Christchurch City Council
SUPPLEMENTARY AGENDA

Notice of Meeting:

An ordinary meeting of the Christchurch City Council will be held on:

Date:	**Thursday 14 June 2018**
Time:	**9.30am**
Venue:	**Council Chambers, Civic Offices, 53 Hereford Street, Christchurch**

Membership

Chairperson	Mayor Lianne Dalziel
Deputy Chairperson	Deputy Mayor Andrew Turner
Members	Councillor Vicki Buck
	Councillor Jimmy Chen
	Councillor Phil Clearwater
	Councillor Pauline Cotter
	Councillor Mike Davidson
	Councillor David East
	Councillor Anne Galloway
	Councillor Jamie Gough
	Councillor Yani Johanson
	Councillor Aaron Keown
	Councillor Glenn Livingstone
	Councillor Raf Manji
	Councillor Tim Scandrett
	Councillor Deon Swiggs
	Councillor Sara Templeton

13 June 2018

Principal Advisor
Dr Karleen Edwards
Chief Executive
Tel: 941 8554

Jo Daly
Council Secretary
941 8581
jo.daly@ccc.govt.nz
www.ccc.govt.nz

Note: The reports contained within this agenda are for consideration and should not be construed as Council policy unless and until adopted. If you require further information relating to any reports, please contact the person named on the report.

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10 Resolution to Include Supplementary Reports

1. Background

1.1 Approval is sought to submit the following report to the Council meeting on 14 June 2018:

11. Well Head Improvements

1.2 The reason, in terms of section 46A(7) of the Local Government Official Information and Meetings Act 1987, why the report was not included on the main agenda is that it was not available at the time the agenda was prepared.

1.3 It is appropriate that the Council receive the report at the current meeting.

2. Recommendation

2.1 That the report be received and considered at the Council meeting on 14 June 2018.

11. Well Head Improvements

Reference: 18/562583

Presenter(s): Helen Beaumont, Programme Manager – Water Supply

1. Purpose of Report

1.1 The purpose of this report is for the Council to be informed of progress on well head improvements and the removal of temporary chlorination.

Origin of Report

1.2 This report *being provided to fulfil the following Council resolutions from CNCL/2018/00073, 26 April 2018:*

4. Resolves to implement temporary chlorination in Wainui until its well is made secure.

5. Requests staff identify funding sources to undertake the well head security improvements when the preferred approach and programme has been confirmed.

6. Requests staff to bring back to a May ITE Committee or Council meeting, a report outlining progress to date and a draft programme of improvements proposed which takes into account the optimum solutions, timing, funding and interdependencies of the water network and future proofing.

2. Significance

2.1 The decision in this report is of low significance as it is an information report. However it concerns an issue of high significance to the Christchurch community.

2.2 Because the decision is of low significance, it is not intended to undertake community engagement or consultation at this stage.

3. Staff Recommendations

That the Council:

1. Receive the information in the Well Head Improvements report.

4. Key Points

4.1 This report supports the Council's Long Term Plan (2015 - 2025):

4.1.1 Activity:

- Level of Service: 12.0.2 Ensure potable water is supplied in accordance with the Drinking Water Standards for New Zealand (microbiology)

4.2 In March 2018 the Council implemented temporary chlorination to water supplies to manage the risk of contamination. This action was in response to December 2017 advice from the Drinking Water Assessor, Canterbury District Health Board, that the status of Council's water supply to the city had been changed from provisionally secure to unsecure. This advice was based on the Council's wells not meeting drinking water standards for well head security.

4.3 The objective of the Water Supply Improvement Programme is to ensure that public health is protected and to return Christchurch's water supply to a secure status which would allow the removal of temporary chlorination. The Chief Executive has recently appointed Helen Beaumont as Programme Manager – Water Supply Improvement for a 12 month period from 1 June 2018 to further increase the resourcing and to coordinate across the multiple aspects of the programme.

4.4 The Council's Water Supply Improvement Programme is overseeing the remediation of the well heads and improvements to pump stations. As well heads are remediated or alternative disinfection (ultra-violet or ozone) is put in place the Council will stop chlorination at that pump station. Staff will prioritise use of water from unchlorinated pump stations, as it becomes available, meaning the number of households with chlorinated water will reduce as the work is completed.

4.5 Key progress under the improvement programme to date includes: improving the safety of below ground well heads and 22 pump stations, bringing 11 wells at four pump stations up to standard (no chlorination), and undertaking investigations to support the decisions about the best approach to future proof each well and pump station. Staff have sought Expressions of Interest from ultraviolet light and ozone water treatment suppliers, and from contractors to convert below ground well heads to above ground well heads.

4.6 Well head remediation must address a complex range of issues including aquifer pressure and depth, individual well head configuration, disinfection regimes, backflow prevention, resource consents and proximity to potentially contaminated sites. The two key constraints on accelerating the programme are the availability of specialist drilling contractors and machinery; and the requirement to maintain an adequate water supply across the city.

4.7 Solutions have been identified and confirmed for a further seven pump stations (Tranche 1) where well head remediation is required – design and physical works are underway for these sites. Once the work to is completed, chlorination will be removed from these pump stations. This will bring the percentage of unchlorinated water to about 25%.

4.8 To progress towards the goal of removing chlorination the work programme for the other pump stations will be prioritised and a water conservation campaign initiated to keep demand to winter levels (approximately half the peak summer demand). Keeping demand low will allow wells to be turned off for remedial works while still maintaining an adequate pressure within the water supply network.

4.9 Staff are also now implementing additional measures to reduce taste and odour issues arising from chlorination including flushing pipelines where taste and odour complaints have been received, reducing the chlorine dose where possible, and favouring the use of water from unchlorinated pump stations.

4.10 The Council is undertaking the work programme in the context of an uncertain regulatory future. Central government has announced a review of three waters services and is yet to respond to the recommendations of the Havelock North Drinking Water Inquiry. While changes are likely there remains uncertainty whether a new regulatory framework for potable water supply will be introduced – which may or may not include mandatory chlorination.

5. Context/Background

Christchurch's water supply network

5.1 Christchurch's water supply network has 139 operating wells (also known as bores) which supply the residents and businesses of Christchurch city and Lyttelton Harbour communities with water. There is also a well supplying Wainui, making a total of 140 wells which normally supply untreated water to the community. A further five wells have been drilled recently and further work is underway to connect them to the network.

5.2 Water flows from each well under natural artesian pressure, or is pumped, to the pump station and from there is pumped directly into the water supply network. There are 53 pump stations and each pump station has between one and six wells supplying it. Four pump stations are already secure and unchlorinated (Keyes, Estuary, Prestons and Gardiners). In 2017 three of these pump stations supplied 10 per cent of the water to the Central Zone and 5 per cent of the city's water (Gardiners is currently being commissioned).

5.3 The Council's water supply network for Christchurch and Lyttelton Harbour is divided into 9 water supply zones, each with between one and 26 pump stations.

- The Central zone is the largest supplying 185,000 people (54 per cent of the population)
- The Northwest zone is the second largest supplying 80,000 people (23 per cent of the population).

5.4 In addition there are separate water supply zones for Brooklands/Kainga and Wainui.

The Council's well heads

5.5 Every well has a well head which is the physical structure at the top of the well. The function of the well head is to connect the well to the water supply network. It is essential that all well heads are secure, otherwise contaminants could enter the water supply and people could become ill, some seriously.

5.6 The Council's well heads are of varying age and quality, with the oldest well dating back to 1924. Before the earthquakes most wells were constructed with below ground well heads. Following the earthquakes, there was a change to only constructing above ground well heads, to improve the resilience and safety of wells and security of water supply.

5.7 The Council has 104 wells with below ground well heads and 36 wells with above ground well heads. The 104 below ground well heads are at more risk of becoming contaminated via groundwater or stormwater.

5.8 The Council has had a standard programme to replace three wells per year. Additional wells have been drilled over the past two years to accelerate the replacement of shallow wells in the north west of Christchurch.

Water Supply Safety

5.9 The Drinking Water Standards for New Zealand (DWSNZ) cover all aspects of how to ensure the drinking water supplied to communities is safe to drink. They require drinking water be treated unless the groundwater source can be demonstrated to be secure. The standards refer to the ground water and the well heads.

5.10 To avoid disinfection treatment under the current drinking water standards, three bore water security criteria need to be met:

1. The bore water must not be directly affected by surface or climatic influences (i.e. the water is at least a year old by which time any pathogens will have died)
2. The well head must provide satisfactory protection to prevent contamination of the water supply
3. E. coli must be absent in the bore water.

5.11 The standards have the status of regulations under the Health Act. They are not guidelines and it is mandatory to take all practicable steps to meet the standards.

Secure groundwater status and the impact of Havelock North

5.12 In August 2016 there was a major outbreak of campylobacteriosis in Havelock North with over 5,000 of the town's 14,000 residents estimated to have become ill. The outbreak was traced to contamination of the drinking water supplied by two bores, into the Te Mata aquifer, on the outskirts of the town. The Havelock North Drinking Water Inquiry, Stage 1 report, found that sheep faeces were the likely source of the campylobacter. It is likely that heavy rain flooded paddocks causing contaminated water to flow into a pond; water from the pond then entered the aquifer and flowed across to one the bores. Contamination may also have occurred when water from neighbouring paddocks flowed into roadside drains and entered the bore chambers, contaminating the supply via the unsealed well head – this was considered less likely.

5.13 A number of failures were identified by the inquiry including:

- Poor knowledge and awareness of the aquifer and contamination risks
- Inadequate standard of care for the public drinking water supply
- Unacceptable delays to the preparation of a Water Safety Plan and reports on bore head security.

5.14 This Council has Water Safety Plans for each of its community water supplies across the district. To demonstrate secure groundwater status with the standards, each well head must be inspected by an expert in well head security every five years and signed off as secure. The Council has complied with this by having an external expert assess around 20 per cent of the well heads each year.

5.15 Since the Canterbury earthquakes, and until December 2017, the city's water supply had a 'provisionally secure' status and complied with the drinking water standards without the need for treatment. On 22 August 2017, the annual compliance report was received from the Drinking Water Assessor confirming that the Christchurch water supply was compliant with the drinking water standards and commending the Council on having full bacterial compliance for all distribution zones.

5.16 The Havelock North Drinking Water Inquiry Stage 2 report was released on 6 December 2017. It was highly critical of the Ministry of Health particularly in the area of enforcement of the drinking water standards. It was also critical of the expert assessments of well head security.

5.17 A relevant recommendation from the Inquiry's Stage 2 report was that:

> *[321] The Ministry, via the [Drinking Water Assessors] and Medical Officers of Health, should take urgent steps to administer and enforce the existing regulatory regime, having regard to the findings and recommendations in this Stage 2 Report.*

5.18 In December 2017 the Council received the draft well head security assessment reports from Beca which found that the wells did not meet the security requirements of the drinking water standards.

5.19 On 20 December 2017, the Director-General of Health issued a statement under the Health Act 1956 to bring the responsibilities under the Act to the attention of drinking water suppliers. On 22 December 2017 the Drinking Water Assessor advised Council that the status for the Christchurch and Brooklands/Kainga water supplies had been changed from provisionally secure to unsecure. On 19 March 2018 the Drinking Water Assessor advised Council that the Wainui water supply status was also unsecure.

5.20 Staff assessed the Council's position in response to the Director General's statement of 20 December 2017 and the loss of the 'provisionally secure groundwater' status and recommended accelerating the well head repair and improvement programme (started in August 2017) and also temporarily chlorinating the water supply to reduce the risks to public health.

Providing safe water – temporary chlorination

5.21 On 25 January 2018 Council voted in favour of fast-tracking the below-ground well head improvement programme and implementing temporary chlorination for 12 months, as an additional risk management process, while the well head improvement work is underway.

5.22 Temporary chlorination started in the Brooklands/Kainga zone on 26 March 2018 and was progressively rolled out at pump stations across the city. The last pump station to be chlorinated was Wainui on 9 May 2018.

5.23 Under the drinking water standards, a chlorine dose of 0.2 milligrams per litre (mg/L) with a 30 minute contact time is required to kill the target pathogens. To achieve this contact time requires a storage tank with a retention time of 30 minutes. However, most Council pump stations do not have a storage tank, so a 30 minute contact time is not possible before the water reaches the first customer.

5.24 Given the lack of storage tanks, an independent expert in chlorination is advising Council on the most appropriate temporary chlorination regime. The initial advice provided was that chlorine be dosed at 1 mg/L with 1 minute contact time. Chlorine breaks down when it comes into contact with organic matter so the level of free available chlorine isn't constant across the network. The maximum acceptable value (to avoid health effects) for chlorine in the drinking water standards is 5 mg/L. The aesthetic guideline value (to avoid taste and odour effects) for chlorine is 0.6 mg/L.

5.25 Temporary chlorination has cost $2.3 million to install with an estimated annual operational cost of $1.1 million to treat and monitor the network, and maintain the temporary plant (for more detail see Attachment A).

6. Progress Update

Reducing the amount of chlorine in the water supply

6.1 Council staff are pursuing several strategies to reduce the amount of chlorine in the water supply:

6.1.1 Favouring the use of four pump stations (Estuary, Keyes, Prestons and Gardiners) that are not chlorinated. These could supply about 5 to 10% of the city's water supply.

6.1.2 Reducing the chlorine dose by up to 50% where there is at least a 2 minute contact time before the first customer and where this reduction would not worsen smell and taste issues. Implementation will take a couple of weeks and chlorination would then be reduced by up to 50% at those pump stations.

6.1.3 Ceasing chlorination at pump stations whose below ground well heads can be isolated and the above ground well heads can be made secure. This is possible where the above ground wells heads would still provide sufficient water including for emergencies such as fire-fighting. Implementation and sign-off would likely take a few weeks.

Well Head Security Improvement: progress to date

6.2 The objective of the water supply improvement programme is to ensure that public health is protected at all times. The goals of the programme are:

Short term:

To return Christchurch's water supply back to secure status or similar to the satisfaction of the Drinking Water Assessor in the most timely, economic, and technically sound manner possible to allow the removal of temporary chlorination.

To develop solutions which improve the likelihood of gaining an exemption to chlorination in the future.

Long Term:

To provide a public water supply network to improve the likelihood of gaining exemption to chlorination.

6.3 Staff have undertaken a substantial programme of work to reinstate secure groundwater status. Since January 2018 the Well Head Security Improvement Programme has:

a. Improved the security of the below-ground well heads at eleven pump stations

b. Made improvements to wells at four pump stations to bring them up to drinking water standards and avoid chlorination (Keyes, Prestons, Estuary and Gardiners) – and favoured the use of water from these pump stations

c. Introduced temporary chlorination where required (48 pump stations)

d. Commissioned and received a report on the options for remediating below ground well heads

e. Undertaken assessments of the work required to remediate each and every well, including cost estimates

f. Undertaken preliminary modelling to determine which pump stations could be abandoned

g. Assessed alternative locations for wells to replace those most vulnerable to contamination from flooding

h. Started investigating the reduction of the chlorine dose where there is at least a two minute contact time

i. Flushing pipelines where taste and odour complaints have been received

j. Started investigating the temporary isolation of below ground well heads at pump stations with a majority of above ground well heads – to enable chlorination to cease at these pump stations (potentially Lake Terrace, Thompsons, Burnside, Farrington and Grampian)

k. Issued and received Expressions of Interest to ultraviolet light and ozone water treatment suppliers

l. Commissioned and received a report on the practicality and cost of ultraviolet light treatment at 12 pump stations and ozone treatment at one pump station

m. Issued an Expression of Interest (which closed on 6 June 2018) inviting contractors to submit on converting below-ground well heads to above-ground and to suggest any innovative solutions to achieve secure status

n. Received advice on European best practice for unchlorinated water supplies.

Well Head Remediation: Immediate works to seven pump stations (Tranche 1)

6.4 On 26 April 2018 the Council approved staff proceeding with raising well heads above ground where this was the obvious solution. Following a rapid assessment staff have selected seven pump stations for immediate works:

- Grampian, Farrington, Burnside and Hills pump stations each have one well with a below ground well head with the remainder of the water supplied from wells with above ground well heads. The solution for these pump stations is to raise the remaining well heads. Best practice grouting (over-drilling and grouting to achieve a full seal around the well casing) will be used.
- Kainga pump station has one well with an above ground well head and the solution for this is to undertake minor remedial works so that the well head can be signed off as secure.

- Grassmere and Mays pump stations are served by three wells each. One well at each pump station takes water from the shallowest aquifer and in both cases these wells are a high priority for renewal. These wells will be renewed in the 2018/19 financial year as part of the Council's long term well renewal programme. The remaining four wells at these pump stations have below ground well heads and these will be raised. Best practice grouting (over-drilling and grouting to achieve a full seal around the well casing) will be used.

Pump Station	Water Supply Zone	Wells	Planned Remedial Works
Burnside	North West	1 below ground well head and 5 above ground well heads	Raise below ground well head above ground, minor works to make above ground well heads secure
Farrington	North West	1 below ground well head and 4 above ground well heads	Raise below ground well head above ground, minor works to make above ground well heads secure
Grampian	North West	1 below ground well head and 1 above ground well head	Raise below ground well head above ground, minor works to make above ground well head secure
Hills	Central	1 below ground well head and 2 above ground well heads	Raise below ground well head above ground, minor works to make above ground well heads secure
Grassmere	Central	3 below ground well heads	Drill one replacement well, raise two below ground well heads above ground
Mays	Central	3 below ground well heads	Drill one replacement well, raise two below ground well heads above ground
Kainga	Brooklands/Kainga	1 above ground well head	Minor works to make above ground well head secure

6.5 The estimated cost for the above works is up to $5 million and will take 12 months to fully implement. Designs have been completed for Grampian and Farrington and the works are out to tender. Design is underway for the remaining 5 pump stations. The initial capital works package of pump stations can be funded from the 2018/19 Water Supply Headworks and Pump Station renewals in the draft Long Term Plan (LTP).

6.6 These seven pump stations supplied 17% of the city's water in 2017. Together with the four unchlorinated pump stations at Keys, Prestons, Estuary and Gardiners, the work to the seven pump stations will mean that about one quarter of the city's water will not be chlorinated.

Well Head Remediation: work to the remaining 42 pump stations (Tranches 2 and 3)

6.7 Staff are investigating the most appropriate solutions for the remaining 42 pump stations. Potential solutions to bring these pump stations to drinking water standards include:

- Raising well heads
- Treating with alternative disinfection – ultra violet or ozone treatment
- Drilling a replacement well
- Not using a well (i.e. turn off those with below ground well heads).

6.8 Attachment B provides some detail on the above solutions.

6.9 To determine the most appropriate solution for each pump station staff will consider factors such as:

- Practicality – both to undertake and for long-term maintenance
- Cost – capital and ongoing operational
- Time to implement.

6.10 The work programme will factor in the two key timing constraints for well head remediation:

- The availability of suitable drilling machines and specialist contractors
- The number of wells that can be taken out of service at any one time while still maintaining adequate water supply.

6.11 In developing the work programme staff will also consider what remedial work might be needed to obtain an exemption from any mandatory treatment introduced by central government. Work to obtain an exemption may be broader than work to well head security only. Work to other parts of the water supply system such as backflow prevention may be required.

6.12 The draft Long Term Plan (LTP) includes a planned spend of $35 million over 10 years for Water Supply – Headworks Well Renewals and Christchurch Well Head Security. This could be brought forward into the first three years of the LTP, with any additional funding that may be required being consulted on as part of a future annual plan, LTP, or special consultative procedure.

6.13 It is likely that implementation of the full work programme would exceed $35 million. The issues of funding and community consultation will be addressed in the September 2018 report.

Appointment to new Programme Manager Role

6.14 The Chief Executive has appointed Helen Beaumont to the new role of Programme Manager – Water Supply Improvement. This 12 month secondment from Helen's substantive role as Head of Strategic Policy commenced on 1 June 2018. This role reports directly to the Chief Executive and has been established to further bolster the resourcing for this key area of focus. This position will coordinate work underway across Council including:

- Temporary chlorination including its reduction
- Well head remediation and improvement
- Water supply strategy including a focus on the Government's current forward work programme around drinking water, and the uncertainty that creates.
- Central government and local government liaison in relation to the findings of the Havelock North Drinking Water Inquiry
- Communications with residents, Community Boards, and Councillors.

6.15 Council will receive a monthly report on progress including options for the future work programme.

Attachments

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Signatories

Author	Helen Beaumont - Programme Manager - Water Supply
Approved By	Karleen Edwards - Chief Executive

Temporary Chlorination costs

Capital expenditure for installation

The supply and installation of temporary chlorination equipment was originally estimated at $690,000 based on the experience of temporary chlorination following the earthquakes. After completing scoping and planning this was revised to $2,251,000 to meet legal requirements for health and safety and handling hazardous substances. The increased budget covers:

- Specially commissioned hypochlorite storage tanks to be manufactured in NZ (25 year life) in accordance with WorkSafe NZ Health and Safety at Work (Hazardous Substances Thermoplastic Stationary Tanks) Safe Work Instrument 2017.
- Chlorine supply to all tanks for duration of commissioning.
- Chlorine monitoring on daily basis as directed by DWA (previously estimated weekly)
- Completion of documentation relating to WorkSafe procedures for each Site.
- Quality assurance processes to ensure full compliance with regulations
- Expert consultant inspecting all installations.

The commissioning will be complete at the end of June 2018.

Operational expenditure for ongoing chlorination

The maintenance contract to begin in July 2018 is estimated at $1,290,000 per annum and includes:

- Technical engineering support and reporting – fortnightly activity report
- Operational and maintenance staff including vehicles and consumables – weekly inspections and assumes 1.5 hours per site per week
- Supply of chlorine including delivery and testing – to achieve 100% availability at agreed sites
- Provision for call-out and non-scheduled maintenance items – 24/7 alarm response to be attended within 60 minutes and chlorine dosing resumed within 90 minutes

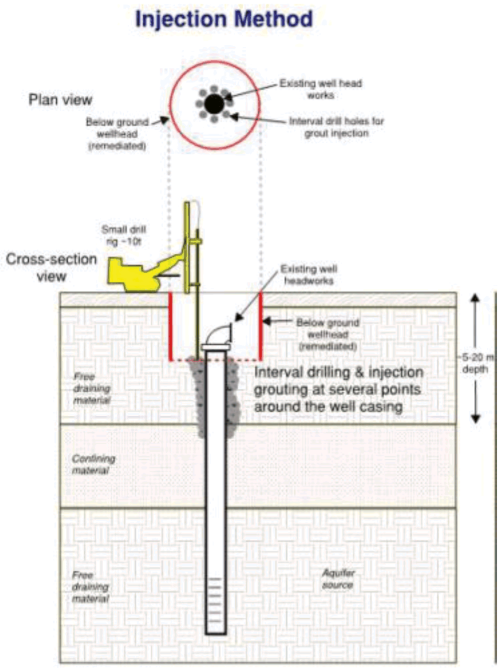
Summary table comparing disinfection and remediation options

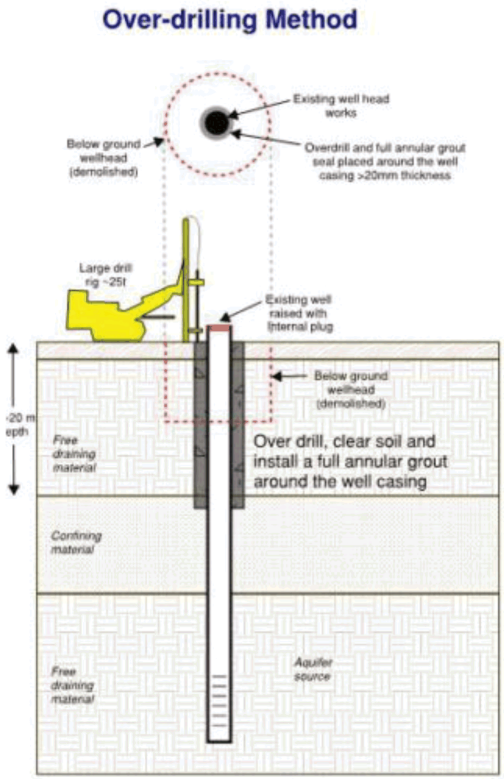
Treatment	Treatment Application	Pros	Cons	Barriers and Constraints
1. Chlorination Treatment	Chlorine has been used around the world for 120 years and its widespread use has been a major factor in reducing illness and deaths from waterborne diseases. It is the most common form of treatment in the world. Every other major city in NZ uses chlorination as their primary treatment. Chlorination is the process of adding chlorine to drinking water to disinfect it and kill germs. Council use sodium hypochlorite solution (NaOCl) at 13.5% concentrate. Commonly occurring bacteria and pathogens require one minute of contact time with a chlorine level of 1 mg/L to inactivate them. Council are temporarily chlorinating at this level. Chlorine levels and deliveries are monitored via the Council Piplot chlorination system installed at each pump station, allowing real time recording of servicing requirements and usage which Council can track.	Very effective treatment dosing agent for bacteria and viruses. The lowest cost treatment option. Quick to implement (and discontinue). The only treatment method which can maintain a residual disinfectant in the reticulation.	When it is first introduced, there may be issues with taste and odour as the chlorine reacts with organic material in the system. In a small number of people, chlorine can be an irritant for an existing condition such as asthma or eczema. Only partially effective at inactivating protozoa. UV is needed in addition to chlorine if the source water is unsecure.	To fully comply with DWSNZ, a 30 minute contact time and a residual of 0.2 mg/L free available chlorine is required. This would require new contact tanks at most pump stations and booster chlorine dosing stations.
2. Ultraviolet Treatment (UV)	UV is an effective water treatment agent. The radiation damages the internal cell structure of the bacteria or protozoa and 'inactivates' them by preventing reproduction. UV lamps are placed inside quartz sleeves (which are completely transparent to UV light) within a 'reactor' vessel through which the water is passed.	No chemicals added to water, or handled at the plant. More effective than chlorine at inactivating protozoa, including giardia and cryptosporidium.	No residual disinfectant in the network. More complex installation than chlorination, and potentially significant consequential costs.	UV units need to be protected by a building, but many of our pump stations don't have a building or it is too small for UV to fit inside. In many cases a new building or container would be required.

Treatment	Treatment Application	Pros	Cons	Barriers and Constraints
	Conceptually simple, the implementation needs to take into account several factors that can significantly increase the cost. These factors are not just limited to additional metering and control, but also issues including time needed to warm up the lamps, limiting the number of times a day the UV is turned on and off, and disposal of any turbid water (especially as the well starts up). In Christchurch, because most water is delivered direct to the network (rather than to a reservoir), frequent variations in water demand and pressure would also have to be addressed in the design. Indicative estimates are in the order of $300,000 for a small pump station, $700,000 for a medium pump station such as Grassmere or Mays, and $1.2 million for a large pump station such as Main Pumps. It is important to understand that these estimates are for the UV supply and install only (including control and mechanicals). Consequential works to power supply (including back-up systems), new buildings, and disposal of turbid water can be significant (at a recent Wellington project, the consequential works were five times the install cost).	No moving parts. Proven technology.	Higher operating costs than chlorine (power, lamp cleaning and lamp replacement), plus higher qualified operators to operate the system.	Turbidity needs to be consistently low for UV to meet the DWSNZ, however some wells have high turbidity when they first start pumping. This water would need to be discharged to a drain or stream if turbidity is high for too long a period to meet the DWSNZ. This can add significant cost if the discharge point is far from the pump station. A resource consent to discharge water would also be required. Changes to the pipework at the pump station would also be required to accommodate the UV. All of the above could significantly increase the time and cost of implementation.
3. Ozone Treatment	Ozone is an unstable colourless or pale blue gas at room temperatures and pressures. It has a distinctive sharp odour which can be noticed by most people at very low concentrations It occurs naturally in the outer atmosphere where intense UV light breaks oxygen (O_2) molecules apart into oxygen atoms, some of which recombine as	Effective at killing bacteria, viruses and protozoa. Can fully meet DWSNZ requirements for a barrier to bacteria and protozoa.	High capital cost to implement ozone disinfection (for a typical pump station with a flow of 260 L/s) for such a site is likely to be in the range of $5-	Bromine concentrations in our groundwater exceed the DWSNZ limits for ozone treatment. Staff are to determine whether this can be treated.

Treatment	Treatment Application	Pros	Cons	Barriers and Constraints
	ozone (O_3). It can also occur in small concentrations in the lower atmosphere due to lightning or other electric discharges (e.g. welding, electric motors), or due to other chemical reactions. Ozone is a very powerful oxidant and has a variety of industrial uses including as a water treatment chemical. The first recorded use of it as a potable water disinfectant is in 1893 in the Netherlands. It is used throughout the world, and interest in its use for water treatment increased following disease outbreaks caused by protozoa. Ozone's powerful oxidising strength makes it a very effective disinfectant, as it physically damages and deactivates particles including bacteria, protozoa and viruses. It also reduces tastes and odours associated with organic matter in the water, and tends to have fewer disinfection by-products than chlorine. Ozone does not provide a persistent disinfection residual – it disperses or degrades quickly (in the order of a few minutes) so does not protect against re-contamination in the distribution network or reservoirs. In any case, the toxic nature of ozone means that any residual must be removed from the water before it enters the reticulation system (which may require additional chemical dosing using hydrogen peroxide or similar). In NZ, ozone is used at Timaru (Claremont WTP) in conjunction with chlorine, for disinfection and taste	Produces fewer disinfection by-products than chlorine when used on waters containing organic matter. Will reduce taste and odour at same time as disinfecting the water. Very effective at oxidising manganese, though this is not an issue for Christchurch.	8 million. Operational costs may be lower than for UV but higher than chlorine. Ozone is very aggressive to many materials, and installations require careful design. Not well suited to numerous small WTPs due to poor economies of scale. It does not provide a residual disinfectant in the reticulation. It is hazardous to health in high and low doses and care must be taken to ensure that excess ozone is destroyed before it exits the plant (either in the water or as a gas). One by-product of potential concern is bromate which is potentially	To comply with the DWSNZ ozone contact tanks are required. This would require new contact tanks at most pump stations, which would significantly increase the time and cost of implementation.

Treatment	Treatment Application	Pros	Cons	Barriers and Constraints
	and odour reduction. This supplies all of Timaru. Ozone is also used at Oamaru, for taste and odour reduction (again in conjunction with chlorine). This supplies Oamaru and some outlying towns.		carcinogenic. This risk of this depends on the levels of bromide in the source water.	
4. Well Head Remediation Options	The below ground well heads security improvement review (Beca, March 2018) described two methods for retrofitting grout seals and these are shown schematically below. The first method involves injection of a bentonite/concrete fluid around the casing to the desired depth. The second method involves over-drilling the casing with a larger casing and then backfilling the annulus with the bentonite/concrete fluid while the outer casing is withdrawn The injection method has been assumed for all wells where the below ground well head is to be maintained while the over-drilling method is assumed for chambers that are to be brought above ground. However, it would also be possible to raise the well head above ground but only do injection grouting.	**Injection grouting** Chamber can be maintained, only the floor will need to be replaced. Likely to take a few days and in some cases the well can be left in service. Smaller sized drill rig required. **Over-drilling** Considered a full annular grout seal and provides full protection around the casing. The below ground well head would be brought above ground which is a preferred solution in terms of well head protection	**Injection grouting** Does not provide a full annular grout seal and so cannot provide full protection around the casing. Testing can be done to check this i.e. monographic downhole geophysical testing. Low risk of damage to the well casing. **Over-drilling** The headworks piping must be removed and the below ground well head either demolished or filled in to allow access for the 25 tonne drilling rig. In this situation it is not worth retaining the well head below ground. The well cannot be left in service during over-drilling and grouting.	We can only take a limited number of wells off line at once and still provide enough water for the community and fire fighting. This increases the time for implementation. There are a limited number of contractors with the right equipment and experience to undertake the work. There are five in the South Island, four of which are based in Canterbury and one is based in Timaru. The limited number of contractors increases the time for implementation. Raising a well head above ground may mean an artesian well may no longer flow or will have significantly reduced capacity. If this is the case, it would trigger the need for a well pump and a suction tank, which would significantly

Treatment	Treatment Application	Pros	Cons	Barriers and Constraints
			Low risk of damage to the well casing.	increase the time and cost for implementation. Wells that take water from the shallowest aquifer may not meet Criterion 1 for bore water security under the DWSNZ (bore water must not be directly affected by surface or climatic influences) and so even if we remediate the well head it may not be signed off as secure. This would mean that treatment is required if the well is to remain in service.

Treatment	Treatment Application	Pros	Cons	Barriers and Constraints
				
5. New Wells	Council have an ongoing wells renewal programme, replacing three wells per year.	New well should provide 60 years of supply (extensive	Substantial works programme for each well (drilling –	There are a limited number of well drilling contractors and

Treatment	Treatment Application	Pros	Cons	Barriers and Constraints
	Well replacement is driven by: 1. Wells have reached the end of their useful life (asset is degraded) 2. The well takes water from a shallow aquifer, which is at more risk of contamination 3. Well extraction has reduced (post-earthquake) 4. New wells to supply water to meet growth demand.	testing occurs prior to well drilling)	headworks – link to pump station. The capital cost is high, around $1 million per well (including drilling, consenting, headworks, testing etc.)	limits the number of wells we can drill at once. Resource consents are needed for new wells and this impacts on the timeframe for implementation. It is not desirable to drill new wells in areas where there are no deep aquifers (e.g. at the base of the Port Hills).

Attachment B Item 11