Manaaki Whenua
Landcare Research

Soil information for four Hamilton southern wastewater treatment plant land treatment sites

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Soil information for four Hamilton southern wastewater treatment plant land treatment sites

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Contents

Summary

Project and client

Beca International Consultants Ltd have requested Manaaki Whenua–Landcare Research (MWLR) undertake soil appraisal at four sites for wastewater discharge to land in the Hamilton South area.

Objectives

- Review existing soil information.
- Make preliminary assessments on the suitability of soils at four sites (i.e., Sharpe Farm, Narrows Road, Golf Course, and Penniket Road) in the Hamilton South region for the land disposal of treated wastewater.

Methods

- Relevant historical soil information was evaluated.
- Soil observations to about 1 metre below soil surface were undertaken using a light coring rig or by hand augering where use of the coring rig would cause crop damage during access.
- Soil descriptions placed emphasis on soil properties most relevant to irrigation of treated wastewater, i.e. colour, texture, consistence, drainage.

Results

- Soils at Sharpe Farm were predominantly developed in imperfectly or poorly drained alluvium with a minor area developed in older clayey volcanic tephra. Imperfect and poor drainage as well as clayey textures are considered restrictions to treated wastewater application.
- Soils on low-lying land at Narrows Road are developed in poorly drained alluvium while those on elevated rolling land are developed in older clayey volcanic tephra. Poor drainage and clayey textures are considered restrictions to treated wastewater application.
- Soils at the Golf Course are developed in well-drained sandy alluvium and likely provide little renovation to applied treated wastewater.
- Wastewater application rates need to be matched to soils at Penniket Road where the upper subsoil probably adsorbs phosphorus and is a filter to bacteria and viruses.

Conclusions

- We investigated soils at four potential Hamilton South wastewater treatment sites (Sharpe Farm, Narrows Road, the Golf Course, and Penniket Road [3N and 3S]) for land application of treated wastewater.
- Most soils at Sharpe Farm and Narrows Road have drainage restrictions and limitations for year-round application of treated wastewater, although deficit irrigation of topsoils may be feasible.

- While most soils at the Golf Course have adequate infiltration characteristics for year-round application of treated wastewater, they will probably provide little renovation of applied wastewater.
- Well-drained soils at both sites within Penniket Road (3N and 3S) have few limitations to year-round application of treated wastewater if application rates are matched to soil infiltration and permeability rates. However, some soils are likely to absorb applied phosphorus and filter out microbes.

1 Introduction

Beca International Consultants Ltd (Beca Ltd) have requested Manaaki Whenua–Landcare Research (MWLR) to undertake soil appraisal at selected sites for wastewater discharge to land in the Hamilton South area.

2 Background

Four potential sites, near Hamilton airport, have been selected by Beca Ltd for the land discharge of treated wastewater. The sites are: Sharpe Farm, Narrows Road, the Golf Course, and Penniket Road (3N and 3S).

3 Objectives

- Review existing soil information.
- Make preliminary assessments on the suitability of soils at four sites in Hamilton South for the land disposal of treated wastewater.

4 Methods

Relevant historical soil information was evaluated from: Grange et al. (1939); Joe (1986); an unpublished NZ Soil Bureau map of the Waikato district; and S-Map online, version 4.2.100 (Manaaki Whenua – Landcare Research 2023). Generally, Joe (1986) reports the mean and standard deviation of replicate hydraulic conductivity results where n=4.

S-Map online is a free-to-access online soil map derived from a combination of field observations supplemented with co-variate layers such as a digital elevation model and geological layers. Geographic soil names have been superseded by new family names and supported by a large database of soil data. Because S-Map online is a nationwide system it allows generation of information on soil chemical and physical properties, often involving complex relationships between soil properties, to be established.

In the field, soil observations to about 1 metre below soil surface were undertaken using a light coring rig (Figure 1) or by hand augering where use of the coring rig would cause crop damage. Appendix 1 shows observation sites at the completion of the observation in the event of claims for crop damage. Soil descriptions placed emphasis on soil properties most relevant to irrigation of treated wastewater (i.e. colour, texture, consistence, drainage). Sites were located using a hand-held Global Positioning System device (Garmin GPSMAP® 64s) and are shown in Appendix 2.

Figure 1. A light coring rig was used to obtain an undisturbed soil core for description where crop damage was not of concern.

5 Results

5.1 Historical data

Grange et al. (1939) undertook a soil survey in the area between 1933 and 1935 at a scale of 1:31,680. The Golf Course is not covered by Grange et al. (1939) but is covered by an unpublished, undated Soil Bureau map at scale 1:63,360. Some saturated hydraulic conductivity data has been elucidated from Joe (1986) and should be considered as a guide only. Joe (1986) also reported near-saturated hydraulic conductivity at a tension of -40 mm water (K_{-40}). At this tension water moves through the pores of 0.75 mm and smaller only. Thus, transient natural soil structural cracks and worm holes are not involved in the transmission of water. K_{-40} is a slower hydraulic conductivity value than K_{sat} and may be more appropriate for wastewater application considerations. S-Map online provides 1:50,000 scale coverage for all of the potential sites.

5.1.1 Sharpe Farm

Grange et al. (1939) show Sharpe Farm soils to be well-drained Horotiu sandy loam with poorly drained Te Kowhai silt loam, clay loam in the lower areas of river terrace (all from alluvium), and imperfectly drained Hamilton clay loam on land above the river terrace developed in airfall volcanic tephra. Hamilton clay loam soils are developed in ‘old’ (>50,000 year) airfall volcanic ash which has now mostly weathered to clay.

Grange et al. (1939) also show a minor area of an unnamed soil in an embayment in surrounding elevated land. Judging from the landscape position between the elevated land and an artificial drain shown on topographical maps, the soil is likely to be poorly or very poorly drained.

At Sharpe Farm (Figure 2), S-Map online shows two map units. The major map unit areas relate to alluvial soils on the Hinuera Formation (deposited by the ancestral Waikato River) but these are away from the levees and in a backswamp landscape position where we would expect less well-drained soils (Pukehina and Wharepunga families). The very minor map unit area pertains to volcanic tephra covered low hills (Mairoa and Te Rahu families) which are surrounded by alluvium of the Hinuera Formation. Before S-Map online the Mairoa family would have been included in Tirau soils while the Te Rahu family would have been included in Hamilton soils.

Figure 2. Sharpe Farm is predominantly flat to undulating but with minor undulating toeslopes in the southwestern part of the site.

5.1.2 Narrows Road

Grange et al. (1939) show lower-lying the land at Narrows Road to be predominantly poorly drained Te Kowhai soils with Hamilton soils on higher elevation rolling land. Te Kowhai soils are relatively fine-grained soils deposited by overbank flow in backswamp positions by the ancestral Waikato River. Hamilton soils are developed in 'old' (>50,000 year) airfall volcanic ash which has now mostly weathered to clay.

At Narrows Road S-Map online shows two map units (Figures 3–4). Major map unit areas relate to alluvial soils on the Hinuera Formation but away from the levees and in a backswamp landscape position, so we expect less well-drained soils (Pukehina and Wharepunga families). Before S-Map, the Pukehina family would have been included in Te

Kowhai soils while the Wharepunga family would have been included in the Bruntwood soils of Singleton (1991). The minor map unit relates to low hills that are volcanic tephra covered (Mairoa and Te Rahu families) which are surrounded by alluvium of the Hinuera Formation. Before S-Map online, the Mairoa family would have been included in Ohaupo soils, Te Rahu family would have been included in Hamilton soils.

Figure 3. Low-lying land at Narrows Road is shown by S-Map online to be predominantly poorly drained Pukehina family soils developed on the alluvial Hinuera Formation.

Figure 4. Higher elevation rolling land is shown by S-Map online to be Mairoa and Te Rahu soil families developed in volcanic tephra.

5.1.3 Golf Course

The unpublished Soil Bureau map shows the Golf Course to have Waikato soils that are developed in rhyolitic alluvium alongside the Waikato River.

S-Map online shows one map unit with two soil classes both developed on terraces formed from the Taupo Pumice alluvium from 186 AD eruption deposited by the Waikato River. The soil classes are both deep (Turangi family), but one is sandy and the other loamy over sand (Figure 5). Before S-Map, the soils were included in Waikato soils.

Figure 5. The Golf Course site has well drained Turangi family soils developed in pumice alluvium.

5.1.4 Penniket Road

There are two sites at Penniket Road (3N and 3S; Figures 6 and 7). Grange et al. (1939) show the Penniket Road sites to be Horotiu sand and coarse sandy loam with Horotiu sandy loam towards the north. At both Penniket Road sites (3N and 3S) S-Map online shows two map units both developed on the alluvial fan surface. The alluvial fan was deposited by the ancestral Waikato River and is known as the Hinuera Formation. Being an alluvial surface, the levees have better drained soils (Otorohanga family) while in lower landscape positions soils become less well-drained (Airfield family). Before S-Map, Otorohanga family soils were included in Horotiu soils while Airfield family soils were included in Whatawhata soils (Bruce 1978). The Otorohanga family developed on Hinuera Formation has volcanic tephra in the upper soil profile (>35 cm thickness) that was deposited in the last 20,000 years and which gives it high phosphorus retention.

Figure 6. S-Map online shows Penniket Road Site 3N to have soils within Otorohanga and Airfield soil families.

Grange et al. (1939) show the southern Site 3S at Penniket Road to be Horotiu sandy loam while S-Map online also shows Otorohanga and Airfield families present, with the potential for Pukehina family towards the south.

Figure 7. S-Map online shows Penniket Road Site 3S to have Otorohanga, Airfield and Pukehina soil families.

5.2 Current investigations

5.2.1 Sharpe Farm

Most of the land at Sharpe Farm is planted in pasture and two distinct landform units are evident. The majority of the land is a dissected terrace (Hinuera Formation) of the Waikato River with a combination of imperfectly drained and poorly drained soils (Figures 8 and 9). Grey colours in the subsoil of these soils indicates waterlogging for considerable periods of the year. Well-drained soils mapped by Grange et al. (1939) were not evident although now the definition of 'well drained' has been revised and formalised. A water table was often encountered between 57 and 70 cm below the soil surface in February 2023. Wetter areas of the farm had drainage ditches.

Typically, the imperfectly drained soils have a dark loamy topsoil overlying a loamy yellowish brown upper subsoil. Lower subsoils are firm and grey. The grey colour indicates waterlogging for considerable periods of the year. Below about 70 cm the soils are often developed in pumice sand, but this can be waterlogged as well. Where upper subsoils are yellowish-brown, they are judged to have moderate anion retention. This means the soil has some ability to retain phosphorus.

Although Joe (1986) did not measure the hydraulic conductivity of similar soils, the upper subsoils are judged to have K_{sat} of 2 $\times 10^{-5}$ m s^{-1} to 1 $\times 10^{-6}$ m s^{-1}; whereas the firm grey lower subsoil is judged to have K_{sat} of c. 2.5 $\times 10^{-6}$ m s-^{1}, with K_{-40} of c. 3.9×10^{-7} m s^{-1}.

Figure 8. Imperfectly drained soil typical of the alluvial Hinuera surface at Sharpe Farm. Grey colours indicate waterlogged conditions for much of the year.

The imperfectly drained nature of the soil, with indication of subsoil waterlogging, combined with restricted subsoil permeability indicates limitations to year-round application of treated wastewater. Deficit irrigation using storage within the topsoil and yellowish-brown upper subsoil is feasible. However, care must be taken not to graze stock on 'wet' topsoils.

Figure 9. Drainage ditches in the terrace land are also a sign of imperfectly and poorly drained soils at Sharpe Farm.

The small area of rolling land (southwestern margin) above the dissected river terrace has Hamilton soils developed in 'older' airfall volcanic tephra, Hamilton Ash beds. 'Hamilton Ash beds' is a colloquial term for volcanic tephras of between c. 50,000 and 340,000 years old. This soil material has mostly weathered to clay and also there is some movement of fine clays downwards blocking soil pores and restricting water movement. Being in a toeslope landscape position, the soils receive water from upslope and the soils show signs of periodic waterlogging, even in the topsoil.

Although Joe (1986) measured hydraulic conductivity of similar soils the ones he measured occurred in a higher landscape position where K_{sat} and K_{-40} were $5.5 \pm 1.0\ \ 10^{-5}$ m s^{-1} and $1.8 \pm 0.2 \times 10^{-6}$ m s^{-1}, respectively, in the upper subsoil; and $2.9 \pm 3.7 \times 10^{-6}$ m s^{-1} and $1.6 \pm 1.0 \times 10^{-6}$ m s^{-1}, respectively, in the lower subsoil.

The 'younger' loamy airfall volcanic tephra has probably been eroded from this site.

Topsoils showing signs of periodic waterlogging indicate the soils have limitations for year-round application of treated wastewater, but limited deficit irrigation of the topsoil may be feasible. However, care must be taken not to stock 'wet' topsoils.

Interpretation for treated wastewater disposal

Low-lying land at the Sharpe Farm site has drainage and permeability restrictions to year-round treated wastewater application. The small area of elevated land above the terraces has rolling slopes, restricted subsoil permeability and evidence of waterlogging in the topsoil. This indicates restrictions to year-round application of treated wastewater. Lateral flow of surface-applied treated wastewater to these slopes is likely to generate seepage zones at the base of slopes. Both the low-lying and small area of elevated land could be considered for deficit irrigation, but care must be taken to avoid stocking ‘wet’ topsoils.

5.2.2 Narrows Road

Most of the land at the Narrows Road site is planted in maize. The flat, low-lying land is predominantly poorly drained with very poorly drained soils in embayments. Deep drains are also indicative of the poorly drained soils while soft surface conditions in the embayments are associated with very poorly drained soils. Very poorly drained soils have a lot of organic matter in the topsoil – an indication of waterlogging where vegetation does not readily decompose. Typically, poorly drained soils have loamy topsoils cultivated to about 20 cm overlying firm, greyish, loamy upper subsoils (Figure 10). Below about 70 to 80 cm in the lower subsoil, soil material is pumiceous sand. Saturated hydraulic conductivity (K_{sat}) in the upper subsoil of similar soils is $8.9 \pm 6.4 \times 10^{-5}$ m s^{-1} with K_{-40} of $1.2 \pm 0.2 \times 10^{-6}$ m s^{-1} (Joe 1986).

The poorly and very poorly drained soils have indications of waterlogging to the base of the topsoil, or even above this level in the case of very poorly drained soils (Figures 11 and 12). The waterlogging is a restriction to year-round application of treated wastewater. Deficit irrigation of poorly drained soils may be feasible where water storage of the topsoil only, is considered. However, care must be taken not to stock ‘wet’ topsoils.

The soils on elevated rolling land are well drained, developed in clayey Hamilton Ash beds. Similarly, topsoils are cultivated to about 20 cm and overlie very firm clayey subsoils (Fugure 13). In these soils, clay from upper soil layers is often translocated down the soil profile and deposited below about 50 cm. The translocated clay tends to block soil pores and reduce hydraulic conductivity. The K_{sat} and K_{-40} of similar soils are $5.7 \pm 1.0 \times 10^{-5}$ m s^{-1} and $1.8 \pm 0.2 \times 10^{-6}$ m s^{-1}, respectively, in the upper subsoil; and $2.9 \pm 3.7 \times 10^{-6}$ m s^{-1} and $1.6 \pm 1.0 \times 10^{-6}$ m s^{-1}, respectively, in the lower subsoil (Joe 1986). At the toe of slopes on the rolling land, soils tend to become less well-drained with manganese concretions in the upper subsoil which indicated waterlogging for some period of the year.

The rolling slopes and potentially restricted subsoil permeability indicate these soils have limitations for year-round treated wastewater application. The rolling land could be considered for deficit irrigation, but care must be taken to avoid stocking ‘wet’ topsoils and to match application rate to infiltration rate to prevent run-off.

Figure 10. Greyish colours in the Pukehina family soil above 30 cm indicate a poorly drained soil.

Figure 11. Deep drains are another indication of poorly drained soils on the low-lying land.

Figure 12. Soft surface conditions in embayments are associated with very poorly drained soils.

Figure 13. On elevated rolling land at the Narrows Road site, soils are developed in clayey Hamilton Ash which is very firm.

Interpretation for treated wastewater disposal

The low-lying land at the Narrows Road site has drainage and permeability restrictions which present limitations for year-round application of treated wastewater, although deficit irrigation of the topsoil may be feasible. Elevated land has rolling slopes and restricted subsoil permeability that also present limitations for year-round application of treated wastewater, although deficit irrigation of the topsoil may be feasible. Lateral flow of surface-applied treated wastewater is likely with a probability of seepage zones at the base of slopes.

5.2.3 Golf Course

At the Golf Course, soils are developed in well-drained rhyolitic alluvium deposited by the Waikato River. Natural river channels and the development of the golf course mean the soils show much variation and disturbance (Figure 14) but typically a dark sandy loam topsoil to about 20 cm overlies yellowish-brown sand to about 50 cm where soil weathering slows, and the sand reflects the colour of the original alluvium (Figure 15). Although Joe (1986) did not report hydraulic conductivity measurements for these soils K_{sat} and K_{-40} are judged to be c. 4.0 $\times 10^{-4}$ m s^{-1} and 7.4 $\times 10^{-5}$ m s^{-1}, respectively. Rhyolitic stones and pumice are common throughout the soil. Although much of the land is disturbed, the disturbed material is generally the same rhyolitic alluvium. An exception is the lower terrace adjacent to the eastern terrace riser which can have up to 70 cm imported fill over an organic-rich buried topsoil (Figure 16).

Figure 14. Turangi family soils at the Golf Course site often show signs of disturbance.

Figure 15. Typical well drained Turangi family soil at the Golf Course site.

Figure 16. The lower terrace adjacent to the eastern terrace riser can have up to 70 cm of imported fill.

Below the topsoil, sandy Turangi family soils are judged to have rapid saturated hydraulic conductivity ($K_{sat} > 4 \times 10^{-5}$ m s^{-1}).

Interpretation for treated wastewater disposal

At the Golf Course site, surface applied treated wastewater will potentially move through the soil rapidly, so this site is suitable for year-round application of treated wastewater. However, the nature of the soil material indicates little renovation is likely. The amount and nature of imported fill on the low terrace adjacent to the eastern terrace riser may need further investigation.

5.2.4 Penniket Road

Soils at Site 3N at Penniket Road are predominantly well-drained Otorohanga family soils developed in < 20,000 year-old volcanic tephra overlying the rhyolitic alluvium of the Hinuera Formation (Figure 17). The alluvium is older (c. 20,000 years old) than the alluvium of the Turangi family soils at the Golf Course site (c. 2,000 years old). Typically, Otorohanga family soils show a dark brown loamy topsoil over a yellowish-brown loamy upper subsoil on a very pale brown sandy lower subsoil. Judging from soil colour and simple reactive aluminium tests done in the field indicate they have high or very high anion retention (Blakemore et al. 1987) indicating they would be able to retain large amounts of applied phosphorus with only minor phosphorus leaching. Similar soils have K_{sat} and K_{-40} of 4.0 ± 1.2 ×10^{-5} m s^{-1} and 5.9 ± 0.7 ×10^{-6} m s^{-1} , respectively, in the upper subsoil; this increases to 4.0 ± 2.9 ×10^{-4} m s^{-1} and 7.4 ± 3.1 ×10^{-5} m s^{-1}, respectively, in the lower subsoil.

Towards the very north of the site and associated with slightly lower land the soils become less well drained (imperfectly drained) with reddish brown mottles and manganese concretions in the upper subsoil. Such features are indicative of short periods of waterlogging and may be associated with rolling land to the north of the site. LiDAR images show slightly elevated land either side of Penniket Road, but the soils are similar to those on the lower land. Well-drained soils on site 3N have few limitations for year-round application of treated wastewater if wastewater application rates are matched to infiltration and permeability rates. Care must be taken to avoid stocking 'wet' topsoils.

Figure 17. Well drained Otorohanga family soil at Penniket Road site 3N where yellowish-brown loamy upper subsoils are expected to retain phosphorus and filter microbes.

Soils at Site 3S Penniket Road are a well-drained inclusion within the map unit showing Otorohanga family soils. They are developed in re-sorted volcanic tephra that has been combined with sandy rhyolitic alluvium of the Hinuera Formation (Figure 18). The alluvium is older than the alluvium of the Turangi family soils at the Golf Course site. Typically, the soils have a dark yellowish-brown loamy topsoil up to 30 cm thick on a brownish-yellow upper subsoil. The lower very pale brown sandy subsoil shows little soil development, reflecting the colour and structure of the unweathered sandy alluvium. Judging from soil colour and simple reactive aluminium tests undertaken in the field they have medium (Blakemore et al. 1987) anion retention in the upper subsoil indicating they would be able to retain moderate amounts of applied phosphorus with only minor phosphorus leaching. Similar soils have K_{sat} and K_{-40} of 4.0 ± 2.9 ×10^{-4} m s^{-1} and 7.4 ± 3.1 ×10^{-5} m s^{-1}, respectively, in the lower subsoil. Our experience is that the loamy upper subsoil material is a good filter to bacteria and possibly viruses.

Well-drained soils on site 3S have few limitations for year-round application of treated wastewater when application rates are matched to infiltration and permeability rates. Care must be taken to avoid stocking 'wet' topsoils.

Figure 18. Well drained soil at Penniket Road 3S.

Interpretation for treated wastewater disposal

Both well-drained sites at Penniket Road will accept treated wastewater on a year-round basis if application rates match the soils' infiltration and permeability. However, stocking of 'wet' topsoils should be avoided. Some long-term removal of phosphorus and pathogens by these soils is expected where upper subsoils are loamy.

6 Conclusions

Site	Notes
Sharpe Farm	Low-lying terrace land has drainage (and in some places) permeability restrictions, while land above the river terrace has rolling slopes, imperfect drainage and restricted subsoil permeability. Sharpe Farm has limitations to year-round application of treated wastewater. Deficit irrigation using storage within the topsoil and yellowish-brown upper subsoil is feasible.
Narrows Road	Low-lying land has drainage and permeability restrictions, while the elevated land has rolling slopes and restricted subsoil permeability. Narrows Road has limitations for year-round application of treated wastewater although deficit irrigation of the topsoil may be feasible. Lateral flow of surface-applied treated wastewater is likely, with seepage zones probable at the base of slopes.
Golf Course	Surface-applied treated wastewater will potentially move through the soil rapidly, but the nature of the soil material indicates little renovation is likely. At the Golf Course, surface-applied treated wastewater will potentially move through the soil rapidly and is suitable for year-round application. However, the nature of the soil material indicates little renovation is likely. The amount and nature of imported fill on the low terrace adjacent to the eastern terrace riser may need further investigation.

Site	Notes
Penniket Road	Match application rate to soil infiltration rate. Some long-term removal of phosphorus and pathogens is expected where upper subsoils are loamy. Both sites (3N and 3S) at Penniket Road can accept treated wastewater on a year-round basis if application rates match the soils' infiltration and permeability.

7 Acknowledgements

Thanks to those who allowed access to land and colleague Isaac Osbaldiston for field assistance at Sharpe Farm as well as Andrew Miram at Sharpe Farm for showing us the location of high-voltage underground cables, fibre optic cable and water pipes.

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Appendix 1 – Photos at waypoints

The photos below are provided to show site disturbance after soil description in the event of claims for crop damage.

Table A1.1. Reference photos

Waypoint 1063 Sharpe by rig in pasture

Waypoint 1064 Sharpe by hand in pasture

Waypoint 1066 Sharpe by hand in pasture

Waypoint 1067 Sharpe by hand in pasture

Waypoint 1069 Sharpe by rig in pasture

Waypoint 1070 Sharpe by hand in pasture

Waypoint 1055 Narrows. By hand in maize

Waypoint 1056 Narrows. By hand in pasture

Waypoint 1057 Narrows. By hand on edge of maize

Waypoint 1058 Narrows. By hand in maize

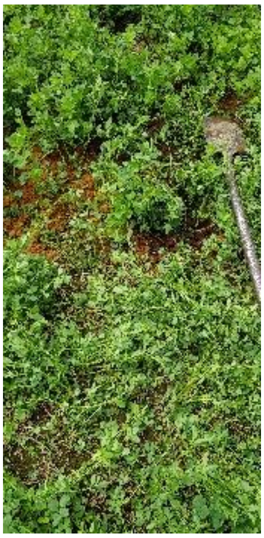
Waypoint 1061 Golf Course. By rig in pasture

Waypoint 1045 Penniket. By rig in harvested lucerne

Waypoint 1048 Penniket. By rig in harvested lucerne

Waypoint 1049 Penniket. By rig in harvested lucerne

Waypoint 1050 Penniket. By hand in pasture



Waypoint 1052 Penniket. By hand in pasture

Waypoint 1053 Penniket. By rig in pasture


Waypoint 1054 Penniket. By hand in pasture

Appendix 2 – Location of waypoints

Figure A2.1 Sharpe Farm.

Figure A2.2. Narrows Road.

Figure 19. Golf Course.

Figure A2.4. Penniket Road.