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Demonstration of a Waste Disposal System for Livestock Wastes

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EPA-R2-73-245
May 1973

DEMONSTRATION OF A WASTE DISPOSAL SYSTEM FOR LIVESTOCK WASTES

By

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Grant No. 13040 FTX
Program Element 1B2039

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ABSTRACT

Laboratory studies of livestock waste were conducted both before and after the construction of an enlarged settling basin, a hydrasieve at the truck washrack and a two cell waste stabilization pond. A determination of the effectiveness of these two systems and the application of them to feedlots and other livestock facilities in the area were the main objectives.

The settling basin and hydrasieve were effective in removing solids and COD from the truck washrack waste. Reductions in COD, total, suspended and settleable solids were 23.9, 14.8, 50 and 80 percent, respectively. DO increased 42.8 percent and total solids decreased 3 percent across the hydrasieve. This 3 percent consisted of straw and other floating debris which would not be removed at the stabilization pond.

The effectiveness of the stabilization ponds was generally good. The BOD_5 of the final effluent was reduced 48.6 percent over that of the drainpipe which had drained directly into the Sheyenne River during previous years.

This report was submitted in fulfillment of Project Number 13040 FTX, between the Environmental Protection Agency and the Union Stockyards Company.

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SECTION I

CONCLUSIONS

1. The two cell waste stabilization pond is an effective method of treating liquid wastes from stockyards facilities.

2. The combination of a hydrasieve and settling basin is effective in cleaning up wastes from washracks serving trucks transporting livestock.

3. The hydrasieve is effective primarily in removing floating and large suspended particles, but does not effect water quality in any other way.

4. The waste materials sampled over a two year period varied in strength with the season but were consistent over the entire period.

5. The strength of wastes is very low during freezing months, even though livestock numbers increase at this time.

6. No pollution of ground water supply has occured since the wells were put in operation in 1935. Nitrate in the ground water has changed from 5 mg/l in 1935 to zero it this time.

SECTION II

RECOMMENDATIONS

1. Based on this study the design criteria for an aerobic lagoon is about 30 lbs. BOD_5/acre/day.

2. Livestock pens should be hard surfaced to prevent pollution of the ground water by infiltration.

3. Pens should be cleaned through the winter when possible to reduce chances of ammonia absorption by nearby surface water.

4. Pens should be cleaned as early as possible in the spring to reduce the potential pollution by heavy spring runoff.

5. A hydrasieve or a settling basin should be used at all livestock facilities using a stabilization pond system. This will prevent the ponds from being filled with settleable solids or covered with floating debris. Possibly for a continuous flow situation with large volumes, the hydrasieve would prove more effective.

SECTION III

INTRODUCTION

The disposal of livestock manure into the environment is a practice as old as the animal. Historically, animal manure was spread over the land surface where the nutrients were used by growing vegetation and the micro-organisms in the soil. The current livestock manure production in the U.S. is estimated to be greater than 1.5 billion tons per year, and 50% originates from some degree of confinement such as feedlots and stockyards. With increasing concentration of livestock and alternative sources of fertilizer, the practice of distributing the manure on the land has become questionable from a profits standpoint. Livestock producers are faced with large volumes of wastes having low value and physical, social and economic restrictions which limit the feasibility of recycling animal wastes through the soil. One of the largest problems associated with the confinement of livestock involves waste disposal.

The trend toward large scale production units has resulted in the building of numerous cattle feedlots with little consideration given to pollution control. In the past the most important criteria used for locating thses feedlots was good drainage with some of them located next to streams or lakes. With public interest and concern about pollution of lakes, streams, rivers and ponds on the increase, most major cattle feeding states will certainly enact legislation to regulate or prohibit the operation of feedlots near bodies of water.

The Federal Government has recognized the need for study in this area of pollution control and entered into an agreement with the Union Stockyards Company in West Fargo, North Dakota to demonstrate the effectiveness of settling basins, a hydrasieve and stabilization ponds as a means of treating stockyards wastes. The study was divided into two phases. The first phase consisted of characterizing the wastes and construction of an enlarged settling basin, a hydrasieve and stabilization ponds as a means of treating stockyard wastes. During the second phase, the quality of the waste inflow and the treated effluent was monitored to determine the efficiency of the treatment system and to establish basic design criteria for use in other areas.

SECTION IV

WASTE TREATMENT FACILITIES

Description

The waste treatment facilities at the Union Stockyards Co., West Fargo, North Dakota consists of two main sub-systems. There is a settling basin (71' x 10' x 2' average depth) with a hydrasieve (Figure 1) at the truck washrack. The function of this unit is to pretreat the truck wash water before it is pumped to the waste stabilization ponds (Figure 2). This system of waste stabilization ponds treats all waste water from the Union Stockyards Company.

Operation

The truck washrack is in operation only during the warm months or from mid-April until the end of October. During the last seven months of 1970, 16,676 trucks unloaded livestock at the stockyards with 25,434 during the first 11 months of 1971. The size of the trucks range from 1/2 ton pickups to five-axle tractor-trailer trucks. When cleaning trucks, drivers are instructed to first unload any straw bedding at the landfill area where all solid waste from the yards are dumped and later covered with earth. Then trucks may be washed with a high pressure water stream; this system is coin operated. Waste water from the trucks flows into the settling basin. During phase one of the study the settling basin was 6 feet by 55 feet and 2.5 feet deep at the deepest point and the effluent from it flowed directly into the Sheyenne River. At the time of construction a hydrasieve was installed and the effluent from the enlarged settling basin is now pumped over a hydrasieve where straw and other floating material is removed. From here the waste water is mixed with the liquid yard waste.

There are three sources of yard waste from the pens: surface runoff due to precipitation; solid and liquid animal waste; and overflow from the animal watering troughs. The liquid waste waters are collected in a combined sewer and until construction of the stabilization pond, were discharged directly into the Sheyenne River. Since construction, however, these liquid wastes from the yard together with the washrack waste water have been pumped to the stabilization ponds.

The pens at the Union Stockyards have concrete floors with floor drains which connect to sewer laterals which discharge

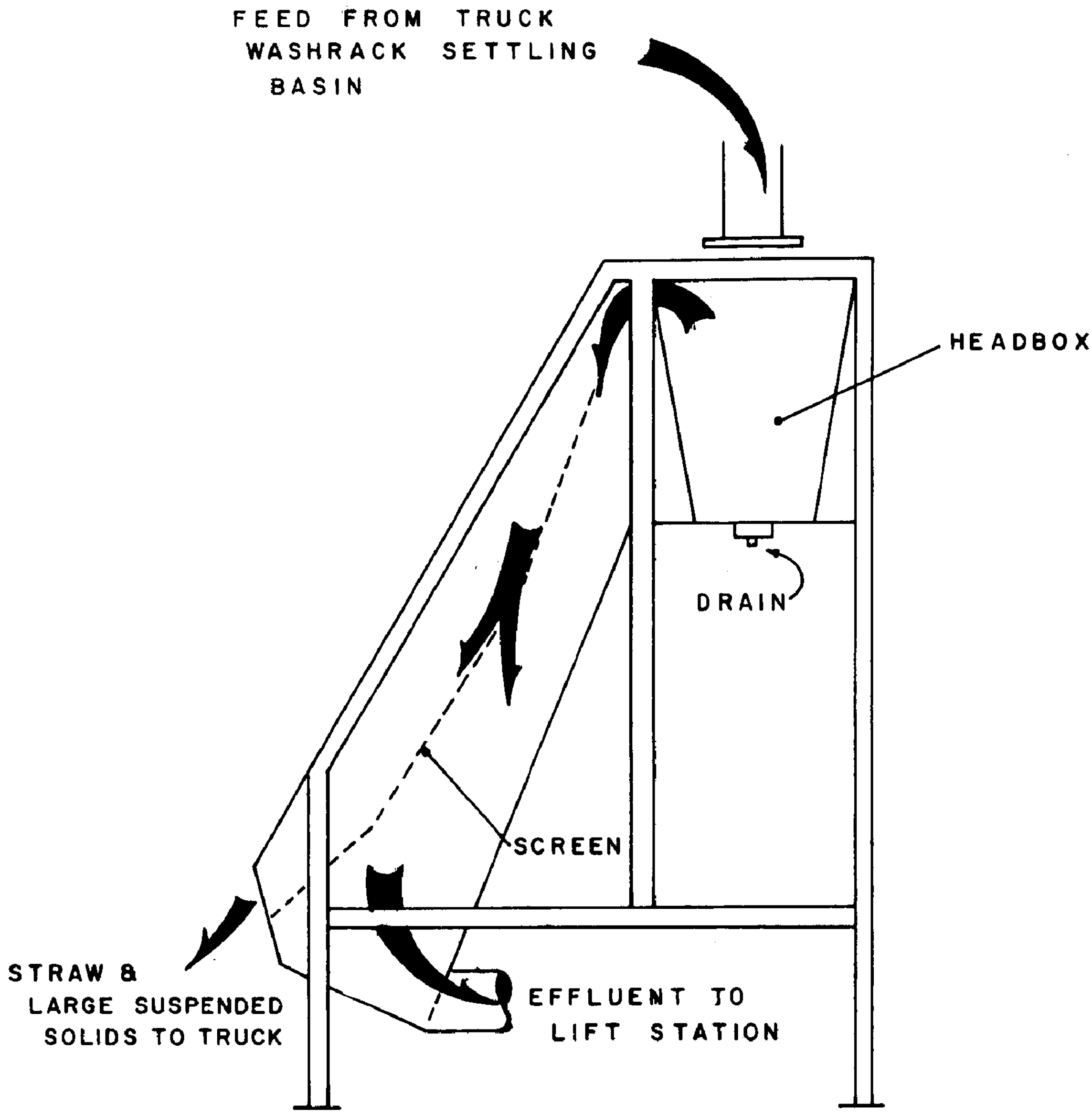

FIGURE I. Hydrasieve

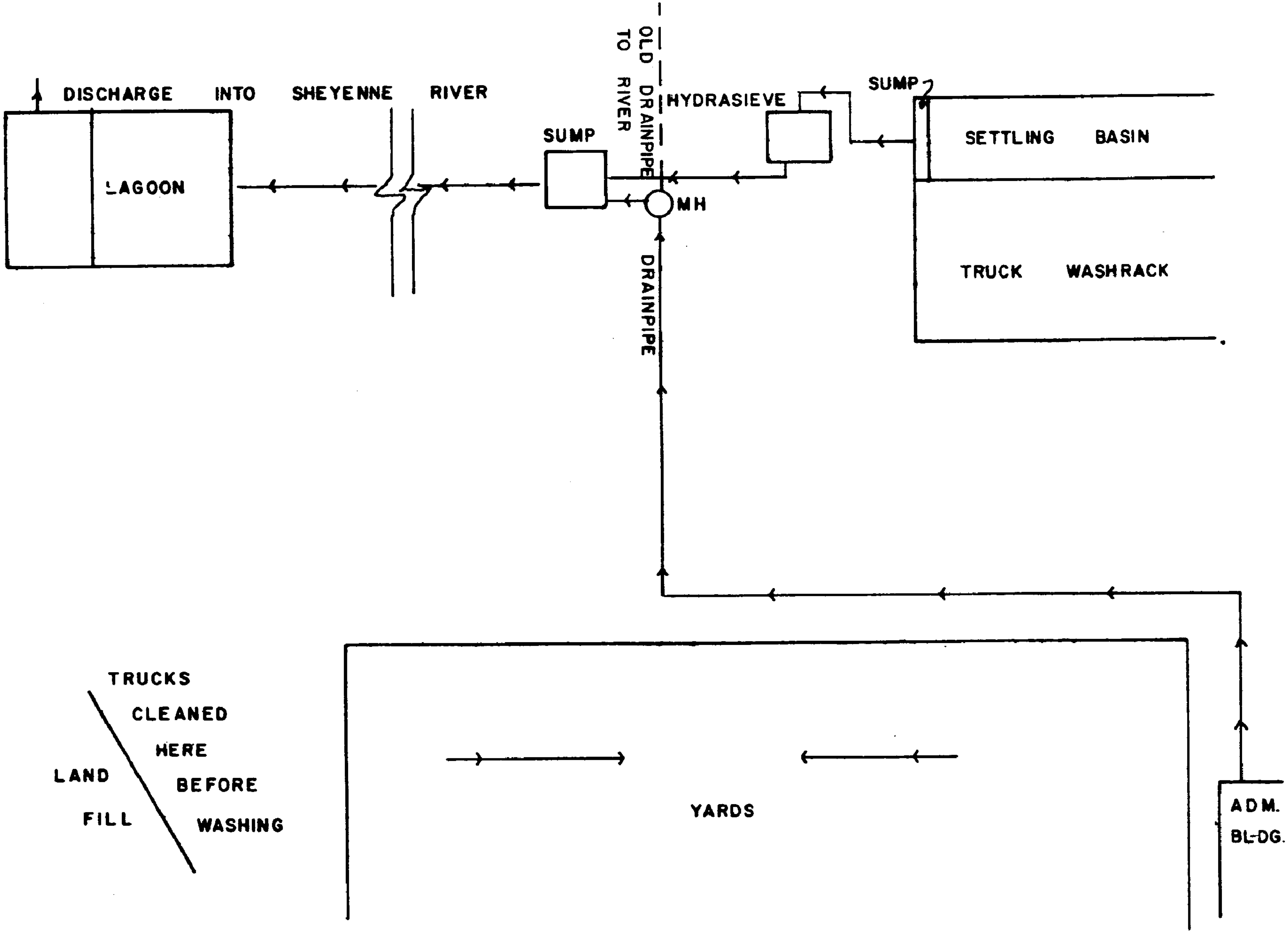

FIGURE 2. SCHEMATIC DIAGRAM OF FACILITIES AT THE UNION STOCKYARDS

into the combined sewer. The drains collect surface runoff and waste water that soaks through the straw bedding. Each pen also has a watering trough with a continuous supply of fresh water flowing through it and overflowing into the sewer. The pens are cleaned regularly.

The sanitary sewage from the administration building and the sanitary facilities scattered throughout the stockyards are also discharged into the combined sewer. As stated earlier, before construction this waste was discharged into the Sheyenne River without treatment. Now, however, this is pumped with the other wastes to the stabilization ponds.

The stabilization ponds were put into operation on April 21, 1971. The primary cell has an area of 2.12 acres and is five feet deep. The detention time is approximately five days. The secondary cell has an area of 1.07 acres, a five foot depth and a detention time of 2.5 days. See Figure 2 for a diagrem of the system.

SECTION V

Sampling and Flow Measurement

During the 1970 phase of the study the waste samples to be analyzed were collected from the truck washrack and the combined sewer drainpipe discharging into the Sheyenne River. The washrack was usually sampled three times a week and the drainpipe twice. The samples were taken directly to the Sanitary Engineering Laboratory at North Dakota State University for analysis, a distance of less than ten miles.

The washrack samples had to be taken carefully to avoid getting a slug sample. One of the first BOD_5 samples from the settling basin was taken before it began overflowing and the BOD_5 was six or seven times the average of all samples. After this instance the remainder of the samples were taken from the overflow which allowed time for mixing of the effluent from several trucks and minimized chances of getting slug samples.

The volume of water from the truck washrack was determined by counting the number of coins in the water meter once a week. The volume of water delivered for one quarter was known and multiplying this times the number of coins gave the total volume for the time period.

The drainpipe was sampled at the outlet of the river. A drainpipe discharge calibration curve was developed from nine dye tests. In these tests the time for a colored dye to flow a known distance was measured and the velocity was calculated. The depth of the water in the pipe was measured several feet back from the outlet, and the cross-sectional area of flow and velocity then determined the flow for that water depth.

The Manning Equation (1) was used to develop the discharge curve. The difference in elevation between the ends of the pipe was measured and the slope was calculated.

(1) $$V = \frac{1.486}{n} R^{2/3} S^{1/2}$$

n = roughness coefficient

R = hydraulic radius

S = slope of hydraulic gradient

From the depth measurements and the dye tests all the variables were known except in n value. The n value for each dye test was calculated and the average of all the n values was used in the calculation of the discharge at different increments of d/D (ratio of water depth to pipe diameter) from 0.1 to 1.0. The average value for n was found to be 0.0165 which is slightly less than the nominal value of 0.020 recommended[6] for use in the design of corrugated metal pipes. The lower value could be caused by the algae slime growing inside the pipe and reducing pipe friction. The resulting computed tests are also plotted on the curve to show the correlation between the computed values and the observed values (Figure 3).

During the second phase of the study or 1971, samples were taken of the secondary lagoon effluent, the primary lagoon effluent, the drainpipe from the yards and the washrack before and after the screen.

Samples of the secondary lagoon effluent were taken daily through most of the summer as were samples of the primary lagoon effluent. Samples were taken of the drainpipe to establish the consistency of the waste material over two years. As can be seen in Tables 1 and 2 all tests are very similar with the exception of COD and suspended solids. However, both these reductions were minor and the consistency of the drainpipe effluent can easily be seen.

The washrack water was also very similar for both years. The reduction in solids, settleable, total and suspended, could be attributed to the enlarged settling basin. There was also a decrease in COD in the second year, along with a decrease in nitrate and nitrite. These reductions would be expected along with the reductions in solids content.

Samples were also taken from the settling basin at the truck washrack. This basin was cleaned each Friday afternoon and samples were taken at that time.

All samples were taken carefully as in the first phase of the study and all tests run in the sanitary engineering laboratory at North Dakota State University.

Flow from the drainpipe was not monitored and was assumed to be consistent with that of 1970. There is no reason why the flow should not be the same with the exception of flows during rain storms.

A record flow through the truck washrack was kept and is shown in Table 3.

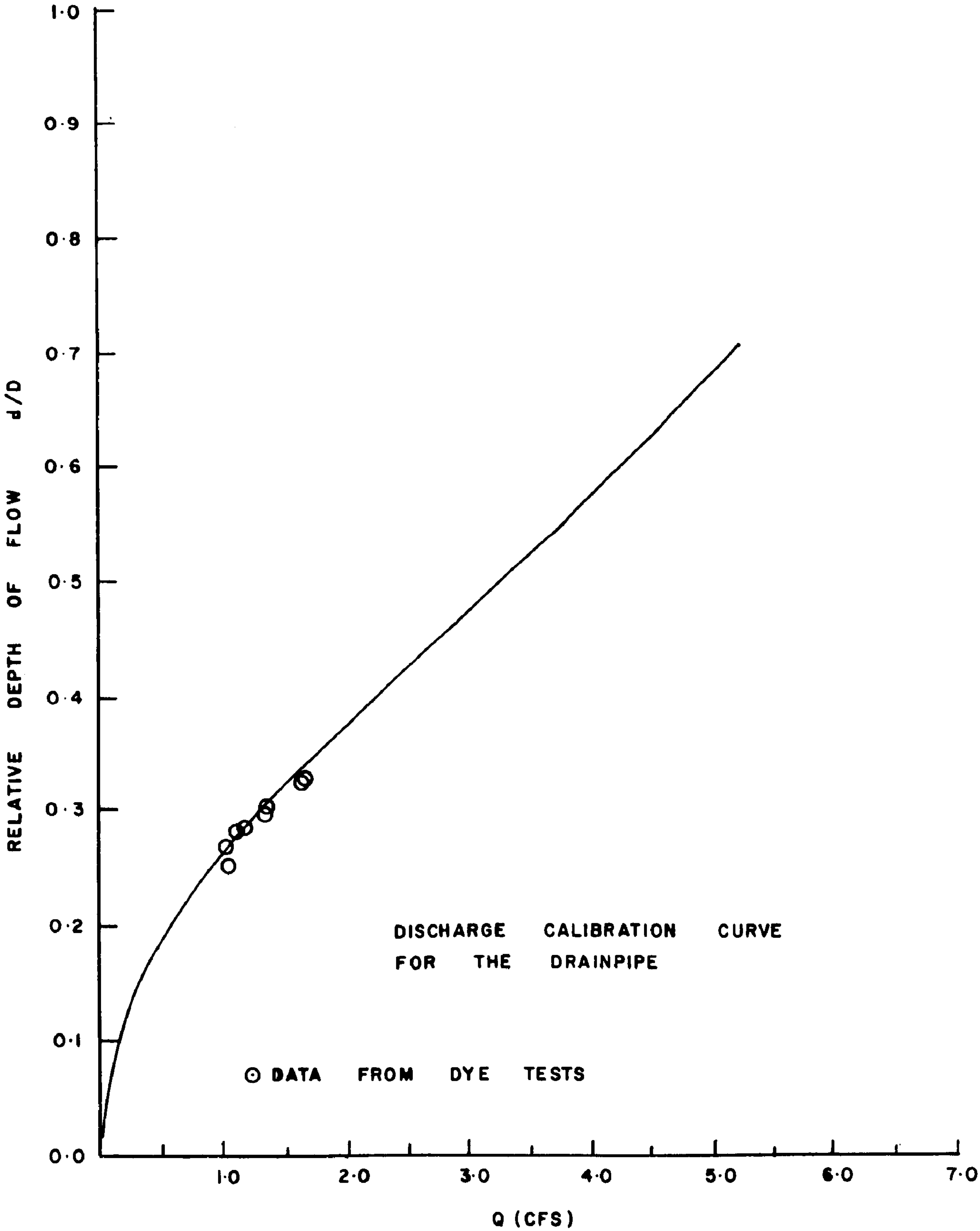

FIGURE 3. DISCHARGE CURVE OF DRAINPIPE

TABLE 1

Summary of Test Results for the
Drainpipe Samples
for 1970

		Min.	Max.	Mean
Q	cfs	1.05	2.02	1.44
BOD_5	mg/l	3.0	100.0	20.0
COD	mg/l	28.0	346.0	86.0
DO	mg/l	7.8	9.6	8.5
Sulfates	mg/l	108.0	146.0	127.0
Total Solids	mg/l	466.0	1934.0	1040.0
Susp. Solids	mg/l	4.0	422.0	69.0
Sett. Solids	ml/l	0.02	1.2	0.3
NH_3-N	mg/l	0.7	6.0	2.7
NO_2-N	mg/l	0.011	0.09	0.024
NO_3-N	mg/l	0.149	0.711	0.235

TABLE 2

Summary of Test Results for the Drainpipe Samples for 1971

		Minimum	Maximum	Average
BOD_5	mg/l	3.0	56.0	19.7
COD	mg/l	12.0	225.0	69.0
DO	mg/l	6.4	9.9	8.5
Sulfates	mg/l	100.0	150.0	122.0
Total Solids	mg/l	684.0	1390.0	971.0
Susp. Solids	mg/l	2.0	178.0	29.0
Sett. Solids	ml/l	0.0	0.8	0.2
NH_3-N	mg/l	0.0	19.8	1.63
NO_2-N	mg/l	0.006	0.104	0.02
NO_3-N	mg/l	0.06	0.626	0.194

TABLE 3

Water Used at Truck Washrack

Month 1971	Gallons
April	27,250
May	159,750
June	214,750
July	271,750
August	235,750
September	291,250
October	224,500

SECTION VI

Results and Discussion

All tables shown in this section are listings giving minimum, maximum and average values of the results for each phase of a particular discharge. A complete waste analysis summary of all results is given in the Appendix, page 35, along with a list of methods used in the analyses of the wastes.

Figures 4, 5 and 6 illustrate the effect of time of year of temperature of BOD_5. It can be seen that the BOD_5 of the drainpipe waste is much greater during the warm summer months. Figure 7 illustrates livestock number varying with Month of Year. Combining these figures it seems the more livestock handled through the yards the lower the BOD_5 is, since BOD_5 is lower in the fall and livestock numbers peak at this time. It seems to indicate that colder temperatures have a greater effect of BOD_5 than increased livestock numbers. Despite the increase in livestock numbers, the strength of the drainpipe waste after November 20 was less than 20 mg/l in all cases and average less than 20 mg/l in September. Gilbertson(2) and Grub(3) both noted this fact in their studies on runoff from cattle feedlots. During freezing weather the waste and bedding are frozen as a solid mass until warmer weather when spring runoff transports the wastes to the sewer or it is removed when the pens are cleaned in the spring.

Grub(3) discussed several important factors that affect the composition and quantity of runoff from the feedlots. They were the effects of precipitation, surfacing material and depth of waste accumulation. In general, greater depths of accumulated wastes have greater absorpton capacity for precipitation and result in lesser quantities of runoff. As much as one-half inch of moisture may be absorbed by each inch of organic mass on the feedlot floor, especially if the mass is slightly damp when precipitation begins. A high-intensity rain falling on a dry-lot surface may result in rapid runoff and consequent removal of large quantities of organic matter, while the same intensity of rain falling on a damp lot might cause little or no runoff. A high-intensity rainfall on a surfaced lot will result in a greater quantity of runoff that will have higher concentrations of BOD_5 and suspended solids than the runoff from unsurfaced lots, and with an appreciable floor slope, may effectively clean the lot. Loehr(8) stated that the minimum rainfall to produce runoff was approximately 0.36 inches for the surfaced lot and 0.42 inches for the unsurfaced lot. If surface water runnoff were the only pollution problem associated with confined

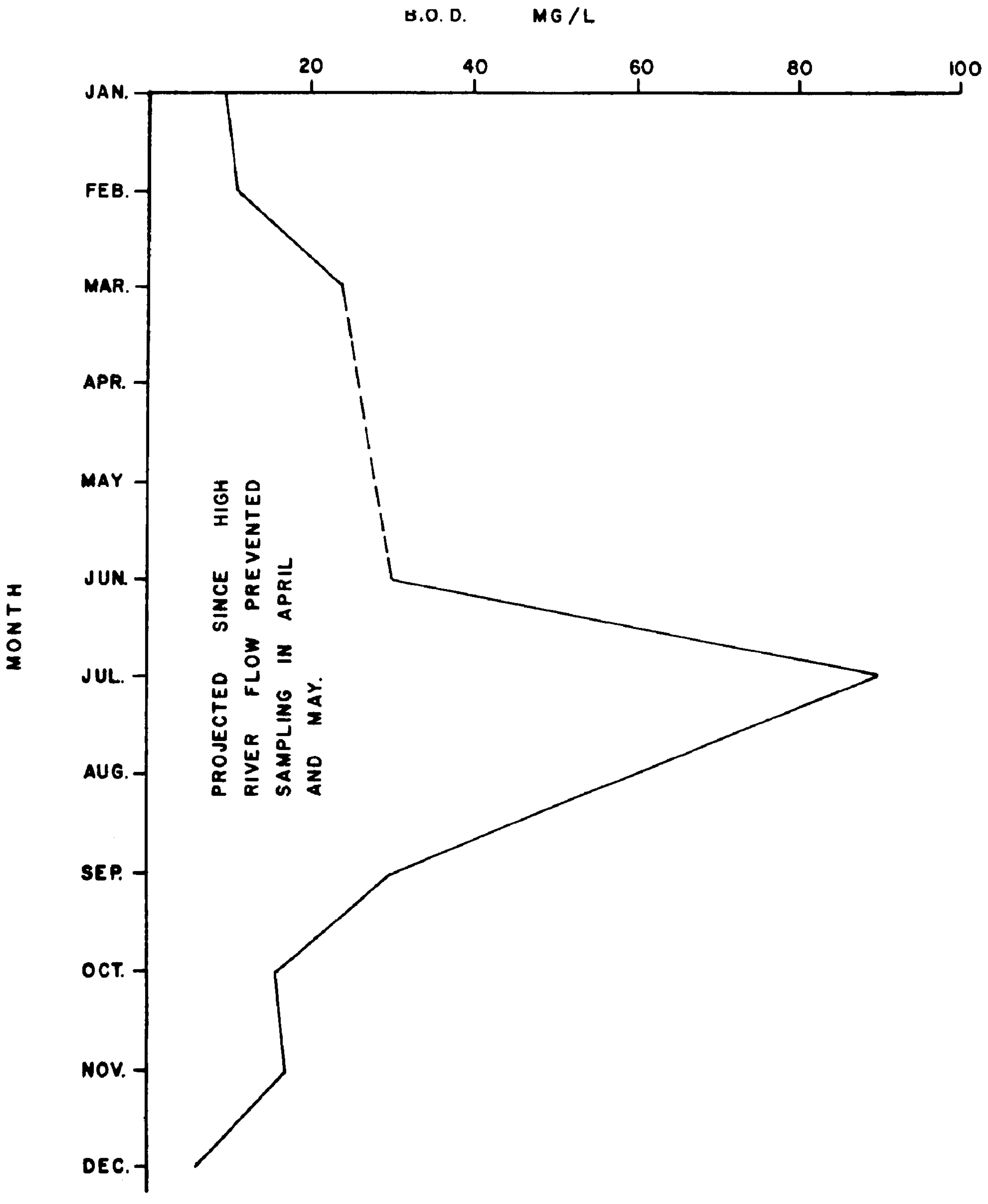

FIGURE 4. DRAINAGE B.O.D. VERSUS MONTH OF YEAR

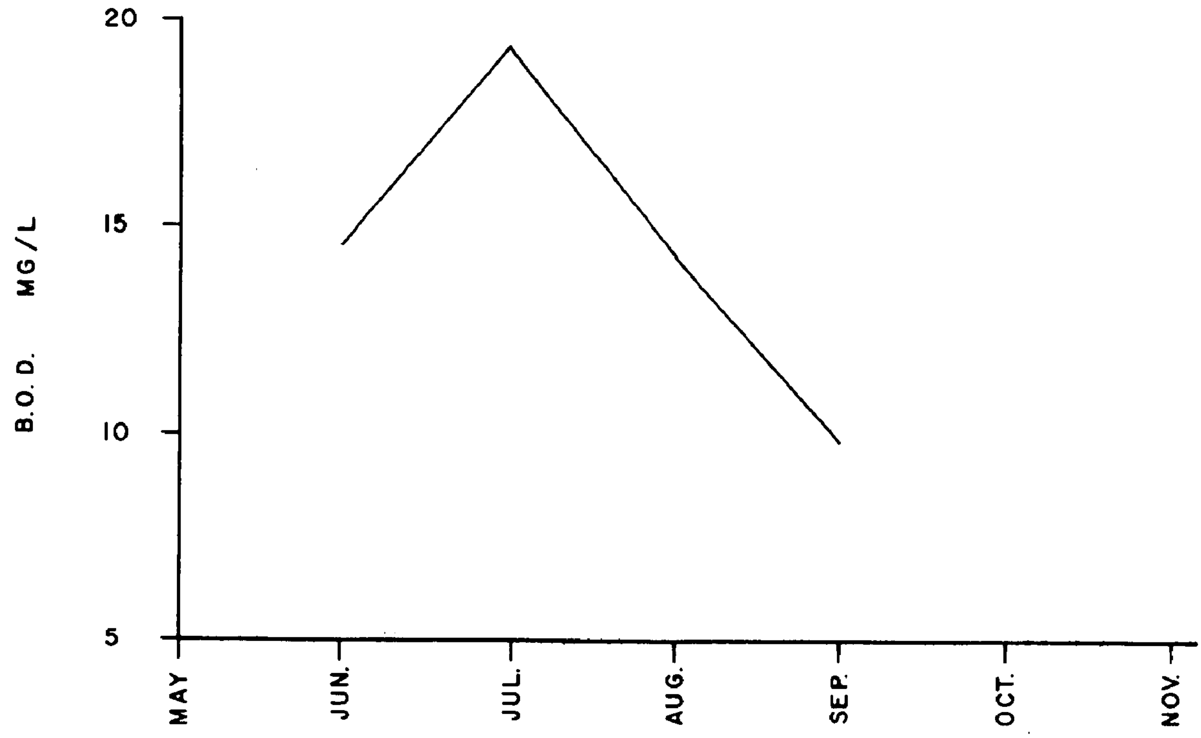

FIGURE 5. PRIMARY LAGOON VERSUS MONTH OF YEAR

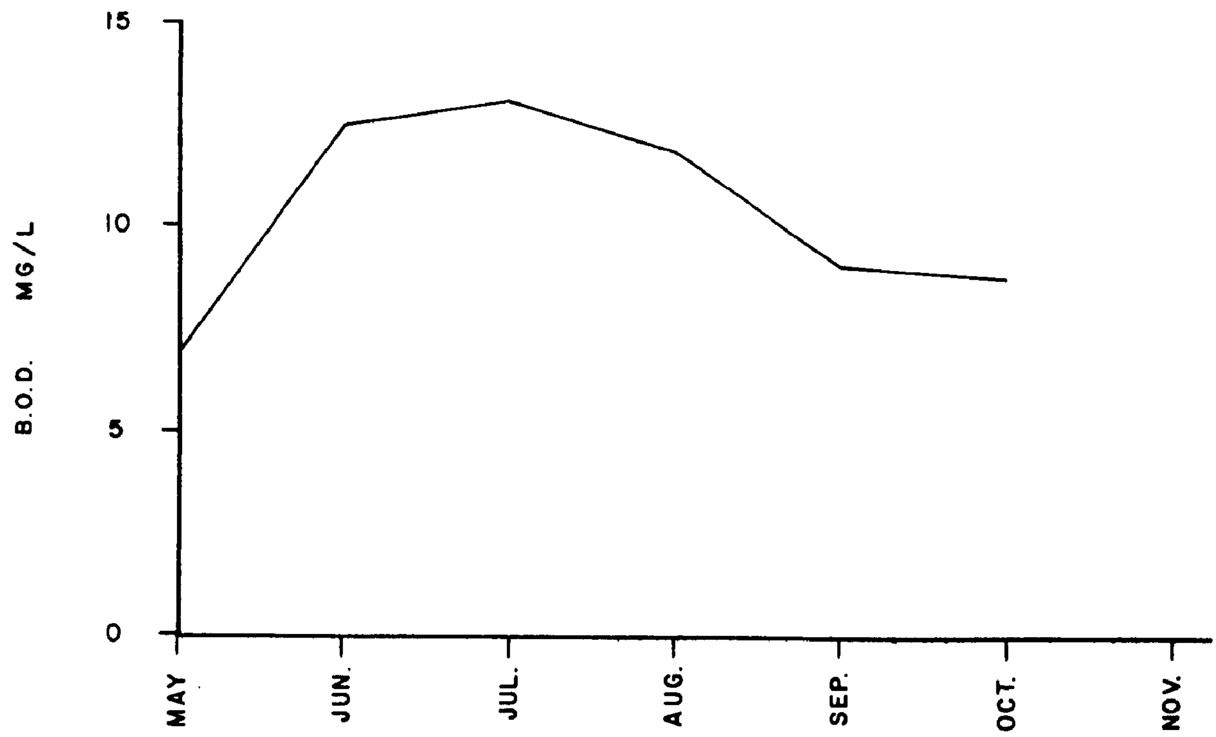

FIGURE 6. SECONDARY LAGOON VERSUS MONTH OF YEAR

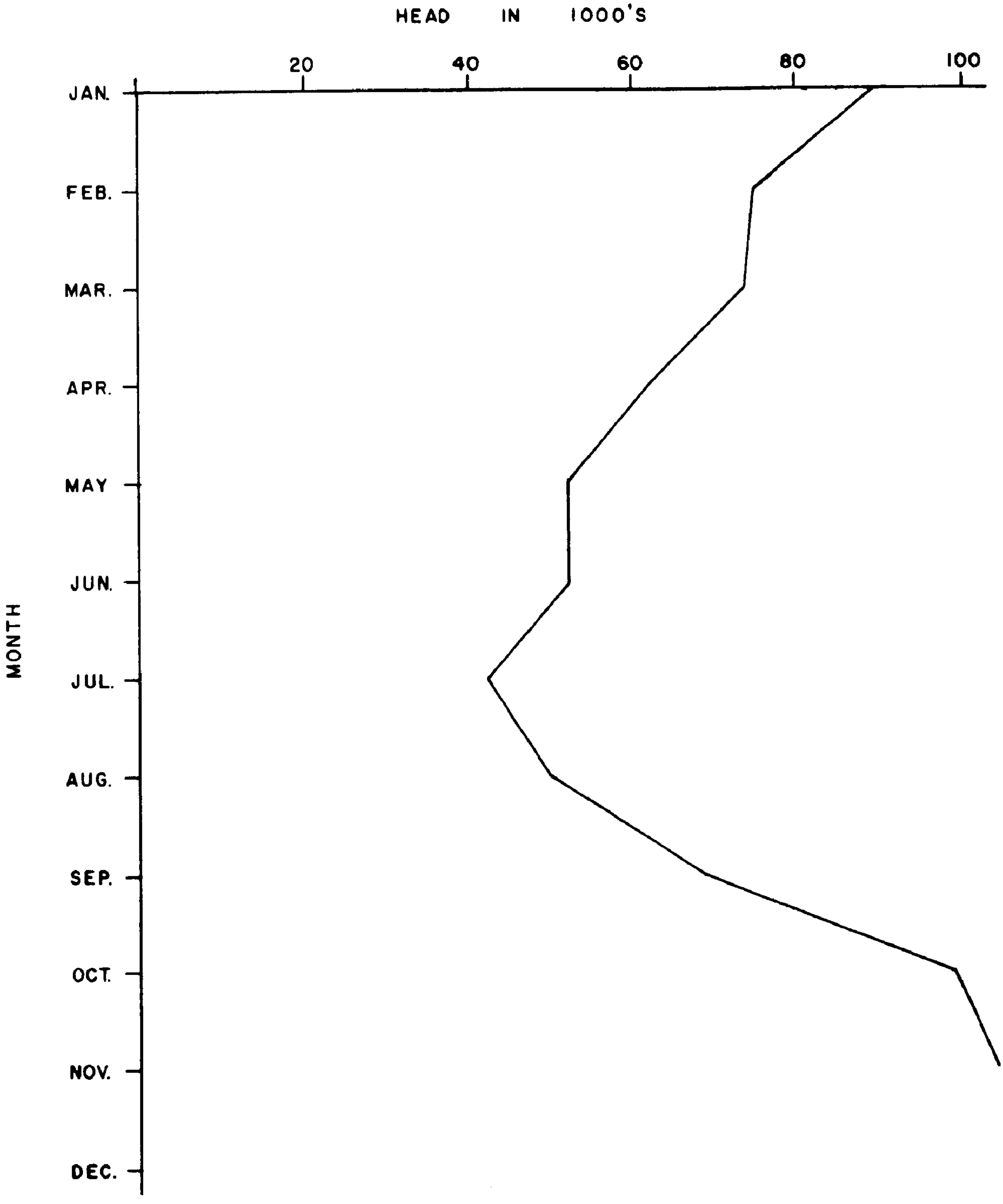

FIGURE 7. NUMBER OF LIVESTOCK HANDLED VERSUS MONTH OF YEAR

livestock operations, it would appear that confinement areas should remain unsurfaced. However, a problem which has received less attention is the pollution of ground water by dissolved chemicals, particularly nitrates, which may percolate into the ground beneath unsurfaced lots.

As can be seen from Tables 1 and 2, the strength of the drainpipe waste was very consistent over the two year period and for practical purposes should be considered equivalent. The load factor calculations(10) of Table 4 for BOD5 per animal were made using the 1970 results.

The total average BOD_5 load discharge to the river during the sampling period was 195 lbs/day. The drainpipe with an average discharge of 1.44 cfs and average BOD_5 of 20 mg/l contirbuted 155 lbs. The truck washrack had an average BOD_5 of 499 mg/l and contributed the remainder of 40 lbs/day BOD_5. The theoretical BOD_5 of the combined average wastes if they could be mixed on a daily basis would be 36 mg/l.

The average daily BOD_5 load would be more useful to design engineers if it could be expressed as a factor of so many pounds per animal, acre of land, truck, etc. At a public stockyards, the livestock are separated in the pens by owner, breed or size. The animal density per acre would vary so much in this tpye of operation, that it was decided to express the daily BOD_5 in lbs. BOD_5 per animal. Cattle, calves, hogs, sheep and horses are traded at the stockyards and due to the variation of the amount of BOD_5 in waste produced by the different animals, a BOD_5 factor was calculated for each one. Only 32 horses were received for the whole year so they were considered to have a negligible effect on the total waste.

Cattle and calves were also totaled as one unit since the average number of calves was less than 4% of the number od cattle. The average weight of each type of animal was established by stockyard's personnel and is listed in Table 4 along with the otehr data necessary to calculate the factors. The daily BOD_5 production rate of sheep was the smallest and was considered unity compared to the rates for cattle, and hogs. The rate for sheep was divided into the rates for cattle and hogs to obtain a weighting factor for each animal. It is important to note that although most of the nanure produced by the animals is removed from the pens and trucks and is buried in a landfill, the amount of BOD_5 reaching the treatment syatem should be in the same ratio as that determined by the overall defecation rates in Table 4.

The total daily BOD_5 discharged to the river by the washrack and drainpipe was previously given as 195 lbs/day. Part of this BOD_5 was also due to the wastes from the stockyard office building. It was assumed that approximately 100 people are on the premises at any given time. Using a population equivalent of 0.17 lbs. BOD_5/day/capita(8), the total BOD_5 contributed by the offices was computed to be 17 lbs/day. This amount was subtracted from the total BOD_5 and the remainder of 178 lbs. was considered to be the total average daily BOD_5 from the washrack and drainpipe attributable to the livestock. Since the washrack does not operate during below freezing temperatures, the daily BOD_5 discharge from the drainpipe less the 17 lbs/day BOD_5 from the stockyards building results in a net daily BOD_5 load of 138 lbs. without the washrack in operation. Equations 2 and 3 are the equations used to calculate the load factors.

(2) $$N_1W_1D_1 + N_2W_2D_2 + N_3W_3D_3 = \text{lbs}/BOD_5/\text{day}$$

$$X \quad \overline{D_3} \quad \overline{D_3} \quad \overline{D_3}$$

Subscripts: 1=cattle 2=hogs 3=sheep

N_1 = average daily receipts of animals

W_1 = average weights of animals in 1000 lbs.

D_1 = BOD_5 defecation rates per 100 lbs. live weight

X = unweighted load factor

(3) $$\text{Load factor } (L.F._1) = X \quad \frac{W_1D_1}{D_3} \text{ lbs/day/animal}$$

The unweighted load factor X is solved for in equateion 2. In equation 3 the quantity in brackets could be called the weighting coefficient since it adjusts the load factor for each type of livestock due to the different BOD_5 defecation rates and live wieghts of the animals. The weighting coefficients are multiplied times X to obtain the daily BOD_5 load factors for each type of animal. These factors are tabulated in Table 4 in lbs. BOD_5/day/average animal in this paper and lbs. BOD_5/day/1000 lbs. live weight to use in estimating the daily BOD_5 from a stockyard that is constructed and operated similar to the Union Stockyards.

TABLE 4

Tabulation of the BOD_5 Load Factors for Cattle, Hogs and Sheep

Daily Receipts	Cattle	Hogs	Sheep
Minimum	298.0	40.0	0.0
Maximum	4855.0	2617.0	2857.0
Mean	1745.0	210.0	699.0
Average Weight (lbs.)	800.0	210.0	95.0
BOD_5 Defecation Rates[8,1] per 1000 lbs. live weight	1.3	3.4	0.7
BOD_5 Loading Factor Expressed as lbs./average animal			
With Washrack	0.072	0.049	0.0046
Without Washrack	0.056	0.038	0.0036
BOD_5 Loading Factor Expressed as lbs./live weight			
With Washrack	0.090	0.233	0.0484
Without Washrack	0.070	0.181	0.0379

In Table 5, 6 and 7 the minimum, maximum and average test results are shown for the washrack waste for 1970, the washrack waste before the hydrasieve for 1971 and the washrack waste after the hydrasieve, respectively.

The consistency of the washrack waste over the two year period can be seen with the only large changes being in COD and solids. Both these changes could be due to the enlarged settling basin installed at the truck washrack.

TABLE 5

Summary of Test Results for the Truck Washrack, Before Improvements, 1970

		Minimum	Maximum	Average
BOD_5	mg/l	137.0	1150.0	499.0
COD	mg/l	622.0	4780.0	1861.0
DO	mg/l	0.7	8.4	3.5
Sulfates	mg/l	115.0	170.0	134.0
Total Solids	mg/l	2072.0	5202.0	3308.0
Susp. Solids	mg/l	564.0	2470.0	1411.0
Sett. Solids	ml/l	1.0	15.0	5.6
NH_3-N	mg/l	2.8	49.1	20.9
NO_2-N	mg/l	0.04	0.49	0.278
NO_3-N	mg/l	0.085	0.57	0.984

Average daily volume of wastewater = 9560 gal/day.

TABLE 6

Summary of Test Results for the
Washrack before Screen Samples
for 1971

		Minimum	Maximum	Average
BOD_5	mg/l	260.0	700.0	492.0
COD	mg/l	710.0	2352.0	1416.0
DO	mg/l	0.4	6.4	2.8
Sulfates	mg/l	46.0	188.0	118.00
Total Solids	mg/l	2026.0	4522.0	2819.0
Susp. Solids	mg/l	209.0	2353.0	706.0
Sett. Solids	ml/l	0.0	8.0	1.1
NH_3-N	mg/l	2.3	5.0	2.94
NO_2-N	mg/l	0.0	0.4	0.093
NO_3-N	mg/l	0.0	2.14	0.322

TABLE 7

Summary of Test Results for the
Washrack after Screen Samples
for 1971

		Minimum	Maximum	Average
BOD_5	mg/l	[illegible]2.0	640.0	495.0
COD	mg/l	956.0	1920.0	1376.0
DO	mg/l	3.8	4.0	4.0
Sulfates	mg/l	80.0	172.0	126.0
Total Solids	mg/l	2162.0	4366.0	2732.0
Sups. Solids	mg/l	116.0	2133.0	707.0

TABLE 7 (Continued)

		Minimum	Maximum	Average
Sett. Solids	ml/l	0.0	7.0	1.020
NH_3-N	mg/l	5.0	53.0	31.2
NO_2-N	mg/l	0.0	0.4	0.093
NO_3-N	mg/l	0.0	2.78	0.4

The dry solids content of this material averaged 15.5 percent and in Table 8 the amount of wet material removed both in settling basin and by the hydrasieve is shown.

TABLE 8

Material removed at Truck Washrack (lbs.)

Month (1971)	Settling Basin	Hydrasieve
April	2,210	-
May	34,150	-
June	72,640	3,020
July	60,830	1,610
August	56,760	2,660
September	88,260	660
October	83,330	-

As can be seen the settling basin is very effective in the removal of solids from the truck washrack waste. In the case of the Union Stockyards little water quality improvement was realized across the hydrasieve. Compare Table 8 with Tables 6 and 7.

Further detail is available in the complete analysis summary given in the appendix Table A5 and A6. Although a very small weight of material was removed by the hydrasieve it was effective in removing floating straw from the truck washrack waste. The hydrasieve would be of more use if large amounts of floating material were present in a waste water.

Table 9 and 10 gives the minimum, maximum and average test results for the primary cell and the secondary cell effluents, respectively.

The average BOD_5 by month and by number of livestock per month are shown graphically in Figures 4, 5, 6 and 7, respectively. Curves for strength of drainpipe wastes, primary cell and the secondary cell effluent versus month and livestock number are shown.

On the average, the total reduction of BOD_5 between the drainpipe and truck washrack to the secondary lagoon effluent was 48.6 percent. This was realized with a system which had a detention time of seven days. Water quality was better after treatment in all cases with the exception of total solids which remained constant with the drainpipe. The effect of addint the washrack waste to the drainpipe waste was not considered and therefore, an additional 4 to 5 mg/l reduction in BOD_5 of the mixed waste was obtained. DO was reduced from 8.8 mg/l in the drainpipe to 5.9 mg/l at the point of discharge or the secondary lagoon outfall. This is not considered to be a problem. Nitrite was up from 0.020 ppm at the drainpipe to 0.061 ppm at the secondary lagoon outfall. Ammonia nitrogen was eliminated and nitrate nitrogen was reduced. No settleable solids were found in the final effluent and suspended solids were down 67 percent. Refer to Tables 1 and 10 for comparison.

TABLE 9

Summary of Test Results for the
Primary Lagoon Effluent
Samples

		Minimum	Maximum	Average
BOD_5	mg/l	2.4	38.0	14.8
COD	mg/l	12.1	168.0	53.0
DO	mg/l	1.0	13.6	3.2
SUlfates	mg/l	94.0	260.0	132.0
Total Solids	mg/l	602.0	1370.0	997.0
Susp. Solids	mg/l	0.0	548.0	27.0
Sett. Solids	ml/l	0.0	1.5	trace
NH_3-N	mg/l	0.0	0.0	0.0
NO_2-N	mg/l	0.02	0.118	0.05
NO_3-N	mg/l	0.059	0.529	0.145

TABLE 10

Summary of Test Results for the Secondary Lagoon Effluent Samples

		Minimum	Maximum	Average
BOD_5	mg/l	1.0	30.0	12.7
COD	mg/l	12.0	146.0	51.0
DO	mg/l	0.1	13.6	5.9
Sulfates	mg/l	94.0	182.0	129.0
Total Solids	mg/l	586.0	2768.0	1038.0
Susp. Solids	mg/l	0.0	100.0	10.0
Sett. Solids	ml/l	0.0	0.0	0.0
NH_3-N	mg/l	0.0	0.0	0.0
NO_2-N	mg/l	0.008	0.132	0.061
NO_3-N	mg/l	0.073	0.861	0.172

The compounds of nitrogen mentioned above are of great interest to sanitary and agricultural engineers cause of the importance of nitrogen in the life processes of all plants and animals. In this study, the samples were analyzed for ammonia nitrogen, nitrite nitrogen and nitrate nitrogen.

The pH of the effluents from the drainpipe and truck washrack was nearly constant at 9.1 during the sampling period. Since the water sources at the stockyards are fresh water wells, it is thought that the quality of the water will stay reasonably constant throughout the year. In accordance with conclusions expressed in the studies by Stratton(11), the ammonia in the waste water would be in a gaseous state and subject to escape to the atmosphere. The washrack effluent had a relatively high ammonia nitrogen concentration of 20.9 mg/l for 1970 and 29.4 for 1971 but only provided 1.7 lbs./day and 2.4 lbs./day, respectively of total ammonia because of its low average volume. The drainpipe had a low average concentration of 2.7 mg/l for 1970 and 1.63 for 1971 ammonia but because of its daily average volume or 930,000 gal/day, it discharged 20.6 lbs./day and 12.4 lbs./day, respectively of ammonia nitrogen into the river for a total average daily ammonia nitrogen loading of 22.3 lbs./day and 14.8 lbs./day. It should be noted that no ammonia nitrogen was present in the final effluent from the waste stabilization ponds.

The nitrate nitrogen concentrations in the samples from the stockyards were quite low compared to the 10 mg/l limit recommended by the Public Health Service. The average nitrate nitrogen concentration in the drainpipe for 1970 and 1971, respectively was 0.238 mg/l and 0.194 mg/l. It was 0.984 mg/l and 0.322 mg/l, respectively in the truck washrack effluent. The well water was analyzed twice, both samples were free of nitrogen in any form.

The concentrations of sulfates in the drainpipe and washrack effluents were 127 mg/l and 134 mg/l, respectively. The well water had 105 mg/l so only 25-30 mg/l were contributed by the stockyards. The Public Health Service has recommended an upper limit of 250 mg/l in water intended for human consumption because of its cathartic effect on humans. Sulfates are also indirectly responsible for two serious problems associated with the handling and treatment of waste. These are odor and sewer-corrosion problems resulting from the reduction of waste water flows in the drainpipe and is usually close to the saturation point with dissolved oxygen, so this problem should not occur in pipes transporting the waste. Also at no time during 1971 did the dissolved oxygen in the waste stabilization ponds go to zero; therefore, odor should be no problem in the area around the lagoons.

SECTION VII

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SECTION VIII

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SECTION IX

APPENDIX

LABORATORY TEST PROCEDURES

Dissolved Oxygen (DO)

The azide modification of the iodometric method for determining the DO was used as described in Standard Methods[1] on page 406 with the exception of titrating 300 ml samples with 0.0275N titrant. Some turbid samples were measured on a Beckman Dissolved Oxygen meter because the indicator endpoint could not be distinguished.

Biochemical Oxygen Demand (BOD)

The procedure outlined in Standard Methods[1], page 415.

Chemical Oxygen Demand (COD)

The dichromate reflux method page 510, Standard Methods[1].

Ammonia Nitrogen

The diazotization method, page 400, Standard Methods[1]. Color intensity was measured with a Bausch and Lomb Spectronic 20 colorimeter. Nitrite concentration was determined from the calibration charts on page 58 in the Hach Chemical Company's colorimetric procedures manual(4).

Nitrate Nitrogen

The cadmium reduction procedures of measuring both nitrate and nitrite nitrogen in Standard Methods[1] on page 395 was used and the nitrite concentration was subtracted to obtain the net nitrate concentration. The color intensity was measured with a Bausch and Lomb Spectronic 20 colorimeter. The nitrate nitrogen concentration was determined from the calibration chart on page 56 in the Hach Chemical Company's colorimeter procedures manual(4).

Sulfates

The turbidimetric method, page 291, of Standard Methods[1] was used to measure sulfates. The turbidity was measured on a Bausch and Lomb Spectronic 20 colorimeter and the sulfate concentration was determined from the calibration chart on page 91 of the Hach Chemical Company's Colorimeter procedure manual(4).

Total Solids

The amount of total solids was determined by measuring the residue left after evaporation, a volume of wastewater. The method is given on page 423 in Standard Methods[1].

Suspended Solids

The Gooch crucible method, page 424, Standard Methods[1].

Settleable Solids

The amount of settleable solids was reported on a volume basis in an Imhoff cone using the procedure on page 426 of Standard Methods[1].

Table A1

Washrack Well Water Analysis
(Average of Two Samples)

BOD_5	mg/l	0.0
COD	mg/l	0.0
DO	mg/l	4.3
Sulfates	mg/l	105.0
Total Solids	mg/l	1083.0
Suspended Solids	mg/l	6.5
Settleable Solids	ml/l	0.0
Ammonia Nitrogen	mg/l	0.0
Nitrite Nitrogen	mg/l	0.0
Nitrate Nitrogen	mg/l	0.0

TABLE A2

WASTE ANALYSIS SUMMARY SHEET
TRUCK WASHRACK

Samples No.	Date	Q cfs	BOD_5 mg/l	COD mg/l	DO mg/l	SO_4 mg/l	Total Solids mg/l	Susp. Solids mg/l	Set. Solids ml/l	NH_3-N mg/l	NO_2-N mg/l	NO_3-N mg/l
1	6-05-70	-	-	1540	-	186	2982	1450	-	25.8	-	-
2	6-08-70	-	-	5730	6.3	182	2215	758	-	2.8	-	-
3*	6-10-70	-	2500	2890	0.7	340	7244	3670	-	47.3	-	-
4	6-12-70	-	860	1110	1.0	176	5202	2470	15.0	42.8	-	-
5	6-15-70	-	380	3160	3.6	245	2482	1050	2.5	13.6	-	-
6	6-19-70	-	800	1410	1.4	220	4536	2080	12.0	26.9	0.310	-
7	6-22-70	-	280	1895	1.9	220	3750	2070	9.0	13.3	0.390	-
8	6-24-70	-	750	2230	2.0	177	4190	2185	7.5	24.5	0.160	-
9	6-29-70	-	690	3620	1.0	205	4260	1925	7.5	35.8	0.450	-
10	7-01-70	-	1150	963	1.7	232	4966	2030	7.0	49.1	0.370	-
11	7-06-70	-	290	1643	3.6	240	2430	871	3.0	13.4	0.160	-
12	7-09-70	-	400	1800	1.2	124	2954	908	1.4	11.2	0.360	-
13	7-10-70	-	570	1155	2.4	155	3132	984	2.0	25.7	0.350	0.750
14	7-13-70	-	567	622	4.6	156	3756	1620	5.5	26.9	0.490	1.260
15	7-15-70	-	162	1890	5.3	132	3226	2010	6.5	9.5	0.150	0.850
16	7-17-70	-	475	944	2.9	135	2900	1290	4.5	21.5	0.260	0.320
17	7-22-70	-	380	1215	5.5	127	2240	676	2.7	10.6	0.120	0.680
18	7-24-70	-	300	1436	4.8	117	2160	564	1.6	9.8	0.260	0.540
19	7-27-70	-	460	876	2.4	170	2916	1020	1.9	19.4	0.245	1.960
20	7-29-70	-	220	1005	4.3	122	2308	1000	3.0	9.8	0.065	0.085
24	8-01-70	-	290	2960	5.7	127	2346	840	2.5	12.3	0.430	2.570
25	8-12-70	-	680	3350	5.5	165	3800	1030	4.5	37.7	0.320	0.580
27	8-17-70	-	960	1037	2.2	125	4282	2040	8.5	25.4	0.215	0.885
33	9-23-70	-	137	3750	7.3	125	2072	670	4.0	7.3	0.040	Trace
38	10-05-70	-	740	782	1.0	140	4766	2067	5.0	39.8	0.815	1.785
39	10-07-70	-	225	2100	8.4	115	2120	676	1.0	9.9	0.265	1.435
41	10-14-70	-	380	4780	2.3	122	3414	1900	12.0	18.8	0.205	0.945
42	10-19-70	-	875	831	2.5	135	4888	2085	9.0	46.9	0.160	0.440
43	10-21-70	-	187	1123	7.0	127	2362	986	4.2	7.1	0.250	0.450
44	10-26-70	-	262	-	5.9	127	3284	1685	7.5	8.8	0.100	0.800

* Results were not included in the average because it was considered a slug sample.

TABLE A3

WASTE ANALYSIS SUMMARY SHEET
SEWER DRAINPIPE

Sample No.	Date	Q cfs	BOD_5 mg/l	COD mg/l	DO mg/l	SO_4 mg/l	Total Solids mg/l	Susp. Solids mg/l	Set. Solids ml/l	NH_3-N mg/l	NO_2-N mg/l	NO_3-N mg/l
19-P	7-27-70	-	80	205	5.5	124	1182	120	0.7	5.0	0.031	0.200
20-P	7-29-70	-	100	346	6.0	138	1310	192	1.2	5.9	0.026	0.214
21-P	8-01-70	1.33	12	47	9.0	134	1026	20	0.05	2.2	0.026	0.274
22-P	8-03-70	1.75	45	41	7.7	142	1174	97	0.25	5.8	0.056	0.284
24-P	8-05-70	1.56	14	64	8.2	116	1020	27	0.02	1.5	0.090	0.210
25-P	8-12-70	-	40	59	7.8	130	1116	79	0.1	6.0	0.040	0.280
27-P	8-17-70	-	35	25	7.9	130	1260	106	0.08	3.4	0.040	0.320
28-P	9-09-70	1.45	19	82	8.3	130	994	54	0.3	2.7	0.036	0.364
29-P	9-11-70	1.25	8	46	8.8	110	1038	24	0.1	3.5	0.036	0.284
30-P	9-15-70	1.38	18	90	8.5	108	1239	24	0.15	2.5	0.038	0.322
31-P	9-18-70	-	3	34	8.9	122	1012	12	0.05	2.8	0.022	0.218
32-P	9-21-70	1.15	5	47	8.6	146	1032	14	0.05	1.7	0.039	0.711
34-P	9-25-70	-	8	47	9.1	138	1008	35	0.1	2.7	0.022	0.248
35-P	9-28-70	1.63	10	69	8.6	128	1444	4.2	0.4	2.7	0.016	0.204
36-P	9-30-70	1.22	26	94	8.3	130	1100	30	0.3	2.8	0.029	0.321
37-P	10-02-70	1.05	8	28	9.0	138	1034	4	0.05	2.5	0.024	0.296
38-P	10-05-70	1.05	30	102	8.0	128	1024	48	0.3	2.8	0.024	0.216
39-P	10-07-70	1.63	22	86	8.2	116	930	24	0.2	2.1	0.029	0.271
40-P	10-12-70	1.45	6	66	8.3	110	1084	54	0.5	2.1	0.018	0.182
41-P	10-14-70	1.50	6	25	9.3	128	1072	-	0.1	1.7	0.020	0.190
42-P	10-19-70	1.38	34	118	8.1	134	922	76	0.5	3.9	0.020	0.320
43-P	10-21-70	2.02	18	86	8.7	142	1484	460	1.2	1.8	0.006	0.170
44-P	10-26-70	-	24	66	9.0	118	980	28	0.2	2.2	0.018	0.162
45-P	10-27-70	-	19	78	8.5	116	904	30	0.5	3.1	0.024	0.206
46-P	10-29-70	1.15	16	82	7.8	138	944	22	0.1	2.8	0.026	0.264
47-P	11-02-70	1.50	40	294	8.3	122	952	64	0.2	4.0	0.022	0.198
48-P	11-04-70	1.68	25	-	9.0	116	1018	66	0.4	31.5*	0.015	0.155
49-P	11-09-70	1.33	8	37	9.0	142	754	-	0.05	2.0	0.015	0.165
50-P	11-11-70	1.38	10	45	8.9	130	802	-	0.1	1.5	0.011	0.209
51-P	11-13-70	1.45	7	57	8.8	128	1934	268	0.3	2.8	0.015	0.195
52-P	11-16-70	-	16	65	8.6	122	992	48	0.1	3.6	0.013	0.187
53-P	11-18-70	1.22	31	102	8.2	116	1144	74	0.5	2.5	0.015	0.195

* Results were not included in the average because it was not consistent with the other results

TABLE A3

WASTE ANALYSIS SUMMARY SHEET
SEWER DRAINPIPE

Sample No.	Date	Q cfs	BOD_5 mg/l	COD mg/l	DO mg/l	SO_4 mg/l	Total Solids mg/l	Susp. Solids mg/l	Set. Solids ml/l	NH_3-N mg/l	NO_2-N mg/l	NO_3-N mg/l
54-P	11-23-70	-	8	40	9.6	108	874	8	0.1	1.5	0.015	0.185
55-P	11-27-70	-	4	40	9.5	116	910	5	-	1.8	0.018	0.162
56-P	12-2-70	1.68	12	76	9.4	138	972	24	0.2	2.5	0.013	0.207
57-P	12-4-70	1.22	12	92	8.5	138	1066	22	0.1	2.1	0.019	0.340
58-P	12-7-70	1.45	14	56	8.9	130	588	10	0.2	2.1	0.011	0.189
59-P	12-9-70	1.50	16	56	9.2	122	776	13	0.4	2.1	0.011	0.149
60-P	12-11-70	1.38	9	44	9.1	134	1204	11	0.05	0.7	0.013	0.167
61-P	12-14-70	1.63	10	52	8.9	130	1068	14	0.1	1.7	0.013	0.187
62-P	12-18-70	1.25	10	40	8.7	134	466	5	1.5	1.7	0.013	0.207
63-P	12-22-70	-	10	40	8.7	124	-	-	0.2	2.2	0.011	0.189
64-P	12-23-70	-	4	35	8.6	127	-	-	0.1	2.1	0.013	0.207

TABLE A4

WASTE ANALYSIS SUMMARY SHEET
DRAINPIPE

Sample No.	Date	Q cfs	BOD_5 mg/l	COD mg/l	DO mg/l	SO_4 mg/l	Total Solids mg/l	Susp. Solids mg/l	Set. Solids ml/l	NH_3-N mg/l	NO_2-N mg/l	NO_3-N mg/l
65	1-04-71	-	17	72	9.2	100	850	14	0.5	1.7	0.018	0.182
66	1-08-71	1.38	11	64	9.3	150	978	32	0.5	2.0	0.013	0.207
67	1-13-71	1.68	7	68	9.3	128	972	7	0.1	1.4	0.011	0.159
68	1-15-71	1.63	3	56	9.9	128	972	7	0.05	2.8	0.011	0.159
69	1-20-71	1.63	9	64	9.0	128	894	16	0.2	1.5	0.011	0.139
70	1-21-71	1.63	12	64	9.1	108	938	10	0.25	2.2	0.011	0.159
71	1-28-71	1.56	12	60	-	130	940	13	0.05	1.7	0.013	0.157
72	1-29-71	1.56	6	40	9.1	124	954	10	0.05	1.5	0.011	0.139
73	2-02-71	1.56	8	48	9.3	116	912	7	0.01	1.4	0.011	0.159
74	2-04-71	-	6	44	9.1	124	946	5	0.05	1.7	0.010	0.140
75	2-09-71	1.56	7	60	9.3	118	954	12	0.05	2.8	0.011	0.149
76	2-12-71	-	7	52	9.7	104	994	12	0.1	1.7	0.010	0.150
77	2-16-71	1.50	13	60	8.7	138	988	16	0.05	2.1	0.019	0.151
78	2-19-71	1.50	13	52	8.8	100	986	13	0.01	2.8	0.018	0.162
79	2-23-71	1.63	25	64	8.8	128	726	47	0.06	2.2	0.019	0.161
80	2-26-71	-	11	48	8.7	118	882	21	0.3	1.7	0.015	0.175
81	3-02-71	-	17	44	8.7	130	1238	33	0.2	1.5	0.019	0.161
82	3-05-71	-	10	20	8.4	124	1102	15	0.2	1.6	0.011	0.139
83	4-08-71	-	10	43	-	118	1066	25	0.1	2.2	0.019	0.151
84	4-16-71	-	56	225	-	102	1164	178	0.8	6.2	0.104	0.626
103	6-16-71	-	30	119	6.4	110	1008	124	0.0	19.8	0.026	0.024
159	9-15-71	-	6.4	47.2	8.3	108	692	2	0.0	0.0	0.018	0.182
161	9-16-71	-	6.8	12	8.2	134	792	-	0.0	0.0	0.240	0.216
163	9-20-71	-	16	75	8.0	138	1262	12	0.2	0.0	0.018	0.142
166	9-24-71	-	10.8	35.3	8.5	166	-	33	-	-	0.018	0.182
168	9-28-71	-	20	54.9	7.3	116	1140	30	0.0	0.0	0.040	0.060
169	10-04-71	-	26.4	74.5	7.7	122	882	56	0.0	0.0	0.024	0.266
172	10-07-71	-	14	51	8.3	114	796	18	0.0	0.0	0.020	0.160
173	10-11-71	-	16.8	47	8.2	130	1032	30	0.2	0.0	0.037	0.163
175	10-13-71	-	13.2	44	8.0	122	1190	31	0.0	0.0	0.018	0.152
177	10-18-71	-	22.8	124	-	122	1074	44	0.0	0.0	0.010	0.480

TABLE A4

WASTE ANALYSIS SUMMARY SHEET
DRAINPIPE

Sample No.	Date	Q cfs	BOD_5 mg/l	COD mg/l	DO mg/l	SO_4 mg/l	Total Solids mg/l	Susp. Solids mg/l	Set. Solids ml/l	NH_3-N mg/l	NO_2-N mg/l	NO_3-N mg/l
179	10-21-71	-	17.2	288	-	108	1020	37	0.0	0	0.020	0.230
180	10-22-71	-	164.0	56	-	121	684	16	0.1	0	0.015	0.205
182	10-26-71	-	15.6	130	7.7	110	846	34	0.0	0	0.018	0.162
186	11-2-71	-	18.8	39.6	8.4	124	922	-	0.0	0	0.006	0.324
189	11-11-71	-	9.6	-	7.8	124	752	3	0.0	0	0.010	0.250
190	11-12-71	-	9.6	35.7	7.6	130	1390	26	0.0	0	0.008	0.162
191	11-23-71	-	10.0	44	8.1	150	170	0	0.0	0	0.015	0.225
192	11-24-71	-	22.0	71	7.3	134	1148	170	2.5	0	0.008	0.222
193	11-29-71	-	8.6	52	8.2	146	858	52	0.0	0	0.008	0.182
194	12-1-71	-	8.0	28	8.4	124	874	2	0.0	0	0.010	0.220
195	12-3-71	-	-	32	8.5	130	880	2	0.0	0	0.008	0.192

TABLE A5

WASTE ANALYSIS SUMMARY SHEET
WASHRACK BEFORE SCREEN

Sample No.	Date	Q cfs	BOD_5 mg/l	COD mg/l	DO mg/l	SO_4 mg/l	Total Solids mg/l	Susp. Solids mg/l	Set. Solids ml/l	NH_3-N mg/l	NO_2-N mg/l	NO_3-N mg/l
86	5-12-71	-	580	993	-	-	2210	395	0.8	23.0	0.000	0.000
87	5-14-71	-	432	1090	-	188	2424	354	0.1	39.0	0.000	0.000
88	5-19-71	-	600	1420	-	154	2452	552	3.0	41.0	0.000	0.000
89	5-21-71	-	560	1370	-	166	2344	302	0.1	44.0	0.400	0.160
90	5-24-71	-	280	1451	-	110	4522	2353	8.0	13.0	0.300	2.140
91	5-26-71	-	336	1115	0.4	-	2608	650	2.0	22.0	-	-
103	6-16-71	-	260	710	2.0	100	2026	209	0.5	2.3	0.000	0.000
158	9-15-71	-	275	1741	-	-	2734	500	-	30.8	-	-
160	9-16-71	-	620	2156	-	-	3570	778	0.0	51.0	0.003	0.157
164	9-21-71	-	650	2007	6.4	130	3622	650	1.5	42.0	0.070	0.170
165	9-23-71	-	700	1411	2.6	130	5558	620	0.5	22.4	0.163	0.357
167	9-27-71	-	-	2352	-	134	2435	585	0.0	27.29	0.270	0.270
170	10-05-71	-	450	1239	-	122	2572	640	0.1	32.9	0.080	0.150
171	10-06-71	-	460	-	-	114	2870	925	1.5	24.1	0.056	0.224
174	10-12-71	-	490	1191	-	118	2150	133	0.0	23.6	0.061	0.299
176	10-14-71	-	530	1072	-	108	2142	560	0.0	39.3	0.056	0.244
178	10-19-71	-	660	1424	-	90	2466	360	0.0	49.3	0.011	0.139
181	10-25-71	-	470	1283	-	116	2448	640	0.6	21.0	0.095	0.135
183	10-28-71	-	590	1980	-	100	2956	1199	0.0	15.7	0.043	0.227
185	11-01-71	-	320	1023	-	46	2438	1130	2.5	10.1	0.049	0.681
187	11-03-71	-	390	1283	-	108	2660	1300	0.7	16.1	0.101	0.739

TABLE A6

WASTE ANALYSIS SUMMARY SHEET
WASHRACK AFTER SCREEN

Sample No.	Date	Q cfs	BOD_5 mg/l	COD mg/l	DO mg/l	SO_4 mg/l	Total Solids mg/l	Susp. Solids mg/l	Set. Solids ml/l	NH_3-N mg/l	NO_2-N mg/l	NO_3-N mg/l
86	5-12-71	-	490	973	-	-	2256	468	0.7	37.0	0.000	0.000
87	5-14-71	-	488	1130	-	172	2610	422	2.0	-	-	-
88	5-19-71	-	575	1420	-	162	2360	530	2.0	37.0	0.000	0.000
89	5-21-71	-	560	1480	-	158	2354	305	0.05	48.0	0.400	0.300
90	5-24-71	-	300	1421	-	116	4196	2133	7.0	14.2	0.280	2.780
91	5-26-71	-	292	1161	3.8	-	2596	576	1.0	-	-	-
158	9-15-71	-	550	1716	-	-	2834	381	0.0	29.1	-	-
160	9-16-71	-	640	1920	-	94	3376	796	1.5	53.0	0.001	0.169
164	9-21-71	-	610	1599	4.5	108	3286	640	3.0	43.7	0.047	0.153
165	9-22-71	-	590	956	3.8	134	4366	730	0.0	23.0	0.104	0.346
167	9-27-71	-	540	1333	-	106	2504	550	1.5	25.3	0.270	0.330
170	10-05-71	-	470	1270	-	164	2560	660	1.5	34.1	0.078	0.202
171	10-06-71	-	420	1568	-	116	2708	920	0.0	24.1	0.033	0.297
174	10-12-71	-	390	1207	-	134	2162	116	0.0	24.8	0.041	0.231
176	10-14-71	-	600	1392	-	138	2412	755	0.0	34.3	0.045	0.255
178	10-19-71	-	610	1232	-	118	2514	412	0.6	64.1	0.008	0.142
181	10-25-71	-	440	1283	-	108	2440	620	0.0	21.0	0.098	0.202
183	10-28-71	-	490	1932	-	116	2980	1065	0.0	26.4	0.040	0.200
185*	11-01-71	-	220	271	-	80	1210	350	0.0	5.0	0.040	0.510
187	11-03-71	-	360	1156	-	118	1360	1360	0.6	17.5	0.104	0.686

* Mix from sump disregarded in averages

TABLE A7

WASTE ANALYSIS SUMMARY SHEET
PRIMARY CELL

Sample No.	Date	Q cfs	BOD_5 mg/l	COD mg/l	DO mg/l	SO_4 mg/l	Total Solids mg/l	Susp. Solids mg/l	Set. Solids ml/l	NH_3-N mg/l	NO_2-N mg/l	NO_3-N mg/l
105	6-22-71	-	14.0	27.9	7.2	142	870	28	0	0	0.050	0.160
106	6-23-71	-	9.0	51.8	8.5	200	1100	15	0.05	0	0.047	0.173
107	6-25-71	-	15.0	60.0	9.5	121	602	3	0	0	0.080	0.280
108	6-28-71	-	32.0	20.0	2.6	154	922	-	0	0	0.092	0.248
109	6-29-71	-	-	76.0	1.1	138	-	-	0	0	0.118	0.232
110	6-30-71	-	20.0	44.0	1.7	130	980	12	0	0	0.089	0.254
111	7-01-71	-	-	168.0	1.0	142	1370	249	0	0	0.118	0.182
112	7-07-71	-	-	136.0	2.5	128	1044	0	0	0	0.070	0.130
113	7-08-71	-	30.0	44.0	2.2	124	990	-	0	0	0.059	0.141
114*	7-09-71	-	12.0	20.0	7.1	94	988	548	1.5	0	0.041	0.529
116	7-14-71	-	18.0	28.0	13.6	136	872	29	0	0	0.108	0.262
117	7-15-71	-	15.0	52.0	11.5	138	822	34	0	0	0.104	0.246
118	7-16-71	-	12.0	12.1	4.2	128	950	3	0	0	0.092	0.238
119	7-19-71	-	13.0	-	1.7	118	952	6	0	0	0.036	0.084
120	7-20-71	-	8.0	52.0	2.0	98	952	1	0	0	0.045	0.125
121	7-21-71	-	25.0	153.0	1.3	150	1072	154	0	0	0.032	0.088
122	7-22-71	-	15.0	36.0	2.5	130	1230	0	0	0	0.039	0.121
123	7-23-71	-	-	40.0	3.5	118	754	0	0	0	0.072	0.108
124	7-27-71	-	27.0	-	1.6	-	928	0	0	0	0.037	0.103
125	7-28-71	-	38.0	60.0	1.8	108	-	0	0	0	0.049	0.117
126	7-29-71	-	18.0	44.0	2.4	118	994	0	0	0	0.056	0.133
127	7-30-71	-	-	-	3.0	130	1028	0	0	0	0.037	0.131
128	8-02-71	-	-	44.0	3.7	138	988	3	0	0	0.043	0.104
129	8-03-71	-	16.0	112.0	2.6	150	1060	2	0	0	0.061	0.133
130	8-05-71	-	20.5	64.0	2.8	130	1040	2	0	0	0.043	0.137
131	8-06-71	-	24.5	42.0	-	150	1028	17	0	0	0.049	0.139
132	8-09-71	-	11.0	58.0	3.6	150	1068	-	0	0	0.041	0.137
133	8-10-71	-	24.5	62.0	-	134	1018	2	0	0	0.043	0.111
134	8-11-71	-	30.0	30.0	1.6	130	1020	5	0	0	0.033	0.109
135	8-12-71	-	-	71.0	2.2	118	1082	3	0	0	0.053	0.107
136	8-13-71	-	11.0	42.0	-	142	992	3	0	0	0.037	0.087
137	8-16-71	-	36.0	-	2.5	114	1192	-	0	0	0.033	0.070

* Sample of river water at outfall

TABLE A7

WASTE ANALYSIS SUMMARY SHEET
PRIMARY CELL

Sample No.	Date	Q cfs	BOD_5 mg/l	COD mg/l	DO mg/l	SO_4 mg/l	Total Solids mg/l	Susp. Solids mg/l	Set. Solids ml/l	NH_3-N mg/l	NO_2-N mg/l	NO_3-N mg/l
138	8-17-71	-	30.0	29.0	1.9	134	1048	7	0	0	0.032	0.078
139	8-18-71	-	11.0	33.0	1.6	130	1002	2	0	0	0.033	0.077
140	8-19-71	-	7.0	33.0	0.7	104	-	-	0	0	0.028	0.122
141	8-20-71	-	3.2	29.0	0.7	124	856	2	0	0	0.028	0.082
142	8-23-71	-	5.3	46.0	3.3	150	1306	22	0	0	0.022	0.088
143	8-24-71	-	2.6	42.2	2.2	110	1094	5	0	0	0.029	0.101
144	8-25-71	-	3.9	42.0	1.3	134	998	2	0	0	0.031	0.069
145	8-26-71	-	5.4	77.0	2.8	124	1002	-	0	0	0.032	0.118
146	8-27-71	-	14.7	79.0	1.9	116	1056	10	0	0	0.029	0.091
147	8-30-71	-	8.8	30.7	2.7	138	1066	2	0	0	0.039	0.129
148	8-31-71	-	5.2	38.4	2.4	122	1104	2	0	0	0.029	0.071
149	9-01-71	-	2.4	3.8	2.0	134	1080	-	0	0	0.029	0.151
150	9-02-71	-	18.0	26.9	2.2	128	928	2	0	0	0.026	0.114
151	9-03-71	-	9.0	69.1	2.6	128	790	0	0	0	0.024	0.076
152	9-07-71	-	16.9	43.3	1.8	122	938	7	0	0	0.080	0.410
153	9-08-71	-	10.9	51.2	1.6	114	1202	4	0	0	0.080	0.140
154	9-09-71	-	9.5	27.6	2.0	96	1010	9	0	0	0.067	0.133
155	9-10-71	-	6.2	15.7	0.6	260	864	2	0	0	0.061	0.059
156	9-13-71	-	12.0	57.0	2.9	110	1034	2	0	0	0.022	0.078
157	9-14-71	-	11.6	74.8	3.6	122	912	-	0	0	0.024	0.136
162	9-17-71	-	8.0	48.0	4.6	138	676	2	0	0	0.020	0.160

TABLE A8

WASTE ANALYSIS SUMMARY SHEET
SECONDARY CELL

Sample No.	Date	Q cfs	BOD_5 mg/l	COD mg/l	DO mg/l	SO_4 mg/l	Total Solids mg/l	Susp. Solids mg/l	Set. Solids ml/l	NH_3-N mg/l	NO_2-N mg/l	NO_3-N mg/l
92	5-27-71	-	11.0	84.0	3.8	122	1242	44	0	0	0.089	0.861
93	5-31-71	-	3.0	76.4	2.8	158	846	8	0	0	0.078	0.630
94	6-01-71	-	5.0	80.2	4.1	138	1174	0	0	0	0.072	0.408
95	6-02-71	-	12.8	-	4.0	154	914	11	0	0	0.074	0.376
96	6-03-71	-	16.0	63.7	5.0	104	-	69	0	0	0.061	0.359
97	6-04-71	-	4.8	75.7	4.2	142	1010	100	0	0	0.056	0.294
98	6-06-71	-	15.6	-	4.8	150	1186	12	0	0	0.061	0.179
99	6-07-71	-	5.2	-	6.0	150	1142	72	0	0	0.047	0.253
100	6-09-71	-	10.5	-	8.8	142	958	0	0	0	0.050	0.200
101	6-10-71	-	10.4	115.0	10.8	-	1122	14	0	0	-	-
102	6-11-71	-	-	63.76	4.7	116	1052	26	0	0	0.050	0.180
104	6-21-71	-	13.0	43.8	2.0	128	838	20	0	0	0.053	0.153
105	6-22-71	-	12.0	-	2.1	110	1016	17	0	0	0.053	0.117
106	6-23-71	-	9.0	35.9	3.3	130	840	6	0	0	0.059	0.151
107	6-25-71	-	13.4	24.0	2.4	138	788	2	0	0	0.061	0.179
108	6-28-71	-	24.0	36.0	0.1	146	1034	-	0	0	0.089	0.251
109	6-29-71	-	16.0	24.0	1.4	130	-	-	0	0	0.104	0.266
110	6-30-71	-	20.0	72.0	1.4	118	1092	16	0	0	0.086	0.214
111	7-01-71	-	16.0	52.0	8.4	116	2786	17	0	0	0.101	0.189
112	7-07-71	-	-	76.0	2.5	146	1550	5	0	0	0.092	0.098
113	7-08-71	-	12.0	16.0	4.0	116	1008	-	0	0	0.061	0.159
114	7-09-71	-	10.5	20.0	5.8	140	1264	-	0	0	0.067	0.143
115	7-13-71	-	7.0	40.0	13.6	118	870	12	0	0	0.132	0.198
116	7-14-71	-	17.0	76.0	12.7	118	2144	7	0	0	0.118	0.222
117	7-15-71	-	15.0	60.0	6.3	86	842	16	0	0	0.121	0.239
118	7-16-71	-	14.0	20.0	2.2	130	914	30	0	0	0.118	0.282
119	7-19-71	-	13.5	-	3.5	130	922	16	0	0	0.083	0.137
120	7-20-71	-	12.5	40.0	2.3	128	1076	-	0	0	0.049	0.111
121	7-21-71	-	11.0	36.0	2.4	118	986	2	0	0	0.056	0.124
122	7-22-71	-	10.0	12.0	3.1	158	1206	-	0	0	0.050	0.130
123	7-23-71	-	-	24.0	4.7	130	762	-	0	0	0.064	0.146
124	7-27-71	-	29.0	-	2.7	-	1000	-	0	0	0.064	0.106
125	7-28-71	-	7.0	40.0	4.6	130	-	-	0	0	0.052	0.138
126	7-29-71	-	18.0	32.0	2.1	124	974	-	0	0	0.045	0.125

TABLE A8

WASTE ANALYSIS SUMMARY SHEET
SECONDARY CELL

Sample No.	Date	Q cfs	BOD_5 mg/l	COD mg/l	DO mg/l	SO_4 mg/l	Total Solids mg/l	Susp. Solids mg/l	Set. Solids ml/l	NH_3-N mg/l	NO_2-N mg/l	NO_3-N mg/l
127	7-30-71	-	-	-	3.1	114	1048	0	0	0	0.070	0.110
128	8-02-71	-	-	40.0	2.6	116	960	1	0	0	0.040	0.170
129	8-03-71	-	7.0	81.0	3.0	150	-	12	0	0	0.050	0.130
130	8-05-71	-	11.0	61.0	5.2	122	1024	2	0	0	0.061	0.149
131	8-06-71	-	23.0	42.0	4.9	142	1032	18	0	0	0.040	0.120
132	8-09-71	-	23.5	77.0	5.0	150	776	-	0	0	0.089	0.141
133	8-10-71	-	28.0	100.0	-	150	1326	2	0	0	0.074	0.146
134	8-11-71	-	30.0	33.0	1.6	128	1052	4	0	0	0.050	0.110
135	8-12-71	-	-	104.0	2.1	158	1042	4	0	0	0.049	0.091
136	8-13-71	-	18.0	37.0	2.2	134	1020	3	0	0	0.050	0.110
137	8-16-71	-	*36.0	21.0	5.7	138	1312	-	0	0	0.052	0.108
138	8-17-71	-	21.0	29.0	5.7	110	904	5	0	0	0.056	0.094
139	8-18-71	-	11.0	37.0	2.7	128	998	2	0	0	0.049	0.101
140	8-19-71	-	5.3	71.0	2.0	122	-	-	0	0	0.033	0.087
141	8-20-71	-	3.2	37.0	2.3	128	886	2	0	0	0.010	0.080
142	8-23-71	-	1.0	146.0	4.7	122	1090	0	0	0	0.040	0.080
143	8-24-71	-	5.0	65.0	4.4	110	1158	7	0	0	0.037	0.073
144	8-25-71	-	2.3	57.0	2.5	122	1298	2	0	0	0.024	0.116
145	8-26-71	-	3.0	73.0	4.0	114	1002	-	0	0	0.022	0.078
146	8-29-71	-	-	58.0	2.5	154	1000	13	0	0	0.033	0.117
147	8-30-71	-	10.0	69.0	2.8	124	1162	2	0	0	0.039	0.101
148	8-31-71	-	4.8	46.1	2.8	118	1080	0	0	0	0.040	0.110
149	9-01-71	-	5.2	11.5	4.0	134	1046	-	0	0	0.033	0.107
150	9-02-71	-	-	30.7	4.3	138	2076	2	0	0	0.041	0.109
151	9-03-71	-	11.4	34.6	4.6	130	836	1	0	0	0.019	0.141
152	9-07-71	-	13.6	125.9	3.5	116	1904	0	0	0	0.180	0.190
153	9-08-71	-	6.9	59.0	2.9	114	1302	5	0	0	0.114	0.166
154	9-09-71	-	7.9	35.4	1.5	134	1040	2	0	0	0.240	Combined
155	9-10-71	-	8.2	19.7	1.2	114	730	2	0	0	0.074	0.086
156	9-13-71	-	9.8	47.0	3.8	134	864	2	0	0	0.037	0.093
157	9-14-71	-	4.8	31.5	5.6	104	1210	-	0	0	0.043	0.117
159	9-15-71	-	4.4	39.4	6.1	182	610	0	0	0	0.041	0.119

* Disregard as BOD must be less than COD

TABLE A8

WASTE ANALYSIS SUMMARY SHEET
SECONDARY CELL

Sample No.	Date	Q cfs	BOD_5 mg/l	COD mg/l	DO mg/l	SO_4 mg/l	Total Solids mg/l	Susp. Solids mg/l	Set. Solids ml/l	NH_3-N mg/l	NO_2-N mg/l	NO_3-N mg/l
161	9- 16-71	-	5.2	24.0	5.7	158	1366	-	0	0	0.032	0.118
162	9- 17-71	-	6.9	39.4	6.4	154	586	2	0	0	0.045	0.125
163	9- 20-71	-	16.4	79.0	-	138	1354	15	0	0	0.047	0.173
166	9- 24-71	-	14.4	54.9	12.1	122	-	14	0	0	0.050	0.150
168	9- 28-71	-	13.6	23.5	9.4	118	956	12	0	0	0.061	0.219
169	10- 04-71	-	14.4	66.6	7.9	94	890	5	0	0	0.052	0.228
172	10- 07-71	-	10.0	43.0	5.3	110	810	21	0	0	0.037	0.023
173	10- 11-71	-	12.8	35.3	7.0	108	1066	15	0	0	0.010	0.150
175	10- 13-71	-	6.0	20.0	7.6	138	1132	0	0	0	0.039	0.201
179	10- 21-71	-	24.4	76.0	-	124	806	11	0	0	0.061	0.229
180	10- 22-71	-	21.0	88.0	-	114	652	1	0	0	0.045	0.135
182	10- 26-71	-	10.8	43.3	4.5	130	812	-	0	0	0.015	0.145
184	10- 29-71	-	7.6	54.0	3.8	124	712	2	0	0	0.018	0.142
186	11- 02-71	-	18.0	51.5	1.9	124	836	19	0	0	0.026	0.314
188	11- 08-71	-	11.2	16.0	8.2	128	1434	0	0	0	0.020	0.240
189	11- 11-71	-	7.2	-	7.0	146	1504	2	0	0	0.008	0.192
190	11- 12-71	-	1.2	15.0	5.6	142	1406	12	0	0	0.013	0.267

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8. Performing Organization Report No.	
7. Author(s)	Moore, Clifford R. Moore Engineering, Inc.
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9. Organization	Moore Engineering, Inc. Consulting Engineers 219 West Main Avenue West Fargo, North Dakota
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16. Abstract

Laboratory studies of livestock waste were conducted both before and after the construction of an enlarged settling basin, a hydrasieve at the truck washrack and a two cell waste stabilization pond. A determination of the effectiveness of these two systems and the application of them to feedlots and other livestock facilities in the area were the main objectives.

The settling basin and hydrasieve were effective in removing solids and COD from the truck washrack waste. Reductions in COD, total, suspended, and settleable solids were 23.9, 14.8, 50 and 80 percent, respectively. DO increased 42.8 percent and total solids decreased 3 percent across the hydrasieve. This 3 percent consisted of straw and other floating debris which would not be removed at the stabilization pond.

The effectiveness of the stabilization ponds was generally good. The BOD_5 of the final effluent was reduced 48.6 percent over that of the drainpipe which had drained directly into the Sheyenne River during previous years.

17a. Descriptors *Cattle, *Hogs, *Sheep, *Animal Wastes, BOD, COD, Waste treatment, Settling basin, Nitrates, Groundwater

17b. Identifiers *Stockyards, *Hydrasieve, Sheyenne River, Truck washrack, Feedlots, Solids separation

17c. COWRR Field & Group Ø5D, Ø5E, Ø5F

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