# DESIGN FOR BENEFICAL USE OF FEEDLOT RUNOFF

by 683

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# INTRODUCTION

The cattle feeding industry in the high plains and in Kansas is growing very rapidly. During 1968, according to the Kansas Crop and Livestock Reporting Service (1), the number of feedlots over 8,000 head capacity has grown 67 percent, and the numbers of cattle on feed as of January 1, 1969, has increased by 26 percent, over the figures for January 1, 1968.

The disposal of waste material generated by these cattle has become a serious problem for not only the feedlot operator, but also the general public. Smith and Miner (2) have listed several serious pollution incidents. These incidents were the pollution of streams in Kansas that could be directly related to feedlots and caused fish kills and septic conditions to exist in the streams.

Due to the recent national and state policies and regulations on water pollution, the Kansas feedlot operators have been required to provide storage for the surface runoff generated from their feedlots. Runoff must be disposed of in some manner in 5 to 10 days after the storm causing the runoff, in order to provide storage for additional runoff from future storms.

Disposal of runoff has lead to a number of questions regarding proper disposal methods. The Kansas State Board of Health has taken the position that, where possible, runoff water shall be returned to agricultural crop land. However, they warn against allowing this material to run off again into the streams of Kansas and against possible pollution of ground-water supplies by saturation of the material above the ground-water table.

It appears only logical that a method of disposal of feedlot runoff be designed to provide an economical use for the excess water. Irrigation of crops with waste water will be investigated in this report and a system designed for its use.

The problem of collection and disposal of dry waste generated by feedlots will not be discussed in this report.

## REVIEW OF LITERATURE

The disposal of sewage waste on agricultural land is not a new concept. Schraufnagel (3) reports that the irrigation of industrial wastes began about 1920.

A wide variety of wastes have been disposed of directly to the land. Schraufnagel (3) presented basic information and loading rates for several installations and wastes. For example, a system was constructed in 1934 for the disposal of pea and corn wastes (4) at Hampton, Iowa. For a 57 day season, the average loading rates were 49,000 GPD per acre and 238 lb. BOD per day per acre. A similar installation at Waverly, Iowa, was loaded at 34,400 GPD per acre and a BOD loading of 2,020 lb. per day per acre average for a 35 day canning period. Several other instances of the use of ridge and furrow irrigation for the disposal of canning wastes were cited by Schraufnagel (3).

Schraufnagel (3) cited use of irrigation for the disposal of meat processing wastes. The Cudahy Packing Company at Phoenix, Wisconsin, has a mechanically cleaned sedimentation basin followed by lagooning. Wastes from the lagoons are used for irrigation of forage crops. Another system at Endeavor, Wisconsin, discharges poultry slaughter wastes to an area of two acres which is divided into four plots which are underlain with drain tile. Loading rates amount to 40,000 GPD per acre with a BOD loading of 100 lb. per day per acre.

Schraufnagel (3) states that if the high application rates of more than 100,000 GPD per acre used by some canneries are discounted as not being typical, the industrial waste load that can be applied to land ranges from less than 2,500 to more than 50,000 GPD per acre. He states that there is such a wide spread in volumetric loadings to different soils that basing a proposed system on a single existing unit could result in over or under designing. A separate appraisal of each site is indicated.

Myers (5) discussed engineering problems in year-round distribution of waste water in a paper published in 1966. Chlorinated sewage plant effluent was pumped to a wooded site for disposal by spray irrigation. Of special interest is the discussion of pipe system problems. It is stated that the pipe system includes the supply lines, pipe from the pumping plant to the distribution area, and the main and lateral lines in the distribution area. Pipe lines must be able to withstand the chemical action of the material being pumped, the pressures involved, and the weather conditions encountered throughout the year. Both steel and asbestos-cement pipe were used in the supply line. Several breaks in the asbestos-cement pipe occurred due to high pressures and stress concentrations at holes drilled for take-off couplings. Aluminum pipe was used at the distribution sites for both the main and lateral lines. It is stated that steel pipe, due to its greater strength, would probably be better where the pipe has to be supported above ground level and where internal and external damage due to ice may occur during winter operation. Also, aluminum pipe is vulnerable to chemical reactions with many animal wastes.

Mr. Gray (6), an irrigator near Lubbock, Texas, has been using the sewage effluent from the city since 1937. When he first started he had 200 acres under irrigation and was getting about 1 to 1.5 million gallons per day and he now operates 2900 acres under irrigation and receives approximately 14.5 to 15 million gallons per day. Mr. Gray indicates that he has found effluent irrigation has been highly successful for him.

The amount of runoff generated by a feedlot is dependent upon the surface of the lot, the slope of the lot, the antecedent moisture condition and the intensity and volume of the storm in question. These items were considered in a study by

Bergsrud (7) in which the values for the 80 percent chance occurrence runoff and the normal annual runoff are shown on Plates I and II, pages 7 and 9.

Quality of liquid waste according to Loehr (8) is very difficult to estimate. He indicates that the values vary due to differences in housing and management practices, type or rations fed, analytical techniques employed, and manure handling and collection techniques.

Liquid waste from cattle feedlots can be a very potent pollution hazard. Miner _et_ _al_. (9) demonstrated that feedlot runoff is a source of high concentrations of bacteria normally considered as indices of sanitary quality, and that greatest pollutant concentrations were obtained during warm weather and during periods of low rainfall intensity, and when the manure had dissolved by water soaking. Ammonia nitrogen concentration ranged from 16 to 140 mg/l, suspended solids concentration ranged from 1500 to 12,000 mg/l, and COD concentrations ranged from 3000 to 11,000 mg/l in the runoff from their studies. The average phosphate concentrations were 50 mg/l for concrete lots, and 26 mg/l for non-surfaced lots.

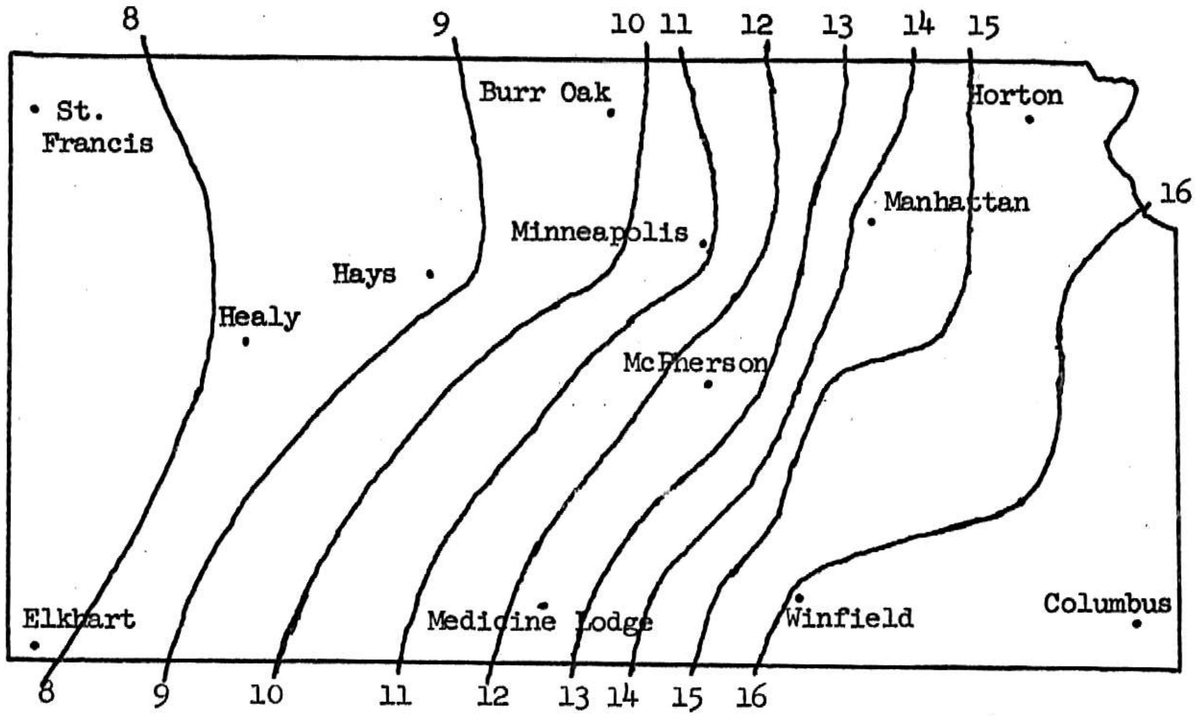
The potassium content of the liquid waste was measured, during the design of the project, at the Pratt Feedlot pond and was found to range from 140 mg/l to 480 mg/l.

According to McKee and Wolf (10) the most recent studies of soil samples at the United States Salinity Laboratory indicate that exchangeable potassium has only a slight or no effect on the physical properties of soil.

## EXPLANATION OF PLATE I

Eighty percent chance occurrence runoff in inches from feedlots, prepared by Bergsrud (7).

PLATE I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9
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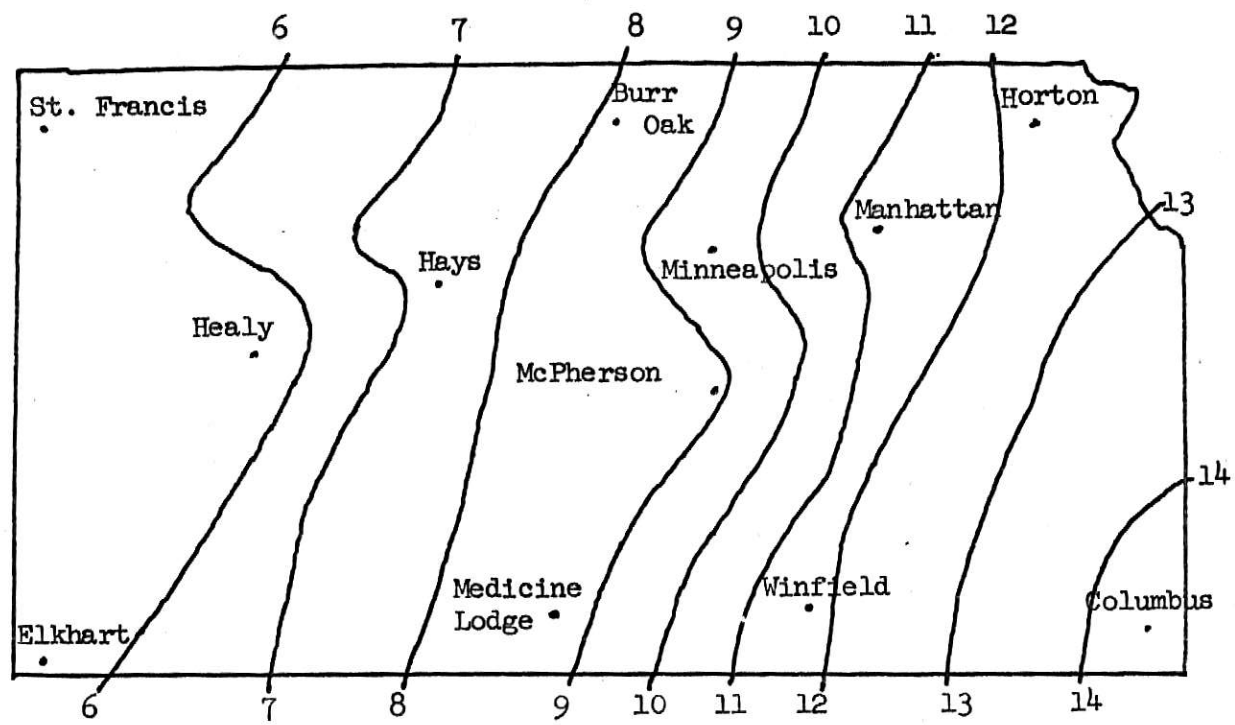
11
12
13
14
15
16
St. Francis
Burr Oak
Horton
Manhattan
Minneapolis
Hays
Healy
McPherson
Elkhart
Medicine Lodge
Winfield
Columbus

## EXPLANATION OF PLATE II

Normal annual runoff in inches from feedlots, prepared by Bergsrud (7).

PLATE II



6
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St. Francis
Burr Oak
Horton
Manhattan
Hays
Minneapolis
Healy
McPherson
Medicine Lodge
Winfield
Columbus
Elkhart

# PURPOSE

The purpose of this report is to investigate one method of disposal of liquid waste from a feedlot operation. This report will deal with only the disposal of the liquid waste generated in the form of runoff caused by rainfall. It is not the purpose of this study to investigate the theory of using water to clean solid waste from feedlots. It is felt that this concept would require far too much water to justify using the water needed.

In this report, the concept of using the liquid waste from the feedlots for irrigation purposes is discussed. The design, operation, and management of such a system is detailed. One of the prime objectives has been to arrive at a total cost for the system, and to relate total cost to a per-head cost based on the present volume of cattle handled through the lot, and on the maximum volume to be processed through the feedlot. The cost will also be presented on a per acre of drainage area basis.

## Specific Problem and Site Location

The feedlot selected for the design of an irrigation system to use the liquid waste is located near Pratt, Kansas. This feedlot holds 20,000 head at one time, and is planned to expand to about 40,000 head in the future. The feedlot is located on an old Army Air Force air field, which had very good drainage away from the runways. Pens are located on the old runways and take advantage of this drainage system. Pens are located so that the concrete runway extends into the pens and covers about one-quarter of each pen.

The feedlot and the surrounding drainage area covers about 260 acres. All foreign drainage is routed around the feedlot area by using dikes and flow-way channels.

At present, the feeding pens occupy only about 100 acres of the total drainage area. Upon completion, at some future date, it is expected that the pens will occupy nearly 200 acres of land.

When this design project was conceived, the Pratt Feedlot had most of the drainage and retention structures completed.

The drainage within all lots was complete, as were the drainage channels carrying runoff away from the lots. Retention ponds were completed, with a total storage of 120 acre-feet in three ponds.

These existing facilities can be seen on Plate III, page 13.

### Volume of Runoff from the Pratt Feedlot

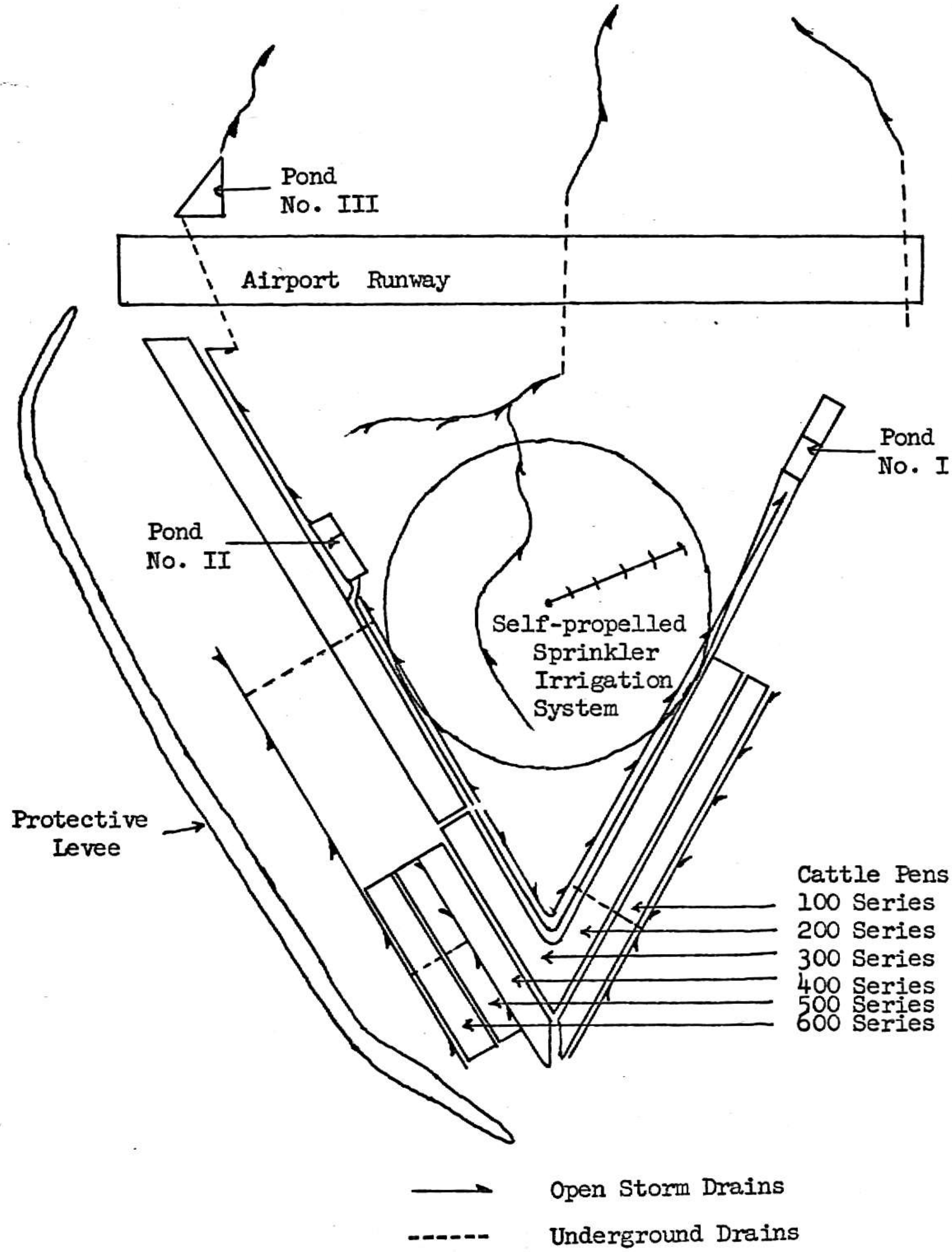
The volume of runoff from any feedlot can be estimated from Plates I and II, pages 7 and 9, prepared by Bergsrud (7) for an 80 percent chance situation and a normal year. The values obtained for the Pratt area are as follows:

| | |
|---|---|
| 80% Chance Occurrence Runoff | 11.8 inches |
| Normal Annual Runoff | 8.4 inches |

## EXPLANATION OF PLATE III

The facilities existing at the Pratt Feedlot prior to construction of the disposal system.

PLATE III


Pond
No. III
Airport Runway
Pond
No. I
Pond
No. II
Self-propelled
Sprinkler
Irrigation
System
Protective
Levee
Cattle Pens
100 Series
200 Series
300 Series
400 Series
500 Series
600 Series
Open Storm Drains
Underground Drains

These values are very good to use for design totals, but for this project it was decided to use actual rainfall data from the U. S. Weather Bureau Station (11) near the feedlot. This data is shown on table 1, page 15.

In order to obtain design data for this design, the 50-year rainfall totals (table 1) were ranked and the 43rd year was selected as the design year. This procedure gave a design value for the runoff of 14.33 inches. The monthly runoff values for each month during this year are shown in table 2, page 16. The hydrologic soil-cover complex number used to obtain the runoff value was 92. The soil-cover complex number was selected from work done by Miner (12), which indicates a 91 value for dirt lots and a 94 value for concrete lots. Since the lots at the Pratt Feedlot are approximately 25 percent concrete and 75 percent dirt, it was assumed that a soil-cover complex number of 92 would represent the conditions that exist in these lots.

The precipitation versus runoff graphs for various soil-cover complex numbers are shown on Plates IV and V, pages 18 and 20. They are taken from Soil Conservation Service data (13).

## Quality of Feedlot Runoff

The quality of the runoff waste water from a feedlot is quite variable as reported by Loehr (8). With this in mind, one must arrive at some values for the amount of nitrogen, phosphate, and potassium that is contained in the runoff that can be used for design purposes.

TABLE 1

50 YEARS RAINFALL RECORD
PRATT, KANSAS

| Date Year | Annual Rainfall Inches | Date Year | Annual Rainfall Inches |
|---|---|---|---|
| | | 1942 | 28.11 |
| 1918 | 24.16 | 1943 | 18.95 |
| 1919 | 21.73 | 1944 | 35.44 |
| 1920 | 31.02 | 1945 | 26.46 |
| 1921 | 19.01 | 1946 | 20.75 |
| 1922 | 29.85 | 1947 | 26.58 |
| 1923 | 25.43 | 1948 | 30.70 |
| 1924 | 19.92 | 1949 | 36.81 |
| 1925 | 24.25 | 1950 | 21.04 |
| 1926 | 18.07 | 1951 | 34.80 |
| 1927 | 26.78 | 1952 | 16.54 |
| 1928 | 34.90 | 1953 | 19.06 |
| 1929 | 21.06 | 1954 | 12.72 |
| 1930 | 19.14 | 1955 | 21.07 |
| 1931 | 23.43 | 1956 | 10.96 |
| 1932 | 21.90 | 1957 | 39.30 |
| 1933 | 13.69 | 1958 | 27.31 |
| 1934 | 22.75 | 1959 | 24.88 |
| 1935 | 23.45 | 1960 | 21.29 |
| 1936 | 16.78 | 1961 | 27.89 |
| 1937 | 18.63 | 1962 | 21.20 |
| 1938 | 27.36 | 1963 | 18.66 |
| 1939 | 19.45 | 1964 | 25.22 |
| 1940 | 26.89 | 1965 | 29.03 |
| 1941 | 34.79 | 1966 | 14.52 |
| | | 1967 | 20.70 |

TABLE 2

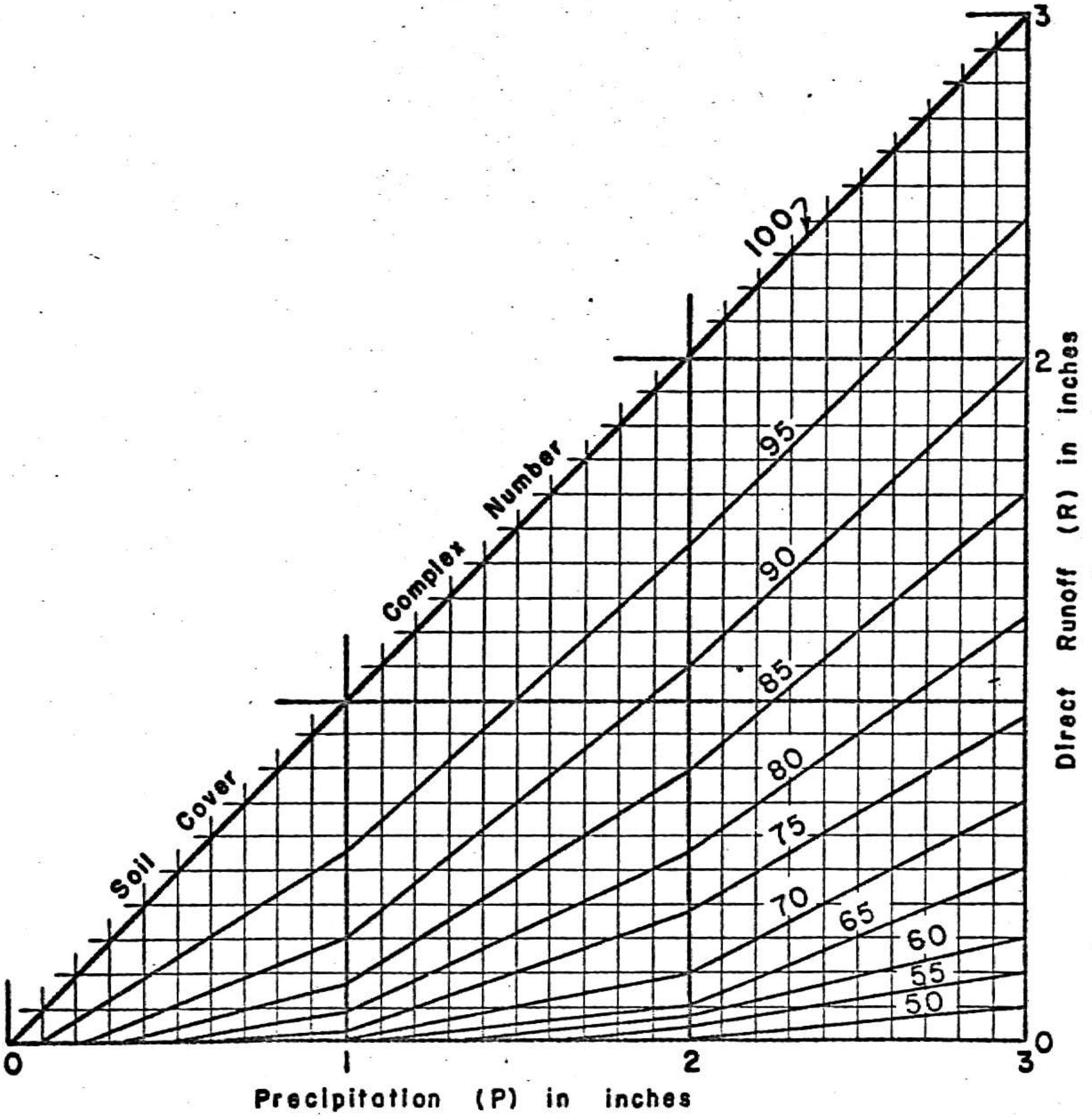
DESIGN MONTHLY RUNOFF (1920)
SOIL COVER COMPLEX NUMBER 92

| Date Month | Rainfall Inches | Feedlot Runoff Inches |
|---|---|---|
| January | 0.19 | 0.00 |
| February | 0.35 | 0.10 |
| March | 1.00 | 0.55 |
| April | 2.26 | 0.80 |
| May | 4.19 | 1.62 |
| June | 2.76 | 1.00 |
| July | 3.59 | 1.62 |
| August | 5.25 | 3.13 |
| September | 3.11 | 1.37 |
| October | 4.28 | 3.00 |
| November | 1.86 | 0.58 |
| December | 1.30 | 0.56 |
| Total | 30.14 | 14.33 |

## EXPLANATION OF PLATE IV

Relationship between precipitation and runoff for a range of soil cover complex numbers. (13)

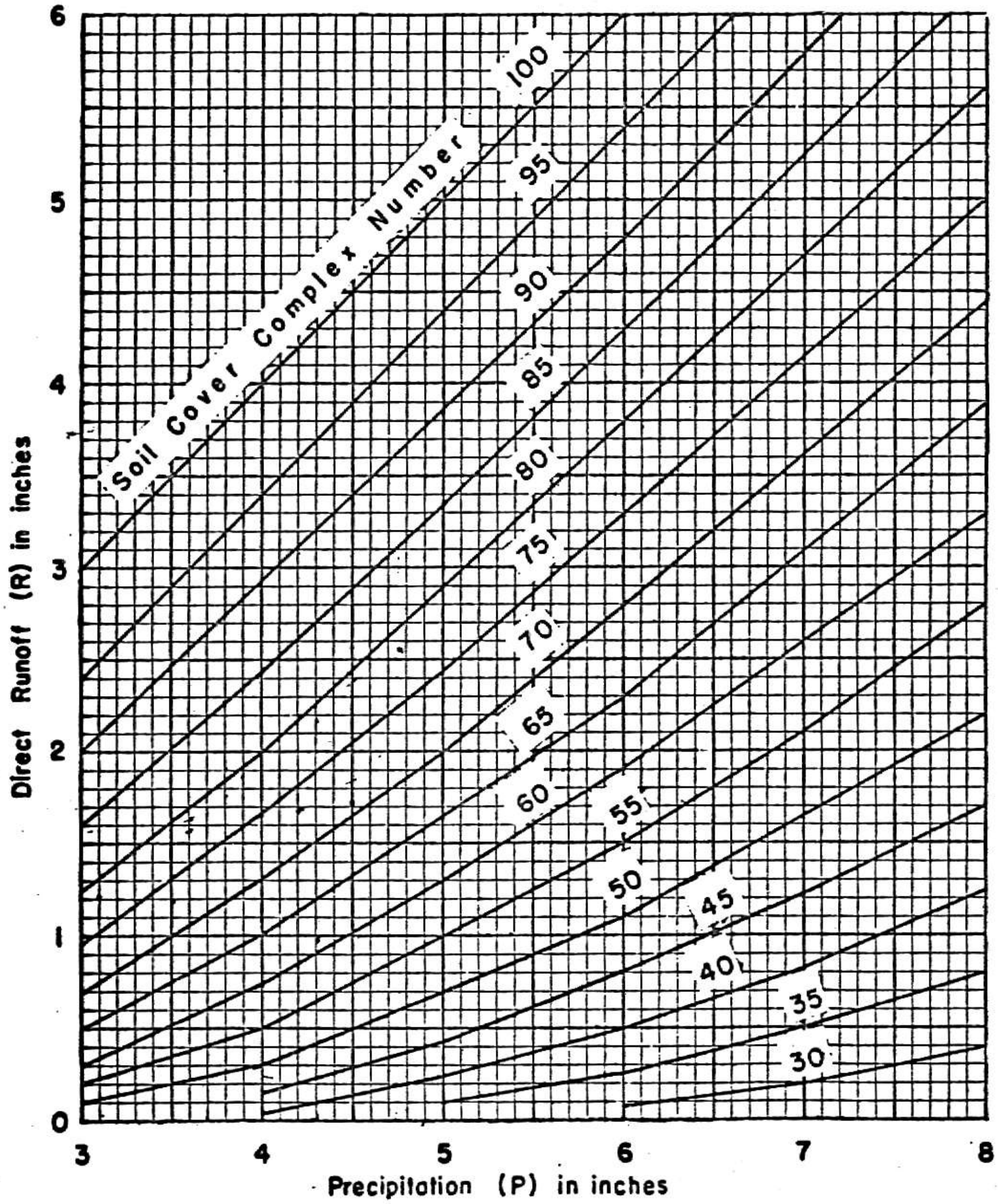
PLATE IV


Soil Cover Complex Number
100
95
90
85
80
75
70
65
60
55
50
0
1
2
3
Precipitation (P) in inches
Direct Runoff (R) in inches

EXPLANATION OF PLATE V

Relationship between precipitation and runoff for a range of soil cover complex numbers (continued). (13)

PLATE V



Soil Cover Complex Number
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
Direct Runoff (R) in inches
0
1
2
3
4
5
6
3
4
5
6
7
8
Precipitation (P) in inches

From work done by Miner *et al.* (9) and tests taken from the ponds at the Pratt Feedlot, the following estimates of design values were obtained for an acre-inch of runoff: nitrogen (N) 40 pounds; phosphate ($P_2O_5$) 6 pounds; and potassium ($K_2O$) 32 pounds.

Irrigation quality for the runoff water at the Pratt Feedlot was checked and the results are shown on Table 3. It should be noted that the water in ponds 1 and 2 had been retained for several months and could have been very concentrated. However, the water in pond 3 was trapped shortly before the sample was taken. This explains the higher electrical conductivity and soluble sodium percentage from ponds 1 and 2.

Table 3

Runoff Irrigation Water Quality
Pratt Feedlot

| Sample No. | Electrical Conductivity Micromhos/cm | Soluble Sodium Percentage |
|---|---|---|
| Pond 1 | 1655 | 25.2 |
| Pond 2 | 1655 | 21.5 |
| Pond 3 | 863 | 19.9 |

Chemical Analysis of Runoff

| Sample No. | Ca(ppm) | Mg(ppm) | Na (ppm) | K (ppm) |
|---|---|---|---|---|
| Pond 1 | 28.0 | 28.0 | 96.6 | 441.8 |
| Pond 2 | 34.0 | 22.0 | 82.8 | 480.9 |
| Pond 3 | 38.0 | 15.0 | 39.1 | 140.8 |

Since the runoff from the feedlots will be used shortly after a storm, and it will not have had a chance to concentrate by evaporation, the value for potassium from Pond 3 was used for design purposes.

The Pratt Feedlot is unusual in the way runoff water is channeled through the lots. The lots themselves drain into drainage ways. The drainage in many cases, empties into underground pipelines and is carried to the storage ponds in this manner. The runoff from the areas not used for cattle feeding purposes does not flow through the feedlots, but it also is carried away through underground pipelines. This arrangement means that the waste water from the 260-acre drainage area will be made up of highly polluted water from the 100-acre feedlot surface and normal storm runoff water from the 160-acre non-feeding area. This would tend to reduce the amount of nutrients per acre inch in the runoff water to the following approximate values: nitrogen (N) 16 pounds; phosphate ($P_2O_5$) 2.5 pounds; and potassium ($K_2O$) 32 pounds. The potassium value will still be the same since it was obtained from actual sampling of waste water from this feedlot.

## Water Supply for Disposal Systems

In order to insure that maximum crop production is obtained to dispose of as much of the applied nutrients as possible, it is necessary to provide an adequate supply of water for irrigation purposes. For this project an irrigation well was located in the NW¼, Section 9, Range 13 West, Township 27 South, Pratt County, Kansas. This well was drilled to a depth of 204 feet and had a 16 inch casing installed in the center of a 36 inch drilled hole. The casing consists of 65 feet of Layne Shutter screen with 0.125 inch openings. The remaining 139 feet is welded, plain steel casing. It was estimated from irrigation charts that a water supply of approximately 1800 GPM would be needed for this project. When this well was test-pumped, it developed 2000 GPM with 37.0 feet of drawdown. Table 4, page 24, shows the test pump information for this well. The geologic formation log of this well is shown in Table 5, page 25.

## Storage Volume for Runoff Management

At the time this disposal problem was proposed, the Pratt Feedlot had already constructed storage facilities to handle 1440 acre inches of runoff. These facilities exceed by 660 acre inches the average volume required by the State Board of Health. Therefore, it was felt that no additional storage would be needed in conjunction with the design of the disposal system.

The regulations of the State Board of Health require an average storage of 3 inches of runoff from any feedlot. This value seems somewhat arbitrary and should be adjusted to fit the rainfall patterns at the location of the feedlot in in question. Runoff information is available from the report

TABLE 4

PUMPING TEST OF WATER WELL
PRATT FEEDLOT

| Time | GPM | Water Level (Feet) | Drawdown (Feet) |
|---|---|---|---|
| 10:00 | 0 | 51.80 | 0.00 |
| 10:30 | 1865 | 80.80 | 29.00 |
| 11:00 | 1865 | 82.80 | 31.00 |
| 11:30 | 1865 | 84.30 | 32.50 |
| 12:00 | 1865 | 85.30 | 33.50 |
| 12:30 | 1865 | 85.30 | 33.50 |
| 1:00 | 1865 | 85.30 | 34.00 |
| 1:30 | 1865 | 85.80 | 34.00 |
| 2:00 | 1865 | 85.80 | 34.00 |
| 2:30 | 1865 | 85.80 | 34.00 |
| 3:00 | 1865 | 85.80 | 34.00 |
| 3:30 | 1865 | 85.80 | 34.00 |
| 3:45 | 2000 | 88.80 | 37.00 |
| 4:00 | 2000 | 88.30 | 36.50 |
| 4:30 | 2000 | 88.80 | 37.00 |

TABLE 5

GEOLOGIC LOG OF WATER WELL
PRATT FEEDLOT

| Depth in Feet | Formation |
|---|---|
| 0 - 3 | Soil |
| 3 - 62 | Sandy tan clay |
| 62 - 90 | Medium to coarse sand and some medium gravel |
| 90 - 106 | Tan clay |
| 106 - 111 | Medium to coarse sand and gravel |
| 111 - 115 | Sandy tan clay |
| 115 - 152 | Medium to coarse sand and gravel |
| 152 - 154 | Tan clay |
| 154 - 166 | Medium to coarse sand and gravel |
| 166 - 180 | Tan and gray sand and gravel |
| 180 - 202 | Medium to coarse sand and gravel |
| 202 - 205 | Red shale |

prepared by Mr. Bergsrud (7). If storage ponds are constructed to be used with an irrigation disposal system, it is suggested that 50 percent more additional storage be provided to allow for the management of this irrigation system in conjunction with the crop program suggested for waste disposal. Additional storage will allow the operator to store waste water while necessary farming operations, such as planting and harvesting, are being conducted.

In many cases where the lots are on steeply sloping land, it would be advisable to provide additional storage in some manner for solids retention.

### Land Area Needed for Disposal of Runoff

The volume of runoff will vary with the location of the feedlot in the State of Kansas. This subject has been discussed at length in the report written by Mr. Bergsrud (7). As has already been discussed, the runoff at the Pratt Feedlot for the average year is 8.4 inches and the design runoff year yielded 14.33 inches.

In order to determine land area needed for disposal of waste water, a cropping program for the land must be outlined. Since the disposal land is usually located very near a feedlot, it was proposed to use a forage corn during the summer months, and wheat for pasture during the winter months.

Forage crops will remove the maximum amount of plant nutrients and will have high water requirements. Both of these factors are very important in the disposal of feedlot runoff.

According to Sander (14), a forage corn crop will remove approximately 180 pounds of nitrogen (N), 70 pounds of phosphate ($P_2O_5$), and 180 pounds of potassium ($K_2O$) per acre per year. The wheat for pasture will remove approximately 70 pounds of nitrogen (N), 20 pounds of phosphate ($P_2O_5$), and 25 pounds of potassium ($K_2O$) per acre per year. These two crops grown in sequence would remove a total of 250 pounds of nitrogen (N), 90 pounds of phosphate ($P_2O_5$), and 225 pounds of potassium ($K_2O$) per acre per year.

Irrigation water requirements of corn and wheat together, according to the Division of Water Resources (15) would be approximately 42 inches annually. The total water required for the crop would also include any rainfall that is beneficial. The monthly water use of these crops was derived in part from work done by Hanson and Meyer (16).

Table 6, page 28, is a monthly program of the rainfall, feedlot runoff, and crop water use of the runoff generated from one acre of feedlot, utilized on one acre of crop land. This table also includes irrigation water that had to be added in order to obtain maximum production from the crops.

Data from table 6, page 28, indicates that 14.33 inches of waste water can be applied to irrigated crops without any problems relating to water disposal. The problem of nutrient disposal is not as easily answered, because 588 pounds of

TABLE 6

DESIGN YEAR-MONTHLY USE OF WATER
PRATT FEEDLOT

| Date | Rainfall (Inches) | Feedlot Runoff (Inches) | Effective Crop Rainfall (Inches) | Crop Use (Inches) | Pond Storage (Acre-Inches) | Water In Soil (Inches) |
|---|---|---|---|---|---|---|
| Dec. 31 | - | - | - | - | | 10.00 |
| Jan. 31 | 0.19 | 0.00 | 0.00 | 2.00 | | 8.00 |
| Feb. 28 | 0.35 | 0.10 | 0.15 | 2.00 | .10 | 6.15 |
| March 31 | 1.00 | 0.55 | 0.60 | 3.00 | .65 | 3.75 |
| | Pump Pit Dry--Add 3" Fresh Water (Pre-irrigate) | | | | | 7.40 |
| April 30 | 2.26 | 0.80 | 1.00 | 1.00 | .80 | 7.40 |
| May 31 | 4.19 | 1.62 | 3.00 | 4.50 | .00 | 5.90 |
| | During May Pump Pit Dry--No Fresh Water | | | | | 8.32 |
| June 30 | 2.76 | 1.00 | 2.00 | 6.50 | .00 | 3.82 |
| | Pump Pit Dry and Add 5' Fresh Water | | | | | 9.82 |
| July 31 | 3.59 | 1.62 | 2.90 | 6.50 | .00 | 6.22 |
| | Pump Pit Dry and Add 2" Fresh Water | | | | | 9.84 |
| Aug. 31 | 5.25 | 3.13 | 4.00 | 6.50 | | 7.34 |
| | Pump Pit Dry | | | | | 10.47 |
| Sept. 30 | 3.11 | 1.37 | 2.30 | 5.00 | | 7.77 |
| | Pump Pit Dry | | | | | 9.14 |
| Oct. 31 | 4.28 | 3.00 | 2.00 | 3.00 | | 8.14 |
| | (One Rain 3.51" Field Runoff of 2.00") | | | | | |
| | Pump Pit Dry | | | | | 11.14 |
| Nov. 30 | 1.86 | 0.58 | 1.30 | 2.00 | | 10.44 |
| | Pump Pit Dry | | | | | 11.02 |
| Dec. 31 | 1.30 | 0.56 | .95 | 1.00 | | 10.97 |
| | Pump Pit Dry | | | | | 11.53 |
| Total | 30.14 | 14.33 | 20.20 | 43.00 | | |
| | Irrigation Water Add 10.00" | | | | | |

nitrogen (N), 86 pounds of phosphate ($P_2O_5$), and 448 pounds of potassium ($K_2O$) would have been applied per acre during this year.

Crops grown during this one year would have removed 250 pounds of nitrogen (N), 90 pounds of phosphate ($P_2O_5$), and 225 pounds of potassium ($K_2O$) per acre, leaving 338 pounds of nitrogen (N), 0 pounds of phosphate ($P_2O_5$), and 223 pounds of potassium ($K_2O$) per acre in the soil for the next year.

Assuming that the applied nutrient level should not greatly exceed the crop needs, it would appear that a policy for design should be considered using only about 8 inches of waste water per acre of crop land. This value does not apply to the Pratt Feedlot because of the blending from other runoff water as discussed in the section on Quality of Feedlot Runoff.

## Distribution System

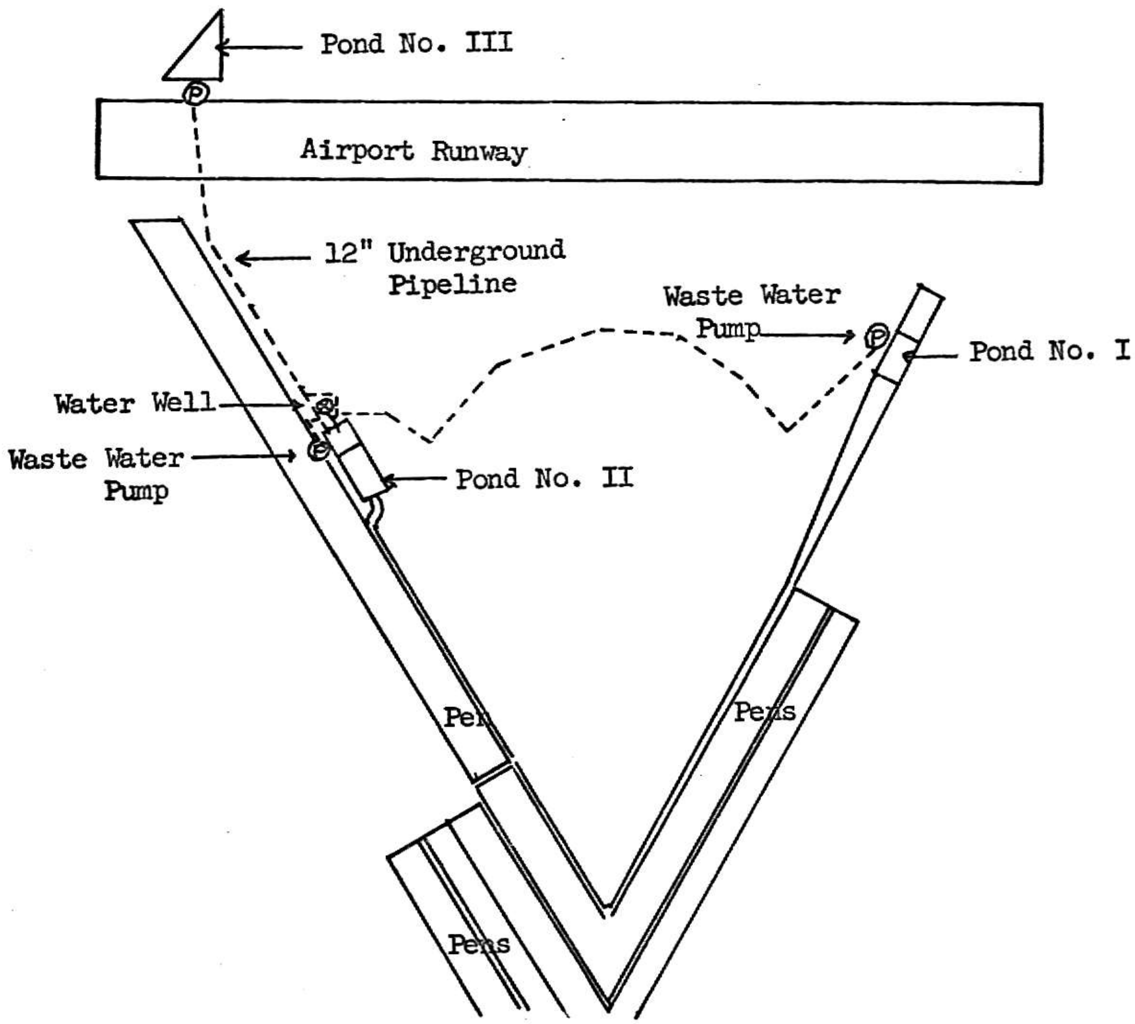
The distribution system selected for a specific feedlot runoff waste disposal system will depend upon the land available and the method of management to be used for the disposal system. Pratt Feedlot personnel wanted to use a gravity irrigation system to dispose of the waste water.

As can be observed from Plate III, page 13, the three ponds used to retain the runoff are located several thousand feet apart. This situation dictated the use of pumps in each of the ponds, and a pipeline to connect the ponds with the fresh water supply (Plate VI, page 31).

## EXPLANATION OF PLATE VI

A plan view showing the location of the 12 inch underground pipelines, water well and waste water pumps installed at the Pratt Feedlot waste disposal system.

PLATE VI




----- Location of Underground Pipeli

Ⓟ Location of Waste Water Pump

⊗ Water Well

The fields to be irrigated were leveled for gravity irrigation. The slopes on these fields varied from 0.05 percent to 0.5 percent in forward grade (Plate VII, page 34). Since these fields were located in the triangle created by the airstrip and the cattle pens, the lengths of runs varied.

The waste water is carried to the high point of each field through an underground pipeline. Waste water is then distributed along the head end of the fields through gated portable aluminum pipeline (Plate VIII, page 36).

Waste water is allowed to flow down the field through open furrows. This procedure is carried out in the same manner as would be used in any normal gravity irrigation system.

Any gravity irrigation system that is operated correctly will have a small portion of the applied water run off the bottom end of the field as tailwater. In the operation of the disposal system, this tailwater can not be allowed to enter the normal drainage patterns. The tailwater from these fields is trapped in small retention pits and pumped back into either pits I or III (Plate IX, page 38).

By using a system of two tailwater recovery pits and automatic pumps, it is possible to insure that no waste water applied to these fields will be allowed to escape as tailwater and enter the normal drainage patterns of the area.

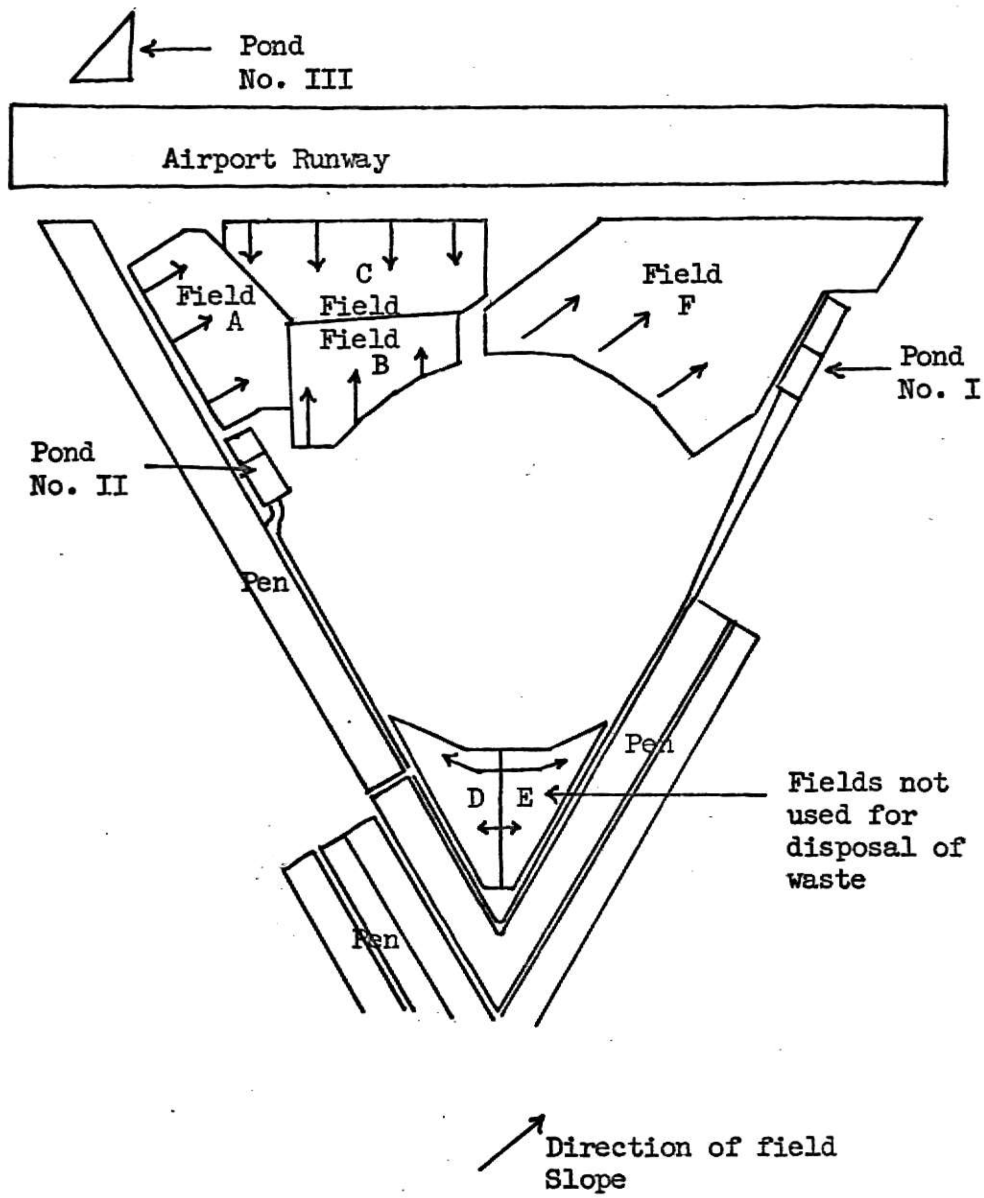
## Equipment Needed for This Project

In the design of a waste disposal system, the selection of the equipment to handle waste water is quite important, due

EXPLANATION OF PLATE VII

A plan view showing the location and direction of flow for each field leveled for the Pratt Feedlot waste disposal system.

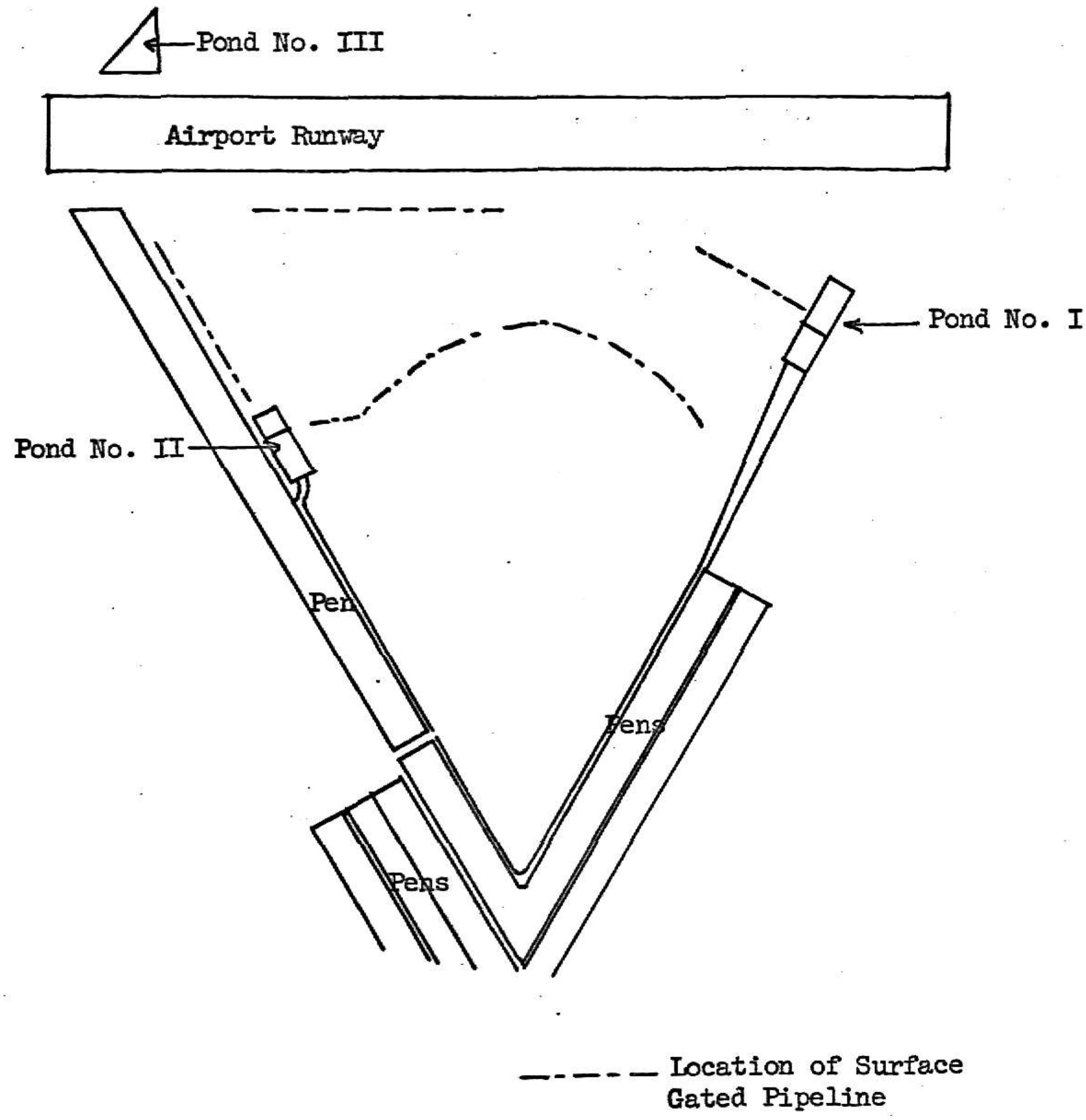
PLATE VII


Pond
No. III
Airport Runway
Field
A
C
Field
Field
B
Field
F
Pond
No. I
Pond
No. II
Pen
Pen
D
E
Fields not
used for
disposal of
waste
Pen
Direction of field
Slope

## EXPLANATION OF PLATE VIII

A plan view showing the location of portable aluminum, gated pipelines used to distribute waste water at the head end of the disposal fields. Pratt Feedlot.

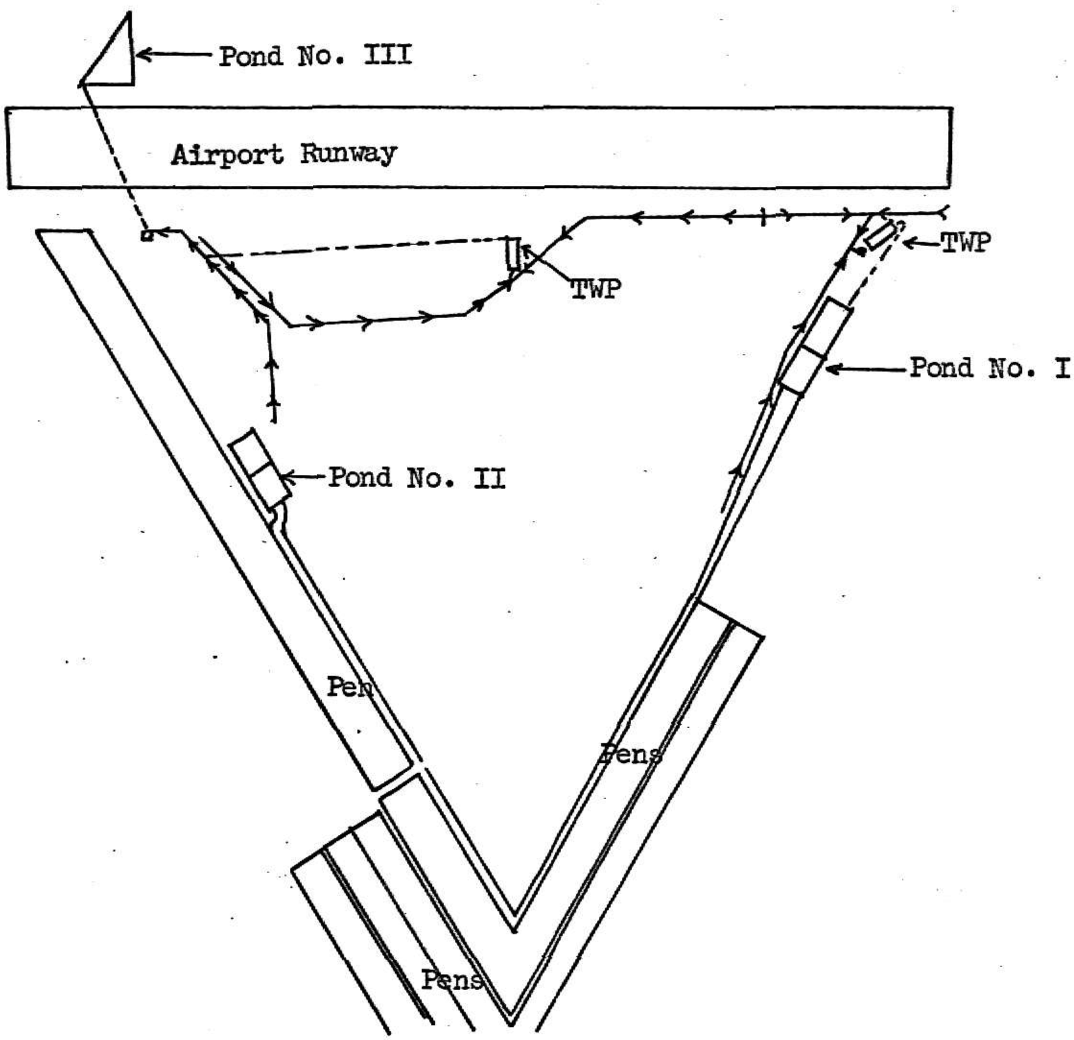
PLATE VIII


Pond No. III
Airport Runway
Pond No. I
Pond No. II
Pen
Pens
Pens
Location of Surface Gated Pipeline

EXPLANATION OF PLATE IX

A plan view showing the tailwater recovery pits, return pipelines and waste water drainage. Pratt Feedlot.

PLATE IX




| | |
|---|---|
| TWP | Tailwater Pit |
| →→ | Tailwater Open Drains |
| — - - — | Underground Tailwater Return Pipeline |
| ------ | Underground Drains |

to the fact that this material is corrosive in nature and also will be carrying suspended solids. In this design, underground pipelines of plastic were selected because of the ability to resist corrosion and to take advantage of the increased water carrying capacity of the plastic pipe. Since this pipeline was to handle a maximum of 2000 GPM at a 50 foot head, a 12 inch diameter plastic pipeline was installed. The pumps for this system were of the "chopper" type which allows any solid that is capable of entering the pump, to be passed on through the pump without creating any problems. The distribution system is made up of conventional, portable, gated aluminum pipeline 8 inch and 10 inch in diameter. The 10 inch lines were used to handle higher volumes on the larger fields; the 8 inch lines were used on the smaller fields. The valves selected to control flows from the pumps were of the flap-type and were relatively inexpensive. These were chosen because positive cut-off was not absolutely necessary and it was felt that they might have an extremely short life. A check valve was installed on the fresh water supply well, and this valve meets the specifications for city water supply. It was felt that a check valve of this quality was needed in order to protect against possible contamination of the ground water supply caused by accidental return flows into the well. In the interest of maintenance and convenience of repair, all valves were installed above the ground in short sections of steel pipe where there would be a minimum of inconvenience involved in repair or replacement, should a valve become defective. The specifications for the equipment purchased for this project and a bill of materials are included in the appendix.

## Operational Procedures

The operation and management of a waste disposal system such as the one detailed in this report is not a simple matter of applying waste water to the soil when waste water is available. A very complete record system must be devised and kept up-to-date. These records should include: quantity of fresh water applied per acre, quantity of waste water applied per acre, the amount of effective rainfall received. These water values should be tabulated along with crop use of water and a water budget maintained for the field. The primary reason for this budget is to protect against over-irrigation and the possible pollution of ground water supplies in the area.

The nutrient budget would be obtained through periodic sampling of the waste water for the nutrients contained per acre-inch and relating this to the amount of waste water applied to each acre to obtain the total amount of nutrients applied to each acre. In some instances, commercial fertilizer or dry feedlot waste may also be applied to this land. The nutrients applied in this manner should be added to the nutrients applied in the water. At the end of each growing season, the nutrients removed from the land through crop removal should be subtracted from those added to the land. At this time, a management decision should be made as to whether or not other fertility is needed to produce a crop during the next season.

As can be seen from table 7, pages 42, 43, 44 and 45, a management and operational chart has been prepared for the years 1964-1967. In all these years, additional irrigation water was needed to produce adequate crops. The system of budgeting is rather simple if adequate records can be maintained and proper tests are made.

In the case where only a small amount of runoff water is available (less than 2 inches), it is suggested that additional fresh water be added. This water should be blended with the waste water and the blended water pumped onto the irrigated land. If this procedure is not followed, the waste water can not be distributed with any uniformity over the entire acreage; since it is extremely difficult, if not impossible, to apply less than 2 inches per acre with a gravity irrigation system.

The facilities at the Pratt Feedlot are designed to use Pond II as a blending or mixing pond. The pipelines are arranged and valved to allow waste water and fresh water to be pumped into this pond at the same time. And, in most instances, the blended water can be removed from the pond simultaneously and distributed through the underground pipelines to most of the irrigated fields. There are certain conditions

TABLE 7

Management Chart

| Date | Rainfall (Inches) | Feedlot Runoff (Inches) | Rainfall Effective (Inches) | Crop Use (Inches) | Pond Storage (Acre-Inches) (1080 total) | Runoff Applied (Inches per Acre) | Water Applied (Inches per Acre) | Soil Moisture (Inches) | Runoff Fertilizer Applied (lbs. per acre) $N+P_2O_5+K_2O$ | Commercial Fertilizer Applied (lbs. per acre) $N+P_2O_5+K_2O$ | Effective Runoff Fertilizer (lbs. per acre) $N+P_2O_5+K_2O$ | Fertility Level after Crop Removal (lbs. per acre) $N+P_2O_5+K_2O$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2/31/63 | | | | | | | | 6.00 | | | | |
| 1/31/64 | 0.71 | 0.21 | 0.43 | 1.00 | 54.6 | | | 5.43 | | | | |
| 2/29/64 | 0.54 | 0.12 | 0.25 | 2.00 | | 0.48 | 1.52 | 5.68 | 008+001+015 | | 004+001+007 | |
| 3/31/64 | 0.85 | 0.26 | 0.50 | 3.00 | | 0.37 | 4.63 | 8.18 | 006+001+012 | | 003+000+006 | |
| 4/30/64 | 1.91 | 0.69 | 1.13 | 1.00 | 179.4 | | | 8.31 | | 018+046+000 | | |
| 5/31/64 | 4.36 | 1.74 | 3.02 | 4.50 | | 3.50 | | 10.33 | 056+010+112 | | 028+005+056 | |
| 6/30/64 | 2.72 | 0.88 | 1.58 | 6.50 | | 1.28 | 4.00 | 10.69 | 020+004+041 | | 010+002+020 | |
| 7/31/64 | 1.48 | 0.30 | 0.55 | 6.50 | | 0.43 | 6.00 | 11.17 | 007+001+014 | | 003+001+007 | |
| 8/31/64 | 4.48 | 2.15 | 2.42 | 6.50 | | 3.10 | 1.00 | 11.19 | 050+009+099 | | 025+004+050 | |
| 9/30/64 | 4.04 | 1.95 | 2.53 | 5.00 | | 2.80 | | 11.52 | 045+008+090 | | 022+004+045 | |
| 10/31/64 | 0.63 | 0.05 | 0.10 | 3.00 | 13.00 | | | 8.62 | | | | |
| 11/30/64 | 4.63 | 2.27 | 2.27 | 2.00 | | 3.34 | | 12.23 | 053+010+107 | | 026+005+053 | |
| 12/31/64 | 1.19 | 0.29 | 0.63 | 1.00 | 75.00 | | | 11.23 | | | | |
| Total/64 | 27.54 | 10.91 | 15.41 | 42.00 | | 15.30 | 17.15 | | 245+044+490 | 018+046+000 | 000+000+019 | 000+000+019 |
| Carry Over | | | | | | | | | | | 124+022+265 | |

TABLE 7 (continued)
Management Chart

| Date | Rainfall (Inches) | Feedlot Runoff (Inches) | Rainfall Effective (Inches) | Crop Use (Inches) | Pond Storage (Acre-inches) (1080 total) | Runoff Applied (Inches per Acre) | Water Applied (Inches per Acre) | Soil Moisture (Inches) | Runoff Fertilizer Applied (lbs. per acre) $N+P_2O_5+K_2O$ | Commercial Fertilizer Applied (lbs. per acre) $N+P_2O_5+K_2O$ | Effective Runoff Fertilizer (lbs. per acre) $N+P_2O_5+K_2O$ | Fertility Level after Crop Removal (lbs. per acre) $N+P_2O_5+K_2O$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1/31/65 | 0.41 | 0.08 | 0.16 | 1.00 | 95.80 | | | 10.39 | | | | |
| 2/28/65 | 1.02 | 0.20 | 0.25 | 2.00 | | 0.81 | 1.19 | 10.64 | 013+002+026 | | 006+001+013 | |
| 3/31/65 | 0.05 | | | 3.00 | | | 2.00 | 9.64 | | | | |
| 4/30/65 | 1.69 | 0.45 | 0.90 | 1.00 | 117.0 | | | 9.54 | | 018+046+000 | | |
| 5/31/65 | 2.33 | 0.79 | 1.10 | 4.50 | | 1.79 | 2.00 | 9.93 | 029+005+057 | | 015+002+028 | |
| 6/30/65 | 7.91 | 4.41 | 4.12 | 6.50 | 260.0 | 4.91 | | 12.46 | 078+015+157 | | 039+008+079 | |
| 7/31/65 | 3.01 | 1.18 | 1.80 | 6.50 | | 3.14 | 1.00 | 11.90 | 050+009+100 | | 025+005+050 | |
| 8/31/65 | 4.55 | 1.68 | 2.94 | 6.50 | | 2.42 | 1.00 | 11.76 | 039+007+077 | | 020+003+034 | |
| 9/30/65 | 3.81 | 1.49 | 2.30 | 5.00 | | 2.15 | | 11.21 | 034+006+069 | | 017+003+035 | |
| 10/31/65 | 1.90 | 0.87 | 1.40 | 3.00 | | 1.25 | 0.75 | 11.61 | 020+004+040 | | 010+002+020 | |
| 11/30/65 | | | | 2.00 | | | | 9.61 | | | | |
| 12/31/65 | 2.37 | 0.69 | 1.18 | 1.00 | 179.4 | | | 9.79 | | | | |
| Total/65 | 29.05 | 11.84 | 16.15 | 42.00 | | 16.47 | 6.94 | | 263+048+526 | 018+046+000 | 256+046+524 | 024+002+119 |
| Carry Over | | | | | | | | | | | 155+026+386 | |

TABLE 7 (continued)
Management Chart

| Date | Rainfall (Inches) | Feedlot Runoff (Inches) | Rainfall Effective (Inches) | Crop Use (Inches) | Pond Storage (Acre-inches) (1080 total) | Runoff Applied (Inches per Acre) | Water Applied (Inches per Acre) | Soil Moisture (Inches) | Runoff Fertilizer Applied (lbs. per acre) $N+P_2O_5+K_2O$ | Commercial Fertilizer Applied (lbs. per acre) $N+P_2O_5+K_2O$ | Effective Runoff Fertilizer (lbs. per acre) $N+P_2O_5+K_2O$ | Fertility Level after Crop Removal (lbs. per acre) $N+P_2O_5+K_2O$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1/31/66 | 0.42 | 0.05 | 0.10 | 1.00 | 192.4 | | | 8.89 | | | | |
| 2/28/66 | 1.63 | 0.78 | 1.00 | 2.00 | | 2.19 | | 10.08 | 035+007+070 | | 017+003+035 | |
| 3/31/66 | | | | 3.00 | | | | 7.08 | | | | |
| 4/30/66 | 0.88 | 0.15 | 0.42 | 1.00 | | 0.22 | 3.00 | 9.72 | 004+001+007 | 000+046+000 | 002+001+004 | |
| 5/31/66 | 0.08 | | | 4.50 | | | 5.00 | 10.22 | | | | |
| 6/30/66 | 1.72 | 0.48 | 0.85 | 6.50 | | 0.69 | 5.00 | 10.26 | 011+002+022 | | 005+001+011 | |
| 7/31/66 | 4.68 | 2.33 | 3.04 | 6.50 | | 3.46 | | 10.26 | 055+010+111 | | 028+005+055 | |
| 8/31/66 | 1.86 | 0.45 | 0.98 | 6.50 | | 0.65 | 5.00 | 10.39 | 010+002+021 | | 005+001+010 | |
| 9/30/66 | 2.06 | 0.59 | 1.25 | 5.00 | | 0.85 | 3.00 | 10.49 | 014+003+027 | | 007+002+014 | |
| 10/31/66 | 0.24 | | 0.09 | 3.00 | | | | 7.58 | | | | |
| 11/30/66 | 0.01 | | | 2.00 | | | 4.00 | 11.58 | | | | |
| 12/31/66 | 1.03 | 0.15 | 0.41 | 1.00 | 39.0 | | | 10.99 | | | | |
| Total/66 | 14.61 | 4.98 | 8.14 | 42.00 | | 8.06 | 25.00 | | 129+025+258 | 000+046+000 | 219+038+515 | 000+000+290 |
| Carry Over | | | | | | | | | | | 064+013+419 | |

TABLE 7 (continued)

Management Chart

| Date | Rainfall (Inches) | Feedlot Runoff (Inches) | Rainfall Effective (Inches) | Crop Use (Inches) | Pond Storage (Acre-inches) (1080 total) | Runoff Applied (Inches per Acre) | Water Applied (Inches per Acre) | Soil Moisture (Inches) | Runoff Fertilizer Applied (lbs. per acre) $N+P_2O_5+K_2O$ | Commercial Fertilizer Applied (lbs. per acre) $N+P_2O_5+K_2O$ | Effective Runoff Fertilizer (lbs. per acre) $N+P_2O_5+K_2O$ | Fertility Level after Crop Removal (lbs. per acre) $N+P_2O_5+K_2O$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1/31/67 | 0.25 | | 0.05 | 1.00 | 39.0 | | | 10.09 | | | | |
| 2/28/67 | 0.58 | 0.22 | 0.40 | 2.00 | | 0.53 | 2.00 | 10.97 | 008+002+017 | | 004+001+008 | |
| 3/31/67 | 0.66 | 0.20 | 0.37 | 3.00 | | 0.29 | 2.00 | 10.63 | 005+001+009 | | 002+000+005 | |
| 4/30/67 | 3.56 | 1.90 | 2.19 | 1.00 | 494.0 | | | 11.82 | | 000+046+000 | | |
| 5/31/67 | 1.75 | 0.55 | 1.05 | 4.50 | | 3.52 | | 11.89 | 056+010+112 | | 028+005+056 | |
| 6/30/67 | 5.36 | 2.01 | 3.46 | 6.50 | | 2.89 | | 11.74 | 046+009+092 | | 023+004+046 | |
| 7/31/67 | 2.29 | 0.78 | 1.44 | 6.50 | | 1.12 | 3.00 | 10.80 | 018+003+036 | 100+000+000 | 009+002+018 | |
| 8/31/67 | 1.60 | 0.50 | 0.75 | 6.50 | | 0.72 | 4.50 | 10.27 | 011+002+023 | | 005+001+012 | |
| 9/30/67 | 1.18 | 0.08 | 0.20 | 5.00 | | 0.12 | 5.00 | 10.59 | 002+000+004 | | 001+000+002 | |
| 10/31/67 | 1.49 | 0.72 | 1.10 | 3.00 | 187.2 | | | 8.69 | | | | |
| 11/30/67 | 0.94 | 0.15 | 0.41 | 2.00 | | 1.25 | 2.00 | 10.35 | 020+004+040 | | 010+002+020 | |
| 12/31/67 | 1.10 | 0.20 | 0.44 | 1.00 | 520.0 | | | 9.79 | | | | |
| Total/67 | 20.76 | 7.31 | 12.06 | 42.00 | | 10.44 | 18.50 | | 166+031+310 | 100+046+000 | 146+028+568 | 000+000+343 |
| Carry Over | | | | | | | | | | | 082+016+504 | |

when the simultaneous blending of waste water with fresh water, and irrigation with this blended water, are impossible. For example, if waste water from Pond I is being transported to Pond II for blending, and if irrigation was desirable on Field F, it would be necessary to store the blended water in Pond II until this pond is filled to capacity. Blending operations should then be halted and the stored water used to irrigate Field F. These conditions were made necessary since only one pipeline is provided for both activities.

The waste materials handled through this system are more corrosive than water normally used for irrigation. For this reason, it is suggested that after each irrigation, the entire system be purged with fresh water in order to try to clean any accumulated waste deposits from the pipes. It is most critical when the pipelines are either steel or aluminum. This is an effort to try to increase the usable life of the component parts of the waste disposal system.

If the operational procedures and the maintenance program are followed in detail, the disposal system should handle the waste problems of the Pratt Feedlot at least 80 percent of the time, and the system should have a reasonable life expectancy.

## Cost Analysis

The cost of a project for the disposal of liquid waste from a feedlot should be held to a desirable minimum. A desirable system should do a thorough and safe job of waste water disposal at the lowest practical cost. Most of the literature regarding disposal of feedlot waste discusses waste on a per animal basis, and therefore they discuss the cost of disposal on a per animal basis. It is believed that a per animal basis may be a desirable method of reporting costs, if the objective is to put a charge per head for purposes of determining the overall feeding costs. However, the magnitude of the problem is dictated by the land area contributing to the drainage from a feedlot and the rainfall at the location of the feedlot, not the number of cattle on hand. In this report, the cost of waste collection and disposal are presented both on a per head basis and on a per acre of drainage area basis.

When the design of the disposal system was undertaken, the collection system was already constructed. The capital investment for the collection system and the disposal system are tabulated in table 8, page 48.

Annual operational costs less labor costs are shown in tables 8 and 9, pages 48 and 49.

Fertility benefits derived from using waste water can be estimated at $3.80 per acre inch. A conservative estimate of the value of one acre-inch is $0.50. The Pratt Feedlot, during a normal year, will generate 2080 acre-inches per year. Using the figures ($3.80 plus $0.50 per acre-inch) during a normal year (2080 acre-inches per year), the feedlot can expect a

TABLE 8

FIXED AVERAGE ANNUAL OPERATIONAL COST
PRATT FEEDLOT

| | Investment Value Assigned to Waste Water Management | Interest on Investment (1) | Depreciation | Repairs (2) | Taxes (3) | Total Costs |
|---|---|---|---|---|---|---|
| Drainage and Storage Ponds | $ 67,533.87 | $2,026.02 | 15 years $ 4,502.26 | $2026.02 | $1013.01 | $ 9,567.31 |
| Pumps-Pipelines Water Well | $ 53,077.53 | $1,990.40 | 10 years $ 5,307.75 | $1592.33 | $ 796.16 | $ 9,686.64 |
| Land Leveling | $ 28,370.00 | $ 851.10 | 20 years $ 1,418.50 | ---- | ---- | $ 2,269.60 |
| Tailwater Recovery System | $ 3,703.48 | $ 138.88 | 10 years $ 370.35 | $ 111.10 | $ 55.55 | $ 675.88 |
| Total Costs | $152,684.88 | $5,006.40 | $11,598.86 | $3729.45 | $1864.72 | $22,199.43 |

(1) Interest on Investment
Real Property (includes all earth work) - 6%
Personal Property - 7.5%

(2) Repairs - 3% of Investment Value

(3) Personal Property - 1.5% of Investment Value

TABLE 9

AVERAGE VARIABLE ANNUAL OPERATIONAL COST
PRATT FEEDLOT

| | Col. 1 Volume (Acre-Inch) | Col. 2 Total Lift (Feet) | Col. 3 Energy Cost Dollars per Acre-Inch per 100 Feet of Lift | Col. 4 Cost of Pumping Col. 1 x Col. 2 x Col. 3 |
|---|---|---|---|---|
| Pond III to Pond II | 1130 | 100 | $0.22 | $ 248.60 |
| Pond I to Pond II | 550 | 60 | $0.22 | $ 72.60 |
| Pond II | 400 | 0 | $0.22 | $ 0.00 |
| Well Water to Pond II | 2080 | 90 | $0.22 | $ 411.84 |
| Pond II to Irr. Field | 4160 | 40 | $0.22 | $ 366.08 |
| Well Water to Irr. Field | 1080 | 120 | $0.22 | $ 285.12 |
| Total Cost | | | | $1384.24 |

return of approximately $9,000.00 per year based on the value of the nutrients and the cost of the water.

Table 10, page 51, shows the total capital investment cost and the annual operational costs based on several volumes of cattle in the feedlot. When a 90,000 head annual capacity is considered, it was found that the capital investment for the complete disposal system was $1.66 per head and the annual operational cost was $0.26 per head.

When the cost figures are based on an acre of drainage area, table 10, page 51, the capital investment was $573.95 per acre and annual operational cost was $90.32 per acre per year.

## CONCLUSIONS

Following are the conclusions of this study.

1. From an engineering standpoint, the disposal of waste water from feedlot drainage areas can be accomplished by using it for irrigation water on agricultural land, where land area permits.

2. It appears safe to assume that groundwater pollution can be avoided if, in the application of waste water, no more nutrients, on the average, are added to the soil than can be removed with the cropping program. It is estimated that the average application of waste water should be limited to 8 inches per acre per year. This design has shown that where well water is available to supplement waste water, a system will produce the crops necessary to utilize the applied nutrients.

3. The cost of this type of disposal system is quite small when expressed on a per animal basis, considering the total annual capacity of the feedlot.

TABLE 10

CAPITAL AND ANNUAL COSTS
COMPARED ON SEVERAL INDICES

| Index | Capital Investment Facilities (From Table 8, Page 48) | Average Annual Operational Costs (Less Labor) (From Tables 8 & 9, Pages 48 & 49) |
|---|---|---|
| Present Capacity 20,000 Head Cost/Head | $ 7.46 | $ 1.17 |
| Present Turnover Capacity, 60,000 Head Cost/Head | 2.47 | 0.39 |
| Expansion 10,000 Head 30,000 Head Capacity Cost/Head | 4.97 | 0.78 |
| Expansion 10,000 Head Turnover Capacity 90,000 Head Cost/Head | 1.66 | 0.26 |
| Expansion 20,000 Head 40,000 Head Capacity Cost/Head | 3.73 | 0.59 |
| Expansion 20,000 Head Turnover Capacity 120,000 Head Cost/Head | 1.24 | 0.20 |
| Drainage Area 260 Acre Cost/Acre | 573.95 | 90.32 |

4. The cost of this project, when expressed on a per drainage area acre, becomes a very substantial investment. A better design of the drainage patterns within the drainage area of the feedlot would reduce the volume of runoff and the total cost of the project.

## SUGGESTIONS FOR FURTHER RESEARCH

1. This design for waste disposal is based on a feedlot having access to land suitable for irrigation. Since this is not always the case, other methods of disposal should be initiated.

2. Since the nutrient content of the runoff is the factor limiting application to agricultural land, more information is needed to determine nutrient losses in the soil. Studies should be initiated in this area.

3. Further studies should be initiated to determine the nutrient content of the runoff from actual feedlot locations. These values are badly needed for design purposes.

## ACKNOWLEDGMENTS

The author is grateful for the advice and assistance of his graduate program committee. The members of the committee were Dr. George Larson, Professor Ralph I. Lipper, and Dr. Larry Murphy.

Acknowledgment is given to Professor Russell L. Herpich of the Extension Agricultural Engineering Department for his review and discussion of the design aspects of this study.

Grateful acknowledgment is given to the owners and operators of the Pratt Feedlot, Inc. of Pratt, Kansas, for their cooperation and understanding during design and construction phases of this study. Without their cooperation this project would not today be in actual operation.

Finally, acknowledgment is given to my wife, Jean, and my daughter, Lesa, for their encouragement and understanding.

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# APPENDIX

## BILL OF MATERIALS

| Item | Reference | Size | No. Needed |
|---|---|---|---|
| Check Valve Water Well | To Meet City Water Supply Specification | 10" | 1 |
| Check Valve Pond Pumps | Irrigation Type | 12" | 3 |
| Valves | See Specifications | 12" | 7 |
| Valves | Common Globe with Long Stem Added | 2" | 2 |
| Flow Meter | Sparling Master Flo Low Pressure | 10" | 1 |
| Steel Pipe | .105" Wall Thickness | 12" | Approx. 120.0' |
| Underground Pipe Low Head | See Specifications | | Approx. 8200.0' |
| Alfalfa Valve w/Air Relief Vent | 10" with 2" Vent | 10" | 12 |
| Air Relief Vents | Geis-ARV 2 | 2" | 12 |
| Air Relief Vents | Geis-ARV 3 | 3" | 4 |
| Surge Plug Valve Pump | Geis-SP6 | 6" | 4 |
| Underground Pipe Low Head | See Specifications | 8" | Approx. 2650.0' |
| Riser Valve High Head | Geis-RVNC-6 | 6" | 1 |
| Valve Opener Elbow | Geis-V06632 | 6" | 1 |
| Steel Pipe | .095" Wale Thickness | 6" | Approx. 40.0' |
| Pumps for Reuse Pits | See Specifications | | 2 |
| Pump for Retention Ponds | See Specifications | | 3 |

# SPECIFICATIONS

## Underground Low Head Pipe

This pipe shall be of a size large enough to transport 2000 GPM a maximum distance of 5200 feet with a maximum head loss of 40.0 feet.

All joints in the pipe shall be sealed with a gasket, solvent welding or other watertight connections.

All pipe shall be installed with a minimum of three feet of earth fill over the pipe.

All connections with steel pipe shall be made below ground level and the steel pipe shall be in a horizontal position at the point of connection.

## Underground Low Head 8" Pipe

This pipe shall be 8 inch plastic pipe with a maximum head pressure rating of 50.0 feet.

All joints in the pipe shall be sealed with a gasket, solvent welding or other watertight connections.

All pipe shall be installed with a minimum of three feet of earth fill over the pipe.

All connections with steel pipe shall be made below ground level.

## 12" Line Valves

The valves shall be of the butterfly type.

## Alfalfa Valves

The alfalfa valves shall be 10 inch with 2 inch air vent pipes on each side. These shall be Geis-AV10-2 or equivalent.

## Check Valve for Water Well

This check valve shall be of the type used on municiple water supply systems. It must keep <u>all</u> water from returning to the well.

Specifications (continued)

## Check Valve for Lagoon Pumps

These valves shall be similar to those used on irrigation units. Similar to Geis-SCV10, only in a 12" size.

## Flow Meter

The meter shall be a 10 inch Sparling Master Flo Low Pressure Line Meter, or equivalent. It shall be mounted in a plain end steel tube.

The unit shall be able to withstand working pressure up to 100 PSI, and it shall measure and record flows within 2 percent accuracy, within the range of 250 GPM.

The meter shall be equipped with a type 245 Sparling Indicator-Totalizer (further described as D.S.-CF340-2), or equivalent.

The indicator shall read in gallons per minute and the totalizer shall record in tenths of acre-feet.

## Retention Pond Pumps

These pumps shall be of a type that will not plug when pump solids. These pumps must deliver 2000 GPM with the following total head pressures:

Pump I and II --- 60 feet

Pump III -------- 90 feet

Power units shall be electric, manual control.

## Tailwater Recovery Pumps

These pumps shall be able to deliver 400 GPM with a total head pressure of 50 feet. They shall be of the turbine type.

The power unit shall be electric with automatic start and stop controls. There shall also be a manual control system.

DESIGN FOR BENEFICAL USE
OF FEEDLOT RUNOFF

by

LYNN ROWE SHUYLER

B. S. Agr. E., Kansas State University, 1961

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AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agricultural Engineering

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1969

The operation and management of the disposal system is a process of keeping a complete set of records and taking sufficient tests of waste water and soil conditions to insure accurate data for the records. The operator of this system must know the amount of nutrients applied to each acre, the amount of nutrients removed by crops and how much water is in the soil at all times.

The disposal system installed for the Pratt Feedlot was designed for 30,000 head capacity with an annual capacity of 90,000 head. The annual operational cost of the disposal system, based on 90,000 head annually, was $0.26 per head. The capital investment cost of the total system including retention ponds and the disposal system based on 90,000 head annually was $1.66 per head. The capital investment cost of the total system based on an acre of drainage area was $573.95 per acre.

From an engineering standpoint, the concept of the disposal of waste water runoff from feedlot drainage area by applying it to agricultural land can be accomplished by using it for irrigation purposes.

The design concepts used in this study should be evaluated for each feedlot location. Care must be taken to avoid possible pollution of groundwater supplies. Pollution could occur by applying more nutrients than the crops can use and moving the nutrients through the soil profile by applying water in excess of the water-holding capacity of the soil in the root zone of the crops.

The objectives of this study were: to design a system for the disposal of feedlot runoff, evaluate each factor considered in the design process, and to investigate the cost of this type of disposal system.

The factors affecting the design of a disposal system using irrigation were: annual rainfall, annual feedlot runoff, annual crop use of water, and most important, the nutrient content of the runoff.

The nutrient content of runoff from the Pratt Feedlot contains approximately 16 pounds of nitrogen (N), 2.5 pounds of phosphate ($P_2O_5$) and 32 pounds of potassium ($K_2O$) per acre inch. This is lower than runoff from test lots because of blending with runoff water from non feeding areas.

The land developed for this system was leveled to a forward grade, varying from .05 percent to .5 percent. The waste water is delivered to the field through underground plastic pipelines and distributed through gated aluminum pipelines. This part of the system is designed very similar to the ordinary irrigation system.

The waste water is blended with fresh water from an irrigation well in order to insure uniform distribution of the waste water over the field. The blending is done in one of the smaller retention ponds. The arrangement reduces the possibility of pollution of the water well from blending in the pipelines, and insures an accurate blending ratio since the pumps are operating with a constant head pressure.