Geomorphological Assessment for the Proposed Runway Extension at Lydd Airport

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Executive Summary

The area of the proposed runway extension at Lydd Airport, lying within the airport boundary, was surveyed to determine the nature of the geomorphological record and the topography of the gravel. The sediment record shows marshland muds overlying a buried gravel surface. Where the gravel is absent, the marshland muds directly overlie a shoreface sand body. The gravel topography and sedimentary record is characteristic of the depositional limits of a series of buried gravel ridges, i.e. ‘feather edges’, that extend north and north-westward from Dungeness Foreland. Here, the gravel was deposited on a shoreface sand body, and thus provided the protected environment in which marshland mud deposition then took place under the influence of the tide. This geomorphological evidence largely replicates that found over much of Denge Marsh and, hence, is not unique within the current SSSI designation.

Introduction

The Lydd Airport site (Figure 1) is currently used as an airport, including a terminal, hangars, taxiways and a runway. A runway extension is proposed (planning application Y06/1048/SM), for which a geomorphological survey has been undertaken to inform decision makers of the value of geomorphology and buried deposits beneath the footprint of the proposed extension and whether the proposed development would be likely to have any significant environmental effects given the value of the geomorphology and buried deposits.

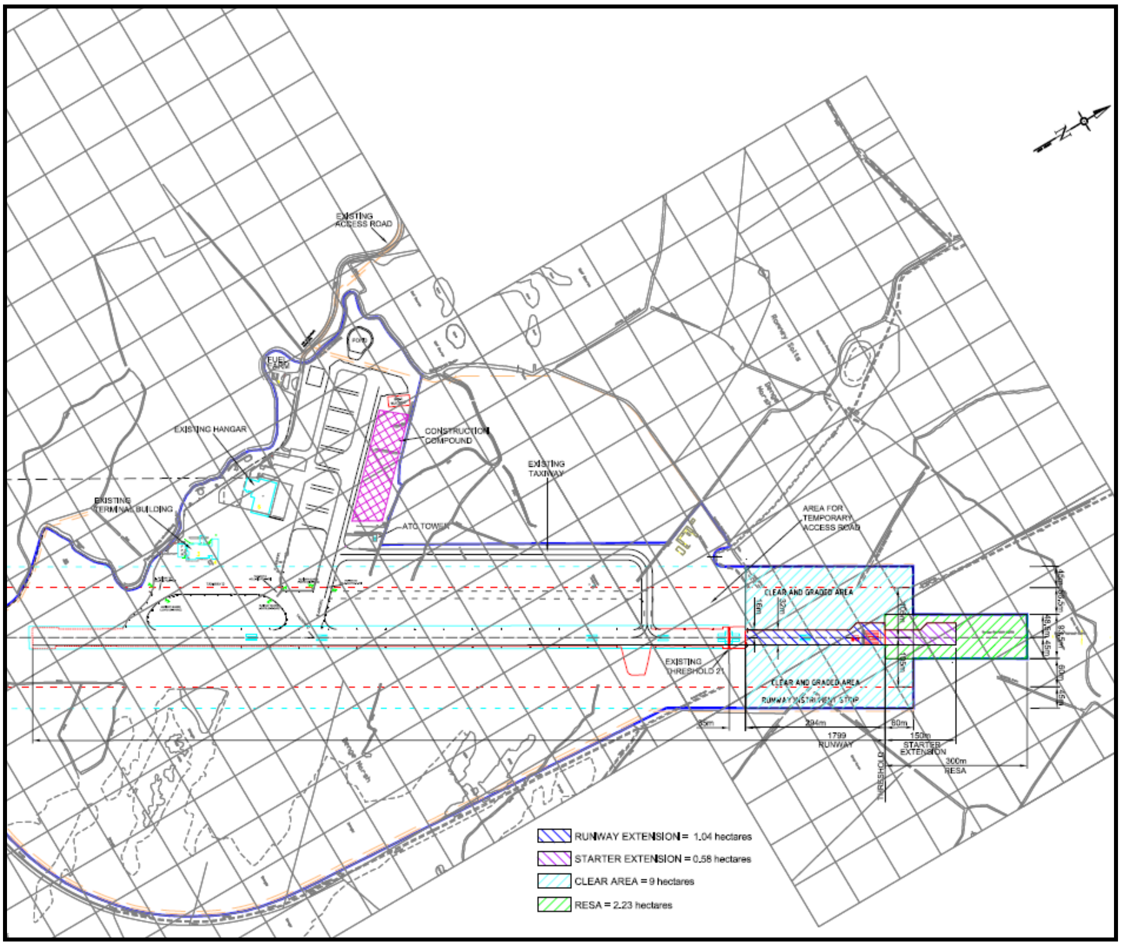

Figure 1: Lydd Airport site, illustrating the planned runway extension.

Desktop Review

The Lydd Airport site lies within Denge Marsh which occupies the geomorphological interface between the gravel foreland of Dungeness and the back-barrier marshland of

Walland and Romney marshes. Previous research in the area provides a sound framework for interpreting and understanding the geomorphology and sedimentology of Denge Marsh in the context of coastal change during the last 5000 years or so.

The general evolutionary model of the coast during the Holocene includes the development and emergence of a shoreface sand body prior to the formation of a series of recurved gravel beaches in the form of a cuspate foreland. The protection given the back-barrier or barrier estuary by foreland development has also been noted by several authors (e.g. Gulliver, 1897; Lewis, 1932; Green, 1968). Once set in motion, gravel foreland development promoted switching from an open coast to a low energy back-barrier setting that enabled rapid tidal deposition in the back-barrier (Plater et al., 2002) and tidal flat emergence (Spencer et al., 1998).

Lewis and Balchin (1940) assigned ages to particular shorelines from historical data, and placed the onset of gravel deposition at Dungeness as pre-Roman. In contrast, Eddison (1983) employed gravel ridge altitude in combination with the established trend in relative sea-level to assign a significantly older ages to an early barrier feature formed around 5500-4000 years ago. Similarly, Greensmith and Gutmanis (1990) dated the lower shoreface sands beneath the gravel at Dungeness to *c.*3100 years ago. Whilst a general sequence of shoreface emergence has been confirmed by recent stratigraphic investigations (Long et al., 2006), the chronology of shoreface emergence and foreland progradation between about 5000 and 1000 years ago is now well-constrained by a suite of consistent and independent Optically-Stimulated Luminescence (OSL) and Radiocarbon (^{14}C) ages for the gravel foreland between Broomhill and Denge Marsh (Roberts and Plater, 2005, 2007). These data show the eastward sand body development over the period from ~5000-400 years ago. The OSL ages are also indicative of sand deposition as an inter- to sub-tidal spit-like formation, with younger sediments being deposited both to the north and the east of the foreland. When coupled with the apparent directions of foreland progradation, these observations are consistent with a model of enhanced easterly growth during the post-Roman era around 2000 years ago, followed by a switch to more northerly accretion from late Saxon times *c.*1300-500 years ago. This is largely in agreement with the evolutionary model of Lewis (1932).

The fine-grained marshland sediments of Denge Marsh that overlie and interfinger with the gravel beach ridges of the Dungeness Foreland are characterised by a relatively thick suite of variably laminated sandy muds to muddy sands at depth, overlain by an increasingly structureless and heavily mottled sandy clayey silt (Plater et al., 2007). The base of the sequence is defined by the sharp contact with the gravel. Overlying the gravel or silty sand is a variably laminated sandy, clayey silt, which occasionally coarsens to a well-laminated silty sand. These laminated sediments tend to constitute half to two thirds of the post-gravel marshland sediments which fine-upward slightly before grading into an oxidation-mottled clay silt with little structure other than a few sandy lenses or partings. The modern vegetation roots into this mottled sandy mud and forms a soil.

Marshland sedimentation generally took place in the quiet water conditions behind the developing gravel ridges (back-barrier sites) and between successive gravel ridges in blind tidal channels (inter-ridge sites). As shown previously from several sites on Denge Marsh (Plater, 1992; Plater and Long, 1995; Plater et al., 1999; Plater et al., 2002), the thickness of the post-gravel marshland stratigraphy is controlled by the topography of the gravel surface and the accommodation space available between the main ridges.

The tripartite marshland lithostratigraphy - a basal gravel or sand overlain by laminated sandy muds and capped by a mottled clayey silt with minor sandy component – shows a high degree of uniformity across the Dungeness back- and inter-barrier environments. The laminated facies show an upward decrease in mean grain size, an increase in sorting, and an increase in the frequency of lamination (Plater et al., 1999). This is interpreted as a decrease in depositional energy due to tidal infilling. Foraminiferal data are indicative of variably open and closed lagoonal embayment conditions, the nearshore forms becoming predominant during periods of open access by marine waters and showing clear evidence of temporal changes in the connection between back-barrier lagoonal and open tidal flat environments (Plater et al., 2007). The same is apparent from diatom analyses of marshland sediments from Denge Marsh (Plater and Long, 1995; Plater et al., 1999).

Once shoreface emergence occurred, it would seem that gravel barrier and marshland deposition were both episodic and rapid, with marshland accretion rates of the order of 0.3 m/year being a non-linear dynamic response to changing boundary conditions (i.e. protected back-barrier or inter-ridge lows created by changing coastal morphology *via* both deposition and erosion) (Stupples and Plater, 2007). Whilst approximate dating of the marshland surfaces in relation to the altitude of limiting tidal levels originally dated the marsh sediments to between 630 and 1130 AD (Plater and Long, 1995; Plater et al., 1999), *in situ* mollusc shells preserved in the laminated facies of Manor Farm gave an age of 1260-1050 years ago (Plater et al., 2002). More recently, Palaeomagnetic Secular Variation (PSV) dating reveals two periods of episodic marshland accretion, an earlier one 1100-600 years ago following cannibalisation of the southern shore and tidal inundation of the exposed gravel lows, and a later period about 600-500 years ago in a back-barrier setting created by eastward extension of the ness (Plater et al., 2006).

The SSSI designation for Denge Marsh is based on the presence of distal limbs of successive gravel recurves at the interface between the barrier and the marshland sediments of Denge Marsh. The site possesses a series of buried gravel ridges and troughs with a general SE-NW orientation. These show some asymmetry in cross-section, with the westerly or 'landward' shoulders of the ridges being steeper, as well as the presence of offshoot limbs. Penetrable 'feather edges' of gravel are present in the upper laminated facies in the region of Boulderwall Farm and Manor Farm, suggesting that the lower laminated facies may pre-date the gravel (Plater et al., 1999). However, this is not the case in the region of Brickwall Farm and the Green Wall where the lower laminated facies overlie the buried gravel surface (Plater and Long, 1995). Irrespective of the site-specific detail, is it clear that the laminated facies are a sedimentary response to the deposition of recurved gravel beaches on the underlying shoreface sand, and hence preserve evidence of a dynamic response of tidal deposition to changing coastal morphology during the late Holocene.

The geomorphological interest features on Denge Marsh are of high geomorphological importance, being a site of international importance, well understood, having a series of academic publications relating to it, and in a partly degraded state (due to previous gravel extraction). At the time of the SSSI review, it was considered to be duplicated to some extent within the wider Dungeness GCR.

Methods

The survey assessed the geomorphic information present in the extent and nature of soils and sediments of the study area (with particular reference to the buried and surface gravel topography). The extent of the study area is shown on Figure 3. This was undertaken using hand coring and surface topographic survey.

Coring

Cores of 30-75mm diameter were sunk using both Edelman auger and Eijkelkamp gouge samplers according to the following schedule:

- Runway Extension: Boreholes were hand-drilled on a 25m-interval grid over the footprint of the proposed development (see Figure 2) with a further series of boreholes in a 'buffer zone' at 25, 50m and 100m from the footprint of the development. Cores were sunk to buried gravel, to 6m max depth if Holocene marsh sediments were encountered, or to non-recoverable saturated sand where present.

Sediments were classified and recorded in their stratigraphic context with reference to the classification scheme of Troels-Smith (1955) for characterising unconsolidated Holocene sediments and soils. Particular features of interest were recorded, including the presence of peat layers, fossiliferous material (noting macrofossils), and material suitable for radiocarbon dating. The extent of stratification (lamination) and oxidation mottling of the minerogenic units (sands and muds) were recorded, as well as the nature and depth of all stratigraphic contacts (including that with the basal gravel) and the state of preservation of any peat layers. The records from each borehole are presented in Appendix 1.

Topographic survey

The present surface of the marshland topography and the relief of the buried gravel surface (where present) were surveyed over the proposed Runway Extension (see Figure 2 for the Runway Extension Area) using a Sokkia SET-5 total station EDM. Altitudes were obtained with reference to established benchmarks on the airport runway surface and, hence, topographic surfaces are given relative to Ordnance Datum.

Present day and buried gravel surfaces in areas where gravel was present at depth are presented in the form of contour plots, where the shading highlights the relief on the gravel topography.

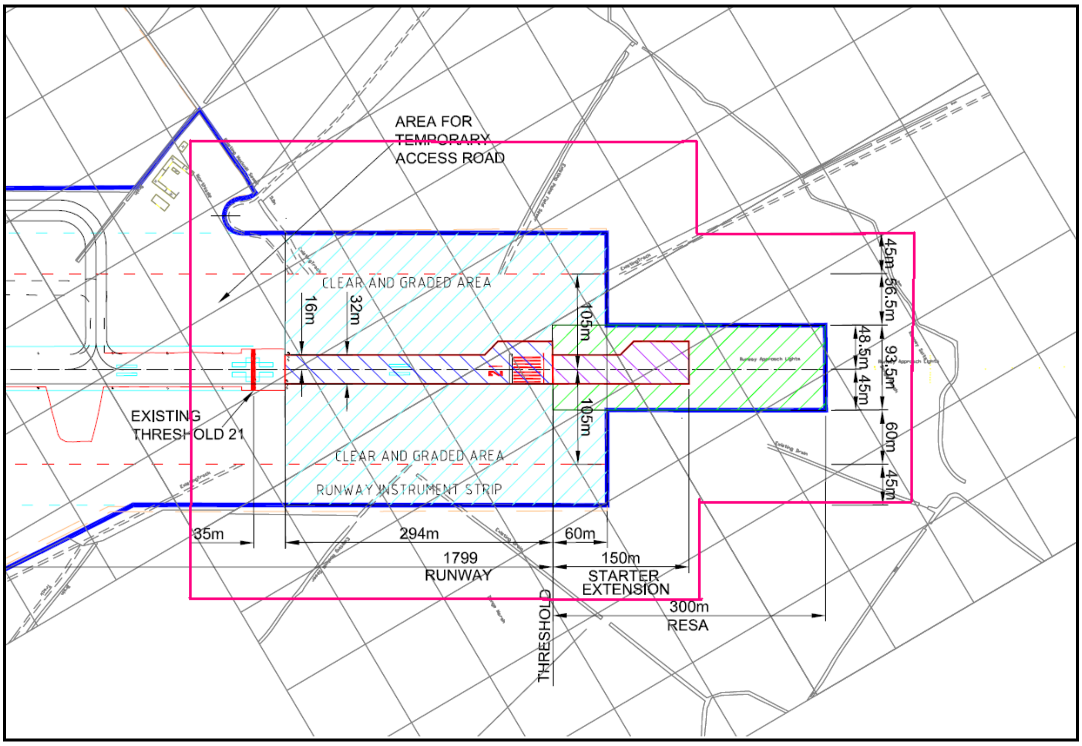

Figure 2. Detail of Runway Extension survey area to the northeast of the present runway. The area delimited in blue and cross-hatched in light blue and green shows the footprint of the proposed runway extension and Clear and Graded Area. The ‘buffer zone’ lies between this area and the boundary delimited in pink.

Results

Coring and Lithostratigraphy

The locations of boreholes drilled in the Runway Extension are given in Figure 3. The 25m-interval grid of cores is illustrated by the series of white dots that mark the site of each borehole. The area surveyed to the northeast of the present runway represents a sample of the area of the SSSI affected, but is considered sufficient for assessment of likely significant environmental effects on the geomorphology and buried deposits in the area of the SSSI affected. The boreholes were drilled in the region defined in Figure 2 as the 'Clear and Graded Area'. At all sites, coring depth rarely reached the 6m maximum limit due to either the presence of buried gravel or saturated sands that were impossible to recover using the Eijkelkamp gouge.

Gravel is present in over half the boreholes drilled in the Runway Extension area within the boundary of the airport (Figure 3). Gravel is either at or very close to the surface, where it is overlain by a gravely topsoil. In some cases, where the depth of the buried gravel permits, it is overlain by a light orange-brown, oxidation-mottled sandy silty-clay with traces of shell fragments and rootlets which overlies a light grey brown to grey clay with silt and sand traces. These are interpreted as back-barrier and inter-ridge marshland deposits laid down under intertidal conditions.

Where the gravel is absent, the marshland muds pass downward into, in turn, a light grey-brown to orange brown shelly silty-sand with traces of oxidation mottling, a grey to orange-brown saturated shelly sand, and an occasionally laminated grey saturated shelly sand and grey to black sandy-silt. This lower sediment facies is interpreted as a sub-gravel tidal flat and shoreface sand body.

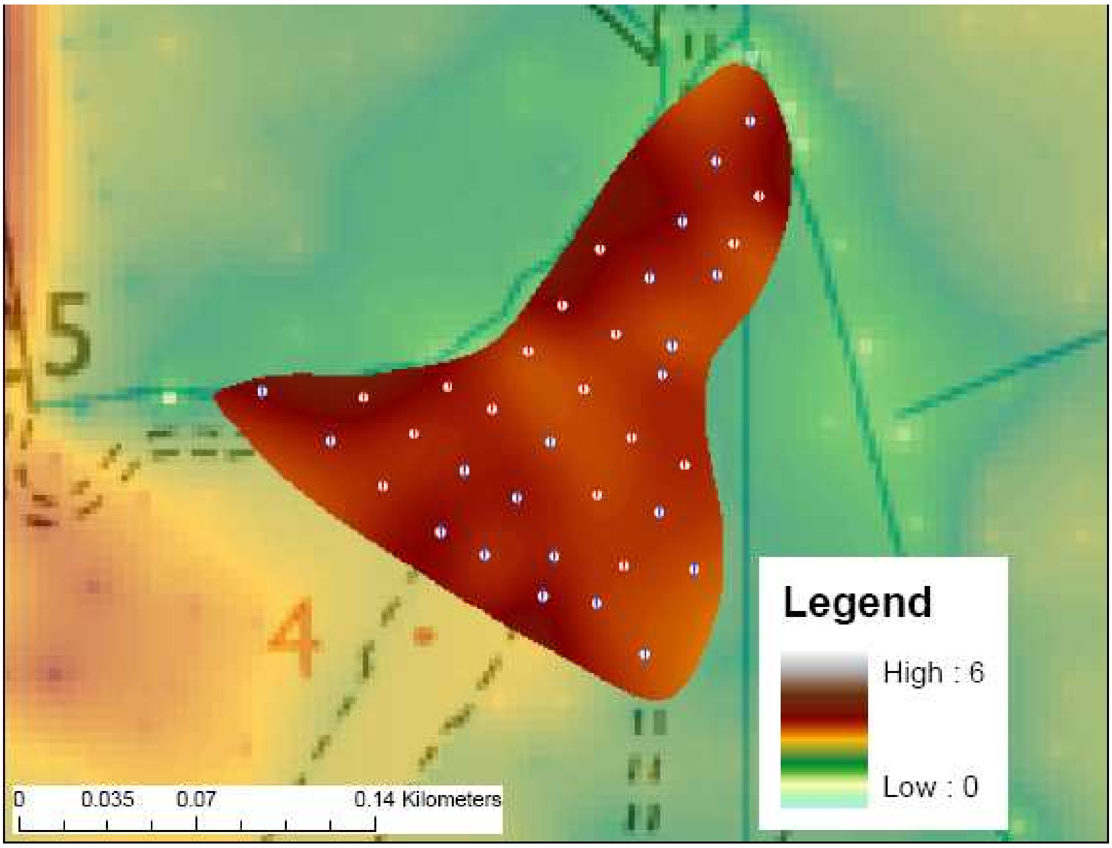

Figure 3: Surface topography of the Runway Extension study area. Cores in which gravel was encountered are denoted in blue.

Surface Topography

Three-dimensional (3-D) topographic surfaces have been constructed for the present-day and buried gravel surfaces in the Runway Extension study area alone. The surface topography (Figure 3) shows little in the way of a clear underlying structure, although there are gentle undulations and some degree of increased elevation where gravel is close to the surface. The buried gravel topography (Figure 4) is much more revealing in terms of gravel ridge topography that has become buried by the subsequent marshland muds. The shading has been adjusted so that those areas where gravel is not present are shown in a lighter colour and, hence, the margins of the buried gravel ridges are demarcated in bright green. The relative ‘height’ of the buried gravel is then shown by an increasing brown shading.

This buried gravel topography is indicative of a series of recurved storm beaches beneath the covering of marshland muds. A reasonable assumption as to their form can be considered in the context of the surface gravel exposures that lie to the south and southwest. Hence, the buried gravel topography is likely to represent the distal limits of storm beach shorelines that extend north- and northwestward from Dungeness Foreland. The fact that these are separated by areas where marshland muds directly overlie tidal flat and shoreface sands suggests that 'feather edges' of gravel are present here, where the thickness of gravel attenuates to nothing at the limit of their deposition.

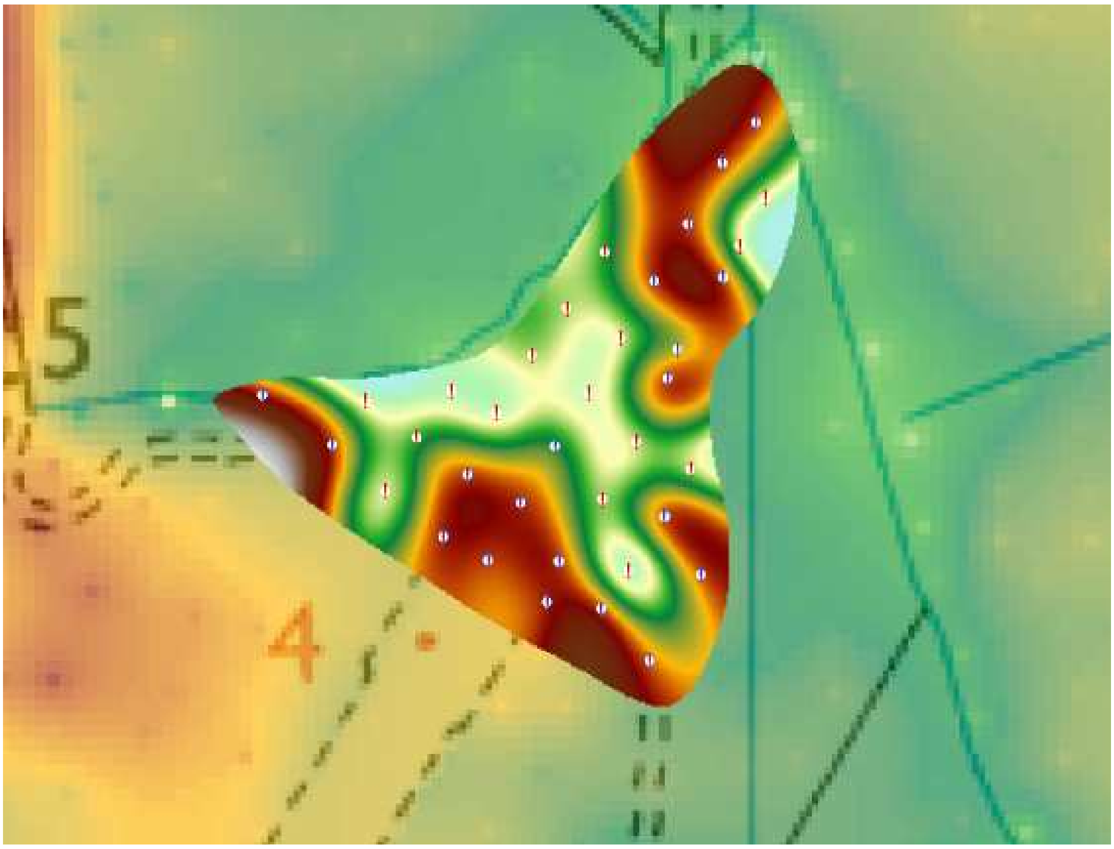

Figure 4: 3-D topography of the buried gravel in the Runway Extension study area. The light blue to cream colours show the areas where gravel is absent at depth, with the greens delimiting the margins of the buried gravel ridges. The relief on the gravel surface is then shown in the bright yellow to brown shades (see Figure 3 for legend).

Interpretation and Discussion

The lithostratigraphy of the study area is almost barren of datable materials, either in the form of peat beds or *in situ* macrofossils (paired whole shells or plant macrofossils). As a result, the only potential for further resolving the chronology of the northern limits of the gravel foreland complex lies in the luminescence (OSL) dating of the sub-gravel sands, as successfully undertaken for other parts of the foreland (Roberts & Plater, 2005, 2007; Long et al., 2006). Furthermore, the potential for late Holocene sea-level reconstruction in this region is significantly impared by the absence of lithostratigraphic sea-level index points and the poor preservation of microfossils in the highly oxidised marshland muds.

The lithostratigraphy confirms the presence of a sub-gravel tidal flat and/or shoreface dominated by shelly- and silty-sands, which appear to exhibit a subtle fining-upward sequence. These give way to a further fining-upward facies of muds (sandy, clayey-silts becoming silty-clays) which are interpreted as being a period of intertidal flat and saltmarsh deposition brought about by foreland progradation and the formation and extension of recurved gravel storm beaches on the underlying sand body. In several cores from the Runway Extension area, marshland muds directly overlie buried gravel. Here the gravel is of sufficient thickness to prevent any further penetration, although it would be expected that the gravel would be underlain by the tidal flat and shoreface sands, as seen beneath Dungeness Foreland (Long et al., 2006). These gravel storm beaches provided the protected conditions in both back-barrier and inter-ridge environments where tidal muds settled from suspension. There is no evidence in the form of tidal rhythmites (*cf.* Supples and Plater, 2007) that would indicate this period of marshland mud deposition was rapid.

The disposition and topography of buried gravel in the region of the Runway Extension is indicative of 'feather edges' of gravel at the very northern limits of the storm beaches – as found over large parts of Denge Marsh to the southwest (e.g. Plater and Long, 1995; Plater et al., 1999).

On the basis of the sample survey undertaken, there are no indications that the gravel in the area to be affected by the proposed runway extension is unique within the SSSI.

Recommendations

In the 'clear and graded area' of the proposed Runway Extension, the distal limits of recurved gravel storm beaches lie buried beneath marshland muds which were deposited in their lee after formation. These findings provide confirmation of what we already know of this part of the SSSI where the gravel storm beaches of Dungeness Foreland extend towards New Romney, decreasing in crest altitude and thickness as they do so. This sedimentological sequence of a tidal flat and shoreface sand body providing the platform for gravel storm beach deposition and, in turn, the formation of quiet-water back-barrier and inter-ridge conditions for tidal mud deposition has been proven for much of Denge Marsh (Plater and Long, 1995; Plater et al., 1999; Long et al., in press). The same can be said for the geomorphological setting of marshland muds occupying hollows between the distal limbs and 'feather edges' of recurved gravel storm beaches.

Based on the sample survey undertaken to date, it is thus reasonable to conclude that the Runway Extension area is likely to largely replicate the geomorphology and sedimentology of the Denge Marsh area. Buried peat horizons, as found the region of Allens Bank (Plater and Turner, 2002), may potentially be found, offering further elucidation of the late Holocene evolution of Dungeness Foreland in response to sea-level change and storms. Particle size analysis, OSL dating of the sub-gravel sand body and micropalaeontological investigation of the marshland muds would be required to confirm this.

Based on the findings above the likely significant environmental effects of the proposed runway extension on the geomorphology and buried deposits within the SSSI will not lead to wholescale loss of geomorphological evidence on the gravel/marsh interface, nor on the geomorphology and sedimentology of recurved gravel ridge 'feather edges' at their distal limits. Indeed, any impacts within the Runway Extension area may be offset considerably by the benefits to be gained from further analysis of the sedimentary record. Such analyses would utilise current state-of-the-art approaches (e.g. OSL and radiocarbon dating, laser granulometry, and pollen, diatom and foram analysis) for environmental reconstruction and, hence, all the potentially available information on past coastal change would be acquired before development commenced. Further detailed surveys could be undertaken over other parts of the Runway Extension area if required following the grant of planning permission but prior to development commencing, but for the purposes of assessing the likely significant environmental effects of the proposed Runway Extension development, the assessment undertaken to date is considered sufficient for reasonable assessment to be made.

It is also considered likely that if any protection measures were required following any further survey work, suitable protection measures could be undertaken to allow the development to proceed.

References

Eddison, J. (1983) The evolution of the barrier beaches between Fairlight and Hythe. *The Geographical Journal* **149**, 39-75.

Green, R.D. (1968) *Soils of Romney Marsh*. Soil Survey of Great Britain, Bulletin No.4. Harpenden.

Greensmith, J.T. and Gutmanis, J.C. (1990) Aspects of the late Holocene depositional history of the Dungeness area, Kent. *Proceedings of the Geologists' Association* **101**, 225-37.

Gulliver, F.P. (1897) Dungeness Foreland. *Geographical Journal* **9**, 536-546.

Lewis, W.V. (1932) The formation of Dungeness Foreland. *The Geographical Journal* **80**, 309-24.

Lewis, W.V. and Balchin, W.G.V. (1940) Past sea-levels at Dungeness. *The Geographical Journal* **96**, 258-85.

Long A.J., Waller, M.P. and Plater, A.J. (2006) Coastal resilience and late Holocene tidal inlet history: The evolution of Dungeness Foreland and the Romney Marsh depositional complex (UK). *Geomorphology*, **82**(3-4), 309-330.

Long A.J., Waller, M.P. and Plater, A.J. (in press). *The Late Holocene Evolution of the Romney Marsh / Dungeness Foreland Depositional Complex, UK.* Oxbow Books, Oxford.

Plater, A.J. (1992) The late Holocene evolution of Denge Marsh, southeast England: a stratigraphic, sedimentological and micropalaeontological approach. *The Holocene* **2**, 63-70.

Plater, A.J. and Long, A.J. (1995). The morphology and evolution of Denge Beach and Denge Marsh. In; Eddison, J. (ed.), *Romney Marsh: The Debatable Ground*, Oxford University Committee for Archaeology Monograph 41, Oxbow, Oxford, 8-36.

Plater, A.J. and Turner, S.D. (2002). Palaeoenvironmental investigation of Allens Bank, Lydd. Report on field and laboratory research commissioned by Brett Aggregated Ltd., Department of Geography, University of Liverpool.

Plater, A.J., Stupples, P. and Roberts, H.M. (2007) The Depositional History of Dungeness Foreland. In: Long, A., Waller, M., Plater, A. (Eds.), *The late-Holocene Evolution of the Romney Marsh/Dungeness Foreland Depositional Complex, UK*. English Heritage Monograph, Oxbow Books.

Plater, A.J., Spencer, C.D., Delacour, R.A.P., and Long, A.J. (1999). The stratigraphic record of sea-level change and storms during the last 2,000 years: Romney Marsh, south-east England. Quaternary International, 55, 17-27.

Plater, A., Stupples, P., Roberts, H. and Owen, C. (2002) The evidence for Late Holocene foreland progradation and rapid tidal sedimentation from the barrier and marsh sediments of Romney Marsh and Dungeness: a geomorphological perspective. In: Long, S.-H., Hipkin, S., Clarke, H. (Eds.), *Romney Marsh: coastal and landscape change through the Ages*. Oxford University School for Archaeology, Monograph Series 56, pp. 40-57.

Plater, A., Stupples, P., Shaw, J. and Hemetsberger, S. (2006). *Dungeness SE England, UK: Palaeomagnetic Secular Variation (PSV) Dating and Environmental Magnetic Properties of Late Holocene Marsh Sediments*. Scientific Dating Report, Research Department Research Series No.48/2006, 66p.

Roberts, H.M. and Plater, A.J. (2005). *Optically Stimulated Luminescence (OSL) Dating of Sands Underlying the Gravel Beach Ridges of Dungeness and Camber, Southeast England, UK* . Centre for Archaeology vol 27/2005, 84p.

Roberts, H.M. and Plater, A.J. (2007) Optically-stimulated luminescence dating of Dungeness: the nature and timing of foreland progradations during the mid- to late-Holocene. The Holocene, **17**(4), 493-504.

Spencer, C.D., Plater, A.J. and Long, A.J. (1998) Rapid coastal change during the mid- to late-Holocene: the record of barrier estuary sedimentation in the Romney Marsh region, southeast England. *The Holocene* **8**, 143-163.

Stupples, P. and Plater, A.J. (2007). Controls on the temporal and spatial resolution of tidal signal preservation in late-Holocene tidal rhythmites, Romney Marsh, southeast England. *International Journal of Earth Sciences,* DOI 10.1007/s00531-006-0134-2

Troels-Smith, J. (1955) Characterisation of Unconsolidated Sediments, Geological Survey of Denmark. Series IV, 3, 1-75.

Appendix 1: Troels-Smith Core Descriptions for Runway Extension Site

R-4A (hit gravel): alt 348.

0-14: Topsoil with trace of gravel.

14: Gravel.

R-3A (hit gravel): alt 326.

0-15: Topsoil with trace of gravel.

15: Gravel.

R-3B (IR): alt 359.

0-63: Topsoil with trace of gravel.

63-98: 2, 0, 0, 3, 0. As 2, Ag 1, Ga 1, Lf +, Th +, Ptm +.
Slightly sandy light orange brown silty clay with traces of sand, shell fragments and rootlets. Oxidation mottling.

98-174: 2, 0, 0, 2+, 0. Ga 2, Ag 1, Ptm 1, Lf +, Anth +.
Light grey brown to orange brown shelly, silty sand. Traces of oxidation mottling and charcoal.

174-201: 3, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Grey.

201-226: 4, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Black.

226-287: 2, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Orange brown to grey.

R-2A (IR): alt 326.

0-35: Topsoil with trace of gravel.

35-84: 2, 0, 0, 3, 0. As 2, Ag 1, Ga 1, Lf +, Th +, Ptm +.
Slightly sandy light orange brown silty clay with traces of sand, shell fragments and rootlets. Oxidation mottling.

84-136: 2, 0, 0, 2+, 0. Ga 2, Ag 1, Ptm 1, Lf +, Anth +.
Light grey brown to orange brown shelly, silty sand. Traces of oxidation mottling and charcoal.

136-152: 2, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Orange brown to grey.

152-215: 3, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Grey.

R-2B (IR): alt 319.

0-36: Topsoil with trace of gravel.

36-55: 2+, 0, 0, 3, 0. As 3, Ag 1, Ga +, Lf +, Th +, Ptm +.
Light orange brown silty clay with traces of sand, shell fragments and rootlets. Oxidation mottling.

55-88: 2, 0, 0, 3, 0. As 2, Ag 1, Ga 1, Lf +, Th +, Ptm +.
Slightly sandy light orange brown silty clay with traces of sand, shell fragments and rootlets. Oxidation mottling.

88-124: 2, 0, 0, 2+, 0. Ga 2, Ag 1, Ptm 1, Lf +, Anth +.
Light grey brown to orange brown shelly, silty sand. Traces of oxidation mottling and charcoal.

124-138: 1+, 4, 0, 2, 0. Ag 2, As 1, Ga 1 Lf +.
Laminated blue grey mottled clay with silt and sand traces.

138-173: 4, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Black.

R-2C (IR): alt 332.

0-65: Topsoil with trace of gravel.

65-127: 2, 0, 0, 3, 0. As 2, Ag 1, Ga 1, Lf +, Th +, Ptm +.
Slightly sandy light orange brown silty clay with traces of sand, shell fragments and rootlets. Oxidation mottling.

127-129: 2, 0, 0, 2+, 0. Ga 2, Ag 1, Ptm 1, Lf +, Anth +.
Light grey brown to orange brown shelly, silty sand. Traces of oxidation mottling and charcoal.

129-132: 2, 0, 0, 3, 0. As 2, Ag 1, Ga 1, Lf +, Th +, Ptm +.
Slightly sandy light orange brown silty clay with traces of sand, shell fragments and rootlets. Oxidation mottling.

132-134: 2, 0, 0, 2+, 0. Ga 2, Ag 1, Ptm 1, Lf +, Anth +.
Light grey brown to orange brown shelly, silty sand. Traces of oxidation mottling and charcoal.

134-144: 2, 0, 0, 3, 0. As 2, Ag 1, Ga 1, Lf +, Th +, Ptm +.
Slightly sandy light orange brown silty clay with traces of sand, shell fragments and rootlets. Oxidation mottling.

144-188: 1+, 4, 0, 2+, 0. As 2, Ag 1, Ga 1, Lf +.
Laminated blue grey clay with silt and fine sand. Traces of oxidation mottling.

188-288: 4, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Black.

R-1A (hit gravel): alt 337.

0-17: Topsoil with trace of gravel.

17: Gravel.

R-1B (hit gravel): alt 324.

0-18: Topsoil with trace of gravel.

18: Gravel.

R-1C (IR): alt 317.

0-46: Topsoil with trace of gravel.

46-82: 2, 0, 0, 3, 0. As 2, Ag 1, Ga 1, Lf +, Th +, Ptm +.
Slightly sandy light orange brown silty clay with traces of sand, shell fragments and rootlets. Oxidation mottling.

82-142: 2, 0, 0, 2+, 0. Ga 2, Ag 1, Ptm 1, Lf +, Anth +.
Light grey brown to orange brown shelly, silty sand. Traces of oxidation mottling and charcoal.

142-157: 3, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Grey.

157-256: 4, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Black.

R-1D (IR): alt 344.

0-33: Topsoil with trace of gravel.

33-53: 2+, 0, 0, 3, 0. As 3, Ag 1, Ga +, Lf +, Th +, Ptm +.

Light orange brown silty clay with traces of sand, shell fragments and rootlets. Oxidation mottling.

53-74: 2, 0, 0, 3, 0. As 1, Ga 3, Ag +, Lf +, Th +, Ptm +.
Light orange brown sand with clay and trace of silt. Traces of shell fragments and rootlets. Oxidation mottling.

74-120: 2, 0, 0, 2+, 0. Ga 2, Ag 1, Ptm 1, Tm +, Lf +, Anth +.
Light grey brown to orange brown shelly, silty sand. Traces of oxidation mottling and charcoal.

120-189: 4, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Black.

R-1E (IR): alt 344.

0-69: Topsoil with trace of gravel.

69-125: 2+, 0, 0, 3, 0. As 3, Ag 1, Ga +, Lf +, Th +, Ptm +.
Light orange brown silty clay with traces of sand, shell fragments and rootlets. Oxidation mottling.

125-160: 2, 0, 0, 2+, 0. Ga 2, Ag 1, Ptm 1, Lf +, Anth +.
Light grey brown to orange brown shelly, silty sand. Traces of oxidation mottling and charcoal.

160-204: 2, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Orange brown to grey.

204-233: 4, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Black.

R-1F (IR): alt 348.

0-30: Topsoil with trace of gravel.

30-110: 2+, 0, 0, 3, 0. As 3, Ag 1, Ga +, Lf +, Th +, Ptm +.
Light orange brown silty clay with traces of sand, shell fragments and rootlets. Oxidation mottling.

110-180: 2, 0, 0, 2+, 0. Ga 2, Ag 1, Ptm 1, Lf +, Anth +.
Light grey brown to orange brown shelly, silty sand. Traces of oxidation mottling and charcoal.

180-196: 2, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Orange brown to grey.

R0A (hit gravel): alt 361.

0-11: Topsoil with trace of gravel.

11: Gravel.

R0B (hit gravel): alt 328.

0-12: Topsoil with trace of gravel.

12: Gravel.

R0C (hit gravel): alt 304.

0-18: Topsoil with trace of gravel.

18-52: 2, 0, 0, 3, 0. As 1, Ga 3, Ag +, Lf +, Th +, Ptm +.
Light orange brown sand with clay and trace of silt. Traces of shell fragments and rootlets. Oxidation mottling.

52-66: 2, 0 , 0, 2, 0. Ag 2, As 1, Ga 1 Lf +.
Grey mottled clay with silt and sand traces.

66-122: 2, 0, 0, 2+, 0. Ga 2, Ag 1, Ptm 1, Lf +, Anth +.
Light grey brown to orange brown shelly, silty sand. Traces of oxidation mottling and charcoal.

122-124: 2, 0, 0, 2, 0. Ag 2, As 1, Ga 1 Lf +.
Grey mottled clay with silt and sand traces.

124: Gravel.

R0D (IR): alt 301.

0-19: Topsoil with trace of gravel.

19-31: 2, 0, 0, 3, 0. As 1, Ga 3, Ag +, Lf +, Th +, Ptm +, G +.
Light orange brown sand with clay and trace of silt. Traces of shell fragments, gravel and rootlets. Oxidation mottling.

31-44: 2, 0 , 0, 2, 0. Ag 2, As 1, Ga 1 Lf +, G +, Tm +.
Grey mottled clay with traces of silt, fine sand and shells.

44-79: 2, 0, 0, 2+, 0. Ga 2, As 1, Ptm 1, Ag +, Lf +, Anth +.
Light grey brown to orange brown shelly, clayey sand. Traces of oxidation mottling, silt and charcoal.

79-103: 2, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Orange brown to grey.

103-236: 4, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Black.

R0E (IR): alt 312.

0-15: Topsoil with trace of gravel.

15-40: 2, 0, 0, 3, 0. As 1, Ga 3, Ag +, Lf +, Th +, Ptm +.
Light orange brown sand with clay and trace of silt. Traces of shell fragments and rootlets. Oxidation mottling.

40-136: 2, 0 , 0, 2, 0. Ag 2, As 1, Ga 1 Lf +, G +, Tm +.
Grey mottled clay with traces of silt, fine sand and shells.

136-213: 4, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Black.

R0F (hit gravel): alt 322.

0-17: Topsoil with trace of gravel.

17: Gravel.

R0G (hit gravel): alt 335.

0-26: Topsoil with trace of gravel.

26: Gravel.

R0H (hit gravel): alt 319.

0-12: Topsoil with trace of gravel.

12: Gravel.

R0G (hit gravel): alt 321.

0-18: Topsoil with trace of gravel.

18: Gravel.

R1A (hit gravel): alt 339.

0-15: Topsoil with trace of gravel.

15: Gravel.

R1B (hit gravel): alt 322.

0-12: Topsoil with trace of gravel.

12: Gravel.

R1C (IR): alt 304.

0-33: Topsoil with trace of gravel.

33-66: 2+, 0, 0, 3, 0. As 3, Ag 1, Ga +, Lf +, Th +, Ptm +.
Light orange brown silty clay with traces of sand, shell fragments and rootlets. Oxidation mottling.

66-89: 2, 0, 0, 3, 0. As 1, Ga 3, Ag +, Lf +, Th +, Ptm +, Tm +.
Light orange brown sand with clay and trace of silt. Traces of shell fragments, shells and rootlets. Oxidation mottling.

89-183: 2, 4, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Laminated saturated shelly sand. Traces of silt and oxidation mottling. Orange brown to grey.

R1D (IR): alt 308.

0-28: Topsoil with trace of gravel.

28-52: 2+, 0, 0, 3, 0. As 3, Ag 1, Ga +, Lf +, Th +, Ptm +, Tm +.
Light orange brown silty clay with traces of sand, shells, shell fragments and rootlets. Oxidation mottling.

52-85: 2, 0, 0, 3, 0. As 1, Ga 3, Ag +, Lf +, Th +, Ptm +, Tm +.
Light orange brown sand with clay and trace of silt. Traces of shell fragments, shells and rootlets. Oxidation mottling.

85-124: 1+, 4, 0, 2, 0. Ag 2, As 1, Ga 1 Lf +.
Laminated blue grey mottled clay with silt and sand traces.

124-152: 2, 4, 0, 2+, 0. Ga 2, Ag 1, Ptm 1, Lf +, Anth +.
Laminated light grey brown to orange brown shelly, silty sand. Traces of oxidation mottling and charcoal.

152-200: 4, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Black.

R1E (hit gravel): alt 314.

0-15: Topsoil with trace of gravel.

15: Gravel.

R1F (hit gravel): alt 300.

0-26: Topsoil with trace of gravel.

26-54: 2+, 0, 0, 3, 0. As 3, Ag 1, Ga +, Lf +, Th +, Ptm +, G +.
Light orange brown silty clay with traces of sand, gravel, shell fragments and rootlets. Oxidation mottling.

54-68: 2+, 0, 0, 3, 0. As 3, Ag 1, Ga +, Lf +, Th +, Ptm +, G +.
Orange brown silty clay with traces of sand, gravel, shell fragments and rootlets. Oxidation mottling.

68: Gravel.

R1G (hit gravel): alt 308.

0-12: Topsoil with trace of gravel.

12: Gravel.

R1H (IR): alt 302.

0-28: Topsoil with trace of gravel.

28-60: 2+, 0, 0, 3, 0. As 3, Ag 1, Ga +, Lf +, Th +, Ptm +.
Light orange brown silty clay with traces of sand, shell fragments and rootlets. Oxidation mottling.

60-102: 2, 0, 0, 3, 0. As 1, Ga 3, Ag +, Lf +, Th +, Ptm +.
Light orange brown sand with clay and trace of silt. Traces of shell fragments and rootlets. Oxidation mottling.

102-138: 2, 0, 0, 2+, 0. Ga 2, Ag 1, Ptm 1, Lf +, Anth +.
Light grey brown to orange brown shelly, silty sand. Traces of oxidation mottling and charcoal.

138-198: 2, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.

Saturated shelly sand. Traces of silt and oxidation mottling. Orange brown to grey.

R1I (IR): alt 331.

0-54: Topsoil with trace of gravel.

54-89: 2, 0, 0, 3, 0. As 2, Ag 1, Ga 1, Lf +, Th +, Ptm +.
Slightly sandy light orange brown silty clay with traces of sand, shell fragments and rootlets. Oxidation mottling.

89-248: 2, 0, 0, 2+, 0. Ga 2, Ag 1, Ptm 1, Lf +, Anth +.
Light grey brown to orange brown shelly, silty sand. Traces of oxidation mottling and charcoal.

R2A (hit gravel): alt 311.

0-8: Topsoil with trace of gravel.

8: Gravel.

R2B (IR): alt 308.

0-34: Topsoil with trace of gravel.

34-92: 2, 0, 0, 3, 0. As 2, Ag 1, Ga 1, Lf +, Th +, Ptm +.
Slightly sandy light orange brown silty clay with traces of sand, shell fragments and rootlets. Oxidation mottling.

92-106: 2, 0, 0, 2+, 0. Ga 2, Ag 1, Ptm 1, Lf +, Anth +.
Light grey brown to orange brown shelly, silty sand. Traces of oxidation mottling and charcoal.

106-206: 3, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Grey.

206-259: 4, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Black.

R2C (hit gravel): alt 311.

0-17: Topsoil with trace of gravel.

17: Gravel.

R2D (IR): alt 318.

0-26: Topsoil with trace of gravel.

26-82: 2+, 0, 0, 3, 0. As 3, Ag 1, Ga +, Lf +, Th +, Ptm +, G.
Light orange brown silty clay with traces of sand, gravel, shell fragments and rootlets. Oxidation mottling.

82-90: 2, 0, 0, 2, 0. Ag 2, As 1, Ga 1 Lf +.
Orange mottled clay with silt and sand traces.

90-120: 2, 0, 0, 2+, 0. Ga 2, Ag 1, Ptm 1, Lf +, Anth +.
Light grey brown to orange brown shelly, silty sand. Traces of oxidation mottling and charcoal.

120-200: 3, 0, 0, 2, 0. Ga 3, Ptm 1, Ag +, Lf +.
Saturated shelly sand. Traces of silt and oxidation mottling. Grey.

R3A (hit gravel): alt 298.

0-11: Topsoil with trace of gravel.

11: Gravel.

R3B (hit gravel): alt 297.

0-8: Topsoil with trace of gravel.

8: Gravel.