

# HIGH QUALITY DRINKING WATER THROUGH ADVANCED TREATMENT PROCESS FOR NOOSA COUNCIL

**Keith Craig**

[kcraig@vivendewater.com.au](mailto:kcraig@vivendewater.com.au)

Technical Director, Vivendi Water Australia

**Ben Bowen**

[bbowen@vivendewater.com.au](mailto:bbowen@vivendewater.com.au)

Operations Manager, Vivendi Water Australia

[www.VivendiWater.com.au](http://www.VivendiWater.com.au)

**Bernie Breiner**

[bbreiner@genwater.com.au](mailto:bbreiner@genwater.com.au)

Plant Manager, General Water Australia

[www.groupVE](http://www.groupVE)

## **Abstract**

Noosa Council undertook an upgrade of their water treatment plant to meet increasing demand and improve water quality through a design build operate (DBO) project. The Noosa area is a major tourist destination on the Sunshine Coast in Queensland and supplying high quality safe water is important to the region. Vivendi Water Australia was the successful tender for the DBO project and has supplied world's best practice technology to achieve the water treatment upgrade.

Noosa Council developed water quality performance levels to ensure the supply of high quality water. This included meeting the latest NHMRC guidelines as well as higher water quality standards on a number of parameters. To achieve these standards, VWA applied a multi-staged continuous process. This process includes: potassium permanganate dosing together with pre-filter chlorination and coated media filtration to remove manganese; improvements to the coagulation process; installation of dual media filter beds, using sand and filter coal in the existing filters; polymer addition before the clarifiers and filters to achieve improved turbidity, colour and particle removal; and the ozone and biological activated carbon process to reduce THM levels, remove algal toxins and taste and odours. The processes were extensively tested in pilot plant studies to develop design criteria and confirm their capability to achieve the water quality targets. The full-scale plant upgrade has been operated for approximately 4 years by Vivendi Water Australia, achieving a high standard of performance that has improved distribution operations and provided improved water quality to customers virtually eliminating customer complaints. These processes and results of testing and full scale performance are presented and discussed.

**Key Words: Water treatment, manganese, pilot plant studies, filter media, ozone BAC, taste and odours, THMs, particle counting.**

## Introduction

Noosa Heads is a picturesque holiday resort on Queensland's Sunshine Coast in Australia. One of the main incomes for the area is from tourism due to the warm climate, beaches, National Parks and lifestyle. The growth rate for the area is also high as a result.

The provision of high quality drinking water is critical for the continued commercial success of tourism. Due to the increased growth rate, an increase in the capacity of the existing Noosa water treatment plant was required to meet consumer demand.

Noosa Council decided to achieve increased plant capacity, upgrade the plant's ability to address water quality issues and provide high quality drinking water through a design build operate (DBO) contract. CGE Australia was the successful tenderer to supply world's best practice to achieve the Noosa water treatment plant upgrade.

This paper reviews the pilot plant studies undertaken to develop the most effective treatment technology for the Noosa water treatment plant and full-scale plant performance.

## Water Quality Issues and Criteria

### Raw Water

The water sources for Noosa water treatment plant (WTP) include Lake Macdonald and the Mary River. Raw water can be obtained from either source or provided as a mixture from both sources.

The typical values and ranges of water quality are shown in Table 1 below.

During high rainfall events, particularly with Mary River water, the turbidity and true colour can rise significantly.

Parameter	Unit	Typical	Range
Turbidity	NTU	2.75	1- 40
True Colour	HU	22	10- 50
pH	-	6.9	6.4-7.3
Total Manganese	mg/L	0.17	0.05-0.30

Table 1 - Raw Water Quality

### Treated Water Quality Criteria

Noosa Council established treated water quality criteria to ensure a high quality drinking water. These requirements included levels for some parameters of a higher standard than any known limits worldwide, especially in relation to manganese. They also included limits for new parameters for drinking water in Australia, especially in relation to particle counts. The limit for particle counts, were established to provide a surrogate measure for *Cryptosporidium* and *Giardia* removal.

The key performance criteria are given in Table 2.

Parameter	Unit	Level
Manganese	mg/L	<0.01
Turbidity	NTU	<0.3
Colour	HU	<5
THMs	µg/L	<50
Particle Counts	counts/ml	<100 or >3 log removal
Taste and Odour	Flavour profile analysis	Effectively remove
Algal Toxins	mouse bioassay test method	Effectively remove

Table 2 - Performance Criteria

## Pilot Plant Studies and Results

### Pilot Plant

The pilot plant was housed in a shipping container and was designed to simulate various treatment processes for inclusion in the Noosa water treatment plant.

This included pre-chemical dosing, clarifier, filters, and the ozone BAC process. Key parameters were monitored and data transferred to a data logger.

### Pilot Plant Programme

The pilot plant study evaluated a number of key processes:

- manganese removal with potassium permanganate and pre-chlorination on coated media.
- dual media filters

- polymers as coagulant and filter aids
- ozone BAC process
- ability to meet water quality performance criteria

The pilot plant study period was 3 months from November 1997 to February 1998.

### **Manganese Removal**

The manganese removal process proposed was a multibarrier process to enable the criteria of <0.01 mg/L of manganese to be met. This included an upgrading of the Lake Macdonald destratification system, first stage oxidation of soluble manganese using potassium permanganate at elevated pH and final removal and polishing to <0.01mg/L manganese, using pre-chlorination coated media process. The coated media process involves establishing a manganese dioxide coating on the filter media and using chlorine to achieve catalytic oxidation (Craig et al 1993, Craig et al 1997).

This staged manganese removal process would also allow reduced levels of pre-filter chlorination compared to using only the coated media process. This reduced the formation of THMs due to the low chlorine dose and short contact time.

Raw water spiked with soluble manganese up to 0.44mg/L and as well, natural raw water manganese up to 0.26mg/L were tested in the pilot plant.

Potassium permanganate on its own could not achieve the performance criteria of <0.01mg/L. However, the combination of potassium permanganate and pre-filter chlorination on coated media achieved levels of <0.01mg/L and on optimised runs levels <0.005 mg/L. Results are presented in Figure 1 and Figure 2 below.

Final THM levels after ozone BAC process and chlorination were less than the 50 µg/L performance criteria with levels typically <30 µg/L.

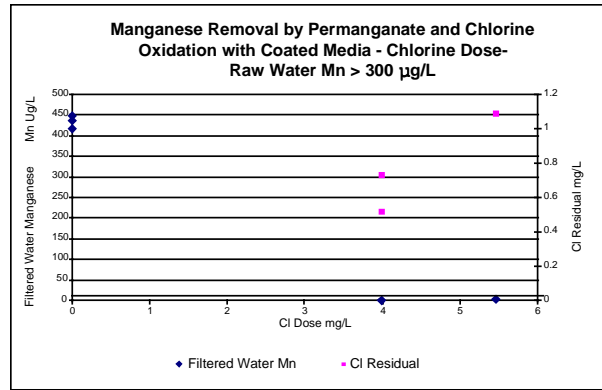


Figure 1- Manganese Removal Mn >300 µg/L

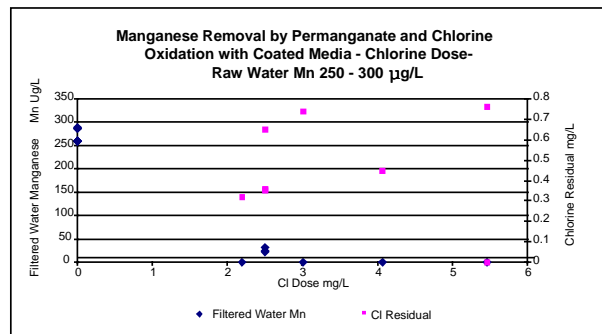


Figure 2 - Manganese Removal Mn 250-300 µg/L

### **Ozone Biologically Activated Carbon (BAC) Study**

The process of ozone and BAC was selected to achieve the following outcomes:

- reduced THM levels,
- taste and odour removal,
- algal toxin removal,
- high microbiological performance,
- reduced turbidity, colour and particle counts,

and provide a continuous multibarrier approach to achieve performance criteria. Ozonation would also provide a high level of inactivation of *Cryptosporidium* and *Giardia*.

The ozone BAC advanced technology is used in Europe to provide high quality drinking water, remove pesticides, improve distribution system performance and reduce disinfection by-products. The activated carbon was Picabiol carbon, which has been

used in plants in Paris for over 10 years in the BAC process. The biological activity on the activated carbon takes 2-4 weeks to establish. At this stage, the performance of the BAC process can be evaluated.

Once the BAC process was established, 20-30% dissolved organic carbon (DOC) removal was achieved. DOC levels were reduced from an average of 3.5 mg/L in the filtered water to 2.4 mg/L in the ozone BAC treated water. Both 10 and 15 minutes BAC empty bed contact time (EBCT) was studied. Generally 5-10% higher DOC removal was obtained with 15 minutes EBCT compared to 10 minutes EBCT.

Final THM levels following the ozone BAC process and chlorination were <30 µg/L with bromate levels <0.02 mg/L. THM levels from the existing water treatment plant were approximately 90 µg/L with THM formation potential approximately 200 µg/L.

Taste and odour problems were evident during the pilot plant study in treated water from the existing water treatment plant. Analysis for taste and odour compounds indicated MIB levels of 10-26 ng/L and geosmin levels of 4-11 ng/L in the raw water. The water supply experienced an earthy musty taste and odour.

After treatment with ozone BAC in the pilot plant, geosmin and MIB levels were <1 ng/L for 10 minutes EBCT, geosmin <1 ng/L for 15 minute EBCT and MIB <5 ng/L for 10 minute EBCT (Figure 3). Taste and odour threshold levels for MIB and geosmin are approximately 10 ng/L.

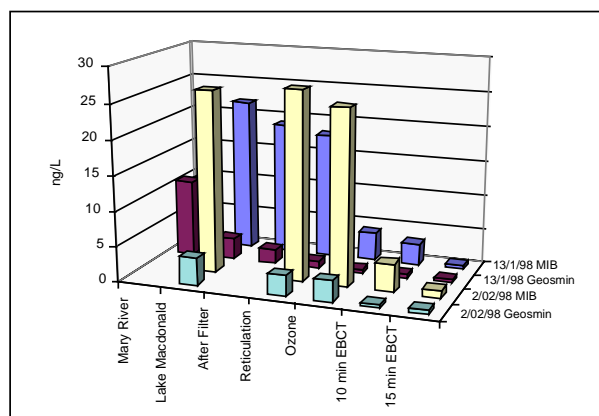


Figure 3 - Taste and Odour Removal

Cyanobacteria toxins have been shown to be removed effectively in previous studies with the ozone BAC process (Craig et al 1998) with rapid removal in the ozonation stage.

### Particle Removal

Particle counting criteria was established to achieve a process that will provide high removal efficiency for *Cryptosporidium* and *Giardia*. Studies were undertaken on the pilot plant using Met 1 and Hiac Royco laboratory particle counters.

The removal through the whole treatment train was studied. Particle counts on optimised runs were <50 counts/ml in 3-150 µm size range. This removal was achieved with the addition of a coagulant aid before the clarifier, pre-filter chlorination (used for coated media process), the use of dual media filters of sand and Australia filter coal in place of mono media sand filters and finally the ozone BAC process.

A balance tank was installed in the plant upgrade to provide a constant pumped flow to the ozone BAC process. This will minimise flow variations and changes in particle counts. A period of filter to waste was provided for the BAC filters. This will reduce particle levels that can be associated with the initial filter start up period. On-line particle counters for raw, filtered and treated water will monitor particle levels and log removal of particles.

This was the first time particle counting had been used in Australia as a performance criteria for treated water.

### Plant Upgrade

The plant upgrade to increase capacity and achieve high treated water quality targets was achieved by:

- Plant capacity
- Provision of cationic polymer
- coagulant and polymer
- filter aid polymer
- installation of dual media filters

- ultimately a high rate clarifier and further dual media filter

#### Water quality targets

- destratification
- potassium permanganate addition at high pH
- increased contact time
- in-line alum mixer
- provision for cationic polymer
- coagulant aid polymer
- provision for filter aid polymer
- pre-filter chlorination on coated media
- installation dual media in the existing filters
- ozone BAC process
- PLC/SCADA upgrade
- On-line monitoring equipment

Figure 4 - at the rear of this paper depicts the Process Upgrade in Schematic format.

### Full Scale Plant Operation

The plant operation since commissioning in 1998 has resulted in improved performance achieving high water quality criteria. There has been a significant improvement in the taste and odour of the water as measured by the FPA method, which includes community involvement. Taste and odour removal is outlined in Figures 5 & 6 at the rear of this paper.

The distribution system performance has also been improved due to the lower manganese levels and reduced organics in the treated water and resulting lower chlorine demand in the treated water and more stable chlorine residuals in the distribution system. Organics removal across the plant and ozone BAC process is shown in Figure 7 at the rear of this paper. TOC removal is typically 60 %

across the plant with 20 % TOC and 60 % BDOC across the ozone BAC stage.

A high level of manganese removal has been consistently achieved through the plant to typically 0.001 to 0.002 mg/L in the treated water despite varying manganese levels up to 0.3 mg/L in the raw water.

### Conclusion

VWA were able to achieve Noosa Council's strict treated water quality guidelines by an innovative approach, introduction of new technology to Australia and the evaluation of options and the thorough testing of the processes in pilot plant studies.

The upgraded plant included the following key processes to address water quality issues.

- Manganese removal with destratification, potassium permanganate oxidation at high pH and contact time, and final polishing with pre-filter chlorination on coated media.
- Turbidity, colour and particle reduction using coagulant and filter aid polymers, coagulant mixing, dual media filters and ozone BAC process.
- Taste and odour, THM and algal toxin removal with the ozone BAC process.

This has allowed Noosa Council to provide high quality drinking water for the consumers and tourists in an area described as paradise by many visitors. The full scale operations have confirmed pilot plant results and achieved improved performance for the distribution system through a continuous multistage advanced treatment process.

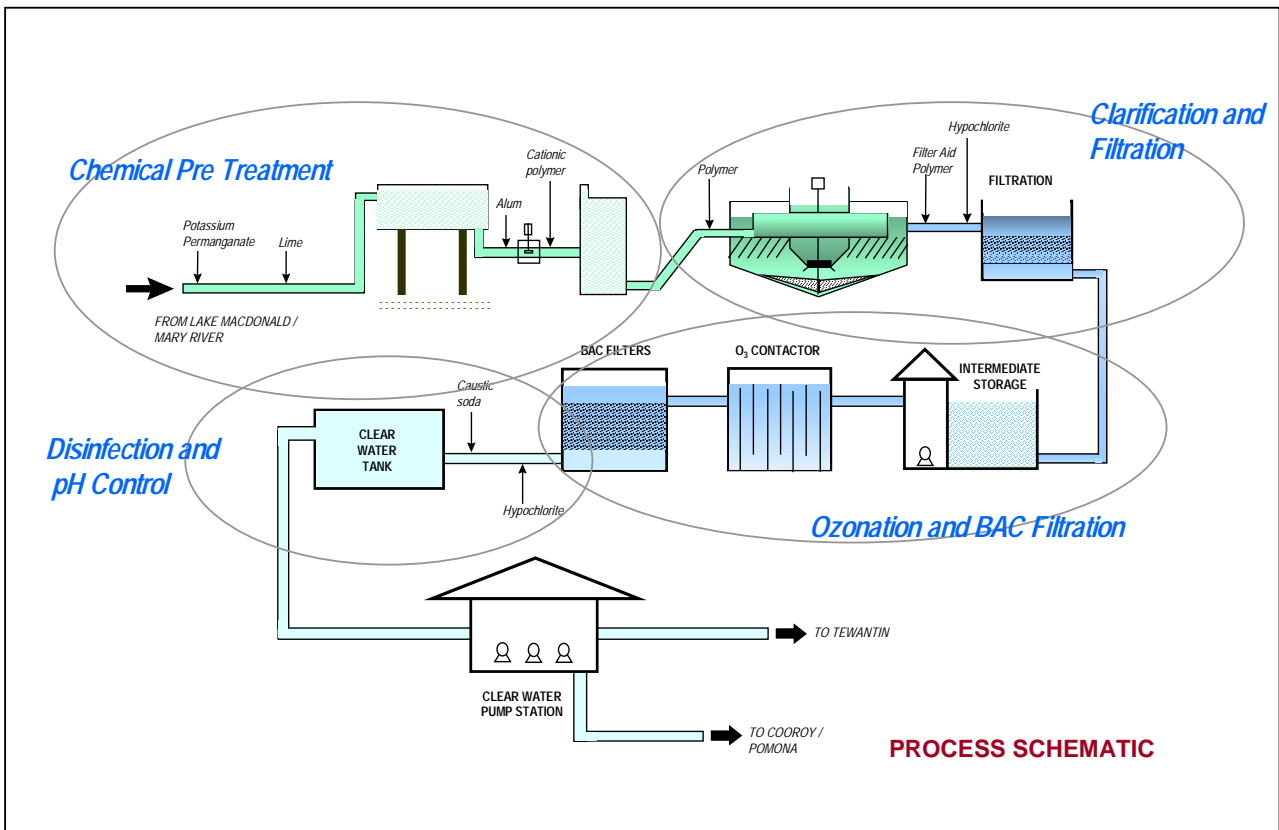


Figure 4 - Process Upgrade Schematic

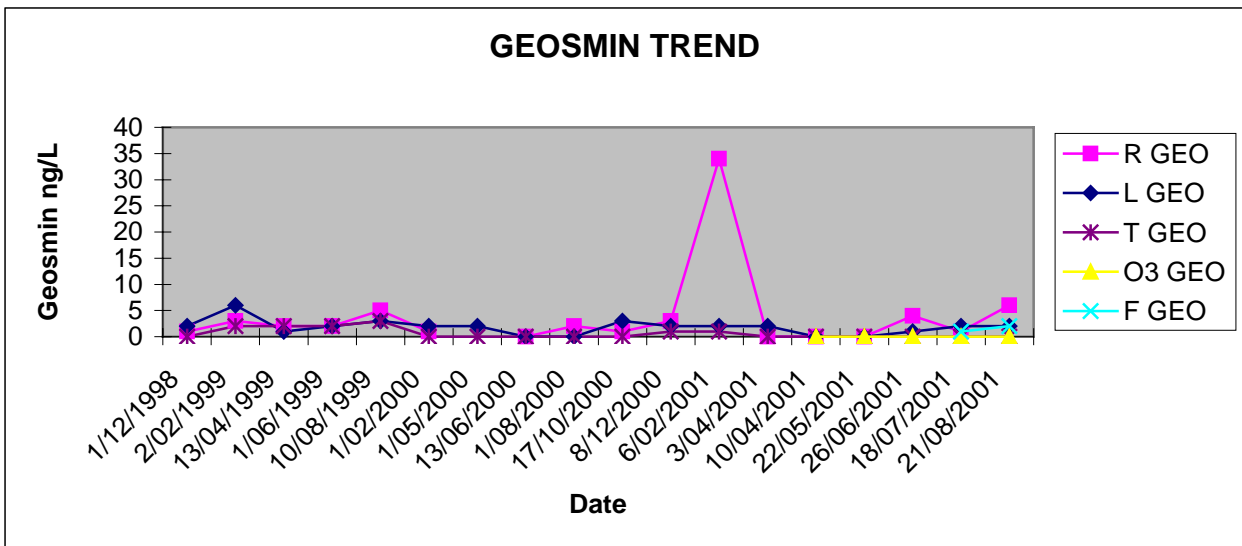


Figure 5 Geosmin Removal

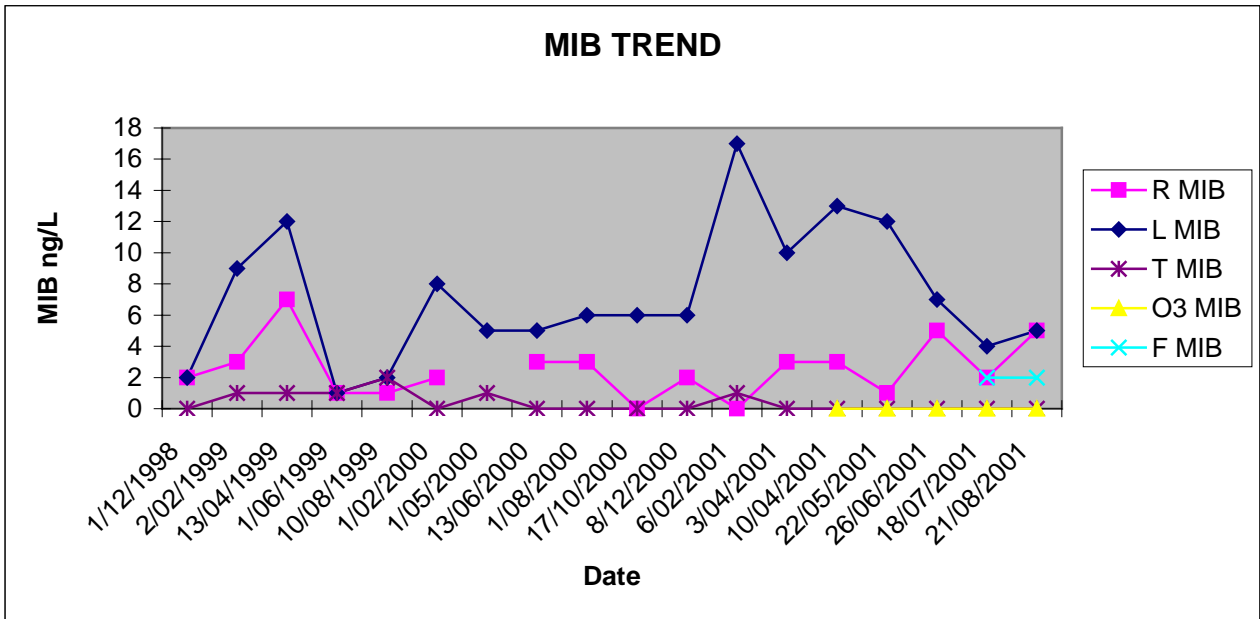


Figure 6 mib Removal

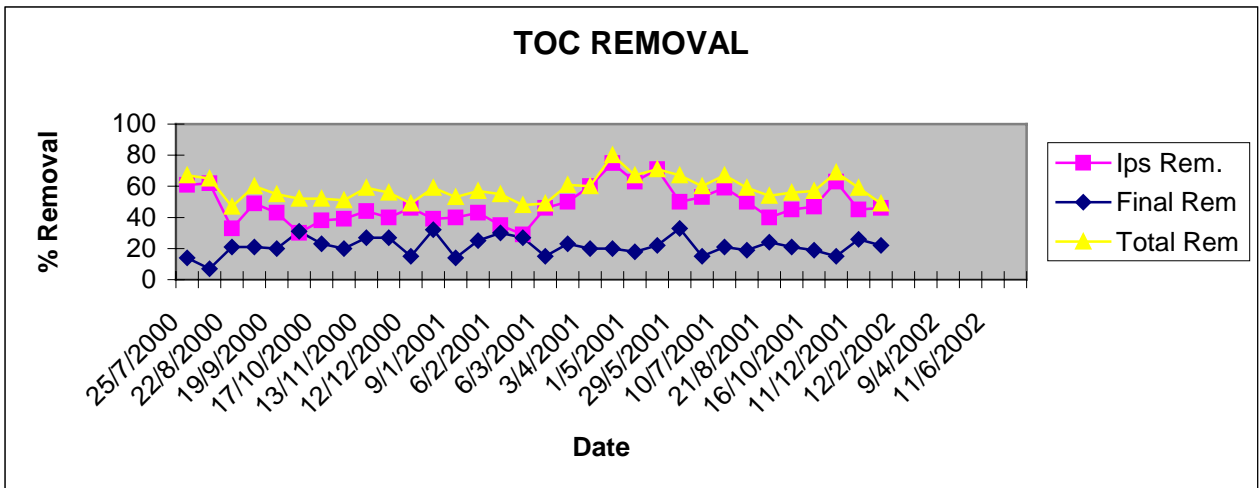


Figure 7 TOC Removal

## References

Bishop S, Bourbigot M-M, (1996)

*Meeting the Proposed Regulations Using Ozone and Biologically Active Carbon*

New England Water Works Association, Vol CV, No1, pp 1 - 12

Craig K, Naylor R, Waite D, Roddy S (1993)

*Manganese Removal from Sydney Waters Using Manganese Oxide Coated Media Filter Pre-chlorination*

Proceedings of 15<sup>th</sup> Federal Convention, AWWA, Vol 4, pp 1065 - 1070

Craig K, Bailey D (1995)

*Cyanobacteria Toxin Microcystin 'LR' Removal Using Activated Carbon - Hunter Water Experience*

Proceedings 16th Federal Conference, AWWA, Vol 1, pp 579 - 586.

Craig K, Murray B, Hamilton G, Waterhouse K (1997)

*Upgrading of a Conventional Water Treatment Plant by Conversion to Contact Filtration*

Proceedings of 17<sup>th</sup> Federal Convention, AWWA

Craig K, Bowen B, Majerowski A (1998)

*The Removal of NOM and Algal Toxins Using Ozone Biologically Activated Carbon Under Australian Conditions*

Watertech Conference, AWWA

Waite T, Zaw M, Naylor R, Craig K, Nicholson C (1993)

*Laboratory and Pilot Plant Studies of Manganese Removal by Potassium Permanganate Oxidation*

Proceedings of 15<sup>th</sup> Federal Convention, AWWA, Vol 4, pp 1075 - 1080

## Author Biography



Keith Craig is the Technical Director for Vivendi Water Australia. He is a Chemical Engineer with over 20 years experience in the Water Industry. He has been involved in the development of advanced treatment techniques in Australia including ozone /BAC technology and membrane filtration.

E-mail: [kcraig@vivendewater.com.au](mailto:kcraig@vivendewater.com.au)

[ Click & paste photo ]

Ben Bowen is currently Operations Manager with Vivendi Water Australia. He has extensive experience in water treatment plant design and operation, in particular with membrane and ozone BAC processes. Ben has most recently played a key role in the successful delivery of Vivendi's three new membrane and ozone BAC water treatment plants in Bendigo, Victoria where he was Vivendi's principal Process Engineer and Commissioning Manager.

**Postal Address:**

**E-mail:** [bbowen@vivendewater.com.au](mailto:bbowen@vivendewater.com.au)



Bernie Breiner is an Industrial Chemist with 25 years experience in the water industry. He joined Vivendi Water Australia in 1998 and is currently the Operations Manager of the recently upgraded Noosa Water Treatment Plant. This plant incorporates advanced treatment including Ozone & BAC.

Vivendi carries out the operation of this plant under a 15 year DBO contract with Noosa Council.

Prior to joining Vivendi, Bernie spent 21 years with Hunter Water Australia. He was involved in many aspects of water & wastewater treatment, operation and research over that period.

The time with Hunter Water provided the opportunity for additional study, which resulted in a Graduate Diploma of Management & a Masters Degree in Business Administration. The more recent qualifications facilitated the transition into a management role.

Bernie's current role with Vivendi is not limited exclusively to Noosa, but also across the organization as a part of the "Vivendi Operations Management Team".

**Email:** [bbreiner@genwater.com.au](mailto:bbreiner@genwater.com.au)