Auckland International Airport second runway, section 56 investigation: final report (HNZPTA Authority 2022/706)

report to
Heritage New Zealand Pouhere Taonga
and
Auckland International Airport Ltd

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Matthew Campbell and Leela Moses

Introduction

Auckland International Airport Ltd (AIAL) propose the construction of a second runway through largely undeveloped farmland north of the current runway. Due to the presence of several recorded archaeological sites in and around the proposed runway footprint (midden sites R11/847, R11/848, R11/846, R11/2571, R11/2291 and R11/2773; and extensive living and burial site R11/859) a Section 56 Investigation was undertaken between 27 July and 2 August 2022 under archaeological authority 2022/706 issued by Heritage New Zealand Pouhere Taonga (HNZPT) under Section 56 of the Heritage New Zealand Pouhere Taonga Act 2014 (Figure 1). The purpose of this minimally invasive exploratory investigation was to characterise the nature and extent of sites impacted by proposed works, inform research strategy for future investigation, and detect possible kōiwi tangata.

Background

Archaeological sites have been investigated on Airport land and nearby over the last 20 years and the archaeology of this part of South Auckland is becoming clearer, as is its place in the wider archaeological landscapes of Tāmaki and the upper North Island.

Pre-European Māori sites investigated on Airport land (Figure 1) include:

- R11/859, the NRD site (Campbell 2011; Hudson and Campbell 2011; Campbell and Hudson 2011);
- R11/1359, 1360, 1361, 2378, 2379, 2952, 2953, 2954 and 2955, Timberly Road (Farley et al. 2015 – a historic period timber structure, R11/2956, was also investigated);
- R11/2915, Landing 2B (Farley and Clough 2014);
- R11/2940, 3055, 3056, 3111 and 3112, Landing 3 (Farley et al. 2017 – two historic period ditch and bank sites, R11/2941 and 2942, were also investigated, and two others, R11/1955 and 2795, were investigated at Landing 2A (Farley and Clough 2013));
- R11/3250, 3267, 3268, 3269 and 3270, all middens, at Taxiway Mike (Farley 2021a);
- R11/3289, 3290 and 3291, middens and firescoops, and R11/3288 and 3292, historic sites, at the Park and Ride South (Farley 2021b);
- R11/3129, 3130, 3131 and 3132, Landing 4 (not yet reported);
- R11/266, Nixon Road (not yet reported);
- excavations are also currently or will soon be under way at R11/2378, 3161 and 2953, 27 Timberly Road, and R11/2490, 3128, 3129 and 3130, Landing POS (Glen Farley pers. comm. 1 March 2019).

The NRD site, R11/859, was excavated in 2008–09 at the western end of the runway designation on a beach terrace beside a small stream outlet into the Manukau Harbour, and on an 8 m bluff above the beach terrace. In Areas A and B, Phase 1 consisted of several drained storage pits cut into the sand of the beach terrace, dated to the later 15th century

Figure 1. The location of the AIAL second runway and recorded archaeological sites in the vicinity, including excvavations to date.

AD. Above these, in both Areas A and B was a midden that had been disturbed by ploughing, overlying numerous human burials (kōiwi tangata). The Area A burials were dated to the mid-17th century while Area B was date to the later 17th or early 18th centuries, one or two generations after Area A. In Area A several burials were placed in large, deep round pits (rua kōpiha) – these pits have been recorded elsewhere but not for burials. Several pits contained items like non-local rocks, dogs or whalebone that appeared to have been buried in place of human bodies, presumably because the body was not able to be buried but the person could be referenced by the item buried in their place. In Area B burial practice was less diverse. In Area A and to a lesser extent in Area B the midden can be interpreted as evidence of funerary feasting where the firescoops surround but do not overlie the burial area. The presence of kōiwi and the rites of burial are tapu are highly dangerous to the participants. The tapu, then, must be controlled and made safe through rites of whakanoa in order to protect the participants and allow them to safely resume their normal day-to-day activities, and one of the agents through which things could be made noa was cooked food. Other evidence of feasting is the very high numbers of shark and ray vertebrae, which do not usually survive well in archaeological contexts (Campbell 2011; Hudson and Campbell 2011; Campbell and Hudson 2011; Shepherd and Campbell 2021; Campbell et al. 2022; Kramer et al. 2022).

Because the midden had been ploughed, disturbing some of the bone out of its original deposition, all excavated material in Areas A and B had to be sieved, meaning all non-human (mammal, bird and fish) bone, all stone flakes and all artefacts could be recovered – shell was subsampled. This resulted in a large faunal assemblage from the site. Fish was dominated by snapper (tāmure, *Chrysophrys auratus*) including numerous small individuals indicating that a nearby snapper nursery was being targeted. Fish would have been caught by both baited hooks and nets. Birds were taken from a variety of environments, including coastal, wetland, open grassland and forest. While some dogs were deliberately buried, most dog bone was food remains. Taonga (artefacts) included 31 bone fishhook points (and one, presumably ceremonial, point in pounamu), two bone shanks, 12 bone needles, a bone tattooing chisel, bone toggles and miscellaneous tools, human tooth, pounamu shell and bone ornaments, a patu handle, 7 small chisels of basalt, argillite and greywacke, and 18 larger adzes of basalt and greywacke as well as hammerstones, abrader, ochre (kōkōwai) and miscellaneous pieces of worked bone. Flaked stone was dominated by obsidian, mostly from Aotea / Great Barrier Island with some from Tūhua / Mayor Island and minor sources, while cherts were also common with lesser quantities of basalt, greywacke, argillite (these three types may have flaked off adzes during use and some were polished) and petrified wood (Campbell 2011).

Three further burials were found in Area I on the bluff, where two phases of drained pits were also excavated, and several other areas of midden included firescoops and postholes, some of which outlined one definite house (approx. 5 x 4 m) with large firescoops outside it, and one possible house or extensive windbreak (approx. 6 x 4 m) with large firescoops inside it (Campbell 2011).

At Timberly Road, east of the designation adjoining the Pukaki Creek, six pre-European Māori sites were investigated. R11/2738, 2592, 2593 and 2594 were simple middens containing no other features. R11/2595 was a larger midden containing a firescoop and several postholes forming no clear alignments. Ten obsidian flakes, primarily from Great Barrier Island and Mayor Island, were recovered.

R11/2379 at Timberly Road was a more significant site, containing several patches of midden, 15 pits, 10 firescoops and three houses outlined by postholes, measuring approx. 5 x 4.5 m, 5 x 3.5 m and 4 x 3.5 m, as well as other posthole alignments suggesting drying racks or similar structures. Several obsidian flakes, primarily from Great Barrier Island and Mayor Island, and one obsidian core from Hahei, were recovered, along with chert flakes, a drill, point and a flake off an adze. The shell assemblage was dominated by tuangi with other,

mostly soft shore, species also present. Charcoal was primarily broadleaf trees with some matai, indicating extensive forest clearance in the vicinity by the time the site was occupied. Radiocarbon dates indicated a series of occupations in the 16th century, although one isolated firescoop around 10 m south of the main site dated to the 14th century, indicating sparse use of the landscape from an early date.

R11/2915 at Landing 2B was a sparse shell midden, primarily tuangi (*Austrovenus stutchburyi*) that dated to AD 1488–1679 (Farley and Clough 2014). To the west of Landing 2B, in Precinct C, considerably more complex archaeology was found along the banks of the Oruarangi Creek, although only interim reports are currently available for these investigations (Farley et al. 2015, 2017). R11/2978 was a midden including two postholes, three firescoops and a small pit. R11/3055 had been truncated by ploughing but a pattern of shallow postholes indicated a small structure or whare, another set of postholes may have been a shelter, perhaps a whare kai close to a set of firescoops, and other alignments suggested drying racks.

The largest site at Precinct C was R11/2940, which was also truncated by ploughing. This site contained several whare and associated storage pits, some with external drains, several firescoops, patches of midden and postholes indicating smaller structures within an extensive palisade. The site is interpreted as a village (Farley et al. 2017: 38). More than 800 features were recorded.

Three smaller middens with associated postholes and small pits were also found at Precinct C: R11/3011, 3012 and 3056. These sites await further analysis and radiocarbon dating, so their potential relationships to the NRD site and Timberly Road remain unclear.

At Taxiway Mike and Remote Stands, five fairly small and simple middens were recorded (R11/3250, 3267, 3268, 3269 and 3270) although recorded sites R11/1792 and 1793 were not relocated (Farley 2021a). R11/3270 was the most extensive of these, containing two firescoops. Midden was dominated by tuangi, with pipi (*Paphies australis*), oyster (Ostreidae) and cat's eye (*Lunella smaragda*) also present. Small fishbone assemblages were dominated by piper (ihi, *Hyporhamphus ihi*) vertebrae by number, although small numbers of snapper and mackerel (hāture, *Trachurus* sp.) would have represented more meat weight. Four sites were dated: R11/3268 and 3270 dated to early the 16th to late 18th centuries, while R11/3250 and 3269 dated to the mid-17th to 20th centuries (they are unlikely to be as late as the 20th century but could conceivably date to the 19th century) (Farley 2021a).

Five new sites were also investigated at the Park and Ride South (Farley 2021b). R11/3289 was three isolated firescoops and a posthole alignment forming a possible windbreak. R11/3290 was a midden containing four firescoops. R11/3291 was a midden with seven firescoops, a posthole alignment forming a possible windbreak and an area of burning with postholes at each corner forming a possible small house or similar structure. Midden was dominated by tuangi with other species in low numbers. R11/3290 was dated to the early 16th to mid-17th centuries. R11/3292 was a European rubbish dump containing a typical late 19th century deposit of glass, ceramics and metal.

Summary

Although the analysis and dating of several sites have not yet been reported, there is evidence that people spread out over the landscape from an early date even if their use of it remained at a low level for many years. The main occupations date to the 16th–18th centuries and provide evidence of habitation in the form of housing; exploitation of the local environment in the form of middens containing primarily shell as well as fish and bird bone, though the latter are only reported so far from the NRD site; indirect evidence of gardening in the form of kumara storage pits but no direct evidence of gardened soils despite the fertility of local soils; wider relationships with other groups throughout the upper North Island in the

form of imported stone; and evidence of ritual in the form of burying of the dead and associated feasting.

Future research should focus on the wider Ihumatao landscape and the interrelationships between the excavated sites, both across time and space.

Historic European occupation

The Tautauroa / Ihumatao area was granted to European settlers in the early 1850s. Several sites dating to this period have already been investigated: R11/2274, the Westney House (Campbell and Furey 2007); R11/2334, the Westney Methodist Denominational Graveyard (Best and Furey 2006); R11/3258 (Furey 2011); and R11 2570, the Gibson House (Campbell et al. 2021); along with R11/2347, Abbeville (Harris 2011) on Nixon Road. These investigations have opened up a window into life in this settler community (Campbell and Furey 2013). Of these, only the Gibson House is directly within the runway designation.

Methodology

Between 27 July and 2 August 2022, 17 trenches were opened in and around the proposed runway footprint, in areas likely to contain archaeological material. Trench locations were selected by Matthew Campbell of CFG Heritage and Sarah Phear of HNZPT to target recorded coastal archaeological sites, the upper and lower stream gullies, coastal zones and the wider landscape, excluding areas previously investigated, R11/859 and areas of interest highlighted by the GPR survey. Trenches 15–17 were located adjacent to the recorded extent of R11/847 and avoided areas identified by the GPR study as areas of interest.

Topsoil was removed by a 5.5 tonne hydraulic excavator using a 1400 mm flat-edged bucket to just below the base of the plough zone, exposing any in-situ features to determine their condition and the extent of site disturbance. Any features identified were left intact, recorded, and photographed. The location of trenches and features were mapped using an electronic theodolite and entered the project GIS. The excavator was operated by Willie Hetareka of Dempsey Wood, with cultural monitoring by kaitiaki Nigel Denny of Te Ākitai Waiohua. Archaeological monitoring and recording were carried out by Matthew Campbell, Hayley Glover and Leela Moses of CFG Heritage. All trenches were backfilled after excavation.

Results

A total of 17 trenches were excavated. Ground conditions were wet with recent record rainfalls. The paddocks were stocked with yearling heifers, and in the wet conditions cattle pugging extended up to 100 mm into the soil, and most of the area had been ploughed, often to the full depth of the topsoil.

Trench 1

R11/2773 was visible on the surface as a shell scatter over 95 x 65 m in the grazed paddock that had previously been cultivated for salad greens. Trench 1 was oriented north-south through the middle of the visible shell scatter, and was 30 m long. A 200 mm deep, organic-rich, dark brown topsoil overlay a silty clay yellow-brown subsoil. Disturbed and fragmented midden was mixed throughout the topsoil layer. Midden consisted largely of tuangi, pipi, whelk and oyster, with some fire cracked rock. Five features were recorded cutting into the subsoil: four fire features (Features 1, 3, 4 and 5) and one posthole (Feature 2) (Figures

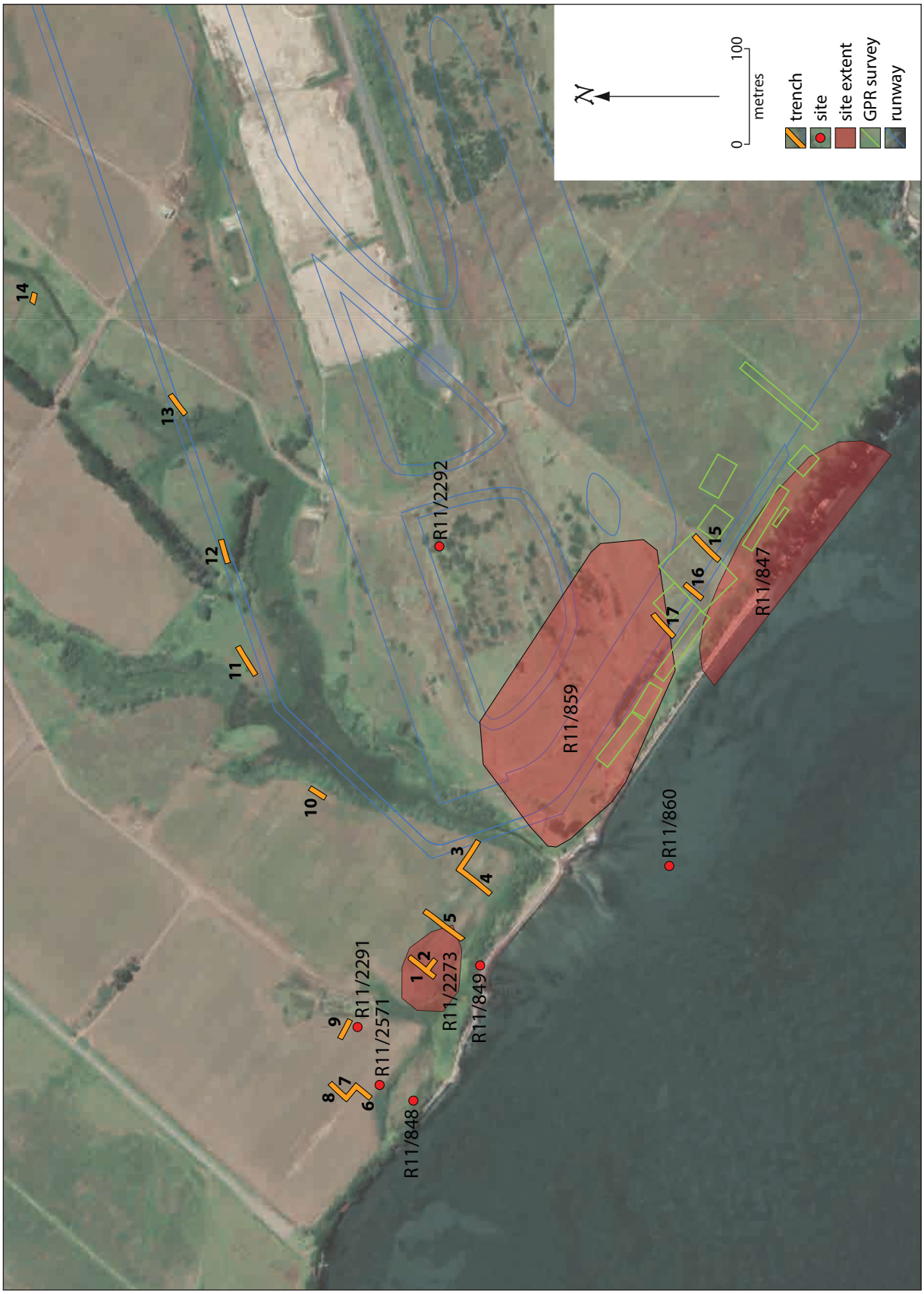

Figure 2. Trench locations.

3 and 4). The wider subsurface scatter was also recorded as Feature 6. The subsoil in the southern 20 meters of the trench was cut by regular plough lines containing crushed midden (Figure 5).

Trench 2

Trench 2 extended at right angles to Trench 1, and was 8 m long. As in Trench 1, Trench 2 contained a 200 mm deep, organic-rich, dark brown topsoil over an orange-brown silty clay subsoil. The western 3 m of the trench was cut by regular plough lines containing crushed midden, with no midden visible beyond this point (Figure 5).

Trenches 3 and 4

Trenches 3 and 4 ran at right angles to each other, with Trench 3 running 35 m west uphill from the stream, and Trench 4 turning towards the coast for 40 m. These trenches were not associated with any recorded archaeological site. These trenches contained a 150–300 mm deep dark brown topsoil overlying a yellow-brown clay subsoil. Plough lines were visible across their extents, running roughly parallel with Trench 3. No archaeological material was identified in these trenches (Figure 5).

Trench 5

Trench 5 ran 46 m uphill from the coast, onto the flat. It contained a 250 mm deep dark brown topsoil overlying an orange-brown clay subsoil. Plough lines running across to the trench were visible in this subsoil, containing very infrequent fragments of shell (Figure 6).

Trenches 6, 7 and 8

Trenches 6, 7 and 8 are connected in a Z pattern, 18, 17 and 21 m long respectively, placed to examine the visible extents of R11/2571. These trenches contained a 250 mm deep dark brown topsoil over a loamy orange-brown clay subsoil. The lower portions of Trench 6, contained sparse and highly fragmented tuangi midden, with little to no material in Trenches 7 and 8. Plough lines were visible cutting the subsoil across all 3 trenches (Figure 7).

Trench 9

Trench 9 was located to examine the visible extents of R11/2291, and contained a 250 mm deep dark brown topsoil over an orange-brown clay subsoil with no evidence of archaeological material. One small cluster of rock and charcoal was interpreted as modern vegetation burn-off. Plough lines cutting the subsoil were visible running diagonally throughout the trench. No archaeological material was identified in this trench (Figure 8).

Trench 10

Trench 10 was 15 m long, aligned across a high point overlooking the stream, and not associated with a recorded archaeological site. It contained a 250 mm deep dark brown topsoil overlying an orange-brown mottled clay subsoil, with occasional rock inclusions. Only a few irregular perpendicular plough lines were visible cutting the subsoil. No archaeological material was identified in this trench (Figure 9).

Figure 3. Features 1, 2 and 3 in Trench 1. Photo scale = 1 m.

Figure 4. Plan of Trench 1.

Figure 5. Feature 5 in the foreground with plough lines extending into Trench 2. Photo scale = 0.5 m.

Figure 6. Trench 4, with water seeping in.

Figure 7. Trench 5.

Figure 8. Trench 7.

Figure 9. Trench 9.

Figure 10. Trench 10.

Figure 11. Trench 11.

Figure 12. Trench 12.

Figure 13. Trench 13.

Trench 11

Trench 11 was 32 m long, located on a small spur between two arms of the stream and sloping towards it, and not associated with a recorded archaeological site. It contained a 200 mm deep dark brown topsoil overlying orange-brown mottled clay subsoil, with visible plough lines cutting the subsoil. At the interface between the topsoil and subsoil was modern material including plastic and a steel pipe, indicating modern soil disturbance. One small scatter of charcoal and burnt clay visible in the subsoil was interpreted as modern vegetation burn-off. No archaeological material was identified in this trench (Figure 10).

Trench 12

Trench 12 was 22 m long, located on a small spur between two arms of the stream but set back from it due to vegetation, and not associated with a recorded archaeological site. It contained a 200–250 mm deep dark brown topsoil overlying an orange-brown clay subsoil, with no clear or regular plough lines. No archaeological material was identified in this trench (Figure 11).

Trench 13

Trench 13 was 22 m long, sloping towards the steam and not associated with a recorded archaeological site. It contained 250 mm deep dark brown topsoil overlying an orange-brown clay subsoil, with no clear or regular plough lines. No archaeological material was identified in this trench (Figure 12).

Figure 14. Trench 14.

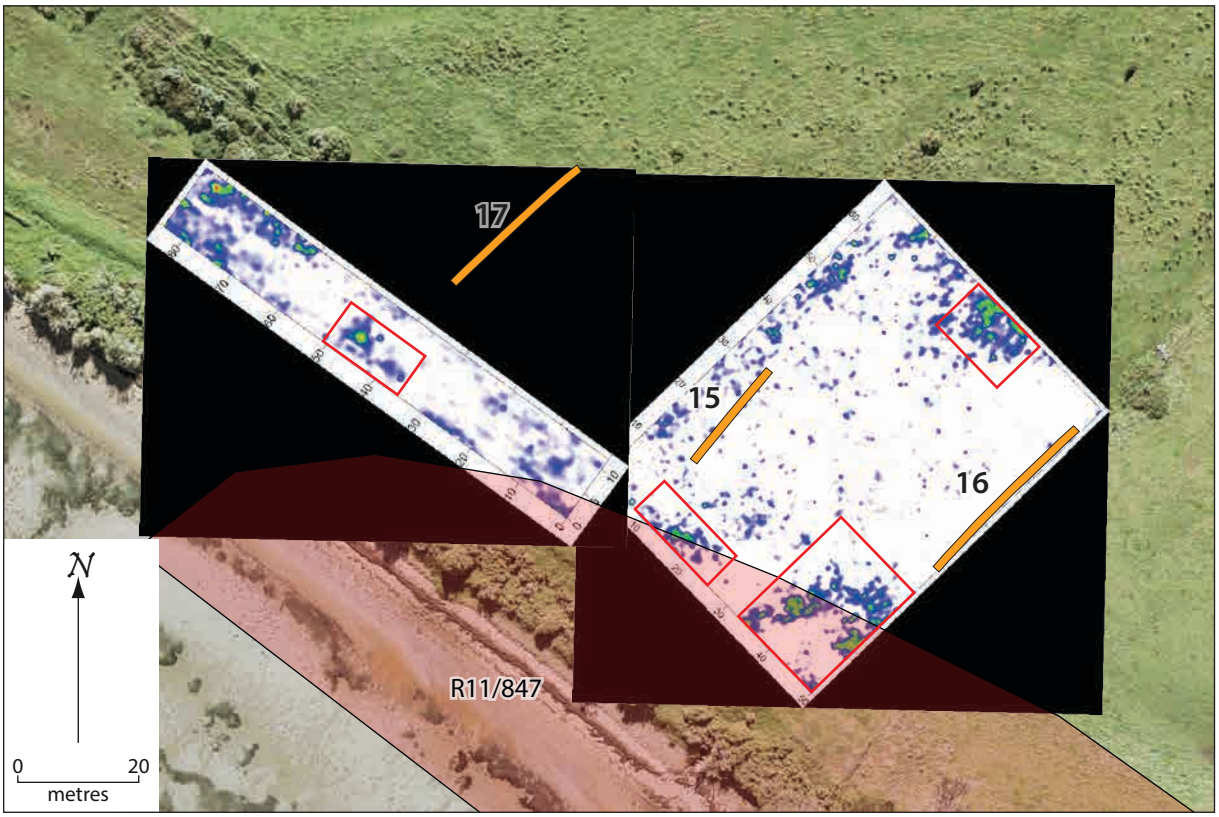

Figure 15. Trenches 15, 16 and 17 and the areas of interest highlighted by the GPR survey with GPR results.

Figure 16. Trenches 15, 16 and 17 and the areas of interest highlighted by the GPR survey.

Figure 17. Trench 15.

Figure 18. Feature 10, Trench 16.

Trench 14

Trench 14 was 7 m long, sloping towards the steam and not associated with a recorded archaeological site. It was dug through highly disturbed fills, with a 250–300 mm deep dark brown topsoil over a deep mixed fill consisting of a mottled yellow-brown and grey-brown clay matrix with large amounts of concrete blocks, bricks, metal pipe and irrigation material. The up-slope portion of the trench had a clean yellow clay cap separating the topsoil and mix fill. This trench was abandoned due to high levels of modern debris (Figure 13).

Trenches 15, 16 and 17

Trenches 15, 16 and 17 were located to avoid areas of interest highlighted by the GPR survey associated with R11/847. It was assumed that the GPR survey had accurately located the densest midden deposit, and trenching concentrated on determining the extent and survival of the middens outside the identified areas of interest (Figures 14 and 15).

Trench 15 runs 20 m upslope from the coast, cutting through midden site R11/847 which is visible as occasional tuangi fragments on the surface. Trench 15 revealed a 150–200 mm deep dark brown topsoil overlying an orange-brown clay subsoil. The downslope five meters of trench contained regular but low density fragmented and disturbed midden, consisting of oyster, tuangi and scallop, concentrated in the lower 50 mm of topsoil. A small patch of seemingly undisturbed midden was recorded as Feature 8 and the extent of disturbed midden was recorded as Feature 7 (Figure 16).

Trench 16 runs 33 m upslope from the coast, cutting through R11/847 with visible surface midden scatter. The trench contained a 250 mm deep dark brown topsoil over an orange-

brown clay subsoil. Trench 16 contained much more midden in the topsoil than Trench 15, though still concentrated in the lower 50 mm of topsoil. The midden largely consisted of whelk and scallop, with consistent regular density across most of the extent of the trench, thinning out in the upslope five meters, and was recorded as a feature. The soils in this upper 5 m were very damp and soft. Trench 16 also contained two postholes cutting into the subsoil (Features 10 and 11) (Figure 18).

Trench 17 extends 28 m uphill from the coast, cutting through R11/847. The topsoil was organic-rich and shallow downslope, deepening upslope from 200mm to 420mm. Infrequent, occasional discrete lensesof fragmented and disturbed midden occurred throughout the topsoil. One small obsidian flake was noted in topsoil halfway along the trench, likely from a Coromandel Volcanic Zone source (which includes Te Ahumatā on Aotea / Great Barrier Island) and not associated with any midden lens. Modern ground disturbance was indicated by irrigation pipes and shotgun casings in the topsoil layer.

Conclusion

The stated purpose of the Section 56 investigation was to:

1 characterise the nature and extent of sites that will be affected by runway construction through a controlled, minimally invasive investigation;
2 inform the Research Strategy for full excavation;
3 provide assurance regarding the potential significance of the sites and the possible presence of koiwi.

The nature and extent of the sites

Although the area has been disturbed by stock and ploughing, archaeological features survive intact beneath the plough zone. R11/2273,R11 /2291 and R11/2571 in particular have been disturbed by regular (several times in a season) cultivation for salad greens for many years (they are currently in grazed paddock), and this will have had a cumulative effect on them. R11/847 appears to be less disturbed. Identified features include midden, postholes and fire scoops, all associated with previously recorded midden sites. While most of the midden was in the plough zone and very little undisturbed midden was found, deep shell deposits of R11/847 are visible in the coastal bank, and the GPR survey indicated that dense deposits remain in the paddock behind the coastal bank. It is probable that other patches of midden will survive beneath the plough zone for all sites investigated. Further truncated deeper features like the firescoops and postholes found in Trenches 1 and 16 will also be present, and stone tools such as formal taonga or simple flakes like the one found in Trench 17 may also be present.

Research strategy

While a comprehensive research strategy, informed by this investigation, will be developed in conjunction with the Archaeological Works Plan to accompany the authority application for a full investigation, this investigation has clarified several points that will become a focus of research:

- What is the nature and origin of the disturbance to the sites?
- What are the undisturbed extents of the sites?
- How do the sites relate to the NRD site R11/859 and other extensive sites along the Manukau coast and in The Landing complex?
- How do the sites relate to the wider South Auckland archaeological landscape?

Significance

The values and significance of the sites have been diminished by the extent of damage from ploughing – they can be assessed as having moderate significance, while their primary values will lie in their potential to provide information complementing our current understanding of local occupation and archaeological landscapes at varying scales.

- Note that this report makes no statement about cultural significance, which is a matter for mana whenua.

No kōiwi were encountered in the investigated sites although there is a low probability of encountering kōiwi during future works. At the NRD site R11/859 the two burial areas appeared to be discrete and were fully excavated although there remains a low probability of encountering kōiwi in the area during future works.

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VIRTUSHERITAGE

Auckland Airport NRD Ground Penetrating-Radar Investigations

Mangere, Auckland

Prepared for CFG on behalf of Auckland Airport

FINAL ♦ July 2022

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Final	27/07/2022	E. St Pierre		

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Cover Photo: GPR data collection of Grid 7

EXECUTIVE SUMMARY

Virtus Heritage was engaged by CFG on behalf of the Auckland International Airport to conduct ground-penetrating radar (GPR) investigations for the identification of potential archaeological deposits in the Northern Runway Development (NRD) Area (refer to **Figure 1**).

The GPR survey was undertaken between 3 to 13 May 2022 and 12 grids were surveyed covering over a 1ha area and producing over 24.5km of radar profiles. Due to the size of the dataset a detailed analysis of each profile was not undertaken. An approach was employed whereby amplitude maps were used to target areas of high potential for more detailed profile analysis and also sample profiles were viewed for areas with no indicators in the amplitude maps. This approach was determined to be appropriate for this study, particularly in areas where there was known recent disturbance, and other grids of low archaeological potential.

Overall, the GPR data from the NRD was 'noisy', complicating data analysis and interpretation. Despite this the following conclusions were made. No archaeological deposits or features were identified within Grids 1-5 in the western field. The GPR data from these grids did demonstrate impacts from more recent agricultural and pastoral activities such as compaction from heavy machinery and digging/ploughing, and construction of farming infrastructure, such as fencing. The GPR analysis does not exclude the potential for archaeology in this area, particularly low-density midden in disturbed contexts, however it is unlikely that archaeological features indicating occupation sites are located in these grids.

Like the grids in the eastern field, GPR data from the grids in the western field also demonstrated impacts from agricultural and pastoral activities. Grids 6, 9, 10 also has evidence of extensive impacts from the recent NRD earthworks and excavations., and very little in the way of archaeology likely remains in these areas.

Grid 7 appears to have largely escaped the impacts of the NRD earthworks, and several potential archaeological features were identified within this grid including a *potential* house or other living surface along with *potential* postholes, pits and midden. Midden is eroding from surface deposits at the southern end of the grid and the grid is partially located within landforms of high archaeological potential including the beach terrace and upper slopes adjacent the now modified bluff.

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FIGURES

APPENDICES

1. INTRODUCTION

Virtus Heritage Pty Limited (hereafter, "Virtus Heritage") was engaged by CFG Heritage on behalf of the Auckland International Airport to undertake ground-penetrating radar (GPR) investigations of targeted areas within the Northern Runway Development (NRD) Area (**Figure 1**). The primary objective of the investigations was to determine whether potential archaeological features, including burials, could be identified with GPR in the targeted areas.

The GPR survey of the Auckland International Airport NRD Area was undertaken between 3 to 13 May 2022. This report provides a brief environmental and archaeological context, description of the GPR method, survey and analysis and the results of the GPR investigations including interpretation of GPR data in relation to the known environmental and archaeological record of the area.

1.1 Project Team and Acknowledgements

This report was prepared by Dr Emma St Pierre (Principal Archaeologist, Virtus Heritage; BA Hons. Archaeology and Anthropology, University of Queensland; PhD Archaeological Science, University of Queensland) with assistance from Elle Lillis (Principal Archaeologist, Virtus Heritage; BA University of Newcastle; M Arch Sci, Australian National University). Assistance with interpretation and peer review was undertaken by Prof. Lawrence Conyers (University of Denver, Colorado, USA). GPR data collection was undertaken by Dr Emma St Pierre with assistance from Elle Lillis, Nigel Denny (Te Ākitai), Brendan Kneebone (CFG Heritage) and Kirstin Roth (CFG Heritage). Brendan Kneebone conducted DGPS survey of grids and features. Special thanks to Mat Campbell and Nigel Denny for site familiarisation.

Figure 1
295 Auckland Airport
GPR Data Collection
Locality

Legend

Study Area

Inset:

GPR Collection Grid

Source:Land Information New Zealand.
Projection: NZGD2000

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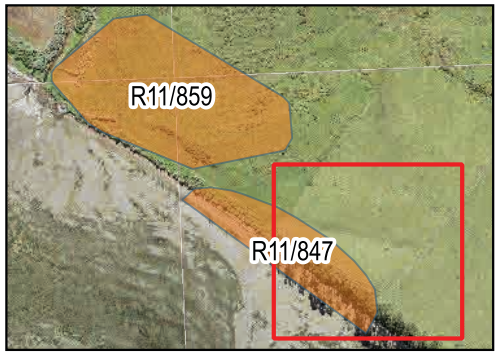
Figure 2
295 Auckland Airport
GPR Data Collection
East

Legend

GPR Collection Grid

Inset:
ArchSite



GR7
GR2
GR5
GR1A
GR1B
GR4B
GR4A
GR3

N

0 20 40 60 80 100 m

Source:Land Information New Zealand; CFG Layout 4.
Projection: NZGD2000

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Figure 3
295 Auckland Airport
GPR Data Collection
West

Legend

GPR Collection Grid

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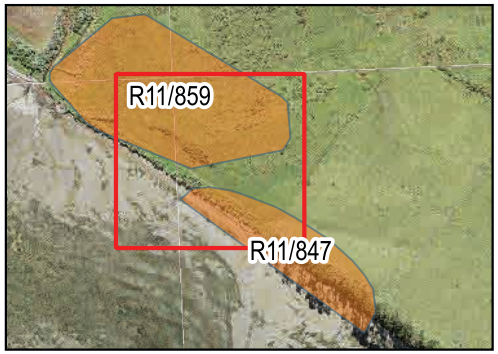
ArchSite



Source:Land Information New Zealand; CFG Layout 4.
Projection: NZGD2000

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GR9
GR10
GR6
GR8
GR7
GR2
GR1A

N

0 20 40 60 80 100 m

2. ENVIRONMENTAL AND ARCHAEOLOGICAL CONTEXT

2.1 Environment and Land Use

The topography of the study area locality is low and gently rolling, becoming steeper to the southeast, and is bisected by shallow gullies draining west. The study area is located on a beach terrace, eroding bluff, and slopes on the Manukau Harbour. The western extent of the study area (comprising GPR Grids 6, 7, 9 and 10) is located along the beach terrace, while the eastern grids (GPR Grids 1 to 5) are located on the bluff, situated on slopes and crests surrounding a natural drainage line. Grid 8 and the northern area of Grid 7 are located on the lower slope of the modified bluff above the beach terrace, and adjacent to a second drainage line (refer to **Figure 4**).

The geology of the study area locality comprises early quaternary alluvium and colluvium, described as 'alluvial and colluvial gravel, sand and mud, commonly pumice-rich in central areas, with intercalated lignite or peat; locally includes non-welded ignimbrite and tephra, and, in the south and east, loess' (Edbrooke et al. 2014). Soils in the study area are volcanic, derived from the adjacent volcano Maungataketake, overlying alluvium originating in the volcanic Central Plateau of The North Island and transported by the Waikato River when it flowed to the sea through the Manukau (Ballance 1993:9 in CFG Heritage 2011:4). Geotechnical testing of the bluff above the beach terrace indicated topsoils of 250-300mm depth overlying deep (2-3m) clays derived from Maungataketake tephras on alluvial silts and sands. This stratigraphy is visible in the eroding bluff face in the southeast of the project area (refer to **Plate 1**, **Appendix A**) (CFG Heritage 2011:4). CFG Heritage (2011:4) noted that these soils were stone free, in contrast to the soils further north and west. While geotechnical tests were not undertaken on the beach terrace landform, during archaeological investigations in this area, CFG Heritage (2011:4) observed sands of alluvial and aeolian origin consisting of a thin dark sand topsoil overlying a light, free draining, yellow-brown sand.

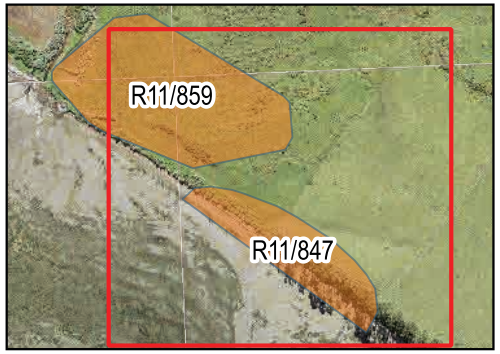
CFG Heritage (2011:4) concluded that the study area soils, while fertile, were less suited to pre-European horticulture, but also that archaeological evidence of such activity is also less likely to survive in these soils. Historic land use in the study area, visible in aerial imagery since 1939 (refer to **Figure 5**), does include European farming practices, including cropping and pasture for stock grazing. CFG Heritage (2011:5) note nearby market garden use, and market gardening or other intensive horticultural use (vine crops) is visible adjacent to Grids 7 and 8 in the 1983 aerial imagery (refer to **Figure 6**). A small structure close to the shoreline, which may be a boathouse, is visible adjacent to Grid 7 in the 1960 aerial imagery (refer to **Figure 7**). Fencing and vehicle tracks associated with farming activities have also been constructed across the study area. At the time of the GPR survey the western field of the study area was being grazed by cattle and the eastern field had been recently harvested for hay.

Figure 4
295 Auckland Airport
GPR Data Collection
Contour Map

Legend

GPR Collection Grid

Inset:
ArchSite



Source:Land Information New Zealand; CFG Layout 4; LINZ 8278_C_3.

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GR9
GR10
GR8
GR6
GR7
GR2
GR5
GR1A
GR1B
GR3
GR4A
GR4B

N

0 50 100 150 200 250 m

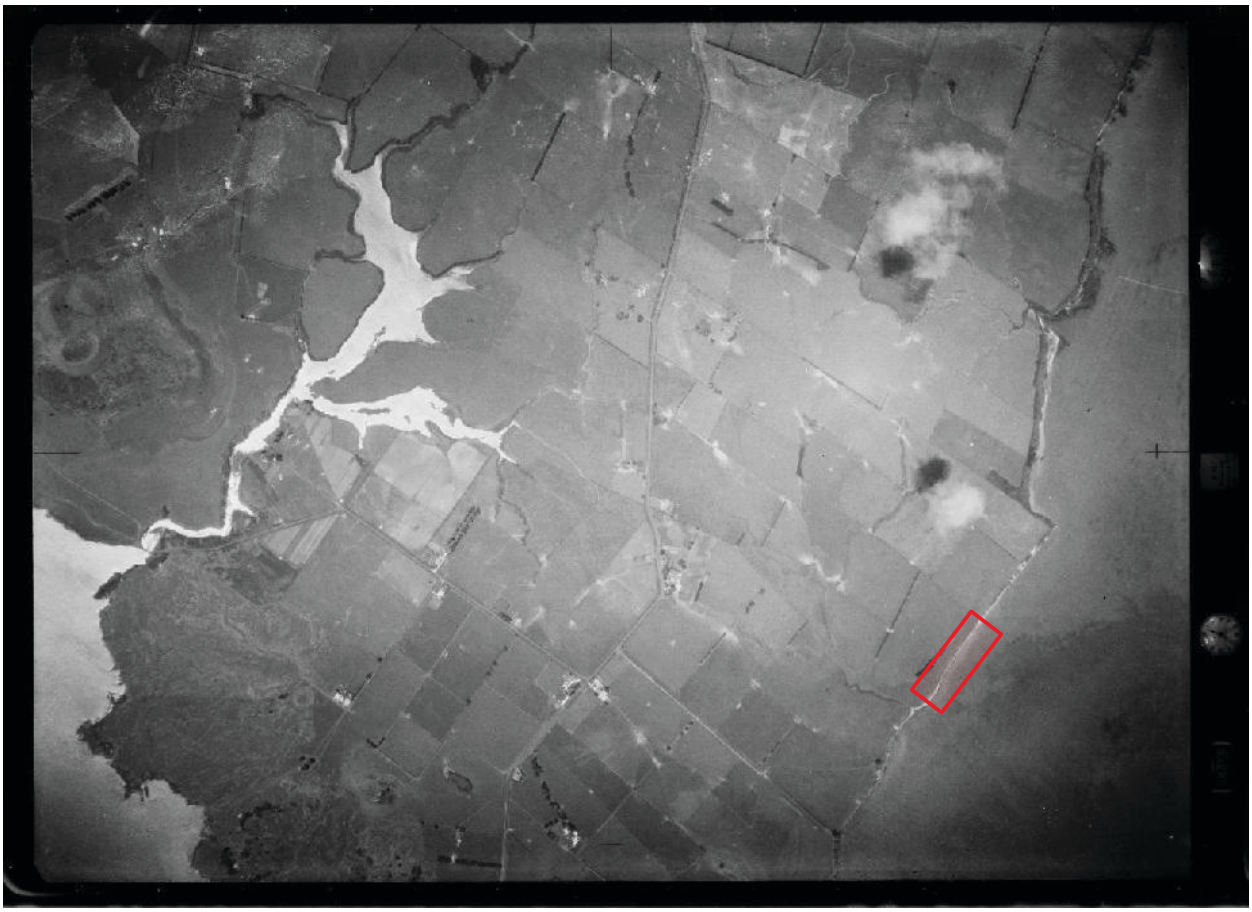


Figure 5. Aerial imagery 1939, showing extensive European farming practices in the study area locality (study area shown in red).

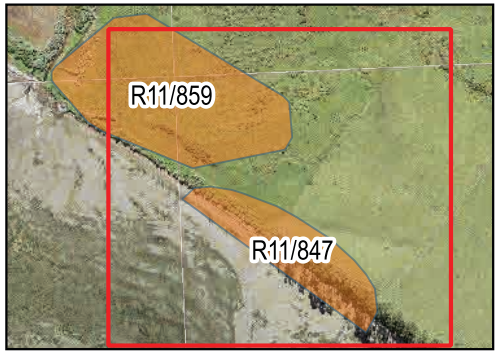
Archaeological excavations in 2008-2009 included extensive ground disturbance through mechanical and manual excavation. Auckland Airport subsequently carried out extensive earthworks for the NRD (refer to **Figure 8**) (CFG Heritage 2011:1). The landform on which part of Girds 7 and 8 are situated has been significantly altered by earthworks associated with the NRD, and Grids 6, 9 and 10 are located on the beach terrace partially subject to archaeological excavations as well as NRD earthworks (refer to **Figure 9**) (CFG Heritage 2011:25).

Figure 6
295 Auckland Airport
GPR Data Collection
1983 Aerial

Legend

GPR Collection Grid

Inset:
ArchSite



Source:Land Information New Zealand; CFG Layout 4; LINZ 8278_C_3.

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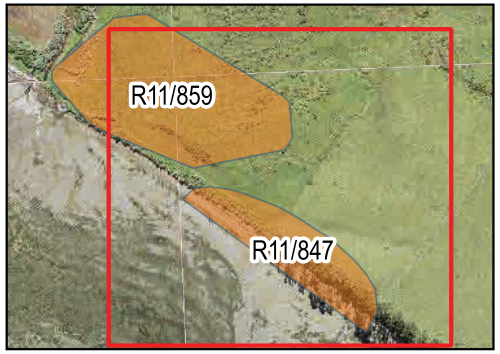
Figure 7
295 Auckland Airport
GPR Data Collection
1960 Aerial

Legend

GPR Collection Grid

Inset:
ArchSite



Source:Land Information New Zealand; CFG Layout 4; LINZ 8278_C_3.

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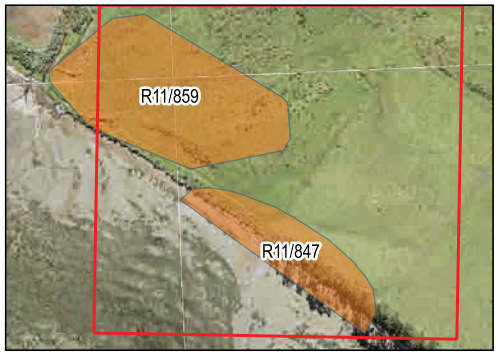
Figure 8
295 Auckland Airport
GPR Data Collection
Earthworks Disturbance Aerials 2007-2017

Legend

GPR Collection Grid

Inset:
ArchSite

0 50 100 150 200 250 m



Source:Land Information New Zealand; CFG Layout 4; Google Earth Imagery September 2007 (Google Earth 2022 Maxar Technologies); Google Earth Imagery February 2008 (Google Earth 2022 Maxar Technologies; Auckland International Airport Ltd); Google Earth Imagery March 2009 (Google Earth 2022)
Projection: NZGD2000

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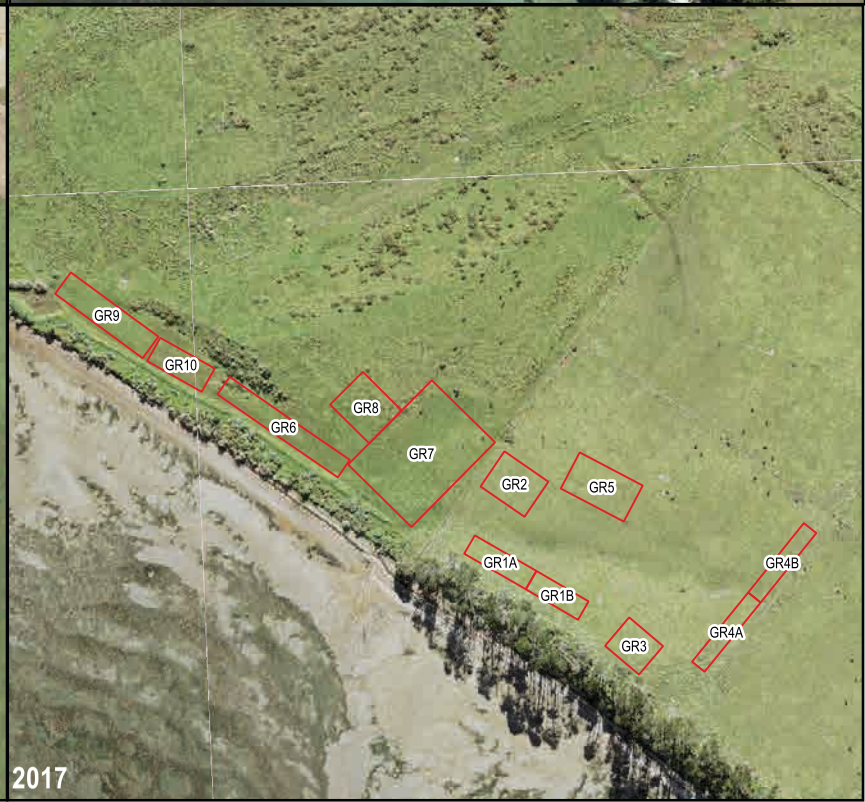


2.2 Archaeological Context

Archaeological excavations were undertaken at the NRD site in 2008-2009 and are presented in full in CFG 2011, and information relevant to the GPR survey is summarised from that report here. Nine areas with archaeological features were identified on the beach terrace (GPR Grids 6, 7, 9 and 10), the bluff above the beach terrace, and the slopes of the bluff (GPR Grids 7 and 8). Topsoil was removed with grader scrapes or hydraulic excavator and were monitored for archaeological deposits. In areas where archaeological material/features were identified, a hydraulic excavator was used to expose the whole deposit and features were excavated manually (CFG Heritage 2011:21).

It was noted that in general the midden was shallow and had been ploughed to its full depth, therefore destroying stratigraphic relationships between features within the midden, however, midden did extend beneath the plough zone to a depth of 50cm in some areas (CFG Heritage 2011:21). Sand topsoil on the beach terrace was generally no more than 15cm deep. Below this was a brown sandy B-horizon into which the archaeological features were cut (CFG Heritage 2011:23). The layer below this, which was evident in some of the deeper features, consisted of a coarser, yellow-brown, sandy pumiceous soil containing fine gravels and occasionally small stones and, close to the beach, natural shell deposits (CFG Heritage 2011:23-24). Soils on the top of the bluff are stone free, red brown volcanic loams (CFG Heritage 2011:48).

Based on the 2008-2009 excavations there are several archaeological elements that may be visible in GPR data. These include:

- ***Earth ovens*** ranged in size, with some up to 270cm diameter, but generally between 30-100cm. Earth ovens may identifiable in the GPR data possibly as high amplitude reflections from baked bottoms producing hard surfaces, and possibly also incisions, though these may be difficult to identify.
- ***Postholes/stakeholes*** range in size, with smaller stake holes approximately 5-6cm in diameter, and post holes averaging 15-20cm in diameter but sometimes 30cm or more in diameter. Stake/postholes smaller than 25cm will not be visible in the GPR data. It is possible that larger postholes may be detected in the GPR data under the right conditions, however these are still very difficult to detect due to their small size and subtlety.
- ***Shell midden*** was detected as a relatively shallow layer in the upper deposits of the study area. Excavations indicated that it was rarely found deeper than approximately 50cm but generally no more than 30cm, and was almost always disturbed by the plough zone. Shell midden can also be difficult to detect or define with GPR, particularly where midden material is of low density. Where is does show in GPR data, it is often with distinct base horizons overlain by many small reflections from larger shells, stone or other items within the feature.
- ***Pits*** were found extensively in a number of the excavated areas. These included distinct Rua Kopiha, round straight sided pits which were used for multiple functions including storage and burial. Rectangular pits, some with drainage holes and associated trenches, were generally used for storage, and were of various size and depth, with the largest being between approximately 4m x 2m and up to half a metre deep. Where pits are visible in the GPR data they will show as incisions through stratigraphic layers, and generally in association with other features.
- ***Houses or other shelters/structures*** were identified during excavations of the NRD site, with the largest definitive house site approximately 570cm x 300cm. Some of these structures appeared to have porches or annexes, and were associated with other features including postholes, ovens and

pits. Archaeologically, the footprint of a house/structure is defined by rows of postholes and sometimes footing trenches. House or other structure platforms are likely to show in GPR data as compact surfaces seen has high amplitude planar reflections. As mentioned, the postholes associated with the house shelters may be difficult to identify.

- ***Burials*** were identified during excavations of the NRD site. Human and animal remains (complete and partial, primary and secondary, and individual and multiple interments) were found in a range of different features including Rua Kopiha, rectangular pits (up to 3.5m x 2.2m x 30cm deep) and shallow scoops (for example 96cm x 60cm x 20cm deep). Some of these features may have been repurposed for burial or had multiple functions. Human remains have only been directly identified with GPR in a few very rare circumstances. Rather, burials are identified by the incisions in stratigraphic profiles where the grave shaft has been excavated (in this case Rua Kopiha, pits and shallow scoops) and/or associated material culture (e.g. coffins or burial goods). Therefore, knowing the context of the burial site (e.g. village site with associated burials, as opposed to urupa or designated cemeteries), is useful to understand the types of burial features you might expect to encounter. It is very unlikely that GPR will specifically identify burials in this study due to the types of features burials are likely to be found in. Instead, it may be that an incision can be identified which could relate to being a burial, or a range of other features such as a pits or ovens.

To summarise, the archaeological features that have the most potential for identification are platforms of houses/other structures, earth ovens and pits and potentially burial scoops or grave cuts. Midden may be identifiable but given the amount of disturbance in the area due to ploughing the basal horizons of these features are likely to have been mixed and no longer detectable. Given the known archaeological stratigraphy of the area, it is also unlikely that midden will be found at depth. It is unlikely that burials will be able to be specifically identified unless their grave cuttings are distinct from other similar features. Likewise, postholes are unlikely to be identified due to their generally small size and subtlety in the archaeological record.

Figure 9
295 Auckland Airport
GPR Data Collection
Previous Excavation Features

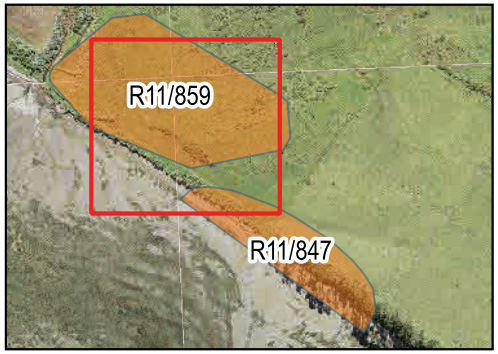
Legend

GPR Collection Grid

Archaeological Feature

Inset:

ArchSite



GR9

GR10

GR6

GR8

GR7

N

0 20 40 60 80 100 m

Source:Land Information New Zealand; CFG Layout 4, NRD Features.
Projection: NZGD2000

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3. METHODS AND LIMITATIONS

This section of the report provides a description of the GPR method, the survey strategy, analysis and project and method limitations.

3.1 Ground-Penetrating Radar

Ground-penetrating radar is a non-invasive geophysical technology which transmits electromagnetic pulses (radar waves) from surface antennas into the ground, allowing an image of the subsurface to be generated. GPR data is acquired by reflecting radar energy produced by the surface antenna, which generates energy waves of various wavelengths that propagate outwards. The waves move into the ground and can be reflected from buried objects, features, or bedding surfaces, back to the surface antenna. Some reflected radar waves will travel back to the ground surface and receiving antenna, while the remaining energy continues to spread downward and outward and can be reflected again and again from additional buried features until all the energy finally disperses with depth (called attenuation). Only the reflected energy that travels back to the surface antenna is recorded and can be interpreted. The velocity of radar energy into the ground can be calculated and reflected wave travel times (measured in nanoseconds) converted to distance (i.e. depth) (Conyers 2012: 25).

The amplitude (that is the strength) of the reflected radar waves are also important because their relative variations are directly related to changes in the physical and chemical properties of different materials in the ground. The velocity (speed) of traveling radar waves will also vary, depending on the physical and chemical properties of the materials in the ground. Accurate depths of buried features can be calculated by the measured travel times of reflections and velocities of the radar energy transmission in the ground. A hyperbola is the shape of reflections generated from "point sources" in the ground, caused by the spreading of transmitting radar energy as it moves deeper in the ground from a surface antenna. Hyperbola fitting is used to define the relative dielectric permittivity (RDP) of ground conditions. RDP is a measure of the ease with which a material is polarized by an electric field relative to vacuum of ground conditions and is used to establish the depth of energy penetration.

The GPR antennas are typically moved along lines (called survey transects) within a survey grid so that the exact location of where the reflected data were collected is known and can be plotted on a map. Distance along transects is measured using a survey wheel attached to the antennas. As the antennas are moved along the ground surface, individual reflections are recorded about every 2 to 10 cm along each parallel survey transect (normally spaced between 25-50cm apart). The structure of each reflected radar wave (called a waveform) that is received by the GPR computer system are digitised into what is called a reflection trace, which is a series of waves reflected back to one surface location from many depths in the ground.

When many traces are stacked next to each other sequentially, a two-dimensional vertical profile is produced along the survey transect which produces two-dimensional images, just like viewing layers in a vertical road-cut or excavation section. When many two-dimensional reflection profiles (each of which contain thousands of reflection traces) are collected within a grid, we can use these data to produce a variety of both two and three-dimensional images that allow us to interpret objects and features in the ground using various software. The main type of image that GPR specialists produce are amplitude maps, which are two-dimensional maps of the grid showing the different strength (amplitudes) of reflections at a variety of chosen horizontal depths.

Amplitude maps are just one step in helping interpret GPR data. The analysis of individual profiles for the interpretation of archaeological features is critical as many archaeological features may not visible in amplitude maps, or may be interpreted incorrectly based only on amplitude maps.

In relation to potential burials, in only a very few unusual cases has GPR been able to detect actual human remains. What usually indicates the presence of burials are faint differences in the natural stratigraphy of the ground where a grave shaft has been dug, and the burial goods, coffins or caskets associated with burials. If the burials are very old, the ground disturbance and/or faint reflections from burial goods may be the only direct indication of a burial.

3.2 GPR Field Survey Auckland International Airport NRD

Prior to the GPR survey for Auckland International Airport Mat Campbell (Director, CFG Heritage), did a site walk over with Virtus staff to identify areas that required survey. The GPR survey was undertaken between 3 to 13 May 2022 and 12 grids were surveyed within two fields. Seven grids (1,a, 1b, 2, 3, 4a, 4b and 5) were set up in the eastern field to identify whether the sites identified during the NRD archaeological investigations extended into this area.

GPR reflections were collected using a 400 MHz antenna, which has the ability to transmit energy to approximately 2 to 3 m depth with subsurface resolution of approximately 25 cm. A GSSI SIR-3000 system was used for data collection and data was processed using the software GPR Viewer, GPR Process, and Surfer 12 for the production of reflection profiles and amplitude maps (Conyers 2012, 2013). Profiles were collected with 50 cm spacing within grids 1-8, and 25cm spacing within grids 9-10.

Over one hectare of data was collected, equating to over 24.5km of profiles. Due to the size of the dataset a detailed analysis of each profile was not undertaken. An approach was employed whereby amplitude maps were used to target areas of high potential for more detailed profile analysis and also sample profiles were viewed for areas with no indicators in the amplitude maps. This approach was determined to be appropriate for this study, particularly in areas where there was known recent disturbance, and other grids of low archaeological potential.

Prior to GPR survey it was unknown how the radar energy would behave in relation to sediments, how deep the energy would penetrate and therefore how much information about subsurface deposits could be obtained. The RDP of deposits in the study area was approximately 10 and this measure was used to estimate the depth of energy penetration, to approximately 1.5m, with energy attenuating from this depth.

The data in all grids was 'noisy'. 'Noise' is created by un-wanted waves recorded during GPR collection, most commonly from background radio transmissions but sometimes also from internal system-generated waves, or air waves, to name a few. Additionally, the very thick and long grass in the eastern field and the remains of newly cut grass on the western field created coupling issues. Coupling of radar energy with the ground is a relative measurement how well transmitted radar waves move across the ground-air interface to propagate into the ground. Variations in coupling can be caused by the constituents of surface materials, the placement of the antenna on the ground, the amount of tilt of antennas, the distance of the antenna off the ground, and other factors. Good coupling means radar waves have moved into the ground and are being transmitted to depth. Coupling variations along an antenna transect create anomalous reflections in GPR reflection profiles and can distort GPR images.

The noise and coupling issues in all grids made analysis of individual profiles challenging, and therefore potentially masked some features that may otherwise have been identified. For this reason, there may be archaeological features that have not been identified within this report, particularly low-density midden and burials which are already very difficult to identify. However considerable efforts have been made to provide as detailed analysis as feasible based on the parameters of the data and the scope of the project.

4. RESULTS AND INTERPRETATION

This section provides the ground-penetrating radar results and interpretation for each grid.

4.1 Grids 1a and 1b

Grids 1a (43m x 12m) and 1b (34m x 12m) were collected along different axes on separate days, and profiles were collected with 50cm spacing. The grids are located on the lower slope of the southern side of a drainage line that runs roughly east-west across the eastern field and approximately 30m north of the harbour cliff face. The grids partially overlap with the estimated boundaries of site R11/847, described as a midden and terraces, although the site report indicates that the terraces are located to the west of the grid 1a, in the west field. These terraces were subsequently reassessed as being natural.

Grid 1a has a high amplitude planar reflection on its southern margin, adjacent to the fence line between the field and the harbour cliff face (refer to **Figure 10**). This high amplitude planar reflection is found between approximately 25-50cm, extending to 75cm in depth in places. This high amplitude reflection likely represents a compacted surface that is modern in origin. A number of high amplitude point source reflections are present within grids 1a and 1b, forming a 'barber pole' reflection, typical of metal. These are likely discarded, near surface metal associated with agricultural/pastoral activities (e.g. fencing material). No archaeological features were identified within these grids.

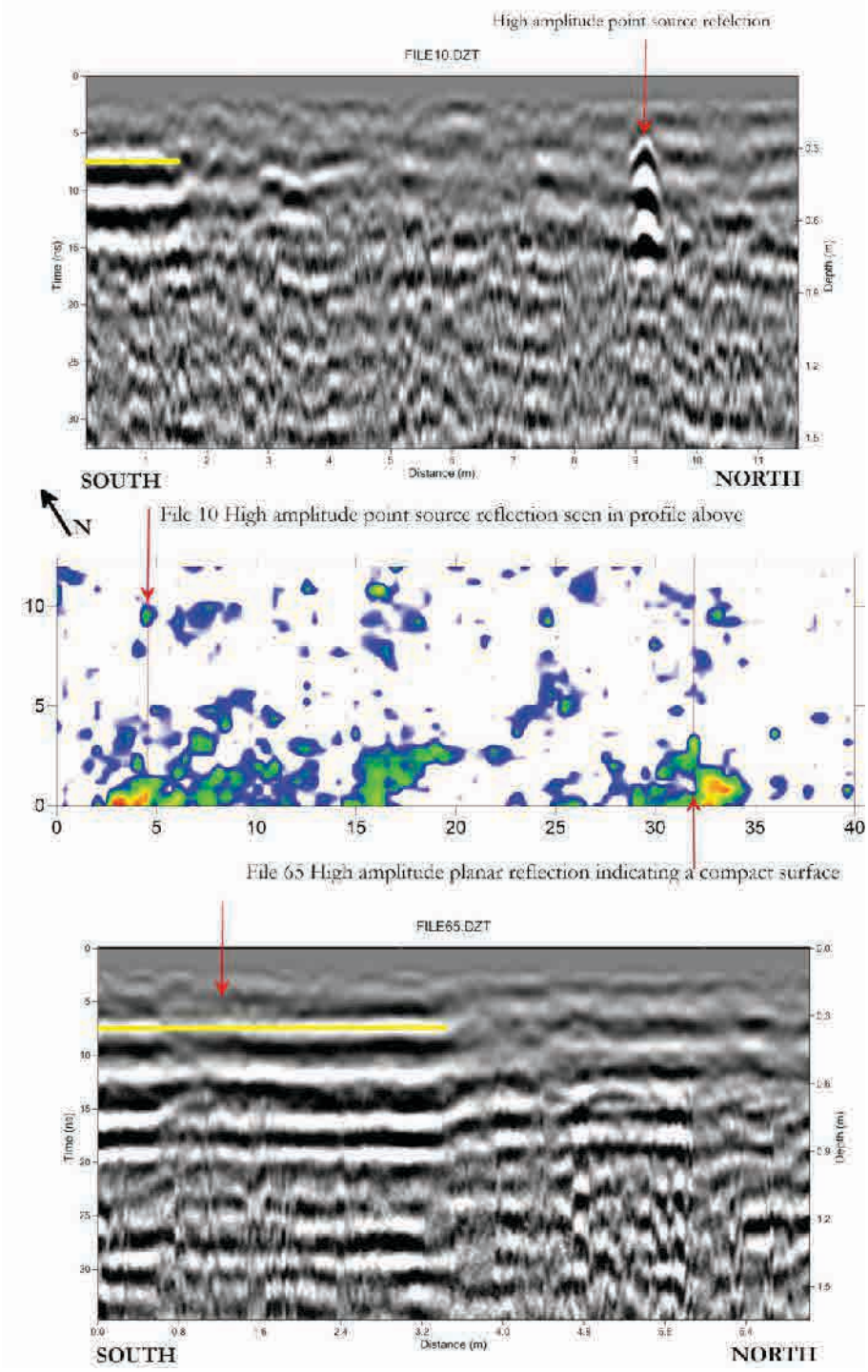


Figure 10. Grid 1a. Point source reflection in profile 10 (4.5m on x-axis) from near-surface metal. Compact surface seen as high amplitude planar reflection in profile 65 (23m on x-axis). Amplitude map represents 25-50cm in depth.

4.2 Grid 2

Grid 2 (24m x 30m) is located on a gentle slope on the northern side of the drainage line that runs roughly east-west across the eastern field (refer to **Figure 2**). The grid is adjacent to the fence bordering fields and the profiles were collected with 50cm spacing. A high amplitude reflection, approximately 3-4m wide, was identified transecting the grid north-south in the upper 0-25cm. This is almost certainly the result of vehicle movement over the field. Multiple reflections at lower depths down to 150cms are the highest amplitude reflections from the surface that are produced as the radar waves "ring" back and forth between the compaction surfaces and deeper strata (refer to **Figure 11**). No archaeological features were identified in this grid.

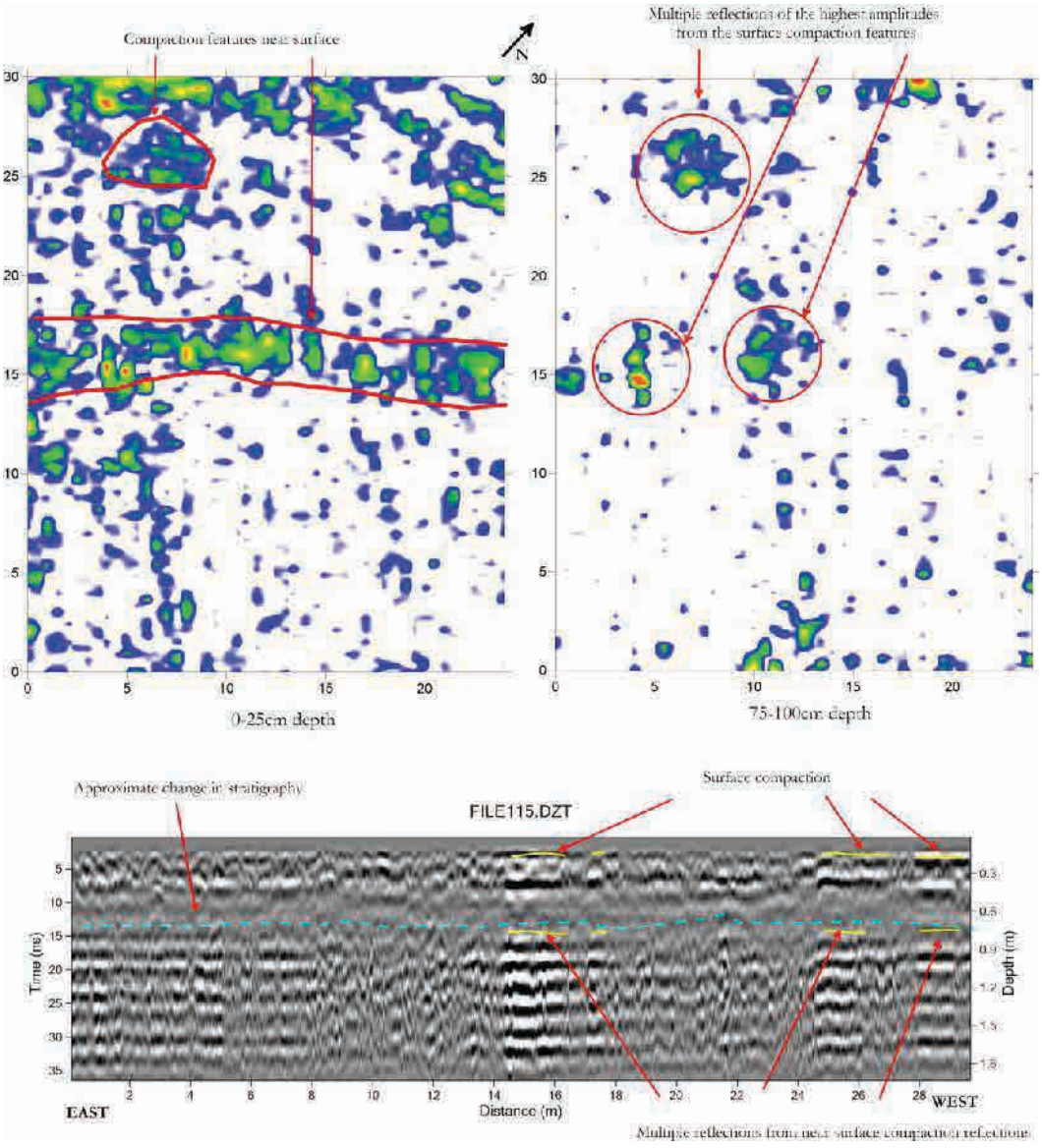


Figure 11. Grid 2. Amplitude map represents 0-25cm depth showing areas of compaction, (top left), and compaction reflecting through ground to a depth of up to 1.5m (top right). Also seen in upper deposits in profile 115 (4m on x-axis).

4.3 Grid 3

Grid 3 (21m x 25m) is located on top of the bluff on the southern side of the drainage line within the eastern field, approximately 30m north of the harbour bluff face. The grid profiles were collected with 50cm spacing. This grid has high amplitude planar reflections in the upper most deposits (0-25cm) that are likely from compaction (refer to **Figure 12**). There is evidence for disturbance on the surface and at depth, including the occasional high amplitude point source reflections from discarded metal, and much of this disturbance is likely associated with pastoral and agricultural activities. No archaeological features were identified within this grid.

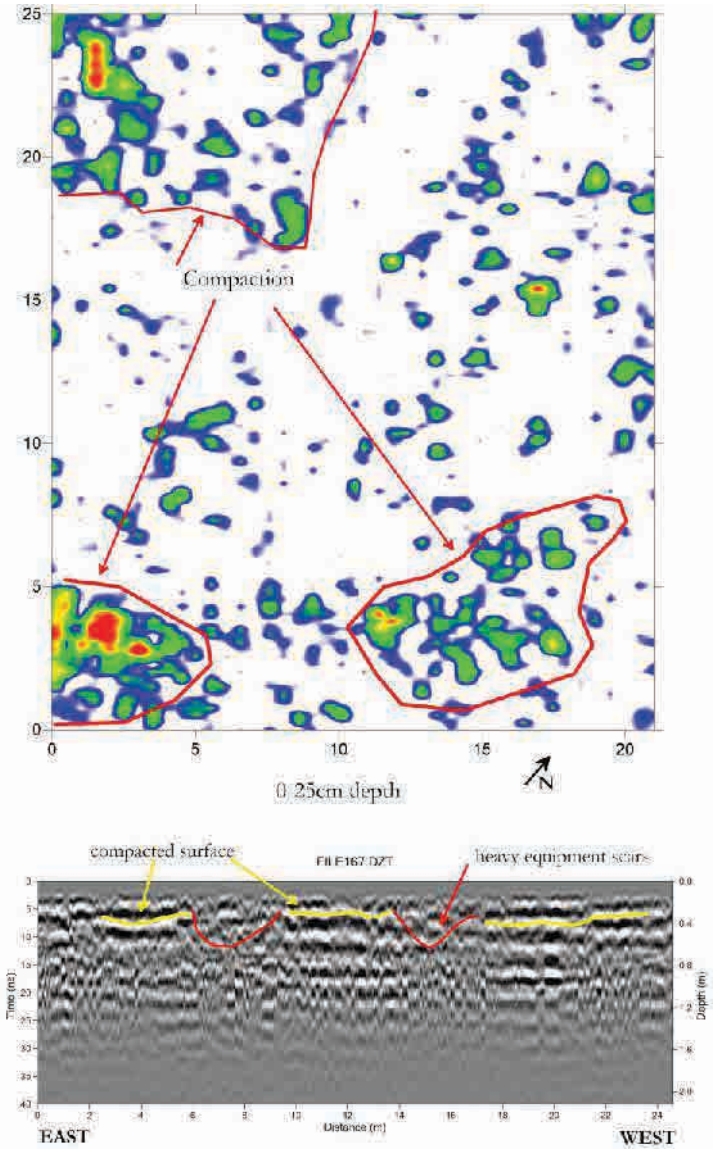


Figure 12. Grid 3. High amplitude reflections are compacted surfaces and are likely associated with heavy equipment disturbance, seen both in the amplitude map (0-25cm depth) and profile 167 (5.5m on the x-axis).

4.4 Grids 4a and 4b

Grids 4a (9m x 50m) and 4b (9m x 50m) are located along the fence line on the eastern end of the eastern field straddling the top of the drainage line. These grids were collected separately to limit the length of profiles to 50m (total grid length for a and b is a 100m). As with Grids 1, 2 and 3, recent disturbance, likely from pastoral and agricultural activities, is evident in these grids. Discarded metal, including some pieces in holes near the surface, and the remains of a post hole within a concrete base are present (refer to **Figures 13** and **14**). No archaeological features were identified within these grids.

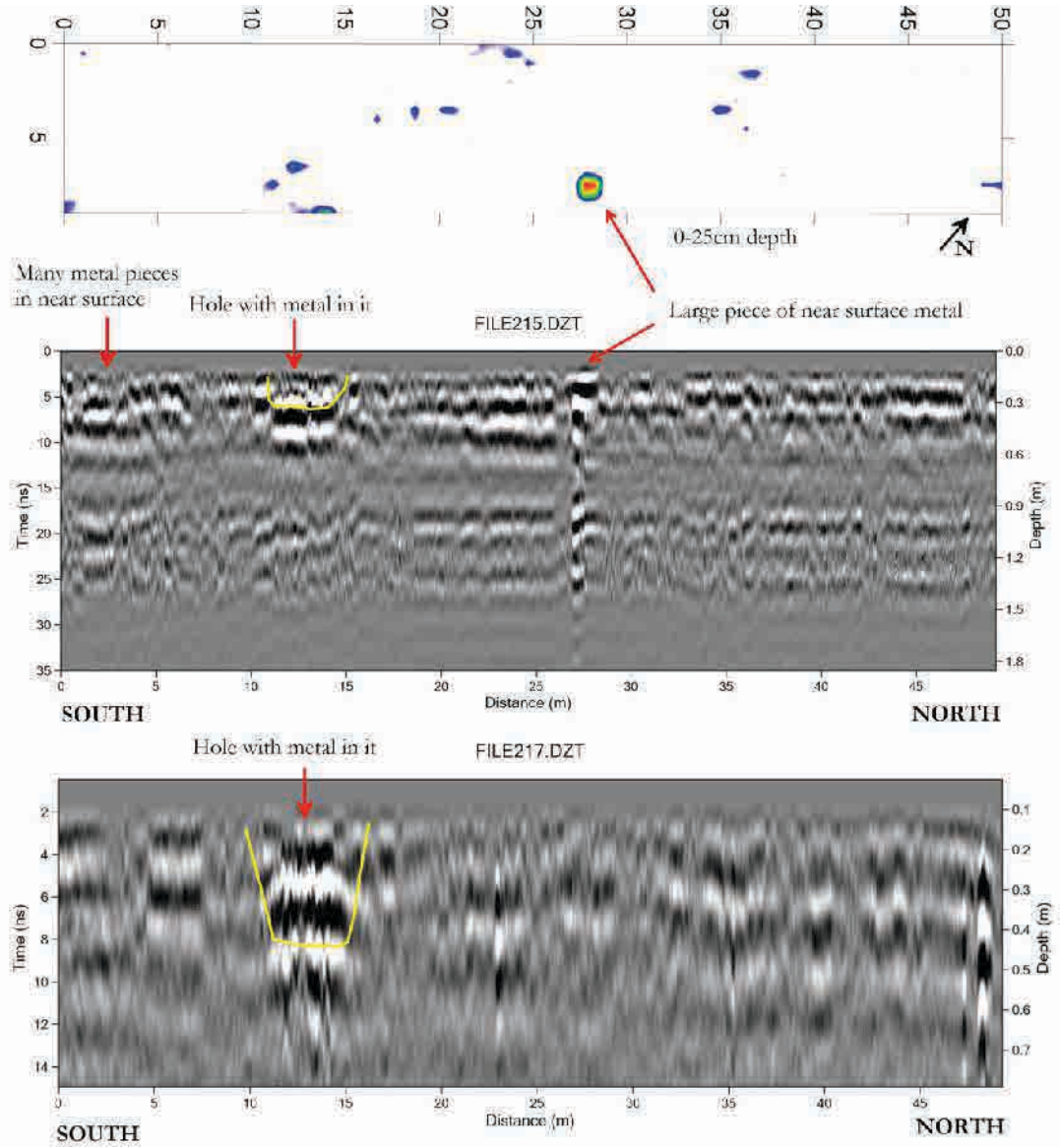


Figure 13. Grid 4a. Amplitude map and profiles 215 (8m on x-axis) and 217 (9m on x-axis), showing discarded metal.

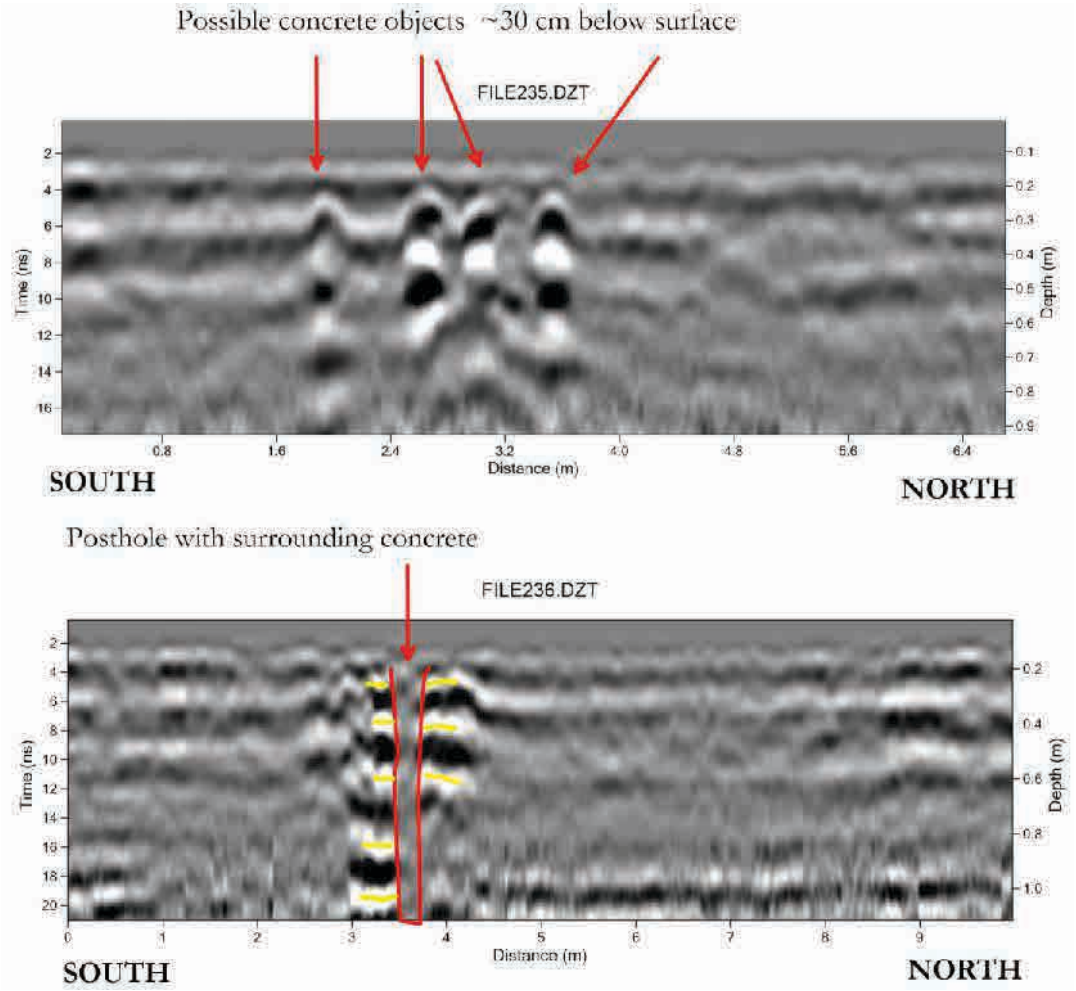


Figure 14. Grid 4b. Profiles 235 (8.5m on the x-axis) and 236 (9m on x-axis) showing modern material including posthole with post surrounded by concrete fill.

4.5 Grid 5

Grid 5 (23m x 40m) is located north-east of Grid 2 on the northern side of the upper slopes of the drainage line in the eastern field. Profiles were collected with 50cm spacing. Like other grids in the eastern field, Grid 5 has some evidence for recent disturbance, including compaction (refer to **Figure15**), likely related to pastoral and modern agricultural activities. No archaeological features were identified in this grid.

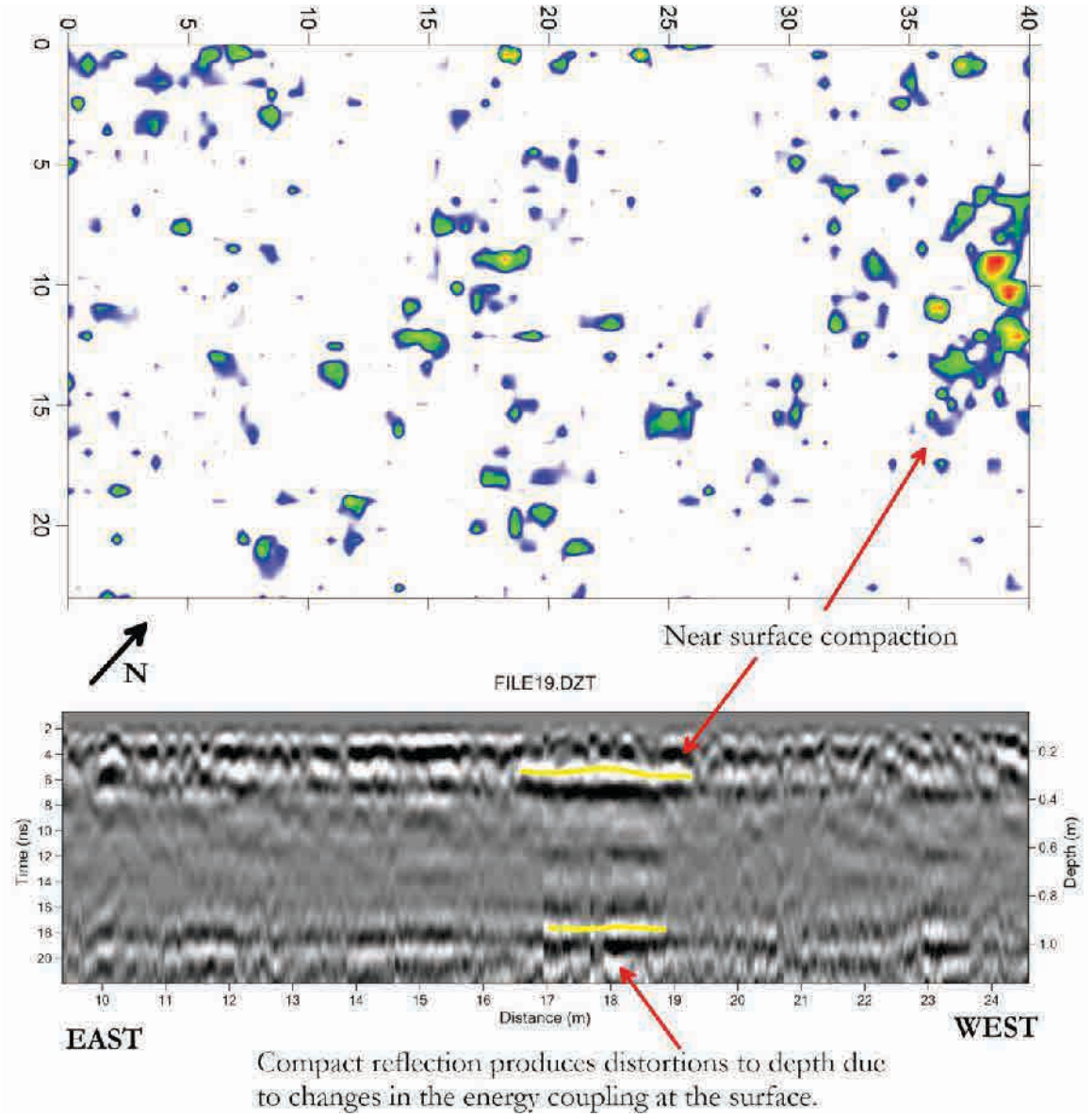


Figure 15. Grid 5. Amplitude map (0-25cm depth) showing compaction, and profile 19 (9m on x-axis) indicating the same.

4.6 Grid 6

Grid 6 is located on the beach terrace in the western field, east of areas C and D excavated in 2009 (CFG Heritage 2011). The archaeological excavations and subsequent earthworks conducted for the NRD have impacted this area (refer to **Figure 8**). These impacts are visible in the GPR data. Heavy-equipment scars can be seen in profile and also as high amplitude reflections in the amplitude map at the western end of the grid (refer to **Figure 16**). Multiple high amplitude reflections of what are likely pieces of metal near the surface and within fill, are seen in the amplitude map and profiles. It is unknown why there is such a high density of this type of material in this area, but it may be related to the type of backfill material. In addition, a hyperbola from a point source reflection showed reversed polarity. A hyperbola with reversed polarity indicates that there is a void space within/beneath the object from which the energy is reflected (for example a piece of pipe or empty container).

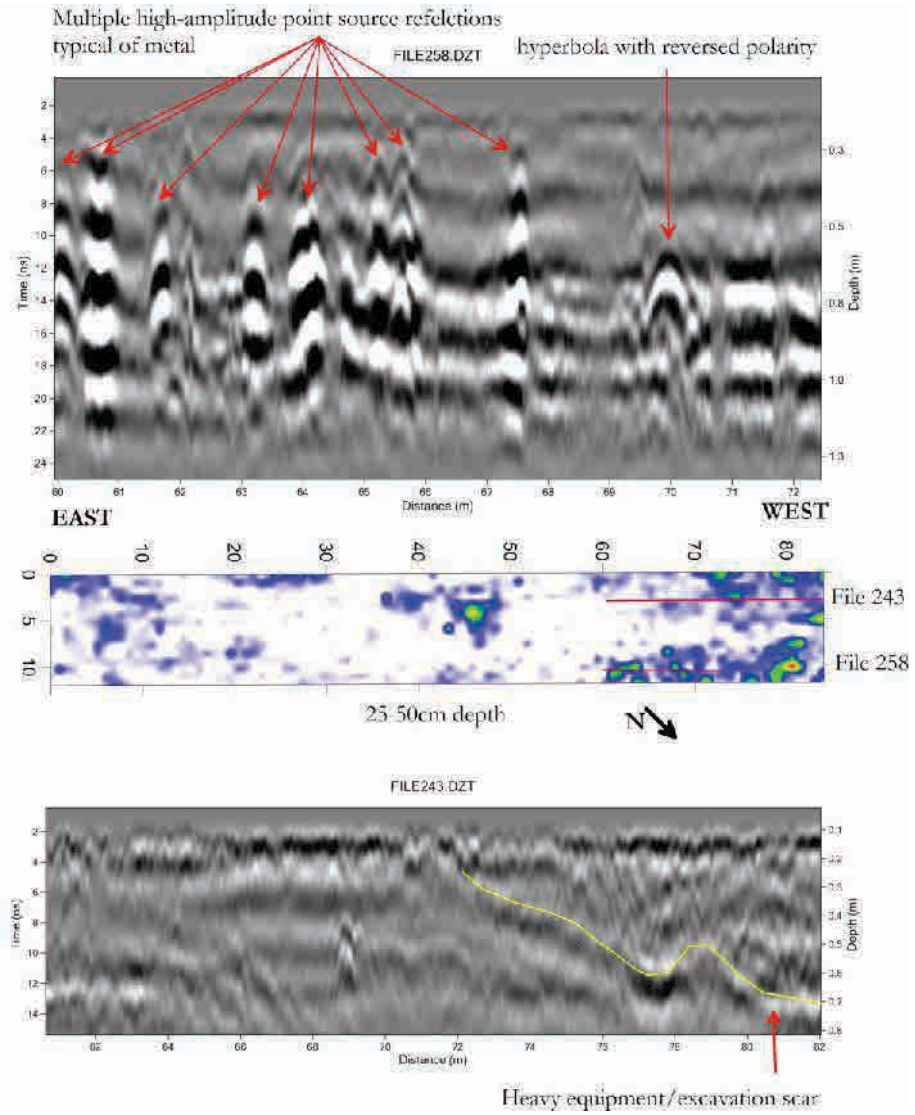


Figure 16. Grid 6. Multiple high amplitude point source reflections in profile 258 (10.5m on x-axis), likely metal in modern fill. Planar reflection in profile 243 (3m on x-axis) indicating cut likely from earthworks and excavation undertaken in this area.

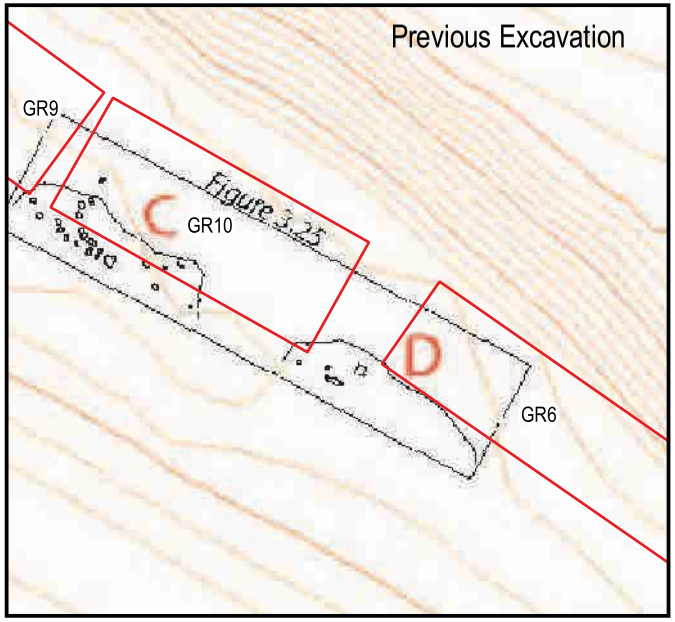
Figure 9
295 Auckland Airport
GPR Data Collection
Grid 6

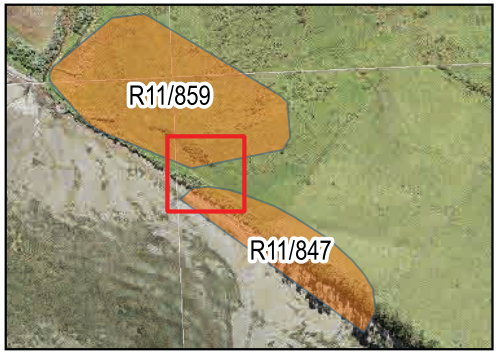
Legend

- GPR Collection Grid
- Archaeological Feature
- Surface feature

Inset:

- ArchSite





Source:Land Information New Zealand; CFG Layout 4, NRD Features; Virtus Heritage GPR Amplitude Slice Map - Grid 6; CFG Heritage 2011:25

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Based on the GPR data, it is suggested that the majority of the upper deposits, and those at depth in the western portion of the grid, are heavily modified, having been excavated and then backfilled. High amplitude planar reflections were noted on the southern half of the grid, again with pieces of near surface metal indicating that at least the upper deposits in this area are disturbed/consist of backfill. Due to the 'noise' in the data, and coupling issues, it is difficult to define the relationship of these planar reflections to the upper deposits. It is possible that planar reflections are in an undisturbed context, however it is unclear as to whether they result from natural or cultural features and further analysis of this area would be required to understand this feature more (refer to **Figure 18**).

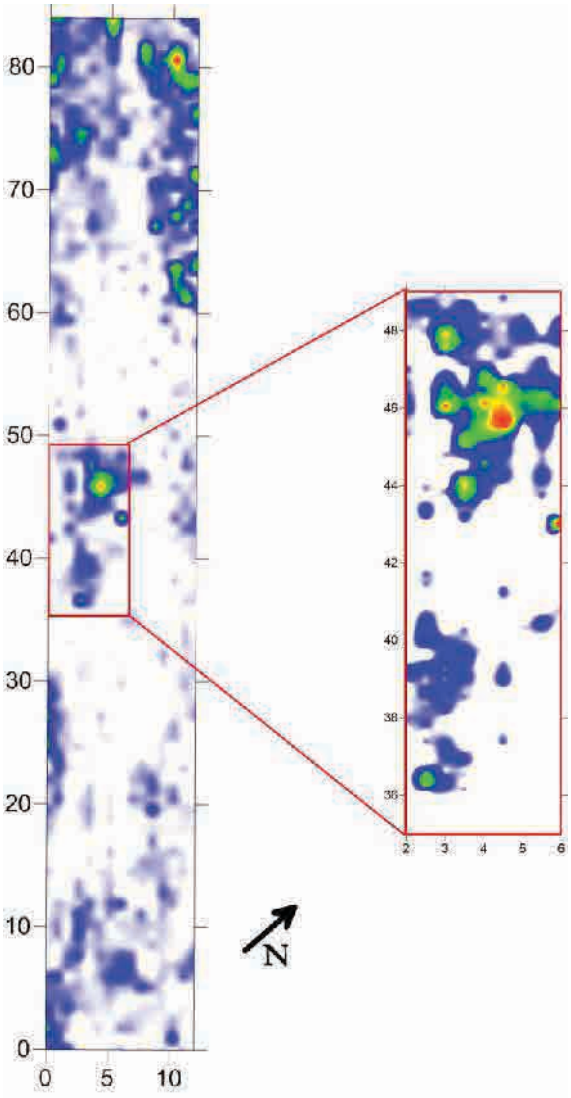


Figure 18. Grid 6 planar reflections of interest (25-50cm depth).

4.7 Grid 7

Grid 7 (50m x 67m) is located within the western field straddling the drainage line that runs north-south in this area (**Figure 19**). The grid is located east of the areas previously subject to archaeological investigations and partially overlaps the site polygons for R11/847 (midden) and R11/859 (occupation site with houses, postholes, pits, terraces, burials, ovens, artefacts). Some shell midden is eroding from what is generally a heavily grassed area at the southern end of the grid and was also seen eroding from a low wooden retaining wall, probably a cattle ramp, immediately south of the grid. As with all the grids, Grid 7 has the occasional near-surface metal visible throughout, indicating the upper deposits have been disturbed, likely through historic and ongoing agricultural and pastoral practices.

The north-western portion of the grid has been heavily impacted by excavation and earth movement for the NDP (refer to **Figure 8** and red outline in **Figure 20**). The area immediately south has been modified by the potential cattle ramp and it is unknown to what extent this has impacted the deposits in the area (**Figure 21**). However, historic aerial photographs indicate that in general, the remainder of the grid has not undergone recent extensive ground disturbing impacts outside of those associated with general agricultural and pastoral activities. Given its position adjacent to a known site, and with estimated site boundaries overlapping with the grid, as well as the presence of shell material eroding from surface deposits, this grid was considered to have the highest potential for archaeological deposits.

A number of *potential* archaeological features were identified within Grid 7. Moderate amplitude reflections seen in the upper deposits of the southern portion of the grid, may indicate the presence of midden material. Midden is very difficult to identify with GPR particularly, low density midden. Where it is visible, it is generally seen with distinct base horizons overlain by many small reflections from larger shells, stone or other items within the feature. A planar reflection with overlying multiple small point source reflections was visible in Grid 7 (shown in **Figure 22**). This planar reflection may represent the interface between two layers, and possibly represents the base of a midden or a compact surface.

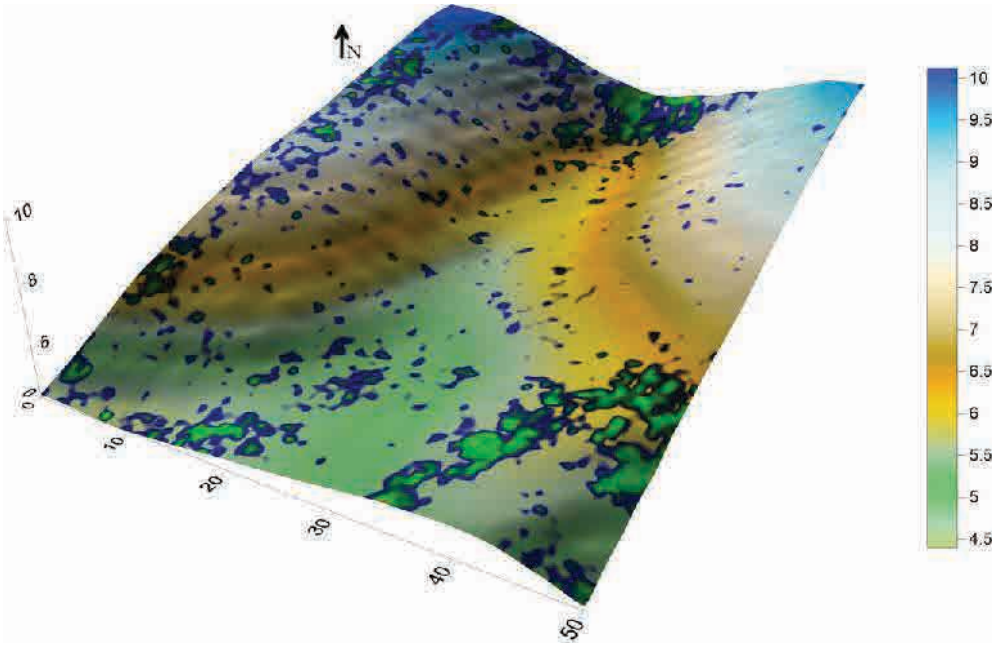


Figure 19. Grid 7 amplitude map (25-50cm depth) with topographic overlay.

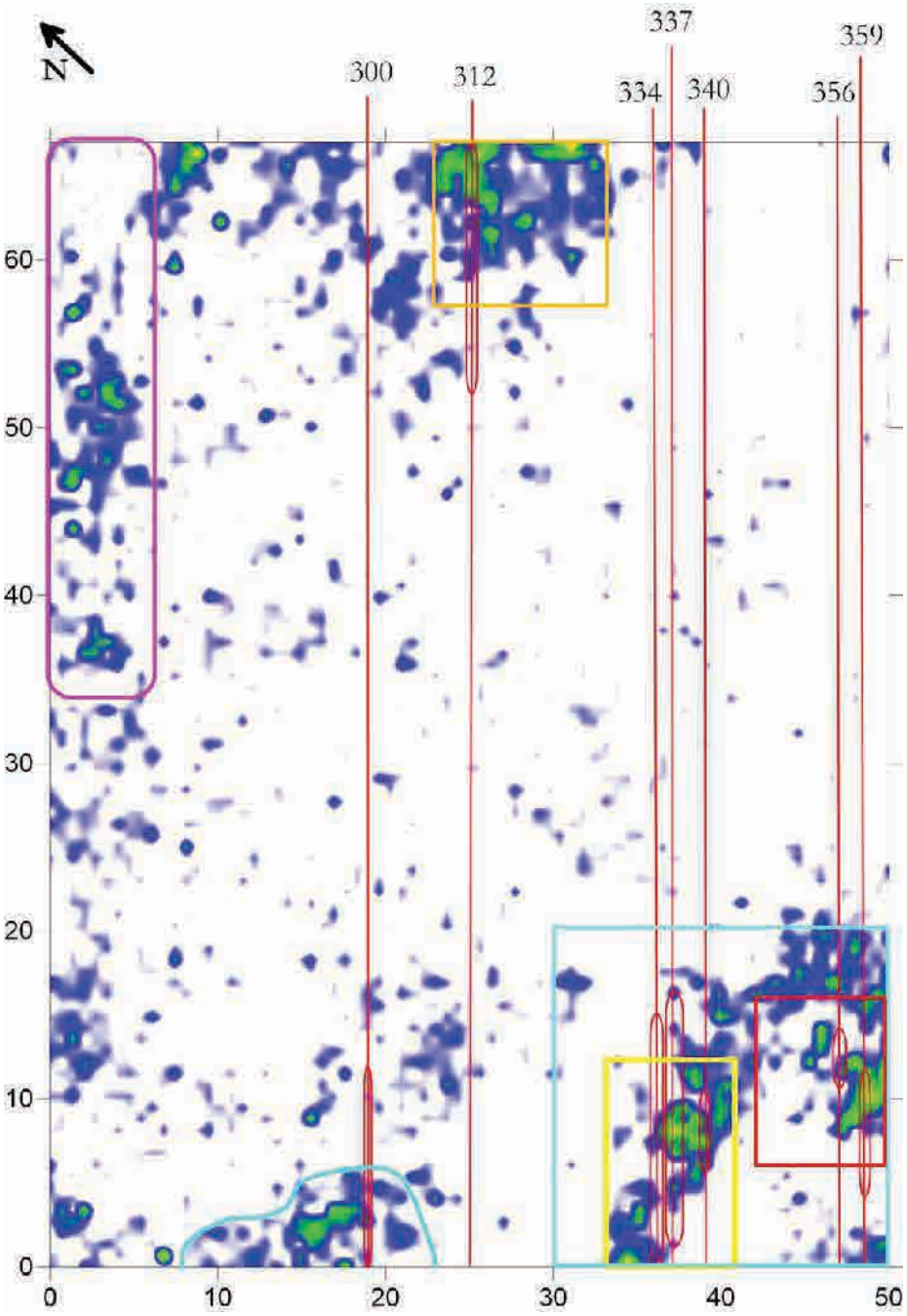


Figure 20. Grid 7 amplitude map (25-50cm deep) with profile locations and inset boxes referenced within text. Red lines represent profiles and numbers, and bubbles represent sections of profiles presented. Note the pink box indicates the area of impact from earthworks. Cyan outline between 8-22m is extent of potential midden as seen in the amplitude maps.

Figure 21
295 Auckland Airport
GPR Data Collection
Grid 7

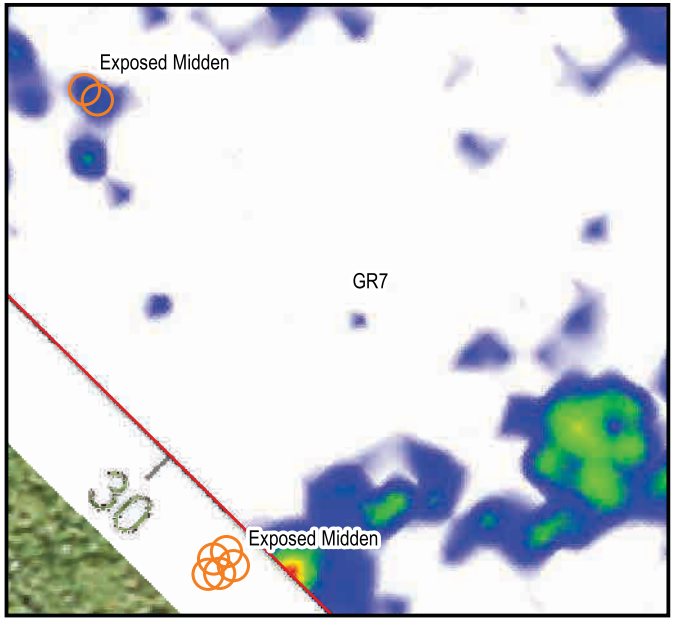
Legend

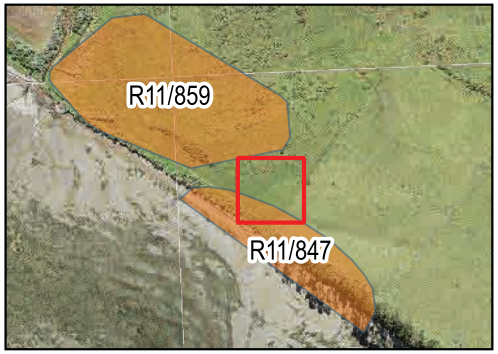
GPR Collection Grid

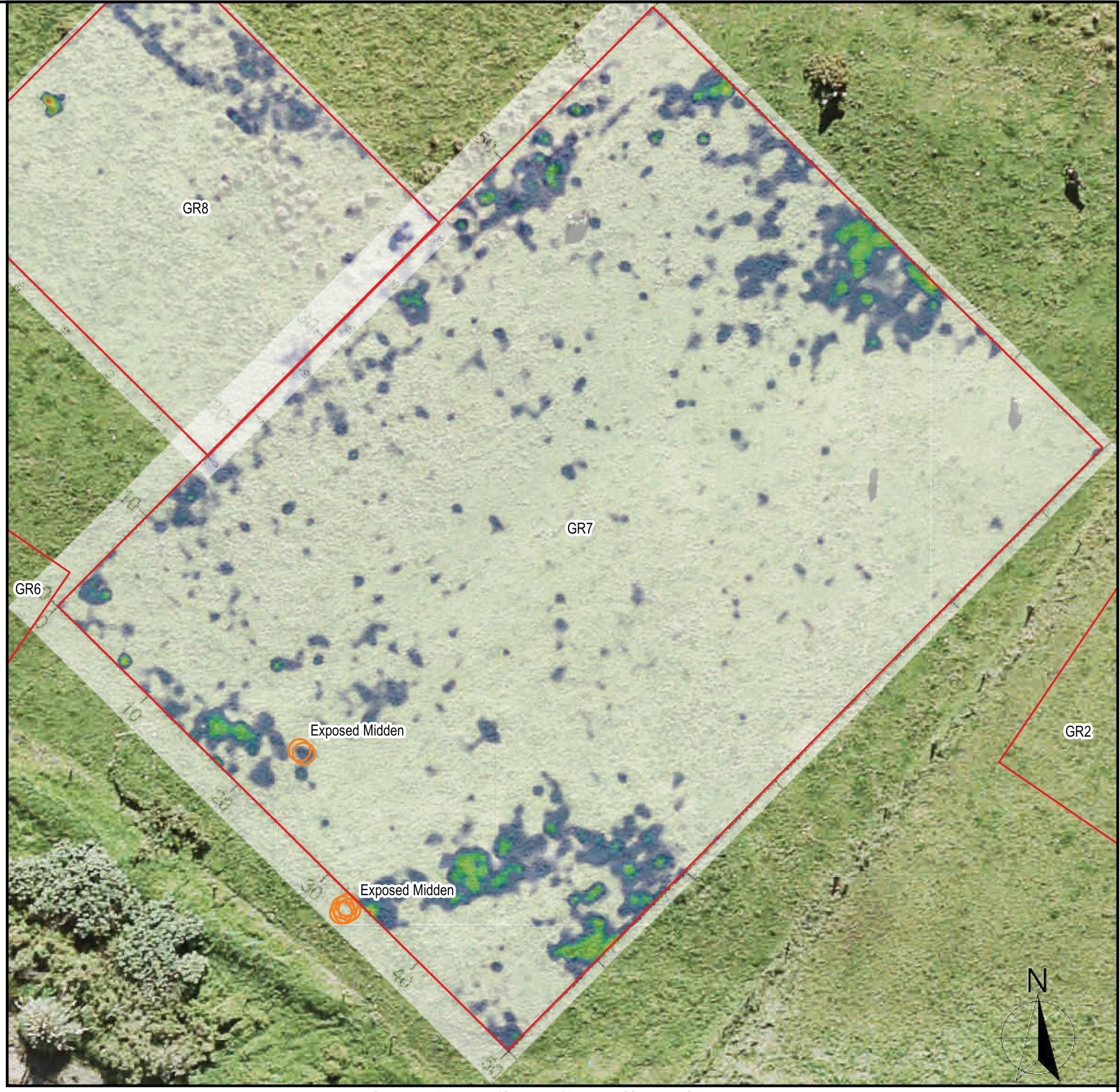
Surface feature

Inset:

ArchSite







Source:Land Information New Zealand; CFG Layout 4, NRD Features; Virtus Heritage GPR Amplitude Slice Map - Grid 7
Projection: NZGD2000

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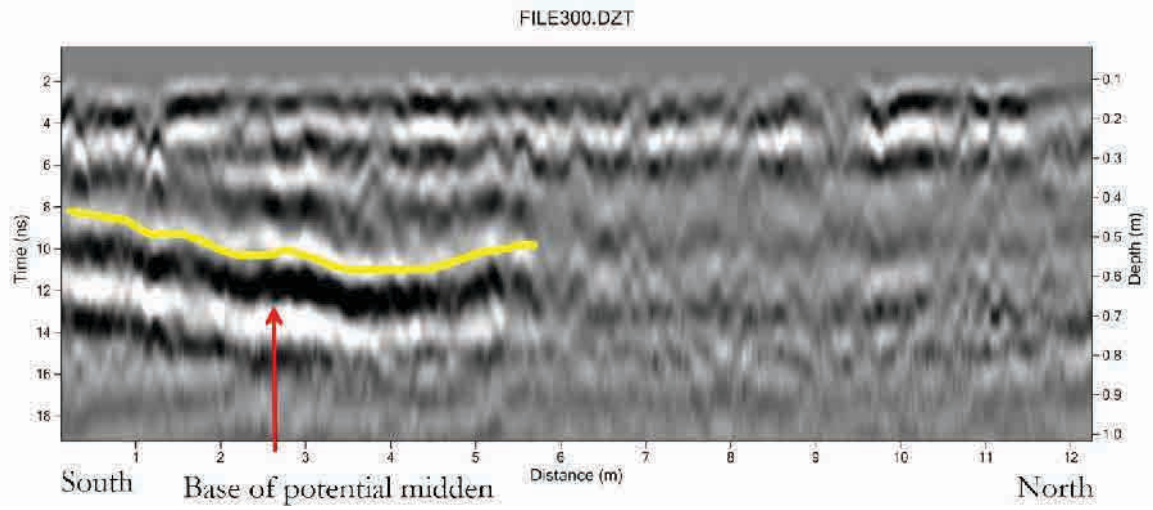


Figure 22. Grid 7. Profile 300 (19m on x-axis). Planar reflection with overlying multiple small point source reflections.

More detailed analysis of the high amplitude reflections in the southeast corner of the grid was undertaken (area shown in Cyan box in **Figure 20**). Analysis of profiles and examination of high-resolution amplitude maps of the area outlined in red (**Figure 20**), as well as corresponding profiles, show that this feature is comprised of high amplitude planar reflections, indicating a compact surface. This compact surface may potentially be the remains of a living surface such as a house or other living surface. North of the compact surface, visible in the amplitude map, but not the profiles, are a row of low amplitude points, which possibly represent large postholes (refer to **Figure 23**), however these reflections are not visible in the profiles. The compact feature is approximately 5m x 3.5m, similar to the dimensions of house remains identified during excavations in Areas B and F to the west (**Figure 24**). Profiles 356 and 359 have point source objects sitting on top of the compact surface (**Figure 25** and **26**). **Figure 25** indicates that smaller compact surfaces are adjacent to the main potential living surface and may represent associated features.

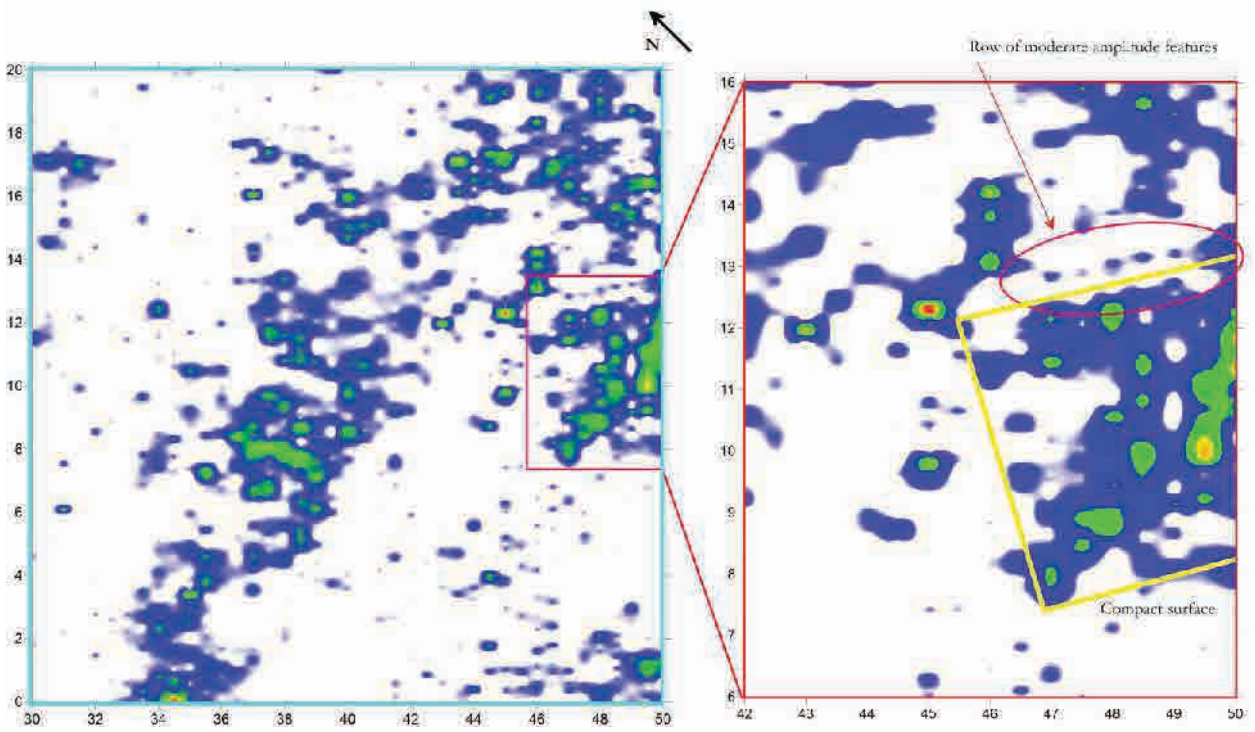


Figure 23. Grid 7. High amplitude planar reflection likely indicating a compact surface and row of round low amplitude features to the north (25-50cm depth).

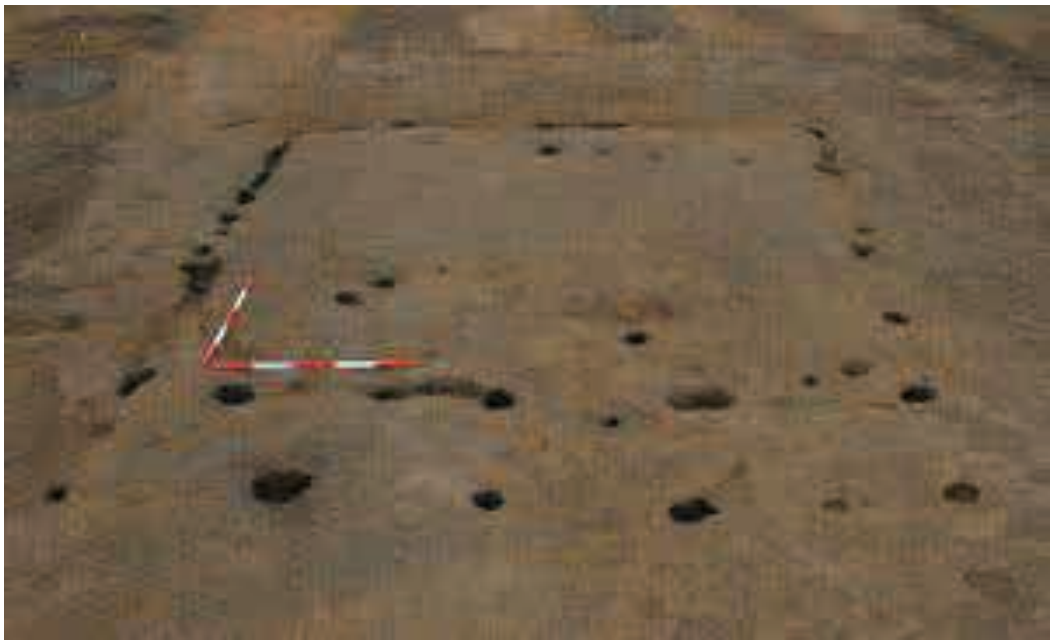


Figure 24. Photograph of excavated house with postholes at area F of the NRD site. High amplitude planar reflections, of similar size and shape alongside potential a row of moderate amplitude reflections, indicate a potential house compact living/working surface (photo credit CFG Heritage 2011).

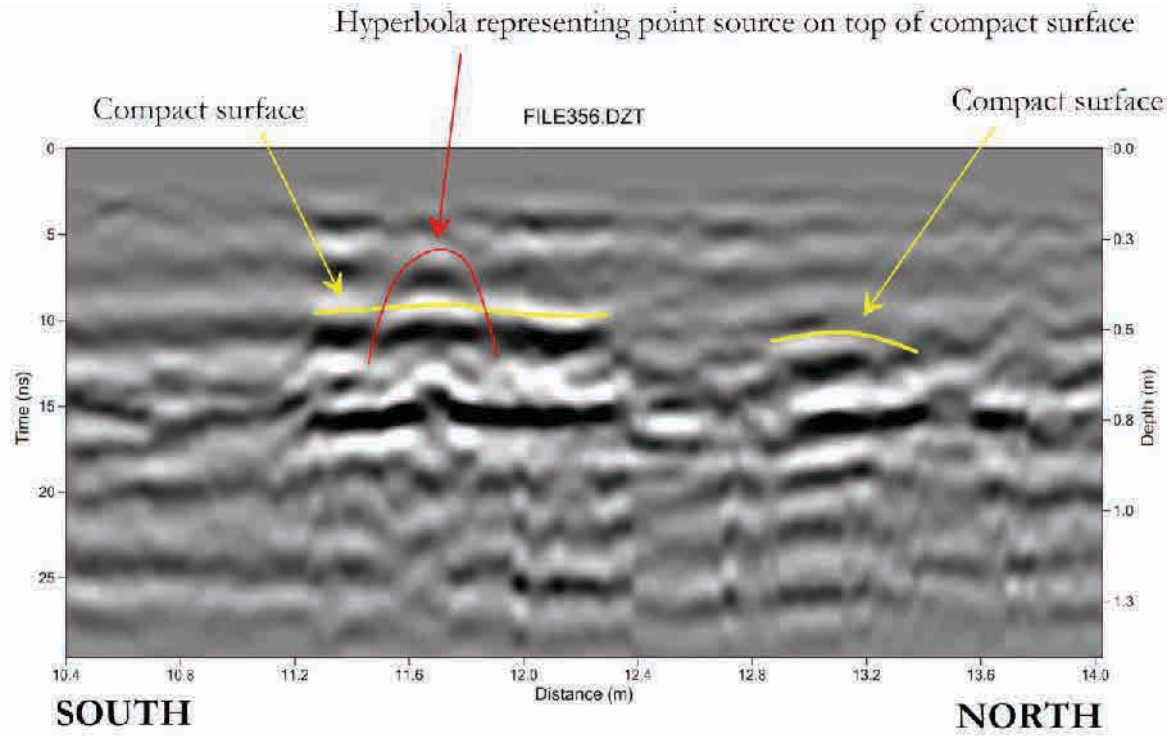


Figure 25. Grid 7. Profile 356 (47m on x-axis). A planar reflection representing a compact surface, with point source reflection indicating an object sitting on top.

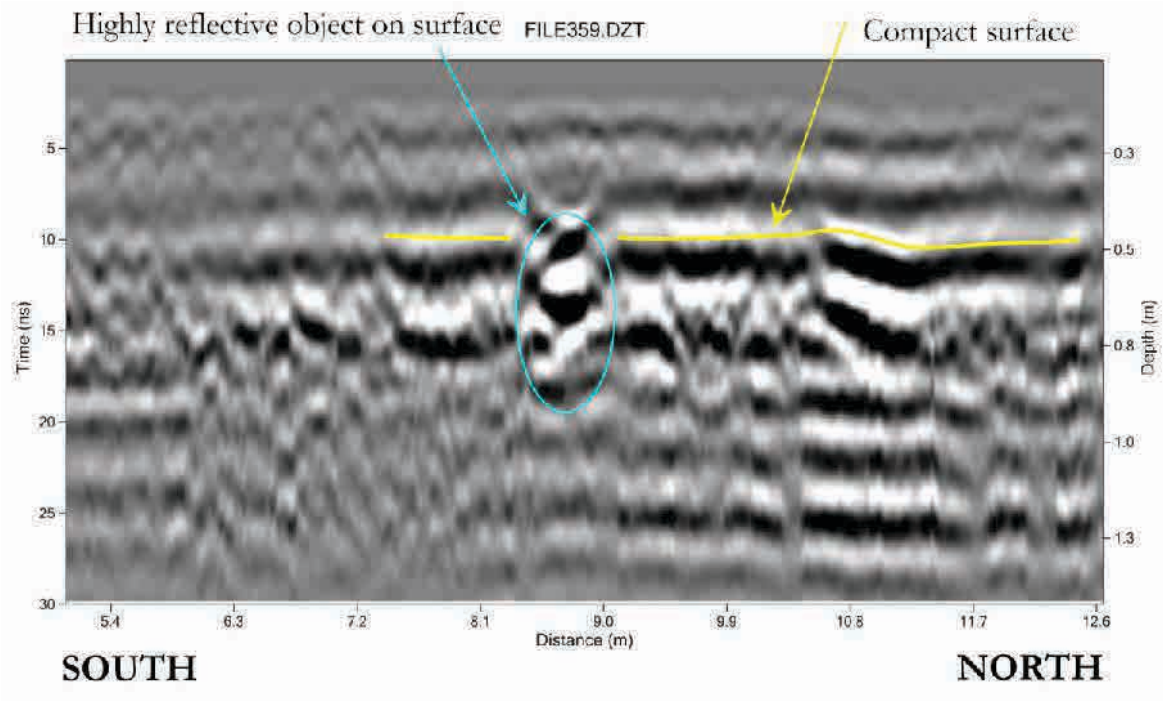


Figure 26. Grid 7. Profile 359 at 48.5m. Planar reflections representing compact surfaces, with a point source reflections indicating an object on the surface.

Southwest of the potential living surface feature discussed above, are more high amplitude reflections (refer to **Figure 27**). Closest to the end of the grid these are characterised by planar reflections seen in the profiles, which may indicate a compact surface. These have been truncated by incisions in some places. File 334 is an example (refer to **Figure 28**). These incisions may be more recent, as they appear to begin from higher in the deposits than the planar surface, seen as a homogenous layer above. Multiple point source reflections within these incisions also indicate they have been filled with material that contain objects large enough to create such reflections (for example midden). Further from the south end of the grid, these planar reflections become more consolidated to an area of approximately 4m x 3m and possibly represent a cultural surface such as a house floor, like that discussed above (refer to **Figure 29**). Like the area to the east, a highly reflective point source object is visible on the compact surface (**Figure 30**). The high reflectivity of this object indicates it may be metal, and therefore intrusive from the upper deposits.

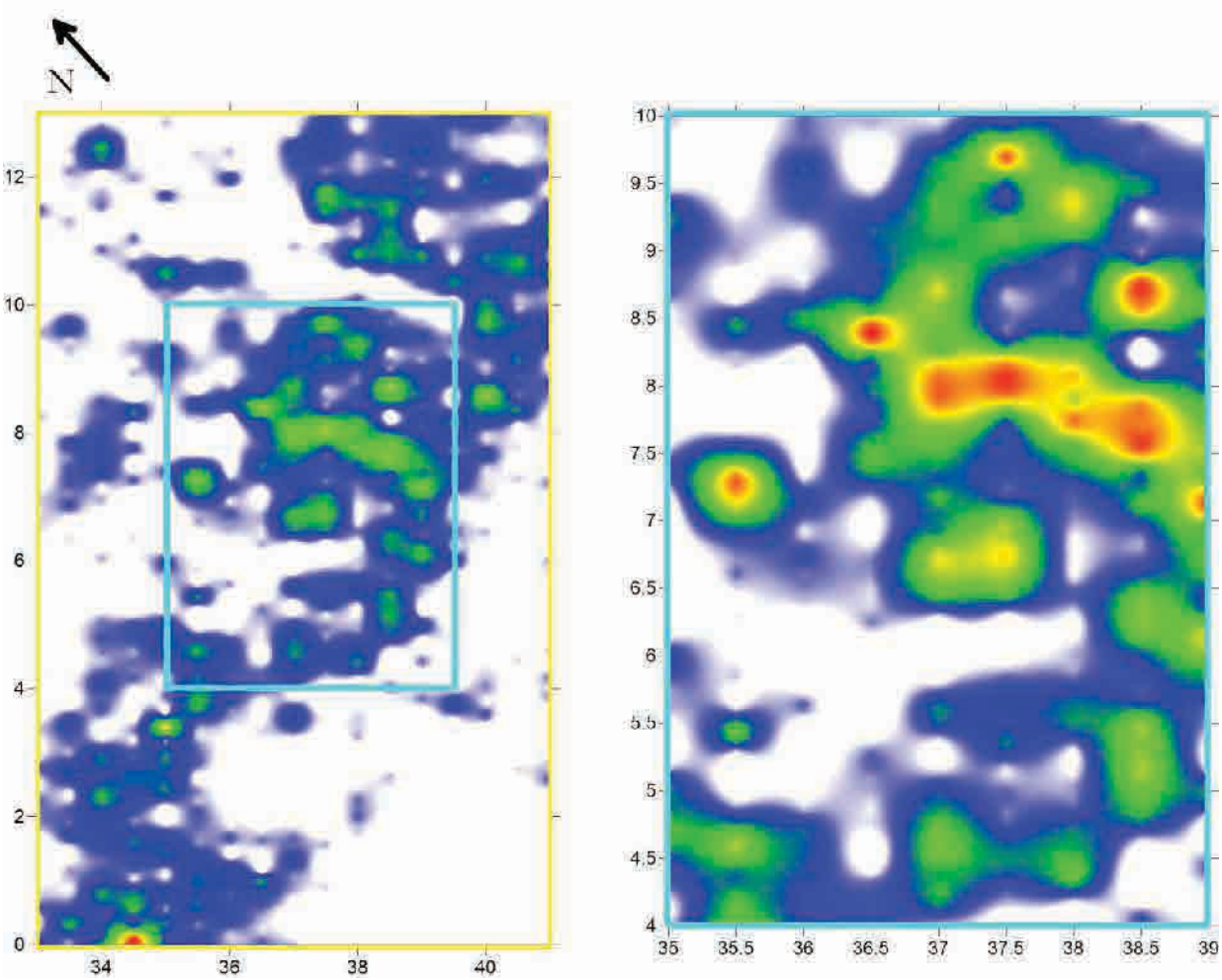


Figure 27. High-resolution area of amplitude map in south of Grid 7 (25-50cm deep). This feature is a compact surface, and may indicate the presence of a possible house or other living/working surface.

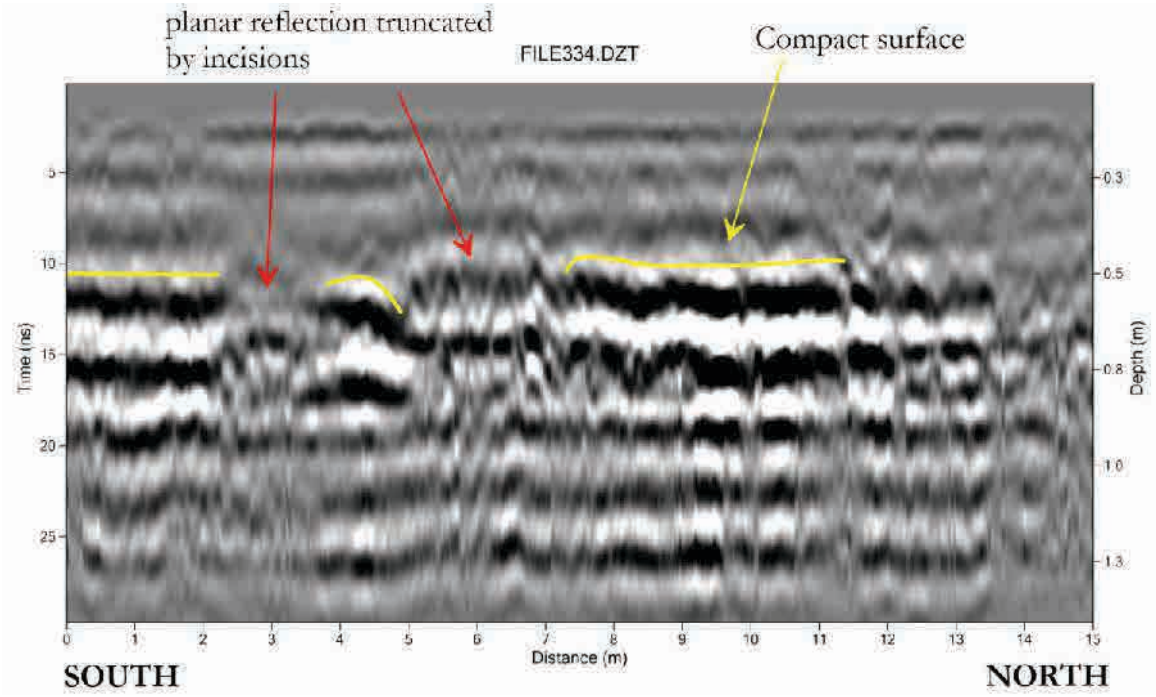


Figure 28. Grid 7. Profile 334 (36.5m on the x-axis). Planar reflections representing compact surfaces or changes in stratigraphy are truncated by incisions.

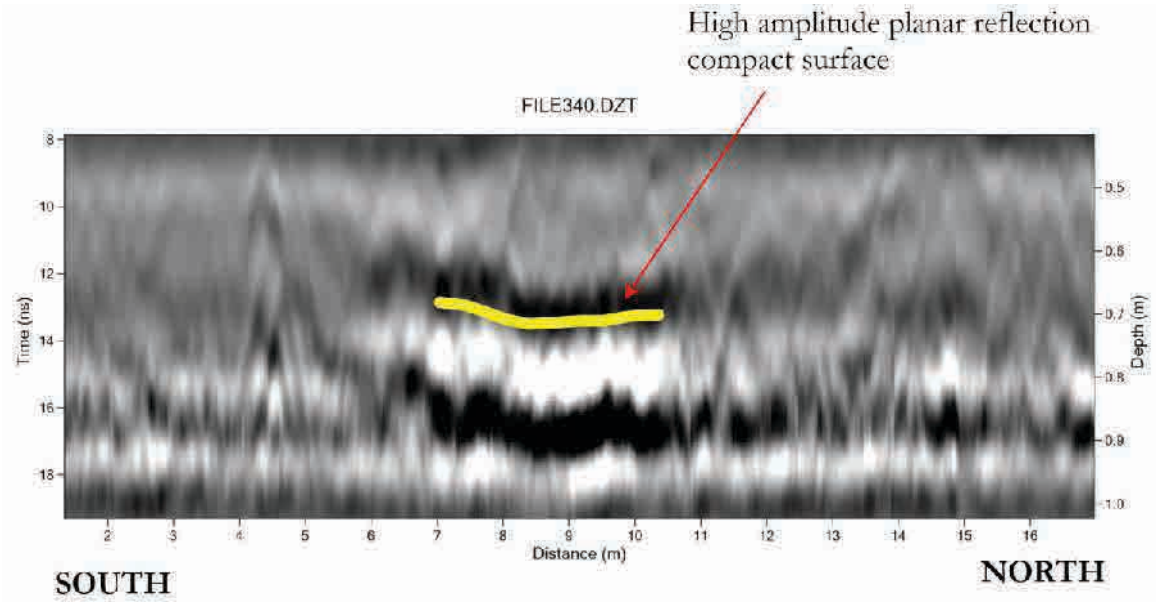


Figure 29. Grid 7. Profile 340 (39m on x-axis). Planar reflection at approximately 70cm deep, indicative of a compact surface.

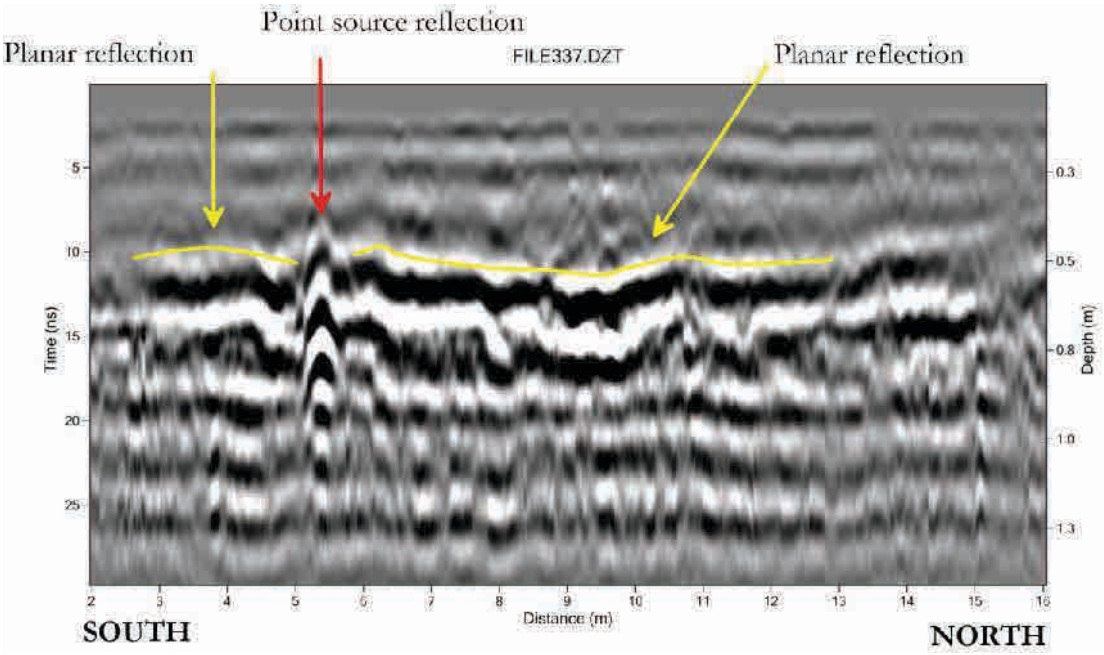


Figure 30. Grid 7. Profile 337 (37.5m on x-axis). Highly reflective point source object sitting above planar reflection.

High amplitude reflections identified in the northern portion of the gird, at the top of the drainage line were also examined in more detail (**Figure 31**). This area is characterised by high amplitude planar reflections, like those to the south, truncated by incisions (**Figure 32**). It may be that the planar reflections are indicative of compact surfaces like those in the south, and possibly represent a cultural surface that has also been incised for various reasons (e.g. pits), however the unusual location of these features at the top of a drainage line makes interpretation difficult and further analysis is required to understand the formation of these features.

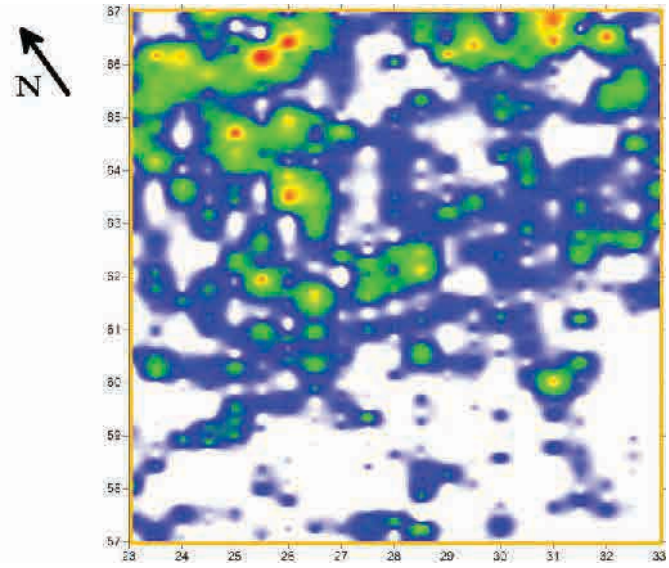


Figure 31. High-resolution area of amplitude map in north of Grid 7 (25-50cm deep).

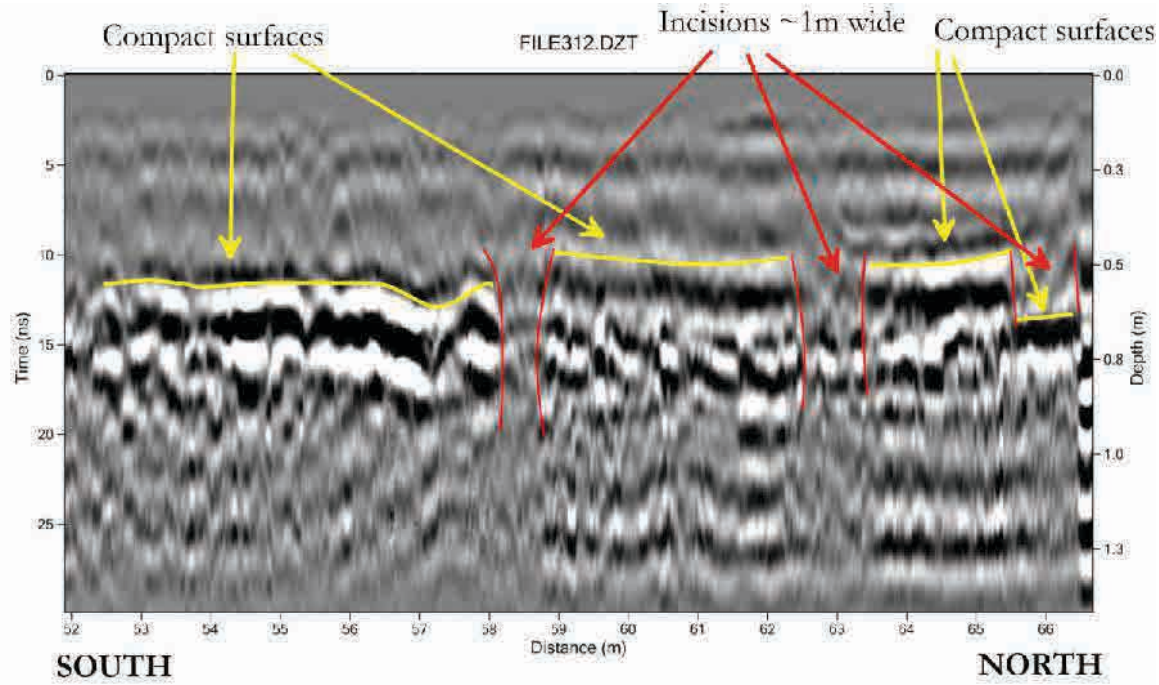


Figure 32. Grid 7. Profile 312 (25m on x-axis). Planar reflections at approximately 60cm deep, likely representative of compact surface with incisions in them.

4.8 Grid 8

Grid 8 (26m x 31m) is adjacent west of Grid 7, on the upper slope of the drainage line. Profiles were collected in 50cm spacing. Recent aerial photographs show that this grid has been subject to earthworks associated with the NRD. As with most of the grids occasional near-surface metal was detected, likely associated with pastoral and agricultural activities in the area. One very high amplitude reflection in the west of the grid is likely a large piece of metal or possibly concrete (**Figure 33**). What appears to be a rectangular feature in the amplitude maps in the northwest corner of the grid appears to be related to the NRD earthworks. Examination of the profiles for this area show heavy machinery scaring from earthworks, and when this feature is overlaid with aerials it is evident this is directly related to the earthworks associated with the NRD (**Figure 34**). Despite its proximity to known archaeological deposits, no archaeological features were identified in this grid.

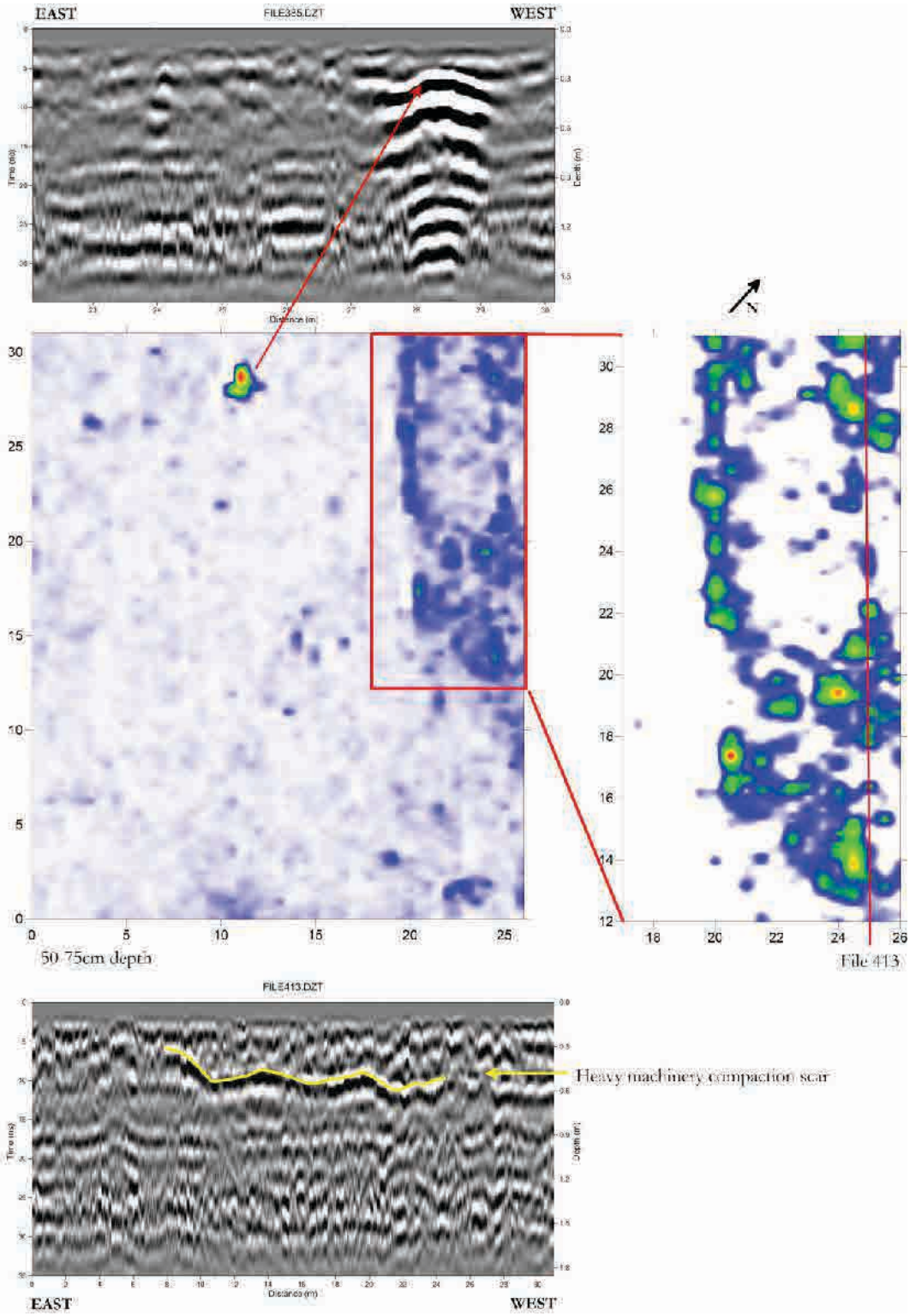


Figure 33. Grid 8. Feature in northwest corner is likely result of heavy machinery cutting and compacting during NRD earthworks. High amplitude reflection is likely a large piece of metal or concrete.

Figure 34
295 Auckland Airport
GPR Data Collection
Grid 8

Legend

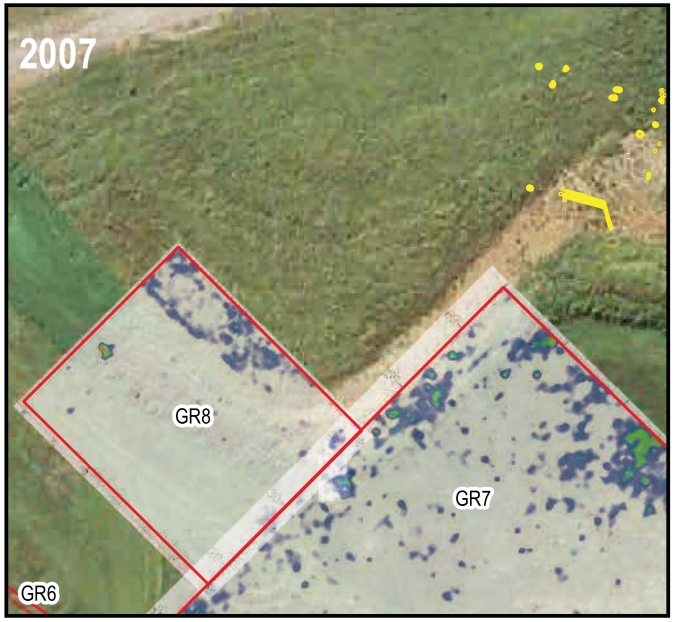
GPR Collection Grid

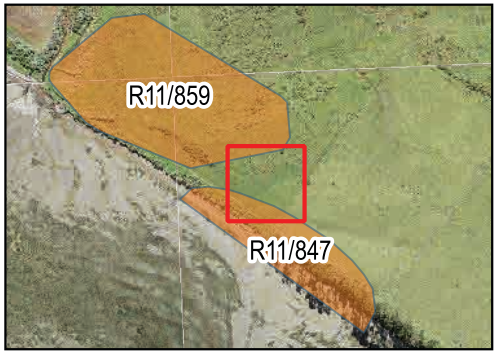
Contour

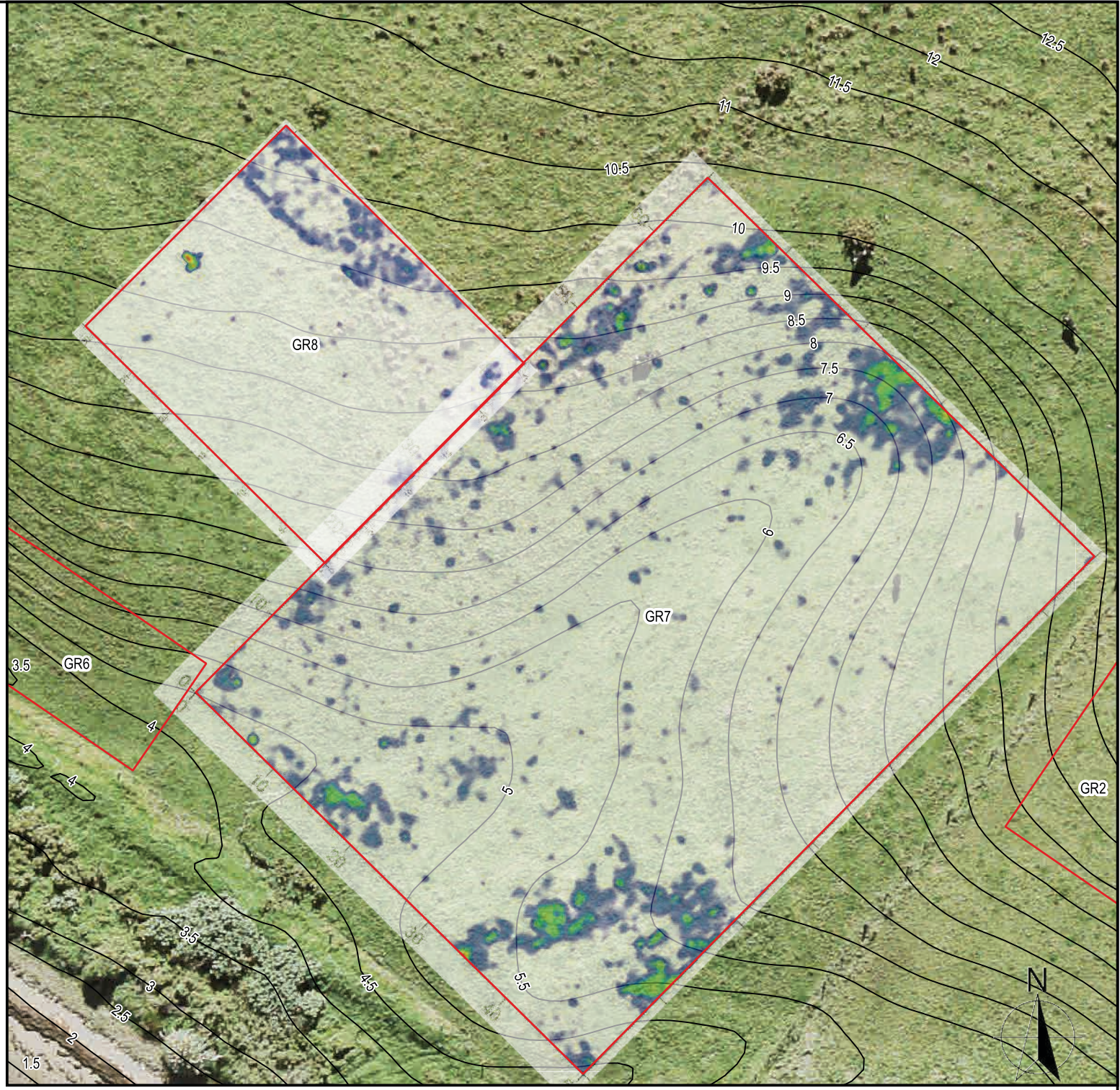
Inset:

ArchSite

Archaeological Feature







Source:Land Information New Zealand; CFG Layout 4, NRD Features; Virtus Heritage GPR Amplitude Slice Map - Grid 7 & 8
Projection: NZGD2000

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4.9 Grids 9 and 10

Grid 9 (15m x 61m) is located at the far western end of the study area on the beach flat that was previously excavated and subject to earthworks associated with the NRD. Disturbance from the earthworks is seen in the GPR data as changes in amplitude of different layers indicating cuts (refer to **Figures 35** and **36**). Grid 10 (10m x 35m) is located between grids 6 and 9 on the beach flat, and was previously excavated and subject to earthworks associated with the NRD. Archaeological excavations identified midden overlying earth ovens and postholes within this area. Similar disturbance from the earthworks is seen in the GPR data as that seen in Grid 9 (refer to **Figures 35** and **36**). As areas within these grids had already been subject to archaeological excavation and subsequent earthworks associated with the NRD, detailed analysis of all profiles was not undertaken in order to focus on grids with higher potential for intact archaeological deposits, and no archaeological features were identified within these grids.

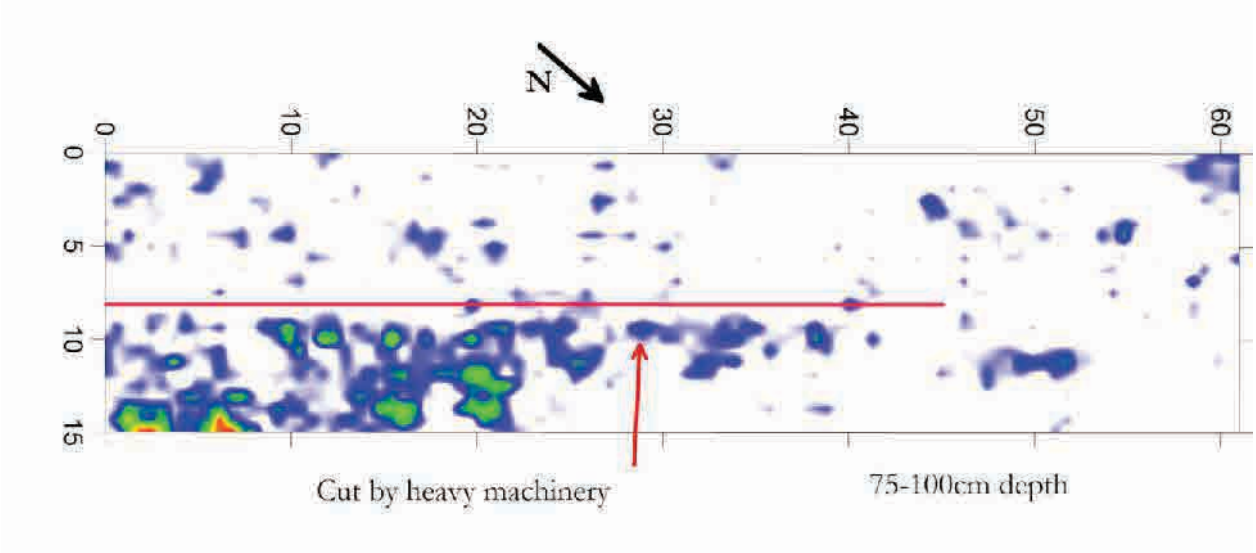

Figure 35. Grid 9 amplitude map showing change in amplitude between stratigraphic layers, with incision during recent excavation and earthworks.

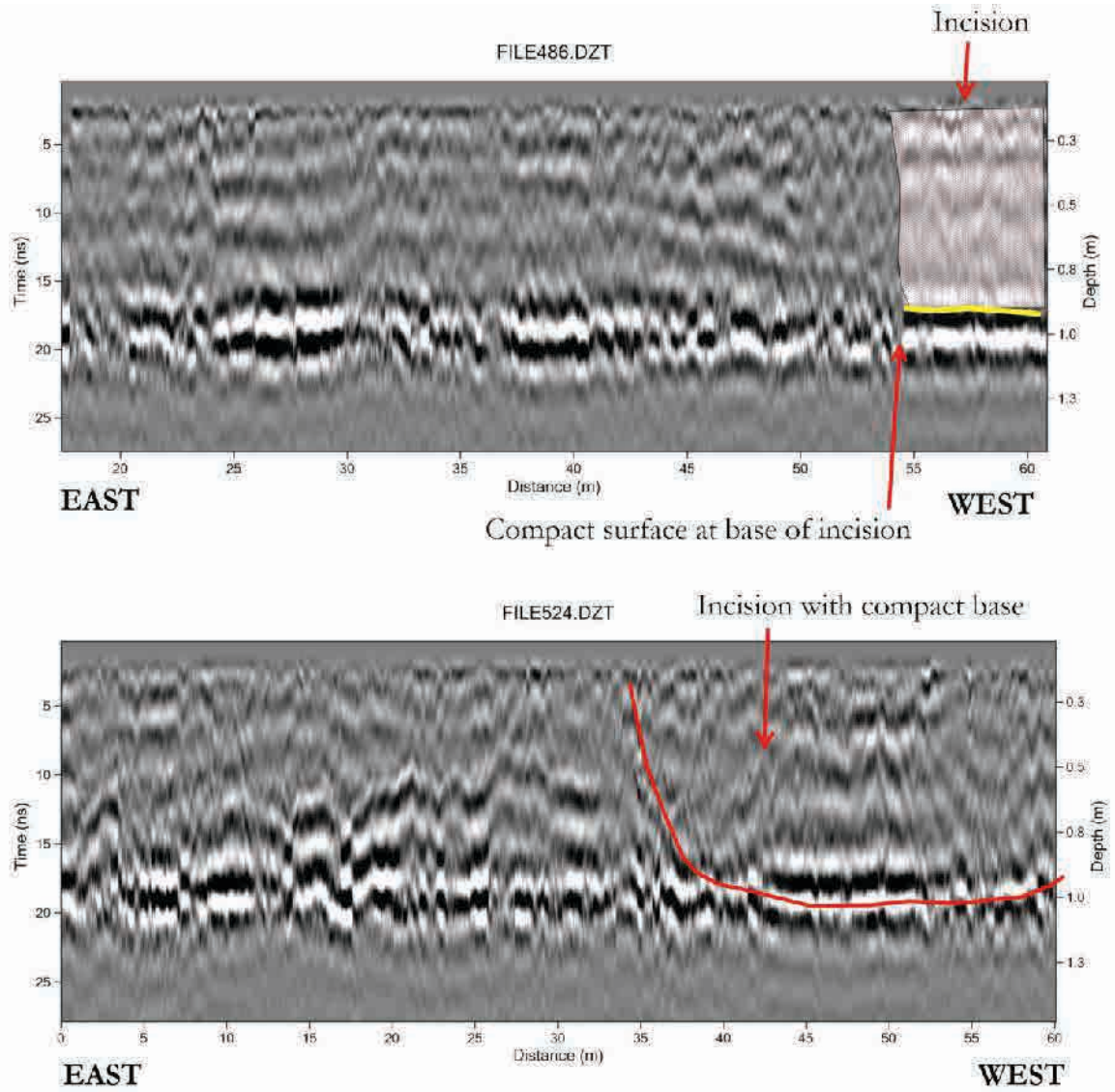

Figure 36. Grid 9 profiles at 2.25m and 11.75m on the x-axis respectively, indicating incisions and fill from pervious excavations and earthworks.

5. CONCLUSIONS

Overall, the GPR data from the NRD was 'noisy' and suffered from issues with coupling due to the uneven surface created by long grass, complicating data analysis and interpretation. Despite this a robust analysis of features identified in both amplitude maps and profiles was undertaken. Based on the GPR data analysis, past archaeological investigations, previous land use disturbance and environmental background, the following conclusions have been made:

- Evidence for disturbance from agricultural and pastoral activities was present within all 12 grids including compaction from heavy machinery and digging/ploughing, construction of farming infrastructure, such as fencing, and disposal of materials, including metal.
- No archaeological features were identified in Grids 1-5 in the eastern field. However, this does not exclude the potential for archaeology in this area, particularly low-density midden in disturbed contexts, which is generally difficult to identify with GPR. However, it is unlikely that archaeological features indicating extensive occupation sites are located in these grids.
- Although archaeological excavations identified midden, ovens and postholes within or adjacent to grids 6, 8, 9 and 10, no archaeological features were identified within these grids due to the level of disturbance from the activities associated with the NRD. Grid 6 has a high amplitude feature between 40-50m on the y-axis that likely relates to the disturbance in the area, but was unable to be interpreted with certainty at this stage. Despite the levels of disturbance in this area it is possible that subtle features, not able to be seen in the GPR data, such as low-density midden, may exist where these deposits have not been disturbed (i.e. grid 8).
- Grid 7 was considered to have the highest potential for intact archaeological deposits, based on the level or previous disturbance and its location on the beach terrace and slopes adjacent the bluff. Potential archaeological features were identified within this grid.
- Shell midden was exposed on the surface of the southern portion of Grid 7, and a planar reflection that may represent the base of midden deposits was seen in profile. Multiple point source reflections above the planar reflection may indicate midden material (disturbed or not).
- At least two areas of planar reflections in the south-eastern portion of Grid 7 represent compact surfaces and are possibly the floors of houses or other living/working structures. Smaller compact surfaces are also in the vicinity of these larger surfaces and are likely associated. One of the larger surfaces has a row of moderate amplitude points on its northern end. These possibly indicate the remains of postholes associated with this feature. Postholes are very difficult to identify with GPR due to their size and subtlety. The row of potential postholes are seen as only low amplitude reflections on the amplitude maps and are not seen in profile. A number of large, high amplitude point source reflections are situated on or above the compact surfaces. Although one of these objects is likely metal intruding from disturbance of upper deposits, in some cases it is possible these objects are associated with the compact surfaces.
- Strong planar reflections at the northern end of the grid, at the top of the drainage line, are similar to those seen in the south-eastern portion of the grid and may represent similar features. However, the location of these topographically is unusual, and further analysis would be required to understand the formation of these features. The planar reflections in this area are truncated in places by incisions. It is possible that these may relate to the compact surfaces, and could represent pits or ovens, as some have compact bases.

- If further excavation is required to be undertaken at the NRD site, based on the GPR data analysis, it is recommended that the south, south-eastern and central northern portions of Grid 7 (refer to **Figure 20**) be investigated to determine the exact nature of the features identified in this report. Additionally, some attention could be paid to the high amplitude reflection in the central portion of Grid 6, to understand how this feature relates to previous disturbances or not.

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APPENDIX A

PLATES

Plate 1. Eroding bluff face adjacent to Grid 1a and 1b, facing north-west. Note shallow layer of midden material is eroding from the uppermost deposits within the root system of the pine trees.

Plate 2. Indicative location of Grids 1a and 1b (orange) and Grid 2 (blue) on opposite sides of a natural drainage line in the east field.

Plate 3. Grid 3 at top of bluff in east field. Photo taken facing north-west.

Plate 4. Grids 4a and 4b, facing south-west.

Plate 5. Grid 5 located on highpoint of east field, north of the drainage line in this area. Photo taken facing west.

Plate 6. Grid 6 on beach flat in front of modified bluff. Note the undulating surface from heavy machinery excavation, and the artificial bund to the right of the photograph. Photo taken facing south-east.

Plate 7. Grid 7 east of the main excavated area. Grid captures beach terrace, shallow drainage line and surrounding slopes. Photograph taken facing north-east.

Plate 8. Grid 8, located adjacent to the northwest side of Grid 7 and on the edge of the now modified bluff above the beach terrace. Note the recently mown thick grass. Photograph taken facing south-west.

Plate 9. Grid 9 below modified terrace. This area has been excavated. Note the artificial bund on the left of the photograph. Photo taken facing west.

Plate 10. Grid 10 located beneath the modified bluff and east of Grid 9. Photo taken facing west.

APPENDIX B

GLOSSARY

amplitude: a measure of the "strength" of radar waves recorded by GPR systems. These values are recorded as dynamic range of digital values that define each sine wave recorded. Variations in wave amplitudes are a function of differences in velocity of traveling waves as they cross bounding surfaces that reflect energy, with the greater the velocity contrast, the higher the reflected amplitude.

amplitude maps: common maps produced by re-sampling the digital values of amplitudes recorded from interfaces in the ground. They are often referred to as "time-slice" maps or "depth-slice" maps, as they are produced from slices of ground defined by wave recording times or depth. Most often they are generated over a "thickness" of material in the ground, such as 5-10 nanoseconds or 20-40 centimetres'. They can also be constructed from only one distinct plane. These maps can also be produced to follow specific horizons that vary in their depth in the ground.

antennas: in GPR antennas these electronic devices transmit radio waves. They can be various shapes and sizes to generate different frequency waves, with larger antennas usually producing lower frequency (longer wavelength) waves. Electrical pulses are applied to an electrically conductive material, which depending on their shape, size and other electronic components, generate electromagnetic waves that propagate outward. They are often used in pairs, with one antenna transmitting with the other receiving and recording waves produced from reflections off interfaces in the ground, or other surfaces.

attenuation: the weakening and general reduction in the strength of radar waves as they move through a medium. In the ground this occurs when waves propagate through electrically conductive or magnetically permeable materials. Weakening also occurs as propagating waves, moving in a conical transmission pattern, spread over a greater amount of ground creating additional weakening.

coupling, of radar energy with the ground: a relative measurement how well transmitted radar waves move across the ground-air interface to propagate into the ground. Variations in coupling can be caused by the constituents of surface materials, the placement of the antenna on the ground, the amount of tilt of antennas, the distance of the antenna off the ground, and other factors. Good coupling means radar waves have moved into the ground and are being transmitted to depth. Coupling variations along an antenna transect create anomalous reflections in GPR reflection profiles and can distort GPR images.

data processing, post-acquisition: digital software methods that modify GPR reflection data after they have been acquired to adjust the reflections in some ways prior to display and interpretation. These methods can be vertical and horizontal axes adjustments, filtering of frequencies, gaining of reflection amplitudes and many other methods used to overcome noise, distortion and other common GPR variations.

electromagnetic energy: energy propagated through space or a material that are the co-joined waves of electrical and magnetic waves. GPR waves are electromagnetic, classified as radio waves (defined only by their frequency). Other electromagnetic energy types, not applicable to this book, are infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays.

frequencies, of antennas: the rate at which a wave vibrates, measured per second in values of hertz. The higher the frequency, the shorter the wavelength generated. Most GPR antennas produce an electromagnetic field that creates propagating waves that vibrated in in the 10-1200 megahertz (MHz) range. One unit of megahertz is 1,000,000 oscillations per second.

hyperbola, as in describing a reflection: shape of reflections generated from "point sources" in the ground, caused by the spreading of transmitting radar energy as it moves deeper in the ground from a surface antenna.

Megahertz (Mhz): unit of measurement of frequency common in with GPR antennas, which are units of the oscillation of waves. Equal to one million hertz. One hertz is one oscillation per second.

nanoseconds (ns): the time used to record the two-way travel times of radar waves. A nanosecond is one billionth of a second.

noise: any un-wanted waves recorded during GPR collection. Most commonly they are background radio transmissions but could be internal system-generated waves or air waves, to name a few.

point-source: a discrete object in the ground that produces a hyperbolic-shaped reflection. These are often rocks, pipes, objects, or any aerially-limited reflection surface.

radar: an acronym, which has now become a word in its own right, which began to be used in 1942 for reflected radio waves used for detecting objects in the air. It stands for "radio detection and ranging". This acronym replaced the British acronym RDF that originally stood for "radio direction finding".

reflections: other than the obvious definition a wave being reflected from a surface, it is also commonly used as slang in GPR and seismic wave interpretation for a visually continuous planar surface visible in a reflection profile.

spreading of radar waves: movement of waves from a surface antenna in a generally conical shape, with the apex of the cone at the surface antenna. The conical radiation pattern produced by most GPR antennas is elongated in the direction of antennas movement, if the paired transmission and recording antennas are placed perpendicular to the transect (the usual way antennas are moved for most applications).

survey transects: any line along the ground surface that an antenna moves. Often, they are usually linear if collected within a grid, using a Cartesian coordinate system to define their location. But they

can be placed in any orientation or geometry if antennas are moved around obstacles or placed in a way to optimize how reflections are recorded from buried interfaces.

trace: a digital recording of waves recorded at one spot on the ground. Usually composed of multiple reflections recorded within a "time window", where all waves are "stacked" into one composite waveform. Traces can be analysed individually to help define reflection at one location but are most commonly "stacked" together sequentially along a survey transect, to generate a reflection profile.

time window: a period of time, measured in nanoseconds, which a GPR system is programmed to record waves that intersect the receiving antenna.

travel time: usually the "two-way" time that is measured from when a radar wave leaves the transmitting antenna, moves through a medium, and is then received and recorded at a paired receiving antenna. Can sometimes be "one-way" if antennas are separated and certain types of velocity tests are being performed, or packages of ground are being studied by separating antennas in some other study method.