Subsoil Investigations for Compacted Soil Liners

Purpose

Provide a consistent, investigative process and acceptable criteria for conducting subsoil investigations for compacted soil liners

Relevant Legislation

Agricultural Operation Practices Act
- Standards and Administration Regulation
- Administrative Procedures Regulation

Related Technical Guidelines

Agdex 096-60	Subsoil Investigation Information for Applicants (*currently under development*)
Agdex 096-61	Determining Equivalent Protective Layers and Constructed Liners
Agdex 096-62	Subsoil Investigations for Manure Storage Facilities and Manure Collection Areas

1. Introduction

This guideline is for consultants to assess subsoil characteristics for a proposed compacted soil liner at a site for a manure storage facility or a manure collection area. "Facilities" in this guideline refers to both manure storages and manure collection areas.

For the purpose of this guideline, "subsoil investigation" is equivalent to "soils investigation" as found in the Administrative Procedures Regulation of the *Agricultural Operation Practices Act*.

Subsoil investigations must be completed by a member of the Association of Professional Engineers and Geoscientists of Alberta (APEGA).

Questions about the use of this guideline for specific projects should be discussed with an approval officer of the Natural Resources Conservation Board (NRCB).

2. Regulatory Information

The subsoil investigation will need to determine the:
- Hydraulic conductivity of the subsoils,
- Depth to the water table, and
- Depth to the uppermost groundwater resource.

The hydraulic conductivity and depth requirements for a compacted soil liner, as regulated by Section 9 of the Standards and Administration Regulation, are found in Table 1. These requirements are based on saturated hydraulic conductivity values and thus all tests and methods in this guideline are for saturated conditions.

More information on determining the depth to the water table and the uppermost groundwater resource can be found in Agdex 096-62, "Subsoil Investigations for Manure Storage Facilities and Manure Collection Areas".

*Table 1. Compacted soil liner depth and hydraulic conductivity requirements**

Facility Type	Depth (m)	Hydraulic Conductivity (cm/s)
Liquid Manure Storage	1.0	not more than 1×10^{-7}
Catch Basin	1.0	not more than 5×10^{-7}
Solid Manure Storage	0.5	not more than 5×10^{-7}

*Technical Guideline Agdex 096-61, "Determining Equivalent Protective Layers and Constructed Liners" provides a method for determining protection that is equivalent to these requirements.

3. Test Holes

The number, location and depth of test holes, which may include both boreholes and test pits, required to assess subsoils for a compacted soil liner is dictated by site characteristics, proposed facility depth, and depth to the water table. Additional test holes will be required if the compacted soil liner material will not be sourced from the facility excavation.

A minimum of one test hole must be advanced to a depth greater than 1.0 metre below the bottom of the proposed compacted soil liner to ensure the water table and the uppermost groundwater resource are not present.

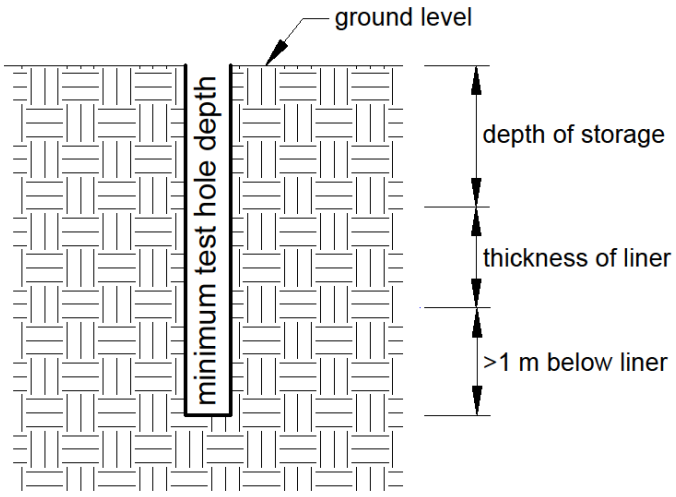


Figure 1. Determining minimum test hole depth for a proposed compacted soil liner.

4. Soil Sampling and Testing of Liner Material

Test holes must be completed to allow proper characterization of subsoils. Subsoil samples should be collected individually and based on differences in observed and hand textured lithology. Sufficient volumes should be collected to complete laboratory testing.

Samples for compacted soil liner material are required to be laboratory tested for particle size, standard proctor density and hydraulic conductivity. Test results may be used to demonstrate uniformity. If samples are not considered uniform, additional boreholes and testing may be required.

4.1 Compacted soil liner material sources *smaller* than 3,600 m^3

A minimum of three representative test holes with one subsoil sample from each test hole is required:

- One or more subsoil samples are tested for particle size, standard proctor density and hydraulic conductivity.
- The other two or more subsoil samples are tested for particle size.

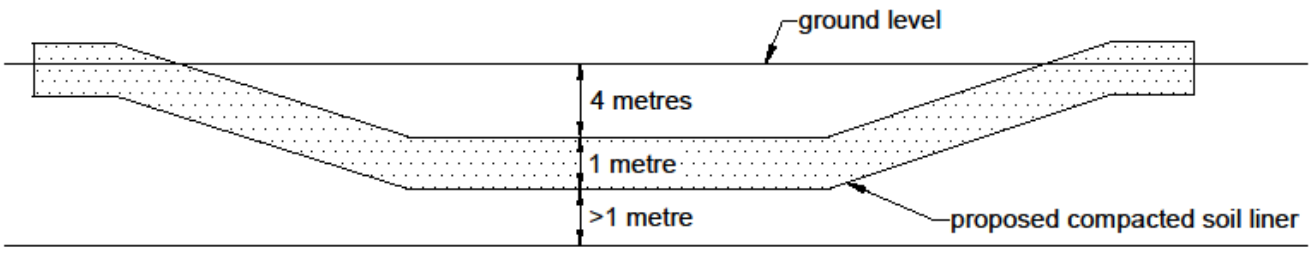
4.2 Compacted soil liner material sources *larger* than 3,600 m^3

A minimum of five representative test holes with one subsoil sample from each test hole is required:

- Two or more subsoil samples are tested for particle size, standard proctor density and hydraulic conductivity. The most conservative (highest) of these hydraulic conductivity results is compared to the regulations.
- Subsoil samples from the other three or more test holes are tested for particle size.

Example

In this example, the liquid manure storage facility has a proposed depth of 4 metres, with a 1-metre thick compacted soil liner. The regulations require the bottom of the liner to be 1 metre or more above the water table so the test hole depth for investigation must be no less than 6 metres.



4.3 Uniformity testing

Once a hydraulic conductivity result has been determined for the subsoil, the particle size analysis from that sample can be used to assess the uniformity of the other samples and can be a proxy for a hydraulic conductivity result. When all samples are ≥ 20% clay, samples are considered to be uniform if the clay content is within plus or minus 3% of the clay content of the sample tested for hydraulic conductivity.

4.4 Additional hydraulic conductivity tests

If more hydraulic conductivity tests are completed than the minimum required on uniform subsoils (based on particle size), the arithmetic mean of the hydraulic conductivity values may be used. If any of these individual hydraulic conductivity values do not meet the regulation, additional design, construction and reporting details may be required.

5. Laboratory Hydraulic Conductivity Testing

Several laboratory test methods are acceptable to test the hydraulic conductivity of material for construction of a compacted soil liner. Disturbed subsoil samples must be compacted to a standard proctor density to obtain a standardized compaction result for that particular subsoil.

These lab hydraulic conductivity tests are generally conducted on subsoil that is compacted at optimum moisture content, unless otherwise reported. Suitable test methods for reconstituted, remolded and compacted samples include:

- ASTM D5084-10, "Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter"
- ASTM D5856-95, "Standard Test Method for Measurement of Hydraulic Conductivity of Porous Material Using a Rigid-Wall, Compaction-Mold Permeameter"

6. Modification of Laboratory Hydraulic Conductivity Values for Liner Design

Hydraulic conductivity values determined by laboratory methods are typically increased by an order of magnitude to determine the field achievable hydraulic conductivity.

For example, a laboratory hydraulic conductivity value of 1 x 10^{-8} cm/s would correspond to an assumed field achievable hydraulic conductivity of 1 x 10^{-7} cm/s.

When a hydraulic conductivity value is increased by an order of magnitude, the liner material must have a moisture content range of plus or minus 2% from the optimum moisture content.

If a laboratory hydraulic conductivity value is not increased by an order of magnitude, additional construction considerations are required, which may add increased costs. As this is not typical, additional considerations would likely at a minimum include increasing the compacted soil's design moisture content to ≥2% more than the optimum moisture content and providing moisture content and density test results for each lift of the compacted soil liner.

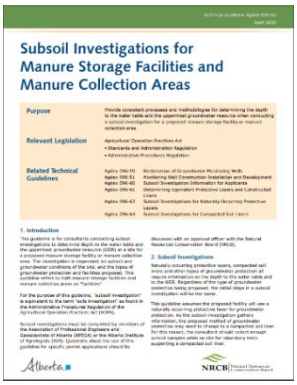
Generally, increasing liner material moisture content gives better groundwater protection than increasing the design compaction above the often specified 95% of standard proctor density.

7. Reporting

The subsoil investigation report should include a compacted soil liner design for the proposed manure facility containing the:

- Source(s) of liner material
- Certificates of analysis from laboratory testing (e.g., subsoil texture, lab hydraulic conductivity, etc.)
- Design hydraulic conductivity
- Recommendations for compacted soil liner design and construction
- Conclusions

Reporting should include all relevant information that was used to determine the water table and the upper most groundwater resource. More information on this reporting requirement can be found in Agdex 096-62, "Subsoil Investigations for Manure Storage Facilities and Manure Collections Areas."


Subsoil Investigations for Manure Storage Facilities and Manure Collection Areas

8. Documentation

Reporting and documentation requirements are specified within the conditions of the permit. Approval officers use their discretion to determine these requirements for each individual file.

The NRCB typically requires a signed and stamped construction completion report from the supervising APEGA member that may include:

- Proof the liner was constructed according to the recommended construction procedures
- Moisture content and density test results of the compacted soil liner, as discussed in section 6
- Liner thickness
- Information to confirm the liner material used is the same material that was submitted for hydraulic conductivity testing
- Other information as required by the NRCB approval officer

9. Construction and Other Considerations

Construction should be completed according to the plan submitted by the APEGA member and as approved by the NRCB.

The optimal construction equipment to compact a soil liner is a sheepsfoot packer. A padfoot packer can be acceptable for soil liner construction. A smooth packer is not acceptable for constructing compacted soil liners.

If a pipe structure or other protrusion extending through the liner is installed after the compacted soil liner has been constructed, proper construction methods must be used to ensure liner integrity around the pipe installation.

Additional liner protection is generally required below the discharge point of the inlet pipe to dissipate the energy from the liquid manure falling onto the compacted soil liner.

Agitation and agitator access areas in a liquid manure storage facility will also require additional protection so wheels and impellers do not damage the compacted soil liner.

For more information

Contact your nearest NRCB field office or Alberta government staff (dial 310-0000 to be connected toll-free)

Government of Alberta
alberta.ca/manure-management-guidelines-and-legislation

Ag-Info Centre	310 FARM (3276)
Publications	(780) 427-0391 or open.alberta.ca
Email	aginfocentre@gov.ab.ca

Natural Resources Conservation Board
www.nrcb.ca

Morinville	(780) 939-1212
Red Deer	(403) 340-5241
Lethbridge	(403) 381-5166
Email	info@nrcb.ca

This guideline was developed by the Technical Advisory Group, a partnership among the Government of Alberta, the Natural Resources Conservation Board (NRCB) and the agriculture industry.