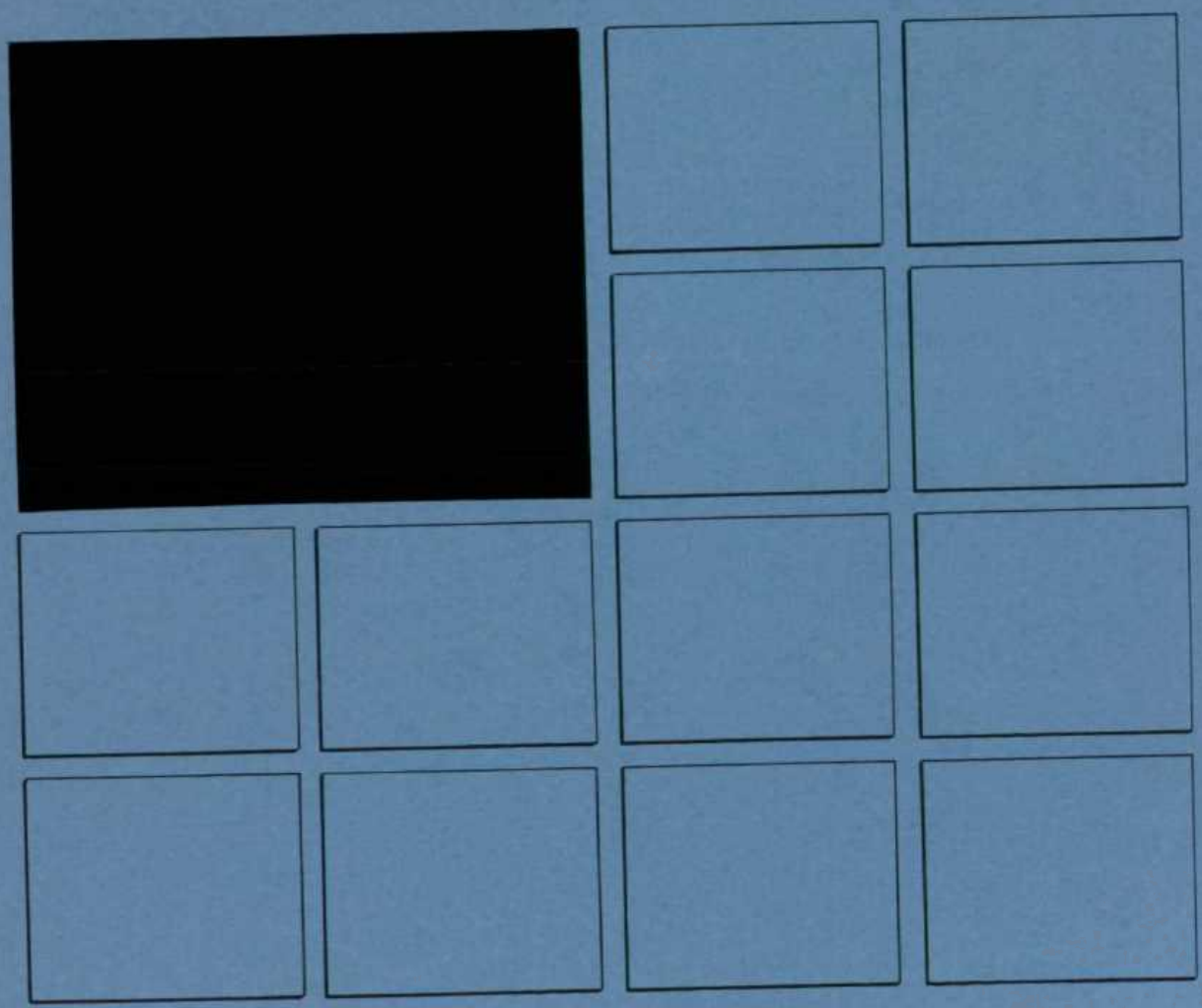
INSTITUTE of HYDROLOGY



SEARLE PLANT,MORPETH

RECONNAISSANCE SURVEY

FEBURARY 1987

INTERIM RESULTS

Confidential

SEARLE PLANT, MORPETH

RECONNAISSANCE SURVEY, February 1987: Interim Results

1. Programme Outline

1.1 Six shallow and two deep wells were drilled by the Institute of Hydrology at six locations in the North East area of the Searle Chemical Plant at Morpeth between 16 and 27 February 1987 (Fig.1). Piezometers with 0.5m perforated tips were installed in all but one of these wells to serve as an initial network for subsequent monitoring of water levels and chemistry.

Seventeen water samples were collected, including four from the North boundary ditch and associated land drain. Methanol and acetone were used as contaminant indicators, although a range of hazardous chemicals were expected to be present.

1.2 This phase (Phase A1) was intended to establish whether contaminants introduced from leaking effluent drains beneath Chem Plants 1 to 4 had extended beyond the perimeter of the site. It was assumed that pollutants were present under Chem Plants 1-4 and that, on the basis of earlier water level data, any contaminant plume would probably be moving in a general North or North East direction. Contaminants had been found in a trench dug in mid-1986 just North of the West end of the effluent plant and investigation logs showed the presence of sand lenses or layers with a shallow water table in the north field area. Since the VOC indicators (methanol/acetone) have an specific gravity of about 0.8 the contaminants would be expected in the upper parts of any permeable zones.

Consequently, the first site drilled to locate any contaminants was drilled in the North field with the intention that if contaminants were not located within the boulder clay horizons or weathered bedrock at this site then subsequent sites would be drilled towards the Chemical plants in an arc extending East and South East from the initial site. Drilling would consist of shallow wells at first to avoid cross-contamination of the underlying sandstone if shallow contaminants were found. If

contaminants were identified at the initial site then the investigation would extend North and North East to locate its extent (within the site boundary only). If contaminants were not found at the shallow sites then some initial investigation of the chemical plant area itself would begin in order to prove that contaminants were definitely present.

An additional deep borehole was drilled upslope of the chemical plant area for lithological control. Deeper holes into the underlying bedrock would require different rigs and more complex borehole design.

1.3 During the course of the investigation additional background information was provided by Searle. Steep slopes, access and the dense network of buried services restricted the final choice of sites, particularly in certain key locations. Having located toxic chemicals by chemical plant 2 it was decided to evaluate the information available in order to locate further target areas more precisely and to allow the necessary arrangements to be made.

2. Summary of Preliminary Results

2.1 Geology

The sequence consists typically of boulder clay (till) which overlies Millstone Grit sandstones north of Chem 1 and 2 and mudstones over the rest of the site (Fig.2). The bedrock surface slopes from 90 to 70 m in a North or North East direction. A weathered surface has developed on the sandstones.

The overlying clay sequence ranges in thickness from 3 to at least 9 m, increasing in a North East direction. Two divisions can be identified separated by a silt layer about 0.5 to 1 m thick. The upper generally brown clay sequence is softer and contains sand lenses in the North field. The lower clay consists of stiff grey clay with small rock fragments and occasional boulders and represents a ground moraine. The elevation of the top of the grey clay is shown in Figure 3 for the North East area. It would appear to be relatively flat South West of Chem Plant 2 at an elevation of about 79-80 m but drops sharply from MP7 to MP6 to an elevation of about 72 m, possibly associated with the mudstone-sandstone junction.

Sections illustrating the geology in the Chem Plant area are shown in Figures 4 to 6.

2.2 Water Levels

During drilling water inflow is usually slow due to the low permeability of the sequence and water levels may take several days or more to reach an equilibrium position. South of MP6 water is usually encountered at the top of the silt horizon lying on the grey clays. This layer becomes increasingly confined downdip. The piezometric surface of the silt layer occurs at a depth of about 3 m (about 79.5 m OD) by Chem Plant 2.

A separate water table appears to be present in the shallowed sand lense in the brown clay sequence North of MP6. In addition, a local shallow water table has formed in the dolerite fill by Chem Plant 2, which on the basis of a chemical analysis is derived from rainfall recharge with inspected drainage.

Water level elevations are shown in Figure 7. These vary from about 90 m in the South West to about 76 m in the North East with an average gradient of about 0.04. These are shown in comparison to the effluent drain effluent levels in Figure 8. This indicates that the invert levels of the drains leading from Chem 1 and the eastern side of Chem 2 are about 0.5 m above or actually intercept the silt layer. Elsewhere the invert levels are about 1.5 to 2 m above the silt layer and as a result the risk of contamination will be less in these areas.

2.3 Permeability (K)

Estimates of permeability have been made from grain size analyses and short 'recovery' tests. As yet these are incomplete but using the more reliable recovery data, K values of about 1 m/d and 0.3 m/d are indicated for the silt layer at MP5 and MP6, respectively. Permeabilities of up to about 15 m/d are indicated for the fine to medium grained sand lenses occurring in the brown clays in the North field. As a general indication of the permeabilities of these sequences we would expect values in the range of 10^{-2} to 10^{-4} m/d for mixed sands, silts and clays, such as those

in the upper clay sequence, and about 10^{-5} for massive clays, such as the lower grey clay sequence. The occurrence of groundwater within the silt layer overlying the grey clay would seem to be due to the higher permeability of this horizon compared to the very low permeability of the grey clays which restrict further downward movement of groundwater.

Using the K value from MP5 of 1 m/d and an average hydraulic gradient of 0.04 the approximate velocity of groundwater flow in the silt layer is about 1.5 m/year. Over, say, 20 years, assuming Chem Plant 1 drains have been leaking since the plant came into operation, the contaminant plume would have moved up to about 30 m and should still be within the site boundary (site MP8 is 40 m and the top edge of the fill slope 15m from the eastern fence). Assuming a porosity of 40% and a thickness of 0.5 m for the silt layer the storage volume of this layer beneath Chem Plants 1 and 2 is about 675 m^3 and for Chem Plants 3 and 4 about 450 m^3, a total of 1125 m^3. On available evidence it is still uncertain as to whether the fill material along the fill slope of the eastern boundary is of a depth that would seal off the silt layer.

3. Sampling Results

3.1 Polluted groundwater was encountered at 2 boreholes some 90 m apart in the North East area:

- at MP6, about 10 m North East of the effluent plant and beyond the foot of the fill slope

- at MP8, about 8 m North of Chem Plant 2.

However, the analyses of the samples from these wells (Table 1) suggests a different source and type of pollutants at each location.

3.2 At MP6 the high Na and Cl levels indicate road salt contamination from stockpiles in this area and/or the adjacent stormwater drain. The high Zn and suspected high NH_3 could be due to spillage in this general area from the effluent tank. It would be noted that an effluent drain from the solvent tank farm passes MP5 and MP6. MP5, however, which is situated close to the trench dug mid-1986 at the western end of the effluent tank, did not show any VOC's.

Table 1

MP6 (IH sample ref 99696) 25/2/87

			mg/ℓ		mg/ℓ		mg/ℓ
EC	7500 µS	Na	830	SO_4	360	Methanol	Nil
pH	6.8	K	≈1	Cl	2200	Acetone	Nil
T	6.4°C	Ca	440	HCO_3	*		
COD	50	Mg	80				
				Fe	8		
				Zn	28		
				Al	2		

* Abnormal titration curve. NH_3 suspected.

MP8

			mg/ℓ
EC	4570 µS	Methanol	Nil
pH	6.3	Acetone	8
		Tetrahydrafluoron	700
		Unidentified	50

COD result not yet available

The nature of the pollution at MP6 is perhaps of less concern at this stage than that at MP8 and is probably a separate problem, even though the same silt layer contains pollutants at both sites. Prior to further investigation around MP6 (where, however, access is limited) we would suggest that full chemical analyses (including VOC's) are made on MP6, MP5 and NE3 to show whether more hazardous pollutants are present. A bacteriological analyses should also be made on a sample from MP6.

3.3 The contaminants at MP8 pose a more serious problem, although the indications are that the extent of pollution is still contained within the site boundaries. Clay fill on brown clay extend from 1.5 to 3.0 m at MP8, the sequence becoming damp at 3 m, which is about the level of the adjacent invert (80.0 m OD). The pollutants were encountered in soft, olive sandy-clayey silt at 3.0-3.7 m (78.9-79.6 m OD) lying on top of the grey clay (which appears to be dry). There is at least 2 m (? > 7 m) of grey clay beneath MP8 which overlie mudstones of low permeability without a weathered layer. The mudstone-sandstone contact appears to run beneath Chem Plants 3 and 4. Hence, if the contaminant source is limited mainly to Chem Plant 1 then the possibility of deeper penetration through the grey clays and into the mudstones is considered to be limited, since the plume would travel preferentially in the direction of groundwater flow within the more permeable silt layer overlying the grey clay.

Head differences in the overall sequence would result in upward movement of contaminants downdip as well as downward movement towards the bedrock if vertical continuity exists in the sequence. The clays above and below the silt layer would, however, make this unlikely. Water from this layer is also unlikely to emerge at the surface downdip or contribute to the shallow ditch in the north.

Groundwater flow in the silt layer is in a North East or possibly Easterly direction. At present no boreholes exist in this area. However, there is the possibility that pollutants could travel preferentially from the silt layer into the backfill of the drainage system at a lower elevation and then towards the effluent plant area, although no pollutants were found at at MP7 or NE4 in the silt layer close to these pipes. Flow along the drainage system backfill material can only be investigated by trenches rather than boreholes.

4. General Conclusions

4.1 The initial survey indicates that toxic effluent contamination is likely to be restricted to the area of Chem Plant 1 and 2 where invert levels are close to or in contact with a silt layer which extends over the site. This layer is also polluted at MP6 just downdip of the effluent tank but this pollution does not appear to be associated with leakage from toxic effluent pipes and as such is of less concern at this stage.

4.2 Groundwater flow is North East or East from the area of pollution but moving at about 1.5 m/year. It is probably still contained within the plant site, although due to the absence of boreholes east of MP8 the extent has not been determined as yet nor has the effect of clay fill in restricting outward flow been established. Upward and downward movement of pollutants from the silt layer is restricted by relatively thick clay layers and the polluted area is underlain by mudstones also of low permeability.

4.3 On the basis of the available information we feel that the contaminant problem can be overcome and that there is no immediate risk to surface water drainage.

5. Recommendations

The initial survey has indicated that the area of hazardous chemical contamination is likely to be limited to the Chem 1 and 2 area, where, however, access is limited. Further drilling may have to be made through road surfaces. We feel that pollution is limited to the silt layer lying on the grey clay and consequently this layer should be the initial target of further investigation. Deeper drilling may necessitate larger rigs and more complex well designs and therefore ought to form a separate programme. The contamination at MP6 also appears to be a new and separate problem.

We propose that a further 5-day drilling programme should be undertaken in the Chem Plant area. During this period about 6 shallow wells or 4 shallow plus 1 deep well could be drilled. This work should be targeted at the following:

- define water levels, geometry of the silt layer, presence of contaminants and relationship with the fill material in the area from MP8 eastwards to the site boundary.

- establish whether pollutants are present beneath Chem Plant 3.

- obtain further information, particularly on water levels around Chem Plants 1, 2 and 3, including a check on pollutants downdip of the laboratory.

- obtain further data on the permeability of the silt layer. Possible drill sites are indicated in Figure 8.

In addition, we recommend that:

(1) Samples are taken for full analysis from MP6, MP5 and NE3.

(2) The effluent pipe from the solvent store area and the stormwater drain system in the area MP5 - MP6 should be pressure tested.

(3) Trenches are used to examine the possibility that pollutants are or could travel along the backfill of the effluent drainage system downdip of Chem Plant 2.

(4) Methanol and acetone may not be the most appropriate contaminant indicators. Since THF was found in high concentrations at MP8 this should also be included.

Cost Estimates: Further Study

Mobilisation and demobilisation		1100
Staff and accommodation costs		3800
Borehole materials (4 shallow and 1 deep borehole)		1200
Analysis and reporting		1800
	Total	£7900

This assumes a 5-day drilling programme. At present we can only undertake this work starting 2 April 1987 due to other commitments.

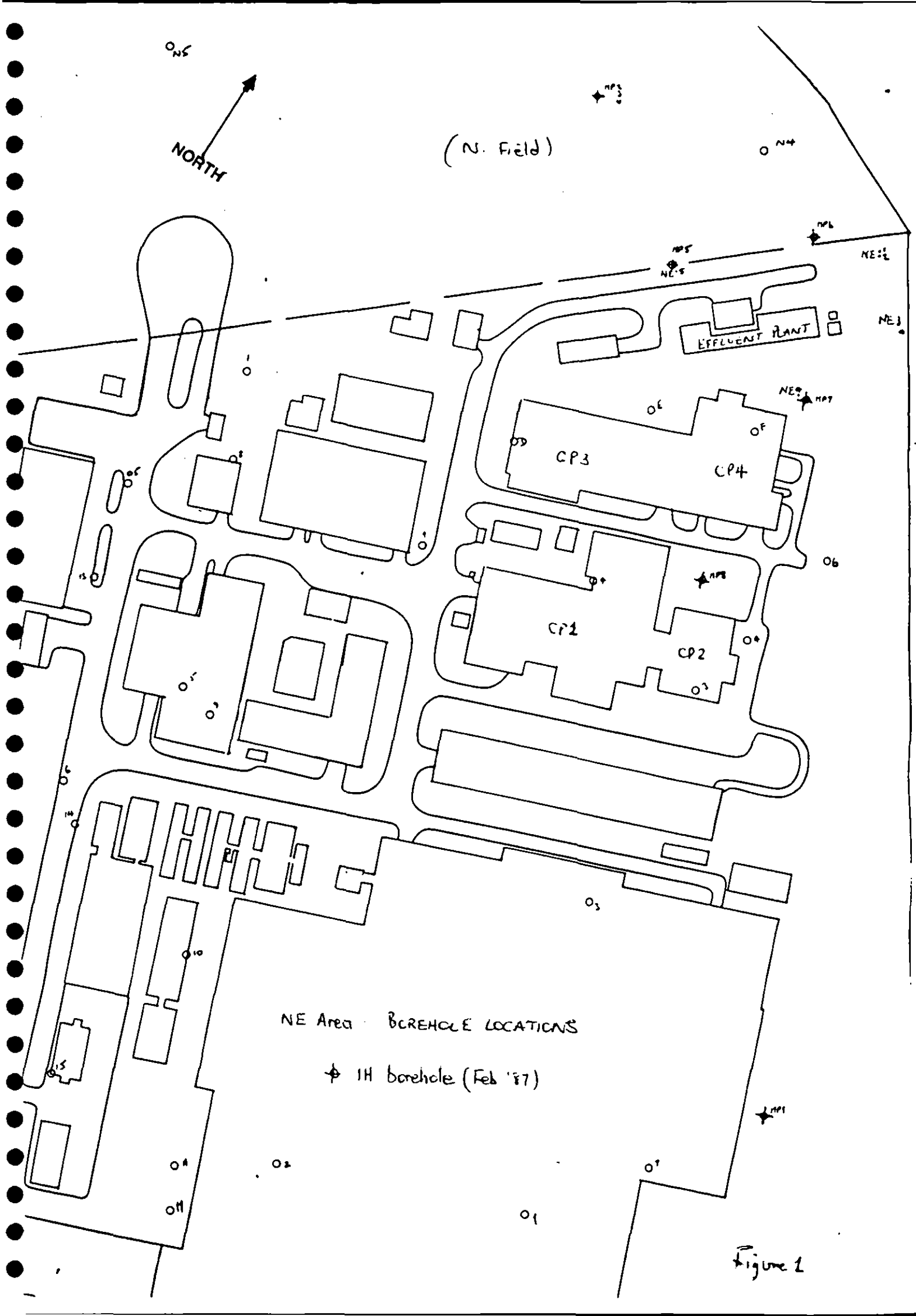

NORTH
(N. Field)
EFFLUENT PLANT
CP3
CP4
CP1
CP2
NE Area BOREHOLE LOCATIONS
IH borehole (Feb '87)

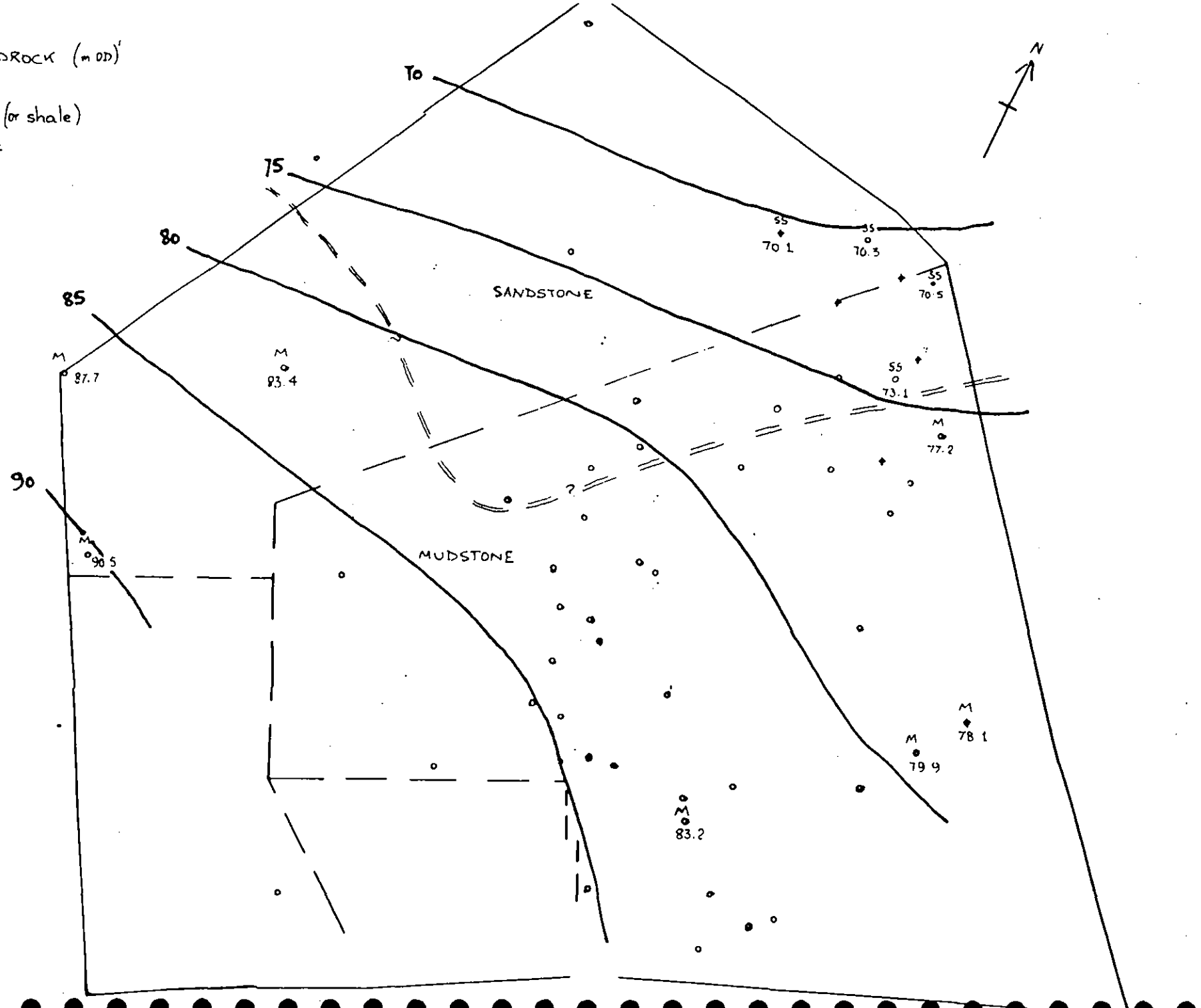
Figure 1

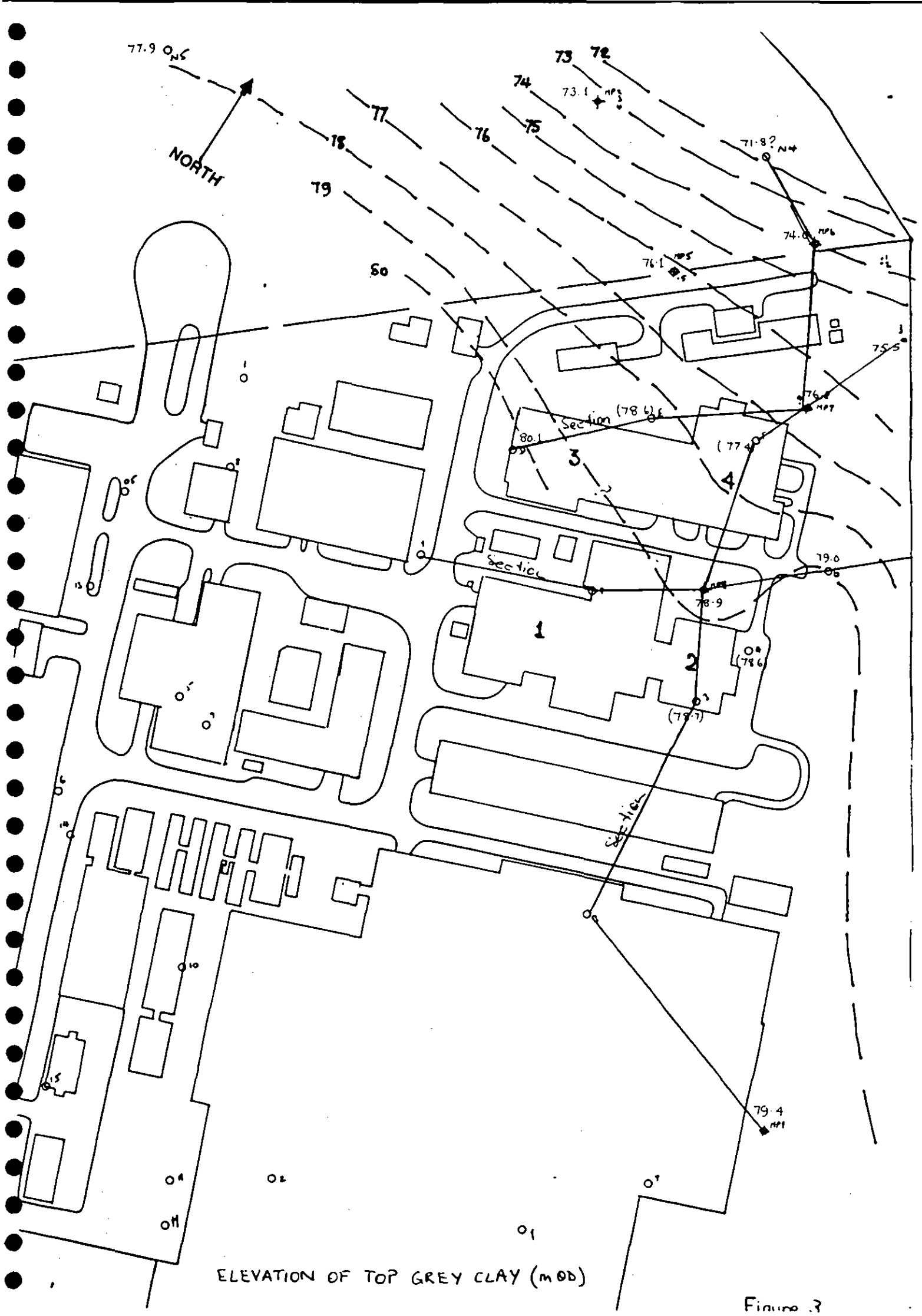
Figure 2

ELEVATION OF BEDROCK (m OD)

M - Mudstone (or shale)

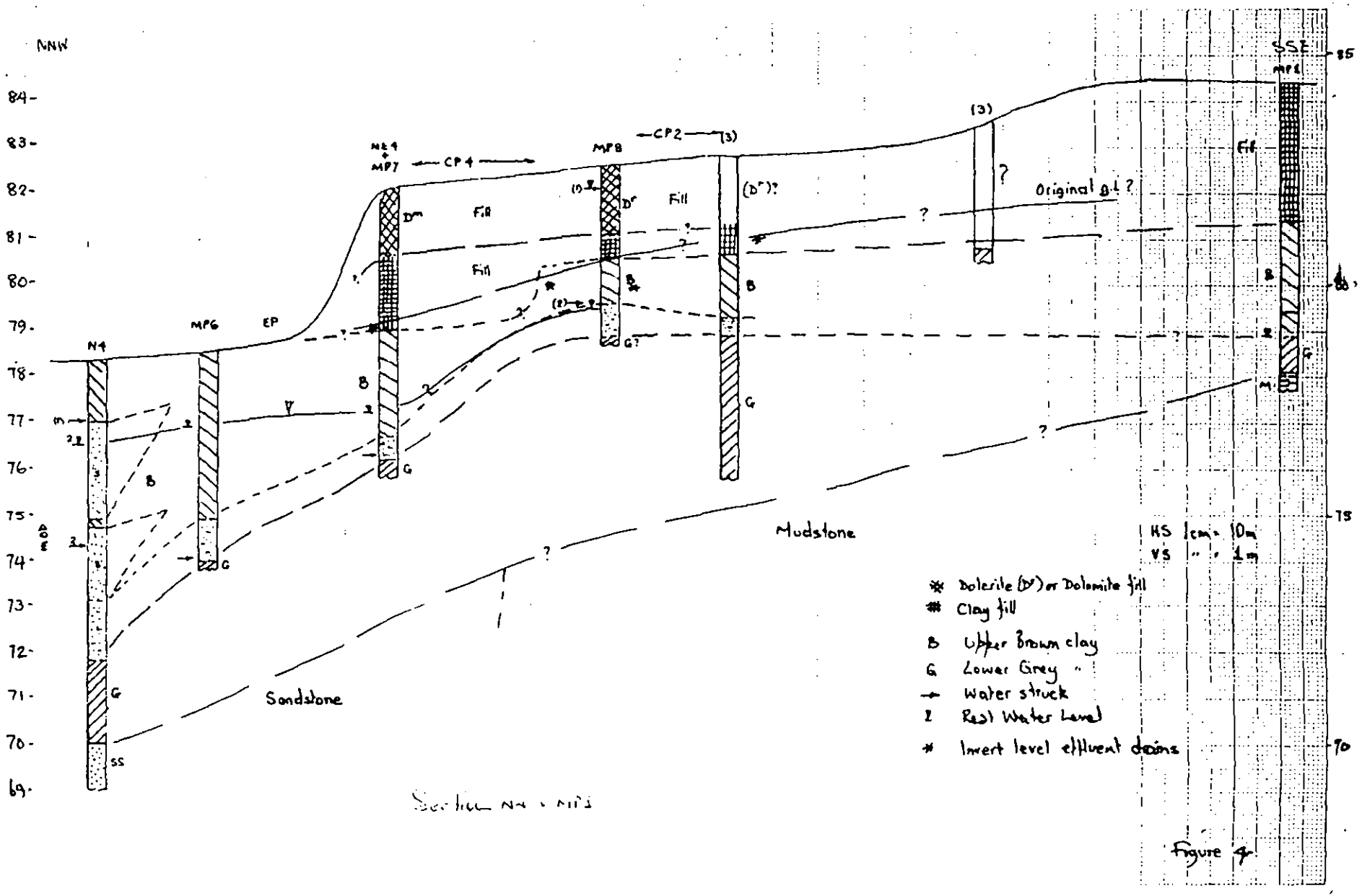
SS - Sandstone





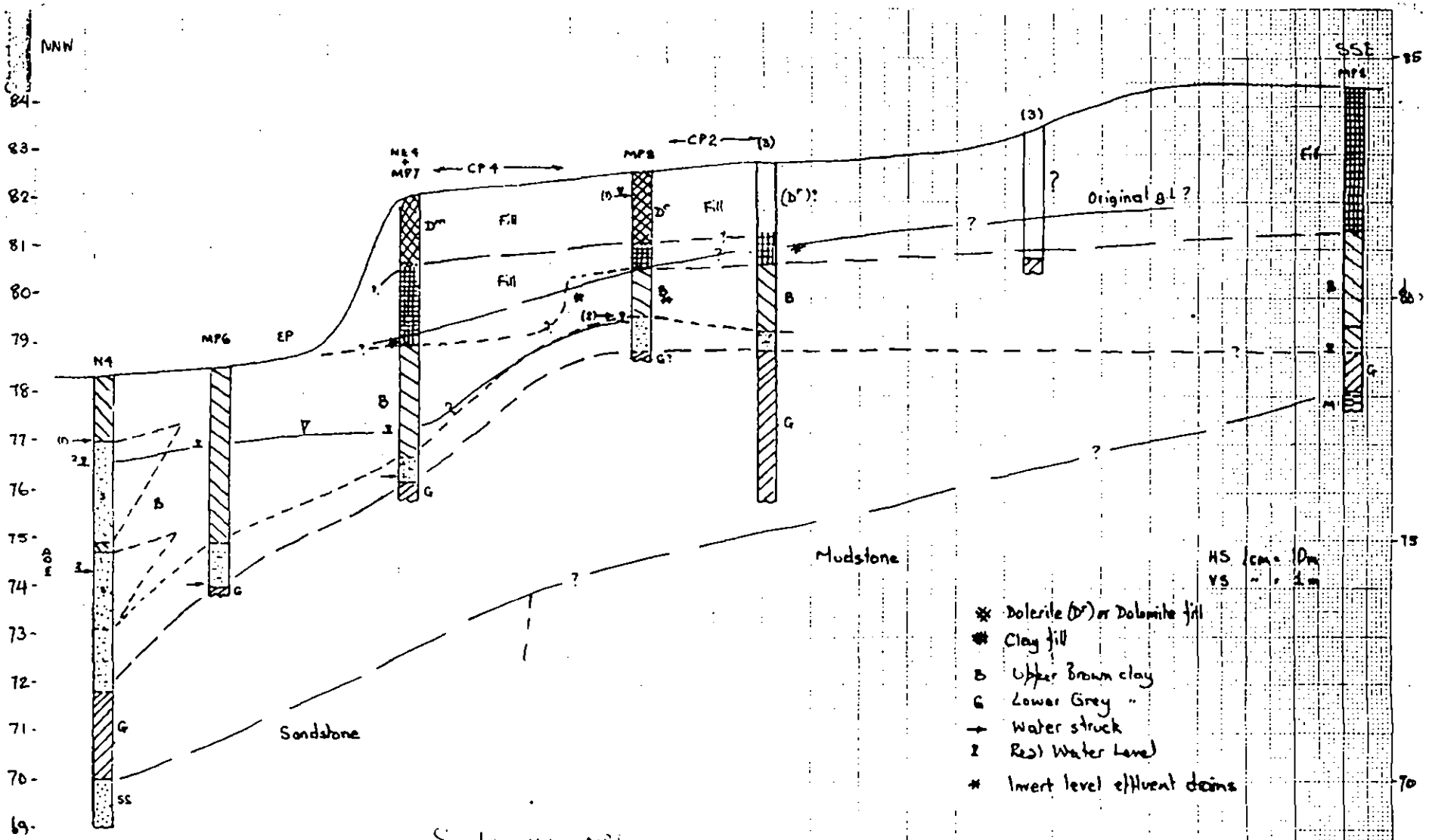
ELEVATION OF TOP GREY CLAY (m OD)

Figure 3



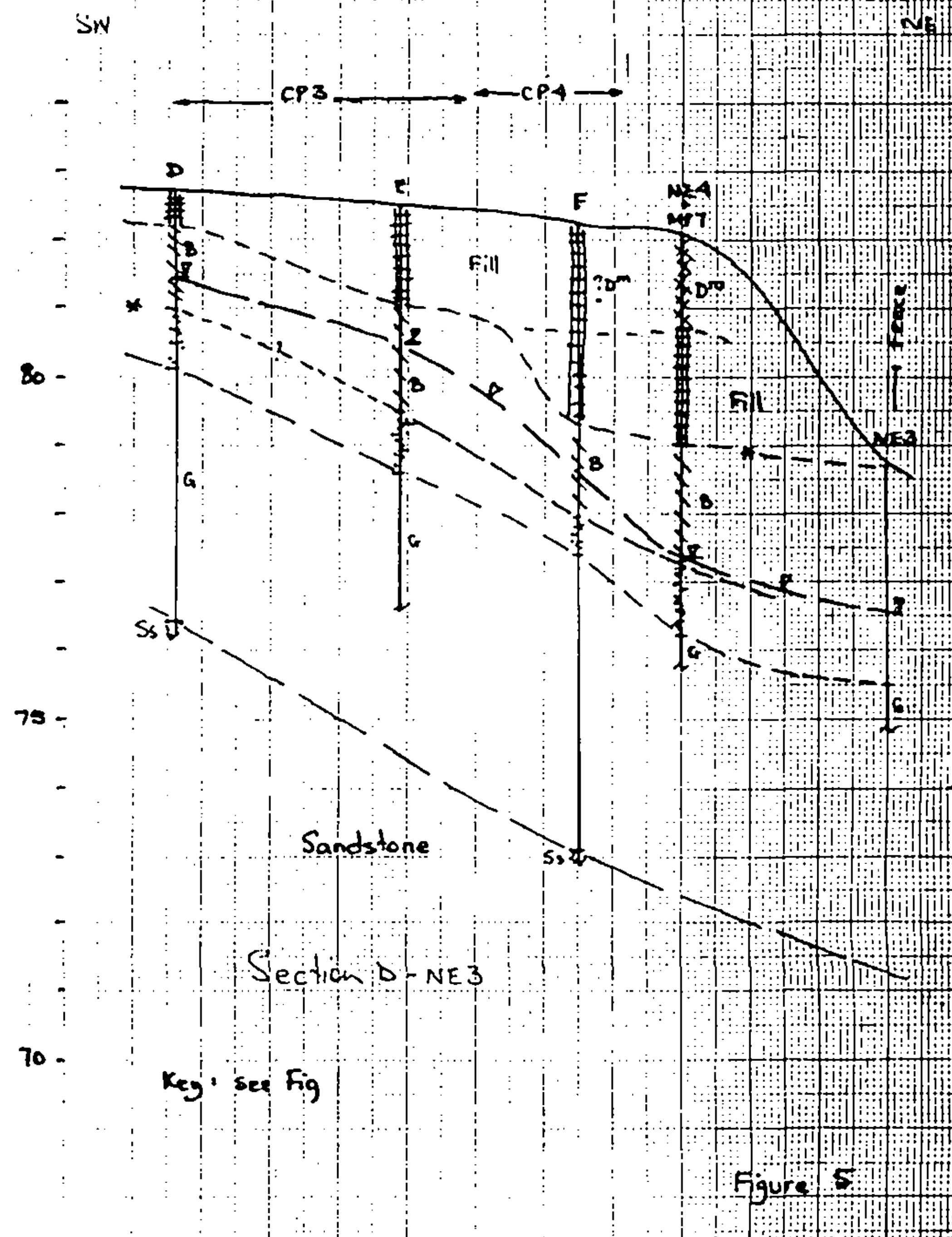
Section N4 - MP5

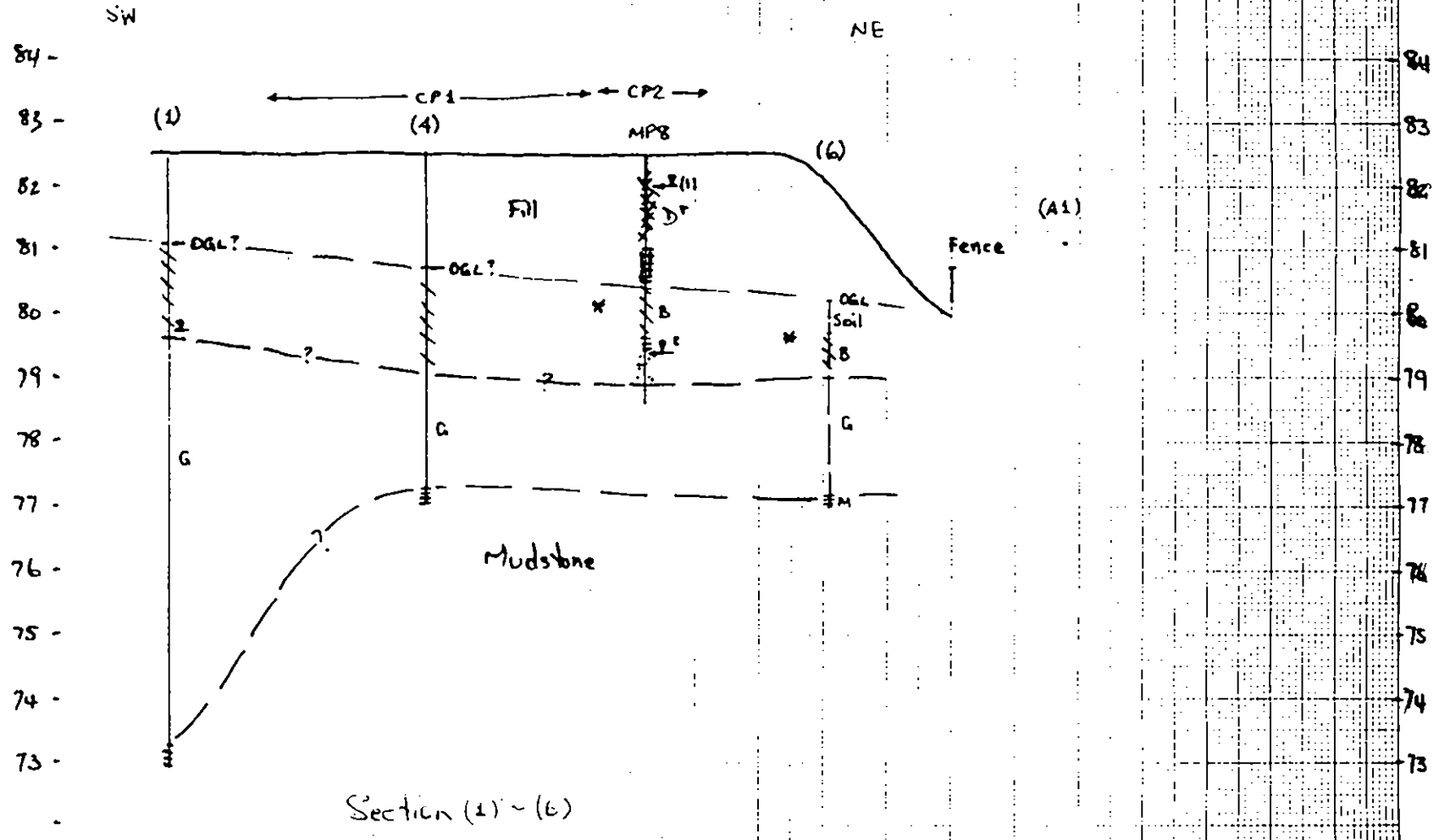
Figure 4



Section N4 - MP1

Figure 4


SW
NE
CP3
CP4
D
E
F
NE4
MFT
NE3
Fence
Fill
Fill
?D^m
D^m
B
G
Ss
Sandstone
84
83
82
81
80
79
78
77
76
75
74
73
72
71
70
80
75
70
Section D - NE3
Key: see Fig
Figure 5



Section (1) ~ (6)

Key: see Fig

OGL Previous ground level (est.)

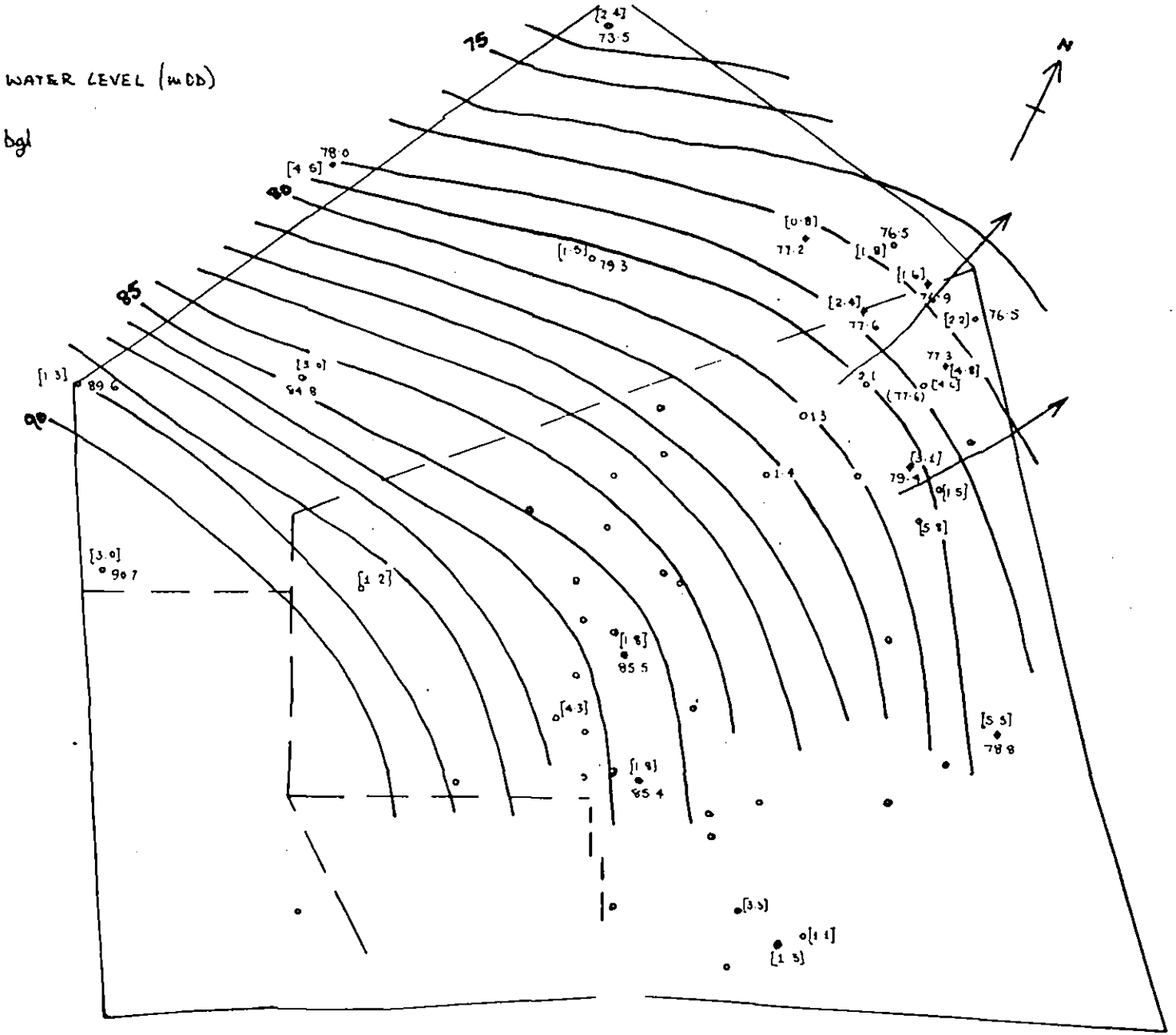
nb. Elevations of sites (1), (4) doubtful

Figure 6

Figure 7

ELEVATION REST WATER LEVEL (mOD)

[1·9] Depth RWL bgl



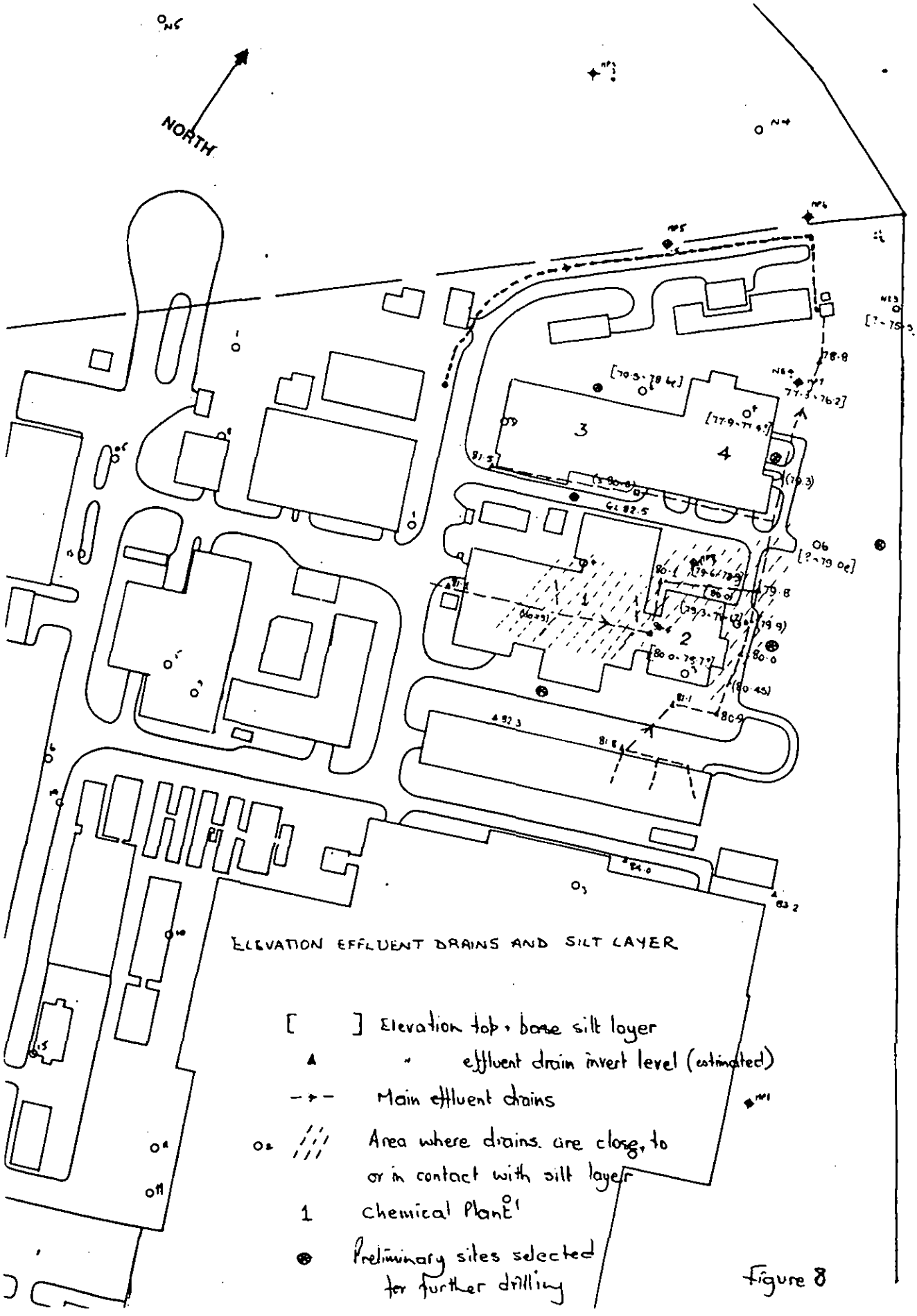

NORTH
3
4
1
2
ELEVATION EFFLUENT DRAINS AND SILT LAYER
[ ] Elevation top + base silt layer
▲ effluent drain invert level (estimated)
Main effluent drains
Area where drains are close to or in contact with silt layer
1 Chemical Plant
Preliminary sites selected for further drilling

Figure 8

Water Sample Analyses

IH Sample No.	Location	Date/method	M	A	COD	Other VOC mg/l	EC µS	pH	T °C
1	N. corner by old railway	20/2/87 Sy	*						
2	Exit land drain N corner	" Sy	*						
3	Ditch by 11	" Sy	*						
4	N3	21/2/87 Si	Nil	Nil					
5	N3	" Si	*						
6	Upstream end land drain	" Sy	*						
7	MP6 (at water struck)	23/2/87 B	-				3160	6·7	6·5
8	NE 4	24/2/87 Si	Nil	Nil	40	-	1575	6·9	-
9	MP5	25/2/87 Si	Nil	Nil	20		1820	6·7	6·5
10	MP6**	" Si	Nil	Nil	50		5910	6·85	6·4
11	MP8 (lower zone)	" Si	Nil	8	*	THF 700 Unknown 50	4570	6·3	-
12	NE3	27/2/87 Si	Nil	Nil					
13	MP1	" Sy	Nil	Nil					
14	MP2	" Si	Nil	Nil					
15	MP3	" Si	Nil	Nil					
16	MP4	" Si	Nil	Nil					
17	MP 8 (top zone)	25/2/87 Sy	Nil	Nil			630	7·4	-

M - Methanol
A - Acetone
THF - Tetrahydrofuran

** See major ion analysis
* Not yet analysed
Sy - syringe
Si - siphon
B - bailed

Water Levels (Depth below top 2" piezometer): 1H wells Feb 1987

No.	Completed	Purged	23/2	24/2	25/2	26/2	27/2
MP1	18/2 (dry)	(Uncased)	–	–	–	5.548	4.582
MP2	20/2	26/2	1.475	–	–	1.469	1.458
MP3	20/2	26/2	1.604	–	–	1.509	1.427
MP4	22/2	26/2	9.07	–	–	8.33	8.133
MP5	23/2	23/2	–	3.296 3.172	3.146	–	–
MP6	24/2	24/2		1.871 1.795	1.773	–	1.768
MP7	24/2				6.598	–	–
MP8	26/2	26/2				0.76 3.385	–
~~MP8~~	~~"~~						
NE3						2.635	2.431
NE4		~~24/2~~		5.343	–	–	–

PROJECT: SEARLE

BOREHOLE NO: MP1

DRILLING METHOD - SHELL & AUGER
CROSS BLADED CLAY CUTTER FROM 0 M. TO 6.3 M.
SHELL & HAMMER FROM 6.3 M. TO 6.8 M.

LOCATION: MORPETH

G. REF.: .....

START DATE: 13/2/87

COMPLETION DATE: 18/2/87

CONTRACTOR: IH

WATER STRUCK. NOT STRUCK .....M.BGL. .....M.BGL.

ROSE TO. 5.55 (24/2/87) .....M.BGL. .....M.BGL.

CASING DIAMETER/TYPE:
...—.....MM FROM ....—..... M.TO....—..... M., TYPE ....—.....
.....MM FROM ..... M.TO..... M., TYPE .....

TOTAL DEPTH: 6.8 M.

DRILLED DIAMETER
...200.....MM. FROM .0..M. TO 6.8 M.
.....MM. FROM ....M. TO .... M.

SCREEN DIAMETER/TYPE:
...—. MM FROM ...—. M. TO ...—. M; TYPE/SLOT(MM) ....—.....
..... MM FROM ..... M. TO ..... M; TYPE/SLOT(MM) .....

DEPTH (M.BGL)	GRAIN SIZE ANALYSES (Sample No. and location)	SUMMARY OF AQUIFER CONDITIONS / LITHOLOGY	DEPTH (MBGL)	BOREHOLE CONSTRUCTION (Casing/screen / gr. pack)	ELEVATION OF WATER M.AOD	DEPTH TO WATER M.BG L.	SYMBOLIC LOG	ELEVATION M. AOD	DEPTH M. BGL.	STRATIGRAPHIC UNITS
1	MP1/0.0-0.5	MADE GROUND (Clay with rubble fill)								
	MP1/0.5-1.0									
	MP1/1.0-1.5									
2	MP1/1.5-2.0									
	MP1/2.0-2.5									
3	MP1/2.5-3.0							81.4	3.0	
	MP1/3.0-3.5	Firm, weathered, variegated yellowish brown (10YR5/8) and grey (10YR5/1) CLAY with occasional sandstone pebbles.						80.9	3.5	BOULDER CLAY

BOREHOLE NO. HP1

DEPTH (M.BGL)	GRAIN SIZE ANALYSES (Sample No. and location)			DEPTH (M. BGL)	BOREHOLE CONSTRUCTION (casing/screen/gr. pack)	ELEVATION OF WATER M. AOD	DEPTH TO WATER M. BGL	SYMBOLIC LOG	ELEVATION M. AOD	DEPTH M. BGL	STRATIGRAPHIC UNITS		
4	HP1/9 2.5-4.0		Firm, yellowish brown (10YR5/6) and greyish brown (2.5Y5/2) CLAY with small 0.01-0.02m patches of grey muddy sand						80.4	4.0			
	HP1/4 4.0-4.5		Firm, greyish brown (2.5Y5/2) sandy CLAY with mainly sandstone pebbles, with some coal ~~pebbles~~ fragments and occasional dolerite and limestone pebbles						79.7	4.7			
5	HP1/10 4.5-5.0		Firm–stiff, ~~silty~~ greyish brown (2.5Y5/2) silty CLAY with some sandstone pebbles						79.4	5.0			
	HP1/11 5.0-5.5		Stiff, dark greyish-brown (2.5Y4/2) silty CLAY with some sandstone pebbles and occasional coal fragments			78.82 ▽	5.55 ▽		78.9	5.5	Boulder clay		
6	HP1/12 5.5-6.0		Stiff, dark grey (5Y4/1) slightly sandy, silty CLAY with sandstone pebbles.										
	HP1/13 6.0-6.5								78.1	6.3			
	14		Hard, grey (N5) sandstone and limestone boulders.						78.0	6.4			
	15		Medium weathered, very dark grey mudstone (N3)						77.9	6.5			
	16		Not weak, ~~one~~ thinly bed. grey (N5) mudstone						77.8	6.6			
	17		Mod. weak, black (N2) thickly lam. mudstone						77.6	6.8	Coal measures		
7			End of borehole										

PROJECT: SEAGLE

BOREHOLE NO: MP2

DRILLING METHOD SPELLANGER

CLAYCUTTER ..FROM 0..M. TO 2.6. M.

BAKER .....FROM 2.6.M. TO 3.6. M.

LOCATION

MOLPEFF

G. REF.:.....

START DATE: 18/2/87.

COMPLETION DATE: 20/2/87

CONTRACTOR IL

WATER STRUCK. ROSE TO.

1.2 ...M.BGL. SEALED OFF ...M.BGL.

2.6 ...M.BGL. (26/2/87) 0.77..M.BGL.

TOTAL DEPTH: 3.6 M.

CASING DIAMETER/TYPE:

200 .....MM FROM ...0..... M.TO.....1.7 M., TYPE 8" BSP MAKER NEW

50 .....MM FROM ...0..... M.TO.....2.6 M., TYPE 2" BSP

DRILLED DIAMETER

200 .....MM. FROM 0..M. TO 1.7. M.

150 .....MM. FROM 1.7.M. TO 3.6 M.

SCREEN DIAMETER/TYPE:

50 MM FROM 2.6 M. TO 3.1 M: TYPE/SLOT(MM) 2" BSP (HERE) WITH 700 TERRAM

..... MM FROM ..... M. TO ..... M: TYPE/SLOT(MM) .....

SUMMARY OF AQUIFER CONDITIONS

HEIGHT of 2" BSP ABOVE GROUND LEVEL = 0.70

" " 8" WATERWELL CASING AGL = 0.76

ELEVATION OF TOP OF 2" BSP AOD = 78.724

ELEVATION OF GL = 78.02 m

W/L IN 2" BSP 10.30 on 20/2/87 = 1.21 BGL

" " 8" " " " = 0.81 BGL

DEPTH (M.BGL)	GRAIN SIZE ANALYSES (Sample No. and location)	LITHOLOGY	DEPTH (MBGL)	BOREHOLE CONSTRUCTION (Casing/screen/ gr. pack)	ELEVATION OF WATER M.AOD	DEPTH TO WATER M.BG L.	SYMBOLIC LOG	ELEVATION M. AOD	DEPTH M. BGL.	STRATIGRAPHIC UNITS
	MP1/1 0.0-0.3	Soft, dark brown (10YR3/3) silty clay loam						77.7	0.3	TOPSOIL
1	MP2/1 0.3-1.0	Firm, variegated yellowish red (5YR5/8) and light brownish grey (10YR6/2) sandy silty CLAY with sandstone and quartzite pebbles and coal fragments			77.25 ▽	0.77 ▽		77.0	1.0	
	MP2/2 1.0-1.2	Soft-firm, yellowish brown (10YR5/4) silty CLAY becoming sandy with depth						76.8	1.2	
	MP1/4 1.2-1.5	Soft Loose, variegated grey (10YR5/1) and yellowish brown (10YR5/8) Silty fine-medium quartz SAND						76.5	1.5	
2	MP2/3 1.5-2.3	Firm, greyish brown (2.5Y5/2) silty CLAY with occasional fine sandstone pebbles	1.7					76.3	1.7	
	MP2/5 2.3-2.6	Firm to stiff, brown (7.5YR4/2) silty CLAY, becoming more pebbly with depth	2.6					75.4	2.6	BOULDER CLAY
3	MP2/6 2.6-3.1	Dense, brown (7.5YR5/4) muddy, gravelly, fine-med quartz SAND with coarse coal sand fragments and coarse limestone and sandstone pebbles, becoming more gravelly towards base	3.1					74.9	3.1	
	MP2/7 3.1-3.3	Dense, brown (7.5YR5/4) muddy fine-med. quartz SAND	3.6					74.7	3.3	
	MP2/8 3.3-3.6	Soft-firm, greyish-brown (2.5Y5/2) CLAY End of borehole.						74.4	3.6	

PROJECT: SEARLE

BOREHOLE NO: MP3

DRILLING METHOD SHELL&AUGER

CLAY CUTTER FROM 0 M. TO 2.2 M.

.....FROM ....M. TO ..... M.

LOCATION

MORPETH.

G. REF.:.....

START DATE: 20/2/87.

COMPLETION DATE: 20/2/87.

CONTRACTOR M

WATER STRUCK. ROSE TO.

1.3 M.BGL. (26/2/87) 0.51 M.BGL.

.....M.BGL. .....M.BGL.

TOTAL DEPTH: 2.2 M.

CASING DIAMETER/TYPE:

200 MM FROM 0 M. TO 1.1 M., TYPE 5" WATER WELL

50 MM FROM 0 M. TO 1.25 M., TYPE 2" BSP

DRILLED DIAMETER

200 MM. FROM 0 M. TO 2.2 M.

..... MM. FROM ....M. TO .... M.

SCREEN DIAMETER/TYPE:

50 MM FROM 1.25 M. TO 1.95 M; TYPE/SLOT(MM) 2" BSP PIPE WITH 750 SLOTS/M

..... MM FROM ..... M. TO ..... M; TYPE/SLOT(MM) .....

SUMMARY OF AQUIFER CONDITIONS

HEIGHT OF 2" BSP AGL = 1.0

" " 8" WATER WELL CASING AGL = 0.50

ELEVATION OF TOP OF 2" BSP AOD = 79.02

WL IN 2" BSP 15.30 ON 20/2/87 = 0.84 BGL

ELEVATION OF G.L. = 78.02m

DEPTH (M.BGL)	GRAIN SIZE ANALYSES (Sample No. and location)	LITHOLOGY	DEPTH (MBGL)	BOREHOLE CONSTRUCTION (Casing/screen/gr. pack)	ELEVATION OF WATER M.AOD	DEPTH TO WATER M.BG.L.	SYMBOLIC LOG	ELEVATION M. AOD	DEPTH M. BGL.	STRATIGRAPHIC UNITS
		AS MP2.						77.7	0.3	SOIL
1		AS MP2			77.51 ▽	0.51 ▽				
		AS MP2	1.25					76.7	1.3	
			1.75					76.3	1.7	
2		End of borehole.						75.8	2.2	

PROJECT: SEAHILL

BOREHOLE NO: MP4

DRILLING METHOD SHELL & AUGER

CRM RADED CLAYCUTTER FROM 0 M. TO 2.6 M.

BAILER FROM 2.6 M. TO 3.5 M.

CLAYCUTTER 3.5 7.9

BAILER 7.9 9.2

WATER STRUCK. ROSE TO.

10 M.BGL. 11:14 - 21/2/87 1.07 M.BGL.

2.6 M.BGL.

7.9 M.BGL. 24/2/87 7.7 M.BGL.

TOTAL DEPTH: 9.2 M.

LOCATION

MORPETH

G. REF.:

START DATE: 20/2/87

COMPLETION DATE: 22/2/87

CONTRACTOR IH

CASING DIAMETER/TYPE:

250 MM FROM 0 M. TO 1.7 M., TYPE 10" WATER WELL CASING

200 MM FROM 0 M. TO 6.25 M., TYPE 8" "

50 MM FROM 0 M. TO 8.65 M., TYPE

DRILLED DIAMETER

250 MM. FROM 0 M. TO 2.6 M.

200 MM. FROM 2.6 M. TO 3.5 M.

SCREEN DIAMETER/TYPE:

50 MM FROM 8.65 M. TO 9.15 M; TYPE/SLOT(MM) 2" RSP

..... MM FROM ..... M. TO ..... M; TYPE/SLOT(MM) .....

SUMMARY OF AQUIFER CONDITIONS

HEIGHT OF 2" BSP AGL = 1.14
HEIGHT OF 8" WATER WELL CASING = 0.6
HEIGHT OF 10" WATER WELL CASING = 0.6
ELEVATION OF TOP OF 2" RSP HOD = 79.157

ELEVATION OF G.L. = 78.06 m

DEPTH (M.BGL)	GRAIN SIZE ANALYSES (Sample No. and location)	LITHOLOGY	DEPTH (M GL)	BOREHOLE CONSTRUCTION (Casing/screen gr. pack)	ELEVATION OF WATER M.AOD	DEPTH TO WATER M.BG L.	SYMBOLIC LOG	ELEVATION M. A.D	DEPTH M. BGL.	STRATIGRAPHIC UNITS
		As MP2.						77.7	0.3	
		Sandy CLAY (As MP2)								
1		CLAY. (As MP2)						77.1	0.9	
								77.0	1.0	
		SAND (As MP2)						76.5	1.5	
		CLAY (As MP2)	1.7							
2								75.4	2.6	
		SAND (As MP2)								
3								75.0	3.0	
	MP4/1 2.6-3.5	Soft to firm, dark grey (N4) very silty CLAY with sandstone, and limestone pebbles and coal fragments.								

BOREHOLE NO. MP4

DEPTH (M. BGL)	GRAIN SIZE ANALYSES (Sample No. and location)			DEPTH (M. BGL)	BOREHOLE CONSTRUCTION (casing/screen/gr. pack)	ELEVATION OF WATER M. AOD	DEPTH TO WATER M. BGL	SYMBOLIC LOG	ELEVATION M. AOD	DEPTH M. BGL	STRATIGRAPHIC UNITS
4	MP4/1 3.8-4.1	D	Soft dark greyish brown (2.5Y4/2) muddy, fine-med SAND with med gravel						74.2	3.8	
	MP4/1 4.1-4.3		Soft-Firm, dark grey (N4) clayey SILT with silty clay laminae.						74.1	3.9	
	MP4/1 4.3-4.9		Soft, olive yellow (2.5Y6/6) very silty fine-med SAND with dark grey (N4) clay laminae.						73.9	4.1	
5	MP4/1 4.9-5.5		Soft, dark grey (10YR4/1) clayey SILT with sand laminae and occasional dolerite and limestone pebbles.						73.7	4.3	
6	MP4/2 5.5-6.5		Stiff, very dark grey (N3) silty CLAY with sandstone and limestone pebbles						73.1	4.9	BOULDER CLAY
7	MP4/2 6.5-7.5		Firm, very dark grey (N3) very silty CLAY with limestone and sandstone pebbles						72.1	5.9	
8	MP4/2 7.5-8.5		Stiff, very dark grey (N3) silty CLAY with mainly weak yellowish (10YR8/8) fine-coarse gritstone pebbles.			70.83	7.19		71.2	6.8	
	MP4/2 8.5-8.9		Stiff, dark brown (7.5YR4/4) silty CLAY with reddish yellow (7.5YR7/8) sandstone pebbles						70.5	7.5	
	MP4/2 8.9-9.1		Mod. strong yellow (10YR7/6) med-coarse SANDSTONE						70.1	7.9	
9	MP4/2 9.1-9.2		Weak, weathered yellowish brown (10YR5/4) SANDSTONE						69.9	8.1	MILLSTONE GRIT
	MP4/2 9.2-9.4		Mod. weak, weathered, brownish yellow (10YR6/8) SANDSTONE						69.4	8.6	
			End of borehole (9.2)						68.8	9.2	

PROJECT: SEARLE

BOREHOLE NO: MP5

DRILLING METHOD SHELL&AUGER

CLAYCUTTER ..... FROM 0 M. TO 4.1 M.

..... FROM .... M. TO ..... M.

LOCATION

MORPETH

G. REF.: .....

START DATE: 23/2/87

COMPLETION DATE: 23/2/87

CONTRACTOR IH

WATER STRUCK. ROSE TO.

3.9 M.BGL. (25/2/87) 2.40 M.BGL.

..... M.BGL. ..... M.BGL.

TOTAL DEPTH: 4.1 M.

CASING DIAMETER/TYPE:

200 MM FROM 0 M. TO 1.7 M., TYPE 8" WATER WELL CASING

50 MM FROM 0 M. TO 3.6 M., TYPE 2" BSP

DRILLED DIAMETER

200 MM. FROM 0 M. TO 4.1 M.

..... MM. FROM .... M. TO .... M.

SCREEN DIAMETER/TYPE:

50 MM FROM 3.6 M. TO 4.1 M: TYPE/SLOT(MM) 2" BSP PERF WITH TERRAM

..... MM FROM ..... M. TO ..... M: TYPE/SLOT(MM) .....

DEPTH (M.BGL)	GRAIN SIZE ANALYSES (Sample No. and location)	SUMMARY OF AQUIFER CONDITIONS / LITHOLOGY	DEPTH (M.BGL)	BOREHOLE CONSTRUCTION (Casing/screen / gr. pack)	ELEVATION OF WATER M.AOD	DEPTH TO WATER M.BG L.	SYMBOLIC LOG	ELEVATION M. AOD	DEPTH M. BGL.	STRATIGRAPHIC UNITS
		ELEVATION OF TOP OF 2" BSP TOB = 80.709 TOP OF 8" CASING = 0.03 AGL TOP OF 2" BSP = 0.75 AGL. ELEVATION OF G.L. = 79.96 m Made Ground						79.3	0.7	
1	MP5/1 0.9-1.2	Loose, yellowish red (5YR5/8) silty fine SAND						78.8	1.2	
2	MP5/2 1.2-2.0	Loose, reddish yellow (7.5YR6/8) silty fine SAND	1.7					78.0	2.0	
	MP5/3 2.0-2.4	Soft, brown, (7.5YR5/2) thinly laminated sandy clayey SILT			77.56	2.40		77.6	2.4	
	MP5/4 2.4-2.8	Loose, strong brown (7.5YR5/6) silty fine SAND						77.3	2.7	
	MP5/5 2.7-3.6	Soft, dark greyish brown (10YR4/2) very clayey sandy SILT	3.6					76.4	3.6	BOULDER CLAY

BOREHOLE NO. MP 5.

DEPTH (M. BGL)	GRAIN SIZE ANALYSES (Sample No. and location)			DEPTH (M. BGL)	BOREHOLE CONSTRUCTION (casing/screen/gr. pack)	ELEVATION OF WATER M. AOD	DEPTH TO WATER M. BGL	SYMBOLIC LOG	ELEVATION M. AOD	DEPTH M. BGL	STRATIGRAPHIC UNITS		
			Loose, light olive brown (2.5Y5/4) very silty fine SAND						76.1	3.9			
4			Stiff, dark grey (N4) very silty CLAY with sandstone and limestone pebbles	4.1					75.9	4.1			
			End of borehole.										

PROJECT: SEAHLE

BOREHOLE NO: MP6

DRILLING METHOD SHELL&AUGER

CLAY COTTER FROM 0 M. TO 4.5 M.

BAILER FROM 4.5 M. TO 4.7 M.

LOCATION

MORPETH.

G. REP.:

START DATE: 23/2/87

COMPLETION DATE: 24/2/87.

CONTRACTOR IH

WATER STRUCK. ROSE TO.

4.5 M.BGL. (25/2/87) 1.65 M.BGL.

M.BGL. M.BGL.

TOTAL DEPTH: 4.7 M.

CASING DIAMETER/TYPE:

200 MM FROM 0 M. TO 1.6 M., TYPE 6" NAPER WELL CASING

50 MM FROM 0 M. TO 4.2 M., TYPE 2" BSP

DRILLED DIAMETER

200 MM. FROM 0 M. TO 4.5 M.

150 MM. FROM 4.5 M. TO 4.7 M.

SCREEN DIAMETER/TYPE:

50 MM FROM 4.2 M. TO 4.7 M; TYPE/SLOT(MM) 2" BSP PERF WITH TERAM.

MM FROM M. TO M; TYPE/SLOT(MM)

SUMMARY OF AQUIFER CONDITIONS

ELEVATION OF TOP OF 2" BSP AOD = 78.648

TOP OF 8" CASING = 0.12 AGL

TOP OF 2" BSP = 0.12 AGL

ELEVATION OF GL = 78.53 m

DEPTH (M.BGL)	GRAIN SIZE ANALYSES (Sample No. and location)	LITHOLOGY	DEPTH (MBGL)	BOREHOLE CONSTRUCTION (Casing/screen / gr. pack)	ELEVATION OF WATER M.AOD	DEPTH TO WATER M.BG L.	SYMBOLIC LOG	ELEVATION M. AOD	DEPTH M. BGL.	STRATIGRAPHIC UNITS
		Topsoil						78.2	0.3	
1	MP6/1 0.3-0.9	Stiff, strong brown (7.5YR5/6) silty CLAY with sandstone and limestone pebbles and coal fragments						77.6	0.9	
	MP6/2 0.9-1.3	As above becoming strong brown (7.5YR4/6)						77.2	1.3	
	MP6/3 1.3-1.8	Stiff, brown (7.5YR 4/2) CLAY			76.88	1.65		76.7	1.8	
2	MP6/4 1.8-2.5	As above, with some sandstone pebbles and coal fragments.						76.0	2.5	BOULDER CLAY
3	MP6/5 2.5-3.0	Firm, dark grey (N4) silty CLAY						75.5	3.0	
	MP6/6 3.0-3.6	Stiff, dark grey (N4) very silty CLAY with occasional sandstone pebbles						74.9	3.6	

BOREHOLE NO. MP6

DEPTH (M.BGL)	GRAIN SIZE ANALYSES (Sample No. and location)			DEPTH (M. BGL)	BOREHOLE CONSTRUCTION (casing/screen/gr. pack)	ELEVATION OF WATER M. AOD	DEPTH TO WATER M. BGL	SYMBOLIC LOG	ELEVATION M. AOD	DEPTH M. BGL	STRATIGRAPHIC UNITS		
4	MP6/4 3.6-4.5		Soft, dark greyish brown (2.5Y4/2) clayey SILT	4.2					7.40	4.5			
	MP6/5 4.5-4.7		Stiff, dark grey (N4) SILTY CLAY.	4.7					7.38	4.7			
5			End of borehole										

PROJECT: SEARLE

BOREHOLE NO: MP7

DRILLING METHOD: HEAD AUGER

CLAY CUTTER FROM 0 M. TO 0.67 (6.3) M.

CHISELLING FROM 0.6 M. TO 1.6 M.

LOCATION: MORPETH

G. REF.:

START DATE: 24/2/87

COMPLETION DATE: 24/2/87

CONTRACTOR: 14

WATER STRUCK: DAMP. 4.8-5.3 (24/2/87) ROSE TO: 5.77 M.BGL.

..... M.BGL. ..... M.BGL.

..... M.BGL. ..... M.BGL.

TOTAL DEPTH: 6.3 M.

CASING DIAMETER/TYPE:

200 MM FROM 0 M. TO 1.6 M., TYPE 6" WATER WELL CASING

50 MM FROM 0 M. TO 5.8 M., TYPE 2" BSP

DRILLED DIAMETER

200 MM. FROM 0 M. TO 6.3 M.

..... MM. FROM .... M. TO .... M.

SCREEN DIAMETER/TYPE:

50 MM FROM 1.8 M. TO 6.3 M: TYPE/SLOT(MM) 2" BSP PERF L.27 SLOTTED.

..... MM FROM ..... M. TO ..... M: TYPE/SLOT(MM) .....

SUMMARY OF AQUIFER CONDITIONS

HEIGHT OF 2" BSP AGL = 0.83

ELEVATION OF TOP OF 2" BSP = 82.936

ELEVATION OF G.L. = 82.11 m

DEPTH (M.BGL)	GRAIN SIZE ANALYSES (Sample No. and location)	LITHOLOGY	DEPTH (MBGL)	BOREHOLE CONSTRUCTION (Casing/screen / gr. pack)	ELEVATION OF WATER M.AOD	DEPTH TO WATER M.BG L.	SYMBOLIC LOG	ELEVATION M. AOD	DEPTH M. BGL.	STRATIGRAPHIC UNITS
		Topsoil								
1	MP7/1 0.2-0.6	Made Ground (Soft-firm, very dark grayish brown very silty CLAY)						81.5	0.6	
	MP7/2 0.6-1.4	Made Ground (Strong, very pale yellow (10YR7/4) crushed dolomite)						80.7	1.4	
2	MP7/3 1.4-2.2	Made Ground (Firm, very dark grey (N3) very silty CLAY)	1.6					79.9	2.2	
3	MP7/4 2.2-3.1	Made Ground (Soft, very dark grey (N3) very clay SILT)						79.0	3.1	
	MP7/5 3.1-4.0	Firm, yellowish red (5YR5/8) silty CLAY with grey (N6) mottles.								

BOREHOLE NO. MP7

DEPTH (M.BGL)	GRAIN SIZE ANALYSES (Sample No. and location)			DEPTH (M. BGL)	BOREHOLE CONSTRUCTION (casing/screen/gr. pack)	ELEVATION OF WATER M. AOD	DEPTH TO WATER M. BGL	SYMBOLIC LOG	ELEVATION M. AOD	DEPTH M. BGL	STRATIGRAPHIC UNITS		
4	MP7/6 4.1-4.8		Soft-firm, dark brown (7.5YR 4/2) CLAY						28.1	4.0			
									27.3	4.8			
5	MP7/8 4.8-5.2		Soft dark greyish brown (2.5Y4/2) sandy clayey SILT						26.8	5.3			
	5.33/54		Soft-firm very dark grey (N3) very silty CLAY						26.7	5.4			
	MP7/9 5.4-5.9		Soft, dark greyish brown (2.5Y4/2) sandy clayey SILT			26.34 ▽	5.37 ▽		26.2	5.9			
6	MP7/10 5.9-6.3		Stiff, very dark grey (N3) sandy very silty CLAY End of borehole						25.8	6.3			

PROJECT: SEARLE

BOREHOLE NO: MAP

DRILLING METHOD SHELL & HAMMER

SHELL & HAMMER FROM 0 M. TO 2.5 M.

CRM BLADED CLAY CUTTER FROM .... M. TO ..... M.

LOCATION: MORPETH

G. REF.: .....

START DATE: 26/2/87

COMPLETION DATE: 26/2/87

CONTRACTOR: IH

WATER STRUCK. ROSE TO.

0.5 M.BGL. 0.5 M.BGL.

damp 3.0-3.7M.BGL. (26/2/86) 3.13 M.BGL.

TOTAL DEPTH: 3.9 M.

CASING DIAMETER/TYPE:

200 MM FROM 0 M.TO 2.3 M., TYPE 8" WATER WELL

50 MM FROM 0 M.TO 3.1 M., TYPE 2" BSP

DRILLED DIAMETER

200 MM. FROM 0 M. TO 3.9 M.

..... MM. FROM .... M. TO .... M.

SCREEN DIAMETER/TYPE:

50 MM FROM 3.15 M. TO 3.65 M: TYPE/SLOT(MM) 2" BSP PERF U.T.F. TERRAM

..... MM FROM ..... M. TO ..... M: TYPE/SLOT(MM) .....

SUMMARY OF AQUIFER CONDITIONS

HEIGHT OF 2" BSP AGL = 0.26

HEIGHT OF 8" WATERWELL CASING AGL = 0.20

ELEVATION OF TOP OF 2" BSP AOD = 82.82

ELEVATION OF G.L. = 82.56 m

DEPTH (M.BGL)	GRAIN SIZE ANALYSES (Sample No. and location)	LITHOLOGY	DEPTH (MGL)	BOREHOLE CONSTRUCTION (Casing/screen / gr. pack)	ELEVATION OF WATER M.AOD	DEPTH TO WATER M.BG L.	SYMBOLIC LOG	ELEVATION M. AOD	DEPTH M. BGL.	STRATIGRAPHIC UNITS
		Topsoil						82.4	0.2	
1	MAP/1 0.2-0.5	Made round. (crushed dolerite).								
								81.1	1.5	
2	MAP/2 1.5-2.0	Made Ground (firm, greyish brown (2.5Y5/2) silty CLAY and crushed dolerite)						80.6	2.0	
	MAP/3 2.0-2.5	Stiff, brown (7.5YR5/4) and grey (N5) mottled silty CLAY with sandstone pebbles	2.3					80.1	2.5	Boulder Clay
3	MAP/4 2.5-3.0	Soft-firm, olive grey (5Y5/2) very silty CLAY						29.6	3.0	
	MAP/5 3.0-3.5	Soft, olive (5Y4/3) sandy clayey SILT with acetone odour	3.15		79.46	3.13				

BOREHOLE NO. MP8

DEPTH (M. BGL)	GRAIN SIZE ANALYSES (Sample No. and location)			DEPTH (M. BGL)	BOREHOLE CONSTRUCTION (casing/screen/gr. pack)	ELEVATION OF WATER M. AOD	DEPTH TO WATER M. BGL	SYMBOLIC LOG	ELEVATION M. AOD	DEPTH M. BGL	STRATIGRAPHIC UNITS		
									78.9	3.7			
3.7 3.9			Firm, dark grey (5Y4/1) and yellowish brown (10YR5/6) very clayey SILT						78.7	3.9			
			End of borehole										

Sources of Information

1. IH Drilling Programme 16 - 27 Feb 1987. Ref Nos MP1 - MP8

(a) Eight boreholes, light percussion rig 6" diam. NE Area

Six locations : Six shallow MP2, 3, 5, 6, 7, 8

Two deep MP1, 4

MP1 E of warehouse for lithological information

MP2, 3, 4 N. drilled, initial contaminant investigation wells

MP5, 6 final N of effluent plant

MP7 adjacent to existing piezometer NE4 in fill area at NE corner of Chem Plant 4.

MP8 in fill area between Chem Plant 2 and 4.

Two-inch galvanized steel piezometers with 0.5m perforated tip wrapped in terram installed in MP2 - MP8. MP1 left as open hole. All sites purged by siphoning and levelled in.

(b) 17 water samples : 4 surface water, 13 groundwater

Surface water 2 from N. boundary ditch; upstream of land drain from factory, downstream of drain at NE corner.

2 upstream and downstream ends of land drain

Groundwater 2 (at different times) from existing standpipe (N3?) in N. corner of field

11 from MP1 - 8, NE3, NE4. Includes sample from shallow water in dolerite fill and silt layer on basal grey clay at MP8

and at water struck at MP6.

Samples obtained by syringe or siphon.

Six samples - measurements of T, EC, pH

Eleven " - methanol/acetone, carried out by Analytical and Technical Services, Newcastle

Four " - COD analysis

Major ion analysis of high EC water at MP6.

2. Existing Information

Ten site investigation reports with records of 47 boreholes:

Gibert Ash - pre-site survey (5)

Geo Research - Jun 1967 (5)

Soil Surveys - Nov 1967 (10)

Soil Engineering Services - Nov 1982 and Apr 1983 (8)
Nov 1984 " Oct/Nov 1985 (11)

Dailey, Son and Clark - Sep 1985 (8)

[Only 9 of these boreholes occur in the NE area around Chem Plants 1 to 4. Most were drilled by light percussion rig at 6" diam to varying depths. Generally ground level elevation was not recorded and ground levels have been altered by subsequent construction of buildings. Water levels may be unreliable due to the slow inflow of water. Including 2 IH boreholes (MP1, MP4) there are 23 boreholes with ~~depths~~ bedrock depth information.]

Topographic map 1:50000 Sheet 81 (Alnwick and Rothbury)

Site Map of Ground Investigation Boreholes 1:750 Dec 1986 (Ref 3251)

Site Services Map NE 1:250 (Ref S/C/1331)

Effluent and Toxic Drainage NE 1:250 (Ref S/C/1011)

Report on Effluent Drainage System Tests

Various maps of Chem Plant foundation structures

Geological Survey Memoir Sheet 9, 10 (Rothbury, Amble and Ashington)

(3) Other

1H samples @ 0.5m intervals

Grain size analyses (to date) MP2 3 samples 1.2 - 3.3m depth

MP4 2 " 3.3 - 4.3m "

Recovery tests 4 sites MP2, 3, 5, 6

Water level data from 10 boreholes during IH programme (8 IH wells, NE3, NE4, KH) taken before and subsequent to recovery test pumping mainly between 23 and 27 Feb 1987 [ab water levels show a slow recovery to equilibrium after drilling and heavy rain occurred for about 6 hours during the afternoon and evening of 26 Feb]