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Assessment for agricultural drainage requirement

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Introduction

Soil is a complex balance of physical, chemical and biological processes which operate at an optimum when the soil is well structured and freely draining. Unfortunately in Scotland, a significant proportion of the soil series are classed as naturally imperfectly or poorly drained.

To overcome these natural impediments to soil drainage, artificial systems of improvement have been practiced since the 1740's with grant schemes of various types employed to encourage the installation of drainage systems to improve the drainage status of the land. The last round of grant schemes on a national basis ended in the late 1980's to early 1990's. However, at the time of writing, drainage improvement grants are still available in the Crofting Counties under the Crofting Agricultural Grants Scheme (CAGS) scheme (2015-2020) and more information can be found at https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/crofting-agricultural-grant-scheme/crofting-agricultural-grants-scheme-full-guidance/.

Due to the cessation of the national grant schemes, drainage work since the 1980's has reduced dramatically to the point where agricultural drainage work is limited to remedial repair work with few new comprehensive schemes being carried out. The lack of investment in drainage is of great concern because the economic life of a drainage system is between 30 and 50 years. Therefore, we will be entering a period when the drainage schemes installed in the 1960's to 1980's during the last period of grant schemes will be starting to come to the end of their usable life.

The most up to date data and information of drainage problems in Scotland is from the 1970's and was available from the Department of Agriculture for Scotland (DAFS) and can be found in Table 1.

Table 1. Scottish drainage data

	Scottish Drainage Problems %				
Year	Ground Water	Impermeable Subsoil	Springs	Failure of Old Scheme	Other
1975 - 1976	20.4	20.2	8.0	44.5	6.9
1976 - 1977	26.8	24.9	9.1	34.4	4.8
1977 - 1978	25.5	15.5	9.9	44.4	5.7

The aim of this Technical Note, along with others following on from it in this series, will provide information on assessing, planning, installing and maintaining drainage systems.

Why Drain?

The installation of land drainage is an expensive capital investment and has to compete with other farming investments for the available investment finance within the agricultural business. The focus on land drainage occurs usually during, and immediately after, a season when rainfall is above average. This focus fades following a period of dry weather when drainage maintenance should be carried out in preparation for the next period of wet weather. A list of the benefits of land drainage is shown below

- Improved soil structure
- Less surface run-off
- Improves soil water storage during flood events
- Less soil damage/compaction
- Reduces risk of environmental pollution
- Warmer soils in spring
- Better weed control
- Reduces livestock parasites (e.g. liver fluke)
- More timely cultivations and sowing
- Better machinery utilisation
- Longer growing season
- Improves fertiliser efficiency of use
- More varied crop rotation
- Better harvesting conditions

These factors should combine to increase the overall productivity of the land allowing a better farming system to be employed, however the level of overall benefit obtained will depend on the location of the farm, excess rainfall, cropping potential and underlying soil type. While some farmers view carrying out regular drainage as essential to maintain business prosperity, others view it as an expensive investment of doubtful value when compared to other projects within the business.

Evaluating Drainage Benefit

Drainage installation is an expensive operation and can cost between £750 to £4,500 per hectare depending on the problems identified and the equipment used. Therefore, a detailed assessment of all the costs and benefits both financial and environmental is required before the work is carried out. While drainage provides many agricultural benefits it can also have environmental costs to water quality and sensitive habitats if installed in inappropriate locations.

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The land most likely to benefit from drainage are:

1. areas where specialist crops are grown
2. areas where root crops and field vegetables are grown
3. areas where arable and intensive grass is grown
4. areas where mixed medium intensive agriculture is practiced
5. areas where grazing and occasional forage conservation are the main farming practices

The soil types that will benefit most from drainage are:

1. Heavy soils – Clay, sandy clay and silty clay
2. Medium soils – sandy clay loam, clay loam and silty clay loam
3. Light soils – Sandy loam, sandy silt loam and silt loam
4. Very light soils – sand and loamy sand

Topography also plays an important role in low lying areas. Sandy soils can have high water table which may require drainage. Undulating topography may concentrate run-off in specific areas which may require drainage regardless of soil type.

Climate also plays a major role in drainage requirement. As noted in the sections above, the main benefit from drainage is in the spring and the autumn as this will increase the length of the growing / grazing season. A good drainage system will drain the excess rainfall during the winter and allow the soil to be ready for seeding earlier in the spring. Furthermore, the drainage system will prevent soils from wetting up in the autumn and over the winter, which will allow later harvest dates and winter sown or harvested crops to be managed more easily. A well-drained soil will also allow livestock to access the land for a longer period thus reducing the length of winter they have to be housed which will in turn reduce the requirement for bought in feed.

Assessing for Drainage

Good soil drainage provides multiple benefits and to assess whether your farm requires drainage improvement requires some investigation. The first thing to do is to ensure that any existing drainage is functioning properly by reviewing any farm drainage maps to identify if any wet areas coincide with the location of installed drainage pipes or open ditches. If no maps are available, the land should be walked to ensure that all the open ditches are running free at their design depth and that the outlets from any pipe drains are clear and running freely. Once the existing drainage system, if any, has been assessed and maintained, the next stage is to review the farm soils.

Soil maps can be obtained online at the "Scotland's Soils" website (https://soils.environment.gov.scot/maps/) which provides information on soil type, drainage class and soil compaction risk. However the maps are at 1:25,000 scale, and may not reveal local issues. In addition to using the soils map data, it is worth walking the areas of the farm where there are drainage concerns and comparing the soil type with the location of any wet areas. The soil can be investigated using a spade or Dutch auger. The soil should initially be assessed for compaction in the topsoil and upper subsoil using the "Visual Evaluation of Soil Structure (VESS) for Soil Health" information found on the SRUC Website (https://www.sruc.ac.uk/info/120625/visual_evaluation_of_soil_structure). In addition to assessing the soil for compaction, the soil colour and wetness should be assessed. Figure 1 shows the effect of drainage on the soil colours with depth which indicate the natural soil drainage status. Figure 2 indicates the length of time soil would be expected to be wet over a year for a particular drainage class.

Figure 1. Soil drainage status

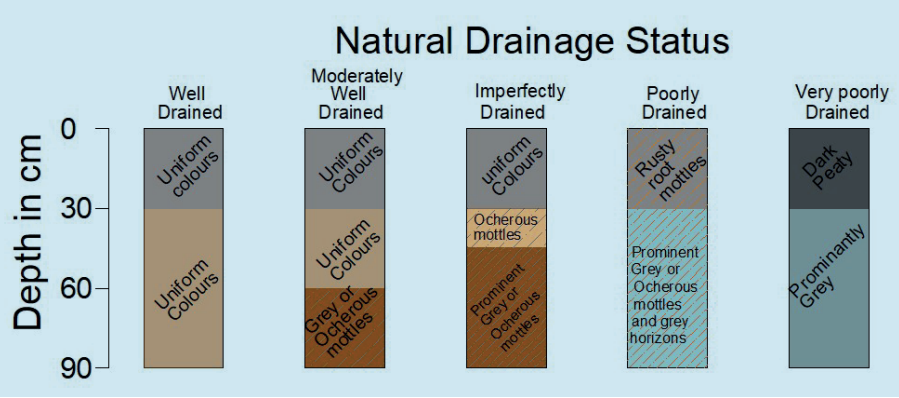
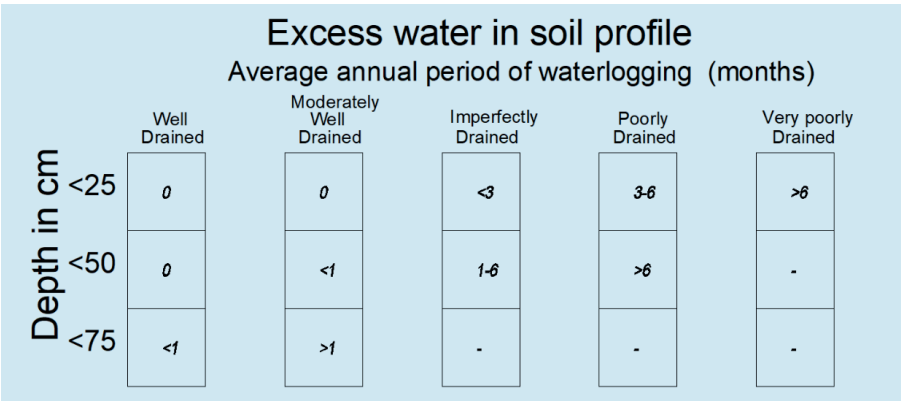


Figure 2. Soil wetness status



In addition to the soil, the other key elements in assessing drainage requirements are climate (in particular, excess rainfall), topography and land use potential. It is essential that any proposed drainage system can cope with the requirements of the crop being grown e.g. a higher value crop such as field vegetables will require a more intensive system compared to lower value crop such as grassland.

The rainfall that a drainage system will have to deal with will depend on its location and the return period for a particular rainfall event, that is, the likelihood of this event of this magnitude occurring. Tables 2 provides annual rainfall information for various locations across Scotland. The rainfall information was obtained from the Centre for Ecology and Hydrology's Flood Estimation Handbook Web Service which provides detailed rainfall information for locations throughout the United Kingdom which can be found at https://fehweb.ceh.ac.uk/.

Table 2. Annual rainfall from Flood Estimation Handbook web service

Annual Rainfall (mm)							
Wick	Inverness	Elgin	Turriff	Aberdeen	Forfar	Cupar	Livingston
809	682	679	790	812	796	718	819
Annual Rainfall (mm)							
Haddington	St Boswells	Dumfries	Ayr	Lanark	Stirling	Oban	Portree
628	681	1,052	932	855	983	1,682	1,998

In addition to the rainfall, the other key climate elements are temperature, wind and sunshine which determine how quickly the ground dries up and how quickly the land returns to field capacity. The Met Office produced a document "Climatological Memorandum No. 108 – The Climate of the Agricultural Areas of Scotland" (Francis, 1991) which provides information for the main agricultural areas of Scotland as indicated in Figure 3.

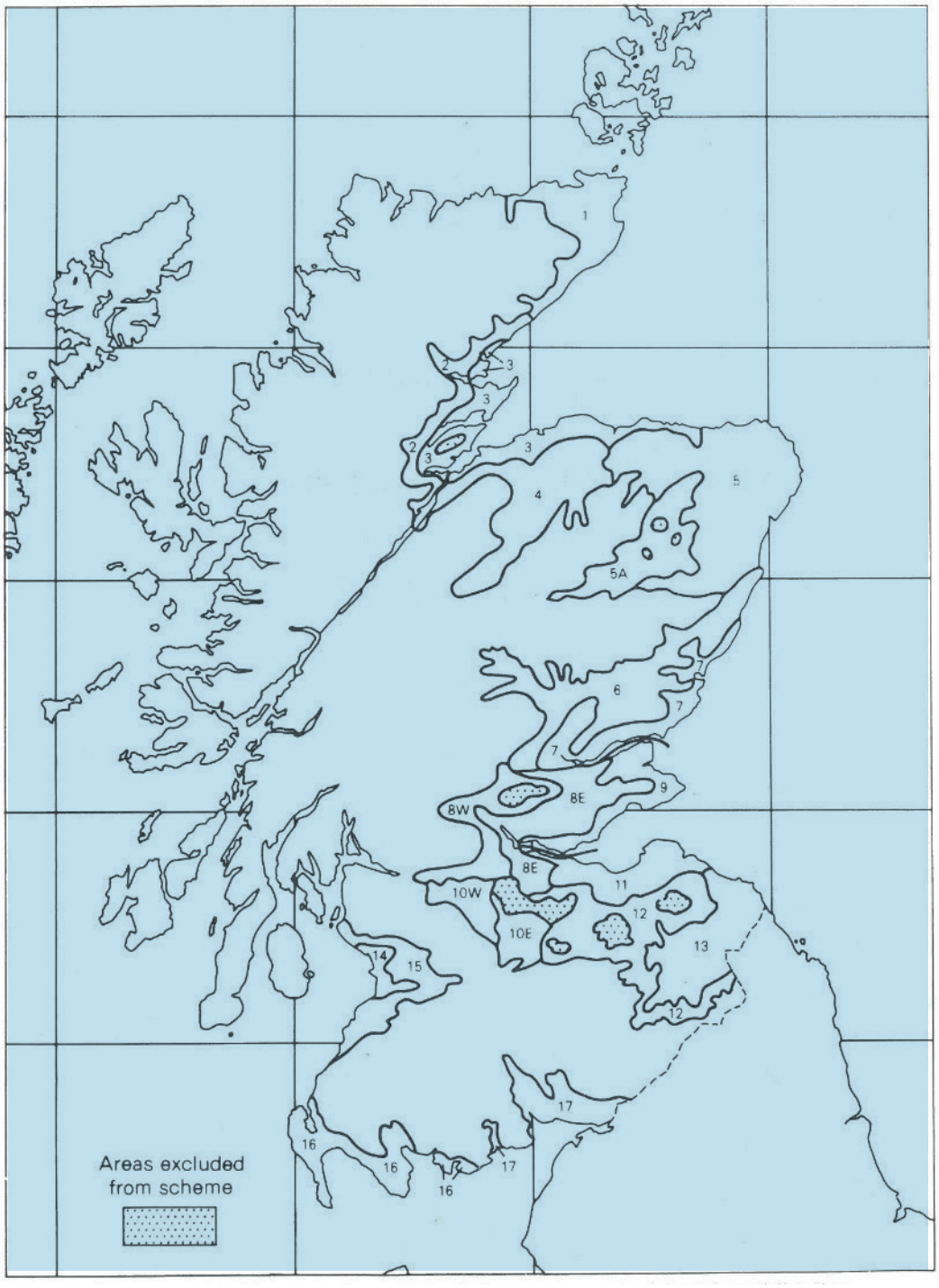


Figure 3. Agro climatic areas from the Climatological Memorandum 108, each number represents an agricultural region of Scotland with the extracted data shown in Table 3

Table 3 provides an extract of some of the information from the 1981 publication providing an indication of some the main climatic features for the agricultural areas. The data is the most current available for the agricultural areas but due to climate change these must be treated with caution.

Table 3. Agro climatic information from Climatological Memorandum 108 for the major agricultural regions of Scotland as shown in Figure 3

Area	Access Period (Days)	End of Field Capacity	Return to Field Capacity	Total Potential Evapotransporation (mm)	Excess Winter Rainfall (mm)
1	180	Early March	Mid October	435	365
2	170	Early March	Mid October	405	365
3	225	Early March	Early November	480	240
4	170	Early March	Mid October	410	365
5	180	Early March	Mid October	435	335
5A	160	Mid March	Mid October	395	400
6	170	Early March	Mid October	415	380
7	210	Early March	Late October	455	260
8E	185	Early March	Mid October	465	385
8W	165	Early March	Early October	450	545
9	225	Early March	Early November	480	255
10E	175	Early March	Mid October	430	375
10W	185	Early March	Mid October	465	385
11	240	Early March	Mid November	500	195
12	180	Early March	Mid October	450	375
13	225	Early March	Early November	480	245
14	190	Early March	Early October	490	410
15	175	Early March	Early October	475	540
16	170	Early March	Early October	465	525
17	160	Early March	Early October	430	520

More information on the cropping potential of agricultural land can be found online at the "Scotland's Soils" website https://soils.environment.gov.scot/maps/. Using the map layer for "Land Capability Classification for Agriculture", the productive capability of the land can be initially assessed to help determine the economic benefit a drainage system may have on the site being assessed.

Topography

Topography is a key component for land use and for drainage design as the higher value crops will be grown on the more gently sloping land. However, from a drainage point of view, there needs to be enough slope from the site to the proposed outfall to provide a suitable discharge for any proposed drainage scheme. Table 4 provides details of the ideal slope for various agricultural land uses from information contained in the Land Capability Classification for Agriculture monograph (Bibby, et al., 1991) published by the Macaulay Land Use Research Institute (MULRI) now part of the James Hutton Institute (JHI).

Once the land has been initially assessed and it has been determined it has potential worth investing in drainage improvement, then a more detailed investigation is required to identify the drainage problem(s). A more detailed investigation will involve taking topographical surveys and carrying to text excavations to depth using an excavator.

Table 4. Approximate slope categories for agricultural land use

Description	Ground Slope (°)	Gradient	Specialist Crops	Root Crops	Cereals	Silage Operations	Grazing
Gently Sloping	0						
	1						
	2						
	3	1 in 19.1					
Moderately Sloping	4						
	5						
	6						
	7	1 in 8.1	Limit of use of three inline forage equipment				
Stongly Sloping	8						
	9						
	10						
	11	1 in 5.2	Limit of Combines and 2 wheel drive tractors with trailed equipment				
Very Strongly Sloping	12						
	13						
	14						
	15	1 in 3.7	Limit of 2 wheel drive tractors with fully mounted equipment				
Steeply Sloping	16						
	17						
	18						
	19						
	20	1 in 2.7					
	21						
	22						
	23						
	24						
	25	1 in 2.1	Limit of 4 wheel drive tractors with trailed equipment				
Very Steeply Sloping	26						
	27						
	28						
	29						
	30	1 in 1.7	Limit of 4 wheel drive tractors with mounted equipment				

Drainage Issues

There are 3 main drainage issues which affect agricultural land:

- Surface water problems
- Ground water problems
- Spring / seepage water problems

Surface Water

Surface water drainage problems are due to soils with low permeability, that is, where water movement through the soil is slower than the rate of rainfall falling on it. The low permeability can be caused by the texture of the topsoil and subsoil but can also be caused by compact layers in the topsoil and subsoil which can slow the water through even permeable soils. However, the most common cause is densely packed subsoils that form a large proportion of Scottish soils. Figure 4 provides an example of the water movement which causes drainage issues.

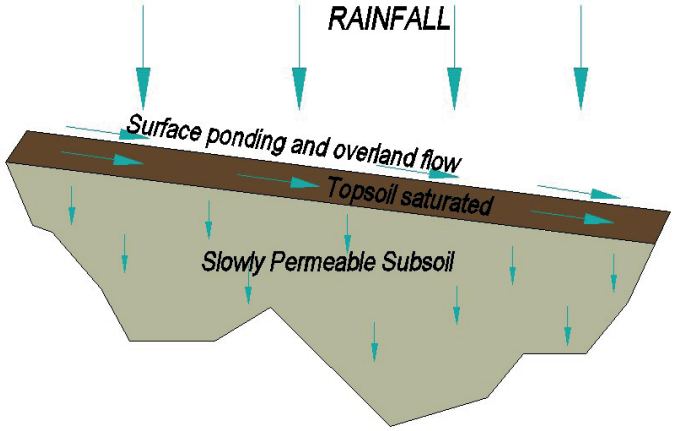


Figure 4 Water flow in soil causing surface ponding and overland flow

Ground Water

Ground water flow problem are usually found in low lying areas like flood plains or coastal areas with soil types ranging from sand and gravels to heavy clays. A typical problem is caused by a fluctuating water table due to a permeable subsoil layer overlying an impermeable or slowly permeable layer at depth. Figure 5 provides a typical example of the problems that can be faced.

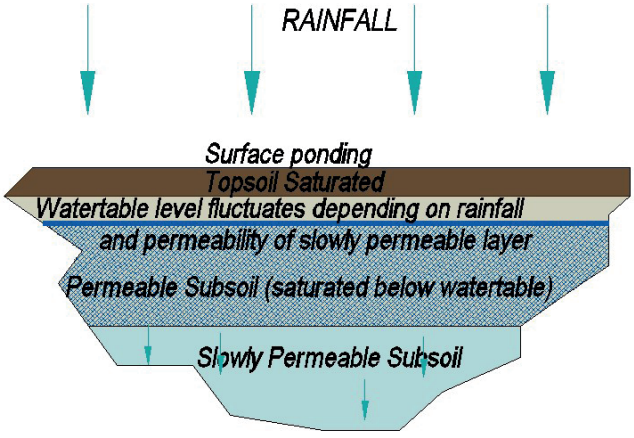


Figure 5. Ground water flow in soil causing surface water problem

Springs and Seepage Water

This is where water is discharged to the ground surface by either gravity seepage or by artesian pressure. The problems can be exhibited under a variety of situations but the common feature is that the underlying soil or geology forces the water to the surface. These problems require detailed investigation to identify the source, or sources, and create an effective drainage solution. Figure 6 provides an example of a common seepage problem.

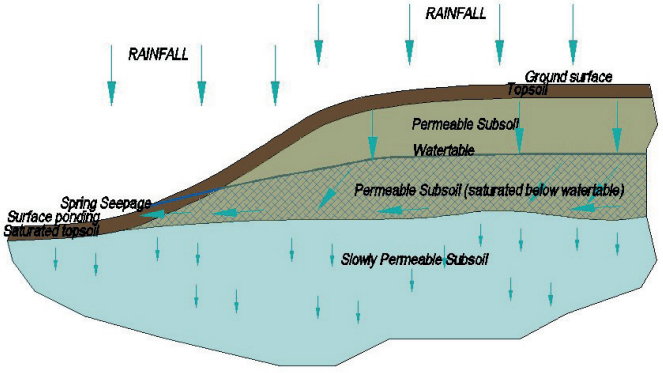


Figure 6. Water flow in soil causing seepage water problem

In addition to these main problems, there are other factors that cause problems to existing and proposed drainage systems which require specialist solutions such as:

- Iron ochre
- Running sand
- Tree and shrub roots
- Peat

All of these factors and the main issues need to be taken into account when proposing new or improving existing systems.

Key Points to Assess if Your Land will Benefit from Drainage

To summarise the information above, the key points you need to consider before carrying out new drainage are as follows:

1. Existing drainage – what is the condition of the existing drainage?
    a. Do you have plans of any existing drainage systems on the land?
    b. Are the field ditches all cleared and running at the depth required?
    c. Are the drain outfalls of any existing drainage all clear?
    d. Do you have any special problems on the farm e.g. iron ochre, peat, trees near the outlet points?

2. Environmental – identify if there are any environmental limitations for your land.
    a. It may be easier to leave some areas wet for wildlife if they are particularly difficult to drain.
    b. If areas have not been improved before check with the local Scottish Government Rural Payments and Inspections Directorate (SGRPID) office in case an Environmental Impact Assessment (EIA) of the site is required.
    c. When clearing open ditches or creating new drainage outlets check with the local Scottish Environment Protection Agency (SEPA) office in case any licencing is required to carry out the proposed work.

3. Location – what are the climatic limitations for your land?
    a. Rainfall especially excess winter (and summer).
    b. Evapotranspiration.
    c. Sunshine hours.

4. Crops to be grown – what crops will the improved drainage allow you to grow compared to current practice?
    a. Alternative high value crops.
    b. Improved yields from existing crop groups.
    c. Longer grazing season.
5. Soil type – what soils are on the farm?
    a. Are the soils heavy, medium or light soil (use soil maps and test excavations)?
    b. Do the soils exhibit drainage problems, waterlogged, surface ponding, and surface runoff?
    c. Are there signs of spring water i.e. areas which remain particularly wet in the summer?
6. Area to drain – have you identified all the areas requiring drainage?
    a. Easier to develop a plan at the start to drain all the land requiring drainage.
    b. System needs to be designed to cope with all the area to be drained as it can be costly to have to replace undersized main drains when starting a new section.
    c. If you have a plan, drainage can be carried out as the budget comes available.
7. Topography – information on site gradients.
    a. Carry out a topographical survey, the flatter the site the more detailed this will require to be.
    b. Prepare contour plans with contours at a suitable interval for the site slopes.
    c. Use GPS surveys where possible as these can be tied into Ordnance Survey (OS) maps.
    d. Mark on scale plans locations of any wet areas and compare with soil maps.
    e. Survey ditch bases and water levels preferably during a wetter part of the year when the land is at field capacity to inform the discharge level for new drains.

References

Bibby, J.S., Douglas, H.A., Thomasson, A.J. & Robertson, J.S. (1991). Land Capability Classification for Agriculture. Macaulay Land Use Research Institute, Aberdeen.

Francis, P.E. (1981). The Climate of the Agricultural Areas of Scotland. Climatological Memorandum 108, Meteorological Office, Edinburgh.

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