Recycled Water Treatment Plant in just 16 weeks from concept design to production

Figure 1 : Brushy Creek RWTP

The extreme drought that Greater Melbourne is experiencing is quite unprecedented in its duration and severity. For the past 10 years, stream flows to the reservoirs have been below average. The water storage level in August 2007, according to Melbourne Water, was 35%. This is the lowest level recorded in the past 10 years.

Stage 3A water restrictions were applied in Melbourne from 1 April 2007. When water storage in the Greater Melbourne area continued to drop, the Victorian Government was preparing to change water restrictions to Stage 4. The main differences between these water restrictions are that in Stage 4 there is a complete restriction in irrigation of sporting grounds, residential, public, commercial gardens and lawns. That means **"All outside watering is BANNED. No watering at any time, by any means".**

Several city councils in Melbourne's eastern suburbs asked the Victorian Government to provide alternative water supplies, like recycling water, for the irrigation of open public places. The Municipal Water Association of Victoria and leading sports bodies called on the Government to provide $80 million funding over eight years to save state ovals.

To allow unrestricted irrigation on open public places would require recycled water of Class A water quality. **Class A recycled water is the highest quality of recycled water available at the present time in Australia .** The Class A water is needed to be produced in accordance with strict standards and guidelines developed by the Department of Human Services and the Environment Protection Authority.

One of the most suitable locations to recycle water in these areas was the Brushy Creek STP. The plant is situated on Maroondah Highway in the eastern suburbs of Melbourne and geographically suitable to most of the councils.

"Fast track" project

Yarra Valley Water Ltd operates Brushy Creek STP and at the end of August 2007 contacted Tenix to discuss options relating to the design and construction of a Class A recycling plant. The project required a fast track approach, as completion was required by summer time (early December 2007).

Tenix is an industry leader in this line of work. It was the first company in Australia to design, construct and commission recycling water treatment plants on Mt. Hotham and Mt. Buller, where the recycled water was used in snow making machines.

On the Brushy Creek Recycled Water Plant project the main objective was to design and obtain approval of the treatment process by both the Department of Health Services and the Victorian EPA before December 2007.

Ultra Filtration (UF) technology, featured in several irrigation schemes in the United States and Australia, demonstrates the ability to use a valuable resource of water safely. There are only 2 (KMS and Norit) UF membrane suppliers providing validated membranes with at least a 4 logs virus (adenovirus etc)and bacteria (Cryptosporidium, Protozoan, Giardia) reduction from the wastewater stream (both approved by DHS and EPA) .

Tenix owns of numbers mobile Ultra Filtration pilot plants with Koch and Norit membrane technologies and both are suitable for the production of Class A recycled water. According to a newsletter from the California DHS (2005-2009) both of these membranes can remove up to 4 logs viruses, cryptosporidium and giardia. Initially two mobile plants, with a total capacity of 700 Kl /day, were considered for use on the Brushy Creek project. However, difficulties in validating the overall treatment process for the mobile plants in less than two months, led Tenix to review alternatives for a permanent plant using pre-validated processes and equipment.

Main dates on the project:

On 31 August 2007, Yarra Valley Water appointed a Project Manager for the Brushy Creek Recycling Water Treatment Plant project.

On 6 September, Tenix Alliance and MWH (project management team) met representatives of Yarra Valley Water for the first workshop.

On 18 September YVW sign on Letter of intend to Tenix Alliance to proceed with project.

Figure 2: 15/09/07 Before construction started on site

On 20 September, procurement of the main components of the project (membranes, UV unit, pumps, tanks and valves) began.

Detailed design was completed on 10 October and construction finished by 1 December. The target date for water Class A water delivery from the site was the first week in December 2007.

The first delivery from the Brushy Creek Recycled Water Plant was on 11 December 2008.

Figure 2: Brushy Creek RWTP site

<u>Techniques and technologies for Class A water production</u>

The Class A water produced at the Brushy Creek Recycled Water Plant is for watering golf courses and gardens in the East Melbourne metropolitan area. As this area has unrestricted irrigation, the water must be free of pathogenic bacteria, parasites (protozoa and helminthes) and viruses. Thus a reliable treatment process must be maintained to reduce pathogen levels to less than <1/l (in accordance with EPA Class A requirements) particularly for higher infectious agents such as Rotavirus.

It was obvious that Class A recycled water from Brushy Creek had to meet the following requirements:

- 7 logs reduction of viral pathogens
- 6 logs reduction of Protozoan pathogens

Currently there are several disinfection and virus/bacterial removal techniques approved by the US EPA and the Californian DHS. As timing was critical for the Brushy Creek Recycled Water Plant we decided to use the world's best practice and approved technologies which could be adopted immediately. On the Brushy Creek Recycled Water Plant, Class B water needed to be treated to Class A quality.


Figure 3: Raw sewage inlet to SBR

The treatment process

The treatment process consists of pre-chlorination of the secondary effluent, ultra filtration, disinfection with ultra-violet light and finally additional chlorination.

We decided to use the following technologies for the Class A water treatment process:

- Ultra filtration with UF membranes using Norit X-Flow XIGA membranes manufactured by X-Flow in Holland which is suitable for surface and recycling water as well as MBR 's.
- Pre-Validated and approved by US-EPA UV reactor – Calgon (medium pressure lamps)

Secondary effluent water characteristics

The effluent water characteristics have been mostly consistent with key design criteria (Table1).

Table 1: Brushy Creek STP Effluent water quality

Parameter	TSS	E.Coli	BOD	Total P	Total Ammonia	Total N	pH	Fe	Mn
	mg/L	Org/100ml	mg/L	mg/L	mg/L	mg/L		mg/L	mg/L
Avg	10	5	3	0.15	3.1	7.5	6	0.1	0.1
Max	20	1000	20	0.3	5	10	7	3	3

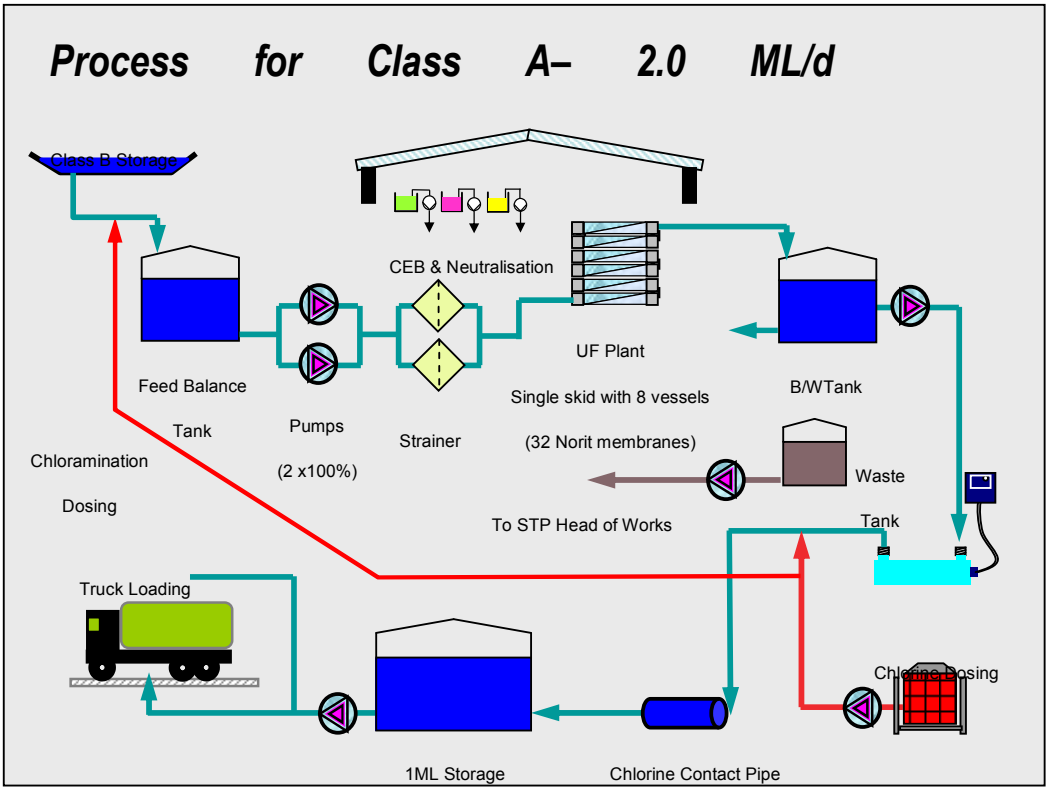

Diagram 1: Brushy Creek Recycled Water Plant process diagram

Reasons why we are using these techniques

- Low cost of chlorination for virus reduction versus the relatively high power cost of ultra-violet technology
- Pressurised feed from balance tank suits a pressurised UF system and delivery up to Class A storage tank
- Micro-strainers and their ability to protect the membrane from algae blooms and large particulates

- The ability of the Norit UF membrane to remove all suspended solids (TSS) and pathogens. This has been demonstrated at Australia's largest (35 ML/D) water reuse plant run by Melbourne Water
- An automated online integrity test (pressure decay) on the membrane plant (recommended for reuse applications requiring high microbial rejection)and required by DHS
- Modular technology for ease of expansion in the future with addition of extra UF skid
- Chlorine residual is maintained in the UF feed water stream to help control bio-film in the pipework across the entire recycling plant and befouling of the UF membranes.

Chloramination

Due to the high levels of ammonia and nitrogen that will be initially present in the secondary effluent from the Brushy Creek Recycled Water Plant, free chlorine from sodium hypochlorite (chlorine-based disinfectant) will be added into raw water and converted to monochloramine (NH_2Cl) and other chloramines (di and three). Chloramines (a form of combined chlorine) does not have the same disinfectant strength as free chlorine. To ensure the complete chloramination process is carried out we are monitoring the free chlorine concentration downstream in the balance tank. The Norit X-Flow membrane can filter water that contains a small amount of free chlorine which can be present in the feed water. To complete the full chloramination process, retention time is provided within the Balance Water Tank prior to filtration through the UF membranes.

UF filtration

UF technology, and in particular the membranes supplied by Norit X-Flow, has demonstrated the ability to filter and supply water free of pathogens for urban reuse. Only four companies have US DHS approval for 4 log pathogens and virus reduction during the filtration process (validation report shown ability to remove up to 6 log virus and pathogens) The X-Flow SXL membrane (with a membrane area of $40m^2$) operates in a dead-end filtration process with relatively low power consumption and transmembrane pressure (usually up to 40kPa). To remove solids built up on the membrane surface during filtration under constant feed pressure, the system is backwashed at regular intervals of 22 to 30 minutes, by reversing flow direction through the membrane filter.

The UF plant effectively provides a physical barrier through the exclusion of phage and viruses, such as MS2 and enteric viruses greater than 35nm in size (the membrane pore absolute cut off size is 25 nm) While other larger viruses like the Adenoviruses still need to be removed, removal rates are much higher for these larger viruses with UF. The UF has the ability to remove all TSS and pathogens.

UV disinfection

Under California's Title 22 regulations a UV dose of 28 mW/cm^2. is usually adopted to give adequate factors of safety related to possible variability of the effluent including ultra-violet transmissivity (UV_T). The UV system is designed to achieve at least a 3 log reduction of Adenovirus.

On a 2 MLD plant, UV medium pressure lamp reactor has a low power consumption nominal capacity of 12kW/hr with usually after-UF plant power consumption of only 6kW/hr). After UF filtration water

has turbidity less than 0.1 NTU and more than 75% UV transmissivity. With UV light we are reducing an extra 2 logs of protozoan.

Chlorination

During the chlorination process we are achieving another 3 logs reduction of viruses. For virus reduction we are using US EPA guidelines with a concentration of 4mg/min / L

The overall process can be illustrated in following diagram:

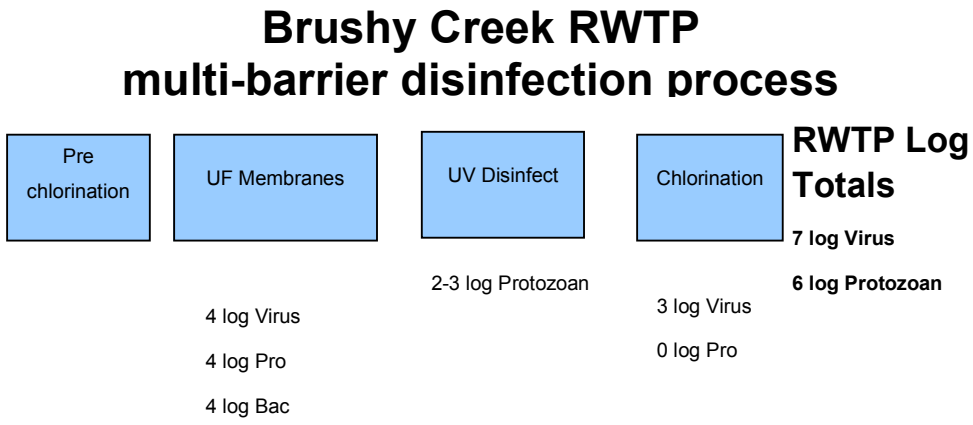

Diagram 2: Multi-barrier disinfection process

Plant performance

The Brushy Creek Recycled Water Plant started Class A water production on 11 December 2007. The plant is running consistently twelve hours a day with the anticipated performance criteria. This plant is fully automated and doesn't required operator attendance.

The Flux rate on the UF membrane was 72 L/m^2 /hr and the backwashing frequency (depends to suspended solids loading) was between 24-28 minutes.

Using a Norit X-Flow membrane in our process we are continuously pre-chlorinating feed water with 0.5mg/L of free chlorine. This has allowed us to run membrane plant with Trans-Membrane pressure (TMP) less then 20 kPa (approximately 1.2-1.4psi) and permeability above 400 when the plant is required to run more than eight hours per day.

At this stage water is being distributed by trucks and daily consumption is around 0.55MLD which can be produced in seven hours.

Water quality out of the Brushy Creek Recycled Water Plant totally complies with EPA guidelines (see Table 2):

Table 2: Brushy Creek Recycled Water Plant Class A water quality

Parameter	Avg	Max
BOD	1	2
Turbidity	<0.3	1
pH	6.5-7.5	6.8
Free Chlorine	0.25	0.8
E.coli	<1 /100ml- Nil	<10/100ml
Protozoa	Nil	<1 in 50l

Figure 5: Online 24/7 water control makes water safe to use

Summary

The outstanding success of the Brushy Creek Water Treatment Plant is testimony to Tenix skills and commitment. To build such a technically complex plant to produce water at Class A water standard, in some 12 weeks, is a first class record of achievement. Tenix's Brushy Creek Water Treatment Plant is now entitled to claim the industry's standard.

Moreover, the installation and commissioning of the plant has allowed the State Government to honour its commitment to maintaining public gardens and sporting ovals in Eastern Melbourne, which have been under threat of destruction due to a lack of available water.

Since 2008 Tenix has constructed several plants in Australia using same advance technologies. It is proven techniques to get fast approvals from DHS and EPA when using pre validated equipment which can be applied for different water sources and achieve same performance and water quality.

On- line monitoring makes these facilities robust and reliable which insure safest water quality.