

Subsurface Investigations for Waste Storage Facilities **Frequently Asked Questions**

What is a subsurface investigation and why is it needed?

A subsurface soil investigation is an exploration of the soil properties where an engineering structure is proposed to determine the suitability of the location. The investigation includes excavation of test holes, observation and logging (recording) of exposed subsurface conditions, collection and testing of soil samples, analysis of laboratory test data, installation of monitoring wells and monitoring of ground water levels. Subsurface investigations of soil and groundwater are generally required for all engineering practices. Some of the reasons for performing a subsurface investigation are listed below:

- a.) Develop a technically sound design and cost estimate.
- b.) Minimize the risk of encountering unforeseen conditions during construction that may result in design changes and increased costs (shallow bedrock, shallow water table, soil unsuitability for foundation support or low permeability pond liner, buried debris, etc.).
- c.) Provide contractors with information that will help them prepare an informed bid.

Subsurface investigations must adequately define the subsurface soil and water conditions pertinent to successfully designing and installing a technically sound waste storage facility.

How many holes are needed and how deep will the holes be?

The soil investigation must be complete and definitive. Nothing may be assumed or left to chance. The investigation is considered complete when the engineer decides there is enough information to develop a technically sound design.

- a.) NRCS conservation practice standards provide minimums – a starting point – regarding the number and extent of the test holes, pits or borings. The minimum number is directly related to waste storage facility surface area, which is directly related to selected depth, waste volume and storage period.
- b.) The actual number of test holes, pits or borings will depend on the complexity of the subsurface conditions encountered. Subsurface soil and water conditions must be adequately defined (soil and water features correlate well between holes) in order to provide confidence that design needs are satisfied and risk of unforeseen site conditions (“surprises”) during construction is minimized.
- c.) A soil survey map of the site may be indicative of site complexity. Sites encompassing several abutting soil types may require a greater number of test holes, pits or borings than sites encompassing a single, uniform soil type. However, due to the nature of soils in Michigan, even a site with only one soil type shown on the soil survey map may require an extensive subsurface investigation.
- d.) Discoveries made during the investigation – unsatisfactory soil or groundwater conditions, discovery of cultural resources, etc. - may result in a decision to change the waste storage facility location, resulting in a need for more soil pits.
- e.) Test holes, pits or borings will be needed within and outside the “foot print” of the proposed waste storage facility.

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For a planned waste storage facility, the Waste Storage Facility practice standard (sometimes referred to by its number "313") requires:

- a.) One test hole, pit, or boring for each 5,000 ft² for the first 20,000 ft² of planned storage facility surface area.
- b.) At least one test hole, pit, or boring for each additional 20,000 ft².
- c.) Each test hole, pit, or boring shall extend at least 2 feet below the planned bottom elevation of the waste storage facility.
- d.) Where groundwater, or evidence of a seasonal high water table is encountered, and a perched water table is suspected, it may be desirable to lower the water table in order to set the waste storage facility bottom elevation lower. In that case, the water table must be proven to be perched. This may require excavation to a depth greater than 2 feet below the proposed facility bottom elevation in order to determine if an unsaturated zone exists beneath the saturated (water table) zone.
- e.) Where a "Natural Clay Base" type of waste storage pond liner is planned, subsurface investigations must demonstrate that suitable natural soil material exists continuously from the freeboard elevation to a depth of at least 10 feet below the design bottom elevation of the pond.
- f.) As needed, enough additional test holes, pits or borings such that soil and water features can be correlated between test pits and subsurface conditions are adequately defined.

Where the waste storage facility will include an earth embankment or an above ground structure, additional investigations include:

- a.) Minimum of one test hole, pit, or boring per each 200 feet of planned earth embankment.
- b.) Each test hole, pit or boring shall extend to a depth greater than the anticipated above-ground height of earth embankments and above-ground structures (such as Slurrystore or fabricated reinforced concrete tanks). Where the above-ground height exceeds 10 feet, the need to extend test holes, pits or borings deeper than 10 feet may be determined on a case-by-case basis. Look for problem soils and subsurface conditions that cause differential settlement, large consolidation and collapse. Low bearing strength is a key factor. Items of concern include fine grained soils with a high water content, organic soil, a buried bedrock surface that is highly irregular or has significant slope, and karst terrain with near surface features showing evidence of piping of soils or collapse of bedrock into underlying voids.

Where soil materials, such as for a clay liner, will originate from an off-site location, a soil investigation of the borrow site is necessary.

Subsurface investigation is required for other component structures, e.g. manure reception pit, manure transfer pipeline, etc.

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What subsurface investigation is required as part of the evaluation of existing components for a Comprehensive Nutrient Management Plan (CNMP)?

Where an existing waste storage facility component is being investigated for preparation of a CNMP:

- a.) All waste storage facilities - One test hole, pit, or boring on at least 3 sides of the waste storage facility to determine the presence and elevation of a water table.
- b.) Natural Clay Base Liner – Minimum of one test hole, pit, or boring on at least 3 sides of the waste storage facility (pond). These may be the same 3 test holes noted above.
- c.) Compacted Clay Liner – Minimum of one liner sample from at least 2 sides of the waste storage facility (pond).

What type of sampling and testing will be done as part of the subsurface investigation?

- a.) Soil intended for use as a waste storage pond Compacted Earth Liner:
 - i.) Disturbed samples are to be laboratory tested for Unified Soil Classification System (USCS) soil type and permeability at 90 percent of the maximum density as determined by the Standard Proctor Test, ASTM D 698.
 - ii.) Request laboratory to test permeability at 95 percent of the maximum density if it fails at 90 percent.
 - iii.) Request laboratory to test using an appropriate additive (bentonite, clay dispersant, etc.) if permeability fails at 95 percent of the maximum density.
- b.) Soil currently being used as a Compacted Earth Liner in an existing waste storage pond undergoing an Evaluation of Existing Components (EEC) study. See Michigan Agriculture Environmental Assurance Program Guidance Document for CNMPs (See - ANIMAL OUTPUTS - What is needed to document and evaluate existing components of a livestock facility?):
 - i.) Undisturbed samples are to be tested for USCS soil type and permeability.
- c.) Soil intended for use as a waste storage pond “Natural Clay Liner, Two (2) Foot Option”:
 - i.) Undisturbed samples are to be laboratory tested for USCS soil type, plasticity index and permeability.
- d.) Undisturbed soil samples used for location of perching layer:
 - i.) Clod or Shelby Tube sample.
 - ii.) Test samples for natural and saturated moisture contents.
 - iii.) Samples testing out at 95 percent or greater natural moisture content may be considered to be saturated.
- e.) Base materials and drain filter materials for drainage systems:
 - i.) Disturbed samples are to be tested for grain size analysis, soil classification, and Atterberg limits.
 - ii.) Sample each different type of base material that will be in contact with the drain filter.
 - iii.) Sample proposed filter and drainage materials that do not already have a certified gradation (MDOT 2NS, ASTM C-33, etc.)

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How much time does it take?

A subsurface investigation may take ½ to 1 or more days of on-site work to fully complete, depending on the scope of the proposed project, and the complexity of the subsurface conditions encountered. Methodical is the operative word for the pace at which an investigation proceeds. This may be an unusual request for a power equipment operator familiar with moving earth rapidly. It is imperative for the power equipment operator to understand that this is not a race to dig and refill the holes as fast possible. The power equipment operator can expect to dig a little bit, and then sit idle for a period of time while investigators make and record observations, perform field tests, collect and package samples. It is also imperative for the landowner/operator understand that a slow and thorough investigation now may reduce construction costs later.

How many on-site visits will be needed?

Subsurface investigations are needed or may be needed during the following steps (or phases) in the process of implementing a waste storage facility:

- a.) Inventory and Evaluation (I&E) Phase - Preliminary Design – Following receipt of a request for NRCS technical and financial assistance for an engineering conservation practice, a subsurface investigation will be performed to determine the technical and economic feasibility of the proposed practice. Ideally, the subsurface investigation will be completed in one site visit and will be sufficient to use for the final design. Repeat site visits for additional soil investigation may be needed where:
 - i.) Poor site conditions, such as frozen soil and inclement weather, impeded the earlier investigation(s).
 - ii.) Excavation equipment (backhoe, drill rig, hand auger, etc.) provided for earlier investigation(s) was not capable of reaching to the required depth, or was not capable of excavating into or through the type(s) of soil materials encountered.
 - iii.) Unsuitable subsurface conditions discovered during an earlier investigation result in relocation of the proposed facility to a new site.
 - iv.) Prolonged dryer than normal weather occurs prior to the investigation or during the monitoring period.

- b.) Design Phase – Once the landowner/operator has entered into a conservation program contract with NRCS, work begins for preparation of the final design, construction drawings and specifications. Additional soil investigation work may be needed where:
 - i.) Insufficient lead time between conservation program sign-up and application submission deadline prevented completion of I&E subsurface investigation, or prevented laboratory testing and analysis of soil test data prior to the deadline.
 - ii.) A change in landowner decision(s) related to the planned facility type, location, depth, bottom elevation, size (waste volume, storage period, herd size).

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- c.) Construction Phase – Excavation during construction may reveal subsurface soil and/or water conditions differing substantially from those found during earlier subsurface investigations. This may require further subsurface investigation to define extent of the differing conditions, determine how the approved design is affected, and determine if changes are needed.

What happens if groundwater is encountered?

The Waste Storage Facility practice standard requires:

- a.) Waste storage pond bottom elevation must be at least 2 feet above seasonal high water table. Waste storage ponds are generally constructed with earth as the liner or earth as the structural support for the liner. They typically have side slopes of 1H:1V or flatter and are constructed by excavation or a combination of excavation and earth embankment.
- b.) A fabricated waste storage structure bottom elevation must be no lower than the seasonal high water table. Fabricated structures typically have vertical side walls and are typically constructed of reinforced concrete or steel.
- c.) A seasonal high water table may be lowered by gravity flow drainage **only** if it is determined to be a **perched** water table, as verified by subsurface investigation. Surface hydrology and nearby well logs alone are not enough to verify a perched water table. Saturated soil overlying an unsaturated soil is indicative of a perched condition.

A system of monitoring wells may be needed to document the presence and elevation of a water table. There are two types of monitoring wells:

- a.) Piezometers – Piezometers are used to monitor the water in a specific soil layer. Where piezometers are needed, they must be installed in undisturbed soil away from soil pits. A minimum of 3 piezometers are needed for each soil layer being tested.
- b.) Observation Wells – Observation wells are used to determine the general water table elevation within the entire soil profile. They are used when it is not necessary to identify a specific water-bearing layer of soil. This type of well is not typically used to determine perching conditions.

Where groundwater or evidence of a seasonal high water table is encountered and it is desired to lower the water table in order to set the bottom elevation lower, then a perching condition must be proven. To document the existence of a perching condition, the investigation must provide evidence of the existence of unconfined groundwater separated from the underlying main body of groundwater by an unsaturated zone. This may require that subsurface soils investigation depths need to exceed the minimums identified previously. Some methods for determining perching conditions are listed below:

- a.) Where moist to wet soil is encountered, non-caving test hole(s), pit(s), or boring(s) may need to remain open for several days in order to make observations of seepage and water level.
- b.) Installation of a system of piezometers.

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- c.) Undisturbed soil samples may need to be submitted for laboratory testing to determine natural water content and saturated water content of the soil.

If perching conditions cannot be demonstrated, the water table may not be lowered. This may result in raising the proposed facility bottom elevation or moving the proposed facility to a new location.

What type of equipment is needed for a subsurface investigation?

Equipment may include manually operated equipment (hand augers and probes) and power equipment (excavators, drill rigs, etc.). Equipment to address safety concerns is addressed later in another question. Listed below are some examples of when different equipment may be suitable:

- a.) Manually augering soil borings may be suitable where the excavation depth is five feet or less, the soil is easily penetrated (no rocks, dense hardpan or glacial till, unfrozen), and it is determined by NRCS that observation of soil features, seepage and/or evidence of seasonal high water in a larger open pit is not necessary.
- b.) Power equipment is required where excavation depth exceeds five feet, where the soil is too difficult to excavate manually, and where an open pit is needed to make adequate observation of soil features, seepage and/or evidence of seasonal high water.
- c.) Power equipment provided for the investigation must be suited to the job. It must have adequate reach and power and suitable attachments in order to excavate the soil materials to the maximum anticipated depth.

Who provides the workers, materials, equipment and pays for the investigation?

NRCS provides the following services:

- a.) Identify initial proposed soil boring locations and depths in advance to landowner/operator.
- b.) Provide workers and equipment to perform soil borings that will be conducted manually by hand augers or soil probes where appropriate.
- c.) Field testing and identification of soils, logging the soil borings and documenting observations of exposed soil and water features.
- d.) Onsite direction for proceeding with soils investigation (where and how many pits/monitoring wells).
- e.) Collection, packaging and shipping of soil samples to the NRCS Soil Mechanics Laboratory.
- f.) Soil testing services (through NRCS Soil Mechanics Laboratory). Depending on number of samples and types of testing requested and existing laboratory workload, test results may not be received for 3 to 6 months.
- g.) Analysis of the soil test results and determination of impact on proposed facility design.

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Landowner/Operator is responsible to provide the following and pay all costs associated with:

- a.) Power equipment – excavator, drill rig, etc. as appropriate to accomplish the planned subsurface investigations.
- b.) Power equipment operator
- c.) Monitoring Well Materials – all materials needed for monitoring wells (piezometers and observation wells) including pipe, screen, granular filter material (graded sand, gravel, etc.), sealing materials (bentonite, etc.).
- d.) Qualified contractor for installation of piezometers.
- e.) If suitable operator and power equipment are not provided, the subsurface investigation cannot be performed and the process stops. This setback may result in missing a conservation program contract application deadline, or delaying design completion and construction.
- f.) Safety
 - i.) Expect to incur costs for site preparation to address safety concerns at each pit location.
 - ii.) Covering and/or barricading soil pits left open for observation.

Factors that may affect the landowner/operator's total cost of subsurface investigation(s) include:

- a.) Contractor rates for equipment, operator, mobilization to and from the investigation site.
- b.) Final extent of soil investigation – number and depth of test holes, pits, or borings.
- c.) Final number, depth, and type of monitoring wells.
- d.) Expect to pay for at least ½ to 1 day of operator and equipment time, plus mobilization, each time they come to the site.
- e.) Expect to pay for refilling holes at a later date if soil pits are kept open for monitoring.
- f.) Expect to pay for "idle" time. The objective is to expose subsurface conditions to visual inspection, collect soil samples, measure elevations and depths, and record observations as the work progresses. Operator can expect to dig a few scoops, then sit idle while investigators complete their work.
- g.) Where monitoring wells are being installed, extra time will be needed to examine soil cores and determine precisely where well point is to be placed.
- h.) Frequency and duration for monitoring wells to be checked for water levels in the weeks or months following installation.

What are safety concerns, activities and equipment related to a subsurface investigation?

Below is a list of safety concerns, activities, and equipment when conducting a subsurface investigation. The investigators have the authority to leave the site if the landowner fails to implement these or other reasonable safety activities or equipment:

- a.) Hard Hats
 - i.) All individuals within reach of the excavator's overhead boom shall wear a hardhat.

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b.) Utilities

- i.) Landowner/operator is responsible to contact MISS DIG (1-800-482-7171) at least 3 working days before subsurface investigation begins if:
 - The power equipment will not be able to maintain at least a 10 foot clearance from any overhead electric lines within the investigation area, OR,
 - The investigation will occur in or adjacent to a street, highway, other public place, in a private easement for a public utility, or near the location of utility facilities.
- ii.) The landowner/operator is responsible for locating any buried utilities (water lines, electric lines, telephone lines, gas lines, sewer lines, etc.) in the work area that are not covered by the MISS DIG system.

c.) Tripping and Slipping Hazards. At the site of each proposed soil pit:

- i.) Tall vegetation within a 20 foot radius of the pit location shall be mowed down to within 2 - 4 inches of ground surface.
- ii.) Uneven ground (furrows, rills, gullies, etc.) shall be leveled off.
- iii.) Debris (rocks, stumps, brush, dead animals, etc.) shall be removed.
- iv.) Ponded surface water shall be removed.
- v.) Snow accumulation more than 4 inches deep shall be removed from the area within a 20 foot radius of the pit location. Ice shall be removed or adequately sanded.

d.) Livestock

- i.) For the safety of the livestock and the investigators, ALL livestock shall be excluded from the investigation area. For the safety of the investigators, aggressive animals (bulls, etc.) shall be confined in a manner that is acceptable to the investigators.

e.) Excavation:

- i.) While overhead power equipment is operating, either stand outside of the boom reach radius, or stand in a location that is clearly visible to the operator. Stand clear of the counter weight.
- ii.) Under no circumstance is anyone at the site allowed to enter excavations greater than 3.5 feet deep unless excavated side slopes above the 3.5 foot depth are sloped back on 1.5 horizontal to 1 vertical or flatter.
- iii.) Under no circumstance is anyone at the site allowed to ride the excavator bucket.
- iv.) Excavated materials shall be deposited as far as practical away from the soil pit edge, preferably a distance greater than the anticipated pit depth, but no closer than 4 feet from the top perimeter.
- v.) Keep visits to the pit edge for making observations and measurements as short as possible. Watch for cracks developing in the soil near the pit edge and for slumping of the pit sides. Watch for seeps eroding away soil and undermining the pit walls.

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- vi.) Where excavation will take place adjacent to an existing waste storage pond, the pond shall be empty or nearly so (not more than 1 foot of waste). Soil pits shall be located a horizontal distance of at least 1.5 times the anticipated depth beyond the outside toe of the pond embankment and beyond the foundation of a structure.

- f.) Fall Protection. Open pits are the best way for the investigator to observe the undisturbed soil profile in place, but they potentially introduce the need for the following fall protection:
 - i.) Where the soil pit depth will exceed 3.5 feet and the pit side slopes will be steeper than 1.5 horizontal to 1 vertical, consider providing equipment to prevent falls into the pit, and in the event of a fall, equipment to allow exiting the pit:
 - a. A “personal fall arrest system” harness with appropriate ropes and hardware.
 - b. Ladder of sufficient length to reach maximum anticipated depths, and of sufficient capacity to support anticipated loads.
 - ii.) Where soil pits will be left open for monitoring, pits shall be covered and/or barricaded/fenced adequately to exclude humans, livestock and wildlife from falling in.

When will you schedule the subsurface investigation?

Presence of groundwater is a key factor. The spring and fall wet season is generally the best time to observe the soil in its wettest condition.

To the maximum extent possible, subsurface investigations should be scheduled and performed during the “field” season when snow, frozen soil, and cold weather conditions will not limit the performance of the investigation. Where subsurface investigations absolutely must be scheduled outside the “field” season, the landowner/operator will be responsible to remove snow and will have to obtain power equipment that can penetrate frozen soil. Follow-up site visit(s) may also be needed in order to complete the investigation at a later date.

A cultural resources review must be completed for the Area of Potential Effect prior to an on site soils investigation. This may take up to 6 weeks to be completed.