A	C	C	C	C	C
Sub-horizon	1	2	3	g1	g2	g3	g4	g5
Depth cm	0–10	10–20	20–34	34–50	50–80	80–100	100–120	120–150+
Particle density Mg m^{-3}	2.31	2.35	2.33	2.28	2	2	1.93	1.99
Bulk density at saturation Mg m^{-3}	1.01	1.08	0.88	0.8	0.48	0.44	0.39	0.37
Bulk density at -59 hPa Mg m^{-3}	1.02	1.08	0.89	0.81	0.48	0.45	0.4	0.3
Air capacity % vol.	4.9	7.3	9.2	9.1	5.1	3.4	4.3	3.0
Retained water % vol.:								
0 hPa	59.2	58.9	66.3	69.1	80.3	82.5	85.0	85.3
-2 hPa	55.3	52.5	58.7	58.8	70.6	73.5	74.7	75.6
-59 hPa	54.3	51.6	57.1	60.1	75.2	79.1	80.7	82.3
-137 hPa	52.8	50.1	55.8	57.1	72.3	76.6	76.5	78.9
-1.5 MPa	22.1	21.1	19.9	17.1	12.6	10.9	10.5	7.9
Total available water % vol.	32.1	30.5	37.2	43.0	62.7	68.2	70.2	74.5
Total available water cm	3.2	3.1	5.2	6.9	18.8	13.6	14.0	22.3
Total available water cumulative cm	3.2	6.3	11.5	18.4	37.1	50.8	64.8	87.2

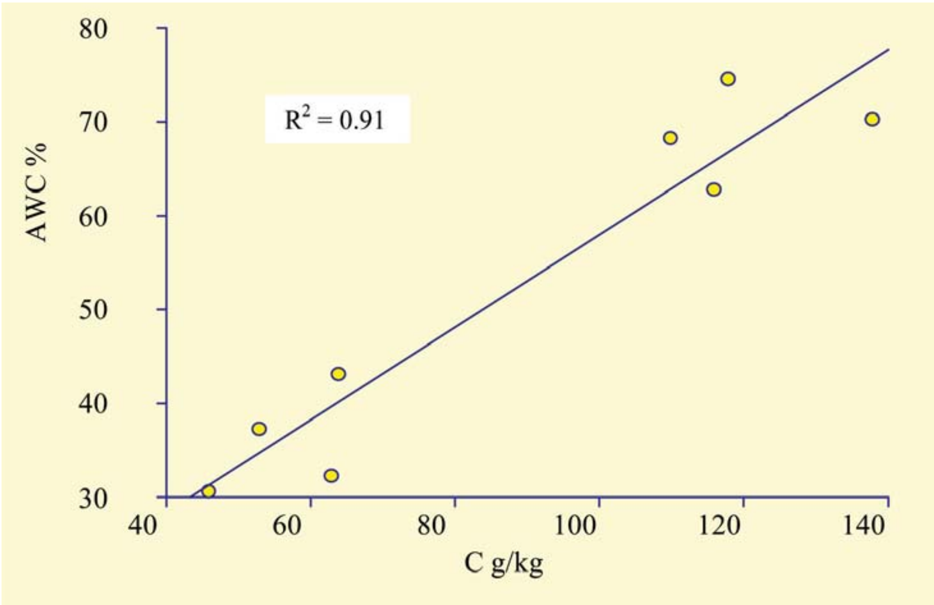


Figure 3.5: Relation between available water capacity (AWC) and carbon (C) content, Coolfinn Series, representative profile.

Curragh Series

This series covers a small area, 120 ha (0.07% of the county), in the southwest of the county. The area mapped is on a low ridge in the Ardmore valley; it is bounded by the Ardmore and Monatray series. Small pockets of similar materials were found also within the Moord and Ballymacart map units, but they were too small to be mapped at the scale employed. Elevation ranges from about 15 to 30 m AMSL; topography is undulating. The parent material consists of bedded sands; some layers have very few subangular stones. The underlying bedrock comprises calcareous mudstone (Waulsortian Limestone) or muddy limestone (Ballysteen Formation). Average annual rainfall is about 1000 mm.

The soil profile is characterised by calcareous coarse textured topsoil. The Curragh series is distinguished from the Callaghane series and Screen series, which are also derived from sands, by the presence of carbonates in the topsoil. The calcareous layer is 40 to 60 cm thick. As the content and depth of carbonates is similar to the Ardmore series, it is likely that the topsoil of the Curragh series was formed by the addition of sea-sand. The series is assigned to the Plaggen Group (Typic Plagganthrept; USDA, 1999).

The topsoil of a representative profile has sandy loam texture, friable consistence, and granular or fine blocky structure. This is underlain by a brown B horizon that has free iron content greater than that of the parent material. However, the index of accumulation of the B horizon, based on cation exchange capacity (CEC) and carbon content, is less than that required for a spodic horizon. The underlying C horizon is a yellowish brown to pale brown loamy sand with single grain structure; thin wavy bands up to one centimetre thick, which occur at 5 to 10 cm intervals, are slightly firm and dense. Fine roots extend into the upper part of the C horizon to 1.2 m depth.

Though adequate, the carbon content of the surface layer of the representative profile is low relative to Irish soils generally. The reaction of the topsoil is neutral to slightly alkaline; the subsoil, including the C horizon, is neutral to 1.2 m depth. Cation exchange capacity (CEC) is moderate in the surface layers (0–18 cm); it is low in the lower part of the topsoil and is very low in the subsoil (B and C horizons).

Bulk density in the surface layer (0–10 cm) is moderate; it increases slightly with depth and is moderately high (1.41–1.56 Mg m^{-3}) in the subsoil, which is lower than that found in the subsoil of soils derived from sandstone till (e.g. Clashmore). The water retained at zero suction (saturation) in the A horizon is much less than the average of A horizons in Co. Waterford. However, the air capacity of the upper part of the A horizon is low, and consequently the available water capacity is high. Conversely, the air capacity of the lower part of the A horizon is high, and the AWC is less than the average found in A horizons in the county. The water retained at saturation in the subsoil (B and C horizons) is only slightly less than average, and the AWC is moderately high. The total available water in the profile to 1 m depth is moderately high. Under the prevailing climate, the soil is estimated to be slightly droughty (Thomasson, 1979). The texture, structure, density, and air capacity imply that the overall permeability of the profile is rapid; nevertheless, it is possible that the numerous slightly firm and dense bands could impede the downward flow of water in the C horizon.

Soil suitability: Like the neighbouring Ardmore and Monatray series, the Curragh series has a potentially long growing season. Having free drainage and friable or very friable consistence, it is very suited to a wide range of crops including out-of-season vegetable production. The principal limitations are slight droughtiness, and nutrient deficiency (e.g. manganese) induced by the neutral reaction. As the nutrient deficiency can be remedied by fertilisation, it is not a significant continuing limitation. This soil is assigned to Class I for tillage as the suitability classification for tillage crops emphasises ease of cultivation. Droughtiness is likely to reduce the yield of grass in some years. As the suitability classification for grassland emphasises yield potential, the soil is assigned to suitability Class B; this is analogous to the classification of the coarse textured Baggotstown series in Co. Offaly (Hammond, 2003).

Representative profile description

Series:	Curragh
Location:	Co. Waterford, Ballynamona Td., Grid Ref. 217000 109000
Classification:	Plaggen (Typic Plagganthrept)
Parent Material:	Calcareous sand over acid sand
Drainage:	Excessive
Topography:	Undulating ridge, crest
Slope:	4º
Altitude:	24 m AMSL
Land-use:	Ryegrass-clover pasture

Horizon	Depth (cm)	Description
A1	0–10	Very dark greyish brown (10YR 3/2); sandy loam; few small rounded stones; moderately developed medium granular structure; friable consistence; non-plastic (wet); abundant very fine roots.
A2	10–19	Similar to A1.
A3	19–35	Yellowish brown (10YR 5/4) and very dark greyish brown (10YR 3/2); loamy sand; common small to medium stones; weakly developed fine subangular blocky structure; friable slightly brittle consistence; non-plastic (wet); common medium macropores coated with A1 material; many very fine roots.
A4	35–50	Similar to A3, clear smooth boundary.
Bw	50–70	Brown (7.5YR 5/4); sand (coarse); no stones; single grain; very friable, slightly brittle consistence; slightly plastic (wet); abundant very fine pores and common coarse macropores coated with A horizon material; few roots; clear wavy boundary.
C1	70–120	Light yellowish brown (10YR 6/4); fine sand; no stones; single grain; very friable, slightly brittle consistence; moderately plastic (wet); abundant very fine macropores and few coarse macropores coated with A horizon material; very few, very fine roots; dark brown (7.5YR 4/4) bands, wavy, sandy, 5 mm thick occur at 2 cm intervals; gradual wavy boundary.
C2	120–150+	Pale brown (10YR 6/3) fine sand (silty); occasional subangular stones; single grain; very friable, slightly brittle consistence; abundant very fine macropores; no roots; dark brown (7.5YR 4/4) bands, wavy, sandy and silty, 1 cm thick, occur at 5 to 10 cm intervals.

Table 3.36: Particle size and chemical analyses, Curragh Series.

Horizon	A1	A2	A3	A4	Bw	C1	C2
Depth cm	0–10	10–19	19–30	35–50	50–70	70–120	120-150+
Particle Size % :							
Coarse sand 200–2000 μm	29	30	29	25	37	10	3
Fine sand 50–200 μm	40	39	39	38	42	76	55
Silt 2–50 μm	19	17	19	24	12	9	35
Clay <2 μm	12	14	13	13	9	5	7
TNV g kg^{-1}	69	79	115	50			
Ca cmol kg^{-1}	14.3	11.2	7.5	6.81	3.96	1.64	2.32
Mg cmol kg^{-1}	0.41	0.35	0.26	0.24	0.05	0.02	0.01
K cmol kg^{-1}	0.32	0.30	0.29	0.26	0.07	0.02	0.05
Na cmol kg^{-1}	0.10	0.08	0.04	0.02	0.01	0.01	0.01
TEB cmol kg^{-1}	15.13	11.93	8.09	7.33	4.09	1.72	2.39
CEC cmol kg^{-1}	17.2	13.8	9.0	8.4	4.6	0.8	2.0
Base Saturation %	88	86	90	87	89	Sat	Sat
pH	7.5	7.7	7.3	7.4	7.1	7	7.2
C g kg^{-1}	24	17	8	6	3	1	2
N g kg^{-1}	2.8	1.9					
C/N	8.6	8.9					
Free iron g kg^{-1}	10	11	10	14	15	11	13

Table 3.37: Curragh Series, Physical analyses.

Horizon	A	A	A	A	B	C	C
Sub-horizon	1	2	3	4	w	1	2
Depth cm	0–10	10–19	19–30	35–50	50–70	70–95	95–120
Particle density Mg m^{-3}	2.51	2.54	2.65	2.65	2.67	2.68	2.68
Bulk density at saturation Mg m^{-3}	1.31	1.33	1.44	1.41	1.4	1.46	1.56
Bulk density at -59 hPa Mg m^{-3}	1.31	1.33	1.44	1.41	1.4	1.46	1.56
Air capacity % vol.	4.2	6.6	13.8	12.9	7.7	10.9	7.8
Retained water % vol.:							
0 hPa	43.1	41.9	37.7	38.8	38.0	39.1	39.3
-2 hPa	42.0	39.1	27.2	29.1	33.0	31.4	34.1
-59 hPa	38.9	35.4	23.9	25.9	30.3	28.2	31.4
-137 hPa	37.8	34.0	22.1	23.9	28.6	26.6	29.1
-0.1 MPa	28.3	25.0	17.8	14.5	17.5	18.5	20.2
-1.5 MPa	15.8	11.9	7.7	11.2	9.5	9.7	9.1
Total available water % vol.	23.1	23.4	16.2	14.7	20.8	18.5	22.4
Total available water cm	2.3	1.9	1.9	2.2	4.2	4.6	5.6
Total available water cumulative cm	2.3	4.2	6.1	8.3	12.5	17.1	22.7

Dodard Series

This series covers 3586 ha (1.95% of the county). It is situated mostly in the northwestern part of the county, where it lies in depressions on the South Ireland Peneplane (Farrington, 1953) and along the foot slopes of the Knockmealdown, Comeragh and Monavullagh mountains. It mostly lies around small streams and extends about 50 m above the stream “rises”; it receives runoff from the surrounding higher ground. In the northwestern region, elevation of the Dodard Series ranges from 150 to 300 m AMSL. A small proportion of the series is situated in the Drum Hills region, north of Slievegrine Hill; here the elevation ranges from 140 to 245 m AMSL.

This series is mostly associated with a reclaimed variant, the Newport series, and with its more freely drained counterpart, the Ballycondon series, which is generally at higher elevations. It also adjoins the Glenary, Knockmealdown, Monavullagh or Knockalisheen series, all of which are generally at higher elevations. Like the Newport map unit, the Dodard map unit contains small pockets of shallow (<1 m) peat suggesting that the area was originally covered by blanket peat. Most of the series is covered by wet heath vegetation dominated by Molinia/Calluna/Erica spp.; part of the series is under coniferous plantations. Strips of bare ground are common; these are mainly due to removal of the surface layer as sod peat for domestic fuel and subsequent erosion. Topography is predominantly undulating. The parent material is loamy till composed predominantly of Devonian sandstone. In the northwestern region the bedrock underlying the till is medium grained sandstone and mudstone of the Knockmealdown and Ballytrasna formations; in the southwestern region (Drum Hills) the underlying bedrock is sandstone, mudstone and siltstone of the Gyleen Formation. Average annual rainfall is about 1250 mm over most of the area; it ranges from 1100 mm to 1500 mm over the entire series.

The surface horizon of the representative profile consists of highly decomposed peat, 10 cm thick. In places this is covered by a thin layer of sand deposited by surface water. In the northwestern region, the peat layer is commonly 10 to 30 cm thick and ranges up to 80 cm; it tends to be thinner in the southwestern region (Drum Hills), where it is generally less than 20 cm thick. A very pale brown to pinkish grey albic (E) horizon extends from immediately below the peaty horizon to 70 cm depth; brownish yellow mottles are found in the lower part of the horizon. This is underlain by a weak-red, weathered B horizon with common coarse strong brown mottles; the mottles decrease with depth and the underlying C horizon, below 110 cm, has few strong brown mottles. Distinct vertical black organic coatings are common in the E horizon along root channels and fissures; these coatings may extend below the E horizon down to 130 cm depth in places and are consistent with the Dodard series having been originally covered by deep peat. The soil is classified as a Peaty Gley. In the USDA (1999) system, the series belongs to the Typic Humaquept subgroup where the organic layer is more than 20 cm thick and to the Humic Epiaquept subgroup where the organic layer is thin or absent. The wetness of the soil is evidently due to episaturation, but the USDA system lacks a subgroup of the Humaquepts differentiated on the basis of episaturation.

Texture of the representative profile is sandy loam in the solum (E and B horizons) over a light loam parent material (C horizon) with a large increase in clay content. Grid samples are not available for the Dodard series. Field evidence indicates that the range in texture is similar to the Newport series i.e. texture ranges from sandy loam to light loam and varies irregularly with depth. Structure of all mineral horizons is massive. Consistence tends to become weaker with depth but porosity increases; the E horizon has extremely firm consistence and no visible pores, whilst the B and C horizons have firm consistence and very few pores. Rooting is poorly developed in the mineral horizons; in the representative profile there are very few roots below 70 cm depth and none below 110 cm.

The free iron content of the E horizon (10–70 cm) of the representative profile is very low (1–2.9 kg^{-1}); it increases in the B and C horizons where the soil material has high chroma. As in the reclaimed Newport series, this pattern is consistent with reduction and removal of poorly ordered and crystalline hydrous oxides under the anaerobic conditions associated with a perched water table (episaturation); it is possible that the peaty surface layer contributed to the removal of iron. Carbon contents of the mineral part of the solum (E and B horizons) are very low and combined with the low clay contents results in a very low cation exchange capacity (CEC). The CEC of the O horizon is very high; hence, the nutrient retention capacity of the profile depends almost entirely on the depth of the O horizon, which varies considerably throughout the series. Reaction is strongly acid throughout the solum of the representative profile; base saturation is extremely low indicating intense leaching.

The O and E horizons of the representative profile have high available water capacity (AWC); these horizons extend to 70 cm depth and the underlying horizons have moderately low AWC. The total amount of available water in the profile down to 70 cm depth is high (157 mm); it will be higher in profiles that have a deeper peat layer at the surface, and under the moderately high rainfall the soil is non droughty. All the mineral horizons are very dense (>1.80 Mg m^{-3}) and have very low air capacity (< 3% vol). These features indicate very slow hydraulic conductivity in the solum, which would contribute to forming the zone of episaturation indicated by the pattern of redoximorphic features.

Soil suitability: The principal limitations are low nutrient status, low bearing strength, wetness, and relatively short growing season due partly to elevation. The combined effect of these limitations is severe and is very similar to that of the Slieve Bloom Series, which Conry (1987) considered to have a limited use range. In its current condition the soil is limited to extensive grazing (Class EV); due to its very low nutrient status it is poorly suited to forestry. Large areas have been reclaimed using traditional methods to form the Newport series. Mechanised reclamation has been carried out in the 1970's. Ripping or deep ploughing improves the permeability of the dense brittle subsoil, but as the effects rarely extend to the bottom of the impermeable layer poor drainage remains a continuing limitation. Provided trace element deficiencies, possibly including copper, cobalt, selenium and sulphur, are identified and alleviated, the soil over time develops into a soil with suitability for agriculture similar to the Newport series; thus, the potential suitability Class is DV.

Representative profile description

Series:	Dodard
Location:	Co. Waterford, Dyrick Lower Td., Grid Ref. 207400 104100
Classification:	Peaty Gley (Humic Epiaquept)
Parent Material:	Sandstone till
Drainage:	Poor
Topography:	Undulating, smooth
Slope:	2°
Altitude:	200 m AMSL
Land-use:	Heathland. Molinia–Calluna >Erica >>Juncus squarrosus. Traces of Potentilla sp.

Horizon	Depth (cm)	Description
O	0–10	Black (N/O); highly decomposed; rubbed fibre content less than 10%; exudate black; abundant fine roots, mainly sedge, some heather; abrupt wavy boundary.
E1	10–40	Very pale brown (10YR 7/3) with common vertical black organic coatings along root channels and fissures; sandy loam; common small stones; massive structure; extremely firm consistence; slightly plastic (wet); no macropores; common vertical, fine dead roots; gradual wavy boundary.
E2	40–70	Pinkish grey (7.5YR 6/2) with coarse brownish yellow (10YR 6/6) mottles; sandy loam; massive structure; common small and medium stones; extremely firm consistence; slightly plastic (wet); no macropores; common vertical dead roots; gradual wavy boundary.
Bg	70–110	Weak red (2.5YR 5/2) with common coarse strong brown (7.5YR 5/8) mottles; sandy loam to loam; many small to large stones; massive structure; moderately firm semi-deformable consistence; moderately plastic (wet); very few, very fine macropores; very few, very fine roots; irregular diffuse boundary.
Cg	110+	As above except few medium strong brown mottles; no roots; no organic coatings.

Table 3.38: Particle size and chemical analyses, Dodard Series.

Horizon	O	E1	E2	Bg	Cg
Depth cm	0–10	10–40	40–70	70–110	110+
Particle Size % :					
Coarse sand 200–2000 μm		19	18	23	17
Fine sand 50–200 μm		36	36	31	35
Silt 2–50 μm		34	37	33	28
Clay <2 μm		11	9	13	20
T.N.V g kg^{-1}	0	0	0	0	0
Ca cmol kg^{-1}	1.20	0.01	0.01	0.01	0.02
Mg cmol kg^{-1}	1.68	0.07	0.06	0.08	0.13
K cmol kg^{-1}	0.2	0	0	0.04	0.06
Na cmol kg^{-1}	0.32	0.01	0.06	0.06	0.09
TEB cmol kg^{-1}	3.4	0.14	0.13	0.19	0.3
CEC cmol kg^{-1}	97.6	6.4	4.4	5.4	4.2
Base Saturation %	3	2	3	4	7
pH	3.8	4.5	4.4	4.5	2.5
C g kg^{-1}	280	5	3	2	2
N g kg^{-1}	8.2				
C/N	34				
Free iron g kg^{-1}	8	1	2	7	7
Loss on ignition g kg^{-1}	540				

Table 3.39: Physical analyses, Dodard Series.

Horizon	O	E	E	E	E	B	B
Sub-horizon		1	1	2	2	g	g
Depth cm	0–10	10–25	25–40	40–55	55–70	70–90	90–110
Particle density Mg m^{-3}	1.86	2.67	2.67	2.68	2.68	2.71	2.71
Bulk density at saturation Mg m^{-3}	0.44	1.8	1.81	1.88	1.89	1.87	1.93
Bulk density at -59 hPa Mg m^{-3}	0.44	1.8	1.81	1.88	1.89	1.87	1.93
Air capacity % vol.	19.7	1.7	1.4	1.9	2.1	2.0	2.3
Retained water % vol.:							
0 hPa	70.6	31.1	30.5	31.5	31.1	33.1	30.8
-2 hPa	51.3	30.6	29.9	30.3	29.9	32.2	29.6
-59 hPa	50.9	29.4	29.1	29.6	29.1	31.1	28.6
-137 hPa	N/A	28.6	28.3	29.3	28.7	30.6	28.0
-0.1 MPa	37.7	24.6	26.7	26.9	25.6	29.1	26.6
-1.5 MPa	28.5	6.5	7.2	7.6	6.9	19.5	20.2
Total available water % vol.	22.5	22.9	21.9	21.9	22.2	11.6	8.4
Total available water cm	2.2	3.4	3.3	3.3	3.3	2.3	1.7
Total available water cumulative cm	2.2	5.7	9.0	12.3	15.6	17.9	19.6

Drumslig Series

This series is not extensive; it occupies 337 ha (0.18% of the county). It is situated in the southwest of the county, near the crest of the Drum Hills. It lies in the upper reaches of the Lickey catchment, where it is associated with the Lickey and Ahaun series. Elevation ranges from 150 to 215 m AMSL, and the topography is undulating. A relatively thin layer of weathered red and green sandstone and mudstone of the Gyleen and Ballytrasna formations underlies the soil profile. Average annual rainfall ranges from 1125 to 1250 mm.

A typical profile has very dark (umbric) topsoil and a yellowish brown spodic horizon. Discontinuous grey eluvial horizons underlain by an ironpan (Placic horizon) are common. The soil is classified as an Ironpan Podzol (Placorthod; USDA, 1999). It lacks the redoximorphic features that are above the ironpan in the adjoining Ahaun series. The Knockboy series is found at similar elevations over sandstone drift, but the Drumslig series, although small in extent, is differentiated because it has an unusual combination of characteristics.

Field estimates of the texture of the B horizon range from loam to clay loam; this is finer than the texture normally found in spodic horizons formed in material derived from sandstone in the county. Description and analyses of a representative profile reveals the following features:

- consistence of the spodic horizon is very plastic when wet
- an exceptionally large amount of water is retained at high suction (1500 hPa) in the spodic horizon resulting in very low available water content
- structure of the lower topsoil is strongly developed
- the liquid limit of the surface layer (0–10 cm) is very high.

The high liquid limit may be due in part to the high carbon content, but the other features outlined above suggest that the Drumslig series may differ in its origin from the Knockboy and Ahaun series. The fine texture may be due to a fine layer in the sandstone bedrock, or it may be the remains of Irish Sea Till that was reworked and redeposited near the crest of the Drum Hills. However, the particle density is greater than that found in Irish Sea Till. An alternative possibility is that the podzolic features developed in an argillic pelosol that was formed during the last interglacial stage.

The Drumslig series is well drained. Texture of the A horizon ranges from loam to sandy loam whilst the texture of the B horizon ranges from loam to clay loam. The clay content of the topsoil (A horizon) of the representative profile is low, and the content in the subsoil is much higher. The topsoil has high carbon content, and the free iron content of the B horizon is large compared to the eluvial horizon (E) that lies directly above. Cation exchange capacity is high to very high in the topsoil; this reflects the high carbon content. CEC decreases with depth in line with carbon content except for the upper part of the spodic horizon, where compared to the next horizon above CEC increases although the carbon content decreases.

Bulk density of the topsoil is low relative to mineral topsoils, probably due to the high carbon content and strongly developed structure. The subsoil (E and B horizons) has high bulk density and low air capacity, which implies moderately slow permeability. The air capacity of the topsoil is moderate. The available water capacity of the topsoil is high, whilst it is very low to low in the subsoil. Although the total available water in the profile is low, the risk of drought is slight or negligible due to the moderately high rainfall.

Soil suitability: As it is well drained and has friable topsoil, the Drumslig series is easily cultivated. The principal limitations for arable crops and grassland are climatic due to the moderately high elevation. Reduced temperatures shorten the growing season. Although easily cultivated, the Drumslig series is only moderately suited to spring cereals or sugar beet, and the optimal arable crops are winter cereals. The high liquid limit, which exceeds the field capacity, suggests that the susceptibility to poaching normally associated with high carbon contents may not occur in the Drumslig series. The soil is estimated to be suited to grassland (Class B) and moderately suited to arable crops (Class III).

Representative profile description

Series:	Drumslig
Location:	Co. Waterford, Carrigeen Td., Grid Ref. 221100 86200
Classification:	Brown Podzolic (Placorthod)
Parent Material:	Thin till composed of sandstone and green shale over weathered sandstone (Gyleen Fm)
Drainage:	Well
Topography:	Undulating crest
Slope:	2^0
Altitude:	152 m AMSL
Land-use:	New pasture, mostly ryegrass. Furze about 10 years previously.

Horizon	Depth (cm)	Description
A1	0–10	Very dark grey (7.5YR 3/1); loam; common small and medium stones; moderately developed coarse granular structure; friable consistence; moderately plastic (wet); abundant very fine roots.
A2	10–18	Very dark grey (7.5YR 3/1); loam; common small and medium stones; strong coarse granular structure; friable consistence; moderately plastic (wet); abundant very fine roots; clear wavy boundary.
E	18–25	Pale brown (10YR 6/3) and very dark greyish brown (10YR 3/2); loam; common small and medium stones; weakly developed medium granular structure; moderately firm brittle consistence; moderately plastic (wet); common very fine roots; sharp wavy discontinuous boundary; extends to .75 of pedon.
Bsm	25	Ironpan, wavy, discontinuous, 2 mm thick.
Bs1	25–45	Strong brown (7.5 YR 4/6); and pale brown (10YR 6/3); loam; common small to large stones; weakly developed compound medium and fine subangular blocky structure; friable brittle consistence; very plastic (wet); abundant very fine macropores; common very fine roots; gradual irregular boundary.
Bs2	45–80	Yellowish brown (10 YR 5/4) and pale brown (10YR 6/3); loam; common small to large stones; weakly developed compound medium and fine subangular blocky structure; brown parts have friable semi-deformable consistence, pale parts are moderately firm, brittle; very plastic (wet); abundant very fine macropores; common very fine roots; clear wavy boundary.
C	80–110+	Pale yellow (2.5 Y 7/4); sand; abundant large and very large angular stones; massive structure; moderately firm brittle consistence; slightly plastic (wet); few very fine macropores; no roots.

Table 3.40: Particle size and chemical analyses, Drumslig Series.

Horizon	A1	A2	E	Bs1	Bs2	C
Depth cm	0–10	10–18	18–25	25–45	45–80	80–110
Particle Size % :						
Coarse sand 200–2000 μm	25	25	29	25	20	31
Fine sand 50–200 μm	25	24	22	22	24	43
Silt 2–50 μm	39	46	32	29	33	8
Clay <2 μm	11	5	17	24	23	18
TNV g kg^{-1}	0	0	0	0	0	0
Ca cmol kg^{-1}	18.6	19.2	3	3.2	2.07	0.66
Mg cmol kg^{-1}	1.18	1.06	0.33	0.46	0.39	0.17
K cmol kg^{-1}	0.24	0.1	0.24	0.02	0.08	0.04
Na cmol kg^{-1}	0.14	0.3	0.05	0.01	0.04	0.02
TEB cmol kg^{-1}	20.16	20.66	3.62	3.69	2.58	0.89
CEC cmol kg^{-1}	42.8	37.2	13.6	18.6	8.4	2
Base Saturation %	47	56	27	20	31	45
pH	5.5	5.9	5.3	5.5	5.4	5.3
C g kg^{-1}	90	66	16	12	5	1
N g kg^{-1}	5.4	3.8	0.8	0.6		
C/N	16.7	17.4	20	20		
Free iron g kg^{-1}	11	13	6	31	25	

Table 3.41: Physical analyses, Drumslig Series.

Horizon	A	A	E	B	B	B
Sub-horizon	1	2		S1	S2	S2
Depth cm	0–10	10–18	18–25	25–45	45–60	60–80
Particle density Mg m^{-3}	2.24	2.23	2.6	2.6	2.69	2.69
Bulk density at saturation Mg m^{-3}	0.92	1.1	1.53	1.43	1.6	1.66
Bulk density at -59 hPa Mg m^{-3}	0.92	1.1	1.53	1.43	1.6	1.66
Air capacity % vol.	11.5	9.7	6.5	7.3	5.8	5.6
Retained water % vol.:						
0 hPa	60.9	52.3	34.4	41.1	38.3	37.1
-2 hPa	50.8	43.8	29.1	35.0	33.8	32.2
-59 hPa	49.4	42.6	27.9	33.8	32.6	31.5
-137 hPa	48.7	41.9	27.3	33.1	31.6	30.7
-0.1 MPa	41.1	34.0	21.6	29.5	29.5	28.4
-1.5 MPa	24.9	22.1	16.7	29.9	25.2	23.4
Total available water % vol.	24.4	20.4	11.3	4.0	7.4	8.0
Total available water cm	2.4	1.6	0.8	0.8	1.1	1.6
Total available water cumulative cm	2.4	4.1	4.9	5.7	6.8	8.4

Dungarvan Series

This is one of the most extensive soils in the county; it occupies 12,132 ha (6.6% of the county). It is situated in the west-central part of the county on the floor of the synclinal valleys that stretch from Dungarvan to the western boundary of the county west of Ballyduff, and from Villierstown to the county boundary west of Tallow. It is the dominant soil in these valleys and is associated with the Killadangan series, the poorly drained counterpart, which is generally found at slightly lower elevations. It commonly lies below the Clashmore Series. The Dungarvan map unit contains small inclusions of soils derived from glaciofluvial gravels (Callaghane series). The Dungarvan series generally lies below the 30.48 m (100 ft.) contour; elevation ranges from 6 to 43 m AMSL. Topography is undulating; slopes are commonly gentle (<3°). Average annual rainfall is generally about 1100 mm.

Noncalcareous till composed predominantly of sandstone forms the parent material. The till is commonly dense and brittle. Limestone pebbles and stones were found in a few profiles at less than 2 m depth. It is likely that the till originally contained limestone, which was largely removed by leaching. The reddish hue and coarse texture, however, suggest that sandstone was originally the dominant component. Carboniferous Limestone, mostly unbedded calcareous mudstone and packstone of the Waulsortian Formation, underlies the till. A small part consists of muddy limestone of the Ballysteen Formation. The Waulsortian Limestone contains important aquifers (e.g. Ballynamuck) and is considered to be extensively karstified. Although relief is low and subdued, the proportion of poorly drained soil in the limestone valley is small (14%); it is much less than that found in the shale, volcanic and sandstone areas (21–29%), which implies that the underlying bedrock is very permeable.

The topsoil is typically dark brown with a reddish hue (7.5 YR). The representative profile, situated near Cappoquin, displays a pale bleached (albic) horizon from 50 to 80 cm depth; this horizon is generally not apparent in moist soil or on auger samples. A yellowish brown spodic pocket which extends to 15% of the pedon occurs at 50 to 60 cm depth; such pockets are uncommon. A profile about 5 km west of Dungarvan has diffuse pale pockets (albic materials) up to 5 cm diameter at 50 to 90 cm depth. The B horizon of the representative profile has a slight increase in clay content (4%) compared to the A horizon; distinct patchy clay coats (argillans) are common on pore linings and ped faces. This profile is classified as a Grey Brown Podzolic (Glossic Hapludalf; USDA, 1999). Some profiles apparently lack albic materials, clay coats, or distinct clay increase in the B horizon; these are Brown Earths. The relative proportions of the two groups in the map unit are uncertain, owing to the difficulty of identification in the field; the series is tentatively assigned to the Grey Brown Podzolic group.

Texture is light loam throughout the solum; the clay content of the surface layer is on average 17.6% and varies very little with depth. Generally, there is very slightly more coarse and very coarse sand in the C horizon than in the A & B horizons. Some profiles have a slight increase in clay content in the B horizon. Stones are common (5–10%) in the topsoil; mostly they are small to medium, and large stones are few. Consistence of the topsoil is generally friable; structure is typically medium granular and ranges from weak to moderately well developed. Structural development decreases with depth and ranges from weak to very weak in the B horizon and from very weak to massive in the C horizon. Consistence of the B horizon is variable and ranges from friable to very firm and brittle. Some pedons have polyhedrons with the bleached faces that are characteristic of fragipans. Except for black manganiferous nodules in some C horizons, pedons generally lack evidence of periodic saturation with water below one metre depth. Moderate to high penetration resistance (1 to 1.5 M Pa) is common in the subsoil; the representative profile illustrates high to very high density in B and C horizons. Roots commonly extend to below one metre depth, but below the topsoil, they are sparse and generally less abundant than in deep well drained limestone soils (e.g. Kilmeadan and Elton series).

The average carbon content of the surface layer is low relative to Irish soils generally, and cation exchange capacity (CEC) is moderate. Reaction ranges from moderately acid to neutral throughout the various horizons of the series. Typically, reaction increases from slightly acid in the surface layer to neutral in the C horizon and carbonates are absent; traces of carbonates are sporadic.

The available water capacity (AWC) of the topsoil (0–50 cm) of the representative profile is moderately high (16.7%), but the AWC of the underlying subsoil down to 120 cm depth is very low to low. The total available water in the profile down to 120 cm depth is only moderate (129 mm). As the average annual rainfall ranges from 1054 mm at Glencairn to 1104 mm at Dungarvan and the mean potential water deficit is less than 50 mm, the drought risk is estimated to be slight or negligible. Although the air capacity of the subsoil is low, and very low below one metre depth, the morphology of the profile and farming experience indicate that the soil is well drained.

Soil suitability: This soil is very suited to grassland and arable crops. The grass growing season is long; on the basis of climatic parameters, the median length of the growing season is estimated to be about 300 days per annum. Owing to free drainage and low risk of poaching, utilisation efficiency of grass is high. This soil is very suited to a wide range of arable crops including maize, sugar beet, and horticultural crops. Out of season vegetables are an important enterprise near the coast in the area around Ballynacourty. Owing to the light texture and friable consistence, the soil is easily cultivated, and a large number of days are suitable for cultivation in spring. The typical phase of the series is very suited to both spring and winter cereals. Stoniness is a slight limitation in places and limits especially the suitability of some fields for the mechanised harvesting of potatoes. The series is assigned to the general suitability class AI.

Representative profile description

Series:	Dungarvan
Location:	Waterford, Drumroe Upper Td., Grid Ref. 220800 95300
Classification:	Grey Brown Podzolic (Glossic Hapludalf)
Parent Material:	Till, sandstone
Drainage:	Well
Topography:	Smoothly Undulating
Slope:	1^o
Altitude:	30 m AMSL
Land-use:	Pasture

Horizon	Depth (cm)	Description
A1	0–10	Dark brown (7.5YR 4/3); loam; common small to large subangular stones; weakly developed medium granular structure; moderately weak consistence; moderately plastic (wet); abundant very fine roots.
A2	10–20	Similar to A1.
A3	20–50	Dark brown (7.5YR 4/3); loam; common small to large stones; weakly developed medium granular structure; moderately weak consistence; very plastic (wet); wavy very fine roots; clear wavy boundary.
E/B	50–80	Pinkish grey (7.5YR 5.5/2) and brown (7.5YR 5/2); sandy loam; common small to large subangular stones; weakly developed coarse subangular blocky structure; moderately firm brittle consistence; very plastic (wet); common very fine macropores; few roots, gradual wavy boundary.
Bs	50–60	Yellowish brown (10YR 5/6); loam; common small to large subangular stones; weakly developed coarse subangular blocky structure; weak semi-deformable consistence; many very fine macropores; common very fine roots; clear discontinuous boundary; horizon extends to 15% of pedon.
B t1	80–120	Brown (7.5YR 4.5/4) and at 0.5 m intervals, 2 to 3 cm wide tongues, pinkish grey (7.5YR 6/2) with strong brown (7.5YR 5/8) rims; loam; common small to large stones (subangular); weakly developed fine subangular blocky structure; moderately weak consistence; very plastic (wet); few very fine macropores; common patchy distinct argillans on pore linings and ped faces; very few, very fine roots.
B t2	120-160	Similar to Bt1. Diffuse boundary.
C	160-200+	Brown (7.5YR 4.5/4-4/4); loam; common small to large stones (subangular); weakly developed fine subangular blocky structure; moderately weak consistence; few very fine macropores; few faint patchy argillans on pore linings; no roots.

Table 3.42: Particle size and chemical analyses, Dungarvan Series.

Horizon	A1	A2	A3	Bs	E/B	Bt1	Bt2	C
Depth cm	0–10	10–20	20–50	50–60	50–80	80–120	120–160	160–200+
Particle Size % :								
Coarse sand 200–2000 μm	23	25	22	21	29	28	20	23
Fine sand 50–200 μm	31	31	30	29	29	27	25	30
Silt 2–50 μm	28	26	31	32	23	26	33	28
Clay <2 μm	18	18	17	18	19	19	22	19
TNV g kg^{-1}	0	0	0	0	0	0	0	0
Ca cmol kg^{-1}	7.7	5.4	3.92	2.8	1.2	1.4	1.8	1.4
Mg cmol kg^{-1}	1.04	0.71	0.42	0.33	0.23	0.22	0.2	0.13
K cmol kg^{-1}	0.16	0.06	0.02	0.04	0.03	0.02	0.03	0.02
Na cmol kg^{-1}	0.11	0.05	0.01	0.03	0.01	0.01	0.01	0.06
TEB cmol kg^{-1}	9.01	6.22	4.32	3.2	1.47	1.65	2.09	1.61
CEC cmol kg^{-1}	16.4	13.8	10	8	3	2.8	2.8	2.3
Base Saturation %	55	45	43	40	49	59	75	70
pH	6	5.9	6.3	6.2	6.2	6.1	6.2	6.1
C g kg^{-1}	23	17	7	5	1	1	1	1
N g kg^{-1}	2.2	1.8						
C/N	10.5	9.4						
Free iron g kg^{-1}	18	17	17	23	15	23	26	22

Table 3.43: Physical analyses, Dungarvan Series.

Horizon	A	A	A	A	E/B	E/B	B	B	B
Sub-horizon	1	2	3	3			t1	t1	t2
Depth cm	0–10	10–20	20–35	35–50	50–65	65–80	80–100	100–120	120–160
Particle density Mg m^{-3}	2.5	2.48	2.6	2.6	2.64	2.64	2.61	2.61	2.69
Bulk density at saturation Mg m^{-3}	1.42	1.48	1.44	1.49	1.79	1.73	1.84	1.79	1.82
Bulk density at -59 hPa Mg m^{-3}	1.42	1.48	1.44	1.49	1.79	1.73	1.84	1.79	1.82
Air capacity % vol.	7.2	6.9	12.7	13.0	8.7	7.9	5.7	4.2	3.3
Retained water % vol.:									
0 hPa	45.6	44.0	46.3	47.3	37.4	36.7	32.8	29.7	30.0
-2 hPa	42.9	41.7	40.7	41.3	32.1	32.1	30.6	27.8	28.5
-59 hPa	38.4	37.1	33.6	34.3	28.7	28.8	27.1	25.6	26.7
-137 hPa	37.4	36.2	31.6	31.7	27.7	27.9	26.3	25.0	26.3
-0.1 MPa	31.4	32.4	23.1	25.4	23.9	25.6	24.1	23.4	24.8
-1.5 MPa	17.7	17.1	20.3	19.2	24.1	21.5	20.9	17.8	13.4
Total available water % vol.	20.7	20.1	13.3	15.1	4.6	7.3	6.2	7.8	13.4
Total available water cm	2.1	2.0	2.0	2.3	0.7	1.1	1.2	1.6	5.3
Total available water cumulative cm	2.1	4.1	6.1	8.3	9.0	10.1	11.3	12.9	18.2

Table 3.44: Descriptive statistics, Dungarvan Series.

Item	Depth cm	Count	Mean	Standard Deviation	Minimum	Maximum	Range
Clay	0–10	55	17.6	2.3	12	24	12
Clay	40–50	55	18.5	3.9	11	26	15
Clay	C[1]	5	18.2	4.1	15	25	10
Fine silt	0–10	55	18.6	3.7	12	28	16
Fine silt	40–50	55	18.3	4.7	8	34	26
Fine silt	C	5	19.8	2.6	16	23	7
Coarse silt	0–10	55	18.3	3.2	9	24	15
Coarse silt	40–50	55	18.7	4.0	10	28	18
Coarse silt	C	5	18.6	4.7	14	26	12
Very fine sand	0–10	55	13.1	3.2	6	23	17
Very fine sand	40–50	55	11.8	2.7	6	18	12
Very fine sand	C	5	9.2	1.9	6	11	5
Fine sand	0–10	55	16.3	4.4	9	35	26
Fine sand	40–50	55	14.7	5.1	5	36	31
Fine sand	C	5	12.0	1.2	11	14	3
Medium sand	0–10	55	9.3	1.8	6	15	9
Medium sand	40–50	55	9.6	2.7	1	19	18
Medium sand	C	5	11.2	3.5	8	17	9
Coarse sand	0–10	55	4.6	1.1	2	8	6
Coarse sand	40–50	55	5.1	1.5	1	9	8
Coarse sand	C	5	6.6	2.3	4	10	6
Very coarse sand	0–10	55	2.4	0.8	1	4	3
Very coarse sand	40–50	55	3.3	1.3	1	7	6
Very coarse sand	C	5	4.4	1.7	2	6	4
TNV g kg^{-1}	0–10	55	0	0	0	0	0
TNV g kg^{-1}	40–50	55	0	0	0	0	0
TNV g kg^{-1}	C	5	0	0	0	0	0
Ca cmol kg^{-1}	0–10	55	10.26	4.07	2.08	18.7	16.62
Mg cmol kg^{-1}	0–10	55	0.90	1.54	0.2	11.7	11.5
K cmol kg^{-1}	0–10	55	0.20	0.14	0.05	0.68	0.63
Na cmol kg^{-1}	0–10	55	0.06	0.05	0.01	0.21	0.2
TEB cmol kg^{-1}	0–10	55	11.20	4.25	2.8	19.45	16.65

Table 3.44: Descriptive statistics, Dungarvan Series (cont'd).

Item	Depth cm	Count	Mean	Standard Deviation	Minimum	Maximum	Range
CEC cmol kg^{-1}	0–10	55	18.0	2.7	11.6	24.2	12.6
Base Sat. %	0–10	55	61.5	19.4	13	94	81
pH	0–10	55	6.4	0.6	4.9	7.4	2.5
pH	40–50	55	6.7	0.5	5.3	7.8	2.5
pH	C	5	7.2	0.4	6.9	7.8	0.9
C g kg^{-1}	0–10	55	24	6	14	37	23
C g kg^{-1}	40–50	55	9	4	2	23	21
C g kg^{-1}	C	5	6	2	4	8	4
N g kg^{-1}	0–10	55	2.6	0.6	1.5	4.5	3
N g kg^{-1}	40–50	27	1.5	0.4	0.8	2.7	1.9
C/N	0–10	55	9.2	0.9	7.6	11.6	4
C/N	40–50	27	8.1	1.6	5.7	13	7.3
Free iron g kg^{-1}	0-10	55	16	3	9	23	14
Free iron g kg^{-1}	40-50	55	19	4	10	37	27
Free iron g kg^{-1}	C	5	19	3	17	24	7

[1] C = C horizon

Fen Peat

This mapunit is not extensive; it occupies only 151 ha (0.08% of the county). In the volcanic region, most of the map unit is in a flat basin near the 91 m AMSL contour, in Carrickphillip Td. In this parcel, the peat is generally more than 1 m thick, and the vegetation is predominantly grass and rushes. It is surrounded by poorly drained Tramore series containing an unmapped peaty phase in places. In the limestone region, in the Dungarvan Valley, elevation of the Fen Peat map unit ranges from 10 m AMSL to sea level. A small parcel that lies among the alluvial deposits in the former flood plain of the Brickey River has peat thickness ranging from 30 to 90 cm; a layer of alluvium covers the peat in places. This parcel has been reclaimed and has grassland vegetation, with rushes in places. The largest parcel is in the flat lowland that extends from Cloncoskoran Castle, about two miles northeast of Dungarvan, to Clonea strand. This area drains through a sluice at Clonea strand. The peat layer is commonly more than 1 m thick; in some places it is about 0.5 m thick. Reeds are common, and deciduous woodland is dominant in the westernmost part in Cloncoskoran Td. Part of the area in Garrynageragh East Td has been reclaimed. Most of this parcel is very poorly drained, and the water table is permanently at, or near, the surface.

The Fen Peat group is separated from the Kilbarry series on the basis of peat thickness; the limit is set at 40 cm. Like the Kilbarry series, the peat is probably minerotrophic. Based on field evidence and the description and analyses for the Kilbarry representative profile, the deep (>90 cm) part of the Fen Peat mapunit is classified as a Typic Haplosaprist, and the remainder (<90 cm) comprises Terric and Fluvaquentic subgroups. Separate series were not delineated. The undrained part is broadly similar to the Pollardstown series, whereas the drained and reclaimed part resembles the Banagher Series; these series were mapped in Co. Laois (Conry, 1987) and Co. Offaly (Hammond, 2003).

Soil suitability: The undrained part, which comprises most of the mapunit, is, in its current condition, unsuited to agriculture or silviculture, owing to wetness and low bearing capacity that does not support either grazing animals or machinery. These areas are best suited to wildlife habitat. Where the water table has been lowered, as in the Brickey catchment, the soil supports moderately productive grassland; similar soils in Co. Offaly have been assigned to suitability class CIII. However, the potential of the map unit varies considerably depending on the degree to which the water regime can be altered by drainage.

Finisk

This is a variant of the Suir series, which is given a series name for ease of reference. This soil is widespread, mostly in the western half of the county, and covers 931 ha (0.51% of the county). It generally forms narrow strips along the tributaries (Nier, Finisk) of the major rivers (Suir, Blackwater) and along the small rivers that flow directly to the sea in the south of the county (Colligan, Douglas, Mahon, Tay). The widest expanse (≈1.5 km) of the soil is around the Finisk River. The parent material is thin (<1 m) alluvium which commonly consists of about 0.5 m of silty material overlying rounded gravel or sand in places. Elevation is higher than the flood plains of the major rivers in which the Suir series lies; it is commonly 30 to 60 m AMSL, but ranges down to 9 m AMSL and, exceptionally, up to 185 m AMSL along the Nier River. As in the Suir series, embankments and sluices are absent, and the OSI sheets (6” to 1 mile) do not indicate liability to flooding. The higher elevation compared to the Suir series also indicates a lower risk of flooding. Topography is generally flat, but may be gently sloping parallel to the gradient of the river. The soil occurs mostly in areas that are underlain by sandstone, comprising various formations, or limestone. The gravels are composed predominantly of sandstone. A small area, situated about 1 km southeast of Lemybrien, is in the volcanic region; here the gravels consist of sandstone and volcanic material.

The soil profile is similar to the Suir series except that the gravels are commonly found at shallower depth (>40 cm). It is classified as a Brown Earth (Fluventic Dystrudept). For a profile description, refer to Suir Series.

Soil suitability: This is broadly similar to the Suir series. The principal limitations are flooding and periodic saturation due to shallow groundwater; however, the risks are probably less than those of the Suir series. Cereals and sugar beet have been successfully grown. The soil is suitable for grassland (Class B) and tillage (Class II).

Table 3.45: Descriptive statistics, Finisk Series.

Item	Depth cm	Count	Mean	Standard Deviation	Minimum	Maximum	Range
Clay	0–10	3	20.3	0.6	20	21	1
Clay	40–50	3	18.0	1.7	17	20	3
Clay	C[1]	2	16.5		14	19	5
Fine silt	0–10	3	27.0	3.0	24	30	6
Fine silt	40–50	3	23.3	7.5	16	31	15
Fine silt	C	2	18.5		18	19	1
Coarse silt	0–10	3	22.0	3.6	18	25	7
Coarse silt	40–50	3	20.0	3.6	16	23	7
Coarse silt	C	2	19.5		18	21	3
Very fine sand	0–10	3	9.3	2.1	7	11	4
Very fine sand	40–50	3	9.7	2.5	7	12	5
Very fine sand	C	2	10.5		9	12	3
Fine sand	0–10	3	9.0	2.6	7	12	5
Fine sand	40–50	3	10.7	3.8	8	15	7
Fine sand	C	2	12.0		10	14	4
Medium sand	0–10	3	7.0	2.0	5	9	4
Medium sand	40–50	3	9.7	3.8	7	14	7
Medium sand	C	2	11.5		9	14	5
Coarse sand	0–10	3	3.7	0.6	3	4	1
Coarse sand	40–50	3	5.7	1.2	5	7	2
Coarse sand	C	2	7.0		7	7	0
Very coarse sand	0–10	3	1.7	0.6	1	2	1
Very coarse sand	40–50	3	3.0	0.0	3	3	0
Very coarse sand	C	2	4.5		3	6	3
TNV g kg^{-1}	0–10	3	0	0	0	0	0
TNV g kg^{-1}	40–50	3	0	0	0	0	0
TNV g kg^{-1}	C	2	0	0	0	0	0
Ca cmol kg^{-1}	0–10	3	9.11	1.29	8.32	10.6	2.28
Mg cmol kg^{-1}	0–10	3	0.7	0.13	0.55	0.78	0.23
K cmol kg^{-1}	0–10	3	0.17	0.04	0.13	0.2	0.07
Na cmol kg^{-1}	0–10	3	0.18	0.12	0.09	0.32	0.23
TEB cmol kg^{-1}	0–10	3	10.16	1.49	9.16	11.87	2.71

Table 3.45: Descriptive statistics, Finisk Series (cont'd).

Item	Depth cm	Count	Mean	Standard Deviation	Minimum	Maximum	Range
CEC cmol kg^{-1}	0–10	3	19.8	1.3	18.6	21.2	2.6
Base Saturation %	0–10	3	51.7	9.0	43	61	18
pH	0–10	3	5.9	0.3	5.7	6.2	0.5
pH	40–50	3	6.4	0.4	6.1	6.9	0.8
pH	C	2	6.9		6.6	7.1	0.5
C g kg^{-1}	0–10	3	26	4	23	30	7
C g kg^{-1}	40–50	3	9	2	7	10	3
C g kg^{-1}	C	2	7		5	9	4
N g kg^{-1}	0–10	3	3.0	0.4	2.7	3.4	0.7
N g kg^{-1}	40–50	2	1.5		1.3	1.7	0.4
N g kg^{-1}	C	1	1.3		1.3	1.3	0
C/N	0–10	3	8.7	0.2	8.5	8.8	0.3
C/N	40–50	2	6.4		5.9	6.9	1
C/N	C	1	6.9		6.9	6.9	0
Free iron g kg^{-1}	0–10	3	19.3	2.1	17	21	4
Free iron g kg^{-1}	40–50	3	22.3	1.2	21	23	2
Free iron g kg^{-1}	C	2	19.5		18	21	3

[1] C = C horizon

Glenary

This series comprises 2790 ha (1.52% of the county) in the northwest of the county. It lies mainly on the upper slopes and crest of the east-west trending northernmost ridge of the Comeragh Mountains. Small areas around Crows Hill, which is south of the Knockmealdown Mountains, and on the foot slopes of Crohaun at the southern end of the Monavullagh Mountains are included in the Glenary map unit. It generally lies above the Knockalisheen or Ballycondon series and, in places, the Dodard, Knockboy or Newport series. Elevation is generally above 244 m AMSL and rises to 520 m AMSL on Laghtnafrankee Mountain and to 390 m AMSL on Long Hill. Vegetation is predominantly heath dominated by Calluna/Erica spp. Eriophorum is present on gentler slopes in places; relatively deep peat was probably cut away in these areas. This series lies mostly on rolling to moderately steep slopes and to a lesser extent on undulating plateaus. The parent material is a coarse loamy diamicton (drift) composed predominantly of Devonian Sandstone; at least part of the diamicton is probably of glacial origin. The parent material is distinguished from other sandstone dominated diamictons by concentrations of stones on the surface that form deeper pockets at regular intervals. On a 9° slope, the stone pockets were observed at 2.7 m intervals and were 50 cm deep. Deeper pockets, up to 3 m deep, were also observed elsewhere. The pattern of stones on the surface was not determined owing to the peat cover; the stones probably form a polygonal network on the gentler slopes and stripes on the steeper ground (Kessler and Werner, 2003). The diamicton overlies medium grained sandstone of the Knockmealdown Sandstone Formation in the Comeragh and Crow's Hill areas and mudstone of the Sheskin Formation in the Monavullagh area. Average annual rainfall is about 1250 mm.

The surface peaty horizon is typically 20 cm thick; it ranges from 5 to 30 cm. Micro-terraces are common and indicate irregular sod removal for fuel. Rubbed fibre content of the representative profile indicates moderate to high physical decomposition, whereas sodium pyrophosphate extract colour (SPEC) indicates a high degree of chemical decomposition (sapric material). The peaty layers that were removed were probably less decomposed. The peaty layer is commonly underlain by a layer of stones, up to 40 cm thick, which forms deep pockets at regular intervals, and the underlying horizons reflect the configuration of the stone layer. The next underlying horizon comprises a grey bleached subhorizon underlain by a subhorizon with dark mottles, which in places are dominant and are also found within the stones. The dark subhorizon shows an increase in organic carbon relative to the next subhorizon above and evidently results from accumulations of soluble organic matter by water movement down the profile from the overlying peat, or also, possibly, downslope. Another possibility is that some of the organic matter is the remains of the original Turbel in which organic matter accumulated at the top of the permafrost layer in periglacial conditions. The albic horizon ranges up to 50 cm in thickness and is most commonly underlain by a thin ironpan; some pedons that lack an ironpan have an accumulation of organic matter in the lower part of the albic horizon. A thin (≈5 cm), typically yellowish red, spodic horizon is found in most pedons. The solum ranges in thickness from 40 cm to over 2 m and is generally underlain by a brown to weak red C horizon, which lacks redoximorphic features associated with wetness. The soil is classified as a Podzol and as a Typic Placaquod in the USDA (1999) system. Where the sorted stone concentrations characteristic of periglacial conditions are absent, the soil is generally similar to the Ballycondon or Dodard series. The amounts of these inclusions are thought to be significant, but their exact extent is unknown.

Texture is typically sandy loam throughout the profile; clay content of each horizon below 10 cm depth in the representative profile is 10%. Stone content of the soil matrix, as distinct from the stone layers, ranges from common in the E and B horizons to many in the C horizon, and size ranges from small to large; the stones are randomly oriented. A profile at Moanyarha (profile II), which lacks a spodic horizon, has loam texture throughout the solum, and the soil material that is within a matrix of abundant angular stones in the C horizon has 15% clay. Structure is massive in the mineral profile, including the parent material, except in the thin spodic horizon which has weakly developed blocky structure. All the mineral horizons, including the parent material, are brittle. Consistence of the mineral material is friable or firm; the parent material is friable indicating that the firm consistence of the lower part of the albic horizon was induced during soil development. Roots are abundant in the peaty horizon, but the mineral horizons, including those below the ironpan, have few roots, which indicate that the ironpan is not impermeable. Effective rooting depth varies considerably depending on the thickness of the peaty and albic horizons; it is most commonly between 20 and 75 cm and is typically about 50 cm.

The free iron contents of the peaty (O) and albic (E) horizons of the representative profile are very low (<1.19 kg^{-1}); it increases substantially in the yellowish horizon below the ironpan indicating that it is spodic. The free iron content of the C horizon is high relative to the albic horizon. The low content in the albic horizon and the formation of the ironpan probably reflects a combination of leaching, and reduction under waterlogged conditions. The very low nutrient retention capacity of the upper albic horizon and the parent material, as indicated by the very low cation exchange capacities (CEC), reflects the very low carbon contents of these horizons.

All horizons are strongly acid and base saturation is extremely low. No exchangeable calcium was found in the mineral horizons of the representative profile that have low organic carbon contents, namely, the upper albic, spodic and C horizons. In profile II (Moanyarha) exchangeable calcium was not found in any mineral horizon including those with moderate (35 g kg^{-1}) carbon contents.

The surface peaty horizon has relatively high bulk density. It also has the relatively low (2.23 g g^{-1}) water content at saturation and the very high water content (24.3 vol %) retained at high (-1.5 MPa) suction that are characteristic of highly decomposed peat (sapric material). Consequently the available water capacity is only moderate and is less than that in the underlying mineral horizons (albic and spodic) which have high or very high capacity. The total available water in a profile with typical effective rooting depth of 50 cm is about 102 mm which is moderate; parts of most pedons with deeper peaty layer and deeper ironpan will have larger AWC. Although the total AWC is moderate in places, the soil is not considered droughty due to the moderately high rainfall and frequent rain-days. The very high air capacity of the peaty horizon suggests that its hydraulic conductivity is at least moderately rapid; the low air capacity or moderately high bulk density in the albic horizon indicates moderately slow hydraulic conductivity.

Water accumulates in the lower pockets of the albic horizon and was observed to flow down through the parent material when the iron pan was broken. The parent material lacks redoximorphic features; it is well drained whereas drainage is impeded in the material above the pan.

Soil suitability: The principal limitations comprise low nutrient status, low bearing capacity, wetness and relatively short growing season due partly to elevation. Moderately steep slopes are an additional limitation in part of the map unit, especially on the side of Laughtnafrankee and Long Hill. The combined effect of the limitations is severe. In its current condition the soil is limited to extensive grazing (Class EV). Due to its very low nutrient status, exacerbated by the very low retention capacity of the mineral subsoil, it is poorly suited to forestry. As the major part of the nutrient retention capacity and available nutrients are in the peaty surface horizon, it is important that this horizon is not cut away. Within the map unit, grassland has been developed in a few fields on gentle slopes, at about 395 m AMSL in Boola Td. Grasses and clovers were established on a heath at 490 m AMSL on Mt. Leinster by surface seeding (Moloney, 1964). This is a long process as it takes three to four years for the mat to be broken down with the application of lime and fertilisers; only then is the best establishment got from surface seeding of grasses and clover. Reclamation by deep ploughing and ripping is expensive due to the abundance of large stones; drainage limitations will persist where the ironpan lies beyond the reach of deep ploughs or rippers. Lime is essential for reclamation; a substantial part of the soil with moderately steep or steep slopes is not reclaimable as application of large quantities of lime is not feasible. Thus, the potential suitability of these areas is the same as the current suitability (Class EV) but the remainder on relatively gentle slopes could be developed to grassland (Class DV).

Representative profile description

Series	Glenary
Location:	Co. Waterford, Glenary Td., Grid Ref. 220300 117200
Classification:	Peaty Podzol (Placaquad)
Parent Material:	Sandstone till
Drainage:	Free below pan; impeded above pan
Topography:	Rolling
Slope:	9°
Altitude:	395 m AMSL
Land-use:	Heath, mainly Calluna spp.

Horizon	Depth (cm)	Description
Oe	0–10	Black (2.5 Y 2/0); rubbed fibre content 22%; exudate black; abundant fine and very fine heather roots; wavy boundary.
	10–15	Continuous layer of stones oriented horizontally; pockets 50 cm thick at 2.5 m intervals.
E	15–25	Pinkish grey (7.5YR 6/2), and brown (7.5YR 5/2) in upper half of horizon; sandy loam; common small and medium stones; massive structure; friable, slightly brittle consistence; moderately plastic (wet); common very fine pores; few fine roots; boundary sharp and mostly wavy.
Eh	25–35	Black (10YR 2/1); humose sandy loam; common small and medium stones; massive structure; firm, slightly brittle consistence; very few, very fine pores; few fine roots; boundary sharp and mostly wavy.
Bir	35	Ironpan; about 1 mm thick, black upper side, reddish brown lower side.
Bs	35–42	Yellowish red 5YR 5/6; sandy loam; common small and medium randomly oriented stones; weak coarse and fine subangular blocky structure; firm and friable, brittle consistence; slightly plastic (wet);

		abundant very fine pores; few very fine and fine roots; clear wavy boundary.
C	>42	Brown (7.5YR 5/3); loamy sand; many small to large randomly oriented stones; massive structure; friable, slightly brittle consistence; slightly plastic (wet); abundant very fine pores; few very fine and fine roots.

Table 3.46: Particle size and chemical analyses, Glenary Series.

Horizon	Oe	E	Eh	Bs	C
Depth cm	0–10	15–25	25–35	35–42	42+
Particle Size % :					
Coarse sand 200–2000 μm	33	25	27	25	
Fine sand 50–200 μm	26	32	35	39	
Silt 2–50 μm	26	33	28	26	
Clay <2 μm	15	10	10	10	
TNV g kg^{-1}					
Ca cmol kg^{-1}	7.2	0	0.06	0	0
Mg cmol kg^{-1}	8.06	0.13	0.18	0.01	0.01
K cmol kg^{-1}	0.56	0.01	0.01	0.01	0.01
Na cmol kg^{-1}	0.92	0.01	0.03	0	0
TEB cmol kg^{-1}	16.74	0.15	0.22	0.02	0.02
CEC cmol kg^{-1}	132.1	2.6	28	12.8	3
Base Saturation %	13	6	1	<1	<1
pH	3.7	4.5	4.2	4.3	4.6
C g kg^{-1}	352	3	27	5	1
N g kg^{-1}	14		1.3		
C/N	25		21		
Free iron g kg^{-1}	6	1	11	25	15
Loss on ignition g kg^{-1}	925				

Table 3.47: Physical analyses, Glenary Series.

Horizon	O	E	E	B
Sub-horizon	e		h	s
Depth cm	0–10	15–25	25–35	35–42+
Particle density Mg m^{-3}	1.48	2.67	2.54	2.65
Bulk density at saturation Mg m^{-3}	0.31	1.47	1.63	1.38
Bulk density at -59 hPa Mg m^{-3}	0.31	1.47	1.63	1.38
Air capacity % vol.	26.7	5.0	9.0	12.0
Retained water % vol.:				
0 hPa	69.9	39.9	36.9	47.7
-2 hPa	45.8	37.8	32.1	37.8
-59 hPa	43.2	34.9	27.9	35.7
-137 hPa	N/A	33.1	26.0	33.4
-0.1 MPa	31.7	31.0	24.0	29.3
-1.5 MPa	24.3	10.1	3.4	7.8
Total available water % vol.	18.9	24.8	24.5	27.9
Total available water cm	1.9	2.5	2.5	1.9
Total available water cumulative cm	1.9	4.4	6.8	8.8

Profile description: Glenary Series, profile II (Moanyarha)

Series:	Glenary
Location:	Co. Waterford, Glendalough Td. Grid Ref. 225400 118300
Classification:	Peaty Gley (cutover peat). [Aeric Epiaquept]
Parent Material:	Devonian sandstone
Drainage:	Slight impedance above C horizon
Topography:	Undulating plateau
Slope:	3º
Altitude:	425 m AMSL
Land-use:	Heath

Horizon	Depth (cm)	Description
Oa	0–5	Black (10YR 2/0) amorphous peat.
E1	5–30	Light brownish grey (10YR 6/2) and black (10YR 2/1); loamy sand; many medium stones; friable, slightly brittle consistence; few very fine pores; common fine and very fine roots; gradual wavy boundary.
E2	30–50	Greyish brown (10YR 5/2) and black (10YR 2/1); loamy sand; many medium stones; very weak medium subangular blocky structure; friable, slightly brittle consistence; few very fine pores; common fine and very fine roots; gradual wavy boundary.
Bg	50–60	Very pale brown (10YR 7/3) with dark brown root channels and brownish yellow band 5 mm thick at lower boundary; loamy sand; common and many small stones; massive structure; firm semi-deformable consistence; few very fine pores; few fine and very fine roots; sharp boundary to yellow band, clear to C horizon, broken; horizon extends to 90% of pedon.
C	60–100	Weak red (2.5YR 5/2); coarse sand; abundant medium angular stones, very large below 100 cm; massive structure; friable brittle consistence; very few roots.

Table 3.48: Particle size and chemical analyses, Glenary Series, profile II (Moanyarha).

Horizon	Oa	E1	E2	Bg	C
Depth cm	0–5	5–30	30–50	50–60	60–100+
Particle Size % :					
Coarse sand 200–2000 μm		24	27	30	40
Fine sand 50–200 μm		11	11	14	13
Silt 2–50 μm		46	43	41	32
Clay <2 μm		19	19	15	15
TNV g kg^{-1}					
Ca cmol kg^{-1}	1	0	0	0	0
Mg cmol kg^{-1}	2.3	0.31	0.12	0.05	0.04
K cmol kg^{-1}	1.2	0.07	0.07	0.01	0.01
Na cmol kg^{-1}	0.5	0.09	0.01	0.03	0.04
TEB cmol kg^{-1}	5	0.47	0.3	0.09	0.09
CEC cmol kg^{-1}	50	33.8	35	7.8	23.4
Base Saturation %	10	1	1	1	<1
pH	3.9	4.1	4.1	4.7	4.8
C g kg^{-1}	284	52	35	6	3
N g kg^{-1}	14	3	2.5		
C/N	20	17.3	14		
Free iron g kg^{-1}	10	3	6	7	14
Loss on ignition g kg^{-1}	809				

Kilbarry Series

The Kilbarry mapunit consists of wetlands, which occupy 1206 ha (0.66% of county). Most of it is in the volcanic region in the southeast of the county. It lies in the flood plains of streams and rivers at low elevations, commonly less than 15 to 30 m AMSL, and in basins around stream "rises" up to about 60 m AMSL. Wetlands in Waterford Harbour and in the flood plains of the rivers Suir, Blackwater, and Bride, in the west of the county, are included in the Kilbarry mapunit. The wetlands consist of swamps with conspicuous reeds (Phragmites spp.) or Tussock Sedge (Carex spp.), and marshes; Alder (Alnus spp.) and Willow (Salix spp.) are frequent in places (Duchas).

As the water table is at, near, or above the surface, the soil is permanently, or virtually permanently saturated with water. Consequently, the soil lacks evidence of the development of pedogenic horizons apart from a peaty horizon, which is common at the surface. The peaty horizon is absent in places, especially within the flood plains of the larger rivers. Its thickness spans the limit (40 cm) between organic and mineral soils. However, as the saturated conditions determine the genesis and use of the soil, and as the mineral subsoil has a weak fluidic consistence (μ >0.7), the soil is assigned to a single series within the Regosol group. Where the peaty horizon is relatively thick (>40 cm), the soil is morphologically very similar to the Pollardstown series, developed over limestone, which Hammond (1981) included in the Fen Peat group. In Fennor Bog, and possibly in other similar situations, the peaty horizon is the remains of deep cutover bog.

The description and analyses given below pertain to a profile with a moderately thick (>40 cm) peaty horizon. The surface layer (0–10 cm) of the O horizon is black; the O horizon (O) becomes paler and browner with depth. The SPEC values and the relatively high ash content indicate that the O horizon consists of highly decomposed sapric material; the ash is composed predominantly of silt or finer material. This horizon is moderately acid; base saturation is higher than that found in the rainfed peats (Knockmealdown, Monavullagh and Aughty series) in the uplands in the west of the county, and calcium is the dominant exchangeable cation. The content and composition of exchangeable cations, and the moderately acid reaction, indicate a minerotrophic origin. The relatively low (≤17.4) carbon-nitrogen ratio indicates development under aerobic conditions; the lighter and browner colours of the lower subhorizons imply less oxidised conditions than at the surface.

The underlying mineral horizon has a grey matrix and few or no mottles. It has little fine sand; silt, and coarse material that ranges from coarse sand to small stones, are the dominant size fractions. This horizon is probably of alluvial origin. It is massive, with a weak fluidic consistence in places. Reaction is moderately acid to neutral. The profile described below is a Terric Haplosaprist. The dominant soil in the mapunit lacks a peaty horizon, or it is thin (<40 cm), and is therefore classified as a Typic Hydraquent (USDA, 1999), which corresponds to the Regosol group. The average hydraulic conductivity of the typic (mineral) phase is moderately slow, whereas that of the peaty phase is moderately rapid; however, both phases are very variable.

Soil suitability: Owing to permanent wetness and low bearing capacity that does not support either grazing animals or machinery, this series, in its current condition, is unsuited to either agriculture or silviculture. Where outfalls permitted, some of this series was drained to form the Ballynabola series. With fertilisation and reseeding the latter series supports moderately productive grassland (Suitability Class DV), which represents the potential suitability of the Kilbarry series. Part of the series has been covered by a municipal dump near Waterford City. The best use of the Kilbarry series is probably as a wildlife habitat, and virtually all of it is a designated or proposed Natural Heritage Area.

Representative profile description

Series:	Kilbarry
Location:	Co. Waterford, Coolnagoppogue Td., Grid Ref. 255300 100900
Classification:	Regosol (Terric Medisaprist)
Parent Material:	Alluvium
Drainage:	Very poor; water table at surface
Topography:	Flat basin
Slope:	0°
Altitude:	60 m AMSL
Land-use:	Phragmites marsh

Horizon	Depth (cm)	Description
Oa1	0–10	Black (10YR 2/1); highly decomposed sapric peat; moderately fluid consistence; non-plastic (wet); abundant roots.
Oa2	10–20	Very dark grey (10YR 3/1); highly decomposed sapric peat; moderately fluid consistence; non plastic (wet); abundant roots.
Oa3	20–30	Very dark greyish brown (10YR 3/2); highly decomposed sapric peat; moderately fluid consistence; moderately plastic (wet); abundant roots.
Oa4	30–40	Very dark grey (10YR 3/1); highly decomposed sapric peat; weakly developed granular structure; moderately fluid consistence; moderately plastic (wet); abundant roots.
Oa5	40–50	Dark greyish brown (10YR 4/2); highly decomposed sapric peat; weakly developed granular structure; moderately fluid consistence; moderately plastic (wet); many roots; clear smooth boundary.
Cg1	50–60	Dark greyish brown (10YR 4/2); loam; few small stones; massive structure; slightly fluid consistence; moderately plastic (wet); common roots; clear smooth boundary.
Cg2	60–80+	Grey (2.5Y N6); loam; common small stones; massive structure; firm consistence; moderately plastic (wet); few roots.

Table 3.49: Particle size and chemical analyses, Kilbarry Series.

Horizon	Oa1	Oa2	Oa3	Oa4	Oa5	Cg1	Cg2
Depth cm	0–10	10–20	20–30	30–40	40–50	50–60	60–80
Particle Size % :							
Coarse sand 200–2000 μm				9	4	27	43
Fine sand 50–200 μm				10	6	8	14
Silt 2–50 μm				43	52	44	26
Clay <2 μm				38	38	21	17
TNV g kg^{-1}	0	0	0	0	0	0	0
Ca cmol kg^{-1}	38.44	44.08	40.32	47.8	33.72	11.95	7.26
Mg cmol kg^{-1}	5.28	6.08	5.28	4.88	4.48	1.72	1.22
K cmol kg^{-1}	0.96	0.32	0.16	0.01	0.01	0.04	0.01
Na cmol kg^{-1}	2.48	2.32	1.92	1.28	1.56	0.58	0.26
TEB cmol kg^{-1}	47.2	52.8	47.7	54	39.8	14.3	8.7
CEC cmol kg^{-1}	100.8	116.8	119.2	119.2	106.4	29.2	8.2
Base Saturation %	47	45	40	45	37	49	Sat
pH	5.4	5.2	5.1	5.1	4.7	4.8	6.9
Free iron g kg^{-1}	16	14	18	24	18	7	12
C g kg^{-1}	412		← 372 →		300	73	18
N g kg^{-1}	23.7		← 38.0 →				
C/N	17.4		← 9.8 →				
Loss on ignition g kg^{-1}	880	816	812	752			
Ash O.D. g kg^{-1}	120	184	188	248			
SPEC[1] value/chroma	7/4	6/3	4/4	3/2	5/4		

[1] Sodium Pyrophosphate Extract Colour

Kill Series

This is among the most extensive soils in the county; it occupies 20,193 ha (11.0% of the county). It is situated in the southeast of the county, in the area between the Waterford to Dungarvan road and the south coast. This area forms the largest area of volcanic soils in the Republic of Ireland. The Kill series is the dominant soil in the volcanic region, covering nearly three quarters of the landscape and occurs in association with the poorly drained Tramore Series. The range in soil morphological properties is less than might be expected on the basis of the complex geology; the bedrock consists of a variety of volcanic rocks and interbedded shales. The soil boundary at the northern end follows closely the junction between the volcanic and shale rocks; it seems that there was very little carryover of shale by ice from the north.

This series generally occupies the upper parts of the landscape at elevations mostly between 30 and 90 m AMSL; minor amounts extend up to 45 m and down to 15 m AMSL. Topography is predominantly undulating broken by rocky knolls and some narrow bands of steep slopes on the sides of river valleys. Much of the rock outcrop and nearly all of the steep slopes are too small to show on the soil map. The parent material is thin till containing volcanic clasts, mainly Rhyolite and Andesite, and a mixture of shales derived from the local bedrock. Rock outcrops are common, especially in the eastern part of the region; they decrease in frequency towards the coast to the south.

Typically, a brown A horizon overlies a thin weathered B horizon, or it may directly overly the C horizon. The soil is classified as a Brown Earth (Typic Dystrudept). Weakly developed spodic horizons occur sporadically, and were estimated by a systematic random sample to be present in 14% of soil profiles. Profile II below represents these inclusions; spodic materials extend to less than half the pedon, which is classified as a Spodic Dystrudept. The solum, which consists of the A and B horizons, is on average 50 cm deep and ranges from 30 to 80 cm. The C horizon generally has a distinctive yellowish hue, which differentiates the Kill series from those derived from shale or sandstone.

The Kill series is well drained. Structure is weak to moderate in the A horizon and becomes massive in the C horizon. Texture is loam to silt loam; clay is typically 20% in the A horizon and decreases slightly with depth. Silt content is generally about twice the clay content and ranges up to 58%. The cation exchange capacity (CEC) of the C horizon, where the influence of carbon is small, is similar to that found in the C horizon of soils derived from shale or sandstone. This implies that the mineralogy of the volcanic soils may not be substantially different and are unlikely to contain appreciable amounts of allophane. Stones are few to common in the surface A horizon; stone content generally increases with depth, and many or abundant stones may be present in the C horizon. Stone picking has been carried out extensively in the area; the resulting pattern of stone distribution is irregular and unpredictable, and so it was not possible to distinguish different phases on the basis of stoniness. It was observed during fieldwork that the shallow to bedrock inclusions, which occur within the map unit, were the most likely to show evidence of drought in an exceptionally dry year.

The available water capacity (AWC) is extremely high in the solum, and it is high in the C horizon. Grass roots generally penetrate about 10 cm depth into the C horizon. Rooting depth is typically about 60 cm and ranges up to 90 cm. The total available water capacity in the profile, calculated on the basis of 60 cm depth, is high. Average annual rainfall is about 1000 mm and ranges from about 900 mm at the coast to about 1100 mm at the northwestern extremity. On the basis of rainfall and evapotranspiration data, Brereton and Keane (1982) estimated an average annual potential yield loss due to drought of about 1 t ha^{-1} and larger losses at the coast. As the high moisture storage capacity mitigates drought risk, the average yield loss due to drought is probably small except in those areas that are shallow to bedrock.

Soil suitability: These soils are very suited to grass production due to the high available water content and favourable climate. The potential yields of grass are among the highest in the country. The four-year mean DM yield at Kilmeadan on a Kill soil, with 56 cm solum thickness, was 13.1 t ha^{-1} (Ryan, 1974). The low risk of poaching associated with the free drainage conditions contributes to high utilisation efficiency and high grazing capacity. Suitability for cultivation varies from place to place depending on the stone content of the surface layer, which is generally not limiting for cereals but would be limiting for mechanised harvesting of potatoes. The soil is assigned to Class A for grassland and to Class I or Class II for cultivation depending on the degree of stoniness of the specific site.

Representative profile description

Series	Kill
Location:	Co. Waterford, Coolnagoppogue Td., Grid Ref. 255600 100400
Classification:	Brown Earth (Typic Dystrudept)
Parent Material:	Till, volcanic material
Drainage:	Well
Topography:	Gently sloping
Slope:	2°
Altitude:	90 m AMSL
Land-use:	Old pasture

Horizon	Depth (cm)	Description
Al	0–10	Dark brown (10YR 3.5/3); loam; few small and medium stones; weak/moderate medium granular structure; friable consistence; moderately plastic (wet); abundant diffuse very fine roots; clear smooth boundary.
A2	10–25	Dark brown (10YR 3.5/3); loam; common small and medium stones; weak/moderate medium granular structure; friable consistence; moderately plastic (wet); many very fine roots; gradual wavy boundary.

A3	25–40	Dark brown (10YR 3.5/3); loam; common small and medium stones; medium granular structure; friable consistence; moderately plastic (wet); many very fine roots; clear wavy boundary.
C1	40–60	Light yellowish brown (2.5Y 6/4); loam; common, small to large stones; weakly developed coarse, breaking to medium subangular blocky structure; firm, slightly brittle consistence; moderately plastic (wet); many very fine and fine pores; common very fine roots becoming few with depth; gradual wavy boundary.
C2	60–80	Light yellowish brown (2.5Y 6/3); few, coarse, strong brown (7.5YR 5/8) mottles; loam; common small to large stones; very weakly developed, coarse subangular blocky structure; firm, slightly brittle consistence; moderately plastic (wet); many very fine and fine pores; few vertical roots; diffuse irregular boundary.
C3	80–120	Light yellowish brown (2.5Y 6/3); common coarse strong brown (7.5YR 5/8) mottles and streaks and black manganiferous mottles; loam; common medium and large stones; very weakly developed coarse blocky structure; firm, semi-deformable consistence; very plastic (wet); many very fine pores; few roots, none below 100 cm.

Table 3.50: Particle size and chemical analyses, Kill Series.

Horizon	A1	A2	A3	C1	C2	C3
Depth cm	0–10	10–25	25–40	40–60	60–80	80–120+
Particle Size % :						
Coarse sand 200–2000 μm	24	23	21	22	18	19
Fine sand 50–200 μm	23	25	24	14	14	13
Silt 2–50 μm	34	31	34	39	42	41
Clay <2 μm	19	21	21	25	26	27
TNV g kg^{-1}	0	0	0	0	0	0
Ca cmol kg^{-1}	8.2	7.7	6.1	3	3	2.6
Mg cmol kg^{-1}	0.8	0.5	0.3	0.3	0.4	0.4
K cmol kg^{-1}	0.12	0.09	0.09	0.06	0.06	0.06
Na cmol kg^{-1}	0.14	0.08	0.06	0.09	0.11	0.11
TEB cmol kg^{-1}	9.26	8.37	6.57	3.45	3.57	3.17
CEC cmol kg^{-1}	21.6	18.4	14.3	6.2	5.6	4.6
Base Saturation %	43	45	46	56	64	69
pH	6	6	6.3	6.7	6.8	6.8
C g kg^{-1}	39	20	14	4	3	4
N g kg^{-1}	3.2	2.2	1.4			
C/N	12	9	10			
Free iron g kg^{-1}	23	18	13	25	24	25

Table 3.51: Physical analyses, Kill Series.

Horizon	A	A	A
Sub-horizon	1	2	3
Depth cm	0–10	10–25	25–40
Particle density Mg m^{-3}	2.42	2.48	2.54
Bulk density at saturation Mg m^{-3}	1.04	1.2	1.33
Bulk density at -59 hPa Mg m^{-3}	1.06	1.22	1.33
Air capacity % vol.	7.6	7.0	10.3
Retained water % vol.:			
0 hPa	61.3	60.7	54.2
-2 hPa	54.6	55.6	48.5
-59 hPa	53.7	53.7	43.8
-137 hPa	49.9	50.5	39.3
-0.1 MPa			
-1.5 MPa	13.6	11.7	11.2
Total available water % vol.	40.1	42.1	32.7
Total available water cm	4.0	6.3	4.9
Total available water cumulative cm	4.0	10.3	15.2

Profile description: Kill Series, profile II

Location:	Co.Waterford, Ballynaclogh North Td., Grid Ref. 255100 105300
Classification:	Brown Earth (Spodic Dystrudept)
Parent Material:	Till. Acid volcanic material
Drainage:	Well
Topography:	Undulating
Slope:	2^o
Altitude:	65 m AMSL
Land-use:	Permanent pasture

Horizon	Depth (cm)	Description
Al	0–10	Brown (10YR 4/3); loam; common medium and small stones; weak to moderate medium granular structure; friable, semi-deformable consistence; moderately plastic (wet); abundant very fine diffuse roots.
A2	10–20	Brown (10YR 4/3); loam; common, medium and small stones; weak to moderate medium granular structure; friable, semi-deformable consistence; moderately plastic (wet); many very fine roots; clear, wavy boundary.
A3	20–30	Brown (10YR 4/3); loam; common medium and small stones; weak to moderate fine subangular blocky structure; friable, semi-deformable consistence; moderately plastic (wet); many very fine diffuse roots.
A4	30–40	Brown (10YR 4/3); loam; common small to large stones; weak to moderate fine subangular blocky structure; friable, semi-deformable consistence; moderately plastic (wet); many very fine diffuse roots; clear wavy boundary.
Bs	40–50	Strong brown (7.5YR 5.5/6); loam; many small to large stones; weakly developed coarse parting to fine sub-angular blocky structure; friable, semi-deformable consistence; moderately plastic (wet); abundant very fine pores; common very fine diffuse roots; clear broken boundary; extends to less than half of pedon.
C1	50–75	Pale brown (10YR 6/2) and yellowish brown (10YR 5/4); loam; many small to large stones; massive structure; very firm, brittle consistence; moderately plastic (wet); many very fine pores; few very fine vertical roots.
C2	75–100+	Pale brown (10YR 6/3) and yellowish brown (10YR 5/4); silt loam; abundant small to large stones; massive structure; very firm, brittle consistence; moderately plastic (wet); many very fine pores; few very fine vertical roots to 100 cm.

Table 3.52: Particle size and chemical analyses, Kill Series, profile II.

Horizon	A1	A2	A3	A4	Bs	C1	C2
Depth cm	0–10	10–20	20–30	30–40	40–50	50–75	75–100+
Particle Size % :							
Coarse sand 200–2000 μm	21	20	19	20	15	27	23
Fine sand 50–200 μm	14	13	13	13	11	15	14
Silt 2–50 μm	43	46	47	46	55	42	50
Clay <2 μm	22	21	21	21	19	16	13
TNV g kg^{-1}	6						
Ca cmol kg^{-1}	14.1	14.1	11.7	9.8	8	2.6	1.9
Mg cmol kg^{-1}	0.41	0.34	0.27	0.27	0.2	0.14	0.14
K cmol kg^{-1}	0.36	0.14	0.1	0.1	0.04	0.03	0.03
Na cmol kg^{-1}	0.39	0.08	0.09	0.1	0.12	0.1	0.06
TEB cmol kg^{-1}	15.26	14.66	12.16	10.27	8.36	2.87	2.13
CEC cmol kg^{-1}	27.6	25.1	22	17.4	18	7.8	4.6
Base Saturation %	55	58	55	59	46	37	46
pH	7.1	6.8	6.7	6.5	6.8	6.5	6.4
C g kg^{-1}	29	25	20	16	13	4	3
N g kg^{-1}	2.8	2.6	2.2	1.8	1.2	0.3	0.2
C/N	10.4	9.6	9.1	8.9	10.8		
Free iron g kg^{-1}	11	8	13	11	18	10	9

Table 3.53: Physical analyses: Kill Series, profile II.

Horizon	A	A	A	A	B	C	C
Sub-horizon	1	2	3	4	s	1	2
Depth cm	0–10	10–20	20–30	30–40	40–50	50–75	75–100+
Particle density Mg m^{-3}	2.46	2.45	2.50	2.53	2.57	2.64	2.65
Bulk density at saturation Mg m^{-3}	1.18	1.29	1.23	1.21	1.16	1.67	1.81
Bulk density at -59 hPa Mg m^{-3}	1.18	1.30	1.23	1.21	1.17	1.67	1.82
Air capacity % vol.	8.2	9.2	13.1	15.5	16.5	7.6	5.5
Retained water % vol.:							
0 hPa	59.4	59.4	54.6	56.7	60.0	41.9	35.6
-2 hPa	52.9	52.5	47.6	49.9	49.4	35.7	31.2
-59 hPa	51.2	50.3	41.5	41.1	43.5	34.3	30.0
-137 hPa	49.0	47.6	37.6	37.1	39.6	32.7	29.2
-0.1 MPa							
-1.5 MPa	15.7	17.5	12.4	10.9	9.0	9.6	9.1
Total available water % vol.	35.5	32.8	29.1	30.2	34.5	24.7	20.9
Total available water cm	3.5	3.3	2.9	3.0	3.4	6.2	5.2
Total available water cumulative cm	3.5	6.8	9.7	12.8	16.2	22.4	27.6

Table 3.54: Descriptive statistics, Kill Series.

	Depth cm	Mean	Standard Deviation	Minimum	Maximum	Range
CSAND	0–10	24.5	4.0	18	36	18
	40–50	25.6	7.9	14	46	32
FSAND	0–10	17.0	3.3	12	28	16
	40–50	14.1	1.7	10	18	8
SILT	0–10	37.0	5.9	15	48	33
	40–50	41.5	8.0	25	58	33
CLAY	0–10	20.9	2.2	17	26	9
	40–50	19.1	5.0	8	29	21
TNV g kg $^{-1}$	0–10	0.1	0.2	0	1	1
	40–50	0.0	0.0	0	0	0
CEC cmol kg $^{-1}$	0–10	26.5	5.1	19	47.6	28.6
	40–50	11.7	5.1	4.4	25.4	21
Base Saturation %	0–10	49.4	16.7	16	84	68
	40–50	34.0	11.8	13	60	47
pH	0–10	6.2	0.7	4.5	7.3	2.8
	40–50	6.7	0.5	5.7	7.5	1.8
C g kg $^{-1}$	0–10	32.9	12.9	16	85	69
	40–50	6.3	4.1	1	17	16
Free iron g kg $^{-1}$	0–10	1.9	0.4	1.3	3.1	1.8
	40–50	2.1	0.5	0.7	3.5	2.8

Killadangan Series

This series occupies 1922 ha (1.0% of the county). It is situated in the west-central part of the county on the floor and lower flanks of the valley that stretches from Dungarvan to Ballyduff, and in the lowland area around Villierstown. It is associated with the Dungarvan series, and to a smaller extent, the Clashmore series. Along the margins of the valley, it is commonly found between the Clashmore series, which lies above it, and the Dungarvan Series. In the centre of the valley it generally lies at slightly lower elevations than the Dungarvan series. In both of these situations it probably receives runoff from the surrounding higher ground. Elevation is generally less than 30 m AMSL; it rises to 60 m AMSL in places along the flanks of the hills. Topography is undulating; slopes are commonly gentle (<3^{o}). The parent material is noncalcareous till composed predominantly of sandstone. Towards the centre of the valley, the underlying bedrock consists of unbedded calcareous mudstone and packstone of the Waulsortian Formation; along the margins, muddy limestone of the Ballysteen Formation is more common. A small part of the area on the southern margin is underlain by sandstone. Average rainfall is about 1100 mm per annum.

A typical profile has a greyish brown mineral horizon underlain by a grey E horizon with few or no mottles. The underlying B horizon is brown with grey mottles that have brittle, firm, red rims. The soil is classified as a Gley (Typic Epiaquept; USDA 1999).

Texture of the topsoil is loam; it is generally finer than the topsoil of the associated well drained soils, the Dungarvan and Clashmore series. Texture of the subsoil (B and C horizons) of the representative profile ranges from sandy loam to silt loam. Field texture of auger profiles includes clay loam in the subsoil. Structure is typically weak granular in the topsoil and becomes very weak or massive in the B and C horizons, respectively. Consistence of the subsoil is moderately firm and brittle and consequently root development is poor; in the profile described below roots are absent below 42 cm depth.

The organic carbon content is moderate and is higher than that of the well drained Dungarvan series; organic surface horizons were not noted in the field. Reaction is moderately acid in the surface and increases to slightly acid in the subsoil. Free iron content is very low in the albic horizon (E) indicating prolonged saturation with surface water; the free iron content increases in the subsoil (B and C horizons) where ochreous mottles are more abundant.

The surface layer (0–10 cm) of the representative profile described below has very high available water capacity (AWC); throughout the remainder of the profile the AWC ranges from moderately high to high. The total amount of available water in the profile, down to one metre depth, is very high (203 mm). However, the amount accessible to plant roots is likely to be much less, owing to high resistance to root penetration in the subsoil. The air capacity is low to moderate in the topsoil; it is low or very low in the rest of the profile. The bulk density of the B horizon is high to very high (1.72 Mg m^{-3}). Hydraulic conductivity data are not available for this soil; the massive structure, low air capacity, and high density, which are similar to that found in the Mothel and Clohernagh series, indicate that the hydraulic conductivity of the Killadangan series is moderately slow. The redoximorphic features indicate prolonged saturation with water, and the soil is considered to be poorly drained.

Soil suitability: The principal limitation is wetness, which would remain a continuing limitation after field drainage owing to the moderately slow hydraulic conductivity. Subsoiling may be beneficial in dry seasons, where the subsoil is brittle. Although root penetration is limited in the subsoil, drought is unlikely to be a significant limitation owing to the large number of rain-days (>150 per annum) and the high available water capacity. The soil is moderately suited to grassland and arable crops. The climate of the area favours a long growing season (>300 days per annum), but wetness reduces dry matter output and shortens the growing season. There is a significant risk of poaching damage. Wetness reduces the number of workdays in spring and sowing date of spring sown crops can be delayed. Winter cereals are the most suitable arable crops. The series is assigned to Suitability Class CIII.

Representative profile description

Series:	Killadangan
Location:	Co. Waterford, Inchindrisla Td., Grid Ref. 223400 96200
Classification:	Gley (Typic Epiaquept)
Parent Material:	Sandstone till.
Drainage:	Poor/Imperfect
Topography:	Undulating
Slope:	2º
Altitude:	27 m AMSL
Land-use:	Ryegrass-clover pasture

Horizon	Depth (cm)	Description
A1	0–10	Greyish brown (10YR 5.5/2) with common fine reddish brown (5YR 4/3) root mottles; loam (silty); few small to medium stones; weak medium granular structure; friable consistence; very plastic (wet); abundant very fine roots.
A2	10–25	Greyish brown (10YR 5/2) with common fine to coarse reddish brown root mottles; loam (silty); few small to medium stones; weak medium granular structure; friable consistence; moderately plastic (wet); many very fine roots; abrupt wavy boundary.
Eg	25–42	Light brownish grey (10YR 6/2) and very pale brown (10YR 6/3) and few fine yellow (10YR 7/6) mottles; loam (silty); few small to medium stones; weak compound coarse and fine subangular blocky structure; moderately firm semi-deformable consistence; very plastic (wet); many very fine and fine pores; common roots; clear wavy boundary.
Bg1	42–80	Brown (7.5YR 5/2) and coarse reddish grey (5YR 5/2) mottles with yellowish red (5YR 5/6) rims 5–10 mm thick; loam; common small to medium stones; very weak very coarse subangular blocky structure; moderately firm brittle consistence; very plastic (wet); few very fine pores; no roots.
Bg2	80–120	Similar to Bg1 above. Gradual irregular boundary. A near horizontal band reddish grey (5YR 5/2), 5 cm thick with yellowish red (5YR 5/6) rims occurs in lower part of horizon.
C	120 +	Dark reddish grey (5YR 4/2) and grey (5YR 6/1); loamy sand; many small to large stones, mostly small; massive structure; moderately firm brittle, and friable consistence; many very fine pores; no roots.

Table 3.55: Particle size and chemical analyses, Killadangan Series.

Horizon	A1	A2	Eg	Bg1	Bg2	C
Depth cm	0–10	10–25	25–42	42–80	80–120	120+
Particle Size % :						
Coarse sand 200–2000 μm	13	14	9	22	17	34
Fine sand 50–200 μm	19	18	14	14	12	21
Silt 2–50 μm	43	44	47	49	55	32
Clay <2 μm	25	24	30	15	16	13
TNV g kg^{-1}						
Ca cmol kg^{-1}	4.78	4.47	4.45	2.22	2.48	1.14
Mg cmol kg^{-1}	0.47	0.36	0.40	0.31	0.47	0.28
K cmol kg^{-1}	0.17	0.05	0.03	0.05	0.05	0.03
Na cmol kg^{-1}	0.05	0.01	0.06	0.05	0.07	0.02
TEB cmol kg^{-1}	5.45	4.89	4.94	2.63	3.07	1.47
CEC cmol kg^{-1}	18.2	15.6	9.6	3.4	6.8	2.4
Base Saturation %	30.0	31.0	51.0	77.0	45.0	61.0
pH	5.1	5.5	5.9	5.9	5.9	5.5
C g kg^{-1}	33.0	16.0	16.0	2.0	2.0	2.0
N g kg^{-1}	3.3	1.5	1.1			
C/N	10.0	10.7	14.5			
Free iron g kg^{-1}	13.0	12.0	6.0	20.0	19.0	20.0

Table 3.56: Physical analyses, Killadangan Series.

Horizon	A	A	E	B	B	B
Sub-horizon	1	2	g	g1	g1	g2
Depth cm	0–10	10–25	25–42	42–60	60–80	80–100
Particle density Mg m^{-3}	2.56	2.51	2.61	2.74	2.74	2.72
Bulk density at saturation Mg m^{-3}	1.25	1.3	1.51	1.86	1.72	1.78
Bulk density at -59 hPa Mg m^{-3}	1.25	1.3	1.51	1.86	1.72	1.78
Air capacity % vol.	4.0	9.8	6.3	5.1	2.4	4.3
Retained water % vol.:						
0 hPa	51.5	48.8	42.4	33.0	33.8	35.6
-2 hPa	48.8	41.6	38.4	30.3	33.1	34.4
-59 hPa	47.5	39.0	36.1	27.9	31.4	31.3
-137 hPa	46.8	38.5	35.7	27.5	30.9	30.9
-0.1 MPa	41.7	37.0	32.9	25.1	30.0	28.6
-1.5 MPa	20.1	18.6	19.4	10.3	10.6	9.5
Total available water % vol.	27.4	20.4	16.7	17.6	20.8	21.8
Total available water cm	2.7	3.1	2.8	3.2	4.2	4.4
Total available water cumulative cm	2.7	5.8	8.6	11.8	16.0	20.3

Kilmeadan Series

This series covers 2,995 ha (1.63% of the county) in the northeast and northwest regions of the county. In addition, small amounts are found within complexes. It occurs mainly in a series of pockets along the margin of the Suir valley that extends from Waterford City to Fourmilewater southwest of Clonmel. It lies either side of the Carboniferous/Devonian boundary and overlies muddy limestone and calcareous shale of the Ballysteen and Ballymartin formations, and sandstone/mudstone of the Kiltorcan Formation. The parent material is mixed calcareous till that contains limestone, and in places volcanic material, as well as material derived from the local rock formations. Topography is undulating, and elevation ranges from 15 m AMSL, near the limit of the Suir floodplain, to 120 m AMSL on the side of the sandstone ridge. It occurs in association with the Waterford series, which is wetter.

These are deep well drained soils in which depth to carbonates is generally greater than 2 m. Typically, the soil profile is characterised by a brown A horizon of light loam texture (18–25% clay) that overlies a yellowish brown textural (argillic), or weathered B horizon. Clay content in the B horizon is typically slightly greater than in the A horizon; it varies widely, even within pedons, and ranges up to 52% in some pockets. Argillans may be present, but they are commonly patchy. The soils are classified as Grey Brown Podzolics (Inceptic Hapludalfs and Typic Hapludalfs); it is likely, however, that some Brown Earths (Dystric Eutrudepts) occur in the map unit. The series is related to the Elton series, which is widespread on limestone till throughout the central plain of Ireland. The Kilmeadan series is differentiated on the basis of:

- higher clay contents in the B horizon,
- greater depth to carbonates,
- wide range of rock types in the parent material.

The finer textured parts of the series are over limestone, mainly around Fourmilewater, while the coarser soils tend to predominate at higher elevations or over sandstone. The description and analyses of the representative profile shown below (Profile I) represents the coarser part of the series, while profile II represents the finer component. In Profile I, clay content increases in the B horizon, below 50 cm depth, and in the C horizon compared to the A horizon. The relatively high clay content below 2 m depth in the C horizon suggests that the clay increase may be the product of weathering or inherited from the parent material. Nevertheless, as the ratio of fine clay ($< 0.2\ \mu$) to coarse clay ($< 2\ \mu$) increases from 0.2 in the A horizon to 0.25 in the B horizon, which indicates movement of fine clay, and argillans are present in places, the B horizon is considered argillic. Because the argillic features are weakly expressed and patchy, the profile is assigned to the Inceptic subgroup. Profile II exhibits distinct lateral variation in clay content within the B and C horizons. The clayey texture is localised in large pockets, about 50 cm in diameter, which have a low content (8–9%) of coarse and fine sand. These pockets are probably the products of the weathering of shale and muddy limestone. The B horizon has many, distinct, entire, argillans lining voids and on ped faces; it also has a significant clay increase compared to the A horizon and is evidently argillic. Profile II is classified as a Typic Hapludalf (Grey Brown Podzolic).

Carbon content in the surface layer (0–10 cm) is low to very low, and is probably due to the effect of cultivation. Potential rooting depth is greater than one metre. The available water capacity is high, notwithstanding the low carbon contents, and the total available water in the profile is high. Air capacity ranges from moderate in the A horizon to low in the B and C horizons; hydraulic conductivity probably follows a similar pattern ranging from moderately rapid in the A horizon to moderately slow in the subsoil.

Soil suitability: Kilmeadan soils are among the most productive soils in the county and have a wide use range. They are very suited to grassland and arable crops. They can be grazed over a long season and potential grazing capacity is high. High yields of arable crops are obtainable, and they are especially suited to winter cereal production. They are assigned to suitability Class AI.

Representative profile description: Profile I

Series:	Kilmeadan
Location:	Co. Waterford, Stonehouse Td., Grid Ref. 251400 110900
Classification:	Grey Brown Podzolic (Inceptic Hapludalf)
Parent Material:	Till. Purple fine sandstone and shale; traces of limestone and chert.
Drainage:	Well drained
Topography:	Undulating
Slope:	3°
Altitude:	65 m
Land-use:	Old pasture

Horizon	Depth (cm)	Description
Al	0–10	Brown (10YR 4/3); loam; common small and medium stones; moderately developed coarse and medium granular structure; friable consistence; moderately plastic (wet); abundant fine diffuse roots.
A1	10–25	Brown (10YR 4/3); loam; common small and medium stones; moderately developed coarse and medium granular structure; friable consistence; moderately plastic (wet); abundant fine diffuse roots; clear wavy boundary.
Bt1	25–50	Dark yellowish brown (10YR 4.5/4) ped interior with abundant brown (10YR 5/3) on ped faces and lining coarse pores (cutans); loam; common small to very large stones; weakly developed coarse subangular blocky structure; firm consistence; very plastic (wet); abundant very fine to medium pores; common very fine roots; irregular gradual boundary.
Bt2	50–70	Dark yellowish brown (10YR 4.5/4) with common brown (10YR 5/3) on ped faces and lining medium pores (cutans); loam; common small and medium stones; weakly developed coarse subangular blocky breaking to fine blocky structure; firm semi-deformable consistence; very plastic (wet); abundant fine to medium pores; few roots.
Bt3	70–90	Dark yellowish brown (10YR 4.5/4) with common brown (10YR 5/3) on ped faces and lining medium pores (cutans); loam; common small and medium stones; weakly developed coarse subangular blocky breaking to medium structure; firm consistence; very plastic (wet); many very fine to medium pores; few very fine roots.
Bt4	90+110+	Similar to next horizon above. Diffuse boundary.
C2	200+	Brown (10YR 5/3.5); common small and medium stones; very weakly developed coarse subangular blocky structure; slightly firm consistence; extremely plastic (wet); many very fine to medium pores; few roots.

Table 3.57: Particle size and chemical analyses, Kilmeadan Series, profile I.

Horizon	A1	A2	Bt1	Bt2	Bt3	Bt4	C1
Depth cm	0–10	10–25	25–50	50–70	70–90	90–110+	200+
Particle Size % :							
Coarse sand 200–2000 μm	22	21	22	26	25	27	25
Fine sand 50–200 μm	20	20	15	14	14	12	14
Silt 2–50 μm	36	36	41	34	31	35	32
Clay <2 μm	22	23	22	26	30	26	29
Fine clay <0.2 μm	4	4	5	6	8	7	6
Fine clay/Coarse clay	0.2	0.18	0.23	0.24	0.25	0.25	0.21
TNV g kg^{-1}	0	0	0	0	0	0	0
Ca cmol kg^{-1}	6.6	5.6	2.8	2.6	4.5	3.0	3.3
Mg cmol kg^{-1}	0.47	0.54	0.34	0.34	0.41	0.41	0.34
K cmol kg^{-1}	0.26	0.14	0.13	0.12	0.13	0.17	0.15
Na cmol kg^{-1}	0.17	0.14	0.15	0.17	0.15	0.19	0.13
TEB cmol kg^{-1}	7.5	6.42	3.42	3.23	5.19	3.77	3.92
CEC cmol kg^{-1}	17	12.4	5.8	5.5	8.5	5.6	5.6
Base Saturation %	44	52	59	59	61	67	70
pH	5.3	6.0	6.3	6.3	6.4	6.4	6.7
C g kg^{-1}	30	13	3	3	2	2	2
Free iron g kg^{-1}	24	24	23	24	28	31	28

Table 3.58: Physical analyses, Kilmeadan Series, profile I.

Horizon	A	A	B	B	B	B
Sub-horizon	1	2	t1	t2	t3	t4
Depth cm	0–10	10–30	30–50	50–70	70–90	90–110
Particle density Mg m^{-3}	2.54	2.58	2.65	2.65	2.64	2.66
Bulk density at saturation Mg m^{-3}	1.22	1.47	1.81	1.77	1.74	1.72
Bulk density at -59 hPa Mg m^{-3}	1.22	1.47	1.82	1.77	1.75	1.73
Air capacity % vol.	7.9	9.3	6.2	6.4	7.2	7.4
Retained water % vol.:						
0 hPa	48.8	42.4	35.7	37.7	37.9	40.2
-2 hPa	46.7	39.4	32.0	33.1	33.3	36.1
-59 hPa	40.9	33.1	29.5	31.3	30.7	33.1
-137 hPa	37.6	30.3	27.8	29.8	28.7	31.0
-0.1 MPa						
-1.5 MPa	18.9	13.0	12.1	13.7	13.7	11.4
Total available water % vol.	22.1	20.1	17.4	17.6	17.0	21.7
Total available water cm	2.2	4.0	3.5	3.5	3.4	4.3
Total available water cumulative cm	2.2	6.2	9.7	13.3	16.7	21.0

Profile description: Kilmeadan Series, profile II.

Location:	Co.Waterford, Ballymakee Td., Grid Ref. 215300 114100
Classification:	Grey Brown Podzolic (Typic Hapludalf)
Parent Material:	Till composed of shale, limestone, and sandstone, over limestone bedrock.
Drainage:	Well
Topography:	Undulating
Slope:	2°
Altitude:	45 m AMSL
Land-use:	Wheat

Horizon	Depth (cm)	Description
A1	0–10	Brown (10YR 4/3); loam; common small and medium stones; weak medium granular structure; moderately weak semi-deformable consistence; very plastic (wet); many very fine roots.
A2	10–30	Similar to A1. Clear wavy boundary.
E/B	30–45	Yellowish brown 10YR 5/4; loam; common small and medium stones; weak compound coarse and medium subangular blocky structure; moderately firm slightly brittle consistence; very plastic (wet); abundant fine and medium pores with few patchy faint argillans; few very fine roots; gradual wavy boundary.
Bt1	45–75	Yellowish brown (10YR 5/4) clay loam; yellowish brown (10YR 5/8) clay with yellowish brown (10YR 5/4) ped faces occupies 20 percent of pedon; weak compound coarse and medium subangular blocky structure; common small and medium stones; moderately firm semi-deformable consistence; extremely plastic (wet); many fine and medium pores with many entire distinct argillans; few very fine roots.
Bt2	75–100	Similar to Bt1. Gradual wavy boundary.
C1	100–160	Yellowish brown (10YR 5/4) and dark grey, reddish and olive patches around weathering stones; clay loam; common small and medium stones; very weak coarse subangular blocky structure; moderately firm, semi-deformable consistence; very plastic (wet); common fine and medium pores with many distinct continuous argillans; very few, very fine roots; diffuse boundary.
C2	160–200	Yellowish brown (10YR 5/4) clay loam and yellowish brown (10YR 5/6) clay pockets; many large stones weathered to dark grey, olive yellow and reddish patches; very weak coarse subangular blocky structure; moderately firm semi-deformable consistence; common fine pores with many continuous distinct argillans; very few, very fine roots.

Table 3.59: Particle size and chemical analyses, Kilmeadan Series, profile II.

Horizon	A1	A2	E/B	Bt1	Bt1	Bt2	C1	C2	C2
Depth cm	0–10	10–30	30–45	45–75	45–75b	75–100	100–160	160–200+	160–200b+
Particle Size % :									
Coarse sand 200–2000 μm	22	22	18	17	9	12	16	15	8
Fine sand 50–200 μm	19	19	16	14	9	15	16	15	8
Silt 2–50 μm	36	36	42	39	30	41	37	41	45
Clay <2 μm	23	23	24	30	52	32	31	29	39
TNV g kg^{-1}	0	0	0	0	0	0	0	0	0
Ca cmol kg^{-1}	8.3	8.51	3.3	3.7	5.62	4	3.8	4.61	5.68
Mg cmol kg^{-1}	0.37	0.35	0.22	0.24	0.31	0.24	0.25	0.27	0.31
K cmol kg^{-1}	0.19	0.12	0.04	0.04	0.06	0.04	0.04	0.05	0.06
Na cmol kg^{-1}	0.03	0.06	0.04	0.04	0.08	0.08	0.03	0.03	0.03
TEB cmol kg^{-1}	8.89	9.04	3.6	4.02	6.07	4.36	4.12	4.96	6.08
CEC cmol kg^{-1}	13.8	13.8	4.2	4.6	11.2	5.4	9	6.2	8.6
Base Saturation %	64	66	86	87	54	81	46	80	71
pH	6.9	7	6.6	6.5	6.4	6.4	6.3	6.3	6.1
C g kg^{-1}	14	14	3	2	2	1	1	1	1
N g kg^{-1}	2	2							
C/N	7	7							
Free iron g kg^{-1}	25	24	31	33	51	35	32	26	43

b = Clayey pocket

Table 3.60: Physical analyses, Kilmeadan Series, profile II.

Horizon	A	A	E/B	B	B	B	C
Sub-horizon	1	2		t1	t2	t3	1
Depth cm	0–10	10–30	30–45	45–60	60–75	75–100	100–160
Particle density Mg m^{-3}	2.58	2.58	2.37	2.69	2.69	2.68	2.69
Bulk density at saturation Mg m^{-3}	1.32	1.34	1.66	1.57	1.61	1.67	1.56
Bulk density at -59 hPa Mg m^{-3}	1.32	1.34	1.66	1.57	1.61	1.67	1.56
Air capacity % vol.	12.5	6.7	5.2	4.2	6.0	3.9	4.7
Retained water % vol.:							
0 hPa	52.6	46.4	37.0	40.9	41.5	36.6	40.9
-2 hPa	44.8	42.1	33.4	37.8	36.8	33.8	37.3
-59 hPa	40.1	39.6	31.8	36.7	35.4	32.8	36.2
-137 hPa	38.8	38.5	30.9	35.9	34.5	31.9	35.5
-0.1 MPa	34.9	34.1	28.1	34.2	31.2	29.9	34.3
-1.5 MPa	16.7	16.5	16.3	21.4	22.9	20.9	20.7
Total available water % vol.	23.5	23.2	15.4	15.3	12.6	11.9	15.6
Total available water cm	2.3	4.6	2.3	2.3	1.9	3.0	9.3
Total available water cumulative cm	2.3	7.0	9.3	11.6	13.5	16.5	25.8

Table 3.61: Descriptive statistics, Kilmeadan Series.

	Depth cm	Count	Mean	Standard Deviation	Minimum	Maximum	Range
Clay	0–10	10	20.7	2.2	18	25	7
Clay	40–50	10	23.6	7.1	11	38	27
Fine silt	0–10	10	19.3	4.7	14	30	16
Fine silt	40–50	10	19.3	4.2	14	25	11
Coarse silt	0–10	10	16.7	2.6	12	19	7
Coarse silt	40–50	10	15.4	4.2	10	26	16
Very fine sand	0–10	10	9.8	0.9	9	11	2
Very fine sand	40–50	10	8.5	1.7	5	12	7
Fine sand	0–10	10	11.9	2.0	10	15	5
Fine sand	40–50	10	11.7	3.1	7	18	11
Medium sand	0–10	10	13.0	1.8	10	15	5
Medium sand	40–50	10	12.5	3.1	6	17	11
Coarse sand	0–10	10	7.1	2.2	5	11	6
Coarse sand	40–50	10	6.8	2.3	4	11	7
Very coarse sand	0–10	10	1.5	0.7	1	3	2
Very coarse sand	40–50	10	2.2	1.4	1	5	4
TNV g kg^{-1}	0–10	10	0	0	0	0	0
TNV g kg^{-1}	40–50	10	0	0	0	0	0
Ca cmol kg^{-1}	0–10	10	8.80	3.39	3.80	14.64	10.84
Mg cmol kg^{-1}	0–10	10	0.66	0.44	0.28	1.46	1.18
K cmol kg^{-1}	0–10	10	0.25	0.08	0.15	0.38	0.23
Na cmol kg^{-1}	0–10	10	0.08	0.04	0.03	0.15	0.12
TEB cmol kg^{-1}	0–10	10	9.99	3.90	4.90	17.40	12.50
CEC cmol kg^{-1}	0–10	10	17.50	3.48	12.60	24.20	11.60
Base Sat. %	0–10	10	57.5	18.0	25	91	66
pH	0–10	10	6.6	0.7	5.2	7.3	2.1
pH	40–50	10	6.9	0.6	5.6	7.5	1.9
C g kg^{-1}	0–10	10	23.4	8.3	13	39	26
C g kg^{-1}	40–50	10	2.7	0.5	2	3	1
N g kg^{-1}	0–10	10	2.8	0.9	1.6	4.5	2.9
N g kg^{-1}	0–10	10	8.4	0.5	7.3	9.3	2
C/N	0–10	10	18.8	2.1	16	22	6
C/N	40–50	10	25.4	6.5	17	39	22
Free iron g kg^{-1}	0–10	10	18.8	2.1	16	22	6
Free iron g kg^{-1}	40–50	10	25.4	6.5	17	39	22

Knockalisheen Series

This series is situated in the northwest of the county where it occupies 1988 ha (1.08% of the county). It lies principally on the lower south-facing slopes of the Knockmealdown and Comeragh mountains; relatively small areas are on the western side of the Monavullagh Mountains near Milk Hill and around Bohadoon Mountain. In the Knockmealdown region, it is associated with the Knockmealdown series, which lies at higher elevations, and with the Dodard and Newport series, which are generally at lower elevations. In the Comeragh region, it is associated with the Glenary series, which is generally at higher elevations, and with the Ballycondon or Dodard series, which are at the same or lower elevations. Elevation ranges from 150 to 300 m AMSL, but most of the series is above 215 m AMSL. Like the adjoining Dodard series, the Knockalisheen map unit, in the Knockmealdown region, contains inclusions of shallow (<1 m) peat indicating that it was originally covered by blanket peat. Vegetation is a wet heath consisting of Calluna spp. and Molinia spp. with some Erica spp., Juncus spp. and mosses. Topography is predominantly undulating or rolling; a few steep slopes were too small to map separately. The parent material is a coarse-loamy till composed predominantly of Devonian sandstone. The till is mostly on medium-grained sandstone and mudstone of the Knockmealdown and Ballytrasna formations; the small area around Bohadoon is on mudstone of the Sheskin Formation. Average annual rainfall is high; it ranges from about 1200 mm to near 1500 mm in the Comeragh region and is greater than 1500 mm in the Knockmealdown, Milk Hill and Bohadoon areas.

Typically, the surface horizon consists of black, highly decomposed, amorphous peat; it is commonly 5 to 30 cm thick, but it is over 50 cm thick in places. A layer of large stones commonly lies at the lower boundary with the albic (E) horizon. The latter horizon is predominantly grey with dark grey mottles that increase in extent with depth; the dark mottles probably reflect concentrations of organic matter. The stones have yellowish zones which indicate periodic waterlogging. A thin ironpan is invariably present; this has a black upper surface and a red lower surface, which indicates better aeration below the pan. The ironpan is generally deep (>0.5 m); pans were observed down to 1.5 m depth, and they possibly occur at greater depths. The associated albic horizons, extending from the bottom of the surface peat layer to the ironpan, are very thick. Some pedons have a thin discontinuous spodic horizon; in many pedons this horizon is absent. The parent material (C horizon) has a reddish hue and lacks redoximorphic features, which implies that the zone below the ironpan has not been waterlogged for long periods. The soil is classified as a Podzol and as a Typic Placaquod in the USDA (1999) system.

Texture is typically sandy loam throughout the profile. Clay contents of all horizons of the representative profile are ≤9%; there are many small to large stones in the E1 horizon (10–25 cm diameter), and stones are less abundant in all the lower horizons. Structural development of the mineral material deteriorates from weak in the top layer (10–25 cm depth) to massive below the ironpan. Moist consistence is friable in the top layer, firm in the remaining layers that are above the ironpan, but it is friable in the C horizon. This suggests that the firm, brittle consistence that is in part of the E horizon was not inherited from the parent material but induced during soil development. Rooting is well developed in the organic (O) horizon. Roots are common in the E1 horizon, but the

E1 and E2 horizons have few roots and very few macropores. There are some roots in the spodic horizon below the ironpan, which indicates that the ironpan is not entirely impermeable. Roots are absent in the C horizon. As the depth to the ironpan varies, the limit of rooting depth also varies widely from pedon to pedon, but it is generally shallow.

Free iron content is very low (1 g kg^{-1}) throughout the albic horizon of the representative profile; it increases substantially in the yellowish red pockets beneath the ironpan indicating that they are spodic. The free iron content of the C horizon is high compared to the albic horizon, and the formation of the ironpan probably reflects a combination of leaching and reduction under waterlogged conditions. Carbon content decreases regularly with depth from 12 g kg^{-1} in the upper mineral layer to 1 g kg^{-1} in the C horizon. The C/N ratio is high indicating a slow rate of decomposition. The very low levels of carbon in the lower albic horizons reflect poor root development. The mean cation exchange capacity of the mineral solum is very low. Base saturation is very low (< 7%) throughout the solum and parent material (< 1%), but reaction increases regularly with depth from strongly acid in the surface (pH 3.3) to moderately acid in the C horizon (pH 4.9).

The available water capacity (AWC) of the surface peaty horizon is very high. Although the clay contents of the mineral horizons are low, the available water capacities are high reflecting the high bulk density. The total available water in the representative profile, down to the ironpan, is high (176 mm). It will be higher in profiles that have a deeper peat layer at the surface and a deeper ironpan; under the high rainfall regime the soil is clearly non-droughty. The mineral horizons above the ironpan have very low (<4.4%) air capacities which, combined with the high bulk density, indicate that the hydraulic conductivity is very slow; the lower bulk density and higher air capacity of the parent material (C horizon) indicates that its hydraulic conductivity is faster than that in the overlying albic horizon.

Soil suitability: The principal limitations are largely similar to the Dodard series; they comprise low nutrient status, low bearing capacity, wetness and relatively short growing season due partly to elevation. The combined effect of these limitations is severe and is analogous to that of the Slieve Bloom series which has a limited use range (Conry, 1987). In its current condition the soil is limited to extensive grazing (Class EV); due to its very low nutrient status, probably exacerbated by the very low nutrient retention capacity of the mineral subsoil, it is poorly suited to forestry. At the lower part of the elevation range, some Ahaun soils were probably originally Knockalisheen series with mostly relatively shallow ironpans. As the remaining Knockalisheen soils are mainly at the higher elevations and have deep ironpans, their suitability for reclamation is very limited. Poor drainage will remain a continuing severe limitation as the ironpans are predominantly at depths beyond the limits of deep ploughs and rippers. A stone layer at the surface adds to the cost of reclamation. Trace elements are likely to be a temporary limitation as in the Dodard series. The soil could possibly be developed on favourable slopes to have suitability for agriculture approaching that of the poorer part of the Newport series with a suitability classification, at best, of DIV.

Representative profile description

Series:	Knockalisheen
Location:	Co. Waterford, Knockmealdown Td., Grid Ref. 205600 106100
Classification:	Ironpan Podzol (Typic Placaquod)
Parent Material:	Sandstone till
Drainage:	Poor above pan. Well drained below pan
Topography:	Undulating bench
Slope:	5°
Altitude:	245 m AMSL
Land-use:	Heath. Calluna–Molinia. Some Erica spp., Juncus squarrosus and mosses.

Horizon	Depth (cm)	Description
Oa	0-10	Black (2.5YR 2/0); amorphous peat; very fine granular structure; abundant fine and very fine roots; abrupt smooth boundary; layer of large stones lies along boundary.
E1	10–25	Dark grey (7.5YR 4/1) and pinkish grey (7.5YR 6/2); sandy loam; many small to large stones; weak medium subangular blocky structure; moderately weak semi-deformable consistence; non-plastic (wet); common fine and very fine roots; gradual wavy boundary.
E2	25–50	Pinkish grey (7.5YR 6/2) and dark grey (7.5YR 4/1); sandy loam; common small to large stones; very weakly developed coarse subangular blocky structure; moderately firm brittle consistence; non-plastic (wet); very few, very fine macropores; few very fine and fine roots; gradual wavy boundary.
E3	50–72	Reddish grey (5YR 5/2) with very dark grey (10 YR 3/1) and common brownish yellow (10YR 6/8) weathering sandstone; sandy loam; common small to large stones; very weakly developed coarse subangular blocky structure; moderately weak semi-deformable consistence; non-plastic (wet); very few, very fine macropores; few fine and very fine roots; sharp wavy boundary.
Bsm	72–74	Black 2 mm thick hard pan over 2 cm red (2.5YR 4/8) very firm to moderately strong brittle consistence; sharp wavy boundary.
Bs	74–79	Yellowish red (5YR 5/6); loamy sand; common small to large stones; massive structure; moderately firm brittle consistence; few very fine macropores; very few roots; broken gradual boundary; horizon is 5 cm thick on average and extends to 25% of pedon.
C	74+	Brown (7.5YR 5/4); loamy sand; common small to large subangular stones; massive structure; very weak slightly brittle consistence; non-plastic (wet); abundant very fine macropores; no roots.

Table 3.62: Particle size and chemical analyses, Knockalisheen Series.

Horizon	Oa	E1	E2	E3	Bs	C
Depth cm	0–10	10–25	25–50	50–72	74–79	74+
Particle Size % :						
Coarse sand 200–2000 μm		27	21	23	22	22
Fine sand 50–200 μm		48	42	44	45	47
Silt 2–50 μm		19	30	24	25	25
Clay <2 μm		6	7	9	8	6
TNV g kg^{-1}	0	0	0	0	0	0
Ca cmol kg^{-1}	0.16	0.03	0.09	0.1	0.08	0.1
Mg cmol kg^{-1}	1.4	0.11	0.08	0.06	0.08	0.05
K cmol kg^{-1}	0.36	0.02	0	0	0.01	0.01
Na cmol kg^{-1}	1.16	0.08	0.06	0.01	0.02	0.01
TEB cmol kg^{-1}	3.08	0.24	0.23	0.17	0.19	0.17
CEC cmol kg^{-1}	7.6	6.8	3.4	4.6	4.2	1.7
Base Saturation %	4	4	7	4	5	<1
pH	3.3	4	4.4	4.6	4.7	4.9
C g kg^{-1}	240	12	3	3	2	1
N g kg^{-1}	11.6	0.6				
C/N	20.7	20				
Loss on ignition g kg^{-1}	550					
Free iron g kg^{-1}	8	1	1	1	15	9

Table 3.63: Physical analyses, Knockalisheen Series.

Horizon	O	E	E	E	E	C
Sub-horizon		1	2	2	3	
Depth cm	0–10	10–25	25–35	35–50	50–72	74+
Particle density Mg m^{-3}	1.98	2.64	2.68	2.68	2.69	2.7
Bulk density at saturation Mg m^{-3}	0.28	1.71	1.72	1.79	1.65	1.58
Bulk density at -59 hPa Mg m^{-3}	0.28	1.71	1.72	1.79	1.65	1.58
Air capacity % vol.	25.8	4.2	4.4	3.5	4.0	9.1
Retained water % vol.:						
0 hPa	82.0	37.4	38.1	35.9	39.7	35.8
-2 hPa	62.5	35.7	36.3	34.2	38.0	32.7
-59 hPa	56.2	33.1	33.7	32.5	35.7	26.7
-137 hPa	N/A	31.8	32.7	31.4	34.3	24.0
-0.1 MPa	36.4	19.7	25.8	24.8	29.7	18.1
-1.5 MPa	20.2	10.2	9.0	12.8	12.1	5.1
Total available water % vol.	36.0	23.0	24.7	19.6	23.6	21.7
Total available water cm	3.6	3.4	2.5	2.9	5.2	2.2
Total available water cumulative cm	3.6	7.0	9.5	12.5	17.6	19.8

Knockboy Series

This is the most extensive series in the county. Including all phases, the total area of the series is 23,967 ha (13.03% of county). It is situated predominantly in the western part of the county; a very small proportion lies on the upper part of the ridge that extends from Kilmeadan to Kilsheelan. This series is the dominant upland sandstone soil in the county, and occurs in association with its poorly drained counterpart, the Newport series. It is interspersed in places with the Ballycondon Series, which occupies similar positions on the landscape. The Ballycondon series is under heathland; this implies that the Knockboy series was formed by reclamation of heathland. This reclamation took place over centuries; a significant amount was reclaimed in the 1970s when the economic environment was very favourable for agriculture. Most of the series lies between 120 m and 215 m AMSL on the dissected surface of the South Ireland Peneplane (Farrington, 1953). It extends in places up to 275 m AMSL, where it adjoins the virgin heaths, which consist mostly of the Ballycondon, Dodard, and Knockalisheen series, on the footslopes of the Knockmealdown and Comeragh Mountains. At its lower boundary, which extends down to 90 m AMSL, it adjoins rolling phases of the Clashmore and Portlaw series. Topography is predominantly undulating with most gradients greater than 3^0; rolling and steep phases lie along the sides of river valleys and along the footslopes of the mountains. Parent material is loamy till composed predominantly of Devonian sandstone. The bedrock underlying the till is medium grained sandstone and mudstone of the Knockmealdown and Ballytrasna formations. Average annual rainfall over most of the area is about 1250 mm; it ranges from 1100 to 1500 mm over the entire series.

Dark grey to black (Umbric) topsoil differentiates the Knockboy series from the Clashmore series, which has brown topsoil. A yellowish red to strong brown horizon, about 30 cm thick, that has high free iron content (spodic horizon) generally underlies the topsoil. As illustrated in the representative profile, a thin ironpan occurs in places, at shallow depth (≈20–40 cm); this is commonly overlain by traces of albic materials and sandstone pebbles with yellowish surfaces. Ironpans were probably extensive originally at shallow depth but were broken during reclamation. In places, ironpans remain at greater depth e.g. 60 cm in Profile II (Typic Placorthod). These pockets are distributed in an unpredictable pattern and are too small to map; they comprise a small proportion of the mapunit. The series is classified as a Brown Podzolic (Typic Haplorthod).

Texture is light loam throughout the solum; clay content of the surface layer is on average 19.1% (SD 3.0%) and varies very little with depth. Texture of the C horizon is generally coarser, it ranges from sandy loam to loam; clay contents of the C horizon of the representative profiles range from 10% to 15%. The amount and size of stones tends to increase with depth. There are common to many stones in the subsoil and generally there are not many large stones in the topsoil due partly to removal during reclamation. Some stony phases were separated mostly near the foot-slopes of the Monavullagh Mountains or over conglomerate bedrock. The topsoil has well developed structure and friable consistence. The C horizon has very weakly developed blocky structure, which contributes to the permeability of the soil. Bulk density of the solum, which generally extends to 60–70 cm depth, is moderate; bulk density of the C horizon of the representative profiles is not very high (<1.65 $Mg\ m^{-3}$). Rooting is well developed in the solum but very few roots extend below the solum. Rooting is restricted in the C horizon, but some vertical roots extend to over 1 m depth.

Although the topsoil is dark, the organic carbon content is similar to the average of mineral soils in Ireland (Brogan, 1966); however, the organic carbon content is greater than that found in the adjoining Clashmore series, which has brown topsoil. The cation exchange capacity (CEC) is relatively high, probably due to the influence of organic carbon. The solum is generally slightly acid and the C/N ratio, although within the normal range of well drained mineral soils, is slightly high (≈15) in places.

Available water capacities (AWC) of all subhorizons in the solum of the representative profile are very high to high. The total available water in the profile is very high. Under the moderately high rainfall regime, the available water in the solum is sufficient to ensure that the soil is non-droughty even if roots are considered to be restricted to the solum (<70 cm). The moderate air capacity of all subhorizons and the well developed structure of the profile indicate that permeability is at least moderately rapid. Except for the few inclusions that have an ironpan, the soil lacks evidence of waterlogging and is considered well drained.

Soil suitability: Having free drainage, friable consistence and gentle slopes, the dominant phase of the Knockboy series is suitable for both grass and arable crops. However, the productive capacity and use range is limited by climatic factors associated with elevation. The median length of the grass growing season is estimated to be 270–300 days at sea level in the region; lower temperatures associated with the higher elevation result in a shorter actual grass growing season. General farming experience indicates two to three weeks reduction at each end of the grazing season. Research at Moorepark (55 m AMSL) and at Coolnakilla (210 m AMSL) near Fermoy in Co. Cork indicates the effect of altitude on climate and grass growth in the region. On the basis of the period in which soil temperature was above 6°C, Kiely (1985) estimated the length of the growing season to be 285 days at Moorepark and 215 days at Coolnakilla (i.e. 75% of Moorepark). Degree day accumulations of air temperature greater than 5.6°C at Coolnakilla are 85% of the Moorepark values. At Coolnakilla, cows go out to grass about 21 days later in spring and are wintered about 14 days earlier than at Moorepark. The 35 day shorter grazing season at Coolnakilla is due mainly to wet soil conditions (Kiely, 1985). Experiments following reclamation showed that this land was capable of carrying about 2 cows ha^{-1} when 297 kg N ha^{-1} was used. Subsequently, when trace element problems were alleviated, the capacity at Coolnakilla reached 2.5 LU ha^{-1}, which is 85% that attained at Moorepark (3 LU ha^{-1}), (Kiely, pers. comm.). This ratio is the same as that calculated on the basis of degree-day accumulations.

Thus, provided that possible trace element deficiencies such as copper, cobalt, selenium and sulphur are identified and alleviated, relatively high stocking rates are obtainable; on this basis, the typic phase of the soil is assigned to suitability class B for grassland. As the slope and climatic limitations are cumulative, the rolling and steep phases have moderate to severe limitations and are assigned to suitability classes C and D respectively. The stony phase has a cumulative moderate limitation for grassland (Class C). The dominant phase is generally easily cultivated; cereals and root crops have been grown successfully. The area devoted to arable crops is small; the best use of the soil is pasture. Low temperatures shorten the growing season and seriously affect the suitability for sugar beet and maize. The moderately high rainfall reduces the number of work days in spring, and therefore winter cereals are probably the most suitable arable crops. In a series of experiments, in 1989 and 1990, MacNaeidhe (1994) found responses to Mn, Cu and Zn on a Knockboy soil at Boola, Youghal. Overall, this phase is only moderately suited to arable crops and is assigned to Class III. The slope phases have severe limitations for arable crops (Class IV and V).

Representative profile description

Series:	Knockboy
Location:	Co. Waterford, Glennaglogh Td., Grid Ref. 201200 87100
Classification:	Brown Podzolic (Typic Haplorthod).
Parent Material:	Till, predominantly purple sandstone, some greenish greywacke
Drainage:	Well
Topography:	Undulating plateau
Slope:	3°
Altitude:	170 m AMSL
Land-use:	Old pasture, yorkshire fog, sweet vernal, buttercup.

Horizon	Depth (cm)	Description
A1	0–10	Very dark grey (10YR 3/1); loam; few small stones; moderately developed medium granular structure; friable consistence; moderately plastic (wet); abundant very fine diffuse roots.
A2	10–20	Similar to A1.
A3	20–40	Similar to A1. Sharp wavy boundary. Patches of albic materials with yellow weathering sandstone lie above the iron pan in places.
Bsm	40	Ironpan, discontinuous, 1–2 mm thick.
Bs	40–70	Strong brown (7.5YR 5/6); loam; common small and medium stones; weakly developed compound medium and fine subangular blocky structure; very friable consistence; moderately plastic (wet); abundant very fine macropores; few very fine roots; clear wavy boundary.
C1	70–100	Brown (7.5YR 5/3) and brown (7.5YR 5/5) near vertical 2 cm wide seams; many stones mainly small; very weakly developed compound coarse and fine angular blocky structure; moderately weak semi-deformable consistence; moderately plastic (wet); many very fine macropores; very few roots; gradual irregular boundary.
C2	>100	Reddish grey (5YR 4.5/2) and few brown (7.5YR 5/5) near vertical seams 5 cm wide; sandy loam; many stones, mainly small; compound very weakly developed coarse and fine angular blocky structure; moderately weak semi-deformable consistence; moderately plastic (wet); many very fine macropores; very few vertical roots.

Table 3.94: Particle size and chemical analyses, Knockboy Series.

Horizon	A1	A2	A3	Bs	Bs	C1	C2
Depth cm	0–10	10–20	20–40	40–55	55–70	70–100	>100
Particle Size % :							
Coarse sand 200–2000 μm	12	15	15	17	20	22	18
Fine sand 50–200 μm	25	22	22	19	22	20	22
Silt 2–50 μm	45	44	44	45	45	48	45
Clay <2 μm	18	19	19	19	13	10	15
TNV g kg^{-1}	0	0	0	0	0	0	0
Ca cmol kg^{-1}	10.7	10.6	9.25	5.41	1.68	6.62	0.5
Mg cmol kg^{-1}	0.56	0.38	0.29	0.2	0.16	0.13	0.07
K cmol kg^{-1}	0.09	0.05	0.04	0.07	0.04	0.01	0.01
Na cmol kg^{-1}	0.16	0.04	0.01	0.01	0.1	0.01	0.04
TEB cmol kg^{-1}	11.51	11.04	9.59	5.69	1.98	6.77	0.62
CEC cmol kg^{-1}	26.4	28	22.6	25.4	15.9	7.2	6.4
Base Saturation %	44	39	42	22	12	14	10
pH	5.5	5.8	6	5.7	5.5	5.4	5.4
C g kg^{-1}	51	43	41	15	9	2	2
N g kg^{-1}	3.4	3.2	2.4	0.9	0.5		
C/N	15.0	13.4	17.1	16.7	18.0		
Free iron g kg^{-1}	14	14	14	44	30	17	17

Table 3.95: Physical analyses, Knockboy Series.

Horizon	A	A	A	A	B	B	C	C
Sub-horizon	1	2	3	3	s	s	1	2
Depth cm	0–10	10–20	20–30	30–40	40–55	55–70	70–100	100+
Particle density Mg m^{-3}	2.3	2.42	2.42	2.42	2.59	2.59	2.51	2.72
Bulk density at saturation Mg m^{-3}	0.97	1.09	1.16	1.21	0.96	1.12	1.51	1.63
Bulk density at -59 hPa Mg m^{-3}	0.97	1.09	1.16	1.21	0.96	1.12	1.51	1.63
Air capacity % vol.	11.3	6.8	6.7	10.0	10.1	11.7	7.4	7.5
Retained water % vol.:								
0 hPa	56.1	52.7	54.4	50.2	61.3	52.9	38.8	36.9
-2 hPa	50.9	49.0	53.1	48.1	56.7	48.2	36.2	34.0
-59 hPa	44.8	45.8	47.7	40.2	51.2	41.2	31.4	29.5
-137 hPa	43.7	44.7	46.4	39.0	49.4	39.7	29.8	28.4
-0.1 MPa	38.5	42.4	40.4	36.5	43.2	34.9	25.6	26.2
-1.5 MPa	18.8	19.0	18.4	17.4	21.4	16.2	9.6	11.8
Total available water % vol.	26.0	26.9	29.3	22.8	29.8	25.1	21.8	17.7
Total available water cm	2.6	2.7	2.9	2.3	4.5	3.8	6.5	1.8
Total available water cumulative cm	2.6	5.3	8.2	10.5	15.0	18.7	25.3	27.0

Table 3.96: Descriptive statistics, Knockboy Series.

	Depth cm	Count	Mean	Standard Deviation	Minimum	Maximum	Range
Clay	0–10	64	19.1	3.0	13	26	13
Clay	40–50	64	18.6	3.3	9	27	18
Fine silt	0–10	64	23.6	3.8	14	36	22
Fine silt	40–50	64	23.5	4.4	12	34	22
Coarse silt	0–10	64	20.0	2.9	13	27	14
Coarse silt	40–50	64	18.4	3.8	3	26	23
Very fine sand	0–10	64	9.6	2.9	5	20	15
Very fine sand	40–50	64	8.9	2.8	3	16	13
Fine sand	0–10	64	9.5	2.8	4	18	14
Fine sand	40–50	64	9.1	2.5	4	17	13
Medium sand	0–10	64	8.8	2.4	4	18	14
Medium sand	40–50	64	9.4	2.7	5	23	18
Coarse sand	0–10	64	6.1	1.9	3	15	12
Coarse sand	40–50	64	7.1	2.0	3	13	10
Very coarse sand	0–10	64	3.1	2.0	1	15	14
Very coarse sand	40–50	64	5.0	2.6	2	16	14
TNV g kg^{-1}	0–10	64	0	0	0	0	0
TNV g kg^{-1}	40–50	64	0	0	0	0	0
Ca cmol kg^{-1}	0–10	64	11.90	5.42	2.6	32.4	29.8
Mg cmol kg^{-1}	0–10	64	1.24	4.56	0.11	37	36.89
K cmol kg^{-1}	0–10	64	0.73	4.36	0.01	35	34.99
Na cmol kg^{-1}	0–10	64	0.08	0.04	0.01	0.26	0.25
TEB cmol kg^{-1}	0–10	64	12.83	5.44	3.05	33.49	30.44
CEC cmol kg^{-1}	0–10	64	26.7	10.2	15.2	70.4	55.2
Base Sat. %	0–10	64	49.7	17.8	12	87	75
pH	0–10	64	5.9	0.6	4.8	7.4	2.6
pH	40–50	64	6.1	0.5	4.9	7.1	2.2
C g kg^{-1}	0–10	64	46.7	19.4	26	124	98
C g kg^{-1}	40–50	64	16.5	7.6	4	44	40
N g kg^{-1}	0–10	64	3.8	1.0	2.3	8	5.7
N g kg^{-1}	40–50	62	1.5	0.5	0.9	3.1	2.2
C/N	0–10	64	12.1	2.5	8.8	21.8	13
C/N	40–50	62	11.0	2.5	7	20	13
Free iron g kg^{-1}	0–10	64	18.0	5.6	6	41	35
Free iron g kg^{-1}	40–50	64	26.7	9.3	9	58	49

Profile II description

Series:	Knockboy
Location:	Co. Waterford, Lyrenacallee West Td., Grid Ref. 206800 101200.
Classification:	Brown Podzolic (Typic Placaquod)
Parent Material:	Sandstone till
Drainage:	Free below pan; impeded above lower pan.
Topography:	Undulating
Slope:	2º
Altitude:	180 m AMSL
Land-use:	Old pasture, many thistles

Horizon	Depth (cm)	Description
A1	0–10	Very dark grey (10YR 3/1); loam; few small stones; weak to moderate medium granular structure; friable consistence; moderately plastic (wet); abundant very fine roots.
A2	10–25	Very dark grey (10YR 3/1); loam; common small and medium stones; moderate medium granular structure; friable consistence; very plastic (wet); abundant very fine roots; sharp wavy boundary.
Bsm	25	Thin ironpan; wavy; broken in places.
A/Eg	25–60	Pinkish grey (7.5YR 5/2 to 6/2) and black (7.5YR 2/0) and olive yellow (2.5 Y 6/8) weathering stones; loam; common small and medium stones; moderate medium granular (dark material) and weak medium subangular blocky (grey material) structure; friable consistence; very plastic (wet); many very fine roots; sharp wavy boundary.
Bsm	60±10	Ironpan, wavy, continuous. Yellow upside, black underside.
C1	60–100	Brown 7.5YR 4/3; loam; common small and medium stones; very weak compound coarse and fine subangular blocky structure; friable semi-deformable consistence; very plastic (wet); common fine pores; very few roots diminishing with depth.
C2	100–160	As next horizon above except no mangans or roots.

Table 3.97: Particle size and chemical analyses, Knockboy Series, profile II.

Horizon	A1	A2	A/Eg	C1	C2	C3
Depth cm	0–10	10–25	25–60	60–100	100–160	>160
Particle Size % :						
Coarse sand 200–2000 μm	18	21	19	23	24	19
Fine sand 50–200 μm	30	29	25	28	33	28
Silt 2–50 μm	34	33	37	36	32	28
Clay <2 μm	18	17	19	13	11	15
TNV g kg^{-1}	0	0	0	0	0	0
Ca cmol kg^{-1}	6.22	6.40	3.81	0.50	0.30	0.23
Mg cmol kg^{-1}	0.71	0.49	0.31	0.12	0.06	0.08
K cmol kg^{-1}	0.12	0.06	0.02	0.02	0.01	0.01
Na cmol kg^{-1}	0.13	0.06	0	0	0	0.03
TEB cmol kg^{-1}	7.18	7.01	4.14	0.64	0.37	0.35
CEC cmol kg^{-1}	26.8	22.2	18.6	4.3	2.8	3.8
Base Saturation %	27	32	22	15	13	9
pH	4.6	4.9	5.3	5.2	5.1	5
C g kg^{-1}	47	38	14	2	2	1
N g kg^{-1}	3.9	3	1			
C/N	12.1	12.7	14			
Free iron g kg^{-1}	10	11	19	11	15	16

Table 3.98: Physical analyses, Knockboy Series, profile II.

Horizon	A	A	E	E	C	C
Sub-horizon	1	2	g	g	1	1
Depth cm	0–10	10–25	25–40	40–60	60–80	80–100
Particle density Mg m^{-3}	2.42	2.47	2.61	2.61	2.69	2.69
Bulk density at saturation Mg m^{-3}	1.01	1.17	1.28	1.38	1.57	1.63
Bulk density at -59 hPa Mg m^{-3}	1.01	1.17	1.28	1.38	1.57	1.63
Air capacity % vol.	11.0	12.1	12.8	9.4	11.1	10.6
Retained water % vol.:						
0 hPa	59.1	54.9	46.5	42.6	42.2	38.7
-2 hPa	50.5	45.6	38.3	35.9	35.1	31.5
-59 hPa	48.1	42.9	33.6	33.2	31.1	28.2
-137 hPa	47.4	42.2	32.9	32.4	29.6	26.7
-0.1 MPa	39.4	36.8	29.9	29.4	26.2	24.3
-1.5 MPa	19.9	19.2	25.0	17.7	15.1	14.1
Total available water % vol.	28.2	23.7	8.6	15.5	16.0	14.1
Total available water cm	2.8	3.6	1.3	3.1	3.2	2.8
Total available water cumulative cm	2.8	6.4	7.7	10.8	13.9	16.8

Knockmealdown Series

This series occupies 2767 ha (1.50% of county) in the northwestern part of the county, immediately south of the Co. Tipperary border. It is on the upper slopes and summits of the Knockmealdown Mountains; it lies mainly above the Knockalisheen series and, to a lesser extent, the Ballycondon and Dodard series. The terrain is mountainous; elevation ranges from about 275 m to 795 m AMSL at the summit of Knockmealdown. Vegetation is mostly sheep-grazed heath dominated by heather and some coniferous forest plantations. East of The Gap, most slopes are moderately steep or steep; towards the west, on the more gently sloping spur south of Knocaunabulloga, rolling slopes, and to a lesser extent undulating slopes, are common. Outcrops of bare rock are sparse; coarse loamy or loamy-skeletal diamicton (drift) composed predominantly of Devonian sandstone covers virtually all the Knockmealdown area. Most of the diamicton was probably of glacial origin. Mitchell (1992) noted silicified limestone, which indicates a glacial origin, up to 570 m AMSL, and Lewis (1976) records that Knockmealdown Mountain is mantled with clitter between 380 and 685 m AMSL; above that altitude there are stone-runs, stone terraces and screes that continue to the summit. Mitchell (1992) concluded that the diamicton on the relatively flat top of the Knockaunabulloga spur was cryoturbated; he described a site at 570 m AMSL in Glentaunatinagh Td., where the diamicton was interrupted by vertical 'walls' of clast-supported cobbles at two to three metre intervals. He regarded the walls as forming a large polygon network; they appear to be similar to the parent material of the Glenary Soil Series. The diamicton overlies medium grained sandstone of the Knockmealdown Formation. Average annual rainfall is over 1500 mm but less than 1750 mm, and on average there are over 175 rain-days (>1 mm) per year.

Thickness of the surface peat layer varies widely; it is commonly 40 to 60 cm and ranges from 5 cm to 1m. Thin (5–10 cm) peat over stones predominates on the mountain summits; on Knockmealdown Mountain, peat thickness varies from 50 cm at the base of the steep slope to 5 cm at the summit. The peat layer generally thickens on the lower slopes and on saddles, but there is considerably local variation due partly to cutting. For example on the lower slopes in Knockaveelish Td. peat is typically about 0.5 m thick, but it ranges from 0.1 to 1 m. The soils are assigned to one map unit, although the depth of peat spans the limit that distinguishes peat and mineral soils; the limit ranges from 30 cm (FAO) to 40 or 60 cm (USDA, 1999) depending on the degree of decomposition. A rigorous application of taxonomic criteria would lead to the classification of a large part of the map unit as peat (Histosol).

The peat layer of the representative profile, situated on a moderately steep (16^{o}) slope at 490 m AMSL, is 75 cm thick. Organic materials are distinguished on the basis of degree of decomposition, which is determined by fibre content and sodium pyrophosphate extract colour (SPEC). However, the fibre and pyrophosphate tests do not confirm one another in all the peat layers. Both tests indicate well-decomposed sapric material at 0 to 25 cm and 65 to 75 cm depths; at 25 to 65 cm depth the fibre test indicates moderately decomposed hemic material, whilst the SPEC test indicates sapric material. The fibre content relates better than the SPEC values to bulk density and volumetric water content at saturation. The material at 25 to 65 cm is designated hemic as it does not meet both the unrubbed fibre content and the sodium-pyrophosphate solubility requirements for sapric materials (USDA,

1999) This layer is underlain by a thin (10 cm) black layer composed of highly decomposed sapric material with very low (<2%) rubbed fibre content. As hemic soil materials are dominant in the subsurface, and as there is a thick (>30 cm) mineral layer within the control section, this pedon is a Terric Medihemist.

The mineral horizons are very irregular and reflect the contorted configuration of the cryoturbated parent material. The uppermost mineral horizon is a pinkish grey albic (E) horizon. Texture is sandy loam with many angular stones; structure is massive and consistence is moderately firm and brittle. The next underlying horizon is reddish and black organic material coats the stones. A thin, 10 cm thick, strong brown spodic horizon extends to about two-thirds of the pedon; it is underlain by very stony sandy loam, which in places, has black organic coats around the stones. Ironpans were observed in exposed sections elsewhere; they are probably extensive, but stones limit their detection with hand augers. It is thought that the dominant soil in the map unit is a Peaty Podzol with ironpan (Typic Placaquod), but there are substantial inclusions of Peat (Histosol).

The entire profile, including both organic and mineral horizons, is strongly acid with a very low base saturation that is ≤ 10% in all horizons. Total exchangeable bases (TEB) of the organic horizons are many times (30–475) greater than that of the mineral horizons; the difference is less when expressed on a volumetric basis, but it is still large. No exchangeable calcium was detected in the mineral horizons that had less than 103 g kg^{-1} organic carbon. The upper albic (E1) horizon and the parent material (C2), which lack accumulation of organic matter, have very low retention capacity as indicated by the very low cation exchange capacity (CEC). The ash content of the lowest organic horizon (Oa3) is relatively high and is consistent with very high decomposition. Compared to peat soils, the C:N ratio of the peat layer is low (<25) and indicates that the nitrogen is potentially mineralisable (Williams, 1983).

The saturated water content of the peat layer of the representative profile is high compared to mineral soils. The average for all horizons of the peat layer is 84% vol.; the highly decomposed (sapric) lowest horizon has the lowest content while the moderately decomposed (hemic) horizons, next above, have the highest contents. The air-filled porosity at –59 hPa is very large in all horizons except the lowest horizon where the porosity is smaller. Most of the air-filled porosity consists of macropores corresponding to suctions lower than –20 hPa; there is very little water held between –20 hPa and –59 hPa. As very long periods (1–6 months) were required to reach equilibrium at – 59 hPa in the laboratory, it is likely that water is seldom at this tension in the field especially under the prevailing frequent rainfalls. The water retained between –59 hPa and 1.5 MPa (AWC) is very large (30–51% vol.), but the available water capacity in the field is likely to be greater owing to disequilibrium between the applied tension and actual water content.

Degree of decomposition influences the hydraulic conductivity of organic materials. Boelter (1969) found the slowest hydraulic conductivity in sapric materials (<2.1 cm sec x 10^{-5}), the most rapid in fibric materials (>180 cm sec x10^{-5}) and intermediate values in hemic materials. This implies slow rates in the peat layer of the Knockmealdown series. The calculated hydraulic conductivity of each peaty horizon, based on drainable porosity at – 99 hPa (Galvin, 1976) and also on bulk density (Boelter, 1969), are shown below (Table, *Physical Analyses*). Whilst the values based on porosity are generally greater than those based on bulk density, the rates range from slow (<10 cm day^{-1}) to very slow (<1cm day^{-1}) for both methods. The very slow rates are in the lowest layer (65–75 cm depth). Owing to the slow drainage rate, moisture equilibrium conditions between matric and gravity forces may not be reached even within a long period of time (Stakman, 1980). Hence, where the peat layer is moderately deep, the soil water regime of the Knockmealdown series is probably similar to blanket bog, where the perched water table may be very shallow (< 0.1 m) in winter or shallow (<0.2 m) in summer (Burke, 1975). In addition, the dense massive albic horizon and in places ironpans contribute to drainage impedance.

Soil suitability: The principal limitations are moderately steep to steep slopes, low nutrient status, weak bearing capacity, wetness and short growing season due partly to high elevation. The combined effect of these limitations for agriculture is generally severe. It is likely that the peat layer contains mineralisable nitrogen, but the status of other nutrients, including bases and phosphorus, is very low; exposure is an additional limitation for forestry. Most of the Knockmealdown map unit, in its current condition, is poorly suited to forestry. As the available nutrients and the nutrient retention capacity are contained predominantly in the peaty layer, it is important that the peat is not cut away or subjected to management practices that induce accelerated erosion. On the south facing steep slope of Knockmealdown there is virtually no erosion, whereas there is a significant amount on the west side. This appears to be attributable largely to peat cutting. Generally, the best use of the Knockmealdown map unit is a combination of extensive sheep grazing, which controls the heath and impedes the development of a low shrub vegetation, and recreational use. Areas suitable for reclamation are limited to undulating or rolling slopes at the lower elevations; suitable topography and road access are an essential requirement for reclamation by both deep ploughing/ripping and surface seeding (cf. Glenary Series) due to the large amounts of lime required. Grassland was established in the Ballysaggart area (Knockaveelish Td.) in 1980 at about 333 m AMSL. With the improvement in soil fertility, rushes gradually invaded the grassland, and eventually most of the area was planted with coniferous trees. Reclamation also presents a risk of enrichment of surface water with phosphorus; large amounts of phosphorus are required to establish grassland; it is only weakly retained by peat, and the risk of overland flow is high, owing to prolonged waterlogging.

Representative profile description

Series:	Knockmealdown
Location:	Co. Waterford, Knocnalougha Td., Grid Ref. 202100 109000
Classification:	Peat over Placic Podzol
Parent Material:	Sandstone Bedrock
Drainage:	Poor
Topography:	Steep to rolling mountain
Slope:	Moderately steep, 15°–17°
Altitude:	490 m AMSL
Land-use:	Heath

Horizon	Depth/ Thickness (cm)	Description
Oa1	0–20	Black (5YR 2/1) semi-fibrous peat; dark brown exudate; gradual smooth boundary to Oe1, sharp to Oa2.
Oa2	20–25	Very dark grey (5YR 3/1); semi-fibrous peat; fibres coarser than in Oa1; sharp smooth discontinuous boundary.
Oe1	20–45	Black (5YR 2/1), semi-fibrous peat; dark brown exudate; gradual wavy boundary.
Oe2	45–65	Black (2.5YR 2/0) amorphous peat; black exudate; clear smooth boundary.
Oa3	65–75	Black 2.5YR 2/0 amorphous peat; black exudate; sharp, wavy boundary.
E1	75–95(105)	Pinkish grey (5YR 6/2) and few yellowish weathering stones; many small to large angular stones; massive structure; moderately firm brittle consistence; very few very fine macropores; no roots; clear wavy boundary.
E2	10–70 (thick)	Weak red (2.5YR 5/2) and common black organic coatings around stones; loamy sand; many very small to very large angular stones; massive structure; moderately firm brittle consistence; moderately plastic (wet); very few fine pores; very few roots; clear irregular boundary.
Bs	10 (thick)	Strong brown (7.5YR 5/5); loam; many medium to large stones; weak compound coarse and fine subangular blocky structure; moderately weak slightly brittle consistence; moderately plastic (wet); abundant very fine pores; few roots; discontinuous irregular boundary; extends to two-thirds of pedon.
C1	50 (thick)	Pockets 50 cm deep, 10–50 cm wide; stones covered with black organic coatings.
C2	> 140(185)	Dark brown (7.5YR 4/3) loamy sand; very abundant medium to very large stones; massive structure; very weak semi-deformable consistence, abundant very fine pores; no roots.

Table 3.64: Particle size and chemical analyses, Knockmealdown Series.

Horizon	Oa1	Oa2	Oe1	Oe2	Oa3	E1	E2	Bs	C1	C2
Depth cm	0–20	20–25	20–45	45–65	65–75	75–95	(10–70 thick)	(10 thick)	(50 thick)	>140
Particle Size % :										
Coarse sand 200–2000 μm						30	30	27	31	33
Fine sand 50–200 μm						29	31	35	9	40
Silt 2–50 μm						32	28	30	25	19
Clay <2 μm						9	11	8	35	8
T.N.V g kg^{-1}										
Ca cmol kg^{-1}	5.36	3.4	2.56	2.16	2.2	0	0	0	1.82	0
Mg cmol kg^{-1}	2.68	3.12	1.8	3.04	5.72	0.13	0.05	0.04	0.79	0.01
K cmol kg^{-1}	0.72	0.54	0.22	0.06	0.04	0.01	0.01	0.02	0.09	0.01
Na cmol kg^{-1}	0.74	0.86	0.54	0.68	0.84	0.03	0.03	0.06	0.47	0
TEB cmol kg^{-1}	9.5	7.92	5.12	5.94	8.8	0.17	0.09	0.12	3.17	0.02
C.E.C cmol kg^{-1}	116	136	64	86.4	90	2.4	10.8	20.4	31.2	3
Base Saturation %	8	6	8	7	10	7	<1	<1	10	<1
pH	3.8	3.7	3.8	3.8	3.8	4.1	4.1	4.2	4.4	4.5
C g kg^{-1}	352	322	350	332	344	1	5	12	103	2
N g kg^{-1}	17.8	20	17.4	14.8	13.6			0.6	5.8	
C/N	19.8	16.1	20.1	22.4	25.3			20	17.8	
Loss on ignition g kg^{-1}	925	943	952	967	847				27.5	
Free iron g kg^{-1}	3	1	2	5	9	6	17	39	68?	20
Fe (Tri-acid) g kg^{-1}									2.9	
Ash O.D. g kg^{-1}	75	57	48	33	153					
Fibre unrubbed % vol	80	80	88	64	12					
Fibre rubbed % vol	16	8	24	24	<2					
SPEC[1] value/chroma	5/4	6/4	5/4	4/4	3/2					

[1] Sodium Pyrophosphate Extract Colour

Table 3.65: Physical analyses, Knockmealdown Series.

Horizon	O	O	O	O	O	E	C
Sub-horizon	a1	a2	e1	e2	a3	2	1
Depth cm	0–20	20–25	25–45	45–65	65–75	10–70	70–80
Particle density Mg m^{-3}	1.52	1.48	1.54	1.46	1.49	2.7	2.64
Bulk density at saturation Mg m^{-3}	0.26	0.18	0.16	0.16	0.31	1.71	0.91
Bulk density at -59 hPa Mg m^{-3}	0.26	0.18	0.16	0.16	0.31	1.71	0.91
Air capacity % vol.	24.1	23.9	22.1	17.5	12.3	4.8	11.3
Retained water % vol.:							
0 hPa	81.6	84.8	90.7	86.1	74.2	39.1	63.6
-2 hPa	59.2	65.7	72.7	70.7	62.8	37.0	55.7
-59 hPa	57.5	60.9	68.6	68.6	61.8	34.4	52.2
-137 hPa	N/A	N/A	N/A	N/A	N/A	33.8	51.4
-0.1 MPa	39.3	41.7	40.2	41.5	43.4	28.9	44.1
-1.5 MPa	27.5	21.2	20.7	17.7	18.6	10.4	25.4
Total available water % vol.	29.9	39.7	47.9	50.8	43.2	23.9	26.9
Total available water cm	6.0	2.0	9.6	10.2	4.3	14.4	2.7
Total available water cumulative cm	6.0	8.0	17.6	27.7	32.0	46.4	49.1
Hydraulic conductivity[A] cm day^{-1}	6.7	8.4	5.8	2.4	0.9		
Hydraulic conductivity[B] cm day^{-1}	0.1	2.9	6.0	6.0	0.02		

[A] Estimate based on drainable porosity at -99 hPa (Galvin, 1976)
[B] Estimate based on density (Boelter, 1969)

Lickey Series

This series occupies 1280 ha (0.70% of the county) in the southwest of the county. It is situated in the upper reaches of the Lickey catchment, where it lies in a gently sloping basin that receives runoff from surrounding higher ground. It is associated on the landscape with the Ahaun, Drumslig, and Knockboy series. Elevation ranges from 125 to 215 m AMSL. The parent material is till composed of sandstone; the Gyleen Formation, which consists of sandstone and mudstone bedrock, underlies virtually all of the till. Rushes are common in pastures including fields that have been artificially drained. Average annual rainfall is between 1125 and 1250 mm.

A typical profile has greyish topsoil with reddish root mottles; this is underlain by a grey horizon (E) with few or no mottles. Some topsoils are dark, but they are generally thin. The dominant colour of the matrix of the B horizon is grey (Chroma ≤ 2); black or strong brown mottles are common to abundant, and the stones have yellowish red outer margins. The soil is classed as a Gley (USDA: Typic Epiaquept). It is differentiated from the Ballymacart series, which has similar parent material, on the basis of the greater amount of low chroma material, which indicates a longer period of saturation (USDA, 1999).

Texture is typically light loam throughout the profile and is similar to the texture of well drained soils derived from sandstone till. The average clay content of the surface layer (0–10 cm) is 21.4% (SD 4.5%). Clay content decreases slightly in the subsoil to 18.4% (SD 5.0%). Structure of the topsoil is generally weakly developed and granular; structure of the subsoil is massive or, as shown in the representative profile, consists of very large, massive, very weakly developed prisms, which extend down to 1.5 m depth. Roots are abundant and diffuse in the topsoil; in the subsoil they are sparse, mainly vertical, and confined to ped faces.

The organic carbon content of the surface layer (0–10 cm) varies widely from low to extremely high; in places, the surface layer is organic. The average organic carbon content is high (9.7%) and is substantially higher than that found in the well drained associate, the Knockboy series. The cation exchange capacity of the surface layer is typically high but, reflecting the variation in organic carbon content, ranges from low to extremely high. A slow rate of decomposition of organic material is indicated by the large carbon to nitrogen ratio. If an outlier with anomalously high free iron content is excluded from the table below (Descriptive Statistics), the average free iron content of the surface layer (1.4%) is very similar to the average content (1.3%) at 40–50 cm depth. The analyses for the representative profile, however, reveals a much higher free iron content in the subsoil horizons that have ochreous mottles than in the topsoil or in the subsoil at 18–30 cm and 100–110 cm depths, where there are less ochreous mottles.

The available water capacity (AWC) of the surface layer (0–10 cm) of the representative profile described below is very high; the AWC is smaller in the rest of the profile where it ranges from moderately low to moderately high. The total amount of available water in the profile, down to one metre depth, is high. Very few vertical roots extend along the faces of peds to 1.5 m depth. Retained water ranges from very high to high in the A horizon and is moderately low throughout the rest of the profile. Air capacity is high in the surface layer but it is low throughout the subsoil, which has a low carbon content and high to very high bulk density. This implies that the hydraulic conductivity of the subsoil is slow or very slow, which contributes to the poor drainage.

Soil suitability: The principal limitation is wetness. Owing to the very slow hydraulic conductivity, wetness will remain a continuing limitation after field drainage. As shown in the representative profile, parts of the subsoil may be brittle; subsoiling is likely to be beneficial where the brittle horizons lie near the surface. However, the dry conditions required for subsoiling are limited by the moderately high rainfall. Owing to the high available water capacity of the profile, drought is not a limitation. The soil is poorly suited to grassland and arable crops. In the undrained state, pastures are dominated by rushes; much of the land is devoted to silviculture. Although the climate favours a long growing season and high levels of grass production, soil wetness reduces substantially dry matter production, and the risk of severe poaching damage shortens the safe grazing season. The soil is poorly suited to arable crops and is assigned to suitability class DIV. The nutrient supply capacity of the subsoil is very low; under agriculture the fertility of the topsoil has been improved, and the soil is very suited to forestry especially Sitka Spruce. Windthrow, however, poses a risk owing to the very plastic consistence of the soil when wet.

Representative profile description

Series:	Lickey
Location:	Waterford, Reamanagh East Td., Grid Ref. 220600 87100
Classification:	Gley (Typic Epiaquept)
Parent Material:	Sandstone till
Drainage:	Poor
Topography:	Undulating
Slope:	3^{o}
Altitude:	145 m. AMSL
Land-use:	Old Pasture. Rush, buttercup, meadow sweet and grass

Horizon	Depth (cm)	Description
A1	0–10	Greyish brown (10YR 5/2) and common reddish brown (5YR 4/4) root mottles; loam; few small stones; weakly developed medium granular structure; friable consistence; very plastic (wet); abundant very fine and fine roots.
A2	10–18	Greyish brown (10YR 5/2) and common reddish brown (5YR 4/4) root mottles; loam; few small stones; weakly developed medium granular structure; friable consistence; very plastic (wet); abundant very fine and fine roots; clear smooth boundary.

Eg	18–30	Light grey to very pale brown (10YR 7/2-7/4) and few medium yellowish red mottles (5YR 5/6); loam; common small and medium stones; weakly developed coarse prismatic structure; firm semi-deformable consistence; very plastic (wet); common very fine and fine macropores; common vertical very fine and fine roots; gradual wavy boundary.
Bg1	30–65	Pinkish grey (7.5YR 6/2-7/2) and abundant strong brown (7.5YR 5/6) mottles and reddish yellow (7.5YR 5/8) weathered stones; loam; common small to medium stones; very weakly developed very coarse prismatic structure; firm semi-deformable consistence; very plastic (wet); few very fine macropores; few very fine vertical roots; abrupt irregular boundary.
Bg2	65–100	Brown (7.5YR 5/2) and many fine to coarse black mottles (mangans) and common coarse pinkish grey (7.5YR 6/2) mottles; loam; common small to large stones; very weakly developed very coarse prismatic structure; very firm brittle consistence; very plastic (wet); few very fine macropores; very few, very fine roots; sharp irregular boundary.
Bg3	100–110	Pinkish grey (7.5YR 6/2) and common coarse strong brown (7.5YR 5/5) mottles and reddish yellow (7.5YR 7/8) weathering stones; loam; common small to large stones; very weakly developed very coarse prismatic structure; firm, semi-deformable consistence; very few, very fine roots; sharp wavy boundary.
Bg4	110–150	Brown (7.5YR 5/2) with many fine and medium black mottles (mangans) and common coarse pinkish grey (7.5YR 6/2) mottles; loam; common small to large stones; very weakly developed very coarse prismatic structure; very firm brittle consistence; few very fine macropores; very few, very fine roots; gradual wavy boundary.
C	150–180+	Brown (7.5YR 5/2) and common medium black mangans; sandy loam; common small to large stones; massive structure; firm brittle consistence; few very fine macropores; no roots.

Table 3.66: Particle size and chemical analyses, Lickey Series.

Horizon	A1	A2	Eg	Bg1	Bg2	Bg3	Bg4	C
Depth cm	0–10	10–18	18–30	30–65	65–100	100–110	110–150	150–180
Particle Size % :								
Coarse sand 200–2000 μm	19	18	26	26	25	20	22	31
Fine sand 50–200 μm	29	27	35	28	25	30	27	23
Silt 2–50 μm	28	30	24	30	30	32	29	26
Clay <2 μm	24	25	15	16	20	18	22	20
TNV g kg^{-1}	0	0	0	0	0	0	0	0
Ca cmol kg^{-1}	3.39	2.95	1.09	1.3	2.09	1.68	2.39	2.1
Mg cmol kg^{-1}	0.5	0.43	0.23	0.19	0.25	0.22	0.21	0.16
K cmol kg^{-1}	0.08	0.02	0.01	0.01	0.05	0.03	0.03	0.04
Na cmol kg^{-1}	0.14	0.08	0.1	0.02	0.04	0.02	0.01	0.01
TEB cmol kg^{-1}	4.11	3.48	1.43	1.52	2.43	1.95	2.64	2.31
CEC cmol kg^{-1}	17.2	12.4	2.4	1.8	3.4	3	3.6	3.2
Base Saturation %	24	28	60	84	71	65	73	72
pH	4.4	4.5	5.3	5.5	5.9	6.2	6.4	6.9
C g kg^{-1}	37	20	4	1	1	1	1	1
N g kg^{-1}	3.3	1.7						
C/N	11.2	11.8						
Free iron g kg^{-1}	13	14	9	22	28	15	22	20

Table 3.67: Physical analyses, Lickey Series.

Horizon	A	A	E	B	B	B
Sub-horizon	1	2	g	g1	g2	g2
Depth cm	0–10	10–18	18–30	30–65	65–80	80–100
Particle density Mg m^{-3}	2.38	2.52	2.69	2.61	2.73	2.73
Bulk density at saturation Mg m^{-3}	0.79	1.27	1.71	1.79	1.81	1.82
Bulk density at -59 hPa Mg m^{-3}	0.79	1.27	1.71	1.79	1.81	1.82
Air capacity % vol.	17.3	6.8	5.3	5.9	3.8	4.1
Retained water % vol.:						
0 hPa	68.8	50.4	35.8	35.1	30.0	31.3
-2 hPa	54.2	45.2	31.5	31.3	28.1	29.4
-59 hPa	51.5	43.7	30.5	29.3	26.2	27.2
-137 hPa	49.9	42.7	29.7	28.5	25.7	26.8
-0.1 MPa	41.1	38.2	26.7	25.0	23.5	23.8
-1.5 MPa	20.8	24.6	19.6	10.5	13.7	10.5
Total available water % vol.	30.7	19.0	10.9	18.8	12.5	16.8
Total available water cm	3.1	1.5	1.3	6.6	3.1	3.4
Total available water cumulative cm	3.1	4.6	5.9	12.5	15.6	19.0

Table 3.68: Descriptive statistics, Lickey Series.

	Depth cm	Count	Mean	Standard Deviation	Minimum	Maximum	Range
Clay	0–10	9	21.4	4.5	14	27	13
Clay	40–50	10	18.4	4.9	8	23	15
Fine silt	0–10	10	16.7	6.9	0	24	24
Fine silt	40–50	10	18.9	4.9	9	25	16
Coarse silt	0–10	10	12.7	5.2	0	18	18
Coarse silt	40–50	10	15.0	2.7	11	19	8
Very fine sand	0–10	10	9.2	3.5	0	13	13
Very fine sand	40–50	10	10.1	1.6	8	13	5
Fine sand	0–10	10	14.4	6.0	0	23	23
Fine sand	40–50	10	15.6	4.6	12	27	15
Medium sand	0–10	10	11.2	5.2	0	19	19
Medium sand	40–50	10	13.1	3.6	10	20	10
Coarse sand	0–10	10	5.1	3.7	0	14	14
Coarse sand	40–50	10	7.1	2.7	4	13	9
Very coarse sand	0–10	10	1.4	1.3	0	5	5
Very coarse sand	40–50	10	1.8	1.0	1	4	3
TNV g kg^{-1}	0–10	10	0	0	0	0	0
TNV g kg^{-1}	40–50	10	0	0	0	0	0
Ca cmol kg^{-1}	0–10	10	5.93	4.78	0	13.2	13.2
Mg cmol kg^{-1}	0–10	10	1.04	0.82	0.27	3.14	2.87
K cmol kg^{-1}	0–10	10	0.19	0.33	0.01	1.12	1.11
Na cmol kg^{-1}	0–10	10	0.29	0.17	0.1	0.6	0.5
TEB cmol kg^{-1}	0–10	10	7.46	5.69	0.93	18	17.07
CEC cmol kg^{-1}	0–10	10	39.4	30.4	12	102.2	90.2
Base Sat. %	0–10	10	22.7	15.8	2	57	55
pH	0–10	10	4.9	0.7	3.6	6	2.4
pH	40–50	10	5.2	0.7	4.3	6.7	2.4
C g kg^{-1}	0–10	10	96.7	95.2	25	278	253
C g kg^{-1}	40–50	10	4.6	2.9	2	12	10
N g kg^{-1}	0–10	10	5.7	5.1	1.3	17.4	16.1
N g kg^{-1}	40–50	1	0.8		0.8	0.8	0
C/N	0–10	10	15.6	3.6	8.3	21.5	13.2
C/N	40–50	1	15		15	15	0
Free iron g kg^{-1}	0–10	10	22.1	27.6	2	96	94
Free iron g kg^{-1}	40–50	10	13.3	7.4	2	25	23

Monatray Series

This series occupies 2243 ha (1.2 % of the county). It is situated in the southwest of the county, where it is associated with the Ardmore and Moord series. On the east and west side of Whiting Bay, and on the Ballynamertinagh ridge that divides the Ardmore valley, it occupies the higher ground above 30 m AMSL, whereas the Ardmore and Moor series occupy the lower ground on the floor of the valley. It extends up to 90 m AMSL on the flanks of the Drum Hills, where it is associated with the Moord series. Topography is undulating except the sides of the valley, which were separated as a rolling phase. On the plateaus around Whiting Bay, the parent material is mainly dense loamy till composed predominantly of Devonian sandstone, similar to the parent material of the Clashmore series; it is stony in places. The parent material also consists of clay loam till with few stones; this till resembles the parent material of the Ardmore series, but the till layer is thinner. The finer parent material is more common towards the northern margin of the Monatray map unit, especially in the Rodeen/Lissaniska area. The underlying bedrock is mudstone and sandstone of the Gyleen and Ballytrasna formations. The average annual rainfall ranges from slightly less than 1000 mm at the coast to about 1100 mm at the northern boundary.

The profile is characterised by topsoil that has shell fragments and rounded stones; the surface layer (0-10 cm) is very commonly, but not always, calcareous. The clay content of the topsoil is about the same as that of the Clashmore series but the fine sand (125-250 μm) content is higher in the Monatray series. Like the Ardmore series, sea-sand was added to the surface over centuries. The topsoil is generally slightly thinner than that of the Ardmore series and is generally 40 to 50 cm thick. Because of the presence of this man-made horizon, the series is placed in the Plaggen Group (Typic Plagganthrept; USDA, 1999). In places, the plaggen layer does not meet the thickness requirement prescribed in the USDA system for plaggen epipedons. A more precise classification would place these in a Plaggeneptic subgroup of the Dystrudepts, but this subgroup is not differentiated in the USDA system.

The topsoil is usually a sandy loam; consistence ranges from friable to very friable. Texture of the subsoil is loam or clay loam depending on the parent material. In the representative profile described below, the topsoil is underlain by a discontinuous weakly developed spodic horizon. Weathered B horizons, however, are more abundant. Where the soil was derived from sandstone till, the solum is commonly 60 cm to 80 cm thick, underlain by shattered rock, and the texture of the B horizon is loam. Deep soil, over 1 m thick, with B horizons having clay loam texture were derived from Irish Sea Till. The subsoil lacks mottling, which distinguishes the Monatray series from the Ardmore series. The surface layer (0–10 cm) has a moderately well developed granular structure, which becomes weakly developed with depth. The C horizon is massive and very brittle, roots extend into the upper part (20 cm) of the C horizon.

Carbon content of the surface layer ranges from very low to low; on average it is very low (18.9 g kg^{-1}). The average cation exchange capacity (CEC) is moderate but the minimum CEC (11.6 cmol kg^{-1}) is low. The pH is neutral to alkaline at both 0–10 cm and 40–50 cm depths; the C horizon of the representative profile, which lacks shale fragments, is also neutral.

Bulk density of the surface layer of the representative profile is moderate; it is moderately high (1.3 to 1.5 Mg m^{-3}) throughout the solum; it is high in the C horizon, which is also firm and brittle. The available water capacity is high in the surface layer (0–10 cm) and moderately high in the rest of the profile including the C horizon. The total available water in the representative profile, to the limit of rooting at 65 cm depth, is moderate (115 mm); extending the rooting depth to 80 cm increases the available water to 140 mm, which is still only moderate. However, increasing the rooting depth to 100 cm increases the total available water to 177 mm, which is high. On the basis of 90 mm average maximum potential soil moisture deficit, profiles with less than 80 cm rooting depth, which are common in the Monatray map unit, are estimated to be slightly droughty. Air capacities at various depths of the A horizon are moderate. The air capacity, bulk density, and lack of morphological evidence of water logging indicate a moderately rapid or rapid hydraulic conductivity; the soil is well drained.

Soil suitability: Situated near the coast, the Monatray series has a potentially long growing season. Having good drainage and friable or very friable consistence, it is very suited to a wide range of crops, including out-of-season vegetables. The principal limitations are a risk of being slightly droughty on the shallower parts and nutrient deficiency (e.g. manganese) induced by the neutral to alkaline reaction. As the nutrient deficiency can be remedied by fertilisation it is not a significant continuing limitation. Compared to the potential wide use range, including valuable crops such as out-of-season carrots and potatoes, the drought risk is a slight limitation. The series is assigned to suitability Class I for tillage. The slope limitation of the rolling phase is a slight limitation for grassland (Class B) and a moderate (Class III) limitation for arable crops. Suitability of the normal phase for grassland production varies depending on the yield reduction due to drought. By analogy with the classification of light soils in other counties (e.g. Baggotstown) the shallow parts are assigned to Class B for grassland; the deep parts are assigned to Class A. Overall, Class B is probably dominant.

Representative profile description

Series:	Monatray
Location:	Co. Waterford, Ardoginna Td., Grid Ref. 217300 77300
Classification:	Plaggen (Typic Plagganthrept)
Parent Material:	Stony till, predominantly greywacke, some purple sandstone and quartzite
Drainage:	Well
Topography:	Undulating plateau
Slope:	3º
Altitude:	60 m AMSL
Land-use:	Grassland; predominantly ryegrass and clover, some buttercup

Horizon	Depth (cm)	Description
A1	0–10	Brown (10YR 4/3); sandy loam; few small rounded stones; moderately developed fine granular structure; moderately weak consistence; moderately plastic (wet); many very fine shell fragments; abundant very fine roots.
A2	10–20	Brown (10YR 4/3); sandy loam; common small rounded stones; moderately developed medium granular structure; moderately weak consistence; moderately plastic (wet); many very fine shell fragments; abundant very fine roots.
A3	20–45	Brown (10YR 4/3); sandy loam; common small rounded stones; weakly developed medium granular structure; moderately weak consistence; moderately plastic (wet); many very fine shell fragments; many very fine roots; clear wavy boundary.
Bs	45–50	Yellowish brown (10YR 5/6); loam; many medium and small stones; weakly developed fine granular structure; very weak consistence; common very fine roots; discontinuous wavy boundary; horizon is on average 5 cm thick and extends to 25% of pedon.
C	45+	Brown (10YR 5/3); loam; abundant small to large subangular stones; massive structure; very firm brittle consistence; moderately plastic (wet); common very fine macropores; very few roots in upper 20 cm.

Table 3.69: Particle size and chemical analyses, Monatray Series.

Horizon	A1	A2	A3	Bs	C
Depth cm	0–10	10–20	20–45	45–50	45+
Particle Size % :					
Coarse sand 200–2000 μm	19	24	25	19	19
Fine sand 50–200 μm	32	34	29	27	19
Silt 2–50 μm	24	25	27	32	41
Clay <2 μm	16	17	19	22	21
TNV g kg^{-1}	0	0	0	0	0
Ca cmol kg^{-1}	16	13.8	10.9	12.19	6.9
Mg cmol kg^{-1}	0.4	0.28	0.19	0.07	0.01
K cmol kg^{-1}	0.14	0.1	0.08	0.16	0.31
Na cmol kg^{-1}	0.21	0.16	0.12	0.12	0.09
TEB cmol kg^{-1}	16.75	14.34	11.29	12.54	7.31
CEC cmol kg^{-1}	20.4	16.4	13.8	18.6	10
Base Saturation %	82	87	82	67	73
pH	7.2	7.5	7.5	7.3	7.4
C g kg^{-1}	27	18	11	13	4
N g kg^{-1}	2.9	2	1.2	1.1	
C/N	9.3	9	9.2	11.8	
Free iron g kg^{-1}	16	15	16	22	19

Table 3.70: Physical analyses, Monatray Series.

Horizon	A	A	A	A	C
Sub-horizon	1	2	3	3	
Depth cm	0–10	10–20	20–30	30–45	45+
Particle density Mg m^{-3}	2.28	2.48	2.51	2.51	2.54
Bulk density at saturation Mg m^{-3}	1.2	1.35	1.5	1.43	1.68
Bulk density at -59 hPa Mg m^{-3}	1.2	1.35	1.5	1.43	1.68
Air capacity % vol.	12.7	10.0	8.9	12.9	9.0
Retained water % vol.:					
0 hPa	51.3	45.2	39.8	46.9	41.0
-2 hPa	45.9	41.7	37.8	43.5	36.3
-59 hPa	38.6	35.2	30.9	34.0	32.1
-137 hPa	36.5	32.7	28.1	31.0	30.6
-0.1 MPa	31.8	27.8	24.6	26.6	26.4
-1.5 MPa	18.0	15.5	14.8	16.8	15.5
Total available water % vol.	20.7	19.7	16.1	17.2	16.6
Total available water cm	2.1	2.0	1.6	2.6	1.7
Total available water cumulative cm	2.1	4.0	5.6	8.2	9.9

Table 3.71: Descriptive statistics, Monatray Series.

	Depth cm	Count	Mean	Standard Deviation	Minimum	Maximum	Range
Clay	0–10	14	17.7	3.1	13	25	12
Clay	40–50	14	24.7	5.6	11	32	21
Fine silt	0–10	14	14.5	5.2	8	28	20
Fine silt	40–50	14	19.7	4.1	11	28	17
Coarse silt	0–10	14	14.7	3.9	8	22	14
Coarse silt	40–50	14	18.2	2.0	14	21	7
Very fine sand	0–10	14	10.1	2.4	6	15	9
Very fine sand	40–50	14	11.0	3.3	8	21	13
Fine sand	0–10	14	21.0	8.8	7	45	38
Fine sand	40–50	14	12.4	3.2	9	20	11
Medium sand	0–10	14	12.5	3.3	5	18	13
Medium sand	40–50	14	7.7	2.1	4	11	7
Coarse sand	0–10	14	7.1	4.4	3	19	16
Coarse sand	40–50	14	4.6	1.6	2	7	5
Very coarse sand	0–10	14	2.4	2.3	1	8	7
Very coarse sand	40–50	14	1.6	0.7	1	3	2
TNV g kg^{-1}	0–10	14	52.9	69.2	0	210	210
TNV g kg^{-1}	40–50	14	0.9	2.4	0	8	8
Ca cmol kg^{-1}	0–10	14	12.92	3.87	6.21	19.85	13.64
Mg cmol kg^{-1}	0–10	14	0.42	0.18	0.26	0.78	0.52
K cmol kg^{-1}	0–10	14	0.24	0.15	0.04	0.49	0.45
Na cmol kg^{-1}	0–10	14	0.14	0.04	0.07	0.20	0.13
TEB cmol kg^{-1}	0–10	14	13.71	3.95	6.65	21.15	14.50
CEC cmol kg^{-1}	0–10	14	16.7	3.7	11.6	26	14.4
Base Saturation %	0–10	14	81.7	12.4	49	96	47
pH	0–10	14	7.2	0.4	6.5	7.7	1.2
pH	40–50	14	7.4	0.3	6.5	7.8	1.3
C g kg^{-1}	0–10	14	18.9	8.1	3	36	33
C g kg^{-1}	40–50	14	4.9	1.8	2	7	5
N g kg^{-1}	0–10	13	2.4	0.8	1.5	4.2	2.7
C/N	0–10	13	8.2	0.5	7.3	9	1.7
Free iron g kg^{-1}	0–10	14	13.9	3.4	10	22	12
Free iron g kg^{-1}	40–50	14	21.7	3.9	12	27	15

Monavullagh Series

This is the most extensive soil on the Comeragh–Monavullagh mountains; it occupies 7198 ha (3.92% of the county). Most of the series is on the east and west facing slopes of the mountains. On the east side it generally lies above the Slievecoiltia, Clonroche, Mothel, or, in places, stony Knockboy series, whereas on the west side it is generally above the Ballycondon or Dodard series, or, in places, cutover peat. It merges with Blanket Peat, which lies above it on the more gently sloping summit. Elevation generally ranges from about 275 up to 685 m AMSL; on the east side some rocky or bouldery land, which extends down to 150 m AMSL, is included in the Monavullagh map unit. Vegetation is mostly sheep-grazed heath dominated by heather and some coniferous forest plantations. The terrain is mountainous; slopes are predominantly moderately steep or steep. The parent material distinguishes the Monavullagh series from the Knockmealdown series; the former consists of loamy-skeletal diamicton derived predominantly from local conglomerates of the Coumshingaun and Treanearla formations. Outcropping conglomerate rock or large boulders are common. Average annual rainfall is generally more than 1500 mm and exceeds 1750 mm in much of the area; on average, the number of rain-days (>1 mm) is over 175 per year.

The surface horizon typically consists of black, highly decomposed amorphous peat, 20 to 40 cm thick; in places, this layer is up to 50 cm thick. Part of the area has been cut over, and the residual peat ranges down to 5 cm depth. Rubbed fibre content and SPEC values confirm that the peat layers of the representative profile are highly decomposed (sapric), especially in the lowest layer, where the rubbed fibre content is extremely low (<2%). The underlying mineral horizons typically have abundant large to very large stones. A sharp boundary separates the peat layer from the upper grey albic horizon, which is 10 to 60 cm thick. The underlying subhorizon, 30 to 60 cm thick, is predominantly black with increased organic matter content, and has yellowish weathering stones, which indicate periodic waterlogging. Depth to ironpan ranges from 10 cm to about 2 m; the pan extends throughout most of the pedon. An iron enriched spodic horizon occurs sporadically directly beneath the humus-enriched horizon where the iron pan is absent. As the peat thickness is typically 40 cm or less, the soil is classified as a Peaty Podzol: a small amount of Blanket Bog, which has peat thickness greater than 40 cm, is included in the Monavullagh map unit. In the USDA system (1999) the soil is classified as a Typic Placaquod.

The chemical characteristics of the representative profile resemble those of the Knockmealdown series. All horizons are strongly acid and have very low (<14%) base saturation. Although the peaty horizons are slightly more acid than the underlying mineral horizons, they have slightly higher base saturation. The contents of total exchangeable bases (TEB) in the peat horizons are many times higher than those in the mineral horizons. No exchangeable calcium was detected in three of the mineral horizons (E, Bs, C); a trace was found in the Eh horizon, where it is probably associated with the small accumulation of organic matter. Virtually all the exchangeable calcium in the profile is in the peaty horizons (6.1–6.6 cmol kg^{-1}).

The upper albic (E) horizon and the parent material (C), which lack accumulations of organic matter, have very low retention capacity as indicated by the very low cation exchange capacity (CEC). The large increases in free iron and organic carbon contents in the yellowish pockets that underlie the albic horizon confirm their spodic nature. The ash content of the lowest organic horizon (Oa2) is relatively high and is consistent with very high decomposition. Compared to peat soils, the C:N ratio of the peat layer is relatively low (<25) and indicates that the nitrogen is potentially mineralizable (Williams, 1983).

Owing to the abundance of boulders on the surface and very large stones in the solum, physical data were not obtained for the representative profile of the Monavullagh series. Apart from stone content, the morphological features are very similar to those of the Knockmealdown series, and it is likely that the physical properties and soil water regime of both soils are also very similar. Like the Knockmealdown series, the Monavullagh series is likely to have high water content and very large available water capacity (AWC). The highly decomposed peat is likely to have slow hydraulic conductivity with very slow rates in the very highly decomposed bottom layer (Oa2). The dense massive albic horizon and the ironpan also contribute to drainage impedance, which, combined with the high and frequent rainfall, is likely to form a shallow perched water table within the peat layer.

Soil suitability: Like the Knockmealdown series, the Monavullagh series is limited by moderately steep to steep slopes, low nutrient status, weak bearing capacity, wetness and short growing season due partly to climatic effects associated with high elevation. In addition, rock outcrops and boulders are common on the Monavullagh series and part of it is wetter than the Knockmealdown series. The combined effects of these limitations are severe for agriculture. It is likely that the peat layer contains mineralizable nitrogen, but the status of other nutrients, including bases and phosphorus, is very low. Exposure is an additional limitation for forestry, and most of the Monavullagh map unit in its current condition is poorly suited to forestry. As the available nutrients and the nutrient retention capacity are contained predominantly in the peat layer, it is important that the peat is not cut away or subjected to management practices that induce accelerated erosion. Generally the best use of the Monavullagh series is a combination of extensive sheep grazing, which controls the heath and impedes the development of low shrub vegetation, and recreational use. The soil is predominantly unsuited to reclamation for agriculture.

Representative profile description

Series:	Monavullagh
Location:	Co. Waterford, Barracreemountain Upper Td., Grid Ref. 226400 106400
Classification:	Peaty Podzol (Typic Placaquod)
Parent Material:	Conglomerate
Drainage:	Impeded above pan, free below pan.
Topography:	Steep
Slope:	15º
Altitude:	490 m AMSL
Land-use:	Heath; mainly Calluna spp., Molinia spp.

Horizon	Depth (cm)	Description
Oa1	0–18	Black (5YR 2/1), amorphous peat.
Oa2	18–32	Black (7.5YR 2/0), amorphous peat, sharp boundary.
E	32–57	Dark grey (5YR 4/1); coarse sand; abundant large and very large stones; many small and medium stones in places; very weak subangular blocky structure; very weak consistence; many roots; clear wavy boundary.
Eh	57–92	Black (5YR 2/1); sand; abundant large and very large stones; many small and medium stones in places; very weak medium and fine subangular blocky structure; very weak consistence; few roots; sharp wavy boundary.
Bsm	40–130	Thin ironpan, wavy, discontinuous.
Bs		Dark reddish brown (5YR 3/4); pockets occupy less than 5% of pedon; occurs below Eh horizon where ironpan is absent.
C	>92	Pale brown (10YR 5.5/3) sand; abundant very large stones and boulders; massive structure; moderately firm slightly brittle consistence; many roots; many fine and very fine pores no roots.

Table 3.72: Particle size and chemical analyses, Monavullagh Series.

Horizon	Oa1	Oa2	E	Eh	Bs	C
Depth cm	0–18	18–32	32–57	57–92	>92	>92
Particle Size % :						
Coarse sand 200–2000 μm			60	58	33	45
Fine sand 50–200 μm			8	8	12	17
Silt 2–50 μm			20	23	38	30
Clay <2 μm			12	11	17	8
TNV g kg^{-1}						
Ca cmol kg^{-1}	6.12	6.6	0	0.06	0	0
Mg cmol kg^{-1}	8.76	6.04	0.22	0.27	0.01	0.01
K cmol kg^{-1}	1.4	0.24	0.02	0.02	0.01	0
Na cmol kg^{-1}	0.92	0.8	0.03	0.06	0	0
TEB cmol kg^{-1}	17.15	13.68	0.27	0.41	0.02	0.01
CEC cmol kg^{-1}	149	100	4.4	23.8	28.2	3.4
Base saturation %	11	14	6	2	<1	<1
pH	3.7	3.8	4	3.9	4.2	4.9
C g kg^{-1}	392	352	7	14	17	1
N g kg^{-1}	18	15		1.2	1.3	
C/N	21.8	23.5		11.7	13.1	
Loss on ignition g kg^{-1}	927	821				
Free iron g kg^{-1}	4	8	13	23	51	11
Ash O.D. g kg^{-1}	73	179				
Fibre unrubbed % vol	64	32				
Fibre rubbed % vol	12	<2				
SPEC[1] value/chroma	6/4	3/2				

[1] Sodium Pyrophosphate Extract Colour

Moord Series

This series is situated in the southwest of the county, where it occupies 2354 ha (1.3% of the county). It lies mainly on the southern slopes of the Drum Hills and in the Ardmore valley; a small area was mapped on the northern side of the Drum Hills, west of Ringville. On the southern side of the Drum Hills it stretches up to 185 m AMSL where it lies alongside the Ahaun series. The Clashmore and Ballymacart series lie below it on the lower slopes. Between Whiting Bay and the Blackwater estuary it occupies the lower part of the landscape at elevations less than 18 m AMSL. On the flanks of the hills, the topography is generally undulating (slopes <7^{o}) and long, low (<5 m), smooth ridges are common. In the Ardmore valley, slopes are gentle (< 3^{o}) to flat, and the Moord series adjoins the Ardmore series. The parent material is very plastic, silty, till of Irish Sea Basin provenance (Ballycroneen Fm), which is up to seven metres thick at the coast at Whiting Bay. It contains shell fragments and few stones composed of sandstone, volcanics, limestone, and chert. The underlying bedrock consists of Devonian mudstone and sandstone of the Ballytrasna and Gyleen formations at higher elevations, and Waulsortian Limestone at lower elevations in the Ardmore valley.

The soil profile usually consists of brown topsoil overlying subsoil that has varying proportions of yellowish brown or grey mottles that are mostly in the lower part of the subsoil. The series forms a transition from Brown Earths to Gleys. In the Ardmore valley, some Gleys on flat slopes were separated as a poorly drained phase. In the USDA system, the moderate to imperfectly drained phase ranges from Dystric Eutrudepts to Aquic Dystric Eutrudepts, depending on the moisture regime as evidenced by the presence of redox depletions of low chroma; however, the poorly drained phase belongs to the Typic Epiaquept subgroup. The series is related to the Macamore series in Co. Wexford, but drainage is generally better and clay content is much less in the Moord series. Part of the low-lying Moord series has a sandy calcareous A horizon. This is not included with the Ardmore series because the Ardmore series has better drainage, and suitability is similar to that of the Moord series.

The solum is characterised by having few stones and very plastic consistence; texture is normally loam or clay loam. Clay content of the subsoil at 40–50 cm depth is on average higher (28% v 22%) than at the surface (0–10 cm), but it is more variable (SD 7.5% v 4.4%). Compared to soils derived from sandstone till, the distinguishing textural characteristic is the large amount (91%) of material that consists of fine sand (<250 μm) or finer particles. Despite the general increase in clay content with depth, the B horizon is not considered argillic, because clay coats are sparse in the representative profile described below.

Carbon content and cation exchange capacity (CEC) of the surface layer (0–10 cm) are moderate on average, but there is wide variation. The surface layer is typically slightly acid, but ranges from moderately acid to neutral; acidity tends to decrease with depth, and at 40–50 cm depth ranges from moderately acid to alkaline. Particle density of the subsoil, and that of the Ardmore and Monatray series, is lower than that expected on the basis of regression analysis that takes carbon content into account; this implies that the provenance of the mineral fraction of these soils is different from the other soils in the county.

A profile representing the moderate to imperfectly drained phase has moderate to high bulk density and predominantly low to moderate air capacity. The subsoil below 40 cm depth has coarse or very coarse structure down to the limit of observation at 1.9 m. Above 1.5 m depth the structure is compound; the coarse blocks are composed of smaller medium sized blocks. Roots are mainly vertical in the subsoil and are common to few to about 1 m depth; some roots penetrate to 1.5 m depth. The air capacity, bulk density and structure indicate that hydraulic conductivity is probably moderately slow. The available water capacity (AWC) ranges from moderately high to high in the topsoil (0–40 cm) and from moderately low to high in the subsoil. The total available water in the soil profile down to 1 m depth is very high, and taking into account the potential for root penetration to greater depths it seems that the risk of drought is negligible. The overall drainage of the series ranges from moderate to poor; where possible, the poorly drained areas have been mapped as a separate phase.

Soil suitability: Wetness and the plastic consistence of the topsoil are the principal limitations. Although the moisture regime can be altered to a certain extent by field drainage, wetness will be a continuing limitation especially in the poorly drained phase. As the subsoil is not brittle, subsoiling is not likely to be effective. Clay content is below the threshold generally thought necessary for stable mole drains; nevertheless, mole drainage of the Moord series merits investigation because of the distinctive plastic consistence.

The moderate to imperfectly drained phase is suited to tillage and arable crops; the poorly drained phase is moderately suited. In both phases winter cereals are the most suitable arable crops because of the risk of delayed sowing of cereals and root crops in spring. The moderate to imperfectly drained phase is assigned to suitability Class BII; the poorly drained phase is assigned to Class CIII.

Representative profile description

Series:	Moord
Location:	Co. Waterford, Newtown Td., Grid Ref. 218300 82700
Classification:	Brown Earth (with gleying). Dystric Eutrudept
Parent Material:	Till, Irish Sea provenance. Mainly red and green sandstone.
Drainage:	Moderate to imperfect
Topography:	Smoothly undulating
Slope:	3^0, crest
Altitude:	115 metres AMSL
Land-use:	Old pasture

Horizon	Depth (cm)	Description
A1	0–10	Dark greyish brown (10YR 4/2); loam; few small and medium stones; weakly developed, medium granular structure; friable consistence; very plastic (wet); abundant roots.
A2	10–20	Dark greyish brown (10YR 4/2); loam; few small and medium stones; weakly developed medium granular structure; friable consistence; very plastic (wet); many very fine roots.
A3	20–40	Same as above. Abrupt smooth boundary.
B/A	40–62	Brown (10YR 5/3) and yellowish brown (10YR 5/4); loam; few small medium stones; weakly developed coarse parting to medium subangular blocky structure; friable semi-deformable consistence; very plastic (wet); many fine to coarse macropores, coarse pores and ped faces coated with A horizon material; common very fine roots, mainly vertical; gradual wavy boundary.
Bw	62–105	Pale brown (10YR 6/3) with common brown (7.5YR 5/5) coarse mottles; loam ; few small medium stones; weakly developed coarse parting to medium subangular blocky structure; moderately firm, semi-deformable consistence; very plastic (wet); many fine pores; common very fine roots becoming few with depth; gradual wavy boundary.
C1	105–150	Pale brown (10YR 6/3) and very many coarse strong brown (7.5YR 5/6) mottles; clay loam; few small to medium stones; very weakly developed very coarse parting to medium subangular blocky structure; moderately firm semi-deformable consistence; very plastic (wet); common fine macropores; very few roots; diffuse wavy boundary.
C2	150–190	Pinkish grey (7.5YR 7/3) and very many medium strong brown (7.5YR 5/6) mottles; clay loam; few small and medium stones; common black mangans; very weakly developed, very coarse blocky structure; moderately firm semi-deformable consistence; common fine macropores; no roots.
C3	190–250+	Auger sample. Sandy loam to loam, more stones than overlying horizons.

Table 3.73: Particle size and chemical analyses, Moord Series.

Horizon	A1	A2	A3	B/A	Bw	C1	C2	C3
Depth cm	0–10	10–20	20–40	40–62	62–105	105–150	150–190	190–250
Particle Size % :								
Coarse sand 200–2000 μm	24	24	23	16	14	10	9	28
Fine sand 50–200 μm	26	25	24	18	19	17	18	24
Silt 2–50 μm	33	32	32	40	44	48	42	34
Clay <2 μm	17	19	21	26	23	25	31	14
TNV g kg^{-1}	0	0	0	0	0	0	0	0
Ca cmol kg^{-1}	9.25	7.93	7.7	4.7	3.86	5.44	6.16	2.3
Mg cmol kg^{-1}	1.3	0.95	0.69	0.26	0.21	0.25	0.17	0.1
K cmol kg^{-1}	0.07	0.04	0.03	0.03	0.03	0.09	0.13	0.04
Na cmol kg^{-1}	0.09	0.09	0.14	0.01	0.12	0.07	0.01	0.04
TEB cmol kg^{-1}	10.71	9.01	8.56	5.00	4.22	5.85	6.47	2.48
CEC cmol kg^{-1}	17.2	15.6	15.4	10.8	10.2	9	11.2	4.4
Base Saturation %	62	58	56	46	41	65	58	56
pH	6.1	6.1	6.6	6.5	6.4	6.3	6.5	6.5
C g kg^{-1}	24	18	13	6	5	3	2	2
N g kg^{-1}	3.0	1.5	1.1					
C/N	8	12	11.8					
Free iron g kg^{-1}	17	18	19	19	21	23	23	14

Table 3.74: Physical analyses, Moord Series.

Horizon	A	A	A	A	B/A	B/A	B	B	C	C
Sub-horizon	1	2	3	3			w	w	1	1
Depth cm	0–10	10–20	20–40	30–40	40–50	50–62	62–80	80–105	105–130	130–150
Particle density Mg m^{-3}	2.35	2.44	2.53	2.53	2.56	2.56	2.59	2.56	2.57	2.57
Bulk density at saturation Mg m^{-3}	1.06	1.35	1.49	1.42	1.26	1.36	1.61	1.63	1.64	1.6
Bulk density at -59 hPa Mg m^{-3}	1.06	1.35	1.49	1.42	1.26	1.36	1.61	1.63	1.64	1.6
Air capacity % vol.	6.9	4.0	10.3	11.8	10.2	9.4	4.3	2.5	3.2	3.4
Retained water % vol.:										
0 hPa	57.4	49.3	43.3	45.8	54.3	50.5	40.9	39.0	39.6	48.4
-2 hPa	53.3	47.4	34.7	35.6	45.5	42.2	37.3	37.1	37.0	45.7
-59 hPa	50.5	45.3	32.9	34.0	44.1	41.1	36.6	36.6	36.4	45.0
-137 hPa	48.7	43.9	31.8	32.9	40.3	37.8	34.7	35.3	34.7	43.2
-0.1 MPa	40.4	38.5	29.3	30.2	32.9	32.6	32.0	33.8	32.3	41.1
-1.5 MPa	27.9	25.0	17.8	18.6	21.3	19.1	18.5	24.6	22.7	21.7
Total available water % vol.	22.6	20.3	15.1	15.4	22.9	22.0	18.1	12.0	13.7	23.3
Total available water cm	2.3	2.0	3.0	1.5	2.3	2.6	3.3	3.0	3.4	4.7
Total available water cumulative cm	2.3	4.3	7.3	8.9	11.1	13.8	17.0	20.0	23.4	28.1

Table 3.75: Descriptive statistics, Moord Series.

Item	Depth cm	Count	Mean	Standard Deviation	Minimum	Maximum	Range
Clay	0–10	15	22.3	4.4	17	33	16
Clay	40–50	15	28.1	7.5	14	39	25
Fine silt	0–10	15	20.7	3.4	16	30	14
Fine silt	40–50	15	22.0	6.1	12	39	27
Coarse silt	0–10	15	18.7	2.5	15	23	8
Coarse silt	40–50	15	18.7	3.3	14	26	12
Very fine sand	0–10	15	11.1	1.5	8	13	5
Very fine sand	40–50	15	11.5	3.6	5	18	13
Fine sand	0–10	15	14.8	2.8	7	19	12
Fine sand	40–50	15	10.6	4.4	5	22	17
Medium sand	0–10	15	8.2	2.2	3	11	8
Medium sand	40–50	15	5.7	2.5	3	11	8
Coarse sand	0–10	15	3.1	1.1	1	5	4
Coarse sand	40–50	15	2.3	1.4	1	6	5
Very coarse sand	0–10	15	1.0	0.0	1	1	0
Very coarse sand	40–50	15	1.1	0.3	1	2	1
TNV g kg^{-1}	0–10	15	1.6	6.2	0	24	24
TNV g kg^{-1}	40–50	15	11.3	29.9	0	94	94
Ca cmol kg^{-1}	0–10	15	10.57	4.30	3.80	18.82	15.02
Mg cmol kg^{-1}	0–10	15	0.90	0.35	0.44	1.49	1.05
K cmol kg^{-1}	0–10	15	0.19	0.10	0.07	0.44	0.37
Na cmol kg^{-1}	0–10	15	0.15	0.05	0.08	0.24	0.16
TEB cmol kg^{-1}	0–10	15	11.81	4.40	4.53	20.50	15.97
CEC cmol kg^{-1}	0–10	15	20.3	4.6	15.2	29.8	14.6
Base Sat. %	0–10	15	58.7	18.8	30	83	53
pH	0–10	15	6.0	0.8	4.9	7.4	2.5
pH	40–50	15	7.0	0.9	4.7	8.1	3.4
C g kg^{-1}	0–10	15	31.7	20.1	2	86	84
C g kg^{-1}	40–50	15	3.0	0.9	2	5	3
N g kg^{-1}	0–10	14	3.3	1.0	1.9	5.5	3.6
C/N	0–10	14	9.8	2.2	7.7	15.6	7.9
Free iron g kg^{-1}	0–10	15	13.5	5.4	4	27	23
Free iron g kg^{-1}	40–50	15	21.6	4.3	14	28	14

Mothel Series

This series is extensive in the northeast of the county; it covers 4852 ha (2.64% of the county). It is closely associated on the landscape with the Clonroche series; it occupies the lower slopes, generally below the Clonroche series. Slopes are gentle, generally ≤3°. Elevation ranges mostly between 60 and 120 m AMSL. The map unit contains a small inclusion of Newport series that extends up to 150 m AMSL along the flanks of the Monavullagh Mountains. Parent material is till composed mostly of slate, shale, and some limestone and sandstone. Like the Clonroche series, it overlies Ordovician and Silurian slate and shale rock formations. This series is very similar to the Kilpierce series in Co. Wexford; it is distinguished from the Kilpierce series on the basis of the presence of limestone, which forms slightly calcareous parent material in places. It also lacks the plastic clay material that forms the surface horizon of the Kilpierce series.

The profile is characterised by pale brown to grey mottles and many yellowish brown mottles in the subsoil. The soil is classified as a Gley or Aeric Epiaquept (USDA 1999); the map unit includes some Typic Epiaquepts.

Typically, structure is weak in the surface, and the subsoil is massive and has high bulk density. All horizons of the representative profile have low air capacity. Hydraulic conductivity is moderately slow (mean 0.12 m day^{-1}; Appendix III). Textures are loam to clay loam, and although drainage is imperfect or poor the available water capacity of most horizons is less than that of the corresponding horizon in the free draining Clonroche series.

Soil suitability: This soil is moderately suited to grass and arable crops. Poor drainage is the principal limitation. The moderately slow hydraulic conductivity limits the improvement attainable by field drainage, and wetness is a continuing limitation for grass and arable crops after drainage. The short growing season reduces the yield of grass, and damage due to poaching impairs utilisation. The difficulty in getting a suitable tilth on a poorly drained soil with weak structure delays sowing date of Spring cereals; the soil is better suited to winter cereals. The series is assigned to suitability class CIII.

Representative profile description

Series:	Mothel
Location:	Co. Waterford, Ballyquin Td., Grid Ref. 242600 118200
Classification:	Gley. (Aeric Epiaquept)
Parent Material:	Till, mostly shale, some limestone and sandstone
Drainage:	Poor
Topography:	Undulating
Slope:	3°
Altitude:	115 m AMSL
Land-use:	New pasture

Horizon	Depth (cm)	Description
Al	0–10	Dark grey (10YR 4/1) loam; weakly developed medium subangular blocky structure; few small stones; slightly firm semi-deformable consistence; moderately plastic (wet); many very fine roots.
A2	10–20	Greyish brown (10YR 4.5/2) and common medium, reddish brown (7.5YR 4/4) mottles; loam; few small and medium stones; weakly developed medium subangular blocky parting to fine blocky structure; slightly firm consistence; moderately plastic (wet); many very fine roots; many very fine pores; clear wavy boundary.
Bg1	20–45	Pale brown (10YR 6/3) and many medium yellowish-brown (10YR 5/6) mottles; loam; common small and medium stones; very weakly developed, coarse and very coarse subangular blocky structure; firm, semi- deformable consistence; very plastic (wet); many very fine pores and few medium pores lined with A1 horizon material; common very fine vertical roots; clear undulating boundary.
Bg2	45–70	Pale-brown (10YR 6/3) and abundant coarse, yellowish-brown (10YR 5/6) mottles and common, coarse black manganese mottles; clay loam; common small to large stones; massive structure; very firm; semi-deformable and brittle consistence; moderately plastic (wet); few fine and very fine pores; few very fine roots.
Bg3	70–95	Same as above except firm, semi-deformable non-brittle consistence.
Cg	95–120+	Light grey (10YR 7/1) and abundant coarse yellowish brown mottles; clay loam; many small to very small stones (mostly small); massive structure; slightly firm, semi-deformable consistence; very plastic (wet); few fine pores; no roots.

Table 3.76: Particle size and chemical analyses, Mothel Series.

Horizon	A1	A2	Bg1	Bg2	Bg3	Cg
Depth cm	0–10	10–20	20–45	45–70	70–95	95–120
Particle Size % :						
Coarse sand 200–2000 μm	29	28	23	28	27	29
Fine sand 50–200 μm	16	17	18	16	17	14
Silt 2–50 μm	31	32	35	31	29	30
Clay <2 μm	24	23	24	25	27	27
TNV g kg^{-1}	0	0	0	0	10	7
Ca cmol kg^{-1}	16	8.6	3.8	5.5	6.6	6.6
Mg cmol kg^{-1}	0.34	0.18	0.05	0.05	0.25	0.07
K cmol kg^{-1}	0.15	0.07	0.03	0.06	0.06	0.09
Na cmol kg^{-1}	0.13	0.05	0.02	0.12	0.11	0.16
TEB cmol kg^{-1}	16.62	8.90	3.90	5.73	7.02	6.92
CEC cmol kg^{-1}	25.2	16.6	9.4	8.6	6.2	6
Base Saturation %	66	54	41	67	Sat	Sat
pH	6.2	5.9	6.7	6.9	7.2	7.3
C g kg^{-1}	48	23	0.5	0.2	1	1
N g kg^{-1}	4.3	2.4				
C/N	11.2	9.6				
Free iron g kg^{-1}	12	14	31	28	29	31

Table 3.77: Physical analyses, Mothel Series.

Horizon	A	A	B	B	B	C
Sub-horizon	1	2	g1	g2	g3	g
Depth cm	0–10	10–20	20–45	45–70	70–95	95–120
Particle density Mg m^{-3}	2.39	2.53	2.64	2.65	2.65	2.69
Bulk density at saturation Mg m^{-3}	1.12	1.2	1.56	1.75	1.74	1.74
Bulk density at -59 hPa Mg m^{-3}	1.13	1.22	1.58	1.75	1.75	1.76
Air capacity % vol.	5.7	6.3	6.4	5.1	6.6	5.3
Retained water % vol.:						
0 hPa	50.2	53.8	40.5	39.9	40.8	39.9
-2 hPa	45.3	49.7	36.1	35.5	35.5	35.1
-59 hPa	44.5	47.4	34.1	34.8	34.2	34.7
-137 hPa	42.6	43.4	31.4	32.5	32.3	33.5
-1.5 MPa	17.6	14.3	11.8	14.6	15.7	19.2
Total available water % vol.	26.9	33.1	22.3	20.1	18.4	15.4
Total available water cm	2.7	3.3	5.6	5.0	4.6	3.9
Total available water cumulative cm	2.7	6.0	11.6	16.6	21.2	25.1

Newport Series

This series occurs extensively in the western part of the county; it occupies 9238 ha (5.0% of the county). It lies mainly in depressions in the South Ireland Peneplane (Farrington, 1953). Elevation ranges from 150 m to 215 m AMSL. As the plain is inclined to the south and east, the series extends down to lower elevations (≈120 m AMSL) at the southern and eastern margins of the plateau. It invariably extends up to and commonly about 50 m above the stream "rises" and receives runoff from the surrounding higher ground. Part of the series lies along the footslopes of the Knockmealdown, Comeragh and Monavullagh mountains; here the soil can extend up to 275 m AMSL. On the peneplane it is generally interspersed with its well drained counterpart, the Knockboy series. In a few places (e.g. Glenaveha), small pockets of shallow (<1 m) peat are situated within the Newport series suggesting that it was originally covered by blanket peat. Generally, the soil has been drained and fertilised, but a small amount remains undrained and dominated by rushes (Juncus spp.). Topography is undulating to flat; small areas with rolling topography, too small to map, are found on the footslopes of the mountains. The parent material is dense loamy till composed predominantly of Devonian sandstone. The bedrock underlying the till is medium grained sandstone and mudstone of the Knockmealdown and Ballytrasna formations. Average annual rainfall is moderately high; it is generally about 1250 mm and ranges from 1100 to 1500 m over the entire series.

The surface horizon is typically greyish brown to grey; in places it is dark grey to black, but it is generally thin. This is underlain by a predominantly grey E horizon with few to common yellowish mottles; this horizon is commonly thick and extends down to 1 m depth in places. The abundance of the ochreous mottles increases with depth; for example, strong brown mottles are predominant in the C horizon of the representative profile shown below. The soil is classified as a Gley. As the morphology of the profile indicates that a zone of water saturation is perched above a relatively impermeable layer (episaturation), the soil is classified as a Typic Epiaquept in the USDA (1999) system.

Texture is typically light loam in the surface horizon and is similar to the other series derived from sandstone materials; subsurface horizons are generally coarser but vary irregularly with depth. The average clay content of the surface layer (0–10 cm) is 16.9% (SD 3.9%) and decreases to 12.0% (SD 2.2%) at 40–50 cm depth. Structure of the surface horizon is typically fine granular to blocky. Structural development decreases from weak very coarse blocky in the underlying E horizon to massive in the C horizon. Roots are abundant in the surface horizon, decrease rapidly with depth in the subsurface horizons, and only a few roots extend below 1 m depth.

The average organic carbon content of the surface layer is high (6.6%); it ranges from low to high, and on average it is higher than that found in the well drained counterpart, the Knockboy series. The ratio of carbon to nitrogen is also higher indicating slower rates of organic matter decomposition. Reaction of the surface layer is typically moderately acid; it ranges from strongly acid to slightly acid and increases slightly in the subsoil of both the random samples and the representative profile. The average free iron contents of the surface layer (0–10 cm) and subsurface layer (40–50 cm) are low. The analysis for the representative profile shown below is low in the A horizon and also in the E horizon, which extends down to 1 m depth; it increases in the B and C horizons where material with high chroma is more abundant. This pattern is consistent with reduction and removal of free iron under anaerobic conditions associated with a perched water table; it is possible that acids derived from peat, which was originally present on the surface, contributed to the removal of iron.

The A horizon (0–25 cm) of the representative profile described below has very high available water capacity (AWC); the AWC is lower in the subsoil but remains moderately high to high throughout the profile. The total AWC of the profile down to 1 m depth is very high (252 mm). However, the amount accessible by plants is less owing to restricted root penetration in the subsoil. The subsoil is dense to very dense, and the bulk density reaches 1.9 Mg m^{-3} in the B horizon below 0.8 m depth The air capacity is moderate in the A horizon (0–25 cm) and low to very low in the subsoil (E and B horizons). Hydraulic conductivity data are not available for this soil; the redoximorphic features, very low air capacity, and poor structural development indicate that it is slow to moderately slow.

Suitability:
The principal limitations are wetness and climatic factors associated with elevation. The climatic limitations are similar to that obtaining for the well drained counterpart, the Knockboy Series. Owing to the slow hydraulic conductivity, wetness will remain a continuing limitation after field drainage. Droughtiness is not a significant limitation due to the high available water content and the relatively high rainfall; the moisture deficits required for effective subsoiling are infrequent. Wetness reduces dry matter production and shortens the length of the grazing season. There is a risk of damage by poaching especially in those parts of the series that have high organic carbon content. As the wetness and climatic effects are largely cumulative, the winter feeding period is about six weeks longer, and the grazing capacity was estimated to be about 35% less than that of well drained lowland soils in the region e.g. Dungarvan series. Owing to the wetness and climatic limitations, the number of suitable workdays in Spring is limited; therefore, winter cereals are the most suitable arable crops. This soil is poorly suited to pasture and arable crops and is assigned to Class D IV.

Representative profile description

Series:	Newport
Location:	Co. Waterford, Killeenagh Nth Td., Grid Ref. 206000 89700
Classification:	Gley (Typic Epiaquept)
Parent Material:	Sandstone till
Drainage:	Poor, undrained
Topography:	Smoothly undulating
Slope:	4^0 concave
Altitude:	100 m AMSL
Land-use:	Juncus dominant pasture

Horizon	Depth (cm)	Description
A1	0–12	Greyish brown (10YR 5/2); loam; weak fine granular structure; friable, semi-deformable consistence; very plastic (wet); abundant fine and very fine diffuse roots.
A2	12–25	Grey (10YR 5/1); sandy loam; many small stones; weak fine granular structure becoming fine blocky with depth; friable, semi-deformable consistence; very plastic (wet); abundant fine and very fine diffuse roots; abrupt wavy boundary.
Eg1	25–60	Light grey (5YR 7/1); common coarse reddish yellow (5YR 6/8) mottles; loam; many medium and large stones; weak, very coarse subangular blocky structure with grey ped faces; firm, semi-deformable consistence; very plastic (wet); common very fine to medium pores; common fine vertical roots; clear wavy boundary.
Eg2	60–100	Light grey (10YR 7/1) to pinkish grey (5YR 6/2); common medium yellowish brown (7.5YR 5/6) mottles; sandy loam; abundant medium to large stones; very weak very coarse subangular blocky structure with grey ped faces; firm, semi-deformable consistence; very plastic (wet); few very fine pores; few roots; gradual wavy boundary.
Bg	100–140	Brown (7.5YR 5/3); common, very coarse, pale red (2.5YR 6/2) mottles; loam; common, medium and large stones; massive structure; firm, semi-deformable consistence; non-plastic (wet); few very fine pores; few roots, gradual wavy boundary.
C	140+	Strong brown (7.5YR 5/4); few coarse pinkish grey (5YR 6/2) mottles; loam with sand lenses; many medium to very large stones; massive structure; slightly firm, semi-deformable consistence; non-plastic (wet); few very fine pores, no roots.

Table 3.78: Particle size and chemical analyses, Newport Series.

Horizon	A1	A2	Eg1	Eg2	Bg	C
Depth cm	0–12	12–25	25–60	60–100	100–140	140+
Particle Size % :						
Coarse sand 200–2000 μm	21	27	24	48	24	39
Fine sand 50–200 μm	30	27	26	20	20	25
Silt 2–50 μm	32	31	36	18	33	20
Clay <2 μm	17	15	14	14	23	16
TNV g kg^{-1}	0	0	0	0	0	0
Ca cmol kg^{-1}	8.4	6.4	1.4	1.1	1.9	1.1
Mg cmol kg^{-1}	0.74	0.41	0.27	0.34	0.95	0.61
K cmol kg^{-1}	0.2	0.03	0.01	0.05	0.14	0.06
Na cmol kg^{-1}	0.21	0.13	0.06	0.04	0.03	0.06
TEB cmol kg^{-1}	9.55	6.97	1.74	1.53	3.02	1.83
CEC cmol kg^{-1}	22.4	16.2	2.8	2.8	6.8	5.6
Base Saturation %	43	43	62	55	44	33
pH	5.6	5.6	6.0	5.9	5.7	6.0
C g kg^{-1}	40	19	1	1	1	1
N g kg^{-1}	2.9	1.7				
C/N	14	11				
Free iron g kg^{-1}	2	4	4	7	18	13

Table 3.79: Physical analyses, Newport Series.

Horizon	A	A	E	E	E	E
Sub-horizon	1	2	g1	g1	g2	g2
Depth cm	0–12	12–25	25–45	45–60	60–80	80–100
Particle density Mg m^{-3}	2.43	2.55	2.7	2.7	2.69	2.67
Bulk density at saturation Mg m^{-3}	0.91	1.32	1.65	1.78	1.86	1.9
Bulk density at -59 hPa Mg m^{-3}	0.91	1.32	1.65	1.78	1.86	1.9
Air capacity % vol.	8.4	7.1	5.4	3.3	2.4	2.5
Retained water % vol.:						
0 hPa	63.0	48.4	39.6	34.6	32.4	29.9
-2 hPa	58.1	43.1	35.7	32.0	30.6	28.0
-59 hPa	54.6	41.4	34.2	31.3	30.0	27.4
-137 hPa	52.7	40.4	33.3	30.6	29.5	26.4
-0.1 MPa	43.6	35.7	28.7	27.4	26.4	17.3
-1.5 MPa	17.4	13.7	12.5	14.1	12.6	6.5
Total available water % vol.	37.3	27.7	21.7	17.1	17.5	20.9
Total available water cm	4.5	3.6	7.6	2.6	7.0	8.3
Total available water cumulative cm	4.5	8.1	15.6	18.2	25.2	33.6

Table 3.80: Descriptive statistics, Newport Series.

Item	Depth cm	Count	Mean	Standard Deviation	Minimum	Maximum	Range
Clay	0–10	10	16.9	4.0	11	23	12
Clay	40–50	10	12	2.2	9	16	7
Fine silt	0–10	10	18.6	5.1	12	29	17
Fine silt	40–50	10	18.8	4.4	12	27	15
Coarse silt	0–10	10	19.1	2.9	16	24	8
Coarse silt	40–50	10	20.2	2.6	17	25	8
Very fine sand	0–10	10	15.2	5.7	8	26	18
Very fine sand	40–50	10	16	5.0	8	25	17
Fine sand	0–10	10	11.9	3.1	6	16	10
Fine sand	40–50	10	14.2	3.0	10	18	8
Medium sand	0–10	10	9.9	2.0	6	14	8
Medium sand	40–50	10	11.2	1.0	10	13	3
Coarse sand	0–10	10	6.6	1.9	4	10	6
Coarse sand	40–50	10	6.2	1.8	5	10	5
Very coarse sand	0–10	10	1.8	1.2	1	5	4
Very coarse sand	40–50	10	1.4	0.7	1	3	2
TNV g kg^{-1}	0–10	10	0	0	0	0	0
TNV g kg^{-1}	40–50	10	0	0	0	0	0
Ca cmol kg^{-1}	0–10	10	7.62	2.88	0	10.46	10.46
Mg cmol kg^{-1}	0–10	10	0.79	0.29	0.38	1.28	0.9
K cmol kg^{-1}	0–10	10	0.17	0.11	0.02	0.4	0.38
Na cmol kg^{-1}	0–10	10	0.15	0.06	0.04	0.26	0.22
TEB cmol kg^{-1}	0–10	10	8.72	3.13	0.57	12.28	11.71
CEC cmol kg^{-1}	0–10	10	26.46	6.99	15.2	39	23.8
Base Sat. %	0–10	10	35.4	15.6	2	56	54
pH	0–10	10	5.07	0.67	3.6	5.9	2.3
pH	40–50	10	5.3	0.5	4.5	6.3	1.8
C g kg^{-1}	0–10	10	66.5	20.8	30	96	66
C g kg^{-1}	40–50	10	4.7	1.4	3	7	4
N g kg^{-1}	0–10	10	4.1	1.2	2.8	6.4	3.6
C/N	0–10	10	16.4	3.1	10.3	20.4	10.1
Free iron g kg^{-1}	0–10	10	10.1	9.1	2	33	31
Free iron g kg^{-1}	40–50	10	10.4	6.5	1	20	19

Portlaw Series

This series is widespread in the county. It occupies 4746 ha (2.58% of the county). It lies mostly along the sides of the main river valleys:

- Suir valley from Kilmeadan to Fourmilewater via Carrick-on-Suir and Clonmel
- Blackwater valley from Ballyduff to Cappoquin
- Bride valley north of Villierstown.

Elevation is mostly between 15 and 150 m AMSL; a small proportion extends up to 215 m AMSL. The soil is associated with the Kilmeadan and Dungarvan series, which are at lower elevations, the Clashmore series, which is at similar or lower elevations, and the Knockboy series, which occupies the highest positions in the topographic sequence. Gradients are very variable and range from undulating (1–6^{o}) to steep (≥19^{o}). Vegetation is predominantly mixed deciduous and coniferous woodland. The soil overlies sandstone and mudstone of the Kiltorcan and Knockmealdown formations. The parent material is drift composed predominantly of sandstone and traces of shale, and limestone at lower elevations.

A typical profile is characterised by a bleached eluvial horizon (E), which may be up to 50 cm thick. This is underlain by a yellowish brown spodic horizon, which is thin in some pedons. This suggests that under woodland the bleached eluvial horizon develops more rapidly than the spodic B horizon. A thin, discontinuous, black, humus B horizon underlies the E horizon in places. The exchange capacity and free iron contents of the B horizon are high. The base saturation throughout the solum is very low. The soil is classified as a Podzol. In most pedons, the humus B horizon (Bh) is thinner than that required for the Humod subgroup; the series is classified as a Typic Haplorthod (USDA, 1999).

The bleached horizon (E) has very high bulk density, brittle consistence and low air capacity. All horizons above and beneath the bleached horizon have moderate (>7%) air capacity, which suggests that their hydraulic conductivity is moderately rapid. Redoximorphic features are absent, and the soil is considered well drained. The available water capacity of the surface organic horizon (O) and the spodic horizon (Bs) are extremely high, and consequently the total available water in the profile is very high.

Soil suitability: The Portlaw series is currently devoted to mixed woodland, and due to the costs of reclamation, this will probably remain the best use. Potentially the soil is suited to grassland, and to tillage where slopes are favourable. The principal limitations are strong acidity throughout the solum and the high density of the subsurface eluvial horizon, which limits root penetration. The acidity can be remedied by liming; since the E horizon is brittle, the high density can be remedied by soil loosening and by mixing the soil material with the organic surface horizons. As the continuing limitations after reclamation would be slight, the undulating phase of Portlaw is potentially very suited to grassland and arable crops; it is assigned to Class AI. Most (83%) of the Portlaw map unit, however, has gradient limitations that range from slight for rolling land under grassland to very severe for steep land under arable crops (Table 4.8).

Representative profile description

Series:	Portlaw
Location:	Co. Waterford, Coolfinn Td, Grid Ref. 246300 113900
Classification:	Podzol. (Typic Haplorthod)
Parent Material:	Till, mostly sandstone, some shale, traces of limestone.
Drainage:	Well
Topography:	Undulating
Slope:	3°
Altitude:	65 m AMSL
Land-use:	Norway Spruce plantation.

Horizon	Depth (cm)	Description
Oi	0–2	Spruce leaf litter, undecomposed.
Oa	2–10	Black (7.5YR 2/0); strongly humified; weakly developed medium and fine granular structure; friable consistence; non plastic (wet); many medium to very coarse woody roots; clear wavy boundary.
E	10–30(70)	Grey (10YR 6/1) and greyish brown (10YR 5/2) loam; common small and medium stones; massive structure; very strong, brittle consistence; slightly plastic (wet); few medium pores; medium and coarse roots; abrupt irregular boundary.
Bh	30–33(73)	Black (10YR 2/1); loam; massive structure; slightly firm, brittle consistence; moderately plastic (wet); broken boundary.
Bs1	33–60(80)	Strong brown (7.5YR 5/6) and dark brown (7.5YR 3/2); loam; common small and medium stones; slightly firm, brittle consistence; moderately plastic (wet); many very fine pores; few medium roots; undulating gradual boundary.
Bs2	60–120	Brownish yellow (10YR 6/5); loam; common small and medium stones; massive structure; firm, brittle consistence; moderately plastic (wet); many very fine pores; few medium roots; clear wavy boundary.
C	120–150+	Greyish brown (10YR 5/2); sandy loam; many small and medium stones; massive structure; firm brittle consistence; very plastic (wet); common fine pores; no roots.

Table 3.81: Particle size and chemical analyses, Portlaw Series.

Horizon	Oa	E	Bh	Bs1	Bs2	C
Depth cm	2–10	10–30	30–33	33–60	60–120	120–150+
Particle Size % :						
Coarse sand 200–2000 μm		25	16	25	34	38
Fine sand 50–200 μm		20	13	15	15	19
Silt 2–50 μm		43	33	36	35	34
Clay <2 μm		12	38	24	16	9
TNV g kg^{-1}						
Ca cmol kg^{-1}	3.80	0.20	0.20	0.10	0.10	0.10
Mg cmol kg^{-1}	4.80	0.20	0.20	0.07	0.02	0.07
K cmol kg^{-1}	1.04	0.04	0.20	0.10	0.06	0.03
Na cmol kg^{-1}	1.5	0.14	0.31	0.29	0.14	0.12
TEB cmol kg^{-1}	11.18	0.58	0.91	0.56	0.32	0.25
CEC cmol kg^{-1}	137.6	9.4	74.2	36	15.2	6.0
Base Saturation %	8	6	1	2	2	4
pH	3.8	4.1	4	4.2	4.7	5.7
C g kg^{-1}	300	9	76	24	7	4
N g kg^{-1}	13.2	0.4	2.9	0.9		
C/N	23	23	26	27		
Free iron g kg^{-1}	3	5	15	41	22	14

Table 3.82: Physical analyses, Portlaw Series.

Horizon	O	E	B	B	B	C
Sub-horizon	a		h	s1	s2	
Depth cm	2–10	10–30	30–33	33–60	60–120	120–150+
Particle density Mg m^{-3}	1.51	2.60		2.55	2.63	2.67
Bulk density at saturation Mg m^{-3}	0.20	1.83		1.01	1.39	1.60
Bulk density at -59 hPa Mg m^{-3}	0.21	1.85		1.01	1.39	1.59
Air capacity % vol.	10.1	3.3		7.7	9.9	9.4
Retained water % vol.:						
0 hPa	87.5	38.1		68.1	48.3	42.9
-2 hPa	82.0	33.8		62.3	44.2	37.3
-59 hPa	77.4	34.8		60.3	38.4	33.5
-137 hPa	67.7	34.4		54.9	34.7	31.7
-0.1 MPa						
-1.5 MPa	10.7	9.1		8.7	10.9	5.0
Total available water % vol.	66.7	25.7	26.0[1]	51.7	27.5	28.5
Total available water cm	5.3	5.1	0.8[1]	13.9	16.5	8.6
Total available water cumulative cm	5.3	10.5	11.3	25.2	41.7	50.3

[1] Estimated

Slievecoiltia Series

This series is situated in the northeastern part of the county where it occupies 896 ha (0.49% of the county). It was mapped previously in Co. Wexford (Gardiner and Ryan, 1964). It lies mainly along the western and eastern margins of the Rathgormuck Plateau and along the north side of Croughaun Hill. To the west, it is on the upper slopes of Clondonnell Hill and on the relatively gently sloping plateau that forms the crest of the hill. It also extends along the foot slopes of the Comeragh and Monavullagh mountains, where it is associated with the Ballycondon and Monavullagh series, which generally lie above it, and with the Clonroche and Mothel series, which are at lower elevations. To the east it lies along the western slopes of the Portlaw ridge, where it is associated with the Ballycondon and Portlaw series, which lie above it, and with the Clonroche and Mothel series, which are at lower elevations. Elevation ranges from 120 to 305 m AMSL, but most of the series lies between 150 and 215 m AMSL. Relief is commonly rolling (7–11°), but ranges from undulating to moderately steep. Undulating relief (<7°) is common on the crest of Clondonnell Hill and south of Lahardan Hill in the townlands of Lahardan and Tigroe. Parent material is slate and siltstone bedrock of the Ballindysert and Kilmacthomas formations, and in places a thin (<1 m) diamicton of similar composition, which is probably of glacial origin. Bedrock outcrops in a few places. Average annual rainfall is moderately high, about 1500 mm per annum, on the western part of the series; it is less on the eastern part, where it is estimated to be about 1125 mm.

A typical profile has a dark brown (ochric) surface horizon, about 20 cm thick, with a clear wavy boundary over yellowish or yellowish red subsoil (B horizon). This series lacks a bleached albic (E) horizon or an ironpan; it is classified as a Brown Podzolic. In the USDA system (1999) it is classified as a Haplorthod; as the solum depth ranges from 30 to 60 cm the map unit comprises both Lithic and Typic subgroups. In places, especially where the solum is shallow, the spodic horizon is thin or absent and forms a Brown Earth inclusion.

Texture of the solum is loam to clay loam; clay content ranges from 25% to 30% in the representative profile; weathered material around rock fragments in the parent material is finer with 37% clay. The abundance of shaly fragments increases with depth; the subsoil typically contains many to abundant fragments. The surface and subsurface horizons have relatively well developed granular structure and friable or very friable consistence. Although the subsoil has many stone fragments, rooting is generally well developed, and effective rooting depth ranges from 30 to 60 cm.

Typically, the carbon content of the surface horizon is moderate to high relative to Irish mineral soils generally and probably reflects the relatively high rainfall and generally poor suitability for cultivation. The nutrient retention capacity as indicated by CEC is correspondingly high. The solum is slightly to moderately acid, and base saturation is very low (<20%) in the subsurface horizons. The relatively high free iron content of the subsurface horizon (B horizon), compared to the surface horizon and the parent material, confirms its spodic quality.

Gardiner and Ryan (1964) noted that a striking feature of the Slievecoiltia series in Co. Wexford, where annual rainfall is about 1000 mm, is its capacity to retain moisture during dry spells. The available water capacity of the surface horizon (A horizon) of the representative profile in Co. Waterford is very high. Due to stoniness, data is not available for all subsurface horizons, but it is likely that the total available water in the profile, assuming an effective rooting depth of 50 cm, is moderate. As the Slievecoiltia series in Co. Waterford, especially the western parts of the series, has higher rainfall than that in Co. Wexford, the risk of drought is very low, and it is likely to be limited to the shallow phase in exceptionally dry spells. Although the clay content is moderately high, the series lacks evidence of wetness, owing to the moderately large air capacity and abundant shaly stones in the subsoil and parent material.

Soil suitability: The principal limitations are elevation, slope, depth, and rockiness in places. The reduction in yield of grass due to the lower temperature regime associated with increased elevation is estimated to be similar to that of the Knockboy series, where elevation forms a slight limitation and was assigned to suitability Class B in the absence of other limitations. However, only the moderately deep phase on undulating relief, which forms a minor part of the Slievecoiltia series, belongs to Class B. The rolling and moderately steep phases have moderate to severe limitations for grassland; as the slope and climatic limitations are cumulative, these phases are assigned to suitability classes C and D respectively. In general, this series is not suitable for arable crops; the combination of elevation, slope, and depth forms a severe limitation (Suitability Class IV and V). Only the moderately deep phase on undulating topography is suited to cultivation (Suitability Class III). Gardiner and Ryan (1964) considered the Slievecoiltia series to be amongst the better hill soils in the country for forestry.

Representative profile description

Series:	Slievecoiltia
Location:	Co. Waterford, Glenhouse Td., Grid Ref. 247800 11900
Classification:	Brown Podzolic (Lithic Haplorthod)
Parent Material:	Shale bedrock
Drainage:	Well
Topography:	Rolling
Slope:	6º
Altitude:	160 m AMSL
Land-use:	Old pasture

Horizon	Depth (cm)	Description
Al	0–10	Dark brown (10YR 4/3); loam; few small stones; weak and moderate medium granular structure; friable, semi-deformable consistence; moderately plastic (wet); abundant very fine grass roots; abrupt smooth boundary.
A2	10–20	Dark brown (10YR 4/3); loam; abundant small stones; moderate coarse and medium granular structure; friable, semi-deformable consistence; moderately plastic (wet); abundant very fine diffuse roots; clear wavy boundary.
Bs	20–45	Yellowish red (5YR 4.5/8); loam; very abundant large stones; weakly developed fine granular structure; very friable consistence; slightly plastic (wet); few to common, very fine pores; many very fine diffuse roots; irregular clear boundary.
C1	45–46	Light yellowish brown loam around rock.
C2	46+	Shale bedrock.

Table 3.83: Particle size and chemical analyses, Slievecoiltia Series.

Horizon	A1	A2	Bs	C
Depth cm	0–10	10–20	20–45	45–46
Particle Size % :				
Coarse sand 200–2000 μm	33	33	24	22
Fine sand 50–200 μm	12	12	14	7
Silt 2–50 μm	28	30	32	34
Clay <2 μm	27	25	30	37
TNV g kg^{-1}				
Ca cmol kg^{-1}	14.3	11	1.6	1.4
Mg cmol kg^{-1}	0.95	0.81	0.07	0.41
K cmol kg^{-1}	0.27	0.26	0.1	0.07
Na cmol kg^{-1}	0.19	0.13	0.12	0.15
TEB cmol kg^{-1}	15.71	12.2	1.89	2.03
CEC cmol kg^{-1}	37	26.1	20.4	11.5
Base Saturation %	42	47	9	18
pH	6.3	6.3	5.1	5.0
C g kg^{-1}	59	33	18	8
N g kg^{-1}	4.8	2.9	2.1	
C/N	12.3	11.4	8.6	
Free iron g kg^{-1}	31	32	45	31

Table 3.84: Physical analyses, Slievecoiltia Series.

Horizon	A	A
Sub-horizon	1	2
Depth cm	0–10	10–20
Particle density Mg m^{-3}	2.36	2.45
Bulk density at saturation Mg m^{-3}	0.98	1.15
Bulk density at -59 hPa Mg m^{-3}	0.99	1.16
Air capacity % vol.	3.5	8.5
Retained water % vol.:		
0 hPa	61.9	59.2
-2 hPa	57.7	54.2
-59 hPa	58.4	50.7
-137 hPa	57.5	43.9
-0.1 MPa		
-1.5 MPa	15.4	16.1
Total available water % vol.	43.0	34.6
Total available water cm	4.3	3.5
Total available water cumulative cm	4.3	7.8

Slob Series

Most of this series occurs around the Back Strand in Tramore Bay. A small area beside Dungarvan Harbour is included in the Slob map unit. The total area of the map unit is 282 ha (0.15 % of the county). Similar soils were mapped previously in Co. Wexford (Gardiner and Ryan, 1964), where two series were distinguished: Wexford Slob and Kilmore Slob. Since the original map units in Co. Wexford contained significant overlap, these two series are combined into a single series (Slob); distinctions are made at phase level in Co.Waterford.

In the Tramore area, the Slob series is situated in a low-lying area which is protected from the sea by a system of embankments and sluices. The parcel in the Dungarvan area lies to the north of a railway embankment. Parent material is estuarine alluvium composed predominantly of silt or fine sand.

The soil profiles consist of varying configurations of layers that are predominantly silty, sandy or peaty. Shells are common in the mineral layers. The series is subdivided into silty, sandy or peaty phases primarily on the basis of the composition of the topsoil. The eastern and northern part of the Lisselan Intake, which consists mostly of about 20 cm of silty loam or silty clay loam overlying fine sandy material, is included with the normal silty phase. Thin fibrous peat layers within the silty and sandy phases indicate little pedogenic development; these phases are classified as Regosols (Aeric Fluvaquents).

A profile description and analyses of the silty phase is shown below. A layer of silt loam, 36 cm thick, overlies a dark brown horizon with high carbon content. Evidently the upper material was dug out to make watercourses and spread over the existing topsoil. Silt content is very high (60–70%) down to 1.5 m depth; below this depth fine sand is dominant (60%). The matrix of the material under the buried A horizon is grey; brown or brownish yellow mottles extend down to 1.5 m depth below which there are no mottles, which indicates that the lowest layer is permanently or near permanently saturated with water. Structure below the buried A horizon consists of very coarse massive prisms, which probably developed after the water table was lowered. Shell fragments are present in the upper A horizon (0–20 cm), while the shells in the lowest horizon (1.5–2.0 m) are intact.

Exchangeable sodium content increases with depth indicating leaching from the upper horizons and increasing influence of saline water with depth. Carbon content is irregular down to 75 cm depth and ranges from low to high. Free iron content is also irregular with depth. The low content in the surface layer (0–20 cm) is consistent with being saturated with water and reduction and removal of iron before the material was spread on the surface.

Air capacity is very low in all horizons except the buried A horizon, where it is low. The low air capacity of the representative profile implies moderately slow hydraulic conductivity. However, mean hydraulic conductivity measured at four sites was moderately rapid (0.60 m day^{-1}), but variation among sites was substantial (Appendix III). The mean hydraulic conductivity was slower than that found in alluvial soils (Coolfinn series) and more rapid than that of poorly drained soils derived from till (e.g. Tramore series). The bulk density of the representative profile is moderate to high throughout the profile, which confirms that the soil is fully ripened and therefore no longer belongs to the Hydraquent group. Roots extend to 1.5 m depth, mainly along ped faces.

The Slob series is generally poorly drained due to the shallow groundwater and, in places, slow hydraulic conductivity. The soil water regime, however, varies widely depending on the effectiveness of artificial control measures.

Soil suitability: Land use varied widely within the series at the time of mapping. The Kilmacleague Slob was devoted to grassland, some of which was reseeded. The Lisselan Intake, which comprises silty and sandy phases, was devoted to wheat and barley. The embankment around the Tramore Intake had broken down and was no longer capable of preventing the sea from encroaching. The old Tramore Racecourse is situated within this intake. Vegetation in the silty area within the Tramore Intake consisted mostly of Spartina sp., which is characteristically found in tidal mud flats; the sandy area was mostly without vegetation.

Wetness is the principal limitation. With embankments, sluices and field drainage, the Slob series is moderately suited to tillage and grassland. The sandy phase is easily cultivated but the silty phase, due to its plastic consistence, presents a greater difficulty in obtaining suitable tilth and is likely to have a later sowing date in Spring. The soil is assigned to suitability class CIII.

Representative profile description

Series:	Slob
Location:	Co.Waterford, Kilmacleague West Td., Grid Ref. 262800 101800
Classification:	Gley (Aeric Fluvaquent)
Parent Material:	Estuarine deposit
Drainage:	Poor
Topography:	Gently undulating
Slope:	1°
Altitude:	3 m AMSL
Land-use:	Reseeded pasture

Horizon	Depth (cm)	Description
Al	0–10	Greyish brown (10YR 5/2) with common fine strong brown (7.5YR 5/6) mottles; silt loam; no stones; very weakly developed fine subangular blocky structure; very firm consistence; moderately plastic (wet); abundant roots; few shell fragments; gradual wavy boundary.
A2	10–20	Greyish brown (10YR 5/2) and common fine reddish brown (5YR 4/4) mottles; silt loam; no stones; very weakly developed medium blocky structure; very firm consistence; moderately plastic (wet); few very fine pores; many roots; few shell fragments; gradual wavy boundary.

A3	20–36	Greyish brown (10YR 5/2) and common fine reddish brown (5YR 4/4) mottles; silt loam; no stones; weakly developed structure, very coarse prisms, about 40 cm diameter, parting to very weakly developed medium blocky structure; very firm, brittle consistence, becoming semi-deformable with depth; moderately plastic (wet); few very fine pores; common very fine roots; abrupt wavy boundary; few shell fragments; this horizon contains a band 10 cm thick 50 cm+ wide similar to next underlying horizon.
A1b	36–48	Dark brown (7.5YR 4/2) and few fine greyish brown (10YR 5/2) mottles; silty clay loam; no stones; weak/moderate medium granular structure; friable consistence; very plastic (wet); few very fine roots; abundant, undecomposed, very fine dead roots; clear wavy boundary.
Cg1b	48–75	Grey (7.5YR 6/0) and many medium, strong brown (7.5YR 5/6) and fine brown (7.5YR 5/4) mottles along root channels; silt loam; no stones; weakly developed very coarse, 40 cm diameter, massive prisms; firm, semi-deformable consistence; common fine pores; few roots along ped faces; gradual boundary.
Cg2b	75–100	Grey (7.5YR 6/0) with many medium strong brown (7.5YR 5/6) mottles; very coarse, 40 cm diameter, massive prisms; firm, semi-deformable consistence; extremely plastic (wet); common, fine pores; few roots along ped faces; clear smooth boundary.
Cg3b	100–150	Grey (7.5YR 6/0) and common medium brownish yellow (10YR 6/6) mottles; silt loam; no stones; massive structure; friable, semi-deformable consistence; moderately plastic (wet); abundant, medium pores; few dead roots; gradual wavy boundary.
Cg4b	150–200	Grey (7.5YR 5/0), sandy loam; massive structure; slightly firm, semi-deformable consistence; slightly plastic (wet); few medium pores; few intact shells.

Table 3.85: Particle size and chemical analyses, Slob Series.

Horizon	A1	A2	A3	A1b	Cg1b	Cg2b	Cg3b	Cg4b
Depth cm	0–10	10–20	20–36	36–48	48–75	75–100	100–150	150–200+
Particle Size % :								
Coarse sand 200–2000 μm	0	1	1	1	1	0	0	4
Fine sand 50–200 μm	13	18	9	7	4	5	24	60
Silt 2–50 μm	63	61	66	64	70	67	62	30
Clay <2 μm	24	20	24	28	25	28	14	6
TNV g kg^{-1}	41	46	0	0	0	0	126	175
Ca cmol kg^{-1}	16.4	14.1	13.4	10.3	4.9	8.4	4.7	5.4
Mg cmol kg^{-1}	1.83	1.76	2.44	4.33	4.4	4.81	1.15	0.81
K cmol kg^{-1}	0.11	0.24	0.37	0.53	0.46	0.84	0.48	0.43
Na cmol kg^{-1}	0.11	0.26	0.32	0.66	0.51	0.8	0.56	0.88
TEB cmol kg^{-1}	18.45	16.36	16.53	15.82	10.27	14.85	6.89	7.52
CEC cmol kg^{-1}	30.6	25.8	32.8	42.8	29.4	15.6	4	3.2
Base Saturation %	60	63	50	37	35	95	Sat	Sat
pH	7.3	7.4	6.7	5.4	5.8	6.6	8.3	7.6
C g kg^{-1}	36	26	40	93	26	8	2	6
N g kg^{-1}	2.5	1.7	3.5	8.1	2.1	0.8		
C/N	14.4	15.3	11.4	11.5	12.4	10		
Free iron g kg^{-1}	9	8	12	11	19	16	6	2

Table 3.86: Physical analyses, Slob Series.

Horizon	A	A	A	A	C	C	C	C
Sub-horizon	1	2	3	1b	g1b	g2b	g3b	g4b
Depth cm	0–10	10–20	20–36	36–48	48–75	75–100	100–150	150–200+
Particle density Mg m^{-3}	2.44	2.49	2.44	2.13	2.50	2.56	2.63	2.65
Bulk density at saturation Mg m^{-3}	1.31	1.34	1.38	1.01	1.42	1.39	1.38	1.47
Bulk density at -59 hPa Mg m^{-3}	1.32	1.35	1.39	1.02	1.45	1.41	1.43	1.50
Air capacity % vol.	3.3	4.1	3.7	7.3	4.2	3.9	5.0	3.4
Retained water % vol.:	45.9	45.8	43.0	52.1	42.0	44.9	45.6	43.4
0 hPa	48.1	48.3	47.0	59.9	48.6	50.0	50.8	47.7
-2 hPa	44.6	44.3	42.5	54.1	42.9	44.7	43.5	42.0
-59 hPa	44.8	44.2	43.3	52.6	44.5	46.0	45.9	44.3
-137 hPa	43.7	42.7	41.0	50.3	42.4	44.3	44.6	43.1
-0.1 MPa								
-1.5 MPa	14.8	14.7	17.9	24.6	17.6	16.9	10.6	6.6
Total available water % vol.	30.0	29.5	25.4	28.0	26.9	29.2	35.3	37.8
Total available water cm	3.0	2.9	4.1	3.4	7.3	7.3	17.6	18.9
Total available water cumulative cm	3.0	5.9	10.0	13.4	20.6	27.9	45.6	64.4

Suir Series

This series is widespread in the county. It occupies 1142 ha (0.62% of the county) in the flood plains of the major rivers, Suir, Blackwater, and Bride. This series is the freely drained counterpart of the Coolfinn series; the Suir map unit contains inclusions of the Coolfinn series. Unlike the Coolfinn series, it is generally not protected from flooding by embankments and sluices. The river valleys are floored by limestone. The parent material is deep alluvium that consists of material derived from till composed predominantly of sandstone and some limestone. Topography is flat with small shallow depressions. Elevation is less than 30 m AMSL along the river Suir and less than 15 m AMSL along the rivers Blackwater and Bride. Average annual rainfall is generally slightly less than 1125 mm.

Layers of rounded gravel or sand are common within 1 m depth and invariably occur within 1.5 m depth. Peaty layers are absent. A typical profile has low (<10) C/N ratios and fine blocky structure in the upper part of the subsoil. These features indicate that some pedogenic development has taken place, and the soil is accordingly classified as a Brown Earth (Dystrudept). Grey mottles, characteristic of long periods of saturation, are generally absent, but yellowish brown or black manganiferous mottles commonly occur in some part of the solum. The absence of grey mottles and the presence of gravel layers indicate free drainage. However, the soil could be saturated frequently for short periods with oxygenated ground water without forming grey mottles. The presence of yellowish and black manganiferous mottles indicates some saturation; the series is placed in the moderately well drained category. As the profile lacks redox depletions with chroma of two or less within 60 cm of the mineral soil surface, and as it is periodically saturated with water in some layer within 100 cm of the soil surface, this series is tentatively assigned to the Oxyaquic subgroup (USDA, 1999). The exact duration of saturation, however, is unknown.

Texture is variable; clay loams, silty clay loams and silt loams predominate in the upper part of the profile and may extend down to 1 m depth in places. Gravel and sand layers generally occur in the lower part of the solum. A typical profile consists of a brown A horizon overlying a dark brown (7.5YR) weakly developed weathered B horizon. Abundant macropores are visible throughout the subsoil.

Carbon contents are medium and decrease regularly with depth. In contrast to the poorly drained counterpart (Coolfinn series) free iron contents are high or very high throughout the solum. The representative profile lacks free carbonates, the entire solum is moderately acid, and base saturation of all horizons is less than 60%, except for the A2 horizon where it is 60%.

Bulk density is medium down to 70 cm depth and increases to high in the next underlying layer (70–95 cm). Air capacity ranges from low in the surface layer (0–10 cm) to high in the subsoil at 55 to 70 cm depth; it is medium in the rest of the solum. The available water capacity in the representative profile is moderate to 70 cm depth and very low in the 70–95 cm layer. The total available water in the profile to 95 cm depth is moderate, but this will vary within the series depending on the depth and thickness of the coarse layers. Hydraulic conductivity data are not available for the series; however, the large air capacity and the presence of coarse layers imply moderately rapid to rapid hydraulic conductivity.

Soil suitability: The principal limitations are risk of flooding and occasional shallow water table. Although the total available water is typically moderate and may be low in places, drought is unlikely to be a significant limitation in most years due to the contribution from ground water. The effect of flooding and ponding is difficult to quantify as it depends on both the frequency and duration of floods. Floods up to 1.5 m high and lasting 2 to 3 days can occur in winter. Local ponding was observed in summer. Cereals and sugar beet have been grown successfully on this soil. High yields of grass and tillage crops are attainable, but because of the flooding limitation the soil is assigned to Class B (suitable) for grassland and to Class III (moderately suited) for spring sown arable crops. The series is poorly suited to winter cereals.

Representative profile description

Series	Suir
Location:	Co. Waterford, Inchinleama West Td., Grid Ref. 189600 99000
Classification:	Brown Earth (Oxyaquic Dystrudept)
Parent Material:	Alluvium
Drainage:	Moderate, water table at 1.4 m
Topography:	Flat
Slope:	1°
Altitude:	20 m AMSL
Land-use:	Ryegrassclover pasture

Horizon	Depth (cm)	Description
A1	0–10	Brown (7.5YR 4/2); clay loam; few small rounded stones; moderately developed medium granular structure; friable semi-deformable consistence; very plastic (wet); abundant very fine roots.
A2	10–20	Brown (7.5YR 4/2); clay loam; few small rounded stones; moderately developed medium granular structure; friable semi-deformable consistence; very plastic (wet); many very fine roots.
A3	20–40	Similar to A2. Clear smooth boundary.
Bw1	40–70	Dark brown (7.5YR 4/2); clay loam; few small rounded stones; weakly developed compound coarse and fine subangular blocky structure; friable semi-deformable consistence; very plastic (wet); abundant very fine to large macropores; common very fine roots; gradual wavy boundary.
Bw2	70–95	Dark brown (7.5YR 4/2); loam; few small and medium rounded stones; very weakly developed coarse subangular blocky structure; very friable semi-deformable consistence; very plastic (wet); abundant fine macropores; few very fine roots; gradual wavy boundary.
C_1	95–110	Brown (10YR 5/3) and yellowish brown (10YR 5/5); sand; single grain; very friable semi-deformable consistence; abundant fine macropores; few very fine roots; gradual wavy boundary.
C_2	110–140+	Greenish grey and purple sandstone; abundant small to large, mostly medium, rounded stones; single grain; loose consistence; no roots.

Table 3.87: Particle size and chemical analyses, Suir Series.

Horizon	A1	A2	A3	Bw1	Bw2	C1	C2
Depth cm	0–10	10–20	20–40	40–70	70–95	95–110	110–140
Particle Size % :							
Coarse sand 200–2000 μm	9	6	7	18	41	52	81
Fine sand 50–200 μm	11	13	11	10	18	34	3
Silt 2–50 μm	42	43	44	29	19	6	7
Clay <2 μm	38	38	38	43	22	8	9
TNV g kg^{-1}	0	0	0	0	0	0	0
Ca cmol kg^{-1}	14.2	13.6	10.2	7.54	3.82	1.47	2.47
Mg cmol kg^{-1}	1.36	0.7	0.38	0.49	0.28	0.16	0.3
K cmol kg^{-1}	0.27	0.07	0.03	0.02	0.01	0.01	0.02
Na cmol kg^{-1}	0.06	0.08	0.06	0.06	0.01	0.01	0.02
TEB cmol kg^{-1}	15.89	14.45	10.67	8.11	4.12	1.65	2.81
CEC cmol kg^{-1}	28	24	21	21	11.6	4.8	6.8
Base Saturation %	57	60	51	39	36	34	41
pH	6.2	6.4	6.3	6	5.7	5.8	6.5
C g kg^{-1}	35	26	16	14	5	1	1
N g kg^{-1}	4.3	3.3	2.1	1.8			
C/N	8.1	7.9	7.6	7.8			
Free iron g kg^{-1}	38	40	47	53	30	18	14

Table 3.88: Physical analyses, Suir Series.

Horizon	A	A	A	A	Bw	Bw	Bw
Sub-horizon	1	2	3	3	1	1	2
Depth cm	0–10	10–20	20–30	30–40	40–55	55–70	70–95
Particle density Mg m^{-3}	2.41	2.53	2.57	2.57	2.57	2.57	2.64
Bulk density at saturation Mg m^{-3}	1.05	1.13	1.18	1.16	1.0	1.19	1.44
Bulk density at -59 hPa Mg m^{-3}	1.05	1.13	1.18	1.16	1.0	1.19	1.44
Air capacity % vol.	4.7	8.0	8.2	10.8	10.7	15.1	12.1
Retained water % vol.:							
0 hPa	54.9	52.5	51.2	54.6	59.7	57.4	47.2
-2 hPa	53.3	49.8	49.7	52.6	55.6	47.1	39.4
-59 hPa	50.2	44.5	43.0	43.8	49.0	42.3	35.1
-137 hPa	49.3	43.2	41.6	42.3	47.4	41.0	33.7
-0.1 MPa	45.4	38.6	37.2	37.5	45.7	37.6	31.0
-1.5 MPa	28.1	27.2	28.1	27.6	30.9	25.0	26.8
Total available water % vol.	22.2	17.3	14.9	16.2	18.1	17.4	8.3
Total available water cm	2.2	1.7	1.5	1.6	2.7	2.6	2.1
Total available water cumulative cm	2.2	3.9	5.4	7.0	9.8	12.4	14.4

Tramore Series

This series occurs in the southeast of the county in the volcanic region. It covers 6748 ha (3.7% of the county) and comprises about one quarter of the soils derived from non-alluvial volcanic materials. This series is the most extensive poorly drained soil in the lowland (<152 m AMSL) areas of the county. It lies downslope of the Kill series at elevations that range from 15 to 120 m AMSL. The boundary with the Kill series invariably extends up to and commonly about 50 m above the stream "rises". Slopes are gentle and are commonly concave. Rock outcrops are absent. The parent material is till containing volcanic clasts, mainly rhyolite and andesite, and an admixture of shale derived mainly from the local bedrock. Fossil pingos lie within this series at Gaultiere Td. and indicate that the soil was subjected to periglacial conditions at some stage, probably in the early stage of soil development. Average annual rainfall is about 1000 mm and ranges from about 900 mm at the coast to about 1100 mm at the northwestern extremity.

A typical profile has a dark grey A horizon, 30–40 cm deep, with weak medium granular structure that becomes blocky with depth. Carbon content of the surface layer is typically medium, but varies widely from low to extremely high. Free iron content is less than that in the A horizon of the Kill series. Beneath the A horizon there is usually a light grey E horizon that, at about 40 cm intervals, extends down in tongues that get narrower with depth. The tongues have yellowish margins and fine fissures near the centre. Roots follow the fissures. Very coarse brownish prisms lie between the tongues; the prisms are massive, very firm and very brittle (fragipan) and lack roots. The tongues generally branch and lie closer together as depth increases, and they can reach 2 m depth. This series is classified as a Gley (Typic Fragiaquept; USDA, 1999).

Textures are very similar to that of the well drained counterpart, the Kill Series. The solum consists mostly of loams in which the silt content is usually about twice the clay content; some are silt loams. The silt to clay and silt to sand ratios of the brittle polyhedrons (Bx horizon) are 5.4 and 2.8 respectively; these ratios are much greater (>1.9 x) than those of the A, E, and C horizons. It has been postulated that concentrations of silt may occur in leached horizons (albic materials) as residual features. The concentration of silt within the polyhedrons, however, is greater than in the albic materials and probably has an inherited cryogenic origin dating back to glacial or late glacial times.

Although the representative profile lacks carbonates, pH ranges from neutral to moderately alkaline; the random samples also lack carbonates but the surface layer (0–10 cm) ranges from strongly acid to neutral, and the subsoil (40–60 cm) is slightly acid to alkaline. This suggests that there may be some limestone influence in the parent material in places.

The soils are poorly drained. The position of the soil on the landscape suggests that it receives runoff from the surrounding higher ground. Mean hydraulic conductivity is moderately slow (0.19 m day^{-1}); however, site to site variation is substantial (Appendix III). Available water capacity (AWC) is extremely high in the surface layer of the representative profile, but it probably varies widely in the map unit reflecting the wide variation in carbon content. AWC is high in the E and B horizons, but it is less than that in the A horizon. Even if the fragipan layer is excluded, because of the lack of root penetration, the total available water in the profile is still high.

Soil suitability: The principal limitation of the soil is poor drainage. Owing to the moderately slow hydraulic conductivity, wetness will remain a continuing limitation after field drainage. The brittleness of the fragipan horizon should be conductive to shattering by subsoiling. However, it would be impractical and uneconomic to shatter the entire layer owing to its thickness. Periodic waterlogging will remain a continuing limitation after drainage.

The soil is moderately suited to grassland and arable crops; its optimum use is likely to be grassland. Wetness is likely to delay sowing of arable crops in spring; the soil is better suited to winter cereals. Wetness delays grass growth in Spring and utilisation efficiency may be reduced by damage due to poaching. The soil is assigned to suitability Class CIII.

Representative profile description

Series:	Tramore
Location:	Co. Waterford, Coolnagoppogue Td., Grid Ref. 255400 100500
Classification:	Gley (Typic Fragiaquept)
Parent Material:	Till containing volcanic clasts
Drainage:	Poor
Topography:	Undulating
Slope:	3º
Altitude:	55 m AMSL
Land-use:	Permanent pasture

Horizon	Depth (cm)	Description
Al	0–10	Dark grey (10YR 4/1); loam; few small stones; weakly developed medium granular structure; friable, semi-deformable consistence; moderately plastic (wet); abundant diffuse very fine roots.
A2	10–25	Dark grey (10YR 4/1); loam; common small stones; weakly developed medium granular structure; semi-deformable; moderately plastic (wet); many very fine diffuse roots; clear wavy boundary.
A3	25–40	Greyish brown (10YR 5/2); few pale brown (10YR 6/3) mottles becoming common with depth; loam; common small and medium stones; weakly developed, fine subangular blocky structure; friable, semi-deformable consistence; moderately plastic (wet); abundant very fine and medium pores; many roots, clear wavy boundary.
Eg	40–120	Irregular tongues 40–50 cm wide; light grey (10YR 7/1) with many brownish yellow coarse mottles (10YR 6/8) and continuous brownish yellow (10YR 6/8) rim, 4 cm wide, along margin of tongue; silt loam; common small stones; massive structure; firm, semi-deformable consistence; moderately plastic (wet); many very fine and fine pores; few, very fine vertical roots; abrupt irregular boundary; tongues occur at 40 cm intervals.
Bx	45–120	Polyhedrons 40 cm wide x 80 cm deep, olive brown (2.5YR 4/3); common, coarse black manganese mottles, few pale brown (10YR 6/3) tongues, 1 cm wide; silt loam; common small stones; massive structure; very firm, very brittle consistence; moderately plastic (wet); fine and very fine pores; no roots.
Cg	120+	Olive brown (2.5YR 4/3); light grey (10YR 7/2) tongues, 3 cm wide, with yellowish brown (10YR 5/8) rim occur at 20 cm intervals; loam; many large stones; very weakly developed very coarse prismatic structure; peds are very firm; very plastic (wet); few fine and very fine pores; pores are common in grey tongues; no roots.

Table 3.89: Particle size and chemical analyses, Tramore Series.

Horizon	A1	A2	A3	Eg	Bx	Cg
Depth cm	0–10	10–25	25–40	40–120	45–120	120+
Particle Size % :						
Coarse sand 200–2000 μm	20	23	24	17	11	20
Fine sand 50–200 μm	23	24	24	16	12	15
Silt 2–50 μm	38	35	35	49	65	41
Clay <2 μm	19	18	17	18	12	24
TNV g kg^{-1}	0	0	0	0	0	0
Ca cmol kg^{-1}	17.3	15.7	9.1	5.2	5.6	6.3
Mg cmol kg^{-1}	0.7	0.3	0.2	0.1	0.2	0.4
K cmol kg^{-1}	0.19	0.08	0.06	0.06	0.06	0.07
Na cmol kg^{-1}	0.3	0.2	0.19	0.1	0.12	0.14
TEB cmol kg^{-1}	18.49	16.28	9.55	5.46	5.98	6.91
CEC cmol kg^{-1}	32.8	18.7	10.4	5.6	7.2	8
Base Saturation %	56	87	92	97	82	86
pH	6.8	7.2	7.6	8.0	8.0	7.9
C g kg^{-1}	45	26	9	2	2	3
N g kg^{-1}	3.7	1.9	1			
C/N	12.2	13.7	9			
Free iron g kg^{-1}	12	11	13	18	18	25

Table 3.90: Physical analyses, Tramore Series.

Horizon	A	A	A	E	B
Sub-horizon	1	2	3	g	x
Depth cm	0–10	10–25	25–40	40–120	45–120
Particle density Mg m^{-3}	2.38	2.48	2.56	2.62	2.62
Bulk density at saturation Mg m^{-3}	0.87	1.24	1.35	1.67	1.76
Bulk density at -59 hPa Mg m^{-3}	0.89	1.26	1.37	1.68	1.77
Air capacity % vol.	8.8	6.2	9.2	5.4	4.6
Retained water % vol.:					
0 hPa	69.9	58.0	54.1	42.0	38.6
-2 hPa	60.0	52.6	47.2	36.5	34.8
-59 hPa	61.1	51.8	44.9	36.6	33.9
-137 hPa	59.5	50.3	43.8	36.1	33.6
-0.1 MPa					
-1.5 MPa	11.9	13.4	10.2	13.3	11.1
Total available water % vol.	49.2	38.4	34.7	23.3	22.8
Total available water cm	4.9	5.8	5.2	1.2	17.1
Total available water cumulative cm	4.9	10.7	15.9	17.1	34.2

Table 3.91: Descriptive statistics, Tramore Series.

	Depth cm	Count	Mean	Standard Deviation	Minimum	Maximum	Range
Coarse sand %	0–10	21	25.5	5.8	12	38	26
	40–50	11	27.7	6.5	17	36	19
Fine sand	0–10	21	16.0	4.4	10	26	16
	40–50	11	14.5	2.1	12	18	6
Silt	0–10	21	38.0	6.7	25	51	26
	40–50	11	39.9	6.2	31	48	17
Clay	0–10	21	20.4	3.5	14	27	13
	40–50	11	17.9	4.3	11	24	13
TNV g kg^{-1}	0–10	21	0		0	0	0
	40–50	11	0		0	0	0
CEC cmol kg^{-1}	0–10	20	29.3	6.3	18.6	42.8	24.2
	40–50	11	10.6	6.8	4.4	27.4	23
Base Saturation %	0–10	20	42.8	21.4	10	78	68
	40–50	11	41.1	12.0	22	60	38
pH	0–10	21	5.7	0.9	4.3	7	2.7
	40–50	11	6.6	0.6	5.6	7.7	2.1
C g kg^{-1}	0–10	21	46.7	23.3	20	118	98
	40–50	11	5.8	7.3	1	26	25
Free iron g kg^{-1}	0–10	21	12.4	5.2	4	20	16
	40–50	11	18.4	7.2	6	28	22

Waterford Series

This series occupies 1901 ha (1.03% of the county). It is widely distributed in the north of the county and occurs mainly as a series of pockets along and below the flanks of the sandstone ridge that stretches from Waterford City to Fourmilewater, south west of Clonmel. It is associated mostly with its well drained counterpart, the Kilmeadan series, but also abuts the Clonroche and Kill series in places. Elevation is mostly between 30 and 60 m AMSL and a small part extends up to 90 m AMSL. Topography is undulating; some slopes are concave. Apart from some alluvial soils, it occupies the lowest position on the landscape and probably receives runoff from the surrounding higher ground. This series overlies a range of rock types including sandstone, limestone, shale, slate, and volcanic rocks, The parent material is mixed calcareous till composed of varying amounts of limestone, sandstone, calcareous shales, slates, and near Waterford City some volcanic material. The parent material is similar to that of the Kilmeadan series; the relatively high limestone content distinguishes it from the Mothel and Clohernagh series. Average annual rainfall ranges from 1000 mm near Waterford City to about 1200 mm near Fourmilewater.

The soil profile is characterised by a grey B horizon with many to abundant yellowish brown and some black manganiferous mottles. In the representative profile described below limestone pebbles and stones are absent above 60 cm depth below which the stone content increases with depth. The representative profile lacks carbonates; acidity is variable but some subhorizons are neutral (Cg) or alkaline (Bg3). Texture is generally light loam in the A horizon and becomes finer with depth; it is generally clay loam in the B and C horizons. In the subsoil, (B and C horizons), structure is very weak or massive, consistence is firm or very firm and bulk density is high to very high. The effect is that roots are sparse below about 50 cm. Some roots follow fine fissures with grey faces which extend down to about 1 m depth. Hydraulic conductivity (Ksat) is slow; the mean Ksat (0.05 m day^{-1}) is slower than that of the other Gleys in the county that are derived from till, but the difference is not statistically significant ($\alpha = 0.05$; Appendix III). Waterford series soils are poor to imperfectly drained and are classified as Gleys (Typic Epiaquept).

The available water capacity is extremely high in the A horizon and is moderately high to high in the subsoil. Total available water capacity in the profile is very high, but the amount of water utilised by plants is restricted by poor root development in the lower (>60 cm depth) parts of the B horizon.

Soil suitability: The principal limitation is wetness and the soil is only moderately suited to grassland and arable crops. Its optimum use is grassland. The slow hydraulic conductivity limits the improvement that can be economically attained by field drainage, and wetness is a continuing limitation after field drainage. Wetness delays grass growth in Spring and utilisation efficiency can be reduced by poaching damage. The grazing season is 3 to 4 weeks shorter than on the associated Kilmeadan series with a corresponding increase in the winter feeding period. Wetness delays sowing date of arable crops in Spring; the soil is better suited to winter cereals. The series is assigned to suitability Class CIII.

Representative profile description

Series:	Waterford
Location:	Co. Waterford, Butlerstown North Td., Grid Ref. 255900 109900
Classification:	Gley (Typic Epiaquept)
Parent Material:	Mixed till, mostly sandstone and shale, traces of limestone and chert.
Drainage:	Poor
Topography:	Gently sloping
Slope:	2^o
Altitude:	30 m AMSL
Land-use:	Old pasture

Horizon	Depth (cm)	Description
Al	0–10	Greyish brown (10YR 5/2) and few fine yellowish brown (10YR 5/6) mottles; loam; few small stones; weak to moderate fine granular structure; friable, semi-deformable consistence; moderately plastic (wet); abundant very fine diffuse roots and few coarse roots.
A2	10–20	Greyish brown (10YR 5/2) and few fine yellowish brown (10YR 5/6) mottles; loam; few small stones; weak to moderate medium granular structure; friable, semi-deformable consistence; moderately plastic (wet); abundant very fine diffuse roots and few coarse roots; clear wavy boundary.
Bg1	20–40	Light brownish grey (10YR 6/2) and common medium light olive brown (2.5Y 5/6) mottles; loam; common small to large stones; very weakly developed, very coarse subangular blocky structure; firm semi-deformable consistence; very plastic (wet); common very fine pores; common very fine to medium roots.
Bg2	40–60	Light brownish grey (10YR 6/2) and many (≈35%) coarse yellowish brown (10YR 5/8) mottles; clay loam; common small stones; weakly developed very coarse subangular blocky structure; firm semi-deformable consistence; very plastic (wet); common very fine to medium pores; common very fine roots; gradual wavy boundary.
Bg3	60–90	Light grey (10YR 7/2) and abundant coarse (10YR 5/8) mottles and common black manganese mottles; clay loam; many small and medium stones, very few large stones; massive structure; very firm, semi-deformable consistence; very plastic (wet); common fine pores; few vertical roots.
Bg4	90–120	Light grey (10YR 7/2) and abundant coarse (10YR 5/8) mottles, few black manganese mottles; clay loam; many small and medium stones, very few very large stones; massive structure; very firm, semi-deformable consistence; few fine pores; few roots (mainly dead); gradual boundary.

Cg	120–140+	Light grey (10YR 7/1) and abundant coarse yellowish brown (10YR 5/4) and black mottles; clay loam; many small and medium stones, few large stones; massive structure; firm, semi-deformable consistence; very plastic (wet); few fine pores; few dead vertical roots.

Table 3.92: Particle size and chemical analyses, Waterford Series Horizon.

	A1	A2	Bg1	Bg2	Bg3	Bg4	Cg
Depth cm	0–10	10–20	20–40	40–60	60–90	90–120	120–140
Particle Size % :							
Coarse sand 200–2000 μm	24	28	17	23	25	27	23
Fine sand 50–200 μm	18	15	14	13	13	13	15
Silt 2–50 μm	40	35	43	35	32	34	32
Clay <2 μm	18	22	26	29	30	26	30
TNV g kg^{-1}	0	0	0	0	0	0	0
Ca cmol kg^{-1}	4.20	3.00	3.30	5.20	8.70	3.50	5.90
Mg cmol kg^{-1}	1.1	0.54	0.34	0.27	0.41	0.2	0.47
K cmol kg^{-1}	0.23	0.12	0.04	0.06	0.08	0.04	<0.01
Na cmol kg^{-1}	0.21	0.2	0.23	0.17	0.15	0.17	0.24
TEB cmol kg^{-1}	5.74	3.86	3.91	5.7	9.34	3.91	6.61
CEC cmol kg^{-1}	24.6	16.0	7.8	6.8	9.8	8.8	8.2
Base Saturation %	23	24	50	84	95	44	81
pH	5.3	5.3	6	6	7.9	6	7.4
C g kg^{-1}	41	28	4	2	1	3	2
N g kg^{-1}	3.2	2.3					
C/N	12.8	12.2					
Free iron g kg^{-1}	10	11	18	13	11	12	31

Table 3.93: Physical analyses, Waterford Series.

Horizon	A	A	B	B	B	B	C
Sub-horizon	1	2	g1	g2	g3	g4	g
Depth cm	0–10	10–20	20–40	40–60	60–90	90–120	120–140
Particle density Mg m^{-3}	2.4	2.48	2.57	2.67	2.68	2.64	2.63
Bulk density at saturation Mg m^{-3}	1.03	1.3	1.72	1.91	1.73	1.76	1.75
Bulk density at -59 hPa Mg m^{-3}	1.04	1.31	1.73	1.92	1.73	1.78	1.77
Air capacity % vol.	9.4	7.8	8.4	4.6	6.5	4.0	3.4
Retained water % vol.:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0 hPa	59.8	50.8	38.7	34.5	39.7	38.8	37.7
-2 hPa	55.6	46.9	32.9	31.4	35.5	34.9	34.1
-59 hPa	50.5	43.0	30.3	29.9	33.1	34.8	34.2
-137 hPa	46.4	40.2	27.7	28.6	31.8	33.2	33.2
-0.1 MPa	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-1.5 MPa	8.6	10.7	16.7	8.0	14.3	14.5	17.8
Total available water % vol.	41.9	32.3	13.7	21.9	18.9	20.3	16.5
Total available water cm	4.2	3.2	2.7	4.4	5.7	6.1	3.3
Total available water cumulative cm	4.2	7.4	10.2	14.5	20.2	26.3	29.6

CHAPTER 4

LAND USE AND SUITABILITY

Land use

This overview of the distribution and recent trends of the major Land Use Types (LUTs) in Co. Waterford is based on data from the Central Statistics Office (CSO). The distributions of the LUTs in Co. Waterford are compared with those in the State for 1980 and 2000; livestock in Co. Waterford and in the State are compared for 1961, 1980, and 2000.

According to the CSO, part of the fluctuation in the areas returned as crops and pasture is attributable to the difficulty of drawing a precise distinction on a consistent basis between rough grazing, which is usually grazed mountain land, and good grazing, which is included as pasture. The decennial returns for crops and pasture between 1851 and 1970 were invariably greater than 4.5M ha and comprised 4.7M ha in 1950. However, the area returned in 2000 dropped to 3.9M ha, and it is probably not strictly comparable to the 1980 return. The 2000 Census of Agriculture was the first to be conducted entirely by post. Areas taken up by roads, tracts, water, bog, marsh, rocks, unused rough grazing land and buildings were excluded from the area farmed (AAU). Returns for the areas under crops and pasture and total area farmed (AAU) were substantially less than in any previous census, and probably represent a more accurate estimate of the net area used in agriculture. Because of this inconsistency, the areas of individual land use types expressed as a percentage of the total area farmed probably gives a better picture of recent land use trends.

A wide range of crops is grown in the county; these crops are grouped into broad land use categories (Table 4.1). The cereal category comprises all cereals; this includes cereals used for human consumption (e.g. milling wheat) and animal feed including grazing livestock. In the case of root and green crops, a category designated “arable forage” is distinguished; it includes turnip, mangle, fodder beet, kale, and arable/maize silage. The “other arable crop” category is composed predominantly of potatoes and sugar beet; horticultural crops and nurseries are included in this category.

In 2000, the land use pattern in Co. Waterford and the State were remarkably similar; in both regions about two-thirds of the land was used for agriculture. Pasture comprises the largest proportion at about half the farmed area while hay, silage and arable forage combined account for about one third. Including rough grazing land in use, at least 92% of the farmed area is devoted to producing feed for grazing livestock. The proportion is probably somewhat larger due to a contribution to feed for grazing livestock from cereals and sugar beet. County Waterford has an exceptionally large land area under woods and plantations; 4,727 ha were within farms in the year 2000, and it is estimated there were an additional 17,570 ha approximately on Coillte property (Anon., 2000). The combined area represents 12.1% of the land area and is significantly larger than the national average. Thus, the area under woodland in the county is almost twice that under arable crops. A significant part (17%) of the woodland is old woodland dating back to pre 1830. Although locally significant in the

Ardmore-Monatray, Dungarvan-Lismore areas, the proportion of land in the county under horticulture and nurseries is very small comprising only 224 ha in 2000.

Within the area used for agriculture (AAU), the principal changes since 1980 in the county were an increase in land under hay/silage, and arable forage and a decrease in cereals. The changes broadly reflect national trends except that the decline in cereals was much greater in Co. Waterford, decreasing from 11.8% to 6.7% compared to a decrease from 7.8% to 6.3% in the State. The proportion of land under pasture was virtually static since 1980 in both Co. Waterford and the State. Whilst the area under arable forage is small, the proportional increase in Co. Waterford (1.1%) was larger than in the State (0.6%). Thus, recent land use changes in agriculture consist mainly of an increased land allocation to winter feed for grazing livestock. The data in Table 4.1 indicate a significant decrease in land designated rough grazing in use, in Co. Waterford and the State, but this may be partly associated with a change in classification. There was a substantial increase of 6907 ha of woodland representing a 44.9% increase since 1980. The increase was proportionally slightly larger than that in the State (39.7%). As the woodland is mainly on poor land, its increase contributes to the decline in rough grazing.

Table 4.1: Land use in 1980 and 2000, Co. Waterford and State.

Year		1980		2000	
Region		Waterford	State	Waterford	State
Total Land	ha	183,782	6,841,891	183,782	6,841,891
Cereal	% Total land	10.0	6.5	4.5	4.1
Arable Forage	% Total land	0.5	0.3	1.2	0.7
Other Arable	% Total land	1.1	1.5	1.1	1.1
Hay & Silage	% Total land	18.2	17.7	20.9	19.3
Pasture	% Total land	42.5	42.8	33.5	32.4
Crops & Pasture	% Total land	**72.5**	**68.6**	**61.3**	**57.5**
Rough Grazing	% Total land	12.2	14.7	6.4	7.4
AAU	% Total land	**84.7**	**83.4**	**67.7**	**64.9**
Wood	% Total land	8.4	4.0	2.6	1.5
Cereal	% AAU	11.8	7.8	6.7	6.3
Arable Forage	% AAU	0.6	0.4	1.7	1.0
Other Arable	% AAU	1.3	1.8	1.6	1.7
Hay & Silage	% AAU	21.4	21.3	30.9	29.6
Pasture	% AAU	50.1	51.3	49.6	49.9
Crops & Pasture	% AAU	**85.6**	**82.3**	**90.6**	**88.6**
Rough Grazing	% AAU	14.4	17.7	9.4	11.4

The amounts of grazing livestock, and the relative proportions of categories of livestock, expressed as standardised livestock units (LU), in Co. Waterford and the State, are in Table 4.2. This distribution is based on the total CSO returns for Co. Waterford and the State; however, data suppression, mostly numbers of sheep in some DED's in the 2000 Census, affects the description of the distribution of livestock within the county. The distribution for Co. Waterford and the State gives an indication of the proportion of the forage area devoted to the various livestock categories; it is not exact, however, because the stocking rate may vary among the different livestock categories.

Table 4.2: Grazing livestock composition, total, and change (a) 1961–1980 and (b) 1980–2000, Co. Waterford and State.

Region	Year	Dairy	Cattle	Sheep	Other	Total	Change
			%			LU	% pa
Co. Waterford	2000	30.7	55.3	12.8	1.3	209,611	0.79b
	1980	43.3	48.1	6.9	1.7	181,071	2.26a
	1961	37.0	44.0	13.0	6.0	126,700	
State	2000	21.2	57.9	19.7	1.2	6,491,228	0.59b
	1980	30.0	59.0	9.0	2.0	5,806,358	1.27a
	1961	31.0	49.0	15.0	5.0	4,678,300	

Total livestock increased substantially in Co. Waterford and the State from 1961 to 2000. The rate of increase was greater in the first period (1961–1980) than in the later period (1980–2000) and was much greater in Co. Waterford than in the State, especially in the first period (Table 4.2). The dominant livestock enterprise was consistently beef cattle followed by dairying, sheep, and other livestock (mainly horses). Dairy cows consistently formed a larger proportion of total livestock in Co. Waterford than in the State, whereas there were proportionally less sheep in Co. Waterford. Since 1980 the proportion of dairy cows has declined significantly in the county from 43.3 to 30.7 per cent, whereas the proportion of sheep has almost doubled. This broadly reflected the national trend where there was a huge increase in sheep numbers, mainly between 1980 and 1991, in response to the inclusion of sheep meat in the Common Market regime in 1980 (Lafferty, 1999). Nevertheless, the proportion of dairy cows remains significantly higher in Co. Waterford (30.7%) than in the State (21.2%).

Stocking rate in Co. Waterford was consistently higher than in the State. On the basis of area farmed, the difference increased only slightly from 13% in 1980 to 15% in 2000, whereas, based on total area, the difference was somewhat greater and increased form 15% in 1980 to 20% in 2000 (Table 4.2).

Figures 4.1A and 4.1B illustrate the distribution in stocking rate among DED's in 1980 and 2000. Summary statistics are in Table 4.3.

The range in stocking rate in 2000 (170 LU km^{-2}) was larger than in 1980 (149 LU km^{-2}). As expected, the lower stocking rates were generally found in the hilly regions, e.g. Kilwatermoy West, Mountkennedy, Kilcockan, and Drumroe, whereas the highest rates were in the lowland region e.g. Dungarvan, Coumarglin, Mothel, Clonea, and Cappagh.

Table 4.3: Summary statistics for stocking rate and grazing capacity of DED's, Co. Waterford.

	Mean	Minimum	Maximum	Range	Skewness
	LU km^{-2}				
Stocking rate:					
1980	104	37	186	149	1.1
2000	117	32	202	170	0.8
Grazing capacity	218	75	278	203	-3.9

Farm size: A distinctive feature of the structure of agriculture in the county is the comparatively large farm size. In the century after 1880, the number of farms in all size categories above 40 ha has increased with a corresponding decrease in the number of holdings in all the lower size categories. In 2000, the average farm size (AAU) was 44.6 ha in Co. Waterford compared to 31.4 ha in the State and was the largest of all counties in the State. The difference is accentuated when account is taken of economic factors. In 2000, the average economic farm size, based on standard gross margins for each crop and each type of livestock, was 37.1 ESU. This was the largest for any county in the State; it was nearly twice the overall average (20.7 ESU), and as well as farm size reflects the comparatively large proportion of land in Co. Waterford devoted to dairying.

Land suitability

Land rather than soil forms the basis of suitability or capability assessment. Land is a broader concept than soil; its characteristics comprise all reasonably stable attributes of the physical environment including, in addition to soil, climate and relief. It may also include vegetation and past and present human activity where these influence potential for land use (FAO, 1976). Suitability classification involves assessing the fitness of mapping units for specified types of land use. Previous county Soil Survey Bulletins refer to Soil Suitability; however, because climate and relief were taken into account at least implicitly, they are essentially similar to the Land Suitability described here.

Systems of land classification derived from the USDA Land Capability Classification (Klingebiel and Montgomery, 1961) are widely used in the interpretation of soil survey data, and such a system was used in the early soil surveys in Ireland in counties Wexford and Limerick. The USDA system was originally developed as part of the programme to control soil erosion; it emphasises the range of uses that may be safely pursued on a given soil and the nature and extent of conservation practices required for permanent sustained use. It is a standard eight-class system in which classes I to IV are suited to cultivated crops, classes V to VII are suited to grazing and forestry and Class VIII is suited only to wildlife.

The USDA system emphasised the adaptability of a soil for a range of uses and implied a hierarchy of kinds of land use viz. cropping, grazing, forestry and wildlife. Whilst potential use-range, including flexibility of cropping, is an important criterion in land classification since it indicates the extent to which a producer can respond to market forces (Bibby, 1982), the USDA based system is less relevant in Ireland where the priority rural land use, on an economic basis, is dairy livestock production, which has a large grazing component.

The system followed in Co. Clare and subsequent counties was to evaluate separately the degree of suitability of each land unit for each specified land use e.g. cultivation, grassland, where kinds of land use have equal rank (Diamond et al., 1977). The system could be extended to other kinds of land use e.g. forestry, urban development, wildlife. The system broadly conforms to the principles of the FAO Framework for land evaluation (FAO, 1976).

The main assumptions that underlie the classification are (FAO, 1976; Bibby, 1982):

- The classification relates land mapping units to specified types of land use e.g. livestock production, arable crops.

- Land is generally classified according to the extent to which its physical characteristics affect productivity and management. Chemical limitations are assumed to be remedied by optimum fertilisation and supplements to animal feed except in hill and mountain moorlands where inherent soil fertility levels are assumed.

- Management practices are optimum and designed to sustain land use indefinitely; in general, management is above average and output approaches that obtained under experimental conditions.

- Whilst a general economic context is implicit in the classification, it is essentially physical and does not indicate best use, which requires an explicit economic evaluation. Nevertheless, economic analysis can be useful in unifying different kinds of limitations, e.g. stoniness and drainage, by assessing improvement costs (Diamond, 1984).

- The classification refers to current suitability. Land that has limitations that can be eliminated or reduced at economic cost by a farmer or his contractors, e.g. field drainage, is classified on the severity of the remaining limitations. Major land improvements, which are generally beyond the capacity of individual farmers, are excluded unless they are already completed e.g. drainage of the Brickey River catchment or reclamation of the Tramore Slob from the sea. Moorland is classified in this section in its current condition, as it was in other counties, although it can be reclaimed by farmers and their contractors on favourable slopes. The limitation is economic, but Gardiner (1980), reflecting the favourable economic context of the previous decade, graded moorland on the basis of potential suitability.

- Current land use, except urban use, is ignored. Thus, land under forest is classified according to its agricultural potential.

- Factors other than physical aspects, which may be critical to land use decisions, do not influence the classification e.g. farm structure, location, legal and planning restrictions.

- The classification is a qualitative categorical system with significant subjective judgement; to retain consistency soils are assigned as far as possible to the same suitability class as that in which analogous soils were placed in previous county Soil Survey Publications.

Classification

Land units are assigned to one of five suitability classes ranging from very suitable to very poorly suitable based on the degree of limitation of the most severely limiting land quality or characteristic. Limitations are also graded in five classes ranging from negligible to very severe. Suitability classes for grassland are designated by capital letters whilst the tillage classes are designated by Roman numeral. The framework of the classification is outlined in Table 4.4. For example, a land unit with a moderate limitation (Grade B) for tillage will be classed as moderately suitable (Class III). Only the severest limitation is normally taken into account; nevertheless, additional limitations may be included where a land unit is near a class boundary. In some situations where the factors are clearly independent the limitations are additive. For example, land at elevation above 152.4 m (500 ft.), with no other limitation, is assigned to Class B, but rolling land, normally Class B, is assigned to the next lowest class, Class C, at these elevations.

Suitability classes are divided into sub-classes on the basis of the kind of principal limitations. These include wetness (w), slope gradient (g), stoniness (s), rockiness (r), liability to drought (d), liability to flooding (f), textural and structural properties affecting tilth and susceptibility to poaching (t), and elevation (e).

Every map separation can be represented by a class letter for grassland (usually capital), class number (usually Roman capital) for tillage and a subscript letter for kind of dominant limitation e.g. (1) AId indicates Class A for grassland, Class I for tillage and liability to drought as the dominant limitation, and (2) CIIw indicates Class C for grassland, Class II for tillage, and wetness as the dominant limitation. Grazing livestock is the land use considered; although it is based on heathland in places, it is referred to as grassland for convenience and to conform to the term already used in other counties.

Table 4.4: Framework of suitability classification.

Suitability Class	Very Suitable	Suitable	Moderately Suitable	Poorly Suitable	Very Poorly Suitable
Symbol:					
Grassland	A	B	C	D	E
Cultivation	I	II	III	IV	V
Degree of limitation	Nil, Very Slight	Slight	Moderate	Severe	Very Severe

Suitability for grassland

Grassland suitability is assessed in two stages. First, the grazing capacity for the whole year is estimated on the basis of soil and climatic conditions, and then the classification is adjusted to take account of factors that affect utilisation and management. Suitability is a broader concept than grazing capacity: the suitability classification reflects actual farm conditions more realistically than an assessment based solely on output.

Grazing capacity

The grazing capacity of each soil unit in the county was estimated by extrapolation from experimental sites to related areas defined by soils and climate (Lee and Diamond, 1972). The calculation assumes that land under grass has adequate reserves of lime, available phosphorus and potassium with field drainage where needed. As outputs of grass are strongly influenced by sward composition and management at low inputs of nitrogenous fertilisers, and are therefore very variable, the grazing capacity is estimated at a high level (230 kg/ha) for most soils. Where land has a severe limitation, e.g. wetness on very slowly permeable soils, the capacity is rated at low N input. The low level was commonly set at 48 kg ha^{-1} with optimum clover contribution in the grazed area (Lee & Diamond, 1972; Lee, 1987). Because of the large variation in response to N due to management factors including sward composition, the low level of N is set here at that amount of N that would produce 80% of the output achievable at the high rate of N on the same soil.

The principal uncontrollable factors that determine grazing capacity are the soil water regime and climatic factors such as temperature and radiation (Brereton, 1981).

Grassland productivity research indicates that pastures on well-drained soils in the south of Ireland have about a 5% advantage in annual dry-matter production over comparable soils in the midland region. The southern part of the country has a climatic advantage for early growth, particularly for grass. This is reflected in the target date of grazing commencement, which is early April in the midlands and early March in the south of the country. A line extending from Waterford City to Ballyduff in the west of the county forms the boundary between the two climatic regions.

Pasture dry-matter production data from experimental sites in the south of Ireland formed the basis for the grazing capacity estimates for most of the well-drained Soil Series. In addition to the pasture data, animal production data from the Teagasc Research Centre at Moorepark, Co. Cork were also used.

The grazing capacity estimates for the Gley soils are based on the extrapolation of animal production data from the Teagasc Research Stations at Mullinahone, Herbertstown and Ballinamore, in addition to pasture output data from experimental sites in Co. Limerick and Co. Wexford.

As about 30% of Co. Waterford is above 152 m AMSL, the influence of climatic factors associated with changes in elevation is an important consideration. Estimates of the grazing capacities of upland mineral soils (e.g. Knockboy Series) were based on a comparison between animal production data from the experimental hill farm at Coolnakilla, which is at 180 to 225 m AMSL, and data from the Teagasc Research Centre at Moorepark, which is situated nearby on lowland (Kiely, 1985). On the hill, the grazing season was 35 days shorter, mainly due to wetness, and the optimum stocking rate was 17% less. This reduction in output was about the same as the reduction in degree-day accumulations.

Heaths and moors, which are mostly on Podzols and shallow Peats, were assessed in their current condition with natural nutrient contents (i.e. without fertilisers). Grazing capacity estimates were based primarily on data from the Teagasc hill sheep farm, near Leenaun, Co. Mayo with some adjustments based on local experience in Co. Waterford (D. Ryan and W. McCarthy, p*ers. comm.*). Although elevation at Leenaun (15–27 m AMSL) is lower than the elevation of most of the heaths and moors in Co. Waterford, rainfall was higher (1887–1993 mm) at Leenaun during the experiment. At Leenaun, an annual stocking rate of 0.9 ewes ha^{-1}, which is equivalent to 12.6 LU km^{-2}, was sustained without detriment to the environment (Walsh, 2000). A slightly higher capacity (15 LU km^{-2}) was assigned to the dry heaths in Co. Waterford on the Ballycondon series on the basis of local experience. These estimates are generally lower than the grazing capacity of hill and mountain land estimated by Lee and Diamond (1972), partly because they assumed some inputs including fertilisers. Blanket Bog, very rocky areas, wetlands (Kilbarry Series) and urban areas are given a zero rating.

The grazing potentials pertain to the central concept of each map unit (Table 4.5) and may not apply to the entire area owing to unmapped phases and inclusions of other series in the map unit.

Table 4.5: Grazing capacity of Soil Series and Phases, Co. Waterford.

Series	Phase	Area	Grazing capacity		
			Class	Rate	Gross
		ha		LU km^{-2}	LU
Ahaun	Typic	1,588	C	213	3,391
Ahaun	Rolling	60	C	213	128
Ardmore	Typic	705	A	289	2,037
Aughty	Typic	1,339	E	0	0
Aughty	Cutover	316	E	0	0
Aughty	Cutover, mod.steep	144	E	0	0
Ballynabola	Typic	1,623	C	189	3,067
Ballynabola	Peaty	130	D	151	197
Ballycondon	Typic	6,388	E	15	958
Ballycondon	Rolling	253	E	15	38
Ballycondon	Moderately steep	802	E	15	120
Ballycondon	Stony	696	E	15	104
Ballycondon	Rocky	305	E	15	46
Ballycondon	Very rocky	128	E	0	0
Ballymacart	Typic	1,786	C	223	3,973
Ballyscanlan	Typic	106	C	208	220
Broomhill	Typic	2,697	A	289	7,794
Broomhill	Rolling	90	A	289	259
Broomhill	Moderately steep	137	B	231	316
Broomhill	Rocky	11	B	231	25
Broomhill	Very rocky	18	E	0	0
Callaghan	Typic	624	A	272	1,694
Clashmore	Typic	15,702	A	289	45,378
Clashmore	Rolling	3,032	A	289	8,762
Clashmore	Moderately steep	447	B	231	1,033
Clashmore	Steep	128	E	22	28
Clashmore	Stony	20	C	208	42
Clashmore	Rocky	100	C	208	208
Clashmore	Very rocky	6	E	0	0
Clohernagh	Typic	3,431	C	223	7,636
Clohernagh	Sandy	43	B	256	111
Clonroche	Typic	18,559	A	274	50,850
Clonroche	Rolling	116	A	274	317

Table 4.5: Grazing capacity of Soil Series and Phases, Co. Waterford (cont'd).

Series	Phase	Area	Grazing capacity		
			Class	Rate	Gross
		ha		LU km^{-2}	LU
Clonroche	Moderately steep	193	C	219	423
Clonroche	Steep	14	E	22	3
Clonroche	Shallow	52	B	255	132
Clonroche	Rocky	20	C	197	39
Clonroche	Very rocky	9	E	0	0
Coolfinn	Typic	1,903	C	189	3,597
Coolfinn	Peaty	30	D	151	46
Curragh	Typic	121	A	272	328
Dodard	Typic	3,586	E	13	452
Drumslig	Typic	337	D	173	582
Dungarvan	Typic	11,999	A	289	34,677
Dungarvan	Rocky	134	C	208	278
Fen Peat	Typic	151	E	0	0
Finisk	Typic	931	B	242	2,258
Glenary	Typic	2,791	E	14	391
Kilbarry	Typic	1,206	E	0	0
Kill	Typic	18,677	A	289	53,975
Kill	Moderately steep	99	B	231	229
Kill	Rocky	597	C	208	1,243
Kill	Very rocky	820	E	0	0
Killadangan	Typic	1,922	C	223	4,276
Killmeadan–Callaghane	Typic	180	A	274	495
Killmeadan–Clashmore	Typic	199	A	274	546
Kilmeadan	Typic	2,862	A	274	7,842
Kilmeadan	Rolling	130	A	274	357
Kilmeadan	Very rocky	2	E	0	0
Knockalisheen	Typic	1,988	E	14	278
Knockboy	Typic	18,900	B	227	42,983
Knockboy	Rolling	2,578	B	227	5,863
Knockboy	Moderately steep	345	C	182	628
Knockboy	Steep	6	E	18	1
Knockboy	Stony	825	D	164	1,352
Knockboy	Rocky	412	C	197	813

Table 4.5: Grazing capacity of Soil Series and Phases, Co. Waterford (cont'd).

Series	Phase	Area	Grazing capacity		
			Class	Rate	Gross
		ha		LU km^{-2}	LU
Knockboy	Very rocky	29	E	0	0
Knockboy	Brown	608	B	227	1,382
Knockboy	Brown, rolling	218	B	227	496
Knockboy	Brown, mod. steep	46	C	182	83
Knockmealdown	Typic	2,767	E	14	387
Lickey	Typic	1,280	D	148	1,892
Monatray	Typic	1,858	A	289	5,371
Monatray	Rolling	325	A	289	938
Monatray	Shallow	60	A	269	161
Monavullagh	Typic	7,198	E	14	1,008
Moord	Typic	1,745	B	253	4,414
Moord	Poorly drained	609	C	217	1,321
Mothel	Typic	4,664	C	211	9,840
Mothel	Peaty	188	D	148	279
Newport	Typic	9,238	D	148	13,673
Portlaw	Typic	802	A	274	2,198
Portlaw	Rolling	1,480	A	274	4,054
Portlaw	Moderately steep	1,376	C	219	3,016
Portlaw	Steep	1,088	E	22	239
SAND	Typic	127	E	0	0
Slievecoiltia	Typic	896	B	227	2,037
Slob	Typic	126	B	227	286
Slob	Sandy	131	B	227	297
Slob	Peaty	25	D	159	39
Suir	Typic	1,142	B	242	2,770
Suir–Coolfinn	Typic	37	C	222	82
Tramore	Typic	6,558	C	223	14,594
Tramore	Peaty	190	C	178	338
Waterford	Typic	1,901	C	217	4,126
URBAN	Typic	1,244	U	0	0
WATER	Typic	279	U	0	0
Total		**183,783**			**378,144**

The class limits, symbols (A–E), and gross area of the grazing capacity classes in the county are in Table 4.6. Class A land occupies 43.6% of the area but it accounts for a much larger proportion, 60.2%, of the grazing capacity; conversely, Class E land occupies 17.6% of the county but comprises only a very small proportion, 1.3%, of the grazing capacity. Class A occupies a larger proportion of the land in Co. Waterford than in the State, which is estimated to be 32.5% (Lee and Diamond, 1972). The amount of Class A land is slightly larger than that estimated for Co. Meath (37%) (Lee, 1983) and much larger than that in Co. Laois (27%) (Lee, 1986) and Co. Offaly (24%) (Hammond, 2003). The large amount of Class A land in Co. Waterford and Co. Meath reflects mainly the small amount of low level peat in these counties.

Table 4.6: Extent of grazing capacity and suitability classes, Co. Waterford.

	Grass				Tillage	
	Grazing Capacity			Suitability	Suitability	
CLASS	Rate LU km^{-2}	Area %	LU %	Area %	Class	Area %
A	>=264	43.6	60.2	40.4	1	40.8
B	227–224	15.3	17.1	16.2	2	1.5
C	178–227	16.1	16.7	16.4	3	25.8
D	130–178	6.6	4.8	8.5	4	10.6
E	<130	17.6	1.3	17.7	5	20.5
U	0	0.8	0.0	0.8	U	0.8

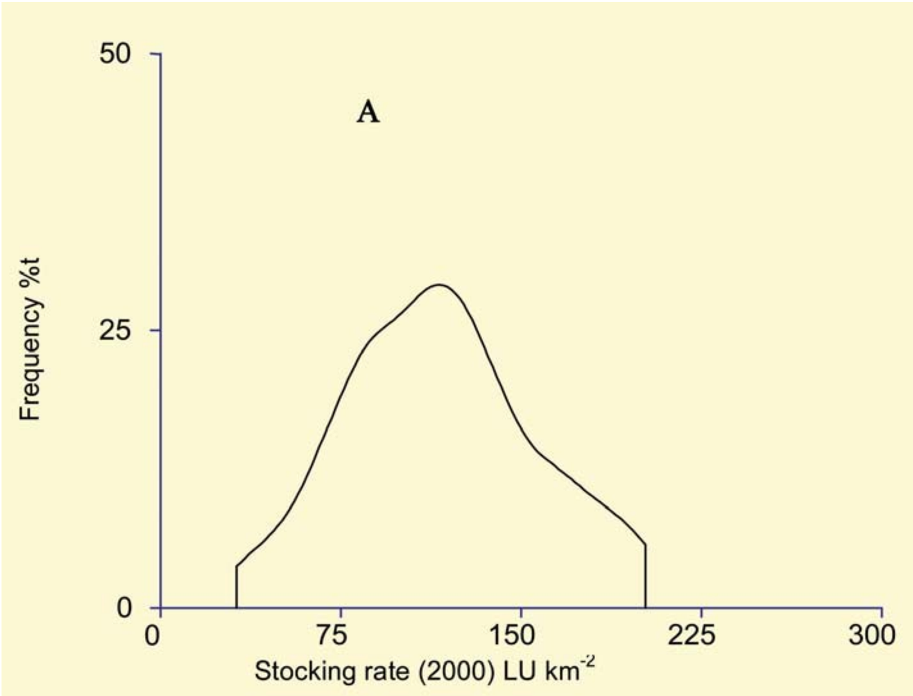
The average grazing capacity (Table 4.7) of all land in the county is greater (x 1.16) than the average for the State. The average capacity of all land in the county is estimated to be 206 LU km^{-2}; this decreases to 160 LU km^{-2} when the capacity of the land not devoted to livestock production is deducted. The CSO returns 68% of the county as utilised for agriculture. When allowance is made for fences and tillage not devoted to forage production, the net area declines to 62% excluding commonage areas. However, the net grazing capacity of the utilised area increases to 256 LU km^{-2} compared to 206 LU km^{-2} for all land. The ratio of actual stocking rate to net grazing capacity, the degree of exploitation, is estimated to be 71% for 2000; if the land under woodland is assumed to have average grazing capacity, the estimate of exploitation increases to 75%. The degree of exploitation in 2000 is only slightly higher than that estimated for the State (Table 4.7). While the degree of exploitation in the range 71 to 75% is larger than that found in Meath (1977) and in Laois (1980), the difference is largely accounted for by the increase in stocking rate in the county since 1980. The estimated exploitation of 62% in the county in 1980 is very similar to that in Co. Meath (61%) and somewhat less than the exploitation in Co. Laois (65%).

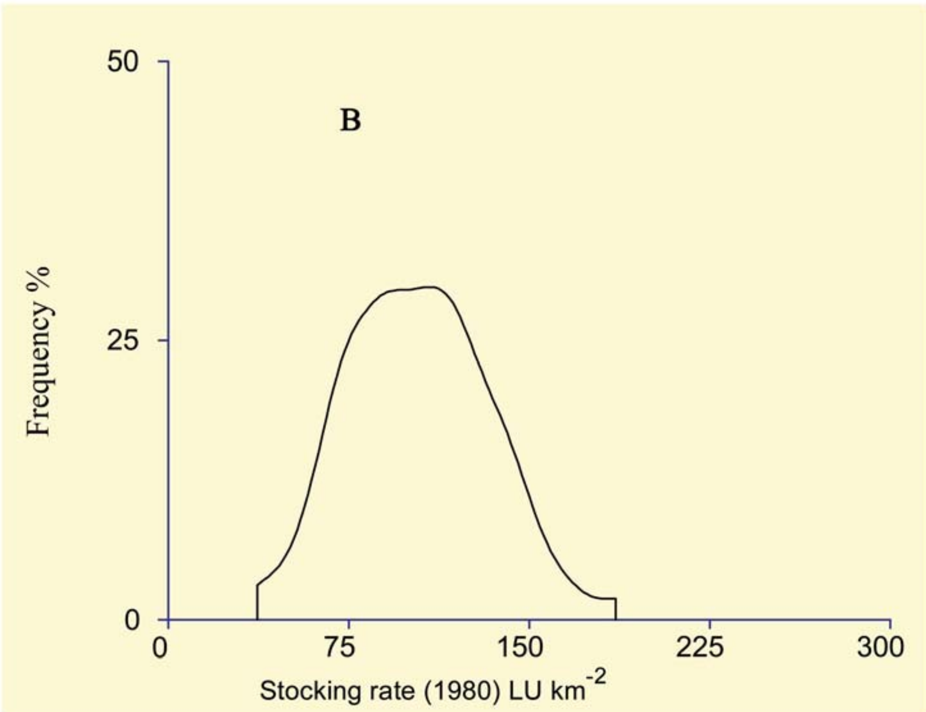
Table 4.7: Net grazing capacity, actual stocking rate (1980, 2000), Co. Waterford and State.

	Waterford			State			Waterford/ State
	Area ha	Rate LU ha^{-1}	Amount LU	Area ha	Rate LU ha^{-1}	Amount LU	Amount Ratio
Total	100	2.06	206	100	1.77	177	1.16
AAU	68			65			
Other land:	32			35			
Woodland (Coillte)	10	1.24	12	7	1.06	7	1.58
Fences, roads	8	2.06	16	8	1.77	14	1.16
Commonage etc	15	0.15	2	20	0.15	3	0.74
Woodland (Farm)	3	1.24	3	2	1.06	2	1.97
Tillage (Non Forage)	5	2.80	15	5	2.70	13	1.12
Net area per km^2	62			59			
Net capacity		2.56	160		2.35	138	1.16
Actual 2000		114			95	1.20	
Exploitation %			71			69	1.03
Actual 1980			99				
Exploitation %			62				

Grazing capacity and stocking rate of District Electoral Divisions

The stocking rate of District Electoral Divisions (DED's) in the county in 1980 and 2000 are compared with grazing capacity in Figure 4.1. Stocking rates in 1980 and 2000 are normally distributed whilst the grazing capacities are negatively skewed with a long tail towards the low values. In 2000, a larger proportion was in the category >150 LU ha^{-2} than in 1980; the minimum, mean and maximum were slightly higher (5–16 LU ha^{-2}), and the range was larger (21 LU km^{-2}). The mean stocking rate in 2000 represented about 54% of the gross grazing capacity. The normal distribution of the stocking rates is consistent with a number of socio-economic factors independently limiting production, whilst the grazing capacity reflects only stable physical factors. The normal distribution of stocking rates is likely to persist in the future. An assumption that the distribution remains the same as in 2000, and that stocking rates increase until the maxima of stocking rate and grazing capacity coincide, implies an increase of 33 LU km^{-2}. The resulting stocking density amounts to 92% of the net grazing capacity and probably represents the practical limit of exploitation. If stocking density increases at the same rate from 2000 to 2020 as the average rate of increase that occurred from 1980 to 2000, then the current exploitation limit would be reached by the end of the period (2020).


A
Frequency %t
50
25
0
0
75
150
225
300
Stocking rate (2000) LU km-2


B
Frequency %
50
25
0
0
75
150
225
300
Stocking rate (1980) LU km-2

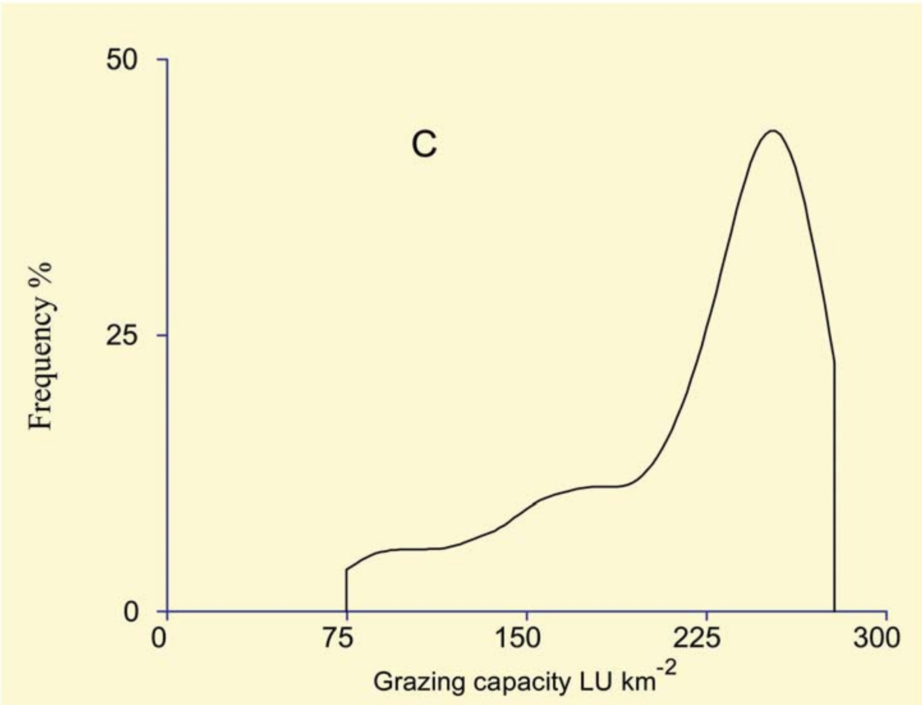


Figure 4.1: Frequency distribution of: (A) stocking rate of DEDs in 2000; (B) stocking rate of DEDs in 1980; (C) grazing capacity of DEDs.

Stocking rates of DED's in 1980 were related to grazing capacity (R^2, 0.37; Fig. 4.2). The relationship in 2000 was weaker (R^2, 0.27) and may be due to data suppression in some DED's. In 1980 the stocking rate was also related to forage area (R^2, 0.39); it appears that a significant part of the larger stocking rate in areas of better land quality can be attributed to the larger amount of land allocated to grazing livestock.

Suitability

The suitability classification for grassland and tillage, principal limitation and gross area of each series and phase mapped in the county are in Table 4.8. The main differences between the grazing capacity and suitability for grassland classifications (Table 4.6) are the larger amount (3.2%) in grazing capacity Class A and a smaller amount (1.9%) in Class D. This is mainly due to slope gradient, which affects management rather than yield, and to a lesser extent depth, stoniness and rockiness all of which may restrict the possibility of reseeding; rockiness also affects silage harvesting and fertilisation. Compared to over 40% in Class A, in both grazing capacity and suitability classifications, the differences between the classifications are relatively small. The most extensive limitations are those that primarily affect grass yield.

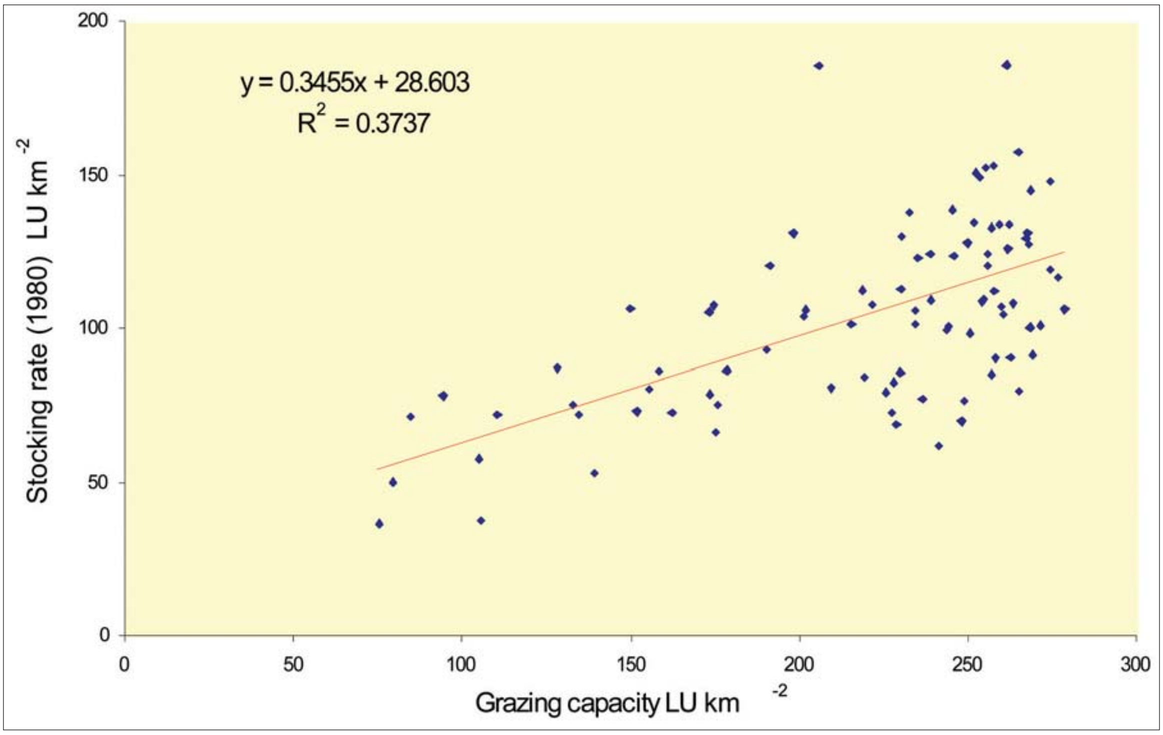


Figure 4.2: Stocking rate (1980) of DEDs in relation to grazing capacity.

Table 4.8: Suitability for grassland and tillage of Soil Series and Phases, Co. Waterford.

Series	Phase	Class		Subclass	Area	
		Grass	Tillage	Principal limitation	ha	%
Ahaun	Typic	C	4	Wetness, elevation	1,588	0.86
Ahaun	Rolling	D	4	Gradient	60	0.03
Ardmore	Typic	A	1	Nil	705	0.38
Aughty	Typic	E	5	Elevation, gradient	1,339	0.73
Aughty	Cutover	E	5	Elevation, wetness	316	0.17
Aughty	Cutover, mod. steep	E	5	Elevation, wetness	144	0.08
Ballynabola	Typic	C	4	Wetness	1,623	0.88
Ballynabola	Peaty	D	4	Wetness	130	0.07
Ballycondon	Typic	E	5	Elevation	6,388	3.48
Ballycondon	Rolling	E	5	Elevation, gradient	253	0.14
Ballycondon	Moderately steep	E	5	Elevation, gradient	802	0.44
Ballycondon	Stony	E	5	Elevation, stoniness	696	0.38
Ballycondon	Rocky	E	5	Elevation, rockiness	305	0.17
Ballycondon	Very rocky	E	5	Elevation, rockiness	128	0.07
Ballymacart	Typic	C	3	Wetness	1,786	0.97
Ballyscanlan	Typic	D	5	Rocky	106	0.06
Broomhill	Typic	A	1	Nil	2,697	1.47
Broomhill	Rolling	B	3	Gradient	90	0.05
Broomhill	Moderately steep	D	4	Gradient	137	0.07
Broomhill	Rocky	D	5	Rocky	11	0.01
Broomhill	Very rocky	E	5	Rocky	18	0.01
Callaghan	Typic	B	1	Drought	624	0.34
Clashmore	Typic	A	1	Nil	15,702	8.54
Clashmore	Rolling	B	3	Gradient	3,032	1.65
Clashmore	Moderately steep	D	5	Gradient	447	0.24
Clashmore	Steep	E	5	Gradient	128	0.07
Clashmore	Stony	C	4	Stony	20	0.01
Clashmore	Rocky	D	5	Rocky	100	0.05
Clashmore	Very rocky	E	5	Rocky	6	0.00
Clohernagh	Typic	C	3	Wetness	3,431	1.87
Clohernagh	Sandy	B	2	Wetness	43	0.02
Clonroche	Typic	A	1	Nil	18,559	10.10
Clonroche	Rolling	B	3	Gradient	116	0.06
Clonroche	Moderately steep	D	4	Gradient	193	0.10
Clonroche	Steep	E	5	Gradient	14	0.01

Table 4.8: Suitability for grassland and tillage of Soil Series and Phases, Co. Waterford (cont'd).

Series	Phase	Class		Subclass	Area	
		Grass	Tillage	Principal limitation	ha	%
Clonroche	Shallow	B	2	Shallow	52	0.03
Clonroche	Rocky	D	5	Rocky	20	0.01
Clonroche	Very rocky	E	5	Rocky	9	0.00
Coolfinn	Typic	C	4	Wetness, flooding	1,903	1.04
Coolfinn	Peaty	D	5	Wetness, flooding	30	0.02
Curragh	Typic	B	1	Drought	121	0.07
Dodard	Typic	E	5	Elevation, wetness	3,586	1.95
Drumslig	Typic	B	3	Rocky	337	0.18
Dungarvan	Typic	A	1	Nil	11,999	6.53
Dungarvan	Rocky	D	5	Rocky	134	0.07
Fen Peat	Typic	D	5	Wetness, flooding	151	0.08
Finisk	Typic	B	2	Wetness	931	0.51
Glenary	Typic	E	5	Elevation, wetness	2,791	1.52
Kilbarry	Typic	E	5	Wetness, flooding	1,206	0.66
Kill	Typic	A	1	Stony	18,677	10.16
Kill	Moderately steep	D	4	Gradient	99	0.05
Kill	Rocky	D	5	Rocky	597	0.32
Kill	Very rocky	E	5	Rocky	820	0.45
Killadangan	Typic	C	3	Wetness	1,922	1.05
Killmeadan–Callaghane	Typic	A	1	Nil	180	0.10
Killmeadan–Clashmore	Typic	A	1	Nil	199	0.11
Kilmeadan	Typic	A	1	Nil	2,862	1.56
Kilmeadan	Rolling	B	3	Gradient	130	0.07
Kilmeadan	Very rocky	E	5	Rocky	2	0.00
Knockalisheen	Typic	E	5	Elevation, wetness	1,988	1.08
Knockboy	Typic	B	3	Elevation	18,900	10.28
Knockboy	Rolling	C	4	Elevation, gradient	2,578	1.40
Knockboy	Moderately steep	E	5	Elevation, gradient	345	0.19
Knockboy	Steep	E	5	Elevation, gradient	6	0.00
Knockboy	Stony	D	5	Elevation, stony	825	0.45
Knockboy	Rocky	D	5	Elevation, rocky	412	0.22
Knockboy	Very rocky	E	5	Elevation, rocky	29	0.02
Knockboy	Brown	B	3	Elevation	608	0.33
Knockboy	Brown, rolling	C	4	Elevation, gradient	218	0.12
Knockboy	Brown, mod. steep	E	5	Elevation, gradient	46	0.02

Table 4.8: Suitability for grassland and tillage of Soil Series and Phases, Co. Waterford (cont'd).

Series	Phase	Class Grass	Class Tillage	Subclass Principal limitation	Area ha	Area %
Knockmealdown	Typic	E	5	Elevation, wetness	2,767	1.51
Lickey	Typic	D	4	Wetness, elevation	1,280	0.70
Monatray	Typic	A	1	Nil	1,858	1.01
Monatray	Rolling	B	3	Gradient	325	0.18
Monatray	Shallow	B	3	Shallow	60	0.03
Monavullagh	Typic	E	5	Elevation, wetness	7,198	3.92
Moord	Typic	B	2	Wetness	1,745	0.95
Moord	Poorly drained	C	3	Wetness	609	0.33
Mothel	Typic	C	3	Wetness	4,664	2.54
Mothel	Peaty	D	4	Wetness	188	0.10
Newport	Typic	D	4	Wetness, elevation	9,238	5.03
Portlaw	Typic	A	1	Nil	802	0.44
Portlaw	Rolling	B	3	Gradient	1,480	0.81
Portlaw	Moderately steep	D	5	Gradient	1,376	0.75
Portlaw	Steep	E	5	Gradient	1,088	0.59
SAND	Typic	E	5	Drought	127	0.07
Slievecoiltia	Typic	C	5	Shallow	896	0.49
Slob	Typic	C	3	Wetness	126	0.07
Slob	Sandy	C	3	Drought	131	0.07
Slob	Peaty	D	4	Wetness	25	0.01
Suir	Typic	B	3	Flooding	1,142	0.62
Suir–Coolfinn	Typic	C	4	Wetness, flooding	37	0.02
Tramore	Typic	C	3	Wetness	6,558	3.57
Tramore	Peaty	D	4	Wetness	190	0.10
Waterford	Typic	C	3	Wetness	1,901	1.03
URBAN	Typic	u	6	Unclassified	1,244	0.68
WATER	Typic	u	6	Unclassified	279	0.15

Wetness and climatic limitations associated with elevation are the most extensive limitations for grassland comprising 32.8 and 29.5%, respectively, of the county (Table 4.9). The wetness limitation ranges from slight to severe; it is the most extensive moderate and severe limitation (Classes D and E) and it is extensive in Class E where, combined with elevation, it forms a very severe limitation. The limitations associated with elevation range from slight (Class B) to very severe (Class E). Elevation is the most extensive limitation in Class B, and in Class E where it is commonly combined with wetness. The spatial distribution of the suitability for grassland classes is outlined in Figure 4.3.

Suitability for tillage

The suitability classification for tillage of each map unit in the county is in Table 4.8. A large proportion of the county (40.8%) was assigned to Class I (Table 4.9). This is considered an overestimate as contrasting inclusions in the map units were not taken into account in constructing the table. Part of the Kill Series, which comprises 10.2% of the county, is stony; in addition, there are stony parts, but to a lesser extent, in the Clashmore, Dungarvan and Monatray series. If these stony parts, which are estimated to comprise about 5% of the county, were included in Class 2, the amount in Class 1, about 35%, would still be slightly larger than the proportion of Class 1 land in Laois (28.2%) and Offaly (31.3%) which were classified on a similar basis. The small amount of low-level peat in the county tends to increase the proportion of Class 1 land compared to counties in the midlands. The amount of tillage in the county is small but the cultivation of the more exacting crops such as winter harvested vegetables (cauliflowers, brussel sprouts), early potatoes, maize, and sugar beet, suggests that the soils in Class 1 are very suitable for arable crops, especially in the south of the county. Higher rainfall is a disadvantage compared to the very suitable regions in the UK but this is offset, at least partly, by the resulting higher yields. Moderately high rainfall may be a factor contributing to the small amount of tillage on the Clonroche soils in the northeast of the county, but the small amount of tillage in the county probably largely reflects an economic preference.

Table 4.9: Extent of suitability subclasses, grassland and tillage, Co. Waterford.

Class		Subclass		Area		Mapunit	
Grass	Tillage	Symbol*	Limitation	ha	%	Series	Phase
A	1		Nil	55,564	30.23	Ardmore	Typic
						Broomhill	Typic
						Clashmore	Typic
						Clonroche	Typic
						Dungarvan	Typic
						Killmeadan–Callaghane	Typic
						Killmeadan–Clashmore	Typic
						Kilmeadan	Typic
						Monatray	Typic
						Portlaw	Typic
A	1	s	Stony	18,677	10.16	Kill	Typic
B	1	d	Drought	744	0.40	Callaghan	Typic
						Curragh	Typic
B	2	h	Depth	52	0.03	Clonroche	Shallow
B	2	w	Wetness	2,675	1.48	Clohernagh	Sandy
						Finisk	Typic
						Moord	Typic

Table 4.9: Extent of suitability subclasses, grassland and tillage, Co. Waterford (cont'd).

Class		Subclass		Area		Mapunit	
Grass	Tillage	Symbol*	Limitation	ha	%	Series	Phase
B	3	e	Elevation	19,508	10.61	Knockboy	Typic
						Knockboy	Brown
B	3	f	Flooding	1,142	0.62	Suir	Typic
B	3	g	Gradient	5,172	2.81	Broomhill	Rolling
						Clashmore	Rolling
						Clonroche	Rolling
						Kilmeadan	Rolling
						Monatray	Rolling
						Portlaw	Rolling
B	3	r	Rocky	337	0.18	Drumslig	Typic
B	3	h	Depth	60	0.03	Monatray	Shallow
C	3	d	Drought	131	0.07	Slob	Sandy
C	3	w	Wetness	20,997	11.42	Ballymacart	Typic
						Clohernagh	Typic
						Killadangan	Typic
						Moord	Poorly drained
						Mothel	Typic
						Slob	Typic
						Tramore	Typic
						Waterford	Typic
C	4	e,g	Elevation, gradient	2,796	1.52	Knockboy	Rolling
						Knockboy	Brown, rolling
C	4	s	Stony	20	0.01	Clashmore	Stony
C	4	w	Wetness	1,623	0.88	Ballynabola	Typic
C	4	w,e	Wetness, elevation	1,588	0.86	Ahaun	Typic
C	4	w,f	Wetness, flooding	1,984	1.06	Coolfinn	Typic
						Suir–Coolfinn	Typic
						Coolfinn–Sand	Typic
C	5	h	Depth	896	0.49	Slievecoiltia	Typic
D	4	g	Gradient	489	0.27	Ahaun	Rolling
						Broomhill	Moderately steep

Table 4.9: Extent of suitability subclasses, grassland and tillage, Co. Waterford (cont'd).

Class		Subclass		Area		Mapunit	
Grass	Tillage	Symbol*	Limitation	ha	%	Series	Phase
						Clonroche	Moderately steep
						Kill	Moderately steep
D	4	w	Wetness	553	0.29	Ballynabola	Peaty
						Mothel	Peaty
						Slob	Peaty
						Tramore	Peaty
		w,e	Wetness, elevation	10,518	5.72	Lickey	Typic
						Newport	Typic
D	5	e,r	Elevation, rocky	412	0.22	Knockboy	Rocky
D	5	e,s	Elevation, stony	825	0.45	Knockboy	Stony
D	5	g	Gradient	1,823	0.99	Clashmore	Moderately steep
						Portlaw	Moderately steep
D	5	r	Rocky	967	0.53	Ballyscanlan	Typic
						Broomhill	Rocky
						Clashmore	Rocky
						Clonroche	Rocky
						Dungarvan	Rocky
						Kill	Rocky
D	5	w,f	Wetness, flooding	181	0.10	Coolfinn	Peaty
						Fen Peat	Typic
E	5	d	Drought	127	0.07	SAND	Typic
E	5	e	Elevation	6,388	3.48	Ballycondon	Typic
E	5	e,g	Elevation, gradient	2,791	1.52	Aughty	Typic
						Ballycondon	Rolling
						Ballycondon	Moderately steep
						Knockboy	Moderately steep

Table 4.9: Extent of suitability subclasses, grassland and tillage, Co. Waterford (cont'd).

Class		Subclass		Area		Mapunit	
Grass	Tillage	Symbol*	Limitation	ha	%	Series	Phase
						Knockboy	Steep
						Knockboy	Brown, mod. steep
E	5	e,r	Elevation, rocky	463	0.25	Ballycondon	Rocky
						Ballycondon	Very rocky
						Knockboy	Very rocky
E	5	e,s	Elevation, stony	696	0.38	Ballycondon	Stony
E	5	e,w	Elevation, wetness	18,790	10.22	Aughty	Cutover
						Aughty	Cutover, moderately steep
						Dodard	Typic
						Glenary	Typic
						Knockalisheen	Typic
						Knockmealdown	Typic
						Monavullagh	Typic
E	5	g	Gradient	1,230	0.67	Clashmore	Steep
						Clonroche	Steep
						Portlaw	Steep
E	5	r	Rocky	855	0.47	Broomhill	Very rocky
						Clashmore	Very rocky
						Clonroche	Very rocky
						Kill	Very rocky
						Kilmeadan	Very rocky
E	5	w,f	Wetness, flooding	1,206	0.66	Kilbarry	Typic
U			Unclassified	1,524	0.83	URBAN	
						WATER	

* d = drought; e = elevation; f = flooding; g = gradient; h = depth; r = rocky; s = stony; w = wetness.

While the range of limitations for tillage is the same as for grassland (Table 4.9), with wetness and elevation being the most extensive, the impact on tillage crops is generally more severe. The main effect compared to grassland is a much smaller amount of land, 14.7% of the county, with slight limitations (Class 2) and a corresponding larger amount with moderate to very severe limitations (Classes 3, 4 and 5). A large amount of land, 10.6%, has a moderate limitation for tillage due to lower temperatures and more rainfall associated with higher elevation; this land is capable of producing good yields of a narrow range of crops mainly cereals and grass, but yields of sugar beet and maize are liable to be reduced more severely. Land with very severe limitations for tillage comprises a substantial part of the county (20.5%); it is effectively unsuited to tillage and the predominant limitations are elevation or elevation combined with steep slopes, rock outcrops, stones or wetness. The spatial distribution of the suitability for tillage classes is outlined in Figure 4.4.

Offsite effects

The suitability assessment described in the preceding section refers to "use on a sustained basis" (FAO, 1983). The kind and intensity of land use, or the management practices, are not expected to initiate or accelerate land degradation in the foreseeable future or possibly indefinitely. Offsite effects, however, were not considered. Possible offsite effects include the transmission of pathogens, agrochemicals including fertilisers, or animal wastes to surface water or groundwater.

Under the Water Framework Directive, Ireland is obliged to achieve 'good water status' by 2015. Although a small increase in unpolluted river channel in Ireland was recorded for the period 2004–2006, some 28% remains unsatisfactory to some degree (Lucy, 2007). Agricultural runoff is considered a key contributor to the eutrophication of both surface water and groundwater (op. cit).

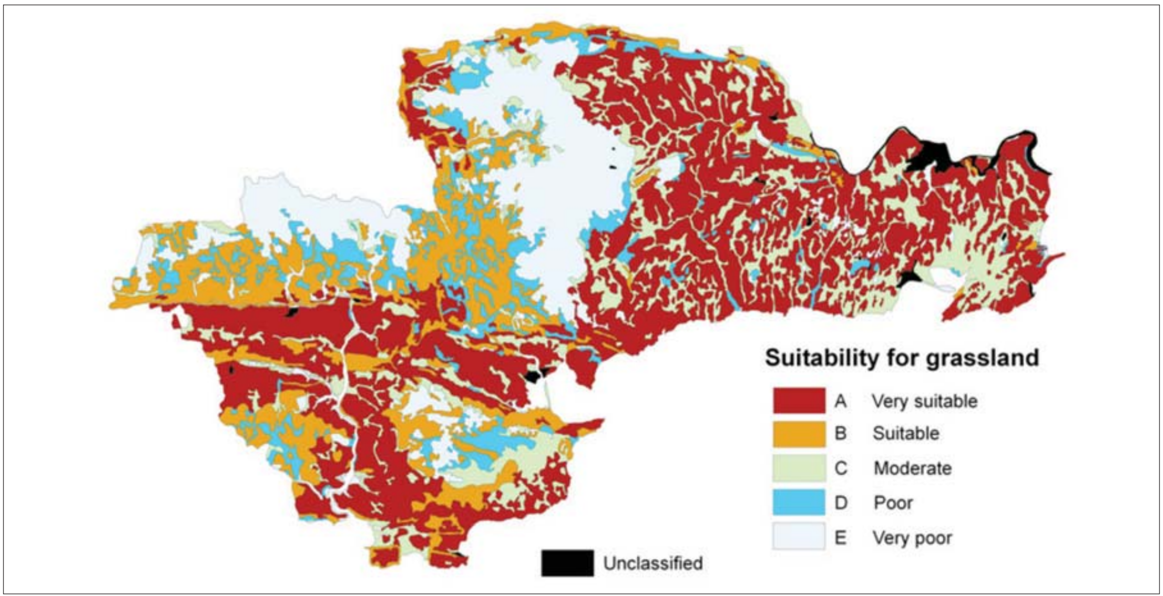


Figure 4.3: Map of suitability for grassland, Co. Waterford.

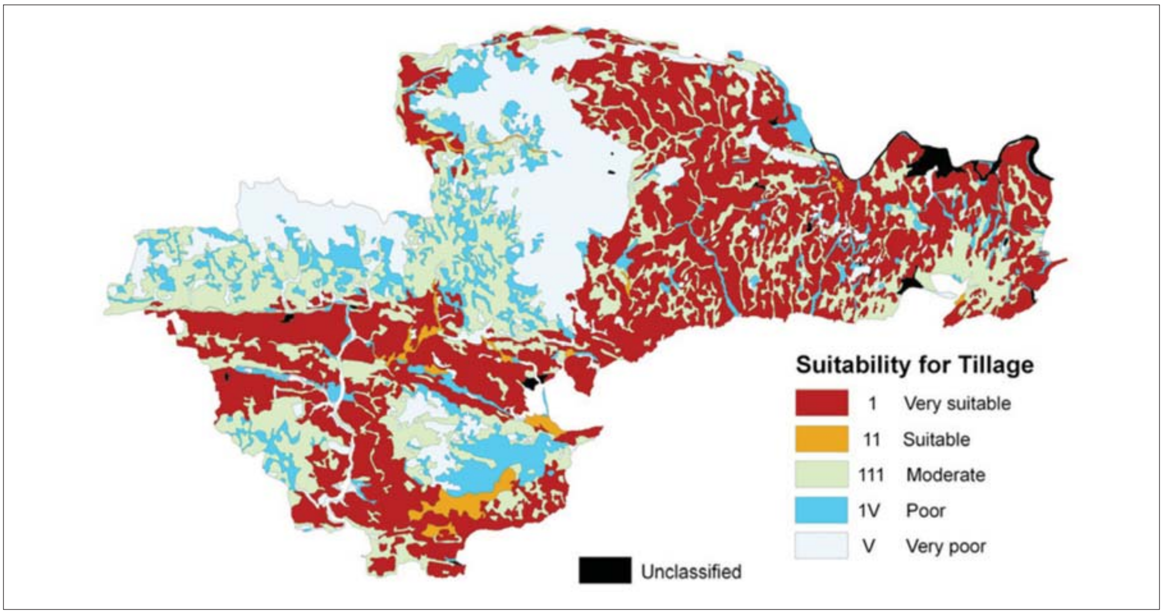


Figure 4.4: Map of suitability for tillage, Co. Waterford.

Nitrate levels have increased significantly in the Blackwater and Suir rivers in 2006 compared with 1979, and are much higher in these rivers than in rivers in the west of the country. Similarly, phosphate contents are higher in the Blackwater and Suir rivers than in the west, but the contents appear not to have increased significantly since recording began in 1979 (Lucy, 2007).

Runoff

Direct Runoff consists of overland flow, interflow and channel flow in varying proportions. Channel flow is generally negligible. In humid regions, interflow may be significant in addition to overland flow (NRCS, 2004).

Hortonian overland flow is produced when the rainfall rate exceeds the infiltration capacity of the soil and the demands of interception and surface storage have been met. Saturation overland flow occurs when the soil is saturated and the rainfall rate is greater than the increase in interflow (Carson and Kirkby, 1972).

In summer, the infiltration capacity of some major well drained soils in Ireland exceeds the five-year return rainfall rate indicating that the risk of overland flow due to infiltration excess is negligible on well drained soils in summer (Diamond and Shanley, 2003). However, there is some risk of overland flow in winter because of saturation excess. Infiltration rate data are available for only one site in Co. Waterford, near Cappoquin, representing the Knockboy Series. Two sets of measurements at this site show rapid infiltration rates ranging from 160 mm hr^{-1} to 196 mm hr^{-1} (op. cit.).

When infiltrated rainfall meets a horizon of lower hydraulic conductivity, it may be diverted laterally to flow downslope as interflow. A reduction in hydraulic conductivity, within the solum, is most likely to occur at the base of O or A horizons, which commonly overlie horizons with weaker structural development (Carson and Kirkby, 1972).

Experimental background: The average annual rainfall at Waterford City (1002 mm) is similar to that at the experimental site at the Cowlands, Johnstown Castle (1031 mm). The Cowlands site is in Hydrologic Group D and gives an indication of the overland flow that can be expected in the lowland farmland areas that are on Gleys derived from till (Group D). Under average rainfall, overland flow at Cowlands amounted to 19.8% of total rainfall (Diamond, 2003) compared to 2.6% on a well drained site (Group B) at Clonroche. Under increased rainfalls of 1246 mm (Kurz, 2000) and 1334 mm (Diamond, 2002), overland flow at Cowlands increased respectively to 35% and 31% of total rainfall. The data imply, by linear extrapolation, that at 1500 mm rainfall, which generally approximates the upper rainfall limit for farmland in Co. Waterford, overland flow would amount to about 45% of total rainfall on land belonging to Hydrologic Group D. This suggests that under similar management regimes the farmland areas in Co. Waterford that are likely to have the largest amount of overland flow, and probably also direct runoff, are Gley soils in the upland areas in West Waterford; these areas are represented mainly by the Newport Series.

Studies on the "Quantification of Phosphorus Loss from Soil to Water" in the Dripsey Catchment are particularly relevant to Co. Waterford as the bedrock is Devonian Sandstone, which is extensive in west Waterford. The parent material is generally sand, and the hydraulic conductivity (Ksat) is high (9 cm hr^{-1}) (Kiely, 2000). Overland flow amounted to 20% of total rainfall. This suggests that soils derived from till dominated by Devonian Sandstone may not belong to Group A. Hence, similar soils in Co. Waterford were tentatively assigned to Group B. The overland flow amount in the Dripsey site is similar to that found at the Cowlands (Group D) and reflects the difference in rainfall. As shown above, a Group D soil in the Dripsey with an annual rainfall of 1443 mm would be expected to contribute approximately 50% of total rainfall as overland flow.

Kiely (2000) concluded that, as subsurface flow contributes 80% of total annual streamflow, most phosphorus travels to the stream from farmland via subsurface flow in dissolved farm. Kiely (op. cit.) attributed the transport of dissolved phosphorus to streams to an interflow layer in which dissolved phosphorus concentrations decreased with depth. At the Beef Unit, Johnstown Castle, phosphorus concentrations in subsurface drainage were substantial at times (Kurz, 2000). Thus, it seems that interflow as well as overland flow should be included in an assessment of pollution risk.

A comprehensive assessment of nutrient transport to streams requires that the influence of rainfall over long periods, as well as the effects of vegetation on retention, should be included. This is outside the scope of this preliminary assessment, which is primarily concerned with the possibility of regionalisation of risk based on the soil factor.

Runoff estimation: Except for hydraulic conductivity data for some Gleys and Regosols, the quantitative physical data required for the application of a rigorous hydrologic model based on scientific theory are unavailable for Co. Waterford. Estimates of runoff for the county are at this stage limited to empirical methods.

The Curve Number Model developed by the National Resources Conservation Service (NRCS) estimates direct runoff. It is an empirical model based on analysis of a large number of runoff events for watersheds. One of its intended principal applications is in estimating quantities of runoff in flood hydrographs (NRCS, 2004). The appropriate curve is determined by:

- vegetation and cultural practices
- hydrologic soil group
- antecedent runoff condition.

The potential maximum retention depends on the soil cover. Grassland and heath/bog are the dominant vegetation types in the county; only these two types are considered as the aim is to estimate the relative contributions of different kinds of soils to potential direct runoff. Estimates of actual runoff would require inclusion of forestry, tillage crops and other land use types. The curve number (CN) for grassland is higher than that for forestry; none of the given CNs corresponds exactly to heathland (NRCS, 2004) Runoff on heathland has been found to exceed that on forest land (Gurnell and Gregory, 1987) and is probably closer to that on grassland.

Soils are assigned to hydrologic soil groups on the basis of depth to a restrictive layer or water table and transmission rate of water. As saturated hydraulic conductivity data is available only for Gley soils (Appendix III), the assignments of free draining soils are based on texture, structure, bulk density, and porosity. Soils developed on sands are assigned to Group A. The remaining free draining soils are assigned to Group B. Free draining soils derived from sandstone or volcanic till are tentatively assigned to Group B rather than Group A because the subsoils are commonly moderately compact. Slope gradient or length is not included in the hydrologic classification (NRCS, 2007)

The Antecedent Runoff condition refers to average conditions (ARC II).

Each curve in the model shows the relationship between cumulative daily runoff and cumulative daily rainfall; rainfall intensity is not considered. The comparisons of the runoff potential of the Soil Series in Co. Waterford are based on the maximum daily rainfall at Waterford City (Tycor) having a return period of one year (40 mm), or ten years (63 mm); the 20 mm rainfall is arbitrarily chosen for comparison and has a return period less than 0.5 years.

Runoff estimates for Soil Series: The Hydrologic Group assigned to each Soil Series and some Phases are in Table 4.10. For each of the three selected rainfall events the associated runoff is shown both as total volume (m^3) and as a proportion (%) of the estimated total runoff in the county; these estimates take into account both the runoff depth (mm) and the area (ha) of each series. Although slope is not considered in the formation of hydrologic groups, the alluvial flats are distinguished from sloping (>1%) land, because the risk of overland flow is lower due to ponding effects. These estimates are not to be taken as quantitatively exact. Although numerical values are given for map units, they should only be taken as broad indicators of relative runoff risk for classification purposes.

The spatial distribution of the hydrologic classes is shown in Figure 4.5.

Table 4.11 summarises for the entire county the distribution of runoff among hydrologic groups, slope and land use classes. Each soil was assigned to a land use/vegetation class on the basis of whether it was predominantly devoted to agriculture (A) or was covered by heath, bog or marsh vegetation (H). The model predicts no runoff, across all hydrologic groups, for daily rainfalls of 20 mm or less. No runoff is also predicted for soils in Hydrologic Group A where the daily rainfall is 63 mm or less. The proportion of land contributing any runoff increases as rainfall increases.

Hydrologic Group D accounts for all of the predicted runoff in the county at 40 mm daily rainfall and most (70%) at 63 mm rainfall. Hydrologic group D land devoted to agriculture, occupies about 18% of the county (Table 4.11; Fig. 4.5); the remainder of group D, mostly hill land, is unfertilised, except possibly under forestry, and the nutrient load in runoff largely represents the natural base level. This suggests that management systems designed to minimise nutrient transfer to water are likely to be most effective if they are targeted primarily at farmland in Hydrologic Group D (Fig. 4.5), which forms a relatively small proportion of the county.

Groundwater

In relation to groundwater contamination, the contribution of soils to pathway susceptibility is generally the increase of runoff risk; susceptibility decreases from Hydrologic Group D to Group A. In the GS1 classification, all areas that have poorly drained soils (Group D) are considered to have low pathway susceptibility regardless of the vulnerability rating of the underlying subsoils or the nature of the bedrock. Sands and gravels and outcropping or near surface bedrock (Group A) are rated Extremely Vulnerable. The proportion of sand and gravel in the county is small; some gravel overlies karstified limestone in the Dungarvan and Suir Valleys forming Extremely Susceptible Pathways. Apart from the areas that underlie gravels or crop out at the surface, the karstified limestone areas are deemed to have high to low susceptibility. Research results at Curtin's Farm near Fermoy confirm highly vulnerable hydrological conditions (Bartley, 2007), but this may not apply to all of the Dungarvan or Suir valleys. Detailed mapping of the composition and thickness of subsoils, and possibly soils also, are needed to separate the vulnerable parts of these predominantly highly productive (A1) areas.

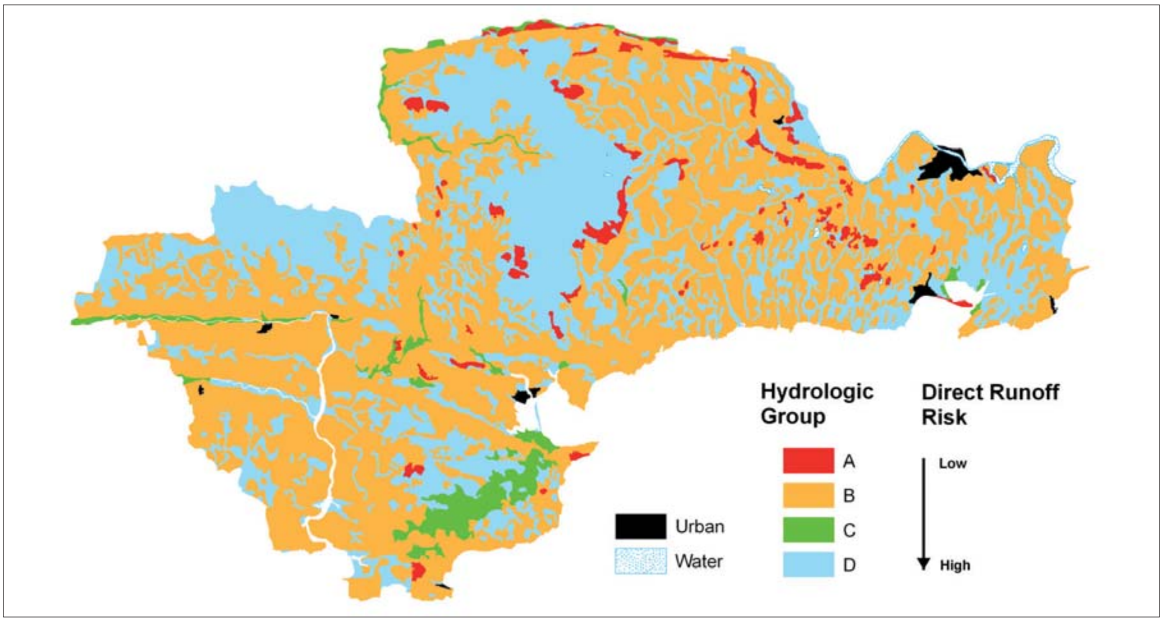


Figure 4.5: Map of hydrologic classes, Co. Waterford.

Table 4.10: Hydrologic Group and estimated runoff for Soil Series and selected Phases at three daily rainfall intensities, Co. Waterford.

				Area		Runoff $m^3 * 10^3$			Runoff %		
						Rainfall mm					
Series *phase*	Hydr.	Relief	Land use[1]	ha	% total	20	40	63	20	40	63
Ballynabola	D	Flat	A	1,753	0.95	0	144	390	0	2.59	1.92
Coolfinn	D		A	1,933	1.05	0	159	430	0	2.86	2.12
Coolfinn–Sand	D		A	44	0.02	0	4	10	0	0.07	0.05
Fen Peat	D		H	151	0.08	0	12	34	0	0.22	0.17
Finisk	C		A	931	0.51	0	41	141	0	0.74	0.70
Kilbarry	D		H	1,206	0.66	0	99	268	0	1.78	1.32
Slob *sandy*	C		A	131	0.07	0	6	20	0	0.10	0.10
Slob	D		A	151	0.08	0	12	34	0	0.22	0.17
Suir	C		A	1,142	0.62	0	50	173	0	0.91	0.85
Suir–Coolfinn	D		A	37	0.02	0	3	8	0	0.05	0.04
Ahaun	C	Sloping	A	1,648	0.90	0	73	250	0	1.31	1.23
Ardmore	B		A	705	0.38	0	0	34	0	0.00	0.17
Aughty	D		H	1,799	0.98	0	148	400	0	2.66	1.97
Ballycondon	A		H	1,129	0.61	0	0	0	0	0.00	0.00
Ballycondon	D		H	7,443	4.05	0	611	1,655	0	11.01	8.14
Ballymacart	D		A	1,786	0.97	0	147	397	0	2.64	1.95
Ballyscanlan	A		H	106	0.06	0	0	0	0	0.00	0.00
Broomhill	A		A	29	0.02	0	0	0	0	0.00	0.00
Broomhill	B		A	2,923	1.59	0	0	141	0	0.00	0.69
Callaghan	A		A	624	0.34	0	0	0	0	0.00	0.00
Clashmore	A		A	126	0.07	0	0	0	0	0.00	0.00
Clashmore	B		A	19,309	10.51	0	0	933	0	0.00	4.59
Clohernagh	C		A	43	0.02	0	2	7	0	0.03	0.03
Clohernagh	D		A	3,431	1.87	0	282	763	0	5.08	3.75
Clonroche	A		A	80	0.04	0	0	0	0	0.00	0.00
Clonroche	B		A	18,881	10.27	0	0	912	0	0.00	4.49
Curragh	A		A	121	0.07	0	0	0	0	0.00	0.00
Dodard	D		H	3,586	1.95	0	294	797	0	5.30	3.92
Drumslig	B		A	337	0.18	0	0	16	0	0.00	0.08
Dungarvan	B		A	11,999	6.53	0	0	580	0	0.00	2.85
Dungarvan *rocky*	A		A	134	0.07	0	0	0	0	0.00	0.00
Glenary	D		H	2,791	1.52	0	229	620	0	4.13	3.05
Kill *rocky*	A		H	1,417	0.77	0	0	0	0	0.00	0.00

Table 4.10: Hydrologic Group and estimated runoff for Soil Series and selected Phases at three daily rainfall intensities, Co. Waterford (cont'd).

				Area		Runoff $m^3 * 10^3$			Runoff %		
						Rainfall mm					
Series *phase*	Hydr.	Relief	Land use[1]	ha	% total	20	40	63	20	40	63
Kill	B		H	18,776	10.22	0	0	907	0	0.00	4.46
Killadangan	D		A	1,922	1.05	0	158	427	0	2.84	2.10
Killmeadan–Callaghane	A		A	180	0.10	0	0	0	0	0.00	0.00
Killmeadan–Clashmore	B		A	199	0.11	0	0	10	0	0.00	0.05
Kilmeadan *rocky*	A		A	2	0.00	0	0	0	0	0.00	0.00
Kilmeadan	B		A	2,993	1.63	0	0	145	0	0.00	0.71
Knockalisheen	D		A	1,988	1.08	0	163	442	0	2.94	2.18
Knockboy *stony, rocky*	A		A	1,266	0.69	0	0	0	0	0.00	0.00
Knockboy	B		A	22,701	12.35	0	0	1,096	0	0.00	5.40
Knockmealdown	D		H	2,767	1.51	0	227	615	0	4.09	3.03
Lickey	D		A	1,280	0.70	0	105	285	0	1.89	1.40
Monatray *shallow*	A		A	60	0.03	0	0	0	0	0.00	0.00
Monatray	B		A	2,183	1.19	0	0	105	0	0.00	0.52
Monavullagh	D		H	7,198	3.92	0	591	1,600	0	10.65	7.87
Moord	C		A	1,701	0.93	0	75	258	0	1.35	1.27
Moord *poorly drained*	D		A	609	0.33	0	50	135	0	0.90	0.67
Mothel	D		A	4,852	2.64	0	398	1,079	0	7.18	5.31
Newport	D		A	9,238	5.03	0	758	2,054	0	13.66	10.11
Portlaw	B		A	4,746	2.58	0	0	229	0	0.00	1.13
SAND	A		A	127	0.07	0	0	0	0	0.00	0.00
Slievecoiltia	A		A	896	0.49	0	0	0	0	0.00	0.00
Tramore	D		A	6,748	3.67	0	554	1,500	0	9.98	7.38
Waterford	D		A	1,901	1.03	0	156	423	0	2.81	2.08
				$ha*10^3$			$m^3 * 10^6$				
Total*				182		0	5	20			

1 A = Agricultural land, H = Heath, marsh

Table 4.11: Distribution of potential runoff, Co. Waterford.

Relief	Hydrologic group	Land use[1]	Area		Runoff % total Rainfall mm day^{-1}		
			ha	%	20	40	63
Sloping	A	A	3,645	1.98	0	0.0	0.0
	A	H	2,653	1.44	0	0.0	0.0
	B	A	86,975	47.32	0	0.0	22.3
	B	H	18,776	10.22	0	0.0	4.8
	C	A	3,393	1.85	0	3.0	2.7
	D	A	33,755	18.37	0	55.2	39.9
	D	H	25,584	13.92	0	41.8	30.2
Flat	C	A	2,204	1.20	0	0.0	0.0
	D	A	3,918	2.13	0	0.0	0.0
	D	H	1,357	0.74	0	0.0	0.01

A = Agriculture, H = Heath, marsh

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APPENDIX I

Terms and Methods used in profile descriptions* and analyses

Texture

Soil texture refers to the relative proportions of the various size particles in the mineral fraction of a soil. More especially, it refers to the relative proportions of clay, silt and sand in the mineral fraction less than 2 mm in diameter. Texture, which is one of the more important of the soils's physical characteristics, influences such factors as moisture retention, drainage and tilling properties of soils, their resistance to damage by stock and heavy machinery and earliness of crop growth.

Classes of texture are based on different combinations of sand, silt and clay; the proportions of these are determined by mechanical analyses in the laboratory. The basic textural classes, in order of increasing proportions of the finer separates, are sand, loamy sand, sandy loam, silt-loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay and clay. Definitions of the basic classes in terms of clay (less than 0.002 mm), silt (0.002 to 0.05 mm) and sand (0.05 to 2.0 mm diameter size) are presented in graphic form (Fig. 1).

Field estimation of soil textural class

The estimation of soil textural class is made in the field by feeling the moist soil between the fingers. The field estimation is checked in the laboratory. In arriving at an estimation in the field the following considerations are taken into account.

Sand: Sand is loose and single grained. The individual grains can readily be seen and felt. Pressed when moist, a weak cast may be formed which easily crumbles when touched.

Sandy Loam: A sandy loam contains much sand but has adequate silt and clay to make it somewhat coherent. If squeezed when moist, a cast can be formed that bears careful handling without breaking.

Loam: A loam has roughly equal proportions of sand, silt and clay. If squeezed when moist, a cast is formed which can be handled quite freely without breaking.

Silt Loam: A silt loam contains a moderate amount of sand, a relatively small amount of clay and more than half the particles of silt size. A cast can be formed which can be freely handled without breaking, but when moistened and squeezed between thumb and finger it does not 'ribbon' but gives a broken appearance.

Clay Loam: A clay loam contains more clay than a loam and usually breaks into clods or lumps that are hard when dry. In the moist state it is plastic and can be formed into a cast which can withstand considerable handling. When kneaded in the hand, it does not crumble readily, but tends to work into a heavy compact mass.

Clay: A clay has a preponderance of finer particles, contains more clay than a clay loam and usually forms hard lumps or clods when dry, but is quite plastic and sticky when wet. When pinched out between thumb and finger in the moist state it forms a long, flexible 'ribbon'.

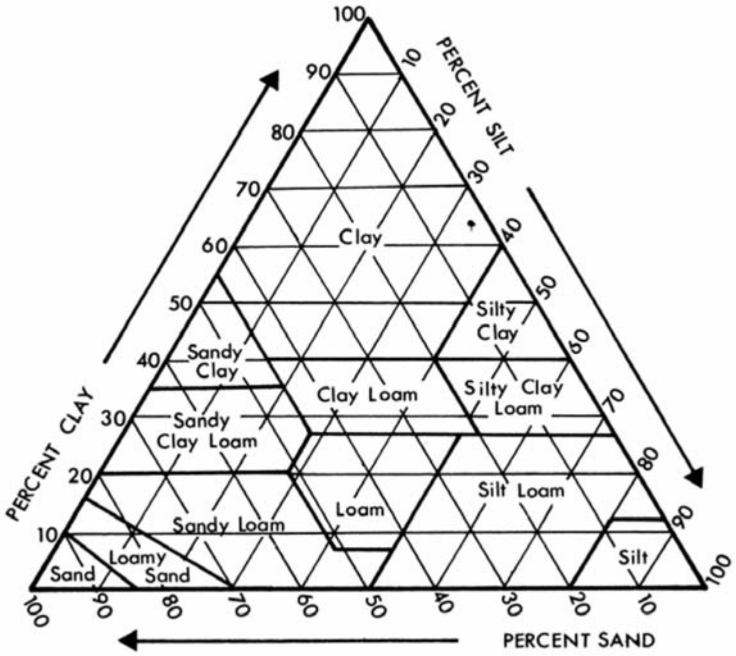

Figure A1.1: Percentages of clay, silt and sand in the basic textural classes (after Soil Survey Manual, No. 18, USDA Washington D.C., 1993).

General grouping of soil textural classes

Often it is convenient to refer to texture in terms of broad groups of textural classes. Although the terms 'heavy' and 'light' have been used for a long time in referring to fine and coarse-textured soils respectively, the terms are confusing as they do not bear any relation to the weight of soil; the terms arose from the relative traction power required for ploughing. An outline of acceptable terms is as follows:

General terms		*Basic soil textural class*
Sandy Soils	Coarse-textured soils	Sands
		Loamy sands
	Moderately coarse-textured soils	Sandy loams
		Loams
Loamy Soils	Medium-textured soils	Silt loams
		Silts

	Moderately fine-textured soils	Clay loams Sandy clay loams Silty clay loams
Clayey Soils	Fine-textured soils	Sandy clays Clays

Structure

Soil structure refers to the aggregation of primary soil particles into compound particles, which are separated from adjoining aggregates by surfaces of weakness. An individual natural soil aggregate is called a ped.

The productivity of a soil and its response to management depend on its structure to a large extent. Soil structure influences pore space, aeration, drainage conditions, root development and ease of working. Soils with aggregates of spheroidal shape have a greater pore space between peds, are more permeable and are more desirable generally than soils that are massive or coarsely blocky.

Field descriptions of soil structure indicate the shape and arrangement the size and the distinctness and durability of the aggregates. Shape and arrangement of peds are designated as type of soil structure, size of peds, as class; and degree of distinctness, as grade.

Type

There are four primary types of structure:
(a) Platy – with particles arranged around a plane and faces generally horizontal.
(b) Prismlike – with particles arranged around a vertical line and bounded by relatively flat vertical surfaces.
(c) Blocklike – with particles arranged around a point and bounded by relatively flat or curved surfaces that are not accommodated to the adjoining aggregates.

Each of the last three types has two subtypes:

Under Prismlike, the two subtypes are prismatic (without rounded upper ends) and columnar (with rounded ends). The two subtypes of blocklike are angular blocky (with sharp-angled faces) and sub-angular blocky (with rounded faces). Spheroidal is subdivided into granular (relatively non-porous) and crumb (very porous).

Class

Five size-classes are recognised in each type. The size limits of these vary for the four primary types given. A type description is generally qualified by one of the following class distinctions; very fine, fine, medium, coarse and very coarse.

Grade

Grade is the degree of aggregation or strength of the structure. In field practice, it is determined mainly by noting the durability of the aggregates and the relative proportions of aggregated and non-aggregated material when the aggregates are disturbed or gently crushed.

Terms for grade of structure are as follows:

0. *Structureless* – No observable aggregation. This condition is described as massive if coherent and single grain if noncoherent.
1. *Weak* – Poorly formed indistinct peds which, when disturbed, break down into a mixture comprising some complete peds, many broken units and much non-aggregated material.
2. *Moderate* – Many well-formed, moderately durable peds that are not so apparent in the undisturbed soil. When disturbed, however, a mixture of many complete peds, some broken peds and a little non-aggregated material is evident.
3. *Strong* – Structure characterised by peds that are well formed in undisturbed soil, and that survive displacement to the extent that when disturbed, soil material consists mainly of entire peds, with few broken peds and a little non-aggregated material.

The appropriate terms describing type, class and grade of structure are combined in that order to give the structural description, e.g., moderate, medium sub-angular blocky; weak, fine crumb.

Porosity

Porosity of a soil is conditioned by the shape, size and abundance of the various crevices, passages and other soil cavities which are included under the general name of soil pores. In this bulletin, porosity refers mainly to the voids between the soil structural units; it is strictly the structural porosity. Soil porosity is influenced largely by type of structure; it is also influenced by rooting and by the activity of earthworms and other soil macro-organisms.

Porosity determines, to a large extent, the permeability rate in the soil and the air to water ratio prevailing and is thus of considerable importance with regard to soil aeration and drainage regime.

Consistence

Soil consistence is an expression of the degree and kind of cohesion and adhesion or the resistance to deformation and rupture that obtains in a soil. Interrelated with texture and structure, and strongly influenced by the moisture condition of the soil, this characteristic is most important in developing a good tilth under cultivation practices. On account of the strong influence of moisture regime, the evaluation of soil consistence is usually considered at three levels of soil moisture – wet, moist and dry.

Consistence When Wet

A. *Stickiness:* Stickiness expresses the extent of adhesion to other objects. To evaluate this feature in the field, soil material is pressed between thumb and finger and its degree of adhesion noted. Degrees of stickiness are expressed as follows:
   0. Non-sticky: On release after pressure, practically no soil material adheres to thumb or finger.

1. Slightly sticky: After pressure, soil material adheres to thumb and finger but comes off one or the other rather clearly.
2. Sticky: After pressure, soil material adheres to both thumb and finger and tends to stretch somewhat and pull apart rather than pull free from either digit.
3. Very sticky: After pressure, soil material adheres strongly to both thumb and finger and is decidedly stretched when they are separated.

B. *Plasticity:* Plasticity is the ability to change shape continuously under applied stress and to retain the impressed shape on removal of the stress. To evaluate in the field, the soil material is rolled between thumb and finger to form a 'wire'.

0. Non-plastic: No wire formable.
1. Slightly plastic: Wire Formable; soil mass easily deformed.
2. Plastic: Wire formable; moderate pressure required to deform soil mass.
3. Very plastic: Wire formable; much pressure required to deform soil mass.

Consistence When Moist

To evaluate in the field, an attempt is made to crush in the hand a mass of soil that appears moist.

0. Loose: Noncoherent.
1. Very friable: Soil material crushes under very gentle pressure but tends to cohere when pressed together.
2. Friable: Soil material crushes easily under gently to moderate pressure between thumb and finger and tends to cohere when pressed together.
3. Firm: Soil material crushes under moderate pressure between thumb and finger but resistance is distinctly noticeable.
4. Very firm: Soil material crushes under strong pressure; barely crushable between thumb and finger.

Consistence When Dry

To evaluate, an air-dry mass of soil is broken in the hand.

0. Loose: Noncoherent.
1. Soft: Soil is fragile and breaks to powder or individual grains under very slight pressure.
2. Hard: Soil can be broken easily in the hands but it is barely breakable between thumb and finger.
3. Very hard: Can normally be broken in the hands but only with difficulty.

Cementation

Cementation of soil material refers to a brittle, hard consistence caused by various cementing substances. Different degrees of cementation occur.

1. Weakly cemented: Cemented mass is brittle but harder than that which can be shattered in the hand.
2. Strongly cemented: Cemented mass is brittle but harder than that which can be shattered in the hand; it is easily shattered by hammer.

3. Indurated: Very strongly cemented; brittle; does not soften when moistened and is so extremely hard that a sharp low with a hammer is required for breakage.

Particle size and chemical analyses

pH

pH is a measure of soil acidity or alkalinity. A soil having a pH of 7.6 to 8.3 is moderately alkaline; pH 7.1 to 7.5, slightly alkaline; pH 7.0, neutral; pH 6.6 to 6.9, nearly neutral; pH 6.0 to 6.5, slightly acid; pH 5.3 to 5.9, moderately acid; pH 4.6 to 5.2, strongly acid; and pH below 4.5, very acid.

Total Neutralising Value (TNV)

This is an index of the level of carbonates present in a soil. These carbonates modify the solubility of other nutrients. Soils showing positive TNV values in the surface horizons contain adequate or excess neutralising materials and are not in need of liming.

Carbon and Nitrogen

The level of organic carbon indicates the amount of organic matter in a soil (Cx1.72=organic matter). The content and nature of organic matter are of fundamental importance. Due to its high cation exchange capacity, organic matter acts as a reservoir for plant nutrients, which are gradually released to meet the requirements of the growing plant. At the same time, acid humus supplements the supply by influencing the extraction of nutrients from the mineral fraction of soils. Organic matter creates favourable physical conditions for crop growth; it promotes granulation of structure by reducing plasticity, influences cohesion and increases the water-holding capacity of the soil. Organic matter in the surface also influences the temperature of soils and, thus, seasonal growth.

Depending on organic carbon content, soils are classified as follows: over 30%, peats; 20 to 30%, peaty; 10 to 20%, slightly peaty; and those with 7 to 10% are usually referred to as 'organic'. In the case of the terms 'peaty', 'slightly peaty', and 'organic', the mineral textural class is included in the definition of the soil, e.g., peaty sandy loam; slightly peaty clay loam; organic loam. The surface horizon of mineral soils in Ireland normally contains 3 to 6% organic carbon.

Nitrogen, which is normally present in soils in relatively small amounts, is extremely important as a plant nutrient. It is easily leached from the soil and supplies need to be constantly replenished. The ratio or carbon to nitrogen (C/N ratio) indicates generally the degree of decomposition of organic matter; a ratio between 8 and 15 is considered satisfactory and indicates conditions favourable to microbial activity. Ratios higher than 15 are associated with a slower decomposition rate and with the accumulation of raw organic matter or, in more extreme cases, with peat development, and are indicative of unfavourable conditions for microbial activity.

Free Iron

A localised accumulation of free iron in a soil profile (Bs horizon), as is evident in brown-podzolic and podzol soils, indicates that leaching and podzolising processes have been operative. On the other hand, a uniform distribution of free iron throughout a profile, as is the case in the Brown Earths, indicates that the soils have not been strongly leached.

Summary of Analytical Methods

Particle Size Analysis: Determined by the International Pipette method as described by Kilmer and Alexander (1949), using sodium hexametaphosphate as dispersing agent.

pH: Determined on ½ soil/water suspension using a glass electrode.

Total Neutralising Value: Determined on HC1 extract using phenolphthalein as indicator and titrating against NaOH. Ca CO_3 was used as a 100% standard.

Organic Carbon: Estimated by the Walkley–Black dichromate oxidation method as described by Jackson (1958), modified for colorimetric estimation. Values were read off on a Spekker Absorptiometer using Orange Filter No. 607. A recovery factor of 1.1 was used.

Total Nitrogen: Estimated by a modification of the method of Piper (1950) by digesting soil with concentrated H_2SO_4 using selenium as a catalyst, distilling into boric acid and titrating with HC1.

Free Iron: Extracted with buffered sodium hydrosulphite (Mehra and Jackson, 1960). Fe determined colorimetrically using o-phenanthroline.

Physical analyses

Undisturbed samples were coated in the field with paraffin wax and transported to the laboratory. Normally, three or more samples per horizon were analysed. Bulk density and soil water retained at various suctions are expressed on a stone-free oven-dry basis. A sand-box apparatus is used for suction measurements at 0 hPa, -2 hPa and -59 hPa and a pressure plate apparatus for measurements at -137 hPa, -0.1 MPa, and -1.5 MPa (Stakman, 1980).

The volumetric water content at saturation (0 hPa) was taken as an estimate of total porosity as estimates based on particle density and bulk density were clearly too low in some samples. By convention the arbitrary -59 hPa cm soil water pressure is assumed to be the pressure reached by top soils in the field 2-3 days after saturation by rain or irrigation, and where gravitational drainage has occurred (Field capacity). The air capacity (drainable porosity) represents the difference between total porosity and field capacity; it broadly indicates permeability.

Available water capacity is the volumetric water content retained between -59 hPa and -1.5 MPa. The arbitrary – 1.5 MPa pressure is assumed to be the limit below which common plants will suffer severe wilting. In practice the “wilting point” is plant specific.

Hydraulic conductivities of some lowland Gleys, and Regosols were measured in the field by the inverse auger hole method (Kessler and Oosterbaan, 1980). This method requires the presence of a water table within the soil. The data are summarised in Appendix III.

APPENDIX II

Classification of soils according to Soil Taxonomy

Table A2.1: Classification of soils according to Soil Taxonomy (USDA, 1999).

	Major		Minor[1]	
Series	**Group**	**Subgroup**	**Group**	**Subgroup**
Ahaun	Haplaquept	Placic		
Ardmore	Plagganthrept	Typic		
Aughty	Haplosaprist	Typic	Haplosaprist	Terric
Ballycondon	Placaquod	Typic	Placorthod	Typic
Ballymacart	Haplaquept	Humic		
Ballynabola	Fluvaquent	Aeric	Fluvaquent	Humaqueptic
Ballyscanlan	Haplorthod	Typic		
Broomhill	Eutrochrept	Dystric	Dystrochrept	Typic
Callaghane	Haplorthod	Entic		
Clashmore	Dystrochrept	Typic	Haplorthod	Entic
Clohernagh	Epiaquept	Typic	Epiaquept	Fragic
Clonroche	Dystrudept	Typic	Eutrudept	Dystric
Coolfinn	Fluvaquent	Thapto-Histic	Fluvaquent	Aeric
Curragh	Plagganthrept	Typic		
Dodard	Humaquept	Typic	Epiaquept	Humic
Drumslig	Placorthod	Typic		
Dungarvan	Hapludalf	Glossic	Dystrudept	Typic
Fen Peat	Haplosaprist	Typic	Haplosaprist	Terric, Fluvaquentic
Finisk	Dystrudept	Fluventic		
Glenary	Placaquod	Typic	Epiaquept	Aeric
Kilbarry	Hydraquent	Typic	Haplosaprist	Terric
Kill	Dystrudept	Typic	Dystrudept	Spodic
Killadangan	Epiaquept	Typic		
Kilmeadan	Hapludalf	Inceptic	Hapludalf	Typic
			Eutrudept	Dystric

Table A2.1: Classification of soils according to Soil Taxonomy (USDA, 1999) (cont'd).

	Major		Minor[1]	
Series	**Group**	**Subgroup**	**Group**	**Subgroup**
Knockalisheen	Placaquod	Typic		
Knockmealdown	Placaquod	Typic	Medihemist	Terric
Lickey	Epiaquept	Typic		
Monatray	Plagganthrept	Typic		
Monavullagh	Placaquod	Typic		
Moord	Eutrudept	Aquic Dystric	Eutrudept	Dystric
Moord poorly drained	Epiaquept	Typic		
Mothel	Epiaquept	Aeric	Epiaquept	Typic
Newport	Epiaquept	Typic		
Portlaw	Haplorthod	Typic		
Slievecoiltia	Haplorthod	Lithic		
Slob	Fluvaquent	Aeric		
Slob peaty	Fluvaquent	Humaqueptic		
Suir	Dystrudept	Oxyaquic		
Tramore	Fragiaquept	Typic		
Waterford	Epiaquept	Typic		
Knockboy	Haplorthod	Typic	Placaquod	Typic

[1] Based on extent within map unit

APPENDIX III

Hydraulic conductivity

Table A3.1: Hydraulic conductivity (Ksat; m day^{-1}) of soil series and phases, Co.Waterford.

Series (phase)	Parent material	Count	Mean	Standard error	Different from ($\alpha = 0.05$)
Clohernagh	Till	24	0.16[b]	0.15	Coolfinn, Coolfinn peaty
Mothel		16	0.12[b]	0.18	Coolfinn, Coolfinn peaty
Tramore		15	0.18[b]	0.19	Coolfinn, Coolfinn peaty
Waterford		13	0.05[a]	0.20	Coolfinn, Coolfinn peaty
Ballynabola	Alluvium	12	0.41[c]	0.21	Coolfinn, Coolfinn peaty
Ballynabola peaty		7	0.93[c]	0.28	Coolfinn peaty
Coolfinn		4	2.14[d]	0.36	Waterford, Mothel, Clohernagh, Tramore, Kilbarry, Ballynabola, Coolfinn peaty
Coolfinn peaty		7	3.69[d]	0.28	Waterford, Mothel, Clohernagh, Tramore, Kilbarry, Ballynabola, Kilbarry peaty, Slob, Ballynabola peaty, Coolfinn
Kilbarry		7	0.24[b]	0.28	Coolfinn, Coolfinn peaty
Kilbarry peaty		3	0.60[c]	0.42	Coolfinn peaty
Slob		4	0.60[c]	0.36	Coolfinn peaty

a = slow; b = moderately slow; c = moderately rapid; d = rapid