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INSTITUTE of HYDROLOGY

EAST CHICHESTER GROUNDWATER MODEL STUDY

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EAST CHICHESTER

GROUNDWATER MODEL STUDY

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Summary

The available hydrogeological information on the gravel deposits in the East Chichester area have been assembled and collated with the historical development of gravel extraction and site restoration, with particular emphasis on the Westhampnett area. However, the lack of sufficient and representative information on aquifer characteristics and water levels has not justified the application of sophisticated, mathematical modelling techniques nor allowed proper calibration.

A simple, regional model was developed to examine the broad controls governing groundwater movement. This has indicated the importance of recharge from the Lavant valley and defined a broad transmissivity distribution.

A more detailed, local model of the Westhampnett area was also constructed incorporating a simplified representation of the areas of extraction or restoration. This model was used to make some initial predictions of water level response to several engineering developments under consideration in this area. Each proposed development was tested separately and in conjunction with each other.

The results of the local model suggest that:

- a rise in water levels of perhaps 2m would occur in the north-west part of Church Farm Pit if this is infilled but levels would show a similar fall to the south and south-east of this pit.

- a seal along the southern edge of Church Farm Pit would cause water levels to rise by about 0.5m in this pit but if the existing "seal" is removed the pit water level would decline by only 1.0m but result in a rise of 0.5m to the south of this pit.

- the excavation and restoration of West Coach Road Pit as a water filled lake is likely to reduce water levels in Church Farm Pit but possibly increase water levels in Shopwyke North Pit. Any infilling of proposed pits to the west or east of Coach Road is likely to cause a rise in water levels in Church Farm Pit.

At this stage, the model predictions must be regarded as indicative and actual water level changes should not be taken too literally given the constraints and assumptions on which the models are based.

Further information on aquifer characteristics and a period of water level monitoring would allow more sophisticated models to be applied to thereby provide more accurate predictions of further development in this area. These could examine in advance the complex, hydrological consequences that might result from the future interaction of pit excavation, sealing and restoration throughout the East Chichester area that would be of benefit to planners and developers alike.

A provisional programme of further works which focuses on the Westhampnett area is proposed to obtain the hydrogeological information for the development of more representative models.

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EAST CHICHESTER GROUNDWATER MODEL STUDY

Chapter 1

INTRODUCTION

1.1 GENERAL

The gravel deposits to the east and south-east of Chichester in West Sussex have been worked extensively for more than fifty years. Excavated sites now cover a total area of over 250 hectares as shown in Figures 1.1 and 1.2.

The widespread removal of aquifer material and the subsequent sealing and infilling of pits has disturbed the natural groundwater regime in the area. For example, over recent years there has been increasing concern about the problems of flooding in the Westhampnett area, and in particular at Church Farm Pit. New developments may increase the rise of flooding. It was apparent that a study of the area was needed to assess both the present situation and the implications of planned developments in the area.

The National Rivers Authority commissioned the Institute of Hydrology to undertake a groundwater study, with additional funding provided by the following organisations, who have an interest in the area :

National Rivers Authority (NRA)
Department of the Transport (DOT)
Tarmac Roadstone Limited
West Sussex County Council (WSCC)
Hall Aggregates (South Coast) Limited (RMC)

1.2 SCOPE OF WORK

The objectives of the study were as follows :

) To assemble hydrogeological data for the study area in order to :

a) improve the level of understanding of the groundwater regime in the study area; and,

b) determine whether groundwater modelling could be undertaken with the information available

2) To apply an appropriate mathematical model of the regional groundwater regime and a local model of the Westhampnett area to predict the impact of several possible development projects on groundwater levels.

3) To identify areas where additional field data would improve the accuracy of regional and local groundwater models.

Data on aquifer characteristics and water levels were collected from a wide variety of sources, and particularly from available borehole information. The locations of the more important boreholes used in the study are shown on Figure 1.3, while a complete listing of all boreholes is included as Appendix B and shown on Appendix B Map 1. The resulting data base represents a comprehensive collection of hydrogeological information for this part of the Chichester area.

In general, data were restricted to small geographical areas, and contained little information on aquifer properties. It was concluded that there was insufficient information on aquifer geometry, properties, or water levels to allow construction of a sophisticated, time varying groundwater model.

1.3 GROUNDWATER MODEL

Initially it was intended that the groundwater modelling study would examine the area between Westhampnett and the Brighton to Chichester railway line. However, because of the requirement to define realistic boundary conditions for the groundwater model it was decided to prepare a more regional model as well as a local model of the Westhampnett area. Extending the regional model allowed most of the Lavant alluvial fan to be included in the study area as shown in Figure 2.1. This then provided a better context for the detailed model at Westhampnett, and included coverage of the possible future gravel extraction sites at Kingsham and Brick Kiln Farms.

The two mathematical models have been used to analyse the aquifer under existing conditions and to make a qualitative assessment of the impact of the proposed developments. These models are described in Chapters 4 and 5 respectively.

Information on groundwater levels and especially aquifer properties is sparse and because of this it has not been possible to accurately calibrate the groundwater models. The model results should therefore be treated with caution. Additional field data would allow the models to be calibrated to provide more accurate, reliable predictions of the impact of proposed future developments.

The modelling described in this report was carried out in association with Hydraulics Research Limited, Wallingford using the AQUA model developed by Vatnaskil Consulting Engineers of Reykjavik, Iceland. AQUA is a program package to solve groundwater flow and transport equations using the Galerkin finite element method. The package includes various graphical preprocessors to make preparation of data as easy as possible, along with graphical postprocessors. A more complete description of the theory used by AQUA is given in Annex 1.

The AQUA model can also simulate contaminant transport, although this capability has not been used in the current study. Hence the model could also be used to examine potential groundwater contamination problems, such as the migration of leachates from reclamation sites in the study area. However, this will require more detailed hydrogeological information in specific areas than is available at present.

Chapter 2

DESCRIPTION OF THE STUDY AREA

2.1 GEOLOGY

The geology of the area, which is shown in Figures 2.1 and 2.2, is described in the Mineral Assessment Report on Chichester and Bognor Regis (BGS IMAU Report 138, 1983). The nomenclature and inferred depositional environments used by the British Geological Survey for the different gravel types has been adopted for the present study as given in Table 1.

Table 1 : Geological Succession.

DRIFT	
Recent and Pleistocene	Alluvium
	Valley - Fan Gravel
	Brickearth
	Head Gravel
	Raised Beach Deposit (Younger)
	Raised Storm Beach Deposit
	Raised Beach Deposit (Older)
SOLID	
Eocene	London Clay
Palaeocene	Woolwich and Reading Beds
Cretaceous	Upper Chalk

Additional information on the solid geology has been provided in a report by Southern Water Authority describing the Chalk hydrogeology in the Chichester region. Some local modifications to these interpretations were made with the more detailed data obtained from the quarry companies or recent engineering studies.

2.1.1 Solid Geology

The gravel deposits of the project area rest unconformably upon Tertiary and Cretaceous sediments along the southern limb of the South Downs Anticline as shown in Figure 2.2. Smaller scale, east-west trending folding of the Chichester Syncline and Portsdown / Littlehampton Anticlines has further deformed this sequence. The Tertiary units act as an impermeable barrier beneath the Quaternary drift deposits as illustrated in the cross sections of Figure 2.3.

The Upper Chalk is exposed along the northern margins of the study area and occurs as drift covered subcrop in the core of the Portsdown and Littlehampton Anticlines. The Upper Chalk is a pure white limestone with closely spaced bands of nodular and tabular flints. Solution collapse structures occur within the Chalk immediately beneath the Pleistocene unconformity, particularly near the Reading Beds/Chalk contact.

The Woolwich and Reading Beds overlie the Chalk with slight angular unconformity and consist of up to 40 m of dark grey waxy clays with distinctive red and green mottling. A basal clastic unit of grey chalk and flint sands is recorded along the northern outcrops but may be absent in the southern parts of the area. The Woolwich and Reading Beds are appreciably thinner along the northern flanks of the Littlehampton Anticline.

The London Clay consists of bluish to dark grey usually laminated clay with sandy seams. Beds of calcareous shelly sandstone are more abundant higher in the sequence. Whilst there are no natural exposures of the London Clay within the study area, this unit has been intersected in numerous boreholes along the Chichester Syncline. Recent roadline investigations near Westhampnett suggest that the London Clay extends further north than had been previously thought (Figure 2.2).

The Cretaceous and Tertiary strata were subject to two periods of erosion during the Pleistocene to form : (a) an upper older wave-cut platform at an elevation of between approximately 20 and 25 metres, and (b) a lower younger wave-cut platform at an elevation of approximately 10 metres. The northern margins of each of these platforms are marked by a cliff-line as illustrated in Figures 2.1 and 2.3. Steeper topographic slopes also form the valley sides of the River Lavant as shown in Figure 2.2. These features are thought to hydraulically isolate the gravels of the upper wave-cut platform from those of the Lavant valley and the lower wave-cut platform.

2.1.2 Drift Deposits

The drift deposits form the aquifer of main interest to the present study, with both the regional and local groundwater models being dominated by the influence of the Fan and Valley Gravels. The distribution of the different drift deposits is shown in Figures 2.1 and the thickness variations illustrated in Figure 2.4

The Fan Gravels are characterized by angular to well rounded flints with a matrix varying from chalky, clayey silt to clean quartz sand. Lithologically the Fan Gravels are more variable and poorly sorted than the Valley Gravels, reflecting deposition in generally lower energy environments. The grain size and sorting characteristics of the Lavant alluvial fan has been used in developing the inferred transmissivity distribution for the groundwater models. Figure 2.5 illustrates the thickness variatiations of the Fan Gravels. A more detailed description of the geometry of the Fan and Valley Gravels is provided in Section 3.1.1..

The upper wave-cut platform is partially covered by the sandy silts to pebbly fine sands of the Raised Beach Deposit (older). The lower wave-cut platform is covered by the Raised Beach Deposit (younger) which consists of silty sand with sandy gravels near the base and is usually fossiliferous, and more marly, calcareous and cemented compared to the overlying Head, Fan or Raised Storm Beach gravels. The general distribution of the Raised Beach Deposit (younger) is shown on the isopach map of Figure 2.6.

The Head Gravel almost totally obscures the Raised Beach Deposit (older) of the upper platform. It is regarded as a periglacial solifluxion deposit developed along the base of the Chalk dip slope. This southward thinning wedge extends between the Raised Storm Beach Deposits above the lower cliff line, to cover the northern parts of the deposits of the lower wave-cut platform as shown in Figure 2.7. It is characterized by angular flint gravel with a dominantly clayey matrix and clasts derived from the Chalk, the local Tertiary deposits and from reworked Raised Beach Deposit. Stratigraphic data available from gravel workings in the Boxgrove area indicate at least two seperate phases of head gravel deposition, each preceeded by periods of silty, wind blown loess deposition ('brickearth').

Raised Storm Beach Deposits are well developed in the Westhampnett area where they occur at the southern margin of the upper wave cut platform. These sandy gravels may be up to 7.0 m thick and outcrop as low hummocky ridges about 1.0 km wide. They are considered by the BGS to have been shingle bars, formed contemporaneously with the Raised Beach Deposit (older) of the upper wave cut platform. The distribution of these deposits is shown in Figure 2.1, and on a more detailed scale they occupy the area defined by the 'zero' thickness contour on the Head Gravel isopach map (Figure 2.7).

2.2 HYDROLOGY

The hydrology of the study area is dominated by the influence of ephemeral flow of the River Lavant. The influence of the more subtle factors such as minor surface flow and rainfall has been more difficult to define from the available data.

2.2.1 Surface Flow

Records of daily mean flow for the River Lavant are available from December 1970 to the present for the Greylingwell gauging station, which is located 750 m upstream from Westhampnett Mill. Flows were measured on a quarterly basis from 1976 to 1981 on the major rifes (streams) draining the study area (Figure 2.8).

2.2.2 Surface Flow in the River Lavant

The River Lavant is considered to be the main source of recharge in the Chichester study area. It is an ephemeral stream fed by Chalk springs and surface runoff on the dip slope of the South Downs. Flow is diverted into three channels, one through Westhampnett Mill (Mill Stream) and the other two through the old Pound Farm gravel pit area. Mill Stream approaches to within 100 m. of the north west corner of Church Farm Pit at which point the bed is at an elevation of 16.8 m.O.D.

Flow in the Lavant may occur from September and July, but typically commences in late November with significant flow continuing through to April. Occasionally the Lavant will be dry for periods of up to 18 months (1972/72 and 1975/76), or, more rarely, flow may continue for two years (1967/69). Figure 2.9 illustrates flow patterns in the Lavant compared to long term rainfall patterns for the period 1968-88. Similar trends are evident from the water level data for Church Farm Pit shown in Figure 2.14 and these are discussed in Section 3.1.1. Peak flow in the Lavant usually lags behind peak seasonal rainfall by approximately two months as shown in Figures 2.10 and 2.12.

The flow volume and duration is determined on a seasonal basis by groundwater levels in the Chalk as shown in Figure 2.10. While there appears to be several factors related to Chalk groundwater levels which ultimately trigger Lavant flow, this surface flow does not occur unless levels reach a certain critical elevation. In the present study Chalk groundwater levels measured at a site at Boxgrove were taken as indicative of the local regime. As shown in Figure 2.11 at Boxgrove this critical elevation is between 11.5 and 13.0 m.O.D.

Once the critical groundwater level is exceeded and flow commences in the Lavant even small local rainfall events may produce a recognizable increase in Lavant flow rates, while below this level major regional rainfall events do not result in any measureable flow within the Lavant. Figures 2.13 and 2.14 illustrate that reductions in Lavant flow may also occur during periods of higher local rainfall.

The mean monthly flow, provided flow occurs, will on average equal or exceed 1.15 cumecs every other year. A flow of 1 cumec will occur in 4 years out of 5 in those years when flow occurs. The total volume of annual flow in the River Lavant measured at Greylingwell for the period 1970-88 ranges from 3 to 21 Mm3.

2.2.3 Surface Flow in the Rifes

Quarterly flow readings between 1976-81 from the rifes draining the study area provide an indication of seasonal flow rates but, as evident from Figure 2.16, these are not sufficiently detailed to allow accurate correlation between rainfall, infiltration and runoff. The majority of the gauging stations for the 1976-81 study were located along the southern margins of the study area where the rifes are better developed. There was no monitoring of rife flow in the immediate Westhampnett area. For these reasons surface flow in the rifes has not been included in either of the groundwater models.

It is probable that the rifes along the southern margins of the study area originate from surface runoff and groundwater from the drift deposits recharged from the Lavant, the numerous water filled pits and from the Chalk. There is a southerly increase in rife flow that may be related to a combination of increasing catchment size, and changes in the character of the drift deposits. The smaller catchment area of the Eldbridge Rife reflects the lower flow rates of this stream, while the high storage capacity of the lakes at the Southern Leisure Centre may be a factor in maintaining high base flows in the Pagham Rife.

The Southern Water Authority has suggested that the high summer base flows and hydrochemistry of the rifes to the west of Aldingbourne indicate that the water in these streams is partly derived directly from the Chalk. The Chalk derived component of flow in these rifes is greatest where the streams and their surrounding drift deposits lie directly upon the Chalk exposed in the cores of the Portsdown and Littlehampton Anticlines. This vertical movement of groundwater from the Chalk and into the drift deposits has been recognised as an important factor in determining the viability of future gravel extraction at Kingsham Farm.

There are insufficient data to show the elevation of the Chalk piezometric surface over the study area. However, the hydrographs shown on Figure 3.4 from twinned boreholes at Tangmere Road indicate that the piezometric surface for Chalk groundwater rises to 18.0 m.O.D., some six metres above the water table in the drift deposits.

The chemistry and high summer base flow of the Oving Rife was interpreted by Southern Water to indicate that overflow of groundwater from the Chalk was occurring along the

Chalk-Reading Beds contact to the north of Oving. This contact lies at approximately 17.0 m.O.D. in this area and at lower elevations north of Westhampnett (15.5 m.O.D.) and in the Lavant Valley (11.5m O.D.).

2.2.4 Rainfall

Rainfall records are available from twelve stations within the study area (Table 2). A long term record from 1898 is also available for Bognor (SZ 913 067). In the present study the records from County Hall for 1961-65, Portfield Depot for 1965-76 and Chichester Ambulance Station 1978-88 have been combined to form a long term record. There are insufficient groundwater level data to determine the contribution of rainfall to groundwater recharge within the regional model area. For this reason the regional and detailed mathematical studies have not attempted to model the effects of rainfall on the groundwater regime.

Table 2 Rainfall Gauging Stations - Chichester Study Area

Met. Office No.	Location	Availability
320730	Apuldram	1931-1959
321092	Amublance Station	1976-present
321103	Kingsham Farm	1938-1952
321109	West Street	1921-1959
321110	County Hall	1925-1965
321064	Lavant Reservoir	1938-1952
328108	Lavant Reservoir	1963-present
320949	Binderton	1969-1973
320391	North Mundam	1961-1963
320380	Portfield Depot	1965-1976
320445	Merton Adelands	1919-1955
320221	Halnaker	1969-present

The long term average annual rainfall for the Chichester study area is 784mm, while over the South Downs the average annual rainfall is in excess of 950mm. Rainfall patterns over the last twenty years suggest that there has been a period of drier than average years from 1970 through to 1978 and a wetter than average period from 1979 through to 1988 (Figure 2.9). The records since 1988 show lower than average annual rainfall over the study area. In an average year a total of approximately 20 Mm^3 of water falls as rain within the regional model area, of which possibly 5 million cubic metres (25%) recharges groundwater.

indicate where and how the natural aquifer had been altered.

The West Sussex County Council general reclamation strategy is to leave the pits south of the Brighton-Chichester railway as water filled lakes for recreational after-use, and to infill pits to the north of the railway with waste material.

Air-photographs were used to examine the development of pits and restoration in the study area. These were supplemented by information from West Sussex County Council, Planning Department and from interviews with individuals involved with the quarrying operations. All areas where gravel extraction was known to have occurred were documented and a seperate file established for each giving details of original gravel characteristics, the date, depth and type of quarrying, and the nature of any sealing and infilling. This information is listed in Appendix A and illustrated on Appendix A, Maps 1 to 4.

There was an expansion in quarrying activities between 1945 and 1960 with operations starting in the vicinity of the Southern Leisure Centre. By 1961 excavation was in progress at Shopwyke North and Church Farm Pits and completed at the Sainsburys site. At this time groundwater levels would have been depressed by pumping from Church Farm Pit, which is thought to have continued until the mid-1970's. However, the gradual infilling of the Sainsburys site and silt ponding in Shopwyke North was also taking place at this time.

In the early to mid 1970's Chichester District Council constructed a pulverisation plant on land on the northern side of Church Farm Pit. With the cessation of quarrying activities and the sealing of the pit walls water levels rose to 13.93 m.O.D., causing flooding of the Council site in January 1975. During 1978 the Bookers site was developed in the northwest corner of Church Farm Pit while the Sainsburys site was completely infilled and siltation continued in Shopwyke North. Since 1981 quarrying activities have been greatly reduced with changes to the groundwater regime being caused by progressive infilling of previous lined pits at Shopwyke South.

A number of the pits that were developed prior to 1939 were excavated with relatively low technology equipment which limited the depth to which they could penetrate. For example the British Rail sites at Portfield (Sites 22 & 23) were hand dug, while the Pound Farm quarry (Sites 3 & 4) were worked with older dragline machinery which was incapable of removing all the Fan Gravel. The transmissivity values assigned to particular sites has been adjusted where the historical records have suggested that either the marine gravels or some of the Fan Gravels may have been left in place.

A study of water level data from the Bulls reclamation site at Shopwyke South (Site 19) has the Fan Gravel. The transmissivity values assigned to particular sites has been adjusted where the historical records have suggested that either the marine gravels or some of the Fan Gravels may have been left in place.

A study of water level data from the Bulls reclamation site at Shopwyke South (Site 19) has shown that the water levels in the individual storage cells are unaffected by fluctuations in the water table outside the site (Figure 2.17). This suggests that the clay lining acts as a barrier to groundwater flow. However, many of the older pits may not have been effectively sealed. This is thought to include sites 3, 5?, 10, 21, 22, and 26 (Figure 1.2). There may be an increased risk of groundwater contamination from such pits.

The majority of the reclaimed pits have been infilled with the silt washings from the sand and gravel screening plants. This material has been assigned a very low permeability in the models. A slightly higher permeability has been assigned for those pits with domestic waste fill compared to the silt filled pits. However, the difference in permeability between these two types of fill relative to the high permeablity of the Valley Gravels means that such distinctions have only a limited effect upon the groundwater model predictions.

Chapter 3

HYDROGEOLOGY

The upper and lower wave-cut platforms represent two distinct groundwater provinces with different sources of recharge, different types of drift deposit and contrasting permeabilities. The drift deposits of the lower wave-cut platform are in hydraulic continuity with the Lavant valley gravels and receive surface and sub-surface recharge from this source. The drift deposits of the upper wave-cut platform receive no recharge from the Lavant valley but are believed to be seasonally in hydraulic continuity with the drift deposits of the lower wave-cut platform across the lower cliff line.

Several previous groundwater studies have been conducted by Southern Water Authority and other organisations with interests in the study area. The information from these was entered into the Institute of Hydrology computer database (GRIPS). Sites still open and available for groundwater monitoring were noted during the course of the data collection.

3.1 THE UPPER WAVE-CUT PLATFORM

Groundwater flow within the drift deposits of the upper wave-cut platform is strongly controlled by the nature of the bedrock. Over the bulk of the area where these deposits are underlain by the Upper Chalk, recharge from rainfall is quickly lost into this highly permeable sequence. Where the drift deposits of the upper wave-cut platform overlie impermeable Reading Beds a local perched water table develops, recharged by winter rains and overflow from the Chalk and losing groundwater by surface and subsurface flow across the cliff line into the drift deposits of the lower wave-cut platform.

Examples of such surface flow occur beside Claypit Lane - Coach Road at Westhampnett, and across the A27, 500 metres east of Maudlin. Over recent years the southerly surface flow beside Coach Road has been re-directed into Church Farm Pit, and could contribute to potential flooding problems in this area. There is very little data from along the cliff line which would allow the quantification of the amount and duration of the surface and sub-surface flow off the upper wave-cut platform. Similarly the regional waterlevel contour maps are not detailed enough to indicate whether a significant amount of water is flowing over this cliff line.

An hydraulic gradient of approximately 1:40 exists across the wave-cut cliff line, compared to the 1:1000 gradient southwards over the lower wave-cut platform. The gravels lying across the cliff line are only one or two metres thick.

3.2 THE LOWER WAVE-CUT PLATFORM

3.2.1 Aquifer Geometry

The Lavant alluvial fan is the primary hydrogeological feature of the East Chichester study area. Surface and groundwater flow through the study area is dominated by the fan geometry with local modifications due to gravel extraction. The isopach data for the combined thickness of all types of gravel shown in Figure 2.4 illustrates the dominant influence of the Lavant alluvial fan on gravel thickness. In the central portions of the fan the alluvial gravels represent 80-90% of the total gravel thickness.

Valley Gravels extend over a width of approximately 200 - 300 metres along the course of the River Lavant, spreading out to become the Fan Gravels as the river crosses the lower cliff-line. Only limited data are available on the Valley Gravels but in the Lavant village area they are at least 5.0 m thick near the centre of the valley, and thin to around 3.0 m along the sides of the valley where they lens into the Head Gravels of the upper wave-cut platform.

The Fan Gravels form a broad fan with a radius of approximately 3.0 km around Chichester, that is up to 10.0 m thick near Westhampnett Mill and lensing out to the east, west and south. This fan has developed during the recent geological past where the Lavant emerges from the Chalk uplands of the South Downs and passes over the less resistant Tertiary strata of the Chichester Syncline as shown in Figure 2.5.

Detailed information from south of Kingsham Farm indicates that the thickness of the Fan Gravel is highly variable, and exposures in the Shopwyke North gravel pit suggest that the Fan Gravels are incised as north-south trending channels into the underlying marine gravels. Figure 2.6 shows the Raised Beach Deposit (younger) to be thinner beneath the central parts of the alluvial fan, perhaps as a result of erosion during the deposition of the overlying Fan Gravels. Thickness and transmissivity variations in the Fan Gravels, and possible erosional thinning of the underlying marine gravels suggest that a paleo-channel of the Lavant may have continued along a southeasterly course from Westhampnett towards Merston.

There is a progressive change across the study area in the relative influence upon the groundwater regime of the Fan and marine gravels. In the area around Westhampnett the water table usually lies several metres above the base of the Fan Gravel, while to the south around Runcton the water table is within the marine gravels. In addition while there are seasonal variations in groundwater levels of 2-3 m. close to the River Lavant, they are only of the order of 0.5 m. around Runcton.

3.2.2 Groundwater Levels

The elevation of groundwater levels within the drift deposits of the lower wave-cut platform decreases gradually towards the south, from approximately 15.0 m.O.D. near the base of the cliff line to 6.5 m.O.D. at Runcton (Figures 3.1 and 3.3). The form of the water level contours reflect :

1) the topographic gradient;
2) the higher transmissivity gravels towards the axis of the alluvial fan;
3) the effects of the man-made lake systems; and
4) the relative thickness of the Fan and marine gravels.

What is not particularly evident from the contour pattern in Figure 3.1 is the effect of recharge from the River Lavant, but this is thought to be largely a function of the widely spaced monitoring points.

Groundwater levels vary seasonally by about 0.5 m in the south of the study area at Runcton, and 0.7 m in the north of the area at Westhampnett Village. As a result of recharge from surface flow and the restricting effects of infilled pits, the seasonal variations in groundwater levels at locations along the course of the Lavant is probably in the order of several metres.

The water filled pits have a high storage capability, with the potential for rapid filling and slow release of water back to the drift deposits. This has the effect of increasing the total volume of water recharging the gravels and probably also maintaining higher baseflows in the rifes draining the area.

Very little detailed information is available on the effects of commencement and changing rates of flow in the Lavant on the local groundwater conditions. It can be assumed that in the areas close to the course of the Lavant, as with Church Farm Pit, there is a rapid rise in groundwater levels at the commencement of river flow. Earlier studies by the Southern Water Authority showed groundwater levels around the margins of Church Farm Pit respond closely to changes in water levels in the pit. Data examined during the present study from Portfield and Drayton and shown in Figure 2.15 would indicate that the seasonal fall in groundwater levels may occur more rapidly in areas close to the Lavant.

3.2.3 Water Levels in Church Farm Pit

Water levels in Church Farm Pit rise rapidly after the commencement of surface flow in the River Lavant. This relationship is illustrated in the data from 1974-75 shown in Figure 2.12. An adequate understanding of this relationship is however impaired by the lack of data for the period immediately before, and just after, Lavant flow commences. The amount of water lost from the Lavant has not been quantified by flow measurements, although pumping rates of 10000 m3./day (0.12 cumecs) are usually required to prevent water levels exceeding 15.5 m.O.D. in Church Farm Pit. At the commencement of river flow water can enter Church Farm Pit at a rate which may be as high as 20000 m3/day (0.23 cumecs).

When seasonal flow begins on the Lavant a hydraulic gradient of approximately 1:20 exists over the 100 metres between the river and the pit. This steep initial gradient would seem to account for the rapid rise in pit water levels that accompanies the commencement of river flow. As water levels rise within the pit there is a corresponding reduction in the hydraulic gradient resulting in a decrease in flow from the Lavant to the pit. Any reductions in pit water levels that may be produced by pumping from Church Farm Pit will be counter-balanced by a corresponding increase in the hydraulic gradient and hence increased flow to the pit.

The effects of varying flow rates in the Lavant on the water levels in Church Farm Pit are not clearly understood. The general trends evident in Figure 2.12 show that water levels fell only slightly in response to the lower river flow rates in January 1975, and slowly declined during the rapid fall in flow rates in March 1975. Similarly, the sudden fall in river flow in late February 1983 shown on Figure 2.13 did not affect lake water levels. This suggests that the slow drainage of water through the clay lining around Church Farm Pit dampens the fluctuations in water levels that might be caused by changing river flow rates.

In the same way that annual Lavant flow rates are comparable to the longer term variations in rainfall that were described earlier (Figure 2.9), peak winter water levels in Church Farm Pit also mirror these longer term seasonal variations as shown in Figure 2.14. The relatively low winter maxima that occurred between 1979 and 1972 corresponding to a period of below average rainfall.

The record of pit water levels between 1969 and 1979 shown in Figure 2.14 suggests that there was been a progressive rise in pit water levels. It is possible that this may be due to a process of natural siltation and decreasing permeability of the pit walls. The apparent levelling off of maximum levels since 1979 is possibly of function of both pumping and natural drainage from the pit. It appears likely that water levels will continue to rise to 15.5 m.O.D. under future average conditions.

The limited data available indicate that local rainfall events do not have a significant effect upon water levels within Church Farm Pit as shown by Figure 2.13. This lack of response may be due to some over-riding control on maximum water levels such as pumping or natural overflow above the clay liner along the walls of the pit. Similarly, there are insufficient data to draw any reliable conclusions regarding the effect of local rainfall events on groundwater recharge. The few detailed hydrographic records that are available such as that reproduced in Figure 2.15, do not indicate any appreciable effects from local rainfall events.

3.2.4 Aquifer Characteristics

Pumping tests were carried out by Southern Water Authority in 1975 at the Pulverisation Plant adjacent to Church Farm Pit. A transmissivity of 650 m2/d was derived using the Jacob Method from these tests of a combined Fan Gravel and Lower Raised Beach Deposit sequence. Assuming an average saturated thickness of 3.5m the indicated average hydraulic conductivity was 185 m/d.

Using distance draw down data from the above tests, the specific yield was calculation at 3.5%. There are no specific yield data available for other areas or other parts of the drift sequence. The lack of specific yield information was one factor in preventing the use of time varying mathematical models during the current study.

Falling head permeability tests were carried out at the Pulverisation Plant during 1975. Falling head and constant head permeability tests were also undertaken along the proposed route of the A-27 By-Pass. These results may be summarised as follows :

	Pulverisation Plant	A-27 Road Line
Made Ground	2 m/d(2 results)	0.1 - 1.0 m/d
Clay	0.1 - 3.0 m/d	0.1 - 3.0 m/d
Fan Gravels	0.3 - 30.0 m/d	approx 180 m/d
Marine Gravels	0.1 -10.0 m/d	

To supplement the limited data on transmissivity from pumping and input tests the hydraulic conductivity of each of the gravel types within the study area was estimated using the specific surface approach from grain size analyses (Boonstra and de Ridder, 1981). These results are given in Table 3 and summarised as follows for each type of gravel.

Gravel type	Bulk Mean Hydraulic Conductivity (m/d)
Head Gravel	31.4 (10 samples)
Raised Beach Deposit (Y)	16.9 (8 samples)
Raised Beach Deposit (O)	(27.6) (1 sample)
Raised Storm Beach Deposit	14.0 (2 samples)
Fan Gravel	189 (8 samples)

With a comparable value for Fan Gravel hydraulic conductivity of approx 180 m/d being obtained using several different methods, the lower result from the input tests at the Pulverisation Plant may be regarded unrepresentative.

As shown above and in Table 3 the Fan Gravels have a higher hydraulic conductivity than either the marine or Head Gravels. The distribution of the data points for which hydraulic conductivity is available is illustrated in Figures 3.6 to 3.8. While these are insufficient to allow detailed interpretation, the higher values at Kives Farm (Borehole 80SE53) may reflect the presence of coarser well sorted gravels associated with a possible paleochannel of the Lavant.

The hydraulic conductivity data has been used to derive a transmissivity for each borehole site assuming saturation of the gravel sequence, and this is represented as Figure 3.5. Grain size analyses are also available for the area covered during engineering studies for the A27 By-Pass and around Kingsham Farm. However these data cover a relatively small area, and as the results are consistent with the overall patterns developed from the more regional data, they are not included in Figure 3.5.

The data available for the present study are not sufficiently detailed to allow for the influence of the different types of gravel to be accurately accounted for in the preparation of the regional model. A qualitative approximation was made in defining the transmissivity variations within the model areas.

3.3 CONCEPTUAL MODEL

The most important features of the groundwater regime in the East Chichester area are summarised in the following sections. These features represent the basic assumptions that were inherent in the development of the mathematical models.

Table 3 Estimates of Hydraulic Conductivities (m/d)[1]

HYDRAULIC CONDUCTIVITIES

Borehole Ref No.	Grid Reference	Gravel Thickness		Head Gravels Thickness	Head Gravels K	Fan Gravels Thickness	Fan Gravels K	Beach Gravels Thickness	Beach Gravels K
		m	m2d	m	m/d	m	m/d	m	m/d
80 NW 134	84530707	1.9	60	1.9	32				
80 NW 135	84510529	1.0	33	1.0	33				
80 NE 36	85150607	4.5	171	3.0	43			1.5	41
80 NE 37	86940801	3.8	260	3.8	68				
80 NE 39	87810757	2.2	92	2.2	42				
80 NE 40	87420661	1.9	75	1.9	39				
80 NE 42	88650678	4.1	23	2.1	?			2.0	12
80 NE 44	89550685	2.0	32					2.0	16
80 NE 45	89690567	4.3	44	4.3	10				
90 NW 57	90350747	1.8	15	1.8	7				
90 NW 58	90210654	2.7	33	2.7	12				
90 NW 59	90730517	2.7	16					2.7	6
90 NW 64	91410548	1.9	15					1.9	8
80 SE 42	85530294	1.8	84			1.8	47		
80 SE 46	86270323	3.8	122			2.0	39	1.8	24
80 SE 49	87030235	2.4	64			2.4	27		
80 SE 52	88230404	4.6	590			3.0	189	1.6	(22)
80 SE 53	88700356	3.1	1145			1.0	1035	2.1	52
80 SE 54	88280266	2.0	72			2.0	36		
80 SE 57	89250458	3.4	396			2.9?	134	0.5?	14
80 SE 58	89750341	2.7	214			2.7	80		
90 SW 35	90230479	4.1	258			1.8	130	2.3	10
90 SW 36	90640338	0.5	6					0.5	13
90 SW 40	91110454	2.8	14					2.8	5

[1] Based on specific surface using constant of 50,000

3.3.1 Regional Model

The following features were incorporated into the regional model:

- The drift deposits of the the lower wave-cut platform comprise the aquifer of primary interest to the present study.
- The Lavant valley is the principal source of recharge in the area and was therefore assigned a high transmissivity with a fixed head upper boundary.

  The cliff-lines were considered as no flow boundaries even though it was appreciated that an apparently small but unquantified amount of surface and groundwater flow was occurring across these features.

- The direction and magnitude of groundwater flow is primarily controlled by the geometry and characteristics of the Fan Gravels. In areas where there was limited data, transmissivity values were extrapolated on the basis of anticipated fan geometry.

- The seasonal fluctuation in groundwater levels across most of the regional study area is less than 1.0 m.

The groundwater regime has been disturbed by excavation and infilling of numerous gravel pits. There are several features which influence the regional groundwater regime but which have not, for various reasons, been incorporated in the mathematical model. These include any vertical groundwater flow from the Chalk, the surface rife flow, and the effects of rainfall on groundwater levels.

There has been no attempt to quantify the licenced and unlicenced abstraction from the gravel aquifer and this has also been omitted from the groundwater models.

3.3.2 Church Farm Pit Model:

In addition to those features included in the regional model the local Church Farm Pit model also included the following:

- The Fan Gravels comprise the aquifer of primary interest in the Westhampnett area where it has been heavily modified by infilled and open pits. The inferred geometry of the alluvial fan was used to extrapolate transmissivity values in undisturbed areas.

- Recharge of the Fan Gravels is predominantly from the Lavant valley which has been assigned a high transmissivity. The inferred no flow boundary of the lower wave-cut platform is within less than 200 m. of Church Farm Pit.

- The available hydrographs for water levels in Church Farm Pit suggest that the seasonal on-set of surface flow in the River Lavant results in rapid water levels rises of up to 2.5 m. The subsequent slow decline in pit water levels is thought to be due to slow seepage through the clay seal around the pit walls. This clay liner was included in the model as a low transmissivity zone around the southern half of Church Farm Pit.

  The high hydraulic gradient between Church Farm Pit and the Lavant results in high groundwater flow rates towards the pit. These high flow rates have been simulated in the model by assigning a high transmissivity to the gravels between the Lavant and Church Farm Pit.

- The nature of the fill material and the thickness of gravel left beneath particular reclamation sites was considered in assigning transmissivity values.

In addition there are certain features which are believed to influence the hydrological regime in the Westhampnett area but which have not been included in the mathematical model:

- An unquantified amount of surface and groundwater flow is known to enter Church Farm Pit from the north-east from north of the cliff line.

- Overflow is thought to occur above the clay seal along the southern wall of Church Farm Pit once water levels exceed approximately 14.5 m.O.D. The simple models employed in the present study could make not provision for this type of outflow.

- Gradual siltation over the last twenty years has increased the effectiveness of the clay seal lining Church Farm Pit, resulting in higher peak winter water levels and slower decline in levels over the summer months.

- No provision has been made for pumping and surface transfer from Church Farm Pit or between different parts of Tarmac's Portfield operations.

  The extent to which different flow rates within the River Lavant, and also local rainfall events affect water levels in Church Farm Pit are inadequately understood and have not been included in the mathematical models.

To take account of all these features in a mathematical model of the Church Farm Pit area would require more information than is presently available.

Chapter 4

REGIONAL MODEL

4.1 INTRODUCTION

The area included in the regional model representing the gravel aquifer east of Chichester is shown in Figure 1.1. The northern limit of the model was taken to be the break of slope between the lower and upper wave-cut platforms. The southern limit of the model was taken to be the point where the overall gravel thickness reduces to less than 1 m. The model was extended in a north westerly direction up the valley of the river Lavant. This river breaks through the cliff line which forms the break of slope between the two raised beaches; the river valley will probably contain a significant thickness of gravel.

Fixed head boundary conditions were applied along both the northern and southern boundaries of the model. Groundwater levels which are representative of winter conditions were utilised. The western and eastern boundaries were parallel to the groundwater contours; these were represented as no flow boundaries. The western and eastern boundaries were located a sufficient distance from the main area of interest that their location would not significantly influence the groundwater levels predicted in this area.

The transmissivity distribution used in the model was based on that described in Chapter 3 of this report. This distribution is based on limited field data and should be treated as only an initial approximation. No gravel pits were explicitly represented in the regional model.

The main objective of the regional model was to bring together the data for the entire region into an analytical framework. The results of this model could then be used to define the boundary conditions and background transmissivity distribution for the localised model which was used to investigate the impact of gravel pits.

4.2 MODEL RESULTS

Insufficient data exist to carry out detailed calibration of the model under either steady state or transient conditions. Results of the steady-state simulations with the model were compared with groundwater levels observed during the winter period.

4.2.1 Flow across northern boundary

In the first simulations with the model groundwater was assumed to enter the area along the entire northern boundary. This representation resulted in groundwater levels higher than those observed in the north-east and north-west of the area. The contour pattern they did not curve sufficiently about a point where the Lavant valley enters the area.

These results suggested that there is no significant flow from the upper raised beach into the gravel aquifer under investigation. The simulated condition was modified so that groundwater could only enter the modelled area from that part of the northern boundary adjacent to the Lavant valley. This simulation gave significantly better agreement with the observed groundwater levels, which would imply that the main source of groundwater for the area under study is flow down the Lavant valley.

4.2.2 Transmissivity distribution

The initial transmissivity distribution used in the model was based on limited field data. This transmissivity distribution has the highest values in the central part of the modelled area. This is inconsistent with the hydrogeological history of the aquifer which suggests that the gravels were deposited by a proto-Lavant. Given this hydrogeological history the highest transmissivities would be expected in the Lavant valley.

The initial model runs which used the transmissivity distribution given in Part A resulted in groundwater levels which agreed poorly with the observed values both in distribution and absolute value. A modified transmissivity distribution consistent with the hydrogeological history of the aquifer was used in an attempt to improve the predictions.

After a number of simulations predicted groundwater levels which agreed reasonably well with those observed were achieved; these are shown on Figure 3.1 together with the observed levels.

The transmissivities used in the final model simulation are shown in Figure 3.2. The highest values occur in the Lavant valley and values decrease with increasing distance from the point where the Lavant valley enters the aquifer.

Chapter 5

CHURCH FARM PIT MODEL

5.1 INTRODUCTION

The Church Farm Pit model was of the area in the immediate vicinity of Church Farm Pit and was used to obtain initial estimates of the impact of selected developments proposed in the Westhampnett area. The major hydrogeological features of this area are shown in Figure 5.1. The regional model was used to define the boundary conditions and the natural transmissivity distribution for this model. The characteristics of the various gravel pits, both open and infilled, were superimposed on this background transmissivity distribution.

5.2 MODEL CALIBRATION

One of the main concerns relating to Church Farm Pit has been the increase in water levels over recent years. This is a particular problem during winter months when areas adjacent to the pit flood and pumping is carried out to provide protection.

In any given year the water levels in the pit exhibit a characteristic hydrograph which shows a rapid rise of between 2 and 3 m over approximately 1 month following by a much slower recession. It was not possible to simulate the changes in water level in Church Farm Pit over a number of years because of the lack of data and instead this model has been calibrated by simulating the characteristic hydrograph of the pit.

The initial rapid rise in water levels cannot be due solely to groundwater inflow. Much of the water must come from a surface water source even through this may not flow directly into the pit as a surface water channel. The nearest surface water source is the river Lavant. It is envisaged that water from the Lavant causes the observed rapid rise in water levels. This water reaches the pit via highly permeable gravels between the river and the pit. The slow recession of water levels in the pit is typical of that due to groundwater flow from a partially sealed gravel pit. This conceptual model of Church Farm Pit was investigated with the model.

Figure 4.2 shows the transmissivity distribution used for the Church Farm Pit simulation of existing conditions. Superimposed on the background transmissivity distribution which was developed with the regional model is the impact of the gravel pits. These have been respresented as follows:

FEATURE	OBJECTIVE	TRANSMISSIVITY
Water Filled (Church Farm Pit, (Shopwyke North)	To ensure a horizontal surface across the water.	Very high (> 50,000) m^2/d
Pit Sealing (Church Farm Pit)	To represent a thin impermeable clay liner.	Very low (< 1.0)
Silt Filled (Tarmac Portfield, (Sainsburys)	To represent impermeable clays.	Very low (< 1.0)
Reclamation Sites (Sainsbury's, Bookers, WSCC Westhampnett)	To account for heterogeneous character.	Low (< 50)
Lavant River	To allow rapid flow of water from the river to Church Farm Pit.	High

Values of storage coefficient were also assigned to the various components of the hydrogeological system: a value of unity was been given to the water filled pits and in the absence of information to the contrary, a value of 10% has been applied to all other features.

In order to represent recharge to the groundwater system from the Lavant a groundwater source was introduced at the points of the Lavant which are closest to Church Farm Pit. Both the quantity and timing of inputs at these locations were varied until an hydrograph for Church Farm Pit which agreed reasonably well with that observed was developed.

The modelled Church Farm Pit hydrograph is shown in Figure 4.3. This hydrograph exhibits a rise in water level of approximately 2.8 m over a 25 day period following by a decline of approximately 1 m over the next 90 days. This hydrograph agrees well with that observed. In order to achieve this hydrograph a rapid rise in recharge from the Lavant is required. After a short period of time the recharge declines since the groundwater levels, and Church Farm Pit level, rise thus reducing the driving force for recharge which is the hydraulic gradient between the river and the watertable. The maximum recharge rate is of the order of 0.4 m3/s. Neither the timing or rate of recharge from the Lavant is unreasonable given the flow conditions in the river during the winter.

The satisfactory simulation of the water level variations in Church Farm Pit indicates that the major hydrogeological features are being reasonably simulated by the model, which meant that the model could be used to make some tentative predictions of the water level response to various developments in the area.

5.3 TRANSIENT PREDICTIONS

The calibrated time varying model described in section 5.2 was used to make transient predictions.

The construction of the proposed Westhampnett By-pass may alter the seal along the southern edge of Church Farm Pit. The extremes of such changes are the extension of the seal along the entire south face of the pit or the removal of the seal along the entire south face of the pit. The impact of these two extremes on water levels in Church Farm Pit were investigated with the time varying model. The results are shown in Figure 5.4.

The extension of the seal along the entire south face of Church Farm Pit prevents groundwater flow from the pit into the area of unworked gravels to the southeast. This results in a rise in water levels in the pit. The peak water level is increased by 10 cm. The rate of recession of pit levels is decreased by extending the seal. Ninety days after the peak level the water levels in the pit could be 30 cm higher than those which occur under existing conditions.

The removal of the seal on the south face of Church Farm Pit has a smaller impact because of the silt pond to the south of the pit which are infilled and have low transmissivities. These pits prevent a significant amount of outflow, in this direction, even in the absence of a seal. Hence the water levels in Church Farm Pit are reduced by less than 10 cm by the removal of the seal along the south face of the pit.

5.4 STEADY STATE PREDICTIONS

The long term impact of the various developments proposed have been investigated using a steady-state version of the Church Farm Pit model. The groundwater levels under a high groundwater level or winter condition have been simulated. The predicted changes in water level generated by the developments are the greatest changes which will occur. It is not possible to estimate how long it will take for these water levels to be reached.

Unless otherwise stated the transmissivity distribution used in the steady state model is the same as that used in the time-varying model and illustrated in Figure 4.2.

5.4.1 Existing conditions

The steady-state, winter groundwater levels which occur with the existing configuration of pits is illustrated in Figure 5.5.

The water surfaces at Church Farm Pit and Shopwyke North Pit occur at levels of 15.5m and 12.8m respectively. The areas of low permeability caused by the Church Farm Pit seal and the silt pond to the south of this pit result in a steep hydraulic gradient between Church Farm Pit and Shopwyke North. It is interesting to note that Pound Farm Pits, Sainsburys Pits and the Westhampnett reclamation site have little impact on the groundwater contours.

5.4.2 Full seal across south face of Church Farm Pit

Figure 5.6 presents the steady state groundwater levels which occur when there is a full seal across the south face of Church Farm Pit. The difference between these water levels and those under existing conditions are shown in Figure 5.7.

Sealing the south face of Church Farm Pit results in an increase in the water level both in and to the north of the pit of in excess of 0.5 m. The groundwater contours to the southeast of Church Farm pit are closer together as a result of the extension of the seal. At this location groundwater levels fell by more than 1 m. A small reduction in the water level in Shopwyke North Pit also occurs as a result of the extension of the seal.

5.4.3 Removal of the seal along the south face of Church Farm Pit

Figure 5.8 presents the steady state groundwater levels which occur when the seal across the south face of Church Farm Pit is removed. The difference between these water levels and those under existing conditions are shown in Figure 5.9. Only minor changes in the groundwater contour pattern occur as result of removing the seal with groundwater levels along the north face of the silt ponds and Tarmacs Portfield site increasing by up to 0.6m.

Water levels in both Church Farm Pit and Shopwyke North Pit are unaltered by removing the seal.

5.4.4 Infilling of Church Farm Pit with domestic waste

Figure 5.10 presents the steady state groundwater level which would occur if Church Farm Pit were to be filled with domestic waste. The difference between these water levels and those under existing conditions are shown in Figure 5.11.

The infilled Church Farm Pit is represented in the model as an area of very low transmissivity. Since this pit is the major hydrogeological feature of the area under investigation, the infilling causes a major change in the transmissivity distribution and thus a significant change in the steady-state groundwater levels.

Groundwater levels to the west of a line which passes through Tarmacs Portfield site and Church Farm Pit are increased by the infilling of Church Farm Pit. Groundwater levels to the east of this line are decreased by the infilling of this pit.

The maximum increase in water levels exceeds 2 m in the area between the Pound Farm pits and Bookers site and the greatest decrease in water levels is in excess of 2m, which occurs at the southeast corner of Church Farm Pit.

At Bookers site, which is already subject to flooding problems, groundwater levels may increase by between 1 and 2 m as a result of the infilling of Church Farm Pit.

At Shopwyke North the water level will decrease by up to 1 m as a result of the infilling of Church Farm Pit.

5.4.5 Compression of the material in the Pound Farm Pits

It has been proposed that the uncompressed domestic waste in the Pound Farm Pits should be removed and replaced by compressed builders waste. This change will result in a reduction in transmissivity in these pits. This reduction was represented in the model by assigning a very low transmissivity to the area of Pound Farm Pits.

Figure 5.12 presents the steady state groundwater level which would occur if the material in Pound Farm Pits were compressed. The difference between these water levels and those under existing conditions are shown in Figure 5.13.

The effect of compressing the material in Pound Farm Pits is minor. Groundwater levels in these pits and the northern part of the Sainsburys Pits are decreased by up to 1 m.

At all other locations including Church Farm Pit, Shopwyke North and Bookers site the groundwater levels are not significantly altered.

5.4.6 West Coach Road pit water filled

Figure 5.14 presents the steady state groundwater level which would occur if the West Coach road pit were to be excavated and left water filled. The difference between these water levels and those under existing conditions are shown in Figure 5.15. The water filled West Coach road pit was represented in the model as an area of very high transmissivity.

Once the West Coach road pit has been excavated there will only be a thin band of undisturbed gravel separating it from Church Farm Pit. If the West Coach road pit is left as a water filled pit this narrow band of gravel will have little impact - the West Coach road pit will effectively become an extension of Church Farm Pit.

A water filled West Coach Road pit will result in a reduction in water levels in Church Farm Pit of more than of 1 m. Groundwater levels at Bookers site will also be reduced by more than 1 m.

Water levels in the West Coach road pit will be up to 1 m higher than the present groundwater level at this location but water levels in Shopwyke North will be up to 0.5m higher as a result of a water filled West Coach Road pit.

5.4.7 West Coach Road pit domestic waste filled

Figure 5.16 presents the steady state groundwater level which would occur if the West Coach road pit were to be filled with domestic waste. The difference between these water levels and those under existing conditions are shown in Figure 5.17. The infilled West Coach road pit was represented in the model as an area of very low transmissivity.

The infilling of the West Coach road pit reduces the amount of groundwater flow from Church Farm Pit in a southerly direction. This results in an increase in the water level in Church Farm Pit of in excess of 0.5 m. Groundwater levels at Bookers site are also increased by more than 0.5 m.

In the western part of the West coach road pit groundwater levels are increased by up to 1 m by the infilling of this pit with domestic waste. Water levels in Shopwyke North are increased by up to 0.5 m by the infilling of the West Coach road pit.

5.4.8 East Coach Road pit domestic waste filled

Figure 5.18 presents the steady-state groundwater level which would occur if the East Coach road pit were to be filled with domestic waste. The difference between these water levels and those under existing conditions are shown in Figure 5.19. The infilled East Coach Road pit was represented in the model as an area of very low transmissivity.

The infilling of the East Coach Road pit reduces the amount of groundwater flow from Church Farm Pit in a south-easterly direction. This causes an increase in the water level in Church Farm Pit, and Shopwyke North Bookers site, by about an 0.5m. Groundwater levels are increased by approximately 1m at the southwest corner of the Westhampnett reclamation site as a result of the infilling of the East Coach Road pit.

As a result of infilling the pit groundwater levels in the East Coach road pit are reduced by up to 0.5 m.

5.4.9 Probable configuration

As a final steady-state prediction the combined impact of the most likely future developments was investigated. The situation investigated had the following differences from existing conditions :

1. The seal along Church Farm pit seal was extended across the entire south face. This was represented in the model as an area of very low transmissivity.

2. Pound Farm Pits were filled with compressed builders waste. This was represented in the model as an area of very low transmissivity.

3. East Coach Road Pit was excavated and left water filled. This was represented in the model as an area of very high transmissivity.

The overall impact of this final configuration on groundwater levels is small, water levels in Church Farm Pit show a small increase and those in Shopwyke North are slightly reduced from their present levels. Groundwater levels beneath Bookers site are increased.

The extension of the seal to the southeast corner of Church Farm Pit together with the excavation and filling of the West Coach Road pit with water results in a decrease in groundwater level of up to 1m immediately to the southeast of Church Farm Pit.

Chapter 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

Insufficient data exists on groundwater levels and aquifer properties to calibrate the groundwater models. The results therefore must be used with great caution.

The main source of groundwater for the area under study would appear to be flow down the Lavant valley.

To achieve reasonably agreement between modelled and observed groundwater levels a transmissivity distribution which has its highest values in the Lavant valley is required. The transmissivities must decrease with increasing distance from the point where the Lavant valley enters the aquifer.

It is not possible for the rapid 2 to 3 m rise in water level in Church Farm pit to occur solely by the inflow of groundwater. Much of the water must come from surface water even through no surface water channel flows directly into the pit. The most likely source of surface water is the river Lavant.

If the seal along the south face of Church Farm pit is extended water levels in the pit may rise by more than 0.5 m. Water levels to the southeast of the pit may fall by up to 1 m as a result of extending the seal. Conversely, if the seal along the south face of Church Farm Pit is removed water levels in the pit may fall by less than 10 cm and groundwater levels immediately to the south of the pit may rise by 0.6 m.

If Church Farm Pit is infilled groundwater levels beneath Bookers site may rise by up to 2 m. At the southeast corner of Church Farm Pit water levels will decrease by up to 2 m as a result of filling the pit. Water levels in Shopwyke North may reduce by 1 m due to filling of Church Farm Pit.

The effect of replacing the material in the Pound Farm Pits by compressed material is insignificant.

Excavation of West Coach Road pit and allowing it to fill with water may result in a reduction in water levels in Church Farm Pit and beneath Bookers site of more than 1 m. Water levels in the West Coach Road pit will be up to 1 m higher than the present groundwater levels. Water levels in Shopwyke North may increase by 0.5 m.

Excavation of West Coach Road pit and infilling it with domestic waste may result in an increase in water levels in Church Farm Pit and beneath Bookers site of more than 0.5 m. Water levels in the West Coach Road pit will be up to 1 m lower than the present groundwater levels. Water levels in Shopwyke North may decrease by 0.5 m.

Excavation of East Coach Road pit and infilling it with domestic waste may result in an increase in water levels in Church Farm Pit and beneath Bookers site of more than 0.5 m. Water levels in the Westhampnett reclamation site may increase by up to 1 m. Water levels in the East Coach Road pit will be up to 0.5 m lower than the present groundwater levels. Water levels in Shopwyke North may decrease by 0.5 m.

The overall impact of a final pit configuration which consists of Church Farm Pit with an extended seal, Pound Farm Pits filled with compressed material and a water filled West Coach Road Pit is small. Water levels in Church Farm Pit are increased slightly and those in Shopwyke are slightly reduced. Groundwater levels immediately to the southeast of Church Farm Pit fall by up to 1 m with this final pit configuration.

6.2 RECOMMENDATIONS

6.2.1 Introduction

It is recommended that additional data should be collected in order to improve the local Church Farm Pit model. Using existing and proposed boreholes additional information should be obtained on groundwater levels, flow directions, and aquifer geometry and characteristics. Any upgrading of the regional model should be restricted to using data derived from the improvement of the Church Farm Pit model, or from local studies within the regional model area.

It is recommended that additional data collection in the Church Farm Pit area should proceed with the objective of preparing a more sophisticated groundwater model. This would be a time varying, finite element, multi-layer model capable of integrating rainfall and evaporation, rife flow, and the local flow patterns that exist around Church Farm Pit. Data collection, and in particular water level monitoring should continue for a period of at least two years. While the more sophisticated groundwater model is being developed all additional information should be periodically intergated into the existing AQUA model. Such upgrading of the existing model will provide more accurate predictions of the impact of proposed engineering works, and identify controls on groundwater flow which may not be evident at the present time.

6.2.2 Additional Monitoring Stations

Several features are believed to have a significant influence upon the local groundwater regime but, because these are not quantifiable at the present time, they have not been included in the current model. A network of new monitoring points is therefore proposed which seeks to address these problems. A itemised listing of the proposed boreholes is included as Appendix C and shown on Figure 6.1.

It is proposed that in addition to detailed geological descriptions of the sequence, laboratory and field aquifer property tests should also be undertaken at selected sites. In order to resolve several of the components of the groundwater regime accurate and continuous monitoring of water levels will be required at several sites.

In total 29 new boreholes are proposed. These have been sited so as to determine the following:

1) The relationship between Lavant flow, groundwater level changes and Church Farm Pit water levels (Boreholes 1-6).

2) Fan Gravel geometry and characteristics around Pound Farm Gravel Pits (Boreholes 7-9).

3) The geometry and properties of the Lavant Valley Gravels and their thinning towards the upper wave-cut platform. To also indicate the hydraulic gradient down the Lavant Valley (Boreholes 10-13).

4) The elevation of the Chalk/Reading Beds contact and monitor Chalk groundwater levels relative to this contact (Boreholes 14-15).

5) Aquifer geometry and characteristics along and above the lower cliff-line in order to establish the volume and timing of flow across this feature (Boreholes 16-19).

6) Fan Gravel characteristics and provide additional groundwater level control points around the south west margins of the local model area (Boreholes 20-21).

7) Measure the extent of overflow above the clay liner in Church Farm Pit (Boreholes 22-23).

8) Aquifer characteristics and monitor groundwater levels in the vicinity of East Coach Road to allow prediction of the impact of quarrying and/or soakaways (Boreholes 24-29)

Surface flow monitoring stations should be established at four locations, on Mill Stream, on the Lower Lavant, along Coach Road, and east of Maudlin. In addition, surface water levels should be monitored in Shopwyke North Pit, Maudlin Farm Pond and the Cottage Pond.

6.2.3 Detailed Proposals

It is recommended that, if there is sufficient interest in further data being collected in the Church Farm Pit area, a detailed costed proposal should be prepared for submission to interested groups.

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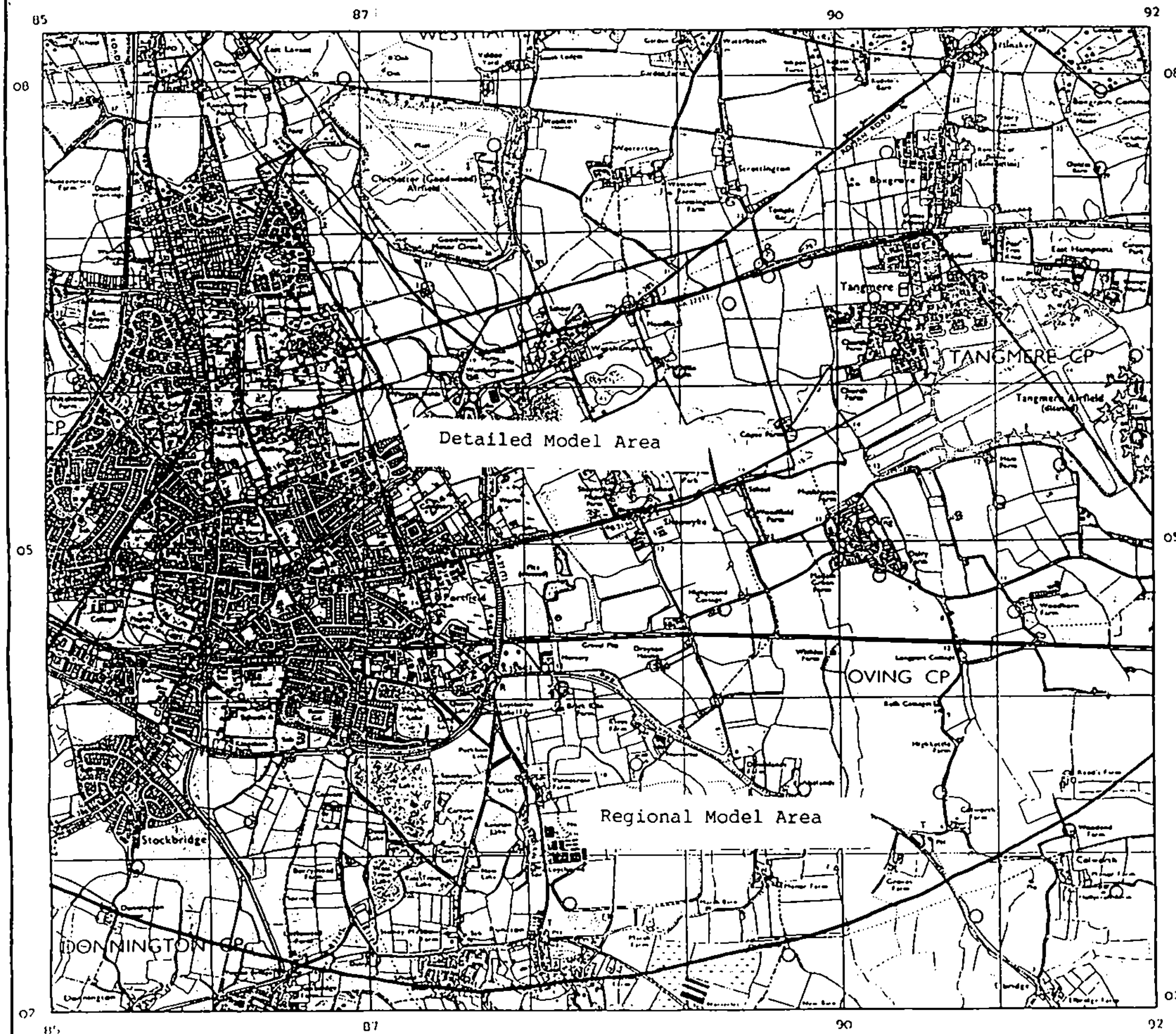


EAST CHICHESTER GROUNDWATER STUDY

Figure I.I LOCATION PLAN

Scale I:36,000 Approx.

Based on Ordinance Survey SUBO/90

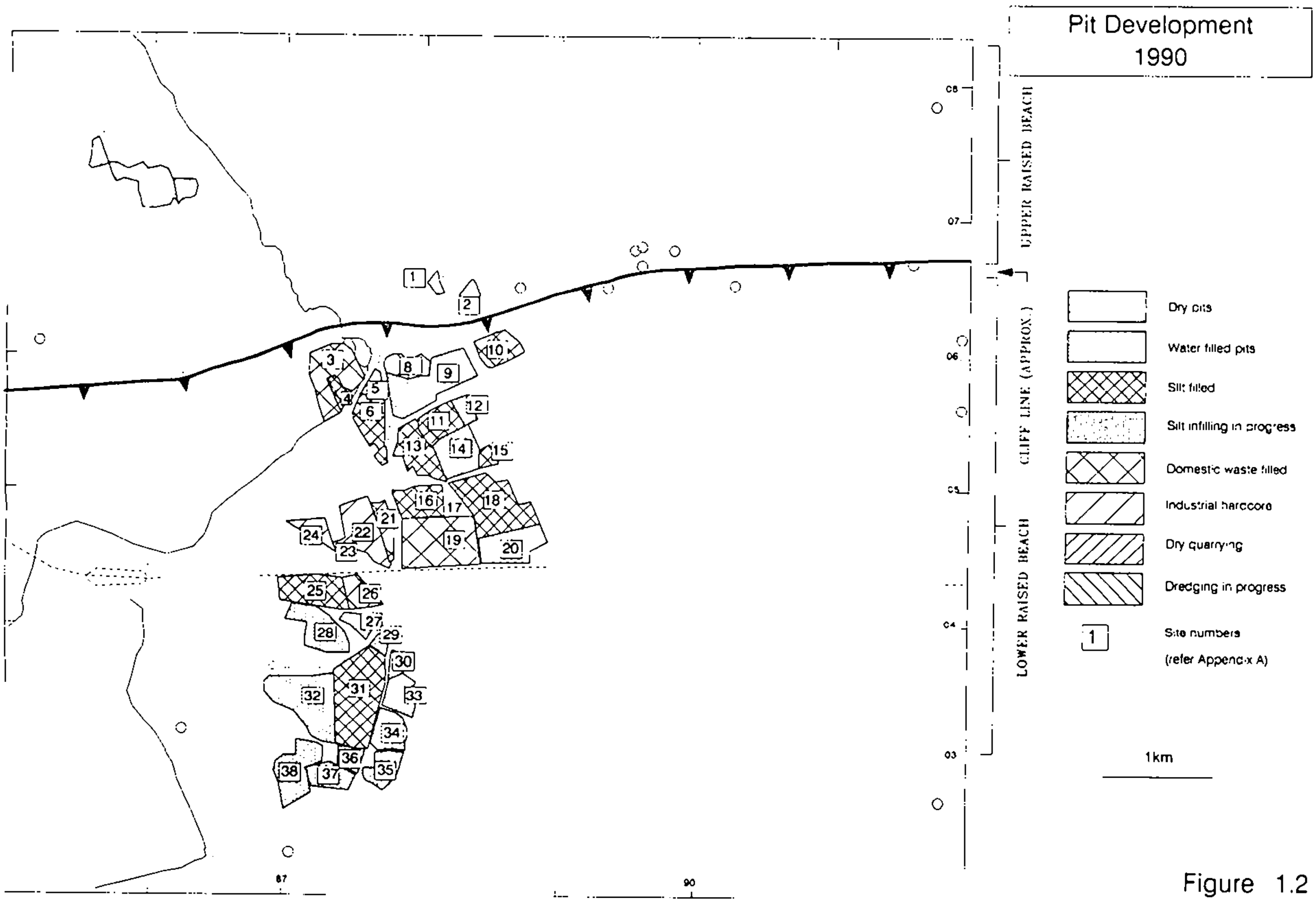

Pit Development
1990
UPPER RAISED BEACH
CLIFF LINE (APPROX.)
LOWER RAISED BEACH
Dry pits
Water filled pits
Silt filled
Silt infilling in progress
Domestic waste filled
Industrial harccore
Dry quarrying
Dredging in progress
Site numbers
(refer Appendix A)
1km
08
07
06
05
04
03
87
90
1
2
3
4
5
6
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38

Figure 1.2

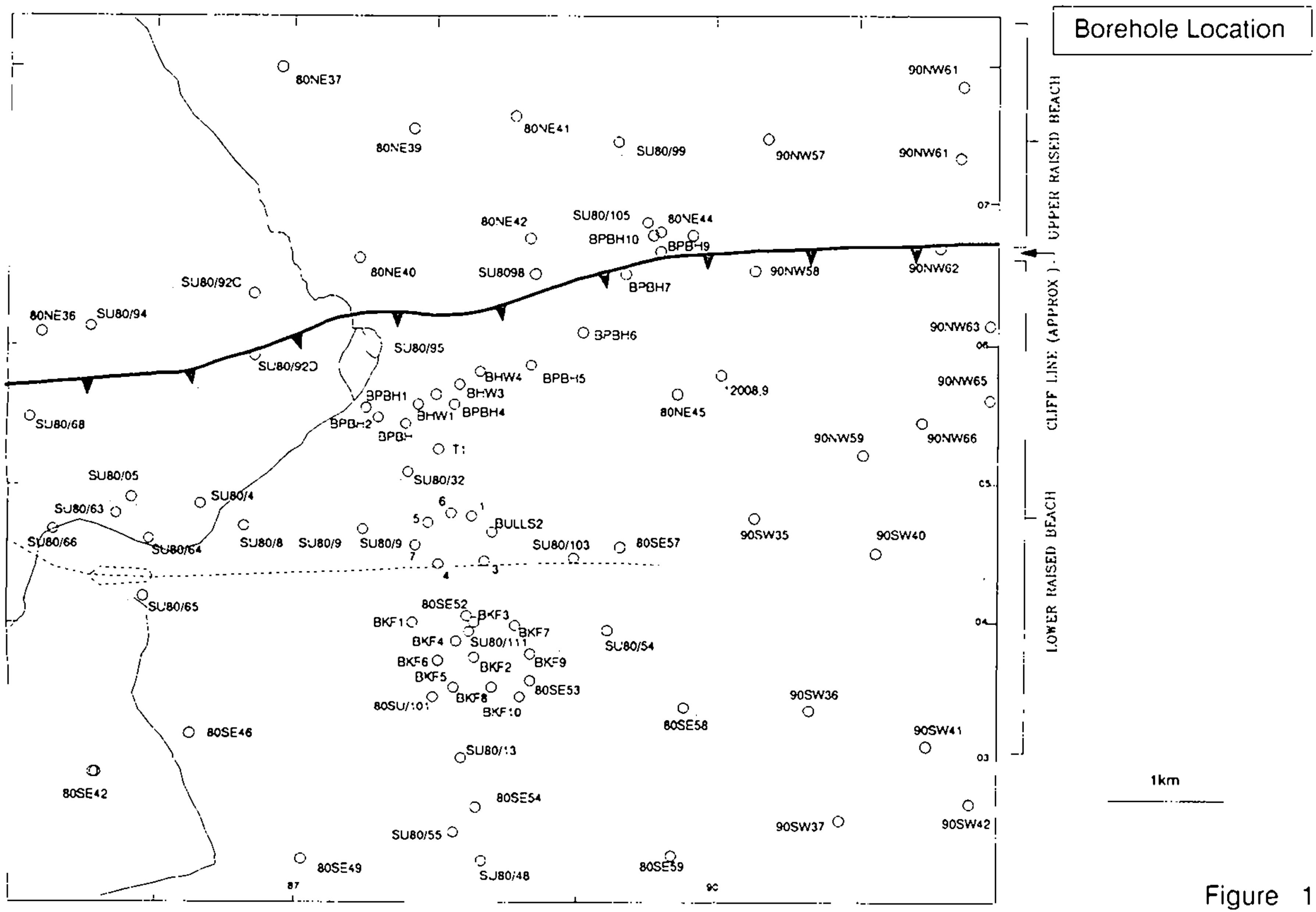
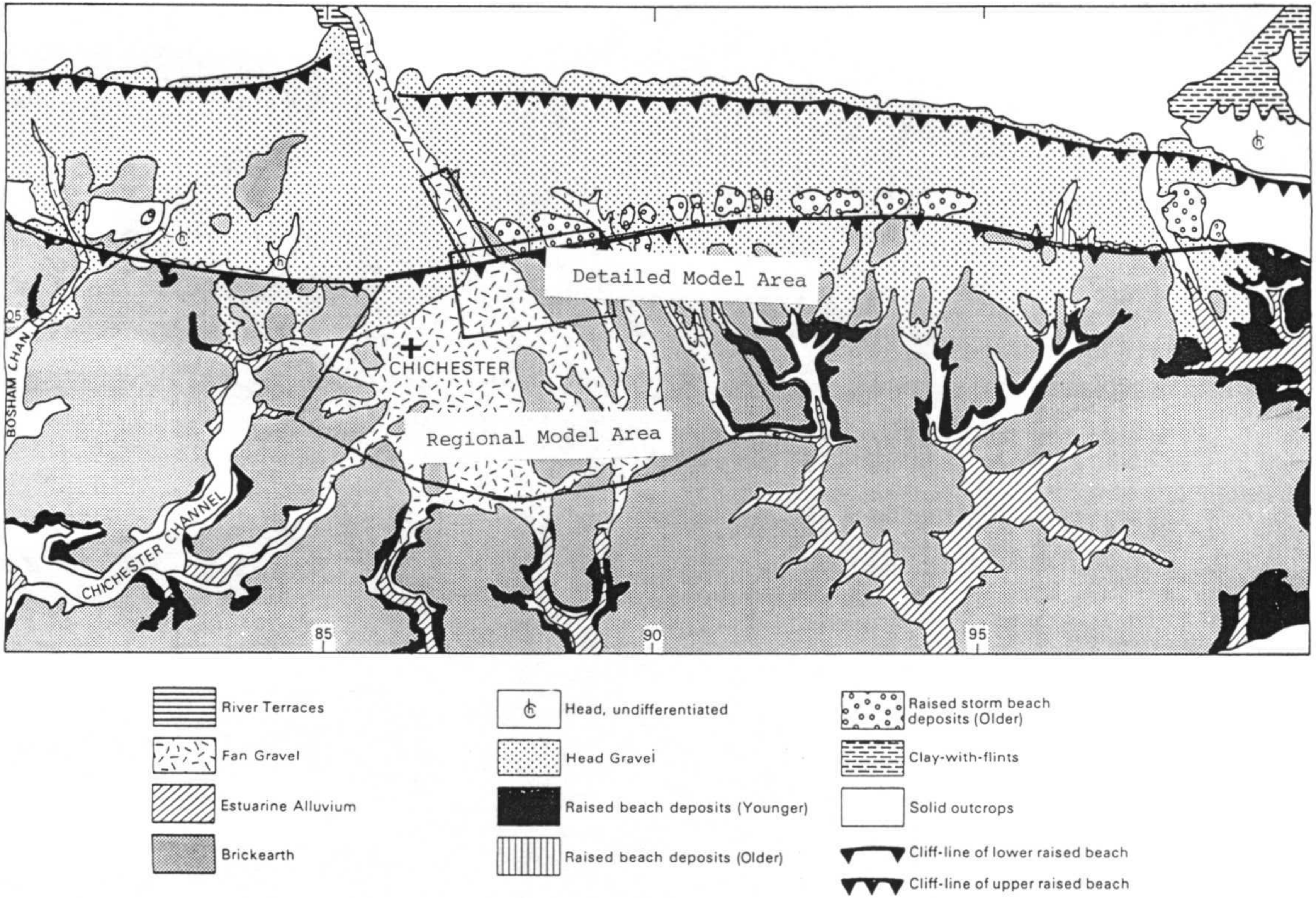

Borehole Location
UPPER RAISED BEACH
CLIFF LINE (APPROX.)
LOWER RAISED BEACH
1km
80NE37
80NE39
80NE41
SU80/99
90NW57
90NW61
90NW61
80NE42
SU80/105
80NE44
BPBH10
BPBH9
80NE40
SU8098
BPBH7
90NW58
90NW62
SU80/92C
80NE36
SU80/94
BPBH6
90NW63
SU80/95
SU80/92D
BHW4
BPBH5
2008.9
90NW65
SU80/68
BPBH1
BHW3
BHW1
BPBH4
80NE45
BPBH2
90NW59
90NW66
T1
SU80/05
SU80/32
SU80/4
SU80/63
BULLS2
SU80/66
SU80/64
SU80/8
SU80/9
SU80/9
SU80/103
80SE57
90SW35
90SW40
SU80/65
80SE52
BKF3
BKF1
BKF7
SU80/54
BKF4
SU80/111
BKF6
BKF2
BKF9
BKF5
80SE53
80SU/101
BKF8
BKF10
90SW36
80SE58
80SE46
90SW41
SU80/13
80SE42
80SE54
SU80/55
90SW37
90SW42
80SE49
SU80/48
80SE59

Figure 1.3



2.1 Drift Geology

(From IMAU Report I38, BGS I983)

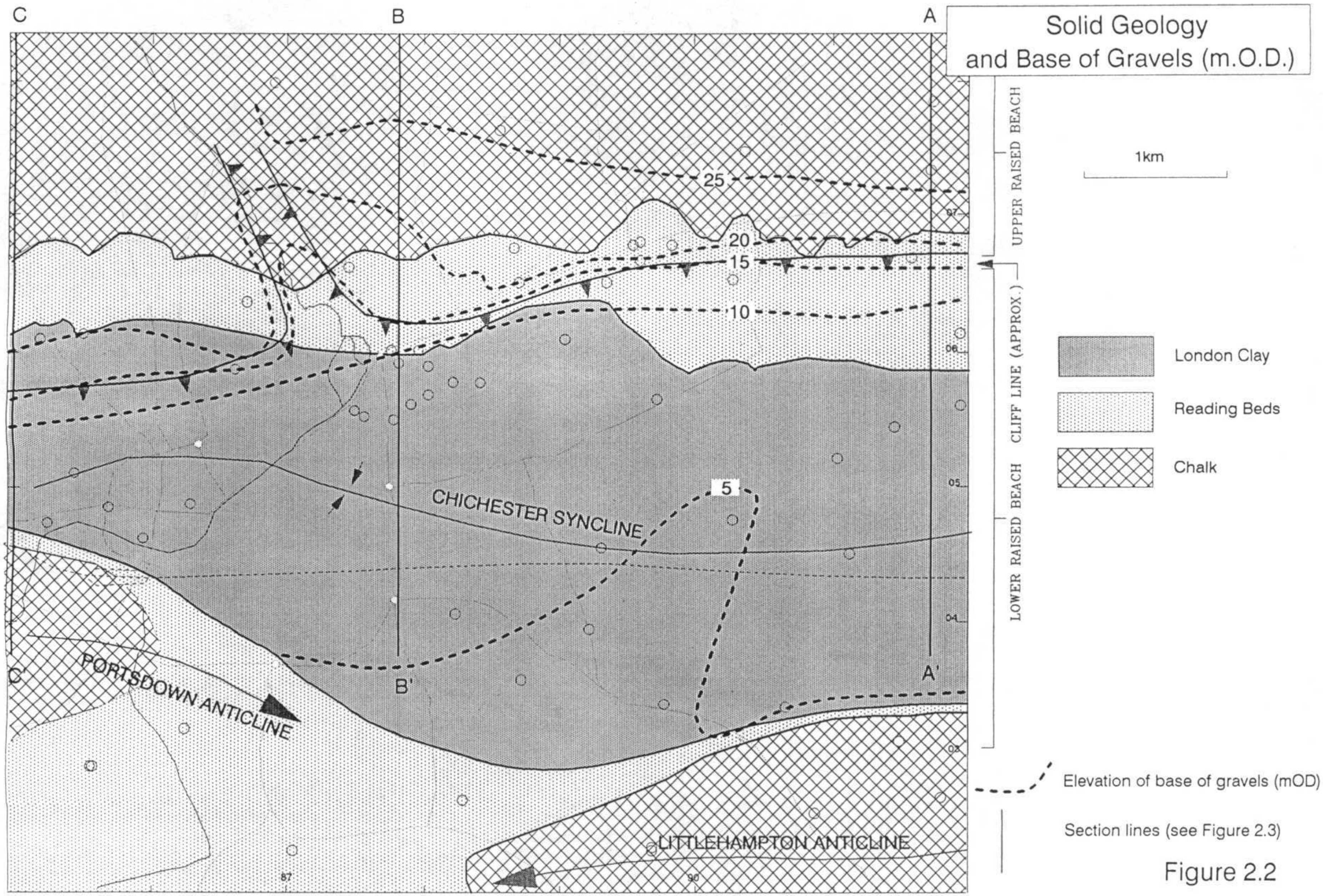

Solid Geology
and Base of Gravels (m.O.D.)
C
B
A
C'
B'
A'
25
20
15
10
5
CHICHESTER SYNCLINE
PORTSDOWN ANTICLINE
LITTLEHAMPTON ANTICLINE
UPPER RAISED BEACH
CLIFF LINE (APPROX.)
LOWER RAISED BEACH
1km
London Clay
Reading Beds
Chalk
Elevation of base of gravels (mOD)
Section lines (see Figure 2.3)

Figure 2.2

Geological Cross Sections

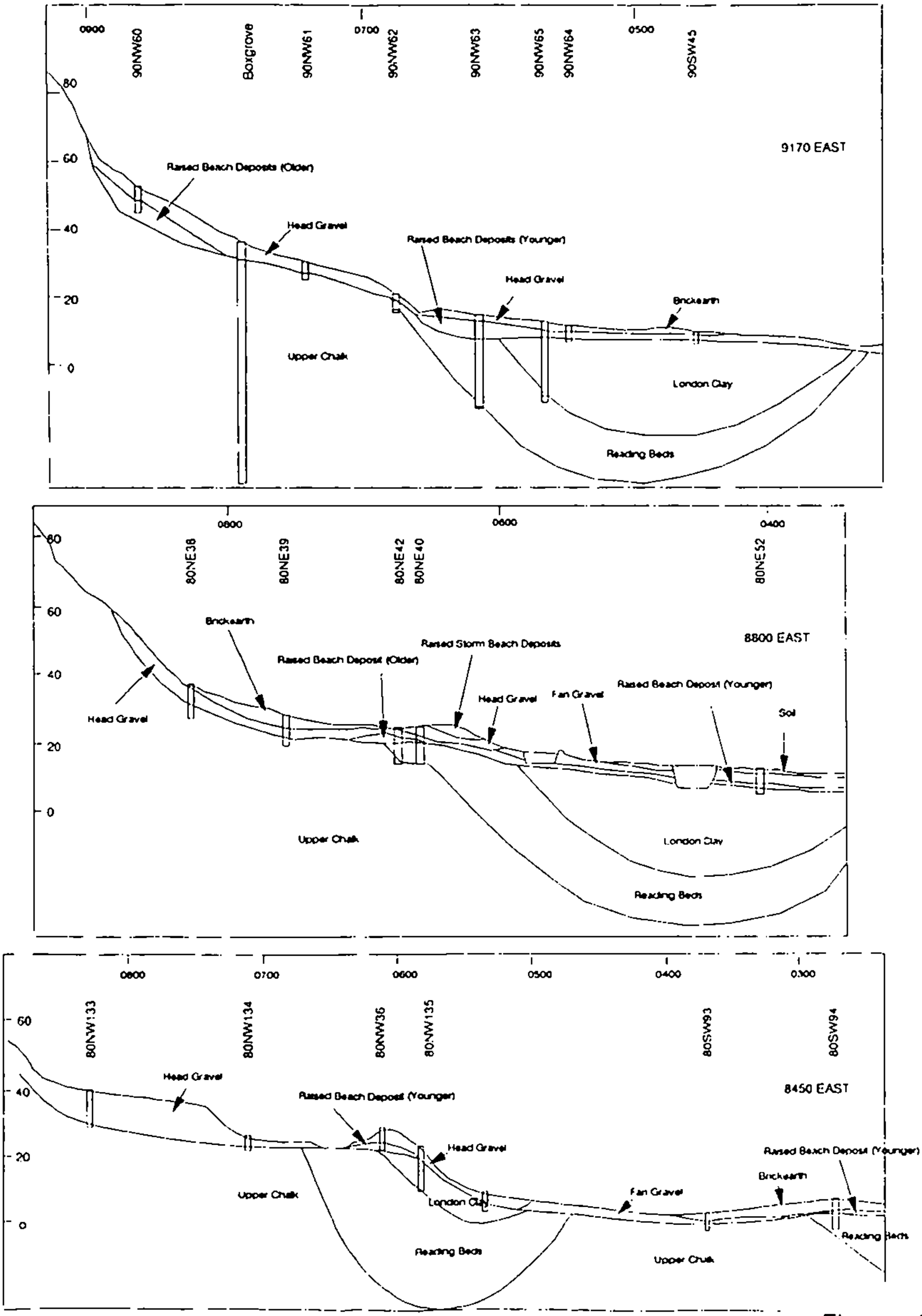


Figure 2.3

Gravel Thickness (m)

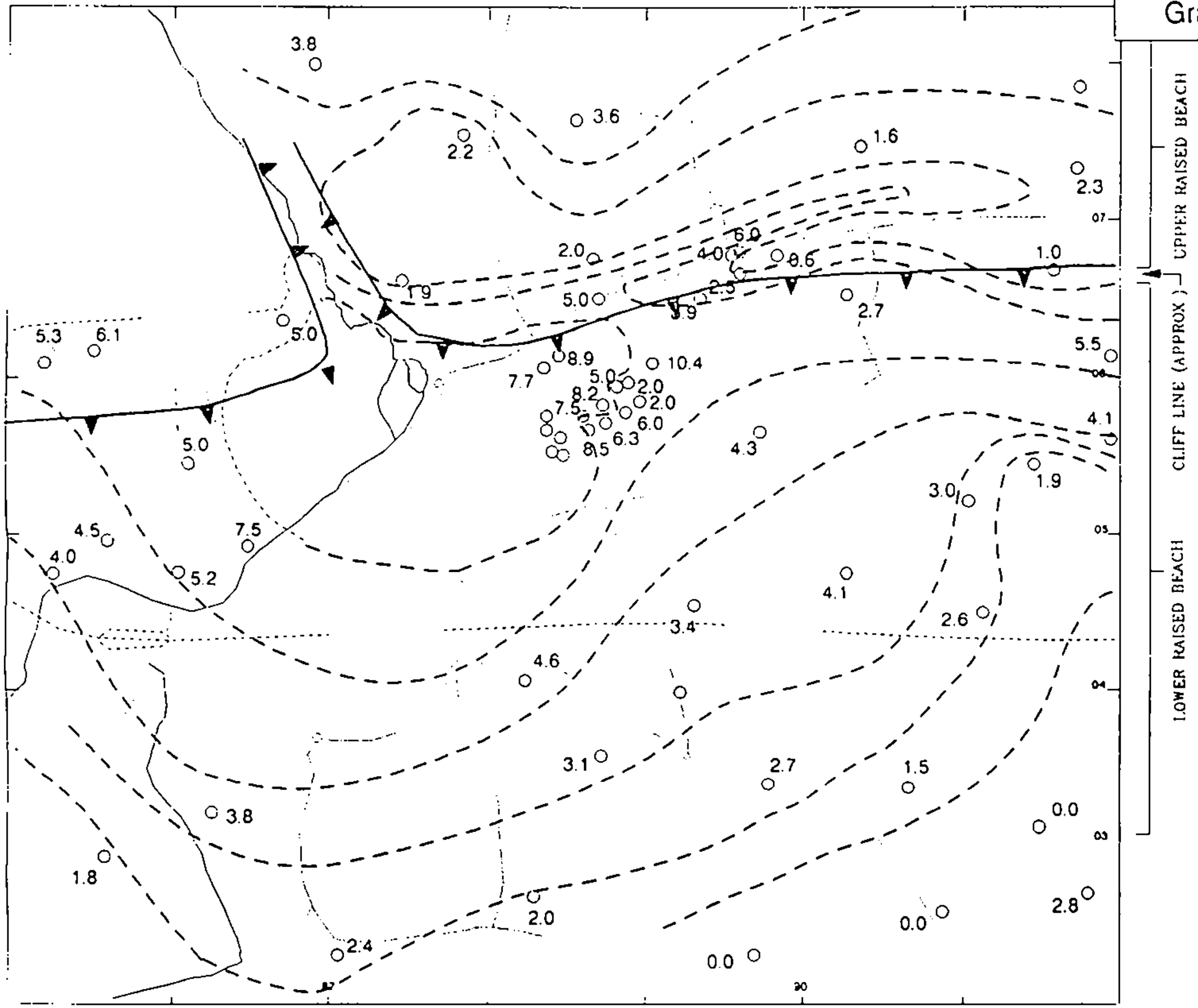
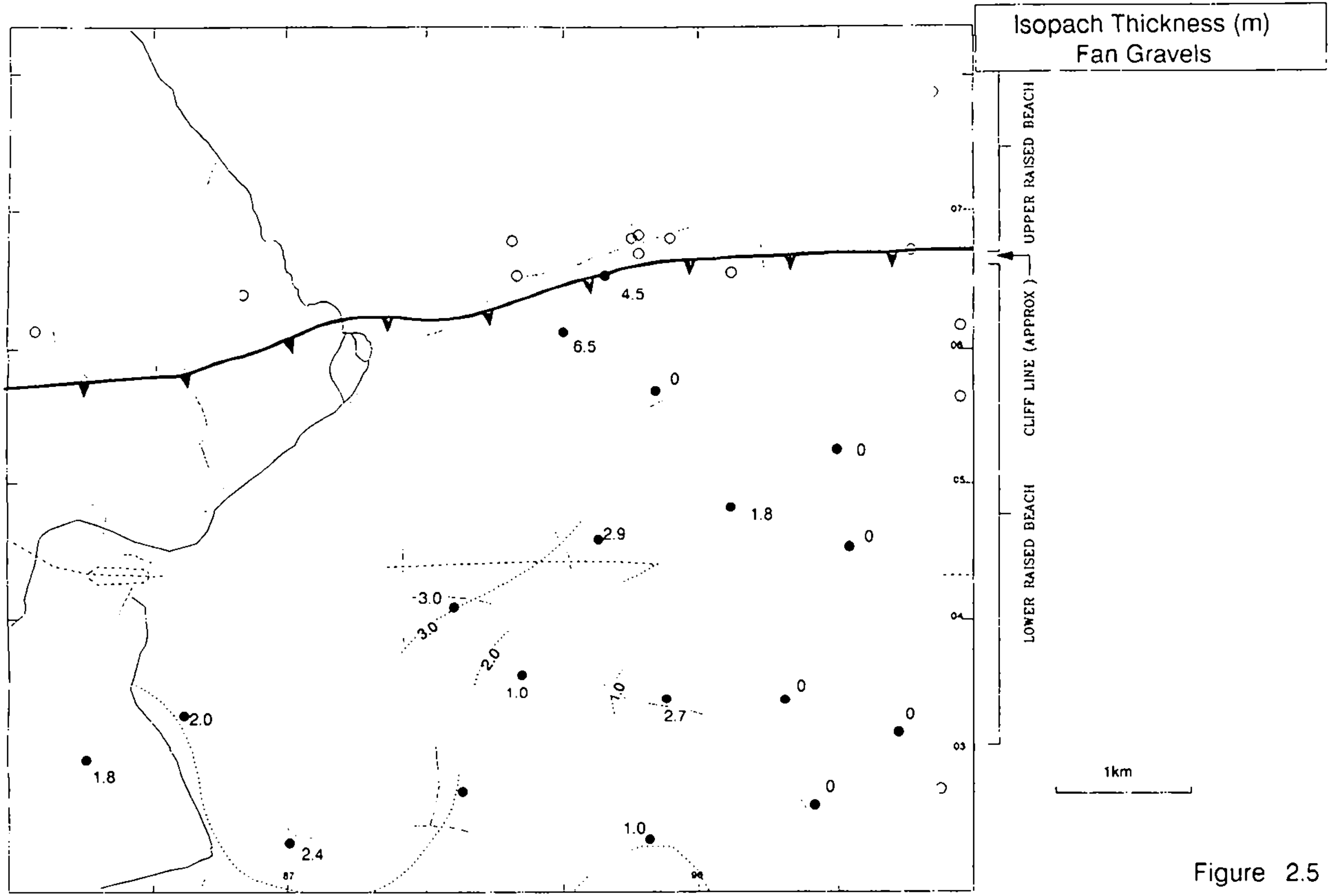


Figure 2.4



Isopach Thickness (m)
Fan Gravels
UPPER RAISED BEACH
CLIFF LINE (APPROX)
LOWER RAISED BEACH
1km
4.5
6.5
0
0
1.8
0
2.9
-3.0
3.0
2.0
1.0
1.0
2.7
0
0
2.0
1.8
0
1.0
2.4

Figure 2.5

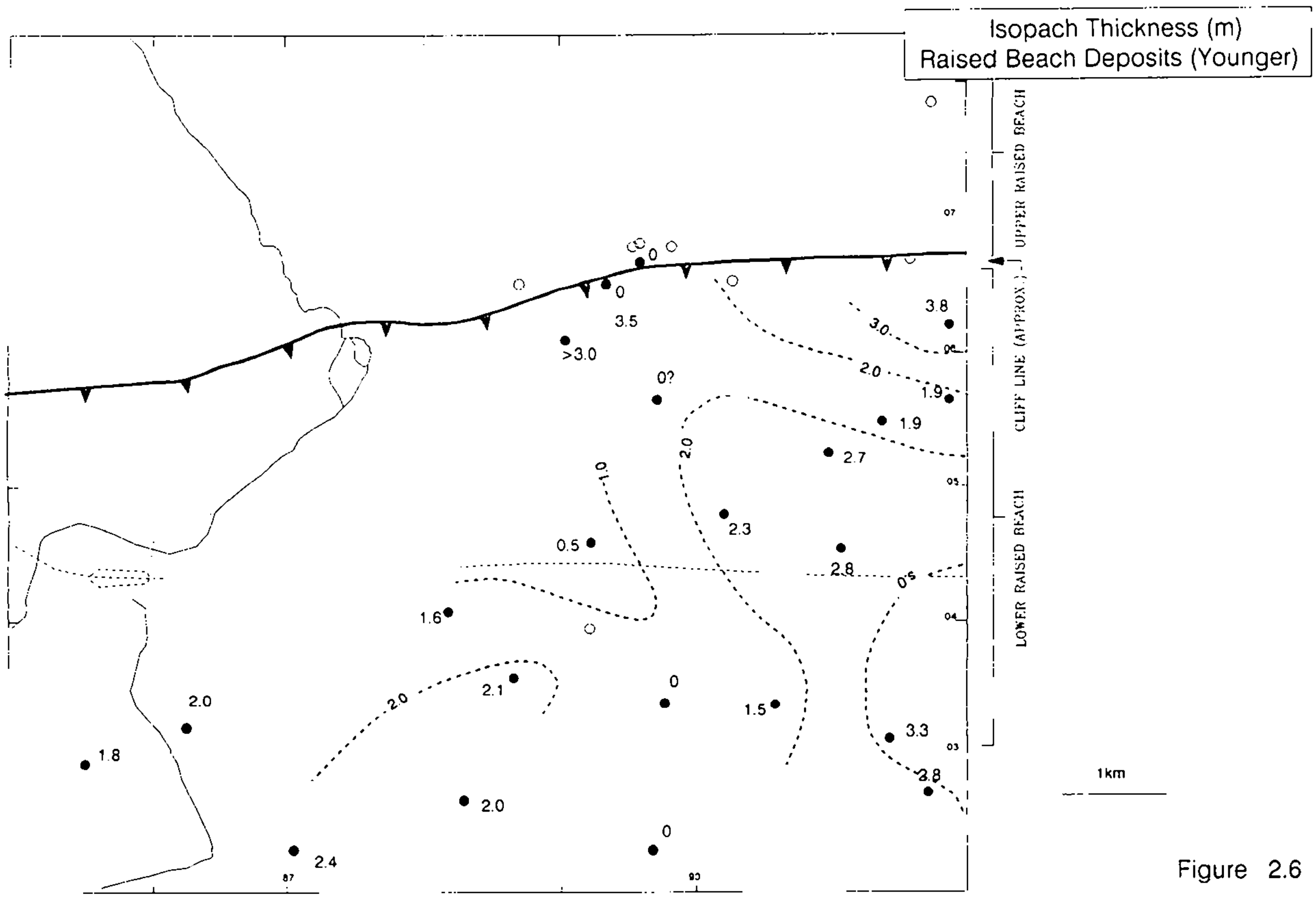
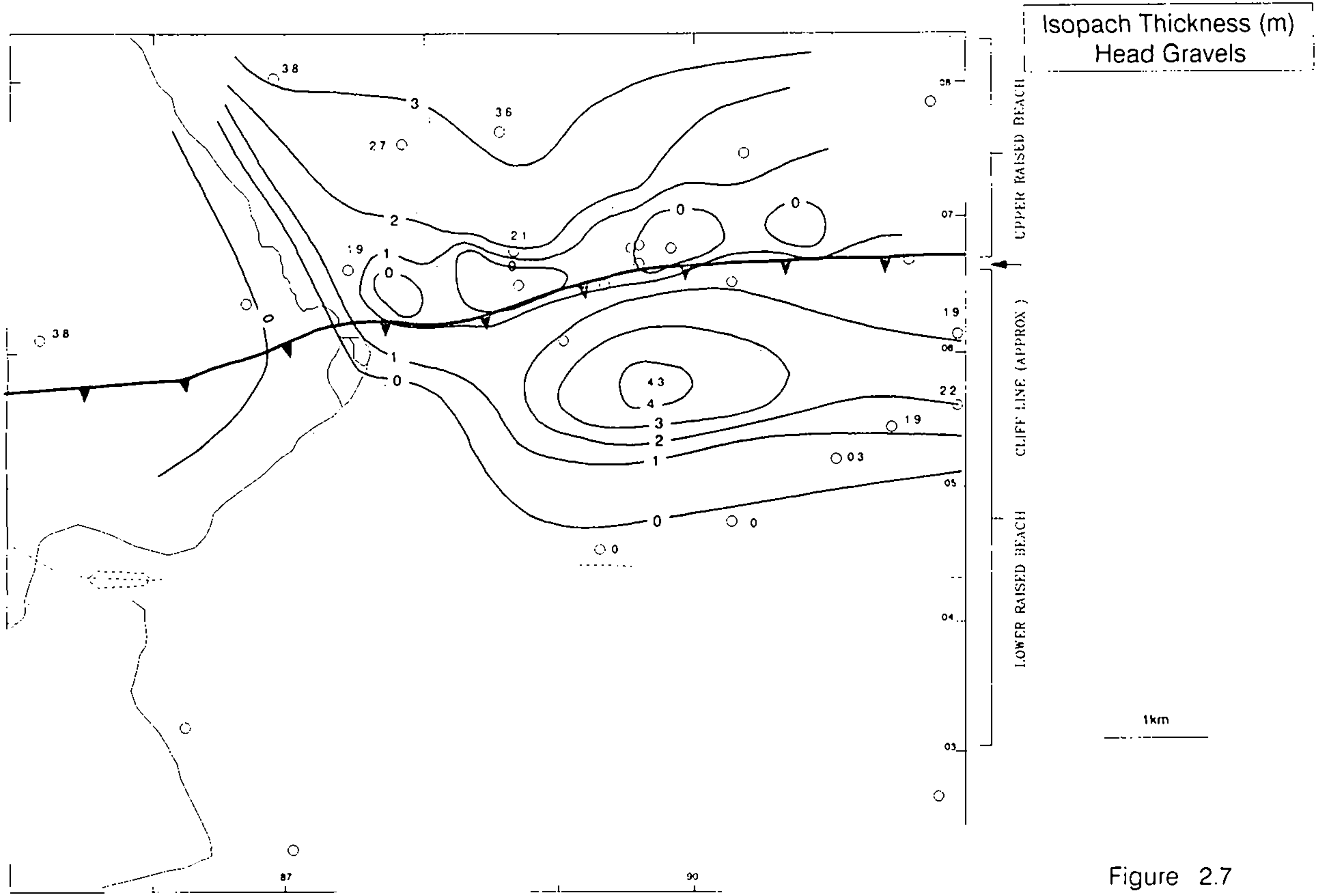

Isopach Thickness (m)
Raised Beach Deposits (Younger)
UPPER RAISED BEACH
CLIFF LINE (APPROX.)
LOWER RAISED BEACH
1km
3.0
2.0
1.0
0.5
3.8
1.9
2.7
2.3
2.8
3.5
>3.0
0?
0.5
1.6
2.1
2.0
1.8
2.4
1.5
3.3
0

Figure 2.6



Isopach Thickness (m)
Head Gravels
UPPER RAISED BEACH
CLIFF LINE (APPROX.)
LOWER RAISED BEACH
1km

Figure 2.7

Surface Flow

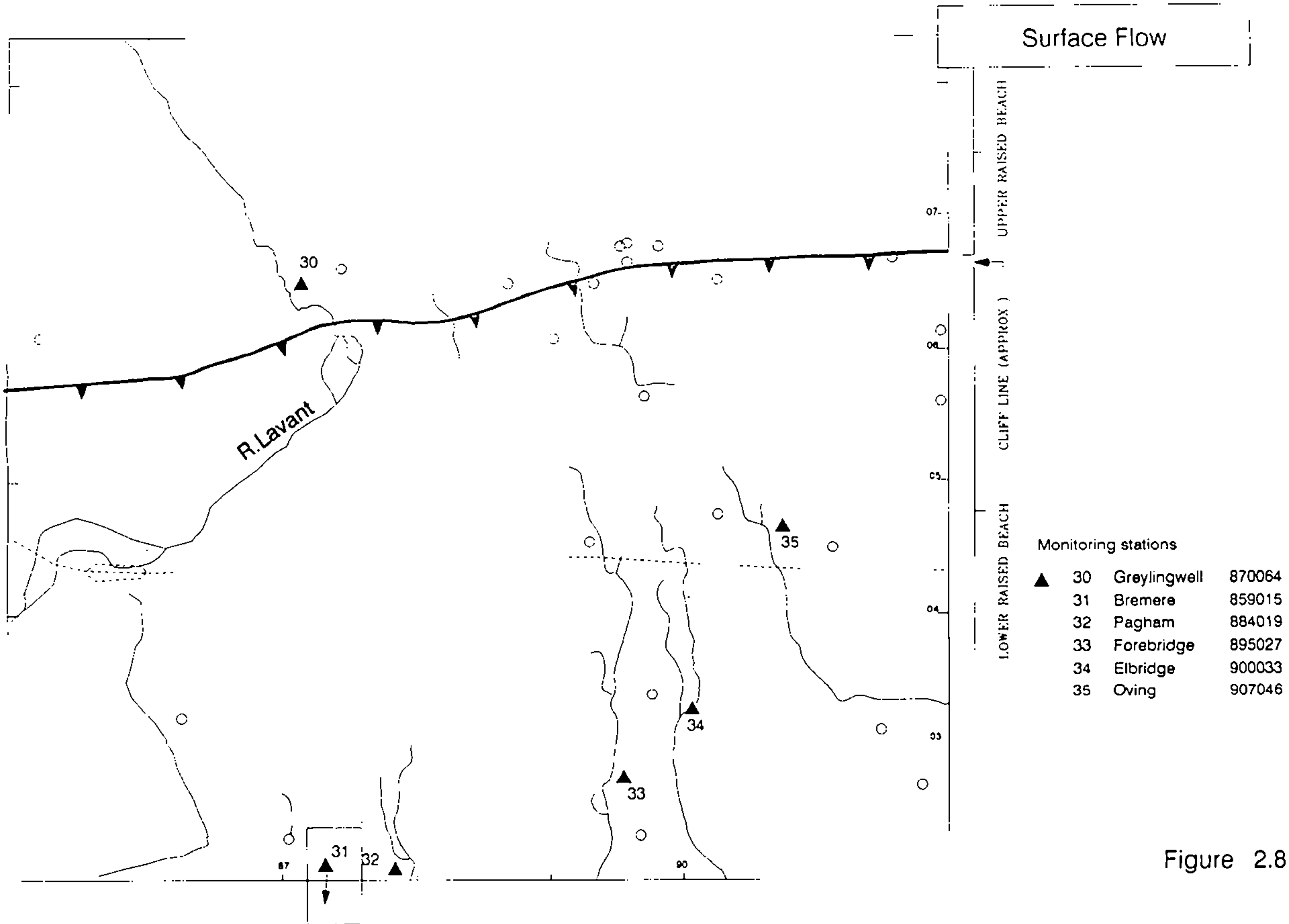
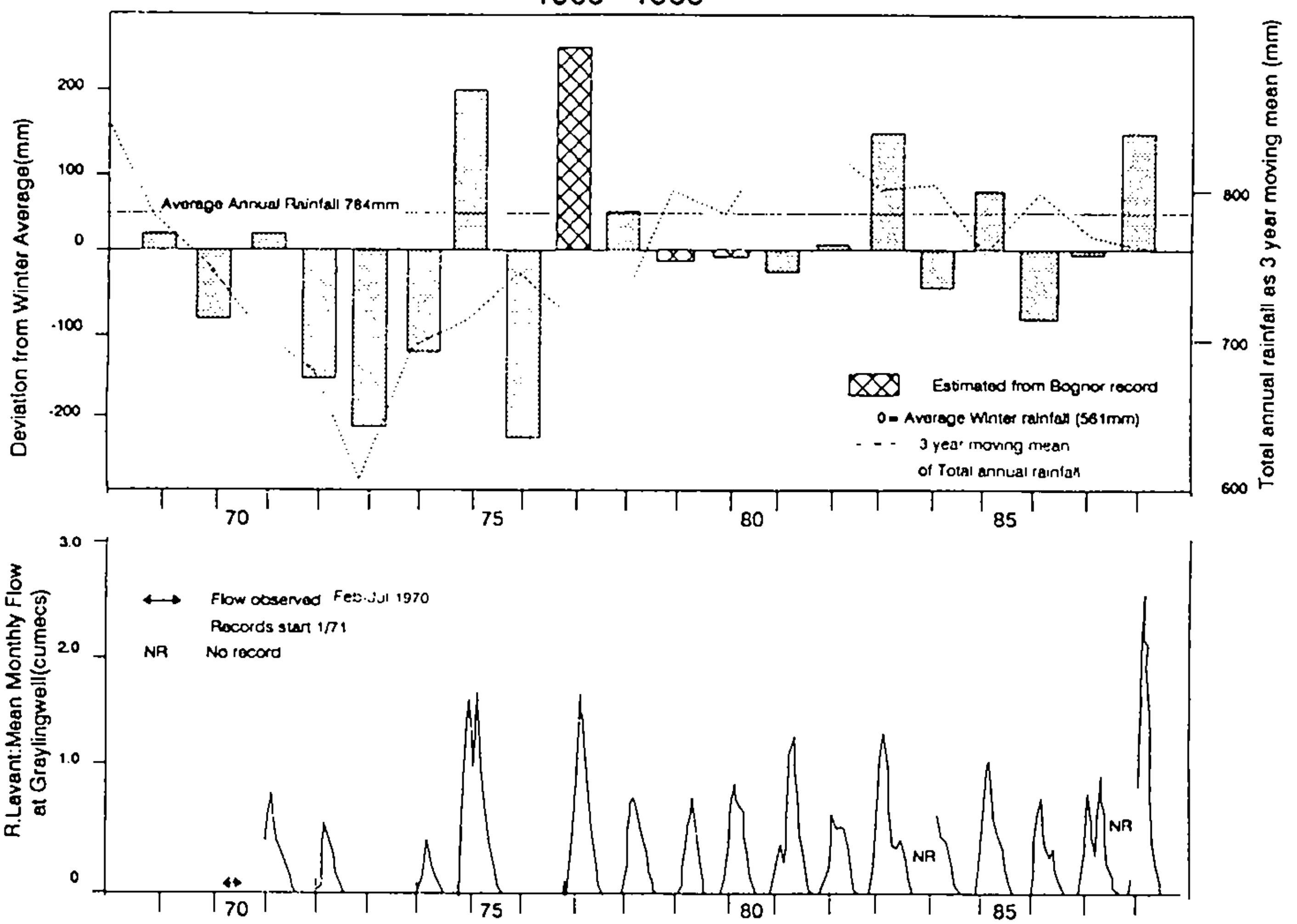


Figure 2.8

R.Lavant flow and Winter Rainfall

1968 - 1988



(From Institute of Hydrology Report Jan 1989)

Figure 2.9

Comparison of Lavant Flow, Chalk Groundwater Levels and Infiltration Rates (1967-1979)

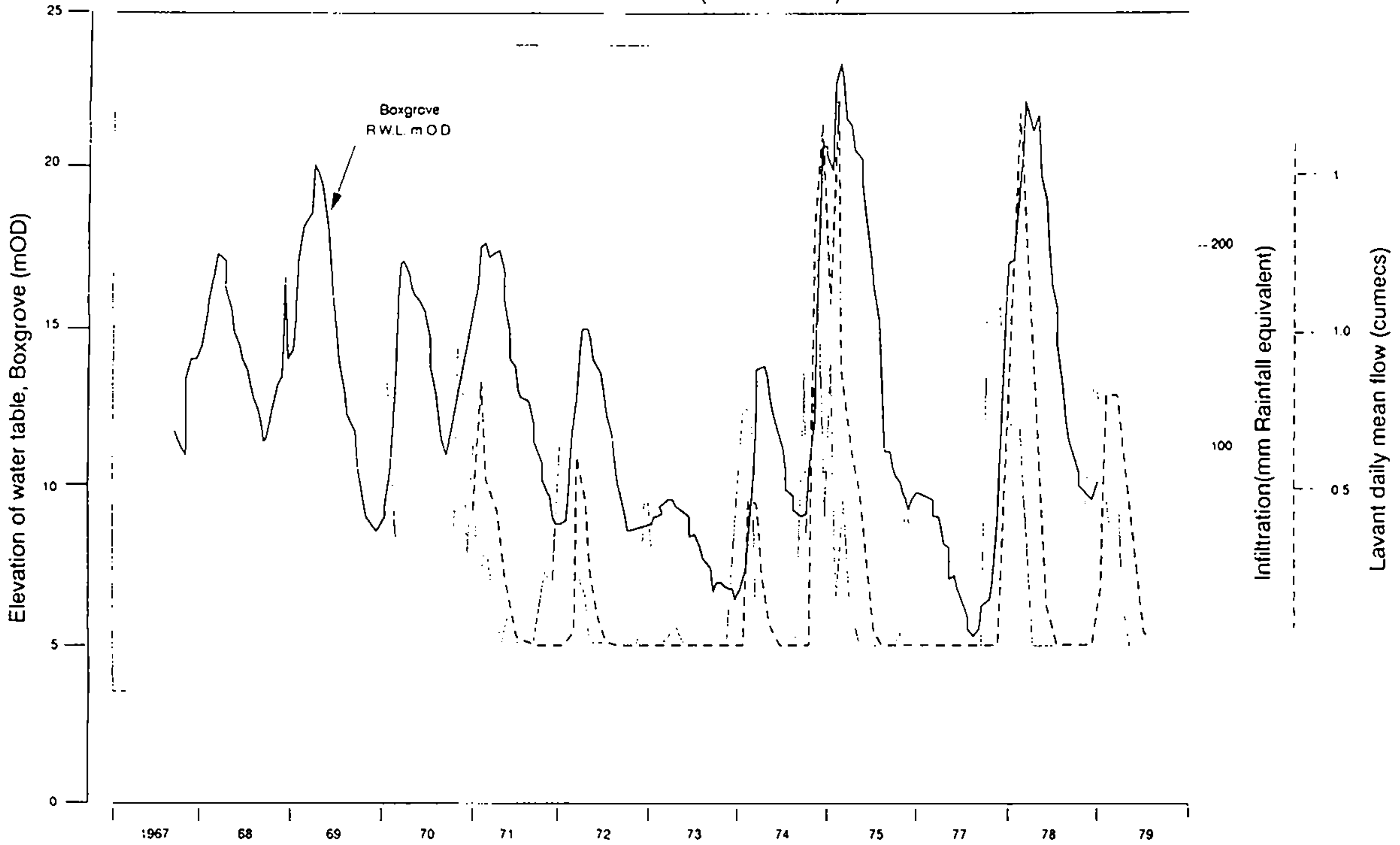
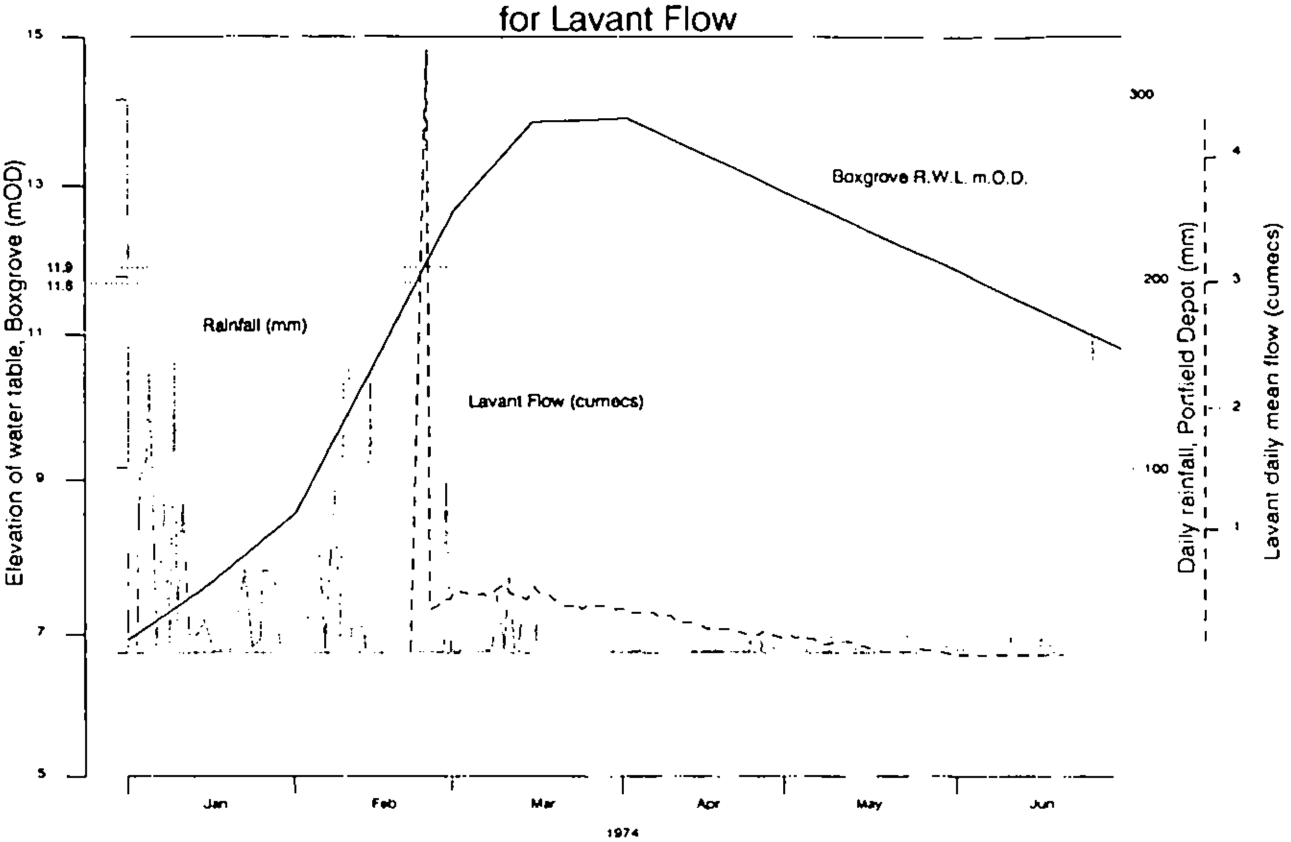


Figure 2.10

Comparison of Rainfall with critical Chalk Groundwater levels for Lavant Flow



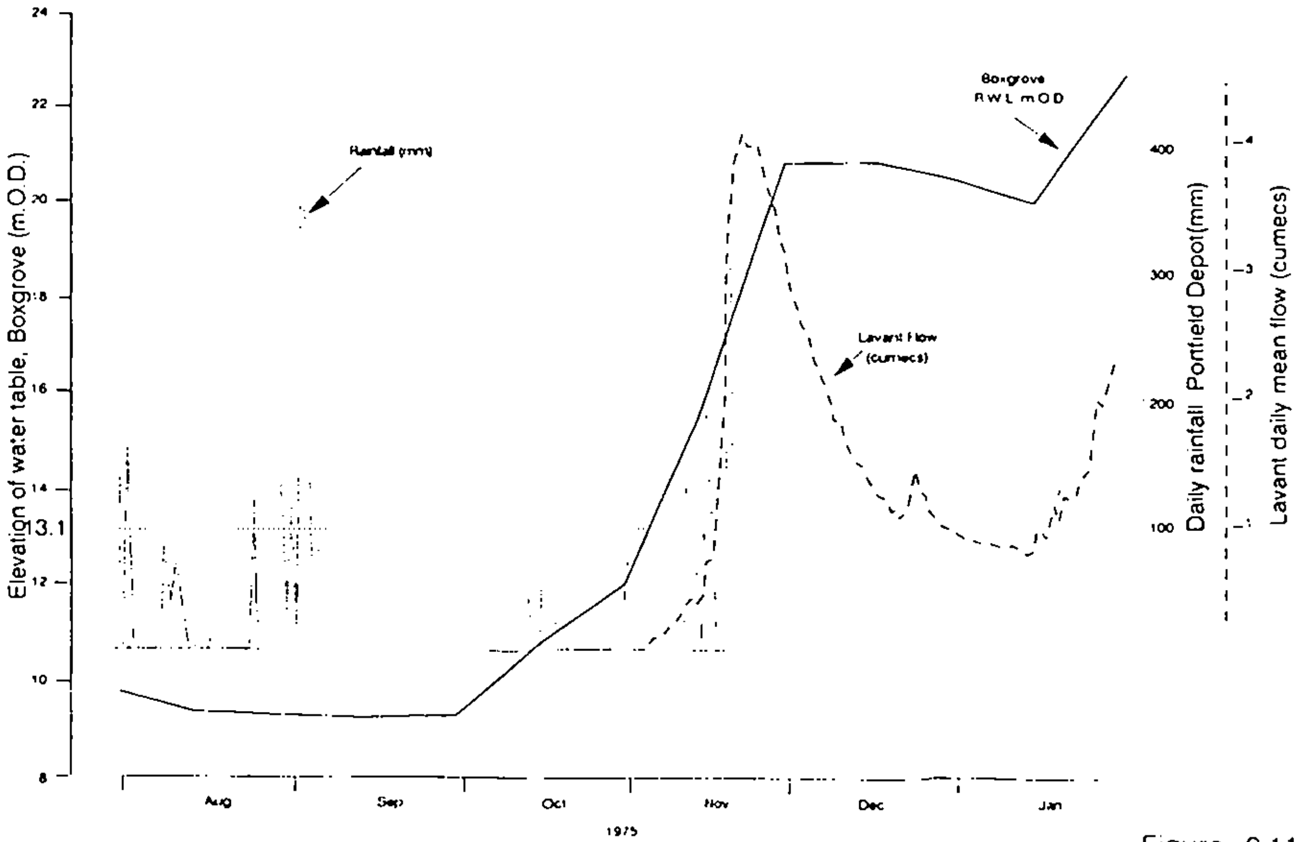


Figure 2.11

Comparison of Lavant Flow, Church Farm Pit Water Level, Monthly Rainfall and Boxgrove Groundwater Levels (1974-1975)

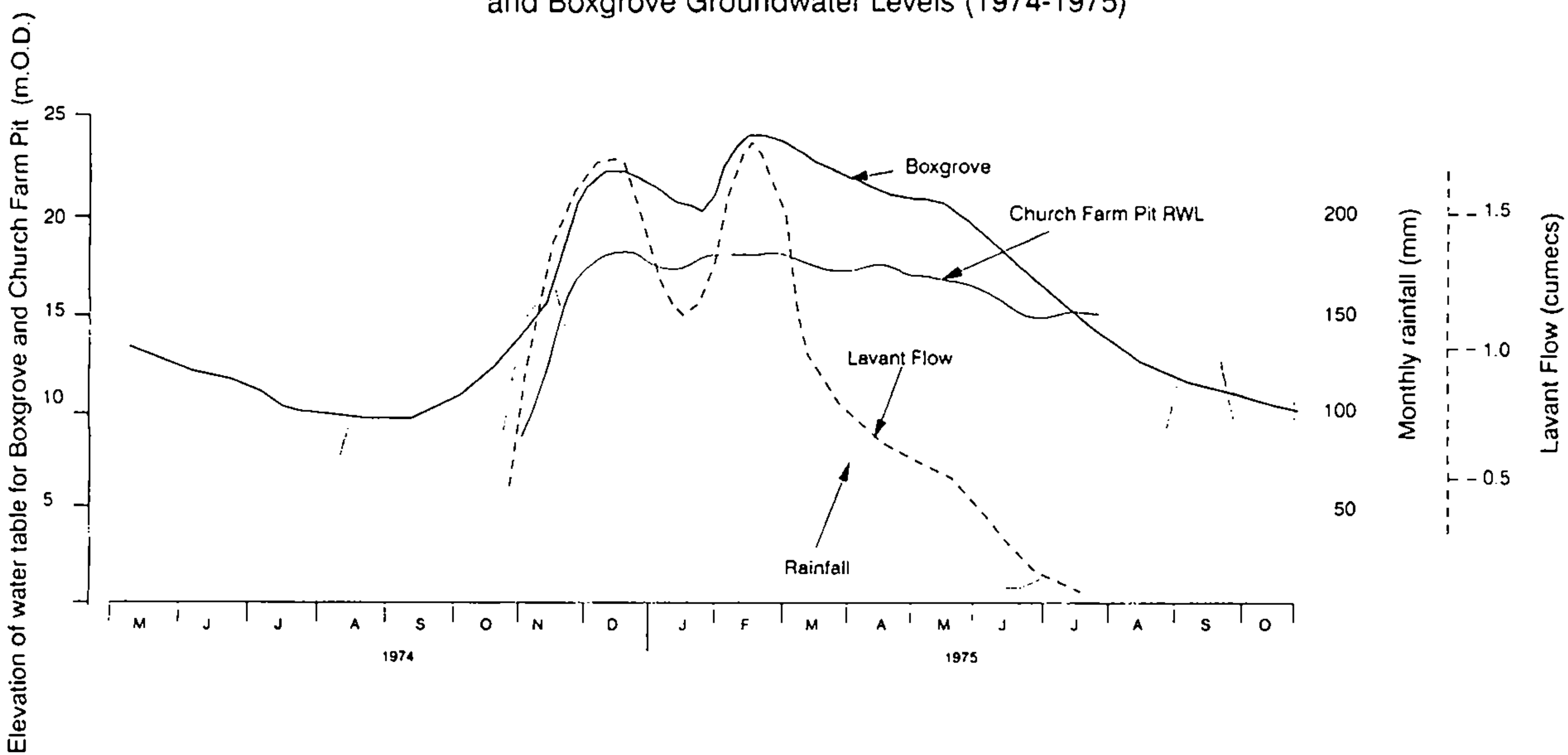
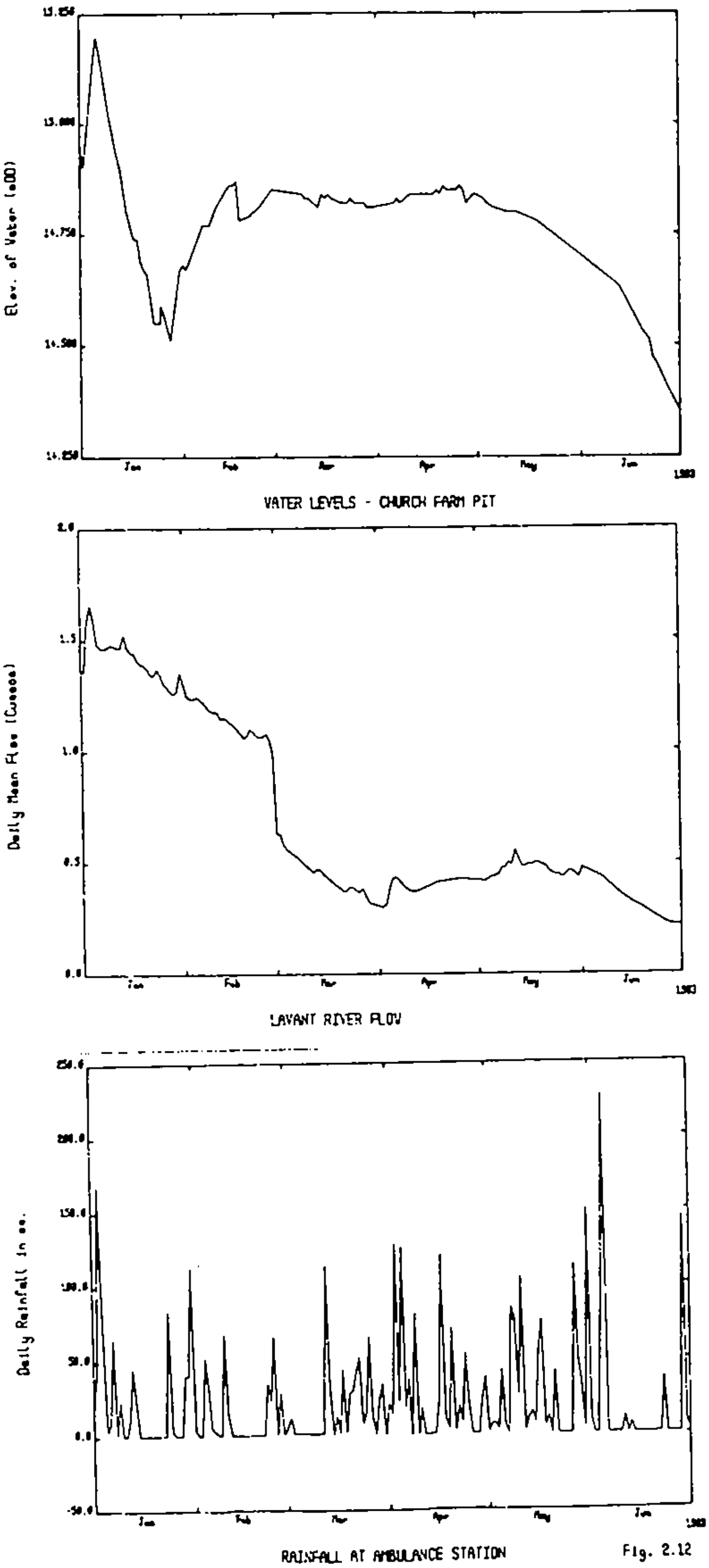
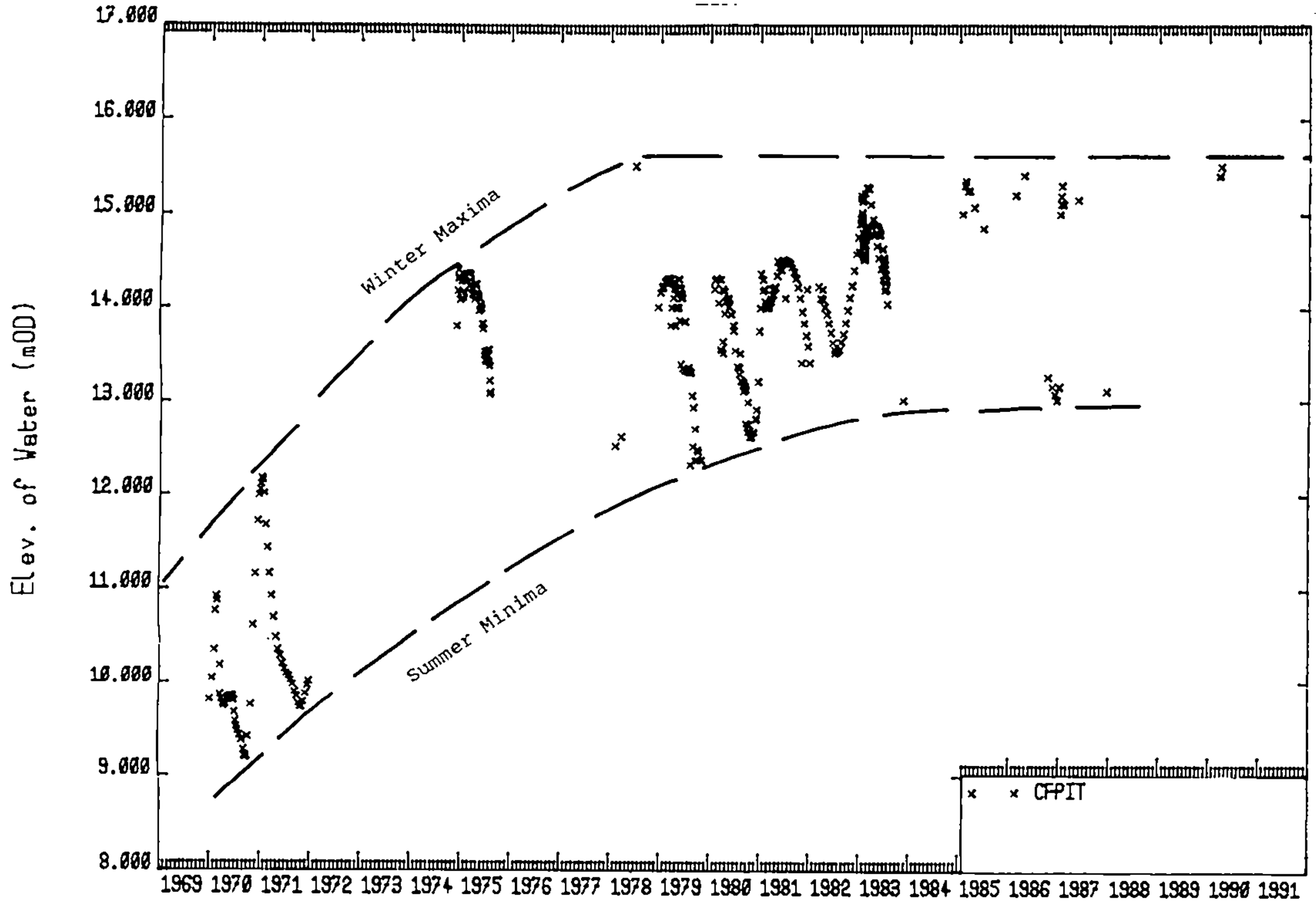


Figure 2.12



2.13 Comparison of Lavant Flow, Church Farm Pit Water Levels and Rainfall in 1983



WATER LEVELS - CHURCH FARM PIT

Figure 2.14

Comparison of declining Lavant Flow Rates and Groundwater Levels

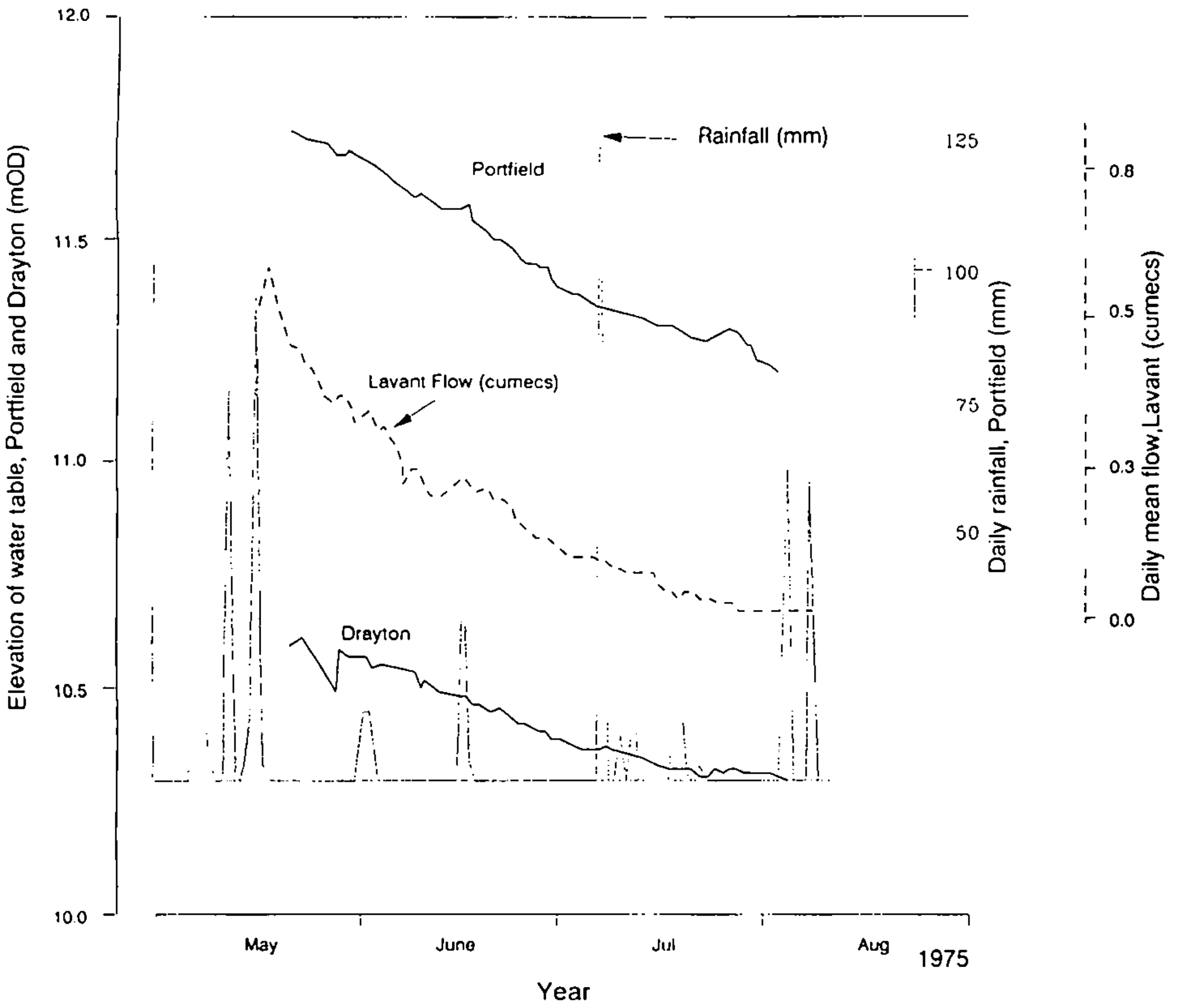
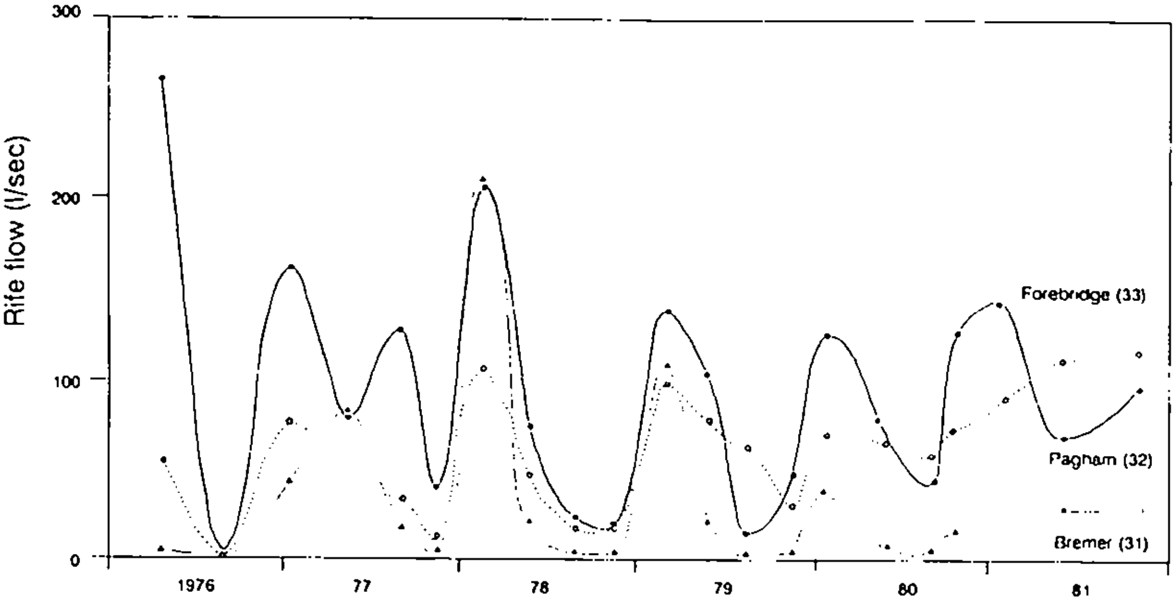


Figure 2.15

Rife Flow Rates 1976-81



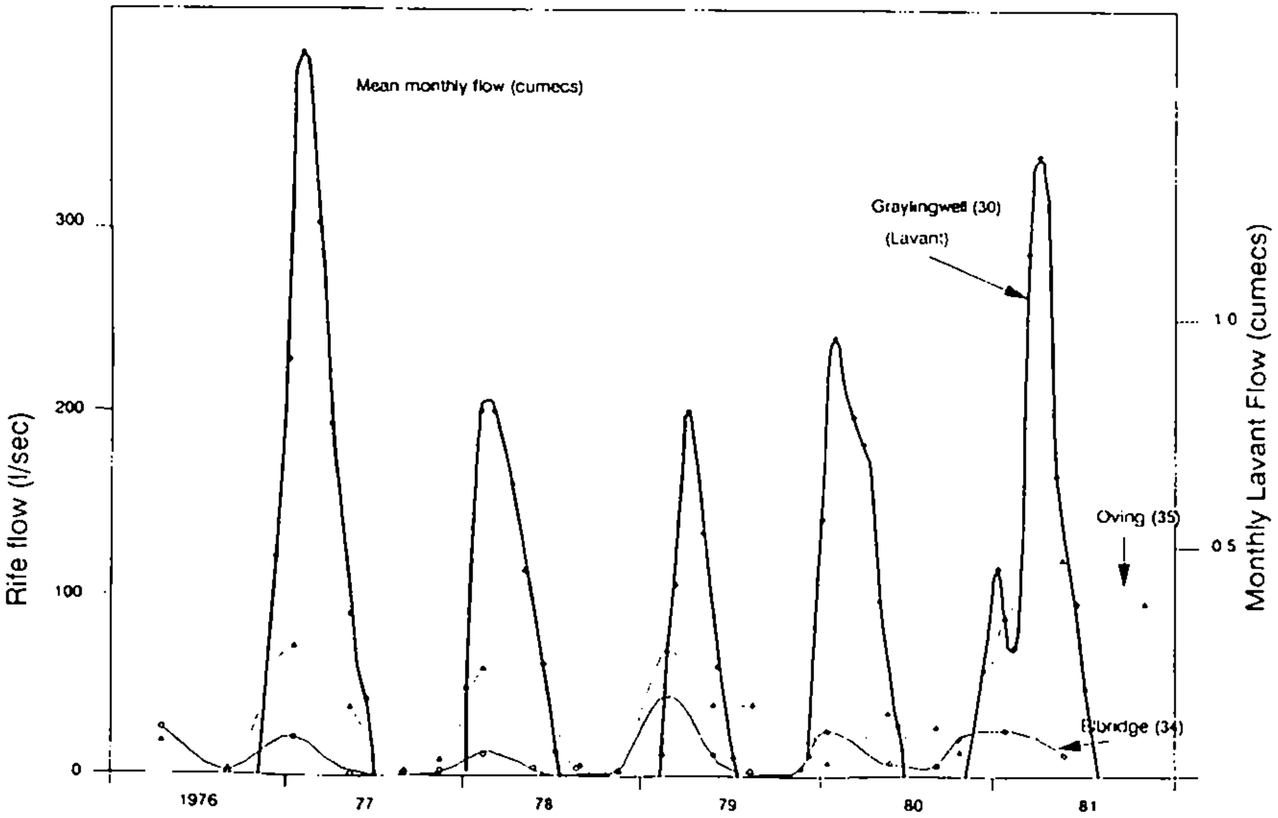
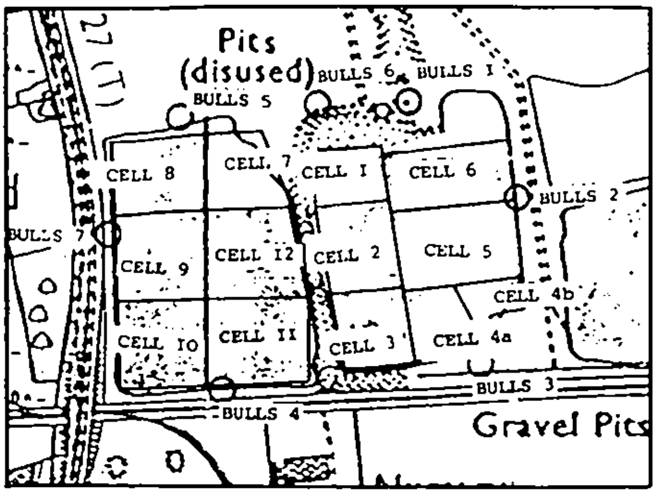
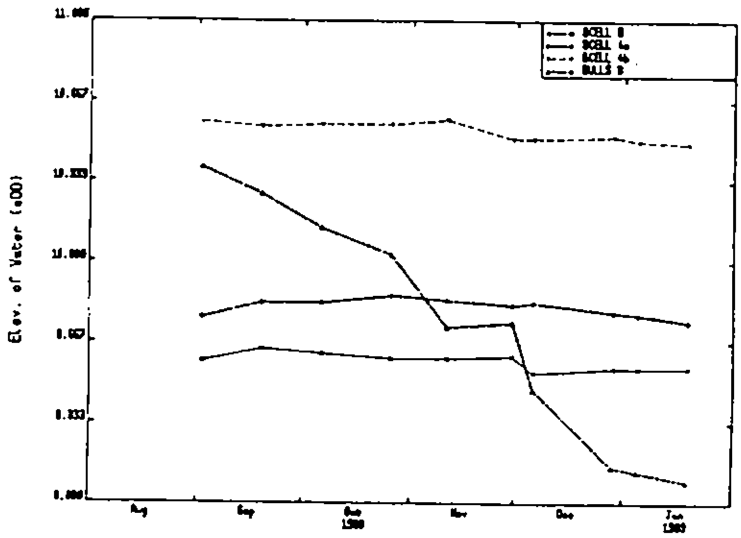
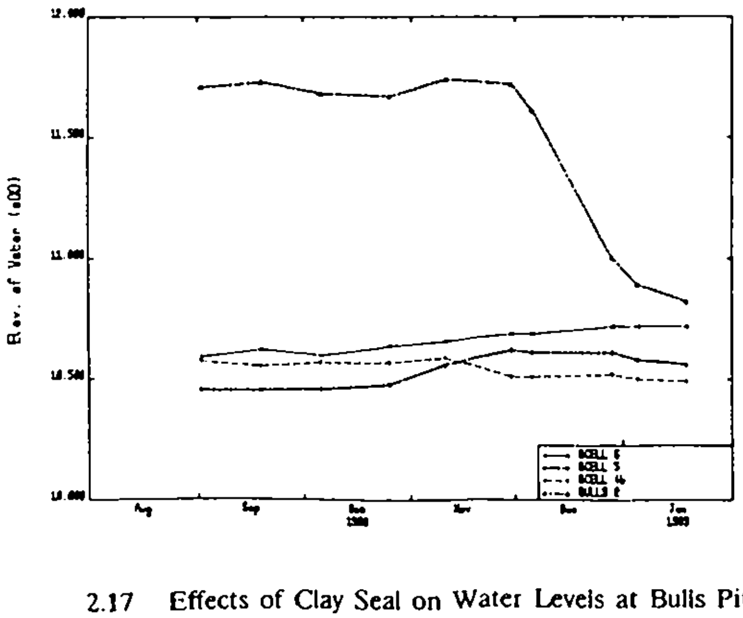


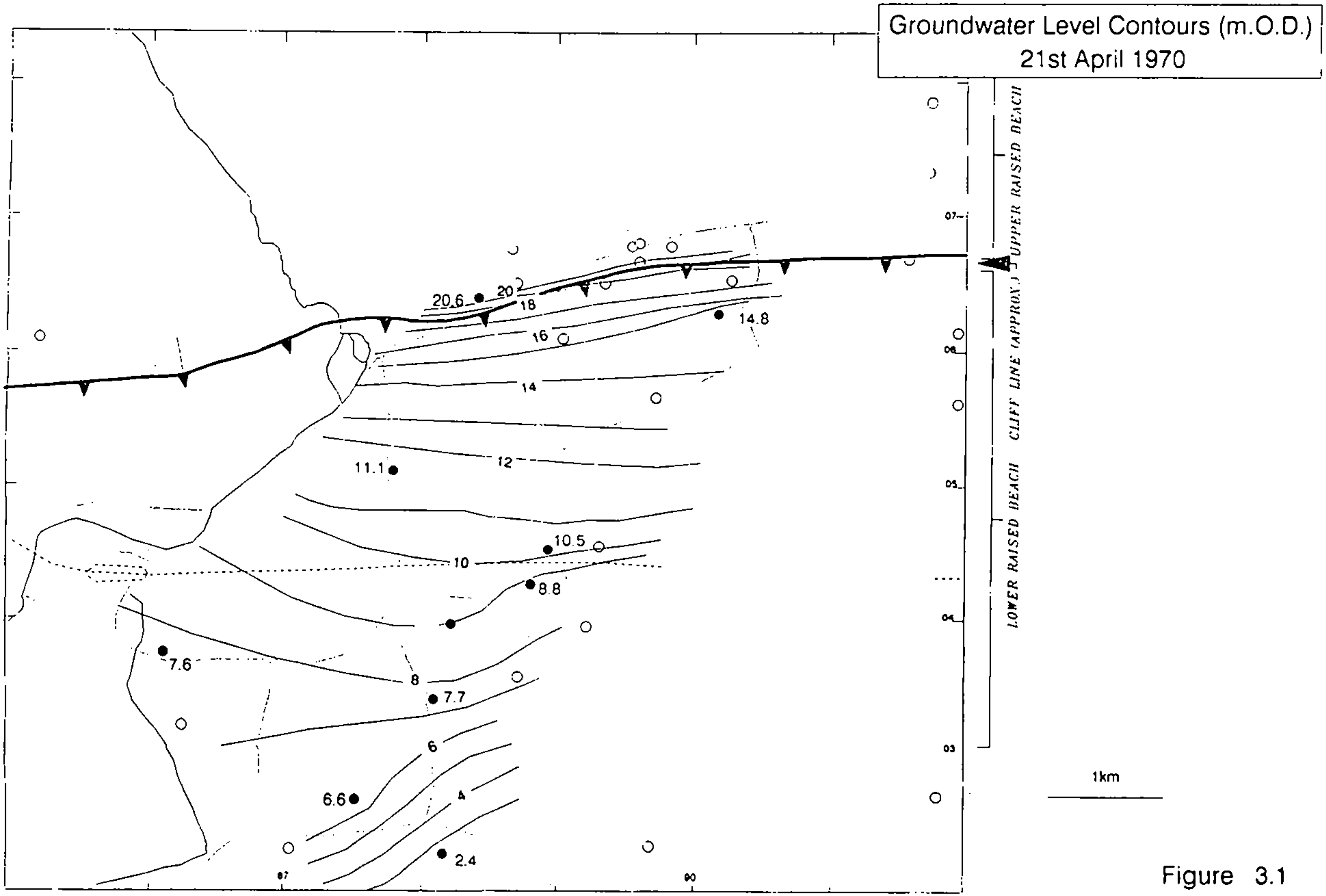
Figure 2.16







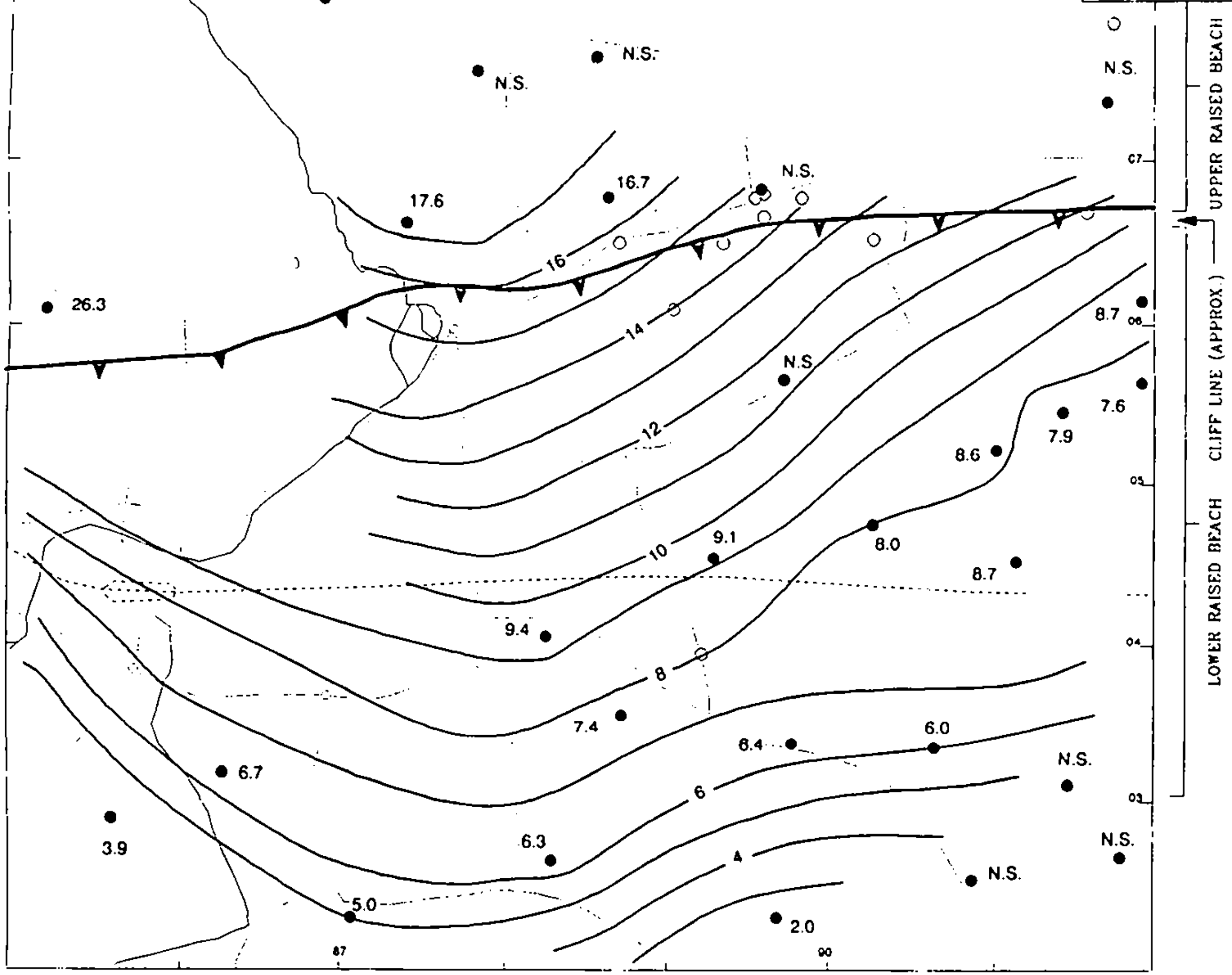
2.17 Effects of Clay Seal on Water Levels at Bulls Pits



Groundwater Level Contours (m.O.D.)
21st April 1970
UPPER RAISED BEACH
CLIFF LINE (APPROX.)
LOWER RAISED BEACH
1km
20.6
20
18
16
14.8
14
12
11.1
10.5
10
8.8
8
7.7
7.6
6
6.6
4
2.4

Figure 3.1

Elevation of Water Struck (m.O.D.)
Oct 81



Note:

This is elevation of water struck,
not a groundwater level contour plan

Figure 3.2

Hydrographs - 1970-71 SWA study

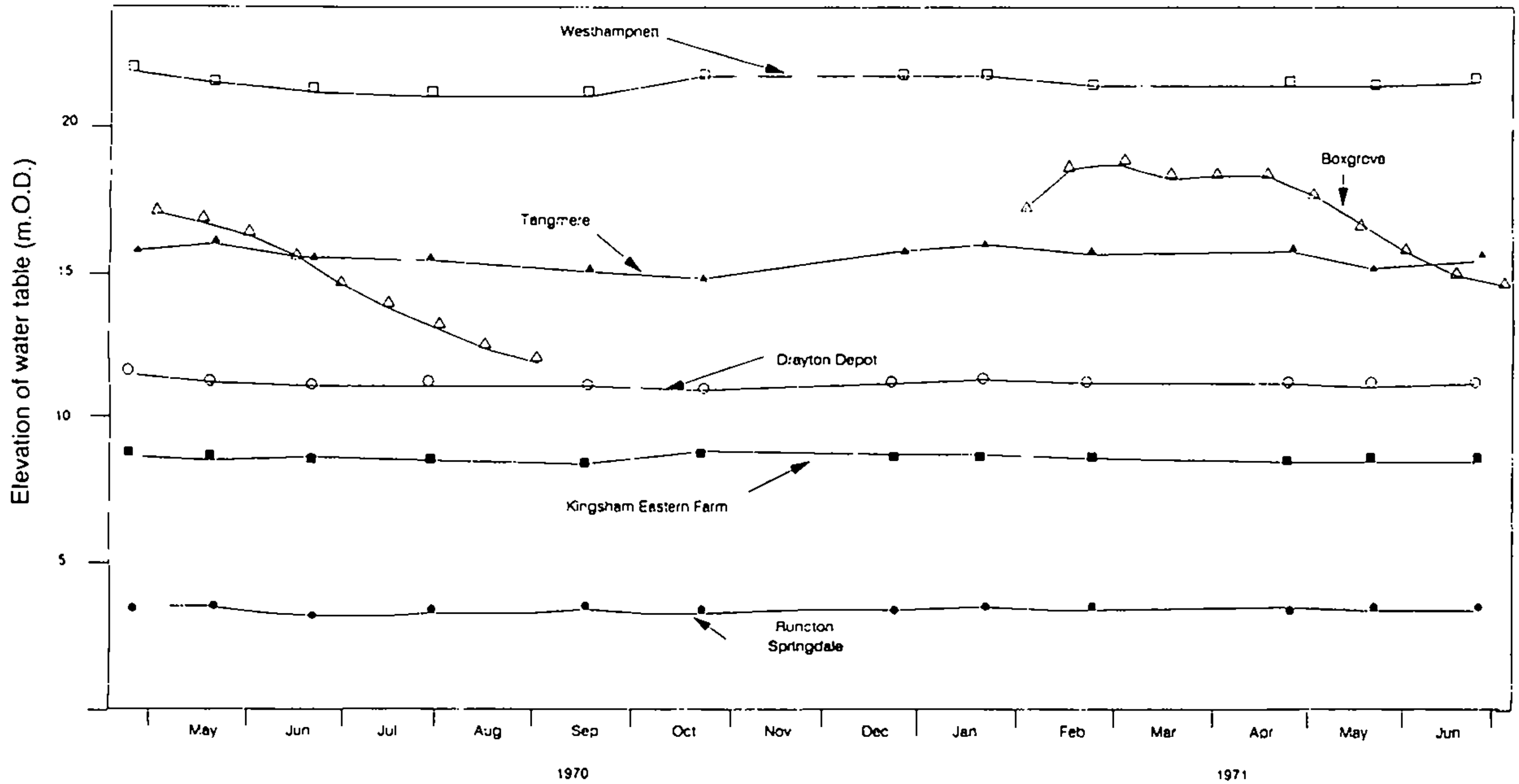
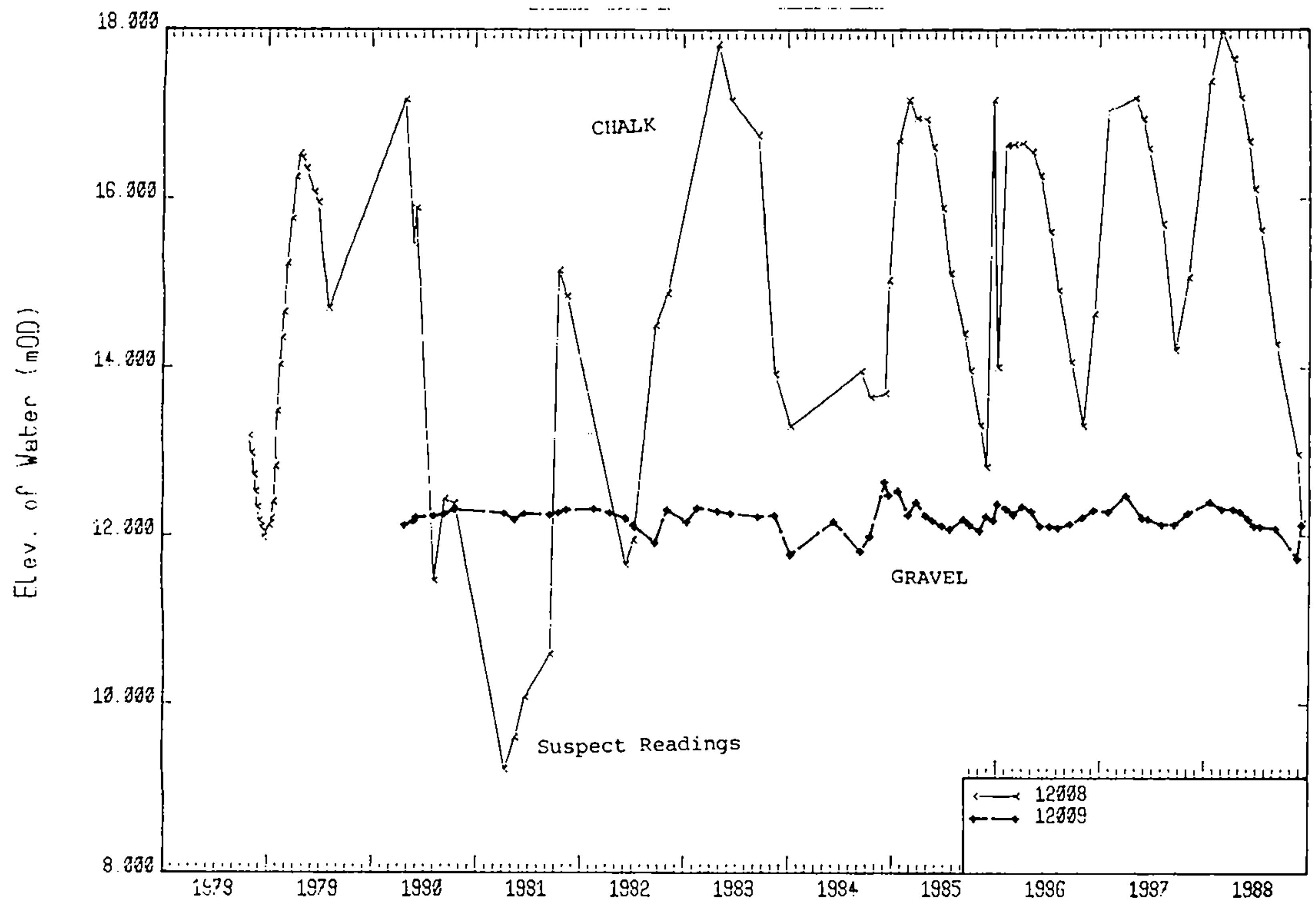


Figure 3.3



3.4 Hydrographs for Tangmere Road Twin Boreholes

Transmissivity (m^2 /d)

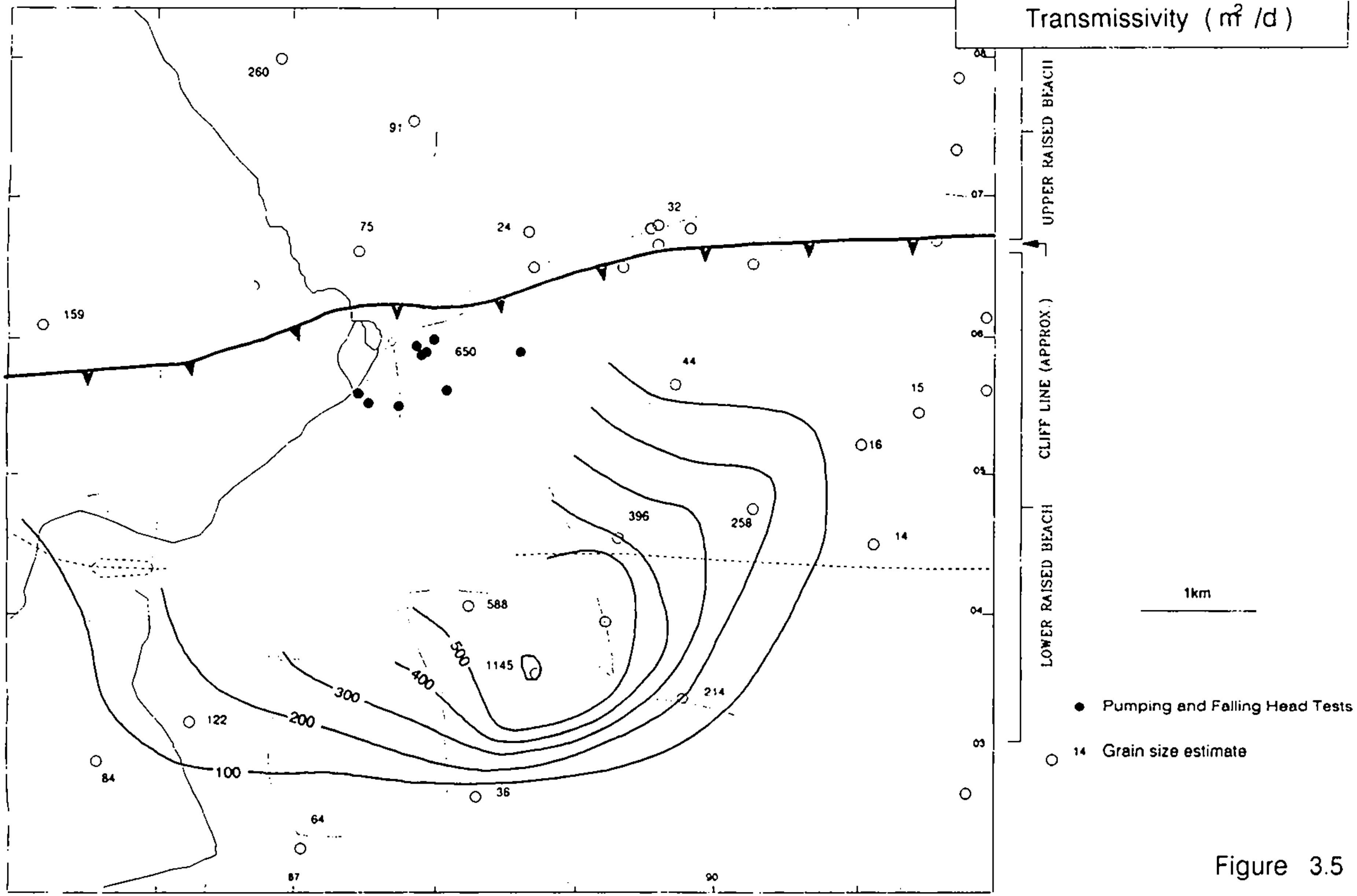


Figure 3.5

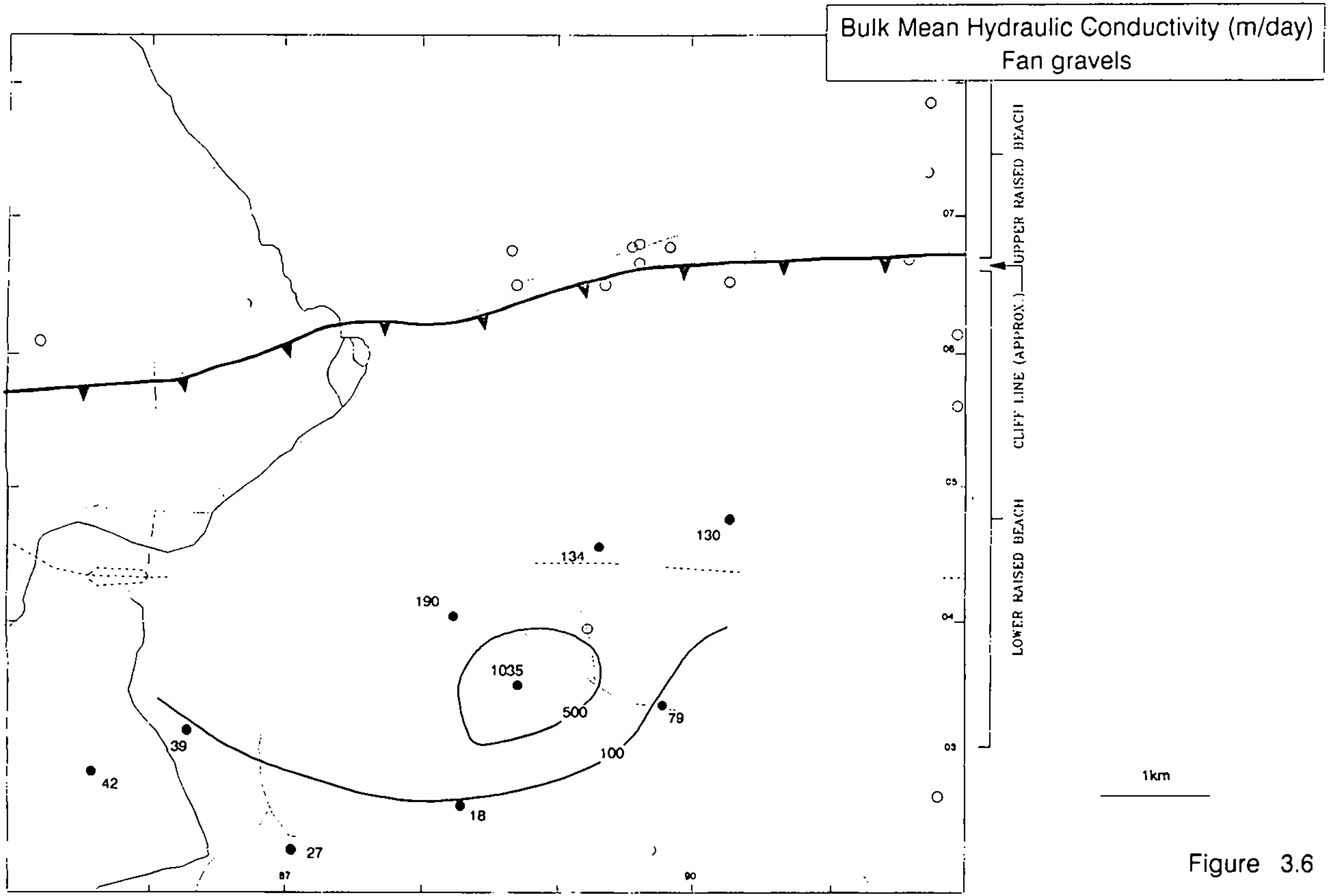

Bulk Mean Hydraulic Conductivity (m/day)
Fan gravels
UPPER RAISED BEACH
CLIFF LINE (APPROX.)
LOWER RAISED BEACH
07
06
05
04
03
87
90
130
134
190
1035
500
79
100
39
42
18
27
1km

Figure 3.6

Bulk Mean Hydraulic Conductivity (m/day)
Head gravel

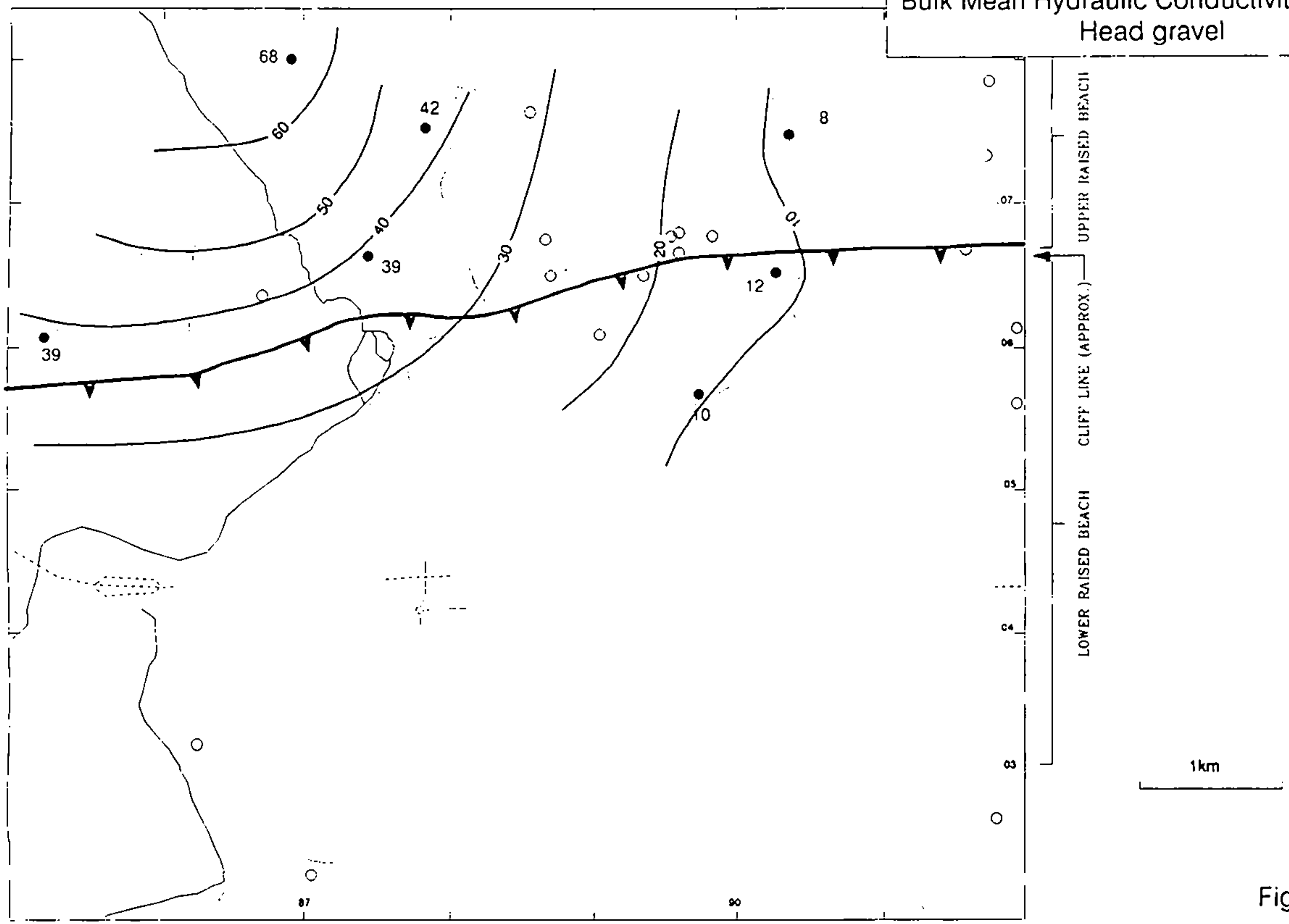


Figure 3.8

Bulk Mean Hydraulic Conductivity (m/day)
Raised Beach Deposits (Y)

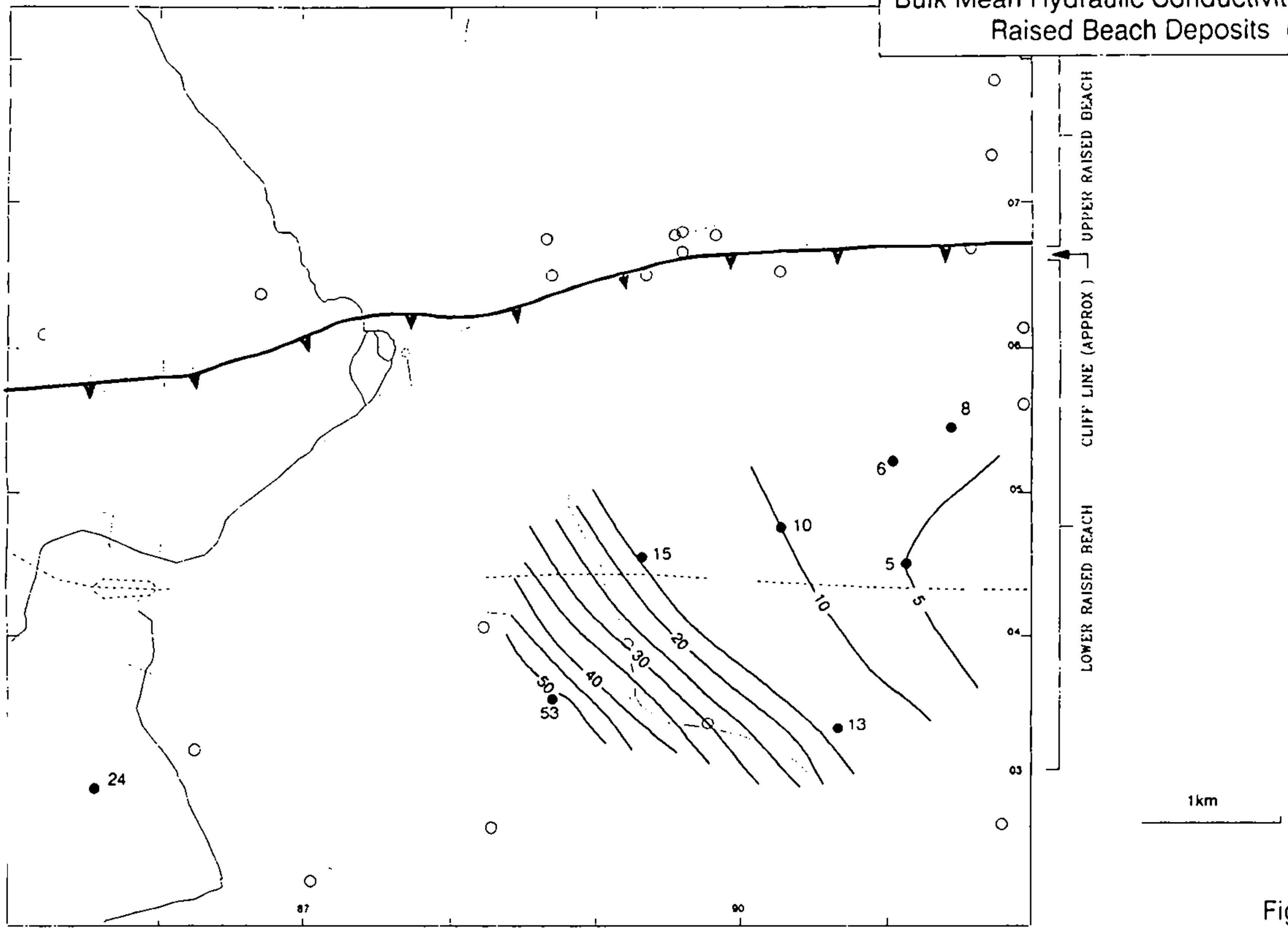


Figure 3.7

Final Regional Model Simulation: Groundwater Levels(mOD)

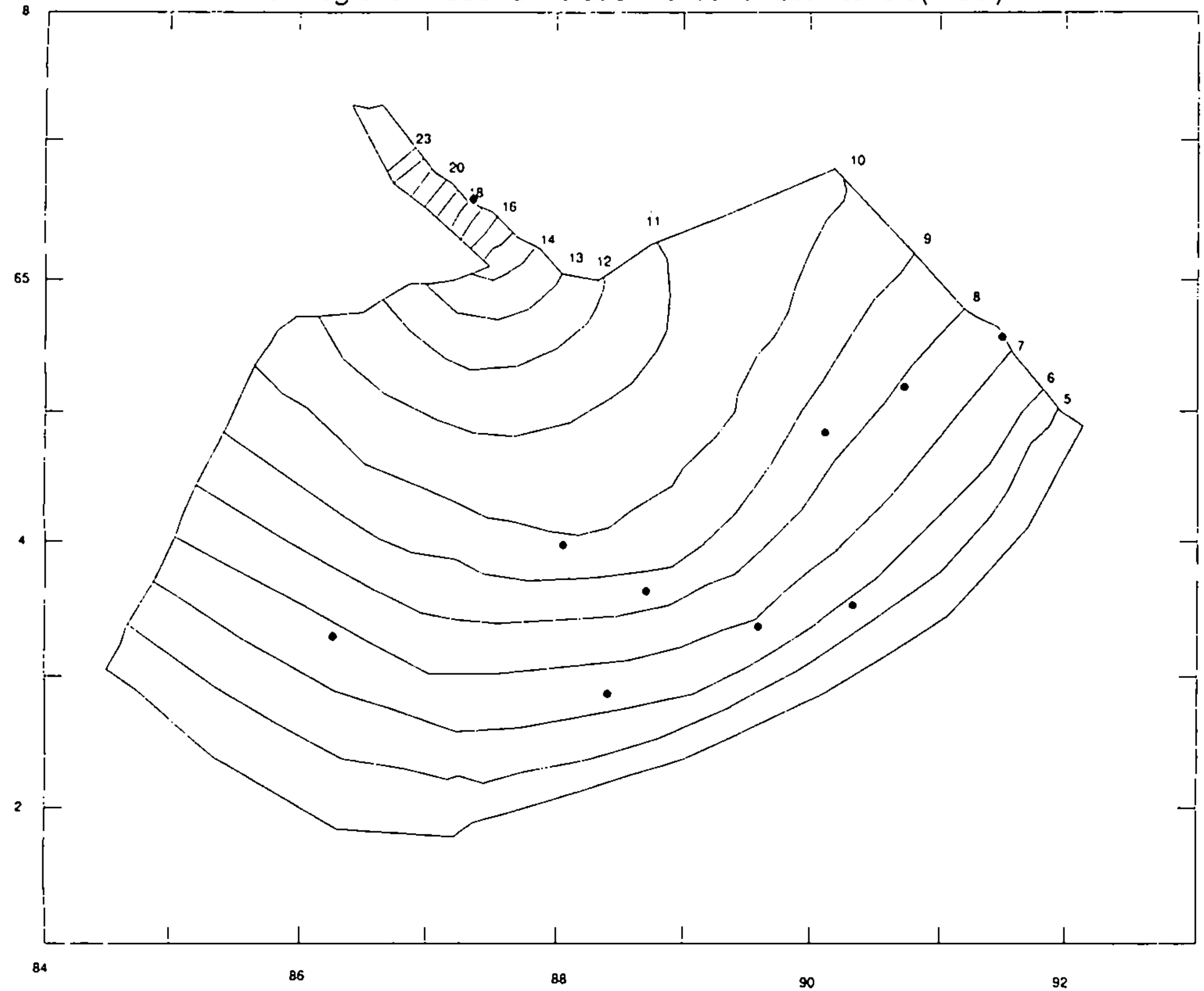
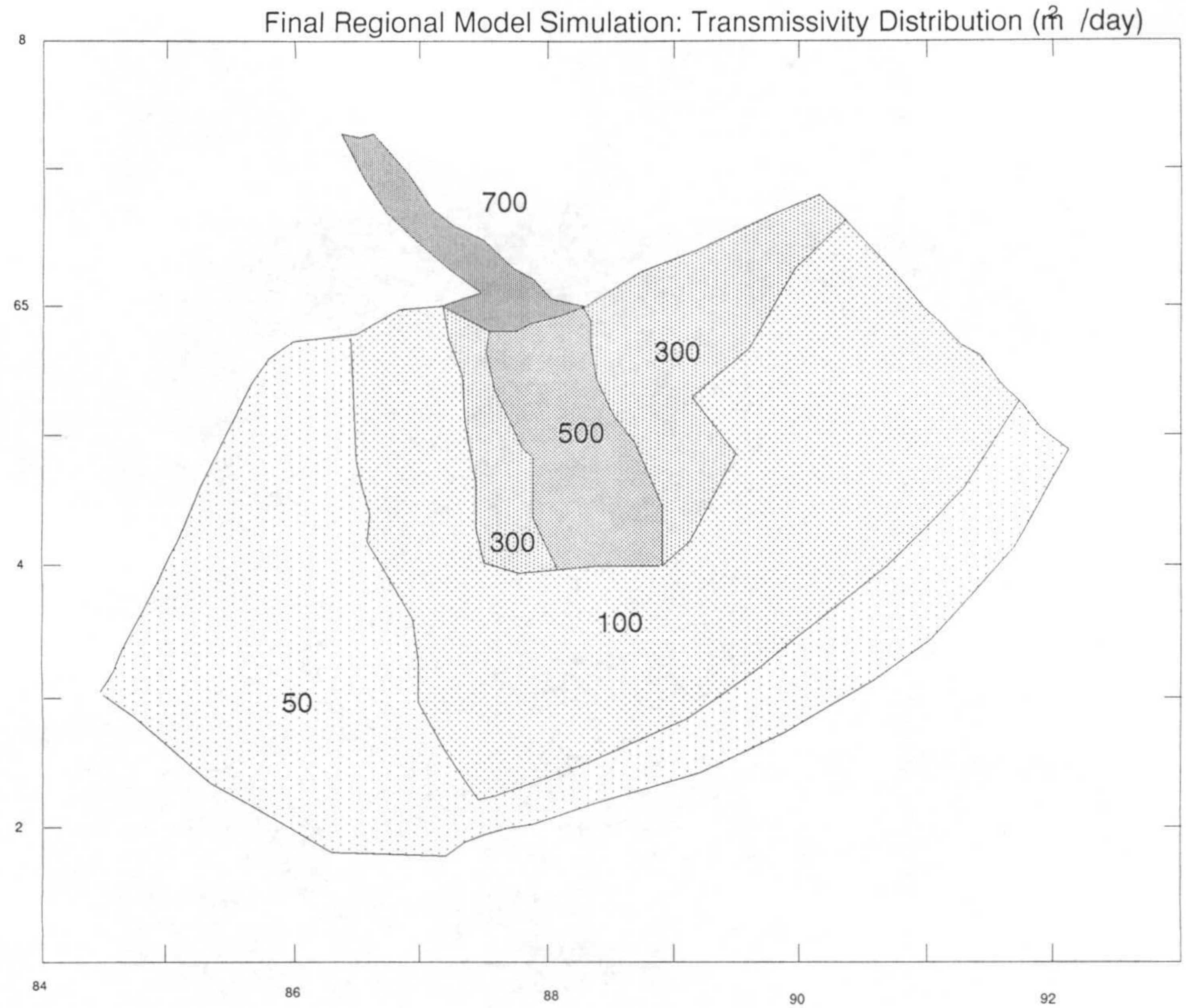
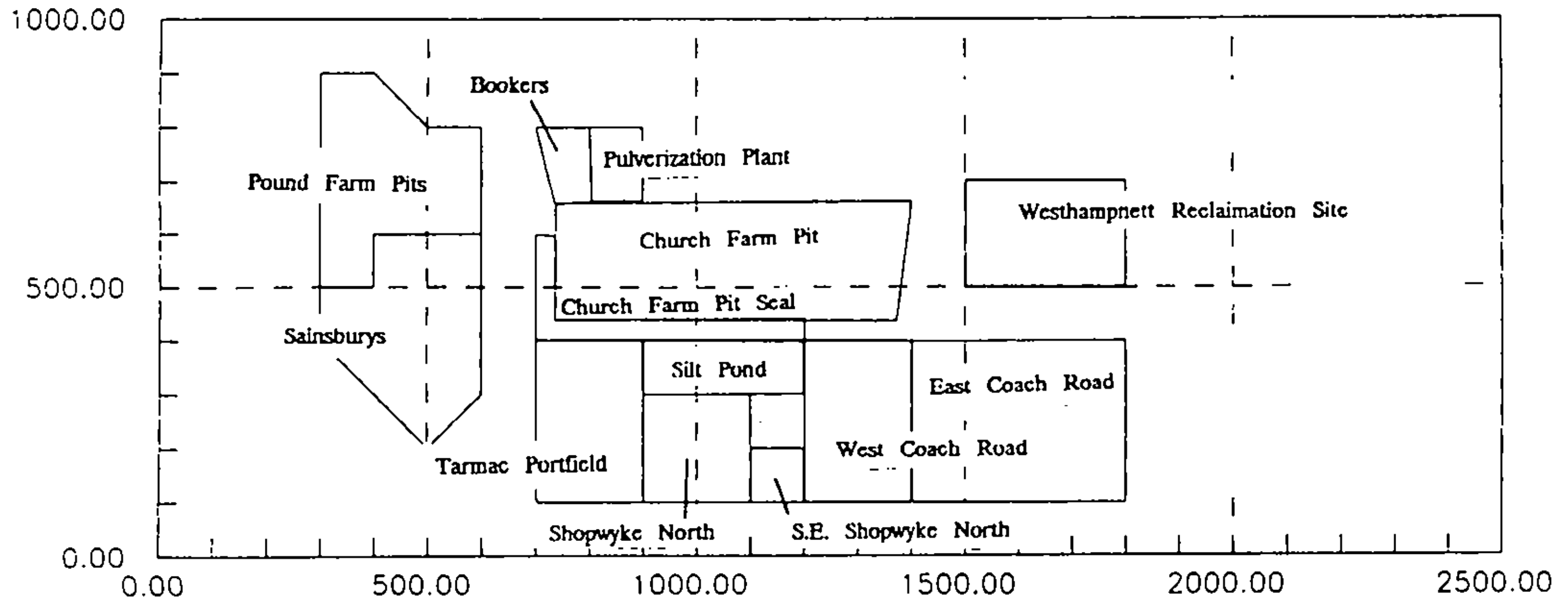


Figure 4.1

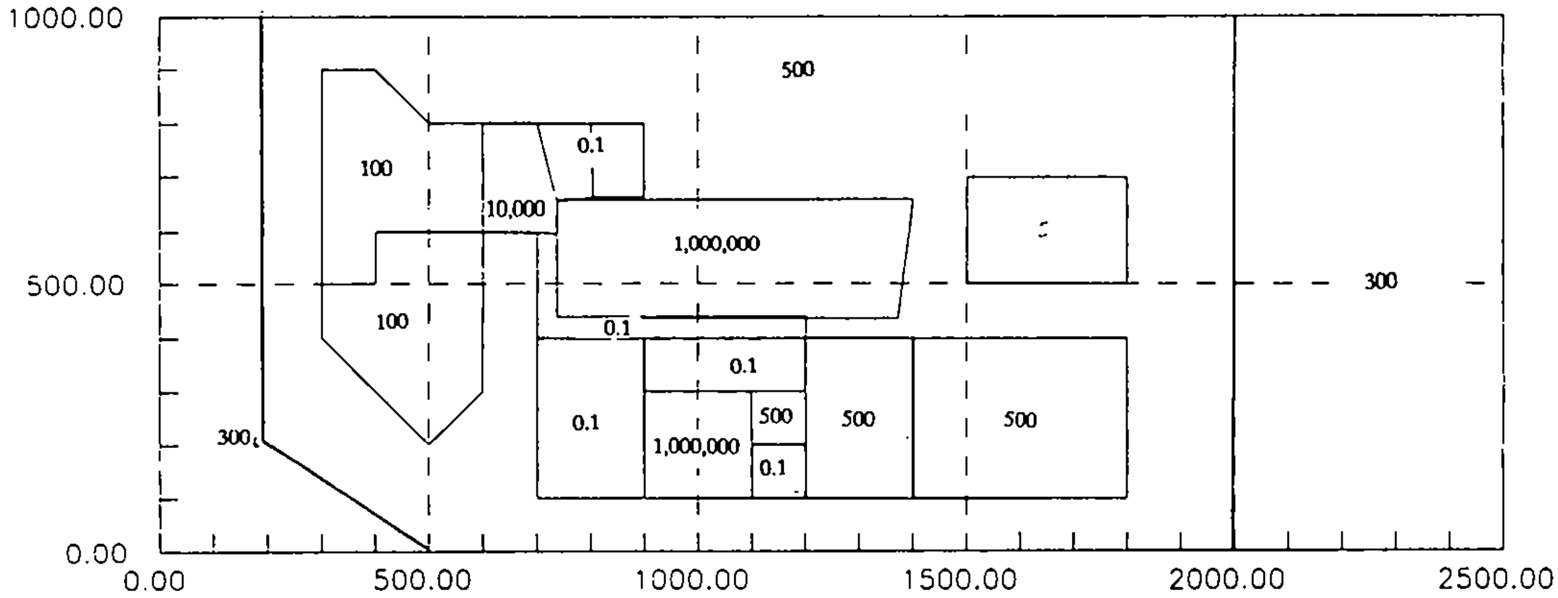


Final Regional Model Simulation: Transmissivity Distribution (m^2 /day)
8
65
4
2
84
86
88
90
92
700
300
500
300
100
50

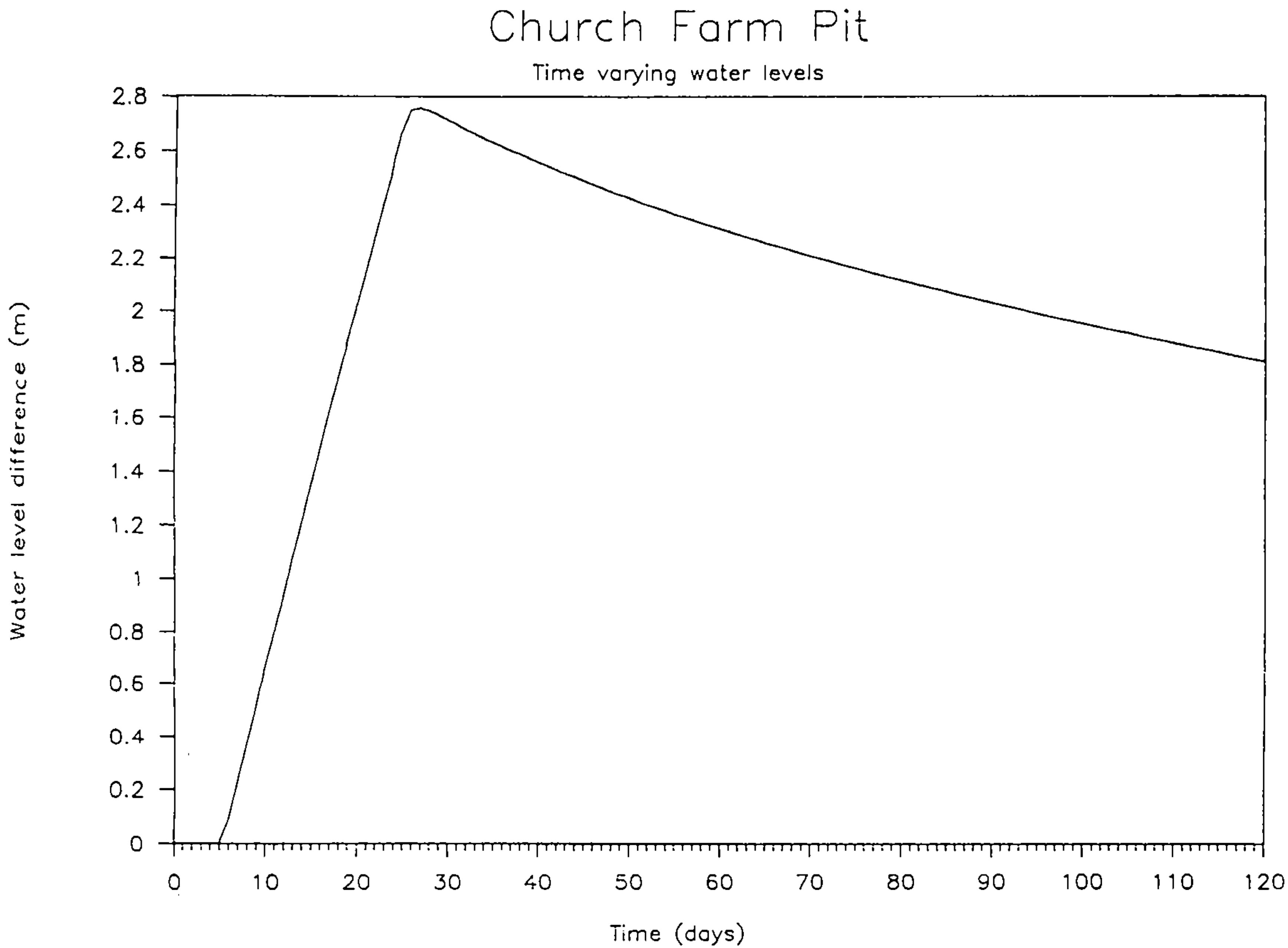
Figure 4.2



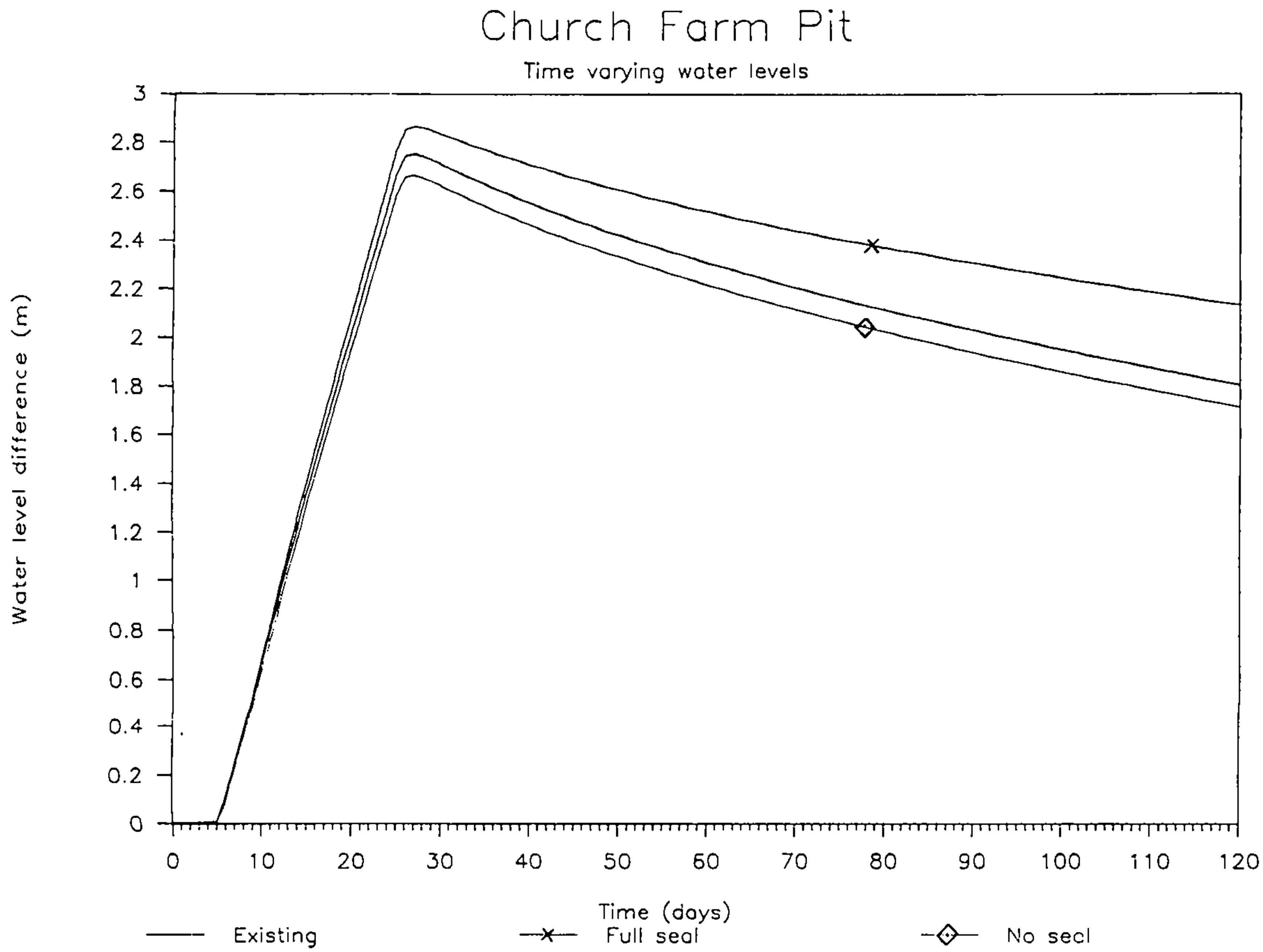
5.1 Principal Features of Church Farm Pit Model



5.2 Church Farm Pit Model: Existing Conditions Transmissivity Distributions



5.3 Model Water Level Variations in Church Farm Pit Under Existing Conditions



5.4 Model Water Level Variations in Church Farm Pit Under Existing Conditions, with a complete seal along the south face of the pit, and with no seal along the south face of the pit

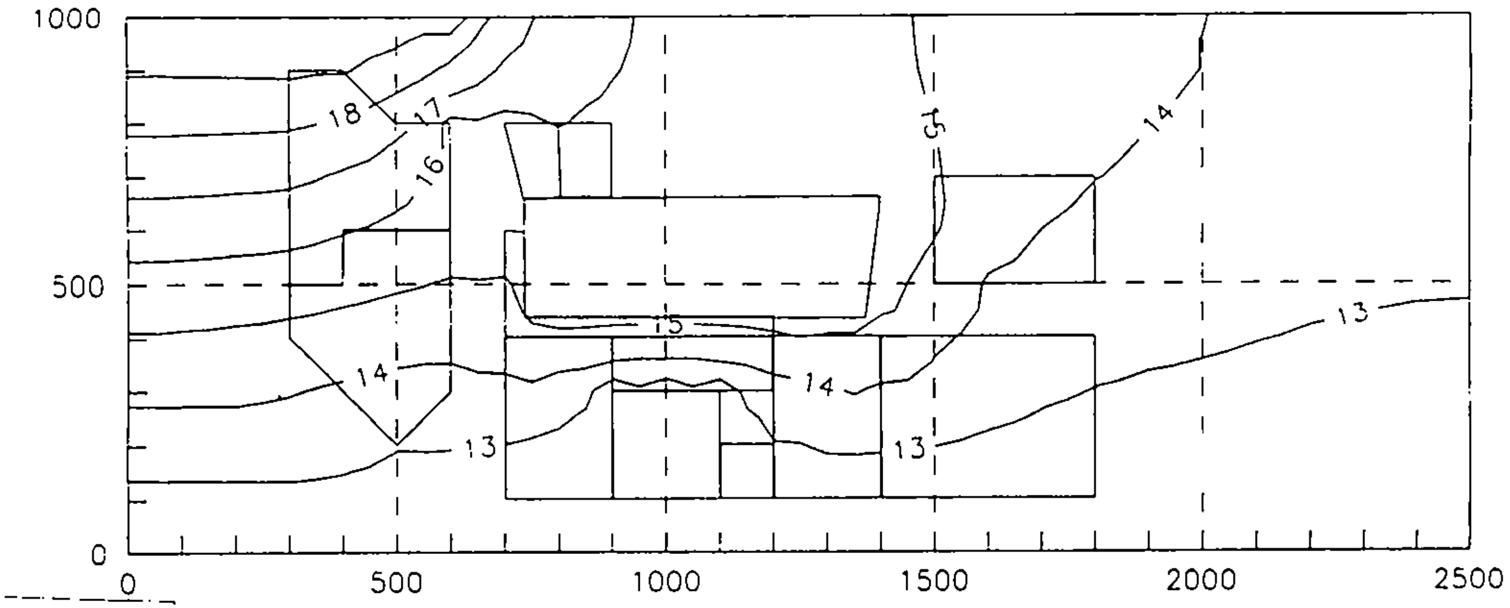
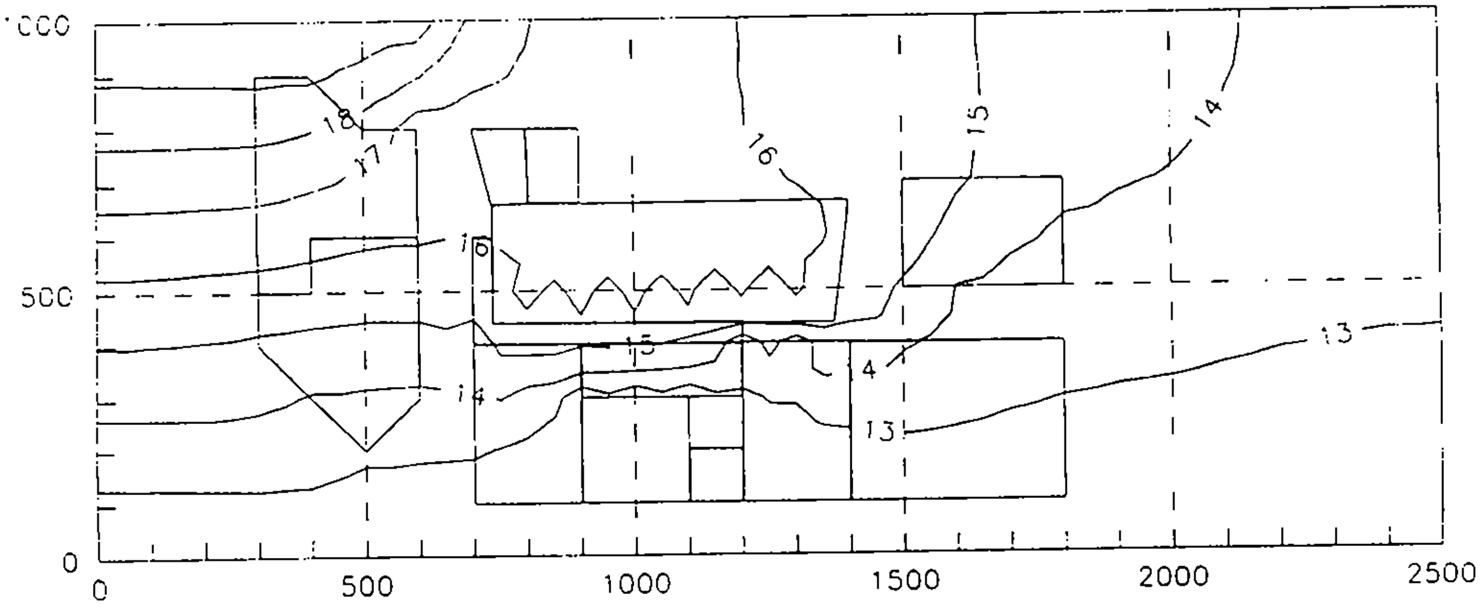
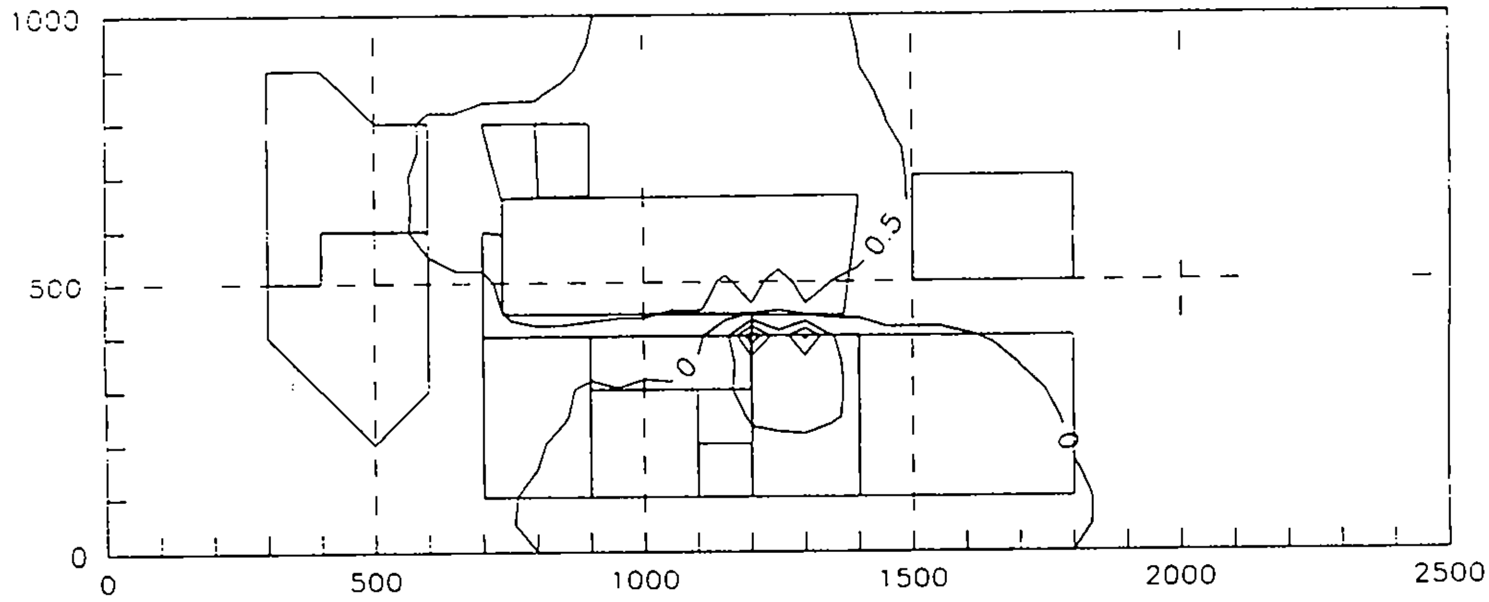


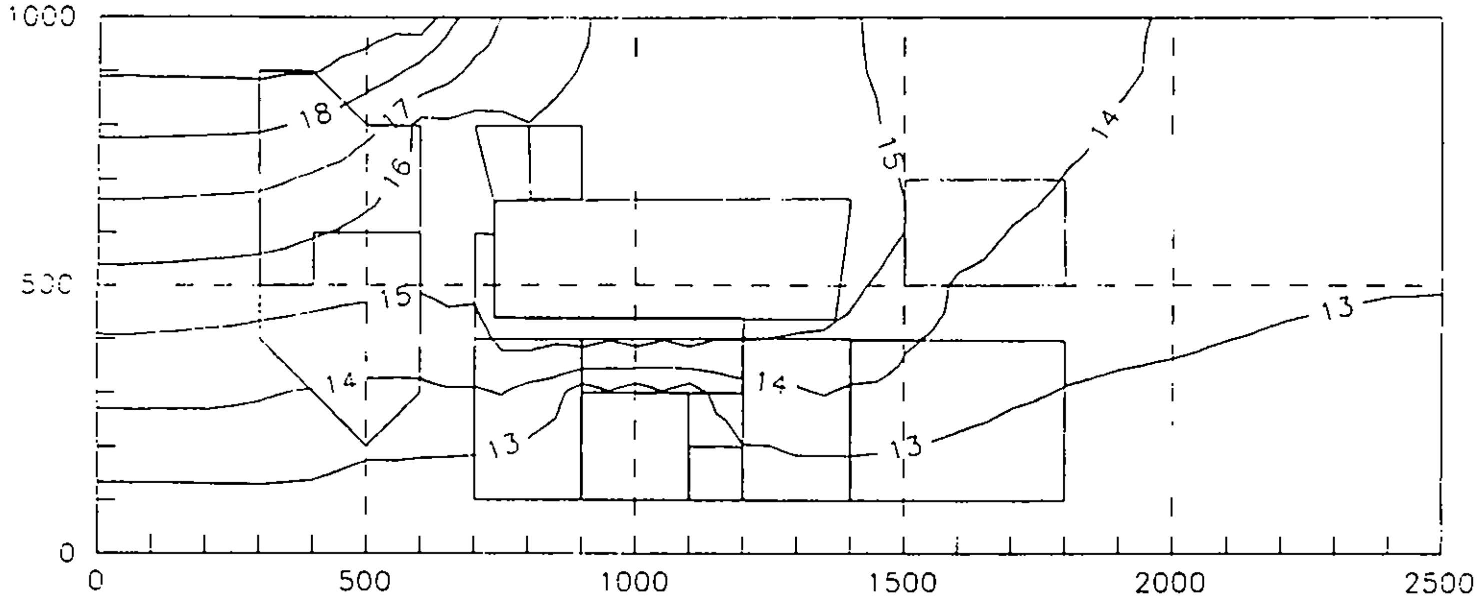
Fig. 7. Modelled Groundwater Levels Under Existing Conditions.



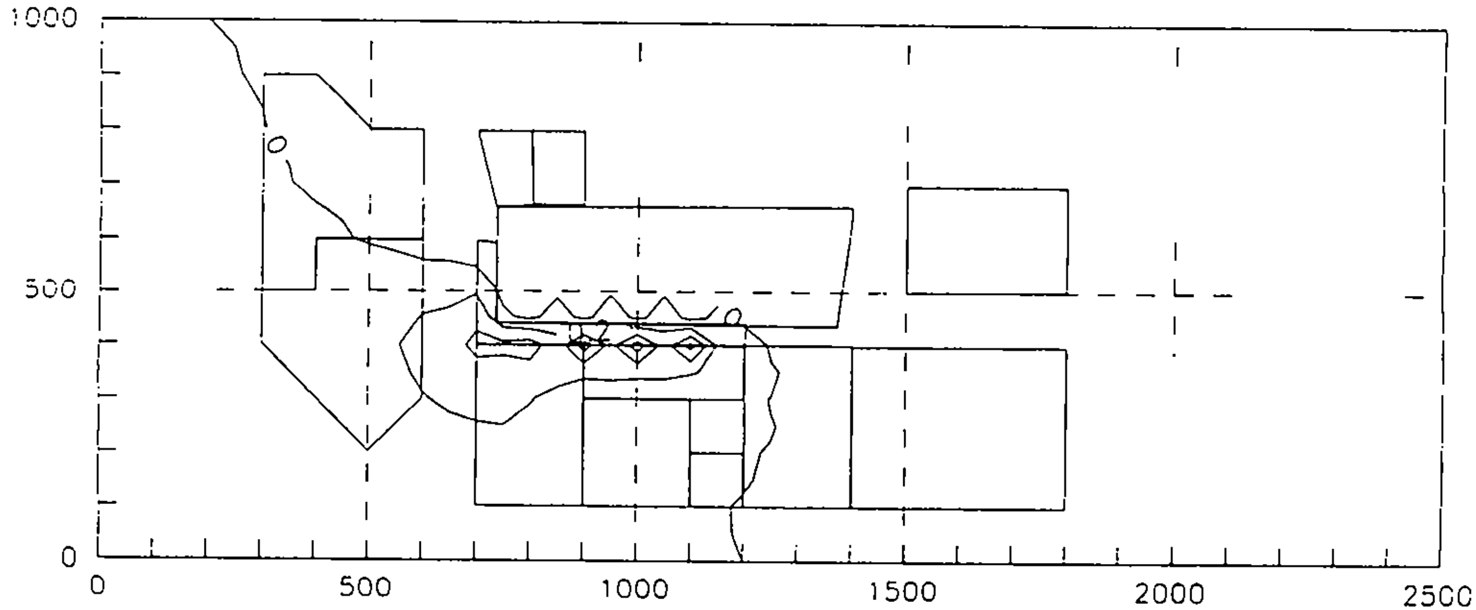
5.6 Full Seal along the south face of Church Farm Pit : Modelled Groundwater Levels



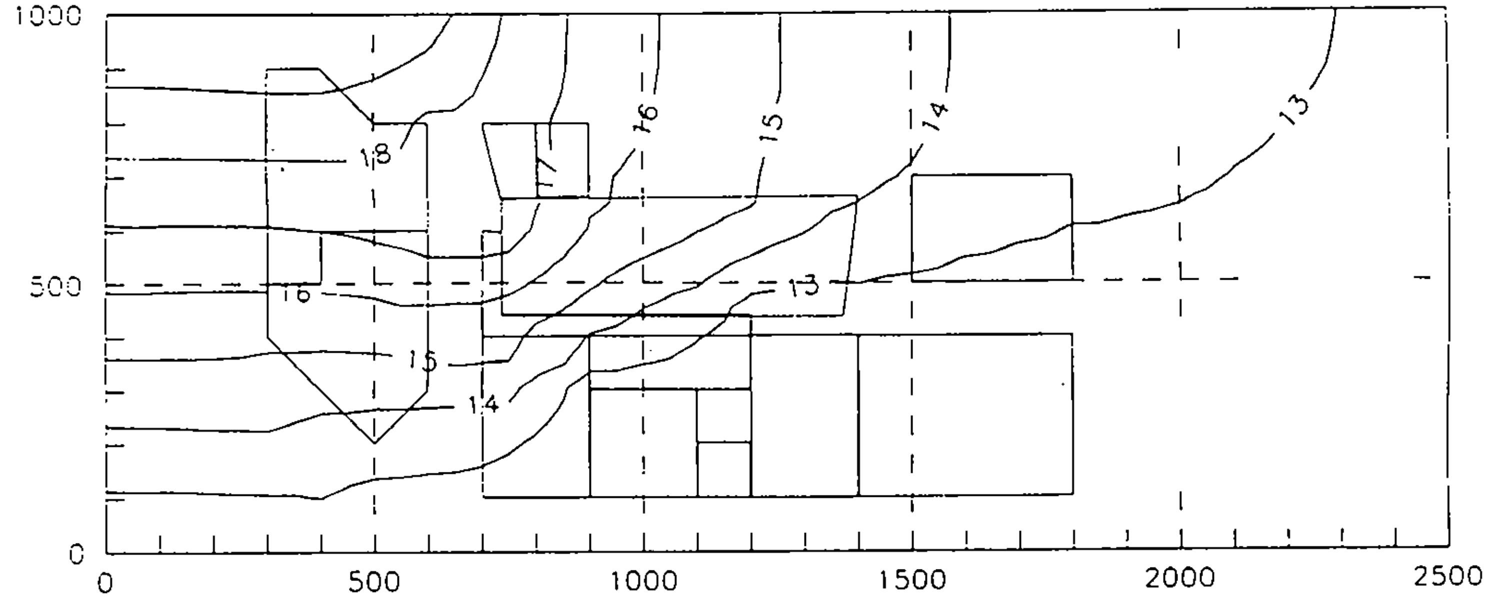
5.7 Full Seal along the south face of Church Farm Pit: Groundwater Level Difference from Existing Conditions.



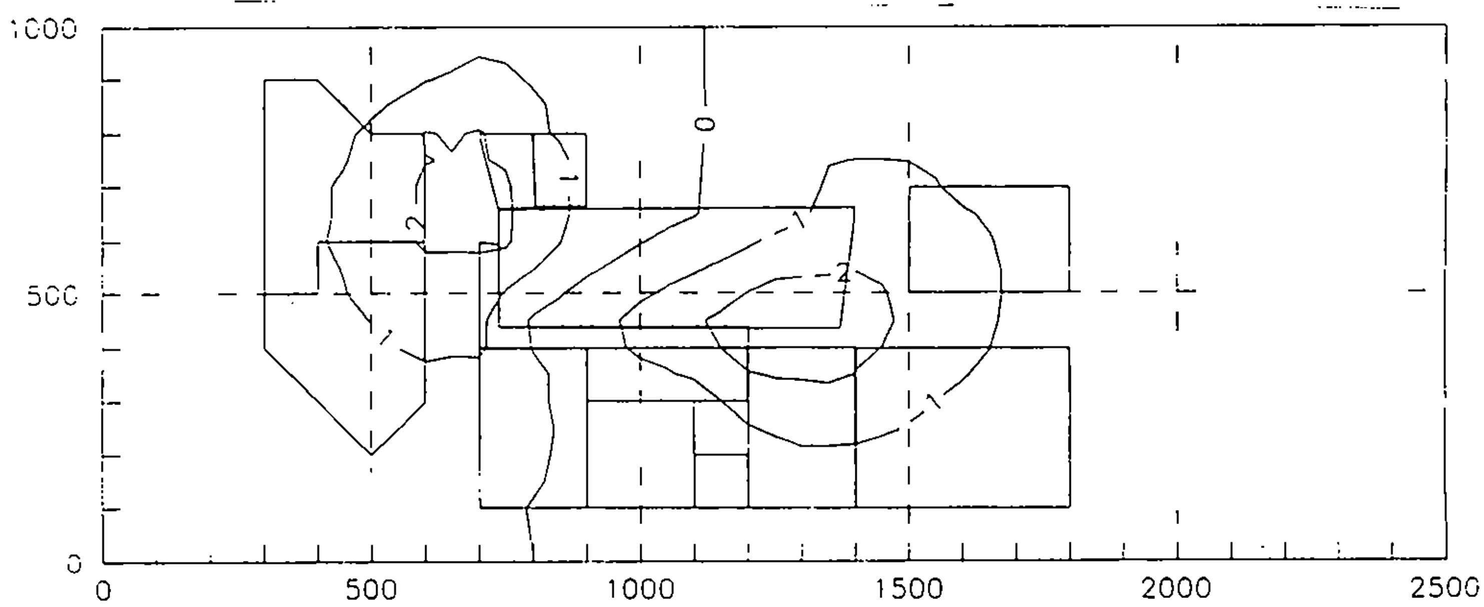
5.8 No Seal along the south face of Church Farm Pit: Modelled Groundwater Levels



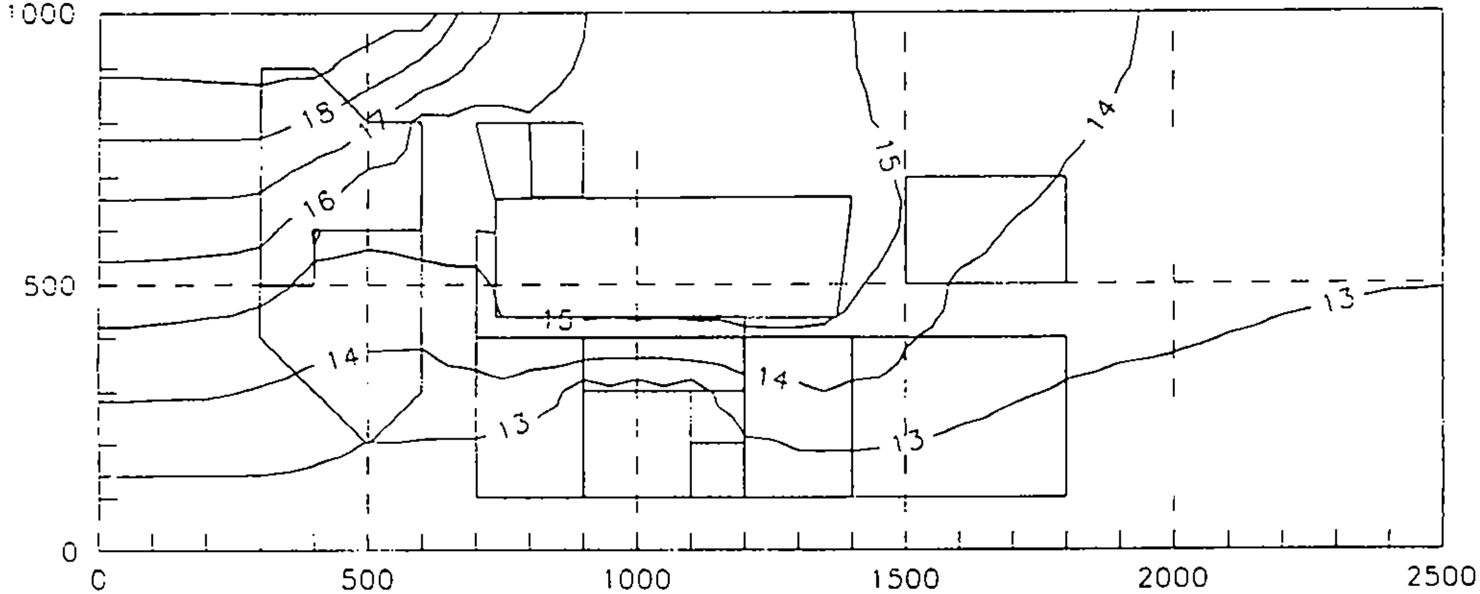
5.9 No Seal along the south face of Church Farm Pit: Groundwater Level Difference from Existing Conditions.



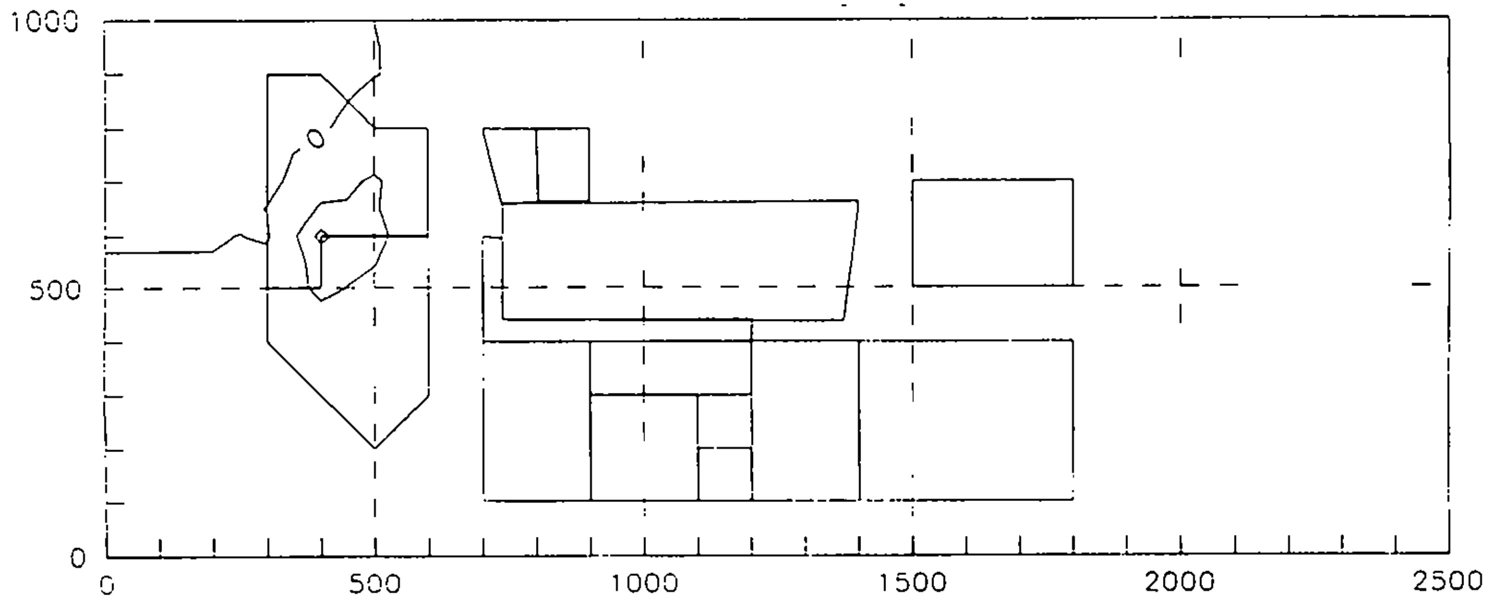
5.10 Church Farm Pit filled with Domestic Waste: Modelled Groundwater Levels.



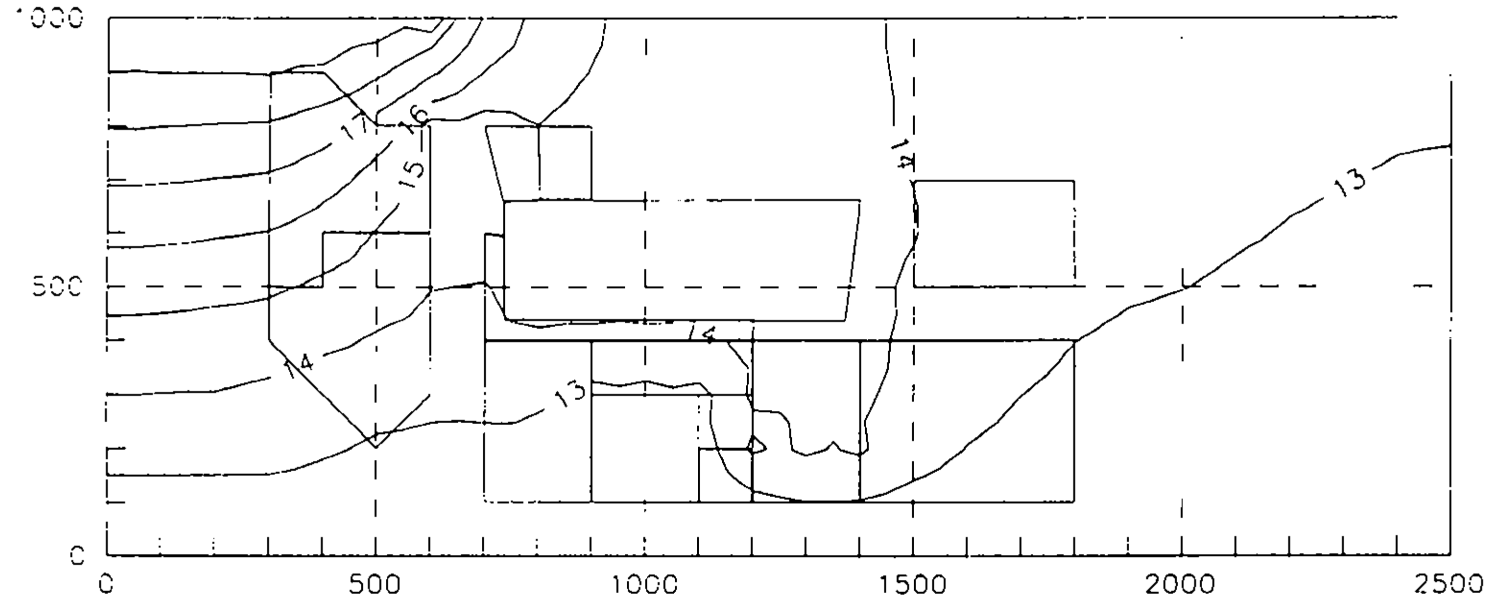
5.11 Church Farm Pit filled with Domestic Waste: Groundwater Level Difference from Existing Conditions.



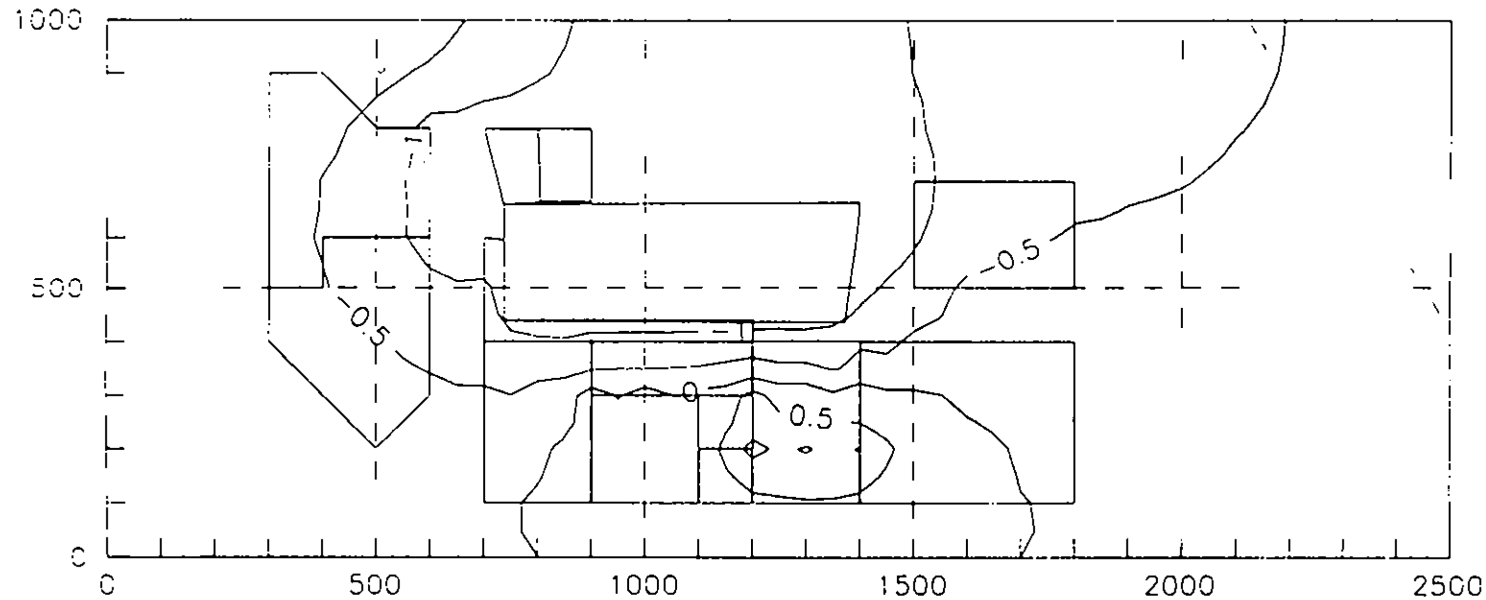
5.12 Pound Farm Pits filled with Compressed Builders Waste: Modelled Groundwater Levels.



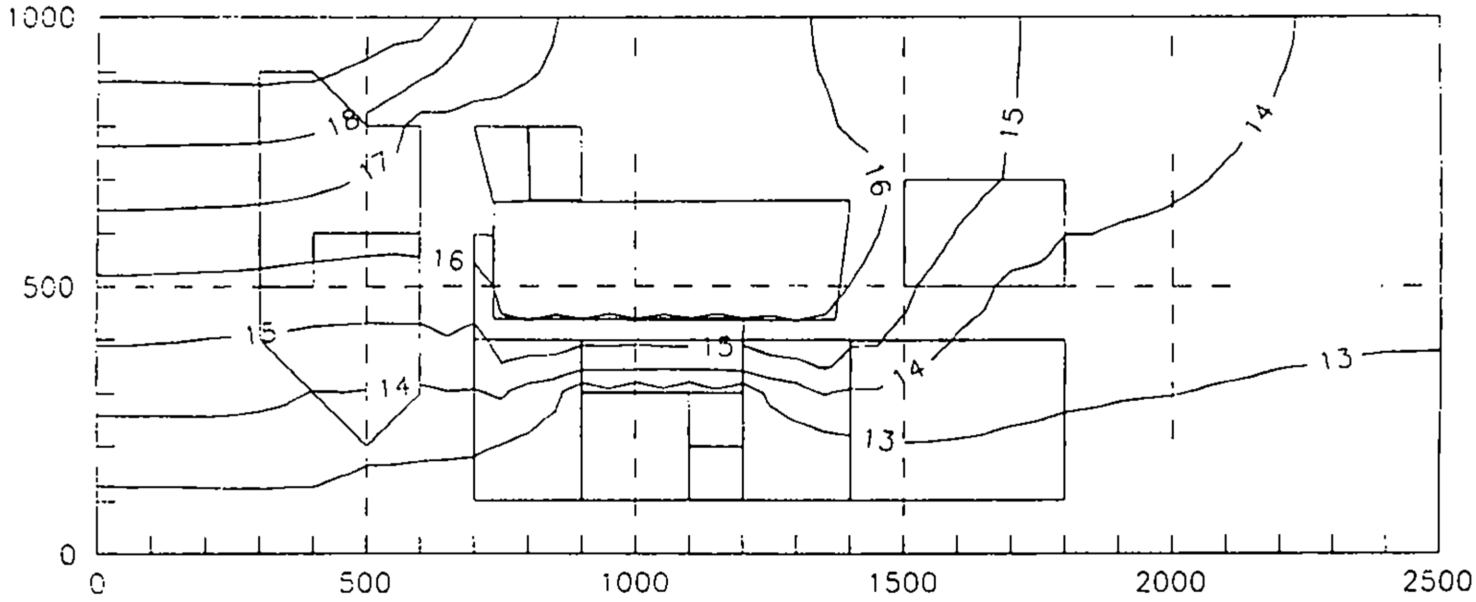
5.13 Pound Farm Pits filled with Compressed Builders Waste: Groundwater Level Difference from Existing Condtions.



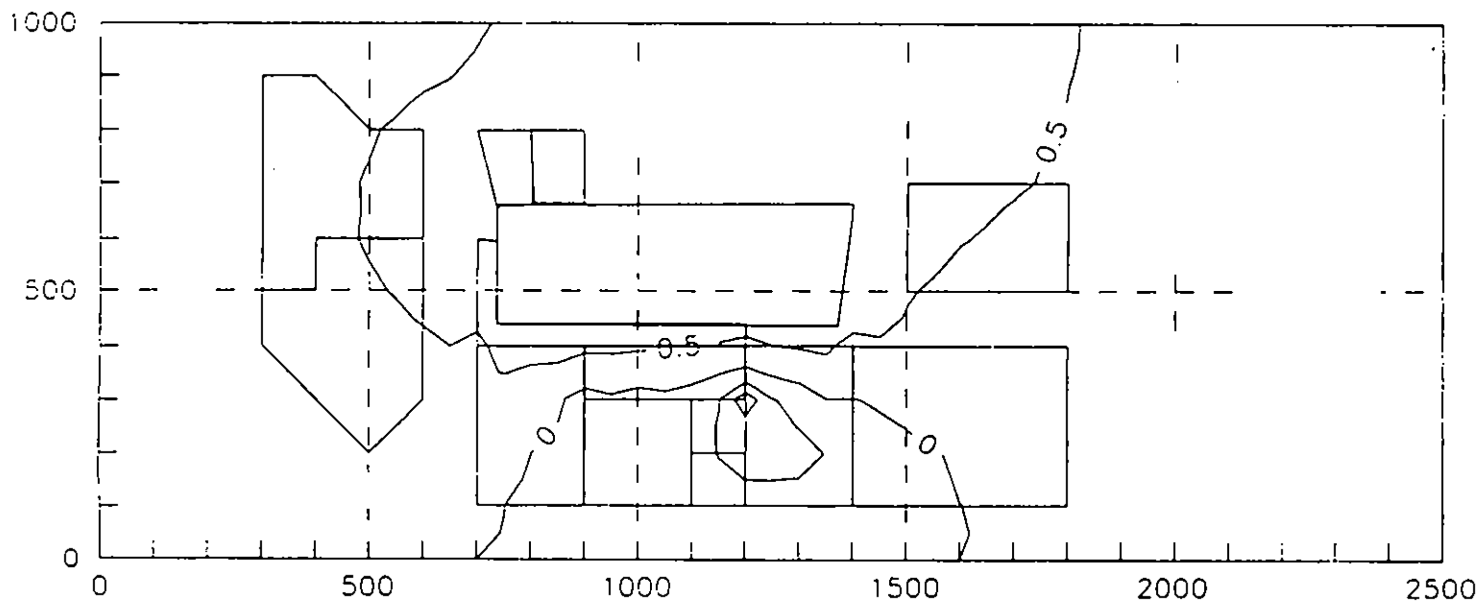
5.14 West Coach Road Pit as Water Filled: Modelled Groundwater Levels.



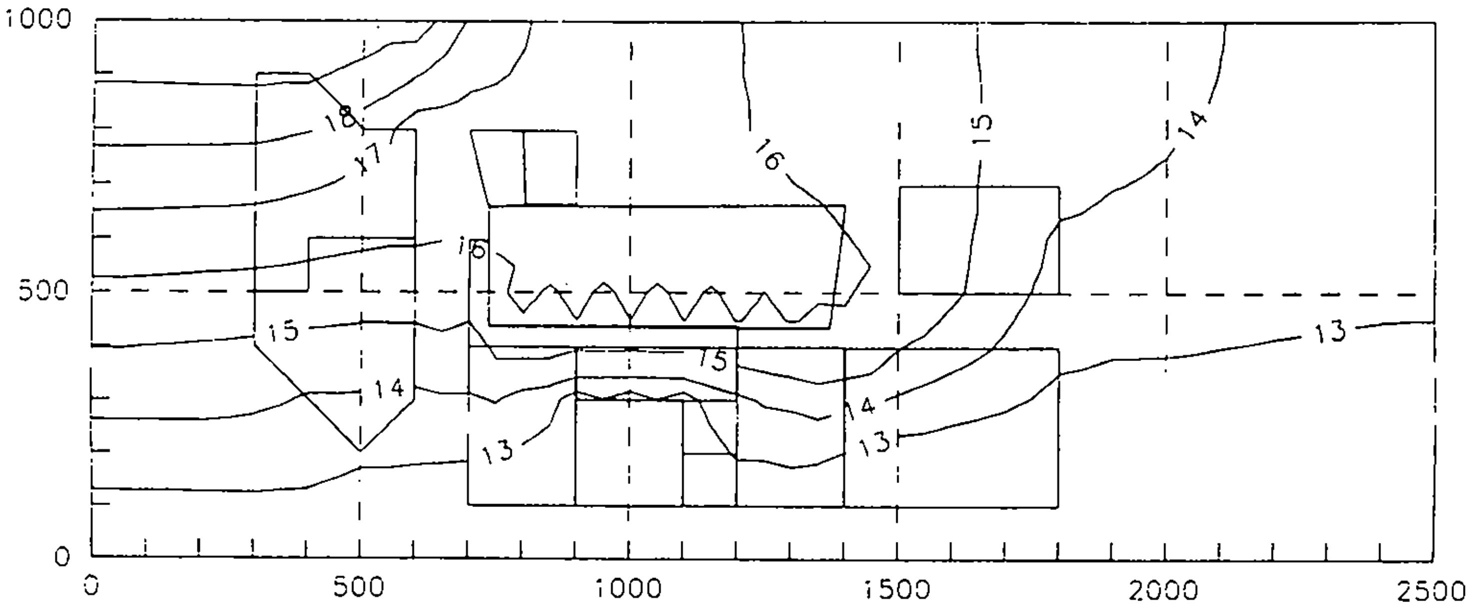
5.15 West Coach Road Pit as Water Filled: Groundwater Level Difference from Existing Conditions.



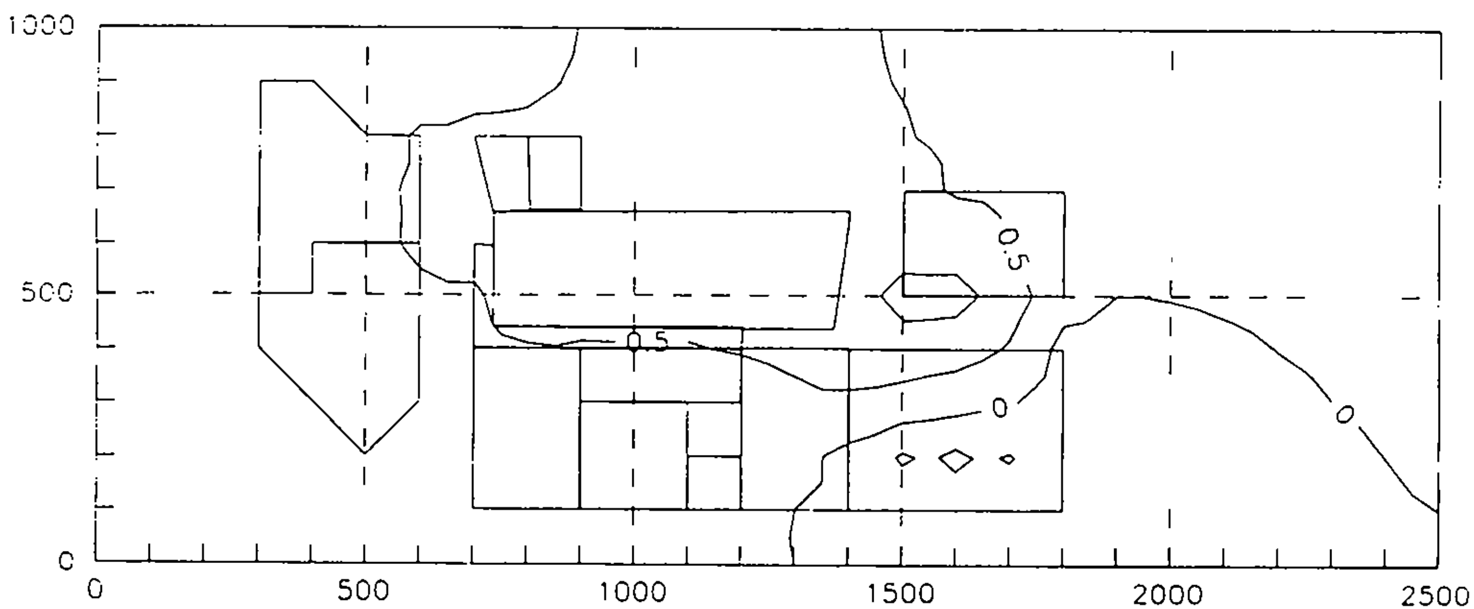
5.16 West Coach Road Infilled: Modelled Groundwater Levels.



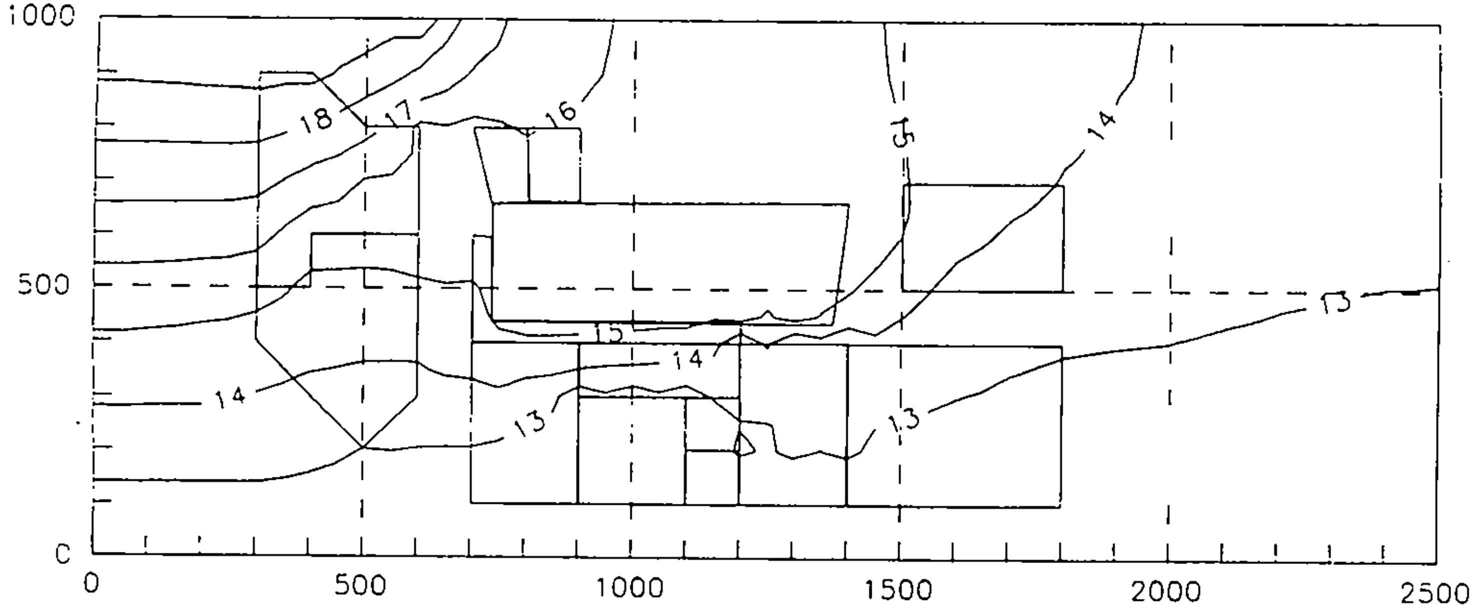
5.17 West Coach Road Infilled: Groundwater Levels Difference from Existing Conditions.



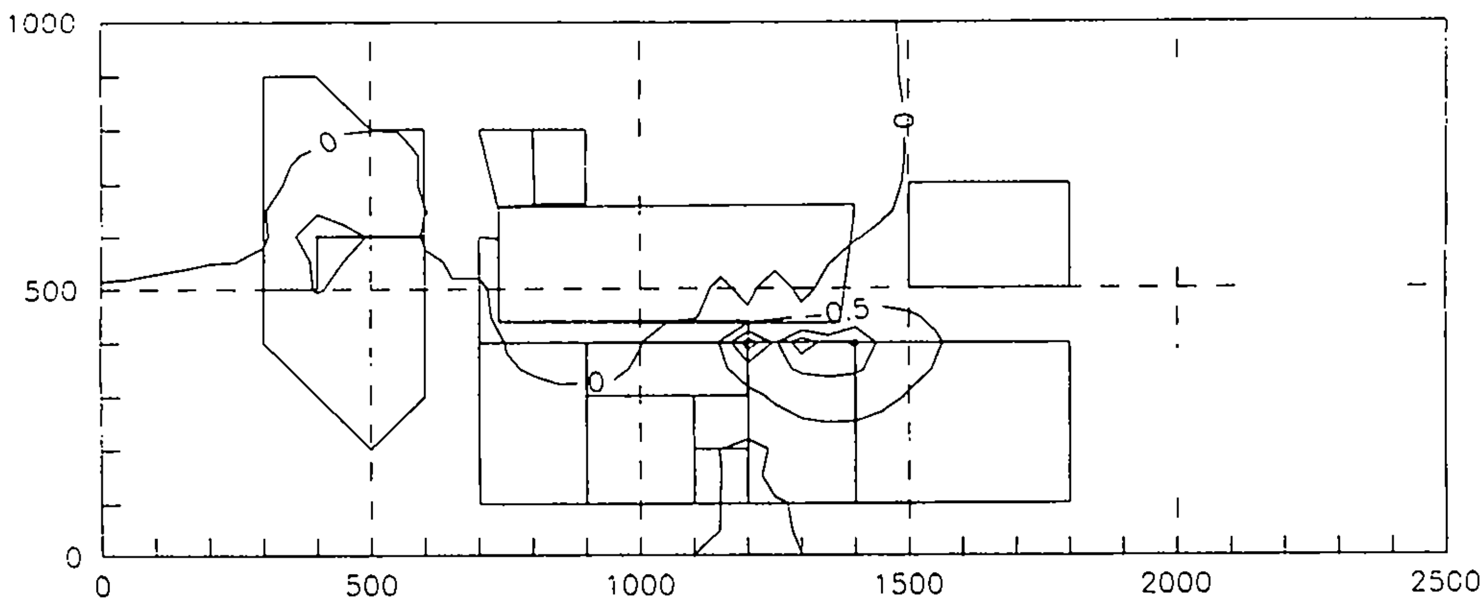
5.18 East Coach Road Infilled: Modelled Groundwater Levels



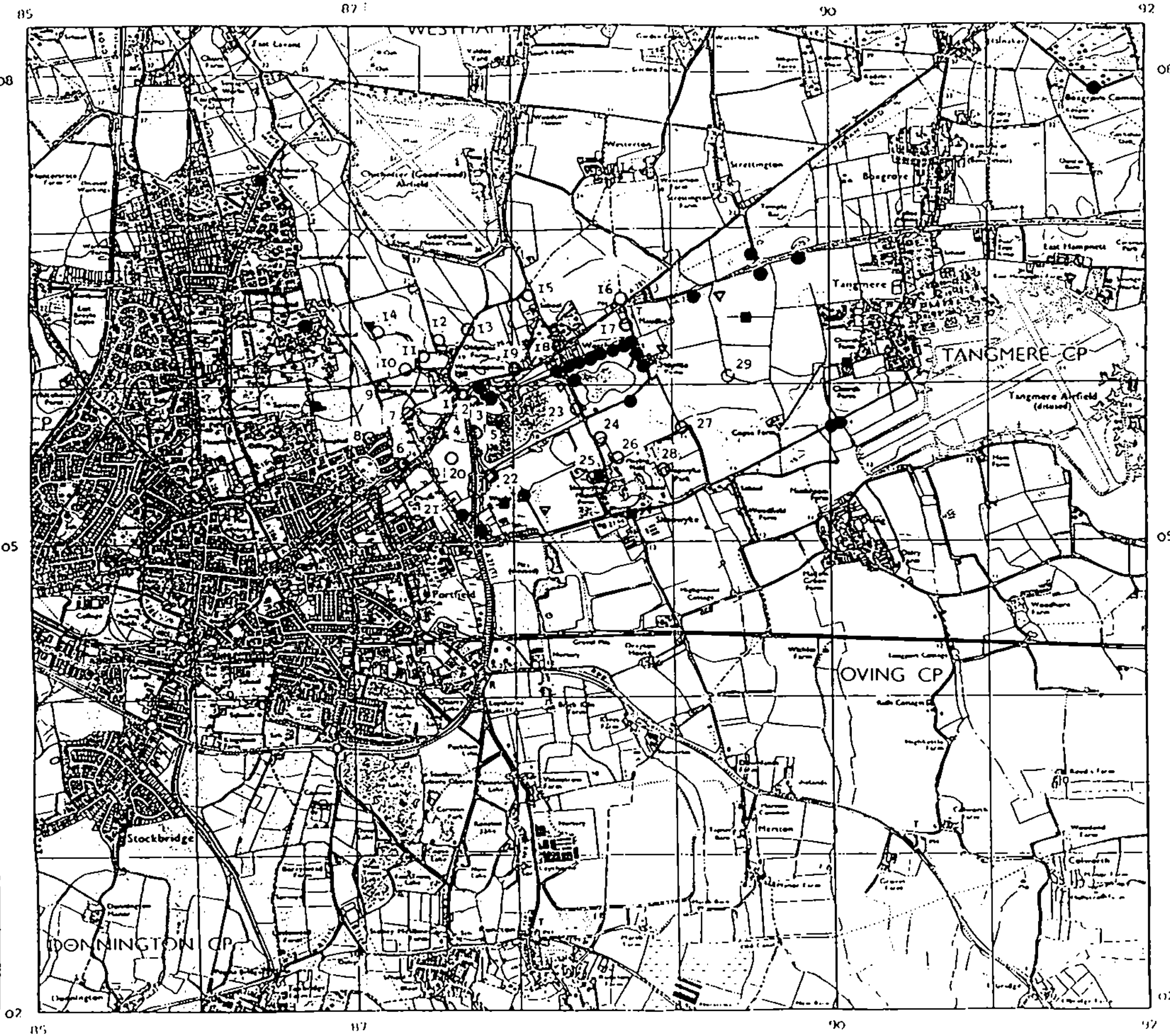
5.19 East Coach Road Infilled: Groundwater Level Difference from Existing Conditions.



5.20 Final Pit Configuration: Modelled Groundwater Levels.



5.21 Final Pit Configuration: Groundwater Level Difference from Existing Conditions.



EAST CHICHESTER
GROUNDWATER MODELLING STUDY

MONITORING SITES

	EXISTING	PROPOSED
Boreholes	●	○
Wells	■	
Surface Flow	▼	▽
Surface Water Levels	▼	▽

Baseplan from Ordinance Survey SU80/90

Scale 1 25,000

Figure 6.I

Annex

THEORY

The equation governing flow in the aquifer being simulated is :

$$\frac{\delta}{\delta x}\left[T\,\frac{\delta h}{\delta x}\right] = \frac{\delta}{\delta y}\left[T\,\frac{\delta h}{\delta y}\right] + Q = S\,\frac{\delta h}{\delta t}$$

where: h is the piezometric head;
T is the transmissivity;
Q is the pumping/recharge; and
S is the storage coefficient

The above equation is for two dimensional (horizontal) flow in a confined aquifer. When steady state conditions are simulated the right hand side of this equation is zero. The following model boundary conditions were applied:

Dirichlet: In the Dirichlet boundary condition the piezometric head is prescribed at the boundary. Fixed head boundaries are represented as Dirichlet boundary conditions.

Neumann: In the Neumann boundary condition the flow at the boundary is prescribed. No flow boundaries are special cases of Neumann boundary conditions where the flow is zero.

In AQUA model spatial discretization is carried out using the Galerkin finite element method with linear basis functions and triangular elements. Time discretization is by the backward Euler method.

The matrix equations which result from the numerical discretization are solved by pivoting and using Cholesky factorization.

Appendix A

Pit Descriptions

Historical Development 1948

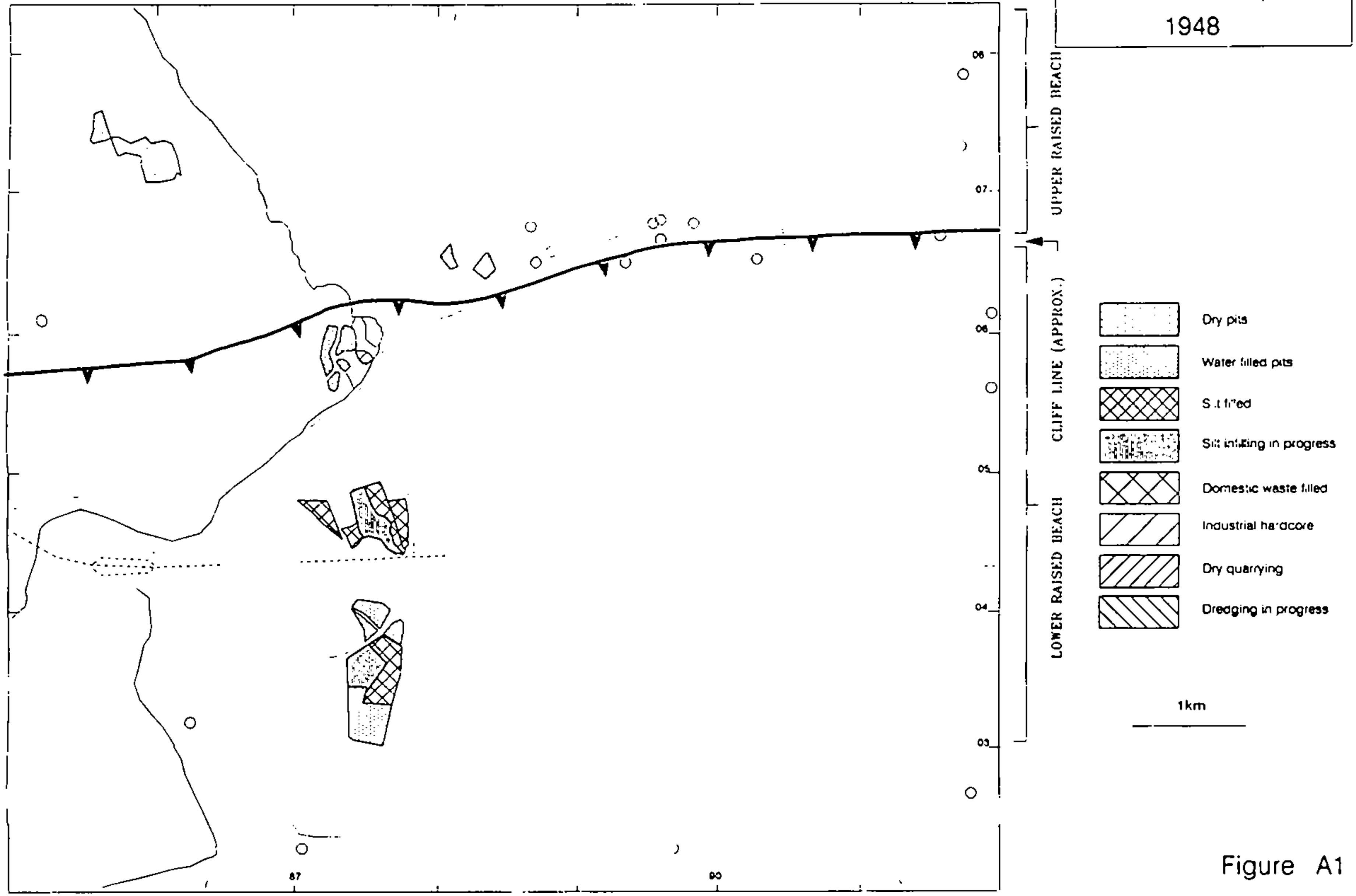


Figure A1

Historical Development 1961

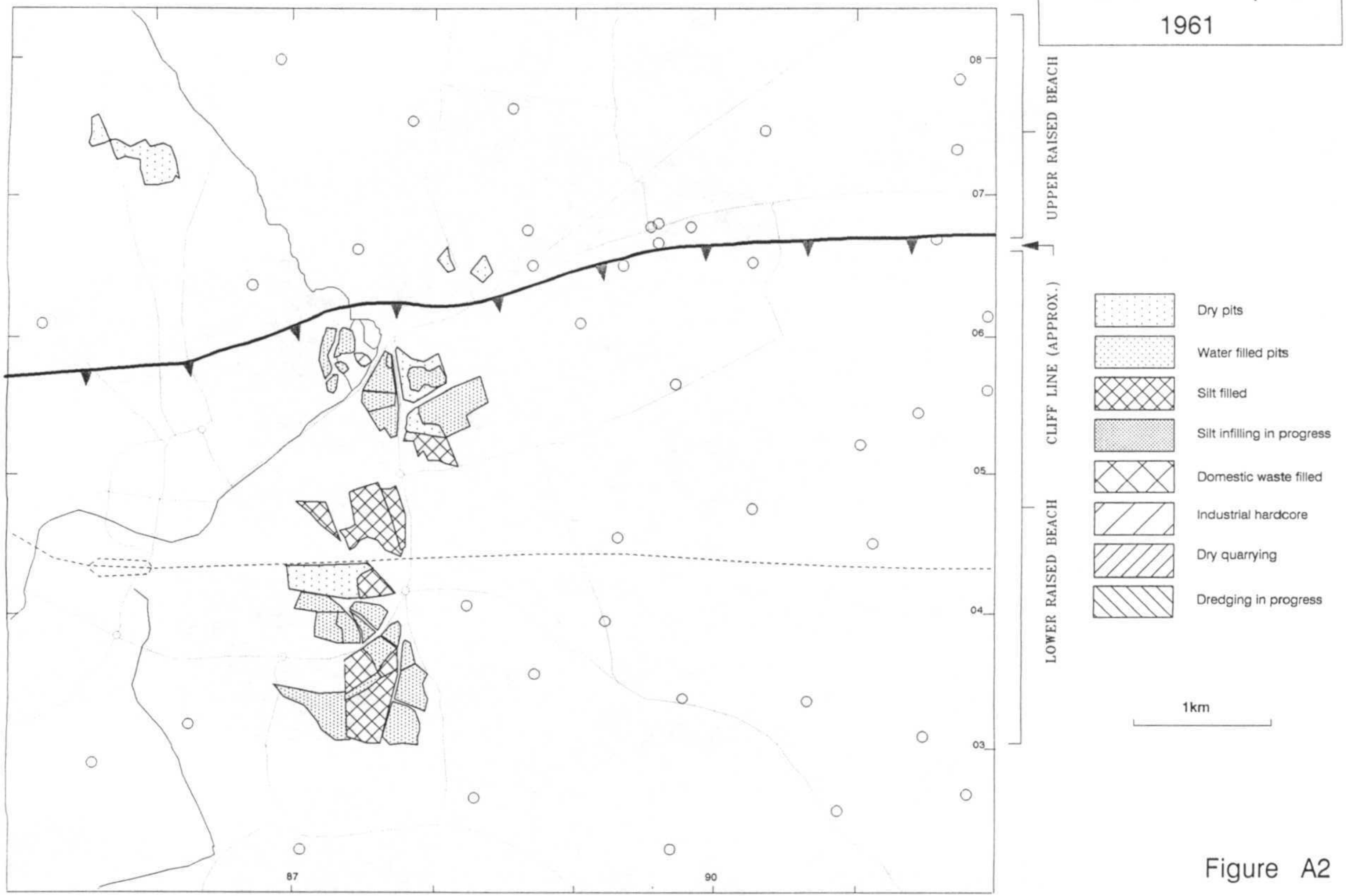


Figure A2

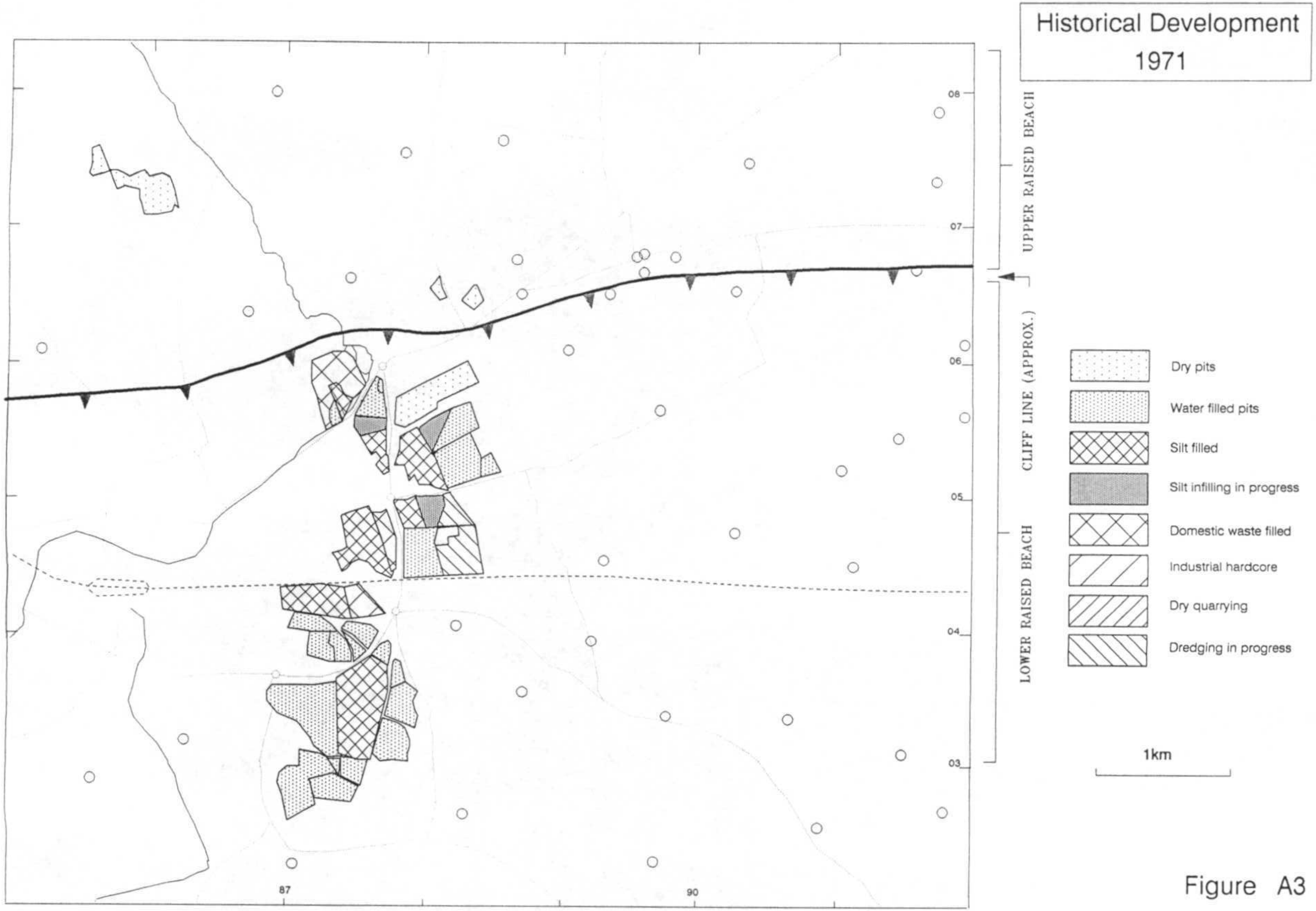
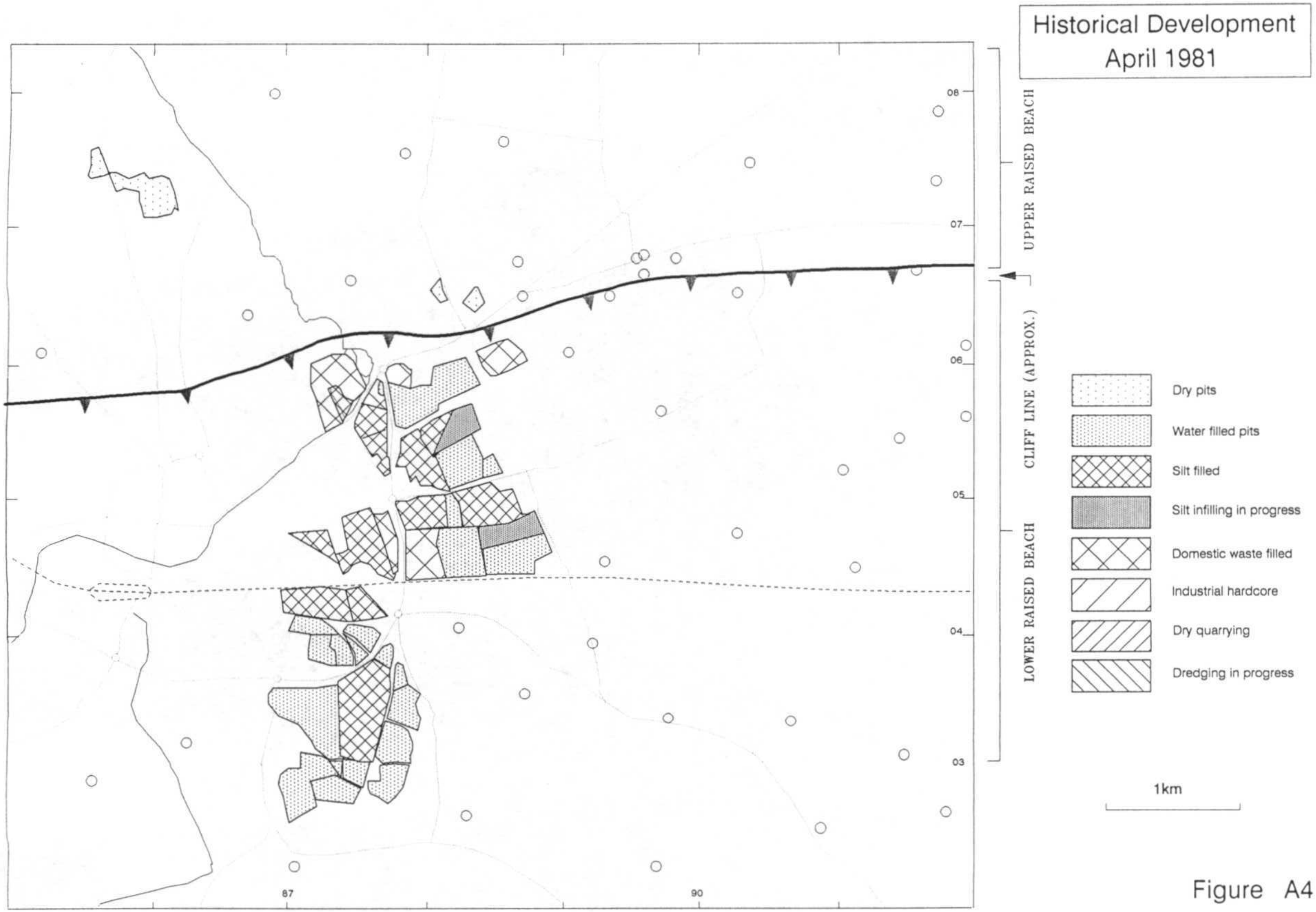

Historical Development
1971
UPPER RAISED BEACH
CLIFF LINE (APPROX.)
LOWER RAISED BEACH
Dry pits
Water filled pits
Silt filled
Silt infilling in progress
Domestic waste filled
Industrial hardcore
Dry quarrying
Dredging in progress
1km
08
07
06
05
04
03
87
90

Figure A3



Historical Development
April 1981
UPPER RAISED BEACH
CLIFF LINE (APPROX.)
LOWER RAISED BEACH
08
07
06
05
04
03
87
90
Dry pits
Water filled pits
Silt filled
Silt infilling in progress
Domestic waste filled
Industrial hardcore
Dry quarrying
Dredging in progress
1km

Figure A4

SITE NUMBER .01.   SITE NAME The March School..

LOCATION : 06500 88100

AREA : 0.944ha

DESCRIPTION : Currently a playing field cut down through approx. 2.5 metres of gravel. Dry and above winter water table.

EXCAVATION HISTORY : Unknown

Dates/Company :

GEOLOGICAL FEATURES Possibly within a raised storm beach deposit ?

Thickness of Gravel/Overburden : Base not seen, >2.5 metres of gravel, with thin soil cover <20 cms

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :

FILLING HISTORY AND AFTER-USE

MATERIAL USED : Not filled

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) :

SITE NUMBER .02.   SITE NAME : BRICK QUARRY

LOCATION : Off Claybrick Lane, Westhampnett 06400 88300

AREA 0.988ha

EXCAVATION HISTORY : Dry excavation area previously site for brickearth mining but now site for unlicenced gravel removal.

Dates/Company : Recent mining bu ? Goodwood Estate

GEOLOGICAL FEATURES : Storm beach gravel deposit, base not seen with >2.5 metres exposed in face. Thin soil cover < 20cm.

Thickness of Gravel/Overburden : 2.5m gravel. <20cm soil

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow : Appears to be standing pools of water during peak winter periods ?possibly just run-off, into lowest excavated areas.

FILLING HISTORY AND AFTER-USE

MATERIAL USED : Dry and unfilled.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) :

SITE NUMBER .03. SITE NAME .. POUND FARM

LOCATION : Surrounding present crematorium, 06000 87300

AREA :

EXCAVATION HISTORY :

Dates/Company : Excavation after 1945 by Pound Farm Gravel
Currently owned by Chichester District Council who are considering removing existing fit, and refilling with inert material prior to subdivision for residential development.

GEOLOGICAL FEATURES : Excavation not very deep due to limited capacity of machinery. Not to base of gravels (ADH)

Thickness of Gravel/Overburden :

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow : Lavant runs through the area with base of the river approx 1.0 below ground level.
Transmissivity/Storativity : No record of measurements.

FILLING HISTORY AND AFTER-USE : Filled by the Chichester Town Council in the post WWII era with domestic waste. Currently a very irregular surface with use as open 'playing'field.

MATERIAL USED : Uncompacted domestic waste

SEQUENCE OF FILLING : The course of the Lavant was left undisturbed during gravel extraction. Hence still underlain by original sequence.

THICKNESS OF FILL(S) : Possibly around 2.5 metres.

SITE NUMBER .04.   SITE NAME CREMATORIUM...

LOCATION : 05700 87400

AREA :

EXCAVATION HISTORY :

Dates/Company : Excavated after 1945 by Pound Farm Gravel

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : Excavations were not to the base of gravels due to limitations of machinery in use (ADH).

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow : Bounded to west by Lavant with river base approx 1.5 metres below ground surface.
Transmissivity/Storativity : No recorded measurements

FILLING HISTORY AND AFTER-USE

MATERIAL USED : Silt/clay washings from plant located approx in location of present crematorium. Presumeably plant washed material from the Sainsbury's site as well?

SEQUENCE OF FILLING : Presumeably from the south.

THICKNESS OF FILL(S) : Probably in the order of approx. 2.5m.

SITE NUMBER .05. SITE NAME SAINSBURY'S.NORTH.

LOCATION :05800 87600

AREA :

EXCAVATION HISTORY :

Dates/Company : Excavated by Bulls at same time as Site06

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : Originally probably 6.0m.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow : Water levels not recorded by Sainsburys during current methane gas monitoring.
Storativity/Transmissivity : No measurements known ? Possibly some data from DOT work or from Sainsbury's engineering work?

FILLING HISTORY AND AFTER-USE

MATERIAL USED : Domestic waste

SEQUENCE OF FILLING : Domestic waste possible overlying variable thickness of inert builders material thickening to the south. The Sainsbury's site was apparently filled last, and with domestic waste because of inadequate supplies of inert material at this time.

THICKNESS OF FILL(S) : Probably in the order of 6.0-6.5m

SITE NUMBER .06. SITE NAME SAINSBURY'S SOUTH.

LOCATION : 05500 78700

AREA :

EXCAVATION HISTORY :

Dates/Company

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : Excavated to approx 6.0m

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow : Present winter ground water levels are sufficiently high to allow accumulation of water to 20-30cm depth in tunnel beneath A27

FILLING HISTORY AND AFTER-USE

MATERIAL USED : Only inert building material

SEQUENCE OF FILLING : Air photo'suggest filling commenced in the south east corner and proceeded to the east and north.

THICKNESS OF FILL(S) : Probably in the order of 5.0 to 6.0m with current north east portion of this area covered by fill material to a height of 2.0m above normal ground level.

SITE NUMBER .07. SITE NAME HALFORDS...

LOCATION : 05400 87600

AREA :

EXCAVATION HISTORY :

Dates/Company :

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : Excavated to approx. 18'

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :

FILLING HISTORY AND AFTER-USE

MATERIAL USED : Infilled by ADH with inert builders waste to about 8' below surface and subsequently covered (CDC?) with 6-7' of domestic waste and 1' of topsoil.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) total thickness of approx 14-15' fill

SITE NUMBER .08. SITE NAME WESTHAMPNETT DEPOT

LOCATION : 06000 88000

AREA :

EXCAVATION HISTORY :

Dates/Company :

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden :

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :

FILLING HISTORY AND AFTER-USE

MATERIAL USED : Layered silt and domestic refuse, built with a view to construction of council waste pulverising plant on site.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) :

SITE NUMBER .09. SITE NAME CHALK FARM PIT..

LOCATION : 05700 88000

AREA

EXCAVATION HISTORY : Excavated dry by RMC

Dates/Company :

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : A thin smear of gravel (marl) left in base of the pit as evident from engineering holes drilled for A23 by-pass. Probably thickens to the south from <0.5m to about 1.0-1.5m beneath the southern embankment.
The bottom of the eastern portions of the pit are shown on certain plans to be quite irregular, with remnant bunds and local 'islands'.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow : Sporadic but at times detailed.

FILLING HISTORY AND AFTER-USE

MATERIAL USED : The banks of the pit have been lined with clay to reduce outflow of water.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) :

SITE NUMBER .10..   SITE NAME COACH ROAD REFUSE DUMP

LOCATION : 0600   8860

AREA : Exact boundary of the excavated site is a little uncertain and is presumed to be the irregular outline shown on most Ordinance Survey maps.

EXCAVATION HISTORY : Prior to gravel extraction there was a brick works located on the north west corner of the site. Presumeably this may have exploited local surficial clays.

Dates/Company : Gravel extraction commenced by ADH but discontinued due to poor quality of material.

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : The gravel thins to the east, with increasing amount of marl. No numerical data (ADH)

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow : Monitoring currently in progress (02/04/90). Neighbour to the north reports gradually increasing winter groundwater levels in small pit in her back garden. Visual estimates would place peak levels at approx 1.0m below land surface.
Transmissivity/Storativity :

FILLING HISTORY AND AFTER-USE : Pit has been filled initially by ADH, then ?Bulls and now by WSCC. The present filling is up to approx. 2.0m above ground and is presumeably extending across undisturbed poor quality gravel left surrounding the original Heavers pit.

MATERIAL USED : Mostly domestic waste, degree of compaction unknown.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) : ADH reports that the excavation thinned to the east but no quantitative data.

SITE NUMBER .11. SITE NAME : TARMAC SILT SITE

LOCATION : 05500 88200

AREA :

EXCAVATION HISTORY :

Dates/Company : Excavated by ADH

GEOLOGICAL FEATURES

Thickness of Gravel/Overburden : Gravel approx. 7.0m thick above hard marl.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :
Transmissivity/Storativity :

FILLING HISTORY AND AFTER-USE : This area has been the site of outflow of water from Tarmac washing plant. At an early stage a north-south and east west bunds were constructed with 'French Drain' features to allow the maximum depth of water to develop in successive settling ponds. These features also restricted the build up of silt/clay along the eastern boundary of site 12 where summer inflow of groundwater was sought.
Currently a large amount of precast concrete waste has been dumped on top of the silt/clay, but this material is unlikely to have affected the hydrogeological character of the site.

MATERIAL USED : Clay/silt from washing plant.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) : Present surface of infill material is approx coincident with existing land surface.

SITE NUMBER .12. SITE NAME .PORTFIELD EAST..

LOCATION : 0560 8830

AREA :

EXCAVATION HISTORY :

Dates/Company : Excavated by dredge for Francis Parker?

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : Approx. 7.0m

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :
Transmissivity/Storativity :

FILLING HISTORY AND AFTER-USE : This area is currently the outflow site for water from the Tarmac washing plant and is very actively accumulating silts and clay. The amount being dumped here is unknown.

MATERIAL USED :

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) : The current level of fill is several metres below present land surface. It is probable that there is at least 2.0m of silt/clay covering the base of this area, with a variable amount of water above this. Water levels in this area probably are only of the order of 0.1-0.5 m.

SITE NUMBER .13. SITE NAME .TARMAC PORTFIELD SITE

LOCATION : 0530 8790

AREA :

EXCAVATION HISTORY : Some late 1940's maps show apparently thin excavations of gravel covering the south-western portions of this site and extending westwards beneath the present A27 route. This may have been a pre-WWII excavation.
The more extensive excavation of the site seems to have been completed by Heavers d

Dates/Company : Heavers, 1950-55?

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : Probably 6.5-7.0m of gravel. A drainage channel was dug along the western side of the site to a sump in the south western corner, near the A27. This sump was apparently within undisturbed gravel.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow : Present day ground water levels vary from less than 0.5 metres below present ground level in winter to approx 4.0 metres below ground level during summer. An incomplete set of water level data is available from a shallow borehole in the NRA yard immediately to the south.
Transmissivity/Storativity : Tarmac pump from a well near the centre of the site and are able to produce production rates of approx. ..... gals/hour. for extended periods of time.

FILLING HISTORY AND AFTER-USE

MATERIAL USED : The site was infilled with silt/clay washings from the Heavers plant, prior to the construction of the present Tarmac facility.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) . Approximately returned to level of surrounding countryside, therefore probably around 6.5m of fill.

SITE NUMBER .14. SITE NAME .SHOPWYKE NORTH...

LOCATION : 0530 8830

AREA :

EXCAVATION HISTORY :

Dates/Company : Excavated by dredge by Francis Parker ?

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : Approx 6.5m gravel a;long Oving Road increasing to 7.0m in the north of the area. reported that the 'marl' beneath the gravels was very hard, requiring explosives to allow excavation of a pipeline through this area. the base of the gravel was very irregular with a pinnacle terrain after extraction. This may have been the result of incision of stream channels into the underlying marine deposits during the deposition of the fluvial sequences.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :
Transmissivity/Storativity : The reported hardness of the underlying marls would suggest that these beds have a low transmissivity/storativity.

FILLING HISTORY AND AFTER-USE : Currently unfilled, and used as water collection point for water from the Tarmac washing plant.

MATERIAL USED :

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) :

SITE NUMBER .15. SITE NAME .SHOPWYKE LODGE..

LOCATION : 0515 8860

AREA :

EXCAVATION HISTORY :

Dates/Company : Excavated by dredge by Francis Parker?

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : Approx 6.5m of gravel above marl.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :
Transmissivity/Storativity : No data available

FILLING HISTORY AND AFTER-USE

MATERIAL USED : This area has been a silt for dumping silt/clay washings from the main Tarmac Drayton site with material piped in and released in the south-east corner. Relaes of silt has now stopped due to the effects this material is thought to have had upon the summer inflow of groundwater into Shopwyke North pit.

SEQUENCE OF FILLING : Filling from the south east corner, probably extending as a thin sheet across a large part of the Shopwyke North pit.

THICKNESS OF FILL(S) : The present surface at the south east corner is approx 1.0m? below the present land surface in this area.

SITE NUMBER .16... SITE NAME .SHOPWYKE NORTH WEST

LOCATION : 0490 8800

AREA :

EXCAVATION HISTORY :

Dates/Company : Dredged by Heavers/Francis Parker

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : Thickness of gravel reportedly approx. 6.5m along Oving Road decreasing to 5.5m at the southern boundary of the area.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :

FILLING HISTORY AND AFTER-USE

MATERIAL USED : Site back-filled with silt/clay washings from gravel processing at a very early stage.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) : Site returned to previous land surface level, hence thickness of fill probably from 6.0 to 5.0m. with thin topsoil covering.

SITE NUMBER .17. SITE NAME .SHOPWYKE NORTH WEST

LOCATION : 0490 8820

AREA :

EXCAVATION HISTORY :

Dates/Company : Dredged by Heavers

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : Reported thickness of gravel south of Oving Road said to be approx. 6.5m thinning to approx 5.5m at the southern boundary of area 17.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow : urface levels will indicate levels in surrounding fill material.

FILLING HISTORY AND AFTER-USE

MATERIAL USED : Currently a water filled open excavation. Depth of water is unknown but the bottom is presumeably well silted up.
Water from this site is apparentle not recirculated by Tarmac.

SEQUENCE OF FILLING : Not filled

THICKNESS OF FILL(S) :

SITE NUMBER .18. SITE NAME .SHOPWYKE NORTH EAST

LOCATION : 0480 8860

AREA :

EXCAVATION HISTORY :

Dates/Company : Excavated by Heavers and ? Francis Parker. worked wet from barges unloading in area 17.

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : Approx 6.5m of gravel at the northern end of the area decreasing to 5.0m at southern boundary. Apparently underlain by marl.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :
Transmissivity/Storativity : No known information.

FILLING HISTORY AND AFTER-USE

MATERIAL USED Entire area filled with silt/mud washings from gravel processing.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) : Northern half of the area is filled back to present ground surface (13.0 m),while the southern half stands approx 1.5m above (14.5m) present land surface.

SITE NUMBER .19. SITE NAME .SHOPWYKE SOUTH-EAST

LOCATION : 0450 8800

AREA

EXCAVATION HISTORY : Excavated wet by A.J. Bull dredge. The western half of this site was reputedly dug down to the London Clay and the clay material used for lining the walls of this and other pits in the area.

Dates/Company : Heavers. Most O.S. maps show this area as two seperate pits and earlier studies of this area refer to these as Shopwyke South and Shopwyke South-West.

GEOLOGICAL FEATURES : ADH reports approx 5.0 m of gravel along the south-western boundary of this area thickening to about 6.0m to the northern boundary, and thinning to 4.0m to the eastern boundary in the vicinity of the present primary washing facility.
Heavers reports that he mined both pits to a marl base.

Thickness of Gravel/Overburden :

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :
Transmissivity/Storativity :

FILLING HISTORY AND AFTER-USE

MATERIAL USED : Predominantly domestic waste.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) : The centre of this area presently rises approx. 3.0 metres above the surrounding land surface. This elevated portion of the site focusses the flow of methane gas to the apex of the landfill where it is burnt off.

SITE NUMBER .20. SITE NAME .SHOPWYKE SOUTH EAST

LOCATION : 0450 8860

AREA :

EXCAVATION HISTORY : Excavated wet by Heavers

Dates/Company :

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : ADH reports approx 3.0m of gravel along the southern boundary overlying approx 1.0m of lug sand.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow : The water level has been know to rise to such a point that it overflow the British Rail Chichester to Brighton line.
Transmissivity/Storativity : The southern bank of the old pit was lined in order to reduce water loss so that dredges could keep afloat.

FILLING HISTORY AND AFTER-USE : Currently unfilled and used as a water reservoir to supplt the primary washing site. Possibly some pumping of water to the main facility at Drayton.

MATERIAL USE : Fine clays used in wall lining.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) : Depth of original pit unknow, it may have extended to as far as the London Clay. Present depth of water is unknown.

SITE NUMBER .21.   SITE NAME .PORTFIELD ALLOTMENTS

LOCATION : 0460 8770

AREA :

EXCAVATION HISTORY : ADH reports that this area was once the property of the Chichester City Council. A thin layer (1.0-1.5m) of gravel was apparently removed prior to the council infilling with builders rubble. ADH refused CCC offer to dig out deeper gravels as the councils asking price was too high.

Dates/Company : Excavation by Chichester City Council

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : Total thickness unknown,but probably varying from 5.0 to 6.5m from south to north.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :
Transmissivity/Storativity : With a considerable amount of gravel still present beneath this area it is likely that there is considerable underflow.

FILLING HISTORY AND AFTER-USE

MATERIAL USED : Inert builders rubble.

SEQUENCE OF FILLING : Unknown

THICKNESS OF FILL(S) : Only 1.0 to 2.0 metres

SITE NUMBER .22. SITE NAME .PORTFIELD RAILWAY

LOCATION : 0460 8760

AREA :

EXCAVATION HISTORY :

Dates/Company : ADH reports that the area was dug bt hand during the 1920-30's

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : Total thickness of gravels not penetrated by workings, which ADH reports as only being approx. 4.0m deep.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow : With a comsiderable amount of gravel left beneath this site it is to be expected that there is a reasonable underflow.
Transmissivity/Storativity :

FILLING HISTORY AND AFTER-USE

MATERIAL USED : Railway ballast, from works associated with the railway, including landslips etc. It is possible also that there may have been ash/sinder material from the coal burning locomotives.

SEQUENCE OF FILLING : Unknown.

THICKNESS OF FILL(S) : Site covered with approx. 4.0m of fill.

SITE NUMBER .23. SITE NAME .PORTFIELD SOUTHWEST

LOCATION : 0450 8750

AREA :

EXCAVATION HISTORY : Same as Site 22

Dates/Company : 1920-30's

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : As for Site 22

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :
Transmissivity/Storativity :

FILLING HISTORY AND AFTER-USE

MATERIAL USED : Some reports (WSCC-Waste Management) suggest that this area was particularly used as a site for dumping ash and cinder from the BR locomotives. ADH rejects this suggestion.Further information on this site may be available from WSCC Building Control.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) : Probably approx 4.0m.

SITE NUMBER .24..   SITE NAME .FLORENCE ROAD...

LOCATION : 0475 8725

AREA :

EXCAVATION HISTORY :

Dates/Company : Probably early 1920-30's (ADH), excavated by Pound farm Gravels... therefore probably non-hydraulic draglines which would not have been able to dig very deep... 3.0-4.0m?

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden :

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :
Transmissivity/Storativity
Degree of Compaction :

FILLING HISTORY AND AFTER-USE

MATERIAL USED : Filled by Chichester District Council with inert builders rubble (ADH). WSCC (Waste Disposal) reports that this site was filled by CDC with domestic waste ?

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) : 3.0-4.0m very approx.

SITE NUMBER .25. SITE NAME .QUARRY LANE WEST.

LOCATION : 0420 8720

AREA :

EXCAVATION HISTORY : Excavated by Heavers, with steam dragline and therefore not dug very deep ...?3.0-4.0m? Excavation of this pit presumeably took place prior to extraction from Whyke Lake (Site 28) and Quarry Lake(Site27).

Dates/Company : Heavers

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : Fully thickness of gravel not exposed during working. On the basis of comparisons with Shopwyke South West(Site19) the thickness of gravel is probable in the order of 6.0m.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :
Transmissivity/Storativity :

FILLING HISTORY AND AFTER-USE

MATERIAL USED : Filled by Chichester District Council pre-WWII with inert building rubble.

SEQUENCE OF FILLING : Unknown

THICKNESS OF FILL(S) : Approx. 3.0-4.0m?

SITE NUMBER .26. SITE NAME .QUARRY LANE EAST.

LOCATION : 0420 8760

AREA :

EXCAVATION HISTORY : As for Site 25

Dates/Company : Excavated by Heavers with steam dragline. The site was probably excavated to a depth of only approx 4.0m due to the limited capacity of the draglines.

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : No data but probably comparable to that at southern boundary of Site 19 (Shopwyke South East).
ADH recalls that the topsoil at Whyke Lake was about 1.0m thick and 'peaty', and this may apply here at Site 26.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :
Transmissivity/Storativity :

FILLING HISTORY AND AFTER-USE

MATERIAL USED : This site was filled with domestic waste by the Chichester District Council, at presumeably a later date than the operation of the two washing plants which were located just west of this site. It is possible that a thin film of silt/clay from the washing plant may underlie this site.

SEQUENCE OF FILLING : Possible lower silt/clay layer of unknown thickness with domestic waste above.

THICKNESS OF FILL(S) : Site returned to present land surface and therefore probably total thickness of approx. 4.0m of fill.

SITE NUMBER .27.   SITE NAME .QUARRY LAKE...

LOCATION : 0400 8760

AREA :

EXCAVATION HISTORY : Excavated using steam draglines by Heavers with material being transported to the Quarry Lane West (Site 25) for washing.

Dates/Company : Heavers

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : Full depth of gravel not penetrated. Probably approx. 5.0m of gravel above 1.0m of lug sand, beneath a peaty topsoil up to 1.0m thick.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :
Transmissivity/Storativity :

FILLING HISTORY AND AFTER-USE : Presently an open lake used for recreation purposes.. fishing.

MATERIAL USED :

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) :

SITE NUMBER .28. SITE NAME .WHYKE LAKE...

LOCATION : 0390 8720

AREA :

EXCAVATION HISTORY : Excavated by steam dragline and therefore the depth of excavation was limited by the capicity of these machines.
The local fishing club deepened this lake by about 1.0m. Current depth unknown.

Dates/Company : Heavers

GEOLOGICAL FEATURES : The excavations stopped where the base of the gravels became marly and hard. The area was covered by 1.0m of peaty topsoil.

Thickness of Gravel/Overburden : 5.0m of excavated gravel beneath 1.0m of topsoil.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :
Transmissivity/Storativity :

FILLING HISTORY AND AFTER USE : Currently left as open lake and used for recreational purposes.

MATERIAL USED : It is probable that the bottom of this lake is considerably silted up, and therefore close to being effectively sealed.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) :

SITE NUMBER .29. SITE NAME .LEYTHORNE LAKE..

LOCATION : 0385 8770

AREA :

EXCAVATION HISTORY : Excavated by steam dragline and material transported by conveyor to the central washing plant near the present Leisure Centre.

Dates/Company : Heavers

GEOLOGICAL FEATURES : Probably about 4.0-5.0m of gravel above 1.0m of lug sand and beneath 1.0m of peaty topsoil. Relevent geological information may be extrapolated from the surveys made of the western portions of Brick Kiln Farm.

Thickness of Gravel/Overburden : 4.0-5.0m of gravel beneath 1.0m of peaty topsoil.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :
Transmissivity/Storativity :

FILLING HISTORY AND AFTER-USE : The site is currently an open lake used for recreational purposes.

MATERIAL USED : This lake is probably partly silted up and therefore moderately well sealed.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) :

SITE NUMBER .30. SITE NAME .PECKHAM LAKE..

LOCATION : 0365 8780

AREA :

EXCAVATION HISTORY : Excavated by steam dragline with material being transported by conveyor to a plant near to the present site of the Leisure Centre.

Dates/Company : Heavers

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : The gravels were excavated down to a basal lug sand. Approx. 5.0 m of gravel overlies 1.0m of lug sand, and is overlain by 1.0m of peaty topsoil.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :
Transmissivity/Storativity :

FILLING HISTORY AND AFTER-USE : The site is currently an open lake used for recreational purposes.

MATERIAL USED : Silting up of this lake will have partially sealed the site.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) :

SITE NUMBER .31. SITE NAME .SOUTHERN LEISURE CENTRE

LOCATION : 0350 8750

AREA :

EXCAVATION HISTORY : Excavated by steam dragline with a washing plant where the presnt Leisure Centre is located.

Dates/Company : Heavers

GEOLOGICAL FEATURES : The gravels were 4.0-5.0 m thick at the northern boundary of the site decreasing to about 3.0m at the southern boundary. The gravels overlay 1.0m of lug sand and were overlain by about 1.0 m of peaty topsoil.

Thickness of Gravel/Overburden : 3.0- 5.0m from south to north, with 1.0m of peaty topsoil.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :
Transmissivity/Storativity :

FILLING HISTORY AND AFTER-USE

MATERIAL USED : The site is filled with silt/clay from the central washing facilities that were located near to the present site of the Leisure Centre.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) : Fill material is probably in the order of 5.0-6.0m, bringing the site back to the surrounding ground level.

SITE NUMBER .32..　　　　SITE NAME .IVY LAKE...

LOCATION : 0340 8730

AREA :

EXCAVATION HISTORY : Excavated by steam dragline and material transported by conveyor to a central washing plant located close to where the present Leisure Centre is located.

Dates/Company : Heavers

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : Varying from approx. 3.0m in the south to 4.0-5.0m in the north, above about 1.0m of lug sand and beneath 1.0m of peaty topsoil.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow :
Transmissivity/Storativity :

FILLING HISTORY AND AFTER-USE Currently an open lake used for recreational purposes.

MATERIAL USED : Silting up has probably partially sealed this site.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) :

SITE NUMBER .33. SITE NAME .VINNETROW LAKE...

LOCATION : 0350 8790

AREA :

EXCAVATION HISTORY : Excavated by steam dragline and material transported to a central plant located approx. where the present Leisure Centre site.

Dates/Company : Heavers

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : Some indication of origanal thickness of gravel is available from borehole SU80/101. In this hole 2.65m of gravel was logged beneath 0.6m of soil and gravel, and above 3.57m of sandy clay (lug sand) before 'hard rock formation' was hit at a depth of 6.85m.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow : Some groundwater level data is available over an approx one year period from a well at Vinnetrow Farm.
Transmissivity/Storativity :

FILLING HISTORY AND AFTER-USE : This site is currently an open lake used for recreational purposes.

MATERIAL USED : Silting has probably partially sealed this site.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) :

SITE NUMBER .34.. SITE NAME .RUNCTON LAKE...

LOCATION : 0310 8780

AREA :

EXCAVATION HISTORY : Excavated by steam dragline

Dates/Company : Heavers

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : Gravel probably around 3.0 m thick, overlain by up to 1.0 m of soil and underlain by lug sand. The lug sand may be up to 2.0-3.0 m thick.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow : Groundwater levels are available for a period 1970-71 from a well at Vinnetrow Farm. Flow in this and other lakes around the Southern Leisure Centre is controlled by a system of levee gates.
Transmissivity/Storativity :

FILLING HISTORY AND AFTER-USE : This site is currently open water used for recreational purposes.

MATERIAL USED : Silting has probably partially sealed this site.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) :
1

SITE NUMBER .35.   SITE NAME .NEW LAKE...

LOCATION 0290 8780

AREA :

EXCAVATION HISTORY :Excavated by steam dragline and material transported to the central washing facilities by conveyor.

Dates/Company : Heavers

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : The southern (?and eastern) boundaries of this lake are defined by the 2.0m gravel thickness cutoff line. It is probable that the thickness of the gravel would have increased to something in the order of 2.5-3.0m to the northern boundary of this lake.
The gravel was underlain by a 2.5-3.5m thick layer of lug sand.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow : Groundwater levels were recorded over an approx one year period 1970-71 from a well on the 'Many Wells' property, north of Stoney Meadow Farm.
Transmissivity/Storativity :

FILLING HISTORY AND AFTER-USE : This site is currently open water used for recreational purposes.

MATERIAL USED : Silting has probably partially sealed this site.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) :

SITE NUMBER .36.   SITE NAME .COPSE LAKE...

LOCATION : 0300 8750

AREA :

EXCAVATION HISTORY : Excavated by steam dragline and material transported by conveyor to the central washing facilities.

Dates/Company : Heavers

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : Gravel was probably in the order of about 2.5m thick with a 2.5-3.5m layer of lug sand beneath, and 1.0m of marly topsoil above.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow : Groundwater level data is available for the period 1970-71 from awell located within the 'Many Well' property to the east of Copse Lake

Transmissivity/Storativity :

FILLING HISTORY AND AFTER-USE : The site is currently open water used for recreational purposes.

MATERIAL USED : Silting has probably partially sealed this lake.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) :

SITE NUMBER .37. SITE NAME .EAST TROUT LAKE..

LOCATION : 0385 8740

AREA :

EXCAVATION HISTORY : Excavated by dragline and material transported by conveyor to the central washing plant.

Dates/Company : Heavers

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : The southern boundary to this area was defined by the 2.0m gravel thickness cutoff that limited economic mining limits. Overburden was probably in the order of 1.0-1.5m of marly topsoil, and 2.0-3.0m of lug sand underlay the gravels.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow : Groundwater level data is available for the period 1970-71 from a well on the 'Many Wells' property to the east of East Trout Lake.
Transmissivity/Storativity :

FILLING HISTORY AND AFTER-USE : The site is currently open lake used for recreational purposes.

MATERIAL USED : Silting has probably partially sealed this site.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) :

SITE NUMBER .38. SITE NAME .WEST TROUT LAKE..

LOCATION : 2900 8710

AREA :

EXCAVATION HISTORY : Excavated by dragline and material transported by conveyor to the central washing site.

Dates/Company : Heavers

GEOLOGICAL FEATURES :

Thickness of Gravel/Overburden : The southern and western boundaries to this lake were defined by the 2.0m gravel thickness cutoff the marked the limit of economic mining.It is probable that these gravels were overlain by 1.0m of marly topsoil, and underlain by 2.0-3.0m of lug sand.

HYDROGEOLOGICAL INFORMATION :

Groundwater levels/flow : The flow in this and other lakes surrounding the Southern Leisure Centre is controlled by a system of levee barrier gates.
Transmissivity/Storativity :

FILLING HISTORY AND AFTER-USE : The site is currenly open water used for recreational purposes.

MATERIAL USED : Silting has probably partially sealed this site.

SEQUENCE OF FILLING :

THICKNESS OF FILL(S) :

Appendix B

Summary of Borehole Information

BOREHOLE NUMBER	DATE DRILLED	CLIENT	LOCATION NAME	UTM NORTHING	CO-ORD EASTING	O.D. (m)
80 NW134	SEPT 81	IGS	W.BROYLE HSE	8453	0707	+26.3
80 NW135	OCT 81	IGS	SALTHILL LDG	8451	0529	+10.0
80 NE 36	SEPT 81	IGS	WHITEHOUSE	8515	0607	+29.3
80 NE 37	SEPT 81	IGS	EASTLAVANT	8694	0801	+32.2
80 NE 39	SEPT 81	IGS	GOODWOOD	8781	0757	+30.4
80 NE 40	SEPT 81	IGS	OLDPLACE	8742	0661	+22.6
80 NE 41	SEPT 81	IGS	WESTERTON	8852	0770	+30.4
80 NE 42	SEPT 81	IGS	MAUDLIN	8865	0678	+24.7
80 NE 44	SEPT 81	IGS	TEMPLEBAR	8990	0820	+39.8
80 NE 45	SEPT 81	IGS	COPSEFARM	8969	0567	+14.0
90 NW 57	SEPT 81	IGS	BOXGROVE	9035	0747	+28.4
90 NW 58	SEPT 81	IGS	TANGMERE	9021	0654	+18.9
90 NW 61	AUG 81	IGS	OUNCES BARN	9169	0739	+28.5
90 NW 62	AUG 81	IGS	EASTHAMPNETT	9152	0673	+18.1
90 NW 63	NOV 81	IGS	TANGMERE A/F	9188	0616	+12.7
90 NW 64	AUG 81	IGS	HAMCOTTAGE	9141	0548	+10.3
90 NW 65	NOV 81	IGS	TANGAIREAST	9188	0564	+ 9.9
80 SE 42	SEPT 81	IGS	SELSEY ROAD	8553	0294	+ 6.1
80 SE 46	SEPT 81	IGS	WATERY LANE	8627	0323	+ 7.7
80 SE 49	SEPT 81	IGS	HUNSTON	8703	0235	+ 6.4
80 SE 52	SEPT 81	IGS	BRICKKILN	8823	0404	+11.4
80 SE 53	SEPT 81	IGS	KIVESFARM	8870	0356	+ 8.8
80 SE 54	SEPT 81	IGS	RUNCTON	8828	0266	+ 6.3
80 SE 57	AUG 81	IGS	HIGHGROUND	8925	0458	+11.8
80 SE 58	SEPT 81	IGS	ABLELANDS	8975	0341	+ 8.7
80 SE 59	SEPT 81	IGS	MERSTON	8965	0238	+ 5.0
80 SW 93	SEPT 81	IGS	APPLEDRAM	8456	0360	+ 4.3
90 SW 35	AUG 81	IGS	OVING	9023	0479	+ 9.8
90 SW 36	AUG 81	IGS	COLWORTH	9064	0338	+ 8.3
90 SW 37	AUG 81	IGS	SWCOLSWORTH	9084	0257	+ 5.7
90 SW 40	AUG 81	IGS	HORNWOOD	9111	0454	+11.7
90 SW 41	SEPT 81	IGS	WOODEND	9144	0314	+ 6.7
90 SW 42	SEPT 81	IGS	MANOR FARM	9172	0278	+ 6.7
90 NW 59	AUG 81	IGS	HAM COTTAGE	9073	0517	+11.4
WPP 1	APR 76	HOLST	CHALKFARM	8780	0562	+16.6
WPP 2				8775	0592	+15.16
WPP 3				8801	0598	+14.49
WPP 4				8832	0621	+19.2
WPP 5				8837	0604	+14.88
BH 1	APR 77	SWA	PILOTPLANT	8805	0594	
BH 2				8802	0586	
BH 3				8797	0585	
BH 4				8795	0590	
BH 5				8795	0596	
BH 6				8800	0590	
BPBH 1	DEC 86	THYSSEN	BY-PASS	8755	0556	+17.34
BPBH 2				8762	0552	+16.73
BPBH 3				8780	0547	+17.21
BPBH 4				8813	0560	+13.49
BPBH 5				8867	0588	+16.16
BPBH 6				8902	0616	+16.09
BPBH 7				8930	0653	+18.19

BOREHOLE NUMBER	THICKNESS HEAD	THICKNESS VALLEY	THICKNESS RBD(Y)	THICKNESS RBD(O)	THICKNESS RSBD	THICKNESS FAN
80 NW134	1.9					
80 NW135	1.8					
80 NE 36	3.8			1.5		
80 NE 37	3.8					
80 NE 39	2.2					
80 NE 40	1.9					
80 NE 41	3.6					
80 NE 42	2.1				2	
80 NE 44					2	
80 NE 45	4.3					
90 NW 57	1.8					
90 NW 58	7.3					
90 NW 61	2.3					
90 NW 62	1.9					
90 NW 63	1.7		3.8			
90 NW 64	1.9		1.9			
90 NW 65	2.2		1.9			
80 SE 42						1.8
80 SE 46			1.8			2
80 SE 49						2.4
80 SE 52			1.6			3
80 SE 53			0.1			3.1
80 SE 54						2
80 SE 57			0.5			2.9
80 SE 58						2.7
80 SE 59						
80 SW 93						1
90 SW 35			2.3			1.8
90 SW 36			1.5			
90 SW 37						
90 SW 40			2.8			
90 SW 41			3.3			
90 SW 42			2.8			
90 NW 59	0.3		2.7			
WPP 1						
WPP 2						
WPP 3						
WPP 4						
WPP 5						
BH 1						
BH 2						
BH 3						
BH 4						
BH 5						
BH 6						
BPBH 1						
BPBH 2	1.5	?1.2				
BPBH 3						
BPBH 4	>2.7	?1.2				
BPBH 5						
BPBH 6						
BPBH 7						

BOREHOLE NUMBER	DEPTH (m)	OD BASE GRAVELS	THICKNESS GRAVELS	WATER STRUCK	RWL SUMMER	RWL WINTER
80 NW134	4	24.1	1.9	N.S.		
80 NW135	5	7.7	1.8	+9.4		
80 NE 36	6.7	23.8	5.3	+26.3		
80 NE 37	5.2	28.2	3.8	N.S.		
80 NE 39	7.9	23.8	2.2	N.S.		
80 NE 40	10.9	16.5	1.9	+17.6		
80 NE 41	6	26.4	3.6	N.S.		
80 NE 42	9.5	19.3	2.0	+16.7		
80 NE 44	7.2	33.5	2	N.S.		
80 NE 45	6	9	4.3	N.S.		
90 NW 57	4	26.3	1.8	N.I.		
90 NW 58	9	10.8	7.3	+12.5		
90 NW 61	4.2	26.1	2.3	N.S.		
90 NW 62	4.5	16.2	1.9	N.S.		
90 NW 63	26.6	5.2	5.5	+8.7		
90 NW 64	5.2	6	3.8	+7.9		
90 NW 65	22.3	5.2	4.1	+7.6		
80 SE 42	4	2.8	1.8	+3.9		
80 SE 46	5	3.6	3.8	+6.7		
80 SE 49	4	3.6	2.4	+5.0		
80 SE 52	6.4	5.6	4.6	+9.4		
80 SE 53	5	4.3	3.1	+7.4		
80 SE 54	4	4.3	2	+6.3		
80 SE 57	7.2	5.5	3.4	+9.1		
80 SE 58	4.6	4.7	2.7	+6.4		
80 SE 59	4.3	1	0	+2.0		
80 SW 93	3.9	1.3	1	+1.3		
90 SW 35	6.4	4.4	4.1	+8.0		
90 SW 36	3.9	5.5	1.5	+6.0		
90 SW 37	5.9	0.6	0	N.S.		
90 SW 40	5.8	6.9	2.8	+8.7		
90 SW 41	5.6	1.4	0	N.S.		
90 SW 42	5.6	-0.4	2.8	N.S.		
90 NW 59	5.8	6.1	3	+8.6		
WPP 1	15.3	6.8	9.8	+11.0		
WPP 2	15.4	7.26	7.8	+10.96		
WPP 3	15.3	6.69	7.8	+10.89		
WPP 4	17.1	10.3	8.9	+11.1		
WPP 5	15.1	7.18	7.7	+10.68		
BH 1						
BH 2						
BH 3						
BH 4						
BH 5						
BH 6						
BPBH 1	30	9.44	<7.9	+14.89		
BPBH 2	30	5.63	<10.4	+ 4.53		
BPBH 3	5	<12.21	>5.0	+14.66		
BPBH 4	10	<3.49	>10.0			
BPBH 5	10	<10.0	>10.0	+13.36		
BPBH 6	10.9	4.69	10.4	+13.79		
BPBH 7	10	14.3	3.9	+14.34		

BOREHOLE NUMBER	DIAM (mm)	TYPE	PUMPING TESTS	GRADING	WTD MEAN PERME-ABILITY	T
80 NW134		S & A	N	Y		60
80 NW135		S & A	N	Y		32
80 NE 36		S & A	N	Y		159
80 NE 37		S & A	N	Y		260
80 NE 39		S & A	N	Y		92
80 NE 40		S & A	N	Y		75
80 NE 41		S & A	N	Y		
80 NE 42		S & A	N	Y		24
80 NE 44		S & A	N	Y		32
80 NE 45		S & A	N	Y		44
90 NW 57		S & A	N	Y		15
90 NW 58		S & A	N	Y		33
90 NW 61		S & A	N	Y		
90 NW 62		S & A	N	Y		
90 NW 63		S & A	N	Y		
90 NW 64		S & A	N	Y		15
90 NW 65		S & A	N	Y		
80 SE 42		S & A	N	Y		84
80 SE 46		S & A	N	Y		122
80 SE 49		S & A	N	Y		64
80 SE 52		S & A	N	Y		588
80 SE 53		S & A	N	Y		1145
80 SE 54		S & A	N	Y		37
80 SE 57		S & A	N	Y		396
80 SE 58		S & A	N	Y		214
80 SE 59		S & A	N	Y		
80 SW 93		S & A	N	Y		
90 SW 35		S & A	N	Y		258
90 SW 36		S & A	N	Y		7
90 SW 37		S & A	N	Y		
90 SW 40		S & A	N	Y		14
90 SW 41		S & A	N	Y		
90 SW 42		S & A	N	Y		
90 NW 59		S & A	N	Y		16
WPP 1	204	PERCUSSION		Y		
WPP 2				Y		
WPP 3				Y		
WPP 4				Y		
WPP 5				Y		
BH 1						
BH 2						
BH 3						
BH 4						
BH 5						
BH 6						
BPBH 1		S & A				
BPBH 2						
BPBH 3						
BPBH 4						
BPBH 5						
BPBH 6						
BPBH 7						

BOREHOLE NUMBER	DATE DRILLED	CLIENT	LOCATION NAME	UTM NORTHING	CO-ORD EASTING	O.D. (m)
BPBH 8	DEC 86	THYSSEN	BY-PASS	8956	0672	+24.09
BPBH 9				8980	0681	+23.69
BPBH 10				8953	0677	+24.42
BHW 1				8791	0555	+ 9.08
BHW 2				8807	0563	+ 9.89
BHW 3				8823	0571	+ 8.77
BHW 4				8838	0578	+ 8.49
WCR 1	OCT 89	TARMAC	WEST	8943	0571	+15.9
WCR 2			COACHRD	8947	0562	+15.5
WCR 3				8951	0553	+15.1
WCR 4				8945	0556	+15.2
WCR 5				8941	0565	+15.6
SU80/04A	AUG 1939	BGS	MEAT FACTORY	8634	0487	14.93
SU80/04B	FEB 1947		MEAT FACTORY			14.93
SU80/04C	MAR 1973		MEAT FACTORY			14.93
SU80/05A	1902		HENTY BREWER	8587	0494	10.36
SU80/05B	1927		HENTY BREWERY			10.36
SU80/05C	OCT 1939		HENTY BREWERY			10.36
SU80/13	1936		LEYTHORN NUR	8820	0303	7.47
SU80/52	DEC 1938		MERSTON MANO	8951	0283	7.01
SU80/53	NOV 1935		MERSTON VICA	8942	0303	7.01
SU80/54	1892		MERSTON	8920	0398	9.14
SU80/55	MAY 1934		WALNUT TREE	8813	0248	7.62
SU80/63	1934		WEST ST DAIR	8575	0483	12.2
SU80/64	1844		FIELDS GARAGE			12.2
SU80/65	MAR 1944		GASWORKS	8597	0423	11
SU80/66			WEST GATE	8527	0473	9
SU80/67			GATEWAY CROSSING			4.6
SU80/68	1898		W. BROYLE FM	8512	0555	14.6
SU80/69	1905		NORTHLANDS			30.5
SU80/89	1909		LAVANT HSE			40
SU80/90			POOK LANE			29
SU80/91	1909		E. OF MARCH			36
SU80/92C	1893	BGS	GRAYLINGWELL	8674	0638	+28.0
SU80/92D	1893			8676	0588	+22.0
SU80/93	1939		CHI. LAUNDRY	8609	0543	14.5
SU80/94	1936		E. BROYLE FM	8554	0615	25.9
SU80/95	OCT 1941		WESTHAMILL	8768	0602	+20.0
SU80/97	1920		SAW MILLS	8838	0623	+20.0
SU80/98	PRE-1941		MAUDLIN	8870	0656	+25.2
SU80/99	1933		STRETTINGTON	8933	0746	29
SU80/101	JAN 1977		VINITROW	8796	0350	8.53
SU80/104			No2 VINITROW	8805	0347	8.53
SU80/105	?APR 1977		STRETTINGTON	8950	0685	24.7
SU80/106	APR 1977		COPSE FARM	8970	0579	14.5
SU80/111	MAR 1980		BRICK KILN F	8822	0394	5.95
SU80/113			E. ASHLING	8200	0700	26.8
SU80/114			LAVANT DOWN	8537	0938	34.24
SU80/115			BR LAVANT	8571	0863	31.06
SU80/116			MARSH LANE	8580	0898	31.14
SU80/118	OCT 1985		VALDOE WOOD	8794	0814	36
SU90/21	1954	BGS	BOXGROVE			36.81

BOREHOLE NUMBER	THICKNESS HEAD GRAV	THICKNESS VALLEY	THICKNESS RBD(Y)	THICKNESS RBD(O)	THICKNESS RSBD	THICKNESS FAN GRAV
BPBH 8						
BPBH 9						
BPBH 10						
BHW 1						
BHW 2	1	0.3				
BHW 3	0.3	0.7				
BHW 4	0.4	1.9				
WCR 1						
WCR 2						
WCR 3						
WCR 4						
WCR 5						
SU80/04A			2.13			
SU80/04B			6.55			
SU80/04C			6.55			
SU80/05A			4.6			
SU80/05B			4.27			
SU80/05C			4.11			
SU80/13			2.29			
SU80/52			3.35			
SU80/53			2.44			
SU80/54	0.46	0.61	2.74			
SU80/55			3.05			
SU80/63						
SU80/64	0.15		5.03			
SU80/65						
SU80/66	1.52		2.43			
SU80/67			1.37			
SU80/68						
SU80/69						
SU80/89			4			
SU80/90						
SU80/91			4.9			
SU80/92C						
SU80/92D						
SU80/93	1.68		5.33			
SU80/94						
SU80/95						
SU80/97						
SU80/98						
SU80/99						
SU80/101	3.6		2.6			
SU80/104						
SU80/105	0.4	2.65	1.9			
SU80/106	1.96	0.3	2.58			
SU80/111	1.22					
SU80/113						
SU80/114						
SU80/115						
SU80/116						
SU80/118						
SU90/21			6.58			

BOREHOLE NUMBER	DEPTH (m)	OD BASE GRAVELS	THICKNESS GRAVELS	WATER STRUCK	RWL SUMMER	RWL WINTER
BPBH 8	20	20.99	2.5	+23.34		
BPBH 9	10	21.29	0.6	+23.09		
BPBH 10	25	20.02	4	+19.49		
BHW 1	15	5.9	>3.2			
BHW 2	15	5.9	>2.7			
BHW 3	15	5.8	>3.0			
BHW 4	15	6	>2.5			
WCR 1		11.6	4			
WCR 2		12	2.5			
WCR 3		10.6	3.6			
WCR 4		9.2	5.1			
WCR 5		8.6	6.1			
SU80/04A	115.8	6.1	>2.13			
SU80/04B	173.7	5.9	6.55			
SU80/04C	173.7	5.9	6.55			
SU80/05A	112.5	5.76	4.6			
SU80/05B	115.8	6.09	4.27			
SU80/05C	121.9	6.25	4.11			
SU80/13	71.3	3.96	2.29			
SU80/52	45.7	3.66	3.35			
SU80/53	55.8	4.57	2.44			
SU80/54	198	5.03	3.81			
SU80/55	30.5	4.57	3.05			
SU80/63	61					
SU80/64	321	5.19	5.2			
SU80/65		<6.12	>4.88			
SU80/66	14	2.6?	6.4			
SU80/67	39.6	2.7	1.37			
SU80/68	87.8					
SU80/69	91.4					
SU80/89	19.8	36	4	29		
SU80/90				26.5	26.5	27.5
SU80/91	29.9	31	4.9	9		
SU80/92C	40	23	5			
SU80/92D						
SU80/93	160.6	6	7		8.1	
SU80/94	76.2	19.8	6.1		7.9	
SU80/95	83			+16.7	13	
SU80/97	50	13.7	5.6	+17.7	17.4	
SU80/98	50	20.2	5		14.6	
SU80/99	31				15.2	
SU80/101	112.8	1.7	6.2		14	
SU80/104	2.78				6.96	
SU80/105	88.5	19.2	5.3	19.2	22.2	
SU80/106	91.4	9.7	4.8		>14.5	
SU80/111	11	5.51				9
SU80/113						18.4
SU80/114	3.7				<30.54	33.4
SU80/115	5.5				29	30.5
SU80/116	5.3				29	30.4
SU80/118	150	30			15.82	
SU90/21	91.44	30.23	6.58			

BOREHOLE NUMBER	DIAM (mm)	TYPE	PUMPING TESTS	GRADING	WTD MEAN PERME-ABILITY	T
BPBH 8						
BPBH 9						
BPBH 10						
BHW 1						
BHW 2						
BHW 3						
BHW 4						
WCR 1		FLIGHTAUG				
WCR 2						
WCR 3						
WCR 4						
WCR 5						
SU80/04A	200					
SU80/04B	254					
SU80/04C	381					
SU80/05A	254					
SU80/05B	405					
SU80/05C	305					
SU80/13						
SU80/52	114					
SU80/53	76					
SU80/54						
SU80/55	76					
SU80/63						
SU80/64						
SU80/65		WELL				
SU80/66						
SU80/67						
SU80/68	50					
SU80/69						
SU80/89						
SU80/90						
SU80/91						
SU80/92C						
SU80/92D						
SU80/93	356					
SU80/94	400					
SU80/95	125					
SU80/97	125					
SU80/98						
SU80/99	127					
SU80/101	254					
SU80/104	686	WELL				
SU80/105	253					
SU80/106	254					
SU80/111	300					
SU80/113		WELL				
SU80/114	<1000	WELL				
SU80/115		WELL				
SU80/116		WELL				
SU80/118	300					
SU90/21	610					

BOREHOLE NUMBER	DATE DRILLED	CLIENT	LOCATION NAME	UTM NORTHING	CO-ORD EASTING	O.D. (m)
WT1/81	MAY 81	TARMAC	EAST	8876	0581	+15.2
WT2/81			COACHRD	8880	0571	+14.9
WT3/81				8898	0581	+14.6
WT4/81				8893	0592	+14.9
WT5/81				8884	0587	+14.7
WT6/81				8890	0576	+14.0
WT7/81				8862	0575	+16.1
WT8/81				8866	0565	+16.1
FGG 1	AUG 1983	FGG	DAIRYLANE	8853	0605	+17.8
FGG 2			INFILL	8877	0602	+16.7
FGG 3				8842	0613	+17.5
FGG 4				8851	0590	+17.0
FGG 5				8870	0626	+17.9
FGG 6				8864	0616	+17.8
NRA 1/S	1980	NRA	SHEEPWASH	9212	0575	
NRA 1/D			COTTAGES	9210	0570	
NRA 2/S			TANGMERE RD	9007	0577	
NRA 2/D				9000	0570	
NRA 3/S			CHURCH LANE	9430	0525	
NRA 3/D			EASTERGATE	9430	0530	
1970/1	1969/70	WS WATER	WESTAHAMPNET	8753	0586	
1970/2				8768	0586	
1970/3				8787	0563	
BULLS 1		BULLS	SHOPWYKE	8830	0480	
BULLS 2			SOUTH-WEST	8840	0467	
BULLS 3				8825	0442	
BULLS 4				8802	0440	
BULLS 5				8798	0476	
BULLS 6				8787	0462	
GW 42	DEC 66	HALL &	NORTH	8811	0667	25
GW 46		HAM	WESTHAMPNETT	8867	0656	25.25
GW 99				8813	0678	25.5
GW 100				8815	0666	25
GW 101				8837	0643	23
GW 102				8841	0638	21.5
GW 103				8828	0643	25
GW 104				8828	0669	25.75
GW 105				8838	0689	26
GW 106				8855	0661	25.5
GW 107				8878	0674	25
GW A1				8819	0656	25
GW B1				8834	0661	25.75
GW C1				8842	0674	26
GW D1				8865	0670	25.5
GW E1				8852	0649	25.5

BOREHOLE NUMBER	THICKNESS HEAD	THICKNESS VALLEY	THICKNESS RBD(Y)	THICKNESS RBD(O)	THICKNESS RSBD	THICKNESS FAN
WT1/81						
WT2/81						
WT3/81						
WT4/81						
WT5/81						
WT6/81						
WT7/81						
WT8/81						
FGG 1	1.1	0.6	<7.6			
FGG 2						
FGG 3	>0.5	0.8	<7.2			
FGG 4	>1.4	>0.3	<6.8			
FGG 5						
FGG 6						
NRA 1/S						
NRA 1/D						
NRA 2/S						
NRA 2/D						
NRA 3/S						
NRA 3/D						
1970/1						
1970/2						
1970/3						
BULLS 1						
BULLS 2						
BULLS 3						
BULLS 4						
BULLS 5						
BULLS 6						
GW 42				1.52	2.44	
GW 46				0.61	3.66	
GW 99					2.13	
GW 100					1.52	
GW 101					1.52	
GW 102					2.13	
GW 103					4.57	
GW 104						
GW 105						
GW 106				0.61	4.27	
GW 107				1.22	1.22	
GW A1					1.22	
GW B1				0.61	2.74	
GW C1					1.83	
GW D1				1.07	3.05	
GW E1					3.81	

BOREHOLE NUMBER	DEPTH (m)	OD BASE GRAVELS	THICKNESS GRAVELS	WATER STRUCK	RWL SUMMER	RWL WINTER
WT1/81		5	8.2			
WT2/81		5.6	6.3			
WT3/81		6.6	2			
WT4/81		11.6	2			
WT5/81		8.7	5			
WT6/81		7.5	6			
WT7/81		7.5	7.5			
WT8/81		6.1	8.5			
FGG 1	10	8.5	9.3	+14.3		
FGG 2	8.5	10.2	6.5	+14.1		
FGG 3	8.5	<9.0	8.5	+17.3		
FGG 4	8.5	<8.5	8.5	+14.5		
FGG 5	7	13.1	4.8	+16.9		
FGG 6	5	<12.8	5	+15.5		
NRA 1/S	7					
NRA 1/D	68					
NRA 2/S	5					
NRA 2/D	79					
NRA 3/S	3.5					
NRA 3/D	100					
1970/1						
1970/2						
1970/3						
BULLS 1						
BULLS 2						
BULLS 3						
BULLS 4						
BULLS 5						
BULLS 6						
GW 42	5.49	20.1	2.44	N.S.		
GW 46	4.88	<20.6	3.66		21.6	
GW 99	4.88	21.84	2.13	N.S.		
GW 100	3.66	22.56	1.52	N.S.		
GW 101	3.66	21.48	1.52		21.5	
GW 102	4.27	19.4	2.13	N.S.		
GW 103	6.1	19.51	4.57		20.1	
GW 104	3.66	<22.09	0	N.S.		
GW 105	3.66	<22.34	0	N.S.		
GW 106	5.18	20	4.27		20.6	
GW 107	3.66	<21.34	1.22	N.S.		
GW A1	3.35	22.26	1.22		22.3	
GW B1	4.5	<21.25	3.35		21.8	
GW C1	2.29	23.99	0.3		24	
GW D1	4.57	21.23	3.96		21.5	
GW E1	3.96	<21.54	3.81		21.5	

BOREHOLE NUMBER	DIAM (mm)	TYPE	PUMPING TESTS	GRADING	WTD MEAN PERME-	T
WT1/81						
WT2/81						
WT3/81						
WT4/81						
WT5/81						
WT6/81						
WT7/81						
WT8/81						
FGG 1	150	S & A				
FGG 2	150					
FGG 3	150					
FGG 4	150					
FGG 5	150					
FGG 6	150					
NRA 1/S						
NRA 1/D						
NRA 2/S						
NRA 2/D						
NRA 3/S						
NRA 3/D						
1970/1						
1970/2						
1970/3						
BULLS 1	150		N	N		
BULLS 2	150		N	N		
BULLS 3	150		N	N		
BULLS 4	150		N	N		
BULLS 5	150		N	N		
BULLS 6	150		N	N		
GW 42	200	AUGER	N	N		
GW 46	200	AUGER	N	N		
GW 99	200	AUGER	N	N		
GW 100	200	AUGER	N	N		
GW 101	200	AUGER	N	N		
GW 102	200	AUGER	N	N		
GW 103	200	AUGER	N	N		
GW 104	200	AUGER	N	N		
GW 105	200	AUGER	N	N		
GW 106	200	AUGER	N	N		
GW 107	200	AUGER	N	N		
GW A1	200	PIT	N	N		
GW B1	200	PIT	N	N		
GW C1	200	PIT	N	N		
GW D1	200	PIT	N	N		
GW E1	200	PIT	N	N		

BOREHOLE NUMBER	DATE DRILLED	CLIENT	LOCATION NAME	UTM NORTHING	CO-ORD EASTING	O.D. (m)
CF A1	MAR 1959	RMC	CHURCH FARM			17.4
CF A3	MAR 1959		E. COACH RD			17.9
CF A5	OCT 1960					18.2
CF B1	OCT 1960					17.5
CF B2	OCT 1960					18.6
CF B4	OCT 1960					17.7
CF C1	MAR 1959					17.4
CF C2	MAR 1959					17.3
CF C3	MAR 1959					17.4
CF C4	MAR 1959					17
CF C5	OCT 1960					16
CF D1	MAR 1959					17.5
CF D2	OCT 1960					17.7
CF D3	MAR 1959					17
CF D4	MAR 1959					16.2
CF E1	OCT 1960					15.5
GE 1	03.05.85	WATERMAN	WESTHAMPNETT			15.5
GE 2	07.05.85					15.5
BKF 1	25.04.68	WSCC	BRICK	8783	0402	10.75
BKF 2	25.04.68		KILN	8830	0380	10.75
BKF 3	25.04.68		FARM	8825	0401	11.25
BKF 4	25.04.68			8820	0390	11
BKF 5	26.04.68			8813	0354	10
BKF 6	26.04.68			8801	0375	9.6
BKF 7	26.04.68			8860	0400	10.8
BKF 8	26.04.68			8842	0354	10
BKF 9	29.04.68			8870	0379	10
BKF 10	29.04.68			8863	0347	9.8
OR 1	1960's?		OVING	8858	0514	14.9
OR 2			ROAD	8820	0503	14.74
OR 3				8782	0494	14.4
WSCC 1	1989	WSCC	WESTHAMPNETT	8834	0610	17.8
WSCC 2	1989		LANDFILL	8837	0614	17.4
WSCC 3	1989		SITE	8842	0617	17.3
WSCC 4	1989			8846	0619	17.6
WSCC 5	1989			8851	0621	18
WSCC 6	1989			8855	0623	18.5
WSCC 7	1989			8859	0625	19
WSCC 8	1989			8864	0626	19.3
WSCC 9	1989			8868	0628	19.3
WSCC 10	1989			8874	0630	19.5
WSCC 11	1989			8876	0626	18
WSCC 12				8878	0621	16.2
WSCC 13				8881	0616	16.2
WSCC 14				8883	0611	15.8
WSCC 15				8884	0605	15.8
WSCC 16	1989			8836	0600	17.2
WSCC 17	1989			8827	0609	17.8
WSCC 18	1989			8865	0587	16
T1	1989	TARMAC	PORTFIELD SITE	8804	0533	15.4

BOREHOLE NUMBER	THICKNESS HEAD	THICKNESS VALLEY	THICKNESS RBD(Y)	THICKNESS RBD(O)	THICKNESS RSBD	THICKNESS FAN
CF A1						
CF A3			1.83			0.91
CF A5						1.22
CF B1			4.57			1.22
CF B2						
CF B4			1.22			1.22
CF C1						6.86
CF C2			0.91			5.18
CF C3			1.22			3.05
CF C4			1.22			0.61
CF C5			0.61			2.13
CF D1						
CF D2						
CF D3						
CF D4			1.21			
CF E1			0.61			
GE 1						2
GE 2						>2.15
BKF 1						>2.29
BKF 2						>2.29
BKF 3						>1.98
BKF 4						>3.20
BKF 5						>1.98
BKF 6						>3.20
BKF 7						>2.51
BKF 8						>2.59
BKF 9						>2.74
BKF 10						>2.21
OR 1						
OR 2						
OR 3						
WSCC 1						
WSCC 2						
WSCC 3						
WSCC 4						
WSCC 5						
WSCC 6						
WSCC 7						
WSCC 8						
WSCC 9						
WSCC 10						
WSCC 11						
WSCC 12						
WSCC 13						
WSCC 14						
WSCC 15						
WSCC 16						
WSCC 17						
WSCC 18						
T1						

BOREHOLE NUMBER	DEPTH (m)	OD BASE GRAVELS	THICKNESS GRAVELS	WATER STRUCK	RWL SUMMER	RWL WINTER
CF A1	9.14	12.5	4.11			13.44
CF A3	4.57	14.2	0.91	N.S.		
CF A5	5.49	15.5	1.22	RUNNING		
CF B1	6.1	11.7	5.18		13.2	
CF B2	3.01	<15.0	>2.44			
CF B4	5.5	13.4	2.44		13.3	
CF C1	11.28	8.7	6.86			12.7
CF C2	8.23	9.7	6.1			13
CF C3	6.71	10.7	4.27			13.4
CF C4	4.57	12.7	1.82		13	
CF C5	5.2	<10.8	>2.74		12.3	
CF D1	9.45	9.14	7.31			12.62
CF D2	5.49	13.1	3.35		13.4	
CF D3	7.62	10	5.18			13
CF D4	5.49	11.9	1.21			
CF E1	5.49	11.2	0.61			11.5
GE 1	5	13.5	2		14.9	
GE 2	5	<10.5	>2.15		15.1	
BKF 1	3.96	<6.79	>2.29	7.7		
BKF 2	3.35	<7.40	>2.29	8.31		
BKF 3	3.2	<8.05	>1.98	8.96		
BKF 4	4.11	<6.89	>3.20	7.65		
BKF 5	3.96	<6.04	>1.98	6.95		
BKF 6	3.81	<5.79	>3.20	8.99		
BKF 7	2.74	<8.06	>2.51	9.43		
BKF 8	4.11	<5.89	>2.59	7.26		6.65
BKF 9	3.05	<6.95	>2.74	9.01		8.55
BKF 10	3.35	<6.45	>2.21	8.28		7.97
OR 1	7.31		6.4			
OR 2						
OR 3						
WSCC 1	5.9					16.67
WSCC 2	6.3					16.72
WSCC 3	6.4					16.85
WSCC 4	6.2					16.91
WSCC 5	6.1					16.83
WSCC 6	6.1					17.68
WSCC 7	5.4					17.65
WSCC 8	5.6					17.78
WSCC 9	5.7					17.75
WSCC 10	6.2					17.98
WSCC 11	6.7					16.42
WSCC 12						
WSCC 13						
WSCC 14						
WSCC 15						
WSCC 16	6.2					14.27
WSCC 17						
WSCC 18						
T1						

BOREHOLE NUMBER	DIAM (mm)	TYPE	PUMPING TESTS	GRADING	WTD MEAN PERME-ABILITY	T
CF A1						
CF A3						
CF A5						
CF B1						
CF B2						
CF B4						
CF C1						
CF C2						
CF C3						
CF C4						
CF C5						
CF D1						
CF D2						
CF D3						
CF D4						
CF E1						
GE 1	150	CABLE		Y		
GE 2	150	PERCUSSION		Y		
BKF 1		PIT		Y		
BKF 2		PIT		Y		
BKF 3		PIT		Y		
BKF 4		PIT		Y		
BKF 5		PIT		Y		
BKF 6		PIT		Y		
BKF 7		PIT		Y		
BKF 8		PIT		Y		
BKF 9		PIT		Y		
BKF 10		PIT		Y		
OR 1						
OR 2						
OR 3						
WSCC 1						
WSCC 2						
WSCC 3						
WSCC 4						
WSCC 5						
WSCC 6						
WSCC 7						
WSCC 8						
WSCC 9						
WSCC 10						
WSCC 11						
WSCC 12						
WSCC 13						
WSCC 14						
WSCC 15						
WSCC 16						
WSCC 17						
WSCC 18						
T1						

Appendix C

Monitoring Sites - Church Farm Pit

EXISTING MONITORING SITES

WESTHAMPNETT AREA

Gravel Boreholes:

1) Approx. 18 holes at WSCC Westhampnett Reclamation site

2) 3 holes planned by DOT along A27 east of Maudlin

3) 2 holes on Bookers site 87750595

4) 1 hole at NRA Portfield depot 87750510

5) 1 hole (12008) on Oving Road 90050580

Wells in Gravel:

1) Greylingwell 86700590

2) Tarmac Portfield Site 87970520

3) Shopwyke Manor Farm 88500545

4) Shopwyke 88700515

5) Tangmere Church Farm 90150615

6) East Maudlin Farm 89500650

Chalk Boreholes:

1) Greyingwell 86700640

2) Tarmac Portfield Site 88100530

3) NRA Oving Road (12009) 90050580

4) Temple Bar 89500685

Surface Flow:

1) Greylingwell 87150650

Surface Water Levels:

1) Church Farm Pit 87850575

PROPOSED ADDITIONAL MONITORING SITES

WESTHAMPNETT AREA

Boreholes:

No's 1-6	to determine the relationship between the Lavant and groundwater flow into Church Farm Pit.
No's 7 & 8 :	to aquifer geometry in and around Pound Farm Gravel pits
No's 9-13	to determine the geometry and aquifer characteristics on the Lavant Valley Gravels and their relation to the river cliff line, and to monitor groundwater levels.
No's 14-15	to determine the elevation of the Chalk/Reading Beds contact and monitor Chalk groundwater levels.
No's 16-19	to determine aquifer charcteristics and monito groundwater levels across the lower wave-cut cliff line.
No's 20-21	to monitor groundwater levels in and south of Sainsburys site, and provide additional data on Fan Gravel geometry and characteristics.
No's 22-23	to determine water level changes that may be associated with groundwater overflow from Church Farm Pit.
No's 24-29	to determine aquifer characteristics and monitor to assist in determining the impact of quarrying the East Coach Road site.

Surface Flow :

1) Mill Stream 87650600

2) Lower Lavant 87300540

3) Coach Road 88400610

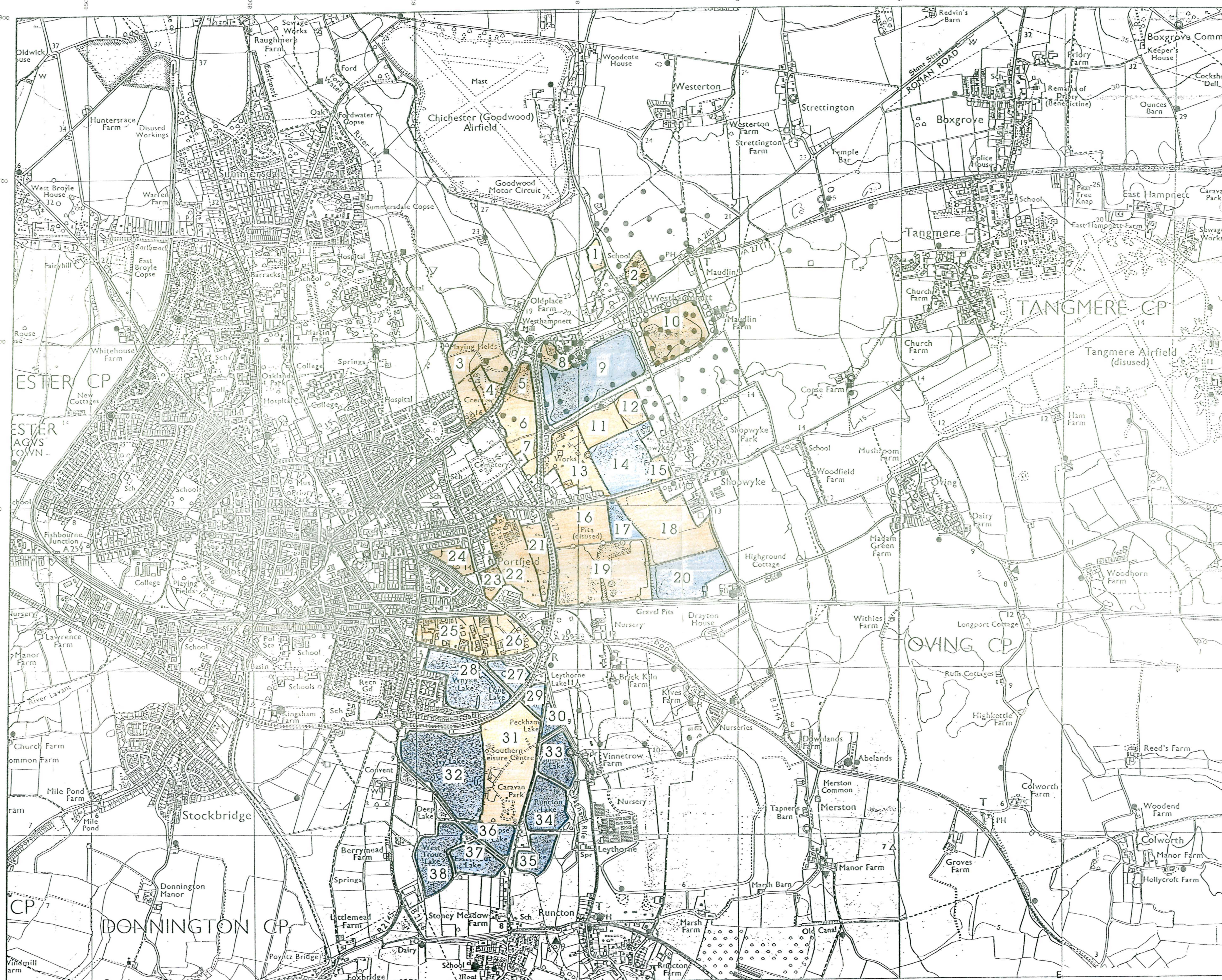
4) East Maudlin 89300665

Surface Water Levels :

1) Shopwyke North Pit 88300520

2) Maudlin Farm Pond 88950625

3) Cottage Pond 88200625



EAST CHICHESTER GROUNDWATER MODELLING STUDY

DATA STATIONS

	Open	Abandoned
Gravel Boreholes	○	●
Chalk Boreholes	◎	◉
Wells into Gravel	□	■
	Current	Abandoned
Surface Water Gauging Boards	▽	▼
Surface Flow Gauging Stations	▽	▼
Rainfall Gauging Stations	⬡	⬢
	Open	Filled
Pit Boundaries and Numbers	9	4

Basemap from Ordinance Survey Map SU 80/90

Scale 1:10,000

Institute of Hydrology July 1990

APPENDIX A FIGURE I