CDS TECHNOLOGIES

Wastewater Reuse Process

A Summary of the 2004 Trials at Brushy Creek STP, Croydon and Evans Road STP Cranbourne

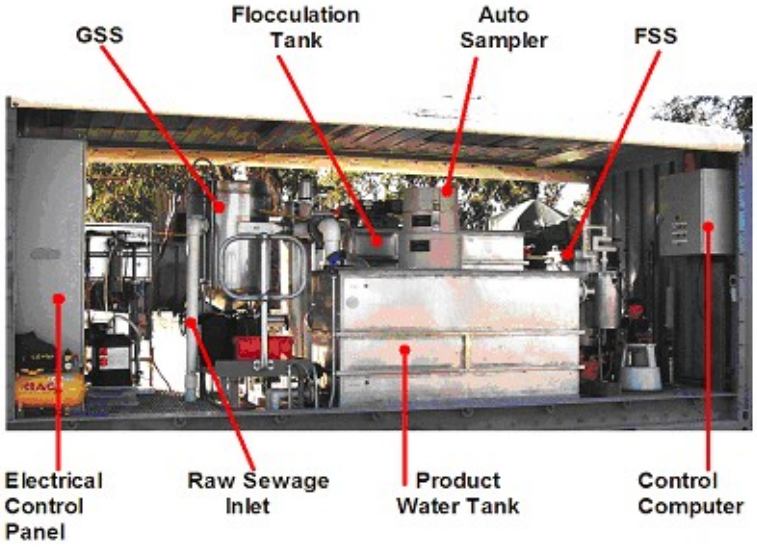
Smart Water Fund

CDS – Wastewater Reuse Technology

Background

CDS Technologies has a patented high rate technology that has been applied chiefly to the physical separation of gross solids from stormwater and sewage. For sewage, this process is known as Gross Solids Separation (GSS) and has been demonstrated to remove particles down to about 1mm.

To remove particles smaller than 1mm, CDS has developed a process known as Fine Solids Separation (FSS). This process has been developed and tested using raw sewage at both the SE Water Mornington sewage treatment plant and the Barwon Water Ocean Grove pumping station in Victoria.



This report covers trials involving application of the FSS process to sewer mining by combining it with other downstream processes to produce a high quality effluent from raw sewage for reuse purposes.

Work was conducted at two sites - the Yarra Valley Water Brushy Creek WWTP at Croydon and the South East Water Cranbourne STP. This report summarises the main findings of the work.

Introduction

Standards for reuse water in Victoria are administered by the EPA (Refs. 1 & 2) wherever its use affects the environment. Where there is a concern for public health, however, the Department of Health Services (DHS) may have additional requirements.

For general, non-potable urban use where public access is uncontrolled, in agriculture where human food crops are consumed raw or for open systems in industry where workers may come into contact with the reuse water, the EPA

specifies maximum values for a group of water quality parameters (Ref 1, Appendix A) referred to as “Class A” reuse water.

Class	Water quality objectives - (medians unless specified)	Range of uses– uses include all lower class uses
A	E.coli org/100 mL < 10 Turbidity NTU < 2 BOD mg/L < 10 SS < 5 pH 6 – 9 1 mg/L Cl_2 residual	Urban (non-potable): with uncontrolled public access Agricultural: e.g. human food crops consumed raw Industrial: open systems with worker exposure potential.

The main public health indicators used are virus, protozoa, bacteria, helminths, suspended solids and turbidity. The last two items are important, as organisms are generally associated with particulate materials.

Overall the project was aimed at providing an attractive option for treating sewage to a standard acceptable for re-use.

More specific objectives were to

- Establish water quality standards through testing that could be achieved by the plant,
- Identify costs per kilolitre for water of different quality
- Establish the footprint required for the various operating regimes.

To achieve an effluent quality suitable for reuse, the concentration of various components of sewage needs to be reduced to meet the reuse standards. Once these are met it is then necessary to obtain approval of the EPA for the process to have an approved Class A treatment process. These components are typically suspended solids (SS), turbidity, BOD and pathogens such as bacteria, protozoa and virus. For some reuse applications it may also be desirable to reduce nutrients such as ammonia and phosphorus. Generally dissolved solids do not require any reduction if the quality of the water initially supplied is high.

Treatment Process

The CDS approach to the production of high quality reuse water was to implement the following improvement steps, starting with raw sewage:

1. Remove the bulk of suspended solids together with their associated biological oxygen demand (BOD) using the Fine Solids Separator.
2. Reduce the bulk of the remaining (soluble) BOD using a rapid biological process (the Submerged Aerated Filter).
3. Polish the effluent by removing residual suspended solids in a clarifier or sand filter.
4. Disinfect the resulting effluent by UV irradiation.
5. Establish a residual chlorine dose to minimise algae formation and prevent bacterial regrowth by injecting a small quantity of hypochlorite.

The overall treatment process is shown in Figure 1. Two different configurations of the process were trialled, with the clarifier used initially being later replaced by a sand filter at the second site. This change has advantages discussed below under Effluent Polishing.

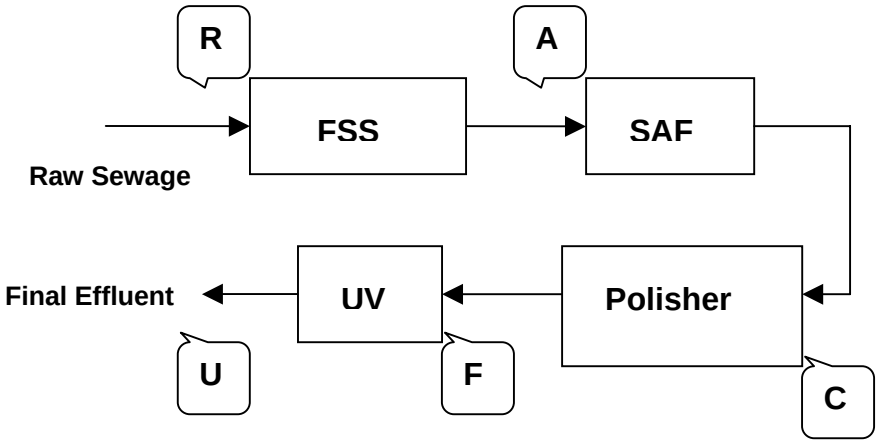


Fig.1

FSS = CDS Fine Solids Separation Process
SAF = Submerged Aerobic Filter
Polisher denotes either Clarifier or Sand Filter – refer text
Sampling points: R, A, C, F, U

Process Steps

Suspended Solids Removal

The CDS Fine Solids Separation Process (see Fig 2 – FSS Process) predominantly removes suspended solids and turbidity from raw sewage, although effluent from the process conforms to no recognised class.

At its simplest (Figure 2), the FSS process employs chemically assisted solids separation using a coagulant (alum) and a flocculant (polymer). Gross sewage solids entering the system are screened out using a high rate physical separator (the Gross Solids Separator - GSS). Flocculated solids are removed from the system at a similar high rate using a second separator (Fine Solids Separator - FSS) specially adapted to manage the sticky flocs.

The Hydraulic Residence Time (HRT) for the process is of the order of 8 minutes.

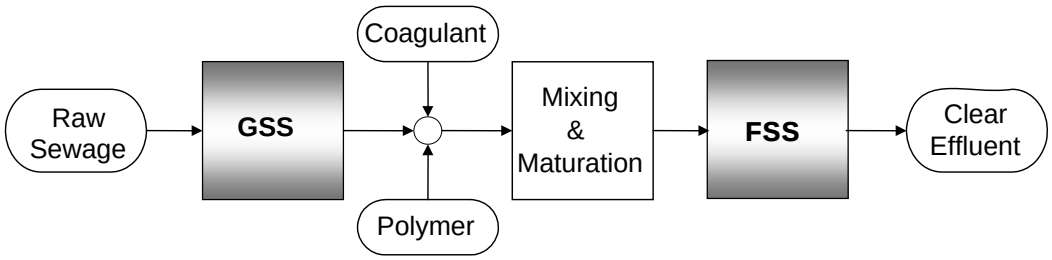


Fig. 2 Flowchart for the CDS Fine Solids Separation Process

Typical reductions in sewage components in the FSS Process are 90-95% for suspended solids, 60-70% for BOD and 85-95% for phosphorus. Because so much of the suspended solids are removed, the turbidity is also reduced around 95% and faecal coliforms by 2 logs.

Solids are removed during this process step in 2 streams from each of the GSS and FSS and returned to the sewer.

Soluble BOD Reduction

Removal of soluble BOD is achieved by a Submerged Aeration Filter or SAF, supplied by Copa UK (part of the CDS group).This is a standard product sold in UK and European markets in a range of configurations and sizes from 100 to 1500EP (Estimated Population).

The Submerged Aerated Filter (SAF) is a multi-cell tank containing a honeycomb packing on which biomass is allowed to grow. Air released from diffusers in the base of the tank bubbles up through the sewage in contact with the biomass. This provides the maximum possible opportunity for exchange of oxygen from the air with the soluble BOD of the clarified sewage from the FSS.

The sewage circulates through the packing and eventually passes into the next stage in the train. At each stage there is a reduction in the soluble BOD content as it is consumed by the biomass. Overall reduction in BOD in this process step is 80-85%. Some oxidation of ammonia also occurs.

The pH of the treated effluent from the FSS is usually around 6.6, but if nitrification occurs in the SAF the pH will drop further. A pH controller is installed as part of the SAF which adds soda ash if the pH drops below a set point, usually pH 7-7.5.

A Copa CB 300 SAF was used in the trials. This had a design flow of 0.75L/s (BOD removal 12.5kg/day) and was arranged to treat a sidestream of the effluent from the FSS. In this application the SAF is treating only the soluble fraction of the BOD present in the sewage, which means that it is underloaded when compared with conventional operation. In order to establish the new operational parameters, the SAF was run under different loading conditions and BOD removal efficiencies compared. Once the unit performance is established for the known feed flowrate and characteristics, it is a simple matter to size the unit(s) required for any other flow.

Fig. 3 Copa CB 300 SAF used throughout the trials

The CB300 SAF consists of three consecutive stages or cells, filled with diagonal corrugated packing. Circular membrane air diffusers are mounted under the packing in each stage with air supplied from a low noise emission centrifugal blower. Air flow to each cell can be individually adjusted.

Effluent Polishing

Final polishing of the effluent is required to remove the last of the suspended solids to ensure that the turbidity of the effluent is low, making the UV disinfection step more effective.

Initially a clarifier (design rise rate ~1m/hr) was used in this process step to remove the suspended solids generated in the SAF, but once trials at the first site confirmed that the rate of production of solids in the SAF was low, an opportunity was provided to remove the clarifier from the process chain at the later site. This enabled discharge directly from the SAF into a sand filter, thereby reducing the system footprint and capital cost as well as removing a potential source of algal growth and pollution from wildlife.

For the initial period of the work at Cranbourne the clarifier was used to check the findings from the Brushy Creek site, but once these were confirmed, the filter was fed directly from the SAF.

The sand filter used for this purpose was a dual media, deep bed pressure filter (Type SMDD 900) supplied by Waterco P/L. The filter bed was 900mm diameter with a maximum depth of 1000mm, made up of sand and anthracite.

Such a filter bed amply meets the requirement of the Livestock Diseases Control Act 1994 (as laid out in Ref. 3) that reuse effluent applied to grazing land either be held in a pond for 30 days or be passed through a membrane filter or a sand filter with a minimum bed depth of 600mm in order to remove helminth ova (worm eggs), should any be present in the effluent.

UV Disinfection

The UV disinfection unit was supplied by Ultraviolet Technology of Australasia. It is a 100 Series unit, rated at a maximum of 4L/s for secondary effluents with turbidity of <5 NTU. This unit was operated on the entire effluent stream from the sand filter.

Conduct of Trials

Feed, intermediate and effluent samples were taken from the various process stages (Fig. 1) in accordance with Victorian EPA guidelines for sampling and sent the same day to a NATA registered laboratory for analysis.

There were minor differences between the conduct of analyses at the two sites. In general, experience at the first site enabled more appropriate testing to be conducted at the second, notably the change to carbonaceous BOD_5 in place of conventional BOD_5 and analysis for bacteriophage in addition to viruses as so few of the latter were present in the sewage feed. These points are described in more detail later.

Sample collection

Samples were collected in sets, consisting of raw sewage, FSS effluent, filter effluent and filter effluent after UV disinfection. Since the Hydraulic Residence Time (HRT) of the FSS stage was about 8 minutes, the SAF about 4 hours and the filter around 4 minutes, samples were collected in the above order over a period of about 4 hours between 08.30am and 12.30pm.

Sample volumes required for virus and protozoa were 50L each, other sample volumes ranged from 250mL up to 1L, resulting in a total sample volume of about 205L to be transported to the laboratory each sampling day.

Three methods of sample collection were used:

1. For discrete non-disinfected samples, two Sigma 900 Wastewater Samplers were used to collect 1L each hour. The 1L samples were later combined to give 2L volumes which were then sufficient for the various parameters to be measured.
2. Biological samples after disinfection were collected by hand from an outlet valve in the transfer pipe between the UV disinfection unit and the product water tank. Because of the need to maintain aseptic conditions for disinfected samples, the small volume requirements and the need to have samples at the analytical laboratory by about 2pm for processing, all biological samples were 'spot' samples, being collected over a period of between 2 to 20 minutes depending on the volume required for analysis.
3. Spot samples were taken by hand from the appropriate sampling point.

Analysis

WSL Consultants Enviroscience were contracted to conduct analyses. Transportation was by courier directly to the WSL laboratories. Table 1 shows the analyses conducted over the 4 week trial period at the Cranbourne site. Analysis work in the Brushy Creek trials did not include carbonaceous BOD, viruses were determined on 10L samples, while analyses for protozoa at this site were not undertaken. Otherwise, the same tests were conducted.

Test Conducted by WSL (or Subcontractor)	
BOD_5	**Bacteria CFU/100mL**
BOD_5 (Filtered)	E-coli
Carbonaceous BOD_5 ($CBOD_5$)	
Total Oxidised Nitrogen (TON)	**Virus/50L**
Turbidity (NTU)	Adenovirus, Enterovirus, Reovirus Bacteriophage (as Coliphage)
Suspended Solids (SS)	Helminths, ova/L
Orthophosphate (PO_4-P)	Taenia ova, Ascaris ova
Ammonia (NH_3-N)	**Protozoa, Oocysts, Cysts/50L**
	Cryptosporidium, Giardia

Table 1. Analyses conducted during the trial period at Cranbourne

Results and Discussion

Owing to the trials' being conducted at 2 sites each with its own sewage characteristics and with differences between these sites in the way that plant was configured and analyses performed afterwards, it is necessary to present 2 sets of results to adequately cover the findings. These are presented separately with some generalisation provided afterwards.

Brushy Creek Plant Trials

Samples from Brushy Creek were analysed over the period 10th October to 28th November 2003. From this data as a whole, the effect of the treatment steps can be seen and are summarised in Figure 4. Appendix C contains a more extensive presentation of the whole of the data.

The changes in raw sewage BOD at Brushy Creek can be quite large at times but the FSS process coped well as shown in Figures 5 & 6. Changes in suspended solids and turbidity for the same two periods are shown in Figures 7 and 8.

The recommended median values for effluents prior to disinfection are shown in Appendix B. From this it can be seen by comparison with the test results (Appendix C) that the effluent produced in the CDS process is suitable for UV disinfection. The results also show that UV disinfection is effective in bringing the E. coli within the required limits for Class A, ie. <10 orgs/100mL. The UV dosage was 30,000 microwatt seconds per cm^2 @ >85% UV transmission (from manufacturer's data).

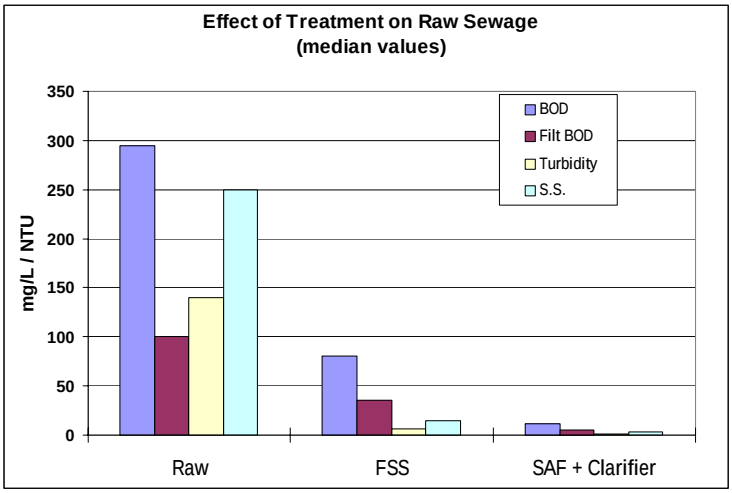


Fig. 4 Reduction in various water quality parameters across the process

Analyses for the detection of virus and helminths are reported in Appendix D, where it is seen that positive results were found only in the raw sewage sample, while for the treated effluent no organisms were detected. Where no organisms were detected in both raw sewage and treated effluent a null result is returned. This means that there are insufficient viruses present in the raw sewage to enable assessment of their removal by the process[a].

[a] As a consequence of this lack of viruses in the raw sewage, additional tests were conducted on coliphages in the second trial – refer text.

The median value of 11mg/L for BOD_5 (Appendix C) appears at first glance to be marginally above the Class A limit of 10mg/L. When considering this result it should be remembered that the SAF was being operated under high-load conditions to establish its proper operating regime. In the last days of the trial, when BOD_5 results were falling towards 10mg/L as the optimum operating regime was being approached, an exceptional daytime composite BOD_5 value of 1000mg/L occurred in the raw sewage feed at the sewage treatment plant.

In the days following this exception until the end of the trials, plant BOD remained in the normal range and effluent from the SAF in this period showed individual results around 10mg/L or less (which conforms to Class A effluent). The table in Appendix C shows only consolidated results which masks this level of detail.

Flow to the SAF in the last 10 days of the work at Brushy Creek gave a calculated hydraulic retention time (HRT) of about 2 hours, whereas previously it was around 2.8 hours, which in either case is very short for a biological process.

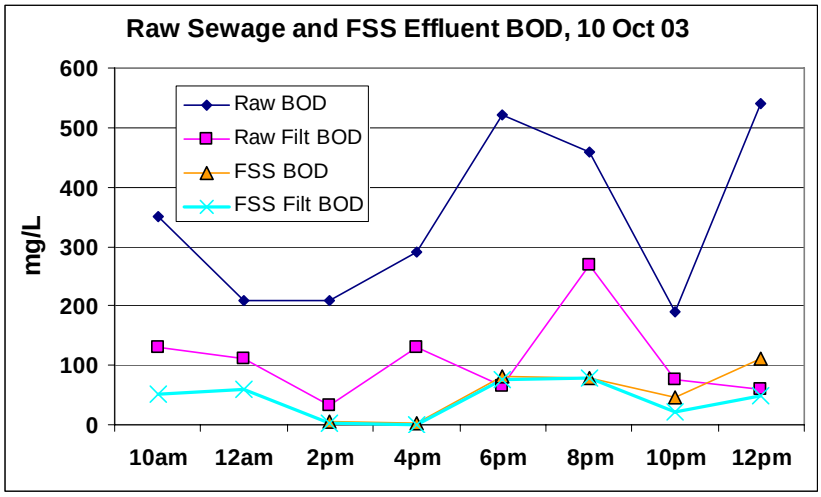


Fig. 5. Raw Sewage and FSS Effluent BOD
Brushy Creek, 10th October 2003

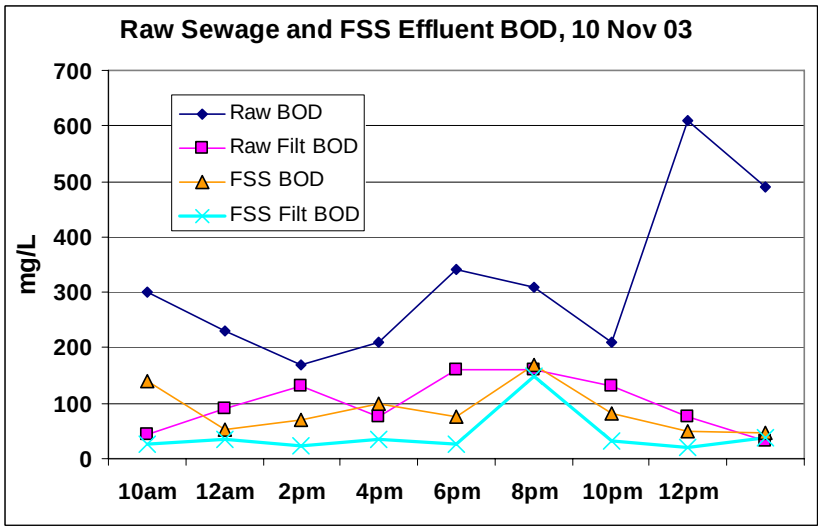


Fig. 6. Raw Sewage and FSS Effluent BOD
Brushy Creek, 10th November 2003

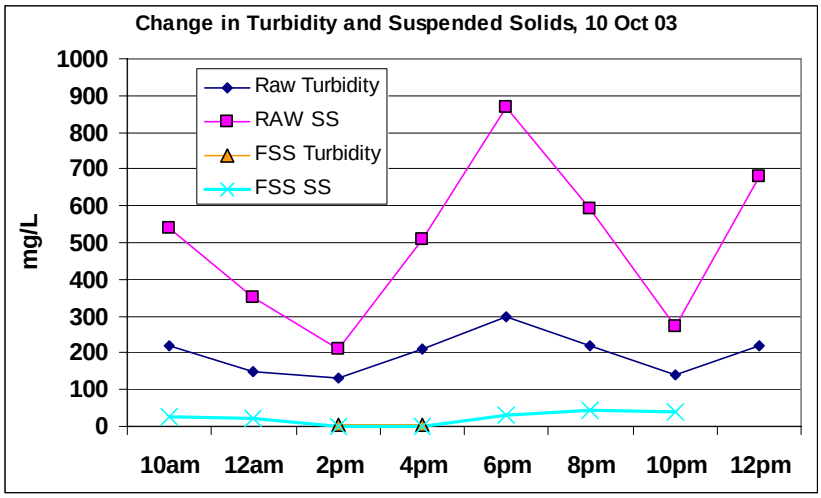


Fig. 7. Raw Sewage and FSS Effluent Turbidity and Suspended Solids, Brushy Creek, 10th October 2003

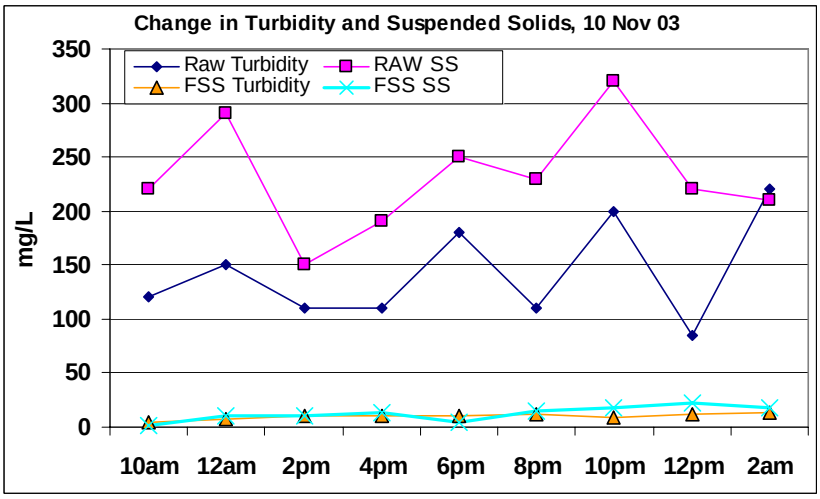


Fig. 8. Raw Sewage and FSS Effluent Turbidity and Suspended Solids, Brushy Creek, 10th November 2003

Cranbourne Plant Trials

The Cranbourne treatment plant operates at around 1MLD depending on seasonal demands from customers for reuse water. Sewage is drawn from an adjacent manhole in a 1.2m diameter sewer, which runs past the plant to the Eastern Treatment Plant at Carrum. The Cranbourne STP wet well was built for a very much higher flow, when the plant was running at full capacity. This results in a very long hydraulic retention time with the current 1MLD. The CDS process was set up to draw sewage from the treatment plant wet well, with treated effluent, sludge and other discharges being made to a second manhole downstream of the draw-off point.

Samples from Cranbourne were collected over a 4-week trial period in the same way as for the Brushy Creek trial. The variation in raw sewage parameters for the period is illustrated in Fig. 9, where it is seen that some very large changes took place in raw sewage BOD. The highly effective removal of SS by the FSS and removal of the remaining BOD by the SAF (which is between the FSS and the filter) can also be seen in the figure.

Although there are large changes in feed concentrations, the corresponding effluent variations are quite small. From the data as a whole, the effect of the treatment steps can be seen and are summarised in Fig. 10. Appendix E contains a more extensive presentation of the whole of the data.

The full data presentation (Appendix E) shows that the effluent parameter with the greatest variability was BOD_5, followed by carbonaceous BOD_5 (CBOD). One of the major realisations from the work at Brushy Creek was that BOD_5 analyses may be influenced by any ammonia present, as it is the second largest source of oxygen demand after carbon. For this reason, analysis for CBOD was conducted in this phase of the work to separate the contribution to BOD_5 caused by the high ammonia present to provide more detailed understanding.

In the trials at Brushy Creek, viruses were only found in the raw sewage in 3 out of 8 data sets. Helminth ova were only found in 2 cases. Neither viruses nor helminths were found in any effluent samples.

The lack of viruses present in the sewage means that results indicating that no viruses were found in the process effluent are not unambiguous. Without sufficient viruses available in the feed it is impossible to demonstrate effective virus removal by the process.

To overcome the high number of ‘null’ results, it was suggested by DHS that analysis should be conducted for bacteriophage (a virus that infects only bacteria) which should be present in greater numbers than human pathogenic viruses and are easier to test for. The results for this are shown in Figure 11. The limit of detection in this test was 5 CFU so that all results from samples taken after UV disinfection were reported as not detected.

Log removal of E-coli across the process is shown in Fig. 12. The detection limit for this test is 0.1 CFU/100mL; the guidelines require < 10 CFU/100mL. Results from Cranbourne are similar to those obtained at Brushy Creek and are within the EPAV current guidelines for Class A reuse water.

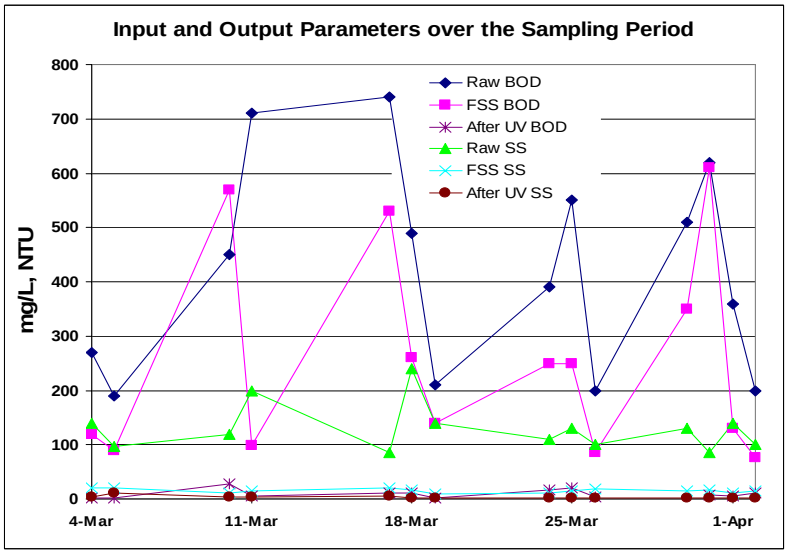


Fig. 9 Variation in raw sewage parameters during the course of the trial

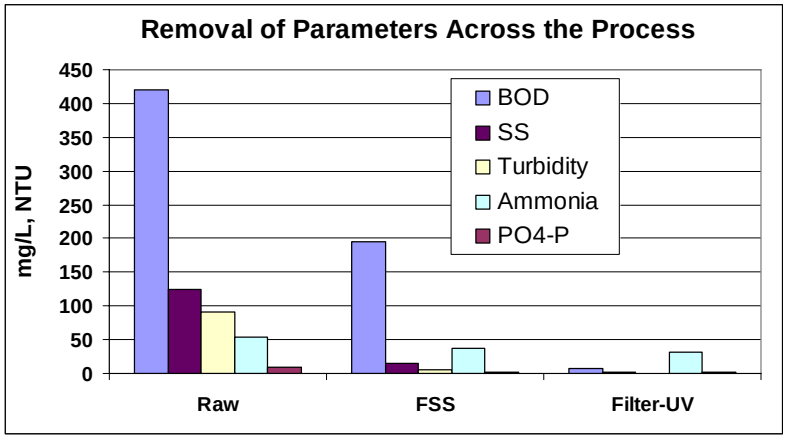


Fig. 10 Effect of treatment on the measured parameters.

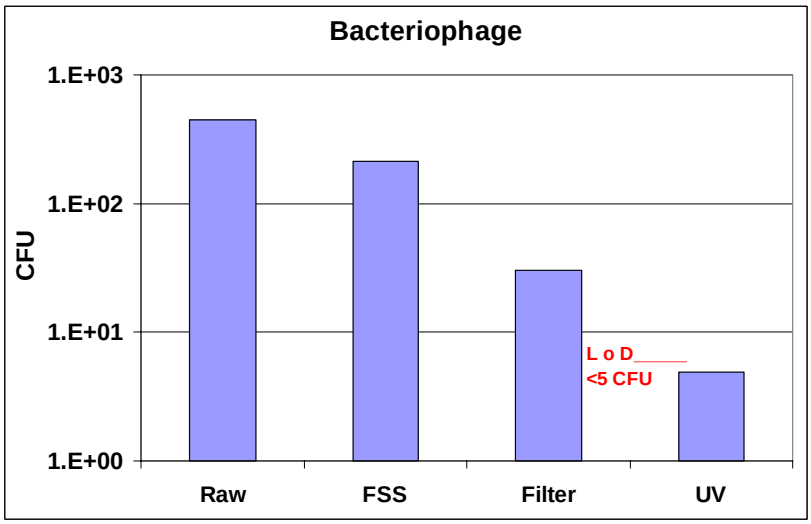


Fig. 11. Log reduction of bacteriophage across the process (LoD = limit of detection).

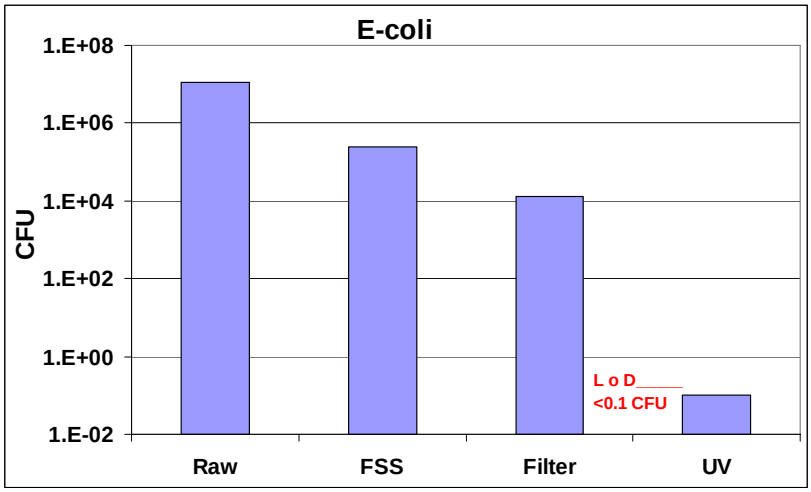


Fig. 12. Log reduction of E-coli across the process (LoD = limit of detection).

Plant Costs

A general analysis of likely operating costs for sewer mining plants of different capacities follows based on the findings of this study.

Operating Costs

Under this heading, allowance is made for electrical power and chemicals only and are quoted as $ per kL of product.

It should be noted that the principal operating cost – chemicals – varies with the sewage, being higher where the sewage contains higher loading of suspended solids or where the alkalinity is less. For this reason, resort has been made to a "type" sewage, an artificial construct with water quality parameters corresponding to "typical" sewage, modelled very closely on the sewage encountered at Brushy Creek. This type sewage is depicted in the Table 2.

BOD	300
SS	250
NH_3	30

Table 2 Parameters of type sewage (mg/L)

In addition, a level of alkalinity has to be assumed for the FSS effluent, as the amount of soda ash added in the SAF for pH adjustment also varies with this parameter. For the purposes of this costing the alkalinity of the raw sewage is taken as 200mg/L.

Based on trial results and these assumptions, the operating cost of plant without amortisation of capital costs has been calculated for plants of 3 different sizes, as shown in Table 3.

		$/kL product		
Cost Item	**Basis**	**0.5MLD**	**1MLD**	**5MLD**
Power	0.14/kWh	0.10	0.09	0.07
Chemicals[1]		0.32	0.32	0.32
Total		0.42	0.41	0.39

Table 3 Operating costs for the sewer mining plant – type sewage

Notes:

1. Chemicals comprise alum, emulsion polymer and soda ash. When powdered polymer is used both operating costs are 17.2% lower than for emulsion shown here.

Capital Costs

No assessment of capital costs has been made in this report.

Conclusions

Under this project, CDS has demonstrated the ability of its Wastewater Treatment Technology to produce Class A quality water as defined by the current EPAV guidelines (ref following table). Full certification of Class A recycled water requires approval by EPAV and DHS.

Parameter	CDS Plant	Class A
BOD5 mg/l	8	<10
SS mg/l	2	<5
Turbidity NTU	0.8	<2
pH	6.5-7.5	6-9
E.coli/100ml	<0.1	<10

Class A quality, as defined by the Victorian EPA, permits urban usage with uncontrolled public access, usage on human food crops consumed raw, and industrial usage involving open systems with worker exposure potential.

Operating costs (chemical and power only) vary with sewage types but are typically around 40 cents per kl, less than half the current cost of potable water.

It is noted that capital costs are not addressed in this report and will vary in any commercial application with plant size, scope of works, storage requirements etc.

References

1. EPA Victoria, Guidelines for Environmental Management, '*Use of Reclaimed Water*, Publication 464.2', June 2003, pp20-21.

2. EPA Victoria, Guidelines for Environmental Management, '*Disinfection of Treated Wastewater*' Publ. 730, September 2002, Table 2, p11.

3. Victorian Government Gazette G47, 23, November 2000.

Appendix A Classes of reclaimed water and standards for biological treatment and pathogen reduction [Ref. 1]

Class	Water quality objectives - medians unless specified[1,2]	Treatment processes[a]	Range of uses– uses include all lower class uses
A	Indicative objectives . < 10 E.coli org/100 mL . Turbidity < 2 NTU[4] . < 10 / 5 mg/L BOD / SS . pH 6 – 9[5] . 1 mg/L Cl_2 residual (or equivalent disinfection)[6]	Tertiary and pathogen reduction[7] with sufficient log reductions to achieve: <10 E.coli per 100 mL; <1 helminth per litre; < 1 protozoa per 50 litres; & < 1 virus per 50 litres.	Urban (non-potable): with uncontrolled public access Agricultural: eg human food crops consumed raw Industrial: open systems with worker exposure potential.
B	. <100 E.coli org/100 mL . pH 6 – 9[5] . < 20 / 30 mg/L BOD / SS[8]	Secondary and pathogen (including helminth reduction for cattle grazing) reduction[7]	Agricultural: eg dairy cattle grazing Industrial: eg washdown water
C	. <1000 E.coli org/100 mL . pH 6 – 9[5] . < 20 / 30 mg/L BOD / SS[8]	Secondary and pathogen reduction[7] (including helminth reduction for cattle grazing use schemes)	Urban (non-potable) with controlled public access Agricultural: eg human food crops cooked/processed, grazing/fodder for livestock Industrial: Systems with no potential worker exposure
D	• <10000 E.coli org/100 mL • pH 6 – 9[5] • < 20 / 30 mg/L BOD / SS[8]	Secondary	Agricultural: non-food crops including instant turf, woodlots, flowers

Notes to Table 1

1. Medians to be determined over a 12-month period. Refer table 6 for Notification / reclassification limits.

2. Refer also to Chapter 6 and 7, and Waste Water Irrigation Guideline (EPA Victoria, 1991 Publication 168) for additional guidance on water quality criteria and controls for salts, nutrients and toxicants.

3. Refer section 4.4 for further description of water quality objectives for Class A reclaimed water.

4. Turbidity limit is a 24-hour median value measured pre-disinfection. The maximum value is five NTU.

5. pH range is 90th percentile. A higher upper pH limit for lagoon-based systems with algal growth may be appropriate, provided it will not be detrimental to receiving soils and disinfection efficacy is maintained.

6. Chlorine residual limit of greater than one milligram per litre after 30 minutes (or equivalent pathogen reduction level) is suggested where there is a significant risk of human contact or where reclaimed water will be within distribution systems for prolonged periods. A chlorine residual of less than one milligram per litre applies at the point of use.

7. Guidance on pathogen reduction measures and required pre-treatment levels for individual disinfection processes are described in *GEM: Disinfection of Reclaimed Water* (EPA Victoria, 2003 Publication 730.1). Helminth reduction is either detention in a pondage system for greater than or equal to 30 days, or by an NRE and EPA Victoria approved disinfection system (for example, sand or membrane filtration).

8. Where Class C or D is via treatment lagoons, although design limits of 20 milligrams per litre BOD and 30 milligrams per litre SS apply, only BOD is used for ongoing confirmation of plant performance. A correlation between process performance and BOD / filtered BOD should be established and in the event of an algal bloom, the filtered BOD should be less than 20 milligrams per litre.

a Where schemes pose a significant risk of direct off-site movement of reclaimed water, nutrient reductions to nominally five milligrams per litre total nitrogen and 0.5 milligrams per litre total phosphorous will be required.

Appendix B

EPA Victoria, Guidelines for Environmental Management, '*Disinfection of treated wastewater*' Publication 730, September 2002, Table 2. p 11 [Ref. 2]

Table 2. Recommended wastewater quality (median) pre-disinfection (adapted from UWRAA, 1996)

Disinfection method	SS (mg/L)	BOD (mg/L)	Turbidity (NTU)[1]	Nitrate (mg/L)	Ammonia (mg/L)[2]	pH
Chlorination	< 20	< 20	< 10	NA	See note 2	6.0 - 9.0
Ozone	< 10 - 15	< 20	< 5	maximised	< 1	6.0 - 9.0
UV[3]	< 10	< 20	< 5	maximised	NA	NA
Microfiltration	NA	NA	< 10	NA	NA	Neutral
Detention lagoons	NA	NA	NA	NA	NA	Neutral

Notes to Table 2

1. If a significant reduction in the number of pathogens is required (that is, less than ten *E.coli* organisms per 100 millilitres), the turbidity of the pre-disinfected wastewater should be less than two NTU (median) for any method.

2. Presence of ammonia with chlorine causes chloramination, which is a less effective disinfection method than chlorine; however, formation of toxic by-products is minimised. The required level of ammonia, therefore, depends on whether chloramination or chlorination is the disinfection process.

3. The transmission capacity of the wastewater is the most important parameter affecting the disinfection efficiency of UV and should be greater than six.

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Appendix C Overall Results for the Treatment Process Trials at Brushy Creek

	BOD_5 mg/L	FILTERED BOD_5 mg/L	TURBIDITY (N.T.U)	AMMONIA N mg/L	SUSPENDED SOLIDS mg/L	OXIDISED NITROGEN mg/L	PHOSPHORUS P mg/L	E.coli (org/100mL)
Raw Sewage								
n	62	62	61	62	62	na	61	13
Av	337	134	153	30	285	na	9.9	223385
StdDev	173	109	61	8.6	138	na	5.0	59908
Max value	1000	700	310	62	870	na	22	240000
Min Value	71	31	11	11	74	na	0.1	24000
Median	295	100	140	29.5	255	na	11	240000
FSS								
n	58	59	40	60	44	na	59	14
Av	103	45	7.1	28.8	19.7	na	0.8	15239
StdDev	78	31	3.8	8.7	14.3	na	1.0	10880
Max value	370	160	17	59	83	na	6.0	24000
Min Value	3	2	2.1	7	2	na	0.1	210
Median	80	36	6.1	28	15	na	0.5	24000
SAF + Clarifier								
n	11	12	16	13	16	13	14	16
Av	13.7	6.8	0.9	15.5	3.1	13.1	1.0	5622
StdDev	6.5	4.0	0.5	9.2	1.1	7.5	0.5	5895
Max value	29	17	2.2	27	5	33	2.4	17000
Min Value	7	2	0.3	1.8	2	0.8	0.1	<10
Median	11	5.5	0.8	18	3	12	1.0	4800
Date	Sample							**After UV**
25-Nov-03	DS1							<10
26-Nov-03	DS1							<10
27-Nov-03	DS1							<10
28-Nov-03	DC1							<10

Note: NA = Sample submitted, result unavailable

Appendix D Virus, Bacteria & Helminth Results for the Treatment Process Trials at Brushy Creek

DATE	SAMPLE	E. COLI org/100mL	ADENOVIRUS (viruses per L)	ENTEROVIRUS (viruses per L)	REOVIRUS (viruses per L)	TAENIA OVA (ova per L)	ASCARIS OVA (ova perL)
Raw Sewage							
17-Oct-03	RC1	>24000	ND	ND	ND	ND	ND
31-Oct-03	RS1	>24000	ND	ND	ND	ND	ND
10-Nov-03	RC1	>240000	25	14	ND	3	ND
11-Nov-03	RC1	>24000	22	12	ND	2	ND
13-Nov-03	RS1	>240000	ND	ND	ND	ND	ND
18-Nov-03	RS1	>240000	ND	ND	ND	ND	ND
27-Nov-03	RS1	>240000	ND	ND	ND	ND	ND
28-Nov-03	RC1	>240000	42	ND	ND	ND	ND
Effluent							
17-Oct-03	AC1	5800	ND	ND	ND	ND	ND
31-Oct-03	AS1	>24000	ND	ND	ND	ND	ND
10-Nov-03	AC1	210	ND	ND	ND	ND	ND
11-Nov-03	AC1	1200	ND	ND	ND	ND	ND
13-Nov-03	AS1	>24000	ND	ND	ND	ND	ND
18-Nov-03	AS1	>24000	ND	ND	ND	ND	ND
13-Nov-03	CC1	200	ND	ND	ND	ND	ND
17-Oct-03	CC1	310	ND	ND	ND	ND	ND
18-Nov-03	CS1	7700	ND	ND	ND	ND	ND
27-Nov-03	CS1	11000	ND	ND	ND	ND	ND
28-Nov-03	CC1	3100	ND	ND	ND	ND	ND
27-Nov-03	DS1	<10	ND	ND	ND	ND	ND
28-Nov-03	DC1	<10	ND	ND	ND	ND	ND

Note: LOD = <1/10L, ND = Not Detected

Appendix E Overall Results for the Treatment Process at Cranbourne STP (Note: LoD = Limit of Detection)

	BOD_5 mg/L	Carbonaceous $CBOD_5$ mg/L	TURBIDITY (N.T.U)	AMMONIA N mg/L	SUSPENDED SOLIDS mg/L	OXIDISED NITROGEN mg/L	PHOSPHORUS P mg/L	Bacteriophage (Orgs/100mL)	E.coli (Orgs/100mL)
	Raw								
N	14		14	14	14		14	13	14
Av	421		100	50	130		9	2258	12035714
StdDev	192		28	11	44		2	2168	5086877
Max value	740		150	64	240		14	5100	24000000
Min Value	190		55	23	85		7	140	5800000
Median	420		91	54	125		9	1300	11000000
	After FSS								
N	14		14		14		14	13	14
Av	254		6.0		15.4		2.3	264	382929
StdDev	190		3.7		3.5		0.8	198	354242
Max value	610		15		21		4.1	680	1300000
Min Value	76		2		10		1.3	50	14000
Median	195		4.9		15		2.3	215	241000
	After FILTER								
N								13	14
Av								85	12779
StdDev								134	8589
Max value								500	28000
Min Value								5	1700
Median								30	13000
	After UV								
N	14	13	14	14	14	12	14	13	13
Av	76	10	1.5	36	3.2	6.8	2.1	4.90	0.38
StdDev	85	8	1.4	19	2.5	3.1	1.2	0.00	0.82
Max value	240	28	5.1	96	11	12	4.9	4.9	3
Min Value	5	1.8	0.5	19	1.9	1.2	0.01	4.9	0.09
Median	32	8	0.8	31	2	7	1.9	4.9 <5.0 = LoD	0.09 <0.1 = LoD

Appendix F Virus, Bacteria & Helminth Results for the Treatment Process Trials at Cranbourne STP

Date	Bacteria CFU/100ml	Virus/50L				Helminths, ova/L		Protozoa, oocysts, cysts/50L	
	E-coli	Bacteriophage (Coli-phage) Orgs / 100mL	Adenovirus	Enterovirus	Reovirus	Taenia ova	Ascaris ova	Cryptosporidium	Giardia
	Raw Sewage								
05-Mar	16000000	2900	<1	<1	<1	NA	NA	NA	NA
10-Mar	11000000	460	<1	<1	<1	<1	<1	<1	<1
11-Mar	6500000	2790	<1	<1	<1	<1	<1	<1	<1
17-Mar	9800000	140	<1	<1	<1	<1	<1	<1	<1
18-Mar	5800000	190	<1	<1	<1	<1	<1	<1	4
19-Mar	12000000	280	<1	<1	<1	<1	<1	<1	<1
24-Mar	12000000	445	NA	NA	NA	NA	NA	NA	NA
25-Mar	11000000	5100	<1	<1	<1	<1	<1	<1	<1
26-Mar	8200000	5100	<1	<1	<1	<1	<1	<1	2
30-Mar	20000000	445	NA	NA	NA	NA	NA	NA	NA
31-Mar	10000000	NA	<1	<1	<1	<1	<1	<1	<1
01-Apr	14000000	1300	<1	<1	<1	<1	<1	<1	3
02-Apr	8200000	5100	<1	<1	<1	<1	<1	<1	6
	Treated Effluent								
05-Mar	3	<5	<1	<1	<1	NA	NA	NA	NA
10-Mar	1	<5	<1	<1	<1	<1	<1	<1	<1
11-Mar	<0.1	<5	<1	<1	<1	<1	<1	<1	<1
17-Mar	<0.1	<5	<1	<1	<1	<1	<1	<1	<1
18-Mar	<0.1	<5	<1	<1	<1	<1	<1	<1	<1
19-Mar	NA	<5	<1	<1	<1	<1	<1	<1	<1
24-Mar	<0.1	<5	<1	<1	<1	<1	<1	<1	<1
25-Mar	<0.1	<5	<1	<1	<1	<1	<1	<1	<1
26-Mar	<0.1	<5	<1	<1	<1	<1	<1	<1	<1
30-Mar	<0.1	<5	NA	NA	NA	NA	NA	NA	NA
31-Mar	<0.1	NA	<1	<1	<1	<1	<1	<1	<1
01-Apr	<0.1	<5	<1	<1	<1	<1	<1	<1	<1
02-Apr	0.9	<5	<1	<1	<1	<1	<1	<1	<1