



Environmental Health Unit  
Department of Human Services  
GPO Box 4057  
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15 August 2007  
Our Ref: 3552306/TPL  
MEL1:23872-Appendix F -  
Chlorination Testing and  
Validation Report.DOC

**Attention: Ms Suzie Sarkis**

Dear Suzie,

**Epsom Spring Gully Water Recycling Project - Validating Chlorination Performance for Virus Reduction**

**1 Introduction**

The Epsom Spring Gully Water Recycling Project is a Class A water recycling project attached to the Epsom Water Reclamation Plant. Class A effluent will be used for irrigation of parks, gardens and sporting grounds within Bendigo and transfer to Spring Gully Reservoir for use by local irrigators.

The project includes construction of the Class A works now (Milestone 1) and subsequently installation of a parallel Ultrafiltration and Reverse Osmosis system, to reduce salt in a portion of the water.

The Victorian EPA and Department of Human Services (DHS) require 6 log<sub>10</sub> removal of protozoan parasites (*Cryptosporidium* and *Giardia*)<sup>1</sup>, which will be achieved by the existing treatment plant and two ultraviolet disinfection units. 7 log<sub>10</sub> removal of viruses is required, which will be met by the existing treatment plant, two ultraviolet disinfection units and the Class A works chlorination system.

The purpose of this document is to confirm the virus disinfection performance of the proposed chlorination system.

**2 Laboratory Trials**

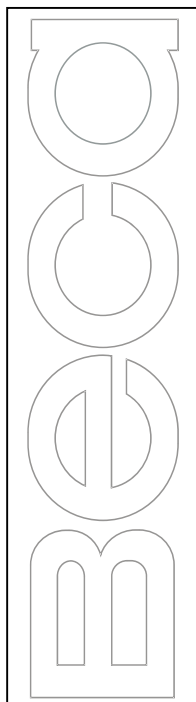
Whilst there is information regarding chlorination of viruses in drinking water, there is limited literature available on the chlorination of viruses in wastewater effluent. It is also expected that wastewater effluent varies and that this may affect the formation and stability of chlorine residuals. In particular ammonia, colour and nitrite, together with suspended solids affect chlorine demand and stability of residuals. It is proposed to chlorinate until a free chlorine residual is achieved in the full-scale process, as disinfection

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<sup>1</sup> Victorian EPA, "Guidelines for Environmental Management Dual Pipe Water Recycling Schemes - Health and Environmental Risk Management", Publication 1015, October 2005, p 16.

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with chloramines requires Ct values of the order of 500 mg.min/L. Laboratory trials were carried out to confirm that a relatively stable free chlorine residual could be achieved, to confirm the chlorine dose and to determine the necessary Ct required to achieve the necessary virus reduction, with Hepatitis A being the target virus. Initially the aim was to achieve approximately four-log reduction through the chlorination system. This target was devised in TM2<sup>2</sup> as the proposed upper limit log reduction for the full scale chlorine system, which is part of the Class A works.

## 2.1 Method

Over seven weeks, six samples were taken of the tertiary treated effluent downstream of the existing ultraviolet disinfection unit. The samples were spiked with fresh MS2 bacteriophage in the laboratory and gently stirred for 30 minutes, in order for the phage to have an opportunity to associate with any suspended particles. The 10 L spiked effluent sample was dosed with sodium hypochlorite to achieve a free chlorine residual in the range of 4 to 5 mg/L. Aliquots were taken at regular intervals, for chlorine residual determination and chemical characterisation and thiosulfate quenched aliquots taken for MS2 phage determination.

## 2.2 Results and Discussion

The complete results of the trials are attached as Appendix A. Summary results are reported below.

### 2.2.1 Wastewater chemistry

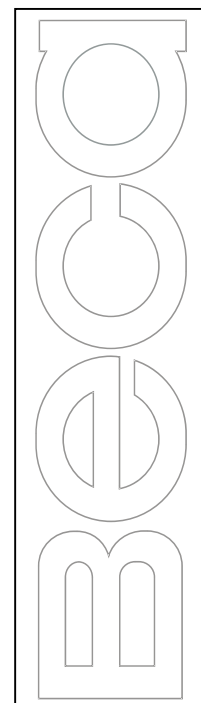
Table 1 below summarises the chemistry results of the effluent used in the trials.

Nitrite-N maximum was 0.39 mg/L. 1 mg/L of nitrite-N will consume 5 mg/L of free chlorine, so maximum chlorine demand will probably not exceed 2 mg/L for oxidation of nitrite. Ammonia-N did not exceed 0.3 mg/L. Since it is necessary to add sufficient chlorine to pass through the breakpoint (at least 8 to 10 mg Cl<sub>2</sub> per mg ammonia-N), so as to achieve a free chlorine residual, chlorine demands of 3 mg/L are necessary for ammonia oxidation. Colour is also known to consume chlorine. The colour tests undertaken before and after chlorination prove that a free residual is achieved, but also that colour bleaching is occurring. It is difficult to estimate the chlorine demand from this mechanism.

Median ammonia quality from historical (2004-2005) records was 0.26 mg/L. Examination of secondary effluent quality over the course of the 9 months monitoring period reveals an ammonia-N concentration range of 0.05 to 36 mg/L. The ammonia maxima occurred from 18 August to 20 October 2006 during the monitoring period. This period commenced with

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<sup>2</sup> Beca, "Technical Memorandum No. 2, Epsom Spring Gully Recycled Water Project - Bendigo WRP Performance Assessment & Class A Upgrade" Section 4.5, Table 6, p 20, 2006

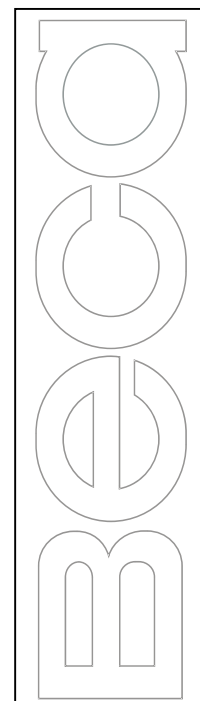


a power outage of some hours, when a car ran onto a power pole, on the Bendigo WRP electricity supply. Following resumption of supply, aeration was increased, to meet the ammonia demand in the aeration tanks, however the plant electricians advised that the main switchboard electricity bus was overloaded. It took a number of weeks before this aeration capacity limitation was overcome and then some three weeks before nitrification returned to normal. It should be noted that plant operators are now more aware of the need for a rapid response and the main switchboard electricity supply limitation is now rectified. In addition it is suspected that some aerators provide less than full oxygen input, due to their age. Coliban Water plan that these be progressively overhauled. Another source of concern was the return of sludge dewatering centrate (high in ammonia and phosphate) back to the head of the works during peak periods. Currently a buffer tank is being constructed, so that the centrate return can be spread out over time and occur during the plant's low influent load period.

It is proposed that from commencement of Class A discharge, the operating philosophy for nitrification will revert to achieving lower effluent ammonia concentrations. The currently proposed critical limit for ammonia-N is 0.9 mg/L. This limit is based upon a maximum chlorine dose of 14.5 mg/L based on the capacity of the dosing, to achieve a residual of 3.7 mg/L at the tank inlet and an outlet free residual of 0.42 mg/L.

The other point that the testing highlights is the improvement in UV transmittance, believed to be due to colour bleaching. Reduction in colour by an average of 24 Pt/Co units was observed, which gave an average increase in UV transmittance of approximately 6 percentage points.

Effluent suspended solids were not measured during these trials. Typical concentrations are available from the plant's sampling program. From this program the turbidity and SS data is summarised in Table 2 as follows.



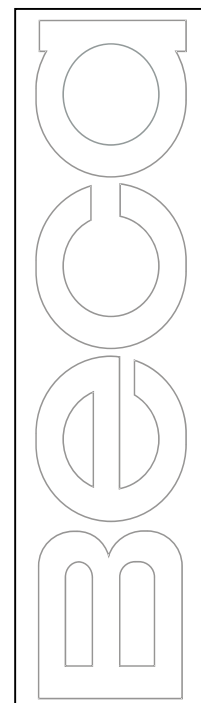
**Table 1**  
**Summary of Wastewater Physical and Chemical Tests**

Date	Sample	pH (pH units)	Ammonia nitrogen (mg/L)	Kjeldahl nitrogen (mg/L)	Nitrate nitrogen (mg/L)	Nitrite nitrogen (mg/L)	UV Transmittance (%)	Colour (Pt/Co units)
26/10/2006	PRE* UV FINAL EFFLUENT (RAW)	8.0	< 0.1	10	5.8	0.07	56.2%	35
	120MINS / PHAGE SPIKED + CL2	8.1					63.1%	10
9/11/21006	POST UV FINAL EFFLUENT (RAW)	7.7	< 0.1	5.2	3.6	0.04	57.5%	25
	120MINS / PHAGE SPIKED + CL2	8.0					63.1%	5
16/11/2006	POST UV FINAL EFFLUENT (RAW)	8.2	< 0.1	0.3	3.1	0.39	61.7%	35
	60MINS / PHAGE SPIKED + CL2	8.0					69.2%	5
23/11/2006	POST UV FINAL EFFLUENT (RAW)	7.9	< 0.1	2.1	2	0.04	61.7%	30
	60 MINS / PHAGE SPIKED + CL2	7.9					64.6%	10
30/11/2006	POST UV FINAL EFFLUENT (RAW)	8.2	0.3	1.3	1.7	0.01	63.1%	25
	50MINS / PHAGE SPIKED + CL2	8.1					70.8%	10
7/12/2006	POST UV FINAL EFFLUENT (RAW)	7.9	< 0.1	0.9	2	0.05	64.6%	35
	120MINS / PHAGE SPIKED + CL2	7.9					72.4%	< 2.0

\* Sample taken prior to the existing UV in error.

**Table 2**  
**Effluent Suspended Solids and Turbidity Data**

Data Period	Parameter	Mean	95 <sup>th</sup> Percentile	Standard Deviation
6 Months	Suspended solids [mg/L]	2.6	3.2	0.24
	Turbidity field 9:00 am [NTU]	1.7	3.2	0.74
	Turbidity laboratory 10:30 am [NTU]	0.5	0.9	0.5
Chlorine Study Period	Suspended solids [mg/L]	2.0	2.0	0
	Turbidity field 9:00 am [NTU]	1.0	2.5	0.74
	Turbidity laboratory 10:30 am [NTU]	0.54	0.78	0.24



**2.2.2 Chlorine Residuals**

Figure 2, below, summarises the free chlorine residual decay, as measured during the trials. For simplicity, the decay curve can be represented by two straight lines. One initially steep from time = 0 to a locus point and then a flatter residual decay to 60 minutes. The following equation describes the typical free chlorine residual (FCR) as a function of time:

Locus point between changes of slope occurs at point

$$T_1 [\text{min}] = (\text{FCR}_0 [\text{mg/L}] - 0.47) / 0.63$$

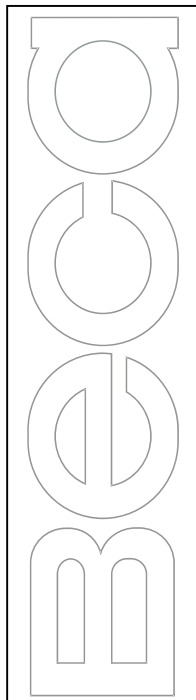
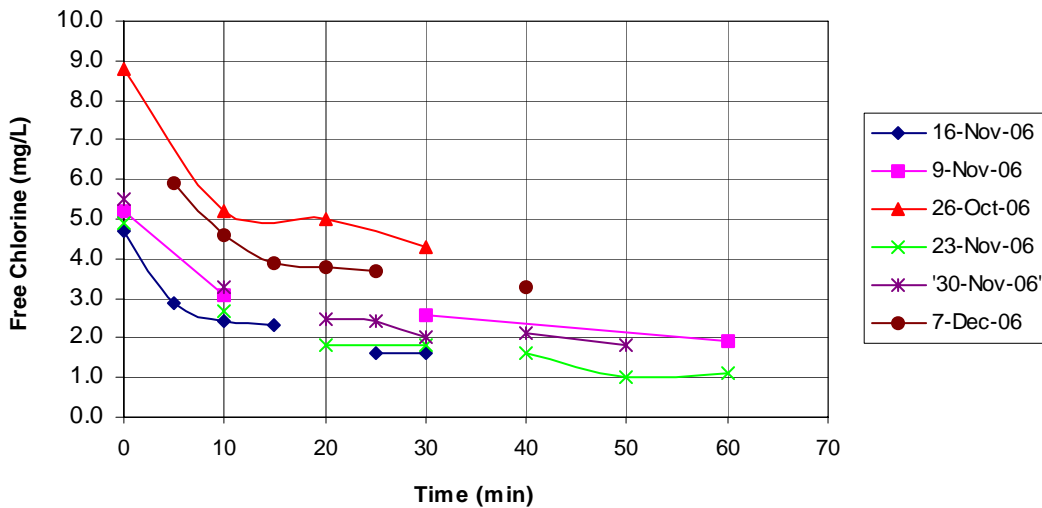
$$\text{FCR}_1 [\text{mg/L}] = 0.50 \text{FCR}_0 [\text{mg/L}] + 0.235$$

$$\begin{aligned} \text{FCR (mg/L)} &= \text{FCR}_0 (\text{mg/L}) - 0.315 \times \text{time (mins)} && t = 0 \text{ to } t = \text{locus} \\ &= 0.466 \text{FCR}_0 (\text{mg/L}) + && \\ &\quad 0.2006 - 0.0217 \times (\text{time}) (\text{mins}) && t > T_1 \text{minutes} \end{aligned}$$

This equation will be used to determine the appropriate dosing setpoints.

**Figure 1**

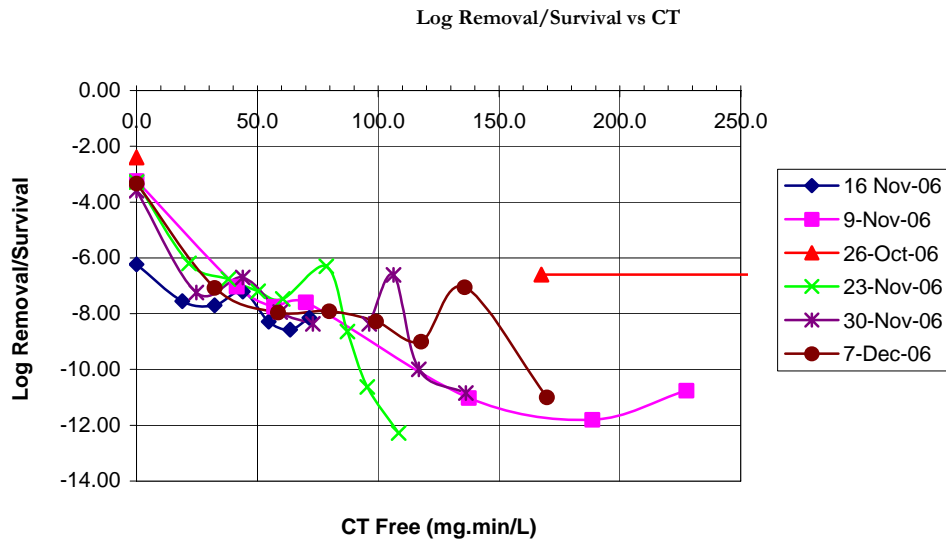
**Free Chlorine vs. Time**



2.2.3 Disinfection Performance

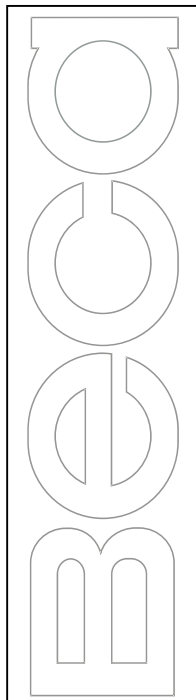
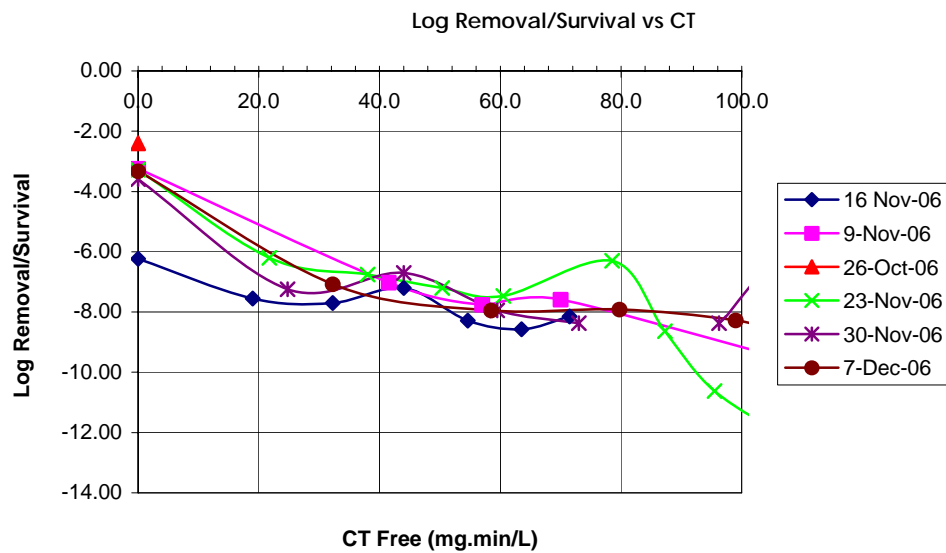
Figure 2 below presents the disinfection performance of free chlorine on MS2 phage.

Figure 2



An expanded version of this graph up to Ct = 100 mg.min/L is presented in Figure 3 below.

Figure 3



The Ct values used in these plots were derived by essentially linearly interpolating between free chlorine residual values, and then integrating the profile with respect to time. Thus the required Ct values are based on the integral of C with respect to time.

It is apparent that a 4-log<sub>10</sub> reduction of viruses occurs readily in this effluent. The USEPA Alternative Disinfectants and Oxidants Manual<sup>3</sup> quotes a Ct of 6 mg.min/L at 10 °C and pH 6 to 9 is necessary for four-log inactivation of viruses, in drinking water. Based on Figure 2, a Ct of 10 mg.min/L at 20 °C and pH 8 would be required to achieve a four-log reduction of MS2 in Bendigo tertiary effluent.

Both Figures 2 and 3 show that there are positive kills at t = 0 min, which is due to the fact that the time taken to complete the chlorine addition, stir and then quench a sample, and mix is of the order of one minute. The time to titrate is longer (say 5 minutes). So the 4 log kill should in reality be moved out a little from the y-axis (Ct = zero). The safety factor, included below, partly addresses this shortcoming. However the dosing and testing will replicate full-scale behaviour, as the chlorine will be dosed into the contact tank inlet line.

#### a. Effect of Microorganism, Temperature and pH on Ct

Reputedly Hepatitis A (HAV) is more resistant to chlorine than MS2. Also pH will influence hypochlorite species and any interaction with the virus protein coating. The work of Sobsey<sup>4</sup> and Grabow<sup>5</sup>, who undertook chlorination trials in buffered water, were used to adjust for the effects of pH and the relative resistance of MS2 and HAV (the target virus).

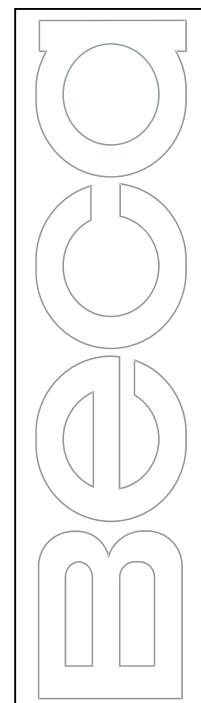
Although the Sobsey testing was carried out at 5 °C, and the Grabow testing was carried out at 25 °C, which reasonably covers the range of temperatures expected (10 °C to 30 °C), it was realised when using their data to produce adjusted Ct curves, that it yielded Ct values where the 5 °C curve was sometimes lower than the 25 °C curve, which does not conform with disinfection science. Accordingly, we have scaled the Ct result from the Bendigo bench trial temperature (20 °C) to the minimum expected temperature of 10 °C by the temperature correction from USEPA<sup>6</sup>.

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<sup>3</sup> USEPA, "Alternative Disinfectants and Oxidants Guidance Manual", April 1999, Table 2-13, p 2-26.

<sup>4</sup> Sobsey M. D., et al., "Inactivation of Hepatitis A Virus and Model Viruses in Water by Free Chlorine and Monochloramine", *Wat Sci Tech*, 20, 11-12, 1988, pp 385-391.

<sup>5</sup> Grabow, W.O.K., et al., "Inactivation of Hepatitis A Virus and Indicator Organisms in Water by Free Chlorine Residuals", *App Env Microbiol*, Sept 1983, pp 619 -624.



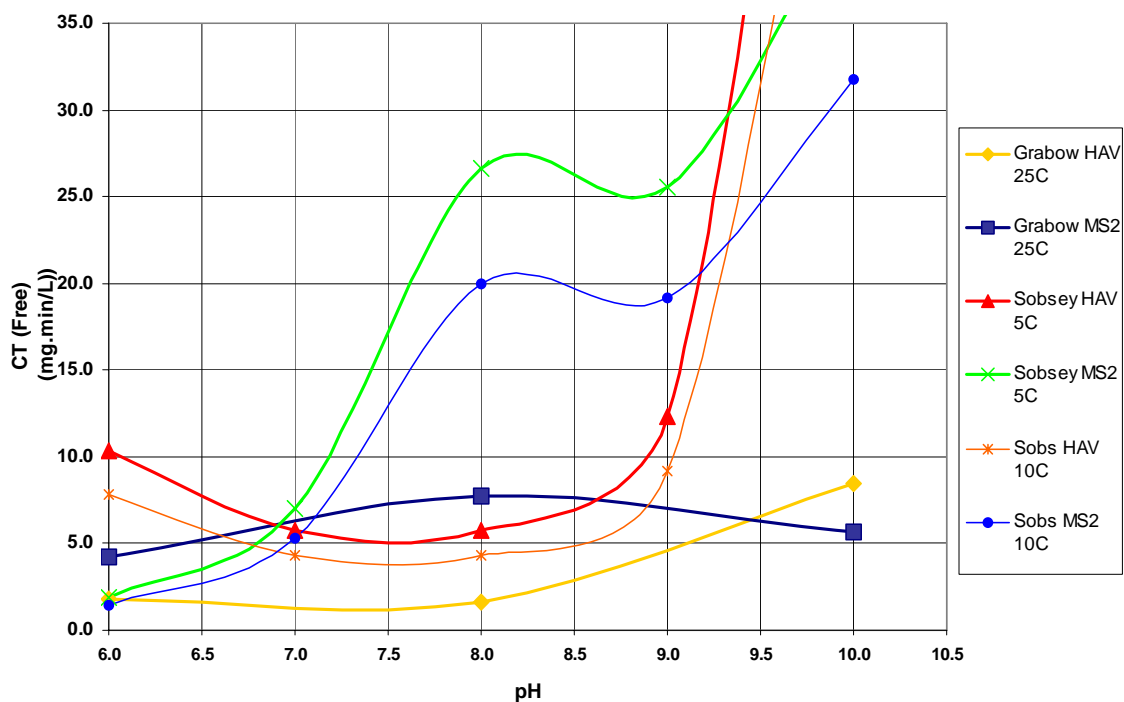
The Ct for a different species (eg. HAV) and at different pH values (eg. pH 9) versus the test pH (eg. pH 8) is given by the following formula. USEPA<sup>6</sup> has been used to convert the results from the bench test temperature to the reference temperature.

$$C.t_{HAV, Bendigo, pH x, oper temp} = \frac{C.t_{HAV, lab, pH x, closest lab temp}}{C.t_{MS2, lab, pH 8, closest lab temp}} \times C.t_{MS2, Bendigo, pH 8, test temp} \times \frac{C.t_{Virus, USEPA, pH 6-9, oper temp}}{C.t_{Virus, USEPA, pH 6-9, test temp}}$$

The Ct values derived from the above formula using the Sobsey and Grabow data to adjust for the effects of pH and the relative resistance of MS2 and HAV are plotted in Figure 4, below.

Figure 4

Computed Ct Values for a Four Log<sub>10</sub> Reduction of HAV and MS2 as a Function of pH and Temperature, Without any Safety Factors



<sup>6</sup> USEPA, "Disinfection Profiling and Benchmarking Guidance Manual", No. 815-R-99-013, August 1999, p 3-20.

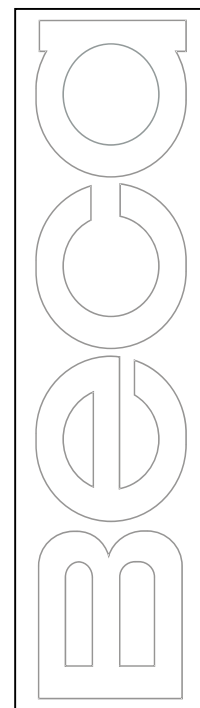


Figure 4 shows that the statement that HAV is more resistant than MS2 is true only at low and high pH values. At pH values of between about 7.0 and about 9.2, MS2 is more resistant to free chlorine than HAV.

### 3 Application to Epsom Spring Gully Recycled Water Project

#### 3.1 Required Ct

The worst case Ct required is derived from Figure 4 for the target virus (HAV) using the worst-case pH and the minimum water temperature expected. Review of the sampling data to date<sup>7</sup>, indicates a maximum pH at the existing UV disinfection unit of 8.14. Use of the Rothberg, Tamburini & Windsor Model<sup>8</sup> for corrosion control and process chemistry, suggests that the chlorine contact tank pH could rise as high as 8.6. To allow for contingencies a maximum pH of 9.0 is adopted as the upper limiting value. From Figure 4, a Ct of 9.2 mg.min/L is required for HAV (Sobsey) at 10 °C. This will also provide adequate performance at pH values down to a worst-case minimum of pH 6.0.

A safety factor of 50% has been added to the Ct (i.e., a design value of 9.2 mg.min/L x 150%) to allow for; virus aggregation and particle attachment, differences in particle attachment and virus aggregation between MS2, poliovirus and hepatitis A, shortfall of data at very low Ct values, excursions in effluent quality, short circuiting, swings in chlorine residual control, errors in free residual chlorine measurement, etc. Further detail justifying this factor can be found in Haylock<sup>9</sup>.

An additional safety factor of 33% (i.e. 9.2 mg.min/L x 150% x 133% = 18.4 mg.min/L, giving an overall safety factor of 2.0), has been allowed for the more resistant viruses such as Norwalk and Coxsackie viruses. These viruses are difficult to assay or tend to form aggregates. The required Ct is thus 18.4 mg.min/L (over the pH range of 6.0 to 9.0).

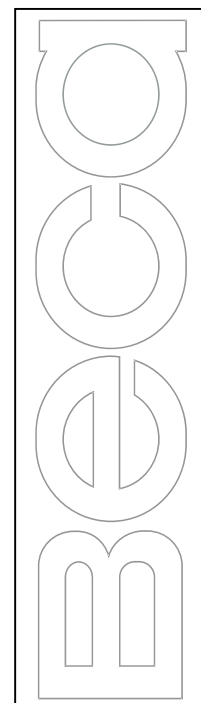
#### 3.2 Chlorine Contact Tank

The layout of the designed chlorine contact tank is detailed in drawing 3552306-200-S-051-1. The tank volume is 485 kL. The tank is a four-pass configuration with fibreglass baffle walls. The overall length to depth ratio is 18:1 and the length to width ratio is 43:1. Eight distributor plates are installed in the tank, perpendicular to the flow direction. These plates are installed at the inlet and outlet and two at each change of direction. The plates have a

<sup>7</sup> Campaspe Asset Management, "Class A Sampling Results Epsom 2006 (Master) recd 10 Jan.xls"

<sup>8</sup> Rothberg, Tamburini and Windsor, Inc, RTW model Ver 3.0, available through AWWA.

<sup>9</sup> Haylock G., "Chlorination for Virus Inactivation for the Epsom Spring Gully Recycled Water Project", Proc AWA Water and Health Specialty Conference III, 2007.



number of 150 mm holes across their face to distribute the flow evenly across the cross section of each pass, in accordance with best practice<sup>10</sup>. The inlet and outlet are at the top and so we are relying on the distributor plates to provide an even velocity profile. Based on the design of the tank, we have adopted a  $T_{10}/T_{\text{mean}}$  factor of 0.67 to account for the short-circuiting of the tank<sup>11</sup>. Tracer testing will be carried out by the Contractor will confirm this factor and Ct values adjusted for any deficit.

The outlet of the tank is an overflow weir. The water depth of the tank is governed by a weir formula applied to this weir. The maximum water depth occurs at maximum flow and is a small amount over the fixed weir crest. To adopt the weir crest level of 191.870 to determine the tank volume gives a lower bound for tank volume. The inside dimensions of the tank are 17 m long x 7.8 m wide x (191.870- 188.300) m deep. The contact tank minimum wetted volume is thus 473 m<sup>3</sup>. At full flow the increase in water level, caused by overtopping the weir will increase the tank wetted volume to a maximum of 485 m<sup>3</sup>.

The following design flows and detention times apply to the Class A treatment plant:

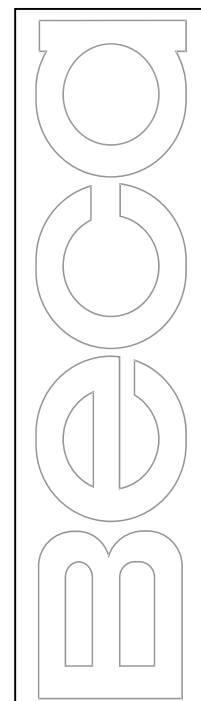
**Table 3**  
**Summary of Detention Times**

Flow Case	Flowrate			$T_{\text{mean}}$ [min]	$T_{10}$ [min]	FCR Outlet [mg/L]
Current Design	9.9 ML/day	115 L/s	413 m <sup>3</sup> /h	71	47	0.39
Ultimate Design	12.2 ML/day	141 L/s	508 m <sup>3</sup> /h	57	38	0.48

The final column of Table 3 shows the required free chlorine residual at the outlet of the tank, and is calculated by dividing the required Ct by the  $T_{10}$ . This calculation is a conservative assumption and is as agreed between DHS and Beca in mid-June 2007. It assumes that the inlet residual equals the outlet residual, whereas the bench testing work showed a systematic decay as summarised in section 2.2.2. In the medium term, Coliban Water may elect to add one or more FCR monitors within the tank to take advantage of higher FCRs nearer the inlet, and thereby reduce the chlorine dose rate.

<sup>10</sup> Hart F. L., "Improved Hydraulic Performance of Chlorine Contact Chambers", JWPCF, 51, 12, pp 2868-2875, 1979.

<sup>11</sup> AWWA ASCE, "Water Treatment Plant Design", Third Edition, Mc Graw Hill, 1998, pp 224-227.



### 3.3 Chlorine Residual Monitoring and Control

The chlorine contact tank is equipped with free chlorine residual monitors at both tank inlet and tank outlet. The residual monitors are free chlorine residual monitors only. Total chlorine residuals are only monitored post dechlorination. The outlet free chlorine residual monitor sets the setpoint for the inlet monitor (i.e. residual trim - low outlet residual increase setpoint for inlet monitor). A free chlorine residual can only be achieved if chlorine is dosed beyond the breakpoint. If no free residual is recorded at the CCT outlet then the inlet residual monitor will increase the inlet free residual setpoint and thus the chlorine dose will increase. If the dose rate is a maximum of dosing pump output and the outlet residual is not reaching the setpoint then the Class A system will automatically shutdown on low outlet free chlorine residual and an alarm will be raised. Tertiary treatment effluent will then automatically overflow to Bendigo Creek. Alternatively the system can be run at a lower flowrate and achieve a free chlorine residual. For example if the Class A flowrate is halved, the process can cope with ammonia-N concentrations of approximately 2 mg/L.

The inlet residual monitor is the main hypochlorite dose rate controller. The dose rate is also flow paced. The required setpoints to meet the required Ct are summarised in Table 4 below. These assume the outlet free chlorine residual is constant throughout the tank.

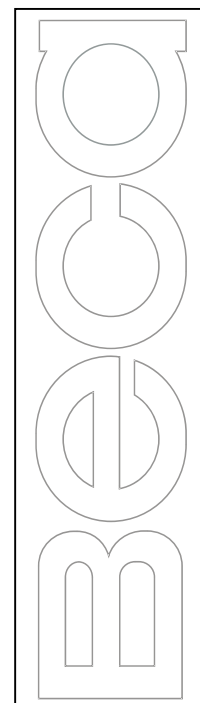
**Table 4**

**Design Free Chlorine Residual Settings**

Flow Case	Inlet Free Chlorine Residual Setpoint (at t = 0)	Outlet Free Chlorine Residual Setpoint (at t = T <sub>10</sub> )	Ct Integral based on worst-case Chlorine Jar Test [mg.min/L]
Current Flow (9.9 ML/d)	3.7 mg/L	0.39 mg/L	79
Ultimate Flow (12.2 ML/d)	3.3 mg/L	0.48 mg/L	57

The calibration of the two free chlorine residual monitors will be checked in accordance with the ESGRWP Monitoring Schedule.

The free chlorine residual declines with decay rate. This rate has been fitted with respect to time by two straight lines (refer section 2.2.2). This curve fit can be integrated with respect to time to derive the Ct integral, matching with the Ct integral from the jar test. The integrated Ct values based on the T<sub>10</sub> detention time, for the 95<sup>th</sup> percentile worst-case residual decay slope, is presented in the final column of Table 4 for each flow case.



It should be noted that these integrated Ct values are for the worst-case (95<sup>th</sup> percentile confidence interval) residual profile (i.e. for a rapid decay in residual at the inlet and the flattest decay in the slow residual decay rate).

### 3.3.1 Critical Limits

The following critical limits apply to the hypochlorite dosing system, operating at 9.9 ML/d production:

**Table 5**

**Chlorination Analyser Critical Limits**

	Chlorination Analyser Error Band	Free Chlorine Concentration Range
Outlet CCT	0.42 ± 0.03 mg/L	0.42 to 0.5 mg/L

### 3.4 Dechlorination Process

The UV outlet stream is dechlorinated by sodium metabisulphite (equals sodium bisulphite) solution. The dosing is flow paced and adjusts to the downstream total chlorine residual measured by an analyser. The aim is to maintain the total chlorine residual at 0.05 mg/L.

#### 3.4.1 Critical Limits

The following critical limits apply to the metabisulphite dosing system:

**Table 6**

**Dechlorination Analyser Critical Limits**

	Dechlorination Analyser Error Band	Total Chlorine Concentration Range
Inlet Final Water Tank residual	0.05 ± 0.03 mg/L	0.02 to 0.08 mg/L

### 3.5 Chlorine Dosing System

The chlorine dosing is based upon the use of 13% w/w sodium hypochlorite solution. The following table outlines the system and the design basis:

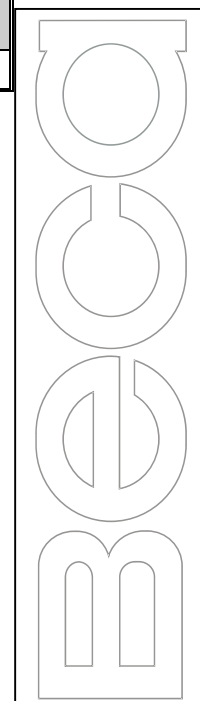


Table 7

## Hypochlorite Dosing System

Parameter/assumption	Value
Maximum effluent flowrate	9.9 ML/d (114.5 L/s)
Hypochlorite dose rate	3.9 - 14.5 mg/L
Hypochlorite consumption	50- 1300 L/d
Hypochlorite storage capacity	20,000 L

It should be noted that the above storage capacity, and also that in Table 8 for sodium metabisulphite, were designed before the virus chlorination testing took place. At this time it was assumed that a dose of up to 11 mg/L and a 3 mg/L residual would be required in the effluent, with a contact time of 30 minutes (i.e. a Ct of 90 mg.min/L). The testing has demonstrated that a lower Ct is required, which means that the chlorine dose will reduce to approximately 9 mg/L (reduction by about a third). The originally specified hypochlorite dosing pump has been retained as it is still suitable for the duty, and can meet a peak ammonia-N concentration of 0.9 mg/L.

Table 9 presents the design details for the dechlorination system.

Table 8

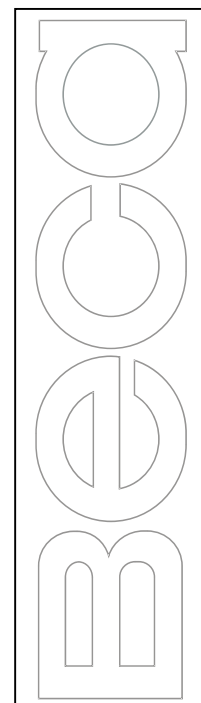
## Sodium Metabisulphite Dosing Pumps

Parameter/assumption	Value
Maximum effluent flowrate	9.9 ML/d* (114.5 L/s)
Metabisulphite dose rate	1.2 - 3.0 mg/L
Metabisulphite consumption	8- 150 L/d
Metabisulphite storage capacity	10,000 L

\* System designed for possible future upgrade to 12.2 ML/d (141 L/s)

The sodium metabisulphite dosing pumps will be reduced in output to the above values (from their original design), to cater for the reduced total chlorine residual to be dechlorinated.

In summary the chlorination process has been designed to deliver a minimum required Ct value, based upon a minimum and maximum pH and minimum temperature and a maximum effluent flowrate. Online free chlorine residual monitors will be used to automatically ensure the minimum outlet free chlorine residual to meet the design Ct. The conservative assumptions with the many variables detailed above, including the fact that



the tank will often operate below its maximum flow, will mean the Ct delivered will typically be much greater than the minimum Ct of 18.4 mg.min/L. The fact that the free chlorine residuals will decay through the tank, means higher inlet residuals, resulting in a Ct integral that is much higher than this number.

The critical limits for the chlorination system are as follows in Table 9:

**Table 9**  
**Chlorination Critical Limits**

Parameter	Critical Limits	Units
Flowrate	> 115	L/s
pH	< 6.0 or > 9.0	pH units
Temperature	< 10	° C
Ammonia-N	> 0.9	mg/L
Free Chlorine Residual at CCT outlet	< 0.42	mg/L
Baffle wall sealing	No gaps, when checked 6 monthly	

Should you require any further information, please contact me.

Yours faithfully  
**Beca Pty Ltd**



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