September 2009 E.B. 2009-16

Bedded Pack Management System Case Study

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The development and publishing of this document was a collaborative effort between Cornell University, Cornell Cooperative Extension of Delaware County and the Watershed Agricultural Council. The project was funded through a Natural Resources Conservation Service, Environmental Quality Incentive Program -- Conservation Innovation Grant received by the Watershed Agricultural Council.

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The project was funded through a Natural Resources Conservation Service, Environmental Quality Incentive Program -- Conservation Innovation Grant received by the Watershed Agricultural Council.

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Bedded Pack Management System
Case Study

Manure storage and application present challenges for managers of many small dairy farms. To be sustainable, manure systems must be environmentally sound, socially responsible and economically profitable for the farmer. One manure management system in limited use for dairy cows is a bedded pack. A bedded pack management system (BPMS) is defined here as a covered barnyard and feeding area that houses a variety of dairy cattle, storing their manure through the accumulation of an unturned bedding of dry material for later use as a nutrient amendment.

The bedded pack management system may provide an effective alternative to the traditional suite of best management practices: manure storage, barnyard runoff management system, and improved feeding area/heavy use area protection. This case study evaluated the practical elements of BPMS design and the labor, management, and economic implications of the BPMS that was implemented on a farm participating in the Watershed Agricultural Council's Agricultural Program in the New York City Watershed.

With its positive environmental benefits, it was believed that the BPMS might provide a greater economic return than a liquid manure system, due to a significantly lower capital cost (versus a liquid manure storage and transfer system, concrete barnyard and feeding area), a reduction in farm labor, and enhanced cow comfort. This system, in conjunction with seasonal grazing, was expected to provide for economical feeding and management of dairy cattle. Farmers that house their cattle year-round will likely find the high cost of bedding with the BPMS economically prohibitive. Bedding cattle year-round in a pack system effectively doubles the use and cost of bedding (12 months versus 6). The additional bedding costs associated with a pack system are offset, to a degree, by savings on construction and maintenance of tie or free-stalls, though that analysis was not part of this study. It was also expected that odors associated with storing manure in the pack and during unloading and spreading would be significantly less than with a liquid manure system.

The BPMS was implemented on the case dairy farm to resolve significant environmental issues, specifically potential farmstead runoff of nutrients and pathogens due to the year-round outdoor housing and feeding of cattle, wet field conditions when manure was applied, and limited access to fields during winter. The dairy consisted of approximately 35 cows, 105 acres of hayland and 65 acres of pasture. The farm was not equipped to handle liquid manure. The farmer did not want to implement a liquid manure system due to potential odor and neighbor complaints and did not believe liquid manure was the best agronomic form of manure to apply to hayfields and pasture. The dairy cattle were on pasture six or more months of the year, and cows were milked in a milking parlor housed in a former tie-stall dairy barn. Milkhouse and parlor waste was stored and spread using a very small tank spreader. The Whole Farm Planning team, consisting of a conservation planner, engineering staff and the case farmer, decided that the bedded pack management system was the best solution.

The results of the study will be explored in four parts: BPMS Planning and Description; BPMS Labor, Management and Economic Study; BPMS Bedding Usage and Pack Compost Analysis; and BPMS Summary and Recommendations

BPMS Planning and Description

Note: The Case Study BPMS planning information and sketches below are for educational purposes only. It is intended that this information will be used in conjunction with a design team including a licensed professional engineer that is familiar with load bearing and other design requirements, building construction, dairy facilities, animal health and care, economic considerations, environmental concerns and farming operations. Check with local authorities and the farm's milk inspector to determine permitting and inspection requirements.

Purpose

The facility was designed to house a 50-cow milking herd for 6 months, approximately mid-November to mid- May, depending on the weather. The farm's average weight per cow was 1,000 lbs. The facility was planned as a natural wood-sided structure with a steel-framed, fabric-covered, roof structure (Figure 1). The facility floor was modified to compacted local road gravel, with wood chips separating the gravel from the bedding.

The facility was designed to allow the animals adequate feeding and resting space and to provide storage for 100 percent of six months' manure and bedding. The system allowed the farmer to bed the animals as needed and to feed forage using round bale feeders. Manure was to stay in place where it landed on the pack. The farmer was to add layers of straw bedding as needed to allow the animals to stay clean and comfortable. Forage feeders (in this case, large round bale feeders) were to be relocated when necessary to evenly distribute the manure and bedding around the structure. The bedded pack was planned to elevate during the housing period.

Design considerations for the facility included animal behavior and comfort, manure and bedding accumulation, ventilation, traffic patterns of cattle and equipment, site and material constraints, structural wall and roof design, and facility utilities. The following is a breakdown of the BPMS planning process.

Figure 1.

Bedded Pack Management System
Covered Manure Storage, Barnyard and Feeding Area

Animal Behavior and Comfort

The size of the facility was based on information provided in the "Dairy Housing and Equipment Systems" [(Northeast Regional Agricultural Engineering Service-(NRAES) 129, pg 334], Penn State Dairy Housing Plans (NRAES-85, pg 75), and University of Minnesota website: www.extension.umn.edu/dairy/management/compostbarns.htm. These sources indicated that the square footage of resting space per animal in a bedded pack facility should be 80-100 sq ft.

Subsequent to the planning of this structure, NRAES published "Penn State Housing Plans for Milking and Special-Needs Cows" (NRAES-200, pg 42) which calls for providing a bedded pack area of 125-150 sq ft per animal, along with a feed alley. The case farm's cows were significantly smaller than the industry average. If one assumes the average weight of a dairy cow is 1,400 pounds, this publication would indicate that the building should provide 89-107 sq ft per animal (1,000# cow ÷ 1,400# cow x 125-150 ft sq per animal) and a feed alley. The authors were unable to identify a source with recommendations for additional space requirements if a feed alley is not incorporated into a bedded pack facility.

Decreasing the square footage per animal increases the need to use bedding material. To put it another way, the more concentrated the cows and manure, the greater the need to add bedding to keep the animals clean and comfortable. Increasing space per animal provides for broader distribution of manure, which allows the manure to dry and for urine to infiltrate into the pack.

Caution: With the high cost of bedding material, producers may be inclined to under-bed their facility which can result in sloppy bedding conditions and filthy cows.

The 50 ft x 100 ft facility was designed to provide 50 mature dairy cows with approximately 100 square feet per animal for a total of 5,000 square feet. This space was also expected to accommodate bale feeders and equipment access when feeding and bedding the cows. The final design interior dimensions were 49' 5" x 102' 8", providing 5,082 square feet.

Manure and Bedding Accumulation
Ten foot high side-walls were intended to provide for 6 ft of manure and bedding storage, with the additional height to accommodate ventilation windows and buck wall areas. Manure accumulation in the 50-dairy cow facility over a six-month period was calculated to be approximately 12,510 cu ft, based on "Livestock Waste Facilities Handbook", Midwest Plan Service-18, Table 2-1, pg 2.1. This computed to 2.5 ft of storage depth in a 5,000 sq ft facility. Bedding was estimated by visiting multiple facilities in Northern Vermont and comparing the animal numbers, cleanliness, and area of the facility.

Ventilation
Since the animals would be housed in the facility during the winter months, there needed to be adequate ventilation through the structure to provide for air exchange for the cattle and to remove moisture without creating excessive drafts. During visits to facilities in Vermont, it was learned that pack barns can get rather dusty when removing the pack at the end of the winter housing period so there is a need for adequate ventilation.

With a total sidewall height of ten feet, the design team and farmer concluded that the standard curtains with a pulley system would be difficult to routinely maintain. Instead, windows were incorporated into the sidewalls with the expectation that the farmer would cover these openings with plywood or plastic as necessary. The end-walls were designed to be half shade cloth and half fabric, allowing air movement through the structure.

Post-construction experience showed that during the winter, cows were comfortable in the structure, so it was not necessary to cover the windows. The farmer adjusted the end-wall doors as necessary to allow for additional airflow. The farmer did not experience dusty conditions when removing the pack.

Traffic Patterns
A laneway was built around the structure to allow the farmer to move the animals to the parlor during the summer months without going through the BPMS. The laneway also provided a route for the farmer to navigate farm equipment when the facility was in use. The facility was constructed to allow drive-through access when adding bedding, when removing the pack, and to allow cattle to exit both ends of the building. A service door was added for easy access when doing barn chores.

Site Constraints and Materials

The site was located in a narrow valley adjacent to a town road and stream. The watershed above the site was large and steep. Surface runoff from the hillside was captured by a stormwater control system consisting of surface inlet settling basins and an underground outlet system. The runoff from the roof structure and snow pack was captured by drip trenches and ditches on the perimeter of the structure.

The farmer requested that concrete and pressure treated wood not be used on the structure, so modified compacted gravel road material was used for the floor; wood chips separated the gravel floor from the bedding. Among other benefits, the layer of wood chips provided the farmer an indicator of where the pack ended when being removed. The design team researched alternative wood species in place of pressure treated lumber and selected black locust and tamarack: locally grown, very strong, and durable. Inherent resins in black locust and tamarack make them naturally resistant to decay and rot.

Sidewalls and Roof

The facility consisted of wood sidewalls and a steel-framed, fabric-covered roof structure (See sketches, Appendix A-C). Forces on the structure accounted for by the structural design engineers include, but are not limited to, the lateral forces of the manure on the side and end walls, vehicle and animal forces pushing on the walls and surcharging of the manure pack, the steel truss forces on the support posts, wind forces, and snow loading.

The steel truss manufacturer designed the trusses to the approving structural engineer's loading criteria. The project structural engineer designed the sidewalls for the ground bearing, uplift, and live lateral forces.

The structural engineer took into account properties of the wood materials used, on-site soil conditions, the truss fastening system and steel fasteners, and the required loading conditions. The walls were composed of rough cut tamarack planks that were nailed and lagged to rough cut locust posts. Using the tamarack and locust materials was less expensive in terms of materials and labor than pressure treated SPF lumber.

Facility Utilities

One waterer was designed for the facility; a second was installed by the farmer. Since the level of the bedded pack continually rises with the addition of bedding material and manure, the waterers need to rise along with the pack; the farmer would add wood cribbing as needed. The designed waterer, located on a sidewall, is plastic, insulated and heated, with flexible water and electric lines enclosed in an insulated tube riser. The airspace around the water line within the cribbing was expected to act as additional insulation to the water supply. Electrical service for lighting and outlets was routed to the facility along with the water line. The waterer installed by the farmer was fed by a water line buried in the bottom of the pack. This waterer was larger and more centrally located on the pack, allowing cows to access from all directions.

BPMS Labor, Management and Economic Study

Purpose

The intent of the labor assessment was to determine how the Bedded Pack Management System affected the efficiency of labor on the case dairy farm. In order to do a complete analysis, the case farmer was interviewed before the new barn was constructed to determine how time was spent utilizing the old outdoor system, a bedded pack with a windbreak, used primarily in the winter. The farmer grazed the herd from mid-April to mid-November. Tasks were outlined and time spent on these tasks was documented (Figure 2).

The farmer was given formatted time sheets to document his workload after the covered barnyard pack was in place. Daily data collection when cattle were housed in the BPMS began in December 2006 and ended in May 2008. The most significant data was for the winter months when the barn was in full use and the data related to the effort expended to remove the pack from the facility. Labor study data for the Pre-BPMS baseline was also compiled in December 2006. A conventional grazing farm in the area with a similar herd size was studied to make a comparison of labor usage between a conventional tie-stall barn system and the bedded pack management system. Each farm had between 1.75 and 2.00 worker equivalents. The financial analysis results will be presented as Prior (prior to BPMS implementation), Year 1 (first full year of implementation) and Year 2 (second full year of implementation).

Labor and Management

Milking and Pre-Milking Preparation - The time spent doing regular milking and chores was reduced when the new structure was completed. The majority of the savings was in pre-milking udder preparation and clean-up, mainly due to cleaner cows. In addition, an improved walkway to the parlor helped cows move in and out of the holding area more quickly. Milking and pre-milking preparation time savings ranged from 45 minutes in the summer to 50 minutes in the winter. Preparation took longer in the summer, because the cows had to move from a distant pasture into the holding area.

Pack Management and Cow Feeding - In the old outdoor system, pack management consisted of adding hay or straw as needed, usually every other day. During the Year 1, the farmer used straw that was not processed as a bedding material. Pack management time was decreased by 6 minutes versus using the outdoor pack. It took 6 more minutes per day to manage the pack in Year 1 (add straw) than it did in Year 2, when primarily processed straw was used. The processed straw broke up more easily, making the bedding process quicker. Removal was also easier because the pack broke into smaller pieces that were easier to collect using a skid steer loader and grapple attachment. The case farm forage feeding consisted of placing round hay bales into feeding rings. This system was a labor-efficient way to feed forages. Grain was fed to cows in the parlor.

In Year 1 it took 13 minutes longer in the BPMS than in the previous system to feed baleage, as the skidsteer had to maneuver into the barn rather than just to the outdoor pack area. Hay was fed daily. By Year 2, the farmer only spent 5 minutes more feeding round bales versus the old system. The plan for Year 3 was to move the calves out of the facility to provide more area to feed baleage, resulting in more even use of the pack.

Calf Feeding and Bedding - During Year 1 it took 32 minutes and in Year 2, 38 minutes less to care for the calves from the original outdoor system since they were in the same structure as the cows, out of the weather and easier to care for on a daily basis. However, the cows were more crowded, and the desire to fill the structure with 50 mature cows in Year 3 will dictate moving the calves out of the structure. It is more biosecure for calves if they are in a separate facility, but more time will be needed for their care. The farmer used two bale feeder rings in Year 1 and three in Year 2.

Herd Health/Heat Detection - It was more difficult and more time consuming to perform this task with the previous outdoor system due to the cow behavior, slippery surfaces, and the animals' exposure to poor weather. The BPMS enabled the farmer to move freely among the cows and observe them on the pack surface. Approximately 10 minutes per day was saved on this task in the new structure, and cows behaved more naturally.

Water System Management - The outdoor pack system was not conducive to managing water efficiently, especially in cold weather. An average of 15 minutes per day was required to ensure that cows had water and to make any necessary repairs when they were on the pack outside. When the cows were housed in the BPMS the central waterer (installed by the farmer) stayed flush with the pack; heat generated in the bedding and the heaters in the waterers kept the system from freezing. Also, the cows were more willing to access water which was not frozen and thus more easily available. Very little time was spent on water system management which consisted of occasionally raising the waterer as the bedding height rose, keeping the waterer accessible to the cows. More efficient systems to raise the waterers would be helpful. The designed waterer tended to freeze during winter, likely due to its location on a wall. Insulation between the wall and waterer probably would have resolved this issue.

Miscellaneous Barn Management - Not needed in the outdoor system, this task took only 7-10 minutes a day. Tasks included monitoring ventilation and mechanical operations and assessing livestock damage to the barn.

Scraping the Milking Parlor Holding Area Entrance Pad - The previous outdoor system required about 15 minutes every other day to keep the pad clean. With the cows in the BPMS, that time was cut by more than half. With the old system, animals were provided water in this area. With the BPMS, animals were watered on the pack. Animals tend to manure when watering, so watering the cows on the pack reduced manure deposited on the pad.

Manure Spreading – To keep up with manure accumulation, the old system required 34 minutes every other day to spread manure removed from the outdoor pack. With the BPMS, spreading of manure taken from the pack during the winter housing season was virtually eliminated. The only manure needing removal was from the milking parlor holding area, the entrance pad and the laneway from the BPMS to the milking parlor.

However, there was a large increase in labor associated with the spring removal of accumulated bedding material and manure from the barn and in hauling the material to a composting area. After the first winter, 160 hours were spent removing and spreading the pack into a compost pile using two manure spreaders. There will be additional labor associated with loading and spreading the composted material.

Record Keeping – Record keeping on the case farm increased marginally over the study period because the time study required the farmer to log in times as they related to various tasks on a daily basis. Other kinds of record keeping remained the same.

Udder Health - General udder health of cows was studied by charting milk tank somatic cell count results for the winter prior to BPMS implementation and the two post implementation winters. The monthly average pre-BPMS implementation bulk tank somatic cell count (SCC) level was 219,000, decreasing to 173,000 in Year 1, and increasing to 216,000 in Year 2. This data seems to indicate that the BPMS had no effect on the herd's udder health as measured by SCC levels. The average age of cows increased during the study, and some "problem" somatic cell count cows were kept to maintain farm milk production, so assessment of the data was difficult. It can be concluded that the farm's somatic cell count was excellent before and after BPMS implementation. In addition, it is imperative that farmers adopting the BPMS use enough bedding to keep the cows' udders clean to promote udder health and quality milk.

Economic Study

Financial Analysis - Three years of financial data using the Cornell Dairy Farm Business Summary Program (CDFBS) were collected on the case farm from 2005 to 2007. This data helped to define the financial performance of the farm before and after the BPMS was implemented. The average number of cows was consistent over the three years at 34-35 cows; youngstock numbers grew from 18 to 32. The case farm was a start-up operation at the beginning of the study and needed to increase youngstock inventory to maintain herd size.

Milk production was approximately 15,000 lbs per cow per year in the mixed herd until Year 1, when it jumped to 17,000 lbs per cow per year. While numerous factors could have resulted in this increase, it is believed that the cows performed better during the winter months while in the BPMS than when the cows were exposed to adverse weather conditions.

Straw as the bedding amendment was costly and was a significant expense to the dairy. The large cost of the straw could be mitigated by growing small grains, but land suitable for annual crops is limited due to steep topography in the case farm's area. The BPMS solved many environmental issues on the farm, but at a large annual bedding cost and the additional expense of pack removal, transport and spreading into a compost pile, then field spreading.

Figure 2: Time Study Chart for Winter Months for the BPMS Case Farm

Daily Task	Pre-BPMS	BPMS Year 1	BPMS Year 2
Prep, milk, feed grain, cleanup	5 hours, 30 minutes	4 hours, 44 minutes	4 hours, 36 minutes
Pack management	22 minutes	16 minutes	10 minutes
Feed baleage	15 minutes	28 minutes	20 minutes
Feed/bed calves	60 minutes	28 minutes	22 minutes
Herd health/heat detection	15 minutes	4 minutes	3 minutes
Water system management	15 minutes	5 minutes	1 minute
Record keeping	4 minutes	3 minutes	5 minutes
Manure spreading	17 minutes	8 minutes	12 minutes
Milking Parlor Holding Area Entrance Pad	15 minutes	8 minutes	6 minutes
Other	15 minutes	7 minutes	10 minutes
Total	508 minutes = 8.5 hrs	391 minutes = 6.5 hours	365 minutes = 6.1 hours
Pack Removal and Spreading into Compost Pile		160 hours	No data
Spreading composted product	No composting, pack spread	No data	No data

Comparisons to a Similar, Conventional Tie-Stall Farm - A comparison farm, similar in herd size and in worker equivalents, was located in the same geographic region as the case farm. The comparison farm housed its cattle in a tie-stall barn, spread manure daily during winter and less frequently in summer, milked with a pipeline and used an automated grain feeding system. Both were hill farms, grazed their cattle and produced no corn. The comparison farm stored haylage in an upright silo and made some dry hay. The BPMS farm made hay as baleage. In a nutshell, both farms were considered to be relatively low-input operations.

A limited time study was done on the comparison farm to account for labor spent during the winter months. The case farm was able to complete all tasks including milking, feeding, cleaning, monitoring, herd health, record keeping, spreading manure, and making repairs in about 6 hours per day by Year 2. The comparison farm spent about 8 hours per day to complete all routine tasks. The savings in labor with the BPMS was therefore 2 hours per day times 180 days = 360 hours in the winter months.

The conventional system required 25 minutes per day for manure spreading for a total of 180 days, with no need for re-spreading later. The amount of time, fuel, and machinery expense related to the BPMS exceeded the conventional daily spread system's requirement by about two times. This disadvantage could be mitigated by having a custom operator remove the pack all at once, spreading the composted material later. Wear and tear on spreaders, skid steers and people are a reality for a do-it-yourself cleanout. The cost to hire a custom operator to clean out the pack would need to be considered, but larger, more efficient machines would likely be more cost-effective than the farmer's equipment, especially considering the value of the farmer's time.

The project and comparison farms had healthy and clean cows. The comparison farm used 6-7 small, square bales of hay per day for bedding that was chopped in a bedding chopper. The total amount spent on bedding at $80 per ton was approximately $1,800. The project farm spent $3,536 on bedding prior to the BPMS, $7,004 (at 34 cows = $206 per cow) in Year 1 and $9,415 (at 34 cows = $277 per cow) in Year 2. The amount of bedding used was the same in Year 1 and 2, 66 tons, but the price per ton increased significantly from $106 to $143.

Bedding represents the third largest expense for the project farm and limits profitability, as other costs are similar to conventional farms. Purchased bedding expense for dairy farms of similar size participating in the Cornell Dairy Farm Business Summary of Intensive Grazing Farms was $1,344 for 2007, $35 per cow (this does not include the use of home harvest crops used for bedding, so the CDFBS cash cost understates this bedding expense).

The added agronomic and associated economic value of using compost as a soil amendment versus fresh manure has been promoted by organic farmers. A literature review did not find published research relating to the benefits of spreading compost on pasture or hayland.

BPMS Bedding Usage and Pack Compost Analysis

The farm used 20 tons of straw bedding prior to the BPMS to bed the cows during winter, 66 tons in Year 1 and 66 tons in Year 2. The farm used 892 pounds of bedding per animal unit (#/AU) prior to the BPMS, 2,970 #/AU in Year 1 and 3,415 #/AU in Year 2. Less bedding was used the year prior to BPMS implementation to a large degree because the cattle were not confined to the pack and manured much of the time off of the pack. The increase in use of bedding in Year 2 may have been due to the fact that there were more cows on the pack, versus youngstock.

The farmer added bedding to the pack every other day using a rear discharge manure spreader. By maneuvering the spreader, the farmer was able to bed the facility mechanically, without having to manually pitch the bedding. The cows remained in the barn during the bedding process and would move to the freshly bedded area with each pass of the spreader. The farmer was generally able to bed the facility with three passes. The farmer suggested that long travel lanes be accommodated in the design to make it easier to bed the cows with the spreader. It was much easier to distribute the bedding when using chopped straw versus unprocessed straw.

Bedding around the round bale feeders, approximately 8-10', tended to get punched up and dirty, and the cows would not lie in these areas. This space needs to be subtracted when calculating the effective bedding area for the cattle to utilize in the BPMS. The participating farmer stated that, given his experiences with feeding on the pack, he would prefer a separate feeding area off of the pack.

One expected advantage of the BPMS was the ability to compost the pack material once it was removed from the barn. The pack was sampled after the second year of housing the animals, and the results show that the pack was readily compostable. Three samples of the pack were taken from the barn and analyzed by the Pennsylvania State University Agricultural Analytical Services Laboratory (Figure 3). The bulk density and carbon-to-nitrogen level of the material proved to be well suited for composting (On-Farm Composting Handbook, NRAES 54). The moisture level of 70 percent was higher than a more optimum level of 60 percent, but this could be managed by turning the windrows. The case farmer created windrows in Year 2 by using a side discharge spreader.

Figure 3: Bedded Pack Analysis Results

		|----------Sample Number-----------|			
Analyte	**Units**	**1**	**2**	**3**	**Average**
pH	--	8.2	8.2	8.2	8.2
Soluble Salts (1:5 w:w)	mmhos/cm[1]	9.1	10.66	11.61	10.46
Solids	%	33	35.7	26.4	31.7
Moisture	%	67	64.3	73.6	68.3
Organic Matter	%	25.9	29.9	21.0	25.6
Total Nitrogen (N)	%	0.75	0.78	0.53	0.69
Organic Nitrogen	%	0.75	0.78	0.53	0.69
Ammonium N (NH_4-N)	mg/kg	15.1	42.1	47.6	34.9
	%	0.0015	0.0042	0.0048	0.0035
Carbon (C)'	%	11.6	10.3	8.8	10.2
Carbon:Nitrogen Ratio	--	15.5	13.2	16.6	15.1
Phosphors (as P_2O_5)[2]	%	0.42	0.29	0.24	0.32
Potassium (as K_2O)[3]	%	1.26	1.13	0.86	1.08

[1]Electrical conductivity

[2]To convert phosphorus as (P_2O_5) into elemental phosphorus (P) divide by 2.29

[3]To convert potassium as (as K_2O) into elemental potassium (K) divide by 1.20

BPMS Summary and Recommendations

The Bedded Pack Management System proved to be an excellent environment for the cattle and provided the intended environmental benefits. The bedding material held the cow manure in the facility and was an excellent composting material. On the whole, there were no large labor saving advantages of the BPMS on the case farm. Farms that have labor intensive tie-stall barns and facilities that don't provide an excellent environment for dairy cattle might experience more benefits than the case farm. The large amounts of bedding required by the BPMS indicate that limiting the use of the facility to half of the year during the inclement months, then keeping animals on pasture, is necessary to make bedding costs manageable.

Reducing bedding cost is important if the BPMS is to be sustainable. Two strategies are to reduce the cost of bedding or to reduce the use of bedding material. The case farm did not raise annual small grain crops, so straw was not produced on the farm. This necessitated the purchase of significant amounts of straw from long distances. Home grown bedding material would reduce the transportation cost associated with purchased straw and, if produced economically, could reduce bedding costs. For farms that don't raise annual cereal crops, the harvest of mature hay, such as Reed Canarygrass, might be a viable option. Another alternative to reduce the net bedding cost would be to sell the composted bedding material.

Organic farms that place a higher value on compost, due to the relatively high cost of organic fertilizers and their increased emphasis on soil health, will be better able to justify the additional cost of bedding material. Research to quantify the economic benefits of adding compost to hayfields and pasture or to determine the positive environmental effects of applying compost versus liquid manure would be helpful in justifying the additional bedding expense of the BPMS. There is a trend of organic dairy farms to produce small grains to feed their cattle as a strategy to reduce purchased feed costs and to better cycle nutrients on the farm. In addition to providing nutrients for cattle, the small grains can also supply the bedding needs of the animals.

A strategy to reduce bedding usage would be to utilize the system as a continuous composting barn, rototilling the waste and periodically removing some bedding material. The savings in bedding with a composting barn strategy would be offset by increased labor and machinery cost to stir the bedding. In many of the composting barn studies, the bedding material used was wood shavings. It is unclear whether processed straw can be effectively stirred. For many dairy farmers shavings and sawdust are not consistently available, so this is not an option.

Another option to reduce bedding costs would be to design the BPMS to include a concrete feed alley, thereby reducing the amount of manure deposited on the pack since livestock excrete significant amounts of manure while eating and drinking. The downside is that manure removed from the feed alley may need to be stored in a liquid manure storage. The capital expense of implementing a solid and liquid system might be economically prohibitive.

Housing two classes of animals in a BPMS leads to uneven elevations of the pack, as the bedding requirements of these animals are generally different. Over time, the difference in bedding usage creates a slope between the two housing areas that is, in effect, unusable space. This idle area requires a larger floor plan in the barn, increasing building costs.

The lack of a feed pad or bunk in the case farm example makes it more difficult to maximize dry matter intake of feed and forages. Farms with seasonal herds calving in the spring will not be as negatively affected by a potentially lower dry matter intake of forages on the pack, since the cows will be in later stages of lactation when housed in the BPMS. Animals in later stages of lactation and in the dry period will also produce less manure that is in a more solid form, reducing the bedding requirement.

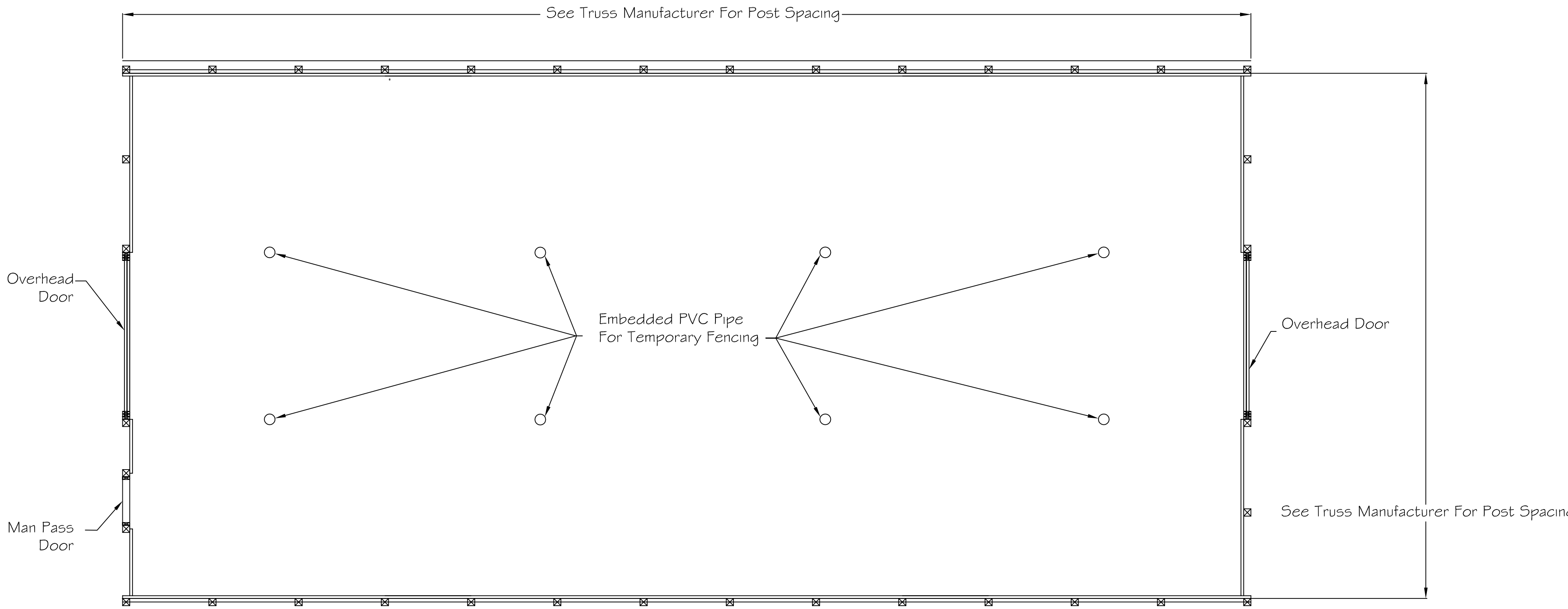
Farms with significant herd health issues that can be transferred between animals, especially through their manure, might not want to implement the BPMS since the animals are fed on the pack. Raising the round bale feeder above the pack, or using a feed alley will reduce this risk.

Finally, the bedded pack may eliminate, or significantly reduce, the hoof and leg problems associated with housing dairy cattle on concrete and other hard surfaces. Animal longevity and productivity would be expected to provide economic gains that were not quantified due to the limitations of this case study.

The Bedded Pack Management System can be significantly less in its initial investment than a traditional suite of BMPs. The whole farm planning team needs to evaluate specific farm characteristics and the producer's goals to determine if the BPMS is the most appropriate BMP for the farm.

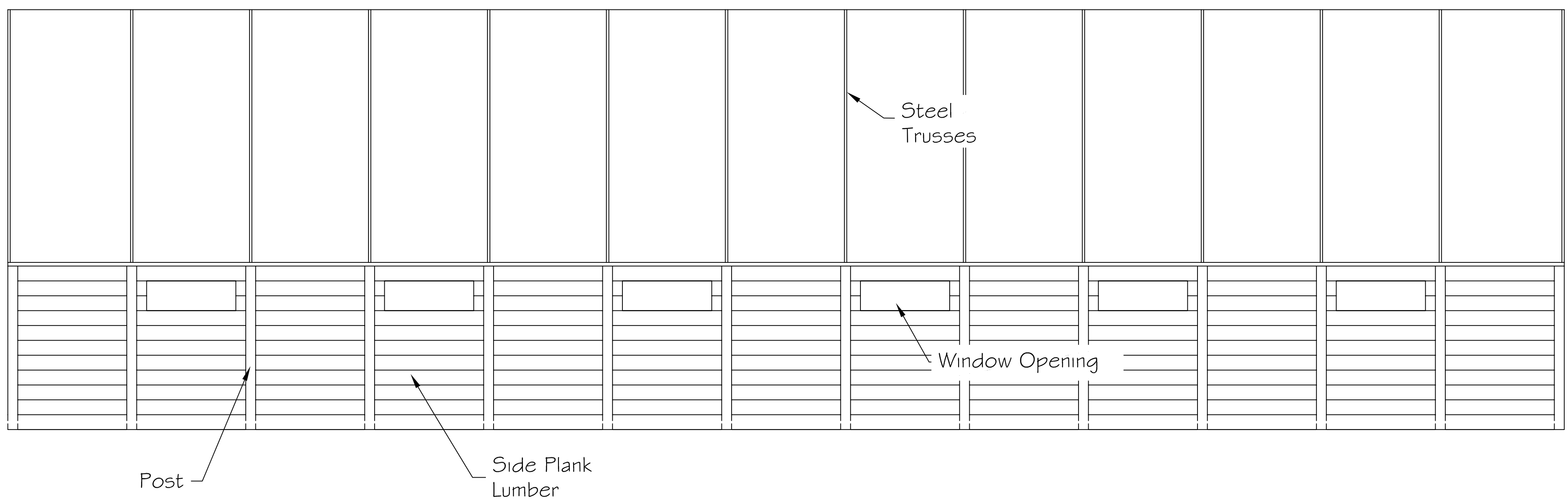
Appendix A: Plan View of Case Study BPMS

(Not to Scale)



Appendix B: Side View of Case Study BPMS

(Not to Scale)



Appendix C: End View of Case Study BPMS

(Not to Scale)