Continental Shelf Northern Unit
Internal Report No. 78/12

Cruise 78/FE/05 - Leg 3

M V Ferder

26 May 1978 - 6 June 1978

CRUISE REPORT

by

N G T Fannin

Introduction

Leg 3 of cruise 78/05 continued the shallow drilling programme in Scottish waters begun in Legs 1 and 2 (CSNU Internal Reports Nos. 78/6 and 78/8).

The main object of Leg 3 was to investigate the thick Quaternary sequence at the northern edge of the continental shelf. In the event only one wholely Quaternary site was attempted and this had to be abandoned after the string had jammed. The remaining time was spent at two sites close to Shetland investigating the solid rock subcrop.

Personnel

N G T Fannin	IGS/CSNU	(Chief Scientist)
R Owens	IGS/CSNU	
A Skinner	IGS/CSNU	
D Long	IGS/EGU	
A Forster	IGS/EGU	
L Hill	Len Hill (Drilling Consultant) Ltd.	
P S Burland	McClelland	

Cruise Results

A summary log of operations is presented in Appendix I and a summary of each site with a geological log is given in Appendix II. A ship useage time analysis is given in Table 1 and presented graphically in Table 2. Weather variations, mud consumption and daily costs are also given in Table 2. Borehole summaries are given in Table 3 (A and B) and drilling rate curves in Table 4 (A, B and C).

Three sites (Fig. 1) were occupied during Leg 3 (78/9, 78/10A, B

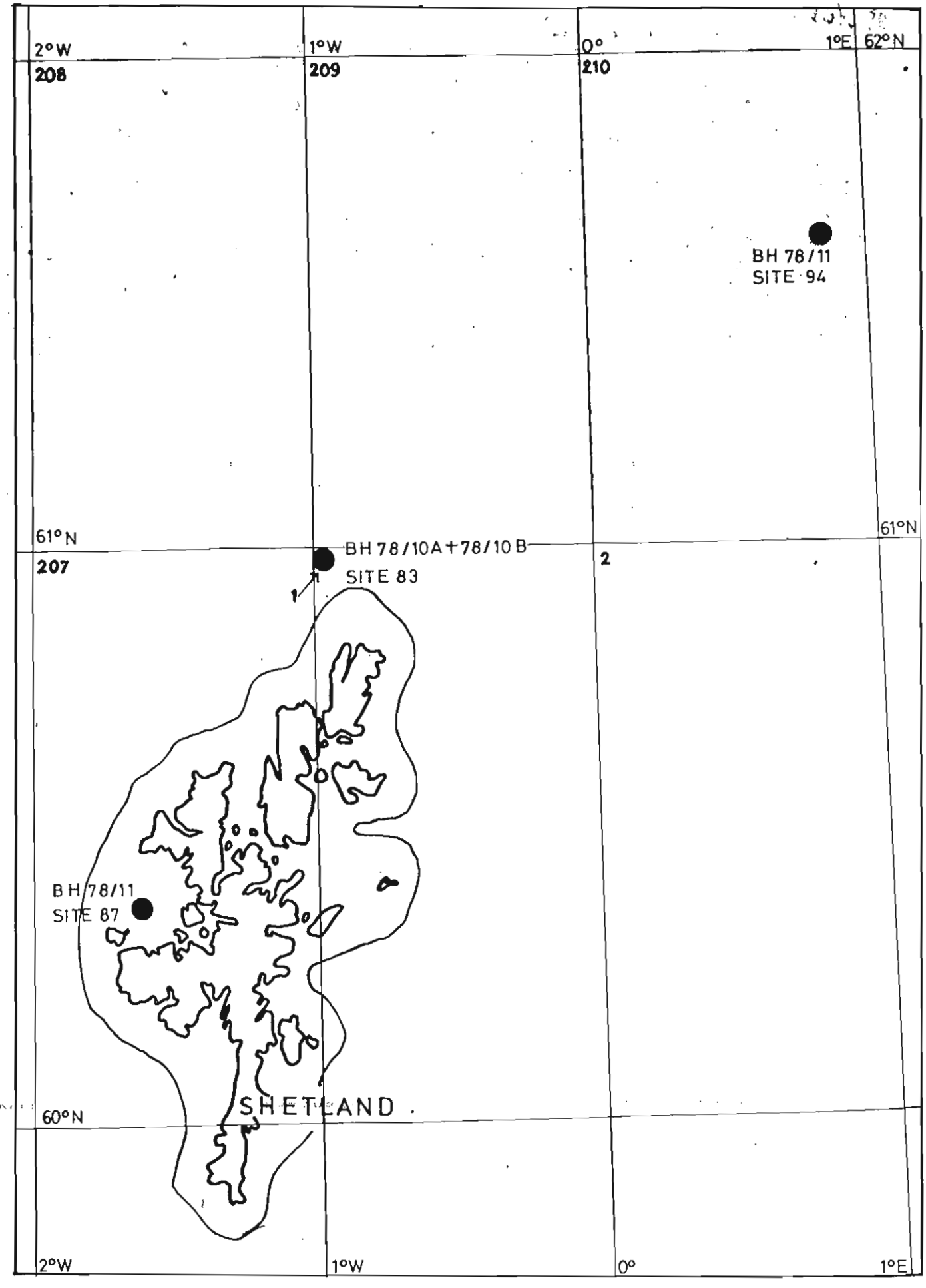


FIG. 1 LOCATION MAP.

and 78/11). Drilling and equipment problems were encountered at all three sites and 58 hours were lost after jamming of the string at site 78/9.

Geological Results

A summary of the geology at each site is given in Appendix II.

Borehole 78/9 (Site 94), 118km NE of Muckle Flugga was drilled to a depth of 182.7m in 191m of water on Phillips/ Fina block 210/15. The objectives at the site were to drill through a number of acoustic reflectors, including reflectors dipping at a shallow angle off the edge of the continental shelf. The identification of these reflectors would be used to assist the interpretation of shallow seismic data and information from commercial site investigation.

The site was abandoned at 182.7m below seabed, before the dipping reflectors were reached. However, valuable information on the shallower horizontal reflectors was obtained. Using an averaged velocity of 1800m/sec three major reflectors have been sampled at 72, 133 and 173m respectively. These three reflectors correlate well with sand layers in the core which can also be identified as zones of relatively low natural gamma radiation in the gamma log. The sand zones may be up to 10m thick and are interbedded with dark grey silty clay with small pebbles and shell fragments. In places thin sandy laminae may be present but clay forms the dominant part of the sequence.

The correlation of the main reflectors with sand bodies leads

to the speculation that the uppermost dipping reflector which was not reached may also represent a major sand unit.

Borehole 78/10A (Site 83), 15km NNW of Unst was drilled to a depth of 7.0m in 119m of water. Considerable difficulties were encountered at this site because of the coarse gravelly nature of the till. It is believed that rockhead was reached at 6.7m where fragments of what is a coarse arkose were recovered, though this could be a large boulder. Attempts were made to re-drill the site a few metres away at 78/10B but this also had to be abandoned because of lack of penetration, this time at 2.0m. The drift sequence at this site is interesting in that it shows recent pebbly and shelly sands resting on a coarse grey till which in turn rests on a sandy and stoney red till. The identification of a possible arkose as the rock-head in this area indicates that the non magnetic poorly bedded strata seen on seismic records is unlikely to be Dalradian, though the nature of the samples leaves open the possibility that the rocks could be Late Palaeozoic or Mesozoic in age.

Borehole 78/11 (Site 87), 7km west of Muckle Roe in St Magnus Bay was drilled to a depth of 40m in 137m of water. This site was of particular interest since it has been suggested that St Magnus Bay has been formed by meteorite impact. However, recent IGS seismic work has indicated that in the centre of St Magnus Bay there is a small faulted basin of folded sedimentary rocks, probably of Mesozoic age,

Drilling problems were again encountered, this time because of the very soft nature of the Quaternary sediments. Therefore to avoid the possibility of jamming the string in the hole the site was drilled to a depth of 40m without removing the inner

barrel. Rockhead was reached at 39.9m and a plug of solid rock was recovered in the shoe before hole collapse forced the abandonment of the site.

The recovered core thus showed surface shelly sand less than one metre thick overlying very soft grey dark clay with thin walled articulated bivalves. The ease of drilling and rate of penetration (Table 4) suggests that the rest of the Quaternary succession was also of soft clays. These clays rest on a soft friable red silty sandstone of Triassic aspect and it seems reasonable to assume that the faulted basin in St Magnus Bay is filled with Triassic sandstones. It is however, possible that the sandstones could be equated with the Old Red Sandstone of the Walls peninsula to the south, where they would most closely resemble the Middle Old Red Sandstone on the west side of the Melby Fault. Alternatively they could also be Torridonian in age, though this seems unlikely because of their poorly cemented nature. The present evidence however, combined with seismic data, supports the hypothesis that St Magnus Bay has at its centre a faulted Mesozoic basin which because of the soft friable nature of its rock was deeply eroded during the Pleistocene.

Drilling and Equipment Performance

Following the loss of the Fugro re-entry system during Leg 2 the McClelland sea floor jack (Stingray) was mobilised in Aberdeen on May 26th during the port call. The jack had been used as a re-entry system in 1977 and during Leg 3 its performance was satisfactory and no problems were encountered.

Likewise the ship performed well and no serious problems were

encountered. A new anchor wire was spooled on to replace the wire which was broken during Leg 2 and a replacement anchor added. Some minor time losses resulted from hydraulic failure of the slips and about eleven hours were lost while waiting on weather.

Most of the problems encountered concerned the drilling equipment and resulted in considerable time loss largely because the string had to be pulled to resolve the problems. The more important problems were:

a) Breakage of leaf springs on the inner barrel; preventing the overshot from latching onto the inner barrel.

b) Jamming of the inner and outer barrel preventing withdrawal of the inner barrel.

c) Seizing of the core barrel head, locking and landing subs with the outer barrel. Two winches and severe heating were required to break these joints on two occasions. It is probable that the metal of the subs and outer tube has been damaged and these parts should be inspected before being used again.

Geological Conditions

A number of problems,, mainly affecting hole stability were encountered during Leg 3.

a) BH 78/9 (Site 94): Core recovery was relatively poor at this site (36.7%) and this may be partly explained by the presence of thin sand layers within the main clay sequence and the thicker sand layers associated with the main seismic reflectors.

At 182.7m the string jammed in the hole. The actual jamming

seems to have occurred during or immediately after stopping to recover the inner barrel. There was no significant increase in mud pressure prior to resumption of rotation but when this was attempted the string would not turn. After jamming there was still no significant increase in mud pressure and it is assumed that mud was being pumped into formation. It seems likely that at this stage the string was about 10m into a bed of very fine sand of the type that is subject to liquifaction. This horizon correlates with the seismic reflector at 173m and seems to be extensive in the Cormorant area. Fluid sand of this type is always a hazard and very high torque or enormous lifting power is required to free pipe jammed in this way. The power swivel on Ferder did not have sufficient power to turn the pipe and a lift of 55 tonnes using two winches aided by the heave of the ship (the drilling derrick on Ferder is rated to 60 tonnes) was unable to free the pipe. Repeated attempts to pull or turn the pipe accompanied by high pressure mud flush were also unable to free the pipe. It was therefore decided to cut the pipe explosively below the mud line as close as possible to the jammed section at the barrel. In the event the pipe was cut cleanly half way up the lowermost pipe stand because the available explosives were limited and a complete cut through a collar could not be guaranteed. (It was considered too risky to attempt to slacken a tool joint and then to back off because with the available torque there was no certainty the string would not back off at a joint above the mud line.) When the pipe was freed the site was abandoned with the loss of the bit, outer barrel, inner barrel, seven collars and a stand of pipe, and a time loss of 58 hours was incurred.

String jamming is a problem that has been encountered in the

past and is usually resolved in a few minutes or hours. The difficulty at this site was exacerbated by the extreme water depth (total string length was 373.7m) and an unusually thick sand layer. None of the shallow drilling ships (with the possible exception of Sea Lab which has a much greater lifting capacity) could have solved the problem of pulling the pipe free. Similarily the torque available from power swivels or power tongs used in shallow drilling would be unable to free the pipe though it was always possible, should the ship have been hazarded, to back off at a joint with the attendant risk of breaking off above the mud line and leaving the pipe above the seabed. The decision to cut the pipe as low as possible was taken in order to minimize pipe losses and to avoid littering the sea floor with the threat of additional site clearance costs.

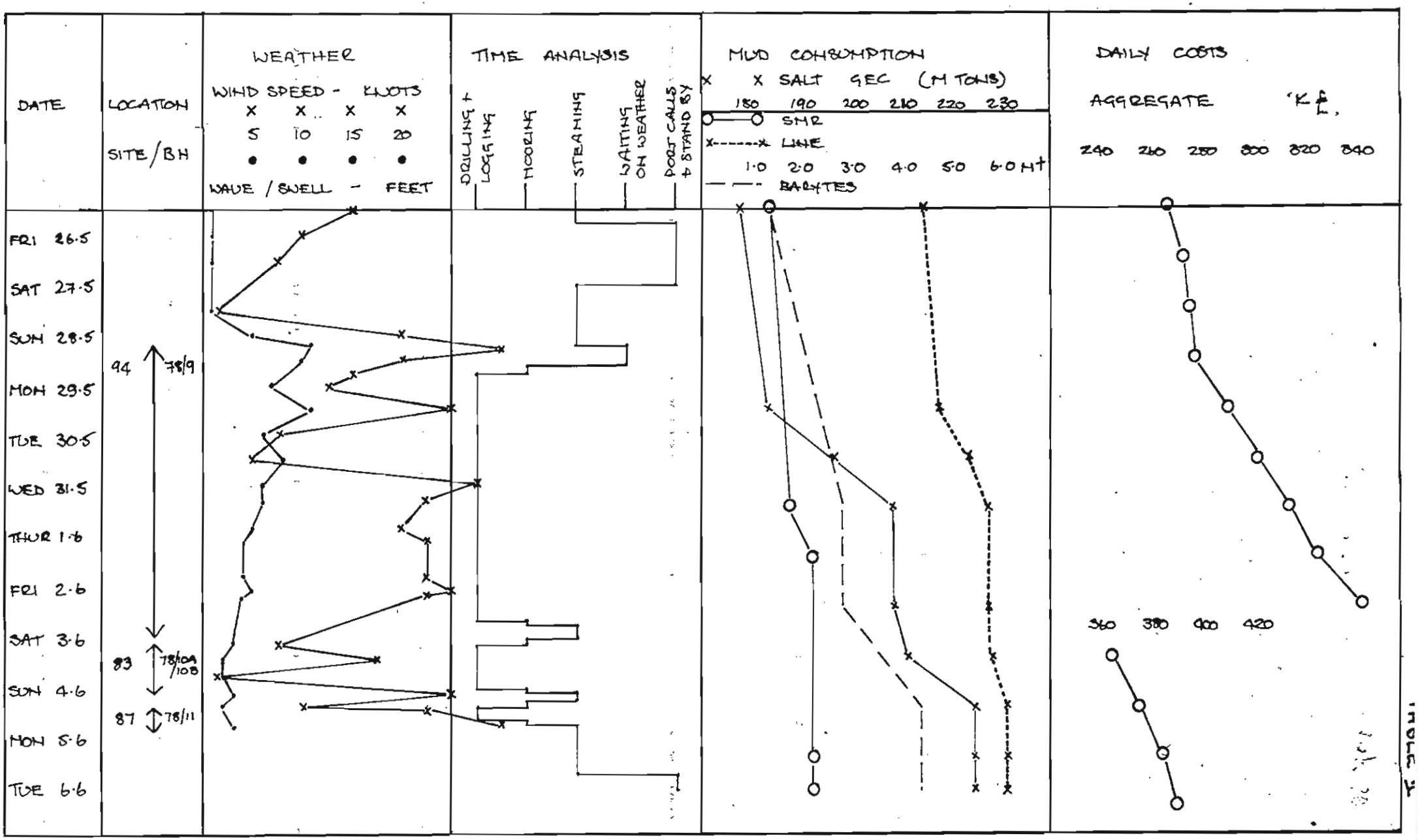
b) BH 79/10A and 79/10B (Site 83): Two attempts were made at this site reaching 7m and 2m respectively. Here the drilling problems were due to the high stone content of the till close to the seabed. With this sort of material the mud flush tends to remove the fines producing a cobble gravel which strips the bit and prevents penetration. The site was finally abandoned because the bit was unable to penetrate the gravel layer.

c) BH 78/11 (Site 87): The superficial cover at this site presented the other extreme to sites 78/10A and 10B. Here penetration rates were high (40m in 1.5 hours) but because of the very soft nature of the clay even at 40m depth, once rotation and mud flush were stopped during inner barrel recovery there was a high risk of jamming of the string as the soft clays closed around the pipe. The hole was therefore

drilled to 40m without pulling the inner barrel and when abandoned the string was pulled before the inner barrel was removed.

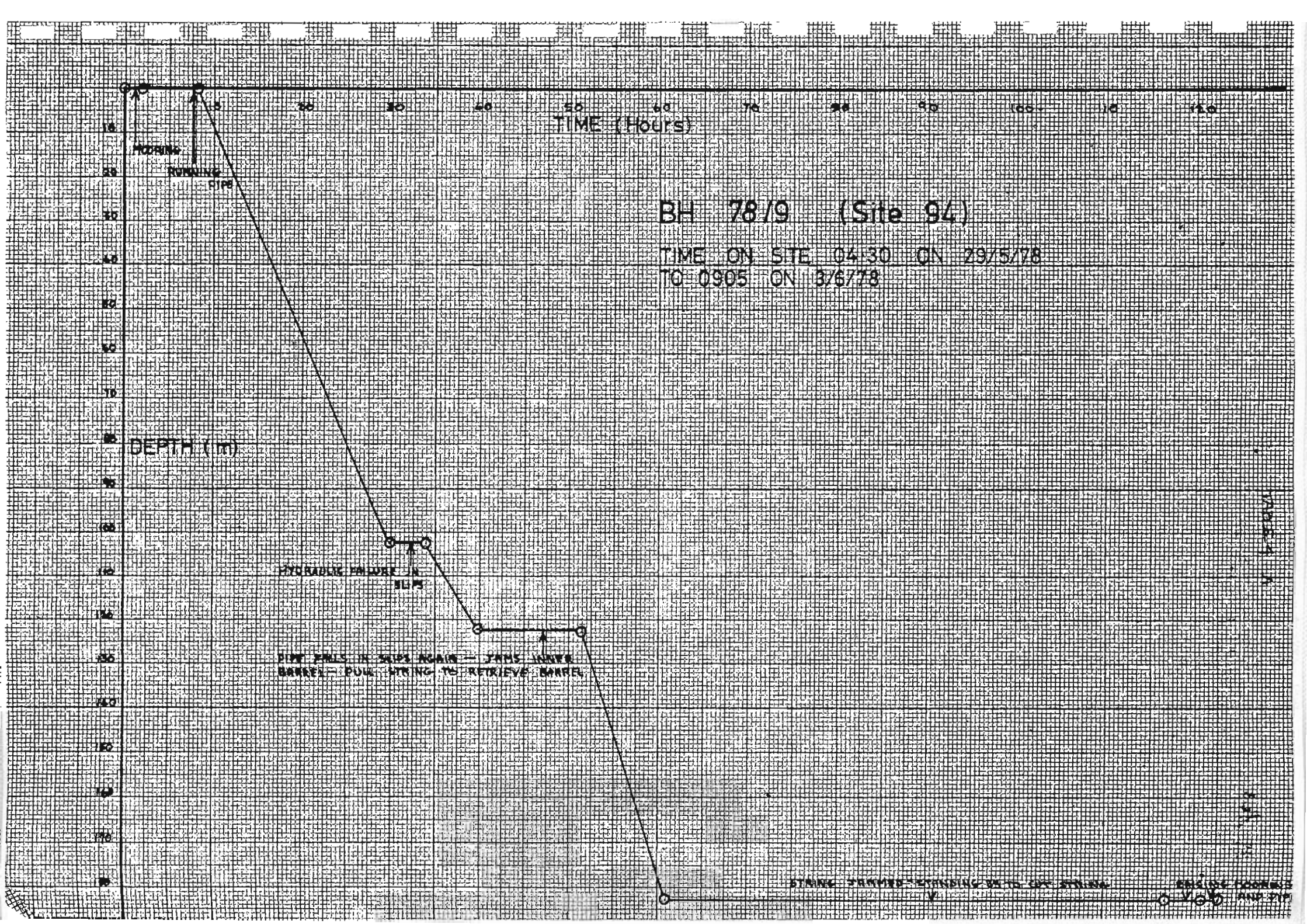
M S Ferder Cruise 78/05 Leg 3 TABLE 1 Time Analysis

Activity	Fri 26	Sat 27	Sun 28	Mon 29	Tue 30	Wed 31	Thur 1	Fri 2	Sat 3	Sun 4	Mon 5	Tue 6
Steaming	6.0	11.0	16.5						7.0	5.0	13.5	8.5
Mooring and Raising				2.0					3.5	3.0	2.0	
Logging												
Drilling etc.				17.5	18.8	24.0	24.0	24.0	13.5	16.0	8.5	
Port Calls	13.0	13.0										8.0
Standby and Downtime	5.0				5.2							
Waiting on Weather			7.5	4.5								


DATE
LOCATION
SITE/BH
WEATHER
WIND SPEED - KNOTS
5 10 15 20
WAVE / SWELL - FEET
TIME ANALYSIS
DRILLING + LOGGING
MOORING
STEAMING
WAITING ON WEATHER
PORT CALLS & STAND BY
MUD CONSUMPTION
SALT GEL (M TONS)
180 190 200 210 220 230
SMR
LINE
1·0 2·0 3·0 4·0 5·0 6·0 MT
BARYTES
DAILY COSTS
AGGREGATE '£K
240 260 280 300 320 340
360 380 400 420
FRI 26·5
SAT 27·5
SUN 28·5
MON 29·5
TUE 30·5
WED 31·5
THUR 1·6
FRI 2·6
SAT 3·6
SUN 4·6
MON 5·6
TUE 6·6
94
78/9
83
78/10A /10B
87
78/11

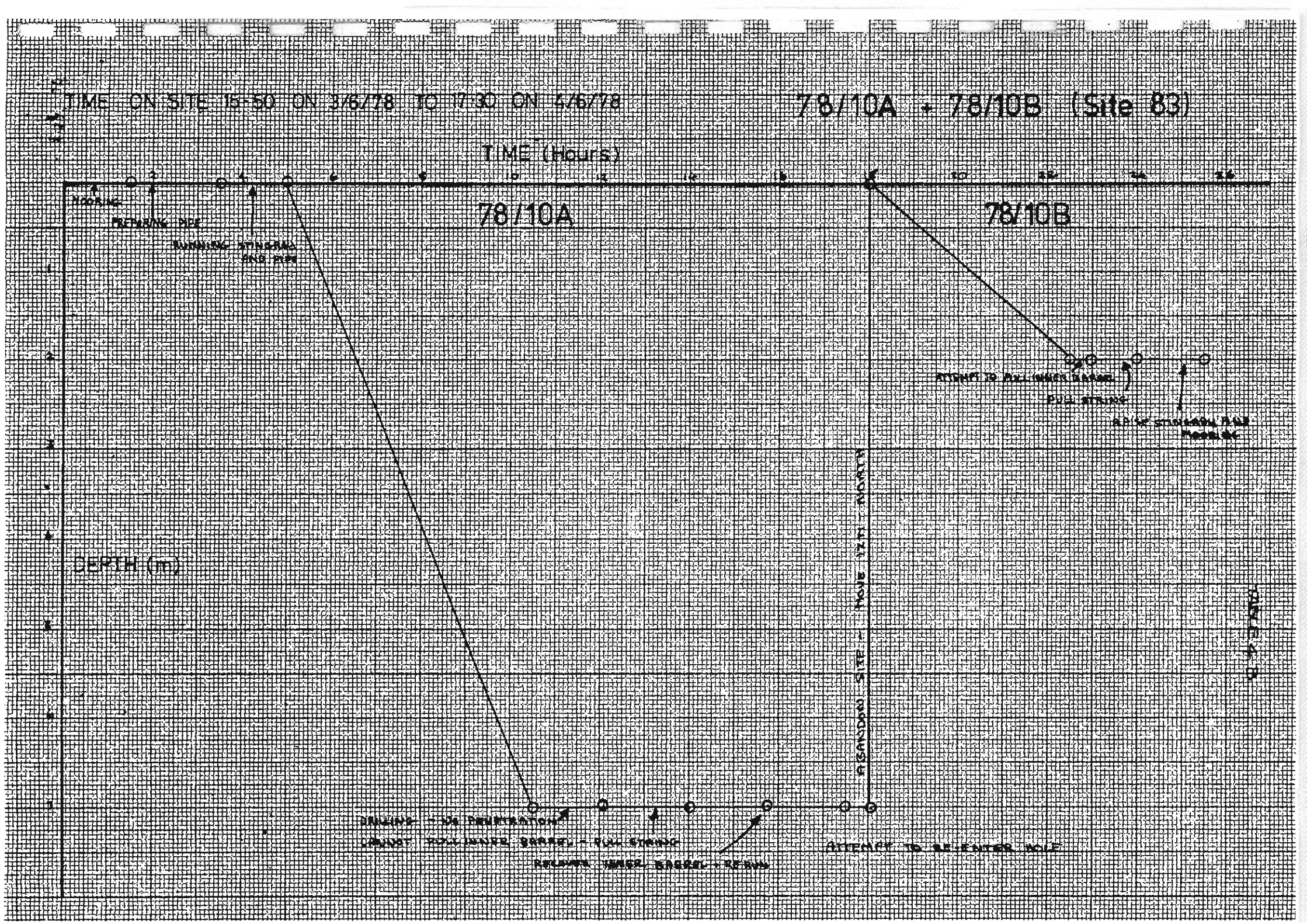
Borehole No. (Site No)	78/9 (Site 94)	78/10A (Site 83)
Water depth	191m	119m
Time on site : dates/days/hours	29/5-3/6 /5.2/ 124.5	3/6-4/6 / 0.75/ 18
Laying/raising/total mooring hours	2 / 2 / 4	1.5 / - / -
Hole length/string length (m)	182.7 /373.7	7.0 / 126
Quaternary thickness/lithology	182.7 / clay with sand layers	?6.7/ shelly sand/stoney clay
Solid thickness/lithology	-	?0.3 / arkose
Recovered Quaternary: Thickness/ % / Open hole	67.11 / 36.7% / 2.5	0.5/ 7% / -
Recovered Solid : Thickness/ % / Open hole	-	? 0.3/ 100% / -
Total recovery : Thickness/ % / Open hole	67.11 / 36.7% / 2.5	0.8 / 11% / -
Mud		
Salt gel- volume/cost	30.7mt / £4116	4.725mt/ £633.48
SMR - volume/cost	0.8mt / £2603	- / -
Lime - volume/cost	1.39mt /£111	0.11mt / £8.75
Barytes - volume/cost	-	0.60mt / £31.82
Additives - volume/cost	-	- / -
Total mud costs	/£6830	/ £674.05
Comments	Lost inner barrel/outer barrel/ TC wing/bit + Pilot/ 7 x collars/ 1 x 30' pipe.	Pull out due to broken latch on inner barrel abandoned - unable to re start hole

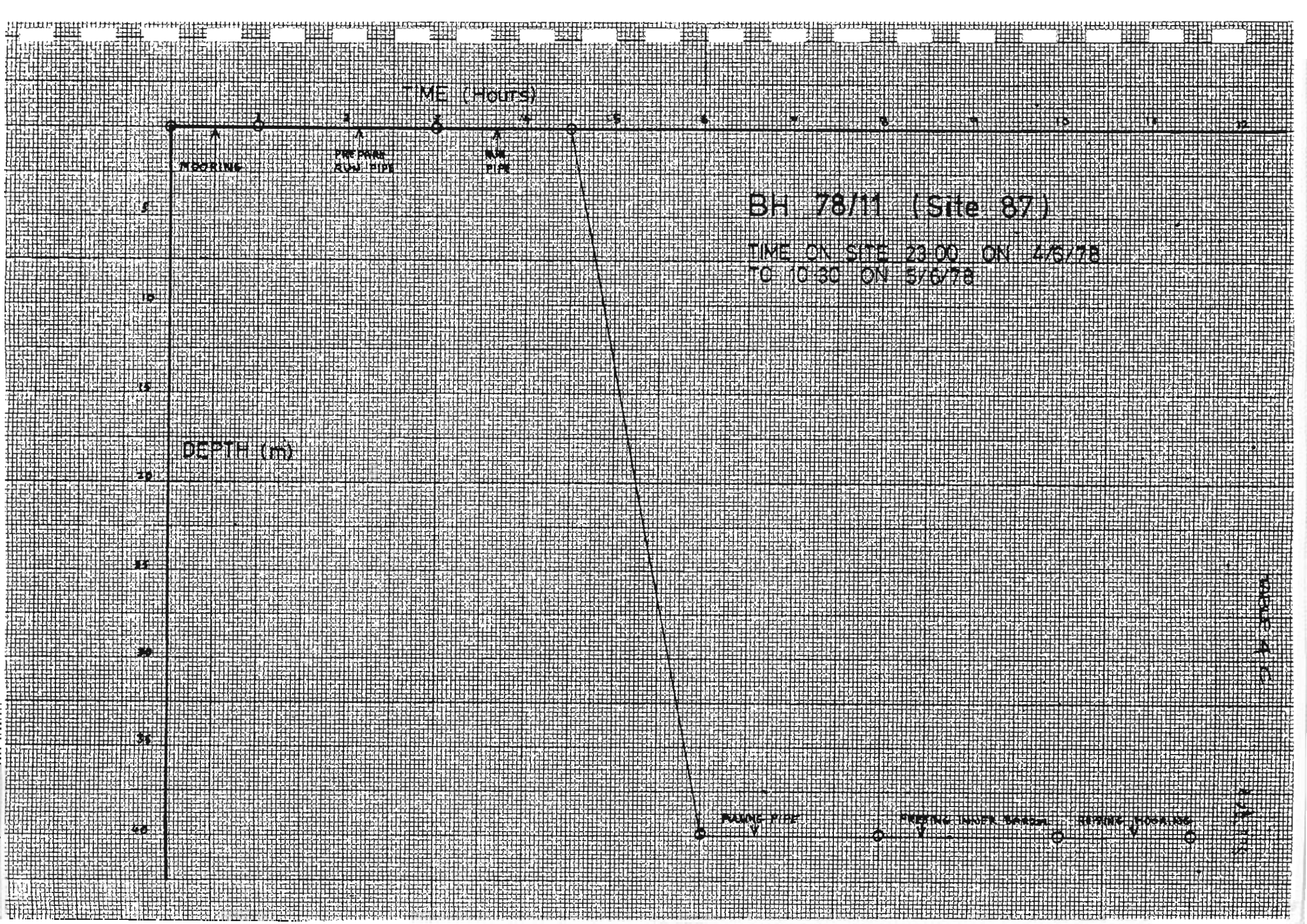
Borehole No. (Site no)	78/10B	78/11 (Site 87)
Water depth	119m	137m
Time on site: dates/days/hours	4/6 / 0.31 / 7.5	4/6-5/6 / 0.48 / 11.5
Laying/raising/total mooring hours	- / 1.5 / 3.0	1.0 / 1.5 / 2.5
Hole length/string length (m)	2.0 / 121m	40m/177m
Quaternary thickness/lithology	2.0 / shelly sand/grey till/red till	39.9/ shelly sand/very soft grey clay
Solid thickness/ lithology	- / -	0.1 / friable red sst.
Recovered Quaternary: Thickness/ % / open hole	0.2 / 10% / -	4.9 / 100% / 35.0
Recovered Solid: Thickness / % / open hole	- / - / -	0.1 / 100% / -
Total Recovery: Thickness/ % / open hole	0.2 / 10% / -	5.0 / 100% / 35.0
Mud		
Salt gel - volume/cost	4.75mt / £633.48	6.75mt / £ 904.97
SMR - volume/cost	- / -	- / -
Lime - volume/cost	0.11mt / £8.75	0.16mt / £ 12.73
Barytes - volume/cost	0.60mt / £31.82	0.40mt / £ 21.22
Additives - volume/cost	-/-	- / -
Total mud costs	/ £674.05	/ £ 938.92
Comments	Abandoned - no penetration in very stiff stoney clay/gravel	Very soft - drilled until met resistence - string jamming, inner barrel jammed - string pulled and hole collapsed


TIME (Hours)
DEPTH (m)
HOISTING
RUNNING PIPE
HYDRAULIC PRESSURE ON SLIPS
PIPE FALLS, IS SLIPS AGAIN — JARS INNER BARREL — PULL STRING TO RETRIEVE BARREL
BH 78/9 (Site 94)
TIME ON SITE 04·30 ON 29/5/78
TO 0905 ON 3/6/78

TIME ON SITE 15-50 ON 3/6/78 TO 17-30 ON 4/6/78

78/10A + 78/10B (Site 83)




TIME (Hours)
MOORING
PIPE PENN. FLOW PIPE
BUR. PIPE
DEPTH (m)
BH 78/11 (Site 87)
TIME ON SITE 23 00 ON 4/6/78
TO 10 30 ON 5/6/78
PULLING PIPE
RETRIEVE MOORING

APPENDIX I

Summary of Operations

Friday 26 May

0000-0600	Steaming to Aberdeen.
0600-1100	Awaiting permission to enter harbour.
1100-2400	Alongside for portcall. Mobilising Stingray.

Saturday 27 May

0000-1300	Alongside for portcall. Spooling new anchor cable.
1300-2400	Leave Aberdeen on passage for site 94.

Sunday 28 May

0000-1700	On passage to site 94.
1700-2400	Waiting on weather.

Monday 29 May

0000-0430	Waiting on weather.
0430-0630	Laying moorings at site 94 (BH 78/9)
0630-1215	Running Stingray and pipe.
1215-2400	Drilling.

Tuesday 30 May

0000-1000	Drilling.
1000-1400	Slips failure - repairing hydraulics.
1400-1945	Drilling.
1945-2030	Slips failure - repairing hydraulics.
2030-2215	Inner barrel jammed - attempting to free barrel.
2215-2400	Pulling string.

Wednesday 31 May

0000-0745	Pulling string, recovering inner barrel, re-running string.

0745-1645	Drilling.
1645-2400	String jammed, attempting to free string.

Thursday 1 June

0000-2400	Attempting to free jammed string.

Friday 2 June

0000-2400	Attempting to free jammed string (JRC technicians on board at 2200 hours from rigboat Stad Sea).

Saturday 3 June

0000-0240	Attempting to free jammed string.
0240-0330	String freed by explosive cutting.
0330-0710	Pulling string.
0710-0905	Raising moorings.
0905-1500	Steaming to site 83.
1500-1720	Laying moorings.
1720-1830	Transferring JRC technicians to fishing boat.
1830-2100	Running pipe and Stingray on site 83 (BH 78/10A).
2100-2400	Drilling.

Sunday 4 June

0000-0430	Drilling.
0430-0915	Inner barrel jammed, pulling string, freeing inner barrel and re-running string.
0915-0945	Hole collapsed - trying to re-enter hole.
0945-1030	Abandon hole and move 12m north to site BH 78/10B.
1030-1430	Drilling.
1430-1600	Inner barrel jammed - pull string and free inner barrel.
1600-1730	Raising mooring.
1730-2230	Steaming to site 87.
2230-2400	Laying moorings.

Monday 5 June

0000-0005	Laying moorings at site 87 (BH 78/11).

0005-0200	Testing inner and outer barrels - inner still jamming in outer.
0200-0330	Running string.
0330-0500	Drilling.
0500-0700	Inner barrel jammed, pulling string to free barrel.
0700-0845	Freeing inner barrel from outer barrel.
0845-1045	Abandon site and raise moorings.
1045-2400	Steaming for Peterhead.

Tuesday 6 June

0000-0830	Steaming to Peterhead.
0830-1630	Demobilising samples and equipment.
	End of charter.

APPENDIX II

BOREHOLE 78/9

Site 94

CONTINENTAL SHELF UNIT NORTH

Proposed Sealab Site 94

Approximate Location 118km NE of Muckle Flugga

Sea Area Cormorant

Area Geologist A. Skinner

Map Area Cormorant NW

1:100,000 Sheet Number 61°30'N 00°

Licence Block Number 210/15

Operator Phill/Fina

Latitude 61°30.6'N

Longitude 00°49.86'E

Decca Main Chain	Decca Hi Fix	Other Navigational
Red	Patt I	Methods used on Seismic
Green	Patt II	Survey Satnav
Purple		

Conditions at Proposed Site

Water Depth = 185 m

Sediment Thickness = 230 m

Solid to be Drilled = _ m

Bottom Conditions - ?flat sandy over stiff clay.

Predicted Age - Quaternary

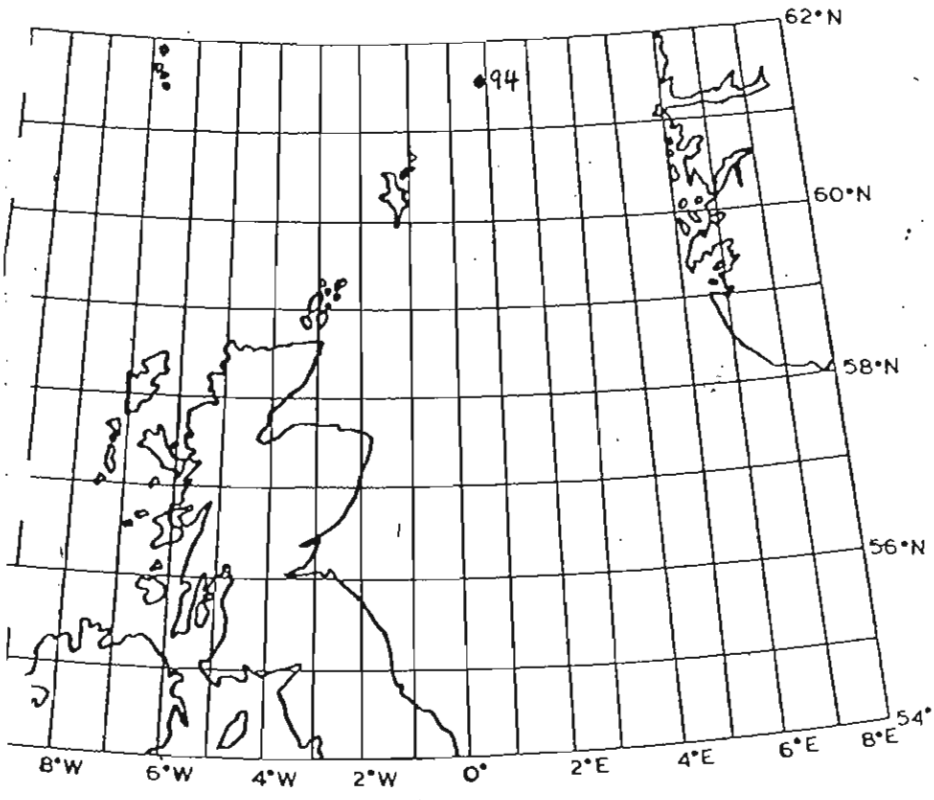
Predicted Age - -

Total Length of Drill String Required = 415m

Site Located on Geophysical Line Number

Year/Cruise/Line/(Fix) 77/07/77/(6)

Location Map



General Notes

To investigate three prominent reflectors dipping northwards towards the continental edge.

Site Approved By D.A.Wadus (D.G.)

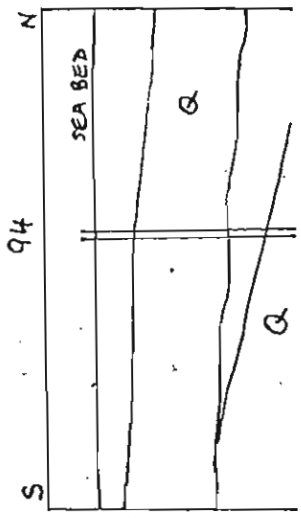
Date 3.2.78

Site Drilled

Date

Site Geologist

Geological Notes and Schematic Section



Predicted Succession
(Including Velocities Used)

185m Water Depth

50

72m reflector

100

133 reflector

150

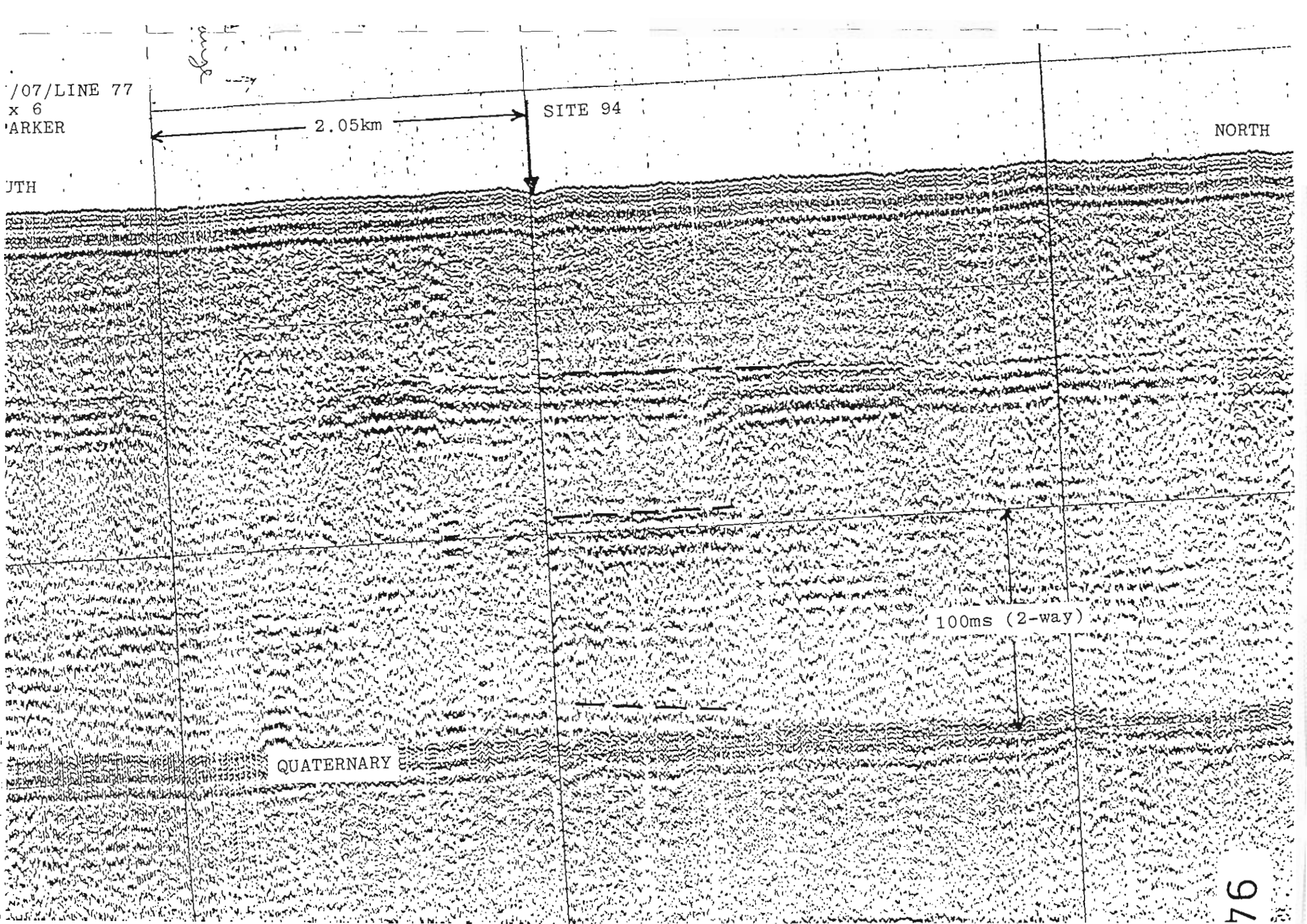
171m reflector

207m reflector

Base of hole

velocity 1800m/sec

Sampling Required	Logging Required
Continuous	Gamma


/07/LINE 77
x 6
'ARKER
JTH
2.05km
SITE 94
NORTH
100ms (2-way)
QUATERNARY
76

BOREHOLE 78/10A and 78/10B

Site 83

CONTINENTAL SHELF UNIT NORTH

Proposed Sealab Site 83

Approximate Location 15km NNW of Unst

Sea Area West Shetland

Area Geologist J.A. Chesher

Map Area Shetland

1:100,000 Sheet Number 60.5N 01W

Licence Block Number 1/1

Operator -

Latitude 60°58.1'N

Longitude 00° 58'W

Decca Main Chain	Decca Hi Fix	Other Navigational
Red	Patt I	Methods used on Seismic
Green	Patt II	Survey Sat.Nav.
Purple		

Conditions at Proposed Site

Water Depth = 120 m

Sediment Thickness = 20 m

Solid to be Drilled = 50 m

Total Length of Drill String Required = 190

Bottom Conditions - sand

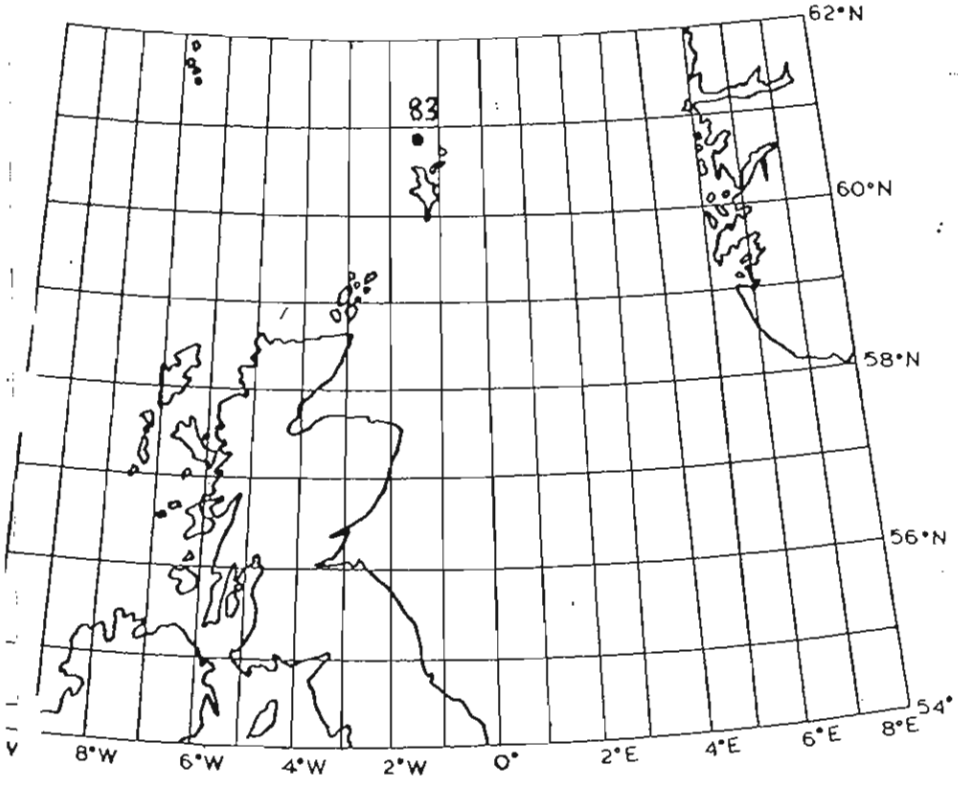
Predicted Age - Quaternary

Predicted Age - Mesozoic or Palaeozoic

Site Located on Geophysical Line Number

Year/Cruise/Line/(Fix) 77/7/37/(13)

Location Map



General Notes

To investigate bedded non magnetic strata N of the Shetlands - ?Mesozoic or Palaeozoic ORS.

Site Approved By

(D.G.)

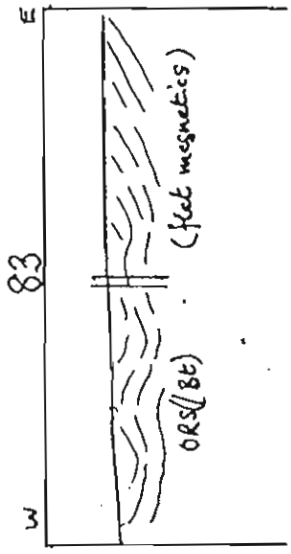
Date 22.11.77 3.2.78 DAC.

Site Drilled

Date

Site Geologist

Geological Notes and Schematic Section



Predicted Succession
(Including Velocities Used)

Water Depth 120m

Seabed

Sea bottom sand

10

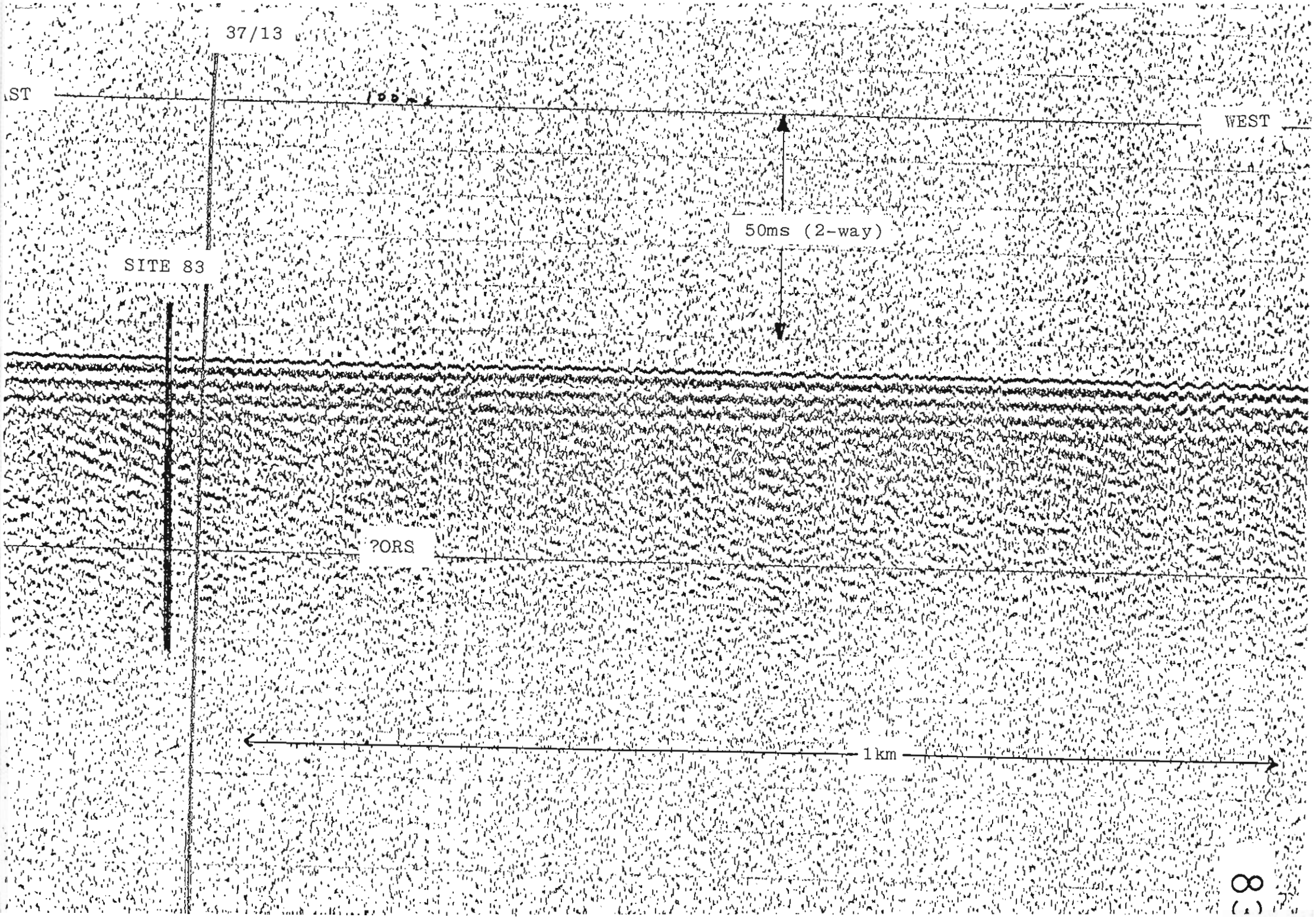
Clay with scattered pebbles Quaternary

20

Solid, Mesozoic or ORS

70 T.D.

Sampling Required	Logging Required
Continuous	


37/13
ST
WEST
SITE 83
50ms (2-way)
?ORS
1 km

Borehole 78/11

Site 87

Proposed Sealab Site 87

Approximate Location 7km west of Muckle Roe

Sea Area West Shetland

Area Geologist J A Chesher

Map Area Shetland

1:100,000 Sheet Number 60N 02W

Licence Block Number -

Operator -

Latitude 60°22·5'N

Longitude 1°35'W

Decca Main Chain	Decca Hi Fix	Other Navigational
Red	Patt I	Methods used on Seismic
Green	Patt II	Survey Sat.Nav.
Purple		

Conditions at Proposed Site

Water Depth = 140 m

Sediment Thickness = 20 m

Solid to be Drilled = 100 m

Bottom Conditions - Sand

Predicted Age - Quaternary

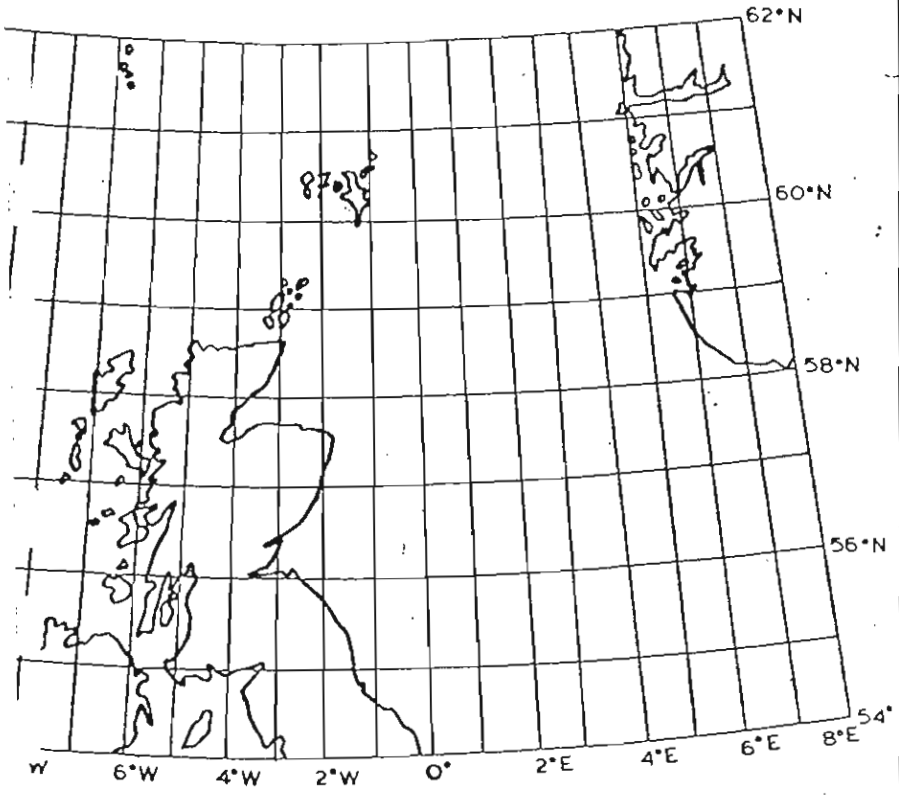
Predicted Age - Mesozoic

Total Length of Drill String Required = 260m

Site Located on Geophysical Line Number

Year/Cruise/Line/(Fix) 77/7/58/(9.5)

Location Map



General Notes

To investigate possible Mesozoic basin in St. Magnus Bay.

Site Approved By

(D.G.)

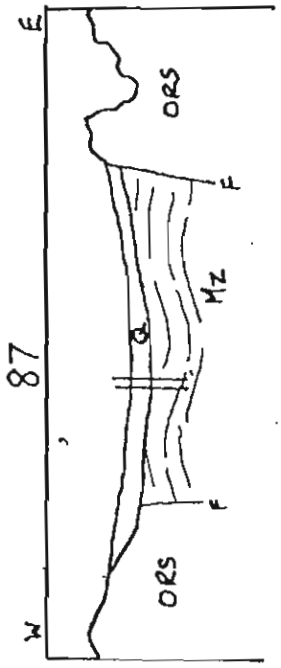
Date 22.11.77 3.2.78

Site Drilled

Date

Site Geologist

Geological Notes and Schematic Section



Predicted Succession
(Including Velocities Used)

Water Depth

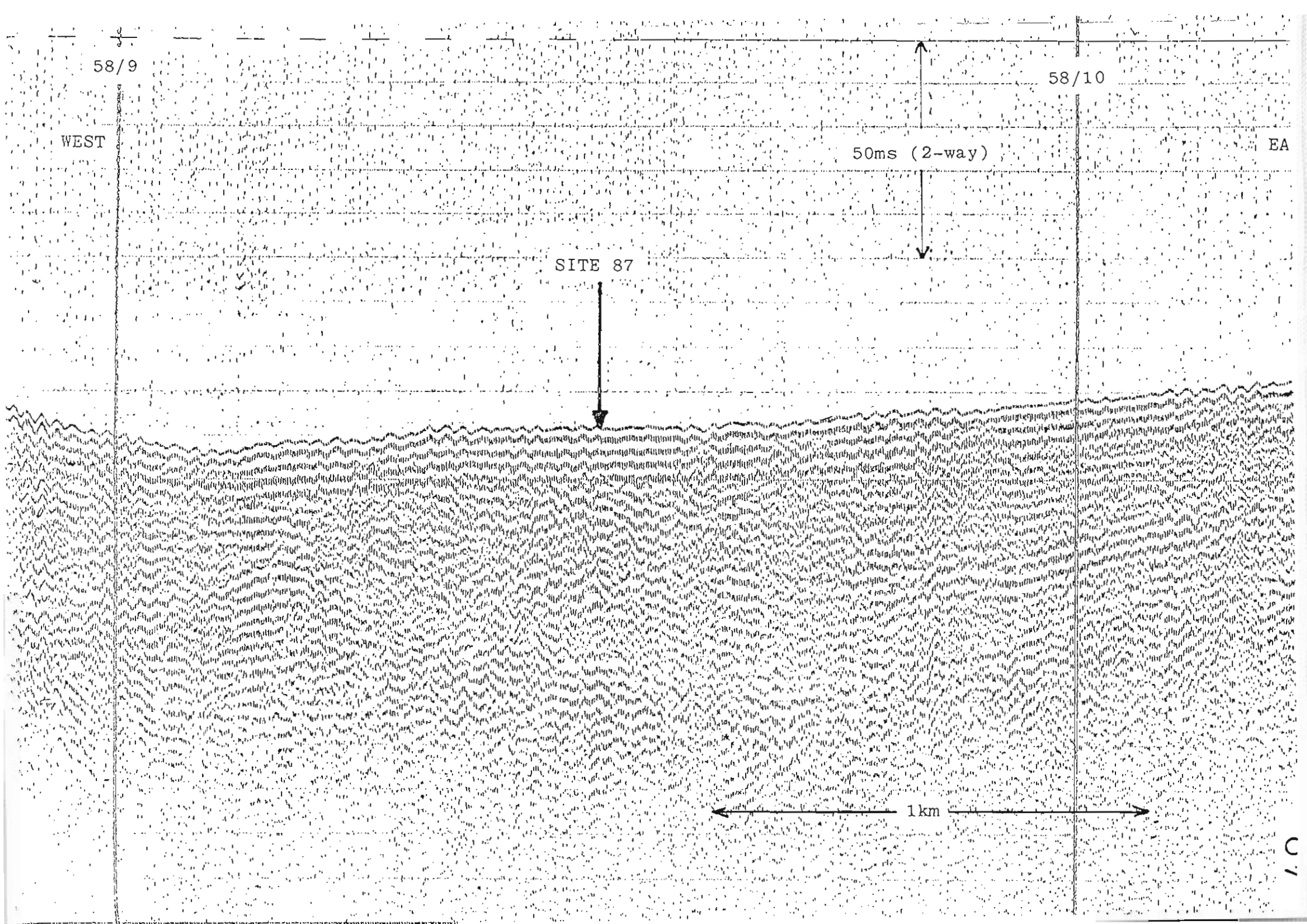
Quaternary

20

Mesozoic

120 T.D.

Sampling Required	Logging Required
Continuous	


58/9
58/10
WEST
EA
50ms (2-way)
SITE 87
1km