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Planning Agricultural Field Drainage

SRDP Farm Advisory Service

National Advice Hub
T: 0300 323 0161
E: advice@fas.scot
W: www.fas.scot

Summary

- **Agricultural drainage needs to be designed to suit the climate, ground conditions and crops to be grown.**
- **For effective agricultural drainage you need to assess the problem(s) to be remediated.**
- **Different risk levels need to be applied depending on crops to be grown.**
- **Detailed site assessments need to be carried out to ensure drainage is adequate for the site requirements.**
- **Prior to carrying out any drainage installations the site needs to be assessed to ensure that the expected economic benefit is technically and economically viable.**
- **Topography is a key factor which influences agricultural drainage design.**

Introduction

Planning agricultural field drainage requires a detailed investigation to obtain the best results. Depending on the site, there could be more than one drainage issue causing the drainage problem. As a recap from TN720 "Assessment for agricultural drainage requirement", there are 3 main causes of drainage issues which affect agricultural land:

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

In addition, there are a number of other problems such as iron ochre, running sand, tree and shrub roots, and peat, which require more specialist solutions.

Each of these issues require a different solution, so it is important that the problem or problems (as there may be multiple drainage issue affecting the site) are identified correctly to ensure the correct solution is proposed.

Site investigation

Prior to any drainage design being developed, a detailed site investigation of the site should be carried out covering the following key points raised in TN720:

- Area to be drained
- Existing drainage
- Climate
- Soil type
- Presence of ground or seepage water
- Topography
- Crops to be grown after the site has been drained

When formulating your proposed drainage solution the first stage should be a desk study to collate as much information on the above points to provide an initial assessment of the site and surrounding area. Following on from the initial information gathering, a site walkover should be carried out to identify any issues that were not apparent in the desk study. As part of the walkover, the soil type and texture should be assessed at different depths either by hand or using an excavator to dig deeper test holes.

Area to be drained

It is essential that the main area to be drained is clearly identified along with any surrounding areas that drain towards the main area, in order to ensure that the proposed drainage system is sized correctly. The best way to review the site is using an Ordnance Survey (OS) 1 to 25,000 scale map as this provides contour data along with details of any watercourses within the area of the site. These maps are a useful tool for an initial desk

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study and site walkover to review and note features and issues that will require to be taken into consideration for the drainage scheme. Figure 1 provides an example of this type of data which can be obtained from the OS website https://www.ordnancesurvey.co.uk/shop/maps.html?cat%5B0%5D=20&cat%5B1%5D=21.

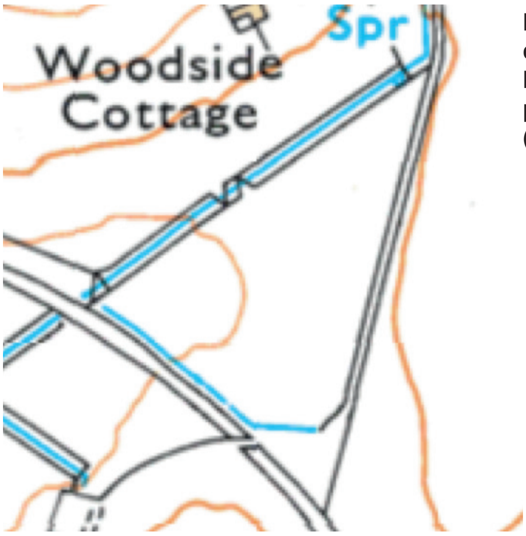
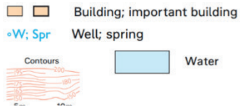


Figure 1 Example of Ordnance survey 1: 25,000 scale map data which details contours (orange lines), waterways (blue lines) and other information that should be considered when planning drainage assessments such as a well (W) or springs (Spr) and buildings (orange boxes)



For detailed drainage layouts, a larger scale map of at least 1: 2,500 scale should be used to mark the location of existing features and locations for existing and proposed pipes and ditches. Figure 2 provides an example of the information on a 1: 2,500 OS map.

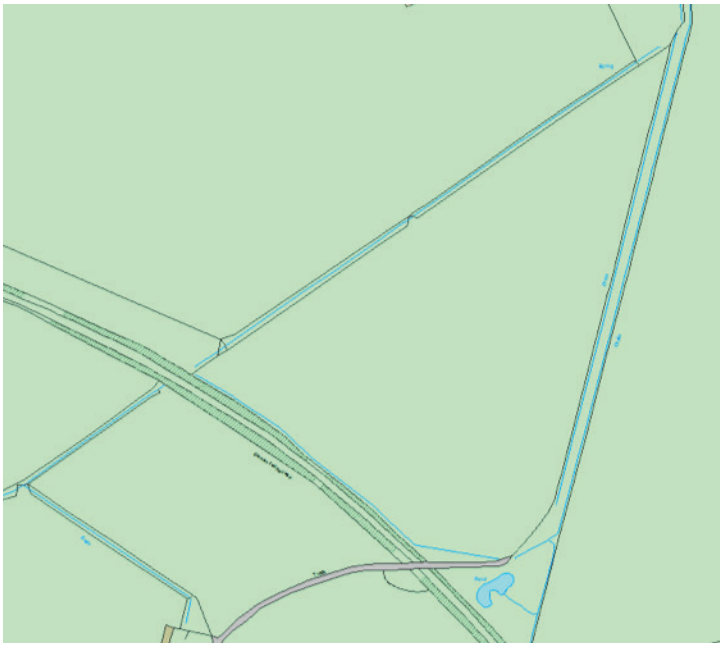


Figure 2 Example of Ordnance survey 1: 2,500 scale map data which should be used to mark the locations of existing drainage features

As can be seen from the maps, the 1: 2,500 scale provides more site detail but does not provide any contour data. The area that requires drainage should be marked on the 1: 2,500 scale plan and then measured either from the plan or on the ground to quantify the size of the area in hectares.

Existing drainage

As part of the site walkover investigation, an assessment of the existing drainage should be carried out to ensure it is functioning and notes taken on the condition of the drainage. For example, open ditches should be clear, pipe outlets should be clear of vegetation and running, and culverts should be clear with no blockages and washouts. Existing wet areas should be marked on the plan and their location compared with any existing drainage plans that are available for the site. All information gathered on the site walkover investigation should be noted on the plan.

Climate

The climate of the site will be need to be taken into account when planning an agricultural drainage system especially rainfall and excess rainfall amounts. Rainfall values can vary considerably across Scotland as was shown in TN720 (Table 2) which indicates that the west side of the country is generally wetter than the east side. Rainfall can vary considerably over short distances, for example, Table 1 below provides rainfall for locations on the east side of the country that are quite close to each other but vary in annual rainfall by up to 350 mm. 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 (https://fehweb.ceh.ac.uk/).

Table 1 A comparison of the annual rainfall amounts for locations in the East of Scotland from the Flood Estimation Handbook Web Service

Annual Rainfall (mm)	
Wick	Thurso
809	939
Turriff	Fraserburgh
790	709
Forfar	Arbroath
796	631
Cupar	St Andrews
718	657
Haddington	Dunbar
628	587

Table 1 indicates the importance of obtaining the best rainfall data available for the site proposed for drainage improvement. For drainage design, the amount of rainfall that the proposed system will need to remove will depend on the risk of waterlogging to the site and an ideal drainage system would remove the excess rainfall falling on that day. Table 2 provides the daily rainfall figures for various risk levels (e.g. 1 in 1 up to 1 in 200 risk) for locations throughout Scotland.

Table 2 Peak daily rainfall across Scotland from the Flood Estimation Handbook Web Service

	Peak Daily rainfall (mm)				
	Return Period (Risk of Rainfall Event)				
Location	1 in 1	1 in 2	1 in 10	1 in 25	1 in 200
Wick	29.8	34.1	46.9	55.9	83.6
Inverness	31.1	40.1	61.6	73.7	102.1
Elgin	33.7	41.2	60.6	72.1	100.3
Turriff	35.1	40.9	56.9	67.6	95.3
Aberdeen	36.7	43.2	61.9	73.9	102.8
Forfar	37.5	43.8	59.1	68.3	95.5
Cupar	34.3	40.3	55.0	64.3	93.8
Livingston	36.4	41.9	58.2	70.8	105.4
Haddington	35.9	42.0	60.0	74.3	115.1
St Boswells	31.6	36.9	50.9	61.4	98.4
Dumfries	37.9	43.6	60.5	72.5	111.1
Ayr	32.4	38.1	52.0	60.7	85.9
Lanark	31.3	36.3	48.9	57.1	83.0
Stirling	35.9	41.9	57.2	67.4	98.4
Oban	43.4	49.8	65.3	74.4	100.2
Portree	56.0	65.6	90.1	103.9	141.8
Average	**36.2**	**42.5**	**59.1**	**69.9**	**100.8**

However, the water reaching the proposed drainage system can be affected by other factors, such as time of year, accumulated temperature of the site, soil type, slope, vegetation cover and wind exposure. It is more economic to take the accumulated rainfall over a five day period and design the drainage system for an average peak rainfall figure for five days as most crops can sustain short periods of waterlogging. Table 3 provides a comparison of the peak five day rainfall amounts for locations across Scotland and Table 4 provides the average daily drainage design rainfall for various rainfall risk occurrences across Scotland.

Table 3 Peak five day rainfall comparisons across Scotland from Flood Estimation Handbook Web Service

Location	Peak 5 Day rainfall (mm)				
	Return Period (Risk of Rainfall Event)				
	1 in 1	1 in 2	1 in 10	1 in 25	1 in 200
Wick	53.8	60.3	78.7	91.2	130.9
Inverness	53.0	65.4	96.5	113.9	153.7
Elgin	50.7	61.9	91.4	108.5	148.0
Turriff	58.0	67.3	93.4	109.9	149.5
Aberdeen	63.1	73.9	103.0	120.0	159.0
Forfar	62.6	67.2	92.2	106.2	145.6
Cupar	57.5	65.9	87.2	101.3	145.9
Livingston	62.6	72.1	100.6	119.0	162.2
Haddington	56.4	66.8	99.9	121.8	172.7
St Boswells	49.4	57.6	81.7	100.1	151.3
Dumfries	71.1	79.7	103.7	120.1	169.3
Ayr	60.1	68.6	88.8	100.6	131.1
Lanark	58.7	66.4	85.4	97.6	133.6
Stirling	67.2	76.8	102.8	120.0	163.3
Oban	92.6	102.6	127.6	143.4	187.9
Portree	113.7	128.4	170.2	198.0	261.4
Average	**64.4**	**73.8**	**100.2**	**117.0**	**160.3**

Table 4 Average daily drainage design rainfall from Flood Estimation Handbook web service

Location	Average Daily Drainage Design Rainfall (mm)				
	Return Period (Risk of Rainfall Event)				
	1 in 1	1 in 2	1 in 10	1 in 25	1 in 200
Wick	10.8	12.1	15.7	18.2	26.2
Inverness	10.6	13.1	19.3	22.8	30.7
Elgin	10.1	12.4	18.3	21.7	29.6
Turriff	11.6	13.5	18.7	22.0	29.9
Aberdeen	12.6	14.8	20.6	24.0	31.8
Forfar	12.5	13.4	18.4	21.2	29.1
Cupar	11.5	13.2	17.4	20.3	29.2
Livingston	12.5	14.4	20.1	23.8	32.4
Haddington	11.3	13.4	20.0	24.4	34.5
St Boswells	9.9	11.5	16.3	20.0	30.3
Dumfries	14.2	15.9	20.7	24.0	33.9
Ayr	12.0	13.7	17.8	20.1	26.2
Lanark	11.7	13.3	17.1	19.5	26.7
Stirling	13.4	15.4	20.6	24.0	32.7
Oban	18.5	20.5	25.5	28.7	37.6
Portree	22.7	25.7	34.0	39.6	52.3
Average	**12.9**	**14.8**	**20.0**	**23.4**	**32.1**

The rainfall figure used in the planning of the drainage system will depend on the area, soil types, proposed crops and the experience of the drainage designer. Table 5 provides an indication of rainfall risk levels to be used for particular land use situations (e.g. cropping or structural engineering).

Table 5 Rainfall risk levels for different land use situations such as cropping or structural engineering works

Land Use	Rainfall Risk Return Period
Grassland	1 in 1 year
Arable Crops and Intensive Grassland	1 in 2 year
Root Crops and Field Vegetables	1 in 5 year
Horticultural Crops	1 in 10 year
Very High Value Specialist Crops	1 in 25 year
General Transfer Ditches	1 in 30 year
Transfer Ditches Near Buildings	1 in 200 year
Storage Ditches	1 in 200 year

Soil Assessment

Soil type has a key influence on the speed that the rainfall percolates to the drainage system and will influence whether the pipes need permeable backfill to be included as part of the drainage system. The speed that the rainfall flows through the soil to the drainage pipes or over the ground surface to an open ditch will influence the peak water flows in the drainage and therefore will influence the size of the drainage pipe or ditch required. Therefore, a soil investigation should be carried out using excavated test holes that takes note of soil features which may cause specific problems during the installation and operation of the drainage e.g. the presence of peat, iron ochre or running sand.

It is important that soil excavations identify the soil texture at different depths to determine potential percolation values of the soil throughout the profile. This would include assessing soil texture variation with depth to identify the capacity of the soil to hold water at different depths. An excavation of the soil profile should also estimate the amount and size of stones in the soil profile as this will have major implications for the method required to install the drainage. It is essential when excavating test holes that no personnel enters the excavation without a risk assessment and unless the appropriate measures have been taken to prevent collapse http://www.hse.gov.uk/construction/lwit/assets/downloads/excavations.pdf.

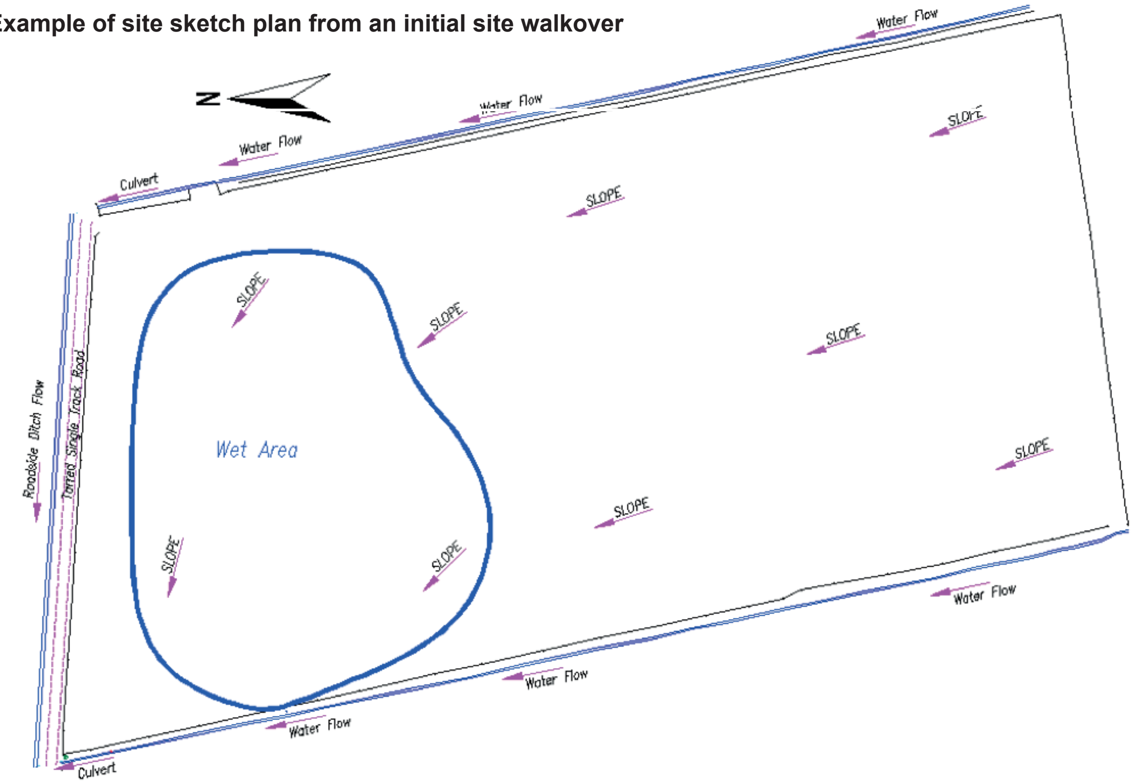
Presence of ground or seepage water

Test excavations should also be used to identify if there is a presence of ground or seepage water in the profile as this will require to be intercepted by the new system and will have implications for the size and depth of the proposed drainage system.

Topography

It is essential that the topography of the site is recorded accurately in order that the drains be accurately positioned to collect the surface water. The initial site walkover should identify the main features and slopes and issues that can be seen at this time. Figure 3 provides an example of a site sketch plan which details the initial information gathered from a site walkover.

Figure 3 Example of site sketch plan from an initial site walkover



Where possible, the initial site sketch plan should be based on an Ordnance Survey scaled map as was shown in Figure 2 with information marked on it from the site walkover. Prior to the walkover, information gathered from other sources during the desk study such as soil maps, aerial photographs and historic drainage plans should be used to mark information on the site plan.
On sites with shallow slopes or an undulating surface, it is always better to carry out a level survey with point data and contours (ideally to OS datum) to ensure the proposed drainage will be located in the ideal location to intercept the drainage water. Figures 4 and 5 provide examples of the information collected and presented on the site sketch plan.

Figure 4 Example of site level and contour plan data

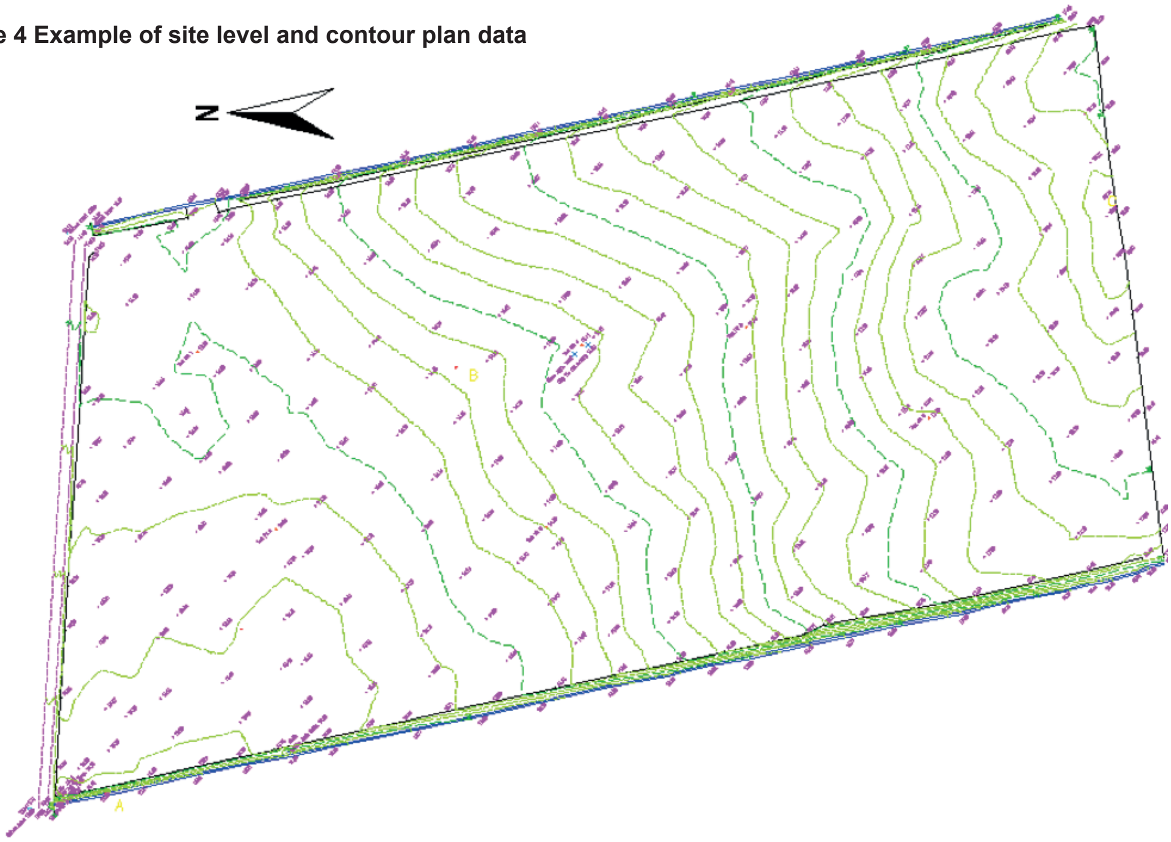
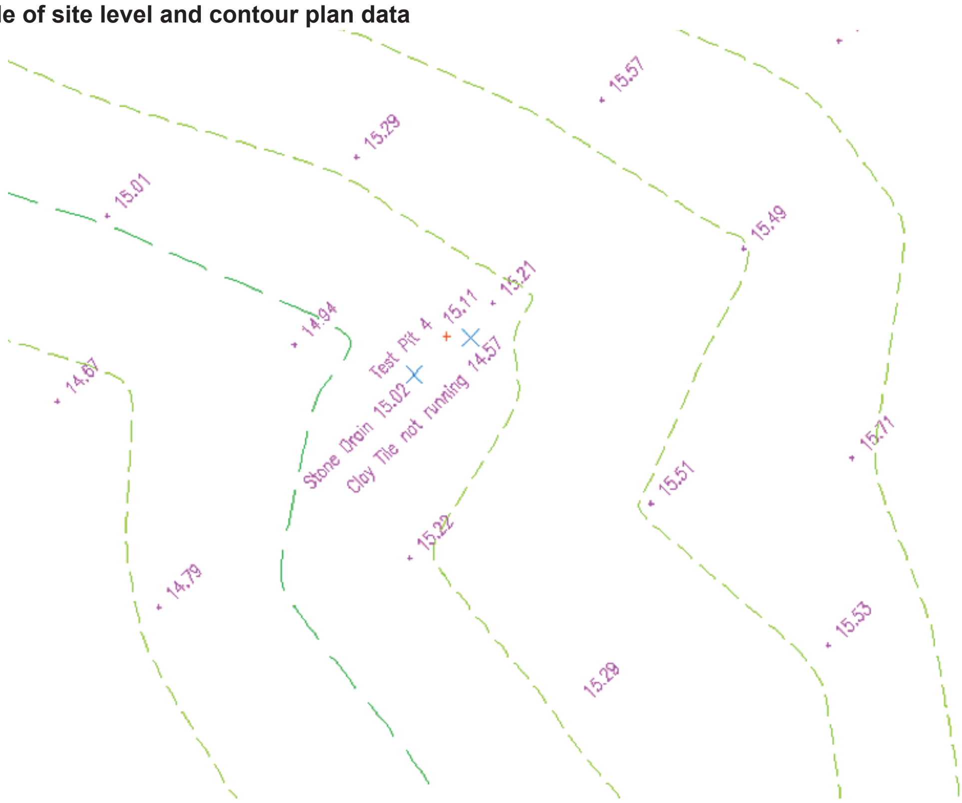


Figure 5 Example of site level and contour plan data



The information from the site survey should be used to identify if the initial proposed draft layout will provide a design that is capable of draining the site to the level that is required for the proposed crops to be grown.

Drainage layouts

The information gathered will be used to create drainage layouts and schemes to overcome the drainage problems identified. Drainage layouts should be laid out so the lateral (collector) drains are positioned as close to parallel with the contours as possible. Figure 6 shows a desirable layout of lateral drains that are aligned with field contours while Figure 7 shows an undesirable layout where the lateral drains cross contours at right angles.

Figure 6 Desirable – lateral drains aligned with field contours

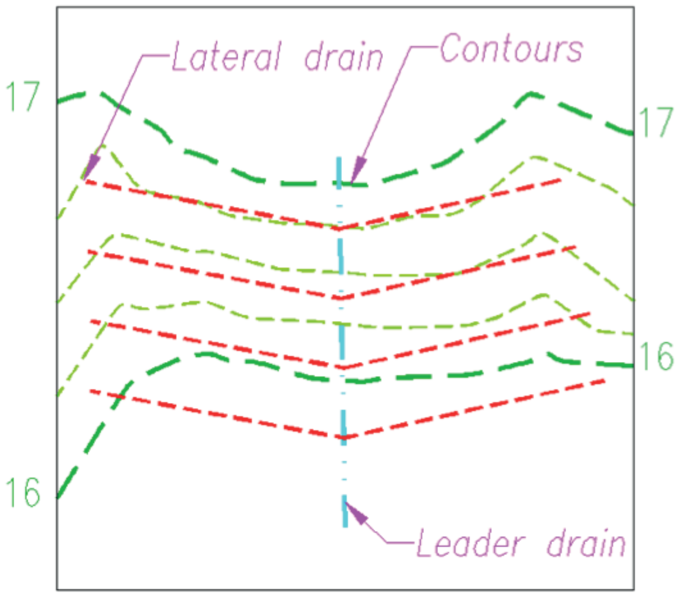
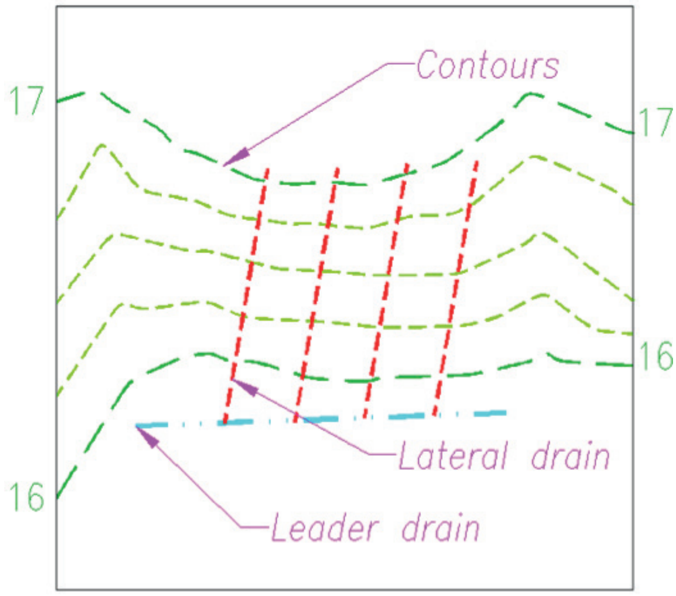
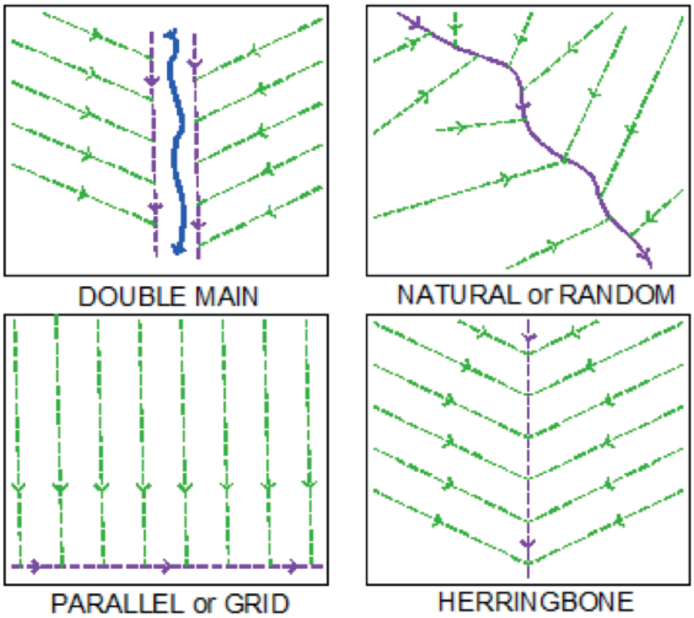


Figure 7 Undesirable – lateral drains cross contours at right angles with field contours



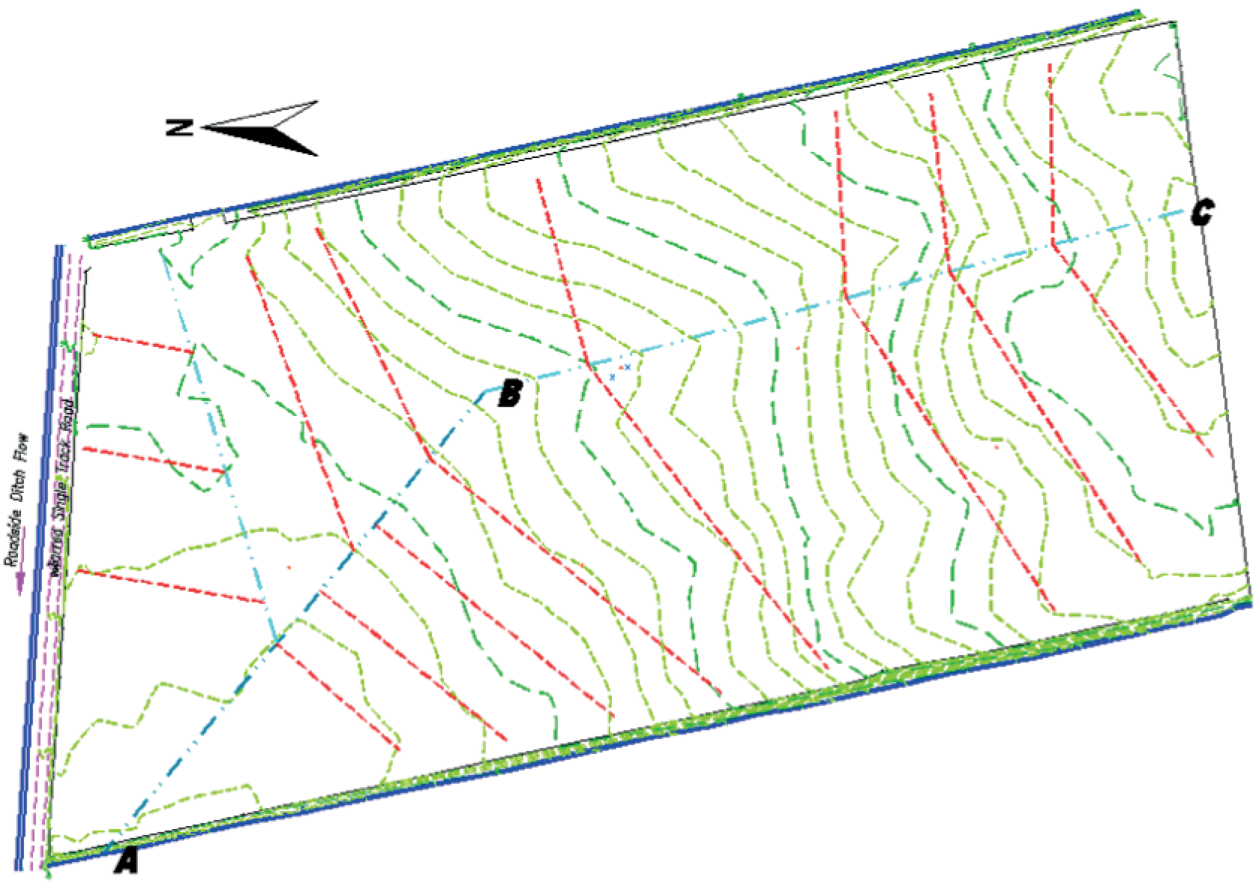
Due to the variable topography in Scotland, the ideal layout proposed in Figure 6 can be difficult to achieve in all occasions. Drainage layouts vary and have different names as shown in Figure 8 which provides examples of the most common layout types.

Figure 8 Most common types of drainage layouts



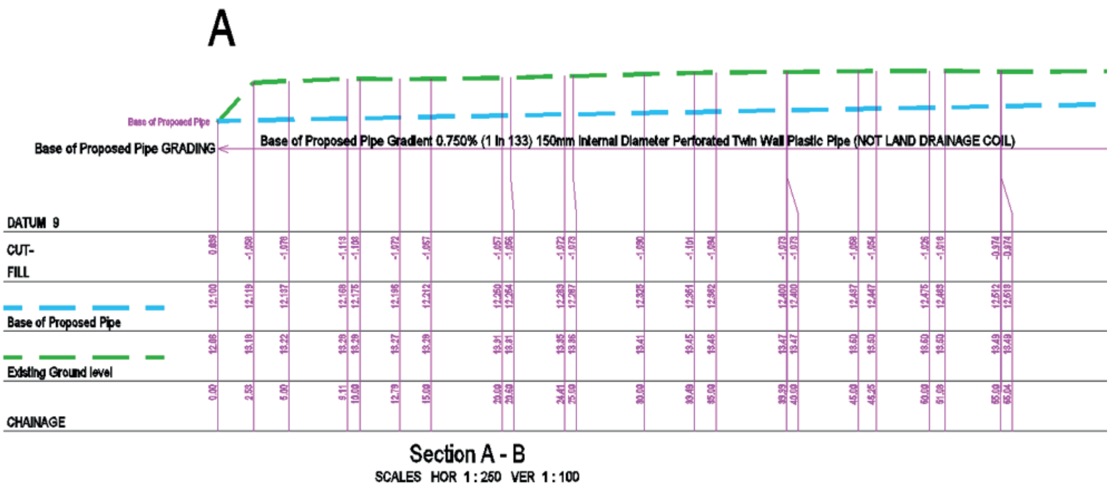
Following the initial investigation and site survey, a draft layout of the proposed system should be made. Figure 9 indicates a potential drainage layout for a site based on the information from Figures 3, 4 and 5.

Figure 9 Draft layout of proposed drainage system



On creation of the draft layout it is prudent to check gradients and cover depths on at least the leader drains. Leaders drains are the main drains which transfer the water from the collecting drains (lateral drains) to the outlet point. A leader drain can be either be a pipe or an open ditch depending on the location and terrain. Sections are essential along the main drainage lines to ensure that the drainage proposal is technically feasible and to identify any potential problems which may need attention during the detailed design phase. Figure 10 provides an example of a section along part of the line A-B that is shown in Figure 9. The points A-B-C indicate the line of the main leader drain for the proposed draft drainage layout.

Figure 10 Example of drainage section



Once it is assessed that the draft layout for the proposed drainage system is initially feasible (both technically and economically) the next stage would be to take the draft design to the detailed design phase in preparation for installation.

Proposed cropping following drainage

The proposed cropping that follows the drainage improvement is key to carrying out the improvements. There are three main questions to ask when considering drainage for cropping:

1. Is it technically feasible to grow the proposed crops for the site?
2. Is it possible to drain the site to meet the proposed crops required drainage criteria?
3. Is it economically feasible to carry out the drainage on the site?

Key Points for planning an agricultural field drainage scheme

To summarise, the points that need to be considered when planning a proposed agricultural field drainage system are as follows:

- Area to be drained
  - Calculate area proposed to be drained
  - Identify any areas to be drained in future that need to drain through the current area
- Existing drainage
  - Review available drainage plans
  - Walkover site to identify existing drainage features
- Climate
  - Review rainfall risk data for the site depending on proposed cropping
  - Obtain other important climate data e.g. accumulated temperature, evapotranspiration data
- Soil type
  - Topsoil and subsoil texture
  - Stone content and size
  - Compaction layers
  - Other problems e.g. presence of peat, iron ochre, running sand
- Presence of ground or seepage water
  - Excavate test holes to depth (using safe methods) to identify seepage layer (if suspected)
- Topography
  - Carry out level survey of the site
  - Prepare level plans and contour maps for area to be drained
  - Prepare a draft drainage layout
  - Prepare level sections along the line of key drainage features
- Crops to be grown after the site has been drained
  - Identify if feasible to grow crop
  - Carry out costings for required drainage
  - Carry out gross margin benefit of drainage on crop to identify how long it will take for pay back

Authors

Gavin Elrick, SAC Consulting, T: 01888 563 333
Samantha Dolan, SAC Consulting, T: 01292 525088

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