papss
Pennsylvania Association of Professional Soil Scientists

MANUAL FOR SOIL INVESTIGATION IN PENNSYLVANIA

Version 2.0 (2010)

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1.0 INTRODUCTION

The purpose of this Manual is to summarize accepted practices and methods for soil scientists in Pennsylvania, and to standardize the way soil scientists in the Commonwealth conduct and report soil investigations. This Manual is the result of several years of work and is not intended to be a "how to" guide. In the compilation of this Manual, an attempt was made to utilize existing protocols wherever possible, adapting them as needed to the needs of soil scientists in Pennsylvania. As such, some of the text may seem familiar to some. A great deal of gratitude is directed toward those sources that we utilized.

This Manual discusses the practice of soil science as it relates to conducting site-specific soil investigations. It is primarily useful in determining non-agricultural and non-silvicultural land use management of a site. This Manual is not intended to be the last and final word on any of the topics covered. Recognizing the evolving nature of soil science, this Manual is intended to be a "living, breathing document" subject to regular revision as more information and newer techniques come to light. It is hoped that we have provided the format of a document that will advance along with science and be of use to soil scientists and other professionals for some time to come.

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Cover: A Glenelg soil profile in the Piedmont of Pennsylvania.

1.1 QUALIFICATIONS

Because of the complexities of soil characterization, any soil investigation shall be conducted by or under the direct supervision of a SSSA (formerly ARCPACS) Certified Professional Soil Scientist or Soil Classifier (CPSS or CPSC) or professional member of the Pennsylvania Association of Professional Soil Scientists (PAPSS). The rigorous standards inherent in these certifications are intended to ensure that qualified individuals are providing such services. Additionally, investigations conducted in areas of karst or other sensitive geology must also be reviewed by a Professional Geologist (PG).

1.2 ETHICS

Any soils investigation has the potential to impact public health, public welfare, safety and livelihood. As such, any investigation conducted must be done so under the strictest of ethical standards. Any Certified Professional Soil Scientist or Soil Classifier (CPSS or CPSC) or professional member of the Pennsylvania Association of Professional Soil Scientists (PAPSS) will be bound by the code(s) of ethics of either or both of these organizations. While any soil investigation should be conducted by a professional soil scientist, if for some reason, a non-professional is conducting a soil investigation of any type, he/she must be held to these same standards. The following is the code of ethics of the Pennsylvania Association of Professional Soil Scientists (PAPSS) and shall be adhered to at all times:

<u>CODE OF ETHICS</u>

To establish and maintain a high standard of integrity, skills, and practice in the Soil Scientist profession, the following shall be binding upon every Association Member.

IN RELATIONS WITH THE PUBLIC, THE PROFESSIONAL SOIL SCIENTIST:

- Shall express an opinion on Soil Science subjects only when thoroughly informed and only when it is founded on adequate knowledge and honest conviction.
- Shall endeavor to extend public knowledge and appreciation of Soil Science and its achievements and to foster broader recognition of the need, use, and application in government and private business.
- Shall oppose and discourage any untrue, unsupported, and/or exaggerated statements regarding the profession.
- Shall not advertise work or accomplishments in a self-laudatory, exaggerated, or unduly conspicuous manner.

IN RELATIONS WITH EMPLOYERS AND CLIENTS, THE PROFESSIONAL SOIL SCIENTIST:

- Shall advise employer or client to engage and cooperate with other experts and specialists whenever the employer's or client's interests would be best served by such service.
- Shall not accept compensation from more than one interested party for the same

services pertaining to the same work without disclosure and consent of the interested parties.

- Shall act as a faithful agent and protect, to the fullest extent possible, the interest of the employer or client insofar as such interest is consistent with professional obligations and ethics.
- Shall not disclose, directly or indirectly, information concerning the business affairs of employer or client in any way without consent.
- Shall not, as an employee of a governmental body, receive personal compensation with respect to services provided when representing employer.

IN RELATIONS WITH EACH OTHER, THE PROFESSIONAL SOIL SCIENTIST:

- Shall refrain from undue criticism of the work of another professional in an attempt to injure the Soil Scientist's reputation.
- Shall freely give credit for work done and to whom the credit is properly due.
- Shall promote high quality standards among Soil Scientists and encourage the ethical dissemination of technical knowledge.
- Shall not compete unfairly with other professional Soil Scientists.
- Shall be candid and forthright in statements and responses to the Society or its representatives in matters pertaining to professional conduct.

IN DUTY TO THE PROFESSION, THE PROFESSIONAL SOIL SCIENTIST:

- Shall foster good land use and environmental programs through the use of sound soil resource information.
- Shall accept personal responsibility for professional work performed.
- Shall not lend use of name in an enterprise of questionable nature.
- Shall strive to increase the competence and prestige of the Soil Scientist profession.
- Shall endeavor to increase the effectiveness of the profession by broadening education, through association with other professional organizations, and by other appropriate means.
- Shall keep abreast of current changes and developments in the field of Soil Science.
- Shall uphold this Code of Ethics by precept and example and encourage, by counsel and advice, other professional Soil Scientists to do the same.

2.0 GEOMORPHOLOGY

Geomorphology is defined as the "branch of both physiography and geology that deals with the formation of the earth, the general configuration of its surface, and the changes that take place in the evolution of landforms." The importance of geormorphology in soil science cannot be overstated as it affects two (2) of the five (5) soil forming factors (parent material and relief).

Although the term geomorphology encompasses a multitude of concepts and ideas, concerns can be refined to the effects that a particular land form has on its corresponding soils. Within this scope, and in consideration of the landscapes of Pennsylvania, the following list generally relates to those geomorphic environments of note within Pennsylvania:

A landscape in the glaciated plateau.

- Coastal marine and estuarine
- Lacustrine
- Fluvial
- Solution (limestone)
- Eolian
- Glacial
- Periglacial

Pennsylvania has been divided into physiographic regions based largely upon the above-noted processes that have created, and continue to effect, the current landscape and its soil. The following map presents of physiographic provinces and regions of Pennsylvania:

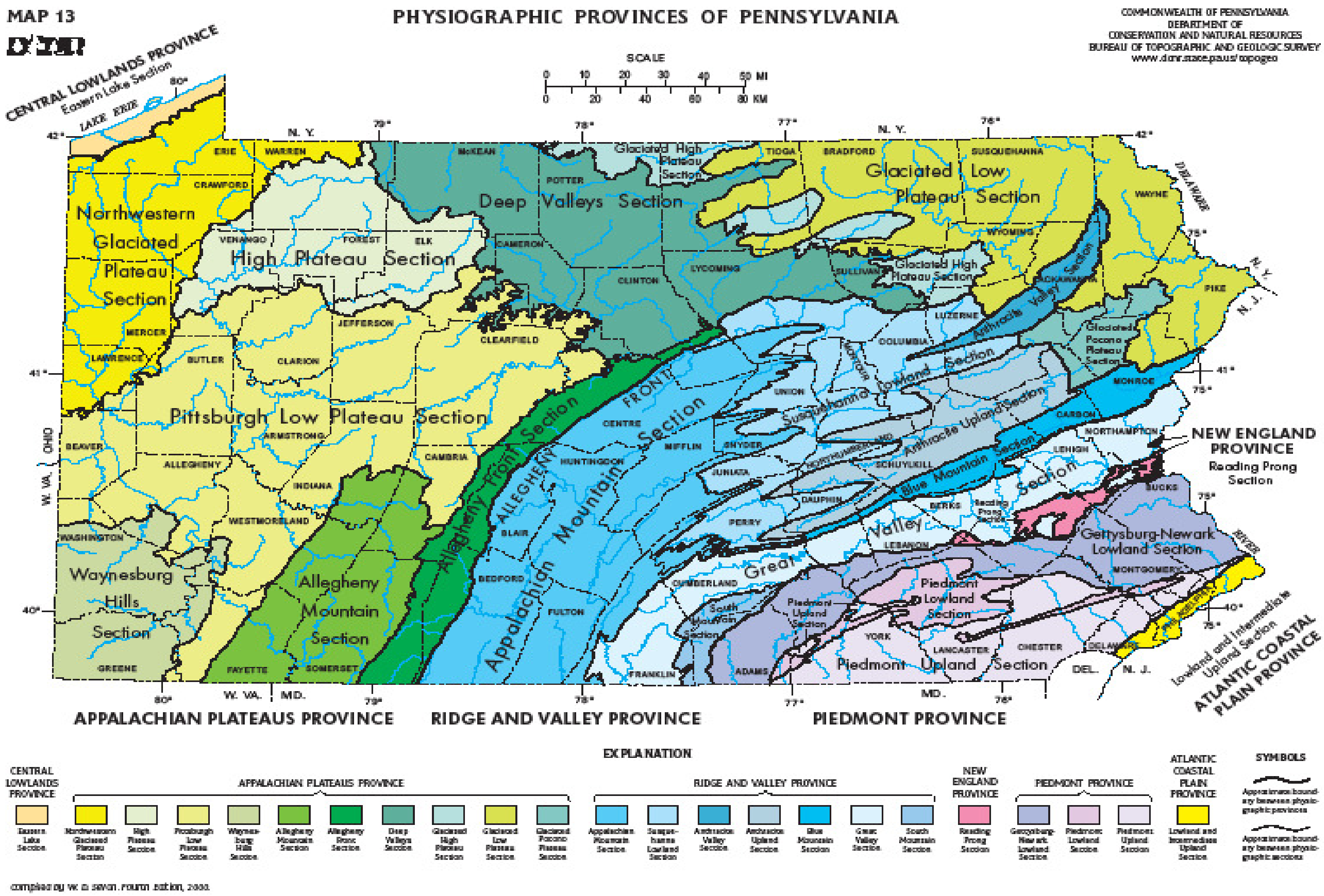


FIGURE 1 – *Physiographic Provinces of Pennsylvania*. **Sevon, W. D., compiler, 2000, Physiographic provinces of Pennsylvania: Pennsylvania Geological Survey, 4th ser., Map 13, scale 1:2,000,000**

As illustrated by the Figure 1, each of the physiographic provinces is further divided into subsequent physiographic regions, though a detailed discussion of these is beyond the scope of this document. (See http://www.dcnr.state.pa.us/topogeo/map13/map13.aspx for more information). However, it is important to understand these concepts as a whole when evaluating any landscape, and to incorporate a basic description of the same when evaluating a site.

2.1 LAND RESOURCE REGIONS / MAJOR LAND RESOURCE AREAS

Another source of geomorphologic information is contained in the NRCS' Major Land Resource Area (MLRA) mapping. MLRAs are a subset of Land Resource Regions (LRRs) which are organized according to broad agricultural uses across a given region. MLRAs contain more detailed information about a particular area, and a basic overview of the following topics is provided for each MLRA:

- Land Use
- Physiography
- Geology
- Climate
- Water
- Soils
- Biological Resources
-

2.2 MACROTOPOGRAPHY (MACROSURFACES)

Provided that the soil scientist details site slopes and landforms, macro topographic features should be adequately documented. Slope is a basic but essential criterion to soil use and management. Furthermore, landforms provide additional and valuable insight into any site description. For the benefit of those who may never visit a site, the difference between a summit position and toe slope are essential. As opposed to microtopographic features (below), macro- features will generally be encompassed by Order 2 mapping procedures (see Section 4.0).

2.3 MICROTOPOGRAPHY

On the opposite end of the spectrum in terms of detail, a site evaluation should also consider the presence and effects of micro-topography or micro-relief, defined according to the Soil Science Society of America (SSSA) glossary as follows:
Microrelief: (i) Generically refers to local, slight irregularities in form and height of a land surface that are superimposed upon a larger landform, including such features as low mounds, swales, and shallow pits. (ii) Slight variations in the height of a land surface that are too small to delineate on a topographic or soils map at commonly used map scales (e.g. 1:24 000 (Order 2) and 1:15 840).

The key consideration is the scale at which these features occur, and that at Order 2 or greater mapping scales, they may escape description. Furthermore, these features can cause localized changes in surficial and subsurface hydrology, among other considerations, that warrant special notation. Siting on on-lot sewage disposal systems, for example, can frequently be afforded by virtue of micro-topographic features, and as such may inaccurately imply site characteristics on a broader scale.

Legacy sediments along the East Branch of the Perkiomen Creek in Montgomery County

According to the USDA-NRCS Sample Pedon Description Form, a site evaluation should include notations for all of the above noted criteria, from the very broad physiographic region to a description of a site's applicable micro-topographic features. Terms used to define these various categories and criteria can be obtained from the "Field Book for Describing and Sampling Soils Version 2.0"Schoeneberger, P.J., Wysocki, D.A., Benham, E.C., and Broderson, W.D., 2002.Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE. (ftp://ftp-fc.sc.egov.usda.gov/NSSC/Field_Book/FieldBookVer2.pdf). Though conflicts may exist between the various sources of information, one should consult all sources in developing an appropriate site description.

3.0 GEOLOGY

Though the individual features of soil and geology are not always directly related, the importance of site geology within a soil description / evaluation cannot be overstated. A detailed discussion of the state geology is beyond the scope of this document; however there are numerous references available on-line and in print. The following Geology subheadings provide a broad overview of the basic concepts that should be observed and considered in a detailed soil evaluation.

3.1 ROCK TYPES/DEPTH TO BEDROCK

Where encountered, a description of general rock types, in the context of a detailed soil evaluation pursuant to the methods in this Manual, should include at a minimum the consideration of lithology and competency. A review of Map I can provide links to information sources on basic lithology, and a further description of competency can assist in basic classification efforts, including lithic and paralithic criteria. The depth class of any soil, as well as some diagnostic taxonomic classifications, are related to specific depths to either lithic or paralithic contact.

Typical geoprobe core used for deeper investigations. Black staining indicates Manganese oxidation to an insoluble state

Residually weathered soils will generally reflect characteristics of the parent rock in terms of mineralogy (and varying degrees of structure in the case of saprolitic material), while other geomorphic processes will produce contrasting horizons and layers. In particular, solution-forming (limestone) and fluvial processes can create unique circumstances that dominate the interpretation and use of the overlying soil.

3.2 DIP/STRIKE

Dip and strike are criteria that assist in describing the layering and orientation of bedded rock units, ranging from unaltered horizontally bedded sedimentary rock to metamorphic rocks that have undergone extensive uplift and folding.

Strike is a line that is parallel to the bedding plane, while dip describes the angle of the plane in relationship to 0°, or a perfectly horizontal surface. The following figure illustrates these concepts:

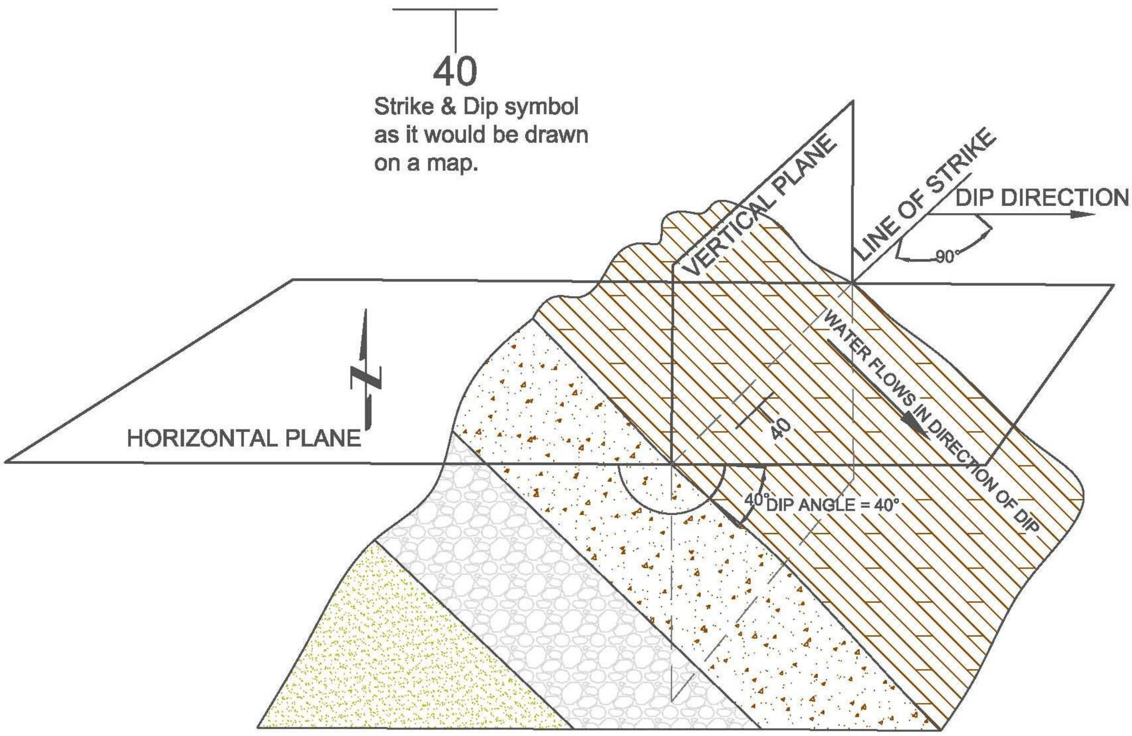


FIGURE 2 - Strike and dip

The easiest way to identify strike and dip is generally through an exposed bedrock surface. This may be possible within the confines of a test pit if sufficient material is exposed. If there is insufficient exposure in a test pit, and no surficial bedrock exposures are present, it may be infeasible and unnecessary to assess this criteria.

Though somewhat outside the scope of most routine detailed soil investigations, strike and dip can nonetheless provide supplementary information that may assist in a larger classification of a site's underlying geology, and correlation to nearby or adjacent geological formations that have been previously mapped.

In some instances, the characteristics of the overlying soil are related to the sites strike and dip features. An understanding of strike and dip may assist in explaining changes in discrete features over a small area, particularly on sites with shallow, residually weathered soils.

3.3 HIGH RISK LANDS, SOILS AND GEOLOGY

One of the major geologic and soils hazards in Pennsylvania is limestone. Entire municipal ordinances have been written and land uses dictated by the presence or absence of limestone geology, including but not limited to some of PA DEP's criteria for sewage and stormwater suitability. Flooding, landslides and acid drainage sources would likely comprise other hazards of great concern. Though review of a site's geologic mapping may not reveal all potential concerns, it still remains as an important requirement and tool in the overall assessment of site soils. Whenever a site investigation goes beyond a routine soils evaluation or if there is uncertainty with regards to the subsurface, the soil scientist shall consult with a registered Professional Geologist (P.G.)

4.0 MAPPING STANDARDS

4.1 MAP SCALE

Prior to a site investigation, the existing published soils information is to be reviewed. While this information is valuable, it must only be viewed as a preliminary first step in the investigation. Soil surveys that are published or available electronically provide a reasonable approximation for the soil properties that one can expect on a given property. However, these soil surveys were intended for farmers and foresters to manage the land so that the natural resources may be harvested in a sustainable fashion. The information in these soil surveys have also been useful for the practice of broad-based civil engineering and general land use planning in identifying areas with poor drainage, steep slopes, rock outcrops, and erosional features.

A raingarden in Abington Township, Montgomery County

In Pennsylvania, there are published and on-line soil surveys for every county in the Commonwealth. The vast majority of these soil surveys are considered "Order 2" Surveys. The scale for these surveys range from 1:12,000 to 1:31,680. This equates to a range of scales on the aerial photograph maps of 1 inch = 1/5 to 1 inch= ½ mile. The minimum soil map unit size for Order 2 Surveys is 1.5 to 10 acres. If a soil map unit is smaller than this minimum size, it will not be utilized in a Survey at this scale. For any type of land use project, this level of investigation is inadequate to determine the site-specific properties of the soil and their relationship to specific uses. A site-specific investigation must be advanced to more accurately identify the pre-development existing soil characteristics of the site. Additionally, further investigations will need to be advanced in the areas proposed for specific uses such as on-site sewage disposal, stormwater infiltration, etc.

It should be noted that the soil series referenced in each published or on-line soil survey is appropriate for the scale of the investigation of that particular soil survey. For the purposes of agriculture and forestry and general land-use planning, the information in the soil survey is accurate. While the soil survey may show one soil type yet a site-specific investigation, one encounters a different soil type; both investigations are correct. Because of the sensitivity and intensity of land development, the information in the site-specific soil survey must be recognized as being the most accurate.

The soil series concept was created with the county-level (Order 2) soil surveys in mind. It is likely that the soils encountered during a site-specific investigation do not match any one particular soil series perfectly and would likely be considered a taxadjunct or variant to a soil series. While soil classification is important relative to pre-existing conditions and in establishing soil hydrologic groups, the soil morphological properties as they relate to specific uses are the critical portion of this investigation.

Site-Specific investigation scale must be large enough to permit refined distinctions among small homogeneous areas of soils. The soil scientist and the user must choose a scale which meets their needs. The needs of each project shall dictate the appropriate scale. For example, site evaluations for land development should have mapping at scales no smaller than 1 inch = 100' and larger scales of 1 inch = 50' or more may be appropriate.

TABLE 1

Order of Soil Survey	Components	Field Procedures	Appropriate Scales	Minimum Size Delineation
Order 1	Phases of soil series	The soils are identified by transecting and traversing. Soil boundaries are observed throughout their length.	<1:12,000	<1.5 acres
Order 2	Phases of soil series	The soils are identified by transecting and traversing. Soil boundaries are plotted by observation and interpretation of remotely sensed data. Boundaries are verified at closely spaced intervals. Most county soil surveys are Order 2.	1:24,000 to 1:31,000	1.5 to 10 acres
Order 3	Phases of soil series and soil families	The soils are identified by transecting and traversing and some observations. Boundaries are plotted by observation and interpretation of remote sensing data and some direct observations.	1:24,000 to 1:250,000	6 to 640 acres

Order 4	Phases of soil families and subgroups	The soils are identified by transecting. Boundaries are plotted by some observation and by interpretation of remote sensed data verified by occasional direct observations.	1:100,000 to 1:300,000	100 to 1,000 acres
Order 5	Phases of subgroups, great groups, suborders and orders	The soils are identified by mapping of selected area with 1st or 2nd order surveys or alternately by transecting. Mapping is by widely spaced observations or by remotely sensed data.	1:250,000 to 1:1,000,000	640 to 1,000 acres

4.2 MAPPING BASE

The soil scientist will be responsible to ensure that site-specific base plans or maps are of suitable quality to meet the planning standards defined in this document. Types of suitable base plans include, but are not limited to:

- Aerial photos
- Site specific topographic maps or engineered plans
- Orthophotos
- Digital Orthophoto Quads (DOQs)

Site specific plans are the preferred methodology and shall be of a scale and detail as to be sufficient for the needs of the proposed project.

4.3 FIELD PROCEDURES

In areas where soils retain a relatively high degree of predictability, delineations are to be identified by traversing the landscape making sufficient soil observations to enable accurate soil boundary placement and to ensure appropriate soil map unit composition. Soil observations are to be conducted by either auger boring, shovel excavation, backhoe excavation, or other accepted means. Soil boundaries are observed throughout their length, and their placement corresponds to changes in soil properties or land form. Remotely sensed data may be used as an aid in boundary delineation. A grid is often not an acceptable method in which to advance these investigations. Soils are predictable across landscapes; therefore an investigation involves mapping landscapes as much as mapping soils. Observations should be conducted within each geomorphic landscape position that is significant to the investigation.

In areas where soils are complex and unpredictable, delineations are to be identified by transecting the landscape and making soil observations at appropriate intervals to justify the map unit selection. Sufficient transecting is to be completed to ensure accurate soil line placement and to ensure appropriate soil map unit composition. Soil boundaries are to be observed throughout their length within the subject property boundaries, and their placement to correspond to changes in soil properties or land form. Remotely sensed data may be used as an aid in boundary delineation.

The method of soil investigation shall be determined by the soil scientist taking into account any regulatory constraints. For example, certain applications under current regulations, such as on-lot sewage disposal, are required to utilize backhoe pits in whole or in part. Other methods such as hand auger, trenching spade or other appropriate methods are suitable for use for purposes other than on-lot sewage disposal or for supplementary information to augment backhoe pits for on-lot sewage disposal cases. In lieu of regulatory constraints it is the duty of the soil scientist to determine the appropriate method of soil investigation for the application at hand. No data available to the soil scientist should be ignored. For example, utility trenches or tree throws shall be observed if available and that data incorporated into any decisions made by the soil scientist.

Soil map units are to be appropriately separated for the purpose of carrying out land use applications.

Ground control is required and shall be at the density specified by the soil scientist. Specific government entities may require specific ground control depending on the purpose of the soil map product being produced. At a minimum, measurements should be made from two permanent reference points while also referenced by GPS coordinates. Survey location of delineations is to be preferred.
The topography of a site comprises all of the surface features of the landscape that influence the distribution and properties of soils, as well as the suitable uses of a particular site. Sound land use decisions are dependent on accurately and thoroughly cataloging site topography. Prior to a field investigation, the soil scientist should review published soil surveys, topographic maps, and aerial photographs. Published data is valuable in determining the scope of a field investigation and in targeting particular areas of a site, but does not substitute for a site-specific study. An accurate description of a site should include the following items:

TABLE 2

Attribute	Attribute Description	Examples
Land Use	Current vegetated habitat or type of human activity	fallow farm field, woodlot
Relief	elevation, change in elevation across the site, micro-relief	550 feet above msl, 100 feet from high point to low point, broad swale, ridge top

Slope	gradient, aspect, length, configuration	50-ft long, north-facing, concave footslope, 8%
Outcrops	type, size, spacing, area occupied	limestone, 5-ft diameter, occupying 20%, regularly spaced 30-ft apart
Vegetation	type, size, vigor	soybean, white pine, scrub-shrub wetland

4.4 RELIEF

Relief describes the elevation of the site above sea level, the overall difference in elevation from the high point to the low point, and descriptions of mounds, swales, pits, and other features that interrupt the overall relief of the site.

Any feature that influences surface runoff should be described, especially if those features are not apparent on a topographic map or plan.

4.5 SLOPE

Descriptions of slope should not only include the percent gradient, but also the slope aspect, slope length, and slope configuration. Slope gradient is the inclination of the surface from level.

Slope gradient must be measured with a clinometer, hand level, transit or other appropriate instrument and never be estimated by eye. Slope is to be reported in percent (elevation change/horizontal distance).

Slope aspect is the direction that the surfaces faces, described in relation to north, south, east, or west, or in degrees from north. Slope aspect affects soil and land use due to differences in temperature, evapo-transpiration, and exposure to wind. The effect of slope aspect is greater on sites at higher latitudes, higher altitudes, and with greater relief.

Slope length is the distance that water runoff will travel before encountering a change in direction or speed. As with slope gradient, the length of the slope should be quantified whenever possible rather than using descriptive terms. A very long slope in the Piedmont may be considered a very short slope in areas of the Allegheny Plateau.

Slope configuration is the relationship between slope gradient and landform shape. Slope configuration determines the direction of surface runoff. Shape of the landform parallel to the contours is described by the shape of the contours. If contours are relatively straight, then the landform is linear. If contours point uphill, the landform is concave, and if contours point downhill, the landform is convex. Where the slope is concave, as in a swale, runoff concentrates near the center of the landform, and where slope is convex, as on a ridge projecting into a valley, runoff is spread out as it moves down the slope.

The shape of the landform is also described perpendicular to the contours and can generally be correlated to hillslope position (summit, shoulder, backslope, footslope, toeslope). Hillslope position affects erosion and deposition of soils, and rate and direction of runoff.

4.6 ROCK OUTCROPS

Rock outcrops are exposures of bedrock or strata projecting through the overlying soil. The impact of outcrops on land use is dependent on the size and spacing of the outcrops, the area occupied by outcrops, and the properties of the soils between the outcrops.

4.7 VEGETATION

Vegetation observed in the field aids in classifying and mapping soils. Differences in the species can provide clues to depth and drainage classification of the soils, particularly in historically agricultural areas, where wooded sites are an indication that the soils are too wet or rocky to be plowed. Within fields of a single crop, differences in plant vigor can indicate changes in soil type.

4.8 MAP UNIT PURITY

Different kinds of soil map units are used to accommodate different complexities of soil patterns on the landscape to best meet the purpose of the survey. Two kinds of units are appropriate for site-specific soil investigation, consociations and complexes.

4.8.1 CONSOCIATIONS

Map units will contain 75 percent or more of pedons that fit within the range of the taxon that provides the name for the map unit, or are in a similar taxon.

- No one similar soil is greater than the named reference taxon.
- The total amount of dissimilar inclusions will not exceed 25 percent.
- No single dissimilar soil will make up more than 10 percent of the map unit.
- Limiting inclusions do not exceed 15 percent of the map unit.

(More intensive separation of dissimilar inclusions within a map unit can be made at the discretion of the soil scientist.)

4.8.2 COMPLEXES

Map units consist of areas of two or more kinds of soils that are in a regularly repeating pattern so intricate that the two components cannot be delineated separately at the scale of mapping.

- The major components that provide the name for the map unit are sufficiently different in morphology or behavior that the unit cannot be named as a consociation.

- No single dissimilar soil will make up more than 10 percent of the map unit.
- Limiting inclusions do not exceed 15 percent of the map unit.
- The total amount of dissimilar inclusions will not exceed 25 percent.

4.8.3 NON-CONFORMING SITUATIONS

At the discretion of the Soil Scientist, areas of dissimilar inclusions, too small to be delineated, will be shown with special features symbols.

5.0 IDENTIFICATION OF MAP UNITS

The identification of soil map units depends upon the proposed usage. Utilization of taxonomic class names at the series level, and accompanying phase terms may be useful for many purposes; however, investigations for specific uses may best utilize functional units that best serve the specific land use proposed. The primary identification of the map unit is described in terms of ranges of soil properties within the limits of defined NRCS/NCSS Official Series Descriptions and ranges of inclusions. Some map units may require naming at a categorical level above the series and based upon the specific purpose of the investigation.

5.1 SOIL SERIES NAMES

Consociations, or complexes composed of major components that fall within the range and characteristics of existing official series, will use the series name to identify the map unit.

5.2 PHASES OF SOIL SERIES

Soil phases are used to identify refinements in classification or definition of an official soil series. They subdivide taxonomic classes at the series level and recognize soil properties that may be used as differentiating criteria. Phase selection is governed by the property which has the greatest impact on use and management of the soils in a survey area. Phases, beyond those identified in official NRCS soils legends, are used only when adequate documentation demonstrates the need to separate map units at the series level on the basis of soil behavior, use and management.

5.2.1 SLOPE PHASES

If symbols are used to identify slope range, they are either alpha or numeric (see state supplements) and will occur as the last digit in a map symbol. Some map units that are level or nearly level may not have a slope designation in the symbol. The symbol identifying slope has a standard range, but on occasion, when landscape patterns dictate, the symbol will represent a narrower or broader slope range from the standard.

Slope may also be labeled as a slope percentage or degree if that best suits the purpose of the site specific investigation.

5.2.2 STONY AND BOULDERY PHASES

Stony and bouldery phases may be recognized where the stones or boulders cover more than 15% of the soil surfaces. Stony and bouldery phases need to be distinguished from outcrops. It must be recognized that it may not be possible in all cases to distinguish between a bouldery phase and an outcrop. In cases where the soil scientist cannot determine whether a site contains boulders or outcrops, this is to be noted in the narrative of the report.

5.2.3 DEPTH PHASES

This phase refers to the total vertical distance from the surface of a soil to any feature for which vertical location is described. The depth terms, when used without specifying the feature to which depth is measured, refer to depth to bedrock, lithic or paralithic contact or other significantly limiting factor.

5.2.4 SUBSTRATUM PHASES

The soil material that lies below the control section is undifferentiated for the series name. In some situations, this material may be important to recognize for some uses for which a soil survey is interpreted. If the underlying material contrasts sharply with that which is normal for the taxa, it may be identified as a phase, specifying the contrast in material of the substratum in the name.

5.2.5 PHYSIOGRAPHIC PHASES

Land form or physiographic position may be used as a phase criterion to distinguish among map units of a single taxon. The physiographic differentiate must be significant to soil behavior or use and management.

5.3 DISTURBED MAP UNITS AND MISCELLANEOUS LAND TYPES

Disturbed soils and miscellaneous areas have little or no identifiable soil as defined in Soil Taxonomy. Most situations are a result of human activity that has altered the area. Map units are named in terms of characteristics of the parent material in the local area. Typically map units are identified at the Great Group level. These map units are to be described in such a way that conforms best to the existing mapping and the interpretation for the use proposed.

Disturbed areas require high intensity Order 1 Surveys in order to determine the depth of fill material, the type of material, the underlying residual soil material (if present) and the degree of compaction from previous human activities.

5.4 DRAINAGE CLASS INTERPRETIVE LIMITS

The soil drainage class interpretive limits used to carry out site-specific soil mapping will be those adopted and approved by the U.S. Department of Agriculture. The drainage class interpretive limits are used to determine soil wetness properties, which can play an important role in determining the proper land use for a soil. As in other states, Pennsylvania's soil drainage classes are inferred based on the depth to redoximorphic features (concentrations and depletions) unless modified by direct observation as noted below in section 9.0.

Drainage class interpretive limits may be adjusted to conform to specific regulatory of application-specific needs, such as on-lot sewage disposal, erosion control, wetland delineations, etc.

6.0 SOILS LEGEND

There are basically four types of soils legends used in site-specific soil mapping in Pennsylvania: a total numeric legend, or an alpha-numeric legend or a total alpha legend or a functional description (i.e. suitable for a given use). The National Cooperative Soil Survey Program in each state has established its own method of maintaining a soils legend and protocols for establishing new legend symbols. The individual state soils legends are described and explained in each of the state supplements. Individual investigations and reports may require more detailed legends for the purposes of that study.

7.0 MAP LABELING

Site specific soil surveys shall be completed by a qualified Soil Scientist and shall be signed by the soil scientist completing the work.

The following statement will be included on all map products produced by consulting soil scientists working in the private sector:

> *"This map product is within the technical standards of the National Cooperative Soil Survey. It is a special purpose product, intended for [intended purpose of the site specific soil survey]. It was produced by a professional soil scientist, and is not a product of the USDA Natural Resources Conservation Service. There is a report that contains both quantitative and qualitative details accompanies that this map."*

Should a client impose constraints on the consulting soil scientist that precludes him or her from producing a product that meets the standards of the National Cooperative Soil Survey, a statement will be added to the map label indicating:

> *"This map product is not within the technical standards of the National Cooperative Soil Survey because ...."*

8.0 SOIL PROFILE DESCRIPTION

Perhaps one of the most important aspects of a soil assessment is the soil profile description. Although there are a number of methods for describing soils, the USDA/NRCS methodology is a) consistent with the National Cooperative Soil Survey, b) the most detailed and c) the method that should be required for describing soils for these purposes. Other methods, such as the AASHTO, Unified Soil Classification system and Modified Burmeister are useful for engineering purposes but exclude much valuable information that is vital. Soil descriptions made using the USDA/NRCS methodology can readily be translated or converted into these other systems, where the reverse is not true.

A soil profile description is only as good as the individual making the description, therefore, in order to be accurate, descriptions must be made by experienced, qualified individuals familiar with the USDA/NRCS methodology and readily conversant in soil taxonomy. Descriptions are to be compiled by SSSA/ARCPACS Certified Professional Soil Scientists, Soil Classifiers, or professional members of PAPSS. Any other individual attempting to complete reports will need to prove their qualifications to do so.

The soil profile description should summarize all relevant information regarding the soil being examined. Minimum details that should be accepted include, but are not limited to the following:

- Soil master horizon and subordinate distinctions.
- Soil color using the Munsell soil color system.
- Soil texture.
- Soil structure.
- Consistence
- Horizon boundaries including distinctness and topography.
- Redoximorphic feature abundance, size, and contrast.
- Coarse fragments.
- Observed depth to bedrock.
- Observed depth to water table or seasonal high water table.
- Taxonomic classification (Approximations can and will need to be made in the absence of laboratory testing where appropriate).
- Observed soil series.

In addition, the soil scientist may need to report other relevant information that may be observed, such as:

- Roots, pores and krotovina.
- Mineralogy.
- Apparent parent material.
- Moisture regime.
- Drainage classification.

- Identification of epi-saturation versus endo-saturation, if present.
- Restrictive horizons.
- Total porosity.
- Bulk density.

Physical location of all testing should be given either by location on a map or plan or by supplying UTM or latitude and longitude as derived by a Global Positioning System. Every soil profile description must bear the signature and seal or proof of qualifications of the individual making the description.

9.0 SOIL DRAINAGE INTERPRETATION

Soil drainage is determined using indirect indicators of the presence of soil water such as redoximorphic features (RMF) and/or accumulations of organic matter. Some indicators, such as RMFs, may persist for thousands or even millions of years and represent past hydrological conditions, thus other potential soil moisture indicators, such as slope shape and vegetation type, or direct measurements should also be observed in order to adequately determine whether a soil tends to be currently wet and for likely how long.

Redox features in a sandy matrix

In USDA-NRCS Soil Surveys, RMFs are indicators of a Seasonal High Water Table (SHWT). In truth, the RMFs reflect saturated soil conditions during the growing season. The SHWT is often mis-interpreted as indicating the presence of true, or apparent water table. Soils may exhibit evidence of a SHWT at 12 inches while well depths into the aquifer are several hundred feet below the surface. For the purposes of the Soil Survey; these saturated soil conditions area a water table and are limiting for both crop and tree roots. Additionally, these saturated soils present problems for the construction farm ponds and houses, which require engineering solutions. For the purposes of a site specific survey, a SHWT often is not considered a true, or apparent water table.

It must be noted that, while RMFs and other indicators are of great value, they are not always perfect indicators. RMFs can form relatively quickly, in a matter of several days or weeks under the right conditions, yet can take thousands or millions of years to dissipate. In cases where RMFs or other indicators are suspected to be relict in nature and not indicative of current conditions, direct observation methodologies are required. This involves installation of monitoring wells with terminal well screens crossing the depths suspected as the SHWT. The water levels need to be monitored on a regular basis throughout the wet season, typically the autumn, winter and spring during a year with normal precipitation. Normal precipitation is defined as amounts of precipitation within one standard deviation of the mean annual precipitation. If the ground water level is found to be different from that determined by the indicator, then the measured water level is determined to be the SHWT. Alternatively, other sound methodologies may be proposed on a case-by-case basis including use of tensiometers in lieu of monitoring wells.

In some Pennsylvania Soil Surveys, one may also find depth breaks in inches of 12, 24, 36 (instead of 40), and 48. When the NRCS began to adopt the use of metric depths, 4 in. was added onto the drainage class depth break resulting in the rounded metric depths.

Note, that the criteria for hydric soils is legally specific (NTCHS, 2003) and employs recording depths to observable features. Where the determination of a soil as a hydric soil is required, as in wetland delineation, one must refer to the national criteria found in NTCHS (2003). For more specific information on hydric soils in the Mid Atlantic region see MAHSC (2004). For specific determination of a site's water table, see Sprecher (2008).

Soil scientists further describe soil drainage using the USDA-Soil Survey term "Natural Soil Drainage Class" to characterize how wet or dry a soil is. While seven drainage classes exist, the USDA-Soil Survey does not set specific, measurable criteria for these classes, and in turn leaves it up to an individual state to set appropriate guidelines. In addition, it is important to understand that soils can be wet for substantial periods of the year but not exhibit RMFs because temperature or oxygen conditions in the soil prevent their formation. In such cases, the determination of a site's hydrology is paramount for accurate land use determination.

Regardless, the depths used to identify the seven drainage classes are based on soil morphology and frequently rely on the depth to, or absence of, RMFs and a seasonal high water table (SHWT). Evidence of a SHWT may include: water at or near the surface; vegetation that require a wet habitat; accumulation of surface horizon soil organic matter; a shallow depth gleyed subsoil horizon; and/or a landscape position that can support a SHWT. In Pennsylvania, we use the following criteria for the seven NRCS natural drainage classes (mineral soil):

9.1 EXCESSIVELY DRAINED

Water removed from the profile rapidly. May have a shallow depth to bedrock, occur in steep landscapes or have very porous (sandy) textures.

9.2 SOMEWHAT EXCESSIVELY DRAINED

Water removed from the profile rapidly. May be free of RMFs throughout the profile.

9.3 WELL DRAINED

Water removed from the profile readily but no rapidly. RMFs or SHWT below 100 cm (40 in.) from the soil surface.

9.4 MODERATELY WELL DRAINED

RMFs or evidence of a SHWT 50 – 100 cm (20 – 40 in.) from the soil surface.

9.5 SOMEWHAT POORLY DRAINED

RMFs or evidence of a SHWT 20 – 50 cm (8 – 20 in.) from the soil surface.

9.6 POORLY DRAINED

RMFs or evidence of a SHWT from 20 cm (8 in.) to the soil surface.

9.7 VERY POORLY DRAINED

RMFs or evidence of a SHWT to the soil surface most of the time. Mucky surfaces common.

9.8 HYDRIC SOILS

Although hydric soils are not a drainage classification per se, discussion of them is relevant here.

Hydric soils are defined as soils that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part. This usually means saturation for at least one week when soil temperatures are above biological zero (41ºF). These anaerobic conditions at the proper temperature, in the presence of sufficient organic material promote microbial activity. The results of the microbial activity are evident in specific morphological characteristics which can be field identified. These characteristics include organic matter accumulation, reduction, translocation and/or accumulation of iron. These features are then used to identify whether hydric soil conditions exist. It is important to differentiate between hydric soils and jurisdictional wetlands. In order to delineate a wetland, hydric soils must exist in addition to current wetland hydrology and presence of hydrophytic vegetation. Hydric soils that are present in area that do not have either wetland hydrology or hydrophytic vegetation are not wetlands.

When determining the presence of hydric soils, a minimum depth of 20 inches is described. Redoximorphic features must be completely described, including color, contrast and abundance, along with type (concretions, pore linings, etc.), manganese or other mineral reductions, and odors (i.e. sulfur). Once the profile is completed, determine which of the Field Indicators of Hydric Soils (if any) are met. The Field Indicators of Hydric Soils in the United States (or the regional Mid-Atlantic Hydric Soils Committee) is used to help identify and delineate hydric soils. Field Indicators are specific to the Land Resource Region (LRR) where the site is located. The Field Indicators were developed to assist in wetland boundary determination, so it is possible that Field Indicators will not be present within a wetland. This does not mean that the soil is not hydric. Refer to the NTCHS for hydric soil criteria. When morphological features are not conclusive, monitoring may be conducted to determine water levels.

10.0 REPORT TO ACCOMPANY SOIL MAP

A narrative report will accompany all map products. Minimum requirements to be included in the report are as follows:

- Reference to these mapping standards
- Date soil map was produced
- Geographic location and size of site. Location is to be provided by Geographical Positioning System (GPS) of test locations and map reference.
- Soil identification legend for the site-specific soil map symbols
- Purpose of the soil survey (intended use of the parcel).
- Soil map unit descriptions, including:
  - Map unit symbol and map unit name
  - Landscape setting and surface features
  - Drainage Class and parent material
- Signature of the Soil Scientist who is responsible for the soil map including the certification seal of the Soil Scientist.
- Other distinguishing features of the site and soils determined to be significant by the soil scientist
- Maximum size of limiting inclusions
- If special features symbols are used., the size of the area represented by each symbol is included as part of the definition of the symbol; and Soil profile descriptions.

11.0 SOIL TAXONOMY

The taxonomic classification of a soil has become the standard, within the USDA-NRCS system, by which individual pedons may be identified and differentiated. Due to the very large number of individual parameters that collectively make up any individual pedon, this standard is necessary to assist in creating a unique language that is understood by soil scientists. Any soil series name by itself does not relate use and management concepts; however, the same soil series, when accompanied by a taxonomic classification, can provide important information in a single line, and allow rapid assessment of basic properties that affect the use and management of a soil body. Since Soil Taxonomy is a constantly evolving set of specifications, the USDA-NRCS has published, and regularly updates, the *Keys to Soil Taxonomy,* currently in the 10th edition. Since a link to this 341-page reference is provided in this Manual, a detailed methodology is not provided; rather, a broad overview of the concepts follows. Much of the technical criteria in *Soil Taxonomy* is well beyond what a typical field investigation will provide; however, there are nonetheless basic criteria, also obtained through a routine investigation and published information, that can be used to provide reasonable classifications.

The Soil Order is the broadest level of classification; there are currently 12 soil orders recognized in Soil Taxonomy:

- Gelisols - ‘newer’ soil order that generally encompasses soils under permafrost (i.e. Alaska).

- Histosols - Soils that have significant organic matter content, and containing a histic epipedon as defined by Soil Taxonomy; by definition, a Histosol may encompass hydric units. Under prolonged saturation and a commensurate absence of oxygen, the decomposition of organic matter is severely reduced or halted.

- Spodosols - Those soils containing a spodic horizon; these commonly occur in acid soils where iron oxides are leached and re-deposited deeper in the profile; they are very common in the glaciated northern regions of the state.

- Andisols - These soils are specific to areas influenced by more recent deposition of volcanic ash; there are none mapped in PA.

- Oxisols - soils generally confined to the tropics; characterized by intense weathering and the accumulation of iron oxides; only mapped in Hawaii and Puerto Rico.

- Vertisols - Soils exhibiting high shrink-swell characteristics; typically includes slickensides caused by montmorillite (2:1) clay mineral content; none are mapped in PA.

- Aridisols - These soils occur in arid climates, and are further characterized by an accumulation of soluble salts such as calcium carbonate ($CaCO_3$); none are mapped in PA.

- Ultisols - A common soil order that occurs in several regions of PA; characterized primarily as a "mature" soil that has had its bases leached out over an extended period of time; technically requires less than 35% base saturation; clay accumulation in the solum is also common.

- Mollisols - These soils contain a mollic epipedon, broadly defined as a thick, dark surface. They are characteristic of the soils of the Midwest that have been subjected to intense and prolonged agricultural activities. They are regarded as some of the more fertile and productive soils in the US. A few are mapped in PA.

- Alfisols - Also common in PA, and similar to Ultisols except that they are less weathered, and contain a base saturation greater than 35%.

- Inceptisols - Inceptisols are mapped extensively across the northeast portion of the state; they generally exhibit some minor pedogenic processes such as a cambic horizon, but have not aged enough to develop other diagnostic horizons.

- Entisols - These are the youngest soils, sometimes formed in very recent alluvium and may exhibit no pedogenesis or horizonation at all.

Of the 12 Soil Orders, the following may be expected to occur in the various geomorphic environments in PA:

- Histosols
- Spodosols
- Ultisols
- Alfisols
- Inceptisols
- Entisols
- Mollisols

As noted above, a complete and official taxonomic classification to the family level is beyond the scope of most routine investigations. However, there are also fundamental aspects which should be respected. Often, soils may be re-mapped or re-classified for a variety of purposes. In these instances, and depending on the extent of re-mapping, it is not unrealistic to include some of the basic taxonomic criteria for which mapping or use changes are based upon, particularly diagnostic horizons and Munsell soil colors. Generally, classification beyond the subgroup level (i.e. to the Family) requires a marked increase in the interpretation of soil characteristics, and a subsequent level of difficulty and involvement. Changes and alterations from published data should be supported with the appropriate documentation.

12.0 PERMEABILITY ESTIMATES

Much confusion has arisen by the utilization of the terms **infiltration**, **permeability**, **saturated hydraulic conductivity** and **percolation**. In order to understand this process, let us define these terms. **Infiltration** refers to the entry of water into soil at a water-soil interface. **Percolation** refers to the downward movement of water through soil and rock. **Permeability** is synonymous with **saturated hydraulic conductivity** and is abbreviated as K or Ksat. The two terms can be used interchangeably; however permeability will be used here. Permeability is defined as a quantitative measure of a saturated soil's ability to transmit water when subjected to a hydraulic gradient. It can be thought of as the ease with which pores of a saturated soil allow gases, liquids or other substances to flow through. Hydraulic conductivity is also the proportionality factor in Darcy's law relating flux density or flux to the hydraulic gradient. Flux represents the quantity of water moving in the direction of, and at a rate proportional to, the hydraulic gradient. If the same hydraulic gradient is applied to two soils, the soil from which the greater quantity of water is discharged (i.e., higher flux) has the higher permeability.

Typical cased borehole method setup

The permeability of saturated soil is one of the most important soil properties controlling water infiltration and surface runoff. Knowledge of the permeability of the vadose zone is needed to solve many agricultural, hydrological, and environmental problems. The permeability rate (K) is the value that is to be used in empirical equations for modeling soil water movement. Permeability depends strongly on soil texture and structure, and therefore can vary widely in space. For this reason, descriptions must be made by experienced, qualified ARCPACS Certified Professional Soil Scientists, Soil Classifiers, or professional members of PAPSS familiar with the USDA/NRCS methodology and readily conversant in soil taxonomy.

In the USDA-NRCS Soil Surveys, there are given ranges of permeability values for each soil map unit. These values are a general guide that provides preliminary information for general planning purposes. In many instances, these permeability values reflect estimations and were not field verified. It is crucial that site specific permeability testing be conducted for a given location.

Permeability testing is not difficult to complete but may be difficult to quantify to determine the appropriate permeability rate (K) to apply to the site. The difficulty in determining the appropriate permeability rate comes as a result of the numerous models, equations and variations of statistical analysis. The purpose of the permeability testing is to provide the design professional with a value to utilize in design. This testing must be completed prior to design. Use of a permeability test must be coupled with a morphologic analysis of the soil profile. Without the morphological analysis, the value of the permeability rate (K) is very limited. The morphological analysis can determine if a permeability rate is anomalous due to preferential flow pathways or physical obstructions.

Since permeability is determined at points on a field scale, enough determinations are required to accurately assess the magnitude and structure of the variation within the selected area and provide a statistically significant value. For structured soils in particular, saturated hydraulic conductivity has to be measured directly in the field to minimize disturbance of the sampled soil volume and to maintain its functional connection with the surrounding soil. The ideal testing method would use small volumes of water, consist of easily transportable equipment, and be conducted as a short-duration measurement and therefore would allow an individual to obtain permeability data at a great number of locations over a large area and with the realistic use of resources in terms of time and costs.

The determination of field permeability and the proposed testing methods are very site specific and depend on the soil texture, structure and moisture content, as well as the rock fragment content and size. The intention of this section is not to limit the testing methods by prescribing a single testing method, nor to list every type of permeability testing methodology. Whatever testing method is used, it should be based on sound science and provide a statistically definable measurement of the soil's hydraulic conductivity. The field testing method should be agreed upon between the consulting soil scientist and the client with a joint understanding of the value and shortcomings of the method which will be employed on the specific project or land use goal.

For a complete discussion of methods of permeability testing, the Soil Science Society of America Methods of Soil Analysis, Part 1, Physical and Mineralogical Methods (1986) is recommended. Following are some of the testing methods commonly used. This is not an exclusive or complete list but only a list of examples of commonly acceptable methods:

- Double ring infiltrometer
- Single Ring Infiltrometer
- Constant-head well permeameter

- Falling-head well permeameter

- Cased-borehole

- Falling Head Test

- Constant Head Test

- Basin Flooding Test

Typical double-ring infiltrometer setup. Note water reservoir with automatic feed tube

Percolation Test – The percolation test is obsolete and is the <u>least</u> accurate methods of measuring soil permeability. Percolation testing is to be avoided unless specifically required by regulation or ordinance. In addition, a number of proprietary apparatus are available for sale for measuring permeability. Following are some of the more common apparatus that are commercially available:

- Amoozemeter – Ksat Corp procedures.
- American Manufacturing Permeameter
- Aardvark Permeameter
- Guelph Permeameter

Analysis of Results

It is not correct to simply take rates of drop and convert them directly to permeability rates. As these rates of drop are dependent upon head pressure and other factors they will vary depending upon the water level. Raw rates of drop are <u>not</u> to be used under any circumstances. Rates of drop rates must be related to Darcy's Law and corrected for head pressure to yield values that are an accurate approximation of permeability (K). The infiltration testing method will dictate which equation/statistical analysis is proper. As soil permeability rates are log-normally distributed, arithmetic averages of multiple test results should not be used. Geometric means of multiple test results should be reported and used. The field data and/or any statistically derived result of field measurements muss pass a rigid quality control.

12.1 CONSIDERATIONS FOR THE RENOVATION OF POLLUTANTS AND CONTAMINANTS IN SOIL

Soil serves as a natural filter to remove large particulates and smaller suspended solids from applied storm water. Soil has the natural ability to provide physical, chemical and biological renovation of contaminants. Numerous factors will affect a soil profile's ability to provide this attenuation or renovation of contaminants. Sandy textured soils provide good filtration and are usually permeable enough to allow higher volumes of water to readily pass through them, due to their greater number of large macropores. Soils richer in silt and clay textures usually have fewer macropores and substantially more micropores. These smaller pores tend to severely restrict soil water movement. Soil with higher silt and clay content will provide an excellent filtration for the removal of solids, but their slow permeability may make their use less practical as they may be prone to clogging.

A soil's ability to provide chemical renovation is facilitated by the cation and anion exchange sites that are present within the soil profile. A soil's cation exchange capacity (CEC) usually increases with the organic matter and clay content in the profile. These charged sites have the ability to fix, or adsorb, nutrients, metals or other chemical elements that are passing through the soil profile. Free nutrients in solution in a soil profile tend to be adsorbed on the humus and clay surfaces. For these reasons, a mixture of sand, silt and clay is the best medium for filtration and sorption of contaminants.

The ability of a soil profile to transmit water is determined by the soils structure, texture, and bulk density. Soil structure is the arrangement of soil particles into peds of recognizable shapes. The grade of structure determines how well defined the divisions are between the structural units (peds). Strong structures will be more permeable than weak structures of the same shape. The size, shape and arrangement of these structural units create a system of macropores and micropores that regulate air and water movement within the soil profile. In general, granular and blocky structures facilitate much better soil water movement than platy or prismatic structures. These soil characteristics control the ability of a soil profile to allow water and gasses to pass through.

It is generally thought that water flows through soil as matrix flow, where the water moves through the soil profile in a consistent and distinct wetting front. Indeed, Darcy's Law assumes matrix flow. Research is indicating that the rule for water, or any liquid, flow through soil is via preferential flow pathways. These pathways may consist of macropores such as krotovina, root channels, fractures, etc. However, some large macropores can actually act as barriers to saturated flow. Research with structureless sands with a high uniformity coefficient shows that preferential flow pathways still develop. This underscores the need for a morphological assessment to accompany any permeability testing. A morphological assessment should include a discussion of any potential preferential flow pathways observed.

13.0 GLOSSARY

ALBIC HORIZON - one from which clay and free oxides have been removed or in which oxides have been segregated to the extent that the color of the horizon is determined by the color of the primary sand and silt particles rather than by coatings on these particles.

AQUIC CONDITIONS - that portion of the soil profile that currently experiences continuous or periodic saturation and reduction. Three elements determine the presence of aquic conditions:

Saturation - characterized by zero or positive pressure in the soil and generally can be determined by observing free water in an unlined auger hole.

Reduction - can be characterized by the direct measurement of redox potential.

Redoximorphic features - associated with wetness resulting from the reduction and oxidation of iron and manganese compounds in the soil after saturation with water and desaturation, respectively.

CERTIFIED PROFESSIONAL SOIL SCIENTIST - an individual certified by the Soil Science Society of America (formerly ARCPACS) as a Certified Professional Soil Scientist (C.P.S.S.)

CERTIFIED PROFESSIONAL SOIL CLASSIFIER - an individual certified by the Soil Science Society of America (formerly ARCPACS) as a Certified Professional Soil Classifier (C.P.S.C.). These individuals typically have additional course work in soil taxonomy.

COLOR CONTRAST - the degree of visual distinction evident between associated colors. Contrast may be described as faint, distinct, or prominent.

Faint: Evident only on close examination. Faint colors commonly have the same hue as the color to which they are compared and differ by no more that 1 unit of chroma or 2 units of value. Some faint colors of similar but low chroma and value differ by 2.5 units (one page) of hue.

Distinct: Readily seen but contrasts only moderately with the color to which compared. Distinct colors commonly have the same hue as the color to which they are compared but differ by 2 to 4 units of chroma or 3 to 4 units of value; or differ from the color to which compared by 2.5 units (one page) of hue but no more than 1 unit of chroma or 2 units of value.

Prominent: Contrasts strongly with the color to which they are compared. Prominent colors are commonly the most obvious color feature of the section described. Prominent colors with medium chroma and value commonly differ from the color to which they are compared by at least 5 units (two pages) of hue if the chroma and value are the same; at least 4 units of value or chroma if the hue is the same; or at least 1 unit of chroma or 2 units of value if hue differs by 2.5 (one page). Hue, value, and chroma are described in the Munsell Soil Color Charts, as printed by Munsell Color, 2441 North Culvert Street, Baltimore, Maryland 21218.

COMPLEX - map unit which is employed when two or more kinds of soil (taxa) occur in a regularly repeating pattern so intricate that the components cannot be delineated separately at the scale of mapping.

CONSOCIATION - soil map unit in which 75 percent or more of the polypedons fit within the range of the taxon or kind of miscellaneous area that provides the name for the map unit or fit in a similar taxa or miscellaneous areas.

CONTROL SECTION – that portion of an exposure of soil that is chosen as representative of the pedon. The control section is what is reported in the soil profile description.

DENSIC CONTACT - contact between soil and densic material that has no cracks, or the spacing of cracks in which roots can enter is 10cm or more.

DENSIC MATERIAL - unaltered soil material that has a bulk density such that roots cannot enter except in cracks. Densic material is confined to firm and very firm compact basal till, with a bulk density typically of 1.7 or higher.

DIGITAL ORTHOPHOTO QUADS (DOQs) - computer generated orthophotos that have been digitized for electronic transfer and manipulation. The level of precision must meet the Federal Geographic Data Committee's National Map Accuracy Standards. The orthophotos are digitized at a scale of 1:24,000 with their center corresponding to the center of USGS topographic 7.5 minute quadrangle maps. Digital orthophoto quarter quads have been digitized at a scale of 1: 12,000 and have quarter-quad centers.

DISSIMILAR INCLUSION - soils that either do not share limits of some important diagnostic properties of the named taxon, or, in the professional judgment of the soil scientist, have different use or management requirements.

EVIDENCE OF WETLAND HYDROLOGY - refers to evidence, other than soil morphology, that indicates permanent or periodic inundation or prolonged soil saturation sufficient to create anaerobic conditions in the soil. This evidence would include, but not be limited to, predominance of hydrophytic vegetation, oxidized rhizospheres, water marks, drift lines, water borne sediment deposits, water-stained leaves, surface scoured areas, wetland drainage patterns, and morphological plant adaptations.

GROUND CONTROL - features which are evident or marked on the ground and located accurately on the base map such as survey markers, utility poles or other permanent features. Ground control is essential for the accurate delineation of soil boundaries.

HIGH INTENSITY SOIL (HIS) MAP - a soil map product originally produced for the sole purpose of a site specific soil-based use. The HIS soils mapping developed under the standards described in this document meet the standards of the National Cooperative Soil Survey and are considered a multi-purpose product. HIS map products conform to a specific set of standards as identified in this document and carries, in addition to the site specific map symbols, map unit symbols representing the connotative HIS soils legend as identified in SSSNNE Special Publication NO.1 dated January 1994.

HISTIC EPIPEDON - a layer, normally at the surface, with a high volume of organic soil materials and is saturated for some time in most years.

HYDRIC SOIL - a soil that is saturated, flooded or ponded long enough during the growing season to develop anaerobic conditions in the upper part.

KEYS TO SOIL TAXONOMY - abridged taxonomic key to soil classification for making and interpreting soil surveys. USDA Natural Resources Conservation Service, TENTH EDITION, 2006.

LIMITING SOIL - a soil that differs appreciably in one or more soil properties from the named soil in a map unit. The difference in soil properties is more restrictive and may affect use and management.

LIMITING ZONE – a regulatory term describing a feature limiting the use of a soil. This definition may vary from one regulation to another. An example can be found in Title 25, PA Code, Chapter 71.1 as follows:

Limiting zone - A soil horizon or condition in the soil profile or underlying strata which includes one of the following:

(i) A seasonal high water table, whether perched or regional, determined by direct observation of the water table or indicated by soil mottling.

(ii) A rock with open joints, fracture or solution channels, or masses of loose rock fragments, including gravel, with insufficient fine soil to fill the voids between the fragments.

(iii) A rock formation, other stratum or soil condition which is so slowly permeable that it effectively limits downward passage of effluent.

MINERAL SOIL MATERIALS - soil horizons or layers comprised mostly of mineral material with relatively low content of organic matter (less than 12 to 18 percent, by weight of organic carbon depending upon clay content).

MOTTLES - refers to features of contrasting colors in a horizon not associated with wetness.

NATIONAL SOIL SURVEY HANDBOOK (NSSH) - standards and guidelines for conducting soil survey operations under the standards of the USDA/NRCS National Cooperative Soil Survey. Latest update: November 1996.

ORGANIC SOIL MATERIALS - soil layers or horizons that typically contain 12 to 18 percent or more organic carbon by weight, depending on the percent clay in the soil.

ORTHOPHOTO - aerial photograph that has been processed to remove distortion and displacement to enable the measurement of true distances, angles and areas on the Earth surface.

REDOXIMORPHIC FEATURES - soil features associated with wetness resulting from the reduction and oxidation of iron and manganese compounds in the soil after saturation with water and desaturation, respectively.

RELICT REDOXIMORPHIC FEATURES – redoximorphic features that are related to a water table or moisture regime entirely different from that which exists today. These are features that are equilibrated with past water tables or moisture regimes. Defining relict conditions may require monitoring of actual water tables or moisture regimes during the wet season in a year of normal precipitation.

RESTRICTIVE FEATURES - characteristics of the soil which may have a negative effect on land use, such as bedrock, hardpan, densic material, or soil horizons with a high clay content within the control section.

SAPROLITE - soil material derived from rock that has weathered in place. Saprolite may retain the color and structure of the parent rock but is not competent bedrock. By definition, saprolite may be considered soil because it constitutes the C horizon and is distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter.

SIMILAR INCLUSION - soils that either share limits of most of the important diagnostic properties of the named taxon, or, in the professional judgment of the soil scientist, have similar use and management requirements.

SITE-SPECIFIC SOIL MAPPING - site-specific soil mapping is conducted for very intensive land uses requiring very detailed information about soils, generally in small areas. Some site specific activities do not produce a survey, per se such as transect logs. Site-specific soil mapping is synonymous with Order 1 soil surveys completed by the National Cooperative Soil Survey. The information can be used in planning individual building sites, experimental agricultural plots, and other uses requiring detailed and very precise knowledge of the soils and their variability. Base map scale is generally 1: 12,000 (1 inch = 1000 feet) or a larger map scale.

SOIL - The unconsolidated mineral or organic material on the immediate surface of the Earth that has been subjected to and shows effects of genetic and environmental factors of: climate (including water and temperature effects), and macro- and microorganisms, conditioned by relief, acting on parent material over a period of time.

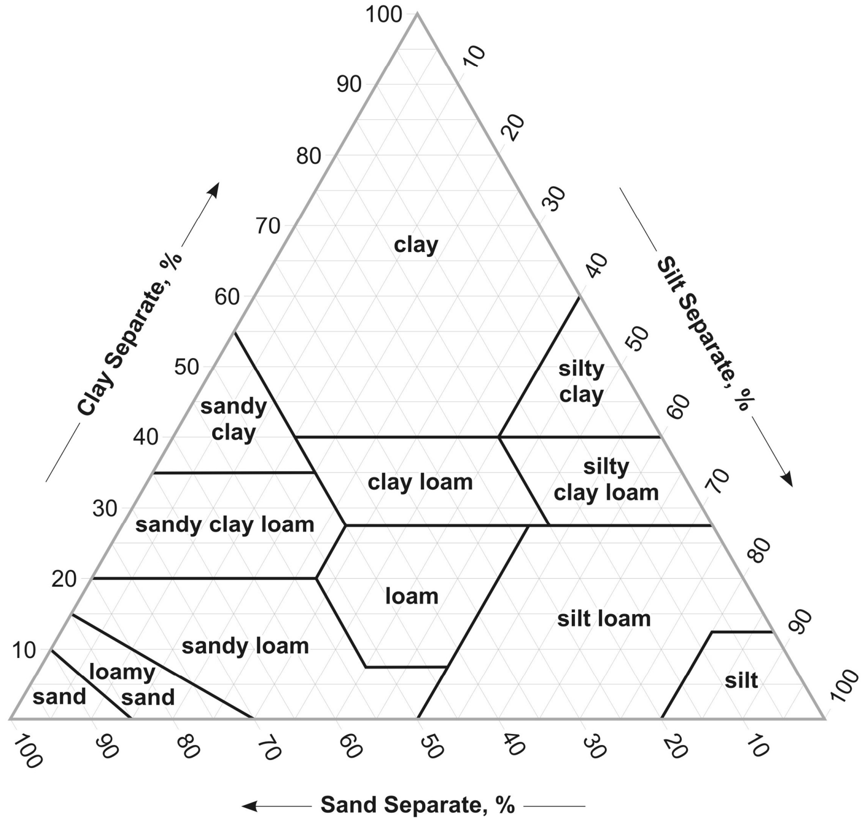
SOIL MAP UNIT - an area defined and named in terms of its soil properties. Each individual area enclosed on the map is a delineation. Each map unit contains a map symbol and that symbol represents one soil type, or a complex of two soil types, with a defined set of soil properties.

SOIL SURFACE - the point at which measurement begins for the description, characterization and taxonomic placement of a particular soil. This is typically the top of the first organic layer, either Oi, Oe, or Oa. For soils lacking organic surface horizons, the surface is considered the top of the A or Ap. Some officially recognized documents refer to different reference points for the start of measuring soil profile descriptions and depth to diagnostic features. The definition of soil surface may vary slightly depending on the reference being used.

SOIL SURVEY MANUAL (SSM) - USDA document published by the Soil Survey Division Staff providing major principals and practices needed for making and using soil surveys and for assembling and using data related to them. Latest addition: United States Department of Agriculture Handbook.s

SOIL TEXTURES - classes based on fine earth fraction (less 2 mm) of soil with different combinations of sand, silt and clay. The amount of each soil separate contained in a soil sample will determine its texture.

Soil Textural Triangle



http://soils.usda.gov/education/resources/lessons/texture/textural_tri_hi.jpg

SPECIAL FEATURES - symbols used on site-specific soils maps to represent small areas of contrasting soil that are too small to delineate at the scale of mapping.

SPODIC HORIZON- subsurface layer of soil characterized by the accumulation of aluminum oxides (with or without iron oxides) and organic matter; a diagnostic horizon for Spodosols. (See *Keys to Soil Taxonomy*)

TRANSECT - to proceed across an area or region, in a linear direction, transversely or at random, recording observations taken at regular intervals.

TRAVERSE - to proceed across an area or region, in an irregular pattern specified by the soil scientist, from one side to the other, making observations at irregular intervals.

UMBRIC EPIPEDON - a mineral surface layer of soil characterized by the accumulation of organic matter to the extent that it has a dark color even when dry.

14.0 LINKS TO STANDARD TECHNICAL REFERENCES

14.1 MID—ATLANTIC HYDRIC SOIL INDICATORS, VER. 1.0

http://www.epa.gov/reg3esd1/wetlands/pdf/hydric_soils_midatlantic_2_2004.pdf

14.2 SOIL CHANGE GUIDE – PROCEDURES FOR SOIL SURVEY AND RESOURCE INVENTORY

ftp://ftp-fc.sc.egov.usda.gov/NSSC/soil_change/soil_change_low.pdf

14.3 KEYS TO SOIL TAXONOMY, 11[TH] EDITION, 2010

ftp://ftp-fc.sc.egov.usda.gov/NSSC/Soil_Taxonomy/keys/2010_Keys_to_Soil_Taxonomy.pdf

14.4 SOIL SURVEY MANUAL (USDA HANDBOOK 18)

http://soils.usda.gov/technical/manual/

14.5 FIELD BOOK FOR DESCRIBING AND SAMPLING SOILS

ftp://ftp-fc.sc.egov.usda.gov/NSSC/Field_Book/FieldBookVer2.pdf

14.6 NATIONAL SOIL SURVEY HANDBOOK

http://soils.usda.gov/technical/handbook/download.html

14.7 SOIL SURVEY LABORATORY METHODS MANUAL

ftp://ftp-fc.sc.egov.usda.gov/NSSC/Lab_Methods_Manual/SSIR42_2004_view.pdf

14.8 2009 NATIONAL HYDRIC SOILS LIST

http://soils.usda.gov/use/hydric/

14.9 Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin

ftp://ftp-fc.sc.egov.usda.gov/NSSC/Ag_Handbook_296/Handbook_296_low.pdf

15.0 REFERENCES

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National Technical Committee for Hydric Soils. 2003. Hydric soils—criteria. <http://soils.usda.gov/use/hydric/index.html> (Verified Aug. 6, 2009).

NRCS, 2010, http://soils.usda.gov/technical/technotes/note6.html

Sevon, W. D., compiler, 2000, Physiographic provinces of Pennsylvania: Pennsylvania Geological Survey, 4th ser., Map 13, scale 1:2,000,000

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Soil Science Society of America, Glossary of Soil Science Terms, 1997.

Sprecher, S.W. 2008. Installing monitoring wells in soils (Version 1.0). National Soil Survey Center, Natural Resources Conservation Service, USDA, Lincoln, NE.

Su, G. & Nimmo, J., Effect of isolated fractures on accelerated flow in unsaturated porous rock. Water Resources Research, Vol. 39, # 12, 2003.

Vortrubova, J., Recurrent ponded infiltration into structured soil: A magnetic resonance imaging study. Water Resources Research, Vol. 39, # 12, 2003.

Wang, Z., Wu, L., Harter, T. Lu, J. & Jury, W., A field study of unstable preferential flow during soil water redistribution. Water Resources Research, Vol. 39, # 4, 2003.

Wu, L., L. Pan, J. Mitchell, and B. Sanden. 1999. "Measuring Saturated Hydraulic Conductivity using a Generalized Solution for Single-Ring Infiltrometers". Soil Sci. Soc. Am. J. 63:788-792; Reynolds, W.D., and Elrick, D.E. 1990. "Ponded infiltration from a single ring: I. Analysis of steady state flow." Soil Sci. Soc. Am. J. 54:1233-1241; Wu, L., L. Pan. 1997. "A generalized solution to infiltration from single-infiltrometers by scaling." Soil Sci. Soc. Am. J. 61:1318-1322.

APPENDICES

APPENDIX 1

INTERIM PAPSS GUIDELINES FOR MORPHOLOGICAL SITE EVALUATIONS FOR ON-LOT WATEWATER DISPOSAL

In the interest of alleviating a disconnect between soil scientists, designers, regulators and installers in regard to drip irrigation on-lot sewage disposal systems and providing continuing guidance to its membership, the PAPSS Board of Directors has developed a set of minimum recommended guidelines to be included in site evaluations. Depending on their locality and current internal procedures, members may already be providing many of these details. It is important to recognize our role in the current site evaluation and permitting process and provide as much pertinent site information as necessary. Though it may take some additional considerations in the current business climate, the inclusion of a site plan and stakeout as part of a soil morphological report would greatly assist in addressing some of the "drip disconnect" issues.

1. A site drawing drawn to scale showing the location of the following details:

   - All test pits or auger borings.
   - The extent of the area deemed suitable.
   - All wells within 150 feet of the approved areas.
   - Houses and other structures.
   - Property lines, rights-of-way, easements or encumbrances.
   - Driveways.
   - Trees over 6 inches in diameter.
   - Surface boulders or rock outcrops.
   - Streams, springs or other surface waters.
   - Floodplains or floodways.
   - Stormwater management structures.
   - Buried tanks (oil, propane, septic, etc.).
   - Slope percent and direction or topographic lines (2 foot interval or less).
   - Steep slopes or escarpments.
   - Cuts and fills.
   - Existing on-site sewage disposal systems.
   - If site drawings are not based upon a survey prepared by a licensed surveyor, then the drawing shall show reference points used to locate features such as a numbered utility pole, utility box, building(s), property corner markers, etc.
   - Site drawings shall be based upon an even number scale not to exceed 1 inch equals 100 feet.

2. Soil profile descriptions prepared in accordance with the procedures and techniques of the USDA/NRCS methodology (i.e. *Field Book for Describing and Sampling Soils* or latest version of the PAPSS Soil Investigation Manual). Test pits or borings may be located by global positioning system (GPS).

3. A report detailing the following:

- Owner's name, address and telephone number.
- Address of site.
- Description of property including total area (acreage).
- Summary of soils encountered.
- Type(s) of on-site sewage disposal systems that are suitable.
- Estimated or measured permeability rates or loading rates.
- Discussion of the soils encountered and any special conditions noted.
- Depth to and type of limiting zones and/or restrictive horizons.
- Drainage classification of soils.
- Recommendations for designers and installers.
- Any other details, suggestions, recommendations, or requirements noted by the soil scientist.

This list is only a guide and subject to any additional regulatory requirements.

APPENDIX 2
SAMPLE SOIL PROFILE FORM

SOIL PROFILE DESCRIPTION

Profile #:		Slope:		Relief:		Estimated Permeability:	
Date:					Drainage Class:		
Cleint:					Depth to Limiting Zone:		
Location:					Soil Series Identified		
Tax Parcel #:					Taxonomic Classification:		
Latitude:					Longitude:		

Horizon	Depth (in)	Matrix Color	Coarse Fragment Modifier	Texture	Structural Size	Structural Size	Structural Type	Consistence	Boundary Distinctness	Boundary Topography	Coarse Fragment%	Redox Feature Color	Redox Feature Desription

____
Soil Scientist's Signature