Testing to Help Your Project Succeed

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Before one gets to a finished development…

One needs to complete:

- A series of tests and reviews from multiple regulatory agencies and/or authorities
- Designs based on test results/ criteria establish by the regulatory agencies (**Conservation Districts & PA DEP**)
- Reviews by the regulatory agencies
- Revisions/additional testing if necessary

Timing of Testing

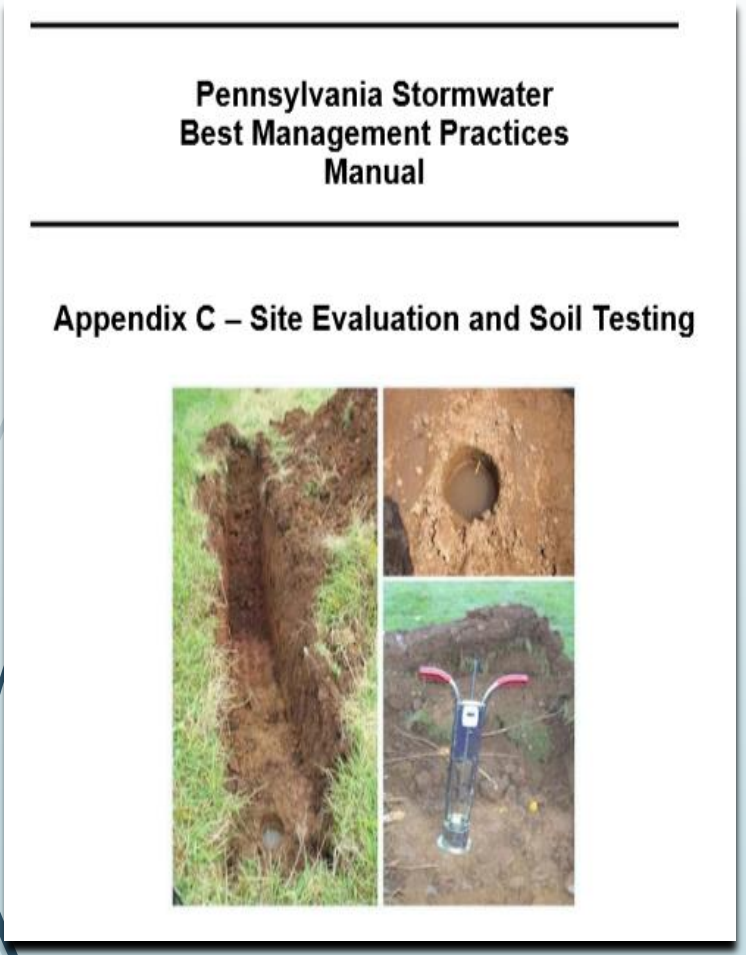
- Lots of questions to be answered:
  - Do you want to test before you start designing and have to revise?
  - How much time will be lost if you have to "go back"?
  - What is the most cost efficient way to deal with the issue?
  - How early in the process do you need to know project cost (or ultimately viability)?

So one starts with a “raw” piece of ground

What are the concerns should be considered?

- Underlying geology
- Soil (developed from the geology)
- Vegetation
  - tree cover
  - wetlands & streams (“regulated features”)
- Slope
- Special considerations –
  - previous land use
  - Land application of materials other than farm waste

Pennsylvania Stormwater Best Management Practices Manual -Appendix C – Site Evaluation and Soil Testing



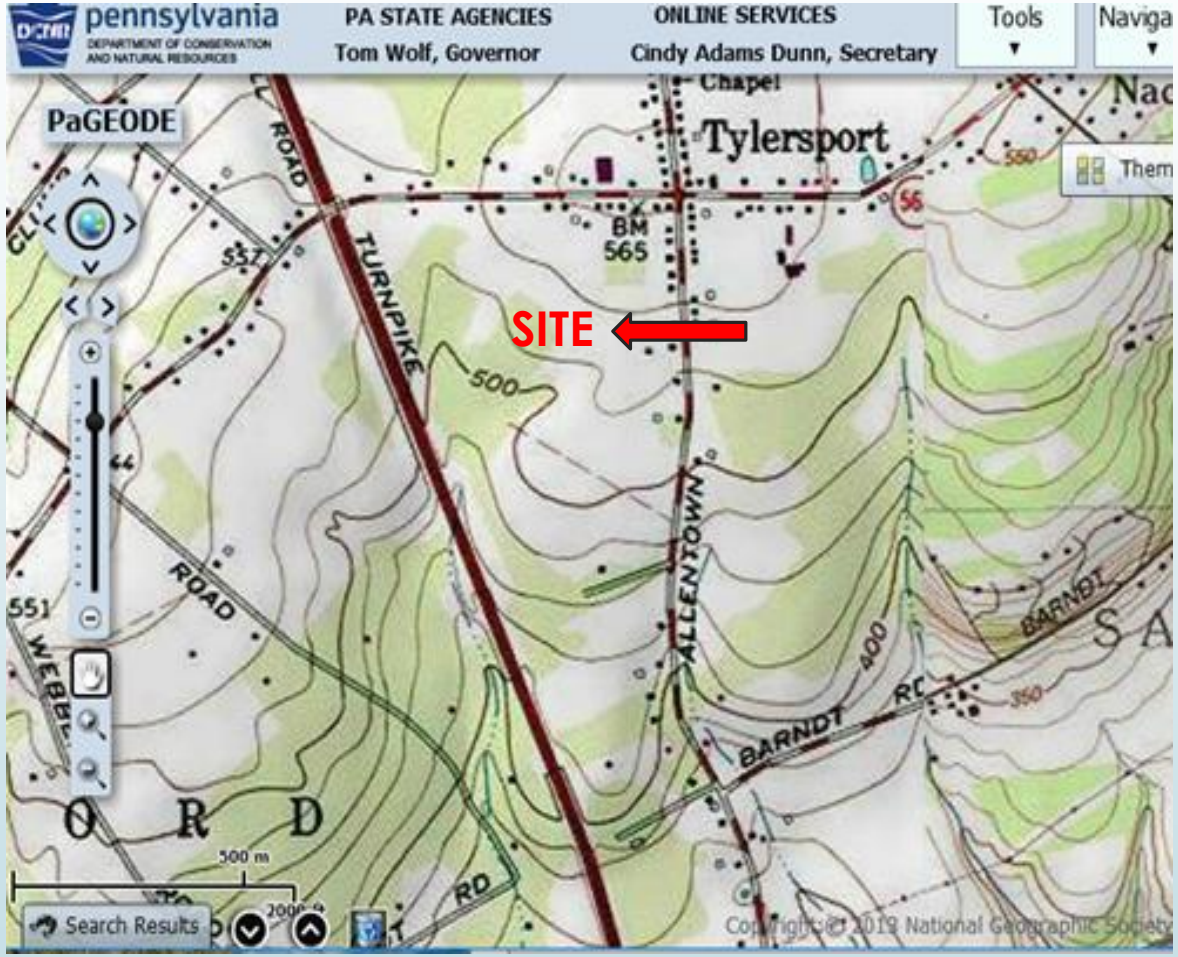
- Designers are encouraged to conduct the Soil Evaluation and Investigation early in the site planning and design process.
- Soil Evaluation and Investigation should be conducted early in the preliminary design of the project so that information developed in the testing process can be incorporated into the design.
- The Designer should possess a preliminary understanding of potential BMP locations prior to testing.
- Adjustments to the design can be made as necessary.

Start by eliminating areas voided by code

- Steep slope
  - Check the municipal ordinance
    - >25% severely restricted
    - 15-25% somewhat limited
    - Can be done on paper

Natural Flow

- Water flows downhill
- Downhill areas are wet areas



https://www.gis.dcnr.state.pa.us/geology/index.html

Start by eliminating areas voided by code

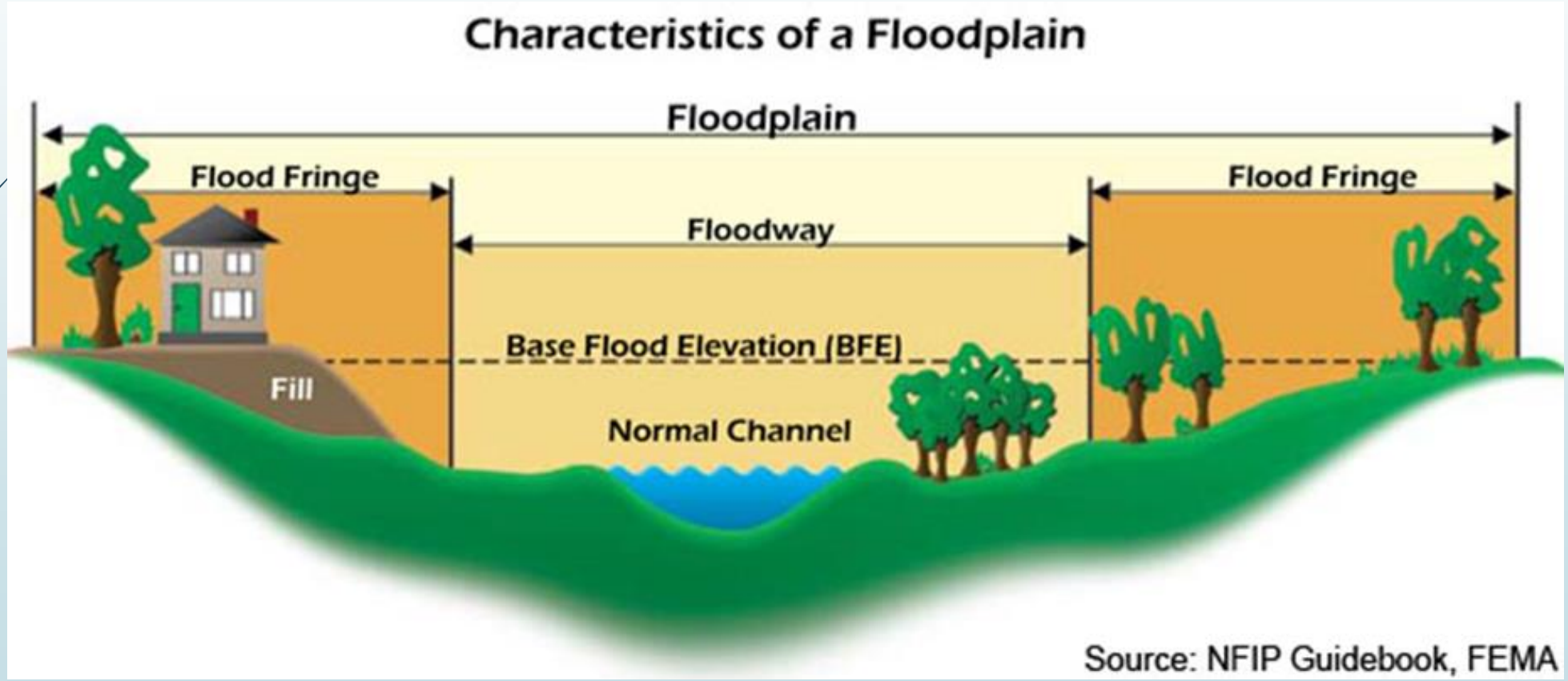
- Wetlands
  - Hydrology (water)
  - Hydrophytic vegetation (plants that LOVE (i.e. need) water)
  - Hydric soils (soils that are saturated)

Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season.

https://www.epa.gov/wetlands/what-wetland

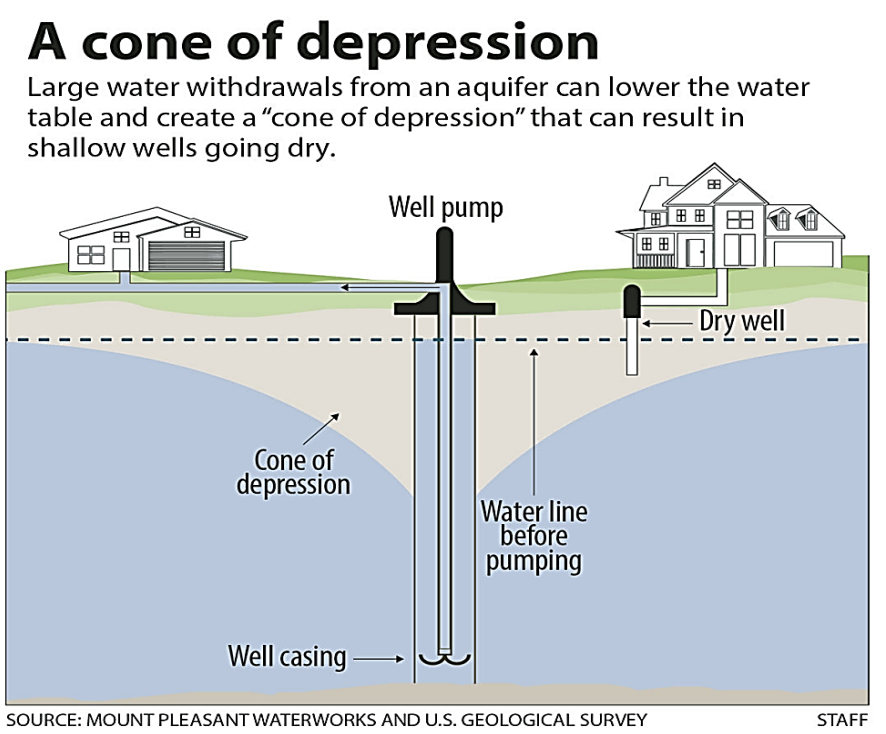
Start by eliminating areas voided by code

- Floodplains – "riparian buffer" – stormwater is already collecting there



Distance to wells & septic systems

- Be aware of other water use/disposal on sites
  - Well water needs to stay clean
  - Soil near septic systems needs to stay dry for ***septic*** use



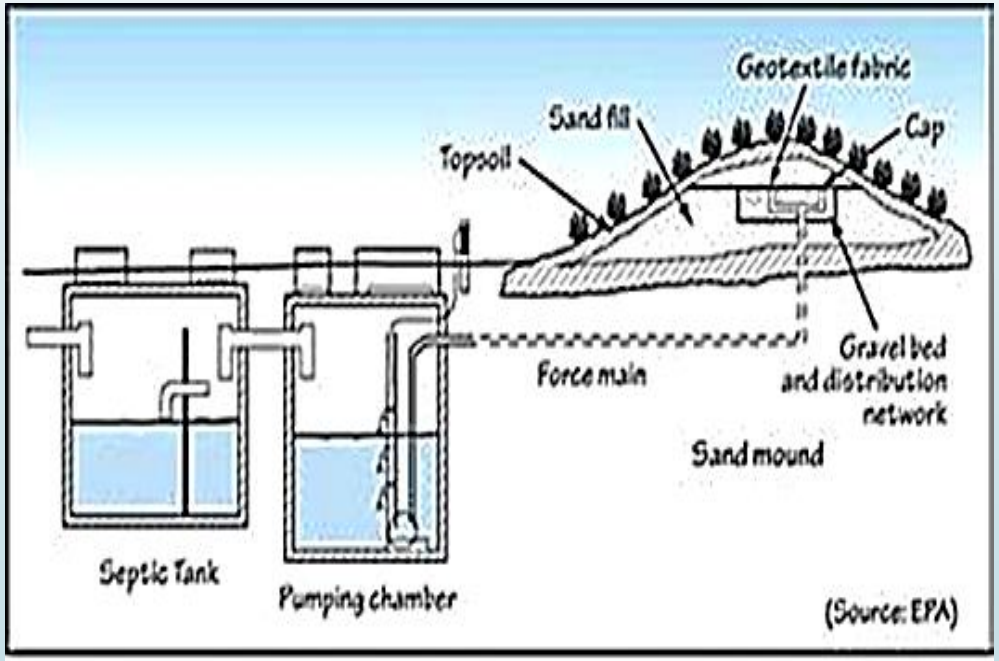
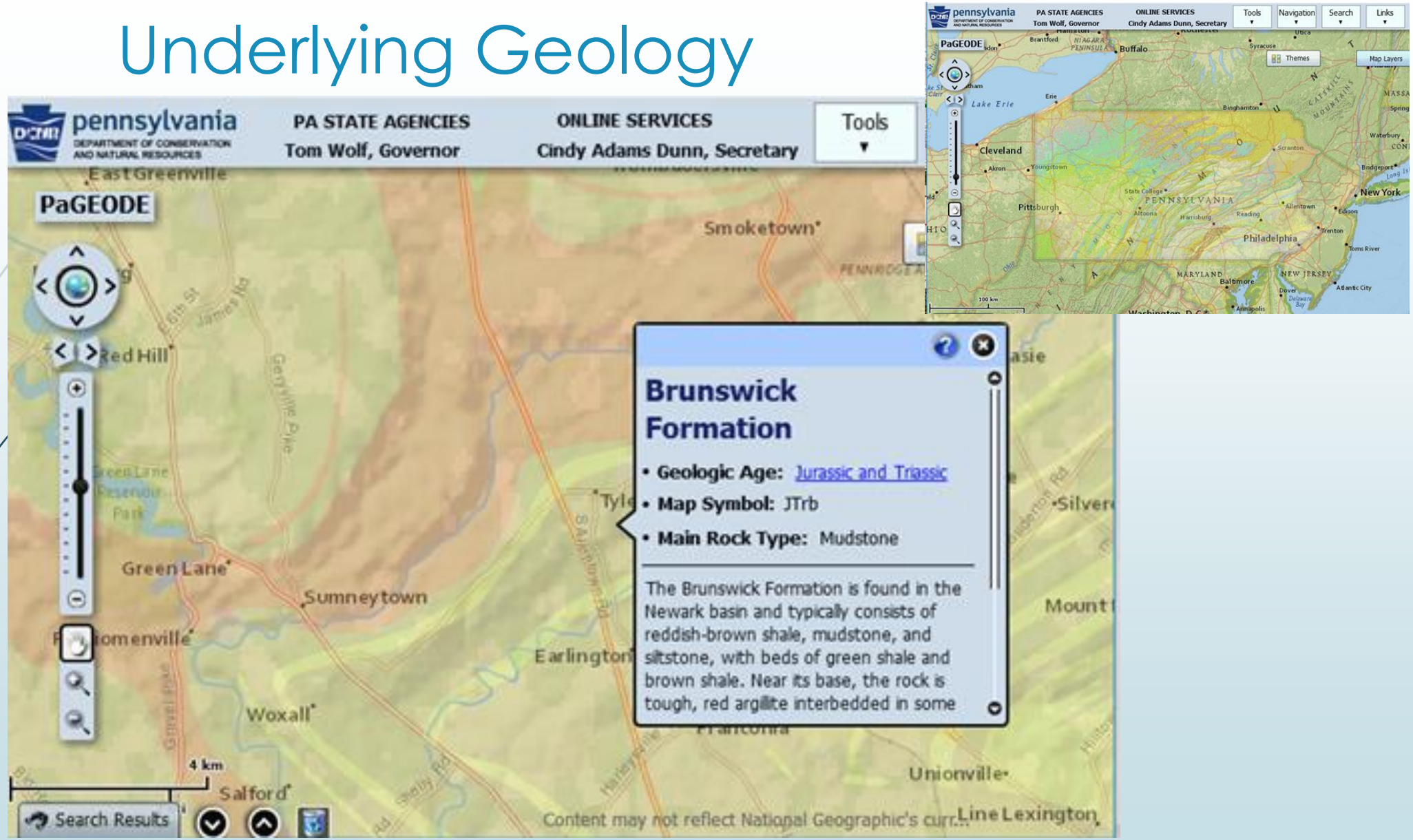


Figure 4 - Schematic of a Sand Mound System

Underlying Geology



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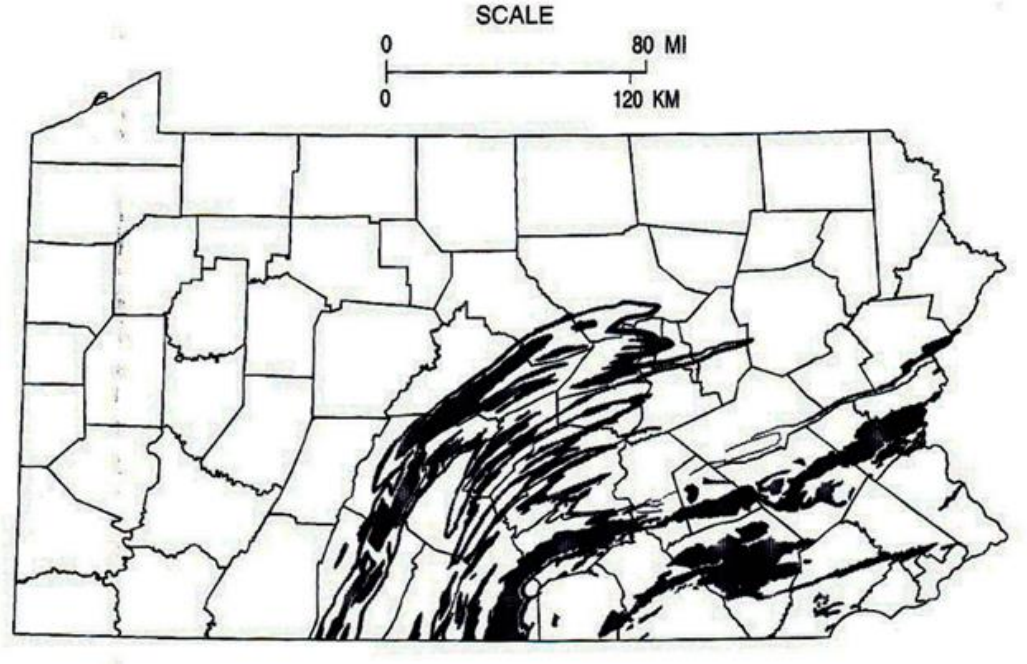
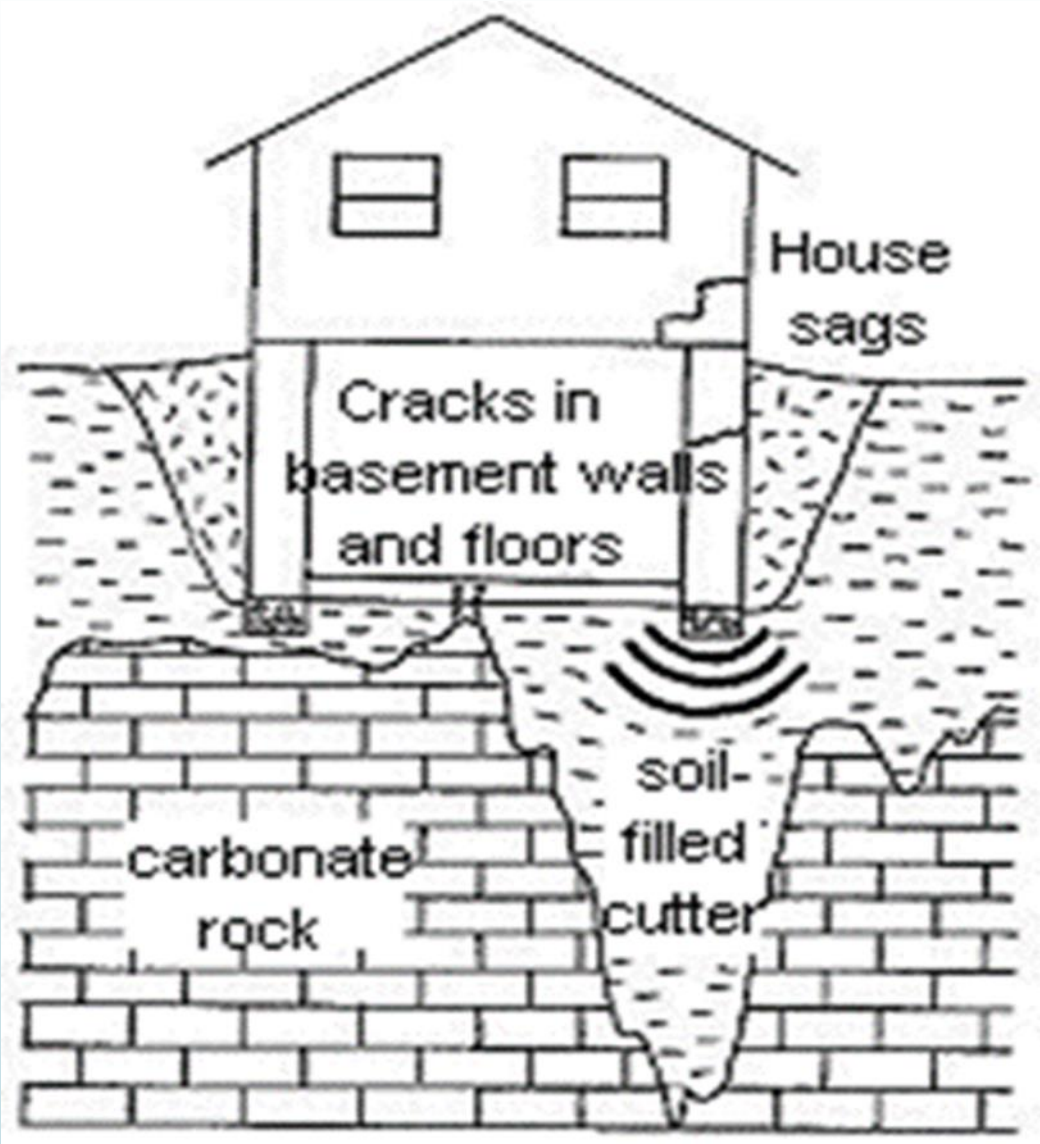
Geology - special concern

- Limestone – dissolves which creates sinkholes & depressions
- $CaCO_3$ – dissolves to CO_2 gas
- Extensive limestone in Lehigh Valley & Lancaster Co.



Structural concerns over limestone

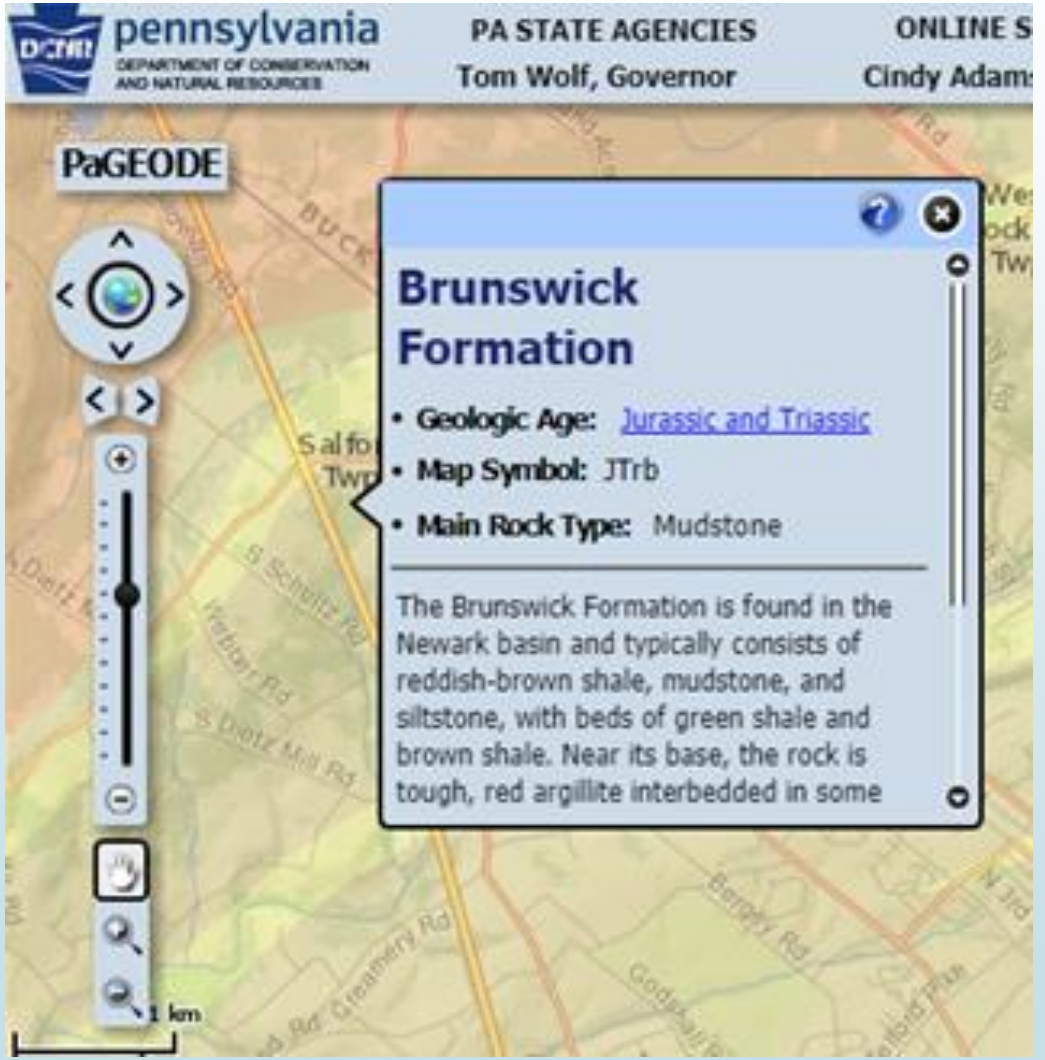


Looking for "good soil"

- What properties make soil "good"?
  - *Depth - deeper is better*
  - *Drainage – water needs to go away*
  - *'Stone-free' – not necessarily good – "rock is our friend"*
    - *No surface stone – not covered with 'diabase'*
    - *Easily diggable – shale is easier to dig than diabase*

Soil Starts with Geology

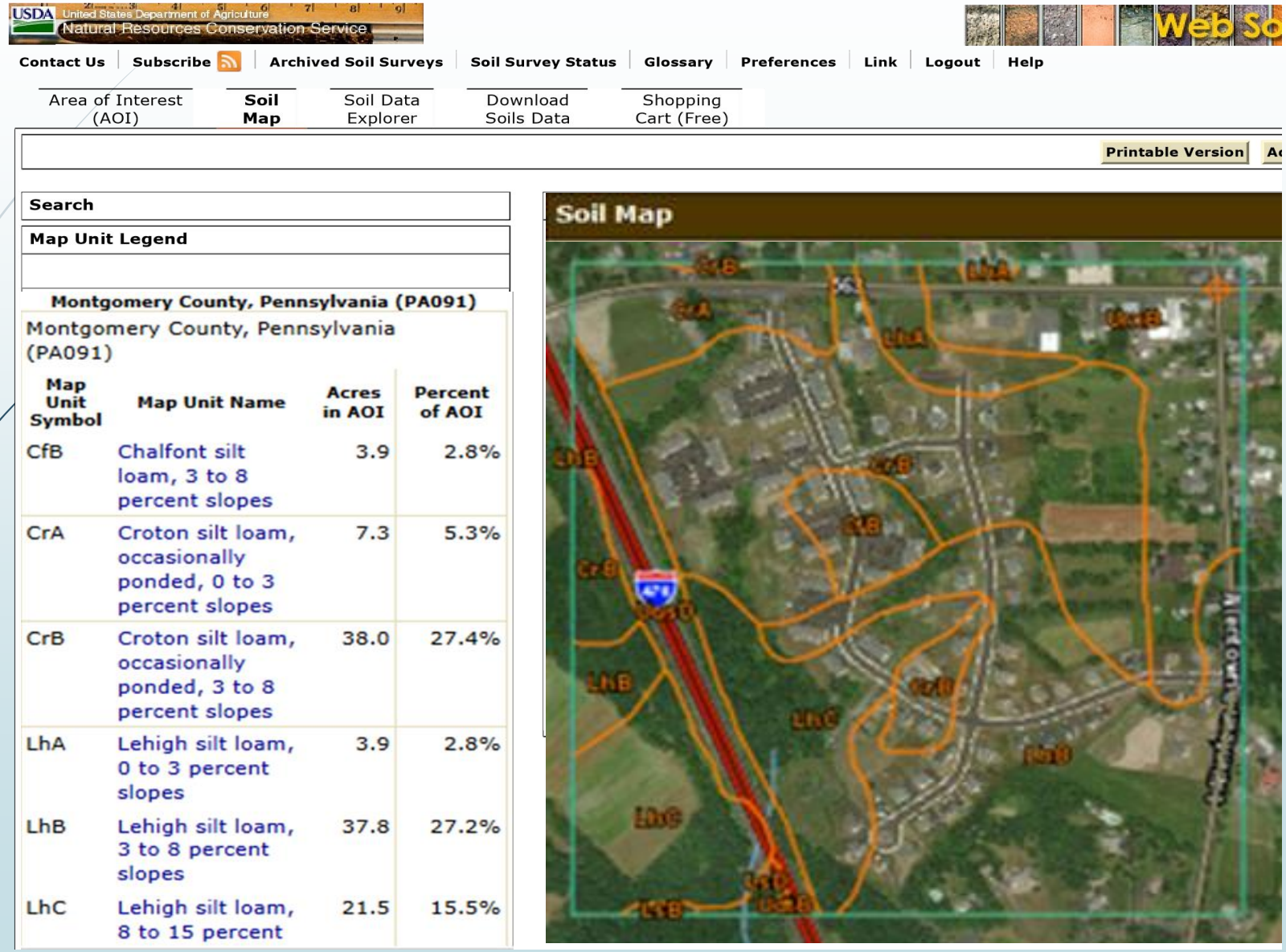
- "Our Site" is mapped as red shale
- Should be "soft", easily diggable
- Mapping isn't always accurate
- Road cut at the Turnpike
  at Ridge Road (clue)



‘Clues’ to Geologic Issues

- *We’re on a ridge – Bedrock is harder than neighboring rock*
- *Deepest cut on the Turnpike*
- *Right down the road is a quarry*

NRCS Soil Map



Montgomery County, Pennsylvania (PA091)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
CfB	Chalfont silt loam, 3 to 8 percent slopes	3.9	2.8%
CrA	Croton silt loam, occasionally ponded, 0 to 3 percent slopes	7.3	5.3%
CrB	Croton silt loam, occasionally ponded, 3 to 8 percent slopes	38.0	27.4%
LhA	Lehigh silt loam, 0 to 3 percent slopes	3.9	2.8%
LhB	Lehigh silt loam, 3 to 8 percent slopes	37.8	27.2%
LhC	Lehigh silt loam, 8 to 15 percent	21.5	15.5%

Variety of Soil vs. Accuracy of mapping

Variety -Four soil types:

- Lehigh soil series - mod. well drained
- Croton soil series – poorly drained
- Chalfont soil series – somewhat drained
- Udorthents (disturbed land)

Variability

- Noted in description only 90%
- *Actual variability within soil mapping units is even greater*

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CfA—Chalfont silt loam, 0 to 3 percent slopes

Map Unit Setting

- Elevation: 200 to 1,500 feet
- Mean annual precipitation: 38 to 48 inches - Mean annual air temp: 50 to 57 degrees F
- Frost-free period: 140 to 200 days
- Farmland classification: Farmland of statewide importance

Map Unit Composition

- Chalfont and similar soils: 90 percent
- Minor components: 10 percent
- Estimates are based on observations, descriptions, and transects of the map unit.

Setting

- Landform: Upland slopes
- Landform (two-dimensional): Footslope
- (three-dimensional): Side slope
- Down-slope shape: Concave, linear
- Across-slope shape: Linear, concave
- Parent material: Loess over residuum weathered from shale and siltstone

Properties and qualities

- Slope: 0 to 3 percent
- Depth to restrictive feature: 15 to 30 inches to fragipan; 42 to 99 inches to lithic bedrock
- Natural drainage class: Somewhat poorly drained
- Runoff class: Very high
- Capacity to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
- Depth to water table: About 6 to 18 inches
- Frequency of flooding: None
- Frequency of ponding: None
- Available water storage in profile: Low (about 3.5 inches)

Interpretive groups

- Land capability classification (irrigated): None specified -3w
- Hydrologic Soil Group: D -Hydric soil rating: No

Minor Components

Doylestown

- Percent of map unit: 7 percent
- Landform: Drainageways
- Landform position (two-dimensional): Toeslope, footslope
- Head slope
- Down-slope shape: Concave, linear –
- Across-slope shape: Linear, concave
- Hydric soil rating: Yes

Lawrenceville

- Percent of map unit: 3 percent
- Landform: Upland slopes
- Landform position (two-dimensional): Footslope
- Down-slope shape: Linear, concave –
- Across-slope shape: Linear, concave
- Hydric soil rating: No

https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

Field Testing for Infiltration

- A Test Pit (Deep Hole) allows visual observation of the soil horizons and overall soil conditions both horizontally and vertically in multiple areas of the site.
- A number of Test Pit observations can be made across a site at a relatively low cost and in a short time period.
- Borings and other procedures are limited for initial screening to develop a preliminary plan for testing, or verification testing.
- The use of soil borings as a substitute for Test Pits strongly is discouraged in the BMP Manual because visual observation is narrowly limited in a soil boring and the soil horizons cannot be observed in-situ, but must be observed from the extracted borings.

Test Pit Description

https://www.aswm.org/pdf_lib/soils_webinar/soil_texture_and_structure_rossi_071316.pdf

Soil Profile Descriptions

- Soil Horizons - layering – A, B, C's of soil
- Soil Texture –percentage sand/silt/clay including estimated type and percent coarse fragments
- Color including redox mottling (indicates drainage problems)
- Depth to Water Table
- Depth to Bedrock
- Observance of Pores or Roots (size, depth)
- Hardpan or Limiting Layers
- Strike and dip of horizons (especially lateral direction of flow at limiting layers)

Soil Descriptions

O (humus or organic

A (topsoil)

E (eluviated horizon)

B (subsoil)

C (parent material)

R (bedrock)

O HORIZON
Surface litter: Partially decomposed organic matter

A HORIZON
Topsoil: Humus, living creatures, inorganic minerals

E HORIZON
Zone of leaching, materials move downward

B HORIZON
Subsoil: iron, aluminium humic compounds are accumulated and clay leached down from A and E horizons

C HORIZON
Weathered parent material: Partial breakdown of inorganic minerals

R HORIZON
Bedrock

Permeability below Restricted Drainage?

- Depends on bedrock ("substrate")
  - Sandy bedrock/subsoil
    - Lower Bucks/Eastern Montgomery
  - Fractured bedrock
    - Red shale and olive shale ~ not usually in gray shale
    - Metamorphic rock near Philly
    - No water

Fractured Rock vs. Consolidated Bedrock

- Water will move through fractured rock
  - Sometimes it moves too quickly (10 inches/hour max)
  - Shale/slate fractures "better"
  - "Rock is our friend" – fragments tend to increase permeability
- Water does not move at any significant rate through consolidated bedrock
  - *Some water moves through sandy bedrock (0.2 inches /hour min.) **

** Editorial notes are italicized*

How much Testing?

- For single-family residential subdivisions with on-lot BMPs, one test pit per lot is recommended, preferably within 25 feet of the proposed BMP area. Verification testing should take place when BMPs are sited at greater distances.
- For multi-family and high density residential developments, one test pit per BMP area or acre is recommended.
- For large infiltration areas (basins, commercial, institutional, industrial, and other proposed land uses), multiple test pits should be evenly distributed at the rate of four (4) to six (6) tests per acre of BMP area.

Infiltration Tests/Permeability Tests

- Double-ring Infiltrometer (DRI)
- Percolation test
- 5-inch diameter casing-Testing as described in the Maryland Stormwater Manual Appendix D.1.
- Guelph Permeameter
- Constant Head Permeameter (Amoozemeter)
- ASTM 2003 Volume 4.08, Soil and Rock (I): Designation D 3385-03, Standard Test Method for Infiltration Rate of Soils in Field Using a Double-Ring Infiltrometer.
- ASTM 2002 Volume 4.09, Soil and Rock (II): Designation D 5093-90, Standard Test Method for Field Measurement of Infiltration Rate Using a Double-Ring Infiltrometer with a Sealed-Inner Ring.

Double Ring Infiltrometer

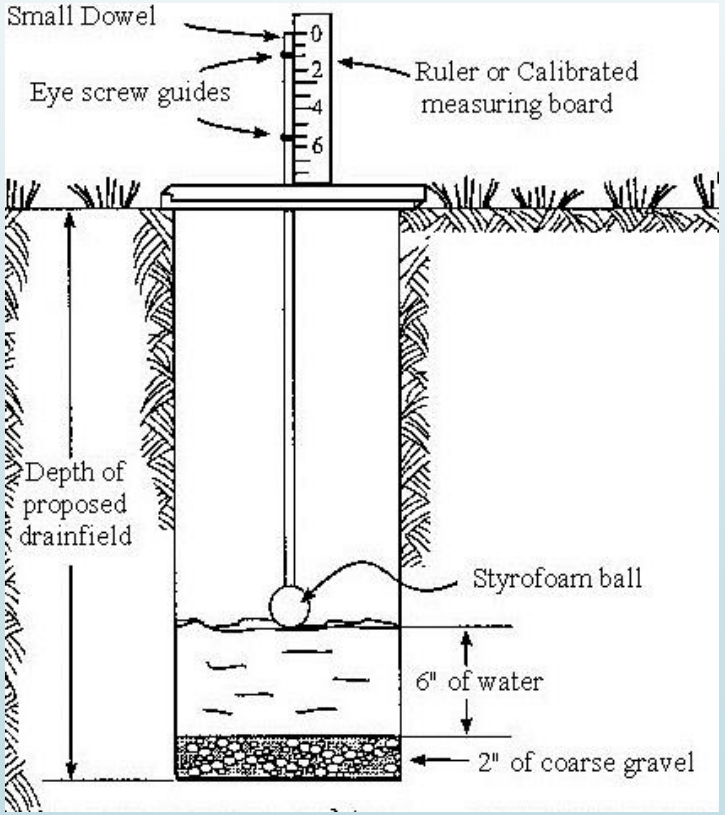
- The minimum water depth should be 4-inches.
- Pre-soak for one hour. The drop in the water level during the last 30 minutes of the hour presoak period determines the time interval between readings:
  - If water level drop is 2-inches or more, use 10-minute measurement intervals.
  - If water level drop is less than 2-inches, use 30-minute measurement intervals.
- Measurement to the water level in the center ring shall be made from a fixed reference point and continue at the determined interval until a minimum of eight readings or until a stabilized rate is obtained.
- A stabilized rate of drop means a difference of 1/4 inch or less of drop between the lowest & highest readings for four consecutive readings.

Percolation Test

This percolation test methodology is based largely on the Pennsylvania Department of Environmental Protection (PADEP) criteria for on-site sewage investigation of soils (as described in Chapter 73 of the Pennsylvania Code) (**septic system testing**).

This should include the 24 hour pre-soak procedure between June 1 and December 31.

The average measured rate must be adjusted to account for the discharge of water from both the sides and bottom of the hole {rate reduction formula applied as described by Elrick and Reynolds (1992), or Fritton, et al (1986)}



SITE CONDITIONS and CONSTRAINTS

- a) **It regularly is desirable to maintain a 2-foot clearance above occurring seasonally high water table**. This reduces the likelihood that temporary groundwater mounding will affect the system, and allows sufficient distance of water movement through the soil to allow adequate pollutant removal. Some minor exceptions for very shallow systems and on grade systems, filter strips, buffers, etc.
- *"Seasonal" water table language needs to be changed/removed.*
- *Late Fall through late Spring a 'seasonal' water table is possible.*
- *Most redox features in soil indicate slow top-down permeability (not water table saturation).*

Restricted Drainage vs. Water Table

"Seasonal High Water Table" versus actual groundwater

SITE CONDITIONS and CONSTRAINTS

- b) **Maintain a minimum depth to bedrock of 2-feet to assure adequate pollutant removal**. In special circumstances, filter media may be employed to remove pollutants if adequate soil mantle does not exist.
- *Research at DelVal University in the 1990's indicates that sewage is cleaned to stormwater quality after going through one foot of soil. One would expect stormwater would be cleaned sufficiently after one foot as well.*

SITE CONDITIONS and CONSTRAINTS

- c) **It is desired that soils underlying infiltration devices should have infiltration rates between 0.1 and 10 inches per hour.**
- Soils with rates in excess of 6.0 inches per hour may require an additional soil buffer (such as an organic layer over the bed bottom) if the Cation Exchange Capacity (CEC) is less than 5 and pollutant loading is expected to be significant.
- In carbonate soils, excessively rapid drainage may increase the risk of **sinkhole formation**, and some compaction or additional soil may be appropriate.
- Where soil permeability is extremely low, infiltration may still be possible but the surface area required could be large, and other volume reduction methods may be warranted.

Finally… (finally!)

- **Do not compact soil infiltration beds during construction!**

  "Bed bottoms should always be graded into the existing soil mantle…"

  Infiltration bed surfaces are best left rough and as un-graded as possible

- **Infiltration BMPs should be sited so that any risk to groundwater quality is minimized.**
- **Infiltration BMPs should be sited so that they present no (*limited*) threat to subsurface structures** – basements, wells, septics, utilities
- **Protect the infiltration area from sediment until the surrounding site is completely stabilized.**

Summary

- *Due diligence – avoid problems*
- *Test early – density is affected by infiltration BMPs*
- *Calculate density to determine project viability*
- *Testing allows engineers to anticipate reviewers concerns/questions.*

Speaking of questions….

- Do you have any questions….?

- Thank you for your attention!