



EARTHEN MANURE STORAGE SYSTEMS

This fact sheet is based on content presented by professional engineer Steve Brogan (Rural Roots Engineering and Design Ltd.) during a webinar on Feb. 11, 2021. The webinar is available for viewing on the Perennia YouTube channel at <https://www.youtube.com/watch?v=kRKm-nVEaNg>

Earthen manure storage systems are a type of engineered structure designed to hold liquid manure safely. They are designed to resist environmental loads such as soil pressure, wind, rain, snow/ice and service loads such as tractors, machinery, agitation equipment and pumps. These types of manure storage systems are widely used in Western Canada but less commonly in Nova Scotia. The structure consists mainly of a below-grade excavation surrounded by a soil berm and a liner. Sides are usually built with a minimum 2:1 slope to resist erosion. Systems must be designed to have enough normal storage capacity for the size of operation, storage time period (minimum recommended capacity is 7 months) and also “freeboard” storage capacity to safely compensate for extreme rainfall events, high wind or agitation causing waves. Siting is an important consideration, and factors such as soil type, depth to water table and bedrock, distances to subsurface drains and location of wells and watercourses must be examined.

IMPORTANT TAKEAWAYS

- Properly designed earthen manure storage systems are a safe and economical method to store liquid manure.
- Suitable liners include clay, geosynthetic and synthetic.
- Concrete bases can aid in cleanout and erosion control.
- Negative air pressure covers reduce odours and rainwater accumulation.
- Environmentally, earthen manure storages can perform comparably or better than concrete storages over the long term.

Liners

The liner is a critical part of an earthen manure storage. A liner prevents liquid manure components from entering the environment. Liners must be very durable and resistant to erosion or puncture by machinery. The liner can be made from one of three materials:

Types of Liners

1. Compacted Clay Liner

Compacted clay liners are formed using clay found on-site or from a nearby borrow pit. The clay is remoulded and compacted into a layer at least 1 m (3 ft) thick using specialized heavy roller machines. The clay must have very specific characteristics to make it suitable for use. Geotechnical lab testing is required to determine factors such as liquid and plastic limits, particle size, remoulded permeability and workability. Clay is tested in a lab to confirm suitability. On-site compaction testing is done during construction to confirm parameters meet specifications.

Pros	Cons
<ul style="list-style-type: none"> • Lowest overall cost • All natural • Easy to repair • Relatively foolproof and durable • Self-healing 	<ul style="list-style-type: none"> • May not have suitable material available to use • Cannot have any large stones • Requires extensive geotechnical testing

2. Geosynthetic Liner

A geosynthetic liner is a constructed material consisting of a layer of bentonite clay sandwiched between two layers of porous fabric. Bentonite is a high swell clay with sealing properties. Geosynthetic liners require professional installation and must be stitched together on-site and installed according to the manufacturer's guidelines. Once installed, the liner is covered with native soil for additional protection. These types of liners are often used at municipal landfill sites.

Pros	Cons
<ul style="list-style-type: none"> • Easy to install • Bentonite clay has self-healing property if punctured 	<ul style="list-style-type: none"> • More expensive than native clay • Can have reactions to certain chemically active soils

3. Synthetic Liner

A synthetic liner consists of very thick plastic made from 30 mil PVC or 60 mil high-density polyethylene (HDPE). The liner is placed over the soil and is in direct contact with the manure. Seams must be joined on-site by certified welders and pressure tested. These types of liners are widely used in civil engineering applications such as municipal wastewater treatment sites, fuel storage sites and stormwater management ponds. Synthetic liners must be vented from underneath as soil gases will cause the liner to bubble and produce gas pockets known as "whales."

Pros	Cons
<ul style="list-style-type: none"> • Easy to install • Widely used in other industries 	<ul style="list-style-type: none"> • Highest cost • Requires specialized professional installation • Must be vented from underneath to prevent tears • More difficult to repair

Additional Options and Features

Many storages will have a **concrete ramp and base** to prevent damage when using machinery to clean out sludge or sand accumulation from the bottom. All storage systems, regardless of the liner, must have erosion protection around pipes and pumps to prevent agitation from eroding the structure or damaging the liner. Another design option is to install a **negative air pressure cover**

over top of the liner. This consists of a light HDPE cover that sits overtop of the manure and is held in place by a vacuum. A ring of perforated pipes is placed around the perimeter of the storage and a small electric blower vacuums out the air. Rainwater collects on top of the cover and may be siphoned off or left in place to help hold down the cover. This system greatly reduces odours and can reduce the loss of nitrogen by volatilization. With covered storage systems, agitation prior to pumping is accomplished by a grid of perforated pipes on the storage floor. A high-volume pump forces air through the pipes to agitate the manure. This system may not be suitable for producers using sand bedding in their barns as the sand may not be sufficiently agitated by air alone, and the cover means the sand cannot be removed easily by a machine.



Figure 1: Earthen manure storage with clay liner showing concrete ramps and erosion protection. Image source: Winnebago County Land & Water Conservation Department (Used with permission)

Costs Considerations

Generally, earthen manure storage will be the **least expensive** type of manure storage. When comparing the different systems, cost from least to most will be clay-lined, geosynthetic lined, synthetic lined, round concrete, square concrete and steel. The cost differences will become larger as the size of the storage increases. A typical uncovered earthen manure storage will collect approximately 20% more rainwater compared to a vertical walled storage leading to increased costs for land application of manure. This is a function of the sloped banks creating a larger surface area to collect rainwater. This can be an important consideration in Nova Scotia due to the amount of rainfall we receive as it means there will be more water in the storage and thus more trips required with a spreader when emptying the storage. Earthen manure storage with machinery access ramps can provide access for a loader tractor to more easily clean out sludge accumulation compared to concrete storages where a long reach excavator would be required at a significant cost.



Figure 2: Typical earthen manure storage system with synthetic liner. Image source: Shutterstock.

Environmental Performance

Environmentally, properly constructed earthen manure storage systems generally **perform comparably or better** over the long term than concrete storages. Clay is more permeable than concrete but does not usually crack unless allowed to dry out. Concrete will almost always crack over time, and clay liners also tend to self-heal if a crack does form. It is highly important that no large vegetation, especially trees, be allowed to grow near earthen manure storages as large roots can puncture the liner. Grass should be encouraged to grow nearby to help with erosion control. Like any manure storage, minimum separation distances from wells, watercourses, property lines must be observed.

Regulatory Considerations

In Nova Scotia, there is currently no regulatory framework for manure storage. However, there are guidelines created by the Department of Agriculture and available in the “Manure Management Guidelines.” These guidelines indicate a qualified engineer should do the preliminary soil investigation and design of the storage before any construction begins. They also recommend minimum separation distances from wells, watercourses, ditches and property lines. Enforcement of complaints falls under Nova Scotia Environment or the Farm Practices Board. Note that hog and mink operations will fall under a different set of guidelines and regulations. A building permit may also be required by the local municipality. A manure spill or leak that reaches ground or fresh water is a serious event and could potentially result in charges under the *Environment Act*, the *Health Act*, the *Canadian Environmental Protection Act* or the *federal Fisheries Act*. In Nova Scotia, you are required to report any spills that have the potential to cause adverse environmental effects (such as contaminating a well or watercourse).

**This document is intended to provide general information. Please consult with a professional engineer and ensure you follow any applicable regulations. For more information on the Nova Scotia Agri-Environmental Program and to view additional resources please visit the website at: www.nsaep.ca*