CH2M Beca

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Report

Water Fluoridation Engineering Costs -

Prepared for Ministry of Health

Prepared by CH2M Beca Ltd

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Executive Summary -

The Ministry of Health (MoH) has commissioned CH2M Beca Ltd (Beca) via Allen + Clarke to provide engineering cost inputs into the cost-benefit analysis for water fluoridation in New Zealand.

In this report we have undertaken a series of capital cost estimates for different sized treatment plant capacities (the four population categories of Neighbourhood, Small, Minor and Medium), as well as four case studies on large supplies. We have presented the costs as a range (shown in the table below) to account for some of the variability in existing facilities and type of treatment process.

Capital Cost Summary for Fluoridation of Different Population Categories

Design Parameters	Neighbourhood	Small	Minor	Medium
Population Served	<100	101-500	501-5000	5001-10000
Capacity (m^3/d)	55	260	2050	6900
Fluoride Chemical	Sodium Fluoride	Sodium Fluoride	Sodium Fluoride	Fluorosilicic Acid
Cost Range	**$65,000 -$160,000**	**$75,000 - $160,000**	**$80,000 - $260,000**	**$145,000 - $260,000**

Capital Cost Summary for Fluoridation of Large Plants (Case Studies)

	Whangarei	Levin	Napier	Blenheim
Design Parameters				
Population Served	48,000	20,000	49,910	24,000
Peak Capacity (m^3/d)	36,000	13,000	50,000	34,000
Average Capacity (m^3/d)	23,000	8,500	29,000	13,000
Fluoride Chemical	FSA	SFS	FSA	FSA
Treatment Plants	Whau Valley Poroti Ruddles	Levin WTP	Ten wells	Central WTP Middle Renwick Road WTP
Total	**$725,000**	**$400,000**	**$2,250,000**	**$580,000**

We have undertaken five case studies on a range of plants that have existing fluoridation systems to estimate the cost required for each plant to meet the Fluoridation Code of Practice (CoP). These cost estimates (shown in the table below) are indicative only based on information gathered from the relevant water suppliers. A more detailed assessment of each plant would be required in order to more accurately assess and cost the upgrades required to meet the CoP.

Summary of Upgrade Costs to meet the Code of Practice

	Waterloo	Waikanae	Hamilton	Balclutha	Milton
Population Category	Large	Large	Large	Minor	Minor
Fluoride Chemical	SFS	SFS	FSA	NaF	NaF
Upgrade Cost	**$15,000**	**$10,000**	**$50,000**	**$25,000**	**$20,000**

The base equipment for a fluoridation system can be installed relatively inexpensively. However, in order for fluoridation to be safe for consumers, operators and the environment; proper controls must be in place regardless of system size. These additional controls add cost, which can be significant.

The cost estimates show that the infrastructure that is existing at a treatment plant has a big impact on the costs of adding fluoridation. Typically smaller plants have less infrastructure than larger ones. Some Small and Neighbourhood supplies may not even have a treatment plant.

The existing configuration of a supply can also affect the costs. The Napier supply is an example of a system that would cost significantly more to implement due to having ten wells feeding directly into the network. Whilst this type of supply is not the norm, it is not unique either. The Christchurch water supply also consists of a network of wells that separately supply the city.

When the cost estimates we have prepared are input into the CBA, it is important to appreciate that while we have given a range of capital costs, this range is not broad enough to cover the situation for all plants in a particular size category. For plants with little or no infrastructure, or supplies with multiple sources, the capital costs will be higher than the upper bound estimate.

Contents

1 Introduction

The Ministry of Health (MoH) has commissioned CH2M Beca Ltd (Beca) via Allen + Clarke to provide engineering cost inputs into the cost-benefit analysis of drinking-water fluoridation in New Zealand.

To develop a cost model that is as representative of the real world as possible, requires the development of realistic engineering estimates of what fluoridation plants actually cost. There are many variables that can influence these costs. For example:

- If the water supply is a groundwater plant from a secure water source it will typically not have a water treatment plant. It will have no chemical reception facilities, may not have a building, may not have SCADA and telemetry, and will not have other treatment plant infrastructure.
- A larger surface water treatment plant may have a good range of facilities, but may not have building space to accommodate a fluoridation plant, thereby requiring a new building with the additional costs this entails.

In this report we have undertaken a series of capital cost estimates for different sized treatment plant capacities (the four population categories of Neighbourhood, Small, Minor and Medium), as well as four case studies on large supplies. We have presented the costs as a range to account for some of the variability in existing facilities and the type of treatment process.

2 Chemical Options

2.1 Fluoridation Chemicals in New Zealand

2.1.1 Key Properties

Three fluoridation chemicals are available to fluoridate water in New Zealand. Details of each chemical including its form, supply options, the dosing system required, and indicative supply costs are presented in Table 1.

Table 1: Fluoridation Chemical Options

Detail	Unit	Fluorosilicic Acid (FSA)	Sodium Fluorosilicate (SFS)	Sodium Fluoride
Chemical Formula	-	H_2SiF_6	Na_2SiF_6	NaF
Alternative Names	-	HFA	SSF	-
Chemical Form	-	Liquid	Powder	Powder or granular
Dosing System	-	Liquid dosing	Dry feed system/liquid dosing	Saturator/liquid dosing
Supplied purity/concentration	% (w/w)	22	98-99	97-99
Solution pH (saturated)	-	1.2	3.5	7.6
Active Fluoride	%(w/w)	17 (at 22% strength)	60	45
Chemical required for dosing at 0.7mg/L	kg/ML treated water	4.4	1.2	1.6
Indicative chemical cost (excl. GST)	$/kg	Bulk: 0.48* IBC: 0.78*	25 kg Bags: 1.80*	25 kg Bags: 5.95^
Treated Water Cost (Fluoride at 0.7 mg/L)	$/ML	Bulk: 2.11 IBC: 3.43	2.16	9.52
Chemical Supply	-	Bulk tanker IBC	25 kg bag	25kg bag

* Based on indicative pricing from Ixom (formerly Orica)

^ Based on indicative pricing from DC Rosser

The costs provided in Table 1 are all indicative only. Actual transport distance, delivery quantity and frequency will affect chemical supply costs.

2.1.2 Fluoride Systems in New Zealand

In New Zealand, Councils take different approaches to water fluoridation. Of those supplies that have fluoride added:

- FSA is favoured in a number of the larger water supplies including Auckland, Hamilton, Gisborne and Hastings.
- SFS is used in the Wellington (Waterloo, Te Marua, Gear Island and Wainuiomata), Kapiti Coast (Waikanae treatment plant) and Dunedin water supplies.
- Sodium fluoride is relatively expensive in New Zealand and is not widely used. Clutha District Council uses sodium fluoride at its Balclutha, Milton, Tapanui and Kaitangata plants.

We have adopted a similar approach in developing the cost estimates, with medium-large plants based on FSA or SFS and smaller plants based on sodium fluoride.

2.2 Fluorosilicic Acid

2.2.1 Chemical Details

Fluorosilicic acid (FSA) is a pale yellow fuming corrosive acid with a pungent odour. In New Zealand FSA is currently delivered at a concentration of 22% (w/w) and has a pH of approximately 1. It is classified as a Dangerous Good[1] with a hazard class of "8 Corrosive".

2.2.2 System Description

FSA is usually added to treated water at the supplied concentration as it may scale if it is diluted. FSA is usually pumped (with a metering pump) from a bulk tank or day tank and injected into the main treated water line. A dosing point schematic is shown in Figure 5.

The NZ Code of Practice requires that a number of "independent checks" are used to minimise the risk of overdosing of fluoride. For water supply systems that serve more than 10,000 people, at least two of the three following independent checks are required. If the water supply system serves 10,000 or fewer people, then at least one of the three independent checks is required. For FSA, the options for independent checks are:

- **Independent Check 1:** use of a day tank that can only be filled once a day and equipped with an online device to measure its contents.
- **Independent Check 2:** use of a fluoride measuring flow meter on the fluoride dosing line before the dosing point.
- **Independent Check 3:** use of a fluoride concentration analyser on the drinking-water line after the dosing point.

For further details refer to the "*Code of practice for fluoridation of drinking-water supplies in New Zealand*".

A schematic of a generic FSA dosing process is shown in Figure 1.

[1] NZS 5433:2012 Transport of Dangerous Goods on Land

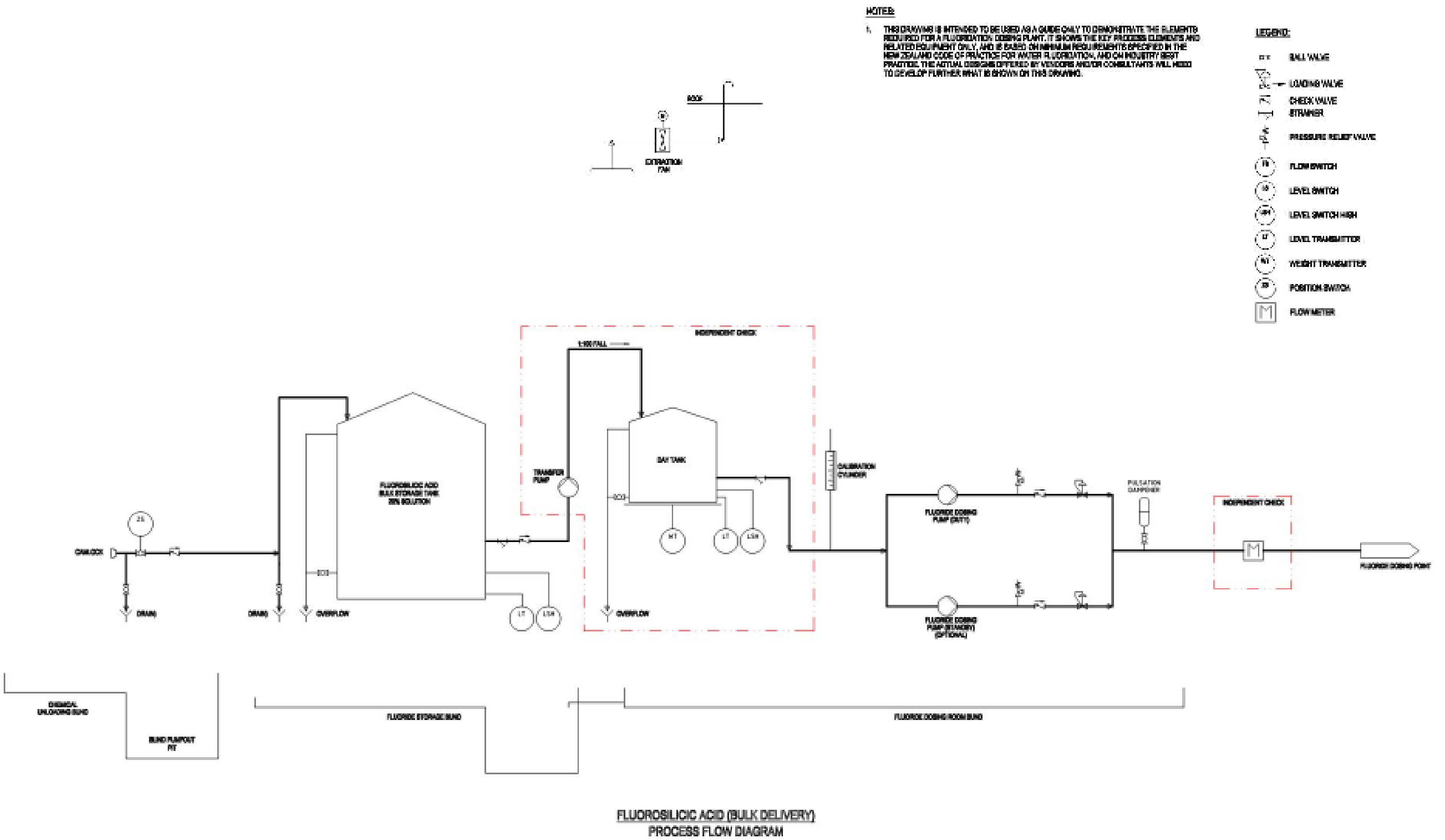

Figure 1: FSA Process Schematic

2.3 Sodium Fluorosilicate

2.3.1 Chemical Details

Sodium fluorosilicate (SFS) is supplied as a white pungent crystalline powder, comprising 60% w/w fluoride ion. It is classified as a Dangerous Good with a hazard class of “6.1 Toxic”.

SFS has a variable solubility in water (unlike NaF) hence for dose control it must be added at a controlled rate.

2.3.2 System Description

An SFS solution is prepared by transferring powder from the storage hopper to a stirred tank at a controlled rate using either a volumetric or gravimetric feeder. The amount of powder fed to the tank is generally controlled to provide flow-paced dosing of constant concentration fluoride chemical.

Industry best practice is to provide for a 10 minute minimum detention time to dissolve the SFS. If this detention time cannot be met with one tank, a separate dissolving tank may be required in addition to the dosing tank.

For a dosing plant using 25kg bags, chemical is loaded from the bags into a hopper mounted on top of the tank. Industry best practice is to use a vacuum loading system fitted with an extendable vacuum wand and dust extraction system. The chemical is drawn directly from the bag into the hopper with minimal dust generation and lifting.

The NZ Code of Practice requires that a number of “independent checks” are used to minimise the risk of overdosing of fluoride. For water supply systems that serve more than 10,000 people, at least both of the following independent checks are required. If the water supply system serves 10,000 or fewer people, then at least one of the two independent checks is required. For SFS, there are only two options for independent checks:

- **Independent Check 1:** use of a day tank that can only be filled once a day and equipped with an online device to measure its contents. In the case of SFS this could be a “day hopper” where a known weight of SFS is transferred on a daily basis. We note that this interpretation is not explicit in the Code of Practice, however as SFS has variable solubility in water, transfer of a known volume of a solution is meaningless unless the concentration is known. Similarly, for this reason a dosing line flowmeter cannot be used as an independent check for SFS.
- **Independent Check 2:** is not suitable for SFS.
- **Independent Check 3:** use of a fluoride concentration analyser on the drinking-water line after the dosing point.

For further details refer to the “*Code of practice for fluoridation of drinking-water supplies in New Zealand*”. We note that strict adherence with the Code of Practice is more difficult for SFS systems, and this is discussed in more detail in Section 5.

If the hardness of the source carrier water exceeds 75mg/L (as $CaCO_3$) then a water softener should be installed to prevent the precipitation of calcium and magnesium fluorides. The water softener will need periodic regeneration producing a strong waste brine solution which will require disposal.

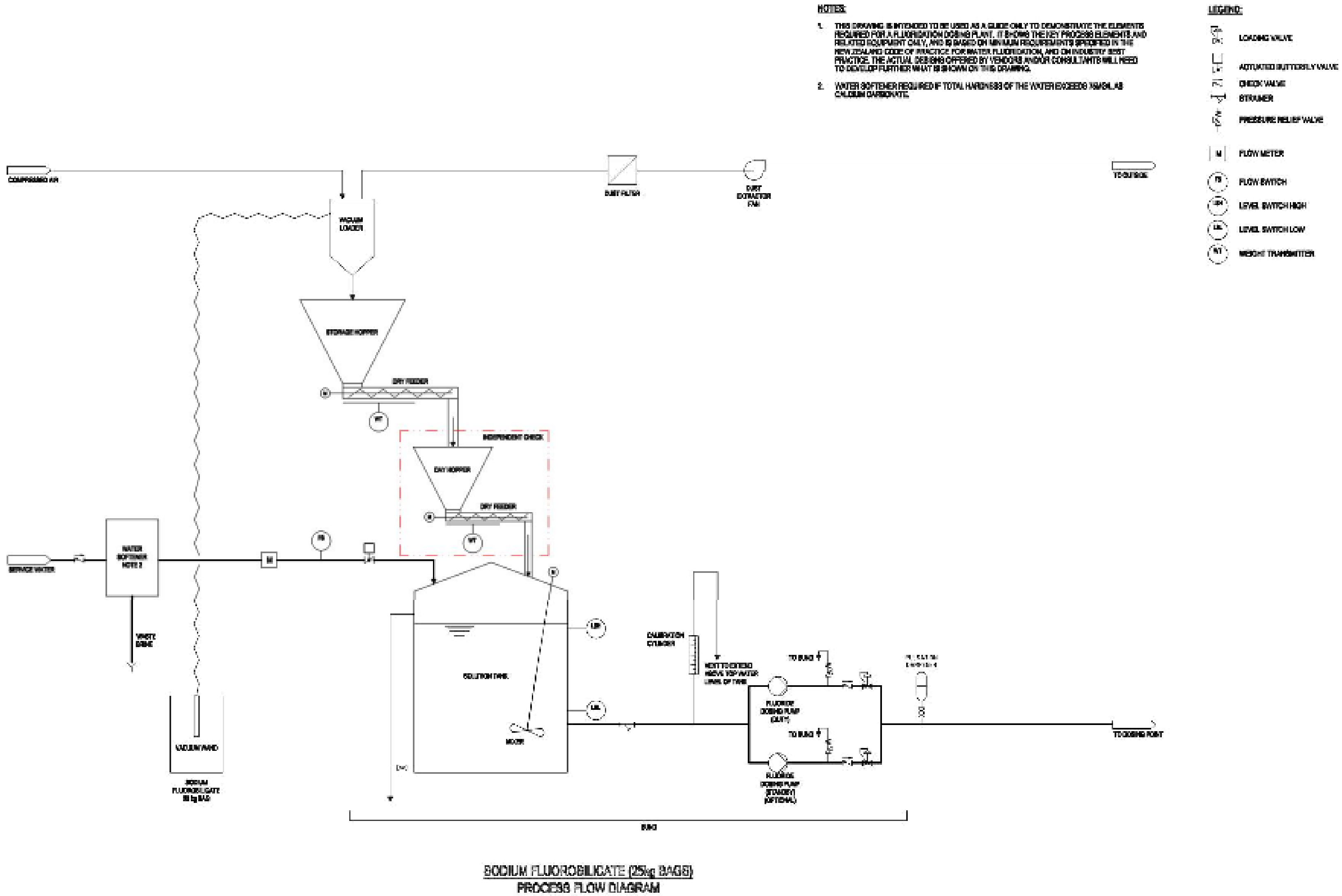

Figure 2: Sodium Fluorosilicate Process Schematic

2.4 Sodium Fluoride

2.4.1 Chemical Details

Sodium fluoride (NaF) is supplied as a white crystalline powder, comprising 45% w/w fluoride ion. It is classified as a Dangerous Good with a hazard class of “6.1 Toxic”.

NaF has an almost constant solubility in water of approximately 4%, regardless of water temperature. This allows for automatic, continuous preparation of saturated solutions in a saturator tank without the need for equipment to measure chemical addition. This reduces the risk of overdosing fluoride.

2.4.2 System Description

A saturated 4% solution of NaF is prepared in a saturator tank. Chemical is loaded into the tank to form a bed. Water is then distributed up through the chemical bed in an upflow saturator, or down through the bed in a downflow saturator. Upflow saturators are typically recommended as they are less susceptible to blockages and require less maintenance.[2]

The NZ Code of Practice requires that a number of “independent checks” are used to minimise the risk of overdosing of fluoride. For water supply systems that serve more than 10,000 people, at least two of the three following independent checks are required. If the water supply system serves 10,000 or fewer people, then at least one of the three independent checks is required. For sodium fluoride, the options for independent checks are:

- **Independent Check 1:** use of a day tank that can only be filled once a day and equipped with an online device to measure its contents.
- **Independent Check 2:** use of a fluoride measuring flow meter on the fluoride dosing line before the dosing point.
- **Independent Check 3:** use of a fluoride concentration analyser on the drinking-water line after the dosing point.

For further details refer to the “*Code of practice for fluoridation of drinking-water supplies in New Zealand*”.

NaF dissociates in water to give Na^+ and F^- which can form precipitates. If the hardness of the source carrier water exceeds 75mg/L (as $CaCO_3$) then a water softener should be installed to prevent the precipitation of calcium and magnesium fluorides. The water softener will need periodic regeneration producing a strong waste brine solution which will require disposal.

In Australia, NaF is available in 5kg “Fluorodose” bags which are manually loaded into the saturator tank. Operators need not open the bags as they are dissolvable, and so dust generation is eliminated. “Fluorodose” is not currently available in New Zealand.

In Australia, Prominent offer NaF in a 5kg plastic bottle with a large screw top lid. Under the lid the bottle is vacuum sealed via a plastic lid hot-glued into place. To use the chemical, the operator removes the screw cap and up-ends the bottle. The bottle screws directly into the lid of the NaF saturator (offered by Prominent). As the bottle screws into place, a small blade inside the reservoir lid cuts the plastic seal and the 5kg of

[2] Manual of Water Supply Practices M4 – Water Fluoridation Principles and Practices, 2004, American Water Works Association (AWWA)

powder falls into the saturator. The reservoir is fitted with a little spray that is then used to wash the bottle clean. Once the spray finishes, the bottle is unscrewed, the cap on the bottle and the cap on the tank lid are both replaced manually by the operator, and the empty bottle is stored for return to Prominent. Such a product is not currently available in New Zealand, but if the demand was there, Prominent may consider supplying their product to New Zealand also.

Where 25 kg bags are used, the product will be loaded from bags into a hopper mounted on top of the saturator tank. Industry best practice is to use a vacuum loading system fitted with an extendable vacuum wand and dust extraction system. The chemical is drawn directly from the bag into the hopper with minimal dust generation and lifting.

A schematic of a generic sodium fluoride dosing process for 5kg bags is shown in Figure 3 and for 25kg bags in Figure 4.

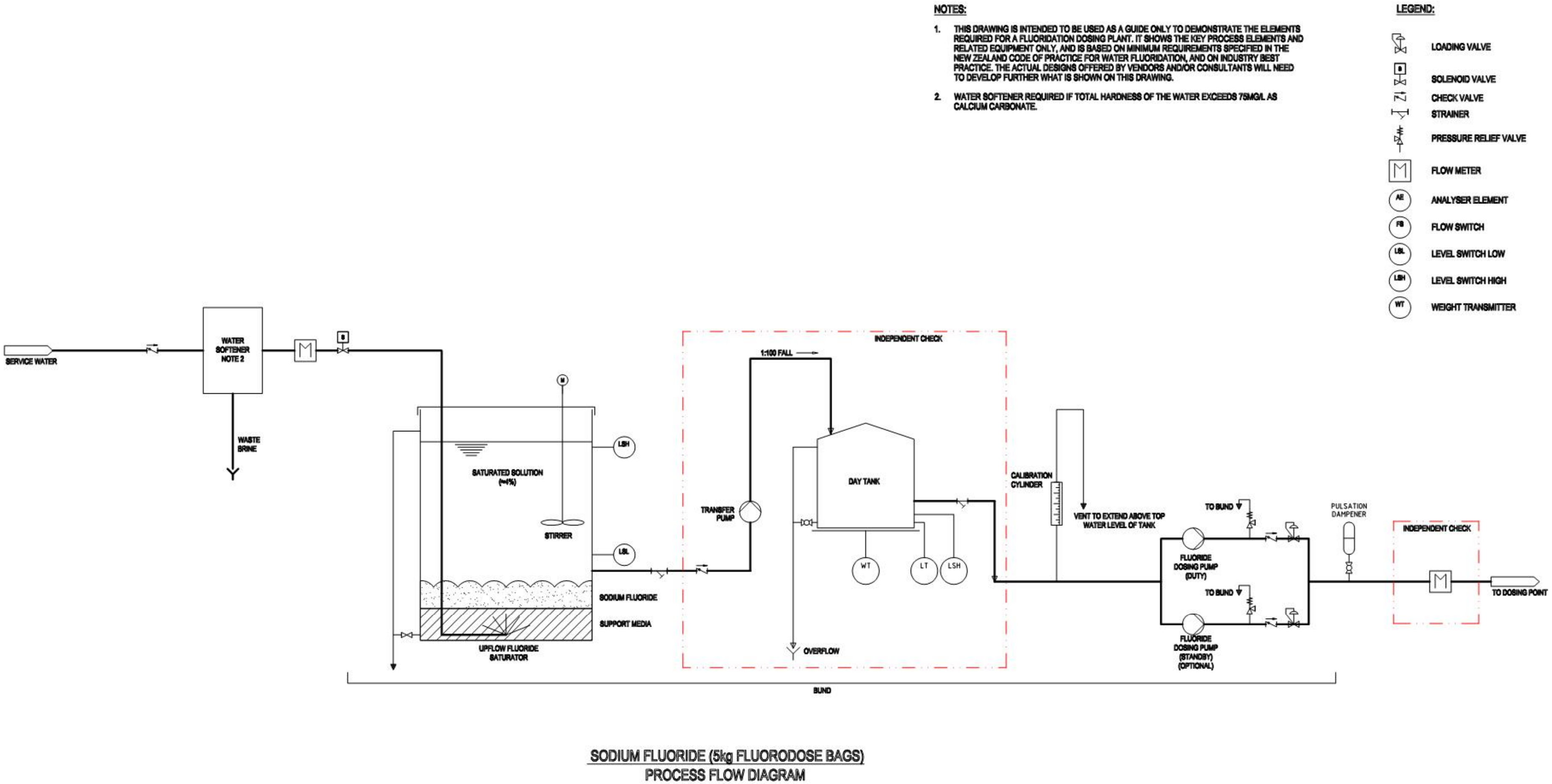

Figure 3: Sodium Fluoride Process Schematic – 5kg bags

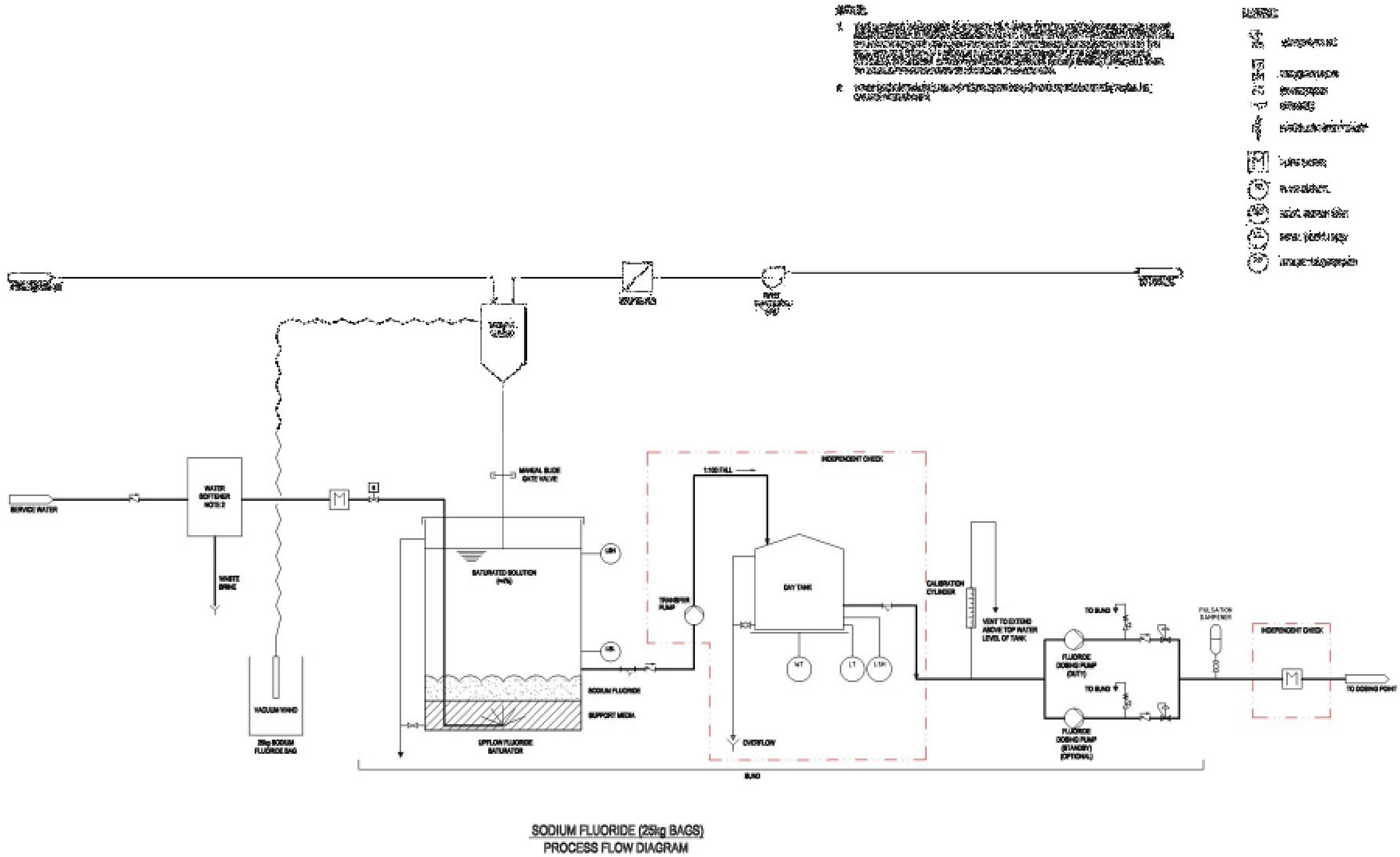

Figure 4: Sodium Fluoride Process Schematic – 25kg bags

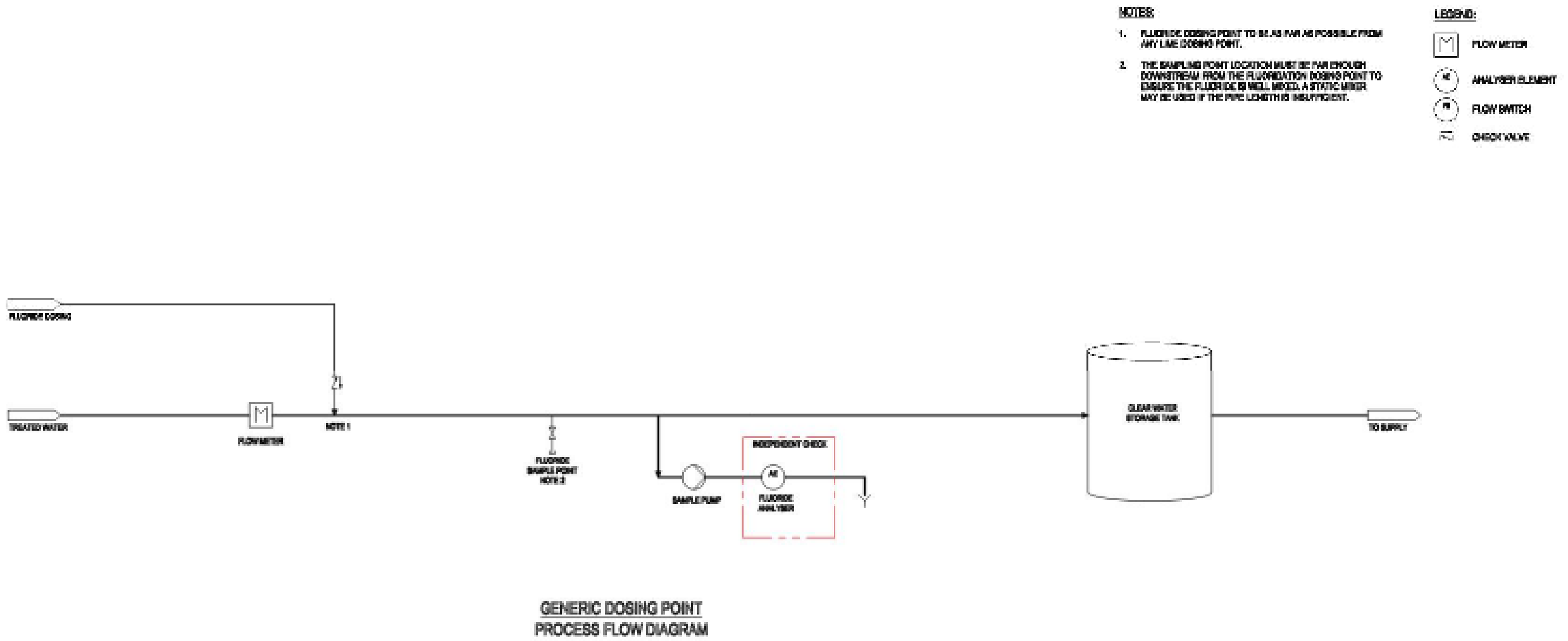

Figure 5: Fluoride Dosing Point Schematic

3 Capital Cost Estimates

3.1 Population Categories

The design flow for each population category has had the following principles applied:

- For large water supplies (population >10,000) the design flow is based on capacity advised by the water supplier. In the absence of actual design capacity, a peak figure of 700 litres/person/day and an average figure of 460 litres/person/day was used.
- For supplies serving populations <10,000 a higher peak per capita water usage rate of 1000 litres/person/day and an average usage of 500 litres/person/day was used.
- For each population category the WTP design flow was based on the per capita flow times the mean population for that category.

The population design basis for each category is shown in Table 2.

Table 2: Population Design Basis

Population category	Population band	Design population	Design Flow (m^3/d)
Large	>10,000	Varies	Varies
Medium	5001 – 10000	6900	6900
Minor	501 – 5000	2050	2050
Small	101 – 500	260	260
Neighbourhood	< 100	55	55

The population categories above are based on those used in the *"Drinking Water Standards New Zealand Cost Benefit Analysis – Engineering Input"* (2010). Rather than use the midpoint population of the population categories, which can cover a large range, the mean population has been used as the design population (based on population data received from ESR for the 2010 study). For all population categories, the mean population was below the midpoint population.

3.2 Cost Assumptions – General Approach

3.2.1 Ancillary Requirements

In addition to the fluoridation equipment detailed in Sections 2.2 to 2.4, ancillary work and equipment installation may be required to implement fluoridation at a WTP depending on the existing layout, equipment, services and operation of the WTP. In our cost estimates, where noted, we have allowed for the following ancillary equipment:

- Installation of a fluoride analyser.
- Construction of, or improvement to, the chemical delivery area.
- Construction of a new building to house equipment, or extension/refurbishment of an existing building.
- Construction of building services (ventilation/air con, lighting, power).
- Installation of a safety shower.
- Incorporation of fluoride dosing system control, monitoring and alarms into existing PLC, SCADA and/or telemetry systems.

The following ancillary work may be required at specific treatment plants, but has not been allowed for (unless otherwise stated) in the cost estimates:

- Engineering investigations (e.g. as built drawings of existing facility, geotechnical, topographical survey).
- Installation of a flow meter on the main process flow into which fluoride is to be dosed.
- Installation of a waste collection sump.
- Upgrade to drainage systems.
- Addition of a water softener (if using sodium fluoride or SFS and dilution water hardness (as $CaCO_3$) is greater than 75 mg/L). Hardness in NZ surface waters is generally less than 75 mg/L, however some groundwater sources (especially in areas with limestone) have high hardness values.
- Installation of a pit for flow meter and analyser.
- Installation of a sampling pump for fluoride analyser.
- Reconfiguration of piping and valving at the treatment plant.
- Relocation of existing services/equipment.
- Installation or upgrading of SCADA and/or telemetry systems for alarms associated with new fluoridation system.
- Installation or upgrade to the PLC system.
- Construction of amenities (possibly for a site that requires and increased level of operator attendance after installation of the fluoridation system).
- Purchase of a gantry/forklift for handling requirements.
- Installation or upgrade of security (fencing, signage and lighting).
- Construction of a laboratory complete with equipment (including bench top analyser for fluoride).
- Provision of personal protective equipment (PPE).
- Construction of or upgrade to power supply and switchboards.
- Construction of new delivery vehicle access and roads.
- Installation of a service water system.
- Land purchase may be required for a dosing building.
- GST is excluded from all cost estimates.

3.2.2 Other

Further requirements that will potentially be involved include:

- Training of operators.
- Waste disposal.
- New standard operating procedures and contingency plans.
- Increased monitoring and reporting requirements.

We have not allowed for these additional costs in our estimates.

3.3 Description and Cost Assumptions – Medium, Minor, Small and Neighbourhood Supplies

Sodium fluoride can be a good choice for smaller water supplies as the capital set up costs are generally lower than the other types of systems and the systems are relatively simple to operate. The chemical cost of sodium fluoride is relatively expensive in New Zealand compared to SFS and FSA. However, smaller supplies (neighbourhood, small, minor) only use a small quantity of fluoride on a yearly basis, so the increase in operating costs is relatively minor.

For costing purposes we have based the Neighbourhood, Small and Minor water supplies on a sodium fluoride system.

At the higher flows associated with a medium supply, the operating cost savings from using FSA are more significant and hence we have based the medium supply on a FSA system.

For each category we have provided a “low” and “high” cost estimate. The low cost estimate assumes there are already reasonable facilities onsite and the equipment installed will be a “low cost” option. Whilst a “low cost” option will be fit for purpose, it may require higher operator input, maintenance and have less robust control checks. The high cost estimate allows for a more robust system with better equipment, safety and controls.

3.3.1 Small and Neighbourhood Supplies

For small and neighbourhood supplies we have made the capital cost assumptions shown in Table 3.

Table 3: Cost Assumptions for Small and Neighbourhood Supplies

Area	Assumptions for Low Cost	Assumptions for High Cost
Equipment	■ A basic 250 L NaF upflow saturator, dosing pump, pipework and valves. Operators manually load bags in unsealed bag loader. ■ New flowmeter on treated water line to be used for control of dose rate.	■ A 250 L NaF upflow saturator, metering pump skid, patented bottle cutter unloader system to minimise dust. ■ New flowmeter on treated water line to be used for control of dose rate.
Independent Check	■ A flowmeter on NaF dosing line as the independent check.	■ Flowmeters (especially on small bore pipe) can be inaccurate and/or prone to failure. A fluoride analyser has been assumed as it is a better method for independently checking the fluoride dose.
EI&C		■ As for the low cost option. ■ A SCADA system could be implemented but is likely to incur significant cost.
Safety Shower	■ New safety shower located in the fluoride dosing room. It has been assumed that a service water system is available to connect to the safety shower.	■ As for the low cost option.
Building	■ Fluoride saturator and dosing pump located in a shipping container or proprietary shed.	■ Fluoride saturator and dosing pump located in a pre-fabricated building complete with ventilation.
Chemical Delivery	■ No chemical delivery area or specific storage facilities required. Chemical would be delivered to a larger site (with adequate handling and storage facilities) and small quantities (eg one bag) would be transported to the Neighbourhood site.	■ As for the low cost option.
Design	■ Assuming installation of a largely pre-engineered system. The allowance is for design of components for integration into the existing site.	■ As for the low cost option.

As discussed in Section 3.2, we have assumed that a WTP site will have a base level of facilities such as road access, power, security, lighting, drainage systems etc. We have not included an allowance for these items in order to keep costs to a reasonable level. Whilst this is a fair assumption for most treatment plants, some smaller plants have very limited facilities such as foot access only or no power. This needs to be carefully considered if assessing and using these capital costs in an analysis at a national level.

3.3.2 Minor Supplies

For minor supplies we have made the capital cost assumptions shown in Table 4.

Table 4: Cost Assumptions for Minor Supplies

Area	Assumptions for Low Cost	Assumptions for High Cost
Equipment	▪ A basic 500 L NaF upflow saturator, dosing pump, pipework and valves. Operators manually load bags in unsealed bag loader (dust risk). ▪ New flowmeter on treated water line to be used for control of dose rate.	▪ A proprietary 500 L NaF upflow saturator, metering pump skid, water softener, vacuum loader system complete with dust extraction to minimise dust and manual handling (refer photo on cover). ▪ New flowmeter on treated water line to be used for control of dose rate.
Independent Check	▪ A flowmeter on NaF dosing line as the independent check.	▪ Flowmeters (especially on small bore pipe) can be inaccurate and/or prone to failure. A fluoride analyser has been assumed as it is a better method for independently checking the fluoride dose.
EI&C		▪ As for the low cost option.
Safety Shower	▪ New safety shower located in the fluoride dosing room. It has been assumed that a service water system is available to connect to the safety shower.	▪ As for the low cost option.
Building	▪ Fluoride saturator, dosing pump and storage facilities can be incorporated into existing building. Some modifications may be needed for ventilation, bunding etc	▪ Fluoride saturator, dosing pump and storage facilities located in a pre-fabricated building complete with ventilation.
Chemical Delivery	▪ Assuming existing chemical delivery area is adequate.	▪ Allowance for a new bunded chemical delivery area and storage facilities.
Design	▪ Assuming installation of a largely pre-engineered system. The allowance is for design of components for integration into the existing site.	▪ As for the low cost option.

3.3.3 Medium Supplies

For medium supplies we have made the capital cost assumptions shown in Table 5.

Table 5: Capital Cost Assumptions for Medium Supplies

Area	Assumptions for Low Cost	Assumptions for High Cost
Equipment	■ A bulk 3000 L FSA tank, dosing pump skid, pipework and valves. ■ Existing flowmeter on treated water line used for control of dose rate.	■ A bulk 3000 L FSA tank, dosing pump skid, pipework and valves. All equipment rated for outside installation. ■ Existing flowmeter on treated water line used for control of dose rate.
Independent Check	■ A flowmeter on FSA dosing line as the independent check.	■ Flowmeters (especially on small bore pipe) can be inaccurate and/or prone to failure. A fluoride analyser has been assumed as it is a better method for independently checking the fluoride dose.
EI&C		■ As for the low cost option.
Safety Shower	■ New safety shower located in the fluoride dosing room. It has been assumed that a service water system is available to connect to the safety shower.	■ As for the low cost option.
Building	■ FSA tank and dosing pump can be incorporated into existing building. Some modifications may be needed for ventilation, bunding etc.	■ FSA tank located outside with bunding, a roof and locked security fence. Dosing pumps located outside but within bund and under roof.
Chemical Delivery	■ Allowance for a new bunded chemical delivery area and storage facilities.	■ As for the low cost option.
Design	■ Assuming installation of a largely pre-engineered system. The allowance is for design of components for integration into the existing site.	■ As for the low cost option.

3.4 Capital Cost Summary – Medium, Minor, Small and Neighbourhood Supplies

The capital costs for the different sized water supplies are shown in Table 6. These costs are indicative only based on a generic plant of that size. More detailed information and design would be required in order to use the capital costs for capital budgeting purposes for a specific plant.

Table 6: Fluoridation Capital Cost Estimates for Different Sized Water Supplies

	Neighbourhood		Small		Minor		Medium	
Design Parameters								
Population Served	<100		101-500		501-5000		5001-10000	
Capacity (m^3/d)	55		260		2050		6900	
Fluoride Chemical	NaF		NaF		NaF		FSA	
Costs	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**
Equipment + Install	15,000	45,000	20,000	45,000	20,000	82,500	50,000	70,000
EI&C	15,000	15,000	15,000	15,000	15,000	20,000	20,000	20,000
Fluoride Analyser	-	15,000	-	15,000	-	15,000	-	15,000
Building	10,000	30,000	12,000	30,000	15,000	30,000	15,000	30,000
Safety Shower	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Chemical Storage and Bunding	-	-	-	-	-	-	10,000	10,000
Chemical Unload Area	-	-	-	-	-	25,000	-	25,000
Design (12%)	6,000	13,000	6,000	13,000	7,000	21,000	12,000	21,000
P&G (15%)	7,000	17,000	8,000	17,000	8,000	27,000	15,000	26,000
Contingency and rounding (nom 15-20%)	7,000	20,000	9,000	20,000	10,000	34,500	18,000	38,000
Total	**$65,000**	**$160,000**	**$75,000**	**$160,000**	**$80,000**	**$260,000**	**$145,000**	**$260,000**

A contingency allowance of 15% has been applied to the “low” cost range and a 20% contingency to the “high” cost range.

3.5 Operating Cost Summary - Medium, Minor, Small and Neighbourhood Supplies

We have estimated costs for the various sized systems as shown in Table 7.

Table 7: Operating Cost Estimates

	Neighbourhood	Small	Minor	Medium
Design Parameters				
Population Served	<100	101-500	501-5,000	5,001-10,000
Peak Capacity (m^3/d)	55	260	2,050	6,900
Average Capacity (m^3/d)	28	130	1,025	3,450
Fluoride Chemical	NaF	NaF	NaF	FSA
Costs/annum				
Chemical	100	450	3,500	4,300
Operator Input	5,200	5,200	5,200	5,200
Maintenance	1,500	1,900	3,000	3,700
Total (per annum)	**$6,800**	**$7,600**	**$11,700**	**$13,200**

The operating costs are based on the following assumptions:

- Chemical costs are based on indicative prices received from Ixom and DC Rosser.
- Operator input is based on 2 hours/week at an operator hourly rate of $50/hour. The hourly rate may be lower for some supplies.
- Maintenance costs have been estimated as 2% of capital costs of the plant.
- Monitoring and compliance costs have been excluded.
- GST is excluded.

3.6 Description and Cost Assumptions – Large Water Supplies

3.6.1 Approach

It is difficult to prepare a generic cost estimate for the “Large” plant category as these are likely to require very specific designs. There are over 20 large supplies in NZ that are not currently fluoridating. Preparing a cost estimate for each of these 20 plants is beyond the scope of this work. Hence, we have selected the following four case studies to prepare cost estimates for:

- Whangarei
- Napier
- Levin
- Blenheim

3.6.2 Whangarei

The Whangarei water supply consists of three WTPs – the Whau Valley, Poroti and Ruddles WTP. In order to fluoridate the entire Whangarei city supply a fluoridation system would be required at all three WTPs.

Whangarei District Council is currently considering replacing the existing Whau Valley WTP with a new WTP at a new site. For the purposes of this costing, we have assumed that a FSA fluoride dosing would be incorporated in the proposed new Whau Valley Water Treatment Plant and at the existing Poroti and Ruddles treatment plants. The cost for including fluoride dosing at the new Whau Valley plant would be less than if it was to be incorporated at the existing plant which is restricted in both space and capacity. For costing purposes we have made the assumptions shown in Table 8.

Table 8: Whangarei Fluoride Dosing System Assumptions

Area	Infrastructure Required	Existing Infrastructure Assumptions
Equipment	■ A bunded bulk 5000L FSA tank with level measurement and a dosing pump at each site. ■ A flowmeter on the dosing line would be used at each site as an "independent check".	■ No current dosing infrastructure that could be utilised at either site. ■ Flowmeter on treated water to be used for flow pacing dose control.
EI&C	■ Automation, monitoring and alarming would be incorporated as per the Code of Practice. ■ Fluoride dosing meter required at each WTP as an independent check of the dose rate.	■ Dosing control, alarming and monitoring could be incorporated into the existing PLC and SCADA system at each site. ■ There is space in the existing MCC for the dosing pumps motor starters at each site. ■ Existing transformer and switchboard can accommodate the extra dosing equipment at each site.
Safety Shower	■ New safety shower located in the fluoride dosing room at each site.	■ A service water system is available for connection to the safety shower at each site.
Building	■ Dosing systems would be incorporated into the new Whau Valley WTP building and Poroti existing building (with some modifications). ■ A standalone building (portable polypanel type construction) to accommodate the FSA tank and dosing pumps would be constructed at the Ruddles WTP.	■ There is space in the Poroti existing buildings for a fluoride dosing system. ■ Land is available at all sites for a dosing building.
Chemical Delivery	■ Upgrades are required for the chemical delivery areas (bunding etc) at both the Poroti and Ruddles WTPs to make it suitable for FSA bulk delivery.	■ Site access is suitable for a chemical delivery truck. ■ The new Whau Valley WTP would have suitable chemical delivery infrastructure.

3.6.3 Levin

The Levin water supply consists of a single surface water source and treatment plant. Water is abstracted from the Ohau River and treated at the Levin water treatment plant located on Gladstone Road. The existing treatment plant consists of coagulant and flocculant dosing, pH control, horizontal pressure media filters, and chlorination. Fluoride could be added to water supply with a single dosing plant located at the existing water treatment plant.

To illustrate the costs of a SFS system for a Large supply, we have assumed a SFS system for the Levin supply. Although this plant is due for upgrading over the next 5-10 years, we have assumed that an SFS plant is added to the existing plant and that there is sufficient space at the Levin site to allow for a SFS system. For costing purposes we have made the assumptions shown in Table 9.

Table 9: Levin Fluoride Dosing System Assumptions

Area	Infrastructure Required	Existing Infrastructure Assumptions
Equipment	▪ A skid mounted SFS powder system complete with storage hopper, load cells, dry chemical feeder, solution tank with mixer, dosing pump and vacuum loader for 25kg bags. ▪ A second "day hopper" with screw feeder and load cell would be required as a second independent check on the fluoride dose.	▪ No current dosing infrastructure that could be utilised. ▪ Flowmeter on treated water to be used for flow pacing dose control.
EI&C	▪ Automation, monitoring and alarming would be incorporated as per the Code of Practice. ▪ The dosing skid would be supplied with a local control panel. ▪ Fluoride dosing meter required as an independent check of the dose rate.	▪ Dosing control, alarming and monitoring could be incorporated into the existing PLC and SCADA system. ▪ There is space in the existing MCC for the screw feeder and dosing pump motor starters. ▪ Existing transformer and switchboard can accommodate the extra dosing equipment.
Safety Shower	▪ New safety shower located in the fluoride dosing room.	▪ A service water system is available for connection to the safety shower.
Building	▪ A standalone building (portable polypanel type construction) to accommodate the fluoride make-up skid and storage of 25kg bags of SFS would be constructed.	▪ There is no space in the existing building for a fluoride dosing system. ▪ Land is available onsite for a dosing building.
Chemical Delivery	▪ A bunded chemical delivery area would be constructed.	▪ Site access is suitable for a chemical delivery truck.

3.6.4 Napier

The Napier water supply consists of ten wells spread over the city network. The groundwater aquifer the supply draws from is considered secure and as such no treatment is required prior to distribution. There is no centralised water treatment plant for the Napier supply, so in order to reliably fluoridate the entire supply a dosing system would be required at each well source. Given the likely space constraints at the well sites and the current level of operator input, we have assumed that FSA would be the most appropriate system for the Napier supply.

The other option, of piping the water from the wells to one centralised treatment plant (or perhaps a few treatment plants), may be more economic. This option has not been costed.

For costing purposes we have made the assumptions shown in Table 10.

Table 10: Napier Fluoride Dosing System Assumptions

Area	Infrastructure Required	Existing Infrastructure Assumptions
Equipment	■ A bunded bulk 3000L FSA tank with level measurement and a dosing pump at each of the ten bore sites. ■ A flowmeter on the dosing line would be used at each site as an "independent check".	■ No current dosing infrastructure that could be utilised at the existing sites. ■ Flowmeter on treated water to be used for flow pacing dose control.
EI&C	■ Automation, monitoring and alarming would be incorporated as per the Code of Practice. ■ Fluoride dosing meter required at each dosing point as an independent check of the dose rate.	■ Dosing control, alarming and monitoring could be incorporated into the existing PLC and SCADA system at each site. ■ There is space in the existing MCC for the dosing pumps motor starters at each site. ■ Existing transformer and switchboard can accommodate the extra dosing equipment at each site.
Safety Shower	■ New safety shower located in the fluoride dosing room at all sites.	■ A service water system is available for connection to the safety shower at all sites.
Building	■ A standalone building (portable polypanel type construction) to accommodate the FSA tank and dosing pumps would be constructed at all sites.	■ There is no space in the existing buildings for a fluoride dosing system. ■ Land is available at each site for a dosing building.
Chemical Delivery	■ A bunded chemical delivery area would be constructed at each site.	■ Site access is suitable for a chemical delivery truck.

3.6.5 Blenheim

The Blenheim water supply consists of a number of bores located in the town and two treatment plants (Central and Middle Renwick Road). The Central WTP draws from five bores and is the primary water supply for Blenheim. The Middle Renwick Road WTP draws from three bores and is used to supplement the primary supply, especially during peak demand. Water treatment consists of pH correction and UV treatment.

We have assumed that a fluoride dosing plant would be required at both WTPs in order to fluoridate the entire supply. Given the likely space constraints at the Central WTP, we have assumed that FSA would be the most appropriate system for the Blenheim supply. For costing purposes we have made the assumptions shown in Table 11.

Table 11: Blenheim Fluoride Dosing System Assumptions

Area	Infrastructure Required	Existing Infrastructure Assumptions
Equipment	■ A bunded bulk 5000L FSA tank with level measurement and a dosing pump at each site. ■ A flowmeter on the dosing line would be used at each site as an "independent check".	■ No current dosing infrastructure that could be utilised at either site. ■ Flowmeter on treated water to be used for flow pacing dose control.

Area	Infrastructure Required	Existing Infrastructure Assumptions
EI&C	■ Automation, monitoring and alarming would be incorporated as per the Code of Practice. ■ Fluoride dosing meter required at each WTP as an independent check of the dose rate.	■ Dosing control, alarming and monitoring could be incorporated into the existing PLC and SCADA system at each site. ■ There is space in the existing MCC for the dosing pumps motor starters at each site. ■ Existing transformer and switchboard can accommodate the extra dosing equipment at each site.
Safety Shower	■ New safety shower located in the fluoride dosing room at each site.	■ A service water system is available for connection to the safety shower at both sites.
Building	■ A standalone building (portable polypanel type construction) to accommodate the FSA tank and dosing pumps would be constructed at both sites.	■ There is no space in either of the existing buildings for a fluoride dosing system. ■ Land is available at both sites for a dosing building.
Chemical Delivery	■ Upgrades are required for the chemical delivery areas (bunding etc) at both WTPs to make it suitable for FSA bulk delivery.	■ Site access is suitable for a chemical delivery truck.

3.7 Capital Cost Summary – Large Water Supplies

The capital costs for the four case study large supplies are shown in Table 12. These costs are indicative only based on preliminary information for each plant. More detailed information and design would be required in order to use the capital costs for capital budgeting purposes.

Table 12: Summary of Capital Costs to provide Fluoridation to Large Water Supplies

	Whangarei	Levin	Napier	Blenheim
Design Parameters				
Population Served[3]	48,000	20,000	49,910	24,000
Peak Capacity (m^3/d)	36,000	13,000	50,000	34,000
Average Capacity (m^3/d)	23,000	8,500	29,000	13,000
Fluoride Chemical	FSA	SFS	FSA	FSA
Treatment Plants	Whau Valley Poroti Ruddles	Levin WTP	Ten wells	Central WTP Middle Renwick Road WTP
Costs				
Equipment	120,000	125,000	350,000	100,000
Mechanical Installation	50,000	30,000	150,000	40,000
EI&C	60,000	20,000	200,000	40,000
Fluoride Analyser	45,000	15,000	150,000	30,000
Building	130,000	55,000	450,000	110,000
Safety Shower	15,000	5,000	50,000	10,000
Chemical Storage and Bunding	30,000	-	100,000	20,000
Chemical Unload Area	50,000	25,000	100,000	50,000
Design (10%)	50,000	28,000	155,000	40,000
P&G (15%)	75,000	42,000	232,000	60,000
Contingency (20%)	100,000	55,000	310,000	80,000
Total	**$725,000**	**$400,000**	**$2,250,000**	**$580,000**

[3] From WINZ database.

4 Implications for Existing Fluoridation Plants

4.1 Case Studies

We have undertaken five case studies on a range of plants that have existing fluoridation systems to estimate the cost required for each plant to meet the Fluoridation Code of Practice (CoP). Existing plants must comply with the code by 2020. These cost estimates are indicative only based on limited information gathered from the relevant water suppliers. A more detailed assessment of each plant would be required in order to more accurately assess and cost the upgrades required to meet the CoP.

4.1.1 Waterloo Water Treatment Plant

The Waterloo WTP has a SFS dosing system consisting of a powder hopper (complete with weigh cell and dust extraction) with screw feeder, dilution tank, day tank and dosing pumps. The system is located in a separate room. The Waterloo fluoridation dosing system is generally in a satisfactory condition and meets most aspects of the CoP. The Waterloo WTP is classified as a large supply and hence requires two independent checks of the fluoride dose in order to be compliant with the CoP. There is a fluoride analyser that monitors fluoride in the treated water and is used to alarm and shut down the system on high readings. Whilst there is a day tank, it may not strictly adhere to the COP (as discussed in Section 2.3.2). Some changes to the automation and alarming may be required in order for it to meet the CoP. We estimate that these upgrades would cost approximately $15,000.

4.1.2 Waikanae Water Treatment Plant

The Waikanae WTP has a SFS dosing system consisting of a powder hopper with conveyor, day hopper and screw feeder (complete with weigh cell and dust extraction) and a dilution tank. The system is located in a separate room. The Waikanae fluoridation dosing system is generally in a satisfactory condition and meets most aspects of the CoP. The Waikanae WTP is classified as a large supply and hence requires two independent checks of the fluoride dose in order to be compliant with the CoP. There is a fluoride analyser that monitors fluoride in the treated water and is used to alarm and shut down the system on high readings. The day hopper could be used as the second independent check, but some automation and operational changes would be required. We estimate that these upgrades would cost approximately $10,000.

4.1.3 Hamilton Water Treatment Plant

The Hamilton WTP has a FSA dosing system consisting of a bulk tank, day tank and dosing pumps. The bulk tank is bunded and located outside under a cover with a security fence. The Hamilton WTP is classified as a large supply and hence requires two independent checks of the fluoride dose in order to be compliant with the CoP. There is a fluoride analyser that monitors fluoride in the treated water and is used to alarm and shut down the system on high readings. The day tank could be used as the second independent check, but some automation and operational changes may be required. There are some modifications to the pipework and chemical delivery area that may also be required to improve the health and safety aspects of the system. We estimate that these upgrades would cost approximately $50,000.

4.1.4 Balclutha Water Treatment Plant

The Balcutha WTP has a NaF dosing system consisting of an upflow saturator and dosing pump located in an isolated room. The Balclutha WTP is classified as a minor supply and hence requires one independent check of the fluoride dose in order to be compliant with the CoP. There are currently no independent checks of the fluoride dose and the dose rate is manually set rather than being flow paced with the treated water flow (although we have assumed there is a plant flow meter). The least expensive independent check would be to install a flowmeter on the dosing line. A fluoride analyser would be a more robust independent check, but it would be more expensive. There is no safety shower at the plant and dust extraction controls may need to be improved. We have not seen the condition of the chemical delivery area or the storage facilities, these may need some improvements. Assuming a dosing line flow meter is installed as an independent check, and the control/programming and dust suppression upgrades are implemented, we estimate that the upgrades would cost approximately $25,000. This figure does not allow for improvements to the chemical delivery and storage area.

4.1.5 Milton Water Treatment Plant

The Milton WTP has a NaF dosing system consisting of an upflow saturator and dosing pump located in an isolated room. The fluoride dosing system is flow paced. The Milton WTP is classified as a minor supply and hence requires one independent check of the fluoride dose in order to be compliant with the CoP. There are currently no independent checks of the fluoride dose. The least expensive independent check would be to install a flowmeter on the dosing line. A fluoride analyser would be a more robust independent check, but it would be more expensive. There is a safety shower at the plant. The dust extraction controls may need to be improved. Assuming a flowmeter is installed as an independent check and the dust suppression and extraction systems are improved, we estimate that the upgrades would cost approximately $20,000.

4.2 Cost Summary – CoP Implications

A summary of the estimated capital costs for each plant to meet the CoP is shown in Table 13.

Table 13: Summary of Upgrade Costs to meet the Code of Practice

	Waterloo	Waikanae	Hamilton	Balclutha	Milton
Population Category	Large	Large	Large	Minor	Minor
Fluoride Chemical	SFS	SFS	FSA	NaF	NaF
Upgrade Cost	$15,000	$10,000	$50,000	$25,000	$20,000

5 Concluding Remarks

The base equipment for a fluoridation system can be installed relatively inexpensively. However, in order for fluoridation to be safe for consumers, operators and the environment; proper controls must be in place regardless of system size. These additional controls add cost, which can be significant.

As the cost estimates show, the infrastructure that is existing at a treatment plant has a big impact on the costs of adding fluoridation. Typically smaller plants have less infrastructure than larger ones. Some Small and Neighbourhood supplies may not even have a treatment plant.

The existing configuration of a supply can also affect the costs. The Napier supply is an example of a system that would cost significantly more to implement due to having ten wells feeding directly into the network. Whilst this type of supply is not the norm, it is not unique either. The Christchurch water supply also consists of a network of wells that separately supply the city.

When the cost estimates we have prepared are input into the CBA, it is important to appreciate that while we have given a range of capital costs, this range is not broad enough to cover the situation for all plants in a particular size category. For plants with little or no infrastructure, or supplies with multiple sources, the capital costs will be higher than the upper bound estimate.