SITE INVESTIGATIONS:

A survey in the North Wirral Coastal Area

by
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April 1981

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THE UNIVERSITY OF LIVERPOOL

DEPARTMENT OF BUILDING ENGINEERING

Site Investigations :

A Survey in the North Wirral Coastal Area.

by

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Dissertation submitted in partial fulfilment of the requirements for the Degree of B.Eng. with Honours in Building Engineering (Construction Engineering or Services Engineering)

Date : April 1981

Contents

A C K N O W L E D G E M E N T S

The author wishes to express his sincere thanks to his supervisor Mr. R. J. Kenna, Liverpool University for his assistance and advice in the compilation of this dissertation.

Also many thanks to Dr. G. Raybould, Merseyside Engineering Department who provided valuable information used in this survey.

A special thanks to my Departmental supervisor Mr. B. Whitehead for monitoring the general progress of the survey work.

ABSTRACT

The aim of this dissertation is to show that even with a basic knowledge of the geology of a region, site investigations (soil surveys) are still essential in making decisions for the design and construction of foundations.

Sites in the North Wirral Coastal area are used to illustrate this.

The cost of such site investigations in relation to the total cost of construction work is analysed.

Consideration is given to the problem of deciding on the scale of site investigations that are needed for particular type of geological areas and the type of superstructure before commencing the design of the foundations.

Another aim of the dissertation is to construct a general geological section along a projected straight line passing through the surveyed sites, the purpose of which is to assist the engineer in any future preliminary studies for construction on sites along this section.

This general section proved the presence of a buried channel in the North Wirral Coastal area.

The North Wirral Coastal area was chosen on the advice of Mr. R. J. Kenna, Liverpool University, because of the variety of geological strata in a relatively compact area.

On the drift geological map of the region the complex changes in stratagraphy are not readily apparent and site investigations are shown to be essential on much of the selected area.

The cost of site investigations is found to be about 0.3% to 0.5% of the total cost of the construction works.

1. Introduction

1.1 Objectives of Site Investigations :

A site investigation, or soil survey. is an essential preliminary to the design stage of the construction of all building or civil engineering works in order to obtain information regarding the sequence of the strata and the ground water levels, and also to collect samples for identification and testing.

The main objectives of such an investigation are listed in the British Standard Code of Practice CP 2001 (1957) 'Site Investigations' as:

(i) To assess the general suitability of the site for the proposed works.

(ii) To enable an adequate and economic design to be prepared.

(iii) To foresee and provide against difficulties that may arise during construction due to ground and other local conditions.

(iv) To investigate the occurance or causes of all natural or created changes of conditions and the results arising therefrom.

In addition to the above objectives, the site investigation is necessary in reporting upon the safety of existing works and in investigating causes when failure has occurred in the existing structures, and to assess the suitability of materials for use as a fill material.

1.2 The Process of Site Investigations.

Site investigations should follow the following order:

A. Preliminary investigations (usually described as the desk study):

In this the engineer studies all available geological reports and maps on the local area, and any site investigation reports on nearby sites.

The aim of this preliminary stage is to give a general idea on the distribution of soils and rock and whether disturbed ground exists, and to show the scale of the future field and laboratory tests that would be needed.

A test trial pit may be made in the site to help at this stage (A trial pit is simply a hole dug in the ground large enough for a ladder to be inserted, thus permitting a close examination of the sides).

On the North Wirral Coastal area this may be difficult due to high water table.

B. Field Investigations: Setting out of trial pits and/or boreholes and collecting disturbed and undisturbed samples for laboratory tests, obtaining ground water levels.

The main excavation and boring methods are: Trial pits and headings, Hand and powered augers, Wash boring and the 'shell and auger' drilling (The most common).

C. Laboratory Tests

Examination of samples obtained from previous field investigation stage.

Laboratory tests such as : Triaxial tests, Consolidation tests, Sulphates analyses of ground water and moisture content measurement.

D. Field Measurements: Such as Plate loading test, The 'Van Shear' test, The 'Dutch' static cone penetrometer, The pressuremeter and the standard penetration tests.

For a small cheap structure such as low rise housing estates only step 'A' might be needed with a small number of boreholes particularly if ground conditions are good.

For a more extensive structure such as medium rise office buildings, stages A, B and C would be needed, the number of boreholes would be determined by the conditions found in the first boreholes.

For a more complicated or potentially dangerous structure such as a dam, bridges and atomic reactors, all stages should be carried out extensively.

Before all the above stages are investigated, a visit to the proposed site is advised and important. Differences in vegetation often indicate changes in sub soil conditions and any cutting, quarry or river on or near the site should be examined. e.g. On the North Wirral brick pits are adjacent to a new housing areas.

At times there may be visible evidence of ground subsidence, springs or other evidence of high ground water tables, and these features may be useful in determining the scale of site investigations required.

Size of nearby buildings and roads should be noted as well to allow for future machinery transport to the site and this is important for sites in the centres of busy cities.

Maps of services such as gas, electricity, water supply and sewage for the area should be examined, boring through these would obviously be extremely dangerous and costly.

1.3 Preliminary investigations (Desk study)

Geophysical Methods

I found the following to be of importance to help at this stage:

1. Topographical maps : Ordinance Survey maps are currently widely available at 1:50000 scale and at 6 inch and 25 inch to the mile.
2. Geological maps, 1:50.000 and 6 inch series : These are available in three variations
   - a) Drift : Chart the outcrops of all known deposits at ground level.
   - b) Solid : giving only the details of the solid recognisable strata below any transported materials such as alluvium or blown sand.
   - c) Solid and drift : essentially similar to drift maps but also shows the boundaries of solid deposits beneath any drift.
3. The geological Regional Guides and Sheet Memoirs : Regional guides are available from the geological museums and provide brief descriptions of the strata shown on the 1:50,000 geological maps.
4. Mining History : Records of mining from 1860 are kept by the National Coal Board and their geology departments should be contacted whenever risk of subsidence is suspected.

The Institute of Geological Sciences have borehole records in many parts of the country.

5. Historic Data Collection :
   Any records of landslides, subsidence, refuse tipping etc. may be held in a number of uncoordinated places such as local Universities, libraries, geological societies and museums.

6. Previous site investigation reports :
   May be available for adjacent or nearby sites, but this source is the hardest to track down. (Contractors and Consultants often charge for their reports).

1.4 Site Investigations and Foundation Design

Since foundation design is of importance in all engineering works, a knowledge of the nature and behaviour of the geological deposits of a chosen site is a primary in the planning of those works.

Since geological deposits are a product of nature, hard and fast rules, or formula can only be applied to them to a limited degree. It is therefore unsafe to assume that conditions found at one site persist beyond the area being examined, even if this appears so from the geological maps, and each site should be regarded as a problem in itself and so checked up and investigated by the methods explained before, so that there can be no doubt that the deposits exist in conditions capable of supporting the loads to be applied and that any excavations will remain stable.

The selection of type of foundation depends on a number of factors such as shape and type of superstructure, availability of construction materials and others, but eventually the type of foundation depends on the geological and engineering properties of the soils and rock of the particular site.

Any delay in the future of the project because of unexpected foundation problems due to the lack of enough subsurface data, will cost the Contractor or owner a great deal in lost time and delayed income. This highlights the value of a thorough site investigation, the cost of which will be shown to be insignificant in relation to the cost of the total works.

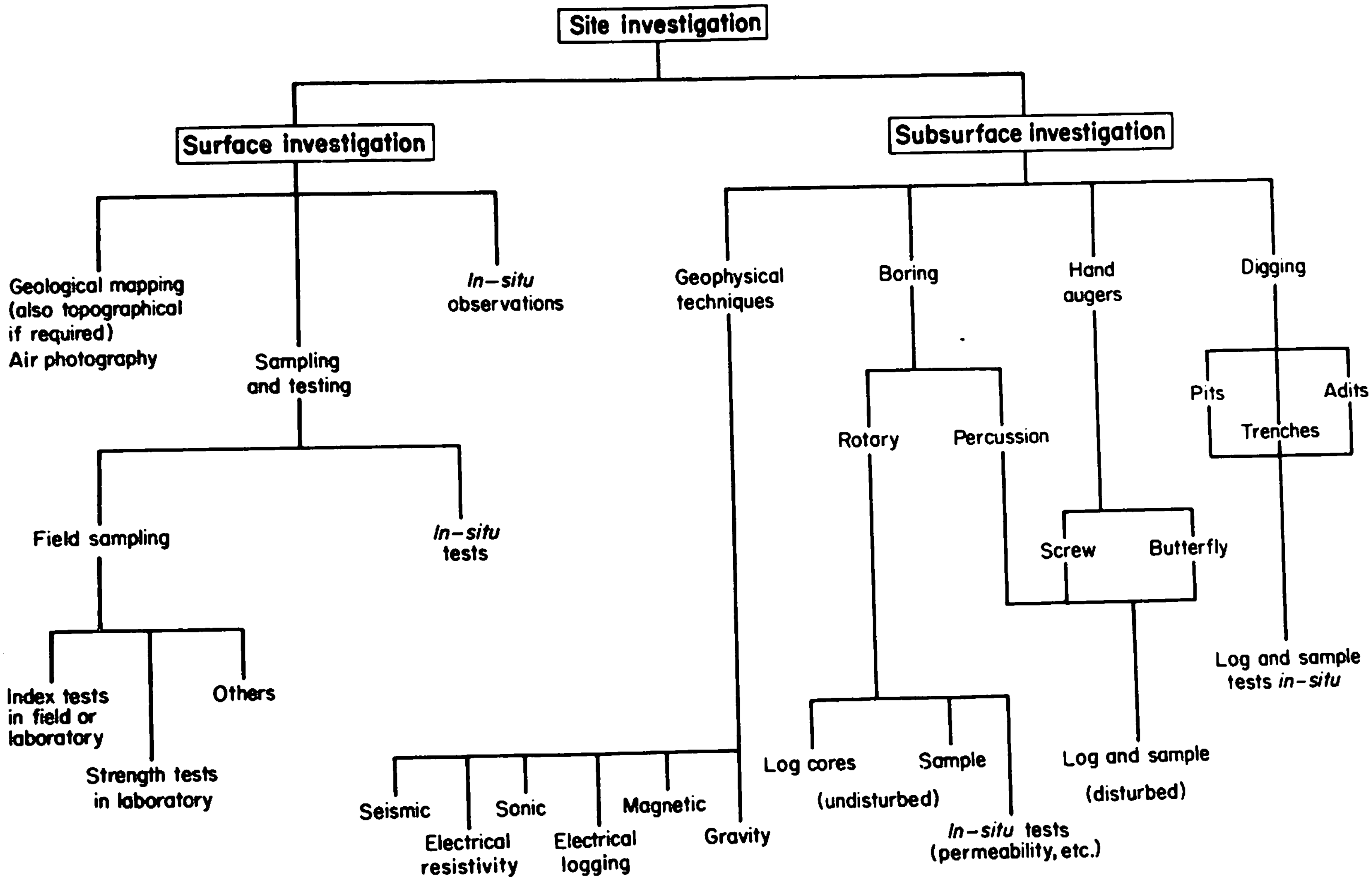


Fig.1. Shows the organisation of a complete site investigation.

2. THE SURVEY

2.1 Method of Study :

Before the start of the survey, the location of the sites to be visited was obtained from different sources and two sites I found while surveying the North Wirral area.

Ten different sites in total were visited. On-sites were possible. I discussed with the engineer or agent any particular difficulties in relation to the construction of the foundations of that site.

The sites were chosen to show how different geological and soil conditions determined the types of foundations required on the North Wirral Coastal area.

See Map 1 for Positions of Sites.

2.2 Results of Survey :

Map 2 shows the position of the boreholes on the sites.

For every site. The borehold profile was drawn from the borehole records the surface levels of each site are related to Ordnance Datum.

Where boreholes had not been levelled, estimated levels have been used from the Ordnance Survey maps.

Then the stratagraphical sections have been drawn from the borehole profile. See sections A, B, C, D, E and F.

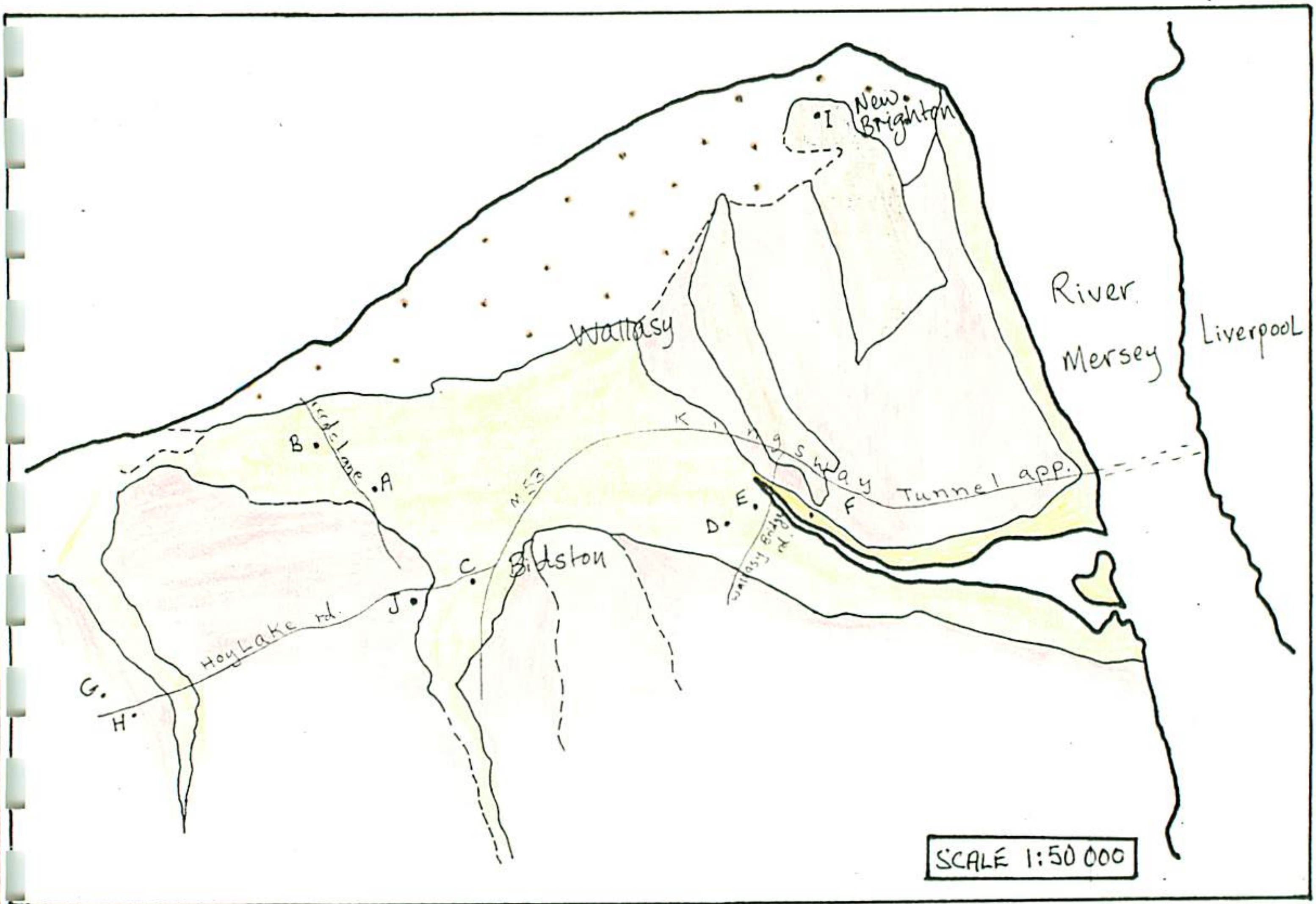
From these separate profiles a main section has been constructed which shows all geological successions along the line of section. See Map 3.

See Appendix 1 for notations and symbols used in sections maps.

Appendix 2 shows plates 1 to 8 taken from some of the sites visited.

MAP SHOWING POSITIONS OF SITES VISITED

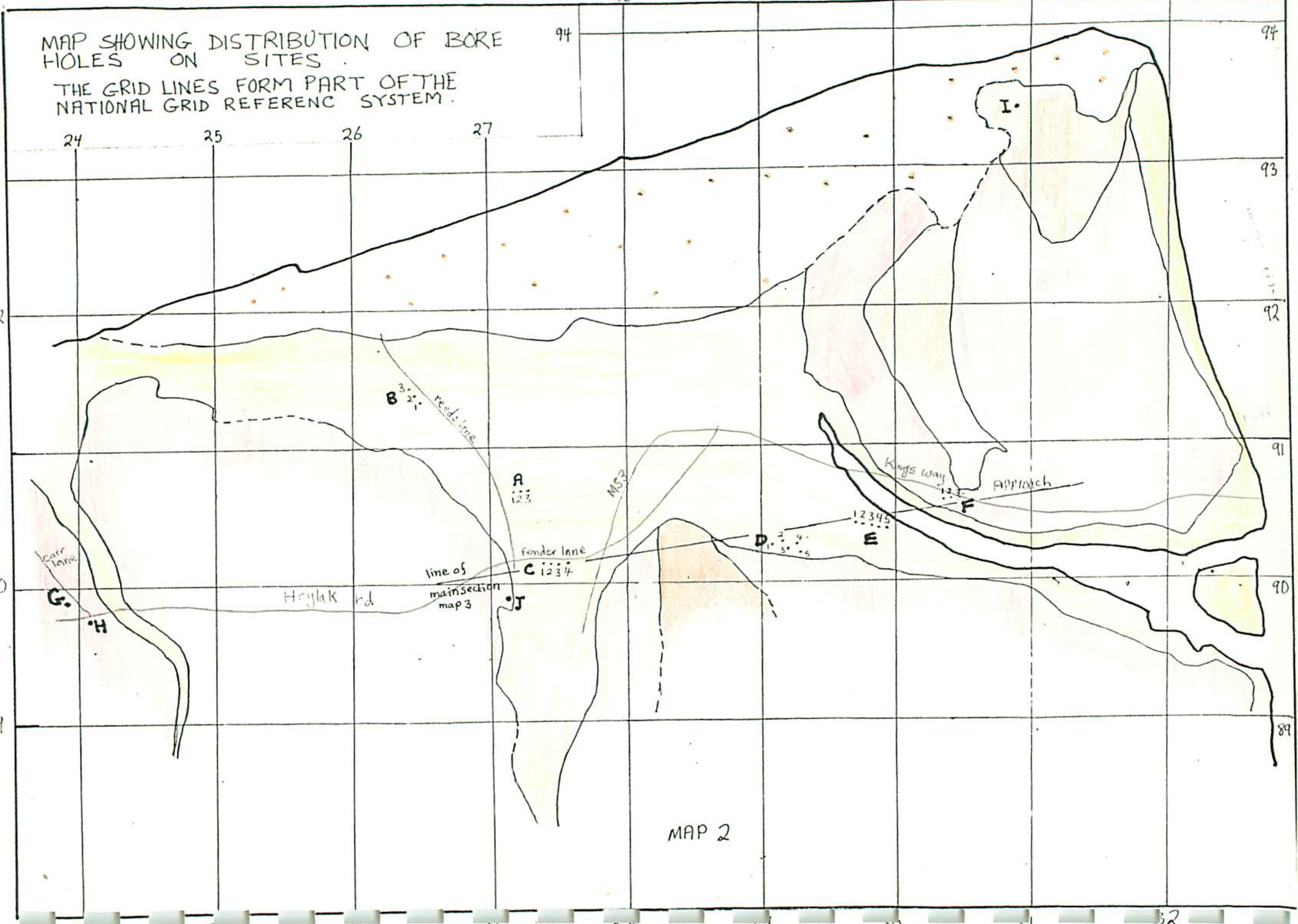
MAP 1



Site.	Name	Site Position on National grid system see map 2
A	Squibbs	273 908
B	Reeds Lane	264 915
C	Fender Bidston	275 903
D	Bidston Railway sidings	293 904
E	Bidston moss	298 904
F	Bidston gas works	305 906
G	Carr lane	239 899
H	Hoylake lane	241 898
I	New Brighton	309 934
J	Barratts	271 899

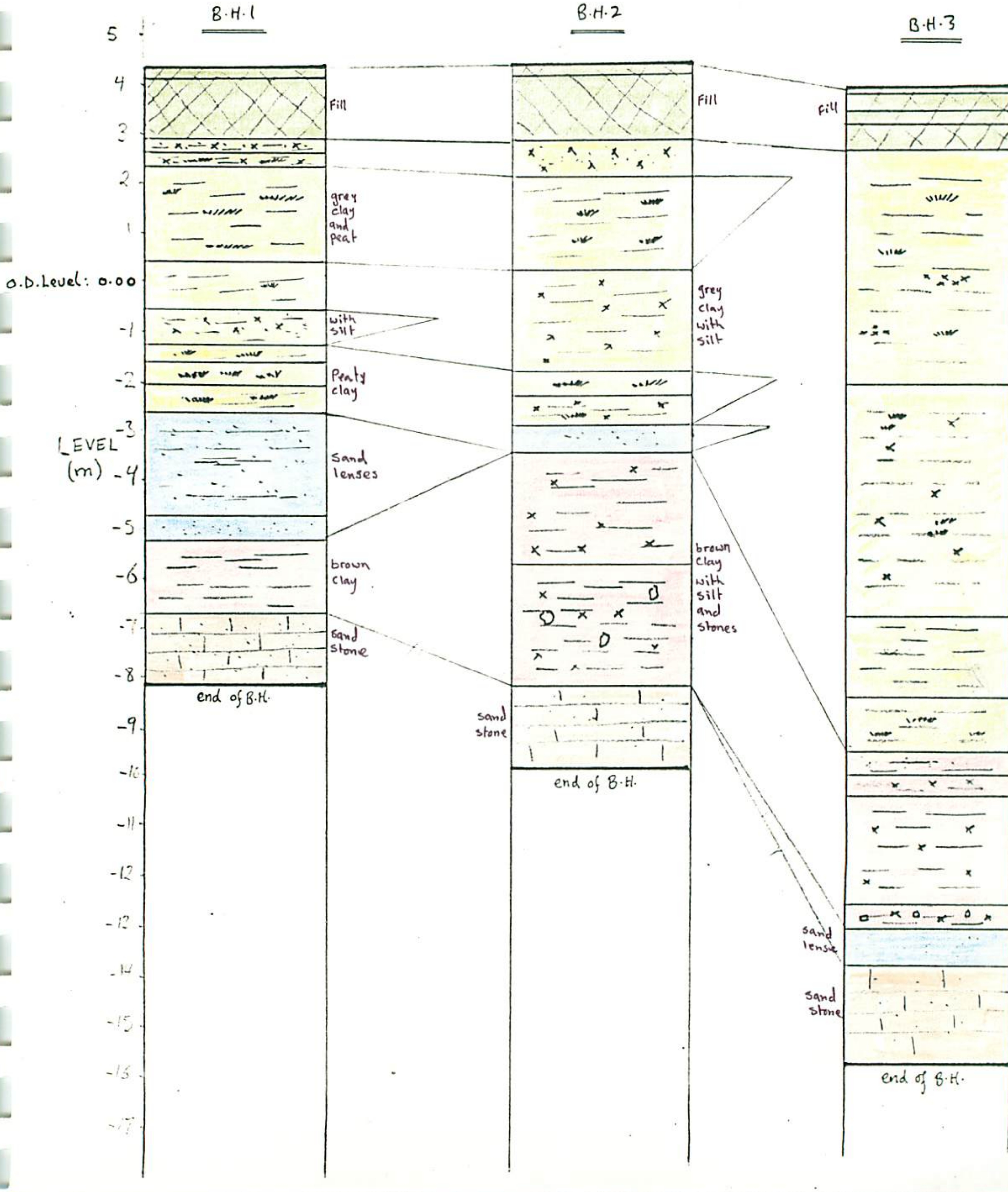
· · · (dots)	Recent Blown Sand
(yellow)	Post glacial Alluvium
(pink)	Glacial Boulder Clay
(beige)	Trias, Keuper Basment Beds

Explanation of geological Colours.

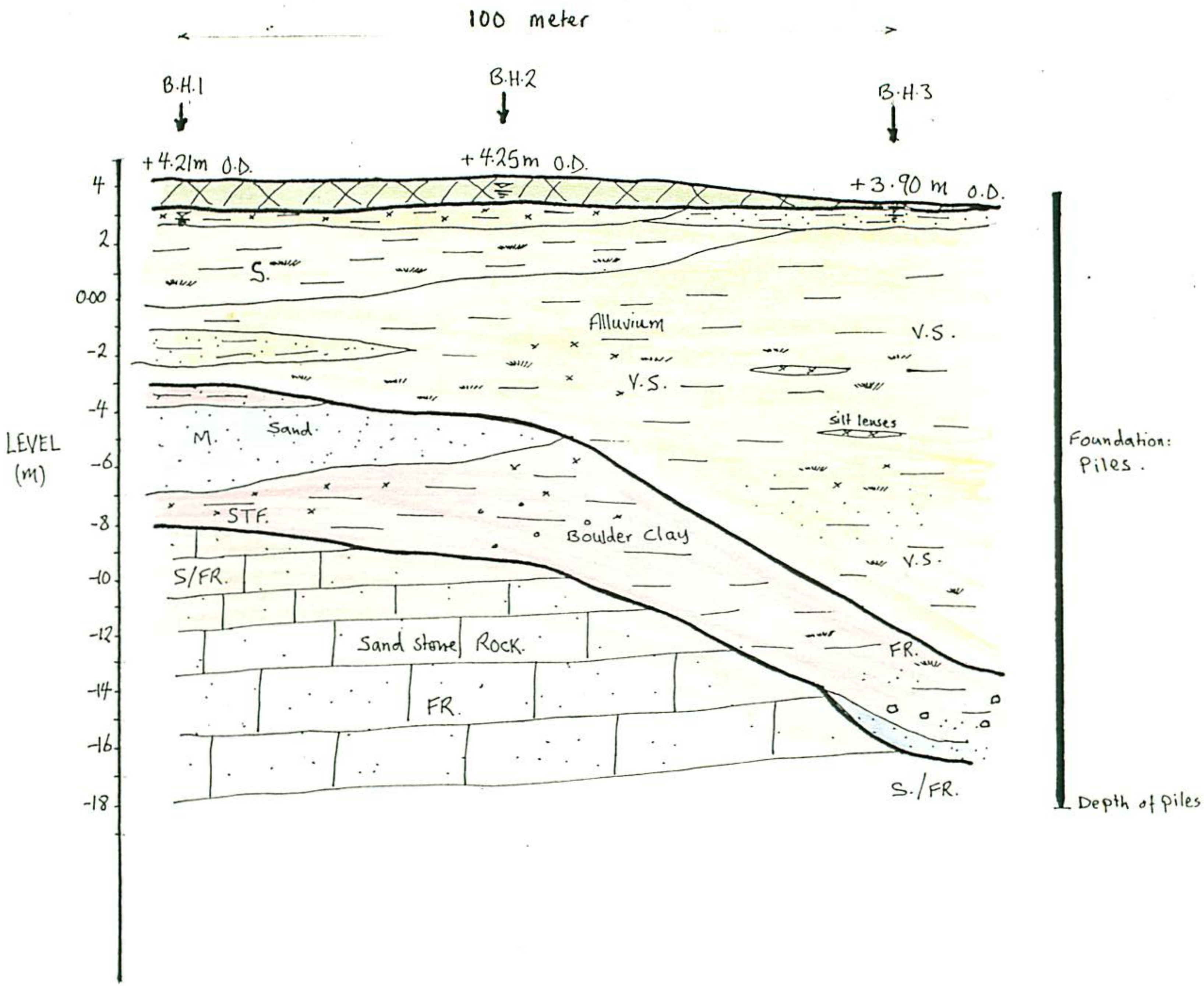

MAP SHOWING DISTRIBUTION OF BORE HOLES ON SITES.
THE GRID LINES FORM PART OF THE NATIONAL GRID REFERENC SYSTEM.
24
25
26
27
28
29
30
31
32
89
90
91
92
93
94
A
B
C
D
E
F
G
H
I
J
reeds lane
carr lane
Heylak rd
line of mainsection map 3
Fender lane
M53
Kings way
Approach
MAP 2

Soil Section through boreholes 1,2 and 3

SITE 'A'
SQUIBB FACTORY



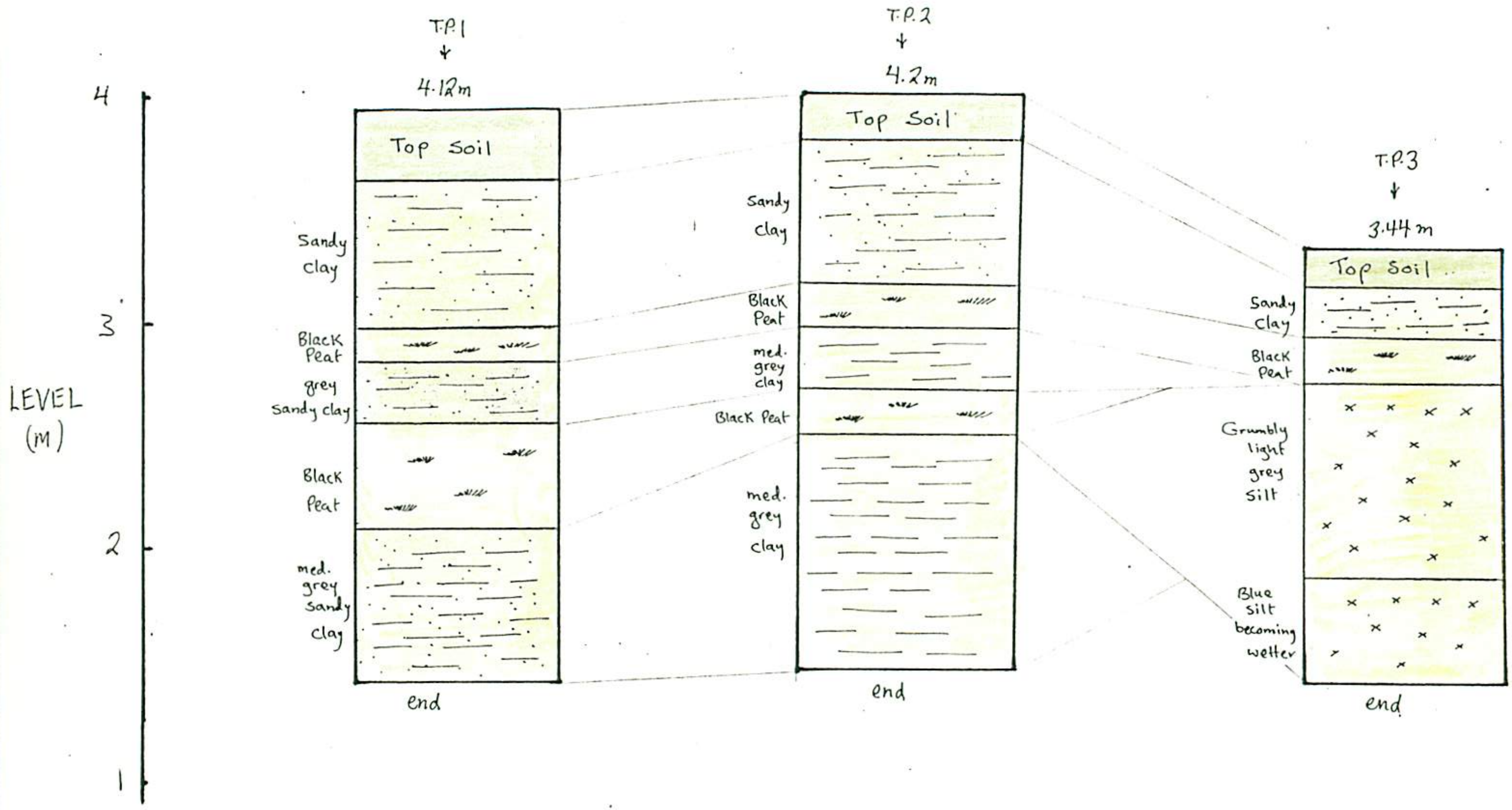
SITE 'A' SECTION
SQUIBB FACTORY

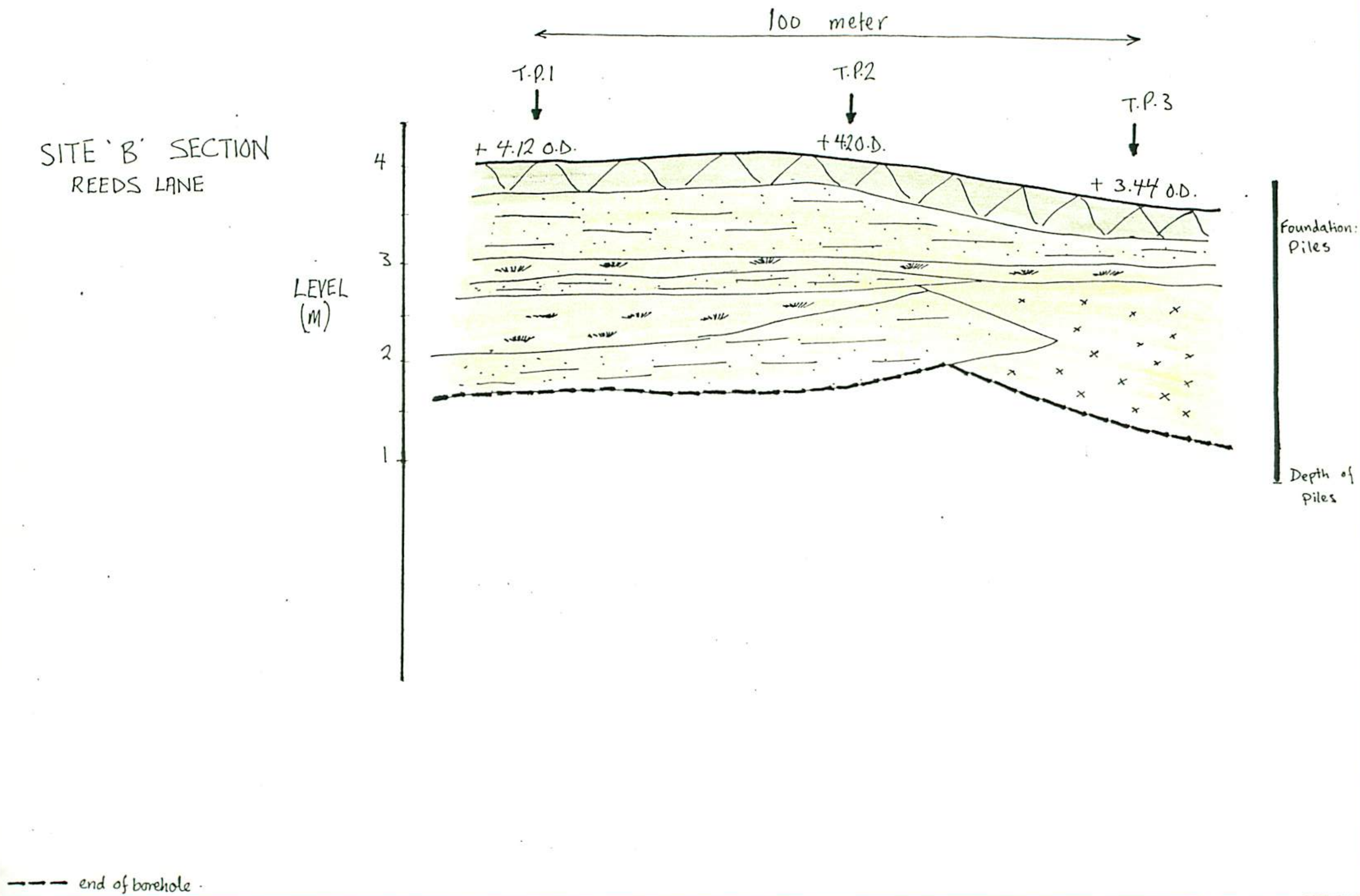


	Top Soil, Fill
	Sand
	Alluvium
	Boulder Clay
	Rock
S.	Soft
V.S.	Very Soft
FR.	Firm
STF.	Stiff
M.	Meduim

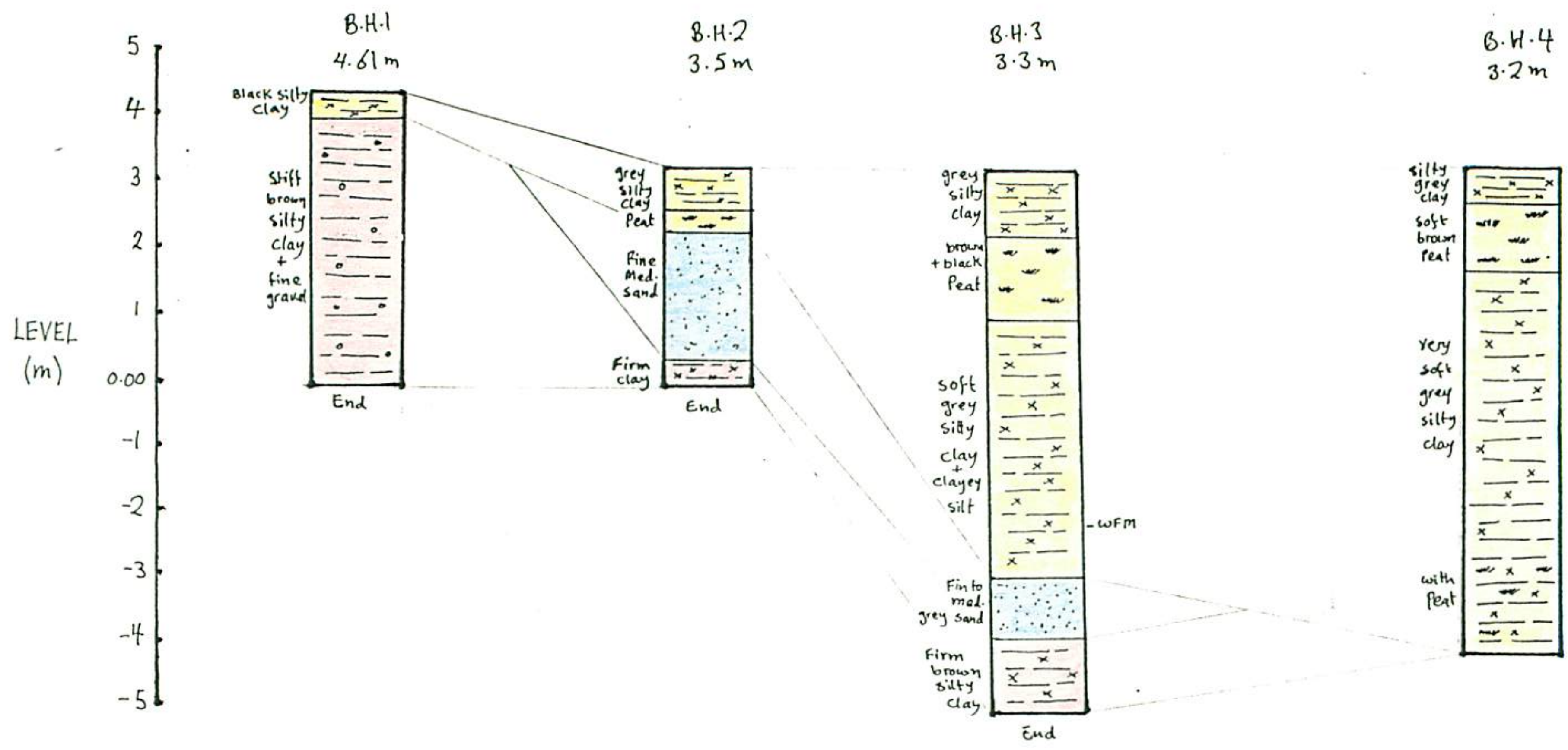
TRIAL PIT PROFILES SITE 'B'

REEDS LANE SITE

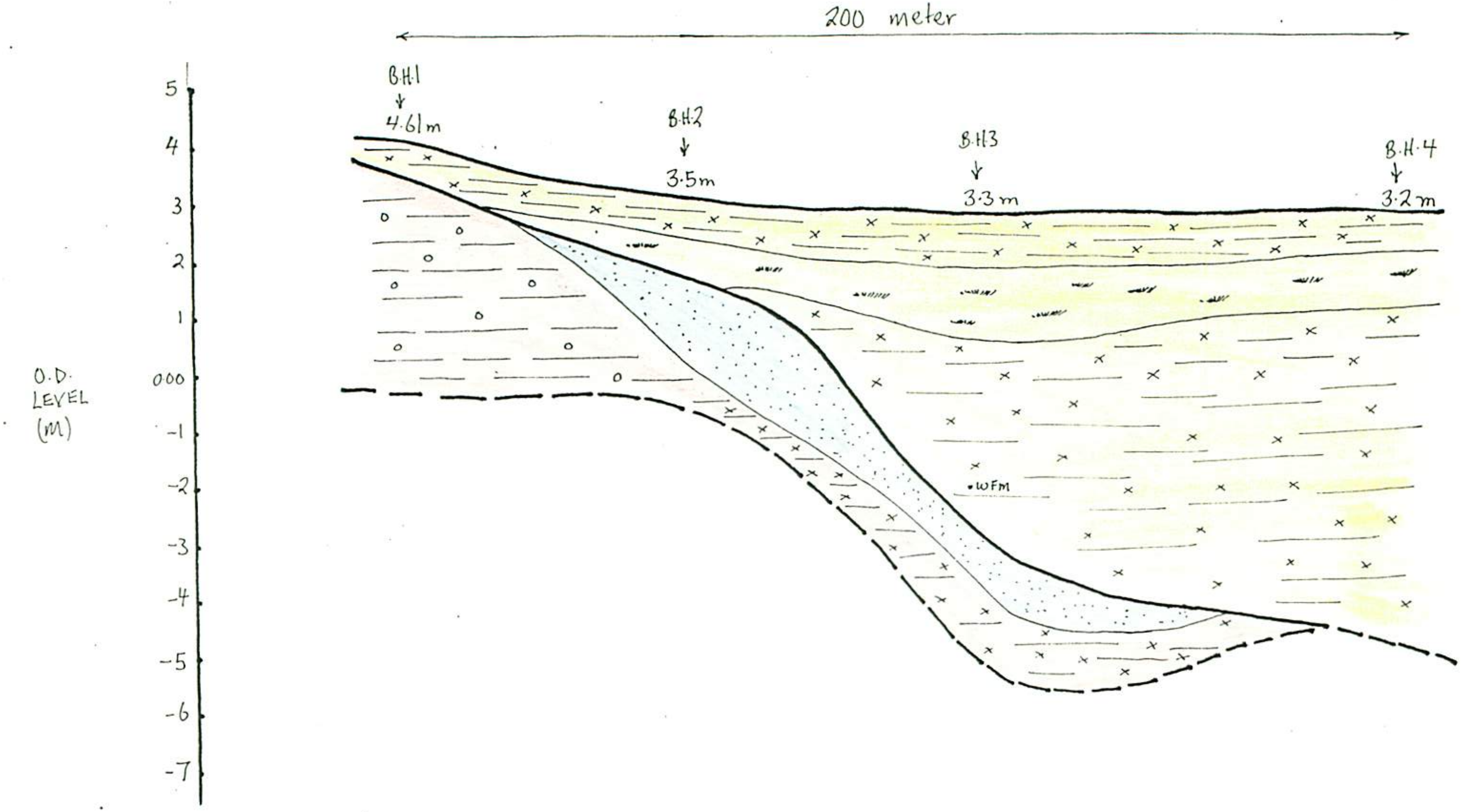



SITE 'B' SECTION
REEDS LANE
LEVEL (M)
4
3
2
1
100 meter
T.P.1
T.P.2
T.P.3
+ 4.12 O.D.
+ 4.2 O.D.
+ 3.44 O.D.
Foundation: Piles
Depth of Piles
end of borehole

FENDER LANE: SITE 'C' BOREHOLES PROFILES



WFM: water first met

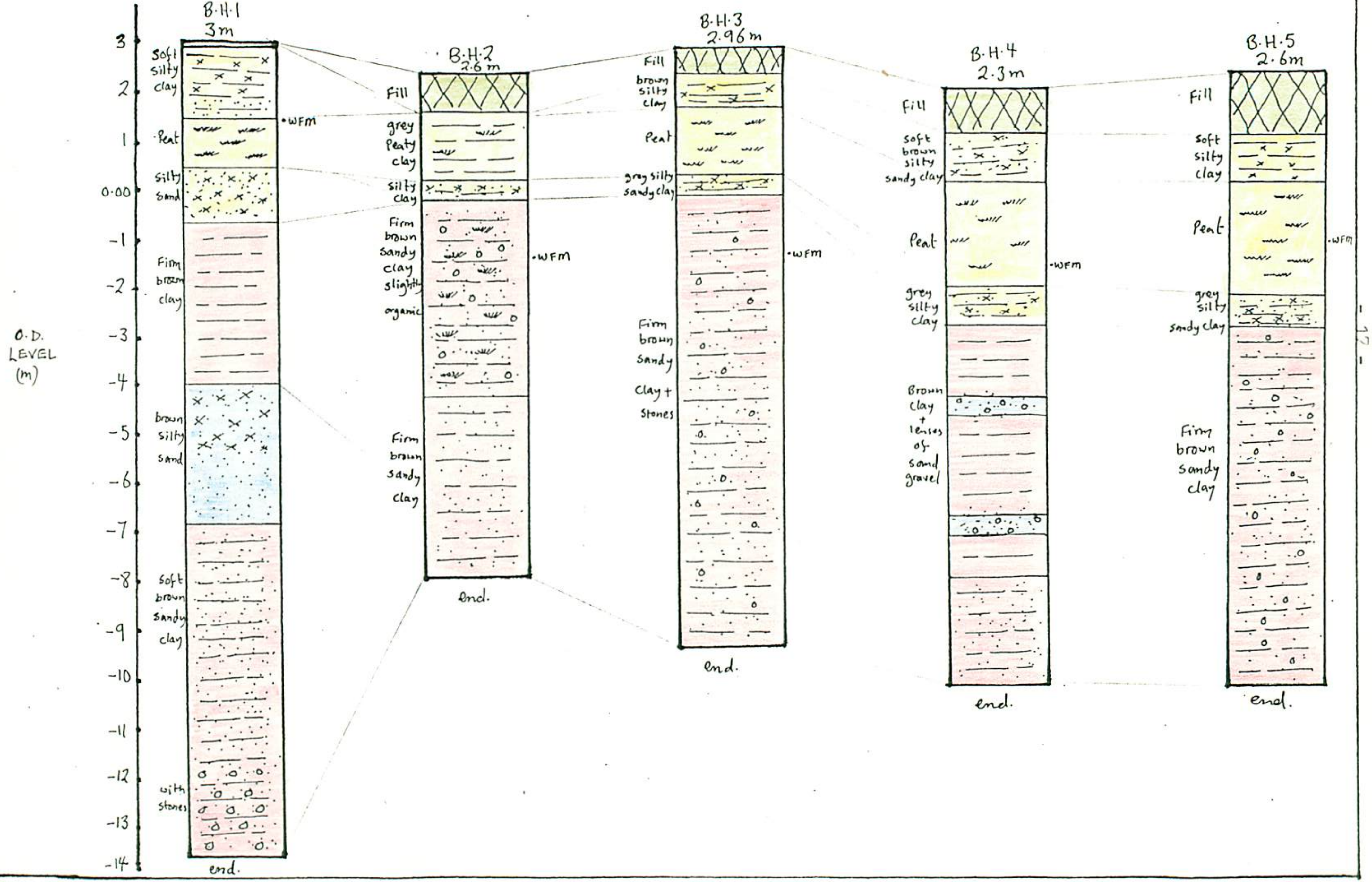


FENDER LANE. SITE 'C' SECTION

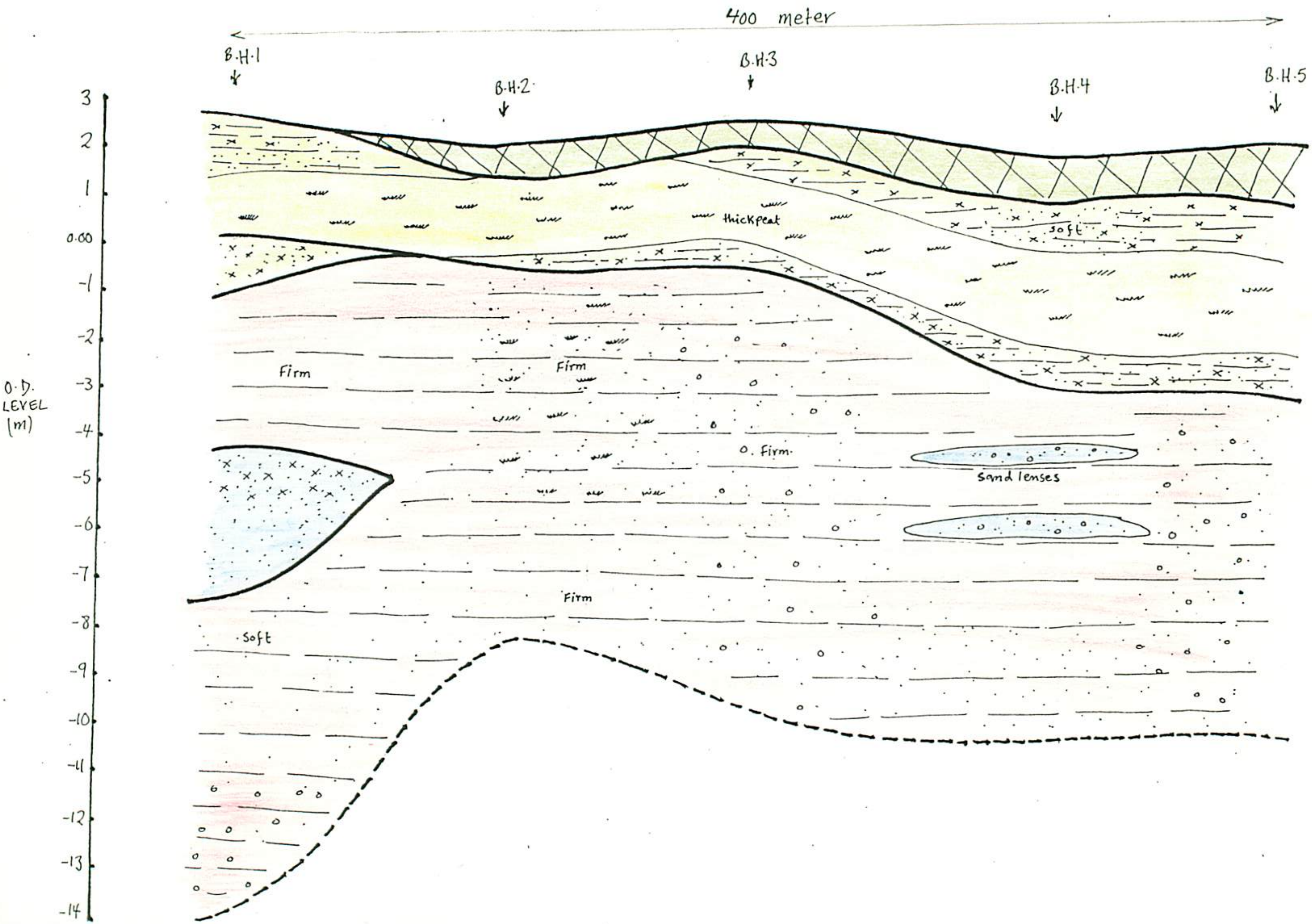
— — — indicates end of borehole.

wFm : water first met.

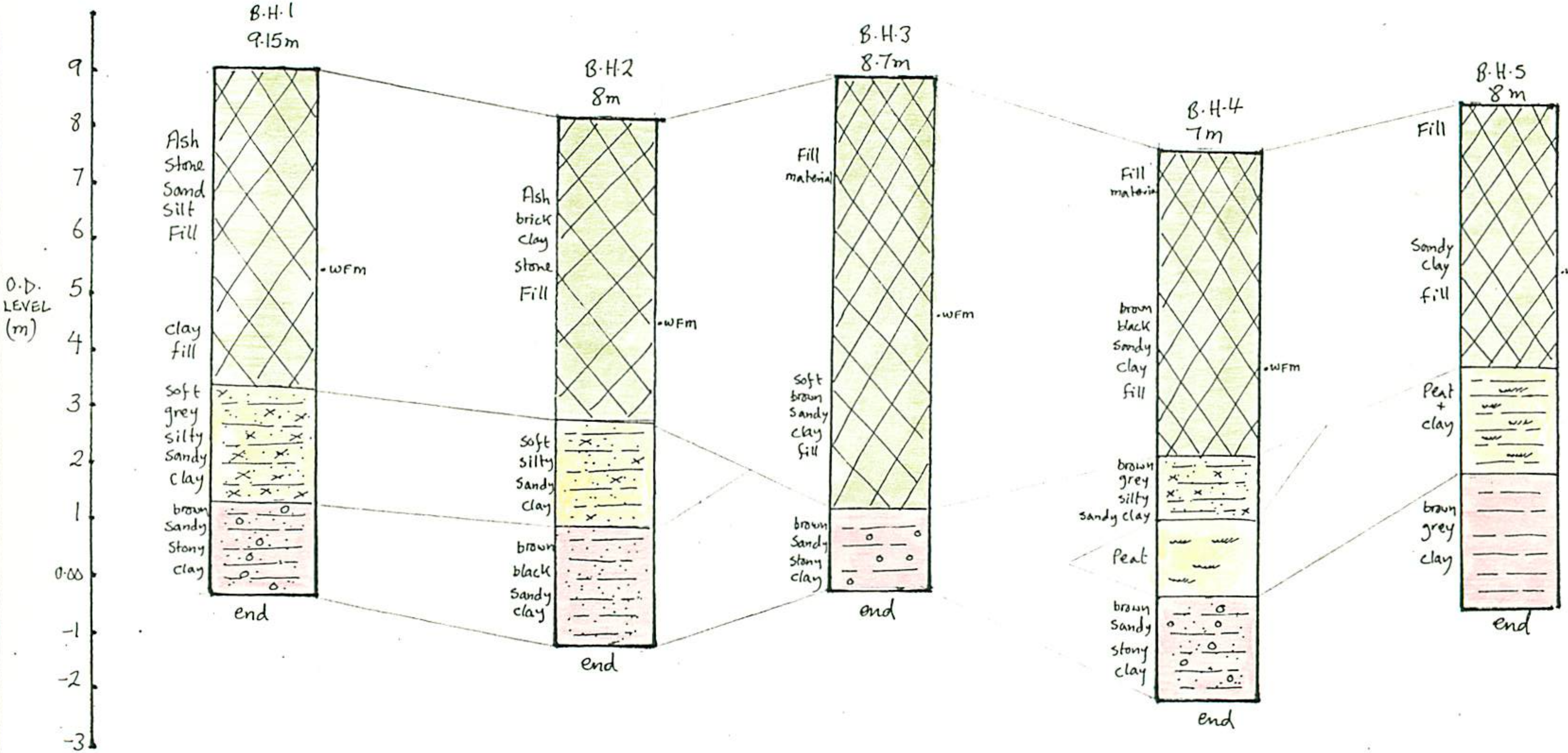
BOREHOLES PROFILES SITE'D'
BIDSTON SIDINGS



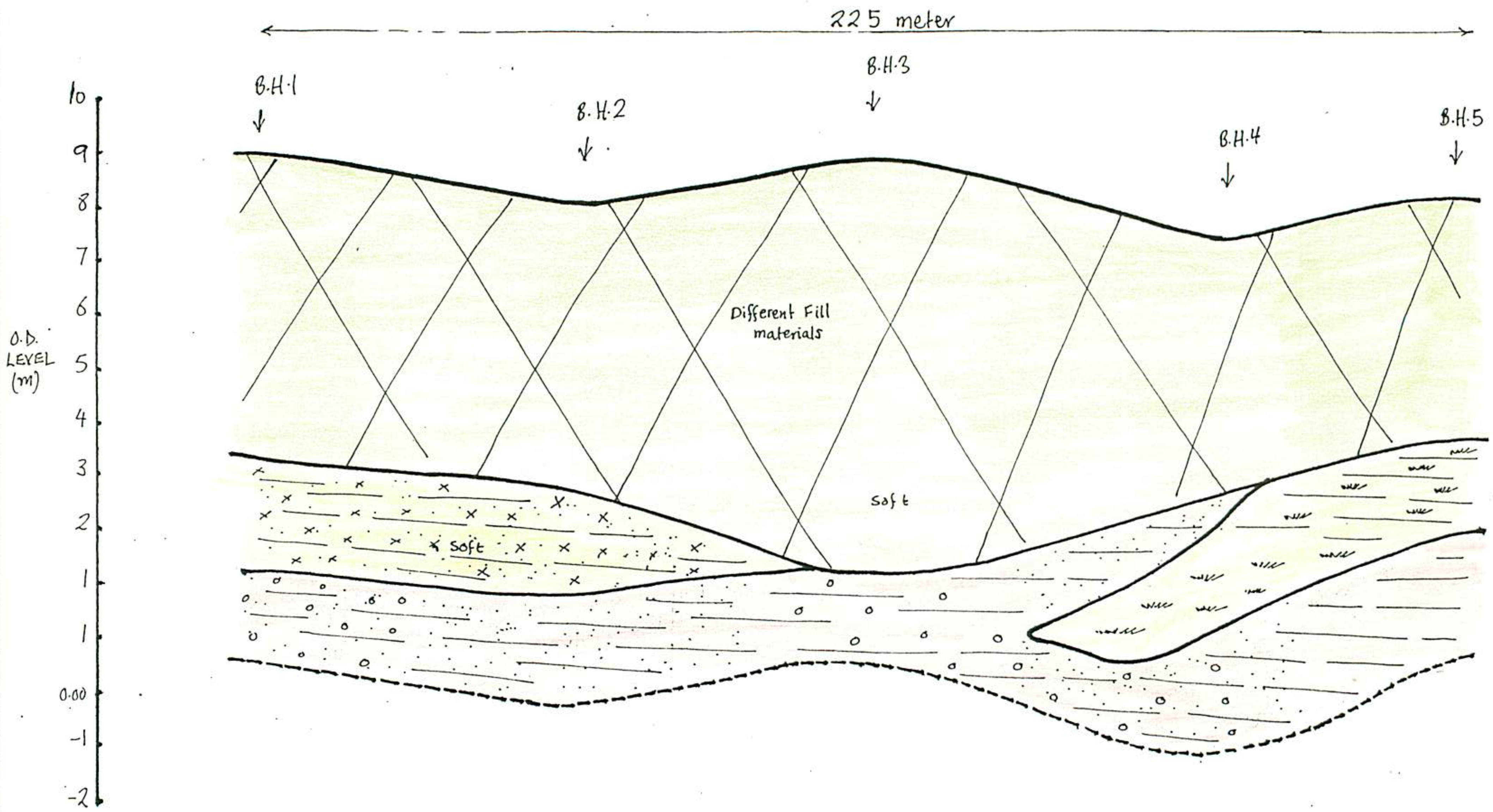
SITE 'D' SECTION BIDSTON SIDINGS



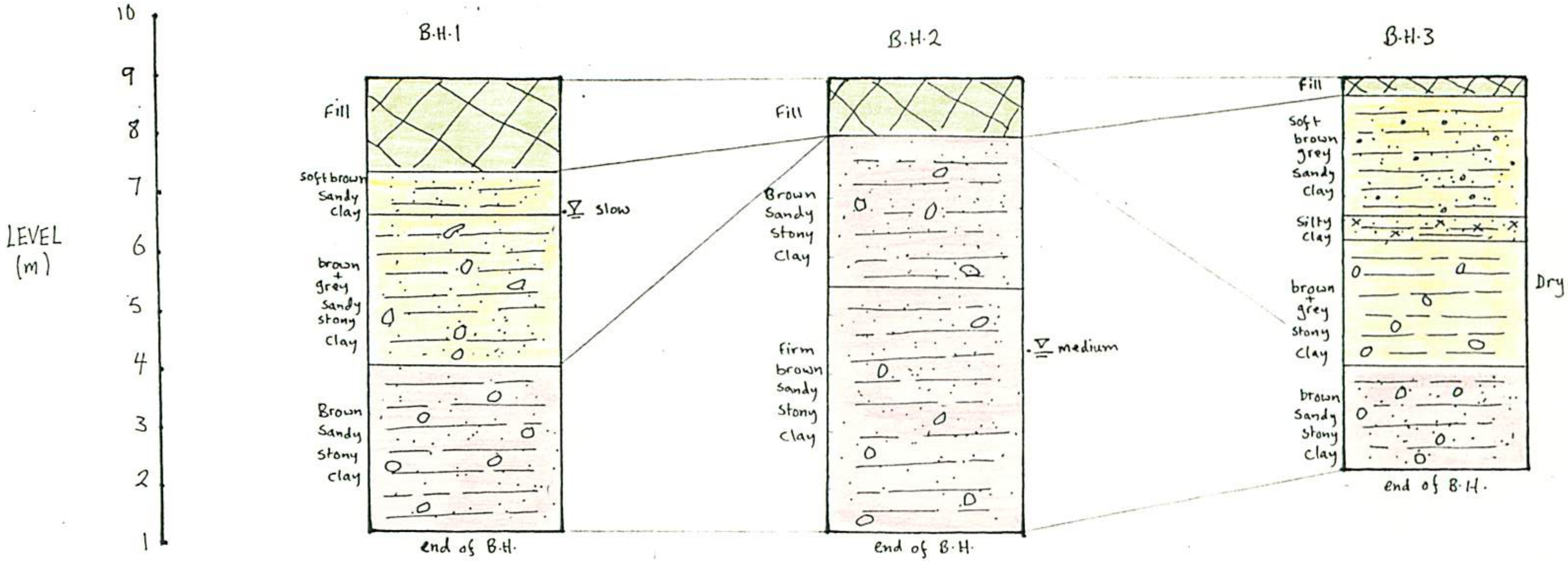
BOREHOLES PROFILES SITE 'E'
WALLASEY BRIDG RD.



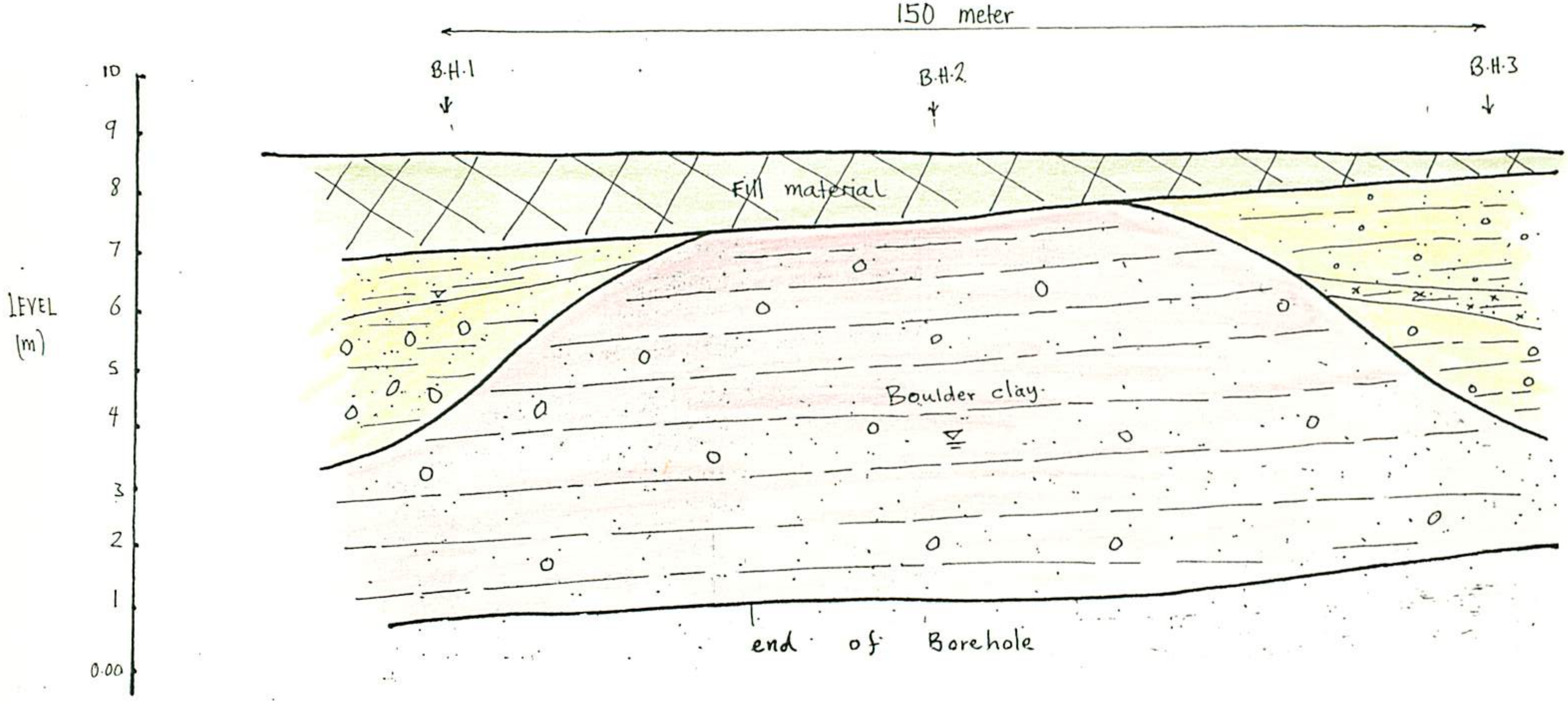
SECTION SITE 'E' WALLASEY BRIDGE RD.



BOREHOLE PROFILE SITE 'F' GAS WORKS



SECTION SITE 'F'



3. Site Analysis

3.1 Discussion on Squibbs Site (Site A) :

The 1 : 50,000 geological map shows the site to lie on an alluvium drift. The section drawn shows the thickness of the alluvium to increase in borehole 3.

Beneath the alluvium lies a thin stratum of boulder clay with thickness of about 3-4 meters. The boulder clay rests on a soft to firm marly sandstone bedrock.

A sand layer is found in borehole 1 at a depth of about 7 meters.

The superstructure is a relatively heavy load, a factory with many heavy machinery, due to this the foundation needed to rest on a stratum of high bearing capacity and to get the settlement and differential settlement to be within the acceptable safe limits.

Due to this and the geology of the site piling was used to the bed rock passing through a soft peat and alluvium with ground water and through boulder clay strata.

Concrete in-situ piles were used which extended to depth of 17 meters in B.H.3 and to depth of 12 meter in B.H.1.

From the tests, the sandstone rock was found to have an N value of 50 for 75mm penetration, and the piles was calculated to have a safe end bearing capacity of 2000 kN/m^2.

This result assumes that the bored piles are resting on a relatively undisturbed base of firm marly sandstone and not on disturbed or softened material.

During the actual construction more money and time was spent in the west side of the site, B.H.3, because there piling needed was of greated depth to reach the sandstone bedrock. See section A.

3.2 Discussion on Reeds Lane site (Site B) :

From the geological survey maps the site is on alluvium. From the trial pits records obtained from the site engineer, the site section was drawn and it shows the top 2.6 meters of the ground to be mainly black peat and sandy clay with running sand lenses in the alluvium stratum. Due to this, and that alluvium extends to depth of 6 meters on some parts of the site, conventional foundation such as strip or raft was rejected because then the structure would settle down extremely at the eventual movements of the sand lenses with the subsequent results of damage to structure drainage installations and to the fabric of the building.

In Reeds Lane 6 boreholes to the north of this site showed boulder clay at level 1.5 meter O.D. because of this, trial holes have been drilled to this level on this site.

Because of the conditions of the soil on this site, pile foundation was most suitable, for each house 5 piles was used, for larger houses 9 piles per house was used.

Piles were ready made reinforced concrete of square section of diameter 0.35 meter each pile costed £100 while the actual material cost in each pile is only £40.

Piles were of 8 meter length, it took 3 weeks to fix the 240 piles on this site. Only one machine and two men was needed to do the whole operation.

See section B.

See plate 5 and 6 Appendix 2.

3.3 Discussion on Fender Lane Site (Site C) :

This site is shown to lie on alluvium on the 1 : 50,000 geological map.

The site section (section C) shows the alluvium, mostly grey silty clay with peat, to increase in thickness towards the east side of Fender Lane. So using ordinary spread foundation will mean excavating the whole thick peat layer, as peat is of a very low bearing capacity material, this is costly and I recommend piling to the boulder clay for light structures.

For heavier structures I recommend piling to reach the sand stone rock. At the western side of the site, ordinary spread foundations could be used and placed in the firm boulder clay.

3.4 Discussion on Bidston Sidings Site (Site D) :

This site lies to the east of Bidston railway station and covers the old railway sidings.

The 1 : 50,000 geological map of the region shows the site to lie on alluvium over glacial drift. The bed rock is shown to be the upper mottled standstone.

ON the site 5 stem augar boreholes were drilled to depths of 11 to 17 meters, a number of undistrubed samples were taken from the cohesive material and these were supplemented by disturbed samples taken at frequent intervals.

From the section shown, there is a thick peat layer which overlies a thin silty clay. this overlies the boulder clay which contains sand lenses and silts found in borehole 1.

In view of the thickness and extent of the peat layers, and the presence of sand lenses, any shallow spread foundation would be unacceptable, piling would be needed; Piles to be driven into the boulder clay or deeper in the bed rock, depending on type of structure. From the triaxial test results, the ultimate skin friction for small diameter piles can be taken as 50 kN/m^2 for foundation design purposes.

The ultimate end bearing capacity value for piles terminating in the sandy boulder clay below depth of 7 metres could be taken as 1000 kN/m^2.

The chemical test made showed the sulphate content of the ground to lie in Categories 2 to 3 of the BRS Digest No. 90, and so sulphate resisting Portland Cement was used for the foundation concrete.

3.5 Discussion on Wallasey Bridge Road Site (Site E) :

This site lies to the west of Wallasey Bridge Road, opposite the oil works.

From the site section it shows the top stratum to be a fill materials of various types, this overlaying boulder clay with a thin stratum of silty sandy clay to the west of the site.

There is a thin lense of peat to the east of the site at a depth of 7 metres. The 1 : 50,000 geological map shows the site to lie on alluvium. This is an error either in the map or in the site investigation.

Standard Penetration tests were taken at regular intervals in all boreholes. Undrained, unconsolidated and triaxial tests were carried out for the sandy clay samples, these gave an apparent cohesion values ranged from 33 to 129 kN/m^2.

The angles of shearing resistance was found to be zero.

In view of the depth of the fill material and the peat in borehole 4, piling was used.

From the triaxial tests, the ultimate skin friction bearing capacity was taken on 40 kN/m^2. The ultimate end bearing capacity was taken as 1000 kN/m^2 for piles terminating below 10 metres.

3.6 <u>Discussion on Bidston Gas Works Site</u> (Site F) :

This site lies north of the Dock Road in Birkenhead off the A 5027. It covers part of the site of a gas works which has been demolished and the ground is generally flat.

The 1 inch geology map shows the site to lie on alluvium covering glacial drift. The bed rock is shown to be upper mottled sandstone.

The type of drilling for boreholes was stem auger drilling. 3 boreholes were drilled.

From the triaxial test result, it showed the allowable bearing capacity of the boulder clay found at depth of 2 metres in B.H.2 for strip footing to be about 140 kN/m^2 for a rectangular foundation at 2 metre depth the allowable bearing capacity can be increased to 200 kN/m^2.

From this, it shows that for a lightly loaded structures such as low rise houses, a conventional strip foundation could be used. This is due to low depth of the boulder clay in area of B.H.2. in the area of B.H.1 and 3 small bored piles will be needed to go to the boulder clay below the alluvium stratum.

The chemical tests made showed the sulphate content of the soil to be of Category 2 in the B.R.S. digest No. 90 and so sulphate resisting cement is to be used for the foundation concrete.

B.H.3 was found to be dry, and ground water was encountered in B.H.1 and 2.

3.7 Discussion on Site G (Carr Lane) and Site H (Hoylake Road)

Both these sites are housing estates and are situated near each other, they both belong to Merseyside Council.

From the 1 : 50,000 geological map, the sites are shown to lie on boulder clay which overlies a red marl bed rock.

No site investigations was carried out by the Council at these sites and so no boreholes records were available. A nearby claypit showed that boulder clay is thick enough for shallow ordinary spread foundations.

In Carr Lane site strip foundations went to a depth of 1.5 metres and at Hoylake Road site the depth of the strip foundations was 1 metre.

In Carr Lane site a few black peat pockets was encountered which was excavated to reach the boulder clay.

I was informed on this site that for one of the houses, excavation was 2.2 metres due to presence of a black peat pocket.

Other than this, no real difficulties were faced in the construction of the foundations for these houses.

See plate 4 Appendix 2.

The cost of the materials for each house's foundation was about £2500 at the 1980 prices.

3.8 Site J (Barrattes Site)

This site belongs to Barratte Company, on this site a large housing estate is being built ranging from small to larger houses.

From the geological maps, it shows the site to lie on alluvium with the east side of the site to lie on boulder clay.

On the boulder clay piling to rock was not needed as boulder clay has a high enough ultimate bearing capacity for the light houses on site, and so ordinary strip foundation was used for the houses on the west side. The depth of foundation was 1.5 metre.

On the east side of the site, where it lies on alluvium deposits, no houses were built as difficulties were facing the Contractor in the construction of the foundation.

The Photos taken at this part of the site show the strata to be:

0.4 meter	fill material
0.5 meter	peat
0.6 meter	grey clay which could extend deeper to lie over the boulder clay.

Note the high water table.

Site investigation on this site was virtually non existent, below the bad ground on the east of the site is buried channels which caused many problems when it came to laying the sewers and piling had not been advised for.

A vast amount of money has been spent in sewerage works and the cost of house construction was increased due to the large amount of piling required to the bed rock. The ground level are to be raised to prevent flooding from the nearby Fender River.

This example illustrates importance of site investigations before any actual construction on the site, so as to be able to avoid any problems when constructing the foundations. See Plates 1, 2 and 3.

3.8 Discussion on New Brighton Site (Site I)

This area was visited to show example of construction on rock. In this area there is 3 high rise buildings on the sea front in New Brighton.

The buildings are on a basement bed rock (Kenper) as shown by the 1 inch geologicap map.

The rock rises above the surface and this provided a strong bearing stratum for the foundation, without the trouble and cost to go deep to reach it.

In this type of ground tests are needed to measure the strength of the weathered rock, as rock looses some of its strength when subjected to open environmental changes as compared to rock under the ground level.

See plate 7 Appendix 2.

Chapter 4

4.1 Summary of Sites Analysis

The area considered in this dissertation can be divided into 4 major geological type areas:

I. Recent (Blown Sand) : This is mostly the sea front area, which extends along the coast of the North Wirral. This area is in places underlined by a thick strata of low bearing capacity. This is mostly silty sand and peat with a high water tab. Where the sand thick, strip or raft foundation could be used depending on type of structure.
There is little construction in this area as it is near the sea. See Plate 8.

II. Recent (Alluvium) : The Alluvium drift are mainly grey clad with silts and peat. Silt usually has a low bearing capacity, and the peat has a very low bearing capacity, so the alluvium has generally a low bearing capacity.
There were 5 sites on this type of ground in North Wirral Coastal area, and two of these are:

(i) The Reeds Lane site of houses required piling to the boulder clay beneath the alluvium stratum.

(ii) The Squibbs factory site in Reeds Lane required piling to the sandstone rock beneath the boulder clay.

The alluvium area in the North Wirral lies on a buried channel (R. J. Kenna, 1978). The effect of this burried channel causes alluvium deposits to increase in thickness over the boulder clay (see Map 3) so piling is required to a greater depth in this case to reach the boulder clay (as in Reeds Lane case) or the rock bed (as in Squibbs factory case).

III Glacial : This is associated with boulder clay and gravel and stones. Three sites in the North Wirral area were visited which lie on this type of stratum. Here shallow spread foundation is generally used for light structures. But where sand lenses are found in boulder clay piling could be necessary, instead of the spread foundation so as to avoid excessive settlement due to eventual lateral movement of the sand lenses under the superstructure's loads.

This shows the importance of site investigations to detect such features of the subsoil and not to rely completely on the geological maps.

In burried channels filled with boulder clay piling to reach the rock bed may be in excess of 70 metres, as the case was with piling for the Bidston site.

IV Trias : Keuper rock : Here the rock strata is at the surface of the ground, and the New Brighton high rise buildings shows that no foundation problems are associated with this stratum.

4.2 Cost Analysis

Analysis of costs of a complete site investigation (4 boreholes to a depth of 10 metres) using :

Shell and auger boring method

drilling boreholes = £480 at £120 per borehole *

movement of equipments £25

extras for boring by Chisel £15

* Assuming bed rock is below 10 meter deep. drilling through rock would cost more.

Sampling and In-Situe testing :

Undisturbed samples (£10), + disturbed samples (5) + extra for U tubes for drilling (£16) + standard or cone penetration tests (£5) + sample of ground water (£2) = £38.

Laboratory tests : (in £)

Moisture content (1) + specific gravity (s) + particle size (28) distribution + sulphate content (6) + Dry density/moisture content relations (70) + California bearing ratio (12) + unconfined compression test (10) + compressive strength in undrained triaxial tests (20) + Consolidation undrained triaxial compression tests (200) + Drained shear box for shear strength (100) + one dimensional Consolidation properties (25) + Rowe Consolidation test (175) + constant and variable head pereambility tests (55) + oedometer test (50) = £757

Preparation of Site investigation report with 3 copies = £100

So total Cost of Site Investigations = £1415 for a site with four boreholes.

In the Reeds Lane site, 4 boreholes was drilled to a depth of 10 metres. i.e. at a cost of £1500 as shown above.

There are 6 houses, estimated cost of each is £18,000

There are 28 houses, estimated cost of each is £14,000

So total cost of houses = ½ million pound at the 1980 prices

∴ % of cost of site investigation in relation to cost of total construction work is 0.3

So the cost of site investigation is only 0.3% of the cost of the construction work.

This shows that the Contractor should carry out site investigations before any construction work as the cost is very small in relation to the final cost of the works, rather than face future problems due to foundations' failure which would cost much more.

4.3 Geophysical Techniques :

In the region where buried channels exist, geophysical techniques can be used to determine the rock bed depth. Geophysical techniques for soil survey can reduce the number of boreholes required and hence the cost. (R. J. Kenna, 1978).

4.4 The main section : See Map 3, page 35.

CHAPTER 5

5.1 Conclusions

1. A geological section is constructed across the North Wirral area. This will help in the preliminary investigations for sites in the region of the section (see Map 3).

2. The main section shows the presence of a buried channel under Fender Lane site, this channel extends from south of Fender Lane to the Coast of North Wirral, and any construction work in this region should be preceeded by an extensive site investigation.

3. The cost of a complete site investigation for a small structure is only 0.3% of the cost of construction work. The percentage of the site investigation cost could go up to 1% of the total construction cost for the large and complicated structures.

4. Geophysical techniques could be used in sites where buried channels are expected.

5. Geological maps should always be supplemented by site investigations before any foundation construction in the North Wirral area due to the complexity of geology in this region.

5.2 Limitations of the Survey

The main section (map 3) is constructed up from the sections of only four sites along the section line, and with the help of the geological maps of the region. Because of this it should only be taken as a general description of the geology of the area.

5.3 'Recommendations'

For future extension of the work carried out in this dissertation and for a more accurate main section more boreholes records would be needed. Such sections should be drawn for different regions in the country where difficult geological conditions is known to exist. Such sections should be kept by the local authorities and made available for consultation by contractors and engineers to help in the preliminary site investigation stage.

5.4 History of Dissertation

The initial proposal was to investigate the ways in which the engineering properties of soil and rock affect the choice of foundations for different structures.

After preliminary study I found that this investigation would be too wide and general as it stands. I decided to concentrate on the importance of site investigations as preliminary to the design of foundations and to look at this in relation to a local area. The North Wirral Costal Area was chosen for this purpose.

Appendix 1

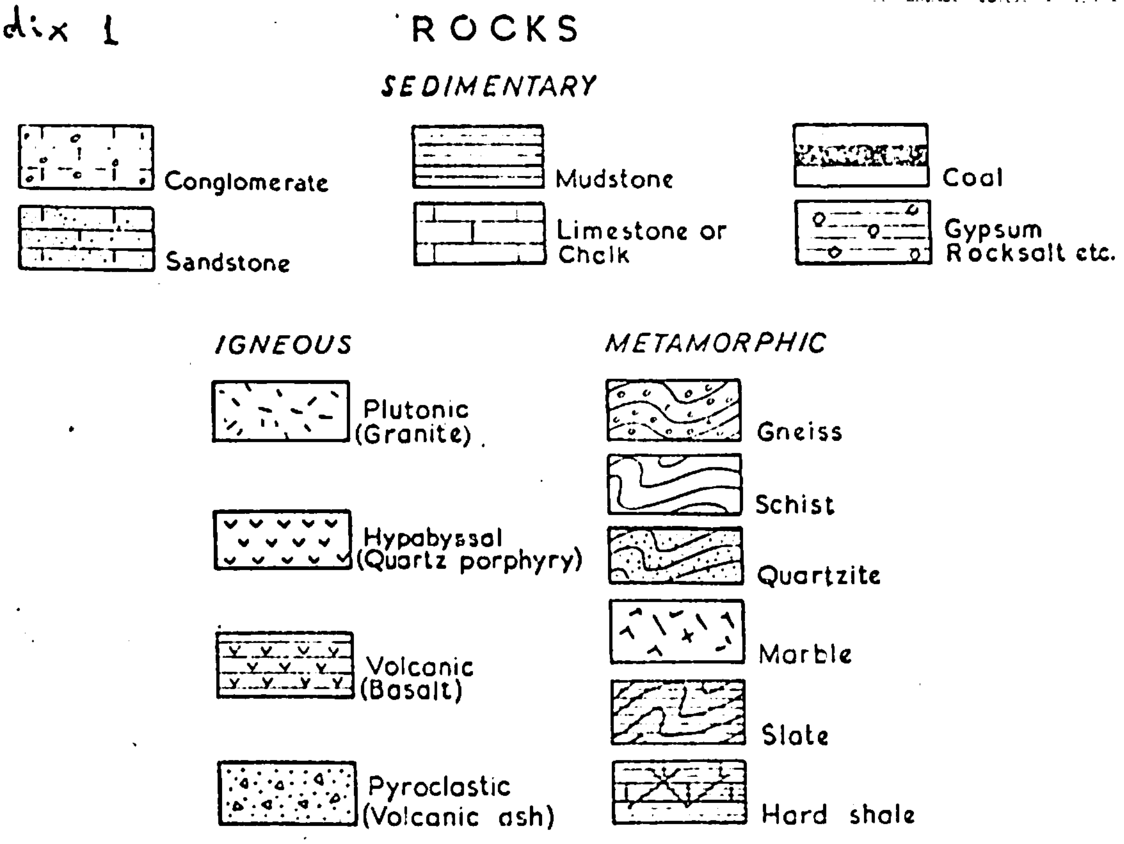


Fig. 2a. Engineering geology—recommended symbols for rocks

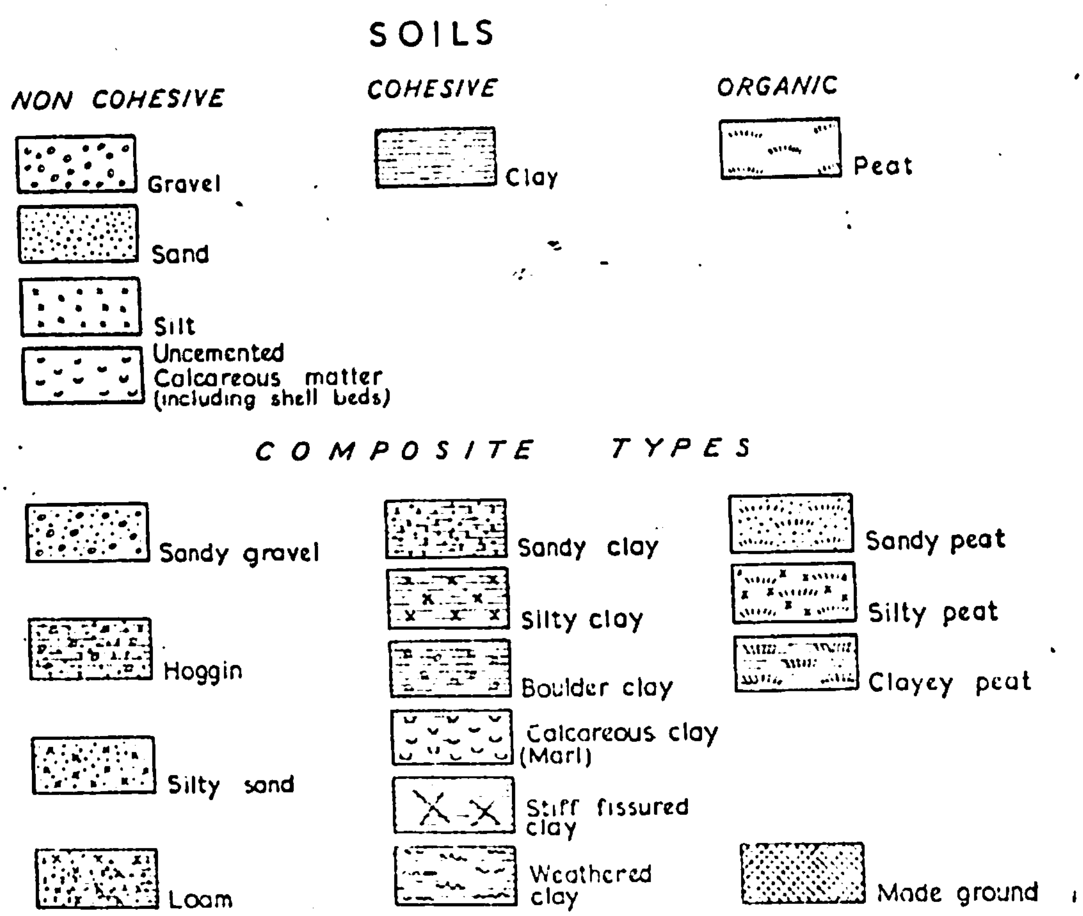
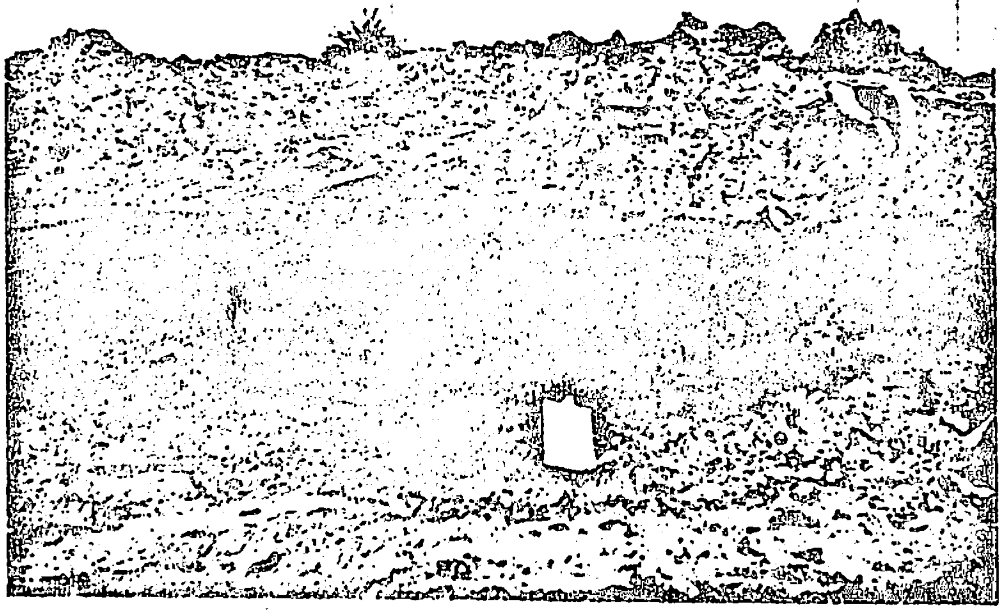


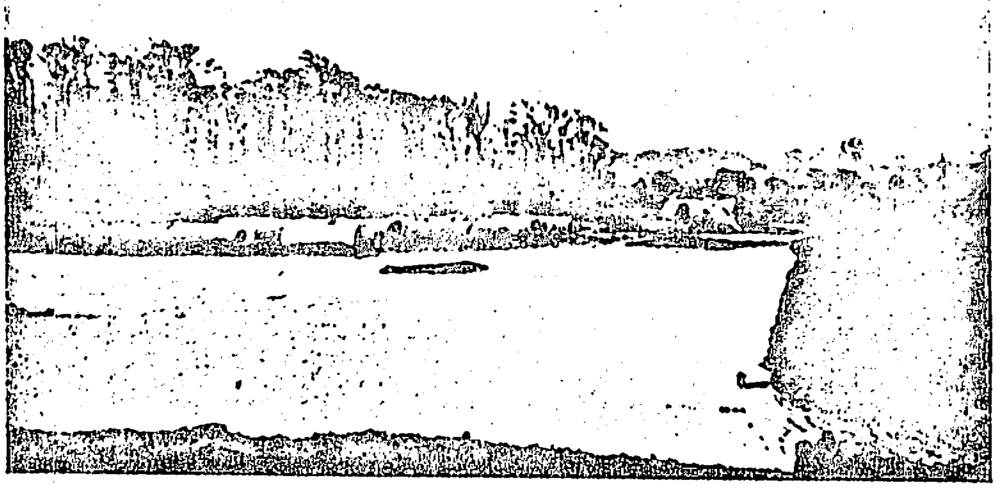
Fig. 2b. Engineering geology - recommended symbols for soils

Appendix 2



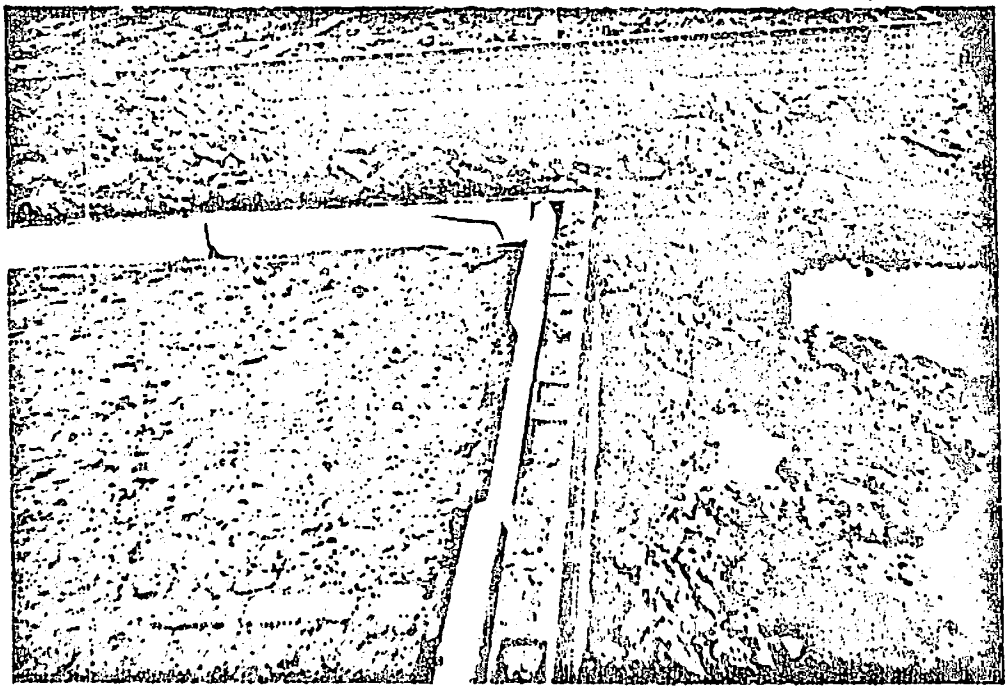
1

Barratte site: shows the thick fill stratum on top of black peat and fill, these strata have low bearing capacity.



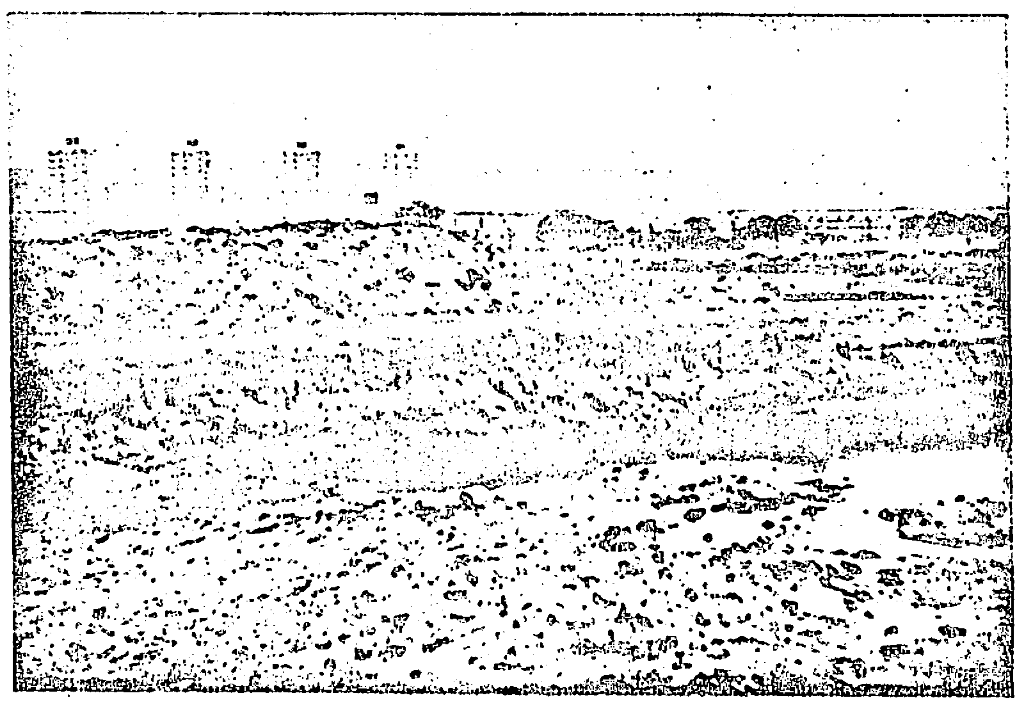
2

Barratte site: vast amount of money was spent on sewerage work. Ground level has to be raised to prevent flooding from the nearby fender river.



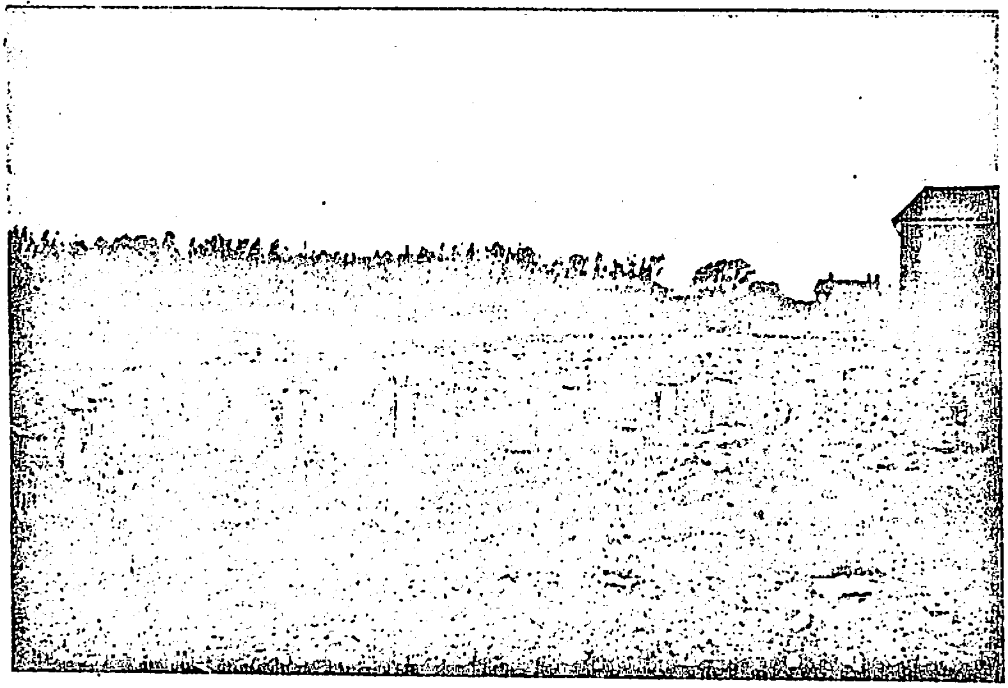
4

Carr Lane site: shallow strip foundations were used. The site lies on boulder clay. No difficulties were encountered in the construction of foundations.



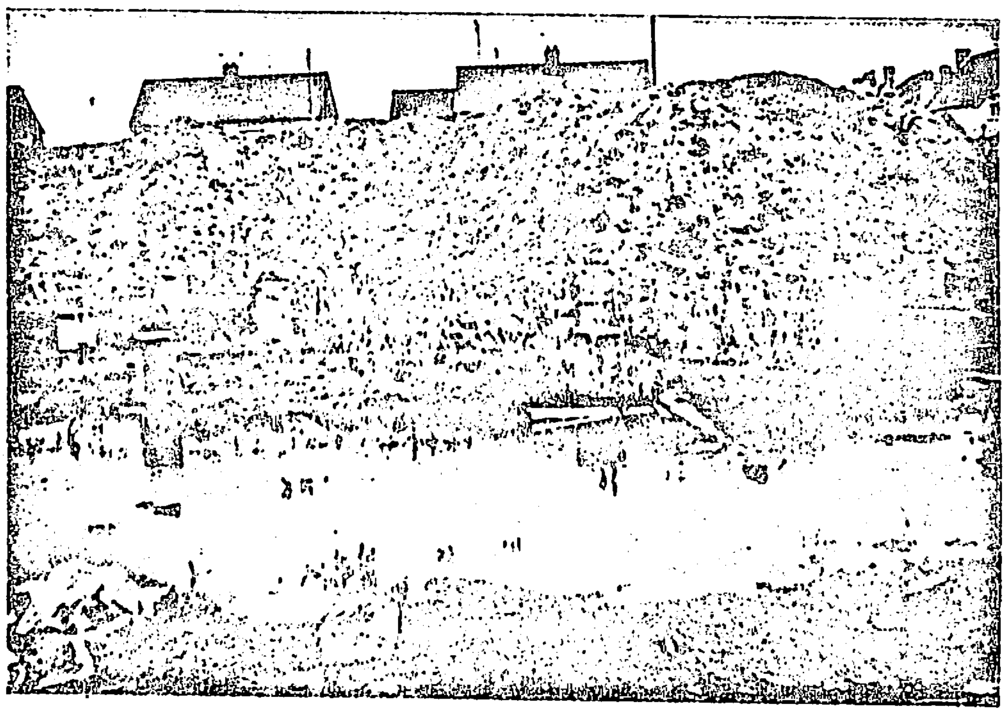
3

Barratte site: shows the strata on the east side of the site. The high depth of alluvium indicates that piling would be needed here.



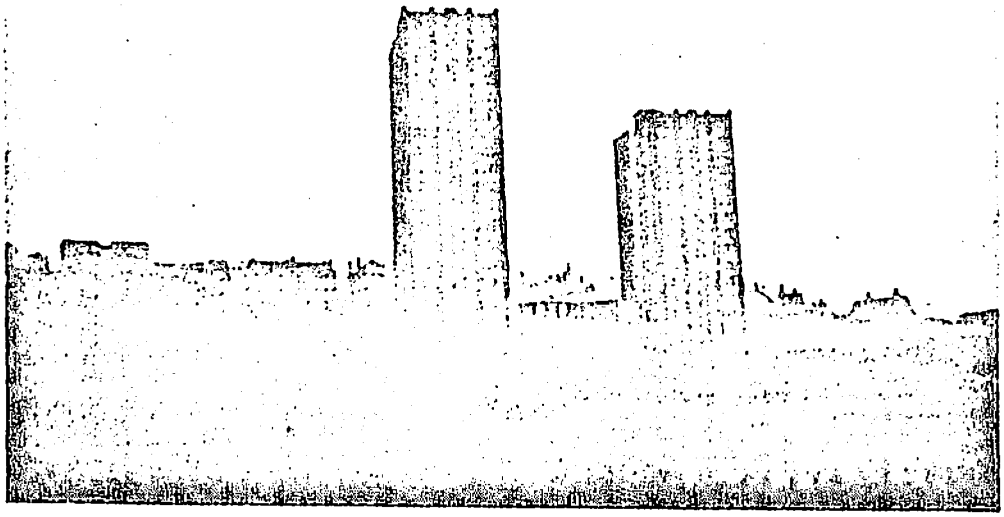
5

Reeds Lane site: 5 to 9 piles were used per house to reach the boulder clay stratum, depth of piles was 10 metres.



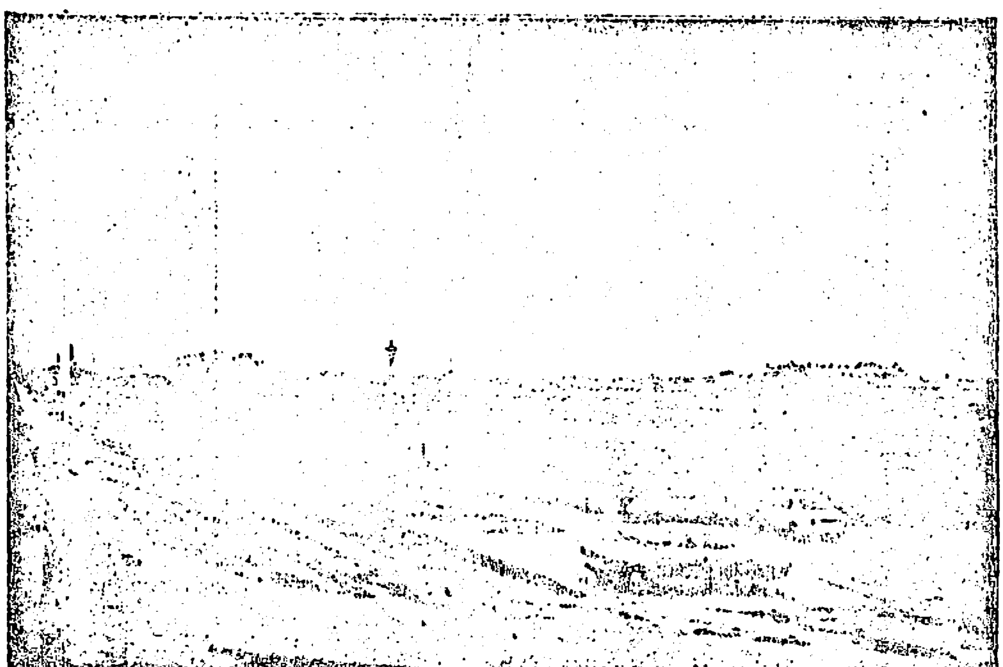
6

Reeds Lane site: shows the high water table. The sea is 500 metres away from this site. Site lies on alluvium overlying the boulder clay.



7

New Brighton: high rise buildings directly on sand stone rock.



8

The above area lies on alluvium: blown sand, little construction in this region.

<u>List of References</u>

1. CP 2004 : 1972 Foundations

2. CP 2001 : 1957 Site Investigations

3. Map : Geological survey of Great Britain
   Sheet 96 scale 1 : 50,000 Drift

4. Map : Geological Survey of Great Britain
   Sheet 96 Scale 1 : 50,000 Solid

5. Map : Ordnance Survey Sheet Sj 29 SE
   Sheet Sj 39 SW
   Scale 1 : 50,000

6. Principles of Engineering geology P.B. Attewell &
   I. W. Farmer 1976

7. Engineering Geology and Geothechnics
   F. G. Bell 1980 edition

8. (Publichsed and Unpublished works) for
   Mr. R. J. Kenna, Liverpool University, (1978 - 1980).

9. Site Investigations in Areas of Mining Subsidence,
   F. G. Bell 1975

10. The 'Site Investigation Reports' for Sites :
    Bidston sidings, Bidston Gas Works and Bidston Moss
    obtained from : Merseyside Engineering Department.