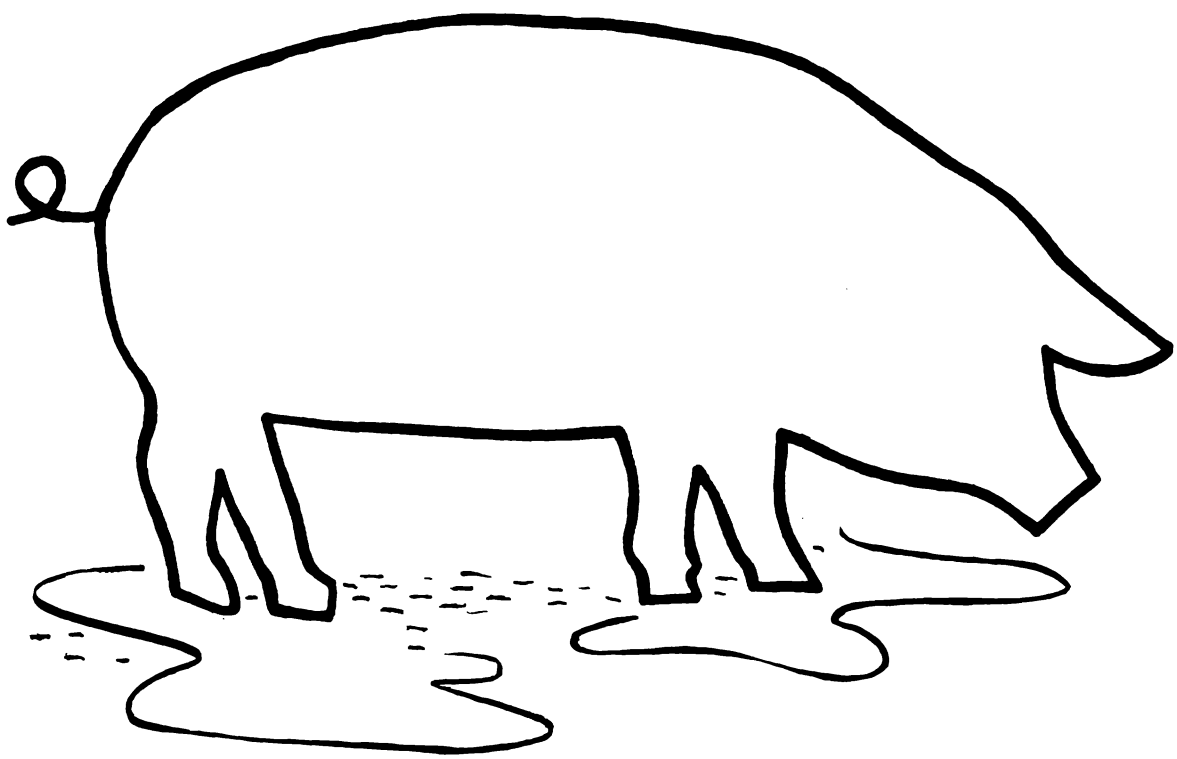
ECONOMIC IMPACT OF CONTROLLING SURFACE WATER RUNOFF FROM POINT SOURCES IN U.S. HOG PRODUCTION



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ABSTRACT

This report discusses the prevention of surface water pollution with hog wastes from point sources, and relates it to major structural characteristics of hog production. Nonpoint source pollution, arising from pasture systems and the application of hog wastes to farmland, is recognized but not evaluated.

This analysis centers on the 15 major hog-producing States. In 1969, they accounted for 511,000 farms selling hogs, and for 89 percent of U.S. hog output. A third of total sales came from 368,000 farms selling fewer than 200 hogs each annually; 12 percent of sales were from farms selling 1,000 head or more.

Open-lot systems of production accounted for 58 percent of all systems; pasture, 33 percent; and total confinement, 9 percent. Uncontrolled runoff is estimated to occur on 112,000 farms; 86,000 of them use open-lot systems.

Effluent guidelines used in this report were assumed, since EPA guidelines had not been issued when this study was made. Under these assumptions, application of runoff control facilities to open-lot systems with problems would require investments in the 15 States of $254 to $290 million, and increased annual costs of $36 to $44, or $0.90 to $1.00 per 100 pounds of hogs produced. Unit investments and annual costs would be over 10 times as great for the smallest as for the largest enterprises.

After control adjustments are complete, water should be free of hog wastes; pork should cost consumers little or no more as a result of the clean-up program. During the adjustment period some producers, agribusiness firms, and rural communities will suffer; pork supplies are likely to drop and prices to rise. Undesirable economic impacts can be minimized through proper application of regulations.

This study was made before the EPA Guidelines were finalized and thus the final Guidelines or interpretations thereof may result in changes in the economic impact.

Key words: Hogs, pollution, runoff control, economic impact

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PREFACE

The Federal Water Pollution Control Act Amendments of 1972 require that the U.S. Environmental Protection Agency (EPA) establish effluent limitation guidelines for point source discharges. Section 301(b) of the Act requires the application of the "best practicable control technology currently available" by July 1, 1977. By July 1, 1983, the Act requires the application of the "best available technology economically achievable."

Guidelines proposed by EPA for cattle feeding, dairy and swine production, and poultry and egg production appeared in the Federal Register of September 7, 1973. They were:

(a) The effluent limitation representing the degree of effluent reduction obtainable by the application of the best practicable control technology currently available is no discharge of process waste water pollutants to navigable waters, except for runoff which is not contained by facilities designed, constructed, and operated to contain all process waste water in addition to the runoff from the 10 year, 24 hour rainfall event as established by the U.S. Weather Bureau for the region in which the point source discharger is located.† /Footnote added./

(b) The effluent limitation representing the degree of effluent reduction obtainable by the application of the best available technology economically achievable is no discharge of process waste water pollutants to navigable waters, except for runoff which is not contained by facilities designed, constructed, and operated to contain all process waste water in addition to the 25-year, 24-hour rainfall event as established by the U.S. Weather Bureau for the region in which the point source discharger is located.

In the proposed rules of September 7, "feedlot" and "process waste water" were defined as follows:

(a) The term "feedlot" shall mean a concentrated, confined animal or poultry growing operation for meat, milk or egg production, or stabling, in pens or houses wherein the animals or poultry are fed at the place of confinement and crop production is not sustained in the area of confinement.

(b) The term "process waste water" shall mean any water from any source which comes into contact with any manure, litter or bedding, or any other raw material or intermediate or final material or product used in or resulting from the production of animals or poultry or direct products (e.g. milk, eggs).

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† A 10-year, 24-hour rainfall event is a rainfall of a specified magnitude or greater that has a 1-in-10 chance of occurring in a 24-hour period in any given year. A 25-year, 24-hour rainfall has a 1-in-25 chance of occurring.

EPA subsequently announced that the effluent guidelines proposed on September 7, 1973, will apply only to operations with 1,000 animal units or more, that is, 1,000 beef cattle, 2,500 swine, 700 dairy cattle, etc. It is possible that guidelines for smaller operations may be proposed for public comment at a later date.

The Economic Research Service initiated the analyses of the cattle feeding, dairy, and swine industries before the passage of the Federal Water Pollution Control Act Amendments of 1972. These analyses were designed to appraise the extent of point surface water runoff control problems; estimate investments and additional operating costs for control of surface water runoff; and evaluate the economic impacts, including supply and price effects, of effluent guidelines.

Because effluent guidelines had not been issued at the time the studies were started, guidelines were assumed for these studies. Assumptions were based on preliminary information available to EPA and on feedlot control practices in major producing States. Although guidelines assumed do not coincide exactly with the guidelines announced September 1973, they are sufficiently close to allow meaningful judgements of economic impacts. In making these estimates it was assumed that all feedlots, regardless of size, would have to comply with effluent guidelines.

This report analyzes the economic impact of proposed regulations on U.S. hog production. Appreciation is extended to the many persons in public and private industry in the 15 major hog-producing States who provided detailed estimates of the production systems in use, the number of farms with uncontrolled runoff, and the best practical alternatives for control of runoff. Special consideration is due staff members of the 15 State Soil Conservation Services, U.S. Department of Agriculture, who provided detailed recommendations for runoff control systems and unit costs for each of the system components.

Credit is also given to James B. Johnson and Gary A. Davis, Commodity Economics Division, Economic Research Service, who collected much of the data on runoff control systems, and developed the computer program for calculating investments and annual costs.

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The 15 major hog-producing States are concentrated in the North Central and Southeast regions of the United States. They account for nearly 90 percent of U.S. hog output.

The number of producers has been steadily declining, and size of enterprise has been increasing. Yet, small enterprises still account for most of the hogs produced. In 1969, 511,000 farmers sold hogs in the 15 major States; 386,000 farmers sold fewer than 200 head per year but they accounted for a third of all sales. Only 12 percent of total sales came from farms selling 1,000 or more hogs. Average annual sale from all farms was only 155 hogs.

Production systems range from extensive pasture to complete confinement. Open-lot systems, which are highly susceptible to point source runoff, comprise 58 percent of the total; pasture systems, 33 percent; and confinement systems, 9 percent.

Nearly 112,000 farms, or over a fifth of all farms producing hogs, are estimated to have runoff problems. These farms accounted for a third of total hog output in 1969. Open-lot systems with runoff problems numbered 86,000; pasture systems, 20,000; and confinement systems, 6,000.

The best practical means of controlling runoff from open-lot systems includes diversion terraces, settling basins, holding ponds, and irrigation equipment that returns polluted runoff to farmland. The cost of applying such facilities varies with the size of the holding pond. Runoff control systems designed to hold the runoff from the expected 10-year, 24-hour rainfall event in each State would require investments of $254 million and would increase annual production costs by $36 million. New investment per hog would average about $13; annual cost per 100 pounds of live hogs produced or sold would increase $0.89. This extra cost reduces to less than $0.25 per 100 pounds when spread over all hogs produced by the industry, as open-lot producers with runoff problems account for only a fourth of total hog output.

Holding ponds designed to hold normal runoff for 4 to 6 months, as well as the runoff from the expected 10-year, 24-hour storm event, would raise investments and annual costs 10 to 15 percent above the amount required to handle only the major storm event.

Investments and annual costs to construct runoff control facilities according to recommendations of leading technicians in each State are slightly more than for control of the major storm event alone, and slightly less than for control of normal runoff plus the major storm event.

The impact of runoff control would fall heavily on small producers. Those selling fewer than 100 hogs annually would incur investments of about $61 per hog and extra annual costs of $4.24 per 100 pounds. These producers would bear a third of the total cost of runoff control for the industry; producers selling fewer than 200 hogs annually would bear over half of it. Farms with annual

output above 1,000 hogs would need to invest about $4.00 per hog; they would incur extra annual costs of $0.26 per 100 pounds of hogs sold.

Regulations requiring complete control of runoff from all hog production systems would accelerate most of the existing trends, and force changes in the structure of the industry. A major trend is toward total confinement. This system of production is competitive with other systems, and is compatible with complete control of runoff. Thus, after adjustments are completed, surface water should be free of hog wastes, and pork should be little or no more costly for the consumer. During the adjustment period, however, the economic penalties could be severe on some individual producers, agribusiness firms, and rural communities. Pork supplies would be likely to drop and prices to rise. Adequate planning and proper implementation of regulations can minimize undesirable impacts.

CONCLUSIONS AND RECOMMENDATIONS

Complete runoff control from open-lot hog-producing farms in the 15 leading States would require an investment of $254 million, and would add $36 million to annual operating costs. This is not a very large sum for an industry that markets about $8 billion worth of live hogs yearly. But it does indicate that runoff control regulations cannot be easily and quickly applied to the hog industry without serious negative economic impacts on producers and consumers. Marginal farmers and agribusiness firms who might cease production sooner than they would have in the absence of regulations would lose millions of dollars in annual income. Intermediate-term price increases to consumers would also likely result. Nevertheless, runoff control is not incompatible with a profitable, efficiently operated hog industry, with only moderate price increases to consumers.

Reasonable runoff control regulations could provide better quality water with minimum cost to all sectors of the economy. However, regulations should be planned to fit the characteristics of the producers, be placed in force so as to complement rather than disrupt ongoing changes, and provide farmers with confidence in the stability of the regulations over time. Recommendations offered below may facilitate such an outcome.

(1) Both the specifics of regulations and the timing of their application should be made known as soon as possible. Producers should be assured that investments made under a given set of regulations will be protected from a change in regulations for a normal write-off period. They can then be expected to modify their present inclination to "wait and see" before remodeling or constructing new facilities.

(2) Most hogs are produced in small enterprises turning out fewer than 100 hogs a year, commonly as part of multi-enterprise farm businesses, including both crops and livestock. Few hog enterprises are large enough to productively employ even half a man-year equivalent. Most of them would be subjected to high unit costs in complying with runoff control regulations. Further, farmers have several alternatives to immediate compliance with regulations, and most of these alternatives would have negative economic impacts on one or more sectors of the economy. Small producers are already under severe economic pressures from many directions.

Producers turning out fewer than 200 hogs a year number 386,000 of the 511,000 farms selling hogs in the 15 major States. They probably could not feasibly install currently recommended runoff control facilities, even if they could management the cash outflow. Over time, most of them would probably either cease production or expand the size of enterprise. They now sell over 25 million hogs a year, or nearly a third of total production in the 15 major States. They are therefore very important in any decision to impose control runoff regulations that might force them out of production quickly and in large numbers. It might take some time for the rest of the industry to take up such a drop in supply. There are alternatives to minimize the impact on supply:

(a) Delay for some time, but a specified number of years, before imposing regulations on such producers; (b) impose regulations within a short time, but help producers through cost-sharing from public funds if rapid compliance is considered necessary, thereby basically postponing the inevitable but easing the adjustment period for all concerned; or (c) impose no specific regulations on small producers, considering the minimal amount of individual pollution potential, but take corrective measures against excessive violators as they are identified.

(3) Many medium-size producers (e.g., annual sales of 200-500 head) may well be able to absorb the average annual cost increases of about $0.75 per 100 pounds of pork produced, and continue to operate on a competitive basis. New investment requirements of up to $10,000, however, may be unacceptable to many of these farmers. The impact of this cash outlay might be eased, as noted in item (2) above, by: (a) allowing producers more time for adjustments, or (b) providing cost-sharing from public funds if rapid compliance with runoff regulations is deemed necessary. In view of the many problems facing these medium-size producers, the second alternative may well be less costly and disruptive, both to individual farmers and to the economy as a whole.

(4) Regulations should be phased into the industry over a period of several years. A start could be made with the very large operations. Because these operations are few in number, they could be reasonably handled in an administrative program. They produce a very small share of total output of hogs; hence, regardless of their reactions to regulations they can have only a small effect on the total supply. Few large producers are likely to cease operations in response to runoff control regulations, simply because of their sizable financial commitment to the industry. Finally, the most severe instances of concentrated pollution could be stopped quickly because most of these large operations already have surface runoff fairly well in hand.

Neither this study nor these conclusions provide the one best solution to the control of surface runoff from open-lot hog production systems. However, the description of the industry, and the identification of possible economic impacts from application of runoff control regulations, do provide information for decisionmakers to use in deciding how best to reach the objectives.

ECONOMIC IMPACT OF CONTROLLING SURFACE WATER RUNOFF FROM POINT SOURCES IN U.S. HOG PRODUCTION

by

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and

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INTRODUCTION

Growing public awareness and concern over environmental quality prompted the U.S. Congress on October 18, 1972, to enact the Federal Water Pollution Control Act Amendments of 1972. In this Act, the U.S. Environmental Protection Agency (EPA) was charged with developing a comprehensive national program to eliminate water pollution. Pollution from agriculture is included as part of this program.

Guidelines are being developed by EPA to insure that all States make progress in reducing the pollutants entering the Nation's water supply. Many livestock producers will be directly affected by these guidelines because of exposed lots that are subject to runoff, especially during periods of heavy precipitation.

Any requirements imposed on livestock producers for added runoff control may influence supply, increase investments and costs of production, apply sufficient economic pressure to alter the structure of the industry, cause shifts in producer income, and increase costs to consumers. Knowledge of these effects and their tradeoffs is essential if guidelines are to be developed for the maximum total benefit of all sectors of society.

This report examines mainly the economic impact of controlling water pollution from concentrated systems (point sources of potential pollution) of hog production in the United States.

METHOD OF ANALYSIS

Pollution from hog production may occur in many forms, including contamination of surface and ground water, odors, dust, insects, rodents, disease,

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noise, and esthetics. It can occur at the site of production or during disposal of hog wastes. Emphasis in this study is on the quality of surface water as it is affected by effluent discharged from the production site. Only limited analysis is made of pasture systems of production, as they constitute a nonpoint source of pollution. For the same reason, the spreading of hog wastes on agricultural land is not discussed.

Hog production occurs throughout the United States, but is heavily concentrated in the grain-producing areas of the North Central States and to a lesser extent in the Southeast. This study was therefore limited to the 15 States that accounted for 89 percent of U.S. hog production in 1969.

The number of producers and the amount of production in the various sizes and types of systems were determined. An estimate was then made of the number of producers with uncontrolled surface runoff in each size-system category. The best practical technology for remedial action was estimated. Additional investments and annual costs for control were then determined, assuming that all producers with a runoff problem would apply the best practical technology for its solution. Finally, the probable economic impacts of imposition of the proposed regulations for control were explored.

Data on size of hog enterprises are from the 1969 Census of Agriculture. The 1973 distribution would undoubtedly show a higher percentage of both producers and hog production in the larger farm size groups, but actual counts are not available.

Whether hogs are produced on pasture, in open lots, or in total confinement under roof has great bearing on the potential for runoff of polluted water. Such information, however, was available only for Illinois. 1/ To obtain similar information for other States, persons having first-hand knowledge of hog production were asked to estimate the distribution of production systems in their respective States. 2/ They were provided with Illinois data, and relevant information for their own States. Means of their responses were used in this analysis. Median estimates of the number of producers with uncontrolled runoff problems and the best available technology for control were obtained the same way.

The leading technicians in each State provided specifications and unit costs of runoff control facilities. 3/ These data were then used to estimate

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1/ A special 1971 survey was made in Illinois by the U.S. Department of Agriculture's Statistical Reporting Service. See John C. Gamble, "Economic Evaluation of the Impact of Alternative Environmental Regulations and Waste Management Systems on Illinois Hog Producers." Unpublished Ph. D. Thesis, Univ. of Ill., July 1972.

2/ Persons who provided estimates included livestock association directors, professional farm managers, agricultural college staff, soil conservation staff engaged in planning control systems, agricultural stabilization and conservation staff, and others familiar with hog production.

3/ Personnel of the U.S. Department of Agriculture's Soil Conservation Service, serving the various States, were considered the leading technicians in designing systems and recommending measures for control of runoff.

investments and annual costs of runoff control under alternative assumptions: (1) adoption of current recommendations issued by the leading technicians in each State, or (2) application of a uniform proposal for all States, requiring containment of runoff for the maximum 10-year, 24-hour rainfall event for each State. 4/ Note that under this alternative, investment and costs would be 10 to 15 percent higher if based on capacity for normal runoff during 4 to 6 months plus the 10-year, 24-hour rainfall.

GENERAL CHARACTERISTICS OF THE HOG INDUSTRY

Hog production is similar to other livestock enterprises insofar as pollution control is concerned. Yet some structural differences of hog production require special consideration in order to avoid excessive costs to both farmers and the economy generally.

Geographic Location of Production

Hog production is concentrated in the grain-producing areas of the North Central States and in the Southeast. For this study, the 15 major States were grouped into the Corn Belt-Lake States, Plains States, and Southeast (fig. 1). Climatic differences among these regions affect both the probability and the amount of runoff and hence the cost of control. These major States have accounted for 85 to 90 percent of total U.S. hog production since 1950 (table 1). Over this period, the Corn Belt-Lake States have consistently produced about two-thirds of the total, although there has been a gradual westward shift within the region. Production has increased steadily in both the Plains States and the Southeast, especially in the eastern grain-producing part of the Plains States.

A few States dominate hog production. Iowa leads; it accounted for nearly a fourth of total production and over 17 percent of the producers in 1969 (tables 2 and 3). Illinois followed with 12 percent of production and 10 percent of the producers. The top four States contribute more than half of total output. Thus, control of runoff in a limited number of States could greatly affect the hog industry.

Hog production and cattle feeding often occur on the same farms in the North Central States. Dairying is a major enterprise in the Lake States and in specific locations throughout the other States. However, dairying is less likely to be found in a combined operation than are hogs and cattle feeding.

Cattle feeding stretches from humid to arid regions. Hog production, on the other hand, is concentrated in areas with annual precipitation ranging from 25 to 40 inches, and relatively long periods of cold weather. Problems with mud and waste management have been partly responsible for the ongoing westward shift of hog production within the North Central States.

4/ A 10-year, 24-hour rainfall event is a rainfall of a specific magnitude or greater that has a 1-in-10 chance of occuring in a 24-hour period in any given year.

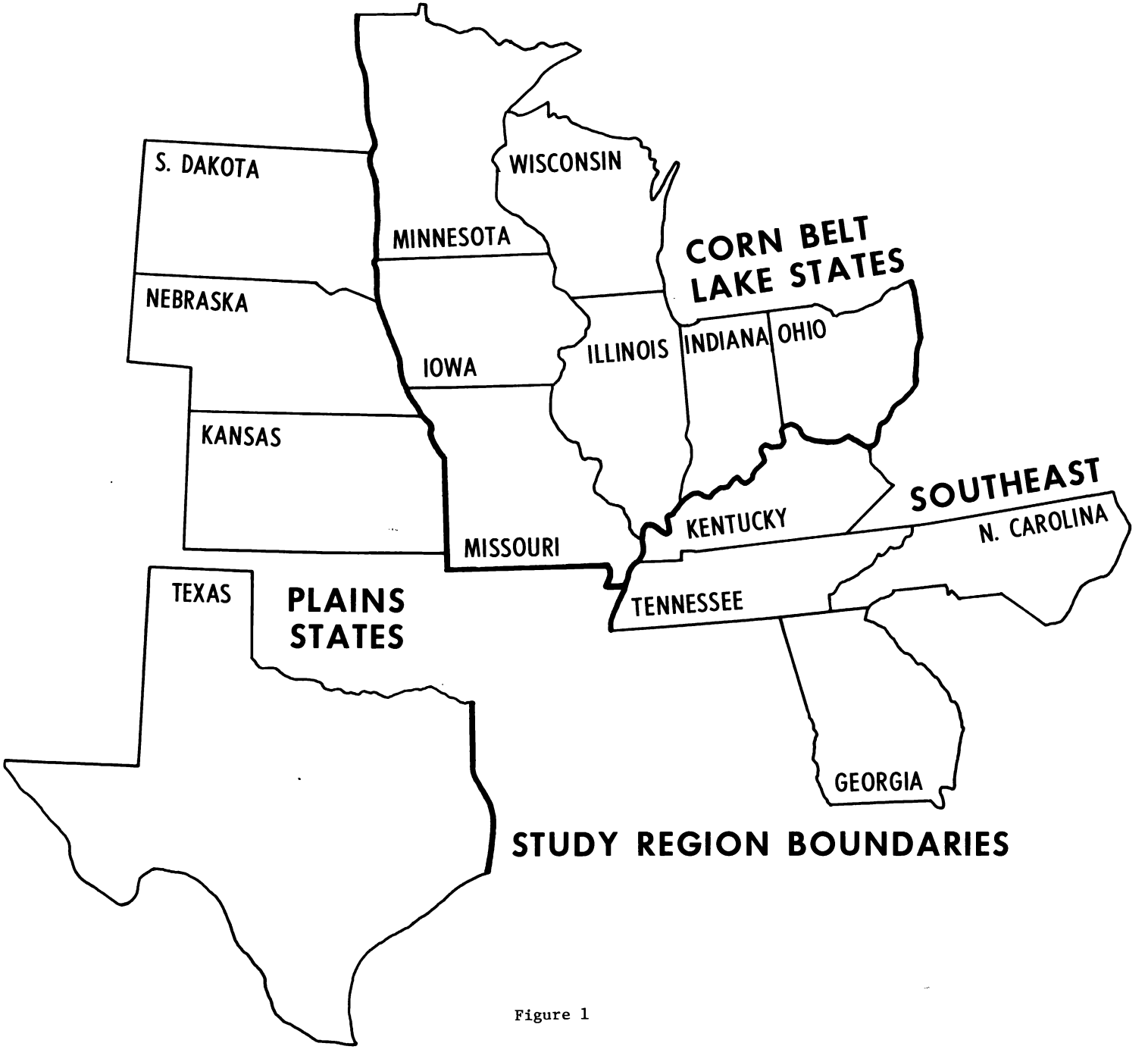
S. DAKOTA
WISCONSIN
MINNESOTA
CORN BELT
LAKE STATES
NEBRASKA
ILLINOIS
INDIANA
OHIO
IOWA
KANSAS
SOUTHEAST
KENTUCKY
N. CAROLINA
MISSOURI
TENNESSEE
TEXAS
PLAINS
STATES
GEORGIA
STUDY REGION BOUNDARIES

Figure 1

Pollution problems and their solutions are similar for all three classes of livestock. To the extent that combined enterprises occur on the same farm and within a region, runoff cannot be fully evaluated by investigating the enterprises separately, as is done here for hogs. But data for a combined approach are not now available.

Size of Enterprise

Nearly half of the hog producers in the Corn Belt-Lake States sold fewer than 100 head in 1969 (table 4). Fifty-nine percent of the producers in the Plains States and 79 percent in the Southeast were in this size class. Seventy-five percent (386,000) of all producers in the 15 major States sold less than 200 hogs annually. Only 1.2 percent sold more than 1,000 head each.

Small producers also accounted for a major share of total hog output (table 5). Nearly a third of the hogs sold came from farms selling less than 200 head a year. Only 12 percent came from farms selling more than 1,000 head. Only 260 farms in the contiguous 48 States had capacities above 3,000 head in 1969 (app. table 1).

Sales of hogs and pigs in the 15 major producing States averaged only 155 head per farm in 1969. Iowa and Illinois exceeded 200 head, but most of the Southeast States fell below 100 head (table 6). Farms selling 1,000 head and over averaged 1,576 head. Large producers are of little significance in the total supply of hogs.

An efficiently managed hog enterprise operated on a year-round basis can yield about two market hogs for each unit of capacity. This level was approached in the largest size class in Iowa and Illinois, where farrow-to-finish enterprises dominate production. Producers with the smallest annual sales in these States turned out only a little more than one head for each hog in inventory (app. table 2). These ratios are affected by both the seasonality of production and the degree of capacity utilization. Although no accurate data are available, the smaller producers probably operate both seasonally and with less efficient use of facilities than large producers.

The supply of labor, and perhaps other resources, may be more important than physical facilities in determining system capacity. Further, the States showing the highest annual turnover ratios (app. table 2) are relatively heavy producers of feeder pigs, commonly sold at weights of 50-60 pounds. The average size system for all groups studied was estimated at only 96 head in 1969, ranging from 31 head on farms selling less than 100 head to 790 head in the largest size class (app. table 3).

Actual system capacity is probably greater than indicated by these data, because the average farmer does not make complete use of his facilities. The degree of underutilization is normally greater in the smaller operations; hence, their size may be underestimated in this analysis. On the other hand, the study data present each farm as having one system. In reality, annual sales

from one farm often come from multiple locations of farmsteads as well as hog production facilities. In spite of these possibly offsetting biases, most production systems are obviously small.

Data on number of producers and size of production systems are essential to an evaluation of runoff, its control, and the resulting impacts. Carefully considered, they point out some of the economic problems likely to be encountered in establishing controls, at both the farm and administrative levels, and the probable direction of producer response to regulations.

Systems of Production

Hogs are produced under a variety of systems, ranging from nothing more than a patch of woods for shelter to totally enclosed, environmentally controlled houses requiring an initial outlay of well over $100 per hog space. Classification of production systems is difficult, especially since the various activities--care of the breeding herd, farrowing, raising of pigs, and finishing of hogs--are sometimes handled in different ways on the same farm. For purposes of examining surface water runoff, however, the most important system characteristics are the degree of concentration of the hogs, the extent of the shelter, and the surface of exposed lots. Where mixed systems occurred, classification for this study was based on the dominant phase of the hog enterprise --growing and finishing.

All hog production was placed in one of the four following systems: (1) Pasture, with portable facilities; (2) open-lot facilities with exposed lots paved; (3) open-lot facilities with exposed lots partly paved, or dirt lots, identified hereafter as "other"; and (4) total confinement, with all areas used by hogs under roof. 5/ The pasture system is essentially a non-point source of pollution, causing problems similar to those that might occur in land-spreading of manure. The three other systems produce wastes and potentially damaging runoff at identifiable point sources.

The pasture system of production accounts for a third of all operations in the 15 States. It is more common in the Corn Belt-Lake States than in the Plains or Southeast, and is much more prevalent on small farms. This system can be essentially free of damaging runoff if it has adequate pastureland and proper management, especially for feeding and watering. However, high-density or poorly managed pasture systems can cause as severe a surface runoff problem as poorly managed open-lot systems with uncontrolled runoff.

Open systems with paved lots are relatively more important in medium-size hog operations, where farmers have committed substantial resources to production but have not specialized to the greatest extent possible. These lots comprise only an eighth of all operations, but they account for a fifth of the farms selling 200 to 999 head annually. The runoff control problem is normally less severe for systems with paved lots than for those with partly paved or

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5/ Survey data were used for Illinois; estimates were made by experts for other States.

dirt lots because the high cost of paving forces producers to make better use of lot space. Hence, the area requiring runoff control is usually much smaller than the area normally involved with other open lots.

Partly paved or dirt-lot systems (that is, "other") are dominant in the 15 major hog-producing States. They account for 40 percent of all farms in the Corn Belt-Lake States and for 46 percent in the 15 States, or a total of 234,000 farms (table 7). Within size groups, this is the most common system in the smaller operations. These open-lot systems with partly paved or dirt lots present the greatest problem in controlling surface runoff. Some liquids may seep into the ground in dirt lots, but most of these lots have been located and constructed for good drainage, in order to cope with the mud problem. However, they are relatively difficult to clean. There is more space per hog than in paved lot systems, and therefore a larger drainage area that must be brought under control for a given size operation. For this reason, the runoff control facilities must be more extensive than those for paved lot systems.

Confinement systems, where all areas used by hogs are completely roofed, are found in all size classes, ranging from less than 5 percent of the total in the smallest class to nearly half in the largest class (table 7). The smaller units are most likely to be old barns with paved floors. A high proportion of the largest ones are probably modern slotted floor facilities, with waste handled in liquid form. Properly designed and managed confinement systems should be compatible with zero runoff. Where problems exist, a change in management is probably more necessary than added investment.

Pasture systems account for a smaller share of hog production than number of farms because of the heavy use of pasture in small operations (table 8). Paved lot systems account for a greater share of production than number of farms. The proportion of all hogs produced in "other" open lot systems approximates the percentage of farmers using this system. The share of confinement-reared hogs is double the share of farms using this system, because confinement is used relatively more frequently in the large operations. These relationships are favorable to runoff control, insofar as lessening any impact on supply is concerned.

Enterprise Combinations

Large, highly specialized, single-enterprise operations dominate the poultry industry, account for a major share of total output of fed beef cattle, and characterize dairying in some regions of the country. There is a trend toward specialized hog producing farms, but as yet they account for only a small share of the industry, as evidenced by the size distribution data in the previous section.

Most hog producing farms are multi-enterprise operations, consisting of a substantial production of crops, especially corn, and often other livestock enterprises as well. Hog producers have a rather broad set of management choices, including discontinuance of production when confronted with pollution control regulations. They also have a wider choice among systems of production, including the extensive pasture system, than do producers of most other kinds of livestock and poultry.

The smaller the acreage associated with a hog operation, the greater the probability of pollution, both from runoff from the production site and from land where manure is applied. Also, alternative methods and costs for controlling surface runoff are affected by both the enterprise mix and the amount of available land. Although there is great variation in enterprise combinations and in livestock-land ratios, data are not available to identify them precisely.

Pasture systems for producing hogs usually require about 2 man-hours of labor per market hog produced. Labor inputs normally decline as output increases and production becomes concentrated. The larger total confinement systems use only about 1 man-hour of labor per hog produced. It is apparent, therefore, that hog production is rarely the major enterprise on the farm, and does not provide the major employment for even one man. About 75 percent of all hog enterprises in the 15 States provide employment for a fifth man-year or less. Only about 1 percent provide the equivalent of a full man-year.

Hog production is of major importance on most farms. Adjustments to pollution regulations or any other force will be influenced by this situation. Economic forces have already caused some small producers to cease hog production, or to enlarge and specialize. Regulations for pollution control will intensify this ongoing adjustment. Certainly, many farmers can continue farming without their hog enterprise. In any case, implementation of runoff-control regulations will entail a considerable amount of planning and evaluation at the farm level.

SURFACE WATER POLLUTION FROM HOG PRODUCTION

Production Site

Good drainage is necessary in hog production. Pasture drainage must be sufficient to keep hogs and equipment from miring in mud, especially around feeding, watering, and farrowing sites. Centralized operations should be designed for rapid drainage of water away from building and lots. Difficulty in achieving adequate drainage, and hence suitable working conditions, has been a major force in the shift to total confinement systems. Because relatively few producers have yet shifted to this system, drainage remains a major problem on most farms.

Rainfall and snow melt, rather than animal wastes, are responsible for the major drainage problems in hog production. Yet these surface drainage waters transport some animal wastes from both pastures and open-lot facilities.

In the past, the objective was to speed drainage to keep production areas as dry as possible. Now the goal is to prevent water pollution by containing contaminated runoff on the farm where it is produced. Emphasis in this study is on control of wastes produced at an identifiable point source, but nonpoint sources will be considered briefly. In hog production, this involves pasture systems of production and land application of wastes, regardless of origin. Both systems need careful management to prevent the equivalent in nonpoint source pollution, and to control disease.

Producers with Uncontrolled Runoff Problems

All of the 511,000 hog production operations in the 15 major States are potential polluters of surface water. For this analysis, producers were considered to have uncontrolled runoff problems if any drainage containing hog wastes moved from the production site onto the property of others or into surface water other than that in an impoundment designed specifically for storage of hog wastes or contaminated water.

Actual measurements of the extent of surface water contamination from hog production have not been made. A time-consuming and expensive engineering analysis of a stratified random sample of farms would be needed to measure the situation accurately. To obtain a quick approximation, the same expert opinion technique was used as for estimating systems of production and their occurance. Ten to 15 knowledgeable people in each of the 15 major States were asked to estimate the number of farmers who would have to increase their runoff control measures. The median values of their estimates were used in this study.

The quantitative estimates thus obtained can be defended only on the basis of the experience and familiarity of the estimators with hog production systems in their States. Nevertheless, the similarity of estimates given by persons with diverse specialities, yet familiar with hog production and the problems of surface water pollution, indicated that the results of the composite estimate were reasonable. Further, the differences in identified problems among the several sizes and types of enterprises, and by regions, provide a valuable insight into the origin of most of the pollution from surface runoff, and who would be most affected by regulations to control it.

In the aggregate, nearly 112,000 hog producers (22 percent of the total in the 15 States) were estimated to have a runoff problem requiring additional control (table 9). In 1969, they produced over 25 million hogs, or nearly a third of total output in the 15 major States (table 10). The proportion with a runoff problem was estimated to be more than twice as great in the Corn Belt-Lake States as in the Plains States, where precipitation is relatively low.

There was clearly a relationship between uncontrolled runoff problems and the size of enterprise and system of production. The larger operations had the highest proportion of producers with runoff problems, regardless of the system of production. For those with annual sales of 1,000 head or more, some remedial action was indicated for 40 percent of the farmers producing 45 percent of the hogs in that size class. Only a sixth of the producers with annual sales of 1 to 99, and a fifth of those producing 100 to 199 head, were estimated to have runoff problems. However, they totaled 66,000, or 60 percent of all problem farms.

Total confinement is the best system for controlling runoff from hog production sites. A unit properly constructed and managed should have no runoff. Yet, the estimators see some flaws in the confinement systems now used. They range from seepage from solid-floor barns and from outside manure piles to overflow of manure lagoons associated with the larger, slotted-floor confinement units. Problem farms with confinement housing ranged from 8 percent of the smallest operations to 18 percent of the largest. Percentages were somewhat

higher in the Southeast than in the other regions, possibly because of heavier rainfall.

Pasture production is considered a nonpoint source of potential pollution and will not be fully investigated in this study. Nevertheless, estimates of the number of problem situations were obtained. The smaller pasture systems are considered to present no more of a pollution problem than the smaller confinement systems. But the largest pasture operations are very likely to pollute surface water, especially in the Corn Belt-Lake States (table 9). In that region, 65 percent of the pasture systems producing 74 percent of the hogs in that system, and selling 1,000 or more hogs, had uncontrolled runoff. The problems are attributed to intense concentration of hogs per unit of land, lack of shelter, poor site drainage, and the probability that none of the larger pasture producers have installed satisfactory runoff control facilities.

Open-lot systems of all sizes are suspect. There was uncontrolled surface runoff on nearly two-thirds of these farms in the largest size class in the Southeast, and on a little less than half of the farms in the Plains States (table 9). There is less incidence of violation by smaller producers with open lots, largely because there are relatively large land areas on most farms between the hog production site and flowing streams or neighboring property. In such cases, wastes in runoff would seep into the soils the same as if they had been spread on cropland.

The numbers of producers and the share of production in the several size-system classes, coupled with estimates of surface runoff on the same basis, constitute the most important data in this report. These data provide a guide to probable sources of pollution, where regulations might be most effectively applied using limited enforcement personnel, and where hog production might be most affected.

Particular attention is called to the medium-size group (annual sales of 200 to 499 head). This group contains some 95,000 farmers; a third are estimated to have uncontrolled runoff problems. These farmers produce about one-third of all hogs in the 15 States (table 10). An enterprise of this size is too small to realize economies of size; yet hogs probably provide a substantial share of the farm income. These farmers are at a major crossroad, and enforcement of regulations will have much to do with their decisions. Farmers' reactions to regulations will also have substantial impact on hog supply, especially in the intermediate adjustment period. Pressures of pollution control regulations will tend to cause the small producer to drop hog production; larger producers will tend to comply or to adopt newer and larger systems of production. The greatest uncertainty rests with the medium-size producer.

Runoff Control Measures

Estimates of the costs and impact of controlling pollution from surface runoff are mainly limited in this report to point sources of production. The nearly 20,000 pasture producers estimated to be responsible for nonpoint pollution are not included. Remedial actions for those producers are likely to involve management shifts, rather than expenditures of money. Methods of controlling nonpoint pollution include care in locating the feeding, watering, and

farrowing sites; maximizing the distance of these areas from streams and waterways; planting pastures to heavy-growing forages; fencing hogs from streams and waterways; and avoiding concentrated stocking. Some of the largest pasture systems may be forced to move into centralized facilities, where runoff can be controlled; but the extent of such a shift cannot be estimated at present, and no costs have been assigned to it.

The remedy for control of runoff from confinement systems is also largely one of better management, including cleaning often enough to prevent seepage outside of buildings, protecting stacked manure from rainfall, hauling liquid manure from pits often enough to prevent lagoon overflows, and perhaps installing diversion terraces to protect capacities of manure lagoons. Some new but presently unmeasurable expenditures may be necessary to meet new regulations, but improved management should largely solve the problem.

The cost of controlling surface water runoff from open lots--paved and unpaved--is the prime target of this study. These systems constitute three-fourths of the nearly 112,000 farms considered to have runoff problems, and they produce 75 percent of the hogs from farms needing control. Changes in management alone are not likely to solve the problem on these farms. Additional expenditures, sometimes substantial, will usually be necessary.

Hog producers could oxidize, filter, recycle, or apply other available technology to prevent polluted runoff from entering the water supply. As long as open-lot systems are used, however, the best practical means is to prevent runoff from leaving the production areas. This is commonly achieved with a control system consisting of the following four components:

(1) Diversion terraces to minimize the amount of water moving across areas used by hogs, and to channel runoff transporting animal wastes.

(2) A settling basin to collect the solids contained in the runoff from pens and lots.

(3) Holding ponds for the liquid portion of the runoff. The pond must be constructed to prevent seepage into ground water. It must also be able to maintain adequate capacity, either by means of a capacity-evaporation balance or by removing the water, commonly via irrigation to farmland.

(4) A transport and distribution system to move the runoff from storage to utilization or disposal area.

The leading technicians on runoff control generally concur with these principles. Specific recommendations and design criteria, however, do differ for the major hog-producing States. A settling basin is not recommended in some areas because of topography or the location of hog lots. Nevertheless, it is included in the computation of added investments and annual costs for all States (app. table 4). Producers might have to put in a special clay lining

not a part of the soil at the site, or plastic, concrete, or other material. Perhaps the major variation is the recommended capacity of the retention pond and associated requirements for emptying it. In some States, ponds must have capacity for a large percentage of the average annual precipitation. In other States, ponds are usually designed to control the major storm event; frequent emptyings are required to maintain needed storage capacity.

This analysis examines the economic impact of applying two options for controlling runoff from open-lot hog operations: (1) systems in which the capacity of the holding pond is set by the runoff expected for the 10-year, 24-hour storm event in each State; and (2) systems designed according to the recommendations of the leading technicians in each State. The first option is uniform among States in that it calls for diversion terraces, a settling basin, and a holding pond with designated capacity (table 11). The second option includes the same three components, but allows for variation in control measures among States (table 12). Dumping and irrigation equipment are added to both options as necessary.

State-by-State requirements indicate variations in State water quality standards (equal to or above the minimum required by Federal law). These variations reflect local considerations relative to the amount of expected runoff, and the necessity or suitability of particular system components. Both runoff control options combine storage capacity and disposal practices to maintain adequate capacity in the retention pond. Both systems irrigate stored runoff from the retention pond to the farmland to insure runoff will remain on the land.

Runoff Control for Open-Lot Hog Production Systems

This study applied two variations of the previously described runoff control systems to open-lot hog operations. The first (fig. 2), hereafter called "Technology 1," is assumed to be installed when there is unrestricted space for the components. It consists of diversion terraces, a settling basin, a holding pond, and an irrigation system to empty the holding pond contents onto cropland.

Technology 1 cannot be installed on some farms because of slope of the land, location of the hog lots relative to buildings and roads, and other conditions. A variation of the standard runoff control system, hereafter called "Technology 2" (fig. 3), was assumed to be installed on farms that could not accommodate Technology 1. This system includes the same components as Technology 1, but requires the addition of a sump, a pump, and pipe to deliver runoff from the hog lot to the holding pond. 6/

6/ Illustrations for Technologies 1 and 2 were taken directly from Livestock Waste Management in a Quality Environment, Ill. Agr. Ext. Serv. Cir. 1074, Coll. of Agr., Univ. of Ill., March 1973, pp. 5 and 6.

FEEDLOT RUNOFF CONTROL (UNRESTRICTED SPACE)

This system is adapted to beef, dairy, and swine operations where runoff from feedlots is sufficient to constitute a potential pollution hazard.

① **Feedlot.** Animal wastes will accumulate on the feedlot and in the open shelter. Most of these wastes will be handled as a solid with conventional equipment and applied to the utilization area, but runoff from the lot will transport some solid and liquid waste that must be intercepted.

② **Clean water diversions.** To minimize the amount of runoff that can transport waste, clean water should be diverted from entering areas where wastes are deposited or stored. Diversions may be needed above and adjacent to the feedlot, and buildings should be guttered. The feedlot size may be reduced to the minimum recommended area needed for good animal growth and management.

③ **Runoff collection.** The runoff from the feedlot must be collected and directed to a central storage area. This may be accomplished by the natural feedlot slope, or by diversions, gutters, curbing, or pipes.

④ **Settling basin.** A settling basin slows the velocity of runoff so that most of the solids will settle from the runoff water. The basin should be large enough to accumulate the solids that are carried in the runoff for a six-month period. Other solids should not be scraped into the basin. The basin should be shaped to permit cleanout with available equipment. When a tractor loader is used, the bottom of the basin may need to be paved for easy operation.

⑤ **Holding pond.** A holding pond receives the liquid from the settling basin. This pond must be large enough to store the runoff from average precipitation during the period from November through April. It must be emptied after major runoff periods and before winter to provide storage for subsequent runoff.

⑥ **Waste water transport.** A system must be included to transport the stored runoff to its utilization area.

⑦ **Utilization.** Liquids should be applied to the utilization area at times and at rates that will not cause runoff, excessive odors, or damage to crops.

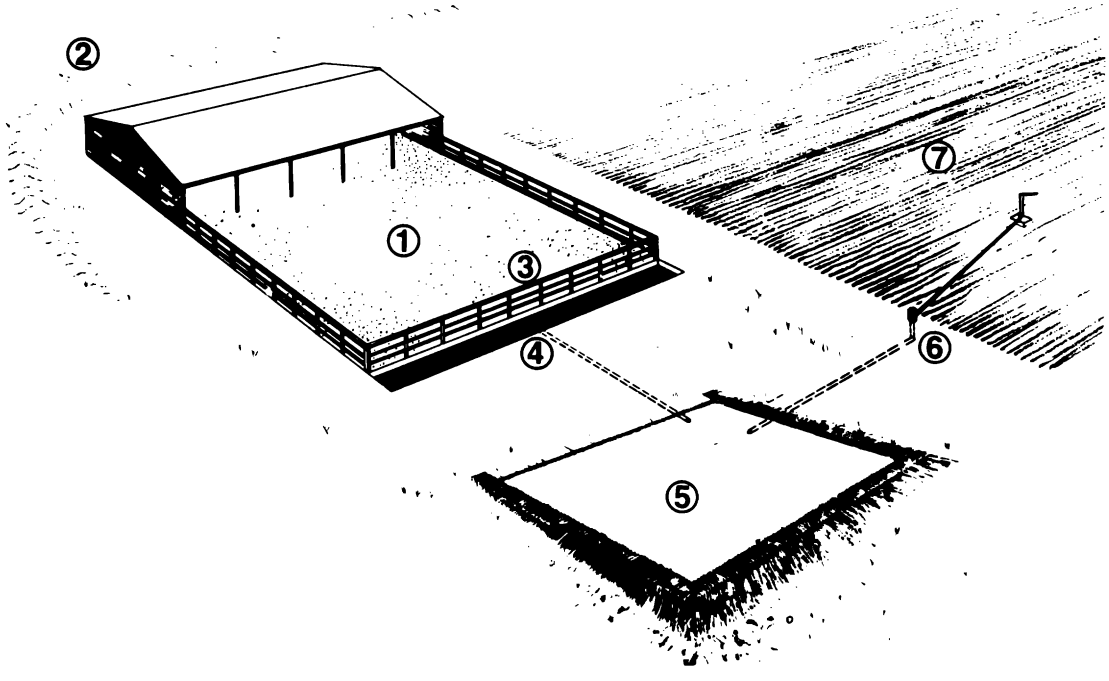

Figure 2

FEEDLOT RUNOFF CONTROL (RESTRICTED SPACE)

Many feedlots are boxed in by buildings, roads, lanes, or waterways so that runoff water may have to be pumped to another area. Or it may be necessary to relocate the livestock operation.

① **Feedlot.** Animal wastes will accumulate on the feedlot and in the open shelter. Most of these wastes will be handled as a solid with conventional equipment and applied to the utilization area, but runoff from the lot will transport some solid and liquid waste that must be intercepted.

② **Clean water diversions.** To minimize the amount of runoff that can transport waste, clean water should be diverted from entering areas where wastes are deposited or stored. Diversions may be needed above and adjacent to the feedlot, and buildings should be guttered. The feedlot size may be reduced to the minimum recommended area needed for good animal growth and management.

③ **Runoff collection.** The runoff from the feedlot must be collected and directed to a central storage area. This may be accomplished by the natural feedlot slope, or by diversions, gutters, curbing, or pipes.

④ **Settling basin.** A portion of the existing lot or a narrow concrete channel along the outside of the lot may serve as a settling basin to slow the velocity of runoff so that most of the solids will settle from the runoff water. The basin should be large enough to accumulate the solids that are carried in the runoff for a six-month period. Other solids should not be scraped into the basin. The basin should be shaped to permit cleanout with available equipment.

⑤ **Sump pit.** A sump pit at the end of the settling basin collects runoff water that is pumped to a place on the farm where space is available to build a holding pond. The sump and pump should be sized to collect and pump water away about as fast as it runs off in the most intense storm.

⑥ **Holding pond.** A holding pond receives the liquid from the settling basin. This pond must be large enough to store the runoff from average precipitation during the period from November through April. It must be emptied after major runoff periods and before winter to provide storage for subsequent runoff.

⑦ **Waste water transport.** A system must be included to transport the stored runoff to its utilization area.

⑧ **Utilization.** Liquids should be applied to the utilization area at times and at rates that will not cause runoff, excessive odors, or damage to crops.

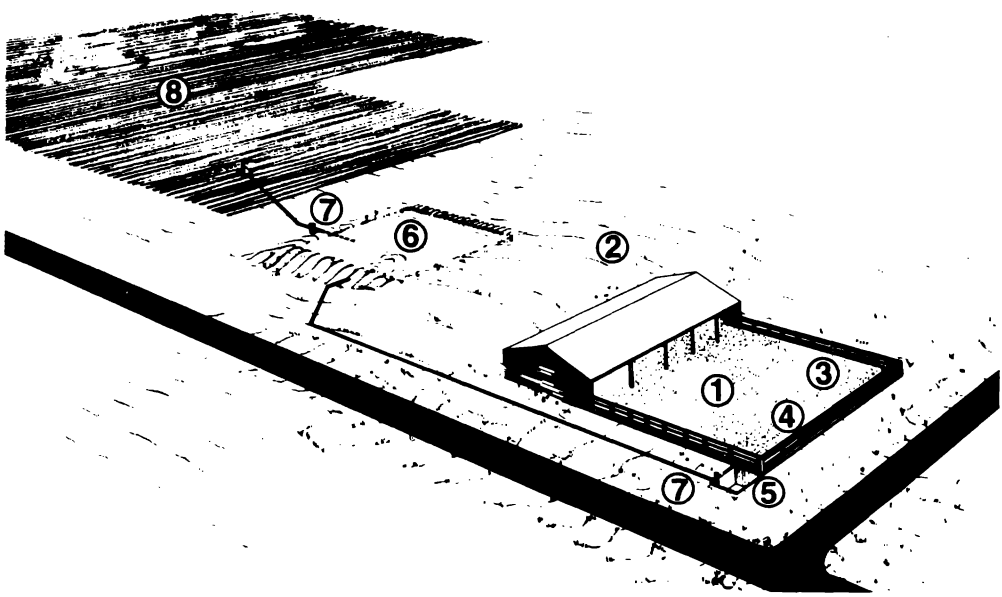

Figure 3

Producers who cannot apply Technology 1 for runoff control will be confronted with a much more serious situation than those who can. Nearness to roadside ditches, other buildings, or property lines of neighbors--major reasons why many producers cannot apply Technology 1--also increases the likelihood of surface water pollution from runoff. Also, investment and operating costs are higher for Technology 2 than for Technology 1, and daily management is likely to be more demanding. Pressure to quit hog production, move to a new location, or change to another system of production will be relatively great for these producers.

It is not known how many hog farms would be suitable for Technology 1 or 2, but the runoff problem in general was considered grave enough to warrant some analysis of the situation. Therefore, the experts in each State were asked to provide estimates based on their personal knowledge of production units.

Of the more than 86,000 open-lot producers deemed to have runoff problems, experts believe that over 79,000 could use Technology 1 (table 13). These farms produced 17.1 million hogs in 1969 (table 14). Only 7,400 farms, producing 2.3 million hogs, were believed to require Technology 2 (tables 15 and 16). Over two-thirds of these, however, used paved lot systems, where one of every four producers with a runoff problem was estimated to require Technology 2.

The 2.3 million hogs produced on farms needing Technology 2 represent less than 3 percent of total production in the 15 leading States. Production would (or might) be seriously interrupted by compliance (installing Technology 2), shifting the hog operation to another location on the farm, or changing the system (that is, from open-lot to total confinement). There will be an adverse supply effect if these people either quit or have to shut down for an extended period for any of the reasons mentioned. These adverse possibilities warrant careful consideration.

INVESTMENTS AND ANNUAL COSTS FOR CONTROL OF RUNOFF FROM OPEN-LOT HOG PRODUCTION SYSTEMS

If all hog producers are required to meet regulations for control of surface runoff, a number of options are available. Not all producers will choose the same route. Some will eliminate runoff simply by ceasing production. Others will relocate their production site. Still others will change to a total confinement system that will eliminate exposed areas, and may very likely expand their output at the same time. Some may revert to a pasture system. A majority, however, are likely to apply the best practical technology to existing facilities, at least for a few years. Technologies 1 and 2 are assumed to typify the best practical control measures.

Application of Technologies 1 and 2 were imposed on all of the hog producers in this analysis to approximate the general cost of remedial action. In reality, we would find less than 100 percent application of Technologies 1 and 2 and we have already noted some of the alternatives.

Costing Procedure

As discussed above, there are two options for controlling runoff from hog operations. One system is recommended by the leading technicians in each State, and one requires control of the 10-year, 24-hour storm event in each State. In addition to these specifications and the data on precipitation, it was necessary to identify the drainage areas for runoff control in order to determine the size of the components of the control systems. No doubt, there is substantial variation among farms, but for this analysis the drainage area was set at 40 square feet per unit of capacity (per hog space) in paved lot systems, and at 125 square feet in other open-lot systems.

Farmers might reduce cash outlay for construction of terraces, ponds, and the like by doing the work themselves. Nevertheless, average contract rates were applied to all construction projects for this study on a State-by-State basis. Investments for equipment reflect early 1973 retail prices.

Annual costs reflect outlays necessitated by runoff control; they represent additions to the costs of operating existing waste management systems in the absence of such control. Overhead charges for the use of added investments, including interest, depreciation, maintenance, taxes, and insurance, were made at the current average rates. Amortization rates reflecting a 7.5 percent interestrate and a 20-year life on all components except the pump irrigation equipment were applied to investments. Additional operating costs for fuel, electricity, repairs, and labor were based on recent averages for each State.

Aggregate Additional Investments

Systems with the ponds designed to hold runoff from the expected 10-year, 24-hour storm event would cost producers nearly $254 million, or slightly below the cost if the recommendations of leading technicians are followed (tables 17 and 18). However, if holding ponds are designed to handle normal runoff over 4 to 6 months, in addition to runoff from the expected major storm, investment would increase 10 to 15 percent--to some $280 to $290 million. Changes in storage capacity of holding ponds has a limited effect on total investment because many of the components of the runoff control systems are not related to the pond capacity. The Corn Belt-Lake States would require nearly four-fifths of the total investment. The Plains States would need somewhat less than the Southeast States, largely because of drier climate and fewer farms with runoff problems.

The new investment burden would fall heavily on the small producers. Regardless of the option chosen for runoff control, producers selling fewer than 100 head per year would have to make about a third of the total outlay, even though they account for only an eighth of national hog production and are estimated to have the smallest share of farms with uncontrolled runoff of any size group. Over four-fifths of total new investment would fall on farmers selling fewer than 500 hogs a year. The large number of small producers and the indivisibility of several of the components of the runoff control systems are mainly responsible for the relatively high investments for small producers.

Aggregate Additional Annual Costs

For the 15 major producing States, new investments to control runoff, plus the operating costs to sustain them, would increase annual production costs by $36 million with storage based on the major storm event (table 19), $38 million with systems designed according to recommendations of leading technicians (table 20), and some $42 to $44 million with storage for normal runoff for 4 to 6 months plus runoff from the major storm event. Most of these costs represent fixed charges for depreciation, interest on investment, and the like. Added operating costs would be nominal--mainly for moving water from the retention pond or moving it from a sump to the retention pond, and thence to the field for irrigation.

As with investments, most of the added annual costs would fall on the smaller producers. Over half would fall on producers selling fewer than 200 head a year and over a third on those selling fewer than 100 head.

Application of Technologies 1 and 2

The cost of preventing runoff from open hog lots, given a level of precipitation and system specifications, is basically determined by the drainage area and the system used to control runoff. The kind of animals and their density within that drainage area have no effect on total investment or annual costs because the regulations would not permit runoff containing any animal waste.

Appendix table 4 shows costs of applying Technology 1 to control runoff from a 1-acre drainage area, following recommendations of leading technicians in Illinois. Installation of a three-unit control system would cost nearly $3,300; equipment for disposal of the contents of the retention pond on cropland would cost over $2,100. Total system outlay would be just over $5,400, and total annual costs (mostly fixed) would be about $700.

A partly paved system with the typical space allowance of 125 square feet per head of capacity would hold 350 hogs at one time. It would have an annual output of 600 head, based on the usual turnover ratio for operations of this size. Investment for runoff control would be $9.05 per hog sold. Added annual costs would be $1.16 per head, a little over $0.50 per 100 pounds of hogs sold at an average market weight of 230 pounds per head.

A completely paved 1-acre drainage area would accommodate over three times as many hogs, assuming the usual 40 square feet of space per hog. Total investment and annual costs would remain about the same, but costs per unit of output would drop by two-thirds.

The partly paved operation would require an additional investment of nearly 50 percent (or $2,172) if runoff could not move from the site into the holding pond by gravity, so that the farmer would have to use Technology 2 (app. table 5). Annual costs would increase $331, to a total of $1,029, or nearly $0.75 per 100 pounds of hogs sold. Increased capacity (or reduction of drainage area per head), made possible by complete paving, would have the same effect on unit costs.

These examples of Technologies 1 and 2 reveal the components of the systems and their relative costs. They also show the overriding importance of the size of the drainage area and its production capacity in terms of unit production costs. Finally, they illustrate the additional financial burden that falls on farmers who cannot employ Technology 1.

Readers are cautioned to note that these two examples of controlling runoff from 1-acre drainage areas reflect operations with annual sales of 600 hogs, using a partly paved system. Three times that number of hogs could be produced using a fully paved system. These examples fall into the two largest size categories, which together market slightly less than a third of total hog output. Some component costs are heavily weighted by the need for at least one of each item, e.g.--one pump, pipe, and sprinkler of the smallest functional size available. Economies of size are gained even in the construction of terraces and ponds. Most hog operations are smaller than the ones in these examples. Unit costs will be higher for these smaller operations, which account for most of the output.

Investments and Annual Costs Based on Precipitation, Runoff, and Storage Requirements

The above examples of controlling runoff from 1-acre drainage areas were based on annual precipitation of 36 inches, runoff equal to half of precipitation, and storage capacity for 38 percent of the precipitation. This is fairly typical of the situation and recommendations for the Corn Belt States. If any of these factors vary, however, the associated investments and costs vary. In the 15 major hog-producing States, annual precipitation ranges from about 20 to 50 inches. Estimated runoff ranges from as low as a fourth of annual precipitation to all of it. Recommended storage capacity ranges from around 10 percent of annual precipitation (about equal to the 10-year, 24-hour rainfall) to nearly half of it.

The effect of these variables on investments and annual costs is illustrated using Technology 1, a 1-acre partly paved drainage area, and Illinois unit cost data. A producer would incur new investment costs ranging from $4,389 to $6,497 (app. table 6), and annual costs from $571 to $900. On a per hog sold basis, investments would range from $7.64 to $11.32 and annual costs from $0.99 to $1.57 (app. table 7). For each 100 pounds of hogs produced, investment would range from $3.32 to $4.92, and annual costs from $0.43 to $0.68 (app. table 8).

Possible variations in precipitation, runoff, and recommendations for storing runoff obviously affect unit investments and annual costs. Differences will be magnified as the same variables are applied to systems smaller than 1 acre. Such cost differences, however, are not likely to give one State or region an insurmountable advantage over another in hog production. Furthermore, even the extremes in unit costs are small, compared with the effect of the control system used (Technology 1 versus Technology 2), drainage area per hog, and size of enterprise, which is examined in the next section.

Investments and Annual Costs Based on Size of Enterprise

Among the variables examined, size of enterprise has the greatest effect on the additional investment and annual costs of controlling surface runoff per unit of pork produced. If producers follow the uniform State recommendations for controlling a maximum 10-year, 24-hour storm event, average investment per hog sold would be $13.16 for all size groups in the 15 major States (table 21). The average varies from over $21 per hog sold in the humid Southeast, to less than $13 for the Corn Belt-Lake States and Plains States. But by size of enterprise, new investments per hog sold range from $2.35 in operations in the Plains States selling 1,000 hogs per year to $75.57 for those in the Southeast selling fewer than 100 hogs.

Cost of hog production is similarly affected by size of enterprise. Added annual cost per 100 pounds of hogs produced varies from only $0.16 in the largest size group in the Plains States to a burdensome $4.73 per 100 pounds for those in the same region selling fewer than 100 head (table 21). Costs in other regions follow similar patterns in relation to size of enterprise. Average added cost for the 15 major States is $0.89 per 100 pounds, ranging from $0.26 to $4.24.

Unit investments and annual costs respond similarly to size of enterprise using the runoff control system recommended by leading technicians (table 22), rather than the system designed to handle the 10-year, 24-hour storm event.

These investments and annual cost estimates reflect a composite of lot surfacing (hence variations in drainage area per hog space) and methods of runoff control (Technologies 1 and 2). Thus for any size group, the values indicated are too high for a fully paved system that can utilize Technology 1, and too low for a dirt lot system, especially if Technology 2 must be employed. The effect of these variables on costs were discussed earlier (app. tables 4 and 5). The composite averages, however, are heavily weighted by Technology 1 as most producers can use it, and by partly paved open-lot systems. Regardless of these relationships, it is obvious that the smaller producers are confronted with much higher unit costs than are the larger ones.

Costs per unit of output increase sharply for the smaller enterprises, largely because of the fixed nature of most of the components of the runoff control systems. The length of diversion terraces is not a direct function of size of the drainage area to be protected. Large settling basins and retention ponds cost much less per unit of capacity than small ones. Requirements for pipes, pumps, sprinklers, and other equipment are essentially the same for all sizes of enterprises included in this analysis, as the smallest equipment is sufficient for the average of the largest size group, i.e., the 1,000 and over.

Further, the small operators are severely disadvantaged because of their low hog turnover rates. Farms in the largest size group produce nearly twice as many hogs per unit of space as those in the smallest size group. Since runoff must be controlled for a given drainage area, regardless of intensity of use, this factor alone nearly doubles the cost per 100 pounds of hogs produced in the smallest compared with the largest enterprises.

Small producers could achieve some reduction in costs. Runoff control facilities might in some cases be constructed with available farm labor and equipment, thus avoiding major cash outlays. Two or more farmers could share some equipment. For example, several small producers might effectively use an irrigation pump. To what extent such arrangements might be feasible in actual operation is unknown. Unit costs, however, would remain relatively high for the small producer under the most favorable of circumstances.

Cost Biases

The procedures used in this analysis permit opposing biases, in costs per farm and per unit of hogs produced, to enter the final estimates of added investments and annual costs. These probable biases are recognized, but they are not quantified at this time because better data are not available.

As indicated above, actual investments and costs per farm could be reduced to the extent that lower priced labor and equipment (farm owned) might be used to construct control facilities. Also, farmers could share equipment. Finally, some hog producers will have other livestock enterprises, especially cattle feeding. To the extent that runoff control facilities can be used for two or more livestock enterprises, the additional unit costs of production would be less than those estimated for hog enterprises alone. Experience suggests, however, that none of these factors will significantly reduce either total or unit costs of production.

There is greater likelihood that added investments and costs per farm and per unit of pork produced are understated in this analysis. First, the production units to which runoff control facilities were added in the study are typical in terms of configuration and space allowances. Many hog enterprises would deviate greatly from the typical, with distribution skewed toward the less desirable situations. Second, the average enterprise in each size class was assumed to consist of one production unit. In reality, a farmer selling a given number of hogs per year, say 500 head, may produce them in several different buildings and lots scattered over his farmstead, or from more than one farmstead under control of the same operator. A separate runoff control system would be needed for each farmstead involved. Multiple control facilities might be needed even on a single farmstead, depending on the location and arrangement of buildings and lots, and slope of the land. To the extent these situations occur, the estimated investments and costs in this study are understated.

ECONOMIC IMPACT OF RUNOFF CONTROL

Elimination of runoff for open-lot hog producers in the 15 leading States would require investments of $254 to $290 million and increased annual production costs of $36 to $44 million. These expenditures would add an average of $0.90 to $1.00 per 100 pounds to production costs on the farms involved, or about $0.25 per 100 pounds to total hog output, since only about a fourth of total production is estimated to come from farms needing surface runoff control.

This analysis determined the general economic magnitude of the pollution control, but not the economic impact on the different sectors of the economy, either through time or after all adjustments have been made. These relationships, although they cannot now be quantified accurately, may be more important for persons formulating environmental control policies than any measures of aggregate investments and annual costs.

Long-Run Economic Impact of Pollution Control

Investments and annual costs of remedial action to control runoff from hog production systems are maximized if we assume, as in the preceding analysis, that all producers with pollution problems will make the necessary adjustments without changing their size of operation or system of production. In reality, producer response will vary greatly, and the total increase in production costs will probably be less than the amount indicated here for total compliance. Available alternatives for runoff control differ among the several sizes of enterprises and systems of production. The potential for damaging runoff also differs among systems. Unit costs of control commonly favor the larger operations. Therefore, a regulation applied uniformly to all producers would bring much more economic pressure on some than on others.

Compliance with a pollution control regulation using the uniform State recommendation is only one of several alternatives for producers. Some will comply, but many, especially the smaller ones, may simply cease production. A few may shift to extensive pasture production to eliminate point source runoff. Others may choose the total confinement system, and perhaps expansion of operation.

Regulations for runoff control will almost certainly alter the structure of the hog industry. They will probably accelerate the present trend toward fewer but larger enterprises, and more rapid adoption of the total confinement system of production. This system not only minimizes runoff potential; it also embodies several economic advantages over other systems.

Such adjustments require new investments and incur added costs, but most of these are only indirectly chargeable to runoff control. They will also improve efficiency and benefit hog production in many ways. Once adjustments are completed, cost of pork production and ultimate prices to consumers may be little changed. Even with full compliance, and no change in the number of producers, size, or system of production, cash increases should be relatively small.

The Illinois hog industry tested the hypothesis that both cleaner water and low-cost pork are possible. That study assumed three successively more rigorous hypothetical regulations, estimated producer adjustments, and computed new investments and annual costs. 7/ It covered replacement of facilities and annual costs of total waste management, including pollution control, used in

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7/ John C. Gamble, "Economic Evaluation of the Impact of Alternative Environmental Regulations and Waste Management Systems on Illinois Hog Producers." Unpublished Ph. D. thesis, Univ. of Ill., July 1972.

1971 by the 50,000 hog producers in Illinois. The total cost for replacing equipment was estimated at $79.8 million; annual costs after allowing for the fertility value of manure were $16.3 million.

The impact of imposing hypothetical Regulation A, B, or C were evaluated. Regulation C, the most strict, required that all runoff be retained on the farm, prohibited spreading manure on frozen ground, and required soil injection of all liquid wastes.

Adjustment to Regulation A caused only a small decrease in the number of hog producers (50,000) in 1971 (table 23). The number dropped to 39,000 under Regulation B and to 32,000 under Regulation 3. The number of hogs produced remained at the 1971 figure of 11.8 million under Regulations A and B, but dropped to 11 million under Regulation C. Investment for waste-management systems increased $36 million from the $80 million spent in 1971 to over $116 million under Regulation C. Annual gross costs increased under all regulations, but were highest under A. However, the range was slight among all four situations. Annual net costs were over $16 million in 1971, and were about $2 million higher under Regulation A, $2.5 million under B, and $1.8 million under Regulation C.

The added cost under Regulation C was only $0.16 per hog, or $0.06 to $0.07 per 100 pounds of hogs produced. Further economies resulting from larger and more specialized hog enterprises might offset this small increase. Other things being equal, surface runoff control could apparently be achieved with little or no increase in pork prices. This conclusion assumes the remaining producers will supply enough hogs to compensate for loss of output from those who cease production. Factors such as land tenure, age of operators, availability of capital, risk, lack of farmers with the management ability, and incentive to continue production could postpone for 10 to 15 years the final outcome of runoff control.

Economic Impact during Adjustment Period

The previous hypothesis suggesting little or no impact of pollution control on hog production or price of pork, while simultaneously creating a better quality of water in the long run, seems reasonable. Of course, large-scale producers using confinement systems could actually reduce the cost of production from present levels if they were to use the environment as a dumping ground, without respect to water quality. But very few followed this path, even in the absence of regulations. Regardless of final cost outcome, the aggregate long-run picture does not reveal the economic impact of adjustments accelerated by regulations to control pollution as they strike farmers and other sectors of the economy during the adjustment period. Increased costs could be substantial for many years.

Impact on Farmers

The Illinois study looks at the adjustment period cost to farmers in the following way:

Costs associated with the alternative waste management systems were based on the new cost of buildings and equipment. In the real world, the actual investment for buildings and equipment for waste handling would be represented by some percentage of this new cost figure. Only a few waste management systems would be valued at new cost with the value of the remainder ranging from zero to new cost.

In the adjustment process after the imposition of the environmental regulations, variable costs for waste management systems no longer used would be eliminated, but the annual fixed cost would continue until the fixed resource had depreciated out or was sold. If the hog producer switched from one hog production method to another, certain variable costs might continue at the same level, be less than, or be increased over those previously incurred. By the same token, investment in existing fixed resources would continue to have an annual cost whether the resource was used or not, until such time that the resource was depreciated out or sold. This cost would be in addition to the annual cost associated with investment for new buildings and equipment.

In this analysis, a long-run time period was assumed in which unused resources were automatically valued at zero. In the short run, the value of these resources should be accounted for and added to the annual waste management system cost.

An implication of the complexity of a true system of cost accounting can be illustrated in the following manner. Producer response to Regulation "C" resulted in an estimated number of 17,830 hog producers deciding to no longer produce hogs. For this group of producers, investment in existing hog production and waste management systems was lost. Now, assume that each one of these producers marketed annually 200 hogs. Based on this assumption, approximately 3.6 million hogs would no longer be produced by this group of producers. If the total cost of hog production had averaged 20 cents per pound and the average price received was 20 cents per pound and feed costs were 14 cents and non-feed costs 6 cents per pound, and the cash portion of non-feed costs was 1 cent per pound, then a 5 cent return per pound for unpaid labor and overhead cost would be lost. This would mean that this group of farmers would lose or have to recover $39.6 million ($.05 x 3.6 million x 220 pounds) from other enterprises or employment options such as expanded grain production or off-farm work. (See footnote 7/; pp. 228-229).

The absolute values presented in the Gamble analysis cannot be supported on a factual basis. They are illustrative of a real world situation. But were the Illinois analysis to hold for the 15 major hog-producing States, the farmers who were compelled to cease production before they would have without regulations could lose (or forego) up to $400 million annually in income to sunken resources (Illinois has about 10 percent of the hog producers in the 15 States). This compares with the $254 to $290 million investment and $36 to $44 million in added annual costs estimated as needed to apply best practical technology for

runoff control. Nonfeed costs have risen rapidly since 1971, so the potential income loss is now even greater.

A major concern is how these farmers who cease production will replace lost income. Their decisions will have a substantial impact on them and society in general. Some will simply subsist on lower incomes. Others may intensify crop production, perhaps to the detriment of proper soil conservation. Some marginal farmers may be forced out of agriculture, thus adding to the employment pressure in other industries, even possibly to welfare rolls.

Hog producers are not immune to economic impacts in addition to the direct costs of runoff control. Those with marginal financial strength, even if they are efficient producers, may not be able to survive the payoff period for required investments. Potentially more damaging, both to individuals and the hog industry, however, is the likelihood that many producers will shift to the total confinement system and enlarge the size of operation before they can develop necessary management capabilities. Hog production is not an enterprise that the unskilled can handle effectively. New methods are mastered through experience and not simply from a book. Gradual growth of management capabilities, increased size of operation, and improved systems of production seem essential; otherwise, large commercial enterprises would have long since dominated the industry. Only time will tell what added costs such as these might result from rapid application of pollution control regulations to all producers.

Impact on Agribusiness Firms--Economic pressures have already caused a rapid dropout of the smaller, less efficient farms. Nationally, total farm numbers declined more than 100,000 per year from 1945 through 1969. The same trend exists in hog production. This change toward fewer but larger farms and hog enterprises has definitely secondary effects on all agribusiness firms providing inputs, in the marketing of products, and on rural communities generally.

Hog production remains largely in the hands of small producers. Feed dealers, equipment suppliers, veterinarians, auction markets, and all of the other firms associated with hog production are oriented basically to the smaller producer.

A requirement for pollution control that accelerates the demise of the small producer and hastens structural shifts in hog production exerts the same forces on the industries related to hog production. As these must quit or change more rapidly than they would have in the normal course of events, there is an economic impact on them similar to that illustrated for hog producers forced to adjust more rapidly than otherwise, either expanding further into the business or dropping out of it. No attempt is made at this time to quantify these economic impacts, but they could be significant when both agribusiness firms and rural community services are considered.

Impact on Consumer Prices--In the long run, consumers may pay little or no more for pork after adjustment to pollution control regulations have been completed. The price of pork will probably increase during the adjustment period, particularly if complete adjustment is required in a short period, say 4 years. Reasons seem clear. First, producers who cease production can do so immediately, simply by marketing all of their hogs. The extra females thus

going to slaughter would increase the supply of pork somewhat, but this increase would be more than offset by the loss of the 14 pigs each such female would likely have produced during the coming year. Second, expanding operations cannot take up the slack in supply until operators have time to evaluate their decisions, acquire more capital, build new facilities, and perhaps even train new personnel. The larger hog operations, which will account for most of the future growth (or fill intermediate supply gaps), probably do not have excess capacity, such as that commonly available to cattle feedlots. Thus, the supply of pork is likely to drop during the adjustment period--certainly it will not increase as fast as it normally would. Third, the demand for pork is inelastic; a drop in supply will result in more than a proportionate increase in price.

In recent years, price flexibility for hogs has been estimated at about 2.5; that is, a 1-percent change in supply means a 2.5 percent change in price. Now it appears the ratio may be considerably higher. Per capita demand for pork seems fairly stable, despite larger swings in price than ever before.

To illustrate, assume a 2.5 price flexibility, a normal national output of 20 billion pounds of hogs (live weight), and an average price of $30 per 100 pounds. If enough farmers cease production so that supply declines by 10 percent, the price would increase 25 percent, or to $37.50 in this instance. Thus consumers would pay $6,750 million for 18 billion pounds of hogs, instead of $6,000 million for 20 billion pounds--an extra expense to consumers of $750 million in one year for 2 billion pounds less pork. Producers of the 18 billion pounds of hogs would receive the extra $750 million. This would be of little consolation to those who had ceased production, and it would not solve the problems caused by their departure. However, the remaining producers would be encouraged to expand output in the long run.

The above is only an illustration, but recent actions of hog producers in the face of many uncertainties including the outcome for pollution control regulations under consideration--quitting production, holding steady, delaying planned construction--strongly suggest that pork supply will be affected by such factors in the future. Obviously, a 10-percent drop in the supply of pork may cost consumers more in higher prices in 1 year than the total investment necessary to comply with the regulations for runoff control, as computed in this analysis.

Table 1 -- Production of hogs, major regions and groups of States, selected years, 1950-71

Region	1950	1955	1960	1965	1967	1969	1971
	1,000 pounds (live weight)						
Corn Belt-Lake States	13,657.0	13,488.8	12,932.0	12,437.8	13,970.4	13,303.6	14,544.3
Plains States	2,410.9	2,376.2	2,091.0	2,317.2	2,759.9	2,925.7	3,559.6
Southeast	1,563.4	1,476.8	1,640.6	1,525.6	1,730.1	1,864.5	2,125.8
15 major States	17,631.3	17,341.8	16,663.6	16,280.6	18,460.4	18,093.8	20,229.7
33 other States	3,295.8	2,630.8	2,325.3	1,927.6	2,127.3	2,254.9	2,684.9
48 States	20,927.1	19,972.6	18,988.9	18,208.2	20,587.7	20,347.8	22,914.6
	Percent						
Corn Belt-Lake States	65.3	67.5	68.1	68.3	67.9	65.3	63.5
Plains States	11.5	11.9	11.0	12.7	13.4	14.4	15.5
Southeast	7.5	7.4	8.6	8.4	8.4	9.2	9.3
15 major States	84.3	86.8	87.7	89.4	89.7	88.9	88.3
33 other States	15.7	13.2	12.3	10.6	10.3	11.1	11.7
48 States	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Agricultural Statistics, U.S. Dept. of Agr.

Table 2 -- Production of hogs, 15 major States and U.S. total, 1969 1/

State	Quantity	State share
	Million pounds	Percent
Iowa	4,957	24.2
Illinois	2,510	12.3
Indiana	1,635	8.0
Missouri	1,552	7.6
Nebraska	1,242	6.1
Minnesota	1,214	5.9
Ohio	845	4.1
South Dakota	737	3.6
Wisconsin	675	3.3
Kansas	660	3.2
North Carolina	601	2.9
Georgia	501	2.4
Kentucky	451	2.2
Tennessee	328	1.6
Texas	326	1.6
15 major States	18,234	89.0
U.S. Total	20,489	100.0

1/ Live weight.

Source: Economic Research Service, Statistical Reporting Service, and Consumer Marketing Service. Livestock and Meat Statistics: Supp. for 1970 to U.S. Dept. Agr. Stat. Bull. No. 333. 1971.

Table 3 -- Number and percent of farms selling hogs and pigs, 15 major States, 1969 1/

State	Number	State share
	Thousands	Percent
Iowa	88	17.3
Illinois	51	10.0
Indiana	37	7.2
Missouri	50	9.7
Nebraska	31	6.1
Minnesota	39	7.6
Ohio	29	5.7
South Dakota	19	3.8
Wisconsin	26	5.0
Kansas	21	4.1
North Carolina	26	5.1
Georgia	22	4.2
Kentucky	25	5.0
Tennessee	28	5.5
Texas	19	3.7
15 major States	511	100.0

1/ Includes all farms selling hogs and pigs, regardless of size class.

Source: U.S. Bureau of the Census. Census of Agriculture, 1969.

Table 4--Number of farms selling hogs and pigs, and percent sold by farm size class, 15 major States, 1969.

State and region	Farms selling hogs	Farm size class (head sold)					
		1-99	100-199	200-499	500-999	1,000 or more	Total
	Thousands	Percent					
Iowa	88	30.3	25.1	33.9	9.0	1.7	100
Illinois	51	44.4	21.2	23.7	8.2	2.5	100
Indiana	37	48.8	20.5	21.5	7.0	2.2	100
Missouri	50	57.2	20.5	17.5	3.9	1.0	100
Minnesota	39	55.2	22.9	17.7	3.5	0.7	100
Ohio	29	60.9	18.4	15.6	4.0	1.1	100
Wisconsin	26	63.0	19.6	14.3	2.6	0.5	100
Corn Belt-Lake States	320	47.3	21.9	23.1	6.2	1.5	100
Nebraska	31	49.9	25.1	20.6	3.6	0.8	100
South Dakota	19	51.6	27.0	18.2	2.6	0.6	100
Kansas	21	60.3	19.5	15.7	3.4	1.1	100
Texas	19	80.9	9.5	6.8	1.8	1.0	100
Plains States	90	59.2	20.9	16.1	3.0	0.8	100
North Carolina	26	82.0	9.4	6.0	1.6	1.0	100
Georgia	22	71.5	15.2	10.1	2.2	1.0	100
Kentucky	25	78.6	12.1	7.2	1.5	0.6	100
Tennessee	28	82.6	10.8	5.4	0.9	0.3	100
Southeast	101	79.1	11.7	7.0	1.5	0.7	100
15 major States	511	55.7	19.7	18.7	4.7	1.2	100

Source: Census of Agriculture, 1969.

Table 5 -- Total number of hogs and pigs sold, and percent by farm size class, 15 major States, 1969

State and region	Hogs and pigs sold	Farm size class (head sold)					
		1-99	100-199	200-499	500-999	1,000 and over	Total
	Thousands	Percent					
Iowa	20,826	6.5	15.1	43.7	24.8	9.9	100
Illinois	10,972	9.3	13.9	34.0	25.2	17.6	100
Indiana	7,208	10.8	14.6	33.0	23.6	18.0	100
Missouri	7,219	16.3	19.6	35.4	17.6	11.1	100
Minnesota	5,488	17.2	22.7	36.5	16.4	7.2	100
Ohio	4,104	17.1	18.3	33.5	19.1	12.0	100
Wisconsin	3,018	20.8	23.1	35.3	14.6	6.2	100
Corn Belt-Lake States	58,835	11.2	16.7	37.8	22.1	12.2	100
Nebraska	4,788	15.0	22.8	39.0	15.2	8.0	100
South Dakota	2,705	17.6	26.8	37.2	11.7	6.7	100
Kansas	2,935	17.5	19.3	33.1	16.1	14.0	100
Texas	1,650	25.4	15.0	23.1	14.2	22.3	100
Plains States	12,078	17.6	21.8	35.0	14.5	11.1	100
North Carolina	2,301	27.0	14.2	19.6	12.0	27.2	100
Georgia	2,288	24.1	19.2	27.3	13.5	15.9	100
Kentucky	2,074	30.4	20.1	25.7	12.5	11.3	100
Tennessee	1,871	39.5	21.8	23.0	8.8	6.9	100
Southeast	8,534	29.8	18.7	23.9	11.8	15.8	100
15 major States	79,447	14.2	17.7	35.8	19.9	12.4	100

Source: Census of Agriculture, 1969.

Table 6 -- Average number of hogs and pigs sold per farm by farm size class, 15 major States, 1969

State and region	Farm size class (head sold)					
	1-99 1/	100-199	200-499	500-999	1,000 and over	All sizes
	Number per farm					
Iowa	51	143	304	648	1,419	236
Illinois	45	141	307	663	1,486	215
Indiana	44	140	302	661	1,614	196
Missouri	41	139	296	685	1,626	145
Minnesota	44	139	289	656	1,479	141
Ohio	39	139	300	666	1,490	140
Wisconsin	39	139	293	654	1,607	118
Corn Belt-Lake States	44	141	301	656	1,504	184
Nebraska	46	140	291	649	1,563	154
South Dakota	48	139	285	634	1,558	140
Kansas	40	138	294	657	1,828	139
Texas	27	137	293	672	1,916	86
Plains States	40	139	290	651	1,726	133
North Carolina	29	132	288	669	2,318	88
Georgia	36	135	288	651	1,696	107
Kentucky	32	136	292	664	1,509	83
Tennessee	32	136	284	654	1,698	67
Southeast	32	135	288	660	1,890	85
15 major States	40	140	299	656	1,576	155

1/ Farm size class 1-99 and totals adjusted to include hogs and pigs sold from farms with less than $2,500 annual sales of farm products.

Source: Census of Agriculture, 1969.

Table 7 -- Number and percent of farms having specified systems of hog production, by regions, 15 major States, 1969.

Region	System	Farms selling hogs	Farm size class (head sold) 1-99	100-199	200-499	500-999	1,000-1,499	1,500 and over	Total
		Thousands	Percent						
Corn Belt-Lake States:	Pasture	114	44.7	33.9	25.0	16.0	14.2	12.9	35.5
	Paved	48	10.5	16.6	21.1	21.5	18.4	11.6	15.0
	Other	130	40.9	40.7	40.6	38.9	32.3	28.2	40.5
	Confinement	28	3.9	8.8	13.4	23.6	35.0	47.3	8.9
	Total	320	100	100	100	100	100	100	100
Plains States:	Pasture	27	34.1	28.0	20.9	17.9	12.5	0.3	30.0
	Paved	10	7.9	13.5	17.9	23.2	21.3	16.6	11.2
	Other	47	54.3	50.4	46.8	34.2	25.0	20.5	51.4
	Confinement	7	3.7	8.1	14.4	24.7	41.2	52.6	7.3
	Total	91	100	100	100	100	100	100	100
Southeast:	Pasture	28	29.3	26.3	21.5	11.8	11.1	9.2	28.0
	Paved	7	5.6	10.5	14.6	15.2	15.9	14.1	7.0
	Other	57	58.3	53.6	50.4	48.1	33.2	34.4	56.9
	Confinement	8	6.8	9.6	13.4	24.9	39.8	42.3	8.1
	Total	100	100	100	100	100	100	100	100
15 Major States:	Pasture	169	38.4	31.9	24.1	15.9	13.7	12.1	33.1
	Paved	65	8.6	15.3	20.1	21.3	18.5	12.6	12.8
	Other	234	48.3	44.0	42.3	39.0	31.5	28.0	45.7
	Confinement	43	4.6	8.7	13.5	23.8	36.3	47.4	8.5
	Total	511	100	100	100	100	100	100	100

Source: Number of farms by size from Census of Agriculture, 1969. Distribution according to system of production reflects the median estimate of the expert panel.

Table 8 -- Number of hogs and pigs sold, and percent sold from farms by specified systems of production, by regions, 15 major States, 1969.

Region	System	Hogs sold	Farm size class (head sold)					
			1-99	100-199	200-499	500-999	1,000 and over	All classes
		Thousands	Percent					
Corn Belt-Lake States:	Pasture	14,849	43.6	33.9	24.9	16.2	13.7	25.2
	Paved	10,806	10.8	16.6	21.1	20.3	15.8	18.4
	Other	23,149	41.6	40.8	40.7	39.5	30.6	39.3
	Confinement	10,069	4.0	8.8	13.3	24.0	39.8	17.1
	Total	58,873	100	100	100	100	100	100
Plains States:	Pasture	2,735	29.7	8.1	21.0	18.1	11.9	22.6
	Paved	1,935	8.6	13.0	17.8	23.1	18.6	16.0
	Other	5,462	58.0	50.8	46.8	34.2	22.9	45.1
	Confinement	1,967	3.7	8.2	14.4	24.6	46.6	16.3
	Total	12,099	100	100	100	100	100	100
Southeast:	Pasture	1,874	29.8	26.3	21.5	11.8	10.3	22.0
	Paved	962	5.7	10.5	14.6	15.1	14.9	11.3
	Other	4,318	57.8	53.6	50.4	48.1	35.6	50.6
	Confinement	1,379	6.7	9.6	13.5	24.9	39.3	16.2
	Total	8,533	100	100	100	100	100	100
15 major States:	Pasture	19,458	37.9	31.9	24.1	16.2	13.0	24.5
	Paved	13,703	9.2	15.3	20.1	20.3	16.1	17.2
	Other	32,929	48.4	44.1	42.3	39.5	30.2	41.4
	Confinement	13,415	4.5	8.7	13.5	24.1	40.7	16.9
	Total	79,505	100	100	100	100	100	100

Source: Number of hogs by size class from Census of Agriculture, 1969. Distribution of hogs by system of production reflects the median estimate of the expert panel as to number of farms in each size-system and assumes that average number sold per farm is the same for all systems of production within a given size class.

Table 9 -- Number and percent of farms with a surface runoff problem from hog production, by regions, 15 major States, 1969

Region	System	Farms with problem	Farm size class (head sold)					
			1-99	100-199	200-499	500-999	1,000 and over	All classes
		Number	Percent					
Corn Belt-Lake States:	Pasture	15,671	9.6	14.5	21.2	43.7	65.4	13.8
	Paved	16,619	25.9	27.0	43.4	48.8	73.2	34.6
	Other	48,762	29.5	37.1	48.6	56.6	64.4	37.6
	Confinement	3,328	5.5	7.7	15.3	15.9	16.2	11.6
	Total	84,380	19.3	25.1	36.2	43.2	46.1	26.4
Plains States:	Pasture	603	1.0	3.1	4.9	15.5	29.7	2.2
	Paved	2,980	26.8	24.8	34.9	37.3	44.1	29.3
	Other	6,184	6.3	18.3	31.3	40.5	46.7	13.3
	Confinement	880	3.2	15.1	18.2	19.3	20.2	13.2
	Total	10,647	6.0	14.7	24.5	30.1	32.0	11.7
Southeast:	Pasture	3,641	11.0	17.4	28.4	34.3	47.9	12.9
	Paved	1,955	25.7	22.6	34.3	46.1	57.4	27.6
	Other	9,846	15.4	17.7	31.1	42.9	41.1	17.1
	Confinement	1,377	12.5	16.3	29.0	39.9	30.4	16.8
	Total	16,819	14.5	18.0	30.7	41.6	39.9	16.6
15 major States:	Pasture	19,915	8.4	12.9	19.6	39.8	59.9	11.7
	Paved	21,554	26.0	26.3	41.7	47.3	64.3	33.0
	Other	64,792	19.8	30.3	44.1	53.9	59.7	27.7
	Confinement	5,585	8.0	9.6	16.8	17.9	18.4	12.9
	Total	111,846	15.4	22.3	34.0	41.7	43.6	21.9

Source: Median estimates of expert panel.

Table 10 -- Number and percent of hogs sold from farms with a surface runoff problem, by regions, 15 major States, 1969

Region	System	Hogs sold	Farm size class (head sold)					
			1-99	100-199	200-499	500-999	1,000 and over	All classes
		Thousands	Percent					
Corn Belt-Lake States:	Pasture	3,514	9.8	14.5	21.2	39.7	74.4	23.7
	Paved	4,858	24.7	26.9	44.2	52.5	69.1	45.0
	Other	11,038	28.6	37.1	48.7	57.3	64.4	47.7
	Confinement	1,507	5.4	7.0	15.3	14.5	18.4	15.0
	Total	20,917	19.1	25.1	36.4	43.2	48.2	35.5
Plains States:	Pasture	169	1.2	3.2	4.8	15.4	28.9	6.2
	Paved	661	26.3	25.7	35.0	37.6	43.5	34.2
	Other	1,334	6.7	18.3	31.4	40.6	45.5	24.4
	Confinement	354	3.2	15.1	18.2	19.3	19.9	18.1
	Total	2,518	6.6	14.8	24.6	30.1	31.2	20.8
Southeast:	Pasture	387	10.8	17.4	28.5	34.3	47.4	20.6
	Paved	360	24.4	22.5	34.4	45.8	57.5	37.5
	Other	1,076	14.7	17.7	31.3	42.7	37.4	24.9
	Confinement	393	12.7	16.3	28.9	39.8	31.7	28.6
	Total	2,216	13.9	18.0	30.8	41.4	39.2	26.0
15 major States:	Pasture	4,070	8.7	12.9	19.5	36.4	65.8	20.9
	Paved	5,879	25.0	26.4	42.5	50.3	63.6	42.9
	Other	13,448	19.9	30.4	44.3	54.5	58.1	40.8
	Confinement	2,254	7.4	9.6	16.8	16.7	20.4	16.8
	Total	25,651	15.6	22.4	34.3	41.6	44.6	32.3

Source: Number of farms estimated to have uncontrolled runoff problem multiplied by the average number sold of each size class as given by Census of Agriculture, 1969.

Table 11 -- Maximum rainfall expected in a 10-year, 24-hour period, 15 major hog producing States 1/

State	Maximum rainfall in 10-year, 24-hour period
	Inches
Iowa	4.0
Illinois	4.0
Indiana	4.0
Missouri	4.8
Nebraska	3.8
Minnesota	3.8
Ohio	3.7
South Dakota	3.5
Wisconsin	3.8
Kansas	4.4
North Carolina	6.0
Georgia	6.4
Kentucky	4.7
Tennessee	5.0
Texas	5.0

1/ These data apply to the areas of each State having the heaviest concentration of hog production. They were used to size holding ponds when the 10-year, 24-hour storm event was the chief basis of the runoff control system.

Table 12 -- Specification of precipitation, estimates of runoff, and facilities and practices recommended by the leading technicians, 15 major hog producing States, 1972 1/

State	Average annual precipitation 2/	Estimated annual runoff from open lots 3/	Recommendations							
			Diversion terraces	Settling basin		Holding pond				
				Concrete	Other	Capacity	Impervious lining	Fenced	Yearly emptyings	Irrigation
	----Inches----		----Yes or no----			Inches	Percent	Yes or no	No.	Yes or no
Iowa	31.8	15.8	yes	no 4/	yes	4.0	0	yes	4	yes
Illinois	35.8	27.6	yes	yes	no	13.8	2	yes	2	yes
Indiana	39.6	24.0	yes	no	yes	12.0	0	yes	2	yes
Missouri	38.2	19.2	yes	no	yes	9.6	0	yes	2	yes
Nebraska	24.6	5.9	yes	no	yes	5.9	0	yes	1	yes
Minnesota	26.9	13.7	yes	no	yes	6.8	0	yes	2	yes
Ohio	37.2	20.2	yes	yes	no	5/10.1	0	yes	2	yes
South Dakota	21.0	7.0	yes	no	yes	3.5	5	yes	2	yes
Wisconsin	31.2	9.0	yes	no	yes	10.0	50	yes	1	yes
Kansas	30.2	13.3	yes	no	yes	14.2	0	yes	3	yes
North Carolina	47.0	43.6	yes	yes	no	4.0	0	yes	11	yes
Georgia	47.0	47.0	yes	yes	no	6.4	0	yes	12	yes
Kentucky	46.0	30.2	yes	yes 6/	no	5.0	0	yes	6	yes
Tennessee	51.0	20.2	yes	yes 7/	no	5.0	0	yes	14	yes
Texas	28.8	4.8	yes	yes	no	4.8	25	yes	1	yes

1/ Specifications used on computing investments and annual costs of runoff control under the leading technician criteria.

2/ Based on the area of the State with the heaviest concentration of hog production.

3/ Estimated runoff that must eventually be removed from holding pond.

4/ A concrete settling basin is considered necessary on only about 10 percent of the farms requiring runoff control.

5/ Holding ponds not considered essential by technicians in Ohio, but were included as part of a 3-component system used in this analysis. Unit cost data for Indiana apply.

6/ Curb at edge of lot.

7/ No settling basin recommended, but one was included by using Kentucky cost data.

Table 13 -- Number of farms selling hogs produced in paved and other open-lot systems with runoff problems controllable by Technology 1, by size classes and by regions, 15 major States, 1969

Regions	Size class (head sold)					
	1-99	100-199	200-499	500-999	1,000 and over	Total
	Number					
	Paved lot systems					
Corn Belt-Lake States	3,558	2,533	5,279	1,553	364	13,287
Plains States	443	411	590	133	49	1,626
Southeast	1,073	246	271	78	43	1,711
15 major States	5,074	3,190	6,140	1,764	456	16,624
	Other lot systems					
Corn Belt-Lake States	18,168	10,450	13,557	4,194	909	47,278
Plains States	1,731	1,625	1,960	345	78	5,739
Southeast	7,007	1,075	1,035	279	86	9,482
15 major States	26,906	13,150	16,552	4,818	1,073	62,499

Source: Median estimates of expert panel.

Table 14 -- Number of hogs produced in paved and other open-lot systems with runoff problems controllable by Technology 1, by regions, 1969

Regions	Size class (head sold)					
	1-99	100-199	200-499	500-999	1,000 and over	Total
	Thousands					
	Paved lot systems					
Corn Belt-Lake States	152	355	1,592	1,020	551	3,670
Plains States	20	57	171	86	82	416
Southeast	33	33	78	51	82	277
15 major States	205	445	1,841	1,157	715	4,363
	Other lot systems					
Corn Belt-Lake States	781	1,471	4,099	2,758	1,363	10,472
Plains States	77	226	571	225	132	1,231
Southeast	210	145	300	184	158	997
15 major States	1,068	1,842	4,970	3,167	1,653	12,700

Source: Average numbers sold in each size group multiplied by median estimate of farm numbers made by expert panel.

Table 15 -- Number of hog farms with paved and other open-lot systems with runoff problems requiring use of Technology 2, by regions and 15 major States, 1969

Regions	Size class (head sold)					
	1-99	100-199	200-499	500-999	1,000 and over	Total
	Number					
	Paved lot systems					
Corn Belt-Lake States	538	608	1,562	563	160	3,431
Plains States	694	225	318	101	18	1,356
Southeast	79	35	83	28	19	244
15 major States	1,311	868	1,963	692	197	5,031
	Other lot systems					
Corn Belt-Lake States	110	110	985	289	38	1,532
Plains States	105	134	173	28	6	446
Southeast	190	49	75	36	13	363
15 major States	405	293	1,233	353	57	2,341

Source: Median estimates of expert panel.

Table 16 -- Number of hogs produced in paved and other open-lot systems with runoff problems requiring use of Technology 2, by regions and 15 major States, 1969

Regions	Size class (head sold)					
	1-99	100-199	200-499	500-999	1,000 and over	Total
	Thousands					
	Paved lot systems					
Corn Belt-Lake States	24	85	472	368	238	1,187
Plains States	28	31	93	66	28	246
Southeast	2	5	24	19	33	83
15 major States	54	121	589	453	299	1,516
	Other lot systems					
Corn Belt-Lake States	5	15	299	189	57	565
Plains States	5	19	51	18	10	103
Southeast	6	7	22	24	22	81
15 major States	16	41	372	231	89	749

Source: Average number sold in each size group multiplied by median estimates of farm numbers made by expert panel.

Table 17 -- Additional investment to control runoff from open-lot hog operations, 10-year, 24-hour storm event, 15 major States, 1972 1/

State and region	Farm size class (head sold)					
	1-99	100-199	200-499	500-999	1,000 and over	Total
			$1,000			
Iowa	7,853	12,066	26,455	8,598	1,772	56,744
Illinois	7,496	8,534	17,041	9,500	4,745	47,316
Indiana	2,344	2,789	6,460	2,952	1,314	15,859
Missouri	2,145	2,276	3,948	1,282	505	10,156
Minnesota	12,646	5,591	5,021	838	233	24,329
Ohio	22,162	6,307	9,217	2,772	1,015	41,473
Wisconsin	143	240	639	209	59	1,290
Corn Belt-Lake States	54,789	37,803	68,781	26,151	9,643	197,167
Nebraska	2,695	3,447	4,546	840	215	11,743
South Dakota	2,009	1,235	1,324	188	195	4,951
Kansas	2,879	959	2,140	740	128	6,846
Texas	511	647	323	116	79	1,676
Plains States	8,094	6,288	8,333	1,884	617	25,216
North Carolina	8,071	1,233	1,018	344	356	11,022
Georgia	3,534	958	1,998	751	358	7,599
Kentucky	3,207	938	1,183	490	221	6,039
Tennessee	5,253	835	462	78	13	6,641
Southeast	20,065	3,964	4,661	1,663	948	31,301
15 major States	82,948	48,055	81,775	29,698	11,208	253,684

1/ Aggregate investment for control of runoff from both paved and other open-lot systems using Technologies 1 and 2 as required.

Table 18 -- Additional investment to control runoff from open-lot hog operations, leading technicians' recommendations, 15 major States, 1972 1/

State and region	Size class (head sold)					
	1-99	100-199	200-499	500-999	1,000 and over	Total
	$1,000					
Iowa	7,854	12,066	24,960	8,505	1,671	55,056
Illinois	7,829	9,385	19,982	12,137	4,953	54,286
Indiana	2,413	2,976	7,122	3,396	1,578	17,485
Missouri	2,166	2,326	4,012	1,353	528	10,385
Minnesota	12,647	5,592	5,025	841	235	24,340
Corn Belt-Lake States	55,365	38,986	71,023	29,327	10,068	204,769
Nebraska	2,709	3,486	4,639	852	222	11,908
South Dakota	2,008	1,236	1,324	188	119	4,875
Kansas	2,897	973	2,239	810	149	7,068
Texas	511	646	322	116	75	1,670
Plains States	8,125	6,341	8,524	1,966	565	25,521
North Carolina	8,025	1,205	994	334	338	10,896
Georgia	3,534	957	2,007	765	363	7,626
Kentucky	3,209	941	1,193	497	217	6,057
Tennessee	5,254	835	454	77	13	6,633
Southeast	20,022	3,938	4,648	1,673	931	31,212
15 major States	83,512	49,265	84,195	32,966	11,564	261,502

1/ Aggregate investment for control of runoff from both paved and other open-lot systems using Technologies 1 and 2 as required.

Table 19 -- Additional annual cost to control runoff from paved and other feedlots, leading technicians' recommendations, 15 major States, 1972 1/

State and region	Farm size class (head sold)					
	1-99	100-199	200-499	500-999	1,000 or more	Total
	$1,000					
Iowa	1,135	1,753	3,825	1,267	258	8,238
Illinois	2,223	1,247	2,490	1,403	499	7,862
Indiana	343	418	987	467	215	2,430
Missouri	314	341	596	202	80	1,533
Minnesota	1,817	799	716	119	33	3,484
Ohio	3,190	894	1,272	376	132	5,864
Wisconsin	31	37	100	35	11	214
Corn Belt-Lake States	9,053	5,489	9,986	3,869	1,228	29,625
Nebraska	392	504	673	124	33	1,726
South Dakota	289	177	190	27	17	700
Kansas	416	139	321	116	21	1,013
Texas	74	93	46	17	11	241
Plains States	1,171	913	1,230	284	82	3,680
North Carolina	1,170	180	145	49	49	1,593
Georgia		145	315	127	63	1,172
Kentucky	)	135	171	73	33	872
Tennessee	2	119	65	11	2	949
Southeast	2,904	579	696	260	147	4,586
15 major States	13,128	6,981	11,912	4,413	1,457	37,891

1/ Aggregate annual costs for control of runoff from both paved and other open lot systems using Technologies 1 and 2 as required.

Table 20 -- Additional annual costs to control runoff from open-lot hog operations, by size class, 10-year, 24-hour storm event, 15 major States, 1972 1/

State and region	Size class (head sold)					
	1-99	100-199	200-499	500-999	1,000 and over	Total
			$1,000			
Iowa	1,155	1,821	3,988	1,348	277	8,589
Illinois	1,084	1,245	2,477	1,402	498	6,706
Indiana	339	409	944	439	195	2,326
Missouri	316	347	213	211	84	1,171
Minnesota	1,817	569	715	118	33	3,252
Ohio	3,211	912	395	390	137	5,045
Wisconsin	26	35	94	31	9	195
Corn Belt-Lake States	7,948	5,338	8,826	3,939	1,233	27,284
Nebraska	397	522	706	133	36	1,794
South Dakota	292	181	196	28	18	715
Kansas	415	139	319	115	21	1,009
Texas	75	97	50	19	14	255
Plains States	1,179	939	1,271	295	89	3,773
North Carolina	1,179	183	149	51	51	1,613
Georgia	522	145	313	125	62	1,167
Kentucky	462	138	175	75	34	884
Tennessee	762	125	69	10	2	968
Southeast	2,925	591	706	261	149	4,632
15 major States	12,052	6,868	10,803	4,495	1,471	35,689

1/ Aggregate annual costs for control of runoff from both paved and other open-lot systems using Technologies 1 and 2 as required.

Table 21 -- Additional investment and annual costs to control runoff from open-lot hog operations, per hog and per 100 pounds of pork sold, leading technicians' recommendations, 15 major States, 1972 1/

Region	Unit	Farm size class (head sold)					
		1-99	100-199	200-499	500-999	1,000 and over	All classes
		Dollars					
Corn Belt-Lake States:	Investment per head	56.62	20.25	11.07	6.83	4.55	12.94
	Annual cost per cwt.	4.41	1.36	.74	.43	.26	.89
Plains States:	Investment per head	69.01	19.11	9.66	4.98	2.15	12.83
	Annual cost per cwt.	4.69	1.30	.66	.34	.15	.87
Southeast:	Investment per head	75.41	20.82	11.01	5.99	3.06	21.37
	Annual cost per cwt.	5.82	1.63	.88	.49	.26	1.67
15 major States:	Investment per head	61.36	20.14	10.91	6.81	4.32	13.57
	Annual cost per cwt.	4.62	1.37	.74	.44	.26	.94

1/ These data reflect the combination of paved and other open-lot systems requiring runoff control, and the combinations of Technologies 1 and 2 required to achieve control, as specified earlier in this report.

Table 22 -- Additional investment and annual costs to control runoff from open lot operations, per hog and per 100 pounds of pork sold, 10-year, 24-hour storm event, 15 major States, 1972 1/

Region	Unit	Farm size class (head sold)					
		1-99	100-199	200-499	500-999	1,000 and over	All classes
		Dollars					
Corn Belt-Lake States:	Investment per head	56.04	19.64	10.73	6.09	4.36	12.38
	Annual cost per cwt.	3.87	1.32	.66	.44	.27	.82
Plains States:	Investment per head	68.74	18.95	9.44	4.78	2.35	12.68
	Annual cost per cwt.	4.73	1.33	.68	.35	.16	.89
Southeast:	Investment per head	75.57	20.96	11.04	5.96	3.12	21.43
	Annual cost per cwt.	5.86	1.66	.89	.50	.26	1.69
15 major States:	Investment per head	60.95	19.65	10.60	6.14	4.19	13.16
	Annual cost per cwt.	4.24	1.34	.67	.44	.26	.89

1/ These data reflect the combination of paved and other open lot systems requiring runoff control, and the combinations of Technology 1 and 2 required to achieve control, as specified earlier in this report.

Table 23 -- Numbers of hog producers and hogs produced, investment, and annual costs of waste management systems in 1971 and under three hypothetical environmental regulations, Illinois

Item	1971 situation	After adjustment to Regulation "A"	After adjustment to Regulation "B"	After adjustment to Regulation "C"
			Number	
Number of hog producers	50,000	49,720	39,150	32,170
			Thousands	
Number of hogs produced	11,800	11,800	11,800	11,800
			$1,000	
Investment for waste handling system	79,812	92,781	102,629	116,194
Annual gross cost for waste management system	22,581	24,897	23,188	23,031
Annual net cost for waste management system	16,319	18,322	18,839	18,169

Source: John C. Gamble, "Economic Evaluation of the Impact of Alternative Environmental Regulations and Waste Management Systems on Illinois Hog Producers," Unpublished Ph D thesis, Dept. of Agr. Econ., Univ. of Ill., July 1972, p. 227.

Appendix table 1 -- Number of farms in specified large size classes based on the number of hogs on hand at inventory, 15 major States and 48 States, 1969.

State	Minimum inventory index	Inventory (head) 1/			Total hog farms
		Less than 1,500	1,500-2,999	3,000 or more	
		Number			
Iowa	1,000	136	131	7	85,000
Illinois	1,500	---	447	42	49,000
Indiana	1,000	236	70	15	37,000
Missouri	1,000	108	25	5	49,000
Nebraska	500	757	48	8	32,000
Minnesota	1,000	109	20	3	39,000
Ohio	1,000	205	39	11	28,000
South Dakota	300	424	22	5	18,500
Wisconsin	500	402	27	5	26,000
Kansas	600	237	29	18	20,000
North Carolina	500	549	47	32	52,000
Georgia	500	227	16	7	30,000
Kentucky	500	369	27	7	36,000
Tennessee	500	148	24	5	40,000
Texas	500	456	34	15	27,000
33 other States	200-1,000	NA	216	75	259,400
Total 48 States	200-1,500	NA	1,222	260	827,900

1/ For enterprises selling 1,000 head or more annually the sold-to-inventory ratio is about 2.0. See appendix table 2.

NA = not applicable.

Source: Statistical Reporting Service, U.S. Department of Agriculture, unpublished data, 1973.

Appendix table 2 -- Estimated rate of turn-over of hogs by size classes, 15 major States, 1969 1/

State and region	Farm size class (head sold)					
	1-99	100-199	200-499	500-999	1,000 and over	All classes
	Turnover ratio					
Iowa	1.13	1.39	1.56	1.69	1.89	1.55
Illinois	1.25	1.46	1.58	1.66	1.74	1.57
Indiana	1.25	1.51	1.62	1.71	1.99	1.62
Missouri	1.37	1.64	1.74	1.83	2.25	1.70
Minnesota	1.29	1.61	1.76	1.91	2.24	1.67
Ohio	1.30	1.58	1.72	1.86	2.05	1.66
Wisconsin	1.49	1.80	1.89	2.04	2.31	1.81
Corn Belt-Lake States	1.27	1.51	1.63	1.73	2.05	1.61
Nebraska	1.24	1.53	1.75	1.91	2.21	1.64
South Dakota	1.28	1.59	1.77	2.04	2.03	1.65
Kansas	1.36	1.74	1.89	2.01	2.21	1.79
Texas	1.21	1.61	1.81	1.92	2.22	1.65
Plains States	1.27	1.60	1.79	1.96	2.19	1.68
North Carolina	1.18	1.57	1.83	1.89	2.50	1.67
Georgia	1.10	1.40	1.60	1.74	1.87	1.45
Kentucky	1.36	1.72	1.86	1.90	2.00	1.67
Tennessee	1.48	1.82	1.90	2.05	2.08	1.71
Southeast	1.28	1.61	1.77	1.87	2.17	1.61
15 major States	1.27	1.54	1.66	1.76	1.99	1.62

1/ Number sold from all farms selling hogs as reported in the 1969 Census of Agriculture divided by the number of hogs in inventory. Turnover ratios in excess of 2.0 reflect substantial sales of feeder pigs. Average liveweight per head for combined hogs and pigs sold was estimated to be as follows (in pounds): Iowa, 220; Illinois, 231; Indiana, 227; Missouri, 207; Nebraska, 218; Minnesota, 203; Ohio, 201; South Dakota, 227; Wisconsin, 180; Kansas, 205; North Carolina, 183; Georgia, 200; Kentucky, 191; Tennessee, 180; Texas, 199.

Appendix table 3 -- Estimated numbers of hog production systems, by size classes, 15 major States, 1969 1/

State and region	Farm size class (head sold)					
	1-99	100-199	200-499	500-999	1,000 and over	All classes
	Number					
Iowa	45	103	175	383	752	152
Illinois	36	96	194	398	847	137
Indiana	34	92	187	384	807	121
Missouri	30	85	172	362	732	85
Minnesota	34	86	165	341	665	84
Ohio	30	88	174	360	728	84
Wisconsin	26	78	155	320	691	65
Corn Belt-Lake States	34	93	185	378	733	114
Nebraska	37	91	166	337	704	93
South Dakota	37	87	160	311	763	85
Kansas	30	78	156	328	822	78
Texas	23	85	161	349	862	52
Plains States	31	87	162	332	789	79
North Carolina	24	85	159	355	927	52
Georgia	33	96	182	378	916	73
Kentucky	23	79	158	352	755	50
Tennessee	22	75	147	321	815	39
Southeast	25	84	163	353	872	52
15 major States	31	91	180	372	790	96

1/ Inventory divided by the number of farms selling hogs shows the number on hand per farm at inventory time. This indicates size of the production system, but is not a precise measure of capacity, as livestock producers seldom achieve more than 75 percent utilization of capacity. Further, degree of utilization of facilities relates directly to size of operation.

Appendix table 4 -- Example of typical components, investments and annual costs for controlling and disposing of runoff from a 1-acre drainage area with Technology 1, leading technicians' recommendations, Illinois 1/

Item	Unit	Quantity	Investment per unit	Total investment	Annual costs 2/		
					Fixed	Variable	Total
			Dollars				
Control:							
Diversion terrace	Linear ft.	835	.80	668			
Settling basin	Each	1	1,344	1,344			
Holding pond:							
Excavation	Cu. ft.	50,094	.0222	1,112			
Fencing	Feet	376	.40	150			
Seeding	Pounds	10	1.00	10			
Lining	--	none	--	--			
Total				3,284	355	0	355
Disposal:							
Pump	Each	1	923	923		30	
Sprinkler	Each	1	533	533		--	
Pipe, fittings	Feet	500	1.38	689		--	
Total		--	--	2,145	313	30	343
Grand total				5,429	668	30	698

1/ Based on annual precipitation of 36 inches, runoff equal to 50 percent of annual precipitation and holding pond capacity for 38 percent of annual precipitation. Lot is partly paved with 125 square feet per hog space. Illinois unit cost data apply. Capacity is 350 hogs; annual output is 600 head at average turnover ratio for an operation of this size. Thus, annual cost per hog is about $1.08, or $0.47 per 100 pounds with sale weight averaging 230 pounds per head.

2/ Not calculated for all separate items.

-- = Not applicable.

Appendix table 5 -- Example of additional components, investments and annual costs for controlling and disposing of runoff from a 1-acre drainage area with Technology 2, leading technicians' recommendations, Illinois 1/

Item	Unit	Quantity	Investment per unit	Total investment	Annual costs		
					Fixed	Variable	Total
			Dollars				
Sump	Cu. ft.	216	3.0648	662	2/	0	2/
Pump	Each	1	900	900	2/	50	2/
Pipe	Linear ft.	500	1.22	610	2/	0	2/
Total		--	--	2,172	281	50	331

1/ The sump and pump will handle runoff from 2.5 inches of rain in a 3-hour period. All specifications of conditions and requirements for Technology 1 (appendix table 5) apply. The investments and annual costs shown here are in addition to those necessary for Technology 1 (appendix table 5).

2/ Not calculated for separate items.

-- = not applicable

Appendix table 6 -- Investments and annual costs for runoff control on a 1-acre, partly paved drainage area using Technology 1, Illinois cost data, and specified levels of precipitation, percentage of precipitation as runoff, and holding pond capacities 1/

Runoff as percent of annual precipitation	Annual precipitation (inches)											
	20			30			40			50		
	Storage capacity (inches)			Storage capacity (inches)			Storage capacity (inches)			Storage capacity (inches)		
	2	5	10	3	7.5	15	4	10	20	5	12.5	25
	Dollars											
	Investment											
25	4,389	4,672	--	4,486	4,989	--	4,579	5,121	--	4,672	5,341	--
50	4,389	4,672	5,121	4,560	4,972	5,634	4,653	5,195	6,067	4,746	5,415	6,497
75	4,463	4,746	5,195	4,560	4,972	5,634	4,653	5,195	6,067	4,746	5,415	6,497
100	4,463	4,746	5,195	4,560	4,972	5,634	4,653	5,195	6,067	4,746	5,415	6,497
	Annual costs											
25	571	602	--	591	635	--	609	667	--	627	699	--
50	588	619	667	613	657	729	636	694	789	658	730	847
75	592	623	671	632	676	748	661	719	814	690	762	879
100	605	636	684	651	695	767	686	744	839	711	783	900

1/ The system holds 350 hogs at one time (space involved is 125 square feet per head), and markets 600 head of 250-pound hogs annually.

-- = Not applicable.

Appendix table 7 -- Investments and annual costs per head of sales for runoff control on a 1-acre partly paved drainage area using Technology 1, Illinois cost data, and specified levels of precipitation, percentage of precipitation as runoff, and holding pond capacities 1/

Runoff as percent of annual precipitation	Annual precipitation (inches)											
	20			30			40			50		
	Storage capacity (inches)			Storage capacity (inches)			Storage capacity (inches)			Storage capacity (inches)		
	2	5	10	3	7.5	12	4	10	20	5	12.5	25
	Dollars											
	Investment per hog sold											
25	7.64	8.14	--	7.82	8.53	--	7.98	8.92	--	8.14	9.30	--
50	7.65	8.14	8.92	7.94	8.66	9.82	8.11	9.05	10.57	8.27	9.43	11.32
75	7.78	8.27	9.05	7.94	8.66	9.82	8.11	9.05	10.57	8.27	9.43	11.32
100	7.78	8.27	9.05	7.94	8.66	9.82	8.11	9.05	10.57	8.27	9.43	11.32
	Annual costs per hog sold											
25	.99	1.05	--	1.03	1.11	--	1.06	1.16	--	1.11	1.22	--
50	1.02	1.08	1.16	1.07	1.14	1.27	1.11	1.21	1.37	1.15	1.27	1.48
75	1.03	1.09	1.17	1.10	1.18	1.30	1.15	1.25	1.42	1.20	1.33	1.53
100	1.05	1.11	1.10	1.13	1.21	1.34	1.20	1.30	1.46	1.24	1.36	1.57

1/ The system holds 350 hogs at one time (space involved is 125 square feet per head), and markets 600 head of 250-pound hogs annually.

-- = Not applicable.

Appendix table 8 -- Investments and annual costs per 100 pounds of pork produced for runoff control on a 1-acre partly paved drainage area using Technology 1, Illinois cost data, and specified levels of precipitation, percentage of precipitation as runoff, and holding pond capacities 1/

Runoff as percent of annual precipitation	Annual precipitation (inches)											
	20			30			40			50		
	Storage capacity (inches)			Storage capacity (inches)			Storage capacity (inches)			Storage capacity (inches)		
	2	5	10	3	7.5	15	4	10	20	5	12.5	20
	Dollars											
	Investment per cwt. of pork produced											
25	3.32	3.54	--	3.40	3.71	--	3.47	3.88	--	3.54	4.05	--
50	3.32	3.54	3.88	3.45	3.77	4.27	3.52	3.94	4.60	3.60	4.10	4.92
75	3.38	3.60	3.94	3.45	3.77	4.27	3.52	3.94	4.60	3.60	4.10	4.92
100	3.38	3.60	3.94	3.45	3.77	4.27	3.52	3.94	4.60	3.60	4.10	4.92
	Annual costs per cwt. of pork produced											
25	.43	.46	--	.45	.48	--	.46	.51	--	.48	.53	--
50	.45	.47	.51	.46	.50	.55	.48	.53	.60	.50	.55	.64
75	.45	.47	.51	.48	.51	.57	.50	.54	.62	.52	.58	.67
100	.46	.48	.52	.49	.53	.58	.52	.56	.64	.54	.59	.68

1/ The system holds 350 hogs at one time (space involved is 125 square feet per head), and markets 600 head of 230 pound hogs annually.

-- = not applicable.