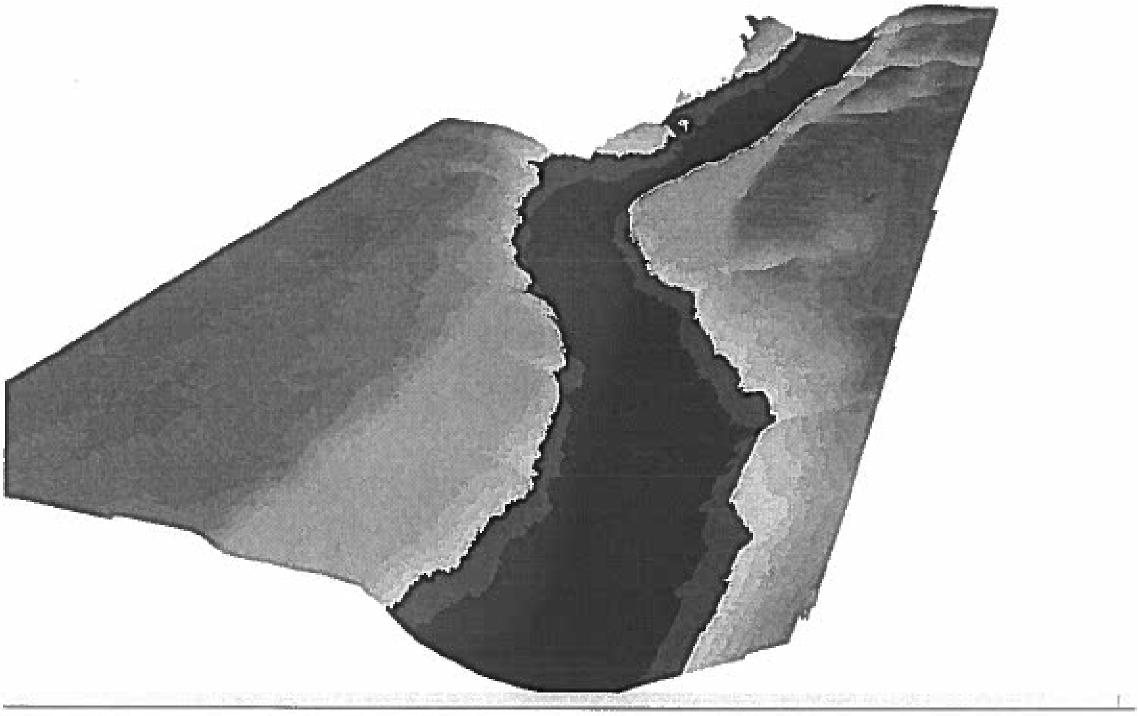
TEAM

QATAR GAS II SOUTH HOOK LNG TERMINAL

A GEOARCHAEOLOGICAL INVESTIGATION OF THE SITE AREA



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EXECUTIVE SUMMARY

This investigation was undertaken for RPS by TEAM in response to a detailed scope of survey works (Archaeology) that was agreed between RPS and TEAM. A geoarchaeological approach to the sub-bottom situations has been adopted and information from bathymetry, sub-bottom evidence, regional sea level patterns and known palaeoenvironmental changes have been used to assess the area of study with regards to archaeological and palaeoenvironmental potential.

Five key areas were identified by the study as having varying potential to contain sub-surface archaeological and palaeoenvironmental potential. These have been designated A – E and are outlined in Figure 12. A number of areas of high potential for the presence and preservation of Late Palaeolithic and early Mesolithic archaeology have been noted (mainly to the south of the incised channel). The discovery of archaeology from these periods within stratified contexts on the floor of the haven could be of national importance.

Sea bed targets have also been considered and the majority of the magnetic and sidescan targets may be debris from exploding ships hit by German bombers in late 1940. Three known wrecks are listed within the study area. The remaining targets (Figure 11, Appendices I and II) may represent larger fragments of sunken vessels as well as potential Bluestone targets.

1.0 INTRODUCTION

This investigation was undertaken for RPS by TEAM in response to a detailed scope of survey works (Archaeology) as set out in Appendix E of the "Draft Final South Hook LNG Facility Dredging Feasibility Assessment Report for QGII UK LNG Terminal" of June 2003. Modification to this scope of works was agreed between RPS and TEAM and a detailed breakdown of the project aims and objectives are outlined in Section 2.

The agreed works adopted a phased approach in order to provide baseline information required prior to considering construction impact and long term changes to the archaeological resource within the area of direct and indirect impact at the site (Figure 1). Initial scopes of works envisaged a first phase including desktop evaluation of extant data sources (including recently collected geophysical data on bathymetry and sub-bottom sequences), examination of recovered core samples from the geotechnical investigation and diver ground truthing of selected sea bed anomalies. However, as a result of the modifications to the specifications the diver ground truthing at this stage of investigation was omitted and is now considered as part of the staged future program of works (see Section 7).

During the period of work taken to produce this report further problems were encountered that have limited the scope of the works. Geotechnical investigation has been undertaken, and samples recovered, however, it emerged at a late stage in the production of the report that no undisturbed samples were available from the boreholes (e.g. 3A and 4) in which archaeologically relevant stratigraphies are present. Consequently it has not been possible to directly observe undisturbed sediments and obtain any meaningful insights into the nature of these deposits. Additionally, although boomer sub-bottom profile data is available, e.g. two lines were presented and interpreted by Titan Environmental Surveys Ltd. and showed internal reflecting horizons, these horizons had not been picked and interpolated across all lines at the site. At the time in which the archaeological brief was being modified it was TEAM's understanding that all transects would have been picked and interpolated, unfortunately this was not the case. Consequently our knowledge of the sub-bottom stratigraphy remains incomplete.

2.0 AIMS AND OBJECTIVES OF THE STUDY

The aims and objectives of the archaeological investigation consist of:

1. To utilise the bathymetric and sub-bottom information of the haven study area to gain an understanding of the region during the late Devensian and Holocene periods.

2. To calibrate our knowledge of the sub-bottom stratigraphy through observations of any recovered core samples.

3. To identify the presence of anomalies on the sea bed surface as potential targets for future archaeological investigation.

4. To determine areas of poor archaeological understanding within the study area.

5. To produce an outline methodology for a structured design for future archaeological investigation.

In order to achieve the aims and objectives of the project the following tasks were undertaken:

Task 1. Sub-bottom modelling (Section 5.1). This involved a consideration of the data sources as provided by Titan/RPS and an evaluation of the significance of the data for archaeological predictive modelling and understanding.

Task 2. Bathymetric modelling including investigation of the bathymetric, sidescan and magnetometer data to identify seabed bottom targets (Section 5.2).

Task 3. Desktop assessment of existing data relating to the archaeological resource. This involved investigation of the regional Sites and Monuments Record (SMR) etc. for the seabed zone affected both directly and indirectly by the development and terrestrial datasets for adjoining inter-tidal zone and dry land (Section 3.3).

Task 4. Desktop assessment of existing data relating to the geological resource (Section 3.1, 3.4).

Task 5. Desktop assessment of existing data relating to the nature of sea level change and environmental history of the late Devensian/Holocene period (Sections 3.1.2 and 3.2).

Task 6. Assessment of recovered drill core samples and logs. This involved a review of the recovered data and any core samples from the unconsolidated sedimentary sequences. The objective of the investigation was to gain a basic ground truthing of the sequences identified in the geophysical investigation. Drill core logs were also assessed in order to refine the regional development of the haven area (Section 5.2).

Task 7. Production of an integrated report. This report draws together the lines of evidence to provide a site specific geological history for site formation. The information is contextualised within the framework of the regional history of late Quaternary development for the area. In particular emphasis is placed on the nature and speed of sea level change and landscape development. This information has been used to determine the archaeological potential of different areas (Figure 14). Furthermore the report has also examined the sea bed archaeological potential.

Task 8. Production of a strategy suitable for a phased response to development. This has been provided as a first stage in the process of progressing archaeological investigation at the site. The structure adopted is based on a phased response to the known development as a series of tasks required in order to both more fully understand the nature of the haven stratigraphy and archaeological potential as well as mitigating against impact (Section 7).

3.0 REGIONAL BACKGROUND

3.1 Geological history

3.1.1 Pre-Quaternary evolution of the study area

The bedrock geology of the Pembrokeshire area consists of two parts; a northern area occupied mainly by Ordovician and Silurian rocks that have been subjected to pressures from the north; and a southern portion (including Milford Haven) consisting of Lower Carboniferous, Old Red Sandstone and narrow belts of Silurian rocks.

Within the southern belt the Coal Measures stretch as highly inclined and anthracitic sequences from Carmarthen Bay to the shore of St Brides Bay and they are bordered on the north and south-east by the Millstone Grits, Carboniferous Limestone series and Old Red Sandstone. These sequences have been extensively folded and faulted by pressure from the south, which has produced a general north-west/south-east strike. On account of the folding the limestone appears again farther south at Pembroke, Caldy Island and St Cowans Head. Most of the remaining ground about Milford Haven is occupied by lower Old Red Sandstone of Middle Devonian age with infolded strips of Silurian rocks.

Today the Old Red Sandstone occurs extensively on both the north and south sides of the Haven (Allen *et al.*, 1982; Williams *et al.*, 1982) where the rocks exhibit a broad west-northwest/east-southeast trend. A major fault follows this pattern through the haven and is known as the Ritec Fault (the incised channel draining the haven can be seen to follow this alignment). Minor fault patterns consisting of conjugate sets of faults with NNW/SSE and NNE/SSW trends can also be traced throughout the region. Note that the faults west of Angle Bay are all parallel to those inferred from the bathymetry plot at the mouth of the haven where the drainage is again exploiting the trend of the faulting. The stepping onshore of these faults suggests that they all have a sinistral displacement so that the Carboniferous syncline is thrown to the south in the haven. These faults probably play an important role in determining location of axes of major drainage lines from the south (Angle Bay) into the main palaeo-channel.

In the vicinity of South Hook Jetty boreholes indicated that mudstones and siltstones belonging to the Red Marl Group (characterised by a sequence of repeated alluvial fining upwards cycles (Anderton *et al.*, 1987)) are present.

3.1.2 Late Quaternary evolution of the study area

The late Quaternary history of the study area is dominated by the Devensian (last glaciation) ice advance attaining maximum extent by c.18,000B.P. Ice within SW Wales derived from either mainland Welsh sources or from within the Irish Sea area (see Campbell and Bowen, 1990). Ice does not appear to have reached Milford Haven at this time (however, the presence of boulders of spotted dolerite from the outcrops of Carn Meini in the Preseli's suggest much of this area was over-run by ice at some point before the last interglacial – prior to 125,000 B.P.)

In the late Devensian Irish Sea ice reached Fishguard and crossed the St.David's peninsula as far south as St. Bride's Bay 18,000 years ago. Within the region of the haven melt water from the ice sheet to the north would have seasonally filled the periglacial river draining the haven area at times of lowered sea levels. At this time all rivers would have drained out across the continental shelf (Bridgland, 2002). This river is likely to have been a predominantly erosional system with steep gradients in the area of the haven but beyond the constraint of the haven, towards the inner parts of the continental shelf, deposition may have replaced erosional processes.

Following the glacial maximum at 18,000 B.P. deglaciation of the area to the north of the haven was likely to have been rapid. Sudden deglaciation may have resulted in catastrophic discharge events and perhaps rapid development of over deepened channels etc. Sediment accumulation in the form of coarse gravel lags may have begun at this time in the base of the channel.

Climatic changes associated with the late glacial climate oscillations between 13,000 and 10,000 B.P. (c.11.5k cal yrs B.P.) (in particular the Loch Lomond ice readvance stage) would have subjected the haven to a sequence of cold-temperate-cold events. The nearest coastal sites with detailed records spanning this period are found well to the north of the haven at Aberaeron and Clarach (Taylor, 1973; Haynes *et al.*, 1977; Heyworth *et al.*, 1985; Walker *et al.*, 2001). Terrestrial sites spanning the late glacial-early Holocene period are also known from Dinas (Seymour, 1985) and Hendre Fach (Donald, 1987) within the Preseli region as well as Cors Carmel near Cross Hands (Walker and James, 1992).

Climate warming at the onset of the Holocene 10,000 years ago would have resulted in successive vegetational changes related to changing temperatures, plant migration rates and soil maturity. A sequence of events has been identified in the vegetation record (Parker and Chambers, 1997) for the earlier Holocene that includes:

1. Pre-Boreal (Pollen zone IV). A phase dominated by rapid warming, birch, juniper and pine lasting from 10-9.3kB.P. (c. 11.5-10.2k cal yr B.P.)
2. Early Boreal (Pollen zone V). A phase dominated by warming climate, hazel, birch and pine lasting from 9.3-8.2kB.P. (c. 10.2-9.2k cal yr B.P.)
3. Late Boreal (Pollen zone VI). A phase dominated by warm and dry climate, oak and elm and lasting from 8.2-7.5kB.P. (c. 9.2-8.3k cal yr B.P.)
4. Atlantic (Pollen zone VII). A phase dominated by warm and wet conditions, oak, elm, lime, ash and alder and lasting from 7.5- k B.P. (c. 8.3k – cal yr B.P.)

3.2 Sea level history

Sea-level data for the Milford Haven area is sparse and certainly when compared with the much more intensively studied Bristol and English Channels few detailed studies have been conducted within the area despite the fact that the abundant "submerged forests" along the Welsh coast have long attracted attention of geologists and archaeologists (e.g. Reid, 1913; Godwin, 1943). The evidence for relative sea-level (RSL) change at Milford Haven will reflect a combination of local, site specific factors such as tidal range and sediment availability as well as sediment compaction. However, the trends they document are part of regional patterns relating to global changes in sea level following the end of the last ice age, as well as regional scale variations in crustal rebound following the melting of the world's ice sheets (Shennan and Horton, 2002). For this reason, it is instructive to consider the rather limited RSL data from the Milford Haven area in the wider context of data from the south of Cardigan Bay, and from the south Wales coast as far as Port Talbot.

The only reliable sea-level index point from the immediate vicinity of Milford Haven is a sample of wood peat collected from a submerged forest at low tide mark on the foreshore in Freshwater West. The forest rests directly on glacial diamicton and is associated with a microlithic industry (Wainwright, 1960). Pollen and plant macrofossil remains suggest deposition in a freshwater fen woodland environment (Godwin and Willis, 1964) and a sample of the peat yielded a radiocarbon age of 5960 ± 120 BP (6312-6780 cal. yr BP, Q-530) from -1.9 m OD.

Further to the north, in Cardigan Bay, Blundell *et al.* (1969) use seismic data to define a series of deeply buried river valleys around the margins of Cardigan Bay, which were incised during periods of lower sea level. These valleys are now infilled with very thick sequences of postglacial sediments that contain an important record of palaeoenvironmental change and RSL history since ice retreat. Haynes *et al.* (1977) describe results of palaeoenvironmental analyses of three cores collected from the infill of these valleys. The most important of these, core ZZ 27, was collected 5 km west of Aberaeron at a depth of -18 m OD, with core retrieval extending to -21.75 m OD. In the base of the core is non-calcareous "Welsh till" which is followed unconformably by a blue-grey laminated clay and then a well-humified peat, c. 0.5 m thick. The peat is overlain by 1.5 m of laminated peaty clays, blue-black in colour and containing small pellet-like lenses of peat. This organic unit is overlain by a 1.25m thick sequence of laminated clays and silts.

A range of palaeoenvironmental proxies (pollen, diatoms, foraminifera and ostracoda) indicate that the peat formed in a freshwater and then saltmarsh environment. The peat probably developed as a result of waterlogging of the land-surface as a direct result of rising sea-level during the early Holocene. A sample of the peat from -20.5 m OD yielded a radiocarbon age of 8740 ± 110 BP (10,150-9535 cal. yr BP, Birm/400) and this provides an excellent basal sea-level index point. The overlying sediment sequence records progressive inundation by the sea, and an increase in water depth as the palaeovalley became infilled with first estuarine and then fully marine sediments.

Further to the north of Aberaeron, at Clarach Bay near Aberystwyth, Heyworth *et al.* (1985) describe an organic sediment sequence located near the mouth of the River Clarach which is related to a foreshore peat exposure. The site contains an uninterrupted sedimentary sequence that extends from the start of the Late Glacial period to the present day. The basal sequence of deposits, which comprise limnic peats and nekron muds, formed from the Late Glacial period (from 13,300 ± 127 BP, 16,583-15,047 cal. yr BP) until the mid Holocene (c. 6800 cal. yr BP). After this time, the sediment sequence in the river valley and on the present foreshore became influenced by rising sea level. Wood fragments from the freshwater clays which underlie the foreshore peat at -1.7 m OD date to 5760 ± 100 BP (6780-6312 cal. yr BP, HAR 1128). This date presumably records the onset of waterlogging of the land-surface and wetland formation ahead of eventual marine inundation. Similarly, a silty clay in Borehole 1 from the river valley records the effects of the approaching marine influence, with a ponding of river water perhaps associated with blocking of the river mouth by a storm beach (Heyworth *et al.*, 1985, p. 471). Once the foreshore peat was inundated, freshwater alder carr developing in the river valley accumulated vertically, keeping approximate pace with sea level until c. 2500 cal. yr BP.

There are limited RSL data from sites to the immediate south of Milford Haven along the shores of the north Bristol Channel. In the Loughar Estuary, Edwards (1998) reports four sea-level index points collected from Llanrhidian Marsh during the late Holocene. These dates are useful because they fill a major time gap in the distribution of RSL data from the Bristol Channel region. The stratigraphy at the site comprises a well-developed suite of organic sediments below +4.1 m OD which rest on a grey, commonly iron-stained consolidated clay with large sand clasts between +2 and +4 m OD. Locally the main peat unit is sub-divided into an upper and a lower peat. The transgressive contact the lower peat is dated to 3840 ± 60 BP (4416-4087 cal. yr BP, CAMS-41308) at +2.42 m OD, with the regressive and transgressive contact to the upper peat dated to 2540 ± 60 BP (2755-2362 cal. yr BP, CAMS-41309) at +2.82 m OD and 740 ± 50 BP (759-562 cal. yr BP, CAMS-41307) at +4.21 m OD respectively.

The last site considered here in detail is from Port Talbot, for the reason that an important set of Late Glacial and early Holocene data exist from this area. They are valuable, when seen in conjunction with the basal index point from Aberaeron described above, in determining the early Holocene RSL history of the region.

Exploratory borings associated with the harbour development scheme at Baglan Burrows revealed peat beds at a considerable depth, samples of which were analysed by Godwin and Willis (1964) for their pollen and plant macrofossil content, and subjected to radiocarbon dating. Borehole 19 recovered a dense compacted peat, c. 20 cm thick, which rested directly on rounded gravel in a matrix of sandy silt. The peat was overlain by >10 m of sands and silts deposited during the Holocene rise in sea-level. A second core (Borehole 4) sampled a 1.3 m thick basal peat overlying gravel at an altitude of -18.41 m OD, from which two further radiocarbon dates were collected (their exact depths in Borehole 4 are not known).

The dates from Borehole 19 yield ages of 10,350 ± 170 BP (12,846-11,362 cal. yr BP, Q-660), 9920 ± 170 BP (12,284-10,760 cal. yr BP, Q-661), 8990 ± 170 BP (10,500-9559 cal. yr BP, Q-662) and 8970 ± 160 BP (10,478-9561 cal. yr BP, Q663) on samples of compressed freshwater peat. The youngest of this sequence, from an altitude of -18.90 m OD, provides a minimum estimate for MHWST at this time, although Godwin and Willis (1964) are uncertain whether the top of the peat has been truncated. The two dates from Borehole 4 are also from a freshwater deposit which contains a Late Glacial pollen flora dominated by herbaceous pollen types. Their age determinations are 11,980 ± 180 BP (15,282-13,475 cal. yr BP, Q-664) and 11,260 ± 170 BP (13,799-12,887 cal. yr BP, Q-665) and they provide minimum estimates on sea level at this time.

3.2.1. Trends in relative sea-level in the Milford Haven region

The data described above are limited in the spatial and temporal distribution. Several of the ages lack proper microfossil analyses and are difficult to relate to a former sea level, whilst most of the data were collected over 30 years ago. Nevertheless there are some very useful index points here, especially the deeply buried index points from Aberaeron and Port Talbot. In addition, the recently collected data from Edwards (1998) provide reasonably good control on trends in the late Holocene. During the mid Holocene, however, the number of dates are limited and they are in some instances influenced by compaction.

Each of the dates within the study area have been reduced to mean sea level (MSL) assuming constant tidal range, and are plotted on Figure 2. The x-axis error for each is equal to the two sigma age range of the calibrated date (using CALIB 4.4) and a y-axis error estimated from the palaeoenvironmental data associated with each index point.

In general, the data depict a relatively consistent pattern with MSL rising from c. -45 m at c. 12,000 cal. yr BP to c. -10 m at 8000 cal. yr BP. After about 6000 cal. yr BP the rate of sea-level rise slowed, with MSL reaching close to present by about 4000 cal. yr BP. The data lack sufficient resolution to identify any oscillations to the smooth trend depicted by the summery line on Figure 2, and there are insufficient data to develop a meaningful analysis of tendencies of sea-level movement. The graph depicts MSL and not mean high water of spring tides, and this should be borne in mind when these data are used in the reconstruction of palaeogeographic maps for the Milford Haven area (see Figure 6 and Section 5.0 below).

3.3 Archaeology

3.3.1 Late Pleistocene/Early Holocene archaeology

A human presence in SW Wales during the later stages of the last cold period can be attested to from the Early Upper Palaeolithic period (immediately prior to 26k B.P.) when caves to the east of the haven at Paviland and Little Hoyle were occupied. An increase in the scale of human activity is attested to by the Late Upper Palaeolithic period (after c14k B.P.) when additional sites such as Cathole, Little Hoyle, Nanna's Cave and Priory Farm Cave were occupied (Lynch *et al.*, 2000). Of particular relevance to the study area is presence of Final Palaeolithic activity at Priory Farm Cave (Green and Walker, 1991) to the south of the study area. This site has most recently been investigated by Barton (see Lynch *et al.*, 2000) who recovered an extensive lithic assemblage in association with abundant small mammal remains.

Following climatic amelioration at the start of the Holocene Earlier Mesolithic occupation of SW Wales is attested to at Nab Head close to 9200B.P. (Lynch *et al.*, 2000) while the earliest Late Mesolithic dates in south Wales are from the Wye Valley at c.8710B.P. (Barton *et al.*, 1997). A substantial Mesolithic and Neolithic presence can also be inferred from the large number of find spots within the immediate terrestrial environment (Figure 1).

A detailed assessment of the archaeological (and palaeoenvironmental) potential of post-glacial sediments within the study area requires, in part, consideration of the terrestrial resource, in particular that exposed in intertidal locations around the Pembrokeshire coast.

The numerous find spots of Mesolithic or Neolithic flint along the high cliffs of Pembrokeshire (see Figure 1) reflect in part the activities of antiquarian collectors (Murphy, 2002; Wainwright, 1963; Lynch *et al*., 2000), biasing the data towards an apparently coastal focus. Models for relative sea level change suggest that many such sites may have overlooked coastal plains which have now been submerged.

Intertidal exposures of Holocene deposits in the bays of Pembrokeshire provide limited evidence for Mesolithic activity on this coastal locale (Bell, 2000; Lewis, 1992). Early studies by Leach (1918) identified the presence of charcoal at a number of intertidal locations on the Pembrokeshire coast below basal peats which might indicate anthropogenic modification of the prehistoric environment. Subsequently, artefact scatters on till below peat dated to 5250±80BP (CAR-1176) have been recovered in Whitesands Bay. Artefact and/or flint scatters were also identified by Lewis below basal peats overlying silts at Amroth, Frainslake, Freshwater West (5960±120BP, Q-530), Lydstep (6150±120BP, QxA-120) and Penybont, Newport (6370±150, HAR-78).

These sites all emphasise the archaeological potential of submerged post-glacial land surfaces where subsequent transgression has protected archaeological material from disturbance. Submerged surfaces and sediment accumulations identified and assigned levels of archaeological (and palaeoenvironmental) potential within the study area may encapsulate comparable assemblages of Mesolithic material. The importance of such assemblages in the British archaeological world cannot be over-stated. To date, survey and excavation of fully submerged Mesolithic sites in British waters has been very limited although ongoing research at Bouldnor Cliff in the Solent, on the north coast of the Isle of Wight, indicates the feasibility of recovering stratified lithics and associated palaeoenvironmental evidence underwater (Momber, 2000). In the Danish Baltic, extensive areas of inundated Mesolithic and Neolithic landscapes have been surveyed and recorded in advance of, and during major developments such as the Storebaelt Fixed Link (Pedersen *et al.*, 1997). In the latter case, the development and testing of models for Mesolithic coastal settlement and exploitation identified locales particularly suited to long term use of fish weirs to support permanent settlement. These models point to a preference for sheltered sites where stationary fishing structures would survive over long periods, and fish runs would be concentrated by river mouths and narrow parts of fjords. The relative sea level change model developed for this part of Milford Haven points to such conditions prevailing during the Mesolithic.

3.3.2 Maritime archaeology: wrecks

The drowned ria of Milford Haven provides the best natural harbour on the whole of the west coast of Wales, and has an unsurprisingly long history of maritime, particularly military, activity. It was from here that Anglo-Normans mustered their fleet for the conquest of Ireland, and it was chosen by Owain Glyndwr and Henry

Tudor as the landing-place for their armies of invasion (Murphy, 2002). Limited defences were put in place in the late 16th century, followed by major building programmes from the mid-nineteenth century through to the Second World War. The Haven also acted as centre for Admiralty ship-building from the end of the eighteenth century through to the mid-1920's. Other maritime activities centred on the Haven included a herring industry in 19th and 20th century, a whaling fleet operated by Nantucket crews (1792—1819), a packet and ferry services from Milford and latterly Neyland (Gwyn, 2002), and a seaplane base.

3.3.3 Maritime archaeology: Bluestones

The presence of Bluestones in the 5th circle and horseshoe at Stonehenge (Lawson, 1997) has resulted in a protracted debate regarding the method of transport of the stones from the source area in the Preseli Hills to the Salisbury Downs. It is now generally accepted that human agents rather than glacial transport was responsible for the movement of the stones (Scourse, 1997; but see Burl, 1999) and consequently the likely mechanisms for transport need consideration. One line of argument suggests that rafts or boats transported the stones from Milford Haven to the river Avon. In an attempt to prove the feasibility of this method a Millennium Project attempted to move a stone by land and water in 2000 but failed when the boat carrying the stone sank in the haven. Despite this setback it remains possible that rafts were used in the stones transport.

If it is accepted that some form of raft or boat was used then it is possible that evidence for similar accidents within the haven may exist within the study area, i.e. Bluestones that sunk and now rest on the haven floor. The discovery of a sunken Bluestone within the haven would be of considerable significance.

3.4 Geoarchaeology

An understanding of the relationship between the archaeological resource and past human patterns of behaviour is necessary in order to attempt to predict the location of archaeological sites within the study area. Furthermore it is also necessary to consider the physical processes operating within the area during and subsequent to human activity. The combination of these fields of study is known as geoarchaeology and our interpretation of the archaeological potential of the haven floor is based, in part, on such an approach.

In this study a number of factors have been identified that will have an important impact on the archaeology present within the study area and the location, nature and date of archaeological materials likely to be present:

1. The timing of human presence in the region.
2. The nature of human activity in the region. This will define the types of material debris left by human activity, the location within the landscape of that activity, the relationship with different sediment substrates.
3. The location in space of the activity. This will have an impact not only on what it is possible to do at any one location but also the predominant

geomorphological processes operating at that locale (i.e. in terms of how quickly sites become buried or eroded etc.).

Specifically within the context of Milford Haven we also need to consider:

1. The impact of sea level change and in particular the processes of marine transgression (flooding of the haven).
2. Processes associated with sea bed patterns of erosion following flooding.

By combining a knowledge of these elements together it is possible to begin to understand the likely nature of environmental changes associated with the physical changes impacting on the landscape in the late Devensian and early Holocene periods. A critical factor controlling the nature of the archaeological resource expected within the haven is that of sea level. Two possible types of archaeological resource are likely to be present:

1. Material deposited in terrestrial, fluvial or estuarine conditions prior to inundation of the haven by sea water.
2. Wreck material accumulating on the haven floor following flooding (a special category of wreck material might be any Bluestones resting on the sea bed as a result of loss at sea of Bluestones on route to Stonehenge).

Using a knowledge of the haven bathymetry (Figure 3) and rockhead topography (Figure 4) and the sea level curve (Figure 2) it is possible to reconstruct the changing palaeogeography (Figure 6) to suggest that:

1. Inundation of the entire study area would have occurred sometime in the earlier part of the Holocene (probably prior to 7.2k B.P.(8k cal yr B.P.)).
2. The transformation of a formerly dry landscape in the late Devensian and early Holocene into a marine situation by 7.2k B.P. would imply that only archaeology of late Upper Palaeolithic and Mesolithic date would have accumulated in terrestrial, fluvial or estuarine conditions in the study area. Archaeology of later periods is likely to be excluded from the study area with the exception of wrecks.
3. A range of ecotonal zones may once have been present within the area (i.e. river side situations, estuaries) that are traditionally the focus of human activity.
4. Archaeological remains from this period are likely to be characterised by raw material working sites, kill/scavenging sites and ephemeral occupation sites.
5. Wreck sites represent the only possible archaeological signature for Neolithic and post-Neolithic periods.

Given the flooding history of the haven it is pertinent to consider in detail the range of situations and likely impact of rising sea levels on any archaeological remains dating to the Upper Palaeolithic and Mesolithic periods.

The topography of the haven bottom (Figures 3-5) suggests that zones of river edge (ecotonal zone on Figure 5A), floodplain floor and shallow bluffs would exist within the area prior to flooding. Following sea level rise and rising water levels this landscape would have been progressively drowned with intertidal estuarine situations replacing dry ground on the terrace flats and erosion of bluffs at the edge of the estuary (Figure 5B). Eventual flooding would subsequently have rendered the former landscape inaccessible (Figures 6H and I).

Topographic change of the scale postulated here has been shown elsewhere (e.g. in the lower Thames area - Bates and Whittaker forthcoming) to have had a major impact on human activity and this can be assumed to have impacted on any occupation of the area. Flooding will also have impacted on the preservational status of any archaeological material on the present haven base.

4.0 Methodology

Digital data was obtained from RPS on the bathymetry, sub-bottom sequences, side scan and magnetic surveys (conducted on behalf of RPS by Titan). These records were supplied in digital format and entered into ARC GIS. Information on the archaeological sites (both terrestrial and maritime) was obtained from a number of sources including CADW, the Royal Commission on the Ancient and Historical Monuments of Wales and Admiralty records.

Sea level information (Section 3.2) has been used to estimate the likely impact of sea level change on the landscape. This has been achieved by estimating RSL (Figure 2) in 500 year slices against rockhead topography (Figure 6). Two major problems are associated with this approach:

1. The sea level data is based on Relative Sea Level and does not take into account tidal envelopes. At present insufficient information is available to estimate tidal variation. Additionally the curve has been constructed using a relatively small data set and small scale variations in RSL cannot be observed (they are however likely to have impacted the area).
2. It cannot be assumed that rockhead datums approximate to the real topography at the time of immersion. However, without detailed palaeoenvironmental information and dating from sediment cores this issue cannot be addressed at the present time. A alternative approach would be to use the bathymetry but this is likely to have been modified considerably by recent processes.

Despite these limitations it is felt that at present these reconstructions (Figure 6) are likely to be a good approximation for the nature and scale of the changes likely to have occurred in this landscape. Consequently the mapping of the transgressive front[1] (Figure 5) was utilised to understand topographic change through time. This can be related to likely patterns of human behaviour and consequently predictions may be made regarding locations of past human activity (e.g. the placement of fish traps in channels during the Mesolithic period – see 3.3.1. above). Additionally we utilise the information on the distribution of areas of net sediment accumulation or loss in conjunction with knowledge on the foci of likely human activity to identify coincident areas where the archaeological potential may be high.

The distribution of significant magnetic anomalies and sidescan signature anomalies obtained from the original Titan survey and report were examined. These have been examined and are plotted in Figures 9-11. The question of the location of any Bluestones on the floor of the haven has also been considered and to this end a sub-set of the magnetic and sidescan anomalies were also chosen in order to investigate the possible occurrence of features that would not be inconsistent with the presence of the Blue Stones (Appendix I and II). This sub-set was chosen from the original data set based on coincident anomalies of the magnetic data with values greater than 20% of the base magnetic signature and sidescan feature of greater than 2m size.

[1] The transgressive front is described by the boundary between dryland and wetland that moves inland and onto higher elevations as a consequence of sea level rise (Bates, 1998)

5.0 RESULTS

5.1 Late Quaternary evolution and archaeology

Both bathymetry (Figure 3) and rockhead (Figure 4) surfaces clearly illustrate the entrenched nature of the palaeo-haven river. This river sits within a stepped channel showing polycyclic evolution of the channel indicating a complex history of incision that is minimally likely to extend back into the Middle Devensian (c.50k B.P.). The shape of this entrenched channel has had a major impact on the nature of Holocene flooding of the palaeo valley complex (Figure 7). The position of the main channel is likely to reflect the position of the Ritic Fault. Minor valleys shown on the bathymetry (Figure 4) are also probably exploiting the structural elements of the area.

Significant levels of detail may be observed in the rockhead topography with 4 small valley like features entering into the main incised channel from the south and a larger feature visible to the western end of the jetty to the north (Figure 4). Sediment isopachs (Figure 8) indicate variable depths of filling for the main valley axis but a substantial wedge of sediment appears to infill the lower end of this valley (Figure 8). Significant thickness of fills are also noted in the feature at the western end of the jettys and in the eastern two valleys to the south of the channel (those draining Angle Bay). An interrupted rock high along the line of the jetty appears to have significant thickness of sediment accumulated behind this feature (sampled in boreholes 3A and 4).

Sediment fills from these features have been penetrated by boreholes 3A and 4 in the jetty region and borehole 29 in one of the small tributaries draining Angle Bay to the south. Up to 16.7m of sediment have been noted in boreholes 3A and 4 that consists of fine clay-rich sediments and shells grading downwards to coarser sediments and gravels. Borehole logs (3A, 4 and 8) indicate that plant remains survive in the sediments and plant remains are inferred from the evidence of acoustic blanking due to the presence of diffuse shallow gas from the decaying biogenics on lines 85, 45 and 50. These characteristics indicate possible accumulation in sub-tidal perhaps becoming intertidal upwards situations. The coarse basal parts of the sequence may relate to the accumulation of sediments within the periglacial river. Borehole 29 to the south of the channel consists of approximately 4.5m of silts over gravels. It is possible these sediments are either related to fluvial activity within a river channel during the late Devensian or may be valley side (Head deposits).

Downstream the rapidly thickening nature of the wedge of sediments seen thinning against the southern side of the channel (Figures 7 and 8) consists of in excess of 17.8m of fine silts with occasional shell fragments (see BH 26, Milford Haven Conservancy Board report of December 1971). The basal parts of the sequence were not observed here.

Borehole and boomer data indicate that over much of the rock terrace surfaces sediment accumulation is minimal and boreholes suggest sands dominate these regions (probably much of it recently accumulated). However at the margins of these features, at the terrace edge, sediment thickness increases to 6m suggesting sediments of the type postulated in Figure 5 may exist as a narrow ribbon along the southern margin of the terrace. These are less well developed in the similar situation to the north of the channel.

Examining the combined data sets along with the knowledge of patterns of environmental change the following points are noted[2]:

1. The area is beyond the limits of the Devensian glacial maximum and consequently no moraines or ice marginal deposits or erosional features from will exist within the area.
2. The Late Devensian river is characterised by deposition of gravels and coarse grained sediments as seen in the base of some boreholes (3A and 4) and inferred from the boomer data.
3. Progressive inundation of the main channel began at the end of the last cold phase (Figure 6A) and the early Holocene (Figure 6B). Infilling of the south bank tributary channels is also likely to have commenced at about this time.
4. The lower channel area appears to have been fully inundated by approximately 10k cal B.P. (Early Boreal) (Figures 6C-E). Until this point sea level rise has had minimum impact on local topographies but will have modified resources associated with this lower channel. This is contemporary with the first known Mesolithic occupation of the area at Nab Head (Lynch *et al.*, 2000).
5. By 9.5kcal B.P. sea level rise is likely to have flooded the terrace adjacent to the incised channel (Figure 6F). Transformation of the terrace surface during this period firstly to inter-tidal conditions and subsequently sub-tidal situations. The ecotonal zone often preferred by human groups shifts inland during this period.
6. Following this flooding at 9.5k cal B.P. accumulation of the downstream wedge of sediments may have begun.
7. A second major transformation of the landscape occurred by 8.5k ca. B.P. with the inundation of the upper terrace (Figure 6H). The sequence of events resulting from inundation is likely to have been similar to that at 9.5k.

A number of other features are of some considerable interest. Sediments were noted to have accumulated within the vicinity of the jetty and off the western end of the jetty. Unfortunately these areas have not been surveyed and consequently the significance of these deposits remains unresolved. However, a small valley form enters the haven at the landward end of the jetty (Figure 1) and this valley is likely to extend outwards to become confluent with the main palaeo channel perhaps at the western end of the jetty. Although incomplete it also appears as if an east/west trending rock ridge (intermittently broken along its length) may be running beneath the jetty. If so this feature may be trapping considerable bodies of sediment behind the feature. The result may be a fan like cone of sediments with its apex at the landward end of the jetty. The sediment body through this area will shallow landwards and consequently young in the direction of the land. The potential for the recovery of later periods of archaeology and sequences spanning more recent times may be higher in this area.

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[2] These interpretations are preliminary and it is emphasised that the timing and nature of changes remains to be ground truthed and consequently any models and predications may be subject to change in the light of further investigations.

From an archaeological perspective the major consequence of sea-level rise within the lower haven area has been the transformation of the landscape. The late-Pleistocene landscape was one dominated by a high energy river system that was transformed through sea level rise in the late Pleistocene/early Holocene into an estuarine situation and subsequently a flooded valley (ria). The loss of this landscape occurred as a consequence of sea-level rise and backup of the river that resulted in a rapid succession from wetland floodplain to estuarine mudflats (perhaps characterised by fine grained sedimentation where freshwater and brackish water elements interacted to control patterns of sedimentation) and ultimately sub-tidal contexts. The result of these changes to the physical landscape would have had far reaching consequences transforming the natural flora and fauna of the region. These changes were occurring at a time of considerable climatic and vegetational change through the late glacial and the early Holocene period. Consequently the combination of these changes would have impacted on the resource base for contemporary populations, modified the location of preferred occupation sites and disrupted long established communication networks.

5.2 Sea bottom targets

The magnetic signatures and sidescan targets are shown in Figures 9 and 10. Two significant magnetic signatures have been noted and may be evidence for the wrecks listed in the Admiralty records. One of the three wrecks noted within the study area (Figure 1) has been positively identified as a landing craft (NGR SM8667403974, south east of BH 27 (Figure 9)) that is well known to sports divers. The craft is recorded as having sunk in December 1951 whilst under tow. Recreational divers are known to dive on the site on occasion. The other sites are now classified as 'dead' and have not been located during recent surveys.

A large number of the magnetic and side scan contacts identified (Figures 9 and 10) for further investigation could relate to shipping losses particularly during World War II. Towards the close of 1940 German Heinkel 111H bombers, flying from captured airfields in northern France, began using new methods of destroying British shipping. This involved parachuting magnetic and acoustic mines into busy harbours and their approaches, including Milford Haven. Immediately to the west of the study area, a number of shipping casualties associated with such attacks have been identified and are regularly visited by sports divers. These include the 6100 ton *Behar*, built in 1928, which sank having hit a mine on 24th November 1940 and the 6,426 ton British freighter *Dakotian*, sunk by a magnetic mine on 21st November. Other vessels known to have perished in this campaign, but so far not located, include the 3683 ton *Pikepool* hit on the 21st November which sank the next day, and the 630 ton salvage ship *Preserver* which blew up on 24th November having struck a mine and sank on the south side of the Haven.

A subset of these targets has been identified as worthy of further investigation (including possible Bluestone targets) (Figure 11, Appendices I and II).

6.0 CONCLUSIONS

6.1 Sub-bottom archaeology: Palaeolithic and Mesolithic periods

From an archaeological perspective we can deduce the following key points regarding the non-wreck archaeology:

1. For the haven bottom we would only expect to find *in situ* (i.e. undisturbed) archaeological sites (other than wrecks) from the Upper Palaeolithic and Mesolithic periods. This is based on deductions from the sea level curve and our knowledge of the rockhead topography.
2. Ecotonal zones frequently utilised by earlier human groups are likely to have existed in the area.
3. Flooding of the landscape would have shifted preferred ecotonal zones to higher elevations and further from the late Devensian river course through time.
4. Although large parts of the haven base are denuded of sediment cover or covered by a thin veneer of sands (probably recent) some areas contain greater thickness' of sediment that may contain archaeological records. These areas are located along the foot of the bluff south of the river, within the tributary valleys to the south and north of the channel and downstream within the wedge of sediments that thickens seawards.

Additionally (and linked to the archaeological points noted) important palaeoenvironmental considerations have been deduced:

1. Thick sequences, at the downstream end of the river as well as within the jetty vicinity, indicate that long records of environmental change within the haven are potentially recorded in these areas and sequences.
2. These sequences are known to be stratified and consequently sequence preservation appears reasonable.
3. Organic material has been noted in some boreholes and shell fragments are frequently referred to; this indicates that a range of biological indicators are likely to be suitable for environmental reconstruction and dating.
4. Minor tributary valleys on the south of the channel are likely to also contain records pertaining to environmental change.

The combined information sources allow an attempt to be made to classify the haven floor in terms of archaeological and palaeoenvironmental potential (Figure 12). Five key areas have been identified and labelled A – E:

Zone A. This zone is based on the distribution of thick sediment accumulation in the downstream end of the channel study area. The thick nature of the sediments suggest rapid sedimentation and consequently reasonable stratigraphic integrity and temporal resolution may be present within the sequences. Consequently it is considered a zones of high palaeoenvironmental potential. Good examples of such sedimentary sequences have recently been located in the palaeo-Arun valley of the Sussex coastaline by Wessex Archaeology. Until more is known of the nature of the sediments it is not possible to comment on the archaeological potential of the sediments.

Zone B. This zone represents the bluff area at the inland edge of the lower terrace. Some intermittent sediment accumulation has been noted against the rising rockhead here that might bury archaeological remains. This zone is of moderate archaeological potential.

Zone C. This zone represents the bluff area at the inland edge of the lower terrace to the south of the channel. Sediment accumulation of up to 6m has been noted against the rising rockhead here that might bury archaeological remains. This zone is of high archaeological potential (particularly where it interfaces with the tributaries entering the main channel from the south).

Zone D. This zone coincides with the position of the infilled tributary valleys on the south of the channel. Sequence potential within some of these has been demonstrated by drilling and boomer data and consequently palaeoenvironmental potential is considered moderate. Archaeological potential is high as the valleys are noted to have been inundated from c.10k cal yr B.P. (Figure 6E) until full immersion of the surrounding landscape by 8.5k cal yr B.P. (Figure 6H). These valleys may have been suitable features in which to establish fish traps. It is also noted that valleys may have acted as natural routeways between the main channel and the higher ground to the south and consequently have been preferred routes through the landscape.

Zone E. This zone is coincident with the jetty area and is considered to be of high palaeoenvironmental potential. Sequences are up to 15m thick in the area and have been reported to contain biological material. The archaeological potential may also be high, perhaps increasing northwards towards the dry land. However, detailed investigations of the bathymetry and sub-bottom stratigraphy as well as the sediments need to be determined prior to fully understanding the archaeological potential of the this zone.

The remaining areas within the study area are considered of low archaeological potential at the present time. However, it should be noted that archaeological sites from this time period are small, ephemeral and of limited durability. The techniques presently used to determine sequence thickness and structure are operating at a scale incompatible with resolving the nature and distribution of all sediment packages that may contain remnants of archaeology.

6.2 Sea bed surface archaeology

The evidence obtained from the desktop studies and haven surveys indicate that a significant number of potential targets for investigation exist in the study area. Specifically:

1. The majority of the magnetic and sidescan targets may be debris from exploding ships hit by German bombers in late 1940.
2. Three known wrecks are listed within the study area. The Landing Craft (resting upside down) is identified and well known to divers and has been located in the current survey to the SE of borehole 27 (Figure 11). A second

major target to the east of BH 30 may represent one of the dead wrecks reported in Admiralty lists.

3. The remaining targets (Figure 11, Appendices I and II) may represent larger fragments of sunken vessels as well as potential Bluestone targets.

7.0 RECOMMENDATIONS FOR FUTURE WORK

Further work in the haven requires a phased approach in order to maximise the return on investment and construct a mitigation framework that is both reasonable and robust. Consequently it is necessary to construct a response that initially refines the present knowledge base, subsequently calibrates this knowledge base and finally responds to construction impacts:

Refinement of knowledge base (desk-based). Additional data on the nature of the sub-surface sedimentary architecture is certainly held within the large quantity of sub-bottom boomer data that has been demonstrated to contain a number of internal reflecting horizons that remain to be picked and interpolated across the study area. This should be completed to allow full modelling of internal sediment bodies to elucidated the detailed stratigraphic architecture.

Refinement of knowledge base (field-based). In order to complete a regional interpretation of the sequences (particularly to understand the sequences within the jetty vicinity) additional surveying is required within the area between the jetty and the mainland to the north. Completion of bathymetric and sub-bottom modelling in this area would provide a full data set for understanding archaeological and palaeoenvironmental potential of the sequences. In conjunction with this data gathering exercise drilling and recording of five boreholes in critical locations (1 in zone A, 2 in zone D and 2 in zone E) to recover samples to ground truth geophysics and determine likely environments of deposition should be considered. An option should also be held for undertaking a single borehole in zone C (depending on the detailed results from the desk-based refinement of knowledge and a diver survey (see below). Finally sample ground truthing of identified magnetic/side scan targets as well as parts of the landscape zones identified (e.g. zone D to look for traces of any features associated with the valley forms) should be considered within zones B, C and D by diver and/or ROV.

Calibration of the knowledge base (laboratory-based). In order to provide information on the environments of deposition of the identified sediment bodies and temporal control on sequences it will be necessary to conduct a assessment of the recovered drill core samples. This is likely to involve both radiocarbon (and possibly Optically Stimulated Luminescence) dating as well as microfossil (pollen, diatom, foraminifera/ostracoda) assessment to determine environments of deposition, sea-level trends etc.

Responses to construction impacts (field and laboratory-based). This phase of works is difficult to predict presently and will depend on the results of earlier phases of work, the nature of the archaeological material reported and the present capabilities of archaeological methodologies. Recovery of archaeological material through sea bed excavations and sampling strategies remains a possibility as does further drilling. Post excavation analysis of recovered materials would also be necessary. Modification to the scheme design should major archaeological remains be discovered may require consideration. Beyond the construction phase of works long term monitoring on significant areas and the impact of dredging, ships manovering and modified patterns of sedimentation and erosion may all need consideration.

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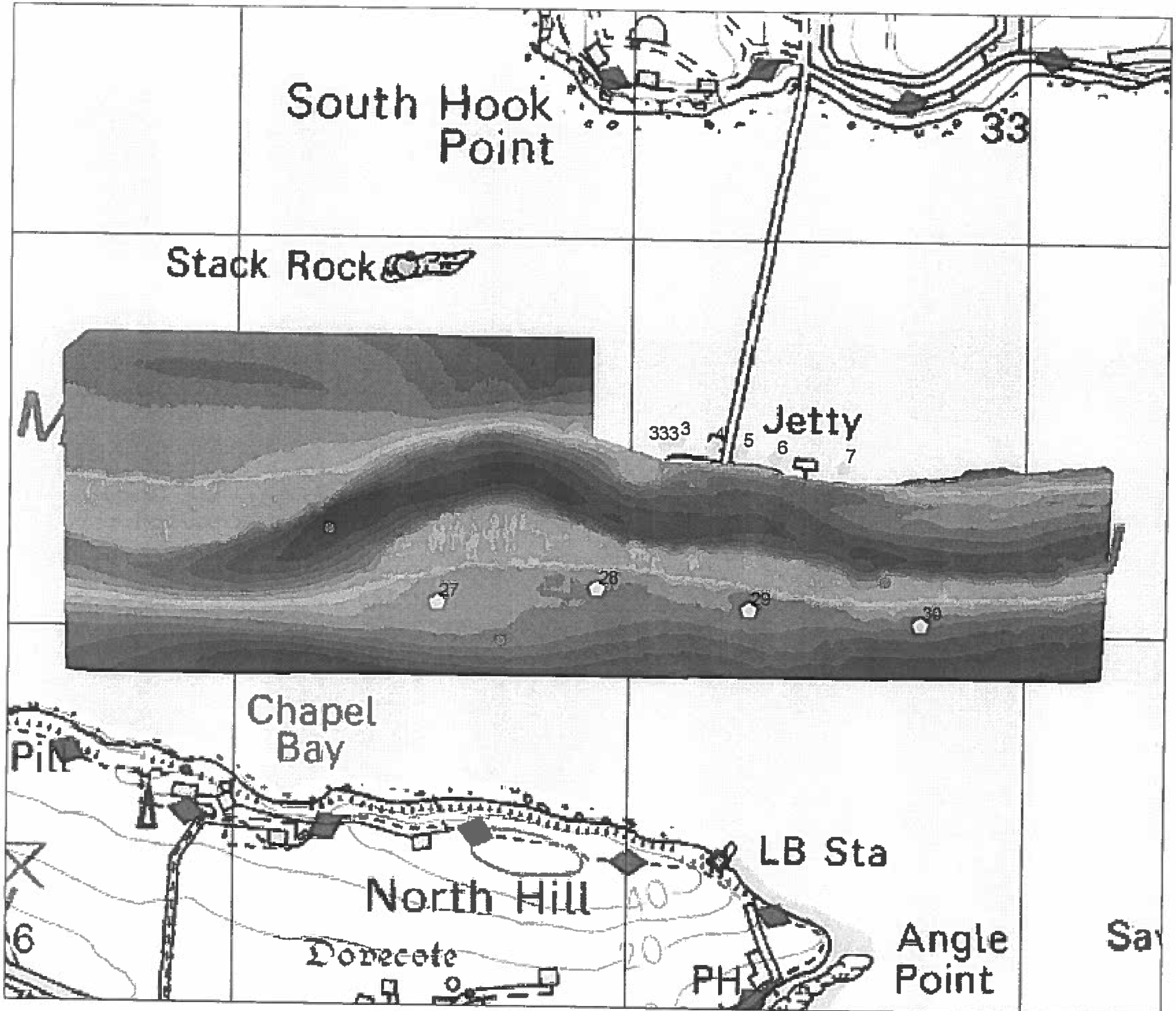
Appendix I. Archaeological Sonar Contacts for further Investigation.

Target I.D.	Easting	Northing	Dimensions in Metres (LxWxH m)
72	185872.77	204473.55	1.4x 0.2x 0.5
77	186589.89	204409.72	1.1x 0.4x 1.4
168	187553.09	204162.98	0.6x 0.4x 0.3
170	186732.56	204182.78	1.6x 1.1x 0.4
177	186982.37	204088.68	3.2x 0.4x 0.5
195	187319.28	204117.15	1.2x 0.2 0.7
197	187250.95	204110.75	1.8x 0.4x 0.5
198	187238.28	204111.29	2.0x 0.4x 0.7
201	187080.77	204151.35	0.4x 0.6x 0.5
206	186795.03	204078.04	2.2x 0.6x 1.1
243	186498.58	204051.61	0.9x 0.6x 0.8
250	187135.61	204084.07	0.9x 0.2x 0.5
251	187176.36	204065.64	2.4x 0.4x 0.8
252	187355.48	204072.93	0.4x 1.9x 0.1
258	186450.44	203989.13	7.7x 0.3x 0.2
268	186950.66	203993.50	4.6x 0.8x 1.3
275	186651.38	203982.03	30x15x4.7 Wreck of Landing Craft

Appendix II. Archaeological Magnetic Contacts for further Investigation.

Point ID	Easting	Northing	Magnetic Response (nT)	Target ID	SSS Target ID
68	186841.1	204175.4	42.64	20	
69	186843.1	204165.9	104.67	20	
70	186843.6	204170.9	92.06	20	206
93	186909	204180.4	135.34	25	
94	186910.5	204188.9	29.94	25	
95	186912	204180.4	19.89	25	
96	186912	204180.4	120.80	25	203
97	186912	204194.9	14.96	25	
98	186914	204174.4	20.80	25	
99	186915	204180.4	-2.38	25	
113	186940.5	203986.9	94.22	29	
114	186942.5	203981.4	64.48	29	
115	186945	203995.4	94.67	29	
116	186946	203983.4	43.7	29	
125	186927	204100.9	34.05	33	268
126	186927	204111.4	557.26	33	268
127	186936.5	204125.4	8.76	33	268
128	186939.5	204122.4	12.80	33	268
129	186942	204120.4	290.81	33	268
187	187077	204163.9	235.07	44	
188	187079	204166.4	140.43	44	
189	187081.5	204164.4	52.36	44	
190	187081.5	204165.4	144.52	44	
211	187085.5	204216.4	111.41	48	
212	187086.5	204201.9	105.20	48	
234	187169	204077.4	29.96	54	
235	187172	204071.9	9.66	54	
236	187173	204044.9	7.58	55	
237	187176	204056.4	38.37	55	
258	187234	204199.9	6.39	59	
260	187242	204110.9	20.84	61	
261	187249.5	204124.9	15.28	61	
283	187318	204102.4	70.30	72	
284	187321.5	204105.4	30.20	72	
285	187330.5	204105.4	10.49	72	
286	187345	204065.9	87.37	73	
287	187348.5	204069.4	76.63	73	
288	187351.5	204080.4	78.08	73	
333	187478.9	204167.9	98.78	76	
334	187479.9	204161.4	225.98	76	
335	187481.4	204174.4	29.66	76	

Point ID	Easting	Northing	Magnetic Response (nT)	Target ID	SSS Target ID
336	187482.9	204167.9	35.77	76	
337	187485.4	204164.9	112.88	76	
358	187559.9	204173.9	38.64	81	
456	186744.1	204187.4	6.42	Esso buoy	
457	186747.1	204194.9	78.56	Esso buoy	
463	186646.1	203971.9	507.66	Landing craft	
464	186649.6	203972.9	175.60	Landing craft	
465	186649.6	203983.4	410.67	Landing craft	
466	186657.6	203967.9	511.14	Landing craft	
467	186657.6	203978.4	746.21	Landing craft	
468	186661.6	203978.4	244.52	Landing craft	
469	186682.6	203963.9	249.66	Landing craft	
470	186686.1	203965.9	247.51	Landing craft	



Legend

Cadwsites.txt Events

age

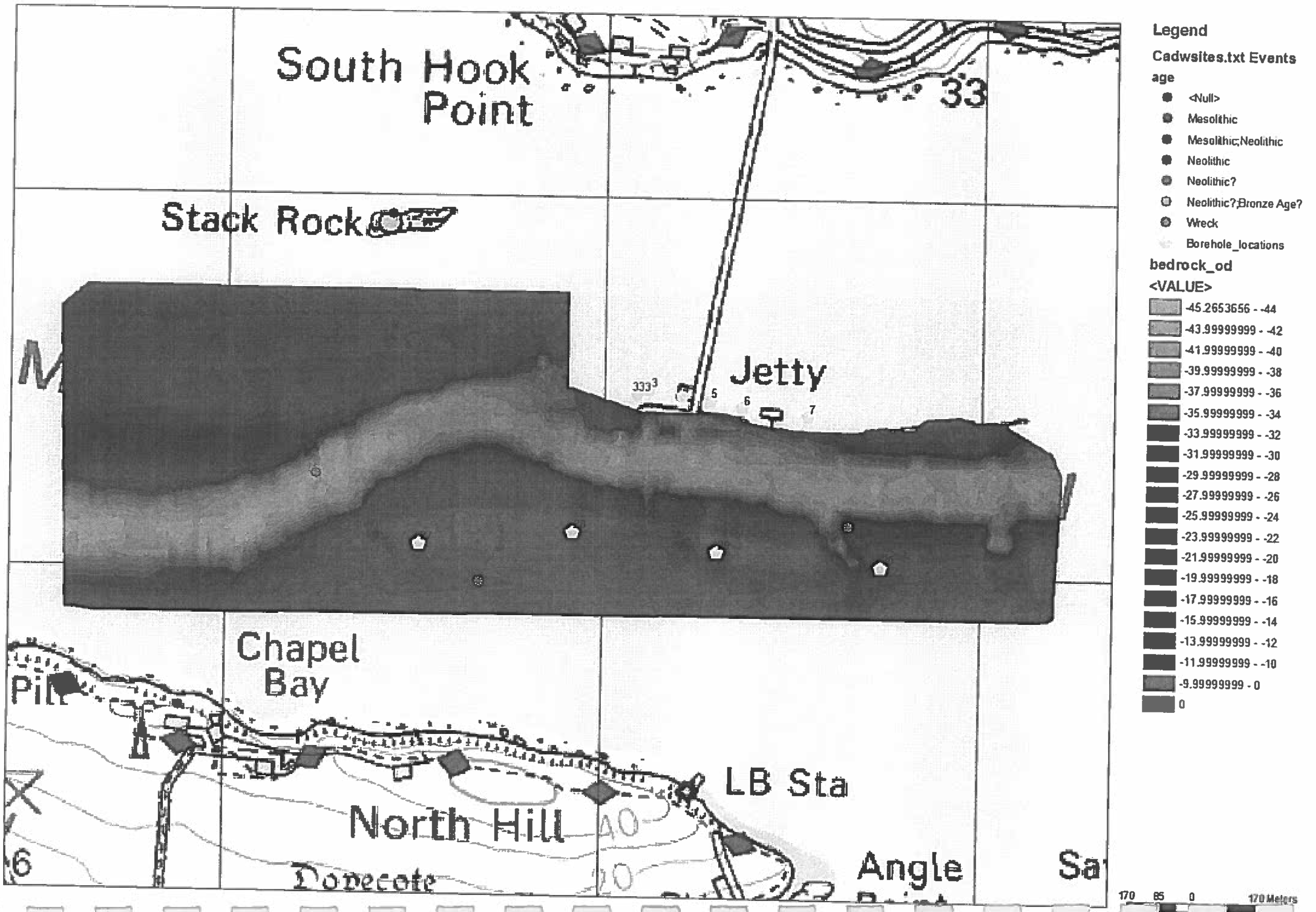
- <Null>
- Mesolithic
- Mesolithic;Neolithic
- Neolithic
- Neolithic?
- Neolithic?;Bronze Age?
- Wreck

bathygrid_od

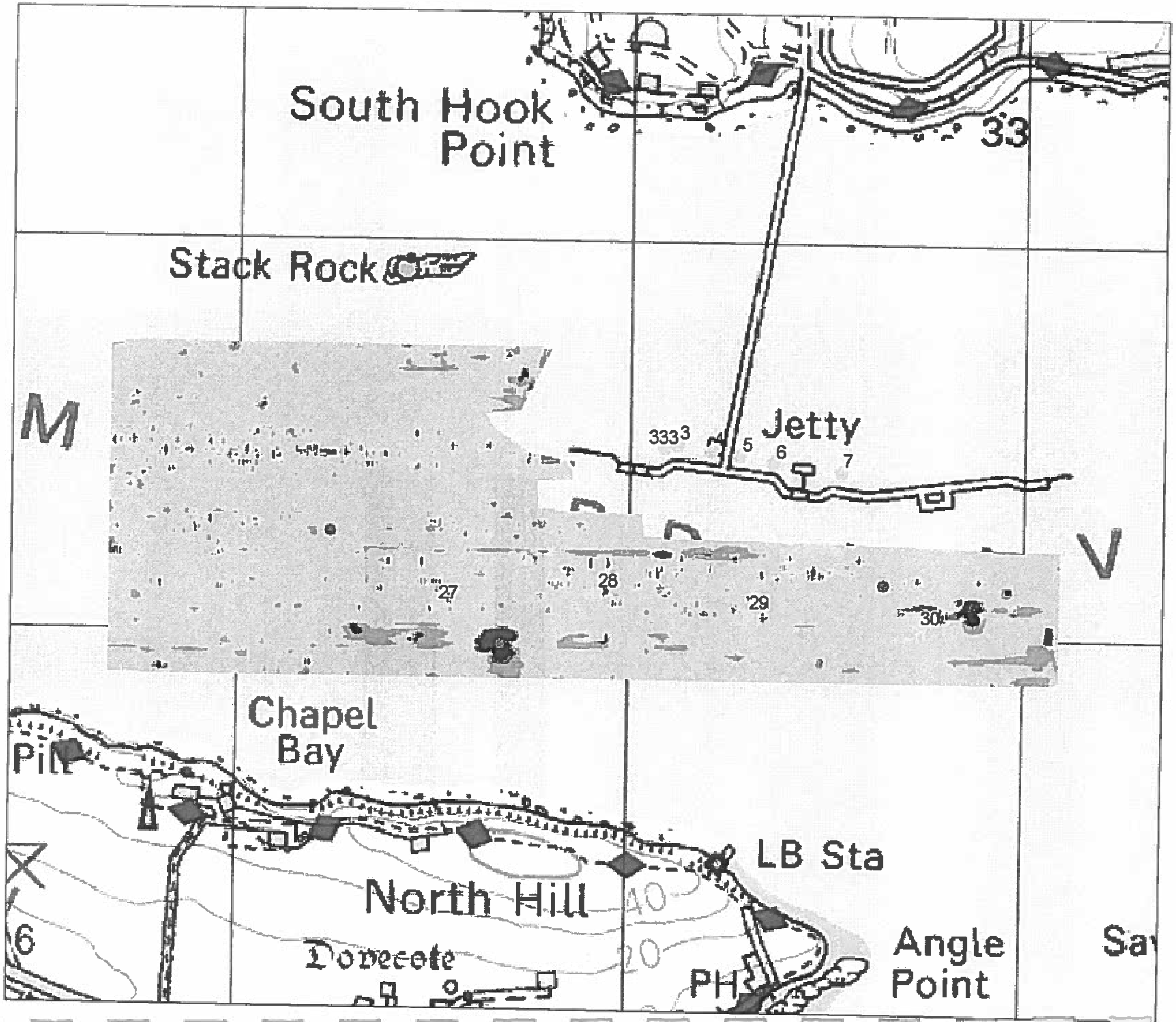
<VALUE>

- -32.96186066 - -31.15747941
- -31.1574794 - -29.35309817
- -29.35309816 - -27.54871693
- -27.54871692 - -25.74433568
- -25.74433567 - -23.93995444
- -23.93995443 - -22.1355732
- -22.13557319 - -20.33119195
- -20.33119194 - -18.52681071
- -18.5268107 - -16.72242947
- -16.72242946 - -14.91804822
- -14.91804821 - -13.11366698
- -13.11366697 - -11.30928574
- -11.30928573 - -9.504904493
- -9.504904492 - -7.700523249
- -7.700523248 - -5.896142006

Borehole_locations



South Hook
Point
33
Stack Rock
Jetty
333
5
6
7
Chapel
Bay
LB Sta
North Hill
Dovecote
Angle
Legend
Cadwsites.txt Events
age
<Null>
Mesolithic
Mesolithic;Neolithic
Neolithic
Neolithic?
Neolithic?;Bronze Age?
Wreck
Borehole_locations
bedrock_od
<VALUE>
-45.2653656 - -44
-43.99999999 - -42
-41.99999999 - -40
-39.99999999 - -38
-37.99999999 - -36
-35.99999999 - -34
-33.99999999 - -32
-31.99999999 - -30
-29.99999999 - -28
-27.99999999 - -26
-25.99999999 - -24
-23.99999999 - -22
-21.99999999 - -20
-19.99999999 - -18
-17.99999999 - -16
-15.99999999 - -14
-13.99999999 - -12
-11.99999999 - -10
-9.99999999 - 0
0
170 85 0 170 Meters



Legend

Cadwsites.txt Events

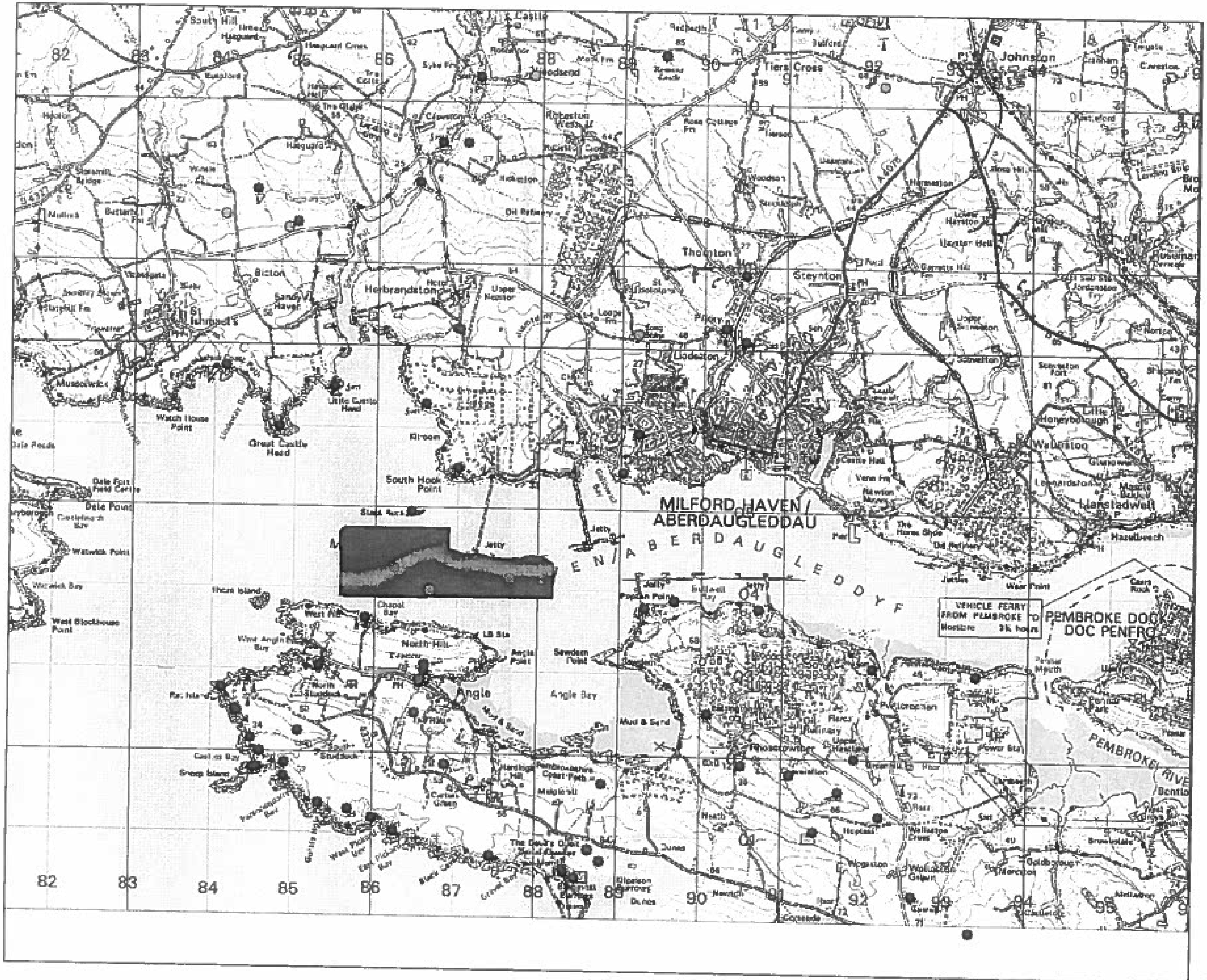
age

- <Null>
- Mesolithic
- Mesolithic;Neolithic
- Neolithic
- Neolithic?
- Neolithic?;Bronze Age?
- Wreck
- Borehole_locations

maggrid

<VALUE>

- -474.8983154 - -36.42941367
- -36.42941366 - -22.12743297
- -22.12743296 - -7.825452273
- -7.825452272 - 6.476528426
- 6.476528427 - 20.77850912
- 20.77850913 - 35.08048982
- 35.08048983 - 306.1497192



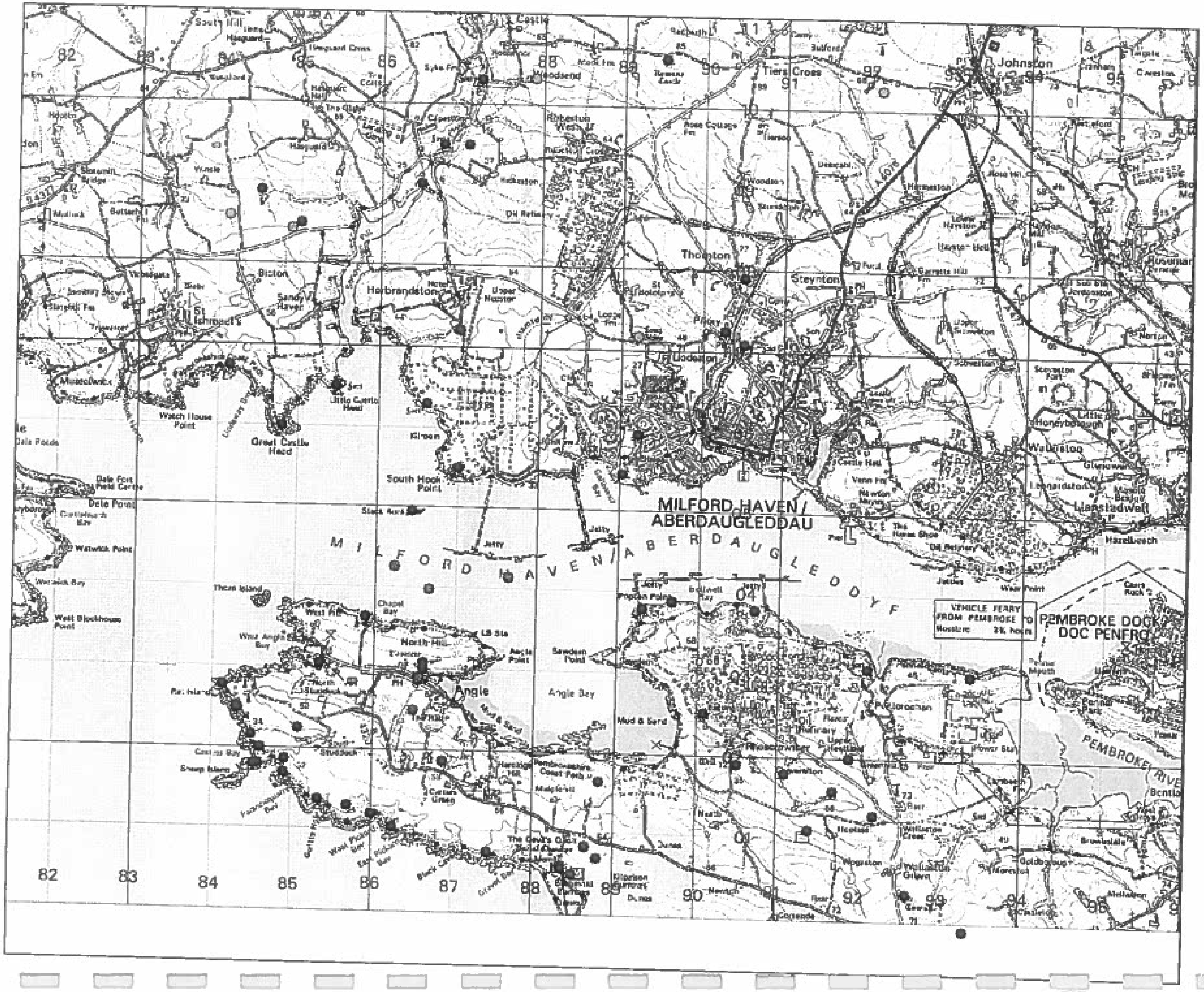
Legend

Cadwsites.txt Events

age

- <Null>
- Mesolithic
- Mesolithic;Neolithic
- Neolithic
- Neolithic?
- Neolithic?;Bronze Age?
- Wreck

825 412.5 0 825 Meters



Legend

Cadwsites.txt Events

age

- <Null>
- Mesolithic
- Mesolithic;Neolithic
- Neolithic
- Neolithic?
- Neolithic?;Bronze Age?
- Wreck

825 412.5 0 825 Meters