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Project Summary

Field Evaluation of a Swirl Degritter at Tamworth, New South Wales, Australia

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The overall objective of this field evaluation program was to provide information on the behavior of a full-scale swirl degritter designed and constructed in accordance with the shapes and proportions developed during model studies.

The swirl degritter was designed to pretreat river water before it enters into the rising main in order to reduce wear and tear on the raw water pumps and also to reduce the solids loading of the rising main and that of the balance tank of the water treatment works.

Results of the solids removal had been evaluated in terms of three parameters: solids larger than 0.2 mm (the classical size aimed at in grit chambers); solids larger than 0.088 mm; and total settleable solids. In general, the tests proved the validity of the laboratory results, and at design flowrates, 98% removal efficiencies were achieved.

Tests at flowrates higher than the design showed slightly better efficiencies than predicted.

The field evaluation tests carried out at Tamworth, New South Wales, Australia, prove the validity of the system in terms of its hydraulic efficiency. When compared with a conventional, constant-velocity, longitudinal flow grit chamber, the construction cost is halved and operation and maintenance costs are considerably lower.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

A considerable number of Australian towns rely on rivers for the source of their water supply. These rivers are generally intermittent flowing streams with highly variable flows, and their degree of pollution depends on the stage of the river and on the prior history of floods.

Many water intake installations are constructed in such a manner that gravitational flow feeds a raw water pumping station, which may be at a considerable distance from town. The water is then pumped to a treatment works closer to the town; from there, it is distributed to the service reservoirs Difficulties have been experienced with solids settling in the gravity lines and also with the excessive wear and tear on the raw water pumps due to the sand content of the water.

Pretreatment of the raw water—removing sand particles larger than 0.2 mm diameter entering the system—had been adopted to alleviate these problems.

Conventional grit removal systems, whether of the longitudinal flow, constant velocity, or aerated grit chamber type, are generally costly installations requiring a high degree of maintenance of the mechanical grit removal devices. The swirl degritter developed by the American Public Works Association (APWA) and the U.S. Environmental Protection Agency (USEPA) was selected because its capital cost is about 50% of the alternative systems and because its operational and maintenance costs are considerably lower as moving components may not be needed. Figure 1 illustrates an isometric view of the swirl degritter.

This swirl degritter was constructed between 1979 and 1980, and being the largest of its kind, an extensive field evaluation program had been carried out to compare its performance with the design manual published by USEPA[1] and also with the results of a previous field evaluation program of a prototype at Denver, Colorado.[2]

Originally the swirl degritter was to be tested with natural water expecting that the river stages would vary considerably during the test period. Owing to an unusually dry period, this did not happen, and the suspended solids content of the river water remained practically constant. To subject the degritter to most of the expected service conditions, sand was added to the influent, and the whole range of service flows was reproduced using the raw water pumps. Removal efficiency rates were determined for three classes of material: 0.2 mm and larger (the classical size aimed at to remove with a grit chamber); particles larger than 0.088 mm; and total settleable solids. A summary of the removal efficiency evaluations and comparisons is depicted by the curves on Figure 2.

The test results essentially proved the predictions of the design manual, which were based on an extensive model study carried out by the LaSalle Hydraulics Laboratories and compared well with the Denver Study.

The swirl degritter constructed at Tamworth, New South Wales, Australia (Figure 2), is about 45 ft (14 m) underground, and the bottom of the grit collector is a further 10 ft (3 m) lower. The collected grit is removed from the hopper with a hydraulically operated jet pump and discharged back into the river. This arrangement coupled with a grit level detector allows for automatic operation through telemetry governed by the central control board of the water supply system.

The field evaluation program consisted of sampling the influent, sampling the effluent, laboratory analyses of the particle size distribution of the samples, and evaluating the results.

Sampling the Influent

The influent was sampled in the inlet conduit just before it entered the degritter, about 45 ft (14 m) underground with three inlet ports: one near the invert, the second in the center, and the third close to the obvert to the square conduit. The samples taken at the lowest intake port had not been included in this evaluation because of their indeterminate solids content—they may have contained either suspended load or bedload. The diameter of the sampling ports was 1.5 in. (39 mm); both the sampling suction and delivery lines were 1.125-in.-diameter (29 mm) unplasticized PVC conduits with a flexible hose at the discharge end. The sampling pump was attached to the intermediate landing of the access ladder, and it delivered the withdrawn liquid into 54 gal (205 L) steel drums sitting on the lid of the structure on the surface.

The velocity in the 1.125-in. (23-mm) sampling line was 2.8 fps (0.85 m/s) during runs 1 through 34 and 4.5 fps (1.37 m/s) during runs 36 through 55. Each sample was collected in a steel drum lined with removable semirigid polyethylene liner. The collection times were about 4 min during runs 1 through 34 and about 2.5 min during runs 36 through 55. Thus the samples represented continuous composite samples. The velocity of the main stream in the conduit varied between 0.75 fps (0.23 m/s) and 6.10 fps (1.86 m/s).

Sampling the Effluent

The effluent was sampled immediately downstream of the raw water pumps with a slotted 0.375-in.-inside-diameter (10 mm) copper tube, inserted into the main 12-in.-diameter (300 mm) cement-lined cast iron pipe. A flexible hose was attached to the discharge end of the copper tube. The sampling velocity depended on the pressures produced in the main stream by the raw water pump. During runs 1 through 34, filling time of one 54-gal (205-L) drum varied between 12 and 25 min; during runs 36 through 55, two 54-gal (205-L) drums were filled in between 17 and 28 min, depending on the pressure available. This procedure resulted in continuous composite samples. The velocity in the main stream varied between 6.4 fps (1.94 m/s) and 15.4 fps (4.7 m/s), and the sampling velocity at the intake slot varied between 0.4 fps (0.13 m/s) and 1.3 fps (0.4 m/s). Thus the ratio of the intake to main stream velocity was very low.

Laboratory Analysis of Particle Size Distribution

All the samples collected were left for at least 1 hr in the drums, allowing for quiescent settlement of all particles of about 25 μm and larger. Floaters were then placed on the surfaces, and the supernatant water was syphoned off, always from about 0.5 in. (12 mm) from the surface. This decanting procedure, which took about 20 to 25 min, allowed additional fine solids to settle because the body of the water remained always still. The liquid-solid mixture left in the bottom 2 in. (50 mm) of water (4 to 7 gal; 15 to 25 L) then were lifted out in the polyethylene liners, sealed, and transported by road to the laboratory in Sydney. In the laboratory, the transparent polyethylene liners were hung up for at least 2 days so that all the solids dropped into one corner. They were then pierced, and the supernatant water was allowed to escape gradually without resuspending the solids.

The solids were dried in an oven and weighed; the material larger than 1.68 mm was removed by sieving; the sample was again weighed; the material smaller than 0.088 mm was removed by washing; and after drying in the oven, the sample was again weighed. The frequency of the particle size distribution of the fraction between 0.088 mm and 1.68 mm was determined with a settling column and recorded on a Hewlett Packard 21 MX and Data Logger. The results were both tabulated and plotted by a computer.

In previous works,[3–5] which published the efficiency of sampling (the ratio of concentration of solids in the sample and concentration in the main stream in a graphical form, it had been established that samplers pick up the concentration of solids at the point of sampling only if the sampling and main stream velocities are equal. Should the sampling velocity be less than that of the main stream, the sample would contain a higher concentration of solids than the sampled liquid; conversely, sampling velocities higher than the main stream velocities result in sample concentra-

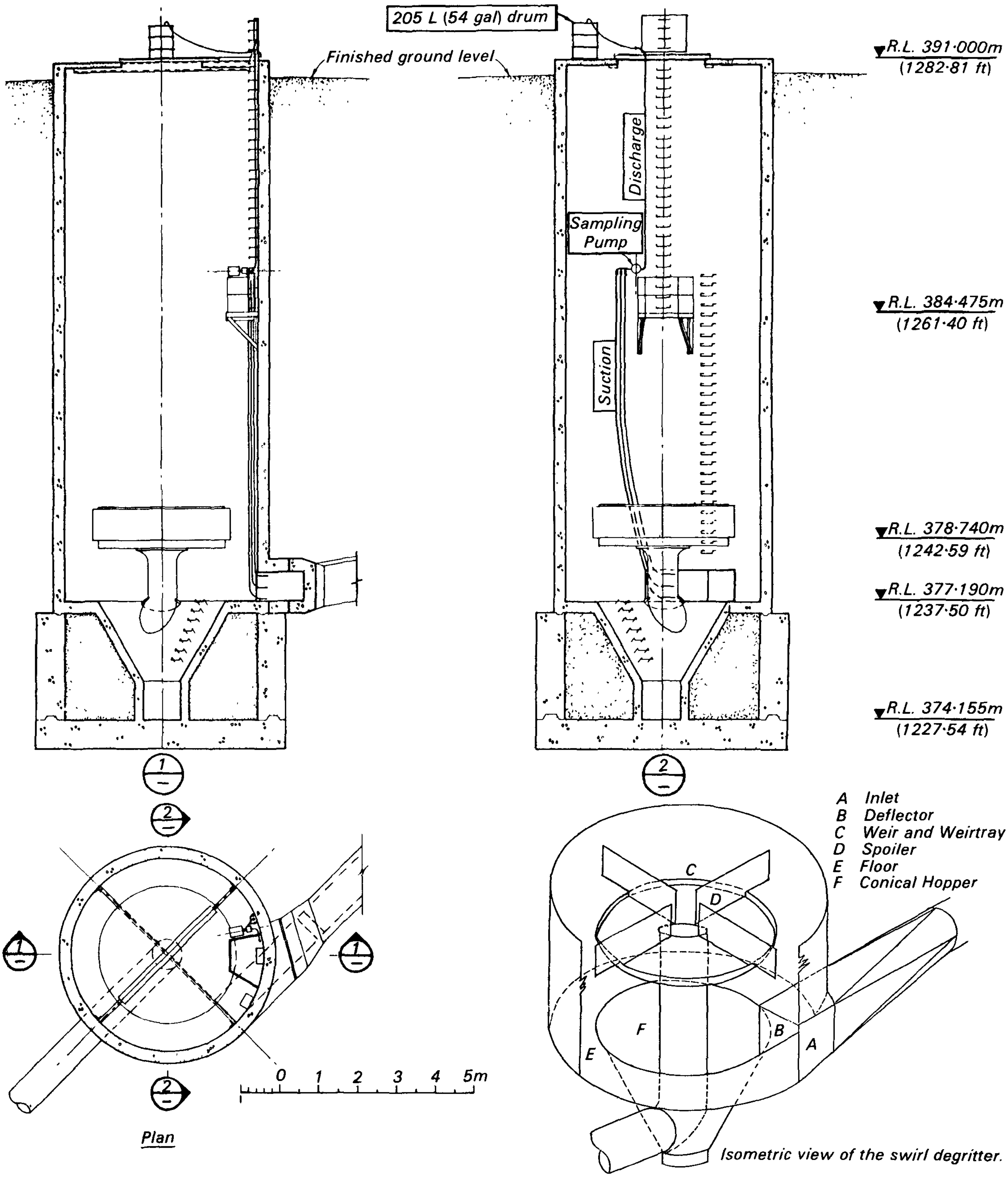

Figure 1. *General arrangement of the Tamworth swirl degritter.*

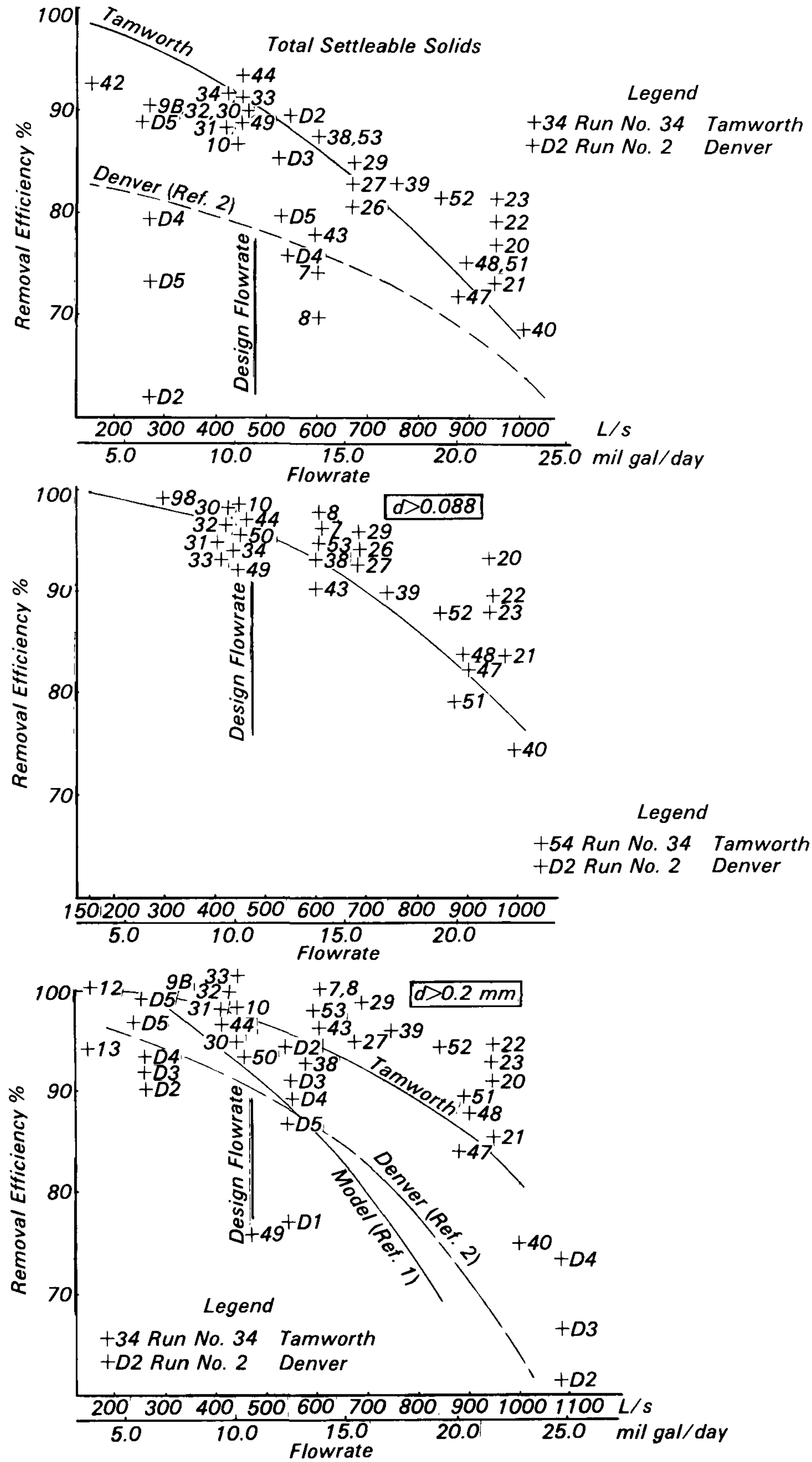

Figure 2. *Removal efficiencies.*

tions lower than those in the sampled liquid. It had also been established that the efficiency of sampling depends on the construction and orientation of the point sampler.

The samplers at Tamworth satisfied all the conditions for fully representative sampling except for the parity in velocities. A further problem was that, in a large conduit with comparatively low laminar flows, the distribution of solids in the main stream is not uniform in the vertical plane. A wide variety of information is available in the literature regarding the solids distribution in free surface flows, but there appears to have been no comprehensive work published for flows under pressure in comparatively large conduits.

To calculate the removal efficiencies, we had to make sure that the samples were representative of the actual concentrations.

In the case of sampling the effluent, the ratio of the sampling velocities to the main stream velocities were always considerably below the unit. For the purposes of this report, we assumed that the sampled concentrations were the equivalent of the main stream concentrations, knowing that any errors in this assumption would result in a higher effluent concentration and, therefore, a lower removal efficiency of the swirl degritter.

In the case of the influent, however, the same assumptions could not be made; the amount of the concentration of solids in the influent had to be adopted either from a previously known value or from the calibrated efficiency of the samplers.

It had been established that the solids content of the natural water was so low (3.4 mg/L) and so fine (d (particle effective diameter) 0.088 mm) that it could safely be neglected, and so the solids content of tested samples depended solely on the artificially introduced sand.

Dewatering and physical inspections after runs 18 and 34 revealed that significant sand deposits and some scouring of the deposited sand had occurred in the inlet conduit between the point of adding sand and that of sampling; thus, the concentration of added sand was not necessarily equivalent to the average concentration of solids reaching the sampling points or reaching the swirl degritter.

Evaluating the Results

The efficiency of sampling could be calculated by synthesizing the diagrams of the FIASP report[3] into one single equation:

$$E = f_1(d) \times (10V)^{f_2(d)} - 100$$

where E = sampling error (%)
d = particle effective diameter (mm)
V = ratio of sampling and main stream velocities

The knowledge of the local concentration of solids, however, was insufficient for calculating the removal efficiency of the swirl degritter because the distribution of solids in the vertical plane at various main stream velocities was still unknown.

Another set of tests was then conducted, whereby frequent dewatering and inspection ascertained that during the test runs no significant deposits of solids occurred between the point of adding sand and the influent sampling (in other words, all the sand added reached the swirl degritter).

Thus runs 36 through 55 achieved a dual purpose. By comparing the known concentration of the artificially added sand with the sampled concentration of the effluent, the removal efficiency of the swirl degritter could be calculated. The ratio of the local concentrations to the average concentration of solids for all the three classes of materials (total solids, solids larger than 0.088 mm diameter, and solids larger than 0.2 mm diameter) at the various main stream velocities could also be established. After multiple regression analyses, the equations took the general shape of:

$$f_3(V) = a_n + b_n \frac{C_{center}(n)}{C_{average}(n)} + c_n \frac{C_{top}(n)}{C_{average}(n)} \pm E_{(n)}$$

where

V = the main stream velocity (m/s)
a_n, b_n, c_n = regression coefficients
$C_{center}(n)$ = concentration of solids of the class of materials considered in the sample withdrawn from the center of the conduit (local concentration)
$C_{top}(n)$ = concentration of solids of the class of materials considered in the sample withdrawn from the top of the conduit (local concentration)
$C_{average}(n)$ = concentration of solids of the class of materials considered as introduced by adding sand (average concentration)
$E(n)$ = standard error of the regression analysis in the $f_3(V)$ value

It was then possible to calculate:

1. The average concentrations in the conduit from the two local concentrations:

$$C_{average}(n) = \frac{b(n)\, C_{center}(n) + c(n)\, C_{top}(n)}{f_3(V) + a \pm E_{(n)}}$$

2. The removal efficiencies of the swirl degritter:

$$R = \left\{ 1 - \frac{C_{effluent}(n)}{b(n)\, C^{center}(n) + c(n) C^{top}(n)} \times (F(V) + a) \pm \frac{C_{effluent}(n) \times E(n)}{b(n) C_{center}(n) + c(n) C_{top}(n)} \times 100 \right\}$$

where R = Removal efficiency (%)
$C_{effluent}(n)$ = concentration of solids of the class of materials considered in the effluent sample

The effect of the third member of this equation, which represents the errors introduced by the regression analysis, was very small and, therefore, it was neglected.

In the case of the "calibration runs," the removal efficiencies calculated from the influent samples with the help of the equations reasonably agreed with the values previously calculated directly from the known quantities of added sand. In the case of the other runs, the removal efficiencies fitted well into the calculated values for the "calibration runs." Those runs that did not include artificially added sand had to be excluded because of the uncertainties introduced by the small numbers. Similarly, the runs during which significant settlement or scouring of solids occurred could not be evaluated with these relationships because the equations yielded inconsistent results (the calculated average concentration of total solids was less than the calculated concentration of solids larger than 0.088 mm diameter).

The field evaluation program together with the similar prototype testing at Denver[1-2] proved the efficiency of the swirl degritter in removing solids from a liquid-solid mixture.

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References

1. Sullivan, R.H., et al. The Swirl Concentrator as a Grit Separator Device, U.S. Environmental Protection Agency, Cincinnati, Ohio, EPA-670/2-74-026, 1974.
2. Sullivan, R.H., et al. Field Prototype Demonstration of the Swirl Degritter, U.S. Environmental Protection Agency, Cincinnati, Ohio, EPA-600/2-77-185, 1977.
3. Federal Inter-Agency Sedimentation Project (FIASP), Laboratory Investigation of Suspended Sediment Samplers. Report No. 5., St. Paul U.S. Engineer District Sub-Office Hydraulic Laboratory, University of Iowa, Iowa City, Iowa, pp 99, 1941.
4. Shelley, P.E. and Kirkpatrick, G.A. An Assessment of Automatic Sewer Flow Samplers, U.S. Environmental Protection Agency, Cincinnati, Ohio, December 1975.
5. Shelley, P.E., Sampling of Water and Wastewater, U.S. Environmental Protection Agency, Cincinnati, Ohio, EPA-600/4-77-039, 1977.

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***Richard Field** and **Hugh Masters** are the EPA Project Officers (see below).*
The complete report, entitled "Field Evaluation of a Swirl Degritter at Tamworth, New South Wales, Australia," (Order No. PB 81-187 247; Cost: $11.00, subject to change) will be available only from:

National Technical Information Service
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