AEN-177

Cooperative Extension Service

Basic Principles for Laying Out Farm Infrastructure on Livestock Operations

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Livestock operations require comprehensive infrastructure to efficiently produce livestock. Key components of this infrastructure include:

- Water fountains to ensure livestock have constant access to clean drinking water
- All-weather surfaces for feeding and confining animals and for ensuring they remain comfortable and safe in various weather conditions
- Handling facilities for the care and monitoring of animals;
- Waste-handling facilities to maintain sanitation and prevent excessive accumulation of manure
- Shade and protection to shield animals from extreme weather;
- Shelter with bedding, for birthing and nursery facilities
- Drainage systems to prevent waterlogging and maintain dry conditions
- Sick pens for isolating and treating ill animals
- Maintenance areas for equipment upkeep and repairs
- Storage areas for tools, equipment, feed, and supplies
- Direct roads, fences, gates, and lanes to facilitate the movement of labor, animals, and equipment

The location of infrastructure and the routes used to distribute materials directly impact the profitability of an operation.

Benefits of a Good Layout

A well-designed layout can reduce:

- Travel distance
- Time consumed in travel
- Number of processing operations
- Cost of moving, storing, and receiving materials
- Cost of transporting labor and the finished product

Objectives of Careful Planning

1. Secure an adequate supply of facilities and provide for their economical distribution under present conditions.
2. Ensure that future changes can be made without replacing the current system.

Guiding Principles for Farm Layouts

The purpose of this publication is to provide a framework of guiding principles for laying out farm infrastructure efficiently. Unfortunately, there is not a template for creating the best layout for a farming operation. The differences between farms, topography, weather patterns, soils, and other site-specific conditions and the interactions of these systems are too complex and too numerous to summarize into a checklist. In addition, there are differences in management style. Given that, the following are basic guiding principles for laying out farms presented by industrial engineer Richard Muther in his 1955 book *Practical Plant Layout.*

- **Principle of Minimum Distance Moved:** Minimize the distance materials need to be moved to increase efficiency.
- **Principle of Flow:** Ensure smooth, uninterrupted movement of materials and animals.
- **Principle of Space:** Utilize cubic, linear, and square footage space effectively.
- **Principle of Satisfaction and Safety:** Improve worker morale and safety.
- **Principle of Flexibility:** Design infrastructure to accommodate various groups of cattle and future changes.
- **Principle of Overall Integration:** Combine all aspects of the layout into a cohesive system.

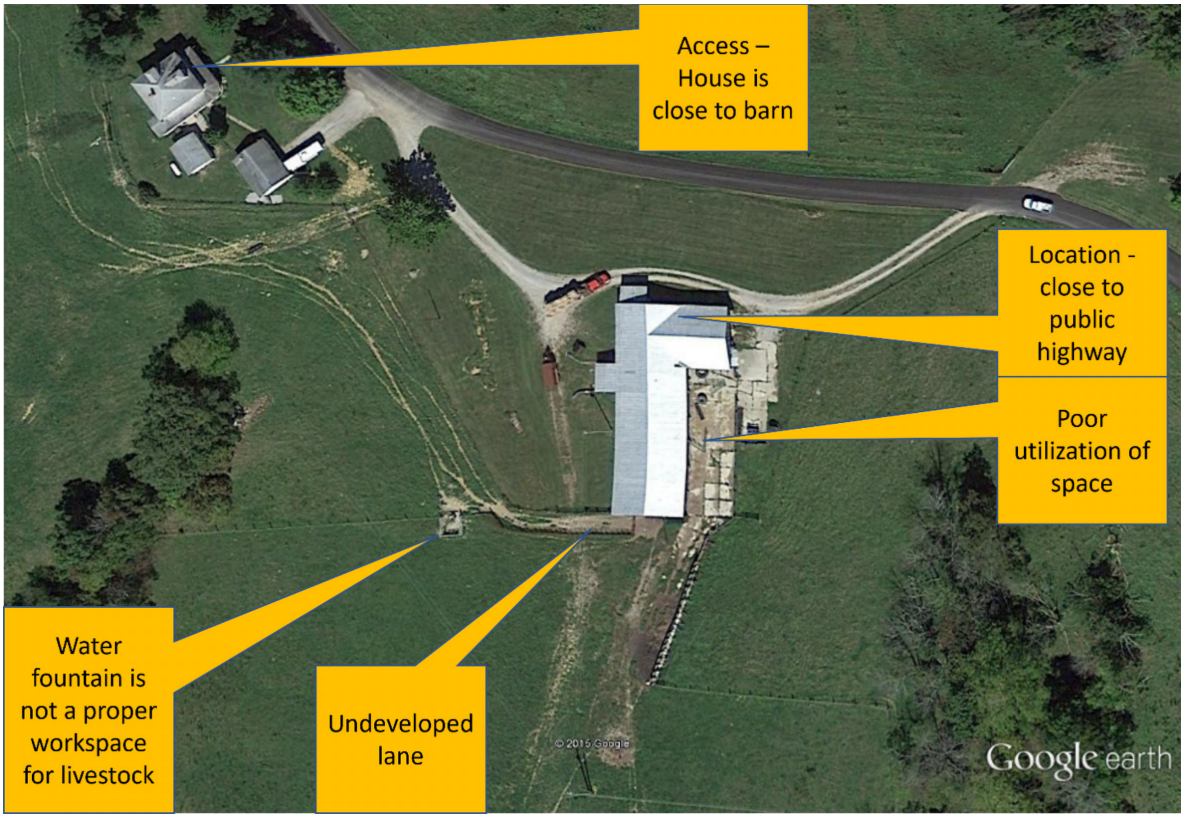

Figure 1. Aerial view of the dairy barn before modifying the layout. The area offered access and location benefits as well as areas for improvement, as indicated.

These principles will be explained in this publication using infrastructure installed at the Eden Shale Farm, located in Owen County, KY. The Eden Shale Farm is a model beef cattle farm managed by the Kentucky Cattlemen's Association. Since 2013, the farm has implemented multiple demonstration projects for raising, feeding, and watering livestock using functional designs and concepts. The site chosen for this discussion is the farm's old dairy barn and the surrounding area (Figure 1). The previous layout of the area mentioned in this publication refers to the infrastructure and processes used prior to the Kentucky Cattlemen's Association taking over management of the farm in 2013. The area has since undergone significant modification and re-layout.

Principle of Minimum Distance Moved

There are many things that need to be moved on a livestock farm. For example, a typical cow-calf pair will require an estimated 137.5 tons of materials per year (Figure 2). The efficient movement of these materials is directly correlated to profitability. Minimizing the distance and number of times these products are moved increases efficiency.

Moving Hay

Before the redesign, the driving route from a hay field to storage for this feeding location was approximately 3,250 feet (Figure 3). Typically, ten hay bales were moved from the field to storage using a truck and trailer. However, when transported for feeding with a tractor, only one or two bales were moved from storage to the feeding area at a time. This process took extra time and multiple moves, resulting in inefficient work.

The new layout offered a more efficient approach that moved the baled hay from the nearby hay field into the barn (approximately 500 feet away) where the hay is fed (Figure 4). This new practice reduced driving distance, driving time, feeding time, fuel consumption, and wear and tear on equipment.

It is not a coincidence that this concept follows several of the guidelines of efficient feeding:

- Feed should be moved as little as possible from the point of production to the cow's mouth.
- Feed should be moved in bulk.
- Feed should be self-fed.
- Feed should be consumed with as little waste as possible.

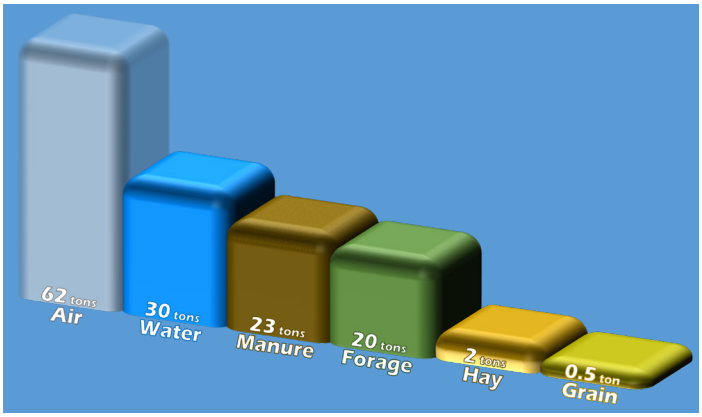

Figure 2. The weight of materials required for a cow-calf pair per year. Source: Nutrient Requirements of Beef Cattle. 1996. 7th revised edition, NRC; ASAE Standards. D384, 2005; ASAE Standards 270. 1986. *(Image by Donnie Stamper)*

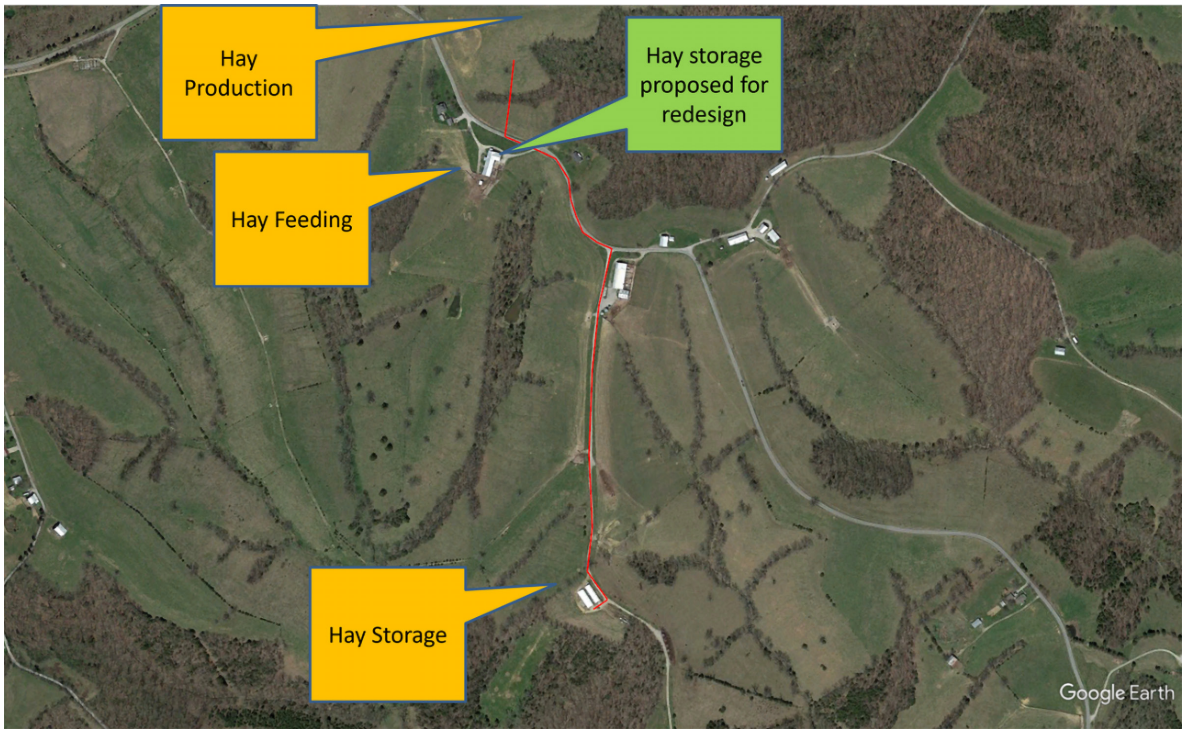

Figure 3. An aerial view of Eden Shale Farm before the redesign, highlighting in red the driving route from a hay field to the previous hay storage area.

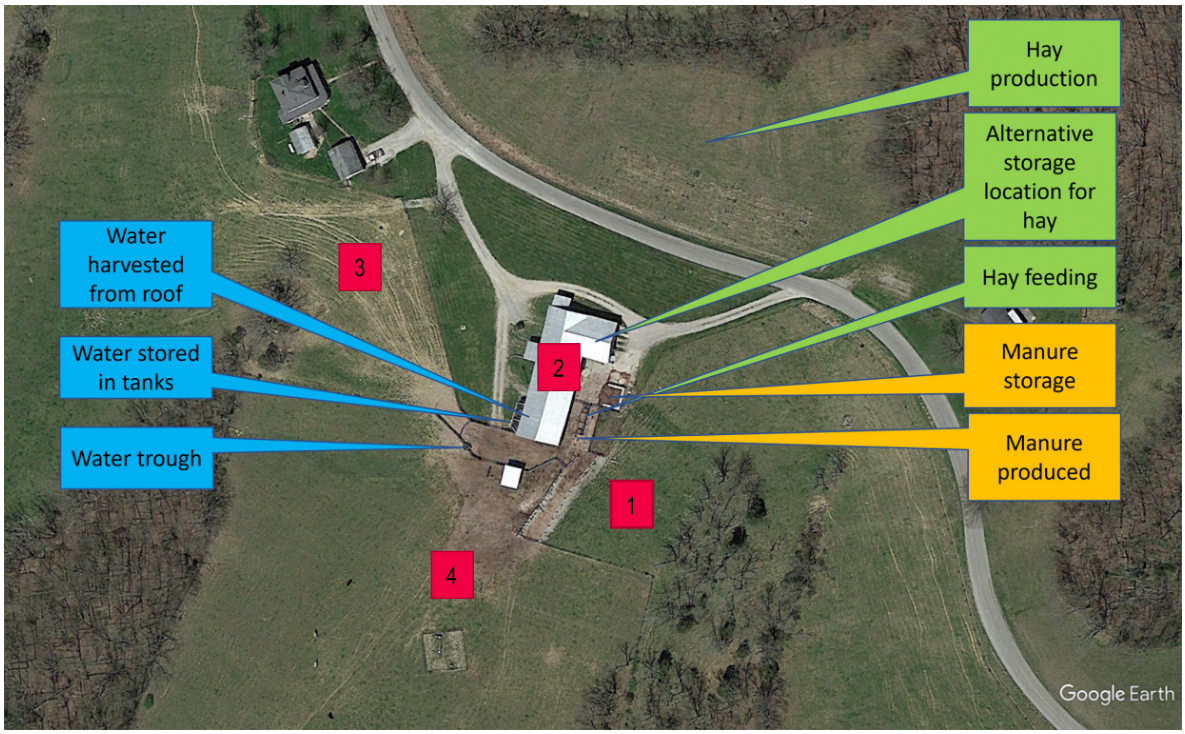

Figure 4. An aerial view of the redesigned area at Eden Shale, showing the shortened distance between where materials are produced, stored, and used. During the calving season, heifers start in the pre-calving field (1) and are moved into the calving pens in the barn (2), where they are scheduled to stay for 24 hours after calving for monitoring and ear tagging. They are then moved to the nursery pasture (3). When a sufficient group of nursing cows are present in the nursery pasture, they are moved to the post-calving field (4).

Feeding and watering animals are fundamental requirements for livestock production. Developing efficient methods to feed can provide huge savings. The factors to consider when laying out a feeder include:

- Locate the feeder at the best possible position or angle for the effective loading of feed and removal of manure.
- Divert and control runoff around the feeder.
- Locate the feeder to utilize prevailing winds and sunshine.
- Locate the feeder close to feed storage.
- Locate the feeder to facilitate the rotation of livestock.
- Provide sufficient space around the feeder for the livestock and producer to perform all the tasks and maintenance.
- Utilize all-weather surfaces to control the creation of mud.
- Use a feeder design and location that saves time and energy while reducing feed waste, such as a fence-line feeder.

Moving Manure

As part of the Eden Shale redesign, the transport of manure was made more efficient by creating a manure stack pad adjacent to the feeder to limit the distance moved (Figure 4). Manure removal is also easier to accomplish under the new system because of the concrete surface and the accessible gates added on each side of the feeder.

Moving Water

In a year, a cow-calf pair requires approximately 30 tons of water. Supplying livestock with abundant clean water is a fundamental requirement. As a result of its redesign improvements, Eden Shale Farm harvests a significant portion of its livestock water requirement from the roofs of the barns, conveying it through gutters and pipes and storing it in tanks and cisterns. The volume of water needed for this site was determined by multiplying the total days the animals will be held by the number of animals and by the daily drinking water requirement per animal. The stored water is moved 50 feet by gravity into a tire trough located in a lane and shared by a pasture (Figure 4). Overflows are piped away from the livestock area to control the creation of mud. In winter, the water-harvesting system is drained, and the trough is switched over to a municipal water supply.

Water Fountain Infrastructure Planning

When planning the location of water fountain infrastructure for livestock operations, the following factors should be taken into account:

- **All-weather surface.** Ensure the location can be hardened with an all-weather surface with minimal excavation to prevent mud and maintain cleanliness.
- **Ergonomic positioning.** Place the water fountain in the best possible position to be ergonomically effective for both livestock and handlers.
- **Travel distance.** Position the water fountain so that travel distances are limited to less than 800 feet to ensure easy access for the animals.
- **Rotational grazing.** Locate water fountains to facilitate rotational grazing, making it easier to move livestock between different fields.
- **Watering hubs.** Install watering hubs that can improve efficiency by providing water to multiple pastures or groups of animals (Figure 5). These hubs can also reduce the number of times mineral supplements need to be moved. If a watering hub is created, ensure there is plenty of space to hold animals for treatment, relocation, or other purposes.

By carefully considering these factors, you can design a water infrastructure that optimizes the efficiency and effectiveness of your livestock operation.

Principle of Flow

For every material moved around the redesigned dairy barn, the distance moved has been reduced to the minimum required. This includes the heifers that rotate through this area during the calving season. The four-step rotation, which is shown in Figure 4, begins with the animals being housed in the field closest to the barn. Once the heifers are about to calve, they are moved into the calving pens in the barn. They are scheduled to stay in the barn for 24 hours after calving, allowing time to make sure the calf is nursing. During this time, an ear tag is attached to the calf's ear and recorded. The configuration of the barn pens also allows a heifer with twins to be placed in an individual pen for additional monitoring and stay.

Once the manager is confident that the pair has bonded, they are moved into a separate nearby pasture, called the nursery. This pasture is designed as a fresh pasture, with limited mud that may interfere with nursing and calf health. Once this pasture has a concentrated group of nursing cows (about ten), they are moved to the final field of the four-step rotation. This practice frees up space in the nursery pasture, while transitioning the moving group to another fresh pasture.

An efficient system redesign also incorporates lanes to connect the pastures. Lanes need to have multiple gates installed to create flow through production areas. At Eden Shale, the previously undeveloped lane shown in Figure 1 stopped short of the barn alley, making it difficult to transfer cattle into the barn. During the redesign, the lane was extended in length to reach the barn alley and also the hay feeding area (Figure 6). In addition, the lane was widened to allow a tractor to place hay bales in the feeder (H) without making an additional three-point turn. An additional lane was added to move the cattle from an adjacent field into the feeding area.

Many factors need to be considered when planning the installation of gates:

- Install only the gates that are needed, because they are expensive to purchase, install, and maintain.
- Gates should be placed as close together as possible.
- The highest concentration of gates should be around a barn.
- The second highest concentration of gates should be around a water fountain.
- A gate should not block access to a barn.
- Gates should be installed on summit positions.

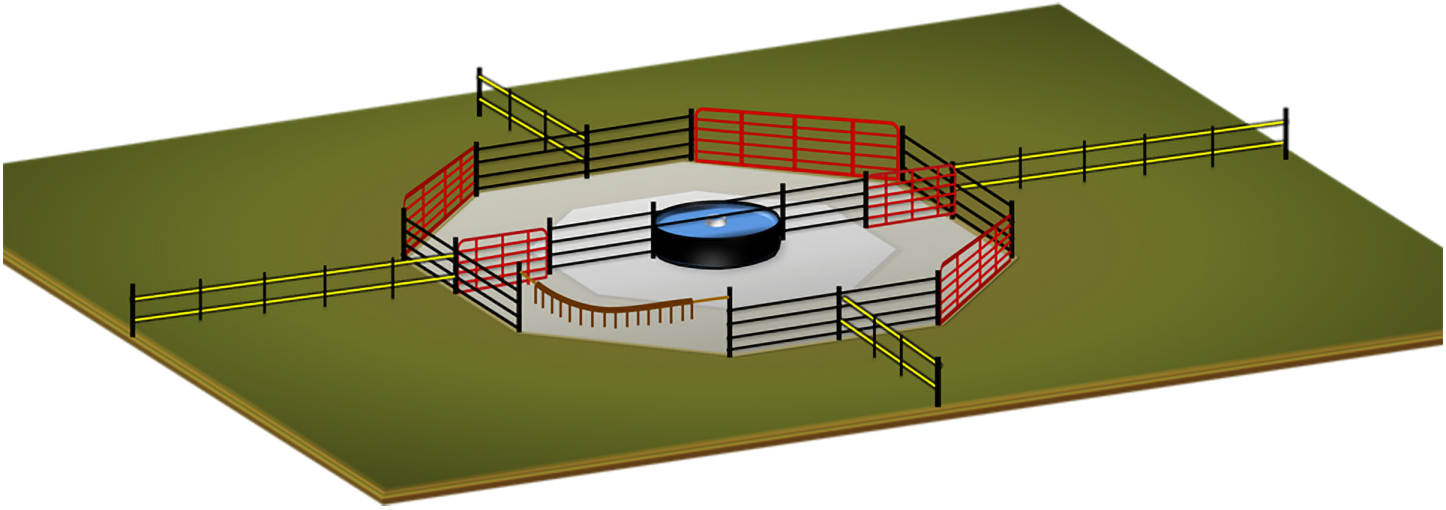

Figure 5. A watering hub that serves four pastures.
(Image by Donnie Stamper)

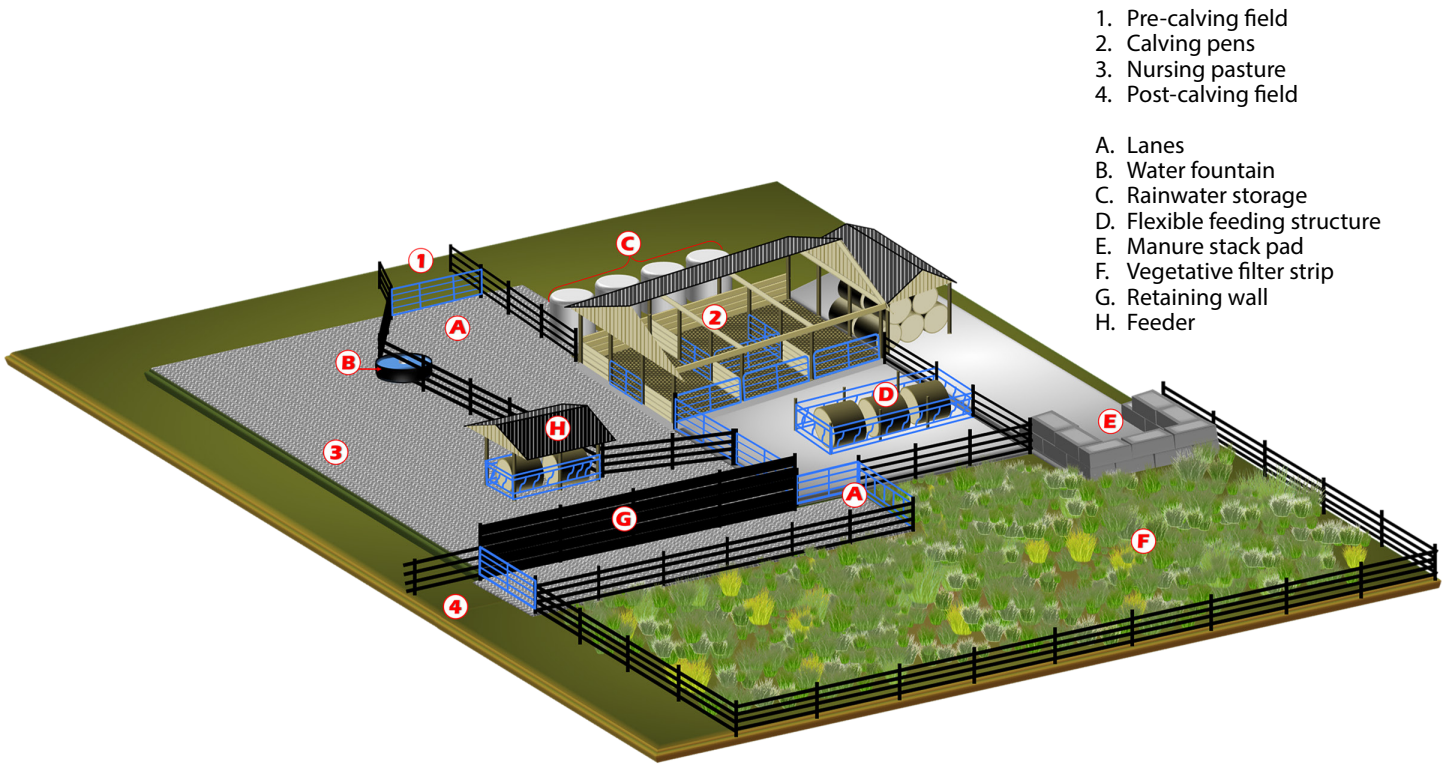

Figure 6. A rendering of the revised layout for Eden Shale's old dairy barn area. The layout contains a high concentration of access gates. The letters A through H represent integrated practices. The numbers 1 through 4 indicate the movement of heifers during calving season through adjacent pastures and the calving pens.
(Image by Donnie Stamper)

Principle of Space (Cubic, Linear, and Square Footage)

All available space should be used effectively, including cubic space for storing bulk materials, linear space for feeding, and area or square footage for animals to express normal behavior.

Square Footage

The original layout had a concrete floor that was not being utilized (Figure 7). The open concrete area was modified in the new layout to better utilize the space by installing a hay feeder on top of the existing concrete (Figure 8).

The original interior barn floor area was completely open with a compromised floor surface (Figure 9). As part of the redesign, a heavy traffic pad was installed with a slope to provide drainage and mechanically stabilized to support the weight of livestock. The open floor area was then subdivided into maternity and sick pens to better utilize square footage. A handling facility was added as an accessory to create greater functionality for the site (Figure 10).

Cubic Space

Cubic space for storing baled hay was created by moving equipment out of the barn (Figures 11 and 12). Cubic space was created for storing harvested water by purchasing four 3,000-gallon plastic tanks and replacing a small energy-free water fountain with an eight-foot diameter trough.

Cubic Air

Changes must be considered to provide an optimum environment for livestock. Circulating air to remove dust, odors, and airborne pathogens was not a critical design component for this project. This was attributed to the cubic capacity of the barn, the fact that it has an open side, and the light stocking density that would be held inside the barn.

Linear Space

Linear space for feeding forages was improved by installing a hay feeder to provide additional linear space and positioning it to provide access to multiple groups of livestock (Figure 8). The hay feeder is a dual-purpose feeder; when it is not being used to feed forages, its linear space can be used to feed concentrates by placing portable feed bunkers over the sewer pipes (Figure 13). Linear space for feeding concentrates was also created by adding portable bunkers to the lane, which serves multiple pastures and animal groups (Figure 14).

Linear space for drinking water was increased by replacing a small water fountain with a large open trough tire waterer (Figure 15). The old location did not provide a proper workstation for livestock to obtain their water requirement. Conversely, the new water fountain provides ample space for approximately 14 head on a flat location.

Figure 7. A previously underutilized concrete surface adjacent to an underutilized barn.

Figure 8. A new hay feeder that provides linear feeding space serves three fields plus two pens inside the redesigned barn. Gates in the foreground allow for manure cleanout, while the gates in the back feed into the pastures and lane.

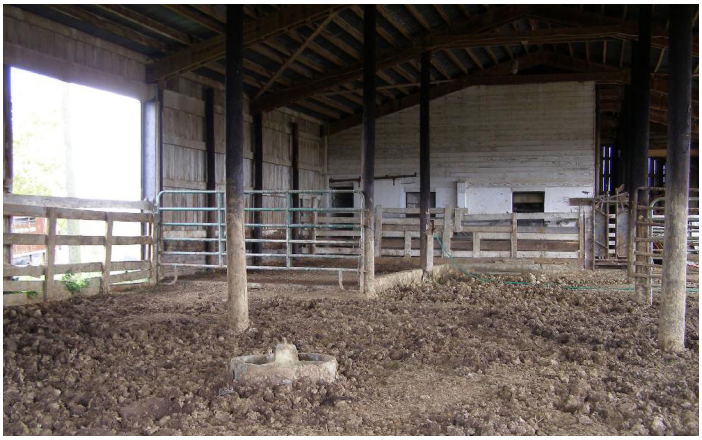

Figure 9. Surfaces for livestock should be created to provide support, drainage, and comfort, unlike this clay-spired floor previously used in Eden Shale's old dairy barn.

Figure 10. The flexible interior layout includes subdivided maternity and sick pens, along with an added handling facility (back left corner), to better utilize square footage.

Figure 11. Mobile equipment in the barn could be stored somewhere else. Moving this equipment allowed the space to be used to store hay bales, thus reducing travel distances.

Figure 12. Storage created for hay bales in the redesigned barn reduces travel distance.

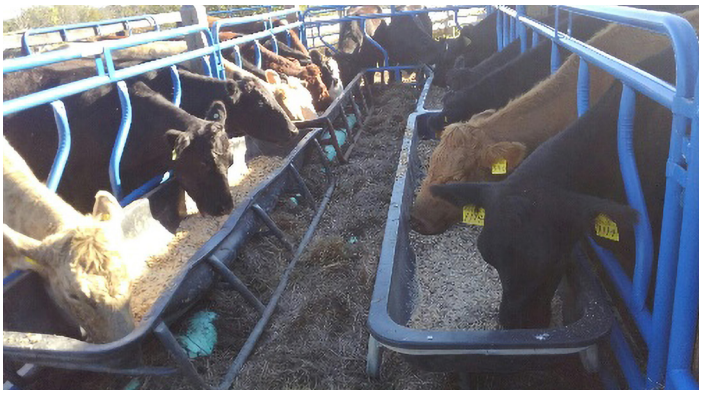

Figure 13. Linear space for feeding forages and concentrates is provided by a new flexible feeding structure.

Figure 14. Portable bunkers that can serve animals on both sides create flexible linear space for feeding concentrates.

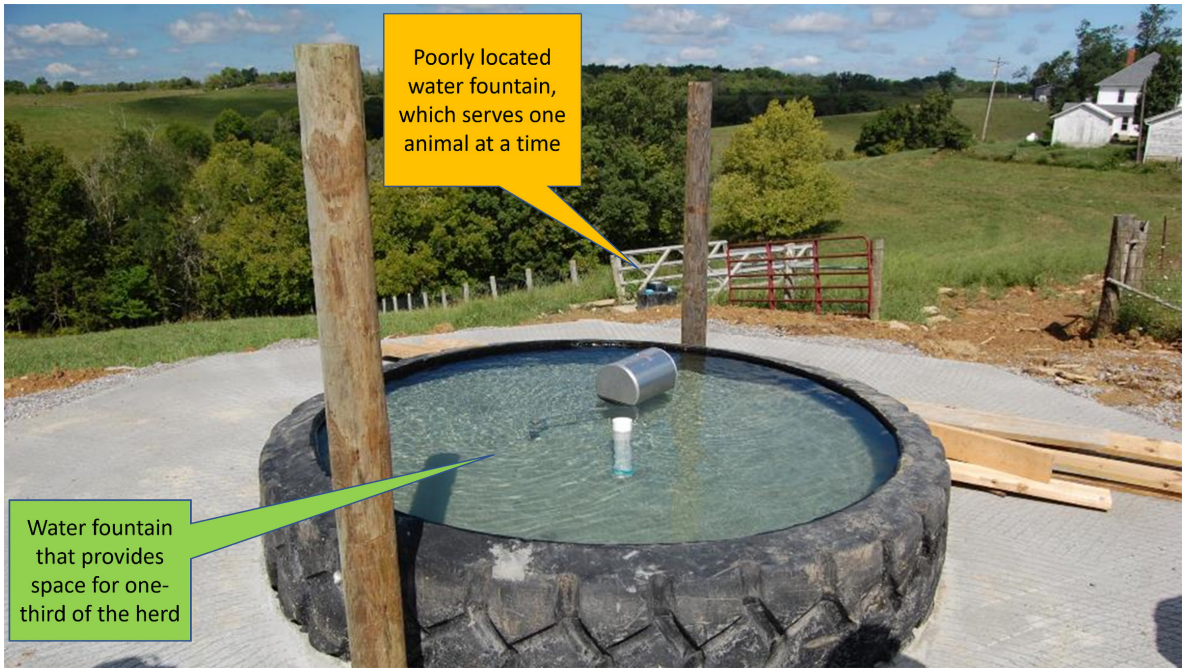

Figure 15. Replacing the water fountain reduced a significant amount of stress for the animals.

Principle of Satisfaction and Safety

Feeding concentrates and forages inside pastures and holding areas requires workers to dismount the tractor to close gates and remove hay wrap or strings. Walking in muddy fields to feed concentrates using buckets can be extremely dangerous for workers. Cold conditions and heavy clothing can also contribute to fatigue.

Worker safety at Eden Shale was addressed by designing the forage feeder so that it could be filled without entering the animal area (Figure 8). The sewer pipes that were installed in the base of the forage feeder can be used to secure portable feed bunkers within the feeder (Figure 13). This allows the producer or worker to conveniently and safely feed and check animals from the protected aisle of the feeder without getting into the livestock area.

Before the new design was implemented, calving occurred in the field or woods. Identifying calves with ear tags was accomplished in the field by catching calves in the open, installing the ear tag, and then identifying the cow they belonged to. The job of installing ear tags was not safe or timely, as it was conducted approximately 30 days after the calves were born. The inclusion of a maternity area in the redesign created holding pens in the barn (Figures 10, 16, and 17). The new design calls for heifers to be placed in the barn just before or right after they calve, allowing the calf to be in a dry environment for its first 24 hours. This also allows the producer to make sure the calf is accepted, is eating, and is fitted with the ear tag within 24 hours of birth. The new system is more efficient and safer, and it provides a better environment for the health and productivity of the stock.

The new water-harvesting system benefits the producer by reducing the monthly water usage bill from March through November. Harvested water is used to provide drinking water for livestock during the highest usage times of the year. In winter, the system is switched to municipal water sources to reduce the chance of freezing.

Overall, producer satisfaction was increased by the redesigned layout. Redesigning the layout has allowed chores to be performed faster and more efficiently. The efficiency allows producers to work on other production matters or spend more quality time with their families.

Principle of Flexibility

Flexibility should be incorporated into designs to serve any group of cattle (e.g., calves, feeders, paired animals, pound cows, developing heifers, maternity, or bulls). Heights of feeders and water fountains, as well as access widths, vary with the size and shape of animals. Flexibility has been incorporated into many elements of the redesign at Eden Shale:

- The feeder is located to provide access to three different pastures, in addition to feeding animals in two of the largest indoor pens.
- The hay feeder can be configured to feed concentrates using portable feed bunkers placed over the sewer pipes.
- Drinking water for livestock is provided by two different sources.
- Water fountain heights and linear access can serve livestock of any size.
- The barn interior is subdivided to create maternity pens for heifers, which require more attention than mature cows. Subdivisions have been used to create a very large pen, a large pen, and two regular-sized pens. The largest pen is a flexible design that allows it to be configured into a creep area to shelter calves from the elements (Figures 16 and 17).

Figure 16. Layouts should provide flexible spaces, like this creep area designed to provide shelter for calves.

Figure 17. A cow and her twins housed in a large, clean pen.

Principle of Overall Integration

The concept of overall integration combines all aspects of a layout into one location by developing a hub with all the necessary materials, infrastructure, and routes needed to efficiently support the livestock operation (Figure 6). This is accomplished by effectively using the space to store bulk materials and providing a logical flow of these materials, while also providing floor space for normal livestock behavior and linear space for eating and drinking.

The layout should be designed to create a flexible system to serve the current groups of livestock and also accommodate changes in the operation. However, changes will not be made to a layout until the livestock producer is dissatisfied. Improving worker morale is a common objective of new layouts and may be the deciding factor to redesign or upgrade the operation.

Summary

Efficient livestock operations require infrastructure based on a planned layout. The efficiency of this infrastructure, in terms of livestock production, labor, and operational cost, heavily depends on the strategic placement of structures and their management within the overall layout. In some cases, the process used to locate infrastructure in the past may have been based on social norms rather than a scientific, analytical approach. In addition, most farm structures were built long ago for enterprises that are no longer active.

An analytical approach requires all the relevant facts that are of value for making sound decisions. Relevant facts and economic analysis are needed to solve problems and bottlenecks that limit efficient operations. Following basic principles for laying out a farm is essential to enhance operational efficiency. Whether the context involves a new farm, an expanding operation, a relocation to a new site, or major or minor adjustments to an existing farm, these principles should be adhered to for optimal results. Redesigns may be necessary for expanding operations or changes in enterprises. Producers may want to create flexible designs rather than custom structures that will be rendered obsolete as enterprises change.

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Further Reading

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