TRIALS OF A NEW RAPID CLARIFICATION PROCESS

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ABSTRACT

A field trial of a proprietary, high-rate physico-chemical sewage clarification process developed by CDS Technologies was conducted jointly with a Victorian water authority. The objective of the trial was to evaluate the suitability of the new process for reducing the load on the sewer during peak periods in a holiday resort area under the authority's jurisdiction by storing clarified sewage off-line for later return to the sewer.

Trials over a 2-month period were conducted, and water quality data on both influent and effluent collected for the process. These show that the process is capable of producing clear effluent suitable for UV disinfection within 3 minutes of start-up.

The off-line storage concept was demonstrated to be feasible for smoothing the loads on sewerage and provides an alternative strategy for the management of excess flows arising from a variety of causes.

KEY WORDS
Sewage clarification, load levelling, flocculation, off-line storage.

1.0 INTRODUCTION

CDS Technologies began developing a high rate physico-chemical clarification process for sewage in 1998, using as its starting point the proprietary non-blinding screening technology already being commercialised for the screening of stormwater.

At that time although high rate physical separation of stormwater solids from liquids was possible, the fibrous nature of sewage solids presented special problems. Through rigorous investigation, it was found that several design modifications and changes in the operation of the basic product were necessary. Once these changes were satisfactorily implemented, non-blinding screening of sewage could be consistently achieved over prolonged periods.

Extensive trialling of this product, the Gross Solids Separator, was later conducted by the US EPA which confirmed the non-blinding capability of the screen at the heart of the unit.

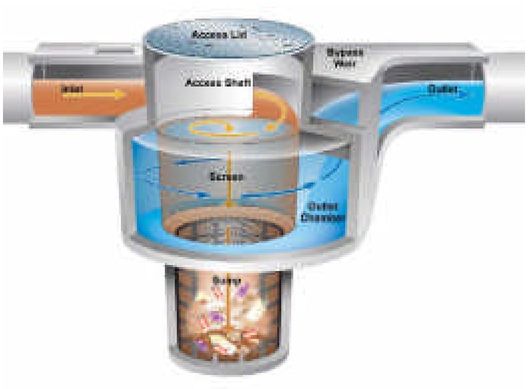
1.1 Development of the Physical Separator

A CDS Gross Solids Separator (GSS) consists of a cylindrical tank with inlet and outlet channels that lead the water smoothly to and from the unit (Fig.1). A cylindrical screen is located inside this tank and the influent is introduced tangentially to the inside of the screen, forming a continuously rotating body of water that produces a washing effect across the face of the screen.

The region inside the screen is known as the separation chamber and trapped solids either float on the top of the fluid there or settle below this chamber into a collection sump where they may be removed by pump or other means.

The contribution to removal of suspended solids by the GSS is only 10-15% of total solids, but amongst these are all the solids larger than about 1mm. The unit provides a screened effluent that is the basis for the high rate clarification process.

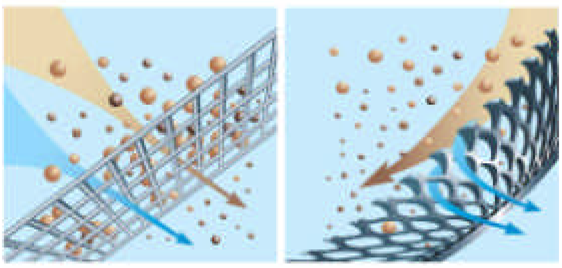
Figure 1: ***Schematic of CDS physical separator showing basic components***



The non-blinding nature of the system is achieved because indirect screening, rather than direct screening is employed (Fig. 2). The water column rotating inside the screen tends to continually "wash" solids away from the screen, overcoming any tendency for the solids to attach to it. With direct screening devices such as sieves or bar screens, the fluid forces solids onto the screen and these must be mechanically removed.

The screen of a CDS separator is an important part of the technology. It contains apertures that are partially shielded from the flow entering the separator so that solids contained in the flow do not actually "see" these apertures, but are deflected away from them as they approach the screen. The screen apertures in common use are in the range 1.2-4.7mm, yet it is a common observation that many particles very much smaller than these aperture sizes are retained by the separator. Grit particles down to around 0.15mm are typically captured and retained, while substantial fractions of even finer particles have been observed during analysis of the contents of stormwater separators.

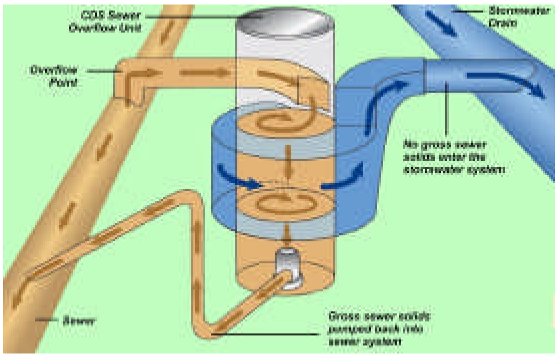
Figure 2: ***Illustration of conventional direct screening and indirect screening***



An immediate application for the GSS was in the screening of sewage at STP's and for sewer overflows, both for separate and combined systems. Single separators have been installed for sewer overflow management that treat up to 1 m^3/sec, but greater capacities can easily be achieved with multiple units.

A schematic of the CDS sewer overflow unit is shown in Figure 3. The figure depicts a configuration for the situation where the sewer and drainage systems are separated (as in Australia), but there is no material difference for the case of the combined sewer.

Figure 3: ***Installation of the CDS sewer overflow unit (separate sewer system)***



When a sewer overflow occurs, excess fluid from the sewer flows into the CDS separator where all solids larger than ~1mm are captured. The screened fluid, which represents around 99% of the incoming flow, is discharged continuously from the unit. Periodically, the solids removal pump discharges the retained solids as a concentrated stream (averaging 1% of the inflow) back into the sewer downstream of the overflow point.

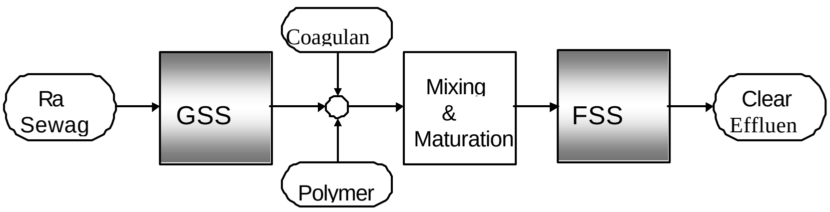
The operation of a sewer overflow unit is automated as it is not usually possible to predict when an overflow event will occur. For this reason, units are provided with programmed logic controllers (PLC) to manage the various operations.

1.2 Development of the Physico-Chemical Process

A significant development was the addition of water treatment chemicals to the effluent from the physical separator above to coagulate the solids and incorporate them into floccs. This led to the development of a system that allows waste streams including raw sewage to be divided into two streams at a high rate – a sludge stream comprising about 1% of the influent and a clarified stream that can be disinfected by UV or other means.

It is expected that this system will have wide application in the treatment of sewer overflows, where the capital costs of idle equipment need to be kept as low as possible. The system – the Fine Solids Separation System - has also been selected for evaluation with sewer overflows by a Japanese supplier of water treatment equipment and by a major water treatment company in North America for potable water pre-treatment.

Figure 4: ***Process flowchart for the CDS Fine Solids Separation system***



The flowchart for the high rate process is very simple (Fig. 4), comprising a 2-stage separation process:

1. Raw sewage is fed into the first separator (GSS). An underflow averaging just 1% of the total inflow is periodically pumped from the GSS to remove accumulated solids (around 10% of the TSS plus gross solids).

2. Coagulant (alum) and a polyelectrolyte are added to the screened sewage from the GSS to cause flocculation. Mixing and maturation of the flocculated sewage takes place either in-line or in a tank before it passes to the second separator.

3. By the time it enters the second separator, floccs have formed and the fluid is relatively clear. These floccs can be removed from this separator in various ways, but the end result is an effluent which is clear and can be disinfected easily.

4. Overall residence time for the process is 2 minutes or less, while startup time is around 3 minutes before steady state operation is achieved.

1.3 Process Trialing and Results

In the STP, where it was developed, the Fine Solids Separation (FSS) system was applied to raw sewage at the inlet headworks of the plant. Runs were conducted at flow rates up to 30 L/s (2.6MLD) to evaluate process performance and water quality data was collected on both influent and effluent (Table 1).

Table 1: ***Water quality data from pilot plant trials of FSS system***

Parameter	Units	Influent	Effluent	Reduction %
Turbidity	NTU	240	7.6	97
TSS	mg/L	259	13.5	95
BOD_5	mg/L	302	38	87
COD	mg/L	531	82	84
FC	CFU/100mL	12.5×10^6	58.6×10^3	99.5
TP	mg/L P	12	0.6	95
TN	mg/L N	71	55	22
NH_4-N	mg/L NH_4-N	40	37	8

In this closed-loop trial, both the reject solids stream and the clarified effluent were returned to the inlet channel of the treatment plant.

Following the pilot plant trials of the new process, it was decided to implement field trials with a Victorian Water authority. Barwon Water had an application requiring an innovative solution that seemed a good opportunity to trial the FSS system.

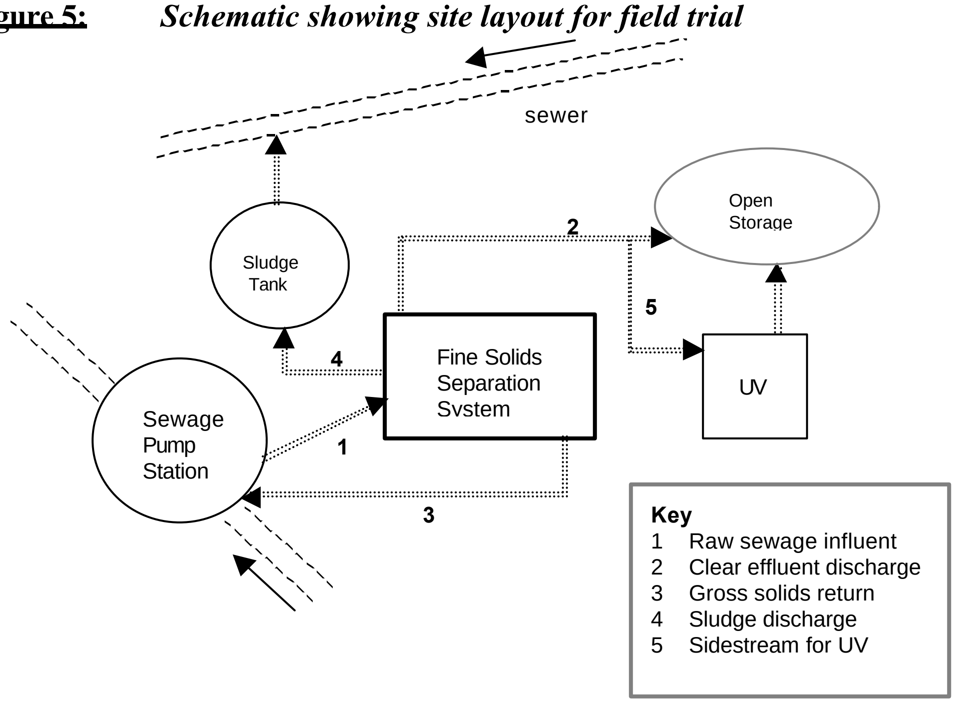
The seaside township of Ocean Grove near Geelong in Victoria sees a quadrupling of its population as holiday makers arrive for around 2 months each summer. The sewerage is not designed to cope with the flows caused by this number of people and to do so it would have to be enlarged in capacity. In such an environmentally sensitive area, this would not be a popular option and there are infrastructure limitations in any case.

Barwon Water wished to evaluate the concept of extracting sewage from the system by day, storing it off line and returning it to the sewer at night when the load on the system is reduced. A prerequisite for successful implementation of this concept was that the extracted sewage be clear and odour-free and that it could be disinfected easily.

If this concept were successful, the load on the sewer could be made more uniform over time and the sewerage would have its capacity effectively increased. The purpose of the field trial was to test this concept and evaluate the FSS system as a means of implementing it. A further objective was to assess the effluent produced for reuse in irrigation.

The layout of the scheme is shown in Figure 5. Two branch sewers passed by a large site of open land, one supplying a pump station, the other being used for disposal of collected solids. An earthworks detention basin had been erected on the site for emergency storage. Although never used, this basin provided ideal detention for the effluent from the FSS system, so that it could be evaluated over time.

Figure 5: ***Schematic showing site layout for field trial***



For the field trial, raw domestic sewage was taken from the pump station and pumped to the FSS. Clarified effluent was discharged to the detention pond for assessment before release. Gross solids were discharged back to the pump well at the end of each day's trial, while flocculated solids were accumulated a small storage tank for release into the sewer at appropriate times.

Analyses were performed on samples of influent, effluent and stored effluent at Barwon Water's NATA registered laboratory. These covered runs at 4 flow rates from 15 to 30 L/s to check that clarification performance was independent of flow rate.

As the trial took place in a region that had suffered from drought for over 4 years, there was considerable interest from nearby agricultural industries in accessing the clarified effluent for reuse purposes. An ultraviolet disinfection facility was therefore incorporated into the system to treat a side flow of the effluent and ensure that it could be disinfected easily for possible use in irrigation.

Results of the water quality tests conducted are given in Table 2 (data taken from an internal report issued by the Barwon Region Water Authority).

Table 2: ***Water quality data from field trials of the FSS system***

Parameter	**Units**	**Influent**	**Effluent**	**Reduction %**
Turbidity	NTU	131	8	94
TSS	mg/L	137	19	86
BOD_5	mg/L	151	48	68
COD	mg/L	365	166	55
FC	CFU/100mL	5.8×10^6	62×10^3	98.9
TP	mg/L P	9.5	1.2	87
Oil/Grease	mg/L	40	10	75
NH_4-N	mg/L NH_4-N	46	38	17

The data show sizeable reductions in particle-related water quality parameters, but only a small reduction in dissolved species such as ammoniacal nitrogen. BOD (and COD) can of course exist either as particulate material or in solution, but only the particulate form is removed by this process, so for best results the sewage should be fresh. Phosphorus is largely precipitated by the alum so that reductions in this quantity are high.

Although clear to the eye, the effluent showed an ultraviolet transmissivity (UVT) of only 55%, indicating the presence of dissolved substances causing absorption of the radiation. This was nevertheless high enough to permit ready disinfection, with results showing that E. coli in the clarified effluent could be consistently reduced to less than 100 CFU/100 mL.

Diurnal variations in some parameters occurred as would be expected, notably in TSS and turbidity. Despite these variations, the final values of these parameters in the effluent were fairly constant (8 NTU for turbidity and <20 mg/L for TSS) regardless of the time of day at which samples were taken.

Some effluent parameters continued to decrease over time on storage. TSS fell to below 6mg/L on storage in the open detention pond, BOD to < 10mg/L and faecal coliforms by a further 1.4 logs (whereas TSS rose again once an algal bloom formed due to the nutrients still present in the stored fluid). Although of no great consequence for the effluent being returned to the sewer each night, such reductions could be useful in other applications where continued storage of the effluent is required. Importantly for this application, stored effluent in the pond had little odour which was unnoticeable at about 20m from the pond.

Dosing was performed using aluminium sulphate as the coagulant (dose 18 mg/L) and a cationic emulsion polymer at around 12 mg/L. Following conclusion of the field trial, work on polymers was continued in the pilot plant, with the result that an alternative polymer was identified that could be dosed at 2.5 mg/L and which gave a greatly improved final turbidity outcome (~2.5 NTU). Future work will involve this polymer in place of the one used in this trial.

2.0 DISCUSSION

Overall, the FSS system satisfactorily performed the high rate sewage clarification required to make this application feasible. The flexibility of the facility meant that sewage could be extracted just to the extent necessary to reduce the load on the sewerage. Importantly, the solids produced can be treated conventionally at the sewage treatment plant so there is no need for radical departure from existing practice.

Cost/benefit calculations for implementing the proposed load levelling strategy show considerable savings over the alternative of upgrading the sewer and indicate a 20-25% increase in effective sewer capacity.

Significantly, there were no complaints regarding noise or odour (or anything else) despite the proximity of residential housing to the site of the field trial. With proper protective fencing of the stored effluent, there should be no loss of public amenity or risk to health from the presence of such a facility.

The quality of the effluent produced by the FSS does not conform to any recognised water class, although it is appropriate to the intended purpose. For reuse purposes, however, the residual levels of TSS (~20 mg/L) and BOD (~50 mg/L) may pose a limitation under existing guidelines, yet the observation that these reduce to acceptable levels after less than a week's open storage of the effluent may provide a possible strategy for reuse.

With respect to disinfection, the results indicate that UV disinfection with a suitably sized unit can meet the required bacterial standard, but for reuse purposes, a small chlorine residual may be necessary to prevent reactivation. Introduction of this residual disinfectant could be easily implemented if the above detention strategy is employed.

3.0 CONCLUSIONS

A proposed strategy for reducing the instantaneous load on the sewerage through the use of off-line storage of the peak flow and its delayed return to the sewer has been tested and its feasibility confirmed. The strategy has been calculated to result in a 20-25% increase in effective sewer capacity.

This load levelling strategy is enhanced through the use of CDS Technologies' Fine Solids Separation system which, operating in real time, produces an effluent that is clear, has low suspended solids and can therefore be easily disinfected. From the standpoint of public amenity the operation is silent and has low odour.

The effluent from the FSS system is potentially applicable to selected agricultural applications, although it does not conform to any recognised water class. Water quality indicators for this effluent are improved on open storage; it may be possible to utilise such storage as part of a viable reuse strategy.

4.0 ACKNOWLEDGEMENTS

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