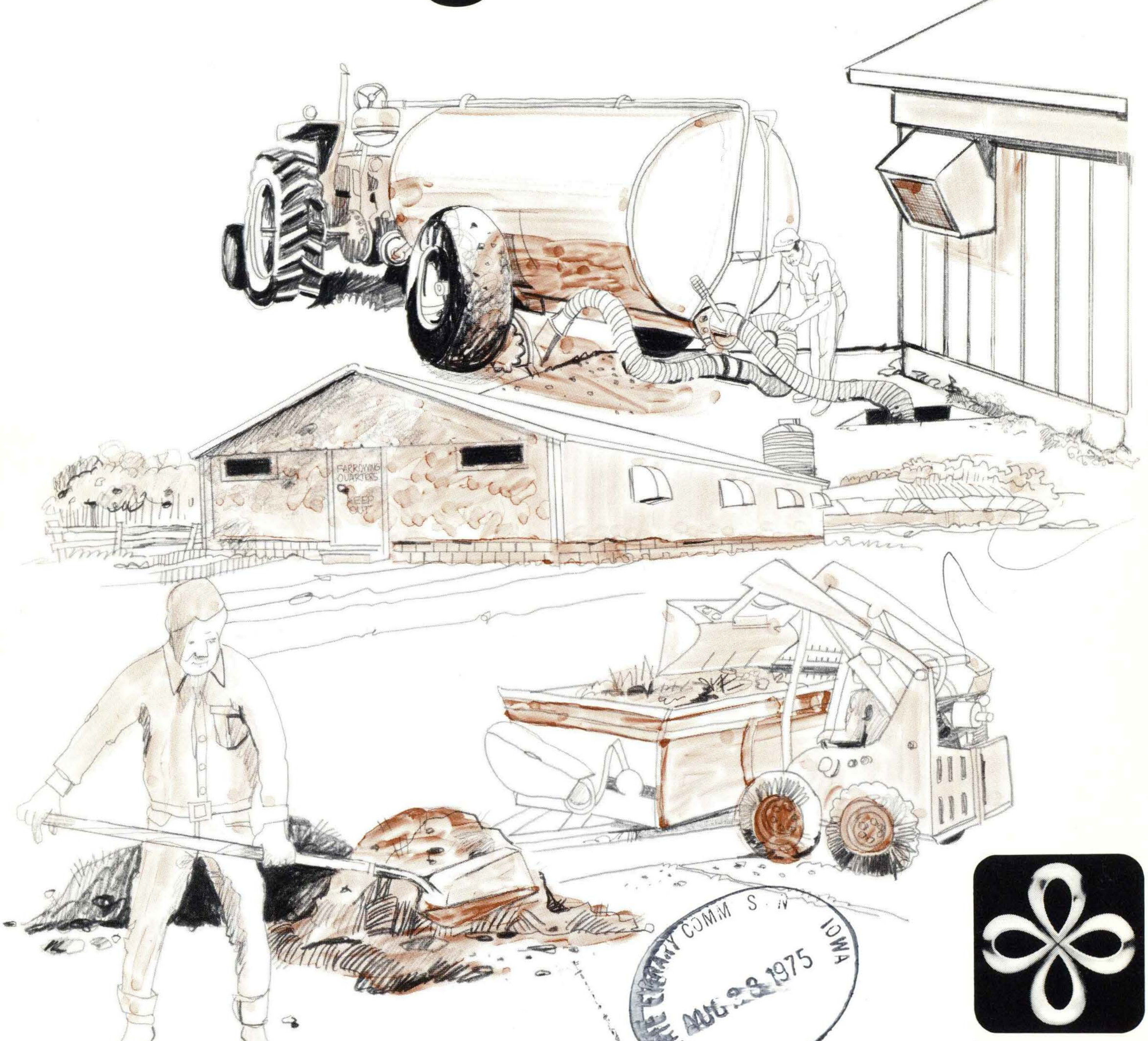
Swine Waste Management



Iowa
a place to grow

A PUBLICATION OF THE IOWA DEVELOPMENT COMMISSION/AGRICULTURE DIVISION

Foreword

For generations Iowa has been known as the "tall corn" state, and rightly so. With much of the nation's best land, the state's combined output of corn and soybeans makes this the feed-grain center of the world.

And much of our crop output is "processed" within the state, by running these feeds through livestock . . . particularly hogs.

It is no accident that Iowa leads the nation in pork production. Nearly one-fourth of the total pork consumed by 210 million Americans comes from Iowa feedlots. The on-farm value of hogs produced for slaughter exceeds $1 billion a year, (value reached $1.7 billion in 1973), which provides a major share of total farm income to some 75,000 farm families . . . and creates nearly 60,000 off-farm jobs in pork processing, transport, and producer-supply businesses.

Although subject to repeated price cycles, pork production is the single most profitable enterprise in Iowa. Hogs are known as the "mortgage lifter."

This booklet, researched and written by the Iowa Development Commission, is designed to help Iowa's hog farmers solve a pesky problem — that of handling swine wastes within sound environmental guidelines.

On-farm interviews produced the basic management information in this brochure, and the editors deeply appreciate the generous assistance of these busy pork producers. Special thanks also to Vernon Meyer and the extension agricultural engineering staff at Iowa State University, and to Emmett Stevermer, extension swine specialist at ISU, for technical advice and consultation.

A PUBLICATION OF THE IOWA DEVELOPMENT COMMISSION/ AGRICULTURE DIVISION

IOWA DEVELOPMENT COMMISSION
250 Jewett Building
Des Moines, Iowa 50309

Del Van Horn, Director
Roger Fisher, Director,
Agriculture Division

Introduction

A pair of compelling factors have teamed up to make the handling, storage and disposal of livestock wastes a major concern for Iowa's hog industry.

First, of course, the economics of hog raising has dictated that the "few sows on pastures on almost every farm" be replaced with fewer, much larger operations with hogs in complete or nearly-complete confinement.

Second, and directly related to the concentration of animal wastes in the confined systems, are the increasing public demands for environmental protection of the soil, water, and air.

At this writing, regulatory agencies, waste-handling engineers, systems researchers and hog producers are agreed on one point: there are no fixed, firm "best answers" available. The industry is feeling its way toward waste systems which are economically viable on the one hand and effective at levels to safeguard the environment on the other.

This report will review briefly the current state-federal regulations affecting swine operations.

A number of waste treatment and handling systems have been developed, ranging from the original scooping-and-spreading of dry matter to the sophisticated aerated-lagoon approach and the conversion of wastes into methane gas.

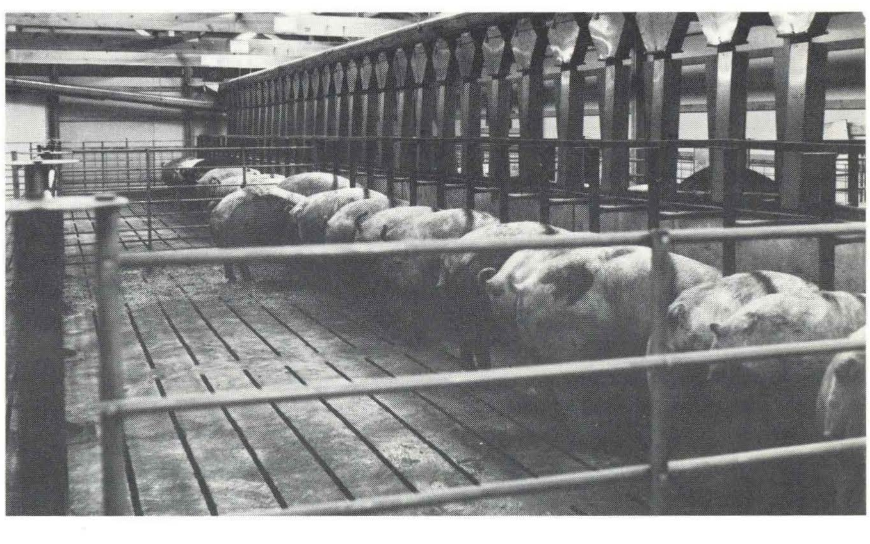
These systems are being checked in their many variations by private and by University research. These early studies offer at least preliminary analysis of system effectiveness. A listing of sources for many of these studies will be found on pages in the back of this brochure.

However, one factor shows up in swine waste handling, regardless of the "system" involved. It is this: Good management can make virtually any system work . . . and poor or uninformed management can seriously reduce the effectiveness of the most carefully designed system.

A section of this report is therefore aimed at the "management side" of swine waste handling . . . since on-farm management is vital regardless of the system in use.

In-depth interviews with progressive pork producers were designed to unearth those management steps — successful and otherwise — which are being applied to the common types of waste-handling facilities and systems. We are indebted to these operators for their freely-given comments on their experiences, innovations and mistakes. We think their "findings" will be helpful to every producer as the industry moves toward improved protection of soil, water and air.

This 200 X 52 foot building features total slats over a pit a full 8 feet deep.



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Environmental Requirements

Society is intensifying its demands that we safeguard the purity of our natural resources . . . soil, air and water. Since agriculture occupies much of our total land area, environmental guidelines and eventually firm regulations will affect farmers in general . . . and livestock farmers in particular.

Because farmers depend directly on soil-air-water for their livelihood, they have been long-timers at the business of careful waste management. For centuries, livestock wastes have been collected and returned to the soil for natural recycling.

Because livestock wastes have economic value, it has never been a farmer's intent to allow these fertilizers to be washed into waterways nor to cause an imbalance in the chemical makeup of his soil. But some pollution did take place, and regulatory patterns being developed are designed to safeguard against the occasional abuses and management errors. Because the trend toward raising livestock in confined areas and facilities is increasing rapidly, the larger operations are the target for first-round regulations.

Environmental Protection Agency Waste Regulations

National Pollution Discharge Elimination System (NPDES) permits are required for any livestock producer who presently or for more than 30 days during the past 12 months has had more than 1,000 beef cattle, 700 mature dairy cows, **2,500 hogs over 55 pounds,** 10,000 sheep, 55,000 turkeys, 30,000 chickens with a liquid manure system, 100,000 chickens with a continuous overflow watering system, or 5,000 ducks or equivalent combinations of livestock.

Livestock producers who through past or present action have demonstrated that their facilities are a "significant contributor" of pollution **should** apply for a permit . . . and any producer making a discharge or potential discharge of pollutants to surface water **must** apply for a permit.

In the above situations, applications must be made immediately. Any new facilities should make application 180 days prior to discharge. To assure that planned waste handling facilities will meet the EPA requirements, the producer should plan to make application 180 days prior to **start** of construction.

Feedlot runoff reaching surface waters is the most common "discharge of pollutants to navigable water". The liquid manure tank and/or lagoon are additional point sources of pollution. If these liquid manure storages are mismanaged so that they overflow, severe damage could be done to surface waters.

The NPDES Discharge Permit is authorization to discharge livestock waste water to a navigable stream. The authorization is written to protect the receiving stream. The producer must provide waste management facilities capable of containing all waste water except for runoff in excess of a severe rainfall or snow melt, as determined by EPA.

General Guidelines

Although initial regulations have been released only for the larger concentrations of livestock and livestock waste, all livestock producers are expected to, and will eventually be required to, protect against pollution of surface and ground waters. Any waste management system being developed should be designed to safeguard soil and water . . . and thus to protect the operator against civil or criminal penalties which could sometimes result if livestock wastes are found to be polluting natural resources.

(Please note that as of this writing, neither EPA nor Iowa DEQ regulations cover **air** pollution. However, odors which are offensive are subject to long-standing laws under public nuisance sections, so odor control should be considered when planning facilities and selecting sites.)

Complete and updated guidelines, regulatory information and Discharge Permits can be obtained from:

Permit Branch, Region 5
U.S. Environmental Protection Agency
One North Wacker Drive
Chicago, IL 60606

or

Iowa Department of Environmental Quality
3920 Delaware Ave, Box 3326
Des Moines, Iowa 50316

This modern farrowing-nursery structure with automated feed-handling is typical of "labor saving".

Major systems in use

As mentioned earlier, a number of waste-handling-systems — with many variations — are being used, researched, improved. Smith-Hazen-Parker at Iowa State make the point that a "systems approach" calls for making the "entire hog producing plant work as an integrated whole, not just a casual assembly of mismatched parts."

The basic elements of a manure handling system may be simply stated: transporting manure from the pig; storage or treatment-storage; applying the waste to the soil.

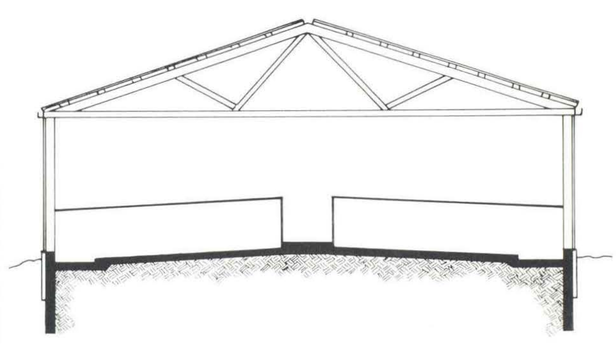
Art Muehling, University of Illinois, lists a number of factors affecting the selection of a system which best suits an individual producer. These include investment and operational costs (with labor a strong element;) size of operation; location (not only physical layout but neighbors downwind, etc.); type of production facility; existing facilities and equipment available to operator; and personal preference ("each operator knows how he expects a system to function and what he is willing to put up with. A particular system could be adequate for one producer, but completely unsatisfactory for another.")

Solid floor, dry manure handling

This system is often found where existing farm structures were converted to swine production. In new construction, it usually features the "open front" building or one of its many modifications.

Manure has long been handled on a dry basis. Bedding and manure solids are scooped or scraped from the solid floors regularly . . . although careful sloping of floors, arrangement of feed and waterers and "hog training" have helped to make the manure travel to specified areas . . . such as a trough outside the feed floor which can be emptied easily with a tractor-loader.

We talked to one producer who had installed a gutter-cleaner in his farrowing house, which moved



Solid floor, shallow trough

wastes to a pit outside the building and solved his odor-gases problem. More on his experience later.

Generally, the advantage of the solid-floor, dry manure system is its **low construction cost.** Materials for solid floors are considerably less costly than for pit and slats. Additionally, most producers can provide labor for solid floors where professional talent is usually required for pits, flushing systems and other more complicated installations.

Additional cost advantage: conventional manure spreader and loader can be kept in use, where liquid wastes require tank spreaders.

Where the operator has time for cleaning and frequent hauling, dry manure handling is easily the most economical system. There is practically nothing mechanical to maintain or wear out. Management demand is at a minimum.

By the same token, **labor** required **is the big disadvantage** . . . and in some cases where waste runoff from the floors is not contained, environmental restrictions will cause a "new look" . . . and probably a holding facility if surface water is nearby. There is also the matter of operator discomfort in bad weather. A second disadvantage: bedding materials are scarce and expensive. Harvesting and storage require manpower and add to cost of waste handling.

Back to the plus side, some operators prefer a system which uses bedding. Others believe that the usual open-fronted facility adds to hog health and growth . . . especially for growing and finishing pigs . . . because the dry manure creates considerably less odor and gases, and ventilation is virtually automatic.

Valuable Waste

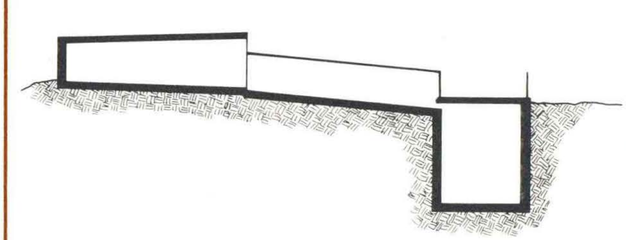
Still another observation: "There is no cheaper way to haul manure. I know I net money on my hog waste . . . and I doubt that the more sophisticated systems actually make a net return in fertilizer benefits."

What about "neighbor" problems with odor when manure is spread? Operators were all aware of potential complaints, but none had heard any to date. One producer said, "Dry manure spread on a field isn't that smelly. If the neighbors didn't see the spreader working, they wouldn't know we'd been hauling manure."

Another said, referring to both dry and liquid manure, "If you can hit a day when the wind is right for your neighbor, you're home free. Even the stuff from the pit loses its big stink overnight."

Is floor design important? Slope apparently is vital. One operator, using an open front 40 x 128 feet (20 feet covered, 20 open to south) sloped his floor a bit more than usual patterns — 1¼ inches per foot — and claims he has never needed to scrape this finishing facility . . . which features a pit along the lower end of the floor.

At least two commercially-designed units feature carefully sloped floors, with manure "working its way" out of the feeding area. One provides waste storage with a pit at the lower end of the feeding floor.



Solid floor, pit storage

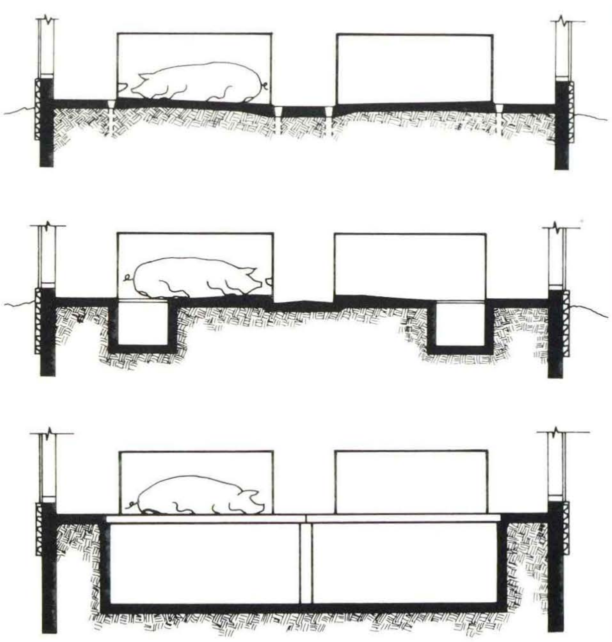
A second commercial design calls for a shallow gutter, wide enough (12 feet) to hold a considerable supply of wastes. This gutter lends itself to easy loading with a tractor-loader.

Liquid handling

Many farmers have found that as their hog numbers were increased, the sheer volume of the waste to be handled required a better pattern than scraping solid floors and handling dry wastes every few days around the year. Bedding became increasingly difficult and costly to obtain in many areas . . . and the environmental regulations increasingly frowned on the uncontrolled runoff from outside feeding floors.

These pressures for time-and-labor-saving systems brought on the move to slotted floors over storage pits . . . and handling swine wastes in liquid form.

A great variety of designs emerged, some with all floors under the hogs slotted, others with partial slots . . . some with full pits under the slats, some with fairly shallow gutters which are flushed to move the wastes to deep pits or lagoons outside the building.


Floor types, farrowing

Producers generally consider the savings on labor-management to be the chief benefit of the slots-and-pit systems. We find that while capacity of the pits varies widely, a clear trend is developing to build in "at least" six months' waste storage. In the Iowa climate, of course, a half-year capacity not only provides flexibility as to when the pit may be emptied and spread, but allows the operator to spread in spring and fall when timing is right for applying this natural fertilizer.

Costs of the slots-and-pit system are considerably higher. Professional installation of the reinforced pits is usually required. Additionally, the liquid waste requires its own equipment for pumping out pits, carrying the liquids to the field, spreading or blading into the soil.

Our interviews indicated, however, that operators are making this system work and in general feel that the additional costs are offset by the labor-time savings.

A southern Iowa operation uses partial slats in a three-year-old building which is 100 x 40 feet. The pits are shallow, sloped to one end for waste removal.

Deeper Pits

This operator would, if "starting over," go to either larger-capacity pits or to a lagoon. He thinks that odor buildup is greater from the shallow pits than it would be in deep, high capacity pits.

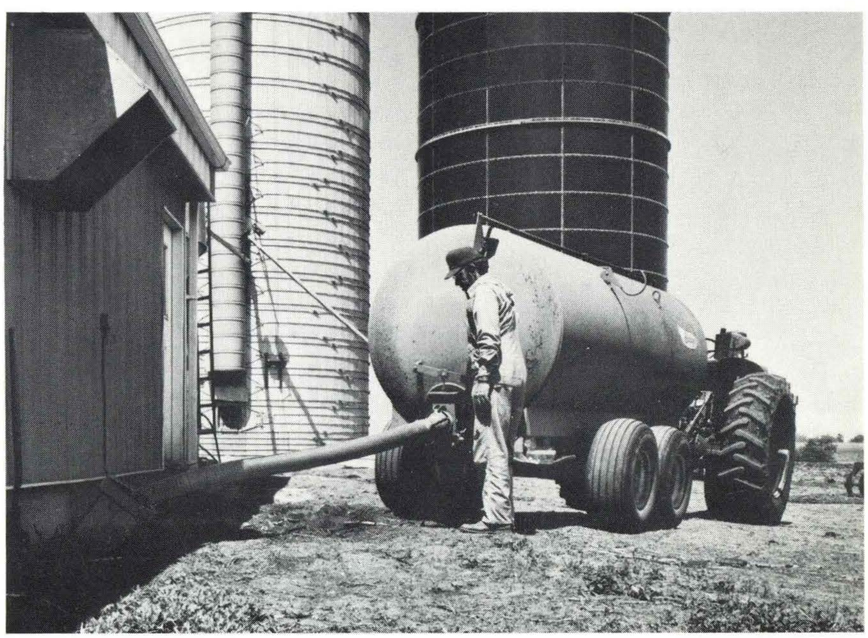
He found — and others have made like comments — that he had to add water to the pits to make the waste fluid enough for pumping . . . and even with his pits sloped to the pumping end, he has a buildup of solids. He suspects that eventually a lagoon would both provide more storage and also supply water to "flush" the system and solve the solids buildup in the pits.

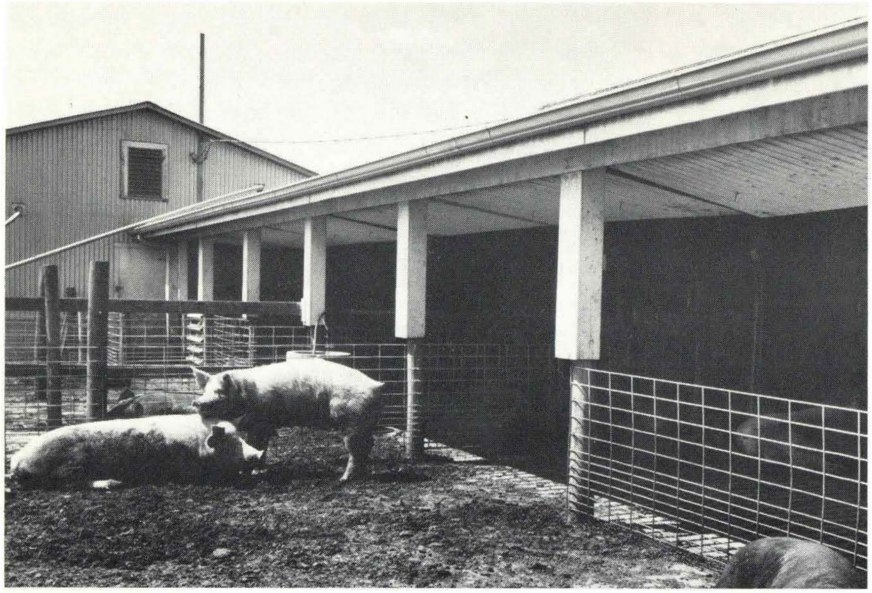
This farmer uses "fail safe" equipment on his fans, so that if electricity is off for five minutes, the louvers open automatically to let gases escape. Odor and gases are his big problem, so ventilation "must work" in the closed house. He thinks the natural gases are hard on the baby pigs.

With farrowing and nursery in his building, this manager is planning an open-front structure for finishing which will push his capacity to about 2,400 hogs.

In northwest Iowa, one of the state's largest hog operations is completely confined, uses slots and pits in all buildings. The operator feels the system works "extremely well", and he looks at waste haul-

This operator likes deep (8-foot) pits in combination nursery-finishing unit. He hauls some waste each month when weather permits.





Some managers believe that breeding sows settle better in open-front facilities than in full confinement.

ing as "part of the business of pork production."

Of his five buildings, only the sow breeding building is open-fronted. Why? "The exposure helps bring gilts and sows into cycle." The breeding building has a single pit in the center, 8′ wide, 6′ deep, sloped to a 4′ sump. This floor must be scraped "inside, three times a week, outside once."

Fertilizer Savings

Pits in the other buildings are large capacity, designed to slope toward a sump at one end for pumping. With this much waste volume, two liquid spreading tanks are used, a 2100- and 1100-gallon. He feels this equipment is a "cheap investment" in comparison with the cost of fertilizer saved. Yearly soil tests show that the liquid manure applied to cropland (about eight tons per acre) provides as much as 90 pounds of nitrogen, 50 pounds of phosphate . . . and that fields receiving the natural fertilizer outyield similar land with fertility levels brought to the same level.

One improvement: this operator thinks he got "bad advice" when he put partial slots in his nursery building. He had "trouble keeping little pigs dry, death loss was too high. I didn't like to be in there, so it's not a good place for little pigs."

The single pit originally installed is being replaced with three new pits to handle the new totally-slotted floors . . . this being the "only major change I've had to make" in original plans.

This operator has modified his spreaders to knife in manure between corn rows, a "net gain" because it provides "an additional 1-2 months time to spread manure."

Backed with exceptionally detailed cost records, this operator supports the thesis that confinement production is an economic improvement over the older outside conditions. "I know that my production costs dropped about $2 per hundred weight when we went to total confinement, and yield went up 1½ percent. We're putting hogs 'to town' at 206 pounds in 4½ months . . . so I see no detrimental effect on swine health or growth in the total confinement operation."

Did he ever, at his volume of production, consider coupling the pits with a lagoon? Decided against, he said, because his goal is to put land into crop production . . . and a lagoon would have taken more land out. "When I apply my waste, I can knife it in when and where I want it applied. I think the only way to improve a good pit system might be pump irrigation . . . with both cost and odor problems on the negative side."

Pit With Lagoon

However, a 3,000 hog operation in west-central Iowa uses pits with a lagoon, and the manager is quite satisfied with the system.

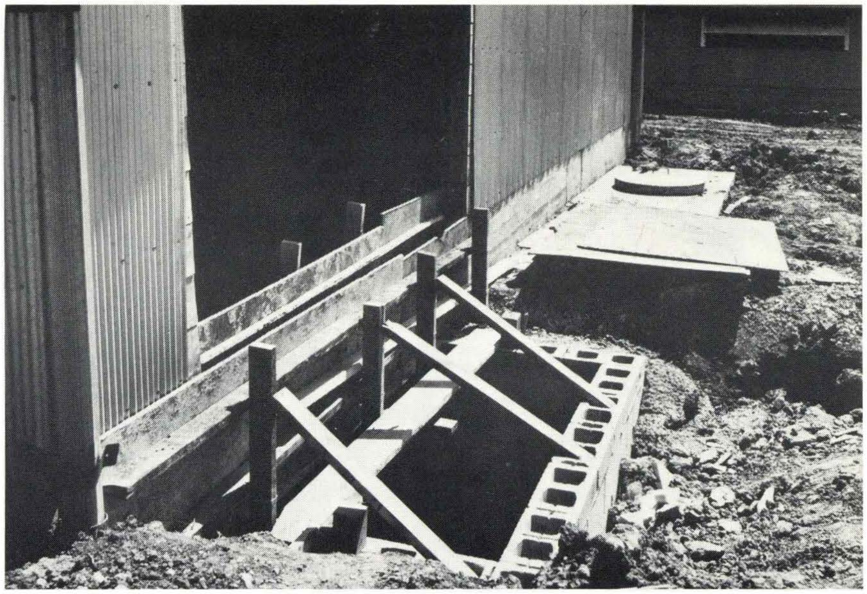
The buildings are 100′ by 40′ — with shallow pits (two feet deep) built level from end to end and utilizing a trickle tile to move effluent to the lagoon.

No problems of consequence have come up. The pits are drained and cleaned once a year. Experience has taught this operator to do the pit cleanup in the spring, when bacteria buildup in the pit will be more rapid. (Others make it a management practice to leave some solids in pits to insure bacteria count for solids breakdown.)

This operator uses a commercial manure treatment, which he says has "nearly eliminated all odor problems." The additive is sprinkled in the pits, and costs are "just a few cents per head."

Nor is odor a problem in the lagoon, he says. "Not as much as a hog lot." His lagoon is about a half-acre in size, up to six feet deep, and is "more than adequate." In fact, he believes that he could double his

This nursery building is being remodelled for total slats over three pits, with outside sumps for removal of waste.



pork output and still have lagoon capacity "by restoring the original banks where it has filled in a little."

Costs for this system are considered "reasonable." The shallow pits are less costly, once-a-year clean-up is a "tremendous" labor saver, and "there simply is no handling. A shovel doesn't fit my hand well."

Little can go wrong with this system, he says. They've never had a tile back up . . . so the trickle tile keeps itself clean. Manager says "the next time, I'd line the buildings up in a straight line, save some tile, improve the flow to the lagoon."

He doesn't attempt to relate fertilizer value to cost of the system, but did mention that if "fertilizer costs go up much more, we could probably pump out the lagoon."

Ventilated

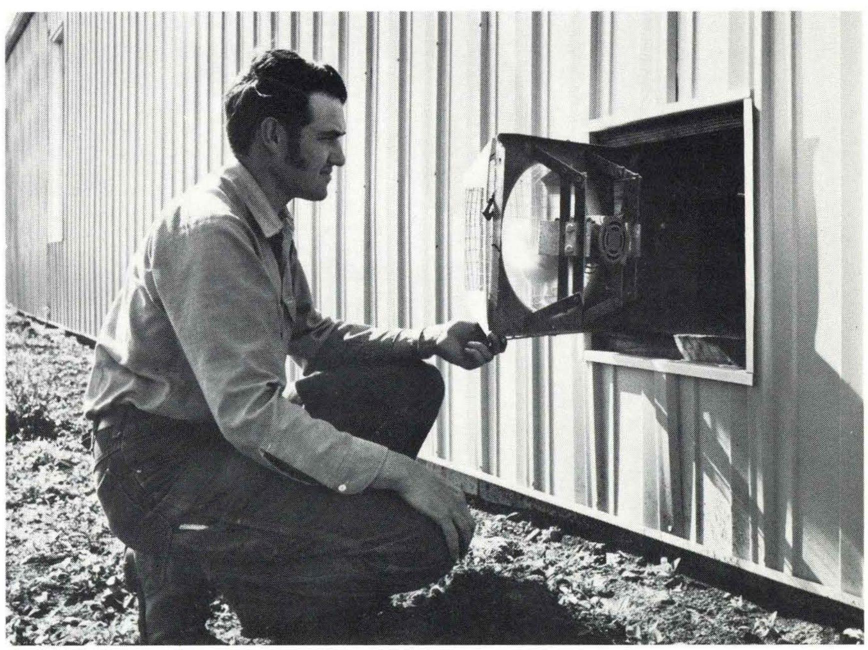
Buildings are well ventilated, with air movement pulled from the top down and out the bottom. Continuous air movement is working. He's had no health or growth problems, even with little pigs. They have weaned at two weeks, moved 19-pounders from the nursery at four weeks, and they "kept on growing."

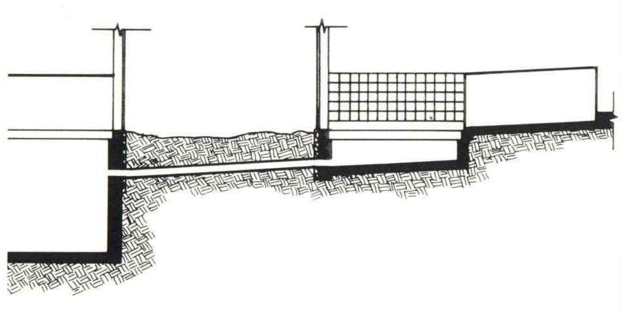
A young farmer east of Des Moines hooked up shallow pits in his nursery building with high-capacity 8-foot pits under his 200 x 52 foot finishing house.

The nursery pits, only two feet deep, slope toward the center to a 12-inch gutter which drains into the finishing house pit "next door."

This huge pit, under the total slats, is pumped through swing-away fan mountings, five on each side wall. The pit is not sloped, since cost is higher

Low-level ventilation fans in this installation are hinged to swing out, and pit is emptied through the fan openings.



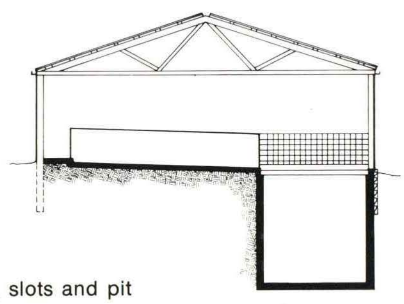


Shallow-to-deep-pit storage

and this operator feels sloping is unnecessary. "Manure makes its own slope."

Emptying the pit means about 200 loads every six months. A part-time high school boy does the hauling, and admits it "gets to be a drag."

This operator figures that the key factor is "having a pit large enough to allow flexibility in the timing for spreading."



Open front, slots and pit

He makes an interesting comment that "an eight-foot pit is really only six feet in capacity. Take a foot off the bottom for buildup, and a foot off the top for safety, and you really have six feet for storage." They drain as empty as possible each time they haul.

This producer believes that his "hooked up" system is near capacity to handle 500 head in the nursery and 1,000 head on finishing floor. To expand, he'd have to add buildings. These could also use the same pit . . . but would require more frequent hauling so "essentially we're at capacity now."

Costs are, in the operator's opinion, very reasonable. Installed in a new building, the eight-foot pit plus slotted floors cost about $20,000 . . . plus a liquid spreader. He thinks the manure value as a fertilizer "about equals" what it costs to handle and spread.

Should environmental regulations get tougher, he thinks he can meet them by knifing in the liquid waste. He has no apparent odor or runoff problems now on the "spreading" end . . . and believes his ventilation must be suitable because he has no special odor problems inside the buildings "for that many hogs."

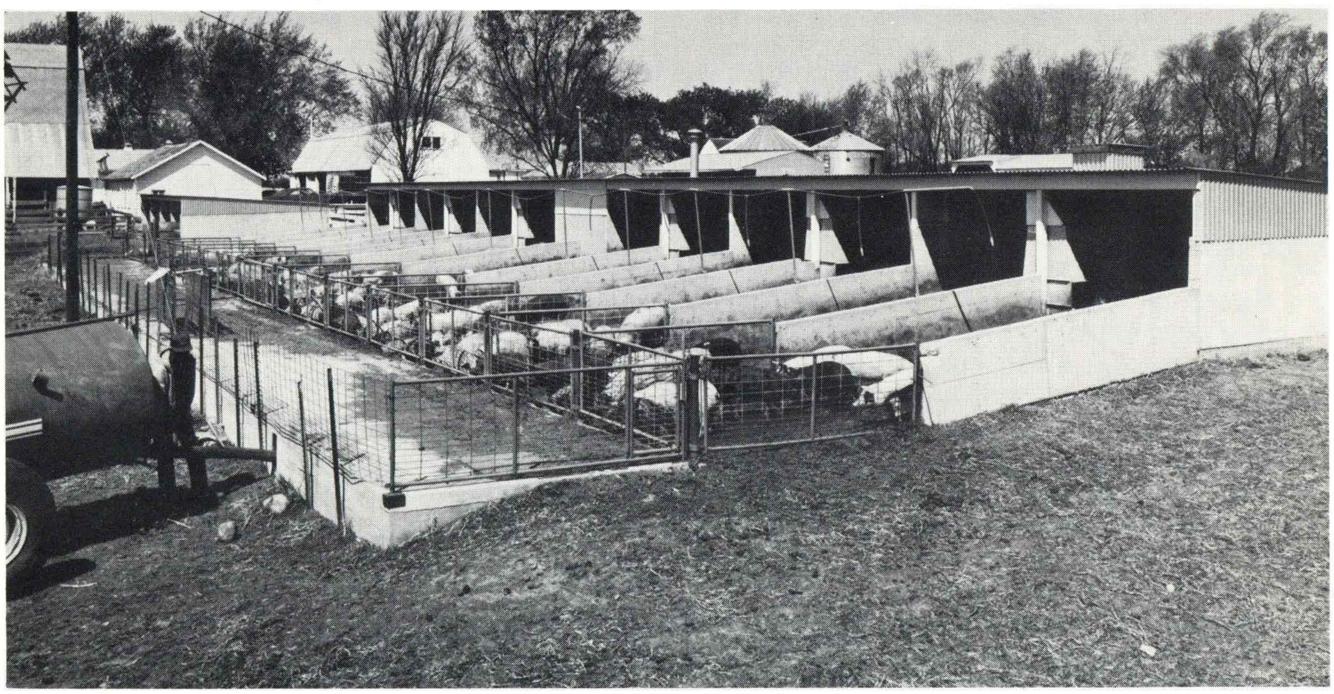
Combination Unit

A south-central Iowa confinement operation features a new building which is a combination nursery and finishing units. Hogs are farrowed on a separate farm.

The nursery area is 20 x 42, with partial slats over a full pit. The finishing area is 42 x 100, using two six-foot wide pits built eight feet deep.

Floors in the nursery are sloped ¼ inch per foot; in

This open-front finishing unit features a covered storage pit at the end of the feeding floor. Outside storage eliminated need for mechanical ventilation.



the finishing area, ½ inch per foot.

He's had no problems with this waste system, except that it requires more water than he had expected, and water is added.

Costs are reported to be "reasonable" . . . cheaper, he believes, than scraping solid floors. He hauls once a month when possible, says it takes 30-35 hours to pump and spread 90 loads. "It is difficult to place a value on the manure, even with commercial fertilizer so high. But waste has to be spread anyway, so if it offsets the cost of spreading that is actually gravy."

This operation has caused no complaints, but he "never loses sight of the possibility." There is a small stream 400 feet from the facility and a neighbor 800 feet to the southeast.

If he were to "start over," he'd change locations. He is now 300 feet from the road, and would prefer to have the building set back a quarter-mile to escape traffic and reduce possible odor problems.

He has thought about adding a lagoon, but isn't sure whether his location would permit this. Expansion will mean a new building with more pits . . . and more hauling . . . but he "may" expand.

Ventilation system provides continuous fresh air with good circulation, so he's had no problems with health and growth . . . is generally quite pleased with the entire setup.

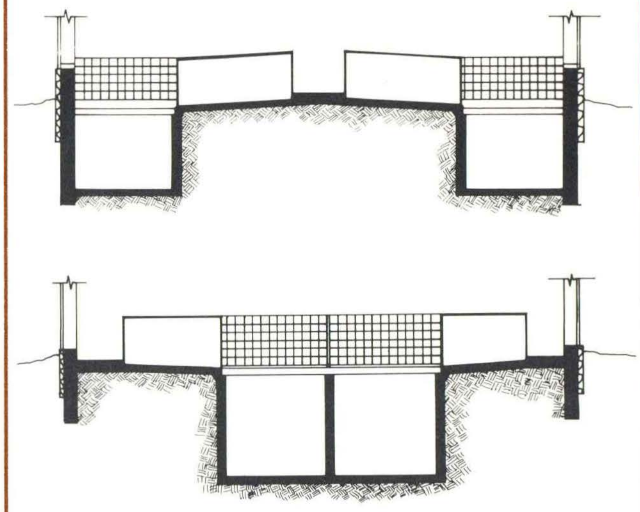
Barn-Scraper

In northwest Iowa, we visited an operation which utilizes a kind of "variety pack" of facilities. The farrowing house, 24 x 82 with 26 stalls, features a dairy-barn scraper circling the two rows of stalls and emptying into a pit at the end of the building.

The nursery is a converted chicken house, 24 x 24, partially slatted over a single pit four feet wide and four feet deep . . . handles 180 pigs.

The finishing unit is a solid floor open front 40 x 128 feet, with 20 feet roofed and 20 feet open to the south. Waste mostly works its way to lower end and a storage pit via a floor slope built at 1¼ inch per foot.

This manager makes his system work well for him. Labor is his chief concern, since he has no boys or part-time help. He is especially pleased with the use of the scraper to remove waste (and odor and gases) from the farrowing building.



Outside-inside partial pits

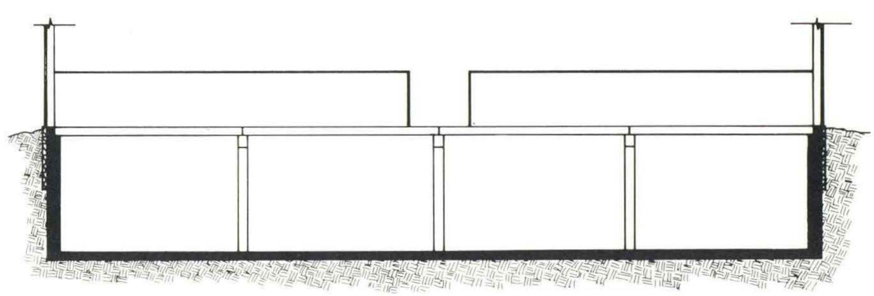
The finishing unit can be pumped out in about eight hours, the entire system can be emptied and spread in two man-days. This operator leaves some semi-solids in the pits, because he feels that bacterial action helps keep odor down. A complete cleanout, he thinks, causes more buildup.

Air and water pollution are recognized problems. Although he has no close streams, he does have close neighbors. "We keep in touch with the neighbors, and so far they haven't complained of odor. I think we can meet almost any regulations required for hogs. I'd probably have to do some work to meet requirements on my dairy operation."

Manure, he feels, is well "worth the time and effort put into it. With fertilizer prices of today, I'm sure it's a net gain."

He likes his open-front finishing unit. Says he doesn't have to fight maintenance with a ventilation system, and believes that his floor slope must be about right because he has "never had to scrape this floor."

Full slots, full pits



Solid floor, flush gutter, lagoon

Developed over a 13-year period at Iowa State, this system uses effluent from the lagoon to flush waters from confinement buildings into the treatment system.

Initially, a mechanical gutter scraper was used to move manure from the pens. In a later adaptation, flushing cleared the old scraper channels. Originally, a trickle of fresh water was run continuously in the gutters, with a "full flush" two hours each day.

For several years, ISU engineers have been refining systems. At one time, oxidation treatment of the anaerobic lagoon liquids was tried, with the treated liquid returned to the swine house for flushing. Held in elevated tanks, the fluids were released to flush channels every hour. This system moved the manure, but the complicated arrangement of time switches, electromagnets and valves was a "mechanic's" nightmare, which later was simplified by a straight pumping arrangement using siphon-flush tanks with no moving parts.

In the original research work on waste handling, the ISU setup ran all wastes and the flush water into the lagoon. Overflow drained into a creek. By re-using lagoon liquids for flushing, overflow is reduced . . . and when the lagoon does fill up, surplus is applied to cropland via an irrigation system.

In studies related to waste handling, ISU researchers have been checking the effects of applying the anaerobic lagoon effluent to cropland. Their work indicates that up to 250 pounds of nitrogen can be applied per acre per year without significant increase in nitrogen levels in tile drainage. Recommendations are that farmers test soil for plant food needs, and test effluent, so that waste can be applied at rates desirable for planned crop yields. (Effluent can be commercially tested for around $20 — and researchers agree that the testing is worth the money.)

Odor is said to be the major problem remaining in the lagoon system. The ISU engineers consider 5,000 hogs to be the maximum in one location with this system, until odors from large anaerobic lagoons can be controlled.

Cost estimates for a system to handle 1,000 growing-finishing pigs include such items as these: (These costs were set "fairly high" when figured in late 1973, but may be somewhat conservative a year later.)

four flushing tanks	$ 400
sewer line to lagoon (100 ft.)	$ 400
digging, landscaping, fencing lagoon @ 17 cents per cubic yard	$ 4,800
pumping equipment for recycle system and plumbing	$ 1,000
irrigation equipment for 45 acres, including a pump, 3 takeoff points and a gun	$18,000
miscellaneous electrical costs	$ 500

With an output of 2,000 finished hogs a year, this system would cost about $3.15 per head spread over 10 years. (Details on design, construction guidelines and equipment for this system are available. Ask for AS-391, cost $1, from the ISU Extension Service, Ames, Iowa 50010.)

Aerobic treatment, pit or lagoon

Because waste storage, in pits under slats or in systems moving waste to lagoons, faces the non-stop problem of odor, and because there are obvious advantages both to storing waste close to the production unit and to storing the manure for longer periods of time, considerable work has been done on aerobic treatment systems.

Although not in common use, this "oxygen added" treatment is being developed for both in-structure use (oxidation ditch) and the aerated lagoon.

It involves a natural process of bacterial action on manure solids, with the bacterial "treatment" speeded up by the mechanical addition of oxygen to the waste in the pit or lagoon.

Aerobic digestion of swine manure has been studied since 1964 at the University of Illinois. Testing determined the minimum capacities of the digester (at least 8 cubic feet per finishing hog,) flow rates which are sufficient to keep solids in suspension, patterns for ditch construction, operation of the rotor, and so on.

Waste can be removed from the oxidation ditch in batches (pumped out periodically), or by a continuous-discharge method where the ditch overflows and gravity carries the effluent to a lagoon or holding tank. (Because effluent still carries NPK, it cannot be simply fed into a stream.) This latter method allows the rotor mechanism to be operated continuously at a constant-immersion depth, and requires less management attention.

Mechanically, the oxidation ditch requires use of a cage rotor, which aerates the waste matter and moves the liquid around the ditch in a closed circuit. This constant circulation of the waste materials furnishes oxygen at each "pass" through the rotor blades. Rotation speeds range from 60-120 r.p.m. Rotor size and speed depend on oxygenation required, desired liquid velocity and the channel of configuration.

NPK in swine waste

Researchers report the quantities of NPK provided from swine manure on a basis of annual live weight on the farm. The Iowa Water Quality Commission used these figures: on a basis of 1,000 pounds of live weight annually, hogs produce 182 pounds of nitrogen, 73 pounds of phosphorus, 91 pounds of potash.

Producers will find it easier to compute the plant food elements provided by swine waste on a per-head basis. Based on a ration using an average of 13 percent protein for farrow-to-finish hogs, each will leave 18 pounds of N on the farm. Each pig sold at feeder-pig age leaves about 6 pounds of N, each feeder pig fed out produces 12 pounds of nitrogen.

On a parallel scale, each finished slaughter hog leaves about 8 pounds of potash, about 7 pounds of phosphorus. On this basis, multiplying the number of hogs finished will give an approximate measure of the basic soil nutrients salvaged as manure.

Since considerable nitrogen losses occur when oxidation ditches or aerobic lagoons are used, farmers who want to bring soil needs up to actual test levels will want to have their waste analyzed for actual NPK content, spread it at safe levels on soil, and make up any difference with commercial plant food.

Threats to the soil

Disposal of animal wastes at high rates of nutrient application can pose threats to the soil itself, as well as to other environmental factors. These threats include movement of animal wastes by runoff water from the land to surface water; percolation of nitrogen applied in excess of crop needs; possible buildup of soil phosphorus, salts and potassium which could affect seed germination and plant growth; and a buildup of toxic chemicals (arsenic, copper, etc.) derived from feed additives and carried in animal wastes.

These hazards are affected by the analysis of the wastes; time, place, rate and frequency of application; crop utilization of the nutrients; topography of the land; physical-chemical characteristics of the soil; erosion characteristics; climatic conditions; ground and surface water movement, and water runoff and erosion control installations.

While research information currently available is insufficient to provide specific answers, guidelines are being developed for waste disposal practices which will protect both environmental and crop-growth problems.

In general, rates of application are within the areas of safety when based on bringing the soil to desired rate of fertility, with annual removal of NPK considered. Recommendations regarding nitrogen: not more than 250 pounds per acre per year, and this only where crop management requires high nitrogen inputs.

Phosphorus applied above a test level of 45 pounds per acre is apparently not helpful to crops . . . but the same tests show no damage to crops at test levels up to 100 pounds of P per acre. Upper limits, at which additional phosphorus would be harmful, are not yet established. Since a bushel of corn removes 0.15 pounds of P, yield factors determine the amounts of phosphorus to be replaced each year to maintain the soil at test levels between 45-100 pounds per acre.

Comparative costs

It is difficult to develop precise cost comparisons for the many types of waste management systems. On-farm labor costs are considerably less than professional builders. Equipment costs vary substantially, as do prices for the many kinds of slatted floors, etc.

Purdue University released a study of waste system costs in December, 1973. Costs were assessed against six possible functional components: separation, collection, transfer, storage, treatment and transport. (Not all of these, of course, would be included in all systems.)

Uniform costs were assumed for the following: formed and poured concrete, $50 per cubic yard; pits designed for 4 inch floors, 8 inch pit walls, 4 feet deep; concrete slats, $1.55 per square foot installed and supported; excavations, 50 cents per cubic yard of capacity.

Facilities and equipment were set up for a 10-year depreciation schedule (except for wood slats, 5-year schedule); interest on investment, 7 percent over 10-year life span; repairs, insurance and taxes, 2.5 percent of earthen and concrete storage structures.

No charge was made for disposal acreage. Labor was computed at $2 per hour (minimal). Waste production was figured at 1640 pounds per hog over 18 weeks.

Costs were applied only to components of the waste system, and not to housing, feeding and watering equipment and such.

Because the capacities of the finishing facilities studied varied from 600 to 2,640 head, and because cost per head is affected by size, comparative costs are shown on a "per head **produced**" basis. Purdue researchers assumed a yearly turnover averaging 2.5 hogs per head of capacity (2½ 18-week finishing periods to move animals from 40 to 210 pounds.)

System	Description	Capacity	Cost/head
A.	Full wood slats, concrete pit, earthen bottom	1,134	$ .98
B.	Partial wood slats, collection pits, two-stage storage	2,640	$ .75
C.	Full wood slats, collection basin, hold-in basin	1,296	$1.11
D.	Flushing, two-stage lagoon	1,024	$1.11
E.	Partial slats, concrete storage	312	$2.10
F.	Concrete slats, concrete storage	600	$1.84
G.	Concrete slats, oxidation ditch, concrete storage	600	$3.89

Looking ahead

Swine waste handling has moved up on the management scale as a combination of larger herds, confinement and early environmental regulations have forced farmers to take a new look at an old chore.

At this point, no single "best for everybody" system has been developed. A number of handling-storage-disposal systems are in use and can meet anti-pollution standards regarding water pollution. Regulatory actions are expected to follow covering air pollution — so sites, systems and management will become increasingly geared to odor problems.

In-depth studies are being done on aeration of pits and lagoons to control odor. Experiments have been started on the conversion of swine waste to useful methane gas . . . and on the use of dried waste solids for "recycling" in feed.

Most observers feel that trends to larger herds and to confinement housing will continue. Fertilizer shortages have caused many producers to pinpoint the value of swine waste as plant food, and to consider the availability of sufficient land on which to spread the waste. Research is underway to determine the maximum use of swine waste per acre.

Labor, investment and operating costs, management requirements and environmental factors are all involved in hog production planning these days . . . and will continue to determine the systems as individual farmers plan their swine operations.

Information Sources

Scores of research and experimental projects are underway relating to swine waste handling. The sources listed here offer useful (and recent) information for producers considering new facilities and waste systems. Please mention the bulletin number when requesting University brochures.

Waste Management: AS 391-G, by Smith-Hazen-Parker, Ag Eng., Iowa State University, Ames, Iowa 50010.

Carries an excellent outline on basic requirements for manure handling systems, lists alternative systems, and covers in careful detail the construction, costs, operation, and explanations of the flush-gutter, anaerobic lagoon, irrigation system developed at ISU.

Aerobic Treatment of Livestock Wastes: Bulletin 737, by Jones-Day-Dale, University of Illinois/Purdue University. Write either University (University of Illinois, Urbana, Ill. 61801; Purdue University, Lafayette, Ind. 47901) for a copy.

Starting with the theory of aerobic treatment, this bulletin capsules much of the work which has been done on "oxygen-added" treatment of animal wastes in both "in-building" and lagoon systems. Also covered, mechanical requirements for rotors, formulas for operation of rotor (speed, immersion), sludge removal. A most useful tool if you're thinking of bacterial treatment of your hog wastes.

Managing Anaerobic Lagoons For Minimum Odors, by Robert George, Ext. Ag. Eng., University of Missouri, Columbia, Mo. 65201.

Management tips for effective use of lagoons. Emphasis on management to minimize odors. Brief, farmer language.

Aerobic Treatment of Livestock Wastes: by John C. Nye, Chief, Agricultural Permit Team, Region V, EPA, One North Wacker Drive, Chicago, Il. 60606.

Features sets of worksheets for developing oxidation ditches and oxidation ponds based on type of livestock, raw manure production rate, other production factors. Includes pumping, oxygenation capacity and power requirements.

Effects of Waste Management Systems on the Animal's Environment: by J. A. DeShazer, Assoc. Prof., Ag Eng., University of Nebraska 68503.

A short review of gaseous environment as influenced by waste handling systems. Comparisons, open-front versus confinement buildings. Concentration of gases during pit agitation and pumping. Frequency of waste removal. Humidity levels related to ventilation.

Cost factors of Swine Waste Management Systems, Journal paper No. 5315, by Horstfield-Gottbrath-Kadlec, Purdue University, Lafayette, Ind. 47901.

These studies covered five unique waste handling systems for confinement finishing hogs, and compared with two common systems for both cost and non-cost factors. Such non-cost factor "scores" are included as odor control, water pollution, management requirements, operational ease, expansion.

Confinement Swine Housing, Publication 1451, released 1971 by the Canada Depart., by Turnbull-Bird.

This 72-page book is a highly practical treatment of housing and related requirements for confined hog raising. Major sections include building arrangement, construction, ventilation and environmental control, swine waste handling systems. For copies, contact Information Division Canada Department of Agriculture, Ottawa, KIA OC7.

Swine Housing and Waste Management, A. J. Muehling, Ext. Ag. Engineer, University of Illinois, Urbana, Ill. 61801.

Effects of Environment, Vernon Meyer and Larry Van Fossen, Ext. Ag. Engineers, Iowa State University, Ames, Iowa 50010.

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