A Mobile And Portable Water Treatment Plant For Small Town Water Supplies*

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ABSTRACT

This paper details successful trials and implementation of a mobile chemical dispensing system, called the Neutra-Mill Technology, to effect a reduction in turbidity via flocculation/sedimentation, improve colour and adjust pH, in multiple drinking water reservoirs in a cost-effective manner. A portable Neutra-Mill has been used by a regional water authority for the last two years to supply residents of five small towns with drinking water that complied with WHO water quality guidelines. The use of a single portable unit provided a potential capital saving of more than $200,000, with operational costs comparable to that of standard treatment plants. This portable unit provided the water authority with significant flexibility in managing their water treatment assets and provided the consumer with a significant increase in customer service that was evidenced by the drop in consumer complaints.

1.0 INTRODUCTION

The non-metropolitan water industry in the State of Victoria, Australia underwent significant changes in the mid-late 1990s with the amalgamation of 120 water authorities into six regional authorities. A stipulation of the reform process was that all water supplies had to comply with World Health Organisation (WHO) drinking water guidelines by the year 2000 or erect signs in the towns affected that stated the water was not fit for drinking.

Many of the smaller towns that were now part of the regional authorities had declined in population since their establishment earlier this century. Water supply systems had not been upgraded over the years and many towns had populations that could not justify the expense of a standard treatment plant to upgrade the quality of water supplied to the consumer. This is a common problem in many parts of the western world where soldier

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settlements were established following World War 1 and rural populations have declined with the advent of mechanised farming.

To address the issue of economically treating small town water supplies, one water authority, "*Goulburn Valley Water*", conducted trials with a new portable chemical dispensing system, the Neutra-Mill Technology. The trials were successful and a single portable Neutra-Mill has been used as the treatment system for five towns over the last two years. This paper outlines the principle behind the Neutra-Mill Technology, how it has been utilised within Goulburn Valley Water and the benefits it has provided to that authority.

2.0 A PORTABLE MOBILE CHEMICAL DISPENSING SYSTEM

The portable Neutra-Mill challenges conventional approaches to water treatment by floating directly on the water body undergoing treatment, rather than pumping water to a treatment plant (Figure 1). A portable unit consists of a rotating, cylindrical, stainless steel drum, supported between pontoons. When placed on the water undergoing treatment, the drum is partially submerged allowing water to flow through freely. The drum rotates around a horizontal central axis, and is powered by an electric motor, gear box and pulley assembly. Chemical dispensing rates from the drum are controlled by varying its speed of rotation.

Figure 1. A Portable Neutra-Mill Showing the Partially Submerged Drum

The drum has large centrally located apertures at either end to permit the free flow of water and reagent solutions through and out of the drum. Reagent is fed into the drum via a feed chute and an impeller directs reagent solution out the other end. The rotating action of the drum performs the mixing, dissolution and dispersion of the reagents facilitating their release in a plume of fine suspension or concentrated solution. The drum of the unit is designed to retain coarse reagent particles until they have been thoroughly disaggregated and can readily dissolve. This provides a higher reagent efficiency with a much lower energy input than compared with conventional chemical dispensing/water treatment systems with similar treatment capacities. The Neutra-Mill floats on the water body and so uses the buoyancy effect to minimise power requirements.

The portable unit is relatively compact and light, weighing only 750 kg which readily allows the transport of the unit between sites using a light truck or custom built trailer. The unit requires a single phase 2.5 kVA generator for power requirements or mains supply equivalent.

The Neutra-Mill is designed to be fed with dry reagents either manually via 25 kg bags or in bulk amounts using an auger and storage silo set-up. Using dry reagent reduces the occupational health and safety issues associated with the handling and storage of liquid alum or lime slurry and also reduces transport costs as excess water is not being transported to sites.

3.0 TREATMENT LOCATIONS

The Western Region of Goulburn Valley Water is located within an intensively irrigated farming area where water is delivered to the farms via open clay-lined channels. Five towns in the region (Stanhope, Gigarre, Merrigum, Colbinabbin, Corop) presented a challenge in providing WHO quality water by the year 2000 in a cost-effective manner. All have small populations (<500), so the cost of supplying fully treated water on a per capita basis were likely to be high. Capital expenditure of $50,000 to $80,000 per site would be required to supply simple flocculation/coagulation treatment plants.

Domestic water for these towns is also sourced from these agricultural irrigation channels. Water is pumped into storages of between 5-40 ML for limited natural settling and then chlorinated prior to distribution. Historically, the water that was distributed exceeded WHO water quality guidelines for turbidity and colour and had variable levels of chlorine depending on sampling locations within the network. As a consequence residents tended to rely on rainwater as their primary source of drinking water.

Consumer complaints regarding water quality were common and the towns had the potential stigma of signs being placed in the town identifying that their tap water was unsuitable for human consumption if the quality was not improved.

4.0 TRIALS AND IMPLEMENTATION

Trials using a portable Neutra-Mill were conducted at several of the sites by Earth Systems (the developers of the Neutra-Mill) and Goulburn Valley Water during November 1996. The trials were conducted to evaluate whether a portable Neutra-Mill could improve the quality of water being provided to consumers by reducing colour and turbidity.

For the trials the portable unit was moved around the storage impoundment, whilst it dispensed alum (aluminium sulphate hydrate) and hydrated lime, to maximise dispersion of flocculant throughout the water body. The storage pond acted as the clarification tank and the whole water body was treated. Once clarification was complete clean water was then drawn off, chlorinated using the existing facilities and distributed to the residents, as required.

The trials were successful with treatment taking only 4-6 hours for each of the 10-20 ML water bodies and clarification completed in 3-7 days. The clarified water that was distributed to consumers complied with WHO water quality guidelines. Each of these water bodies held sufficient water for 2-3 months demand and small in-town storages generally held 3-7 days supply so clarification times were not a concern.

Following the trials Goulburn Valley Water purchased a portable Neutra-Mill for the routine treatment of water at these five sites. The unit was modified by the addition of an outboard motor and a mounting bracket for a generator, to allow the unit to be used for the routine treatment of the water supplies of the towns identified. Routine deployment of the Neutra-Mill required limited vehicle access works at one or two of the sites.

Water sourced from the agricultural irrigation channels is of variable quality, so jar tests are conducted at each site prior to treatment to determine the optimum dose rates for the alum. Alum dose rates generally vary from 10-30 mg/L with an alum to lime ratio of 3:1. Lime is used for pH adjusted and assists in flocculation/coagulation.

As part of a routine treatment program a portable Neutra-Mill is transported to a site either behind a four wheel drive on a custom built trailer, or using a 3 tonne crane truck, along with the bagged reagent. When onsite the unit is deployed onto the waterbody either directly from its trailer or using the crane. Once the outboard motor and generator are attached bags of alum and lime are loaded onboard and the system is ready for operation.

The drum is initially charged with 200-400 kg of reagent. The unit is then slowly propelled along the surface of the waterbody in a grid pattern whilst it slowly dispenses the reagent throughout the upper potion of the waterbody (Figure 2). Further reagent is added continuously as required. Using this method the whole process of deployment, treatment and unit retrieval can be conducted in under 6 hours for a 40 ML waterbody and requires only two personnel.

Figure 2: Treating Turbid Water Using The Portable Neutra-Mill (During Training).

5.0 WATER QUALITY RESULTS

The turbidity and colour of the water improves significantly within 3-5 days of treatment using a portable unit. Table 1 shows the daily change in water quality at Stanhope following treatment on 19/10/99 with alum dosage of 21mg/L. The Girgarre storage was treated on 5/10/99 with alum at the rate of 25 mg/L (Table 2). At these sites there are generally two water storages or a storage and a holding tank. As clarification may take several days, storages of clean water are managed to avoid disruption to consumers.

Table 1: Change In Water Quality Stanhope Storage

Date	pH	Turbidity NTU	Colour	Aluminium Residual
19/10/99	7.2	21.3	23	0
20/10/99	7.2	16.9	17	0
21/10/99	7.2	12.8	6	0
25/10/99	7.2	3.8	0.06	0.03

Table 2: Change In Water Quality Girgarre Storage

Date	pH	Turbidity NTU	Colour	Aluminium Residual
5/10/99	6.95	27.9	N/A	0
7/10/99	7.25	19.6	N/A	0.1
9/10/99	7.32	8.38	N/A	0.1
14/10/99	7.24	4.94	N/A	0.1
16/10/99	7.32	3.03	2	0.1

The analyses in Table 3 show the water quality from the regional irrigation channel, water quality in the storages post treatment with the portable unit and water quality from the reticulation network. As stated on all analyses received since treatment started “This water complies with the recommended guidelines [WHO] for drinking water quality.”

Table 3: Comparison Of Untreated And Treated Water

Site		pH	Colour (Pt/Co units)	Turbidity (NTU)	Aluminium (mg/L)
Untreated source water	Waranga Main Channel	7.4	40	28	0.15
Treated water					
Gigarre	Storage	7.5	3	1.0	0.11
	Reticulation	7.4	<2	1.6	na
Corop	Storage	7.9	8	1.6	<0.05
	Reticulation	7.9	5	1.9	na
Stanhope	Storage	7.3	8	1.6	0.06
	Water	7.2	6	2.0	na
Colbinabbin	Storage	7.7	5	2.1	0.08
	Reticulation	7.3	4	2.1	na
Gigarre	Storage	7.4	6	1.0	0.14
	Reticulation	7.3	2	1.1	na
WHO guidelines		**6.5-8.5**	**15**	**5**	**0.2**

na - not analysed

Treating drinking water using the portable Neutra-Mill has resulted in the consumers being routinely supplied with water that complies with WHO water quality guidelines. Colour improved and turbidity dramatically decreased and in some sites was below detection limits. Other important outcomes occurred in the area of disinfection. The chlorine residual values throughout the reticulation system, improved considerably with the reduction in turbidity, with more consistent chlorine values at the sampling points in the reticulation network but with a significant reduction in chlorine dosage rates.

There has also been a large decrease in the number of consumer complaints regarding water quality, which can be used as an indicator of the satisfaction with the quality of service being provided. Concurrent with the decrease in complaints has been an increase in the consumption of water with rates of usage trebling at some towns.

Sludge accumulation within the impoundment and resuspension of floc following the re-filling of impoundments were two issues that could potentially affect water quality. Settled floc was resuspended during refilling but it was found that the resuspended floc actually reduced time that was required for clarification, possibly because it acted as a seed to initiate flocculation of added reagents. Following two years of treatment and based on calculations of accumulated sludge it has been estimated that sludge may need to be removed from the impoundments every 20-40 years or longer.

Providing cleaner water to the consumers also reduced maintenance demands as less routine flushing is required of the mains reticulation system . The higher turbidity levels previously resulted in sludge build up in the mains which reduced the quality of the water that reached the consumers and also affected the chlorine residual levels throughout the reticulation system.

6.0 ECONOMIC ANALYSIS

6.1 CAPITAL COSTS

One portable Neutra-Mill is used to treat five different water storages for various towns over five days (Figure 3). This provides enough treated water at each site for 1-3 months usage. The budget for the portable Neutra-Mill was AUD$45,000 (US$30,000). Within two weeks of a portable unit being provided to Goulburn Valley Water the five towns had water supplies that complied with WHO drinking water quality guidelines, the equipment had been commissioned and personnel trained in its operation.

Planning estimates by Goulburn Valley Water for the supply of conventional flocculation/sedimentation/coagulation plants were also conducted. A conventional plant would cost between $50,000 -$80,000 for each site for a total capital cost of between $250,000-$400,000 compared with that of $45,000 for the Neutra-Mill to achieve the same outcome.

Figure 3: Portability Is Key To Capital Cost Savings Using The Neutra-Mill

6.2 OPERATING COSTS

Table 4 outlines the costs, as budgetted for by Goulburn Valley Water, for two of the sites that are routinely treated using the portable Neutra-Mill. Information is shown so that operators can compare operating costs with their own systems taking into account variables such as variation in source water quality and local labour and equipment costs.

Goulburn Valley Water had a strict compliance date of 1st January 2000 to provide quality water to its residents. With such a short time frame and the delay involved in designing and constructing standard treatment plants, there was limited time to fully examine all options regarding the provision of suitable quality water to all consumers. Using a portable Neutra-Mill, the five towns involved were receiving water complying with WHO water quality guidelines 18 months earlier than had been scheduled in the authority's works programs and at a much lower capital cost and comparable operational cost.

Table 4: Operation Costs Using Portable Neutra-Mill

Costs	Site 1 – 40ML 6 hours required for treatment	Site 2 – 12ML 4 hours required for treatment
Operators @ $25/hr	$300	$200
Crane truck @ $50/hr	$300	$200
Alum at 20mg/L ($500/tonne)	$400	$240
Lime at 7mg/L ($200/tonne)	$56	$16
Other equipment @ $100/day	$100	$100
Total per waterbody	**$1156**	**$756**
Cost per KL	**2.9 cents**	**6.3 cents**

7.0 OTHER BENEFITS

A portable Neutra-Mill can clearly treat small town drinking water supplies to satisfy WHO water quality guidelines and at cost levels that are favourable in comparison to other treatment options. The Neutra-Mill Technology has also enabled Goulburn Valley Water to provide an improved service to their consumers in small towns.

The Neutra-Mill has provided the Manager, Western Region with flexibility in managing the plants under his responsibility and provided an emergency response capability. Problems were encountered at a conventional water treatment plant when the flocculator failed. This plant is fed via a 30 ML holding reservoir. The Neutra-Mill was rapidly mobilised and used to treat the water in this holding storage using an expedient alum dosing rate. Within twelve hours the water had clarified to the required levels and was passed through the treatment plant for final filtration and disinfection. This resulted in no disruption of supply to both commercial and household consumers and the water treatment plant was repaired two days later.

As part of the Y2K management strategy a portable Neutra-Mill will be located at a site near one of the fixed treatment plants in case there is a power failure. The portable unit has the capability of providing the required treatment thereby ensuring supplies to consumers will not be disrupted.

The portable unit has also been used to supplement the treatment of another fixed treatment plant, again highlighting its comparative flexibility. Drinking water was treated at a plant and then piped to a storage basin some tens of kilometres away. The storage was earthen and the inflowing water resuspended clay particles. The portable unit was then used at this site to provide treatment before the water was then delivered to consumers – an option that was not available with fixed water treatment plants.

Based on the demonstrated flexibility of the portable Neutra-Mill, several other potential applications have been identified and may be addressed in the future including:

- management of algal blooms through prevention by nutrient stripping or treatment via an algacide or flocculation/sedimentation;
- pre-treatment of high turbidity raw water in storages prior to treatment in conventional plants; and,
- lowering of suspended solids in waste water including sewage and agribusiness effluent (although a separate unit would be required for this).

8.0 CONCLUSION

A portable Neutra-Mill has provided a regional Australian water authority with a cost effective and efficient method of supplying small towns with drinking water that complies with WHO guidelines. The portable Neutra-Mill provides a flexible technology to managers of water treatment assets that is not available using standard water treatment plants.