 Report No. 109

ANIMAL FEEDLOT RUNOFF IN THE PIEDMONT

by R. O. Hegg, C. L. Barth, and W. H. Hanvey

Department of Agricultural Engineering

Clemson University, Water Resources Research Institute

Clemson, South Carolina 29631

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Final Technical Completion Report

to

Bureau of Reclamation

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ABSTRACT

This project was designed to determine the quantity and quality of rainfall runoff from a 10-acre feedlot in the Piedmont and to evaluate a grassed waterway or overland flow treatment for final disposal of this runoff. Due to extremely dry conditions during the last two years of the study there was not enough runoff to initiate the land application phase of the proposed project.

A sampling station was installed to sample the feedlot runoff and to measure the quantity of runoff before it entered an earthern settling basin (designed to hold approximately one inch of runoff). Animal stocking rates ranged from 4400 ft^2/hd to infinity (no animals on the feedlot). Runoff volume and percentage of rain that resulted in runoff were dependent on rainfall duration, rainfall intensity, vegetative cover, slope, antecedent soil moisture and soil type. The percentage of runoff ranged from 2 to 99 percent depending on the above conditions. There was no direct relationship between average rainfall intensity (ranged from 0.01 to 0.6 in/hr) and the percentage of runoff due to the variability of parameters involved.

Runoff wastewater quality results were highly variable. Typical average values by storm were: pH, 6.5-7.2; total coliform bacteria 6E5-3E7 col/100 ml; total fecal coliform, 0-2E6 col/100 ml, total organic carbon, 4-900 mg/L; total kjeldahl nitrogen, 2-30 mg/L; total phosphorus, 1-50 mg/L; chemical oxygen demand, 30-1400 mg/L, fixed solids, 30-3400 mg/L; volatile solids, 200-2000 mg/L; nitrate-nitrogen, 0.2-10 mg/L; and ammonia-nitrogen, 1-10 mg/L.

Feedlot runoff from a lightly stocked feedlot does contain enough nutrients and bacteria to create a potential water pollution problem. The sediment removal from the feedlot on a per storm basis ranged from less than 1 lb/ac to more than 100 lbs/ac. The overall average was approximately 17 lbs/ac per storm.

ACKNOWLEDGEMENTS

The cooperation of the Animal Science Department at Clemson University was extremely beneficial in completion of this project. They made land available for the settling basin and the utilization/disposal area. W. H. Hanvey and T. G. King were graduate students who maintained the field equipment and analyzed the data. Thanks are expressed to R. E. Gantt and L. S. McCarthy for sample collection, field work and water analysis.

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INTRODUCTION

The Southeastern Region of the United States is characterized by warm temperatures and high rainfalls. The high rainfalls in the Piedmont area, which has low permeable soils and an undulating topography, result in large volumes of runoff. Runoff from concentrated livestock areas can contaminate and degrade surface water supplies of the State. The present State guidelines require that livestock operations prevent runoff from entering lakes or streams because of the nutrients and sediment contained in runoff. There was a need to evaluate the treatment capability of a grassed waterway for removing nutrients and sediment prior to stream discharge. Another need was to evaluate the treatment of runoff applied onto grassed areas set aside as a disposal site. Both of these approaches would provide the necessary information regarding the potential use of overland flow (OLF) as a treatment system in the Piedmont region of the Southeastern United States.

OBJECTIVES

This report completes a 3-year study concerning runoff from a beef feedlot in the Piedmont and the treatment of this water using a plant-soil system. The specific objectives were:

1. Determine the quantity and quality of runoff from an unsurfaced beef feedlot in the Piedmont Region.
2. Determine the changes in water quality of stored beef feedlot runoff resulting from treatment and dilution in a grassed waterway.
3. Determine the nutrient and sediment removal rates of feedlot runoff using overland flow treatment.

This project fit into two of the identified research needs developed by the South Carolina Water Resources Research Institute. These identified needs are: (1) effects of land use on water quality and quantity and (2) land application of waste waters and sludges.

LITERATURE REVIEW

A great deal of research has been conducted on control and disposal of beef feedlot runoff in the Midwest (Swanson et al., 1975) (Nienaber et al., 1975) (Schottman et al., 1975) (Satterwhite and Gilbertson, 1972) (Linderman and Mielke, 1975). Estimates of feedlot runoff from a more humid area (Ohio) were reported by Edwards and McGuiness (1975). Wallingford et al. (1975) conducted studies in Kansas on the use of beef feedlot lagoon water and manure on corn using furrow irrigation as the means of application. Powers et al. (1973) developed guidelines for disposal of feedlot lagoon water. The build up of the salt levels in the soil from the manure may be the limiting parameter for applying animal waste to the soil. Electrical conductivity of the soil serves as a measure of salt levels relative to the tolerance levels of crops. Wittmuss (1975) described some of the engineering practices related to the disposal site for the most effective design of a land treatment system.

Overcash et al. (1976) evaluated the overland flow (OLF) system for municipal, industrial and agricultural waste disposal. They concluded that OLF was a good method for treatment if the objective is to minimize the land area needed by reducing the quantity of nitrogen (N). The loss of N by nitrification-denitrification and ammonia volatilization accounted for 50-70 percent of the influent N in poultry wastes. Terraces with 6-8 percent slope and various lengths to 54 ft were planted with Reed Canary grass and used as

disposal sites. Three different loading schemes were used to study the system (1) frequency of loading (daily or every other day), (2) flow rate per unit time, and (3) total N load applied. Swine lagoon effluent was applied to research plots of 3 percent slope (Willrich and Boda, 1976). Sutton et al. (1976) also conducted studies using a settling basin followed by a grassed infiltration channel for controlling runoff from an open swine feedlot. Westerman et al (1977) used swine lagoon effluent on fescue and coastal bermuda grass. Proper design of a waste disposal system must consider the soil properties, reactions of the chemical properties of the waste and soil, selection of proper crops and the climatological characteristics (Larson and Gilley, 1974).

EXPERIMENTAL PROCEDURE

The beef feedlot at the Clemson University Simpson Experiment Station was chosen as the site for this study. This feedlot (unsurfaced, 10.19 ac), consisted of four 1.73 acre lots and one 3.27 acre lot (Figure 1). All surface runoff except approximately 0.5 ac drains into a culvert under the adjacent paved road. This culvert drains into an earthern settling basin located across the paved road from the feedlot (Figure 2). The feedlot is ideally situated because three sides are along ridges and the fourth side is along the road, which means very little non-feedlot runoff water enters the culvert. Slope on the feedlot ranges from 2.2 - 9.1 percent (average of 5.7 percent). The feedlot was designed for up to 250 animals (approximately 1500 ft^2/animal).

By draining into an earthern basin, runoff velocity is reduced, allowing a portion of the solids to be removed by gravity settling. The schematic drawing of Figure 3 shows the overall design and options for handling this

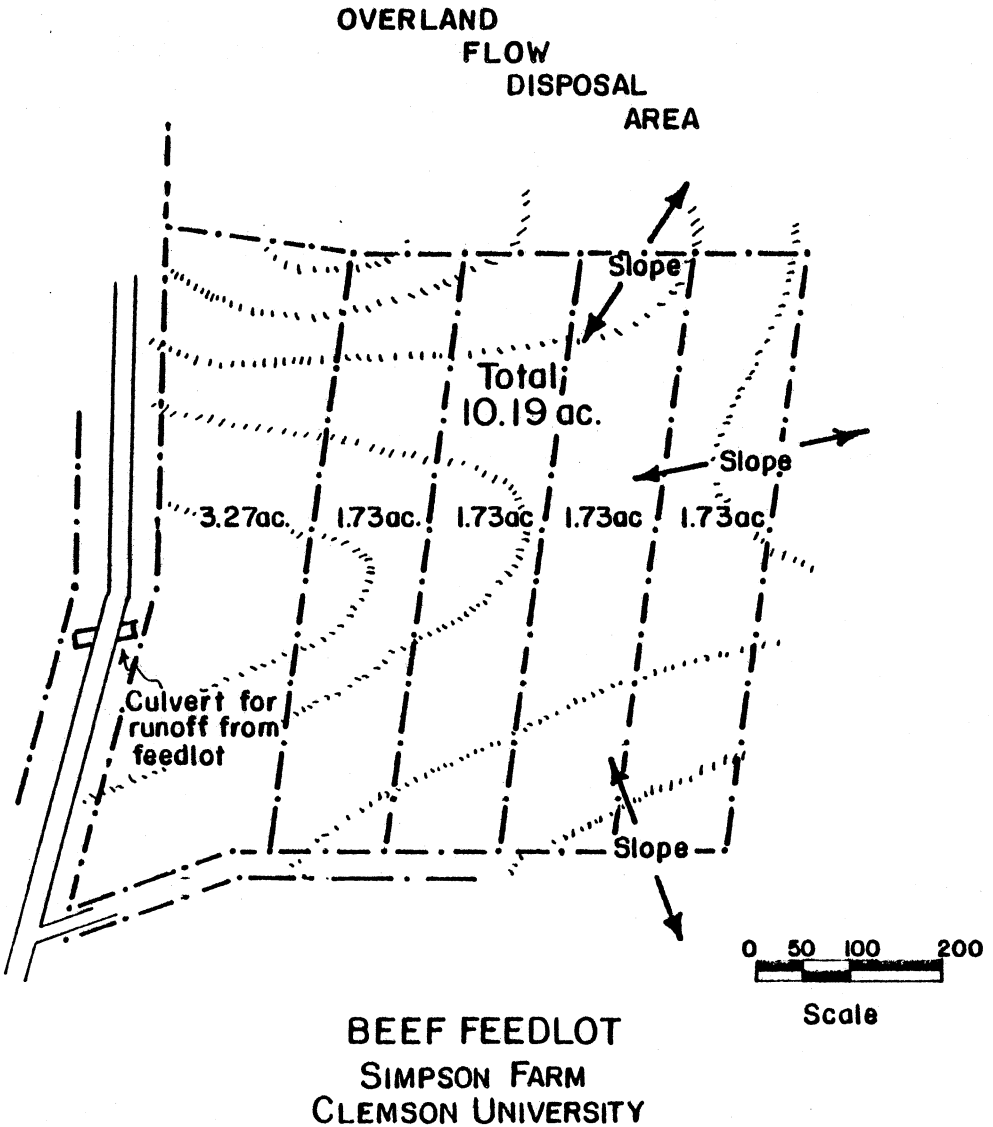

Figure 1. Plan view of beef feedlot.

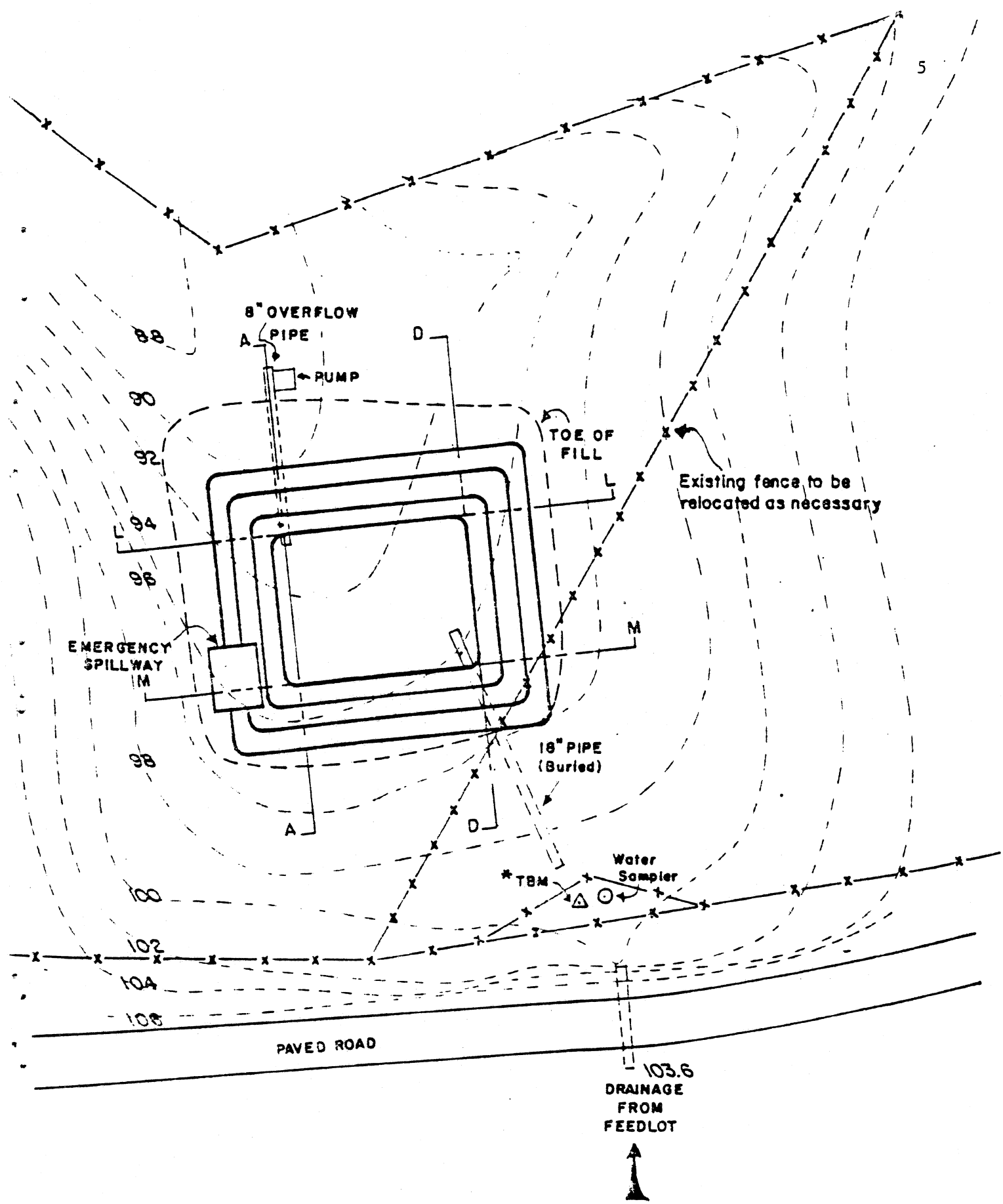

Figure 2. Plan view of settling basin.

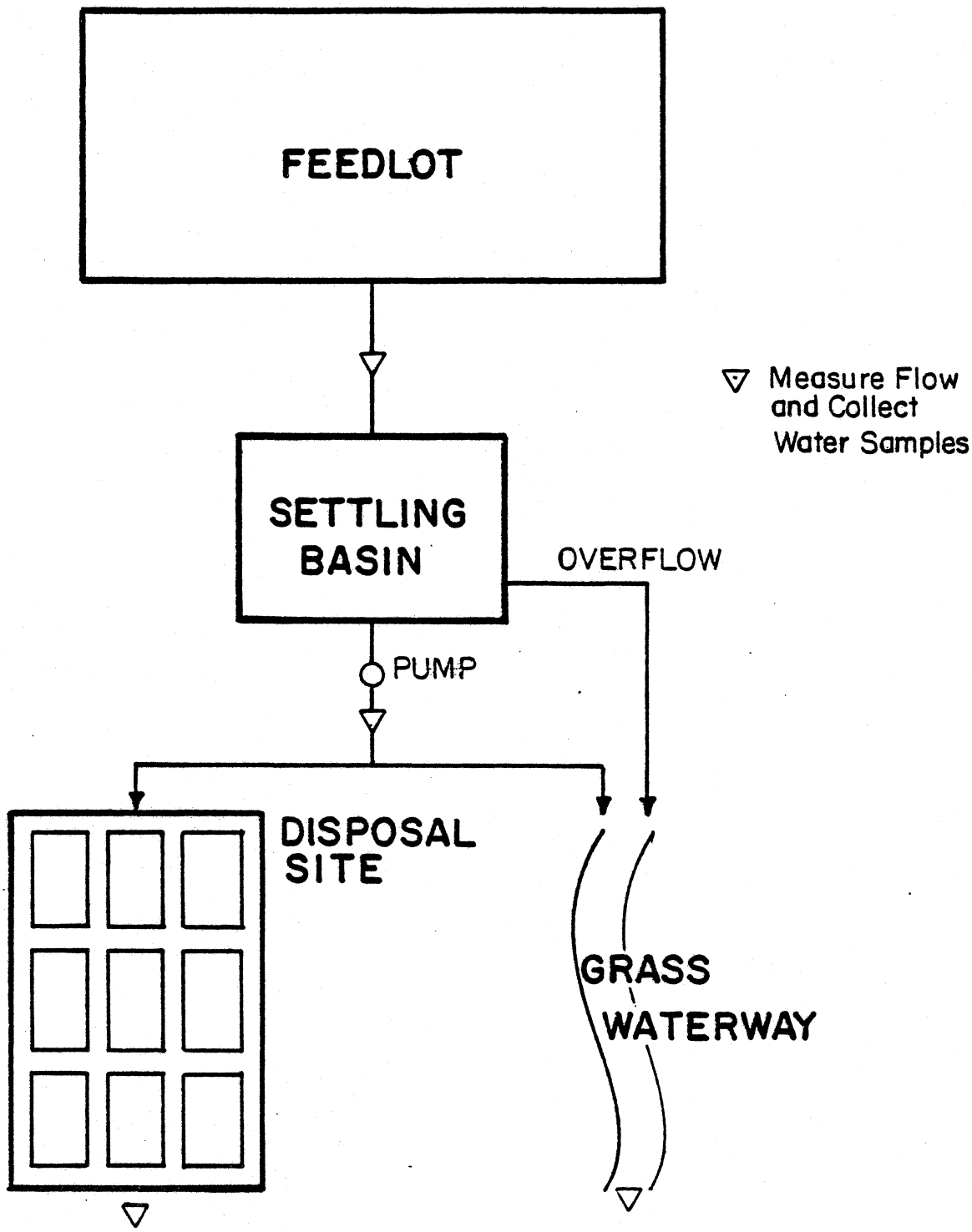

Figure 3. Flowchart showing options for handling the feedlot rainfall runoff.

runoff. The primary option was to treat the runoff water by the OLF system on a pasture area adjacent to the feedlot as indicated in Figure 1.

An eight-inch galvanized culvert laid horizontally and at the same elevation as the bottom of the basin provided water to the irrigation pump and also served as a method for discharging water to the existing grassed waterway. An eight inch riser from the culvert allowed excess water to discharge to the grassed waterway. An emergency spillway was also built into the settling basin nine inches above the top of the eight-inch riser.

The settling basin was not designed to contain the 25-year, 24-hour storm as is generally recommended for runoff control structures for animal waste system. The settling basin had bottom dimensions of 60 feet by 80 feet with a maximum depth of eight feet. Due to sediment accumulation over several years, the operational depth will probably be less than eight feet. Based on a six-foot operating depth the settling basin will hold approximately 30,000 ft^3. A one-inch runoff from the 9.5 ac of the feedlot that drains to the settling basin will generate 34,500 ft^3 of water.

A sampling station was installed in late 1978 to measure the quanity of runoff from the feedlot and to collect runoff samples at various intervals during a rain storm. This sampling station was located just below the culvert that received the runoff from the feedlot and prior to the settling basin. The sampling station consisted of: (1) recording rain gage, (2) 2:1 V-notched weir (3/4 inch plywood), (3) stilling well with a water level recorder, (4) float switch to activate water sampler and (5) an automatic water sampler (Model 1680, Instrumentation Specialities Company). The water level recorder gave a continuous readout of the depth of water passing through the V-notched weir vs. time. The float switch was mounted on the weir and adjusted to activate the automatic sampler when runoff began flowing

over the weir. The sampler (capacity for 28 samples) was set to collect a 500 ml sample each hour whenever there was flow over the weir. The 500 ml samples were normally paired (1-2, 3-4, etc.) to make a 1000 ml sample for laboratory analysis. One to 14 water samples, depending on the duration of the runoff event, were analyzed.

Laboratory analysis was done in the Agricultural Engineering Chemical and Biological Laboratory at Clemson University. Analyses performed on the runoff samples included: total kjeldahl-nitrogen (TKN), ammonia-nitrogen (NH3-N), nitrate-nitrogen (NO3-N), total phosphate (TP) chemical oxygen demand (COD), total organic carbon (TOC), total solids (TS), volatile solids (VS), total coliform (TC), fecal coliform (MFC) and pH. Ammonia-N was determined by the steam distillation method and phosphate by the vanadomolybdophosphoric acid method. All other procedures were done according to Standard Methods (1975).

To calculate the volume of runoff, readings were taken from the water level recorder hydrograph at hourly intervals. Each successive pair of readings was added together and divided by two to give an average depth for each hour. The averages were then converted to volume using the equation (King, 1954):

$$Q = 2.5 \tan \frac{\theta}{2} H^{2.5}$$

H = depth (ft)

Q = volume of flow, cubic feet per second (cfs)

θ = 127° for a 2:1 V-notched weir

To calculate the mass of a nutrient that ran off the feedlot the volume was multiplied by the concentration of the particular nutrient and the necessary conversion factors.

All feedlot runoff data was entered into an IBM computer located on campus for statistical evaluation. Arithmetic means of the various water quality results were calculated and graphs of concentration vs. time were plotted using the Statistical Analysis System (SAS) also available at the Clemson University Computer Center.

The pump and distribution system for the OLF treatment was installed in the fall of 1979 and consisted of the following equipment and controls:

1. 5 HP, Berkley B 1 1/2 TPLS pump, single phase, 230 volt, 140 foot TDH at 75 gpm.
2. 2 1/2 inch bronze gate valve (two).
3. Filter assembly for above pump, 100 mesh screen, capable of handling 100 gpm.
4. 2 1/2 inch, discharge check valve.
5. Pump starter, overload protection for 5 HP pump, with hand-off operate switch.
6. Automatic irrigation controller, 0-24 hours of irrigation with 15 minute increment control, 5 stations,) (Bartrow Model 305-12, Short Beach, Conn.).
7. Solenoid valves, rainbird EP100F (three).
8. 2 1/2 inch PVC pipe, 160 lb. (1200 ft).
9. 1 inch PR200 PVC pipe (200 ft).
10. Spray heads (18), (Rainbird 2400).
11. #12 Conductor wire, for underground use (4800 ft).
12. #16 Control wire (100 ft).

Three sites were selected on an existing fescue pasture adjacent to the feedlot for use in the OLF treatment of the runoff. The soil was a Cecil sandy loam (Clayey, kaolinitic, thermic typic Hapludults). Under ideal conditions, site preparation is the initial procedure in the establishment of an OLF site. This consists of top soil removal, land leveling to the desired slope, replacement of top soil and reseeding. The chosen areas were used

just as they were with no land leveling or reseeding. The average slope on the three different sites was 2, 4 and 8%. For each site six spray heads were mounted on 1/2 inch PVC risers at 10 ft intervals in a line perpendiular to the slope. The spray heads produced a 20 ft diameter pattern at 40 psi (15 gpm). It was expected that some channelling of the surface flow would take place due to the sites not being leveled. Grab sampling of the surface flow was to be done at intervals of 50 feet downslope from the spray heads.

RESULTS AND DISCUSSION

Due to low rainfall in 1980 and 1981 there was an inadequate amount of runoff to operate the OLF system or to discharge water from the holding basin to the grassed waterway. There were some equipment problems and also a shortage of water in 1982. For these reasons this report will address only objective one: to determine quantity and quality of runoff from an animal feedlot area.

Appendix B provides detailed information on individual storms and the resultant runoff volumes and water quality. Appendix C lists the average water quality concentration for twelve parameters for 78 storms. Some data points are missing due to various factors, such as analysis errors, sample discarded and equipment failures (rain gage, stage recorder or sampler).

Many factors are involved in producing a runoff event and may include: rainfall duration, rainfall intensity, vegetative cover, slope, preceeding soil moisture conditions, and soil type. In this project, two of these factors were constant (slope and soil type) while the remaining factors varied from storm to storm. The interaction of these other factors influenced the volume of runoff and the quality of the water. Figure 4 shows that there is very little relationship between rainfall intensity and the

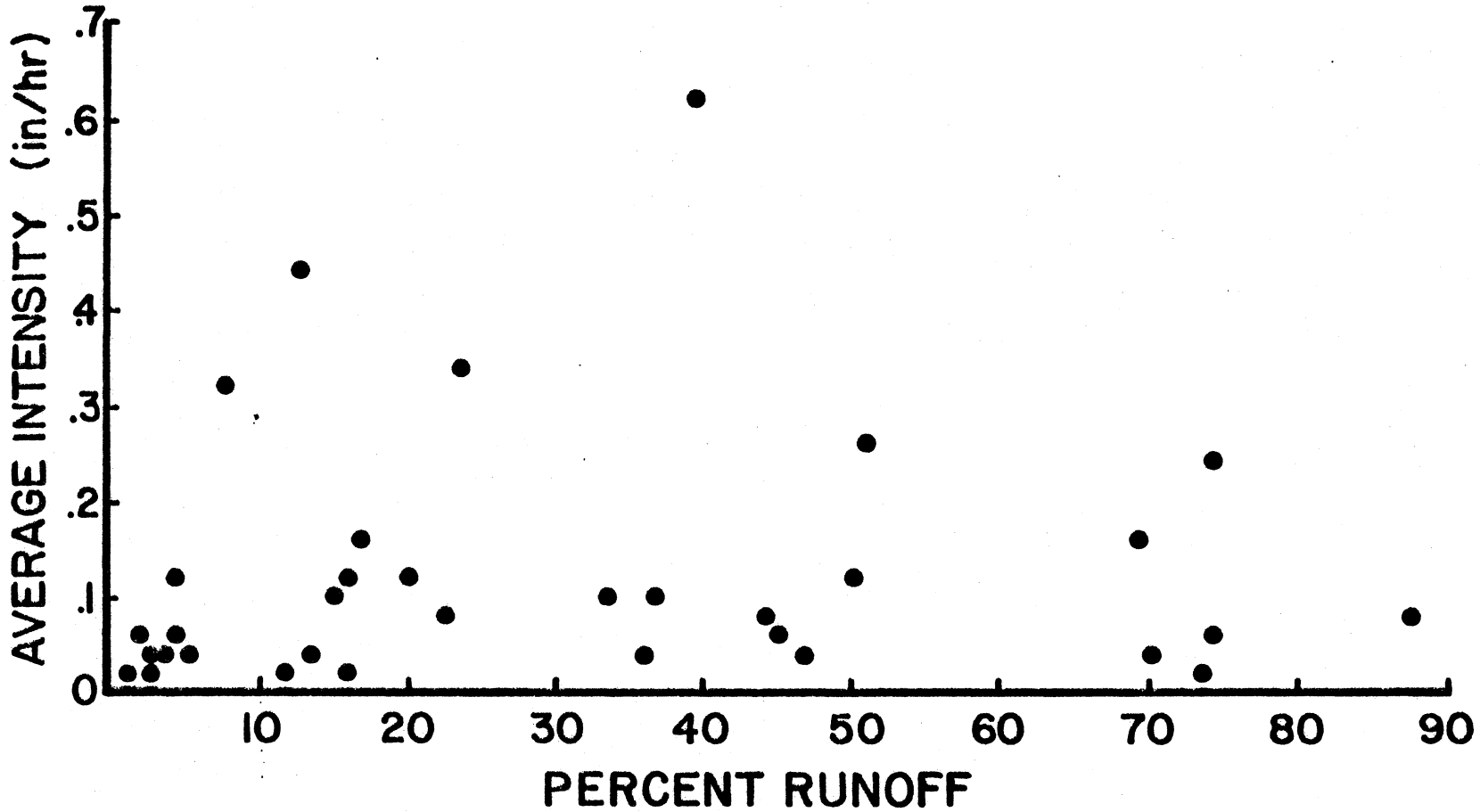

Figure 4. The percentage of feedlot rainfall runoff vs. the average rainfall intensity.

percentage of runoff from this feedlot. A majority of the intensities were from 0.01 to 0.2 in/hr but the percentage of runoff ranged from less than 5% to over 90%. This means that it is nearly impossible to predict runoff percentage based on average rainfall intensity. Table 1 lists the average fixed solids (FS) value per storm and the corresponding FS loss on a per acre basis. The pounds per acre of fixed solids removed was calculated from the formula:

$$LBSACR = AFS \times 28.27 \times ROV / 2.09\ E+7,$$

where LBSACR is pounds per acre of FS, AFS is the average concentration of FS in mg/L over the event, and ROV is the volume of runoff in cubic feet. Of the 47 storms evaluated only two had values over 100 lbs per acre (storms no. 73 and 74). These values occurred when there was a moderate stocking rate on the feedlot (Table 2) and there was almost no vegetation on the feedlot. The average sediment loss from 11 storms when no animals were on the feedlot was 5.4 lb/ac and from 35 storms with animals on the feedlot the average was 20.3 lb/ac. The mean loss for all 46 storms was 16.8 lb/ac. The total erosion for storms 1-51 (1979) was 0.03 tons/ac/yr and for 1980 (storms 52-95) it was 0.34 tons/ac/yr. The SCS has estimated that annual erosion in the Piedmont of SC as 13.83 tons/ac/yr for cropland and 0.34 tons/ac/yr for pastureland on slopes of 5-6%. The values from the feedlot are comparable to pastureland which means there is not a problem with erosion from a lightly stocked feedlot although there is slightly more erosion when more animals are present.

Lot 5 was closest to the road; therefore, if there were no animals in this lot the resulting vegetation served as a filter for the runoff from the upper lots. The stocking rate on the feedlot in this report was much less than for feedlots in the Western or Southwestern United States because these areas are much drier and the lots will generally have less slope.

Table 1. Rainfall and runoff characteristics from an unsurfaced feedlot.

	Storm number	Rainfall (inches)	Average intensity (in/hr)	Runoff volume (ft^3)	Percent runoff	Average fixed solids (mg/L)	Fixed solids loss (lbs/ac)
1	3	1.20	0.03	7069	17	266	2.5
2	21	0.62	0.31	1613	8	7200	15.7
3	23	2.03	0.09	23250	33	360	11.3
4	34	0.95	.	1450	4	800	1.5
5	42	.	.	262	.	400	0.1
6	43	0.19	0.09	1000	15	400	0.5
7	49	1.29	0.03	20595	46	1200	33.4
8	50	.	.	600	.	2300	1.8
9	51	.	.	75	.	533	0.0
10	52	0.45	0.02	2425	16	266	0.8
11	53	0.35	0.01	1374	11	1533	2.8
12	54	0.55	0.17	3150	17	4400	18.7
13	55	0.31	0.07	4775	45	400	2.5
14	56	1.57	0.05	19475	35	1333	35.1
15	57	.	.	2575	.	1000	3.4
16	59	0.37	.	3275	26	410	1.8
17	61	.	.	50	.	600	0.0
18	62	0.71	.	1050	4	1933	2.7
19	63	2.03	.	20150	29	914	24.9
20	65	1.03	0.06	26200	74	1866	66.1
21	67	0.24	0.02	6100	74	4400	36.3
22	68	2.33	0.26	40775	51	300	16.5
23	70	0.46	0.03	1800	11	1200	2.9
24	71	0.47	0.05	2150	13	2400	6.9
25	72	1.68	0.08	50750	88	600	41.1
26	73	1.35	0.08	10600	23	20433	292.9
27	74	2.09	0.08	32113	44	28100	1220.6*
28	75	0.31	0.16	10690	99	800	11.5
29	77	0.63	0.16	14999	69	3000	60.8
30	83	1.07	0.12	7400	20	1500	15.0

* value not used in calculating mean because it was larger than all other 46 storms combined.

Table 1. (cont.)

	Storm number	Rainfall (inches)	Average intensity (in/hr)	Runoff volume (ft^3)	Percent runoff	Average fixed solids (mg/L)	Fixed solids loss (lbs/ac)
31	85	2.11	.	5000	7	800	5.4
32	88	0.36	0.03	275	2	1100	0.4
33	89	0.34	0.34	2775	24	1500	5.6
34	90	0.81	0.11	10276	37	733	10.1
35	92	0.38	0.13	500	4	1000	0.6
36	93	0.16	0.02	150	3	200	0.0
37	94	0.13	0.01	2125	47	1600	4.6
38	95	1.25	0.62	16951	39	800	18.3
39	98	1.57	.	7080	13	525	5.0
40	99	0.46	.	1700	11	300	0.6
41	100	0.72	.	1376	6	333	0.6
42	109	1.34	.	1675	4	1700	3.8
43	110	0.24	.	350	4	600	0.2
44	113	0.22	.	1225	16	2720	4.5
45	115	0.69	.	525	2	1000	0.7
46	117	0.60	.	1025	5	600	0.8
47	118	0.70	.	500	2	900	0.6
							$\bar{x}$ = 17.0

Table 2. Stocking rate of animals on the feedlot.

Time Period	Number of Animals					Average Stocking Rate (ft^2/hd)	Storm Numbers Included
	lot 1	lot 2	lot 3	lot 4	lot 5		
1/1/79 - 5/1/79	20	20	20	20	19	4400	1 - 11
5/1/79 - 11/1/79	0	0	0	0	0	+	13 - 47
11/1/79 - 8/1/80	20	20	20	0	0	7260	48 - 78
8/1/80 - 10/1/80	0	0	0	0	0	+	83 - 85
10/1/80 - 2/1/81	0	0	0	24	24	9080	88 - 95
2/1/81 - 6/1/81	0	0	0	0	0	+	98 - 109
6/1/81 - 9/1/81	0	0	30	30	30	4840	110 - 118

+ no animals on the feedlot

A more complete picture of several selected storms is given in Table 3. A nearly complete set of information was available for these rainfall-runoff events. These seven storms are relatively large rainfalls with varying intensities (0.02 - 0.16 in/hr) and varying durations (7 - 29 hours). Storm 9 had the highest intensity and resulted in runoff 0.75 hours after the rain began. There was rain on the day preceeding storm 9 so the soil was already moist. The percent of the rain that ran off was 59 for storm 9. These variables (intensity, duration, preceeding rain) make it difficult to predict the runoff percentage for a given storm.

Average water quality of the runoff from storms is presented in Appendix C. There were wide ranges in the values of TOC and TS (1.2 - 962 mg/L and 33 - 30,600 mg/L, respectively). The other parameters had narrower ranges with TKN values from 2 - 74; PO4-P, 3 - 59; COD, 0.4 - 1613 and NO3-N, 0.21 - 12.9. Storms 13 - 47, 83 - 85 and 98 - 109 represent periods when there were no animals on the feedlot (Table 2). The concentrations of animals on the lots at other periods was relatively light so there is little difference in the water quality of the runoff whether there were animals on the lots or not.

For comparison purposes the water quality data from this feedlot is compared to data from two other states (Table 4). These states have higher animal concentrations (100 - 200 ft^2/animal) and this is reflected in the higher concentration except for TS.

Table 3. Results of selected rainfalls on beef feedlot

Storm Number	Date	Animal Stocking Rate (ft^2/hd)	Rainfall (inches)	Average Rainfall Intensity (in/hr)	Runoff Volume (ft^3)	Hours of Rain	Hours of Runoff	Lag* Time (hr)	Antecedent** Moisture	% Runoff
8	4/3/79	4400	0.80	0.10	8930	8	10	1.25	yes	39
9	4/4/79	4400	1.07	0.16	21960	7	10	0.75	yes	59
23	7/6/79	+	2.03	0.09	23250	22	10	-	no	33
24	7/9/79	+	0.51	0.02	-	29	18	-	yes	-
63	3/9/80	7260	2.03	-	20150	-	28	-	yes	29
73	5/17/80	7260	1.35	0.08	10600	18	-	1.75	no	23
98	2/18/81	+	1.50	-	7080	-	-	-	-	13

+ no animals on the feedlot

* hours between beginning of rain and beginning of runoff

** rain occurred within 3 days of a preceeding runoff event

Table 4. Water quality parameters of feedlot runoff.

Parameter	Range of Values		
	Clemson, SC	Nebraska*	Kansas**
pH	5.7 - 8.0	6.6 - 9.4	--
TKN (mg/1)	1.7 - 850	65 - 5765	165 - 1580
COD (mg/1)	0.4 - 3815	1300 - 77,804	800 - 16,000
VS (%)	0 - 0.36	0.12 - 1.50	0.36 - 0.96
TS (%)	0 - 3.06	0.24 - 3.30	0.84 - 1.92
NO_3-N (mg/1)	0.1 - 25.0	0 - 217	--
NH_4-N (mg/1)	0 - 483	2 - 1425	--
PO_4-P	0.9 - 72	4 - 5200	--

*McCalla
**USDA

CONCLUSIONS

1. Rainfall intensity was not correlated with the percentage of runoff from a rainstorm.
2. The overall sediment loss from this lightly stocked feedlot was 20.3 lbs/ac and when no animals were on the feedlot it was 5.4 lbs/ac. Both of these values are quite small and would cause no erosion problem.
3. The water quality results from the feedlot runoff were highly variable. Average values by storm ranged as follows: pH, 6.5-7.5; TC, 6E5-3E7; TFC, 0-2E6 (col/100ml); TOC, 4-900; TKN, 2-30; TP, 1-50; COD, 30-1400; FS, 30-3400; VS, 200-2000; NO3-N, 0.2-10 and NH3-N, 1-10 (as mg/l).

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Appendix A

Key to Symbols Used in Graphs and Tables

Symbol	Indicates
STORMNO	The number of the storms that produced this runoff event.
TC	Total coliform bacteria (colonies/100 ml).
MFC	Fecal coliform bacteria (colonies/100ml).
TOC	Total organic carbon (mg/l).
TKN	Total Kjeldahl nitrogen, the sum of ammonium nitrogen and organic nitrogen (mg/l).
PO_4P	Phosphate forms of phosphorous (mg/l).
COD	Chemical oxygen demand (mg/l).
FS	Fixed solids (mg/l).
VS	Volatile solids (mg/l).
TS	Total solids, the sum of fixed and volatile (mg/l).
NO_3N	Nitrate nitrogen (mg/l).
NH_3N	Ammonium nitrogen (mg/l).
PCTRUN	The percent of the total rainfall that the runoff represents.
INT	Rainfall intensity expressed in inches per hour.
RAINF	The quantity of rainfall expressed in inches.
ROV	The volume of runoff expressed as cubic feet.
A	An "A" preceeding a symbol means that it is the average value for the storm.

APPENDIX B. Water Quality data on feedlot runoff.

OBS	DATE1	DATE2	TIME1	TIME2	STORMNO	ROV	TS	FS	COD	PH	PO4P	TKN	TOC	NH3N	NO3N	TC	MFC
1	01/12/79	01/12/79	.	.	1	.	1140.00	584.00	345.90	6.7	9.2	27.0	.	9.13	1.72	6.0E+07	1.0E+08
2	02/08/79	02/09/79	.	.	2	8375.0	.	.	266.66	6.6	46.5	18.7	.	5.40	1.60	4.6E+05	7.0E+05
3	02/19/79	02/21/79	22:00	18:00	3	7069.0	933.33	266.66	209.91	6.8	6.2	30.2	.	6.00	2.40	4.6E+04	1.6E+05
4	02/22/79	02/25/79	19:00	18:00	4	66434.5	.	.	105.36	6.7	4.7	19.7	.	2.70	2.10	1.3E+06	1.0E+06
5	03/23/79	03/23/79	.	.	7	.	.	.	698.00	6.6	11.7	28.6	.	7.11	1.10	.	.
6	03/23/79	03/23/79	.	.	7	.	.	.	244.00	6.6	9.6	23.3	.	6.90	1.00	.	.
7	03/23/79	03/23/79	.	.	7	.	.	.	360.00	6.3	11.7	56.2	.	5.00	0.10	.	.
8	03/23/79	03/23/79	.	.	7	.	.	.	214.00	6.6	12.2	32.5	.	4.40	0.10	.	.
9	03/23/79	03/23/79	.	.	7	.	.	.	326.00	6.6	23.2	65.2	.	1.80	0.10	.	.
10	03/23/79	03/23/79	.	.	7	.	.	.	143.00	6.6	5.4	18.4	.	1.80	0.10	.	.
11	04/03/79	04/03/79	7:00	16:00	8	8928.0	1144.00	.	500.00	6.8	8.5	29.8	143.0	7.80	2.30	.	9.6E+06
12	04/03/79	04/03/79	7:00	16:00	8	8928.0	668.00	.	455.00	6.9	9.0	32.8	263.0	8.30	2.26	.	9.6E+06
13	04/03/79	04/03/79	7:00	16:00	8	8928.0	69.30	.	273.00	7.0	10.2	27.1	348.0	8.40	1.00	.	9.6E+06
14	04/03/79	04/03/79	7:00	16:00	8	8928.0	316.00	.	288.00	7.0	8.1	27.7	254.0	7.80	0.30	.	9.6E+06
15	04/03/79	04/03/79	7:00	16:00	8	8928.0	216.00	.	327.00	7.3	10.5	30.6	59.1	11.60	0.30	.	9.6E+06
16	04/04/79	04/04/79	1:30	11:00	9	21960.0	1444.00	.	292.00	7.1	11.7	34.3	81.7	7.96	0.10	.	.
17	04/04/79	04/04/79	1:30	11:00	9	21960.0	948.00	.	128.00	7.0	12.2	32.5	72.1	4.10	0.10	.	.
18	04/04/79	04/04/79	1:30	11:00	9	21960.0	928.00	.	176.00	6.9	10.6	94.8	149.0	2.88	0.10	.	.
19	04/04/79	04/04/79	1:30	11:00	9	21960.0	408.00	.	162.00	6.9	6.9	42.2	162.0	2.72	0.10	.	.
20	04/12/79	04/14/79	21:30	14:00	11	52220.0	1115.00	.	56.00	7.1	51.5	1.7	146.0	1.50	0.20	.	.
21	04/12/79	04/14/79	21:30	14:00	11	52220.0	1075.00	.	680.00	6.9	50.0	1.8	331.0	1.50	0.20	.	.
22	04/12/79	04/14/79	21:30	14:00	11	52220.0	1765.00	.	.	6.9	61.5	1.7	197.0	1.50	0.10	.	.
23	04/12/79	04/14/79	21:30	14:00	11	52220.0	1235.00	.	648.00	6.7	72.0	1.7	103.0	1.50	0.10	.	.
24	05/04/79	05/04/79	19:00	21:00	13	550.0	1060.00	.	1032.00	6.7	12.9	30.9	.	5.40	1.40	.	.
25	05/09/79	05/10/79	11:00	9:00	14	.	3400.00	2600.00	1201.00	6.9	6.8	18.6	120.0	4.80	2.50	4.3E+06	3.9E+06
26	05/21/79	05/21/79	4:00	14:00	15	1175.0	1400.00	600.00	327.00	6.9	7.5	18.2	67.3	6.20	0.80	4.7E+07	3.7E+07
27	05/21/79	05/21/79	4:00	14:00	15	1175.0	1000.00	400.00	97.20	7.0	8.6	23.0	.	8.60	0.70	4.7E+07	3.7E+07
28	05/22/79	05/24/79	3:00	17:00	16	8999.0	1800.00	400.00	338.00	.	4.2	20.2	48.1	5.60	.	.	.
29	05/22/79	05/24/79	3:00	17:00	16	8999.0	1800.00	400.00	415.00	.	6.4	21.3	66.3	4.90	.	.	.
30	05/22/79	05/24/79	3:00	17:00	16	8999.0	2800.00	400.00	323.00	.	8.7	17.9	56.1	4.10	.	.	.
31	05/22/79	05/24/79	3:00	17:00	16	8999.0	1200.00	0.00	299.00	.	7.4	16.5	56.5	4.10	.	.	.
32	05/22/79	05/24/79	3:00	17:00	16	8999.0	.	.	.	.	7.4	.	55.6	.	.	.	.
33	05/22/79	05/24/79	3:00	17:00	16	8999.0	3800.00	1000.00	908.00	.	15.1	23.9	78.0	6.30	.	.	.
34	05/22/79	05/24/79	3:00	17:00	16	8999.0	2200.00	600.00	615.00	.	10.6	29.3	92.8	6.90	.	.	.
35	05/22/79	05/24/79	3:00	17:00	16	8999.0	1800.00	200.00	418.00	.	8.1	21.5	80.6	6.40	.	.	.
36	05/22/79	05/24/79	3:00	17:00	16	8999.0	1600.00	0.00	393.00	.	7.5	21.9	84.5	5.80	.	.	.
37	05/22/79	05/24/79	3:00	17:00	16	8999.0	1000.00	400.00	319.00	.	7.9	21.9	75.9	6.20	.	.	.
38	05/31/79	05/31/79	13:00	17:00	17	425.0	3800.00	.	706.00	6.8	8.2	32.1	160.0	2.46	2.29	2.2E+06	0.0E+00
39	06/03/79	06/03/79	4:00	14:00	19	30942.0	4000.00	.	1104.00	6.9	6.7	21.2	169.0	4.90	3.90	2.5E+05	1.5E+05
40	06/04/79	06/05/79	23:00	5:00	20	325.0	1800.00	.	.	7.0	6.6	19.6	126.0	4.10	2.30	9.6E+06	0.0E+00
41	06/04/79	06/05/79	23:00	5:00	20	325.0	1000.00	.	.	6.9	5.5	15.9	58.3	5.00	3.30	7.8E+06	0.0E+00
42	06/07/79	06/08/79	22:00	6:30	21	1613.0	9800.00	7200.00	1613.30	6.8	14.3	40.2	31.8	5.40	.	9.8E+06	3.2E+06
43	06/30/79	06/30/79	5:30	8:00	22	1908.0	104.00	.	277.00	8.0	15.5	.	.	.	0.30	1.9E+05	0.0E+00
44	06/30/79	06/30/79	5:30	8:00	22	1908.0	120.00	.	287.00	7.8	14.9	.	.	.	0.30	1.9E+05	0.0E+00
45	06/30/79	06/30/79	5:30	8:00	22	1908.0	116.00	.	244.00	8.0	13.8	.	.	.	0.30	1.9E+05	0.0E+00
46	06/30/79	06/30/79	5:30	8:00	22	1908.0	40.00	.	204.00	8.0	13.8	.	.	.	0.30	1.9E+05	0.0E+00
47	06/30/79	06/30/79	5:30	8:00	22	1908.0	100.00	.	244.00	7.9	16.4	.	.	.	0.30	1.9E+05	0.0E+00
48	07/06/79	07/07/79	23:00	7:00	23	23250.0	1600.00	400.00	618.00	6.5	6.3	134.0	15.4	.	0.20	1.9E+06	.
49	07/06/79	07/07/79	23:00	7:00	23	23250.0	1000.00	400.00	460.00	6.6	5.3	139.0	12.1	.	0.20	1.9E+06	.
50	07/06/79	07/07/79	23:00	7:00	23	23250.0	800.00	400.00	236.00	6.6	4.7	138.0	16.8	.	0.20	1.9E+06	.
51	07/06/79	07/07/79	23:00	7:00	23	23250.0	200.00	.	131.00	6.7	7.1	24.4	23.0	.	0.60	1.9E+06	.
52	07/06/79	07/07/79	23:00	7:00	23	23250.0	400.00	200.00	113.00	6.9	8.1	12.0	22.9	.	0.50	1.9E+06	.
53	07/06/79	07/07/79	23:00	7:00	23	23250.0	1600.00	.	421.00	6.9	7.4	38.9	20.9	.	6.00	1.9E+06	.
54	07/06/79	07/07/79	23:00	7:00	23	23250.0	1000.00	400.00	.	7.0	6.3	29.9	.	.	3.00	1.9E+06	.

APPENDIX B. (cont.)

OBS	DATE1	DATE2	TIME1	TIME2	STORMNO	ROV	TS	FS	COD	PH	PO4P	TKN	TOC	NH3N	NO3N	TC	MFC
55	07/09/79	07/10/79	.	.	24	.	1200	400	826.0	6.6	.	632.2	206.00	.	0.40	5.9E+05	.
56	07/09/79	07/10/79	.	.	24	.	1200	400	909.0	7.3	.	738.1	167.00	.	.	5.9E+05	.
57	07/09/79	07/10/79	.	.	24	.	1400	600	849.0	7.2	.	853.5	240.00	.	0.40	5.9E+05	.
58	07/09/79	07/10/79	.	.	24	.	1200	600	700.0	7.6	.	814.0	250.00	.	0.50	5.9E+05	.
59	07/21/79	07/22/79	18:00	12:00	28	.	7400	5000	923.0	7.0	17.3	.	724.00	8.10	0.20	.	.
60	07/21/79	07/22/79	18:00	12:00	28	.	4200	2600	894.7	6.6	15.2	.	1200.00	483.10	7.20	9.8E+00	1.9E+01
61	07/23/79	07/24/79	3:00	11:00	29	.	1800	800	209.7	6.4	8.0	.	86.50	2.30	0.30	.	.
62	07/23/79	07/24/79	3:00	11:00	29	.	1000	0	248.0	6.8	10.4	.	86.50	2.50	0.30	.	.
63	07/24/79	07/24/79	16:00	24:00	30	.	5400	3200	1489.3	6.7	50.5	.	199.00	.	0.20	.	.
64	07/30/79	07/31/79	18:00	10:00	33	.	76	.	.	6.9	3.2	.	453.00	.	0.40	.	.
65	07/30/79	07/31/79	18:00	10:00	33	.	14	.	.	7.0	2.9	.	500.00	.	0.20	.	.
66	07/30/79	07/31/79	18:00	10:00	33	.	10	.	.	7.3	2.9	.	311.00	.	0.30	.	.
67	08/22/79	08/23/79	22:00	2:00	34	1450	1200	800	182.0	6.3	.	16.0	.	1.50	5.90	6.1E+05	0.0E+00
68	08/29/79	08/29/79	.	.	35	.	1400	800	144.0	6.2	5.0	32.5	.	2.80	2.90	.	.
69	09/29/79	09/30/79	21:30	5:00	42	262	1200	400	112.0	6.9	53.4	10.8	108.00	2.30	9.80	.	.
70	09/30/79	10/01/79	21:30	8:00	43	1000	1000	400	91.8	7.0	53.2	9.5	93.10	2.20	13.90	.	.
71	10/04/79	10/05/79	14:00	3:30	44	4025	.	.	126.5	6.7	2.9	8.1	63.60	2.57	10.40	.	.
72	10/29/79	10/30/79	.	.	46	.	2000	1600	.	5.7	10.5	33.4	286.00	2.29	7.23	.	.
73	11/02/79	11/02/79	.	.	47	.	36200	34000	67.4	6.6	3.3	14.7	300.00	1.60	10.90	.	.
74	11/02/79	11/02/79	.	.	47	.	.	.	3.7	6.5	3.7	12.8	310.00	0.50	11.40	.	.
75	11/10/79	11/11/79	.	.	48	.	.	.	135.0	6.5	5.1	6.4	.	3.60	1.80	.	0.0E+00
76	11/10/79	11/11/79	.	.	48	.	.	.	175.0	6.8	3.1	9.3	.	2.50	6.80	.	0.0E+00
77	11/10/79	11/11/79	.	.	48	.	.	.	177.0	6.6	4.6	8.3	.	2.00	0.90	.	0.0E+00
78	11/24/79	11/25/79	15:20	3:00	49	20595	1200	.	176.0	6.7	8.9	25.6	117.00	6.90	8.50	.	.
79	11/24/79	11/25/79	15:20	3:00	49	20595	1400	1200	251.0	6.8	9.5	22.4	123.00	5.70	7.80	1.1E+08	2.4E+08
80	12/24/79	12/24/79	14:00	19:00	50	600	4200	3200	1424.9	7.0	13.5	42.8	419.00	7.70	2.60	.	.
81	12/24/79	12/24/79	14:00	19:00	50	600	2200	1400	1425.8	7.1	11.9	.	297.00	1.40	6.20	.	.
82	12/29/79	12/30/79	8:40	11:30	51	75	800	400	1431.1	6.9	2.8	8.2	56.00	1.10	2.70	.	.
83	12/29/79	12/30/79	8:40	11:30	51	75	2480	800	400.0	6.8	7.2	24.0	178.00	10.10	20.30	.	.
84	12/29/79	12/30/79	8:40	11:30	51	75	600	400	1429.8	6.8	6.6	22.8	165.00	11.40	15.80	.	.
85	01/04/80	01/04/80	4:30	17:00	52	2425	1400	400	1428.7	6.9	9.4	24.7	226.00	7.80	8.30	1.0E+07	2.0E+05
86	01/04/80	01/04/80	4:30	17:00	52	2425	1000	200	1428.6	7.0	9.3	23.2	222.00	7.10	7.70	1.0E+07	2.0E+05
87	01/04/80	01/04/80	4:30	17:00	52	2425	1000	200	1428.9	7.1	9.3	26.2	176.00	6.30	8.80	1.0E+07	2.0E+05
88	01/09/80	01/10/80	14:20	3:00	53	1374	1800	1400	237.5	6.5	9.8	22.5	70.50	11.10	0.50	.	.
89	01/09/80	01/10/80	14:20	3:00	53	1374	3400	2200	389.8	6.5	14.3	29.2	94.50	13.00	0.40	.	.
90	01/09/80	01/10/80	14:20	3:00	53	1374	1600	1000	451.3	6.5	13.6	28.7	114.00	13.00	0.30	.	.
91	01/12/80	01/12/80	14:20	20:00	54	3150	6000	4400	1227.6	6.3	13.4	35.3	201.00	7.30	0.10	.	.
92	01/14/80	01/15/80	19:10	9:00	55	4775	800	400	162.6	6.3	6.9	21.9	42.80	4.90	3.20	2.3E+07	8.9E+06
93	01/14/80	01/15/80	19:10	9:00	55	4775	1600	400	281.7	6.3	9.0	19.7	46.10	4.30	0.10	.	8.9E+06
94	01/18/80	01/19/80	5:30	13:00	56	19475	800	400	6.6	7.0	7.7	17.0	.	6.20	0.90	.	.
95	01/18/80	01/19/80	5:30	13:00	56	19475	2600	1800	48.3	7.1	10.6	34.7	171.00	9.00	0.90	.	.
96	01/18/80	01/19/80	5:30	13:00	56	19475	2200	1800	2.9	7.0	9.4	31.1	1.02	5.80	0.80	.	.
97	01/22/80	01/22/80	13:10	23:00	57	2575	1200	1000	0.4	7.0	8.7	21.2	77.00	8.30	0.40	.	.
98	02/10/80	02/11/80	16:20	14:00	59	3275	512	282	56.9	6.7	4.1	8.0	.	4.30	4.50	1.5E+05	.
99	02/10/80	02/11/80	16:20	14:00	59	3275	838	538	103.6	6.6	5.9	13.3	.	11.00	3.30	3.0E+05	.
100	03/01/80	03/01/80	15:00	18:00	61	50	1000	600	214.2	7.1	8.6	34.8	87.00	20.20	0.40	.	.
101	03/05/80	03/05/80	7:00	16:00	62	1050	4400	3000	193.3	6.7	8.7	18.6	.	6.20	1.30	2.1E+06	3.8E+06
102	03/05/80	03/05/80	7:00	16:00	62	1050	1200	400	238.8	6.7	7.8	14.8	92.90	5.00	2.20	1.2E+06	2.8E+06
103	03/05/80	03/05/80	7:00	16:00	62	1050	3800	2400	184.7	6.8	8.1	16.5	213.00	5.00	0.50	6.0E+05	1.6E+06
104	03/07/80	03/08/80	20:00	16:00	63	20150	800	400	183.5	6.8	4.8	13.3	67.70	5.70	0.50	1.1E+06	0.0E+00
105	03/07/80	03/08/80	20:00	16:00	63	20150	400	0	188.4	6.8	5.0	12.3	54.20	3.40	1.90	1.1E+06	0.0E+00
106	03/07/80	03/08/80	20:00	16:00	63	20150	800	200	140.5	6.8	5.4	12.1	52.10	3.50	2.10	1.1E+06	0.0E+00
107	03/07/80	03/08/80	20:00	16:00	63	20150	400	200	198.2	6.8	6.0	15.0	28.20	4.20	1.80	1.1E+06	0.0E+00
108	03/07/80	03/08/80	20:00	16:00	63	20150	800	200	140.5	6.8	5.7	11.8	59.40	3.40	2.30	1.1E+06	0.0E+00

APPENDIX B. (cont.)

STATISTICAL ANALYSIS SYSTEM 12:04 TUESDAY, DECEMBER 1, 1981 4

OBS	DATE1	DATE2	TIME1	TIME2	STORMNO	ROV	TS	FS	COD	PH	PO4P	TKN	TOC	NH3N	NO3N	TC	MFC
109	03/07/80	03/08/80	20:00	16:00	63	20150	5400	4800	22.5	.	10.20	10.1	118.00	.	.	.	.
110	03/07/80	03/08/80	20:00	16:00	63	20150	600	600	.	.	7.90	9.6	59.20	.	.	.	.
111	03/17/80	03/18/80	10:00	4:00	65	26200	3200	2600	28.7	6.7	4.90	18.6	23.80	5.4	0.50	.	.
112	03/17/80	03/18/80	10:00	4:00	65	26200	3400	2800	28.7	6.7	4.90	27.0	52.10	5.9	1.10	.	.
113	03/17/80	03/18/80	10:00	4:00	65	26200	3400	200	52.0	6.6	5.20	59.1	131.00	2.9	0.30	.	.
114	03/24/80	03/24/80	6:00	22:00	67	6100	4000	2600	20.1	6.7	1.90	3.8	630.00	2.8	1.59	4.0E+06	3.0E+06
115	03/24/80	03/24/80	6:00	22:00	67	6100	8800	6200	53.3	6.7	1.10	5.5	1144.00	3.0	0.30	4.0E+06	3.0E+06
116	03/28/80	03/28/80	4:00	23:00	68	40775	800	200	96.3	6.6	1.20	9.6	284.00	4.2	0.30	.	.
117	03/28/80	03/28/80	4:00	23:00	68	40775	800	400	96.3	6.8	0.90	6.4	210.00	3.1	0.30	.	.
118	04/08/80	04/08/80	6:00	17:00	70	1800	1000	1000	141.7	6.7	3.00	23.9	237.40	6.6	10.60	.	.
119	04/08/80	04/08/80	6:00	17:00	70	1800	1600	1400	140.5	6.7	2.40	10.8	290.00	4.5	1.10	.	.
120	04/12/80	04/12/80	11:00	17:00	71	2150	2400	2400	135.6	6.6	5.20	9.5	496.10	3.7	6.80	.	.
121	04/13/80	04/14/80	11:00	12:00	72	50750	800	600	93.8	6.7	1.30	8.1	400.70	2.5	3.20	.	.
122	04/13/80	04/14/80	11:00	12:00	72	50750	.	.	194.5	6.8	1.90	10.5	1548.00	3.0	0.60	1.3E+07	3.6E+06
123	05/17/80	05/17/80	10:00	17:00	73	10600	5000	2600	977.8	6.9	9.50	16.1	589.00	6.6	0.50	.	.
124	05/17/80	05/17/80	10:00	17:00	73	10600	1000	400	418.1	7.2	7.40	25.4	1119.00	8.3	0.80	.	.
125	05/17/80	05/17/80	10:00	17:00	73	10600	6400	3800	1148.7	7.0	12.80	46.7	359.00	8.0	1.00	.	.
126	05/17/80	05/17/80	10:00	17:00	73	10600	81200	79000	562.8	6.9	8.20	15.3	265.00	5.0	0.90	.	.
127	05/17/80	05/17/80	10:00	17:00	73	10600	26000	24800	361.5	6.8	5.10	12.6	130.00	4.7	0.30	.	.
128	05/17/80	05/17/80	10:00	17:00	73	10600	12600	12000	308.1	6.9	17.00	15.9	219.00	5.4	0.50	3.0E+07	2.0E+05
129	05/19/80	05/20/80	16:30	17:00	74	32113	11400	7800	931.7	6.7	16.80	33.0	910.00	4.8	0.20	.	.
130	05/19/80	05/20/80	16:30	17:00	74	32113	116600*	113000	*473.7	6.7	5.10	14.5	241.00	3.1	0.10	.	.
131	05/19/80	05/20/80	16:30	17:00	74	32113	49800	48400	194.9	6.7	4.70	10.2	61.80	2.8	1.90	0.0E+00	2.1E+06
132	05/23/80	05/23/80	19:00	22:00	75	10690	1400	800	206.4	6.7	5.90	15.1	426.00	.	0.10	.	.
133	06/25/80	06/25/80	0:00	7:00	77	14999	22200	5400	1322.7	6.8	21.50	21.9	170.60	6.7	0.30	.	.
134	06/25/80	06/25/80	0:00	7:00	77	14999	1200	600	579.5	7.0	12.40	22.4	102.70	7.9	1.20	.	.
135	07/26/80	07/28/80	17:00	1:00	78	150	.	.	221.0	7.0	15.30	28.5	.	5.9	0.30	.	.
136	07/26/80	07/28/80	17:00	1:00	78	150	.	.	78.5	7.4	7.80	8.1	.	1.6	8.10	.	.
137	09/25/80	09/25/80	6:30	10:00	83	7400	4000	2200	1088.9	.	12.65	53.6	8.22	4.4	2.00	1.1E+07	2.2E+07
138	09/25/80	09/25/80	6:30	10:00	83	7400	1200	800	190.7	.	7.20	17.2	0.80	3.1	22.58	2.2E+07	2.2E+07
139	09/29/80	09/30/80	16:00	7:00	85	5000	1000	400	167.6	6.7	2.50	8.1	1.00	4.0	25.00	.	.
140	09/29/80	09/30/80	16:00	7:00	85	5000	1400	1000	496.7	6.8	6.00	24.6	1.30	5.7	1.20	.	.
141	09/29/80	09/30/80	16:00	7:00	85	5000	1200	1000	148.7	6.7	2.70	21.4	.	3.3	1.40	1.9E+07	.
142	10/25/80	10/25/80	2:00	10:00	88	275	1400	1200	481.0	7.3	8.70	28.0	34.30	8.7	8.70	.	.
143	10/25/80	10/25/80	2:00	10:00	88	275	1200	1000	364.7	7.3	7.50	17.7	20.20	6.6	5.30	.	.
144	10/28/80	10/28/80	3:00	12:00	89	2775	2000	1800	354.2	7.3	6.50	23.0	18.90	5.8	8.30	1.1E+07	0.0E+00
145	10/28/80	10/28/80	3:00	12:00	89	2775	1600	1200	362.6	7.3	8.30	17.4	23.90	6.9	5.10	1.6E+07	0.0E+00
146	10/30/80	10/31/80	21:00	17:00	90	10276	1400	800	339.5	7.1	9.00	19.3	24.20	6.6	.	.	.
147	10/30/80	10/31/80	21:00	17:00	90	10276	1200	800	275.6	7.0	9.80	15.5	17.10	5.4	.	.	.
148	10/30/80	10/31/80	21:00	17:00	90	10276	1000	600	239.9	7.1	8.20	14.6	14.40	6.9	.	.	.
149	11/15/80	11/15/80	13:00	18:00	92	500	1800	1200	483.1	7.2	9.80	19.5	58.50	6.6	14.30	3.9E+07	.
150	11/15/80	11/15/80	13:00	18:00	92	500	800	800	365.7	7.1	11.30	17.5	10.60	8.1	5.70	3.0E+07	.
151	11/17/80	11/17/80	18:00	20:00	93	150	600	200	476.8	7.1	9.70	25.9	49.30	.	11.20	.	.
152	11/23/80	11/23/80	2:00	9:00	94	2125	.	.	517.7	7.0	10.10	30.9	63.60	6.1	4.50	.	.
153	11/23/80	11/23/80	2:00	9:00	94	2125	800	.	657.1	7.1	11.30	32.8	74.40	6.3	1.50	.	.
154	11/23/80	11/23/80	2:00	9:00	94	2125	1000	.	463.2	7.1	12.20	26.8	59.80	7.8	1.20	.	.
155	11/23/80	11/23/80	2:00	9:00	94	2125	2000	1600	526.1	7.2	11.20	27.1	59.10	8.5	1.10	.	.
156	11/28/80	11/28/80	0:00	16:00	95	16951	800	.	413.0	.	7.40	27.6	54.60	10.5	6.90	.	.
157	11/28/80	11/28/80	0:00	16:00	95	16951	1200	800	373.0	.	5.70	27.1	55.60	8.0	10.80	.	.
158	11/28/80	11/28/80	0:00	16:00	95	16951	800	600	354.0	.	6.40	20.7	48.20	5.2	1.30	.	.
159	11/28/80	11/28/80	0:00	16:00	95	16951	800	1000	360.0	.	5.20	18.7	46.20	4.0	1.00	.	.
160	02/18/81	02/19/81	14:00	14:00	98	7080	3200	2000	823.6	6.7	8.10	18.3	.	5.8	.	.	.
161	02/18/81	02/19/81	14:00	14:00	98	7080	800	200	385.8	6.7	6.30	16.1	.	4.9	.	.	.
162	02/18/81	02/19/81	14:00	14:00	98	7080	1000	400	556.9	6.9	8.90	25.0	.	7.8	.	7.8E+00	.

* these values were not used in calculating the average value for storm 74 because of possible

APPENDIX B. (cont.)

STATISTICAL ANALYSIS SYSTEM 12:04 TUESDAY, DECEMBER 1, 1981 5

OBS	DATE1	DATE2	TIME1	TIME2	STORMNO	ROV	TS	FS	COD	PH	PO4P	TKN	TOC	NH3N	NO3N	TC	MFC
163	02/18/81	02/19/81	14:00	14:00	98	7080	1000	0	529.6	7.0	11.6	30.5	.	8.8	.	.	.
164	02/18/81	02/19/81	14:00	14:00	98	7080	1000	400	500.2	7.1	9.1	32.5	.	7.5	.	2.5E+06	0.0E+00
165	02/18/81	02/19/81	14:00	14:00	98	7080	1000	400	630.4	7.2	12.6	30.0	.	9.9	.	.	.
166	02/18/81	02/19/81	14:00	14:00	98	7080	1000	0	582.1	7.0	11.8	27.6	.	10.4	.	.	.
167	02/18/81	02/19/81	14:00	14:00	98	7080	1600	800	638.8	6.9	7.9	25.7	.	5.2	.	.	.
168	02/23/81	02/23/81	0:00	5:00	99	1700	800	200	336.4	7.0	3.1	11.8	.	3.0	.	.	.
169	02/23/81	02/23/81	0:00	5:00	99	1700	600	400	321.8	7.0	3.0	10.6	.	4.8	.	.	.
170	03/04/81	03/04/81	18:00	24:00	100	1376	1000	600	359.5	6.6	7.3	12.7	.	2.9	.	5.5E+06	.
171	03/04/81	03/04/81	18:00	24:00	100	1376	800	0	409.9	6.7	9.4	15.0	.	3.0	.	4.5E+06	.
172	03/04/81	03/04/81	18:00	24:00	100	1376	1000	400	458.2	7.0	10.0	15.3	.	3.1	.	4.3E+06	.
173	03/30/81	03/30/81	7:00	12:00	102	8500	.	.	447.7	6.5	5.7	18.1	.	2.0	8.1	.	.
174	03/30/81	03/30/81	7:00	12:00	102	8500	.	.	386.8	6.6	6.0	14.4	.	2.3	6.5	.	.
175	05/10/81	05/11/81	22:00	4:00	106	3950	.	.	1915.0	6.6	9.7	49.0	.	4.7	2.6	.	.
176	05/10/81	05/11/81	22:00	4:00	106	3950	.	.	3815.0	6.5	10.5	21.1	.	4.1	4.7	.	.
177	05/26/81	05/26/81	10:00	17:00	109	1675	3400	2800	552.7	6.7	6.1	28.0	.	4.9	0.6	.	.
178	05/26/81	05/26/81	10:00	17:00	109	1675	1000	600	256.7	6.4	5.5	13.9	.	4.0	6.6	.	.
179	06/01/81	06/02/81	23:00	0:00	110	350	1000	600	354.3	6.6	5.4	.	.	5.3	3.0	.	.
180	06/25/81	06/25/81	19:15	21:00	113	1225	7200	6000	1062.7	6.8	7.0	35.5	.	1.0	0.5	.	.
181	06/25/81	06/25/81	19:15	21:00	113	1225	2000	1600	348.8	7.1	6.9	17.3	.	0.0	4.7	.	.
182	06/25/81	06/25/81	19:15	21:00	113	1225	4400	3400	711.0	6.7	8.3	31.1	.	3.1	8.0	.	.
183	06/25/81	06/25/81	19:15	21:00	113	1225	2200	1800	490.5	6.8	8.1	23.8	.	5.4	9.5	.	.
184	06/25/81	06/25/81	19:15	21:00	113	1225	1000	800	228.0	7.0	6.5	17.9	.	4.9	21.2	.	.
185	07/03/81	07/03/81	17:15	19:00	115	525	1400	1000	.	6.4	4.6	11.3	.	2.5	7.8	.	.
186	07/03/81	07/03/81	17:15	19:00	115	525	1400	1000	.	6.6	5.5	15.0	.	1.9	12.4	.	.
187	07/11/81	07/11/81	19:15	22:00	117	1025	1400	1000	313.4	6.6	5.7	14.5	.	3.0	1.4	1.3E+06	6.5E+05
188	07/11/81	07/11/81	19:15	22:00	117	1025	600	200	189.5	6.7	5.1	8.4	.	2.3	17.2	3.3E+04	0.0E+00
189	07/19/81	07/19/81	20:20	22:00	118	500	1000	600	199.9	6.1	5.2	13.3	.	.	.	.	.
190	07/19/81	07/19/81	20:20	22:00	118	500	1600	1200	255.6	6.1	5.4	13.1	.	.	.	.	.

APPENDIX C. Average water quality data by storm event from feedlot runoff.

TABLE #2 14:12 THURSDAY, JANUARY 7, 1982 9

OBS	STORMNO	APH	ATC	AMFC	ATOC	ATKN	APO4P	ACOD	AFS	AVS	ATS	ANO3N	ANH3N	LBSACR	ROV
1	1	6.70000	60000000	100000000	.	27.000	9.2000	345.90	584.0	556.00	1140.0	1.7200	9.130	.	.
2	2	6.60000	460000	700000	.	18.700	46.5000	266.66	.	.	.	1.6000	5.400	.	.
3	3	6.80000	46000	160000	.	30.200	6.2000	209.91	266.7	666.67	933.3	2.4000	6.000	.	.
4	4	6.70000	1300000	1000000	.	19.700	4.7000	105.36	.	.	.	2.1000	2.700	.	.
5	7	6.55000	.	.	.	37.367	12.3000	330.83	.	.	.	0.4167	4.502	.	.
6	8	7.00000	.	9600000	213.420	29.600	9.2600	368.60	.	.	482.7	1.2320	8.780	.	.
7	9	6.97500	.	.	116.200	50.950	10.3500	189.50	.	.	932.0	0.1000	4.415	.	.
8	11	6.90000	.	.	194.250	1.725	58.7500	461.33	.	.	1297.5	0.1500	1.500	.	.
9	13	6.70000	.	.	.	30.900	12.9000	1032.00	.	.	1060.0	1.4000	5.400	.	.
10	14	6.90000	4300000	3900000	120.000	18.600	6.8000	1201.00	2600.0	800.00	3400.0	2.5000	4.800	.	.
11	15	6.95000	47000000	37000000	67.300	20.600	8.0500	212.10	500.0	700.00	1200.0	0.7500	7.400	.	.
12	16	.	.	.	69.440	21.600	8.3300	447.56	377.8	1622.22	2000.0	.	5.589	.	.
13	17	6.80000	2200000	0	160.000	32.100	8.2000	706.00	.	.	3800.0	2.2900	2.460	.	.
14	19	6.90000	250000	150000	169.000	21.200	6.7000	1104.00	.	.	4000.0	3.9000	4.900	.	.
15	20	6.95000	8700000	0	92.150	17.750	6.0500	.	.	.	1400.0	2.8000	4.550	.	.
16	21	6.80000	9800000	3200000	31.800	40.200	14.3000	1613.30	7200.0	2600.00	9800.0	.	5.400	.	.
17	22	7.94000	190000	0	.	.	14.8800	251.20	.	.	96.0	0.3000	.	.	.
18	23	6.74286	1900000	.	18.517	73.743	6.4571	329.83	360.0	600.00	942.9	1.5286	.	.	.
19	24	7.17500	590000	.	215.750	759.450	.	821.00	500.0	750.00	1250.0	0.4333	.	.	.
20	28	6.80000	10	20	962.000	.	16.2500	908.85	3800.0	2000.00	5800.0	3.7000	245.600	.	.
21	29	6.60000	.	.	86.500	.	9.2000	228.85	400.0	1000.00	1400.0	0.3000	2.400	.	.
22	30	6.70000	.	.	199.000	.	50.5000	1489.30	3200.0	2200.00	5400.0	0.2000	.	.	.
23	33	7.06667	.	.	421.333	.	3.0000	.	.	.	33.3	0.3000	.	.	.
24	34	6.30000	610000	0	.	16.000	.	182.00	800.0	400.00	1200.0	5.9000	1.500	.	.
25	35	6.20000	.	.	.	32.500	5.0000	144.00	800.0	600.00	1400.0	2.9000	2.800	.	.
26	41	.	.	.	.	.	.	.	.	.	.	.	.	.	.
27	42	6.90000	.	.	108.000	10.800	53.4000	112.00	400.0	800.00	1200.0	9.8000	2.300	.	.
28	43	7.00000	.	.	93.100	9.500	53.2000	91.80	400.0	600.00	1000.0	13.9000	2.200	.	.
29	44	6.70000	.	.	63.600	8.100	2.9000	126.50	.	.	.	10.4000	2.570	.	.
30	46	5.70000	.	.	286.000	33.400	10.5000	.	1600.0	400.00	2000.0	7.2300	2.290	.	.
31	47	6.55000	.	.	305.000	13.750	3.5000	35.55	34000.0	2200.00	36200.0	11.1500	1.050	.	.
32	48	6.63333	.	0	.	8.000	4.2667	162.33	.	.	.	3.1667	2.700	.	.
33	49	6.75000	110000000	240000000	120.000	24.000	9.2000	213.50	1200.0	200.00	1300.0	8.1500	6.300	.	.
34	50	7.05000	.	.	358.000	42.800	12.7000	1425.35	2300.0	900.00	3200.0	4.4000	4.550	.	.
35	51	6.83333	.	.	133.000	18.333	5.5333	1086.97	533.3	760.00	1293.3	12.9333	7.533	.	.
36	52	7.00000	10000000	200000	208.000	24.700	9.3333	1428.73	266.7	866.67	1133.3	8.2667	7.067	.	.
37	53	6.50000	.	.	93.000	26.800	12.5667	359.53	1533.3	733.33	2266.7	0.4000	12.367	.	.
38	54	6.30000	.	.	201.000	35.300	13.4000	1227.60	4400.0	1600.00	6000.0	0.1000	7.300	.	.
39	55	6.30000	23000000	8900000	44.450	20.800	7.9500	222.15	400.0	800.00	1200.0	1.6500	4.600	.	.
40	56	7.03333	.	.	86.010	27.600	9.2333	19.27	1333.3	533.33	1866.7	0.8667	7.000	.	.
41	57	7.00000	.	.	77.000	21.200	8.7000	0.40	1000.0	200.00	1200.0	0.4000	8.300	.	.
42	59	6.65000	225000	.	.	10.650	5.0000	80.25	410.0	265.00	675.0	3.9000	7.650	.	.
43	61	7.10000	.	.	87.000	34.800	8.6000	214.20	600.0	400.00	1000.0	0.4000	20.200	.	.
44	62	6.73333	1300000	2733333	152.950	16.633	8.2000	205.60	1933.3	1200.00	3133.3	1.3333	5.400	.	.
45	63	6.80000	1100000	0	62.686	12.029	6.4286	145.60	914.3	400.00	1314.3	1.7200	4.040	.	.
46	65	6.66667	.	.	68.967	34.900	5.0000	36.47	1866.7	1466.67	3333.3	0.6333	4.733	.	.
47	67	6.70000	4000000	3000000	887.000	4.650	1.5000	36.70	4400.0	2000.00	6400.0	0.9450	2.900	.	.
48	68	6.70000	.	.	247.000	8.000	1.0500	96.30	300.0	500.00	800.0	0.3000	3.650	.	.
49	70	6.70000	.	.	263.700	17.350	2.7000	141.10	1200.0	100.00	1300.0	5.8500	5.550	.	.
50	71	6.60000	.	.	496.100	9.500	5.2000	135.60	2400.0	0.00	2400.0	6.8000	3.700	.	.
51	72	6.75000	13000000	3600000	974.350	9.300	1.6000	144.15	600.0	200.00	800.0	1.9000	2.750	.	.
52	73	6.95000	30000000	200000	446.833	22.000	10.0000	629.50	20433.3	1600.00	22033.3	0.6667	6.333	.	.
53	74	6.70000	0	2100000	404.267	19.233	8.8667	533.43	28100.0	2866.67	30600.0	0.7333	3.567	.	.
54	75	6.70000	.	.	426.000	15.100	5.9000	206.40	800.0	600.00	1400.0	0.1000	.	.	.

APPENDIX C. (cont.)

TABLE #2 14:12 THURSDAY, JANUARY 7, 1982 10

OBS	STORMNO	APH	ATC	AMFC	ATOC	ATKN	APO4P	ACOD	AFS	AVS	ATS	ANO3N	ANH3N	LBSACR	ROV
55	77	6.90000	.	.	136.650	22.1500	16.9500	951.10	3000.00	8700.00	11700.0	0.750	7.30000	.	.
56	78	7.20000	.	.	.	18.3000	11.5500	149.75	.	.	.	4.200	3.75000	.	.
57	83	.	16500000	22000000	4.510	35.4000	9.9250	639.80	1500.00	1100.00	2600.0	12.290	3.75000	.	.
58	85	6.73333	19000000	.	1.150	18.0333	3.7333	271.00	800.00	400.00	1200.0	9.200	4.33333	.	.
59	86	.	.	.	.	.	.	.	.	.	.	.	.	.	.
60	88	7.30000	.	.	27.250	22.8500	8.1000	422.85	1100.00	200.00	1300.0	7.000	7.65000	.	.
61	89	7.30000	13500000	0	21.400	20.2000	7.4000	358.40	1500.00	300.00	1800.0	6.700	6.35000	.	.
62	90	7.06667	.	.	18.567	16.4667	9.0000	285.00	733.33	466.67	1200.0	.	6.30000	.	.
63	92	7.15000	34500000	.	34.550	18.5000	10.5500	424.40	1000.00	300.00	1300.0	10.000	7.35000	.	.
64	93	7.10000	.	.	49.300	25.9000	9.7000	476.80	200.00	400.00	600.0	11.200	.	.	.
65	94	7.10000	.	.	64.225	29.4000	11.2000	541.02	1600.00	400.00	1266.7	2.075	7.17500	.	.
66	95	.	.	.	51.150	23.5250	6.1750	375.00	800.00	133.33	900.0	5.000	6.92500	.	.
67	98	6.93750	1250004	0	.	25.7125	9.5375	580.92	525.00	800.00	1325.0	.	7.53750	.	.
68	99	7.00000	.	.	.	11.2000	3.0500	329.10	300.00	400.00	700.0	.	3.90000	.	.
69	100	6.76667	4766667	.	.	14.3333	8.9000	409.20	333.33	600.00	933.3	.	3.00000	.	.
70	102	6.55000	.	.	.	16.2500	5.8500	417.25	.	.	.	7.300	2.15000	.	.
71	106	6.55000	.	.	.	35.0500	10.1000	2865.00	.	.	.	3.650	4.40000	.	.
72	109	6.55000	.	.	.	20.9500	5.8000	404.70	1700.00	500.00	2200.0	3.600	4.45000	.	.
73	110	6.60000	.	.	.	.	5.4000	354.30	600.00	400.00	1000.0	3.000	5.30000	.	.
74	113	6.88000	.	.	.	25.1200	7.3600	568.20	2720.00	640.00	3360.0	8.780	2.88000	.	.
75	115	6.50000	.	.	.	13.1500	5.0500	.	1000.00	400.00	1400.0	10.100	2.20000	.	.
76	116	.	.	.	.	.	.	.	.	.	.	.	.	.	.
77	117	6.65000	666500	325000	.	11.4500	5.4000	251.45	600.00	400.00	1000.0	9.300	2.65000	.	.
78	118	6.10000	.	.	.	13.2000	5.3000	227.75	900.00	400.00	1300.0	.	.	.	.