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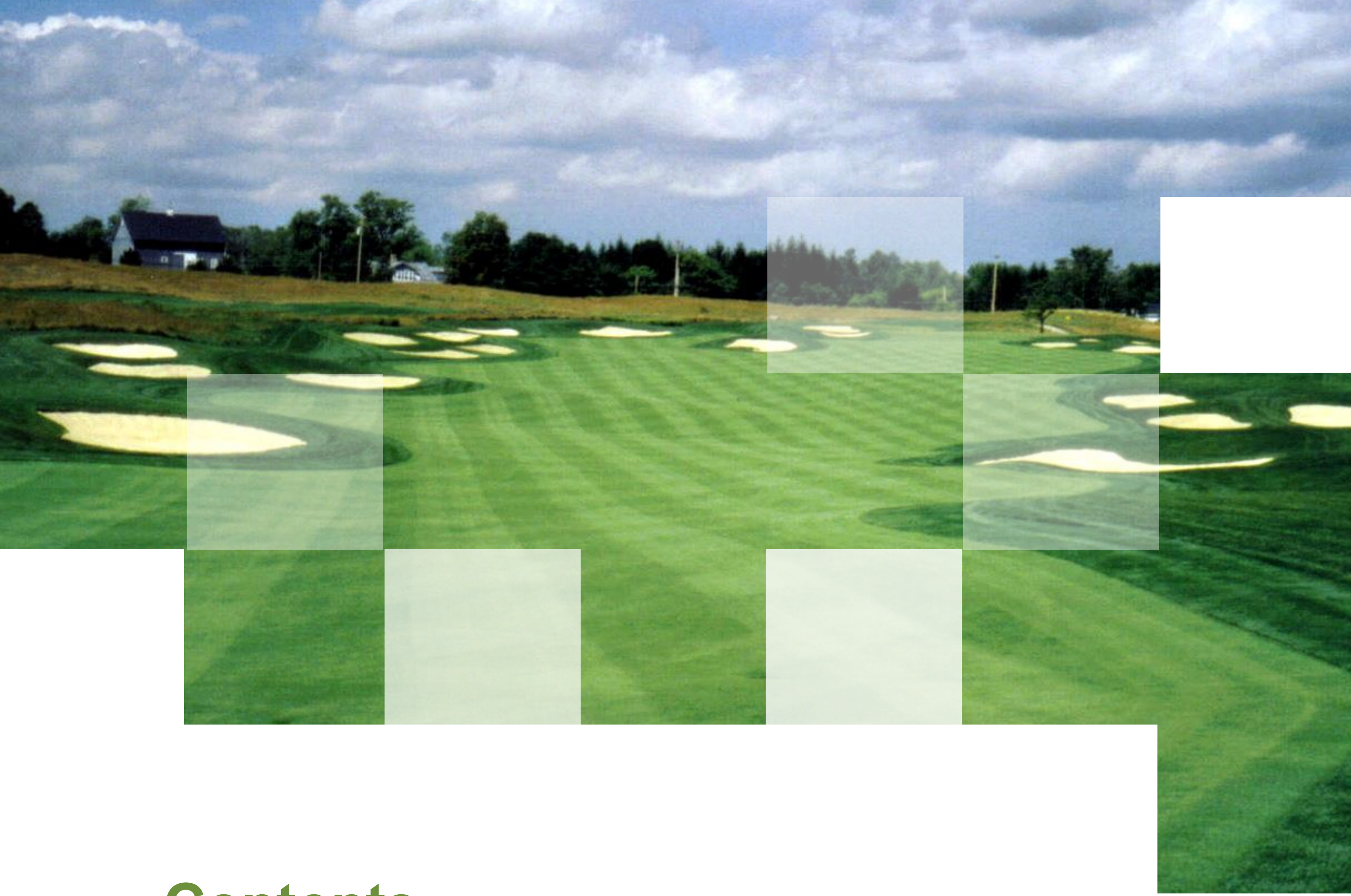
Muriwai Golf Project:

Effect on soils

Report Date: 20 August 2021

LABOSPORT



Contents

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1. Executive summary

Based on available soil map and land use capability (LUC) information, on-site investigation of the soils and Auckland Unitary Plan (AUP) Soil Definitions, there are no areas within the site that could be classified as "Land containing Elite Soils". There are however, several areas within the site that could be classed as ‘Land containing Prime Soils’. These areas carry the LUC classification of 2e2. Investigation of these soils on the site revealed that the soils identified in maps as ‘Prime Soils’ conform with that classification but with rooting depth potential and drainage performance both towards the lower end of the expected range for these characteristics, for ‘Prime Soils’.

There will be some adverse effects on soil health from the construction of the golf course, but these will be minor and temporary in nature – a fundamental aim of golf course turf management practices is to alleviate these adverse effects as quickly as possible because that will benefit golf course turf quality into the future. Strict golf course construction protocols and procedures will be put in place with the aim of minimising any adverse effects on soil health due to construction.

Much of the golf course, including both ‘Prime’ and non-prime soils, will have improved soil quality as a result of the development. For example, drainage and soil structure will be improved as a consequence of golf course construction and then on-going golf course maintenance practices.

It is likely that construction of the golf course will increase the total area of soil on the site that can be classified as ‘Prime Soil’ by an estimated 16ha, primarily through improved (less steep) land contours that will be formed. Further to that, as a consequence of improved land contours, better drainage, better access pathways plus the availability of water for irrigation that will all occur as integral parts of the golf course development, the development will broaden the range of rural activities that could be carried out successfully on the site in future.

Construction of the golf course greens and tees will involve removing the existing site soil from these areas and replacing it with sand. None of the soil removed from such areas (and also including areas such as buildings, paths, etc) will be removed from the site as part of the golf course construction process. Any such excavated soil from the golf course construction process will be retained and used in other areas on site. This will improve soil quality in those areas by increasing topsoil depth and hence potential root depth.

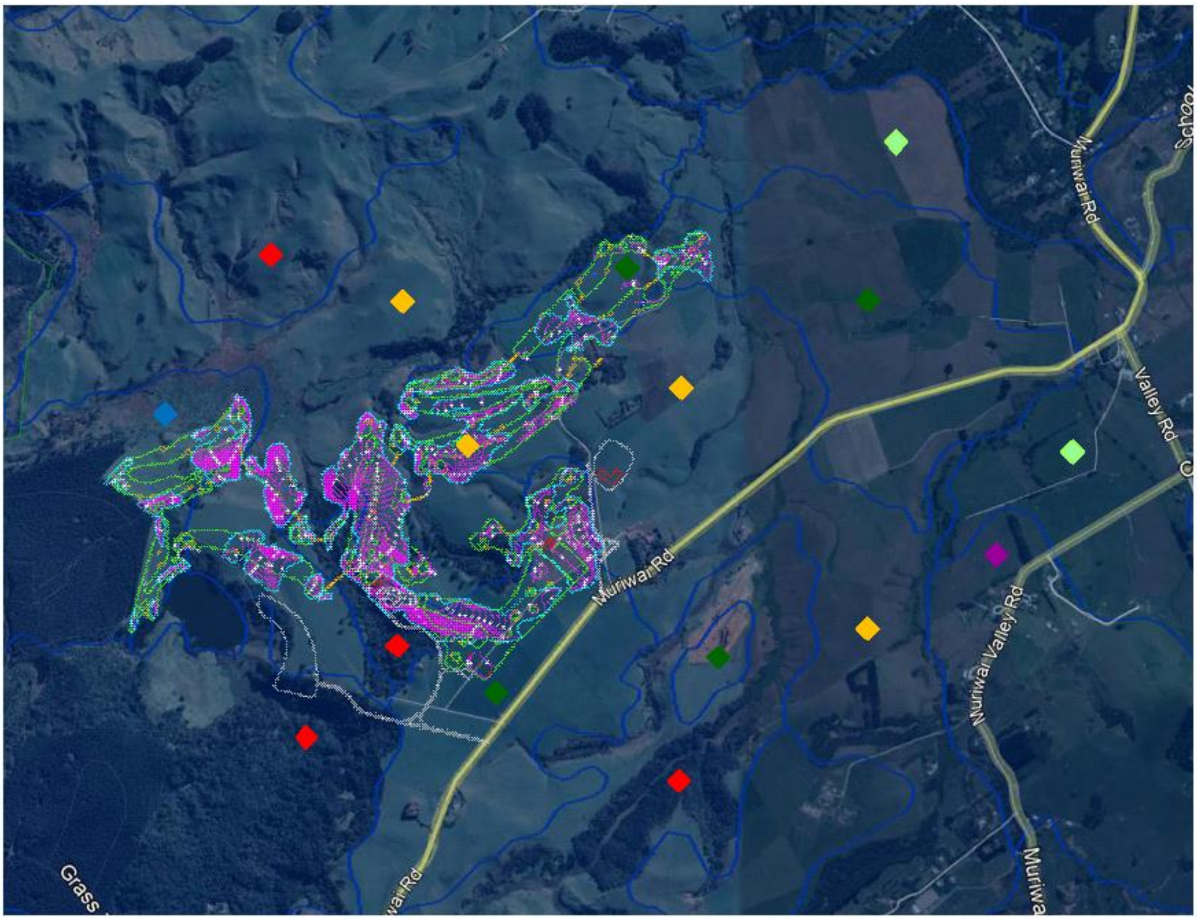
Other than in locations where permanent built structures are proposed (including the water reservoir), the proposal does not limit the ability of the site to be used for agriculture, horticulture, or other activities dependent on the quality and productivity of the soil present, in the future.

2. Description of soil types on the property

According to New Zealand Soil Classification and LRIS Portal from Manaaki Whenua - Landcare Research's Soils Portal there are three soil types on the property:

- Orthic Granular Soil (areas indicated by red, dark green, light green and yellow diamonds in Figure 1 below),
- Sandy Recent Soil (area indicated by blue diamond in Figure 1 below) and.
- Impeded Allophanic Soil (area indicated by purple diamond in Figure 1 below).

Orthic Granular Soil makes up the bulk of the soil on the property with smaller areas of Sandy Recent Soil and Impeded Allophanic Soil. Within these three soil types there are 5 Land Use Capabilities (LUC) units as indicated in Figure 1. The extent and locations of each LUC unit is also illustrated in Figure 1. Within the site of the golf course there are two soils; Orthic Granular Soil and Sandy Recent Soil and the features / properties of the two soil types are summarised below.



—	Blue line indicates approximate outline of the LUC units
◆ (blue)	Typic Sandy Recent Soil (RST), Pinaki Soil Series, LUC 6e15
◆ (yellow)	Acidic Orthic Granular Soil (NOA), Red Hill Soil Series, LUC 4e9

◆	Typic Orthic Granualr Soil (NOT), 4e3
◆	Acidic Orthic Granular Soil (NOA), Red Hill Soil, LUC 6e6
◆	Acidic Orthic Granular Soil (NOA), Red Hill Soil, LUC 2e2
◆	Typic Impeded Allophanic Soil (LIT), Waitematā Series, 2e2

Figure 1: Map of the property showing the proposed site layout in relation to the four LUC soil types present

2.1 Orthic Granular Soils

Orthic Granular Soils are normal granular soils. Granular soils are clayey soils formed from material derived by strong weathering of volcanic rocks or ash. Dry or moist soil samples may be easily parted into small hard fragments. Parent materials are usually strongly weathered tephras, mostly older than 50,000 years.

2.1.1 Physical and chemical properties of Orthic Granular Soils

Soil structure is usually well developed polyhedral (granular) structure. These soils tend to be slowly permeable, with limited rooting depth. Topsoils have limited workability when wet. These soils are strongly weathered with naturally low nutrient reserves and low phosphorus and sulphate status in the subsoil layers (B horizons).

2.2 Sandy Recent Soils

Sandy Recent Soils are comprised of sand or loamy sand soils. They are weakly developed, showing limited signs of soil-forming processes. A distinct topsoil is present, but a B horizon is either absent or only weakly expressed. They occur throughout New Zealand on young land surfaces, including alluvial floodplains, unstable steep slopes, coastal sand dunes and slopes mantled by young volcanic ash. Their age varies depending on the environment and soil materials, but most are less than 1000 to 2000 years old.

On this site, these soils were formed from sand blown inland from the coast.

2.2.1 Physical and chemical properties Sandy Recent Soils

These soils have variable soil texture, often with layers of contrasting materials and spatial variability is high. They generally exhibit deep rooting and have high plant-available water capacity (plants can extract a large proportion of the water that is present). Natural fertility in the topsoil layer is usually high with high base saturation.

3. Land Use Capability

In order to determine the Land Use Capability (LUC) of the soils on the property and the site, a desktop exercise was undertaken of the LUC rating of the site using the New Zealand Land Resource

Inventory (NZLRI) and Fundamental Soils Layer (FSL) North Island (all attributes) of the LRIS Portal and 'Land Use Capability Classification of the Northland Region' (Harmsworth, 1996). The following tables summarise the information commonly found for each LUC found on the site from the desktop exercise. A description of the LUC system and the individual classes can be found in 'Land Use Capability Survey Handbook- A New Zealand handbook for the classification of land' (Lynn, *et. al*, 2009).

Some care is needed when reviewing the LUC information as it is based on allocating properties to similar landforms based on historic data from a small number of site assessments. None of the LUC assessments summarised in Tables 1 to 4 below are based on information collected from the site. For example, according to 'Land Use Capability Classification of the Northland Region' (Harmsworth, 1996), LUC2e2 description is based on assessment of a similar landform at Tawa Road, Kumeu.

Table 1: Key attributes of LUC 2e2 soils

LUC 2e2 (◆in Figure 1)	**Attributes**
Description	Land with slight limitations for arable use and suitable for cultivated crops, pasture, or forestry
Texture	Sandy clay loam
Slope	Undulating, 2-7° slopes
Erosion form and degree	Negligible erosion, potential for slight (1-10% land affected) sheet and rill erosion when cultivated
Rock type	Unconsolidated to moderately consolidated clays, silts, sands, tephra, and sedimentary rock (braccia)
Productivity indices	High productivity
Potential rooting depth	Very deep; up to 1.5m
Drainage and permeability	Well drained, moderate permeability
Profile readily available water (in top 0.9m)	Moderate; 25-99mm
Soil conservation management	When cultivating, contour cultivation and minimum tillage practices are recommended. Seasonal irrigation may be required to maintain plant growth.

Table 2: Key attributes of LUC 4e9 soils

LUC 4e9 (◆in Figure 1)	**Attributes**
Description	Land with moderate limitations for arable use, but suitable for occasional cropping, pasture, or forestry.
Texture	Sandy clay loam
Slope	Rolling to strongly rolling, 8-20° slopes
Erosion form and degree	Slight sheet erosion, 1-10% of area affected, potential for slight to moderate (11-20% of land affected) soil slip, sheet, gully, and wind erosion on steeper slopes and/or where cover has been lost
Rock type	Unconsolidated to moderately consolidated clays, silts, sands, tephra, and sedimentary rock (braccia)
Productivity indices	Medium to high productivity
Potential rooting depth	Very deep; up to 1.5m
Drainage and permeability	Well drained, moderate permeability
Profile readily available water (in top 0.9m)	Moderate; 25-99mm

Soil conservation management	When cultivating, contour cultivation and minimum tillage practices are recommended. Cultivated areas should not be left exposed and unprotected for long periods (exposed to wind erosion). Important to maintain vegetative cover to limit erosion potential. Seasonal irrigation important to maintain plant growth. Soils subject to seasonal soil moisture deficits.

Table 3: Key attributes of LUC 6e6 soils

LUC 6e6 (◆ in Figure 1)	**Attributes**
Description	Non-arable land with moderate limitations for use under perennial vegetation such as pasture or forest
Topsoil texture	Sandy clay loam
Slope	Moderately steep to strongly rolling, 16-25° slopes
Erosion form and degree	Negligible erosion, potential for moderate soil slip, sheet, gully, and wind erosion on steeper slopes and/or where cover has been lost
Rock type	Unconsolidated to moderately consolidated clays, silts, sands, tephra, and sedimentary rock
Productivity indices	Medium productivity
Potential rooting depth	Very deep; up to 1.5m
Drainage and permeability	Well drained, moderate permeability
Profile readily available water (in top 0.9m)	Moderate; 25-99mm
Soil conservation management	To minimise soil erosion, carefully plan all earthworks and excavations of drains and paths (roadways). Maintain good ground cover particularly on steeper slopes to minimise sheet and wind erosion. Control wear to prevent repeated tracking which can lead to loss of ground cover. Bare-ground areas can be difficult to re-vegetate and are more prone to erosion. Control runoff away from steep slopes and potentially unstable areas. Gully erosion can occur in drainage depressions.

Table 4: Key attributes of LUC 6e15 soils

LUC 6e15 (◆ in Figure 1)	**Attributes**
Description	Non-arable land with moderate limitations for use under perennial vegetation such as pasture or forest
Topsoil texture	Sand
Slope	Rolling to strongly rolling, 8-20° slopes
Erosion form and degree	Negligible erosion; potential for moderate to severe wind, sheet and gully erosion and moderate soil slip erosion on steeper slopes.
Rock type	Windblown sand
Productivity indices	Medium to high productivity
Potential rooting depth	Very deep; up to 1.5m
Drainage and permeability	Well drained, rapid permeability
Profile readily available water (in top 0.9m)	Low; 60-89mm
Soil conservation management	Permanent vegetation cover is advisable to reduce the risk of wind and other types of erosion. Grass growth and quality can be limited by long periods of soil moisture deficit

4. Site specific attributes

To better understand the specific attributes of soils potentially affected by the site and to confirm whether the information from the desktop exercise was accurate, a range of samples were taken and analysed to determine:

- potential rooting depths
- topsoil depths
- soil drainage rates and
- hand and laboratory textures (quantities of sand, silt and clay),

Sample locations were focussed within key areas of the proposed site as illustrated in Figure 2. Soil analysis results are presented in the sections further below.

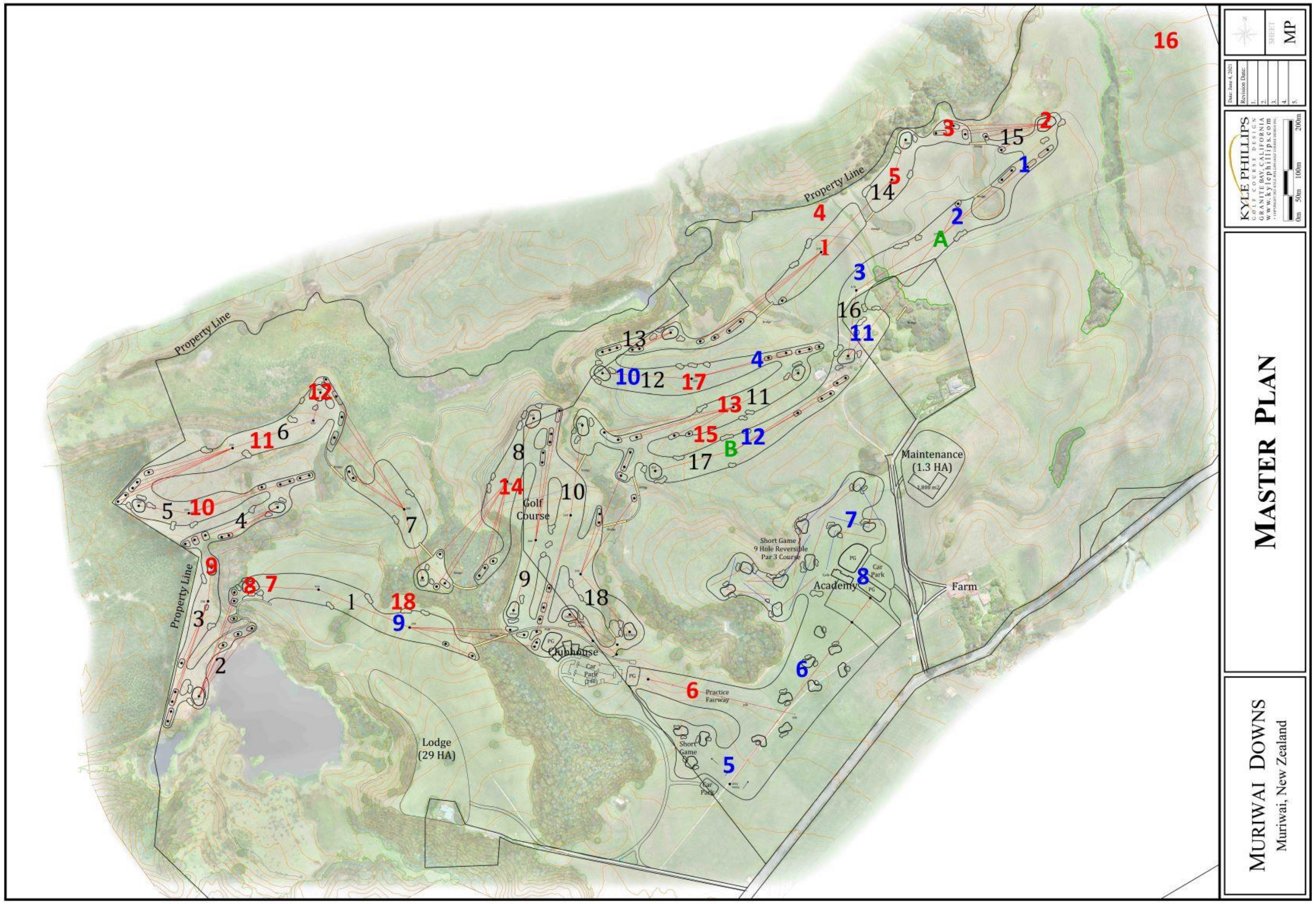


Figure 2. Approximate locations of soil sampling sites (red numbers) collected for hand and laboratory textures (Table 5 below), topsoil and subsoil depth sample sites (blue numbers) and locations of drainage potential test sites (green letters).

4.1 Topsoil and potential rooting depths

Topsoil and subsoil depths on the site were assessed at 12 locations primarily from areas with a LUC classification 2e2 to determine at what depth the potential root growth may be limited by soil conditions such as high bulk densities and poor aeration. Photographs of each sample are presented in Figure 3.

These assessments were done by extracting soil samples down to depths as great as 1.0m using either a core or auger sampler. Extracting soil samples in this way enables the soil type to be visually observed and assessed by feel. This greatly increases our understanding of the characteristics and variation of the soils on site beyond that provided by the LUC soil maps.

Figure 3: Examples of topsoil and subsoil depths (left to right and top to bottom) from sampling locations L1-L12 (refer blue numbers in Figure 2).

Potential rooting depth is the depth (in metres) to a layer that may impede root extension. Such a layer may be due to compaction causing penetration resistance, poor aeration, or very low available water capacity. Topsoil depth of a soil generally makes up the majority of the potential root depth with the balance made up by the more friable upper subsoil layers. Therefore, topsoil and subsoil layers across the site were assessed at 12 locations primarily from areas with a LUC classification 2e2 to determine at what depth the potential root growth may be limited by soil conditions such as penetration resistance and poor aeration. Potential rooting depth and topsoil depths are shown in Table 5. Photographs of each sample are presented in Figure 3.

Table 5: Topsoil and potential rooting depths for 12 sampling locations

Location	Topsoil depth (m)	Potential rooting depth (m)
1	0.2	0.34
2	0.21	0.32
3	0.15	0.24
4	0.24	0.38
5	0.22	0.4
6	0.36	0.84
7	0.24	0.28
8	0.26	0.33
9	0.22	0.29
10	0.22	0.31
11	0.18	0.29
12	0.18	0.29

Potential rooting depths were generally in the range of 0.29m-0.4m. One location (location 6) had the deepest potential rooting depth of 0.84m. By contrast, location 3 only had a potential rooting depth of 0.24m. The potential rooting depths are considerably lower than those from the desktop exercise described earlier.

Topsoil depths were variable across the locations but were generally in the range of 0.2-0.3m deep. One location (location 6) had a topsoil of depth of around 0.36m. By contrast, location 3 only had a topsoil depth of 0.15m. Topsoils generally consisted of friable sandy or silt loams.

The subsoils were typically clay loams, sandy clays or clays but these were also generally friable and free of noticeable impediments to root growth down to 0.3-0.4m deep. Below 0.4m the subsoils were heavier, less-friable, poorly aerated clay soils which are likely to limit root growth below that depth. However, in one location (L6) the subsoil was found to be friable down to 0.84m deep (note in L6 photo above, how the sub-soil to greater depths has crumbled showing that it is more friable than the sub-soils in the other locations where it has remained as a solid block).

4.2 Soil drainage rates

The saturated hydraulic conductivity was measured in the intact subsoil in two locations by excavating down to a depth of 250mm and then inserting infiltration rings, ponding water inside the rings and measuring the rate of water movement down into the soil. The aim of this is to measure the drainage rate in the intact sub-soils in an effort to gauge drainage of the site soils. But in practice this is difficult to do reliably, and drainage performance is usually best assessed through observation of drainage performance during extended periods of wet weather.

The high clay contents of the subsoils found on the site raised concerns about the drainage rates within this layer of the soil profile. Therefore, the drainage assessments (saturated hydraulic conductivity) were conducted at approximately the 260m mark of the 16th fairway and the 270m mark of the 17th fairway (refer green letters in Figure 2).

Testing recorded average drainage rates of 93mm/hr and 219mm/hr respectively, indicating there are currently no major impediments to drainage in the subsoils of these areas of the site. However, some caution is required when considering on-site drainage assessments. On-site spatial variability in the depths of soil layers, soil textures and structures that occur naturally within soils can strongly influence the results. In addition, these assessments have probably overestimated drainage rates that would occur when the soils were at or beyond field capacity (approaching saturation). This is because when a soil's moisture content is between field capacity and saturation it has a much lower capacity to absorb and conduct water from rainfall or irrigation, so drainage rates are expected to be considerably lower under those circumstances. These assessments were conducted after an extended period of dry weather, when the soil was still below field capacity, thus requiring considerable wetting up to provide a truer indication of the likely saturated hydraulic conductivity under normal winter conditions.

Examination of surface conditions and the soil cores collected from the L1 - L12 (refer blue numbers in Figure 2) indicate that, during extended periods of wet weather and low evapotranspiration (the combined processes of transpiration from the plant and evaporation of free water from leaf and soil surfaces) that occurs during winter, the high clay contents of these subsoils, once wet, will limit drainage.

For example, location 3 had 0.15m of topsoil before changing to a very dense subsoil that could not be sampled easily with a soil sampler. This area had suffered from pugging during break feeding of cattle (Figure 4) indicating soil wetness and that the subsoil was limiting drainage at this location. At location 5, grasses were showing signs of nutrient stress. This is commonly seen in grass plants growing in poorly aerated soil during the winter months (Figure 5). While there was around 0.4m of friable top and upper subsoil, the yellowness of the grass suggests that soil at this location was suffering from extended periods of wetness.

4.2.1 Summary: Soil drainage rates

Drainage assessments and examination of soil conditions of the sandy clay loam soils that occur across a majority of the site shows that when the soil is relatively dry (below field capacity) there are no major impediments to water movement within the soil. It also has considerable capacity to absorb water from rainfall or irrigation. However, when these soils are at field capacity or wetter (approaching saturation) their ability to conduct water down through the profile is considerably reduced meaning that these soils exhibit drainage limitations during the wettest part of the year (i.e. those months of the year when rainfall significantly exceeds "drying" from evapotranspiration – typically the months of June, July, August and September).

Figure 4: Pugging damage from break feeding cattle at location 3.

Figure 5: Yellow grass plants indicating nutrient stress from growing in poorly aerated soils due to poor drainage.

4.3 Site specific soil textures

In soil science, soil texture is determined by the % of sand, silt and clay particles present in the soil. Sand, silt and clay particles are simply defined by their size. Sand particles (grains) are 0.05 to 2.0mm in diameter, silt particles are 0.002 to 0.05mm in diameter and clay particles are less than 0.002mm in diameter. It is an important characteristic because it determines many of the soil's physical and other characteristics. Soils are classified based on texture – for example, sandy loams, clay loams, sands, silts, clays, sandy clays, etc are all distinct soil types that are defined by the amounts of sand, silt and clay particles present. The soil texture is important in this context because it is a key determinant of a soil's LUC.

Samples of topsoil and subsoil were collected from within the proposed golf course layout for texture analysis (refer red numbers in Figure 2). Texture analysis was done either by feel to determine the soil's textural classification or by laboratory analysis to determine the % content of sand, silt and clay particles (which definitively identifies the soil's texture).

The texture of the topsoil or subsoil from various locations was determined by texture by feel analysis (Thein, 1979). Samples of topsoil from 3 locations and sub soil from 4 locations were also sent to Manaaki Whenua - Landcare Research soils laboratory for full laboratory texture analysis. This information is summarised in Table 6.

Table 6: Texture by feel and laboratory texture from a range of location of the proposed golf course.

Site	Golf course location	Texture by feel		Laboratory texture (numbers are % of sand:silt:clay)	
		Topsoil	Subsoil	Topsoil	Subsoil
1	14th Fairway	Silt loam	Clay		Silty clay (23:28:49)
2	15th Green	Sandy loam	Sandy clay		
3	15th Tee	Silt loam			
4	14th Rough	Sandy loam	Sandy clay		Sandy clay (38:21:41)
5	14th Fairway	Sandy loam	Sandy loam	Silt loam (48:29:23)	
6	Practice Area	Sandy loam	Clay loam		
7	1st Approach	Sandy loam	Sandy clay		
8	1st Green	Sand			
9	3rd Green	Sand			
10	5th fairway	Sand			
11	6th Fairway	Sand			
12	6th Green	Sandy loam			
13	11th fairway	Sandy loam	Clay loam		Clay (29:19:52)
14	8th Fairway		Clay loam		
15	17th Rough	Sandy loam	Clay		
16	Possible lake	Silt loam	Clay		Clay (16:19:65)
17	12th Fairway	Sandy loam		Sandy loam (58:22:20)	
18	1st Rough	Silt loam		Silt loam (40:35:25)	

4.3.1 Summary: Site specific soil textures

The proposed golf course (that is, formed golf course areas as opposed to areas such as bush areas within the area encompassed by the golf course to be left in their current or naturalized state) sits on either LUC2e2, LUC4e9 or LUC6e15 soils (from soil maps). According to these classifications, each of these soils has the following soil texture classification:

LUC2e2: Sandy clay loam

LUC4e9 Sandy clay loam

LUC6e15 Sand

Determination of the soil texture of soil samples from the site showed that the predicted soil classification of the soil LUC6e15 as a sand is accurate (the on-site samples confirmed this).

Determination of the soil texture of soil samples from the site showed that the predicted soil classification of the soils LUC2e2 and LUC4e9 as sandy clay loams is too narrow a classification for the site. On site determination of soil texture in the LUC2e2 and LUC4e9 areas identified various soil types including clay loams, sandy loams, silt loams, clays, silty clays and sandy clays. Some of these soil types found on site would be typically regarded as inferior to sandy clay loams, some would be regarded as of similar quality and some would be regarded as superior.

4.4 Auckland Unitary Plan Soil Definitions

Prime and Elite soils definitions within the AUP make reference to the New Zealand Land Resource Inventory and are respectively defined as follows.

Land containing elite soil:

Land classified as Land Use Capability Class 1 (LUC1). This land is the most highly versatile and productive land in Auckland. It is:

- well-drained, friable, and has well-structured soils;
- flat or gently undulating; and
- capable of continuous cultivation.

Includes:

- LUC1 land as mapped by the New Zealand Land Resource Inventory (NZLRI);
- other lands identified as LUC1 by more detailed site mapping;
- land with other unique location or climatic features, such as the frost-free slopes of Bombay Hill;
- Bombay clay loam;
- Patumahoe clay loam;
- Patumahoe sandy clay loam; and
- Whatitiri soils.

Land containing Prime Soil:

Land identified as land use capability classes two and three (LUC2, LUC3) with slight to moderate physical limitations for arable use. Factors contributing to this classification are:

- readily available water;
- favourable climate;
- favourable topography;
- good drainage; and
- versatile soils easily adapted to a wide range of agricultural uses.

4.5 Soil types on site: Summary

Based on the above LUC information, site-specific soil textures determined for soils found at the site, and AUP Soil Definitions, there are:

- no areas within the site that could be classified as "Land containing Elite Soils" because no LUC Class 1 soils were found.
- several areas within the site that could be classed as 'Land containing Prime Soils'. These areas carry LUC classification of 2e2 which only have a slight risk of erosion and are indicated by the blue lines surrounding the dark and light green diamonds in Figure 1.

Areas of the site that could be classed as 'Land containing Prime Soils' include:

- the 14th hole
- the 15th hole
- the eastern part of the 16th hole;
- parts of the practice area and short course;
- the golf academy and associated car park; and
- the water reservoir and a portion of its associated construction fill area.

In total, these areas comprise 28.9% of the site (excluding the reservoir) and represent 18.6% of the 'Land containing Prime Soils' on the entire property (including the reservoir).

The majority of other prime soil' within the property will remain available for rural productive uses (81.4%).

The majority of the site (71.1%) will be located on soils not carrying LUC classifications that meet the AUP definitions of 'Elite or Prime Soil'. However, construction of the golf course will result in recontouring of considerable areas of soils classified as LUC 4e9.. Provided there is no reduction in the potential rooting depth or topsoil depths in these areas, some of the LUC 4e9 areas of the site could potentially end up being able to be reclassified as LUC 2e2. The extent of the area involved will be difficult to quantify until the course construction has been completed. From the desktop exercise, main difference between soils with LUC2e2 and 4e9 is the steeper slope of the LUC 4e9 areas.

The potential root depths found on site were generally between 0.29-0.4m, far below 1.2m – 1.5m reported in the LUC information from the desktop exercise.

The topsoil and subsoil layers are generally reasonably well drained, although examination of the soil at multiple locations during winter indicates that drainage slows considerably when the soil profile is wet. This is not uncommon for soil with subsoils that are dominated by clay (clay loams, etc). The Prime Soil definition includes "good drainage" and observation of the site in winter confirms that most of the LUC2e2 soil areas on the site exhibit what would be considered to be good drainage. However, that is not universally the case and there are areas within the LUC2e2 soil areas that exhibit poor drainage.

5. Impact of constructing and maintaining a golf course on the soils present on the site

This section identifies what potential impact construction and maintenance of the golf course would have on the site soils.

The “construction period” is the period when the golf course is physically constructed plus the following period when the grasses establish (turf establishment) prior to when the golf course can open for play. The golf course will only be able to open for play once all of the grass is fully established on all of the playing areas.

The “post construction period” commences once the golf course opens for play. At that stage all of the grass is fully established on all of the playing areas and turf maintenance practices will become less intensive than they were during the turf establishment phase. An annual, on-going maintenance programme will be implemented. There will be only minor changes to this programme from one year to the next. (the on-going maintenance of the golf course is detailed in “Golf Course Operations and Maintenance” report prepared by NZSTI and SMTS (Steve Marsden Turf Services) – Sections 8, 9, 11 & 12).

5.1 Greens and tees

5.1.1 Construction

These surfaces will comprise a relatively small proportion of the total area of the golf course (total area of greens and tees to be 6.74 hectares). These areas need to have very good drainage performance and for this reason their rootzone will be constructed from sand that is selected and imported specifically for this purpose. Construction of these features would involve:

- Excavating a cavity for the new imported rootzone - the existing site topsoil and sub-soil excavated for this purpose which would be used elsewhere on the golf course
- Drainage and irrigation would be installed and an amended sand rootzone would be imported and placed to form the green and tee rootzones.
- Refer also to “Golf Course Operations and Maintenance” report prepared by NZSTI and SMTS (Steve Marsden Turf Services) – Section 9.4

5.1.2 Maintenance

- Irrigation will be required to maintain these areas to the required standard
- A different fertilizer / pesticide programme than used at present on these locations will be implemented.
- Organic matter (om) will be managed at low levels in these areas (ie will not be allowed to build up as would normally occur if under pasture).
- Refer also to “Golf Course Operations and Maintenance” report prepared by NZSTI and SMTS (Steve Marsden Turf Services). – Sections 11 & 12

5.1.3 Greens and tees construction period: potential effects and impact on the site soils

Green and tee construction would result in small, localised sand areas throughout the site. The existing site soil will be removed from these areas (down to a depth of about 400mm and re-used elsewhere on the site). In the absence of irrigation (which would be the case if the site reverted to pasture) these areas would be droughtier than the adjacent “normal” soil areas comprising most of the golf course area. There is already a sand area at the western end of the site (soil classified as LUC 6e15) and the greens/tees of the proposed golf course would behave in the same manner as that existing sand area, if returned to pasture without irrigation.

Irrigation of pasture is now commonplace and could be carried out on parts of the if it was returned to pasture, in which case the impact of these areas could be negligible.

Existing topsoil and some sub-soil would be removed from these areas as part of construction. Re-use of the topsoil elsewhere will increase the depth of topsoil elsewhere on the site – it will be added to existing topsoil layers. The increased depth of topsoil in those locations will increase the potential rooting depth that will be achievable.

5.1.4 Greens and tees post-construction period: potential effects and impact on the site soils

Post construction (i.e. during normal on-going maintenance of the golf course), the presence of the greens and tees will have no further effect on the site soils in these locations. This is because the site soils will have been removed and replaced with new soil (imported sand). The presence of the greens and tees will have no significant effect on the site soils that remain intact in their immediate vicinity. One possible effect is that some of the greens and tees irrigation will also provide coverage of some adjacent surrounding areas that are on existing site soils. The effect of this will be to increase slightly productivity in these areas which will have the benefit of increasing the organic matter content in these areas.

5.2 Fairways and primary (mown) rough

5.2.1 Construction

The construction process for these areas would typically involve:

- Stripping and stockpiling of topsoil.
- Earthworks to re-shape the subgrade to form the contours designed for the golf holes.
- Installing sub-surface pipe drainage and automatic irrigation.
- Respreading the previously stripped topsoil and installing secondary drainage (slit drains) at 1.5m centres in the fairway areas.
- Importing and placing a 50mm sand layer on the fairways establishing the fairways in Cynodon (couch) turf sward.
- Refer also to “Golf Course Operations and Maintenance” report prepared by NZSTI and SMTS (Steve Marsden Turf Services) – Section 9.2

Note that the re-shaping of the land contours to form the golf course fairways and primary rough (and some of the naturalised rough areas) is done to create gently rolling contours that are suitable for playing golf on. Broadly speaking, the type of contour present on the LUC2e2 soils on site is suitable for golf course fairways and primary rough. Conversely, the type of contour present on the LUC4e9 soils on site is too steep for golf course fairways and primary rough.

The characteristic that creates the distinction between the LUC2e2 and LUC4e9 soils on the site is the contour – the LUC4e9 soils are more steeply contoured than the LUC2e2 soils. Therefore, reducing the steepness of the contour on areas of LUC4e9 soils on site to create suitable contours for fairways and primary rough will in effect change their classification to LUC2e2.

The existing LUC2e2 soils on site are considered to be "Prime Soils" as defined by the AUP. Thus, constructing the golf course fairways and primary rough will convert some of the LUC4e9 soils to LUC2e2, thereby increasing the total area of "Prime Soils" on the site.

5.2.2 Maintenance

- Irrigation will be required to maintain these areas to the required standard
- Different fertilizer / pesticide programme than at present on these areas
- Organic matter (om) will be managed at low levels in surface layer (50mm sand carpet layer) in these areas (om will not be allowed to build up as would normally occur if under pasture but existing om levels in the underlying soil will remain the same).
- Different grasses to those currently used will be established and maintained
- Refer also to "Golf Course Operations and Maintenance" report prepared by NZSTI and SMTS (Steve Marsden Turf Services)- Sections 11 & 12.

5.2.3 Fairways and primary rough construction period: potential effects and impacts on the site soils

Overall, the construction of the fairways would not have significant effects on the site soils and is expected to improve the aspects of the site soils.

Golf course fairway construction and maintenance would likely enhance the property's overall soil productivity capability as a result of:

- Dense grass cover being maintained for the duration of the golf course's existence. The benefits from this would be the same as maintaining an area in pasture (organic matter accumulation, soil structure development).
- The shallow sand depth prevents 'surface pugging' allowing improved soil structure to develop within the upper part of the soil profile.
- The use of warm season grass, Cynodon, allows turf management to actually improve soil structure as less water is required, and Cynodon is a deeper more aggressive rooting grass than traditional cool season species such as rye grass.
- The installation of a drainage system will mean fairway areas will have significantly better drainage than presently occurs.

- Management of turf areas for golf requires a range of rootzone aeration treatments, all of which are designed to improve soil structure.
- The contours created for the golf course fairways and rough would improve the suitability of the land for potential uses such as horticulture and cropping because the new contours will be less steep. Based on this, the construction of the golf course will actually increase the total area of soil type on the site that could be classified as “Prime Soils”.

The construction process will disrupt the existing soil structure present in the site soils. Some disruption to soil structure is inevitable from construction. The degree of this can be reduced by:

Using appropriate earthworks machinery:

From a golf course construction perspective this means minimising the weight of earthworks machinery as much as is practicable. Using bulldozer pulled scraper boxes rather than motor scrapers when completing bulk earthworks, using tracked machinery as opposed to rubber tyred equipment, any rubber tyred equipment used should have turf type tyres.

Good traffic management during construction

Specific traffic management would be required in the different construction areas (different component parts of the golf course). For example working away from completed earthworks so that driving over prepared areas is avoided, using designated haul roads which would be de-compacted as part of reinstatement works. The overarching goal is to minimise traffic on the playing surfaces of the golf course as the are constructed and completed.

Completing earthworks only when the soil is dry, specifically during the period from late October until the end of March is important to this. So too is undertaking compaction relief (for example deep ripping) of the re-worked areas prior to installing the sand layer and planting of the grass.

On-going turf management (including soil compaction relief treatments) will help to restore soil structure. This combined with the use of Cynodon will re-establish and then enhance soil structure within an estimated 2 – 4-year period following completion of construction.

5.2.4 Fairways and primary rough post construction: potential effects and impacts on the site soils

Post construction (i.e. during normal on-going maintenance of the golf course), the presence of fairways and primary rough will have some impact on the site soils.

Maintenance of most turf grasses used in golf courses relies on lower fertility levels than typically used on productive pasture such as on this farm. In turf we want a slow growing, low production grass surface as that provides the best playing quality; whilst in agriculture higher fertility is used to increase production and a greater financial return. Preparing quality fairway, tee, mown rough turf surfaces will likely result in a slight reduction in overall nutrient fertility (mainly phosphorus, calcium levels). This is desirable from both a turf and environment perspective. Nutrient levels or soil fertility can be quickly and easily increased at any time in the future if required through the use of fertiliser. The impact of this is considered to be negligible as soil fertility is very easy to correct.

Some agrichemicals have a degree of persistence within the soil, and some are damaging to the grasses and other crops that are used in agriculture. Typically, some of the products used could require a with-holding period (<12 months) prior to any return to conventional pastoral agriculture use. The impact of this is considered to be minor and would be quickly reduced by cultivation and grow-in processes required if the land use was changed from a golf course.

In the golf course role, the site soils will no longer be subject to winter pugging damage from stock under wet conditions. On the golf course all soil damaging traffic will be kept off when conditions are too wet.

Without stock, removal and depletion of fertility from the site soils by stock (or cropping) will not occur. In addition, redistribution of fertility and concentration of nutrient in small areas via animal urine and faeces (especially by cattle) will not occur. Potential leaching of nutrients into water ways due to high concentrations in cattle urine patches will not occur on the golf course.

Fairway irrigation will increase productivity in these areas above what would be achieved all else being equal (i.e. for any specific grass type and management regime, productivity will be higher with irrigation than without). Increased productivity will increase the rate of organic matter accumulation in the rootzone. On this site, this will be especially beneficial on the area of pure sand soils present at the western end of the site (Typic Sandy Recent Soil (RST), Pinaki Soil Series, LUC 6e15). It is proposed that all of this soil type that is present on the site will be incorporated in the golf course.

Management of the golf course will maintain the improved drainage in the site soils in the fairways and primary rough. This improved drainage of these site soils will be a long term legacy of the presence of the golf course.

5.3 Naturalised Rough

5.3.1 Construction

Construction of the rough areas would involve:

- Topsoil being selectively stripped and stockpiled. Stripping and subsequent stockpiling of the topsoil may occur as two distinct zones to avoid re-invasion by Kikuyu and to lower the fertility of these areas to reduce turf vigour in the rough.
- Reshaping the subgrade.
- Subsoil drainage will be installed in some of these areas depending on the specific situation (dependent on contour and golf course traffic).
- Spreading a uniform depth of topsoil over the entire area of rough and then grass establishment.
- Refer also to “Golf Course Operations and Maintenance” report prepared by NZSTI and SMTS (Steve Marsden Turf Services) – Section 9.5.

5.3.2 Maintenance

- Different fertilizer / pesticide programme than at present on these areas (these areas will be minimally maintained).
- Organic matter will be allowed to accumulate “naturally”
- Different grasses to those currently used will be established and maintained
- Refer also to “Golf Course Operations and Maintenance” report prepared by NZSTI and SMTS (Steve Marsden Turf Services) – Sections 11 & 12.

5.3.3 Naturalised rough construction: potential effects and impacts on the site soils

The overall impact of constructing and maintaining the rough is considered negligible as these areas will be maintained as low productivity grassland areas.

The construction process will disrupt the existing soil structure present in the soils in these areas. Some damage to soil structure is inevitable from construction. he degree of this can be reduced by:

As on the fairways, the degree of this can be reduced by using correct types and sizes of earthworks machinery, good traffic management and completing earthworks when the soil is dry.

Compaction relief (deep ripping, etc) the areas prior to topsoiling and then prior to sowing the grass will alleviate some of the damage from construction. Some extra initial turf management practices (soil compaction relief) plus the absence of irrigation which will allow normal drying/wetting soil forming processes will help to re-establish soil structure within an estimated 2 – 4 year period following construction.

The topsoil depth is likely to increase in some of these areas as topsoil removed from areas such as greens, tees, building and road sites will be redistributed to areas such as these. The increased topsoil depth will increase potential rooting depth in such areas.

5.3.4 Naturalised rough post construction: potential effects and impacts on the site soils

Post construction (i.e. during normal on-going maintenance of the golf course), the presence of the naturalised rough will have some impact on the site soils.

Managing the naturalised rough will result in a reduction in overall nutrient fertility (fertiliser applications will be reduced from what occurs at present). This is desirable from both a turf and environmental perspective. Nutrient or soil fertility can be quickly and easily corrected should the property return back to use as a farm or other uses. The impact of this is considered to be negligible as soil fertility is very easy to correct.

Agrichemical use in these areas will be limited. Some agrichemicals have a degree of persistence within the soil. In these areas any such impact is likely to be minor and would be quickly reduced by cultivation and grow-in processes required if the land use was changed from a golf course.

In the golf course role, the site soils in these areas will no longer be subject to winter pugging damage from stock under wet conditions. On the golf course all soil damaging traffic will be kept off when conditions are too wet.

Without stock, removal and depletion of fertility from the site soils in these areas by stock (or cropping) will not occur. In addition, redistribution of fertility and concentration of nutrient in small areas via animal urine and faeces (especially by cattle) will not occur. Potential leaching of nutrients into water ways due to high concentrations in cattle urine patches will not occur on the golf course.

6. Built Structures

A number of permanent built structures are proposed as part of the site. These structures include:

- Lodge;
- Club house and associated carpark;
- Academy with café and associated carpark;
- Carpark next to the practice area;
- Golf and property maintenance facility; and
- Water reservoir

Following the construction of these elements, any underlying land and soil is permanently removed from the site's rural production area. Of these, the academy and associated carpark, the small carpark next to the practice area and the water reservoir will be built within 'Prime Soil' areas (LUC 2e2). This represents only 4.6% of the total area of 'Prime Soil' on the property. This area of "Prime Soil" will be eliminated from the site through the construction of these built structures. However, in the LUC2e2 areas, a key determinant of that classification is the actual soil material that is present (in particular the upper sub-soil and topsoil layers). Construction of these built structures will require the defining upper sub-soil and topsoil layers to be removed to create suitable foundations for construction of these structures. That soil will not be destroyed or disposed of, rather it will be retained and used elsewhere on the site.

All other proposed buildings will be located on land carrying LUC classification of 4e9, which does not meet the AUP definitions of 'Elite or Prime Soil'. As with the LUC2e2 areas, existing soil underlying these structures will not be destroyed or disposed of, rather it will be retained and used elsewhere on the site.

Specifically, topsoil depth will be increased elsewhere on the site as topsoil removed from these areas will be redistributed to areas such as the naturalised rough (or elsewhere onto parts of the associated farm). The increased topsoil depth will increase potential rooting depth in those areas.

7. Key Conclusions

- The property does not contain any 'Elite Soils' as defined by the AUP.
- The property does include some soils considered to be 'Prime Soils' as defined in the AUP.
- They comprise relatively small proportions of the property (30.2%) and of the site (24%) and a much smaller proportion (4.4%) of land occupied by proposed permanent built structures.
- The identification of "Prime Soils" across the wider property and within the site is based on a combination of non-site-specific landform data and land use capability classification mapping plus on-site investigation of the soils.
- On-site investigation of the soils present on the proposed golf course site revealed that the soils identified in maps as being suspected 'Prime Soils' conform with that classification but with rooting depth potential and drainage performance both towards the lower end of the expected range for these characteristics, for 'Prime Soils'.

- It is likely that construction of the golf course will actually increase (by an estimated 16 ha) the total area of soil on the site that can be classified as 'Prime Soil' through improved land contours.
- The majority (85.6%) of the property's 'Prime Soils' will continue to be available for rural production activities.
- Any adverse effects on soil health from the golf course construction will be minor and, in most cases, temporary in nature.
- Much of the golf course site will experience improved soil quality and health as a result of the proposal. For example, improved drainage and improved soil structure will occur as a consequence of golf course construction and ongoing maintenance activities.
- Other than in locations where permanent built structures are proposed (including the water reservoir), the proposal in no way limits the ability of the site to be used for other agricultural or horticultural uses dependent on the quality and productivity of the soil, in the future.
- Further to that, as a consequence of improved land contours, better drainage, better access plus the availability of water for irrigation - all occurring as integral parts of the golf course development, the construction of the golf course would actually broaden the range of agricultural or horticultural activities that could be carried out successfully on the site in future.

8.References

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