

# UV PEROXIDE – A NEW ZEALAND APPROACH

*Daniel Stevenson (Harrison Grierson) and Holger Zipfel (Harrison Grierson)*

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## ABSTRACT

Water sources in New Zealand are coming under increased environmental stresses due to climate change, microbial contamination, nutrient inputs, algal blooms, and cyanotoxins. These toxins can result in the water becoming distasteful with an unpleasant odour. Water authorities are then left with increased taste and odour complaints.

New Zealand consumers expect high quality fresh tasting drinking water. Traditional water treatment processes are ineffective at significantly reducing taste and odour issues.

There are several proven technologies available to treat taste and odour in water. In the New Zealand context, only some of these technologies are applicable. This paper reviews the use of UV peroxide in New Zealand for advanced oxidation of taste and odour causing compounds. Advanced oxidation has been used successfully internationally since the 1980s for control of taste and odour issues. However, only recently has UV peroxide begun to be used in New Zealand.

This paper outlines the recent upgrades to the Invercargill City Council's (ICC) Branxholme WTP as a case study for UV peroxide application within the New Zealand context. Invercargill City Council was the first Council to commit to this technology on a large scale. The recently completed and successful 45MLD upgrade to the Branxholme WTP includes the largest water treatment UV peroxide installation in New Zealand.

Discussed are the challenges faced by the Branxholme WTP and the decision making process that led to the selection of the UV peroxide technology. The paper outlines the design decisions made and lessons learnt in the design, construction, commissioning and operation of the UV peroxide plant.

The paper includes a discussion of how UV peroxide was incorporated in the existing plant treatment train, and decisions on the method used for peroxide quenching. A comparison is made to different design approaches taken in smaller installations at other New Zealand water treatment plants (WTPs) and the reasoning behind these decisions.

Since the construction of the Branxholme WTP UV peroxide plant, ICC have not had to deal with any customer taste and odour complaints.

## KEYWORDS

**Taste and Odour, UV Peroxide, Advanced Oxidation**

## PRESENTER PROFILE

Daniel is a Process Engineer within the Auckland water and wastewater team. He has experience working through WTP upgrade projects from initial concept to detailed design including upgrades to the Branxholme, Paeroa and Waihi WTP's.

Holger is a Project and Design Manager with over 19 years' experience in the consulting, product development industries as well as the engineering, procurement, and

construction business. Holger provided mechanical engineering design expertise and construction assistance for Branxholme WTP upgrade.

# 1 INTRODUCTION

Issues around water and its management including drinking water and its aesthetic properties have become increasingly important to the public. It is critical that the appearance, taste and odour of drinking water be acceptable to maintain consumer confidence in the treatment process. Aesthetically unpleasing water can cause consumers to question the safety of the water supply. This can lead to consumers turning to alternative water sources that are aesthetically more acceptable, but potentially less safe.

Many water suppliers in New Zealand struggle with taste and odour complaints from their customers whilst also trying to maintain clean safe drinking water. This is exacerbated by fresh water resources coming under increasing demand and ecological pressure in many areas of New Zealand. In recent years many water suppliers have chosen to prioritize taste and odour removal in upgrades to water treatment plants.

Of note is the increase in taste and odour issues in cooler regions that typically experience less algae growth and taste and odour issues. This could be attributed to climate change, changes in catchments or increases in nutrient loading on fresh water sources.

## 2 CAUSES OF TASTE AND ODOUR

The taste and odour properties of drinking water are subjective and different people will have different sensitivities for detection and intensity. Issues most readily arise when the raw water conditions change or supplies are changed to new water sources with different taste and odour profiles.

Taste and odour issues can be attributed to a number of factors including algae, organics from decaying vegetation, hydrogen sulphide, natural inorganics (such as iron and manganese) or water treatment chemicals (such as chlorine).

Taste and odour issues in surface water sources have been associated with blue green algae, Actinomycetes, fungi and decaying vegetation among others. Evidence suggest that taste and odour compounds may be produced both in the aquatic environment and in the terrestrial environment, transported to waterways by runoff. As such the presence of these species in waterways may indicate a risk of taste and odour events but do not always correlate with such events (Zaitlin, B & Watson, S.B., 2006).

A number of odour producing organic compounds have been identified in water associated with earthy, musty, grassy or fishy odours. The most common of these being geosmin and 2-methylisoborneol (2-MIB) (Wnorowski, A.U., 1992). These two compounds can impart objectionable odours at concentration as low as 10 ng/L. Sampling for taste and odour often considers these two compounds as an indicator of taste and odour issues and a measure of taste and odour removal.

Natural algae levels generally increase in the summer months with the combination of the low flowing stream and warm temperatures. As a result taste and odour issues tend to be seasonal around summer months.

### **3 FRESHWATER STREAM QUALITY**

A recent Ministry for the Environment & Stats NZ report (2017) has identified that nitrate-nitrogen levels are worsening at 55% of monitored sites. In monitored river sites in the pastoral class this was higher at 61%. Dissolved reactive phosphorus was found to be improving at more sites than worsening. However 25% of monitored sites had worsening dissolved reactive phosphorus levels. These increase in organics levels may adversely affect the taste and odour of some water supplies.

Of the total river segment length of large rivers, 83% was not expected to have regular or extended algal blooms. This is because it was modelled to either meet the periphyton national bottom line in the National Objectives Framework (60%) or had fine sediment (23%) that does not usually support algal growth. Assessment was only made on large rivers, stream order 3 and greater, as the input data used to form the model was collected from these stream types. The study was designed to estimate the extent of rivers and streams in New Zealand with an abundance of periphyton/algae (estimated at 17%) (Ministry for the Environment & Stats NZ, 2017). As such it gives an indication of the impact of algae on streams and rivers in New Zealand but not an indication of how this may be affecting the aesthetic properties of the water.

### **4 TASTE AND ODOUR CONTROL**

The control of taste and odour can be managed in the following three areas; prevention in source water, removal through water treatment plant processes and controls in the distribution system. Effective taste and odour control should consider all these aspects.

At the source water, catchment management should be in place to reduce the impact of catchment activities on the water source and its taste and odour properties. Other source management techniques may include management of raw water reservoir stratification, source water flows or algal growth through the use of ultrasonic or chemical dosing. Any source water control method must consider the environmental and cultural impact and must seek to restore the mauri to the source water.

The removal of taste and odour causing compounds through water treatment plant process is discussed further in section 5. The method of taste and odour removal will depend on the particular taste and odour issues faced and the raw water characteristics. Additionally when upgrading existing treatment plant process the effect of the existing treatment train must be considered. This paper focuses primarily on the removal of taste and odour issues caused by organic compounds as these are most commonly encountered.

Economics are an important consideration when selecting taste and odour removal treatment processes. These processes can have significant ongoing operational costs that must be balanced with removal objectives. Economics are not discussed in detail in this paper. These will vary depending on the removal objectives, plant size, extent and frequency of taste and odour issues.

Control of taste and odour in the distribution system involves managing biogrowth and corrosion. This is typically performed by maintaining a chlorine residual in the distribution network, avoiding dead ends in distribution system and regular maintenance and flushing of the distribution network.

## **5 WATER TREATMENT TASTE AND ODOUR REMOVAL**

Taste and odour removal processes used in water treatment can be grouped into three main methods: aeration, adsorption and oxidation. The optimal method will depend on a number of different factors including raw water characteristics, operational requirements, and spatial constraints.

### **5.1 AERATION**

Aeration allows for high amounts of contact between air and water and can oxidize dissolved iron, hydrogen sulfide, and volatile organic chemicals (VOCs). Aeration can be achieved through a number of different methods including spray nozzles, tray cascade or mechanical aeration.

It is found to be most effective for VOCs and hydrogen sulphide. Oxidization of and removal of dissolved metals can occur but oxidation rates are typically slow and are less effective than with stronger oxidants. Aeration is generally not an effective means of controlling organic taste and odour compounds (Crittenden et al 2005, Kawamura 2000).

### **5.2 ADSORPTION**

Adsorption for taste and odour removal is typically performed by the addition of activated carbon. Activated carbon acts to adsorb the taste and odour causing compounds. As activated carbon has a limited adsorption capability, it must periodically either be replaced or regenerated. Two forms of activated carbon typically used in water treatment include powdered activated carbon (PAC) or granular activated carbon (GAC) filters. Both PAC and GAC are found to be effective at removing organics including taste and odour causing compounds (Hargesheimer, E.E. & Watson, S.B. 1996, Bertone, E et al. 2018, Thiel, P. and Cullum, P. 2007).

PAC is the most common method for taste and odour removal. PAC is typically dosed to raw water in response to taste and odour events (or during peak summer months). Dosing of PAC tends to be very messy and quite operator intensive. Additionally, dosing PAC increases the solids loading on the water treatment plant which must be removed during clarification. This also has the negative impact on the backwash waste streams which may require additional waste handling treatment.

GAC filters for taste and odour removal are more correctly described as GAC adsorbers and are not intended as a means of filtration. They are typically installed post coagulation and filtration but before chlorination. GAC filters require sufficient contact time between the activated carbon and water to achieve effective taste and odour removal. As a result the footprint of these filters tends to be quite large to achieve the desired empty bed contact time (EBCT), typically between 5-30 min (Crittenden et al 2005, Ridal, J.J. 2001).

GAC filters are slowly expended over time as the carbon adsorption capacity is exhausted. Therefore, GAC filters must be regenerated or replaced typically every 4-5 years to remain effective for taste and odour removal. Longer EBCT can increase the carbon life of GAC filters and decrease operating cost (Kawamura 2000, Pirbazari, M. et al. 1993).

Over time biological growth will form on GAC as microorganism in the water are attracted to the activated carbon surface. The biological activity provides some removal and degradation of biodegradable dissolved organic compounds. Ozonation before GAC filters is found to break down organics into more readable biodegrade organic compounds promoting biological growth. These types of filters with high promoted biological growth

are often referred to as biologically activated carbon (BAC) filters. BAC filters alone have been shown to provide some taste and odour removal but are not effective for long term taste and odour control (Zearley, T.L. and Summers, S.R. 2015).

GAC are also commonly added to existing filters to create dual media filter absorbers. However these filters typically have low carbon life due to media losses during backwashing and typically low contact times. As a result taste and odour removal effectiveness quickly drops off (Graese et al. 1987, Pirbazari, M. et al. 1993).

## **5.3 OXIDATION**

Oxidation of taste and odour causing compounds can be very effective at removing taste and odour. A number of different process exist for oxidation and advanced oxidation of taste and odour compounds in potable water. These are discussed below.

### **5.3.1 CHLORINE / CHLORINE DIOXIDE**

Chlorine is more commonly used for disinfection, however pre chlorination can be used to oxidise dissolved iron and manganese. The use of pre chlorination for taste and odour must be evaluated carefully due to the potential to form disinfection by products. This is more common for water with high dissolved organics.

As chlorine is a relatively weak oxidiser (having oxidizing potential of just 1.26V (Grote, Bill 2012) oxidizing reactions tend to be slow requiring high doses and long contact times. To effectively remove iron and manganese oxidation times of 30min and 3hrs respectively are required (Crittenden et al 2005). Catalysing these reactions with the use of greensand filtration significantly improves the iron and manganese removal performance. Chlorine dioxide is a stronger oxidant and can provide oxidation and removal of iron and manganese including organically complexed iron in under 20 seconds (Kawamura 2000, Crittenden et al 2005). Chlorine dioxide however is not typically used due to its high cost and potential generation of toxic chlorite and chlorate ions.

Studies have shown that chlorine and chlorine dioxide are ineffective at removing organic taste and odour compounds (Glaze, William H. et al. 1990 and Lalezary, S, et al 1986). Pre chlorination for taste and odour removal also has the potential to lyse algae cells if present releasing intracellular toxins and taste and odour compounds exacerbating taste and odour issues (Wert, E.C. et al. 2014).

### **5.3.2 POTASSIUM PERMANGANATE**

Potassium permanganate is a commonly used oxidant for the oxidation and removal of iron and manganese. Potassium permanganate provides rapid oxidation of iron and manganese over a wide range of pH (Kawamura 2000, Crittenden et al 2005).

In Australia potassium permanganate is regularly dosed to the head of water treatment plant for manganese removal. In New Zealand this practice is less common but is sometimes used particularly for groundwater sources high in iron and/or manganese. Care must be taken when dosing potassium permanganate as slight overdosing can turn water to a characteristic pink/purple colour. This is seen as unacceptable by consumers.

Studies have found that potassium permanganate alone is ineffective for the removal of organic taste and odour compounds such as geosmin and 2-MIB (Glaze, William H. et al. 1990, Lalezary, S, et al 1986 and Lionel Ho et al 2009).

### **5.3.3 ADVANCED OXIDATION**

Advanced oxidation processes (AOPs) were first proposed in the 1980s. During advanced oxidation, hydroxyl radicals are first formed. These hydroxyl radicals are non-selective,

highly reactive and very strong oxidisers. These radicals break down organic compounds into carbon dioxide and mineral acids and are found to remove taste and odour causing compounds very effectively. Different advanced oxidation processes vary in the methods used to create the hydroxyl radicals. This typically involves the use of hydrogen peroxide, ozone or UV, however other less common methods exist.

## **OZONE / PEROXONE**

Ozone is a very strong oxidant and an effective disinfectant. Ozone is found to partly oxidize natural organic matter to more easily biodegradable organic compounds. Despite this, ozone alone is found to be ineffective for the removal of organic taste and odour compounds such as geosmin and 2-MIB (Glaze, William H. et al. 1990, Lalezary, S, et al 1986). However, when combined with granular activated carbon (GAC) filters, UV or hydrogen peroxide (also referred to as peroxone) can provide effective taste and odour removal.

Due to its low stability, ozone is typically generated onsite using ozone generators. Onsite ozone generation introduces significant chemical hazards due to ozone's highly toxic and highly reactive nature (BOC 2015). Ozone is also known to react with bromide forming bromate identified as mutagenic and a probable human carcinogen (WHO, 2005). Bromate has a Maximum Acceptable Value MAV of 0.01mg/L in the Drinking Water Standards for New Zealand 2005 (revised 2008) (MOH 2008). The reaction equilibrium and thus conversion of bromide to bromate depend on a number of different factors including ozone dose rate, concentrations of natural organic matter, pH, temperature and alkalinity (Von Gunten, 2003, Krasner et al 1993).

Due to the risk of bromate formation ozone is not recommended for treating water with bromide levels of above 0.02mg/L without careful consideration to bromate formation. Raw water sources in New Zealand are found to be typically quite high in bromide, therefore ozone (including peroxone and ozone UV) is not commonly used for municipal potable water treatment.

## **UV PEROXIDE**

UV peroxide is an advanced oxidation process that involves dosing hydrogen peroxide upstream of UV. UV irradiation converts peroxide to hydroxyl radicals which rapidly oxidizes organic compounds. In order to provide effective hydroxyl generation higher power UV reactors are used for advanced oxidation than used for disinfection alone. UV peroxide is found to be less energy efficient when compared to ozone UV due to its lower hydroxyl radical formation (Zoschke, K. et al. 2012).

UV peroxide is found to provide effective taste and odour removal (Glaze, William H. et al. 1990, Lalezary, S, et al 1986, Mofidi, A.A. et al. 2002, Jo, C.H. et al 2011). The degree of taste and odour removal is found to increase with both UV dose and peroxide dose (Antonopoulou, M. et al., 2014, Mofidi, A.A. et al. 2002, Jo, C.H. et al 2011, Zoschke, K. et al. 2012).

## **QUENCHING**

During the process of advanced oxidation not all the peroxide or ozone is converted to hydroxyl radicals. Therefore quenching of residual unreacted peroxide/ozone is required. Quenching is typically performed using GAC contactors or chlorine dosing. Peroxide dosing can also be used to quench residual ozone (Jans, U & Hoigné, J 1998, Keen, O.S et al 2013).

Quenching with chlorine involves high chlorine doses, which can result in increased formation of trihalomethanes (THMs). This risk must be considered when quenching particularly for sources high in organics.

## **6 CASE STUDY: BRANXHOLME WTP**

Invercargill City Council recently completed a major upgrade of its Branxholme Water Treatment Plant in 2017. Branxholme is the sole water source for the Invercargill and Bluff (approximately 51,000 people). The objectives of the upgrade were the following:

- Increase the capacity of the plant from 34 to 45MLD
- Provide full compliance with the Drinking Water Standards for New Zealand 2005 (revised 2008)
- Provide effective taste and odour control
- Improve plant automation and operational stability

Plant upgrades were carried out by UGL and practical completion was achieved in June 2017.

### **6.1 DESIGN DECISIONS**

Pre upgrade taste and odour had been identified as an issue from the Oreti River source. Taste and odour events typically occurred during warmer summer months (Dec-March). To respond to these taste and odour events, a PAC batching and dosing plant was established. PAC was dosed to raw water 1-2 min upstream of coagulant and clarification. It was reported that the plant's reliance on PAC dosing was increasing.

Issues were raised about the PAC plant's capacity and the operator hours required to run it. This was particularly important as the taste and odour period tends to coincide with peak demand dry months. It was noted that up to 45 25 kg bags per day were required to be loaded into the PAC plant at peak plant flow and PAC dose. Additionally, this was increasing the solids loading on the plant increasing stress on filters and clarifiers.

An options report developed by H2ope (now Lutra) identified a number of treatment options to deal with taste and odour, including a PAC plant upgrade, GAC/BAC filters, ozone GAC and UV peroxide. UV peroxide was selected through a multi criteria analysis as the preferred option due to its raw water properties (elevated bromide), ease of operability, and additional protozoal log credits provision.

A design decision was made early in the design following an evaluation of the potential impact of Assimilable Organic Carbon (AOC) levels that would result from the advanced oxidation process. Elevated AOC may contribute to excessive biofilm growth in the reticulated potable water network. Pre and post filtration samples from the water treatment plant were sent to Australia for AOC evaluation. A benchtop cost comparison of Capex and Opex for GAC quenching and Chlorine quenching had both technologies at about break even after 10 years. The advantage of a reduced biofilm build, up coupled with the extra hazards involved with chlorine quenching swayed the decision to GAC.

### **6.2 DESIGN CHALLENGES**

The main design challenge for installing UV peroxide into the existing Branxholme WTP was integration into the plant's existing hydraulic grade. The UV unit required to achieve advanced oxidation of up to 45MLD at Branxholme was larger than initially anticipated.



The UV unit installed was a Wedeco K143 (600W) reactor. The reactor is 6.5m long, has 144 UV lamps (with capacity for a further 24 lamps), weighs 16 tonnes and has been installed inside a purpose built UV building. As a result of its size, installing the UV in the tight hydraulic grade between the existing plant filters and treated water reservoirs was not possible. Instead a set of low head high flow lift pumps were installed to pump treated water through the UV.



*Photograph 1: Branxholme WTP UV reactor*

This had the benefit of providing additional head to allow for the installation of GAC contactors for residual peroxide quenching. GAC quenching of residual peroxide was preferred over chlorine quenching as this reduced chemical handling and storage risks, risk of THMs. It provided some reduction in assimilable organic carbon, which could result in an increased biofilm growth in the network. The plant was designed with 4 GAC filters 9.5m long and 3m in diameter providing an EBCT of 3 min (at full plant capacity). The GAC filters were designed by the upgrade works engineers (UGL) and manufactured in Invercargill.

A peroxide plant was designed to safely store and dose peroxide upstream of the UV reactor. Due to the limited chemical delivery options, a safe method of transferring 50% hydrogen peroxide from IBC's to the 10,000L stainless steel peroxide tank was developed. The peroxide plant was designed with particular attention to the hazards posed by peroxide as an oxidizer, corrosive, toxic and ecotoxic substance. Particular care was taken to ensure that the system was protected from over pressurisation from the slow decomposition of hydrogen peroxide to oxygen gas.



*Photograph 2: Branxholme WTP aerial photograph showing the major plant extent inclusive of the GAC filters*

### **6.3 RESULTS**

Upgrades to the Branxholme WTP, New Zealand's largest UV peroxide installation, were completed in June 2017. The plant has shown good performance for taste and odour removal and no customer complaints have been received over the summer period. Summarized below are the results of sampling over the peak taste and odour period. As can be seen, the UV peroxide system was able to achieve up to 1.7 log removal of 2-MIB during a peak taste and odour event.

ICC consultation with Wedeco has indicated that ICC could expect up to a 2 log reduction of 2MiB with maximum available UV dose and an optimal peroxide dose. The UV/peroxide process for the Branxholme treatment plant was designed for a minimum UV transmission of 64.9%. At times, during elevated organic carbon in the treated water, the UV transmission fell below 94.9% with a resultant drop-off in log removal efficiency. During these periods a significantly higher UV dose is required to produce sufficient hydroxyl radicals to maintain the required log removal of 2-MiB.

Date	Pre treatment 2MiB (ng/L)	Post treatment 2MiB (ng/L)	Peroxide Dose (mg/L)	UV Dose (mJ/cm2)	UV Transmission (%)	Expected Log Reduction (ICC Calc)	Actual Log Reduction
13/11/17	3.2	<1	0	40	99.2	0	0.51
20/11/17	4.6	2.2	0	40	97.5	0	0.32
27/11/17	13	8.1	0	40	97.6	0	0.21
30/11/17	4.1	<1	2.5	250	97.7	0.3	>0.61
4/12/17	33	7.8	3	450	97.8	0.6	0.63
11/12/17	34	5.7	3	450	97.7	0.6	0.78
18/12/17	4.4	<1	4	600	97.8	0.5	>0.64
25/12/17	82	-	4	600	98.0	0.5	-
1/01/18	190	3.5	4	600	99.0	1	1.73
8/01/18	73	7.3	4	600	98.2	0.9	1.00
15/01/18	130	4.7	4	800	100.0	1.3	1.44
22/01/18	120	5	4	800	97.4	1.2	1.38
29/01/18	58	3.2	4	800	97.7	1.2	1.26
5/02/18	5.6	3.1	4	800	93.1	<0.5	0.26
19/02/18	<1	<1	4	600	95.8	0.7	-
26/02/18	<1	<1	4	500	93.5	<0.5	-
5/03/18	<1	<1	4	45	93.2	0	-
12/03/18	<1	<1	0	45	97.3	0	-

Table 1: Branxholme WTP taste and odour sampling data summer 2017/2018

Resulting from the first season of the advanced oxidation process the

## 7 CASE STUDY: PAEROA AND WAIHI WTP'S

Hauraki District Council completed upgrades of their Paeroa and Waihi WTPs in 2014/2015. The plant upgrades objective were to increase capacity of the plants to 6MLD and 4.3 MLD respectively whilst ensuring compliance with the Drinking Water Standards for New Zealand 2005 (revised 2008). The upgrades included installation of membrane filtration plants at both sites. At the time of upgrade taste and odour was identified as a potential treatment risk. It was decided to hold off installing specific taste and odour treatment to assess the performance of coagulation and membrane filtration on taste and odour. An allowance was made for future installation of a UV downstream of the membranes for advanced oxidation of taste and odour if required.

### 7.1 DESIGN DECISIONS

Following main plant upgrades it was found that taste and odour issues remained. Taste and odour issues were particularly pronounced at Waihi with the introduction of a new water take from the Ohinemuri River. A decision was made to go ahead with installation of UV peroxide for advanced oxidation of taste and odour in Sept 2016. This contract was awarded to Filtec and was completed in March 2017. Paeroa and Waihi WTPs were the first supplies in New Zealand to employ UV peroxide advanced oxidation for the treatment of taste and odour.

## 7.2 DESIGN CHALLENGES

The main challenge for installing UV peroxide at the Waihi and Paeroa WTPs was spatial constraints onsite. These constraints were more pronounced at the Paeroa WTP. In order to save space, chlorine quenching of residual peroxide was performed by dosing from existing onsite chlorine stores. Additionally, 50% hydrogen peroxide is brought to site in 1,000L IBCs and stored and dosed from roll top IBC bunds.



*Photograph 3: Waihi UV reactor (left) and hydrogen peroxide IBC store (right)*

During construction, gassing off of the peroxide was identified as an issue for the dose pumps. In order to minimize these issues suction lines were kept as short as possible and carry water was added to speed up the peroxide dose time. This reduced the amount of gassing off in the line and the chance of air locking of the dose pumps.

## 7.3 RESULTS

At Waihi, a Trojan UVPHOX 72AL75 reactor was installed. At Paeroa, a higher power medium pressure Trojan Swift 4L24 reactor was installed due to spatial constraints. Both UV peroxide plants have been in operation over the 2017/2018 summer taste and odour period and have been effective at managing the taste and odour issues at both sites.

## 8 CONCLUSIONS

In order to maintain public confidence in water supplies and the treatment provided, water suppliers in New Zealand must deliver water that is both safe and aesthetically pleasing. This is becoming increasingly important as environmental pressure increases in a number of our raw water sources leading to increasing taste and odour issues. This is a very important matter to public and must be managed through a combination of source water protection/management, treatment and distribution system controls.

A number of options exist for the removal of taste and odour compounds from raw water sources. The option selected will depend on a number of factors including raw water quality, degree of taste and odour problems, spatial constraints, budget, existing treatment and operational requirements. For removal of organic taste and odour, advanced oxidation provides a good alternative to traditional adsorption process employing activated carbon.

UV peroxide is an appropriate technology that has recently been introduced in New Zealand for potable water treatment. UV peroxide has been installed in medium and small sized WTPs at Branxholme, Paeroa and Waihi. These installations have shown good performance for the removal of taste and odour and have been successful in addressing public taste and odour concerns and the client's operational requirements.

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We would like to acknowledge Invercargill City Council and Hauraki District Council. These Councils were some of the early adopters in New Zealand of advanced oxidation for taste and odour removal. Their supplies stand as examples of how UV peroxide technology can be used effectively in New Zealand for taste and odour control.

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