ENVIRONMENTAL POLLUTION AND THE CATTLE FEEDLOT INDUSTRY IN THE UPPER NEOSHO WATERSHED OF KANSAS

by 682

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CHAPTER I

INTRODUCTION

Pollution is presently one of the most pervasive problems of our society. The rapid growth and sheer density of population, urbanization, and industry have greatly changed the quantity and quality of wastes in the environment.[1] Normally, nature can rid itself of waste: The rivers by oxidation, the air by precipitation and the soil by bacterial or chemical decomposition. However, man's ability to produce waste has seriously overburdened nature's capacity to cleanse itself. The result is pollution--a two-edged sword by which both man and nature lose through the lowering of environmental quality.

In the context of this paper pollution may be defined as the undesirable alteration of the physical, chemical, and/or biological characteristics of the air, soil and water by the introduction of excessive amounts of

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[1]Throughout this paper "environment" is to be defined as the material resources of the earth that are found above, below, and upon its surface. The resources referred to in this study are specifically air, water, and soil, plus vegetation and animal life. The words "nature", "physical environment", and "natural environment" are used as synonyms of "environment" and all have the same meaning. The pollutants reported herein undoubtedly influence other types of environments than that specified above. One can speak of the cultural or social environment of an urban area, of the economic environment of an area or industry, or of the political or legal environment of a government unit. In truth, feedlot pollutants do have an effect upon all these environments, however it is the physical or natural environment as defined above that is given prime consideration in this paper. It should be noted that what the author refers to as a "natural environment" undoubtedly is not in a natural (meaning original) state, for there is little in this world that has not been modified to a greater or lesser degree by Man's occupance.

waste material.[2]

While the capacity of the physical environment to assimilate residues and wastes varies widely with the geology, hydrology, and meteorology of an area, the capacity of a society to produce pollutants, wastes, and nuisances varies with the technologic and economic levels of the society.

The Role of Technologic and Economic Gain in Pollution

Technology has provided the impetus for tremendous gains in the efficiency of production in all parts of our economy. The advances have been translated into a greater overall production with a corresponding increase in individual affluence and consumption by most members of our society. One result has been the spewing out of vast quantities of wastes annually in the magnitude of sixty-five billion metal and plastic cups and lids, forty-eight billion cans, twenty-six billion bottles and jars, and more than a half billion dollars worth of miscellaneous packaging materials.[3]

Not only are the problems of pollution and waste growing quantitatively but qualitatively as well. Technology has created more durable forms of waste products: aluminum cans litter and pollute long after the "old fashioned" steel "tin" cans have rusted away; plastic wrappings and containers decompose at a much slower rate than cardboard or paper litter. In addition, pollutants are becoming increasingly subtle and more difficult to detect. It is almost impossible not to be aware of the stench of garbage

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[2]National Academy of Sciences, Waste Management and Control (Washington: National Research Council, 1966), p. 3.

[3]Resources for the Future, Incorporated, Resources for the Future (Annual Report, Washington: Resources for the Future Incorporated, 1966), p. 11.

floating in a stream or coal dust falling from the sky; however, a persistent organic chemical with a complex molecular chain in the same stream or the tasteless, odorless, and colorless carbon monoxide in the dust-laden air, although potentially more harmful, may go unnoticed. Yet the consequences of their increased and continued pressure on the environment may be irreversible.

Sources of Pollution

Urban areas and industries with their capacity to produce smoke, fumes, solid wastes, irritating noises and offensive odors are usually considered to be the major sources of pollution, solid wastes and nuisances. However, urban and industrial activities do not have monopolies as sources of environmental contamination; agriculture is discharging an increasing quantity of pollutants in the form of fertilizers, herbicides, insecticides, irrigation waters, and animal wastes into the environment. These pollutants and wastes ". . . from crop and livestock production may pose more difficult problems than do those of municipal or industrial origin."[4] Of the agents of agricultural pollution, one of the most recently recognized has been animal wastes.

Animal Wastes as Agents of Pollution

The vast accumulations of animal wastes are rapidly becoming major sources of air, soil and water pollution. "pollution from animal manure is known to have reached such proportions in some areas that massive

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[4] L. K. Fischer, "Water Pollution," Farm Policy Forum, 18:29, August, 1963.

fishkills[5] and water contamination have been observed."[6] In addition, the waste accumulation is a nuisance creating odors and attracting insects and rodents. The livestock feeding industry has undergone rapid changes in scale and the trend is toward confining many thousands of animals in a small area. The problem of waste disposal and water, air, and soil pollution resulting from these concentrations are a challenge to feedlot operators, planners, engineers, developers, and health officials alike.

Awareness of the problem. The problems associated with animal wastes, while vigorously denied by some individual feedlot operators, have been recognized by several groups. To date the most comprehensive review of animal waste management problems appears in a report by the American Society of Agricultural Engineers.[7] Various aspects of the problems of pollution and nuisances associated with the feedlot industry have come under the scrutiny of such diverse groups as the National Communicable Disease Center, the United States Department of Interior, and The International Association of Game, Fish and Conservation Commissioners.

Other individuals and groups have also taken cognizance of the actual and potential effects of feedlot runoff, but in most cases there has been

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[5]A fish kill may range in size from a few dozen fish to a million or more depending upon the potency of the pollutants and/or the fish population of the affected area, and will occur when surface water becomes polluted through the introduction of excessive amounts of toxic chemicals and/or the depletion of oxygen to a degree that the aquatic environment become lethal to any or all fish in the polluted water.

[6]President's Science Advisory Committee, "Agricultural Wastes," Restoring the Quality of Our Environment, (Report of the Environmental Pollution Panel, Washington: 1966), p. 170.

[7]American Society of Agricultural Engineers, Proceedings of the National Symposium on Animal Waste Management (Publication No. SP-0366, St. Joseph: 1966).

little more than an acknowledgement that a problem does exist. Two noteworthy exceptions are a study by Miner to determine the nature of feedlot runoff and its water polluting potential,[8] and one by Loehr, who is presently evaluating a system designed to treat wastes and alleviate nuisance and stream pollution problems associated with cattle feedlot operations.[9]

Purpose of the Study

To date there has not been a study that has investigated the cattle feedlot industry to determine the reasons the industry has become a major source of nuisance and pollution, and/or the actual effects of feedlot pollution upon the environment of a given area. Therefore, the purpose of this study is to determine: (1) the growth of the cattle feedlot industry of the United States and its problem of animal waste disposal; (2) some of the salient cultural and physical factors which are responsible for feedlots being a major source of environmental pollution; (3) some actual effects of feedlot-derived pollution upon the environment of a given area; and (4) some proposed methods of abating feedlot-derived pollution.

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[8]J. R. Miner, "Water Pollution Potential from Cattle Feedlot Runoff" (unpublished Ph. D. dissertation, Kansas State University, 1967).

[9]R. C. Loehr, "Annual Progress Report to the Federal Water Pollution Control Administration on Demonstration Grant WPD 123-01-66, Cattle Feedlot Waste Water Treatment," (Lawrence: University of Kansas, July, 1967). (Mimeographed.)

CHAPTER II

EVOLUTION OF THE CATTLE FEEDLOT INDUSTRY: 1950-1968

Tremendous gains in the efficiency of agricultural production in the United States have drastically changed the traditional view of a farm as an isolated self-sufficient microcosm. In perhaps no other phase of agriculture has the impact of change been greater than in the livestock industry. Until post World War II, many beef cattle were raised in relatively small herds by individual farmers. The cattle were pasture-fed during the warm months and grain-fed only during the winter. Animal waste problems were minimal. The cattle grazed in pastures much of the year at low densities per acre; the waste decomposed and was recycled through the soil with a minimum of direct release into the environment; animal waste that accumulated in the barnyard in the winter months was returned to the soil by the farmer during spring plowing. Under this system of beef production, animal waste was generated in manageable quantities.

I. DEVELOPMENT OF FEEDLOT INDUSTRY

After World War II there was a shift from the primarily pasture-fed small herds to grain-fed large herds in the major cattle feeding areas. In 1950, approximately 4,400,000 cattle were on feed in the United States; within eighteen years the number had increased 162 per cent to 11,541,000

(Table I).[10] A majority of the cattle feeding operations have been, and continue to be located in an eleven state area (Figure 1). In January of 1968, almost 78 per cent of all beef cattle on feed were concentrated in these states.[11]

Growth of Feedlots in the United States

Commercial feedlots are defined by the United States Department of Agriculture as lots with a capacity to feed one thousand or more cattle in a confined area. Young cattle, weighing from four to seven hundred pounds, are fed highly concentrated rations of grain, silage, and additives. The objective is to achieve a maximum rate of weight gain in the shortest possible time. The cattle are confined in pens (Figure 2) at densities ranging from seventy to four hundred head per acre.[12] Densities vary according to cattle size, time of year, and the degree of capacity achieved in the lot. Attempts are made to obtain the maximum rate of weight gain. The average rate of gain is a little under three pounds per day, but may vary considerably between and within lots. Cattle remain in the lot for three to five months until they weigh between eight and eleven hundred pounds. They are then sent to other feedlots for additional finishing, to terminal markets,

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[10] United States Department of Agriculture. Agricultural Statistics: 1967. (Washington: Government Printing Office, 1967), p. 367; United States Department of Agriculture. Agricultural Statistics: 1968. (Washington: Government Printing Office, 1968), p. 309.

[11] Ibid., p. 308.

[12] John C. McCoy and Robert Wuhrman, Some Economic Aspects of Commercial Cattle Feeding in Kansas, Agricultural Experiment Station Bulletin 424 (Manhattan: 1960), p. 17; S. A. Wittwer, "Animal Waste Management," Proceedings of the National Symposium on Animal Waste Management, American Society of Agricultural Engineers, Publication Number SP-0366, 1966, p. 8.

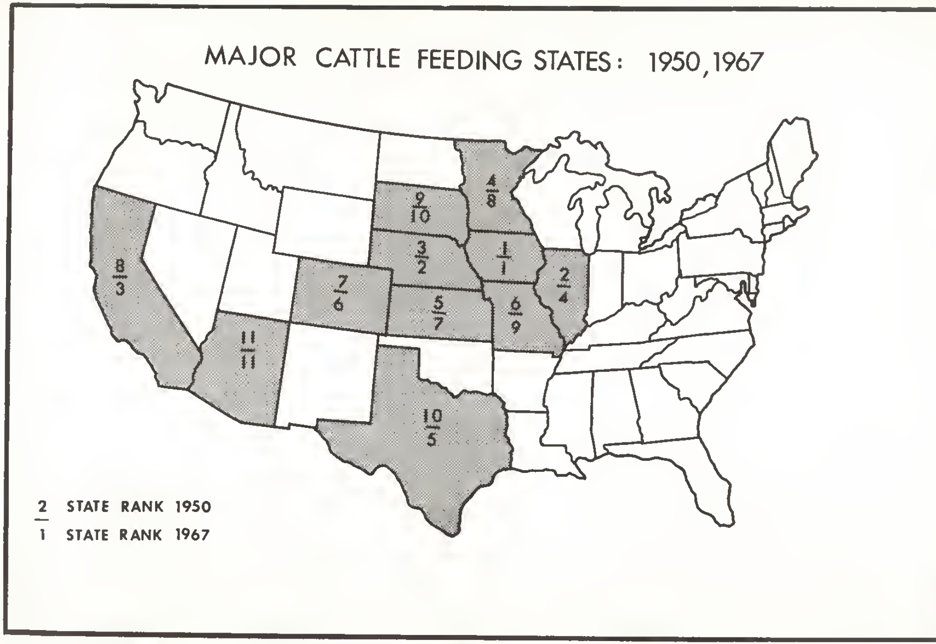
TABLE I

NUMBER OF CATTLE AND CALVES ON FEED, UNITED STATES, JANUARY 1, [a]1950–1968[b]

Year	Number (in thousands)
1950	4,390
1952	4,961
1954	5,370
1956	5,929
1958	5,898
1960	7,574
1962	8,520
1964	9,845
1966	10,582
1968	11,451

[a]The number of cattle grain-fed varies seasonally. It normally reaches a peak in mid-winter, declines in mid-summer and increases again in the fall.

[b]United States Department of Agriculture. Agricultural Statistics: 1950–1966. (Washington: Government Printing Office, 1967), p. 367; United States Department of Agriculture. Agricultural Statistics: 1968. (Washington: Government Printing Office, 1968), p. 309.



U S DEPARTMENT OF AGRICULTURE

Fig. 1.

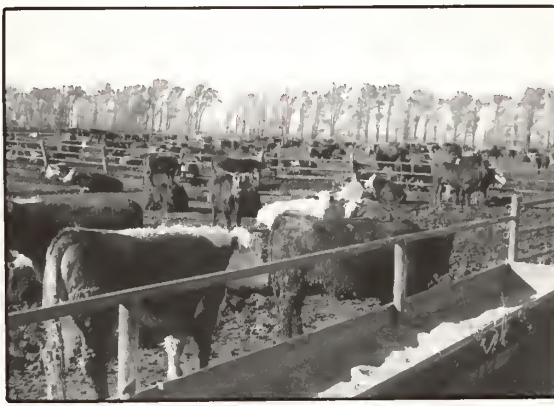


Fig. 2. Part of a ten thousand head feedlot.

or directly to packers.[13]

Although complete data are not available, there is evidence that, in the major cattle feeding states, an increasing number of cattle are being fed in, and subsequently marketed from commercial feedlots. The number of cattle marketed from non-commercial lots (those of less than one thousand head capacity) in the eleven major cattle feeding states increased 38.4 per cent from 1962 to January 1968 (Table II). During the same period the number of cattle marketed from commercial feedlots increased 96.5 per cent (Table III).

The number of non-commercial feedlots has consistently been greater than that of the commercial lots in the major cattle feeding states, but the degree to which they dominate has begun to decline. In 1968 there were almost fifteen thousand fewer non-commercial feedlots in the area than in 1963 (Table IV). This represents an 8.7 per cent decrease in the number of non-commercial feedlots. The number of commercial lots in the area however, increased over 36 per cent from 1962 to 1968 (Table V). The increase in the number of commercial feedlots has been paralleled by a corresponding increase in the size of the feedlots. This phenomenon is occurring not only in the major cattle feeding states, but in the thirty-two states (including the eleven major cattle feeders) from which the United States Department of Agriculture collects feedlot data (Table VI). Table VI reveals that in all the cattle feeding states only 9 per cent of the commercial lots had a capacity of eight thousand or more cattle in 1962; six years later the figure was 21 per cent. During the same period the number of

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[13]*Ibid.*, p. 21.

TABLE II

NUMBER OF CATTLE MARKETED FROM FEEDLOTS WITH A CAPACITY OF LESS THAN ONE THOUSAND HEAD, 1962-1968[a]

State	Year						
	1962	1963	1964	1965[b]	1966[b]	1967	1968
	(000)	(000)	(000)	(000)	(000)	(000)	(000)
Arizona	36	27	24	--	--	7	4
California	42	33	50	--	--	31	27
Colorado	265	338	315	--	--	319	321
Illinois	1095	1148	1139	--	--	1162	1185
Iowa	2567	2779	2853	--	--	3804	4005
Kansas	353	371	376	--	--	601	529
Minnesota	558	578	666	--	--	793	818
Missouri	374	356	435	--	--	597	644
Nebraska	1322	1458	1496	--	--	1636	1811
South Dakota	424	418	545	--	--	519	535
Texas	116	129	122	--	--	138	112
Total	7152	7635	8021	--	--	9607	9991

[a]United States Department of Agriculture, Number of Feedlots by Size Groups and Number of Fed Cattle Marketed: 1962-1964, Statistical Reporting Service (Washington: 1966), pp.2-6.; United States Department of Agriculture, Cattle on Feed, Cattle Sold for Slaughter--Selected Markets, Statistical Reporting Service (Washington: January, 1969), pp. 22-23.

[b]Data not available for 1965 and 1966.

TABLE III

NUMBER OF CATTLE MARKETED FROM COMMERCIAL FEEDLOTS, 1962-1968[a]

State	Year						
	1962	1963	1964	1965[b]	1966[b]	1967	1968
	(000)	(000)	(000)	(000)	(000)	(000)	(000)
Arizona	532	581	576	--	--	658	699
California	1802	1866	2011	--	--	2018	2041
Colorado	550	562	636	--	--	1000	1110
Illinois	86	97	101	--	--	117	93
Iowa	83	83	116	--	--	277	345
Kansas	190	246	310	--	--	720	803
Minnesota	38	41	37	--	--	76	87
Missouri	62	59	61	--	--	93	72
Nebraska	500	590	940	--	--	1430	1650
South Dakota	27	32	46	--	--	99	116
Texas	640	767	849	--	--	1516	1858
Total	4510	4864	5683	--	--	8004	8874

[a]United States Department of Agriculture, Number of Feedlots by Size Groups and Number of Fed Cattle Marketed: 1962-1964, Statistical Reporting Service, (Washington: 1966), pp. 2-7.; United States Department of Agriculture, Cattle on Feed, Cattle Sold for Slaughter--Selected Markets, Statistical Reporting Service (Washington: January, 1969), pp. 22-23.

[b]Data not available for 1965 and 1966.

TABLE IV

NUMBER OF FEEDLOTS WITH A CAPACITY OF LESS THAN ONE THOUSAND HEAD IN MAJOR CATTLE FEEDING STATES, 1962-1968[a]

State	Year						
	1962	1963	1964	1965	1966	1967	1968
Arizona	95	38	27	34	32	11	9
California	307	296	281	281	253	231	203
Colorado	1,208	1,204	1,152	1,150	1,240	1,286	1,263
Illinois	b	31,935	31,934	b	b	25,963	25,963
Iowa	b	44,964	45,949	b	b	45,850	45,835
Kansas	14,954	14,449	13,444	13,437	13,412	11,900	11,400
Minnesota	b	23,980	21,060	b	b	19,870	19,865
Missouri	b	17,984	17,984	b	b	17,967	17,968
Nebraska	23,008	21,803	24,110	24,120	22,676	21,944	21,215
South Dakota	10,787	11,186	9,584	9,585	10,384	9,380	9,674
Texas	1,651	1,583	1,527	1,500	1,500	1,397	1,300
Total	b	169,422	167,052	b	b	156,799	154,695

[a]United States Department of Agriculture, Number of Feedlots by Size Groups and Number of Fed Cattle Marketed: 1962-1964, Statistical Reporting Service, (Washington: 1966), pp. 2-7.; United States Department of Agriculture, Cattle on Feed, Cattle Sold for Slaughter-Selected Markets, Statistical Reproting Service, (Washington: 1966), pp. 17, 27.; United States Department of Agriculture, Cattle on Feed, Cattle Sold for Salughter--Selected Markets, Statistical Reporting Service, (Washington: January, 1969), pp. 22-23.

[b]Data not available.

TABLE V

NUMBER OF COMMERCIAL FEEDLOTS IN MAJOR CATTLE FEEDING STATES, 1962-1968[a]

State	Year						
	1962	1963	1964	1955	1966	1967	1968
Arizona	94	87	82	75	70	65	68
California	298	317	323	323	310	300	288
Colorado	72	76	81	83	79	94	97
Illinois	61	65	66	b	b	37	37
Iowa	36	36	51	b	b	150	165
Kansas	46	51	56	63	88	100	100
Minnesota	21	20	20	b	b	30	35
Missouri	16	16	16	b	b	33	32
Nebraska	312	327	330	320	314	416	463
South Dakota	13	14	16	15	16	20	26
Texas	152	170	207	234	245	294	294
Total	1121	1179	1248	----	----	1539	1605

[a]United States Department of Agriculture, Number of Feedlots by Size Groups and Number of Fed Cattle Marketed: 1962-1964. Statistical Reporting Service (Washington: 1966), pp. 2-7.; United States Department of Agriculture, Cattle on Feed, Cattle Sold for Slaughter--Selected Markets, Statistical Reporting Service, (Washington: 1966), pp. 17, 27.; United States Department of Agriculture, Cattle on Feed, Cattle Sold for Slaughter--Selected Markets, Statistical Reporting Service, (Washington: January, 1969), pp. 22-23.

[b]Data not available.

TABLE VI

NUMBER OF COMMERCIAL FEEDLOTS BY CAPACITY OF LOT, 32 STATES, 1962-1968[a]

	Capacity of Lot					
Year	1000-1999	2000-3999	4000-7999	8000-15999	16000-31999	32000 & over
1962	752	373	179	105	13	3
1963	785	388	215	114	28	7
1964	808	421	242	120	34	10
1965[b]	--	--	--	--	--	--
1966[b]	--	--	--	--	--	--
1967	975	514	314	156	62	13
1968	967	522	316	167	80	19

[a]United States Department of Agriculture, Number of Feedlots by Size Groups and Number of Fed Cattle Marketed: 1962-1964, Statistical Reporting Service, (Washington: 1966), pp. 2-7; United States Department of Agriculture, Cattle on Feed, Cattle Sold for Slaughter--Selected Markets, Statistical Reporting Service, (Washington: January, 1969), pp. 22-23.

[b]Data not available for 1965 and 1966.

lots of eight thousand or more capacity increased 92 per cent in the eleven major cattle feeding states (Table VII). Moreover, the trend toward more and larger feedlots is accelerating. An excellent example is Kansas which has witnessed a phenomenal 830 per cent increase in the number of commercial feedlots between 1956 and 1967.

Growth of Feedlots in Kansas

Kansas presently ranks fourth in the nation in the total number of all cattle and, since 1950, has consistently been one of the top eleven cattle-feeding states.[14] Within the state the number of cattle on feed has increased more rapidly than has the number of all beef cattle as seen in Table VIII.

The great change in livestock production has occurred within the past decade. Whereas there were only ten commercial lots feeding a total of 30,000 cattle in 1956, on January 1, 1967, the numbers were ninety-three and 311,000 respectively (Table IX). This is an increase of 830 per cent in the number of commercial lots and 903 per cent in the number of cattle on feed in the lots. Further the trend toward more lots is continuing; in January of 1967 there were ninety-three commercial feedlots in Kansas, by September of that year the number had increased to one hundred five commercial lots.[15] In Kansas, as in many of the other major cattle-feeding

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[14]United States Department of Agriculture, Cattle and Calves on Feed, 1950-1967, Statistical Reporting Service (Washington: Government Printing Office, 1950-1967).

[15]Based on figures from the Kansas Crop and Livestock Reporting Service, Topeka, Kansas, and the Office of Livestock Sanitary Commissioner, Topeka, Kansas.

TABLE VII

NUMBER OF COMMERCIAL FEEDLOTS WITH A CAPACITY OF EIGHT THOUSAND OR MORE CATTLE IN MAJOR CATTLE FEEDING STATES, 1962-1968[a]

State	1962	1968
Arizona	18	19
California	53	73
Colorado	13	26
Illinois	0	0
Iowa	0	4
Kansas	8	25
Minnesota	0	0
Missouri	0	0
Nebraska	11	23
South Dakota	0	0
Taxas	14	53
Total	117	223

[a]United States Department of Agriculture, Number of Feedlots by Size Groups and Number of Fed Cattle Marketed: 1962-1964, Statistical Reporting Service, (Washington: 1966), pp. 2-3.; United States Department of Agriculture, Cattle on Feed, Cattle Sold for Slaughter--Selected Markets, Statistical Reporting Service, (Washington: January, 1969), pp. 22-23.

TABLE VIII

CATTLE ON FEED AS PERCENTAGE OF ALL BEEF CATTLE, KANSAS, JANUARY 1, SELECTED YEARS[a]

Year	All Beef Cattle (thousands)	Cattle On Feed (thousands)	Cattle on Feed as % of all Beef Cattle
1954	4,304	216	5.6
1959	4,324	293	7.3
1965	4,848	407	8.4
1967	5,506	586	10.6

[a]Compiled from various publications of Kansas Crop and Livestock Reporting Service, Topeka, Kansas.

TABLE IX

NUMBER OF COMMERCIAL FEEDLOTS AND CATTLE IN LOTS, KANSAS, JANUARY 1, OF SELECTED YEARS[a]

Year	Lots	Cattle (thousand)
1956	10	30
1960	23	58
1965	63	200
1966	88	260
1967	93	311

[a]Compiled from various publications of Kansas Crop and Livestock Reporting Service, Topeka, Kansas.

states, the development of the commercial cattle feedlot industry has been a direct outgrowth of several factors.

II. FACTORS IN THE DEVELOPMENT OF FEEDLOTS

Several major factors are responsible for the great increase in the number of cattle on feed, the number of commercial feedlots, and the large capacity of the lots. While the factors below apply specifically to Kansas, many of them have had some influence on cattle feeding operations throughout the United States.

Technological Advances

The availability of feed grains is perhaps the single most important factor in the development of cattle feedlots and the availability increased in response to the development of technology. Drought-resistant sorghum, introduced into the Great Plains during the 1930's, had the potential to make a great impact upon the cattle feeding industry as its feed value was almost equal to corn. However, the plant did not lend itself to mechanization until plant breeders literally tailored the crop to fit available machinery.[16] In areas too dry for corn, sorghum provided winter feed as grain, silage, and forage. In these same areas sophisticated irrigation techniques were developed that enabled farmers to grow not only assured supplies of sorghum but corn as well. The development and use of hybrid seeds, fertilizers, and pesticides greatly increased grain yields per acre. These developments were applied to all grain crops including wheat which eventually came under a federal program of restricted acreage. When this

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[16] L. Haystead and Gilbert Fite, The Agricultural Regions of the United States (Norman: University of Oklahoma Press, 1956), p. 198.

occurred many wheat farmers planted their diverted wheat acreage to unrestricted sorghum and the supply of livestock feed grain increased. Other technological advances, including improved feed-handling systems, better disease control, and the development of feed supplements, have enabled one man to manage thousands of animals within an area one-tenth as large as that required twenty years ago.[17]

Increased Markets

Population growth and increased affluence have generated a growing market for meat products. Between 1950 and 1968, the population of the United States increased approximately forty-seven million; during the same period meat consumption (excluding poultry, fish, and game) increased from 144.6 to 178.2 pounds per capita. The beef industry profited greatly from the increased consumption (Figure 3). In 1950, beef made up 43 per cent of all meat consumed; in 1967 beef constituted 60 per cent of all meat eaten in the United States.[18]

Monetary Return

The last major factor to be considered in the development of the industry is the profit motive. With efficient management, the concentration and and feeding of thousands of cattle in a small area can be a lucrative business. Approximately one hundred acres are required for a 20,000 head feedlot.[19]

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[17]C. S. Morrison, "Farm Animal Waste Problems," Proceedings of the National Symposium on Animal Waste Management, American Society of Agricultural Engineers. Publication No. SP-0366, 1966, p. 8.

[18]United States Department of Agriculture, Agricultural Statistics, 1968 (Washington: Government Printing Office, 1968), p. 358.

[19]This acreage would be exclusive of office space, feed storage facilities, and of course cropland.

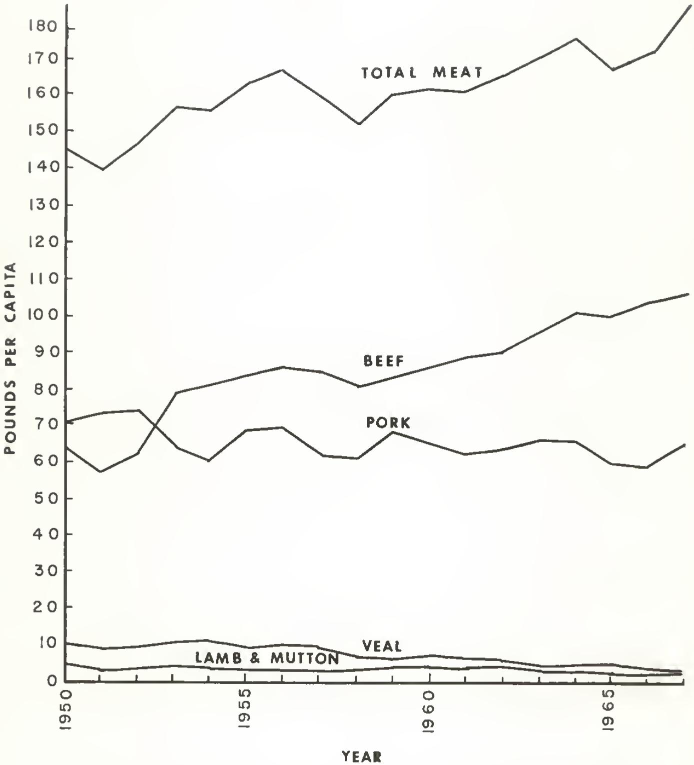

Fig. 3. Meat Consumption in the United States, 1950-1967. (USDA, Agricultural Statistics, 1968)

Two herds of this size can easily be fed each year with a net profit of five dollars per head or a total of two thousand dollars per acre.[20] A per-acre net profit of this magnitude is much higher than could be realized from the growth of any crop, with the possible exception of a specialty crop. Too, economy of scale is an important consideration in the size of operation. Studies in Kansas indicate that per-head non-feed costs of large feedlots (twelve to twenty thousand head) are less than the same costs in lots of fewer than twelve thousand head. It was suggested that even further economies could be gained by still larger lots.[21]

Thus the combination of technological advances, increased markets, and financial rewards has fostered a thriving industry, and at present there is every indication of even a greater concentration of livestock enterprises in the future. Despite the continued success of the industry, there are some problems in transportation, feed storage, and continuous disease vigilance, but the single most serious threat to the industry today is that of animal waste management.[22]

III. ANIMAL WASTE MANAGEMENT

The growth of the feedlot industry was so rapid and apparently so successful that few realized the full significance of the fact that each

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[20]T. M. Stubblefield, "Problems of Cattle Feeding in Arizona as related to Animal Waste Management," Proceedings of the National Symposium on Animal Waste Management, American Society of Agricultural Engineers, Publication No. SP-0366, 1966, p. 121.

[21]J. C. McCoy and C. C. Hausman, Economics of Scale in Commercial Cattle Feedlots of Kansas--An Analysis of Non-Feed Costs, Kansas State University Tech. Bulletin 151 (Manhattan: 1967), p. 35.

[22]Stubblefield, p. 120.

animal required output as well as input. As a result manure is now piling up faster than feedlot operators can dispose of it. Animal waste disposal has grown to such dimensions it is probably the major unsolved problem in the confinement feeding of livestock and poultry.[23]

Magnitude of Waste Accumulation

It is difficult to obtain an accurate average figure on animal waste production. Published values vary in estimating the amount of manure produced by beef cattle in feedlots because of differences in: 1) size of the animal, 2) type of rations fed, 3) housing and management practices, 4) manure handling and collection methods, and 5) analytical techniques employed in measuring the waste.[24] Despite the difficulties in obtaining accurate data on waste elimination Taiganides and Loehr did achieve remarkably similar results. Taiganides found that the amount of waste voided by a beef animal as a percentage of body weight approximated 6.4 per cent; in a separate study Loehr computed the amount to be 6.6 per cent.[25] Taiganides compared the daily amount of waste voided by man to that of the animals he raises (Table X) and considered sixty-four pounds per day to be a representative figure for the amount of manure eliminated by a one thousand pound beef animal. Loehr computed the amount of waste eliminated daily by a nine hundred pound steer to be sixty pounds of wet manure, of which forty-three

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[23]President's Science Advisory Committee, p. 170.

[24]R. C. Loehr, Pollution Implications of Animal Wastes--A Forward Oriented Review, Federal Water Pollution Control Administration, (Ada, Oklahoma: Robert S. Kerr Water Research Center, 1968), p. 51.

[25]Ibid., p. 36.

TABLE X

COMPARISON OF AVERAGE DAILY AMOUNT OF WASTE VOIDED BY MAN AND BY FARM ANIMALS[a]

Species	Live Weight (lbs.)	Waste (lbs./day)
Man	150	3.9
Chicken	4-5	.26
Swine	200	14.0
Cattle	1,000	64.0

[a]E. P. Taiganides and T. E. Hazen, "Properties of Farm Animal Excreta," Transactions of American Society of Agricultural Engineers, 9:375, 1966.

pounds was manure and seventeen pounds was urine.[26]

The value obtained by Loehr may be used to give an indication of the magnitude of waste accumulation in a commercial feedlot. If these figures are accepted and projected, a total amount of 7.84 tons of feces per year per nine hundred pound animal or almost eighty thousand tons are defecated annually by the cattle in a ten thousand head lot.[27]

Common Disposal Method

Land disposal, the spreading of manure on crop land, has traditionally been the most widely practiced method of barnyard-waste disposal. When small volumes of waste are involved this method is often satisfactory, but when vast quantities of animal wastes are generated the practicality of this disposal method declines. Even with relatively heavy applications of fifteen tons of manure per acre, it would require approximately 5,200 acres to dispose of the feces generated in a ten thousand head feedlot. It is not surprising that few of the large operators have sufficient land to accommodate all the bulk manure generated in their lot. In an effort to utilize this method of disposal some feedlot operators in Kansas give manure away and, if necessary, assume the cost of transporting it to their neighbors' fields.

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[26] Ibid., p. 41.

[27] The following computations were used to obtain these figures: 43 pounds of feces per day x 365 days x 10,000 cattle ÷ 2,000 pounds avoirdupois. The assumptions are made that: 1) the average weight of each animal during its confinement will approximate 900 pounds; 2) the average feces output per animal will average 43 pounds per day; and 3) the lot will operate at full capacity for 365 days during the year. It is acknowledged that all of these assumptions, particularly the latter, may not be totally realistic and are meant only as an indication of the volume of waste that must be managed in a feedlot.

Some problems still exist for those who are fortunate enough to have sufficient land to accommodate all the manure produced in their lot; once the fields have been seeded this method of disposal cannot be utilized again until after the crop has been harvested--a period of perhaps a hundred or more days. Yet during the planting, growing and harvesting season a ten thousand head feedlot may produce in excess of twenty thousand tons of manure that must be left to accumulate on the feedlot floor or be scraped into huge mounds to await fall spreading. Under such circumstances manure can only be put on the fields during the fall, winter, and early spring. In areas where the ground freezes during the winter months, the covering of manure may wash away during snow melt or heavy spring rains before it can be plowed under. When this occurs large quantities of manure may be carried into rivers and streams.

Cost of Waste Disposal

Not only is the traditional method of animal waste disposal unsatisfactory in several respects, the collecting, hauling and spreading of manure onto the fields is time-consuming and expensive. A study, conducted in Michigan, revealed that an average of thirty man-days per year was required to collect, haul, and spread the manure generated by 218 head of beef cattle.[28] On the basis of this study it would require approximately 1,300 man-days to dispose of the manure generated by the cattle in a ten thousand head feedlot.[29]

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[28] E. T. Benn, C. R. Hoglund, and E. D. Longnecker, Animal Manures--What Are They Worth Today?, Michigan Agricultural Experiment Station, Bulletin 231 (East Lansing: 1961), p. 13.

[29] This straight line projection may not apply in a large commercial feedlot. In lots of this type specialized equipment is often used. There

Nutrient Value of Manure

Not only is the cost of handling expensive in time, but the maximum value of the manure as a source of plant nutrients is seldom obtained. From 20 to 60 per cent of the original plant nutrients are contained in the liquid portion of manure; if the manure is allowed to accumulate on the lot without bedding to absorb and hold urine, over 50 per cent of its nutrient value is lost through evaporation and percolation.[30] Precipitation further reduces the nutritive value of the manure. A rainfall of 1.5 inches will remove a large part of the soluble nutrient through runoff and leaching.[31]

Another unsatisfactory aspect to the utilization of manure as fertilizer is its low monetary value, even when all nutrients are retained. The values derived by Taiganides in Table XI reveal that of the three major sources of animal fertilizer, cow manure has the least potential worth. As a result, it is often more economical and beneficial to apply chemical fertilizers, which retain full potency, than to apply cow manure with its low nutritive value. The application of manure as a means of improving the tilth, structure, and humus content of the soil is of much more benefit and

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is a need for detailed cost studies in waste removal and disposal in large feedlot operations. The feedlot operator does not usually know the time and money expenditure involved. For instance, it was found that none of the operators of commercial cattle feedlots in the Upper Neosho Watershed of east central Kansas would even attempt to estimate the cost of waste removal and disposal from their lots. Yet these operators appeared to be astute businessmen who had figures on weight-gain, feed costs, transportation charges and many other variable and non-variable operation expenses.

[30] E. P. Taiganides, The Value of Animal Manures, Behlen Manufacturing Co. (Columbus, Neb., 1964), p. 9.

[31] M. S. Anderson, "Farm Manure," Soils, Yearbook of Agriculture, U.S.D.A (Washington: Government Printing Office, 1957), p. 234.

TABLE XI

POTENTIAL WORTH OF ANIMAL MANURES ASSUMING NO LOSSES FROM TOTAL EXCREMENT[a]

	Potential Dollar Value[b] Per 1,000 Lbs. Live Weight			
Manure	Day	Year	Ton	1,000 Gals.
Hen	$0.20	$71.00	$7.00	$29.00
Hog	0.11	42.00	3.40	14.00
Cattle	0.07	26.00	2.30	9.40

[a]E. P. Taiganides, _The Value of Animal Manures_, Behlen Manufacturing Co. (Columbus, Neb., 1964), p. 8.

[b]Based on current (1964) retail prices of 12, 10, and 5 cents per pound of nitrogen, phosphoric acid and potash respectively.

importance than is either the quantity or quality of any fertilizer that may be derived from the manure. However, it is questionable as to whether these soil-building attributes of manure are sufficient to overcome the expense involved.

Cognizance of the high cost factor in animal-waste management was noted by the Chief of the Office of Solid Waste of the U. S. Public Health Service who stated: "Entirely apart from the environmental problem associated with the practice of manure spreading on open fields the sheer cost of field spreading . . . is becoming more and more economically unacceptable."[32] In addition to the problem of disposal, the presence of a twenty-thousand-ton manure pile can be, and all too often is, a constant source of nuisance and environmental pollution.

Success *vs.* Failure

The growth of the commercial cattle feedlot industry in the United States was very rapid. The factors of a cattle-raising history, feed availability, disease control, and expanded markets produced the necessary conditions which fostered a thriving industry. It would appear that technology, which was in large part responsible for the success of the industry, has failed to find a solution to the major problem of animal waste accumulation. However, it has not been the failure of applied technology *per se*, but rather a failure of the operators, public officials, engineers, and other interested parties to devise the proper technology to be applied to

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[32]Wesley E. Gilbertson, "Animal Wastes: Disposal or Management," *Proceedings of the National Symposium on Animal Waste Management*, American Society of Agricultural Engineers, Publication No. SP-0366, 1966, p. 144.

be applied to the problem. The growth of the industry occurred so quickly that the industry was confronted with a massive problem before it became aware that any problem existed. It is ironic that the very success of the industry and the rapidity with which it developed are largely responsible for the major problem of animal waste disposal which threatens the industry today.

CHAPTER III

CATTLE FEEDLOTS AS A SOURCE OF POLLUTION

Feedlot pollution affects all the basic elements of the physical environment: the air, land, and water. The air is polluted by dust and offensive odors. The soil may become polluted by the excessive leaching of minerals and elements from animal wastes into the ground. The major problem and greatest danger of soil pollution is its ultimate effect upon ground and surface water, for it is the liquid realm of our physical environment that has been the most seriously affected by feedlot-derived pollutants.

I. WATER POLLUTION

The physical, chemical, and aesthetic quality of water has declined as a direct consequence of feedlot-derived pollution. Manifestations of the feedlot pollutants in water have been massive fish kills, unpalatable drinking water, and the abandonment of water-recreation areas. Waste material carried into lakes and streams by feedlot runoff is considered by some to have resulted in pollution as, ". . . detrimental to a receiving water body as that of the wastes of any other industry."[33] It is considered by still others to be the leading uncontrolled source of water pollution in some areas. The Assistant Director of Environmental Health Services of the

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[33] U. S. Dept. of Health, Education and Welfare, Pollution Caused Fishkills in 1964, Public Health Service Publication No. 847 (Washington: Government Printing Office, 1965), p. 3.

Kansas State Department of Health reported that "currently in Kansas . . . our most significant uncontrolled source of water pollutants is surface water runoff from the confined feeding of domestic livestock."[34]

Areal Variation in Occurrence

Surface-water pollution derived from feedlot waste is not everywhere equal; indeed, it may be shown that the deleterious effects of cattle feedlots upon the water environment vary considerably from place to place. The state of Kansas may again be cited as an example of the areal variation in the incidence of feedlot-derived water pollution. The meridian st 98° 30' West Longitude conveniently divides the state into two almost equal parts. Although both the eastern and western sections have almost an equal number of commercial feedlots (fifty-two and fifty-three respectively) as shown in Figure 4, the eastern section contains only 39 per cent of all cattle in commercial feedlots within the state; yet, the occurrences of water pollution attributed to feedlot wastes have been much greater in number and much more severe in nature in the eastern part of the state. This is evidenced by Figure 5 which depicts the number and location of fishkills that have occurred in Kansas during the six year period, 1962 through 1967. In each instance the kills were attributed to the decline of water quality as a consequence of the introduction of feedlot-derived wastes into the river system.

Thus it is obvious that cattle density alone is not responsible for feedlots' being a major source of pollution. In order to determine some of the more salient factors responsible for feedlot-induced pollution, the

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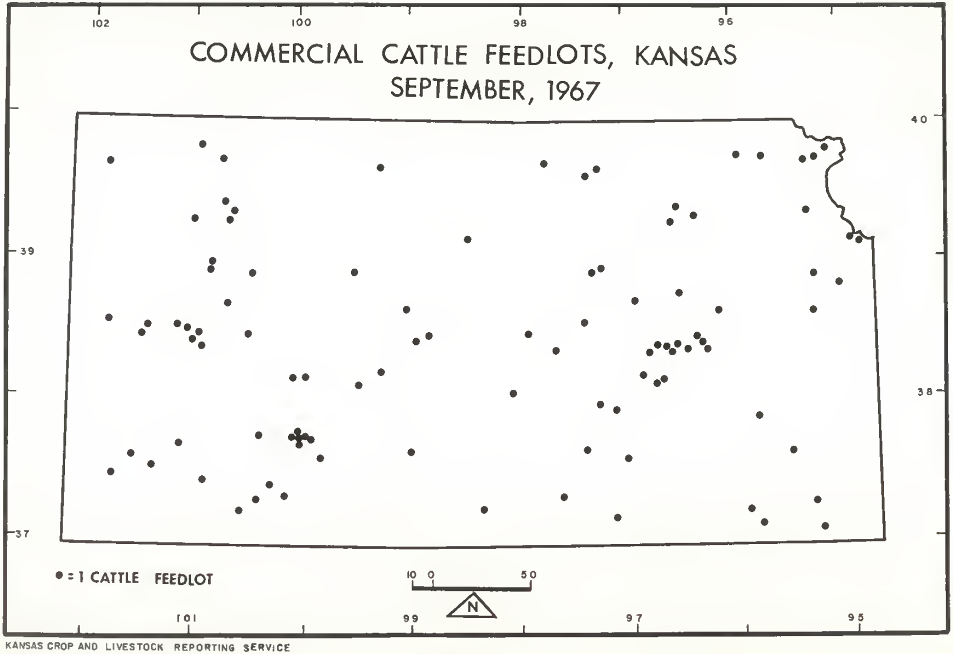
[34] M. E. Gray, "Cattle Feedlots and Pollution" (paper read at Ramada Inn, Topeka, Kansas, March 3, 1967).


102
100
98
96
COMMERCIAL CATTLE FEEDLOTS, KANSAS
SEPTEMBER, 1967
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37
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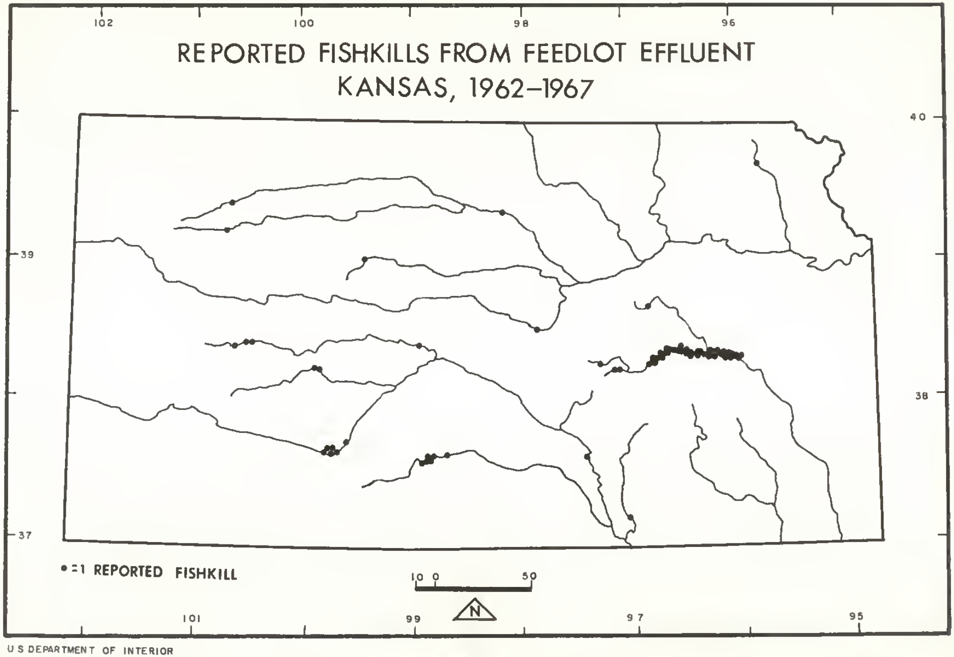
KANSAS CROP AND LIVESTOCK REPORTING SERVICE

Fig. 4.


REPORTED FISHKILLS FROM FEEDLOT EFFLUENT
KANSAS, 1962–1967
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U S DEPARTMENT OF INTERIOR

Fig. 5.

properties of the pollutants, and the effect of pollutants upon the physical environment, studies were conducted in a section of east-central Kansas, the Upper Neosho Watershed.

II. FEEDLOTS IN THE UPPER NEOSHO WATERSHED

The Upper Neosho Watershed of east-central Kansas was studied to determine the role of the commercial feedlot industry in producing pollutants, and the effect of the pollution upon the natural or physical environment. This area was selected for the following reasons: (1) it is one of the major centers of the feedlot industry within the state; (2) it has experienced much of feedlot-derived pollution; and (3) it is accessible for field study.

Physical and Economic Parameters of Study Area

For the purposes of this study, the Upper Neosho Watershed is defined as all the area drained by the Neosho River above the John Redmond Reservoir Dam. It encompasses the drainage basins of all the Neosho's upstream tributaries, including its major one, the Cottonwood River (Figure 6). The Upper Neosho Watershed covers approximately 3,015 square miles.[35] The study area includes most of Morris, Marion, and Chase Counties, much of Lyon County, the northwestern quarter of Coffey County and very small sections of Wabaunsee and McPherson Counties. The study area borders the Great Plains on the west and lies wholly within the Flint Hills Upland and the Osage Cuesta of the Central Lowlands (Figure 7).

The major economic activity of the Flint Hills and Osage Cuesta is agriculture. The lush blue-stem covered uplands support a thriving

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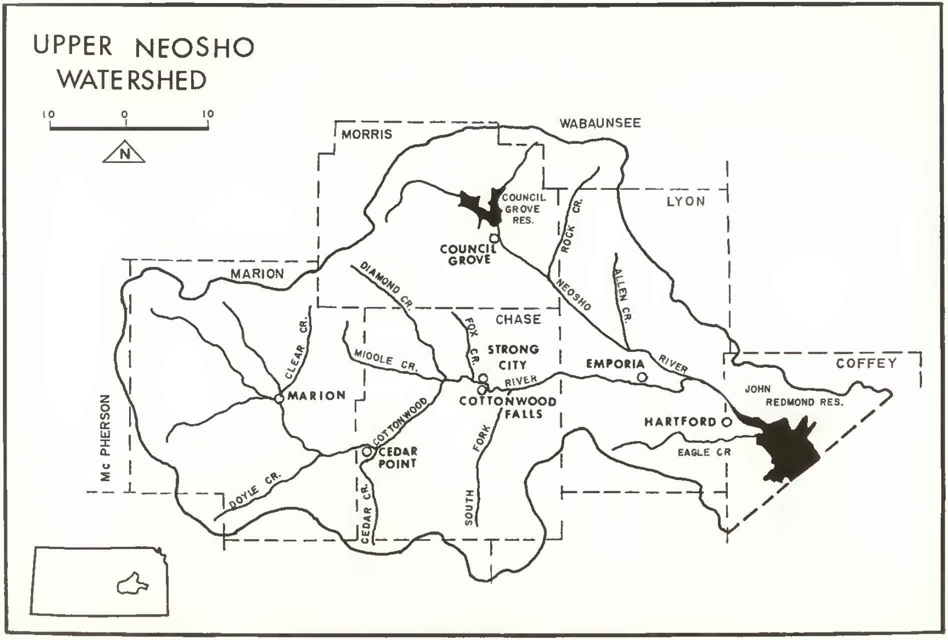
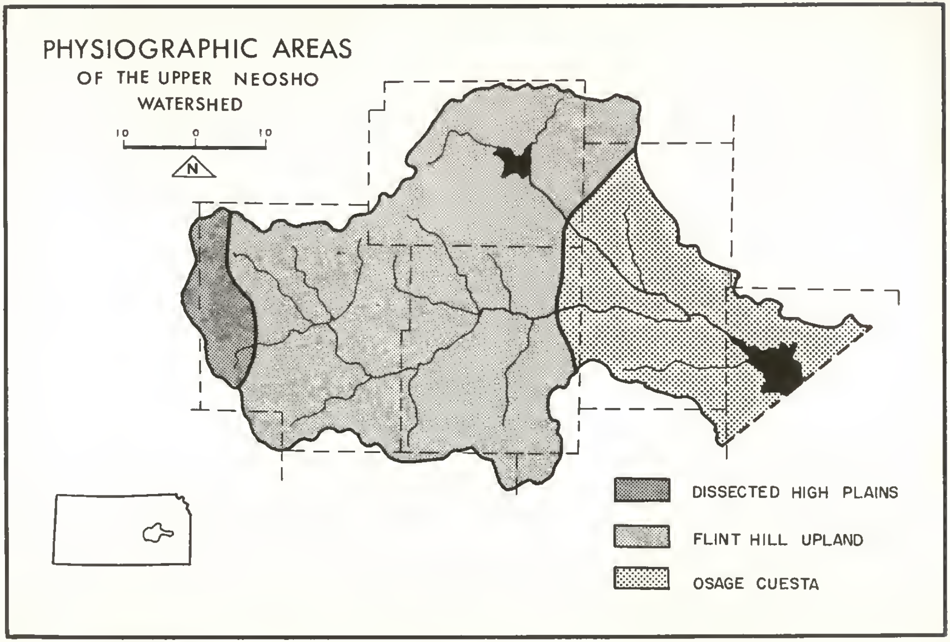
[35]State of Kansas, State Water Plan Studies, Neosho Unit, Kansas Water Resources Board (Topeka: 1962), p. 41.



KANSAS WATER RESOURCE BOARD

Fig. 6.



KANSAS WATER RESOURCE BOARD

Fig. 7.

beef-grazing industry. In the lowland valleys are many cash grain and general farms where corn, winter wheat, oats, and hay are important crops.[36]

Site and Situation of Feedlots

The Upper Neosho Watershed constitutes less than 4.0 per cent of the total surface area of Kansas; however, as of September, 1967, the study area contained 10 per cent of all the commercial feedlots in the state and 23 per cent of all cattle in commercial lots. A total of twelve commercial lots containing approximately 76,5000 cattle are situated within the watershed (Figure 8).[37]

The twelve commercial feedlots in the watershed are concentrated in Chase and Lyon Counties, and with the exception of one lot are located on the higher margins of the flood plains of the Cottonwood River and the South Fork of the Cottonwood River and on the uplands immediately adjacent to the flood plains. A sloping site away from the river is usually selected to minimize danger of flooding and to insure sufficient slope for adequate drainage. The latter is an important consideration in feedlot site selection in the area as is slope orientation. All feedlots, except one, are located on south or east facing slopes.

The topographic details of ten of the twelve feeding sites are shown in Figures 9-12. The feedlots are numbered for identification; the size of

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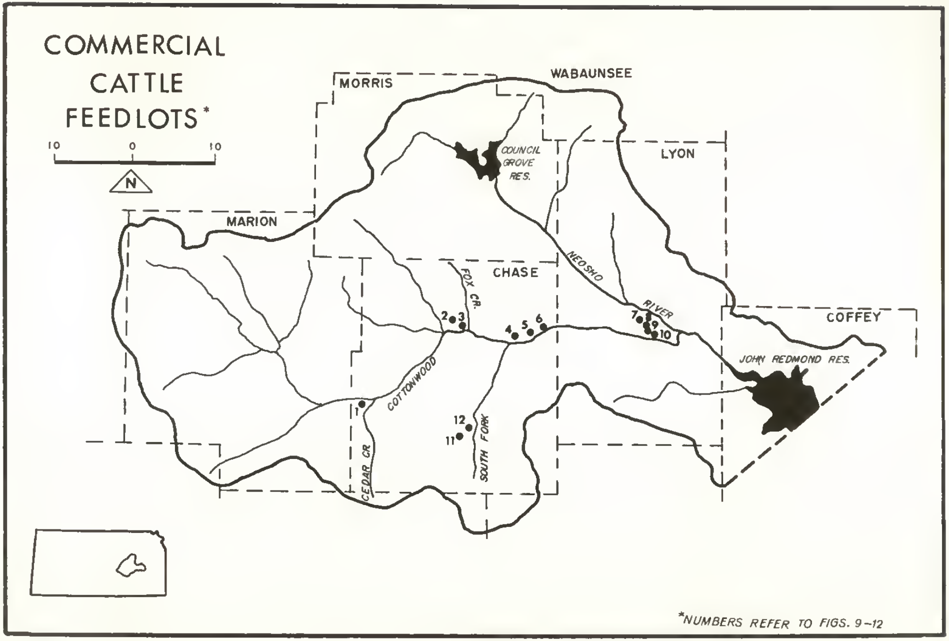
[36]Huber Self, Geography of Kansas (Oklahoma City: Harlow Publishing Corp., 1960), p. 27.

[37]In October, 1967, the twelve lots had a capacity of 76,500 cattle. Since livestock are moved into or out of a lot almost daily, the actual number of cattle on hand in a large lot may fluctuate as much as a thousand head on any given day. However, most lots operate at near or even over capacity, particularly during fall and winter months. Thus lot capacity figures may be used to approximate the number of cattle in any lot.


COMMERCIAL
CATTLE
FEEDLOTS*
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MORRIS
WABAUNSEE
COUNCIL GROVE RES.
LYON
MARION
CHASE
FOX CR.
NEOSHO
RIVER
COFFEY
JOHN REDMOND RES.
COTTONWOOD
CEDAR CR.
SOUTH FORK
1
2
3
4
5
6
7
9
10
11
12
*NUMBERS REFER TO FIGS. 9-12

Fig. 8.

operation and period of time located at present site are given below:

Number 1: The lot is approximately forty-five acres in size and has a capacity of five thousand head of cattle. The lot has been in operation since 1960 (Figure 9).

Number 2: The lot is approximately forty-five acres in size and has a capacity of forty-five hundred head. The lot, which has been in operation since 1951, also feeds approximately fifteen hundred hogs (Figure 10).

Number 3: This is the single largest lot in the watershed, both in area and capacity. The lot is approximately two hundred acres in size and has a capacity of twenty thousand head. When visited in October, 1967, less than seventeen thousand cattle were being fed, but several thousand more head were expected within a few days. The lot has been in operation since 1951 (Figure 10).

Number 4: The lot covers approximately forty acres, feeds forty-five hundred cattle and has been on this site since 1963 (Figure 11).

Number 5: This lot is approximately forty-five acres in size and feeds forty-five hundred cattle. It has been in operation since 1965 (Figure 11).

Number 6: The actual feedlot operation covers approximately eighty acres. The lot which began as a small operation in 1941 has a present capacity of ten thousand head of cattle (Figure 11).

Number 7: The pen area of the lot covers approximately thirty-five acres. The lot has been in operation since 1951 and has a capacity of six thousand head of cattle (Figure 12).

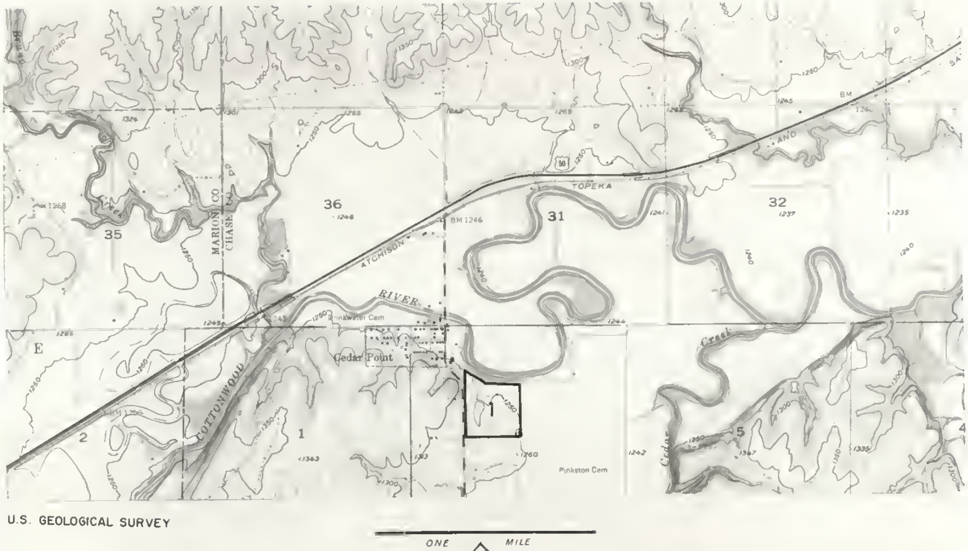


Fig. 9. A feedlot site in the Cottonwood valley.

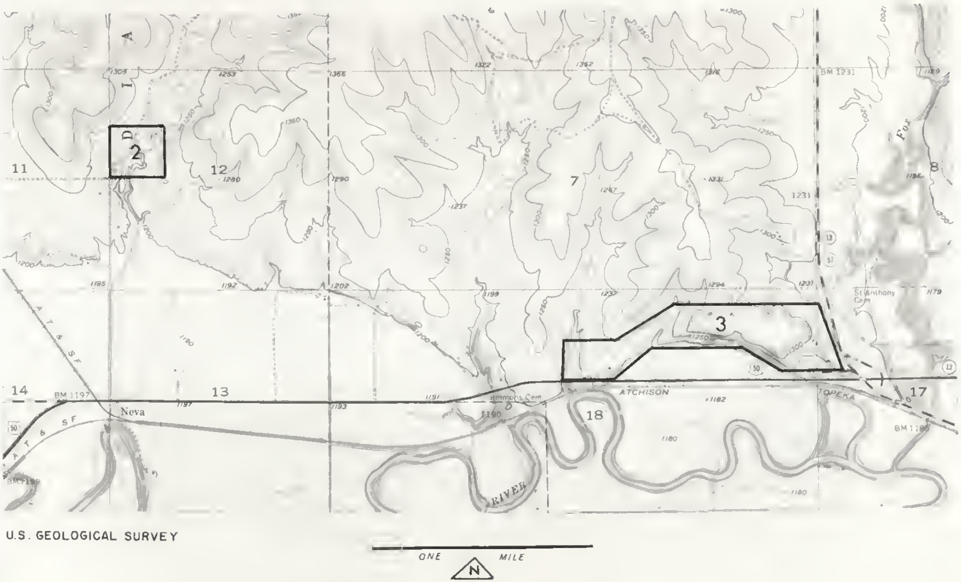


Fig. 10. Two feedlot sites in north central Chase County.

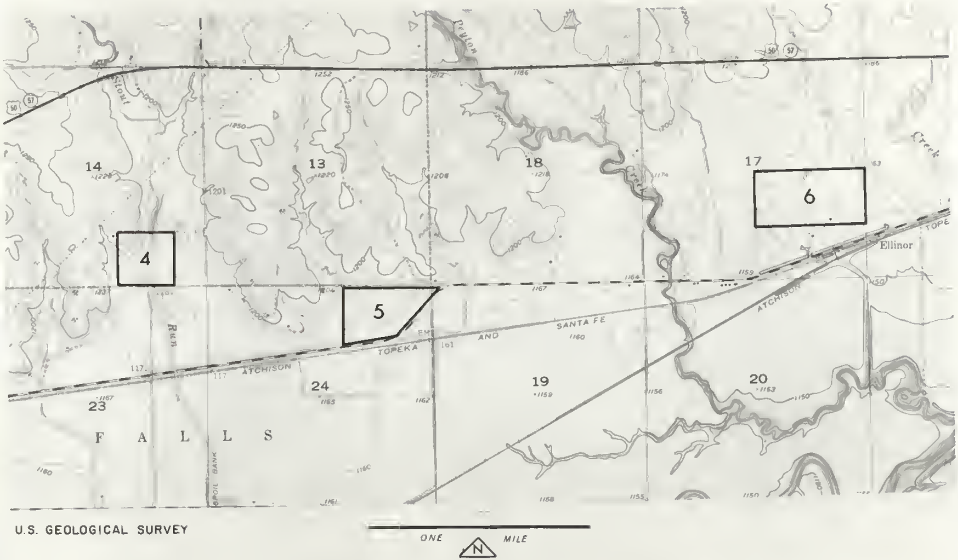


Fig. 11. Three feedlots in Chase County.

Number 8: This lot contains approximately one hundred and five acres and has been in operation since 1950. With a capacity of twelve thousand head it is the second largest in the study area (Figure 12).

Number 9: The lot is thirty-five acres in size and contain fifteen hundred cattle as well as several thousand sheep (Figure 12).

Number 10: This lot has a pen area of approximately fifty acres and feeds fifty-five hundred head of cattle (Figure 12).

In addition to those above, there are two other lots located on the South Fork of the Cottonwood. The one farthest south (Figure 8, p. 41) is located on the uplands immediately adjacent to the flood plain. The lot covers an area of approximately twenty acres and feeds one thousand cattle. Lot Number 12 is located approximately one mile north of Lot 11. Its forty-acre feeding area is situated on the flood plain and has a capacity of two thousand head.

Concentration of Feedlots Near Emporia

Nine of the feedlots in the watershed are located along a forty-seven-mile stretch of the Cottonwood River from Emporia to a point four miles west of Strong City. The greatest concentration occurs at Emporia where four lots daily feed a total of twenty-five thousand cattle. Emporia is the largest city in the area and contains approximately 40 per cent of the watershed's population. In the past decade, both the numbers of cattle in the feedlots and the population of Emporia have greatly increased, and the city is now faced with problems of foul odors, insects, and aesthetic decline of the areas near the feeding lots.

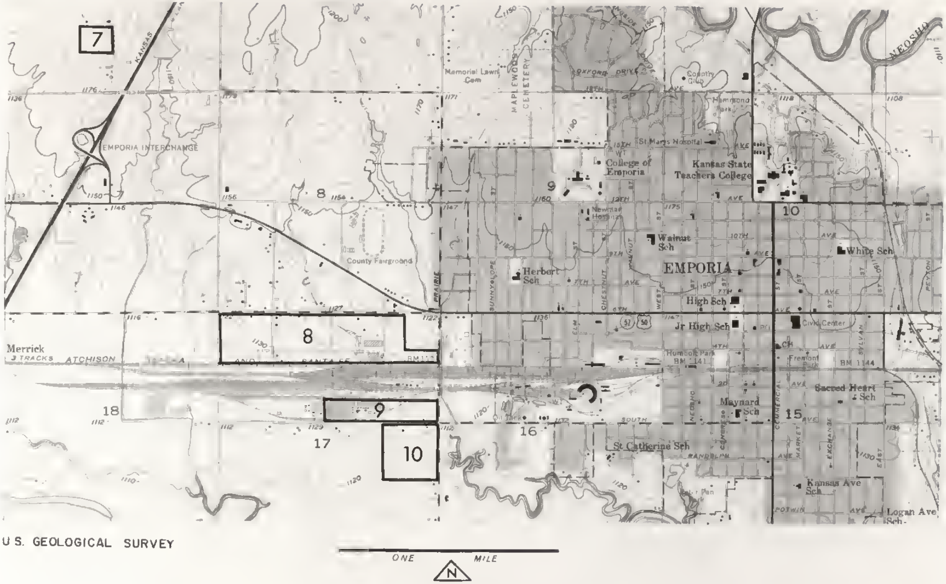
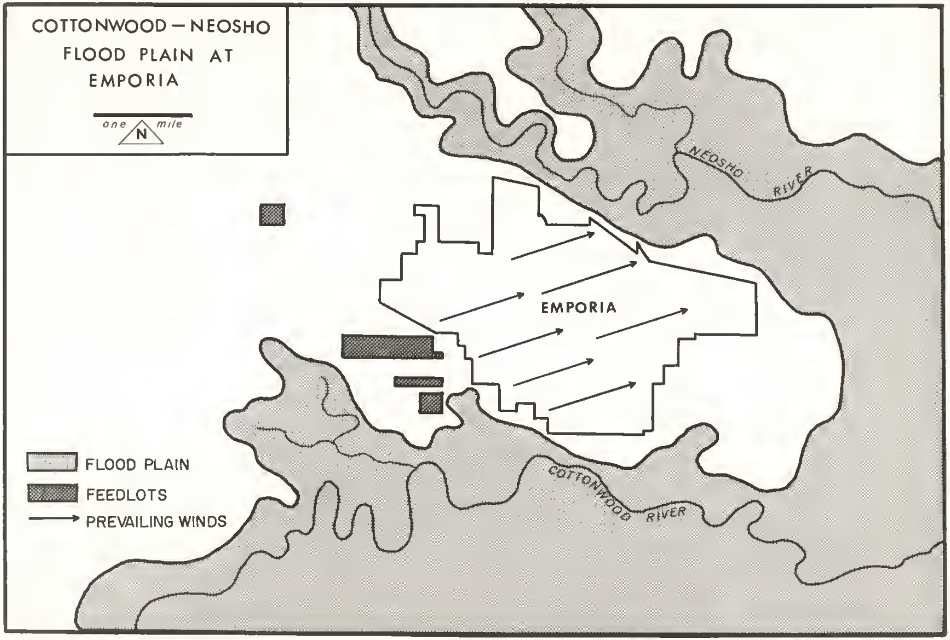


Fig. 12. Feedlots near Emporia.

Many feedlot operators consider it too expensive to move to more rural locations. Any advantages usually obtained from increased efficiencies of operation are not great enough to offset the cost of constructing new pens, feed bunks, water systems, and the moving or replacing of feedmill facilities. The operators at Emporia have the additional advantages of an ideal location for both truck and rail transport plus a packing house situated less than a mile from the lots. The location of feedlots to the west and northwest may create problems for the continued growth of Emporia, as the city is vulnerable to flooding on the north, east and south (Figure 13); thus flood-free development can only expand to the west and northwest into the area where the feedlots are presently located. In addition, odors and insects associated with the feedlots may act as deterrents to the further westward development. Emporia is particularly vulnerable to feedlot odors as prevailing winds from the southwest quadrant carry feedlot odors throughout the city (Figure 13).

Accumulation and Disposal of Feedlot Wastes

It was noted above that a nine hundred pound steer defecates almost eight tons of manure a year exclusive of urine. The volume of manure deposited in the commercial feedlots of the Upper Neosho is in the magnitude of 600,000 tons annually. All of the operators utilize manure as top dressing for their grain and roughage fields (Figure 14), but only five own or rent sufficient land to utilize all the manure generated in their lots. Five others spread the excess manure on their neighbors' fields. The remainder hire private parties to scrape and remove much of the manure from their lots. In three of the lots the bulk of manure is so great that special equipment must be used (Figures 15-16). It is interesting to note that all the feedlot



EMPORIA COMPREHESIVE PLAN

Fig. 13.

Fig. 14. Traditional method of animal waste disposal.

Fig. 15. Cleaning a feedlot in the Upper Neosho Watershed.

Fig. 16. A paddle-wheel scraper used to clean feedlots.

operators of the Upper Neosho Watershed complained of the cost and labor involved in removing animal wastes from their lots, but when asked, they either could not, or would not, give an estimate of what the cost might be. However, some indication may be gained from Stubblefield's study of manure removal cost in Arizona feedlots. He found that when the amount generated exceeded the quantity that could be readily disposed of, the cost or removal was $1.00 to $1.50 per ton. He further noted that a product that was once an asset has become a definite liability.[38]

Despite relatively heavy manure applications of fifteen or more tons per acre to cultivated fields, ten of the operators periodically apply commercial fertilizers, particularly phosphates. Most feedlot operators considered the manure to be more important as a means of improving soil tilth and structure than as a source of plant nutrients.

Feedlot Effluent as a Major Pollutant

In the Upper Neosho Watershed, pollution from feedlots appears to have been most devastating to the aquatic environment. The quality of the water, particularly surface water, has been greatly altered by the physical and chemical changes brought about by the introduction of wastes in the form of manure, bedding, urine, feed, hormones and pesticides from feedlots into the aquatic environment.

These feedlot wastes, known collectively as feedlot effluent, are physically moved from the feedlot by gravity alone or with the help of a transporting agent such as water plus gravity. By far the greatest amount of feedlot effluent is carried from the feedlot as solids or in solution by

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[38]Stubblefield, p. 121.

precipitation runoff. The movement of surplus precipitation across a lot initiates the movement of feedlot wastes or effluent into streams and lakes. If the deposition of pollutants is excessive, the self-cleansing ability of a water body is impaired, and the quality of the aquatic environment will deteriorate.

III. FACTORS AFFECTING THE AMOUNT OF RUNOFF

If movement of all or at least most of the wastes from the feedlot to the streams could be eliminated or greatly reduced, a major source of water pollution in feedlots areas could be eliminated. There are two sets of factors, one physical and the other cultural, which govern the quantity and quality of effluent carried from the feedlots by runoff.

Physical Factors

The physical factors are phenomena over which the operator has little or no control. The most important are precipitation, temperature, slope and soil permeability.

Precipitation. Since water is the primary transporting agent of effluent, it would be expected that the greater the amount of rainfall, the greater would be the amount of effluent carried from the lot; however, this is not necessarily true. It has been found that the intensity and duration of rainfall exert a greater influence upon the quantity and quality of effluent runoff than does the total amount of precipitation. Low-intensity precipitation over extended periods produces more heavily polluted runoff than do hith-intensity storms of short duration, even though much more precipitation and actual runoff may occur during the latter type of storm.[39] Little of the waste is actually carried along bodily in suspension by the flowing water; rather it is carried in solution. The more water absorbed by the waste, the more soluble it will become. Manure will absorb more water from one-half inch of precipitation falling over an extended period of time than from one inch of precipitation occurring as a quick hard rain. Even in high-intensity storms of long duration, total waste runoff is of relatively small amounts because in the manure the runoff forms small channels which cut through the waste to the ground beneath; the runoff tends to follow the channels and does not transport a great deal of waste material from the lot.[40]

Temperature. Temperature exerts an influence in at least two ways. If the ground and manure are frozen, little if any precipitation will penetrate the surface, and water will run off more quickly. Under such conditions, relatively little effluent will be carried from the lot. Secondly, feedlot wastes follow the same laws of solubility as other solids, namely that materials are more soluble at higher temperatures. Therefore, runoff from a feedlot would be more heavily polluted in the summer than at any other time of year, all else being equal.

Slope. Some degree of slope is desirable in any feedlot. Usually a three or four per cent slope is sufficient to drain the lot of urine and rainfall. Miner found the actual physical transport of material from

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[39] J. R. Miner, et al, "Cattle Feedlot Runoff--Its Nature and Variation," Journal of Water Pollution Control Federation, 38:1590, October, 1966.

[40] Ibid.

"slightly sloping lots" to be limited to small particles which remain after adjacent material was dissolved and the total amount of material removed in this manner was relatively small.[41] However, the physical transport of wastes from steep slopes may be considerable. Some feedlots in the study area have steep slopes; an example may be seen in Figure 17. The hillside between points A and A' has approximately a twenty per cent slope. Undoubtedly the physical transport of solid waste from this lot is considerable.

There is a relationship between degree of slope and temperature which can influence the amount of solid matter transported from a feedlot. The more nearly the angle of incidence of the sun's rays approaches the perpendicular, the greater will be the amount of heat absorbed on the surface of the ground. Increased absorption is paralleled by a surface temperature increase, and as noted above, solids become more soluble at higher temperatures; thus solids such as manure are more easily transported from the lot when precipitation does occur.

Soil Permeability. Probably the least important physical factor to be considered is soil permeability. If the soil is permeable, less water will run off and less waste will be carried into the streams. However, the continuous trampling and mixing of soil, litter and manure along with surface scraping by heavy machinery reduces permeability and after several years the soil becomes highly compacted and almost impermeable.

Cultural Factors

Cultural factors are those over which the individual feedlot operators can exercise some degree of control that will influence the quantity and/or

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[41] Ibid., pp. 1587-88.

Fig. 17. An Upper Neosho feedlot situated on a hillside with twenty per cent slopes.

quality of effluent emanating from a feedlot. The three most important are the cleaning of the lots, the composition of the lot surface, and the use of diversion ditches.

Cleaning of lots. In the study area, all feedlots are scraped and all manure and wastes removed periodically. The office of the Kansas Livestock Sanitary Commissioner has ruled that all feedlots shall be "thoroughly scraped and cleaned and all manure removed, at least two times each calendar year, and more frequently if necessary to maintain proper standards of cleanliness and sanitation" (Appendix A).[42] The feedlot operators are usually conscientious about this regulation as it is to their interest that the lots be scraped. When the lots are scraped, the drainage improves, the surface is drier, the cattle have better footing, and the possibility fo disease is reduced. Only one operator admitted to meeting no more than the minimum scraping requirements; eight operators cleaned "three or four times a year," and the remainder "continuously," by which the operator really meant every six or eight weeks.

However, in order for scraping to be a major deterrent to the runoff of feedlot wastes, the pens should be cleaned every two weeks. Miner found that two weeks after cleaning, the feedlot runoff had deteriorated to almost the same pollutional quality as before cleaning.[43] Much of the pollution resulting from feedlot effluent could be eliminated at the source if a semimonthly cleaning schedule could be adhered to. Unfortunately, the feedlot operators of the Upper Neosho Watershed feel that present labor costs

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[42]Kansas State Livestock Sanitary Commission, "Rules and Regulations," Topeka, Kansas, 1966.

[43]Miner, et al., p. 1584.

prohibit the scraping and cleaning of the pens on this frequent a basis.

Composition of lot surface. The amount of effluent carried from a hard surfaced concrete lot is much greater than than from an unpaved dirt lot, all else being equal. The characteristics of runoff from both concrete and dirt lots have been extensively studied at Kansas State University, where researchers controlled slope, precipitation, amount of waste, etc., and found that the total volume and the concentrations of pollutants were much higher from the hard surfaced lot. Through continuous trampling, the soft-surfaced dirt lot becomes pocked with literally thousands of small "catchment ponds," which trap and hold both water and wastes during and after precipitation (Figure 18). The "ponds" impede the rapid flow of water and wastes from the lot. Eventually much of the trapped polluted water evaporates, thus the amount of waste carried from the lot is considerably reduced.

Diversion ditches. In an area of rolling topography, the volume of water flowing across a feedlot can be partially controlled by the utilization of diversion ditches. A feedlot may receive varying amounts of runoff from uphill slopes and any resulting increase in the amount of water flowing across the lot is usually matched by a corresponding increase in the amount of pollutants carried from the lot. However, if diversion ditches are constructed up-slope, runoff can be intercepted and diverted around the lot, thereby effectively reducing excessive runoff.

Fig. 18. Uneven surfaces of dirt lot impede runoff.

IV. SOME PHYSICAL AND CHEMICAL PROPERTIES OF FEEDLOT RUNOFF

Feedlot wastes are highly pollutional in nature. Once the wastes enter a stream, their properties are difficult to characterize because of the many controlling factors, the constant state of change, and the complex reactions which occur in the composition of the wastes. However, some of the more common polluting parameters of feedlot effluent have been recognized.

Biological Oxygen Demand

Cattle feedlot runoff is a high strength organic waste. The principal objectionable characteristic of the waste is its high content of putrescible organic matter, commonly measured by its Biological Oxygen Demand (BOD). Feedlot effluent has been found to be high in BOD. The BOD of untreated domestic sewage is approximately two hundred milligrams per liter (mg/l). To emphasize this point Gray stated that on a BOD basis, one twenty-thousand-head feedlot produces as much waste per day as does the city of Wichita (population 175,000).[44] Miner found that runoff from concrete feedlots had a BOD value seven times as great as domestic sewage while dirt-surfaced lots (most feedlots) had BOD values as much as four times that of domestic sewage.[45] As a point of reference, streams with BOD concentrations

[44] M. W. Gray, "Water Pollution and Agriculture" (paper read at the Kansas Livestock Association Meeting, Wichita, March 14, 1966).

[45] Miner, 1967, p. 58.

in excess of four mg/l are considered poor sources of domestic water supplies.[46] Henderson states that runoff from a watershed with a large animal population ". . . may make municipal sewage loads appear insignificant on a BOD basis."[47]

When a stream contains large amounts of animal wastes great quantities of oxygen must be available in the water to decompose the waste material. If the amount of putrescible waste exceeds the availability of oxygen necessary for decomposition, the stream may become little more than an open sewer incapable of further sustaining endemic plant and animal life.

Dissolved Oxygen

In order for a stream to decompose organic material, oxygen is required, and the ability of a stream to decompose material is dependent upon the amount of dissolved oxygen (DO) in the water. In order for a stream to maintain a balanced aquatic environment for fish, optimum DO levels should be maintained at approximately five mg/l or five parts per million (ppm).[48] At levels below three mg/l fish may become asphyxiated.

A stream receives most of its DO from surface aeration. Turbulent streams take up oxygen more rapidly and thus have a greater capacity to assimilate wastes than do slow sluggish streams. In the latter, a BOD concentration of ten mg/l may be sufficient to produce anaerobic conditions,

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[46] J. E. McKee and H. W. Wolf, "Water Quality Criteria," State Water Quality Control Board (Sacramento: 1963), p. 146.

[47] J. M. Henderson, "Agricultural Land Drainage and Stream Pollution," Journal of Sanitary Engineers, 88:61, 1962.

[48] One part per million is equivalent to one pound of substance per million pounds of water or 8.33 pounds per million gallons of water.

whereas a turbulent mountain stream may assimilate BOD concentrations of fifty mg/l without experiencing any significant oxygen depletion.[49] Another factor is the relationship between oxygen solubility and temperature. The solubility of oxygen in water decreases as temperature increases. At 4°C the amount of oxygen contained in oxygen-saturated water is approximately fourteen mg/l, at 10°C about eleven mg/l and at 24°C only 8.3.[50] Thus more wastes can be assimilated with less harmful pollutional effects in the swifter streams and/or during the cooler months.

There is evidence that the susceptibility of fish to poison greatly increases as the availability of dissolved oxygen in the water decreases. An immediate reaction to an insufficient oxygen supply is an increase in the volume of water passing through the gills which results in an increase in the amount of poison absorbed. Thus, any decrease in oxygen causes an increase in blood pressure and heartbeat, which are in turn responsible for the lethal effects of poisons under conditions of oxygen deficiency.[51]

Suspended Solids

Some of the wastes carried by streams are in a solid state. When large amounts of solid material are present, even if the particles are minute, the quality of the aquatic environment is impaired. The amount of material carried from a lot in runoff varies according to, (1) the solubility of the material, (2) the amount of time water is in contact with waste in

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[49] National Academy of Sciences, p. 187.

[50] J. R. Erickson and P. Jones, Fish and River Pollution (Washington: Butterworths, 1964), p. 13.

[51] Ibid., p. 183.

the lot, and (3) the physical transport of the solid.[52] Except under conditions of high runoff velocities, such as on steep slopes, the physical movement of solids is relatively minor.

Feedlot litter and wastes, as with most solids, are most soluble at higher temperatures; therefore, runoff concentrations of material are higher during summer. In addition, moist manure is more readily carried by water than is dry manure; as the contact time between water and solids lengthens, the quantity of solids dissolved becomes greater. Thus runoff generated by a low-intensity rainfall contains a much higher quantity of pollutants than that generated by a heavy rainfall of short duration. As can be seen in Table XII, Miner found the concentration of suspended solids in runoff from a nonsurfaced wet lot with a rainfall intensity of 0.3 inches per hour to be five times that found in the runoff from a dry lot with a rainfall intensity of 2.5 inches per hour. The concentration differences were even greater on the hard surfaced lot; however, most lots are unsurfaced and thus the first figure better approximates actual concentration found in feedlot effluent.

It was also found that under simulated precipitation intensities of one inch per hour, the average concentration from a moist unsurfaced lot was 6,000 mg/l or over thirteen hundred pounds of solids per acre-inch of runoff.[53] Large amounts of suspended solids render the water murky and greatly decrease the availability of light for photosynthesis by aquatic

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[52] Harry Manges, "Quality and Quantity of Feedlot Runoff" (paper presented at meeting of Soil Conservation Service Engineers in Salina, Kansas, October 17, 1967).

[53] Ibid.

TABLE XII

VARIATION IN AMOUNT OF SUSPENDED SOLIDS CONTAINED IN FEEDLOT RUNOFF, BY TEMPERATURE AND PRECIPITATION[a]

			Suspended Solids, mg/l	
Month	Lot Condition	Precip. Intensity	Nonsurfaced Lot	Concrete Lot
July & Aug.	Moist	1.0"/hr	5,000	6,000
	Dry	0.4"/hr	1,500	3,000
	Dry	2.5"/hr	2,000	1,400
	Wet	2.5"/hr	3,000	3,000
	Wet	0.3"/hr	10,500	12,000
Oct. & Nov.	Wet	1.0"/hr	1,800	2,000
	Wet	0.5"/hr	--	2,500

[a]J. R. Miner, *et al*., Cattle Feedlot Runoff--Its Nature and Variation," *Journal of Water Pollution Control Federation*, 38:1589, October, 1966.

vegetation. Additional damage is done to the aquatic environment by organic solids as they stimulate bacterial activity which in turn increases the areal extent of the anaerobic zone.

Precipitated Solids

Eventually many of the suspended particles settle and produce a "bed-load" which has a degrading effect upon the aquatic environment and water quality. Aside from the filling of stream channels, these precipitates necessitate expensive treatment of domestic and industrial water supplies. They reduce the ability of a stream to assimilate oxygen-demanding wastes and reduce fish populations by covering nests and food organisms. It has been found that when a stream bed is damaged by large amounts of precipitates, the chances for natural stream rejuvenation are greatly reduced.[54]

Nitrogen

Studies have shown that an acre-inch of feedlot effluent contains approximately forty pounds of nitrogen. In its most highly oxidized state nitrogen becomes nitrate, and high nitrate concentrations in water lead to eutrophication, a profuse growth of vegetation, which can lower the water quality.

Ammonia

Ammonium nitrogen, or ammonia, can be a lethal constituent of feedlot runoff. Large quantities are found in feedlot effluent due to the voiding of urine and the anaerobic decomposition of some organic compounds. At concentrations between 0.3 and 10.0 mg/l ammonia can be lethal to almost any

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[54]National Academy of Sciences, p. 143.

species of fish. The point at which it becomes lethal depends on the pH, temperature, and amount of dissolved oxygen in the water. For example, either neutrality or acidity is favorable for the formation of ammonium ions; decreased availability of oxygen, or anaerobic conditions further increase the conversion of nitrogen to ammonia.[55] As with other parameters of runoff, concentrations of ammonia in feedlot runoff fluctuate widely. Smith[56] reports concentrations in excess of 130 mg/l and Loehr[57] in excess of 400 mg/l. Because of its highly soluble nature in water, ammonia is usually the first constituent of feedlot pollution to be noted in a stream.

Bacteria

Feedlot effluent contains great numbers of bacteriological populations. Traditionally, the coliform organisms have been used as an index of the sanitary quality of water supplies. Coliform organisms are found in the feces of both warm and cold-blooded animals as is another organism, the fecal streptococcus.

The fecal coliform/fecal streptococcus ratio (FC/FS) is used to distinguish human fecal contaminate from that of various domestic animals. The ratio approximates 4.4, 0.4, and 0.2 for humans, chickens and cattle respectively according to Dr. C. W. Prophet, a biologist at Kansas State Teachers College at Emporia. Thus, if the FC/FS is a lower value than four (4.0), a nonhuman source of contamination is indicated.

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[55] Erickson and Jones, p. 101.

[56] Miner, et al., p. 586.

[57] Loehr, 1967, p. 45.

As a frame of reference, municipal drinking-water standards specify that in order to protect public health, water supplies are to contain fewer than one coliform per one hundred milliliter (1/100 ml); Prophet reports coliform counts in excess of twenty-five million per one hundred milliliter in ditches draining feedlots.[58] The bacterial count below two feedlots in the Upper Neosho Watershed is shown in Table XIII. The low FC/FS at both stations during dry weather indicates that even under dry conditions, the bacterial pollution in the streams is of non-human origin. It was found that animal wastes enter streams without the aid of precipitation in several feedlots in the study area. Even during dry periods urine containing solid fecal particles flow from feedlots directly into ditches leading to streams (Figures 19 and 20).

Discoloration

Receiving streams take on the yellow-brown color of the wastes (Figure 21). The discoloration does not respond to biological treatment; once discolored, dilution is necessary to restore any degree of clarity. Water discolored in this manner is not only aesthetically displeasing, but may cause problems for downstream users if there is insufficient dilution.

Slugging Effect

Except for the instances noted above, feedlot pollutants usually enter a stream with surface runoff.[59] Effluents discharge into the receiving

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[58]C. W. Prophet, personal correspondence, Oct. 26, 1967.

[59]An exception to this are nitrates which may enter a stream by direct flow, by surface runoff, or by ground water feed. In view of the high nitrate content of some wells in the area (pg. 97), undoubtedly some nitrates do enter the streams by ground water feed, but as yet this has not been determined.

TABLE XIII

FOX CREEK AND COTTONWOOD RIVER BACTERIAL

POLLUTION,[a] NOVEMBER, 1962[b]

	Fecal Coliform	Fecal Streptococcus	FC/FS
Fox Creek			
Mean Dry Weather	1,148	13,800	0.08
After rainfall (11-27)	542,000	1,600,000	0.3
" " (11-28)	17,200	1,410,000	0.01
" " (11-30)	7,900	1,610,000	0.005
Cottonwood River below Fox Creek			
Mean Dry Weather	2,061	3,492	0.6
After rainfall (11-27)	130,000	230,000	0.53
" " (11-28)	10,900	348,000	0.03

[a]Average number of bacteria per 100 ml of river water.

[b]S. M. Smith and J. R. Miner, "Stream Pollution from Feedlot Runoff," Transactions of the Fourteenth Annual Conference on Sanitary Engineering (Lawrence: University of Kansas Press, 1964), p. 20.

Fig. 19. Feedlot waste draining into an intermittent stream.

Fig. 20. Feedlot waste draining into a ditch.

Fig. 21. Discoloration of water by feedlot waste.

stream as long as runoff occurs. Thus a sudden load, called a "slug," is carried into the stream at a fairly constant rate until runoff ceases. The nature of the pollution imposed on the stream by a slug load of this type is unique in several respects when compared to pollution caused by continuous discharge. The polluted water (slug) moves downstream in a single mass. The water above and below the slug may be relatively free of pollutants while that within the slug may contain extremely large amounts of bacteria, suspended solids, and/or concentrations of lethal chemicals; at the same time, it may be very low or completely devoid of dissolved oxygen.[60] If precipitation and runoff cease, then begin again in a few hours, or if runoff occurs from several feedlots along a watercourse, the stream will carry several slugs, each one separated by relatively unpolluted water.

The potency of the slug is dependent upon the relationships between, (1) the concentration of the feedlot effluent, (2) the amount of effluent entering the stream, and (3) the amount of water in the stream. A fast-moving, bank-high stream is capable of assimilating a greater quantity of polluted runoff, with less harm to the aquatic environment, than a stream with a slow shallow flow. If the slug is sufficiently potent, there is little chance of survival for fish caught in the slug. The potential for harm is compounded as there may be no warning to downstream water-users.

A certain amount of time is required for the various chemical reactions, bacterial growths and precipitation of solids to take place; thus the quality of the aquatic environment may not be affected until the slug

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[60]Miner, 1967, p. 42.

has moved downstream several miles. The time-distance lag is illustrated in Table XIV, in which it may be noted that it required thirteen hours for the ammonia-charged water and twenty hours for the de-oxygenated slug to reach a sampling station located several miles below a feedlot in the Upper Neosho Watershed. Because of the time-distance lag, investigation may not reveal the pollutional nature of the slug as the slug may have already moved downstream, or it may not have yet reached the sampling station.

The combination of large numbers of cattle, feedlot sites, uncontrollable physical factors, cultural practices within the lot and physical and chemical actions and reactions have had an adverse effect upon the quality of the environment of the Upper Neosho Watershed. The total effect of this pollution cannot be assessed. The pollution is continuing and it is more than possible that the environment may be degraded in some manner(s) as yet unnoted. It is known, however, that the effects which have already been noted and studied are of a sufficient magnitude to cause grave concern that some elements of the physical environment of the Upper Neosho Watershed may already have been irreversibly altered by pollution from animal wastes.

TABLE XIV

DISSOLVED OXYGEN AND AMMONIA LEVELS

IN MG/L, FOX CREEK, 1962[a]

Time	DO	NH_3[b]
August, dry weather	8.4	.06
November, after rainfall		
13 hrs. " "	7.2	12.00
20 hrs. " "	0.8	5.30
26 hrs. " "	5.9	c
46 hrs. " "	6.8	.44
117 hrs. " "	6.2	.08

[a]S. M. Smith and J. R. Miner, "Stream Pollution from Feedlot Runoff," Transactions of the Fourteenth Annual Conference on Sanitary Engineering (Lawrence: University of Kansas Press, 1964), p. 22; for significance of these parameters see pp. 62 and 66 above.

[b]The statement above that NH_3 ammonia) is usually the first parameter of feedlot pollutants to be noted is evidenced by the fact that its maximum precedes the oxygen minimum by seven hours.

[c]Not reported

CHAPTER IV

THE EFFECT OF FEEDLOT POLLUTION UPON THE PHYSICAL ENVIRONMENT OF THE UPPER NEOSHO WATERSHED

Pollutants emanating from feedlots have the capacity of degrading the quality of the water, air and soil, and rendering these parts of the environment harmful to both the plant and animal realms. Empirical observation indicates that of the total physical environment, surface and subsurface waters are the most greatly impaired by feedlot pollutants. In addition, feedlots are generators of noise, dust, insect infestations, disease and other nuisances.

I. SURFACE-WATER POLLUTION

Every river and stream has an innate capacity to assimilate waste and cleanse itself. A certain amount of waste is beneficial to the stream's aquatic communities. A stream has the capacity to utilize some wastes by converting them into food sources for aquatic life, thereby actually increasing the productivity of the water. The aquatic life in a healthy stream is an integrated system of interdependency in dynamic equilibrium. However, excessive amounts of pollutants can disrupt the equilibrium. When a stream becomes overloaded with pollutants, its ability to cleanse itself greatly diminishes and an imbalance in the life system of the stream occurs. As a result, a degenerating cycle is put in motion whereby an ecological imbalance reduces the ability of a stream to resist pollution or to become rejuvenated; the less ability for rejuvenation the greater is the imbalance in the aquatic system.[61] Thus, when a stream becomes overburdened with pollutants, the aquatic environment begins to degenerate.

Fish Kills

In Kansas, and particularly in the Upper Neosho Watershed, the most overt effect of effluent-caused stream pollution is the high incidence of fish kills. When a slug moves downstream, the fish have little chance of escaping and they die by the thousands and hundreds of thousands. Tables XV and XVI indicate the magnitude of the fish kills in the United States, Kansas, and the Upper Neosho Watershed.[62]

Fish killed by feedlot effluent rose from 2.3 per cent in 1963 to 11.4 per cent of the 1967 total of all the pollution-killed fish in the United States. Between 1962 and 1968 over 90 per cent of all fish killed by feedlot effluent in the United States were killed in Kansas, and most of these died in the streams of the Upper Neosho Watershed (Figure 22). In 1966 alone almost 90 per cent of all fish reported killed by feedlot effluent in the United States died as a result of runoff from some or all of the

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[61] National Academy of Sciences, p. 46.

[62] While the Federal Water Pollution Control Administration makes every effort to get all information on fish kills, the data are not complete. For instance, the states of Colorado, Maryland and North Dakota did not submit reports in 1966. Even in the cooperating states some kills may go unreported and undoubtedly some, especially small ones, may be unobserved. Unless a kill is large, fish and game agencies may be unaware of its occurrence. Of those observed and reported in 1966, only 85 per cent gave a definite figure as to the number killed. Some gave such totals as "many hundreds," or "thousands," or "pounds," or left the question unanswered. In addition the cause is not always determined; in 1966 an estimated 757,000 fish died from unknown causes.

TABLE XV

COMPARISON OF NUMBER OF FISH KILLED BY FEEDLOT EFFLUENT TO TOTAL OF ALL FISH KILLED IN UNITED STATES, KANSAS, AND UPPER NEOSHO WATERSHED: 1963-1967[a]

Area	1963	1964	1965	1966	1967
	(000)	(000)	(000)	(000)	(000)
United States					
Total	6,816	17,869	11,393	8,742	11,119
Feedlots	158	1,231	616	1,050	1,268
Kansas					
Total	138	1,351	570	1,144	1,031
Feedlots	123	1,196	569	1,027	982
Upper Neosho					
Total	115	602	b	1,021	771
Feedlots	115	600	b	921	771

[a]United States Department of Health, Education, and Welfare. Pollution-Caused Fish Kills, 1963, Public Health Service Publication No. 847 (Washington: Government Printing Office, 1964); United States Department of Health, Education, and Welfare. Pollution-Caused Fish Kills, 1964, Public Health Service Publication No. 847 (Wsshington: Government Printing Office, 1965); United States Department of Interior, Pollution-Caused Fish Kills in 1965, Federal Water Pollution Control Administration (Washington: Government Printing Office, 1966); United States Department of Interior. Fish Kills by Pollution: 1966, Federal Water Pollution Control Administration (Washington: Government Printing Office, 1967); United States Department of Interior. Fish Kills by Pollution: 1967, Federal Water Pollution Control Administration (Washington: Government Printing Office, 1968).

[b]Not reported

TABLE XVI

KILLED FISH ATTRIBUTED TO FEEDLOT EFFLUENT IN KANSAS AND IN THE UPPER NEOSHO AS A PER CENT OF KANSAS AND UNITED STATES TOTAL: 1963-1967[a]

Area	1963	1964	1965	1966	1967
	%	%	%	%	%
United States	100.0	100.0	100.0	100.0	100.0
Kansas	77.9	97.1	92.3	97.8	77.5
Upper Neosho	72.9	49.6	b	87.7	60.8
Kansas	100.0	100.0	100.0	100.0	100.0
Upper Neosho	93.4	48.8	b	89.7	78.7

[a]United States Department of Health, Education, and Welfare. Pollution-Caused Fish Kills, 1963, Public Health Service Publication No. 847 (Washington: Government Printing Office, 1964); United States Department of Health, Education, and Welfare. Pollution-Caused Fish Kills in 1964, Public Health Service Publication No. 847 (Washington: Government Printing Office, 1965); United States Department of Interior. Pollution-Caused Fish Kills in 1965, Federal Water Pollution Control Administration (Washington: Government Printing Office, 1966); United States Department of Interior. Fish Kills by Pollution: 1966, Federal Water Pollution Control Administration (Washington: Government Printing Office, 1967); United States Department of Interior. Fish Kills by Pollution: 1967, Federal Water Pollution Control Administration (Washington: Government Printing Office, 1968).

[b]Not reported

Fig. 22. Dead fish on the shore of the Neosho River. (Courtesy of Kansas Forestry, Fish and Game Commission.)

twelve feedlots located in the Upper Neosho Watershed.[63]

Of the almost one million fish that perished in water contaminated by feedlot runoff in the Upper Neosho during 1966, approximately 25 per cent were game fish (Figure 23). A single kill, in March of that year, destroyed approximately three hundred thousand fish and was particularly damaging to the existing and future game-fish population. It occurred in a section of the Neosho to which walleye (Stizostedion vitreum) from the John Redmond Reservoir were migrating to spawn, and several thousand of the game fish, including many egg-bearing females, perished (Figure 23). According to federal statistics 50 per cent of all fish killed by feedlot pollution in the Upper Neosho Watershed in 1966 had an unspecified commercial value.[64]

Most of the fish die as a result of oxygen depletion or ammonia poisoning. They either die quickly from suffocation in the de-oxygenated water or slowly from internal hemorrhaging and/or decomposition of gill

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[63]United States Department of Health, Education, and Welfare. Pollution-Caused Fish Kills, 1963, Public Health Service Publication No. 847 (Washington: Government Printing Office, 1964); United States Department of Health, Education, and Welfare. Pollution-Caused Fish Kills, 1964, Public Health Service Publication No. 847 (Washington: Government Printing Office, 1965); United States Department of Interior. Pollution-Caused Fish Kills in 1965, Federal Water Pollution Control Administration (Washington: Government Printing Office, 1966); United States Department of Interior. Fish Kills by Pollution: 1966, Federal Water Pollution Control Administration (Washington: Government Printing Office, 1967; United States Department of Interior. Fish Kills by Pollution: 1967, Federal Water Pollution Control Administration (Washington: Government Printing Office, 1968).

[64]The designation "commercial value," is based on the harvest and subsequent sale of fish for humans and/or animal food, fertilizer, etc. In the study area this designation tends to be more theoretical than actual as the fish life of the Upper Neosho Watershed is not exploited for any commercial purpose other than that associated with recreation.

Fig. 23. Gamefish killed by feedlot effluent in the Upper Neosho Watershed. (Courtesy of Kansas Forestry, Fish and Game Commission.)

structure caused by excessive amounts of ammonia. Whereas oxygen minimum and ammonia maximum tolerance levels are three and fifteen ppm respectively, Smith and Prophet both report feedlot waste-charged streams with oxygen and ammonia concentrations varying greatly from these tolerance figures. Water samples taken from four stations on a 6.7 mile stretch of the Cottonwood on May 30, 1963, all had a DO level of zero with the exception of one:[65]

River Mile	Dissolved Oxygen
7.1	0
13.4	1.9
13.5	0
13.8	0

It is interesting to note that of the sites sampled, the river contained oxygen at only one station (13.4) which is located immediately below a dam. Undoubtedly the river became slightly aerated as the water flowed over the dam. Even at the dam, however, the DO level of 1.9 ppm was well below the minimum oxygen requirement. Within a day, a massive fish kill, in which approximately one hundred thousand fish perished, was reported along the same stretch of river.[66]

Through repeated sampling, Prophet found that during normal flow the Cottonwood River exhibited an oxygen level in the range of six to nine ppm and an ammonia level of less than one ppm. However, "after runoff the oxygen level frequently drops to zero; the ammonia level . . . may reach concentration as high as twenty-five ppm." Such condition, ". . . may

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[65]Smith and Miner, p. 22.

[66]United States Department of Health, Education and Welfare, Pollution-Caused Fish Kills, 1963, p. 6.

exist along a reach of several miles and for [a duration of] several hours."[67] In conditions such as these described by Smith and Prophet, it is not difficult to understand why massive kills occur. Fish cannot survive a physical environment that is so grossly hostile.

Secondary pollution. The pollution described above, which results in the massive killing of thousands of fish, is, unfortunately, only the initial step in the pollution cycle. A secondary pollution soon follows. It is caused by the putrefying and the decomposing of the thousands of dead, bloated fish killed by the initial pollution. Small quantities of the offal are consumed by scavenger fish, reptiles and insects; most of it, however, decomposes through oxygen-using aerobic action. As a result oxygen levels are further decreased, additional minerals are released into the water, the stream bed receives more precipitates, thus the quality of the water is further impaired. The effect of this secondary pollution on the aquatic environment has not been investigated, but it is obvious that it can only be detrimental.

Fish eggs. Feedlot runoff occurs primarily in the spring when many game fish--walleye, bass, crappie, and channel catfish--are moving out of the John Redmond Reservoir into feeder streams to spawn. According to Clyde Bolen, the district fish and game protector, "Spawning fish can't find any decent bottom areas, but they're bound to spawn, so they drop their eggs anyway; the eggs don't have much chance."[68] Some species of roe are

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[67]Prophet, correspondence.

[68]G. D. Warner, "Pollution from Cattle Feedlots Spread Sludge of Death in Kansas Streams," Kansas City Star, May 14, 1967.

more sensitive to the toxicity of polluted water than are adult fish and even those that do survive the toxic environment may be destroyed if the spawning beds are covered with precipitates.[69] If the eggs do not hatch, game-fish population will drastically decline both in number and type. Rough fish will move into the area and become the major fish species. It is feared that John Redmond, which has produced some of the best game fishing in the state, may soon produce nothing but an abundance of carp.[70]

Changes in fish species. Some pollutants kill quickly; others kill or damage over a long period of time. Sub-lethal, yet harmful, quantities of pollutants will inhibit fish growth and reproduction. If a species is rendered noncompetitive, it may eventually result in the extinction of that particular species in the polluted aquatic system. Sub-lethal toxicity can cause flesh-tainting whereby the fish become unpalatable and unsafe for human consumption; it may also affect the aquatic food organisms which support fish life.[71]

Even though a single slug of polluted water may kill as many as three or four hundred thousand fish, feedlot wastes exert the greatest toll on the fishery, not by causing massive kills, but by destroying fish habitat. Both lethal and sub-lethal concentration of pollutants affect not only the individual species, but whole communities.[72] The Upper Neosho system is an

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[69] C. W. Prophet, Interview at Kansas State College of Emporia, Oct. 17, 1967.

[70] Warner.

[71] United States Department of Interior. Pollution-Caused Fish Kills in 1965, p. iii.

[72] United States Department of Health, Education and Welfare. Pollution-Caused Fish Kills, 1964, p. 1.

excellent example of aquatic habitat-change as a result of pollution. The chemical and physical alterations wrought by feedlot effluent have brought about both qualitative and quantitative variations in the species of fish which inhabit the river system.

In 1952, and again in 1967, inventories were made of the native fish of the Upper Neosho River System by Dr. F. B. Cross, an ichthyolcgist at the University of Kansas. The second study used the same collection sites and sampling techniques as the earlier one, whenever possible. When the results of the two studies were compared, Cross found notable differences in the species composition at all stations on the Cottonwood and Neosho Rivers upstream from the John Redmond Reservoir.

Six kinds of fish, the hornyhead chub (Hybopsis biguttata); the gravel chub (Hybopsis x-punctata); the rosy-face shiner (Notropsis rubellus); the blue sucker (Cycleptus elongatus); the yellow bullhead (Ictalurus natalis); and the Neosho madtom (Noturus species) [undescribed] were obtained repeatedly in 1952, but were not found at any of the sites in 1967.[73] In addition, the 1967 study showed a noticeable decline among fifteen other species, particularly in the mainstreams of the Cottonwooe and Neosho. For instance, the stoneroller (Compostoma anomalum) occurred at all seining sites in great numbers in 1952, ". ... but was found at only one place . . ." in 1967 ". . . where a single specimen was obtained."[74]

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[73] F. B. Cross and M. Braasch, "Qualitative Changes in the Fish-fauna of the Upper Neosho River System, 1952-1967," (Lawrence: University of Kansas, 1967), pp. 3-4. (Mimeographed).

[74] Ibid., p. 6.

Eight species were found in greater abundance in 1967. The gizzard shad (Dorosoma cepedianum); and the channel catfish (Ictalurus punctatus); were found in more locations and in larger numbers. The blackstripe top-minnow (Fundulus notatus); the mosquitofish (Gambusia affinis); and the brook silverside (Labidesthes sicculus), while known to inhabit the system, were not found in 1952. However, large numbers were taken in 1967. The remaining three species, found in greater number in the second sampling, were gamefish which had been introduced into John Redmond Reservoir since the first sampling and which had migrated into the streams from the reservoir.

The majority of the species that had markedly declined or completely disappeared were the bottom-dwellers which require clean, clear, well-oxygenated water and clean gravel beds for spawning. Cross believes that gross changes in the environment brought about by depleted oxygen supplies, murky water, and sediment-covered stream beds are directly responsible for the decline of the bottom-dwelling fish.[75] The fish which have increased are of several types: (1) the surface dwellers that avoid the subsurface depletion of dissolved oxygen, (2) species that prefer a turbid habitat, or (3) species that are large in size and sufficiently vagile to disperse rapidly when conditions become intolerable.[76]

Cross believes severe droughts in 1955-1957 have been a contributing factor in the change, but he consideres the most important single factor to be "organic pollution of some sort," and the source of the pollution to be

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[75]F. B. Cross, Personal Interview, University of Kansas, November 8, 1967.

[76]Cross and Braasch, pp. 7-10.

"feedlot effluent."[77]

Vegetation

The change in the fish species has been paralleled by a change in the vegetation species. In recent years there has been an increasing overabundance of aquatic vegetation in lakes, rivers and streams throughout the country. This condition, known as eutrophication, is a result of the excessive introduction of plant nutrients such as nitrates and phosphates into the water. Eutrophication, or an accumulation of nutrients, is a natural process and occurs in the absence of man. However, induced or "cultural" eutrophication as a result of man's activities greatly accelerates the aging of lakes or streams.

The growth of aquatic plant life is directly related to the availability of certain mineral compounds or nutrients in solution. The term "nutrients" as used by biologists and limnologists refers to the nitrate and phosphate compounds in the water which sustain plant life. Fish, in turn, utilize certain types of vegetation such as algae for food. Some algae, particularly diatom algae, are a highly nutritious type of aquatic flora which benefit fish populations, and the fish tend to increase or decrease according to the amount of diatom algae available for food. Thus, a stream or lake, rich in diatom algae, usually supports a large fish population. However, if the nitrate concentration in the water increases from two to four ppm, along with additional increases in phosphorus and ammonia, the environment will no longer be favorable for the growth of diatom algae but ideal for the growth of blue-green algae. The latter are a filamentous

[77]Cross, Personal Interview.

or scum-forming algae of very low food value. As a result, the numbers and kinds of fish species that blue-green algae-infested water can support declines to the point that some species may be entirely eliminated. Preliminary findings indicate that the amount of diatom flora in parts of the watershed is declining while the less desirable blue-green algae are increasing in direct response to the high phosphorus content of the water.[78]

There appears to be little doubt as to the source of this element particularly since the Sogn, Summit, Florence, and Idona silty clay loams of the Upper Neosho drainage basin are actually phosphorus-poor soils with phosphorus amounts averaging less than 0.1 ppm.[79] Yet, Prophet reports phosphorus concentration of 0.5 ppm below feedlots following runoff,[80] while concentrations as high as 1.6 ppm have been found in the Cottonwood River at a sampling station less than four miles downstream from a large feedlot.[81] It is also interesting to note that the single largest hyperbloom of blue-green algae known to exist in the watershed is located on the Cottonwood, less than a mile below the largest cattle feedlot in the area.

A lush growth of blue-green algae not only results in a decline in the amount of nutritious food available for fish but creates taste and odor problems in drinking water. Unsightly scum accumulates on the surface; the recreational uses of the stream are drastically curtailed; the stream bed

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[78] Prophet, Interview.

[79] O. W. Bidwell, Personal Interview, Kansas State University, August 2, 1967.

[80] Prophet, Interview.

[81] Kansas State Department of Health, "Chemical Analysis of Water--Cottonwood River," Environmental Health Service (unpublished) Plymouth Station, June 5, 1967.

fills with accumulations of decaying organic matter; and there is a general deterioration of the water quality.[82]

Water Recreation

The National Academy of Science's Committee on Pollution noted that neither matters of human health nor industrial demands for water of high purity have ". . . inspired public action to the degree that it has been inspired by demands for pure water for swimming, recreation, and fishing ...."[83] This observation appears to be valid in regards to fishing in the Upper Neosho Watershed, for it has been the individual fishermen and sportsmen groups that have voiced the loudest protests about the effect of feedlot effluent in the watershed.

Fishing. After a major fish kill along the Neosho River and the John Redmond Reservoir in March of 1967, in which many game fish were killed, sportsmen collected several dozen large rotting walleye from the upper end of John Redmond Reservoir, and threatened to take them to Topeka and place them on the capitol steps to demonstrate the effect of feedlot effluent upon prime fishing water.

Massive fish kills have greatly affected recreational fishing on the Cottonwood River. Many fishermen presently (1967) consider the Cottonwood to be "worthless" for catching anything except carp.[84] In the John Redmond Reservoir catches have greatly declined and fishermen and game protectors

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[82]National Academy of Sciences, p. 42.

[83]Ibid., p. 71.

[84]Warner.

alike have fears for future fishing in the reservoir. The Kansas Forestry, Fish and Game Commission has spent thousands of dollars stocking the reservoir with game fish and is presently concerned with the cost of restocking and, more important, the possibility that the restocked fish may also be killed by feedlot pollution.[85]

Contact sports. The quantity of pollutants carried by the Neosho River into John Redmond Reservoir was so great in June, 1967, that the Kansas State Department of Health deemed it necessary to close the reservoir to swimming, water skiing and all other forms of water-contact recreation. The action was taken when the bacterial count greatly exceeded the department's safety standards for body-contact recreation.

Coliform bacteria are indicative of the presence of pathogens (disease causing organisms) and many states use the standard of one thousand to twenty-four hundred coliform organisms per one hundred milliliters of water as the maximum concentration permissible for safe beaches and bathing areas.[86] The Kansas Department of Health however has established that areas designated for water-contact recreation have less than one thousand coliform bacteria per one hundred milliliters of water.[87]

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[85] Roy Schoonover, Head of Fishery Division, Kansas Forestry, Fish and Game Commission, Personal Interview, Pratt, Kansas, September 19, 1967.

[86] It is noted in The National Academy of Sciences' Waste Management Control, page 76, that while this standard is commonly used, epidemilogical evidence is lacking that these levels are significant from a public-health standpoint.

[87] Kansas State Department of Health, Water Quality Criteria for the Neosho River Basin, Environmental Health Services (Topeka: 1961), p. 6.

Table XVII lists the coliform count at several reservoir stations on June 14, 1967; it may be noted that every station had readings far in excess of the maximum established by the health department. Accordingly, the department closed the Reservoir to all forms of body-contact recreation on June 16, 1967. The ban remained in effect until June 29, 1967, when the bacteria count dropped to an acceptable level.

Dr. H. Kierker, State Health Officer, attributed the excessive bacterial pollution to heavy rains during the first two weeks of June in which pollutants were carried into the main body of the Reservoir. Although when interviewed, he declined to pinpoint feedlot runoff as the initial cause of pollution, the FC/FS ratios shown in Table XVII are one (1.0) or less, thus indicative of bacterial contamination from a warm-blooded nonhuman animal source. This may be compared to the 5.0 FC/FS ratio which is normally found in the reservoir. It is evident that under normal conditions much of the bacterial pollution in the Neosho River is from a human source and undoubtedly stems from treated municipal sewage effluent released into the Cottonwood at the Emporia treatment plant.[88]

Water Potability

Perhaps the greatest immediate danger to both the animal and human population of the Upper Neosho Watershed is the effect of feedlot-induced

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[88] A FC/FS ratio of 5.0 under normal conditions, indicating contamination from human sources, in the Neosho River is not inconsistent with the findings of Smith and Miner, page 69 above, in which they found FC/FS ratios of less than one even during dry weather on Fox Creek and the Cottonwood River immediately below several feedlots. The amount of Emporia sewage released directly into the watershed just twenty miles above the Reservoir is more than twice as much as that dumped into the Cottonwood and its tributaries by all the other municipalities in the study area.

TABLE XVII

COMPARISON OF COLIFORM AND STREPTOCOCCUS BACTERIA COUNT IN JOHN REDMOND RESERVOIR DURING PERIODS OF POLLUTED AND NONPOLLUTED FLOW[a]

Station:	Bacterial Count/100 m. of water		
	Fecal Coliform	Fecal Streptococcus	FC/FS
Polluted Count for Individual Stations June 14, 1967			
Strong Ramp	10,000	30,000	.3
Hartford	10,000	120,000	.09
Two Miles Above Dam	3,000	6,000	.5
Neosho River Outlet	10,000	10,000	1.0
Normal Average Nonpolluted Count for all Stations, August 21, 1967	100	20	5.0

[a]Dr. Vern Heble, Kansas State Department of Health, Personal Interview, Topeka, Kansas, November 27, 1967.

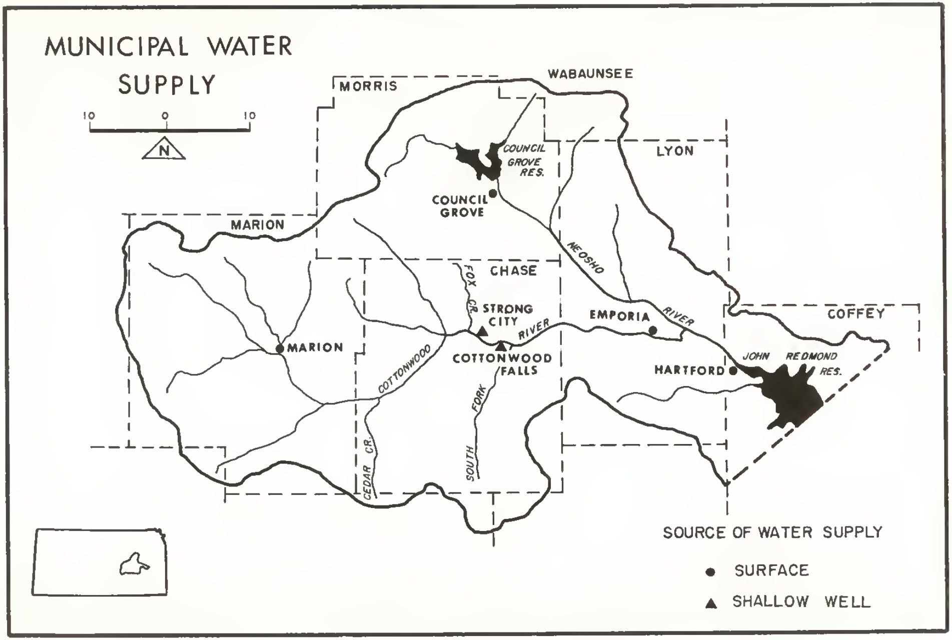
pollution upon the potability of both surface and subsurface water. Feedlot pollution is a threat to the water supplies derived from both municipal water systems and private wells which are utilized by the 50,000 residents of the study area.

Four of the thirteen communities with municipal water systems obtain water from surface flows, the remainder utilize either deep or shallow wells (Figure 24). The communities which utilize surface water and their main source(s) of supply are:

Council Grove	Council Grove Reservoir and Neosho River
Emporia	Lake Kahola and Neosho River
Hartford	Neosho River
Marion	Mud Creek and Overflow Dam

To date the surface municipal water supplies of Council Grove, Marion, and Emporia have not been contaminated by feedlot runoff as there are no feedlot concentrations upstream from their water-intake. Hartford, however, has not been as fortunate. The small community of 400 population is located on the upper reaches of the John Redmond Reservoir, below the Cottonwood-Neosho confluence (Figure 24). In the latter two weeks of January, 1967, rains in the Cottonwood drainage system caused heavy runoff from feedlots along the Cottonwood River. As the slugs of polluted waste flowed out of the Cottonwood into the Neosho, they carried such vast quantities of organic matter, suspended solids and de-oxygenated water that cattle drinking from the Cottonwood became sick.[89] The slugs flowed into the Neosho and eventually into John Redmond carrying an estimated quarter

[89]Warner.



KANSAS WATER RESOURCE BOARD

Fig. 24.

of a million dead fish. When the polluted water reached the Hartford water-intake area on February 9, 1967, thousands of dead bloated fish covered the surface; the water had a stench of raw sewerage and the rocky bed of the Neosho was covered with a red-brown slime.[90]

Seven times the normal amount of chlorine was required to purify the water to a point at which it was safe to drink. Even then, although pathogenically safe for consumption, the water was not palatable. It was brownish in color, foaming with an obnoxious taste and the odor of dead fish and manure. Despite increased filtration with activated carbon, the water remained cloudy; eight ounces of water produced one-sixteenth of an inch of sediment in the bottom of a glass.[91]

As unpleasant as the above experience was, the citizens of Hartford were fortunate that none suffered any illness from the polluted water. The color and odor of the water and presence of dead fish in the Neosho River made it obvious that extra precaution would be necessary at the water-treatment plant. Other communities and individuals in the study area who utilize well-water may not be as fortunate; subsurface water may become grossly contaminated by feedlot runoff yet not exhibit any overt sign of pollution.

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[90]Vern Baker, Water and Sewer Superintendent, Hartford, Personal Interview, November 15, 1967.

[91]L. J. Imhof, State Southeast District Sanitation Engineer, in written report to Dr. V. Heble, Kansas State Department of Health, February 15, 1967.

II. SUBSURFACE WATER POLLUTION

One polluting agent found in the subsurface water is nitrate. Excessive concentrations of nitrate in well-water can be harmful to man and animals alike.

Nitrates in Drinking Water

The significance of nitrate in drinking water has received considerable attention since the discovery (1945) that high concentrations of nitrate water used in baby formulas may cause fatal methemoglobinemia ("blue babies") in infants under six months of age. The Kansas State Board of Health considers concentrations of ninety ppm sufficient to induce cyanosis in infants. Unfortunately, the Kansas State Board of Health does not require cases of methemoglobinemia to be reported; thus it is not known if wells polluted with excessive nitrates have actually caused this deformity.[92]

Not only humans but animals as well may be affected. In cattle excessive concentrations of nitrates are known to cause metheoglobinemia, decreased milk production, Pink Eye, thyroid distrubances, reproductive difficulties, abortions, and reduced rates of gain.[93] The latter should be of particular concern to all cattlemen and feedlot operators.

Incidence of nitrates. The Kansas State Geologic Survey analyzed the chemical characteristics of sixty-five private wells in both Chase and Lyon County and found nitrate concentrations exceeding forty-five ppm in

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[92]Dr. Donald Wilcox, M.D., Kansas State Board of Health, Personal Interview, Topeka, Kansas, November 15, 1967.

[93]G. E. Smith, "Contamination of Water by Nitrates," Fertilizer Solutions, 2:14, May-June, 1967.

43 per cent and concentrations exceeding ninety ppm in 29 per cent with a maximum concentration of five hundred eighteen ppm.[94] An accumulation of nitrate in subsurface water will occur in nature either as a result of nitrate minerals naturally present in the rocks or as a result of organic action. It is quite possible that in both Chase and Lyon County the nitrate concentrations are a result of organic action inasmuch as ". . . .no nitrate minerals are known to exist in any of the rocks at or near the surface."[95]

Probable source of nitrates. In rural areas, organic action which produces nitrate concentration can usually be attributed to the use of chemical nitrogen fertilizer or animal wastes.[96] Evidence for this is offered by G. E. Smith in studies conducted in Missouri where he found no correlation between the use of chemical nitrogen fertilizer and the nitrate content of well-water, but a very high correlation between livestock numbers and the percentage of wells containing significant amounts of nitrate.[97]

Movement of nitrates. Nitrates are readily soluble in water and move with soil moisture; as the water percolates through the soil, the nitrates may be carried great distances depending on the subsurface soil

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[94] Kansas State Geological Survey. Geology, Mineral Resources, and Ground-Water Resources of Chase County, Kansas. Vol. XII (Lawrence: University of Kansas Publications, 1953), pp. 34-35; Kansas State Geological Survey. Geology, Mineral Resources, and Ground-Water Resources of Lyon County, Kansas. Vol. XI (Lawrence: University of Kansas Publications, 1951), pp. 40-41.

[95] Ibid., pp. 38, 42.

[96] G. E. Smith, p. 17.

[97] Ibid., p. 10.

and rock structure. With the exception of the unconsolidated alluvium of the river valleys, most of the rocks of the Upper Neosho consist of alternating beds of limestone and shale. Some of the limestone, particularly those of the Chase and Council Grove groups, contains many joints, fractures and caverns which allow the lateral movement of ground water over great distances.[98] Many rural wells in the central part of the Upper Neosho Watershed derive water chiefly from these jointed, fractured and cavernous limestones. Eight feedlots in the Watershed are situated on Chase and Council Grove formations (Figure 25). At present there is no proof that excessive nitrates leached from feedlot waste do actually percolate into the aquifers of these formations; however, this is known to have happened in other areas, and it is a distinct possibility in the Upper Neosho. If this is occurring, an additional threat is posed, as subsurface flow does not necessarily conform to surface drainage basins. Wells outside of the watershed may be polluted by the excessive nitrates leached from some or all of the twelve cattle feedlots in the study area.

III. HUMAN HEALTH

For many years, public-health agencies have been concerned with health problems that are associated with animal wastes. Some are pathogenic, others chemical in nature. The former are known to exist; the latter are suspected.

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[98]Kansas State Geological Survey, Geology, Mineral Resources, and Ground-Water Resources of Lyon County, Kansas, p. 44.

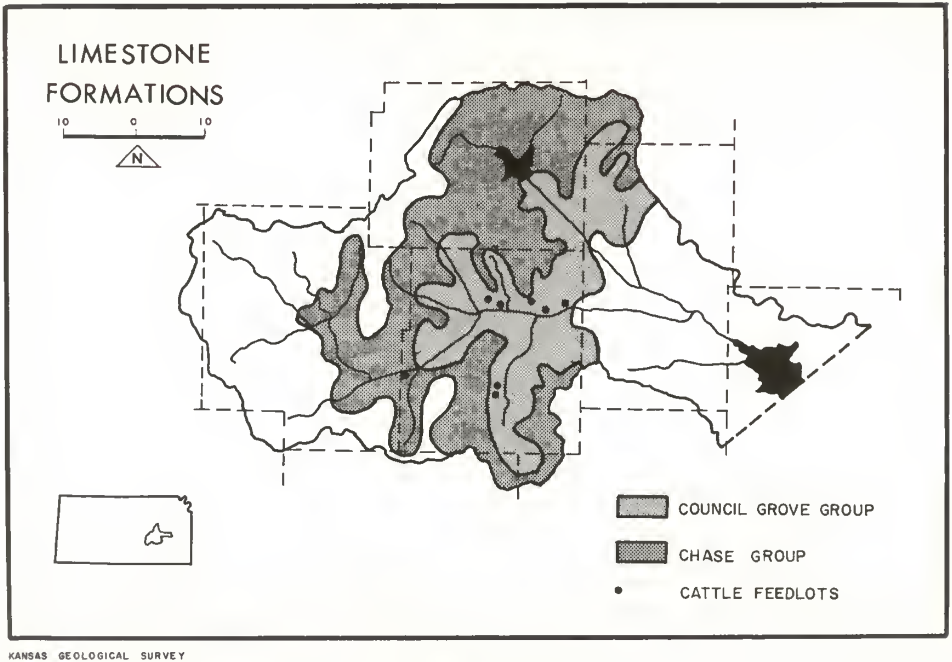
LIMESTONE
FORMATIONS
10
0
10
N
COUNCIL GROVE GROUP
CHASE GROUP
CATTLE FEEDLOTS
KANSAS GEOLOGICAL SURVEY

Fig. 25

Pathogens

There are approximately fifty bacterial species and an unknown number of viruses common to livestock which can be pathogenic to man.[99] One of the most prevalent pathogens that is zoonotic, or communicable from animal to man, is Salmonella. Two of the most common types of Salmonella found in cattle are Salmonella typhimurium and Salmonella dieblin. The former can cause meningitis and septicaemia in humans; the latter, which is much more common, causes enteritis not only in man but in other animals and birds as well.[100]

These zoonotic pathogens along with leptospirosis, which produces severe jaundice in humans, develop in the intestinal tract of cattle. These pathogens are readily transported to both surface and underground water by runoff and leaching. Few physicians report Salmonella cases--thus it is not possible to determine the incidence, if any, of Salmonella infestation in the feedlots of the Upper Neosho. However, a recent study in southern Arizona indicated that the disease was wide-spread in the feedlots of that area. Fortunately, aridity and high evaporation rates of the area precluded runoff or percolation into either surface or subsurface waters.[101] In recent years, the Kansas Public Health Department has not recorded any known cases of cattle-induced Salmoneallа in the study area. Dr. Donald Wilcox

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[99]Gray, Speech to Kansas Livestock Association.

[100]E. H. Gibson, "Salmonellosis in Cattle," Agriculture, 73:213-216, June, 1966.

[101]W. M. Decker and J. H. Steele, "Health Aspects and Vector Control Associated with Animal Wastes," Proceedings of the National Symposium on Animal Waste Management, American Society of Agricultural Engineers, Publication No. SP-0366, 1966, p. 19.

of that agency noted that the absence may be one of recording rather than occurrence. Cattle-induced Salmonella may have occurred but simply not have been reported to the Health Department.

Chemicals

Animal wastes may also contribute to man's exposure to a number of potentially hazardous chemicals. Toxic pesticides are both excreted in the urine and feces and stored in the body tissue. Medicinal agents and growth-stimulating hormones are similarly excreted and stored. In order to eliminate the excessive assimilation of chemicals in the meat tissue, dosages are stringently administered; however, significant additional amounts may be taken into the tissue of the cattle if grain or roughage is eaten from the excreta-littered lot surface, a not uncommon practice. The cattle are produced for eventual human consumption and presently it is not known what long-term health effects these chemicals may have upon man.[102] The possible effect, if any, may be worthy of investigation.

IV. FEEDLOTS AS GENERATORS OF NUISANCES

The feedlots of the Upper Neosho Watershed have affected other than the aquatic environment and may be cited as sources of odor, dust, rodent and insect infestations, and noise; in addition, the feedlots, particularly those adjacent to urban areas, are responsible for a general aesthetic decline of the surrounding areas. While these effects have been observed, they have not been measured; indeed, some cannot be measured, and for the purposes of this paper will be considered as nuisances rather than

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[102] Ibid., p. 20.

pollutants. In reality semantics is not the important factor, rather it is the deleterious effect these phenomena have upon the environment that is of major concern.

<u>Odor</u>

Odors emanating from feedlots are usually the most noticeable characteristic of any feedlot. Not only is the immediate vicinity charged with odor, but the unpleasant smells become wind-borne and are spread over wide areas. The most obvious source of odor is the tons of manure in the lots. Less recognized, but equally pungent sources, are manure spread on fields, ammonia from urine, and ensilage. In many lots ensilage, dumped in large uncovered mounds (Figure 26), gives off odors just as potent as manure. In addition to the odors originating in the feedlots, effluent-charged streams become sources of foul odors as do the rotting carcasses of the many fish killed by feedlot wastes.

While all feedlots in the Upper Neosho are redolent to some degree, odor has not become a major problem except in the area around Emporia where the proximity of twenty-five thousand cattle and nineteen thousand people has created problems. Despite efforts of the Emporia feedlot operators to keep odor at a minimum through the use of deodorants, the proximity of the feedlots to the urban area is too great to avoid all odor problems. Many residents of the city complain about the odor, but few have taken any action or filed formal complaints.[103] To date only one property owner has taken

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[103]Several residents of Emporia have complained to the Lyon County Board of Health; however, the residents were reluctant to sign a formal complaint which would enable the Board of Health to investigate or take action.

Fig. 26. Huge mounds of ensilage (background) stored in feedlot.

legal action against a feedlot. He was awarded a judgment which was subsequently appealed by the feedlot operator and is still pending.[104]

Several operators in the study area felt that odor became a problem only during periods of high humidity and seldom constituted "much of a problem." In two other lots, the pens and manure piles are treated with a commercial enzymatic preparation designed to prevent offensive odors from being released into the air. In general, most of the Upper Neosho feedlot operators do attempt to minimize the odor emanating from their lots.

Dust

If the surface of a feedlot becomes too dry, dust clouds are raised by the milling and kicking of the cattle. The dust can affect the health of the livestock, be harmful to crops and create a nuisance for nearby residents. This problem can be eliminated by periodically sprinkling the feedlot during extended dry spells; a practice that most operators follow.

Insects and Rodents

Feedlots attract and harbor many filth-pests such as flies, cockroaches and rats. The most common filth-fly, the house fly (*Musca domestica*), is found in countless numbers in any feedlot. Studies in California indicate that one of the foremost causes of the current filth-fly population-explosions is the recent growth of small area, high density livestock-feeding operations.[105] The moist manure piles are extremely attractive to

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[104] *Emporia Gazette*, May 20-22, 1962; June 20, 1962; July 3, 1962; February 20, 1967.

[105] R. H. Soraker and J. A. Poll, "A Report on a Survey of Fly Production at Some Cattle Feedlots in Imperial County," Bureau of Vector Control, California State Department of Public Health (Sacramento: 1964), p. 16.

egg-laden females and provide an ideal environment for developing larvae. Feedlots are so attractive to egg-bearing female flies that it has been suggested that livestock operations in California actually perform a service to the surrounding countryside by attracting all the flies in the area. Further, with a proper manure-management program a feedlot could function as a death trap for flies by rapidly drying the feces after the fly eggs have been deposited in the manure.[106] However, these suggestions are not applicable everywhere.

According to Dr. Herbert Knutson of the Kansas State University Department of Entomology, fly production in eastern Kansas feedlots far exceeds the number of flies attracted from outside the lots. Also, the humid climate of the study area prolongs the drying of fecal matter, thereby allowing the larvae sufficient time to develop.

All Upper Neosho feedlots have severe fly infestation, although the operators regularly use insecticides to protect the cattle from flies in order to attain maximum weight-gain in the shortest possible time. Within the past year the Livestock Sanitary Commission has ruled that chemicals must be used to control the fly population in each lot (See Appendix A), but the infestation remains severe. Rats and other rodents are attracted to the lots in large numbers by the availability of grain and other food and mosquitoes are attracted to the breeding sites afforded by large pools of polluted water (Figure 27).

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[106] J. R. Anderson, "Biological Interrelationships Between Feces and Flies," Proceedings of the National Symposium on Animal Waste Management, American Society of Agricultural Engineers, Publication No. SP-0366, 1966, p. 21.

Fig. 27. Pools of runoff produce breeding sites for mosquitoes.

Noise

Feedlots are not usually considered to be generators of noise despite the bawling of cattle; however, in urban-oriented lots, noise can and often does become a problem. It is not the cattle per se which create the noise, but rather the trucks which transport stock to and from the lots. Despite the proximity of a railroad, approximately 90 per cent of all cattle in the Upper Neosho feedlots are moved by large semitrailer trucks. It is not unusual for twenty-five or thirty trucks carrying cattle or feed to enter or leave a large lot during a single day. The trucks not only create noise, but further promote air pollution through dust and diesel or gasoline fumes as well.

General Aesthetic Decline

It is not possible to determine quantitatively the extent to which feedlots are responsible for the decline of aesthetics in the surrounding area.[107] One reason is the nebulous nature of "aesthetics"; conditions which are intolerable to one may go unnoticed or be even pleasant to another. Perhaps a better standard would be the degree to which the land use of the feedlot and that of the surrounding area are compatible. In rural areas where an agricultural land use dominates, the smell of manure, prevalence of insects and other nuisances associated with feedlots may, to a greater or lesser degree, be natural components of the rural culture. However, the same phenomena may be foreign to an urban culture and create acute problems. As a result, a feedlot located on the periphery or within

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[107]The explicit definition of environment used throughout this paper must of necessity be broadened to consider the possible effect of feedlots upon the aesthetics of the surrounding area.

the confines of an urban area may be considered to have a more deleterious effect upon the aesthetic qualities of its environs than a rurally situated feedlot. Still, there is little doubt that all property adjacent to scum-covered, foul-smelling water courses does decline in value both aesthetically and economically despite the nature of the land use.

The accumulation of animal wastes has resulted in the pollution of the ground, air and water of the Upper Neosho Watershed. The pollution has been manifested by fish kills, unpalatable drinking water, hyper algea blooms, disease and nauseous odors. The evidence of the cause-and-effect relationship between animal wastes and the degraded quality of the physical environment is sufficient to cause many conscientious and informed people to realize the need for stringent pollution controls and more effective methods of animal-waste management.

CHAPTER V

POLLUTION ABATEMENT

Commercial cattle feedlots have grown with little planning and without adequate concern for the nuisance and pollutional characteristics of the industry. Public officials, feedlot operators, and to a limited degree, the general public, are not becoming aware that these characteristics and the consequent lowering of environmental quality must be checked. Various methods have been proposed, and in some instances initiated, to prevent or at least to reduce the nuisance and pollutional vectors inherent in animal-waste management.

It has been suggested that commercial feedlots not be allowed to operate adjacent to populated areas. Feedlots and their associated problems of odor, flies and dust have been protested by townspeople in Ventura and Pomona, California; Lubbock, Texas; Emporia, Kansas; and Tempe, Arizona.[108] In Tempe, public pressure became so great, one feedlot operator decided to relocate.[109] In such instances, the feedlot operator becomes a victim of urban encroachment, yet one livestock trade publication encouraged such operators to retain possession of their lots as long as possible. Even though encroachment will eventually force the operator to relocate, the longer the move can be delayed, the more the land will appreciate in

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[108] Carl Safley, "'Good Neighbor' Atmosphere Profits This Feedlot," Western Feed and Seed, October, 1962, p. 89.

[109] "Creeping Urbanism," Calf News, September, 1963, p. 20.

value as a housing, factory or shopping-center site.[110] In view of this, three of the four Emporia feedlots may eventually find it financially expedient to move to a rural area. However, when queried, the operators disclaimed any intent to relocate "in the near future."

Odor and fly problems can be reduced appreciably by the use of deodorants and insecticides. Feedlot operators acknowledge that fly infestations are detrimental to the welfare of the cattle; since ecnomic weight gain is of paramount importance, operators consider the cost of insecticides to control fly population a necessary expense. However, all too often the control or elimination of odor is an entirely different matter. Chemical odor control is an expense that does not improve beef quality or production and thus many operators do not consider it a necessary expense. The result is that most operators will not incur the expense of odor control unless forced to do so by either public pressure or a regulating body such as a sanitary commission or health department.

I. LEGISLATION

In the state of Kansas various tools are being utilized and others are being considered to control the disposal of animal wastes and the water pollution emanating from the wastes. Kansas has long had a tradition of water-pollution control dating back to 1907 with the passage of the Water and Sewage Law. The responsibility for controlling water pollution was, and continues to be, delegated to the State Department of Health. While the legislation was originally concerned primarily with the control of

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[110] Ibid.

municipal water and sewer systems, there have been several amendments since 1907, extending the Department's authority to control pollution from other sources as well. The most recent amendment, House Bill 1497, passed by the 1967 Legislature, placed control of agricultural effluents under the jurisdiction of the Health Department. In response to the new legislation, the Health Department has adopted regulations for the control of water pollutants from agricultural feedlot operations.[111]

The Health Department's 1967 regulations governing feedlots (Appendix B) have been a significant step. For the first time in Kansas history, any confined feeding operation with three hundred or more head of livestock is required to register with the Health Department. As of July 1, 1967, every new applicant must supply information on type of operation, topography, drainage, and primary receiving stream (see Appendix C); and all operators of existing feedlots are required to submit the same information by January 1, 1968. The department has the authority to compel operators to provide water-pollution-control facilities if, in the opinion of the department, a potential runoff problem does exist at the feedlot site. If the operator does not comply with the department's requests, he can be restrained from taking any other animals into the lot until minimum requirements for water pollution controls, as sepcified by the Health Department, are fulfilled.[112]

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[111]Leroy E. Lyons, "What Price Pollution," Kansas Fish and Game, 25:11, December, 1967.

[112]Kansas State Department of Health, "Agricultural and Related Waste Control," State Board of Health Regulations (Topeka: 1967), pp. 2-3.

II. RESEARCH

Two studies, financed in part by the Kansas Livestock Sanitary Commission, are currently underway at Kansas State University in Manhattan and the University of Kansas at Lawrence. The studies at Kansas State University are concerned with determination of the quantity and quality of feedlot runoff. Concurrent studies at the University of Kansas are being undertaken to determine the most satisfactory methods of animal-waste treatment and disposal. Although still in progress, the studies have yielded much important information.[113]

III. WASTE TREATMENT

Various methods of animal-waste disposal and treatment aimed at curbing pollution have been proposed. As noted above, the traditional method of animal-waste disposal, spreading manure on cropland, has certain drawbacks when large quantities of manure are involved. Of greater concern, however, is the fact that this method has proved unsatisfactory in preventing runoff-induced water pollution. Another proposal is the use of slotted floors whereby the waste drops into ditches or trenches rather than accumulate on the lot surface. This has proved successful in poultry and swine operations, but to date has not proved to be economically feasible for large cattle feedlots. A third method, which holds more promise, is the incineration of manure. Daily or weekly collections of manure are burned to a fine ash; the mineral-containing ash is then spread on the fields.

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[113] Many of the references to works by R. C. Loehr, J. R. Miner and S. M. Smith cited in this paper are the initual results from these studies.

Incineration can be very expensive if the waste material has a high moisture content and is practical only in areas where cheap fuel is available. However, after the initial drying, much of the heat required for complete incineration can be obtained from the combustible waste itself. This form of disposal may merit consideration in the Upper Neosho Watershed because of the availability of fossil fuels. Chase County has several large gas pools, one of which is located less than three miles from the largest feedlot in the Watershed. Just to the east, in Lyon County, there are approximately 5,520,000 and 303,180,000 tons respectively of proven and potential coal reserves.[114] If this manner of disposal were utilized, care would have to be taken to prevent any resulting smoke from becoming a source of air pollution.

Each of these methods either is less than satisfactory as a means of disposing of the vast quantities of waste generated by a large cattle feedlot, or has little pollution reduction capacity at the present time. The Kansas State Health Department has stated that its objectives in regard to the controlling of water pollution from cattle feedlots are to ". . . assure the continued growth and maintenance of the livestock industry and the protection of water quality for all beneficial use."[115] The department does not view the objectives as being inconsistent with one another; it intends to fulfill the objectives with competent engineering judgment and the use of water-pollution control principles on an individual-need-basis to avoid unwarranted expense to individual operators. If water-carried

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[114] Kansas State Geological Survey, Geology, Mineral Resources, and Ground-Water Resources of Chase County, Kansas, pp. 3031; Geology, Mineral Resources, and Ground-Water Resources of Lyon County, Kansas, pp. 26-28.

animal waste can be kept on the land and out of the watercourses, stream pollution from feedlots can be greatly reduced. The department believes this can be accomplished by controlling drainage through multiple retention ponds or treatment lagoons along with controlled water release or irrigation.[116]

Retention Ponds

The amount of feedlot waste which enters a stream can be greatly reduced by the impondment of waste-charged runoff. This can be accomplished by channeling all runoff into excavated or diked structures or by damming a natural depression. Pond size is dependent upon the size and slope of the drainage area but should be large enough to impond a minimum of three-acre-inches of runoff per acre of contributing drainage area. On hilly terrain, diversion ditches should be constructed to divert upslope runoff around the lot and out of the impondment basins. The pond acts as a sedimentation unit or catchment basin for the bulk of litter, debris and chemicals which settle or precipitate out of the runoff. At least one, and usually two, additional ponds are constructed downslope from the first (Figure 28). They accommodate any overflow from the first pond, but more importantly, they contain the effluent until a significant amount of self-cleansing has occurred. This will usually take three to five days; meanwhile the first pond is free to receive additional runoff. The flow of water from the pond into a receiving watercourse will occur within four to six days and is controlled to allow sufficient dilution to take place to eliminate the formation of a slug.

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[116]Ibid.

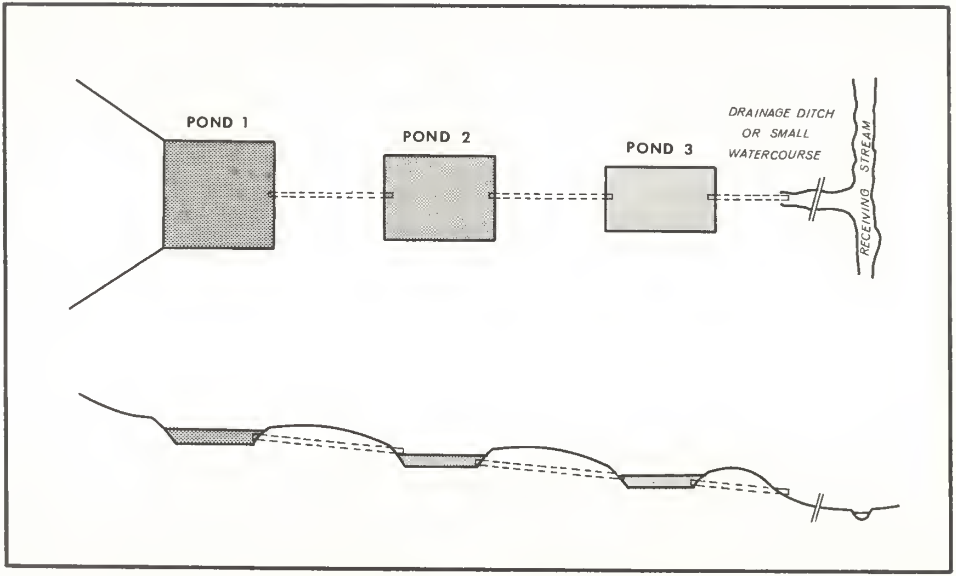

Fig. 28. Schematic drawing of a multiple retention pond system.(not to scale).

The lots and the dried-out ponds must still be cleaned mechanically, and the waste returned to the soil, incinerated or disposed of in some other way. Water retention ponds are designed to control the quantity and improve the quality of feedlot runoff that flows directly into a river system. If they are constructed and used responsibly, stream pollution from feedlots should be greatly reduced.[117]

Lagoons

Lagoons differ from retention ponds in that their principal function is waste treatment. In the process they also serve as an effective means of abating the runoff-induced pollution of surface waters. The initial channeling of runoff from the lot into a lagoon is similar to that followed when retention ponds are utilized. However, lagoons are deeper and designed to hold not inches but acre-feet of water and sludge. They differ from sedimentation units in that settled solids are not routinely removed, but are left to decompose fully. The digestion of wastes occurs through either aerobic or anaerobic action.

The aerobic digestion of waste occurs in relatively shallow lagoons that have a large surface area in relation to the amount of waste contained. Oxygen is added to the effluent both from the air and by photosynthesis. Because of the shallow depth (three to four feet) sufficient sunlight penetrates the lagoon surface to support algae and other micro-organisms by the oxygen-producing process of photosynthesis. In turn, the absorbed oxygen supports the bacterial action required to digest waste material.[118]

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[117] Heble, Interview.

[118] "How Practical Are Lagoons?" Feedlot, 11:23, May, 1967.

Anaerobic digestion conversely takes place in lagoons that are fifteen to twenty feet deep and greatly overloaded with organic wastes. Despite the depth of the lagoon, there is a considerable amount of mixing as a result of gases released through decomposition (Figure 29).

The septic tank function of an anaerobic lagoon which would efficiently treat all manure generated by a large feedlot is not presently feasible in practice. It would require twelve hundred gallons of water to dilute the daily excretement of one cow to the concentration of municipal sewage.[119] Even assuming the availability of water, the cost would be prohibitive. However, aerobic lagoons are proving to be a satisfactory method of treating waste flushed from feedlots. An additional advantage is that the stored plant-food-laden water can be utilized for irrigation.

Impondment and Treatment of Wastes in Study Area

Since the spring of 1967, four of the Upper Neosho feedlot operators have constructed runoff or waste treatment facilities including one multiple retention pond, two aerobic lagoons and one anaerobic lagoon system. A second anaerobic system designed to treat and store forty-five acre-feet of liquids is presently under construction. The liquid will be used to irrigate and fertilize adjacent fields of feed crops.

Two other operators anticipate that they may have to build some type of structure but will not undertake construction until required to do so. The operators of the remaining five lots feel they are able to control runoff by the use of diversion ditches and that wastes from their lots do not

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[119] Ibid.

Fig. 29. An anaerobic lagoon.

contribute significantly to water pollution.[120] Only one operator in the study area was adamant in his refusal to construct a runoff or treatment facility and stated he ". . . will go out of business" rather than comply.

Any resistance by the operators to the confinement and/or treatment of waste runoff is based primarily upon two factors. One, they resent being singled out as <u>the</u> major contributors of water pollution in the area. Some refuse to admit that feedlot runoff is responsible for the massive fish kills that have occurred in the Cottonwood and Neosho Rivers. Others admit that feedlots "may contribute" to water pollution but deny that they constitute the major source of pollution. They offer the rather irrational logic that while they do not know what the source of pollution is, they do know it is not derived from their feedlots.

The second, and perhaps major, factor is the expense involved in the construction of retention or treatment facilities. The expense involved is similar to that for deodorants in that the operator cannot "see" the return in terms of weight gain by the cattle. Therefore, many operators consider the expense to be unnecessary, a burden, and a threat to the continued economic growth of the industry in general and to his own business in particular.

It is not necessary that the cost of effective control of feedlot wastes be either a burden or a threat to the industry. It has been estimated that animal wastes can be controlled at an average cost of one dollar per head capacity of a feedlot. This estimated cost for water pollution

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[120]This information was obtained prior to the health department's deadline for registration to control agricultural waste; hence the lots had not been investigated by that department.

control, amortized over a ten-year period, would provide control at an average annual cost of three cents per head.[121]

This is a very small price to pay for the cleansing of a significant part of our environment. All too often economic restraints are responsible for the lack of pollution control and the resulting deterioration in the quality of our environment. This is true of cattle-feeding operations as well as other types of industries. At last the justification of continued "erosion of environmental quality" for continued economic gain is now being questioned.[122] The questioning is long overdue.

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[121] Gray, Speech to Kansas Livestock Association.

[122] Resources for the Future, p. 18.

CHAPTER VI

SUMMARY

The quality of all segments of our physical environment is seriously threatened by the discharge of pollutants into, onto, and above the earth. Although the pollutants have as a source many sectors of our culture and economy, the agricultural industry is increasingly becoming a major source of soil, water and air pollution. In some states today, the major source of uncontrolled water pollution emanates from the commercial cattle feedlot industry.

The commercial cattle feedlot industry has grown rapidly and is concentrated in an eleven-state area in the mid and southwest regions of the United States. The small herd, pasture-fed, ancillary livestock operation of pre-1950 has given way to livestock "factories" in which the chief purpose is to raise thousands of high-grade beef cattle. To achieve this purpose, cattle are concentrated in feedlots at densities of two to four hundred head per acre and are fed highly nutritional grain and forage along with selected additives to insure a maximum rate of gain in a minimum amount of time. The change of livestock feeding from a subordinate to a dominant position in agriculture was occasioned by several technological advances in agronomy, feed-handling systems and veterinary science along with increased consumer demand from a larger and more affluent population. The commercial-feedlot industry has steadily grown, particularly in the eleven leading cattle-feeding states, and today feedlot operations are increasing in both number and size.

Despite the apparent success of the industry, it is threatened by the problem of animal-waste management. Traditional methods of manure disposal are no longer adequate to dispose of the thousands of tons of waste generated annually in a large commercial feedlot. As a consequence various constituents of animal manure permeate the physical environment in the cattle feedlot areas. The quantities released into the environment are too large for nature to absorb readily, and the land, air and water of the physical environment become severely polluted.

A prime example of the deleterious effect of feedlot-derived pollution upon the physical environment may be found in the Upper Neosho Watershed of east-central Kansas where twelve commercial feedlots are concentrated. In the Watershed, the aquatic realm of the environment has been drastically changed by the runoff of manure-charged wastes into both the surface and subsurface waters of the area. Sections of the rivers downstream from the feedlots have been found to be discolored, odoriferous, deoxygenated, and charged with harmful amounts of nitrogen, ammonia, bacteria and suspended solids whenever large quantities of animal wastes are carried into the streams by precipitation.

The chemical and physical changes to the aquatic realm have produced an environment that is grossly hostile to the fauna and flora present in the area prior to the situation and growth of the cattle feedlot industry. Both the numbers and species of fish and the species of vegetation have changed as a consequence of the pollutants generated by animal wastes. Polluted surface waters have produced massive fish kills, unpotable drinking water, health hazards to water recreationists and unpleasant vistas. There are indications that subsurface waters have also been polluted by the leaching of nitrates from feedlots into underground aquifers. Feedlots in the area may also be cited as generators of dust, odor, insects and rodents.

The rapid growth of the feedlot industry in the Watershed precluded an adequate evaluation of the problems inherent in a large confined-animal feeding practice, and the quality of the environment was badly compromised before the pollutional potential of the industry was recognized. With the recognition of the pollutional effects of the industry, the State of Kansas passed legislation to curb feedlot-generated surface-water pollution. In the Upper Neosho Watershed and throughout Kansas, it is now mandatory for commercial feedlot operators to submit to the inspection of their feedlots, and if necessary, control the flow of waste-charged runoff from their lots into neighboring streams by the construction of diversion ditches, retention ponds, and/or lagoons. As commendable as this action is, it is not sufficient.

The technology which made concentrated feeding practices possible has accelerated at a much faster rate than that devoted to the treatment and disposal of animal wastes. The technological gap which exists between the creation of wastes and the pollution-free disposal of wastes must be closed if the industry is to survive. The pollution potential of the industry must be negated before the quality of the physical environment in the feedlot areas is impaired beyond reclamation. Hopefully, it is not yet too late.

LITERATURE CITED

A. BOOKS

Ericksen, J.R. and P. Jones. Fish and River Pollution. Washington: Butterworths, 1964.

Haystead, L. and Gilbert Fite. Agricultural Regions of the United States. Norman: University of Oklahoma Press, 1956.

Self, Huber. Geography of Kansas. Oklahoma City: Harlow Publishing Company, 1960.

B. PUBLICATIONS OF GOVERNMENT, LEARNED SOCIETIES AND OTHER ORGANIZATIONS

Anderson, M.S. "Farm Manure," Soils. Yearbook of Agriculture, United States Department of Agriculture. Washington: Government Printing Office, 1957.

Kansas State Board of Agriculture. "Cattle on Feed, January 1, 1964; 1965; 1966; and 1956." Kansas Crop and Livestock Reporting Service. Topeka: 1964, 1965, 1966, 1967.

Kansas State Department of Health. "Agriculture and Related Waste Control," State Board of Health Regulations. Topeka: 1967.

________. "Water Quality Criteria for the Neosho River Basin, Kansas," Environmental Health Service. Topeka: 1961.

Kansas State Geological Survey. Geology, Mineral Resources and Ground-Water Resources of Chase County, Kansas. Lawrence: University of Kansas, 1951.

________. Geology, Mineral Resources, and Ground-Water Resources of Lyon County, Kansas. Lawrence: University of Kansas, 1953.

Kansas State Livestock Sanitary Commission. "Rules and Regulations." Topeka: 1966.

Loehr, R.C. Pollution Implications of Animal Waste--A Forward Oriented Review. Federal Water Pollution Control Administration, United States Department of Interior. Ada, Oklahoma: Robert S. Kerr Water Research Center, 1967.

McKee, J.E. and H.W. Wolf. "Water Quality Criteria." State Water Quality Control Board. Sacramento: 1963.

National Academy of Sciences. Waste Management and Control. Washington: National Research Council, 1966.

President's Science Advisory Committee. Restoring the Quality of Our Environment. Report of the Environment Pollution Panel. Washington: Government Printing Office, 1966.

State of Kansas. State Water Plan Studies, Neosho Unit. Kansas State Water Resource Board. Topeka: 1961.

Soraker, R.H. and J.A. Poll. "A Report on a Survey of Fly Production at Some Cattle Feedlots in Imperial County." Bureau of Vector Control, California State Department of Public Health. Sacramento: 1964.

Resources For The Future, Incorporated. Resources for the Future. Annual Report of Resources for the Future. Washington: Resources for the Future, Incorporated, 1966.

United States Department of Agriculture. Agricultural Statistics: 1950. Washington: Government Printing Office, 1950.

_______. Agricultural Statistics: 1967. Washington: Government Printing Office, 1967.

_______. Agricultural Statistics: 1968. Washington: Government Printing Office, 1968.

_______. Cattle and Calves on Feed: 1950 through 1967. Statistical Reporting Service. Washington: Government Printing Office, 1950-1967.

_______. Cattle on Feed. Statistical Reporting Service. Washington: Government Printing Office, January, 1969.

_______. Cattle on Feed, Cattle Sold for Slaughter--Selected Markets. Statistical Reporting Service. Washington: Government Printing Office, 1967.

_______. Number of Feedlots by Size Groups and Number of Fed Cattle Marketed: 1962-1964. Statistical Reporting Service. Washington: Government Printing Office, 1966.

United States Department of Health, Education, and Welfare. Pollution-Caused Fish Kills: 1963. Public Health Service, Publication Number 847. Washington: Government Printing Office, 1964.

_______. Pollution-Caused Fish Kill: 1964. Public Health Service, Publication Number 847. Washington: Government Printing Office, 1965.

United States Department of Interior. Pollution-Caused Fish Kills: 1965. Federal Water Pollution Control Administration. Washington: Government Printing Office, 1966.

_______. Fish Kills by Pollution: 1966. Federal Water Pollution Control Administration. Washington: Government Printing Office, 1967.

_______. Fish Kills by Pollution: 1967. Federal Water Pollution Control Administration. Washington: Government Printing Office, 1968.

C. PERIODICALS

American Society of Agricultural Engineers. Proceedings of National Symposium on Animal Waste Management, Publication SP-0366. St. Joseph: American Society of Agricultural Engineers, October, 1966.

Anderson, J.R. "Biological Inter-relationships Between Feces and Flies," Proceedings of the National Symposium on Animal Waste Management, American Society of Agricultural Engineers, Publication SP-0366, October, 1966.

Anon. "Creeping Urbanism," Calf News, 26:20-21, September, 1963.

Anon. "How Practical Are Lagoons?" Feedlot, 8:22-23, May, 1967.

Decker, W.M. and J.H. Steele. "Health Aspects and Vector Control Associated with Animal Wastes," Proceedings of the National Symposium on Animal Waste Management, American Society of Agricultural Engineers, Publication SP-0366, October, 1966.

Fischer, L.K. "Water Pollution," Farm Policy Forum, 18:24-31, August, 1963.

Gibson, E.A. "Salmonellosis in Cattle," Agriculture, 73:213-216, June, 1966.

Gilbertson, Wesley E. "Animal Waste: Disposal or Management," Proceedings of the National Symposium on Animal Waste Management, American Society of Agricultural Engineers, Publication SP-0366, October, 1966.

Henderson, J.M. "Agricultural Land Drainage and Stream Pollution," Journal of Sanitary Engineers, 88:59-62, March, 1961.

Lyons, Leroy E. "What Price Pollution?" Kansas Fish and Game, 25:6-12, December, 1967.

Miner, J.R. "Cattle Feedlot Runoff--Its Nature and Variation," Journal of Water Pollution Control Federation, 38:1582-1592, October, 1966.

Morrison, C.S. "Farm Animal Waste Problems," Proceedings of the National Symposium on Animal Waste Management, American Society of Agricultural Engineers, Publication SP-0366, October, 1966.

Safely, Carl. "'Good Neighbor' Atmosphere Profits This Feedlot," Western Feed and Seed, 8:8-9, October, 1962.

Smith, G.E. "Contamination of Water by Nitrates," Fertilizer Solutions, 2:8-18, May-June, 1967.

Stubblefield, T.M. "Problems of Cattle Feeding in Arizona as Related to Animal Waste Management," Proceedings of the Symposium on Animal Waste Management, American Society of Agricultural Engineers, SP-0366, October, 1966.

Taiganides, E.P. and T.E. Hazen. "Properties of Farm Animal Excreta," Transaction of the American Society of Agricultural Engineers, 9:373-376, May, 1966.

Wittiver, S.H. "Animal Waste Management," Proceedings of the Symposium on Animal Waste Management, American Society of Agricultural Engineers, SP-0366, October, 1966.

D. UNPUBLISHED MATERIALS

Cross, Frank B. and M. Braasch. "Qualitative Changes in the Fish-Fauna of the Upper Neosho River System." Lawrence: University of Kansas, 1967. (Mimeographed.)

Gray, M.E. "Cattle Feedlots and Pollution." Paper read at the Ramada Inn, Topeka, March 3, 1967.

________. "Water Pollution and Agriculture." Paper read at a meeting of the Kansas Livestock Association, Wichita, March, 1966.

Kansas State Department of Health. "Chemical Analysis of Water--Cottonwood River." Environmental Health Service, Topeka, June 5, 1967.

Loehr, R.C. "Annual Progress Report, Federal Water Pollution Control Administration Demonstration Grant WPD-123-01-66, Cattle Feedlot Waste Water Treatment." Lawrence: University of Kansas, July 1967. (Mimeographed.)

Manges, Harry. "Quality and Quantity of Feedlot Runoff." Paper read at meeting of Soil Conservation Service Engineers, Salina, Kansas, October 17, 1967.

Miner, J.R. "Water Pollution Potential from Cattle Feedlot Runoff." Unpublished Doctorate dissertation, Kansas State University, Manhattan, 1967.

E. NEWSPAPERS

Emporia [Kansas] Gazette. May 20, 21, 22, 1962; June 20, 1962; July 3, 1962; February 20, 1967.

Warner, G.D. "Pollution From Cattle Feedlots Spread Sludge of Death in Kansas Stream," Kansas City Star, May 14, 1967.

F. INTERVIEWS

Baker, Vern. Hartford Water and Sewer Superintendent, Hartford, Kansas, November 15, 1967.

Bidwell, O.W. Professor of Agronomy, Kansas State University, Manhattan, Kansas, August 2, 1967.

Cross, Frank B. Professor of Zoology, University of Kansas, Lawrence, Kansas, November 3, 1967.

Heble, Vern. Kansas State Department of Health, Topeka, Kansas, November 27, 1967.

Prophet, C.W. Professor of Biology, Kansas State College of Emporia, Emporia, Kansas, October, 1967.

Schoonover, Roy. Head of Fishery Division, Kansas Forestry, Fish and Game Commission, Pratt, Kansas, September 19, 1967.

Wilcox, Donald. Public Health Physician, Kansas State Department of Health, Topeka, Kansas, November 15, 1967.

G. OTHER

Benn, E.T. and E.D. Longnecker. Animal Manures--What Are Really Worth Today? Michigan Agricultural Experiment Station, Bulletin 231. East Lansing: Michigan State University, 1961.

Emporia, Kansas Comprehensive Plan-1964. Salina, Kansas: Bucher and Willis, Consulting Engineers and Planners, 1964.

Imhof, L.J. State Southeast District Sanitation Engineer. Written report to Dr. Vern Heble, Kansas State Department of Health, Topeka, Feb. 15, 1967.

McCoy, John H. and Calvin C. Hasuman. Economies of Scale in Commercial Cattle Feedlots of Kansas--An Analysis of Non-Feed Costs. Kansas State University Technical Bulletin 151. Manhattan: Kansas State University, 1967.

McCoy, John H. and Robert Wuhrman. Some Economic Aspects of Commercial Cattle Feeding in Kansas. Agricultural Experiment Station, Bulletin 424. Manhattan: Kansas State University, 1960.

Prophet, C.W. Personal correspondence, October 26, 1967.

Taiganides, E.P. The Value of Animal Manures. Columbus, Nebraska: Behlen Manufacturing Company, 1964.

AGENCY 9 -- LIVESTOCK SANITARY COMMISSIONER

RULES and REGULATIONS

ARTICLE 8 -- LIVESTOCK FEED LOTS RULES AND REGULATIONS

9-8-1. CLEANING OF PREMISES.

(1) Feed Lots shall be thoroughly scraped and cleaned, and all manure removed, at least two times each calendar year, and more frequently if necessary to maintain proper standards of cleanliness and sanitation.

(2) Manure removed from a feed lot shall be disposed of in one of the following manners: (a) hauling to and placing upon farm land, where same shall be spread out and plowed under the soil surface. (b) dehydrating by a mechanical dehydrating process; (c) depositing in lagoons or settling tanks, having such construction and size to effectuate substantial reduction by bacterial action; (d) using any other method specifically approved by the Livestock Sanitary Commissioner. Manure removed from a feed lot may be stock-piled, and shall be moved for final disposal when conditions permit.

(3) Locations at a feed lot which might be the source of insect breeding, (a) shall be cleaned, or (b) shall be treated with approved chemicals, or (c) shall be both cleaned and treated with approved chemicals. The procedure followed shall be in such manner as to eliminate or substantially reduce the breeding of flies.

(Authorized by K.S.A. 47-1505 and 47-1506; compiled Jan. 1, 1966.)

9-8-2. CONTROL OF INSECTS, RODENTS, AND PESTS.

(1) Effective chemicals, approved by the Livestock Sanitary Commissioner, shall be used for killing of flies on and about the feed lot premises. Such chemicals shall be applied with such frequency, and with such coverage, as will eliminate or reasonably control the fly population on such premises.

(2) Effective methods, approved by the Livestock Sanitary Commissioner, shall be used for the eradication of the rodent population. Approved formulas of gas and poisons, may be used.

(Authorized by K.S.A. 47-1505 and 47-1506; compiled Jan. 1, 1966.)

9-8-3. LOCATION AND CONSTRUCTION OF FACILITIES.

(1) Feed bunks, hay feeders, water tanks, and other permanent installations, shall be located and constructed in such a manner as to permit adequate cleaning of premises adjacent to such permanent facilities.

(2) Weather resistant platform aprons shall be provided adjacent to all feed bunks, feeders, water tanks and other permanently affixed facilities. Such aprons shall be of concrete, blacktop, compacted gravel, crushed rock, or other approved materials.

(Authorized by K.S.A. 47-1505 and 47-1506; compiled Jan. 1, 1966.)

9-8-4. DRAINAGE OF FEED LOT.

(1) Surfaces of feed lot pens shall be prepared and maintained at a grade or slope, and in a manner which will prevent future and eliminate present accumulations of surface waters, and which will permit and facilitate the immediate runoff of surface waters, from the feeding area.

(2) The surface waters running off, or being discharged from, the feeding area, shall be directed into storage reservoirs or settling basins, where practical and recommended, or shall be diverted and spread over fields, thus preventing the direct drainage and movement of solids being carried by water into draws, ravines, streams, and rivers.

(Authorized by K.S.A. 47-1505 and 47-1506; compiled Jan. 1, 1966)

9-8-5. VETERINARIAN.

A licensed veterinarian shall be available at the feed lot, or subject to call at any time.

(Authorized by K.S.A. 47-1505 and 47-1506; compiled Jan. 1, 1966.)

9-8-6. MECHANICAL EQUIPMENT.

The operator of a feed lot shall have available at his feed lot, either by ownership or by lease arrangement, necessary equipment, in good repair, which shall include the following: a bulldozer, a road grader, and a scoop or other mechanically operated equipment capable of scraping pens and loading manure.

(Authorized by K.S.A. 47-1505 and 47-1506; compiled Jan. 1, 1966.)

APPENDIX B

CHAPTER 28. STATE BOARD OF HEALTH REGULATIONS

ARTICLE 18. AGRICULTURAL AND RELATED WASTES CONTROL

28-18-1. DEFINITIONS

For purposes of the regulations in this article, the following words, terms and phrases are hereby defined as follows:

(a) The words "confined feeding" shall mean the confined feeding of animals for food, fur, or pleasure purposes in lots, pens, pools or ponds which are not normally used for raising crops and in which no vegetation, intended for animal food, is growing. This will not include a wintering operation for cows in lots or on farming ground unless the operation causes a pollution problem.

(b) The words "confined feeding operation" shall mean (1) any confined feeding of 300 or more cattle, swine, sheep, or horses at any one time, or (2) any animal feeding operation of less than 300 head using a lagoon, or (3) any other animal feeding operation having a water pollution potential, or (4) any other animal feeding operation whose operator elects to come under these regulations.

(c) The term "operator" shall mean an individual, a corporation, a group of individuals, joint venturers, a partnership, or any other business entity having charge or control of one or more confined feeding installations.

(d) "Food animals" shall mean fish, fowl, cattle, swine, and sheep.

(e) "Fur animals" shall mean any animal raised for its pelt.

(f) "Pleasure animals" shall mean dogs and horses.

(g) The words "waste retention lagoon" or "retention ponds" shall mean excavated or diked structures, or natural depressions provided for or used for the purpose of containing or detaining animal wastes consisting of body excrements, feed losses, litter, cooling waters, wash waters, whether separately or collectively, or any other associated materials detrimental to water quality or to public health, or to beneficial uses of the waters of the state. A waste retention structure shall not be construed to be a treatment facility and discharges of waste water therefrom shall not be allowed except as authorized by regulations 28-18-3 and 28-18-4.

(h) The words "waste treatment facilities" shall mean structures and/or devices which stabilize, or otherwise control pollutants so that after discharge of treated wastes, water pollution does not occur and the public health and the beneficial uses of the waters of the state are adequately protected.

(i) The words "water pollution control facilities" shall mean waste retention lagoons, retention ponds, or waste treatment facilities.

(j) The term "department" shall mean the Kansas State Department of Health. (Authorized by K.S.A. 65-164, K.S.A. 65-171f, K.S.A. 65-165 as amend., K.S.A. 65-167 as amend., K.S.A. 65-171d as amend., K.S.A. 65-171h as amend.; effective 31 May 1967.)

28-18-2. REGISTRATION AND WATER POLLUTION CONTROL FACILITIES PERMITS.

(a) Effective July 1, 1967, the operator of any newly proposed confined feeding operation as defined in regulation 28-18-1(b) must register with the Kansas State Department of Health prior to construction and operation of the lot, pen, pool or pond. The operator of any existing confined feeding operation as defined in regulation 28-18-1(b) must register by January 1, 1968. Application for registration shall be made on a form supplied by the department.

(b) Applicants shall submit the completed application form to the department together with supplemental information regarding general features of topography, drainage course and identification of ultimate primary receiving streams. Additional information which may be deemed necessary for satisfactory evaluation of the application may be required by and shall be submitted to the department.

(c) If in the judgment of the department, a proposed or existing confined feeding operation does not constitute a potential water pollution problem because of location, topography, or other reasons, provision of water pollution control facilities will not be required.

(d) If in the opinion of the department a confined feeding operation does constitute a water pollution potential, or if water pollution occurs as a result of any confined feeding operation, the operator shall provide water pollution control facilities which shall be constructed in accordance with plans and specifications approved by the department.

(e) Water pollution control facilities shall not be placed in use until a permit has been issued. Permits for water pollution control facilities will be issued by the executive secretary of the Kansas State Board of Health upon satisfactory completion of construction in accordance with plans and specifications approved by the department. Water pollution control facilities permits shall be revocable for cause on thirty days' written notice. If a water pollution control facilities permit is revoked, the owner or operator of the confined feeding operation involved shall be allowed to finish feeding existing animals in the lot, pen, pool or pond at the time of revocation but shall not place or allow to be placed in the lot, pen, pool or pond any other animals until the minimum requirements for water pollution control as set forth in regulations 28-18-3 and 28-18-4 have been met and a new water pollution control facilities permit has been issued. (Authorized by K.S.A. 65-164, K.S.A. 65-171f, K.S.A. 65-165 as amend., K.S.A. 65-166 as amend., K.S.A. 65-167 as amend., K.S.A. 65-171d as amend., K.S.A. 65-171h as amend.; effective 31 May 1967.)

28-18-3. REQUIREMENTS FOR FACILITIES

Water pollution control facilities required shall be kept at the minimum requirements stated in the following paragraphs; provided that when site topography, operating procedures, and other available information indicate that adequate water pollution control can be effected with less than the minimum requirements, the minimum requirements may be waived; provided further that if site topography, operating procedures, experience, and other available information indicate that more than the minimum requirements will be necessary to effect adequate water pollution control, additional control provisions may be required.

(a) CATTLE: The minimum water pollution control facilities for the confined feeding of cattle shall be retention ponds capable of containing three inches of surface runoff from the feedlot area, waste storage areas, and all other waste contributing areas. Diversion of surface drainage prior to contact with the confined feeding area or manure or sludge storage areas shall be permitted. Waste retained in detention ponds shall be disposed of as soon as practicable to insure adequate retention capacity for future needs.

(b) SWINE: Waste retention lagoons for swine feeding operations may be allowed in lieu of waste treatment facilities. Waste retention lagoons must be capable of retaining all animal excreta, litter, feed losses, cooling waters, wash waters, and any other associated materials and shall additionally be capable of retaining three inches of rainfall runoff from all contributing drainage areas. Diversion of surface drainage prior to contact with the confined feeding area or manure or sludge storage areas shall be permitted. Provision must be made for periodic removal of waste material from retention lagoons.

(c) SHEEP: The minimum water pollution control facilities for the confined feeding of sheep shall be retention ponds capable of containing three inches of surface runoff from the confined feeding area, waste storage areas, and

and all other waste contributing areas. Diversion of surface drainage prior to contact with the confined feeding area or manure or sludge storage areas shall be permitted. Waste retained in detention ponds shall be disposed of as soon as practicable to insure adequate retention capacity for future needs.

(d) OTHER ANIMALS: Each confined feeding operation registered involving other animals shall be evaluated on its own merits with regard to the water pollution control facilities required, if any. The confined feeding of other animals shall not cause or lead to the pollution of the waters of the state by runoff water from confined feeding areas, release or escape of water from pools or ponds, improper storage or disposal of waste materials removed from the confined feeding area, or by any other means.

(e) Waste treatment facilities shall be designed, constructed, and operated in conformance with the provisions of regulation 28-18-4. If waste treatment facilities consist only of pond or lagoon type structures, there shall be a minimum of two such structures for series operation.

(f) Other methods of water pollution control shall be permitted where in the judgment of the department effective results will be obtained. (Authorized by K.S.A. 65-164, K.S.A. 65-171f, K.S.A. 65-165 as amend., K.S.A. 65-166 as amend., K.S.A. 65-167 as amend., K.S.A. 65-171d as amend., K.S.A. 65-171h as amend.; effective 31 May 1967.)

28-18-4. OPERATION OF FACILITIES.

(a) The water pollution control facilities shall be operated and maintained so as to prevent water pollution and to protect the public health and the beneficial uses of the waters of the state.

(b) Waste discharges from retention ponds, lagoons, or waste treatment facilities into any watercourse shall be in conformance with the water quality requirements of the appropriate river basin criteria as set forth in chapter 28, article 16 of regulations adopted by the Kansas State Board of Health and regulation 28-18-3.

(c) Waste materials removed from retention ponds, waste treatment facilities, and/or confined feeding areas shall be disposed of or stockpiled in a manner which will not contribute to water pollution. Wastes may be used for irrigation or spread on land surface and mixed with the soil in a manner which will prevent runoff of wastes. Other methods of disposal of wastes from retention ponds, retention lagoons, waste treatment facilities, and/or confined feeding areas shall be evaluated and permitted if in the judgment of the department effective water pollution control will be accomplished. (Authorized by K.S.A. 65-164, K.S.A. 65-171f, K.S.A. 65-165 as amend., K.S.A. 65-166 as amend., K.S.A. 65-167 as amend., K.S.A. 65-171d as amend., K.S.A. 65-171h as amend.; effective 31 May 1967).

APPENDIX C

THE KANSAS STATE DEPARTMENT OF HEALTH

TOPEKA
KANSAS

REGISTRATION APPLICATION
for the
CONTROL OF AGRICULTURAL AND RELATED WASTES

To: State of Kansas
Environmental Health Services
Kansas State Department of Health
5th Floor, State Office Building
Topeka, Kansas 66612

Name of Applicant ____
Company, Corporation, or Individual (Owner)

Name of Confined Feeding Operation ____

Address of Applicant ____
(P.O. Box) (Street) (City) (Phone)

Operator or Manager if other than Applicant ____

Address ____
(P.O. Box) (Street) (City) (Phone)

hereby makes application to the Kansas State Department of Health in conformance with Kansas State Board of Health regulations 28-18-1 through 4.

Legal description of proposed or existing confined feeding operation
Township __________, Range __________ (E)(W), Section __________ County __________

Numerical capacity of confined feeding operation __________. Number of animals (cattle, swine, sheep or horses) presently confined __________. Area of confinement __________ acres.

Total land area owned by applicant adjacent to confined feeding operation ________ acres. Would this land be available for irrigation by gravity flow or pumping from the lowest elevation of the confined feeding operation? Yes __________ No __________. Explain

____

____

____

____

REGISTRATION APPLICATION
for the
CONTROL OF AGRICULTURAL AND RELATED WASTES

Attach a sketch of the existing or proposed confined feeding operation and indicate the following on the sketch: (1) overall dimensions of confinement, (2) direction of surface drainage from confined area, (3) location of water supply wells within 1000 feet of the area. An SCS aerial photograph of the area involved is desirable.

Name of watercourse receiving drainage from operation________________________

Name of primary receiving stream________________________

Has a complaint been issued against the confined feeding operation by downstream water users? Yes________ No________

Do you contemplate expansion of operation in the future? If yes, give estimate of date and future operation capacity________________________

____

____

To whom should future correspondence be addressed?________________________

____

____

________________________ ________________________

Date Signature of Applicant or Duly Authorized Agent

ENVIRONMENTAL POLLUTION AND THE CATTLE FEEDLOT
INDUSTRY IN THE UPPER NEOSHO WATERSHED
OF KANSAS

by

MARY LOU KENNON TRUE

B. A., Eastern Michigan University, 1958
B. S., Michigan State University, 1961

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF ARTS
Geography

Department of Geology and Geography

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1969

AN ABSTRACT

The quality of our physical environment is seriously jeopardized by the vast quantity of pollutants disgorged into the environment. The commercial cattle feedlot industry has been cited as a major source of pollutants in some areas. This study was undertaken to determine, 1) why the industry is a major source of pollution; 2) the polluting nature of the industry; and 3) some of the effects of the industry upon the quality of the physical environment.

Since 1950, the United States has experienced a dramatic change in the methods by which beef cattle are produced for slaughter. Technological changes in agronomy, feed-handling systems and veterinary science have made it possible for one man to raise thousands of cattle on a very few acres of land. The concentrated or confined feeding practices have generated large accumulations of animal wastes in micro areas. Traditional methods of waste disposal are no longer feasible with the great volume of waste there is to be managed. The animal wastes are carried by natural processes into the land, air, and water in quantities too great for nature to assimilate readily, thus the quality of the environment is seriously impaired.

The Upper Neosho Watershed, a commercial feedlot area of east-central Kansas, has experienced pronounced environmental pollution from cattle feedlots. Streams of the area have been found to be lacking in oxygen and contain harmful quantities of nitrogen, ammonia, bacteria, and suspended solids. The effects of these changes upon the aquatic

environment have been massive fish kills, changes in fish number and species composition, changes of flora species, and the creation of health hazards to both humans and animals. In addition to the possible contamination of ground water, feedlots in the area are sources of dust, odor, insects and rodents.

The harmful effects of animal wastes upon the quality of the environment have at last been recognized, and steps are now being taken to curb the quantity and quality of pollutants which emanate from the cattle feedlots of the area.