Pumping Station - Efficiency Of Operation And Cost For A Design Life Span

Survey of Pumping Installations and Design Philosophy Initiatives.

Research Contractor:
Bullen and Partners

R&D Project Record 363/ 1 /NW

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National Rivers Authority

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R&D Project Record 363/1/NW

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APPENDICES

1.0 SUMMARY

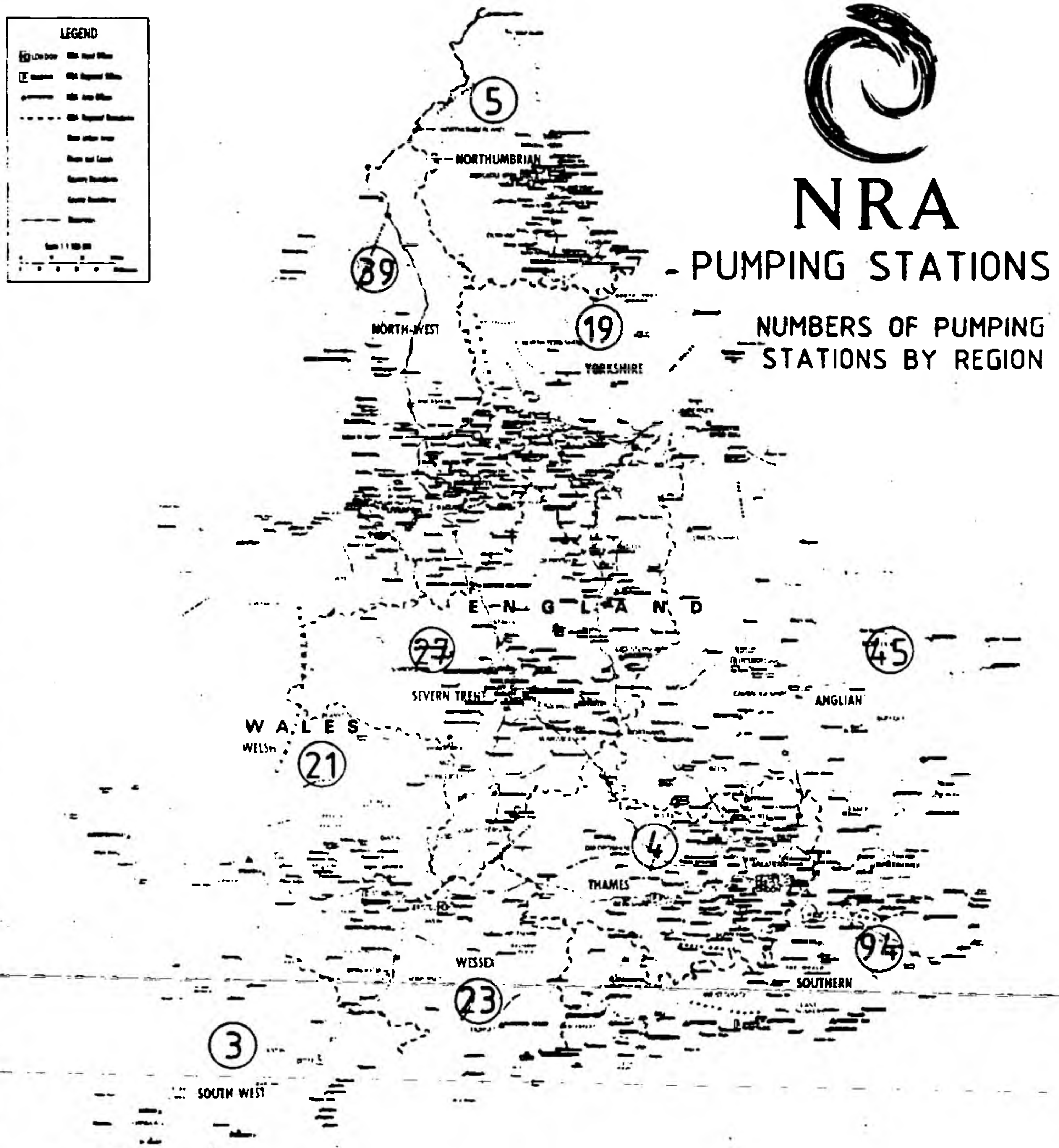
The National Rivers Authority is currently responsible for 280 pumping stations (see map overleaf). These not only represent a very large capital investment in mechanical and electrical equipment but also involve the Authority in high annual expenditure in respect of their operation, maintenance and replacement. In view of the large financial commitment, the Authority wish to ensure that the most cost effective solutions are adopted for all new stations.

Preliminary investigation would appear to indicate that there is no common approach to the design and maintenance of flood defence pumping stations. It is evident that benefit would result from a detailed study of design philosophy and maintenance methods used. The object of the present study is to produce a manual of recommended practice for the guidance of engineers.

This interim report follows completion of the first phase of the study which comprised the following; a detailed survey of all land drainage pumping plant, preparation of a data base, and analysis of design philosophy throughout all regions. The report describes the project, summarises the results of the pumping plant survey and indicates the generally accepted current approach to the design of flood defence pumping stations. It also outlines some of the topics and problems that will be addressed in detail in the final report.

NRA - PUMPING STATIONS

NUMBERS OF PUMPING STATIONS BY REGION



HEAD OFFICES

BRISTOL

LONDON

NATIONAL RIVERS AUTHORITY – REGIONAL OFFICES

ANGLIAN

NORTHUMBRIAN

NORTH-WEST

SEVERN TRENT

SOUTHERN

SOUTH-WEST

THAMES

WELSH

WESSEX

YORKSHIRE

2.0 PROJECT DESCRIPTION

There is no common approach or code of practice applied to the design of flood defence pumping installations and it is thought that over-reliance may be placed on established custom and practice. This approach can lead to the specification and adoption of old and possibly well proven designs even though they may be less cost effective or efficient than alternative solutions. In addition, no consistent strategy exists for electrical and mechanical maintenance procedures. There would also appear to be current lack of forward planning in establishing the life expectancy of plant and associated systems and implementing long, medium or short term capital investment programmes for their replacement.

Having identified the above problems, the National Rivers Authority is addressing them by commissioning the present study of the land drainage pumping stations under its control. Particular emphasis is to be placed on the efficiency of operation and costs incurred for a design lifespan. In the past, initial cost has often been the main criterion possibly influenced by the grant-aid regulations, but it is obvious that prudent investment and financial control requires consideration of operating, maintenance and repair costs incurred during the entire life of the station. The overall objectives of the project are to:

i) produce a detailed database of all the National Rivers Authority mechanical and electrical pumping plant, categorised into type, size, duty, age and other relevant criteria.

ii) analyse design philosophy and detail of flood defence pumping stations throughout all regions and determine best practices and relevant costings.

iii) review national strategies for maintenance investment and mechanical and electrical maintenance procedures.

iv) publish results and prepare a manual of recommended practice for guidance of engineers.

To achieve these objectives, the study is divided into three phases with the following specific objectives:

Phase 1 - To conduct a detailed survey of flood defence pumping plant installations through the NRA and prepare a detailed categorised data base. To analyse design philosophy and carry out field studies to determine how decisions are made and developed through to final selection of type, site, and pumping station arrangement.

Phase 2 - To conduct a detailed survey into strategy and the decision making process in mechanical and electrical maintenance. Research samples in the field.

Phase 3 - Carry out a detailed analysis of Phase 1 and 2. Propose a code of practice and recommendations for design and maintenance investment applying any benefits from "Life Cycle Costing - A Radical Approach" (CIRIA Report 122). Publication of results and education in the field through to final implementation.

Phase 1 of the study has now been completed and this report presents a summary of the results from the survey of pumping plant and an interim report on design philosophy.

3.0 STUDY APPROACH

The approach to the study is summarised in the flow diagram overleaf and details of the methodology and approach for each phase of the study are provided on the following pages.

3.1 Phase 1 - The Data Base

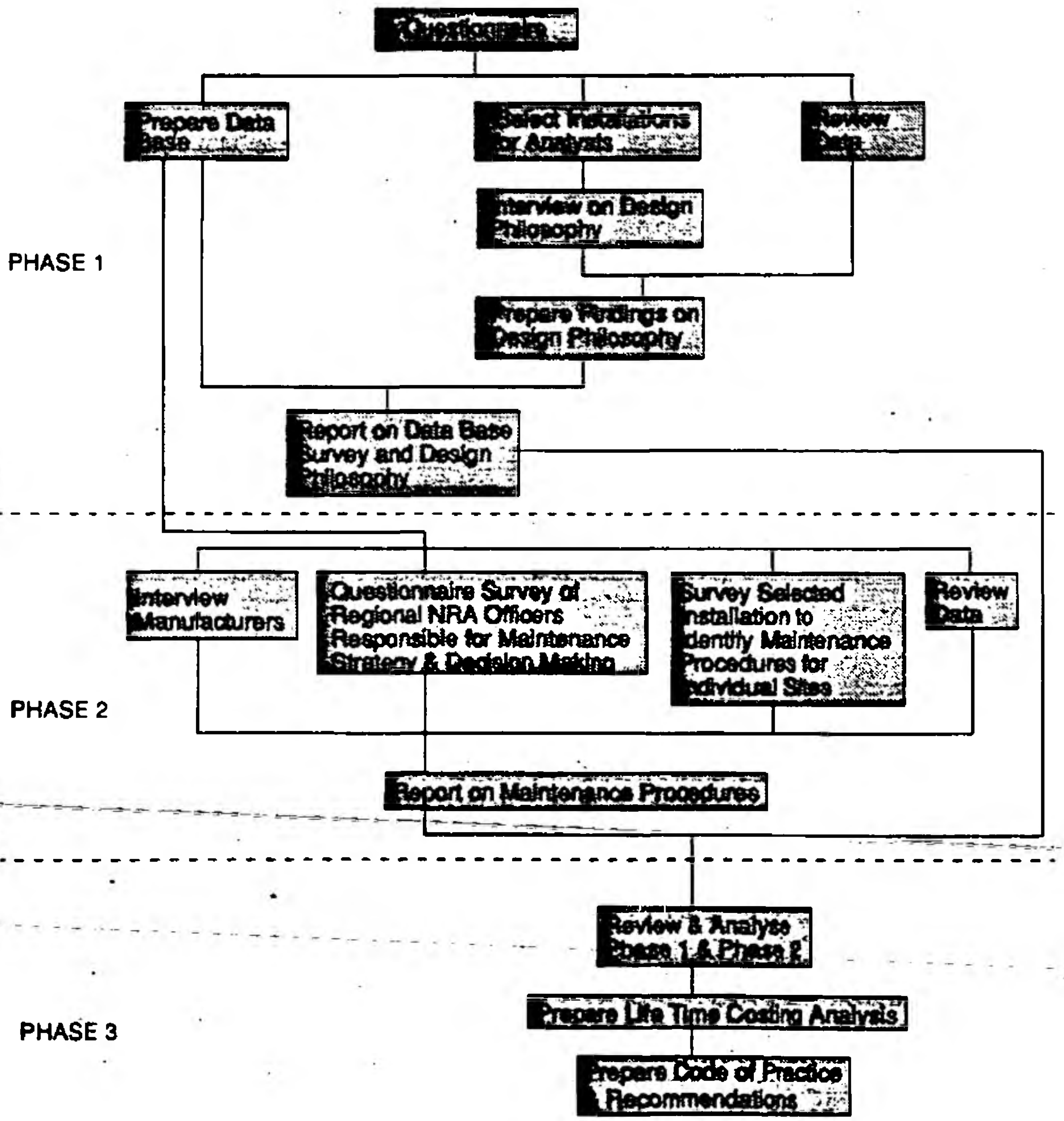
The data base provides detailed information on National Rivers Authority pumping installations throughout England and Wales. For each pump installation general particulars have been collated, this comprises details of station layout and monitoring system, responsibility for design and specification, costs and any other relevant information.

In addition, more detailed information has been collected as indicated in the following categories:

National Grid Reference.
Station Catchment Area.
Total Capacity of Station.
Number of pumps.
Manufacturer.
Date commissioned.
Pump Type (Centrifugal, Axial, Mixed Flow or Screw).
Size, Diameter.
Housing (High building with crane, low building, removable roof, outdoor or submersible).
Mounting (Horizontal or vertical).
Capacity (per pump).
Design Static Head.

National Rivers Authority

PUMPING STATION RESEARCH PROJECT
STUDY APPROACH



Impeller Speed RPM.
Drive (Diesel or Electric).
HP.
Supply voltage.
Discharge type (Syphonic, Sluice or Sluice and Reflux).

The information was gathered by means of a simple questionnaire, the format is presented in Appendix A1. The first two sheets allow the recipient to insert general particulars and the third contains detailed information. The questionnaire was designed to be simple to complete to ensure a high response rate whilst containing enough information to permit meaningful analysis. The questionnaires were circulated and completed during early 1992, and the database was constructed on the information supplied.

The amount of information provided in the completion of the questionnaire was variable both by region and by individual station. Most of the information supplied relates to pump size and characteristics, the information relating to design and costs is generally less well covered. It is recognised that this information is difficult to recover as many of the stations are over twenty years old and original documentation is no longer available.

A summary of the data base information is presented as part of this report. The complete document is held by Mr A. Taylor, the Mechanical Services Manager of the NRA, North West Region. It can be inspected by request.

3.2 Design Philosophy

It was agreed at the start of the study that the analysis of current design philosophy would be based on interviews with the designers of a 10% sample of stations selected from each NRA region. These pumping stations were chosen from those recorded on the Data Base, to cover the widest possible range of size and type in current operation. Site visits were made by Bullen and Partners engineers during 1992, the interviewees were engineers with responsibility for design of mechanical and electrical plant and/or civil works and they were in the main current NRA engineers. Detailed questions were asked about the design, construction and operational history, a list of standard questions being used to ensure uniformity of approach in the various areas. The format for the standard questions is presented in Appendix A2, in addition, relevant documentation was also obtained such as tender documents, reports and specifications. Following the site visits and collation of relevant documents detailed reports were completed and design implications studied.

A number of manufacturers have been approached regarding their philosophy in respect of the design and supply of pumps for flood defence purposes. A questionnaire was again used to ensure uniformity in the information supplied. Several replies have been received, in particular detailed comments were provided by the Bedford Pump Company Ltd and KSB's London office.

An interim report on design philosophy based on these initial interviews and information from manufacturers is presented in sections 5.0 of this report.

3.3 Phase 2 - Maintenance Practices

The review of the strategy and decision making processes in mechanical and electrical maintenance will be based on a combination of questionnaires and interviews.

The questionnaire will be completed by regional or district managers, who are responsible for maintenance of pumping installations within their area. Typically the regional/district managers would be responsible for several installations, and so these questionnaires will give general information on strategy and decision making for maintenance adopted on an area basis. The questionnaire will be circulated to district managers within the Authority so that coverage of all installations will be achieved.

The suggested basis for the questionnaire is in Appendix A3. The first part giving general information on maintenance strategy followed by detailed questions on inspections and checks.

The questionnaire will be followed up by interviews with selected area managers and also first line supervisors who carry out maintenance duties at individual sites. Again standard format interview check lists will be used and the contents will be agreed with the Authority where appropriate.

Companies involved in the manufacture or maintenance of pumping plant will also be interviewed.

The field work will be complemented by a review of any information available to give background information for the final report.

This phase of the project is programmed to take place during the winter of 92/93.

3.4 Phase 3 - Detailed Analysis and Reporting

The results of Phase 1 and 2 will be analysed to provide a review of performance, suitability for purpose, design life and costs of pumps and ancillary equipment of various types and manufacture. Analysis will span the whole asset life cycle of the plant, which involves the activities of specification, design, manufacture, operation and maintenance and finally replacement.

Review of costs over the whole life cycle of an installation will enable conclusions to be made on the appropriateness of initial capital investment and ongoing maintenance expenditure.

The review of design practices will identify successful approaches and the report will provide guidelines to be used by engineers when specifying plant to ensure new methods and design criteria are examined and adopted when appropriate.

Design criteria, some of which have been adopted on an arbitrary basis, will be considered. These include pump peripheral speeds, bellmouth clearances, shaped sump backs, syphonic discharges and other features.

The final report will be in the form of a manual which will include recommendations on design practices and maintenance strategies to achieve optimum life cycle costing. The manual will provide guidance for design engineers and those responsible for the maintenance of land drainage pumping stations.

It is important that the information in the guide is widely circulated to practising engineers. This could be achieved by the holding of seminars in the National River Authority Regions, the publication of abstracts and papers, presentations at Conferences (Loughborough), and courses run by Water Training International and other similar bodies.

This phase of the project is programmed for 1993 with the review period for the final documentation during 1994.

4.0 DATA BASE PRELIMINARY REPORT

4.1 Summary of Pump Data

The data base information presented in this report Appendix B1 is a summary of the total information available. It provides basic data on geographical spread, numbers, size and type of the Authority's pumping plant. The information is presented on a Regional basis and a map is provided to show the location of installations in each region.

It should be noted that within the total number of 94 stations for Southern Region 28 are assets of Internal Drainage Boards which are operated and maintained by the NRA. In the Yorkshire Region 6 stations have been included which were constructed on behalf of the Coal Board for mining subsidence purposes, again these stations are operated and maintained by the NRA.

4.2 Analysis by Capacity

The number of stations by capacity are illustrated graphically for the whole country and by Region, Appendix B2.

Presented overleaf is the analysis for the whole country and this indicates that the bulk of the stations have a capacity of 2 cumecs or less. This confirms that any standardization of designs should be concentrated on stations of this size.

4.3 Analysis by Type

The number of pumps of different type are illustrated graphically for the whole country and by Region, Appendix B3.

Presented overleaf is the analysis for the whole country, this confirms that as expected the bulk of the installations use axial flow vertical lift pumps. A point to note is the high number of archimedean screw type pumps, the bulk of which are located in the Southern Region. Another unusual type of installation was the floating type, again in the Southern Region.

4.4 Analysis by Manufacturer

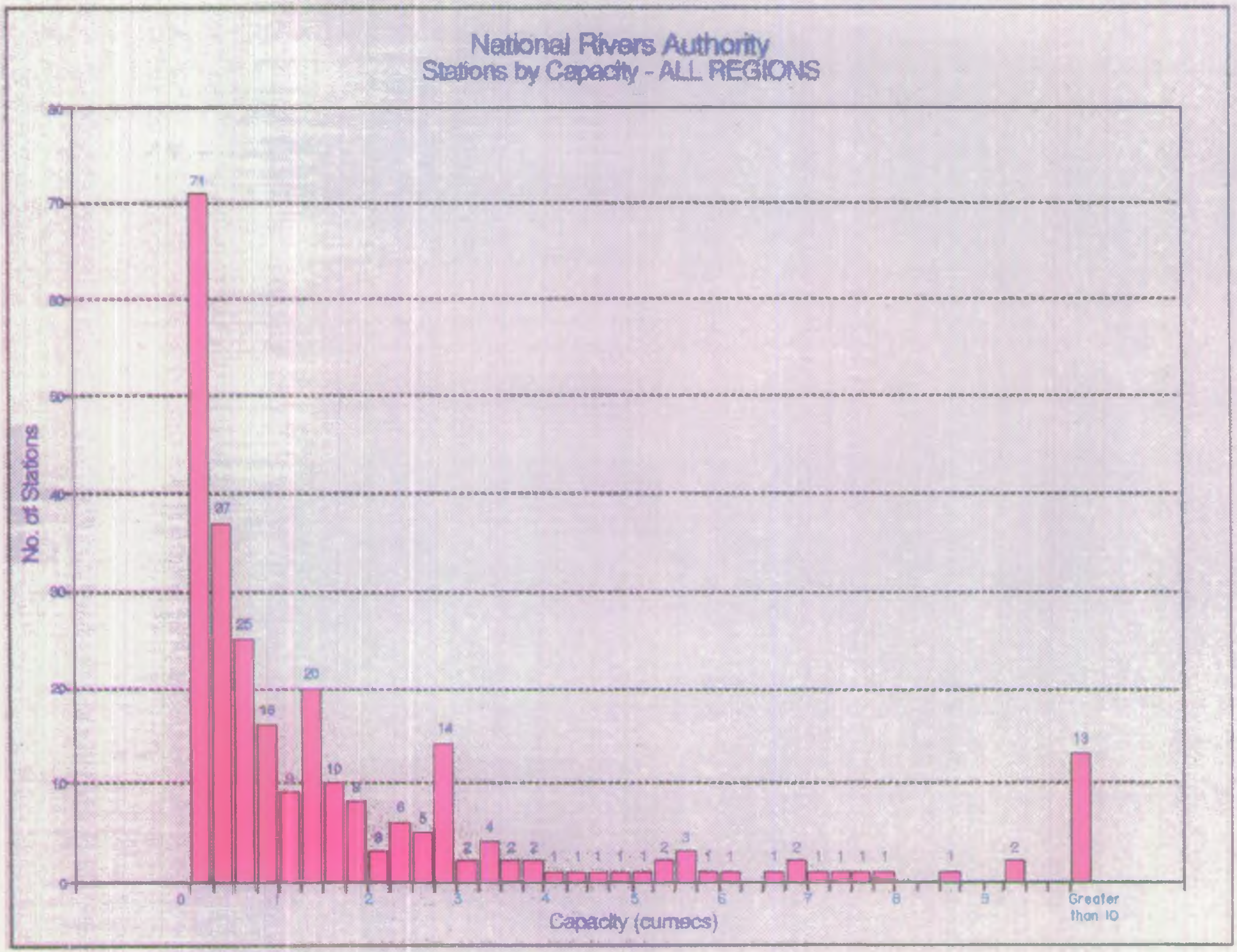
The number of pumps by Manufacturer are illustrated graphically for the whole country and by Region Appendix B4.

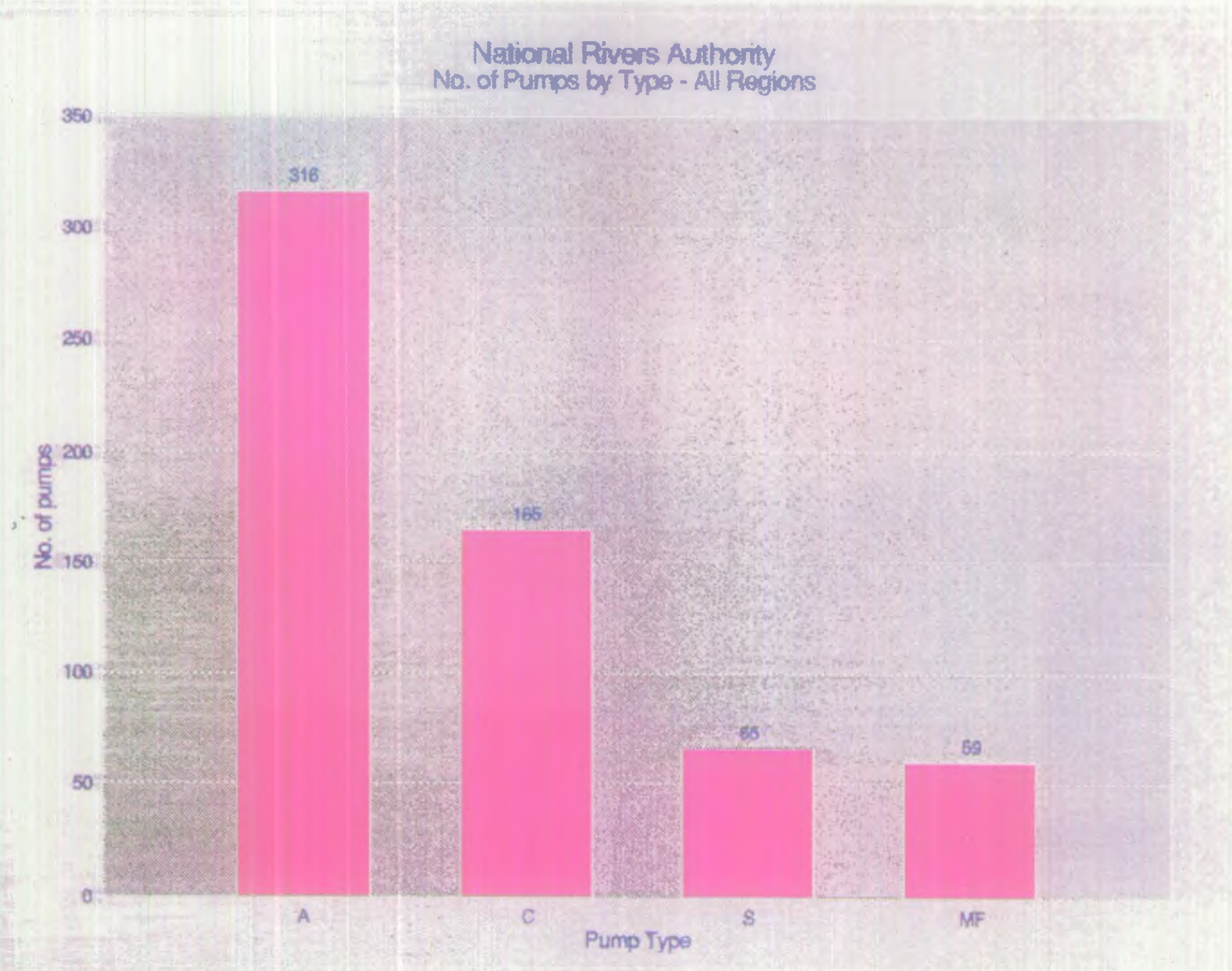
Presented overleaf is the analysis for the whole country which highlights that the bulk of the pumps were manufactured by the A.P.E. Allen Group which was generally known as "Allen Gwynnes". This company, which had a long association with the manufacture of land drainage pumping plant, is now no longer in existence. A large number of the modern small submersible stations were manufactured by Flygt. Spaan represent the archimedean screw type pumps.

4.5 Cost of Stations by Capacity

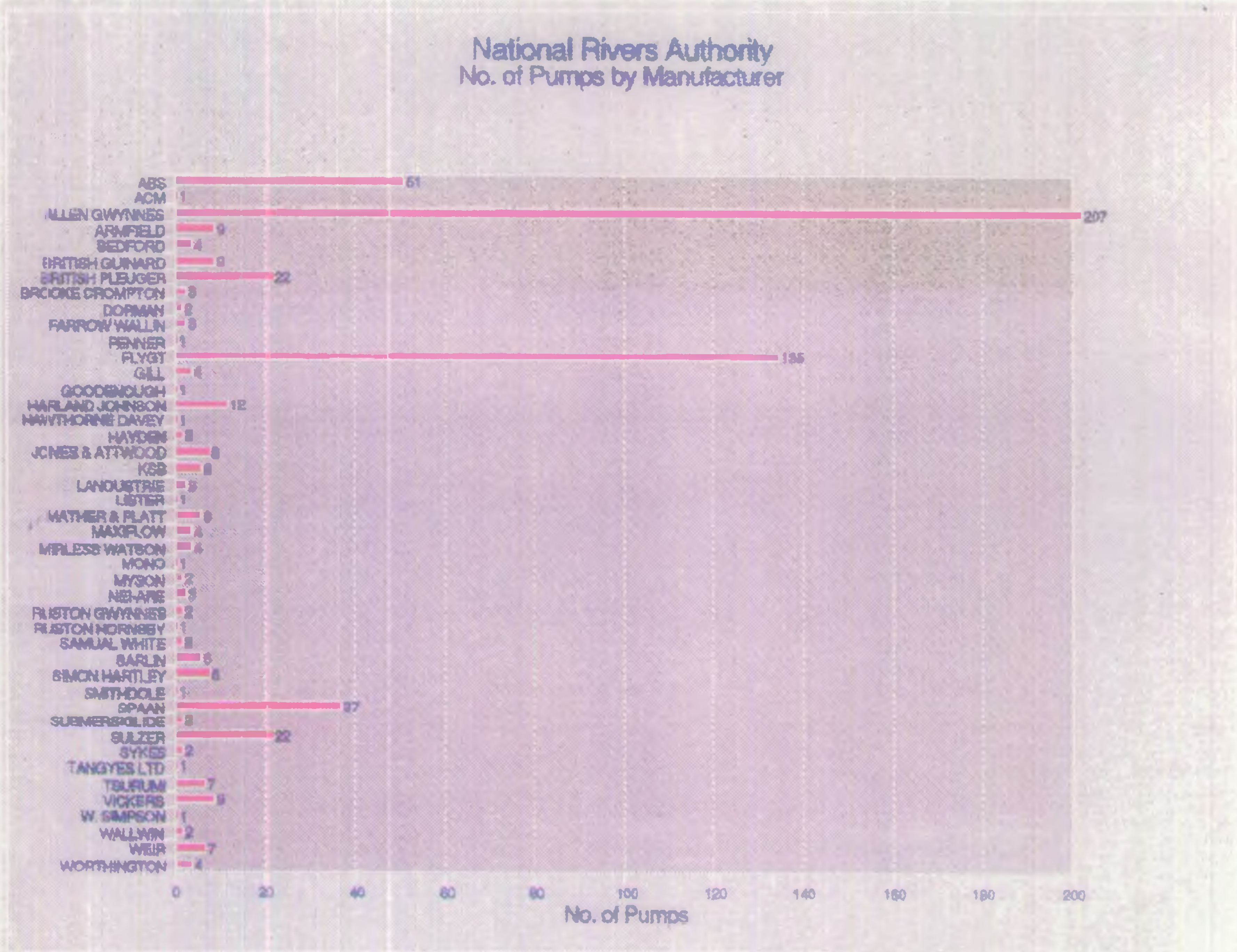
Although cost information could only be obtained for about 20% of the stations, this information does represent a reasonable sample to analyse costs of installations. The costs of pumping stations by capacity are indicated graphically in Appendix B5, also illustrated are costs for the Mechanical and Electrical (M&E) and Civil elements only.

All costs have been converted to 1992 prices and the best line has been fitted to a log/log plot. As would be expected, the best fit line is for the M&E element as this cost is less variable than the Civils aspect. It should be noted that more cost information is available for M&E as compared to Civils as a result of the number of recent replacements of M&E plant.


National Rivers Authority
Stations by Capacity - ALL REGIONS
No. of Stations
Capacity (cumecs)
Greater than 10
71
37
25
16
20
9
10
8
3
6
5
14
2
4
2
2
1
1
1
1
1
2
3
1
1
1
2
1
1
1
1
1
2
13



National Rivers Authority
No. of Pumps by Type - All Regions
350
300
250
200
150
100
50
0
No. of pumps
316
165
65
59
A
C
S
MF
Pump Type



National Rivers Authority
No. of Pumps by Manufacturer
ABS 51
ACM 1
ALLEN GWYNNES 207
ARMFIELD 9
BEDFORD 4
BRITISH GUINARD
BRITISH PLEUGER 22
BROOKE CROMPTON
DORMAN
FARROW WALLIN
FENNER
FLYGT 135
GILL
GOODENOUGH
HARLAND JOHNSON 12
HAWTHORNE DAVEY
HAYDEN
JONES & ATTWOOD
KSB
LANOUSTRIE
LISTER
MATHER & PLATT
MAXIFLOW
MIRLESS WATSON
MONO 1
MYSON 2
NIS-ARE
RUSTON GWYNNES 2
RUSTON HORNSBY
SAMUAL WHITE
SARLIN
SIMON HARTLEY
SMITHDOLE
SPAAN 37
SUBMERSIGLIDE
SULZER 22
SYKES 2
TANGYES LTD 1
TSURUMI 7
VICKERS
W. SIMPSON 1
WALLWIN 2
WEIR 7
WORTHINGTON 4
0
20
40
60
80
100
120
140
160
180
200
No. of Pumps

5.0 PUMPING STATION DESIGN PHILOSOPHY - PRELIMINARY REPORT

5.1 Summary

This interim report following discussions with senior engineers in the ten NRA regions indicates the generally accepted current approach to the design of flood defence pumping stations and outlines some of the topics and the problems that will be addressed in detail in the Manual.

5.2 Introduction

Since the first half of the nineteenth century, a large number of pumping stations have been constructed in England and Wales to drain some 900,000 hectares of land that cannot be drained effectively by gravity. A high proportion of this fertile and productive agricultural land is located in the fens of East Anglia, the Vale of York, the Kent and Sussex coastal lowlands, the Somerset Moors and Levels, and in the Lower Severn, Trent and the Mersey and Ribble estuaries.

Apart from the drainage of the above areas, pumping stations have also been constructed in Yorkshire, Lancashire, Staffordshire and in other areas where the effects of mining subsidence would have otherwise resulted in permanent flooding or waterlogging. Stations have also been constructed to facilitate the drainage of flat urban areas, particularly where the free discharge from tributary watercourses is impeded by high levels in the main arterial watercourse eg. the Foss at York.

5.3 Historical Background

Wind and Steam - The history of land drainage pumping and pumping station design in the United Kingdom has been one of continuous evolution, following technical innovations in the field. The earliest 17th and 18th century systems made use of windmills and scoop wheels. These, following Dutch practice, were often placed in a row, each unit raising the water some two or three feet. The 19th century saw the development of the steam engine, coupled to the low specific speed centrifugal pump. Their high capacity and reliability, when compared to the wind driven units, gave rise to a great upsurge in the drainage of lowland areas and enabled land, well below sea level, to be reclaimed.

Gas and Oil - Although steam driven pumps were still in operation in some areas up to the Second World War the drive units had largely been replaced by slow running gas and oil engines linked to the low specific speed centrifugal pumps or with mixed flow or "bowl" type pumps where higher speed engines were employed.

Diesel, Electric and Axial Flow - Further progress was made with the development of the axial flow pump which has a higher specific speed than the earlier centrifugal and mixed flow units. Its greater rotational speed meant that it was capable of pumping large quantities of water at low head. It is lighter and smaller than a mixed flow unit of similar capacity and in consequence has been very widely adopted for land drainage use. In most stations it was driven by electric motors and despite the high electricity charges imposed by some electricity companies, this type of unit was almost universally adopted in the immediate post-war years.

The Outdoor Station - All the earlier pumping units, up to the 1960's were housed in purpose built pumping stations, most of the buildings being high enough to allow for the installation of lifting beams or travelling cranes for use when the pumps were initially installed and subsequently when they were dismantled or removed for maintenance or major repair. The buildings and lifting equipment were a major item of cost. In the early 60's "outdoor" type stations were introduced in the Middle Level I.D.B. by their Engineer, L.F.Fillingham. These made use of standard, shaft driven pumps, powered by a weatherproof motor fixed on an open slab at ground level, the switchgear being housed in a small weatherproof cubicle close by. Whilst the outdoor stations with weather-proofed motors proved effective they can be at risk in vandal prone areas even though the exposed motors are protected by sealed cover plates.

The submersible Pump - The principle of the "outdoor" pumping station was developed still further in the late 60's and early 70's by the development of submersible pumps with capacities large enough for land drainage use. Although it has been claimed, and in some instances it is no doubt true, that their use can result in great savings over the traditional, shaft driven unit, there have been numerous cases of failure in service of this type of pump and evidence of short working lives in some marques.

Floating Pumping Stations - Floating pumping stations, many of them designed by Stephen Hawes, were constructed in some numbers in the 1960's but are now no longer in vogue. Advantages claimed are those of cheapness (half the cost of a conventional station), the fact that no foundation is required and their low profile presents no intrusion on the landscape. Disadvantages are the complicated arrangement necessary for discharge, the small size of weedscreen that can be provided (and the difficulty of keeping it clean), though this can be offset by the construction of a separate screen structure, on the channel, upstream of the pontoon. Problems can also arise in some instances by silt building up under the pontoon.

Archimedean Screw Pump - Another post-war innovation was the introduction of the screw pump for land drainage use. Although they have been employed in large numbers in the Netherlands and to a certain extent at sewage works in the U.K., it is only in the South East that they have been adopted in any number - over 60 being located in the Anglian, Thames and Southern NRA Regions. They are best employed where there is little variation in discharge level and can deal with weed and the complete range of flows up to their maximum capacity. Critics say that their installation can seldom be justified if initial cost and operational factors are taken into consideration. Their employment in such large numbers in the South East calls for a closer study.

Operation and Control - There have been considerable changes, over the years, in the methods used to operate and control pumps. Initially, starting and operating were entirely manually controlled. The impellers of many of the early pumps were not submerged and the pumps had to be primed by the use of "exhausters" prior to starting. The introduction of the axial or "propeller" type pump, driven by electric motor, with the impeller always submerged, lent itself to automatic operation. Early systems were switched by floats. These were followed in their turn by "no-flote" electrode systems, air bubblers and ultrasonic level switches. Control equipment is now often connected to a telemetry system that allows information on the equipment and its status to be monitored, and even operated, from a control room many miles away.

Screens - One of the constant problems in the past was dealing with the considerable quantity of weed and debris of all shapes and sizes that was carried to the pumping station in times of storm. This collected on the weed screen and up to comparatively recent times was always removed by hand raking - an arduous and unpopular job, at night or in inclement weather. Automatic, mechanical raking gear, capable of dealing with the wide variety of river debris has now been introduced from the Continent and is being installed in increasing numbers at both old and new stations.

Power Strikes and Motive Power - The general and almost universal move to larger electrically driven pumps in post-war years, prompted by improved electricity supplies, received a severe set-back in the late 1960's with the interference to supplies brought about by the strikes of power company workers and the miners' strike. The indication that this previously considered secure source of power was liable to be cut by industrial action prompted many authorities to install both diesel and electrically driven pumps in new medium sized stations, to ensure that there would be some pumping capacity available under similar circumstances. Most authorities subsequently modified switchgear at existing stations to allow for the connection of a mobile generator. In recent times large mobile pumps have become available on the hire market and these could be used in case of emergency.

Siphonic Discharge - In most of the early pumping stations the discharge was through a reflux or flap valve that prevented reverse flow when the pump was stopped. A sluice valve was normally placed on the discharge side of the pump to allow the flap or reflux valve (or the pump) to be removed for repair or maintenance. Reflux valves and sluice valves are very expensive, particularly in the larger sizes, and from the 50's these have been largely replaced by the use of siphonic discharge pipes. A siphon breaker valve is incorporated to prevent reverse flow when the pump is stopped. This arrangement is cheap and effective and is still in general use at the present time.

5.4 Design Philosophy

Whilst some minor differences in approach were noted in the various Regions, the current consensus in the approach to flood defence pumping station design is:-

i) that operational staff should play a part in the design team from the start to the finish of the project;

ii) that the station must be capable of pumping all flows, up to its design capacity, with a high degree of reliability;

iii) that the pumps must be able to deal with the weed and other river borne debris that can pass through the weedscreen;

iv) that the station should be easy to operate, and where possible, automatic in operation and capable of being supervised by non-technical staff;

v) that the equipment, whilst being secured against vandalism, should be accessible, easy to maintain, and should operate efficiently for long periods before requiring major maintenance or overhaul;

vi) that the station must be environmentally acceptable, must not obtrude unduly on visual amenity, must not generate unacceptable noise levels or cause pollution of the watercourse;

vii) that it should present no safety hazards to those working on, or in it, or to members of the public;

viii) that the station should be constructed at the least possible overall cost commensurate with satisfying the above criteria.

Note:

a) Whilst agreeing that pump and water efficiencies are important, it is generally accepted that in the case of flood defence pumping stations (where hours run are usually less than 500/annum), that reliability and the ability to deal with weed and other suspended solids take precedence.

b) The concept of lifetime costing is readily accepted in the design of flood defence schemes and is required by MAFF for the economic analysis of schemes. However, MAFF will only grant aid the capital costs of a project.

5.5 General Considerations

The approach to pumping station design and construction requires specialised knowledge but involves the same four basic steps, common to all engineering design processes - "the brief", "analysis", "synthesis" and "implementation".

Too much emphasis cannot be placed on the need to involve operational staff in the project, from initial inception right through to final completion of the work. They must be encouraged to produce a clearly written brief of their requirements and in particular, should be asked for information about problems that may have been encountered at previous stations and to list any features they would like incorporating in the new structure.

It should be confirmed that there are no objections to the construction of a pumping station as the solution to the particular flood defence problem. Whilst it might appear to be a perfectly logical engineering answer, it may be unacceptable in environmentally sensitive wetlands.

The broad range of topics that must be considered during the design of a pumping station are shown in Figure 1. Although the "required capacity" is listed, and its calculations an essential step, the scope of the present research project is limited to the station itself - from the downstream side of the weedscreen to the discharge point on the delivery side. It is assumed for the purposes of this study that the run-off from the catchment and the hydraulic design of the approach channels to the station, have been carried-out in accordance with the methods outlined by Charnley (1987).

5.6 Selection of Pumps and Ancillary Equipment

A considerable number of options are open to the designer when choosing the equipment to install, and the method of housing it. These are shown in matrix form in Figure 2. The selection from among the various options is usually not as difficult as it might appear, as many of the choices are dictated by local conditions, the capacity of the station, the pumping head and planning or environmental constraints.

PUMPING STATION DESIGN CONSIDERATIONS

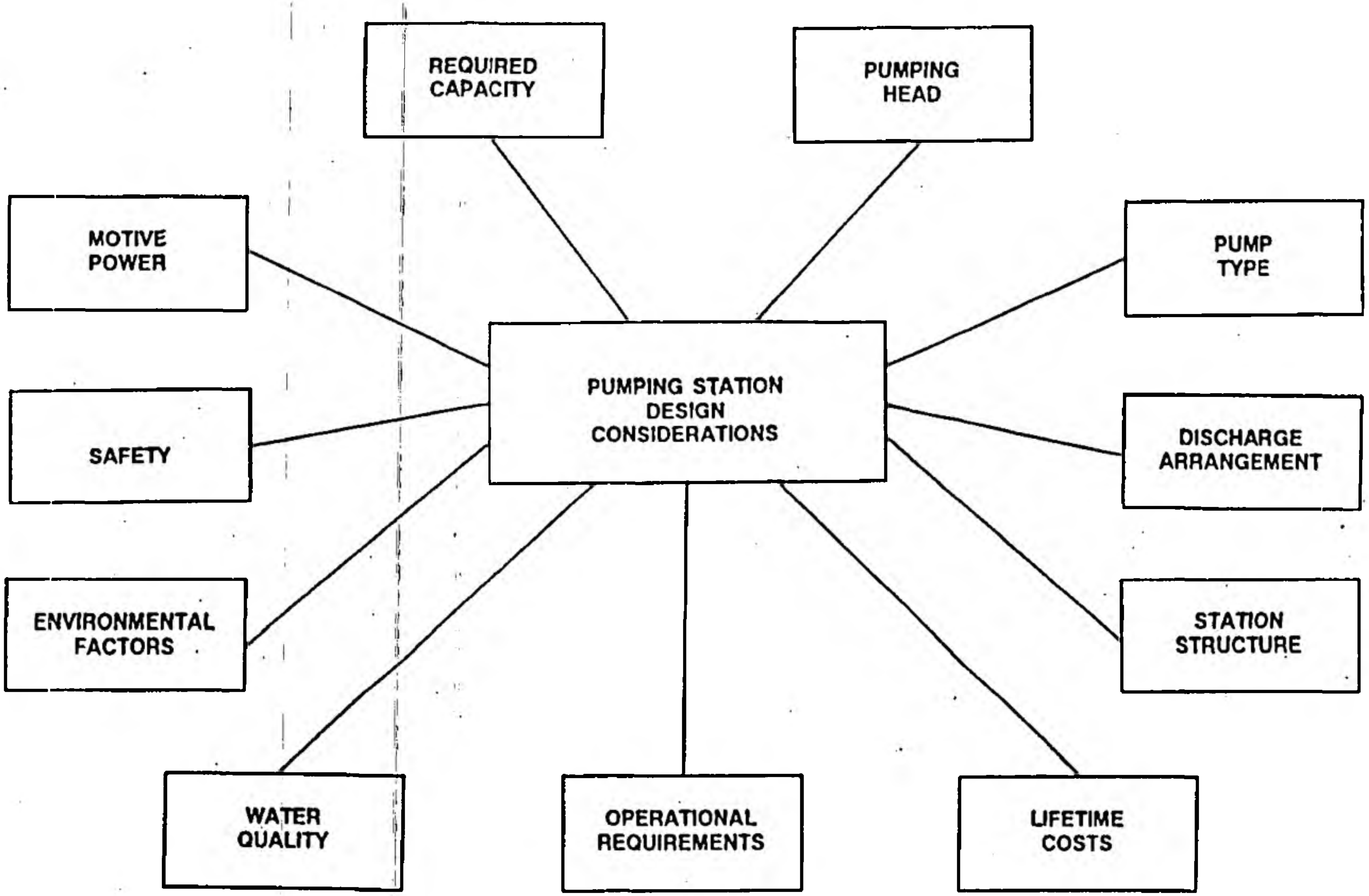


FIGURE 1.

PUMPING STATION OPTIONS

ALTERNATIVES / KEY PARAMETERS		1	2	3	4	5	6
MOTIVE POWER	A.	Electric Squirrel Cage	Diesel				
STARTER	B.	Direct On Line	Star Delta	Electronic Soft Start	Auto Trans - Former	Diesel - Compressed Air	Diesel - Electric Starter
PUMP TYPE	C.	Centrifugal	Axial Flow	Mixed Flow (bowl)	Mixed Flow (volute)	Archimedean Screw	
MOUNTING	D.	Horizontal	Vertical	Inclined			
DISCHARGE ARRANGEMENT	E.	Free Discharge	Siphonic	Sluice	Sluice + Reflux Valve	Sluice and Flap	Flap
HOUSING	F.	High Bldg. With Crane	Low Bldg. Removable Roof	Low Building	Outdoor	Submersible	Floating
PUMP CONTROL	G.	Float	No - Flote	Ultrasonic	Pressure Transducer		

FIGURE 2.

Motive Power - For small or medium sized modern stations electrically driven pumps would normally be selected, providing that a power supply is available or could be brought to the site at reasonable cost. Consideration would of course have to be given to the tariff that the electricity board would charge. Where heavy maximum demand charges are likely to be faced, consideration would be given in preliminary investigation to the possibility of confining pumping to off-peak periods (providing sufficient storage was available) and increase the pump capacity to deal with the accumulated water.

Although slip-ring motors were sometimes specified in the past and are still in use in some stations, the squirrel-cage motor is now generally adopted. The squirrel-cage is cheap, strong and simple in construction but has a high starting current and careful consideration must be given to the selection of the starter where high starting currents are not acceptable to the supply company.

Diesel engines, many of them turbo-blown, are mainly confined to very large stations and drive large capacity pumps through right-angle reduction gearboxes. They require heavy foundations, need fuel storage tanks, are very costly and required skilled operators. Although automatic starting is technically feasible, the risk of malfunction of associated equipment is such that it is not adopted for flood defence pumping. Without automatic starting, pumping at week-ends and outside normal working hours can result in heavy wage bills. In some stations it is now proving economical to replace diesel driven pumps with automatic electric units to overcome this difficulty.

Starters - The starter and motor combination is usually dictated by the limits on starting current set by the supply company. Where no restrictions apply, a direct on line starter and squirrel-cage motor can be employed. In the past when the starting current was restricted to 2.5 times the full load current, one option was to use a Wauchope starter, developed at Allen Gwynnes which could hold the starting current close to this value. Present practice would favour the use of an electronic soft starter or an auto transformer starter that can reduce the starting current to a value between 1.5 and 3.5 times the full load current.

Pump Types - Five types of pumps are in current use in flood defence pumping stations, namely:-

i) Centrifugal.
ii) Axial flow.
iii) Mixed flow (bowl).
iv) Mixed flow (volute).
v) Archimedean screw.

The centrifugal pump with a low specific speed was in universal use for many years and some large units are still in operation today. It has now been superseded by axial and mixed flow pumps where large capacity units are required, but is still continuing in use in some of the smaller submersible models.

The axial flow pump, with its high specific speed, is smaller in size and requires a smaller motor for a given head and discharge than other types. In many respects it is ideal for flood defence pumping duty up to a head of 6m. With its impeller set below water lever and no priming problems it lends itself to automatic operation. In small sizes problems may be experienced where weed is present due to the small clearance between the impeller blades. One experienced manufacturer always recommended the use of mixed flow bowl pumps when sizes less than 36cm were required (Terry, 1967). Whilst the axial flow pump can prove highly efficient at high rotation speeds in clean water, serious vibration and overloading can occur when the water contains weed and other debris - the typical river condition. Experience has shown that where these conditions are likely to be encountered, conservative values of tip speed (20m/sec) should not be exceeded.

The mixed flow, bowl type pump has many of the advantages of the axial, but has a lower specific speed and requires a larger pump and motor than the former for a given head and capacity. It is mainly employed where heads are in excess of 6m or as indicated above, in small sizes, where its ability to deal with weed is superior to that of a similar capacity axial flow unit.

The mixed flow, volute pump is generally capable of passing large solids and in the small sizes it can be used in similar situations to its bowl type counterpart. It is also used when a very large capacity is required, with the volute cast in-situ in concrete in the pumping station structure. In these large scale applications its small variation in power demand over its pumping range proves a worthwhile advantage.

The archimedean screw pump is better able to deal with large quantities of weed than any of the other types. Its disadvantages are that it cannot be employed efficiently where there are large variations in discharge level and that the slow speed of revolution of the screw necessitates the use of a gearbox. It has been claimed that the screw pump is unlikely to be cost effective for flood defence purposes, but this is belied by the large number of small units employed in the South East.

Mounting - Although many of the early centrifugal pumps were mounted horizontally this arrangement is now little used except for some submersible pumps. The inclined position was used for some large axial flow pumps in the past and is still adopted for some light-weight pumps developed for irrigation or stormwater use and for screw pumps. Suspending the pump vertically is the most widely used method, both for the traditional shaft driven pump and submersible units.

Discharge Arrangements - A great variety of discharge arrangements are currently used. Since the early 1950's the use of siphonic discharge pipes, incorporating a siphon breaker valve, have been in widespread use. It is much cheaper and generally more effective than the earlier combination of a sluice and reflux valve - both very expensive in the larger sizes. Care must be taken to ensure that flow velocities on starting are not less than 2m/sec or the siphon may not prime. Some care is required in the design of the siphon if optimum performance is to be achieved (Charlton,1972). Lack of maintenance and air leakage at the valve can seriously reduce the pumps output. Free discharge above maximum downstream flood level has been adopted in some case but involves the extra cost of pumping against a high head at all times. The minimum requirement of a discharge flap has been adopted on some small stations. Problems can be experience with slamming of the flap and velocities should be kept down to 2m/sec, by use of a taper pipe or a flap with a "dashpot" should be fitted. Where reliance is placed on a single flap, provision for stop logs should be made in the discharge bay for emergency use or repair of the flap.

Housing - The traditional pumphouse is no longer required when "outdoor" or submersible pumps are installed. A small cubicle or building is required to house the switchgear and this is sometimes made larger to store tools or other items for local use. For large stations a pumphouse building is still generally provided, to house the engines and ancillary equipment and control gear. An overhead crane is normally provided. In some instances the crane is omitted and a low building constructed with removable roof sections, to permit the use of a mobile crane when the pumps have to be removed for maintenance or renewal.

Pump Control - For very large diesel driven stations manual control is invariably used, although several phases of the starting sequence may be automated. In electrically powered stations the pump units are equipped for both manual and automatic operation, the latter being initiated by electrode systems of the "no-flote" variety. Alternatives are floats that may incorporate mercury tilting switches, or systems using "air bubblers" or pressure cells to gauge water levels. In recent years ultra sonic equipment has been used to monitor levels and trigger pump starts. Connections can be made to telemetry systems to report the status of the station and to indicate whether it is fully functional.

5.7 Design Check List

The Design Check List (Appendix C2.) has been produced to indicate the major tasks and key events in the design of a flood defence pumping station. The list is not exhaustive and cannot show the overlap of activities that occur in practice. For completeness some of the early operations, which are outside the scope of this study, are included, namely items 3 to 7. For the guidance of readers brief mention of them will be made in the manual.

5.8 Points for Further Study

Several points of interest where further study will be undertaken as part of this study arose from interviews with designers and correspondence with pump manufacturers. They are as follows:-

i) There would appear to be no general agreement on the sizing of pumps in a multiple pump station. Some engineers think that pumps of equal capacity and type should be selected to reduce the range and amount of spares required. Others are of the opinion that more than one size of pump should be used, a small one (or ones) to deal with dry weather flow and larger pumps to handle storm flows.

ii) There are similar differences of opinion as to whether wear should be evenly distributed over all pumping units, by a periodic change in the "duty pump", or whether one pump should remain as "duty pump", so that possible failure or need for major overhaul of all the units should not occur at the same time.

iii) There are conflicting reports about the performance and cost-effectiveness of screw pumps. The latest report by CIRIA on the design of low-lift pumping stations states that they are "not usually cost-effective when total installation and operational costs are considered; now therefore, they are not normally considered for new stations". In view of the very large number of small screw pumps installed in the Southern Region of the NRA, it is important that we find the reason for their widespread adoption in this particular locality and whether they are in fact cost-effective when compared with other small rotodynamic pumps.

iv) Some engineers favour letting a single contract for a station to the main civil engineering contractor, leaving him to deal with the pump manufacturer as a nominated supplier. Other engineers prefer to let the work out as two separate contracts and co-ordinate the work themselves, on the grounds that they have more direct control over the mechanical and electrical work.

v) The conservative value of tip speed for axial flow pumps of 20m/sec, recommended by Allen Gwynnes for many years, has been confirmed by research in Germany by KSB Pumps Ltd. The company do claim however that a new impeller that they have designed and are marketing, prevents weed and other streamer type debris from sticking to the blades, thus permitting a much higher tip speed without any problems. They have published a video of tests on a standard impeller but unfortunately it does not show pictures of the new impeller working under similar conditions.

Appendix A

Study Approach

Contents

Appendix A1

Survey of Pumping Plant

Questionnaire

National Rivers Authority

SURVEY OF LAND DRAINAGE PUMPING PLANT INSTALLATIONS QUESTIONNAIRE

NRA Region ______________________________

Address ______________________________

____

Name & Tel. No of person for further information ______________________________

____

____

GENERAL DETAILS OF INSTALLATION

1. Name & Location ______________________________

   ____

2. National Grid Reference ______________________________
3. Catchment Area Served (Sq.km) ______________________________
4. Total Capacity (Cumecs) ______________________________
5. Details of Pumps - *** Complete Appendix "A" ***
6. Are pumps separated in sump by dividing walls? Yes/No
7. Dimensions of Screen (inc. Bar Sizes & Spacing) ______________________________

   ____

8. Is there a gravity by-pass to station? Yes/No
9. Is screen cleaned manually or automatically? Yes/No
10. Does station operate automatically? Yes/No
11. Is it manned during normal working hours? Yes/No
12. Are pump running hours recorded? Yes/No
13. Is station connected to a remote monitoring or control system?

    For water level recording? ______________

    For equipment status? ______________

    Can it be operated remotely? ______________

14 Is standby power supply available in the event of mains failure? Yes/No

DESIGN

15. Who was responsible for the specification and design of the station?

____

____

16. Are detailed M+E drawings and specifications available Yes/No

17. Are detailed civils drawings and specifications available Yes/No

COST

18. What was the cost of the station?

Civil £______ Mech & Elec £______ Date ________________

FURTHER INFORMATION

19. Any further pertinent information or problems experienced

____

____

____

____

____

20. Any particular unique design features

____

____

____

____

Appendix "A"

National Rivers Authority

SURVEY OF LAND DRAINAGE PUMPING PLANT INSTALLATION

Pumping Station Name:..

NRA Region:..

Pump No	Make	Date Com.	Pump Type (i)	Size Diam.	Housing (ii)	Mounting (iii)	Capacity (cumecs)	Design Static Head (m)	Impeller Speed (R.P.M)	Drive (iv)	H.P	Supply Voltage	KVa	Discharge Type (v)	Hours Run/ Pump/year	Notes
1.																
2.																
3.																
4.																
5.																
6.																
7.																
8.																

(i) Pump Type
- Centrifugal 'C'
- Axial 'A'
- Mixed Flow 'MF'
- Screw 'S'

(ii) Housing
- High [illegible] 'HH'
- Low [illegible] 'LH'
- Outdoor 'OO'
- Submersible 'SB'

(iii) Mounting
- Horizontal 'H'
- Vertical 'V'

(iv) Drive
- Diesel 'D'
- Electric 'E'

(v) Discharge
- Siphonic 'SI'
- Sluice 'SL'
- Sluice & Reflux 'SR'

Appendix A2

Survey of Pumping Plant Design

Questionnaire

National Rivers Authority

SURVEY OF LAND DRAINAGE PUMPING PLANT INSTALLATIONS
SITE VISIT - QUESTIONS ON DESIGN AND DESIGN PHILOSOPHY

NRA Region ______________________________

Address ______________________________

____

Name & Tel. No of person interviewed

____

____

Pumping Station Name and Location ______________________________

____

INTERVIEW QUESTIONS

1. Who was responsible for design?

   In house? ______________________________

   Consultants? ______________________________

2. How was it carried-out?

   Intergrated part of drainage scheme?

   Seperate design package?

3. Design Team

   (i) C.E. led with vetting by M & E engineers?

   (ii) Integrated C.E and M & E team?

   (iii) Project Engineer co-opting specialists?

4. Who made the major decision in respect of design?

   ____

   ____

5. Siting

Was siting dictated by catchment constraints? If large single station, was consideration given to use of several small peripheral stations?

6. Environmental considerations?

Did environmental considerations have a major influence on design - if so how?

7. Capacity

How was capacity of station arrived at?

Locally accepted run-off/ unit area?

Following detailed analysis of C.E. machinery, storage, power supply and operating costs?

Particular constraints on any of the above?

Need to confine pumping to off-peak periods?

8. Alternatives considered

Were alternative designs considered? ie. shaft driven indoor, outdoor, submersible, pontoon, archimedean screw?

9. What influcenced final choice?

Initial cost?

Lifetime cost?

Operating costs?

Reliability?

Previous experience of equipment or marque?

10. What basic information was given to pump manufacturer?

a) Total capacity of pumps?

b) Number of pumps?

c) Capacity per pump?

d) Max. suction W.L.?

e) Max. discharge W.L.?

f) Min. suction W.L.?

g) Min. discharge W.L.?

h) Lowest start level?

i) Normal static duty head at design capacity?

j) Prime mover type - diesel, electric, mixed?

k) Ground level at site?

l) Max. flood level at site?

m) Screen - manual or machine raked?

n) Other?

11. Weed, debris, solids?

Was pump supplier informed of potential problems in respect of weed, urban or other debris, silt abrasive material?

12. Discharge arrangement?

Was siphonic or other discharge arrangement specified?

13. M & E rerquirements specified to manufacturer?

Were specific requirements in respect of mechanical and electrical items (starters, switchgear, lubrication, cooling, bearings, motor speeds, tip speeds, discharge velocites, materials etc.) given to suppliers - if so what?

14. Performance tests?

What performance guarantees were given by pump manufucturer?

Estimated life - running hours?

Power consumption?

Maintenance spares requirement?

15. Performance guarantees?

What performance guarantees were given by pump manufactuere?

Estimated life - running hours?

Power consumption?

Maintenance spares requirement?

16. Pump control

Manual?

Automatic?

Float? No Float? Air bubbler? Pressure transducer? Ultrasonic? Other?

Are interlocks with time delays fitted to prevent simultaneous starts on power restoration after mains failure?

17. Instrumentation

What instrumentation is installed?

Ammeter? Hours run meter? U/S level and D/S level?

Other? What records are kept?

18. Telemetry

Is the station linked by telemetry to a control centre?

If so what parameters are monitored and what alarms given?

Power supply? Pump running? Water levels? Equipment status and serviceability - seals? Bearing temperature? Start and stop levels? Building security - fire, intruder?

19. Standby provision

What provision has been made in the event of power failure?

Installed standby generator? Mobile generator? Mixed diesel and electric pump units?

20. Provision for uprating?

Has provision been made for uprating the capacity of the station should this be required in the future?

21. Station performance

Has station performed in accordance with design expectations?

Any particular problems?

Any feature you would omit or include as a result of operational experience?

Appendix A3

Survey of Pumping Plant Maintenance

Questionnaire

National Rivers Authority

SURVEY OF LAND DRAINAGE PUMPING PLANT INSTALLATIONS
MAINTENANCE QUESTIONNAIRE

NRA Region ______________________________

Address ______________________________

____

Name & Tel. No of person for further information

____

____

DETAILS OF MAINTENANCE

1. Who is responsible for P.S maintenance?

____

____

2. Do you have written terms of reference establishing overall strategy and policy in respect of pumping station maintenance? Yes/No

3. How often is the policy reviewed? ______________________________

4. Are detailed records kept of all stations? Yes/No

5. Do these include: -
   (i) Individual pump running hours? Yes/No
   (ii) Details of all maintenance? (Planned and break-down) Yes/No
   (iii) Dates of running checks and inspections? Yes/No

6. Are these records kept on a data base? Yes/No

7. Are specific time intervals laid down for running tests and minor and major maintenance i.e Monthly, Yearly, Three yearly (Diesels - manufacturers recommendations)?

____

____

____

13. Are standard report and check sheets used for annual and major maintenance inspections? Yes/No

14. Major maintenance inspections (3 years) (?)

What checks are carried-out?

(i) Sump dewatered and cleared ____________

(ii) Bearing wear checked ____________

(iii) Impeller wear checked ____________

(iv) All couplings checked ____________

(v) Lub. system & pipes ____________

(vi) Seals ____________

(vii) Other ____________

____

15. When pumping plant is purchased is the manufacturer asked for any guarantees in respect of: -

(i) Consumable spares Yes/No

(ii) Power consumption Yes/No

(iii) Life of plant Yes/No

16. Do you carry-out post project appraisals to confirm design performance, power consumption and maintenance and operating costs? Yes/No

17. Are analyses of past maintenance costs used in the selection of new pumping plant? Yes/No

18. Any further comment on pumping station maintenance (Use separate sheet if required)

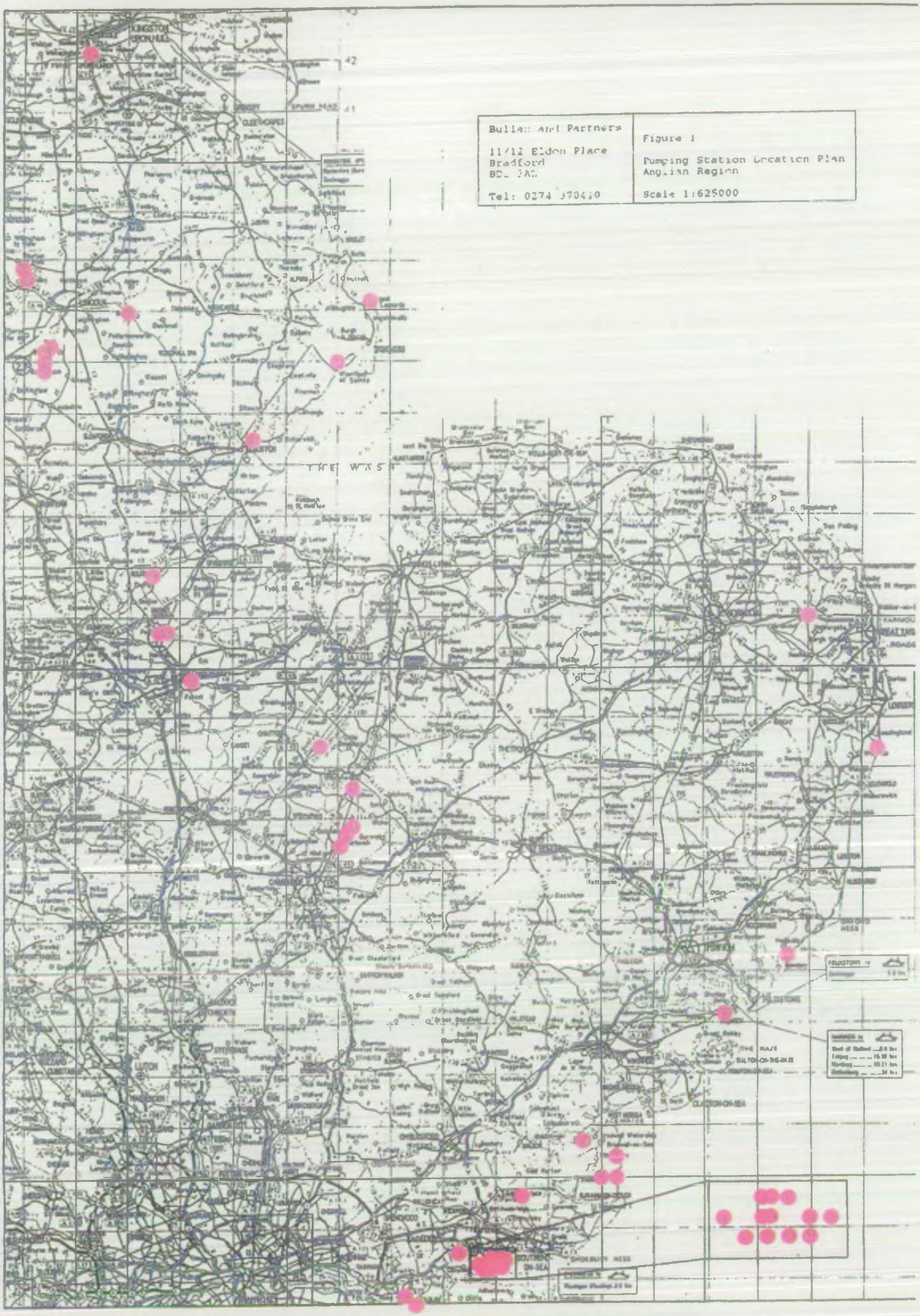
Appendix B

Data Base

Contents

Contents

REGION	SUB REGION	STN. NO	NAME
Anglian			
		032	CHAPEL - OLD & NEW
		033	CROFT LANE
		034	BUTTS ROAD
	Chelmsford	001	THORNEY BAY
		002	WINTER GARDENS
		003	DUTCH VILLAGE
		004	ANTLERS
		005	PITSEA HALL FLEET
		006	BECKNEY FARM
		007	BRIDGEWICK
		008	MARSH HOUSE
		009	LANDWICK
		010	MAY AVENUE
		011	KNIGHTSWICK
		012	WORLDS END
		013	ST.ANNES
		014	TILBURY MARSH
		015	LEIGH BECK
		016	CROPPENBURG
		017	RAIN BOW
		018	ST.JOSEPHS
		019	HILTON
	Norwich	020	ACLE
	Ipswich	021	HOLLESLEY
		022	BENACRE
	Lincoln	023	BLACKMOOR FARM
		024	MEADOW FARM
		025	BRANSBY
		026	TILL
		027	WITHAM
		028	BRANT
		029	SAND SYKE
		030	BRANSTON ISLAND
		031	BLACK SLUICE
	Peterborough	035	PADHOLME
		036	PEAKIRK (ELECTRIC)
		037	PEAKIRK (DIESEL)
		038	BOURNE EAU
	Colchester	039	PARKESTON
	Kelveden	040	MELL HOUSE
	Ely	041	BOTTISHAM LODE
		042	SWAFFHAM LODE
		043	WELCHES DAM
		044	UPWARE
		045	SOHAM LODE



Bullen and Partners 11/12 Eldon Place Bradford BD1 3AS Tel: 0274 370410	Figure 1 Pumping Station Location Plan Anglian Region Scale 1:625000

NRA - Survey of Land Drainage Pumping Plant Installations
Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer
Anglian						
001	THORNEY BAY	TQ 795 827		0.060		
					1	FLYGT
					2	FLYGT
002	WINTER GARDENS	TQ 790 840		0.060		
					1	FLYGT
					2	FLYGT
003	DUTCH VILLAGE	TQ 775 838		0.620		
					1	SPAAN
					2	SPAAN
004	ANTLERS	TQ 789 827		0.060		
					1	FLYGT
					2	FLYGT
005	PITSEA HALL FLEET	TQ 738 859		0.060		
					1	FLYGT
006	BECKNEY FARM	TQ 852 962		0.100		
					1	FLYGT
					2	FLYGT
007	BRIDGEWICK	TM 030 004		0.510		
					1	SULZER
					2	SULZER
008	MARSH HOUSE	TM 032 046	248.63	2.970		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
					3	ALLEN GWYNNES
009	LANDWICK	TM 008 009	0.30	0.990		
					1	GILL
					2	GILL
010	MAY AVENUE	TQ 805 825		0.590		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
					3	ALLEN GWYNNES
011	KNIGHTSWICK	TQ 805 843		0.310		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
					3	ALLEN GWYNNES
012	WORLDS END	TQ 648 753		1.520		
					1	SAMUAL WHITE
					2	SAMUAL WHITE

Year	Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
1980	S	100 mm	SB	-	0.03	1.60	960	E	3.0	415	SL
1980	S	100 mm	SB	V	0.03	1.60	960	E	3.0	415	SL
1980	S	100 mm	SB	V	0.03	1.35	960	E	3.0	415	SL
1968	C	100 mm	SB	-	0.03	1.35	960	E	3.0	415	SL
1978	S	900 mm	LB	-	0.31	2.60	20	E	3.0	415	SR
1978	S	900 mm	LB	V	0.31	2.60	20	E	3.0	415	SR
1978	C	100 mm	SB	V	0.03	1.50	960	E	3.0	415	SL
1978	C	100 mm	SB	-	0.03	1.50	960	E	3.0	415	SL
1980	C	75 mm	SB	V	0.06	1.50	960	E	3.0	415	SL
1982	C	100 mm	SB	-	0.05	2.55	960	E	3.0	415	SL
1982	C	100 mm	SB	V	0.05	2.55	960	E	3.0	415	SL
1949	A	406 mm	HB	V	0.34	3.66	720	E	25.0	415	SR
1949	A	355 mm	HB	V	0.17	3.66	960	E	14.0	415	SR
1949	A	610 mm	HB	V	0.99	3.66	580	E	75.0	415	SL
1949	A	610 mm	HB	V	0.99	3.66	580	E	75.0	415	SL
1949	A	610 mm	HB	V	0.99	3.66	580	E	75.0	415	SL
1961	A	508 mm		H	0.71	2.44	720	E	45.0	415	SR
1961	A	355 mm		H	0.28	2.44	960	E	20.0	415	SR
1968	C	300 mm	LB	V	0.28	2.20	960	E	10.0	415	SR
1968	C	300 mm	LB	V	0.28	2.20	960	E	10.0	415	SR
1968	C	248 mm	LB	V	0.03	2.20	960	E	5.0	415	SR
1968	C	300 mm	LB	V	0.14	1.60	960	E	10.0	415	SR
1968	C	300 mm	LB	V	0.14	1.60	960	E	10.0	415	SR
1968	C	248 mm	LB	V	0.03	1.60	960	E	5.0	415	SR
1968	A	450 mm	OD	-	0.76	2.88	720	E	140.0	415	SR
1968	A	450 mm	OD	H	0.76	2.88	720	E	140.0	415	SR

NRA - Survey of Land Drainage Pumping Plant Installations
Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer	Year
013	ST.ANNES	TQ 811 827		0.590			
					1	ALLEN GWYNNES	1978
					2	ALLEN GWYNNES	1978
					3	ALLEN GWYNNES	1978
014	TILBURY MARSH	TQ 636 778		0.170			
					1	SPAAN	1974
015	LEIGH BECK	TQ 821 830		0.300			
					1	BRITISH PLEUGER	1978
					2	BRITISH PLEUGER	1978
016	CROPPENBURG	TQ 816 833		0.560			
					1	ALLEN GWYNNES	1968
					2	ALLEN GWYNNES	1968
017	RAIN BOW	TQ 799 838		0.060			
					1	FLYGT	1968
					2	FLYGT	1968
018	ST.JOSEPHS	TQ 799 837		0.030			
					1	FLYGT	1968
019	HILTON	TQ 796 844		0.460			
					1	SPAAN	1968
					2	SPAAN	1968
020	ACLE	TQ 408 106	17.22	0.700			
					1	SMITHDOLE	1944
021	HOLLESLEY	TM 367 439	15.00	2.510			
					1	HARLAND JOHNSON	1969
					2	HAWTHORNE DAVEY	1940
022	BENACRE	TM 536 845	80.00	4.248			
					1	ALLEN GWYNNES	1969
					2	SULZER	1955
					3	SULZER	1955
023	BLACKMOOR FARM	SK 946 628	0.05	0.015			
					1	SYKES	1989
024	MEADOW FARM	SK 933 589	0.01	0.013			
					1	SYKES	1989
025	BRANSBY	SK 904 788	1.00	0.180			
					1	FLYGT	1988
					2	FLYGT	1988
026	TILL	SK 910 763	3.00	1.600			
					1	FLYGT	1986
					2	FLYGT	1986

[redacted]

Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
C	300 mm	LB	V	0.28	2.30	960	E	10.0	415	SR
C	300 mm	LB	V	0.28	2.30	960	E	10.0	415	SR
C	244 mm	LB	V	0.03	2.30	960	E	5.0	415	SR
S	900 mm	OO	H	0.17	0.00	20	E		415	SL
C	150 mm	LB	V	0.15	4.03	900	E	28.0	415	SR
C	150 mm	LB	V	0.15	4.03	900	E	28.0	415	SR
C	254 mm	LB	V	0.28	2.55	960	E	15.0	415	SR
C	254 mm	LB	V	0.28	2.55	960	E	15.0	415	SR
C	100 mm	SB	V	0.03	1.12	960	E	3.0	415	SL
C	100 mm	SB		0.03	1.12	960	E	3.0	415	SL
C	100 mm	SB	V	0.03	1.71	960	E	3.0	415	SL
S	838 mm	LB	H	0.23	2.15	20	E	15.0	415	SR
S	838 mm	LB	H	0.23	2.15	20	E	15.0	415	SR
A	450 mm	LB	V	0.70	3.00	725	E	55.0	415	SR
A	406 mm	OO	V	0.51	3.60	940	E	30.0	415	SL
MF	914 mm	HB	H	2.00	3.13	315	E	110.0	415	SR
A	600 mm	HB	V	0.85	5.79	585	E	100.0	415	SR
MF	600 mm	HB	H	1.13	6.95	575	D	125.0		SR
MF	900 mm	HB	H	2.26	6.80	440	D	247.0		SR
C	100 mm	SB	V	0.01	4.00		E		415	SL
C	100 mm	SB	V	0.01	4.00		E		415	SL
A	200 mm	SB	V	0.09	3.00	1,450	E	8.9	415	SI
A	200 mm	SB	V	0.09	3.00	1,450	E	8.9	415	SI
A	460 mm	SB	V	0.80	3.00	975	E	50.0	415	SI
A	460 mm	SB	V	0.80	3.00	975	E	50.0	415	SI

NRA - Survey of Land Drainage Pumping Plant Installations
Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer	Year
					2	FLYGT	1986
027	WITHAM	SK 952 639	1.50	1.000			
					1	FLYGT	1989
					2	FLYGT	1989
028	BRANT	SK 948 625	4.00	2.800			
					1	FLYGT	1991
					2	FLYGT	1991
					3	FLYGT	1991
					4	FLYGT	1991
029	SAND SYKE	SK 943 601	2.50	1.800			
					1	FLYGT	1991
					2	FLYGT	1991
					3	FLYGT	1991
030	BRANSTON ISLAND	TF 103 703	0.80	0.110			
					1	GOODENOUGH	1962
031	BLACK SLUICE	TF 327 428	710.00	59.900			
					1	ALLEN GWYNNES	1946
					2	ALLEN GWYNNES	1946
					3	ALLEN GWYNNES	1946
					4	ALLEN GWYNNES	1965
					5	ALLEN GWYNNES	1965
032	CHAPEL - OLD & NEW	TF 560 729	66.00	14.790			
					1	N E I - ARE	1986
					2	N E I - ARE	1986
					3	N E I - ARE	1986
					4	ALLEN GWYNNES	1948
					5	RUSTON HORNSBY	1948
					6	ALLEN GWYNNES	1948
033	CROFT LANE	TF 501 600	5.05	7.430			
					1	ALLEN GWYNNES	1971
					2	ALLEN GWYNNES	1971
034	BUTTS ROAD	TA 030 226	2.02	1.050			
					1	ABS	1985
					2	ABS	1985
					3	ABS	1985
035	PADHOLME	TL 229 984	8.02	3.000			
					1	HARLAND JOHNSON	1973
					2	HARLAND JOHNSON	1973
					3	HARLAND JOHNSON	1973
036	PEAKIRK (ELECTRIC)	TF 175 072		12.750			
					1	ALLEN GWYNNES	1973

Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
A	460 mm	SB	V	0.80	3.00	975	E	50.0	415	SI
A	460 mm	SB	V	0.50	3.00	725	E		415	SI
A	460 mm	SB	V	0.50	3.00	725	E		415	SI
A	460 mm	SB	V	0.50	3.00	970	E		415	SI
A	460 mm	SB	V	0.50	3.00	970	E		415	SI
A	550 mm	SB	V	0.90	3.00	970	E		415	SI
A	550 mm	SB	V	0.90	3.00	970	E		415	SI
A	460 mm	SB	V	0.50	3.00	725	E		415	SI
A	460 mm	SB	V	0.50	3.00	725	E		415	SI
A	550 mm	SB	V	0.80	3.00	970	E		415	SI
C	200 mm	LB	H	0.11	3.35		D			SL
C	2540mm	HB	V	11.30	4.00	70	D	900.0	110	SL
C	2540mm	HB	V	11.30	4.00	70	D	900.0	110	SL
C	2540mm	HB	V	11.30	4.00	70	D	900.0	110	SL
C	2540mm	HB	V	13.00	4.00	70	D	975.0	110	SL
C	2540mm	HB	V	13.00	4.00	70	D	975.0	110	SL
A	1000mm	OO	V	2.63	3.60	355	E	270.0	415	SI
A	1000mm	OO	V	2.63	3.60	355	E	270.0	415	SI
A	1000mm	OO	V	2.63	3.60	355	E	270.0	415	SI
A	900 mm	HB	V	2.10	3.60	415	E	160.0		SR
C	1050mm	HB	H	2.40	3.60	350	D	156.0		SR
C	1050mm	HB	H	2.40	3.60	350	D	156.0		SR
A	685 mm	LB	V	3.42		580	E	70.0	415	SI
A	450 mm	LB	V	4.00		735	E	40.0	415	SI
S	300 mm	SB	V	0.35	10.40	950	E	75.0	415	SR
S	300 mm	SB	V	0.35	10.40	950	E	75.0	415	SR
S	300 mm	SB	V	0.35	10.40	950	E	75.0	415	SR
A	600 mm	OO	V	1.00	6.54	985	E	135.0	440	SI
A	600 mm	OO	V	1.00	6.54	985	E	135.0	440	SI
A	600 mm	OO	V	1.00	6.54	985	E	135.0	440	SI
A	750 mm	OO	V	4.25	1.83	490	E	90.0	440	SI

NRA - Survey of Land Drainage Pumping Plant Installations
Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer	Year	Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
037	PEAKIRK (DIESEL)	TF 175 072		4.800														
					1	FARROW WALLIN	1983	A	600 mm	HB	V	1.60	2.80	600	D	180.0		SI
					2	FARROW WALLIN	1983	A	600 mm	HB	V	1.60	2.80	600	D	180.0		SI
					3	FARROW WALLIN	1983	A	600 mm	HB	V	1.60	2.80	600	0	180.0		SI
038	BOURNE EAU	TF 156 187	15.37	4.500														
					1	ALLEN GWYNNES	19	A	600 mm	HB	V	1.50	3.84	485	E	100.0	440	SI
					2	ALLEN GWYNNES	19	A	600 mm	HB	V	1.50	3.84	485	E	100.0	440	SI
					3	ALLEN GWYNNES	19	A	600 mm	HB	V	1.50	3.84	485	E	100.0	440	SI
039	PARKESTON	TM 243 323	28.50	2.820														
					1	GILL	1961	MF	750 mm	-	H	1.41	4.50		E	90.0	415	SL
					2	GILL	1961	MF	750 mm		H	1.41	4.50		E	90.0		SL
040	MELL HOUSE	TL 963 085	5.00	0.850														
					1	BRITISH PLEUGER	1972	A	450 mm	SB	H	0.28	1.40		E	40.0	415	SL
					2	BRITISH PLEUGER	1972	A	530 mm	SB	H	0.57	1.40		E	70.0	415	SL
041	BOTTISHAM LODE	TL 510 658	72.20	4.000														
					1	WORTHINGTON 36	1948	C	914 mm	HB	V	2.00	5.10	237	D	150.0		SI
					2	WORTHINGTON 36	1948	C	914 mm	HB	V	2.00	5.10	237	D	150.0		SI
042	SWAFFHAM LODE	TL 522 673	36.40	2.000														
					1	WORTHINGTON 24	1948	C	609 mm	HB	H	1.00	1.00		D	95.0	240	SI
					2	WORTHINGTON 24	1948	C	609 mm	HB	H	1.00	1.00		D	95.0	240	SI
043	WELCHES DAM	TL 471 859	100.30	12.620														
					1	ALLEN GWYNNES	1948	MF	1145mm	HB	H	6.31	3.35	475	D	500.0	415	SL
					2	ALLEN GWYNNES	1948	MF	1145mm	HB	H	6.31	3.35	475	D	500.0	415	SL
044	UPWARE	TL 538 698	63.60	2.500														
					1	BEDFORD SA.80.04	1990	A	996 mm	SB	V	1.25	2.25	485	E	46.0	415	SL
					2	BEDFORD SA.80.04	1990	A	996 mm	SB	V	1.25	2.25	485	E	46.0	415	SL
045	SOHAM LODE	TL 540 764	104.00	5.400														
					1	ALLEN GWYNNES	1985	A	1000mm	LB	V	2.70	1.45	420	E	90.0	415	SI
					2	ALLEN GWYNNES	1985	A	1000mm	LB	V	2.70	1.45	420	E	90.0	415	SI

NORTHUMBRIAN

REGION	SUB REGION	STN. NO	NAME
Northumbrian			
	Darlington	001	MORDEN CARRS
		002	SWAN CARR
		003	SEAMER CARRS
		004	MAINSFORTH STELL
		005	VAN DIEMANS LAND

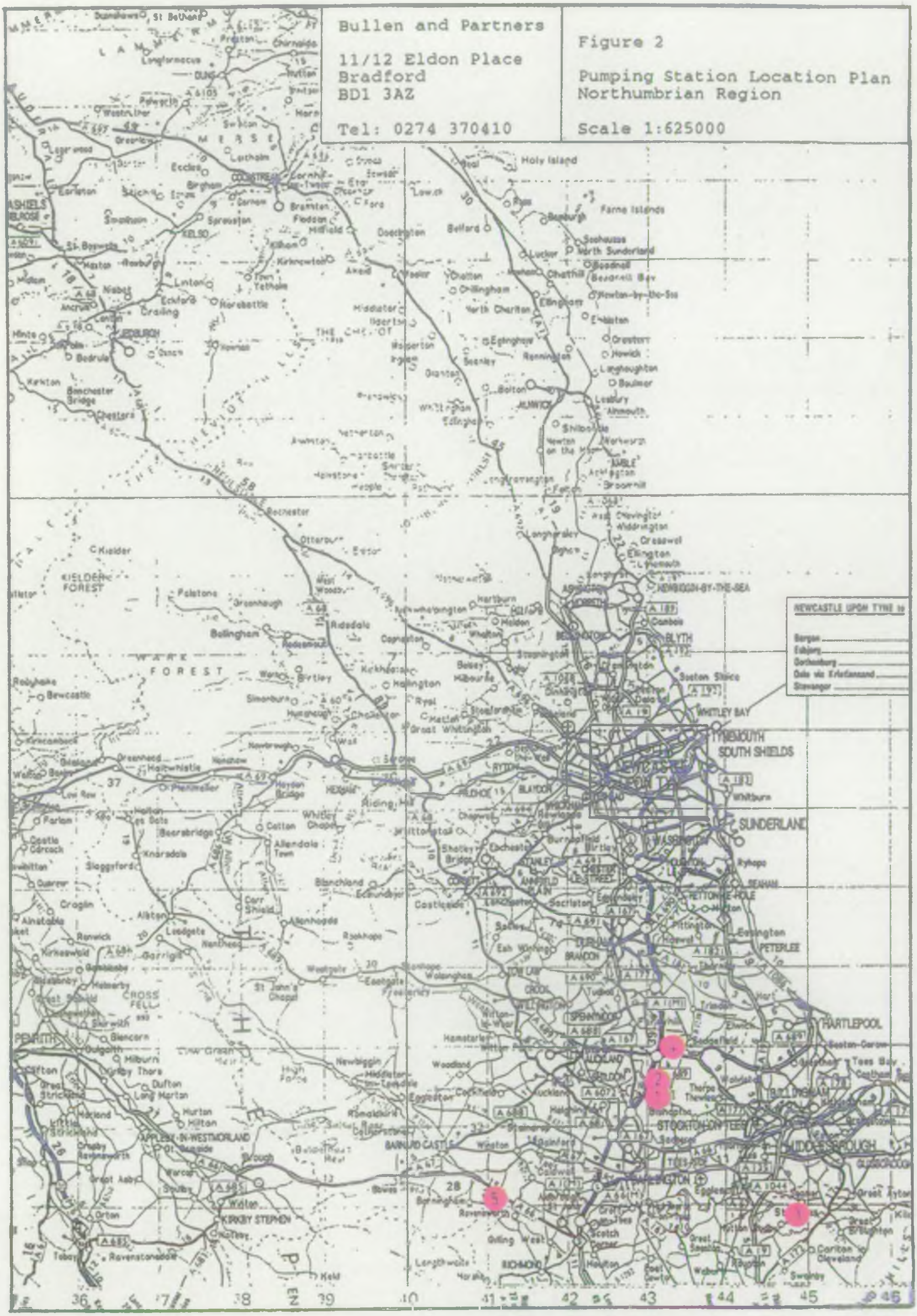


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Figure 2

Pumping Station Location Plan
Northumbrian Region

Scale 1:625000

NRA - Survey of Land Drainage Pumping Plant Installations
Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer
Northumbrian						
001	MORDEN CARRS	NZ 318 248	2.10	0.420		
					1	FLYGT LL3152
					2	FLYGT LL3152
002	SWAN CARR	NZ 311 255	1.60	0.200		
					1	FLYGT LL3152
003	SEAMER CARRS	NZ 491 096	2.38			
					1	TANGYES LTD
004	MAINSFORTH STELL	NZ 330 301	15.30	2.400		
					1	BRITISH GUINARD
					2	BRITISH GUINARD
005	VAN DIEMANS LAND	NZ 114 128	4.97	1.340		
					1	A.B.S. VUP400
					2	A.B.S. VUP400

Year	Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
1986	A	450 mm	SB	V	0.20	2.20	950	E	12.0	415	SR
1986	A	450 mm	SB	V	0.22	2.20	950	E	12.0	415	SR.
1986	A	450 mm	SB	V	0.20	2.20	950	E	12.0	415	SR
1955	C	mm	LB	V			715	E	10.0	415	SR
1987	A	800 mm	SB	V	1.20	3.00	750	E	100.0	415	SR
1987	A	800 mm	SB	V	1.20	3.00	750	E	100.0	415	SR
1985	A	700 mm	SB	V	0.67	2.00	960	E	40.0	415	SR
1986	A	700 mm	SB	V	0.67	2.00	960	E	40.0	415	SR

NORTH WEST

REGION	SUB REGION	STN. NO	NAME
North West	North Cumbria	001	COLMIRE SOUGH
		002	DURRANHILL
		003	GAMELSBY
		004	RUMBLING BRIDGE
		005	THACKA BECK
		006	WOLSTY
	South Cumbria	007	JOHNSCALES
		008	LEVENS
		009	POOL BRIDGE
		010	SAMPOOL
		011	ULPHA
	North Lancs	012	PREESALL
		013	RAIKES BROOK
		014	RED BRIDGE
		015	YOAD POOL
	South Lancs	016	BANKS MARSH
		017	BOUNDARY BROOK
		018	CLAY BROW
		019	CROSSENS
		020	CROSTON
		021	HOLMES WOOD
		022	KEW
		023	MAWDESLEY
		024	SOLLOM
		025	RUFFORD
	Cheshire	026	FRODSHAM
		027	INCE MARSH
		028	MORPETH
	North Manchester	029	BEDFORD
		030	JENNETTS LANE
		031	PENNINGTON
	Merseyside	032	ALTCAR
		033	ALTMOUTH
		034	DOG CLOG
		035	FINE JANE
		036	HEY COP
		037	INCE BLUNDELL
		038	NEW CUT
		039	PENDLEBURY

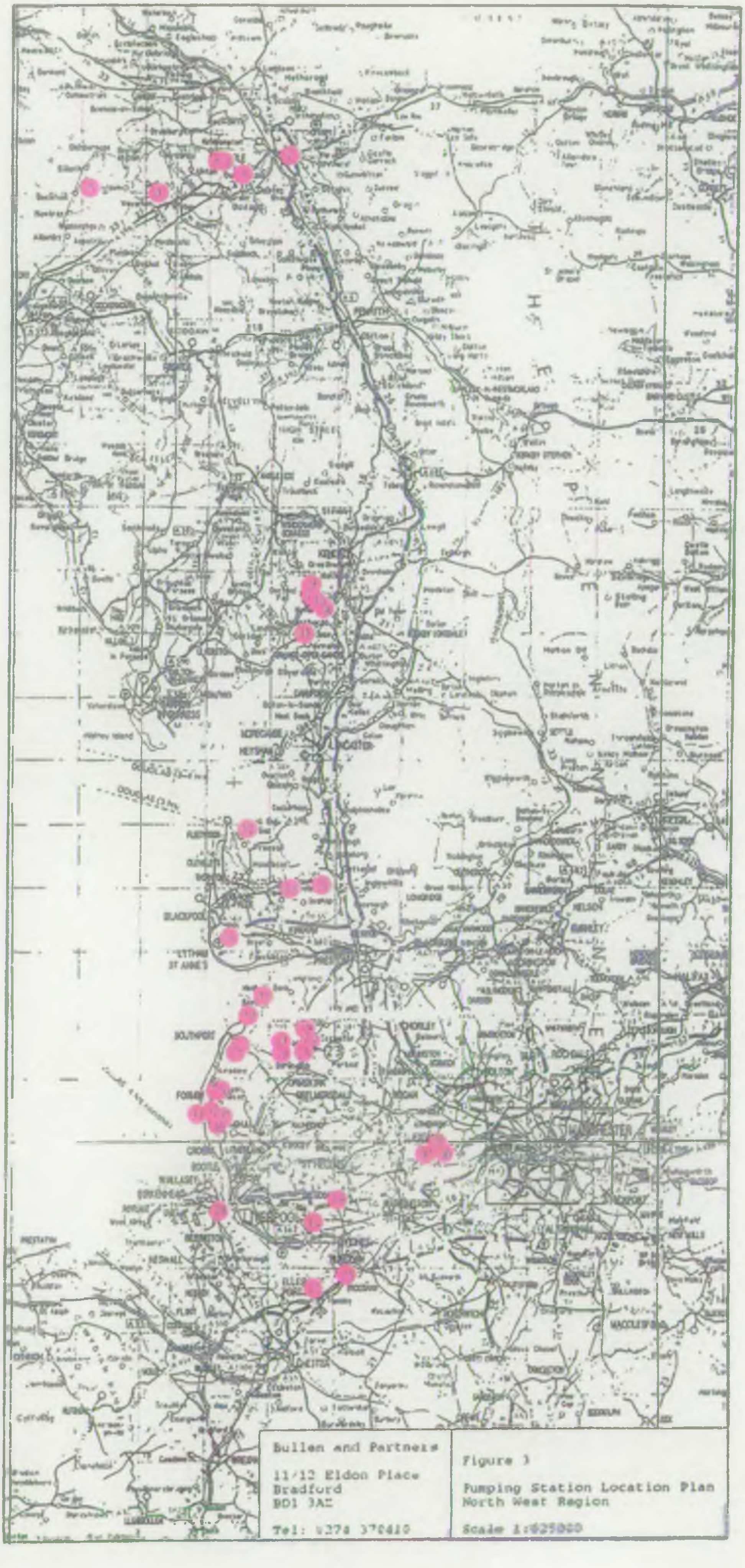

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Figure 3

Pumping Station Location Plan
North West Region

Scale 1:625000

NRA - Survey of Land Drainage Pumping Plant Installations
Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer	Year
North West							
001	COLMIRE SOUGH	NY 225 505	2.90	0.600			
					1	A.B.S.	1978
					2	A.B.S.	1978
002	DURRANHILL	NY 421 562	0.32	0.360			
					1	FLYGT	1991
					2	FLYGT	1991
					3	FLYGT	1991
					4	FLYGT	1991
003	GAMELSBY	NY 326 553	0.59	0.090			
					1	FLYGT	1975
004	RUMBLING BRIDGE	NY 315 552	0.97	0.085			
					1	FLYGT	1974
005	THACKA BECK	NY 350 531	0.76	0.085			
					1	FLYGT	1974
006	WOLSTY	NY 114 515	3.30	0.800			
					1	ALLEN GWYNNES	1985
					2	ALLEN GWYNNES	1985
007	JOHNSCALES	SD 468 868	0.29	1.080			
					1	A.B.S	1984
					2	A.B.S	1984
008	LEVENS	SD 487 849	3.83	0.700			
					1	FLYGT	1987
					2	FLYGT	1987
009	POOL BRIDGE	SD 464 885	0.34	1.700			
					1	A.B.S.	1984
					2	A.B.S.	1984
010	SAMPOOL	SD 473 855	0.80	2.520			
					1	A.B.S.	1991
					2	A.B.S.	1981
					3	A.B.S.	1981
011	ULPHA	SD 456 806	11.52	1.720			
					1	K.S.B.	1989
					2	K.S.B.	1989
012	PREESALL	SD 374 495	0.41	0.840			
					1	SARLIN	1983
					2	SARLIN	1983
013	RAIKES BROOK	SD 434 402		0.660			
					1	FLYGT	1984

Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
A	300 mm	SB	H	0.30	2.54	960	E	20.0	415	SR
A	300 mm	SB	H	0.30	2.54	960	E	20.0	415	SR
C	200 mm	SB	V	0.09	4.00	1,450	E	6.0	415	SR
C	200 mm	SB	V	0.09	4.00	1,450	E	6.0	415	SR
C	200 mm	SB	V	0.09	4.00	1,450	E	6.0	415	SR
C	200 mm	SB	V	0.09	4.00	1,450	E	6.0	415	SR
C	200 mm	SB	V	0.09	3.35	1,450	E	6.0	415	SR
C	200 mm	SB	V	0.09	3.79	1,450	E	6.0	415	SR
C	200 mm	SB	V	0.09	3.35	1,450	E	6.0	415	SR
A	400 mm	SB	V	0.40	3.40	975	E	43.0	415	SL
A	400 mm	SB	V	0.40	3.40	975	E	43.0	415	SL
A	550 mm	SB	V	0.54	4.83	960	E	74.0	415	SI
A	550 mm	SB	V	0.54	4.83	960	E	74.0	415	SI
A	300 mm	SB	V	0.35	2.80	725	E	30.0	415	SL
A	300 mm	SB	V	0.35	2.80	725	E	30.0	415	SL
A	500 mm	SB	V	0.85	5.18	720	E	120.0	415	SI
A	500 mm	SB	V	0.85	5.18	720	E	120.0	415	SI
A	500 mm	SB	V	0.84	4.50	960	E	100.0	415	SR
A	500 mm	SB	H	0.84	4.50	960	E	100.0	415	SR
A	500 mm	SB	H	0.84	4.50	960	E	100.0	415	SR
A	500 mm	SB	V	0.86	4.02	985	E	56.0	415	SR
A	500 mm	SB	V	0.86	4.02	985	E	56.0	415	SR
C	300 mm	SB	V	0.42	2.90	720	E	36.0	415	SR
C	300 mm	SB	V	0.42	2.90	720	E	36.0	415	SR
A	300 mm	SB	V	0.30		725	E	27.0	415	SR

NRA - Survey of Land Drainage Pumping Plant Installations
Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer	Year
014	RED BRIDGE	SD 347 323	0.08	0.720			
					1	GUINARD	1980
					2	GUINARD	1980
015	YOAD POOL	SD 482 416		0.300			
					1	FLYGT	1985
016	BANKS MARSH	SD 396 231	4.45	1.600			
					1	ALLEN GWYNNES	1987
					2	ALLEN GWYNNES	1987
017	BOUNDARY BROOK	SD 351 144		1.500			
					1	K.S.B.	1988
					2	K.S.B.	1988
018	CLAY BROW	SD 424 149	0.81	0.260			
					1	FLYGT	1986
					2	FLYGT	1986
019	CROSSENS	SD 376 206	143.94	23.770			
					1	ALLEN GWYNNES (L.L.)	1961
					2	ALLEN GWYNNES (L.L.)	1961
					3	SULZER (L.L.)	1989
					4	SULZER (L.L.)	1989
					5	ALLEN GWYNNES (L.L.)	1961
					6	ALLEN GWYNNES (L.L.)	1961
					7	ALLEN GWYNNES (L.L.)	1961
					8	ALLEN GWYNNES (H.L.)	1961
					9	ALLEN GWYNNES (H.L.)	1961
					10	ALLEN GWYNNES (H.L.)	1961
					11	ALLEN GWYNNES (H.L.)	1961
					12	ALLEN GWYNNES (H.L.)	1961
					13	ALLEN GWYNNES (H.L.)	1961
020	CROSTON	SD 468 163	5.53	0.864			
					1	MIRLESS WATSON	1944
					2	MIRLESS WATSON	1944
021	HOLMES WOOD	SD 424 162	4.46	0.460			
					1	A.B.S	1989
					2	A.B.S	1989
022	KEW	SD 361 153	0.65	0.600			
					1	A.B.S	1982
					2	A.B.S	1982
023	MAWDESLEY	SD 468 158	6.66	1.360			
					1	ALLEN GWYNNES	1966
					2	ALLEN GWYNNES	1966

Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
A	450 mm	SB	V	0.36	2.70		E	29.0	415	SR
A	450 mm	SB	V	0.36	2.70		E	29.0	415	SR
A	300 mm	SB	V	0.30	3.70	730	E	27.0	415	SR
A	600 mm	SB	V	0.80	1.40	730	E	43.0	415	SL
A	600 mm	SB	V	0.80	1.40	730	E	43.0	415	SL
A	500 mm	SB	V	0.75	2.10	980	E	26.0	415	SI
A	500 mm	SB	V	0.75	2.10	980	E	26.0	415	SI
C	200 mm	SB	V	0.13			E		415	SL
C	200 mm	SB	V	0.13			E		415	SL
C	609 mm	HB	H	0.85	6.86	465	D	143.0		SR
C	609 mm	HB	H	0.85	6.86	465	D	143.0		SR
A	500 mm	HB	V	0.85	6.98	743	E	100.0	415	SR
A	500 mm	HB	V	0.85	6.98	743	E	100.0	415	SR
C	609 mm	HB	H	0.85	6.86	465	D	138.0		SR
C	609 mm	HB	H	0.85	6.86	465	D	138.0		SR
C	609 mm	HB	H	0.85	6.86	465	D	138.0		SR
A	1067mm	HB	V	2.97	5.33	365	D	288.0		SI
A	1067mm	HB	V	2.97	5.33	365	D	288.0		SI
A	1067mm	HB	V	2.97	5.33	365	D	288.0		SI
A	1067mm	HB	V	2.97	5.33	365	D	288.0		SI
A	1067mm	HB	V	2.97	5.33	365	D	288.0		SI
A	1067mm	HB	V	2.97	5.33	365	D	288.0		SI
A	400 mm	LB	V	0.43	6.40	960	E	0.0	415	SR
A	400 mm	LB	V	0.43	6.40	960	E	0.0	415	SR
C	300 mm	SB	V	0.23	8.20	950	E	44.0	415	SR
C	300 mm	SB	V	0.23	8.20	950	E	44.0	415	SR
A	350 mm	SB	H	0.30	2.97	960	E	25.0	415	SI
A	350 mm	SB	H	0.30	2.97	960	E	25.0	415	SI
A	508 mm	HB	V	0.68	6.86	750	E	60.0	415	SI
A	508 mm	HB	V	0.68	6.86	750	E	60.0	415	SI

NRA - Survey of Land Drainage Pumping Plant Installations
Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer	Year
024	SOLLOM	SD 466 182	7.27	1.440			
					1	PLEUGER	1977
					2	PLEUGER	1977
					3	MIRLESS WATSON	1941
					4	MIRLESS WATSON	1941
025	RUFFORD	SD 461 151	0.67	0.180			
					1	PLEUGER	1966
					2	PLEUGER	1966
026	FRODSHAM	SJ 523 791	10.93	1.800			
					1	ALLEN GWYNNES	1938
					2	ALLEN GWYNNES	1938
027	INCE MARSH	SJ 465 774	17.42	1.120			
					1	MIRLESS WATSON	1938
					2	MIRLESS WATSON	1938
					3	ALLEN GWYNNES	1946
					4	ALLEN GWYNNES	1946
028	MORPETH	SJ 328 895	64.80	10.160			
					1	ALLEN GWYNNES	1964
					2	ALLEN GWYNNES	1964
					3	ALLEN GWYNNES	1964
					4	ALLEN GWYNNES	1964
029	BEDFORD	SD 669 001	26.93	9.430			
					1	ALLEN GWYNNES	1962
					2	ALLEN GWYNNES	1962
					3	ALLEN GWYNNES	1962
					4	ALLEN GWYNNES	1962
					5	ALLEN GWYNNES	1962
					6	ALLEN GWYNNES	1962
					7	ALLEN GWYNNES	1962
030	JENNETTS LANE	SJ 671 981	6.50	0.220			
					1	FLYGT	1971
					2	FLYGT	1971
031	PENNINGTON	SJ 647 985	1.32	0.700			
					1	FLYGT	1991
					2	FLYGT	1991
032	ALTCAR	SD 319 053	16.20	0.650			
					1	A.B.S.	1991
					2	A.B.S.	1991
					3	SARLIN	1991
033	ALTMOUTH	SD 295 044	51.84	83.720			
					1	VICKERS	1972
					2	VICKERS	1972

Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
A	450 mm	SB	V	0.34	6.55	1,450	E	55.0	415	SL
A	450 mm	SB	V	0.34	6.55	1,450	E	55.0	415	SL
A	385 mm	LB	V	0.38	6.50	960	E	45.0	415	SL
A	385 mm	LB	V	0.38	6.50	960	E	45.0	415	SL
A	203 mm	SB	V	0.09	1.50	1,650	E	5.0	415	Free
A	203 mm	SB	V	0.09	1.50	1,650	E	5.0	415	Free
A	609 mm	HB	V	0.90		585	E	60.0	415	SR
A	609 mm	HB	V	0.90		585	E	60.0	415	SR
A	356 mm	HB	V	0.28		580	E	26.0	415	SR
A	356 mm	HB	V	0.28		580	E	26.0	415	SR
A	356 mm	HB	V	0.28		580	E	26.0	415	SR
A	356 mm	HB	V	0.28		580	E	26.0	415	SR
MF	1016mm	HB	V	2.54	5.50		E	400.0	7	SI
MF	1016mm	HB	V	2.54	5.50		E	400.0	7	SI
MF	1016mm	HB	V	2.54	5.50		E	400.0	7	SI
MF	1016mm	HB	V	2.54	5.50		E	400.0	7	SI
MF	305 mm	HB	V	0.15	8.31	940	E	25.0	415	SI
MF	686 mm	HB	V	1.13	8.31	586	E	160.0	415	SI
MF	838 mm	HB	V	2.29	8.31	494	E	654.0	415	SI
MF	838 mm	HB	V	2.29	8.31	494	E	654.0	415	SI
MF	838 mm	HB	V	2.29	8.31	494	E	654.0	415	SI
MF	686 mm	HB	V	1.13	8.31	586	E	160.0	415	SI
MF	305 mm	HB	V	0.15	8.31	940	E	25.0	415	SI
C	305 mm	SB	V	0.11	6.25	2,950	E	14.0	415	SI
C	305 mm	SB	V	0.11	6.25	2,950	E	14.0	415	SI
C	300 mm	SB	V	0.35	8.52	725	E	50.0	415	SR
C	300 mm	SB	V	0.35	8.52	725	E	50.0	415	SR
C	300 mm	SB	V	0.30	4.50	960	E	50.0	415	SR
C	300 mm	SB	V	0.30	4.50	960	E	50.0	415	SR
A	150 mm	SB	V	0.05	4.50	728	E	11.5	415	SR
A	686 mm	HB	V	1.13	6.10	735	E	160.0	415	SI
A	686 mm	HB	V	1.13	6.10	735	E	160.0	415	SI

NRA - Survey of Land Drainage Pumping Plant Installations
Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer
033	ALTMOUTH	SD 295 044	51.84	83.720		
					1	VICKERS
					2	VICKERS
					3	VICKERS
					4	VICKERS
					5	VICKERS
					6	VICKERS
					7	VICKERS
					8	VICKERS
034	DOG CLOG	SJ 471 878	7.94	0.070		
					1	FLYGT
					2	FLYGT
035	FINE JANE	SD 328 088	14.17	2.600		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
					3	ALLEN GWYNNES
					4	ALLEN GWYNNES
036	HEY COP	SD 338 040	6.80	3.390		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
					3	ALLEN GWYNNES
037	INCE BLUNDELL	SD 329 046	4.46	0.660		
					1	TSURUMI
					2	TSURUMI
038	NEW CUT	SD 333 080	5.30	0.900		
					1	TSURUMI
					2	TSURUMI
039	PENDLEBURY	SJ 516 913	2.17	0.740		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
					3	ALLEN GWYNNES

Year	Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
1972	A	686 mm	HB	V	1.13	6.10	735	E	160.0	415	SI
1972	A	686 mm	HB	V	1.13	6.10	735	E	160.0	415	SI
1972	A	686 mm	HB	V	1.13	6.10	735	E	160.0	415	SI
1972	A	686 mm	HB	V	1.13	6.10	735	E	160.0	415	SI
1972	A	2210mm	HB	V	19.80	6.10	195	D	1,800.0		SL
1972	A	2210mm	HB	V	19.80	6.10	195	D	1,800.0		SL
1972	A	2210mm	HB	V	19.80	6.10	195	D	1,800.0		SL
1972	A	2210mm	HB	V	19.80	6.10	195	D	1,800.0		SL
1973	C	152 mm	SB	V	0.04			E		415	SR
1973	C	152 mm	SB	V	0.04			E		415	SR
1956	A	254 mm	HB	V	0.15	0.00		E	12.0	415	SI
1956	A	508 mm	HB	V	0.59	0.00		E	50.0	415	SI
1956	A	508 mm	HB	V	0.59	0.00		E	50.0	415	SI
1956	A	914 mm	HB	V	1.27	0.00		E	100.0	415	SI
1974	A	686 mm	LB	V	1.13	4.57		E	132.0	415	SI
1974	A	686 mm	LB	V	1.13	4.57		E	132.0	415	SI
1974	A	686 mm	LB	V	1.13	4.57		E	132.0	415	SI
1980	C	300 mm	SB	V	0.33	7.75	1,000	E	60.0	415	SI
1980	C	300 mm	SB	V	0.33	7.75	1,000	E	60.0	415	SI
1982	C	400 mm	SB	V	0.45	7.50	1,000	E	60.0	415	SI
1982	C	400 mm	SB	V	0.45	7.50	1,000	E	60.0	415	SI
19	A	254 mm	HB	V	0.17	4.10		E		415	SI
19	A	254 mm	HB	V	0.17	4.10		E		415	SI
19	A	406 mm	HB	V	0.40	4.10		E		415	SI

SEVERN-TRENT

REGION	SUB REGION	STN. NO	NAME
<u>Severn-Trent</u>			
	Lower Trent	001	TUNNEL PITS
		002	SNOW SEWER
		003	NEW ZEALAND
		004	MEDGE HALL
		005	LOW BANK
		006	KEADBY
		012	WOODCARR
		013	WEST STOCKWITH
		014	WATERTON FARM
		015	GOODCOP
		016	DIRTNESS
		017	CANDY FARM
		018	BULL HASSOCKS
		019	BELTON GRANGE
		020	BECKINGHAM
		021	ARMTHORPE RESERVOIR
		024	SHARDLOW
		025	KNOWLESTON PLACE
		026	NORMANTON
		027	GREYTHORNE DYKE
	Lower Severn	007	CAM
		008	LONG ITCHINGTON
		009	CLAY COTON
		010	BARTON
		011	SEDGEBERROW
	Upper Trent	022	PERRY HALL FIELDS
		023	HIGH BRIDGE

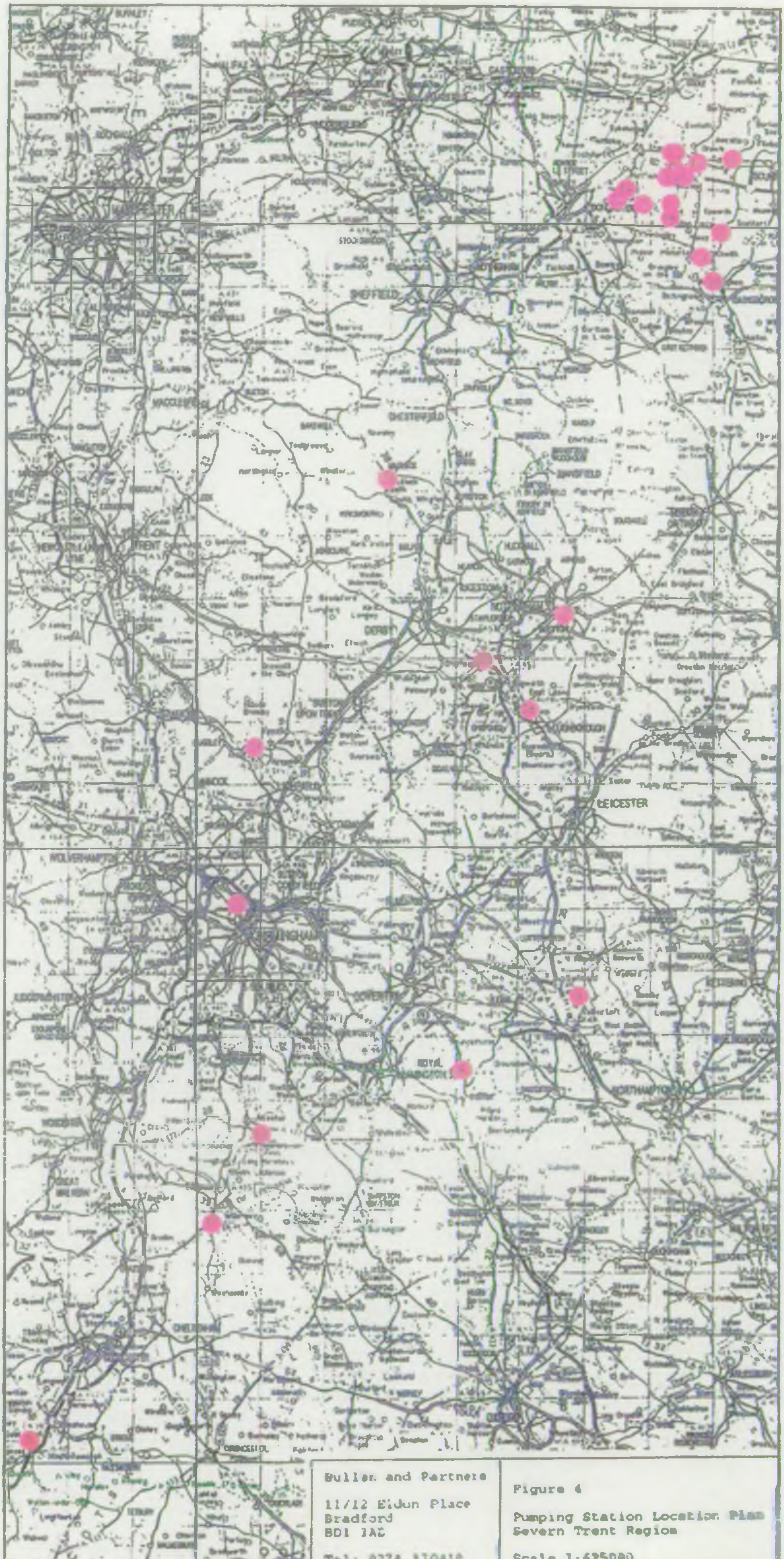

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Figure 4

Pumping Station Location Plan
Severn Trent Region

Scale 1:625000

NRA - Survey of Land Drainage Pumping Plant Installations
Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer
Severn-Trent						
001	TUNNEL PITS	SE 735 041	17.01	1.480		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
					3	ALLEN GWYNNES
					4	ALLEN GWYNNES
002	SNOW SEWER	SK 813 994	34.27	2.850		
					1	SULZER
					2	SULZER
					3	SULZER
003	NEW ZEALAND	SE 734 122	15.37	1.850		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
004	MEDGE HALL	SE 748 123	6.23	0.480		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
005	LOW BANK	SE 739 085	8.90	2.130		
					1	BRITISH PLEUGER
					2	BRITISH PLEUGER
					3	BRITISH PLEUGER
006	KEADBY	SE 835 114	377.80	32.280		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
					3	ALLEN GWYNNES
					4	ALLEN GWYNNES
					5	ALLEN GWYNNES
					6	ALLEN GWYNNES
007	CAM	SO 746 045	45.00	1.500		
					1	FLYGT
					2	ALLEN GWYNNES
					3	ALLEN GWYNNES
008	LONG ITCHINGTON	SP 412 651	1.00			
					1	FLYGT
					2	FLYGT
009	CLAY COTON	SP 592 769	1.00	0.213		
					1	FLYGT
010	BARTON	SP 108 513	1.00	0.095		
					1	FLYGT
011	SEDGEBERROW	SP 026 386	1.00	0.300		
					1	FLYGT

Year	Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
1963	A	457 mm	HB	V	0.37			E	35.0	415	SI
1963	A	457 mm	HB	V	0.37			E	35.0	415	SI
1963	A	457 mm	HB	V	0.37			E	35.0	415	SI
1963	A	457 mm	HB	V	0.37			E	35.0	415	SI
1976	MF	610 mm	HB	V	0.95			D	165.0		SE
1976	MF	610 mm	HB	V	0.95			D	165.0		SE
1976	MF	610 mm	HB	V	0.95			D	165.0		SE
1981	A	610 mm	HB	V	1.00		585	E	84.0	415	SE
1941	A	560 mm	HB	V	0.85		580	E	60.0	415	SE
1941	A	355 mm	HB	V	0.24			E	15.0	400	SL
1941	A	355 mm	HB	V	0.24			E	15.0	400	SL
1977	A		SB	H	0.71	6.18		E	100.0	415	SI
1977	A		SB	H	0.71	6.18		E	100.0	415	SI
1977	A		SB	H	0.71	6.18		E	100.0	415	SI
1940	MF	1524mm	HB	H	5.38		1,440	D	420.0	400	SR
1940	MF	1524mm	HB	H	5.38		1,440	D	420.0	400	SR
1940	MF	1524mm	HB	H	5.38		1,440	D	420.0	400	SR
1940	MF	1524mm	HB	H	5.38		1,440	D	420.0	400	SR
1940	MF	1524mm	HB	H	5.38		1,440	D	420.0	400	SR
1940	MF	1524mm	HB	H	5.38		1,440	D	420.0	400	SR
1980	A	250 mm	HB	V	0.15			E	12.0	415	SL
1980	A	500 mm	HB	V	0.68	2.75	730	E	46.0	415	SL
1980	A	500 mm	HB	V	0.68	2.75	730	E	46.0	415	SL
1970			SB	V			1,440	E	4.1	415	SR
1970			SB	V			1,440	E	4.1	415	SR
1982	A		SB	V	0.21	3.35	965	E	33.0	440	SR
1981	A	410 mm	SB	V	0.09	2.30		E	8.0	415	SR
1982	A	500 mm	SB	V	0.30	4.00	950	E	12.0	415	SR

NRA - Survey of Land Drainage Pumping Plant Installations
Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer
012	WOODCARR	SE 754 088	2.38	0.630		
					1	ARMFIELD
					2	ARMFIELD
					3	ARMFIELD
013	WEST STOCKWITH	SK 787 952	842.00	35.400		
					1	WEIR
					2	WEIR
					3	WEIR
					4	WEIR
014	WATERTON FARM	SE 663 066	18.62	2.931		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
					3	ALLEN GWYNNES
015	GOODCOP	SE 736 083	31.77	4.610		
					1	FLYGT
					2	FLYGT
					3	ALLEN GWYNNES
					4	ALLEN GWYNNES
016	DIRTNESS	SE 747 097	19.80	3.640		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
017	CANDY FARM	SE 698 031	23.25	3.160		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
					3	ALLEN GWYNNES
018	BULL HASSOCKS	SE 732 016	27.35	5.610		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
					3	ALLEN GWYNNES
					4	FLYGT
019	BELTON GRANGE	SE 771 105	1.54	0.210		
					1	ARMFIELD
020	BECKINGHAM	SK 801 915	21.17	2.830		
					1	RUSTON/ALLEN GWYNNES
					2	RUSTON/ALLEN GWYNNES
021	ARMTHORPE RESERVOIR	SE 658 048		0.450		
					1	BRITISH PLEUGER
					2	BRITISH PLEUGER
022	PERRY HALL FIELDS	SP 062 919				
					1	FLYGT

Year	Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
1978	A	250 mm	OO	V	0.20	5.50		E	25.0	415	SI
1978	A	250 mm	OO	V	0.20	5.50		E	25.0	415	SI
1978	A	250 mm	OO	V	0.20	5.50		E	25.0	415	SI
1980	A	2440mm	HB	V	12.70		273	E	1,400.0	33,000	SI
1980	A	2440mm	HB	V	12.70		273	E	1,400.0	33,000	SI
1980	A	1520mm	HB	V	4.96		330	E	600.0	33,000	SI
1980	A	1520mm	HB	V	4.96		330	E	600.0	33,000	SI
1977	A	610 mm	OO	V	0.97	4.91		E	57.6	415	
1977	A	610 mm	OO	V	0.97	4.91		E	57.6	415	
1977	A	610 mm	OO	V	0.97	4.91		E	57.6	415	
1983	A	975 mm	HB	V	1.60			E	73.0	415	
1983	A	975 mm	HB	V	1.60			E	73.0	415	
1965	A	500 mm	HB	V	0.71			E	40.0	415	
1965	A	500 mm	HB	V	0.71			E	40.0	415	
1952	A	915 mm	HB	V	1.82	7.00		E	105.0	400	SI
1952	A	915 mm	HB	V	1.82	7.00		E	105.0	400	SI
1940	C	840 mm	HB	H	1.44			D	103.0	400	SV
1940	C	686 mm	HB	H	0.71			D	57.0		SV
1940	C	686 mm	HB	H	1.01			D	78.0	415	SE
1941	C	914 mm	HB	H	1.64			D	100.0		SV
1941	C	914 mm	HB	H	1.64			D	100.0		SV
1941	C	914 mm	HB	H	1.64			D	100.0		SV
1988	A	675 mm	SB	V	0.68	0.00		E		415	SI
1979	A	250 mm	LB	V	0.21		1,465	E	25.0	415	
1945	C	915 mm	HB	H	1.42			D	114.0	230	SR
1945	C	915 mm	HB	H	1.42			D	114.0	230	SR
19	A	375 mm	SB	V	0.30			E	40.0	415	
19	A	225 mm		V	0.15			E	25.0	415	
19	A		SB	V				E		415	SR

NRA - Survey of Land Drainage Pumping Plant Installations
Pump Summary

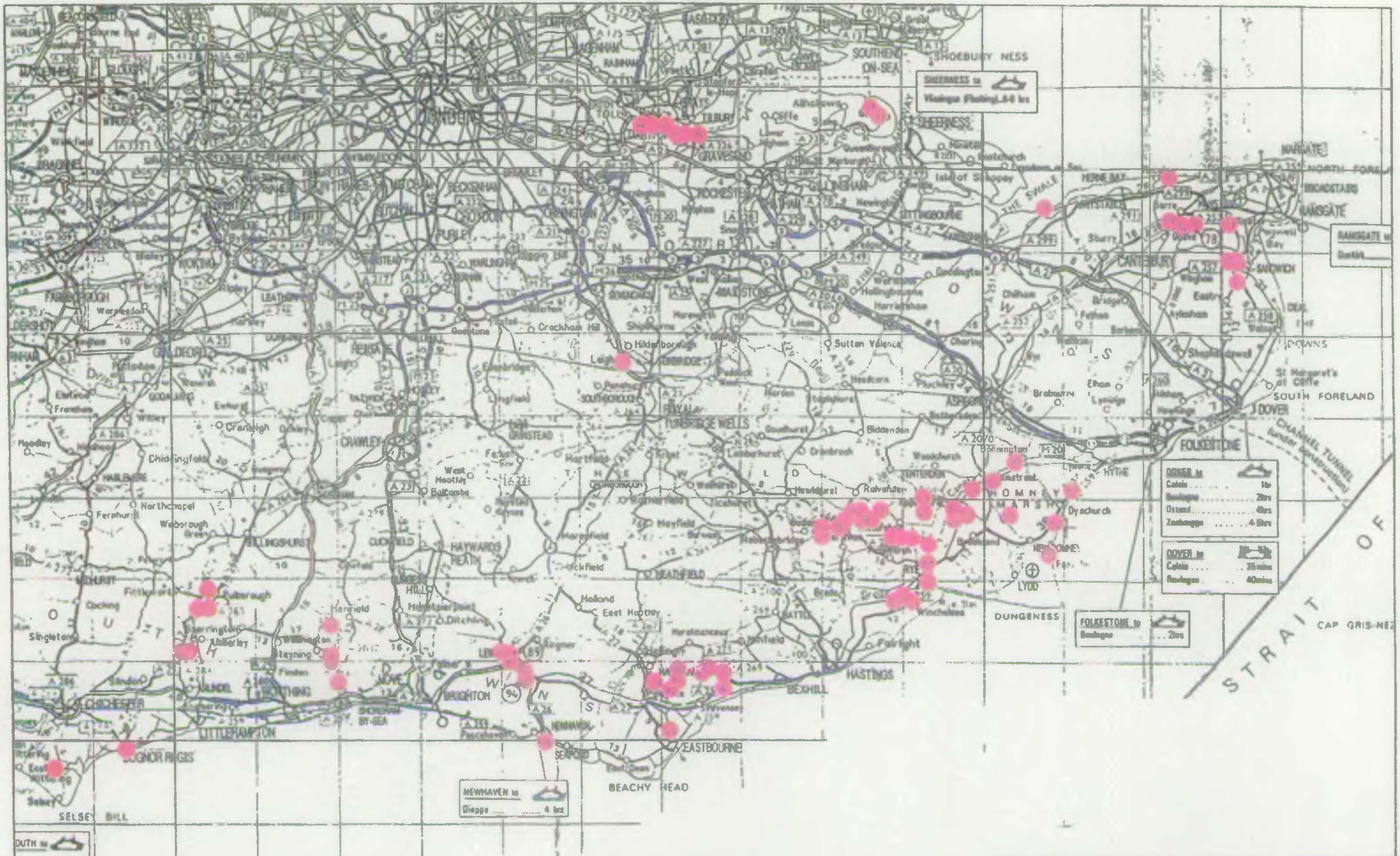
Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer
023	HIGH BRIDGE	SK 091 167		3.600		
					1	FLYGT
					2	FLYGT
					3	FLYGT
					4	FLYGT
					5	FLYGT
					6	FLYGT
024	SHARDLOW	SK 448 306				
					1	ARMFIELD
					2	ARMFIELD
					3	ARMFIELD
					4	ARMFIELD
025	KNOWLESTON PLACE	SK 301 599		6.100		
					1	WEIR
					2	WEIR
					3	WEIR
					4	ABS
026	NORMANTON	SK 520 225		0.076		
					1	FLYGT
					2	FLYGT
027	GREYTHORNE DYKE	SK 573 374	306.00	1.300		
					1	BRITISH PLEUGER
					2	BRITISH PLEUGER
					3	BRITISH PLEUGER
					4	BRITISH PLEUGER

Year	Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
1986	A	600 mm	SB	V	0.60	6.00	965	E	30.0	415	SR
1986	A	600 mm	SB	V	0.60	6.00	965	E	30.0	415	SR
1986	A	600 mm	SB	V	0.60	6.00	965	E	30.0	415	SR
1986	A	600 mm	SB	V	0.60	6.00	965	E	30.0	415	SR
1986	A	600 mm	SB	V	0.60	6.00	965	E	30.0	415	SR
1986	A	600 mm	SB	V	0.60	6.00	965	E	30.0	415	SR
19	A		00	V			1,450	E	24.0	415	
19	A		00	V			1,450	E	24.0	415	
19	A		00	V			1,450	E	24.0	415	
19	A		00	V			1,450	E	24.0	415	
1984	A		LB	V	2.00	3.75	585	E	130.0	415	
1984	A		LB	V	2.00	3.75	585	E	130.0	415	
1984	A		LB	V	2.00	3.75	585	E	130.0	415	
1991	C		SB	V	0.10	6.20	2,850	E	3.0	415	
1991			SB	V	0.05	2.00	1,440	E	4.1	415	
1991			SB	V	0.03	2.00	935	E	1.2	415	
19	C	350 mm	SB	H	4.30			E	40.0		-
19	C	350 mm	SB	H	0.43	0.00		E	40.0		SI
19	C	350 mm	SB	H	0.43	0.00		E	40.0		SI
1992	C	300 mm	SB	V	0.32	5.00	960	E	30.0	415	SI

SOUTHERN

REGION	SUB REGION	STN. NO	NAME
Southern			
		042	CRAVEN
		045	EBONY
		054	* KITSBRIDGE IDB
	Chichester	001	* APPLESHAM
		002	* ANNINGTON
		003	* BEEDING BROOKS
		004	* NORTHOVER
		005	PULBOROUGH
		006	* HARDHAM
		007	* GREATHAM
		008	* HOUGHTON
		009	* BURY
		010	FELPHAM
		011	FERRY
	Tunbridge	012	BAXTER FELL
		013	HAMS HILL
		014	LEIGH
		015	G.E.C.
		016	NORTHFLEET NO.2
		017	NORTHFLEET NO.1
		018	BOWATER NO.2
		019	BOWATER NO.1
		020	ROBINS CREEK
		021	SHELL
		022	TOWER DRAIN
		023	BRITANNIA LEAD
		024	M+B DREDGING
		025	M+B ROYALE
		026	EMPIRE PAPER NO.2
		027	EMPIRE PAPER NO.1
		028	BENDIGO WHARF
		029	WHITE HART
		030	EVERARDS
		031	GRAVESEND
		032	ALEXANDRA
		033	MILL MARSH
	Rye	034	APPLEDORE
		035	BILSINGTON
		036	BLACKWALL EAST
		037	BLACKWALL NORTH
		038	BLACKWALL SOUTH
		039	BOONSHILL
		040	* BRACK IDB
		041	COURT LODGE
		043	DIMSDALE
		044	DIXTER
		046	GREATSTONE
		047	HERONDEN
		048	HEXDEN NORTH
		049	HEXDEN SOUTH
		050	* ICKLESHAM
		051	* INDRAFT IDB
		052	JESSON
		053	KENT DITCH
		055	KNELLE
		056	* LODGELAND IDB
		057	MAYTHEM
		058	NEWBRIDGE NORTH
		059	NEWBRIDGE SOUTH
		060	* NEWHOUSE
		061	NORTHPOINT
		062	POTMANS HEATH
		063	READING SEWER
		064	SHIRLEY MOOR
		065	UNION
		066	WAREHORNE
		067	WILLOP
		068	WOODSIDE
		069	SARRE
		070	ASH LEVEL
		071	SEASALTER
		072	NORTH POUDLERS
		073	MINSTER
		074	STOURMOUTH
		075	RECULVERS
		076	BUTTERFLY
		077	COOPER STREET
		078	MILE END
	Pevensey	079	HONEYCROCK
		080	* DROCKMILL

REGION	SUB REGION	STN. NO	NAME
		081	* MALLING BROOKS
		082	* MANXEY
		083	* RICKNEY
		084	* STAR INN
		085	* HORSEBRIDGE
		086	* NEWBRIDGE
		087	* RODMEL
		088	* NEWHAVEN
		089	* STONEHAM
		090	* OFFHAM
		091	* RANSCOOMBE
		092	* BARNHORN
		093	* LOTTBRIDGE
		094	BEDDINGHAM



PUMPING STATIONS 12, 15 - 32

PUMPING STATIONS 44, 47-49, 55, 57, 62, 63

PUMPING STATIONS 36-39, 42, 58, 59, 68

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Figure 5

Pumping Station Location Plan
Southern Region

Scale approximately 1:455000

NRA - Survey of Land Drainage Pumping Plant Installations
Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer	Year	Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
Southern																		
001	* APPLESHAM	TQ 200 075	5.10	0.100														
					1	MAXIFLOW TYPE4	1960	A	250 mm	LB	V	0.10	4.00	1,440	E	15.0	415	SL
002	* ANNINGTON	TQ 193 100	1.30	0.400														
					1	FLYGT	1979	C		OO	V	0.20	3.60		E	30.0	415	SI
					2	FLYGT	1979	C		OO	V	0.20	3.60		E	30.0	415	SI
003	* BEEDING BROOKS	TQ 191 110	5.00	0.400														
					1	MAXIFLOW TYPE4	1973	A	250 mm	OO	H	0.20	4.30	1,450	E	15.0	415	SL
					2	MAXIFLOW TYPE4	1973	A	250 mm	OO	H	0.20	4.30	1,450	E	15.0	415	SL
004	* NORTHOVER	TQ 196 144	0.40	0.100														
					1	MAXIFLOW TYPE4	1972	A	250 mm	LB	V	0.10	4.00	1,440	E	15.0	415	SL
005	PULBOROUGH	TQ 046 185	0.10	0.200														
					1	WALLWIN	1967	C		LB	V	0.10	3.40	580	E	5.0	415	SI
					2	WALLWIN	1967	C		LB	V	0.10	3.40	580	E	5.0	415	SI
006	* HARDHAM	TQ 045 168	1.20	0.200														
					1	FLYGT	19	C		SB	V	0.10	5.00		E	8.0	415	SL
					2	FLYGT	19	C		SB	V	0.10	5.00		E	8.0	415	SL
007	* GREATHAM	TQ 037 165	1.20	0.300														
					1	FLYGT	19	C		SB	V	0.10	5.00		E	8.0	415	SL
					2	FLYGT	19	C		SB	V	0.10	5.00		E	8.0	415	SL
					3	FLYGT	19	C		SB	V	0.10	5.00		E	8.0	415	SL
008	* HOUGHTON	TQ 023 117	1.50	0.100														
					1	ARMFIELD	19	A		OO	V	0.10	4.00		E	15.0	415	SL
009	* BURY	TQ 016 125	2.60	0.100														
					1	FLYGT	1991	C		OO	V	0.10	3.50	1,450	E	8.0	415	SL
010	FELPHAM	SZ 947 992	5.50	2.700														
					1	ALLEN GWYNNES	1961	A		HB	V	0.90	4.90	580	E	84.0	415	SI
					2	ALLEN GWYNNES	1961	A		HB	V	0.90	4.90	580	E	84.0	415	SI
					3	ALLEN GWYNNES	1961	A		HB	V	0.90	4.90	580	E	84.0	415	SI
011	FERRY	SZ 856 963	10.70	2.400														
					1	ALLEN GWYNNES	1975	A		OO	V	1.20	3.90	490	E	160.0	415	SL
					2	ALLEN GWYNNES	1975	A		OO	V	1.20	3.90	490	E	160.0	415	SL
012	BAXTER FELL	TQ 617 752		0.100														
					1	FLYGT	1979	C		SB	V	0.10	7.50	1,450	E	20.0	415	SR
013	HAMS HILL	TQ 868 773		0.225														
					1	FLYGT	19	C		LB	V	0.23	2.24	950	E	12.0	415	SI
014	LEIGH	TQ 550 461	1.00	1.400														
					1	JONES AND ATTWOOD	1979	S	2162mm	HB		1.40	3.15	31	E	100.0	415	SI

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Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer	Year
015	G.E.C.	TQ 636 744	0.10	0.200			
					1	FLYGT	1979
					2	FLYGT	1979
016	NORTHFLEET NO.2	TQ 634 745	0.10	0.100			
					1	FLYGT	1979
017	NORTHFLEET NO.1	TQ 630 746	0.10	0.100			
					1	FLYGT	1979
018	BOWATER NO.2	TQ 628 746	0.10	0.100			
					1	FLYGT	1979
019	BOWATER NO.1	TQ 627 747	0.10	0.100			
					1	FLYGT	1979
020	ROBINS CREEK	TQ 619 750	0.10	0.200			
					1	CCD/ABS	1981
					2	CCD/ABS	1981
021	SHELL	TQ 617 752	0.10	0.200			
					1	CCD/ABS	1981
					2	CCD/ABS	1981
022	TOWER DRAIN	TQ 616 754	0.10	0.300			
					1	CCD/ABS	1981
					2	CCD/ABS	1981
					3	CCD/ABS	1981
023	BRITANNIA LEAD	TQ 613 756	0.10	0.200			
					1	CCD/ABS	1981
					2	CCD/ABS	1981
024	M+B DREDGING	TQ 613 758	0.10	0.100			
					1	CCD/ABS	1981
025	M+B ROYALE	TQ 612 759	0.10	0.200			
					1	CCD/ABS	1981
					2	CCD/ABS	1981
026	EMPIRE PAPER NO.2	TQ 594 754	0.10	0.100			
					1	FLYGT	1978
027	EMPIRE PAPER NO.1	TQ 592 753	0.10	0.100			
					1	FLYGT	1978
028	BENDIGO WHARF	TQ 588 753	0.10	0.200			
					1	FLYGT	1978
					2	FLYGT	1978

Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
C		SB	V	0.10	5.00	1,450	E	20.0	415	SR
C		SB	V	0.10	5.00	1,450	E	20.0	415	SR
C		SB	V	0.10	6.80	1,450	E	20.0	415	SR
C		SB	V	0.10	6.80	1,450	E	20.0	415	SR
C		SB	V	0.10	7.00	1,450	E	20.0	415	SR
C		SB	V	0.10	7.40	1,450	E	20.0	415	SR
C		SB	V	0.10	5.50	950	E	24.3	415	SR
C		SB	V	0.10	5.50	950	E	24.3	415	SR
C		SB	V	0.10	9.70	950	E	24.3	415	SR
C		SB	V	0.10	9.70	950	E	24.3	415	SR
C		SB	V	0.10	10.50	950	E	24.3	415	SR
C		SB	V	0.10	10.50	950	E	24.3	415	SR
C		SB	V	0.10	10.50	950	E	24.3	415	SR
C		SB	V	0.10	7.80	950	E	24.3	415	SR
C		SB	V	0.10	7.80	950	E	24.3	415	SR
C		SB	V	0.10	7.80	950	E	24.3	415	SR
C		SB	V	0.10	7.80	950	E	24.3	415	SR
C		SB	V	0.10	7.80	950	E	24.3	415	SR
C		SB	V	0.10	6.70	1,450	E	20.0	415	SR
C		SB	V	0.10	7.10	1,450	E	20.0	415	SR
C		SB	V	0.10	8.40	1,450	E	20.0	415	SR
C		SB	V	0.10	8.40	1,450	E	20.0	415	SR

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Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer	Year
029	WHITE HART	TQ 586 752	0.10	0.300			
					1	FLYGT	1978
					2	FLYGT	1978
					3	FLYGT	1978
030	EVERARDS	TQ 585 752	0.10	0.100			
					1	FLYGT	1978
031	GRAVESEND	TQ 652 745	0.10	0.100			
					1	HAYDEN	1982
032	ALEXANDRA	TQ 652 745	0.10	0.100			
					1	HAYDEN	1982
033	MILL MARSH	TQ 871 763	2.00	0.100			
					1	FLYGT	1983
034	APPLEDORE	TQ 960 295		1.220			
					1	ALLEN GWYNNES	1950
					2	ALLEN GWYNNES	1950
035	BILSINGTON	TR 046 340		1.000			
					1	SPAAN	1969
					2	SPAAN	1969
036	BLACKWALL EAST	TQ 886 258	2.27	0.350			
					1	SPAAN	1970
037	BLACKWALL NORTH	TQ 885 259	4.33	1.420			
					1	SPAAN	1970
038	BLACKWALL SOUTH	TQ 885 258	7.73	2.830			
					1	SPAAN	1970
					2	SPAAN	1970
039	BOONSHILL	TQ 935 246	1.87	0.350			
					1	SPAAN	1969
040	* BRACK IDB	TQ 969 275	4.54	0.380			
					1	ALLEN GWYNNES	19 3
041	COURT LODGE	TQ 803 257	2.85	0.570			
					1	SPAAN	1972
042	CRAVEN	TQ 934 247	8.24	1.300			
					1	SIMON HARTLEY	1974
043	DIMSDALE	TQ 914 173	4.24	0.400			
					1	MYSON	1976
					2	MYSON	1976

Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
C		SB	V	0.10	6.10	1,450	E	20.0	415	SR
C		SB	V	0.10	6.10	1,450	E	20.0	415	SR
C		SB	V	0.10	6.10	1,450	E	20.0	415	SR
C		SB	V	0.10	6.80	1,450	E	20.0	415	SR
C		SB	V	0.10	3.80		E	1.5	415	SR
C		SB	V	0.10	3.80		E	1.5	415	SR
C		SB	V	0.10	2.00		E	1.5	415	SR
A	610 mm	HB	H	0.61	3.35		D			SR
A	610 mm	HB	H	0.61	3.35		D			SR
S	1400mm	LB	-	0.50		35	E	25.0	415	SR
S	1400mm	LB	-	0.50		35	E	25.0	415	SR
S	1200mm	LB	-	0.35	1.90	41	E	25.0	415	SR
S	2150mm	LB	-	1.42	1.98	29	E	100.0	415	SR
S	2150mm	LB	-	1.42	1.37	29	E	125.0	415	SR
S	2150mm	LB	-	1.42	1.37	29	E	100.0	415	SR
S	1200mm	LB	-	0.35	2.80	41	E	25.0	415	SR
A	225 mm	LB	H	0.38	0.00		E	25.0	415	SR
S	1500mm	LB	-	0.57	3.22	35	E	50.0	415	SR
S	2000mm	LB	-	1.30	2.55	30	E	100.0	415	SR
	300 mm	SB	V	0.20			E	33.0	415	SR
C	300 mm	SB	V	0.20			E	33.0	415	SR

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Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer	Year
044	DIXTER	TQ 835 270	2.91	0.570			
					1	SPAAN	1972
045	EBONY	TQ 937 291	8.98	1.300			
					1	SIMON HARTLEY	1975
046	GREATSTONE	TR 082 237	1.34	0.215			
					1	MATHER & PLATT	1962
					2	MATHER & PLATT	1962
047	HERONDEN	TQ 828 269	2.13	0.300			
					1	SPAAN	1972
048	HEXDEN NORTH	TQ 854 287	6.22	1.000			
					1	SPAAN	1972
049	HEXDEN SOUTH	TQ 841 283	1.29	0.300			
					1	SPAAN	1972
050	* ICKLESHAM	TQ 891 176	5.86	0.920			
					1	JONES AND ATTWOOD	1976
					2	FLYGT	19
051	* INDRAFT IDB	TQ 981 285	1.30	0.150			
					1	SPAAN	1971
052	JESSON	TR 090 273	25.35	2.800			
					1	JONES AND ATTWOOD	1980
					2	JONES AND ATTWOOD	1980
053	KENT DITCH	TQ 801 260	3.76	0.570			
					1	SPAAN	1972
054	* KITSBRIDGE IDB	TR 016 329	4.05	0.427			
					1	ALLEN GWYNNES	1963
055	KNELLE	TQ 850 269	9.75	2.000			
					1	SPAAN	1972
					2	SPAAN	1972
056	* LODGELAND IDB	TR 031 281	2.57	0.250			
					1	SIMON HARTLEY	1983
057	MAYTHEM	TQ 865 276	1.88	0.300			
					1	SPAAN	1972
058	NEWBRIDGE NORTH	TQ 915 254	4.28	0.710			
					1	SPAAN	1969
059	NEWBRIDGE SOUTH	TQ 914 253	1.13	0.212			
					1	SPAAN	1969

Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
S	1500mm	LB	-	0.57	2.92	35	E	50.0	415	SR
S	2100mm	LB	-	1.30	2.54		E	100.0	415	SR
A	450 mm	HB	V	0.11	2.10	730	E	20.0	415	SR
A	450 mm	HB	V	0.11	2.10	730	E	20.0	415	SR
S	1100mm	LB	-	0.30	3.32	46	E	25.0	415	SR
S	1900mm	LB	-	1.00	3.10	30	E	75.0	415	SR
S	1100mm	LB	-	0.30	3.55	46	E	25.0	415	SR
S	1730mm	LB	-	0.90	2.00	37	E	50.0	415	SR
		LB	-	0.02	0.00		E	0.0	415	-
S	840 mm	LB	-	0.15	6.20	53	E	12.0	415	SR
S	2162mm	LB	-	1.40	4.20		E	120.0	415	SR
S	2162mm	LB	-	1.40	4.20		E	120.0	415	SR
S	1500mm	LB	-	0.57	3.37	35	E	50.0	415	SR
A	450 mm	HB	V	0.43	4.20	725	E	22.5	415	SR
S	1900mm	LB	-	1.00	2.71	30	E	75.0	415	SR
S	1900mm	LB	-	1.00	2.71	30	E	75.0	415	-
S	950 mm	OO	-	0.25	1.37	55	E	15.0	415	SR
S	1100mm	LB	-	0.30	3.07	46	E	25.0	415	SR
S	1600mm	LB	-	0.71	2.40	33	E	50.0	415	SR
S	950 mm	LB	-	0.21	2.87	47	E	15.0	415	SR

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Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer	Year
060	* NEWHOUSE	TQ 901 180	5.73	1.260			
					1	JONES AND ATTWOOD	1976
					2	FLYGT	19
061	NORTHPOINT	TQ 932 200	2.63	0.300			
					1	SPAAN	1982
062	POTMANS HEATH	TQ 872 281	7.96	1.415			
					1	SPAAN	1970
063	READING SEWER	TQ 876 288	15.09	2.830			
					1	SPAAN	1972
					2	SPAAN	1972
064	SHIRLEY MOOR	TQ 935 301	41.20	6.600			
					1	SIMON HARTLEY	1974
					2	SIMON HARTLEY	1974
065	UNION	TQ 938 225	66.97	7.000			
					1	ALLEN GWYNNES	1969
					2	ALLEN GWYNNES	1969
					3	ALLEN GWYNNES	1969
066	WAREHORNE	TQ 990 320		1.420			
					1	SIMON HARTLEY	1971
067	WILLOP	TR 118 311	16.20	1.660			
					1	SPAAN	1979
					2	SPAAN	1979
068	WOODSIDE	TQ 900 251	9.69	1.530			
					1	SPAAN	1969
069	SARRE	TR 245 649	21.60	1.100			
					1	FENNER	1972
070	ASH LEVEL	TR 269 633	25.70	2.400			
					1	ALLEN GWYNNES	19
					2	ALLEN GWYNNES	19
					3	ALLEN GWYNNES	19
071	SEASALTER	TR 076 650		2.920			
					1	ALLEN GWYNNES	19
					2	ALLEN GWYNNES	19
					3	ALLEN GWYNNES	19
072	NORTH POWDLERS	TR 321 588	4.50	0.500			
					1	JONES AND ATTWOOD	19

Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
S	2030mm	LB	-	1.24	1.93	32	E	75.0	415	SR
-		-	V	0.02			-		415	-
S	1100mm	LB	-	0.30	3.85	46	E	29.0	415	SR
S	2150mm	LB	-	1.41	2.97	29	E	125.0	415	SR
S	2150mm	LB	-	1.41	2.67	29	E	125.0	415	SR
S	2150mm	LB	-	1.41	2.67	29	E	100.0	415	SR
S	3000mm	LB	-	3.30	2.54		E	250.0	415	SR
S	3000mm	LB	-	3.30	2.08		E	250.0	415	SR
A	1067mm	OO	V	2.80	5.79		E	220.0	415	SI
A	1067mm	OO	V	2.80	5.79		E	220.0	415	SI
A	686 mm	OO	V	1.40	5.79		E	115.0	415	SI
S	2100mm	LB	-	1.42	1.45	32	E	75.0	415	SR
S	1700mm	LB	-	0.83	3.52	34	E	75.0	415	SR
S	1700mm	LB	-	0.83	3.52	34	E	75.0	415	SR
S	2100mm	LB	-	1.53	3.12	28	E	100.0	415	SR
S	1800mm	LB	-	1.10	2.13	33	E	60.0	415	SR
A	500 mm	HB	V	0.79	2.40	725	E	60.0	415	SI
A	500 mm	HB	V	0.79	2.40	725	E	60.0	415	SI
A	500 mm	HB	V	0.79	2.40	725	E	60.0	415	SI
A	600 mm	LB	V	0.98	3.63	585	E	85.0	415	SI
A	600 mm	LB	V	0.98	3.63	585	E	85.0	415	SI
A	600 mm	LB	V	0.98	3.63	585	E	85.0	415	SI
S	1400mm	LB	-	0.50	1.70	40	E	18.0	415	SR

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Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer	Year
073	MINSTER	TR 310 632	20.80	1.190			
					1	ALLEN GWYNNES	19
					2	ALLEN GWYNNES	19
					3	ALLEN GWYNNES	19
074	STOURMOUTH	TR 250 630	200.00	5.600			
					1	ALLEN GWYNNES	19
					2	ALLEN GWYNNES	19
					3	ALLEN GWYNNES	19
					4	ALLEN GWYNNES	19
075	RECULVERS	TR 230 693	4.70	0.311			
					1	ACM	1972
076	BUTTERFLY	TR 320 592	0.30	0.100			
					1	JONES AND ATTWOOD	19
077	COOPER STREET	TR 313 597	3.60	0.450			
					1	JONES AND ATTWOOD	1977
078	MILE END	TR 265 639		0.450			
					1	FLYGT	19
079	HONEYCROCK	TQ 596 072	13.40	3.200			
					1	ALLEN GWYNNES	1979
					2	ALLEN GWYNNES	1979
					3	ALLEN GWYNNES	1979
080	* DROCKMILL	TQ 618 069	4.10	0.800			
					1	FLYGT	1969
					2	FLYGT	1969
081	* MALLING BROOKS	TQ 418 106	0.20	1.200			
					1	SUBMERSIGLIDE	1991
					2	SUBMERSIGLIDE	1991
082	* MANXEY	TQ 655 084	17.30	1.200			
					1	ALLEN GWYNNES	1975
					2	ALLEN GWYNNES	1975
083	* RICKNEY	TQ 627 070	10.50	2.200			
					1	SIMON HARTLEY	1973
					2	SIMON HARTLEY	1973
084	* STAR INN	TQ 682 062	7.30	1.300			
					1	SPAAN	1976
					2	SPAAN	1976
085	* HORSEBRIDGE	TQ 669 090	9.20	1.600			
					1	HARLAND JOHNSON	1964
					2	HARLAND JOHNSON	1964

Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
A	450 mm	OO	V	0.39	2.90	730	E	19.0	415	SI
A	450 mm	OO	V	0.39	2.90	730	E	19.0	415	SI
A	450 mm	OO	V	0.40	2.90	730	E	19.0	415	SI
A	500 mm	HB	V	1.40		725	E	75.0	415	SI
A	500 mm	HB	V	1.40		725	E	75.0	415	SI
A	500 mm	HB	V	1.40		725	E	75.0	415	SI
A	500 mm	HB	V	1.40		725	E	75.0	415	SI
S	1100mm	LB	-	0.31	3.12	47	E	18.0	415	SR
S	690 mm	HB	-	0.10	2.17	68	E	4.1	415	SR
S	1297mm	HB	-	0.45	2.30	40	E	15.0	415	SR
A		OO	V	0.45			E	17.0	415	-
A	385 mm	OO	V	0.40	3.00	970	E	40.0	415	SI
A	613 mm	OO	V	1.40	3.00	585	E	130.0	415	SI
A	613 mm	OO	V	1.40	3.00	585	E	130.0	415	SI
A		OO	V	0.40	2.70	730	E	29.0	415	SL
A		OO	V	0.40	2.70	730	E	29.0	415	SL
C		OO	V	0.60	5.90		E	50.0	415	SI
C		OO	V	0.60	5.90		E	50.0	415	SI
A		OO	V	0.60	2.50	980	E	43.0	415	SI
A		OO	V	0.60	2.50	980	E	43.0	415	SI
S	1900mm	HB	-	1.10	2.10	38	E	50.0	415	SL
S	1900mm	HB	-	1.10	2.10	38	E	50.0	415	SL
S	1500mm	HB	-	0.60	4.60	38	E	75.0	415	SL
S	1500mm	HB	-	0.60	4.60	38	E	75.0	415	SL
A	450 mm	OO	H	0.80	4.50		E	56.0	415	SI
A	450 mm	OO	H	0.80	4.50		E	56.0	415	SI

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Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer
086	* NEWBRIDGE	TQ 626 098	6.80	0.800		
					1	HARLAND JOHNSON
					2	HARLAND JOHNSON
087	* RODMEL	TQ 432 070	1.90	0.700		
					1	HARLAND JOHNSON
088	* NEWHAVEN	TQ 453 007	3.60	0.400		
					1	HARLAND JOHNSON
					2	HARLAND JOHNSON
089	* STONEHAM	TQ 418 117	3.20	0.300		
					1	FLYGT
					2	FLYGT
					3	FLYGT
090	* OFFHAM	TQ 405 117	1.80	0.100		
					1	FLYGT
091	* RANSCOOMBE	TQ 442 082	2.50	0.400		
					1	FLYGT
					2	FLYGT
					3	FLYGT
					4	FLYGT
092	* BARNHORN	TQ 689 082	0.60	0.300		
					1	FLYGT
					2	FLYGT
					3	FLYGT
093	* LOTTBRIDGE	TQ 615 013	2.80	0.400		
					1	HARLAND JOHNSON
094	BEDDINGHAM	TQ 443 081	62.00	9.300		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
					3	ALLEN GWYNNES

Year	Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
1968	A	450 mm	OO	V	0.40	4.50	970	E	35.0	415	SI
1968	A	450 mm	OO	V	0.40	4.50	970	E	35.0	415	SI
1964	A	450 mm	OO	H	0.70	4.50		E	56.0	415	SL
1970	A	250 mm	OO	V	0.20	3.50	1,460	E	20.0	415	SI
1970	A	250 mm	OO	V	0.20	3.50	1,460	E	20.0	415	SI
1976	C		SB	V	0.10	2.00	1,450	E	8.0	415	SL
1976	C		SB	V	0.10	2.00	1,450	E	8.0	415	SL
1976	C		SB	V	0.10	2.00	1,450	E	8.0	415	SL
1971	C		SB	V	0.10	5.70	1,450	E	8.0	415	SL
1977	C		SB	V	0.10	3.00	1,450	E	7.0	415	SI
1977	C		SB	V	0.10	3.00	1,450	E	7.0	415	SI
1977	C		SB	V	0.10	3.00	1,450	E	7.0	415	SI
1977	C		SB	V	0.10	3.00	1,450	E	7.0	415	SI
1975	C		SB	V	0.10	3.70	1,450	E	8.0	415	SL
1975	C		SB	V	0.10	3.70	1,450	E	8.0	415	SL
1975	C		SB	V	0.10	3.70	1,450	E	8.0	415	SL
1964	A	450 mm	OO	-	0.40	3.10		E	25.0	415	SL
1971	A		OO	V	3.10	3.40	365	E	220.0	415	SL
1971	A		OO	V	3.10	3.40	365	E	220.0	415	SL
1971	A		OO	V	3.10	3.40	365	E	220.0	415	SL

SOUTH WEST

REGION	SUB REGION	STN. NO	NAME
<u>South West</u>			
	Exeter	001	POLMORLA
		002	ST.BLAZEY
		003	MIDDLEWAY

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Figure 6

Pumping Station Location Plan
South West Region

Scale 1:625000

NRA - Survey of Land Drainage Pumping Plant Installations
Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer	Year	Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
South West																		
001	POLMORLA	SW 991 724	15.20	5.400														
					1	ABS	1990	A	750 mm	SB	V	1.80	2.30	710	E	119.0	415	Flap
					2	ABS	1990	A	750 mm	SB	V	1.80	2.30	710	E	119.0	415	Flap
					3	ABS	1990	A	750 mm	SB	V	1.80	2.30	710	E	119.0	415	Flap
002	ST.BLAZEY	SX 075 536	2.20	1.710														
					1	FLYGT	1984	A	800 mm	SB	V	0.57	1.00	733	E	22.8	415	Flap
					2	FLYGT	1984	A	800 mm	SB	V	0.57	1.00	733	E	22.8	415	Flap
					3	FLYGT	1984	A	800 mm	SB	V	0.57	1.00	733	E	22.8	415	Flap
003	MIDDLEWAY	SX 069 542	0.01	0.008														
					1	FLYGT	1976	C	50 mm	SB	V	0.01	3.00	2,850	E	0.8	240	SR

THAMES

REGION	SUB REGION	STN. NO	NAME
Thames			
		001	GREAT BREACH
		002	GALLIONS (LAKE 5)
		003	TRIPCOCK (LAKE 4)
		004	GREEN LEVEL

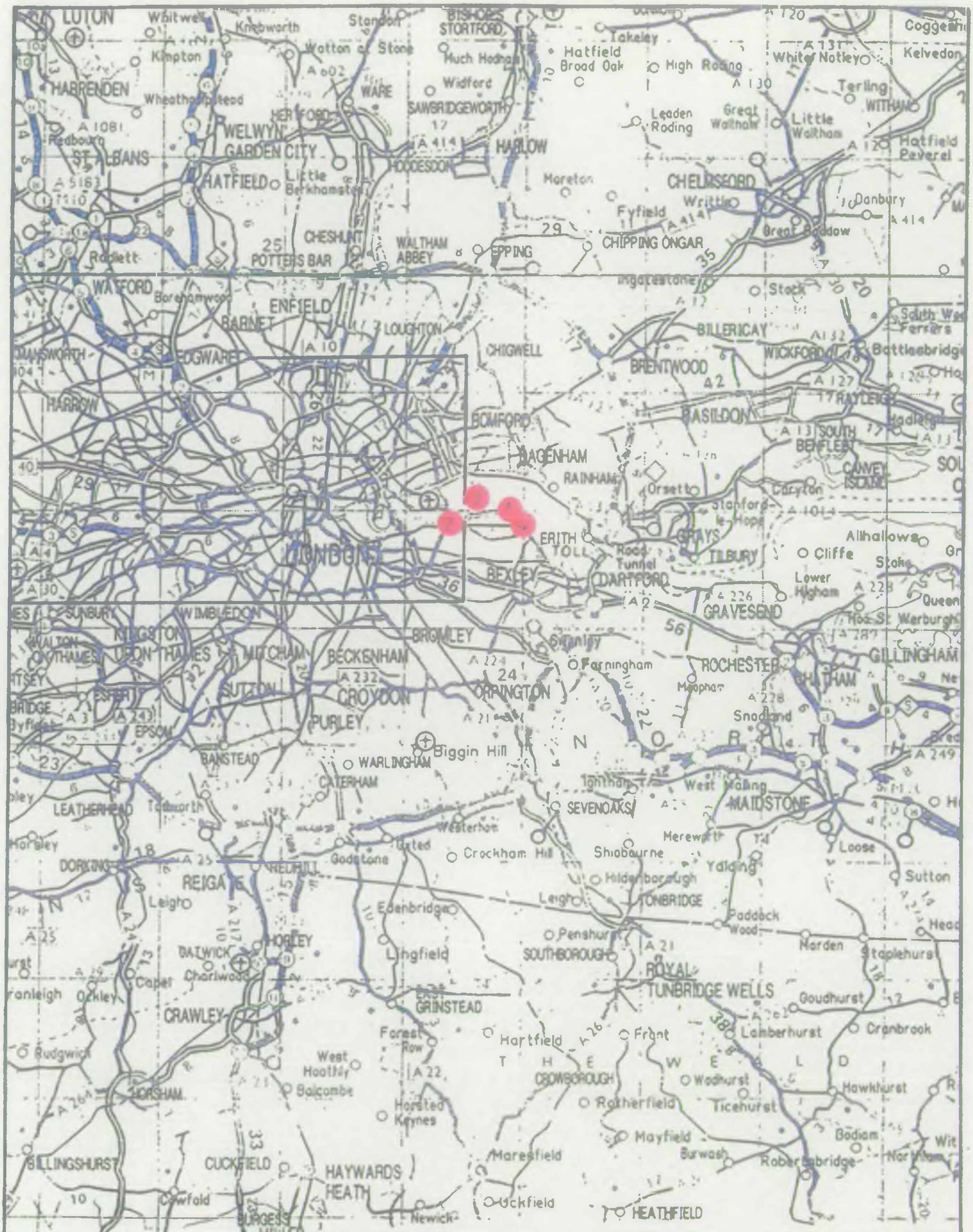

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Figure 7

Pumping Station Location Plan
Thames Region

Scale approximately 1:455000

NRA - Survey of Land Drainage Pumping Plant Installations
Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer
Thames						
001	GREAT BREACH	TQ 493 807	9.00	1.710		
					1	BROOKE, CROMPTON
					2	BROOKE, CROMPTON
					3	BROOKE, CROMPTON
002	GALLIONS (LAKE 5)	TQ 449 798	4.00	0.940		
					1	Flygt B2250
					2	Flygt B2250
					3	Flygt B2250
					4	Flygt B2250
003	TRIPCOCK (LAKE 4)	TQ 464 810	18.00	8.510		
					1	MATHER & PLATT
					2	MATHER & PLATT
					3	DORMAN DIESEL
					4	DORMAN DIESEL
004	GREEN LEVEL	TQ 508 796	3.00	0.690		
					1	METROPOLITAN VICKERS
					2	LISTER DIESEL

Year	Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
1982	A	45 mm	HB	V	0.57	7.00	730	E	87.0	415	SR
1982	A	45 mm	HB	V	0.57	7.00	730	E	87.0	415	SR
1982	A	45 mm	HB	V	0.57	7.00	730	E	87.0	415	SR
1978	C		LB		0.23	7.30		E		415	SR
1978	C		LB		0.23	7.30		E		415	SR
1978	C		LB		0.23	7.30		E		415	SR
1978	C		LB		0.23	7.30		E		415	SR
1977	S	2900mm	HB		2.13	8.36	1,500	E		11,000	SL
1977	S	2900mm	HB		2.13	8.36	1,500	E		11,000	SL
1977	S	2900mm	HB		2.13	8.36	1,500	D		11,000	SL
1977	S	2900mm	HB		2.13	8.36	1,500	D		11,000	SL
1959	A		HB		0.43	6.10		E		415	
1972	C		LB		0.26			D			

WELSH

REGION	SUB REGION	STN. NO	NAME
Welsh			
	Buckley	001	BALDERTON
		004	WERN Y.DAVY
		005	DOL ERION
		006	FINGERPOST
		007	DOG KENNEL
		008	GWERN Y TO
		009	QUEEN FERRY
		010	THORNLEIGH PARK
		011	BURTON PUDDINGTON
		012	ROWLEYS GUTTER
		013	GREEN MOOR
		014	COLLISTER PILL
		015	TREVALYN MEADOW
		021	SEALAND MAIN
	Rhuddlan	002	RHYL
		003	CLWYD
		016	TALACRE
		017	GRONNANT
		018	BELGRAD
		019	BODORYN
		020	GYPSY LANE

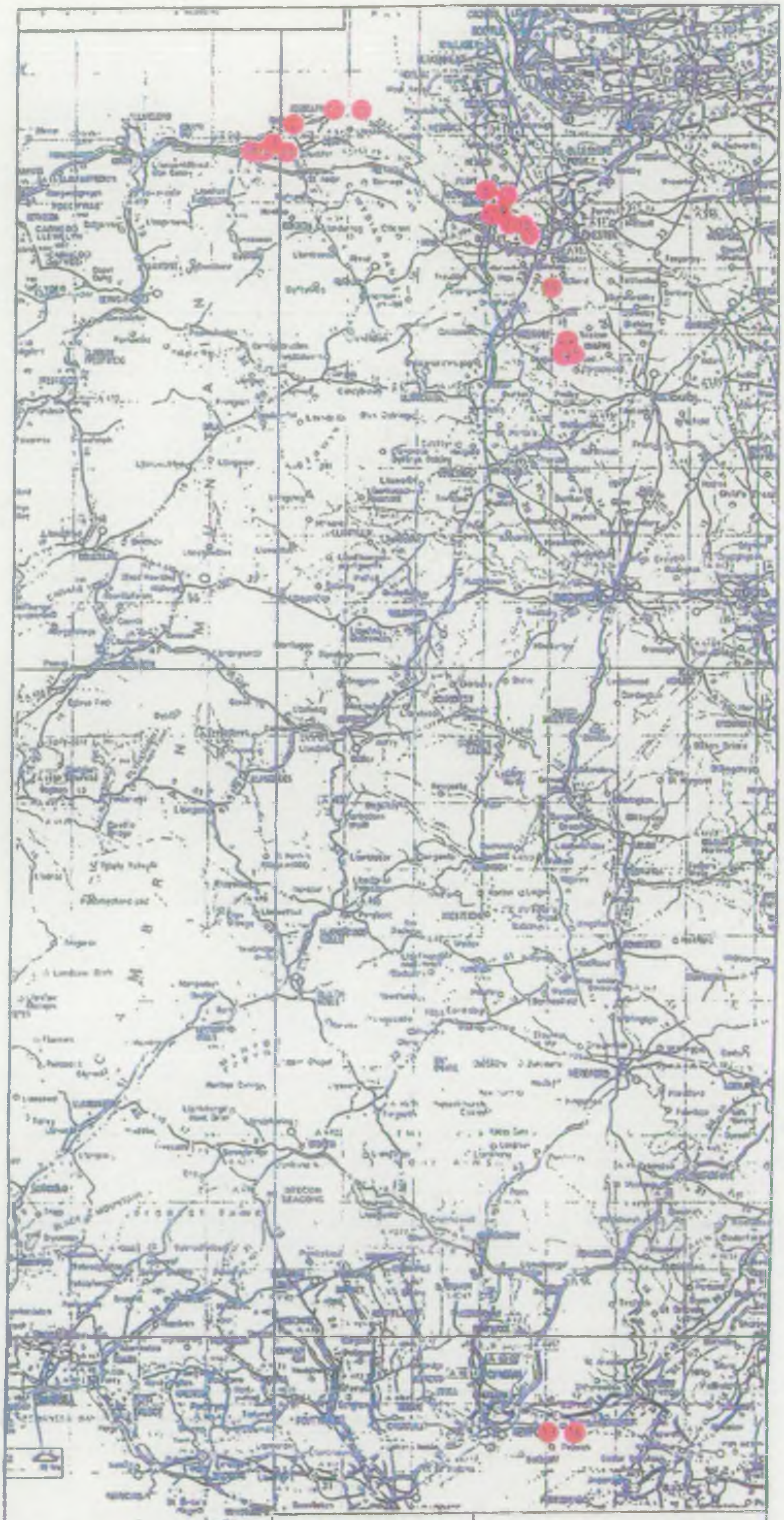

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Figure 8

Pumping Station Location Plan
Welsh Region

Scale 1:625000

NRA - Survey of Land Drainage Pumping Plant Installations
Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer	Year
Welsh							
001	BALDERTON	SJ 378 652	30.00				
					1	A.B.S.	19
					2	A.B.S.	19
002	RHYL	SJ 029 825	10.23	2.800			
					1	ALLEN GWYNNES	19
					2	ALLEN GWYNNES	19
					3	ALLEN GWYNNES	19
					4	ALLEN GWYNNES	19
003	CLWYD	SH 999 797	563.00	2.770			
					1	ALLEN GWYNNES	19
					2	ALLEN GWYNNES	19
					3	ALLEN GWYNNES	19
004	WERN Y.DAVY	SJ 423 494	255.00	0.150			
					1	FLYGT	19
005	DOL ERION	SJ 432 476	320.00				
					1	TSURUMI	19
					2	TSURUMI	19
006	FINGERPOST	SJ 307 723		0.220			
					1	MATHER & PLANT	19
					2	MATHER & PLANT	19
007	DOG KENNEL	SJ 424 480	170.00				
					1	FLYGT	19
008	GWERN Y TO	SJ 424 473	210.00	0.153			
					1	TSURUMI	19
009	QUEEN FERRY	SJ 323 685	275.00	2.800			
					1	ALLEN GWYNNES	19
					2	ALLEN GWYNNES	19
010	THORNLEIGH PARK	SJ 364 662	24.00	1.500			
					1	A.B.S	19
					2	A.B.S	19
011	BURTON PUDDINGTON	SJ 330 718		0.350			
					1	K S B	19
					2	K S B	19
012	ROWLEYS GUTTER	SJ 316 689	14.85				
					1	SPAAN	19
					2	SPAAN	19
013	GREEN MOOR	ST 405 863					
					1	MONO	19

Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
A	700 mm	SB	H			720	E	0.0	415	
A	700 mm	SB	H			720	E	0.0	415	
A	508 mm	HB	V	0.70			E	0.0	415	
A	508 mm	HB	V	0.70			E	0.0	415	
A	508 mm	HB	V	0.70			E	0.0	415	
A	508 mm	HB	V	0.70			E	0.0	415	
A	609 mm	HB	V	0.92			E	0.0	415	SI
A	609 mm	HB	V	0.92			E	0.0	415	SI
A	609 mm	HB	V	0.92			E	0.0	415	SI
C	250 mm	SB	H	0.15		950	E	0.0	415	
C	250 mm	SB	H			1,500	E	0.0	415	
C	250 mm	SB	H			1,500	E	0.0	415	
A	304 mm	HB	V	0.11		945	E	7.0	415	
A	304 mm	HB	V	0.11		945	E	7.0	415	
C	250 mm	SB	H			950	E	0.0	415	
C	250 mm	SB		0.15		1,500	E	0.0	415	
A	762 mm	HB	V	1.40		487	E	105.0	415	
A	762 mm	HB	V	1.40		487	E	105.0	415	
A	500 mm	LB	H	0.75		960	E	0.0	415	
A	500 mm	LB	H	0.75		960	E	0.0	415	
A	350 mm	SB	V			740	E	0.0	415	
A	350 mm	SB	V			740	E	0.0	415	
S	mm	OO				30	E	0.0	415	
S	mm	OO				30	E	0.0	415	
A	mm	OO	V				E	0.0	415	SR

[redacted]

Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer	Year	Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
014	COLLISTER PILL	ST 446 866		0.070														
					1	PLEUGER	19	A	475 mm	SB	H	0.07	5.12	965	E	100.0	415	SR
					2	A.B.S	19	A	475 mm	SB	H			720	E	75.0	415	SR
015	TREVALYN MEADOW	SJ 402 576	30.09	1.400														
					1	ALLEN GWYNNES	19	A	558 mm	HB	H	0.70		750	E	55.0	415	
					2	ALLEN GWYNNES	19	A	558 mm	HB	H	0.70		750	E	55.0	415	
016	TALACRE	SJ 125 847	31.00															
					1	SARLIN	19	C	152 mm	SB					E		415	
017	GRONNANT	SJ 087 840	11.03	0.021														
					1	ALLEN GWYNNES	19	A	558 mm	HB	V	0.07			E		415	
					2	ALLEN GWYNNES	19	A	558 mm	HB	V	0:07			E		415	
					3	ALLEN GWYNNES	19	A	558 mm	HB	V	0.07			E			
018	BELGRAD	SH 961 788	1.60	0.700														
					1	ALLEN GWYNNES	19	A	355 mm	HB	V	0.35			E		415	
					2	ALLEN GWYNNES	19	A	355 mm	HB	V	0.35			E		415	
019	BODORYN	SH 985 786	14.85															
					1	A.B.S	19		mm	SB					E		415	
					2	A.B.S	19		mm	SB					E		415	
020	GYPSY LANE	SJ 011 786		0.220														
					1	SARLIN	19		mm	SB		0.11			E			
					2	SARLIN	19		mm	SB		0.11			E			
021	SEALAND MAIN	SJ 339 677	24.00	1.500														
					1	A.B.S	19	A	500 mm	SB	H	0.75		960	E		415	
					2	A.B.S	19	A	500 mm	SB	H	0.75		960	E		415	

WESSEX

REGION	SUB REGION	STN. NO	NAME
Wessex			
	Bridgewater	001	HENLEY
		002	MIDELNEY
		003	WEST SEDGEMOOR
		004	WESTOVER
		005	HUISH EPISCOPI
		006	LONG LOAD
		007	STOCKMOOR
		008	NORTHMOOR
		009	SALTMOOR
		010	STANMOOR
		011	WESTON ZOYLAND
		012	CURRY MOOR
		013	CLEWER
		014	SOUTH HILL
		015	WHITEHOUSE
		016	BLACKFORD
		017	CROSSMOOR
		018	GOLD CORNER
		019	SLOWAY LANE
		020	WITHYDROVE
		021	NORTH DRAIN
	Bath	022	LADDEN BROOK
	Blandford	023	WEST BAY,

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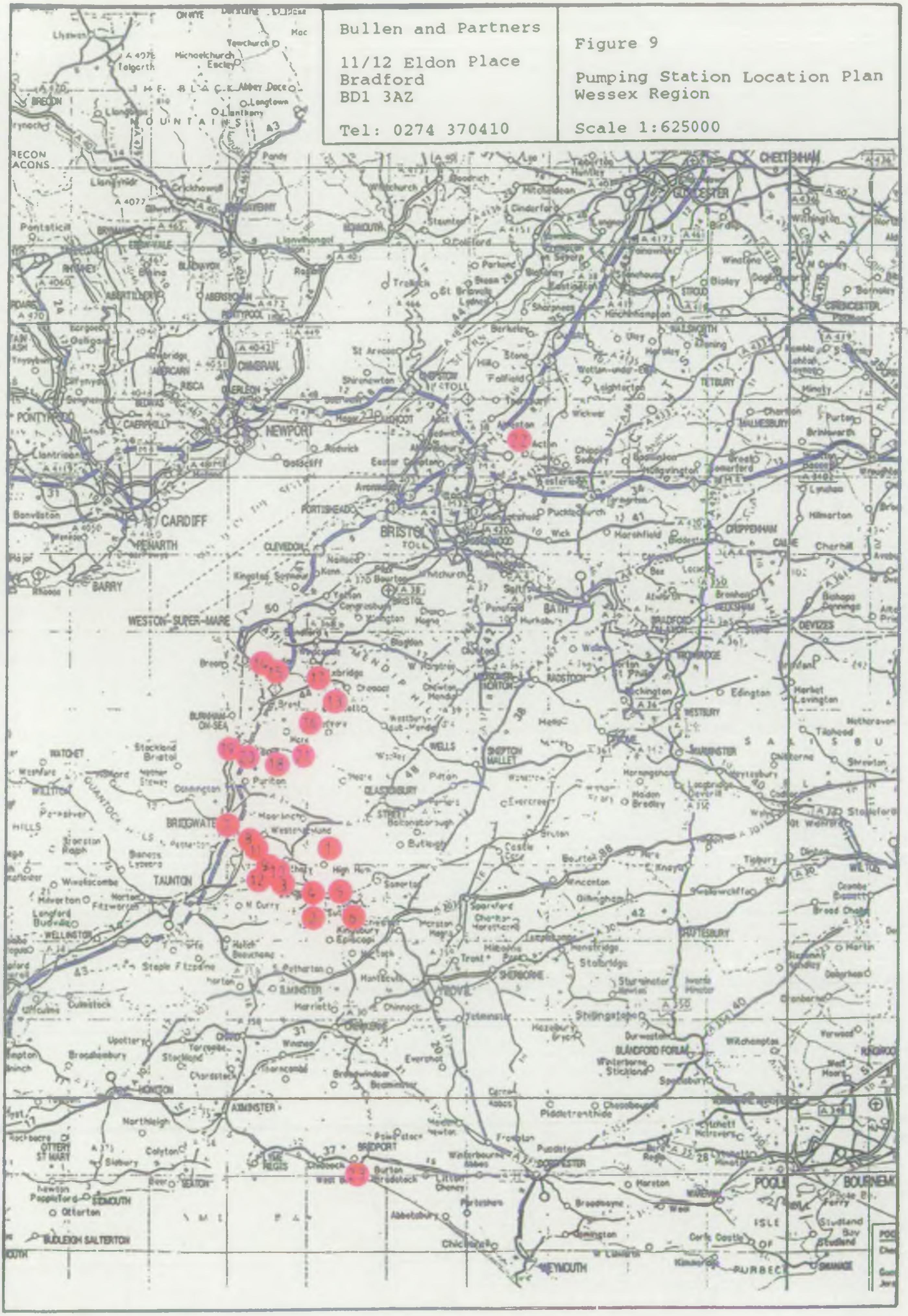


Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer	Year
Wessex							
001	HENLEY	ST 436 327		0.220			
					1	PLEUGER	1971
					2	PLEUGER	1971
002	MIDELNEY	ST 416 235	22.50	3.300			
					1	ALLEN GWYNNES	1963
					2	ALLEN GWYNNES	1963
					3	ALLEN GWYNNES	1963
003	WEST SEDGEMOOR	ST 376 286	44.50	6.800			
					1	ALLEN GWYNNES	1945
					2	ALLEN GWYNNES	1945
					3	ALLEN GWYNNES	1945
					4	ALLEN GWYNNES	1986
004	WESTOVER	ST 416 265	9.80	1.860			
					1	ALLEN GWYNNES	1966
					2	ALLEN GWYNNES	1966
					3	ALLEN GWYNNES	1966
005	HUISH EPISCOPI	ST 441 262	27.50	5.100			
					1	ALLEN GWYNNES	1963
					2	ALLEN GWYNNES	1963
					3	ALLEN GWYNNES	1963
006	LONG LOAD	ST 468 237	32.60	7.200			
					1	ALLEN GWYNNES	1977
					2	ALLEN GWYNNES	1977
					3	ALLEN GWYNNES	1977
007	STOCKMOOR	ST 306 357	7.30	1.420			
					1	ALLEN GWYNNES	1977
					2	ALLEN GWYNNES	1977
008	NORTHMOOR	ST 332 330	20.70	2.200			
					1	ALLEN GWYNNES	1942
					2	ALLEN GWYNNES	1942
009	SALTMOOR	ST 353 308	2.50	0.925			
					1	ALLEN GWYNNES	1942
					2	BEDFORDS	1991
					3	BEDFORDS	1991
010	STANMOOR	ST 361 298	4.10	0.905			
					1	ALLEN GWYNNES	1942
					2	ALLEN GWYNNES	1967
					3	ALLEN GWYNNES	1967
011	WESTON ZOYLAND	ST 340 328	8.10	1.000			
					1	W.SIMPSON	1947

Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
A		SB	V	0.11	2.28	1,450	E	7.5	415	SI
A		SB	V	0.11	2.28	1,450	E	7.5	415	SI
C	750 mm	HB	V	1.10	3.35	486	E	95.0	415	SI
C	750 mm	HB	V	1.10	3.35		E	95.0	415	SI
C	750 mm	HB	V	1.10	3.35		E	95.0	415	SI
C	1000mm	HB	V	2.20	2.59	265	D	132.0		SL
C	1000mm	HB	V	2.20	2.59	265	D	132.0		SL
MF	1000mm	SB	V	2.20	2.59	265	D	132.0		SL
MF	700 mm	SB	V	1.20	3.00	800	E		415	SI
A	550 mm	HB	V	0.62	1.20	730	E	50.0	415	SI
A	550 mm	HB	V	0.62	1.20	730	E	50.0	415	SI
A	550 mm	HB	V	0.62	1.20	730	E	50.0	415	SI
A	900 mm	HB	V	1.70	3.35	420	E	130.0	415	SI
A	900 mm	HB	V	1.70	3.35	420	E	130.0	415	SI
A	900 mm	HB	V	1.70	3.35	420	E	130.0	415	SI
A	1050mm	OO	V	2.40	4.00	375	E	200.0	415	SI
A	1050mm	OO	V	2.40	4.00	375	E	200.0	415	SI
A	1050mm	OO	V	2.40	4.00	375	E	200.0	415	SI
A	600 mm	OO	V	1.00	3.85	585	E	94.0	415	SI
A	450 mm	OO	V	0.42	4.17	980	E	47.0	415	SI
C	675 mm	HB	H	1.10	2.44	265	D	66.0		SR
C	675 mm	HB	H	1.10	2.44	265	D	66.0		SR
C	500 mm	HB	H	0.42	3.05		D	34.0		SL
MF	400 mm	SB	V	0.25	3.67	730	E	18.0	415	SI
MF	400 mm	SB	V	0.25	3.67	730	E	18.0	415	SI
C	450 mm	HB	H	0.45	2.44	310	D	34.0		SR
MF		OO	V	0.22	3.05	960	E	20.0	415	SL
MF		OO	V	0.22	3.05	960	E	20.0	415	SL
C	600 mm	HB	H	1.00	5.60	1,600	D	129.0		SL

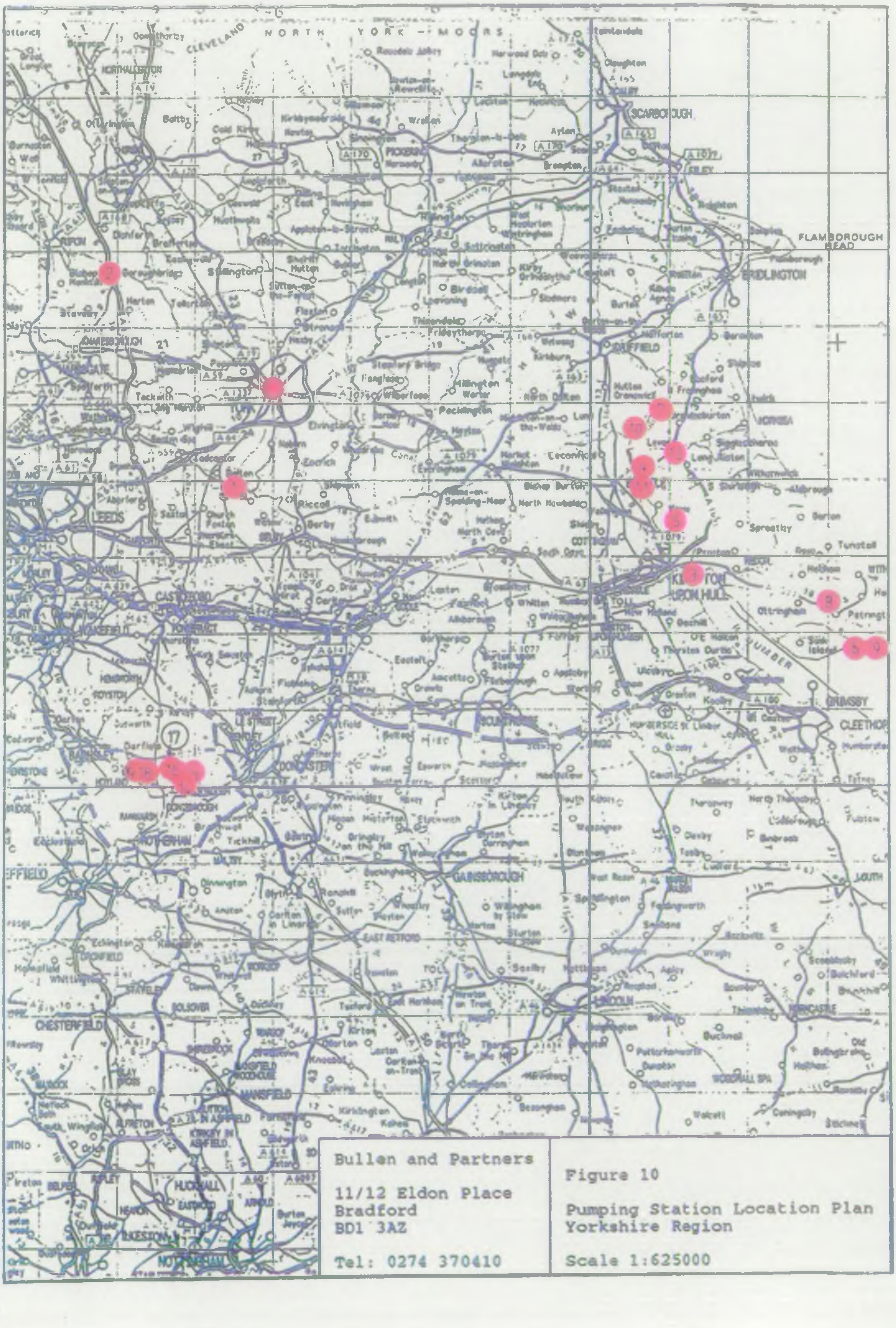
NRA - Survey of Land Drainage Pumping Plant Installations
Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer	Year
012	CURRY MOOR	ST 345 288	15.50	3.470			
					1	SULZER	1955
					2	SULZER	1955
					3	LANDUSTRIE	1983
013	CLEWER	ST 438 515	34.50	6.000			
					1	ALLEN GWYNNES	1969
					2	ALLEN GWYNNES	1969
					3	ALLEN GWYNNES	1969
014	SOUTH HILL	ST 346 564		0.720			
					1	PLEUGER	1963
					2	PLEUGER	1963
015	WHITEHOUSE	ST 362 552		0.720			
					1	PLEUGER	1963
					2	PLEUGER	1963
016	BLACKFORD	ST 401 485	1.90	0.260			
					1	LANDUSTRIE	1973
017	CROSSMOOR	ST 415 544	1.40	0.720			
					1	LANDUSTRIE	1980
018	GOLD CORNER	ST 368 431	104.10	17.500			
					1	SULZER	1942
					2	SULZER	1942
					3	SULZER	1942
					4	SULZER	1942
019	SLOWAY LANE	ST 302 451	16.20	0.132			
					1	FLYGT	1991
					2	FLYGT	1991
020	WITHYDROVE	ST 326 441	16.20	0.132			
					1	FLYGT	1990
					2	FLYGT	1990
021	NORTH DRAIN	ST 398 448	35.10	5.520			
					1	ALLEN GWYNNES	1960
					2	ALLEN GWYNNES	1960
					3	ALLEN GWYNNES	1960
022	LADDEN BROOK	ST 667 840	41.00	2.000			
					1	SPAAN	1980
					2	SPAAN	1980
023	WEST BAY,	SY 463 905	1.70	1.500			
					1	FLYGT	1984

Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
C	900 mm	HB	V	1.56	3.50	320	D	136.0		SL
C	900 mm	HB	V	1.56	3.50	320	D	136.0		SL
S	1300mm	OO		0.35	3.50	44	E	23.0	415	
A	900 mm	OO	V	2.00	2.59	415	E	120.0	415	SI
A	900 mm	OO	V	2.00	2.59	415	E	120.0	415	SI
A	900 mm	OO	V	2.00	2.59	415	E	120.0	415	SI
A		SB	V	0.36	1.83	960	E	20.0	415	SI
A		SB	V	0.36	1.83	960	E	20.0	415	SI
A		SB	V	0.36	1.83	960	E	20.0	415	SI
A		SB	V	0.36	1.83	960	E	20.0	415	SI
S	950 mm	-	-	0.26	1.52	48	E	10.0	415	-
S	1645mm	OO	-	0.72	2.20	36	E	30.0	415	-
A	1500mm	HB	H	4.38	2.59	250	E	315.0	415	SL
A	1500mm	HB	H	4.38	2.59	220	D	240.0		SL
A	1500mm	HB	H	4.38	2.59	220	D	240.0		SL
A	1500mm	HB	H	4.38	2.59	220	D	240.0		SL
C	200 mm	SB	V	0.07	6.00		E		415	SL
C	200 mm	SB	V	0.07	6.00		E		415	SL
C	200 mm	SB	V	0.07	6.00		E		415	SL
C	200 mm	SB	V	0.07	6.00		E		415	SL
A	900 mm	HB	V	1.84	3.66			136.0	415	SI
A	900 mm	HB	V	1.84	3.66		D	136.0	415	SI
A	900 mm	HB	V	1.84	3.66		D	136.0	415	SI
S	1800mm	SB		1.00			E		415	SL
S	1800mm	SB		1.00			E		415	SL
	920 mm	LB/SB	V	1.53	2.50	585	E		415	SI

YORKSHIRE

REGION	SUB REGION	STN. NO	NAME
Yorkshire			
		014	* PASTURES ROAD P.S.
		015	* BARNBORGH GRANGE
		016	* MILL LANE
		017	* ADWICK-ON-DEARNE
		018	* BOLTON INGS P.S.
		019	* OLIS MOOR
	York 1	001	FLEET
	York 2	002	BOROUGHBRIDGE
		013	FOSS BARRIER
	Humberside	003	EAST HULL
		004	TICKTON
		005	GREAT CULVERT
		006	WINESTEAD OUTFALL
		007	HEMPHOLME
		008	WINESTEAD BOOSTER
		009	SKEFFLING
		010	WILFHOLME
		011	WATERSIDE
		012	ARNOLD AND RISTON



Bullen and Partners

11/12 Eldon Place
Bradford
BD1 3AZ

Tel: 0274 370410

Figure 10

Pumping Station Location Plan
Yorkshire Region

Scale 1:625000

NRA - Survey of Land Drainage Pumping Plant Installations
Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer
Yorkshire						
001	FLEET	SE 555 398	32.00	2.260		
					1	SULZER
					2	SULZER
002	BOROUGHBRIDGE	SE 396 670		1.050		
					1	A.B.S. VOP 400/BRB
					2	A.B.S. VOP 400/BRB
003	EAST HULL	TA 130 284		22.600		
					1	NO INFORMATION
004	TICKTON	TA 074 425	0.55	2.550		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
					3	ALLEN GWYNNES
005	GREAT CULVERT	TA 115 355	5.50	12.720		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
					3	ALLEN GWYNNES
					4	ALLEN GWYNNES
006	WINESTEAD OUTFALL	TA 335 185		7.540		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
007	HEMPHOLME	TA 095 495	9.92	1.870		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
					3	ALLEN GWYNNES
008	WINESTEAD BOOSTER	TA 301 234		3.390		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
					3	ALLEN GWYNNES
009	SKEFFLING	TA 369 184		2.400		
					1	SULZER BROS
					2	SULZER BROS
					3	SULZER BROS
010	WILFHOLME	TA 062 472	1.09	8.000		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES
					3	ALLEN GWYNNES
					4	ALLEN GWYNNES
011	WATERSIDE	TA 057 393		4.000		
					1	ALLEN GWYNNES
					2	ALLEN GWYNNES

Year	Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
1975	MF	450 mm	HB	V	1.13	6.10	725	E	130.0	415	SL
1975	MF	450 mm	HB	V	1.13	6.10	725	E	130.0	415	SL
1988	A	400 mm	LB	V	0.50	3.30	950	E		415	SL
1988	A	400 mm	LB	V	0.50	3.30	950	E		415	SL
19	-		-	-				-			-
1972	A	525 mm	HB	V	0.85	5.00	735	E	55.0	415	SI
1972	A	525 mm	HB	V	0.85	5.00	735	E	55.0	415	SI
1972	A	525 mm	HB	V	0.85	5.00	735	E	55.0	415	SI
1969	A	1050mm	OO	V	3.18	9.00	328	E	250.0	415	SI
1969	A	1050mm	OO	V	3.18	9.00	328	E	250.0	415	SI
1969	A	1050mm	OO	V	3.18	9.00	328	E	250.0	415	SI
1969	A	1050mm	OO	V	3.18	9.00	328	E	250.0	415	SI
1977	A	1067mm	HB	V	3.77	3.80	321	E		415	SL
1977	A	1067mm	HB	V	3.77	3.80	321	E		415	SL
1974	A	525 mm	HB	V	0.60	12.50	735	-	41.0	415	SI
1974	A	525 mm	HB	V	0.60	12.50	735	-	41.0	415	SI
1974	A	525 mm	HB	V	0.67	6.25	735	-	29.0	415	SI
1978	A	675 mm	HB	V	1.13	4.10	585	E		415	SL
1978	A	675 mm	HB	V	1.13	4.10	585	E		415	SL
1978	A	675 mm	HB	V	1.13	4.10	585	E		415	SL
1982	A	675 mm	LB	V	0.80	4.50	580	E		415	SR
1982	A	675 mm	LB	V	0.80	4.50	580	E		415	SR
1982	A	675 mm	LB	V	0.80	4.50	580	E		415	SR
1981	MF	900 mm	HB	V	2.00	6.35	420	E		415	SI
1981	MF	900 mm	HB	V	2.00	6.35	420	E		415	SI
1981	MF	900 mm	HB	V	2.00	6.35	420	E		415	SI
1981	MF	900 mm	HB	V	2.00	6.35	420	E		415	SI
1982	MF	900 mm	HB	V	2.00	7.00	420	E		415	SI
1982	MF	900 mm	HB	V	2.00	7.00	420	E		415	SI

NRA - Survey of Land Drainage Pumping Plant Installations
Pump Summary

Stn. No.	Stn. Name	National Grid Reference	Catchment Area (Sq.km)	Total Capacity (Cumecs)	No of Pump	Manufacturer
012	ARNOLD AND RISTON	TA 107 434		0.730		
					1	SULZER
					2	SULZER
013	FOSS BARRIER	SE 605 512	125.00	30.000		
					1	FLYGT
					2	FLYGT
					3	FLYGT
					4	FLYGT
					5	FLYGT
					6	FLYGT
					7	FLYGT
					8	FLYGT
014	* PASTURES ROAD P.S.	SE 496 009	4.00	0.440		
					1	FLYGT CP3300
					2	FLYGT CP3300
015	* BARNBORGH GRANGE	SE 492 016		0.040		
					1	GUINARD ER1000C617
					2	GUINARD ER1000C617
016	* MILL LANE	SE 480 018		0.080		
					1	BRITISH GUINARD
					2	BRITISH GUINARD
017	* ADWICK-ON-DEARNE	SE 473 023	1.00	0.132		
					1	FLYGT CP3151
					2	FLYGT CP3151
018	* BOLTON INGS P.S.	SE 439 022	0.30	0.066		
					1	FLYGT CP3101MT
					2	FLYGT CP3101MT
019	* OLIS MOOR	SE 435 021	0.30	0.120		
					1	FLYGT CP3126
					2	FLYGT CP3126
					3	FLYGT CP3127MT 430IM

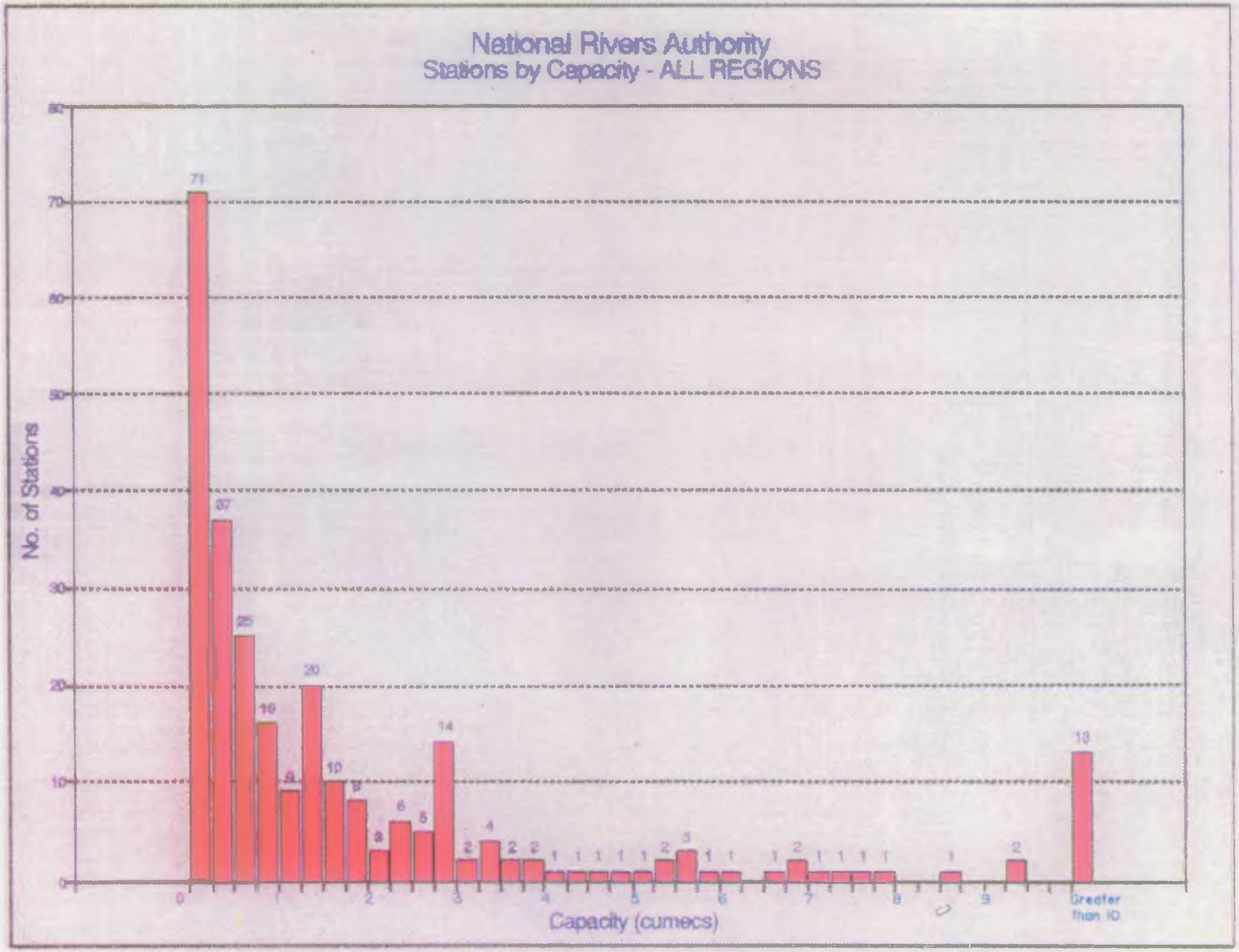
Year	Pump Type	Size Diam.	Hous.	Moun.	Capacity (cumecs)	Stat. Head (m)	Impel. Speed (R.P.M)	Drive	H.P.	Supply Voltage	Disc. Type
1980	MF	400 mm	LB	V	0.36	5.40	970	E		415	SR
1980	MF	400 mm	LB	V	0.36	5.40	970	E		415	SR
1988	MF	930 mm	SB	V	3.80	3.70	490	E		415	SL
1988	MF	930 mm	SB	V	3.80	3.70	490	E		415	SL
1988	MF	930 mm	SB	V	3.80	3.70	490	E		415	SL
1988	MF	930 mm	SB	V	3.80	3.70	490	E		415	SL
1988	MF	930 mm	SB	V	3.80	3.70	490	E		415	SL
1988	MF	930 mm	SB	V	3.80	3.70	490	E		415	SL
1988	MF	930 mm	SB	V	3.80	3.70	490	E		415	SL
1988	MF	930 mm	SB	V	3.80	3.70	490	E		415	SL
1979	MF		SB	V	0.22	7.75		E		415	SL
1979	MF		SB	V	0.22	7.75		E		415	SL
1991	MF	80 mm	SB	H	0.02	4.20		E	2.0	220	SL
1991	MF	80 mm	SB	H	0.02	4.20		E	2.0	220	SL
1982	MF	100 mm	SB	V	0.04	3.40	1,450	E		415	SL
1982	MF	100 mm	SB	V	0.04	3.40	1,450	E		415	SL
1970	MF		SB	H	0.07	5.80		E	15.0	440	SL
1970	MF		SB	H	0.07	5.80		E	15.0	440	SL
1974	MF		SB	V	0.03	5.87		E	4.0	415	SL
1974	MF		SB	V	0.03	5.87		E	4.0	415	SL
1974	A		SB	V	0.06	6.10		E	8.0	415	SL
1974									8.0		
1986	A		SB	V	0.06	6.10		E	8.0	415	SL

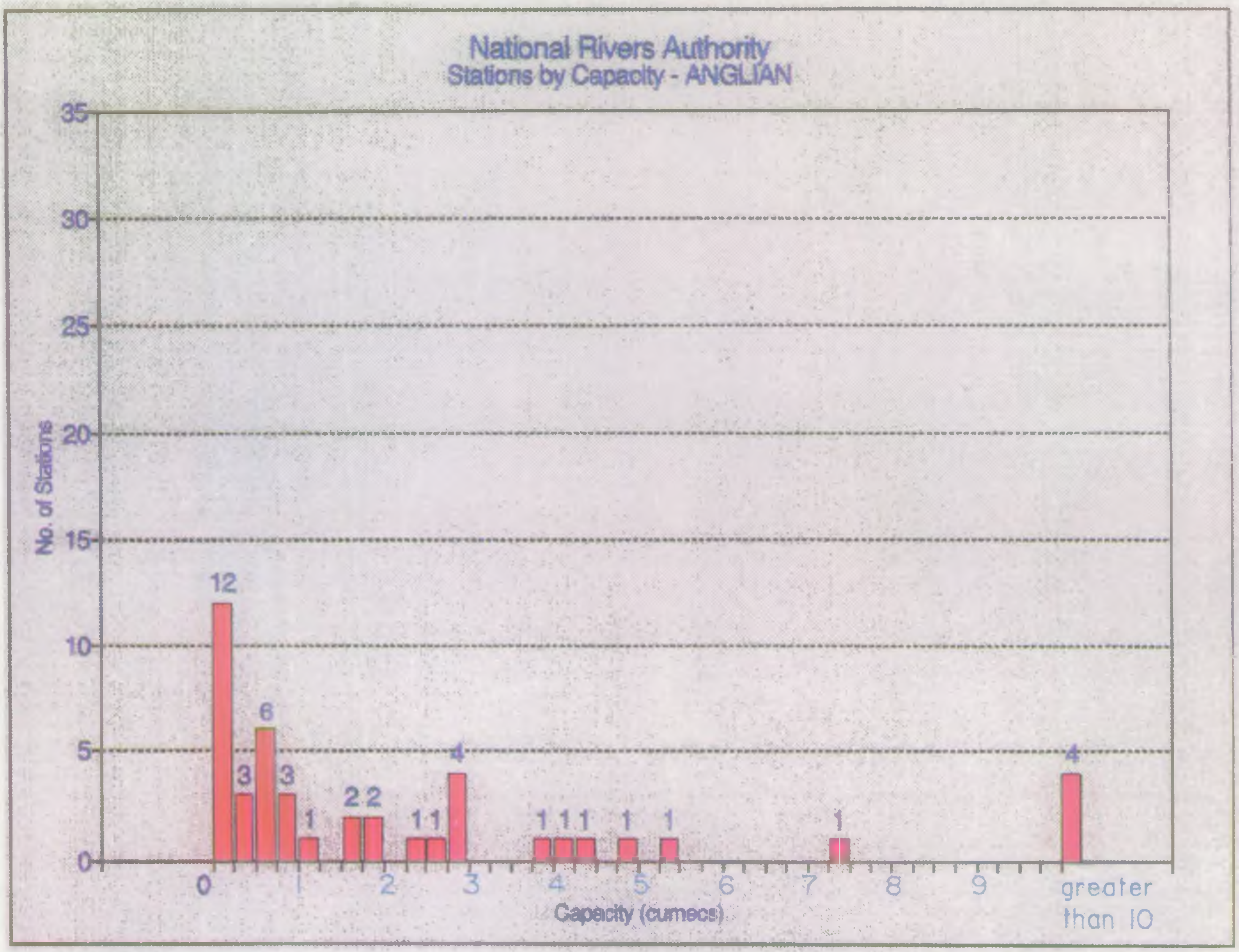
Appendix B2

Pump Analysis

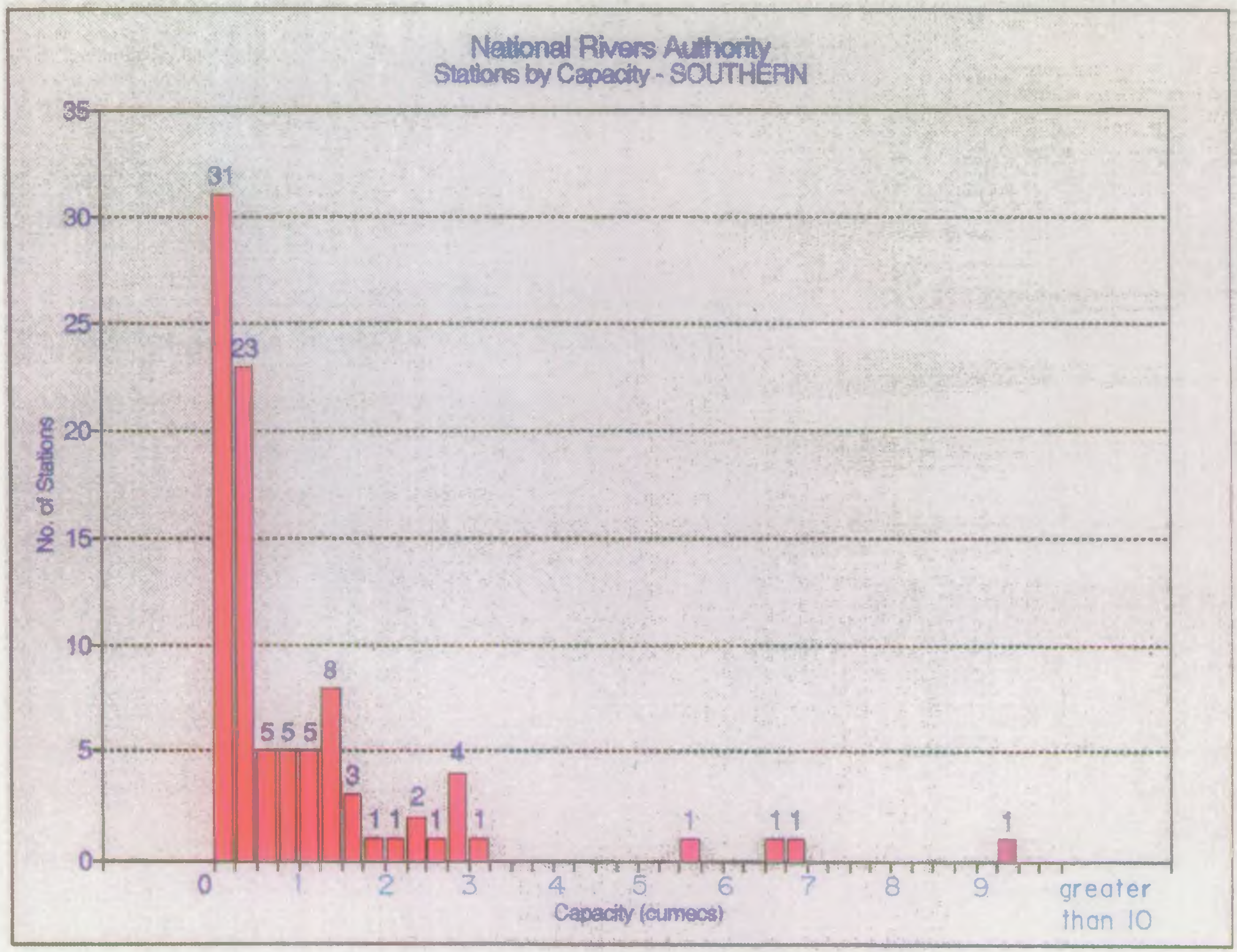
Listed by Capacity

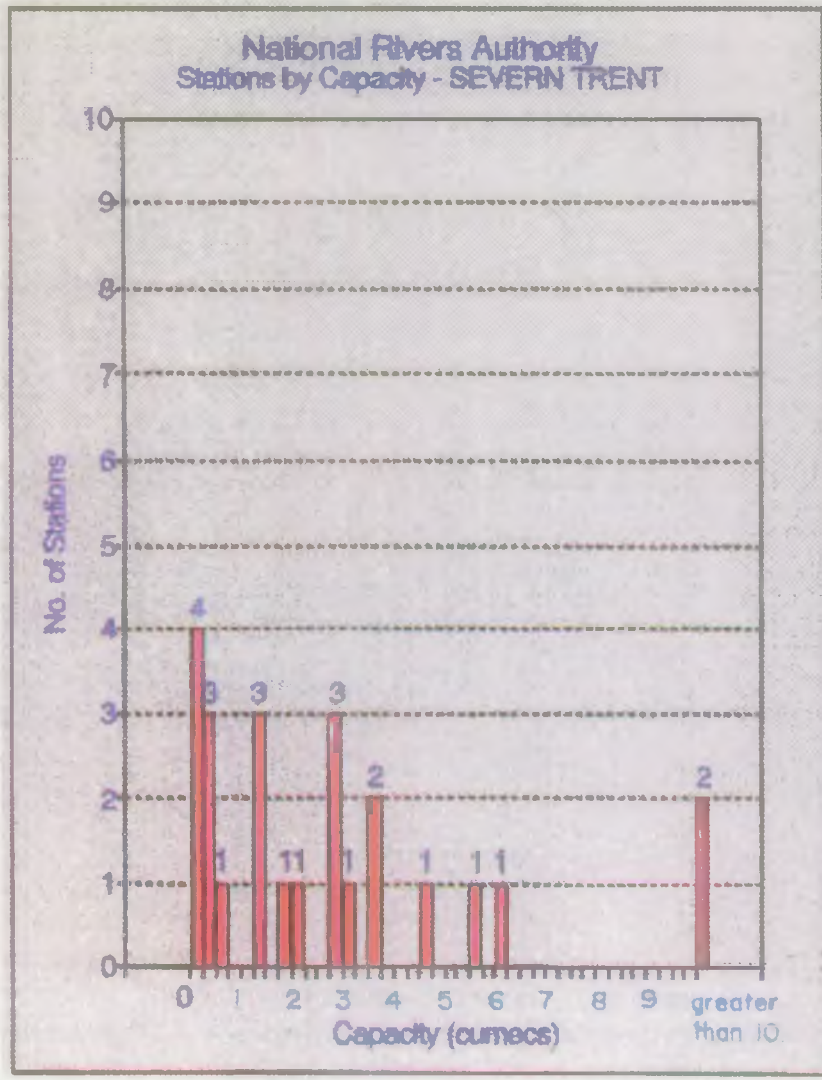
Contents

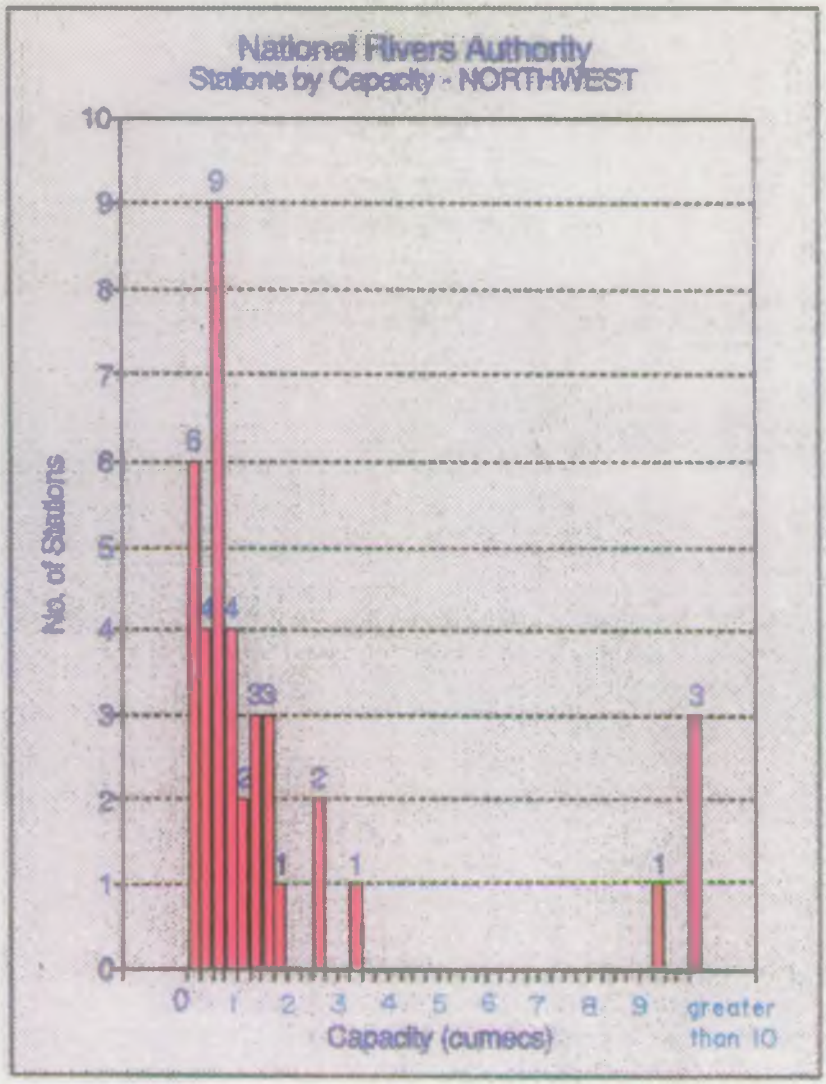

National Rivers Authority
Stations by Capacity - ALL REGIONS
No. of Stations
Capacity (cumecs)
0
10
20
30
40
50
60
70
80
1
2
3
4
5
6
7
8
9
Greater than 10
71
37
25
16
9
20
10
8
3
6
5
14
2
4
2
2
1
1
1
1
1
2
3
1
1
1
2
1
1
1
1
1
2
13



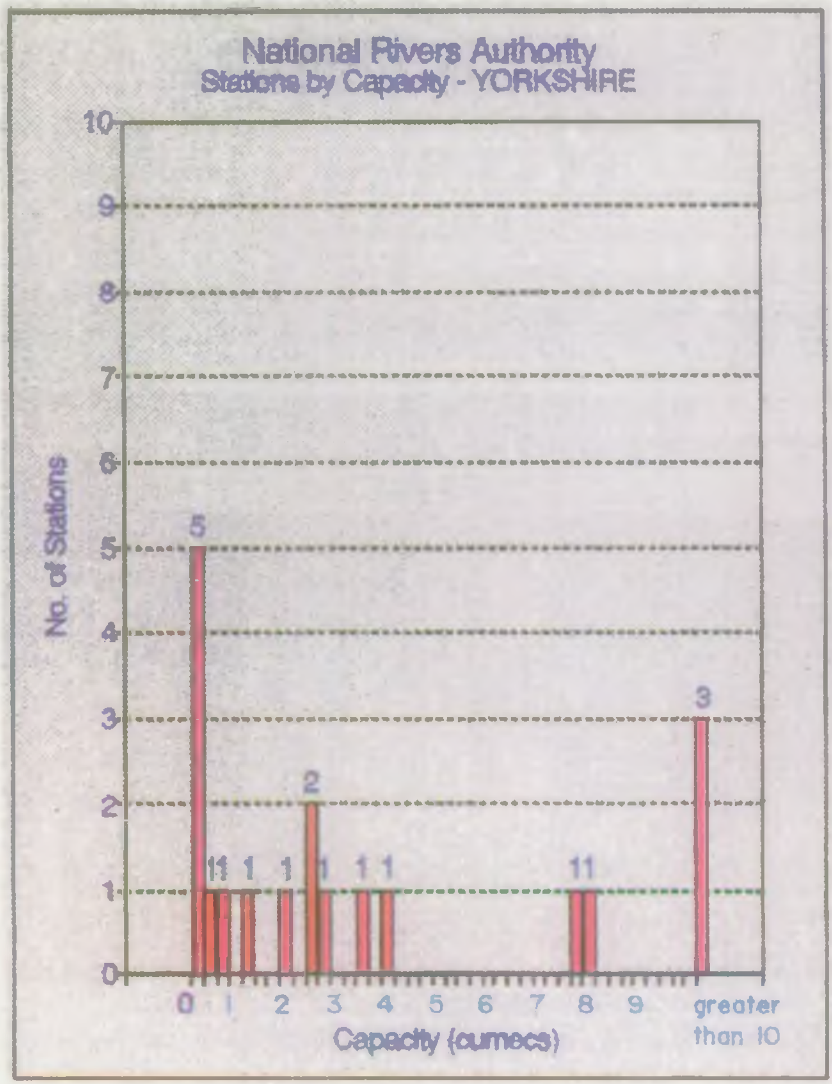
National Rivers Authority
Stations by Capacity - ANGLIAN
No. of Stations
35
30
25
20
15
10
5
0
12
3
6
3
1
2 2
1 1
4
1 1 1
1
1
1
4
0
1
2
3
4
5
6
7
8
9
greater than 10
Capacity (cumecs)

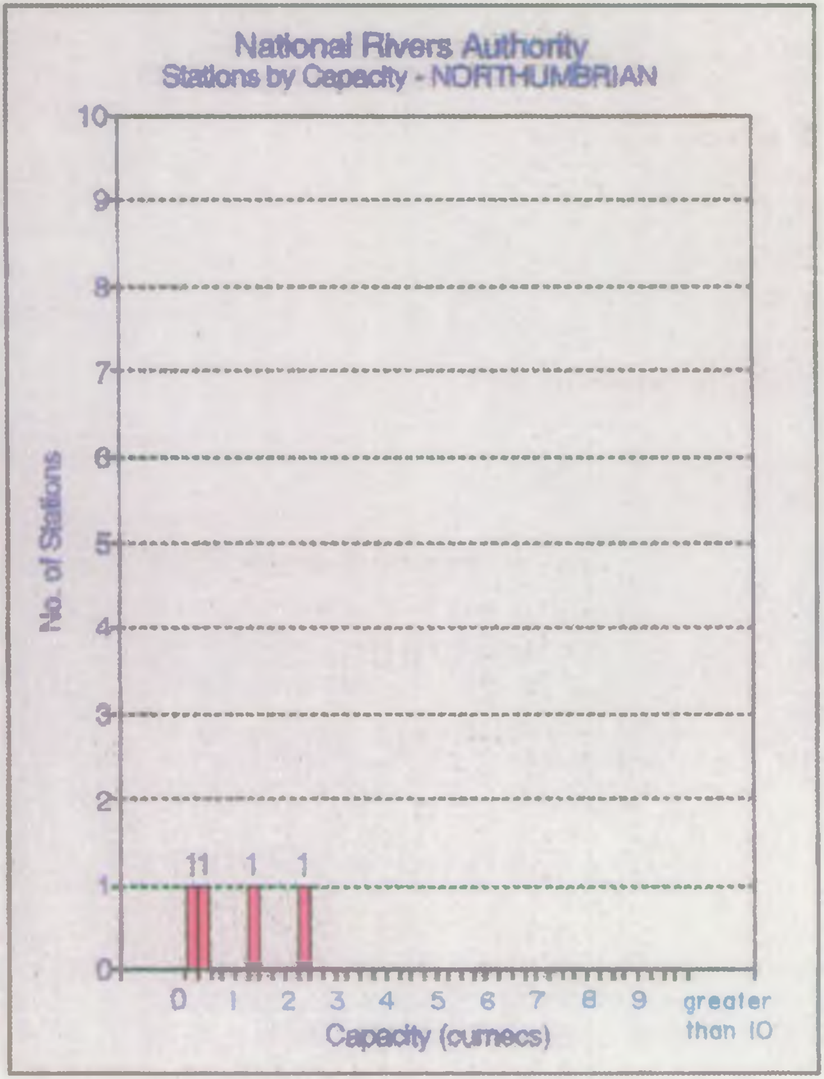

National Rivers Authority
Stations by Capacity - SOUTHERN
No. of Stations
Capacity (cumecs)
0
5
10
15
20
25
30
35
0
1
2
3
4
5
6
7
8
9
greater than 10
31
23
5 5 5
8
3
1 1
2
1
4
1
1
1 1
1

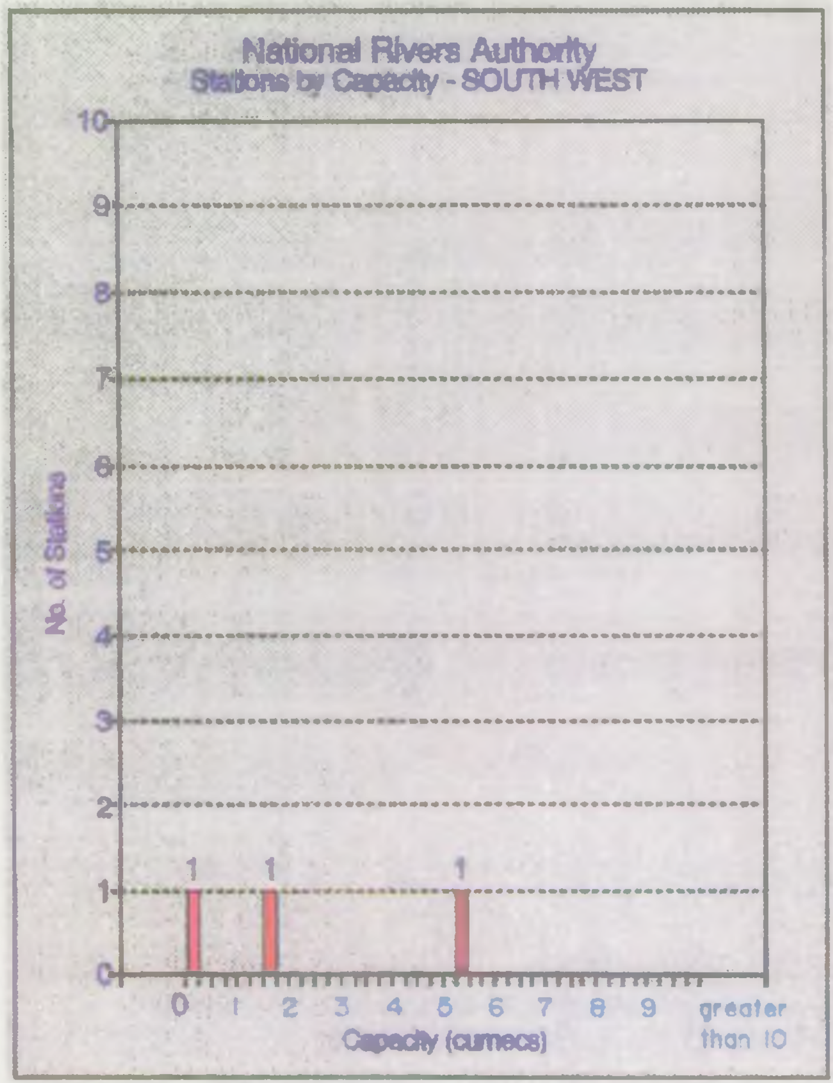

National Rivers Authority
Stations by Capacity - SEVERN TRENT
No. of Stations
Capacity (cumecs)
0
1
2
3
4
5
6
7
8
9
10
greater than 10
4
3
1
3
1
1
3
1
2
1
1
1
2



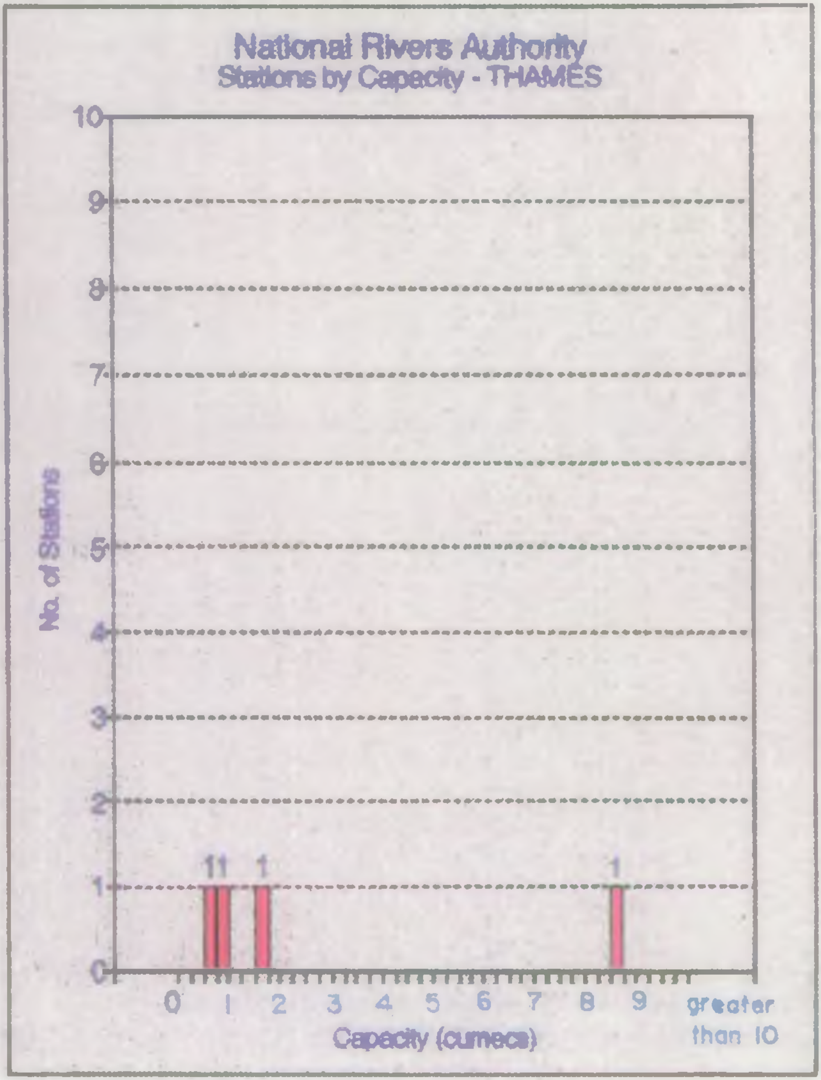
National Rivers Authority
Stations by Capacity - NORTHWEST
No. of Stations
Capacity (cumecs)
greater than 10

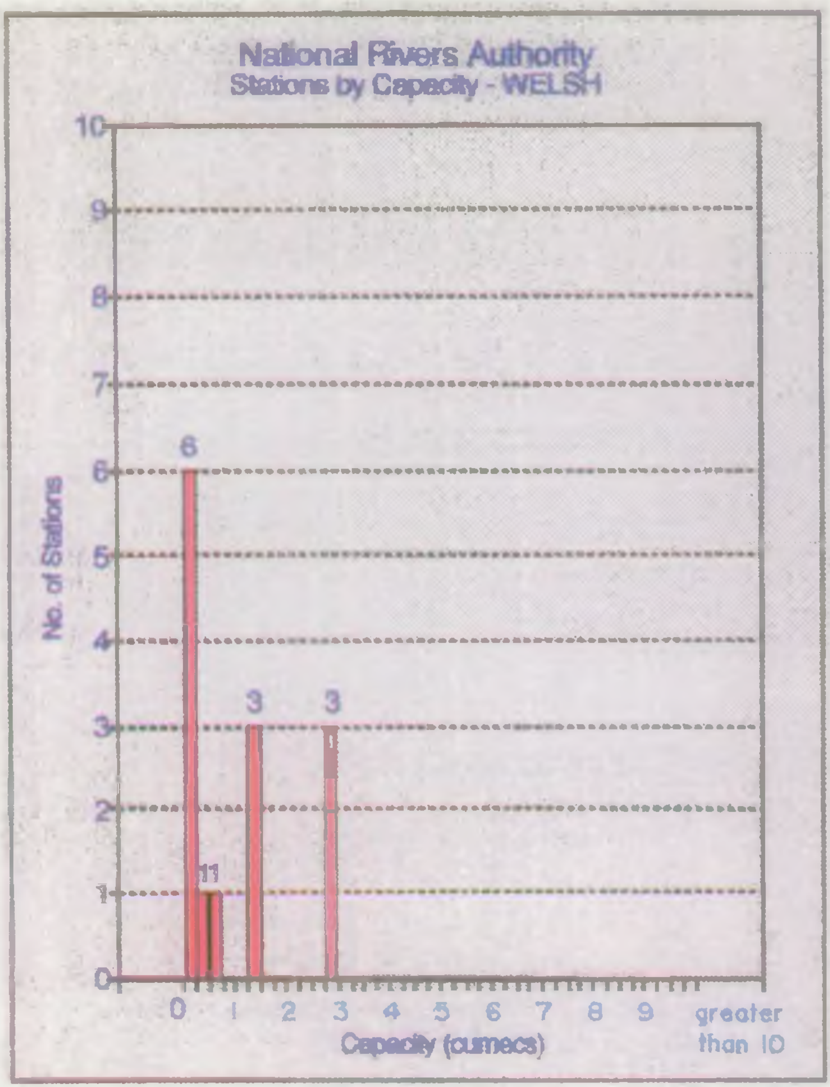

National Rivers Authority
Stations by Capacity - YORKSHIRE
No. of Stations
Capacity (cumecs)
0
1
2
3
4
5
6
7
8
9
10
greater than 10

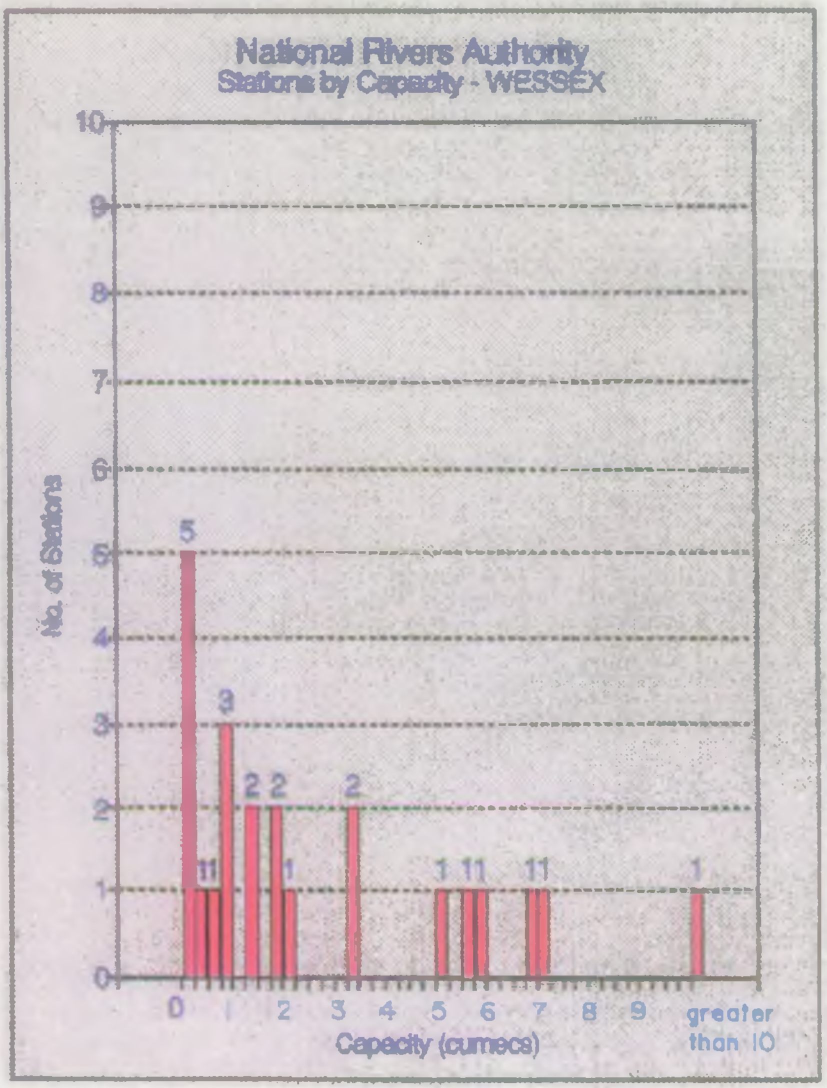

National Rivers Authority
Stations by Capacity - NORTHUMBRIAN
No. of Stations
0
1
2
3
4
5
6
7
8
9
10
11
1
1
0
1
2
3
4
5
6
7
8
9
greater than 10
Capacity (cumecs)



National Rivers Authority
Stations by Capacity - SOUTH WEST
No. of Stations
0
1
2
3
4
5
6
7
8
9
10
1
1
1
0
1
2
3
4
5
6
7
8
9
greater than 10
Capacity (cumecs)


National Rivers Authority
Stations by Capacity - THAMES
No. of Stations
0
1
2
3
4
5
6
7
8
9
10
1
1
1
1
0
1
2
3
4
5
6
7
8
9
greater than 10
Capacity (cumecs)


National Rivers Authority
Stations by Capacity - WELSH
No. of Stations
Capacity (cumecs)
greater than 10
0 1 2 3 4 5 6 7 8 9 10
6
1 1
3
3

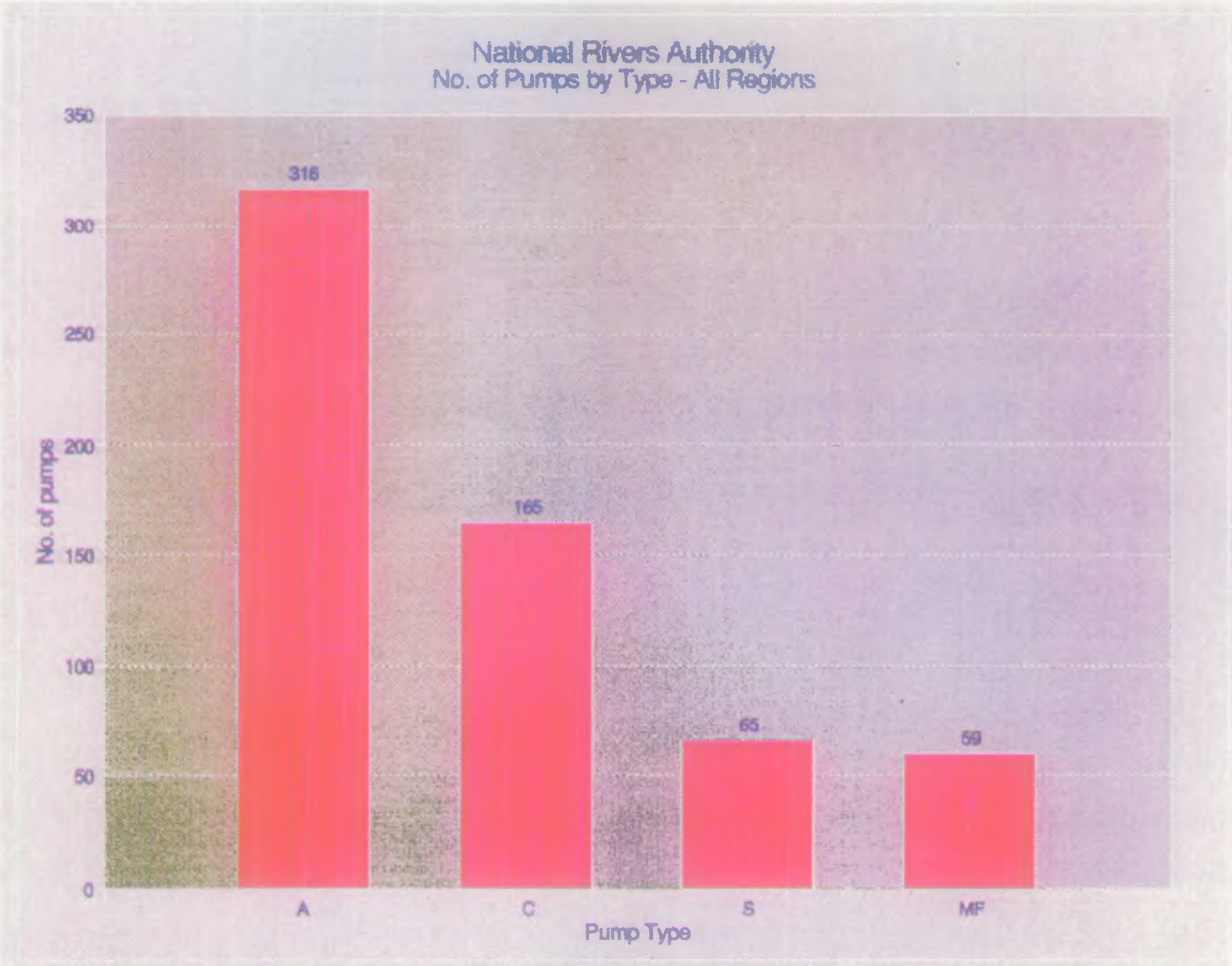

National Rivers Authority
Stations by Capacity - WESSEX
No. of Stations
Capacity (cumecs)
0
1
2
3
4
5
6
7
8
9
10
greater than 10
5
3
2
2
2
1
1
1
1
1
1
1
1
1
1

Appendix B3

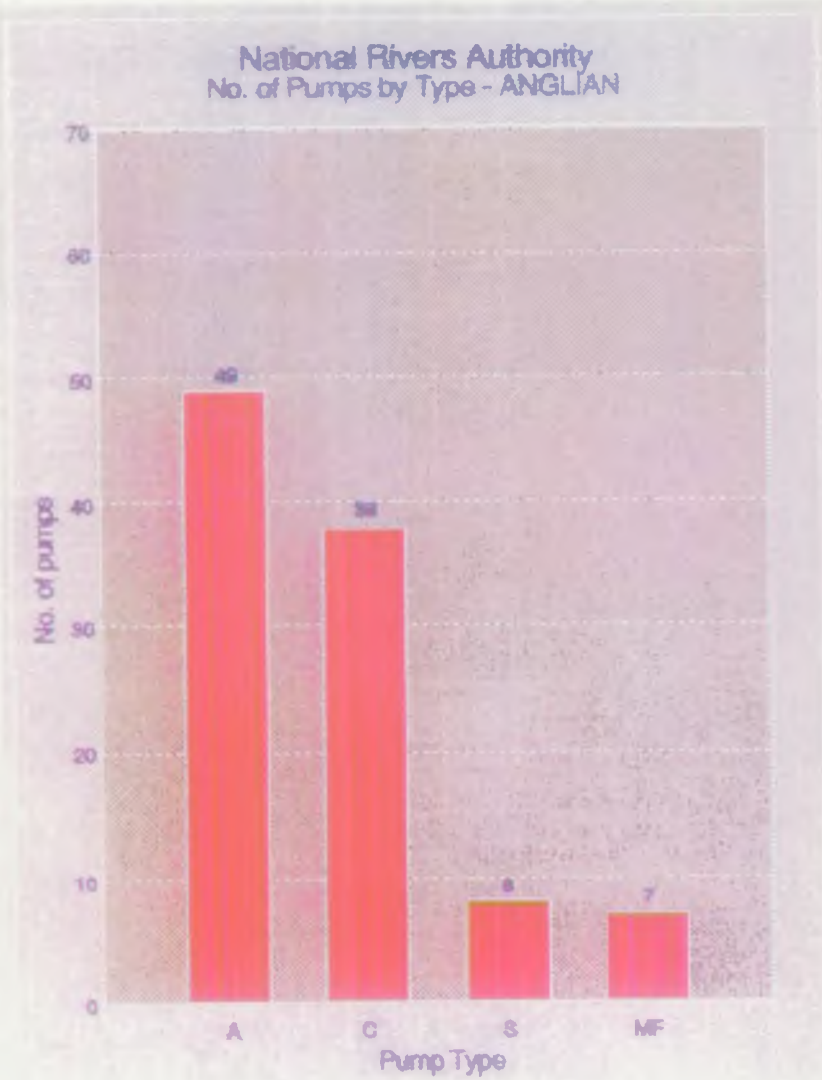
Pump Analysis

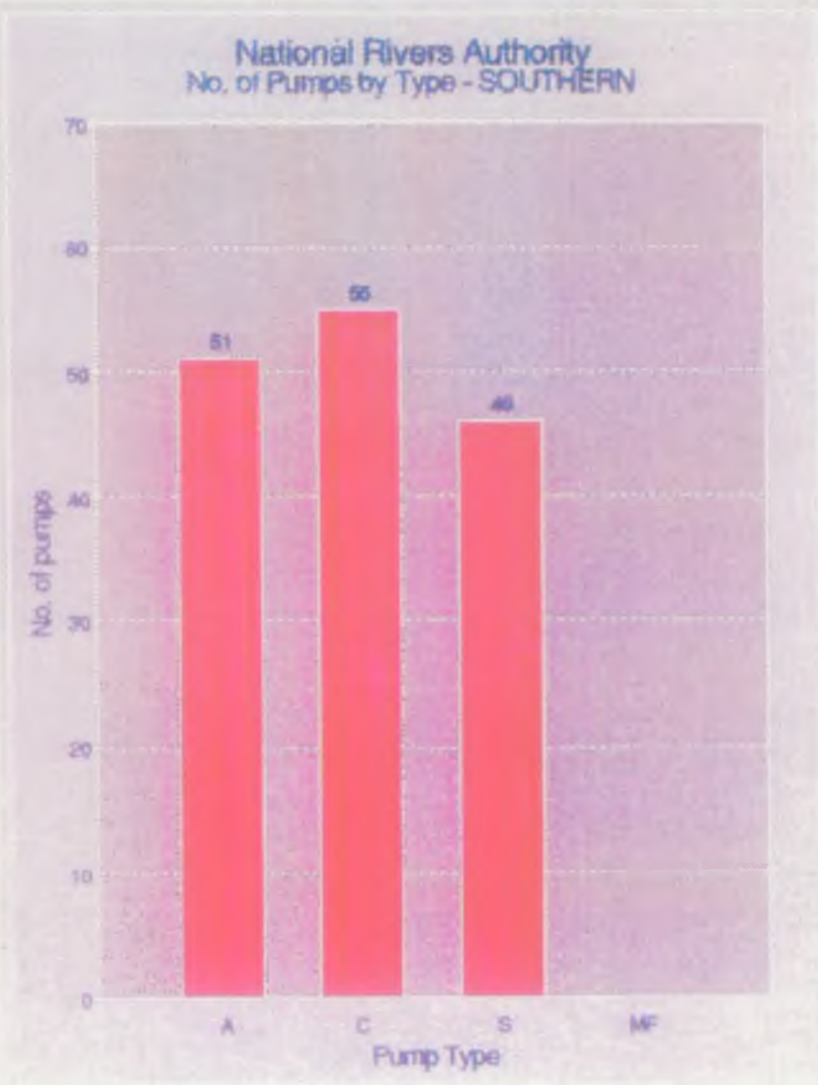
Listed by Pump Type

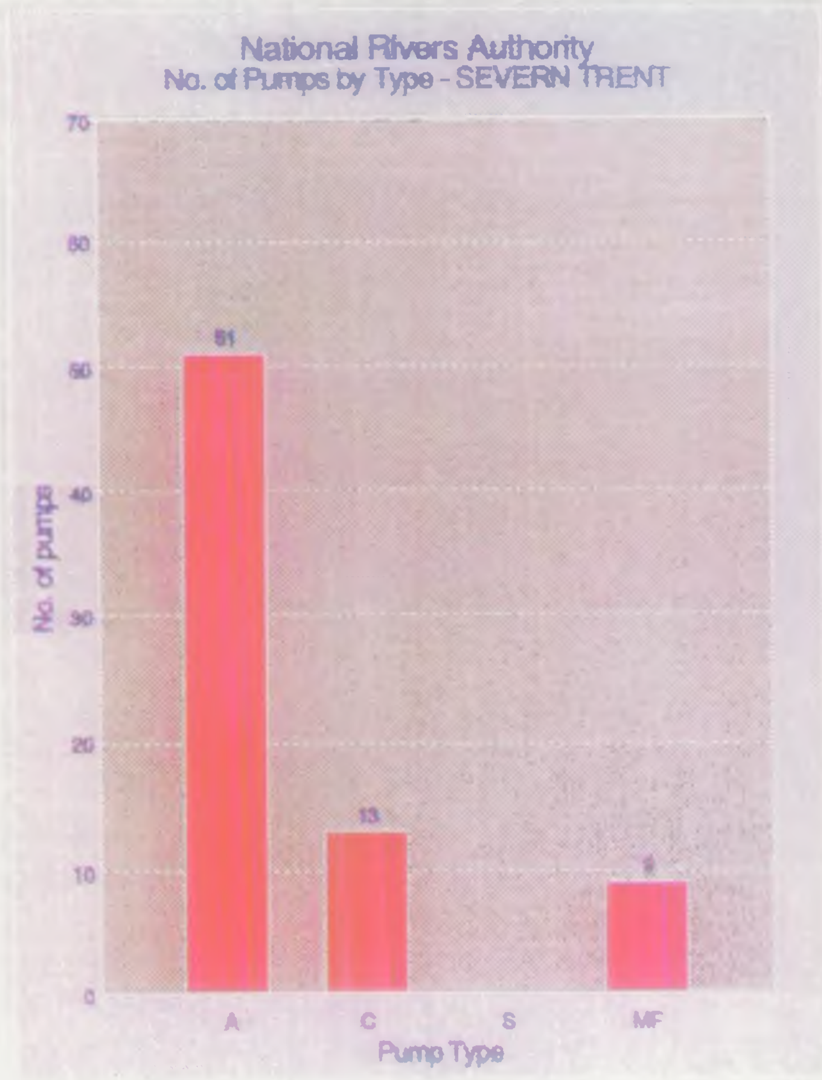
Contents



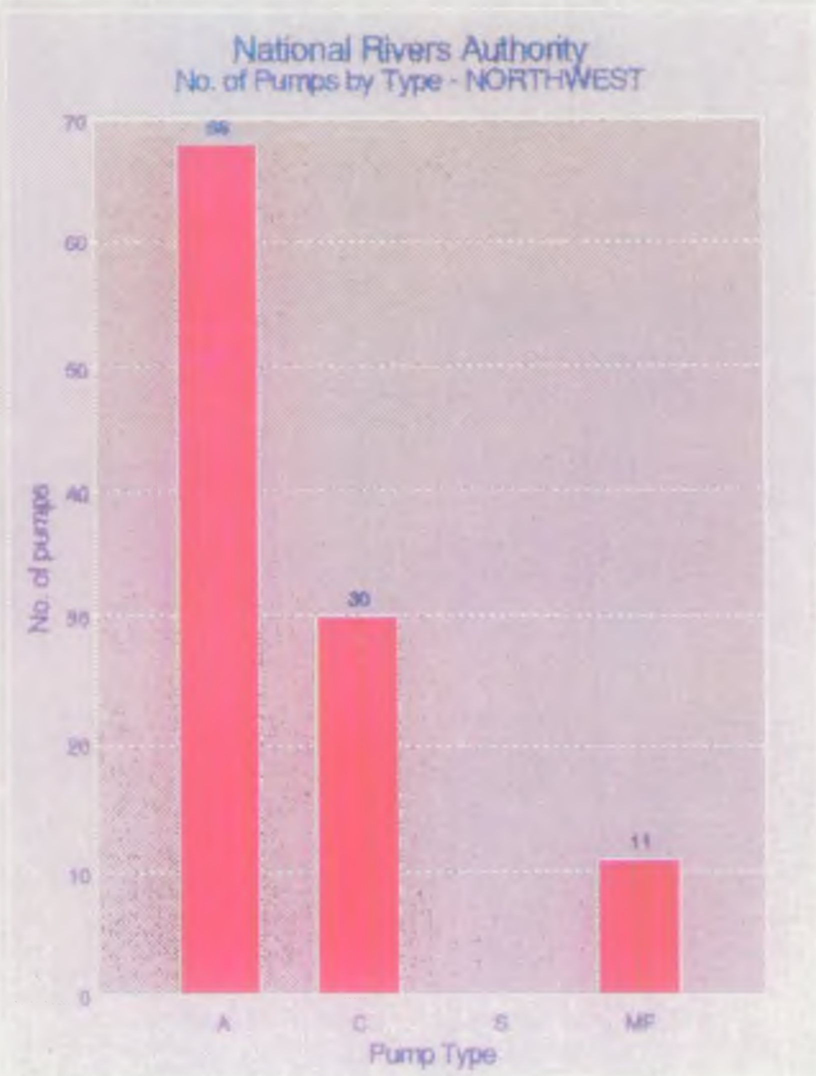
National Rivers Authority
No. of Pumps by Type - All Regions
350
300
250
200
150
100
50
0
No. of pumps
316
165
65
59
A
C
S
MF
Pump Type

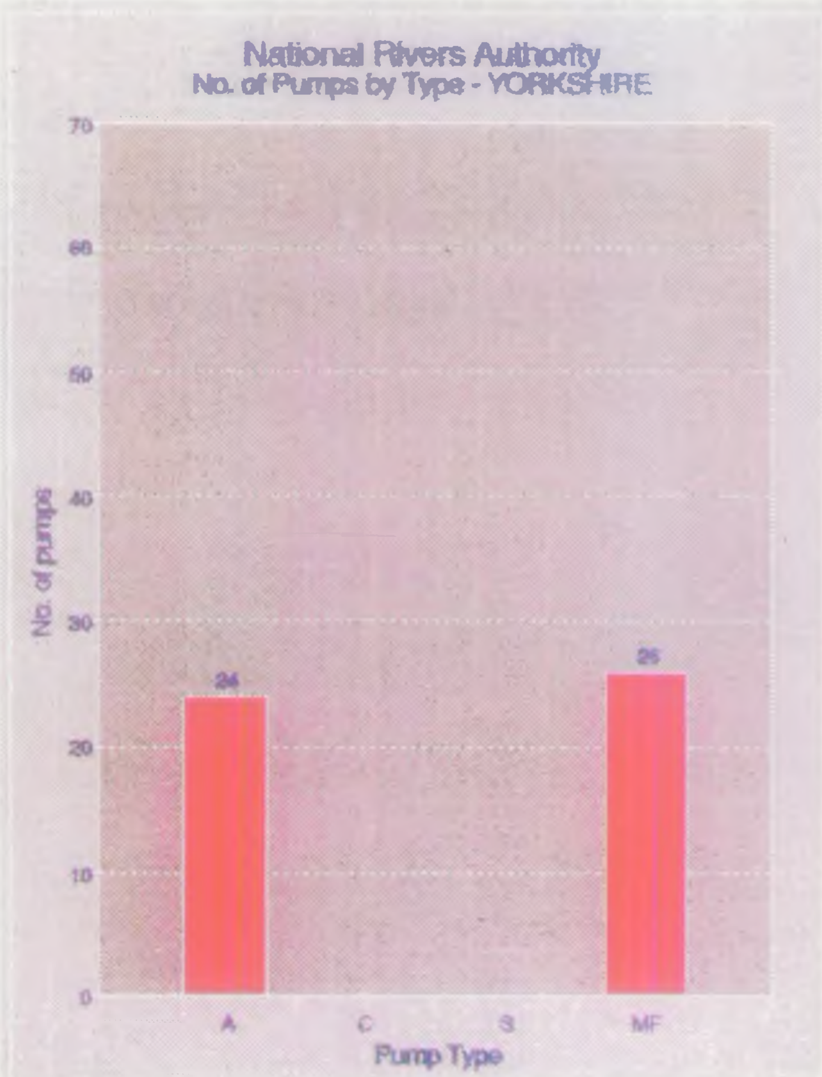

National Rivers Authority
No. of Pumps by Type - ANGLIAN
No. of pumps
70
60
50
40
30
20
10
0
49
38
8
7
A
C
S
MF
Pump Type

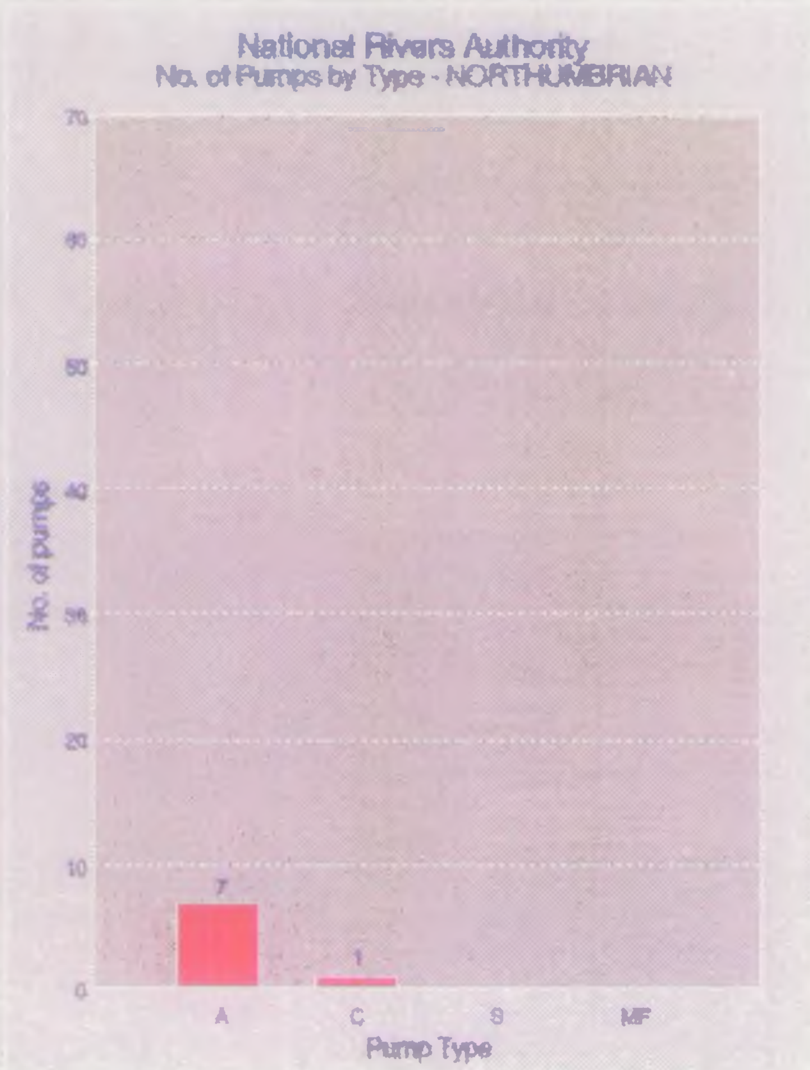

National Rivers Authority
No. of Pumps by Type - SOUTHERN
70
60
50
40
30
20
10
0
No. of pumps
51
55
46
A
C
S
MF
Pump Type

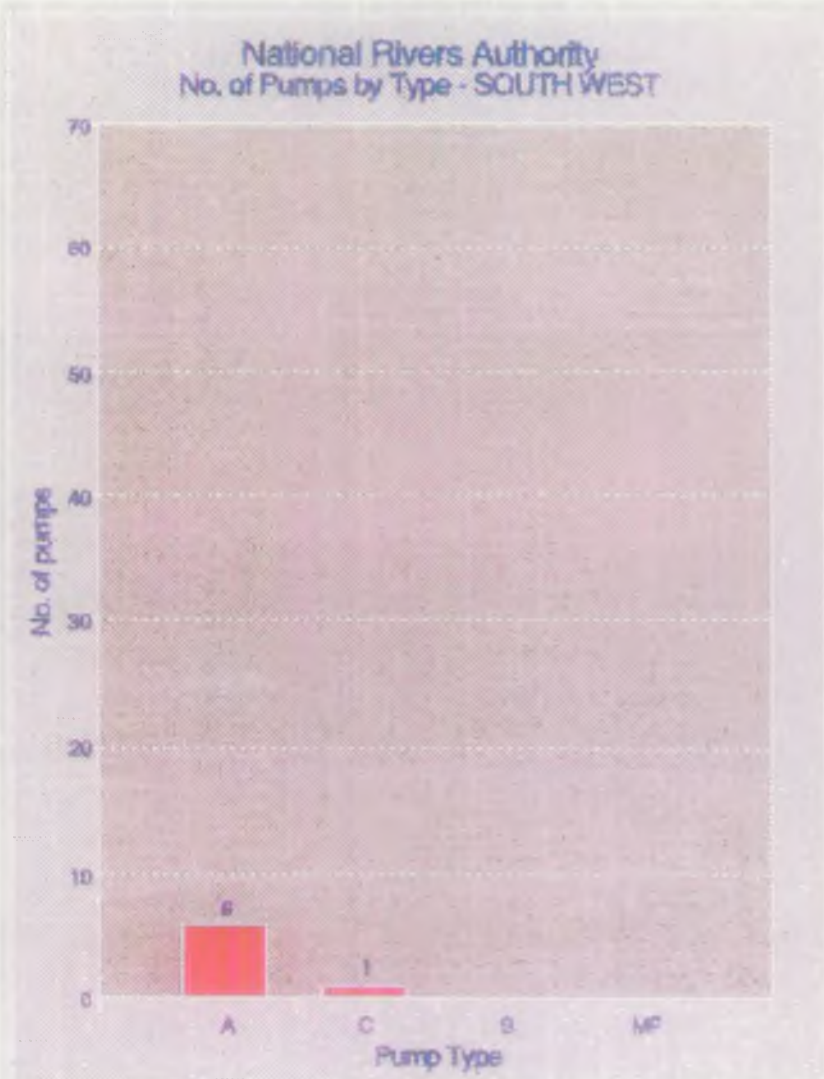


National Rivers Authority
No. of Pumps by Type - SEVERN TRENT
No. of pumps
0
10
20
30
40
50
60
70
51
13
9
A
C
S
MF
Pump Type

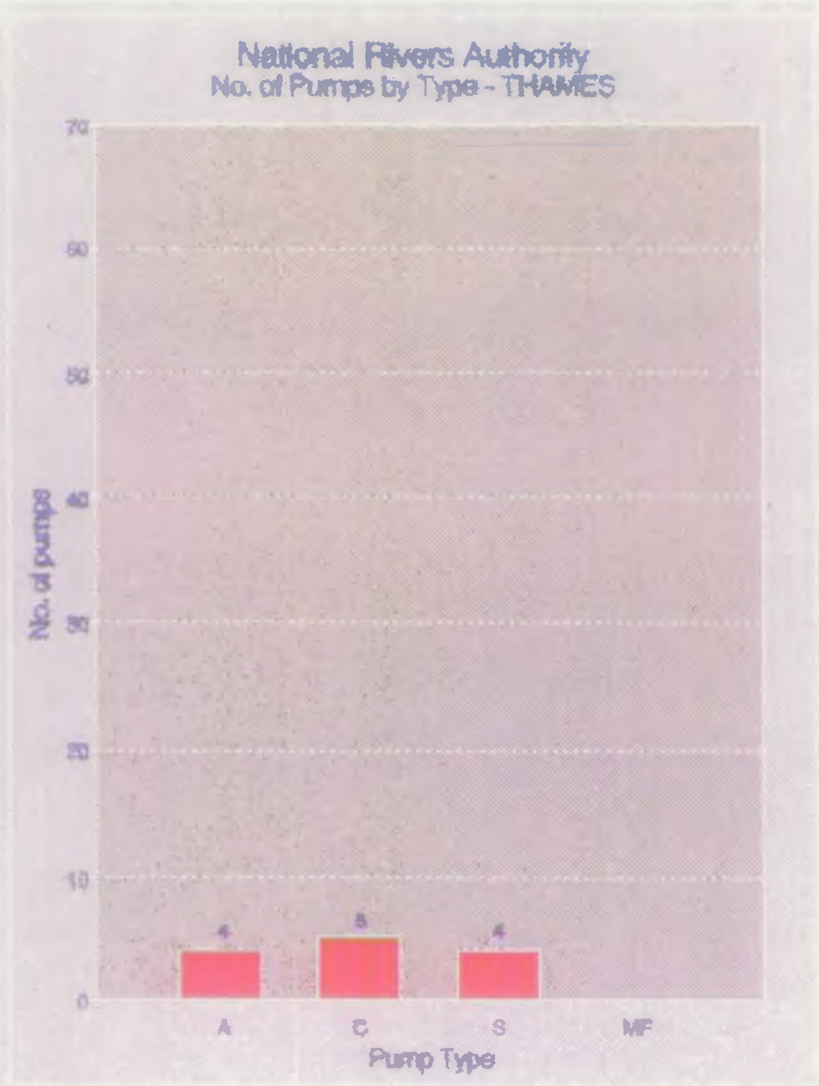

National Rivers Authority
No. of Pumps by Type - NORTHWEST
No. of pumps
70
60
50
40
30
20
10
0
30
11
A
C
S
MF
Pump Type

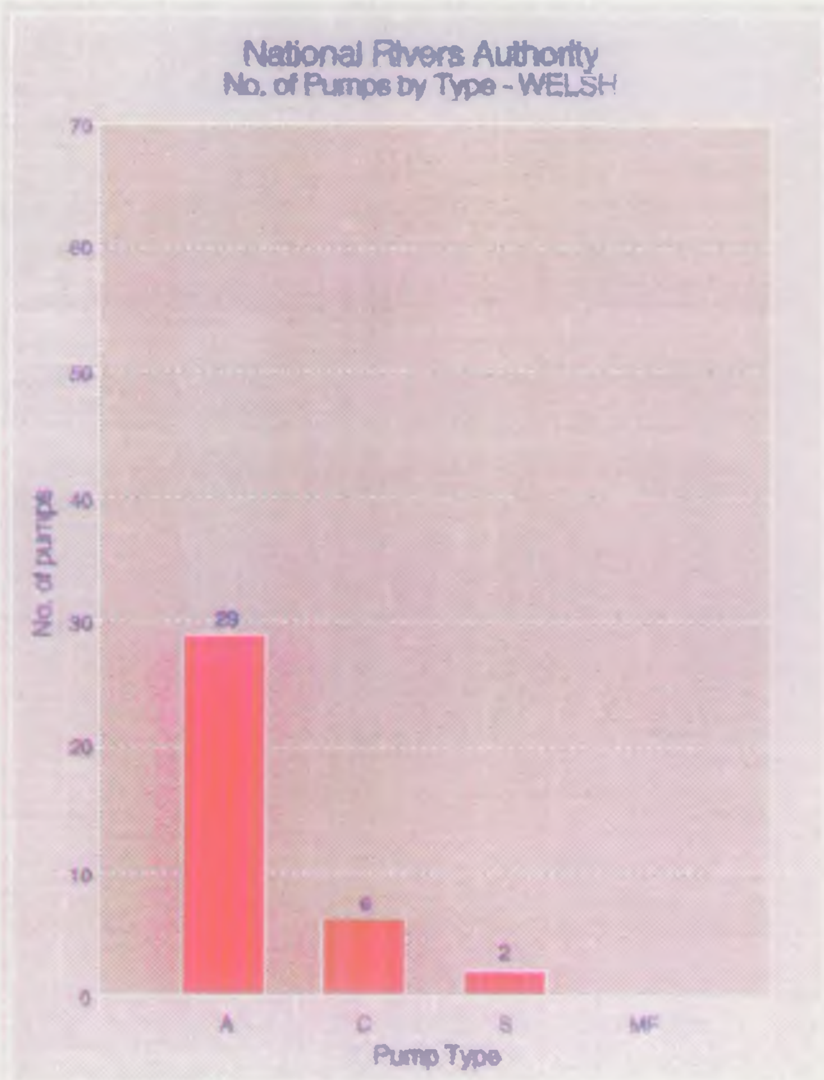

National Rivers Authority
No. of Pumps by Type - YORKSHIRE
70
60
50
40
30
20
10
0
No. of pumps
24
26
A
C
S
MF
Pump Type


National Rivers Authority
No. of Pumps by Type - NORTHUMBRIAN
70
60
50
40
30
20
10
0
No. of pumps
7
1
A
C
S
MF
Pump Type

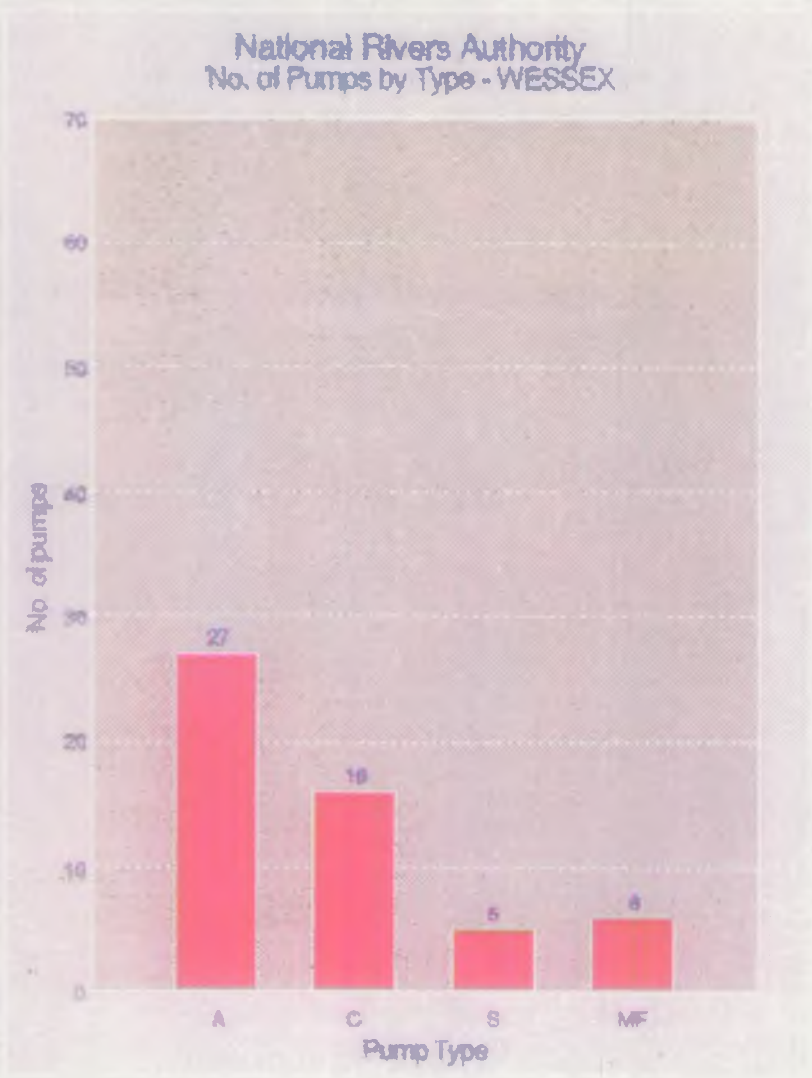


National Rivers Authority
No. of Pumps by Type - SOUTH WEST
No. of pumps
70
60
50
40
30
20
10
0
6
1
A
C
S
MF
Pump Type


National Rivers Authority
No. of Pumps by Type - THAMES
No. of pumps
70
60
50
40
30
20
10
0
4
5
4
A
C
S
MF
Pump Type



National Rivers Authority
No. of Pumps by Type - WELSH
No. of pumps
70
60
50
40
30
20
10
0
29
6
2
A
C
S
MF
Pump Type

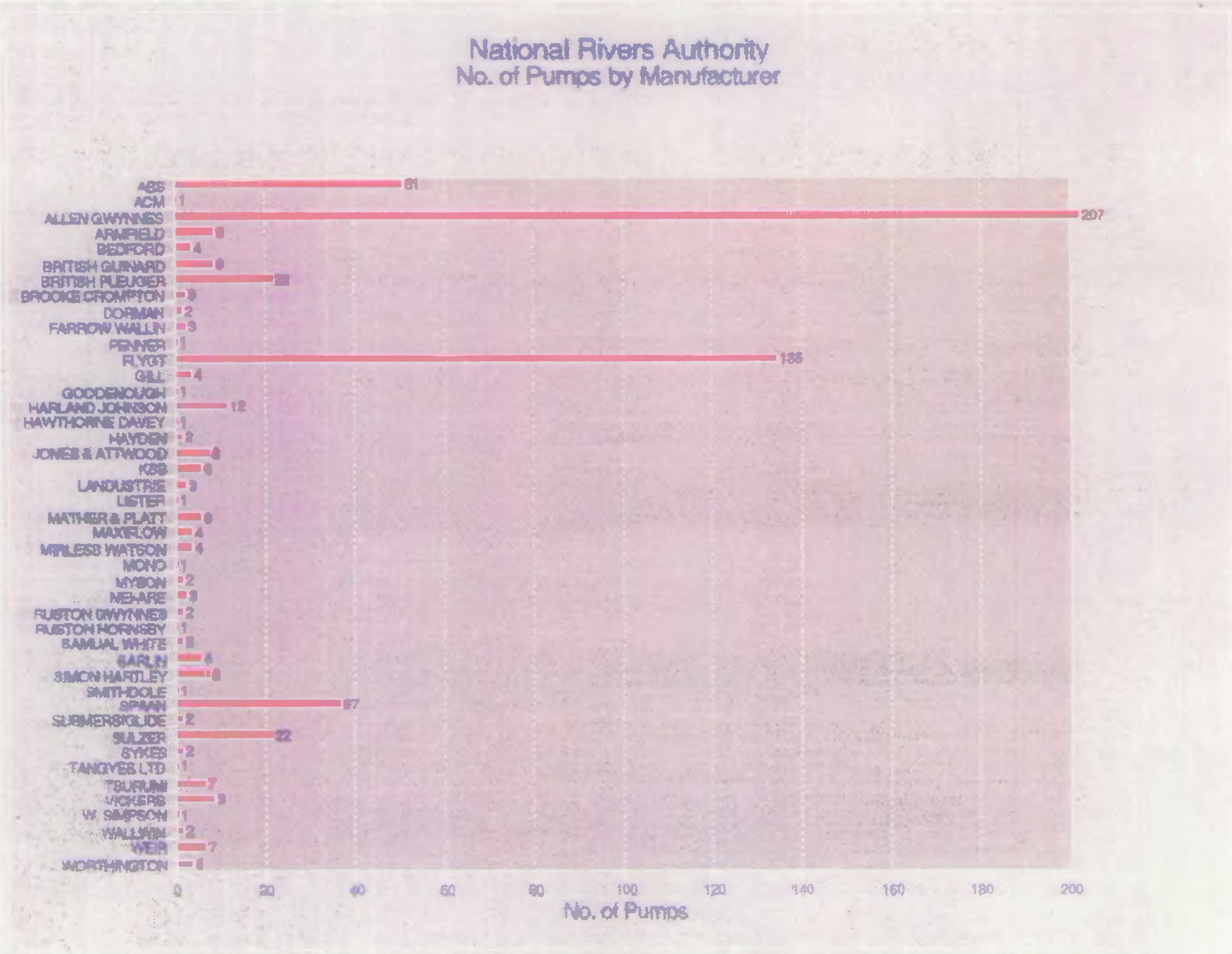

National Rivers Authority
No. of Pumps by Type - WESSEX
No. of pumps
70
60
50
40
30
20
10
0
27
16
5
6
A
C
S
MF
Pump Type

Appendix B4

Pump Analysis

Listed by Manufacturer

Contents



National Rivers Authority
No. of Pumps by Manufacturer
ABS 51
ACM 1
ALLEN GWYNNES 207
ARMFIELD 8
BEDFORD 4
BRITISH GUINARD 8
BRITISH PLEUGER 22
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DORMAN 2
FARROW WALLIN 3
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FLYGT 135
GILL 4
GOODENOUGH 1
HARLAND JOHNSON 12
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KSB 6
LANDUSTRIE 3
LISTER 1
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VICKERS 9
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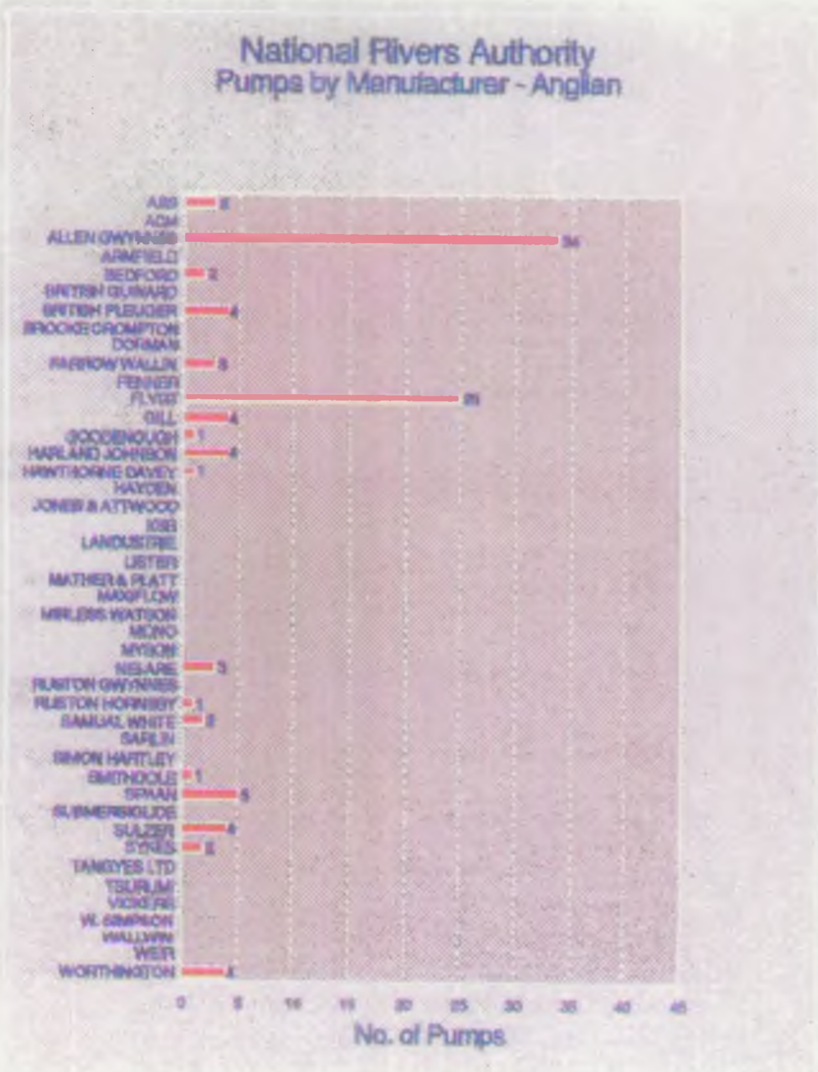
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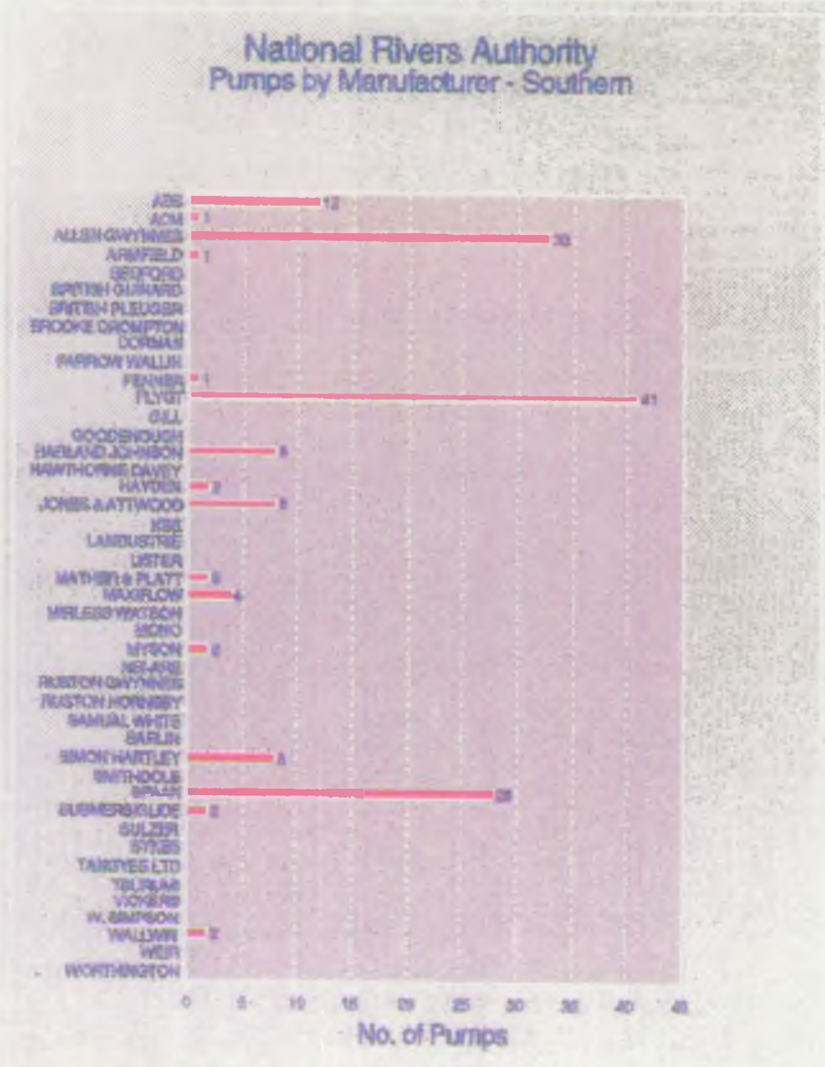
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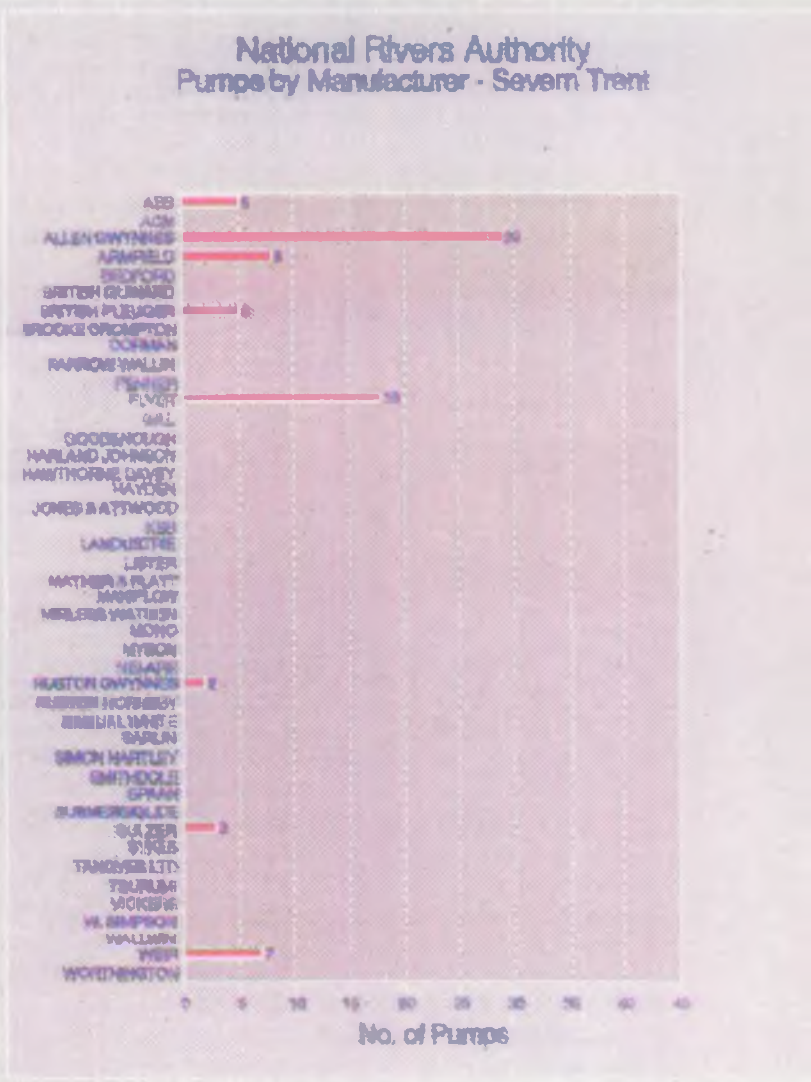
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LANDUSTRIE
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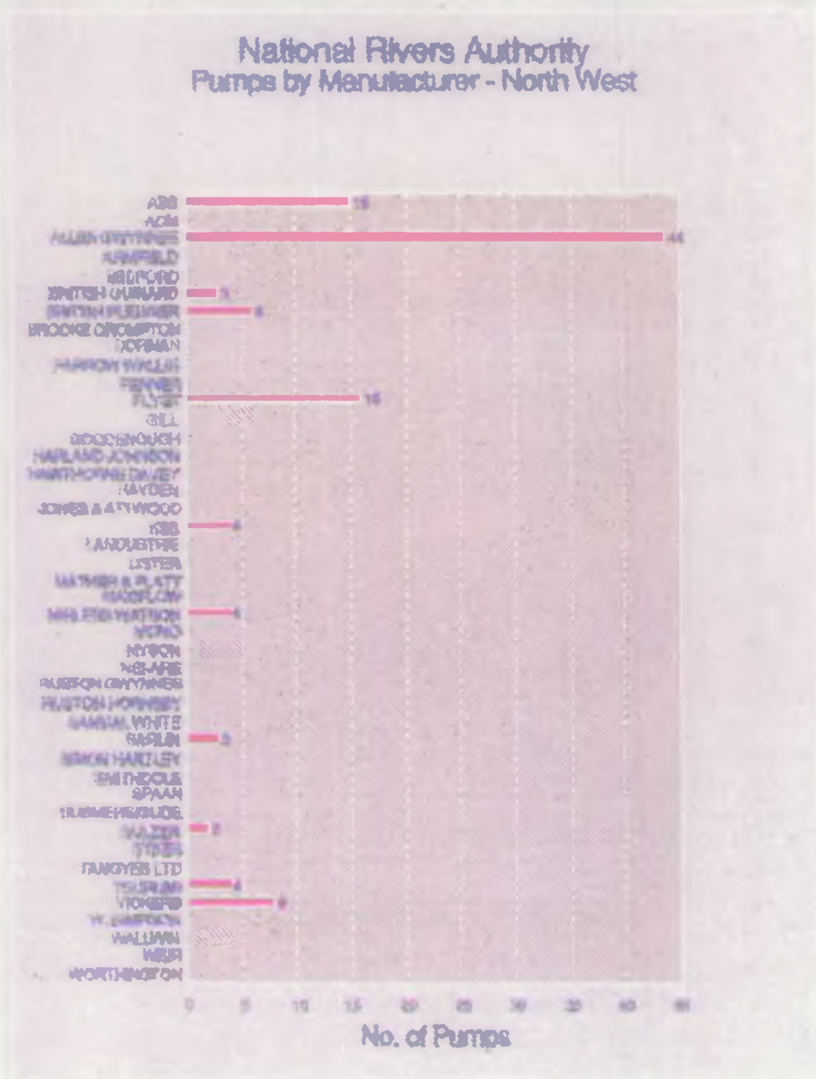
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SARLIN
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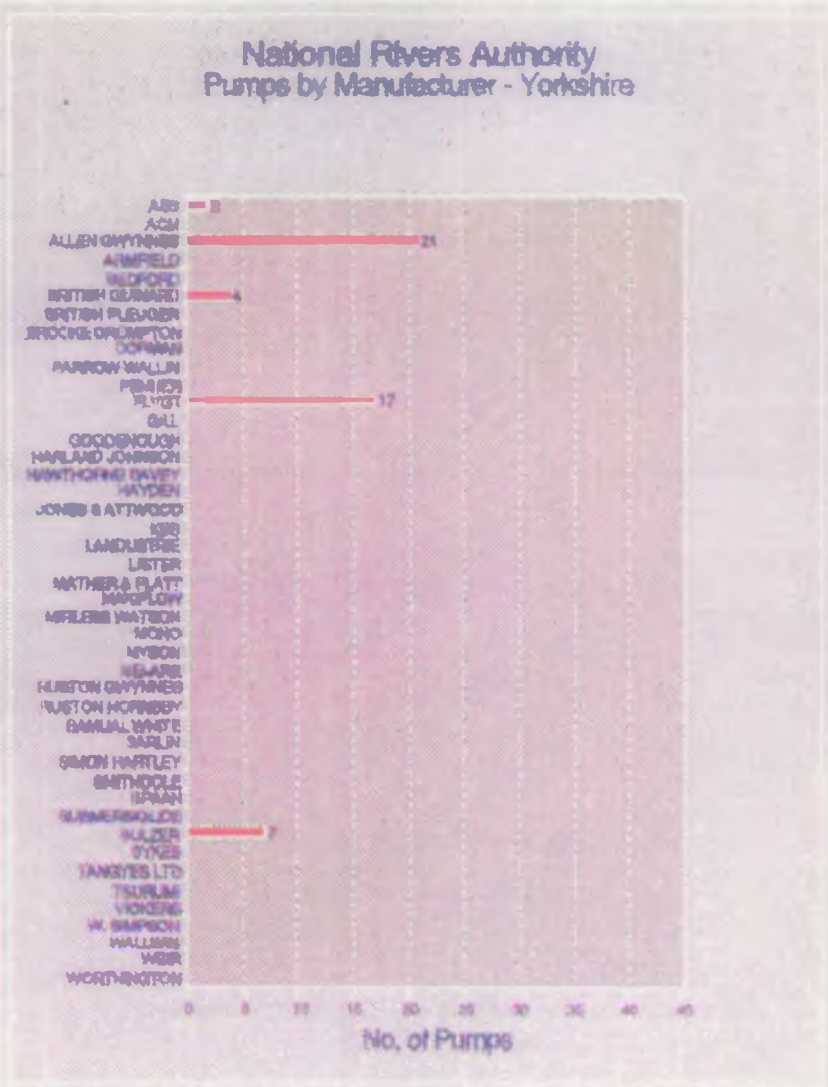
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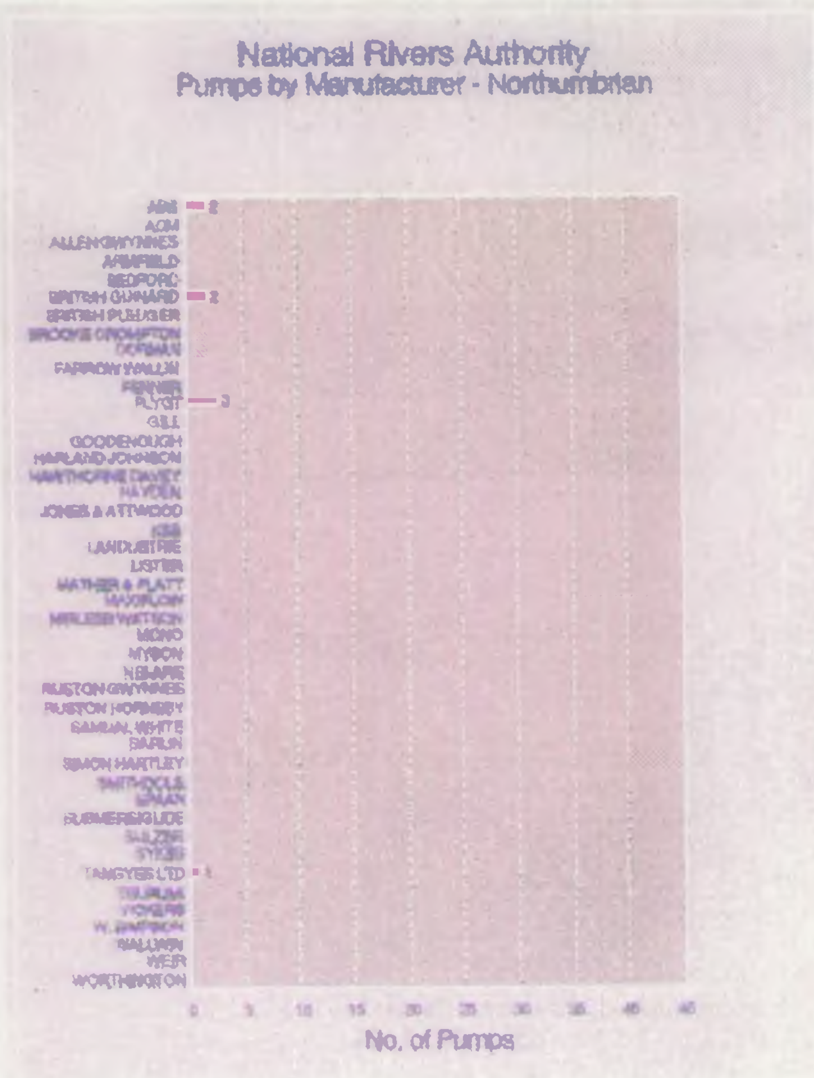

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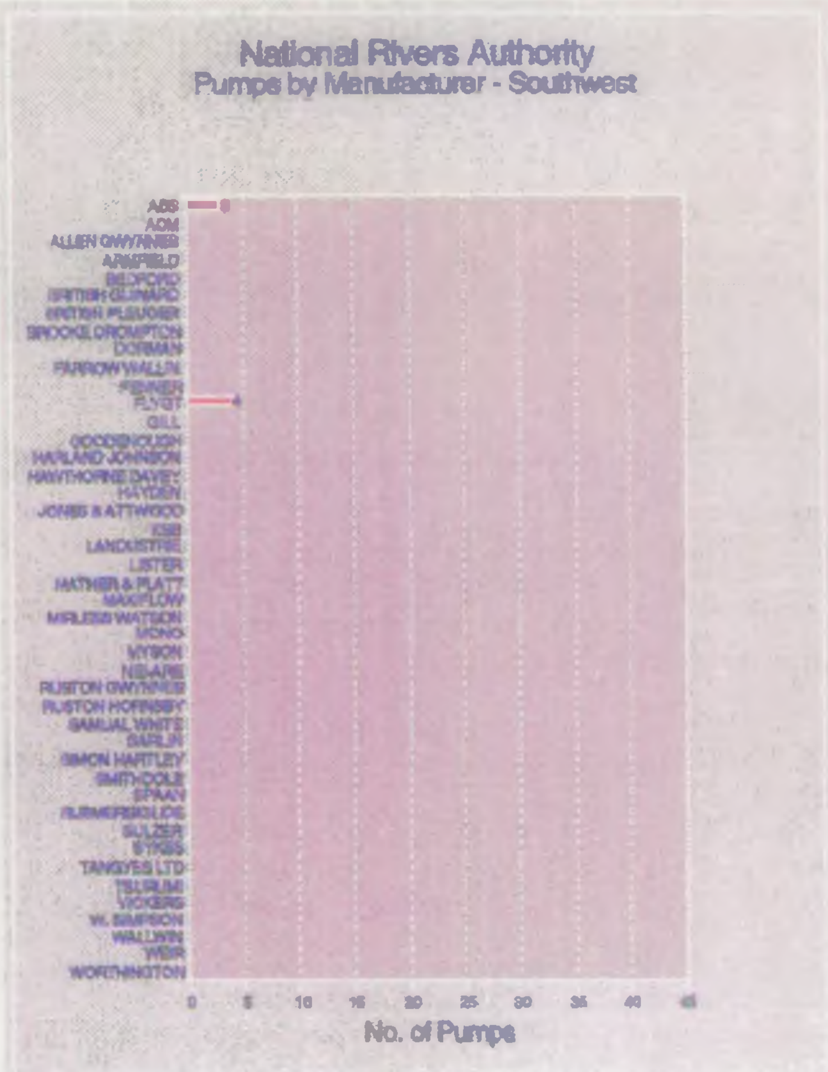

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No. of Pumps

National Rivers Authority
Pumps by Manufacturer - Thames
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ARMFIELD
BEDFORD
BRITISH PLEUGER
BROOKE CROMPTON
3
DORMAN
FENNER
FLYGT
4
GILL
GOODENOUGH
HARLAND JOHNSON
HAWTHORNE DAVEY
HAYDEN
JONES & ATTWOOD
KSB
LANDUSTRIE
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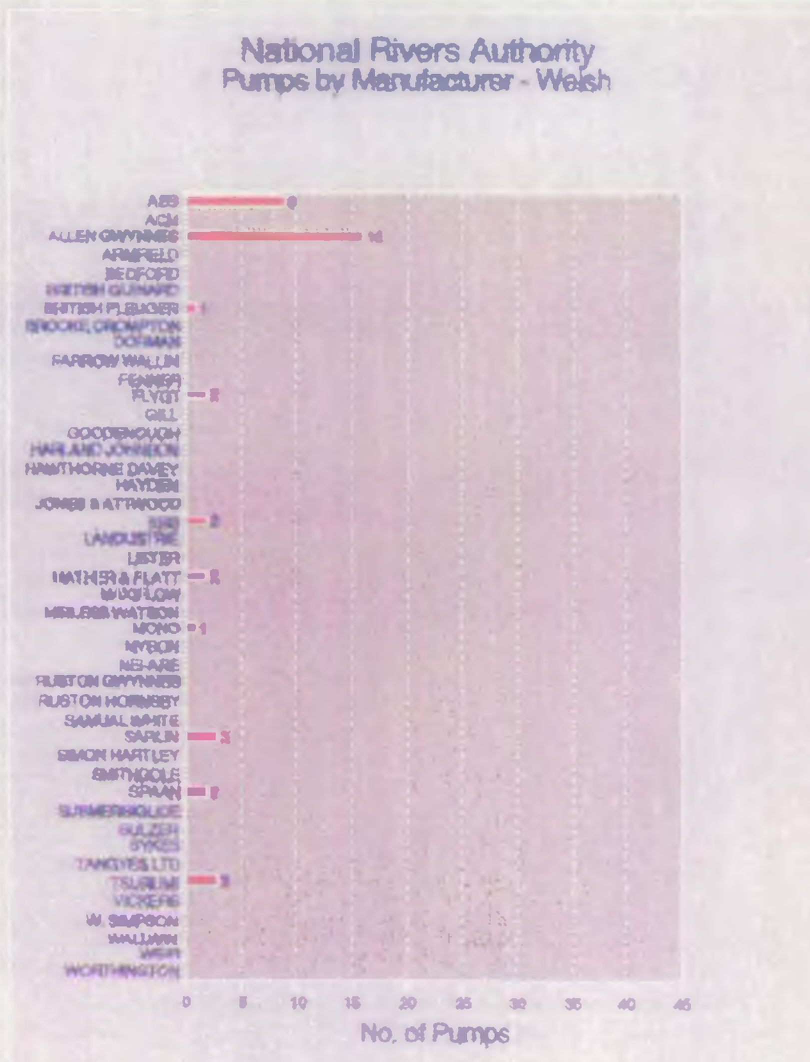
No. of Pumps



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RUSTON HORNSBY
SAMUAL WHITE
SARLIN
SIMON HARTLEY
SULZER
SYKES
TANGYES LTD
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W. SIMPSON
WEIR
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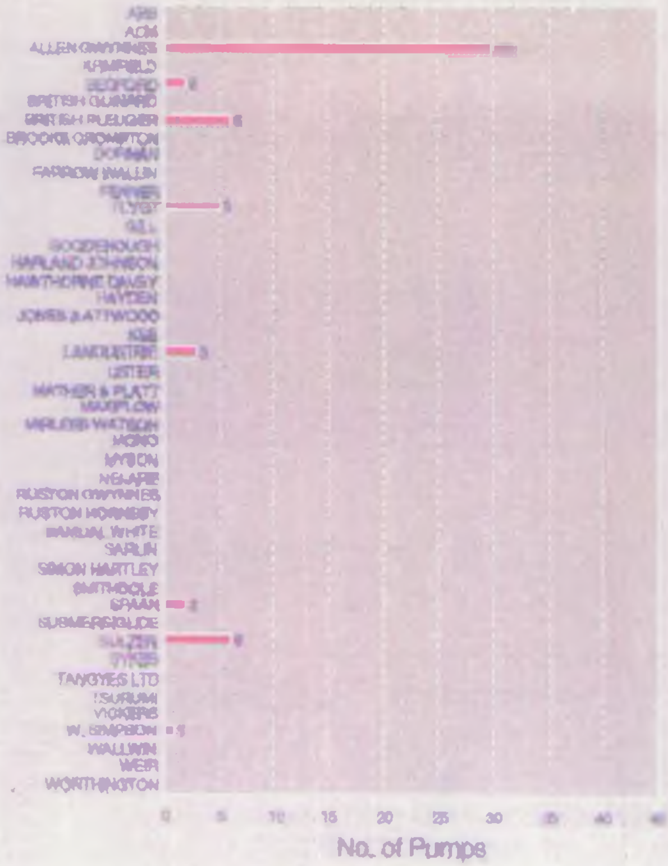
No. of Pumps

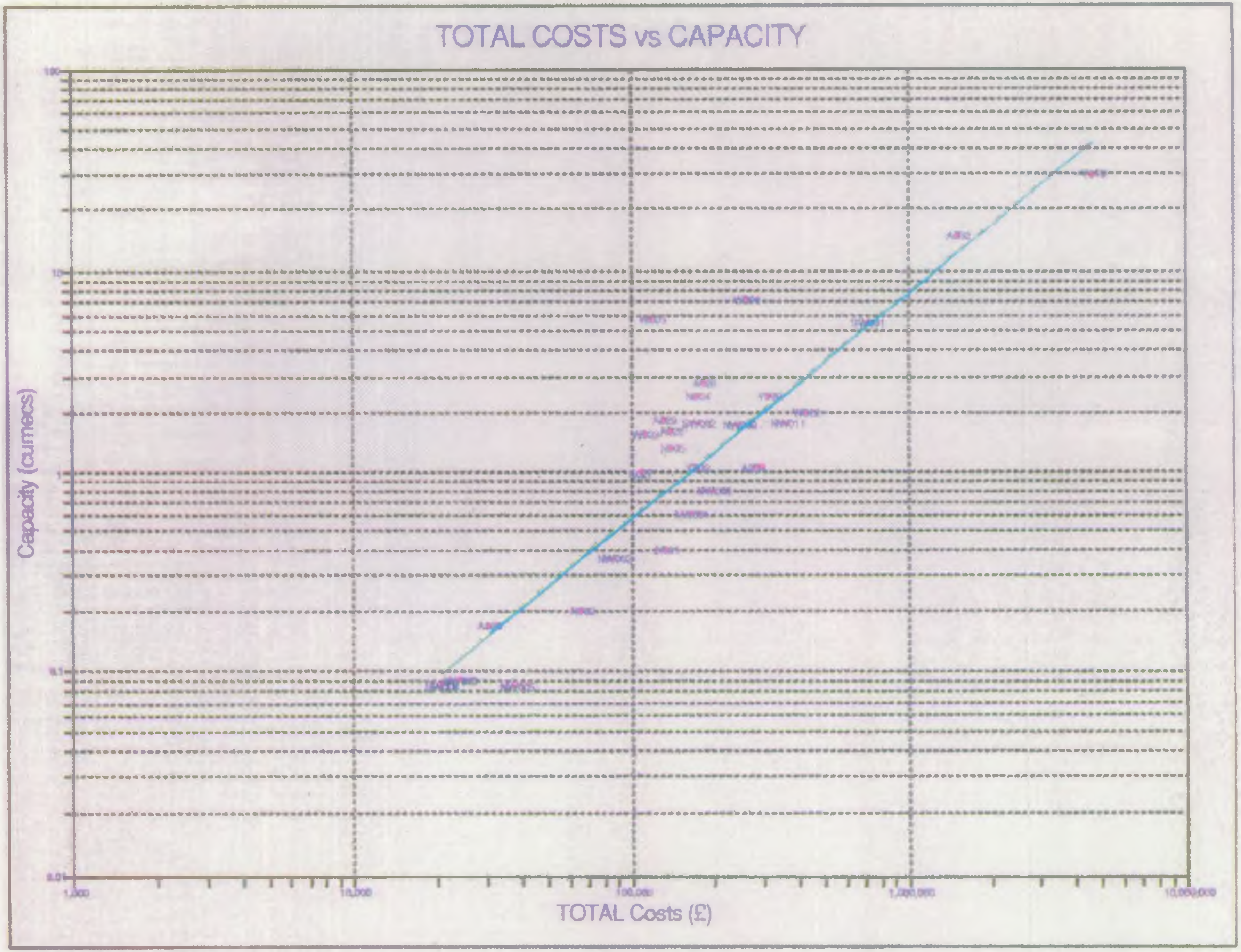
National Rivers Authority
Pumps by Manufacturer - Wessex



Appendix B5

Cost of Stations by Capacity

Contents


TOTAL COSTS vs CAPACITY
Capacity (cumecs)
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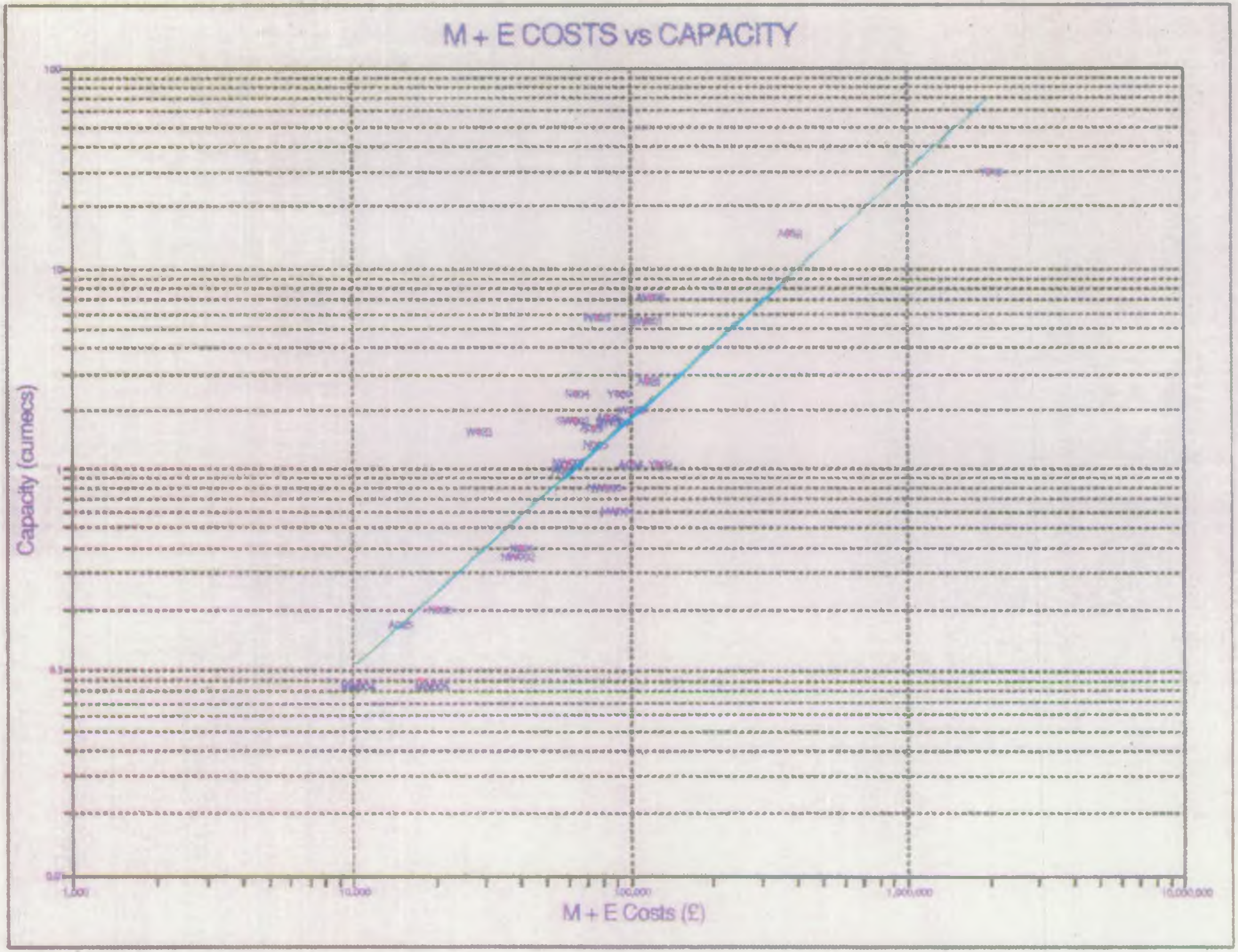
0.1
0.01
1,000
10,000
100,000
1,000,000
10,000,000
TOTAL Costs (£)


M + E COSTS vs CAPACITY
Capacity (cumecs)
M + E Costs (£)
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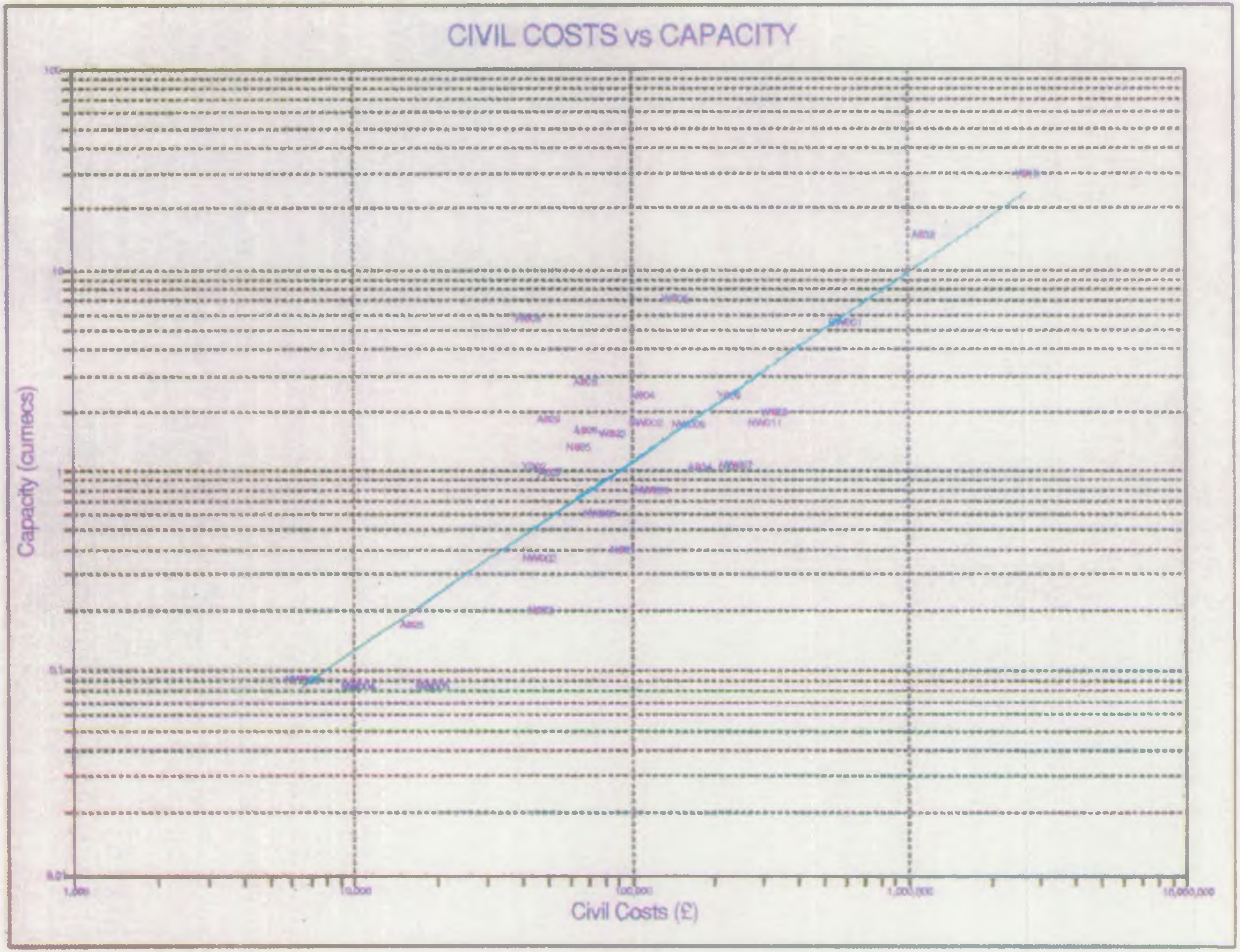
10
1
0.1
0.01
1,000
10,000
100,000
1,000,000
10,000,000



CIVIL COSTS vs CAPACITY
Capacity (cumecs)
100
10
1
0.1
0.01
1,000
10,000
100,000
1,000,000
10,000,000
Civil Costs (£)

Appendix C

Design Philosophy

Contents

NRA PUMPING STATION RESEARCH PROJECT

DESIGN CONSIDERATIONS

REQUIRED CAPACITY

Catchment Characteristics :
- Size.
- Topography.
- Impermeability.
- Rainfall.

Design standard :
- Channel storage.
- Channel conveyance.
- Power supply constraints.
- Gravity by-pass.

PUMPING HEAD

Low : - Axial flow.
Screw pump.

High : - Mixed flow - bowl type centrifugal.

Range of heads - maximum, minimum, duty head.

Duty head - maximum efficiency at this head if pump design allows.

PUMP TYPE

Head and size

- Axial - low heads (less than 6 metres).
- Mixed flow - higher heads - small size pumps.
- Centrifugal - higher heads.
- Concrete volute - large capacity.
- Screw - low heads, fixed discharge level.

Clearances

- Axial pumps not suitable in small sizes below 360mm dia., small space between rotor blades can lead to "balling" of weed and choking of pump. Where weed is present use a mixed flow bowl unit in these circumstances.

- Impellers must pass suspended solids - preferably up to 75mm dia., without blockage, damage, or undue wear.

Mounting Position

- Can be horizontal, vertical or inclined. A number of problems experienced with horizontal submersible units of different manufacture - one pump firm has ceased production. Vertical position preferable.

Axial Pumps Impeller Tip Speeds

- Problems of vibration and overloading can be experienced with axial flow pumps having high impeller tip speeds. Conservative values are recommended. One experienced manufacturer gives an upper limit of 20.0m/sec. The same manufacturer also recommends a maximum axial velocity through the rotor of 5.0m/sec. Liable to 'choke' on weed in small sizes - use mixed flow bowl or volute type if less than 36cm required.

Pump characteristic curves

- Curves of typical performance of the various types of pump can be found in pump manufacturers literature and technical publications.

Cavitation

- Can be a problem - need for adequate submergence of the impeller - related to suction lift, vapour pressure and pump speed. Causes vibration, increased power demand and can cause pitting and erosion of the impeller.

Testing

- All units should normally be tank tested and the tests witnessed, prior to delivery. Very large pumps cannot be tank tested -preliminary estimates of performance are normally made with a model and prototype performance measured by gauging on site, after erection.

DISCHARGE ARRANGEMENTS

Alternatives

- Siphonic.
- Sluice and reflux valve.
- Sluice and flap.
- Flap.
- Free discharge.

- The various alternatives can have a marked effect on the pumping station structure and cost. Sluice valves and reflux valves are costly in the larger sizes and siphonic discharge pipes with siphon breaker valves are now usually adopted.

Problems

- Siphon breakers can jamb, though this is not a common occurrence, and can allow water to flow into the catchment and might cause damage to the pump by contra rotation. They can also freeze and provision now usually made for heating in cold weather.

- Where a siphonic discharge is used it is important that the velocity of discharge at on start at maximum head is greater than 2m/sec or the siphon may not prime -motor must be of adequate power to ensure this. Required pump priming head can be reduced by inclusion of priming aid in the siphon downstream leg. Charlton,J.A. 1972. Journal I.W.E., Vol.26, No.1.

- Hammer can take place where flaps are used as a discharge control. The possibility of this can be reduced by keeping velocities through it low (not greater than 2m/sec.).

MOTIVE POWER

Electric

- Most modern small to medium sized stations have electrically driven pumps which lend themself to automatic.operation and supervision by less skilled staff than diesel powered units. Provision should be made for connecting a portable generator should the mains supply be disrupted for any length of time or provision made for bringing in mobile pumps.

- Need for agreement with supply company on tariff.

- Power factor correction.
- Limits on starting current can dictate type of starter or motor used.
- Need for regular motor and starter maintenance.

Diesel

- Used almost exclusively for the largest flood defence pumps, driving the pump through a right angle gearbox. The engine might be turbo blown and will require a skilled operator and maintenance personnel. Fuel storage tanks required and suitable road access for fuel tankers.
- Following the Miners Strike and strike of power workers, many of the subsequent medium sized stations have been designed with half their pumps diesel powered and half electric powered to guarantee some pumping capacity under similar conditions.

WATER QUALITY

General

- Flood defence pumps must be capable of dealing with river water that will normally contain quantities of weed, mud, sand and various floating debris.
The pump manufacturer must be made aware of this. The pump should be capable of dealing with these conditions for long periods without undue wear or blockage. Chemical composition should be checked for possible adverse effects on pump materials.

Weed

- As indicated above (Pump Type) clearances on small axial flow pumps are such that weed can cause problems and mixed flow, bowl pumps are preferable for small pumps where weed is present.

Bearings

- The presence of sand, grit and coal dust can cause lower bearing problems and special precautions are required - proper sealing, pumped lubrication, cutlass rubber bearings etc. Where pumped grease lubrication is used for lower bearings these should be sealed and a return provided to prevent pollution of watercourse.

STATION STRUCTURE

Type

- High house and crane.
- Low building - removable roof section.
- Low building.
- Outdoor type - weather proof motors.
- Submersible pump - sump & switchgear cubicle or house.
- Housing for screw pump.
- Floating station.

Ground Conditions

- These can influence design.
- Check for flotation when sump dewatered.
- Pressure relief valves in floor?
- Earth loading on sump.
- Ground water - affect on concrete?
- Presence of gypsum - ditto
- Good foundation material?
- Need for bearing piles?
- Coffer dam - battered excavation.
- Need for dewatering?
- Steel sheet pile sump.
- Steel sheet pile with R.C. lining.

Sump design

- Guidance - Prosser - "Design of pump sumps and intakes" CIRIA/BHRA and other publications - see refs. Even with guidance model tests advisable in all but smallest stations. Checks should be made during construction to ensure sump conforms to design drawing.

Access

- Adequate access to station required for installation and removal of equipment for repair.Turning space for vehicles.

  Geotextile reinforcement for access roads on poor soils.

Screens

- Adequate area - width 4 times the diameter of pumps
- Bar spacing approx. 6cm. - spacing to be confirmed by pump manufacturer. Angle 60 to 70 degrees to facilitate raking.Any bracing to be set back from rear of screen on spacer bars to allow free raking.
- Galvanized finish advisable.
- Screen preferably "rolled over" at screen bridge to prevent debris falling back. Fabricate in sections for stiffness and reduced weight for installation and removal for repair or maintenance.
- Use of automatic screen cleaning gear "Bosker" on large stations and others where economically justified.

Security

- Need to make station vandal proof will vary with locality but must be considered.

ENVIRONMENTAL FACTORS

- Visual amenity
- Can be very important in National Parks and other areas.
- Consider use of submersible pump station. Where house required model it on local farm building. Screen by planting. Keep profile below adjoining embankment - local raising of floodbank for this purpose, if necessary.
- Consider possibility of several small, less obtrusive stations where this might be possible (might also reduce depth of excavation in poor ground, required for channel works).
- Over head electricity cables sometimes objectionable, possible underground feed at higher cost.
- Adverse visual effect of asphalt or concrete access roads and paving round stations can be reduced by use of "grasscrete" or other perforated concrete blocks.

Noise

- Can be problem with large diesel stations near residential property.

- Good silencers and enclosure of exhausts can reduce noise to acceptable limits.

OPERATIONAL REQUIREMENTS

- Vary with circumstances and siting.
- Reliability always paramount.
- Easy to operate.
- Automatic operation.
- Operational procedures.
- Long interval between need for major overhaul.
- Easy to maintain.
- Automatic screen cleaning.
- Good access.
- Adequate lighting (inside and out).
- Adequate warning instruments.
- Proper hand over including all maintenance and operating manuals.
- Presence at commissioning.
- Telemetry link to remote operations room.
- Self diagnostic instrumentation.
- Adequate fire fighting equipment.
- Pump hours run meters.
- U/s and d/s level recorders.
- Need for post project appraisal - confirm design assumptions and obtain information for improvement of subsequent stations.

SAFETY

- All equipment and the complete station must comply with the requirements of the Health and Safety at work Act 1974 and any subsequent legislation and with all Board of Trade and Home Office Regulations which may be applicable.

- Close co-operation with local Safety Adviser is required from early stages of design right through to completion and commissioning.

LIFETIME COSTING

- The basic objective of the designer is to provide a pumping station that will pump all flows up to the maximum design flow, reliably and at minimum cost for the whole of the pumping station's life. This implies that all costs must be considered and not just the initial costs of the structure, pumping and ancillary equipment. These should include:-

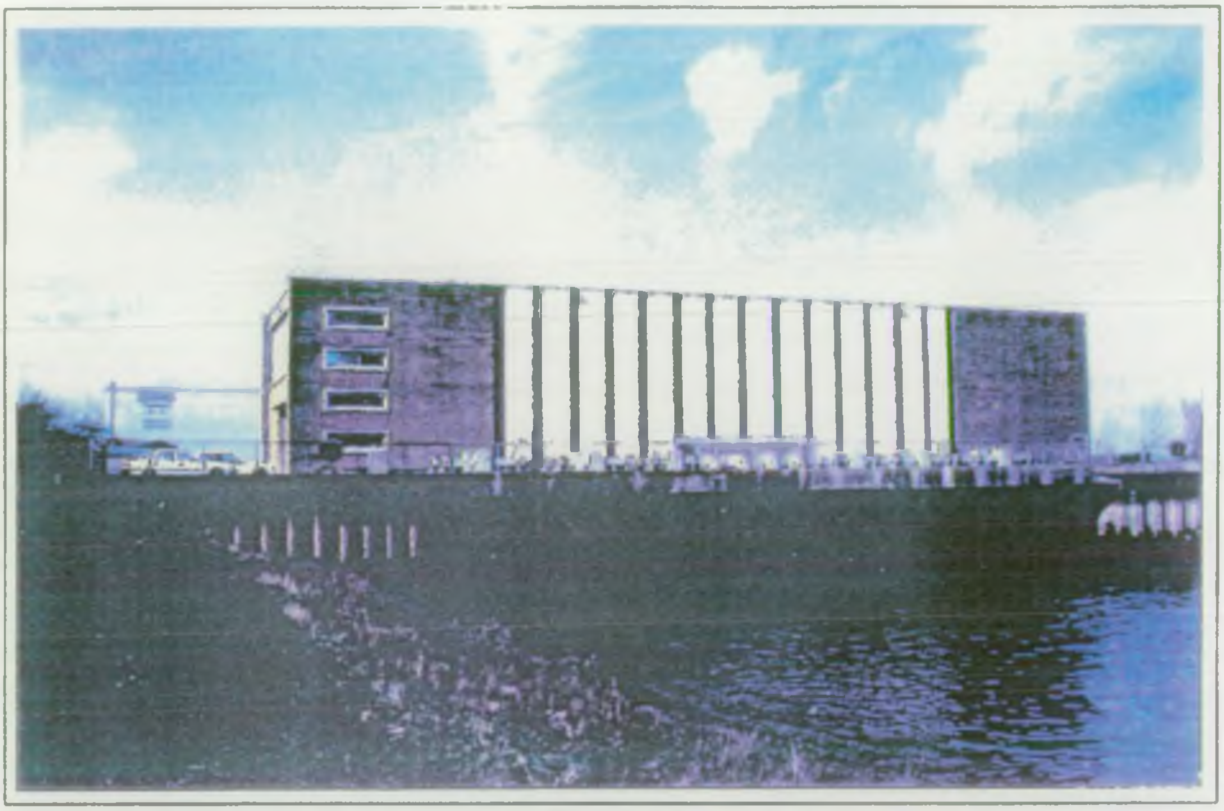
- Equipment capital cost.
- Structure capital cost.
- Routine operating.
  - Power
  - Labour
- Routine maintenance and inspection.
  - Materials
  - Labour
- Preventative maintenance.
  - Materials
  - Labour
- Repair and replacements.
  - Materials
  - Labour
  - Other
- Major overhauls.
  - Materials
  - Labour
  - Other

- In the absence of detailed records from a similar station with similar equipment, subjective estimates will have to be made for some of these items.

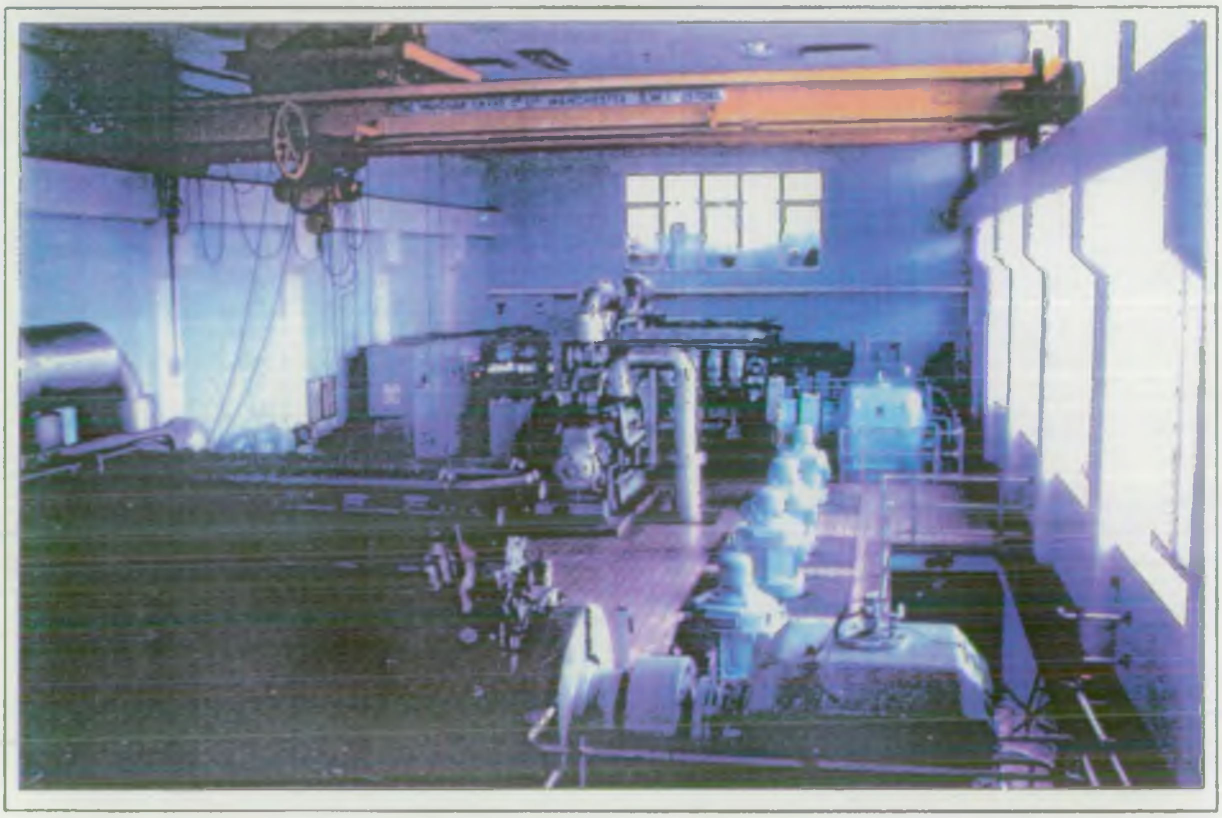
- There is a need to ensure that sufficiently detailed records are kept by operational staff to ensure that data is available to make more accurate assessments of lifetime costs in the future. More information and longer guarantees on the maintenance and replacement requirements, and performance of their products should be demanded from suppliers.

Appendix D

Photographs



Altmouth Pumping Station - North West Region
Axial Flow Vertical Lift Station Capacity 84 cumecs



Altmouth Pumping Station - North West Region
Internal Layout

Wolsty Pumping Station - North West Region
Submersible Pump Installation Capacity 0.80 cumecs

Bedford Pumping Station - North West Region
Capacity of Pumps Recently Upgraded

Court Lodge Pumping Station - Southern Region
Archimedean Screw Pump Installation

Rodmell Pumping Station - Southern Region
Floating Pump Installation

Appendix E

References

PUMPS AND PUMPING STATIONS

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Dissemination and Uptake Note

This note provides details of how the attached output from the R&D programme is to be disseminated to the end-user and details of how the customer wishes the output to be taken up.

1. Project

Commission	FLOOD DEFENCE		Topic Area	RIVER STRUCTURES.	
Project Number	363	Project Leader	ALAN H. TAYLOR	Region	NORTH WEST

2. Output

Title: PUMPING STATION - EFFICIENCY OF OPERATION AND COSTS FOR A DESIGN LIFESPAN. SURVEY OF PUMPING INSTALLATIONS AND DESIGN PHILOSOPHY.

Reference: R&D 363

Output Type[1]: PROJECT RECORD PHASE I ~~(PRELIMINARY REPORT)~~

Distribution Instructions

FLOOD DEFENCE MANAGERS
PROJECT LEADER
TOPIC LEADER
COMMISSIONER.
R&D CO-ORDINATORS
R&D SECTION H.O.
TEAM MEMBERS.

Dissemination Status — Internal: RELEASED TO REGI — External: RESTRICTED

3. Uptake

Responsibility: FLOOD DEFENCE

Details (should include any seminars, training sessions or Working Group considerations as necessary)

THIS PROJECT RECORD (PHASE I) WILL FORM PART OF THE BASIS FOR A R&D NOTE WHICH WILL CONTAIN GUIDANCE ON THE SELECTION, DESIGN AND OPERATIONAL MAINTENANCE OF PUMPING STATIONS.

4. Core Function/Customer Authorization

Project Leader	A H Taylor (signature)	Topic Leader	
Commissioner		Group Chairman[2]	

Notes: [1] Reference to paper R&D(92)3 Definition of R&D Outputs.
[2] Signature of Chairman of Working Group if appropriate.

Date Output Sent: / /