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FALKLAND ISLANDS

A Report on the Stanley Potable and Fire-Fighting Water Supply Systems

Crown Agents for Oversea
Governments and Administrations
4 Millbank
London SW1P 3JD

Ref. Q367/44
March 1977

CROWN AGENTS

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His Excellency
The Governor
Port Stanley
FALKLAND ISLANDS

Our ref Q 367/44

Your ref

Date March 1977

Sir

PORT STANLEY WATER SUPPLY

Acting in accordance with the instructions given us by the Ministry of Overseas Development our senior engineer, Mr A A Smith, B Sc, C Eng, FICE, FIWES visited Port Stanley from 13 to 27 January 1977 to carry out an inspection of the potable and fire-fighting water supply systems in the town of Port Stanley and to make recommendations for their improvement.

2 We now have pleasure in submitting ten copies of our Report. Should there be any further information or explanation which you require, we should be pleased to be of service to you.

Yours faithfully

N B DYKE, B Sc, ACGI, C Eng, FICE, MBIM
Head of Engineering Advisory Services Division

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INTRODUCTION

AN APPRAISAL OF THE POTABLE AND FIREFIGHTING WATER SUPPLIES TO THE TOWN OF PORT STANLEY FALKLAND ISLANDS

1 INTRODUCTION

1.1 Origin of the Study

1.1.1 On 11 November 1976 the Ministry of Overseas Development commissioned the Crown Agents on behalf of the Falkland Islands Government to inspect the potable water supply to the town of Port Stanley, Falkland Islands.

1.2 The Terms of Reference

1.2.1 To check and examine the Water Filtration Plant near Stanley, to advise on its future and to produce a report with recommendations.

1.2.2 To advise on the water supply system for fire-fighting including the positions of hydrants, in the town of Stanley and to produce a report with recommendations.

1.3 The Survey

1.3.1 The survey was the responsibility of the Head of Engineering Advisory Services, Mr N B Dyke, B Sc, ACGI, C Eng, FICE, MBIM and was carried out by Mr A A Smith, B Sc, C Eng, FICE, FIWES, Senior Engineer.

1.3.2 Mr Smith arrived in Stanley on 13 January 1977 and left on 27 January 1977.

1.3.3 A list of officers and members of staff of the Falkland Islands Government with whom Mr Smith had discussions is given in Appendix 1.

1.4 Acknowledgements

1.4.1 We wish to express our sincere thanks to Mr Arthur Monk, the Government Chief Secretary and members of his staff for the arrangements made and the help given during the survey. Their friendliness and co-operation is gratefully acknowledged.

1.4.2 We also wish to thank Assistant Divisional Officer D J Davis of the Cheshire Fire Brigade, in Stanley on assignment by ODM, for his invaluable assistance in assessing the fire risks and the quantity of fire-fighting water needed, also for his recommendation for siting of fire hydrants.

1.5 Responsibility for Report

Although this Report has been commissioned by the British Government under British aid arrangements, the British Government bears no responsibility for, and is not in any way committed to, the views and recommendations expressed herein.

CHAPTER 2

SUMMARY OF RECOMMENDATIONS

2 SUMMARY OF RECOMMENDATIONS

2.1 Recommendations for immediate implementation

2.1.1 Carry out items of urgent repair, renovation or improvement as listed in Appendix 11.

2.1.2 Purchase items of small equipment as listed in Appendix 12, the estimated total cost of which is £1215.00.

2.1.3 Put in hand items of minor works as listed in Appendix 13, the approximate cost of which, excluding waterworks labour is estimated to total £2835.00.

2.1.4 Improve chemical dosing procedure by:

2.1.4.1 Obtaining assistance with water treatment expertise to direct dosaging of chemicals (5.1).

2.1.4.2 Correct chemical treatment (5.2).

2.1.4.3 Ensure post-filtration soda-ash dosing point is in such a position as to provide proper mixing (5.2.2).

2.1.5 Prepare a maintenance programme with record book to ensure that no essential work is overlooked (5.2.4).

2.1.6 Provide meters on outlets of Dairy Paddock Reservoir and Sapper Hill Tank and carry out regular night waste detection tests (5.2.5). The approximate cost of meters is £700.00.

2.1.7 Prepare and promulgate Bylaws (5.2.6).

2.1.8 Install meters to register consumption on trade premises (5.2.7). The current fob UK port costs of suitable meters are:

1/2in meter	£ 9.20
3/4in meter	£12.03
1in meter	£19.09

2.1.9 Set up new gauging station on the Murrel River (7.1.4).

2.2 Recommendations for implementation before 1982

2.2.1 Design and construct new treatment works (7.3).

2.2.2 Prepare engineering design and tender documents for constructing a new intake and pumping station on the Murrel River together with raw water pumping main to new treatment works (7.2).

2.3 Recommendations for implmentation at some future date

2.3.1 Construct work described in 2.2.2.

2.3.2 Provide new fire-fighting water supply system (8.3). The estimated fob UK Port prices of the necessary imported plant and materials are:-

		£
2.3.2.1	Hydrants	1386
2.3.2.2	Sluice Valves	2607
2.3.2.3	Indicator Plates and Posts	320
2.3.2.4	Pipes	82046
2.3.2.5	Storage Tank	18464
2.3.2.6	Pumps and Control Gear	1000
2.3.2.7	Miscellaneous	6000
Total fob UK Port		£111823

CHAPTER 3

PREAMBLE

3 PREAMBLE

3.1 Historical

Since World War II the potable water supply of Port Stanley has been the subject of two engineering reports which were:

3.1.1 The Pape Report in 1953 and

3.1.2 The Casserly Report in 1972.

Reference is also made to it in Volume 1 of Lord Shackleton's "Economic Survey of the Falkland Islands - Resources and Development Potential" which is herein referred to as "the Shackleton Report".

Prior to 1956 when the Treatment Works which are the subject of this Report, were commissioned Stanley relied on the Mount William Springs and springs in Mullet Creek for its water supply. Both these sources were abandoned when the new Works were brought into use.

The Casserly Report was the result of a survey of the Works and distribution system carried out early in 1972 under assignment by the Overseas Development Administration of the Foreign and Commonwealth Office on behalf of the Falkland Islands Government.

3.2 References to previous reports

For convenience references to paragraphs in the Pape and Casserly Reports will be prefixed by the letters "P" and "C" respectively. Hence (C1.3) refers to paragraph 1.3 of the Casserly Report entitled "Rising Main and Service Reservoirs". Also those pages of the Casserly Report which are of particular relevance to this report are repeated as Appendix 2. The Casserly Report similarly had parts of the Pape Report appended thereto.

3.3 Interpretation of Terms of Reference

In carrying out our Survey we set out to answer the following questions:

3.3.1 What is the current state of the treatment plant and distribution recticulation and how is it operated and maintained?

3.3.2 What supply of water is required for fire-fighting and is it currently available from the hydrants?

3.3.3 Are the existing fire hydrants properly sited, indicated and maintained?

3.3.4 In the event of deficiences of supply being found, can these be remedied by improvements to the existing plant, storage and mains or are complete new works and augmentation of the distribution recticulation necessary?

3.3.5 To achieve an adequate supply of water for fire-fighting can this best be done by augmenting the existing potable water mains and storage or by constructing a completely new salt water system?

3.3.6 Over many years the population of Stanley has remained virtually constant with a gradual increase in demand, will this state obtain with the completion of the permanent airport, the possible exploitation of oil deposits and other developments recommended by Lord Shackleton?

3.4 Limitations upon recommendations

In making our recommendations we have been particularly careful not to overlook the limited resources of local funds and of labour and also of the rising costs of imports.

In considering recommendations involving capital expenditure we have kept in mind that the cheapest to buy is unlikely to be the cheapest to run and maintain, that installations should be easy to operate and maintain with the minimum of labour and imported chemicals.

CHAPTER 4

REPORT ON CURRENT STATE OF THE PLANT

4 THE CURRENT STATE OF THE PLANT

The general description of the plant remains as described by Casserly (C1) with a few exceptions which are hereinafter mentioned.

4.1 The Source (C3.1)

Prior to our survey the Islands had experienced a period of relatively dry weather and in consequence the flow of water in the Moody Brook was low and very little more than the abstraction rate.

4.2 The Intake and Raw Water Main (C3.3)

Repairs recommended by Casserly to prevent water by-passing the weir were carried out shortly after his visit and there was no visual evidence of any water finding its way past the weir. There was no evidence of deterioration of the raw water main and the float-operated plant inlet control valve was working properly.

4.3 Raw Water (Low Lift) Pumps

These pumps are both capable of meeting the current output of the works viz 5400 gph (6.82 litre/second). They require cleaning and painting and adjustment of glands to avoid excessive leakage. Adequate lubrication is provided by a small weepage past the glands.

4.4 Flocculation and Sedementation Tanks

The tanks are of sectional plate steel construction by Braithwaites and, as a result of lack of maintenance have deteriorated to the state of requiring repair or replacement. We are advised by the Falkland Islands Government that glass reinforced plastic (GRP) sectioned plate replacement units are on order. It is difficult to see how it is possible to remove the old units and install the new ones without causing a considerable disruption of the supply of colour-free water. We are of the opinion that it would have been easier to have cleaned out the tanks and applied an epoxy resin lining, which would not only have made them waterproof but also have protected them from further internal corrosion.

If these tanks are to be retained in service for any length of time they sh[illegible]ld be both cleaned internally and painted [illegible]th a non-taste producing bitumastic solut[illegible]n such as Wailes Doves Bituros.

4.5 The Filters

4.5.1 The condition of the filter shells is excellent internally and is an example of what can be achieved by providing the correct initial protection. The shells should be repainted externally to bring the protection up to the necessary standard.

4.5.2 The filter media is deficient in both filters. We were shown a sample of sand from the Murrel River which it was intended should be used to make the top layers up to the correct thickness. This sample was sieved at the new airport by kind permission of Preece, Cardew and Rider's Representative, Mr Brian Ashfield. The replacement sand should be uniformly grade 14/30 using BS Sieves. From the result of the sieving - Appendix 3 it can be seen that only 50%, or thereabouts, of the sample is suitable. However in view of the small quantity required the sieving out of the unwanted fines would not be a costly task. The replacement sand must not be placed in the filters without first having been properly graded as with the correct rate of backwash the fines will be washed out of the filters and deposited in the drain whence they would have to be manually removed. Neither should the rate of backwash be reduced to prevent these fines being washed out of the filters. Such action would reduce filter runs between washes and also prevent the correctly graded sand being properly cleansed.

4.5.3 Both filter outlet float operated valves require attention. Probably adequate greasing of the operating linkage would enable them to work freely and enable the weight of the linkage to be sufficient to keep the outlets drop-tight during backwashing as intended and thus obviate the long established custom of jamming them closed with a bar during backwashing.

4.5.4 The condition of both plate steel filter outlet inspection chambers is poor. They urgently require cleaning out and repainting to prevent further corrosion which is already extensive.

4.6 The Chemical Dosing Plant, Stores and Laboratory.

The chemical dosing equipment now comprises five gravity dosers with dissolving and mixing tank together with a 'Clorocel' chlorinator.

4.6.1 The condition of the gravity doser tanks is satisfactory. Unfortunately a number of orifices, the means by which the flow of solution is regulated, have been tampered with and many of those examined did not produce the flow engraved on them. No confidence can now be placed on these engravings and after changing an orifice to alter the dosage, the actual discharge must be calculated by timing the filling of a litre flask. A record should be made, (a chalked figure on the side of the solution tank would suffice) of the flow passing the installed orifice, after which minor dosage changes can best be achieved by altering the concentration of the solution.

4.6.2 Unfortunately the Clorocel Unit went unserviceable a few days before Mr Smith's arrival and replacement parts had not arrived in Stanley. Since it was no longer possible to sterilise the water pumped to supply, the Senior Medical Officer was advised and he authorized the broadcasting of a warning to consumers over the local radio to boil all drinking water as a precaution against water-borne pathogenic diseases. It had a further unfortunate effect that we were unable to check the working of the chlorinator or the effectiveness of the sterilisation both at the Works and in the distribution reticulation. The replacement unit was on board the chartered supply ship due in Stanley on 31 January 1977.

4.6.3 The chemical Store appears adequately stocked.

4.6.4 The Chemical Laboratory is well stocked both with equipment and reagents but there are a few additions which are desirable. They are:-

4.6.4.1 Only two pH range comparator discs are there covering 6.0 - 7.6 and a universal disc covering 5.0 - 10.0. The latter is used to determine in which pH range a sample lies. Smaller range discs are then used to determine the pH more accurately. Since coagulation is best achieved with a pH 5.6 - 6.1 and the treated water should have a pH 8.1 - 8.3, it is recommended that discs covering pH ranges 5.2 - 6.8 and 7.0 - 8.6 should be purchased together with a supply of appropriate indicators.

4.6.4.2 Whilst the provision of further discs is essential, it is also desirable that a laboratory type pH meter should be purchased. This is easier to use than a comparator which is dependent upon the operator's ability to compare colours.

4.6.4.3 Whilst an excellent laboratory balance is available, someone has removed the tweezers from the weight box. These should be replaced.

4.6.4.4 The laboratory is clean and tidy.

4.6.4.5 The sampling cocks recommended by Casserly (C4.33c) have not yet been provided. This recommendation should be implemented.

4.7 The Workshop and Stores

The Workshop and Stores are not as tidy as they should be. There are parts of plant in the room which have been removed due to defects. These should either be renovated or discarded.

4.8 The Treated Water (High Lift) Pumps

Both sets are currently delivering 5,400 gph (6.82 litre/s) to the low level service reservoir at Dairy Paddock. Until about a year ago the output of both was around the designed figure of 6,000 gph (7.58 litre/s). The decline in output is probably due to the condition of the interior of the pumping main (see para 4.11). Both pumps require cleaning and painting and their glands adjusted to prevent excessive leakage. One air-release valve is leaking and should be attended to or replaced. Since one pump is a recent replacement, it is reasonable to assume there is no deterioration in the performance of the old one.

4.9 The Electrical Equipment

This equipment is in good working order and appears to be properly serviced.

4.10 Treatment Plant Building

The building generally badly needs painting. A start has been made on the exterior but the Contractor failed to complete his contract. It should be remembered that it is easier to retain staff if one provides them with pleasant conditions in which to work. In this connection the heating provided is poor and should be improved or new equipment installed.

4.11 Treated Water Pumping Main

Since the output of both the old pump and the new one is the same it is reasonable to conclude that the decline in output is due to the interior condition of the main. A series of flow and pumping head readings were taken and these were plotted. The result is appended (Appendix 4). In his design Pope (P10.4) allowed for 14,000 ft of 6in NB cement lined pipe, 5.82in id, having a C value in Hazen William's pipe friction formula of 130. He gives a total friction head allowing 6.2 ft for specials of 30ft. The loss through 14000 ft of main given by Pope corresponds to a C value of 143 not 130. A value of 143 however is acceptable. The current value of C is only 84 indicating that there is probably a considerable deposit within the main or that the cement lining has been attacked by low pH treated water. In paragraph 5.3.1 mention is made of excessive alum and low pH of the final water. Both of these conditions are probably contributing to the increased pipe friction. The first requisite is that the treatment should be corrected and the second that the main should be cleaned out using a pig, sometimes referred to as a swab, to dislodge any slime adhering to inside of the pipe, followed by a flushing. This should restore the main to its original capacity, unless the low final pH found has had an opportunity to attack the cement lining in which case there may be little improvement.

4.12 The Low Level Reservoir at Dairy Paddock

This reservoir supplies the lower areas of the town. It existed as an open reservoir supplied from the Mount William springs until the works recommended by Pope were constructed. At the same time a roof was put over the reservoir to protect the water from contamination. The roof of the reservoir is now in need of repairs to the asbestos cement sheeting which has been holed in a number of places. This damage is apparently not the result of human vandalism but from stones dropped by seagulls. The reservoir, we understand, has to be cleaned out at least once a year. This is probably due to existance of perspex transparent sheets in the roof which let in the daylight and promote algal growth. These sheets should either be replaced by asbestos cement sheets or simply painted over. Thereafter cleaning out should be carried with the assistance of artificial lighting. There is also evidence in the reservoir of excessive alum carry-over which also has to be avoided. This can be achieved by correct treatment. This is referred to later. The roof structure appears to be in good condition. Provision should be made for re-painting this within the next two years.

4.13 High Level Booster Pump and Storage Tank on Sapper Hill

The higher areas of the town are supplied from Sapper Hill Tank. This is a Braithwaite tank, with central dividing wall, having a total capacity of 100,000 gallons. It is fed by a single electrically driven booster pump installed in a small pumphouse adjacent to Dairy Paddock Reservoir whence the supply is obtained.

4.13.1 The booster pump and pumphouse are badly in need of cleaning and repainting. Whether or not our recommendations for the supply of water for fire-fighting are implemented, this pump should be duplicated and the duty pump should be controlled by an electrode relay with the electrodes installed in the high level tank. The existing pushbutton starter with inherent no-volts release has to be manually reset to start the pump after the briefest power interruption. This is an undesirable feature. The starter should be replaced by one of a more suitable type.

4.13.2 The Sapper Hill tank is built on sleeper walls with the floor about 3 feet off the ground. There is ample evidence both on the exterior surfaces and soffit of the floor plates that the tank is badly corroded within. It is confirmed locally that this is so and that the division has been equally attacked. Unless urgent remedial measures are taken this tank will soon become a write-off. At the moment it appears structurally sound and could be preserved by applying an epoxy resin lining. This tank forms an essential part in our proposals for providing an adequate supply of water for fire-fighting and should be properly protected as soon as possible.

4.14 <u>The Distribution Reticulation</u>

4.14.1 All the distribution mains are of the order of 50 years or more old. None of them is more than 4in NB. There is evidence from the poor flow from fire hydrants that many must be badly tuberculated or the flow otherwise impaired. To provide an adequate supply to all consumers it is necessary that the flow in some mains should be improved. This can best be achieved by providing cross-connection to the proposed new fire mains. (See 8.3).

4.14.2 As recommended by Casserly (C5.1) all air valves have been made to work correctly.

4.14.3 All fire hydrants are properly maintained but the flow from most, it is understood, is virtually useless for fire-fighting. No equipment is available for flow-testing hydrants. A set of this equipment should be procured so that flow and residual pressure available at hydrants, essential information for fire services, can be found and scheduled.

4.14.4 All valves and hydrants should be provided with British Standard Indicator Plates. Such indications that exist are not sufficiently prominent.

4.14.5 One cross-connection between the high and low level systems mentioned by Casserly (C7.4) is still the only one in existence.

CHAPTER 5

REPORT ON STAFFING AND OPERATION OF PLANT

5.1 Staffing

5.2 Plant Operation

5.1 Staffing

Casserly recommended (C8) a re-organisation of the Public Works Department to provide adequate staffing of the Waterworks under the Superintendent of Works. Due to shortage of labour it has not been found possible to implement the recommendation completely but at the time of the inspection three full-time plant operators were employed under the immediate supervision of the Senior Plumber, Mr R Smith. The principal deficiency is the absence of a senior plant operator knowledgeable of the fundamentals of water supply chemistry and capable of giving the operators instructions regarding the correct doses of the various chemical reagents to apply. It is unfortunate in the circumstances that the quality and characteristics of the raw water drawn from Moody Brook are subject to frequent variations which in turn call for constant surveillance and adjustment to dosages particularly after heavy rainfall. At the time of Mr Casserly's visit Mr R Stewart was Senior Plant Operator and, implementing Casserly's recommendation (C8.5), Mr Stewart was sent to the UK where he underwent a course of training at West Pennine Water Board. From discussions our Mr Smith had with Mr Stewart he obviously benefitted greatly from attending this course and until he was transferred to become Fire Brigade Superintendent about 18 months ago all was going well at the treatment works including the keeping of records recommended by Casserly (C4.2). From August 1975 to November 1976 the plant was run by a number of untrained part-timer workmen without any technical supervision. This resulted in improper dosing, neglect of maintenance and the failure to keep proper records. As previously mentioned they now have three full-time operators but no technical supervision. Proper records are again being kept but the gap in these was a considerable handicap during our survey. It is understood that a chemist is shortly to join the Government staff in Stanley and it is possible that he may have sufficient knowledge of water treatment to advise on treatment on a part-time basis. In the meantime it is recommended that the expertise and experience of Mr Stewart should be used say for a couple of hours each week to ensure that the usage of chemicals is kept as little as possible consistent with obtaining a water of adequate clarity and sterility.

5.2 Plant Operation

5.2.1 Pre-Sedimentation Chemical Dosing

Reference has previously been made (4.12) to the evidence of excessive carry-over of alum found in Dairy Paddock Reservoir. This was investigated and all dosages were checked. It was found that the following were being administered:

Sodium Carbonate (Soda Ash)	-	42 mg/l
Aluminium Sulphate (Alum)	-	292 mg/l
Sodium Aluminate	-	10 mg/l
Magnafloc LT 24	-	0.44 mg/l

There is ample evidence (P Appendix 9, Table 1) and (C Appendix H, Sheet 2) that the dosages of Sodium Carbonate and Aluminium Sulphate were grossly in excess of those necessary to obtain satisfactory flocculation and colour removal. Reference to Appendix 5 will provide the reader with the chemistry of flocculating this water. From these notes it will be seen that satisfactory flocculation and colour removal should be possible from the following dosages when using first Alum, Soda Ash and Magnafloc and second when using Alum Soda Ash, Sodium Aluminate and Magnafloc:

5.2.1.1	Alum	40.0 mg/l
	Soda Ash	39.0 mg/l
	Magnafloc LT 24	0.5 mg/l
5.2.1.2	Alum	54.0 mg/l
	Soda Ash	40.0 mg/l
	Sodium Aluminate	10.0 mg/l
	Magnafloc LT 24	0.5 mg/l

The amount of Soda Ash administered should be varied to maintain a pre-flocculation pH of 6.1 and a further dose of Soda Ash is required after filtration to bring the pH of the supplied water to about 8.1. This should be about 20 mg/l.

It will be noted that the additiona of Sodium Aluminate as well as Magnafloc should not be necessary as the purpose of both is to give more weight to the floc. We recommend that the dosages of Alum and Soda Ash should be adjusted to those recommended above. This is best done by adjusting the solution strengths. The way of doing this is shown in Appendix 6. At the moment all three pre-flocculation chemicals are being added simultaneously in the raw water pump sump. Better results are often obtained by dosing one before another. Trials would show which order would produce the best results. Unfortunately using gravity type dosers it is not possible to make these trials as the float-operated flow control valve is immediately upstream of the raw water pump sump and pressure upstream of this valve is too high to allow the solution to flow by gravity into the raw water. There is a further disadvantage of these gravity dosers in that it is practically impossible to make rapid fine adjustments to the dosages. It is necessary that this should be possible to cope with rapid change in water characteristics following heavy rainfall. It is recommended that five electric motor driven dosing pumps should be purchased and installed. Four of these would be duty dosers and the other standby to the four. The duty units would be used to dose Alum, Soda Ash and Magnafloc prior to flocculation and Soda Ash after filtration for final pH correction. A further advantage which would accrue from the installation of these dosers is that the strengths of the solutions could be increased to 10% thereby minimising the labour necessary to replenish the tanks.

5.2.2 Post-filtration Chemical Dosing

5.2.2.1 Satisfactory control of the final pH, the accurancy of which is essential to provide a stable non-corrosive water, is thwarted first by difficulty of making a fine adjustment to the dosage and second by the point of dosing the solution. At present this takes place in a pocket of dead water upstream of the filter outlets and results in very poor mixing. This in turn results in almost hourly changes in the final pH although treatment has remained unaltered and one cannot be certain at any time that a sample examined will have the true pH corresponding to the dosage of Soda Ash administered. To overcome this defect a threader pipe should be fixed to the wall of the clear water tank through which the solution hose should be run to a point to discharge downstream of the outlet of No 2 Filter. The mixing would then be sufficient to give a steady final pH.

5.2.2.2 The effect of chlorination could not be observed due to the failure of the chlorinator. Recommendations mad made by Casserly (C4.3.5) should be followed closely.

5.2.3 Operation of Filters and of Pumping Equipment

The recommendations made by Casserly (C4.3.1 and C4.3.2) are being implemented except that it still appears necessary to use a bar to ensure that the filter outlet control valves remain closed during filter washing. Proper maintenance would make this practice unnecessary.

5.2.4 Reticulation Maintenance

We are advised that the periodical flushing out of mains (C7.3) is undertaken but it seems that no specific record of these operations is made. It is recommended that a book should be made available especially for recording where and when maintenance operations on the distribution reticulation are carried out. A programme should be compiled to ensure that all essential work is carried out at appropriate intervals.

5.2.5 Waste Detection (C7.5)

Meters have not yet been provided on the outlets of Dairy Paddock Reservoir and Sapper Hill Tank. It is still therefore not possible to carry out routine night flow tests. A relatively small leak on such a small system can result in a loss which is quite a large percentage of the true daily demand. Without regular checks on night flow one cannot be sure if the steady increase in annual consumption is due to increased demand by the consumer or the accumulation of undetected leaks. We strongly recommend that the necessary meters should be installed as soon as possible and regular night flow tests undertaken.

5.2.6 Plumbing Standards

To ensure that wastage does not take place on consumers' premises it is necessary that fittings and installations should conform to minimum standards. This is achieved in the UK by the enforcement of bylaws made in accordance with Water Acts of Parliament. Enabling powers exist in local Ordances in the Falkland Islands to allow the 'Waterworks' to require standards of consumers' installations but to date no action has been taken to put in print what standards are required. Hence both the consumer and the inspector have no reference by which to work and the inspector's view of what is or is not satisfactory is all that exists. Further no right of entry upon consumers premises exists to enable inspections of installations to be carried out. In the UK this right exists during normal working hours. Whilst we understand most consumers are co-operative and allow inspection of their installations, a few do not. We recommend that to assist in maintaining essential standards that Bylaws based on the model Bylaws used in the UK should be brought into force. In preparing these Bylaws the need for lagging of hot water pipes feeding wash basins and baths should not be overlooked. As point out by Casserly (C2.5) the necessity to run a hot water tap for an unduly long time to obtain hot water is a common form of wastage.

5.2.7 Metering Policy (C11.0)

As a means of restricting consumption Casserly recommended that universal metering of consumers' premises should be undertaken. He set out the extra labour and test equipment necessary to implement this policy. Due to the shortage of suitable labour this has not been found possible. Neither is it likely that such labour will become available in the foreseeable future. The writer does not completely share Mr Casserly's view that universal metering would have a significant effect. It could well do so initially but unless a punitive price is put on the water it is more than likely that the existence of a meter would soon be forgotten. Above all it should not be overlooked that the majority of the water used on domestic premises is for sanitation purposes and any restriction on its correct use for these purposes is highly undesirable. However water used for business purposes, whether it be for manufacturing or for a hotel, should be paid for in proportion to the amount used. This is the more usual in the UK and we recommend that the same policy should be adopted in Stanley.

CHAPTER 6

WATER CONSUMPTION AND FUTURE DEMAND

6.0 WATER CONSUMPTION AND FUTURE DEMAND

6.1 Consumption 1973 - 1976 (Recorded in Gallons)

January	1,688,893	1,921,326	1,092,490	(X)
February	1,702,375	1,259,654	1,694,080	(X)
March	2,160,000	1,477,540	1,880,030	(X)
April	1,368,000	1,755,980	1,893,420	(X)
May	1,700,106	1,684,540	1,823,630	
June	1,586,263	1,373,150	1,808,730	
July	1,482,890	1,988,820	2,780,020	
August	1,289,180	1,625,550	1,871,480	
September	1,857,078	1,673,400	1,940,950	
October	1,542,000	1,819,530	3,156,610	(?)
November	1,398,000	1,667,790	2,354,610	(?)
December	1,626,000	2,057,740	3,322,080	(?)
TOTALS	19,400,785	20,305,020	25,618,130	

(X) figures not in agreement with those at the treatment works.

(?) figures not recorded at treatment works.

The figures for January to May 1975 recorded at the Treatment Works were:

January	2,034,329
February	1,715,200
March	1,958,740
April	1,979,330
May	1,788,850

These figures together with those for October to December 1975 given by Lord Shackleton, which are extremely dubious, give a total consumption for 1975 of 26,710,929 gallons. This total is more than that given by Lord Shackleton who explains the high consumption in the later part of the year as being due to the construction of the new airport.

We were told that the whole of the water for the airport construction was carried by a 500 gallon tanker and that about five trips a day were undertaken. Assuming a seven day working week this amounts to 77,500 gallons a months, which does not equal the 1.1/2 million gallons above a normal consumption for the month recorded. We must confirm our opinion that the high figures given for October to December are extremely dubious and should be discounted in considering future requirements.

It has already been mentioned that due to staffing problems there was a period from October 1975 to December 1976 when few records were kept at the Treatment Works. The plant output flow meter readings are amongst those missing. It might be thought that the last reading before the break together with the first after the break would give an indication of the output over that period. Unfortunately this is not so as the meter integrator only reads up to 9,999,999 gallons and then returns to zero. From the recorded readings the consumption in 1976 was 9 9,783,400 gallons plus some multiple of 10,000,000 gallons. In practice it could have been either 19,783,000 or 29,783,000 gallons. Both these figures however appear unrealistic, the first being too low and the second too high. Bearing in mind the doubtful figures given for the latter part of 1975 it is reasonable to assume that the true figure for 1975 was more likely to have been about 22,500,000 gallons and that for 1976 about 23,000,000 gallons. This gives an average increase over the past four years of about 5%. The Chief Secretary has said that the "water population" of Stanley has remained sensibly constant during this period at about 1250. This means that the current consumption is about 50 gallons per head per day (gpcpd) including trade and shipping supplies. Without having detailed knowledge of these it is difficult to say if the consumption is reasonable or not. It is however not in excess of the per capita figures quoted by Casserly (C2.2) which also included an unrecorded trade demand.

6.2 Future Demand

In calculating estimates of future demand we are faced with a problem in that the future development or even lack of development will be materially affected by political issues now facing HM Government in the UK. If the economy of the Islands remains as at present, that is to say, principally dependent upon the growing of wool, there seems no reason to expect that the population of Stanley will increase much beyond its present 1250. If however the runway at the new airport is extended beyond its present 1250 m, as recommended by Lord Shackleton, it is possible that improved communications with the outside world would increase demand. As the prospect of any extension of the runway being constructed appear, at the moment at least, to be somewhat distant, we are lead to conclude that unless there is some industrial development in Stanley, the current supply of potable water should, with the minimisation of waste; suffice for the foreseeable future. It would however be prudent to consider the possibility of a small increase in demand of about 5% per annum which is about the present average rate of increase. If on the other hand industrial development does take place, it would then be necessary to make an estimate of the future demand based on the known requirements of those industries and of the number of immigrant workers who would be brought to live in Stanley.

CHAPTER 7

FUTURE OF SOURCES AND TREATMENT PLANT

7.0 FUTURE OF SOURCES AND INSTALLATIONS

7.1 Current Availability of Water

At the time of Mr Smith's inspection Stanley had enjoyed a period of dry weather and it remained mainly dry throughout the fortnight he was there. Consequently it was possible to observe the various sources available at a low yield. This advantage had been denied both Pope and Casserly.

7.1.1 Moody Brook

It was not possible to gauge the flow in the Moody Brook but when the supply to the treatment plant was 5,400 gph there was very little surplus passing over the intake weir (see photograph). It is unlikely that the quantity of water available much exceeded the designed capacity of plant, namely 6,000 gph. We must conclude that this source cannot be relied on to provide more than 144,000 gpd.

7.1.2 Mount William Springs

These springs which, together with the springs in Mullet Creek, provided the supply to Stanley before the construction of the present Works, were inspected and gauged and were found to be yielding only 4750 gpd. Pope (P7.3) noted at the end of his visit that after a short period of dry weather the yield had fallen to 11,000 gpd and went on to assume that the minimum could drop below 10,000 gpd. It is obvious that the quantity of water available from these springs is negligible and there is no point in spending money on providing any pipes to divert the water into Moody Brook.

7.1.3 Mullet Creek Springs

These springs were inspected and although it was not possible to gauge the yield, there appeared to be very little water flowing.

7.1.4 Murrel River

The Murrel River, as concluded by both Pope (P9.3) and Casserly (C3.4), remains the only source of sufficient yield to supplement the present supply to Stanley. This source was visited and despite a prior period of some weeks of practically dry weather, it showed a flow much in excess of anything likely to be required in Stanley for domestic use. It is unfortunate that the gauging weir constructed some time ago on the river has now been washed away, otherwise it would have been possible to quote the actual flow. In view of our conclusions it would be desirable that a new gauging station should be constructed on the river before next summer so that minimum flows can be measured. The flow should be recorded at least weekly during periods of dry weather and monthly at other times. The recorded flows should prove invaluable if it is ever decided to supplement the Moody Brook supply.

7.2 Future of Sources

It is obvious that the Moody Brook, even if supplemented from Mount William Springs, cannot meet the future needs of Stanley during the summer should there be any sizeable increase in demand. Lord Shackleton reported that during November 1970 there was a shortage which called for an appeal for restraint in the use of water. It would appear that this need was principally due to the leakage of water past the extremities of the weir. Since the wing walls were extended there has been no recorded instance of any shortage of water from this source. It would however be imprudent to assume that the safe yield of Moody Brook exceeds 6,000 gph, which is the designed throughput of the existing works. Both Casserly (C4.4) and Lord Shackleton are misleading when they conclude that because filter washing can be accomplished in 1/2 hour per day the output of the plant is 23.1/2 times 6,000 gpd viz 141,000 gpd. Unfortunately 5,600 gallons of this is required for the replenishment of the washwater tank. In our opinion however it would be unwise bearing in mind the need for flushing mains and other maintenance uses, to assume that more than 22 hours output a day viz 132,000 gpd are available for public consumption. At the moment due to the state of the rising main this figure is reduced to 123,200 gpd. Assuming that the demand for 1976 was 23,000,000 gallons and that the increase is 5% per annum, then the demand in 1981 will be 29.35 million gallons per annum or about 112,600 gpd if a 5-day week is still worked. This represents just over 85% of the available water with the delivery main in prime condition or 91% of the water currently available. Provided there is ample storage of treated water to ensure that peak demands are met, the current source at Moody Brook will be able to provide the demand until at least 1981 unless as aforesaid the town's population and industrial demands increase. However, in view of the time that would be necessary to develop any new source, should the need arise, it would be prudent to undertake the necessary engineering survey and design work as soon as any industrial development calling for a substantial amount of water and/or involving immigration of large numbers of persons is projected. It is envisaged that from the start of surveying to the conclusion of construction the time needed would be in the region of three years. On this time scale it would be wise to proceed at once to the tender stage, leaving the tendering and construction till it is apparent that the increased supply will be needed. We do not feel competent, in the view of the political and financial issues involved, to judge exactly when this work should be carried out. In the event of the water from the Murrel River being used to supplement the supply from the Moody Brook we envisage that an intake and pumping station would be constructed as near to the existing works as possible and that raw water would be pumped to a tank built adjacent to the existing works whence a supply of water could be drawn for either the existing or proposed new treatment plant. It is suggested that the new raw water pumping plant should be remotely controlled from the proposed new treatment works. We would not advise that the water from the new station should be delivered into the Moody Brook as the watertightness of the formation through which the brook runs is in doubt.

7.3 Future of the Treatment Works

It has been shown that provided the increase in demand does not exceed 5% per annum the existing source can provide the required water. It was also shown that the expected demand in 1981 would take up between 85% and 91% of the capacity of the plant. This was calculated on the assumption that all maintenance work could be undertaken at weekends when the plant is normally idle. Not having had at least 50% spare capacity for many years has made proper maintenance at all times difficult and often impossible. The state of the plant after 20 years of usage is now such that many replacements in the not too distant future will be essential. This essentially applies to the Braithwaite tank plates. The question arises as to whether it would be better in the long run to install a completely new plant rather than spend money on a plant which, even if it were possible to recondition, would remain difficult to operate and maintain. The present capacity not only calls for three working shifts, summer and winter but also is such that it is impossible to reduce the number of shifts when ample water is available in the winter. Again the ability to cut out the night shift in the winter would be conducive to retaining operating staff. We are of the opinion that, taking into account the current state of the plant with its method of treating an acknowledged difficult water and its manning difficulties, the construction of a completely new plant within the coming five years is the best solution. The new plant should be designed to use modern methods of treatment of highly coloured waters and have a large enough capacity to enable proper regular maintenance to be carried out. This presupposes that at least a third of the plant could be taken out of service without preventing the average demand being met and it should be capable of being extended in stages to meet future needs. To facilitate operation and maintenance standby units should be provided for all items of plant essential for the continuous production of potable water together with instrumentation indicating and recording raw treated and wash water flows, pH of raw, settled and treated waters and residual chlorine. The flow meters should be provided with integrators.

We recommend that the new plant should have a maximum capacity of 9,000 gph (11.4 litre/s) and arranged in three units each of 3,000 gph (3.8 litr/s) capacity. The flocculation and sedimentation tanks should be of concrete or glass reinforced plastic (GRP) construction with 3 No 7ft dia steel rapid gravity filters. The low and high lift pumps should also be rated at 3,000 gph. Each filter should be capable of passing 4,500 gph so as to enable one filter to be washed whilst maintaining normal throughput. This arrangement would be convenient for staffing and maintaining in that when more than 9000 gph is available from Moody Brook, the estimated daily demand in 1981 of 112,600 gpd could be treated in about 14 hours including replenishment of the washwater tank. When the flow in the brook falls below 9000 gph a third shift would have to be worked. To enable a check to be made on the yield of the brook a vee-notch should be installed in the intake weir with a flow recorder in the Treatment Works. When the plant is running this would show the surplus water and when the plant is not running, the total yield. There should be three duty pumps of each type, with a standby unit. The three duty high lift pumps when running together should be capable of delivering 9,000 gph through the existing main to Dairy Paddock Reservoir.

7.4 Future Storage

It is normally considered adequate to have storage equal to two days supply. In 1981 this will amount to about 225,000 gallons on the basis of a five day working week.

The existing storage of 500,000 gallons, of which 350,000 gallons is in Dairy Paddock Reservoir and 150,000 gallons in Sapper Hill Tank, is therefore adequate for the supply of potable water. However if our proposals for the provision of an adequate fire-fighting water supply are adopted Sapper Hill Tank would have to be duplicated (see Chapter 8). If this is done at an early date it would facilitate the re-conditioning of the existing tank (4.13.2).

CHAPTER 8

FIRE-FIGHTING WATER SUPPLY

8.0 FIRE FIGHTING WATER SUPPLY

8.1 Existing Installation

The existing hydrants are fed from a reticulation of 4ins, 3ins and smaller diameter mains. No equipment was available for testing the hydrants but a visual inspection of the available flow from many was sufficient evidence upon which to conclude the inadequacy of the existing system. Our proposals therefore discount the existence of these old hydrants.

8.2 Fire Risk and Requirements

Due to the large numbers of buildings of timber construction and to the prevalence of high winds which blow mainly along the length of the town from the NW, it is essential that any outbreak of fire should be extinguished as rapidly as possible so as to avoid the wind carrying the fire to nearby premises and creating an incident which could quickly get out of hand. The risk has been assessed by Assistant Divisional Officer D J Davis on secondment to Falkland Islands Government. The layout of hydrants which he considers are necessary to meet the risk are shown in Appendix 7. He is of the opinion that in the event of a fire occurring which is beyond the extinguishing capacity of the first aid supply carried on the appliances, resort should first be possible to three adjacent hydrants, each of which was capable of supplying not less than 450 gpm with a residual pressure of not less than 25 psi. This supply should be available for not less than 60 minutes and should it appear that a longer period of full supply will be needed, there would be ample time to set up trailer pumps on the foreshore and pump seawater until the fire is extinguished.

8.3 Proposal for Meeting water requirements

Having regard to the need for improving the potable water distribution and that any salt water distribution proposal must of necessity be completely separate, we have constantly hoped that a solution to the problem of providing an adequate supply of fire-fighting water could be found using potable rather than salt water. Mr Davis's proposals make this possible in that by duplicating Sapper Hill Storage Tank, 111 minutes supply of water at 1350 gpm could be made available without calling on any water required for supplying consumers. By providing a ring main fed from Sapper Hill tanks, the sizes of the new mains can be minimised and in addition by installing a number of cross-connections to the existing reticulation, with pressure reducing valves where necessary, the existing supplies could be improved. To ensure that adequate storage is maintained in the Sapper Hill tanks it is necessary that the booster pumps at Dairy Paddock Reservoirs should be duplicated, one duty and the other standby, with automatic starters operated by the water level in the tanks. There should also be automatic changeover from the duty to the standby set in the event of the duty set failing to start. Overload trip indicators should be provided on the starters to warn the operator of the failure. Remote water level indicators and recorders with low level alarms of the water levels in the Sapper Hill Tanks and Dairy Paddock Reservoir should be installed at the PWD Office with repeater indicators at the Pumping Station. Our proposals for the ring and spur mains together with new hydrants are detailed in Appendices 7, 8, 9 and 10.

APPENDICES

Appendix 1	List of Officials with whom discussions were held
Appendix 2	Casserly Report pp 1 - 40
Appendix 3	Grading of Sample of Filter Sand from Murrel River
Appendix 4	H/Q Curve of Treated Water Pumping main as at January 1977
Appendix 5	Technical Notes on Flocculation
Appendix 6	Notes on Chemical Solution Preparation
Appendix 7	Map showing siting of hydrants and mains for new fire-fighting water system
Appendix 8	Schedule of Recommended Hydrants
Appendix 9	Schedule of Recommended mains and isolating valves for new fire-fighting water supply
Appendix 10	Estimated Flows from sample groups of three hydrants running full bore
Appendix 11	List of recommended repairs, reovations and improvements for immediate implementation
Appendix 12	List of items of small equipment for purchasing
Appendix 13	List of minor works to be put in hand at an early date

APPENDIX 1

LIST OF OFFICIALS WITH WHOM DISCUSSIONS WERE HELD

1	Mr A Monk	-	Chief Secretary
2	Mr T Royans	-	Supt of Works
3	Mr R Smith	-	Senior Plumber
4	Mr R Stewart	-	Fire Brigade Supt
5	Asst Div Officer D J Davis	-	On secondment from Cheshire Fire Brigade

APPENDIX 2

CASSERLY REPORT pp 1 - 40

APPENDIX 2

CASSERLY REPORT

FALKLAND ISLANDS

A REPORT ON THE STANLEY WATER SUPPLY

Crown Agents

London

February 1972

Reference

Q.367/39

1.0 General Description

1.1 Source: The source of the existing supply is the Moody Brook, the extraction point or intake being the old Trout Hatchery weir, built about 1941, some 500 ft from the filter plant.

1.2 Filter Plant House: The equipment in this house was installed in 1956, the main items consisting of:

(a) Two steel shell Rapid Gravity filters, total production rated at 6000 gph.

(b) One flocculator and mixer, total production rated at 6000 gph.

(c) Two low lift electrically driven centrifugal pumps, each rated at 6000 gph.

(d) Two high lift electrically driven centrifugal pumps, each rated at 6000 gph.

(e) Chemical Solution Tanks.

(f) Chlorcel unit for Sterilisation.

(g) Laboratory with various items of equipment.

(h) One steel Brathwaite type sedimentation tank.

(i) One small workshop.

(j) One chemical store, adjoining the plant house.

(k) One wash water tank in the roof, above the Filters.

Generally, the equipment is capable of producing the rated amount. See Layout Appendix C.

1.3 Rising Main and Service Reservoirs: The rising main between the filter house and the reservoir is a 6" dia. Cast Iron main, 2½ miles long, which feeds the main reservoir at Dairy Paddock, TWL 135.00 (350,000 gallons capacity). The latter is of concrete block construction, with two separate independent compartments and an asbestos cement roof. The depth of water is 7 feet, maximum. This reservoir, built in 1928, supplies the lower levels of Port Stanley. Adjacent to the reservoir is a small pumphouse with an electrically driven centrifugal pump, which pumps water from the reservoir to an Elevated Braithwaite steel tank (150,000 gallons capacity) which supplies the higher reaches of the town. The elevated tank was erected in 1961.

1.4 Reticulation: Some of the supply mains in the town are 50 years old - others have been added in recent years to meet the demands. Appendix D shows the layout.

1.5 Population of Stanley: 1250 people.

1.6 Appendices: The following appendices are attached:

(a) 1953 Pape Report - this is included for ease of reference since many recommendations therein, upon which no action has been taken, will be referred to in this Report - Appendix A. It is regretted that some of the appendices in that Report are missing.
(b) General layout of the Water Supply - Appendix B.
(c) General Arrangement of the Filter House - Paterson Engineering drg. No. 93151/B Appendix C.
(d) Reticulation - Appendix D.
(e) Organisational Chart - Appendix E.
(f) Diurnal variation in demand - Appendix F.
(g) Seepage control measures at Intake - Appendix G.
(h) PCI Laboratory Results - Appendix H.
(i) Diversion of flow from the Mount William catchment - Appendix I.
(j) Metering - Information by Geo Kent Ltd - Appendix J.

2.0 Water Consumption:

2.1 Metering: The flowmeter on the rising main appears to be in good working order but it's counter, which gives the actual number of gallons pumped in any given period, has not been read or recorded for a considerable time - about 2 years - and when it was being recorded, the simple arithmetical computation was not correct. (The Senior Filter Plant Operator has been informed that this reading should be taken daily at a fixed time and recorded). The method of assessing the consumption for the past year or so, was to assess the pumping rate from the flowmeter chart and multiply by the number of hours. This is not the most accurate method of obtaining the consumption but is approximately correct.

2.2 The Consumption: At present is indicated by the following amounts during 1971:

July	2,417,050	gallons
August	2,450,000	"
September	2,095,000	"
October	2,102,000	"
November	3,000,000	"
December	1,989,000	"

These amounts give a total of 14,053,050 gallons from which 378,700 gallons, provided to shipping, should be deducted when calculating the per capita consumption. Thus, for the above period of 184 days and based on a Stanley population of 1250 people, the water consumption is 61 gallons per capita per day (gpcpd). This figure is high, considering that the demands of industry in Stanley are small, and even though all the sewage in Stanley is water-borne.

In November 1970, during the most recent very dry spell, an appeal was made over the radio to conserve water. The appeal resulted in a reduction in consumption to 40 gpcpd and it is worthy of note that in the previous October and subsequently in

January 1971, the consumption figures were 55 and 60 gpcpd respectively. These amounts were calculated by PWD, based on a population of 1100.

2.3 Water Consumption elsewhere: For comparison purposes, Table I shows the per capita consumption for certain towns in England and Wales. It will be noted that even in towns with formidable industrial areas, the consumption rarely exceeds 60 gpcpd. Climatic conditions do influence water demand, but the similarity of climate between the Falkland Islands and the United Kingdom rules out this as a cause of excessive consumption. The following figures show the water consumption in warmer climates:-

	rural supply	urban supply	
Malaya (all supplies metered)	20 gpcpd	40 gpcpd	Including water-borne sewage and light-industry.
Malta & Gozo combined (all supplies metered)		32 gpcpd	
Gozo	20 gpcpd		
Gibraltar (all supplies metered)		10 gpcpd	Sea water use for carriage of sewage and fire-fighting.

Australia, range 60 - 90 gpcpd.

2.4 Water Charges: There is no metering of water supplied to consumers premises. A 'flat' charge, a water rate, is levied, which is no incentive to reduce consumption. This matter will be discussed later.

2.5 Waste: There is, it would appear from the consumption figures, some waste of water taking place but it is not possible to give an accurate amount. An estimate would be the difference between what the maximum consumption should reasonably be, 40 gpcpd and the approximate actual consumption 60 gpcpd, ie 50%. In simple terms, this means that, if the waste could be reduced by a substantial percentage, the number of operating shifts worked each day could be reduced by one.

Whether this waste is due to extravagant use or to leakage from reservoirs and pipes, one cannot positively say, but the indications are that the consumers are at fault for the following reasons:

(i) leaks in the reticulation of a major nature are generally discovered early and are quickly repaired - the oldest mains in the system are 50 years of age and although this is old, it is not abnormal for Cast Iron mains.

(ii) Some of the service connections to consumers premises between the stop-cock and the premises themselves must be in a very bad condition and are probably leaking to some extent as well as carrying a heavy deposit on the pipe internally. These service connections are generally provided in galvanised pipes which have a reliable life of not more than 20 years. Some of these in Stanley are believed to be about 50 years old. In a metered system, any leakage on the consumer's side of the stop-cock would be reflected in the meter reading, as the meter would be installed as near the stop-cock as possible, and it would thus be to the consumer's benefit to keep his plumbing in good order.

(iii) As pointed out in para 2.2, the consumption in November 1970 was reduced to 40 gpcpd. This indicates that consumption can be reduced, if necessary.

(iv) Another possible cause of the excessive consumption is the amount of cold water which has to be run to waste in most of the heating systems in Stanley, before a supply of hot water is available at the sink, bath, or other points in any premises, where hot water is required. This may be a matter of internal plumbing or method of heating but must be for the consumer's account.

There are two measures which could be taken early to assess the leakage - one for the low and one for the high level area:

(a) The meter on the outlet of the main reservoir, installed in 1928, has been out of action since 1938, i.e. 33 years. Although it was recommended in the Pape Report page 35, that this meter be repaired, this has not been done. (I have suggested to the Supt of Works, PWD, that this be removed, dismantled and if possible repaired locally). If this meter were in operation, it would be possible to determine the night-flow and thus assess leakage. This meter should be read daily, an assessment made of the population in the low area, fed by the reservoir and thus an accurate figure for the consumption in that area obtained.

(b) The Pape Report, page 36, also recommended that a new meter be installed at the Murray Heights tank. This was not done but a meter should now be purchased and installed on the outlet main of the Elevated Tank - a 3" dia. Master type, Rotary Piston Kent Meter would be suitable. This has a range of 60 - 4,500 gph and will cost £60 FOB. This meter will perform the same service for the High Level area as will the existing meter at the main reservoir for the low level, provided the same procedure is followed. These should be the first steps to be taken to assess the wastage in the different areas. A waste water survey is discussed later.

3.0 Source of Supply and Intake

3.1 The Source of raw water for the supply is the Moody Brook as recommended in the Pape Report, pages 39 - 47. I agree with all the findings discussed in the above pages, although of course the river gauge mentioned is no longer in existence and, during my visit, owing to heavy rains, it was not possible to establish the dry weather conditions in the upstrean channel of the Moody Brook itself as described in pages 44 - 46 of the Pape Report.

3.2 The Recommended Improvements: For augmenting the flow in the Moody Brook during drought periods, outlined at the bottom of page 46 of the Pape Report, have not been carried out. Had they been executed, it is unlikely that the water shortage experienced during November 1970 would have been so serious. A method of dealing with recommendation (i) i.e. diverting the flow from the Mount William catchment into the Moody Brook, is given in Appendix I at the end of this Report.

3.3 The Intake consists of a concrete weir about 7 feet high, 40 feet wide built in 1941, across the Brook. Much of the impounded water is now finding paths around the wing walls of the weir, through the peaty top-soil and is lost to the supply. It is necessary to take remedial measures to prevent this loss, especially during dry spells.

3.3.1 During the writer's visit, an attempt was made to determine the depth to bedrock near the weir. A small mechanical excavator was used for the work. Four pits were dug, two on each bank, and the results of each were almost identical. The bed of peat was 3' - 4' deep overlying a strata of 'blue clay' which was impermeable of water. Further investigation with a mackintosh probe in each pit revealed a depth of 'blue clay' varying from about 10'-6" to 12 feet. It was not possible to excavate in the stream bed because of the very soft nature of the ground, nor could it be done by hand owing to the depth of water. The JCB excavations were also limited by the length of the arm to a depth of about 6 feet. However, it is considered that most of the leakage can be prevented by importing some 'blue clay' from the immediate vicinity, substituting this for the peat, thus building a barrier to the escape of water around the weir. The details of this measure and a proposal for improving conditions at the weir itself are given in Appendix G, and can be executed at minimal cost.

3.3.2 In November 1970, as mentioned in para 2.2, a serious drought occurred which made it difficult to maintain supplies of water to the public. One of the emergency measures then taken was to build a small dam about 2 feet high across the Brook a short distance downstream of the weir in an endeavour to trap the water escaping from the weir. This dam was hurriedly built, badly founded, and had no wing walls. It is now of no practical use. This is mentioned merely to point out that remedial measures must be taken in good time, when there is ample supply and should not be postponed until the very last moment.

3.3.3 Chamber on raw water main near Intake: (a) This chamber houses some valves on the raw water main, which are not operating correctly. They should be dismantled, repaired and replaced early. (b) The raw water is drawn from the bottom of the Intake where sediment is deposited which cannot be removed. Some of this sediment is carried into the raw water main and into the sedimentation tank. This could be prevented almost entirely by placing some small stop-logs in the chamber near the intake. The level of the top of the stop-logs over which the water would be drawn, could be altered as frequently as necessary so that, for the most part, the raw water would be drawn from the top level rather than from the bottom level of the water in the intake. This will decrease the load on the plant and the adjustments can be made by the Plant Operator on duty at any particular time. A sketch, showing what is required has already been sent to the Superintendent of Works.

3.4 Murrel River: The writer visited the Murrel River which has been suggested in the Pape Report as an eventual alternative source of supply, if required. All the points made in the above Report are agreed but it is hoped that recourse to this measure will not be necessary.

4.0 Filter Plant House: The rated capacity of the plant in the filter house is 6000 gallons per hour. The plant is generally in good condition but some items are not being correctly operated in accordance with good practice and the Manuals of Instruction provided which are available to them. This point is discussed in detail below.

4.1 Staff

(a) The present staff consists of one Senior Filter Plant Operator and one Plant Operator. During a normal week, two shifts of eight hours duration each are worked on two days and three shiffs of the same duration are worked on three days. Normally there is no work on Saturdays or Sundays. Sometimes the Senior Operator has to operate a shift on his own. Usually for the 2nd and 3rd shift of the day, someone - a driver or someone else from the PWD who is available and willing, - is nominated for the additional shifts. Work in the filter plant is unpopular and even the part-time personnel are changed frequently. Some of these personnel are very willing and capable but are not really interested in the work - some are the reverse and should not be allowed near the plant.

(b) The correct staffing for the plant is: One Senior Filter Plant Operator in overall control with one permanent Plant Operator for each shift. If three shifts are worked at any time during the week then there should be three permanent Plant Operators. The new Plant Operators should be appointed on the understanding that when shift work is not necessary they will be required to join the plumber's gang or some other squad, on other water supply work. Thus they will be doing useful work even if not always employed in the filter house.

The new Plant Operators should preferably be young, interested and capable of being taught how to carry out some of the simple routine tests necessary in the filter house. Veterans on the edge of retirement, incapable, disinterested and unwanted elsewhere, should not be considered. Each Plant Operator should be capable of taking over the duties of the Senior Filter Plant Operator in an emergency. The Senior Filter Plant Operator should not be required to do shift work - he has sufficient work to do carrying out laboratory tests, keeping the log, general supervision and checking of the plant, which if properly done, will keep him well occupied throughout the day.

(c) There appears to be at present, no clear understanding of a Plant Operator's duties. As well as attending to the operational matters, i.e. charging the chemical tanks as necessary, ensuring that the sedimentation tanks, mixing chamber and filters are at all times performing satisfactorily, that the pumps and all other equipment are operating as required, it is the duty of every Plant Operator on every shift to attend to the general cleanliness and tidiness of the filter house and its precincts. A filter house since it is required to produce sterile, potable water should be kept in a clinical condition, There should be no dust, dirt or leaks anywhere. All rust should be removed from pipes and valves. A plentiful supply of non-water tainting bituminous paint should be available for painting pipes, valves and the insides of tanks and filters. The latter should be cleaned, scraped and painted at regular intervals. All painting inside the filter house, except for the roof of the structure itself and the insides of tanks and filters is the task of the Plant Operators.

(d) One of the prime duties of the Senior Filter Plant Operator is to study carefully all the manuals of instructions and leaflets and to see that the plant is operated accordingly. He must also ensure that the Plant Operators do likewise.

4.2 Filter Plant Records: Log sheets for even a small filtration plant are an essential feature of the workings of that plant and should be carefully maintained and recorded. The present records are in some cases non-existent and generally quite unsatisfactory. (A log-sheet was prepared during the writers visit and handed to the Supt. of Works for printing). This should be completed daily by the Senior Filter Plant Operator.

4.3 Operational Procedure: Past practice for operating the various pieces of equipment in the filter house has been to accept verbal instructions from the former holder of the post without reference or consultation with the Manuals of Instructions prepared by the manufacturers. This has led to a number of un-acceptable practices.

4.3.1 Pump Operation

(a) All pumps were being started against valves with open gates on the delivery side of the pumps. This is bad practice with centrifugal pumps - particularly the high lift pumps - and leads to an un-necessarily heavy electrical load on the pump motor and a strain on the pump bearings. The pumps should be started against closed delivery valves.

(b) The low lift pumps were being operated with the valve on the suction side throttled in an attempt to balance the output between low lift and high lift pumps. If throttling is necessary, it should be done by the valve on the delivery side of the pump. The valve on the suction side should be fully open during operation - otherwise unwanted eddies and possibly cavitation leading to loss of performance, wear and erosion will occur.

(c) Spare impellors for pumps were ordered and installed but there is no record of the changes or why these changes were made with such frequency. Not even approximate dates are available. One replaced impellor has been removed at the writer's request and is being sent to the manufacturers for examination.

(d) The float controlled butterfly valve in the clear water well is being forcibly held permanently in the open position. It should be released and allowed to function as intended. The purpose of this valve is to throttle the rising main automatically and prevent air being entrained into the high lift pumps if the clear water well is starved of water.

(e) A check should be made on the accuracy of the flowmeter on the rising main. This is best done at night when the outlet from the service reservoir can be closed for 3 - 4 hours. The interconnecting pipe between the two compartment of the reservoir should be closed and the water level in the compartment clearly marked with a thin steel point. Measure the cross-section of the reservoir carefully, remembering that the section changes with height. Only one compartment of the reservoir should be used. The outlets to the Marine Department, the EZRO station and any others should be closed. Pumping should be carried out for 3 - 4 hours, the counter on the flowmeter being read when the motors are switched on and again when they are switched off. The volume pumped into reservoir in that time should then be calculated and compared with the difference in the counter reading. Also the level of the water in the compartment not used should be checked to see that the interconnecting valve was not leaking.

4.3.2 Filter Operation

(a) It is reported that 6 - 9 months ago, the only media in the filters was coarse crushed stone. Some sand has since been replaced in the filters but only about 50% of the required amount. An order for the balance was placed at the writer's request. The filter cannot function properly until the correct amount of sand is provided.

(b) Both outlet control valves on the filters were alleged to be leaking badly and had to be held forcibly in the closed position by crow-bars. However, the Senior Filter Plant Operator discovered during my visit that a small adjustment to one of the level arms was all that was necessary to make them operate satisfactorily, automatically.

4.3.3 Chemical Dosing and Laboratory

(a) It has been reported that under a previous Senior Filter Plant Operator, not only were some of the chemicals not weighed, they were applied by the shovel-ful! This was certainly not the case at the time of my visit but could be one of the main reasons for the highly unsatisfactory state of the rising main, which will be discussed later. During the visit, however, a serious mistake in dosing was suspected - this is one of the dangers of permitting untrained and disinterested personnel to operate a shift. The dosages should be recorded in parts per million where shown in the log sheet.

(b) The laboratory contains the following equipment:

(i) Paterson's Colorimeter.
(ii) " Turbidity Meter.
(iii) Stirring Equipment for Coagulation and Flocculation Tests.
(iv) Hardness and Alkalinity testing equipment.

(v) Comparator with discs for testing Ph and residual Chlorine.

(vi) Scientific laboratory balance.

There is a large deficiency in beakers, flasks and test tubes and many of the solutions are no longer reliable or are missing, but, if this deficiency is made good, there is ample equipment available for a major water supply undertaking. Much of the equipment has never been used. Item (iii) is particularly useful for peaty water and should be in daily use, particularly in rainy weather, to determine the frequent changes necessary in the dosage to obtain the best results. Records should be kept of all the tests and a record sheet was prepared and supplies issued to the Senior Filter Plant Operator during the visit. A book entitled "Operation and Control of Water Treatment Processes" by Charles R Cox, has since been handed to the Supt. of Works, for use in the laboratory. This describes in sufficient detail all the necessary tests.

(c) Sampling Cocks: Standard bronze sampling cocks should be provided in the laboratory for taking samples of raw water, settled water, filtered water and final effluent. There are none at present. It can also be mentioned here that similar sampling cocks should be provided at three points in the town reticulation, one at either end of the system and one in the centre. These can be located in existing valve chambers at some convenient point.

4.3.4 Coagulation and Flocculation

(a) The treated water leaving the filter house is not always up to the required standard as regards colour. It should have a colour of not more than 5 - 10 units (Hazen). In the time available at the site, it was not possible to achieve this, permanently, mitigating factors being insufficient sand in the filters and the condition of the rising main. If these factors are rectified and continuous tests to determine the optimum dosage are carried out in the laboratory, satisfactory results will be achieved.

(b) Samples of the raw water were flown to this country in December 1971 and coagulation tests were carried out in the laboratory of PCI Ltd. Copies of the results are attached, Appendix H.

After heavy rains the raw water is a very dark brown colour and chemical dosing for coagulation needs constant attention. Alumino-Ferric, Sodium Aluminate and Sodium Carbonate are introduced into the Low Lift Pump well, immediately outside the filter house, Sodium Carbonate for Ph correction is added to the Clear Water well.

(c) The chemical doses in use at present, in ppm, of the actual amount of chemical used, are:

Alumino-Ferric	Sodium Carbonate	Sodium Aluminate
140	20	40

which in terms of the strength of the active constituent is

28	20	21

The Sodium Aluminate dose is unusually high and attempts to obtain equally good results during the visit with less quantity of that chemical failed. A request for further tests in the filter house laboratory has since been made with the same object in view and when the results are known recommendations will be made. Results of various tests made are shown on Table 2.

(d) Since the quality of the final effluent depends so much of the flocculation, several alternatives have been considered for this part of the treatment in order to achieve the optimum results as economically as possible. The Superintendent of Works has been requested to carry out two further trials, one applying the Sodium Aluminate at the chamber near the intake and another replacing the Sodium Aluminate with Magnafloc, which is also a coagulant aid. Yet another alternative may be the use of the Braithwaite tank or portion of it, from Murray Heights. This would be used as a settling tank to assist in removing some colour and generally reducing the load in the filters. Recommendations on these alternatives will be made when the results of the trials and tests are known.

TABLE 2

RESULTS OF SOME COAGULATION TESTS CARRIED OUT AT STANLEY.

QUANTITIES GIVEN IN PPM OF ACTUAL CHEMICALS USED

ulphate of Alumino (Alumino-ferric)	Sodium Carbonate	Dry Sodium Aluminate	Comments
40	20	0	No floc
60	30	0	" "
80	40	0	" "
	———	———	
140	20	40	Good floc and colour
120	20	40	Fair floc - little colour removed
120	15	40	Poor floc - little colour removed
	———	———	
160	25	0	Very poor floc & colour
160	25	20	Poor floc
160	25	40	Fair floc
	———	———	
160	25	40	Good floc & good colour
180	25	40	Less good floc & colour
200	25	40	Fair floc
200	25	20	Poor floc & poor colour
	———	———	
160	25	40	Good floc. Quite good colour
140	20	40	Less good floc. Good colour
140	30	30	Fair floc. Slight brown colour
160	30	30	Fair floc. Slight brown colour

4.3.5 Chlorination

(a) Chlorine is provided by a Chlorocel unit using Unstoved Vacuum Salt (Dried Vacuum Salt may be used equally well). The equipment is working satisfactorily but the records of the dose applied are very scanty and it appears that the same dose is nearly always applied in the clear well irrespective of conditions elsewhere. The Senior Filter Plant Operator was not familiar with the calculation necessary to determine the actual chlorine dose and a specimen calculation was left with him.

(b) A test for residual chlorine in the Clear Water Well should be made at least twice daily; in the Main Service reservoir and in the Elevated Tank at least once daily and at one point in the reticulation - at a standard sampling cock - once daily. Up to the moment, tests in the reservoirs and the reticulation have been very rare indeed and there are no records of the frequency of tests in the Clear Water Well. Records of all these should be maintained.

(c) The results of the tests in the reservoirs and reticulation will generally determine the dose of chlorine to be applied in the Clear Water Well so that a potable sterilised water is provided to the consumer. As a general guide there should be a residual of free chlorine equivalent to 0.2 ppm in the reservoirs and a trace at any reticulation sampling point. These conditions will determine the initial dose, which should be adjusted as often as necessary to meet these requirements.

4.4 Ultimate Capacity of the Plant: The plant is rated at 6000 gph so that the ultimate capacity is reached when the plant is operating 24 hours a day, every day of the week, allowing a deduction of, say, half an hour per day for filter washing. Thus this ultimate capacity is 141,000 gallons per day, which should never be required with the present population figure and the existing industrial demands. As far as can be ascertained, the new airstrip, when it is completed, is unlikely to require a water supply and the only other projected industry mentioned to the writer was that of Alginate Industries, who would require about 1½m. gallons per day, who are aware that this far exceeds the capacity of the existing plant, and intend providing their requirements from their own resources, should their present thinking eventually become a reality.

4.4.1 Chemical Storage

(a) The maintenance of adequate chemical stocks is of special significance in Port Stanley due to the infrequent arrival of shipping from the UK. This shipping is spasmodic and reliance on the next arrival to replenish stocks of any sort is liable to be disappointing. The chemicals involved are:

Sulphate of Alumina,
Sodium Carbonate,
Dry Sodium Aluminate,
Undried Vacuum Salt.

Long delivery periods are the rule rather than the exception. The following are actual examples:-

	Date Order Placed	Date Order Received
(i)	July 1970	13/ 1/71
(ii)	January 1970	8/10/70
(iii)	February 1971	16/10/71

(b) Recently some stocks of chemicals were completely exhausted. For the week ending 11/1/72, no carbonate was available with the result that an acid water was being supplied to the consumers. The results of this might be serious. On 11/1/72 it was discovered that sufficient stocks of Vacuum Salt for sterilising the water were available for the next 72 hours only and that none had arrived on the recent ship. Fortunately a sufficient quantity of the chemical was discovered locally - enough to suffice for a limited period. The ordering of chemical stocks should be organised on a firm basis and it is recommended that at all times a stock sufficient for 1 year should be held and that this be the responsibility of the Senior Filter Plant Operator. The stock should be used in the order in which it is received.

4.4.2 Fencing

(a) There is no fencing around the filter house and the writer has seen sheep within a few feet of the walls. At times, sheep have had to be removed from the filter floor. This proximity to a filter plant is highly undesirable and dangerous - the water could become contaminated and it should be borne in mind that rapid filtration cannot be relied on to remove bacteria. Nor is chlorine in the usual doses effective against certain cysts and ova or organisms embedded in solid particles. The filter house should be fenced off for a minimum distance of 200 feet in all directions and the fenced area cleaned up and maintained to a suitable standard. The fencing from the old Windmill site, which is no longer in use, can be used for this purpose.

(b) It can be mentioned here that the main service reservoir is also unfenced. Many of the valves outside the reservoir are in a neglected state, some of them leaking and partially submerged in water. If this water is contaminated by animals and a sudden negative pressure develops, which can be caused by a burst main in the town area, the contaminated water could be sucked into the main.

This actually happened elsewhere some years ago and caused a typhoid epidemic in which many people died. The reservoir area should be fenced. Likewise the Elevated Tank, which although not resting on the ground, has inlet and outlet pipes at ground level. It may be of interest to know that in most countries, catchments are protected and it is suggested that consideration be given to fencing off a portion of the Moody Brook, on both banks, for say half a mile upstream of the filter house, to keep animals away.

(c) It is understood that a certain amount of sheep-slaughtering is carried out in the farm buildings adjacent to the filter house. These buildings, about 100 yds distant from the filter house, are upstream of the latter, although downstream of the intake itself. The practice of slaughtering so near the filter house even if all the animals are in a perfectly healthy condition is most undesirable and should be discontinued. Furthermore, if the recommendation of the Pape Report for directing the water from the Mount William catchment into the Moody Brook, is put into effect, it will be imperative that all slaughtering operations at these farm buildings cease, since the pipe or channel carrying this water must pass quite close to the buildings.

5.0 Rising Main from Filter Plant to Main Service Reservoir: This is a cast iron main, 6" dia., with five scour valves and three air valves. Although the scour valves nearest the plant has been opened periodically, it is very doubtful if the other scour valves were opened with any frequency in the past. The main was in a very filthy condition and appeared to be coated internally with a heavy deposit, probably calcium, which although probably not injurious to health, does add colour and sediment to the water reaching the reservoir. This deposit is probably due to excess dosing of sodium Carbonate over the years, and although a slight deposit is beneficial, an excess is undesirable and wasteful of chemicals. This deposit would have been removed had regular routine scouring of the main been carried out. This should be done once monthly and the whole operation could be done by one main in about an hour. As it was, five people spent two whole days, on 15 and 16 January trying to clear the main and they were only partially successful. This operation should be continued every week-end, until the main is in a clean satisfactory condition.

5.1 Air Valves: The air valves on the main were in a very bad state, and did not appear to have been maintained or serviced since they were first installed, 15 years ago. They were completely in-operable with the spheres rusted into their positions and the valves themselves partially submerged in water. During the scouring operation, they were opened up and serviced but one of the spheres could not be replaced owing to its damaged condition. Spares should be obtained as soon as possible. The person who has been responsible for the maintenance of this main should be relieved of all waterworks duties.

5.2 Pumping Main from Main Reservoir to Elevated Tank: This main should be scoured occasionally.

6.0 Reservoirs

6.1 Main Service Reservoir: This reservoir, 350,000 gallons capacity, appears to be in good condition. It is divided into two sections which can be operated independently. Due to the quality of the water entering the reservoir, a dark brown deposit appears on the floor and walls which accumulates and has to be removed about every 3 months, thus incurring unnecessary wastage of treated water. A reservoir such as this, receiving treated water, should require cleaning only once in two years. All equipment used during the cleaning operation, e.g. boots, brushes, buckets etc, should be sterilised in chloride of lime at the commencement of the work.

6.2 Main Reservoir Valves: These have a very neglected appearance. Some are buried with only the stem accessible, some are leaking, some are partially submerged in standing water and the Ham Baker 4" Flow Meter, as previously mentioned, has been out of action for 34 years. These valves should all be examined, serviced, replaced if necessary and installed in concrete chambers, with drainage outlets.

6.3 Pumphouse at Main Reseevoir: This small pumphouse houses a pump for delivering water to the Elevated Tank. This centrifugal pump should also be started against a closed valve and the motor turned off only after the valve on the delivery side of the pump has been closed, as described for the pumps in the filter house. The equipment here needs cleaning up, removal of rust and painting similar to that prescribed for the filter house.

6.4 Elevated Tank: This is a comparatively new (1961) Braithwaite tank in good condition but there are incipient rust marks on the outside of the tank. The tank should be wire brushed to remove the rust and painted regularly. The inside should also be painted as a routine measure, after removal of the rust, with bituminous non-water-tainting paint.

6.5 Murray Heights Tank: This Braithwaite tank, 105,000 gallons capacity, has been out of operation for some time and is no longer needed in its present condition. It is not in good condition but it should be dismantled as soon as possible, and as much of it as is serviceable should be salvaged, cleaned, painted and prepared for re-erection near the filter house. The details of this are discussed later. All pipes valves and specials not in use at this site, should be removed and serviced for use as spares.

6.6 Windmill Site: There are a number of pipes specials and valves at this abandoned site which should be recovered and serviced for use as spares.

6.7 Marine Detachment Storage: There are indications that consumption in the Marine Detachment is excessive and may be of the order of 80 gpcpd. The storage tank is leaking badly and should be repaired or replaced. In addition a pressure reducing valve should be placed in the line to the tank near the off-take to lower the pressure, as this line is supplied directly from the pumping main.

6.8 Total Storage: The total storage provided, by the main reservoir and the elevated tank, is 500,000 gallons equivalent to almost 3.5 days supply, when the filter house is operating 24 hours each day. This is ample.

7.0 Reticulation

7.1 General: Many of the ma..ns in the distribution system - the reticulation - are old and should be replaced as soon as funds are available, according to a phased replacement programme. The mains are almost entirely cast iron and galvanised iron. Some scouring has been done from fire hydrants and from a few scour valves, but no systematic cleansing and sterilising of the mains has been carried out. Some of the mains are probably heavily coated internally with a deposit and need cleaning badly. It is also likely that there is some leakage through the joints of the older mains which is not noticeable at the surface.

7.2 Scouring and Sterilising: This should be done systematically throughout the system, main by main, preferably between 2300 and 0600 hours, so that the main can be returned to service in the early morning. The scouring should be done with treated water, i.e. from the reservoir. When the water from the scour valve or scouring point has run clear for five minutes, the inlet to the main should be closed, the main emptied and a chlorine dose of 10 ppm poured by hand into the empty main through some convenient orifice, provided say by removing an air valve or drilling a hole in the pipe. When the chlorine has been introduced, the main should be filled and allowed to stand for as long as possible, but not less than three hours. Then the scour valve can be opened, the contents run to waste and the main put back into service. The most convenient chemical to use for this operation is chlorinated lime i.e. bleaching powder or chloride of lime but allowance should be made for the fact that the available chlorine in the powder is only 30% approx. Stocks of this chemical should therefore be obtained. Currently with this operation, the nominal size of every main should be determined accurately and recorded. These records are incomplete at the moment. Scouring materials and a pamphlet on their use have already been sent to the Superintendent of Works.

7.3 Dead Ends: There are a large number of 'dead ends' in the system at the moment. These contain stagnant water, make the main difficult to clean and restrict circulation. They should be eliminated as far as possible, by connecting the 'dead ends' to other nearby parts of the systems, and installing isolating valves where desirable, for control purposes. If it is not possible to eliminate the 'dead ends', they should be flushed monthly, but this is the least satisfactory method. This measure should be carried out prior to the sterilising operation.

7.4 Cross-connection between High and Low Level Systems: There was a cross connection between the high and low level level distribution systems at the junction of Dean Street/ Fitzroy Road. This should be checked to ensure that the isolating valve is in good operating condition - it may be necessary to open it during an emergency, such as a fire.

7.5 Waste Water Survey: Before a waste survey is undertaken, it is necessary to determine the flow from the main reservoir and elevated tank between 0000 hours and 0600 hours, when the draw-off should be a minimum. The meters already mentioned in connection with these reservoirs will provide the information required, provided they are read daily and recorded at the above hours. Appendix F shows graphically the typical daily draw-off from a reservoir. If the nightly flow is less than 10% of the average, than the wastage is within acceptable limits and is accounted for by some minor leaks, consumer's taps not closed etc. If the wastage reaches 20% of average visual checks should be carried at night time and an attempt made to locate the leakage by isolating parts of the reticulation, if necessary on successive nights. A full-scale waste survey in this instance would probably be un-economical. If the wastage is above 20% a full-scale waste survey should be undertaken. A waste water meter would be necessary for this operation. Details of a suitable Kent meter, the price and a leaflet indicating how the survey should be carried out have been left by the writer with the Senior Filter Plant Operator at the filter house. Further information on the above has since been sent to the Superintendent of Works. When the results of the preliminary waste survey as outlined above are known, further recommendations on the full-scale survey will be made.

7.6 <u>Obsolete Pipe-lines</u>: There are a number of pipe-lines which are no longer used but which are still in the ground. Some of these have already been mentioned and generally it would be economical to have these recovered, treated and made ready for re-use as spares.

8.0 Organisation

8.1 The attached chart Appendix E, shows inter alia, the organisation of the water supply section of the Public Works Department, and also the recommended alterations. The responsibility in the water supply section is too fragmented - there should be one man in charge, an Inspector of Waterworks, responsible to the Superintendent of Works.

8.2 Filter Plant and Reservoirs: The Senior Filter Plant Operator should have his responsibilities extended to include:

(a) the rising main to the main reservoir, the main reservoir itself and the outlet mains and valves as far as and including the flow-meter and

(b) the pump house at the main reservoir, the rising main to the elevated tank, the tank and outlet up to the new flow meter, when it is installed. This places the treatment and the clear water storage under the control of one person which is preferable to the existing system.

8.3 Plumbing Section and Supply to Ships etc: It is recommended that these duties be combined and that the present plumber, Mr Alan Jeffries, be placed in charge. It will be necessary to work overtime on occasions when supplying ships but this will not cost any more than does the present system. The plumber with his present staff of two men can cope with the additional duties and this arrangement will place the control of the distribution under one head.

8.4 Inspector of Waterworks

(a) As mentioned in para 8.1 above, ideally there should be an Inspector of Waterworks responsible for all facets of the water supply.

(b) Excluding the Superintendent of Works, there is no one in Stanley at present, who is capable of carrying out the duties of an Inspector of Waterworks. There are two alternatives for filling the appointment; one is to find a suitable person in the United Kingdom who has had adequate experience, the other is to train someone already engaged in the waterworks in Stanley. The latter is recommended and a confidential letter regarding this appointment is attached to one copy of this Report. It is further recommended that the appointment be made within 18 months.

8.5 <u>Training</u>

(a) It is recommended that in about nine months, the Senior Filter Plant Operator, Mr Robert Stewart, be sent to the United Kingdom for one month for further training as Senior Filter Plant Operator. It can be arranged for him to be attached to a water supply undertaking with raw water and treatment of similar size and characteristics to that of Stanley. This will be of great benefit to him and the department as a whole.

(b) A training syllabus for Plant Operators is attached. It is recommended that a new recruit be on probation as a Trainee Filter Operator for six months and then be given an examination on the running of the plant. Subject to a satisfactory report either by the Superintendent of Works or a visiting Water Engineer, he could then be confirmed in the post of Filter Operator. In view of the risk to public health of using untrained personnel, it is recommended that this training course be instituted as early as possible.

9.0 Records

(a) It is difficult to exaggerate the importance of maintaining adequate records in a water supply undertaking, large or small. The need to know the past history of the treatment used and the equipment is always there, if the supply is to be operated on an efficient basis and if changing conditions are to be encountered and the difficulties overcome. Testing equipment and measuring devices are provided to this end, and it is imperative that they be maintained in good order. If, for instance, a measuring device is not used regularly and allowed to fall into dispair, then it would have been better had it not been installed and the money used for some other purpose.

(b) It is recommended that a photo-stat copy of the filter house log sheet be sent to this office for comments at the end of every month, when the log sheet is complete, for one year. It would also be very interesting to see all the laboratory results of flocculation and coagulating tests carried out. Copies of these sheets could be sent with the log sheet monthly. Furthermore, raw water samples should be sent at intervals for independent analysis, particularly after rainy weather when the colour is most troublesome.

10. Bacteriological Tests: A regular monthly check on the bacteriological standards is fairly general practice in a water supply undertaking. The samples are taken from the bronze sampling cocks provided at selected points on the reticulation, by the Medical and Health Officer accompanied by the Superintendent of Works or their representatives. The sampling may be done by the Superintendent of Works or his representatives alone, provided the bottles are prepared by the Medical and Health Officer and the sterilising routine strictly adhered to. The tests are carried out by the Medical and Health Officer and made known to the Superintendent of Works as soon as possible, who is responsible for taking any action indicated by the results. These monthly tests are very valuable checks on the quality of the treated water and should indicate the presence and type of pollution, if any, in the distribution system. It is recommended that this routine be established as early as possible. Tests should also be carried out after the reservoir has been entered for cleaning and after any extensions to the distribution system are brought into service.

11.0 Metering of Supplies

(a) In the gas and electrical industries and in the telephone utility with some exceptions, metering is almost universal. Consumers are required to pay for the amounts they use. This factor is borne in mind by consumers and the service in question is used as required and reasonably sparingly. This is rarely the case when a water service is unmetered - there is no incentive to reduce consumption, to use only the amount required and to check waste.

(b) At present, the filter plant is in operation for 104 hours per week - see para 4.1. With a population of 1250 and a daily consumption of 40 gpcpd, the total daily requirement should be 50,000 gallons, which at the rate of 6000 gph, would require about 58½ hours operation. To this must be added a few hours for filter cleaning and unforseen requirements, making a total of, say, 65 hours. It is not possible to guarantee these figures, which are estimates, but this is the trend which could be expected if metering were instituted and would be a reversal of the present trend towards more and more consumption. Reference is made here to the Pape Report, page 19, para 6.1, which estimates the consumption at 40 gpcpd.

Thus, it would appear, that if metering were introduced, eight or nine working shifts only would be required per week and only two permanent Filter Operators needed, thus saving the wages of the third Operator. Added to that, total water demand would be contained well within the capacity of the plant for the foreseeable future. Tables 3, 4 and 5 extracted from a paper by Messrs A. L. McClure and B. Whitteron are given for information. These show the consumption in metered supplies in tropical and temperate climates.

(c) The disadvantages of metering are as follows:-

(i) The cost of the meter including installation, about £12, which would have to be borne by the consumer.

(ii) The cost of the part-times services of a meter reader - he would read 50 - 60 meters per day. It would thus take about 10 days per month and the reader would be detached from the plumbers gang for this duty.

(iii) The billing would be somewhat more complicated than at present and bills should be issued monthly for the initial year or so. However, existing staff should be able to cope with the additional work. A sliding scale is considered the most equitable.

(iv) A meter workshop would be required for the repair and testing of meters. One additional man attached to the plumbers gang, would be required for this work, but he would only be required part-time on meter work.

(d) Although a proposal to meter all supplies sounds very attractive, it is desirable, before reaching a firm decision on this matter, to await the result of the measures recommended to assess the leakage and waste. If these indicate that the leakage is within acceptable limits, then it can be concluded that the per capita consumption is too high and the only recourse left is to meter all supplies. If the results of the waste survey are forwarded to this office, further recommendations will be made.

(e) Appendix J gives some general information on equipment, costs, layout and general requirements for a metered supply and workshop.

TABLE 3

CONSUMPTION AND METERING POLICY - TEMPERATE CLIMATE

METERED SUPPLIES

Ref No	Authority	Daily consumption		Extent metered	Uniform rate or sliding scale •
		Total mgd	Per capita: ghd		
1	Johannesburg	47	45	Largely	D
2	Capetown	33	40	Fully	U
3	Pretoria	29	45	Largely	U
4	Salisbury	15	60	Fully	D
5	Bulawayo	10.4	112) 20)	Fully	D
6	Bloemfontein	6.5	60	Fully	U
7	East London	4.5	40	Fully	U
8	Luscka	2.3	50) 15)	Fully	U
9	Umtali	2	47) 19)	Fully	D
10	Malta & Gozo	8	26	Fully	R
11	- ‡	1.6	36	Fully	R
12	Limassol	1.5	34	Fully	R
13	Famagusta	0.9	26	Fully	R
14	Great Nicosia	0.6	28	Fully	R

UNMETERED SUPPLIES

Ref No	Authority	Daily consumption	
		Total mgd	Per capita: ghd
15	Auckland	27	66
16	Wellington	11	89
17	Dunedin	7.9	91
18	Hobart	5.5	98
19	Hastings	2.5	107

• D = Descending scale of charges

R = Rising scale of charges

U = Uniform rate

For Ref Nos 5, 8 and 9, higher per capita figures are for European consumers; lower for non-Europeans.

‡ Ref No 11, asked to remain anonymous.

TABLE 4

CONSUMPTION AND METERING POLICY - TROPICAL WET CLIMATE

METERED SUPPLIES

Ref No	Authority	Daily consumption		Extent metered	Uniform rate or sliding scale
		Total mgd	Per capita: ghd		
20	Tampin-Alor-Gajah, Malacca	0.1	25	Largely	U
21	Hong Kong	61	20	Fully	U
22	Singapore	69	39	Fully	U
23	Selangor	32	44	Fully	U
24	Kingston, Jamaica	21	59	Fully	U
25	Perak	20	28	Fully	R-U
26	Georgetown, Penang	15	44	Fully	R
27	Marc-Aux-Vacoas, Mauritius	12	47	Two-thirds	U
28	Johore	12	29	Fully	U
29	Kedah	6.0		Fully	U
30	Fiji	5.8	71	Fully	R
31	Tanganyika	5.8	18	Fully	U
32	Piton du Milieu, Mauritius	5.7	21	Two-thirds	U
33	Negeri-Sembilan	5.6	30	Largely	U
34	Mombasa	4.3	27	Fully	U
35	Penang	3.9	19	Fully	U
36	Pahang	3.3	28	Fully	U
37	Johore Bahru	3.2	41	Fully	U
38	North Borneo	2.8	10-80	Largely	U
39	Kuching, Sarawak	2.1	35	Fully	U
40	Brunei	1.8	43	Fully	U
41	Nassau	1.2	25-30	Fully	R
42	Kisumu	0.9	36	Fully	D-U
43	Sibu, Sarawak	0.8	32	Fully	U
44	Kuala Trengganu	0.4	14	Fully	U

UNMETERED SUPPLIES •

Ref No	Authority	Daily consumption	
		Total mgd	Per capita: ghd
45	Kampala	4.5	40
46	Ghana	18	4-25
47	Abadan	11.5	97
48	Barbados	11.0	45
49	Port-of-Spain	9.5	73
50	E Nigeria	6.0	13
51	Uganda	5.8	42
52	Ibadan	4.5	4.9
53	Zanzibar	1.9	33
54	Gwelo	1.8	65
55	Oshogbo-Ede, Nigeria	0.4	2.1

• Some places have an appreciable percentage of metered consumers but the majority are unmetered.

D = Descending scale of charges

R = Rising scale of charges

U = Uniform rate

Figures given by Mr Hetherington in 215

R-U (Ref. No 25) indicates that the present rising scale is to be changed to a Uniform rate.

D-U (Ref. No 42) indicates that the present descending scale is to be changed to a Uniform rate.

Ref. Nos 38 and 46 are authorities

TABLE 5

CONSUMPTION AND METERING POLICY - TROPICAL DRY CLIMATE

Metered supplies *

Ref No	Authority	Daily consumption		Extent metered	Uniform rate or sliding scale
		Total mgd	Per capita phd		
56	Baghdad	30	35	Largely	U
57	Aden	6.5	30	Fully	U
58	Addis Ababa	4.0	13	Fully	U

* No returns were received for unmetered supplies.

U = Uniform rate.

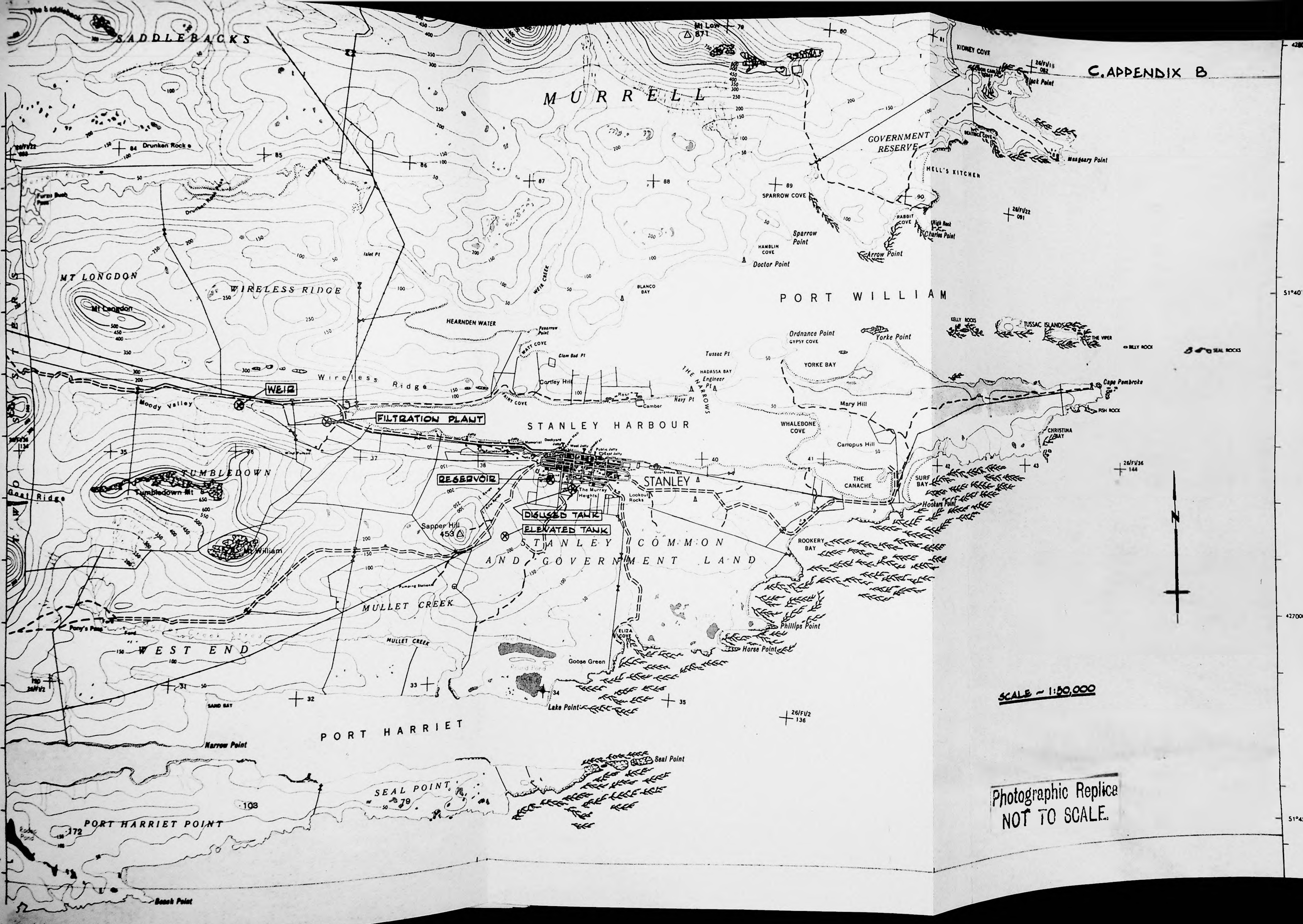
12.0 Cost of rehabilitation: Since the majority of the recommendations in this Report involve the use of labour already engaged on the water supply, an estimate of the costs of these measures has not been made.

13.0 Future Visits and [illegible]ice: It is recommended that, for the next few years, a vi[illegible] be paid annually by a Water Engineer from The Crown Agents to [illegible]spect the water supply and make any further recommendations necessary. It is also recommended, subject to the approval of the Foreign and Commonwealth Office that the present advice be continued for as long as is necessary to put the recommendations made in this Report into effect. In this way it is hoped that any matter of detail concerning these recommendations will be referred to this Office, if desired and that the records mentioned in para 9.0 will be forwarded to this Office regularly for comment.

SUMMARY OF RECOMMENDATIONS

Section	2.1	Read and record the counter on the flowmeter.
	2.5	Repair Meter and install new meter at Reservoirs.
Section	3.2	Execute improvements for augmenting the flow in the Moody Brook.
	3.3.1	Make alterations to reduce seepage around Intake.
	3.3.3	Alterations to chamber at Intake.
Section	4.0	Filter Plant operations to be carried out in accordance with Manuals of Instructions.
	4.1	Permanent Filter Plant Operators to be appointed.
	4.2	Keep daily log sheets.
	4.3.1	Check flowmeter.
	4.3.2	Place additional sand in filters.
	4.3.3	Make up deficiency in minor equipment for laboratory and carry out regular coagulation tests. Provide sampling cocks.
	4.3.4	Carry out trials, applying chemical at difficult points and using new coagulant aid.
	4.4.1	Maintain adequate chemical stocks.
	4.4.2	Provide fencing. Stop sheep-slaughtering near filter house.
Section	5.0	Carry out regular cleaning of rising main and maintenance of valves.
Section	6.1	Sterilise equipment when cleaning reservoir.
	6.2	Rehabilitate meter and valves.
	6.3	General cleaning up of pump house at main service reservoir.
	6.4	Paint Elevated Tank.
	6.5	Remove and salvage tanks, at Murray Heights.
	6.6	Salvage Pipes, specials and valves at Windmill site.
	6.7	Fit pressure reducing valve on pipe to Marine Detachment.

Section	7.2	Scour and sterilise mains.
	7.3	Eliminate 'dead ends'.
	7.4	Check cross-connection between High and Low level systems.
	7.5	Carry out preliminary waste survey and report results.
	7.6	Remove obsolete pipe lines.
Section	8.0	Carry out alterations to organisation and institute training programme.
Section	9.0	Maintain records and send results to this Office where requested.
Section	10.0	Organise routine Bacteriological tests.
Section	11.0	Request annual visit of Water Engineer and continue contact with Crown Agents until recommendations implemented.


C. APPENDIX B
SADDLEBACKS
MURRELL
Mt Low
KIDNEY COVE
GOVERNMENT RESERVE
HELL'S KITCHEN
Drunken Rock
SPARROW COVE
Sparrow Point
Doctor Point
Arrow Point
MT LONGDON
Mt Longdon
WIRELESS RIDGE
Wireless Ridge
HEARNDEN WATER
BLANCO BAY
PORT WILLIAM
Ordnance Point
GYPSY COVE
Yorke Point
YORKE BAY
TUSSAC ISLANDS
KELLY ROCKS
SEAL ROCKS
Cape Pembroke
FISH ROCK
Tussac Pt
THE NARROWS
HADASSA BAY
Engineer Pt
Mary Hill
WEIR
Moody Valley
FILTRATION PLANT
STANLEY HARBOUR
WHALEBONE COVE
Canopus Hill
CHRISTINA BAY
TUMBLEDOWN
Tumbledown Mt
Goat Ridge
RESERVOIR
STANLEY
The Murray Heights
Lookout Rocks
THE CANACHE
SURF BAY
Hookers Point
DISUSED TANK
ELEVATED TANK
Sapper Hill
453
Mt William
STANLEY COMMON AND GOVERNMENT LAND
ROOKERY BAY
MULLET CREEK
Pony's Pass
WEST END
ELIZA COVE
Goose Green
Phillips Point
Horse Point
Lake Point
SCALE ~ 1:50,000
PORT HARRIET
Narrow Point
Seal Point
SEAL POINT
79
103
PORT HARRIET POINT
172
Beach Point
51°40'
51°45'
4270000N
4280000N

C. APPENDIX H.

PCI

Paterson Candy International Limited
21 The Mall
Ealing London W5 2PU
Telephone: 01-579 1311
Telegrams: Clarify London
Telex: 27239

Our Ref: DWD/JB/117/6

12th January, 1972.

Mr. E. Lawrence,
Q Department,
Crown Agents,
4, Millbank,
London, S.W.1.

Dear Mr. Lawrence,

FALKLAND ISLANDS WATER SUPPLY

We have pleasure in enclosing two copies of our laboratory report including analysis and coagulation tests.

In the report, you will notice that reference is made to settlement rates expressed in feet per hour. These rates should not be confused with rise rates in clarifiers. The settlement rate is the rate at which the floc falls under static conditions and the purpose in reporting it is to give a comparative guide. It does appear however that using just alum and hydrated lime alone would necessitate using a clarifier working at a surface rating not exceeding approximately 10 gallons/sq.ft./hour. However, the position is much improved when a coagulant aid such as Magnafloc or Welgum S (sodium alginate) is used and one would expect to be able to reach ~~settlement~~ a surface rating rates of 20 - 25 gallons/sq.ft./hour without too much difficulty. However, this does mean introducing additional equipment for the dosing of the coagulant aid. If your Engineers decide that this is feasible then we shall be very happy indeed to quote you for the necessary additional plant.

We have not reported on the water biologically since we assume that it is bacteriologically unsafe for human consumption until sterilised by chlorine.

If we can be of any furtherassistance in this matter please do not hesitate to contact us.

Yours sincerely,

PCI

Paterson Candy International Limited

CHEMICAL LABORATORY REPORT

No. 72/5 Ref: DWD/JB/117/6

DATE REPORTED 6th Jan.1972

SAMPLE RECEIVED FROM CROWN AGENTS, 4 MILLBANK, S.W.1.

COLLECTED ON .... BY .... RECEIVED ON 3/1/72

SOURCE Sample from the Falkland Islands.

APPEARANCE Coloured

Odour	None			
pH Value	5.6			
Equilibrium pH Value (pHs)				
Saturation Index (pH—pHs)				
Colour ° Hazen	50			
Turbidity—Silica Standard	3.0			
	mg. per litre	mg. per litre	mg. per litre	mg. per litre
Suspended Solids—dried at 105°C.				
Total Dissolved Solids—dried at 180°C.				
Carbonate Hardness as $CaCO_3$	3			
Non Carbonate Hardness as $CaCO_3$	21			
Total Hardness as $CaCO_3$	24			
Total Alkalinity as $CaCO_3$	3			
Calcium Hardness as $CaCO_3$	12			
Magnesium Hardness as $CaCO_3$	12			
Acidity to pH 8.3 as CO_2	6			
Iron in filtered sample as Fe	0.24			
Iron—Total as Fe	0.36			
Manganese in Filtered Sample as Mn				
Manganese—Total as Mn.	Nil			
Chlorides as Cl	44			
Sulphates as SO_4				
Nitrates as N				
Free Ammonia as N				
Silica as SiO_2				
Oxygen Absorbed (O_2) (4 Hrs at 27°C)	6.4			
Chlorine Absorbed as Cl_2				

COAGULATION TESTS

REPORT No. 72/5

SHEET No. 2

(CH)EMICAL DOSES (mgs per litre) (ADD)DED IN ORDER REPORTED	FLOC SIZES (mm's) AFTER STIRRING FOR 20 MINUTES	SETTLEMENT	SLUDGE % v/v	BEFORE Filtration pH	BEFORE Filtration pHs	AFTER FILTRATION COLOUR ° HAZEN	AFTER FILTRATION OTHER TESTS
Alumino-ferric)	0.75 - 1.0	Poor	-	6.3	-	3	Res.Al. 0.1 mg/1
Hydrated Lime)							
Alumino-ferric)	0.75 - 1.0	Poor	-	6.1	-	3	Res.Al. 0.05 mg/1
Hydrated Lime)							
Alumino-ferric)	0.75 - 1.0	Poor	-	6.1	-	3	Res.Al. 0.06 mg/1
Hydrated Lime)							
Alumino-ferric)	1.0 - 1.5	6.5'/hr.	1.5	6.1	-	3	Res.Al. 0.05 mg/1
Hydrated Lime)							
Magnafloc L.T.24.)							
Alumino-ferric)	0.75 - 1.0	Poor	-	6.1	-	3	Res.Al. 0.06 mg/1
Hydrated Lime)							
Wisprofloc 20)							
Alumino-ferric)	1.0 - 1.5	7'/hr.	-	6.1	-	3	Res.Al. 0.05 mg/1
Hydrated Lime)							
Welgum S)							
Alumino-ferric)	0.75 - 1.0	5'/hr.	-	6.1	-	3	Res.Al. 0.06 mg/1
Hydrated Lime)							
Zulbent 570)							
Alumino-ferric)	1.5 - 2.25	13'/hr.	-	6.1	8.1	3	Res.Al. 0.05 mg/1
Hydrated Lime)	11 mg/1 Hydrated Lime raised the pH value to 8.1						
Magnafloc L.T.24)							

The raw water is very soft, coloured and acidic, but with little turbidity. Traces of iron were present in solution and suspension. The colour is due to oxidisable organic matter in solution giving a fairly high oxygen absorbed value from permanganate.

Coagulation with alumino-ferric and lime gave good colour removal and low residual aluminium at pH 6.1 but settlement of floc was very slow which would necessitate very low clarifier rise rates to prevent floc carry-over. The addition of various polyelectrolytes were tried to improve floc settlement rate. Welgum S (sodium alginate) and Magnafloc L.T.24 gave the best results. Magnafloc L.T.24 at 0.5 mg/l gave excellent results with floc settlement at 13 ft/hr., while 0.2 mg/l gave 6.5 ft/hr.

To improve settlement it is suggested that a cationic polyelectrolyte such as Magnafloc L.T.24 added after alum and lime would give significant improvements. Further lime dosing after filtration will be required for final pH correction. The total alkalinity of the final water is not likely to be more than 20 mg/l as $CaCO_3$ which will be associated with a chloride content of 44 mg/l. This alkalinity/chloride ratio is one likely to cause dezincification of Duplex brass and therefore such fittings should be avoided if possible.

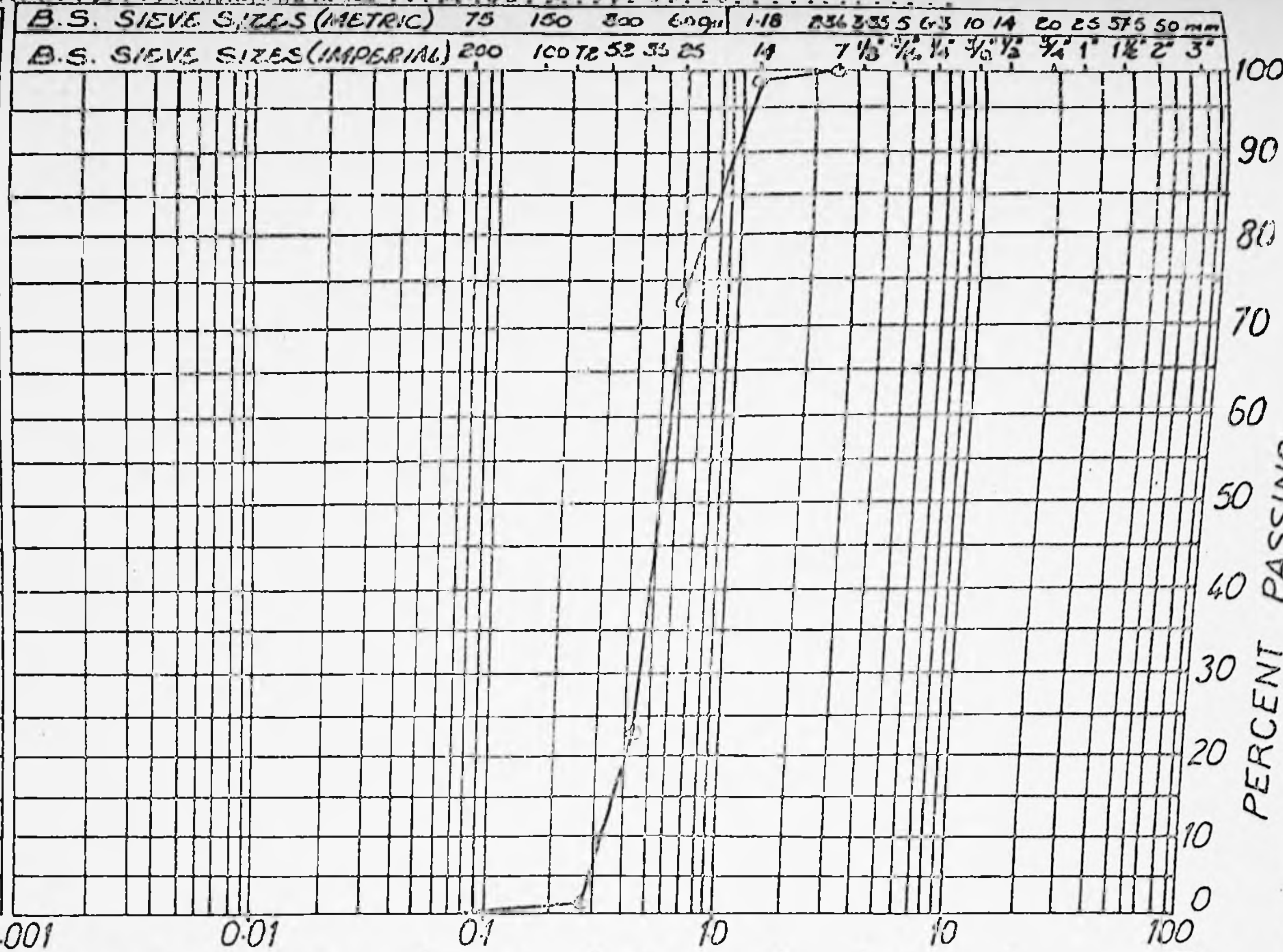
3 Dry Sieving

TOTAL WEIGHT OF DRY SAMPLE 554 g SITE [illegible] SAMPLE No. — OPERATOR [illegible] PROJECT [illegible]

LOCATION ...... DATE 17.1.77

Description FILTER MEDIA (PWD) MEDIAN GRAIN SIZE 0.5 mm UNIFORM SAND

B.S. SIEVE SIZES METRIC	B.S. SIEVE SIZES IMPERIAL	WEIGHT RETAINED gm	WEIGHT RETAINED gm	PERCENT RETAINED	TOTAL PASSING %	REMARKS
76 mm	3 in					
50 mm	2 in					
37.5 mm	1½ in					
25 mm	1 in					
20 mm	¾ in					
14 mm	½ in					
10 mm	⅜ in					
6.3 mm	¼ in					
5 mm	3/16 in					
3.35 mm	⅛ in					
2.36 mm	No 7		TRACE		100	RUST SCALE
1.18 mm	No 14		12	2	98	
600 µ	No 25		148	25	73	
425 µ	No 36		218	50	23	
300 µ	No 52		129	22	1	
215 µ	No 72		7	1		
150 µ	No 100		TRACE			
75 µ	No 200		TRACE			
PASSING 75 µ	PASSING 200		TRACE			
	TOTAL					



Unified soil classification system. (soil fractions)

SILT OR CLAY (BASED ON PLASTICITY)	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLES
	SAND			GRAVEL		

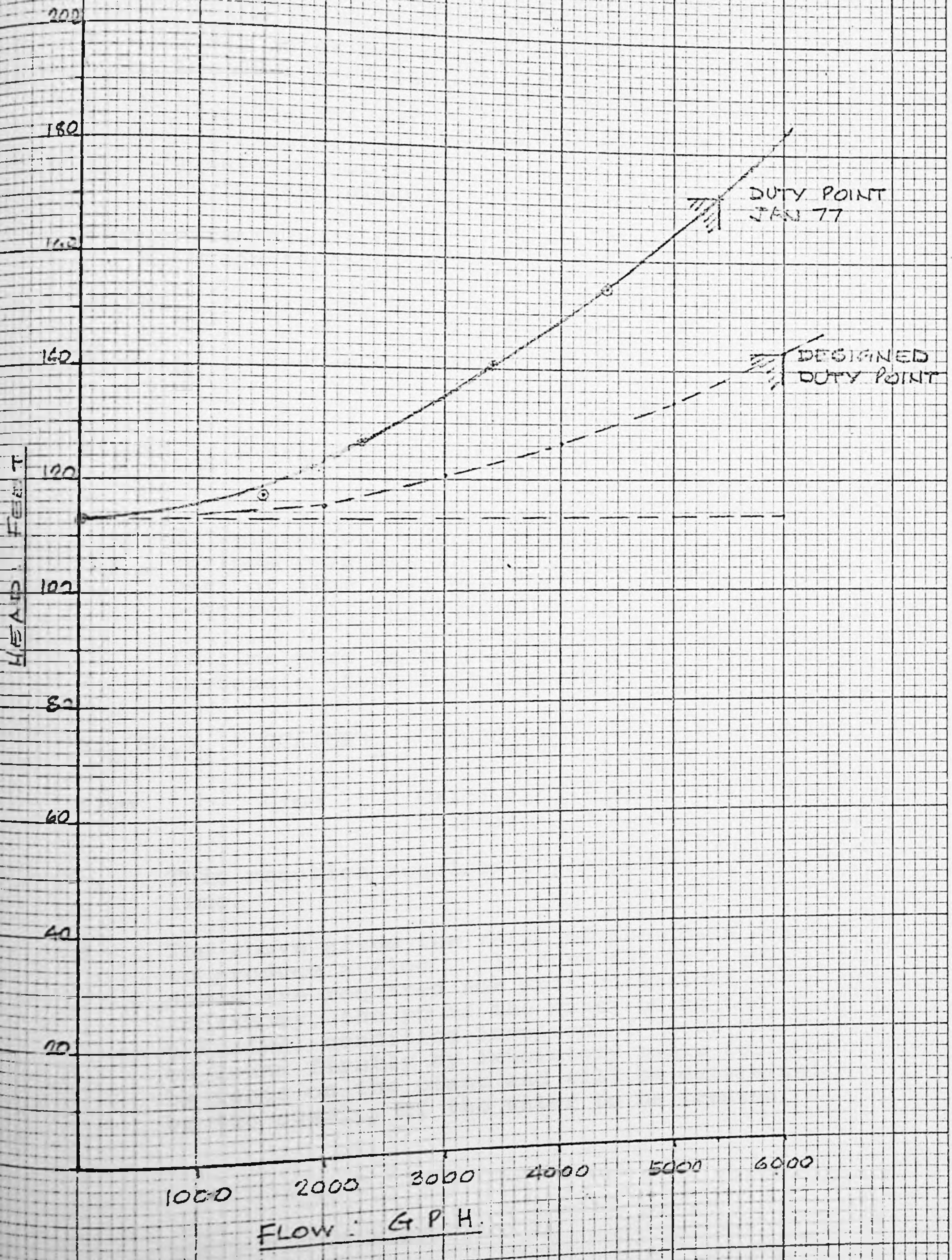
British standards Inst. (soil fractions)

CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	COBBLES
	SILT			SAND			GRAVEL			

PARTICLE SIZE DISTRIBUTION/MECHANICAL ANALYSIS

APPENDIX 4

H/Q CURVE OF TREATED WATER PUMPING MAIN AS AT JANUARY 1977



A.A.S
1 MAR 77

TECHNICAL NOTES ON FLOCCULATION

1 These notes are produced to enable the reader to understand the dosing problem more clearly.

2 Flocculation is a chemical reaction which like all chemical reactions requires the correct quantities of reagents and conditions for it to take place.

3 Using Aluminium Sulphate (Alum) and Sodium Carbonate (Soda Ash), there are two reactions:

$$Al_2(SO_4)_3 + 3Na_2CO_3 + 3H_2O = 2Al(OH)_3 + 3Na_2SO_4 + 3CO_2$$

Alum; Sod Carb; water; Alum. Hydroxide (Floc); Sod. Sulphate; Carb. dioxide

$$Al_2(SO_4)_3 + 6Na_2CO_3 + 6H_2O = 2Al(OH)_3 + 3Na_2SO_4 + 6NaHCO_3$$

By setting out the molecular weights of the various reagents it will be seen that for each part of Alum 0.45 parts of Sodium Carbonate are required for the reaction.

If lime were to be used instead of sodium carbonate (Soda Ash) the reaction would be:

$$Al_2(SO_4)_3 + 3Ca(OH)_2 = 3CaSO_4 + 2Al(OH)_3$$

Alum; Lime; Calcium Sulphate; Al.Hydroxide (Floc)

This reaction requires 1 part Alum to 0.3 parts lime.

4 The above gives the ratio of chemicals required to produce a floc. It does not tell what doses are required nor what conditions are necessary, the pH of the water being the principal condition involved. These will be found firstly by laboratory tests followed by tests on the plant and will be determined by the quality of the water to be treated.

5 As an example take the results of coagulation tests carried out by PCI on the water in 1972 (C Appendix H). It can be seen that test (8) gave the best settlement rate.

The doses were:

Alummo-ferric (Alum)	40 mg/l
Hydrated Lime	26 mg/l
Magnafloc LT24	0.5 mg/l

The action took place with the pH = 6.1.

To produce a non-corrosive final water the post-filtration dosage was 11 mg/l lime.

6 Similar result could be obtained using soda ash instead of lime when the following are the equivalent dosages:

Alum	40 mg/l
Soda Ash	39 mg/l
Magnafloc LT24	0.5 mg/l

and for post-filtration conditioning 17 mg/l soda ash bringing the pH to 8.1.

From the above it will be noted that the ratio of Soda Ash to Alum is not 0.45 to 1.0. The reason for this is that the soda ash is performing two functions. First to condition the water to the correct pH namely 6.1 (the untreated water had a pH of 5.6) and second to react with the alum to form a floc, for this purpose 18 mg/l would be required leaving 21 mg/l for pH correction. One should note that this latter requirement will remain constant provided the pH of the raw water remains constant. This may not be the case after climatic changes. If the pH of the raw alters, it is necessary to alter the dosage of soda ash to bring the pH back to 6.1. If the amount of colour increases it may be necessary to produce more floc to coagulate the colour coloids. Before increasing the alum dosage it is most important that the correct pH is first obtained by varying the soda ash dosage or it will not matter how much alum and soda ash are added the colour will not be removed. Summarising - if x mg/l is the alum dosage and y mg/l is the soda ash dosage to bring the pH to 6.1 then the dosages would be

Alum	Nx mg/l
Soda Ash	0.45Nx + y mg/l

where N is any number.

Thus one would expect the following to produce good colour removal:

Alum 1.5 x 40	60 mg/l
Soda Ash (0.45 x 1.5 x 40) + 21	48 mg/l
Magnafloc LT24	0.5 mg/l

Provided the water is adjusted to pH 6.1, the post filtration dosage of 17 mg/l should be sufficient to raise the pH to 8.1.

7 For the most economical use of chemicals it is necessary to endeavour to work with the smallest dosages consistent with obtaining satisfactory colour removal and without carrying any floc over on to the filters. Thus if it is found necessary after heavy rainfall to increase the alum and soda ash dose, then as soon as conditions return to as they were before the rain, the extra dosages should be discontinued.

8 Referring to the dosages obtaining when Mr Smith first checked the plant (6.2.1), it will be noted that sodium aluminate was also being used. The reaction in this case is:

$$6NaAlO_2 + Al_2(SO_4)_3 + 18H_2O = 8Al(OH)_3 + 3Na_2SO_4 + 6H_2O$$

Sod. Aluminate	Alum	Al. Hydroxide	Sod. Sulphate

The weight of sodium aluminate required is 75% of the weight of alum. The dose of sodium aluminate may in some cases be less. When this is so the reaction serves only to initiate the coagulation of the alum.

Thus 10 mg/l sodium aluminate would require 14 mg/l alum with which to react and assuming precoagulation pH correction required 21 mg/l soda ash, then there would be 19 mg/l available to react with 42 mg/l alum. It follows that any alum in excess of (42 + 14) = 56 mg/l would pass on to and through the filters in solution. This would react with any soda ash added for final pH correction and produce secondary coagulation in the treated water tank. The estimated carry over is 292 - 56 = 236 mg/l. This would react with the 43 mg/l post filtration soda ash dosage taking up a further 96 mg/l alum leaving 140 mg/l to pass into supply. Hence the evidence of alum carry over in Dairy Paddock Reservoir and low final pH.

9 If it is found necessary to continue the use of sodium aluminate then it is suggested that the following dosages should be tried:

Sodium Aluminate		10.0 mg/l
Sodium Carbonate	(1)	40.0 mg/l
Alum		54.0 mg/l
Magnafloc LT24		0.5 mg/l

Post-filtration

Sodium Carbonate	(2)	20.0 mg/l

(1) vary as necessary to bring pH to 6.1.
(2) vary as necessary to bring pH to 8.1.

Subsequently, try reducing the sodium aluminate. When doing so adjust sodium carbonate to bring pH back to 6.1.

NOTES ON CHEMICAL SOLUTION PREPARATION

1 In the report (5.2.1) mention is made of the difficulty of varying the dosing of the various chemical reagents using only the orifices provided with the gravity dosers and it is recommended that fine adjustments should be made by adjusting the solution strength.

2 Orifices are provided giving nominal flows of 2 - 10 gph. Some of these have been tampered with and now give flows well in excess of 10 gph. Flows derived from orifices must be checked when installing by measuring the time necessary to fill a litre flask. Using a litre flask will give flows in litres. To convert to gallons divide by 4.546.

3 Dosage rates quoted include the weight of water of crystalisation. Hence 40 mg/l of alum means 40 mg of $Al_2(SO_4)_3 . 21H_2O$ if alumino ferric is used or $Al_2(SO_4)_3 . 14H_2O$ if granulated alum is used. The available alum as $Al_2(SO_4)_3$ is 14% and 17% respectively. Thus to be exact if a satisfactory dose using alumino ferric is 40 mg/l, then the equivalent using granulated alum would be $40 \times \frac{14}{17} = 33$ mg/l.

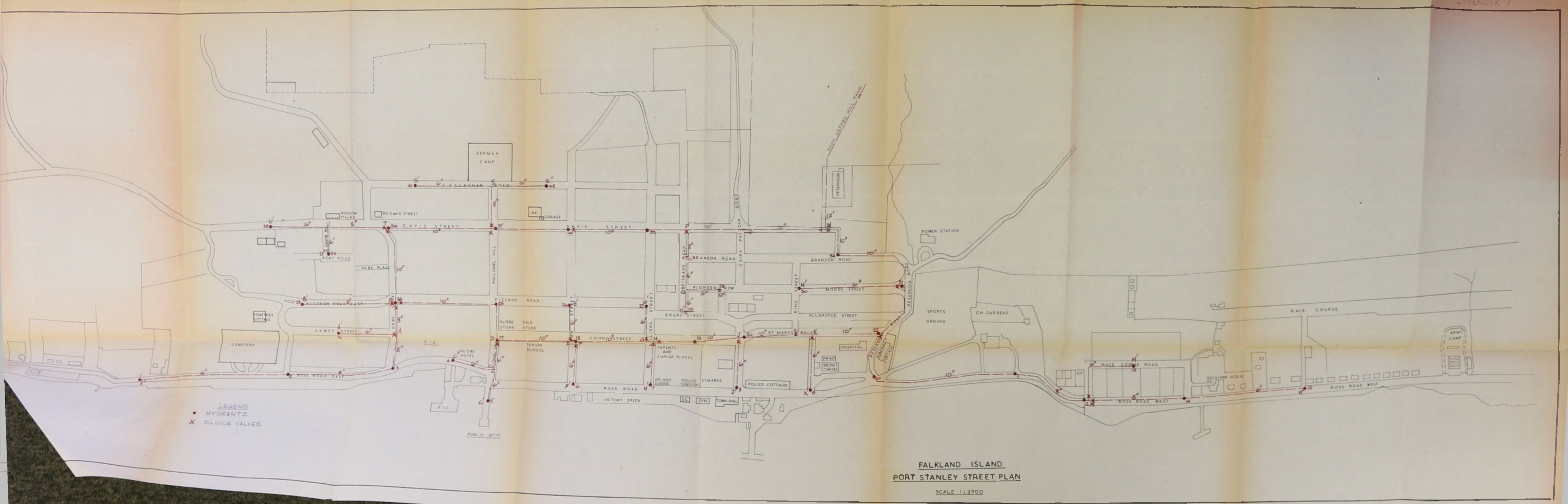
4 Solutions are made up in 65 gallon batches. It is usual to assume the specific gravity of the solutions to be 1 when calculating the weights of chemicals required. Since 65 gallons of water weigh 650 lb a 10% solution of alum will be made by mixing 65 lb of alum to (650 - 65) lb = 58.5 gallons of water. This will not give an exact 10% solution but it is accurate enough for the purpose. In practice the solution is made up by dissolving the weighed quantity of chemical in an auxiliary tank which is then discharged into the main tank and made up to 65 gallons by adding water. Thus if a solution having concentration x% is required, the quantity of chemical used will be $\frac{x}{10} \times 65$ lb or 6.5x lb.

5 Dosages today are expressed in mg/l instead of parts per million. A litre of water has a mass of 1 kg only at one temperature, at others it is slightly different, but for practical purposes mg/l and ppm are synonymous.

6 As a practical example when Mr Smith was at the plant the flow was 5,400 gph. If our recommended flushing out of the treated water pumping main is carried out, the output may well return to 6,000 gph. This increase will require a $\frac{600 \times 100}{5400} = 11.1\%$ increase in amount of chemicals dosed. The orifice in the pre-flocculation soda ash doser was giving a flow of 56.25 l/h or 12.39 gph of 1.85% solution which is equivalent to a dosage of 42.4 mg/l. To increase the amount of soda ash by say 11% without changing the orifice requires that the solution strength should be increased by 11% ie to 1.85 x 1.11 = 2.05%.

Therefore the required weight of soda ash per 65 gal batch becomes 6.5 x 2.05 = 13.33 lb (see para 4 above).

APPENDIX 7



FALKLAND ISLAND

PORT STANLEY STREET PLAN

SCALE 1/2500

APPENDIX 8

SCHEDULE OF RECOMMENDED HYDRANTS

No	Location	Main dia mm
1	Ross Rd. East outside YPF Depot	150
2	Ross Rd. " near Cemetary	200
3	" " " outside FIC Store	200
4	" " " near Globe Hotel	150
5	Public Jetty	150
6	Ross Rd	150
7	" " by Upland Goose	150
8	" " by Town Hall	150
9	" " near Secretariat	150
10	" " junc Reservoir Road	250
11	Ross Rd West by Governors House	250
12	" " " junc Race Course Rd	200
13	Race Course Road	150
14	Ross Rd West nr Sullivan House	200
15	" " "	150
16	James Street	150
17	Crn Philomel Hill and John St	250
18	Crn John St and Dean St	250
19	John St nr School	250
20	St Marys Walk	250
21	" " "	250
22	Crn St Marys Walk & Reservoir Rd	250
23	Fitzroy Road East	150

No	Location	Main dia mm
24	Crn Fitzroy Rd East & Hebe St	250
25	" " " " & Philomell Hill	250
26	" " " " & Dean St	150
27	" " " " & Villiers St	150
28	Crn Drury St & Brisbane Rd	150
29	Pioneer Rd	150
30	Crn Moody St & King St	150
31	Crn " " & Reservoir Rd	150
32	" Kent Rd & Glasgow Rd	150
33	Crn Brandon Rd & Brisbane Rd	200
34	" " " & Davis St	250
35	Davis St (East end)	150
36	Crn Davis St & Hebe St	250
37	" " " & Philomell Hill	250
38	" " " & Dean St	250
39	" " " & Villiers St	250
40	" " " & Dairy Paddock Rd	250
41	Callaghan Rd	150
42	" "	150

SCHEDULE OF RECOMMENDED MAINS AND ISOLATING VALVES FOR NEW FIRE-FIGHTING SUPPLY

Code	Length(metres)/No Sluice Valves				Hydrants
	150 ND	200 ND	250 ND	300 ND	
B-D			315/1		2
D-E			170/-		1
E-F			10/-		
F-G			160/-		1
G-H			10/-		1
H-J			200/1		1
J-K			150/-		2
K-L			150/-		
L-N			130/-		1
N-W			285/1		1
W-P			310/1		1
P-R			435/1		2
R-T			240/-		1
T-B			150/-		1
A-A'	140/1				1
A-A"	350/-	380/1			3
B-B'	220/1				1
C-C'	75/-				1
C-C"	90/-				1
D-C	65/1				
E-E'	80/1				1
F-F'	100/1				1
G-G'	80/1				1

Code	Length(metres)/No Sluice Valves,				Hydrants
	150 ND	200 ND	250 ND	300 ND	
H-H'	100/1				1
J-J'	110/1				1
K-K'	120/1				1
L-M		180/1	440		2
M-M'	170/1				2
M-M"	275/-	210/1			2
N-N'	240/1				2
W-W'				1300	
P-Q		60/1			1
Q-Q'	50/-				1
Q-Q"	85/-				1
R-S		90/1			
S-S'	180/-				1
S-S"	125/-				1
T-U		140/1			
U-U'	130/-				1
U-U"	60/-				1
Totals	2845/11	1060/6	3155/5	1300	42

ESTIMATED FLOWS FROM SAMPLE GROUPS OF 3 NO HYDRANTS RUNNING FULL BORE

No	Position	Est Height ft ASL	Est Flow gpm
1	Ross Road East by YPF Depot	10	487
2	Ross Road East by Cemetary	10	577
3	Ross Road East by F I Cc	10	630
4	Ross Road East by Globe Hotel	20	707
5	On Public Jetty	10	735
17	Corner Philomel Hill anc John Street	40	617
12	Corner Ross Road West & Racecourse Road	20	590
13	Racecourse Road	30	510
14	Ross Road West nr Sullivan House	10	603
12	Corner Ross Road West and Racecourse Road	20	597
14	Ross Road West nr Sullivan House	10	574
15	Ross Road West nr Army Camp	10	500
37	Corner Davis St and Philomel Hill	115	517
41	Callaghan Road	120	436
42	" "	120	450

No	Position	Est Height ft ASL	Est Flow gpm
32	Kent Road	105	502
35	Davis Street (East end)	115	450
36	Corner Davis St & Hebe Street	115	517
16	James St	50	588
23	Fitzroy Rd East	70	504
24	Corner Fitzroy Road & Hebe St	70	569

APPENDIX 11

LIST OF RECOMMENDED REPAIRS, RENOVATION AND IMPROVEMENTS FOR IMMEDIATE IMPLEMENTATION

1 Clean and paint raw water (low lift) pumps (4.3).

2 Clean and apply an epoxy-resin lining to the interior of the flocculation and sedimentation tanks (4.4).

3 Clean and paint exterior surfaces of filter shells (4.5.1).

4 Obtain suitably graded sand and replenish top layer of filter beds (4.5.2).

5 Service float-operated filter outlet control valves (4.5.3).

6 Clean and repaint with non-taste producing bitumastic paint interior and exterior surfaces of filter outlet inspection chambers (4.5.4).

7 Repair and recommission the chlorinator (4.6.2).

8 Clear workshop of useless items (4.7).

9 Clean and repaint high lift (treated water) pumps (4.8).

10 Redecorate interior of Treatment Works and complete the repainting of the building exterior (4.10).

11 Clean and flush out treated water pumping main to Dairy Paddock Reservoir (4.11).

12 Repair roof of Dairy Paddock Reservoir and replace or paint over transparent roof panels (4.12).

13 Clean and repaint booster pump at Dairy Paddock Reservoir (4.13.1).

14 Clean and redecorate interior of booster pumphouse at Dairy Paddock Reservoir (4.13.1).

15 Clean and paint interior of Sapper Hill Tank with an epoxy-resin paint. Repaint exterior of tank with bitumastic paint (4.13.2).

LIST OF ITEMS OF SMALL EQUIPMENT FOR PURCHASING

1 pH Comparator Discs and supply of indicating reagents for ranges 5.2 to 6.8 and 7.0 to 8.6. (4.6.2.1) Approximate cost £40 fob UK port.

2 Laboratory type pH meter (4.6.2.2). Approximate cost £360 fob UK port.

3 Tweezers for laboratory balance weight box (4.6.2.3).

4 Flow, pressure testing and recording equipment for fire-hydrants (4.14.3) Approximate cost £440 fob UK port.

5 BS Service Valve and Fire Hydrant Indicator plates (4.14.4) Approximate cost complete with digits and mild steel posts £375 fob UK port.

APPENDIX 13

LIST OF MINOR WORKS TO BE PUT IN HAND AT AN EARLY DATE

1 Install raw, settled and treated water sampling cocks in laboratory (4.6.2.5). Allow £50 for materials.

2 Improve or install new heating system at Treatment Works (4.10). Allow £500.

3 Replace starter of Dairy Paddock Booster Pump (4.13.1). Allow £35.

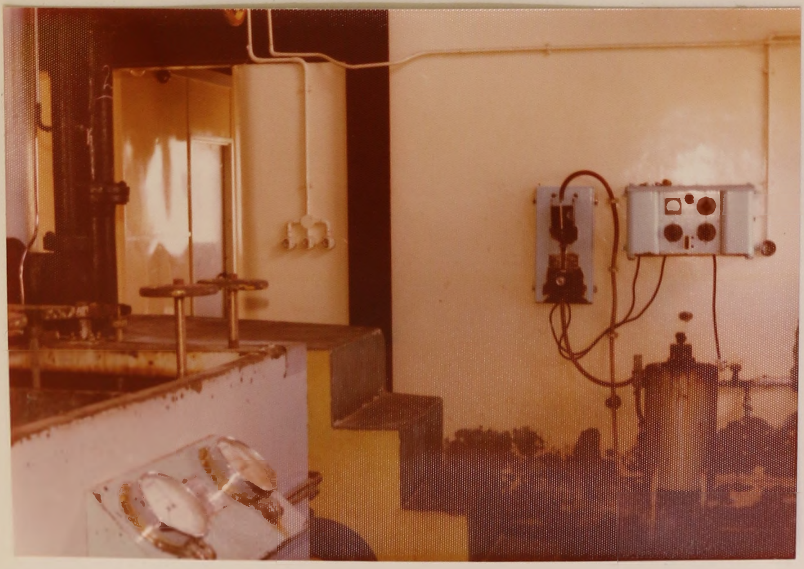
4 Purchase five and install four motor-driven dosing pumps (5.2) Allow £2250.

PHOTOGRAPHIC SUPPLEMENT

R/UTI/WAT/1 #A-01

No 1 - MOODY BROOK INTAKE - 14/1/77
Showing surplus water after abstracting 5,400 gph

R/UTI/WAT/1 #A-02



No 2 - INTERIOR OF TREATMENT WORKS - 14/1/77
Showing condition of Chlorinator, Filter Inspection Chambers and building.

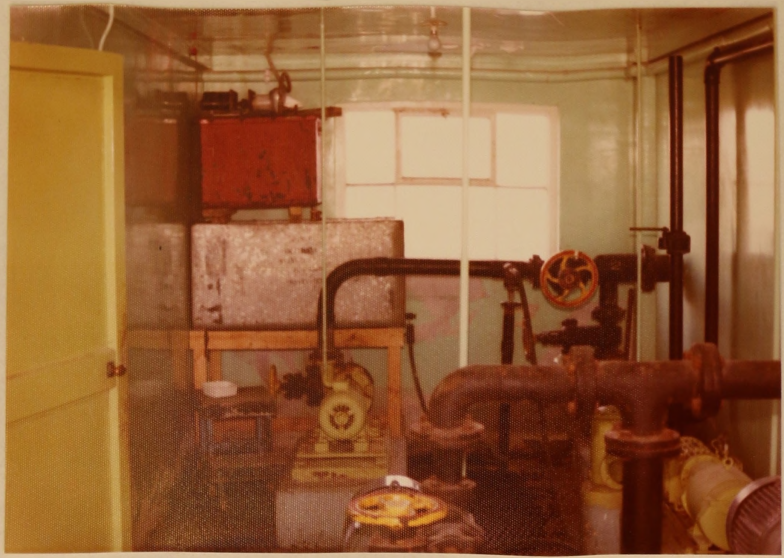
R/UTI/WAT/1#4-03

No 3 - DAIRY PADDOCK RESERVOIR ROOF - 17/1/77

R/UTI/WAT/1#4-04

No 4 - SAPPER HILL TANK - 17/1/77

R/UTI/WAT/1#4-05



No 5 - INTERIOR OF TREATMENT WORKS - 14/1/77
Showing Magnafloc mixing and gravity dosing tanks, raw water pumps at rear, air scour blower on r h s and treated water pumps in foreground

R/UTI/WAT/1#4-06

No 6 - MOUNT WILLIAM ABANDONED WORKS - 14/1/77
Showing 4,750 gpd issuing from springs

R/UTI/WAT/1#4-07

No 7 - ESTUARY OF MURREL RIVER - 26/1/77

R/UTI/WAT/1#4-08

No 8 - MURREL RIVER FLOW - 26/1/77
Site of former gauging station