

SOUTHERN WATER AUTHORITY GENERAL REPORT ON RESERVOIR INVESTIGATIONS HAMPSHIRE 1975-78

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This Report summarises and correlates the results of two inter-related studies of potential reservoir sites, one group in the Test and Itchen Valleys and the other in the Portsmouth area of supply in East Hampshire, each of which has been the subject of individual engineering reports dated November 1976 and February 1978 respectively. It also examines in rather more detail possible reservoir developments at the preferred sites identified in the two individual reports and includes an additional section on the influence of hydrological considerations on the conclusions reached.

It comprises two parts. Part I summarises the studies as a whole, together with a summary of general conclusions with technical references; Part II provides more details of the preferred solutions, together with the section on hydrology.

The Report is presented in a single volume including the figures referred to in the text.

I.2.0 INTRODUCTION

I.2.1 Scope

In the early summer of 1975 the Southern Water Authority, as part of an overall review of potential water resources, appointed Mander, Raikes & Marshall to carry out site investigations and outline design studies and comparative estimates on 10 potential reservoir sites in the Test and Itchen Valleys, Hampshire. These sites had already been selected for further study from a larger number of sites identified in a preliminary report in 1965 by Herbert Lapworth Partners; and the selected sites had been reserved pending further study, so that one of the essential objectives of the study commissioned in 1975 was to identify, if possible, those sites which compared so unfavourably with the remainder that they could safely be eliminated and released for other use.

This work and the results of the study are described in a report entitled "Reservoir Site Investigation - Hampshire 1975/76 - Engineering Report" and dated November 1976.

It was subsequently decided that similar studies should be carried out on a further five potential reservoir sites in East Hampshire and the same Consultants were accordingly instructed to carry out this work also, with a view to producing an overall engineering report on both of these studies in such a way that, as other work carried out by the Authority on both demand and other potential resources came to fruition, it would be possible to draw upon this overall report of the Itchen, Test and East Hampshire sites in order to place them - and where necessary re-evaluate them in the light of other forthcoming information - within the broad context of the Authority's own overall review of its full resources and requirements.

This Report, therefore, is the overall Engineering Report on the two separate studies referred to in the preceding paragraphs, and it has to be borne in mind that the various possible reservoir development discussed herein - and possibly their apparent relative merits compared with each other - have yet to be seen in the full context of parallel studies being carried out by others; and that certain of the basic data on which these comparative studies partly rest are still subject to further review. As far as possible the significance of these data and their effect upon the conclusions and recommendations contained in this Report, are indicated.

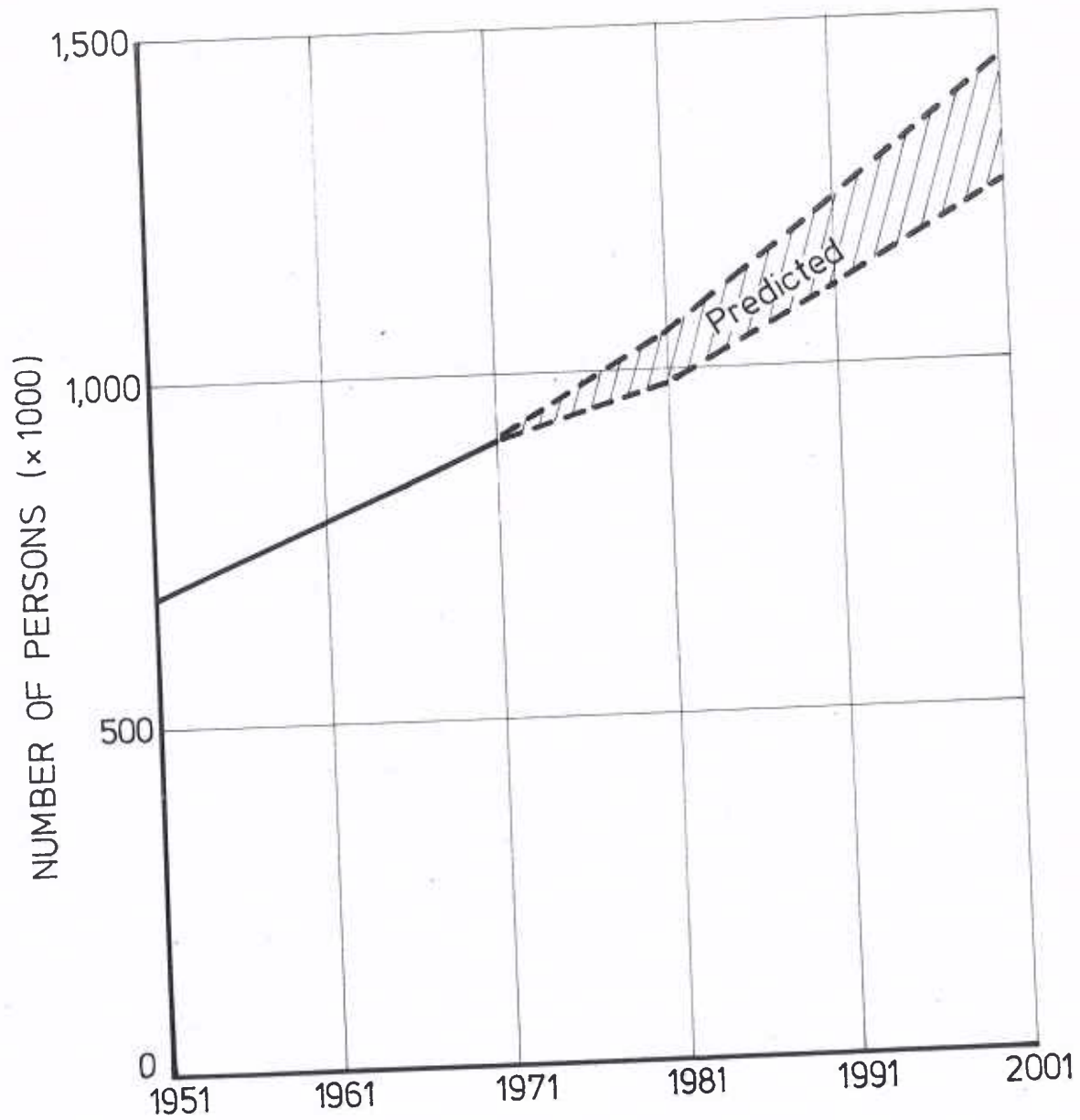
Although the Authority will doubtless produce in due course its own strategic overall review of all its resources, it may nevertheless be helpful to place the work described in this Report, and the thinking on which it has been based, into perspective by commencing with a brief review of the historical background, estimates of demand and strategic goals.

I.2.2 Historical Background

Beginning with the South East Study (1964) a progression of reports identified South Hampshire as an area of particular growth potential. These reports (South Hampshire Study 1966; A Strategy for the South East 1967; Strategic Plans for the South East 1970) culminated in the South Hampshire Structure Plan 1972, which defined in detail the various means of realising "Solent City" with a population of 1.4 million by the end of the century. This was seen as a logical continuation of the trend over the decades 1950-1970 when the rate of population increase in the area was twice that of the national average (Fig. I.1).

The statutory Water Authorities had made early plans to meet the increased demand resulting from this growth. The Study Report "Water Supply" (1969) estimated that although consumption could well exceed 455 litres/day per head (100 gallons) this could be met by the cautious and conservative estimate of the potential supply of the area of 910 million litres/day (200 million gallons). To realise this figure surface reservoir storage would be essential. Therefore the Local Planning Authority had agreed to protect 12 possible reservoir sites from development and to consult the Water Authorities in respect of a further five. These sites had been short-listed from the much larger number of possible sites that had been identified in a study carried out in 1965 by Herbert Lapworth Partners. This study had been commissioned jointly by the Hampshire River Authority and Portsmouth Water Company. The ^{company} ~~latter~~ had proceeded somewhat further by carrying out a detailed site investigation of one of the sites (Edgar Morton and Partners 1963) and then reserving this site by its purchase along with the purchase of another site at Southleigh Forest.

POPULATION IN SOUTH HAMPSHIRE FIG.I.1.



Since 1972, the reorganisation of the Water Supply Industry, the shelving of the plan to develop Solent City, and the decline in the rate of population increase, coupled with a falling off in the rate of increase of consumption have all indicated the need for a reappraisal of the Southern Water Authority's commitments and requirements. This implied reviewing the need to reserve up to 17 sites for possible reservoir development. Hence the studies reported here.

I.2.3 Estimated Demand

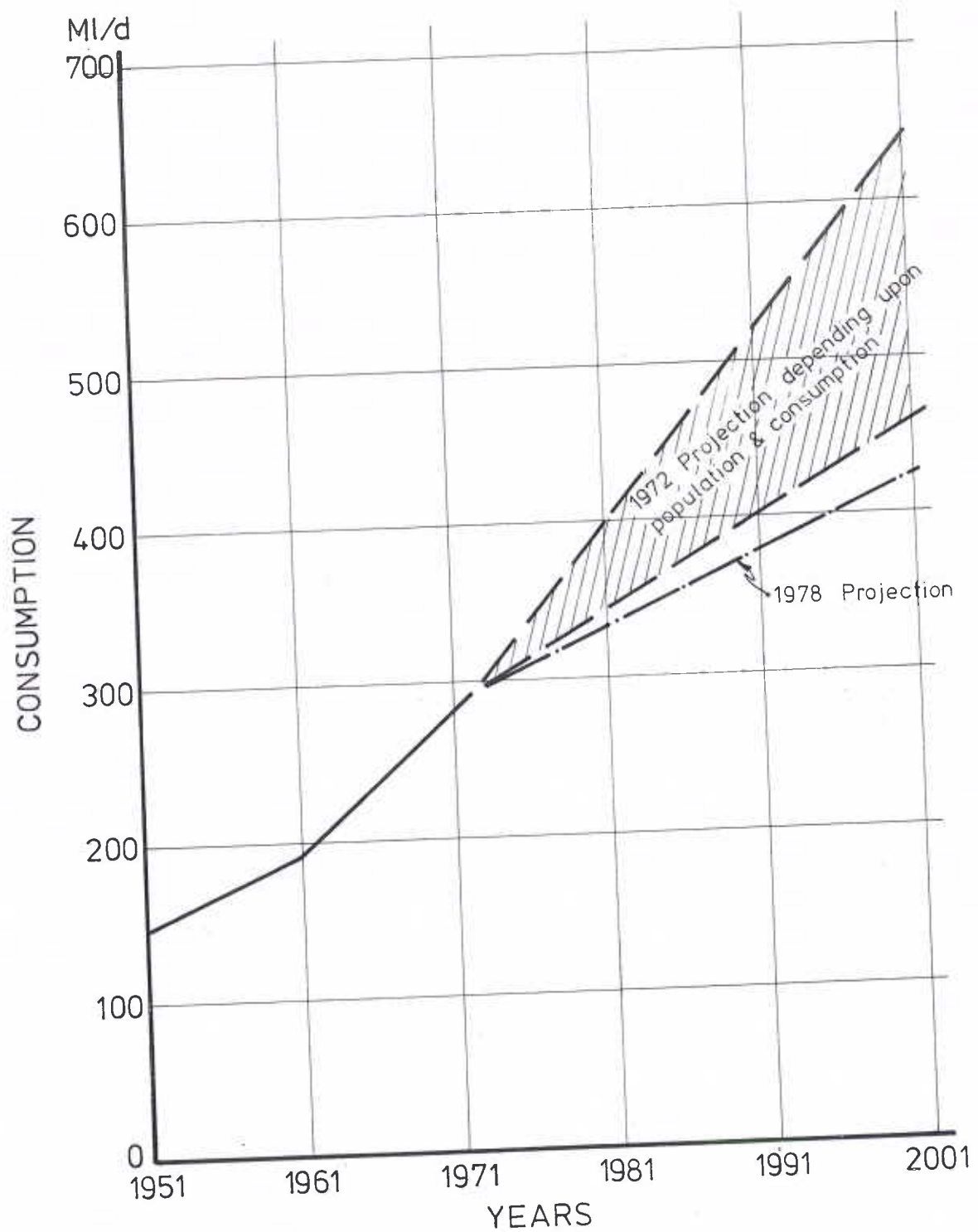
In 1972 the average consumption in South Hampshire was some 20% higher than the average in the remainder of south east England. This was influenced to a large extent by substantial industrial use. In 1972 this was 290 litres/capita/day (63 gallons/day) which resulted in a total average supply of 260 million litres/day (57 million gallons/day). The combined anticipated growth of both water consumption and population resulted in a prediction of 645Ml/d (140 m.g.d.) for 2001 (Fig I.2).

Both of these factors have now been reduced in scale to give a current prediction of 417 Ml/day. The demand for new reservoirs does not quite reduce in a direct proportion, as the River Itchen is already over-extended and requires augmentation to bring it up to an acceptable level in order to meet desirable water quality and fish capacity standards.

I.2.4 Strategy

A detailed description of the hydrology of the study areas would be outside the scope of this Report. For present purposes, it is sufficient to recall that by far the greater proportion of the natural catchment area of each of the two major rivers, the Test and the Itchen, is underlain by thick chalk deposits. This has resulted in naturally well-regulated stream flows

FIG. I.2.

PREDICTED CONSUMPTION IN SOUTH HAMPSHIRE

in these rivers which, together with numerous boreholes also based on the layer of chalk, have hitherto supported the whole of the water demands of the area without the need for any reservoir.

By contrast, the southern part of the catchment, whose characteristics result in "flashy" stream flows, is divided into numerous small catchments which will not lend themselves to development of impounding reservoirs, so it is not surprising that there are none at present.

Now, the studies covered by the present Report were specifically concerned with surface reservoir sites per se, and not with the far wider and possibly more complex subject of optimisation of the water resources within the study areas by other means, such as bulk transfers from one catchment to another, conjunctive use with other schemes outside the study areas, such as the Candover Scheme, and so forth. On the other hand, to ignore the economies - some obvious, some less so - which can be achieved by mutual augmentation would be absurd, not only because the omission of strategically relevant factors from the comparative evaluation of the reservoir sites would distort their apparent relative merits out of any likely reality, but it would also mask the relevance of the optimum capacities discussed as well as directly affecting some of the actual cost elements. It was therefore essential, in carrying out the studies, to pay due regard to the possible mutual influence between different catchment areas and between possible developments within each and also possible or known developments elsewhere. This has been made possible by maintaining a dialogue on these other aspects with the officers of the Authority during the whole of the study period besides, to a limited extent,

carrying out independent conjectural reviews of the possible effect on basic strategy of factors not necessarily fully assessed as yet by the Authority, which have appeared to have a particular bearing on the value of this reservoir site or that.

A brief review of the possible effect on the need for reservoir storage of bulk transfers between the catchment and the possible effect of optimisation of other resources, is given in Part II.5 at the end of this Report. By way of placing the studies in a rational context, strategic effects of these considerations may be summarised as follows:-

The Test

This River is able to meet its own projected demand without the need for any summer augmentation. Therefore, provided there is no great cost penalty attached to the treatment and distribution of supplies from the Test, then these should be developed in preference to, and earlier than, supplies from the Itchen or other sources requiring augmentation.

The Itchen

It can be shown that this River already suffers a deficit of 7.5 million m³ in the conditions obtained in 1973 (taken as the design study year). This deficit can be limited to some such value by providing for additional demand in the Southampton area from the Test. The deficit would have been increased to 15 million m³ by the originally proposed increases of capacity at Otterbourne and Twyford to 150Ml/d.

A 7.5 million m³ deficit could be met either by developing a full Itchen groundwater scheme (at an approximate cost of £4.5m) or by constructing a surface reservoir near Eastleigh plus the Candover scheme (cost £4.5m) or by transfer from the Test (cost £4.0m). It was concluded in the first of the two studies reported here that reservoirs in the vicinity of Eastleigh are unlikely to be feasible until the airport ceases to be operational. As a part of the groundwater scheme is already committed, completion of the full development might appear to be the most reasonable option. However, it has been shown that this would not meet any increase in demand which could, on the other hand, be met by a transfer from the Test of up to 135 Ml/d together with a first-stage Candover Scheme at 30 Ml/d. It can further be shown that this would require no further augmentation of the Test, though in view of the heavy demand upon this River in this instance, it would be recommended that a site adjacent to the Testwood works should be reserved, with a capacity equivalent to seven days' supply (2 million cubic metres). It is thus clear that the possibility of reinforcing the Itchen by transfer from the Test has a profound effect on the possible relevance of a number of the sites covered in the first of the two studies.

East Hampshire

The present supply and demand of the Portsmouth Water Company (Hampshire) can be shown to be very evenly matched. To meet any future increase in demand, the basic choice lies between the provision of surface storage on the one hand and increased abstractions from the Itchen on the other. The summer M.R.F. in the Itchen at Allbrook has been given as 245Ml/d, compared with 130Ml/d at Gaiter's Mill. On the assumption that the difference of 115Ml/d may be taken as an additional

54 mg

available abstraction at Gaiter's Mill, without further support to the Itchen, the latter option appears to be open. Indeed it can be shown that this is sufficient to meet demand to the year 2001 without surface reservoir storage. On this basis, it would seem better policy to reserve a reservoir site to the east of Hampshire to balance transfers from the west in order to meet still further increase in demand.

I.2.5 Summary of Introductory Notes

The foregoing comments should not be interpreted as conclusions or recommendations; indeed, some of them stray into areas which are still the subject of studies which are not yet complete. In general, they should be taken as no more than inferences arising from an attempt to orientate the study of the reservoir sites in a way which appears to be most compatible with likely future trends. Even if a number of these factors are subsequently found, on review, to be wholly or partially invalid, these introductory notes would at least serve as a reminder that the reservoir studies reported here constitute only one part of a wide range of interdependent studies being carried out by the Authority.

I.3.0 GENERAL DESCRIPTION OF THE POTENTIAL RESERVOIR SITES

As it turned out, the studies examined some twenty sites in all, nine in the River Test Valley, one on the Tanner's Brook, five in the Itchen Valley and five separate sites in East Hampshire; these numbers include additional sites identified as the work proceeded. Each site was designated by a number or letter as shown on Figs I.3 and 4. Sites 1-13 and Sites B, C and D are all potentially capable of storing water for supply to Southampton, whilst Sites 15-20 would augment Portsmouth's demand.

From the outset, it was clear that it was unlikely that the investigation would result in an early discernible order of merit of the sites. So it has proved, and the technical merits and drawbacks of each site must be carefully weighed against many other factors, recreation, amenity, fishing, birdstrike hazards, nature conservancy, agriculture, etc. Some of these will almost certainly be of greater influence in a final choice than the fine engineering detail on each site.

This investigation has been primarily concerned with the soil conditions, for the natural topography is such that most of the sites require extensive earthworks to create a useful storage. Thus the suitability of the local soils for use in an embankment dam, and the ease with which the soils can be handled during construction become of ~~permanent~~ ^{primary} technical importance. In order to reduce water loss through leakage, the sites had all been originally selected to lie on London Clay, but this formation is variable in consistency, with lenses of sand bedded in predominantly silty materials. Whilst in general this has not prejudiced the watertightness of the reservoir area, it does give rise to some potential design and construction problems.

The scale of the earthworks has also led to an investigation into the sand and gravel industry, not primarily because of the demand that reservoir construction might make upon it (though this is a factor in the East Hampshire sites) but because a joint exploitation of a site, first as a gravel pit and then subsequently as a reservoir, can result in a much more economic solution than separate developments.

I.3.1 Description of Each Site in Turn

This Report covers only the salient points of each site in barest outline, summarising the potential of each site with reference to the matrix of comparative factors, shown on Figure I.5. The matrix value ranges from 46 on the better sites to 29 for the worst. Fuller descriptions of each site are contained in the previously published technical reports. However, detailed proposals for the preferred sites are contained in Part II of the present Report.

Hampshire Reservoir Study - Matrix of comparative factors

Factors of importance

Reservoir Sites

5 (very good) 4 (good) 3 (medium) 2 (poor) 1 (very poor)	1/2	3	4	5	6	B/C	D	8	9/10	12	11/13	15	17	18	19	20
A Strategic location 5(very good) - 1 (very poor)	3	3	4	4	4	5	5	4	3	4	5	2	2	4	4	3
B Cost per cubic metre stored. 5(B/C & 18), 4(+20%) - 1(+ 80%)	4	3	(4)	2	2	5	(1)	3	2	5	3	3	1	5	1	4
C Effective use of site - inverse of area flooded 5(>13m) . . 1(<7m)	5	2	(3)	3	(3)	5	(3)	5	4	3	2	2	4	2	1	5
D Water quality 5(very good) - 1 (very poor)	4	4	4	3	2	4	4	2	4	4	4	2	2	3	3	3
E Technical problems - design of works, cut offs, constructions 5 (very good) 1 (very poor)	2	2	(4)	4	3	2	1	4	2	2	2	2	2	2	2	4
F Technical problems - external access, birdstrike, services	3	3	(3)	4	4	3	3	3	2	2	2	4	4	4	4	4
G Annual costs 17 B/C & 18 (3) 7 5	3	3	3	3	3	3	3	1	3	3	3	2	2	3	3	2
H Gravel released 5(1.2 Mm ³), 4(1.2-0.9), 3(0.9-0.6), 2(0.6-0.3) 1(0.3)	5	5	?	0	0	5	2	0	3	4	1	0	0	0	0	0
I Planning impact 1(very poor) - 5 (very good)	3	3	2	3	3	4	3	4	3	2	2	2	2	4	3	3
J Relative Ecological evaluation. 1(areas of greatest ecological interest) -5 (little)	2	4	4	4	4	1	1	3	4	4	3	2	3	2	2	4
K Recreational & amenity value 1(poor) - 5 (good)	1	2	1	2	3	4	3	4	2	4	4	3	2	4	2	4
L Landscape & environment value 1(poor) - 5(good)	2	2	2	2	2	2	2	3	3	2	2	2	2	3	3	3
M Agriculture 1(Class 1) - 5 (Class 5) (forest - 3)	3	1	2	2	5	3	3	3	4	4	4	3	3	4	3	2

40 37 (36) 36 38 46 (34) 39 39 43 37 29 29 40 31 39 41

Notes: General - No attempt has been made to weight factors A - M according to their relative importance

A - Discussed in text.

D - Stored water quality is taken as good where reservoir is excavated into gravels and input water has low nutrient values; as medium where one of these factors is absent; and as poor when both are absent.

J - South Hampshire structure plan

K - South Hampshire structure plan and communications.

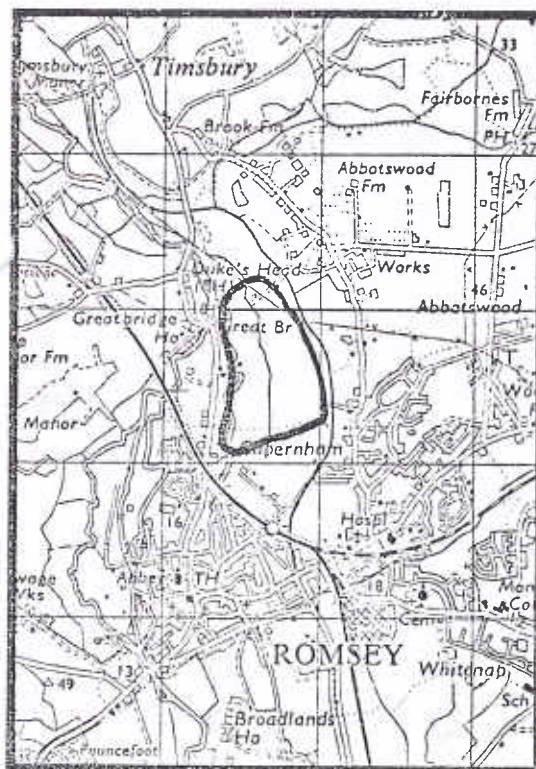


Reservoir on Site 1/2 - SU345235

Location - west bank of River Test 2km north of Romsey
 Total area taken by reservoir and embankments - 80 ha
 Total area taken by spoil - 28 ha
 Type of reservoir - fully bunded
 Top water level - 20.0m O.D., 1.4m above ground
 Maximum water depth - 8.0m
 Storage - 1.6 - 3.9 million cubic metres
 Input - pumped from River Test
 Function - regulation of Test for abstraction at Testwood Works
 Surplus gravel - 1.4million cubic metres
 Cost - 1.05 x base case (B/C) per m³ stored
 Matrix Value - 40

Recommendation

This site is ranked second on the River Test and would be of value should this river ever need augmentation from a surface reservoir. In the meantime, it should be reserved against this possible use by excluding developments that would be prejudiced. The siting of agricultural buildings and the method of extraction of gravels should be permitted if necessary, but only after detailed discussion with the Water Authority.

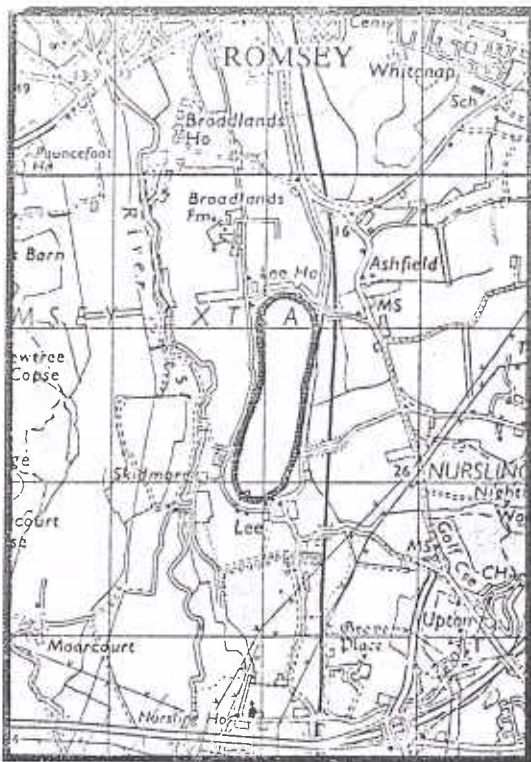


Reservoir on Site 3 - SU356216

Location - east bank of River Test 1km north of Romsey
 Total area taken by reservoir and embankments - 114 ha
 Total area taken by spoil - 40 ha
 Type of reservoir - fully bunded
 Top water level - 17m O.D., 2m above ground
 Maximum water depth - 8m
 Storage - 4.0 million cubic metres
 Input - pumped from River Test
 Function - Regulation of Test for abstraction at Testwood Works
 Surplus gravel - 1.3 million cubic metres
 Cost - 1.2 x base case (B/C) per m³ stored
 Matrix value - 37

Recommendation

This site would be comparatively costly to develop. It is founded on rather poor soils, and it supports a flourishing and specialised tree nursery. The site should be abandoned as a possible reservoir site.



Reservoir on Site 4 - SU360185

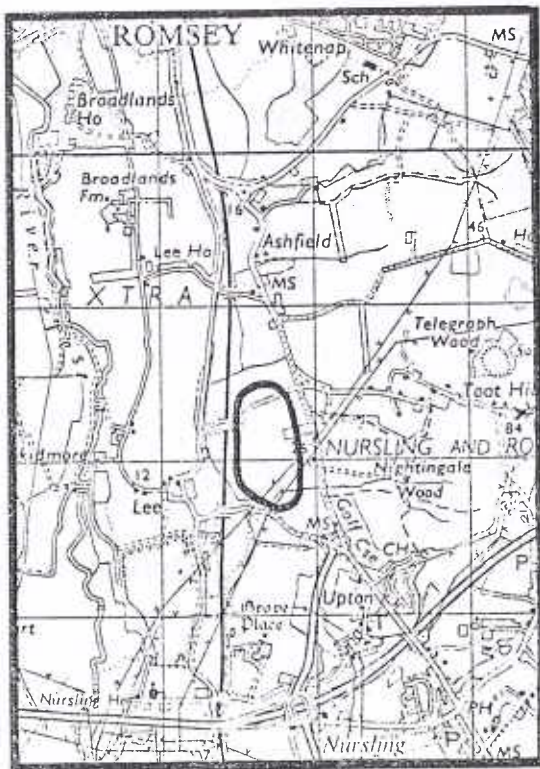
Location - on valley gravels to east of River Test and 3kms south of Romsey

Further details - none as the site was not selected during the site investigation

Matrix value - 36

Recommendations

This site comprises fine (Class II) agricultural land on a mature and unspoiled valley terrace landscape. It was not investigated and there is no evidence from the adjoining Site 6 that it will offer any particular or unique advantages, rather its sub-soil conditions may be poor. The Water Authority has already given notice that it intends to abandon this Site.



Reservoir on Site 5 - SU366183

Location - on valley side to the east of the Romsey/Southampton railway

Total area taken by reservoir and embankments - 96 ha.

Total area of spoil - 32 ha.

Type of reservoir - bunded against sidelong ground

Top water level - 24.0m O.D., bottom ground level 17m

Maximum water depth - 14.0 m

Storage - 1.4 - 7.4 million cubic metres

Input - pumped from River Test

Function - regulation of Test or direct supply to Testwood Works

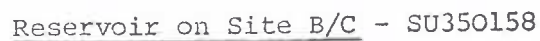
Surplus gravel - none

Cost - 1.5 x 2.0 x base case (B/C) per m³ stored

Matrix value - 36

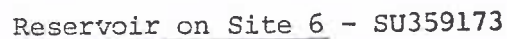
Recommendations

This site would be relatively expensive to develop, contains no marketable quantities of gravel and is on good agricultural land. The site should be abandoned as a possible reservoir site.



Matrix value - 46

to be a preferred site on planning grounds. The changed land use would not degrade the ecological worth of the area. Moreover, it is adjacent to the existing abstraction works at Testwood and so can be designed to supply Testwood should any pollution take place in the River Test. Thus, the supplies from the river can be both augmented and protected. This site should eventually be developed as the principle reservoir site on the Test. Part II discusses the long term sequence of development, landscaping and gravel working that could eventually result in a useful reservoir. See notes in text regarding moisture content of fill materials.



Matrix value - 38

The previous working of this Site for gravel, together with the use of part of it as a tip for municipal rubbish, make this a difficult site to develop. Its soils are poor and there are some doubts about the water losses which might take place through seepage. The Water Authority has already given notice that it intends to abandon this Site. However, future proposals for the reinstatement of this gravel pit may bear in mind that topsoil and large quantities of peat may be made readily available from the nearby, and preferred, Site B/C.

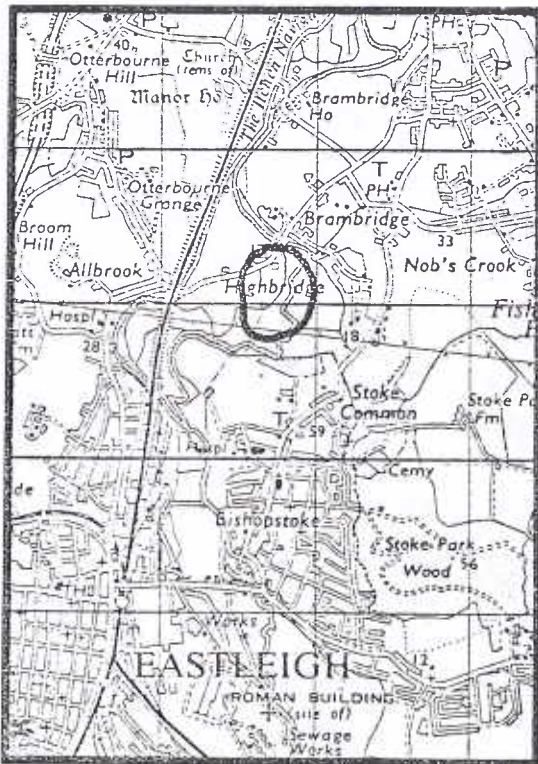


Reservoir on Site 8 - SU394173

Location - either side of M27 crossing of
Tanner's Brook
Total area of reservoir - 250 ha
Total area of spoil - none
Type of reservoir - single embankment
Top water level - 43.5m O.D., ground level 28m
Maximum water depth - 15.5m
Storage - 50 million cubic metres
Input - pumped from River Test
Function - direct supply; standby for Testwood;
or feed to Otterbourne
Surplus gravel - none
Cost - 1.6 x base case (Site B/C) per m³ stored
Matrix value - 39

Recommendations

The dissection of the Site by the recently constructed M27 motorway has reduced the economic attractiveness of this Site, in that significant works will be required to protect the motorway embankment. In certain respects, but not all, this Site could be a substitute for Site B/C, particularly if it were carefully integrated into the Southampton distribution system. An option on this Site should be retained until development at Site B/C is assured in which case it can be abandoned as a reservoir site.

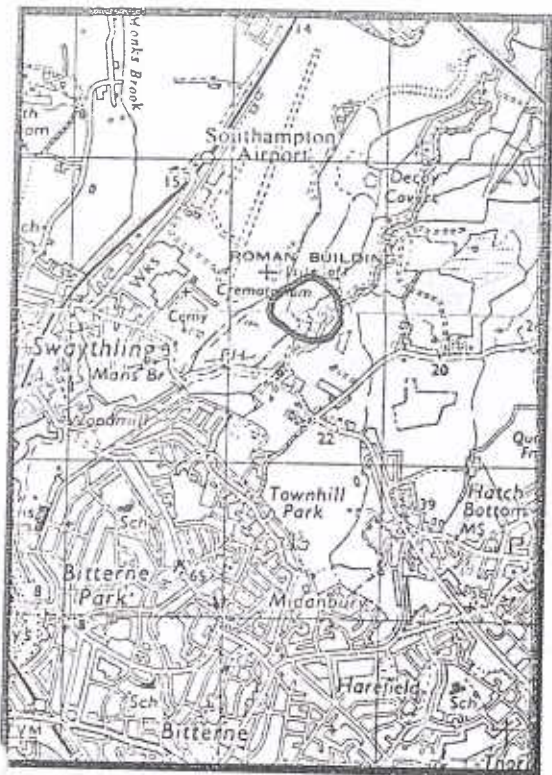


Reservoir on Site 9/10 - SU467214

Location - astride present site of River Itchen
immediately south of Highbridge
Total area taken by reservoir - 60 ha.
Total spoil area - 25 ha.
Type of reservoir - fully bunded
Top water level - 22.5m O.D., ground level 15m O.D.
Maximum water depth - 18m
Storage - 1.7 - 4.3 million cubic metres
Input - pumped from River Itchen
Function - regulation of Itchen for abstraction
at Gaiter's Mill
Surplus gravel - 0.6 million cubic metres
Cost - 1.5 - 2.0 x base case (B/C) per m³ stored
Matrix value - 39

Recommendations

Due to the variable thickness of gravel, this Site is the least attractive of the reservoir sites on the River Itchen. The Water Authority has already indicated that it intends to abandon this Site.



Reservoir on Site 11/13 - SU455160

Location - west bank of River Itchen immediately to the north of the proposed M27
 Total reservoir area - 35 ha.
 Total area of spoil - 12 ha.
 Type of reservoir - fully bunded
 Topwater level - 5.0m O.D., ground level 3.8m
 Maximum water depth - 7m
 Input - gravity leat
 Function - seven day standby storage for Gaiter's Mill abstraction
 Surplus gravel - 0.3 million cubic metres
 Cost - 1.5 x base case (B/C) per m³ stored
 Matrix value - 37

Recommendations

The continuing use of Eastleigh Airport raises unquantifiable danger and consequent cost of bird strike hazard. A scheme of a multitude of small ponds over the site was considered and then abandoned on the grounds of impracticability. A small reservoir near the abstraction works at Gaiter's Mill may be of value, and the opening up of a borrow pit for the motorway construction should be done in such a way so as to facilitate its further use as a potential reservoir. But otherwise, these two sites should be abandoned for future reservoir use.



Reservoir on Site 12 - SU472183

Location - east bank of the River Itchen, opposite Chickenhall sewerage works
 Total reservoir area - 105 ha.
 Total area of spoil - 54 ha.
 Type of reservoir - fully bunded
 Top water level - 10.5m O.D., ground level 8.0m
 Maximum water depth - 9.3m O.D.
 Storage - 3.0 - 4.3 million cubic metres
 Input - pumped from River Itchen
 Function - discharge upstream of Chickenhall for maintaining M.R.F.
 Surplus Gravel - 1 million cubic metres
 Cost - 1.0 x base case (B/C) per m³ stored
 Matrix value - 43

Recommendations

This Site could be used to construct a large single reservoir at an economical cost per unit stored. However, due to the characteristics of the river flow this would still represent a relatively costly way of augmenting Itchen flows

which can be achieved by other means discussed elsewhere. In addition, there is the problem of Eastleigh Airport. Therefore, this Site should be maintained as a possible distant future site that could be developed if and when the Airport were closed or birdstrike problems solved in other ways. In the meantime, the Site's use as open space and river valley countryside is fully compatible with the intention of the local planning authorities.

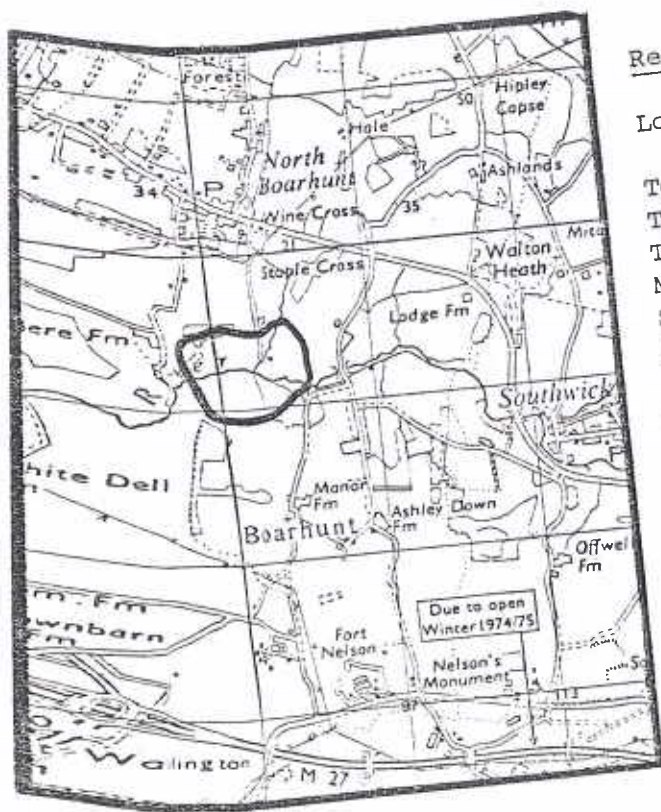


Reservoir on Site 15 - SU595132

Location - in Forest of Bere 2.5kms north east of Wickham
 Total area of reservoir - 52 ha
 Type of reservoir - single embankment
 Top water level - 58.5m O.D.
 Maximum water depth 19.5m
 Storage - 3.4 million cubic metres
 Input - pumped from River Meon and surplus of other existing sources
 Function - direct supply to treatment at Hood's Hill
 Cost - 1.7 x base case (18(1)) per m³ stored
 Matrix value - 29

Recommendations

This site is one of two sites to the west of Portsmouth that are thought to be of less strategic value than the remainder to the east. Examination of the matrix shows that it is less attractive than other sites on a number of counts. This site should be abandoned for reservoir use and so allow the Forestry Commission to plan a long term timber and recreational development programme.

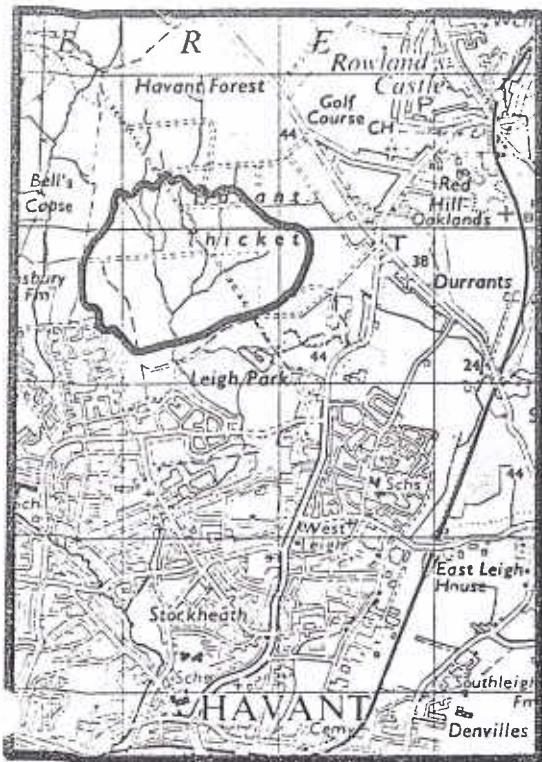


Reservoir on Site 17 - SU603092

Location - astride Wallington River 3kms north east of Fareham
 Total reservoir area & diversion - 72 ha.
 Type of reservoir - multiple embankments
 Top water level - 24.5m O.D.
 Maximum water depth - 14.5m
 Storage - 1.9 to 4.3 million cubic metres
 Input - pumped from Wallington River and surplus of other existing sources
 Function - direct supply to treatment at Hood's Hill
 Cost - 2 x -3 x base case (18(1)) per m³ stored
 Matrix value - 29

Recommendations

This site is the second of the two sites to the west of Portsmouth that has a low matrix value. Like site 15 it has a rather low storage potential. It is also comparatively expensive. It should be abandoned in favour of sites 18 and 20.



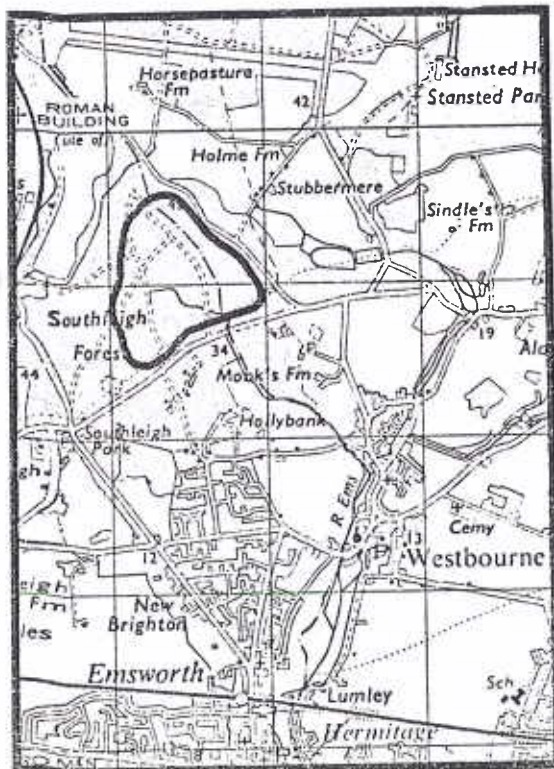
Reservoir on Site 18 - SU715098 *PAVANT FOREST*

Location - 3kms north of Havant
 Total area of reservoir - 118 ha.
 Type of reservoir - single embankment with subsidiary bunds
 Top water level - 38.5m O.D.
 Maximum water depth - 16.5m
 Storage - 6.3 - 9 million cubic metres
 Input-pumped from Bedhampton Springs
 Function - direct supply for treatment at Farlington Works
 Cost - base rate
 Matrix value - 40

Recommendations

This site is equally attractive on the basis of the matrix with site 20. It is however 50% more economic to construct, and the land is already owned by the Authority and put to marginal use. We recommend that this site be retained for use as a reservoir site inspite of having

some considerable and unresolved problems relating to ground conditions.



Reservoir on Site 19 - SU744090

Location - Southleigh Forest, 3.5kms to north east of Havant
 Total reservoir area - 55 ha.
 Type of reservoir - multiple embankments
 Top water level - 44.5m
 Maximum water depth - 11.5m
 Storage - 2.8 million cubic metres
 Input - pumped from Bedhampton Springs
 Function - direct supply for treatment at Farlington Works
 Cost - 2 x base case (site 18(1)) per m³ stored.
 Matrix value - 31

Recommendations

This site has a comparatively small overall capacity. It is likely to have some cutoff problems since its matrix value is low it is probably not worth retaining for reservoir use.



Reservoir on Site 20 - SU737068

Location - 2kms east of Havant
 Total area taken by reservoir - 87 ha.
 Type of reservoir - fully bunded
 Top water level - 24.5m O.D.
 Maximum water level - 18.0m
 Storage - 11.8 million cubic metres
 Input - pumped from Bedhampton Springs
 Function - direct supply for treatment at
 Farlington Works
 Cost - 1.6 x base case (site 18(1)) per m³ stored
 Matrix value - 39

Recommendations

This site is equally attractive on the matrix to site 18. However it is probably the more difficult site to visualise as a reservoir because of its present high quality agricultural use. We recommend that it is retained as the standby site until problems on site 18 are resolved and its future development, if necessary, assured. Then it can be abandoned.

I.3.2 Summary of Description of Sites

Most sites lie on the alluvial or terrace levels of the Test or Itchen Valleys. The exceptions are Site 8 which lies in the wooded valley of Tanner's Brook due north of Southampton, and the five East Hampshire sites, four of which are situated in gently rolling countryside which is forested or arable land, whilst the fifth and last site to the east of Havant lies on the level agricultural land bordering Langstone Harbour.

Although the sites have fairly similar characteristics for reservoir potential, the study has concluded that a the probable strategy would be to promote Site B/C in the Southampton area and Site 18 in the Portsmouth area. Standby Sites 8 and 20 should be reserved until such time as it is certain that the first sites can be developed in which case Sites 8 and 20 should be abandoned. Sites 1/2 and 12 may be reserved against possible eventual use for future need simply because present and foreseen use within their respective local plans would not prejudice an eventual reservoir development.

I.4.0 THE SITE INVESTIGATION & LABORATORY TESTING PROGRAMME

I.4.1 Introduction

Central to the reservoir study has been a careful examination of the soils on each site in order to determine their characteristics relevant to embankment construction. Given the basis upon which the sites had been selected, it was unlikely that any site would be totally unsuitable for reservoir use, although Site D was quickly struck off the list due to the sandy and permeable nature of its soils. More generally, the investigation sought to assess the permeability of the in-situ soils so that water losses could be calculated, their strength which determines the cross section of the embankments, and hence the project cost, and their workability as fill materials, which determines the practical difficulty of constructing the earthworks.

The field work was done over three consecutive years, 1975 and 1976 in the Test and Itchen Valleys and 1977 in East Hampshire. The work was let as three separate competitive contracts for the boring and drilling of trial holes, each of which included for the testing of samples as directed by the Consultants, in the contractor's laboratory. Full details of the borehole logs and the results of the laboratory tests are contained in the detailed engineering reports for each site. Generally it was found that the permeabilities were satisfactory and that losses through lenses of more permeable material could be economically controlled by cut-offs; that the strengths were poor ($\phi' = 19^{\circ} - 24^{\circ}$) which will necessitate careful attention to design; and that the soil in situ was often 2% or more wet of optimum which will cause some problems in construction, may determine the type of construction plant used and the sequence of operations and will necessitate extensive drainage measures in embankments to reduce construction prewater pressures.

The site investigations did not locate any one site which had markedly better soil conditions than any other, though certain problems at site 18 are discussed later.

At an early stage in the overall investigation it became clear that the quantity of gravel of commercial quality on any site might prove to be of great significance as the exploitation of gravel and the development of the reservoir could then go hand in hand, reducing the pressure on the limited amount of available land in south Hampshire. In addition, the carefully controlled extraction of gravel could materially contribute towards reducing the cost of the reservoir works. Thus, it became important that the site investigations were done in sufficient detail to be able to draw up an inventory of the gravels available. This was done from the borehole records, from electrical resistivity surveys of the more important areas, and by including the findings of any known previous survey in the area.

A separate contract was let in 1976 to investigate the permeability of these river gravels by means of large scale pumping tests adjacent to the Rivers Test and Itchen. It had been thought that it might have been possible to store water in these shallow gravels and so in the Itchen Valley at any rate, reduce the area of open reservoir to an extent that would be compatible with Eastleigh Airport and its attendant birdstrike problems. This work showed that the river banks themselves were so permeable that any extensive abstraction scheme would simply draw upon the river itself and so defeat its purpose.

Taken overall, the site investigations have provided two valuable contributions towards the development of reservoir capacity in south east Hampshire. They have

shown that, on the sites considered at any rate, there is no over-riding reason based on soils engineering data for preferring any one site or discarding another. Topography, strategic location and overall water resource development policy will all play more significant roles, as will planning and environmental matters. For this reason, the matrix of comparative factors (Fig. I.5) attributes to each of these factors an equal value. This is of course a subjective judgement. Secondly, the site investigation work has provided a valuable source of data for the eventual development of a scheme on any one site, as well as material which will be of use to any construction project on any of the sites.

I.4.2 Desk Studies

Parallel with the field investigations, a number of desk studies were carried out on subsidiary problems as follows:-

I.4.2.1 Hydrological Studies

These have been, and are still being, carried out by the Southern Water Authority. The Candover Scheme pilot study for the regulation of the Itchen by abstraction from the chalk, and the study into the minimum residual flows in the Test and the Itchen, are both of the greatest importance in determining the levels of augmentation required to support a given abstraction. The consultants prepared a simple hydrological memorandum to assist in identifying the strategically important sites. This Memorandum (July 1977) suggested that transfer of water from the Test to the Itchen could be seen to be as significant a single resource as any reservoir. (This Memorandum has been updated and is included in Part II.5). Consequently the consultants were asked to carry out a desk study of possible pipeline routes.

I.4.2.2. Pipeline Routes

Detailed desk studies of a pipeline route from Testwood on the Test to Otterbourne on the Itchen have been carried

out and the results were given separately in a study report submitted in November 1977. This study also included two possible routes linking Havant and Bedhampton Springs to Site 18, since it had by then become clear that such a link was a fundamental part of the cost of the reservoir construction itself. This study identified and costed feasible routes, giving the Authority the opportunity to reserve these routes in much the same way as it has reserved reservoir sites in the past.

I.4.2.3 Gravels

The Southampton area is short of local aggregates. Large quantities are imported by sea or hauled in by rail. Local reserves with planning permission have dwindled to barely sufficient for three years of extraction at the present rate. Consequently, there is pressure to develop new resources and this pressure might be channelled to in such a manner as to contribute indirectly towards the cost of development of a new reservoir.

Discussions with gravel operators showed that the typical conditions on any such site, whilst not perfect in that the overburden/gravel ratio is high, are sufficiently promising to justify the premise used in the costings in this Report, namely that the removal of the overburden to previously agreed spoil areas and the extraction of the gravels leaving a clean pit could be done at no cost to the Water Authority.

I.4.2.4 Peat

Enquiries were made and samples taken to determine whether or not there was a commercial value in the overburden of peat. It appears that the peat is of too poor a quality to be marketable except at a very local level.

I.4.2.5 Eastleigh Airport and the Probable Increase of Birdstrike Associated with the Presence of Future Nearby Reserves

The Civil Aviation Authority has adopted the policy that because of birdstrike problems, there should be no reservoir developments within 5 miles of an airport. In the reservoir studies, it has been accepted that unless counter measures could be proved effective, then it would not be possible to develop reservoirs in the Itchen Valley whilst Eastleigh Airport is still operational. The Engineering Report (November 1976) detailed a number of possible solutions to this problem, the preferred option being the reduction of the large expanse of open water which is attractive to roosting gulls in particular, by means of a combination of numerous small (1 ha.) lakes and underground storage. Unfortunately, this proposal proved to be both of doubtful practicability and unpopular with the planners, so has been dropped.

I.4.2.6 Landscaping and Amenity

A detailed landscape analysis of Site B/C, carried out to assess the impact of reservoir construction in the flat river valleys of the Test and Itchen, concluded that provided the development area is planted with trees at an early stage, well before construction actually takes place, then the impact of 4 to 8m high embankments is minimal. Further details are given in the appropriate section in Part II of this Document.

1.5.0 CONCLUSIONS

1.5.1 The Hampshire Reservoir Study will enable decisions affecting the future of the 20 sites to be made on a rational basis. Taken in conjunction with the Authority's own investigation into the overall operating procedure for their whole system, and their detailed study of the MRF and groundwater schemes, it will be possible to draw up a measured comparison of each site with the others.

Having decided which sites it will reserve for future use, the reservoir study identifies the nature of problems requiring further attention before proceeding to the design stage and provides a basis for the detailed design on each site, as well as for the accurate programming of its development into an overall programme.

And lastly the study provides a detailed economic analysis of each preferred site for use in any financial forecast.

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5. Brief Preliminary Report and Proposals - 1975
 6. Reservoir Site Investigation - Hampshire 1975-76 Engineering Report 1976
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 8. Preliminary Study of Pipeline Routes from the River Test at Testwood and to the River Itchen at Otterbourne and from Bedhampton to Site 18 - October 1977, together with accompanying photograph collections.

~~PART~~
SECTION II - PART 1

SITE B/C

- II.1.1 Background to the Selection of this Site for investigation
- II.1.2 Summary of Investigation
- II.1.3 Design Considerations for an Embankment bund on B/C
- II.1.4 Plans, Sections & Details of Scheme

Figures.

- II.1.1 Schematic description of main reservoir types in Test & Itchen Valleys.
- II.1.2 Log of boreholes of M27 crossing of Test.
- II.1.3 Plan of first stage development at B/C
- II.1.4 Plan of ultimate development at B/C with the River Blackwater routed to the west.
- II.1.5 Plan of ultimate development at B/C with the River Blackwater diverted to the east.
- II.1.6 Schematic Section of B/C bunds at different Stages of development.
- II.1.7 Schematic sections of soils.
- II.1.8 Alternative programmes of development on B/C.
- II.1.9 Photomontage view of B/C from M27.
- II.1.10 Photomontage view of B/C from Colbury House
- II.1.11 Photomontage view of B/C from near Nursling Mill
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- II.1.13 Graph showing estimated cost of increased storage.

SECTION II - DETAILED TECHNICAL PROPOSALS AT PREFERRED SITES

II.1.0 SITE B/C

II.1.1 Background to the Selection of this Site for Investigation

Prior to the commencement of the reservoir study, the Consultants had submitted a report in 1975 (Brief Preliminary Report and Proposals) which catalogued the possible types of reservoir solution that might be expected to emerge during the course of the study. For a site in the Test or Itchen Valleys, the four basic types were thought to be as shown in Fig.II.1.1, where they are arranged in order of ascending cost. Type I is applicable to sites where substantial gravel formations are founded about 7m below the water table. It was thought that Sites 1, 3 and part of Site 6 on the Test, as well as possible sites on the Itchen, might be of this type. This was based upon the available borehole information along the route of the M27 crossing the Test Fig.II.1.2. In the event, none of these sites had gravels of adequate thickness and consequently embankment solutions would be of type II.

However, during the course of the first year of the investigation in 1975, its scope was extended to cover areas in the vicinity of the M27 on the Test, in order to search further for Type I sites. A combination of parts of two of the new sites, B and C, seemed promising. This was not entirely satisfactory in that the average bed level of the commercial gravels was found to be 4.5m below average water table level across the site. However, the total quantities of gravel were considerable, of a thickness varying from 3.5m to 5.9m and so located that some 1.8 million m³ could be extracted from a potential reservoir site. Thus, although this site would be a Type II solution, it would be one of the most economic found during the reservoir investigation. No Type I solutions were found during the course of the investigations.

Discussions between the Water Authority and other parties involved in the consideration of reservoir development - planners and environmentalists, for instance - have shown that Site B / C would be a more favoured site. Strategically, it is well placed, adjacent to the existing abstraction works at Testwood. This will enable the construction of a direct link at the minimum cost. The sum of the characteristics of a reservoir on this site are summarised in the matrix Figure I.5 which shows that this site is about 10% ahead of its nearest rival. For these reasons, this site has been given priority at this stage of the Water Authority's investigations.

The remaining sections discuss the detailed investigation on Site B/C.

II.1.2 Summary of Investigation

A total of 14 shell and auger boreholes were drilled on B/C. The alluvial overburden, predominantly well decomposed peat, was found to average just over 2.0m thick, ranging from 1.0 metres to the north to 3.2m towards the south.

The gravels varied in thickness from 1.6m to 5.8m. They were of good commercial quality.

The underlying Tertiary strata was found to be predominantly a fine sandy clay in the southern part of Site B. A reservoir across this area would require a perimeter cut-off over this length. The remainder of the Tertiary clays have poor, although adequate, characteristics for excavation and reservoir bund construction. The material is 2% wet of optimum and ϕ' is 19° - 24° . The full borehole logs and sections are shown in Fig. II.1.3&4 together with a summary of test results.

II.1.3 Design Considerations for an Embankment Bund on Site B/C

Plans on Figures II.1.3, II.1.4 and II.1.5 show alternative plan layouts, depending upon the route chosen for the diversion of the River Blackwater.

Schematic cross-sections through two possible embankments whose height may range from about 4m to about 8m above original ground level are shown on Fig. II.1.6. If the Blackwater is diverted to the east, then the more southerly of the 2 lakes comprising the eventual reservoir will be bounded only on the north east and easterly side by a river; in the second alternative illustrated, with the diversion to the west, then both lakes would be bounded to both east and west by a river. In either case, the northern lake would have a river flowing fairly close to the embankment on three sides. The presence of a river near the "downstream" side of the embankment complicates the design of the embankment itself somewhat, as does the need to dewater the excavation, which will eventually constitute the reservoir, during construction after the abstraction of gravel. This dewatering is necessary, not only to ensure that the foundation of the embankment itself may be properly prepared, but also to facilitate the winning of further clay, exposed by the gravel extraction, from a lower level slope. This exacerbates the problem created by the natural moisture content of the clays, already about 2% higher than the optimum of compaction.

The succession of soils is detailed in the Engineering Report of November 1976, but is summarised schematically in the sections in Fig. II.1.7 as follows:-

Topsoil/peat; gravel; clay subsoil.

The first phase of development is, of course, the extraction of gravel for commercial use, and in this phase the water level in the pit - corresponding to the adjacent river level approximately - is no problem as it is a normal practice in the area to extract gravel from below the natural ground water level. Thus, reservoir development as such commences with the open pit left by the gravel workings, almost completely filled with water. In order that this pit may be dewatered, it is virtually certain that a cut-off be required to prevent ingress of river water; and hence a cut-off (probably a bentonite-filled trench) is envisaged between the river and the proposed bund. It would probably be formed as close to the river as possible; it may require to be continued around all or part of the reservoir perimeter even where this is remote from the river. The necessity for this extension of the cut-off, and its own extent, will require to be determined by further study and calculations in the design stage.

For estimating purposes, it has been assumed that a cut-off 6.5 metres deep will be required around the total perimeter of the reservoir.

The cross-section of the proposed embankment is shown schematically on Figure II.6, and incorporates the following essential features:-

1. Independent cut-off. In view of the relatively impermeable nature of the clays in the foundation and to be used as a fill material, a fairly shallow trench is probably all that would be required, in order to achieve a proper seal between the subsoil and the clay fill above.
2. In the preliminary stability calculations which have been carried out, so far on the schematic cross-section shown, low factors of safety - in the order of unity - have indicated that using the design parameters available from the Test data obtained during investigation, the cross-section indicated may require some modification in detail in the design development stage, when it will be necessary to extend the investigation of the shear strength of fill and foundation materials. Some protection against surface slippage on drawdown would probably be required on the perimeter of the excavation into the clay below gravel level (not shown on the cross-section). The number and frequency of the granular blanket drains, and the thickness of granular fill on the inner and outer slopes, will also require further review on the basis of more detailed testing and calculations into the residual pore pressures to be expected during and on completion of construction. Preliminary discussions with Professor Nash and Professor Gibson of Kings College, London suggest that these may be high, but this will depend so much upon a number of factors which can only be determined in the light of more detailed overall development of the scheme, but there was little point in going into more detail than was necessary at this stage to identify and report on these design aspects requiring further attention, and in order

to establish feasibility in principle. It can safely be reported that these problems are readily soluble, and the solutions are not considered likely to have much significant effect upon the validity of the cost estimates given in this Report. The main parameters influencing the construction pore pressures are (a) the rate of construction of the embankments themselves (briefly, the slower the better); (b) the placement moisture content of the fill - a function of the likely method of construction and of the length of time for which it was possible to keep the reservoir bed dewatered prior to construction; and (c) the weather during the construction period itself. Obviously, the latter cannot be foreseen, but it is a relatively simple matter to include additional drainage layers, as may be necessary in the light of piezometer observations taken during the early stages of construction.

3. The unusual juxtaposition of two cut-offs, one beside the river, the other in the more usual position beneath the dam, create a drainage problem at the toe of the outer slope. The solution to this would be the perimeter drain or leat (not shown on the schematic cross-section) which, owing to the natural fall in the rivers, can gravitate to the south eastern limit of the site and hence to the river.

In the light of the 1977 investigation of East Hampshire sites, albeit some way removed from Site B/C, it emerges that the London Clays in Hampshire can exhibit unusually low values of the shear strength parameter ϕ' . In the November, 1976 Engineering Report, a possible design value of 28 degrees was inferred, and it now appears that this may have erred somewhat on the optimistic side. This is by

no means certain, however, and for the purpose of this Report, it seems sufficient to note that, in the design stage, some further testing should be carried out in order to establish a safe set of working parameters. Because this doubt, such as it is, may apply more or less equally to all the sites investigated and because this Report is essentially a comparison between the sites and does not set out to provide absolute cost estimates so much as comparative ones, this area of doubt is likely to have little or no effect upon the conclusions and recommendations herein, and is recorded here for the sake of completeness and by way of a reminder for the future that some additional work for design purposes will be required.

As has already been reported and discussed with the officers of the Authority, it is also recommended that, prior to construction, a trial embankment should be constructed in order to investigate the "workability" of the clay fill, and to ascertain the best method of handling it and placing it.

Again, this problem is not thought to be likely to influence feasibility, but it may very well have an important effect upon the contractor's choice of plant and the proposed trial should therefore be carried out and the results available for inspection by tenderers, before the main construction contract is put out to tender.

II.1.4 Plans, Sections and Details of Scheme

II.1.4.1 Plans

Site B/C may be developed in a number of ways depending upon the scale of the initial storage and the diversion plans for the River Blackwater. This latter can either be diverted to the western edge of the valley floor, so allowing a single reservoir from the M27 to Testwood, or from a point on its present course approximately half way down the site it could be diverted to join the Test opposite Nursling Hill. This will allow the site to be developed as two separate reservoirs. It is also a somewhat simpler solution to construct. The development of the reservoir can also be in two phases; the first of a relatively small capacity resulting from the extraction of the gravel and the second resulting in a subsequent increase of capacity through raising perimeter bunds.

These various arrangements and phasing schemes are illustrated in Fig.II.1.8. From this figure it can be seen that increase in reservoir capacity would result from a gradual incremental progress of construction, each of which could be complete in itself, and each of which could permit further development if it becomes required. Some of these stages could be omitted if the programme requires accelerating. Figs.II.1,3,4 & 5 show the working arrangement of three possible phases of development.

II.1.4.2 Sections

There is a complete contrast between the nature of the plan arrangement, which is dictated more by programme and circumstance than by site conditions and topography, and the sections, which are a precise consequence of the particular soil conditions found. The detailed design of the proposed section has been discussed in Section 1.3.

II.1.4.3 Spoil Area

A total of 2 million m³ of spoil, largely peats and sandy silts must be disposed of away from the reservoir sites. This quantity must be dealt with in a positive manner to create a new landscape. A number of areas have been suggested on the various plans. Perhaps the most valuable solution would be to restore the worked out gravel areas on the east banks of the Test, Site 6 and south of the M27, to something like their former configuration. Since it would be difficult to recreate Class II agricultural land, the drawings have shown forestry as the first and stabilising use.

I.1.4.4 Intakes and Water Controls

The whole of the supply to Site B/C would be derived from the Test upstream of its confluence with the Blackwater, which is a "dirty" river. (In this respect the

diversion of the Blackwater to the east has the disadvantage that the existing abstraction point at Testwood would have to be moved and extended to upstream of Nursling Mill). In the early phases the input could be by means of a simple gravity leat until such a time as the top water level rises above about +3.00 m O.D. Thereafter, it must be pumped. It may be possible to confine this within the same plant as would pump water from the reservoir to Testwood for treatment. Its capacity would be adequate for any combination of operations since it would be designed to handle the whole of Testwood's capacity, should the reservoir have to act as an alternative to a temporarily contaminated River Test.

The actual design of both the bankside intake and the pumping house could be very similar to that already at Testwood or it could be given further landscaping and other cosmetic treatment to meet any planning requirements. The draw-off tower would include provision for multi-level draw-offs to suit water quality as well as angled entrance jets to cause the incoming water to promote a degree of mixing to enhance the water quality.

I.1.4.5 Water Quality

The Authority is carrying out its own assessment of the water quality changes that could be expected to take place in stored Test water. The reservoir has very similar characteristics to those of Farmoor Reservoir on the River Thames.

	<u>Site B/C to 8m</u>	<u>Farmoor</u>
Volumes	$6.8 \times 10^6 \text{ m}^3$	$4.5 \times 10^6 \text{ m}^3$
Area	54.5 ha	50.6 ha
Mean depth	12.5m	9.2 m
Length of Shore line	4.5 kms	2.5 kms

It is unlikely that a reservoir on Site B/C will have the water quality problems of Farmoor because the nutrient level of the River Test is lower than that of the River Thames. It should be noted in passing that Farmoor, highly entrophic though it is, has been able to cope with all but a few blooms of algae at the worst periods. This has been achieved through a typical modern treatment plant, with micro-straining as well as filtration provision, and through an inbuilt flexibility with a variable draw-off and bypass system to the river. In addition, it is proposed that in Farmoor II, now under construction, the water should be maintained with a different biological quality, at least temporally, so that the peaks of algae blooms do not coincide with each other. This can be provided for by developing Site B/C as two separate reservoir sites.

The full details of the water quality assessment must await the Authority's findings which will dictate the scale of the treatment plant and management works. In the meantime, the estimates of cost have assumed that the treatment costs will be no different to those incurred in treating water from any other reservoir site.

1.1.4.6

Landscaping

Landscaping and tree planting will play a particularly important role in the overall development of Site B/C. This is partly because its gradual development over a long period will allow the forward planting of trees to mature in time to mask and soften the development and partly because these and the existing trees are quite large in scale, compared with even the highest bund projected to rise 8m above the valley floor. This is demonstrated in the photomontages, Figs.II.1, 9, 10 and 11, which show views of a completed development from various view points. Indeed,

so flat is the whole topography that it is difficult to find any view point of the reservoir that would give the observer much sense of a great expanse of water.

Nonetheless, the construction of the reservoir would represent a change in the form of the valley and its design should be carefully and sympathetically considered.

II.1.4.7 Recreation, Amenity and Other Uses

Part of the site is in an area of special scientific importance situated on the lower Test from Nursling Mill down to tidal waters. It is not thought that the provision of a reservoir on Site B/C would be detrimental for although it would slightly reduce the extent of the existing habitat, it could also provide a new fresh water lake environment which would in itself be of interest.

The area is close to urban areas and therefore would come under pressure as a centre for leisure and recreational pursuits. There is a shortage in the area of coarse fishing facilities, of inland sailing and any form of freshwater sport. All these should be catered for wherever they do not conflict with the proper management of a reservoir. Again, the development of two reservoirs together may allow activities that perhaps could not otherwise co-exist such as water skiing, canoeing, sailing and angling.

II.1.4.8 Planning

It is understood that the local planning authorities would tend to favour this site in preference to others in the Test and Itchen Valleys that are more remote from existing developments and therefore more intrusive into the valley landscape. In addition, access to the highway work is reasonable.

II.1.4.9 Tentative Programme

As has been indicated before in this Report, reservoir development on Site B/C would take a considerable time to reach its full capacity. One possible programme might be as follows:-

<u>Year</u>	<u>Operation</u>	<u>Capacity</u>
1978	Start	-
1978-80	Planning, Design and Negotiations	-
1980-83	Public approval and permissions	-
1983-85	Preliminaries to gravel extraction	-
1985-88	Gravel extraction to south at 200,000m ³ /year	-
1988	First stage	1.1Mm ³
1988-90	Gravel extraction to north at 200,000m ³ /year	1.1 0.8 Mm ³
1990-92	Raising southern reservoir bunds	0.8Mm ³
1992	Storage in the south	4.0Mm ³
1994-96	Raising northern reservoir bunds	4.0Mm ³
1996	Storage in the north complete	7.5Mm ³

Notes - Landscaping and tree planting can take place from 1979.

- Diversion of the gas main would occur in 1988
- Diversion of the low voltage lines across the southern part of the site in 1990.
- Diversion of the 450kV line parallel to the M27 is only necessary in 1994 if northern phase exceeds 4m in height.

This programme shows a gradual increasing capacity developing to a total of about 7 million m³ over the next 20 years. The actual rate of development can be tailored to suit actual developing needs.

II.1.4.10 Summary of Quantities & Estimates of Costs for B/C

The tables of quantities and estimates overpage in Fig.II.1.12 is broken down into phase by phase detail so that modifications can be accommodated without re-working.

It should be noted that the overall costs do not necessarily relate particularly closely to those derived in the previous engineering reports on the site investigations. This is because of design changes, additional requirements for water control and landscaping and cost updating. Because these changes are common to all sites, the general relationship between each will not be changed.

II.1.4.11 Summary of Estimates

From Fig.II.1.12 it can be seen that:-

- (i) Total cost of developing B/C to store 7,500,000m³ in a number of stages is £ 7,430,000
- (ii) In this case the top water level is 10.5m O.D., bund height approximately 8m above ground
- (iii) Over all cost per cubic metre stored is £0.99/m³
- (iv) Cost per cubic metre stored for southern pit alone is £0.37/m³
- (v) Volume of commercial gravel released 1,200,000m³
- (vi) Total volume of spoil off site 2,020,000m³

Further arrangements with bund water level varying between 3m O.D. (pit level) and 10.5m O.D. will give a total expenditure graph similar to that shown in Fig. II.1.13.

Summary of Quantities, rates and estimates for B/CDiversion of River Blackwater to west and final water level + 10.5

Item		Quantity	Rate	Estimated Cost
			£	£1000
<u>Excavation of southern pit</u>				
1.	Diversion of River Blackwater	sum		100
2.	Topsoil and peat to spoil area	m ³ 600,000)	zero	-
3.	Gravel to industry - 90% recovery	m ³ 800,000)		
4.	Perimeter bentonite cut off 10 m deep	m 2,300	100	230
5.	Gravity inlet leat with manual sluice control	1 No	sum	10
6.	Standby mobile pumping facilities direct to Testwood		sum	20
7.	Landscaping, planting & environmental work		sum	20
Sub total:				£380,000
Volume of water stored in this phase		m ³ 1,100,000		
<u>Excavation of northern pit</u>				
1.	Diversion of gas main			180
2.	Topsoil and peat to spoil area	m ³ 500,000	0.2	100
3.	Gravel to industry - 90% recovery	m ³ 400,000		
4.	Perimeter bentonite cut off, 10m deep	m 2340	100	230
5.	Gravity inlet leat with manual sluice control	1 No	sum	10
6.	Standby mobile pumping facilities direct to Testwood		sum	20
	+ 1000 Ø pipeline	m 1000	150	150
7.	Landscaping, planting & environmental work		sum	20
Sub total:				£710,000
Volume of water stored in this phase		m ³ 800,000		
<u>Raising southern pit with 8 m bunds</u>				
1.	Peat to spoil	m ³ 210,000	1.0	210
2.	Store, spread & seed topsoil	m ³ 50,000	1.0	50
3.	Bund materials - drainage layers & shoulders	m ³ 150,000	1.5	230
	excavated, placed - impermeable material	m ³ 1,000,000	1.5	1,500
	compacted etc. - unsuitable materials to spoil	m ³ 250,000	1.0	250
4.	Wave protection - nylon netting over gravel	m ² 1,000,000	0.3	300
5.	Water control wks for } - river intake		sum	150
	300 mld (i.e. for the } - pumping station		sum	600
	full 200 demand from } - conduit & draw off			
	River Test } tower		sum	150
				300
	- pipe to Testwood			
6.	Landscaping, planting & environmental work		sum	100
7.	Diversion of services		sum	100
Sub total:				£3,900,000
Total volume of water stored in this phase		m ³ 4,000,000		

Item		Quantity	Rate	Estimated Cost	
Raising northern pit with 8m bunds				£1050	X
1.	Peat to spoil	m ³	280,000	1.0	280
2.	Topsoil to stack, spread and seed	m ³	40,000	1.0	40
3.	Bund materials - drainage layers & shoulders		130,000	1.5	190
	excavated, placed, - impermeable material		740,000	1.5	1,100
	compacted & married - unsuitable material to spoil		180,000	1.0	180
4.	Wave protection - nylon netting over gravel	m ²	1,000,000	0.3	300
5.	Water control works - 2nd 1000 Ø pipeline	m	700	150	100
	to link up with s. - conduit & drain off tower pumping station			sum	150
6.	Landscaping, planting & environmental work			sum	100
	Sub total				£2,440,000
	Total volume of water stored in this phase	m ³	3,500,000		

SCHEMATIC DESCRIPTION OF MAIN RESERVOIR TYPES IN TEST AND ITCHEN VALLEYS

FIG. 1.1

 ORGANIC SPOIL
  OVERBURDEN
  SAND AND GRAVELS
 WATER TABLE
  IMPERMEABLE STRATA

EXTRACT FROM INITIAL REPORT 1975

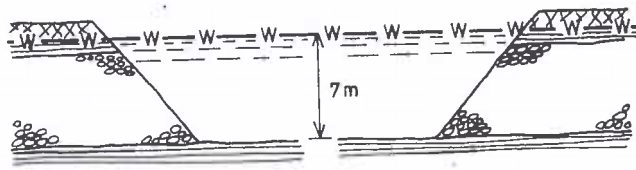
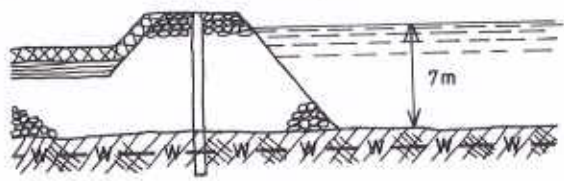
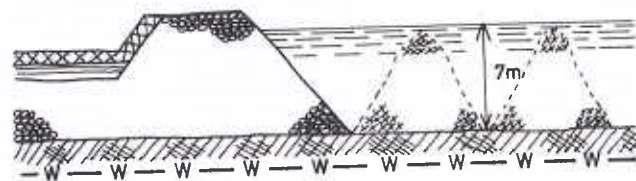
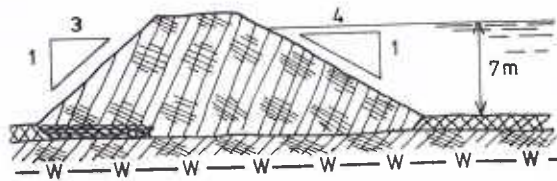
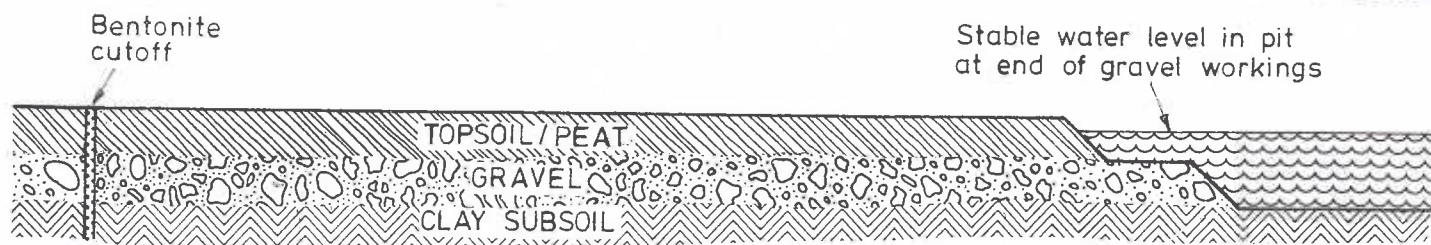
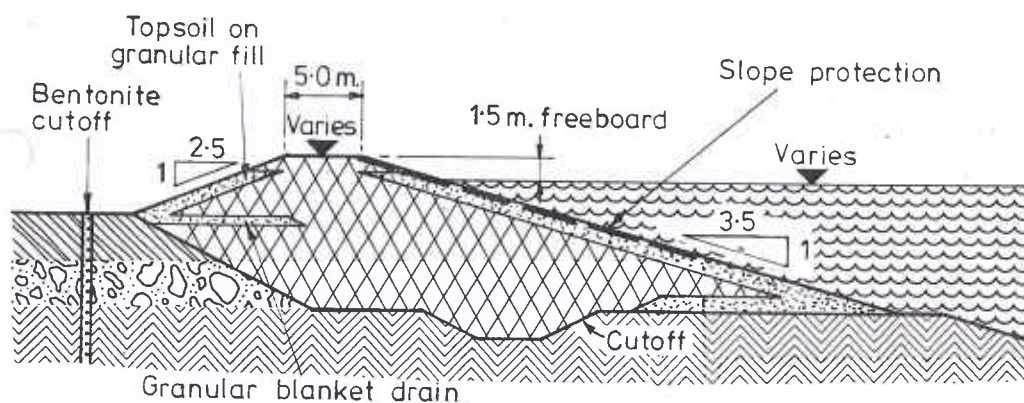
Geological Condition	Reservoir Type	Section	Description	Comparative Cost. £
1	Type 1		Reservoir excavated in aggregates to 7m. min. below water table. No cutoff required as gravity inflow acceptable. Direct gravity inflow. Water meadows do not function as flood plain	zero  1.2m
2	Type 2		Reservoir excavated in to shallow aggregates; top water level above water table. Bentonite/cement cutoff to impermeable stratum (or diaphragm wall; inflow pumped or via gravity canal	0.9m  1.6m
3	Type 3		As type 2 but aggregates already worked out. Costs as above, plus cost of removing spoil	1.9m  2.2m
4	Type 4		Reservoir of impermeable bunds on impermeable base.	1.9m

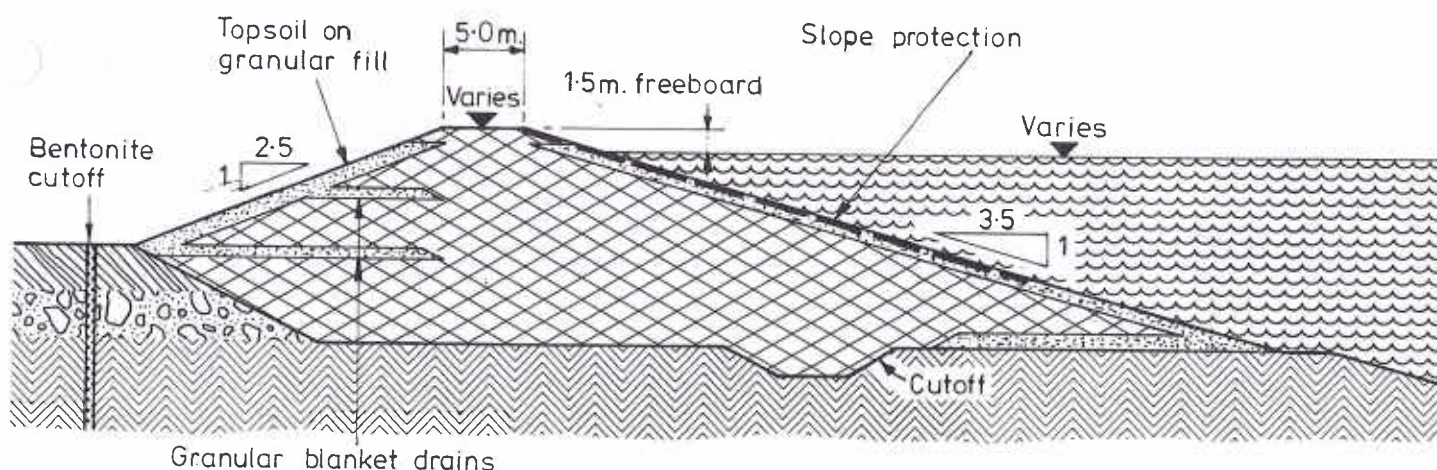
FIG. II.16.



1. Site worked out by gravel company and Bentonite cutoff constructed through gravels to clay.



2. Section through 4.0 m. high embankment.



3. Section through 8.0 m. high embankment.

SCHEMATIC SECTIONS OF
SITE B/C BUND AT VARIOUS
STAGES OF DEVELOPMENT

HAMPSHIRE - SUMMARY OF LABORATORY TESTS - SITE NUMBER C

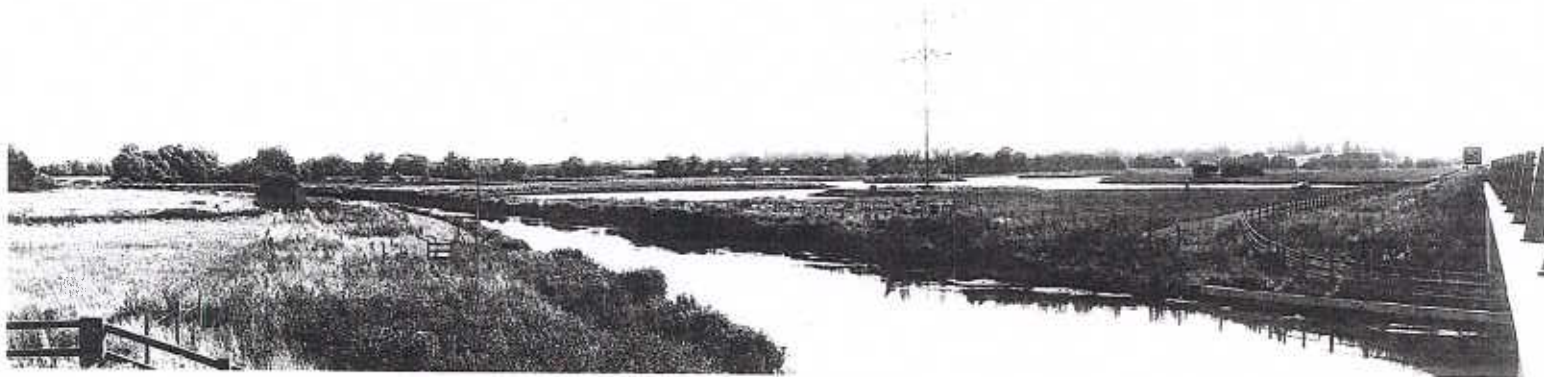
BOREHOLE	SAMPLE	Depth m	Nat mc %	LL %	PL %	PI %	SHEAR STRENGTH				COMPACTION				GRADING			
							Test Type	C' kN/m2	ϕ°	Cu kN/m2	Opt mc %	Max γ_d Mg/m3	Nat-opt mc %	Nat mc - PL %	CLAY %	SILT %	SAND %	GRAVEL %
C1	10	3.0															9	91
C1	17	6.7	22	53	19	34	CU	23	24		17	1.72	5	3	27	63	10	
C2	10	4.0															5	95
C2	20	7.5															57	43
C2	25	10.0															100	
C3	5	2.0															8	92
C3	10	4.0															24	76
C3	12	5.0	20	51	18	33	CU	18	17						20	65	15	
C3	13+15	5.5+6.0	19								15	1.76	4					
C4	9	3.5															24	76
C4	19	7.5															15	85
C4	23+24	8.8+9.2													2	20	60	18
C4	26	10.0	18	51	16	35	CU	13	26						24	63	13	

FIG. 17A.

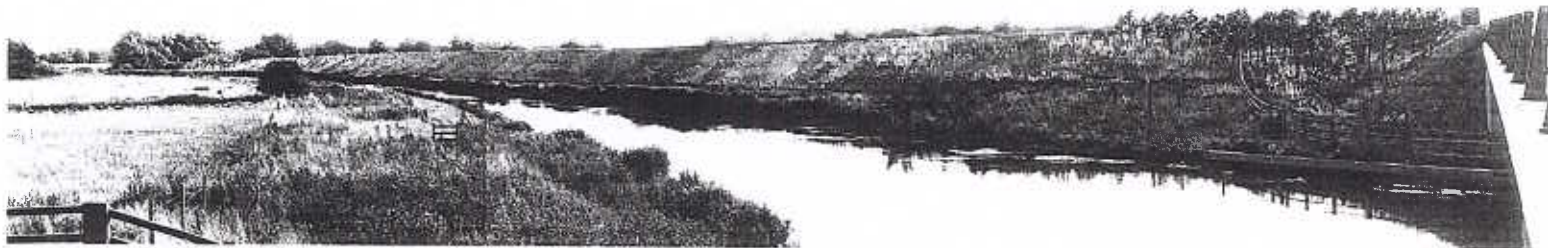
FIG. II.17A.



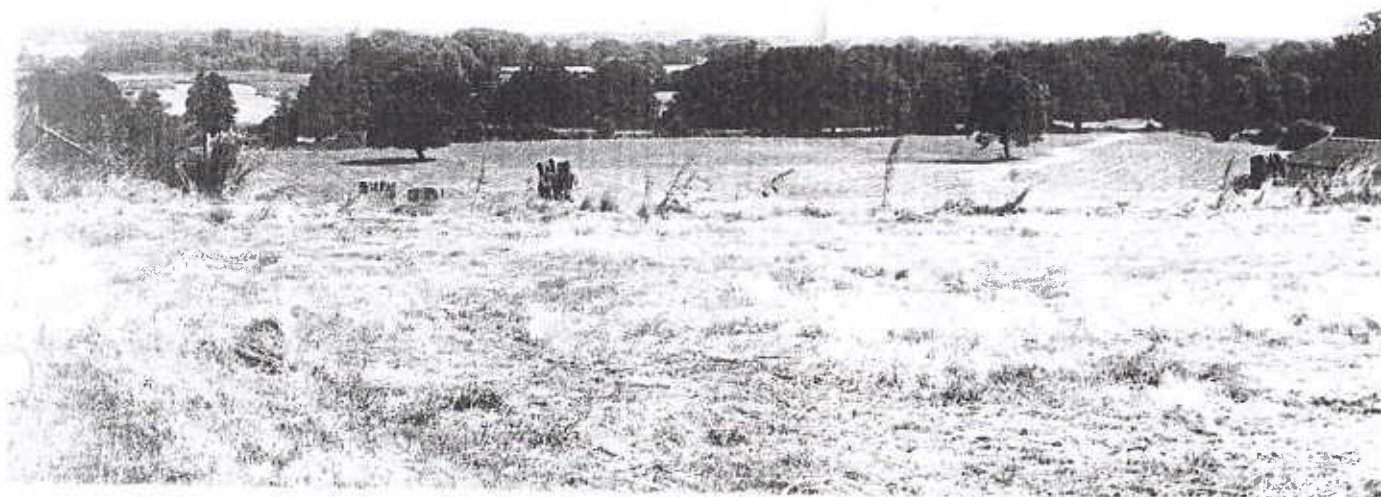
View southward from the M27 River Test Bridge: 1977



The same view showing the first phase reservoir. (4m bund)



The final reservoir's 8m bund seen from the motorway.



View from Colbury House today.



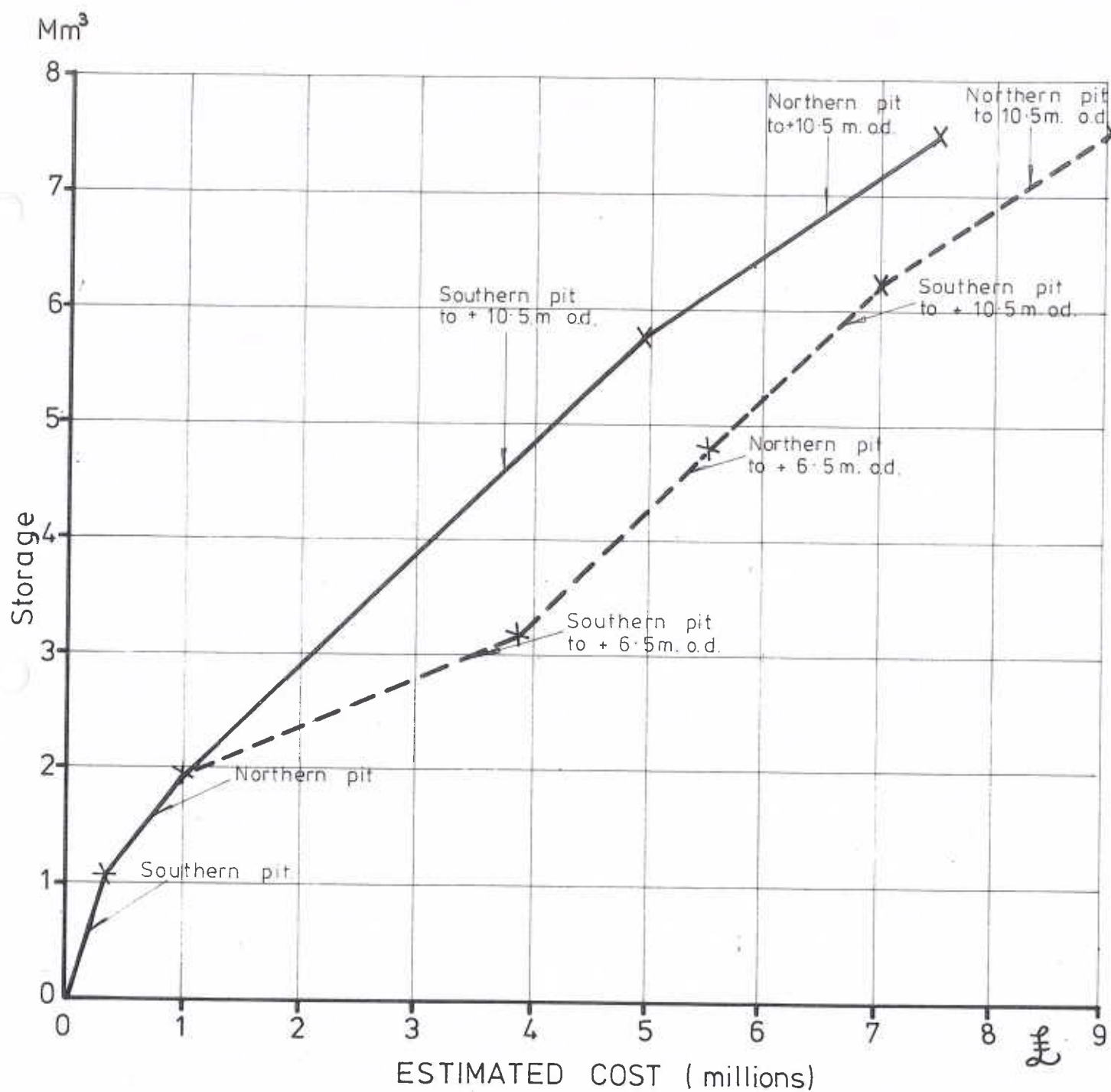
Same view of the final reservoir.



View from the River Test bridge at Nursling Mill: Present day.



The alder trees are an effective screen at all stages. Final 8m bund shown.



GRAPH SHOWING ESTIMATED COST OF INCREASED STORAGE ON SITES B&C

SECTION II - PART 2

TEST - OTTERBOURNE PIPELINE

- II.2.1 General
- II.2.2 The Route
- II.2.3 Ground Conditions
- II.2.4 Estimates of Cost
- II.2.5 Summary

Figures

- II.2.1 Plan of pipeline corridor from Testwood to Otterbourne
- II.2.2 Summary of estimated Pipeline Costs.

II.2.0 TEST-OTTERBOURNE PIPELINE

II.2.1 General

It has been shown, and will be repeated in detail in Section II.5 of this Report, that the facility to transfer water from the River Test to the Itchen system at Otterbourne is a major resource in its own right. Consequently, a general desk study was made of possible pipeline routes and construction problems in order to estimate the total cost of such a resource. This preliminary study was completed and presented to the Authority in October 1977.

The pipeline could be operated in a number of ways, namely: direct transfer of raw water from the Test to the Itchen, transfer of raw water from the Test for treatment at Otterbourne, transfer of treated water from the Testwood works, or the delivery of raw water to Site 8 if that was developed. To meet all these conditions, the pipeline has been taken to run from the Testwood works to the Otterbourne works. No allowance has been made of any modifications that would be required with these works since they would in general be common to any scheme to increase supply.

II.2.2 The Route

The general corridor selected for the pipeline is shown on Figure II.2.1. The actual route costed in detail is shown following the existing utility corridor to the north of Chilworth. From starting at the Testwood Treatment works, it runs north east towards Rownhams, crossing the railway and M271 by thrust bored crossings on the way. The M27 is crossed at a point where it is on a slight embankment, near Aldermoor Copse, to facilitate a thrust bored crossing. The route passes north of Chilworth and crosses the Bournemouth road just south of the electricity station. This section is already subject to negotiation

for another water mains, and part is scheduled for future housing. The A33(T) is crossed near the subway in Northend Copse, from where the pipeline skirts to Fleming Park Golf Course, before heading northwards. There is a thrust bored crossing of the Romsey/Eastleigh railway after which the route passes between the Boyatt Wood and the A33(T), then through Allbrook to finally follow the railway line northwards to the Otterbourne Waterworks. This is all shown in detail on the photographic record of the walkover. The alternative route shows a short deviation to enable a link to be made to Site 8 if it were constructed.

II.2.3 Ground Conditions

From information supplied by the Institute of Geological Sciences, it is known that the pipeline crosses an area made up of entirely unconsolidated Drift and Tertiary deposits. The extent of these deposits is shown together with the route of the pipeline in Figure II.2.1 .

Extensive river deposits consisting of modern alluvium and an older river terrace gravel will be encountered at the south western and north eastern ends of the pipeline. The alluvium frequently consists of silty and sandy clays, sometimes with peat, usually overlying a gravel. A borehole put down for the previous site investigation near the railway line at Manor House, Otterbourne revealed 1m of made ground and 2.9m of peat lying on 2m of sandy gravel. A borehole alongside Monks Brook in Eastleigh, again in the alluvium, showed 2m of grey very silty clay on 1m of gravel with grey sandy clay lying on 1.5m of compact light brown gravel and sand. The older river terrace deposits consist mainly of gravel but frequently with a loamy top and borehole indications at the Nursling end of the corridor show thickness of gravel up to 5m. Where these river deposits are encountered the ground will have a high water table and any excavation will be wet and may require dewatering.

These are the lengths from 0 to 1.3kms, 10.4 to 10.8 kms, and 14.1 to 15.8 kms.

Small patches of plateau gravel are scattered on the higher ground along the route and these are liable to be highly variable in thickness due to the amount of erosion that has taken place.

The Bracklesham Beds in this area consists mainly of silty clayey sands and silty sandy clays which are green or bluish green at depth but near the surface, due to weathering, are frequently a yellow brown colour. These clays and sands can be soft near the surface but become stiffer with depth. Some thin bands of green running sand may also be encountered in this formation,

Coarse to medium sands with only a small clay content are the main deposit of the Bagshot Beds, although particular masses of pipe clay may occur within the sands. These deposits act as running sands if they are water logged, thus the ground water conditions in these deposits are very important.

The London Clay consists chiefly of a blue-grey sandy clay with some beds of clayey sand. This weathers down near the surface. This material may be soft near the surface but may become quite stiff within one or two metres of the surface.

The Reading Beds consist chiefly of grey red mottled plastic clay which sometimes contains extensive verticular masses or brown to yellow coarse to medium sand.

A small outcrop of chalk occurs to the extreme north east of the pipeline and is likely to be rubbly and soft with many flints.

It should be remembered that the geological map upon which Figure II.2.1 was based was made last century before any mechanical aids to geological mapping were used and thus some of the boundaries may show considerable error.

Ground conditions are thought generally suitable for the construction of the pipeline although wet conditions will be encountered in the river deposits and it is thought there may be bad ground conditions where the pipeline crosses the motorway at 3.0km.

II.2.4 Estimates of Cost

The pipeline size has been taken as 1,000mm I.D. with an ultimate capacity of 135Ml/d. The pumping station has been costed with this capacity in mind, but with the pumping and ancillary equipment installed in three equal stages of 45Ml/d.

Figure II.2.2 summarises the characteristics of this route and gives the unit costs used. The pipeline is estimated to cost £2.8m and the pumping station £0.5m.

II.2.5 Summary

It is recommended that consideration is given to reserving a pipeline route from the Test, in much the same way that the reservoir sites have been reserved. The detailed route shown on Figure II.2.1. may provide a basis for fixing such a reservation.

Summary of Estimated Costs River Test to Otterbourne

<u>Pipeline</u>		<u>Unit Rate</u>	<u>Estimate</u>
Total length	16.00kms	£150,000/km	£ 2,400,000
Extra for:-			
Peats & other saturated soils	6.00kms	£ 20,000/km	£ 120,000
Woodland	3.40kms	£ 4,000/km	£ 13,600
Under road	0.65kms	£ 30,000/km	£ 19,500
Urban site	0.90kms	£ 56,000/km	£ 50,400
Thrust bored crossings	175m	£ 500/m	£ 87,500
River crossings	30m	£ 1,000/m	£ 30,000
Other items		sum	£ 35,000
<u>Pipeline Total</u>			<u>£ 2,756,000</u>
<u>Pumping Works</u>			
Intakes and Pump Houses	135Ml/d	£ 2,500/Ml/d	£ 340,000
Pumpsets (45Ml/d)	51 w.h.p.	£ 300/w.h.p.	£ 160,000
<u>Pumping Works Total</u>			<u>£ 500,000</u>

SECTION II - PART 3

SITE 18

- II.3.1 Background to the Investigations on Site 18
- II.3.2 The Scope of the Site Investigation
- II.3.3 Interpretation of the Soil Data
- II.3.4 Plans, Sections and Details of the Scheme
- II.3.5 Pipeline
- II.3.6 Landscaping and the Environment
- II.3.7 Amenity and Recreation
- II.3.8 Programme and Cost
- II.3.9 Conclusion

Figures

- II.3.1 Typical section of embankment on Site 18 as put forward by Prof. Rowe.
- II.3.2 Plan and geological Sections through 18
- II.3.3 Summary of Results of Laboratory Tests
- II.3.4 Typical Section of embankment on 18.
- II.3.5 Plan of reservoir on Site 18 (Solution 1)
- II.3.6 Plan of reservoir of Site 18 (Solution 2)
- II.3.7 Table of quantities, rates and estimates for Site 18.

II.3.0 SITE 18 *NAVANT THICKET*

II.3.1 Background to the Investigations on Site 18

As far back as the early 1960's, the Portsmouth Water Company had identified Site 18 as a possible reservoir site. In 1965 they purchased the land from the Forestry Commission for this purpose. A detailed site investigation carried out in 1963 resulted in Professor Rowe putting forward specific proposals for the development of the site. He proposed the typical section shown in Fig. II.3.1. The numerous blanket drains and sand wells were introduced in order to lower the high anticipated construction porewater pressures and assist in the consolidation of the foundation materials. This would increase the factor of safety of the embankment which was to be built and on top of materials characterised by values of ϕ' as low as 16° .

In 1965 Herbert Lapworth Partners produced a whole range of reservoir sites in Hampshire. Certain preferred sites were selected by the authorities for reservation against future development. These included Site 18.

Over the years the timber has been felled wholesale and the site is now almost completely cleared, only Middle Clearing remaining standing.

The preliminary desk studies carried out during the current investigation confirmed that all other things being equal, Site 18 offered the most economical storage. In addition, as discussed in Part I, Site 18 is strategically well located, being to the east of the demand area and the other side from the major source at Gaiters Mill. The preference for Site 18 is borne out by its high rating on the matrix of potential (Fig I.5) (only site 20 equals it), together with its other scenic advantages, cost, location and ownership and landuse which are not perhaps reflected adequately in this coarse version of the matrix.

II.3.2

The Scope of the Site Investigation

In view of the work already carried out on this Site and referred to in previous paragraphs, the field work included in the 1977 programme was designed to fill the gaps in the data already available from the earlier work and only four boreholes were put down. Two of these were positioned fairly close to the earlier holes, in order to check on the correlation between the two sets of data, the other two being located so as to provide data on a possible variant on the plan layout.

II.3.3

Interpretation of the Soil Data and the Design of the Embankment

As stated earlier, the desk study showed that, all other things being equal, site 18 appeared to be economically advantageous compared with the other East Hampshire sites. However, not all other things were found to be equal in fact and it may be as well to examine and discuss these inequalities before proceeding to the design approach.

Professor Rowe had already reported unusually low values of the shear strength parameter of ϕ' in some of the samples tested in the earlier study; indeed, he commented that some of the recorded values were the lowest in his experience. A more detailed discussion of these values, compared with tests carried out from samples obtained in the 1977 investigation, will be found in the Engineering Report on the East Hampshire sites, but the conclusion - which is relevant here - is that certain of the test results give rise to the suspicion that the samples contained zones or surfaces which had already undergone some

degree of shear strain in their geological history, resulting in laboratory shear strength results which might lie somewhere between the so-called "peak" and "residual" values; the former being the values which would be obtained for identical materials which had not suffered previous deformation, the latter being the values applicable to surfaces which had already undergone sufficient deformation to reduce the shear strength parameters to the lowest value possible for the given material. There is insufficient evidence at present on which to base a firm opinion as to how typical these low shear-strength samples may be, or whether any of these postulated shear zones occur in a sufficiently systematic orientation to demand the application of ultra-low values for the foundation in any stability analysis. Such a cautious approach would be unusual, though not without precedent; it is suggested that it would only be justified on the basis of substantially more complete evidence than has been obtained in the 1977 study, or would have been justified for the purposes of anything less than a full-blown, final design exercise. Instead, it has been decided that for the purpose of this Report, the typical cross-sections for this site should be taken as somewhat flatter than those used in the consideration of the other East Hampshire sites (all of which, apart from Site 20, exhibit somewhat lower in-situ shear strength properties than the Test and Itchen sites) and it will therefore be seen on Figure II.3.4 that, for estimating purposes, a token 0.5 has been added to the cotangent of the upstream and downstream angles, by way of taking account of the possibility that the embankment design might require to be somewhat more conservative than the others. This simplified approach has been adopted in preference to the use of a basically different design such as that advanced by Professor Rowe, mainly because it makes subsequent adjustment of cost estimates - for comparative purposes - a good deal simpler and partly because, apart from the specific problem here of possible

sheared or partially-sheared zones, there is a more or less equal possibility of the emergence of somewhat more sophisticated designs emerging from more detailed final design studies, whichever site is finally developed.

As explained in the Engineering Report, some of the more tangible evidence of this possible problem on Site 18 has only fully emerged in the few weeks preceding the presentation of the present Report, and this has had the effect of modifying to a certain extent some of the preliminary conclusions put forward in discussion with the officers of the Authority during the regular progress meetings preceding the presentation of this Report.

The second design problem which is more or less peculiar to Site 18 is represented by the Basal beds, between the Reading and London Clays, which outcrop on a line running across the proposed reservoir and intersecting the line of the embankment dam (this applies equally to the two alternative layouts considered). This stratum is water-bearing and has been found to exhibit a small artesian pressure in the lower part of the valley. Because it crosses the line of the embankment it represents a potential cut-off problem, and here again the optimum solution would be a matter for a more detailed study in the design stage. Briefly, the two alternative methods of treating it would be by means of grouting or by means of a surface "blanket" sealing the outcrop over the full extent of the reservoir area. In purely technical terms, the latter is the simpler method to define and would be the more positive, provided that it were properly linked into the embankment itself, more or less as per the tentative cross-section put forward by Professor Rowe (though it is suggested that this feature of the embankment cross-section might well be local only, giving way on either side to the simpler cross-section which has been taken as the typical one for this Report). Given the semi-intimate permeable zone represented by the Basal beds, dipping at about 5 degrees only, a grouted solution would not, theoretically, be 100% positive whatever

its extent, though it seems highly likely that a practical limit could be found, capable of performing quite satisfactorily. For estimating purposes, the "blanket" solution has been taken and included in the estimated cost of either of the alternative developments considered for this Site.

The sand drains in the foundation, proposed by Rowe, are certainly not without precedent and are not discounted here as a possible method of improving foundation strengths by assisting in the process of consolidation under the embankment, during and after construction. However, they are not shown in the proposed tentative typical cross section, nor has any provision been made for them in the cost estimates, because on the balance of all the evidence available it seems to be an open question (a) whether the dependable foundation shear strengths are in fact going to constitute a major design factor; (b) whether the answer to (a) would apply to both the Reading and London Clay which occur under the two lengths of the dam provided by the Basal bed outcrop; and (c) even if so, whether a very large number of sand drains (also, incidentally, incorporated under the embankment at Impingham reservoir) necessarily constitute the most economical solution compared with the use of flatter slopes, berms or other expedients, particularly in view of the relative smallness of embankment over a substantial proportion of its length.

Particular attention should also be drawn, especially in this case, to the relative points allotted in the matrix, as between environmental, amenity and similar factors on the one hand, and possible design problems on the other. Whilst the figures entered in the matrix represent the best and fairest assessment against each parameter out of its own individual maximum of 5 "points", it has already been pointed out that the relative weighting allocated to each parameter is very much a matter of subjective judgement. Where, as in the case of this site, design problems have been identified

and feasibility demonstrated, but where the actual design solution requires subsequent special study so that the cost estimates lie within somewhat wider confidence limits at this stage than do the estimates for developments at the other sites considered, it may be that the rating allocated to present design unknowns is not adequate to stand up to the numerical weight allocated to the other factors, which in any case cannot be expressed in the same units - at least in the present state of the art.

The question may perhaps arise, whether a more detailed study of the two special problems applying to Site 18 would be justified as a supplementary exercise arising from the present Report. Such a study, concentrating upon the cut-off problem and the definition of safe working shear strength parameters in the foundations, could be put in hand, and might be justified if (a) there is a fair measure of acceptance of the overall strategic concepts propounded in the introductory section of this Report; and (b) if the other relative advantages of Site 18 compared with the other East Hampshire sites are found to be sufficiently convincing to make it highly desirable that a more accurate cost/benefit analysis of one or other - or both - of the two possible developments at this site be obtained at this stage of the Authority's overall resources survey. The soil mechanics problem, relating to foundation shear strengths in particular, might require the technical resources of a university rather than a commercial soils laboratory; in discussion with the engineers involved with the M27 motorway, it appears likely that there is some further technical information which may be available shortly, derived from a recent slip in an embankment forming part of that scheme. A "back-analysis" which the R.C.U. are proposing to carry out might provide at least an interesting analogy with Site 18, though a full study of the problem would probably involve an appreciable number of additional boreholes and a detailed search for slicken-sides in undisturbed samples; a time consuming exercise, and costly, at least in relation to more usual site investigation works.

The earlier study proposed a reservoir 118 ha, in overall extent with a capacity of approximately 8.9 million m³. This solution was found to be the best in terms of volume of storage compared with volume of fill, of all the five sites in East Hampshire. This is shown on Table I below. This general arrangement is shown in Figure II.3.5.

6.3
This study also examined the possibility of a less extensive reservoir (77 ha), of similar depth, (16.5m) with a reduced capacity of 63 million m³. As Table I shows, this alternative has a less favourable volumetric aspect. However, this may not be the determining factor as its weight will be determined by the influence given to all other criteria indicated in the matrix of potential. The smaller arrangement, Fig II.3.6 may be thought to be more appropriate to the site, to leave free land that might otherwise have been flooded and to provide greater potential for expanding the landscaped grounds of Leigh Park and Gardens.

The design and details of the sections are discussed in Sections 3.3 above.

Permanent public access to the site and its facilities may be made readily available from either Swanmore Lane as ^{was} its western boundary, or from Middle Parkway ^{Road} to the south. The reservoir construction will not generate a great deal of road traffic except for the supply of 150,000 tonnes of gravel. (The A3 (M) would give ready access to marine sources). Owing to the large concentrations of residual ^{residual} areas in the immediate vicinity of the reservoir, safety considerations will determine that all water control, inlet and outlet structures are completely inaccessible to the public. These will probably all be concentrated in a freestanding draw-off tower.

This site has only a small natural catchment of 240 ha.

TABLE I

Table Comparing the Ratio of the Water Storage
to Embankment Fill for Sites 15, 17, 18, 19, & 20

<u>Name of Site</u>	<u>Number of Site</u>	<u>Ratio</u>
West Walk	15	7.5
Boarhunt	17(1)	2.9
Boarhunt	17(2)	8.0
Boarhunt	17(3)	5.3
Havant Thicket	18(1)	12.2
Havant Thicket	18(2)	8.0
Southleigh Forest	19	6.2
Southleigh Farm	20	4.2

II.3.8 Programme and Cost

Provided that supplies from Gaiter's Mill are readily available, the need for the development of Site 18 will not arise until late in the 1990's. Within this context there should be adequate time to meet any likely programme. Clearly, the Authority will draw up a detailed programme in due course which will identify the critical points in the overall resource development programme.

The estimate of cost is based upon the table of quantities and rates shown in Fig.II.3.2. This estimate excludes any treatment costs common to all sites, land costs (already owned by the Company).

The total estimated cost at February 1978 prices is estimated to be:-

	<u>Solution I</u>	<u>Solution II</u>
Total Cost	£ 4,094,000	£ Approx. equal
Cost/m ³ stored	£ 0.47m	£ 0.67m

The total natural run-off may be written off against evaporation and seepage so that nearly all the live storage will be fed by pipeline from Bedhampton and Havant Springs.

1.3.5 Pipeline

A general review was made of the possible routes linking Bedhampton Springs to Site 18. It was concluded that the route following the stream running through Havant was the most economical. All pumping plant would be concentrated at the Portsmouth Water Company's existing site. Indeed, there is adequate installed capacity for the first stages of the reservoir development.

The proposed mode of operation is as follows: During winter months and other periods of relatively low demand Bedhampton Spring water would be pumped to Site 18 whilst the remaining demand is met by other existing water sources and an increased supply from Gaiter's Mill. As demand increases so more and more water from Bedhampton Springs would be devoted to supply until eventually the demand calls upon storage from Site 18. This is able to gravitate to the pumping plant at all times and hence to be pumped to Farlington for treatment.

Inevitably, the reservoir water will be of a different quality from the spring water. No great amount of thought has been given in the course of these reservoir studies to the consequent problems but it may be found advantageous to install some sort of preliminary treatment such as micro-straining and chlorination at the reservoir itself so raw water from the two sources is more similar before reaching Farlington. There are already a number of mains linking Bedhampton to Farlington and it may be found that one of these is set aside for Site 18 water so that little mixing takes place until reaching Farlington, where additional capacity and, if necessary, special treatment plant could be constructed. The existing bottleneck on the expansion of supplies is at the treatment works. The Bedhampton/Farlington pipeline, like the pumping plant, has considerable capacity in hand. Thus

the cost estimates for the development of Site 18 include only for the construction of a pipeline from the reservoir to Bedhampton. Full details of the pipeline route are given in the consultant's report entitled " Preliminary Study of Pipeline Routes from River Test to Otterbourne & from Bedhampton to Site 18" and accompanying photographs.

3.6 Landscaping and the Environment

No detailed work has been done on the landscaping of the proposals. In this context, the reservoir may be best seen as an extension to the small lake in Leigh Park Gardens. Additional small lakes could be incorporated wherever the topography allowed as part of the general construction programme. The surroundings should be carefully planted to extend the idea of a public park to which use it will undoubtedly be put in that it is located in an area of high population density.

On the whole, the existing stripped reservoir basin is at present both bleak and unnatural. A reservoir will certainly add to the range of habitat and consequent flora and fauna in the area.

3.7 Amenity and Recreation

It has already been noted that the South Hampshire study found that there is a shortage of fresh water sports in the area, coarse fishing, sailing, etc. There could be great conflict from the competing interests which will need to be carefully integrated so as to ensure the best use of this public resource for the widest sector of the population.

TABLE OF QUANTITIES, RATES & ESTIMATES FOR SITE 18 (SOLUTION 1)

<u>ITEM</u>	<u>QUANTITY</u>	<u>RATE</u>	<u>ESTIMATE</u>
<u>Reservoir</u>			
Mobilisation		sum	£ 100,000
Site clearance of remaining forest	10 ha	1,000	£ 10,000
Stripping under embankments and on borrow area and reusing	200,000m ³	1.50	£ 300,000
Clay embankment material - all costs	900,000m ³	2.00	£1,800,000
Gravel drainage materials	110,000m ³	4.00	£ 440,000
Landscaping and topsoiling		sum	£ 100,000
Wave protection	50,000m ³	2.00	£ 100,000
Cut-off and blanket sealing		sum	£ 300,000
Draw off & diversion works		sum	£ 300,000
<u>Total Cost of Reservoir</u>			<u>£3,450,000</u>
<u>Pipeline</u>			
Total length (700Ø)	3.66km	130,000	£ 476,000
Extra for:-			
Woodland	0.40km	4,000	£ 1,600
Under roads	0.41km	30,000	£ 12,300
Urban site	2.15km	56,000	£ 120,400
Thrust bored crossings	20 m	1,000	£ 20,000
Cut and cover road crossings	105m	100	£ 10,500
Other items			£ 3,200
<u>Total Cost of Pipeline</u>			<u>£ 644,000</u>
<u>Total Cost of Scheme</u>			<u>£4,094,000</u>

Note:- Additional expenditure will be necessary at some later stage to uprate the capacity of the Bedhampton pumps and existing pipelines at Farlington Treatment Works.

Conclusion

On the basis of the matrix, Site 18 is the preferred site. Depending, therefore, upon acceptance of the weighting of the criteria on which the matrix is based, Site 18 is recommended for development as a reservoir should such a resource become needed in East Hampshire.

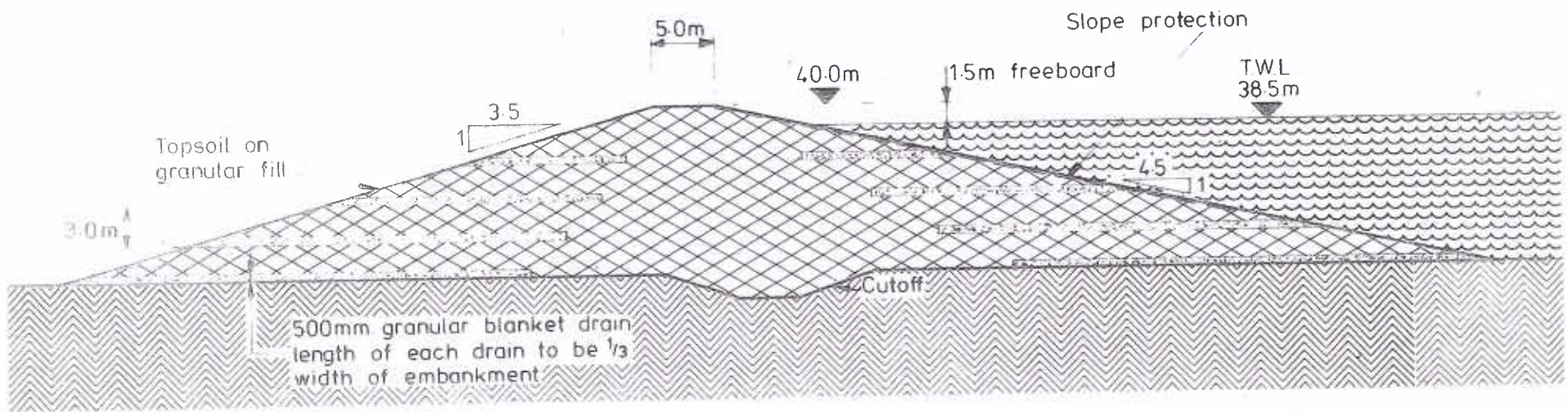
Until the Authority has obtained detailed and final consent for its eventual construction it may wish to keep a standby site in case of unforeseen difficulties leading to the abandonment of Site 18. This should be Site 20 which ranks equally high on the matrix and is as economical as any of the remaining sites.

The Authority will then be in a position to abandon Sites 15, 17 and 19 for reservoir use.

TABLE I.3
EAST HAMPSHIRE - SUMMARY OF LABORATORY TESTS - SITE NUMBER 18

DEPTH m	SAMPLE	Depth m	Nat mc %	LL %	PL %	PI %	SHEAR STRENGTH			COMPACTION				GRADING				
							Test Type	C' kN/m2	ϕ °	Cu kN/m2	Opt mc %	Max/d Mg/m3	Nat-opt mc %	Nat mc - PL %	CLAY %	SILT %	SAND %	GRAVEL %
18/1	3	0.85	30	60	23	37								7	52	43		
18/1	7	2.15	23	66	23	43					21.5	1.65	1.5	0	61	35		
18/1	17	5.40	20	61	22	39					22.5	1.64	-2.5	-2	61	35		
18/2	7	2.15	16	48	16	32								0	41	57		
18/2	19	6.05	16	45	15	30					16	1.79	0	1	28	64		
18/2	27	8.75	16	32	12	20					13	1.84	3	4	23	50	27	
18/3	9	2.9	15	46	17	29	RemCU	12	18					2	55	40		
18/3	11	3.5	18	48	19	29	CU	11	18					-1	61	34		
18/3	15	4.7																
18/3	17	5.3	15	55	15	40								0	30	65		
18/3	32	10.1	16	54	18	36					17	1.76	-1	-2	40	58		
18/4	3	1.1	30	86	28	58								2				
18/4	7	2.3	30	72	27	45	CU	18	20					3	60	38		
18/4	11	3.5	33	98	31	67								2	65	31		
18/4	15	4.7	27	79	26	53								1	45	47		
18/4	17	5.3	28	71	25	46	DS	55	16					3	53	45		
18/4	25	7.7	26	63	19	44								7				
18/4	31	9.5	25	71	21	50								4	55	43		
18/4	39	11.9	27	NP	NP	NP									5	37	58	
18/4	51	15.6	16	46	16	30								0	49	42		

FIG. II. 3.3.



TYPICAL SECTION THROUGH EMBANKMENT

SECTION II - PART 4

ADDITIONAL SITES IN THE SOUTHAMPTON AREA

II.4.1 Site 8

II.4.2 Site 12 and Site 1/2

Figures

II.4.1 Location of borehole positions on Site 8 and log of holes.

II.4.2 Plan and Section of reservoir on Site 8.

II.4.3 Location of borehole positions on Site 1/2 and log of holes.

II.4.4 Location of borehole positions on Site 12 and log and holes.

II.4.5 Plan and Section of reservoir on Site 1/2

II.4.6 Plan and Section of reservoir on Site 12.

II.4.0 ADDITIONAL SITES IN THE SOUTHAMPTON AREA

II.4.1 Site 8

II.4.1.1 General Introduction

This site is the "maverick" of the Southampton sites. The comparative evaluation of all the sites on the Test and on the Itchen has assumed common, or similar, constraints. In principle, each site is adjacent to the river from which it draws its storage and to which it releases water for abstraction downstream. This is not so with Site 8 which is astride Tanner's Brook perched up high in the hills between the two main rivers.

The value of Site 8 will depend upon how it can be incorporated into, and be of benefit to, the eventual overall arrangement of mains in the Southampton area. Without substantial advantages derived in this way, Site 8 is rather low in the order of preference. Even with the full cost of the pipeline covered by the Test/Otterbourne Link, its relative cost is still more than 10% greater than that of providing storage on Site 1/2. On the other hand, compared with this, Site 8 is able to provide some protection to the abstraction at Testwood, although not to the full extent that can be met by Site B/C, because of the limitations of pipeline capacity.

II.4.1.2 Site Investigation

A total of ten boreholes were drilled on this site to retrieve samples of the predominantly clayey Tertiary strata (Fig.II.4.1). Laboratory tests revealed that many of the problems which have been discussed on Site B/C and Site 18 may be expected here. Consequently, a basically similar embankment section has been adopted, apart from the obvious differences attributable to the adjacent water courses at B/C. The scheme shown in Fig.II.4.2 envisages the water levels in the northern and southern halves of the reservoir

as being equal. The existing culvert under the M27 embankment will be sufficient to accommodate the corresponding flows. However, the motorway embankments will have to be supported with free-draining shoulders so as to maintain stability. These, together with the drainage zones on the main dam, will require an estimated 50,000 tonnes of gravel to be brought to the site.

II.4.1.3 Other Design Details

Services

Twin sewers and twin water mains run down the valley at the embankment site. Rerouting of these accounts for 20% of the total estimated costs.

Motorway Service Station

Special care will have to be taken to ensure that there is no spillage of pollution from either the M27 or its service station, as both of whose drainage systems at present fall towards the centre of the valley.

Natural Catchment

Site 8 has a natural catchment of 610 ha. This contains about 100 ha. of housing and other development and some industrial units, at least one of which has been the cause of significant pollution in the past. Discussions with the Drainage Division are proceeding to safeguard this plant in future and the resulting measures would have to be implemented before impounding.

Amenity and Environment

Site 8 is rated as having some ecological worth, more so than other sites. It is thought that although the habitat will change, it will nonetheless remain of considerable interest.

*

Like all other sites, Site 8 has a recreational and amenity potential which will need careful detailing to be completely realised.

II.4.1.4 Recommendation

Site 8 should be kept until the availability of Site B/C is clarified. Then it may be disposed of, studied in further detail, or kept until pressure for alternative and preferential development makes it essential for an irrevocable decision to be made.

II.4.2 Site 12 and Site 1/2

II.4.2.1 General Introduction

Each of these sites give useful amounts of storage at reasonable cost. Neither is a first choice, Site 1/2 because of the preferred Site B/C and Site 12 because of the prohibition imposed by birdstrike. There are also other problems at Site 12, discussed in the 1976 Report. On the other hand, neither are likely to be developed in any other way since both lie in the river valleys which have been identified as important elements of the countryside in south Hampshire, on which only essential and sympathetic development will be permitted. Therefore, there is no particular reason why the Authority should not keep some sort of option on these Sites so that it has a reserve, should other schemes be discarded or demand increase unforeseeably.

II.4.2.2 Site Investigation

On Site 1/2 a total of 9, and on Site 12 a total of 10, boreholes were put down. The results and boreholes are shown in Figures II.4.3 & 4.

In general, the design of the bunds on each of these sites will be similar to that for Site B/C which was discussed in detail in Section II.1. Site ~~1/2~~ has a rather

sandy/silty base which may result in fairly high seepage loss that will emerge in the River Itchen downstream, but which may have to be made good by pumping to maintain storage levels.

No further design development work has been done on either of these sites since the completion of the November 1976 Report and the limitations reported there should be read in conjunction with the above brief notes.

The arrangement for each of these sites proposed in the detailed engineering report (1976) is reproduced in Figure II.4, 5 and 6.

SECTION II - PART 5

HYDROLOGY

- II.5.1 Mander, Raikes & Marshall Memorandum of July 1977
- II.5.2 Review
- II.5.3 The Itchen
- II.5.4 Portsmouth
- II.5.5 Overall
- II.5.6 Contingency Provision

Figures

- II.5.1 Plan of South Hampshire Area showing the principle sources and Distribution Mains together with preferred elements of the reservoir study.
- II.5.2 Hydrograph of Test and Itchen with the present demands on each river.
- II.5.3 Hydrograph showing combined historical flows in the River Test & Itchen.
- II.5.4 Natural streamflow in River Itchen 1973.
- II.5.5 Cost of alternative means of augmenting Itchen
- II.5.6 Natural Stream Flow in River Test, 1973.
- II.5.7 Present Position in Portsmouth Water Company (Hampshire)
- II.5.8 Position with 6 Mm³ storage.
- II.5.9 Position with 115 Ml/d from Gaiter's Mill

I.5.0 HYDROLOGY

I.5.1 Mander, Raikes & Marshall Memorandum of July 1977

This was prepared to be a simple overview of the hydrological relationships governing the relevance of reservoirs in the developing strategy of water supply in South Hampshire. It was designed to give the study team some idea as to the relevance of particular sites, of the more useful storage capacities for each site, and the likely use to which they would be put, so determining their mains links and effective yields. These factors have resulted in some values in the overall matrix of comparative values (Fig. I.3).

The memorandum concluded that "there was a good case for a reservoir of about $5-7\text{Mm}^3$ at Testwood, a similar sized one near to Bedhampton Springs and a smaller 7 day storage reservoir of 1Mm^3 capacity at Gaiter's Mill. Accordingly, it suggests that Sites B/C, 11 (south) and one in the east, at that time to be decided, be kept; that Site 8 may in certain circumstances be an alternative to Site B/C, and that Sites 1/2 and 12 possibly be kept as standby, but that all others be abandoned as the need arises. If, in the very long term, unforeseen circumstances demand yet further resources, then it would be best to start afresh, looking at the overall situation when other locations, such as the area north of the M27 on the Test may become available". This resulted in the general development shown on Figure II.5.1.

Since submitting this, various errors have been pointed out in discussion with the Water Authority, some of the parameters have been changed and further work has been done on the overall study. The following paragraphs briefly set out a reworked "memorandum" to give some idea of the scope of that work.

II.5.2 Overall Review

Reviewing the Southampton and Portsmouth areas of Hampshire overall, it is found that present supply and demand is well balanced in the Portsmouth area, that the River Itchen already has a gross deficit, and that the River Test has comparatively large reserves. This is shown on Fig. II.5.2 where it can be seen that there was an actual deficit in the Itchen in 1972 and 1973. For the purposes of this study, 1976 has been taken as a freak drought outside the scope of these proposals and that 1973 conditions will be taken as the critical ones to be satisfied. Fig. II.5.3 with the demand on resources of the Test and Itchen combined shows that there is adequate water if the two could be interlinked.

II.5.3 The Itchen

First consider the Itchen. Fig. II.5.4A shows its natural flow during the critical year of 1973. Line A is the minimum flow at Allbrook required to satisfy the M.R.F. without any abstraction at Otterbourne. Line B includes the present abstraction of 100Ml/d. The total present shortfall is 7.5Mm^3 with a peak of 114Ml/d in November as shown in Figure 4B.

This can be met by a variety of policies:-

1. Reduction of the November/December M.R.F. by tertiary treatments of the sewage outfall over those months, by increasing the water temperature, by temporarily storing part of the effluent in the gravels or a small reservoir, or by dividing it elsewhere.
2. By introducing a complete Itchen groundwater scheme which would be able to meet the peak demand of 114Ml/d.

3. By constructing a storage reservoir of 4Mm^3 capacity and 75Ml/d peak discharge rate to augment the Itchen in conjunction with the Candover Scheme. (This, the first stage of a full Itchen scheme is presumed to be commissioned and capable of 40Ml/d in November/December).
4. By introduction of water from elsewhere (the Test) to supply Otterbourne and thus reduce the level of line B.

The comparative costs of these four options are shown in Figure 5. It should be noted that option 5.3 above is not practical whilst Eastleigh Airport remains operational because of birdstrike problems. Option 5.4 has the potential to transfer up to 135Ml/d from the Test to the Itchen without the Test requiring any augmentation. (this is shown in Fig.II.5.6).

Fig.II.5.4 also shows why it would be desirable not to increase the abstraction at Otterbourne beyond the present to 100Ml/d . Line C with the abstraction of 150Ml/d results in 16Mm^3 of augmentation at a peak rate of 164Ml/d as shown in Fig.II.5.4C This could only be met by a combination of schemes.

Fig.II.5.4A shows that up to 115Ml/d may be abstracted from the Itchen at Gaiter's Mill without the need for any augmentation. This is the difference between the M.R.F. at Allbrook of 245Ml/d and the estuarial M.R.F. below Gaiter's Mill of 130Ml/d . This provides a significant resource for the Portsmouth area.

II.5.4 Portsmouth

Fig.II.5.7 shows the present position of the Portsmouth Water Company (Hampshire Area) approximately averaged over 1973, 1974 & 1975. The available resources just match the present demand, with a minimum resource of 202Ml/d in September. It should be noted that, unlike the situation on the Itchen, the peak demand does not coincide with the minimum supplies, being July and September respectively. Fig.II.5.8 shows how this situation may be modified by means of direct supply from a 6Mm³ capacity reservoir. The peak (average month) supply rises from 224 to 260Ml/d. Fig.II.5.9 shows how alternatively this situation may be modified by means of an increased supply of 115Ml/d from Gaiter's Mill. This enables a total of 292Ml/d to be met, which is close to the estimated 298Ml/d.

The capacity of the existing 40 ins. diameter line from Gaiter's Mill probably exceeds 135Ml/d, with boosting. Since, as it was shown in Fig.II.5.4A abstraction of up to 115Ml/d requires no further augmentation works on the Itchen, it must be probable that this is the most economical solution for Portsmouth at present.

I.5.5 Overall

Summarising the overall position, it would appear that

1. All further development of supplies for Southampton should be taken from the River Test which can support the abstraction without augmentation.
2. The existing deficit on the Itchen can either be made good by a full Itchen groundwater scheme, or by transfer from the Test, or by a combination of these two, or finally by some lesser combination, together with a reduction in the November/December effluent load from Chickenhall.

3. Further development for the Portsmouth area can be met until the foreseeable future by abstraction from the Itchen at Gaiter's Mill.

II.5.6 Contingency Provision

Should the recommended M.R.F. fail to be accepted, or should the demand forecast have been underestimated, then what is the best reserve strategy? There already is a standby on the Itchen in that there is the option of a full Itchen scheme or transfer from the Test. Further abstraction from the Test could be met by groundwater control or a surface reservoir. Site B/C adjacent to Testwood would also serve to safeguard the by then considerable abstraction of at least 292Ml/d. Further demand for Portsmouth could be met by one of the eastern reservoirs, in order to balance the layout of distribution mains with the other bulk supply from Gaiter's Mill in the west.

PLAN OF SOUTH HAMPSHIRE AREA SHOWING THE PRINCIPAL SOURCES AND DISTRIBUTION MAINS TOGETHER WITH PREFERRED ELEMENTS OF THE RESERVOIR STUDY

- (R) = RESERVOIR WITH No.
- = SOURCE
- = TRUNK MAIN
- - - = BOUNDARY OF PORTSMOUTH WATER COMPANY (HAMPSHIRE) AREA
- = BUILT-UP AREA

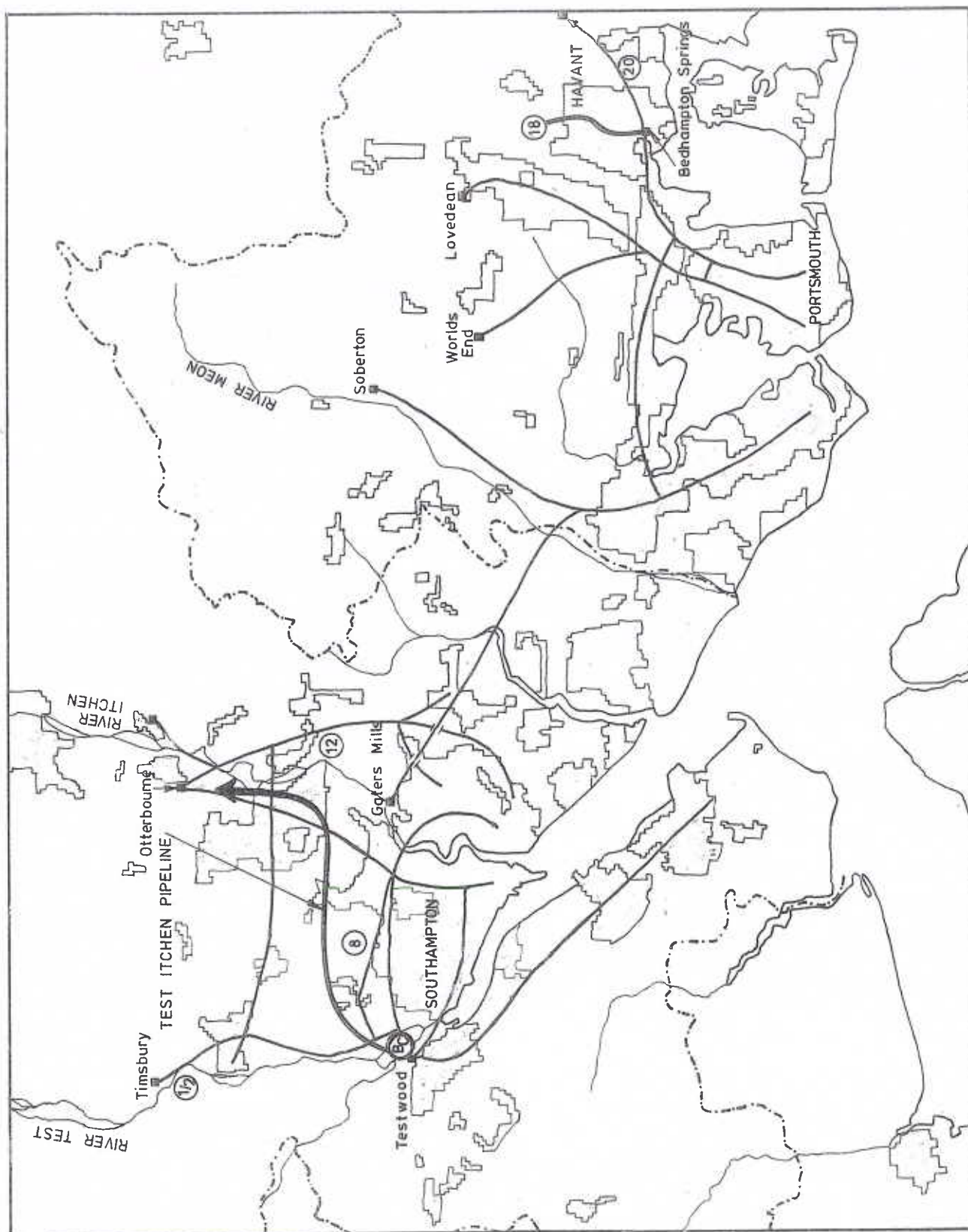
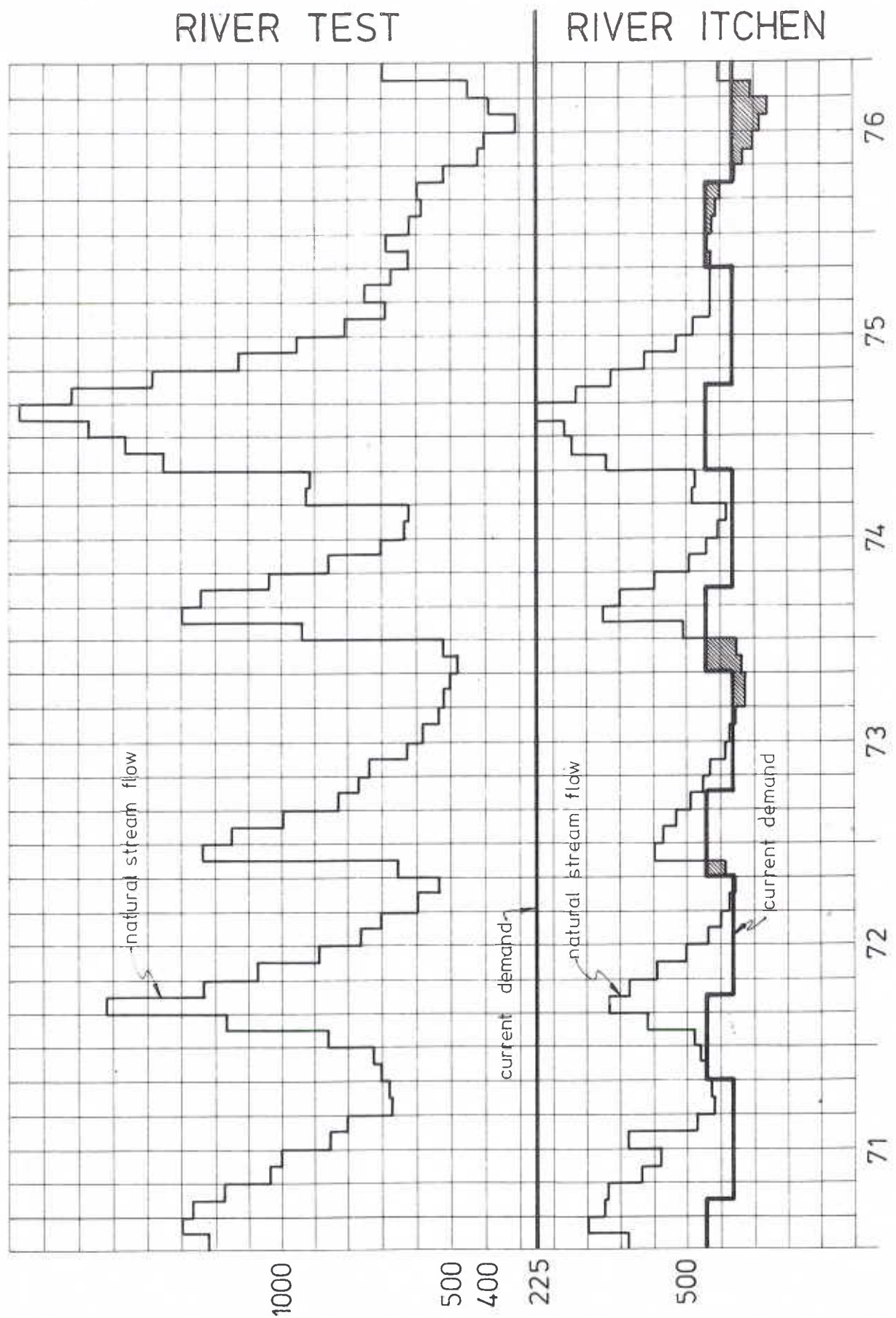


FIG. II. 5.2

HYDROGRAPH OF TEST & ITCHEN WITH THE PRESENT DEMANDS ON EACH RIVER



HYDROGRAPH SHOWING COMBINED HISTORICAL FLOWS IN THE RIVERS TEST & ITCHEN.

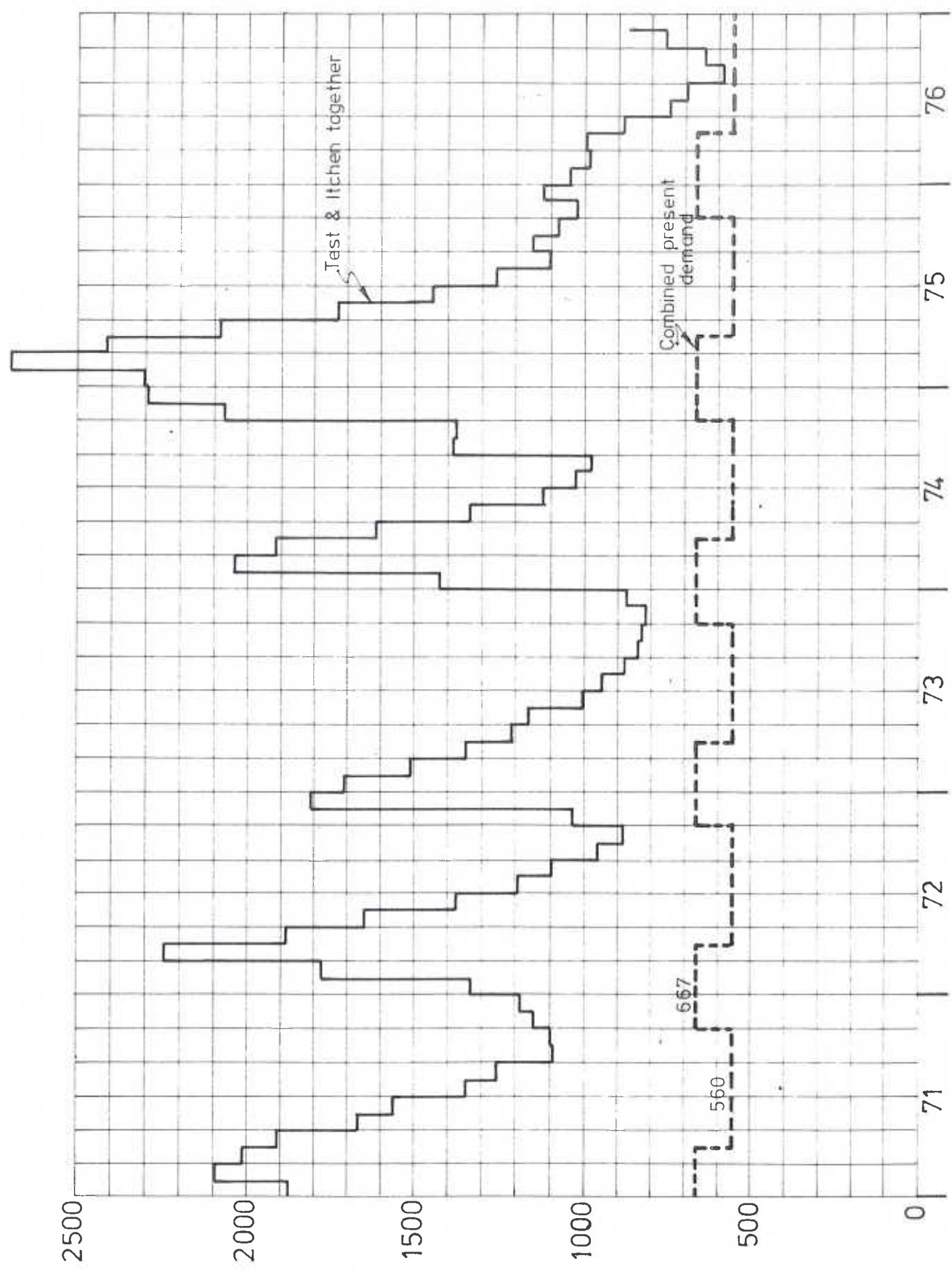
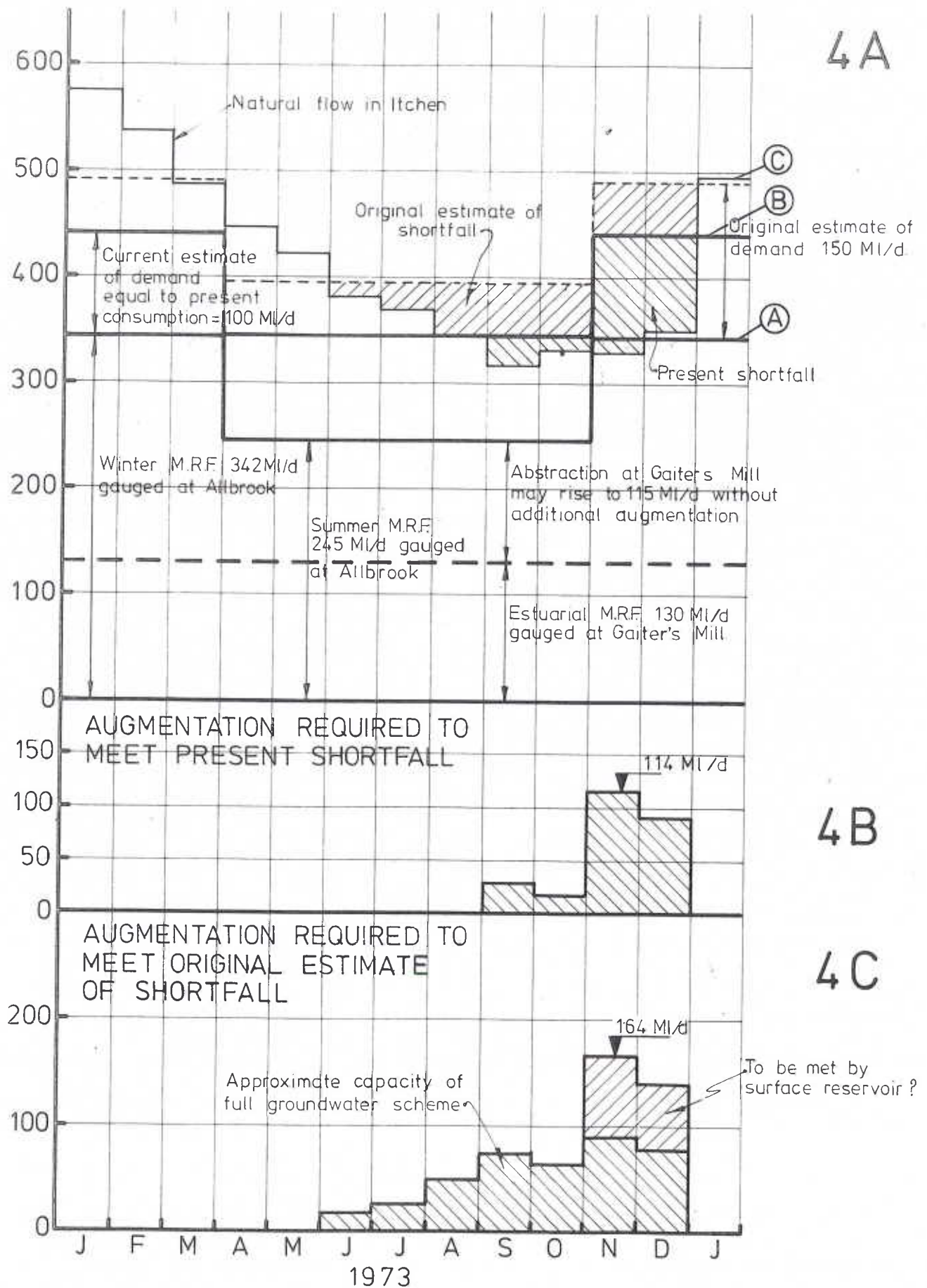
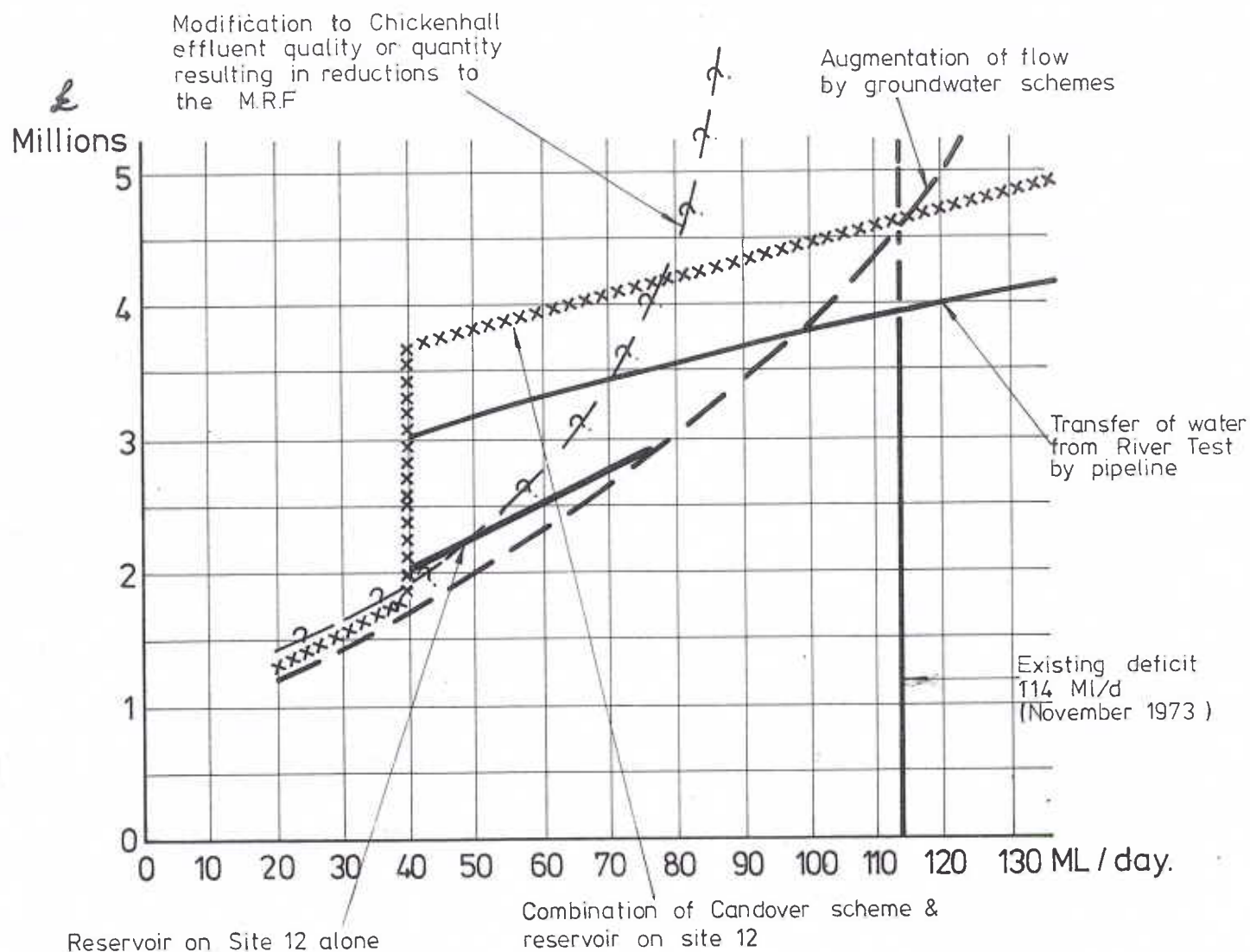


FIG. II.5.4

NATURAL STREAMFLOW IN RIVER ITCHEN 1973 SHOWN TOGETHER WITH SOME ALTERNATIVE DEMANDS

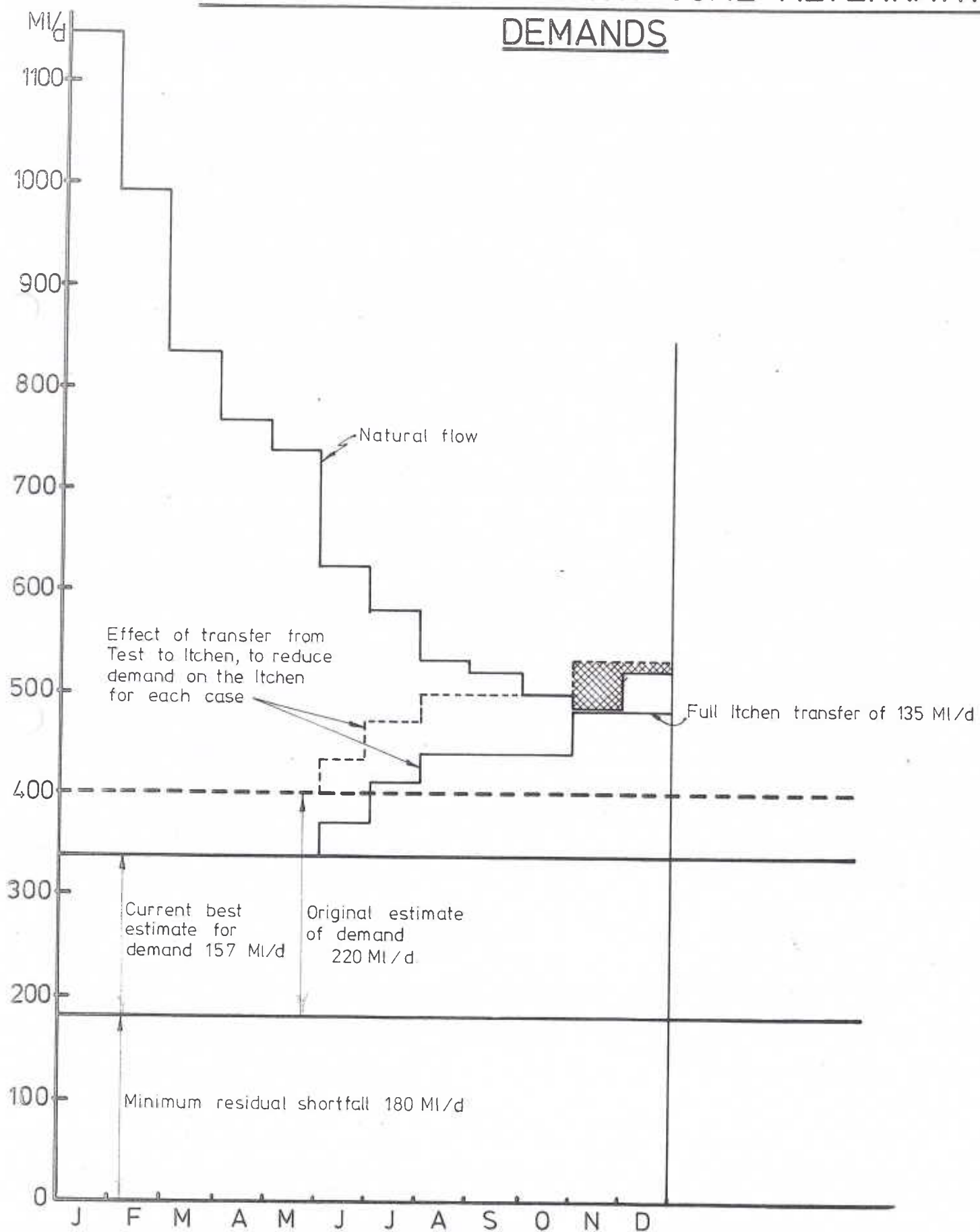




GRAPH RELATING ESTIMATED COSTS OF VARIOUS ALTERNATIVES FOR MAINTAINING THE RIVER ITCHEN M.R.F

FIG.II.5.6

NATURAL STREAMFLOW IN RIVER TEST 1973
SHOWN TOGETHER WITH SOME ALTERNATIVE
DEMANDS



PRESENT POSITION IN PORTSMOUTH WATER COMPANY (HAMPSHIRE) AREA

