Soils Report 9, James McMahon, Swans Cross

Introduction

The Heavy Soil Farm at Swans Cross is a dairy farm of just over 32 hectares. There are 90 cows on this milking platform. The farm is located in county Monaghan, 10 km west of Ballybay and 12 km south of Monaghan town (Figure 1). The landscape is marked by the Drumlins synonymous with this county and its neighbour Cavan. 200 tonnes of lime have been spread on the farm over the last five years suggesting trouble with low pH. Subsoiling has been regularly undertaken due to stagnation and high coarse fragments in the soil. The main conduit for drainage in the area is a tributary of the Bunnoe River, this skirts along the northern part of the farm near paddocks 11 to 14 (Figure 2). This tributary feeds into Annaghmakerrig Lough which is joined to Carratraw Lough and eventually runs into the Erne system.

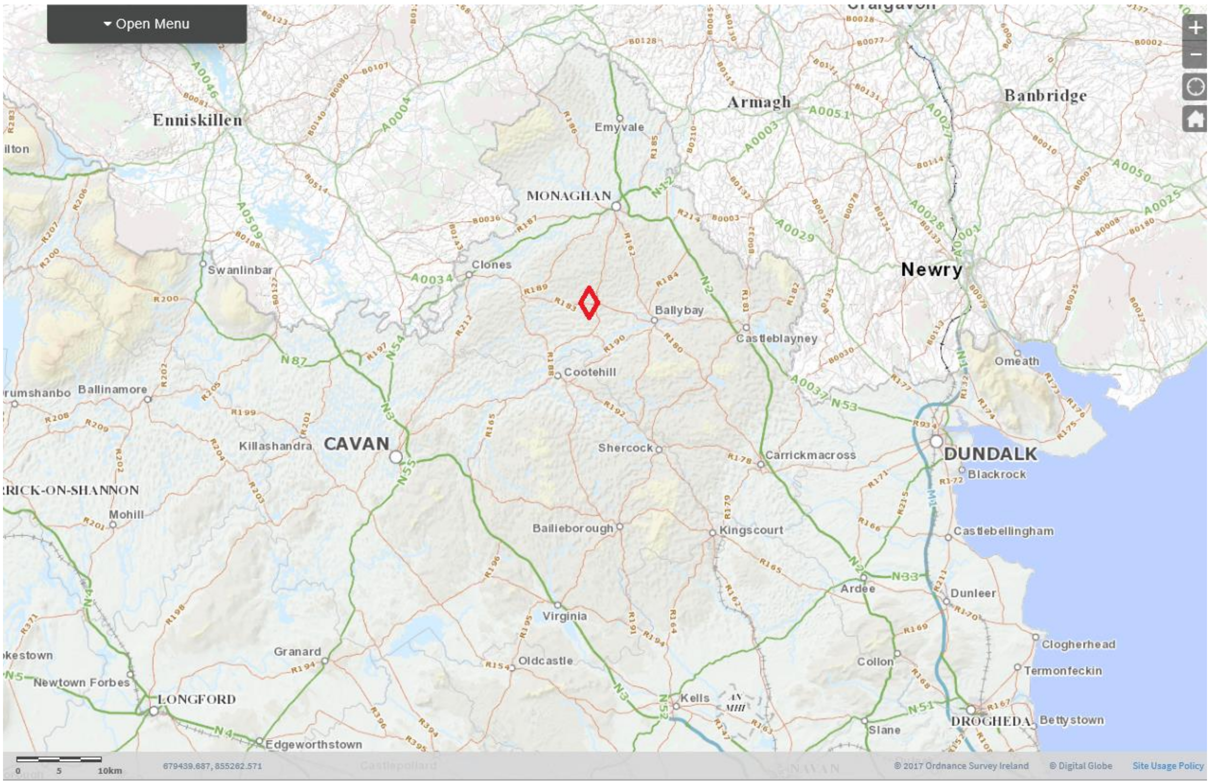

Figure 1. Location of HSP farm (red diamond) west of Swans Cross, Co. Monaghan.

The area where the farm is found is on a drumlin belt of between 100 m and 200 m in elevation, to the south of Monaghan town, north of Ballybay and east of Clones. It contrasts greatly with the low lying areas around Monaghan town itself. The major drumlin belt in the county is found to the south of the town and this farm is located on the edge of an area where the elevations of the drumlins drop to below 100 m and a band of lakes is found between Cootehill and Ballybay. The drumlin belt once again rises to the south of the county and the border with Cavan. There is 1078 mm average yearly rainfall recorded in the area.

The geology of the area is described as the Red Island formation, consisting of Greywacke, microconglomerate & argillite. Greywacke is a variety of sandstone generally characterized by its hardness, dark colour and small rock fragments or lithic fragments set in a compact, clay-fine matrix. Argillite is a fine-grained sedimentary rock composed predominantly of indurated clay particles. Argillaceous rocks are basically lithified muds and oozes. They contain variable amounts of silt-sized particles. It would be reasonable to expect drift derived from this geology to have high clay and silt contents and therefore be considered heavy till. There is a fault line to the east of paddocks 6, 7 and 16 and it cuts through vertically south to north through paddock 17. Other local bedrock geology includes turbidite, red shale, minor volcanics to NW and Siltstone, mudstone & thin turbidite to SE and Massive sandstone & microconglomerate further to the east again.

The Midlandian glaciation obliterated all the evidence of previous glaciations in Monaghan up to the period 11,000 years before present. The drift geology at the site consists of glacial deposits comprising boulder clay with small areas of moraine sands and gravels. This till was deposited by glacial ice. Glacial deposits in the form of drumlins typify the landscape surrounding the study area. Enclosed hollows are found between drumlins giving rise to bogs and small lakes. For this reason drumlin areas provide a variety of habitats which are of ecological importance.

Drumlins are smooth, oval shaped hills consisting mostly of deposited boulder clay or till. The long-axis runs parallel to the direction of the ice flow with the higher wider 'stoss' side upstream, tapering down to a pointed 'lee' end (West 1968). Two different types of drumlins occur, rock and till. Till or drift drumlins are comprised of compact, unstratified glacial till or drift. In contrast, rock drumlins are mostly made up of rock core with a concentric covering of drift. Rock drumlins tend to have a slightly better drainage status than till drumlins due to their tendency to have a wider extent of freer-draining soils (Soils of Ireland, in press).

The whole footprint of the farm is a ribbed moraine formation to the west and centre, with a drumlin in the eastern part of the farm rising up through paddocks 18, 19 and 20.

The Geological Survey of Ireland quaternary map, predicts the area would be covered in till derived from Lower Palaeozoic sandstones and shales (GSI, 2017). Cut over raised peat is predicted in the area north of paddock 17, NW of paddock 22 and west of 18, 19 and 20. It is also predicted south east of paddock 6. Alluvium is found north of paddocks 13 and 14, And south of paddocks 3, 5 and 6. There is more peat predicted to the west of these paddocks also.

Historical soil information

County Monaghan did not have a National Soil Survey report or map published for the area. As part of the An Forais Talúntais, AFT general soils map of Ireland (1980) a reconnaissance survey of the area was carried out. Consequently it was mapped indicating the county to be composed of acid brown earthy soils with inter-drumlin peat and peaty gleys. These soils were reported as having formed mainly from shale drift from gravels of mixed origin. Brown earths were described as mature, well-drained, mineral soils that have a relatively uniform profile. These soils are acidic in nature as they occur on lime-deficient parent material. They have a medium texture of sandy loam, loam and sandy clay loam. Brown earth soils are extensively cultivated soils owing to their texture and good drainage characteristics. Peaty gleys are poorly drained soils with a low base status. The weak structure of the mineral profile and the high silt content of these soils are mainly responsible for the poor drainage.

The Irish Soil Information System (Irish SIS, Creamer et al 2014), is now the primary resource available for soils in this area. There was ground-truthing of the soils of county Monaghan via a soil

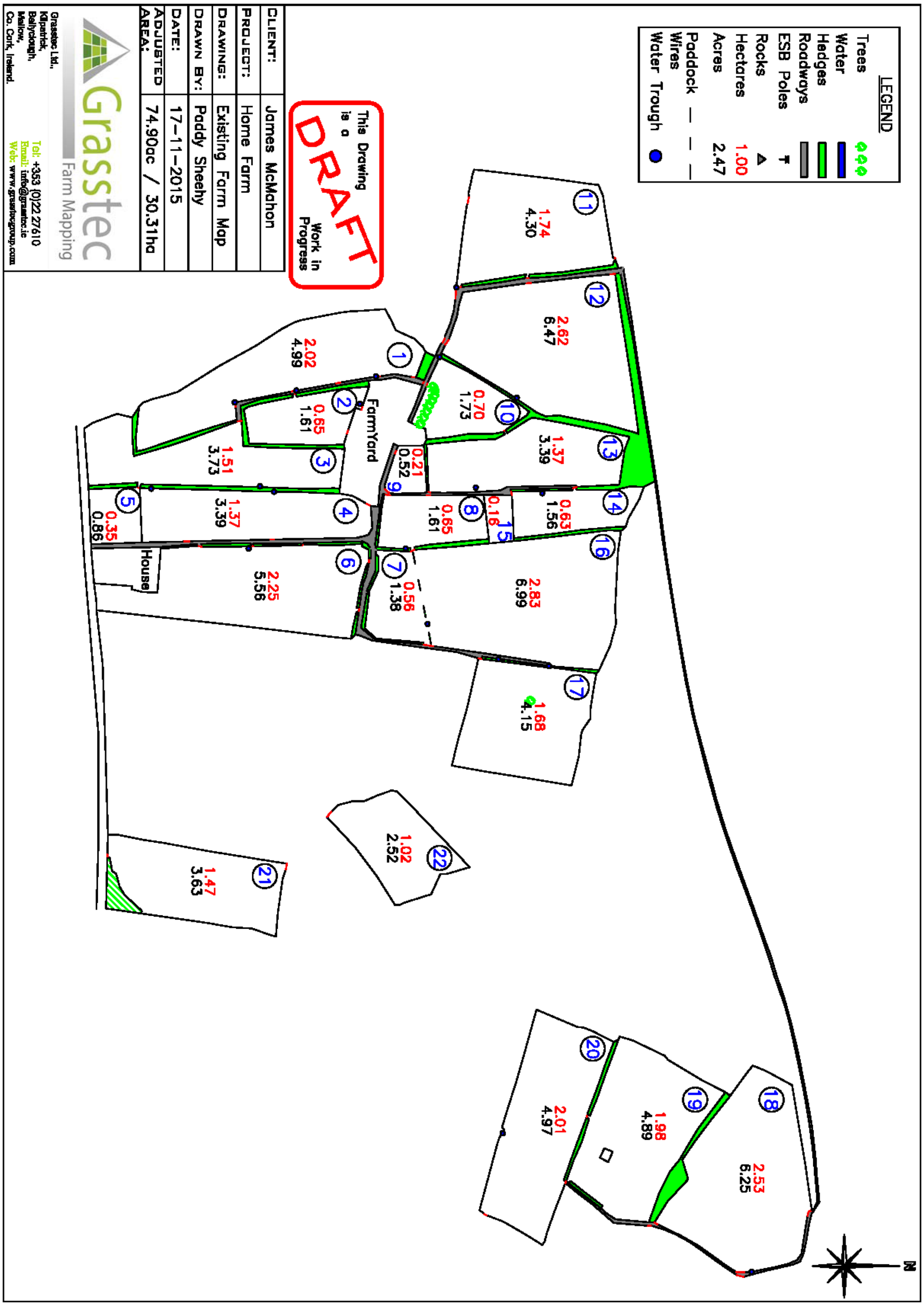

Figure 2. Paddock distribution at the Swans Cross Heavy Soil Farm, Co. Monaghan.

auger campaign and profile pit description of new soils encountered. Generally the soils were found to be heavier in texture than the AFT report. In the map viewer, there is a polygon covering over 90 % of the farm area, soil association Moord (Figure 3). This association is led by the Stagnic Brown Earth (11.3.0), Moord, which tends to have high clay contents in the upper horizons leading to stagnation. It also is found to be acidic. Due to the heavier textures in this drift there are two gleys associated with Moord, Kilrush a Typical Surface-water Gley (07.0.0) and Gortaclareen a Humic Surface-water Gley (07.6.0). There is also a Humi-Stagnic Brown Earth, Gneaves (11.3.6), a Humic Brown Earth, Brosna (11.6.0) and a Typical Luvisol, Dunboyne (10.0.0). The map also indicates a fen peat area, likely to be Banagher, Drained Minerotrophic Peat (02.7.0) in the north and eastern part of the farm near paddocks 17, 18, 19, 20 and 22. This would be groundwater fed rather than rainwater.

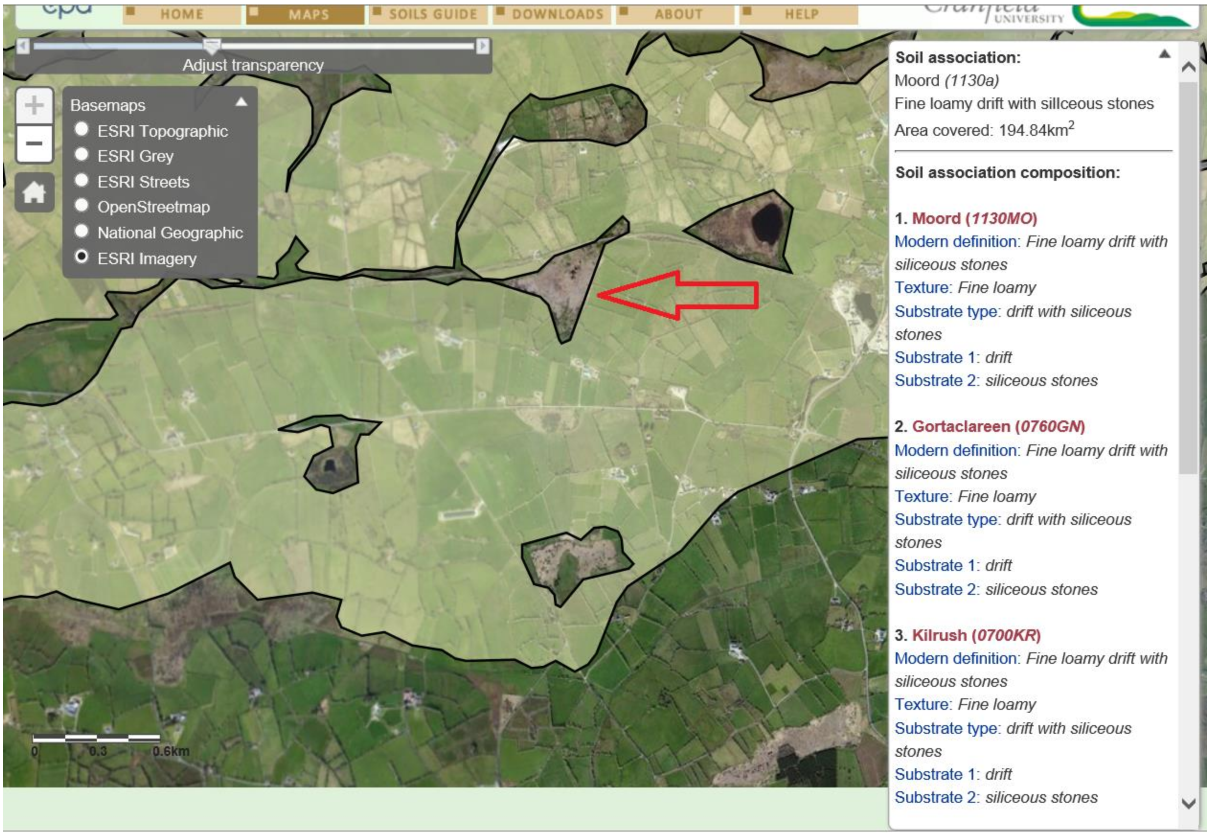

Figure 3. The Moord soil association is predicted to cover over 90 % of the farm. The red arrow indicates the area of fen peat running along the north and into the central eastern part of the farm.

Auger campaign

Method

An auger bore was carried out on average every hectare to investigate the soil physical features. In practice, more augers were used based on landscape complexity. Their resulting distribution was a relatively even coverage in each part of the farm (Figure 4). The Dutch auger was driven into the soil to a depth of 1 metre if possible. The coordinates, landscape features and soil features were described and recorded on a field tablet. Horizon type, depth, texture, colour, mottling, structure, roots and stones were recorded along with many more physical attributes detailed in the Irish SIS soil profile handbook (Simo et al 2014).

Figure 4. Auger distribution on the Heavy Soil Farm at Swans Cross.

Surface-water Gleys

There are 36 auger records for this farm and the majority fall under the soil Great Group of Surface-water Gleys (15). These soils have a Btg horizon where there was an increase in clay due to illuviation but there was also an increase in mottling and a gleying of the horizon (Paddocks (P) 3 b, 4 a, 4 b, 6 a, 6 b, 9, 12 c, 12 a, 16 b, 18 a, b & c, 19 a & b, and 20 a & b). The increase in clay is leading to stagnation of water on a regular basis. The amounts of water falling in rainfall regularly exceed the percolating capacity of the soil pore space. This can be described as a perched water table, found much closer to the surface than the actual groundwater table. These soils are known as the series Kilrush when the drift is 80 cm depth and deeper (Figure 5) and soil series Lismeelcunnin when the drift is over bedrock within 80 cm depth (Figure 6). Only one of the augers had a Humic layer at the surface, Gortaclareen (P 3 b). In this case there is a build-up of organic material at the surface. This is due to a reduction of the breakdown of organic material due to anaerobic conditions where only specialist microbes can consume the material. It also creates more resistant biproducts of microbial digestion. Therefore, litter and humus begins to accumulate.

Brown Earths

The next largest soil Great Group was the Brown Earths with 13 auger records. Of these 9 suffer from water restrictions. There are 5 Stagnic Brown Earths where water is impeded from flowing downwards due to a clay or silt levels in the B horizon. Here some mottles form after the water eventually percolates downwards, however this is never severe enough to create a gleyed horizon at this depth. Where this occurs on drift it is soil series Moord (3, P 7, 13 a and 21 b) and over bedrock it is named series Duarrigle (2, P 10 and 21 a). Another form of water impediment is where the groundwater rises through the soil profile and creates mottles as it fluctuates, again this process does not occur any shallower than 40 cm depth. Therefore, the gleyed horizons are at depth. These soils are known as Gleyic Brown Earths (4, P 8, 11 a & b and 14) and are referred to as series UN16 when found over fine loamy drift (Figure 7).

Figure 5. Paddock 18 c, Typical Surface-water Gley (07.0.0), soil series Kilrush. Looking west towards the fen area of the farm.

Figure 6. P4 b Typical Surface-water Gley (07.0.0), soil series Lismeelcunnin. Looking northwards up slope.

Figure 7. Paddock 11 b, Gleyic Brown Earth (11.2.0), series UN16. Found in lower slopes looking southwards.

Figure 8. Paddock 16 a, Typical Brown Earth (11.0.0), Clonroche. Found on a shallow incline.

There are 3 Typical Brown Earths where there is no water restriction (P 2, 3 a & 16 a). These relatively young soils are very good for productivity as they have a good balance between pore space to allow drainage and loam texture allowing retention of high nutrient status (Figure 8). There is one Anthric Brown Earth series Clashmore anthropic (paddock 16 c). Here material has been imported to fill a hollow area and has been mixed with the local drift. Remnants of A horizon can be found mixed in with the C horizon and vice versa. In time management and natural leaching/illuviation should return this to a highly productive area as there is not a great contrast between both of the soils.

Figure 9. Paddock 1 a, Stagnic Luvisol (10.3.0), series Crosstown.

<u>Luvisol</u>

There were 6 soil augers described as luvic on the farm having a Bt horizon. Luvisols are where there is a distinct increase in clay content within 30 cm of the surface. The illuviation process has leached clay from the surface layer, these soils also tend to be decalcified. Generally, these soils are still highly productive and have good drainage. The most common soil series was the Stagnic Luvisol series Crosstown (5, P 1 a, b & c and 17 a & b). Here the accumulation of clay is beginning to restrict the downward movement of water. Some mottling has occurred when iron precipitates out of solution with the return of oxidising conditions following the draining of water. However, this process is not causing the gleying of the entire soil matrix at this stage (Figure 9). There was one Typical Luvisol (P 12 b) series Dunboyne, where there is no evidence of stagnation.

<u>Histic</u>

There was one paddock with peat, 13 b, here the peat is associated with the Fen area seen in figure 3, which runs along the northern boundary of the farm. This Drained Mineratrophic Peat, series Banagher has accumulated over the millenia due to constant waterlogging. The horizons have been mixed over the years in an attempt, to make the soil more trafficable. Mineral material is found in all horizons mixed with organic material. The field drains are not removing sufficient water to prevent organic matter build.

Paddock 3 b could have been designated Histic Surface-water Gley, but there is no series in the Irish SIS, so Humic Surface-water Gley is a best fit. It would appear likely that histic material could be found in the toe slope areas of paddocks 5, 6 and 17. This was not recovered in the auger campaign but the original road construction may have removed this organic material in the area.

Figure 10. Paddock 12 b, Typical Luvisol (10.0.0), series Dunboyne.

There was also one Typical Brown Podzolic (UN 29) described in the auger campaign, paddock 22. Here there is an increase in iron and/or aluminium content at depth to be designated a Bs horizon. In this case the iron increase was in a BC horizon (53 cm +) which felt very greasy compared to the Bw horizon above it. This is an indication of increased iron content. However this Bs horizon was found at depth and is unlikely to have a major impact on productivity in the medium term.

Conclusion

The auger survey is indicating a farm of two distinct contrasts in soil type: heavier textured soils suffering from water impediments in the form of Surface-water Gleys and those that are more free draining and conducive to high productivity in the form of Brown Earths and Luvisols. The Surface-water Gleys are found in the lower slopes in the paddocks around the farm yard in the areas with a high incline and throughout the paddocks in the drumlin area in the east. The distribution of the Gley throughout the drumlin would indicate that it is a Till drumlin. Paddocks 18, 19 and 20 all have evidence of a lithological discontinuity at depth. It is likely that a fluvio-glacial event formed these subsoils before the deposition of the current glacial till of topsoil. The structure (or lack of, massive) and the texture of the soil at depth (high silt and/or high clay coupled with low stone content) is impeding most downward water flow and there is evidence of lateral stagnic channels feeding the water laterally down slope.

In the upper and mid slopes surrounding the farm yard, the Brown Earths and Luvisols are found, they are also found in the lower slopes where the incline is shallower. Here the water content is having an effect with Gleyic and Stagnic versions of these Great Soil groups becoming evident. Where the textures are coarse the Gleyic subgroups are found due to the rising water table. The Stagnic subgroups are found where there is an increase in clay and in the case of Brown Earths, the increase in coarse fragments creates its own restrictions on water movement. These soils have good and/or manageable drainage characteristics for grassland production. The high coarse fragments on the farm mean susceptibility to poaching or mechanical compaction is likely when there is stagnation recently.

Generally, the inter drumlin peat and gleys with peat surface horizons have been fenced off and are out of production. Parts that have extended into reclaimed fields have been managed with field drainage, sub soiling and surface drains. Out of 37 augers only one was considered peat and one had a humic layer, this indicates good management of these particular drainage problems over all.

Table 1. Field observations of soil type during the auger campaign on Swans Cross Heavy Soil Farm. Paddocks are listed with Subgroup and Soil series based on the Irish SIS (Creamer et al 2014). The drainage class is described in Schulte et al (2015).

Paddock	SUBGROUP	Series Name	Drainage Class
1a	Stagnic Luvisol	Crosstown	Moderately
1b	Stagnic Luvisol	Crosstown	Moderately
1c	Stagnic Luvisol	Crosstown	Imperfectly
3a	Typical Brown Earth	Clonroche	Moderately
3b	Humic Surface-water Gley	Gortaclareen	Poorly
4b	Typical Surface-water Gley	Lismeelcunnin	Poorly
4a	Typical Surface-water Gley	Lismeelcunnin	Poorly
11a	Gleyic Brown Earth	UN16	Moderately
11b	Gleyic Brown Earth	UN16	Moderately
2	Typical Brown Earth	Ballylanders	Well
6a	Typical Surface-water Gley	Kilrush	Poorly
6b	Typical Surface-water Gley	Kilrush	Poorly
9	Typical Surface-water Gley	Kilrush	Poorly
13a	Stagnic Brown Earth	Moord	Moderately

Paddock	SUBGROUP	Series Name	Drainage Class
13b	Drained Minerotrophic Peat	Banagher	Poorly
12b	Typical Luvisol	Dunboyne	Moderately
12c	Typical Surface-water Gley	Lismeelcunnin	Poorly
10	Stagnic Brown Earth	Duarrigle	Moderately
12a	Typical Surface-water Gley	Lismeelcunnin	Poorly
8	Gleyic Brown Earth	UN16	Moderately
14	Gleyic Brown Earth	UN16	Moderately
16b	Typical Surface-water Gley	Kilrush	Poorly
16c	Anthric Brown Earth	Clashmore antropic	Imperfectly
16a	Typical Brown Earth	Clonroche	Poorly
7	Stagnic Brown Earth	Moord	Moderately
17b	Stagnic Luvisol	Crosstown	Moderately
17a	Stagnic Luvisol	Crosstown	Moderately
22	Typical Brown Podzolic	UN29	Moderately
21a	Stagnic Brown Earth	Duarrigle	Moderately
21b	Stagnic Brown Earth	Moord	Moderately
18c	Typical Surface-water Gley	Kilrush	Poorly
18a	Typical Surface-water Gley	Kilrush	Poorly
18b	Typical Surface-water Gley	Lismeelcunnin	Poorly
19a	Typical Surface-water Gley	Kilrush	Poorly
19b	Typical Surface-water Gley	Kilrush	Poorly
20b	Typical Surface-water Gley	Kilrush	Poorly
20a	Typical Surface-water Gley	Kilrush	Poorly

Representative Soil Profile pits

Using the auger survey as a guide, three pits were selected to represent the dominant soils on the farm and any significant drainage restrictions throughout the farm (Figure 11). Paddock 18, represents the Typical Surface-water Gley formed in siliceous drift, which is poorly drained. Paddock 4, was chosen to represent the shallow Typical Surface-water Gleys formed on shale bedrock, also poorly drained. Paddock 17 was chosen to represent the Stagnic Luvisols formed on Fine Loamy drift, which are moderately drained. The excavation of a soil profile pit coupled with detailed chemical and physical tests will give a clearer picture of the soil formation, productivity, drainage and classification. The results may contrast in some cases but ultimately enhance the auger survey covering the whole farm area.

Figure 11. Location of soil profile pits on the Swans Cross Heavy Soil Farm, Co. Monaghan.

The profile pit excavated in paddock 18 was a Typical Surface-water Gley 07.0.0 series Kilrush. The gleyed Bg horizon commencing at ~35 cm can be seen in Figure 12. This has many mottles and water entering at two points. The horizon is compacted and restricts water movement to preferential pathways where the texture and structure allows. This is followed by the Cg horizon where there is an increase in gravels and the appearance of manganese coats. These coats are indicative of greater periods of anoxic conditions. There is even less potential for water movement as there is less soil matrix and more gravels and stones with no water holding capacity. This is described as being fragic. The CG horizon is intensely gleyed and is described as cemented with no water movement from above or below possible (Table 2).

Figure 12. Paddock 18, 0700 Typical Surface-water Gley, series Kilrush. Fine Loamy drift with siliceous stones.

Table 2. Soil description of paddock 18, Swans Cross Heavy Soil Farm.

Horizon depth (cm)	Horizon designation	Description
35	Apg	Greyish Brown, many mottles, common gravels, Silt Loam, common fine roots, few manganese coats, angular blocky structure. Pottery from ceramic pipe.
75	Bg	Light yellowish brown, many red and yellow mottles, many stones, Loam, massive structure, few fine roots. Sand lens bottom of hz. Water infiltration at two points 50 cm, Sandy Clay Loam patches. Non-cemented but compacted.
120	Cg	Yellowish brown, many mottles, common and abundant gravels. Clay Loam. Very few fine roots, few manganese coats. Massive. Water entry at 3 points 90 cm. Dead roots. Fragic, Non- cemented but compacted.
180	CG	Dark grey. Many mottles, yellow, greenish and bluish hues. Intensely gleyed.

The Apg horizon appeared to be quiet deep possibly due to mixing with the previous B horizon following subsoiling. This subsoiling has created a deeper topsoil for grass production but will require maintenance to prevent stones rising through the horizon once again. A balance will be required between traffic and compaction in subsoiling versus soil structural development. A shale gravel drain was found at 60 cm deep at opposite end of pit, with no water was evident in it, this was unknown to the farmer and likely to have been in place many decades before. This indicates at least that measures were taken to solve the stagnation problem before and the duration of the problem. Bearing this in mind it is possible that an old clay brick or pipe was broken up before with subsoiling which can be seen at 40 cm depth in the walls of the pit (Figure 13). This was hard and non-greasy and did not allude to any Bs or iron deposition. There was some water in the bottom of the pit which arrived through the points described in horizon 2 and 3. The heavy soil textures, lack of soil structure and many stones restrict the water movement greatly in this profile.

Figure 13. Paddock 18, broken clay pipe/brick on side of pit wall, not a Bs horizon.

Paddock 4 was chosen as a shallow soil to represent the drift over bedrock around the farmyard. Using the excavator it was shown that the many and abundant gravels at depth prevented the use of the auger and hence the incorrect bedrock description (Figure 14). The Ap horizon once again had evidence of being ripped recently, with parts of the B horizon found in places (Table 3). There were few amounts of gravel in this layer. The Bwg horizon had some mottles but was not sufficiently gleyed to be designated at Bg horizon. The Clay Loam texture does prevent some water movement and iron mottles are formed. This horizon had some angular blocky structure which allowed water movement below.

The Cg1 and Cg2 horizons both had massive structure and were compacted. The increase in stones and abundant gravels was the main difference between the two. They are both gleyed horizons allowing very little water movement and have low water holding capacity (Figure 15). A clay pipe was found at the opposite end of pit wall. Again it was dry. Some water gathered at bottom of pit. But generally no water entered the pit at specific points indicating no preferential flow pathways. There are water movement restrictions at times in this profile but not severe enough to be designated a Surface-water Gley. This is now a Stagnic Brown Earth under current management.

Figure 14. Paddock 4, 1130 Stagnic Brown Earth, series Moord. Fine Loamy drift with siliceous stones.

Table 3. Soil description of paddock 4, Swans Cross Heavy Soil Farm.

Horizon depth (cm)	Horizon designation	Description
30	Ap	Dark Greyish Brown, common mottles, few gravels, Clay Loam, common fine roots, angular blocky structure. Ripped recently, mixing of A and B horizons evident.
58	Bwg	Greyish brown, common red mottles, common gravels, Clay Loam, sub angular blocky structure, few fine roots. Patches of clay and silt along with weathered stones.
95	Cg1	Light yellowish brown, many brown and grey mottles, common and many gravels. Loam. Very few fine roots. Massive. Fragic. Non cemented but compacted.
160	Cg2	Greyish brown. Abundant stones and gravels, no roots. Clay Loam. Massive.

Paddock 17 was chosen to represent the Luvisol soils found on the farm from the auger survey. Following the excavation of the pit this soil is now described as a Typical Surface-water Gley (Figure 16). The main reason for the change is the gleyed horizon commencing within 40 cm of the surface and the clay increase of this horizon occurred deeper than 30 cm. This does not qualify as a Luvisol and is not designated at a Bt horizon (Table 4). The surface horizon has been ripped but there is also

Figure 15. Paddock 4. Gleyic zone starting from ~55 cm depth.

evidence of surface compaction in the upper half of the Ap horizon. There are manganese coats found at the bottom of this compaction. Below this there is good soil structure with subangular blocky designation (Table 4).

The clay content increases by 5 % in the BCg horizon and the texture is now Clay Loam compared to the Loam of the Ap horizon. The stone content has increased. The roots are now described as fine and few and there is a clay intrusion on the left hand side of the pit wall. This may indicate that the material below this point was deposited in a different event. The CG is firm and fragic with no roots and evidence of dead roots which again may indicate a different top soil at some point. It is intensely gleyed with few stagnic channels the only means for water movement at this depth. The texture again is Clay Loam and the intense gleying is evident throughout the profile (Figure 17). This soil is now poorly drained and management is crucial to maintaining a good sward without exacerbating the mechanical compaction at the surface.

Figure 16. Paddock 17, 0700 Typical Surface-water Gley, series Kilrush. Fine Loamy drift with siliceous stones.

Table 4. Soil description of paddock 17, Swans Cross Heavy Soil Farm.

Horizon depth (cm)	Horizon designation	Description
32	Ap	Greyish Brown, common mottles, few gravels, Loam, many fine roots, sub angular blocky structure. Few manganese coats. Mechanical compaction top 15 cm.
70	BCg	Yellowish Brown, abundant brown and grey mottles, many stones. Clay Loam, CEY in places, massive, very few fine roots. Firm, Clay intrusion on LHS of wall 45 cm.
145	CG	Dark grey. Many and abundant mottles, yellow, greenish and bluish hues. Many and abundant stones and weathered stones. Clay loam, firm, no roots, massive. Dead coarse roots, Intensely gleyed, fragic. Stagnic channels and wet films around stones indicating preferential flow pathways.

Figure 17. Detail of massive structure of the BCg horizon from 40 to 70 cm. Difficult to penetrate with trowel coupled with many stones.

Conclusion

The majority of the soils on this farm suffer from some form of water movement restriction. Over half the soil augers are described as poorly drained indicating drainage problems most of the time. This is the Surface-water Gleys and peat. The majority of the remainder have moderate drainage where there are restrictions at some point throughout the year. This includes the Brown Earth and Luvisol great soil groups. There are only two areas considered well drained.

The old reconnaissance survey indicated that there would be soils of medium texture: sandy loam; loam and sandy clay loam however, from the laboratory results (appendix, table 5) most soils are heavier, either Clay Loam, Silt Loam and even Clay in places. The recent liming of the farm has reaped dividends, with the pH being 6 or higher at the surface and increasing to over 7 with depth in all cases. The bulk density has been improved in the surface horizons in all cases being close to 1 g cm^{-3} and then increasing to 1.5 g cm^{-3} in the subsoil horizons. However, the use of subsoiling would need to be restricted for the sake of soil structure formation and problems with mechanical compaction in relation to the soil textures present.

Phosphorus levels were moderate in the Typical Surface-water Gleys but where high in the Stagnic Brown Earth. Potassium levels were moderate again for the Gleys but nearly tenfold higher in the Brown Earth. This increase in the Brown Earths levels could have been due to a recent fertilisation, following a removal of silage crop. With greater nutrient availability in the Brown Earths the productivity is greater in these upper slopes around the farm yard.

More Surface-water Gleys were found on the farm than the Irish SIS predicted, this could be due to microclimates between the drumlins and the increased precision of the amount of auger points taken in this farm area. As mentioned earlier, this is likely to be a Till drumlin in the farm footprint.

Due to the high levels of rainfall and the inclines on this farm, compaction from machinery and livestock poaching is very likely, particularly where there is a surface horizon with few stones above layers with many stones. Also, continuous maintenance of the drainage measures is advised in the areas close to the peat soil as it could encroach easily within farm paddock boundaries. The farmers approach here allows trafficability and productivity but the peat remains within the soil matrix. Long term measures may need to be put in place to allow for the breakdown of the peat. The current measures appear sufficient to prevent humic material build as was noted in the lack of this characteristic throughout the farm. The dominant soils are described on the farm in the map of Figure 18.

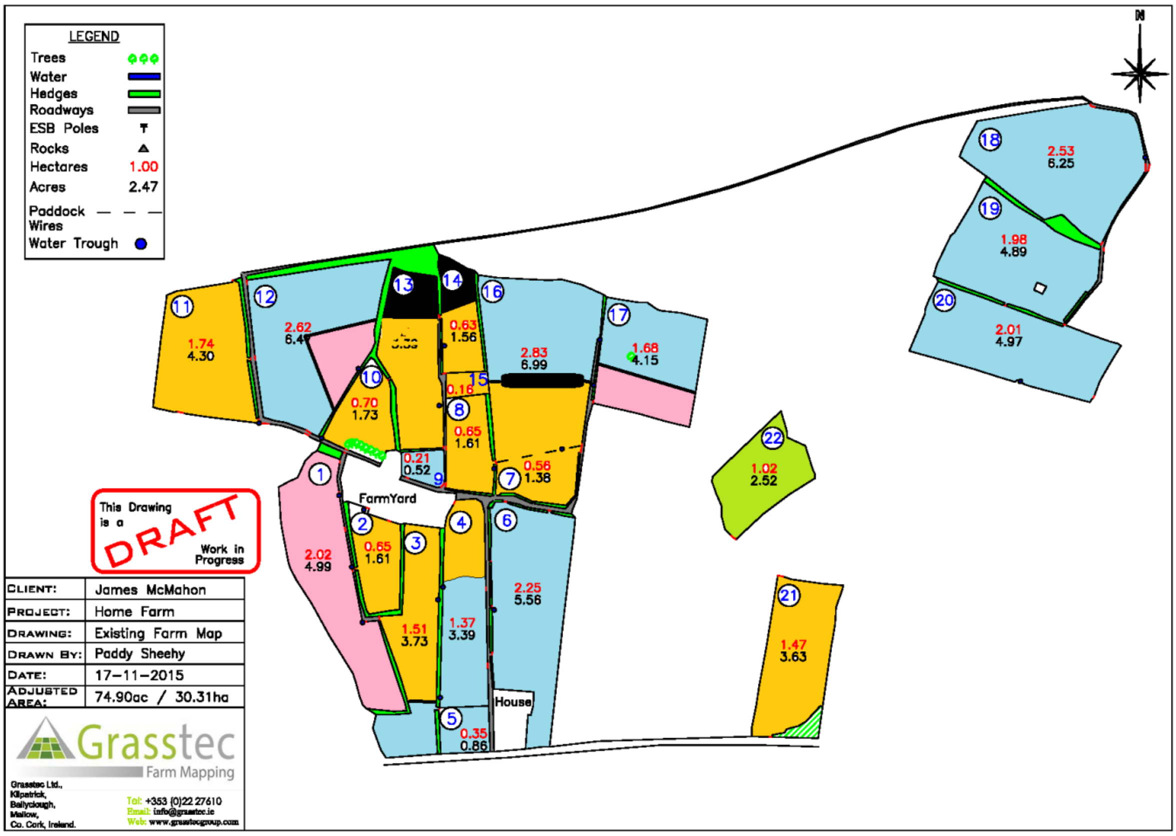

Figure 18. Soil map of the dominant Great Group found within paddocks and parts of paddocks on the Swans Cross Heavy Soil Farm, Co. Monaghan. Resolution 1:5000 approx.

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Appendix.

Table 5. Laboratory data for samples taken from soil pits at Swans Cross Heavy Soil Farm.

Paddock	Sample	Clay (%)	Silt (%)	Sand (%)	Dry Density (g/cm^3)	Bulk Density (g/cm^3)	Gravimetric Moisture Content (%)	Total Exchange Capacity (meq/100 g)	pH	Organic Matter (%)	Estimated Nitrogen Release (#'s N/acre)
18	HZ1	27	35	38	0.96	1.46	51.23%	10.22	6	7.47	112
18	HZ2	25	35	40	1.51	1.89	21.20%	6.67	6.6	1.69	54
18	HZ3	28	30	42	1.61	1.99	19.45%	9.45	7.2	1.28	46
17	HZ1	26	34	40	0.99	1.51	55.09%	8.69	6.1	7.64	113
17	HZ2	31	33	36	1.55	1.97	24.99%	10.07	6	1.69	54
17	HZ3	29	32	39	1.55	1.92	18.66%	12.42	7	1.28	46
4	HZ1	27	31	42	1.10	1.55	39.29%	11.13	6.1	6.37	107
4	HZ2	27	32	41	1.20	1.66	36.93%	7.53	6.5	4.15	92
4	HZ3	26	32	42	1.45	1.79	18.39%	9.32	7.2	1.39	48

Table 5 continued…

Paddock	Sample	S* (ppm)	P* (mg/kg)	Bray II P (mg/kg)	Ca* (mg/kg)	Mg* (mg/kg)	K* (mg/kg)	Na* (mg/kg)	Ca** (%)	Mg** (%)	K** (%)	Na** (%)
18	HZ1	19	37	26	1375	111	66	38	67.27	9.05	1.66	1.62
18	HZ2	10	4	3	971	100	39	37	72.79	12.49	1.5	2.41
18	HZ3	6	2	2	1484	164	48	34	78.52	14.46	1.3	1.56
17	HZ1	16	37	24	1172	106	65	36	67.43	10.16	1.92	1.8
17	HZ2	7	2	< 1	1157	237	46	32	57.45	19.61	1.17	1.38
17	HZ3	6	2	10	1765	329	57	37	71.05	22.07	1.18	1.3
4	HZ1	21	52	51	1157	223	458	53	51.98	16.7	10.55	2.07
4	HZ2	13	22	14	979	138	140	44	65.01	15.27	4.77	2.54
4	HZ3	8	1	1	1576	90	47	40	84.55	8.05	1.29	1.87

Table 5 continued…

Paddock	Sample	Other Bases** (%)	H** (%)	B* (mg/kg)	Fe* (mg/kg)	Mn* (mg/kg)	Cu* (mg/kg)	Zn* (mg/kg)	Al* (mg/kg)	% Fe	% Al
18	HZ1	5.4	15	0.42	267	21	7.26	1.42	1109	0.0267	0.1109
18	HZ2	4.8	6	< 0.20	182	8	1.04	0.4	1175	0.0182	0.1175
18	HZ3	4.2	0	< 0.20	88	30	0.95	< 0.4	694	0.0088	0.0694
17	HZ1	5.2	13.5	0.35	297	21	3.29	1.27	838	0.0297	0.0838
17	HZ2	5.4	15	< 0.20	139	9	1.32	< 0.4	946	0.0139	0.0946
17	HZ3	4.4	0	< 0.20	120	29	2.14	0.92	720	0.012	0.072
4	HZ1	5.2	13.5	0.62	292	41	8.84	1.99	884	0.0292	0.0884
4	HZ2	4.9	7.5	0.36	194	33	3.99	0.68	827	0.0194	0.0827
4	HZ3	4.2	0	< 0.20	87	27	0.82	< 0.4	737	0.0087	0.0737