ARCHAEOLOGICAL SERVICES
DURHAM UNIVERSITY

on behalf of

BMMJV Ltd

Greatham South Flood Alleviation Scheme Stockton on Tees

post-excavation assessment

report 4590rev2
August 2018

Durham University

Contents

Photographs

Figures

Green Lane · Durham · DH1 3LA · tel 0191 334 1121 · fax 0191 334 1126
archaeological.services@durham.ac.uk · www.dur.ac.uk/archaeological.services

1. Summary

The project

1.1 This report presents the results of a scheme of archaeological works conducted in conjunction with a flood alleviation scheme at Greatham South, Stockton on Tees. The works comprised:

- Archaeological recording and monitoring for the excavation of a WWII Spigot Mortar emplacement
- Targeted excavation of two salterns
- Strip, map and record of two locations
- Excavation of a section across the old sea wall
- Archaeological monitoring of excavation work for two pond connectors

1.2 The works were commissioned by BMMJV Ltd and conducted by Archaeological Services Durham University.

1.3 Approximately 50% of the spigot mortar gun emplacement was excavated and recorded. This revealed a high level of preservation of the gun emplacement itself, with the floors of the emplacement and the ammunition locker still surviving. The construction cut for the emplacement was also identified, and some of the chestnut paling used as internal walling was recovered from the backfill and topsoil deposits.

1.4 Organic deposits were identified at both saltern sites, indicating former channels beneath the saltern mounds. Above these deposits, laminate deposits and thin layers of soil were identified, forming the mounds themselves. These were interpreted as being waste deposits from the 'sleeching' process during salt production. Industrial residue was present in several of the laminate deposits, which is consistent with the sleeching process. No other features associated with salt production were identified during the works.

1.5 No archaeological resource was identified within the strip, map and record areas, or the channel widening trenches. The deposits identified related to the natural silting up of former and existing water courses. Modern made ground deposits relating to landscaping or levelling were identified in both pond connector trenches.

1.6 Prior to excavation, it was assumed that the old sea wall defences consisted of two embankments. However, only the narrower western embankment formed the sea wall. The eastern embankment, constructed of industrial deposits and stone layers, is likely to be part of a road built by prisoners of war during the First World War between Port Clarence to Seaton Carew, running for most of its length under the existing A178 Seaton Carew road). It is suggested that the excavated embankment was a north-west leg of the road that branches off before stopping abruptly at Greatham Creek, where a WWII section post is now located.

1.7 The results of radiocarbon and palaeoenvironmental investigation indicates peat layer [9] in saltern Test Pit 3 began to accumulate in the middle Neolithic period within an alder carr environment. Organic silty clays dating from the late Neolithic to late Bronze Age contain plant macrofossils and forams typical of saltmarsh vegetation. Charred palaeoenvironmental remains are absent from the samples from the salterns.

1.8 No further analysis work is required, and the results do not justify academic publication. This analysis report will be a publically accessible document through OASIS and the Historic Environment Record, and the results will be available for any future synthesis of works on salterns. It is recommended that a short article on the works is placed in the Teesside Archaeological Society Bulletin as a further means of public dissemination.

2. Project background

Location (Figure 1)

2.1 The site is located within Cowpen Marsh, immediately south of Greatham Creek, approximately 3km east of Billingham, Stockton on Tees (NGR centre: NZ 506 251). It covers an area of around 58ha. Flood embankments relating to Greatham Creek bound the site to the north, with Cowpen Bewley landfill site immediately to the west. There are further areas of marshland to the south and west, with the A178 dividing the site into east and west sections.

Development

2.2 The development is a flood alleviation scheme, comprising the creation of new embankments and breaches on the existing embankment.

Objective

2.3 The overall aim of the archaeological works is to further understand the site in relation to the strategic aims as set out in the North East Regional Research Framework for the Historic Environment (see section 2.4 below). Specific aims of the fieldwork were as follows:

- Understand the palaeoenvironment associated with any peat layers identified
- Understand the salt industry in the north-east
- Understand the previous flood defences of the salt marshes
- Record and understand the World War II structures

Research Objectives

2.4 The regional research framework (Petts & Gerrard 2006) contains an agenda for archaeological research in the region, which is incorporated into regional planning policy implementation with respect to archaeology. In this instance, the scheme of works was designed to address agenda items:

- **Science and Environment**
  - SEii Paleaeoenvironmental evidence
- **Palaeolithic and Mesolithic**
  - Mi Understanding coastal environmental change, in particular the drowning of the North Sea basin and its links with patterns of early human settlement
- **Later Medieval**
  - MDviii Other medieval industries
- **20th century**
  - MOvi Military and defence

Specification

2.5 The works have been undertaken in accordance with a Project Design provided by Mott Macdonald (2017) and a Written Scheme of Investigation provided by Archaeological Services Durham University (reference DS17.144r) and approved by the planning authority. In the case of the Spigot Mortar emplacement, the feature was excavated and recorded, but due to a change in the project design, it was not necessary to remove it.

Dates

2.6 Fieldwork was undertaken between 18th May and 2nd October 2017. This report was prepared for August 2018.

Personnel

2.7 Fieldwork was conducted by Hilary Andrews, Jenny Richards and Rebekah Watson (supervisor), with recording of the spigot mortar by Richard Annis. This report was prepared by Rebekah Watson, with illustrations by David Graham. Specialist reporting was conducted by Dr Carrie Armstrong (animal bone), Jennifer Jones (other artefacts) and Dr Charlotte O'Brien (palaeoenvironmental). Pollen preparation was by Dr Charlotte O'Brien and Lisa Snape-Kennedy. Foraminifera identification was by Dr Sarah Woodroffe. Bulk sample processing was undertaken by Lauren Kancle and Laura Watson. The Project Manager was Daniel Still.

Archive/OASIS

2.8 The site code is **GSF17**, for **G**reatham **S**outh **F**lood Alleviation Scheme 20**17**. The archive is currently held by Archaeological Services Durham University and will be transferred to Tees Archaeology in due course. The flots, charcoal and pollen preparations will be retained at Archaeological Services Durham University. Archaeological Services Durham University is registered with the **O**nline **A**cces**S** to the **I**ndex of archaeological investigation**S** project (**OASIS**). The OASIS ID number for this project is **archaeol3-298231**.

3. Landuse, topography and geology

3.1 At the time of this assessment, the development area comprised reclaimed salt marsh used for grazing.

3.2 The area was predominantly level with a mean elevation of approximately 1.5m AOD. Existing flood defences stand to approximately 3.5m AOD.

3.3 The underlying solid geology of the area comprises Permian and Triassic strata of the Sherwood Sandstone Group, which are overlain by Tidal Flat Deposits of sand, silt and clay from the Quarternary period (www.bgs.ac.uk). The soil is characterised as 'Soilscape 21: Loamy and clayey soils of coastal flats with naturally high groundwater' (www.landis.org.uk/soilscapes).

4. Historical and archaeological background

4.1 The following is a summary of the background to the site set out in the project design (Mott Macdonald 2017).

4.2 Peat deposits have been recorded within the scheme boundary during ground investigation work. Palaeochannels are also recorded within the development area which could have a deep record of prehistoric sedimentation and are likely to have been exploited during the prehistoric period.

4.3 Documentary evidence indicates that from the 12th century salt manufacturing was undertaken in the area, with Cowpen Marsh the main area for production. A complex of ten salterns (salt working sites) is recorded within the scheme boundary.

Two of these are within the footprint of the scheme and will be disturbed by alterations to the embankment.

4.4 The salterns fell out of use in 1650 following a period of severe tidal inundation. Land reclamation was undertaken up to the 20th century and cut the salterns off from the tide. The 1838 tithe map of Cowpen Bewley illustrates the Old Sea Wall.

4.5 In 1887 rock salt was discovered at Greatham and deep solution mining continued until the late 20th century.

4.6 During both WWI and WWII coastal defences were constructed at Greatham Creek. Within the development area these include three concrete section posts and a spigot mortar emplacement.

5. The archaeological works

Introduction

5.1 The works comprised several tasks at various locations across the site (Figure 2). These may be summarised as:

- Archaeological recording and monitoring for the excavation of a WWII Spigot Mortar emplacement
- Targeted excavation of two salterns
- Strip, map and record of two locations
- Excavation of a section across the old sea wall
- Archaeological monitoring of excavation work for two pond connectors

All groundworks were conducted using a machine equipped with a toothless ditching bucket and under constant archaeological supervision. Context data is summarised in Table 1.1.

Spigot Mortar emplacement (Figure 6)

5.2 Prior to the works, only the top dome of a concrete cylinder with a metal pin in the centre was visible on the ground surface (Photo 1). The works comprised the exposure and recording of the southern half of the gun emplacement. The original specification was for the removal and relocation of the spigot mortar; however, due to a change in the location of the new flood embankment it was not necessary to remove the gun emplacement.

5.3 Natural subsoil, a yellow-grey sand [58] was identified between 0.9m and 1.25m below the ground surface. The construction cut [F53] for the gun emplacement was visible in section, measuring approximately 3m wide, but only between 0.33m to 0.42m deep. This indicates that the walls of the gun emplacement were built up further than the level of the original ground surface, possibly using sandbags.

5.4 The floor of the gun emplacement [F54] was constructed using concrete around 0.1m thick. This base was roughly circular, measuring approximately 2.25m in diameter. At the eastern edge of the base was a roughly rectangular slab of concrete [F55: at least 1.1m by 0.67m] which was probably the floor surface of an ammunition locker. This floor was slightly raised from the circular base and extended into the edge of the trench, underneath the embankment.

5.5 The main part of the gun emplacement consisted of a central concrete cylinder with a slightly domed top, known as a 'thimble' [F56]. This thimble stood 1.05m high, with a diameter of 1.05m (Photo 2). A metal plate was fixed to the top of the dome, measuring 0.3m across, with a central pin still in place measuring 50mm in diameter, where the gun would have been attached. A lip of concrete, or 'fillet', ran around the base of the cylinder, connecting it to the base; this measured 0.1m in width. A crack was recorded on the southern edge of the concrete thimble, as was a shutter seam.

5.6 Once the spigot mortar fell out of use, the emplacement was backfilled with a mottled sandy deposit [52: up to 0.9m deep], and a layer of grey-brown silty topsoil [57: 0.3m deep] was laid down above it in order to raise the ground level to form the current embankment.

5.7 Several fragments of chestnut paling were recovered from deposits [52] and [57] during the excavation, comprising both twisted wire and wood fragments. This would have been used as a rough wall around the inside of the gun emplacement, supporting the surrounding earth and/or sandbags.

Targeted excavation of two salterns

5.8 These works comprised the excavation and recording of five test pits, one in Area 1 and four in Area 2. Area 1 consisted of a saltern at the western edge of the site, the western part of which would be affected by the construction of embankments. Area 2 was a saltern near the southern end of site, again much of which would be affected by embankment construction. An existing track went through the centre of the saltern, with the test pits located on either side. Each test pit measured approximately 5m by 2m.

Test Pit 1 (Figure 3)

5.9 This test pit was located near the western edge of Area 1. Natural subsoil, a dark grey silty clay [21], was identified at approximately 2.5m below the ground surface. Overlying this was a much firmer deposit of light grey silty clay [20: 0.3m deep], with a thin layer of yellow-brown silty clay [22: 0.1m deep] above it. Overlying this was a blackish-grey silty clay [19: 0.25m to 0.5m deep]. These organic deposits probably represent silting deposits of a former channel below the saltern (Photo 3). Overlying these organic layers was a thick laminate layer of yellow-brown silty clay [18], up to 1.45m deep, with a thin layer of light grey silty clay [17: 0.15m deep] above it. These deposits formed the bulk of the saltern mound and were interpreted as waste from 'sleeching', a process of salt production. This will be discussed further in section 8.3. A grey-brown silty topsoil [16: 0.25m to 0.3m deep] overlay the whole trench. Small quantities of cinder and magnetic fuel waste were recovered from channel deposit [19], perhaps relating to the earliest phase of salt-production on the site, before the saltern mound had built up.

Test Pit 2 (Figure 4)

5.10 This test pit was located near the north-western edge of Area 2, on the north side of the track. Natural subsoil, a grey-yellow silty clay [3], was identified between 2.45m and 2.8m below the ground surface. Overlying this was a firm blackish-grey silty clay deposit [15: 0.5m to 0.95m deep], probably relating to a former channel. Above this was a thick deposit of grey-brown silty clay [13: 0.45m to 1.0m deep], which contained several fragments of industrial waste and had been deposited in thin laminate layers. Overlying this was a black silt [4: 0.2m deep], with another laminate deposit above it [5], this time a brown-yellow silty clay, between 0.6m and 1.0m deep. These three deposits ([13], [4] and [5]) formed the bulk of the saltern mound (Photo 4) and it is likely they relate to the 'sleeching' process. Overlying the whole trench was a grey-brown silty topsoil [1: 0.2m deep]. As in Test Pit 1, some cinder and magnetic fuel waste were recovered from channel deposit [15].

Test Pit 3 (Figure 4)

5.11 Test Pit 3 was located near the western edge of Area 2, on the south side of the track. Natural subsoil, a grey silty clay [3], was identified at 2.6m below the ground surface. Immediately overlying this was a dark brown peat deposit [9: 0.4m to 0.55m deep], with a black very silty clay deposit [8: 0.2m deep] above it. Deposit [8] contained small quantities of cinder and magnetic fuel waste, as seen in other test pits. These organic deposits are probably associated with a former channel in the area. As in Trench 2, a laminate grey-brown silty clay [13: 0.65m to 0.75m deep] was identified overlying the organic deposits, containing fragments of industrial waste. Above this was another laminate deposit, a brown-yellow silty clay [5: 0.65m deep]. A thin layer of grey-brown silt with orange stony inclusions [6: 0.1m deep] was identified above deposit [5] at the western end of the trench. Across the whole trench was another laminate brown-yellow silty clay [2: 0.3m to 0.4m deep]. Deposits [13], [5], [6] and [2] are likely to be related to the 'sleeching' process and formed the main bulk of the saltern mound. A grey-brown silty topsoil [1: 0.25m deep] overlay the whole trench.

Test Pit 4 (Figure 4)

5.12 This test pit was located near the centre of Area 2, on the north side of the track. Natural subsoil, a grey-yellow silty clay [3], was identified at 1.7m below the ground surface. Immediately overlying the natural subsoil was a laminate deposit of grey-brown silty clay [13: 0.2m deep], overlain by a layer of reddish-brown clayey silt [12: 0.1m to 0.25m deep]. Above this deposit was a laminate brownish-red clayey silt [7: 0.35m deep], with a laminate brown-yellow silty clay [5] above it, between 0.7m and 0.8m deep. Deposits [13], [12] and [7] all contained industrial waste. Again, these laminate deposits are probably associated with 'sleeching'. Across the whole trench was a grey-brown silty topsoil [1: 0.35m deep].

Test Pit 5 (Figure 4)

5.13 Test Pit 5 was located on the eastern edge of Area 2, on the south side of the track. Natural subsoil, a grey-yellow silty clay [3], was identified between 0.9m and 1.4m below the ground surface. The disparity in depths was due to the sloping nature of the ground surface in this area; the base of the trench was fairly level. Overlying the natural subsoil was a laminate deposit of grey-brown silty clay [13: 0.25m deep] containing industrial waste, as seen in the other test pits in Area 2. Above this was a laminate brown-yellow silty clay [5], which was 0.2m deep at the east end of the trench, increasing to 0.8m deep at the west end. These two deposits probably relate to the 'sleeching' process. Across the whole trench was a grey-brown silty topsoil [1: 0.15m to 0.35m deep].

Strip, map and record

5.14 Two locations (Areas 3 and 4) were stripped to a depth of approximately 0.7m to 0.8m. A test pit was dug in both of these areas to identify the natural subsoil, which was identified at 1.9m below the ground surface in Area 4, but was not found in

Area 3 despite reaching a depth of 2.5m. It was agreed that to excavate these areas to the natural subsoil was not feasible. Two further areas were also monitored, for the widening of existing water channels.

Area 3

5.15 This area measured approximately 19m by 8m (Photo 5). Natural subsoil was not identified in this area. A test pit was dug in the southern corner of the excavated area to a depth of 2.5m, which was the furthest reach of the machine. The earliest deposit identified was a black silty clay [37: at least 1.5m deep], identified at 1.0m below the ground surface and extending beyond the base of the test pit. Overlying this was a laminate deposit consisting of several thin layers of brown-grey clay and sand [36: 0.2m deep], containing frequent shells. The majority of the area was stripped to the top level of this deposit. Above it was another laminate deposit, consisting of layers of brown and orange sand and clay [35: 0.6m deep], though this deposit contained no shells. Across the whole area was a grey-brown silty topsoil [34: 0.2m deep]. No archaeological features were identified and no artefacts were recovered.

Area 4

5.16 This area measured was excavated in two parts to avoid an existing water course. The northern trench measured around 51m by 4.5m, with the southern measuring approximately 15.5m by 4.5. Natural subsoil, a yellow-grey running sand [38], was identified within a test pit in the centre of Area 4, at a depth of 1.9m below the ground surface. Above this was a black silty clay [37: 0.4m deep], with a laminate deposit of brown-grey clay and sand [36: 0.8m deep] overlying it. As in Area 3, this deposit contained frequent shells. The presence of these shells and the depth of the deposit indicate significant natural coastal build up in this area. The majority of the area was stripped to the top level of this deposit (Photo 6). Above [36] was another laminate deposit of brown and orange sand and clay [35: 0.5m deep], overlain by a grey-brown silty topsoil [34: 0.2m deep]. No archaeological features were identified and no artefacts were recovered.

Channels

5.17 Channel Trench 1 was located to the west of Area 4, and was roughly right-angled in shape, measuring *c.*50m by 10m. Natural subsoil, a yellow-brown sandy clay [40], was identified at 0.2m below the ground surface. However, this was not visible across the whole trench; along the southern end of the trench it was overlain by a black silt [41], likely to represent the silting up of the existing water channel. This deposit was not fully excavated. Across the whole trench was a grey-brown silty topsoil [39: 0.2m deep]. No archaeological features were identified and no artefacts recovered.

5.18 Channel Trench 2 was located to the west of Area 3 and was roughly S-shaped in plan, measuring approximately 109m by 8m. Natural subsoil, a yellow-brown sandy clay [40], was identified between 0.1m and 0.3m below the ground surface. Again, this was not visible across the whole trench, with the black silt deposit [41] seen in Channel Trench 1 also present here, along the western side of the trench. This deposit was not fully excavated. Across the whole trench was a grey-brown silty topsoil [39: 0.1m to 0.3m deep]. No archaeological features were identified and no artefacts recovered.

Excavation across the old sea wall (Figure 5)

5.19 A trench was excavated in the centre of the site in order to evaluate the old sea wall in section and identify any features adjacent to it. The trench measured 22m by 8m and was aligned roughly east/west across two embankments aligned roughly north/south. The eastern embankment was the wider of the two, but both were of a similar height, and prior to excavation it was assumed that both embankments formed part of the old flood defences.

5.20 Natural subsoil, a yellow-brown clay [27], was identified between 0.25m and 1.5m below the ground surface (a mean elevation of 1.74m AOD across the trench). Overlying this across most of the trench was a layer of laminate orange-grey silty clay [26: 0.3m to 0.75m deep], from which a post-medieval brick fragment was recovered. The western embankment consisted of a layer of yellow clayey sand [25: up to 0.5m deep] overlying deposit [26], with a layer of yellow-brown silty clay [24: 0.3m deep] directly above it (Photo 7).

5.21 The eastern embankment was constructed out of different material. Prior to its construction, a compacted black gritty sand [31] had been used to level the ground; this was visible in plan in the base of the trench and in section, up to 0.45m deep. Overlying this, and forming the primary layer of the embankment, was a loose black sandy silt [30], measuring 4.45m wide and up to 0.5m deep. Industrial residue was recovered from this deposit. Above this was a red-brown rubbly sandy silt [29: 6.6m wide, up to 0.5m deep], containing stone and brick fragments. Directly above this was another similar deposit comprising red silty sand [33: 6.15m wide, up to 0.5m deep]. Industrial residue and bricks were recovered from these deposits along with two iron nails and a glass bottle fragment. The uppermost deposit in the eastern embankment was a layer of loose grey pebbles [28], 9.9m in width and up to 0.5m in depth. This deposit was present along almost the entire width of the embankment. The whole trench was overlain by a thin layer of grey-brown silty clay topsoil [23] between 0.05m and 0.25m deep (Photos 8 & 9).

5.22 No features were identified in the easternmost part of the trench, to the east of the embankments. In this area, the topsoil [23: 0.25m deep] lay directly above the natural subsoil [27].

5.23 The difference in the materials of the embankments indicates a different date of construction and a different purpose. This is discussed further in sections 8.7 and 8.8.

Archaeological monitoring of pond connectors

5.24 Two stretches of pipe trench were monitored during the installation of pond connectors, in the eastern half of the site. Pond Connector Trench 1 (PCT1) was aligned north-west/south-east and measured approximately 125m by 2m, though in some areas it was made wider for health and safety reasons. Pond Connector Trench 2 (PCT2) was aligned north-east/south-west and measured around 28m by 2m, again being made wider in some areas.

Pond Connector Trench 1

5.25 PCT1 was excavated to a depth of 1.1m to 1.4m. The natural subsoil [46] varied between a yellow sand and a grey running sand, and was identified at a depth of between 0.2m and 0.7m below the ground surface. However, it was not identified throughout the trench. At the south-eastern end of the trench, where the trench cut an existing road, a brown-grey silt [44] was identified approximately 1.1m below the ground surface, and extended beyond the base of the trench. Above this was a thick layer of rubble [43: 0.8m deep], mainly consisting of modern bricks, which formed a hardcore base for the gravel road surface [42: 0.3m deep] above it.

5.26 At several locations in the trench a reddish-brown clay [47: 0.2m to at least 0.8m deep] was identified, in some cases overlying the natural subsoil, in others extending beyond the base of the trench. A layer of modern rubble [48: 0.5m deep] was identified near the north-western end of the trench overlying the natural subsoil (Photo 10). It is possible that these two deposits relate to landscaping or levelling activities in the area. Several modern services were also identified within the trench. Across much of the trench (apart from the area of road mentioned above) was a layer of grey-brown silty topsoil [45: 0.2m to 0.3m deep]. No archaeological features were identified and no artefacts recovered.

Pond Connector Trench 2

5.27 PCT 2 was excavated to a depth of 0.9m. The natural subsoil, a grey running sand [50] was identified at 0.6m below the ground surface. Overlying the natural subsoil was a layer of loose sandy silt [49] up to 0.55m deep and containing frequent stones, bricks and other rubble. Several modern services were also present within the trench. Across the whole trench was a thin layer of grey-brown silty topsoil [51: 50mm deep] (Photo 11).

6. The artefacts

Animal bone assessment

Results

6.1 An extremely small (1mm long) fish vertebra, probably from an unidentified wild species, was recovered from the sample from context [37], from the bottom of a test pit in Area 3. A small quantity of crushed fragments of unidentified marine and bi-valve mollusc shells also came from context [37] and from context [15].

Recommendation

6.2 No further work is recommended.

Glass assessment

Results

6.3 The neck, rim and part of the shoulder from a rectangular bottle came from sea wall context [29]. The weathered and bubbled glass is blue/green/clear. The bottle was mould blown with an applied ring finish to take a cork. Possibly a medicine bottle, it is of mid-late 19th century date.

6.4 A flake of weathered blue/grey glass was recovered from the sample from sea wall context [33]. Post-medieval.

Recommendation

6.5 No further work is recommended.

Fired clay and building material assessment

Results

6.6 Fragments of fired clay (179g wt) came from the environmental samples from contexts [7] in saltern test pit 4, [15] in saltern test pit 2 and [19] in saltern test pit 1. Most fragments (175g wt) came from context [7]. The material is pink/orange/red in colour and fairly soft with little tempering apart from minute fragments of black/brown, cinder-like material. There are no original surfaces or evidence of shaping or substrate. The fired clay may be part of a structure associated with the sleeching process, but this cannot be determined from examination of these highly abraded fragments. Undateable.

6.7 Part of a mould-made brick was hand recovered from sea wall context [33]. It is 110mm wide x 67mm thick, with flat faces and no frog. The fabric is yellow with an open structure, very liberally tempered with angular and rounded yellow rock fragments, other crushed rock and sand. Cindery, slaggy material covers much of the surviving faces. Dimensions suggest it is 19th century to modern.

6.8 The corner from a mould-made brick with no measurable dimensions came from context [26] below the sea wall. The fabric is orange/red and tempered with softish, rounded pellets of yellow rock, crushed slag material and sand. A small quantity of cinder/clinker adheres to one face. Post-medieval.

Recommendation

6.9 No further work is recommended.

Iron objects assessment

Results

6.10 Splintered fragments of highly corroded iron – possibly originally part of a nail – came from sea wall context [30]. Undateable.

Recommendation

6.11 No further work is recommended.

Industrial residues assessment

Results

6.12 A total of 21467g of industrial/fuel waste residues were retained from the site, taken from 10 contexts – 6 saltern contexts from test pit 1 in Area 1 and test pits 2, 3, 4 and 5 in Area 2, and 4 contexts from the section through the old sea wall (Table 1.2).

6.13 Contexts [7, 8, 12, 13, 15 and 19] in saltern test pits 1, 2, 3, 4 and 5, produced 700g of residue, comprising small, fairly thin pieces of dark coloured, vesicular cinder, with small stones and burnt fuel. The salterns are thought to have used the sleeching process, whereby salt-rich marsh mud is diluted then boiled or allowed to evaporate to obtain the salt. The mainly organic waste was then discarded, gradually building up into the saltern mound. Residues examined from these contexts are consistent with this process, including cinder and burnt fuel from the evaporation fires and small stones which were probably inclusions in the marsh mud.

6.14 The majority of the waste (20767g) came from the section through the old sea wall. Residues were found to be mainly of two types.

6.15 Most are variably-sized (up to *c*.265 x 158 x 140mm) pieces of black/brown/red/grey cinder/clinker, some fairly dense, some with degrees of vesicularity, with evidence of heating and plasticity. The fragments can be seen to have incorporated small pieces of brick, stone and burnt and semi-burnt, shaley coal. Residues of this type were found in contexts [29, 30 & 33]. One piece is of particular note. Hand-recovered from context [33], it is the largest piece, weighing 10439g. It has some rectangular shaping, suggesting it has been removed in one block, probably from a rectangular structure, and is fairly dense, suggesting a build-up and compression of the waste.

6.16 Other residues are light grey in colour, with occasional reddened areas, highly vesicular, with a lumpy, irregular internal structure. There is evidence of plasticity, and small pieces of stone /?brick and burnt fuel have become incorporated. Residues of this type were found in contexts [28 & 29].

Discussion

6.17 The small quantity of residues from the saltern test pits is consistent with the type of inorganic waste which might result from the heating part of the sleeching process, though no evidence for structures or vessels associated with sleeching were recovered within the excavation area.

6.18 The larger quantity of waste from the sea wall contexts is unlikely to derive from the sleeching process and was probably brought in from elsewhere - possibly from several different sources - to fulfil its function in the construction of the protective embankment. The waste derives from unidentified, high-temperature processes, but is not metalworking residue. The (presumed) large quantity of this waste within the embankment suggests fairly largescale, post-medieval to modern industrial origins.

Recommendation

6.19 Further examination and analysis of the sea wall residues is unlikely to be able to determine the processes from which they originate.

6.20 It is possible to use chemical analysis (X-ray fluorescence) to test for the presence of brine within residues (Timberlake, 2016, 65). Elevated levels of a suite of trace heavy metals, principally strontium (Sr), are associated with sea salt and the evaporation of brine. However, in this case, documentary evidence for the existence of the salterns and the small quantity and type of residues available renders further analysis unnecessary and perhaps unlikely to be successful. No further work is therefore recommended.

7. The palaeoenvironmental evidence

Methods

7.1 A section of the peat layer [context 9] in Test Pit 3 was sampled using a monolith tin (sample 8). The stratigraphy in the column sample is described in Table 1.3. Pollen assessment was undertaken on four samples through the organic deposits at 0.16m, 0.22m, 0.28m and 0.34m below the top of the tin (1.4677, 1.4077, 1.3477 and 1.2877m AOD). Pollen was extracted from 2ml of sediment from each level, using standard techniques of sodium hydroxide digestion, followed by heavy liquid separation (Moore *et al*. 1991). A *Lycopodium* spore tablet was added in order to facilitate calculation of total pollen concentrations. Each tablet has an average of

18583 spores per tablet. The pollen was mounted in silicone fluid and scanned at up to x600 magnification. At least six traverses of a 24 x 24mm coverslip were scanned for each sample. Pollen nomenclature follows Moore *et al.* (1991). The results are presented in Table 1.4.

7.2 Palaeoenvironmental assessment was carried out on 15 bulk samples, comprising sleeching deposits within the salterns, layers associated with the old sea wall and organic former channel fills. The samples were manually floated and sieved through a 500μm mesh. The residues were examined for shells, fruitstones, nutshells, charcoal, small bones, pottery, flint, glass and industrial residues, and were scanned using a magnet for ferrous fragments. The flots were examined at up to x60 magnification using a Leica MZ7.5 stereomicroscope for waterlogged and charred botanical remains. Identification of these was undertaken by comparison with modern reference material held in the Palaeoenvironmental Laboratory at Archaeological Services Durham University. Plant nomenclature follows Stace (2010). Habitat classifications follow Preston *et al.* (2002).

7.3 Charcoal fragments, and a selection of the larger wood fragments, were identified. The transverse, radial and tangential sections were examined at up to x600 magnification using a Leica DMLM microscope. Identifications were assisted by the descriptions of Schweingruber (1990) and Hather (2000), and modern reference material held in the Palaeoenvironmental Laboratory at Archaeological Services Durham University. The results of the palaeoenvironmental assessment are presented in Table 1.5.

7.4 Five AMS radiocarbon dates were obtained from samples comprising suitable material. The samples were sent to the radiocarbon lab at SUERC, East Kilbride. Details of the radiocarbon results are presented in Table 1.6.

7.5 The works were undertaken in accordance with the palaeoenvironmental research aims and objectives outlined in the regional archaeological research framework and resource agendas (Petts & Gerrard 2006; Hall & Huntley 2007; Huntley 2010).

Results

Column sample 8 [context 9]

7.6 The organic deposits within column sample 8 comprise a dark brown wood peat intercalated by dark grey clay. Pollen concentration ranges from good to very low.

0.34m below top of tin (1.2877m AOD)

7.7 Pollen concentration is very low (3614 grains/ml) and grains are degraded. The small pollen assemblage comprises the tree/shrub species alder, birch, pine, oak, lime and hazel. A few spores of polypody and other ferns are present. Microscopic charcoal is rare.

0.28m below top of tin (1.3477m AOD)

7.8 Pollen concentration is low (47313 grains/ml). Tree and shrub pollen dominates the assemblage, with alder and hazel most frequently recorded. Other species include birch, pine, oak, lime, elm and heather. Herbaceous taxa comprise plantains and members of the goosefoot, sedge and grass families. Spores of polypody and other ferns are present. Microscopic charcoal is rare.

0.22m below top of tin (1.4077m AOD)

7.9 Pollen concentration is low (54988 grains/ml). Tree and shrub pollen dominates the assemblage. As with the previous sample, alder pollen is frequent, but hazel declines and oak increases to 25% of total land pollen (tlp). Willow pollen is present, in addition to many of the previously recorded tree/shrub species. Herbaceous taxa comprise members of the carrot, goosefoot, sedge and grass families. Spores of ferns and Sphagnum moss are present. Microscopic charcoal is rare.

0.16m below top of tin (1.4677m AOD)

7.10 Pollen concentration is good (110363 grains/ml) and grains are generally well preserved. Arboreal pollen dominates the assemblage with alder and oak remaining the most frequently recorded trees. A single ash pollen grain is present, in addition to many of the previously recorded tree/shrub species. Herbaceous taxa comprise members of the pink, sedge, grass and bedstraw families. Ferns spores (including bracken) are present. Microscopic charcoal is rare.

Bulk samples

7.11 Sleeching deposits [4], [7] and [18] comprise small amounts of coal and varying quantities of clinker/cinder. Humified organic material and a few waterlogged seeds of crowfoots, buttercups (including celery-leaved buttercup) and thistles are present in [4], reflecting anaerobic preservation of this deposit. Charcoal and charred seeds are absent from the sleeching deposits.

7.12 Peat deposit [9] comprises vegetative material, wood fragments, buds and beetle remains. A selection of the wood fragments was identified as alder and oak. Waterlogged seeds are low in number and comprise occasional bramble fruitstones, sedge nutlets and achenes of celery-leaved buttercup.

7.13 Evidence for anaerobic preservation is present in most of the silty clay channel deposits, particularly [8], [15] and [37]. This includes remains of wood, vegetative material and occasional beetles. Vivianite, a blue mineral which indicates the former presence of organic material in wet or waterlogged conditions (McGowan & Prangnell 2006), is present in [20]. Waterlogged seeds occur in low numbers with sedges, thistles, buttercups and members of the goosefoot family recorded most frequently. Many of the goosefoot family seeds resemble those of annual sea-blite (*Suaeda maritima*), which is common in saltmarsh vegetation (Preston *et al.* 2002). Foraminifera, present in [8], [19] and [15], are dominated by *Trochammina inflata,* a species of high and middle saltmarsh environments (Horton & Edwards 2006). Small quantities of cinder and magnetic fuel waste are recorded in some of the channel fills, with larger amounts in [15]. With the exception of a tiny fragment of oak charcoal in [15] and [37], charcoal and charred plant macrofossils are absent from the channel deposits.

7.14 Charcoal and plant macrofossil remains (waterlogged or charred) are absent from the deposits associated with the sea wall. Large amounts of clinker/cinder are present in [28], [29], [30] and [33].

Discussion

7.15 Pollen and plant macrofossil evidence from the wood peat [9] indicates it was deposited within a wet woodland environment. The results suggest this was an alder carr, with additional components of birches, willows and oak. The latter is presumed to be pedunculate oak (*Quercus robur*), which is tolerant of waterlogging (Preston *et al.* 2002). Radiocarbon analysis of a piece of oak wood from the base of the layer indicates peat accumulation began in the middle Neolithic period (3095-2918 cal BC). Radiocarbon dating of an alder cone in overlying organic silty clay layer [8] suggests persistence of at least pockets of alder carr into the late Neolithic period (2566-2342 cal BC).

7.16 Analysis of the other organic silty clays [15, 19 and 37] produced radiocarbon dates ranging from the late Neolithic to late Bronze Age. During this period, the area was subject to rising sea levels, albeit with fluctuations (Waughman 2005). The resulting landscape is likely to have included areas of mud flats, tidal creeks and saltmarsh. Evidence for this within the samples includes plants and foraminifera typical of saltmarsh vegetation.

7.17 The samples from the salterns have provided little palaeoenvironmental information about salt production at the site. In the absence of charcoal or charred plant macrofossils, it remains unclear whether charcoal or peat formed a fuel source for the evaporation process, as has been suggested elsewhere. The presence of some coal and cinder may relate to its use in the saltworkings or other industrial activities on the site.

Recommendations

7.18 No further analysis is recommended for the organic deposits as the assessment has provided an overview of the palaeoenvironment of the site and full analysis is unlikely to produce significant additional information relating to former environmental conditions or the known prehistoric activity in the area (e.g. Northern Archaeological Associates 2016; Waughman 2005).

7.19 No further analysis is recommended for the sleeching deposits due to a lack of diagnostic palaeoenvironmental remains.

8. The archaeological resource

8.1 Approximately 50% of the spigot mortar gun emplacement was excavated and recorded. This revealed a high level of preservation of the gun emplacement itself, with the floors of the emplacement and the ammunition locker still surviving. The construction cut for the emplacement was also identified, and some of the chestnut paling used as internal walling was recovered from the backfill and topsoil deposits.

8.2 Organic deposits were identified at both saltern sites indicating former channels beneath the saltern mounds. Above these natural deposits, various laminate deposits and thin layers of soil were identified, forming the mounds themselves. These were interpreted as being waste deposits from the 'sleeching' process during salt production (see below). Industrial residue was present in several of the laminate deposits, which is consistent with the sleeching process and may indicate that an area of industrial activity was nearby. No other features associated with salt production, i.e. filtration tanks, kilns or structures, were identified during the works; however, excavation was only conducted on the waste mounds themselves and, if they survive, associated features are likely to have been in the adjacent areas.

8.3 The evidence from the test pits indicates that salt was produced through 'sleeching'. This involved the collection of salt-rich soil deposits (known as 'sleech') that would accumulate on the mud flats at high tide. These would then be diluted in seawater to create a concentrated brine, which would be boiled for up to six hours in order to extract the salt; solar evaporation was another method often used. The de-salted sleech would then be thrown into a waste heap, which over time would form a saltern mound (Barford *et al* 1998, 6). This was primarily a medieval technique (*ibid*) which fits with the documentary evidence that the saltern complex on Cowpen Marsh was in use from the 12th to the 17th century. The location also fits in with a 'typical' medieval saltern, in that it was located on the marsh itself, rather than on the periphery, and in a low lying area (*ibid*, 4).

8.4 Archaeological work conducted to the north of Greatham Creek (Fell & Robinson 2015) identified a probable settlement dating from the Iron Age and Roman periods. Although no work was conducted on the saltern mounds themselves during these works, it was suggested that this occupation activity may have been associated with salt production in the vicinity, and that the location of the settlement was chosen in order to take advantage of the salt marshes. Despite the lack of evidence for pottery vessels or *briquetage* associated with Iron Age salt production, it is possible that the saltern mounds in this area originated at an earlier date than records suggest (*ibid*, 30-31, 33). Archaeological works conducted on wetlands to the south-east found no evidence of salt production (Mott MacDonald 2018).

8.5 Comparable saltern complexes survive across the country but in a lot of cases little or no archaeological work has been conducted on them. Various phases of excavation were carried out on a site at Wainfleet St Mary, Lincolnshire, which identified filtration tanks and channels, but the saltern mounds themselves had been levelled so the reports contain little comparable data (Albone 1999; McAvoy 1994). Excavations undertaken on salterns near Whitstable, Kent in 1955 identified mounds of similar dimensions to those at Greatham, with pits, wooden hurdles, burnt areas and tracks recorded both within and beneath the mound deposits (Thompson 1956). However, there was little discussion about the mound deposits themselves, some of which had been bulldozed prior to excavation. More recently, a saltern was excavated at Walpole, Norfolk. These works identified several layers of clays, silts and sands in the base of the mound, which were interpreted as natural silting up and development of the salt marsh, as seen at Greatham. Pits, tanks, troughs and revetments were all identified, though the location of all of these features in relation to the saltern mound is unclear (Clarke 2011).

8.6 An excavation was undertaken on a saltern mound at King's Lynn in 2015 (Clarke 2016). This identified that the mound lay immediately above the natural saltmarsh deposits representing tidal creeks, as seen at Greatham. Features such as hearths and filtration units were recorded within the mound itself as well as tipping deposits containing industrial waste and fired clay (*ibid*). However, the features in the mound were mainly early medieval in date, with medieval deposits overlying them. These later deposits were similar in nature to those found at Greatham.

8.7 Little actual excavation work has been done on saltern mounds, with most of the work tending to focus on the associated features, such as pits and filtration tanks, as the mounds themselves do not always survive. It is therefore difficult to find comparable data for the mounds at Greatham, but this serves to enhance the importance of this scheme of works.

8.8 No archaeological resource was identified within the strip, map and record areas, or the channel widening trenches. The deposits identified related to the natural silting up of former and existing water courses.

8.9 Prior to excavation, it was assumed that the old sea wall defences consisted of two embankments. However, the difference in the construction materials indicated that only the narrower western embankment, comprising two soil deposits, formed the sea wall. Although it does not appear to be a particularly substantial flood defence, it must be quite efficient as it has lasted for around two centuries – it can be seen on the 1838 tithe map of Cowpen Bewley.

8.10 The eastern embankment was constructed of various industrial deposits and stone layers. It is likely that it was in fact part of a road built by Prisoners of War during the First World War, using materials brought in from elsewhere specifically for the construction. This road is believed to go from Port Clarence to Seaton Carew, running for most of its length under the existing road (the A178 Seaton Carew Road). It is suggested that the excavated embankment is a north-west leg of the road that branches off before stopping abruptly at Greatham Creek, where a WWII section post is now located.

8.11 Modern made ground deposits relating to landscaping or levelling were identified in both pond connector trenches.

8.12 The results of radiocarbon and palaeoenvironmental investigation indicates peat layer [9] in saltern Test Pit 3 began to accumulate in the middle Neolithic period within an alder carr environment. Organic silty clays dating from the late Neolithic to late Bronze Age contain plant macrofossils and forams typical of saltmarsh vegetation. Charred palaeoenvironmental remains are absent from the samples from the salterns.

8.13 The regional research framework (Petts & Gerrard 2006) contains an agenda for archaeological research in the region, which is incorporated into regional planning policy implementation with respect to archaeology. In this instance, the archaeological resource addresses Agenda Items:

- **Science and Environment**
    - SEii Palaeoenviromental evidence
- **Later Medieval**
    - MDviii Other medieval industries
- **20th century**
    - MOvi Military and defence

9. Recommendations

9.1 No further analysis work is required. No further analysis work is required, and the results do not justify academic publication. This analysis report will be a publically accessible document through OASIS and the Historic Environment Record, and the results will be available for any future synthesis of works on salterns. It is recommended that a short article on the works is placed in the Teesside Archaeological Society Bulletin as a further means of public dissemination.

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Appendix 1: Data tables

Table 1.1: Context data

The • symbols in the columns at the right indicate the presence of artefacts of the following types:
B bone, S shell, M metals, I industrial residues, G glass, C ceramic building material, W wood.

No	Area*	Description	B	S	M	I	G	C	W
1	STP 2-5	Topsoil							
2	STP 3	Laminate brown-yellow silty clay – sleeching waste							
3	STP 2-5	Natural subsoil							
4	STP 2	Black silt – sleeching waste							
5	STP 2-5	Laminate brown-yellow silty clay – sleeching waste							
6	STP 3	Grey-brown silt – sleeching waste							
7	STP 4	Brownish-red clayey silt – sleeching waste				•		•	
8	STP 3	Black very silty clay – former channel				•			
9	STP 3	Brown peat layer							
10	-	VOID							
11	-	VOID							
12	STP 4	Reddish-brown clayey silt – sleeching waste				•			
13	STP 2-5	Laminate grey-brown silty clay – sleeching waste				•			
14	-	VOID							
15	STP 2	Blackish-grey silty clay – former channel		•		•		•	
16	STP 1	Topsoil							
17	STP 1	Grey silty clay – sleeching waste							
18	STP 1	Laminate yellow-brown silty clay – sleeching waste							
19	STP 1	Blackish-grey silty clay – former channel				•		•	
20	STP 1	Light grey silty clay – former channel							
21	STP 1	Natural subsoil							
22	STP 1	Yellow-brown silty clay – former channel							
23	SW	Topsoil							
24	SW	Brown silty deposit (W embankment)							
25	SW	Yellow sandy deposit (W embankment)							
26	SW	Re-deposited clay						•	
27	SW	Natural subsoil							
28	SW	Grey stones (E embankment)							
29	SW	Red crushed waste deposit (E embankment)			•	•	•	•	
30	SW	Black industrial deposit (E embankment)			•	•			
31	SW	Loose black levelling deposit							
32	-	VOID							
33	SW	Red deposit (E embankment)			•	•	•	•	
34	SMR	Topsoil							
35	SMR	Laminate clay and sand							
36	SMR	Laminate sand and clay containing shells		•					
37	SMR	Black silty clay	•	•					
38	SMR	Natural running sand							
39	SMR C	Topsoil							
40	SMR C	Natural subsoil							
41	SMR C	Black silty layer							
42	PCT 1	Road surface							
43	PCT 1	Rubble hardcore							
44	PCT 1	Brown-grey silt							
45	PCT 1	Topsoil							
46	PCT 1	Natural subsoil							
47	PCT 1	Redeposited clay							
48	PCT 1	Modern rubble							
49	PCT 2	Rubble layer							
50	PCT 2	Natural subsoil							
51	PCT 2	Topsoil							
52	SM	Backfill of gun emplacement			•				•
F53	SM	Construction cut of gun emplacement							
F54	SM	Concrete base							
F55	SM	Concrete floor surface of ammunition locker							

No	Area*	Description	B	S	M	I	G	C	W
F56	SM	Concrete gun emplacement (thimble and mount)							
57	SM	Topsoil			•				•
58	SM	Natural subsoil							

*STP Saltern test pits 1 to 5
SW Sea wall
SMR Strip, map and record areas
SMR C Channels in strip, map and record areas
PCT Pond connector trenches 1 and 2
SM Spigot Mortar

Table 1.2: Residues by context, context type and weight

Context no	Context Type	Wt g
7	Saltern TP4	120
8	Saltern TP3	34
12	Saltern TP4	85
13	Saltern TP5	96
15	Saltern TP2	352
19	Saltern TP1	13
28	Sea wall	2950
29	Sea wall	1774
30	Sea wall	2537
33	Sea wall	13506
Total		**21467**

Table 1.3: Stratigraphy of the column sample <8> in Test Pit 3

Sample (Tin)	Depth (cm below top of tin)	Depth (m AOD)	Munsell	Description
1	0-9	1.63-1.54	2.5Y 3/2 (very dark greyish brown)	Clay with organic inclusions
	9-19	1.54-1.44	-	Transition to above. High organic content with clay
	19-23	1.44-1.40	10YR 2/2 (very dark brown)	Wood peat including large fragments of wood
	23-29	1.40-1.34	2.5Y 3/1 (very dark grey)	Clay with high organic content in laminations
	29-37	1.34-1.26	10YR 2/2 (very dark brown)	Wood peat including large fragments of wood (up to 4cm long)
	37-48 (not bottomed)	1.26-1.15	2.5Y 4/1 (dark grey)	Silty clay

Table 1.4: Data from pollen assessment of peat [9]<8>

Depth below top of monolith tin (m)	0.16	0.22	0.28	0.34
Depth (mOD)	1.4677	1.4077	1.3477	1.2877
Volume processed (ml)	2	2	2	2
Tree taxa				
Alnus glutinosa (Alder)	31	30	23	8
Betula sp. (Birches)	-	1	1	1
Fraxinus excelsior (Ash)	1	-	-	-
Pinus sp. (Pines)	3	1	1	1
Quercus sp. (Oaks)	42	18	4	2
Tilia sp. (Limes)	2	1	1	2
Ulmus sp. (Elms)	3	-	1	-
Shrub taxa				
Corylus avellana (Hazel)	4	10	14	2
Erica type (Heathers)	-	-	1	-
Salix sp. (Willows)	-	1	-	-
Herbaceous taxa				
Amaranthaceae undiff. (Goosefoot family)	-	1	3	-
Apiaceae undiff. (Carrot family)	-	1	-	-
Caryophyllaceae undiff. (Pink family)	1	-	-	-
Cyperaceae undiff. (Sedge family)	3	2	1	-
Plantago sp. (Plantains)	-	-	2	-
Poaceae undiff. (Grass family)	4	5	4	-
Rosaceae undiff. (Rose family)	-	-	-	-
Rubiaceae undiff. (Bedstraw family)	1	-	-	-
Saxifragaceae undiff. (Saxifrage family)	-	-	-	-
Spores				
Polypodium vulgare (Polypody)	2	1	3	3
Pteridium aquilinum (Bracken)	3	-	-	-
Pteridophyta (monolete) undiff. (Ferns)	12	6	12	4
Sphagnum sp. (Sphagnum moss)	-	2	-	-
Other				
Total land pollen counted	95	71	56	14
Concentration of land pollen (grains/ml of sediment)	110363	54988	47313	3614
Exotic (*Lycopodium*) spores	8	12	11	36
Microscopic charcoal	Rare	Rare	Rare	Rare
Unidentified pollen grains	1	1	1	-

Table 1.5: Data from palaeoenvironmental assessment

Sample		1	2	3	4	5	6	7	9
Context		4	7	8	9	19	20	15	18
Test Pit		2	4	3	3	1	1	2	1
Feature		SD	SD	C	P	C	C	C	SD
Material available for radiocarbon dating		-	-	✓	✓	✓	-	✓	-
Volume processed (l)		17	9	17	4	18	16	20	19
Volume of flot (ml)		2000	150	400	900	200	33	150	50
Residue contents									
Bone (unburnt)	fish	-	-	-	-	-	-	-	-
Clinker / cinder / magnetic fuel waste		+	+++	++	-	+	-	++	+
Coal		+	++	+	-	+	+	+	++
Fired clay		-	+++	-	-	(+)	-	+	-
Glass (number of fragments)		-	-	-	-	-	-	-	-
Marine shell	cockle/mussel	-	-	-	-	-	-	-	-
Vivianite		-	-	-	-	-	+	-	-
Flot matrix									
Beetle	indet. frags	-	-	(+)	+	(+)	-	+	-
Buds		-	-	-	+	-	-	-	-
Charcoal		-	-	(+)	-	-	-	(+)	-
Clinker / cinder / magnetic fuel waste		-	++	++	-	+	+	+++	++
Coal / coal shale		-	+	-	-	-	+	+	++
Earthworm egg case		-	+	-	-	-	-	-	-
Foraminifera		-	-	+	-	+++	-	++	-
Roots (modern)		-	+++	-	-	-	-	-	++
Snails (freshwater)		-	-	-	-	-	-	-	-
Vegetative material (uncharred; humified)		++++	-	++++	++++	++	+	+++	-
Waterlogged seeds		++	-	+	+	+	-	++	-
Wood / bark		-	-	+++	+++	(+)	-	++	-
Wood / roots (mineral-encrusted)		-	-	-	-	-	+++	-	-
Identified charcoal (✓presence)									
Quercus sp (Oaks)		-	-	-	-	-	-	✓	-

[SD-sleeching deposit; C-former channel; P-peat layer; SW-sea wall
(+): trace; +: rare; ++: occasional; +++: common; ++++: abundant]

Sample		12	13	14	15	16	17	18
Context		33	24	28	30	25	29	37
Test Pit		-	-	-	-	-	-	-
Feature		SW	SW	SW	SW	SW	SW	C
Material available for radiocarbon dating		-	-	-	-	-	-	✓
Volume processed (l)		3	16	3	4	17	2	8
Volume of flot (ml)		20	1200	2	20	150	2	50
Residue contents								
Bone (unburnt)	fish	-	-	-	-	-	-	(+)
Clinker / cinder / magnetic fuel waste		++++	(+)	++++	++++	-	++++	-
Coal		+	(+)	-	+	(+)	(+)	+
Fired clay		-	-	-	-	-	-	-
Glass (number of fragments)		1	-	-	-	-	-	-
Marine shell	cockle/mussel	-	-	-	-	-	-	++
Vivianite		-	-	-	-	-	-	-
Flot matrix								
Beetle	indet. frags	-	-	-	-	-	-	++
Buds		-	-	-	-	-	-	-
Charcoal		-	-	-	-	-	-	(+)
Clinker / cinder / magnetic fuel waste		++	-	(+)	++	-	-	+
Coal / coal shale		-	-	(+)	(+)	(+)	(+)	+
Earthworm egg case		-	+	-	-	+	-	-
Foraminifera		-	-	-	-	-	-	-
Roots (modern)		-	++++	(+)	-	+++	(+)	-
Snails (freshwater)		-	-	-	-	-	-	(+)
Vegetative material (uncharred; humified)		-	-	-	-	-	-	++++
Waterlogged seeds		-	-	-	-	-	-	++
Wood / bark		-	-	-	-	-	-	++
Wood / roots (mineral-encrusted)		-	-	-	-	-	-	-
Identified charcoal (✓presence)								
Quercus sp (Oaks)		-	-	-	-	-	-	✓

[SD-sleeching deposit; C-former channel; P-peat layer; SW-sea wall
(+): trace; +: rare; ++: occasional; +++: common; ++++: abundant]

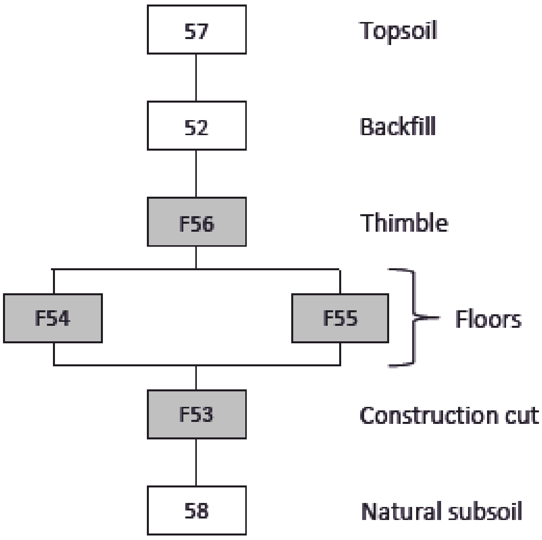
Table 1.6: Summary of radiocarbon dating

Laboratory code	Context	Sample	Material	$\delta^{13}C$ ‰	Radiocarbon Age BP	Calibrated date 95.4% probability
SUERC-78106 GU46911	19	5	Indeterminate waterlogged roundwood	-27.6	2863 ± 29	1120 (95.4%) 930 cal BC
SUERC-78107 GU46912	8	3	Waterlogged alder female cone	-27.2	3945 ± 29	2566 (13.6%) 2523 cal BC 2498 (81.8%) 2342 cal BC
SUERC-78108 GU46913	9	8	Waterlogged oak large branchwood	-27.0	4396 ± 29	3095 (95.4%) 2918 cal BC
SUERC-78109 GU46914	15	7	Indeterminate waterlogged bark	-25.9	3163 ± 29	1501 (94.5%) 1393 cal BC 1333 (0.9%) 1327 cal BC
SUERC-78110 GU46915	37	18	Indeterminate waterlogged bark	-28.9	3840 ± 29	2456 (8.0%) 2418 cal BC 2408 (9.2%) 2374 cal BC 2368 (78.2%) 2203 cal BC

[The calibrated age ranges are determined using OxCal4.2.4 (Bronk Ramsey 2009); IntCal13 curve (Reimer *et al.* 2013)]

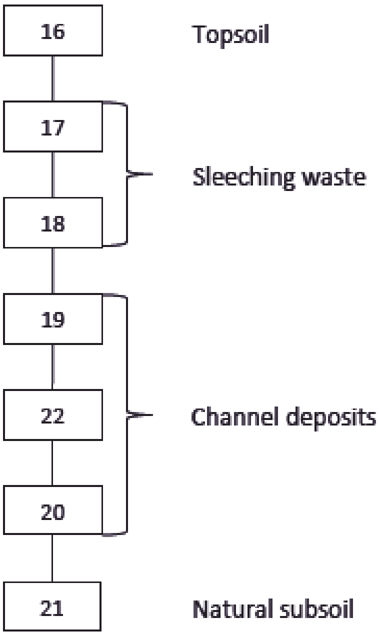
Appendix 2: Stratigraphic matrices

Spigot Mortar

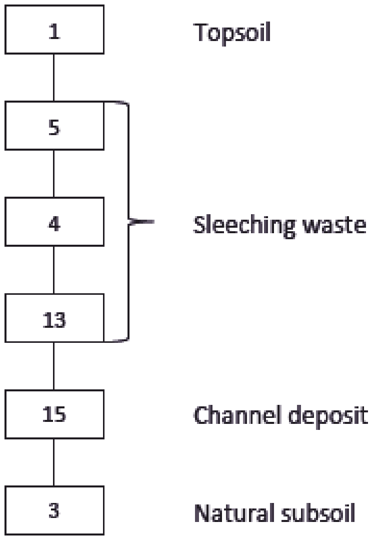


Salterns

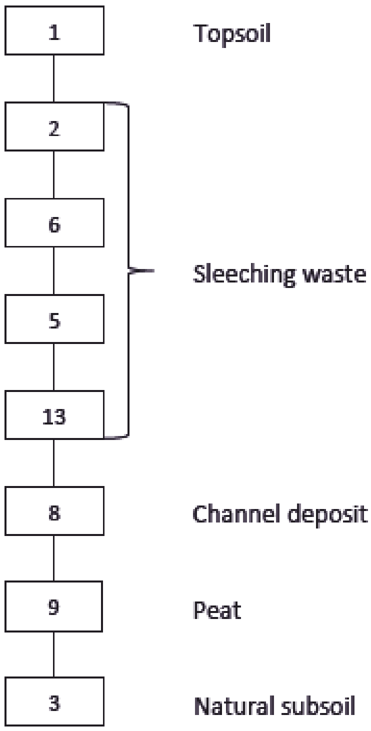
Test Pit 1



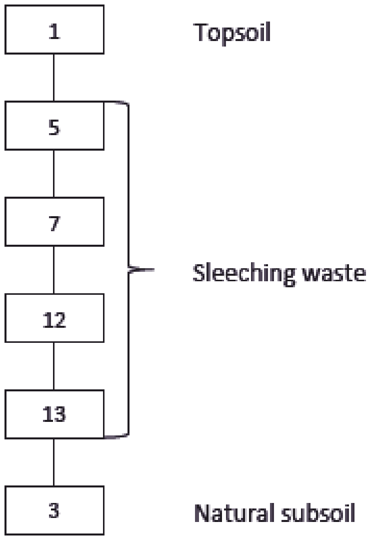
Test Pit 2



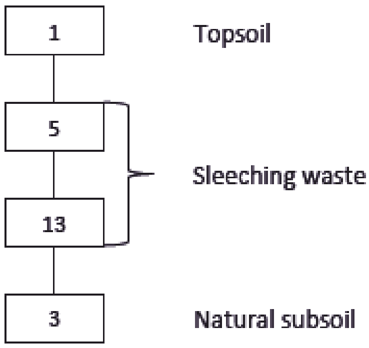
Test Pit 3



Test Pit 4

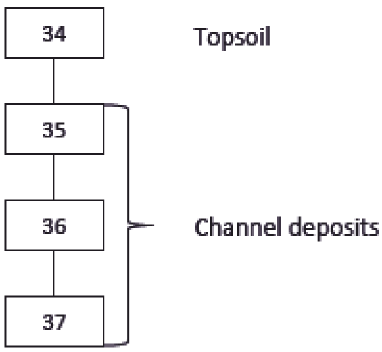


Test Pit 5

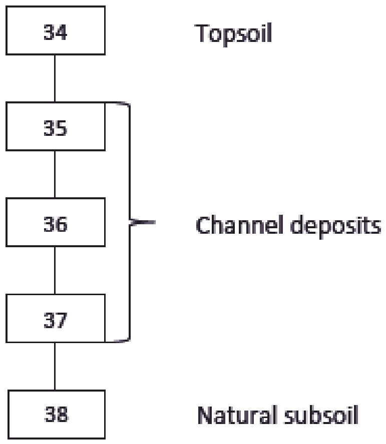


Strip, map and record

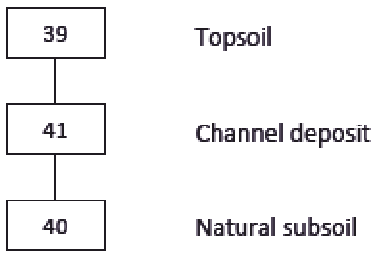
Area 3



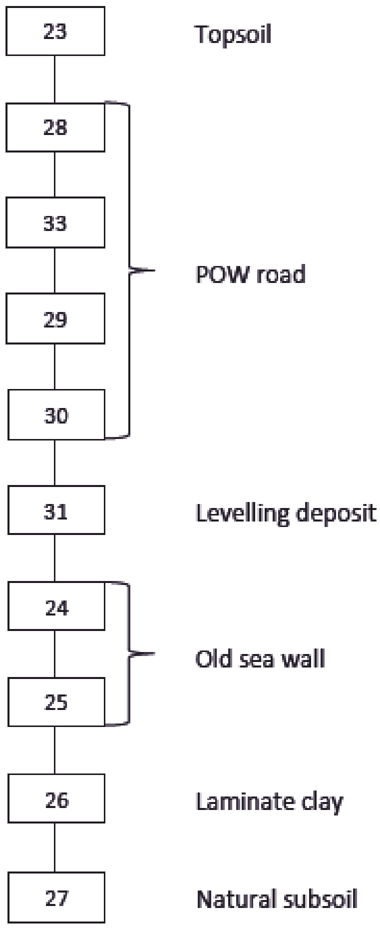
Area 4



Channel Trenches 1 & 2

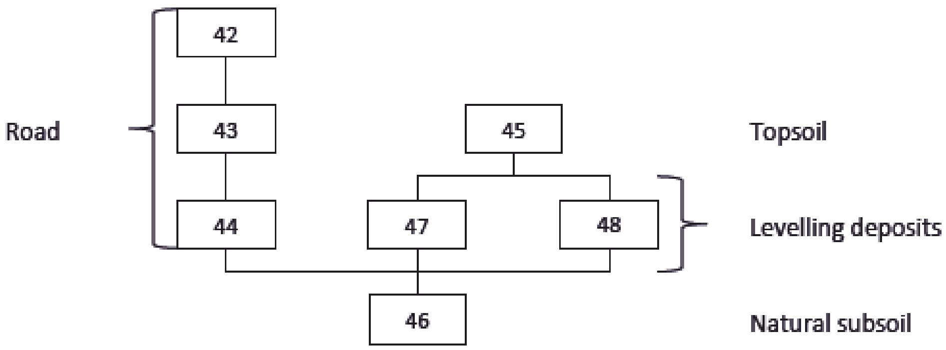


Sea Wall

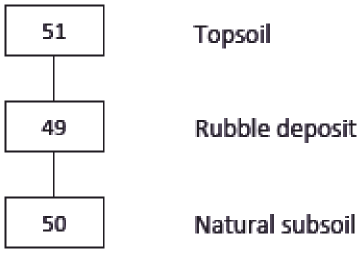


Pond Connectors

PCT1



PCT2



Appendix 3: Radiocarbon certificates

Scottish Universities Environmental Research Centre
Rankine Avenue, Scottish Enterprise Technology Park, East Kilbride, Glasgow G75 0QF, Scotland, UK
Director: Professor F M Stuart Tel: +44 (0)1355 223332 Fax: +44 (0)1355 229898 www.glasgow.ac.uk/suerc

RADIOCARBON DATING CERTIFICATE
26 March 2018

Laboratory Code	SUERC-78106 (GU46911)
Submitter	Charlotte O'Brien Archaeological Services Durham University South Road Durham DH1 3LE
Site Reference	Greatham South Flood Alleviation, Stockton on Tees
Context Reference	19
Sample Reference	5
Material	Waterlogged wood : Indeterminate
$\delta^{13}C$ relative to VPDB	-27.6 ‰
Radiocarbon Age BP	2863 ± 29

N.B. The above ^{14}C age is quoted in conventional years BP (before 1950 AD) and requires calibration to the calendar timescale. The error, expressed at the one sigma level of confidence, includes components from the counting statistics on the sample, modern reference standard and blank and the random machine error.

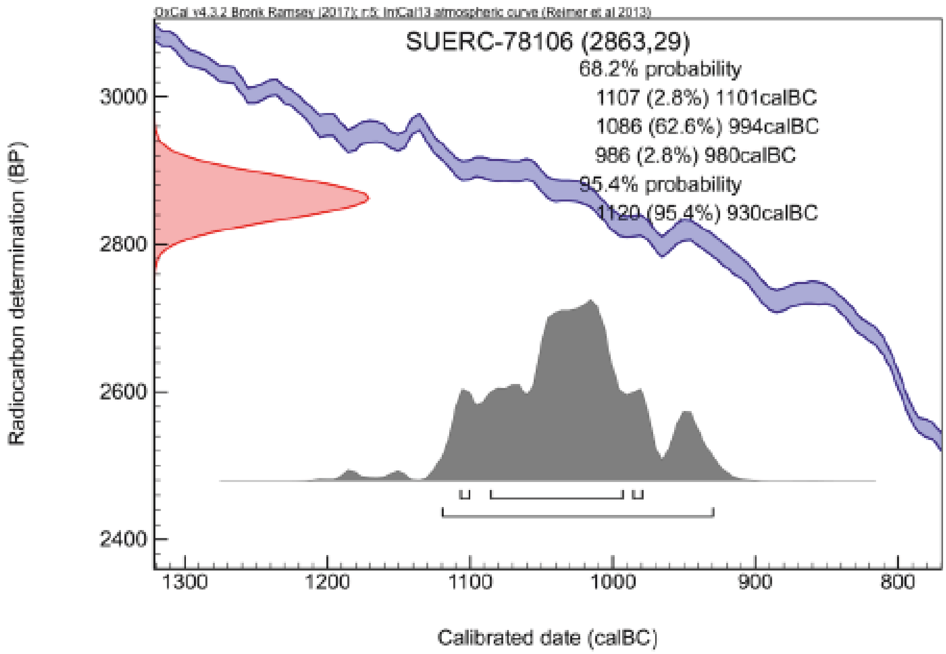
Samples with a SUERC coding are measured at the Scottish Universities Environmental Research Centre AMS Facility and should be quoted as such in any reports within the scientific literature. The laboratory GU coding should also be given in parentheses after the SUERC code.

Detailed descriptions of the methods employed by the SUERC Radiocarbon Laboratory can be found in Dunbar et al. (2016) *Radiocarbon 58(1) pp.9-23.*

For any queries relating to this certificate, the laboratory can be contacted at suerc-c14lab@glasgow.ac.uk.

Conventional age and calibration age ranges calculated by : E. Dunbar

Checked and signed off by : P. Naysmith



The radiocarbon age given overleaf is calibrated to the calendar timescale using the Oxford Radiocarbon Accelerator Unit calibration program OxCal 4.*

The above date ranges have been calibrated using the IntCal13 atmospheric calibration curve.†

Please contact the laboratory if you wish to discuss this further.

* Bronk Ramsey (2009) *Radiocarbon 51(1) pp.337-60*
† Reimer et al. (2013) *Radiocarbon 55(4) pp.1869-87*

Scottish Universities Environmental Research Centre
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RADIOCARBON DATING CERTIFICATE
26 March 2018

Laboratory Code	SUERC-78107 (GU46912)
Submitter	Charlotte O'Brien Archaeological Services Durham University South Road Durham DH1 3LE
Site Reference	Greatham South Flood Alleviation, Stockton on Tees
Context Reference	8
Sample Reference	3
Material	Waterlogged female cone : Alnus glutinosa
$\delta^{13}C$ relative to VPDB	-27.2 ‰
Radiocarbon Age BP	3945 ± 29

N.B. The above ^{14}C age is quoted in conventional years BP (before 1950 AD) and requires calibration to the calendar timescale. The error, expressed at the one sigma level of confidence, includes components from the counting statistics on the sample, modern reference standard and blank and the random machine error.

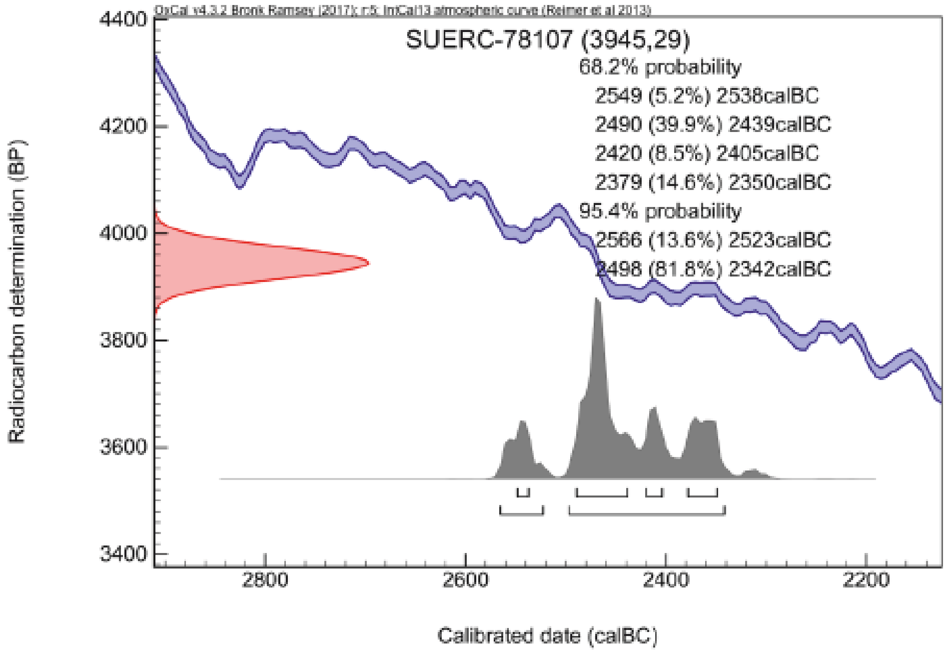
Samples with a SUERC coding are measured at the Scottish Universities Environmental Research Centre AMS Facility and should be quoted as such in any reports within the scientific literature. The laboratory GU coding should also be given in parentheses after the SUERC code.

Detailed descriptions of the methods employed by the SUERC Radiocarbon Laboratory can be found in Dunbar et al. (2016) *Radiocarbon 58(1) pp.9-23.*

For any queries relating to this certificate, the laboratory can be contacted at suerc-c14lab@glasgow.ac.uk.

Conventional age and calibration age ranges calculated by : E. Dunbar

Checked and signed off by : P. Naysmith



The radiocarbon age given overleaf is calibrated to the calendar timescale using the Oxford Radiocarbon Accelerator Unit calibration program OxCal 4.*

The above date ranges have been calibrated using the IntCal13 atmospheric calibration curve.†

Please contact the laboratory if you wish to discuss this further.

* Bronk Ramsey (2009) *Radiocarbon 51(1) pp.337-60*
† Reimer et al. (2013) *Radiocarbon 55(4) pp.1869-87*

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RADIOCARBON DATING CERTIFICATE
26 March 2018

Laboratory Code	SUERC-78108 (GU46913)
Submitter	Charlotte O'Brien Archaeological Services Durham University South Road Durham DH1 3LE
Site Reference	Greatham South Flood Alleviation, Stockton on Tees
Context Reference	9
Sample Reference	8
Material	Waterlogged wood : Quercus sp
$\delta^{13}C$ relative to VPDB	-27.0 ‰
Radiocarbon Age BP	4396 ± 29

N.B. The above ^{14}C age is quoted in conventional years BP (before 1950 AD) and requires calibration to the calendar timescale. The error, expressed at the one sigma level of confidence, includes components from the counting statistics on the sample, modern reference standard and blank and the random machine error.

Samples with a SUERC coding are measured at the Scottish Universities Environmental Research Centre AMS Facility and should be quoted as such in any reports within the scientific literature. The laboratory GU coding should also be given in parentheses after the SUERC code.

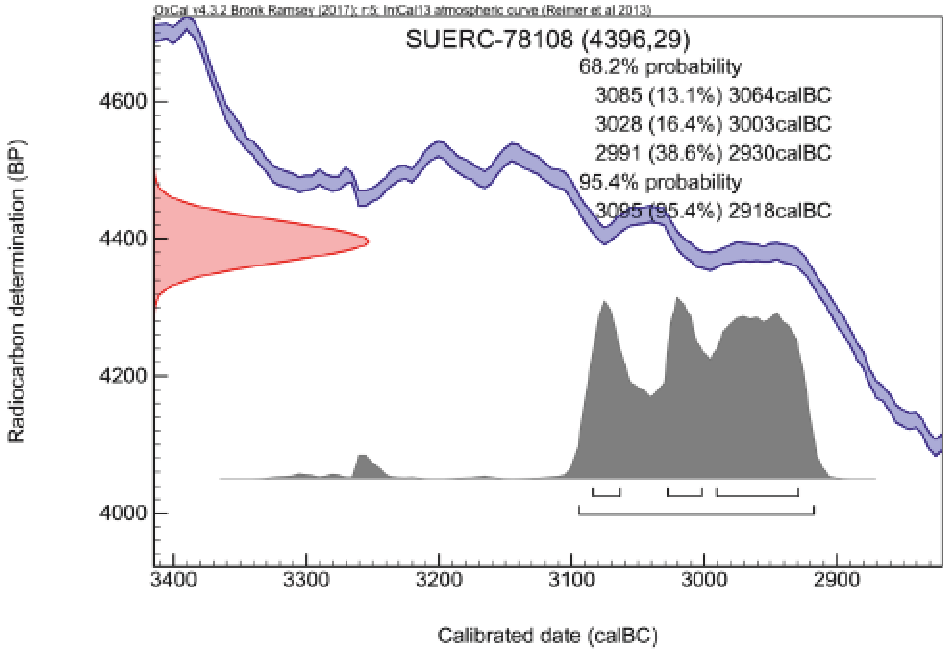
Detailed descriptions of the methods employed by the SUERC Radiocarbon Laboratory can be found in Dunbar et al. (2016) *Radiocarbon 58(1) pp.9-23.*

For any queries relating to this certificate, the laboratory can be contacted at suerc-c14lab@glasgow.ac.uk.

Conventional age and calibration age ranges calculated by : E. Dunbar

Checked and signed off by : P. Naysmith

University of Glasgow



The radiocarbon age given overleaf is calibrated to the calendar timescale using the Oxford Radiocarbon Accelerator Unit calibration program OxCal 4.*

The above date ranges have been calibrated using the IntCal13 atmospheric calibration curve.†

Please contact the laboratory if you wish to discuss this further.

* Bronk Ramsey (2009) *Radiocarbon 51(1) pp.337-60*
† Reimer et al. (2013) *Radiocarbon 55(4) pp.1869-87*

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RADIOCARBON DATING CERTIFICATE
26 March 2018

Laboratory Code	SUERC-78109 (GU46914)
Submitter	Charlotte O'Brien Archaeological Services Durham University South Road Durham DH1 3LE
Site Reference	Greatham South Flood Alleviation, Stockton on Tees
Context Reference	15
Sample Reference	7
Material	Waterlogged bark : Indeterminate
$\delta^{13}C$ relative to VPDB	-25.9 ‰
Radiocarbon Age BP	3163 ± 29

N.B. The above ^{14}C age is quoted in conventional years BP (before 1950 AD) and requires calibration to the calendar timescale. The error, expressed at the one sigma level of confidence, includes components from the counting statistics on the sample, modern reference standard and blank and the random machine error.

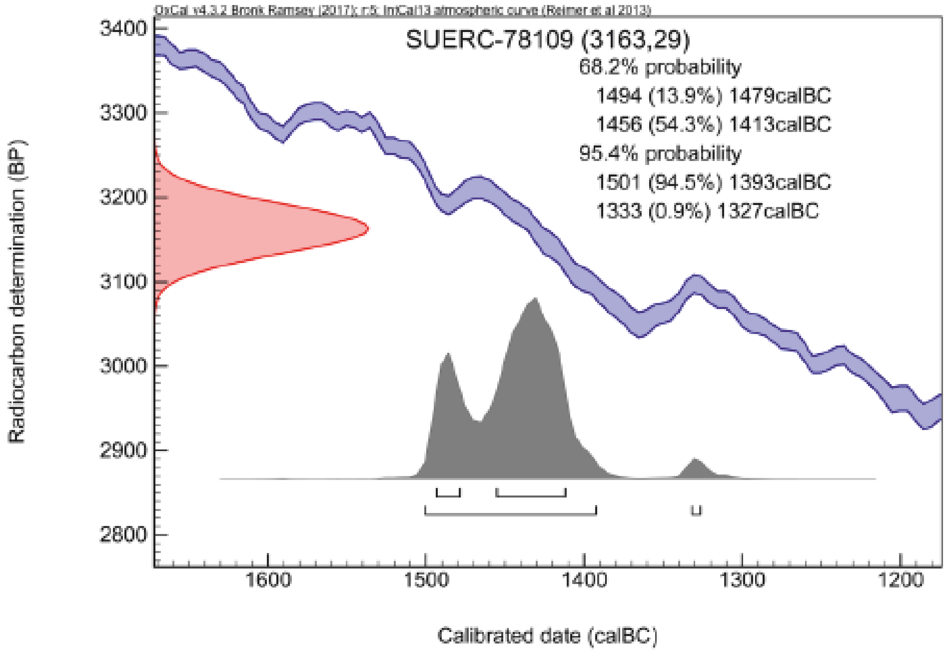
Samples with a SUERC coding are measured at the Scottish Universities Environmental Research Centre AMS Facility and should be quoted as such in any reports within the scientific literature. The laboratory GU coding should also be given in parentheses after the SUERC code.

Detailed descriptions of the methods employed by the SUERC Radiocarbon Laboratory can be found in Dunbar et al. (2016) *Radiocarbon 58(1) pp.9-23.*

For any queries relating to this certificate, the laboratory can be contacted at suerc-c14lab@glasgow.ac.uk.

Conventional age and calibration age ranges calculated by : E. Dunbar

Checked and signed off by : P. Naysmith



The radiocarbon age given overleaf is calibrated to the calendar timescale using the Oxford Radiocarbon Accelerator Unit calibration program OxCal 4.*

The above date ranges have been calibrated using the IntCal13 atmospheric calibration curve.†

Please contact the laboratory if you wish to discuss this further.

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† Reimer et al. (2013) *Radiocarbon 55(4) pp.1869-87*

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RADIOCARBON DATING CERTIFICATE
26 March 2018

Laboratory Code	SUERC-78110 (GU46915)
Submitter	Charlotte O'Brien Archaeological Services Durham University South Road Durham DH1 3LE
Site Reference	Greatham South Flood Alleviation, Stockton on Tees
Context Reference	37
Sample Reference	18
Material	Waterlogged bark : Indeterminate
$\delta^{13}C$ relative to VPDB	-28.9 ‰
Radiocarbon Age BP	3840 ± 29

N.B. The above ^{14}C age is quoted in conventional years BP (before 1950 AD) and requires calibration to the calendar timescale. The error, expressed at the one sigma level of confidence, includes components from the counting statistics on the sample, modern reference standard and blank and the random machine error.

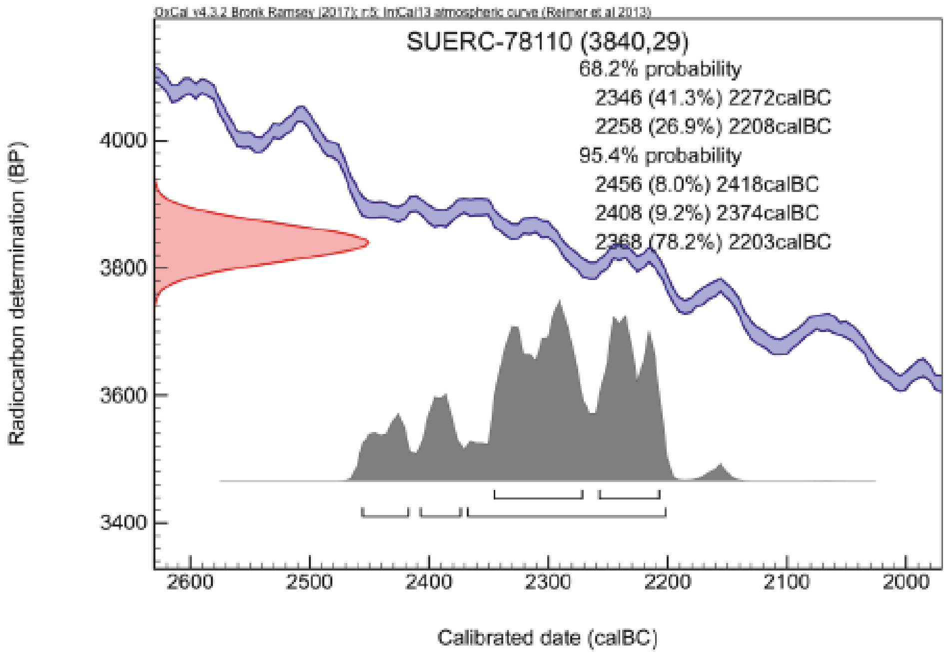
Samples with a SUERC coding are measured at the Scottish Universities Environmental Research Centre AMS Facility and should be quoted as such in any reports within the scientific literature. The laboratory GU coding should also be given in parentheses after the SUERC code.

Detailed descriptions of the methods employed by the SUERC Radiocarbon Laboratory can be found in Dunbar et al. (2016) *Radiocarbon 58(1) pp.9-23.*

For any queries relating to this certificate, the laboratory can be contacted at suerc-c14lab@glasgow.ac.uk.

Conventional age and calibration age ranges calculated by : E. Dunbar

Checked and signed off by : P. Naysmith



The radiocarbon age given overleaf is calibrated to the calendar timescale using the Oxford Radiocarbon Accelerator Unit calibration program OxCal 4.*

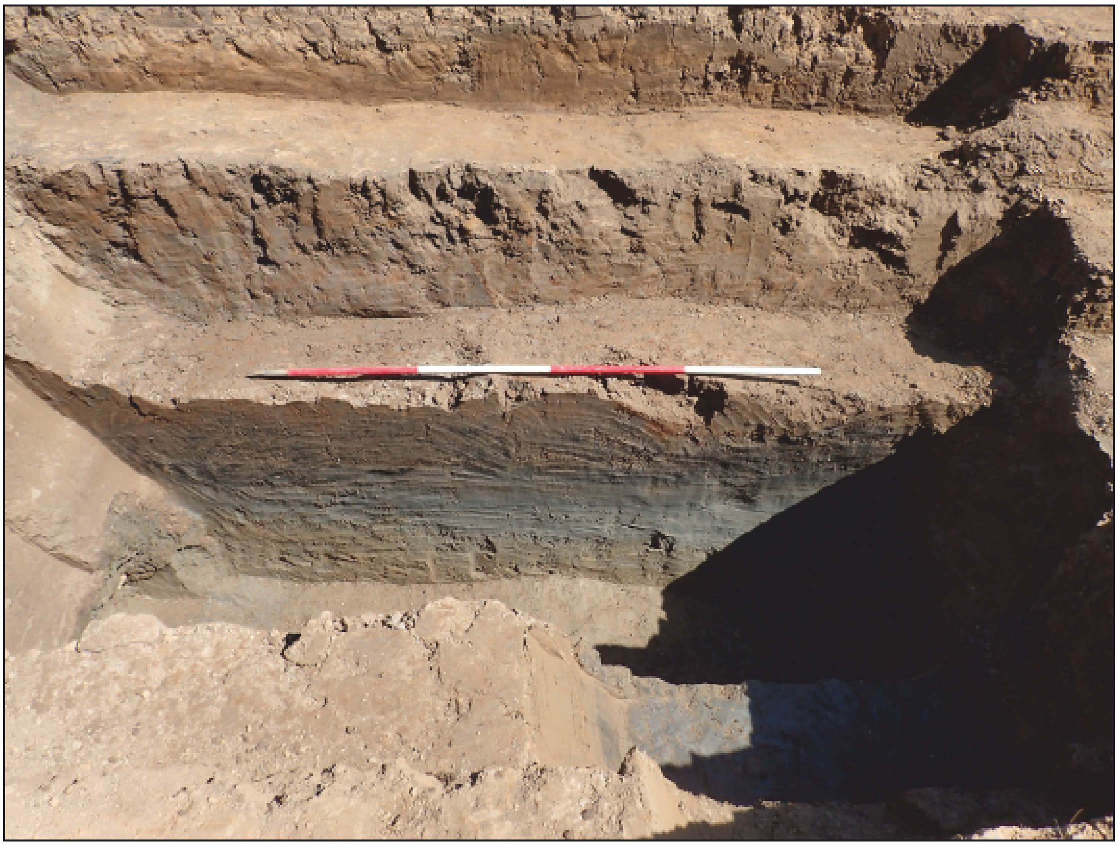
The above date ranges have been calibrated using the IntCal13 atmospheric calibration curve†

Please contact the laboratory if you wish to discuss this further.

* Bronk Ramsey (2009) *Radiocarbon 51(1) pp.337-60*
† Reimer et al. (2013) *Radiocarbon 55(4) pp.1869-87*

Photograph 1: The spigot mortar pre-excavation, looking north-west

Photograph 2: The spigot mortar post-excavation, looking north



Photograph 3: Organic layers with 'sleeching' deposits above, Saltern Test Pit 1, looking east

Photograph 4: Oblique shot of 'sleeching' deposits in Saltern Test Pit 2, looking north-east

Photograph 5: Strip, map and record Area 3, looking north-east

Photograph 6: Strip, map and record Area 4, looking south-west

Photograph 7: The old sea wall, looking north, with the WWII section post in the distance

Photograph 8: The POW road, looking north

Photograph 9: Oblique shot of the old sea wall and POW road, looking north-west

Photograph 10: Pond Connector Trench 1, looking north-east

Photograph 11: Pond Connector Trench 2, looking south-east

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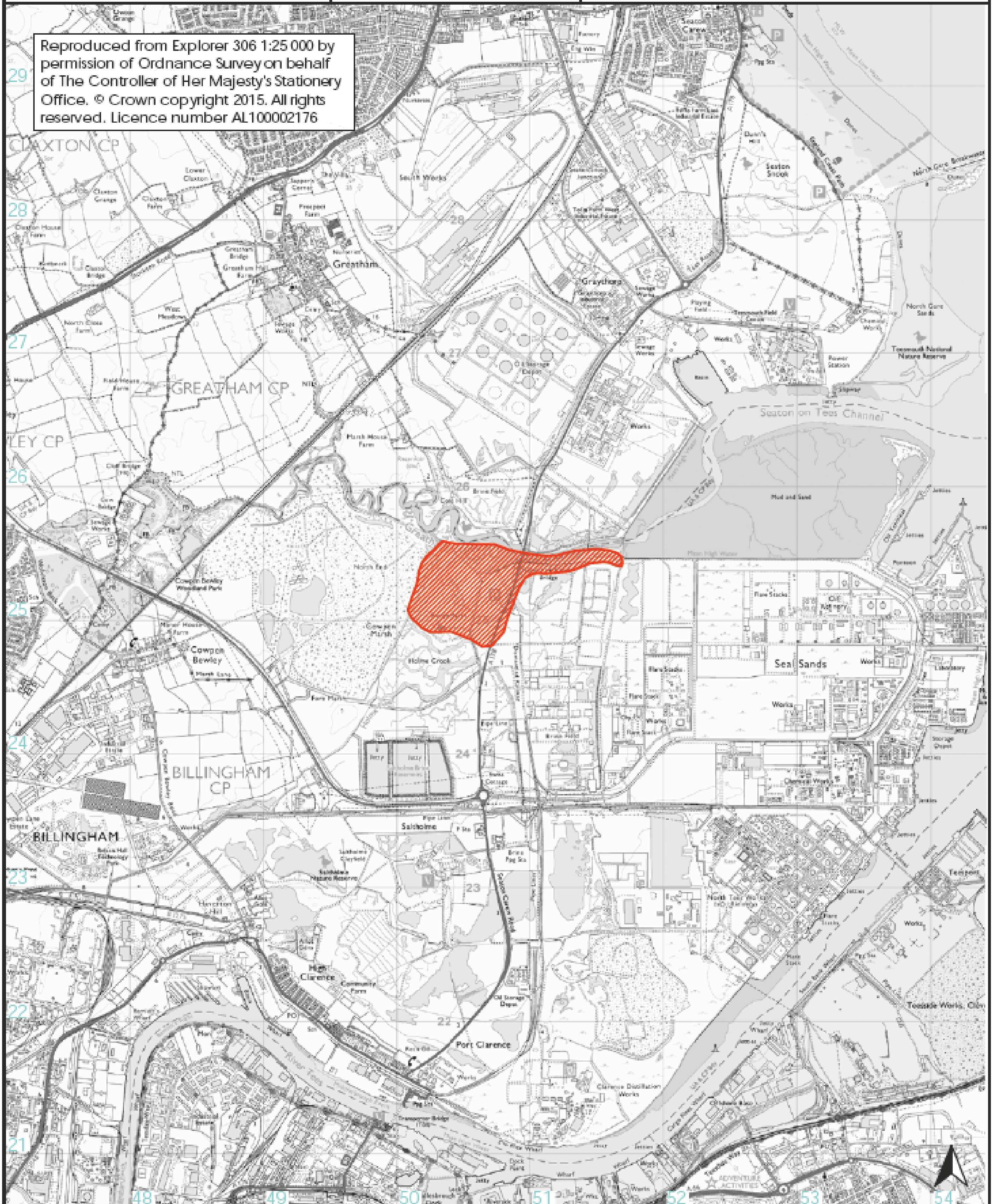
on behalf of
BMMJV Ltd

Greatham South
Flood Alleviation Scheme
Stockton on Tees

post-excavation assessment
report 4590

Figure 1: Site location



site location

0 2km
scale 1:40 000 for A4 plot

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BMMJV Ltd

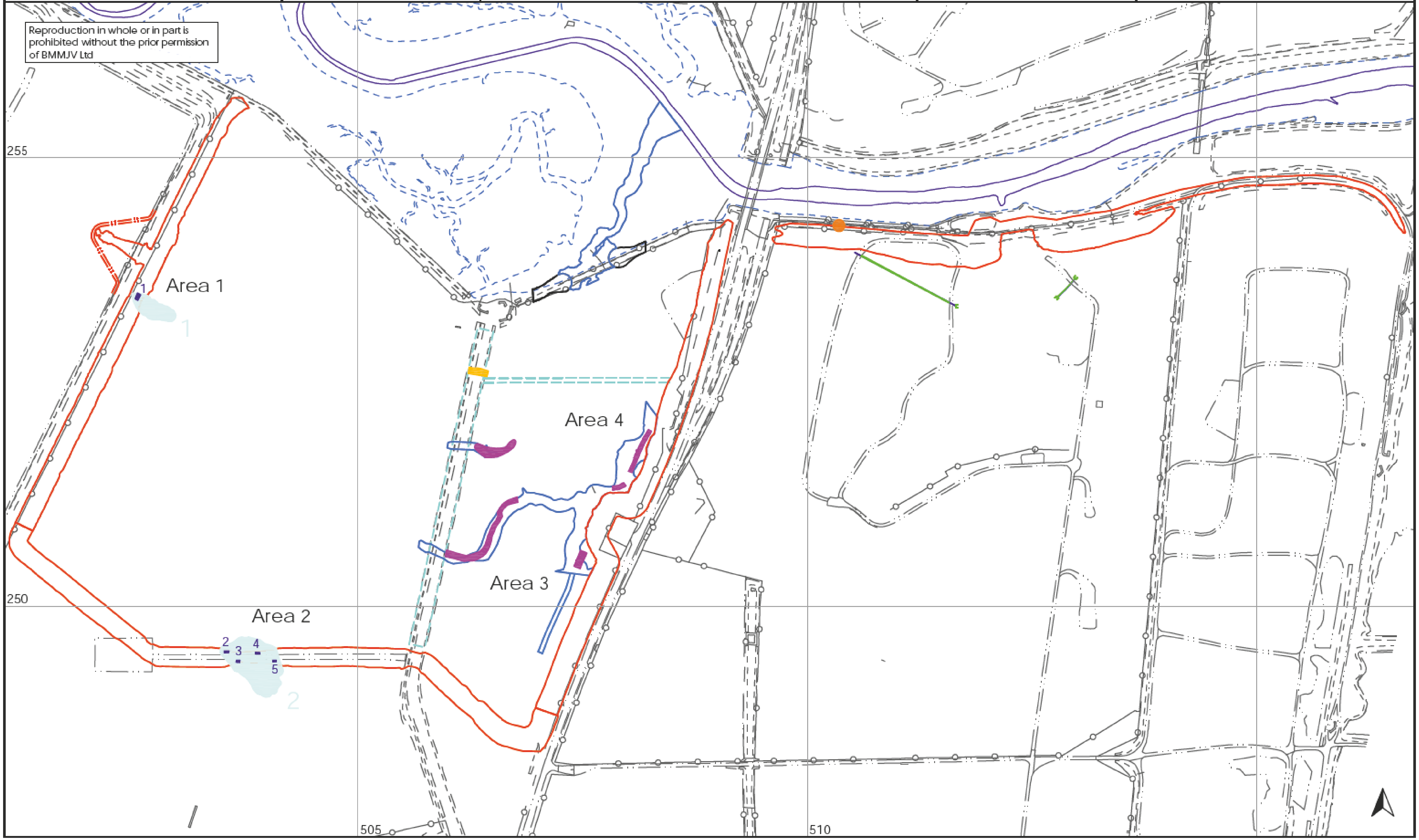
design footprint	strip and record	spigot mortar emplacement
targeted excavation	pond connectors	
saltern	old sea wall section	

0 — 200m
scale 1:4000 for A3 plot

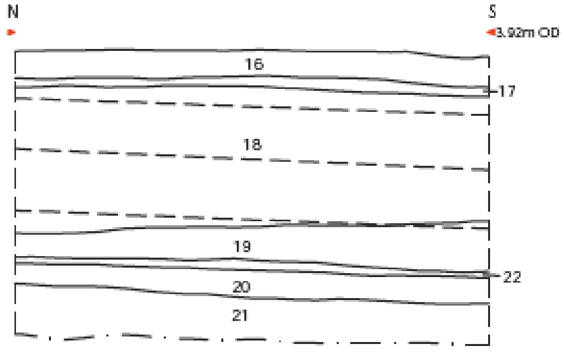
Greatham South
Flood Alleviation Scheme
Stockton on Tees

post-excavation assessment
report 4590

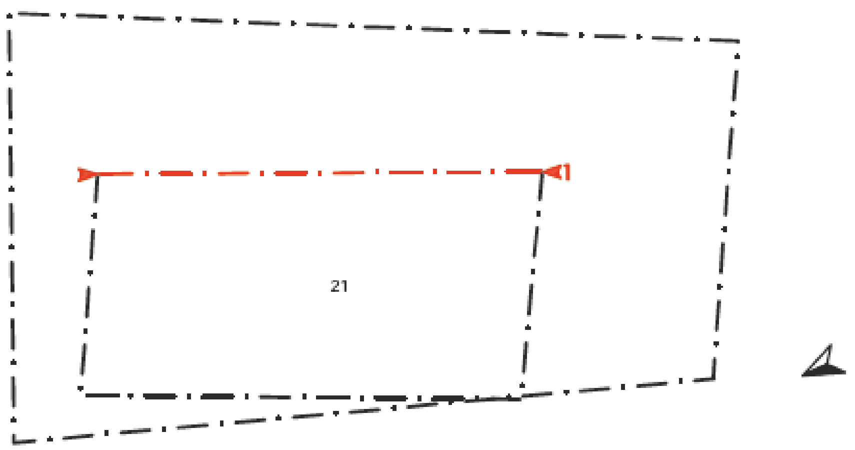
Figure 2: Location of works

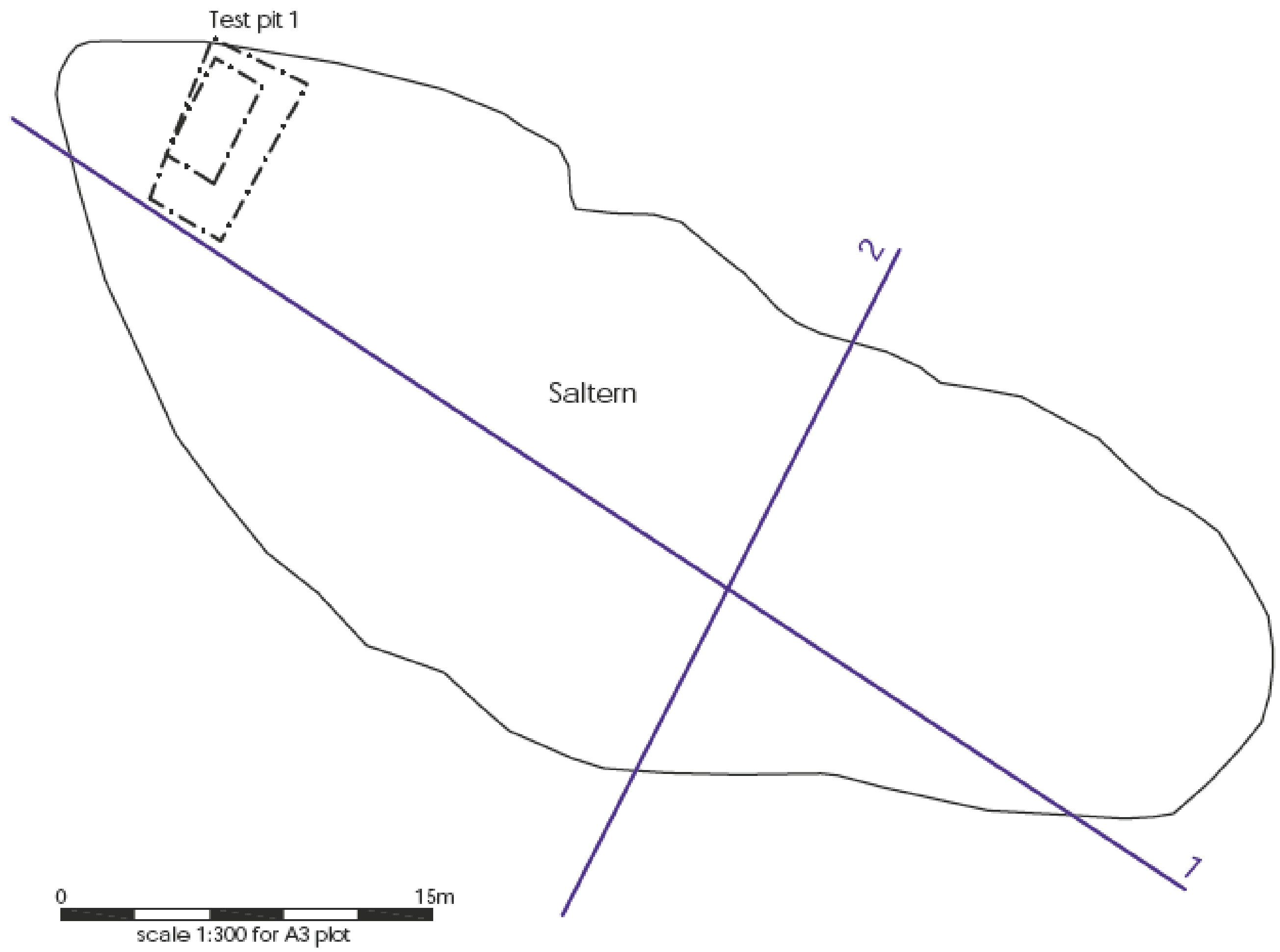


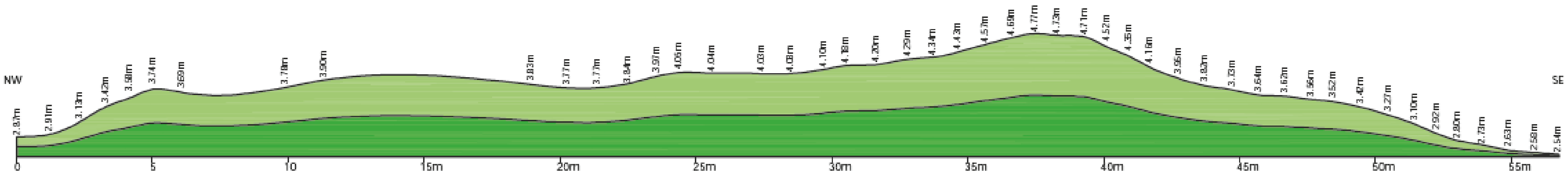
Section 1



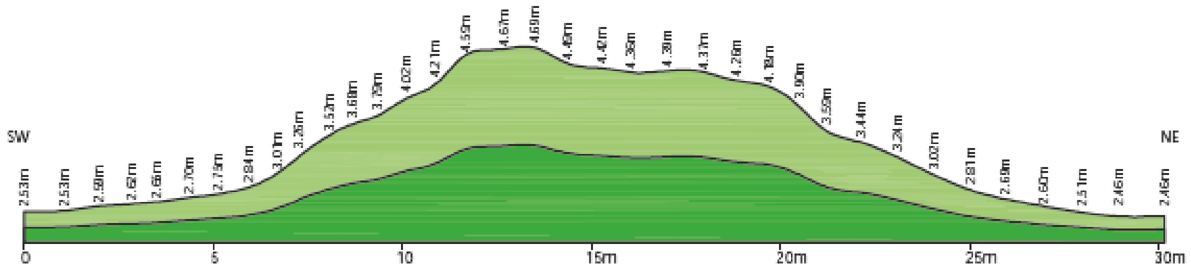
Test pit 1, plan







Saltern, profile 1



Saltern 1, profile 2

0 10m
scale 1:200 for A3 plot

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Flood Alleviation Scheme
Stockton on Tees

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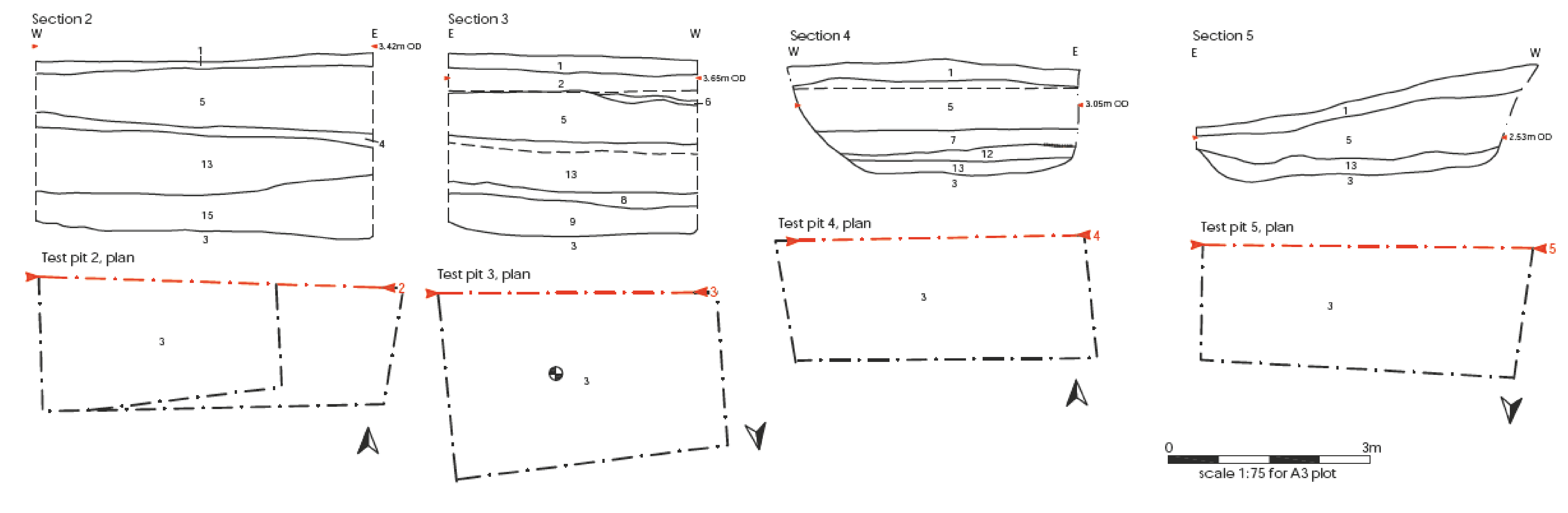
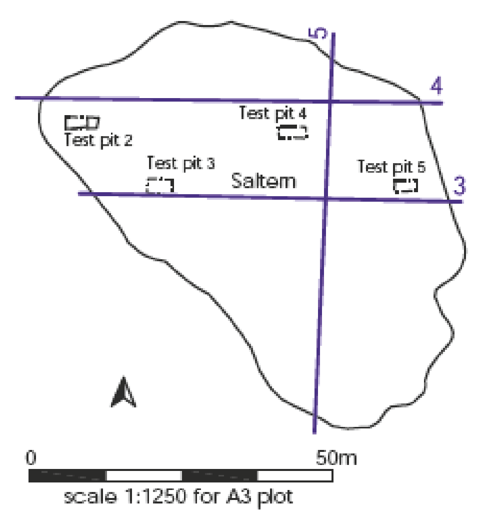
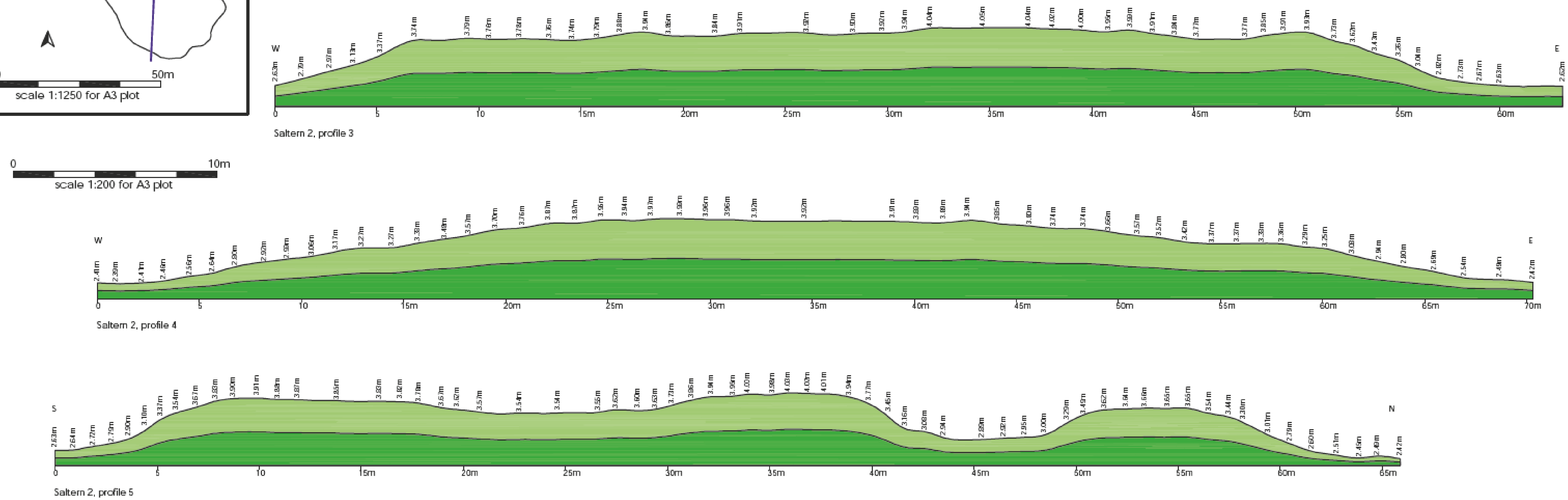
Figure 3: Test pit 1 plans, section and profiles of saltern

0 3m
scale 1:75 for A3 plot

- extent of excavation
- section
- step in section
- profile x1
- profile x2







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Flood Alleviation Scheme
Stockton on Tees

post-excavation assessment
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Figure 4: Test pits 2-5 plans, sections and profiles of saltern

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BMMJV Ltd

extent of excavation
section
stone

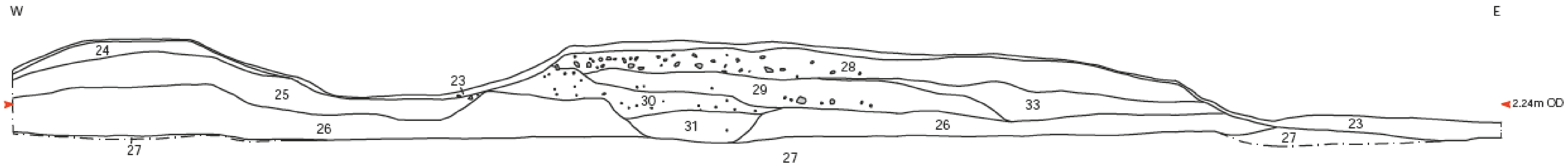
0 3m
scale 1:75 for A3 plot

Greatham South
Flood Alleviation Scheme
Stockton on Tees

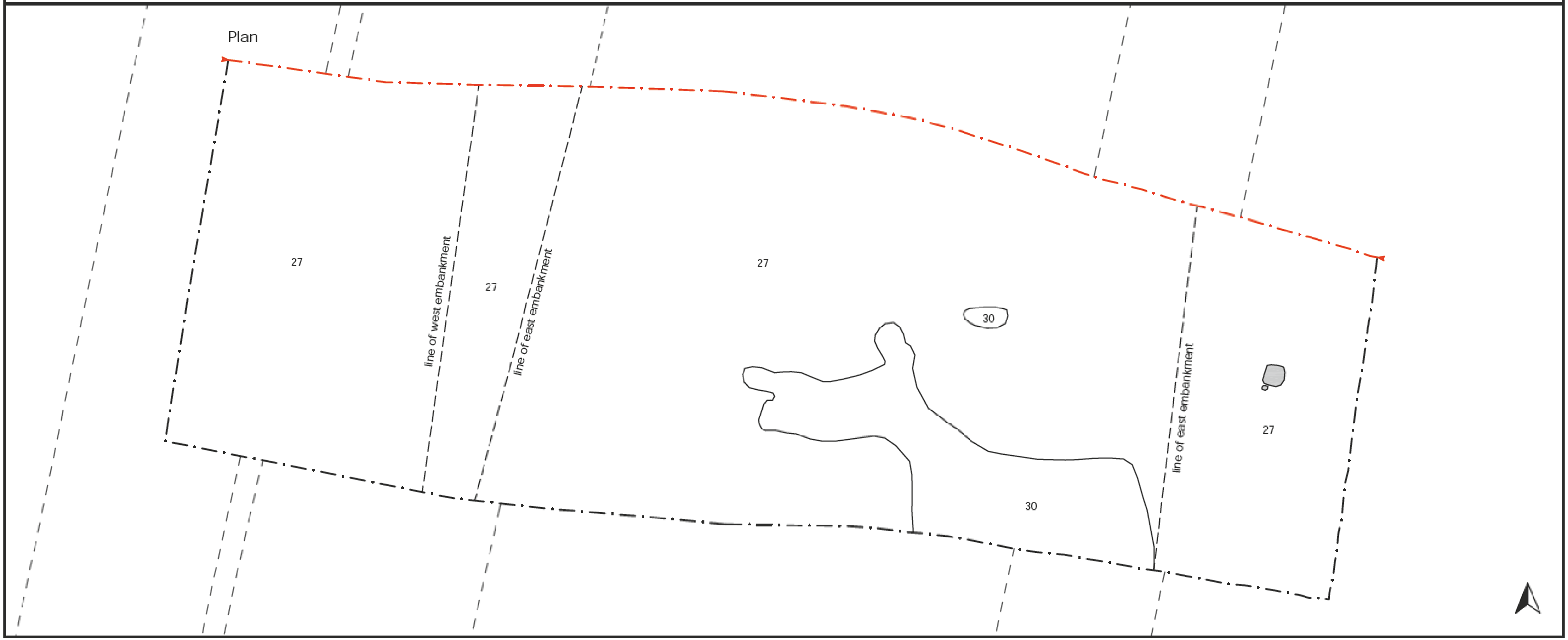
post-excavation assessment
report 4590

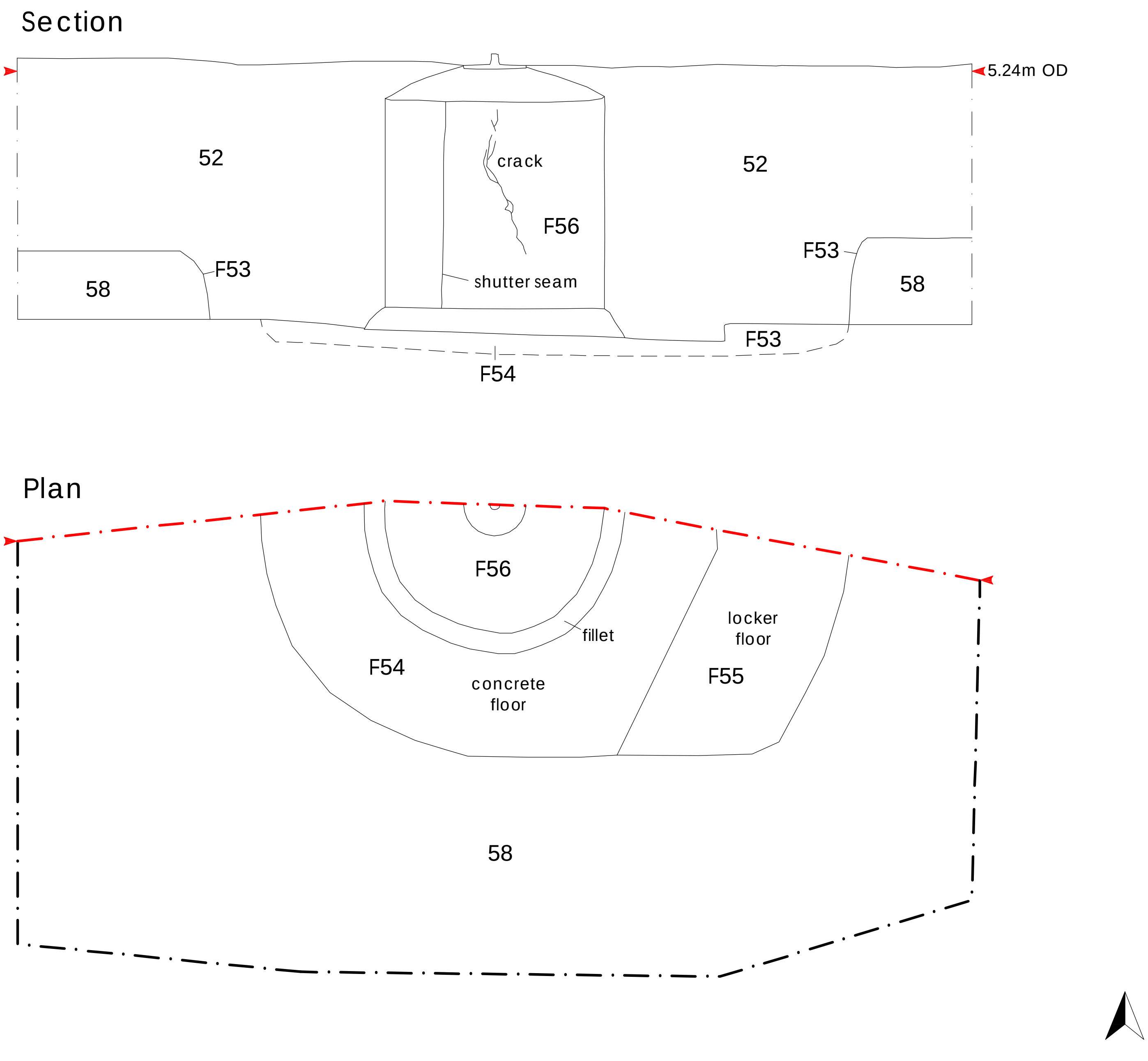
Figure 5: Sea wall plan and section

Section



Plan





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Greatham South
Flood Alleviation Scheme
Stockton on Tees

post-excavation assessment
report 4590

Figure 6: Spigot mortar plan and section

0 1.5m
scale 1:30 for A4 plot

extent of excavation

section