FALKLAND ISLANDS

A REPORT ON THE STANLEY WATER SUPPLY

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

Ref Q 367/39

February 1972

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CROWN AGENTS
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4 MILLBANK
LONDON SW1P 3JD

Our ref Q367/39

Your ref

Date 9 March 1972

His Excellency
The Governor
Stanley
FALKLAND ISLANDS

Dear Sir

PORT STANLEY WATER SUPPLY

In accordance with the instructions of the Foreign and Commonwealth Office, Mr M J P Lasserly visited Stanley from 8 January 1972 to 19 January 1972 to carry out an examination of the Water Supply at Stanley and to recommend measures for its improvement, if necessary. We now have pleasure in enclosing twenty copies of our Report, which was prepared in accordance with the terms of reference quoted therein.

2 Our detailed recommendations are summarised at the end of the Report, and in general, with adequate maintenance, we consider the filter plant to have a further useful life of about fifteen years. We also consider that the measures recommended for augmenting the flow in the Moody Brook according to the Pape Report are essential for maintaining the Stanley supply and should be executed.

3 We shall be very pleased to give any further information you may require on the matters mentioned in the Report and, later to assist in the implementation of the recommendations, should these prove acceptable to you.

4 We greatly appreciate the courtesy and assistance given to our representative and endorse here the thanks expressed in the Report.

Yours faithfully

L. Jackson
pp. KD

L JACKSON
Director of Advisory Services

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FALKLAND ISLANDS - STANLEY WATER SUPPLY

INTRODUCTORY

On the 20 July 1971, the Overseas Development Administration of the Foreign and Commonwealth Office, on behalf of the Governor of the Falkland Islands, commissioned the Crown Agents for Oversea Governments and Administrations, 4 Millbank, London SW1 to conduct an examination of the existing water supply at Port Stanley, Falkland Islands.

The terms of reference were as follows:-

> To check and examine the present Water Filtration plant near Stanley, to advise on its future and on the future of the water supply to the town of Stanley, and to produce a report, with recommendations, on the filtration plant and the town water supply.

Mr M J P Casserly accordingly visited Port Stanley, from the 8 to 19 January 1972 and prepared the following Report.

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.

TABLE I

Per capita consumption in 1962 of certain towns in England and Wales

Town	g p c d		
	Domestic	Trade	Total
Small Urban Areas:			
Arundel			51
Ashbourne (1961)			42
Bedwellty			32
Chichester	32	23	55
Ebbw Vale			44
Eton			42
First Garden City(1960)	35	43	78
Halstead	33	6	39
Kendal (1961)	36	8	44
Macclesfield (1961)	37	17	54
Pontypool			30
Port Talbot	27	25	52
Slough	32	19	51
Tewkesbury			39
Watford	30	15	45
Large Urban Areas:			
Birmingham	24	28	52
Bradford	31	24	55
Brighton			49
Croydon	31	9	40
Doncaster (1961)	33	18	51
Gloucester	33	26	59
Halifax	28	18	46
Huddersfield	31	20	51
Lancaster	35	18	53
Leeds	29	15	44
Liverpool	32	21	53
Manchester	31	34	65
Metropolitan Water Board			57
Newcastle	26	22	48
Oxford	26	23	49
Plymouth			69
Portsmouth			58
Sheffield	27	26	53
Southampton			57
South Staffs	27	19	46

Acknowledgement: The figures are from the Water Engineer's Handbook, 1963.

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 nc 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 <u>Chamber on raw water main near Intake</u>: (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) <u>Sampling Cocks</u>: 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 <u>Coagulation and Flocculation</u>

(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

Sulphate 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 <u>Ultimate Capacity of the Plant</u>: 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 mains 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 Obsolete Pipe-lines: 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 Training

(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.

10.0 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	Lusaka	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 Trengannu	0.4	14	Fully	U

UNMETERED SUPPLIES •

Ref No	Authority	Daily consumption	
		Total mgd	Per capita: gnd
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 covering diverse communities, hence wide variation in consumption.

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 <u>Future Visits and Advice</u>: It is recommended that, for the next few years, a visit be paid annually by a Water Engineer from The Crown Agents to inspect 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.

ACKNOWLEDGEMENTS

The writer wishes to acknowledge the assistance given to him during his visit by Mr S Booth, Headmaster, in providing laboratory equipment and assistance; by Mrs S Blyth in performing all the extra secretarial duties requested and by Dr J H Ashmore for lending his laboratory equipment so willingly on request.

PAPE REPORT (1953)
(COPY)

To the Crown Agents for the Colonies

1.1 Gentlemen

I have the honour to submit my report on the existing water supply of the town of Port Stanley, with recommendations for its improvement and extension.

My full terms of reference, which were communicated to me by you on behalf of the Falkland Islands Government in a letter M29523/D, dated the 21 August 1952, were:-

(a) To examine and report on the existing water supply of the town of Port Stanley and to make recommendations for its improvement, extension and conservation.

(b) To advise on improved methods of purifying the supply having regard, in particular, to the removal of peat stain.

My Commission to make the investigations and to report was given me by the Falkland Islands Government on the 15 September 1952 and, before leaving for the Falkland Islands, I interviewed Mr A E Livermore, Superintendent of Works, Falkland Islands, who was on leave in the United Kingdom, and Mr G Knowles of the Water Pollution Research Laboratory, Watford, who had recently made an examination of a sample of water taken from the supply.

1.2 I left London by air on the 10 October 1952 and disembarked from the SS Fitzroy at Port Stanley on the 15 October. Six months of exceptionally dry weather had preceded my arrival and the water supply was showing signs of its inadequacy. Thus, an excellent opportunity was afforded me to examine the deficiences of the two existing sources of supply and to assess the capacities of possible alternative sources under the driest conditions likely to arise.

1.3 A survey was first made of the existing supply comprising the Mount William intake, rough filters and pipe line, the Mullet Spring, pumps and pipe line and the town service reservoirs and tanks and the reticulations. This was followed by an investigation into the possibilities of improving or extending the existing sources of supply or conserving their water by constructing a dam and impounding reservoir. As will be shown I found myself unable to recommend any scheme on these lines and turned my attention to finding a new, single, adequate source of supply where a treatment plant could be installed. When it was found to be unlikely that the rock underlying Port Stanley would be water bearing, the camp for a distance of some six miles around the Town was explored, to find the best surface source and for the reasons given in this report, the Moody Valley stream was selected.

1.4 At the request of the Honourable, the officer administering the Government in the absence of Sir Miles Clifford, an interim statement was made to the Executive Council of the Falkland Islands recommending that, subject to confirmation by a detailed survey, the existing sources of supply at Mount William and Mullet Springs should be abandoned and a new source of supply developed from the Moody Brook at a point about a quarter of a mile above where it flows into Stanley Harbour about two and half miles west of Port Stanley. The very rough cost of the scheme was given as about £50,000, a figure which more detailed estimates made since, have found no cause to vary. The detailed survey of the scheme and the investigations into the flow of the Moody Brook and the quality of its water are described in the report together with the reasons confirming my recommendations to use this stream as the new source of supply.

1.5 A suggestion by the Agricultural Officer at the Executive Council Meeting that the Murrel River would be a better source of supply was followed up but, while the water from this river is of excellent quality and more than sufficient in quantity, the nearest point to Port Stanley from which it could be taken is three miles more distant than the proposed Moody Brook intake so that an extra pipe line of this length would be necessary if this source were chosen. However, by siting the new treatment plant at Moody Brook intake it will always be possible, at a later date, if the demand for water grows beyond what can at present be foreseen, to pump Murrel River water to the treatment plant and use the proposed Moody Brook pumping equipment to convey it to the Port Stanley service reservoirs. In other words, the Moody Brook scheme is capable of development by bringing in Murrel River water should the need ever arise.

1.6 A V-notch measuring gauge was installed on the weir at the trout-hatchery and the flow of the Moody Brook was observed from 3 of November onwards and co-related with the rain fall records of the Meteorological station at Port Stanley. When I left Port Stanley on 21 November 1952, the dry spell was still continuing and flow records were kept until it broke on the 29 November and for some days afterwards. A comparison of rain fall records, of which details are given in the report, shows that over the critical period drier conditions than the winter and spring of 1952 have only occurred perhaps four times in 48 years records and that the low flow in the Moody Brook measured on the 28 November 1952 on an average is not likely to occur more often than once in 12 years. The flow records, taken together with observations described in the report regarding the Moody Brook above the intake, show that the lowest flow measured is sufficient for the foreseen maximum requirements of Port Stanley.

1.7 A sample of water taken from the Moody Brook on the 20 November was flown with me to the United Kingdom and examined by the Water Pollution Research Laboratory early in December. The Laboratory's report, attached as an appendix to my report, based on this single sample, states that the proposed source of water - the Moody Brook - will give a clear colourless supply after coagulation with aluminoferric (alum) provided that sodium carbonate (soda ash) is also added, and that, as it seems likely that the treated water will be corrosive, it will be desirable to add an alkali before distribution. The proposed treatment plant will include a coagulation stage using alum and soda ash and a stage where soda ash is added to the water to render it non-corrosive to pipes before it is pumped to the mains. It will also include filtration and sterilisation stages in accordance with accepted modern practice and be as described in this report and in accordance with the arrangements set out by the Paterson Engineering Company Limited in their letter to me of the 16 January 1953 and the accompanying drawing. The Paterson Engineering Company have very wide experience in the design and construction of water purification plant including the treatment of peat-stained moorland waters. On my return to the United Kingdom from Port Stanley I discussed this project with them and they agreed to submit a preliminary design and estimate for a treatment plant on the lines arrived at by us. The letter from the Paterson Engineering Company giving a description and approximate estimate of cost of the proposed plant forms an appendix to my report. Their co-operation in this respect has been most valuable.

1.8 The sample of water taken from the Moody Brook after a long spell of fine weather was less coloured and turbid than the water becomes after heavy rain. It is desirable therefore, and the water Pollution Research Laboratory recommend, that further samples should be taken at other seasons of the year for testing, particularly when the peat stain is most in evidence so that its behaviour and the chemical dosing required to treat it can be observed. Experience with peaty waters indicates that very deep colour can be removed successfully by the alum-soda ash coagulation process and there is no reason to doubt its efficiency with Moody Valley water under all conditions.

1.9 The succeeding sections of the report cover the topography, geology, climate weather and population of Port Stanley, a description of the existing water supply in detail and lead to recommendations regarding the existing water supply, proposals for a new source of supply with a scheme for purifying it and pumping it to Port Stanley, and recommendations as to how it can best be carried out together with approximate estimates of capital and operating costs.

2.1 PORT STANLEY AND THE SURROUNDING COUNTRYSIDE

A topographical map, prepared by the Geographical section of the General Staff and published by the War Office in 1943 is the only map of this kind which has been made of the Falkland Islands. A photostat copy is attached to this report (Appendix Number 1.) It covers Stanley Harbour, Port Stanley and the surrounding countryside to a distance beyond which it would be uneconomical to pipe water to the town. Port Stanley is the capital - and only - town of the Falkland Islands which lie in the South Atlantic Ocean between 54^{o} and 53^{o} south latitude and 57^{o} and 62^{o} west longitude and about 300 miles east, and somewhat to the North of, the Straits of Magellan. Port Stanley is situated on the north-eastern side of the easternmost of the two main islands - East Falkland - and lies along a narrow and sharply rising strip of land forming the southern shore of Stanley Harbour - an inlet from Port William, (which is itself an inlet on the north east coast) with which it is connected by a passage, the Narrows, upwards of 300 yards in width.

2.2 The town of Port Stanley extends for about 1.1/2 miles along the shore of the harbour and rises steeply inland for about half a mile to a height of some 150 feet above sea level. The main street - Ross Road - runs parallel with the shore and about 100 yards distant from it and here are located most of the important buildings - the Town Hall, the Secretariat, Government House, the Cathedral and the Falkland Island Company's jetty, stores and offices. Three other jetties - the Government, the public and the west jetties - are also approached from it. Most of the houses, the two schools, the hospital and the few shops lie clustered on the hillside behind Ross Road in a rectangular layout of streets parallel to the harbour and running at right angles to it steeply up hill. The importance of this from the water-supply angle is the variation in level - and therefore in pressure head - between the lower parts of the town alongside the harbour and the higher parts on the Murray Heights. The maximum difference in level is about 130 feet.

2.3 The countryside surrounding Port Stanley is bare rolling moorland rising to rocky hills 500 to 800 feet high, forming small catchments none of which are more than a few square miles in area. The vegetation is sparse, there are no trees, and such shrubs as there are grow no higher than three feet. The top soil, which is extensively peat, lies thinly over the virgin rock to a depth of not more than a few feet. Rock outcrops and stone runs are frequent and distinctive features of the landscape. The grass is tough, coarse and white in colour and is intermixed with a type of heather (diddle-dee) mosses, Christmas bush and mountain berry. The natural drainage is through the top soil and along the underlying rock rather than over the surface of the ground. Typical moorland streams are found only in the lower valleys of the larger catchments and flow either eastwards and northwards into Stanley Harbour and the Murrel River or eastwards and southwards into Mullet Creek and Port Harriet.

3.1 GEOLOGY

Geologically the Port Stanley area, including Mount William, the Moody Valley, Mount Longden, the Two Sisters and Mount Harriet, is formed in quartzite and quartzitic sandstones - intercolated with shales - of the carboniferous or Devonian series and much folded. The rock succession in the Falkland Islands has been investigated by H A Baker and published in his report on "Geological Investigations in the Falkland Islands 1920 - 1922". He found it to be essentially similar to that of the Cape Colony and he named the beds - downwards - as follows:-

Rhaetic Triassic Permian and Upper Carboniferous (In lower part of series)	West Lafonian Beds Bay of Harbours Beds Choiseul Sound & Brenton Rock Beds Lafonian Sandstones Black Rock Slates Lafonian Tillite Bluff Cove (Fitzroy Basin) Beds
UNCONFORMITY	
Carboniferous or Devonian	Port Stanley Beds
Devonian	Port Philomel Beds
Lower Devonian	Fox Bay Beds Port Stephen Beds
UNCONFORMITY	
Archaen	Cape Meredith series

Of the Port Stanley area, he says, it consists of gaunt barren ridges outcropping through a thin layer of clay and peat top-soil.

3.2 Stone runs - or rivers of stone - are an interesting natural phenomena in sub-antartic regions and are much in evidence around Port Stanley and other parts of the upper quartzitic series in East Falkland to which they are confined. A photograph of the Mount Will stone-run has been included in Appendix Number 2 and gives a good idea of their nature. They consist of loose blocks of stone two to six or more feet in size spreading to a width of some thirty to fifty feet and lying, perhaps, ten to fifteen feet deep, although there is no evidence of excavations having ever been made to verify the latter. Some run progressively downhill, others lie across the tops of low dome like hills, some are exposed, others are concealed by vegetation. The material in stone-runs is always quartzitic and the blocks, which may be of considerable size - up to forty tons - but are more generally about two to four tons, are obviously derived by parting along the jointing and bedding planes of the virgin rock. J R F Joyce in his "Stone-runs of the Falkland Islands" attributes their formation to the following:-

1 A rock series of jointed quartzites interbedded with easily weathered shales.

2 Small sharp folds in the strata in anticlines.

3 A tundraic climate of alternate freeze and thaw.

He considers that these factors cause denudation of the quartzite scarps which retreat, leaving their blocks as debris in their original positions, to form "stone-runs". When investigating proposals for a water supply, the importance of the stone-run is in the complication it introduces into the construction of dams and reservoirs. Excavation for the dam foundations, which must be carried down to the virgin rock, becomes difficult and laborious so that it is not easy to estimate before work commences the extent to which excavation will be necessary in order to reach a watertight strata. Stone-runs within the reservoir area form courses for underground drainage which must be located and sealed before the reservoir is watertight. Many stone-runs are covered by peat and topsoil and cannot be found by surface examination. The hazards of building a watertight dam and impounding reservoir in the Port Stanley area are therefore considerable and success might only be achieved after excessively expensive work.

4.1 CLIMATE AND WEATHER

Port Stanley is about as far south of the equator as London is north but, due to the influence of ocean currents, the temperatures at all times of the year are lower. The mean annual temperature is 42°F, with January (mean 48°F), the warmest month, and July (mean 35°F) the coolest month, thus giving a mean annual range of 13°F. The corresponding mean temperatures at Kew Observatory (London) are Annual 50°F, July 63°F, January 39°F, so that in Port Stanley the winters are slightly colder and the summers much cooler than in London. The absolute maximum temperature recorded in Port Stanley is 75°F and the absolute minimum 13°F. The annual mean maximum is 48°F and the annual mean minimum is 36°F. The mean annual diurnal range of temperature is small (5.9°F), varying from a monthly mean diurnal range of 8.3°F in November to only 2.9°F in May.

4.2 The relative humidity of Port Stanley is always high, the annual percentages being:- mean maximum 98, mean minimum 59, mean 81%. Humidity is greatest in the winter (July mean maximum 99, mean minimum 70 mean 88%) and lowest in the summer (December mean maximum 98, mean minimum 55, mean 74). The absolute maximum relative humidity recorded is, of course, 100% and the absolute minimum 29%. The diurnal range of humidity is greatest in the summer (February monthly mean 21.6%) and least in the winter (June monthly mean 3.6%). The sky conditions in the average month are two days clear, fourteen days part cloudy and fourteen days cloudy with small variation throughout the year. The annual mean sky conditions, based on three years observations, are 7.3 tenths cloud. Frequent high winds are a characteristic of the climate. For 1948, records show, calms 0.7%, 1-3 mph winds 3.9%, 4-15 mph winds 38.9%, 16-31 mph winds 47.7% and over 32 mph winds for 8.8% of the time.

4.3 The intensity and distribution of rainfall is the most important climatic factor influencing the quantity of water available as run-off at a source of supply and it is fortunate that fairly full records have been kept at Port Stanley since 1874. There have been breaks in their continuity between 1879-80, 1891-1905, 1914-15, 1920-29 and in 1950 but data is available for about 48 years between 1874 and 1952, sufficient to compare the dryness of 1952 with other dry spells and estimate their frequency. The records of all monthly rainfalls available since 1874 are set out in Appendix Number 3. From these it will be seen that the rainfall at Port Stanley (mean annual 27.50 inches) is well distributed throughout the year. The wettest months are December and January (means 3.00 and 2.87 inches) and the driest, September and October (means 1.63 and 1.55 inches). In the driest month ever recorded, September 1905, 0.35 inches fell and in the wettest, January 1911, 6.64 inches. The driest year, 1877, totalled 18.77 inches and the wettest, 1911, showed 36.96 inches. The average annual rain fall at Kew Observatory is 23.80 inches with monthly means varying from 2.70 to 1.45 inches so that the rainfall at Port Stanley is not greatly different from that at London being slightly heavier with more rainy days. The average number of rainy days (0.01 inch or more) at Port Stanley is 223 per annum varying from 14 in October to 22 in January. The corresponding figure at Kew is only 167 per annum. Heavy rainfalls (i e, greater than 1.0 inch in 24 hours) are infrequent and average only 17 per annum.

4.4 In order to obtain comparable statistics, the following definitions were introduced in "British Rainfall 1887". Absolute drought, a period of at least 15 consecutive days none of which is credited 0.01 inches of rain or more. Partial drought, a period of at least 29 consecutive days the mean daily rainfall of which does not exceed 0.01 inches, i e, a total of 0.29 inches.

4.5 By these standards, it is doubtful whether a drought, partial or absolute, is ever experienced in Port Stanley when one considers that rain falls on an average 223 days out of 365 and 0.35 inches is the least rain recorded to have fallen in 30 days. When corelating rain fall with stream flows, it is dry spells of long duration, when rain falls run much below the average, that are more important and have greater effect on run-off, than shorter periods without any rainfall at all. The late G J Symonds, in dealing with the record dry year 1887, put forward a definition of an engineer's drought which serves as a useful criterion. He defines it as:-

> "A period of three or more consecutive months, the aggregate rainfall of which is less than half the average for that period."

Although dryness of this intensity is not experienced in the Falkland Islands it is by judging rainfalls of such periods (three or more months) that corelation with stream flows can best be made and critical flows assessed. The following data has, therefore, been abstracted from the monthly rainfall records of Port Stanley (Appendix Number 3) and arranged to show the relative dryness of all observed dry spells since 1874.

Year	Dry Spell ended on	Inches of rain falling during the preceding months						
		1	2	3	4	5	6	7
1952	29th Nov	0.99	2.09	3.53	5.01	7.00	8.18	9.55
1949	31st Oct	0.43	1.86	3.88	4.76	8.38	9.81	11.71
1946	31st May	0.64	3.01	4.75	7.33	9.68	13.22	14.09
1945	30th Nov	0.87	1.78	4.86	7.61	9.61	13.26	15.96
1938	31st Oct	0.71	1.66	4.27	6.88	9.79	13.22	17.27
1934	31st Oct	0.96	1.85	3.60	6.29	8.39	10.37	11.23
1917	30th Nov	0.98	2.13	4.63	5.85	7.94	11.19	11.58
1912	30th Sept	0.99	2.64	3.55	4.84	6.36	8.50	11.19
1883	31st Oct	0.55	1.98	3.15	5.78	7.51	9.20	12.50
1877	30th Sept	1.02	1.92	3.49	5.27	7.25	9.79	10.99
1876	31st Dec	0.99	1.90	3.18	4.76	6.46	9.22	10.32
1875	30th Sept	0.84	1.75	2.93	4.36	6.51	8.91	10.67
Av. Year	31st Oct	1.55	3.18	5.19	7.26	9.48	12.05	14.59
½ average	(Symonds definition of drought)			2.59	3.63	4.74	6.03	7.30

First it will be noticed that no "engineers drought" by Symonds definition has ever occurred in Port Stanley. Then taking the periods of three months or longer of Symonds definition, we see the dry spell which ended on the 29th November 1952 has only been exceeded for three months, four times (1883, 1877, 1876, 1875); for four months, four times (1949, 1912, 1876, 1875); for five months, three times (1912, 1876, 1875). And that for periods of six and seven months, it has never been exceeded. It may fairly be assumed, then, that the exceptional dry spell, which ended on the 29th November 1952, was one which is only likely to be repeated once in 12 years on the average, and is only likely to be exceeded by a small percentage, say 20%.

5.1 POPULATION

The last census of population was taken in the Falkland Islands in 1946, but vital statistics, published in the biennial reports of the colony, bring records up-to-date. The following figures have been compiled from these sources:-

YEAR	Total Population of Falkland Islands	Population of Port Stanley
1891	1,789	
1901	2,043	
1911	2,272	
1921	2,094	
1931	2,392	1213
1946	2,239	1252
1949	2,267	
1950	2,231	
1951	2,280	(say) 1270

POPULATION CHANGES 1932 - 1945

Year	Births	Deaths	Natural Increase	Immigration or Emigration	Net total change
1932	51	12	39	- 26	+ 13
1933	52	27	25	- 26	- 1
1934	54	28	26	- 16	+ 10
1935	50	19	31	- 36	- 5
1936	45	21	24	- 57	- 33
1937	37	20	17	- 25	- 8
1938	41	20	21	- 34	- 13
1939	47	17	30	+ 17	+ 47
1940	37	20	17	- 37	- 20
1941	58	30	28	0	+ 28
1942	41	34	7	+ 11	+ 18
1943	44	27	17	- 26	- 9
1944	54	30	24	- 107	- 83
1945	33	29	4	- 79	- 75
Totals	644	334	310	- 441	- 131
Averages	46	24	22	- 31.5	

POPULATION CHANGES 1949-51

Year	Births	Deaths	Natural Increase	Immigration or Emigration	Net total change
1949	40	33	7	- 8	- 1
1950	35	26	9	- 45	- 36
1951	45	27	18	+ 31	+ 49
Averages	40	$28\frac{2}{3}$	$11\frac{1}{3}$	- $7\frac{1}{3}$	+ 12

The Falkland Islands are thinly populated, 2280 persons inhabit 4,618 square miles (approximately 1 person to 2 square miles), but of these, rather more than half, say 1270, are concentrated in Port Stanley where the population density is quite high (approximately 2,100 persons per square mile). The town has 308 dwellings, giving a density of approximately four persons per dwelling - no crowding or housing shortage is evident. The total population of the Falkland Islands over the past 20 years, as can be seen from the tables, has diminished by approximately 5%, but the population of Port Stanley has increased slightly during the same period. The peak year for the Falkland Islands was 1931 and from then, until the outbreak of the second World War, the population remained steady, the natural increase of births over deaths being offset by emigration. Between 1939 and 1943 movements into and out of the Islands approximately balanced and the population rose by natural increase. But during 1944 and 1945 there was a heavy exodus which caused a net fall of about 6% in the population. Between 1946 and 1950, the pre-war conditions, with emigration balancing natural increase, returned. In 1951 there was a sharp increase by immigration, probably accounted for by personnel for the building operations in Port Stanley and for the construction of the freezer at Ajax Bay. In assessing the future population of Port Stanley, in order to estimate the maximum demand likely to be made on the water supply, it will be advisable to allow for a slow but steady growth. The present population of 1270 may increase at the average natural rate of increase (10 per 1000 per annum), say 12 per year to a figure of approximately 1,500 in 20 years. There are no indications of any developments in Port Stanley which would cause this rate of growth to be exceeded, but it is so small that it would be very susceptible to changing economic or other conditions. However, the estimated ultimate population of the water supply area will be taken to be 1,500 persons but, as will be seen, the new scheme is being designed in a manner that will allow for any increased demands that might conceivably arise by running the pumps for more hours.

6.1 <u>WATER CONSUMPTION</u>

The existing water supply is not metered, but it is estimated that the water consumption at present of Port Stanley reaches a maximum of 33,000 gallons a day (if a ship happens to take water on a Monday) and averages 29,000 gallons a day. This gives an average consumption of 23 gallons per head per day - a low figure due to three reasons:-

1. Some sixty of the 308 dwellings are not connected to the piped water supply and obtain water by trapping rain from the house roofs and storing it in tanks.
2. Only about 100 of the 308 dwellings are connected to the water borne sewage system, the others use bucket closets from which night soil is collected and dumped into the harbour.
3. The demand for water for trade purposes is small.

In assessing the ultimate demand for water, it must be assumed that eventually all dwellings will be connected to the water supply and sewerage systems and that the night soil collecting arrangements will be abandoned. Allowance must also be made for some trade developments. It is, therefore, estimated that the average daily consumption of water may rise to 40 gallons per head, that is to a total of 60,000 gallons per day.

7.1 THE EXISTING WATER SUPPLY OF PORT STANLEY

Port Stanley at present takes its piped water from two sources; the Mount William supply, installed in 1925-1926, and the Mullet Springs supply, built in 1936. Their combined yield is inadequate in dry weather to meet the demand and the quality of the water delivered to the reticulation, especially from the Mount William source, leaves much to be desired. It is deeply coloured by peat stain at all seasons and, after heavy rain, its turbidity and colour are so great that, as it runs from the tap, it resembles tea rather than water and when standing a few inches deep in a bath completely obscures the bottom. The Mullet Springs water receives no treatment and the Mount William only an entirely ineffective passage through a "filter" - so called - which will be described later. The water is distributed unsterilised, corrosive to metals, and highly coloured. Its appearance is a long standing subject of complaint by the community, and housewives on many occasions find it impossible to use it for washing clothes because of the stains it causes. Lack of sterilisation would be most dangerous if pathogenic, water borne, bacteria were introduced into the supply, say by a typhoid carrier, and it may be that the intestinal troubles which occur so frequently are caused by less virulent bacteria in the water supply.

7.2 The Mount William supply is by gravity from a small spring issuing from the stone-run on the slopes of the mountain about three miles due west of the town, supplemented by two smaller springs situated nearby. All three springs are fed by surface water which, after percolating through the shallow peat topsoil, finds its way, either down the stone-run, or along small courses on the rock surface. The natural drainage of the slopes of Mount William is typically that of the "camp" area; that is percolating through the topsoil and sub-surface flow over the underlying quartzite rock along more or less defined channels, of which in this instance the stone-run is the largest, to a stream in the valley bottom - the Moody Brook - and hence to the sea - Stanley Harbour. The catchment of the northern slope of Mount William above the three springs is small, not more than two thirds of a square mile in area. There is no reason to suppose that all the drainage from the catchment is along the three courses that have been trapped, undoubtedly other drainage channels distributed across the slope carry water down the hill side to the valley bottom, all of them small and most of them drying out after a spell without rain. The stone-run forms the main collecting channel and advantage of this was evidently taken when, in 1925, it was adopted as the source for the first piped water supply for Port Stanley which, hitherto, had depended on rain water collected from roof-tops. A small headwall was constructed across the eastern part of the stone-run, thus intercepting the flow of water and diverting it into a 4 inch diameter cast-iron pipe. The inadequacy of this source must have been realised during the first dry spell for, in order to supplement it, the two nearest drainage courses lying about two hundred feet to the east were trapped and led through 2 inch diameter galvanised pipes to the collecting point. In the original scheme, constructed during 1925-1926, a 4 inch diameter pipe carried water, without any treatment, direct to the service reservoirs, built at the same time, at Port Stanley.

7.3 The combined flow of the three springs at Mount William during normal rainy periods probably yields 100,000 gallons a day, more than the 4 inch diameter main can convey, but when little rain falls the flow diminishes rapidly. A measurement made on the 22nd of October, soon after my arrival in the Falkland Islands, registered 16,000 gallons a day flowing at Mount William; this fell away steadily during my stay until no more than 11,000 gallons a day were reaching the collecting point. Exceptionally dry weather persisted after my departure until the 28th of November 1952 and it will be reasonable to assume that the minimum flow at Mount William can drop below 10,000 gallons a day.

7.4 When Port Stanley came to rely on the piped water from Mount William, and people abandoned their roof-water collecting tanks, the shortage of the supply in dry weather became apparent once more and, coupled with the unsatisfactory colour and appearance of the water, this led to investigations to find an alternative source of supply.

A spring was found a foot or two below ground level, discharging through a pocket of sand, at the 175.00 level on the southern side of Sappers Hill at a distance of about 3,000 yards from Port Stanley. This spring is typical of the natural drainage of the camp area, in that it is fed by rain percolating through the top-soil and flowing over the surface of the underlying quartzite rock, but it differs because in this case the sand stratum acting as a natural filter removes some of the colour from the water. The proposal to develop this source was accepted, although it involved pumping the water to convey it to Port Stanley, and, in 1936, work on the Mullet spring supply was started. A concrete wall 10 feet x 10 feet was sunk over the spring from whence the flow is by gravity into a pump well, 8 feet by 16 feet by 5 feet 3 inches deep (4,200 gallons capacity). Pumping plant was installed consisting of a Tangye, three cylinder piston pump, belt driven by a 7 h p petrol engine, rated to deliver 3,000 gallons per hour. A 3 inch diameter steel pipe conveyed water to a covered Braithwaite pressed-steel tank of 100,000 gallons capacity which was erected on the Murray Heights behind Port Stanley at a top water level of 170.70 O.D. A photograph of this tank, which is still in very good condition, appears in Appendix Number 2.

7.5 The capacity of the Mullet spring proved to be insufficient to supply all the needs of Port Stanley so that the proposal to abandon the Mount William supply in its favour was not realised. Various expedients were employed to improve the supply. Two headings were opened up through the top-soil near the spring to collect surface water and the flows from them were led, by 2 ins diameter pipes, to a forebay discharging into the pump well; the arrangement of the forebay being such that either spring water or surface water from the headings - or both - can be fed to the pump well. An additional quantity of water was obtained from the headings, but at the expense of quality, as this water, like the Mount William water, does not benefit by flowing through a sand pocket and therefore is highly coloured after rain. It was found that the capacity of the pump was greater than the combined flow from the Mullet Springs and its contributory headers and a second expedient to improve the efficiency of the pumping system was adopted. A storage reservoir measuring 40 feet square and 2ft 6ins deep (capacity 25,000 gallons) was built, sited about fifty feet away from the pump well and at such a level that the latter overflows into the reservoir when full and draws on it when emptying. In this way the capacity of the pump well (4,200 gallons) was increased by the capacity of the reservoir (25,000 gallons) thus giving ten hours pumping storage at the rated capacity of the pump (3,000 gallons per hour) so that continuous economical pumping shifts were possible. At a later date, when the troops left Port Stanley after the Second World War a second Braithwaite steel tank became available from the camp water supply and a further expedient to improve the Mullet Springs supply was undertaken. The tank - an open one of 38,500 gallons capacity - was erected on the saddle of Sappers Hill at the highest point on the 3 ins diameter pumping main (about top water level 312.00 O D). This provided additional storage but, more important, improved the performance of the pump which was probably at this time not lifting more than one third of its rated capacity to the Murray Heights tank. The free water surface at the Sappers Hill tank shortened the length of pumping main by about 1200 yards and the water then flowed on by gravity to the Murray Heights tank. The full rated capacity of the pump, if it were ever achieved, was not maintained; a flow test made during my visit showed that the pump could not now deliver more than 1,800 gallons per hour.

7.6 The Mullet Springs supply, then, can deliver 1,800 gallons per hour to Port Stanley and when working a 56 hours week, (ie 7 days of 8 hours) can give about 15,000 gallons a day - or about half the present demand. During normal rainy weather the spring and the headers can yield more than this quantity, but during dry spells it falls away very considerably. In early November 1952, for instance, the yield was only 3,000 gallons per day from the spring and 7,000 gallons per day from the headers - a total of 10,000 gallons per day - sufficient to keep the pump running for 40 hours a week only. Even this is probably not the minimum flow and by the end of November it was probably less.

The combined dry weather yields of Mount William and Mullet Springs supplies can be placed at a minimum of less than 20,000 gallons a day, probably as low as 18,000 gallons a day, against a present day demand of 30,000 gallons and an estimated future demand of 60,000 gallons. This then is the measure of the inadequacy of the existing water supply for Port Stanley.

7.7 The failure of Mullet Spring to give sufficient clear water for the town refocussed attention on the poor quality of the Mount William water and brought forth proposals for its improvement. Before anything eventuated, however, war had broken out in 1939 and eventually about 4,000 troops arrived in Port Stanley so that an urgent need for more, as well as better, water arose. The original Mount William system included two service reservoirs built at Dairy Paddock on the southwest boundary of Port Stanley (at elevation T W L 135.00 O D) fed by the flow from the stone-run spring at elevation 240.00 O D through a 4 ins diameter cast iron pipe. The reservoirs, which are still in good condition today, are uncovered, rectangular in plan, each 68 ft 8 ins by 82 ft 8 ins at the top with sloping sides, forming truncated pyramids 9 ft 6 ins deep and retaining 7 feet of water, combined capacity 355,000 gallons. Two photographs of these reservoirs appear in appendix No 2. They were constructed half in excavation and half in clay embankment and lined with precast concrete blocks set in cement mortar. They are in good condition except for some leaks through the top two feet of lining which needs repointing and one corner of the embankment which requires slight repairs.

7.8 In 1942, in an attempt to treat the Mount William water to remove peat stain, a break was made in the 4 ins diameter main at a point about a hundred yards distant, and 20 feet below the stone-run intake and the combined flow of the stone-run spring and the two supplementary springs was discharged into a small pressed steel tank (see photograph appendix No 2). Two filter beds - so called - were constructed to receive this flow with the object of improving the colour and delivering a water of better quality into the main. They failed for two reasons, first because filtration alone cannot remove colour and impurities of a peaty nature, and secondly because these filter beds were incorrectly designed. No provision was made for regulating the flow through them by controlling the head of water between inlet and outlet and they operated at too high a rate. Only 1,200 square feet of area was provided instead of about 4,000 square feet needed if the normal rate of 4 inches per hour were to obtain. The grading of the sand bed was too coarse for the zooglea and schmutze-decke organisms to build up, without which the biological process of filtration does not take place. The beds can only ever have operated as coarse strainers and never as slow sand filters. During my visit the beds were by-passed and out of service, and I gathered that they had been abandoned. Each bed is about 600 square feet in area and about 3 ft 6 ins deep, constructed with mass concrete walls and rudimentary underdrains, and filled with coarse gravel and about 3 ins of coarse sand. As originally constructed they were trickling filters with pipe-sprinkler distributing systems which were removed because the sprinkler holes clogged. The water was then led on to the beds through holes in the side walls and, owing to the high rate at which the filters were operated, it is certain that the sand beds were never inundated or worked under a head of water. A photo of one filter inundated when receiving the pumped water from Moody Brook in November 1952, is included in appendix No 2 but this unusual condition only occurs when the inflow exceeds the capacity of the Mount William main and causes a head to build up. It seems that the failure of the filter beds to improve the quality of the Mount William water was soon apparent and little care was taken to control their operation, which indeed, owing to fundamental faults in their design, was uncontrollable.

7.9 At the same time that this attempt was being made to improve the quality of the Mount William water, the need for a larger quantity of water to supply the troops had arisen and was met by improvised methods. A pump house was built at Moody Brook about 200 feet lower, and half a mile north, of the filter beds, and two small pumping sets and a 3 ins diameter steel pumping main were installed so that water could be pumped up from the Moody Brook to the filter bed and hence into the 4 ins diameter Mount William main at a rate of about 3,000 gallons per hour. The principal army camp was situated approximately half way between Mount William and the Dairy Paddock reservoirs, near and below the line of the 4 ins diameter main. Advantage was taken of this to give the camp a supply of water by gravity from the 4 ins diameter main by inserting a tee junction in it near the camp thus tapping part of the flow into a 38,500 gallon open Braithwaite, pressed steel, tank sited to command the camp. As we have seen this tank was afterwards dismantled and re-erected on the saddle of Sappers Hill in the pipe line of the Mullet Spring supply.

7.10 When the 4 ins diameter cast iron main from Mount William to the Dairy Paddocks reservoirs was new, in 1927, it must have been capable of discharging approximately 4,000 gallons per hour (96,000 gallons per day) and even in 1942, fifteen years later, after some incrustation had developed and the head been reduced 20 feet by the construction of the filters, there is evidence to show that it carried fifty or sixty thousand gallons a day to the camp and Port Stanley. Today, owing to the rapid and progressive growth of incrustations in the pipe, it is only capable of discharging about 32,000 gallons a day. This was proved by a flow test made on 12 November 1952, the details of which are set out in Appendix No 4.

7.11 It has been established that, in periods of dry weather usually throughout October and November each year, - and in very dry years longer -, the combined capacities of the present sources of the Port Stanley water supply yield less than 20,000 gallons a day, while the demand is about 30,000 gallons a day, thus leaving a deficiency of approximately 10,000 gallons a day to be met. It has been seen that, during the war years, the supply was supplemented from Moody Brook and, although the pumps and engines used then are no longer in working order, the 3 ins diameter pipe up to Mount William filter beds is still in existence and is employed each year to convey Moody Brook water to increase the Mount William supply. The motive power at present brought into service for this purpose is one of the Port Stanley Fire Brigade's trailer pumps and a photograph of the operation appears in appendix No 2 while another photograph in the same appendix shows the discharge of Moody Brook water through the 3 ins pipe into one of the Mount William filter beds on its way into the main. The trailer-pump is a standard Merryweather's unit consisting of a petrol engine driving a 4 ins centrifugal pump capable of deliverying 80 gallons of water per minute (approximately 5,000 gallons per hour) at a pressure of 115 lb per square inch (equivalent to 265 feet of head). It can only develop the head necessary to lift water up to the filter beds (ie 200 feet static head plus about 65 feet of friction head) when delivering at least 65 gallons a minute.

When in use, therefore, it discharges about 4,000 gallons per hour at the filter beds, but we have seen that the Mount William main to Port Stanley is now only capable of carrying 1350 gallons per hour (32,000 gallons per day). The capacity of the filter beds is about 15,000 gallons, so that, after the trailer-pump has been pumping for about 5 hours, the filter beds overflow and the pump must stop until their contents have been discharged down the Mount William - Port Stanley main at the rate of 1350 gallons per hour - say for about 16 hours, if allowance is made for an inflow of 400 gallons per hour (10,000 gallons per day) from the Mount William springs. Obviously then, the present method of supplementing the water supply in dry weather is an expensive and inefficient makeshift, and immobilises an important piece of fire fighting equipment for a number of weeks each year. The real cost of this improvisation is concealed because it appears that the Fire Brigade do not present the P W D with a bill for the full cost of the loan of the trailer-pump. However, the fuel cost alone is seen to be a considerable item.

7.12 The water from the two sources of supply is delivered, as has been described, into service reservoirs at different levels. The Mount William water is held in the Dairy Paddock reservoirs (355,000 gallons capacity) at top water level 135.00 O D and the Mullet Springs water is stored in the Murray Heights tank (100,000 gallons capacity) at top water level 170.70 O D. The combined capacity, 455,000 gallons, represents 15 days supply at present consumption and 7.1/2 days at estimated maximum future consumption. This is more than adequate by normal design standards and no recommendation to increase service reservoir storage capacity is necessary. The Dairy Paddock reservoirs are, however, uncovered and when a treatment plant is installed they should be covered to prevent deterioration of the water after treatment and before delivery to the consumer. A recommendation to this effect will therefore be made and an item for the cost included in the estimate. The configuration of the town is such that it has been necessary to keep the water reticulations served by the reservoirs and the tank separate from each other. The Dairy Paddock reservoirs supply the reticulation which feeds the part of the town lying below the 100 feet contour. The Murray Heights tank supplies the reticulation which feeds the higher parts of the town above this contour. The two reticulations are interconnected by a valve at the junction of Dean Street with Fitzroy Road which is normally kept closed so that they operate independently. The details of the reticulation are shown in the map at Appendix No 5. There is an area of the town, around the Meteorological Station and along Callaghan Road, which is too high by some 25 feet to be served from the Murray Heights tank and no piped water supply is at present given here. Recommendations are made later in the report for supplying this part of the Town. Elsewhere, as the map Appendix No 5 shows, about 80% of the houses and buildings are connected to the water reticulations. Service connections are by galvanised steel pipes screwed direct into the mains, no ferrules being used. The mains and service connections generally appear to be in fair condition but considerable incrustation has probably occurred due to the untreated water. There is no external evidence of leakages of any magnitude and, judged by the low demand per head of population, it is unlikely that much occurs. The mains meter on the Dairy Paddocks reticulation is not in working order and there is no mains meter on the Murray Heights reticulation so that it was not possible to check leakages by observing night flows. There are no service meters, water being charged for by assessment.

8.1 RECOMMENDATIONS REGARDING THE EXISTING WATER SUPPLY

The description of the existing water supply to Port Stanley, in Section No: 7, underlines the inadequacy of the present sources of supply. The catchment of the Mount William source is barely two thirds of a square mile in area, the catchment of the Mullet Springs is even smaller. The combined dry weather flow from them is less than 20,000 gallons a day. The only way in which the existing catchment could be developed to yield more water would be by conserving the surplus wet weather flows from them in impounding reservoirs and drawing upon these to supply the deficiency in dry periods. The wet-weather flow of the Mount William catchment would be just about sufficient, calculated on the following basis:- Rainfall of the driest year recorded - 18.77 inches assume 20% of the rainfall appears as run-off and the average daily yield in the driest year is then 100,000 gallons a day (1.2/3 times the maximum estimated demand). In order, however, to balance dry weather flows with surplus wet weather water, to yield a constant 60,000 gallons a day, it would be necessary to provide an impounding reservoir capable of holding almost all the surplus run-off from the catchment during the wettest six months of the year and it is estimated that a capacity of at least six million gallons would be needed. The problem then becomes one of finding a site where the construction of a dam at an economic cost will create a watertight impounding reservoir of this size and it is here that difficulties arise. Examining primary considerations, the principle has been accepted that it will be neither economic nor desirable to construct and operate more than one treatment plant, therefore it follows that one source of supply must be developed to meet the total requirements of the town. The Mullet Springs supply is unsuitable for development because the estimated total run-off in a dry year is less than the estimated demand. When the Mount William catchment was explored and inspected it was found that this too was unsuitable for development because, although the estimated total run-off in a dry year is sufficient, the construction of a dam and impounding reservoir would be a hazardous and uneconomic proposition for the following reasons:-

(a) there is no natural dam site in the catchment and the configuration of the ground at the desired level is such that the dam would form the longest side of the reservoir;

(b) the ground slopes steeply and, therefore, the average depth of the reservoir would be small compared with the height of the dam;

(c) the rock formation is broken by a visible stone-run and, very probably, all the underlying rock in the catchment is fissured and jointed and there may be other concealed stone-runs. The task of carrying down the foundations of the dam to sound rock and of making the rock under both the dam and the reservoir watertight, would be formidable, hazardous and expensive;

(d) a great deal of labour would be required to construct the dam and impounding reservoir and shortage of labour is the principal embarrassment of the economy of the Falkland Islands;

(e) the existing main from Mount William to Dairy Paddock reservoir is no longer capable of carrying 60,000 gallons a day and would require replacing.

8.2 At an early stage in my investigations after exploring the Mount William and Mullet Springs catchments, I reached the conclusion that I would be unable to recommend any scheme for the improvement or extension of the existing sources of supply or for their development by conservation of their water in impounding reservoirs. I, therefore, make it my main recommendation that a new, single, adequate source of supply be selected and that the Mount William and Mullet Springs sources be abandoned.

8.3 Other recommendations concerning the existing supply are:-

1 That the Dairy Paddock reservoirs be repaired and covered by a roof of corrugated steel - or asbestos - sheets carried on steel trusses. The design and order for these should be placed through the Crown Agents for the Colonies.

2 That, when the new source of supply is operating, the Mount William - Dairy Paddock 4 inch diameter cast iron main be lifted, cleaned by scraping, and used to improve the reticulation in Port Stanley, as and when defects show themselves, also the Mullet Springs 3 inch diameter main.

3 That, the mains-meter at the Dairy Paddock reservoir outlet be put into working order, any spare parts required being ordered through the Crown Agents.

4 That a new mains-meter be installed at the outlet to the Murray Heights tank, and that for this purpose a 4 inch diameter Torrent meter be ordered, through the Crown Agents, from Messrs George Kent and Company of Luton.

5 That the need for public standpipes - most of which are out of order - be reviewed and all the redundant ones removed.

6 That the part of the town lying above the level which can be fed by the Murray Heights tank should be served by a small pumped supply drawing water from the Murray Heights tank. In this scheme the capacity of the pump should be 10 gallons per minute and its motive power a fractional horsepower electric motor (say 1/4 h.p.) fitted with an automatic stop and start mechanism. The pumping plant should be housed in a small building over a pumping well, sited adjacent to the Murray Heights tank and drawing water from it through a 4 inch diameter pipe with a ball-valve controlling the outlet. The pump should deliver water through a 4 inch diameter pipe to a covered pressed steel tank 12 feet x 8 feet x 4feet deep (about 2,000 gallons capacity) raised on a steel staging to a topwater level of 195.00 O.D. The ground level at the Murray Heights tank is 158.50 O.D. so that, if the new high level tank were sited here, the staging would have to be 33 feet high - allowing a depth of 3ft 6 inches of water in the tank.

The ground level near the Meteorological station is about 170.00 O.D. so that, if the new tank were sited there, the staging would have to be only 21ft 6 ins high. If the latter site is chosen, then the 4 inch diameter pumping main could be laid along Gallaghan Road and serve, in addition, as a reticulation main to the houses on the way to the tank and, in this case, there would be no need for separate inlet and outlet mains to the new tank, the 4 inch diameter pumping-reticulation main serving both to fill and empty the tank as conditions demanded. The automatic stop-start control of the pump would be linked to the top water level indicator of the new tank and this apparatus can be supplied by Messrs George Kent. Orders for this and the other equipment should be placed through the Crown Agents for the Colonies.

9.1 AN ALTERNATIVE SOURCE OF SUPPLY

The selection of a new source of supply required an examination of several possibilities. The use of deep wells is always an attractive proposition in the absence of any obvious nearby surface source and merited investigation. A tentative attempt to find a ground-water supply appears to have been made in 1923 when two bores were drilled in the "camp", behind Port Stanley. One, at Spring Paddock, was sited where 5 feet of peat had previously been removed. It penetrated 22 feet of stiff clay, followed by 13 feet of boulder-clay and entered the quartzite rock at 35 feet below the surface. It was not taken any lower as the boring equipment was not capable of drilling hard rock. The second, on the east side of Sapper's Hill, after passing through a thin layer of surface clay, met a bed, 10 feet thick, of soft sandstone containing fossils; this was followed by peaty matter and, at 18 feet below the surface the hard quartzite rock was reached. These bores were said to have yielded between 200 and 400 gallons a day, but, as no pumping tests were made, it is not known whether even these small yields could have been sustained. The underlying rock was not bored into in either case and no examination of the water bearing possibilities of the quartzite strata was made. The water found was surface water which had percolated down through the overlying top-soil in the manner of the natural drainage of the camp area. The bores did little more than determine the thickness of top-soil over the rock at the selected points. An examination of the water bearing properties of the quartzite strata for the development of deep wells would be a much more extensive and costly business requiring diamond drills to penetrate the hard rock to depths up to 100 feet. Before recommendations could be made for such an investigation there should be geological indications that it would have a reasonable chance of success. These are absent. Quartzite, even when fissured and jointed, is not usually a water bearing rock, the topography and geology of the camp around Port Stanley is not hopeful, and there is nothing in H A Baker's report to indicate that his investigations led him to anticipate that the underlying rock in the Falkland Islands would be water bearing. I am therefore, led to recommend that no examination of the possibility of locating a ground water source of supply in the rocks underlying the top soil near Port Stanley be made, because the chance of finding a site for a deep well capable of yielding up to 60,000 gallons a day is slight and the risk of spending a considerable sum to no purpose is very considerable.

9.2 After the possibilities of developing the existing sources of supply and of finding a ground water source had been examined and dismissed, the investigation was narrowed to seeking the most economical surface source which would yield at least 60,000 gallons a day at all times of the year, because a reconnaisance of the camp for about 8 miles around Port Stanley had failed to reveal any likely dam-site which could be easily developed to form an impounding reservoir in which surface flow could be conserved. The chief streams within eight miles of Port Stanley are:-

(i) Mullet Creek Stream, which drains a catchment of about 4.1/2 square miles to the south west of Port Stanley and enters Mullet Creek (which is an arm of Port Harriet) approximately 2.3/4 miles south west of the service reservoirs.

(ii) Moody Brook, which drains a catchment of about 6 square miles, due west of Port Stanley and enters Stanley Harbour approximately 2.1/2 miles west of the service reservoirs.

(iii) The Murrel River, which drains a catchment of over 30 square miles, to the west and north west of Port Stanley and discharges into Port William through Hearnden water, north west of the town. The nearest point to Port Stanley from which fresh water can be taken from the Murrel River lies 5.1/4 miles distant from the service reservoirs.

9.3 The Murrel River, at the nearest point to Port Stanley has a dry weather flow many times greater than 60,000 gallons a day. Although accurate gaugings were not made when I inspected it in November 1952, I estimate that at least one million gallons a day were flowing. It is therefore a much more than adequate source of supply, but, also, it is twice as distant from the town as the other two streams. Pipes are costly items and a 6 inch diameter cast-iron, cement lined, pipe laid in position with the necessary air, scour and sluice, valves is estimated at not much less than 18/-d. a foot. The extra capital cost of conveying water from this more distant source, therefore, would be more than £13,000 to which must be added the additional daily operating cost of pumping it 5.1/4 miles instead of 2.1/2 miles. Obviously a nearer source is more economical if proved adequate.

9.4 Of the two nearer sources, the Moody Brook is preferred because

(i) Its catchment is six square miles against 4.1/2 square miles for the Mullet Creek stream and its dry weather flow must be correspondingly greater.

(ii) It is slightly - 1/4 mile - nearer to the Dairy Paddock Reservoirs and Murray Heights tank.

(iii) There is road access already existing which would have to be provided to reach the Mullet Creek stream.

(iv) The direct line from the Murrel River to the service reservoirs passes the point where water would be taken from the Moody Brook and where the treatment plant would be built. Therefore, if it ever became necessary to bring in Murrel River water, this could easily be done as an extension to the Moody Brook scheme.

9.5 Accordingly, the Moody Brook was selected for detailed investigation and survey of the stream and its catchment. The most important matter for investigation was to ascertain whether the dry weather flow is always in excess of 60,000 gallons daily. Here, some small difficulty arose in fixing a gauging weir through which the whole flow of the Brook could be directed. There is in existence a well-built concrete weir, sited about 1/4 mile up the Moody Brook from the point where it discharges into Stanley Harbour, constructed in connection with a trout hatchery. The weir, a photograph of which appears in Appendix No: 2, is about seven feet high and 40 feet broad and creates a reservoir in the Brook about two hundred feet long which, it is estimated, contains 150,000 gallons. Unfortunately, the stream banks at the weir are low and a fairly substantial quantity of water finds its way down stream through the ground around both ends of the weir and from at least one point just up-stream. An attempt, therefore, was first made to construct a gauging weir about 50 yards below the trout-hatchery weir in the hope of trapping the whole flow of the brook. This proved unsuccessful owing to the broken rocky nature of the stream bed and banks and no greater proportion of the flow passed through the gauge than was passing over the trout-hatchery weir. It was abandoned and the decision was taken to place the gauge on the crest of the trout-hatchery weir and make an estimated allowance for the quantity of water which was by-passing this weir; this was done using pre-cast concrete blocks and a sheet-steel V notch, with the results shown in the photograph. Gauging readings were started on the 3 November 1952 and observed as frequently as possible until the 5 December 1952 (the latest readings available). These readings - as has been seen in paragraphs 4.4. etc - covered a period when stream flows were as low as they are ever likely to be on a twelve year average and are as follows:-

DATE	GAUGE READINGS		Rainfall at Met.Station
	Inches on V notch	Gallons per day	
3.11.52	5¾	210,000	Trace
4.11.53	5	150,000	0.08
5.11.53			NIL
6.11.53			0.12
7.11.53			Trace
8.11.53			Trace
9.11.53			Trace
10.11.53	5	150,000	NIL
11.11.53			NIL
12.11.53	4½	116,000	0.02
13.11.53	4¾	132,000	0.41
14.11.53	8	485,000	0.07
15.11.53	6½	290,000	0.02
16.11.53	5½	190,000	NIL
17.11.53	5	150,000	0.03
18.11.53	5	150,000	0.03
19.11.53	4⅞	142,000	NIL
20.11.53	4¼	101,000	NIL
21.11.53			NIL
22.11.53			NIL
23.11.53	3½	63,000	NIL
24.11.53	3½	63,000	Trace
25.11.53	3⅛	48,000	NIL
26.11.53	3	42,000	NIL
27.11.53	3	42,000	Trace
28.11.53	2¾	34,000	0.09
29.11.53			0.30
30.11.53			0.22
1.12.53	6½	290,000	0.04
2.12.53			Trace
3.12.53			0.02
4.12.53			Trace
5.12.53	3¾	74,000	0.05

Until the 13th of the month practically no rain had fallen in November after, as we have seen, a period of six exceptionally dry months; as a result the flow through the gauge fell away to 116,000 gallons a day. A not exceptionally heavy fall of rain on the 13th raised the flow through the gauge on the 14th to 485,000 gallons a day. A spell of fifteen days with practically no rain followed and the flow through the gauge fell away again to the disappointing figure of 34,000 gallons a day, just a little more than present daily requirements. However, a fall of 0.52 inches of rain on the 29th and 30th November again raised the flow so that 290,000 gallons a day were recorded by the gauge on the 1 December and, after a further five days without rain, this had fallen to 74,000 gallons a day by the 5th of December.

9.6 It is unfortunate that all the stream flow was not passing through the gauge and that an estimate has to be made of how much was escaping around the weir, in view of the fact that the minimum recorded flow for a period of four days was less than the estimated ultimate requirements of the town (although more than the present requirements). I hesitate to place the non-recorded flow around the weir higher than 15 gallons a minute (ie about 20,000 gallons a day) although this is a conservative estimate and it might well be more. We are, however, with the stream in its existing condition, evidently, at the trout-hatchery weir, below the margin of 60,000 gallons a day during exceptionally dry spells. So low a run-off from a catchment of 6 square miles in area is remarkable and required further investigation. The first area inspected in detail was that portion of the catchment which, lying to the south of Moody Brook, includes the northern slopes of Mount William and the stone-run. We have seen that there is from here, a minimum flow of about 10,000 gallons per day being taken into the Mount William - Dairy Paddock Reservoir main but, in addition it was found that the flow from the foot of the stone-run was making its way down to Stanley Harbour in a channel which did not flow into Moody Brook. It was also found that only a small amount of work would be required to divert this flow into the reservoir in Moody Brook formed by the trout hatchery weir. This, together with the water at present going down the Mount William main to Port Stanley, would form a useful addition to the dry-weather flow. A more important state of affairs, influencing the run-off at the trout-hatchery weir of Moody Brook, was discovered by a detailed examination of the Brook above the weir right up to its source. The upper part of the catchment, below the Two Sisters and Goat Ridge, is drained in the manner which I have referred to as typical camp drainage - that is by percolation through the top soil and underground flow along the underlying rock surface. At a point about 2½ miles above the trout-hatchery weir, however, the underground flow is of such a magnitude and has collected sufficiently in the dips of the valley for regular water courses to have been formed. These courses, cut in the topsoil, join together about half a mile lower down becoming the Moody Brook which continues as a single stream bed down towards the trout-hatchery weir. So far there is nothing remarkable about the Brook which, as the photograph in Appendix No: 2 shows, is a normal moorland stream with well defined banks and a gravel and sand bed broken occasionally by ridges of the underlying rock where the latter has been only thinly covered by topsoil. But, at a point about 1½ miles above the trout-hatchery weir, the appearance of the stream bed changes; the ground becomes broken and boulder strewn, the well defined banks and bed cease and the stream disappears into an area of weathered rock and boulders, almost a stone-run. After, perhaps, a quarter of a mile, the stream reappears with regular banks and a less rocky bed, only to disappear again nearer the trout-hatchery weir in another rocky patch and not to reappear until only a few hundred yards from the weir. There are signs in the rocky patches that the Brook does not flow through them in a single definite course, but splits up into several channels and, it is probable, that not all of these reunite to form the stream on which the trout-hatchery weir is built. It is likely that there are other courses, running roughly parallel, which carry water under the top soil and through broken rock down to Stanley Harbour. It is very probable, then, that if the course of the Brook were canalised through the broken rock areas by clearing a regular bed with good banks, a substantially increased dry-weather flow would result. These two improvements are, therefore, recommended:-

(i) Bring the flow from the end of the Mount William stone-run, by a channel, to discharge into the reservoir formed by the trout-hatchery weir.

(ii) Construct a regular channel for the Moody Brook through the broken rock areas where none exists at present.

I consider that, if these works were carried out, the dry-weather flow of the Moody Brook at the trout-hatchery weir would be always sufficient to provide a minimum of Sixty thousand gallons per day for a water supply for Port Stanley, and I recommend that the Moody Brook be selected as the new source of supply and that the reservoir formed by the trout-hatchery weir be used as the intake.

10.1 RECOMMENDATIONS FOR PUMPING AND TREATMENT PLANT.

A very considerable part of the operating cost of a water purification and pumping scheme lies in the wages paid to the operating staff. If the scheme is designed to work 24 hours a day it is, of course, smaller, and therefore cheaper in capital cost, than one designed to cope with the demand in one shift; but this saving is more than offset by the need to employ and pay three sets of operating staff. It has been proved that for smaller schemes - say less than two million gallons a day - it is more economical to build them for operation on a one-shift-a-day basis. There is also the advantage that, in emergency, the plant can deal with three times its rated capacity daily by running the full 24 hours. This is useful if, for instance, an unusual demand - a big fire perhaps - has depleted the contents of the service reservoirs. It is proposed, therefore, that the pumps and treatment plant shall be capable of 100 gallons a minute (that is 6,000 gallons an hour). Present day demand then would be satisfied in five hours rising to ten hours when demand reaches the estimated maximum of 60,000 gallons a day. In emergency, with this plant, 144,000 gallons a day could be delivered and the Dairy Paddock reservoirs and Murray Heights tank (total capacity 455,000 gallons) filled from empty in a little over three days.

10.2 It is proposed that the site of the pumps and treatment plant shall be on the south side of the Moody Brook adjacent to the trout-hatchery weir, and that water shall be led in a channel from the reservoir formed by the weir to a suction-pump well situated at the side of the pump and treatment plant building. The ground here is subject to flooding in rainy weather, when the Moody Brook is in spate, and it is proposed that the floor of the building shall be raised 2ft 6ins above ground level and the building approached by an embanked path from the road about 300 yards distant. The Paterson Engineering Company have prepared a sketch plan of the pumping and treatment plant building, which is attached as Appendix No: 7 of this report. The proposed building is 60 feet long by 25 feet wide with a wing 27 feet x 22 feet housing the sedimentation tank. Thus it is proposed that all the plant and machinery shall be under cover, protected from the effects of frost, snow and rain. The cubic contents of the building are about 50,000 cubic feet so that, allowing a unit cost of 3/6d per cubic foot, the estimated cost is about £9,000.

10.3 Some consideration has been given to the best method of driving the pumps. The water has first to be lifted to flow through the treatment plant - referred to as the low lift - and afterwards lifted to the service reservoirs

- referred to as the high lift. The pumps are required in duplicate - making a total of four pumps - in order to provide stand-bys in case of breakdown. Electric light and power is required in the building. The most convenient arrangement would be for an electric supply to be given from the Port Stanley electric power house, but, on enquiry, it seems that the cost of running a line out to Moody Brook would be excessive because no other consumers are likely in that area. Individual diesel drive for two pumping sets, with high lift and low lift pumps on one shaft, was considered and estimated but, owing to the need to use non-standard equipment, it proved to be as expensive as electric drive. The arrangement selected is the most convenient and flexible one, and will provide for electric lighting, heating, and power in the building. It is proposed to install two diesel generator sets each of about 29 kilowatt capacity - one a stand by to the other - to produce electric power to drive four electric motors each coupled to a pump. The low lift pump motors would be 2 h.p. to raise 6,000 g.p.h. against a head of 33 feet and the high lift pump motors would be 15 h.p. to raise the same quantity of water against a head of 180 feet. The data for the pumps, showing how the heads have been computed, is to be found at Appendix No: 8. The arrangement of the pumps in the building and the circuit of the water from the suction sump, through the low lift pumps, the treatment plant, and the high lift pumps to the service reservoirs is shown in the Pattersons Engineering Company's drawing (Appendix No: 7). It will be noticed that the treated water is collected in a balance tank of about one hours capacity (i e 6,000 gallons) placed under the floor of the building and that the suction pipes for the high lift pumps draw from this. Arrangements are included to balance the deliveries of the low and high lift pumps against each other as obviously these must be the same within narrow limits. It will also be noticed that the washwater for the filters is to be stored in a 6,000 gallon pressed steel tank placed on the flat roof of the building where it will provide the required head for back washing. The tank will be filled by a connection from the high lift delivery main (not shown in the drawing). The filter-wash waste water and the sludge water from the sedimentation tank will, on the occasions when back washing and desludging is in progress, flow from the point marked WASTE in the drawing, in an open channel direct to Stanley Harbour and not into Moody Brook below the weir. In this way any possible effect on trout from sludge or chemicals will be avoided.

10.4 It is proposed to convey the water from the high lift pumps in the building alongside Moody Brook to the Dairy Paddock Reservoirs and Murray Heights tank through a 6 inch diameter, spun-iron, cement lined, pipe laid along the line shown in the map, Appendix No: 1. A survey of the line has been made and it is the most direct one between the points of departure and arrival. It meets the road about 400 yards from the Moody Brook building, and follows it for another 400 yards until the road bends. It then strikes out straight for the corner of the race-course and follows the northern side of the course past the winning post and leaves the course at the north easterly corner. The pipe will then cross the paddock to the high ground behind Government House gardens and the football field and cross the Sappers Hill road near the bridge. From this point it will turn uphill to the south-west corner of the Dairy Paddock reservoirs and continue to the Murray Heights tank on the same line as the existing 2.1/2in diameter main - which will no longer be required. A 6 inch diameter tee will be fitted into the main near the south-east corner of the Dairy Paddock reservoirs and a 6 inch diameter junction pipe will be laid from it to the existing twenty feet square concrete tank which adjoins the reservoirs at their division wall. It is proposed that this tank shall be remodelled to form a fore-bay to the reservoirs. The 6 inch diameter junction from the pumping main will be led into the fore-bay and will terminate in a balanced ball valve (Glenfield and Kennedy pattern H 45) of 6 inch diameter, working to a pressure of 25lbs square inch. The water level in the fore-bay will be the same as the water level in the reservoirs and the ball valve will be adjusted to shut when the reservoirs are full and to open when the water level in them drops. A 6 inch diameter sluice valve (Glenfield and Kennedy pattern series No: 2) will be fitted in the junction pipe so that flow to the reservoirs can be shut off even when they are not full to allow water to reach the Murray Heights tank. Arrangements will also be made for a by-pass pipe, 6 inch diameter, from the junction pipe to the reservoir outlet pipes near the mains meter in order that water can, when required, be pumped direct into the reticulation without passing through the reservoirs. The discharge of the pumping main into the Murray Heights tank will also be controlled by a 6 inch diameter balanced ball valve and a 6 inch diameter sluice valve and a by-pass pipe to the reticulation will also be provided. It is proposed that the pumping main shall be Class B (i e 200 feet working head) spun iron pipes to British standard specification No: 1211 of 1945, 6 inch nominal diameter, lined with 1/4 inch thickness of cement, thus giving an internal diameter of 5.82 inches. Each pipe to be 12 feet long and jointed with a flexible mechanical joint of, for example, the Stanton screwed gland type, this will reduce the amount of skilled work in pipe-laying to a minimum and also the number of special bends required. The high lift centrifugal pumps should be protected on their delivery sides by non-return valves, preferably of the Glenfield and Kennedy "Recoil" type No: M.7. Air valves of the Glenfield and Kennedy double type with screw-down isolating valve (type H.40), 2 inch diameter should be fitted into the main at all summits on its line and at, at least, six places in all. Washout valves, 6 inch diameter, series No: 2 sluice valves, should be provided at all dips in the main and at, at least, four places in all. They should be set on 6 inch x 6 inch Tees laid in the main. Provision should be made to isolate the main into four sections by introducing three series No: 2, 6 inch diameter, sluice valves between the pumps and the Dairy Paddock reservoirs.

A concussion relief valve of the Glenfield and Kennedy spring type (No: H20) should be set in the main near the pumps. The surveyed length of the pumping main is approximately 14,000 feet and the following calculations have been made of the probable friction head when the pumps are pumping 100 gallons a minute (6,000 gallons an hour). Velocity in main = 1.5 feet per second. Using the Hazen and Williams formula $V = 1.318C\ (D/4)^{0.63}(H/L)^{0.54}$ with $C = 130$ (for cement lined pipes) and $D = 5.82$ inches, the H/L (i e head lost per 1000 ft) = 1.7 feet, giving a total head lost in 14,000 feet of 23.8 feet, to which must be added an estimated allowance for head lost through valves and around bends, say 6.2 feet, making an estimated total friction head of 30 feet through the main when delivering at rated discharge of 6,000 gallons per hour. The main should be laid about 2ft 6in below ground level to be below the effects of frost.

10.5 A Sample of water was taken from the Moody Brook, at the trout-hatchery weir on the 20th of November 1952 in a glass winchester bottle and was flown home with me and examined by the Water Pollution Research Laboratory of the Department of Scientific and Industrial Research. A copy of their report is attached at Appendix No: 9, and their conclusions are reproduced below:

"So far as can be judged from a single sample, the proposed source of water, the Moody Brook, will give a clear colourless supply after coagulation with alumino-ferric (alum), provided that sodium carbonate (soda ash) is also added to keep the pH value within the optimum range.

As it seems likely that the treated water will be corrosive, it will be desirable to add an alkali to raise its pH value before distribution. Lime would be best, but we understand that it may be necessary to use sodium carbonate instead.

It is recommended that samples should be taken at all seasons of the year for tests of the nature described in this report, and the metal corrosive tests on treated water should be undertaken at the Falkland Islands. It would be difficult to make metal corrosion tests elsewhere since a supply of running water is required".

10.6 Taking the final paragraph first, arrangements should now be made to collect a sample of water from the Moody Brook after heavy rain, when the water will be carrying the maximum amount of peat stain and impurities, and send it by sea-mail in a winchester bottle, securely sealed and fully labelled, to the Water Pollution Research Laboratory, 103 Langley Road, Watford, Herts, addressed to Mr G Knowles, who has charge of the examination of Falkland Island water. There is little chance that the coagulation process, followed by filtration, will fail to remove all the peat stain and impurities; the examination of the heavily stained water is aimed rather at ascertaining what quantity of chemicals will be required to effect it. There seems to be no reason why the preliminary moves in the scheme should be held up pending the additional tests recommended. As regards metal corrosion tests, it is suggested that it be accepted that the treated water will be corrosive and steps taken in the treatment process to correct this by adding sodium carbonate to the water in the filtered water tank before it is pumped to the main. Sodium carbonate has been selected in preference to lime, for simplicity in operation and Mr Knowles has confirmed its use.

10.7 Accordingly it is proposed that the treatment processes shall consist of:-

(i) Adding controlled doses of alum and soda ash.

(ii) Mixing these so that coagulation takes place and aluminium hydroxide floc is formed.

(iii) Removing the colloids, which form the peat stain, by allowing the floc to settle in a sedimentation tank.

(iv) Filtering the sedimentation tank effluent through rapid gravity filters.

(v) Correcting the pH value of the filtrate to non-corrosive balance point by adding soda ash.

(vi) Sterlilising the treated water before delivery into the mains by dosing with chlorine.

The Patterson Engineering Company of Windsor House, Kingsway, London, are specialists in the design and manufacture of water treatment plant of this type and I have sought and obtained their co-operation in supplying a preliminary design and estimate of cost. This has been attached as Appendix No: 6, and gives a full description of what we propose. The Patterson Engineering Company are preparing a more detailed drawing than No: 72846, together with a firm tender for the supply of the plant described, and will submit these upon request. In designing the plant the difficulties of constructing complicated re-inforced concrete structures at Port Stanley have been kept in mind and, apart from the flat roof of the building and the filtered water tank, re-inforced concrete work has been avoided by using pressed-steel work for the tanks and mild steel pre-fabricated filters. The design, throughout, has been with an eye to reducing the amount of work required at site. The Patterson Engineering Company, if the order is placed with them, will supply instructions and drawings for the erection of the plant and for its subsequent operation and will supply suitable laboratory equipment so that the tests necessary to ensure the correct chemical dosing etc. can be made daily. I recommend, however, that an experienced water-engineer be engaged for a period of about eighteen months to supervise the construction of the building, intake, and waste channels, the erection of the pumps, treatment plant, and pipeline, and the bringing into operation of the scheme as a whole. He will train staff to operate the treatment plant in the proper manner and make the routine control tests so that, upon his departure, the scheme will continue to function properly under the charge of the Superintendent of Works. I suggest that the Crown Agents for the Colonies be asked to engage the water engineer who should have had experience in the erection and operation of pumping-sets, sedimentation tanks, and rapid gravity filters in addition to the laying of water mains. Allowance has been made in the preliminary estimate for his salary and passages.

1.1 A PRELIMINARY ESTIMATE OF THE CAPITAL COST OF THE MOODY BROOK SCHEME

ITEM	DESCRIPTION	ESTIMATED COST £	s	d
1	The building (50,000 cubic feet) for pumps and treatment plant, including intake and waste channels.	9000	0	0
2	Canalisation of part of Moody Brook and channel for stone-run water.	1000	0	0
3	Pumping and purification plant in accordance with the Patterson Engineering Cos. approximate estimate f.o.b. British Port.	15000	0	0
3a	Shipping charges on 3	1200	0	0
3b	Erection charges on 3	1800	0	0
4	Pumping main from Moody Brook to the Murray Heights tank, supply, shipment, and laying, including valves meters specials, branches to reservoir etc. 14,000 feet at 18/- per ft.	12600	0	0
5	Covering in Dairy Meadow reservoirs and the reconstruction of the forebay and repairs to reservoirs.	3500	0	0
6	Lifting, scraping and storing of the Mount William 4" and Mullet Springs 3" mains against relaying in the reticulation.	400	0	0
7	Auxiliary pumped supply and storage tank for Met. Station area.	2300	0	0
8	Expenses of supervising water engineer for 18 months.	2000	0	0
9	Contingencies 2.1/2% say.	1200	0	0
		£50,000	0	0

2.1 ESTIMATE OF TIME TO COMPLETE THE MOODY BROOK SCHEME

The Paterson Engineering Company say that, based on present commitments and availability of materials, they estimate that shipment could be given of the purification and pumping plant in twelve months from the receipt of order. I estimate that, if the building is started about three months before the plant is shipped, it should be completed, with plant installed within twelve months of shipment date, i.e. operating two years after date of order. At the present time, pipes and valves delivery can be estimated as shipment twelve months after date of order. This will allow a further twelve months for shipment and laying. The same phasing can be estimated for the roofing for the Dairy Paddock reservoir, and the pump and materials for the auxiliary supply. The estimated time to complete the whole scheme is two years after the date orders are placed. The supervising water engineer should be engaged to reach the Falkland Islands about eight months after the date orders are placed and he will then be able to discuss the details of the orders with the Crown Agents and the manufacturers before he leaves the U.K.

3.1 A ROUGH ESTIMATE OF THE OPERATING COST OF THE MOODY BROOK SCHEME PER ANNUM WHEN DELIVERING 30,000 GALLONS PER DAY

		£	s	d
1	Fuel for diesel generators operating 5 hours per day say 2,000 gallons per annum at 20d. per gallon	166	13	8
2	Lubricating oil, spares etc. for generators, say	33	6	4
3	Spares and stores for pumps and treatment plant	50	0	0
4	Chemicals Alum 3 tons per annum Soda Ash 2 tons per annum Common Salt one ton per annum	100	0	0
5	Salary of Superintendent and cost of living bonus	350	0	0
6	Wages of Labourer including C.O.L. bonus	200	0	0
7	Electrical stores, cleaning materials etc.	15	0	0
8	Contingencies 10% say	85	0	0
	Total	£1,000	0	0

It would be advisable to have a renewals fund for the pumps and treatment plant, based on a capital expenditure of £18,000 and a life of twenty years, say about £600 per annum.

4.1 SUMMARY OF RECOMMENDATIONS

1 Abandon the Mount William and Mullet Springs sources.

2 Develop the Moody Brook as a new source by installing a pumping and treatment plant at the trout-hatchery weir and conveying water to the existing service reservoirs.

3 Improve the dry weather flow of the Moody Brook by canalising the sections which at present run through broken rocky ground and also by leading in water from the end of the Mount William stone-run.

4 Cover Dairy Paddock reservoirs and carry out minor repairs to them.

5 Reclaim the Mount William and Mullet Springs mains for re-use in the reticulation.

6 Put the mains meter at Dairy Paddocks reservoirs in order.

7 Install a mains meter at Murray Heights tank.

8 Review the need for public-standpipes.

9 Construct an auxiliary, pumped, reticulation for the high area around the Meteorological Station and along Gallaghan Road.

10 Ask the Engineering Department of the Crown Agents for the Colonies to design the roof over the Dairy Paddock reservoirs and the auxiliary scheme for the Met. Station, - Gallaghan Road area, and ask them to arrange for placing orders for the design and supply of the main scheme.

11 Engage a water-engineer, through the Crown Agents, to supervise the construction of the scheme and train operators.

12 Take a water sample from the Moody Brook after heavy rain and send it to the Water Pollution Research Laboratory for examination.

13 If, in subsequent years the dry weather flow of the Moody Brook proves insufficient for Port Stanley's needs, bring an auxiliary supply of water from the Murrel River to the treatment plant to supplement the Moody Brook supply. It is hoped that this recommendation will never need to be implemented.

APPENDIX NUMBER 3

MONTHLY TOTALS OF RAINFALL AT PORT STANLEY IN INCHES

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total for year
1874	2.17	1.40	2.43	2.13	0.73	1.01	1.42	2.77	1.56	1.21	1.03	2.46	20.32
1875	3.27	3.32	1.76	2.40	1.45	1.43	1.18	0.91	0.84	1.07	1.24	2.92	21.79
1876	3.27	2.00	2.12	1.07	1.64	1.10	2.76	1.70	1.58	1.28	0.91	0.99	20.42
1877	1.60	1.23	1.20	2.54	1.98	1.78	1.57	0.90	1.02	1.71	1.27	1.97	18.77
1878	1.15	1.21	1.78	-	-	-	-	-	-	-	-	-	-
1879	-	-	-	-	-	-	-	-	-	-	-	-	-
1880	-	1.96	4.46	3.09	2.09	1.87	1.48	2.66	1.84	1.07	2.50	4.00	-
1881	4.00	2.10	2.52	2.99	2.37	2.91	3.09	2.01	1.87	1.95	1.77	3.45	31.03
1882	2.79	2.38	2.76	3.03	5.19	2.24	0.84	2.00	1.70	2.15	2.75	2.58	30.41
1883	3.31	2.99	5.34	3.30	1.69	1.73	2.63	1.17	1.43	0.55	2.07	3.18	29.39
1891	2.06	3.38	1.65	0.88	1.88	-	-	-	-	-	-	-	-
1904	-	-	-	-	-	-	-	2.04	2.44	2.81	1.61	2.82	-
1905	3.57	4.57	1.90	2.11	2.81	2.53	2.58	2.09	0.35	1.29	1.07	2.77	27.64
1906	2.09	1.87	2.67	2.15	2.21	2.90	2.09	1.49	0.91	2.33	1.61	3.34	25.66
1907	1.05	1.68	0.73	1.24	2.07	1.77	1.85	1.23	1.37	1.55	2.60	3.60	20.74
1908	2.43	2.19	2.49	2.01	1.81	1.31	2.55	1.06	1.73	2.83	3.07	1.75	25.23
1909	2.33	2.14	2.29	3.54	2.47	2.03	1.20	3.12	1.14	2.08	2.08	4.81	29.23
1910	3.77	2.42	0.82	2.57	4.39	1.73	1.98	3.01	1.12	0.34	2.40	3.23	27.78
1911	6.64	1.57	2.35	3.31	3.96	2.43	4.29	4.08	1.35	1.57	2.83	2.48	36.96
1912	1.99	4.28	2.69	2.14	1.52	1.29	0.91	1.65	0.99	1.33	2.62	3.48	24.89
1913	1.75	1.75	4.51	2.68	2.33	2.41	1.43	2.23	0.59	1.28	2.52	2.60	26.08
1914	3.14	1.61	1.42	2.10	1.43	2.43	-	-	-	-	-	-	-
1915	2.90	1.60	1.26	3.25	4.21	1.87	2.48	3.53	1.00	0.84	2.27	2.69	27.90
1916	1.71	0.95	3.29	1.80	5.69	3.00	1.71	1.44	1.18	1.62	2.74	2.99	28.12
1917	3.87	1.39	2.10	1.52	1.39	3.25	2.09	1.22	2.50	1.15	0.98	3.22	24.68
1918	2.16	2.47	3.02	2.65	2.58	2.97	2.96	2.60	2.06	1.78	1.75	0.57	27.57
1919	1.58	2.79	1.09	3.64	5.69	2.94	2.72	2.84	2.38	1.04	1.87	2.37	30.95
1920	2.96	3.02	3.15	1.27	2.76	3.32	2.03	0.87	1.38	1.03	2.77	4.92	29.48

1929	2.87	2.80	2.76	3.15	2.01	1.93	1.37	1.99	1.43	3.01	3.09	5.84	33.84
1930	2.30	1.34	3.69	1.81	2.11	2.17	2.04	1.42	2.02	1.43	1.32	2.69	23.18
1931	2.61	2.56	3.04	3.37	1.98	2.92	1.74	1.39	0.86	1.44	2.27	2.15	27.94
1932	4.94	2.03	3.20	3.49	3.35	2.87	1.65	2.47	1.09	1.65	2.40	2.18	32.26
1933	2.03	3.03	1.80	1.50	1.02	2.00	1.38	0.87	3.41	2.76	3.59	3.26	24.15
1934	2.21	4.43	3.64	0.86	1.98	2.10	2.69	1.75	0.89	0.96	2.80	3.12	27.61
1935	2.47	4.41	1.42	5.92	3.21	2.76	2.48	2.65	1.07	0.60	2.08	3.25	33.83
1936	3.10	2.41	3.21	3.02	2.89	1.49	3.70	2.03	2.58	2.47	0.89	2.65	30.60
1937	3.46	2.92	2.32	2.45	3.34	1.36	1.46	3.28	1.01	1.44	1.97	2.76	27.77
1938	3.31	2.31	2.46	4.05	3.43	2.91	2.61	2.61	0.95	0.71	2.31	3.21	30.87
1939	3.50	1.01	2.96	4.13	3.11	1.91	1.87	1.94	1.49	1.29	4.62	3.45	31.37
1940	2.85	3.70	2.54	3.15	3.20	2.74	2.02	1.88	1.08	1.61	1.03	4.65	30.45
1941	2.91	1.33	1.86	5.87	3.22	2.17	2.15	3.20	2.75	3.35	1.59	1.74	32.14
1942	2.60	2.17	3.13	1.69	2.20	2.40	0.85	1.89	2.85	1.06	1.46	1.38	23.68
1943	3.95	3.20	1.99	1.64	1.85	1.04	2.92	2.23	2.56	1.01	2.10	2.72	27.21
1944	2.29	2.21	1.24	1.37	2.05	2.82	4.42	2.25	0.83	2.37	1.18	4.66	28.36
1945	0.80	2.75	2.90	3.48	2.70	3.65	2.00	2.75	3.11	0.91	0.87	3.54	29.46
1946	2.35	2.58	1.74	1.37	0.64	1.13	2.62	2.82	2.27	1.27	2.31	0.91	22.03
1947	3.56	3.16	2.86	1.66	4.07	2.08	1.36	1.00	1.10	1.19	1.57	3.32	26.93
1948	4.52	4.67	2.03	1.98	3.20	1.14	1.15	1.12	2.52	2.35	3.92	3.70	32.30
1949	1.96	2.77	4.08	1.90	1.43	3.62	0.98	2.02	1.43	0.43	1.34	3.76	25.72
1951	3.95	3.08	2.03	1.55	2.63	3.89	1.52	2.04	2.04	2.51	3.59	3.68	32.51
1952	2.22	4.55	2.98	3.18	1.38	1.18	1.99	1.49	1.44	1.10	0.99 (1st to 29th)		
Total	137.99	123.88	121.95	121.63	123.34	104.53	95.34	94.49	76.49	72.92	94.87	138.03	
No of years observed	48	49	49	48	48	47	46	47	47	47	47	46	
Monthly Averages	2.87	2.53	2.49	2.54	2.57	2.22	2.07	2.01	1.63	1.55	2.02	3.00	27.50

APPENDIX NUMBER 4

- FLOW TEST ON MOUNT WILLIAM TO DAIRY PADDOCKS RESERVOIR MAIN -

Observed flow when discharging full capacity with a head of about three feet over the inlet at Mount William was 1.75 gallons in 4.75 seconds $= \frac{1.75 \times 60}{4.75}$ = 22.1 gallons per minute

= 1326 gallons per hour

= 31,824 gallons per day.

Length of Main = 14,463 feet.

Diameter of Main= 4in C.1. pipe = 4.02in internal diameter Head.

Level at inlet 210ft O.D. (approx).

Level at outlet 137ft O.D.

Difference 73 feet.

Hazen and Williams pipe flow formula

$$V = C.R.^{0.63}S^{0.54}0.001^{-0.04} = 1.318\ (D/4)^{0.63}(H/L)^{0.54}$$

Where V = mean velocity in feet per second

D = internal diameter of pipe in feet

$H/L = \frac{\text{head loss}}{\text{pipe length}}$ in same units

$$V = \frac{22.1 \text{ g.p.m.}}{6.25 \times 3.14 \times \frac{2^2}{1\overline{1}4} \times 60} = 0.675 \text{ feet per second}$$

$$H/L = \frac{73}{14,463} = 0.00505 \ \& \ D = 0.335 \text{ feet}$$

$$D/4 = 0.084 \text{ feet}$$

Substituting $0.675 = 1.318C \times 0.084^{0.63} \times 0.00505^{0.54}$

and $C = \frac{0.675}{1.318 \times 0.084^{0.63} \times 0.00505^{0.54}} = 40.29$

The normal value for C in a new cast-iron pipe is 125 which usually falls to 95 under ordinary conditions, 55 is considered to be a very rough pipe so that 40.29 is exceptionally rough and incrusted.

The discharge is only $\frac{40.29}{120} \times 100 = 33.5\%$ of what the pipe discharged when new.

APPENDIX NUMBER 8

DATA REGARDING THE PUMPS REQUIRED BY THE MANUFACTURERS FOR ESTIMATES AND ORDERS IN ACCORDANCE WITH BRITISH STANDARD SPECIFICATION NO 994: 1941.

1	Number of pumps required and destination	Two lowlift and Two highlift Port Stanley, Falkland Islands	
2	Height above mean sea level and maximum ambient temperature	24 feet and 70°F	
3	Discharge of each pump	100 gallons per minute	
4	Is the manufacturer at liberty to quote for the nearest standard pump for approximately this discharge?	Yes	
5	Character of Liquid	Fresh water	
6	If solid matter is contained, state maximum size of solids and their nature.	Peaty vegetable matter up to about 200 p.p.m. size 1.0 mm down	
7	Maximum temperature of liquid	65°F	
8	Specific gravity of Liquid at pumping temperature.	0.998	
9	Whether for continuous or intermittent operation	Continuous for periods up to ten hours	
		Low Lift	High Lift
10	Total Head from all causes - including pipe friction and suction head	33 feet	180 feet
11	Suction lift (if any) including pipe friction (included in 10).	8 feet	6 feet
12	Positive suction head (if any) (included in 10).	Nil	Nil
13	Amount of fluctuation (if any) in the suction head	from 8 feet to 3 feet	from 6 feet to 3 feet
13a	Amount of fluctuation (if any) in the delivery head	Nil	from 175 feet to 140 feet
14	State if pumps are required direct-coupled, geared, belt (flat or V) or rope driven	direct coupled	

15 State if prime mover is electric motor, petrol engine, diesel engine steam turbine, line shafting etc.	electric motors from diesel engine generators
16 If electric motor state whether	
AC or DC	AC
Voltage	230
if AC phase and cycles	3 phase 50 cycles.
17 If petrol or diesel engine state if any particular make of engine is necessary	No, but Lister preferred.
18 If prime mover is to be supplied by the purchaser, state the speed and direction of radiation.	Prime mover (ie diesel generators) electric motors, switchgear etc to be supplied by pump manufacturers.
19 What means are available for priming pump	Pump manufacturers to supply suction and delivery pipes and valves and provide priming by by-pass around reflux valves.

APPENDIX NUMBER 9

Examination of a sample of water taken from the Moody Brook, Falkland Islands, taken on 20th November 1952, and the results of coagulation and other tests

ANALYSIS

Appearance	'Peaty' yellow colour
Colour	80 Hazen units
Turbidity	less than 2 p p m* (Silica scale)
pH value	6.2
Total alkalinity to methyl orange (expressed as $CaCO_3$)	15 p p m
Total hardness (expressed as $CaCO_3$)	20 p p m
Calcium (expressed as Ca)	5 p p m
Iron in solution (expressed as Fe)	0.2p p m
Magnesium (expressed as Mg)	1.2p p m
Sodium (expressed as Na)	17 p p m
Chloride (expressed as Cl)	36 p p m
Sulphate (expressed as SO_4)	7 p p m
Total dissolved solids (dried at 180°C)	70 p p m

From the above it is seen that the water is very soft and contains a high amount of sodium and of chloride.

POSSIBLE METHOD OF TREATMENT

The usual way to remove peat colour is to coagulate by addition of suitable chemicals, preferably in conjunction with slow stirring, and, if necessary after sedimentation, to filter through sand or other suitable material.

* parts per million

Accordingly, laboratory-scale coagulation tests were made to find a good chemical treatment.

Somewhat similar peaty waters are treated in the North of England by coagulation and sand-filtration. As in the present case the waters are soft, and the pH value is often raised by addition of alkali, usually lime, to make the water less corrosive.

COAGULATION TESTS

The rate of stirring was 80 r p m for the first five minutes and 20 r p m for the next ten minutes.

The only coagulant tried was aluminoferric, at different pH values, quite good results being obtained in the pH value range of 5 to 7 for a dose of 40 parts per million aluminoferric. Sodium carbonate was added before the aluminoferric to obtain the various pH values. Results are given in detail in Table 1.

CHLORINE DEMANDS OF RAW AND TREATED WATERS

Chlorine demand tests were made on the raw water and on the same water after good coagulation with aluminoferric added after sodium carbonate. The coagulated sample was filtered before test. The results (Table 2) show that the water has only a low chlorine demand, especially after treatment. For the untreated water a dose of 0.5 p p m chlorine gave a residual of 0.1 p p m free chlorine after 15 minutes contact, and for the treated water a dose of 0.4 p p m chlorine gave a residual of 0.3 p p m free chlorine, after the same period of contact.

TABLE 1. The effects of coagulants on water from the Moody Brook

Coagulant and dose in p.p.m							Time required for floc to settle (min)	Appearance of water after settlement
Sodium Carbonate	Alumino-ferric	of raw water	after addition of coagulant	5 min	10 min	15 min		
Nil	20	6.5	4.8			0.1	20	Clear, colourless
4	20	6.5	5.1	0.1	0.1	0.2	15	Clear, colourless
8	20	6.3	5.4		0.1	0.1	15	Clear, colourless
16	26	6.6	6.4			minute	15	Slightly coloured
15	20	6.4	6.6			No floc		
14	30	6.3	6.6	0.1	0.1	0.2	6	Clear, colourless
Nil	40	6.4	4.6			0.1	30	Slightly coloured
18	40	6.2	6.4	0.1	0.1	0.2	5	Clear, colourless
21	40	6.5	7.1	0.1	0.2	0.2	5	Clear, colourless
70	80	6.5	7.0	0.1	0.2	0.2	5	Clear, colourless

Adjustment of pH value to make treated water less corrosive

A portion of the sample was well coagulated by adding 14 p.p.m sodium carbonate (expressed as Na_2CO_3) followed by 30 p.p.m aluminoferric and stirring. After filtering through filter paper a further 15 p.p.m sodium carbonate was added: this raised the pH value to 8.6.

The sample was next allowed to stand for 18 hours in a closed bottle after which time the pH value had fallen to 7.6. On shaking with A. R. calcium carbonate the pH value increased to 8.1 indicating that calcium carbonate had been dissolved and that the treated water would not have deposited a protective scale of this salt. This test gives no indication, of course, as to whether corrosion of metal would occur at a serious rate but points to the need for tests that will measure the actual corrosion of metals that it is proposed to use for pipes.

TABLE 2 Chlorine demand of untreated and treated water from the Moody Brook

Chlorine added (p p m Cl)	Residual chlorine after 15 min (as p p m Cl)	
	Chlorine	Chloramines
Untreated water		
0.20	0.0	0.0
0.40	0.0	0.0
0.50	0.1	0.1
0.70	0.2	0.3
Freshly treated sample		
0.20	0.0	0.0
0.40	0.3	0.0
Treated sample after standing in the laboratory for several days		
0.20	0.0	0.0
0.30	0.1	

CONCLUSIONS

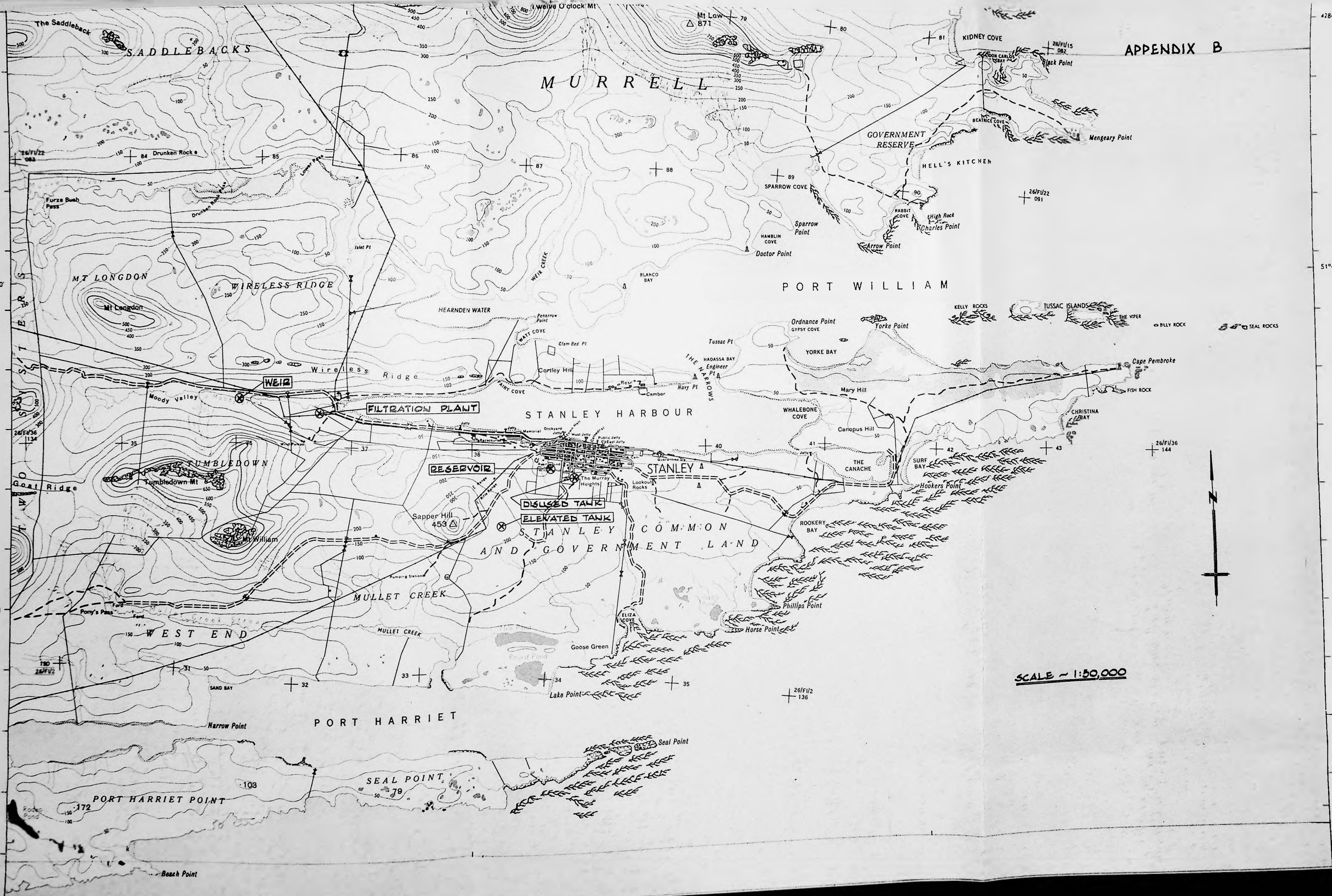
So far as can be judged from a single sample the proposed source of water, the Moody Brook, will give a clear colourless supply after coagulation with aluminoferric, provided that sodium carbonate is also added to keep the pH value within the optimum range.

As it seems likely the treated water will be corrosive it will be desirable to add an alkali to raise its pH value before distribution. Lime would be best but we understand that it may be necessary to use sodium carbonate instead.

It is recommended that samples should be taken at all seasons of the year for tests of the nature described in this report, and that metal corrosion tests on treated water should be undertaken at the Falkland Islands. It would be difficult to make metal corrosion tests elsewhere since a supply of running water is required.

(End of Pape Report)

APPENDIX B



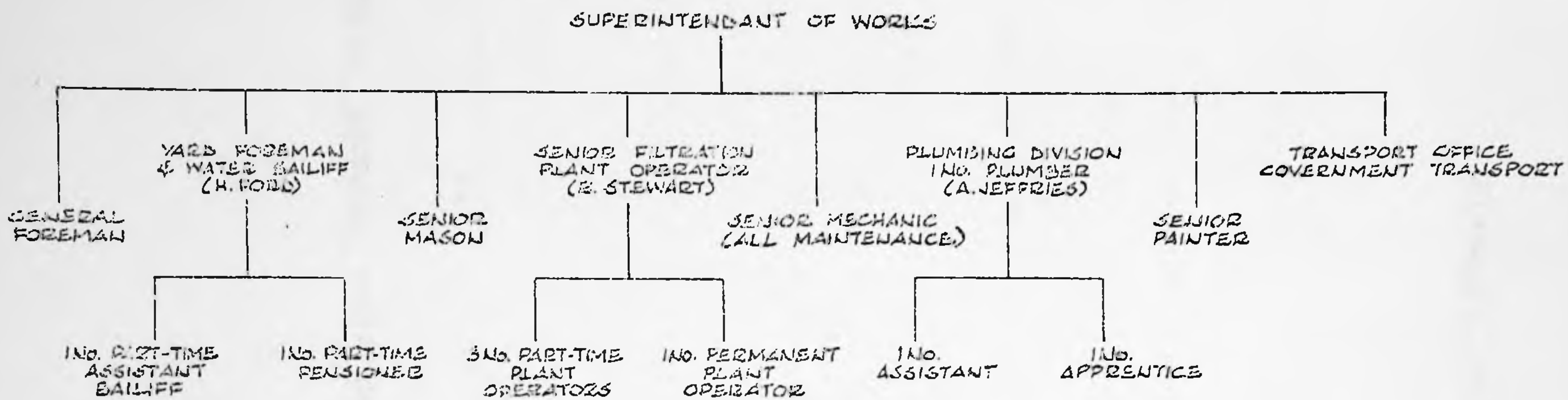
The Saddleback
SADDLEBACKS
MURRELL
Mt Low
871
KIDNEY COVE
Black Point
GOVERNMENT RESERVE
HELL'S KITCHEN
Mengeary Point
Drunken Rock
Furze Bush Pass
SPARROW COVE
RABBIT COVE
High Rock
Charles Point
Arrow Point
Sparrow Point
HAMBLIN COVE
Doctor Point
Islet Pt
MT LONGDON
Mt Longdon
WIRELESS RIDGE
WEIR CREEK
BLANCO BAY
PORT WILLIAM
HEARNDEN WATER
KELLY ROCKS
TUSSAC ISLANDS
THE VIPER
BILLY ROCK
SEAL ROCKS
Ordnance Point
GYPSY COVE
Yorke Point
WATT COVE
Clam Bed Pt
Tussac Pt
YORKE BAY
Cape Pembroke
HADASSA BAY
Engineer Pt
THE NARROWS
Navy Pt
Cortley Hill
Camber
Wireless Ridge
WEIR
Moody Valley
FAIRY COVE
FILTRATION PLANT
STANLEY HARBOUR
Mary Hill
FISH ROCK
WHALEBONE COVE
Canopus Hill
CHRISTINA BAY
THE CANACHE
SURF BAY
Hookers Point
TUMBLEDOWN
Tumbledown Mt
Goat Ridge
RESERVOIR
STANLEY
The Murray Heights
Lookout Rocks
DISUSED TANK
ELEVATED TANK
Sapper Hill
453
STANLEY COMMON
AND GOVERNMENT LAND
ROOKERY BAY
Mt William
Pumping Station
MULLET CREEK
Pony's Pass
WEST END
ELIZA COVE
Phillips Point
Horse Point
Goose Green
SAND BAY
Lake Point
PORT HARRIET
Narrow Point
Seal Point
SEAL POINT
PORT HARRIET POINT
Beach Point
SCALE ~ 1:50,000
N
51°40'
51°45'
4270000N
4280000N


APPENDIX C.
ELEVATION ON A-A
ELEVATION ON B-B
PLAN
A
A
B
B
GENERAL ARRANGEMENT
OF
PATERSON WATER TREATMENT PLANT
FOR
FALKLAND ISLANDS WATER SUPPLY
PORT STANLEY.
THE PATERSON ENGINEERING CO. LTD
WINDSOR HOUSE KINGSWAY LONDON. W.C.2
SCALE
DRG Nº 93151/B
REF Nº 4061
DATE
INITIALS

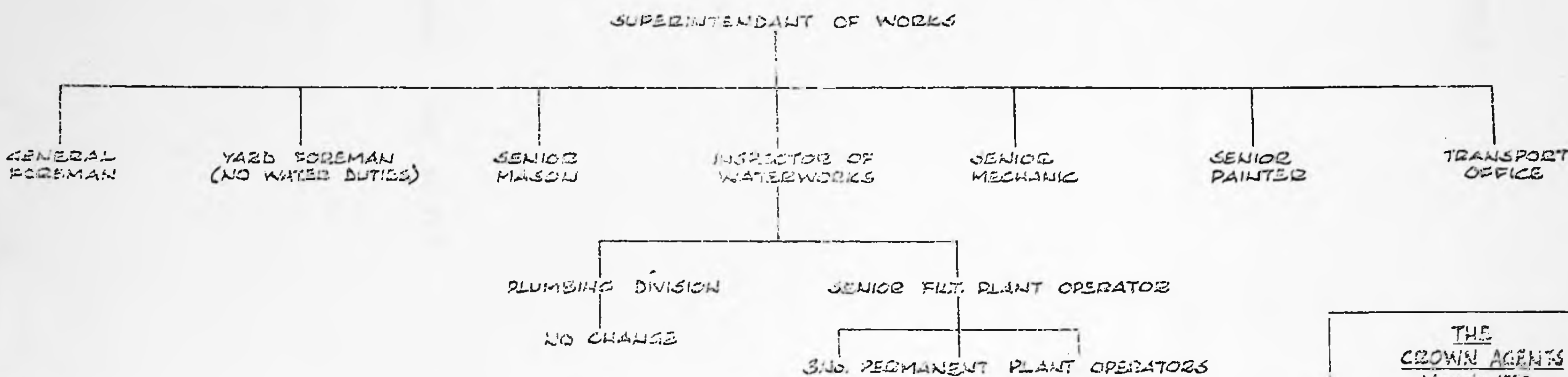

FALKLAND ISLANDS
STANLEY WATER SUPPLY – RETICULATION
DAVIS STREET
CALLAGHAN ROAD
ROSS ROAD
ROSS RD WEST
ST MARY'S WALK
RACE COURSE
CEMETERY
PUBLIC JETTY
HYDRANTS

STANLEY WATER SUPPLY

EXISTING ORGANIZATIONAL CHART OF PUBLIC WORKS DEPARTMENT

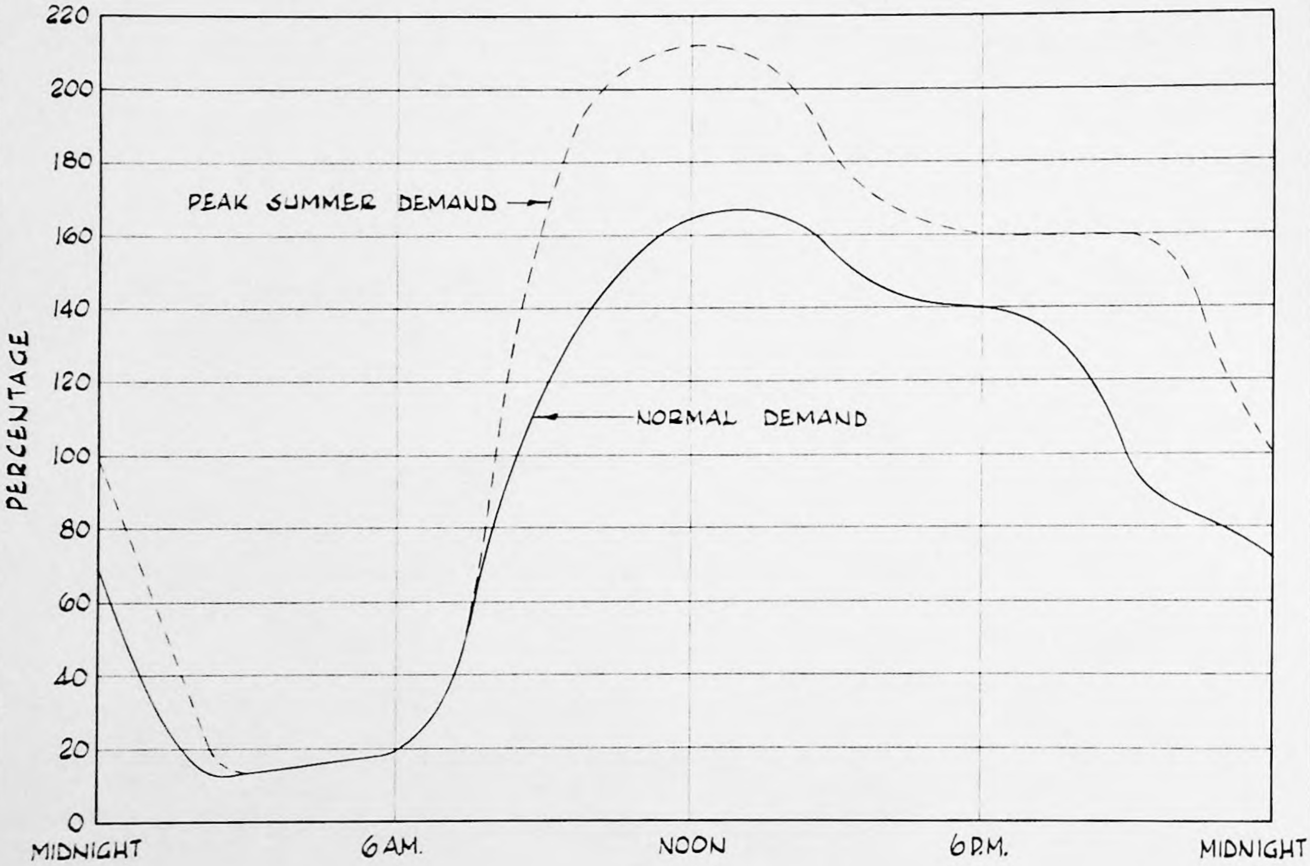


PROPOSED ORGANIZATIONAL CHART OF PUBLIC WORKS DEPARTMENT



THE CROWN AGENTS
March 1972

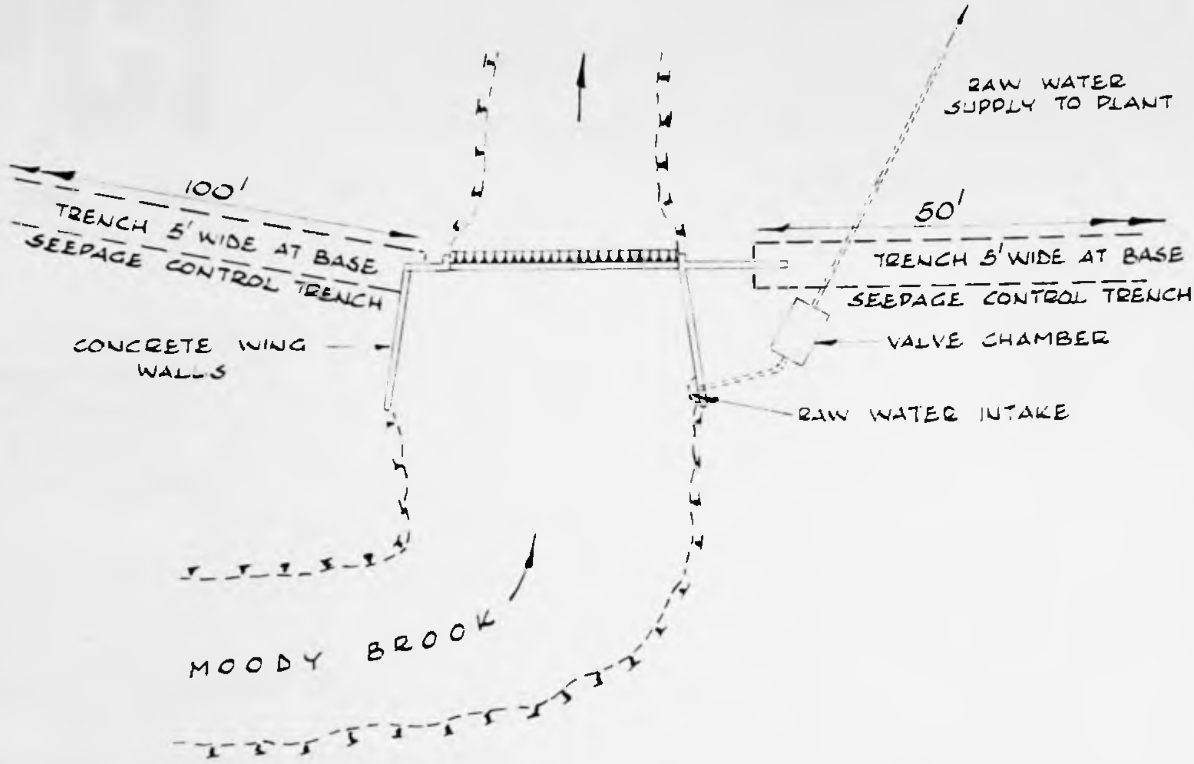
STANLEY WATER SUPPLY



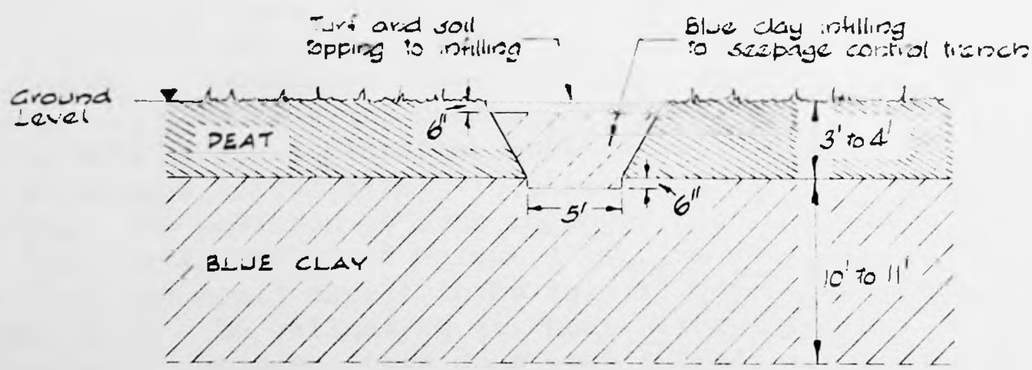
TYPICAL DIURNAL VARIATION IN DEMAND FOR WATER

THE
CROWN AGENTS
March 1972

STANLEY WATER SUPPLY



SITE PLAN OF WEIR AT INTAKE



CROSS SECTION OF PROPOSED SEEPAGE CONTROL TRENCH

NOTES

1. Excavate the trench, in lengths of not more than 20 feet, to a depth of 6" into the blue clay and remove all excavated material from the immediate vicinity.
2. Remove any large stones or boulders extruding from the bottom of trench.
3. Refill trench with clean blue clay, to depth of 6" below ground level, in layers not exceeding 6" thick, treading each layer well in to remove all voids. Any large stone must be removed from the clay before placing in the trench.
4. Fill the remaining 6" of the trench with soil and turf (not peat) all as shown in the above plan and cross-section.
5. Excavation nearer than 5' to the wing-wall structure must be done by hand, not by mechanical excavator.

THE CROWN AGENTS
March 1972

APPENDIX H

Paterson Candy International Limited
21 The Mall
Ealing London W5 2PU
Telephone: 01-579 1311
Telegrams: Clarify London W5
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 s~~ettlement~~ 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,

D.W. DUFOUR

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.L.

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

CHEMICAL DOSES (mgs per litre) ADDED IN ORDER REPORTED	FLOC SIZES (mm's) AFTER STIRRING FOR 20 MINUTES	SETTLEMENT	SLUDGE % v/v	BEFORE Filtration		AFTER FILTRATION	
				pH	pHs	COLOUR °HAZEN	OTHER TESTS
1) 30 Alumino-ferric) 22 Hydrated Lime)	0.75 - 1.0	Poor	-	6.3	-	3	Res.Al. 0.1 mg/1
2) 40 Alumino-ferric) 26 Hydrated Lime)	0.75 - 1.0	Poor	-	6.1	-	3	Res.Al. 0.05 mg/1
3) 60 Alumino-ferric) 30 Hydrated Lime)	0.75 - 1.0	Poor	-	6.1	-	3	Res.Al. 0.06 mg/1
4) 40 Alumino-ferric) 26 Hydrated Lime) 0.2 Magnafloc L.T.24.)	1.0 - 1.5	6.5'/hr.	1.5	6.1	-	3	Res.Al. 0.05 mg/1
5) 40 Alumino-ferric) 26 Hydrated Lime) 0.2 Wisprofloc 20)	0.75 - 1.0	Poor	-	6.1	-	3	Res.Al. 0.06 mg/1
6) 40 Alumino-ferric) 26 Hydrated Lime) 0.5 Welgum S)	1.0 - 1.5	7'/hr.	-	6.1	-	3	Res.Al. 0.05 mg/1
7) 40 Alumino-ferric) 26 Hydrated Lime) 10 Fulbent 570)	0.75 - 1.0	5'/hr.	-	6.1	-	3	Res.Al. 0.06 mg/1
8) 40 Alumino-ferric) 26 Hydrated Lime) 0.5 Magnafloc L.T.24)	1.5 - 2.25	13'/hr.	-	6.1	8.1	3	Res.Al. 0.05 mg/1
	11 mg/1 Hydrated Lime raised the pH value to 8.1						

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.

DIVERSION OF THE FLOW FROM THE MOUNT WILLIAM CATCHMENT INTO THE MOODY BROOK

It is reported that during the November 1970 drought, only a very small quantity of water from the Mount William catchment flowed down the stream bed from the stone run. During normal periods throughout the year, this flow is considerable. In dry or drought periods, most of the flow disappears into the stone run. It is necessary therefore to establish how much can be recovered from underground during periods when it may be necessary to supplement the Moody Brook as a source of raw water. It is recommended that the following method, which is the least expensive, be adopted: With a mechanical excavator, excavate a trench about 5 feet wide, 50 feet long about half-way up the stone run. The trench should be excavated down to bedrock, and should be left open until the next dry period when an estimate of the quantity of water passing through can be assessed. The trench can then be used as a pump-sump or depending on levels, the water, if in useful quantity, can be piped to the intake or low lift pump sump. The excavation should be fenced off. If the quantity of water available during a dry period proves to be worth-while, then measures can be taken to bring it into permanent use. This operation need not be put into effect until July 1972.

APPENDIX J.

Kent Meters Limited
incorporating The Leeds Meter Company Limited
Pondwicks Road Luton Bedfordshire England LU1 3LJ
Telephone Luton 31100 Cables Kentmeters Luton Telex 825367

your reference
our reference PK/MRC 71E10639

25th February 1972

The Crown Agents,
'Q' Department,
4 Millbank,
LONDON, S.W.1.

For the attention of Mr. M.J.P.Casserly

Dear Sirs,

Proposed Metering Project -
Falkland Islands

We have pleasure in confirming the recent telephone conversation between Mr.Casserly and the writer regarding the above mentioned requirement, which, we understand, may amount to approximately 500 meters in the domestic sizes.

It was also understood that the Authority concerned may wish to set up facilities for meter maintenance, including provision for testing.

During our conversation we confirmed that we were able to supply both flow and pressure testing equipment.

Dealing first with the former requirement, enclosed is a copy of our illustration showing the standard type of meter testing plant,complete with bench,which will take up to 6 - 1/2" meters at a time, as well as being suitable for testing 3/4" and 1" meters, also 1,1/2" meters of the flanged pattern.

For pressure testing we can recommend the type of rig shown on the enclosed Publication No. PT1-11-72, this being manufactured by our Associate Company in Malaysia.

We could, of course, also supply the necessary key tools for dismantling PSM type meters, as well as sealing wire, seals and sealing pliers.

In response to Mr.Casserly's request for details of a repair-shop layout, we have pleasure in enclosing a diagrammatic plan showing various items for which provision should be made, as well as their possible location. We have not attempted to give specific dimensions as the repair-shop may

-continued-

Pressure Test Rigs as illustrated and described on Leaflet No. PT1-11-72

PRICE: ....£25.00 each

The prices quoted are net, including export packing and delivery FOB U.K. Port.

With regard to delivery, we anticipate that we could despatch all items, ex works, in 6-8 weeks from date of receipt of order with the possible exception of the pressure test rig which would need to be obtained from Malaysia and might take a little longer

Yours faithfully,
for KENT METERS LTD

P Knellet

P.KNELLER
Contracts Manager, Export

possibly be conveniently situated in some existing room or floor area and the positions of items could, of course, be arranged to suit the local physical conditions.

We also take the opportunity of enclosing two copies of our latest publication dealing with the PSM type meter and our quotation for these, together with the other items mentioned, is confirmed below.

1/2" PSM rotary piston type cold water meters with fully sealed straight reading counters registering in Imperial gallons or, alternatively, in m3 and litres as may be specified on ordering. Complete with connections for iron pipe threaded 1/2" BSP male. Non-return valves and return flow strainers not included

PRICE: ....£4.10 each

3/4" -ditto-

PRICE: ....£5.40 each

1" -ditto-

PRICE: ....£8.75 each

One - Water meter flow-testing plant complete comprising test bench, 100 gallon tank, stand and overhead tank complete with interconnecting pipework to the bench. Also complete with connection pieces for testing 1/2", 3/4" and 1" meters

PRICE: ....£600.00 each

Key tools, Part No. 2MMT 150 for use with 1/2" and 3/4" PSM meters

PRICE: .... £2.50 each

Key tools, Part No. MMT 157 for use with 1" PSM meters

PRICE: .... £3.40 each

Sealing wire for use with PSM type meters in all sizes

PRICE PER 1000ft LENGTH: £2.94

Lead seals

PRICE PER 1000: £0.49

Sealing pliers

PRICE PER PAIR: £2.96

-continued-

Pressure Test Rigs as illustrated and described on Leaflet No. PT1-11-72

PRICE: ....£25.00 each

The prices quoted are net, including export packing and delivery FOB U.K. Port.

With regard to delivery, we anticipate that we could despatch all items, ex works, in 6-8 weeks from date of receipt of order with the possible exception of the pressure test rig which would need to be obtained from Malaysia and might take a little longer

Yours faithfully,
for KENT METERS LTD

P. Kneller

P.KNELLER
Contracts Manager, Export

Kent PSM Water Meter

A semi-positive rotary piston water meter to provide maximum accuracy and reliability when installed in any position.

Sizes mm:	*12-15*	*20*	*25*	*30*
in:	*½*	*¾*	*1*	*1¼*

The PSM, designed for the measurement of potable water, has a specially developed thermoplastic working chamber to ensure an exceptionally long working life. It is also highly resistant to chemically aggressive water whilst still retaining its high accuracy and reliability.

Each PSM is individually tested over its flow range before desptach and may be installed in horizontal, vertical or inclined pipelines without affecting accuracy.

Over 2,000,000 PSM water meters are now in service throughout the world.

Standard Features

Simple construction – enables speedy replacement of all internal components.

Semi-positive rotary piston of latest design ensures maximum accuracy at all flow rates.

Tamper proof, liquid-filled sealed counter unit ensures good readability under all conditions.

No separate gear train.

Pressure difference across the sealed counter unit is eliminated by means of an automatic compensating device.

Body lengths are available to meet most international standards.

Counters and working chambers interchangeable between 12-15 mm (½ in) and 20 mm (¾ in) meters.

Available with counters registering in litres and cubic metres (m^3), Imperial gallons, U.S. gallons or cubic feet.

Optional Features

Disc-type non-return valve.

Frost protection device.

Connectors normally supplied with tailpieces threaded BSP, but other international threads available.

Connectors for lead, copper and polythene pipes are also available.

Remote read-out systems which can also be used with existing meters.

PERFORMANCE

Size of meter		12 mm ($\frac{1}{2}$ in) 114 mm ($4\frac{1}{2}$ in) body length	12 mm ($\frac{1}{2}$ in) 134 mm ($5\frac{1}{4}$ in) body length	20 mm ($\frac{3}{4}$ in) 165 mm ($6\frac{1}{2}$ in) body length	25 mm (1 in) 198 mm ($7\frac{13}{16}$ in) body length	30 mm ($1\frac{1}{4}$ in) 198 mm ($7\frac{13}{16}$ in) body length
Starts to register at about	l/h	3,4	3,4	3,4	5,7	13,6
	gal/h	0.75	0.75	0.75	1.25	3
Capacity at 3 m (10 ft) w.g. head loss	m^3/h	1,95	2,5	2,77	4,1	5,8
	gal/h	430	550	610	910	1300
Capacity at 10 m (33 ft) w.g. head loss	m^3/h	3,5	4,5	5,0	7,5	11
	gal/h	780	1000	1100	1650	2400
Maximum recommended continuous flow	m^3/h	2,73	2,73	2,95	4,55	6,8
	gal/h	600	600	650	1000	1500
Minimum accurate registration ±2%	l/h	22,7	22,7	22,7	31,8	68,1
	gal/h	5	5	5	7	15
Meter resets to zero at	m^3	10000	10000	10000	100000	100000
	gal	1000000	1000000	1000000	10000000	100000000

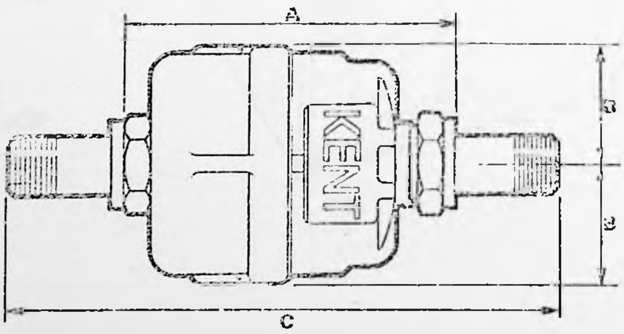
On metric counters black numbers denote cubic metres, red numbers denote litres. On gallons counters black numbers show thousands of gallons and red numbers indicate quantities below one thousand gallons.

DIMENSIONS						
A.	mm	114	134	165	198	198
	in	$4\frac{1}{2}$	$5\frac{1}{4}$	$6\frac{1}{2}$	$7\frac{13}{16}$	$7\frac{13}{16}$
B.	mm	43	43	43	52	60
	in	$1\frac{11}{16}$	$1\frac{11}{16}$	$1\frac{11}{16}$	$2\frac{1}{16}$	$2\frac{3}{8}$
Length over connectors	mm	200	228	267	311	327
	in	$7\frac{7}{8}$	9	$10\frac{1}{2}$	$12\frac{1}{4}$	$12\frac{7}{8}$
NET WEIGHTS						
Meter only	kg	1,02	1,08	1,27	2,83	3,57
	lb	2.24	2.38	2.81	6.25	7.88
Meters with connectors	kg	1,24	1,31	1,66	3,46	4,48
	lb	2.74	2.88	3.66	7.63	9.88
SHIPPING SPECIFICATION						
Number of meters per case		50	50	50	50	50
Net weight	kg	61,1	64,3	82,0	154	224,1
	lb	137	144	183	350	494
Gross weight packed for shipment	kg	68,4	71,6	91,5	181	265
	lb	153	160	204	400	584
Bulk packed for shipment	m^3	0,07	0,08	0,10	0,28	0,36
	ft^3	2.5	2.7	3.4	10.0	12.6

The following information is common to all sizes of PSM:

Test pressure 21 kg/cm^2 (300 lb/sq in).

Suitable for water temperature up to 50 °C (120 °F).



MATERIALS

All Kent Meters are manufactured from highest quality materials ensuring maximum resistance to wear and corrosion.

Certain parts of this meter are patented in the U.K. and other countries.

A comprehensive Technical Manual is available.

Kent Meters Limited

incorporating The Leeds Meter Company Limited

the GEORGE KENT group

Pondwicks Road Luton
Bedfordshire England LU1 3LJ
Telephone Luton 31100 Telex 825367
Cables Kentmeters Luton

Printed in England.

PT1-11-72

Kent PT1 Pressure Test Rig

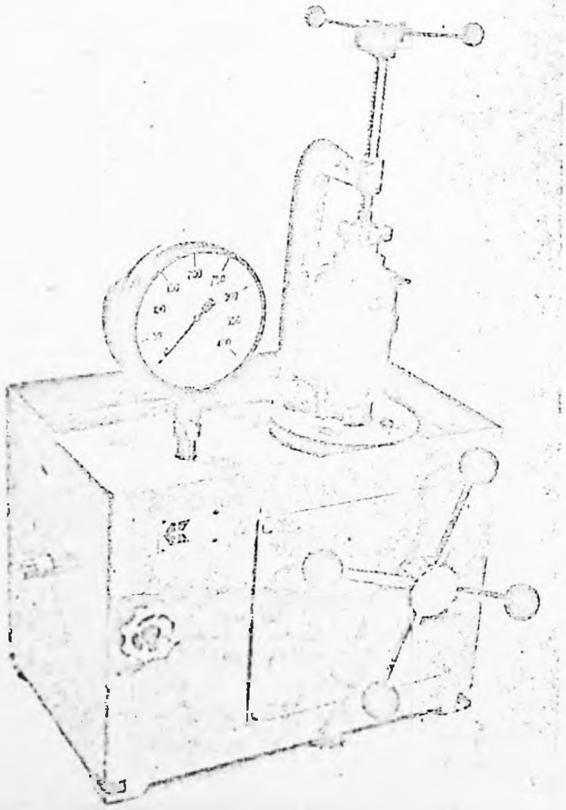
A simple rig for pressure testing of water meters.

The Model PT1 is designed to meet the requirement of the small and medium size of water meter repair workshop for pressure testing of the J.S.M. and P.S.M. range of meters after repair.

The rig has been designed for simplicity and reliability of operation. It is capable of developing pressures up to 350 psi and is complete with adaptors to suit ½ in. (12 - 15 mm), ¾ in. (20 mm), 1 in. (25 mm) and 1¼ in. (30 mm) J.S.M. and P.S.M. meters.

Installation is simple all that is required is a firm bench to which the rig should be bolted and a water supply.

On application adaptors can be made available to suit other manufacturers range of meters.



Technical Specification

Maximum obtainable test pressure 350 psi (25 Kg/cm^2)

Minimum water input pressure 3 psi (0.2 Kg/cm^2)

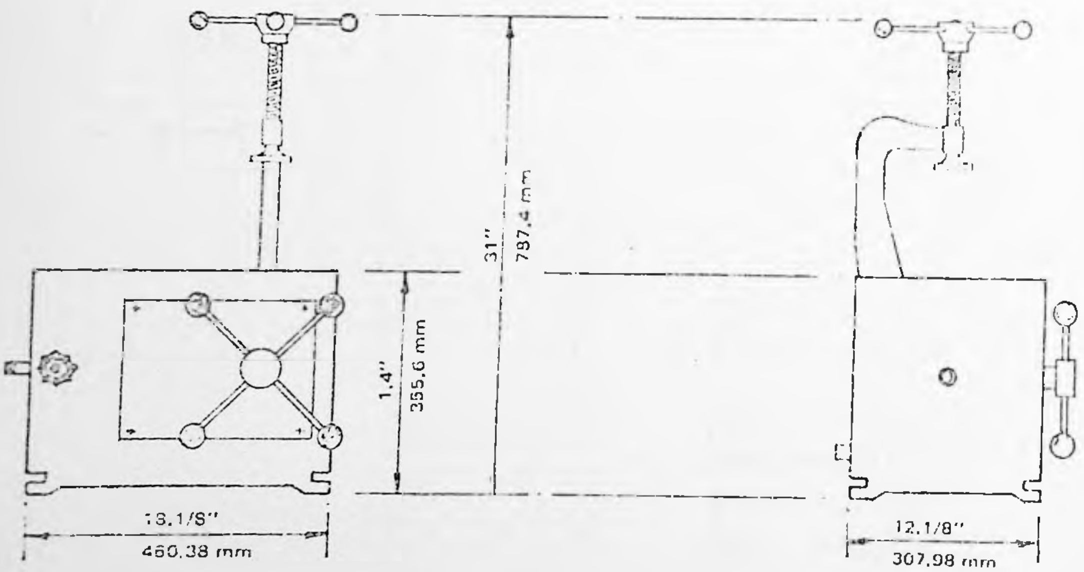
Water connection ½" BSP

Finish: Hammer Grey Case

Tray: Epoxy coated

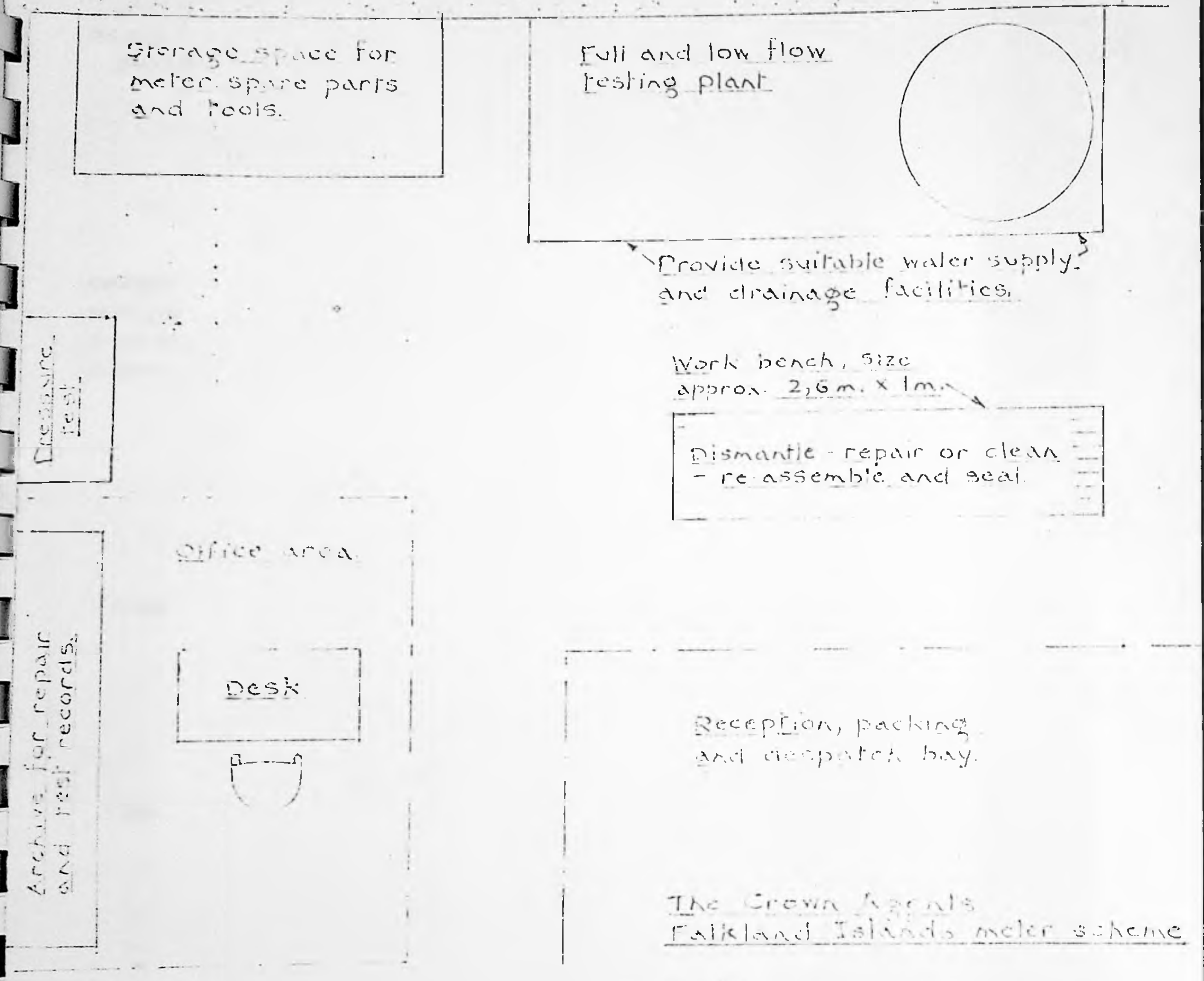
Nett weight: 89 lbs.

Gross weight packed for shipment 125 lbs.



Continuous development may necessitate change in these details without notice.

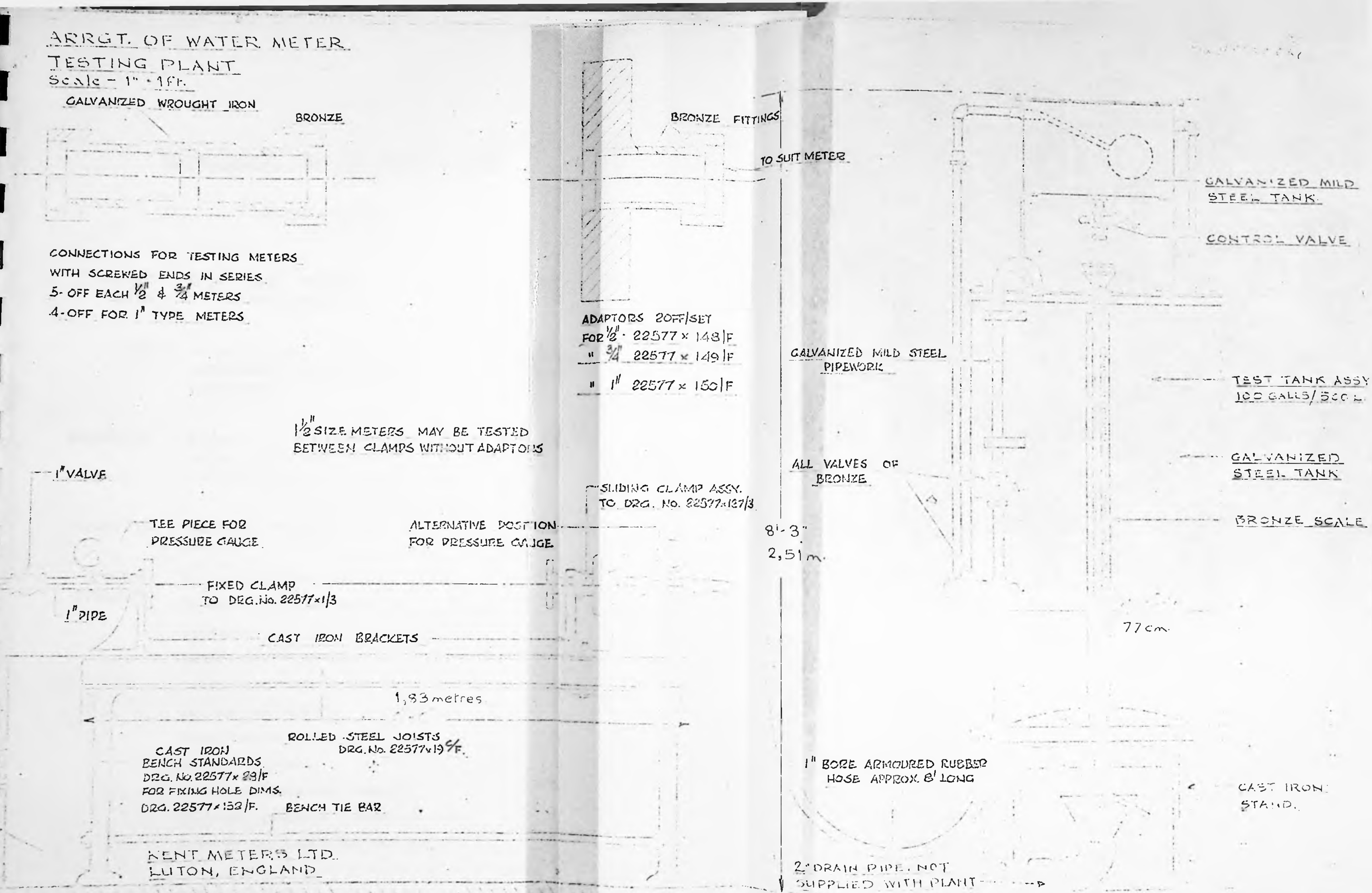
George Kent (Malaysia) Berhad
(Incorporated in the States of Malaya)
P.O. Box 1100, Jalan Semangat
Petaling Jaya, Malaysia
Telephone Kuala Lumpur 53571/2/3/4/5
Cables Kentmeters Petaling Jaya Telex KLTX 365



DIAGRAMMATIC LAYOUT OF PROPOSED METER SERVICING WORK-SHOP

Not to scale.

Kent Meters Ltd.
Luton, England.


ARRGT. OF WATER METER
TESTING PLANT
Scale – 1" = 1 Ft.
GALVANIZED WROUGHT IRON
BRONZE
CONNECTIONS FOR TESTING METERS
WITH SCREWED ENDS IN SERIES
5-OFF EACH ½" & ¾" METERS
4-OFF FOR 1" TYPE METERS
BRONZE FITTINGS
TO SUIT METER
ADAPTORS 2OFF/SET
FOR ½" 22577 × 148/F
" ¾" 22577 × 149/F
" 1" 22577 × 150/F
1½" SIZE METERS MAY BE TESTED
BETWEEN CLAMPS WITHOUT ADAPTORS
1" VALVE
TEE PIECE FOR
PRESSURE GAUGE
ALTERNATIVE POSITION
FOR PRESSURE GAUGE
SLIDING CLAMP ASSY.
TO DRG. No. 22577×137/3
FIXED CLAMP
TO DRG. No. 22577×1/3
1" PIPE
CAST IRON BRACKETS
1,83 metres
ROLLED STEEL JOISTS
DRG. No. 22577×19 C/F.
CAST IRON
BENCH STANDARDS
DRG. No. 22577×28/F
FOR FIXING HOLE DIMS.
DRG. 22577×152/F.
BENCH TIE BAR
KENT METERS LTD.
LUTON, ENGLAND
GALVANIZED MILD STEEL TANK
CONTROL VALVE
GALVANIZED MILD STEEL
PIPEWORK
TEST TANK ASSY
100 GALLS/500 L
ALL VALVES OF
BRONZE
GALVANIZED
STEEL TANK
BRONZE SCALE
8'-3"
2,51 m.
77 cm.
1" BORE ARMOURED RUBBER
HOSE APPROX. 8' LONG
CAST IRON
STAND.
2" DRAIN PIPE, NOT
SUPPLIED WITH PLANT

WATER SUPPLY INDUSTRY TRAINING BOARD

Outline Syllabus

COURSE TITLE: 0.30 WATER TREATMENT AND FILTRATION OPERATIONS - (Refresher).

AIM: To reinforce the existing skills and knowledge of experienced filter plant and treatment plant attendants.

SELECTION: Experienced attendants who have acquired the basic skills and knowledge of filtration and treatment plant operations.

DURATION: One week, mid-day Monday to mid-day Friday.

OUTLINE SYLLABUS:

History and background.

Valves and valve operation.

Physical measurement techniques.

Definition of terms.

Filtration techniques.

Safety and health.

Chlorination techniques.

Fault analysis.

Water turbines and pumping.

Pressure gauges and flow recorders.

Records and recording systems.

APPLICATIONS FOR PLACES: All applications to be made on Form T.3. and submitted to: The Administrative Officer, Water Supply Industry Training Board, Tadley Court, Tadley Common Road, Tadley, Nr. Basingstoke, Hants.

WATER SUPPLY INDUSTRY TRAINING BOARD.

Outline Syllabus

COURSE TITLE: 0.44 WATER TREATMENT AND FILTRATION OPERATIONS.
B.1 - RAPID GRAVITY FILTERS.

AIM: To give instruction in the operation and use of gravity filters.

SELECTION: A basic course for all operators engaged on filtration and treatment work of the rapid gravity type.

DURATION: One week, mid-day Monday to mid-day Friday.

OUTLINE SYLLABUS:
Basic Chemistry of Water Treatment.
Purpose and Description of Rapid Gravity Filters.
Operation of Sedimentation Plant.
Operation of Rapid Gravity Filters.
Sludge Disposal.
Emergency Action.
Safety Practices.
Fault Analysis.
Records and Testing.

APPLICATIONS FOR PLACES: All applications to be made on Form T.3 and submitted to: The Administrative Officer, Water Supply Industry Training Board, Tadley Court, Tadley Common Road, Nr. Basingstoke, Hants.

I/June 1970