EPA-600/2-77-185
September 1977

Environmental Protection Technology Series

FIELD PROTOTYPE DEMONSTRATION OF THE SWIRL DEGRITTER

Municipal Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
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FIELD PROTOTYPE DEMONSTRATION OF THE SWIRL DEGRITTER

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Grant No. S-803157

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FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, for the preservation and treatment of public drinking water supplies and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research; a most vital communications link between the researcher and the user community.

The study describes the evaluation of a prototype swirl degritter to perform the function of grit separation more effectively than conventional units for concentrated grit as may be found in the treatment of stormwater discharges.

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ABSTRACT

A prototype swirl degritter was tested by the Metropolitan Denver Sewage Disposal District No. 1. The unit was designed to duplicate the grit removal device needed to degrit the underflow from the proposed swirl concentrator as a combined sewer overflow regulator at Lancaster, Pennsylvania under EPA Grant No. S802219 (formerly 11023 GSC). Degritting is considered in Lancaster to protect pumps and prevent siltation in the interceptor.

The 1.8 m (6 ft) diameter device was designed for a flow of 65.6 l/s (1.5 mgd). It was found that under the physical arrangements in Denver, and testing with domestic sanitary wastewater, that the swirl unit performed at slightly less efficiency than the conventional aerated grit unit which was operating at less than twice the normal flow-through rate. The characteristics of the grit removal from the swirl degritter were excellent and particles of 0.2 mm (.008 in) were removed.

Analyses of grit removal was accomplished with three Chasick sampling units. Blasting sand was added to provide extremely high concentrations of 0.2 mm (.008 in) particles (lower definition of grit) to duplicate the concentrate from the swirl regulator. It was found that the unit could efficiently remove the small particles at the high concentrations.

It was concluded that the degritter could be used for domestic wastewater, combined sewer overflows, or urban stormwater runoff treatment. The absence of moving parts in the basic unit and small relative volume 1:10 (compared to conventional grit chambers) may make the unit particularly desirable for many applications. A comparison of the present worth of the cost of construction, operation and maintenance for a 20-year life indicates that the swirl degritter is from 26 to 38 percent less costly than a conventional aerated grit chamber.

This report is submitted in partial fulfillment of EPA Grant S803157 by the American Public Works Association under the sponsorship of the U.S. Environmental Protection Agency. This report covers a period from January, 1975 to August, 1976, and work was completed as of December, 1976.

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ACKNOWLEDGEMENTS

The American Public Works Association is deeply indebted to the following persons and their organizations for the services they have rendered to the APWA Research Foundation. The initiative of the Metropolitan Denver Sewage Disposal District No. 1 in providing the prototype swirl degritter for the comparison studies is acknowedged.

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SECTION I

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. The swirl degritter can efficiently and effectively remove grit from all wastewater flows. Even though the percent dry grit removal in the aerated grit chamber for raw sanitary sewage was consistently higher (77.3 percent) than that accomplished in the swirl degritter (66.4 percent), the aerated grit chamber retained an undesirably higher percentage of organic particles (volatile solids) than the swirl unit (19-30 percent for the aerated grit chamber as compared to 3-10 percent for the swirl degritter). To test the effectiveness of the swirl degritter in removing grit from combined sewer overflow and overflow concentrate, the plant influent was spiked by adding blasting sand (0.20 mm size). Removal efficiencies under these conditions were improved for the swirl unit. They ranged from 50 to 87 percent for the swirl degritter; and for the aerated grit chamber the range was considerably lower.

2. The swirl degritter remains effective at flows of twice the design flow. Efficiency falls off markedly at three times design flow, which is similar to other types of degritters.

3. Because the swirl degritter is compact in size and has no moving parts it is attractive for application on stormwater, combined sewer overflows, or treatment at remote locations where maintenance capability is limited. Such degritting may be desirable prior to pumping of the flows.

4. Since the swirl unit requires no aeration or moving parts in its internal operation, energy consumption/unit flowrate for this unit is less than any other method of grit removal.

5. Because of the mechanics of flow in the swirl degritter, the detention time in the unit is one minute or less as compared to a standard design of about three minutes for a conventional aerated grit chamber.

6. The present worth, including construction, operation, and maintenance of the swirl degritter compared to an aerated grit chamber indicates a savings of 26 percent for a 43.8 l/s (1 mgd) unit to 38 percent for a 438 l/s (10 mgd) unit. DSWD SAVINGS ≈ 30%

RECOMMENDATIONS

1. The City of Lancaster, in conjunction with the construction of a swirl concentrator as a combined sewer overflow regulator, should consider constructing a swirl concentrator as a grit chamber to reduce maintenance on its lift pumps. 8 ft DIA SWIRL UNIT 3 CFS 1346 GPM 1.9 MGD

2. Agencies that construct swirl degritters should be encouraged to install Chasick sampling units on the influent and effluent lines to enable further testing of the efficiency of the units.

SECTION II

THE DEMONSTRATION PROJECT

A related family of research studies has been carried out during the past four years to determine the ability of solids-liquids separation flow-through devices to remove unwanted solids in wastewater flows by means of induced swirl pattern hydraulic flows in time periods shorter than those required by conventional gravity separation treatment systems. The success of laboratory-based investigations in small-scale chambers on synthesized wastewater flows has led, progressively, to consideration and study of the application of such swirl concentration chambers for such purposes as combined sewer overflow regulation, grit removal from wastewater flows, primary clarification of wasteaters and erosion control devices.

A "first-generation" study was carried out on behalf of the U.S. Environmental Protection Agency (USEPA), by the American Public Works Association (APWA) Research Foundation to develop and investigate the feasibility of utilizing a swirl device to perform the dual function of hydraulically regulating overflows from a combined sewer system while simultaneously reducing the solids content and pollutional characteristics of the overflows discharged to receiving water by solids-liquid separation. The first report (1) recognized the applicability of the swirl separation principle for other than the combined sewer overflow regulator-separator.

It is obvious that a natural application of this relatively "flash-type" solids-liquid phase separation would be the removal of heavier grit from wastewater flows because such solids are more readily treatable because of their higher settling velocities. It was a new innovation in the separation of heavy inorganic solids from lighter organic materials by selective use of longitudinal flow velocities. It also offered opportunities to effectively remove grit from either the underflow concentrate (foul sewer discharge), of a swirl concentrator combined sewer overflow regulator or from normal dry-weather and wet-weather influents into treatment plants.

A "second-generation" study followed to develop and evaluate the swirl concentrator for grit removal for a planned installation of such a device for the City of Lancaster, Pennsylvania, (2) as part of a system for the treatment-disinfection of combined sewer overflow and pumping of the concentrated underflow back into the interceptor to the treatment plant. Removal of grit was intended to protect the wet well and pumping units of this proposed installation from the eroding and siltation effects of solids concentrations as high as 13,000 mg/l as well as reduce the effects of deposition in the downstream interceptor.

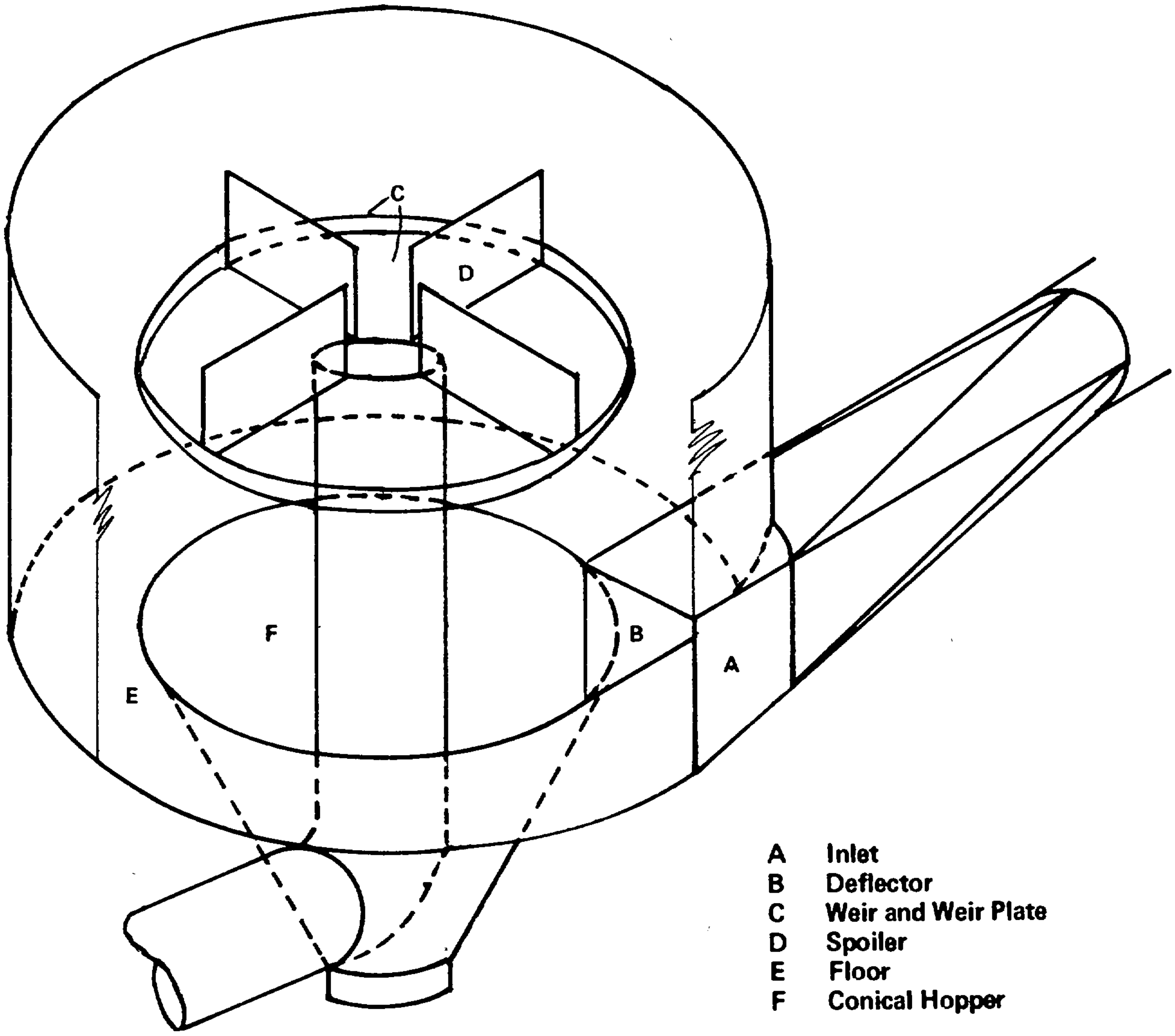


FIGURE 1 ISOMETRIC VIEW, SWIRL DEGRITTER

SECTION III

DESCRIPTION OF THE TEST LAYOUT

The prototype swirl degritter installation at the Metropolitan Denver Sewage Disposal District No. 1 treatment plant has two purposes: to ascertain the grit removal efficiency of the test system, and to compare these results with the grit removal performance of the plant's conventional aerated grit chamber (AGC). The layout of the swirl system, in relation to the plant's aerated grit removal facilities has been planned to make these two functions attainable. This installation is shown on Figure 2.

The 43.8 l/sec (1.0 mgd) swirl unit was constructed in 1974 at a cost of $4,500 exclusive of pumps, valves and grit washer elements which were readily available to the District. The cost of a comparison conventional grit removal unit of the same design flow is approximately $57,500.

Sewage for the swirl degritter was pumped from the influent channel to the AGC. The problem was to ascertain that the sewage delivered to the swirl degritter contained the same grit as the sewage entering the AGC. Sampling of the flow in the influent channel indicated that the solids were not evenly distributed in the channel. A baffle plate was installed initially to produce turbulence but sampling indicated this did not provide an even distribution of the grit and other suspended solids. An air header with six precision-type tubes was then installed and subsequent sampling indicated that the solids distribution was satisfactory. This procedure of assuring uniform concentrations of grit in the pumped sample reduced the settling efficiency in the swirl degritter since the solids would normally enter the swirl degritter as a stratified sewer load. The procedure did not affect the AGC efficiency. As a result both the evaluations of the swirl degritter and its comparison with the AGC are believed to be conservative.

The sewage was raised to a Parshall flume by two 15 cm (6 in) self-priming solids-handling pumps, each with a capacity of 78.8 l/s (1.8 mgd). The suction hoses for the two pumps were located to pick up sewage at the same point so that the use of either pump would obtain similar sewage samples. The pumps delivered the sewage into a channel set about 1.83 m (6 ft) above the ground, which discharged through a 22.8 cm (9 in) Parshall flume to measure the flow prior to entry into the swirl degritter. Grit was discharged from the bottom of the swirl degritter into a standard grit elevator and washer and after sampling, was returned to the AGC. Effluent from the swirl degritter was also returned to the AGC after sampling.

Details of the swirl degritter are shown in Figures 3, 4 and 5. The diameter selected was 1.8m (6 ft) and the other dimensions were chosen to

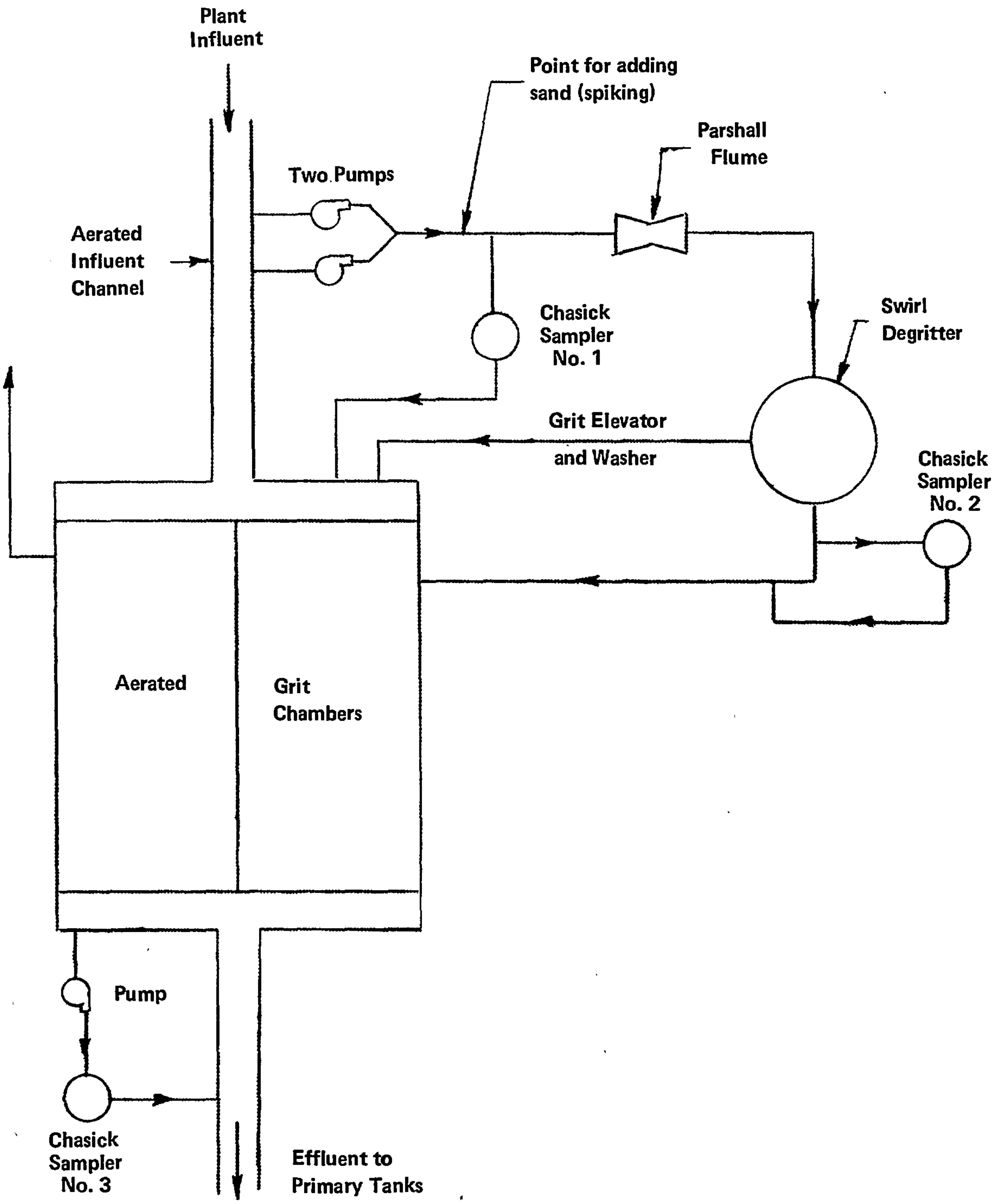


FIGURE 2 LAYOUT FOR DENVER TESTS

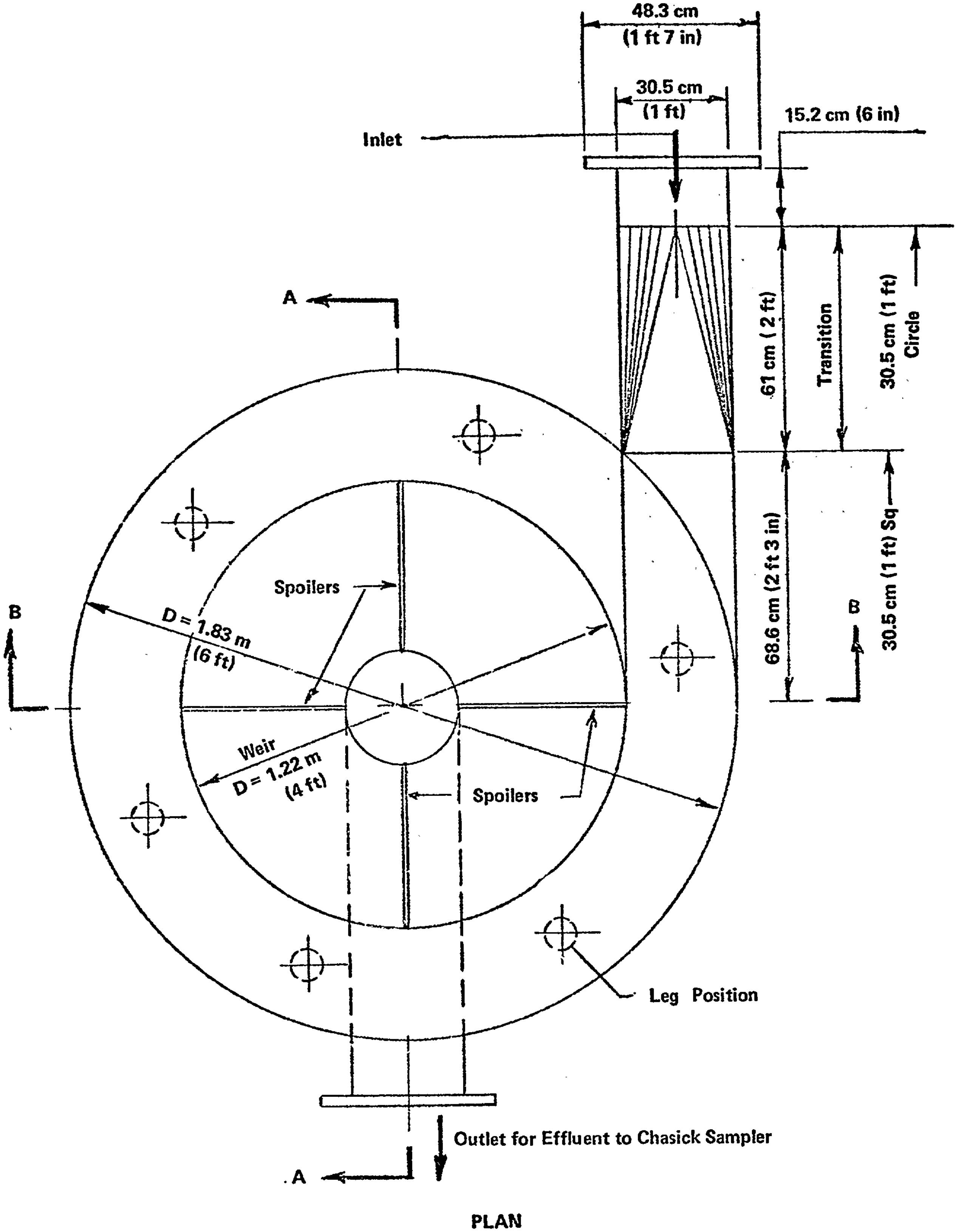
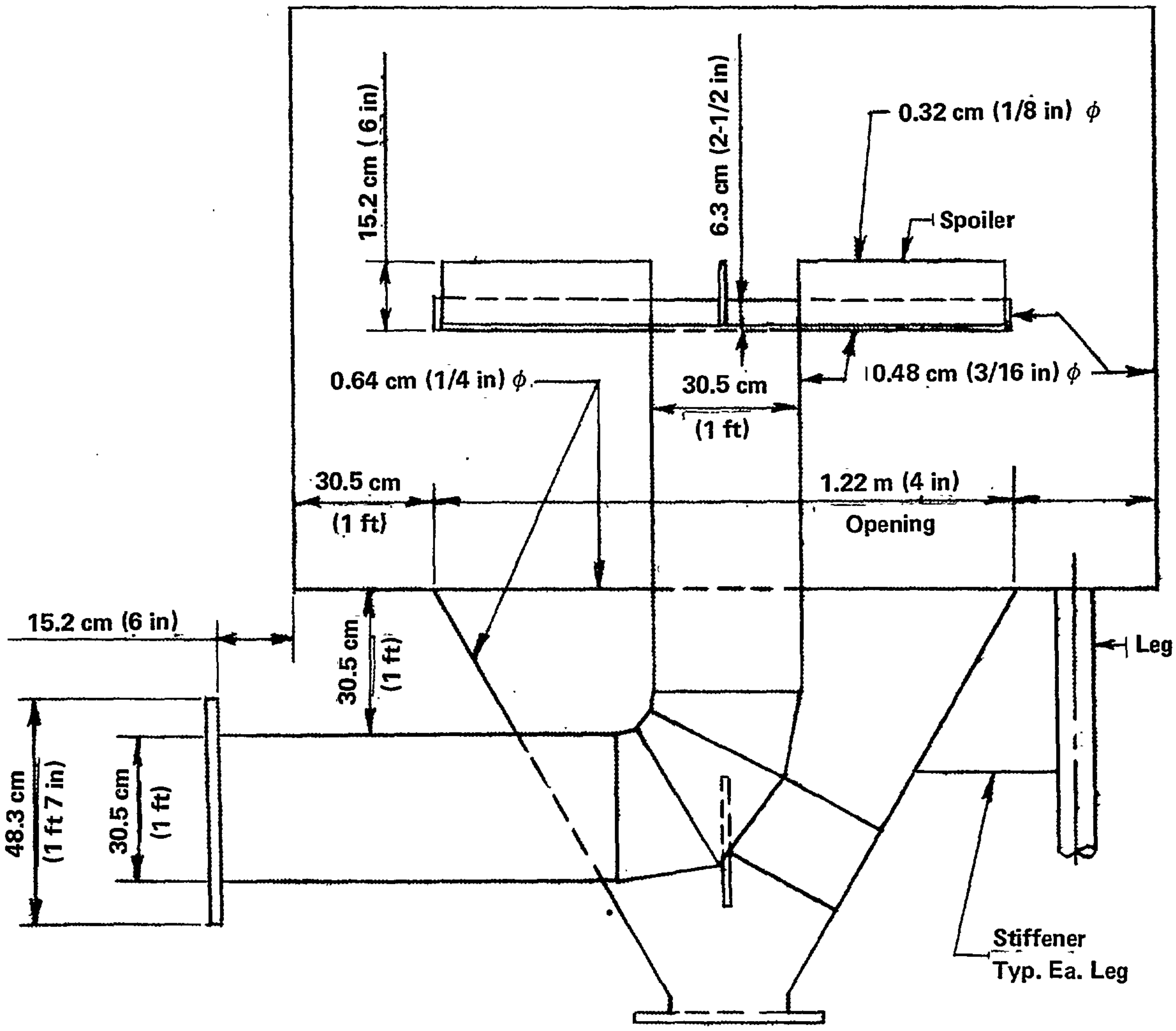


FIGURE 3 PLAN OF SWIRL DEGRITTER



SECTION A-A

FIGURE 4 SECTION A–A OF SWIRL DEGRITTER

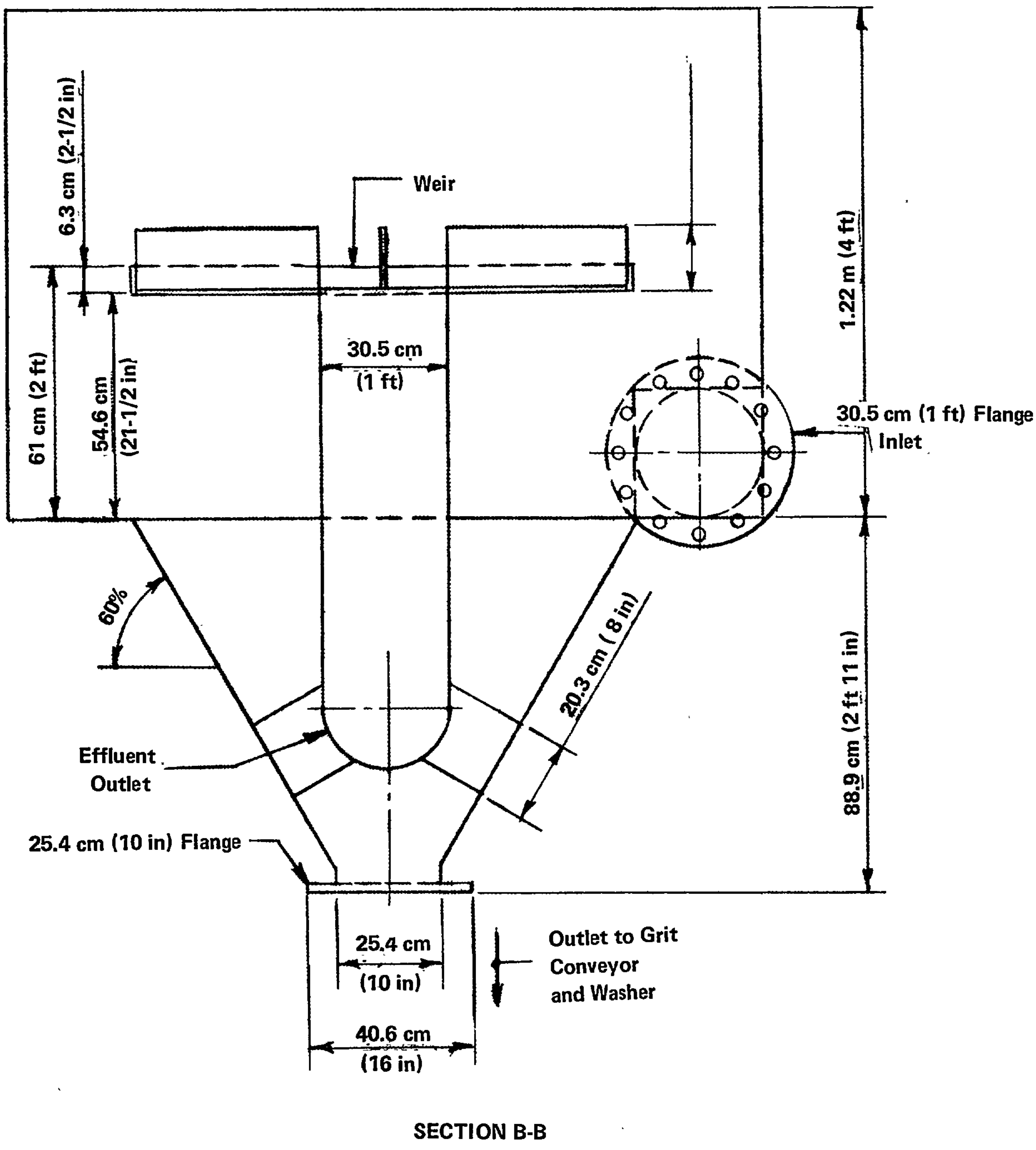


FIGURE 5 SECTION B–B OF SWIRL DEGRITTER

THIS SPECIFIC FIG IN REFERENCE HAS BEEN REVISED!

agree with Figure 3 of the laboratory model study (2). Excluding the volume in the cone-shaped hopper the detention time in the swirl degritter for various flows is shown in Table 1, based on the net volume in the main chamber being 1,486 l (52.5 cf).

TABLE 1. DETENTION TIMES

Flow				Actual Detention Time		Detention Time
AGC		Swirl Degritter 1.8 m (6 ft)		AGC(1)	Swirl Degritter, Tm, 1.8 m (6 ft)	Prototype Swirl, Tp(2)
l/s	mgd	l/s	mgd	min	min	min
438	10	21.9	0.5	40	1.1	2.00
876	20	43.8	1.0	20	0.6	1.09
1,952	40	87.6	2.0	8	0.3	0.55
2,190	50	131.4	3.0	8	0.2	0.35

Note 1: Conventional design basis 3 to 4 minutes
2: From Froude number equation $Tp = Qp^{1/5}/Qm^{1/5}(Tm)$ for swirl degritter prototype flow of 438 to 2,190 l/sec (10 to 50 mgd)

The transition length of pipe used at the inlet was only two inlet diameters because the unit was constructed prior to completion of the laboratory studies. The recommended length as shown in reference (2) is three diameters.

The aerated grit chamber was designed to remove both grit and grease. The initial design average flow was 876 l/s (20mgd), based on a 20-minute detention time. The unit was originally designed with a long detention time to facilitate removal of grease. During the study tests, flows in the aerated grit chamber approached 2,190 l/s (50 mgd), the detention time was about eight minutes. The usual basis for design of aerated grit chambers is to provide about three minutes detention time at peak flow. In a large plant like Denver, where the peak flow may be two times average flow, the detention time for average flow would be about six minutes.

In most cases, the rational design of grit chambers is based on removing particles over 0.20 mm or 0.25 mm in size with s.g. of 2.65. U.S. Standard Sieve number 70 has an opening of 0.21 mm. Little data are available on the percentage of grit removed in existing grit chambers over any given size. It is common knowledge that grit over 0.20 mm in size is found in plant units following grit removal (2).

It was considered necessary for purposes of this study to determine the presence of grit over 0.20 mm in size in the influent and effluent sewage of the aerated grit chamber and the swirl degritter. For this purpose it was decided to use the model grit cyclone developed by A.H. Chasick

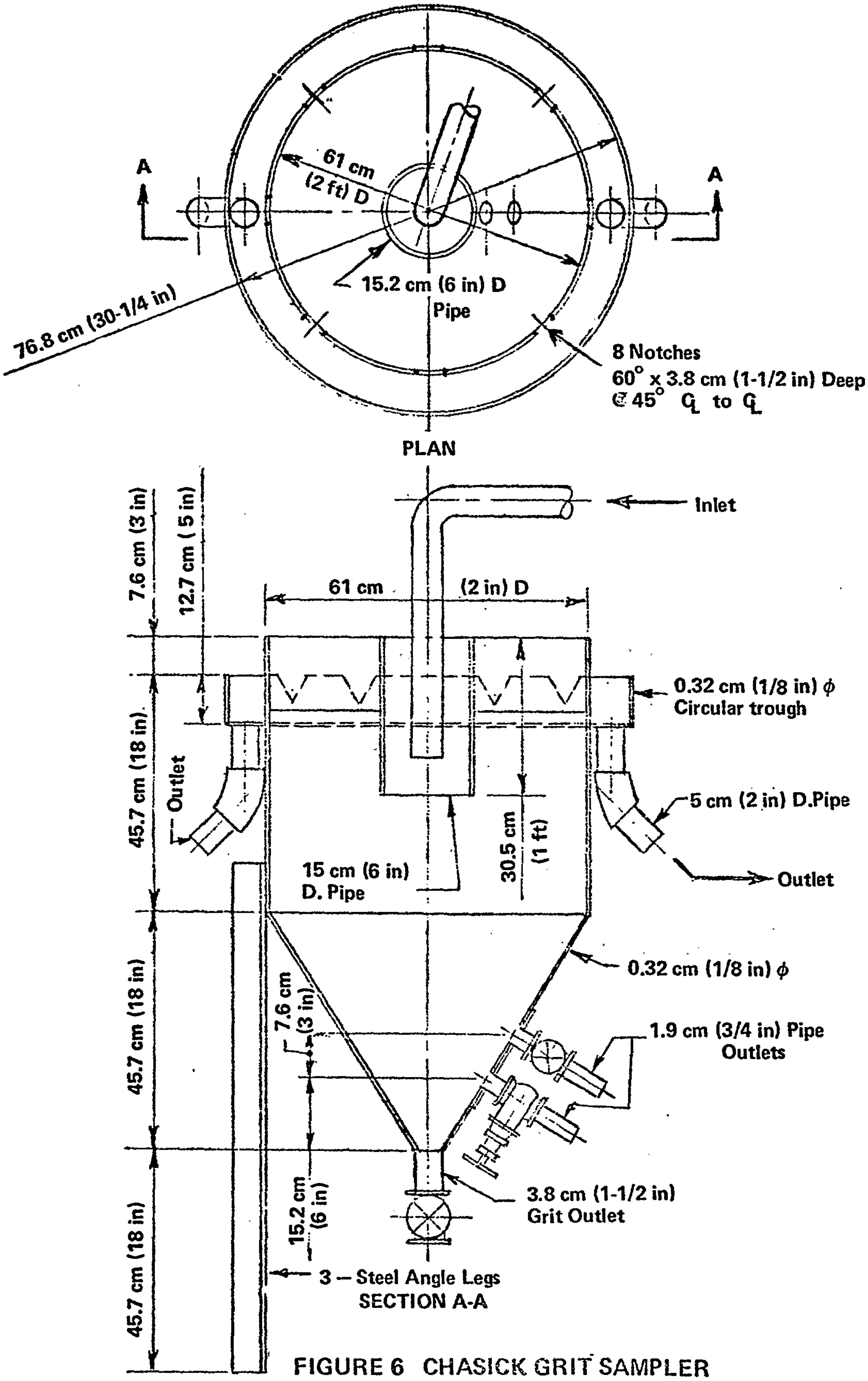


FIGURE 6 CHASICK GRIT SAMPLER

and T.B. Burger (3), as a sampling device. This grit cyclone is shown in Figure 6 and is referred to in this report as the Chasick sampler. Experiments by Chasick and Burger indicated the percent recovery of various size sands for various overflow rates.

Intially, in Denver, it was proposed to use and overflow rate of 814.6 $m^3/d/m^2$ (20,000 gpd/sf) on the Chasick samplers, but this flow resulted in the deposition of so much grit that these units had to be emptied every hour. Therefore the overflow rate was reduced to 407.3 $m^3/d/m^2$ (10,000 gpd/sf). This overflow rate is equivalent to an inlet flow of 1.38 l/s (21.8 gpm). According to Chasick and Burger, (3) this overflow rate should result in capturing 100 percent of the grit larger than 0.20 mm in the Chasick sampler. Three Chasick samplers were installed as shown in Figure 2: No. 1 to determine the grit in the influent to the plant, and therefore to the AGC and the swirl degritter; No. 2 for the effluent from the swirl degritter; and No. 3 for the effluent from the AGC. Gravity flow was possible to Chasick samplers No. 1 and No. 2, but it was necessary to pump up into Chasick sampler No.3.

In the second series of tests, dry blasting sand, size 0.25 mm, was added to the sewage after it was pumped from the influent channel. The point where sand was added is shown if Figure 2. Because of the location of the sand injector, only Chasick samplers Nos. 1 and 2 were effected by this addition. Therefore, results from these two samplers could not be compared to the test results from Chasick sampler No. 3 when the flow was enriched with sand. The process of sand addition is called spiking in this report.

SECTION IV

EVALUATION OF TEST RESULTS

The first series of tests were established to evaluate flows of 43.8, 87.6 and 131.4 l/s (1.0, 2.0, and 3.0 mgd) in the swirl degritter. The sampling points and proposed tests are shown in Table 2. The test run for each flow was to be seven consecutive days. However, during the test run for a flow of 131.4 l/s (3.0 mgd) the tests were interrupted for three days. The results are shown in Tables A-1, A-2, and A-3 in the Appendix.

The data on grit removal for the first series of tests are shown in Table 3. The weight of dry grit is converted to the weight of grit ash in the table on the basis of the percent of volatile solids. The percentage removal of grit ash in the swirl degritter ranged from 68.0 to 84.2 percent, with an average of 76.0 percent. The highest percent removal occurred with the highest flow rather than with the lowest flows, as might be expected. The removals in the AGC ranged from 86.8 to 92.7 percent with an average of 89.8 percent. Therefore, on the average the AGC performed about 18 percent better than the swirl concentrator. Because similar data are not available on the performance of standard grit removal units, no comparison with such units can be made.

DENVER'S AGC IS OVERSIZED 20 MIN. DETENTION TIME NORMAL 6 MIN - MAX

Table 3 also shows the pounds of grit ash per million gallons. This is obtained by dividing the pounds per day of grit ash by the daily flow through the Chasick sampler, based on a flow of 1.38 l/s (21.8 gpm). In all cases there was more grit in the effluent from the swirl degritter than in the effluent from the aerated grit chamber. It should be noted that the flow to the Chasick sampler No. 3 was pumped from the effluent channel of the aerated chamber. The original centrifugal pump used for this purpose tended to plug and it was replaced by a diaphragm pump. After this change it appeared that the surge from the pump might be blowing solids out of the Chasick sampler. Therefore, a surge tank was added ahead of the Chasick sampler. Flow to both Chasick No. 1 and Chasick No. 2 was by gravity so this problem did not occur in these units. It should be noted that although the quantity of grit ash increased from 15.7 to 29.6 kg/1,000 l (131 to 247 lbs/m gal), an increase of 88 percent, the change in the percent removal was considerably less.

Grit ash is used as a measure of efficiency of grit chambers since it represents the inorganic, heavier material that a grit chamber is designed to remove. During certain periods of low flow, organic particles also settle and were present in the samples, however, if the chamber is operated at the design flow rate, organic particles would not be entrapped, and therefore cannot be included in the efficiency calculation.

TABLE 2. PROPOSED TESTS - FIRST SERIES--MAY 23 TO JUNE 21, 1975

Sample Point	Grit Volume	Dry Grit Weight	Total Solids %	Volatile Solids %	Putrescibles %	Sieve Analysis
Chasick # 1 Influent	D	D		2W		
Chasick # 2 Swirl Effluent	D	D		2W		
Chasick # 3 AGC Effluent	D	D		2W		
Grit Swirl Concentrator Post-Wash	D		CW4	CW4	SS	WC
Grit Dorr-Oliver Classifier Discharge	D		CW4	CW4	SS	WC

Notes:
Run 7 days each at Swirl flows of 43.8,87.6 and 131.41/s (1.0, 2.0 & 3.0 mgd)

D - daily total

2W - average of two samples/week

WC - weekly composite on dry grit (not ashed grit)

SS - single sample

CW4 - weekly composite of samples taken at 4 hour intervals

(continued)

TABLE 2. (continued)

Sample Point	Suspended Solids mg/1	Volatile Suspended Solids mg/1	BOD mg/1	COD mg/1
Grit Swirl Concentrator Pre-Wash	CW4	CW4		
Grit Dorr-Oliver Classifier Influent	CW4	CW4		
Aerated Channel #1 influent	CW2	CW2	CW2	CW2
Swirl Effluent	CW2	CW2		
Aerated Grit Chamber (AGC) # 2 influent	CW2F	CW2F	CW2F	CW2F
Primary influent (AGC effluent)	CW2F	CW2F		

Notes:

CW4 - weekly composite of samples at 4 hour intervals

CW2 - weekly composite of 250 ml samples taken at 2 hour intervals

CW2F - weekly composite of flow adjusted samples at 2 hour intervals

TABLE 3. REMOVAL OF GRIT ASH--MAY 23 - JUNE 21, 1975

Chasick Sampler		Dry Grit Lbs/Day	(Kgs/Day)	Volatile Solids %	Grit Ash Lbs/Day	(Kgs/Day)	Removal of Grit Ash % Swirl	Removal of Grit Ash % A.G.C.	Lbs of Grit Ash / Million Gallons	Kgs of Grit Ash / Million Liters
Flow: Swirl - 43.8 l/s (1.0 mgd); AGC - 2028 l/s (46.3 mgd)										
1	Inflow	9.04	(4.1)	54.3	4.13	(1.87)			131	(16)
2	Swirl	2.13	(0.97)	53.1	1.00	(0.45)	75.8		31.8	(4)
3	AGC	0.74	(0.34)	59.2	0.30	(0.14)		92.7	9.6	(1.2)
Flow: Swirl - 87.6 l/s (2.0 mgd); AGC - 2177 l/s (49.7 mgd)										
1	Inflow	8.14	(3.7)	20.8	6.45	(2.93)			205	(25)
2	Swirl	3.55	(1.6)	41.9	2.06	(0.93)	68.0		65.6	(8)
3	AGC	2.86	(1.3)	70.4	0.85	(0.4)		86.8	27.0	(3.2)
Flow: Swirl - 131.4 l/s (3.0 mgd); AGC - 2147 l/s (49.0 mgd)										
1	Inflow	9.40	(4.3)	17.5	7.76	(3.5)			247	(30)
2	Swirl	3.17	(1.44)	61.4	1.22	(0.55)	84.2		38.8	(4.6)
3	AGC	2.33	(1.06)	66.9	0.77	(0.35)		90.0	24.5	(3.0)

Average % removal of grit ash:

Swirl	76.0	
AGC		89.8

The removal of dry grit is shown in Table 4. The removals in the swirl concentrator ranged from 56.4 to 76.4 percent, with an average of 66.4 percent. In the aerated grit chamber the removals ranged from 65.9 to 91.8 percent, with an average of 77.3 percent. In all three test runs the percent removal in the aerated grit chamber was better than that accomplished in the swirl degritter.

TABLE 4. REMOVAL OF DRY GRIT
MAY 23-JUNE 21, 1975

1.8m (6 ft) Diameter Swirl Flow	% Removal Dry Grit: Swirl Degritter	% Removal Dry Grit: Aerated Grit Chamber	% Predicted Swirl Efficiency From Figure 47 (2) for Height/Diameter = 2
43.8 l/s (1.0 mgd)	76.4	91.8	97
87.6 l/s (2.0 mgd)	56.4	64.9	78
131.4 l/s (3.0 mgd)	66.3	75.2	71
Average	66.4	77.3	

Table 5 shows the removal of suspended and volatile solids for the test period May 23 - June 21, 1975. Removals of suspended solids ranged from 4.3 to 10.9 percent in the swirl degritter compared to 18.8 to 29.6 percent in the aerated grit chamber. Removals of volatile solids ranged from 3.0 to 9.8 percent in the swirl degritter, compared to 19.0 to 30.0 percent in the aerated grit chamber.

Samples of washed grit were collected at four-hour intervals during each seven-day test run. A sample of this seven-day composite was tested for total suspended solids and volatile suspended solids. These results, while not pertinent to this study, reflect a field test efficiency of the grit washers. Sieve analyses were performed on samples of dried grit collected from the Dorr-Oliver Classifier and the swirl unit elevator-washer from the weekly composites. These indicated the relative size of the grit removed by the two units.

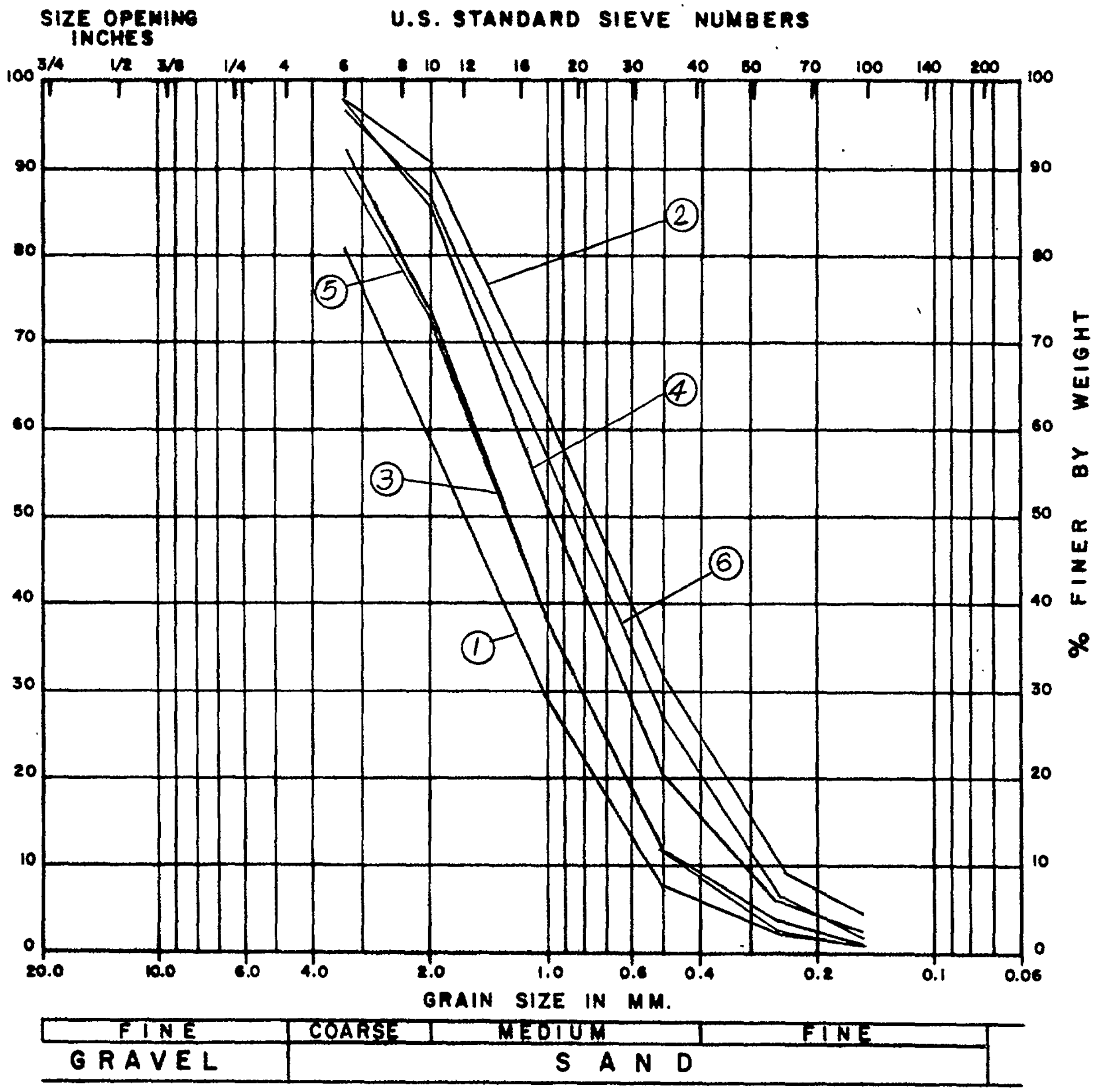
The results are plotted in Figure 7, where the curves indicate the coarsest grit was collected in the swirl degritter when the flow was lowest

TABLE 5

REMOVAL OF SUSPENDED AND VOLATILE SOLIDS
MAY 23 - JUNE 21, 1975

Flow in Swirl	Suspended Solids					
	Swirl Degritter			Aerated Grit Chamber		
	Influent mg/1	Effluent mg/1	% Removal	Influent mg/1	Effluent mg/1	% Removal
43.8 l/s (1.0 mgd)	266	248	6.7	249	184	26.1
87.6 l/s (2.0 mgd)	233	223	4.3	239	194	18.8
131.4 l/s (3.0 mgd)	219	195	10.9	209	147	29.6
AV	239	222	7.1	232	175	24.6

	Volatile Solids					
	Swirl Degritter			Aerated Grit Chamber		
	Influent mg/1	Effluent mg/1	% Removal	Influent mg/1	Effluent mg/1	% Removal
43.8 l/s (1.0 mgd)	199	193	3.0	184	143	22.2
87.6 l/s (2.0 mgd)	184	173	6.0	194	157	19.0
131.4 l/s (3.0 mgd)	173	156	9.8	160	112	30.0
AV	185	174	5.9	179	137	23.5



1 Swirl @ I mgd
2 Dorr @ 46.3 mgd
3 Swirl @ 2 mgd
4 Dorr @ 49.7 mgd
5 Swirl @ 3 mgd
6 Dorr @ 49.0 mgd

FIGURE 7 DENVER TESTS GRIT GRADATION CURVES
MAY 23 – JUNE 21 FIRST SERIES

at 43.8 l/s (1.0 mgd). The grit samples from the swirl at the two higher flows showed almost identical gradation curves and indicated coarser grit than that obtained from the aerated grit chamber. It should be noted that the sieve analyses were carried out on dry grit which may have contained considerable large-sized organic matter such as coffee grounds, seeds, corn, and other material. The indication that the aerated grit chamber produces finer grit may be due to the better washing and removal of organic matter performed in the Dorr-Oliver Classifier than was performed by the screw elevator and washer used in conjunction with the swirl concentrator. Therefore, on the next series of tests the sieve analyses were carried out on grit ash from the Chasick sampler. It should also be noted that the recovery of grit of less than 0.2 mm size was 10 percent or less. For this reason it was decided to spike the second series of tests with fine sand.

The second series of test was limited to analyses of the contents of the Chasick samplers. Each test run was limited to two hours and 20 test runs were made with five each at flows in the swirl degritter of 21.9, 43.8, 87.6, and 131.4 l/s (0.5, 1.0, 2.0, and 3.0 mgd). The entire contents of the samplers were collected for each run and tested as described in the Appendix.

The second series investigation is described in Table 6.

To test the effectiveness of the swirl degritter in removing grit of 0.20 mm size, the flow to the swirl unit was spiked by added blasting sand during certain test runs. The spiking material was added just upstream of the discharge point to Chasick sampler No. 1, as shown in Figure 2. About 22.7 kg (50 lb) of sand were added during a one-hour period, beginning about 15 to 30 minutes after the two-hour test run. This quantity of sand, averaged over the two-hour test run, is equivalent to adding 144 gm/m^3, 72 gm/m^3, 36 gm/m^3, and 24 gm/m^3 (1,200, 600, 300, and 200 lbs per mg) for the flows of 21.9 l/s (0.5 mgd), 43.8 l/s (1.0 mgd), 87.6 l/s (2.0 mgd), and 131.4 l/s (3.0 mgd), respectively.

The sieve analysis and gradation curve for the spiking sand is shown in Figure 8.

The second series of tests were run from August 27-30, 1975. The test results are shown in Tables A-4, A-5, A-6, and A-7 of the Appendix.

The efficiency of the swirl chamber in removing dry grit is shown in Table 7.

No removals are shown for the AGC when the flow was spiked, since the spiking only affected the grit collected in Chasick samplers Nos. 1 and 2 and not No. 3. Thus, only 8 of the 20 tests applied to AGC. The results for the AGC ranged from a 51 percent reduction to a 132 percent increase in grit.

This great variation in grit removal in the AGC is difficult to explain since, during the first series of tests, the removals for the seven-day period were 91.8, 64.9, and 75.2 percent, with an average of 77.3 per-

TABLE 6

PROPOSED TESTS SECOND SERIES
AUGUST 27 - 31, 1975

Sample Point		Grit Volume	Dry Grit Weight	Volatile Solids %	Sieve Analysis
Chasick # 1	Inflow	2H	2H	SS	2C
Chasick # 2	Swirl	2H	2H	SS	2C
Chasick # 3	AGC	2H	2H	SS	2C

Note:

Spiking - Spike influent sewage with 0.25 mm sand at rate of 22.7 kg/hr * (50 lb/hr) if Chasick # 1 does not indicate 20% of 0.2 mm grit.

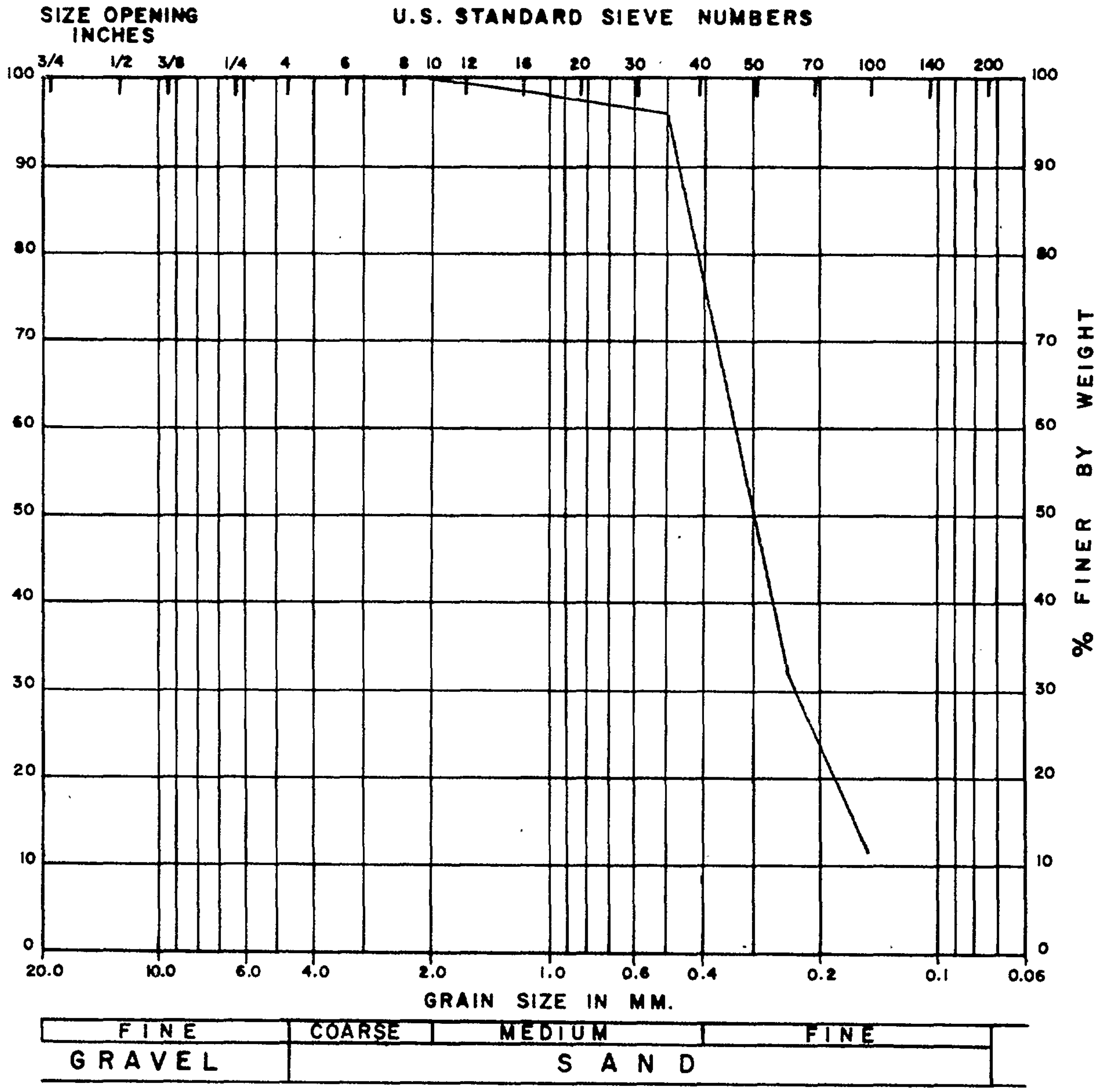
2H Total for two hour tests. Five tests each at flows of 21.9, 43.8, 87.6 and 131.4 l/s (0.5, 1.0, 2.0 and 3.0 mgd) in swirl.

SS Single sample from each two hour test.

2C On incinerated contents of two hour test or aliquot sample if volume too great.

* GRIT CONCENTRATIONS

flow mgd	lbs/mg	gpm
0.5	2400	288
1	1200	144
2	600	72
3	400	48



Spike is dry blasting sand, 0.25 mm size.

SIEVE ANALYSIS

U.S. Sieve No.	% Finer by Weight
100	11.4
60	32.0
35	96.0
18	99.9
10	100.0

FIGURE 8 GRADATION CURVE OF SPIKING SAND

TABLE 7. REMOVAL OF DRY GRIT
AUGUST 27-30, 1975

Flow Swirl Degritter	Run Number	Percent Removal		
		Swirl Degritter		
		Normal	Spiked	AGC
21.9 l/s (0.5 mgd)	1	57	64	14
	2			
	3		83	
	4		70	
	5	66	—	+127
	AV	62	72	+ 56
43.8 l/s (1.0 mgd)	1	50		51
	2		87	
	3	79		9
	4		68	
	5	—	72	—
	AV	64	76	30
87.6 l/s (2.0 mgd)	1	26		43
	2		48	–
	3		43	
	4		59	
	5	+50	—	+132
	AV	+12	50	+ 44
131.4 l/s (3.0 mgd)	1	8		17
	2		+32	
	3		+46	
	4		41	
	5	24	—	11
	AV	16	+12	14

Note: Percent removed based on dry weight. Flow rate in the AGC was at approximately 2,190 l/s (50 mgd).

cent, as shown in Table 4. Subsequent tests with the AGC at higher flow rates showed a significant reduction in efficiency, as shown in Table 8.

The percent removals of dry grit from the swirl degritter were fairly uniform for flows of 21.9 and 43.8 l/s (0.5 and 1.0 mgd) with removals ranging from 50 to 87 percent. There was no marked difference in the removals at the top flow rates. However, the removals at the two higher flow rates of 87.6 and 131.4 l/s (2.0 and 3.0 mgd) were erratic, with 3 of 10 test runs showing an increase in grit. Here again, the results failed to agree with

TABLE 8

REMOVAL OF GRIT ASH
AUGUST 27, 1975

Swirl Flow 21.9 l/s (0.5 mgd)

Run No.	Chasick Sampler	Grit Ash gr/hr	Grit Ash lbs/hr	%Removal of Grit Ash Swirl	%Removal of Grit Ash AGC	gr/m^3	lbs per Million Gallons
1	1	104	0.229			21	175
	2	24	0.053	76.8		5	40
	3	19	0.042		S	4	32
2	1	29	0.063			58	48
	2	11	0.024	61.9		2	18
	3	13	0.028		55.6	3	21
3	1	163	0.358			33	274
	2	17	0.037	89.7		3	28
	3	22	0.049		S	4	37
4	1	42	0.093			9	71
	2	9	0.019	79.6		2	14
	3	14	0.031		S	3	24
5	1	15	0.034			3	26
	2	4	0.009	73.5		1	7
	3	15	0.033		2.9	3	25
	Average Spiked			82.0			
	Average Normal			67.7	29.2		

Note:
lbs/mg = lbs/hr x 764

S - Flow Spiked - not applicable

the first series of tests which showed removals of 76.4, 56.4, and 66.3 percent, as reported in Table 4. This may be due to removal by the higher flow of grit deposited in the inlet conduit in previous runs.

The percent removals of dry grit are shown graphically in Figure 9. This figure shows that only at the two lower flows did the swirl degritter perform as well as in the first series of tests. The figure also shows the erratic results obtained in the AGC.

The weight of dry grit collected in the Chasick samplers in the two-hour test runs were converted to grams/m^3 (lbs/mg), based on a constant flow of 1.38 l/s (21.8 gpm) through the samplers. The results are shown graphically in Figure 10. These curves show the effect of spiking on Chasick samplers Nos. 1 and 2. Denver personnel reported that the point of spiking was too close to the outlet point of Chasick sampler No. 1 and hence, the full effect of spiking was not always felt by that sampler. This was most obvious on August 20, 1975 when sampler No. 2 showed more grit in Runs 2 and 3 than sampler No. 1. The figure also shows that the spiking had little effect on sampler No. 3.

During the second series of tests the volatile solids in the various grit samples ranged from 17.2 to 83.0 percent. Therefore, it was thought it might be significant to work up data for the grit ash which would exclude the effect of organic matter on the quantity of grit. These results are shown in Tables 8 through 11. The percent removals are shown graphically in Figure 11. The results are similar to those for removal of dry grit except that the large increase in grit for Run 5 on August 27 and August 29, 1975 for Chasick sampler No. 3 have been changed to slight reductions, indicating that the large increase was due to the collection of organic matter. The weight of grit ash is shown graphically in Figure 12. This indicates a weight of grit ash ranging from 2.39 to 55.1 kg/1,000 m^3 (20 to 460 lbs/mg) in the various samplers. The results are similar to those shown for the dry grit except that the weights are less.

In the second series of tests all material collected in the Chasick samplers in each two-hour period was analyzed for volatile solids. Thus, it is possible to compare the weight of volatile solids in the influent to the plant to the volatile solids in the effluent from the swirl concentrator and from the AGC. The ratio of these quantities is shown in Tables 12 through 16.

Table 13 indicates the results with flow of 21.9 l/s (0.5 mgd) in the swirl concentrator and normal daily flow in the AGC. This indicates the volatile solids in the effluent from the swirl has 51 percent of the volatile solids in the influent. Thus 49 percent of the volatile solids were removed with the grit. The data indicates that the effluent from the AGC had produced a volatile solids greater than 100 percent on each of the five two-hour tests. This is no doubt due to sampling methods. The influent sample was taken from the influent channel which was aerated to keep the solids in suspension. The effluent sample was pumped from the effluent channel from the AGC with no aeration. Possibly the pump suction was located near the bottom of the channel where there was greater density of volatile solids.

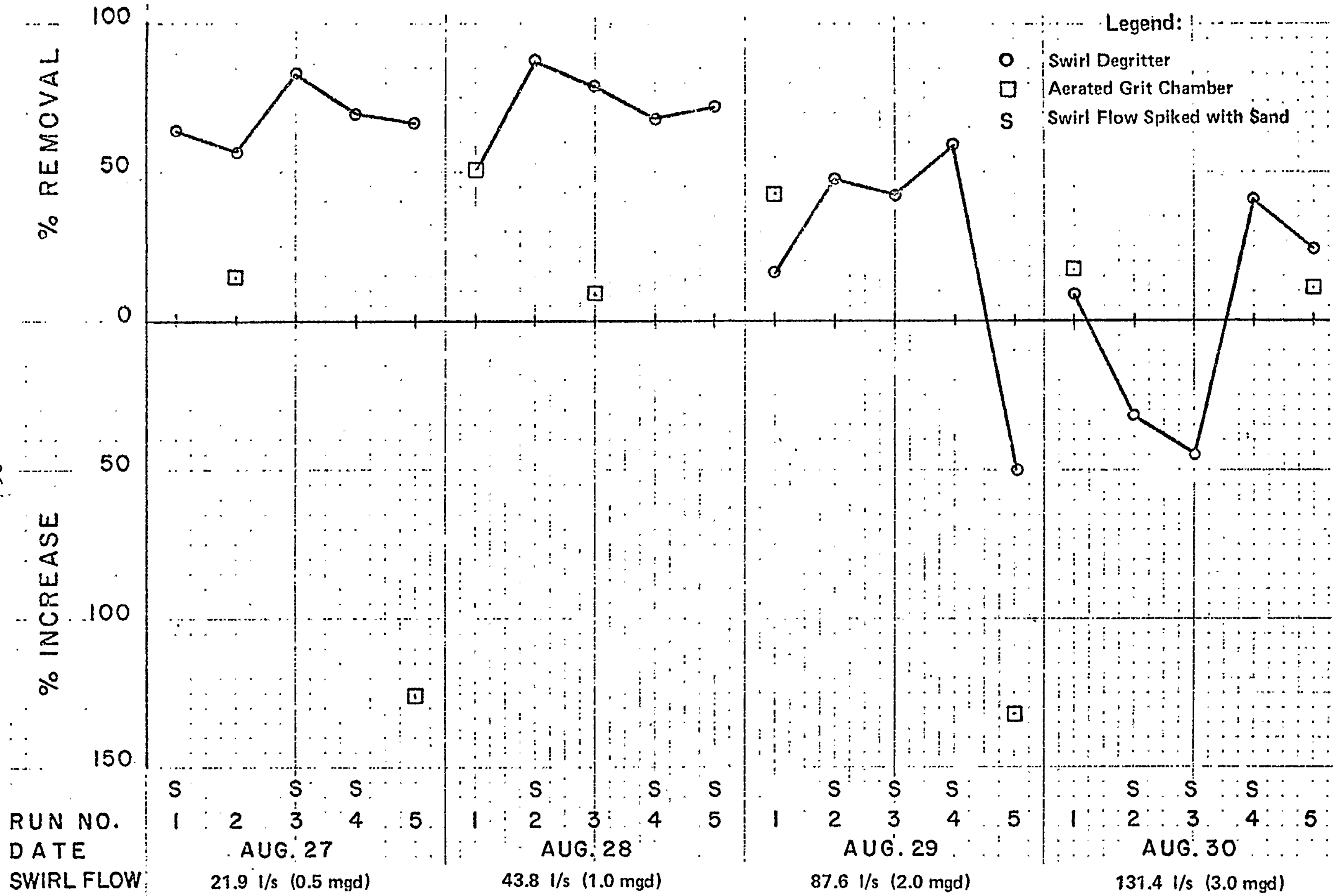


FIGURE 9 REMOVAL OF DRY GRIT – AUGUST 1975

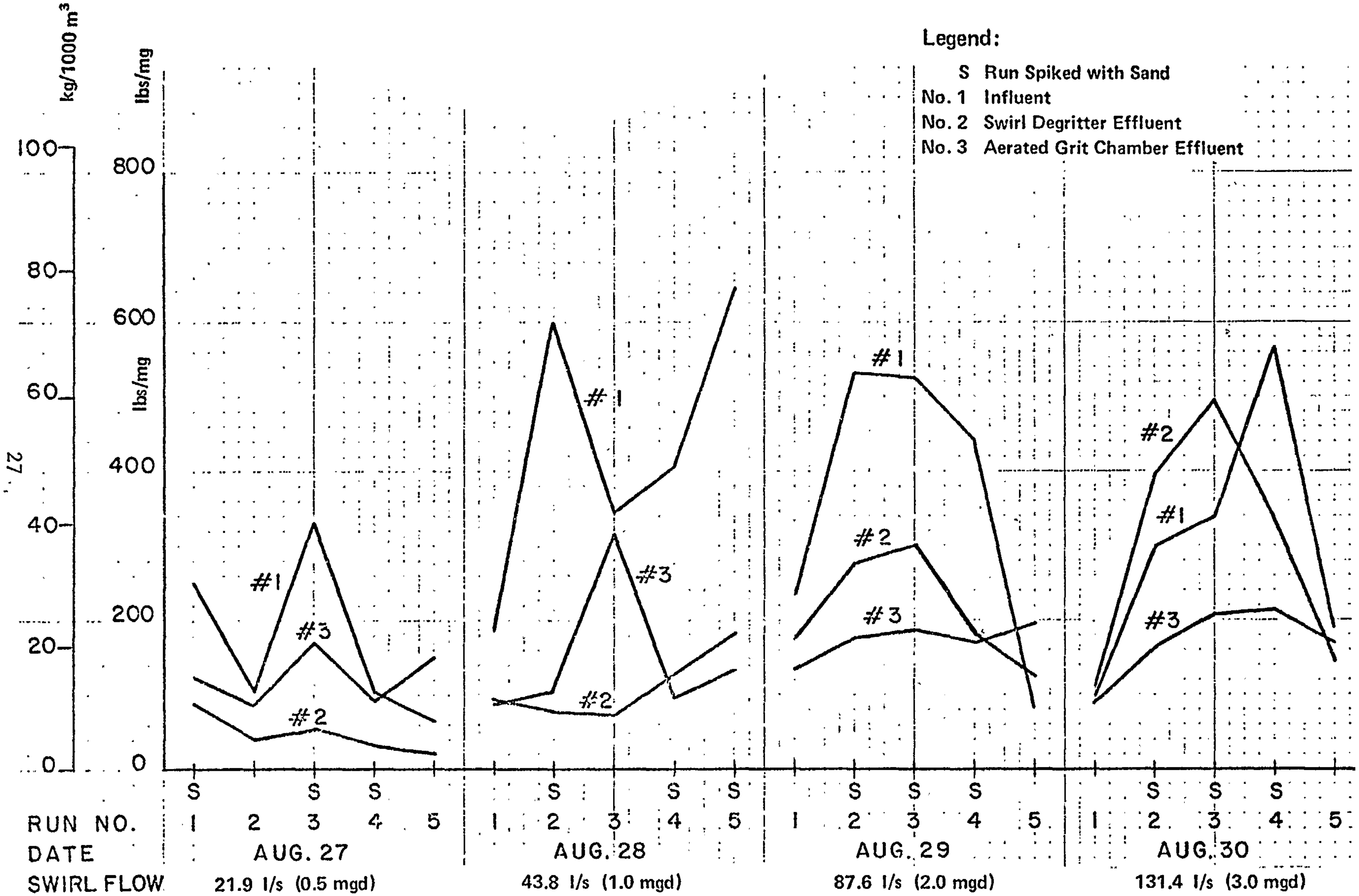


FIGURE 10 WEIGHT OF DRY GRIT – AUGUST 1975

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TABLE 9

REMOVAL OF GRIT ASH
AUGUST 28, 1975

Swirl Flow 43.8 l/s (1.0 mgd)

Run No.	Chasick Sampler	Grit Ash		%Removal of Grit Ash			lbs per Million Gallons
		gr/hr	lbs/hr	Swirl	AGC	gr/m^3	
1	1	72	0.159			15	121
	2	30	0.065	58.9		6	50
	3	22	0.048		69.6	4	37
2	1	263	0.580			53	443
	2	28	0.062	89.3		6	47
	3	25	0.056		S	5	43
3	1	114	0.250			23	191
	2	16	0.036	85.6		3	28
	3	81	0.179		28.4	16	187
4	1	166	0.366			34	280
	2	40	0.088	76.0		8	67
	3	20	0.045		S	4	34
5	1	277	0.611			56	467
	2	57	0.126	79.4		12	96
	3	27	0.059		S	5	45
	Average Spiked			81.6			
	Average Normal			72.2	49.0		

Note:
lbs/mg = lbs/hr x 764

S - Flow Spiked - not applicable

TABLE 10

REMOVAL OF GRIT ASH
AUGUST 29, 1975

Swirl Flow 87.6 l/s (2.0 mgd)

Run No.	Chasick Sampler	Grit Ash gr/hr	Grit Ash lbs/hr	%Removed of Grit Ash Swirl	%Removed of Grit Ash AGC	gr/m^3	lbs per Million Gallons
1	1	78	0.171			16	131
	2	47	0.104	39.2		9	79
	3	28	0.062		63.7	6	47
2	1	247	0.543			50	415
	2	102	0.225	58.6		21	172
	3	30	0.067		S	6	51
3	1	248	0.546			49	417
	2	101	0.222	59.3		20	170
	3	32	0.070		S	6	53
4	1	208	0.458			42	350
	2	67	0.147	67.9		13	112
	3	28	0.062		S	6	47
5	1	30	0.065			6	50
	2	23	0.051	21.5		5	39
	3	28	0.062		4.6	6	47
	Average Spiked			61.9			
	Average Normal			30.4	34.2		

Note:
lbs/mg = lbs/hr x 764

S - Flow Spiked - not applicable

TABLE 11

REMOVAL OF GRIT ASH
AUGUST 30, 1975

Swirl Flow 131.4 l/s (3.0 mgd)

Run No.	Chasick Sampler	Grit Ash gr/hr	Grit Ash lbs/hr	%Removal of Grit Ash Swirl	%Removal of Grit Ash AGC	gr/m^3	lbs per Million Gallons
1	1	28	0.062			6	47
	2	20	0.043	30.6		4	33
	3	17	0.037		40.3	3	28
2	1	121	0.267			24	204
	2	185	0.408	+52.8		37	312
	3	27	0.060		S	6	46
3	1	141	0.311			29	238
	2	238	0.524	+68.5		48	401
	3	44	0.096		S	9	73
4	1	251	0.553			51	423
	2	97	0.213	61.5		20	163
	3	34	0.074		S	7	57
5	1	63	0.138			12	105
	2	33	0.073	47.1		6	56
	3	29	0.063		54.3	6	48
	Average Spiked			+19.9			
	Average Normal			38.8	47.3		

Note:
lbs/mg = lbs/hr x 764

S - Flow Spiked - not applicable

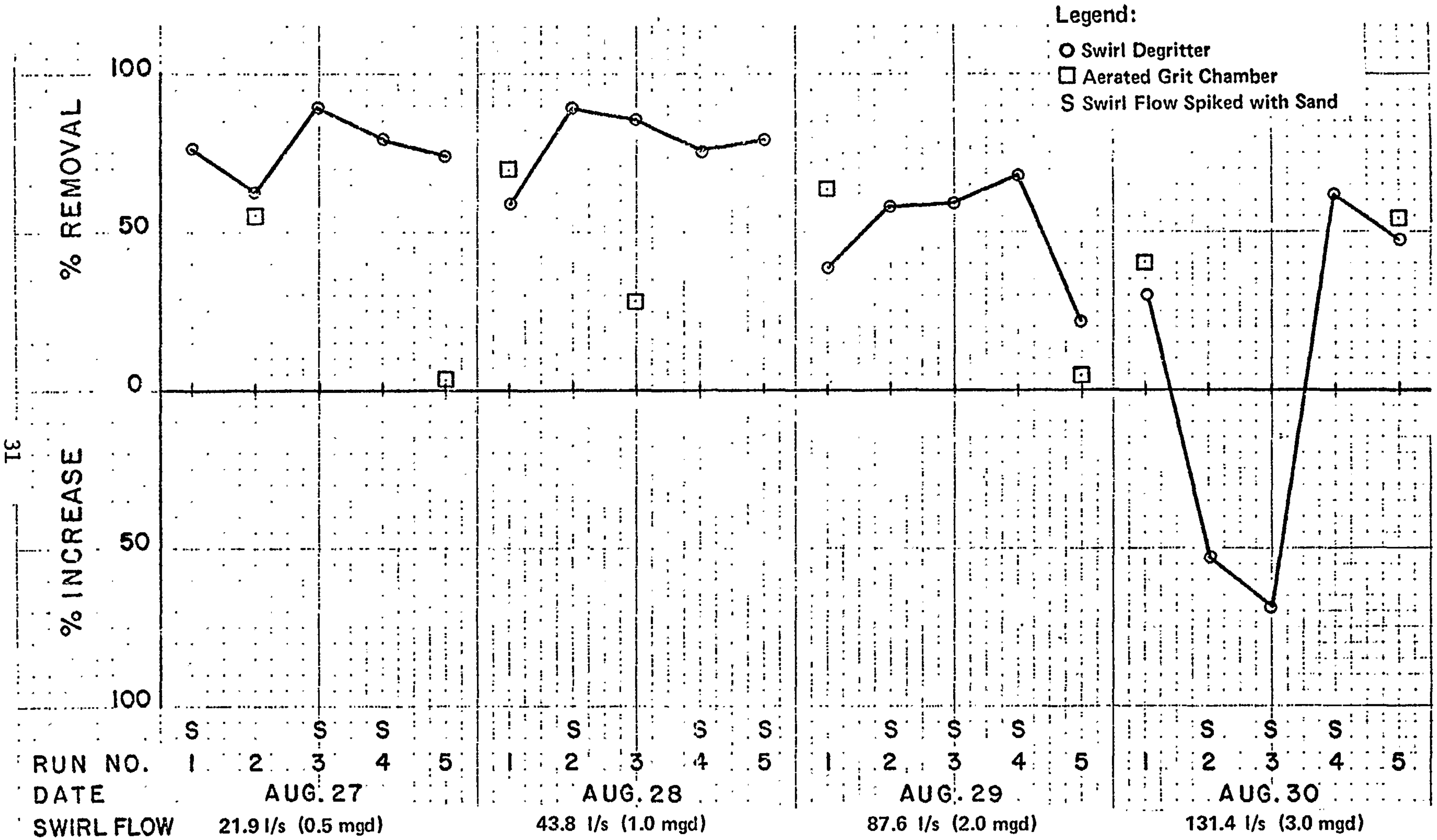


FIGURE 11 REMOVAL OF GRIT ASH – AUGUST 1975

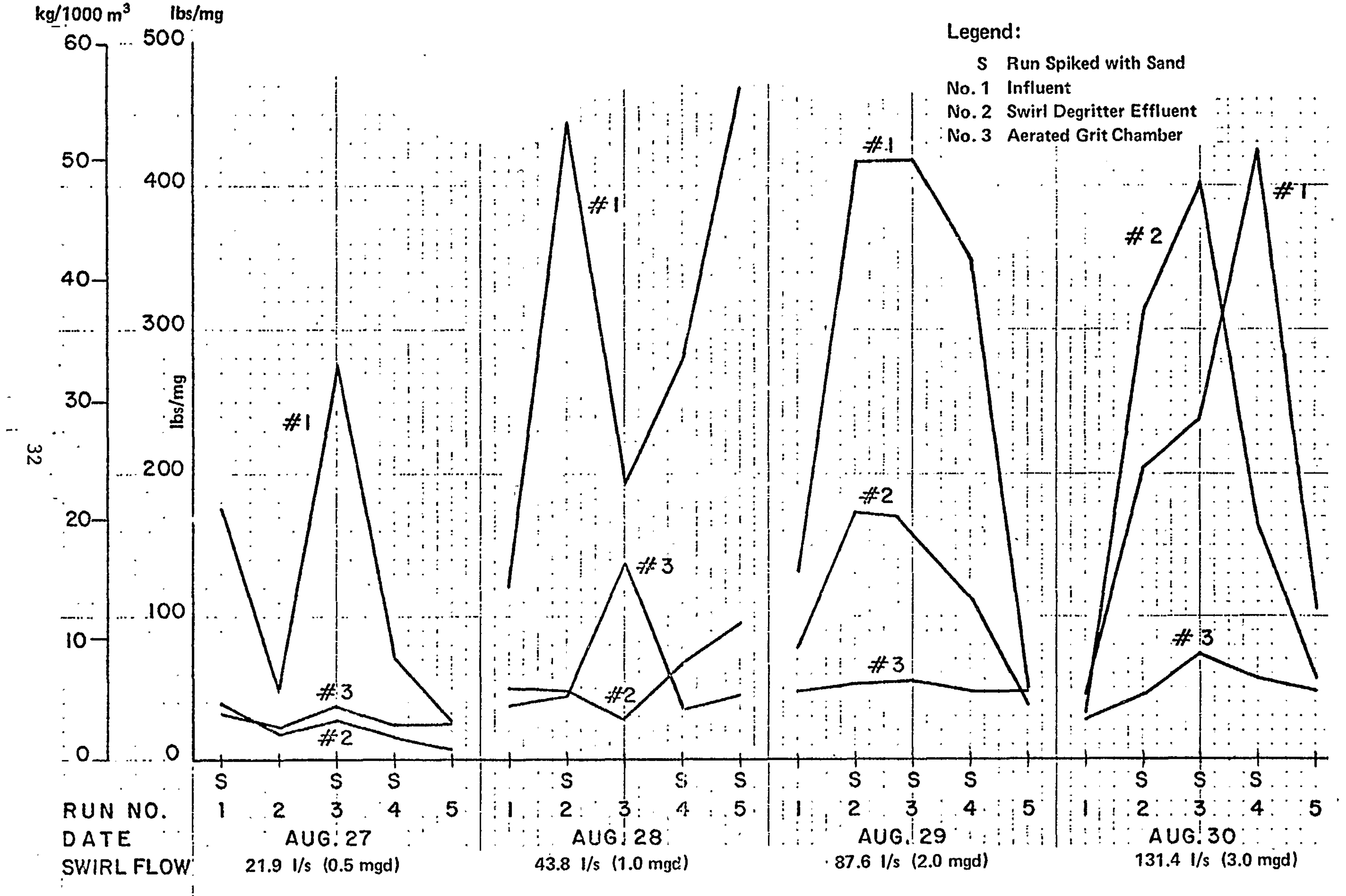


FIGURE 12 WEIGHT OF GRIT ASH – AUGUST 1975

TABLE 12

REMOVAL OF VOLATILE SOLIDS
MAY 23 - JUNE 21, 1975

Test No.		Chasick #	Dry Grit lbs/day	Volatile Solids %	Volatile Solids lbs/day	Ratio of Volatile Solids Effluent To Influent Swirl	AGC
	Influent	1	9.04	54.3	4.91		
1	Swirl	2	2.13	53.1	1.13	0.23	
	Effluent	3	0.74	59.2	0.44		0.09
	Influent	1	8.14	20.8	1.69		
2	Swirl	2	3.55	41.9	1.49	0.88	
	Effluent	3	2.86	70.4	2.01		1.19
	Influent	1	9.40	17.5	1.65		
3	Swirl	2	3.17	61.4	1.95	1.18	
	Effluent	3	2.33	66.9	1.56		0.95

Test No.	Flow Swirl	Flow AGC
1	43.8 l/s (1.0 mgd)	2028 l/s (46.3 mgd)
2	87.6 l/s (2.0 mgd)	2177 l/s (49.7 mgd)
3	131.4 l/s (3.0 mgd)	2147 l/s (49.0 mgd)

TABLE 13

REMOVAL OF VOLATILE SOLIDS
AUGUST 27, 1975

Run		Chasick #	Dry lb/hr	Volatile Solids %	Volatile Solids lb/hr	Ratio of Volatile Solids Effluent To Influent: Swirl	Ratio of Volatile Solids Effluent To Influent: AGC
	Influent	1	0.324	29.2	0.095		
1	Swirl	2	0.117	54.5	0.064	0.67	
	Effluent	3	0.163	74.5	0.121		1.27
	Influent	1	0.133	52.6	0.070		
2	Swirl	2	0.057	57.3	0.033	0.47	
	Effluent	3	0.114	75.5	0.086		1.23
	Influent	1	0.432	17.2	0.074		
3	Swirl	2	0.074	49.4	0.037	0.50	
	Effluent	3	0.225	78.2	0.176		2.38
	Influent	1	0.138	32.6	0.045		
4	Swirl	2	0.042	54.7	0.023	0.51	
	Effluent	3	0.116	73.0	0.085		1.89
	Influent	1	0.086	60.9	0.052		
5	Swirl	2	0.029	67.9	0.020	0.38	
	Effluent	3	0.195	83.0	0.162		3.11
					Total	2.53	9.88
					Average	0.51	1.98

Notes:

Swirl Flow 21.9 l/s (0.5 mgd)
AGC = Aerated Grit Chamber

TABLE 14

REMOVAL OF VOLATILE SOLIDS
AUGUST 28, 1975

Run		Chasick #	Dry lb/hr	Volatile Solids %	Volatile Solids lb/hr	Ratio of Volatile Solids Effluent To Influent Swirl	AGC
	Influent	1	0.242	34.8	0.084		
1	Swirl	2	0.122	46.5	0.057	0.68	
	Effluent	3	0.119	59.4	0.071		0.85
	Influent	1	0.783	25.9	0.203		
2	Swirl	2	0.100	38.3	0.038	0.19	
	Effluent	3	0.140	59.7	0.084		0.41
	Influent	1	0.453	44.9	0.203		
3	Swirl	2	0.095	62.4	0.059	0.29	
	Effluent	3	0.414	56.8	0.235		1.16
	Influent	1	0.531	31.1	0.165		
4	Swirl	2	0.170	48.2	0.082	0.50	
	Effluent	3	0.128	65.0	0.083		0.50
	Influent	1	0.844	27.6	0.233		
5	Swirl	2	0.238	47.2	0.112	0.48	
	Effluent	3	0.174	66.1	0.115		0.50
					Total	2.14	3.42
					Average	0.43	0.68

Notes:

Swirl Flow 43.8 l/s (1.0 mgd)
AGC = Aerated Grit Chamber

TABLE 15

REMOVAL OF VOLATILE SOLIDS
AUGUST 29, 1975

Run		Chasick #	Dry lb/hr	Volatile Solids %	Volatile Solids lb/hr	Ratio of Volatile Solids Effluent To Influent Swirl	AGC
	Influent	1	0.305	43.8	0.134		
1	Swirl	2	0.226	54.0	0.122	0.91	
	Effluent	3	0.175	64.6	0.113		0.84
	Influent	1	0.693	21.6	0.150		
2	Swirl	2	0.361	37.6	0.136	0.91	
	Effluent	3	0.230	70.9	0.163		1.09
	Influent	1	0.686	20.4	0.140		
3	Swirl	2	0.392	43.4	0.170	1.21	
	Effluent	3	0.241	70.8	0.171		1.22
	Influent	1	0.579	20.9	0.121		
4	Swirl	2	0.236	37.9	0.089	0.74	
	Effluent	3	0.221	71.9	0.159		1.31
	Influent	1	0.109	40.5	0.044		
5	Swirl	2	0.164	68.8	0.113	2.57	
	Effluent	3	0.253	75.5	0.191		4.34
					Total	6.34	8.80
					Average	1.27	1.76

Notes:

Swirl Flow 87.6 l/s (2.0 mgd)
AGC = Aerated Grit Chamber

TABLE 16

REMOVAL OF VOLATILE SOLIDS
AUGUST 30, 1975

Run		Chasick #	Dry lb/hr	Volatile Solids %	Volatile Solids #/hr	Ratio of Volatile Solids Effluent To Influent Swirl	AGC
	Influent	1	0.141	55.9	0.079		
1	Swirl	2	0.129	66.8	0.086	1.09	
	Effluent	3	0.117	68.2	0.080		1.01
	Influent	1	0.393	32.0	0.126		
2	Swirl	2	0.519	21.4	0.111	0.88	
	Effluent	3	0.202	70.1	0.142		1.13
	Influent	1	0.443	29.8	0.132		
3	Swirl	2	0.645	18.7	0.121	0.92	
	Effluent	3	0.271	64.5	0.175		1.33
	Influent	1	0.739	25.2	0.186		
4	Swirl	2	0.436	51.2	0.223	1.20	
	Effluent	3	0.279	73.4	0.205		1.10
	Influent	1	0.248	44.3	0.110		
5	Swirl	2	0.187	60.9	0.114	1.04	
	Effluent	3	0.221	71.4	0.157		1.44
					Total	5.13	6.01
					Average	1.03	1.20

Notes:

Swirl Flow 131.4 l/s (3.0 mgd)
AGC = Aerated Grit Chamber

Table 14 shows the results with flow of 43.8 l/s (1.0 mgd) in the swirl. These results show the average remaining percentage of volatile solids is 43 percent for the swirl and 68 percent for the AGC. Both results appear reasonable.

Table 15 shows the results for flow of 87.6 l/s (2.0 mgd) in the swirl. The remaining percentage of volatile solids is 127 percent for the swirl and 176 percent for the AGC. If the results for Run No. 5 are deleted, the percentates are 94 for the swirl and 111 for the AGC, which would be reasonable. Obviously as the flow in the swirl increases the percentage of volatile solids retained in the swirl decreases.

Table 16 shows the results with a flow of 131.4 l/s (3.0 mgd) in the swirl. The remaining percentage of volatile solids are 103 percent in the swirl and 120 percent in the AGC. These results appear reasonable if allowance is made for sampling errors.

The foregoing would indicate that at flows up to 43.8 l/s (3.0 mgd) up to 50 percent of the volatile solids will be removed by the swirl concentrator. Therefore the grit removal mechanism must be selected so that the grit will be thoroughly washed and the wash water returned to the swirl concentrator effluent channel. At flows of 87.6 l/s (2.0 mgd) and greater all the volatile solids appear to pass through the swirl concentrator. The above results are considered reliable because flow from the influent and effluent channels to the Chasick sampler was by the gravity in both cases.

The results for the AGC are not considered reliable because the sample from the effluent channel to Chasick sampler No. 3 was pumped. Possibly the pump intake line was located near the bottom of the channel where the density of volatile solids were greater. Aeration was not provided at this sampling point as was at the point in influent channel from which the influent sample was pumped.

After ignition of the dry grit for determination of volatile solids, the ashed grit in its entirety was sieve-analyzed. The data from the sieve analyses are shown in Tables A-4 through A-7 in the Appendix. The sieve analyses for the three grit samples from each test run are shown graphically on Figures 13 through 32. These gradation curves are discussed below for each of the 4 flows through the swirl degritter.

A. Gradation curves for a swirl flow of 21.9 l/s (0.5 mgd):

- With spiking--Figures 13, 15 and 16. These figures are similar. Due to spiking with fine sand, the grit in the influent is finer than the grit from the AGC which did not receive spiking sand. The grit from the swirl concentrator is as in the case without spiking, finer than that in the spiked plant influent.

- Without spiking--Figures 14 and 17. These 2 figures are similar. They indicate that influent grit is coarsest, AGC is medium-sized, and the swirl grit is finest.

Hence, the swirl was removing more of the larger size grit than the AGCs.

B. Gradation curves for swirl flow of 43.8 l/s (1.0 mgd):

- Without spiking--Figures 18 and 20. The swirl grit is coarser than in Figures 14 and 17 and is still finer than the AGC grit. The influent and AGC grit vary considerably between Figures 18 and 20. In Figure 20 the 2 have similar gradation whereas in Figure 18 the influent grit is much coarser and the grit chamber is much finer.

- With spiking--Figures 19, 21 and 22. These curves show the effect of spiking on the influent grit which is finer than without spiking. However, the swirl grit remains about the same as without spiking. The AGC is about the same in Figure 22 as in Figure 18 and is finer than the influent grit. In figures 19 and 21 the AGC is coarser than in Figure 22 and is coarser than influent grit.

C. Gradation curves for swirl flow of 87.6 l/s (2.0 mgd):

- Without spiking--Figures 23 and 27. These curves show a definite change from Figure 18. The gradation for the influent grit and the AGC is similar to Figure 18. However, in both Figures 23 and 17 the gradation of the swirl grit is not greatly different from the influent grit and the grit from the grit chamber is the finest grit. This would indicate that at some point between a flow of 43.8 l/s (1.0 mgd) and 87.6 l/s (2.0 mgd) the swirl degritter ceases to produce a grit as fine as that from the AGC.

- With spiking--Figures 24, 25 and 26. Figures 25 and 26 exhibit influent grit similar to Figurese 23 and 27 which are without spiking. The laboratory personnel at Denver felt that sometimes during the tests the point of spiking was too close to the inlet to Chasick sampler No. 1 to impose the full effect of the spiking on that sampler. This condition seemed to prevail in Figures 25 and 26. The grit from the swirl is finer than the grit from the AGC, indicating that the spiking may have less effect on the influent as the swirl.

D. Gradation curves for swirl flow of 131.4 l/s (3.0 mgd):

- Without spiking--Figures 28 and 32. These curves indicate that the swirl grit is about the same as, or a little finer than, the influent grit and in both cases much coarser than the AGC grit shown in Figures 23 and 27.

- With spiking--Figures 29, 30 and 31. Figures 29 and 30 are the same for influent and swirl grit, both showing the effect of spiking and both indicating the same gradation. For some reason, the AGC grit is much coarser than the other grit in Figure 30 and much finer than the other grit in Figure 29. In Figure 31 the AGC grit lies between the 2 gradation curves shown in Figures 29 and 30.

In summary, the grit from the swirl is finer than the AGC grit for flows through the swirl of 21.9 l/s (0.5 mgd) and 43.8 l/s (1.0 mgd). At swirl flow of 87.6 l/s (2.0 mgd), without spiking, the swirl grit gradation is about the same as influent grit and coarser than AGC grit. With spiked flow, the same holds true for 2 out of 3 runs.

At a swirl flow of 131.4 l/s (3.0 mgd) for unspiked influent the gradation of the influent grit and the swirl grit is similar but coarser than the AGC grit. For spiked flow, the swirl and influent grit have the same gradation in all three cases. Compared to the AGC grit the swirl and influent grit is finer in one case and coarser in another.

While the swirl degritter results overall were lower than predicted by the LaSalle model hydraulic tests for the higher flow rates of 87.6 l/s (2.0 mgd) and 131.4 l/s (3.0 mgd), at an average flow of 43.8 l/s (1.0 mgd) the results were good. It was suspected that the AGC, like the swirl unit, also would not operate at rated efficiencies for the high rates of flow of 2 and 3 times average flow. These tests were conducted on April 29 and 30, 1976, and were restricted to measuring the efficiency of the AGC only, using Chasick samplers Nos. 1 and 3 as shown in Figure 2. The actual data is presented in Table A-8.

The efficiencies were calculated only for those runs where applicable, and are presented in Table 17. Where the volume of grit in the effluent exceeds the volume of the influent, no efficiency figure is reported. Only in the last two runs does the data show a removal of the grit by the AGC. It is obvious from these data that there is a significant reduction in grit removal when flows exceed design limits regardless of the grit removal method used.

ESTIMATED COSTS

General

For comparative purposes estimates were made of construction and annual operation costs of the swirl concentrator as a grit separator and the standard aerated grit chamber. Estimates were made for three sizes of each type for average flows of 43.8, 131.4 and 438 l/s (1, 3 and 10 mgd). Present worth was determined for each size and type based on a 20-year period and 6-1/8 percent interest rate.

Swirl Degritter

The size of the swirl concentrator was based on data given in The

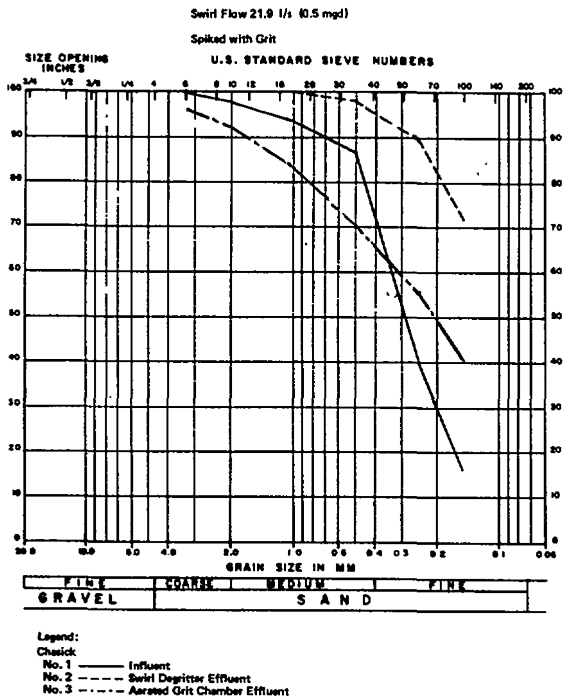


FIGURE 13 GRIT GRADATION CURVES — RUN NO. 1 AUGUST 27, 1975

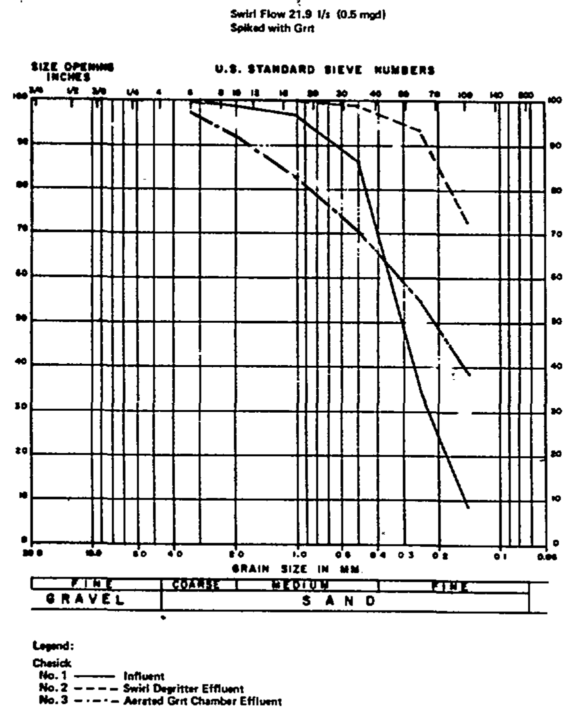


FIGURE 15 GRIT GRADATION CURVES RUN NO. 3 AUGUST 27, 1975

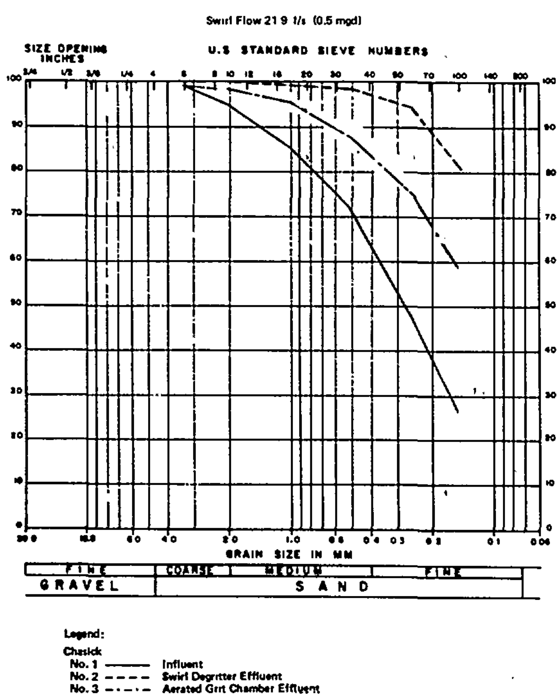


FIGURE 14 GRIT GRADATION CURVES RUN NO. 2 AUGUST 27, 1975

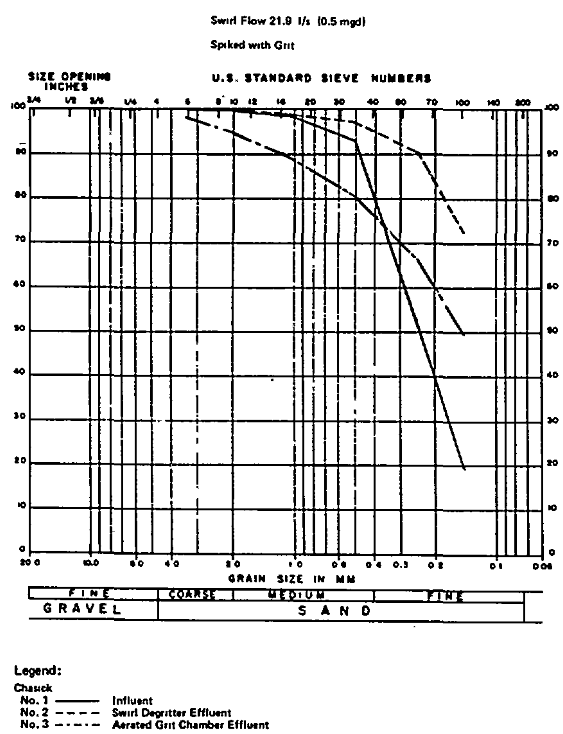
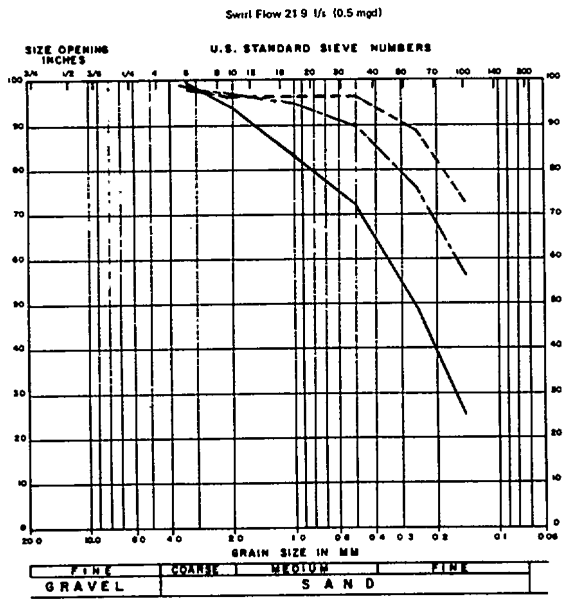
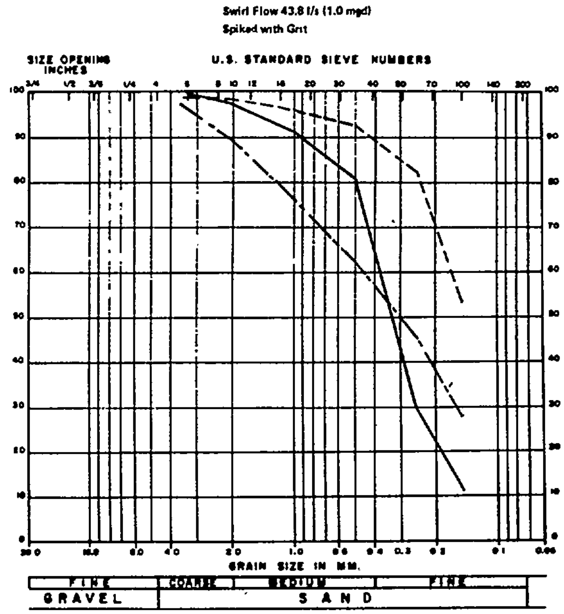


FIGURE 16 GRIT GRADATION CURVES RUN NO. 4 AUGUST 27, 1975



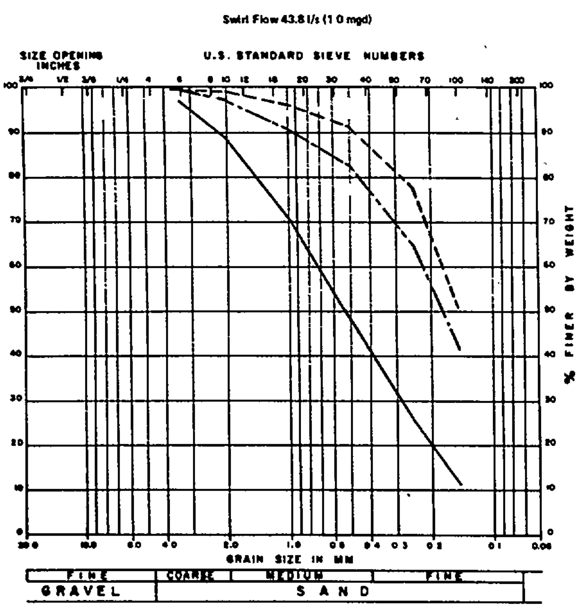
Legend:
Chasick
No. 1 ——— Influent
No. 2 – – – – Swirl Degritter Effluent
No. 3 – · – · – Aerated Grit Chamber Effluent

FIGURE 17 GRIT GRADATION CURVES
RUN NO. 5 AUGUST 27, 1975



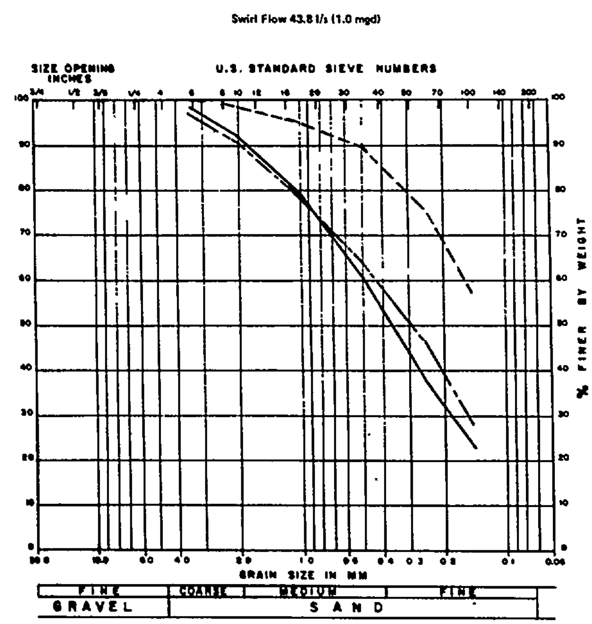
Legend
Chasick
No. 1 ——— Influent
No. 2 – – – – Swirl Degritter Effluent
No. 3 – · – · – Aerated Grit Chamber Effluent

FIGURE 19 GRIT GRADATION CURVES
RUN NO. 2 AUGUST 28, 1975



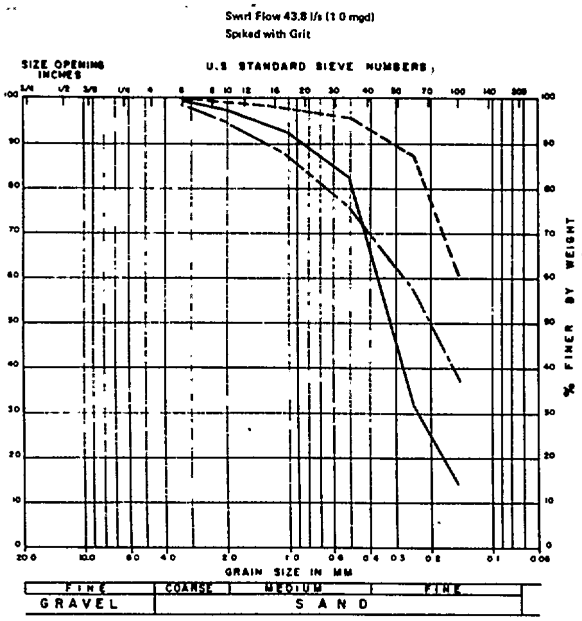
Legend:
Chasick
No. 1 ——— Influent
No. 2 – – – – Swirl Degritter Effluent
No. 3 – · – · – Aerated Grit Chamber Effluent

FIGURE 18 GRIT GRADATION CURVES
RUN NO. 1 AUGUST 28, 1975



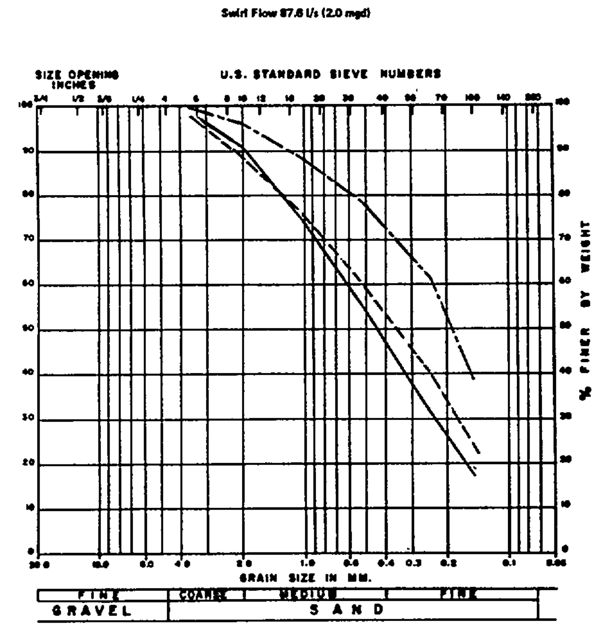
Legend:
Chasick
No. 1 ——— Influent
No. 2 – – – – Swirl Degritter Effluent
No. 3 – · – · – Aerated Grit Chamber Effluent

FIGURE 20 GRIT GRADATION CURVES
RUN NO. 3 AUGUST 28, 1975



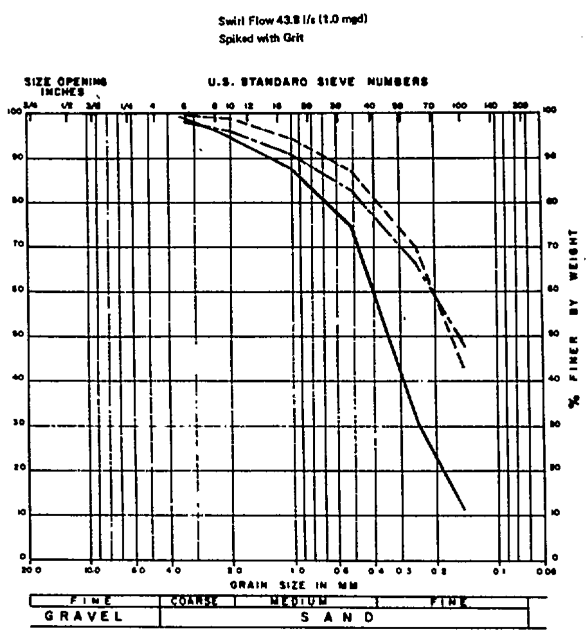
Legend:
Chasick
No. 1 ——— Influent
No. 2 – – – – Swirl Degritter Effluent
No. 3 – · – · – Aerated Grit Chamber Effluent

FIGURE 21 GRIT GRADATION CURVES RUN NO. 4 AUGUST 28, 1975



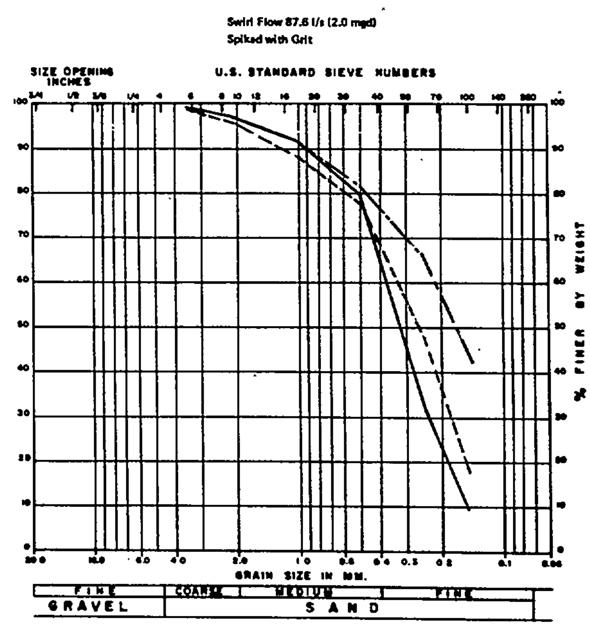
Legend:
Chasick
No. 1 ——— Influent
No. 2 – – – – Swirl Degritter Effluent
No. 3 – · – · – Aerated Grit Chamber Effluent

FIGURE 23 GRIT GRADATION CURVES RUN NO. 1 AUGUST 29, 1975



Legend:
Chasick
No. 1 ——— Influent
No. 2 – – – – Swirl Degritter Effluent
No. 3 – · – · – Aerated Grit Chamber Effluent

FIGURE 22 GRIT GRADATION CURVES RUN NO. 5 AUGUST 28, 1975



Legend:
Chasick
No. 1 ——— Influent
No. 2 – – – – Swirl Degritter Effluent
No. 3 – · – · – Aerated Grit Chamber Effluent

FIGURE 24 GRIT GRADATION CURVES RUN NO. 2 AUGUST 29, 1975

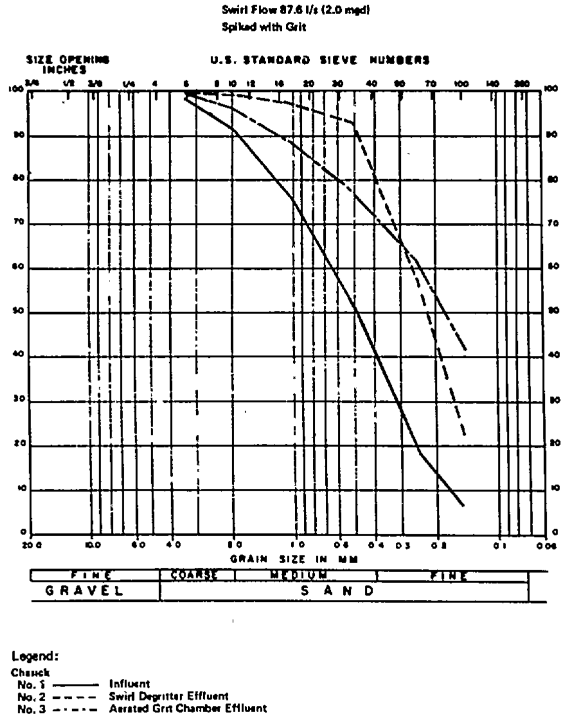


FIGURE 25 GRIT GRADATION CURVES RUN NO. 3 AUGUST 29, 1975

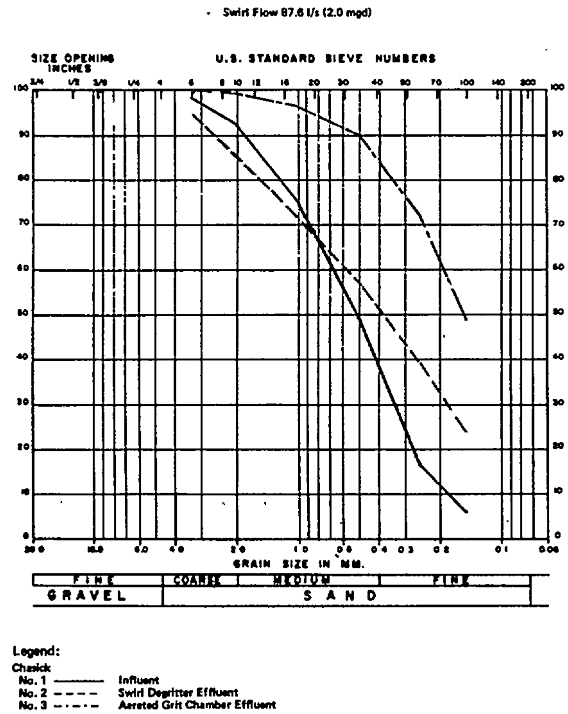


FIGURE 27 GRIT GRADATION CURVES RUN NO. 5 AUGUST 29, 1975

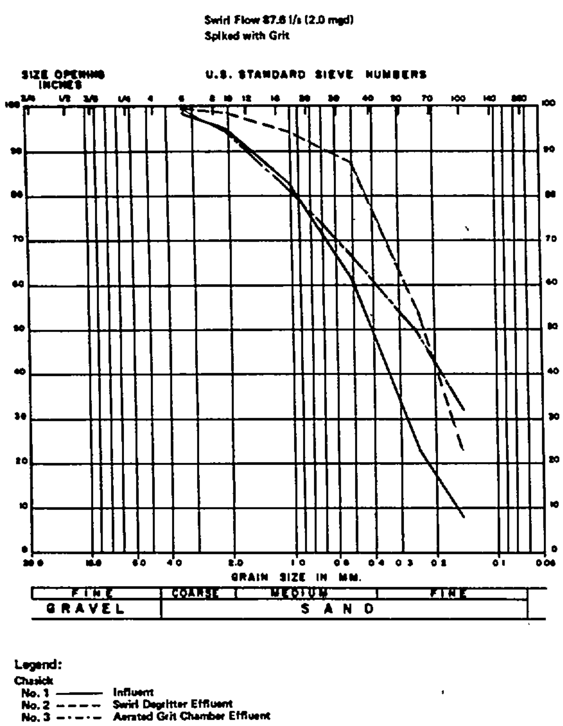


FIGURE 26 GRIT GRADATION CURVES RUN NO. 4 AUGUST 29, 1975

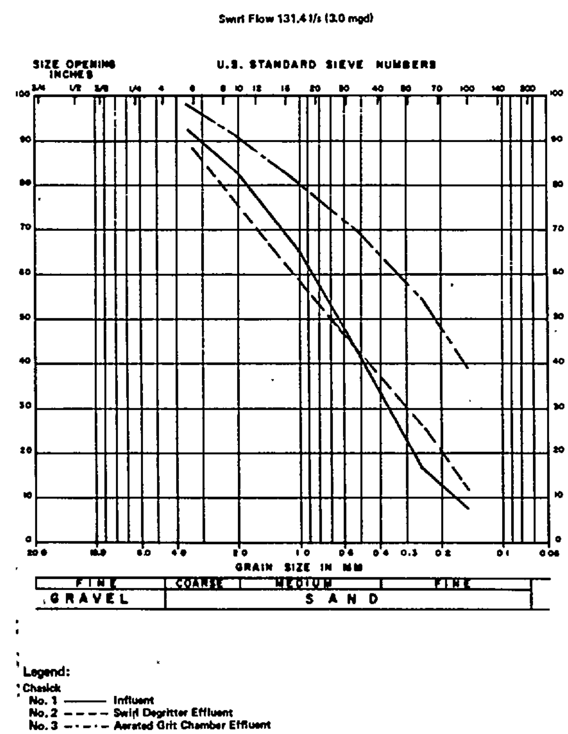
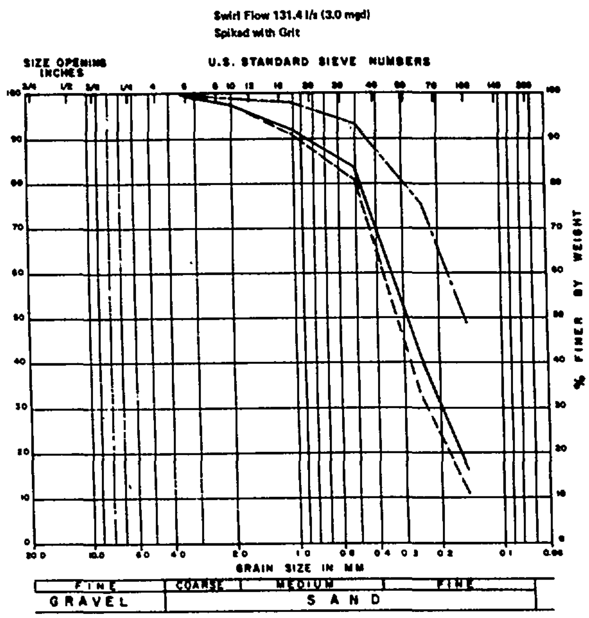
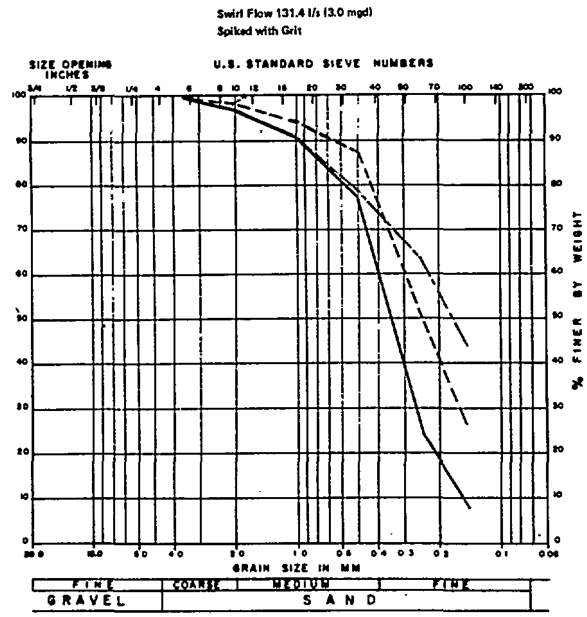


FIGURE 28 GRIT GRADATION CURVES RUN NO. 1 AUGUST 30, 1975



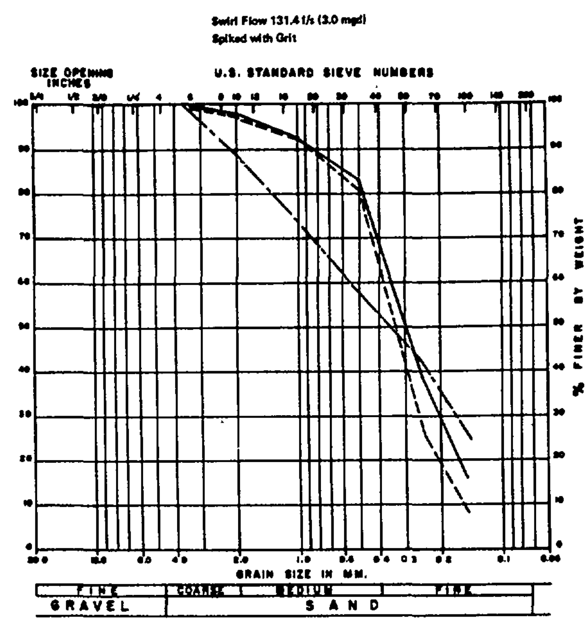
Legend:
Chasick
No. 1 ——— Influent
No. 2 – – – – Swirl Degritter Effluent
No. 3 – · – · – Aerated Grit Chamber Effluent

FIGURE 29 GRIT GRADATION CURVES
RUN NO. 2 AUGUST 30, 1975



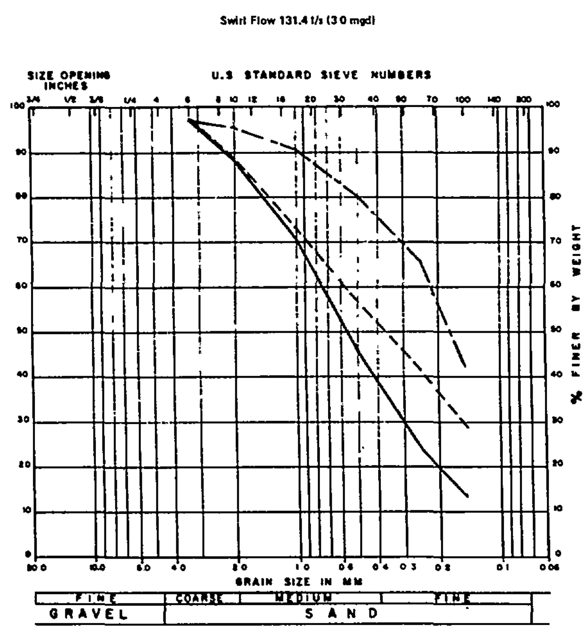
Legend:
Chasick
No. 1 ——— Influent
No. 2 – – – – Swirl Degritter Effluent
No. 3 – · – · – Aerated Grit Chamber Effluent

FIGURE 31 GRIT GRADATION CURVES
RUN NO. 4 AUGUST 30, 1975



Legend:
Chasick
No. 1 ——— Influent
No. 2 – – – – Swirl Degritter Effluent
No. 3 – · – · – Aerated Grit Chamber Effluent

FIGURE 30 GRIT GRADATION CURVES
RUN NO. 3 AUGUST 30, 1975



Legend:
Chasick
No. 1 ——— Influent
No. 2 – – – – Swirl Degritter Effluent
No. 3 – · – · – Aerated Grit Chamber Effluent

FIGURE 32 GRIT GRADATION CURVES
RUN NO. 5 AUGUST 30, 1975

TABLE 17

AERATED GRIT CHAMBER
SINGLE CHAMBER HIGH FLOW EFFICIENCY

Date	Time	Total AGC Flow-mgd	Influent Sampler # 1 Flow-gpm	Influent Grit Volume Quarts	Effluent Sampler # 3 Flow-gpm	Effluent Grit Volume Quarts	Efficiency %
4/28/76	7:30 am	35	21.8	2.25	21.8	2.5	—
	9:30 am	58	21.8		21.8		
	10:30 am	70	21.8		21.8		
	12:30 pm	69	21.8	2.0	21.8	2.25	—
4/29/76	8:00 am	22.3	21.8		21.8		
	9:00 am	36.5	21.8		21.8		
	10:00 am	62	21.8	2.0	21.8	2.0	—
	11:00 am	61	21.8		21.8		
	12:00 am	68	21.8	3.75		3.5	6.7
4/30/76	8:00 am	23.5	21.8		21.8		
	9:00 am	36	21.8	2.0	21.8	1.75	12.5

DEGRITTER DESIGN - DENVER 1974 600/2-77-185

$Q = 43.8\ l/s$ 1.0 MGD 694 GPM 1.55 CFS

$D_2 = 6$ ft @ 2 CFS & 90% EFFICIENCY D_2 IS OK FIG 15 REF 026 p 27

$D_1 = 1$ ft GIVEN

DENVER DESIGN		JAN 1978 DESIGN REVISION
$D_3 = 4$ ft	OK	$D_3 = \frac{2}{3} D_2 = 4.002'$
$D_4 = 1$ ft	OK	$D_4 = D_1 = 1$ ft
$H_1 = 2$ ft	OK	$H_1 = 2D_1 = 2$ ft
$H_2 = \frac{1}{4} D_1 = 2\frac{1}{2}''$	OK	$H_2 = \frac{1}{4} D_1 = .25$ ft $= 3''$
$H_3 = 1$ ft	OK	$H_3 = D_1$ or > 1.0 or >
INLET 2 ft	N.G.! WHY	INLET $= 3D_1 = 3.0$ ft

GRIT CHAMBER DESCRIPTION 670/2-74-026 P 88-89

VILLINGEN - IN THE BLACK FOREST

1) HAS A BAR RACK WITH 40 mm FOR BULKY MATERIAL - MECHANICALLY CLEANED
2) COMPRESSED AIR IN THE PUMP PIPE SMALL AMOUNT FOR ABOUT 10 MINS.
3) SAND (GRIT) HAD A BRIGHT COLOR AND WAS PRACTICALLY FREE OF ORGANIC ODOR
4) 2ND COLDEST CITY IN GERMANY - USES LARGE AMOUNTS OF SAND IN WINTER - THE SAND COLLECTED IS REUSED FOR SPREADING ON SHEET ICE.
5) MINIMUM FLOW 125 l/SEC (2.8 MGD)
   MAXIMUM FLOW 625 l/SEC (14.3 MGD)
   D.A 3.9 METRES (12.8 ft)

Swirl Concentrator as a Grit Separator Device (2). The principal diameter of the chamber, D_2 was obtained from Figure 13, Chamber Diameters for 90 Percent Recovery and $H_1/D_1 = 2$ (2), using a ratio of H_1 to D_2 of 0.333. The remaining dimensions were obtained from Figure 3, General Design Dimensions (2). The derived dimensions are as follows:

Average Flow	43.8 l/s (1 mgd)	131.4 l/s (3 mgd)	438 l/s (10 mgd)
D_2	1.83 m (6.0 ft)	2.44 m (8.0 ft)	4.27 m (14.0 ft)
D_1 & D_4	0.30 m (1.0 ft)	0.40 m (1.33 ft)	0.71 m (2.33 ft)
D_3	1.22 m (4.0 ft)	1.62 m (5.33 ft)	~~1.42 m~~ (4.67 ft) 2.85 m 9.34 ft
H_1	0.61 m (2.0 ft)	0.81 m (2.67 ft)	1.42 m (4.67 ft)
H_2	0.08 m (0.025 ft)	0.10 m (0.33 ft)	0.17 m (0.58 ft)
H_3 min	0.30 m (1.0 ft)	0.40 m (1.33 ft)	0.61 m (2.0 ft) .71 m 2.0 ft

The type unit used for estimate purposes was similar to that shown in Figure 9, Grit Chamber Below Ground with Inclined Screw Conveyor (2) with following revisions: (1) the exterior wall of the grit separator was assumed to be of concrete with a vertical exterior face, (2) a horizontal passage through the concrete assumed to provide access for lubricating the bottom fitting of the inclined screw conveyor and (3) a manhole, 0.91 m (3.0 ft) square, was provided to give access to the bottom fitting of the screw conveyor.

Aerated Grit Chamber

The aerated grit chamber was sized to provide a detention period of 3 minutes at the maximum rate of flow. Peak flow factors were based on Figure 4 in American Society Civil Engineers Manual No. 37 (4). The resultant dimensions are as follows:

Average Flow	43.8 l/s (1 mgd)	131.4 l/s (3 mgd)	438 l/s (10 mgd)
Peak flow factor	3.0	2.5	2.0
Maximum flow	131.4 l/s (3 mgd)	328.5 l/s (7.5 mgd)	876 l/s (20.0 mgd)
Required volume	23.6 cu m (835 cf)	59.2 cu m (2090 cf)	157.9 cu m (5,560 cf)

Selected depth	2.44 m (8.0 ft)	3.05 m (10.0 ft)	3.66 m (12.0 ft)
Selected width	2.29 m (7.5 ft)	3.05 m (10.0 ft)	4.27 m (14.0 ft)
Selected length	4.27 m (14.0 ft)	6.41 m (21.0 ft)	10.06 m (33.0 ft)
Selected volume	23.65 cu m (835 cf)	59.08 cu m (2085 ct)	157.09 cu m (,544 cf)

Construction Costs

Cost estimates of the swirl concentrator as a grit separator device were made for two purposes: (1) to indicate the probable construction cost of the facility; and (2) to compare its cost with that of a conventional aerated grit chamber.

The cost estimates are considered to be reasonable engineer's estimates However, during periods of economic inflation, it is not unusual for contractor's bids to materially exceed engineers' estimates.

Cost Basis

The costs are based on the following:

a. Engineering News Record Construction Cost Index average for U.S. is 2,500

b. Unit prices as follows:

Steel Sheet Piling (for temporary use during construction)	$108/sq m	$10/ sq ft
Excavation	$ 18/cu m	$14/cy
Reinforced Concrete	$392/cu m	$300/cy

c. Contingent and engineering costs are assumed to be 35 percent of the foregoing items.

The swirl separator dimensions are derived in the previous section. It is assumed that the ground surface is 0.61 m (2 ft) above the crown of the inlet pipe and the top of tank is 0.30 m (1 ft) above the crown of the inlet pipe, this will provide 0.61 m (2 ft) of freeboard above the weir.

The conventional aerated grit chamber is set to provide a freeboard 0.46 m (1.5 ft) with a top of wall 0.30 m (1 ft) above ground surface.

The following assumptions are made for both structures:

a. Excavation is all earth. The unit price includes cost for backfilling and crushed stone under the structures.

b. Temporary steel sheet piling is required 0.61 m (2 ft) outside the exterior walls of the structures. Sheeting assumed to extend 0.61 m (2 ft) below lowest point of excavation and 0.30 m (1 ft) above the existing ground elevation.

c. Equipment costs for the aerated grit chamber include the cost of bucket elevator, screw conveyor, transverse baffle, diffuser piping, motors, and electrical work.

d. Miscellaneous costs for the aerated grit chamber include the cost of the longitudinal and effluent baffles, compressors, slide gates, baffle supports, and grating for by-pass channel.

e. Equipment costs for the swirl concentrator include the cost of a grit wash screw.

f. Miscellaneous costs for the swirl separator includes the cost of piping skirt, weirs and plates.

Cost of Swirl Separator as a Grit Separator

The estimated construction cost of a swirl separator with a capacity of 43.8 l/s (1.0 mgd) is $47,000, for 131.4 l/s (3.0 mgd), $57,000, and for 438 l/s (10.0 mgd), $69,000. The breakdown of these costs is shown in Table 18.

Cost of Conventional Aerated Grit Chamber

The estimated construction costs of a conventional aerated grit chamber with a capacity of 43.8 l/s (1.0 mgd) is $69,885, for 131.4 l/s (3.0 mgd) $89,775, and for a 438 l/s (10.0 mgd), 124,965, as seen in Table 19.

Operation and Maintenance Costs

The estimated operation and maintenance costs for the swirl separator and the aerated grit chamber for capacities of 43.8 l/s (1.0 mgd), 131.4 l/s (3.0 mgd) and 438 l/s (10.0 mgd) are shown in Table 20. For units with capacity of 43.8 l/s (1.0 mgd) the annual expenses are estimated at $4,910 for the aerated chamber and $4,450 for the swirl separator. For capacity of 131.4 l/s (3.0 mgd) the annual expenses are $8,300 for the aerated chamber and $7,430 for the swirl separator. For capacity of 438 l/s (10.0 mgd) the annual expenses are $15,740 for the aerated chamber and $13,250 for the swirl separator.

The operator labor is assumed to be 1.5 hours per day for the 131.4 l/s (1.0 mgd) unit. This assumes 1.0 hours for operation of the equipment and 0.5 hours for disposal of the grit. This is based on the actual experience at a unit with the capacity where the daily operation ranges from 0.5 to 1.0 hours with occasional periods of 1.5 hours following storm periods.

TABLE 18 CONSTRUCTION COST OF SWIRL CONCENTRATOR AS A GRIT SEPARATOR

Capacity 43.8 l/s (1.0 mgd)

ITEM	QUANTITY	AMOUNT
Sheet piling	60 sq m (650 sq ft)	$ 6,500
Excavation	95 cu m (125 cy)	1,750
Reinforced Concrete	10 cu m (13 cy)	3,900
Equipment	Job	16,800
Miscellaneous and Bypass	Job	7,400
SUBTOTAL		$36,350
Contingent and Engineering Costs	35%	12,650
TOTAL		$49,000
Capacity 131.4 l/s (3.0 mgd)		
Sheet Piling	70 sq m (750 sq ft)	$ 7,500
Excavation	110 cu m (145 cy)	2,030
Reinforced Concrete	12 cu m (15 cy)	4,500
Equipment	Job	19,200
Miscellaneous and Bypass	Job	8,600
SUB TOTAL		$41,830
Contingent and Engineering Costs	35%	15,170
TOTAL		$57,000
Capacity 438 l/s (10.0 mgd)		
Sheet Piling	100 sq m (1000 sq ft)	$10,000
Excavation	150 cu m (195 cy)	2,730
Reinforced Concrete	16 cu m (21 cy)	6,300
Equipment	Job	22,000
Miscellaneous and Bypass	Job	10,000
SUBTOTAL		$51,030
Contingent and Engineering Costs	35%	17,860
TOTAL		$68,890

TABLE 19 CONSTRUCTION COST OF CONVENTIONAL AERATED GRIT CHAMBER

Capacity 43.8 l/s (1.0 mgd)

ITEM	QUANTITY	AMOUNT
Sheet Piling	67.5 sq m (725 sq ft)	$ 7,250
Excavation	78 cu m (101 cy)	1,415
Reinforced Concrete	11 cu m (14 cy)	4,200
Equipment	Job	30,800
Miscellaneous	Job	8,100
SUB TOTAL		$51,765
Contingent and Engineering Costs	35%	18,120
TOTAL		$69,885

Capacity 131.4 l/s (3.0 mgd)

ITEM	QUANTITY	AMOUNT
Sheet Piling	98 sq m (1066 sq ft)	$10,660
Excavation	cu m (127 cy)	2,325
Reinforced Concrete	cu m (27 cy)	7,200
Equipment	Job	36,400
Miscellaneous	Job	9,900
SUBTOTAL		$66,485
Contingent and Engineering Costs	35%	23,270
TOTAL		$89,775

Capacity 438 l/s (10.0 mgd)

ITEM	QUANTITY	AMOUNT
Sheet Piling	157 sq m (1710 sq ft)	$17,100
Excavation	276 cu m (361 cy)	5,054
Reinforced Concrete	34.2 cu m (44.7 cy)	13,410
Equipment	Job	45,000
Miscellaneous	Job	12,000
SUBTOTAL		$92,565
Contingent and Engineering Costs	35%	32,400
TOTAL		$124,965

The labor rate used of $7.00 per hour is intended to include the actual labor cost plus all benefits but excludes administration and general expenses of the overall plant.

Based on the results shown in Table 20, the annual operation costs of the aerated grit chamber will exceed the annual costs of the swirl separator by about 10 percent for each size unit.

<u>Present Worth</u>

The present worth of the grit removal units is shown in Table 21. The present worth is based on a life of 20 years and an interest rate of 6-1/8 percent. Hence the present worth of the operation and maintenance costs for a 20-year period is 11.35 times the annual cost.

For the unit with capacity of 43.8 l/s (1.0 mgd) the present worth of the aerated chamber is $125,885 and the swirl separator is $100,000. Thus the present worth of the aerated chamber is 26 percent greater than that of the swirl separator.

For the unit with capacity of 131.4 l/s (3.0 mgd) the present worth of the aerated chamber is 183,755 compared to $141,000 for the swirl separator. Thus the present worth of the aerated chamber is 30 percent greater than that of the swirl separator.

For the 438 l/s (10.0 mgd) unit, the present worth of the aerated chamber is $303,615 compared to $219,280 for the swirl separator, or 38 percent greater.

TABLE 20

OPERATION AND MAINTENANCE COSTS FOR GRIT REMOVAL

Capacity 43.8 l/s (1.0 mgd)

	Aerated Chamber	Swirl Separator
1. Labor		
Operation 1.5 hr/day @ $7.00/hr	$3,830	$3,830
Maintenance 0.2 hr/day @ $7.00/hr	510	510
2. Materials and Supplies	200	100
3. Power		
1 Compressor @ 1 hp, 24 hr/day x $0.04/kwh	350	---
1 Screw Conveyor @ 1/2 hp, 1 hr/day x $0.04/kwh	10	10
1 Bucket Conveyor @ 1/2 hp, 1 hr/day x $0.04/kwh	10	---
TOTAL ANNUAL COSTS	$4,910	$4,450

Capacity 131.4 l/s (3.0 mgd)

	Aerated Chamber	Swirl Separator
1. Labor		
Operation 2.5 hr/day @ $7.00/hr	$6,490	$6,490
Maintenance 0.3 hr/day @ $7.00/hr	770	770
2. Materials and Supplies	300	150
3. Power		
1 Compressor @ 2 hp, 24 hr/day x $0.04/kwh	700	---
1 Screw Conveyor @ 1/2 hp, 2 hr/day x $0.04/kwh	20	20
1 Bucket Conveyor @ 1/2 hp, 2 hr/day x $0.04/kwh	20	---
TOTAL ANNUAL COSTS	$8,300	$7,430

Capacity 438 l/s (10.0 mgd)

	Aerated Chamber	Swirl Separator
1. Labor		
Operation 4.5 hr/day @ $7.00/hr	$11,680	$11,680
Maintenance 0.5 hr/day @ $7.00/hr	1,280	1,280
2. Materials and Supplies	600	250
3. Power		
1 Compressor @ 6 hp, 24 hr/day x $0.04/kwh	2,100	---
1 Screw Conveyor @ 1/2 hp, 4 hr/day x $0.04/kwh	40	40
1 Bucket Conveyor @ 1/2 hp, 4 hr/day x $0.04/kwh	40	---
TOTAL ANNUAL COSTS	$15,740	$13,250

TABLE 21

PRESENT WORTH
GRIT REMOVAL UNITS

Capacity 43.8 l/s (1.0 mgd)

	Aerated Chamber	Swirl Separator
Construction Cost	$69,885	$ 49,000
Operation and Maintenance Cost	56,000	51,000
COST TOTAL PRESENT WORTH	$125,885	$100,000

Capacity 131.4 l/s (3.0 mgd)

Construction Cost	$89,755	$ 57,000
Operation and Maintenance Cost	94,000	84,000
TOTAL PRESENT WORTH	$183,755	$141,000

Capacity 438 l/s (10.0 mgd)

Construction Cost	$124,965	$ 68,890
Operation and Maintenance Cost	178,650	150,390
TOTAL PRESENT WORTH	$303,615	$219,280

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APPENDIX

TABLE A-1

TEST DATA SWIRL FLOW 43.8 l/s (1.0 mgd)
MAY 23 - 29, 1975

Sample	Grit (ft^3/day)	Grit, Dry (lbs/day)	Total Solids (%)	Vol. Total Solids (%)	Susp. Solids (mg/l)	Vol. Susp. Solids (mg/l)	Putrescibles (%)	BOD (TSS) (mg/l)	COD (TSS) (mg/l)
Chasick # 1	0.55	9.04	-	54.3 *	-	-	-	-	-
Chasick # 2	0.20	2.13	-	53.1 *	-	-	-	-	-
Chasick # 3	0.076	0.74	-	59.2 *	-	-	-	-	-
Grit S.C. Post-Wash	25.1	-	35.3	45.7	-	-	1.4 +	-	-
Grit D.O.C. Eff.	52.1	-	62.7	16.6	-	-	0.8 +	-	-
Grit S.C. Pre-Wash	-	-	-	-	2490	1950	9.1 +	-	-
Grit D.O.C. Inf.	-	-	-	-	728	395	0.9 +	-	-
A.G.C. # 1 Inf.	-	-	-	-	266	199	-	158 (223)+	389 (223)+
Swirl Eff.	-	-	-	-	248	193	-	-	-
A.G.C. # 2 Inf.	-	-	-	-	249**	184**	-	170 (260)+	522 (260)+
P.I.	-	-	-	-	184**	143**	-	-	-

A.G.C. = Aerated Grit Chamber
D.O.C. = Dorr-Oliver Classifier
S.C. = Swirl Concentrator
Inf. = Influent
Eff. = Effluent
P.I. = Primary Influent

AGC FLOW 46.3 mgd

* Average of 2 samples/week

** Average weekly, flow adjusted

\+ Single sample analysis

TABLE A-2

TEST DATA SWIRL FLOW 87.6 l/s (2.0 mgd)
MAY 31 - JUNE 6, 1975

Sample	Grit (ft^3/day)	Grit, Dry (lbs/day)	Total Solids (%)	Vol. Total Solids (%)	Susp. Solids (mg/l)	Vol. Susp. Solids (mg/l)	Putrescibles (%)	BOD (TSS) (mg/l)	COD (TSS) (mg/l)
Chasick # 1	0.35	8.14	-	20.8 *	-	-	-	-	-
Chasick # 2	0.37	3.55	-	41.9 *	-	-	-	-	-
Chasick # 3	0.41	2.86	-	70.4 *	-	-	-	-	-
Grit S.C. Post-Wash	16.4	-	46.6	35.1	-	-	2.4 +	-	-
Grit D.O.C. Eff.	52.1	-	64.6	16.0	-	-	1.3 +	-	-
Grit S.C. Pre-Wash	-	-	-	-	1130	780	Not Run+	-	-
Grit D.O.C. Inf.	-	-	-	-	998	358	Not Run+	-	-
A.G.C. # 1 Inf.	-	-	-	-	233	184	-	176 (288)+	414 (288)+
Swirl Eff.	-	-	-	-	223	173	-	-	-
A.G.C. # 2 Inf.	-	-	-	-	239**	194**	-	172 (245)+	435 (245)+
P.I.	-	-	-	-	194**	157**	-	-	-

A.G.C. = Aerated Grit Chamber
D.O.C. = Dorr-Oliver Classifier
S.C. = Swirl Concentrator
Inf. = Influent
Eff. = Effluent
P.I. = Primary Influent

AGC FLOW 49.7 mgd

* Average of 2 samples/week
** Average weekly, flow adjusted
\+ Single sample analysis

TABLE A-3

TEST DATA SWIRL FLOW 131.4 l/s (3.0 mgd)
JUNE 12-16 AND 20-21, 1975

Sample	Grit (ft^3/day)	Grit, Dry (lbs/day)	Total Solids (%)	Vol. Total Solids (%)	Susp. Solids (mg/l)	Vol. Susp. Solids (mg/l)	Putres-cibles (%)	BOD (TSS) (mg/l)	COD (TSS) (mg/l)
Chasick # 1	0.33	9.40	-	17.5 *	-	-	-	-	-
Chasick # 2	0.47	3.17	-	61.4 *	-	-	-	-	-
Chasick # 3	0.45	2.33	-	66.9 *	-	-	-	-	-
Grit S.C. Post-Wash	16.1	-	57.8	23.6	-	-	1.4+	-	-
Grit D.O.C. Eff.	67.5	-	67.2	17.3	-	-	0.2+	-	-
Grit S.C. Pre-Wash	-	-	-	-	364	290	0.8+	-	-
Grit D.O.C. Inf.	-	-	-	-	347	271	2.5+	-	-
A.G.C. # 1 Inf.	-	-	-	-	219	173	-	155 (189)+	394 (189)+
Swirl Eff.	-	-	-	-	195	156	-	-	-
A.G.C. # 2 Inf.	-	-	-	-	209**	160**	-	163 (242)+	383 (242)+
P.I.	-	-	-	-	147**	112**	-	-	-

A.G.C. = Aerated Grit Chamber
D.O.C. = Dorr-Oliver Classifier
S.C. = Swirl Concentrator
Inf. = Influent
Eff. = Effluent
P.I. = Primary Influent

AGC FLOW 49.0 mgd
* Average of 3 samples/week
** Average weekly, flow adjusted
+ Single sample analysis

TABLE A-4

TEST DATA SWIRL FLOW 21.9 l/s (0.5 mgd)
AUGUST 27, 1975

RUN	CHASICK #	SAMPLE #	GRIT cu ft/hr.	DRY GRIT lbs/hr.	% vol. sol	SIEVE ANALYSIS, % FINER THAN U.S. SIEVE NUMBER (WGT) 100	60	35	18	10	6	
	1	1	0.013	0.324	29.2	16.4	40.4	87.3	93.9	98.4	99.8	
1	2	1	0.017	0.117	54.5	71.4	89.5	98.3	99.8	100.0	100.0	S
	*3	1	0.058	0.163	74.5	40.2	55.6	70.6	83.2	92.1	96.3	
	1	2	0.009	0.133	52.6	26.5	47.8	71.7	85.4	94.6	98.4	
2	2	2	0.012	0.057	57.3	81.1	94.2	98.3	99.6	100.0	100.0	
	*3	2	0.048	0.114	75.5	58.8	75.6	87.8	95.4	98.4	99.2	
	1	3	0.014	0.432	17.2	8.9	34.8	86.1	96.7	99.1	99.8	
3	2	3	0.016	0.074	49.4	72.9	93.4	99.1	100.0	100.0	100.0	S
	*3	3	0.074	0.225	78.2	38.7	54.8	70.3	83.2	92.9	97.4	
	1	4	0.011	0.138	32.6	19.6	52.8	93.1	98.4	99.8	100.0	
4	2	4	0.011	0.042	54.7	72.8	90.1	97.6	98.8	100.0	100.0	S
	*3	4	0.042	0.116	73.0	49.7	66.4	80.2	88.6	95.2	98.2	
	1	5	0.012	0.086	60.9	25.1	48.2	72.3	83.3	94.0	99.3	
5	2	5	0.010	0.029	67.9	72.9	88.2	96.4	96.4	96.4	97.6	
	*3	5	0.084	0.195	83.0	56.6	75.8	89.9	95.0	97.0	98.0	

NOTES: *Indicates a representative sample, rather than entire Chasick contents was used for analysis. In no instances were the sample sizes less than ¼ of the total sample.

S = Flow Spiked with Sand.

TABLE A-5

TEST DATA SWIRL FLOW 43.8 l/s (1.0 mgd)
AUGUST 28, 1975

RUN	CHASICK #	SAMPLE #	GRIT cu ft/hr.	DRY GRIT lbs/hr.	% vol. sol.	SIEVE ANALYSIS, % FINER THAN U.S. SIEVE NUMBER (WGT) 100	60	35	18	10	6	
	1	1	0.013	0.242	34.8	11.5	25.4	48.0	70.9	89.1	96.8	
1	2	1	0.020	0.122	46.5	51.0	77.5	91.4	96.6	99.1	99.6	
	*3	1	0.048	0.119	59.4	41.9	64.6	82.8	90.9	97.0	99.5	
	*1	2	0.042	0.783	25.9	11.6	29.7	80.4	91.7	97.6	99.5	
2	2	2	0.016	0.100	38.3	53.6	82.1	92.7	96.2	98.4	99.3	S
	*3	2	0.028	0.140	59.7	28.1	45.4	62.7	76.7	89.2	96.2	
	*1	3	0.060	0.453	44.9	23.4	37.7	60.7	79.6	92.0	98.3	
3	*2	3	0.042	0.095	62.4	57.1	76.0	89.8	94.9	98.5	100.0	
	*3	3	0.042	0.414	56.8	28.2	46.4	63.7	78.5	90.7	96.3	
	*1	4	0.075	0.531	31.1	14.6	32.0	82.3	92.4	97.5	99.2	
4	*2	4	0.050	0.170	48.2	61.5	87.3	95.8	97.9	99.0	99.3	S
	*3	4	0.042	0.128	65.0	37.9	57.5	75.7	86.8	95.0	98.6	
	*1	5	0.058	0.844	27.6	11.4	30.8	73.6	87.7	95.6	98.9	
5	*2	5	0.050	0.238	47.2	43.2	69.9	86.4	94.4	98.9	99.7	S
	*3	5	0.067	0.174	66.1	49.2	66.1	82.3	90.8	96.2	98.5	

NOTES:

* See Table

S = Flow Spiked with Sand

TABLE A-6

TEST DATA SWIRL FLOW 87.6 l/s (2.0 mgd)
AUGUST 29, 1975

RUN	CHASICK #	SAMPLE #	GRIT cu ft/hr.	DRY GRIT lbs/hr.	% vol. sol.	SIEVE ANALYSIS, % FINER THAN U.S. SIEVE NUMBER (WGT) 100	60	35	18	10	6	
	*1	1	0.033	0.305	43.8	17.4	32.3	54.3	73.8	91.0	97.7	
1	*2	1	0.037	0.226	54.0	23.2	40.5	59.4	75.4	89.0	96.5	
	*3	1	0.040	0.175	64.6	39.2	61.2	78.1	88.3	96.5	99.6	
	*1	2	0.037	0.693	21.6	9.7	32.1	79.8	91.8	97.1	99.1	
2	*2	2	0.048	0.361	37.6	18.4	47.5	77.7	88.2	95.8	98.6	S
	*3	2	0.053	0.230	70.9	44.2	65.8	81.8	91.7	97.2	98.9	
	*1	3	0.038	0.686	20.4	6.9	18.6	51.9	75.3	92.0	98.4	
3	*2	3	0.055	0.392	43.4	23.2	56.6	92.9	97.4	99.4	99.7	S
	*3	3	0.065	0.241	70.8	42.3	61.7	77.1	88.5	96.5	99.4	
	*1	4	0.033	0.579	20.9	8.1	23.6	61.3	82.7	94.4	98.6	
4	*2	4	0.037	0.236	37.9	22.9	54.4	87.3	94.3	98.4	99.7	S
	*3	4	0.065	0.221	71.9	32.3	49.4	66.5	81.2	94.1	99.4	
	1	5	0.008	0.109	40.5	6.4	16.4	49.7	75.0	92.4	98.3	
5	*2	5	0.050	0.164	68.8	24.0	39.1	57.3	71.9	85.4	94.8	
	*3	5	0.075	0.253	75.5	48.9	72.3	90.0	96.4	99.3	100.0	

NOTES:

*See Table

S = Flow Spiked with Sand

TABLE A-7

TEST DATA SWIRL FLOW 131.4 l/s (3.0 mgd)
AUGUST 30, 1975

RUN	CHASICK #	SAMPLE #	GRIT cu ft/hr.	DRY GRIT lbs/hr.	% vol. sol.	SIEVE ANALYSIS, % FINER THAN U.S. SIEVE NUMBER (WGT) 100	60	35	18	10	6	
	1	1	0.020	0.141	55.9	7.7	16.3	41.2	65.2	82.8	91.4	
1	2	1	0.023	0.129	66.8	11.8	25.7	41.2	59.0	75.5	88.4	
	*3	1	0.030	0.117	68.2	39.2	54.1	69.0	80.4	90.7	97.4	
	1	2	0.030	0.393	32.0	16.2	40.5	83.4	92.3	97.7	99.5	
2	2	2	0.023	0.519	21.4	11.2	31.3	80.6	90.7	97.8	99.7	S
	*3	2	0.042	0.202	70.1	49.0	75.0	93.5	98.0	99.0	99.5	
	1	3	0.037	0.443	29.8	16.1	38.4	83.0	92.8	98.1	99.6	
3	2	3	0.025	0.645	18.7	9.0	26.1	80.8	92.1	97.6	99.5	S
	*3	3	0.058	0.271	64.5	26.1	41.9	57.7	73.9	89.7	98.2	
	1	4	0.025	0.739	25.2	8.1	24.4	77.2	90.5	96.9	99.3	
4	*2	4	0.042	0.436	51.2	26.4	50.3	87.5	94.4	98.6	99.5	S
	*3	4	0.067	0.279	73.4	43.8	63.0	78.8	90.4	97.2	99.3	
	1	5	0.025	0.248	44.3	13.5	23.9	45.6	70.3	88.9	97.1	
5	*2	5	0.033	0.187	60.9	29.3	41.6	57.1	73.2	88.7	97.7	
	*3	5	0.067	0.221	71.4	42.4	65.7	80.2	90.7	95.9	97.1	

NOTES:

* See Table

S = Flow Spiked with Sand

TABLE A-8

AERATED GRIT CHAMBER DATA
SINGLE CHAMBER HIGH FLOW

Date	Time	Total AGC Flow-mgd	Influent Sampler No. 1 Flow gpm	Influent Grit Volume Quarts	Effluent Sampler No. 3 Flow gpm	Effluent Grit Volume Quarts
4/28/76	7:30 am	35	21.8	2.25	21.8	2.5
	9:30 am	50	21.8		21.8	
	10:30 am	70	21.8		21.8	
	12:30 pm	69	21.8	2.0	21.8	2.25
4/29/76	8:00 am	22.3	21.8		21.8	
	9:00 am	36.5	21.8		21.8	
	10:00 am	62	21.8	2.0	21.8	2.0
	11:00 am	61	21.8		21.8	
	12:00 am	68	21.8	3.75		3.5
4/30/76	8:00 am	23.5	21.8		21.8	
	9:00 am	36	21.8	2.0	21.8	1.75

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-600/2-77-185		

4. TITLE AND SUBTITLE	5. REPORT DATE / 6. PERFORMING ORGANIZATION CODE
FIELD PROTOTYPE DEMONSTRATION OF THE SWIRL DEGRITTER	5. September 1977 (Issuing Date) 6.
7. AUTHOR(S) Richard H. Sullivan, James E. Ure and Paul Zielinski	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS AMERICAN PUBLIC WORKS ASSOCIATION 1313 East 60th Street Chicago, Illinois 60637	10. PROGRAM ELEMENT NO. 1BC611 11. CONTRACT/GRANT NO. Grant No. S803157
12. SPONSORING AGENCY NAME AND ADDRESS Municipal Environmental Research Laboratory--Cin., OH Office of Research & Development U.S. Environmental Protection Agency Cincinnati, Ohio 45268	13. TYPE OF REPORT AND PERIOD COVERED Final 14. SPONSORING AGENCY CODE EPA/600/14

15. SUPPLEMENTARY NOTES Project Officer: Richard Field (201) 321-6674, FTS 340-6674. This report supplements EPA-670/2-74-039, "Relationship Between Diameter and Height for the Design of a Swirl Concentrator as a Combined Sewer Overflow Regulator."

16. ABSTRACT

A prototype swirl degritter was tested by the Metropolitan Denver Sewage Disposal District No. 1. The unit was designed to duplicate the grit removal device needed to degrit the underflow from the proposed swirl concentrator as a combined sewer overflow regulator at Lancaster, Pennsylvania under EPA Grant No. S802219 (formerly 11023 GSC). Degritting is considered in Lancaster to protect pumps and prevent siltation in the interceptor.

The 1.8 m (6 ft) diameter device was designed for a flow of 65.6 l/s (1.3 mgd). It was found that under the physical arrangements in Denver, testing with domestic sanitary wastewater, the swirl unit performed at slightly less efficiency than the conventional aerated grit unit which was operating at less than twice the normal flow-through rate. The characteristics of the grit removal from the swirl degritter were excellent and particles of 0.3 mm (.012 in.) were removed.

Analyses of grit removal was accomplished with three Chasick sampling units. Blasting sand was added to provide extremely high concentrations of 0.2 mm (.008 in.) particles (lower definition of grit) to duplicate the concentrate from the swirl regulator. It was found that the unit could efficiently remove the small particles at the high concentrations.

It was concluded that the degritter could be used for domestic wastewater, combined sewer overflows, or urban stormwater runoff treatment. The absence of moving parts in the basic unit and small relative volume 1:10 (compared to conventional grit chambers) may make the unit particularly desirable for many applications. A comparison of the present worth of the cost of construction, operation, and maintenance for a 20 year life indicates that the swirl degritter is from 26 to 38 percent less costly than a conventional aerated grit chamber.

This report is submitted in partial fulfillment of EPA Grant S803157 by the American Public Works Association under the sponsorship of the U.S. Environmental Protection Agency. This report covers a period from January 1975 to August 1976, and work was completed as of December 1976.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Grit chambers Prototypes Water treatment Overflows	Combined sewer overflow Stormwater treatment Stormwater discharge Swirl Degritter	13B

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
	Unclassified	74
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE

EPA Form 2220-1 (9-73)

☆U.S. GOVERNMENT PRINTING OFFICE: 1977—757-056/6555