from 12 per cent. with scale 1/16in. thick, to 90 per cent. with ¾in. of scale on the inside of a boiler. This scale is objectionable also on account of the reduction of life in the boiler due to the overheating of the plates, caused by the insulation placed between the water and the boiler shell.

The principal impurities in hard water are carbonates and sulphates of lime and magnesia. For the removal of the former, a process was invented many years ago by Dr. Clark, which consists in the addition of lime, whereby the lime in solution, which exists in the form of a bicarbonate, is precipitated.

For the removal of the sulphates the Porter process is used, which consists in the addition of soda ash.

The Railway Department has installed several Water Softeners of the "Desrumaux" type in connection with locomotive supplies, and there is also a softener of the same type used at the Aberdeen Meat Works, but up to the present there is no softener in use in connection with the Water Supply for any of the Country Towns in this State.

In the case of the Singleton water no analysis of the water from the Pump Well was available at the time when the Water Softener was ordered, as the Well had not then been sunk, but samples of water were analysed from an adjacent source, the results of which are given in Appendix B.

Based upon this information, tenders were invited by Mr. J. Davis, M. Inst. C.E., Consulting Engineer for New South Wales, London, for a Water Softener, capable of dealing with 30,000 gallons per hour. Six tenders were received, and that of the Kennicott Water Softening Company, London, was accepted, at £1700, f.o.b., London, for a plant complete, 25ft. diameter, 35ft. high, of the cylindrical type, fitted with special devices for mixing and adding the lime and soda ash required. The erection of this plant, including the concrete foundations, has been undertaken by Day Labour, and is now nearly complete. The total cost, including freight, duty, foundations and erection complete, is estimated at about £3200. Although part of the original scheme, the inclusion of the Water Softener was not agreed to by the Council until somewhat late in the day, so that the results of working are not yet available.

Based upon the information given in the analysis referred to, the Kennicott Company estimated the amount of lime and soda ash required to soften 1000 gallons, as 2.64lb. of lime, and 1.06lb. of soda.

Allowing for softening an average of 177,000 gallons per day, and taking lime at £2 2s., and soda ash at £8 8s. 6d. per ton delivered at site, the cost of these reagents has been estimated at £417 per annum. Subsequent analyses, however, have shown that the water derived from the Pump Well itself is not so hard as that for which the original analysis was made (see Appendix B) and a considerable reduction in the cost of the reagents will probably be made.

For the storage of the lime and soda ash a shed is being provided near the Softener.

SERVICE RESERVOIR.

This is 75 feet inside diameter, 14ft. 6in. deep to top water level, 400,000 gallons capacity, of the excavated type. The rock was first excavated and the sides and bottom lined with concrete 18in. thick. Above the rock the walls of the reservoir are constructed of concrete, with 1 to 3 back slope, as shown. The 8in. inlet pipe is brought in at about the level of the top of the concrete wall (Plate 3), and the water is drawn off through a cast iron pipe 6in. diameter. The bottom of the reservoir is graded into a dump, from which leads a scour pipe 6in. diameter for cleaning purposes, and a 4in. overflow pipe has also been provided. For indicating to the engine-driver at the Pumping Station the height of water in the reservoir, a signal column has been fixed, with a ball 2ft. 6in. diameter, operated by means of a float.

The concrete was mixed in the proportion of 15 cub. feet bluestone to 7½ cub. feet sand, to one cask or 3 bags, or 375lb. of cement.

The concrete walls were carried up in four lifts. The framing consisted of 4in. x 1in. t. and g. Kauri boards, fixed to 6in. x 2in. moulding boards, cut to the curve, and held in position by 6in. x 4in. hardwood verticals. These were held in place by 1in. bolts with a nut at each end let 8 inches into the concrete, and strutted from the floor. When it was desired to lift the framing the bolts were unscrewed, and the nuts left in the wall, the holes being filled in with stiff cement grout.

Upon completion the walls and bottom were treated with two coats of cement wash, laid on with stiff brushes.

SERVICE MAIN.

This is of cast iron, 6in. diameter, about 6500 feet long to the commencement of the reticulation, where the head, with reservoir full, is about 194 feet.

The capacity (Q) of the main at this point, allowing for a co-efficient (N) of .013, as calculated by Kutter's formula, is as under:—

$$Q = AC\sqrt{RS}$$

where

$$C = \frac{\frac{1 \cdot 811}{n} + 41 \cdot 65 + \frac{\cdot 00281}{S}}{1 + \frac{n\left(41 \cdot 65 + \frac{\cdot 00281}{S}\right)}{\sqrt{R}}} = 70$$

A = Area of pipe = ·196.
R = Hydraulic mean depth of pipe = ·125.
S = Sine of Slope = $\frac{194}{6500}$
Velocity = $C\sqrt{RS}$ = 4·28.
Therefore Q = 18,900 gallons per hour.

For a comparison of pipe discharges calculated by various formulae, Members are referred to an excellent paper entitled "The Flow of Water in Long Pipes," by G. M. Lawford, M. Inst. C.E., in Proc. Inst. C.E., Vol. 153. The discharge calculated by Kutter's formula is less than that estimated by some of the other formulas, and is on the conservative side when the pipes are new and clean.

RETICULATION.

Including the Service main, the Scheme as originally completed covered the following service and reticulation mains:—6 in. diameter, 229 1-3 chains; 4in. diameter, 304 2-3 chains; 3in. diameter, 331 1-3 chains. The pipes used are all of cast iron, with stop valves at intersections of streets, and hydrants spaced about 3 chains apart. The stop valves and hydrants are fitted with cast iron surface boxes set in concrete blocks, which were moulded round them and rest upon rubble supports.

A minimum cover of 18 inches has been provided over the pipes, increased somewhat in the vicinity of the valves and hydrants, which are set deeper in order to give the necessary clearance.

The pipes were jointed in the usual manner, as follows:—A ring of plain gasket was first forced to the bottom of the socket, after which tarred gasket was tightly caulked in, so as to leave a minimum depth of 1⅞in. of lead. After this had been run in, each joint was caulked with suitable tools, and the trenches filled in. As is customary the refilled material stood at first about 9 inches above the surface of the streets, but in a few months the trenches settled down to their original level, or in some cases, slightly below.

The reticulation pipes were laid down the centres of the streets in order that the house connections on either side might be of equal length. Where, however, only one side of a street is to be served it is preferable to keep the pipes to one side in order to avoid interference with the crown of the road.

Since the Water Supply was handed over to the Singleton Council many house connections have been made, and the scheme has proved so successful that at the Council's request a Contract has been recently let for reticulation extensions, estimated to cost about £1750.

The rates paid for the supply on trucks, Sydney, of the reticulation pipes, was £8 6s. per ton for 6in., and £7 17s. and £7 19s. per ton for 4in. and 3in. pipes respectively. For excavating trenches and laying and jointing, including supply of lead and gasket, the Contract rates were 1/6 and 1/4 and 1/2 per lineal yard respectively.

The total cost of the Scheme as handed over to the Singleton Council on 10th August, 1910, was £17,857 1s. This is exclusive of the cost of the Water Softener and extensions.

The scheme was formulated in 1906 by Mr .T. Pridham, M. Inst. C.E., acting under Mr. L. A. B. Wade, M. Inst. C.E., then Chief Engineer for Rivers, Water Supply and Drainage. The design was prepared by the Author, with the assistance of Mr. R. S. Littlejohn, and the work has been completed under the direction of Mr. E. M. de Burgh, M. Inst. C.E., Chief Engineer for Harbours and Water Supply, Mr. J. B. A. Reed, Assoc. M. Inst. C.E., acting as Resident Engineer, and Messrs. Gilliver, Gilmore and Connell as Contractors. The Water Softener is being erected under Mr. T. E. Burrows, M. Inst. C.E., Chief Assistant in Water Supply matters to Mr. de Burgh.

The author is indebted to Mr. de Burgh and to Mr. W. J. Hanna, Under Secretary for Public Works, for permission to use Departmental plans and information.

APPENDIX "A."

Tests of Pumping Machinery made by Mr. A. M. Howarth.

TEST NO. 1—PUMPS ACTING SINGLY.

This test was made on 10th February, 1910, when each of the units was run independently at full speed for 1½ hours, with the result that the delivery from each unit was at the rate of 16,515 gallons per hour, or 10.1 per cent. in excess of the Contract quantity. During the tests the steam pressure in the boiler was easily kept constant at 105lb. per sq. in., with coal fuel of inferior quality.

TEST NO. 2—PUMPS ACTING TOGETHER.

At 7 a.m. on the 11th February, the 10-hour double pumping test began; readings of temperature, speeds, pressures, feed water consumption, vacuums, flow of service water in main, and depth of water in well, being carefully measured and noted every twenty minutes. The recorded averages for the whole test are as follows:—

Temperature of water in well, 68 deg. Fah.

Temperature of atmosphere of pump house, 119 deg. Fah. Maximum, 125 deg. Fah.

Temperature of feed water to boiler, 117 deg. Fah.

Steam pressure per sq. inch at boiler, 102lbs.

Vacuum in Condenser in inches, 21¾.

Surface of well water below pumps, in feet, 9¾.

R.P.M. of pumps, 49.

R.P.M. of engines, 196.

Gallons of water per hour to reservoir, 32,358.

Feed water consumption in pounds per 1000 gallons lifted to reservoir, 53.

Pounds of coal burned per 1000 gallons lifted to reservoir, 8¼.

Pounds of water evaporated per lb. of fuel (very bad), 6½

Percentage of ash in fuel, 12.

The total quantity of water lifted in 9 hours, when tests had to stop because of a leaky pipe at the tank, was 291,222 gallons, at the rate of 32,358 gallons per hour, or 7.86 per cent in excess of contract.

The static head in these tests was 253 feet, or about 11 feet more than specified.

The fuel available for making the tests was found to be dirty, and the fire had to be forced to keep a good head of steam. Mr. Howarth estimated that with satisfactory fuel, and after the boiler and steam pipes had been lagged, the steam consumption would be reduced to 50lbs. per 1000 gallons raised.

APPENDIX B.

SINGLETON WATER SUPPLY—WATER SOFTENER—REAGENTS REQUIRED.

The Kennicott Company estimated that the amount of reagents required per 1000 gallons would be as shown in Analysis

No. 1. This was based upon the analysis of water taken from the Co-operative Butter Company's well, distant about one-quarter of a mile from the Pump Well, as furnished to them in 1909.

Analysis No. 2 is of water taken from the Pump Well itself on 2nd April, 1910, and shows a much softer water. The quantity of reagents required to treat this water is not yet available.

	Analysis No. 1.			Analysis No. 2.
	(Water from Co-operative Butter Co.'s Well). Solid residue 62·80 parts per 100,000. Re-agents required per 1,000 gallons.			(Water from Pump Well). Solid residue 30·70 parts per 100,000.
	Solids.	Lime. lb.	Soda. lb.	Solids.
Sodium Nitrate	2·97	...	...	·07
,, Sulphate	5·18	...	...	...
,, Chloride	14·98	...	...	9·66
Magnesium Chloride ...	6·93	·44	·82	0·32
Calcium Chloride	1·29	...	·12	...
,, Carbonate	15·97	·90	...	7·72
,, Sulphate	1·36	...	·12	1·30
Magnesium Carbonate ...	9·81	1·30	...	6·60
Silica	3·00	...	...	3·56
Organic matter, &c.... ...	1·31	...	...	1·35
Ferric Oxide and Alumina...	...	...	...	0·12
	62·80	2·64	1·06	30·70