

Environmental Protection Report

EAST DEVON PUBLIC WATER SUPPLY STRATEGY THE EXISTENCE AND POTENTIAL USE IN YIELD ANALYSIS OF HISTORIC FLOW RECORDS

June 1993

RP-NRA-2001AA-1001(01)

Author: Lisa Roach

Technical Assistant



NRA

National Rivers Authority

South West Region

AUTHORISATION SHEET FOR BINDING WITH REPORT

PROJECT TITLE: EAST DEVON PUBLIC WATER SUPPLY STRATEGY

REPORT TITLE: THE EXISTENCE AND POTENTIAL USE IN YIELD ANALYSIS OF HISTORIC FLOW RECORDS

REFERENCE NUMBER: RP-NRA 2001AA - 1001 (01)

AUTHORS(S)	L ROACH	SIGNATURE(S)	DATE
		<u>Lisa Roach</u>	<u>27/8/93</u>

CHECKED BY	G BOYCE	SIGNATURE(S)	DATE
		<u>G. Boyce</u>	<u>21/10/93</u>
	A WESTON	<u>A Weston</u>	<u>21/10/93</u>

FUNCTIONAL	C D N TUBB	SIGNATURE(S)	DATE
		<u>C D N Tubb</u>	<u>17/12/93</u>

APPROVAL			
BY			

REGIONAL	G R BATEMAN	SIGNATURE(S)	DATE
		<u>G R Bateman</u>	<u>7/1/94</u>

APPROVAL			
BY			

ENVIRONMENT AGENCY



110293

ACKNOWLEDGEMENTS

I would like to thank the staff at NRA SW who helped me with the investigations and the production of this report, particularly Dr. Robert Grew, project supervisor and the Water Resources Planning Team who were always willing to suggest ideas and provide encouragement.

I would also like to thank Hydrometric Services (NRA SW) and staff at the Surface Water Archive, Institute of Hydrology, the West Devon Record Office and the Devon Record Office at Marsh Barton for their patience and assistance in helping me to locate and collect the flow record information.

**THE EXISTENCE AND POTENTIAL USE IN YIELD ANALYSIS OF HISTORIC FLOW
RECORDS**

CONTENTS

	Page No.
List of Figures and Tables	iii
List of Symbols and Abbreviations	iiii
1.0 SUMMARY	1
2.0 INTRODUCTION	2
3.0 AIMS	5
4.0 OBJECTIVES	5
5.0 METHODOLOGY	6
5.1 The location and recovery of flow records	6
5.2 Criteria construction	6
5.3 Scoring the criteria	7
5.4 Grading the scores	7
6.0 RESULTS	10
6.1 Flow record existence	10
6.2 Flow record catalogue	10
6.3 Flow record scores and grades	14
7.0 DISCUSSION AND CONCLUSIONS	17
7.1 Record existence	17
7.2 Grades obtained	17
7.3 Further use of the criteria	18
7.4 Criteria adjustments	19
7.5 Grading system application	19
8.0 RECOMMENDATIONS	21
8.1 Further investigations	21
8.2 Flow record use	21
8.3 Use of the criteria	21
9.0 REFERENCES	22
10.0 GLOSSARY	23
APPENDIX 1	Criteria and criteria interpretation
APPENDIX 2	Score chart
APPENDIX 3	Additional flow records discovered
APPENDIX 4	Catalogue: Trenchford/Blackingstone
APPENDIX 5	Catalogue: Kennick, Bullaton 1 and 2, Clampitt, Higher and Lower Mardon

APPENDIX 6 Catalogue: South Teign Intake
APPENDIX 7 Catalogue: Fernworthy Compensation
APPENDIX 8 Catalogue: Swincombe Intake
APPENDIX 9 Catalogue: Bala Brook Intake
APPENDIX 10 Catalogue: Avon Intake
APPENDIX 11 Catalogue: Irishmans Wall
APPENDIX 12 Catalogue: Abbey Weir
APPENDIX 13 Catalogue: Meavy
APPENDIX 14 Catalogue: Brampford Speke
APPENDIX 15 Catalogue: Exeter Quay
APPENDIX 16 Directory of organisations contacted
APPENDIX 17 Data discs

LIST OF FIGURES AND TABLES

FIGURES

- Figure 1 Location of the eighteen flow record sites within the South West region

TABLES

- Table 1 Possible historic flow records
Table 2 Guide to the usefulness of a flow record for yield analysis
Table 3 Summary information on the flow records
Table 4 Grades obtained

LIST OF SYMBOLS AND ABBREVIATIONS

IoH	Institute of Hydrology
km ²	square kilometres
l/s	litres/second
m ³ /s	cubic metres per second
MG/d	Million gallons per day
NGR	National Grid Reference
NRA (SW)	National Rivers Authority (South Western Region)
SWWSL	South West Water Services Limited

SUMMARY

Recent NRA SW water resources planning work identified a need to maximise the availability of quality assured historical flow data for yield assessment purposes. This report summarises the results of a study aimed at achieving this.

The possible existence of 6 historic flow records, listed in Table 1 were brought to the attention of NRA SW during a search for a suitable record to use in the determination of the reliable yield of the Wimbleball/Exe system. Investigations into the existence of these flow records also lead to the discovery of other historic flow data.

Eighteen flow records were recovered, catalogued and assessed for their potential usefulness in yield analysis using the criteria and grades shown in Appendix 1. The criteria may be used to assess the usefulness of other flow records yet to be discovered. The flow record information is catalogued in Appendices 4-15. To assess usefulness a quality grading chart was devised, shown in Table 2. No flow record was graded highly enough to be used as a primary source of data in yield analysis but ten records were graded highly enough to be used in validating primary data. Of the other records, two were in measurements of stage only and eight were affected by abstractions.

It is recommended that the Abbey Weir and Fernworthy records are digitised, and the flow data for the Fernworthy record transferred onto the disc containing the South Teign record (Appendix 17). The missing data for both records should then be infilled, naturalised where necessary and both records reconsidered for use as primary data in yield analysis. Before using any record as primary data however, quality control checks should be carried out.

In January 1993 South West Water Services Limited (SWWSL) applied to NRA SW for a licence to abstract water from the River Exe during the winter months to pump into Wimbleball Reservoir. In order to determine the licence, NRA SW made an assessment of the availability of resources for public water supply in the Wimbleball supply area. This involved the Water Resources Planning Team determining the drought reliable yield of the Wimbleball/Exe system. The drought reliable yield was defined as the maximum amount of water the system can supply throughout a 1 in 50 year drought. Typically the drought reliable yield varies according to a range of factors including the size of the reservoir, the pattern of the demand placed upon it, and most importantly, the nature of the inflow sequence.

Recent work to identify the most appropriate methodology for accurately determining the yield of surface water resources such as Wimbleball Reservoir, indicates that ideally a daily flow record of about 100 years is required to represent the inflows into the reservoir (NRA, 1992). The record should be accurate, reliable and unaffected by artificial influences.

The longest river flow record in the south west that can be obtained from the current network of gauging stations, initiated by the former River Boards, is 35 years. Both Thorverton gauging station, N.G.R. SS 936 016, and Preston gauging station, N.G.R. SX 856 746, on the Rivers Exe and Teign respectively have records of this length. However, neither of the records are sufficiently long to meet the requirements outlined above.

It is possible to extend flow records using catchment models. Catchment models require a long rainfall record with at least 10 years of accompanying river flow data (Wright, 1978). A relationship is obtained between the rainfall and river flow data and the relationship is then applied to the rest of the rainfall record to obtain a synthetic river flow sequence.

When using catchment models it is important that both the gauged river flow and rainfall measurements used to produce the relationship are accurate as any errors are compounded when the synthetic flow sequence is produced. The gauged flow record also needs to contain several sequences of wet and dry years if the synthetic flow sequence is to be representative. The length of the synthetic flow sequence is dependant on the length of the available rainfall record. The length of the gauged river flow data influences the accuracy of the synthetic sequence. The gauged flow data is used to determine the rainfall/river flow relationship and then to validate the relationship. The longer the gauged flow record, the higher the confidence which can be placed in the extended flow sequence.

The Water Resources Planning Team sought to maximise the value of historic flow records for overcoming the limitations of current catchment models. The initial list of six potential historic flow records presented to NRA SW is shown in Table 1. Other historic flow records identified during the investigation were also recovered.

This report details the research undertaken to locate, recover and catalogue the flow data and then assess its usefulness for yield analysis. The latter included an assessment of whether it could form primary data to represent reservoir inflows.

Table 1: Possible historic flow records

Site of Gauging Station	Records collected by	Start date
Tributary of W.Dart	Paignton Urban District Council	1924
Bala Brook	South Devon Water Board	1933
R.Taw at Belstone (Irishmans Wall)	North Devon Water Board	1943
R.Meavey	Plymouth City Water Works	1906
Trenchford Stream	Torquay Waterworks	1911
South Teign	Torquay Waterworks	1929

3.0 AIMS

1. To confirm or otherwise, the existence of the six flow records.
2. To obtain information about all records identified and in doing so determine their usefulness for yield analysis.
3. To summarise the information obtained in a reference document.

4.0 OBJECTIVES

1. Locate all historic flow records.
2. Where possible obtain the records and any accompanying information.
3. Produce a catalogue detailing each record and any accompanying information.
4. Construct a list of criteria to assess the usefulness of flow records for yield analysis.
5. Using the criteria develop a grading system and assess the suitability of all historic flow records obtained, for yield analysis.
6. Make recommendations for further research.
7. Produce a quality assured summary report which satisfies NRA requirements as a reference document.

5.0 METHODOLOGY

5.1 The location and recovery of flow records

Investigations to locate the six records listed in Table 1 were concentrated initially within NRA SW. The NRA library at Manley House (Exeter), the database of abstraction licence files and the Hydrometric Archive were examined in an attempt to obtain exact site names, locations and where possible the flow data itself.

Where the flow information was not available within NRA SW, external organisations such as libraries and record offices were approached. The investigations also highlighted the potential existence of other historic flow records. In some cases the recovery of this data required further investigation.

5.2 Criteria construction

The records were individually scored against a range of criteria in order to assess their usefulness as primary data for yield analysis. When constructed the criteria had to satisfy the following:

- Be objective.
- Applicable to all flow records.
- Be unbiased and not favour any type of record

The criteria was structured using sections and subsections to ensure relevant information was covered. The sections were based on Water Resources Planning requirements for flow records that:

- cover drought sequences;
- are accurate and reliable measurements, particularly at low flows and;
- are natural or naturalised.

From these requirements four sections were obtained: record coverage, accuracy, reliability and artificial influences. Another section was added covering the availability of supporting information. Supporting information can contain useful information relating to record accuracy and reliability.

Following discussion with Water Resources Planning and Hydrometric Services the factors influencing record coverage, accuracy etc. were determined and developed into a list of questions to form the criteria. This process included prioritising, in terms of importance and usefulness, answers to the questions. Modifications to the criteria were made during the assignment of scores, grading of scores and trial applications of the records.

5.3 Scoring the criteria

Initially each question was allocated a maximum score of 10, the maximum score being allocated to the answers required to satisfy Water Resources Planning requirements of a flow record, as defined in Section 5.2. During trial record applications the scores were refined as their allocation was found to favour records with a lot of supporting information. The finalised criteria with their scores are in Appendix 1.

5.4 Grading the scores

The criteria were scored using a 'model' record that would just be satisfactory for use in yield analysis. The definition of a 'model' record is based on the general requirements of a flow record for use as primary data, as discussed in Section 2.0. These are largely the same as Water Resources Planning requirements of flow records as mentioned in Section 5.2. The scores for each question and the section scores allocated to the 'model' record are shown in the first column of the score sheet in Appendix 2.

Three grades A, B and C are applied to each section to cover all of the scores obtainable. For a record to score grade C in a section, the score will be below the equivalent 'model' record score. The 'model' record score forms the lower limit of grade B scores. The upper limit of grade B is obtained using the middle point between the maximum score and the 'model' record score. The diagram below shows how this works when applied to Section 1.0 of the criteria. If a record obtains a score above the upper limit it is assigned grade A. Except for Section 2.0 of the criteria all section scores were assigned grades in this way.

Minimum obtainable score	Model record score	Upper limit score	Maximum obtainable
0	43	54 (65-43/2+43)	65
<div><div></div><div></div><div></div></div>			
Grade A = >54 Grade B = 43-54 Grade C = <43			

The grading system attempts to distinguish between those records with missing information on record accuracy and reliability and those records that are inaccurate and unreliable. The scores and allocation of scores to grades were changed in Section 2.0 because this was not being achieved. Consequently scores above the 'model' record score are assigned grade A and a score below 23 is assigned grade C. The score of 23 was chosen so a record can obtain grade B even though information is missing for up to two questions but, ensures a record is not graded B if more than one question is scored negatively.

Table 2 is a guide to the usefulness of a flow record for yield analysis based on the grades obtained. The first three rows in the table refer to a record's suitability as primary data in yield analysis. Records graded highly would be very good as primary data and therefore very useful in yield analysis, row 1, Table 2. Those graded less highly, rows 2 and 3, may still be useful but may need modification and may be less reliable.

Records graded lower due to short record coverage but are natural or can be naturalised can still be used in yield analysis but only for validating other records, row 4 in Table 2. All records that are of stage only and/or are currently unable to be naturalised fall into the 'difficult to use category', row 5, Table 2.

**Table 2: Guide to the usefulness of a flow record
for yield analysis**

Usefulness	Section				
	1.0 Record Coverage	2.0 Accuracy	3.0 Reliability	4.0 Supporting Information	5.0 Artificial Influences
Very useful with high measurement accuracy	A	A	A/X/*	A	A
Useful but may need modifying. Measurement reliability reduced	A/B	A	B/X/*	A/B	A/B
Useful but confidence in measurement accuracy is reduced	A/B	B/*****	B/X/*	A/B/C	A/B
Limited in use. Can be used for validating other flow records	B/C	A/B/C/*****	A/B/X/*	A/B/C	A/B
Difficult to apply for use in yield analysis	A/B/C	A/B/C/*****	A/B/C/X/*	A/B/C	C

X= Rating curve not available

***= No information**

/= And/or

6.0 RESULTS

6.1 Flow record existence

- The location and names of the six gauging stations relating to the records listed in Table 1 were identified. In addition the locations and names of a further nineteen gauging stations were established, in association with historic flow records. Flow data and information was found for the six listed gauging stations and twelve of the additional nineteen. Consequently catalogues have been produced for a total of 18 flow records. They are presented as Appendices 4-15. The seven gauging stations not catalogued through lack of information are listed in Appendix 3.

Figure 1 shows the location of the eighteen catalogued gauging stations, within the South West. Table 3 summarises the information presented in the catalogues for each flow record in terms of gauging station name and location, the length of flow record, data format in terms of frequency and media, and whether the record is artificially influenced.

Catalogues 4 and 5 cover the Trenchford/ Blackingstone streams and the Kennick/ Bullaton 1/ Bullaton 2/ Clampitt/ Higher Mardon/ Lower Mardon streams respectively. These records have been grouped together because they have similar record information and were all collected for the same purpose - to measure the inflows into the Kennick, Tottiford and Trenchford Reservoir complex.

6.2 Flow record catalogue

The catalogues all have a standard format and are split into the following sections:

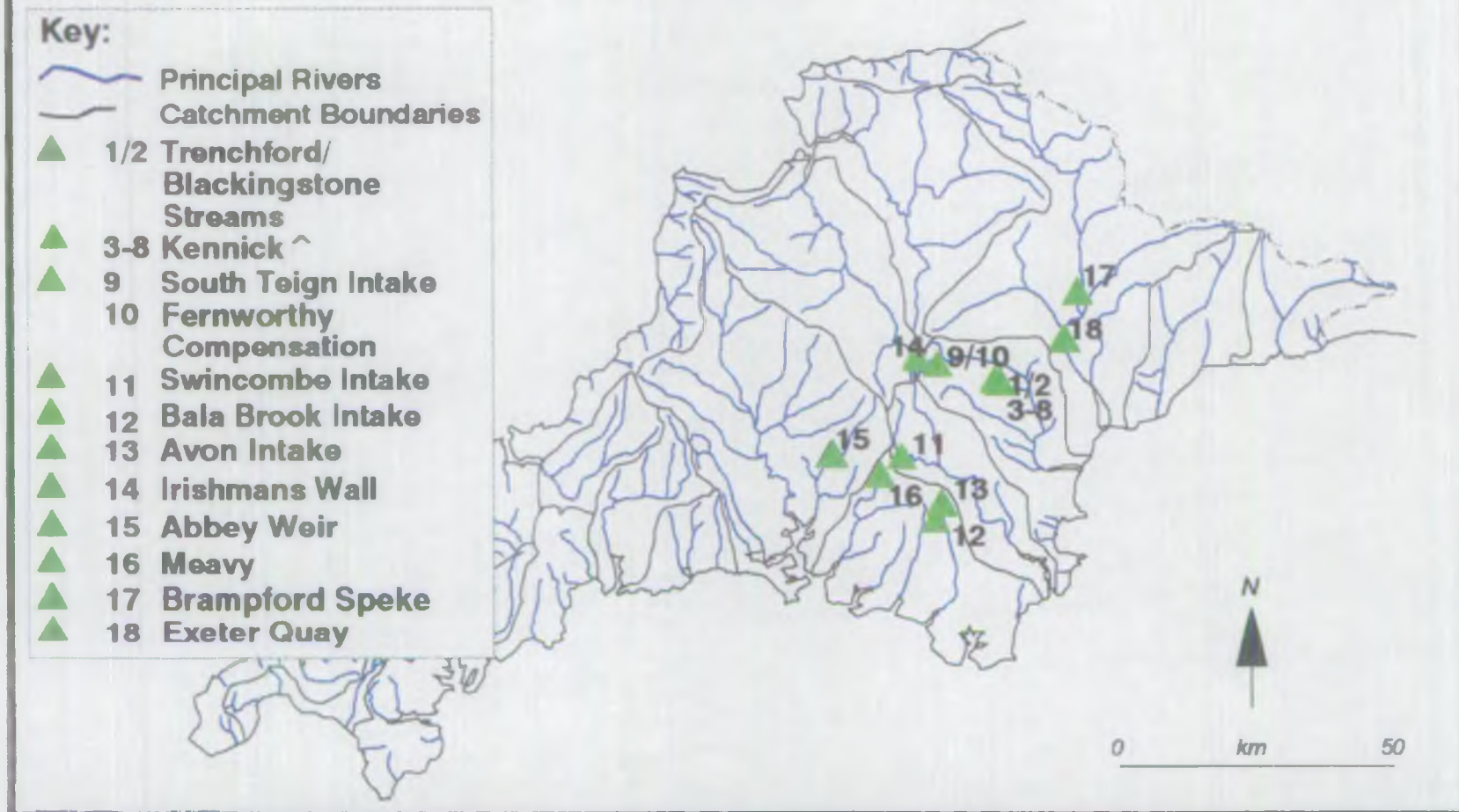
- Summary
- Site information
- Record details, including problems with the data
- Measurement structure and equipment
- Artificial influences
- Other records available
- Supporting documentation

The 'other records available' section details meteorological records and/or records of reservoir levels, transfers and outflows which were found accompanying the flow records.

The supporting documentation section of the catalogue lists the sources and locations of the information relating to the record. Appendix 16 contains a directory of the names and details of organisations holding flow record information. A list is also provided of those organisations contacted but who were unable to provide any relevant information.

Figure 1

Location of the eighteen flow record sites within the South West region



^ Kennick covers the Kennick, Bullaton 1 and 2, Clampitt and Higher and Lower Mardon records

Table 3: Summary information on the flow records

Gauging Station Name	N.G.R	Length of record	Format of Data		Artificially Influenced?
			Frequency	Media	
Trenchford	SX 801 830	1908-1939 1948-1964	Monthly Totals Discharge Weekly Stage	Photocopies/ 3.5" Disc Tabulated Chart/ Microfilm/3.5" Disc	No
Blackingstone	SX 800 850	1908-1939 1948-1964	Monthly Totals Discharge Weekly Stage	Photocopies/ 3.5" Disc Tabulated Chart/ Microfilm/3.5" Disc	No
Kennick Bullaton 1 Bullaton 2 Clampitt Higher Mardon Lower Mardon	SX 808 839 SX 803 826 SX 802 828 SX 806 844 SX 805 824 SX 805 827	1908-1938	Monthly Totals Discharge	Photocopies/ 3.5" Disc	No
South Teign Intake	SX 671 844	1929-1939	Monthly Totals Discharge	Hand Written Copy/ 3.5" Disc	PWS,R
Fernworthy Compensation	SX 671 844	1947-1972	Continuous Discharge	Chart/Microfilm	PWS,R

PWS = Public Water Supply

R = Reservoir

Table 3: Continued

Gauging Station Name	N.G.R	Length of record	Format of Data		Artificially Influenced?
			Frequency	Media	
Swincombe Intake	SX 633 719	1934-1968	Daily Mean Discharge	3.5" Disc/ Spreadsheet	PWS
Bala Brook Intake	SX 671 629	1933-1966 1969-1973	Continuous Discharge	Chart/Microfilm/ 3.5" Disc	PWS
Avon Intake	SX 681 641	1936-1937 1939-1972	Continuous Discharge	Chart/Microfilm/ 3.5" Disc	PWS,R
Irishmans Wall	SX 621 918	1943-1944 1948-1973 1987-1992	Continuous Discharge	Chart/Microfilm/ 3.5" Disc	PWS
Abbey Weir	SX 482 743	1938-1993	Continuous Stage	Chart	I
Meavy	SX 566 692	1904-1905 1906-1920	Daily Stage	Tabulated Ledgers	PWS
Brampford Speke	SX 927 987	1907-1912	Monthly Means Discharge	Photocopies/ 3.5" Disc	No
Exeter Quay	SX 928 919	1907-1912	Monthly Means Discharge	Photocopies/ 3.5" Disc	PWS

I = Industrial Abstraction

PWS = Public Water Supply

R = Reservoir

Maps, photos and where necessary, sketches and diagrams of the river system and/or gauging station design are included in the catalogues. Tabulated river flow data recovered by NRA SW has been converted to cumecs and put onto 3.5" disc in ASCII and Lotus 123 format. Appendix 17 contains the data discs and a summary of the information contained on each of the discs.

Five years of the Abbey Weir record is available from NRA SW (Details in Abbey Weir catalogue, Appendix 12). Microfilmed data in continuous chart format for the other flow records are available on request from Water Resources Planning, NRA SW. The rest of the data for Abbey Weir is held by National Power Plc, Mary Tavy Power Station. The tabulated data for the River Meavy has also not been obtained by NRA SW and is held at the West Devon Record Office, Plymouth (Addresses and telephone numbers in Appendix 16).

6.3 Flow record scores and grades

The criteria was applied to the eighteen records and scored. The scores for individual questions, section totals, and grades for each flow record are in Appendix 2. Except for Abbey Weir, the scores obtained for Section 1, Record Coverage, are very similar, as all records contain few long drought sequences. Abbey Weir is the longest record, scoring 8 in 1.1b.

The 1908-1939 section of the Trenchford and Blackingstone Stream records are scored separately from the 1948-1964 section of the records as the early (Trenchford and Blackingstone 1 1908-1939) section is in monthly totals of discharge and the later section (Trenchford 2 and Blackingstone 2 1948-1964) is in weekly stage values. Therefore different scores are obtained for the questions in Section 1.0 of the criteria, see Appendix 2.

On average only two questions per record are answered on measurement accuracy, Section 2. The Bala Brook record scored the highest on measurement accuracy (39*). The South Teign record could not be scored in this section as the limited supporting information did not identify any measurement accuracies.

Only two of the flow records, Brampford Speke and Exeter Quay are available with rating curves. However the stage/discharge relationships are only representative at low flows with the relationship at high flows being theoretically derived. Without the original rating curves visual checks of measurement reliability are not possible for the rest of the records.

There were variations in the amount of supporting information, Section 4, available for each record. For example, the River Meavy scored 75 and the South Teign 28.

When applying the criteria to the Swincombe record it is assumed that all of the record was affected by abstractions. The record was obtained from the Surface Water Archive, at IoH, who were unsure to which of the four weirs the measurements apply (Diagrams 1 and 2, Appendix 8). However, Gustard et al (1992) analysed the record in the report 'Low Flow Estimation in the United Kingdom' and concluded that the record was artificially influenced.

The scores obtained for the Kennick record also represent the scores for Bullaton 1 and 2, Clampitt and the Higher and Lower Mardon Streams as the information and details for these records are the same.

Table 4 summarises the grades obtained for each record.

By comparing the grades shown in Table 4 with Table 2, the only records likely to be useful in yield analysis for validating primary flow records are Trenchford and Blackingstone 1, Kennick, Bullaton 1 and 2, Clampitt, Higher and Lower Mardon, and Brampford Speke. The other records are in the 'difficult to apply' category either because the flow measurements are of stage, and there is no rating curve available, or, because a large proportion of the record is affected by artificial influences. These are the only reasons why the remaining flow records have fallen into the 'difficult to apply' category. The Swincombe record is as accurate as some of the records listed above and the Bala Brook record is more accurate but because both records are artificially influenced they are unable to be used in yield analysis.

Table 4: Grades obtained

Site	Section				
	1.0	2.0	3.0	4.0	5.0
Trenchford 1 1908-39 Blackingstone 1	C	C/****	B/X	B	A
Trenchford 2 1948-1964 Blackingstone 2	C	C/****	C/X	B	A.
Kennick	C	B/**	B/X	B	A
South Teign Intake	C	*****	B/X	B	C
Fernworthy Compensation	C	C/*****	B/X	B	C
Swincombe Intake	C	B/**	A/X	B	C
Bala Brook Intake	C	B/*	B/X	B	C
Avon Intake	C	C/*****	B/X	B	C
Irishmans Wall	C	C/*	A/X	B	C
Abbey Weir	B	C/*	C/X	B	A
Meavy	C	C/*****	A/X	B	C
Brampford Speke	C	C/****	A	B	A
Exeter Quay	C	C/****	A	B	C

X = rating curve unavailable

* = no information

/ = and/or

7.0 DISCUSSION AND CONCLUSIONS

7.1 Record existence

As mentioned in Section 6.1 of this report, flow data and supporting information was recovered for eighteen sites. With the exception of the Brampford Speke and Exeter Quay records, they all centre around Dartmoor and the South Hams. Also all, apart from the Abbey Weir and River Exe records are related to public water supply development. The Abbey Weir record relates to abstraction of water for hydro-electric power and the Brampford Speke and Exeter Quay records were collected as part of an investigation into rivers carried out by the Royal Geographic Society (Strahan et al, 1916).

7.2 Grades obtained

None of the records were graded highly enough for use as primary data in yield analysis. The Trenchford 1, Blackingstone 1, Kennick, Bullaton 1 and 2, Clampitt, Higher and Lower Mardon and the Brampford Speke records were the only records to be graded for use in validating primary data.

The first section of the Trenchford record (Trenchford 1) has already been used to validate a synthetic flow sequence produced by the University of East Anglia (Jones, 1984) for the River Exe at Thorverton, N.G.R. SS 936 016.

It should be emphasised that the guide to the grades, Table 2, is only approximate and should be used in conjunction with the information provided in the catalogues to enable a more accurate assessment of a records usefulness. Table 2 places the Abbey Weir record in the 'difficult to apply' category because the measurements are of stage. However, South West Water Authority obtained a rating curve for the site in 1986 which could be used to convert the data to discharge.

The criteria do not consider a record's geographical location or the resources required to put the data in to a usable format. Both of these factors will influence the decision on whether a record is actually used.

The criteria also do not consider the method used to obtain the spot gaugings for the stage/discharge relationship. The spot gaugings for the lower halves of the Brampford Speke and Exeter Quay rating curves were obtained using a surface slope method which involved timing floats over a set distance to obtain velocities. This method is less accurate than the method of obtaining spot gaugings by current meter (Grover and Harrington, 1949). Therefore the usefulness of both records, especially the Brampford Speke record, graded, 'useful for validating primary data', is questionable.

If the criteria are to be applied to other flow records where a current meter was not used to obtain the spot gaugings then another question should be added in to Section 3.2, listing the possible methods in terms of their accuracy.

In the criteria only abstractions and reservoirs are scored under the artificial influences section. However, the Abbey Weir record is affected by sluice gates opening and shutting immediately above the measuring weir. Significant fluctuations in the river flow on a daily basis also occur due to the abstractions and releases of water at the Mary Tavy Power Station further upstream. Water is abstracted continuously and only released back to the river during the day. These factors will affect the decision on whether the record is used. The Abbey Weir record, if it could be converted to discharge, would be applicable for use as primary data in yield analysis, unless quality control checks on the data negate this due to the impacts of the abstractions.

The Abbey Weir rating curve and the rating curve for Irishmans Wall (SWWSL, 1992) have not been scored as the interpretation notes state that all rating curves produced in the last twenty years should not be scored. The use of these notes when scoring the flow records is important as they can prevent unrealistic assumptions being made, particularly relating to Section 2.0, Measurement Accuracy. For example, it could be assumed that where a measurement structure has been erected under a Parliamentary Act it must have been approved. Question 2.1(a) should only be scored positively if there is proper documentation that this is the case within the supporting documentation.

Further investigations could lead to the scores and possibly the grades improving if additional supporting information and missing flow, and abstraction data could be located.

7.3 Further use of the criteria

The criteria and the application of the grading system have generally met the requirements set out in Section 5.2 of the report. The criteria are objective except for question 2.1(b) on evaluating gauging station accuracy where the possible responses are based on people's opinions documented in supporting information rather than set guidelines. This is because when gauging stations were built, pre 1950, set guidelines such as British Standards were unavailable.

The finalised criteria were applicable to all eighteen flow records and there is no obvious reason why the criteria cannot be applied to other flow records. The criteria, however, are slightly biased towards records collected by water boards/companies, particularly in Section 2.2 where the definition of trained personnel, shown in the interpretation notes relates only to water board employees. However, it is difficult to determine whether people employed by other organisations with the responsibility of maintaining gauging stations

and extracting measurements were carrying out their tasks correctly, unless it has been documented. This is another reason why quality control checks should be carried out on all data as it can be the only way of determining if the measurements are correct.

The scoring system for Section 5.2 penalises the Fernworthy Reservoir record as the question relates to reservoir construction and to whether a record is affected by compensation flows. The Fernworthy record is a record of compensation flow and has a low score, despite the availability of abstraction data for 1948-1972 providing the potential to naturalise the data. Also, the record for the South Teign was collected at approximately the same site as the current compensation weir at Fernworthy Reservoir allowing the two records to be put together. Both records were used together in a report for the Plymouth Water Undertaking, investigating the potential of the Swincombe Valley for a future reservoir (Plymouth Water Undertaking, 1969).

7.4 Criteria adjustments

In Section 3.0 of the criteria, only Brampford Speke and Exeter Quay were graded on their measurement reliability as no rating curves were available at the other sites. These two records both scored grade A although due to a fault with the criteria they should not have been graded so highly. The Swincombe, Irishmans Wall and the Meavy records also scored grade A but they obtained a grade X (for no rating curve) as well. Therefore grades have been assigned to scores with the assumption that a rating curve is not available. It would be wrong for a record with a poor rating curve to be assigned grade A.

A way of overcoming this limitation would be for questions 3.0(a) and (ai) to have their own section allowing measurement reliability to be scored on the rating curve only.

The criteria are not fixed and can be changed or altered if required, for example, by inserting a question to identify whether quality control checks have been undertaken and also a question to assess the accuracy of the method used to obtain spot gaugings for the rating curve. The criteria and Table 2, assessing the usefulness of the records, may need to be adapted or changed as more flow records are applied. In this investigation all eighteen records found were categorised into the last two rows of the table. Therefore a record that should be useful as primary data in yield analysis has not been assessed using the criteria and Table 2.

7.5 Grading system application

The allocation of scores to grades is purposely biased towards yield analysis of large reservoirs. The grading system would be weakened if applied to other uses of flow records. For example, catchment models require a record of at least 10 years (Wright, 1978) whereas the

recommended methodology (NRA, 1992) states the need for about 100 years of record. Therefore ideally every use requires its own grading system. The method used to allocate grades to scores described in Sections 5.2-5.4 could be used when constructing individual grading systems for other purposes.

8.0 RECOMMENDATIONS

8.1 Further investigations

- Investigations should be made into the existence of the other flow records listed in Appendix 3.
- SWWSL should be asked:
 - If flow data exists for the River Meavy upstream of Burrator Reservoir, Fernworthy compensation weir and the Bala Brook and Swincombe Intakes from 1920, 1972, 1973 and 1968 respectively.
 - If abstraction data is available pre 1975 for the Bala Brook and Avon Intakes and pre 1974 for the Swincombe Intake.
 - If the flow record for the Swincombe Intake is affected by abstraction, and to which of the four weirs the data applies.

8.2 Flow record use

- Set up a system to ensure quality control checks are always carried out before using historic flow records as primary data.
- Undertake a study to increase the value of the Abbey Weir record for yield analysis. This will involve digitising the remaining Abbey Weir record, naturalising the record, and carrying out appropriate quality control checks before reconsidering its usefulness in yield analysis.
- Undertake further work on the Fernworthy record to increase its value for yield analysis. This will include digitising the Fernworthy record and transferring both the flow and abstraction data onto the disc containing the River Teign data (Appendix 17), naturalising the record and carrying out appropriate quality control checks before reconsidering its usefulness in yield analysis.
- Make use of the historic flow records where possible.

8.3 Use of the criteria

- Use the criteria, including altering it where necessary, and the appropriate grading structures to assess flow records for other applications.
- Advise staff to always use the interpretation notes when applying the criteria to a flow record.

REFERENCES

- Grover, N.C. and Harrington, A.W. (1949) Stream Flow Measurements, Records and their Uses. New York, John Wiley and Sons, Inc.
- Gustard, A., Bullock, A. and Dixon, J.M. (1992) Low Flow Estimation in the United Kingdom. Wallingford, Institute of Hydrology. IH Report No 108.
- Jones, P.D., Ogilvie, A.E.J. and Wigley, T.M.L. (1984) Riverflow data for the United Kingdom: Reconstructed Data back to 1844 and Historical Data back to 1556. East Anglia, Climatic Research Unit.
- NRA. (Nov 1992) Surface Water Yield Assessment. South Glamorgan, Wallace Evans. Interim Report (Phase 2) 0414/2/N, Draft Version 1.1.
- Strahan, A., McKenzie, N.F., Mill, H.R. and Owens, J.S. (1916) The Investigation of Rivers. Final Report 1916. London, The Royal Geographical Society.
- Plymouth Water Undertaking. (March 1969) Report on Future Water Resources. Westminster, Binnie and Partners. Vol II.
- SWWSL. (December 1992) Taw Marsh Investigation, Interim Report. Shrewsbury, Water management Consultants Ltd.
- Wright, C.E. (1978) Synthesis of River Flows from Weather Data. Reading, Central Water Planning Unit. Technical Note No.26.

10.0 GLOSSARY

DISCHARGE

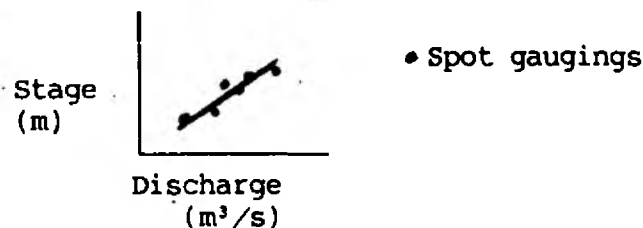
The volume of water flowing past a point in a specified time. The units of discharge are usually cumecs or cubic metres per second.

1: 50 YEAR DROUGHT

A severe drought that can be expected to occur on average once in every 50 years (obtained from statistical analysis). Often referred to as a 'design drought' it is commonly used for determining reservoir size.

RATING CURVE

The stage/discharge relationship at a site, usually represented in a graphical format by plotting discharge measurements against corresponding values of stage. Spot gaugings or check gaugings are used to check if the relationship is correct. The rating curve generally applies to data over a particular period, as changes may occur in the rating as a result of bed movement etc (e.g from flood events).



SPOT GAUGINGS

An instantaneous measurement of flow in a river at a specific location point.

STAGE

The water level in a river with respect to a fixed datum. This is often referred to as Ordnance Datum.

STAGE/DISCHARGE RELATIONSHIP

The relationship is the formula used to obtain the discharge value from a corresponding value of stage. The formula varies depending on the site.

APPENDIX 1

Criteria and criteria interpretation

INTERPRETATION OF THE CRITERIA FOR DETERMINING THE POSSIBLE USEFULNESS OF HISTORIC RIVER FLOW RECORDS

GUIDANCE NOTES

General Information:

1. The guidance notes are sectioned and numbered to correspond with the criteria.
2. All organisations that were placed with a statutory requirement to provide an area with water supplies who owned or oversaw a gauging station are referred to in the text as 'water boards'.
3. The 'no information' option in some questions should only be marked when a definite response cannot be made. For the majority of the flow records this is likely to occur at least once due to the lack of supporting information. Information may exist but remains undiscovered at the time of applying the criteria.

1.0 RECORD COVERAGE

1.1 Length of record:

- a. The years shown represent the start date of each decade. None of the records used in this project post date 1960.
- b. The length of the record should be inclusive of all the years between the start and end date, even when many years of the record are missing. For example, a record that is in two parts, from 1910 to 1930 and 1942 to 1960 would be 50 years in length and consequently would fall in the 50-60 year category.

A record that is 49 years and 11 months in length should be placed in the 40-50 year category. However, a record length of 50 years exactly should be scored in the 50-60 year category.

- c. The one year category covers any number of days, from one up to and including 365.

For data on charts, the number of missing charts need to be counted to obtain the number of missing days. Charts that are available but have no, or incorrect, flow readings due to faulty equipment should still be included.

1.2 Data availability

- a. Flow measurement frequency should be scored according to the frequency the data was in when the NRA first obtained the flow record. Any subsequent manipulation of the data should be ignored.

- b. Wright (1978) ranked historic rainfall sequences for Exeter, from 1817 to 1976, to identify years with the highest residual rainfall deficits. The question uses nine of the highly ranked years, dating post 1855, to define drought years.
- c. Wright (1978) identified drought end years for minimum rainfall events lasting 15, 18 and 24 months. This information has been used to identify droughts that have spread over two to three years, again all dating post 1855.

For a flow record to score on any one drought sequence, flow data must be available for every month identified in the sequence.

2.0 ACCURACY OF FLOW MEASUREMENTS

In this section, if 'no' is answered for questions 2.1(b), (bi) and 2.2(b), minus ten is scored. When the total score for the section is summed the minus scores should be included. Therefore it is possible that the section total may be a negative number.

2.1 Gauging Station Information

- a. British Standards for gauging station design were not available before the 1960s. Therefore pre 1960, design approval for gauging structures, where deemed necessary, could be obtained direct from Government departments, or indirectly through government designated organisations such as fishery boards.

Where flow records have been collected in order to monitor public water supply abstractions, the information relating to the gauging structure approval should be extracted from individual Parliamentary Acts. Where gauging structures have not been mentioned in the Acts the information concerning design approval can also be obtained from water board minute books, engineers reports and similar types of supporting information.

- b. The accuracy of gauging structures at high and low flows can be obtained from supporting information only. In the majority of cases numerical values defining accuracy at high and low flows are not available and scoring has to be based on subjective evidence only. However, if for example the gauging structure was remodelled early on in the record in order to ensure high flows are measured correctly then accuracy at high flows can be scored.

2.2 Maintenance of Gauging Structures

- a. 'Trained personnel' covers water board engineers that oversee the running of the gauging station, their assistants and/or any consulting engineers that the Boards may have employed to help with the new water schemes. Where the gaugings are carried out

by an organisation other than a water board, a qualified engineer can be classed as 'trained personnel'.

The words 'attended to' cover any visit made to the gauging station including the recording apparatus by any of the above personnel.

A score should only be allocated if the frequency of visits has been documented in the supporting information. No assumptions should be made. If the frequency has not been mentioned place a star for no information by the question.

- b. This question should only be scored if reference has been made to the rating curve and the spot gaugings in the supporting information.

The definition of 'trained personnel' provided in Section 2.2(a) is also applicable to this question.

3.0 RELIABILITY OF THE FLOW RECORDS

3.1 Existence of stage/discharge conversion

- a. Several of the flow records on charts are in discharge as the chart itself has been calibrated with the stage/discharge relationship. Despite this the stage discharge relationship is still required to allow confidence to be placed in the accuracy of the charts and therefore the flow measurements.

3.2 Stage/discharge relationship

Questions 3.2(a)-3.2(d) can only be scored if a rating curve is available to accompany the record. A new rating curve developed in the last twenty years due to inaccuracies in the old rating curve should be ignored. Only the old rating curve should be scored as this will be applicable to the majority of the flow record. However where this situation arises a reference is made in the record's catalogue.

If no rating curve is available or only a formula or a stage/discharge table is available an X should be scored for Section 3.2.

- b. A 'good fit' is to be decided subjectively.
- c. The representativeness of the spot gaugings at high and low flows are also to be scored on a subjective basis.
- d. Information relating to regular checking of the rating curve should be obtained from supporting information only.

4.0 SUPPORTING INFORMATION

- a. All the sources of supporting information concerning the flow records should be identified, including verbal communications.

The type of information that each source can provide is as follows:

Surface Water Archive - The nationwide archiving of surface water data has been in operation since 1935. Initially flows from the majority of gauging stations were included but as the gauging station network increased archiving became more selective, with tighter quality controls. Consequently flow record information before 1950 may have been completely lost or only partially archived. However, due to the quality controls on the data any information from the Archive should be reasonably accurate.

Where the data is available the Surface Water Archive at the Institute of Hydrology, Wallingford offer different retrieval options relating to both the flow data and gauging station information.

Measurement charts/tables - If the engineer responsible found unusual flow readings on the tabulated data or the original recorder charts comments were usually made.

Work Engineers Reports - The work engineer, in some cases called the water engineer was employed by the water boards to oversee their water interests. The work engineers reports are usually annual reports containing information relating to the water situation in the past year. They include details of water consumption, construction of new works, rainfall and river flows. Problems that have occurred over the past year or are likely to occur in the next year are also discussed. These problems can include burst pipes, leaks, damage to the board's property and supply problems caused by high demand.

Consulting Engineers Reports - Water boards had a tendency to use consulting engineers to identify water resource schemes and to oversee their implementation. The overseeing included interviewing and training suitable engineers to take over the day to day running of the schemes.

The consulting engineers had to make regular progress reports to the water boards as well as presenting new ideas. Therefore their reports can contain information relating to gauging station design, summaries of existing water resources including drought reliable yields and details of the relevant Parliamentary Acts.

Minutes of the Water Boards - Minutes can be either signed or unsigned and relate to any of the committees associated with the water board, such as works committees and finance committees as well as the company board meetings. Minutes of the company board tend to give limited information on river flow records.

Usually only problems are considered, for example the continuous poor performance of a chart recorder. The minutes of the specialised committees such as finance and work committees also have limited relevant information. An example of the type of information obtained from both these committees the materials and names of companies used in the construction and maintenance of a gauging station.

Fishery boards - The information from fishery boards tends to deal with river flows, particularly any reductions in flow, and also the effects on fish movements of works such as the construction of a gauging station.

Letters - Letters should be identified as a source of information even if only one letter provides relevant information. For the purposes of the criteria a letter is defined as being complete, ie with addresses and the correct titles. Therefore the source of information in a minute book referring to part of a letter should not be identified as a letter. Letters forming part of a report from consulting engineers to the water board, and vice versa, are also not to be identified.

Letters can contain a variety of information, including the name of companies supplying materials and the materials supplied, problems occurring at the gauging station such as bathers in the weir pools and requests for river flow information from fishery boards and the Ministry of Health.

Licence files - The files are held at NRA SW and contain a variety of information relating to an abstraction. This includes Parliamentary Acts, site plans, licence updates, drought orders, licence problems as well as the licence itself. Information obtained from the Parliamentary Acts is usually the most useful as works such as gauging stations are described.

Other - Information sources that have not been covered above can include maps and drawings, site audits, SWWSL reports, Institute of Hydrology reports, newspaper articles, parliamentary notes on the Acts and other related documentation as well as information communicated verbally.

The total score for question 4.0(a) will be the sum of the scores allocated to each source of supporting information relating to the record.

- b. The percentage of the record that the above information covers needs to be worked out for each information source and the scores allocated accordingly. The total score obtained for this question will be the sum of all these scores.

Sources that contain descriptive information only such as the location of the gauging station, licensed abstraction amount, gauging station details, photographs and maps should all score the minimum value of 2.

- c. The question applies to any of the information sources accompanying the record as previously identified in question 4.0(a). No consideration should be given to the actual number of sources that highlight inaccuracies. The word 'inaccuracy' is used to describe incorrect values of flow data.

5.0 AFFECTS OF ARTIFICIAL INFLUENCES

5.1 Abstractions

- a. 10 l/s and 8km are both arbitrary values. However, in the report, 'Low Flow Estimation in the United Kingdom', Gustard et al (1992) also used abstractions over 10 l/s in determining the influence of abstractions on river flow data.

If no information exists concerning the quantity of non public water supply abstractions but reference is made to an abstraction occurring in the record documentation, score as though the abstraction was over 10 l/s but provide a comment on the score obtained. If the abstraction is referred to as a small quantity such as an 'ox-eye' then score as though there was no abstraction.

- b. The term 'natural' refers only to affects of abstractions. The affects of all abstractions should be included. A record can only be scored for naturalisation if abstraction data is available for all abstractions as previously defined.

5.2 Other artificial disturbances

- a. Only reservoir compensation releases are be scored in this question. Prescribed and residual flows referring to river intakes upstream of a gauging station should be noted alongside the final score when the record is graded. Weir constructions and alterations and borehole abstractions affecting river flows are also not to be included. The latter should be scored in Section 5.1 and commented upon when grading the record.
- b. If a record is influenced by both a major disturbance to river flows and compensation releases at different times, then the total number of years that river flows are affected need to be obtained before a score can be allocated.

SCORING

The scoring of the records is self explanatory. Each of the criteria should be scored following the guidance notes. The total for each section is added up and then a grade can be assigned using the table shown below.

Section	Grade		
	A	B	C
1.0	>54	43-54	<43
2.0	>43	23-43	<23
3.0	>180	100-180	<100
4.0	>86	19-86	<19
5.0	>29	28-29	<28

REFERENCES

Gustard, A., Bullock, A. and Dixon, J.M. (1992) Low Flow Estimation in the United Kingdom. Wallingford, Institute of Hydrology. IH Report No.108.

Wright, C.E. (1978) Synthesis of River Flows from Weather Data. Reading, Central Water Planning Unit. Technical Note No.26.

CRITERIA FOR DETERMINING THE POSSIBLE 'USEFULNESS' OF HISTORIC
FLOW RECORDS

Please read the guidance notes accompanying the criteria when scoring the flow records.

1.0 RECORD COVERAGE (Maximum Score 65)

1.1 Length of record:

a. What decade do the records date from?

Pre 1880	10		
1880	9	1920	5
1890	8	1930	4
1900	7	1940	3
1910	6	1950	2

b. What is the length (from start to end date inclusive) of the record?

70 years+	10
60-70 years	9
50-60 years	8
40-50 years	7
30-40 years	6
20-30 years	5
10-20 years	4
0-10 years	3

c. How many years are missing in the record, whether continuous or not?

None	10
One year	9
One-5 years	8
6-10 years	7
11-20 years	6
+20 years	5

1.2 Data availability

a. Is data available:

Continuously	10
Daily	9
Weekly	8
Monthly	7
Yearly	6

- b. Is data available for any of the following drought years (as ranked by Wright (1978)) for Exeter, 1858, 1870, 1887, 1893, 1907, 1911, 1921, 1949 and 1976?

All	10
8 of the droughts	9
7 of the droughts	8
6 " "	7
5 " "	6
4 " "	5
3 " "	4
2 " "	3
1 " "	2
None	1

- c. Is data available for the following drought sequences (as identified by Wright (1978) for Exeter), 1857-58, 1887-88, 1893-95, 1905-07, 1920-22, 1943-44, 1947-49, 1952-54 and 1974-76?

All of the drought sequences	10
8 of the drought sequences	9
7 " "	8
6 " "	7
5 " "	6
4 " "	5
3 " "	4
2 " "	3
1 " "	2
None	1

- d. Is data also available for any of the droughts in the last decade, ie 1984, 1989 and 1990?

All	5
2 of the droughts	4
1 " "	3
None	2

2.0 ACCURACY OF FLOW MEASUREMENTS (Maximum Score 50)

2.1 Gauging Station Information

- a. Was the gauging structure approved by MAFF or an equivalent body?

Yes	10
No	5
No information	*

- b. Has the gauging structure been described as accurate at low flows?

Yes	10
No	-10
No information	*

- bi. High flows?
- | | |
|----------------|-----|
| Yes | 10 |
| No | -10 |
| No information | * |

2.2 Maintenance of gauging structures

- a. How often was the gauging station, including recording apparatus, attended to by trained personnel?
- | | |
|-------------------------|----|
| Approximately every day | 10 |
| Once a week or more | 9 |
| Fortnightly | 8 |
| Monthly | 7 |
| < once a month | 6 |
| No information | * |
- b. Had the stage discharge relationship, including the gaugings used in the rating curve been developed by trained personnel?
- | | |
|----------------|-----|
| Yes | 10 |
| No | -10 |
| No information | * |

3.0 RELIABILITY OF THE FLOW RECORDS (Maximum Score 260)

3.1 Existence of stage/discharge conversion

- Are the measurements of:
- a. Stage?
- | | |
|---------------------------------|-----|
| with a conversion chart/formula | 200 |
| without " " " " | 30 |
- or ai. Discharge?
- | | |
|---|-----|
| with the stage conversion chart/formula | 200 |
| without " " " " " " | 100 |

If the measurements do not have a rating curve accompanying them, score an X for Section 3.2 and continue on to Section 4.0.

3.2 Stage/discharge relationship:

- a. How many spot gaugings make up the rating curve?
- | | |
|--------|----|
| 100+ | 10 |
| 80-100 | 9 |
| 60-80 | 8 |
| 40-60 | 7 |
| 20-40 | 6 |
| 10-20 | 5 |
| 5-10 | 4 |
| 0-5 | 3 |

- b. Do the spot gaugings represent a good fit of the rating curve?
 Yes 10
 No 0
- c. Do the spot gaugings represent flows well at:
Low Flows? Yes 20
 No 0
- ci. High Flows? Yes 10
 No 0
- d. Is/was the rating curve regularly checked throughout the year?
 Yes 10
 No 5
 No information *

4.0 **SUPPORTING INFORMATION (Maximum Score 154)**

- a. Are any of the following sources of information available accompanying the record?
- | | |
|--|----|
| Surface Water Archive | 10 |
| Notes on the measurement charts/tables | 9 |
| Work Engineers Reports | 8 |
| Consulting Engineers Reports | 7 |
| Minutes of the Water Boards | 6 |
| Fishery Boards | 5 |
| Letters | 4 |
| Licence Files | 3 |
| Other | 2 |
- b. What proportion of the record is the information available for?
- | | |
|-----------------------|----|
| 95-100% of the record | 10 |
| 90-95% | 9 |
| 80-90% | 8 |
| 70-80% | 7 |
| 60-70% | 6 |
| 50-60% | 5 |
| 40-50% | 4 |
| 20-40% | 3 |
| 0-20% | 2 |
- c. Does any of the supporting information identified highlight inaccuracies in the record?
 Yes 10
 No 5

5.0 AFFECTS OF ARTIFICIAL INFLUENCES (Maximum Score 30)

5.1 Abstractions

- a. Is the record affected by one or more of the following abstraction types:

Public Water Supply and/or Non Public Water Supply >10l/s and less than 8km away from the gauging station?

Yes 0

No 10

- b. Where abstractions have taken place, what proportion of the record is natural and/or can be naturalised due to the existence of abstraction data?

95-100% of the record 10

90-95% 9

80-90% 8

70-80% 7

60-70% 6

50-60% 5

40-50% 4

20-40% 3

5-20% 2

0-5% 0

5.2 Other artificial disturbances:

- a. Is the record affected by reservoir compensation releases and/or major disturbances to the river flow such as the construction of a reservoir upstream?

No 20

Yes 0

- b. What is the total proportion of the record influenced by major disturbances to the river flow and/or reservoir compensation releases?

Up to 5% of the record 10

5-10% 9

10-20% 8

20-30% 7

30-40% 6

40-50% 5

50-60% 4

60-70% 3

70-80% 2

80-95% 1

95-100% 0

APPENDIX 2

Score chart

Scores/Grades Obtained

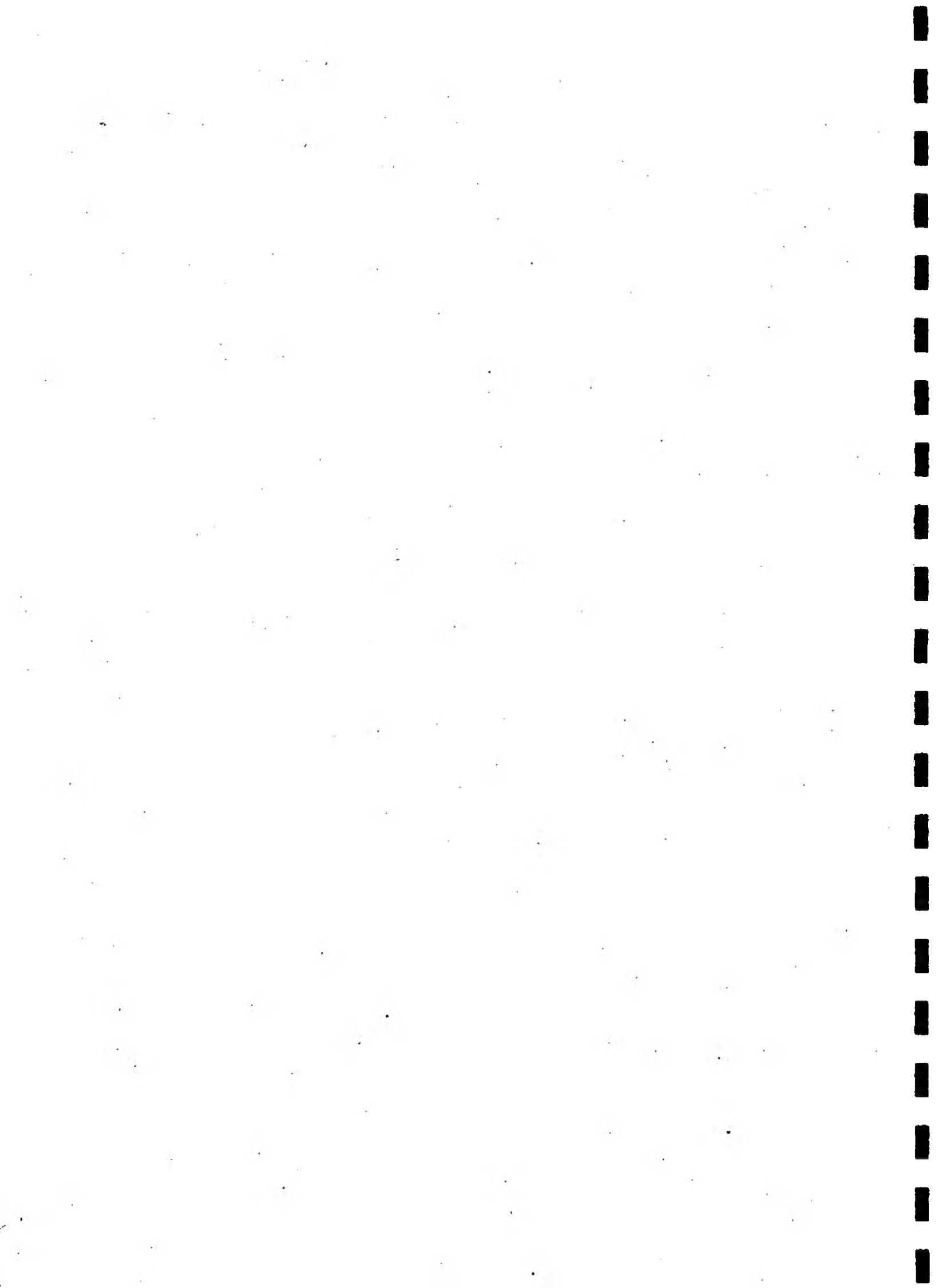
		'Model' Record	Trenchford/ Blackingstone 1 1908-1939	Trenchford/ Blackingstone 2 1948-1964	Kennick	South Telgn Intake	Fernworthy	Swincombe Intake
Coverage	1.1a	7	7	3	7	5	3	4
	1.1b	9	8	4	8	4	5	6
	1.1c	7	8	10	8	9	9	10
	1.2a	7	7	8	7	7	10	9
	1.2b	5	1	2	1	1	2	2
	1.2c	6	1	2	1	1	2	4
	1.2d	2	2	2	2	2	2	2
	Total Score	43	32	31	32	29	33	37
	Grade	B	C	C	C	C	C	C
Accuracy	2.1a	5	*	*	*	*	10	10
	2.1b	10	10	10	10	*	*	10
	2.1bl	10	10	10	10	*	*	10
	2.2a	8	*	*	10	*	*	*
	2.2b	10	*	*	*	*	*	*
	Total Score	43	20***	20***	30**	*****	10*****	30**
	Grade	B	C/***	C/***	B/**	*****	C/*****	B/**
Reliability	3.1a/al	100	100	30	100	100	100	200
	3.2a	X	X	X	X	X	X	X
	3.2b							
	3.2c							
	3.2cl							
	3.2d							
	Total Score	100/X	100/X	30/X	100/X	100/X	100/X	200/X
	Grade	B/X	B/X	C/X	B/X	B/X	B/X	A/X
Supporting Information	4.0a	8	13	22	12	11	24	15
	4.0b	8	14	16	14	12	16	14
	4.0c	5	5	5	5	5	10	10
	Total Score	19	32	43	31	28	50	39
	Grade	B	B	B	B	B	B	B
Artificial Influences	5.1a/b	8	10	10	10	10	8	0
	5.2a/b	20	20	20	20	6	0	20
	Total Score	28	30	30	30	16	8	20
	Grade	B	A	A	A	C	C	C

Scores/Grades Obtained

		'Model' Record	Bala Brook Intake	Avon Intake	Irishmans Wall	Abbey Weir	Meavy	Brampford Speke	Exeter Quay
Coverage	1.1a	7	4	4	3	4	7	7	7
	1.1b	9	7	6	7	8	4	3	3
	1.1c	7	7	8	5	8	8	10	10
	1.2a	7	10	10	10	10	9	7	7
	1.2b	5	2	2	2	3	3	3	3
	1.2c	6	3	4	2	5	2	1	1
	1.2d	2	2	2	4	5	2	2	2
	Total Score	43	35	36	33	43	35	33	33
	Grade	B	C	C	C	B	C	C	C
Accuracy	2.1a	5	10	10	10	10	*	*	*
	2.1b	10	10	*	10	10	*	*	*
	2.1bl	10	10	*	-10	-10	10	*	*
	2.2a	8	9	*	8	*	*	6	6
	2.2b	10	*	*	*	10	*	10	10
	Total Score	43	39*	10****	18*	20*	10****	16***	16***
	Grade	B	B/*	C/****	C/*	C/*	C/****	C/***	C/***
Reliability	3.1a/al	100	100	100	200	30	200	200	200
	3.2a	X	X	X	X	X	X	4	4
	3.2b							10	10
	3.2c							20	20
	3.2cl							0	0
	3.2d							5	5
	Total Score	100/X	100/X	100/X	200/X	30/X	200/X	239	239
	Grade	B/X	B/X	B/X	A/X	C/X	A/X	A	A
Supporting Information	4.0a	6	28	28	29	12	37	10	10
	4.0b	8	18	19	35	14	28	12	12
	4.0c	5	10	10	10	5	10	10	10
	Total Score	19	56	57	74	31	75	32	32
	Grade	B	B	B	B	B	B	B	B
Artificial Influences	5.1a/b	8	0	2	3	10	6	10	0
	5.2a/b	20	20	4	20	20	20	20	20
	Total Score	28	20	6	23	30	26	30	20
	Grade	B	C	C	C	A	C	A	C

APPENDIX 3

Additional flow records discovered



FLOW RECORDS STILL TO BE FOUND

River	Gauging Station	N.G.R.	Records collected by	Start Date
W.Okement	Vellake	SX557903	North Devon Water Board	1943
Venford Stream	Venford Reservoir	SX687712	Paignton Urban District Council	1900
Erme	Erme Intake	SX640632	Plympton Rural District Council	1951
Otter	Knackers Hole	ST221121	Taunton Corporation	1950's
Otter	Royston Water	ST226131	Taunton Corporation	1950's
Withey Brook	Withey Brook	SX241749	Torpoint	1904
Plymouth Leat/Meavy	Head Weir	SX551679*	Plymouth Corporation	1858

* The N.G.R. is approximate as the gauging station was made obsolete when the impoundment of Burrator Reservoir began

APPENDIX 4

**Catalogue: Trenchford/
Blackingstone**

1.0 SUMMARY

GAUGING STATION NAME: TRENCHFORD BLACKINGSTONE
RIVER: TRENCHFORD STREAM BLACKINGSTONE
STREAM
START AND END DATE OF RECORD: 1908-1964
ARTIFICIALLY INFLUENCED?: NO

2.0 SITE INFORMATION

- River
Trenchford Stream and Blackingstone Stream
- Grid Reference
SX 801 830 and SX 800 850 (See Map 1)
- Catchment area
3.26km² and 1.80km²

2.1 Background to the measurements

The Trenchford and Blackingstone Streams were two of eight streams gauged by the Torquay Corporation in association with the Kennick, Tottiford and Trenchford reservoir complex. The six other streams are listed in Section 6.2 of the catalogue and are documented in Catalogue 5, Kennick. The measurement structures, as shown in photographs 1-5, were constructed pre 1906 to measure inflows into the Kennick and Trenchford Reservoirs.

2.2 Current measuring authority

No longer used

3.0 RECORD DETAILS

3.1 Record length, with details of missing records

1908 - 1939 and 1948 - 1964. In the 1908-1939 section of the records the following records are missing:
1910, 1911, 1921, 1925 and 1931.
From 1964 measurements are only available for the total inflows into the three reservoirs, see chart 2.

3.2 Record format (Includes data type and media of the data)

1908-1939 Monthly totals of discharge, on *spreadsheet and *photocopies (Explanation of * in Section 7.0). The discharge values have also been converted to cumecs and are available on 3.5" disc. Summary information of the data on disc, filenames and the disc itself is contained in Appendix 17.

1948-1964 Weekly values of stage, tabulated on weekly charts, see Chart 1. All weekly charts are on microfilm, held at NRA SW, Devon Record Office and IOH. (Addresses in Appendix 16). The values from the charts have been copied onto 3.5" disc (see Appendix 17) and are also available on *spreadsheet.

3.3 Problems with the record format

Data: The 1908-1939 section of the Trenchford record has been analyzed by Water Resources Planning, NRA SW and some of the measurements during the winter months were found to be incorrect, probably due to ice forming behind the weir.

The 1948-1964 sections of the two records are of stage with units of inches. Rating curves are unavailable for the sites.

4.0 MEASURING STRUCTURE AND EQUIPMENT

4.1 Measurement Structure

- Brief description

Purpose built gauging weir

- Type of structure

Thin plate rectangular notch

- Weir approval?

No information

- Weir alterations?

The Trenchford Stream measuring weir was remodelled in 1912 to ensure accurate recording of large floods.

- Operational problems?

No information

4.2 Recorder unit

- Manufacturer
No information
- Type
Chart
- Measurement in discharge or stage?
Stage 1948-64
- Units of measurement
Inches 1948-64
- Rating curve available?
No
- Stage/discharge conversion tables available?
No
- Operational problems?
No information

5.0 ARTIFICIAL INFLUENCES

5.1 Abstractions

- Has the record been affected by abstractions?
No
- What is the purpose of the abstractions?
-
- Abstraction Details
-
- Period of abstraction?
-

- What are/were the volumes of water abstracted, either licensed or approximate?
-

- Is the actual abstraction data available?
-

5.2 Reservoirs

- Has the gauging station been affected by the construction of a reservoir?

No

- When did construction begin?
-

6.0 OTHER RECORDS AVAILABLE

6.1 Availability of meteorological data

- Are meteorological records available for the site such as rainfall, evaporation records etc? Give details

Rainfall values for the Kennick rain gauge are available for the years 1897, 1904-1936, and 1948-1972. However, figures are shown for an old and new Kennick gauge so the gauge seems to have been changed between 1948-1964. The 1908-1939 and 1948-1964 sections of the record have rainfall values for the Tottiford and Smithacott rain gauges.

Monthly evaporation figures are shown for the years 1906 to 1936. Monthly sunshine values for Torquay are shown from 1908-1912. Air temperatures inside and outside the screens are shown from 1948-1964. The locations of all the measuring apparatus are not documented.

Wind directions have been noted from 1948-1964.

6.2 Availability of reservoir records

- If the record is an inflow or outflow to a reservoir, are there any other records available. Eg, transfers, reservoir levels, change in storage? Give details

Other inflow records are available for the reservoir complex. These are:
Kennick Stream 1908-1938
Bullaton 1 1908-1938

Bullaton 2 1908-1938
Clampitt Stream 1908-1938
Higher Mardon 1908-1938
Lower Mardon 1908-1938

From 1964-1972 measurements for total inflows are shown on the microfilm charts. Chart 2 is an example of the charts.

Overflow records for the Trenchford Stream are available from 1914-1938 and 1948-1972.

Abstraction details on the volume of water abstracted from Fernworthy Reservoir to Trenchford Reservoir are available between 1929-1939 and 1948-1972.

Depths of the three reservoirs are available from 1948-1972. Values for the quantity in storage are shown from 1964-1972.

Additional information is also tabulated on Microfilm. Two examples of the tabulated charts are included with the catalogue. Chart 1 is the chart used from 1948-1964. Chart 2 was used from 1964-1972.

7.0 SUPPORTING DOCUMENTATION

7.1 Data sources and locations

NRA SW Hydrometric Services: Microfilms KTT Reservoirs 1948-1953
1953-1963
1963-1964
1964-1972

NRA SW Registry: Licence file 14/46/03/0615

NRA SW: *Ministry of Health and Scottish Office. (1939) The Surface Water Year Book of Great Britain. London, H.M.S.O.

Torquay Reference Library: *Chapman, S. (1909) Annual Report for the year 1908. Torquay, Borough of Torquay Waterworks Department.

The library has annual reports by S. Chapman from 1906-1939 with the following years missing; 1910, 1911, 1921, 1925 and 1931. The library has bound the reports into two volumes, *1906-1929 and *1930-1939.

Devon Record Office: Above Microfilms

Institute of Hydrology: Microfilms KTT Reservoirs 1948-1953
1953-1963
1963-1964

* Extracts and data from information marked with a * are available from NRA SW Water Resources Planning in the following file:

HYDROMETRY: Hydrometric Data. Riverflow; Historic Records, Wallet numbers 1-3.

N



Chart 1

TOTTIFORD DAILY GAUGINGS

Month		Year							
		1966							
DEPTHS	KENNICK	9.30	9.30	9.30	9.30	9.30	9.30	9.30	9.30
	TOTTIFORD	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
	TRENCHFORD	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.40
Gaugings	KENNICK	07.00	07.00	07.00	07.00	07.00	07.00	07.00	07.00
	TOTTIFORD								
	TRENCHFORD								
METERS	30" (OLD) MAIN	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	10" (NEW) MAIN	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	15" MAIN	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
	18" MAIN	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
	24" MAIN	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
FERNWORTHY	WEIR (Inches)	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
	RECORDER								
	FLOW								
RAINFALL	KENNICK (NEW)								
	do. (OLD)								
	TOTTIFORD								
	SMITHAMOTT								
TEMPERATURE	LAPLOYD								
	TRENCHFORD								
	BLACKINGSTONE								
TEMPERATURE	AIR INSIDE SCREENS	55	42	37	43	39	43	35	37
	AIR OUTSIDE SCREENS	34	44	38	42	39	44	37	34
WIND		E	E	E	E	E	E	E	E
SUSTAINING VALVE - PRESSURE									
FLOW AT TOTTIFORD									
LEEDS ROTARY METER									

TOTTIFORD CATCHMENT

READINGS TAKEN AT 09 00 HRS.

MONTH: _____

24" DALL TUBE		TRENCHFORD OVERFLOW		TOTAL OUTFLOW	IMPOUNDING RESERVOIR								FROM FERNWORTH	WASH WATER RECOVERY	INFLOW
INDEX	FLOW	HEAD (INS)	QUANTITY (GPD)		KENNICK		TOTTIFORD		TRENCHFORD		TOTAL STORAGE	CHANGE IN STORAGE			
					DEPTH	QUANTITY IN STORE	DEPTH	QUANTITY IN STORE	DEPTH	QUANTITY IN STORE					
111	5.110	29'10"		5.110	29'10"	192.750	23'0"	103.200	29'10"	192.750	121.002	1.747 -	3.059		0.337
112	5.070	29'10"		5.070	29'10"	192.750	23'0"	103.200	29'10"	192.750	121.002	1.747 -	3.059		0.337
113	5.230	29'10"		5.230	29'10"	192.750	23'0"	103.200	29'10"	192.750	121.002	2.127 -	3.059		0.721
114	4.970	29'10"		4.970	29'10"	192.750	23'0"	103.200	29'10"	192.750	121.002	2.335 -	3.059		0.721
115	4.810	29'10"		4.810	29'10"	192.750	23'0"	102.453	29'10"	192.750	121.002	2.335 -	3.059		0.721
116	5.310	29'10"		5.310	29'10"	191.500	23'0"	102.453	29'10"	191.500	121.002	1.948 -	3.059		0.721
117	5.350	29'10"		5.350	29'10"	191.500	23'0"	102.453	29'10"	191.500	121.002	1.948 -	3.059		0.721
118	4.870	29'10"		4.870	29'10"	192.750	23'0"	103.200	29'10"	192.750	121.002	1.113 -	3.059		0.721
119	4.850	29'10"		4.850	29'10"	192.750	23'0"	103.200	29'10"	192.750	121.002	1.092 -	3.059		0.721
120	4.650	29'10"		4.650	29'10"	192.750	23'0"	103.200	29'10"	192.750	121.002	1.752 -	3.059		0.721
121	4.850	29'10"		4.850	29'10"	191.500	23'0"	103.200	29'10"	191.500	121.002	0.752 +	3.059		0.721
122	4.210	29'10"		4.210	29'10"	192.750	23'0"	103.200	29'10"	192.750	121.002		3.059	0.721	0.721
123	4.060	29'10"		4.060	29'10"	192.750	23'0"	103.200	29'10"	192.750	121.002	2.325 +	3.059		0.721
124	4.000	29'10"		4.000	29'10"	191.000	23'1"	103.200	29'10"	191.000	121.002		3.059		0.721
125	5.080	29'10"		5.080	29'10"	191.000	23'1"	103.200	29'10"	191.000	121.002	2.325 -	3.059	0.337	0.337
126	5.570	29'10"		5.570	29'10"	192.750	23'0"	103.200	29'10"	192.750	121.002	1.075 -	3.059		1.131
127	5.650	29'10"		5.650	29'10"	192.750	22'9"	101.050	29'10"	192.750	121.002	1.970 -	3.059		0.721
128	5.430	29'10"		5.430	29'10"	192.750	22'8"	97.466	29'10"	192.750	121.002	1.897 -	3.059		0.721
129	5.410	29'10"		5.410	29'10"	192.750	21'11"	93.900	29'10"	192.750	121.002	0.955 -	3.059		1.131
130	4.600	29'10"		4.600	29'10"	192.750	21'8"	91.833	29'10"	192.750	121.002	0.833 -	3.059		0.721
131	4.560	29'10"		4.560	29'10"	192.750	21'5"	89.833	29'10"	192.750	121.002	0.811 -	3.059		1.131
132	4.710	29'10"		4.710	29'10"	192.750	21'2"	87.833	29'10"	192.750	121.002	0.875 -	3.059		1.131

ADDITIONAL DATA, NOT PUT ON TO DISC, FOR THE KENNICK, TOTTFORD, TRENCHFORD
RESERVOIR COMPLEX

RAINFALL (INCHES) DURING DRY/WET PERIODS BETWEEN 1901/06 FOR KENNICK RAIN
GAUGE

Year	Monthly periods		
	1/1 - 1/3	1/3 - 1/10	1/10 - 31/12
1901	5.95	21.57	11.5
1902	4.73	18.91	13.72
1903	7.03	26.89	18.26
1904	13.59	18.03	8.36
1905	3.12	21.19	9.48
1906	12.4	10.08	12.36
Aver. 29yrs	7.57	19.17	14.02
Driest yr. on record	4.29	10.27	12.98

RESERVOIR STATUS IN 1913/1914

Reservoir	Capacity of the reservoirs	Quantity drawn from Res.	First drawn down	First Filled	Amount in Reservoirs in 31/12/13
Kennick	194,000,000	92,000,000	12/6	9/11	158,000,000
		100000,000	11/5	31/10*	194,000,000
Tottiford	103,000,000	96,000,000	1/7	9/11	29,000,000
		96,000,000	5/6	15/10	103,000,000
Trenchford	171,000,000	22,000,000	9/6	10/11	171,000,000
		134000,000	9/5	21/11*	171,000,000

*=repairs

YIELD OF CATCHMENT AREA

1915	Abstraction by Venturi Meter	Trenchford Overflow (gallons)
January	57,810,000	239,127,228
February	52,770,000	281,260,528
March	58,450,000	54,423,438
April	56,640,000	-
May	59,930,000	-
June	58,975,000	-
July	56,635,000	-
August	57,015,000	-
September	53,785,000	69,075,466
October	51,905,000	46,068,380
November	50,760,000	-
December	51,865,000	43,219,200

TOTAL INFLOWS INTO THE RESERVOIRS

	1926	1927	1928
January	340,584,000	162,515,648	244,281,180
February	268,572,000	202,201,264	195,004,430
March	62,460,000	219,207,726	223,860,470
April	29,805,000	146,407,278	126,953,680
May	16,991,000	28,929,000	44,274,358
June	30,205,000	12,065,000	19,699,000
July	12,908,000	33,792,000	9,655,000
August	11,418,000	35,215,000	10,640,000
September	12,997,000	84,596,000	8,690,000
October	11,282,000	92,905,000	55,834,000
November	235,584,000	140,788,000	173,206,000
December	159,795,000	205,059,032	226,224,000

**AVERAGE ANNUAL FLOWS IN TO AND OUT OF THE KENNICK, TOTTFORD AND
TRENCHFORD RESERVOIR COMPLEX**

	Abstraction (cumeecs)	Trenchford Overflow (cumeecs)	Added to Storage (cumeecs)	Fernworthy Supply (cumeecs)	*Yield (cumeecs)
1915	0.0961	0.1001	-	-	0.1962
1916	0.0963	0.1193	-	-	0.2156
1917	0.1007	0.0473	-	-	0.1480
1918	0.1054	0.0331	-	-	0.1384
1919	0.1045	0.1171	-	-	0.2216
1920	0.1071	0.0757	-	-	0.1828
1922	0.0884	0.0314	0.0545	-	0.1743
1923	0.0963	0.1083	-	-	0.2046
1924	0.0983	0.1384	-	-	0.2367
1926	0.1095	0.0624	-	-	0.1720
1927	0.1154	0.0703	0.1098	-	0.1966
1928	0.1213	0.0817	(0.0062)	-	0.1968
1929	0.1244	0.1403	0.0066	(0.0276)	0.2427
1930	0.1284	0.1235	0	(0.0235)	0.2283
1932	0.1303	0.0816	0.0039	(0.0304)	0.1854
1933	0.1369	0.0558	0.0283	(0.0279)	0.1365
1934	0.1344	0.0633	0.0264	(0.0480)	0.1761
1935	0.1390	0.0674	0.0057	(0.0357)	0.0357
1936	0.1468	0.1130	0.0006	(0.0392)	0.2200
1937	0.1517	0.1386	0.0218	(0.0287)	0.2399
1938	0.1524	0.0537	0.0222	(0.0488)	0.1795

*Yield = Trenchford Overflow + Abstraction +/- Change in Storage -
Fernworthy Supply







APPENDIX 5

Catalogue: Kennick

Bullaton 1

Bullaton 2

Clampitt

Higher Mardon

Lower Mardon

1.0 SUMMARY

GAUGING STATION NAME: KENNICK, BULLATON 1 AND 2, CLAMPITT,
HIGHER AND LOWER MARDON

RIVER: ALL STREAMS OF THE SAME NAME

START AND END DATE OF RECORD: 1908-1938

ARTIFICIALLY INFLUENCED?: NO

2.0 SITE INFORMATION

- River

a) Kennick Stream, b) Bullaton 1 Stream, c) Bullaton 2 Stream,
d) Clampitt Stream, e) Higher Mardon Stream and f) Lower Mardon
Stream

- Grid Reference

a) SX 808 839, b) SX 803 826, c) SX 802 828, d) SX 806 844,
e) SX 805 824 and f) SX 805 827 (See Map 1)

- Catchment area

a) 0.46km², b) 0.055km², c) 0.18km², d) 0.58km², e) 0.045km²
and f) 0.13km²

2.1 Background to the measurements

The six streams were gauged by the Torquay Corporation, along with the Trenchford and Blackingstone Streams, (see Appendix 4), in association with the Kennick, Tottiford and Trenchford reservoir complex. The measurement structures shown in photographs 1-10, were constructed pre 1906 to measure inflows into the three reservoirs.

2.2 Current measuring authority

No longer used

3.0 RECORD DETAILS

3.1 Record length, with details of missing records

1908 - 1938. In the 1908-1938 section of the records the following records are missing:
1910, 1911, 1921, 1925 and 1931.

3.2 Record format (Includes data type and media of the data)

1908-1938 Monthly totals of discharge, on *spreadsheet and *photocopies (Explanation of * in Section 7.0). The discharge values have also been converted to cumecs and are available on 3.5" disc. Summary information of the data on disc, filenames and the disc itself is contained in Appendix 17.

3.3 Problems with the record format

No information

4.0 MEASURING STRUCTURE AND EQUIPMENT

4.1 Measurement Structure

- Brief description
Purpose built gauging weirs
- Type of structure
Thin plate "V" notch
- Weir approval?
No information
- Weir alterations?
No information
- Operational problems?
No information

4.2 Recorder unit

- Manufacturer
No information
- Type
Staff gauge
- Measurement in discharge or stage?
Stage

- Units of measurement
Feet and inches
- Rating curve available?
No
- Stage/discharge conversion tables available?
No
- Operational problems?
No information

5.0 ARTIFICIAL INFLUENCES

5.1 Abstractions

- Has the record been affected by abstractions?
No
- What is the purpose of the abstractions?
-
- Abstraction Details
-
- Period of abstraction?
-
- What are/were the volumes of water abstracted, either licensed or approximate?
-
- Is the actual abstraction data available?
-

5.2 Reservoirs

- Has the gauging station been affected by the construction of a reservoir?
No

- When did construction begin?

6.0 OTHER RECORDS AVAILABLE

6.1 Availability of meteorological data

- Are meteorological records available for the site such as rainfall, evaporation records etc? Give details

Rainfall values for the Kennick rain gauge are available for the years 1897 and 1904-1936. Rainfall values are also available for the Tottiford and Smithacott rain gauges.

Monthly evaporation figures are shown for the years 1906 to 1936. Monthly sunshine values for Torquay are shown from 1908-1912. The locations of all the measuring apparatus are not documented.

6.2 Availability of reservoir records

- If the record is an inflow or outflow to a reservoir, are there any other records available. Eg, transfers, reservoir levels, change in storage? Give details

Two other inflow records are available for the reservoir complex. They are:

Trenchford Stream and blackingstone Stream 1908-1939
1948-1964

Overflow records for the Trenchford Stream are available from 1914-1938.

Abstraction details on the volume of water abstracted from Fernworthy Reservoir to Trenchford Reservoir from 1929-1939.

7.0 SUPPORTING DOCUMENTATION

7.1 Data sources and locations

NRA SW Registry: Licence file 14/46/03/0615

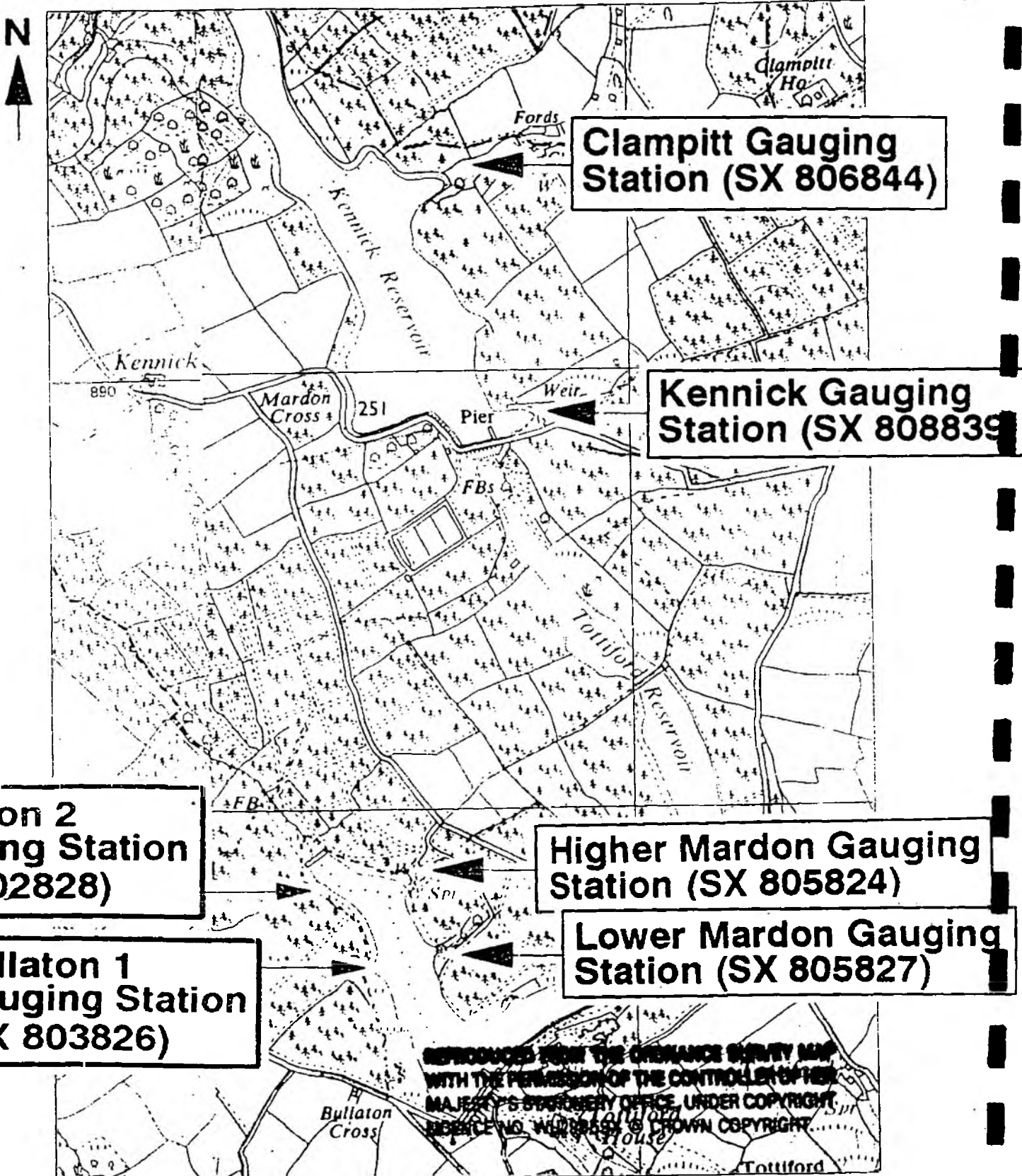
Torquay Reference Library: *Chapman, S. (1907) Annual Report for the year 1906. Torquay, Borough of Torquay Waterworks Department.

The library has annual reports by S. Chapman from 1906-1939 with the following years missing; 1910, 1911, 1921, 1925 and 1931. The library has bound the reports into two volumes, *1906-1929 and *1930-1939.

* Extracts and data from information marked with a * are available from NRA SW Water Resources Planning in the following file:

HYDROMETRY: Hydrometric Data. Riverflow; Historic Records, Wallet numbers 1-3.

Map 1: Kennick



Scale
1: 12500

APPENDIX 6

Catalogue: South Teign Intake

1.0 SUMMARY

GAUGING STATION NAME: SOUTH TEIGN INTAKE

RIVER: SOUTH TEIGN

START AND END DATE OF RECORD: 1929-1939

ARTIFICIALLY INFLUENCED?: YES

2.0 SITE INFORMATION

- River

South Teign

- Grid Reference

Approximately SX 671 844 (See Map 1)

- Catchment area

9.71km²

2.1 Background to the measurements

The South Teign Intake and measuring weir were constructed under the Torquay Corporation Water Act in 1927. The Corporation were able to abstract water from the South Teign River providing the flow below the weir was no less than 1,250,000 gallons/day. The measuring equipment was set up to measure this flow. Once Fernworthy Reservoir was completed in 1943 the Intake was no longer used. However, the approximate site of the Intake is where the compensation weir of Fernworthy is now, see photographs 1 and 2 in Appendix 7, Fernworthy Compensation.

2.2 Current measuring authority

No longer used

3.0 RECORD DETAILS

3.1 Record length, with details of missing records

1929 - 1939 with the 1931 record missing.

3.2 Record format (Includes data type and media of the data)

1929-1939 Monthly totals of discharge, on *spreadsheet (Explanation of * in Section 7.0). The discharge values have also been converted to cumecs and are available on 3.5" disc. Summary information of the data on disc, filenames and the disc itself is contained in Appendix 17.

3.3 Problems with the record format

No known problems

4.0 MEASURING STRUCTURE AND EQUIPMENT

4.1 Measurement Structure

- Brief description
Purpose built gauging weir
- Type of structure
Thin plate rectangular notch
- Weir approval?
No information
- Weir alterations?
No information
- Operational problems?
No information

4.2 Recorder unit

- Manufacturer
No information
- Type
Chart
- Measurement in discharge or stage?
No information

- Units of measurement
No information
- Rating curve available?
No
- Stage/discharge conversion tables available?
No
- Operational problems?
No information

5.0 ARTIFICIAL INFLUENCES

5.1 Abstractions

- Has the record been affected by abstractions?
Yes
- What is the purpose of the abstractions?
1 public water supply
- Abstraction Details

The abstraction was authorised under the Torquay Corporation Water Act in 1927. The water was abstracted via a gravity pipeline to Trenchford Reservoir. Photographs 5 and 6 in Appendix 7, Fernworthy Compensation, show the site where the water was released into Trenchford Reservoir. The water released into the Reservoir today has been abstracted from Fernworthy Reservoir.
- Period of abstraction?
1929 to the present day
- What are/were the volumes of water abstracted, either licensed or approximate?
3,000,000 gallons per day
- Is the actual abstraction data available?

Yes. Abstraction data in monthly totals of discharge are available on *spreadsheet. The discharges have been converted to cumecs and are on 3.5" disc (See Appendix 17).

5.2 Reservoirs

- Has the gauging station been affected by the construction of a reservoir?

Yes

- When did construction begin?

June 1934

6.0 OTHER RECORDS AVAILABLE

6.1 Availability of meteorological data

- Are meteorological records available for the site such as rainfall, evaporation records etc? Give details

Monthly rainfall figures for the Fernworthy catchment are shown from 1928 to 1936.

6.2 Availability of reservoir records

- If the record is an inflow or outflow to a reservoir, are there any other records available. Eg, transfers, reservoir levels, change in storage? Give details

-

7.0 SUPPORTING DOCUMENTATION

7.1 Data sources and locations

NRA SW Registry: Licence file *14/46/03/0614

NRA SW:* Plymouth Water Undertaking. (March 1969) Report on Future Water Resources. Westminster, Binnie and Partners. Vol II.

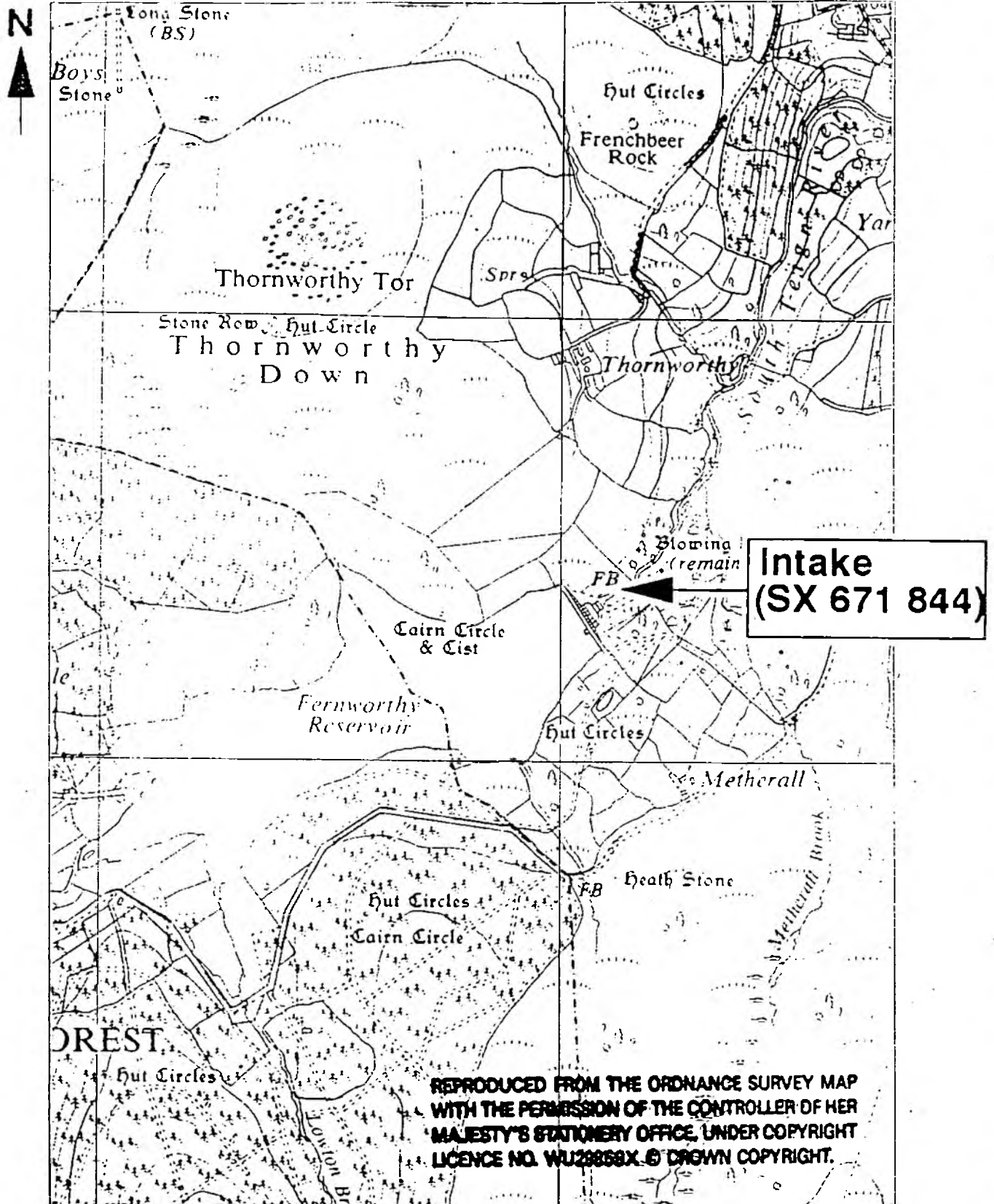
Torquay Reference Library:*Chapman, S. (1930) Annual Report for the year 1929. Torquay, Borough of Torquay Waterworks Department.

The library has annual reports by S. Chapman from 1906-1939 with the following years missing; 1910, 1911, 1921, 1925 and 1931. The library has bound the reports into two volumes, *1906-1929 and *1930-1939. Relevant information is from 1929 onwards.

- * Extracts and data from information marked with a * are available from NRA SW Water Resources Planning in the following file:

HYDROMETRY: Hydrometric Data. Riverflow; Historic Records, Wallet numbers 4-7

Map 1: South Teign Intake



Scale
1: 12500

APPENDIX 7

Catalogue: Fernworthy
Compensation

1.0 SUMMARY

GAUGING STATION NAME: FERNWORTHY COMPENSATION

RIVER: SOUTH TEIGN

START AND END DATE OF RECORD: 1947-1972

ARTIFICIALLY INFLUENCED?: YES

2.0 SITE INFORMATION

- River

South Teign

- Grid Reference

SX 671 844 (See Map 1)

- Catchment area

10km²

2.1 Background to the measurements

Fernworthy Reservoir, including the compensation weir was constructed under the Torquay Corporation Act 1934. The Corporation were able to impound water on the South Teign providing a compensation flow of 1.25 MG/d was released to the South Teign below the reservoir. The measuring equipment, shown in photographs 1-4, was set up to measure this flow.

2.2 Current measuring authority

SWWSL

3.0 RECORD DETAILS

3.1 Record length, with details of missing records

September 1947 - January 1972

3.2 Record format (Includes data type and media of the data)

1947-1972 Continuous measurements of discharge and stage on weekly charts, see Chart 1. All weekly charts are on microfilm held at NRA SW, Devon Record office and the Institute of Hydrology (Addresses in Appendix 16).

3.3 Problems with the record format

Problems with the chart recorder has meant that some of the data is missing or has been recorded incorrectly. In some cases this has been noted on the charts.

4.0 MEASURING STRUCTURE AND EQUIPMENT

4.1 Measurement Structure

- Brief description
Purpose built gauging weir
- Type of structure
Thin plate compound weir 28m long
- Weir approval?
Yes. Approved by the Fishery Board.
- Weir alterations?
None
- Operational problems?
None

4.2 Recorder unit

- Manufacturer
George Kent Limited
- Type
Chart. Photograph 4 shows the mechanical recorder that was used to measure the compensation flow.
- Measurement in discharge or stage?
Discharge and stage, see Chart 1.
- Units of measurement
Million gallons per day and inches over an 18" notch

- Rating curve available?

No. Recorder charts are calibrated for automatic conversion of stage to discharge.

- Stage/discharge conversion tables available?

No

- Operational problems?

Notes on the charts detail problems such as the clock stopping or being out of order.

5.0 ARTIFICIAL INFLUENCES

5.1 Abstractions

- Has the record been affected by abstractions?

Yes

- What is the purpose of the abstractions?

1 public water supply

- Abstraction Details

The abstraction was authorised under the Torquay Corporation Act 1934. The water is abstracted via a gravity pipeline to Trenchford Reservoir. Photographs 5 and 6 show the abstracted water being released into Trenchford Reservoir. A small off-take from the pipeline takes water to Bovey Tracey Water Treatment Works. Under the Water Resources Act 1963, a licence was issued. Details of the licence are in licence file *14/46/03/0614 (Explanation of * in Section 7.0).

- Period of abstraction?

1942, reservoir completion date, to the present day.

- What are/were the volumes of water abstracted, either licensed or approximate?

Licensed abstraction of 3.75 MG/d (Licence file *14/46/03/0614). However, the capacity of the gravity pipeline is approximately 2.64MG/d (NRA SW, 1993).

- Is the actual abstraction data available?

Yes. The amount of water abstracted from Fernworthy and released into the Trenchford Reservoir is available in tabulated daily format on microfilm from 1948 to 1972. The microfilms are available from NRA SW, Devon Record Office and IoH (Addresses in Appendix 16).

5.2 Reservoirs

- Has the gauging station been affected by the construction of a reservoir?

Yes

- When did construction begin?

June 1934

6.0 OTHER RECORDS AVAILABLE

6.1 Availability of meteorological data

- Are meteorological records available for the site such as rainfall, evaporation records etc? Give details

6.2 Availability of reservoir records

- If the record is an inflow or outflow to a reservoir, are there any other records available. Eg, transfers, reservoir levels, change in storage? Give details

Availability of abstraction data is discussed in Section 5.1

7.0 SUPPORTING DOCUMENTATION

7.1 Data sources and locations

NRA SW Hydrometric Services: Microfilms Fernworthy 1947-1951
 Waste Water 1952-1962
 (Compensation) 1963-1968
 1969-1969
 1969-1972

Trenchford 1948-1953
 Reservoir 1953-1963
 (KTT) 1963-1964
 1964-1972

NRA SW Registry: Licence file *14/56/03/0614

NRA SW: NRA SW. (February 1993). Abstraction Compliance Monitoring Stations Phase 1: Capital Scheme Assessment: Site Audits.
Scott Wilson Kirkpatrick. (Licence No. 14/46/03/0614: Fernworthy Reservoir).

*Ministry of Housing and Local Government, Scottish Office.
(1955) The Surface Water Year - Book of Great Britain.
London, H.M.S.O

Water Data Unit. Surface Water: United Kingdom 1971-73.
Department of the Environment (passive author). London,
H.M.S.O.

Devon Record Office: Above Microfilms

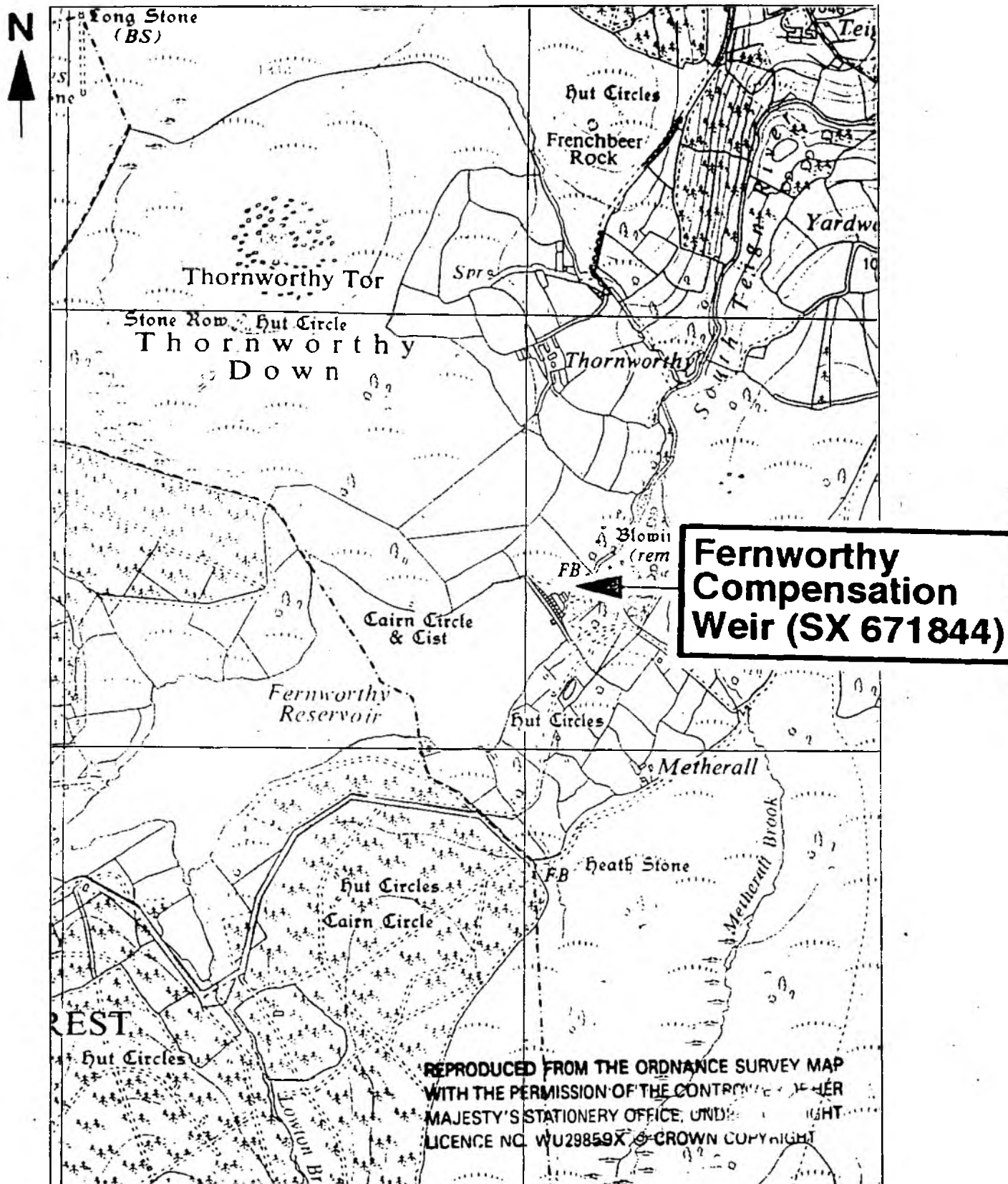
Institute of Hydrology: Microfilms Fernworthy 1963-1968
Waste Water

Trenchford 1948-1953
1953-1963
1963-1964

* Extracts and data from information marked with a * are available from NRA SW Water Resources Planning in the following file:

HYDROMETRY: Hydrometric Data. Riverflow; Historic Records,
Wallet numbers 4-7.

Map 1: Fernworthy Compensation



Scale
1: 12500

Chart 1

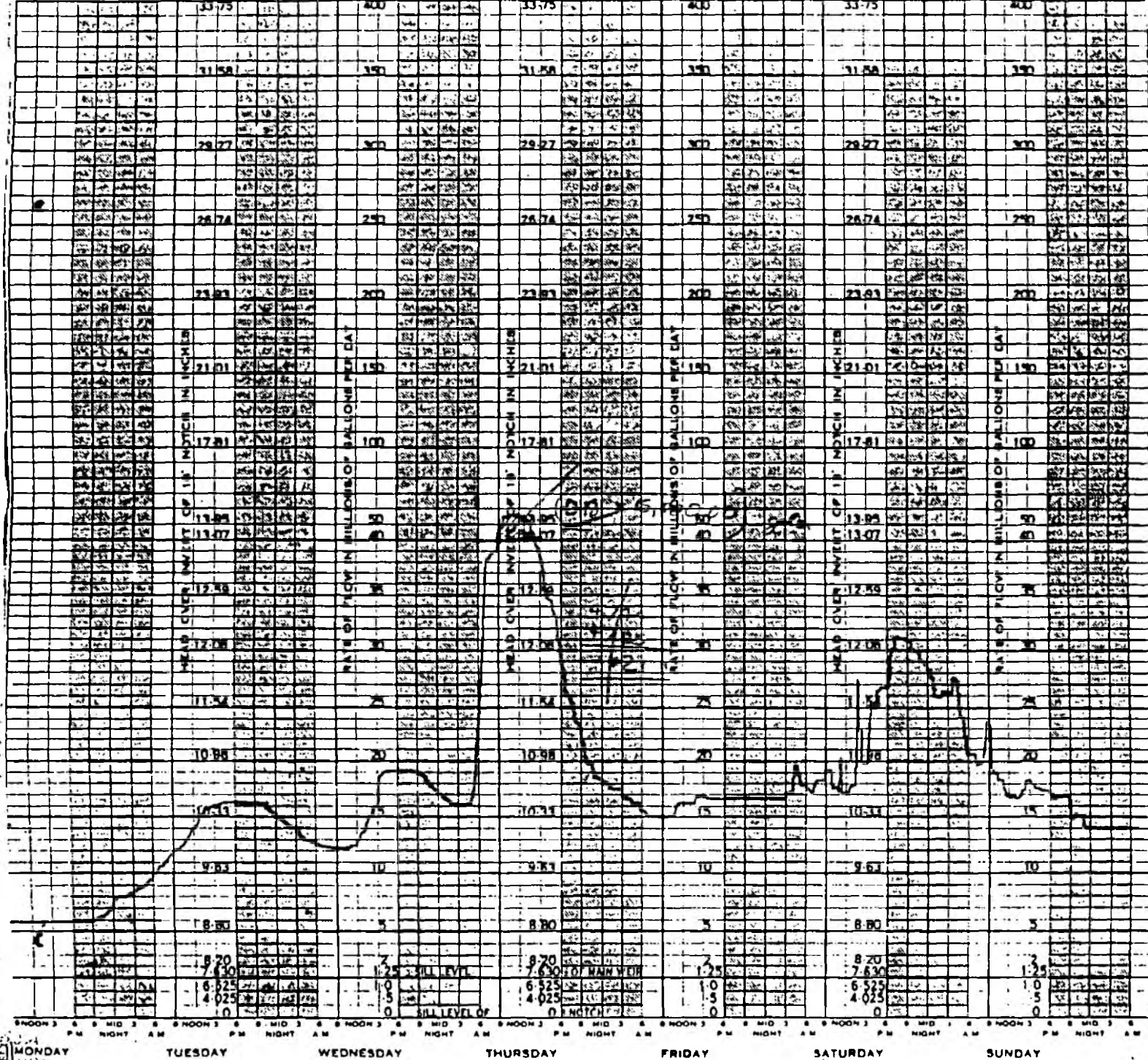
TORQUAY CORPORATION WATERWORKS

FERNWORTHY WASTE WATER WEIR

DIAGRAM SHOWING RATE OF FLOW IN MILLIONS OF GALLONS PER DAY

RECORDED NO. 8018/228
DIAGRAM NO. L. 937
GEORGE KENT LIMITED
LONDON & LUTON.
(ENGINEERS) LIMITED

WEEK ENDING 22 March 1930













Fernworthy Compensation

1.



Compensation weir viewed upstream from RHB

2.



Compensation weir viewed downstream from RHB

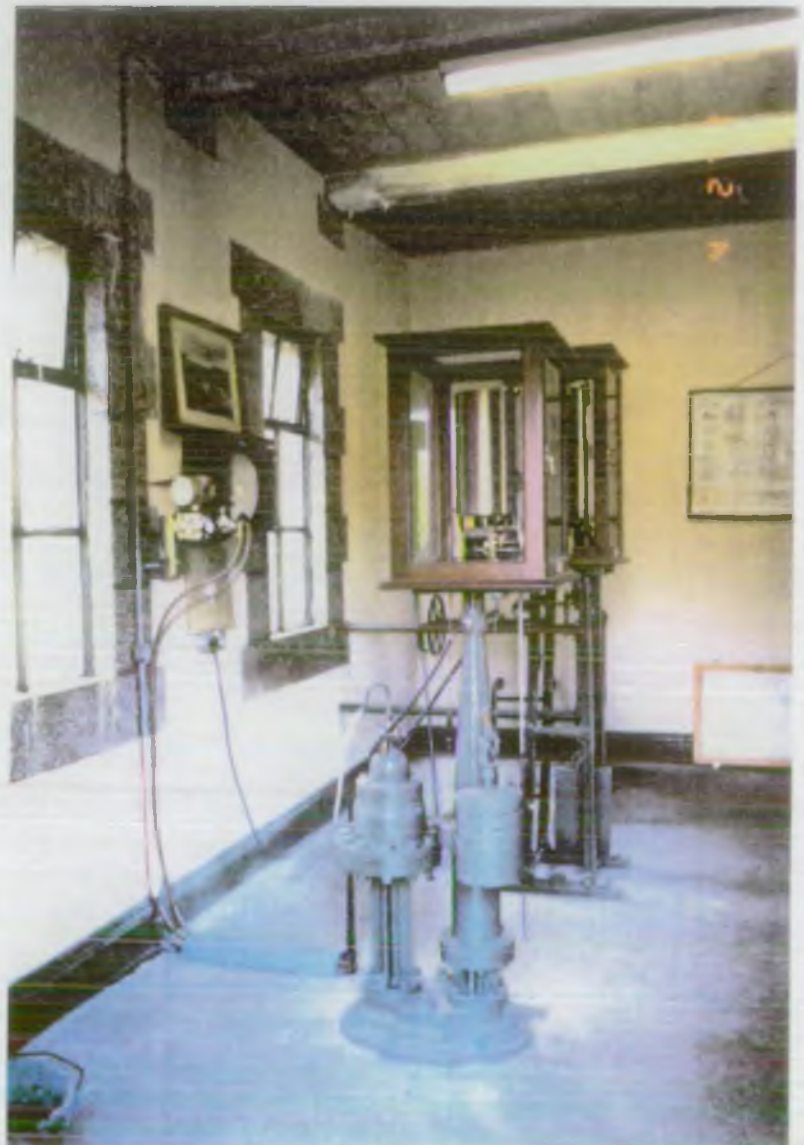
3.



Recorder House

4. Original mechanical
meters, abstraction
nearest, compensation
furthest

Fernworthy
Compensation





APPENDIX 8

Catalogue: Swincombe Intake

1.0 SUMMARY

GAUGING STATION NAME: SWINCOMBE INTAKE

RIVER: RIVER SWINCOMBE

START AND END DATE OF RECORD: 1934-1968

ARTIFICIALLY INFLUENCED?: YES

2.0 SITE INFORMATION

- River

Swincombe

- Grid Reference

SX 633 719 (See Map 1)

- Catchment area

14.2km²

2.1 Background to the measurements

The Swincombe Intake and measuring weirs, see photographs 1-4 and Diagrams 1 and 2, were constructed under the Paignton Urban District Council Water Act 1926. The Council were able to abstract water from the River Swincombe providing the flow below the abstraction point was no less than 1.8 million gallons per day during October to June and 0.5 million gallons per day during July to September. The measuring equipment was set up to measure this flow and the rate of abstraction.

2.2 Current measuring authority

SWWSL

3.0 RECORD DETAILS

3.1 Record length, with details of missing records

1934-1968 with no missing data. NRA SW, Devon Record Office and the Institute of Hydrology have microfilms relating to the Swincombe Intake after 1960 but these have not been included in the catalogue. This is because the microfilmed data and the 1934-1968 data are at present, difficult to assess as one record. The 1934-1968 data has been obtained from the Surface Water Archive at IoH and they were

unable to identify which of the four weirs the data relates to whereas the microfilmed data does identify which measuring weir it was taken from. The microfilms are listed in Section 7.0 of the catalogue.

3.2 Record format (Includes data type and media of the data)

1934-1968 Daily mean flows, in cumecs, on 3.5" disc. Summary information of the data on disc, filenames and the disc itself is contained in Appendix 17. This data is also available on *spreadsheet (Explanation of * in Section 7.0).

3.3 Problems with the record format

Data: The Surface Water Archive have a data checking system which identifies errors with the data. Therefore, the data should be accurate. The only problem with the record, as mentioned above is that it is uncertain which of the four weirs the measurements relate to.

4.0 MEASURING STRUCTURE AND EQUIPMENT

4.1 Measurement Structure

- Brief description

Purpose built gauging weirs

- Type of structure

Group of thin plate weirs

- Weir approval?

Yes. Approved by the Minister of Agriculture and Fisheries.

- Weir alterations?

No information

- Operational problems?

No information

4.2 Recorder unit

- Manufacturer

Lea Patent Recorders manufactured by the Lea Recorder Company Ltd, Manchester, England.

- Type
Chart
- Measurement in discharge or stage?
Discharge
- Units of measurement
Gallons/day
- Rating curve available ?
Yes
- Stage/discharge conversion tables available?
Yes. Tables for all four weirs are appended in an NRA SW report on the site audit of the Swincombe Intake (February 1993).
- Operational problems?
No information

5.0. ARTIFICIAL INFLUENCES

5.1 Abstractions

- Has the record been affected by abstractions?
Probably. In the Surface Water Year Book 1971-73 (Water Data Unit, 1978) the record for the Swincombe Intake has been listed as abstraction affected. Gustard et al (1992) also found the record to be affected by abstractions.
- What is the purpose of the abstractions?
1 public water supply
- Abstraction Details
The abstraction was authorised under Paignton Urban District Council Act 1926. The water is abstracted via a 24" gravity pipeline to Venford Reservoir. Under the Water Resources Act 1963, a licence was issued. Details of the licence are in licence file *14/46/04/0651.
- Period of abstraction?
1933 to the present day

- What are/were the volumes of water abstracted, either licensed or approximate?

7 million gallons per day. (Licence file *14/46/04/0651)

- Is the actual abstraction data available?

Some. Abstraction data from 1974 onwards is available from NRA SW abstraction licensing. Continuous abstraction data is available on microfilmed charts for Swincombe Venturi meter and the 24" main outlet to Venford Reservoir. The microfilms are available for 1963-1969 from NRA SW, Devon Record Office and IoH (Addresses in Appendix 16).

5.2 Reservoirs

- Has the gauging station been affected by the construction of a reservoir?

No

- When did construction begin?

6.0 OTHER RECORDS AVAILABLE

6.1 Availability of meteorological data

- Are meteorological records available for the site such as rainfall, evaporation records etc? Give details

6.2 Availability of reservoir records

- If the record is an inflow or outflow to a reservoir, are there any other records available. Eg, transfers, reservoir levels, change in storage? Give details

7.0 SUPPORTING DOCUMENTATION

7.1 Data sources and locations

IoH Surface Water Archive: 3.5" disc 1934-1968

Institute of Hydrology: Microfilms Swincombe Intake 1963-1969
and Abstraction

NRA SW Hydrometric Services: Microfilms Swincombe 1960-1962
Intake - 1961-1961
1961-1969
1962-1968
1963-1967
1963-1968
1967-1968
1969-1972
Abstraction 1963-1969

NRA SW Registry: Licence file *14/46/04/0651

NRA SW Licensing: Abstraction data

NRA SW: Gustard, A., Bullock, A. and Dixon, J.M. (December 1992) Low Flow Estimation in the United Kingdom. Wallingford, Institute of Hydrology. IH Report No 108.

NRA SW. (February 1993) Abstraction Compliance Monitoring Stations Phase 1: Capital Scheme Assessment: Site Audits. Scott Wilson Kirkpatrick. (Licence No. 14/46/04/0651 River Swincombe).

Water Data Unit. (1978) Surface Water: United Kingdom 1971-73. Department of the Environment (passive author). London, H.M.S.O.

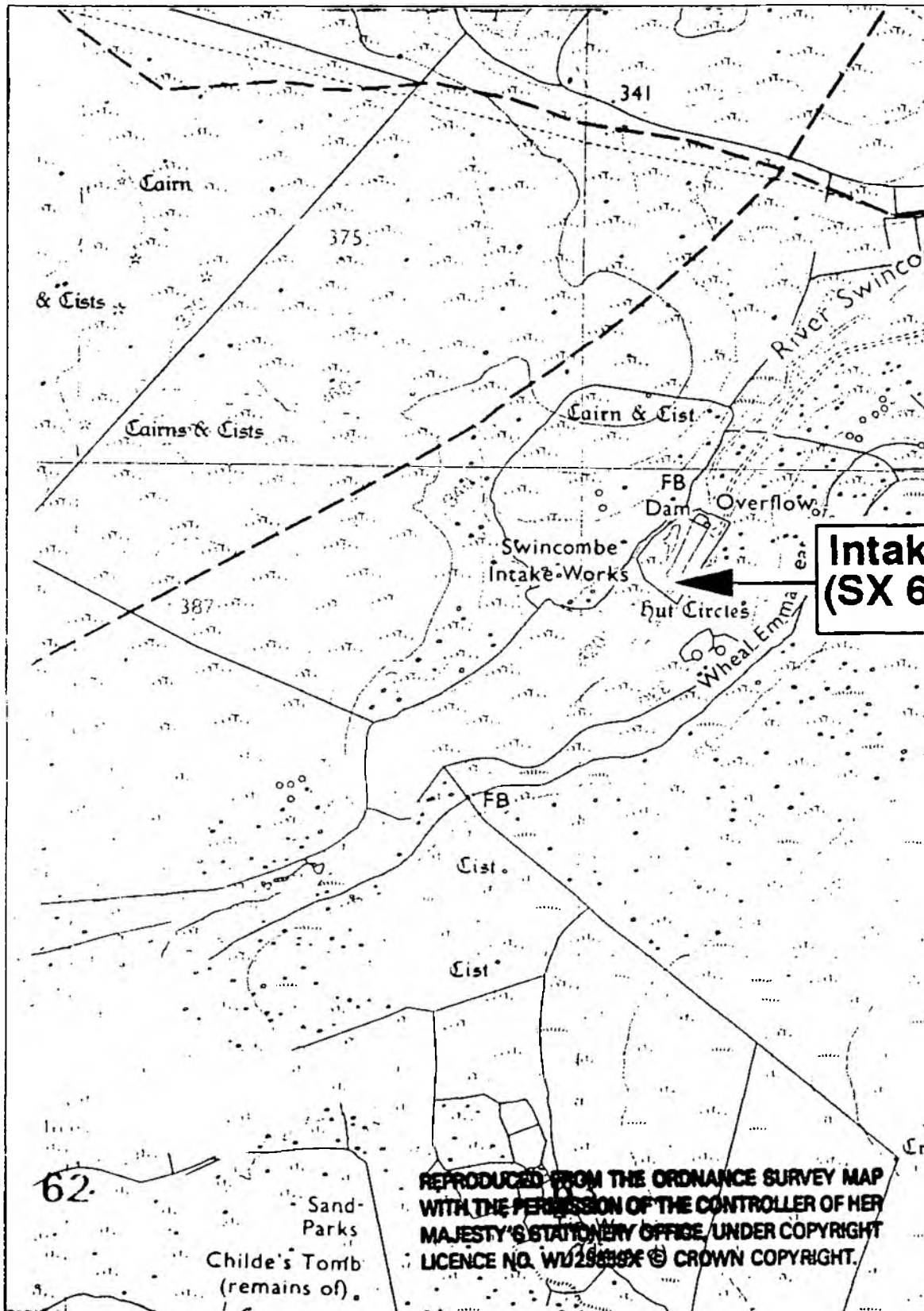
Devon Record Office: Above Microfilms

Devon River Board Signed Minutes 1952

- * Extracts and data from information marked with a * are available from NRA SW Water Resources Planning in the following file:

HYDROMETRY: Hydrometric Data. Riverflow; Historic Records, Wallet numbers 8-10.

Map 1: Swincombe Intake



**Intake
(SX 633 719)**

REPRODUCED FROM THE ORDNANCE SURVEY MAP
WITH THE PERMISSION OF THE CONTROLLER OF HER
MAJESTY'S STATIONERY OFFICE, UNDER COPYRIGHT
LICENCE NO. WU28489X © CROWN COPYRIGHT.

**Scale
1: 12500**

Diagram 1

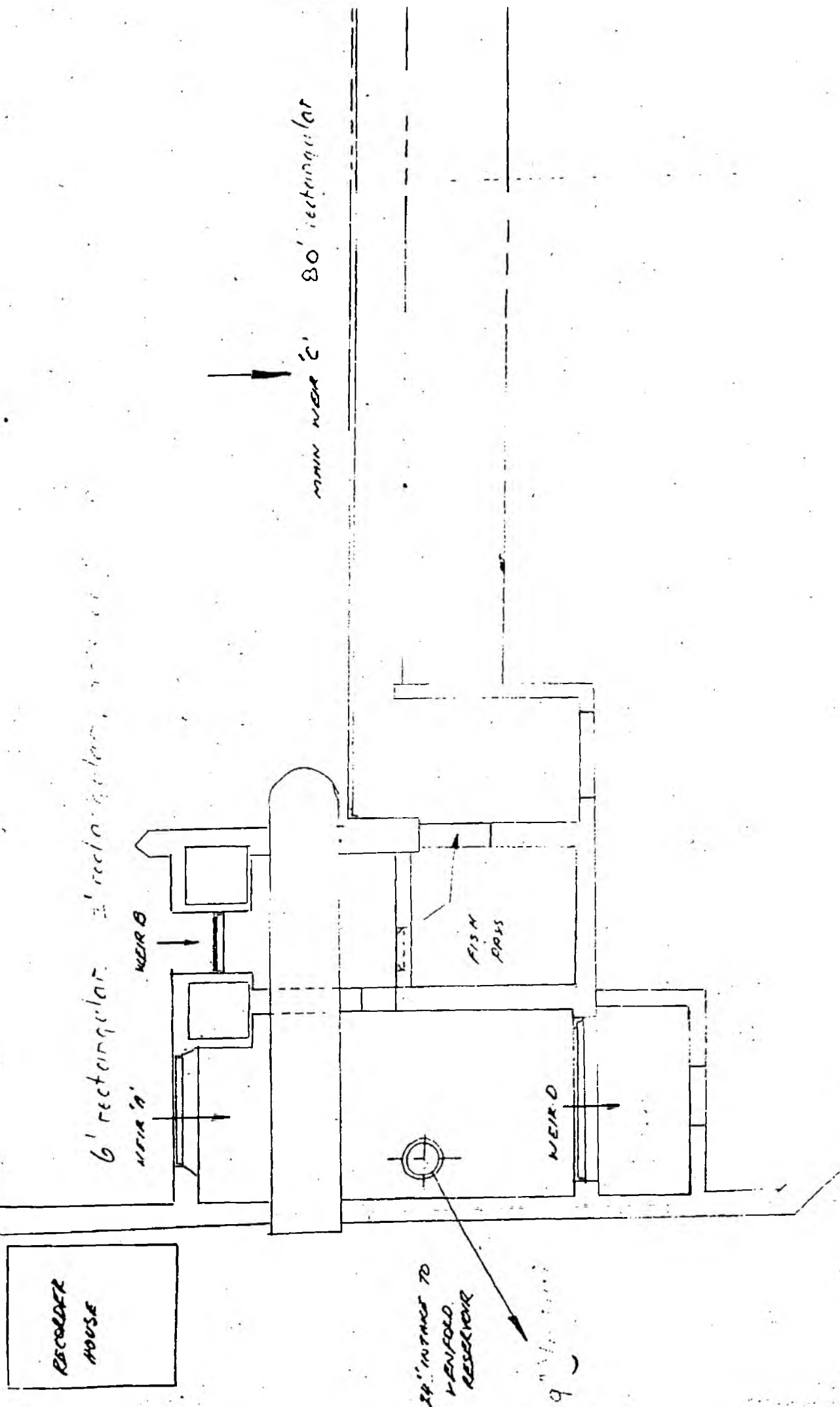
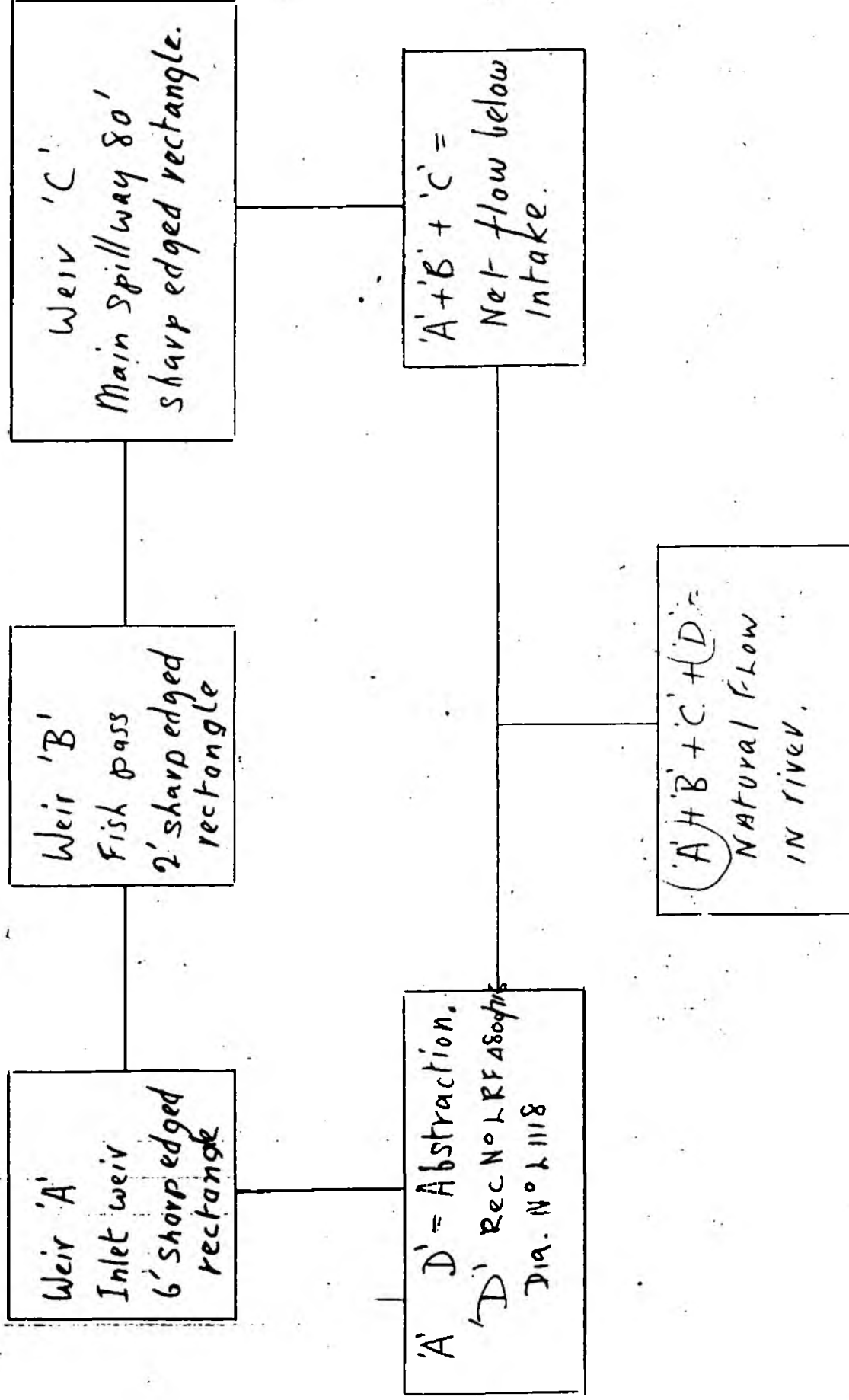


Diagram 2

SWINCOMBE INTAKES



Swincombe Intake

1.



General view looking upstream from footbridge

2.



Main weir viewed from LHB

Swincombe Intake

3.



Intake and prescribed flow weirs looking upstream

4.



Intake and prescribed flow weirs looking downstream

APPENDIX 9

Catalogue: Bala Brook Intake

1.0 SUMMARY

GAUGING STATION NAME: BALA BROOK INTAKE

RIVER: BALA BROOK

START AND END DATE OF RECORD: 1933-1973

ARTIFICIALLY INFLUENCED?: YES

2.0 SITE INFORMATION

- River

Bala Brook

- Grid Reference

SX 671 629 (See Map 1)

- Catchment area

5.9km²

2.1 Background to the measurements

The Bala Brook Intake and weir, see photographs 1 and 2, were set up under the Kingsbridge and Salcombe Water Board Act 1930. The Board were able to abstract water from the Bala Brook providing the flow below the weir was no less than 225,000 gallons/day. The measuring equipment was set up to measure this flow.

2.2 Current measuring authority

SWWSL

3.0 RECORD DETAILS

3.1 Record length, with details of missing records

May 1933 - March 1966 and February 1969 - October 1973. In the 1933-1966 section of the record the following records are missing:

1933: 19-26 May

1945: 8 Oct-1 Nov

1953: 31 Aug-4Sept

14-21 Dec

1956: 30 July-9 Sept

1959: 2-10 March

1961: 2 Jan- 7 Feb

3.2 Record format (Includes data type and media of the data)

1933-1966 Continuous measurements of discharge on weekly charts, see 1969-1973 Chart 1. All weekly charts are on microfilm held at NRA SW, Devon Record office and IoH (Addresses in Appendix 16).

/3/1951-/2/1957 Monthly totals of discharge, on *spreadsheet (Explanation of * in Section 7.0). The discharge values have been converted to cumecs and are available on 3.5" disc. Summary information of the data on disc, filenames and the disc itself is contained in Appendix 17.

3.3 Problems with the record format

Data: Problems with the chart recorder has meant some of the data is missing or has been recorded incorrectly. In some cases this has been noted on the charts. Also the data is sometimes difficult to read because of ink spills.

Microfilm: The microfilm is scratched in places and difficult to read.

4.0 MEASURING STRUCTURE AND EQUIPMENT

4.1 Measurement Structure

- Brief description

Purpose built gauging weir

- Type of structure

Thin plate rectangular weir

- Weir approval?

Yes. Approved by the Ministry of Agriculture and Fisheries.

- Weir alterations?

None

- Operational problems?

None

4.2 Recorder unit

- Manufacturer

Lea Patent Recorder manufactured by the Lea Recorder Company Ltd, Manchester, England.

- Type
Chart
- Measurement in discharge or stage?
Discharge
- Units of measurement
Gallons/day
- Rating curve available?
No. Recorder charts are calibrated for automatic conversion of stage to discharge.
- Stage/discharge conversion tables available?
No
- Operational problems?
In *Kingsbridge and Salcombe Water Board Minutes (1933-1950), references were made to the clock not working. However, a representative of the Lea Company inspected the recorder on a yearly basis.

5.0 ARTIFICIAL INFLUENCES

5.1 Abstractions

- Has the record been affected by abstractions?
Yes
- What is the purpose of the abstractions?
1 private farm supply
1 public water supply
- Abstraction Details
Farm supply: Abstraction is taken via a leat, known as the Badworthy Gutter, shown in photograph 4. Water is taken from the Red Brook, a tributary of the Bala Brook.

Public water supply: The abstraction was authorised under the Kingsbridge and Salcombe Water Board Act 1930. Under the Water Resources Act 1963, a licence was issued. Details of the licence are in licence file *14/46/05/0115.

- Period of abstraction?

Farm supply: pre-1900 until the present day
Public water supply: 1933 to the present day

- What are/were the volumes of water abstracted, either licensed or approximate?

Farm supply: approx. 50-70,000 gpd as estimated in 1935.
Public Water Supply: 400,000 gpd, in emergency 500,000 gpd
(Licence file *14/46/05/0115).

- Is the actual abstraction data available?

Farm supply: No
Public Water supply: Available from 1975

5.2 Reservoirs

- Has the gauging station been affected by the construction of a reservoir?

No

- When did construction begin?

6.0 OTHER RECORDS AVAILABLE

6.1 Availability of meteorological data

- Are meteorological records available for the site such as rainfall, evaporation records etc? Give details

Rainfall gauge at the Intake provided by J. Castonelle and Sons. The gauge was used as a site by the Meteorological Office. For 1950-57 monthly rainfall figures are available (*South West Devon Water Board Minutes, 1950-57). Other rainfall statistics available include the wettest day of the month, the monthly average and the number of days in the month on which rain fell.

6.2 Availability of reservoir records

- If the record is an inflow or outflow to a reservoir, are there any other records available. Eg, transfers, reservoir levels, change in storage? Give details

7.0 SUPPORTING DOCUMENTATION

7.1 Data sources and locations

NRA SW Hydrometric Services: Microfilms Bala Brook 1933-1944
1944-1954
1955-1964
1965-1966
1969-1973

NRA SW Registry: Licence file *14/56/05/0115
NRA SW Licensing: Abstraction data

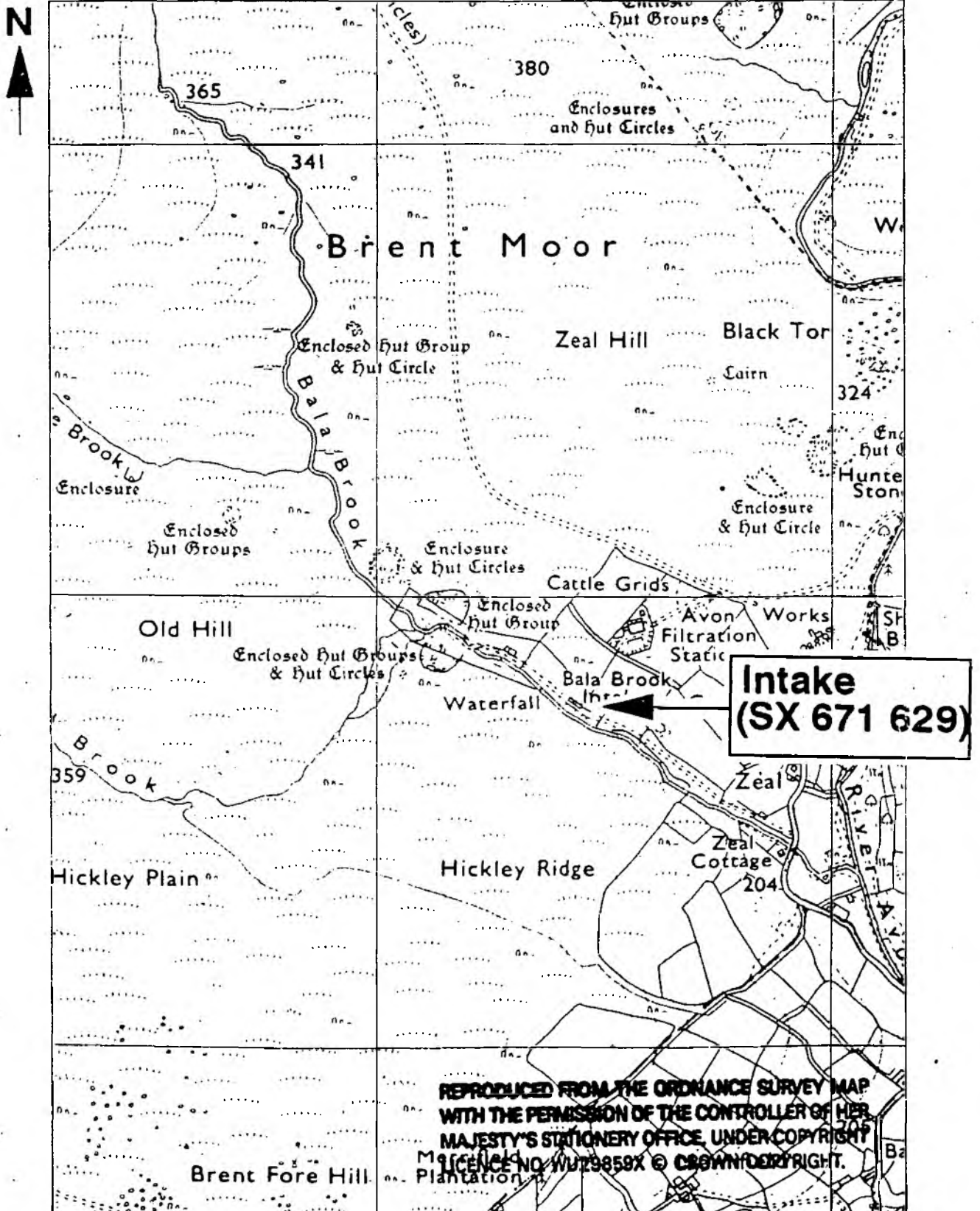
Devon Record Office: Above Microfilms
*Kingsbridge and Salcombe Water Board Minutes
1930-1950
*South West Devon Water Board Minutes 1950-1957

Institute of Hydrology: Above Microfilms

* Extracts and data from information marked with a * are available from NRA SW Water Resources Planning in the following file:

HYDROMETRY: Hydrometric Data. Riverflow; Historic Records, Wallet numbers 11-13.

Map 1: Bala Brook Intake



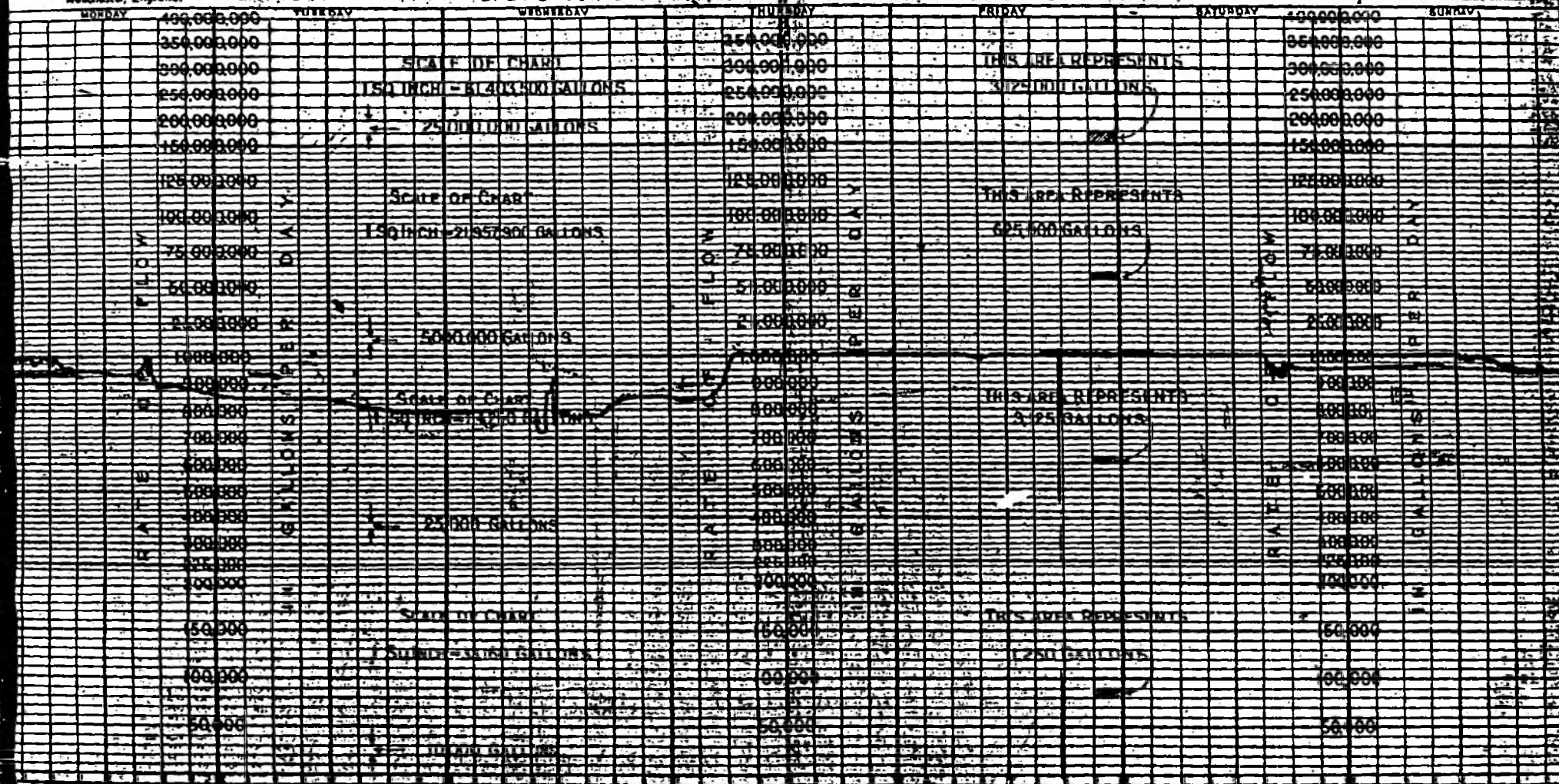
Scale
1: 12500

Chart 1

SEA'S PATENT RECORDER
The Lat Recorder Co Ltd,
Wendover, England.

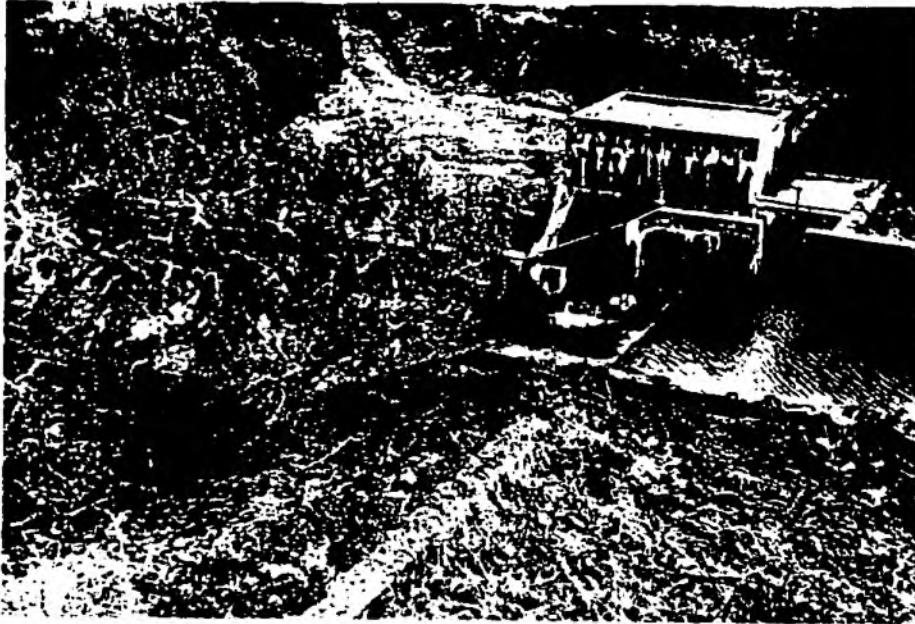
KINGSBRIDGE & SALCOMBE WATER BOARD. BALA BROOK FLOW BELOW WEIR.

DATE PUT ON *July 20 1911*
DATE TAKEN OFF *Jan 5 1912*



Bala Brook

1.



Intake looking across from LHB

2.



Compensation weir looking upstream from LHB

Bala Brook

3.



Bala Brook downstream from the Intake at Zeal Cottage

4.



Badworthy Gutter looking upstream

APPENDIX 10

Catalogue: Avon Intake

1.0 SUMMARY

GAUGING STATION NAME: AVON INTAKE
RIVER: RIVER AVON
START AND END DATE OF RECORD: 1936-1972
ARTIFICIALLY INFLUENCED?: YES

2.0 SITE INFORMATION

- River
Avon
- Grid Reference
SX 681 641 (See Map 1)
- Catchment area
14km²

2.1 Background to the measurements

The Avon Intake and weir, see photographs 1-4, were set up under the Kingsbridge and Salcombe Water Board Order 1937. The Board were able to abstract water from the River Avon providing the flow below the weir was no less than 750,000 gallons/day. The measuring equipment was set up to measure this flow.

2.2 Current measuring authority

No longer used

3.0 RECORD DETAILS

3.1 Record length, with details of missing records

November 1936 - April 1937 and September 1939 - January 1972. The record from January 1969 to October 1969 is missing.

3.2 Record format (Includes data type and media of the data)

1936-1937 Continuous measurements of discharge on weekly charts, see 1939-1972 Chart 1. All weekly charts are on microfilm held at NRA SW, Devon Record office and IoH (Addresses in Appendix 16).

/3/1951-5/1957 Monthly totals of discharge, on *spreadsheet (Explanation of * in Section 7.0). The discharge values have been converted to cumecs and are available on 3.5" disc. Summary information of the data on disc, filenames and the disc itself is contained in Appendix 17.

3.3 Problems with the record format

Data: Problems with the chart recorder has meant some of the data is missing or has been recorded incorrectly. In some cases this has been noted on the charts. Also the data is sometimes difficult to read because of ink spills.

Microfilm: The microfilm is scratched in places and difficult to read.

4.0 MEASURING STRUCTURE AND EQUIPMENT

4.1 Measurement Structure

- Brief description

Purpose built gauging weir

- Type of structure

Compound rectangular thin plate weir

- Weir approval?

Yes. Approved by the Ministry of Agriculture and Fisheries

- Weir alterations?

Yes. In November 1946 the compound weir was put in. The previous weir type and the reason for changing the weir is unknown.

- Operational problems?

No information

4.2 Recorder unit

- Manufacturer

Lea Patent Recorder manufactured by the Lea Recorder Company Ltd, Manchester, England.

- Type

Chart

- Measurement in discharge or stage?

Discharge

- Units of measurement

Gallons/day

- Rating curve available?

No. Recorder charts are calibrated for automatic conversion of stage to discharge.

- Stage/discharge conversion tables available?

No

- Operational problems?

In *Kingsbridge and Salcombe Water Board Minutes (1933-1950) references were made to incorrect positioning of the recorder. However, a representative of the Lea Company inspected the recorder on a yearly basis.

5.0 ARTIFICIAL INFLUENCES

5.1 Abstractions

- Has the record been affected by abstractions?

Yes

- What is the purpose of the abstractions?

2 public water supply: Avon Intake and Avon Reservoir

- Abstraction Details

Avon Intake: The abstraction was authorised under the Kingsbridge and Salcombe Water Board Order 1937. Under the Water Resources Act 1963, a licence was issued. Details of the licence are in licence file 14/46/05/0069.

Avon Reservoir: Construction was started on the Reservoir in July 1954 and first filled in 1956. Under the Water Resources Act 1963, a licence was issued. Details of the licence are in licence file *14/46/05/0114. It is unclear how the Avon Intake and Avon Reservoir licences operated together.

- Period of abstraction?

Avon Intake: 1939 to early 1970's
Avon Reservoir: 1956 to the present day

- What are/were the volumes of water abstracted, either licensed or approximate?

Avon Intake: 700,000 gpd (Water Board Order 1937)
Avon Reservoir: 3,250,000 gpd (*Licence file 14/46/05/0114)

- Is the actual abstraction data available?

Avon Intake: Mean daily abstraction in cumecs available from March 1951 to February 1953 on *spreadsheet and on 3.5" disc (See Appendix 17).

Avon Reservoir: Available from 1975

5.2 Reservoirs

- Has the gauging station been affected by the construction of a reservoir?

Yes

- When did construction begin?

July 1954

6.0 OTHER RECORDS AVAILABLE

6.1 Availability of meteorological data

- Are meteorological records available for the site such as rainfall, evaporation records etc? Give details

6.2 Availability of reservoir records

- If the record is an inflow or outflow to a reservoir, are there any other records available. Eg, transfers, reservoir levels, change in storage? Give details

Continuous measurements of reservoir levels and compensation flows are available on weekly charts on microfilm. The microfilms are available from NRA SW and the Devon Record Office (Addresses in Appendix 16).

7.0 SUPPORTING DOCUMENTATION

7.1 Data sources and locations

NRA SW Hydrometric Services: Microfilms Avon Intake. 1936-1937
1939-1950
1950-1960
1960-1969
1969-1972

Avon Dam 1966-1968
Levels 1969-1972

Avon Dam 1957-1966
Downstream 1966-1968
1969-1972

NRA SW Registry: Licence files 14/56/05/0069 and *14/56/05/0114
NRA SW Licensing: Abstraction data

NRA SW: Water Data Unit. Surface Water: United Kingdom 1971-73.
Department of the Environment (passive author). London,
H.M.S.O.

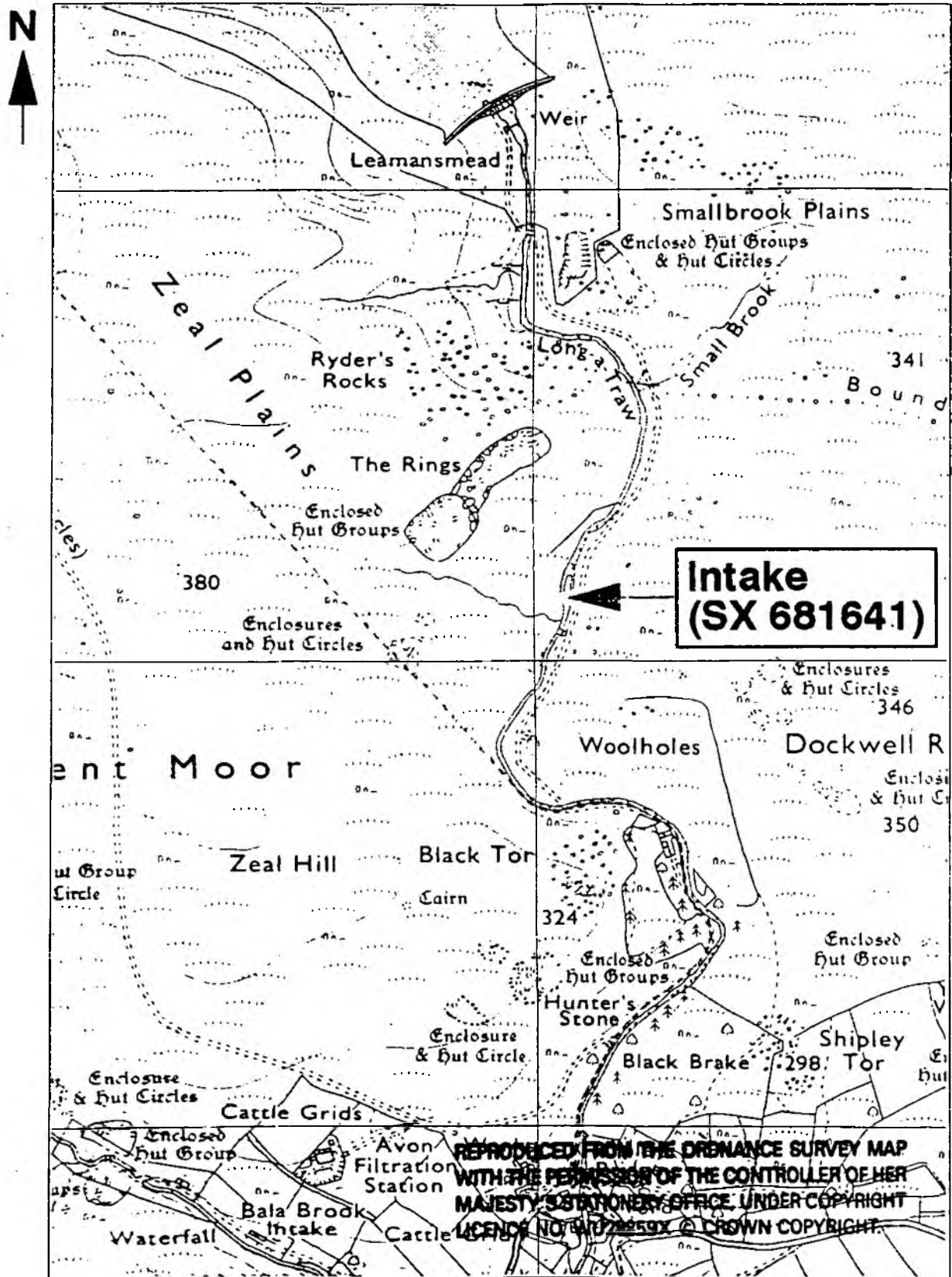
Devon Record Office: Above Microfilms
*Kingsbridge and Salcombe Water Board Minutes
1930-1950
*South West Devon Water Board Minutes 1950-1957

Institute of Hydrology: Above microfilms for the Avon Intake

* Extracts and data from information marked with a * are available
from NRA SW Water Resources Planning in the following file:

HYDROMETRY: Hydrometric Data. Riverflow; Historic Records,
Wallet numbers 11-13.

Map 1: Avon Intake



Scale
1: 12500

Chart 1

KINGSBRIDGE AND SALCOMBE WATER BOARD.

RIVER AVON - FLOW BELOW INTAKE.

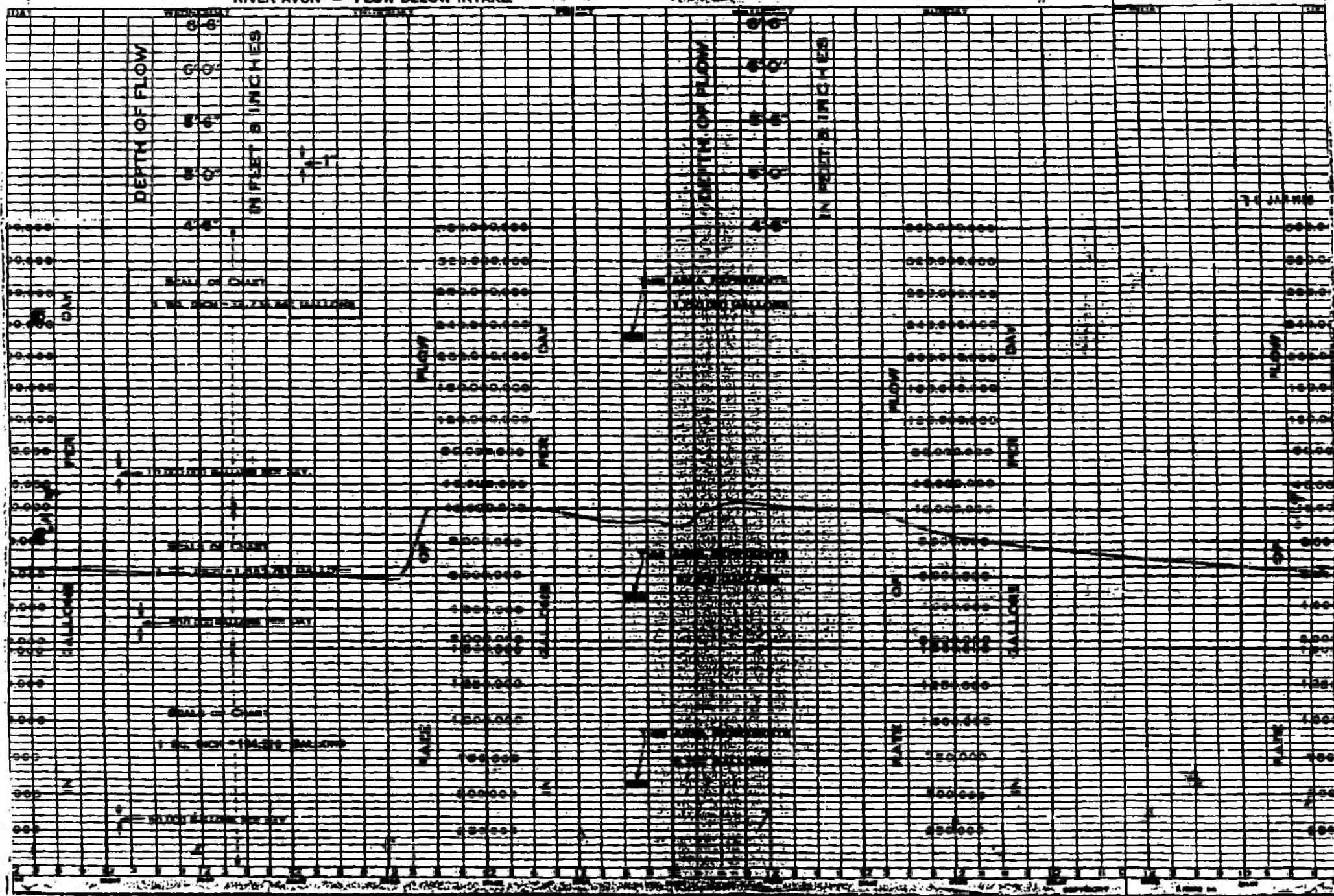
DATE PUT ON _____

1 JAN 1950

DATE TAKEN OFF

10 JAN 1971

THE LEA RECORDER CO. LTD.
MANCHESTER, ENGLA







APPENDIX 11

Catalogue: Irishmans Wall

1.0 SUMMARY

GAUGING STATION NAME: IRISHMANS WALL

RIVER: RIVER TAW

START AND END DATE OF RECORD: 1943-1992

ARTIFICIALLY INFLUENCED?: YES

2.0 SITE INFORMATION

- River

Taw

- Grid Reference

SX 621 918 (See Map 1)

- Catchment area

10.9km²

2.1 Background to the measurements

The weir at Irishmans Wall, see photographs 1-3, was set up under the North Devon Water Board Act 1945. The Board were able to abstract water from the River Taw providing the flow below the weir was no less than 600,000 gpd. The measuring equipment was set up to measure this flow.

2.2 Current measuring authority

SWWSL

3.0 RECORD DETAILS

3.1 Record length, with details of missing records

April 1943-November 1944, November 1948-October 1973 and September 1987-November 1992. Data is missing throughout the record, particularly in the early sections. Approximately two years of data are missing in total.

3.2 Record format (Includes data type and media of the data)

1943-1944 Continuous measurements of discharge on weekly charts, see
1948-1973 Charts 1 and 2. Chart 1 is an example of the charts used
from 1943-1944 and Chart 2 is an example of the chart used
in the 1948-1973 section of the record. All weekly charts
are on Microfilm held at NRA SW, Devon Record Office and
IoH. (Addresses in Appendix 16).

1987-1992 Hydrographs available from Hydrometric Services, NRA SW.

All the data has been digitised by SWWSL (December 1992) and the
daily mean flows in cumecs are available on 3.5" disc. Summary
information of the data on disc, filenames and the disc itself is
contained in Appendix 17.

3.3 Problems with the record format

Data: The digitised data has been analysed by SWWSL (December 1992).
The 1992 data is incorrect due to problems with the stilling well
silting up. Also, due to the limitations of the chart recorder, water
levels over 0.635m have not been recorded.

4.0 MEASURING STRUCTURE AND EQUIPMENT

4.1 Measurement Structure

- Brief description

Purpose built gauging weir

- Type of structure

Thin plate rectangular notch in two stage broad crested masonry.

- Weir approval?

Yes. Approved by the Minister of Agriculture and Fisheries.

- Weir alterations?

No information

- Operational problems?

No information

4.2 Recorder unit

- Manufacturer

No information

- Type

Chart. Photograph 4 shows one of the old chart recorders used to record river flow.

- Measurement in discharge or stage?

Discharge

- Units of measurement

Gallons/day

- Rating curve available?

Yes. Rating curve shown in *SWWSL Interim report on the Taw Marsh Investigations (December 1992) but the measurements of stage below 0.3m are not shown (Explanation of * in Section 7.0). The recorder charts are calibrated for automatic conversion of stage to discharge.

- Stage/discharge conversion tables available?

No

- Operational problems?

Yes, clock often stopped. Usually, where there were problems, notes have been made on the charts. Also in 1992 the stilling well silted up. This may have occurred in the past but has not been documented.

5.0 ARTIFICIAL INFLUENCES

5.1 Abstractions

- Has the record been affected by abstractions?

Yes

- What is the purpose of the abstractions?

1 public water supply

- Abstraction Details

The Water Board never abstracted from the River Taw under the 1945 Act and another Act was passed in 1959, the North Devon Water Act. This allowed the Board to abstract water from boreholes sited above Irishmans Wall gauging station. The licence was for 11 boreholes but, because the boreholes provide a base flow to the River Taw, a maintained flow at Irishmans Wall of 1.25 million gallons per day was required. If the river fell below this figure, abstracted water was returned to the river as compensation water, shown in Diagram 1. Under the Water Resources Act 1963, a licence was issued. Details of the licence are in licence file *14/50/08/0563.

- Period of abstraction?

1959 to the present day

- What are/were the volumes of water abstracted, either licensed or approximate?

1.75 Million gallons per day (Licence file *14/50/08/0563).

- Is the actual abstraction data available?

The abstraction is not directly from the river so the amount abstracted from the boreholes cannot be used to produce a naturalised flow record. However, SWWSL are undertaking an investigation into the Taw Marsh boreholes *(December 1992) to obtain a relationship between the amount of water abstracted and the river flows.

5.2 Reservoirs

- Has the gauging station been affected by the construction of a reservoir?

No

- When did construction begin?

6.0 OTHER RECORDS AVAILABLE

6.1 Availability of meteorological data

- Are meteorological records available for the site such as rainfall, evaporation records etc? Give details

6.2 Availability of reservoir records

- If the record is an inflow or outflow to a reservoir, are there any other records available. Eg, transfers, reservoir levels, change in storage? Give details

7.0 SUPPORTING DOCUMENTATION

7.1 Data sources and locations

NRA SW Hydrometric Services: Microfilms Irishmans, 1943-1944
Wall 1948-1973
Hydrographs 1987-1992

NRA SW Registry: Licence file *14/50/08/0563

NRA SW: NRA SW. (February 1993). Abstraction Compliance Monitoring Stations Phase 1: Capital Scheme Assessment: Site Audits.
Scott Wilson Kirkpatrick. (Licence No. 14/50/08/0563 Taw Marsh Boreholes).

SWWSL. (December 1992). Taw Marsh Investigation, Interim Report. Shrewsbury, Water Management Consultants Ltd.

Devon Record Office: Above Microfilms

North Devon Water Board Signed Minutes 1945-1974
*North Devon Water Board Unsigned Minutes
1947-1968
North Devon Water Board Duplicate Minutes
1968-1974
*North Devon Water Board Works Committee
1946-1953
1954-1970

Institute of Hydrology: Above Microfilms

- * Extracts and data from information marked with a * are available from NRA SW Water Resources Planning in the following file:

HYDROMETRY: Hydrometric Data. Riverflow; Historic Records, Wallet numbers 14-18.

Chart 1

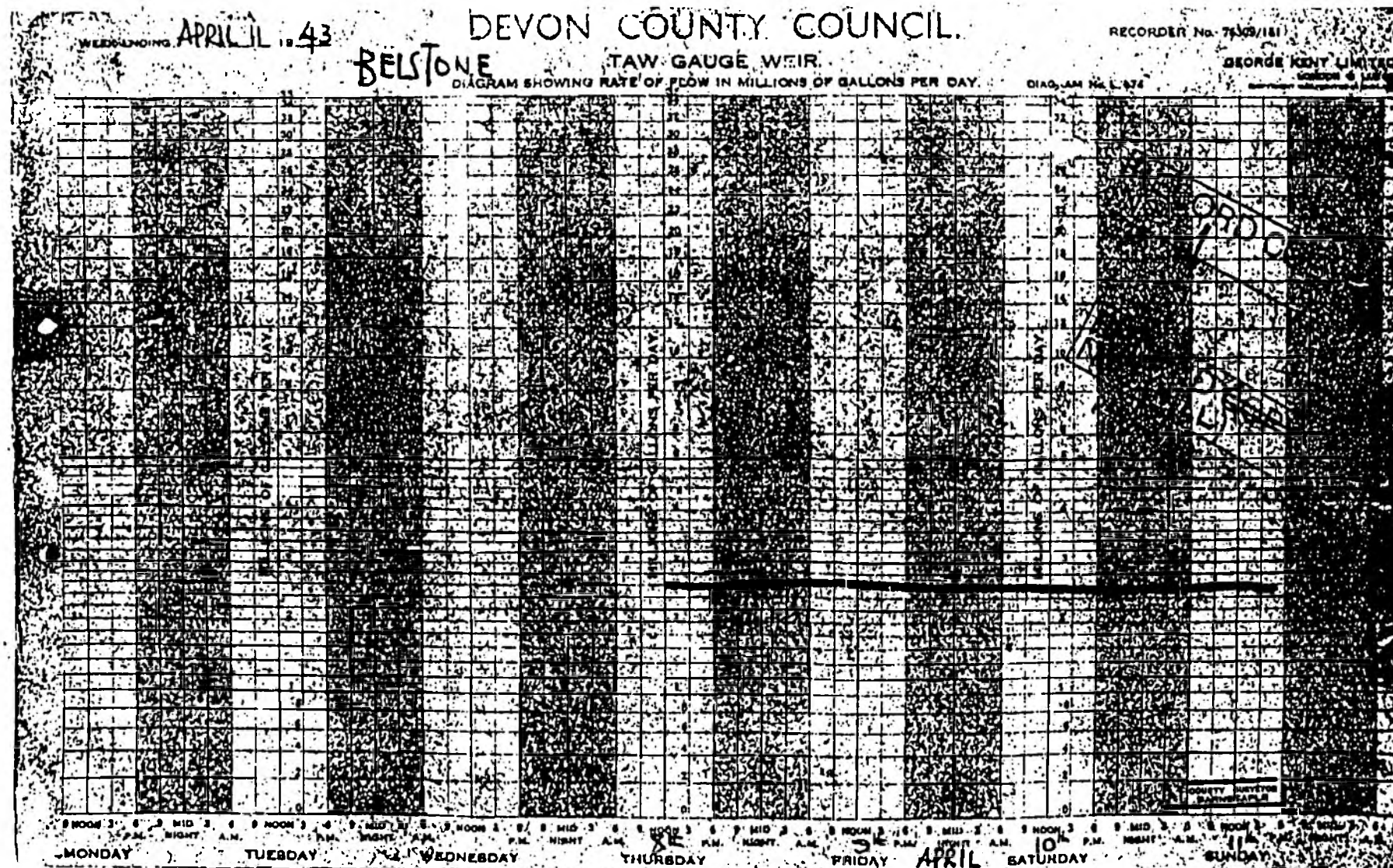


Chart 2

WEEK ENDING 1st Dec 1949

NORTH DEVON WATER BOARD.

RECORDER No. 76309/181

TAW GAUGE WEIR.

DIAGRAM SHOWING RATE OF FLOW IN MILLIONS OF GALLONS PER DAY.

DIAGRAM No. L.874A.

GEORGE KENT LIMITED
LONDON & LUTON
COPYRIGHT 1941 PRINTED IN ENGLAND

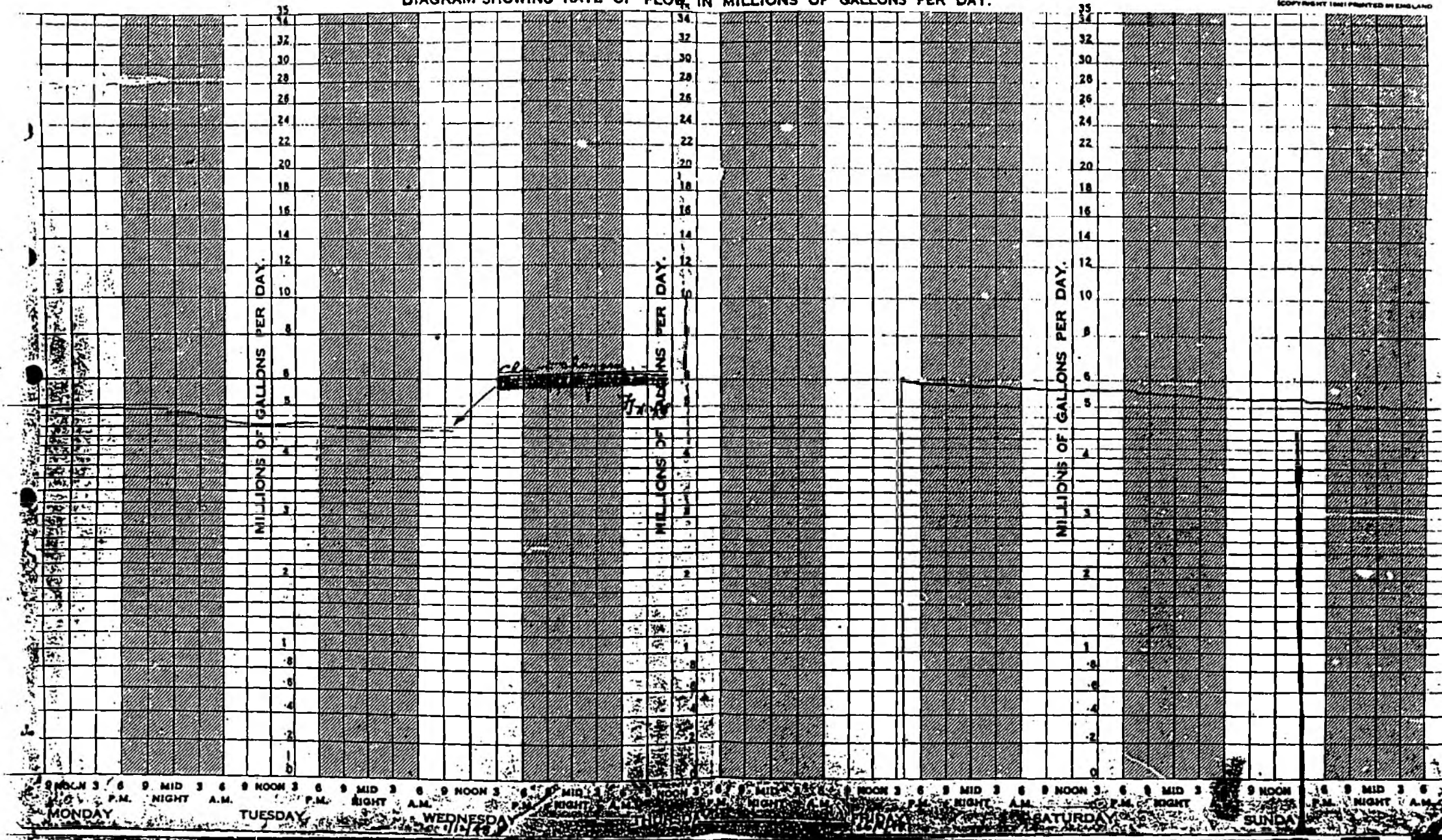
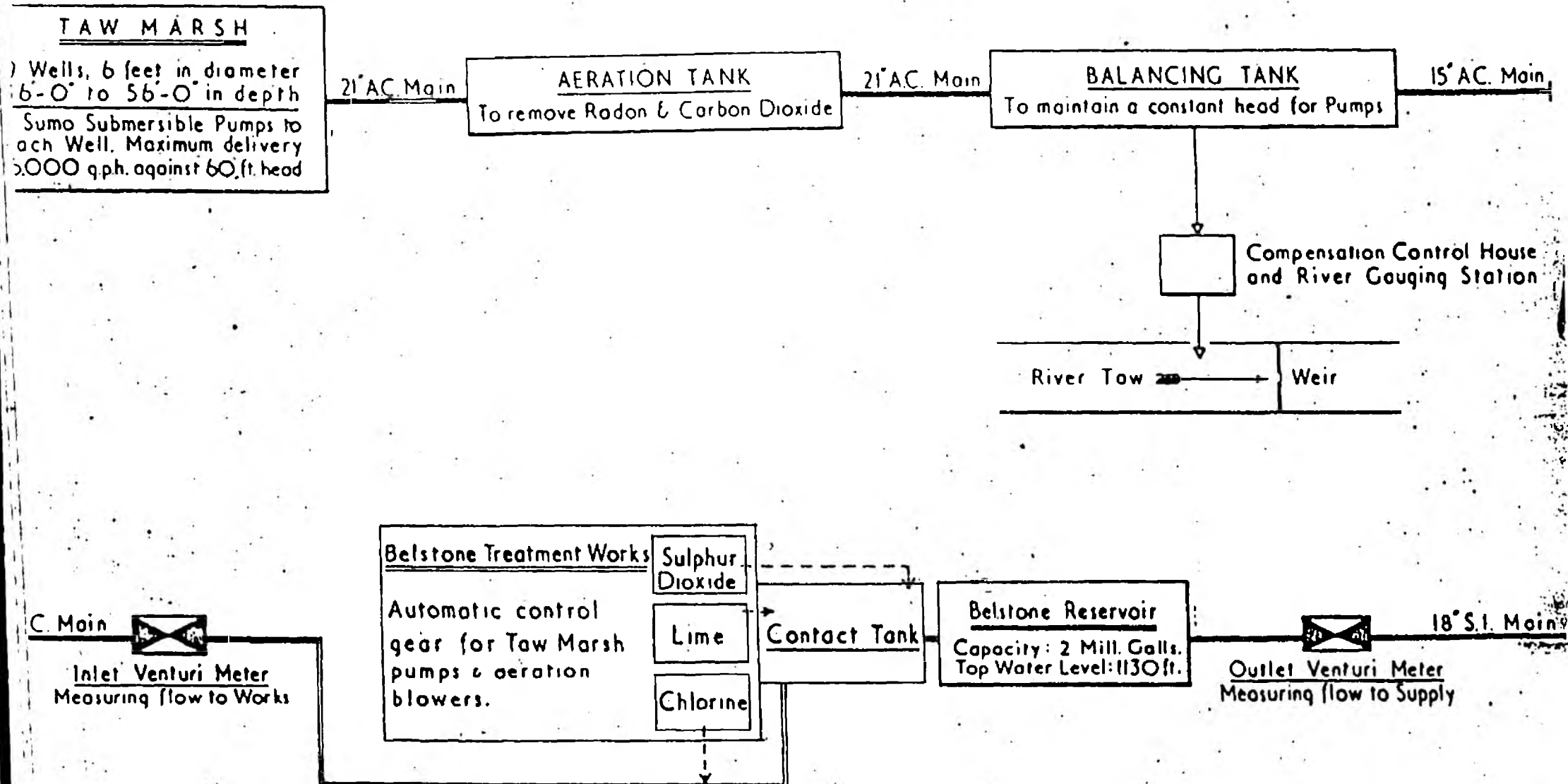


Diagram 1



SCHEMATIC DIAGRAM OF TAW MARSH & BELSTONE TREATMENT WORKS

Irishmans Wall

1.



Gauging station looking downstream from LHB

2.



Gauging weir looking downstream from LHB

3.



Gauging weir looking upstream from LHB

4. Mechanical chart recorder

Irishmans Wall



APPENDIX 12

Catalogue: Abbey Weir

1.0 SUMMARY

GAUGING STATION NAME: ABBEY WEIR

RIVER: TAVY

START AND END DATE OF RECORD: 1938-1993

ARTIFICIALLY INFLUENCED?: YES

2.0 SITE INFORMATION

- River

Tavy

- Grid Reference

SX 482 743 (See Map 1)

- Catchment area

103km²

2.1 Background to the measurements

The weir and fish pass, photographs 1 and 2, were adapted in 1934 by the West Devon Mining and Power Company Ltd in association with the abstraction of water to Morwellham Power Station, via Morwellham Canal, see Diagram 1. The water rights to the Canal and part of the River Tavy were leased to the Company in 1933 by the Duke of Bedford for the generation of hydro-electricity. One of the conditions of the lease was that the Company could only abstract water if the level of water was at, or above, 3" of the top cill of the fish pass. The measuring equipment was set up to measure this level.

2.2 Current measuring authority

National Power Plc

3.0 RECORD DETAILS

3.1 Record length, with details of missing records

1938 to the present day. From 1938 to 1941 National Power Plc have individual charts which are insufficient in number to form a complete record for these three years.

3.2 Record format (Includes data type and media of the data)

1938-1993 Continuous measurements of stage, up to 2 feet, on weekly charts. The following sections of the record have been digitised by Hydrometric Services, NRA SW, but have not yet been converted to discharge:

26/01/41 - 21/10/42

17/01/75 - 2/10/76

10/12/88 - 16/09/90

20/01/91 - 11/08/92

Hydrometric Services, NRA SW have had their own measuring equipment measuring the flow in the river, 40m upstream of the weir, from July 1991. The data from this equipment is also available from them.

All weekly charts are held at Mary Tavy Power Station (Address in Appendix 16).

3.3 Problems with the record format

Data: Problems with the chart recorder has meant that the data is missing or has been recorded incorrectly. In some cases this has been noted down on the charts. Also the data is sometimes difficult to read because of ink spills. Water levels above 2 feet are only shown as a horizontal line at the top of the chart.

4.0 MEASURING STRUCTURE AND EQUIPMENT

4.1 Measurement Structure

- Brief description

Weir

- Type of structure

Weir and fish pass

- Weir approval?

Yes, by the Agent acting for the Duke of Bedford

- Weir alterations?

No information

- Operational problems?

None

4.2 Recorder unit

- Manufacturer

No information

- Type

Chart

- Measurement in discharge or stage?

Stage. However, the recorder is only designed to measure up to 2ft. Levels above this line are shown as a horizontal line at the top of the chart.

- Units of measurement

Feet and inches

- Rating curve available?

Yes. A rating curve is available for 1986.

- Stage/discharge conversion tables available?

No

- Operational problems?

Notes on the digitised charts documented problems with the float chamber being washed out, the blocking of the inlet, wires replaced and broken weight cables. However, the recorder readings are checked at 7am each morning by an employee of the electricity company, using a staff gauge. Where necessary corrections are made to the recorder and are usually noted on the charts.

5.0 ARTIFICIAL INFLUENCES

5.1 Abstractions

- Has the record been affected by abstractions?

Yes

- What is the purpose of the abstractions?

3 Hydro Electric Power: Tavy Cleave, Hill Bridge, Abbey Weir

- Abstraction Details

Hydro-electric power:

Tavy Cleave: Abstraction is via the Willsworthy Mine Leat at SX 552 831 (See Diagram 1). The Leat supplies water to the Mary Tavy Power Station, built in 1936. The abstraction is licensed under the water Resources Act 1963 and details of the licence are in licence file 15/47/41/S/27.

Hill Bridge: The abstraction is via the Hill Bridge Leat at SX 532 804 (See Diagram 1). The Leat also supplies water to the Mary Tavy Power Station. The abstraction is licensed and the details are in the above licence file.

Abbey Weir: Abstraction is via the Tavistock/Morwellham Canal. Sluice gates upstream of the measuring weir control the amount of water to be abstracted. The Canal transports the water 4.5 miles to the River Tamar catchment for use at the Morwellham Power Station (See Diagram 1). Under the Water Act 1963 a licence was issued. Details of the licence are in licence file 15/47/41/S/26.

- Period of abstraction?

Tavy Cleave: 1933 to the present day

Hill Bridge: 1933 to the present day

Abbey Weir: 1934 to the present day

- What are/were the volumes of water abstracted, either licensed or approximate?

Tavy Cleave: 19.3 MG/d (Licence file 15/47/41/S/26)

Hill Bridge: 13.2 MG/d (Licence file 15/47/41/S/27)

Abbey Weir : 23.4 MG/d (Licence file 15/47/41/S/27)

- Is the actual abstraction data available?

Tavy Cleave: Yes. However the water abstracted via the Leat is

Hill Bridge: taken continuously and returned to the River Tavy during the day when electricity generation at Mary Tavy Power Station occurs.

Abbey Weir: Yes. Output data is available from the 1930's, at Morwellham Power Station which can be used to represent the amount abstracted.

5.2 Reservoirs

- Has the gauging station been affected by the construction of a reservoir?

No

- When did construction begin?

6.0 OTHER RECORDS AVAILABLE

6.1 Availability of meteorological data

- Are meteorological records available for the site such as rainfall, evaporation records etc? Give details

6.2 Availability of reservoir records

- If the record is an inflow or outflow to a reservoir, are there any other records available. Eg, transfers, reservoir levels, change in storage? Give details

7.0 SUPPORTING DOCUMENTATION

7.1 Data sources and locations

NRA SW Hydrometric Services: Digitised stage data 1941-1942
1975-1976
1988-1990
1991-1992

NRA SW Registry: Licence file 15/47/41/S/26
15/47/41/S/27

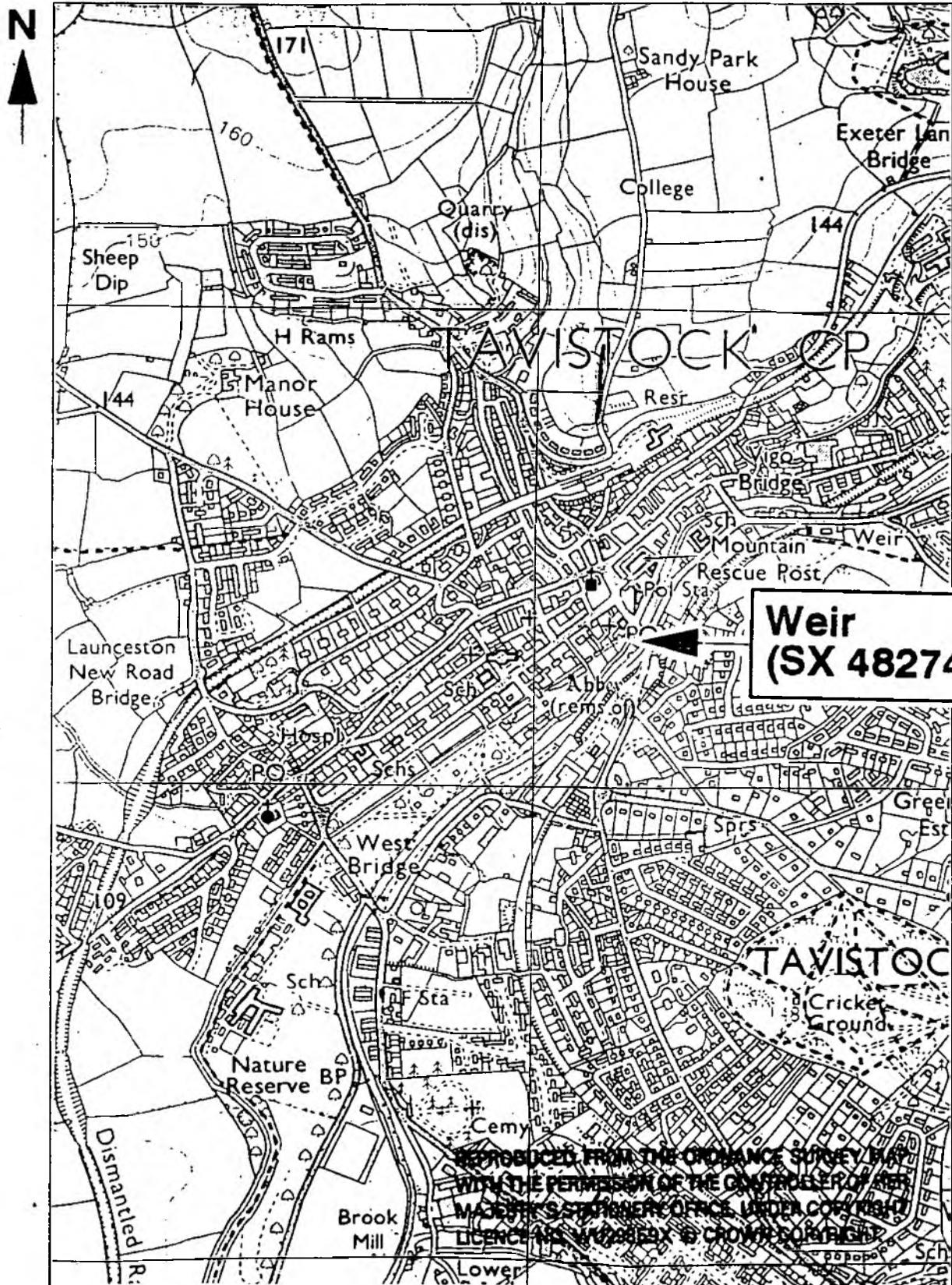
NRA SW:*NRA SW. (March 1993) Alleviation of Low Flows-Phase 1A-
Site Investigation Project Inception Report. River Tavy
Catchment. Exeter, NRA SW. (WR/34/30/06).

National Power Plc, Mary Tavy Power Station: Weekly charts
Output data

- * Extracts and data from information marked with a * are available from NRA SW Water Resources Planning in the following file:

HYDROMETRY: Hydrometric Data. Riverflow; Historic Records, Wallet number 19.

Map 1: Abbey Weir



**Scale
1: 12500**

Diagram 1:



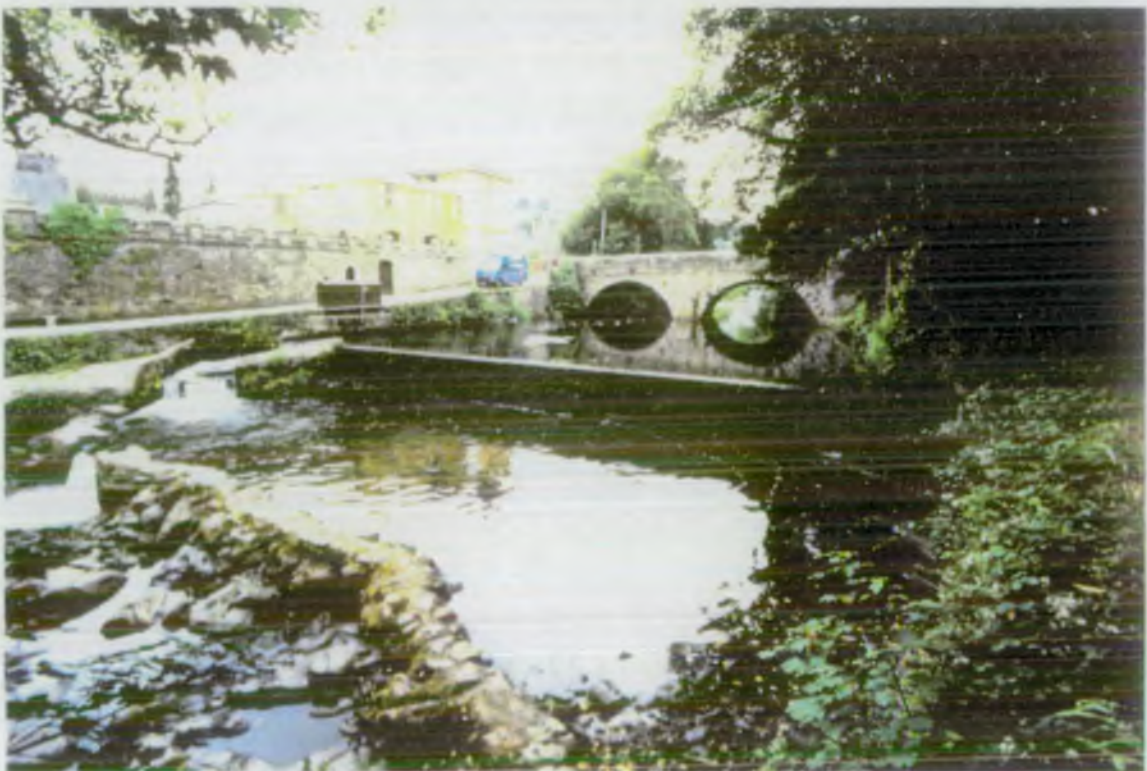
Abbey Weir

1.



Gauging weir looking upstream from LHB. Morwellham Canal offtake on left hand side by the brown sluice gates

2.



Abbey Weir looking upstream from RHB

APPENDIX 13

Catalogue: Meavy

1.0 SUMMARY

GAUGING STATION NAME: MEAVY
RIVER: RIVER MEAVY
START AND END DATE OF RECORD: 1904-1920
ARTIFICIALLY INFLUENCED?: YES

2.0 SITE INFORMATION

- River
River Meavy
- Grid Reference
SX 566 692 (See Map 1)
- Catchment area
18.4km²

2.1 Background to the measurements

The River Meavy was gauged by the Plymouth Corporation in association with Burrator Reservoir. The measurement structure and equipment, shown in photographs 5-7 was constructed in 1904 to measure the inflows into Burrator Reservoir.

2.2 Current measuring authority

No longer used

3.0 RECORD DETAILS

3.1 Record length, with details of missing records

December 1904-March 1905 and 1906-1920.

3.2 Record format (Includes data type and media of the data)

1904-1905 Daily values of stage and discharge on loose sheets in file: BURRATOR: Rainfall, flow and evaporation gauges, which is held at the West Devon Record Office (WDRO).

1906-1920 Daily values of stage in ledger books, at the WDRO. A typed example of the layout of the ledger is shown in Diagram 2.

3.3 Problems with the record format

No known problems

4.0 MEASURING STRUCTURE AND EQUIPMENT

4.1 Measurement Structure

- Brief description

2 purpose built gauging weirs

- Type of structure

One 20ft weir and one 50ft weir. When more than 1ft of water passed over the 20ft weir, the water passing over the 50ft weir was measured. The weirs have thin plate rectangular notches.

- Weir approval?

No information

- Weir alterations?

In 1905 a rubble dam was constructed below the Intake to catch debris. The walls of the Intake were also raised and concrete was laid on the floor of the weir pool.

- Operational problems?

No information

4.2 Recorder unit

- Manufacturer

Hutchinson Recorder. Photograph 7 shows a chart recorder used to measure the inflows. This replaced the Hutchinson recorder.

- Type

Chart

- Measurement in discharge or stage?

Stage and discharge

- Units of measurement

Depth of water over the weir in feet and inches and gallons/minute

- Rating curve available?

No

- Stage/discharge conversion tables available?

Yes, available for the 20ft weir but the tables for the 50ft weir would need to be checked to see if they refer to the Meavy or another 50ft weir.

- Operational problems?

No information

5.0 ARTIFICIAL INFLUENCES

5.1 Abstractions

- Has the record been affected by abstractions?

Yes

- What is the purpose of the abstractions?

1 public water supply

- Abstraction Details

The abstraction takes place at the head of the Meavy at the *Stanlake Intake, see Diagram 1 and photographs 1-4 (Explanation of * in Section 7.0). Water is taken via a gravity pipeline and released several hundred yards away into the Devonport Leat. The Leat terminates at the Dousland Intake, photograph 8, where the water is piped to the Dousland Water Treatment Works. Any excess water is released into Burrator Reservoir, photograph 9.

- Period of abstraction?

1915 to the present day

- What are/were the volumes of water abstracted, either licensed or approximate?

Approximately 9092 gallons/day (Licence file 14/46/2/S/33).

- Is the actual abstraction data available?

No

5.2 Reservoirs

- Has the gauging station been affected by the construction of a reservoir?

No

- When did construction begin?

6.0 OTHER RECORDS AVAILABLE

6.1 Availability of meteorological data

- Are meteorological records available for the site such as rainfall, evaporation records etc? Give details

Yes. The ledgers relating to the river flows have daily readings of rainfall at Head Weir, Burrator and Roborough, air temperature and evaporation. The locations of the measuring apparatus are not documented. Also the list in Section 7.0 of the documents held by the WDRO contains files and registers of rainfall data. Due to time constraints quite a lot of the data at the WDRO was not looked at.

6.2 Availability of reservoir records

- If the record is an inflow or outflow to a reservoir, are there any other records available. Eg, transfers, reservoir levels, change in storage? Give details

Diagram 2 is an example of the daily register from 1906-1920. Reservoir depths, leat and abstraction data are all shown. Some of the documents listed in Section 7.0 that were not looked at may also contain similar information.

7.0 SUPPORTING DOCUMENTATION

7.1 Data sources and locations

NRA SW Registry: Licence file*14/46/2/S/31
14/46/2/S/32
14/46/2/S/33

*Hawkings, D.J. (1987) Water from the Moor; An Illustrated History of the Plymouth, Stonehouse and Devonport Leats. Exeter, Devon Books.

West Devon Record Office:

*Howarth, F. (1906) Annual report to the Water Committee for 1905-06.
Plymouth, Plymouth Corporation Water Works.

*Howarth, F. (1907) Annual report to the Water Committee for 1906-07.
Plymouth, Plymouth Corporation water Works.

The following is a list of the ledgers held at the Record Office relating to gaugings. Not all of the ledgers have been looked at, those that have are marked with a dash (-). Ledgers that were useful are marked with an asterisk (*). Other documents from the Record office such as newspaper articles, engineering reports etc were also looked at and relevant information from these documents have been extracted*.

Rainfall:

Rainfall Register 1858-1889
1891-1936

Register of rainfall 1876-1906

Rainfall gauge book 1906-1914

File: Rainfall in catchment area of Burrator and units of supply
1912-14

Gauge Registers:

Gauge register for Head Weir and Crownhill	1850-1865	-*
Gauge Register for Head Weir	1858-1882	-*
" " " " " "	1883-1889	-
Gauge register for Head Weir and Reservoir	1864-1876	
" " " " " " " " " "	1883-1887	

Daily Registers:

Daily register of reservoir and leat	1881-1883
" " " " " " " "	1883-1885
" " " " " " " "	1886-1888

Daily register of reservoir and leat	1888-1891
" " " " " " " "	1891-1895

Daily register: Reservoir

" " " " "	1894-1895
" " " " "	1895-1896
" " " " "	1896-1897
" " " " "	1897-1898
" " " " "	1898-1899
" " " " "	1900
" " " " "	1901
" " " " "	1902 etc. upto 1920**

Daily records	1895-1902	-*
" " "	1906-1909	-*
" " "	1910-1914	-*
" " "	1915-1920	
" " "	1921-1929	-*
" " "	1929-1940	
Gauge book, Burrator and Roborough	1906-1909	
" " " " " "	1909-1912	
Leat and reservoir Gauge Book	1878-1889	
" " " " " "	1889-1895	
" " " " " "	1895-1901	-
" " " " " "	1901-1909	
" " " " " "	1909-1915	
Burrator Gauge Book	1931-1936	**
Files:		
Reservoirs, watershed and leat	July-Dec 1923	
" " " " " "	Apr-Dec 1925	
" " " " " "	Jan-Dec 1935	
" " " " " "	1943-44	-*
Rainfall, flow and evaporation gauges	1898-1903	**
Burrator, other reservoirs and supply		-

* Extracts and data from information marked with a * are available from NRA SW Water Resources Planning in the following file: '

HYDROMETRY: Hydrometric Data. Riverflow; Historic Records, Wallet numbers 20-24.

Diagram 1: River Meavy system

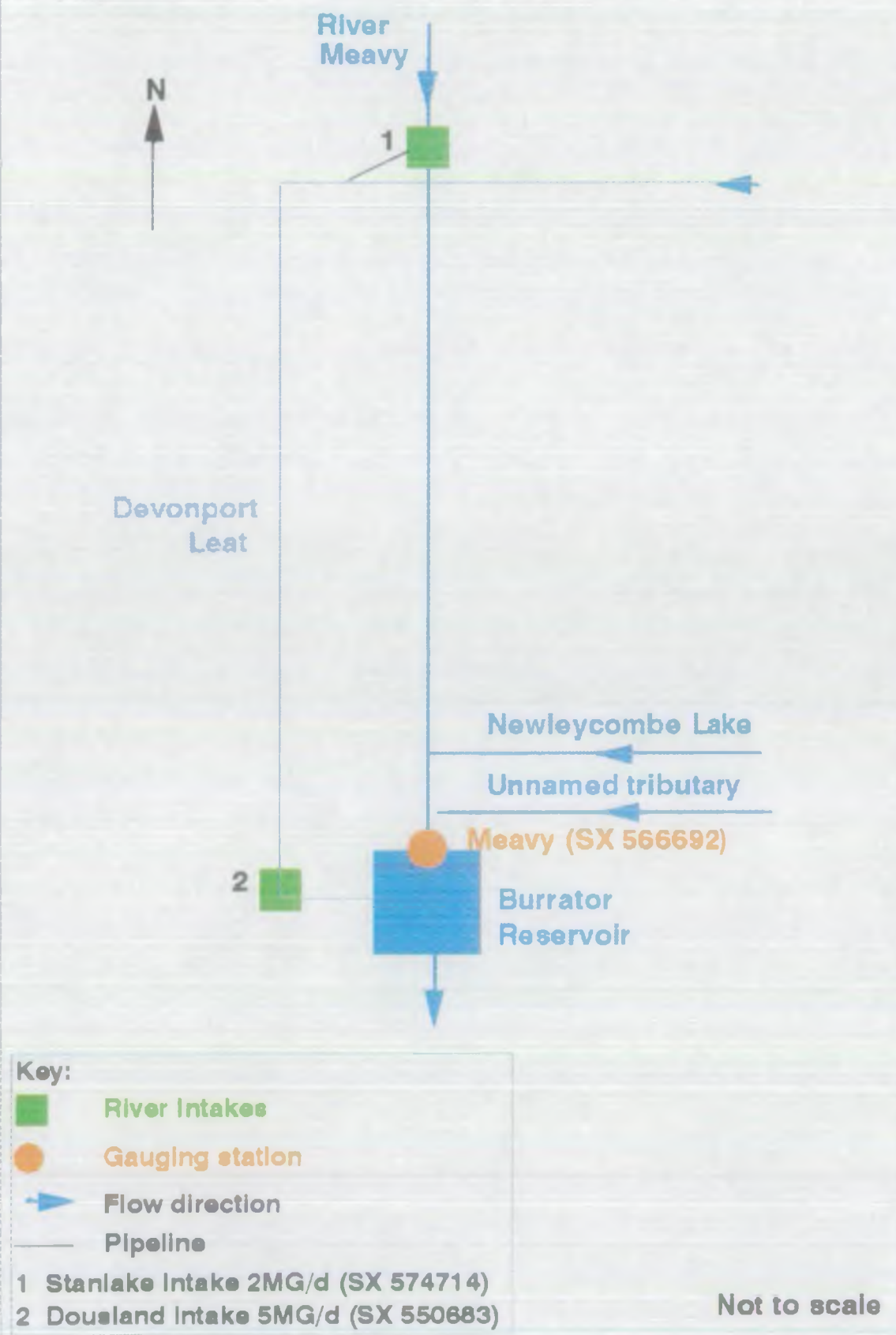


DIAGRAM 2:

Layout of the register:

9/1/08

Burrator Reservoir. 708.00 OD. in....708'3.5	Rainfall (Head Weir)....0.14
Screen chamber gauge (12ft)...5 3/8"	River Gauge (20ft)..0.83 (50ft)..-
Temperature: Water 42' Air 43'	Leat (4ft).....8"
Well Gauge (9ins).....1 1/4"	Weir pond (50ft)....5"
Venturi Meter: Index..5080400000	Consumption.....6320000
Evaporation reading...frozen	Rainfall (Burrator).0.16
Yelverton Meter.....7460100	Consumption.....62900

Roborough Reservoir (Depth 11'6")	8am..8'6"	Noon..10'3"	Overflow (10ft)..
Temperature: 8am..32	9pm..29	Rainfall.....0.12	
Wellpit Gauge (12ft)..5 1/16"		Leat Gauge (4ft)....0 7/8"	

Crown Hill Reservoir (Depth 15ft 6")	9am..4'9"	pm..
Leat (4ft).....9"	Pressure	9am..48 5pm..0

Hartley Reservoir (Depth 20ft 9")	9am..12'7"	pm..10'8"
Gauge (6ft) 9am..10 1/4" 9pm..8"	Pressure	9am..6 5pm..18

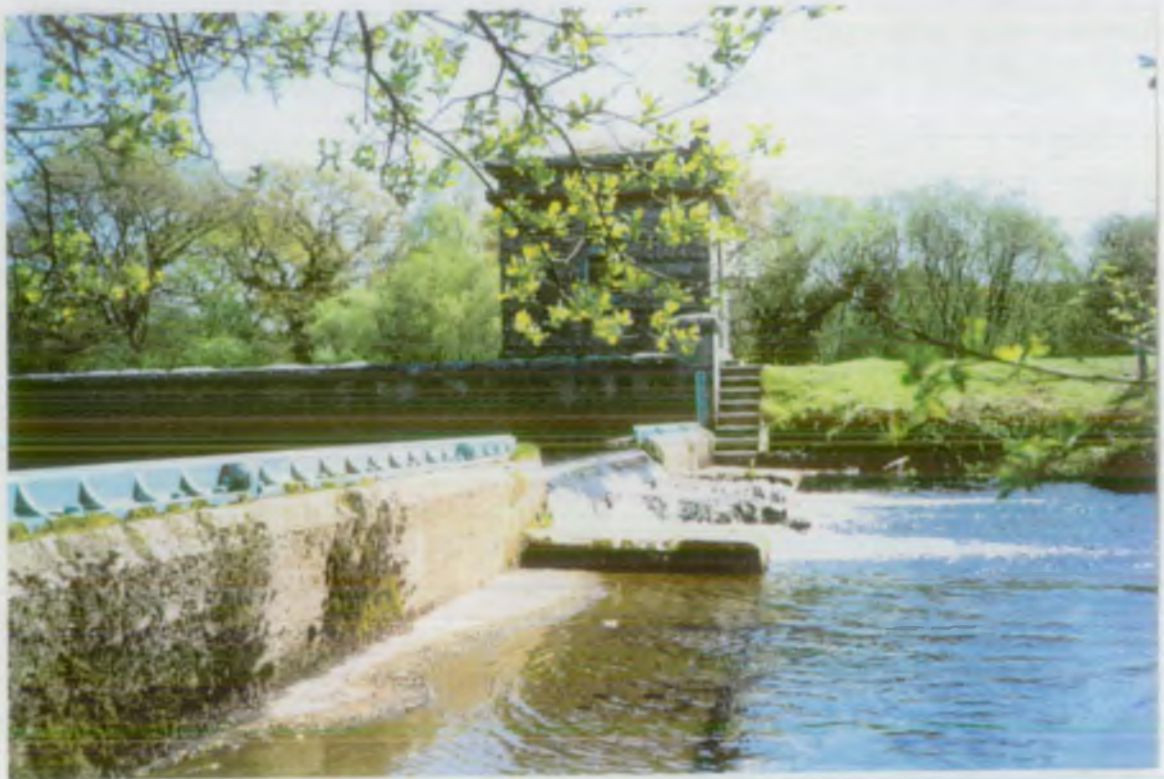
Drakes Place Reservoir (Depth 11ft 6")	9am..4'9"	Rainfall..0.02
--	-----------	----------------

Admiralty Reservoir (Depth 9ft 6")...8'0"

Meter (Siemens)	Index....7616000	Consumption.....179000
" (Bye Pass)	No1 Index..	Consumption.....
"	No2 Index..	Consumption.....
Pressure Gauge	Drakes Place Reservoir.....52	
"	Central Main above Pressure Reducer 50.....Below 30	
"	Municipal Offices.....65	
Citadel Meter	Index...6542000	Consumption.....8000
Stonehouse Meter	No1 Index..29533000	Consumption.....228000
"	No2 Index..52806000	Consumption.....303000
"	No3 Index..22155000	Consumption.....
		Total Stonehouse...531000











APPENDIX 14

Catalogue: Brampford Speke

1.0 SUMMARY

GAUGING STATION NAME: BRAMPFORD SPEKE

RIVER: RIVER EXE.

START AND END DATE OF RECORD: 1907-1912

ARTIFICIALLY INFLUENCED?: NO

2.0 SITE INFORMATION

- River

Exe

- Grid Reference

Approximately SX 927 987 (See Map 1)

- Catchment area

Approximately 621km²

2.1 Background to the measurements

The gaugings at Brampford Speke were undertaken as part of an investigation on the River Exe, by the Royal Geographical Society to determine:

- a) The winter, summer and annual discharge.
- b) The amount of suspended and dissolved matter in dry and wet periods and the total amount for the year.
- c) The rainfall falling in different parts of each catchment and the average rainfall falling over the whole catchment.
- d) Area of each catchment, including the areas of calcareous, non calcareous, pervious and impervious rock formations and the different elevations of the catchments,

(Strahan et al 1916). Measuring weirs were not used because of the construction costs. Therefore to obtain the discharges for the stage discharge relationship the cross sectional area of the river was measured and multiplied by the mean velocity. The mean velocity was computed from the measurement of surface velocities. The report by Strahan et al (1916) on the investigation provides a more detailed explanation of the methods used. (Explanation of * in Section 7.0).

2.2 Current measuring authority

No longer used

3.0 RECORD DETAILS

3.1 Record length, with details of missing records

1907-March 1912 with no missing data.

3.2 Record format (Includes data type and media of the data)

1907-1912 Monthly mean discharges in cusecs on *photocopies. The discharge values have also been converted to cumecs and are available on *spreadsheet and 3.5" disc. Summary information of the data on disc, filenames and the disc itself is contained in Appendix 17.

3.3 Problems with the record format

No known problems

4.0 MEASURING STRUCTURE AND EQUIPMENT

4.1 Measurement Structure

- Brief description
Natural control
- Type of structure
-
- Weir approval?
-
- Weir alterations?
-
- Operational problems?
No

4.2 Recorder unit

- Manufacturer
-
- Type
Cast iron staff gauge

- Measurement in discharge or stage?

Stage

- Units of measurement

Feet and inches

- Rating curve available ?

Yes. Eight measured discharges were used for the rating curve, below 4.3ft. Above 4.3ft the rating curve was computed using a surface slope method, detailed in, *'The Investigation of Rivers. Final Report 1916' (Strahan et al 1916). A *photocopy of the rating curve is available.

The measurements for the discharge curve were taken by the research team working on the project but the daily readings of stage were carried out by the stationmaster at Brampford Speke.

- Stage/discharge conversion tables available?

No

- Operational problems?

No information

5.0 **ARTIFICIAL INFLUENCES**

5.1 Abstractions

- Has the record been affected by abstractions?

No

- What is the purpose of the abstractions?

-

- Abstraction Details

-

- Period of abstraction?

-

- What are/were the volumes of water abstracted, either licensed or approximate?

-

- Is the actual abstraction data available?
-

5.2 Reservoirs

- Has the gauging station been affected by the construction of a reservoir?

No

- When did construction begin?
-

6.0 OTHER RECORDS AVAILABLE

6.1 Availability of meteorological data

- Are meteorological records available for the site such as rainfall, evaporation records etc? Give details

Monthly and yearly rainfall means for Brampford Speke are available (Strahan et al, 1916) The rainfall is obtained from various sites in the catchment to represent the rainfall at Brampford Speke.

6.2 Availability of reservoir records

- If the record is an inflow or outflow to a reservoir, are there any other records available. Eg, transfers, reservoir levels, change in storage? Give details
-

7.0 SUPPORTING DOCUMENTATION

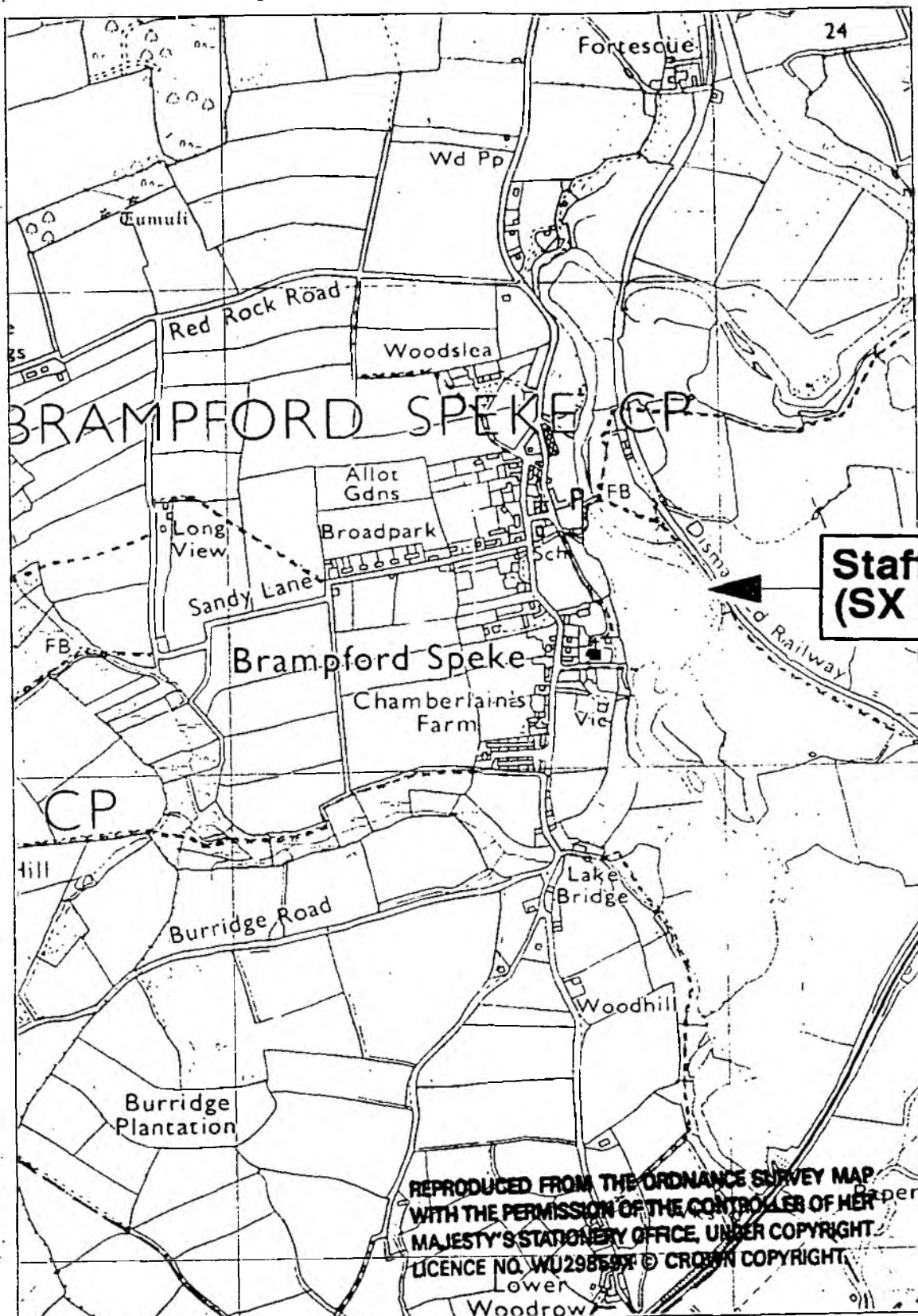
7.1 Data sources and locations

Strahan, A., McKenzie, N.F., Mill, H.R. and Owens, J.S. (1916). The Investigation of Rivers. Final Report 1916. London, The Royal Geographical Society.

- * Extracts and data from information marked with a * are available from Water Resources Planning in the following file:

HYDROMETRY: Hydrometric Data. Riverflow; Historic Records, Wallet numbers 25 and 26.

Map 1: Brampford Speke



Scale
1: 12500

APPENDIX 15

Catalogue: Exeter Quay

1.0 SUMMARY

GAUGING STATION NAME: EXETER QUAY
RIVER: RIVER EXE
START AND END DATE OF RECORD: 1907-1912
ARTIFICIALLY INFLUENCED?: NO

2.0 SITE INFORMATION

- River
Exe
- Grid Reference
Approximately SX 928 919 (See Map 1)
- Catchment area
1192 km²

2.1 Background to the measurements

The gaugings at Exeter Quay were undertaken as part of an investigation on the River Exe, by the Royal Geographical Society to determine:

- a) The winter, summer and annual discharge.
- b) The amount of suspended and dissolved matter in dry and wet periods, the total amount for the year.
- c) The rainfall falling in different parts of the catchment and the average rainfall falling over the whole catchment.
- d) Area of each catchment, including the areas of calcareous, non calcareous, pervious and impervious rock formations and the different elevations of the catchments,

(Strahan et al 1916). Measuring weirs were not used because of the construction costs. Therefore to obtain the discharges for the stage discharge relationship the cross sectional area of the river was measured and multiplied by the mean velocity. The mean velocity was computed from the measurement of surface velocities. The report by Strahan et al (1916) provides a more detailed explanation of the methods used. (Explanation of * in Section 7.0).

2.2 Current measuring authority

No longer used

3.0 RECORD DETAILS

3.1 Record length, with details of missing records

1907-March 1912 with no missing data.

3.2 Record format (Includes data type and media of the data)

1907-1912 Monthly mean discharges in cusecs on *photocopies. The discharge values have also been converted to cumecs and are available on *spreadsheet and 3.5" disc. Summary information of the data on disc, filenames and the disc itself is contained in Appendix 17.

3.3 Problems with the record format

No known problems

4.0 MEASURING STRUCTURE AND EQUIPMENT

4.1 Measurement Structure

- Brief description

Natural control

- Type of structure

-

- Weir approval?

-

- Weir alterations?

-

- Operational problems?

No

4.2 Recorder unit

- Manufacturer

-

- Type

Cast iron staff gauge

- Measurement in discharge or stage?

Stage

- Units of measurement

Feet and inches

- Rating curve available ?

Yes. Nine measured discharges were used for the rating curve, below 4.5ft. Above 4.5 ft the rating curve was computed using a surface slope method, detailed in; 'The Investigation of Rivers. Final Report 1916' (Strahan et al 1916). A *photocopy of the rating curve is available.

The measurements for the discharge curve were taken by the research team working on the project but the daily readings of stage were carried out by employees of Exeter City Council.

- Stage/discharge conversion tables available?

No

- Operational problems?

No information

5.0 ARTIFICIAL INFLUENCES

5.1 Abstractions

- Has the record been affected by abstractions?

Yes

- What is the purpose of the abstractions?

1 public water supply

- Abstraction Details

Water abstracted from the River Exe to supply the City of Exeter. The volume of water abstracted is almost constant at 750 million gallons per year (Strahan et al 1916). No other information on the abstraction has been found.

- Period of abstraction?

No information

- What are/were the volumes of water abstracted, either licensed or approximate?

750 million gallons per year

- Is the actual abstraction data available?

No

5.2 Reservoirs

- Has the gauging station been affected by the construction of a reservoir?

No

- When did construction begin?

-

6.0 OTHER RECORDS AVAILABLE

6.1 Availability of meteorological data

- Are meteorological records available for the site such as rainfall, evaporation records etc? Give details

Monthly and yearly rainfall means for Exeter Quay are available (Strahan et al, 1916). The rainfall is obtained from various sites in the catchment to represent the rainfall at Exeter Quay.

6.2 Availability of reservoir records

- If the record is an inflow or outflow to a reservoir, are there any other records available. Eg, transfers, reservoir levels, change in storage? Give details

-

7.0 SUPPORTING DOCUMENTATION

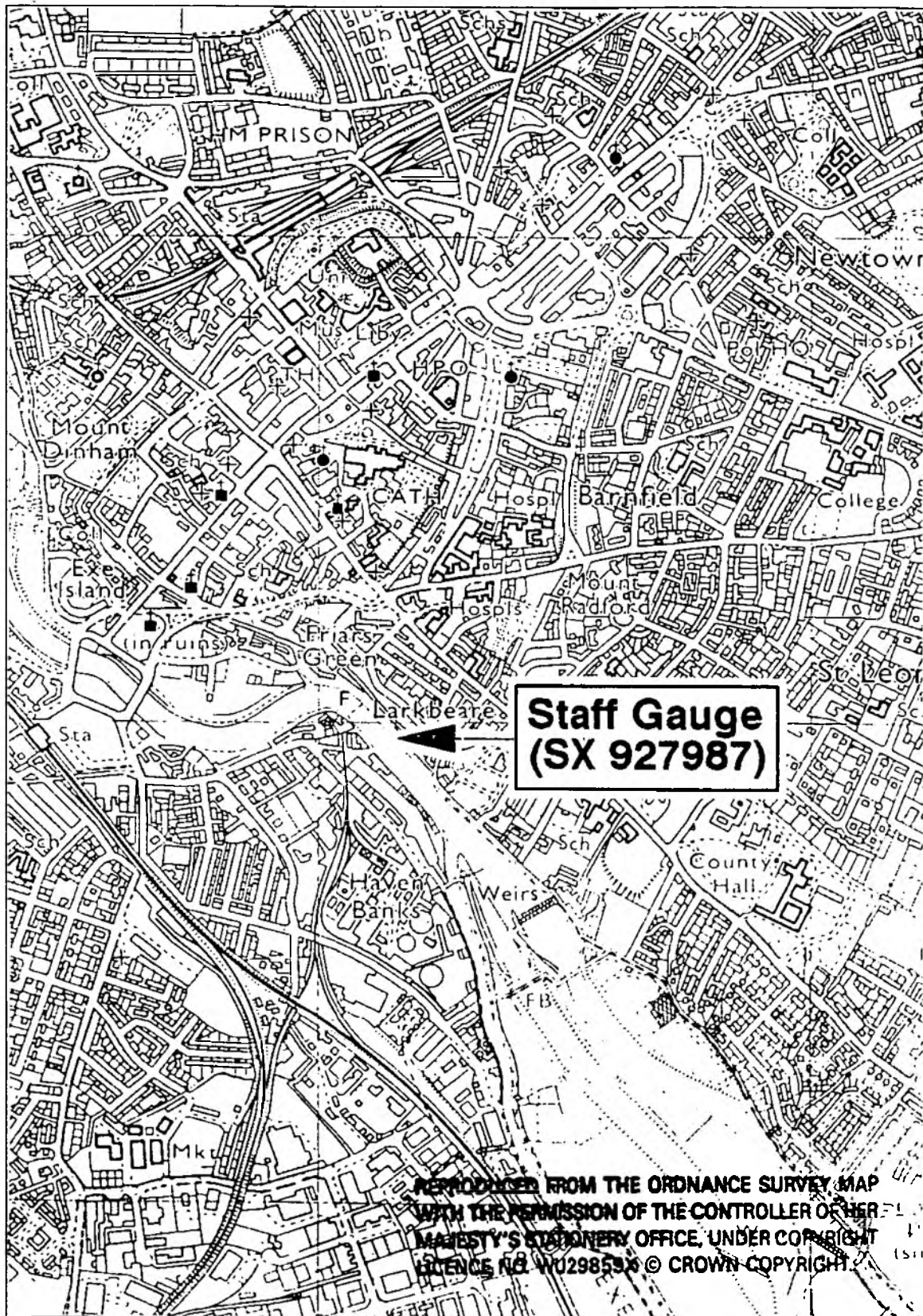
7.1 Data sources and locations

Strahan, A., McKenzie, N.F., Mill, H.R. and Owens, J.S. (1916). The Investigation of Rivers. Final Report 1916. London, The Royal Geographical Society.

* Extracts and data from information marked with a * are available from Water Resources Planning in the following file:

HYDROMETRY: Hydrometric Data. Riverflow; Historic Records, Wallet numbers 25 and 26.

N



Scale
1: 12500

APPENDIX 16

Directory of organisations contacted

DIRECTORY OF ALL ORGANISATIONS CONTACTED WHILST INVESTIGATING THE EXISTENCE
OF THE FLOW RECORDS

Organisations holding relevant flow record information:

Devon Record Office Tel: (0392) 437845
Hennock Road
Marsh Barton
Exeter

National Power Plc Tel: (0822) 810248
Mary Tavy Power Station
Nr Tavistock
West Devon

NRA SW Tel: (0392) 444000
Manley House
Kestrel Way
Sowton Industrial Estate
Exeter

Surface Water Archive Tel: (0491) 838800
Institute of Hydrology
Maclean Building
Crowmarsh
Wallingford

Torquay Reference Library Tel: (0803) 217679
Lymington Road
Torquay

West Devon Record Office Tel: (0752) 385940
Clare's Place
Coxside
Plymouth

Organisations where the flow record information has not all been looked at or
where information may still be found:

Museum of Dartmoor Life Tel: (0837) 52295
3 West Street
Okehampton

North Devon Record Office Tel: (0271) 47119
Tuly Street
Barnstaple

SWWSL Tel: (0392) 219666
Peninsula House
Rydon Lane
Exeter

West Devon Record Office
Clare's Place
Coxside
Plymouth

Tel: (0752) 385940

Organisations with no flow record information:

Councils:

Teignmouth District Council
Torbay Borough Council

Libraries:

Ashburton Library
Bovey Tracey Library
Brixham Library
Buckfastleigh library
Combe Martin Library
Cornwall Library Services
Cornwall Reference Library
CREDITON Library
Devon Library Services
Exeter Reference Library
Kingskerswell Library
Kingsteignton Library
Moretonhampstead Library
Newton Abbot Library
Okehampton Library
Teignmouth library & Advice Centre
West County Studies Library

APPENDIX 17

Data discs

DATA ON DISCS

File name	Gauging Station	Dates	Data
TRENCHFOR.DAT TRENCHFOR.WK3	Trenchford Stream	1908-1939 1948-1964	Mean daily discharges in cumecs Weekly stage values in inches
BLACKING.DAT BLACKING.WK3	Blackingstone Stream Kennick Bullaton 1 Bullaton 2 Clampitt Higher Mardon Lower Mardon	1908-1939 1948-1964 1908-1938	Mean daily discharges in cumecs Weekly stage values in inches Mean daily discharges in cumecs
RIVERTEI.DAT RIVERTEI.WK3	South Teign Intake	1929-1939	Mean daily discharges in cumecs Mean daily abstractions in cumecs 'Naturalised' flow data
SWINCOMB.DAT SWINCOM2.DAT SWINCOMB.WK3 SWINCOM2.WK3	Swincombe Intake	1934-1951 1952-1968 1934-1951 1952-1968	Daily mean discharges in cumecs
BALABROO.DAT BALABROO.WK3	Bala Brook Avon Intake	Mar 1951-May 1957 Mar 1951-Feb 1953 Mar 1953-May 1957	Mean daily discharges in cumecs Mean daily abstraction in cumecs Mean daily abstraction total for both the Avon and Bala Intakes in cumecs
IRISHMAN.DAT IRISHMAN.WK3 IRISHMA2.DAT IRISHMA2.WK3	Irishmans Wall	1943-1944 1948-1964 1964-1973 1987-1991	Daily mean discharges in cumecs
BRAMPFOR.DAT BRAMPFOR.WK3	Brampford Speke	1907-Mar 1912	Mean daily discharges in cumecs
EXETERQU.DAT EXETERQU.WK3	Exeter Quay	1907-Mar 1912	Mean daily discharges in cumecs