2007 ADS Stormwater Workshop

January 19th, 2007

Geotechnical Engineering Design Pitfalls

and

Fundamentals of Ground Water/Surface Water Interaction

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PART 2B

Estimating the Seasonal High Water Table A Mix of Art & Science

This paper was originally written in 1993 & generated a lot of interest. The approach described in this paper is now being used by SWFWMD in their training workshops and is now recognized as acceptable by the NRCS.

Seasonal High Water Table

Perhaps the most important soil feature affecting site engineering in Florida is the water table and particularly its range of fluctuation from season to season.

The prediction of the seasonal high water table is a subtle combination of many sciences, including soil science, shallow aquifer groundwater mechanics, geohydrology, hydrometeorology, geotechnical engineering, and bryology which remain a mystery to the uninitiated, non-soil engineer.

What is the SHWT?

- A seasonal high water table (SHWT) is the shallowest depth to free water that stands in an unlined borehole or where the soil moisture tension is zero for a significant period (more than a few weeks) (Watts and Hurt, 1991).
- According to Rule 40C-42, Florida Administrative Code, the seasonal high groundwater table (SHWT) elevation means the highest level of the saturated zone in the soil in a year with *normal* rainfall.

What is the SHWT? (Continued)

- Groundwater professionals are routinely called upon by site grading and drainage engineers and other professionals to predict these groundwater elevations, typically to within an accuracy of ±6 inches
- Errors in these estimates can result in detrimental environmental, economic, and functional impacts, such as the hydrologic failure of created wetlands, septic tank drainfields, stormwater management ponds, effluent reuse land application systems, road base distress due to saturated conditions, etc

What is the Starting Point?

- The starting point is the measurement of the stabilized groundwater level in a newly opened borehole, or piezometer at a selected location and time.
- A stabilized reading, in this sense, means that the water level in the newly created borehole or well has equalized with the water table level in the aquifer.
- A minimum of 24 hours is usually allowed before taking a reading, although sandy soils require less time than silty or clayey soils to achieve equilibrium levels.
- Although the published sources of information (such as the NRCS publications) generally provide reliable preliminary guidance on the depth to the water table at a site, there is no substitute for a site-specific investigation for design level studies.

What is the Starting Point? (Continued)

- The date of the water table measurement is very important and must be recorded since the groundwater table fluctuates throughout the year in response to seasonal rainfall.
- In addition, the soil profile in the test hole or boring should be described, noting soil texture (i.e., sand, silty sand, "hardpan", clayey sand, etc.), color (including mottling and staining, more formally known as redoximorphic features), and, if available, Standard Penetration Test boring "N" values variations which may manifest memory of the seasonal fluctuation.

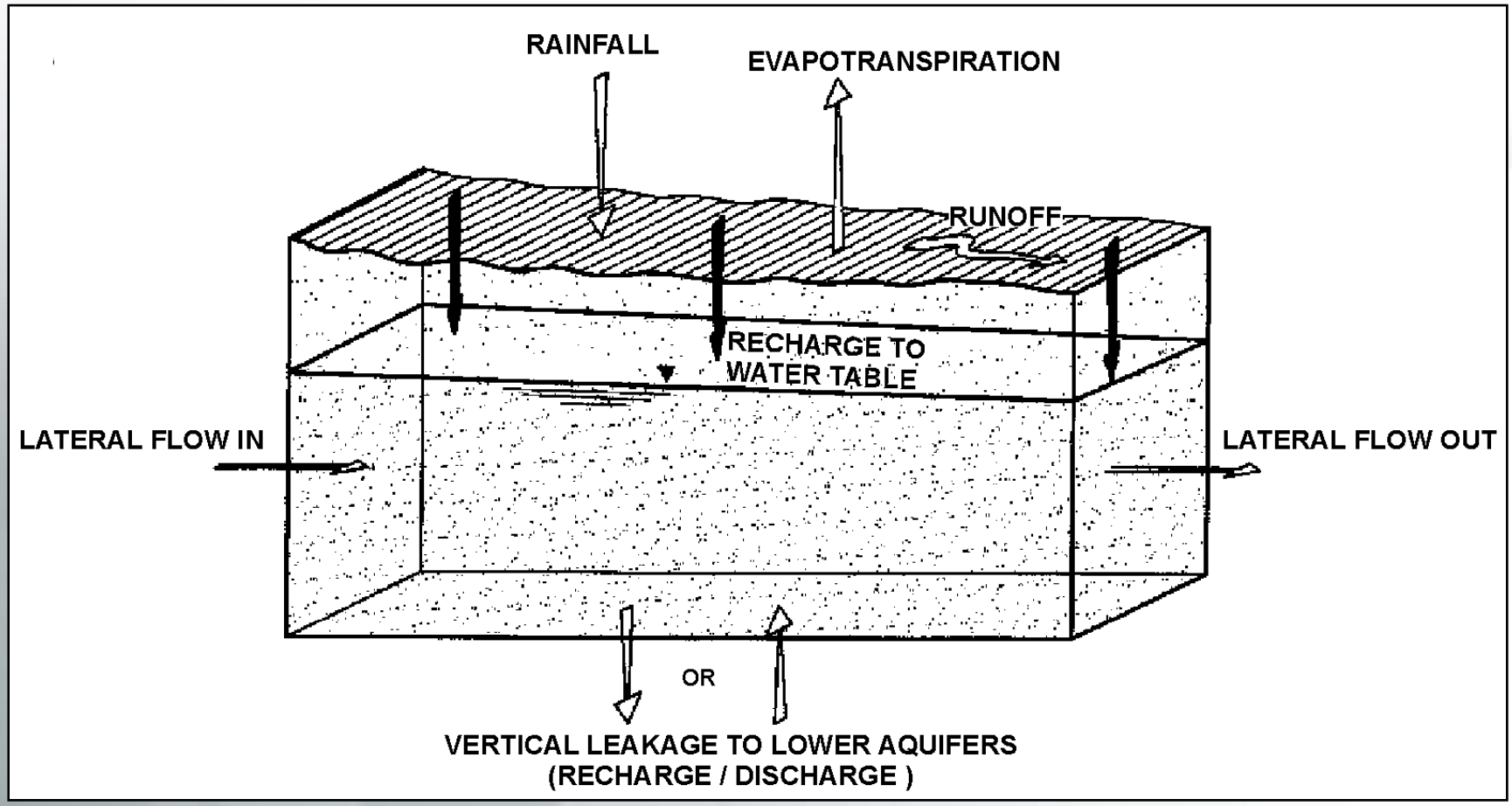
How do we adjust from the starting point?

- Antecedent rainfall (short-term as well as long-term)
- Soil map unit descriptions published by the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS)
- Examination of the soil profile, including color variations (redoximorphic features), SPT "N" values, depth to "hardpan" or other impermeable horizons (such as clayey fine sands and clays), etc.
- Consistency of water levels with adjacent surface water bodies and knowledge of typical hydraulic gradients (water table slopes).
- Vegetative indicators

How do we adjust from the starting point? (Continued)

- Effects of existing and future development
- Hydrogeologic setting including potentiometric surface of Floridan aquifer and degree of connection between the water table aquifer and the Floridan aquifer.
- Mathematical Correlation With Soil Morphological Features

ANTECEDENT RAINFALL



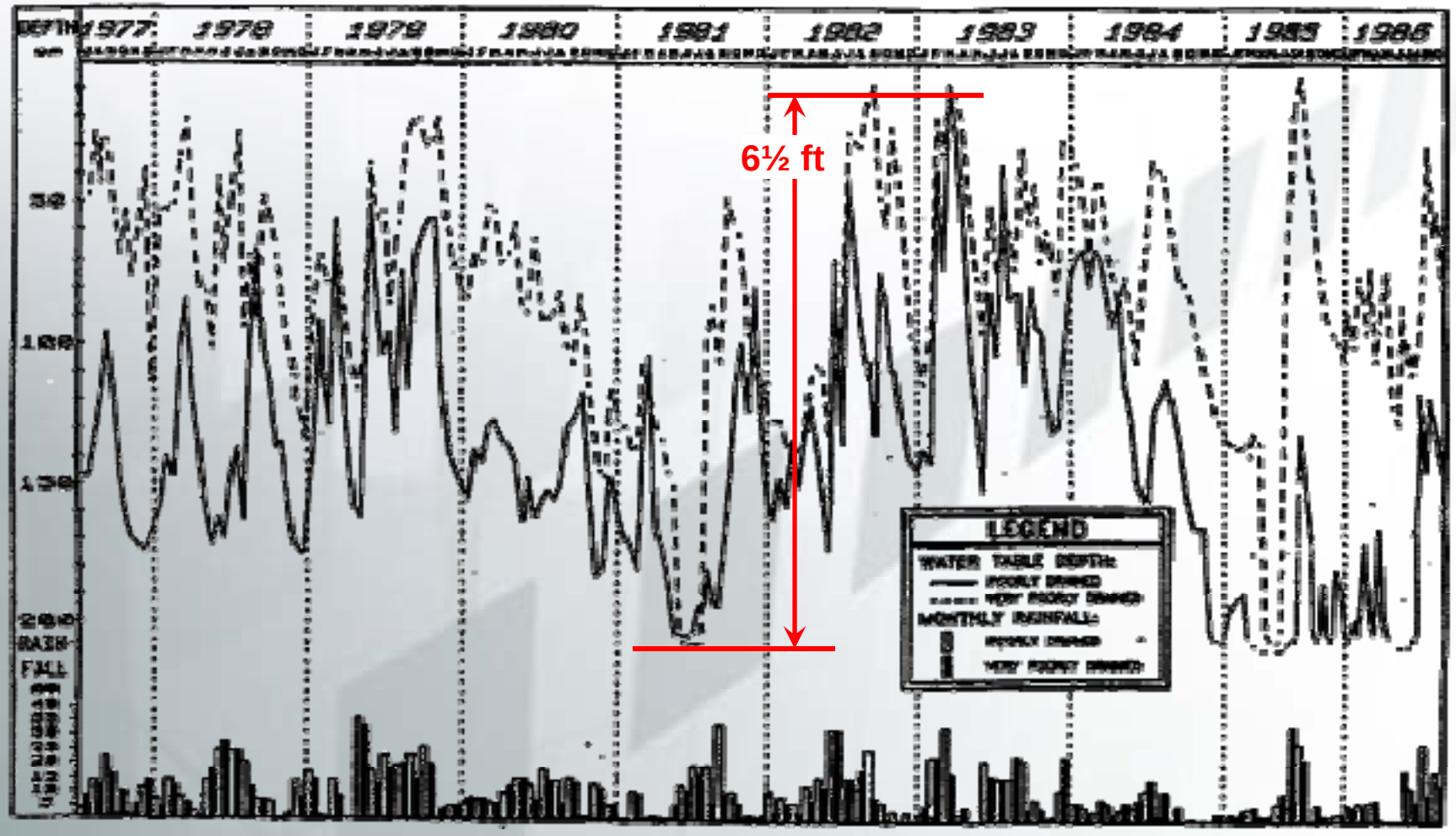
Can run continuous simulation

Hydrology of the Uppermost Aquifer

A Key Point To Note

It is first important to appreciate that, under natural conditions, the rate of lateral groundwater movement in the uppermost water table aquifer in Central Florida is no more than 300 to 400 feet per year and usually much less. Therefore, a water particle entering the water table aquifer at one end of a site may take several years before it exits the downgradient boundary of the site or discharges into a surface water body within the site. The reaction of the water table within a wet season, spanning typically about 4 months (June through September), is therefore not controlled significantly by lateral groundwater inflows and outflows to the prism or by conditions which exist greater than a lateral distance of 300 to 400 feet.

Water Table Fluctuations Example
- Pine Flatwood in Polk County -



Long-Term Fluctuation of the Water Table (After HYDE and Ford, 1989)

Water Table Fluctuations Example
- Sand Ridge in Lake County -

Estimating SHWT - The NRCS Methods

REDOXIMORPHIC FEATURES

- NRCS procedure is based solely on morphology; i.e., identifying mottles and low chroma colors in a soil horizon which form by processes related to saturation and reduction of iron. These processes may be actively occurring during the year or have occurred in the horizon at some time in the past.
- Soil mottling patterns can also be relicts of past moisture regimes.
- NRCS maps are on a scale of 1:20000 and are not a substitute for on-site investigations. Experience indicates that the NRCS estimates of SHWT are reliable in areas where recent development or long-term hydrogeologic changes have not influenced the shallow groundwater flow regime.
- NRCS data should always be reviewed as part of the water table evaluation.

Myakka Fine Sand - The State Soil

SHWT determination in E horizon of Spodsoils (Soils with hardpan)

Chroma 1
no organic matter accumulation around root

SHWT
area where chroma 1 & 2 are mixed

Chroma 2
organic matter accumulation around root

Sandy Soil, no mottles

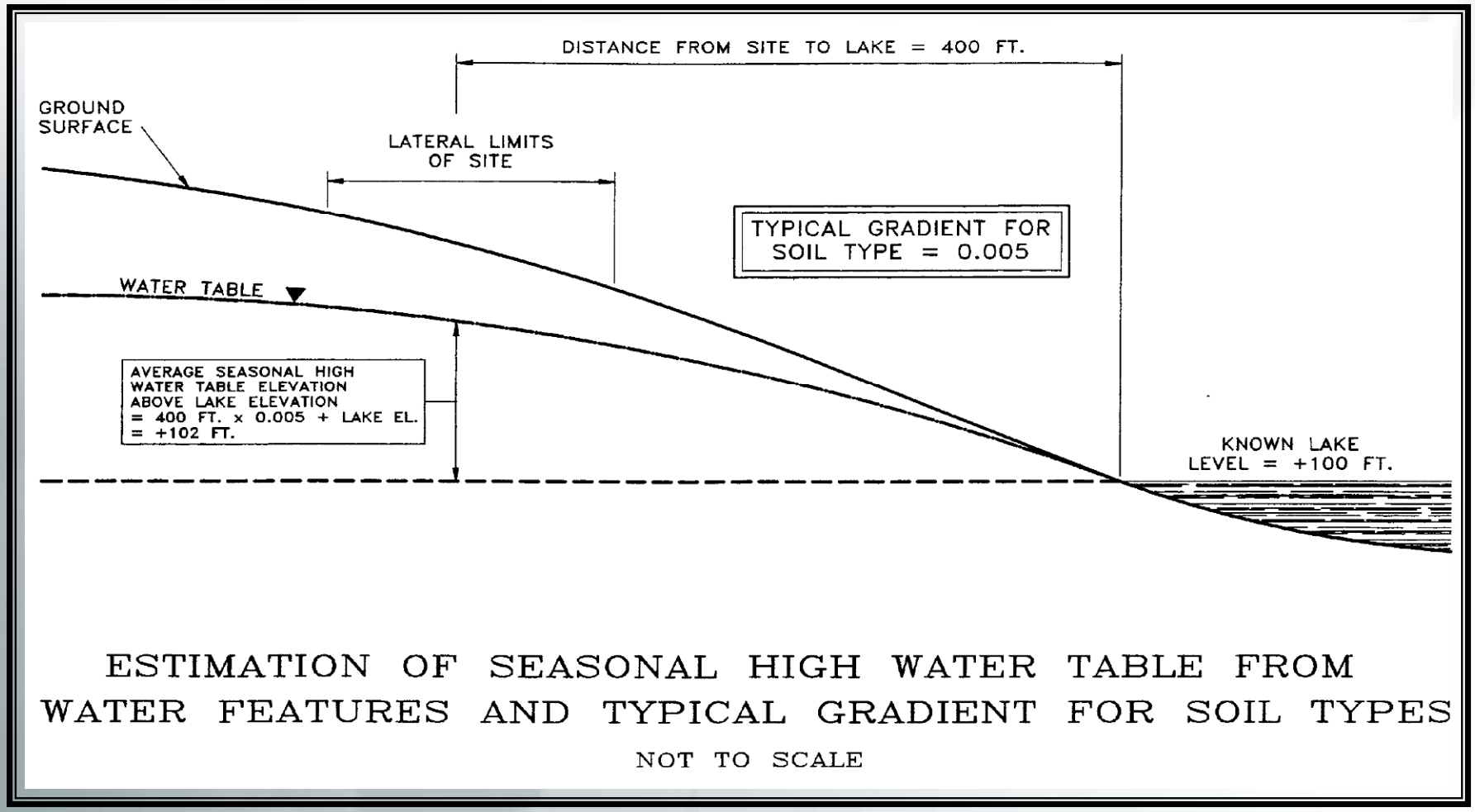
Sandy Soil - few mottles, not indicative of SHWT

Sandy Soil – common bright iron colored mottles, indicative of SHWT

Sandy Soil - many bright iron colored mottles, indicative of SHWT

Loamy soil - gray at ped surfaces, indicative of SHWT

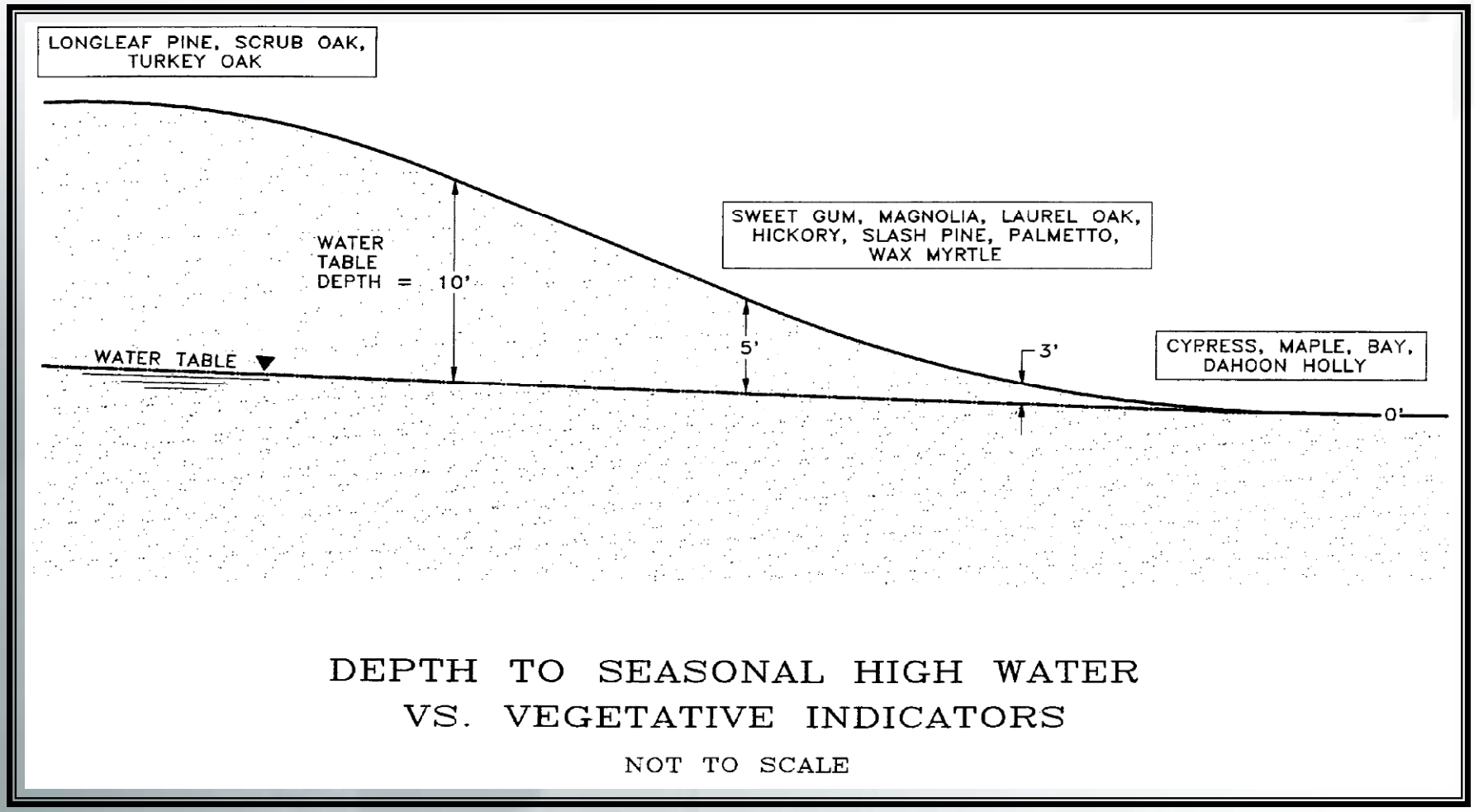
CORRELATION TO TYPICAL GRADIENTS



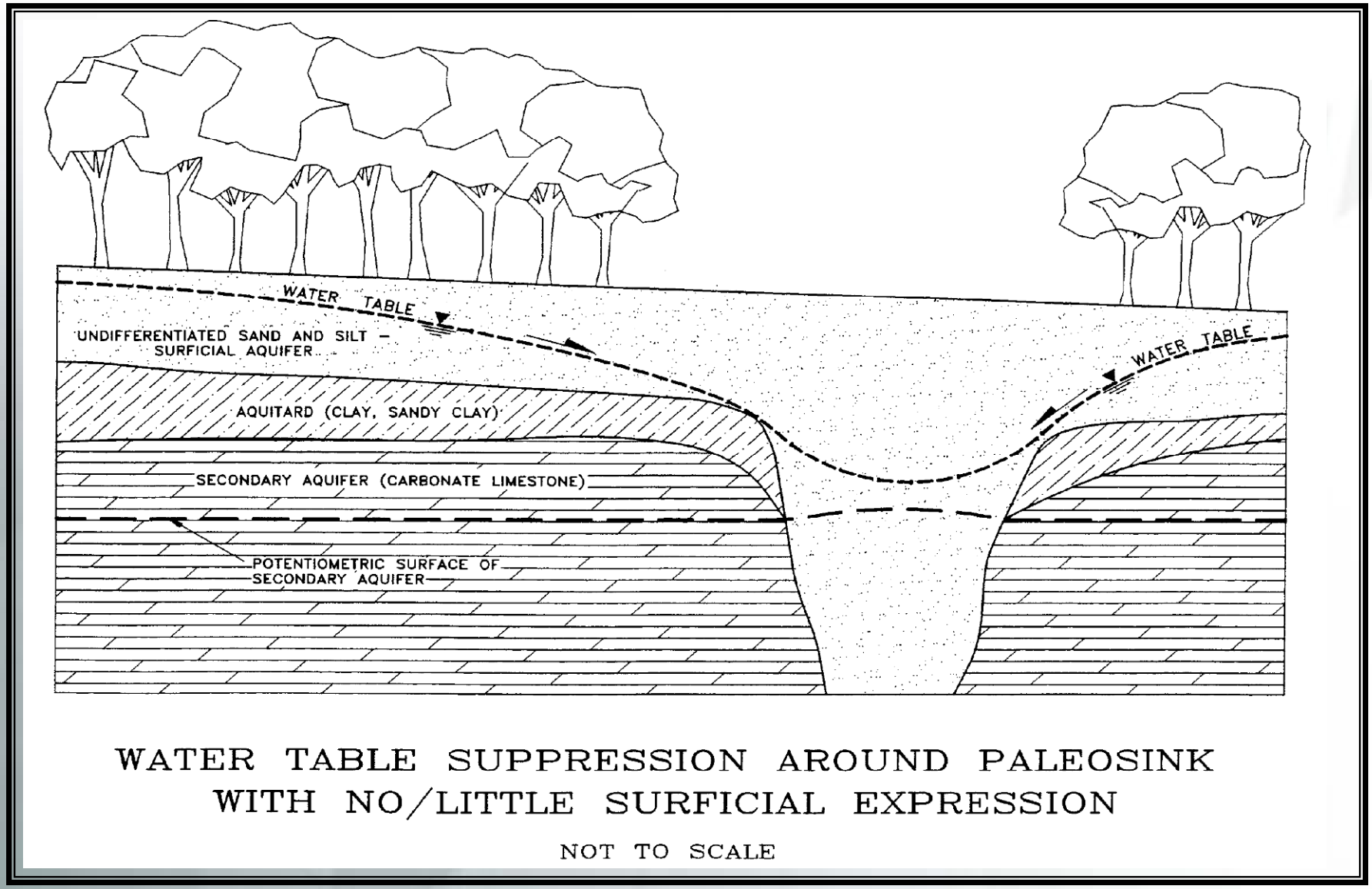
ESTIMATION OF SEASONAL HIGH WATER TABLE FROM WATER FEATURES AND TYPICAL GRADIENT FOR SOIL TYPES

NOT TO SCALE

VEGETATIVE INDICATORS



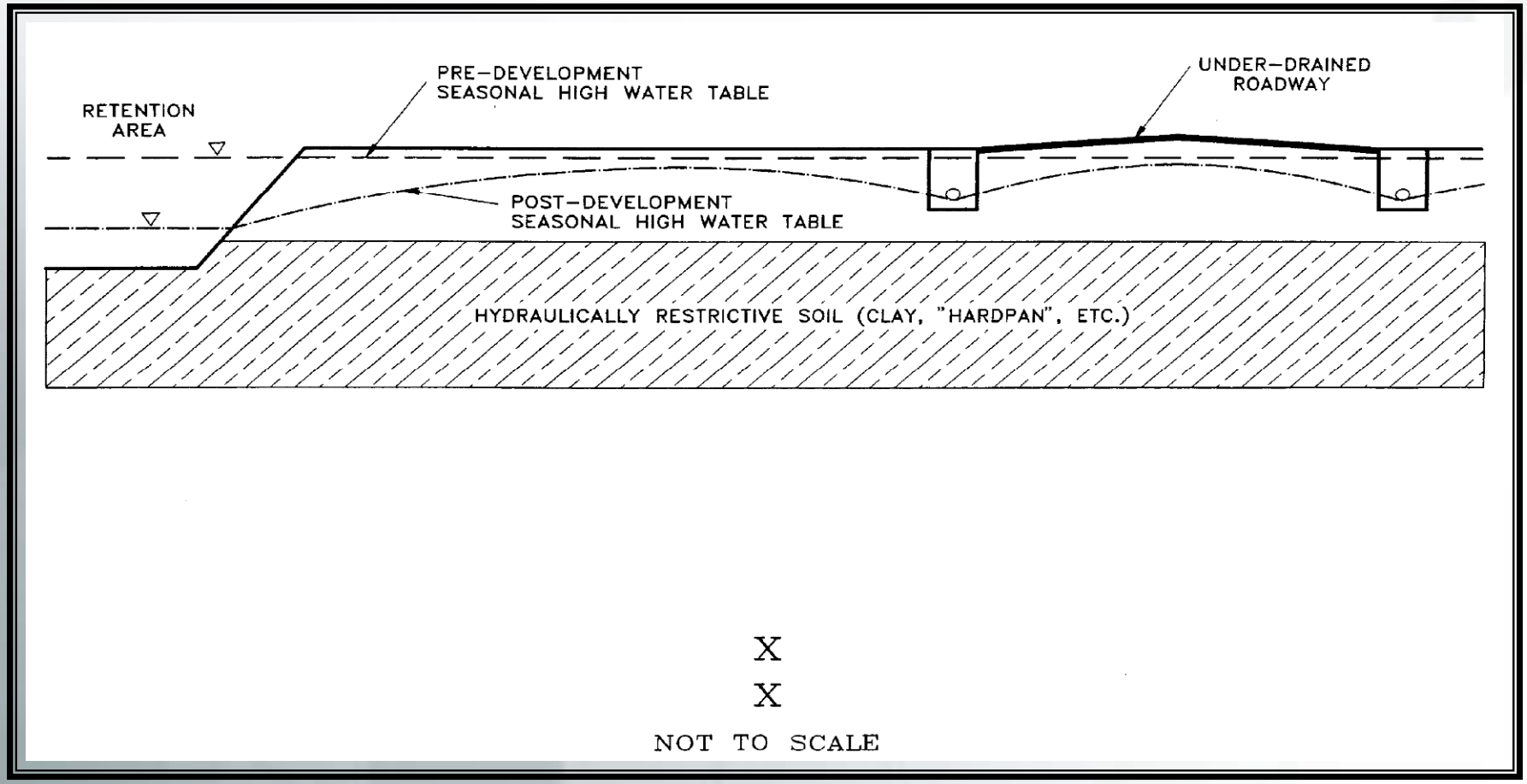
BURIED PALEOSINKS - ORANGE GROVE AERIALS



WATER TABLE SUPPRESSION AROUND PALEOSINK
WITH NO/LITTLE SURFICIAL EXPRESSION

NOT TO SCALE

IMPACTS OF DEVELOPMENT



RECOMMENDED ADDITIONAL READING

The following resource provides additional information on soil redoximorphic features:

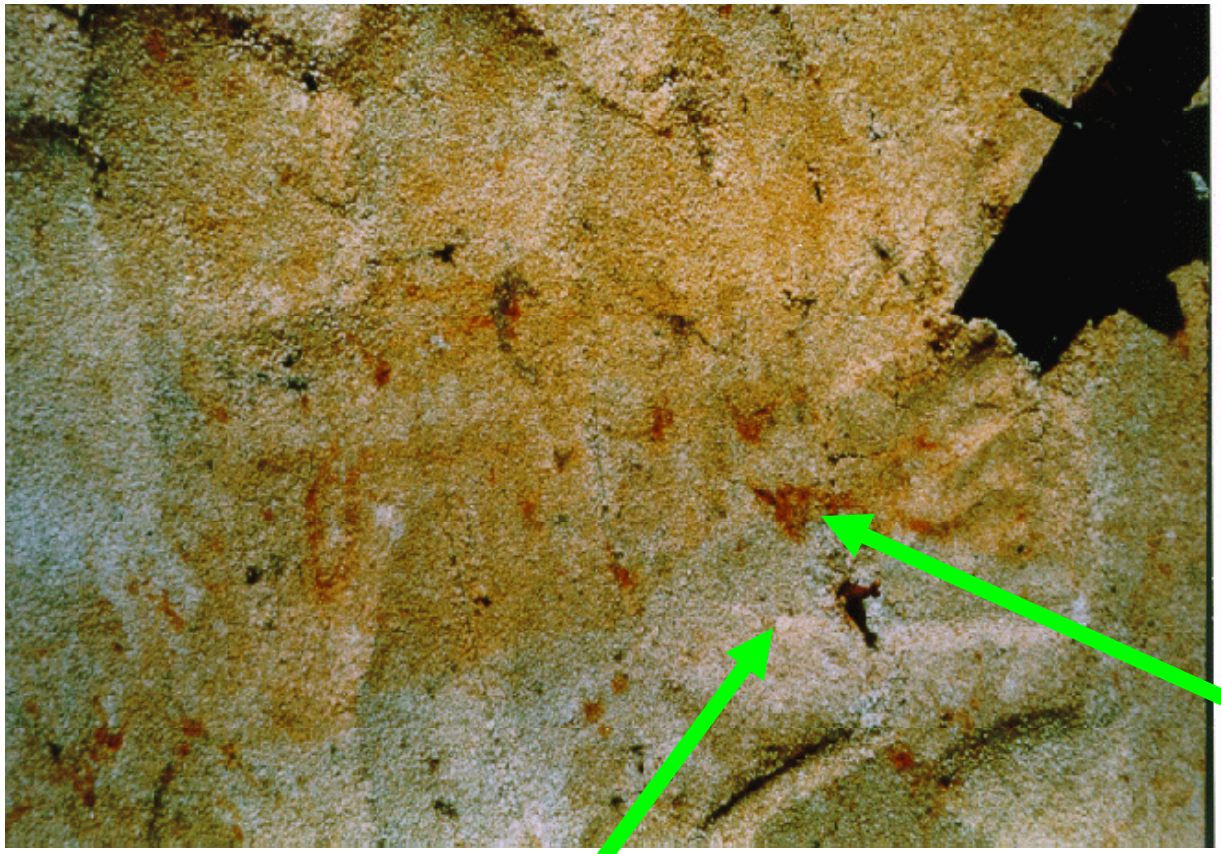
Definition of Mottles

Mottling, (Soil)

Irregular spots of different colors that vary in number and size. ***Mottling generally indicates poor aeration and impeded drainage.*** Descriptive terms are as follows: abundance (few, common, and many), size (fine, medium, and coarse), and contrast (faint, distinct, and prominent). The size measurements are of the diameter along the greatest dimension. Fine indicates less than 5 millimeters (about 0.2 inch); medium, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and coarse, more than 15 millimeters (about 0.6 inch).

Color soil profile showing many mottles

an indicator of the SHGWT



Soil mottles, an indicator of anaerobic (water saturated) conditions.

“Grey” soil colors, an indicator of wetness.

Color photograph of hand auger soil sample showing many soil mottles.

“Grey” soil colors, an indicator of wetness.

Soil mottles, an indicator of anaerobic (water saturated) conditions.

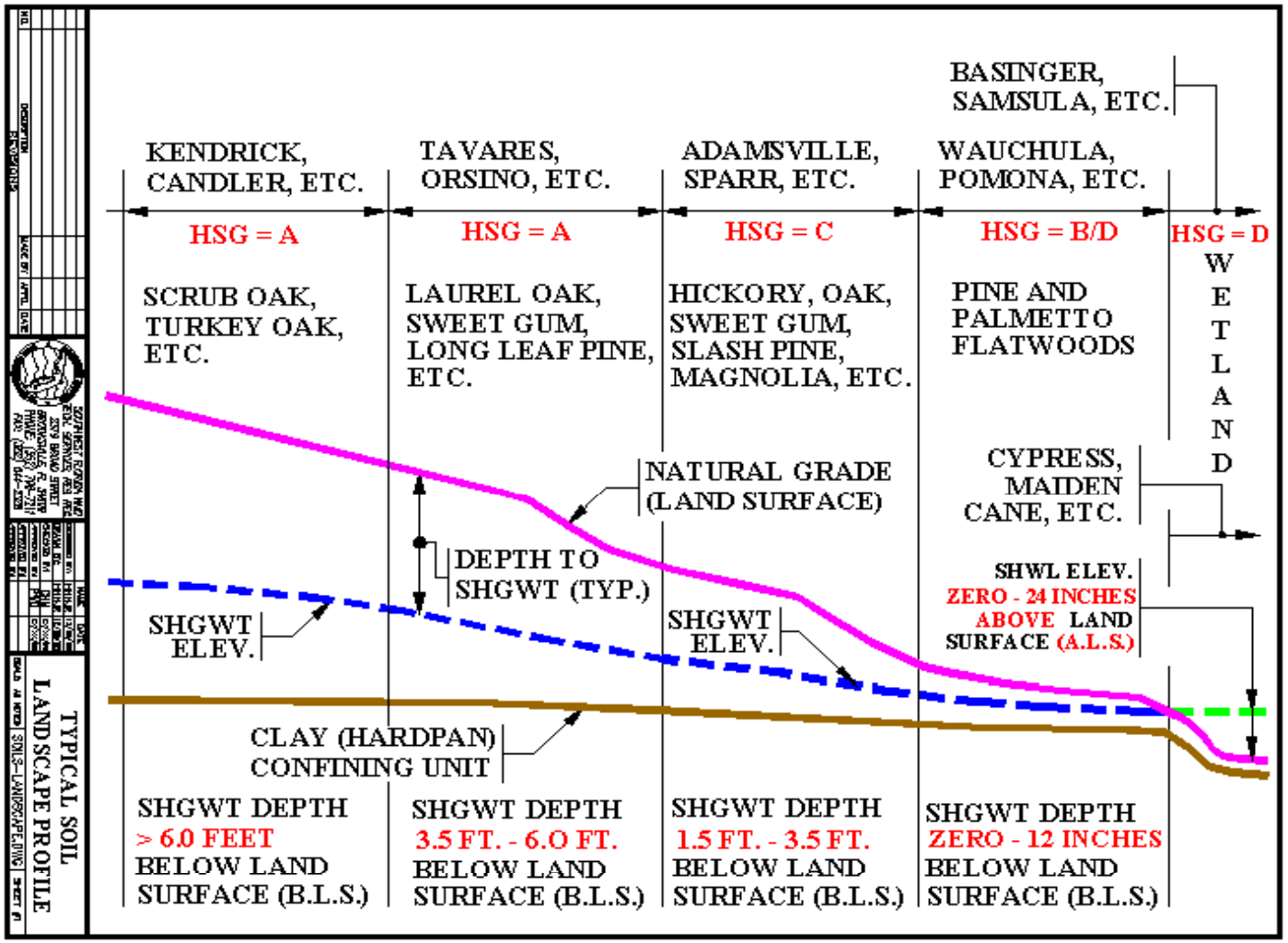
Color photograph of hand auger soil sample showing many soil mottles.

“Grey” soil colors, an indicator of wetness.

Soil mottles, an indicator of anaerobic (water saturated) conditions.

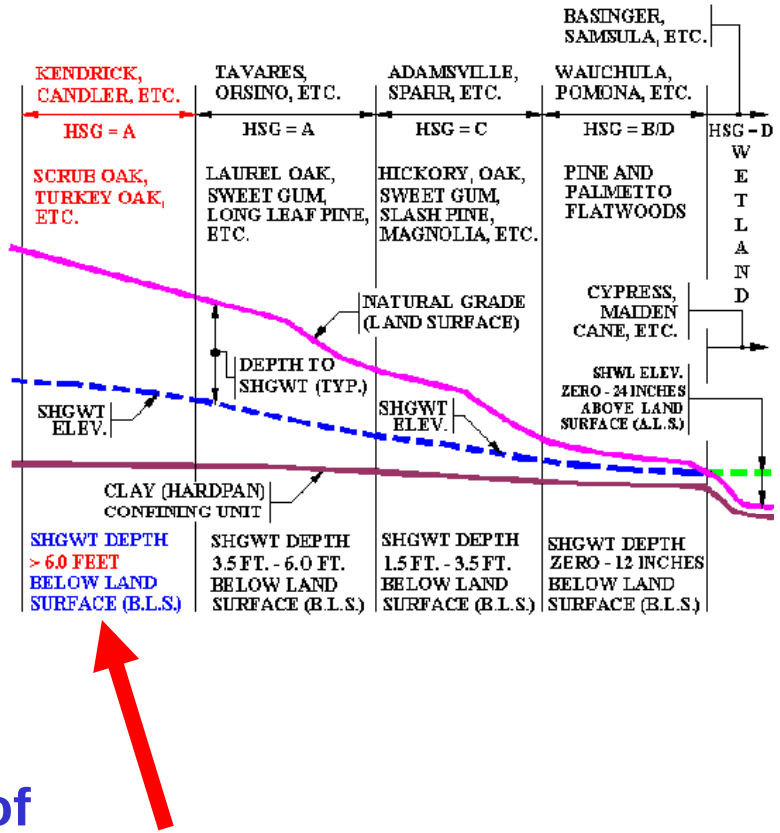
Natural vegetation (overstory & understory)

Remember your position on the landscape when performing your auger borings



Lake soil, HSG = A

SHGWT depth > 6.0 feet B.L.S.



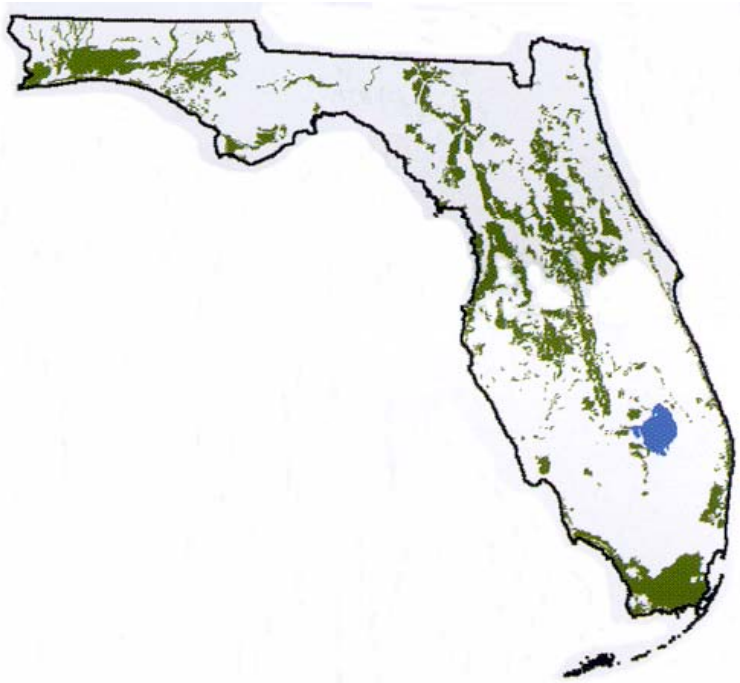
Notice the upland vegetation, consisting of scrub and turkey oaks, and a sparse ground cover, all of which indicate excessively drained ("dry") conditions.

"Top of the hill" in regard to landscape position.

Generalized location map of Entisols

Excessively drained soils (i.e. sandy scrub) in Central Florida

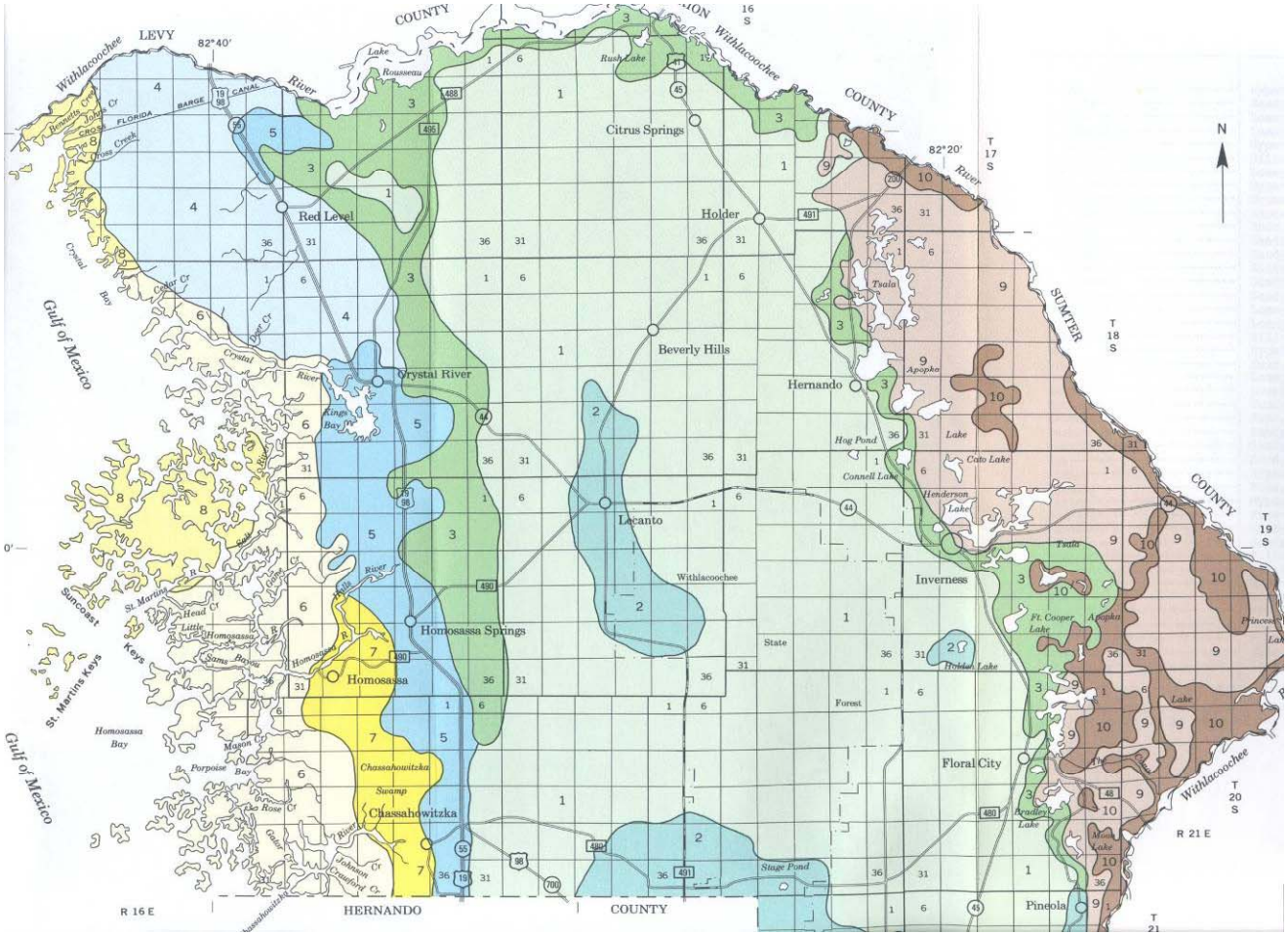
Not for site specific use. Refer to the County Soil Surveys for more detailed information.

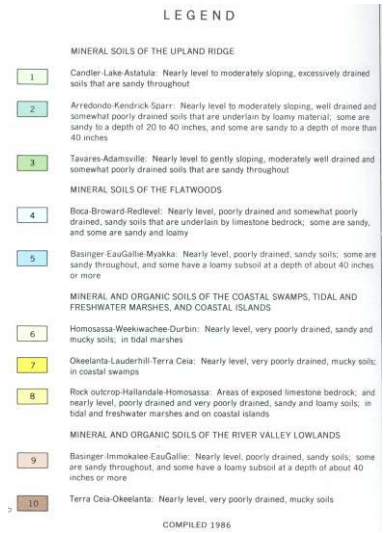


ENTISOLS are generally young, sandy soils that show little or no development of pedogenic horizons except for ochric epipedons and albic horizons. Entisols are excessively to poorly drained. Some of the soils include the Astatula (see photo), Candler, Lakeland, Paola, Kershaw, Ortega, Chipley, and St. Lucie soils. Entisols cover approximately 7.5 million acres.

General Soils Map of Citrus County

For information purposes only, NOT for detailed site - specific investigations





Notice the large percentage of Tavares *well drained soil*, (HSG = A) with a SHGWT depth 3.5 feet - 6.0 feet B.L.S.

Note that the majority of Citrus County contains upland ridge Candler and Kendrick *excessively drained soils* (HSG = A) with a SHGWT > 6' B.L.S. Karst topography is also present in many parts of this county (i.e. potential sinkholes).

Candler soil, HSG = A

SHGWT depth > 6.0 feet B.L.S.

Color landscape photograph in S.E. 1/4 of S06, T28S, R20E (Hillsborough County), within Trout Creek Park (District property).

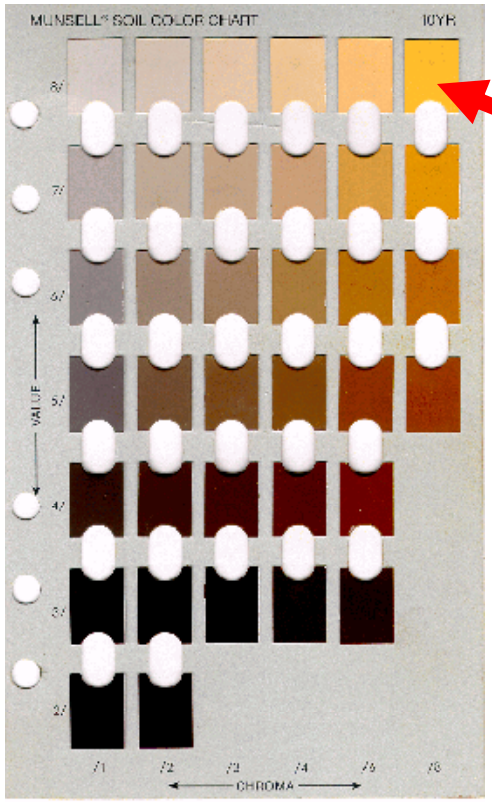
Kendrick soil, HSG = A

SHGWT depth > 6.0 feet B.L.S.

Color profile of soil

Notice the deep roots.

Notice the bright <u>uniform</u> colors, depth to the root zone, and a lack of soil mottles or hardpan.



Excessively drained, HSG = A soils typically fall in this area of the 10YR page.

10YR page. Upper right corner indicates excessively drained soils (HSG = A), lower left corner indicates wetlands (HSG = D).

Candler soil, HSG = A

SHGWT depth > 6.0 feet B.L.S.

Color profile of soil

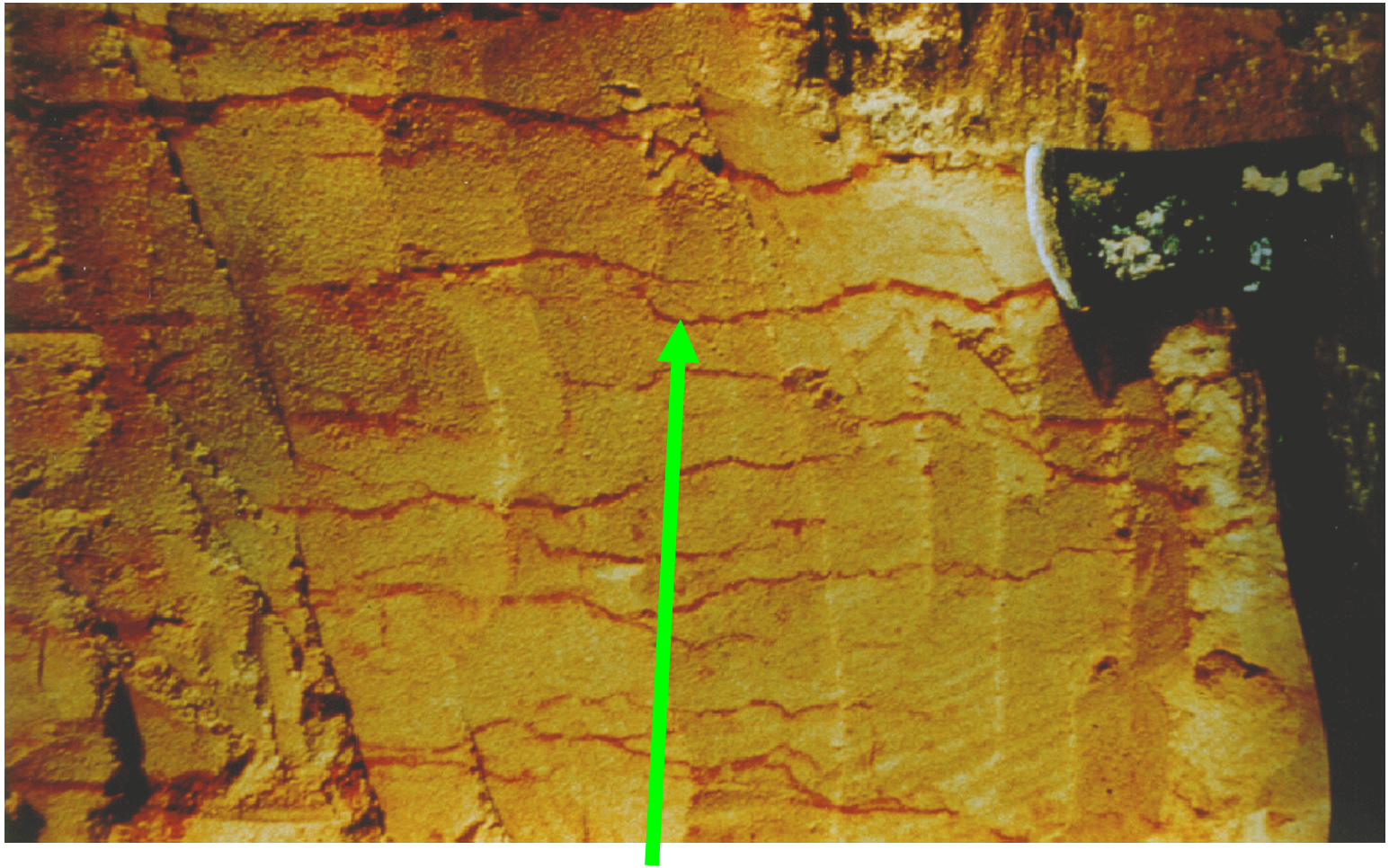
Lamella

(thin clay ribbons that are fractured, and do NOT impede the flow of ground water)

Candler soil, HSG = A

SHGWT depth > 6.0 feet B.L.S.

Color profile of soil

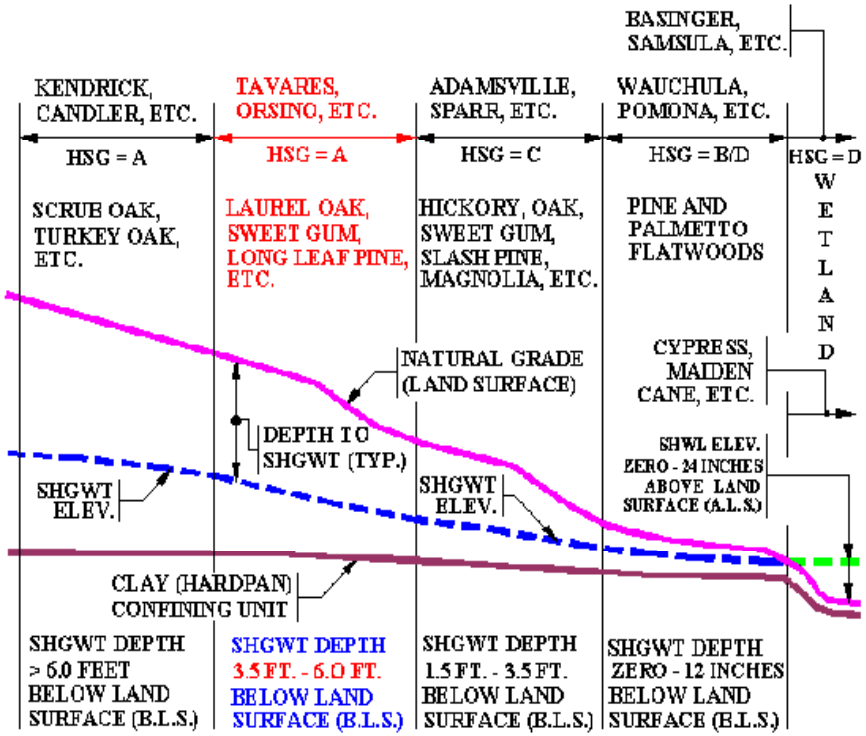


Lamella

(thin clay ribbons that are fractured, and do <u>NOT</u> impede the flow of ground water)

Tavares soil, HSG = A

SHGWT depth 3.5 feet - 6.0 feet B.L.S.



Notice the change in upland vegetation, and a thicker ground cover. Tavares is a well drained soil, with a higher SHGWT elevation.

Moving down gradient in regard to landscape position.

Sand Scrub on Duette soil

HSG = A
SHGWT depth 3.5 feet - 6.0 feet B.L.S.
Color landscape photograph in S.E. 1/4 of S31, T34S, R20E, Lake Manatee State Recreation Area (Manatee County)

Tavares soil, HSG = A

SHGWT depth 3.5 feet - 6.0 feet B.L.S.

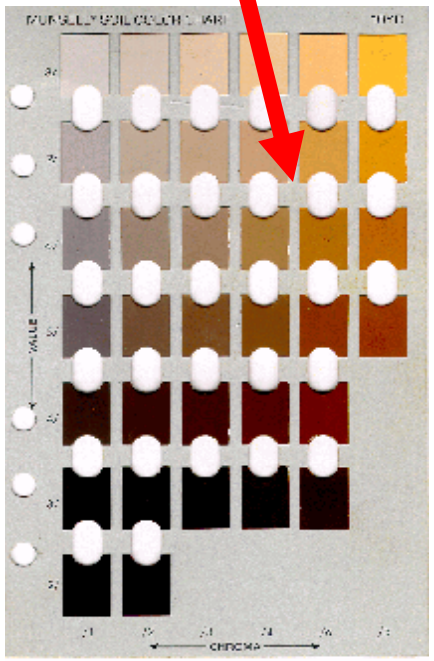
Color profile of soil (Highlands County)

Notice the shallower root depths.

Notice the change in colors at this depth.

Soil mottles, an indicator of anaerobic (water saturated) conditions.

Well drained, HSG = A soils of this type typically fall in this area of the 10YR page.

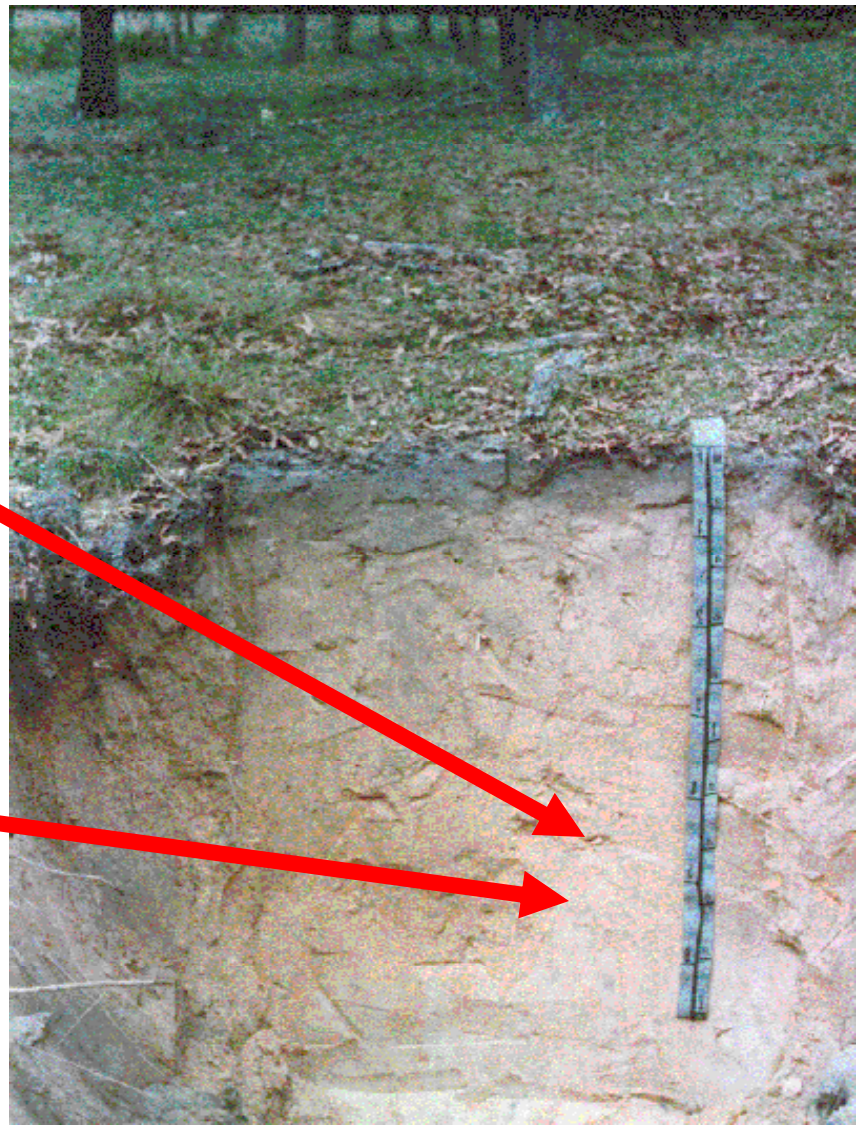


10YR page. Upper right corner indicates excessively drained soils (HSG = A), lower left corner indicates wetlands (HSG = D).

Tavares soil, HSG = A

SHGWT depth 3.5 feet - 6.0 feet B.L.S.

Color profile of soil (Pasco County)

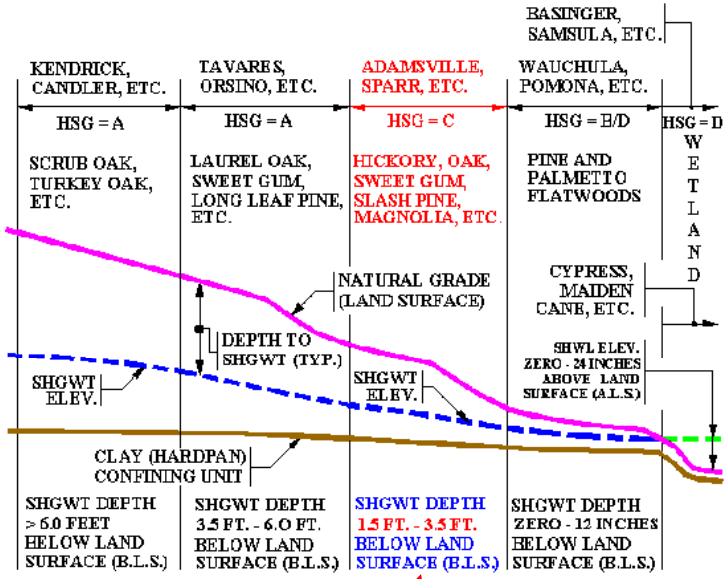


Notice the shallower root depths.

Notice the change in colors at this depth.

Nobleton soil, HSG = C

SHGWT depth 1.5 feet - 3.5 feet B.L.S.



Notice the thick upland vegetation, both in the overstory and ground cover. Nobelton is a moderately drained soil, with a shallow SHGWT elevation.

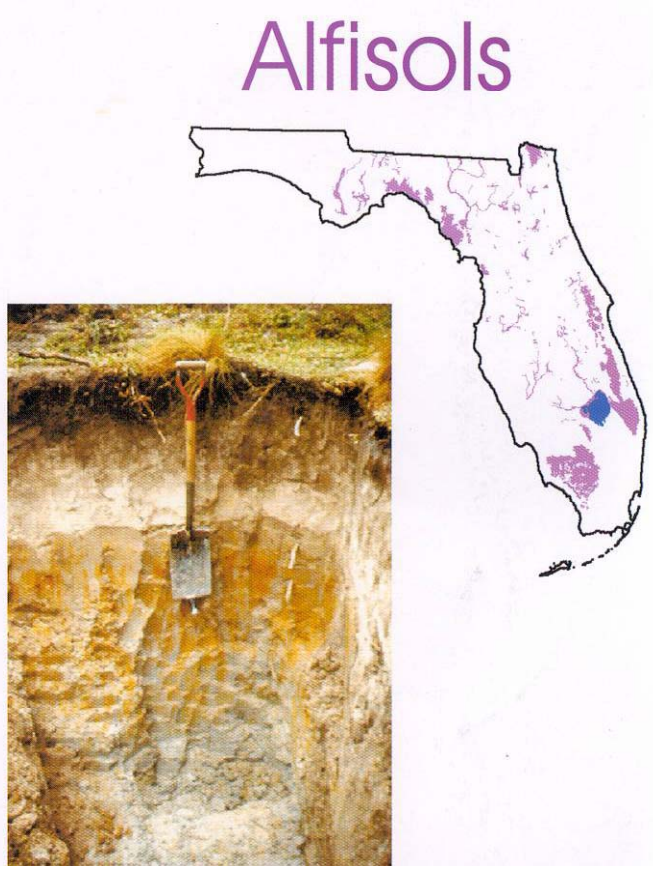
Moving farther down gradient in regard to landscape position.

Generalized location map of Alfisols

Extent of Alfisols Soils in Florida – 4.6 Million Acres

Not for site specific use. Refer to the County Soil Surveys for more detailed information.

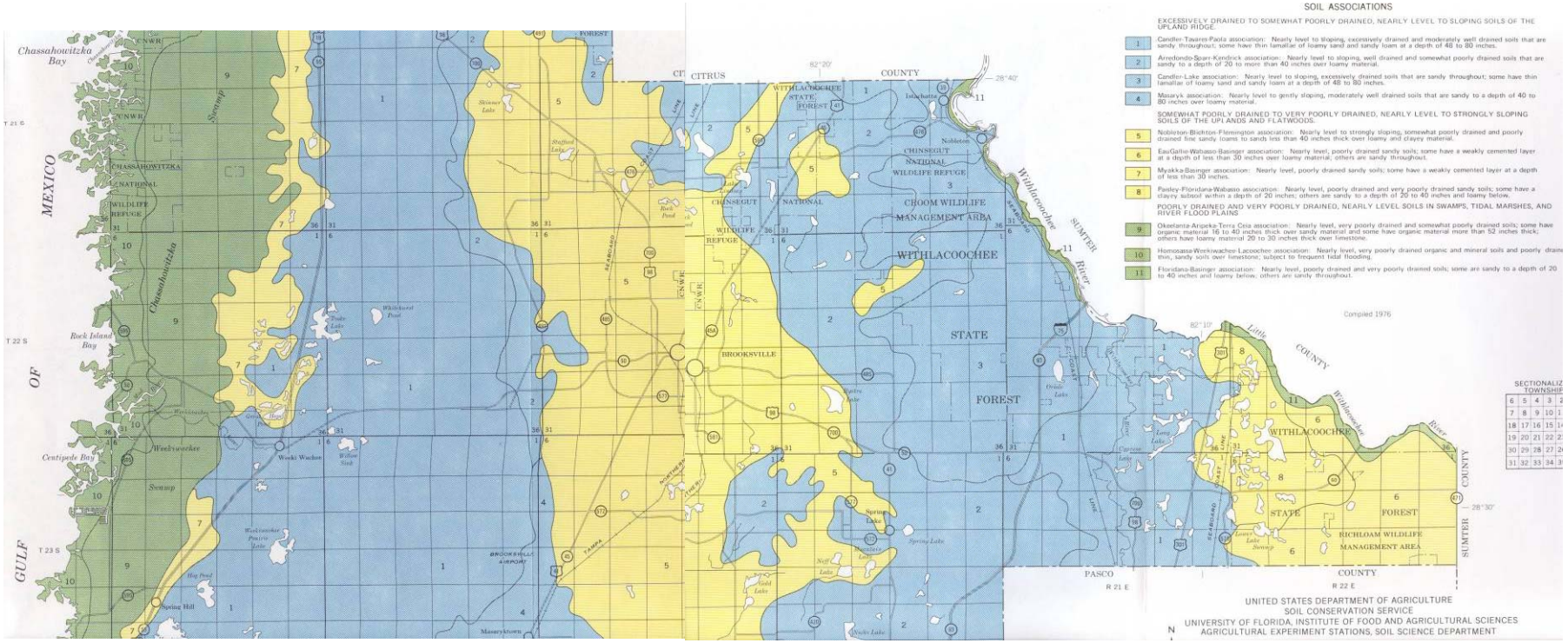
ALFISOLS are soils that have an ochric epipedon (surface layer), an argillic horizon (subsoil with a higher clay content than the layers above), and a moderate to high level of bases. Alfisols range from well drained soils on ridges, and knolls to very poorly-drained soils on flats, depressions, and floodplains. Limestone sometimes occurs below the argillic horizon. Some of the more extensive Alfisols in Florida include the Boca, Felda (see photo), Malabar, Meggett, Pineda, and Riviera soils. Alfisols cover approximately 4.6 million acres.



Alfisols are typically classified as moderately drained, HSG = C, with a SHGWT between 1.5' to 3.5' B.L.S.

General Soils Map of Hernando County

For information purposes only, NOT for detailed site - specific investigations

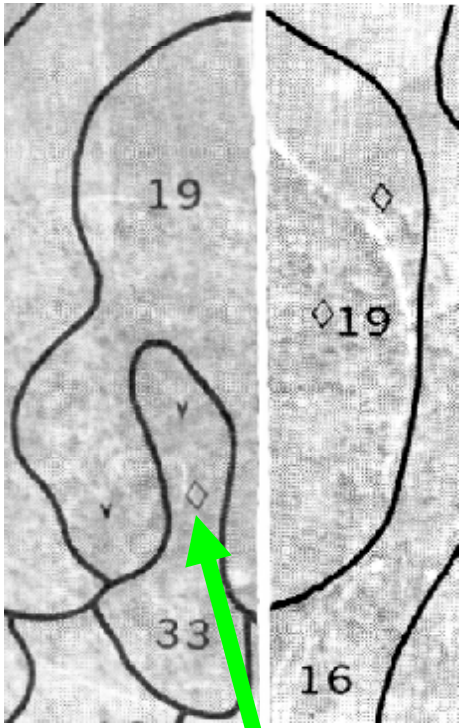


Note that a large portion of Hernando County contains Nobelton / *moderately to somewhat poorly drained soil* (HSG = C) with a SHGWT > 1.5' – 3.5' B.L.S.

Upland Hardwood Hammock on Micanopy soil

HSG = C
SHGWT depth 1.5 feet - 2.5 feet B.L.S.
Color landscape photograph in S.E. 1/4 of S017 T20S, R19E, (Withlacoochee State Forest, Citrus County)

Relic sinkhole area in background.



Notice diamond symbol which indicates karst topography

Sparr soil, HSG = C

SHGWT depth 1.5 feet - 3.5 feet B.L.S.

Color profile of soil (Hardee County)

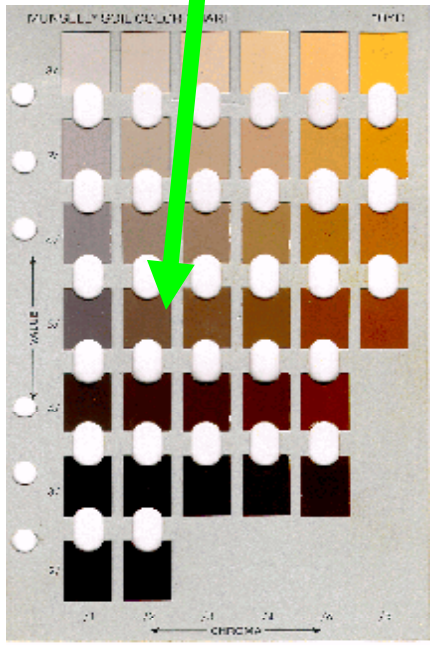
Notice the shallower root depths.

Soil mottles, an indicator of anaerobic (water saturated) conditions.

Notice the change in colors at this depth.

Notice the well defined hardpan.

Moderately drained, HSG = C soils typically fall in this area of the 10YR page.



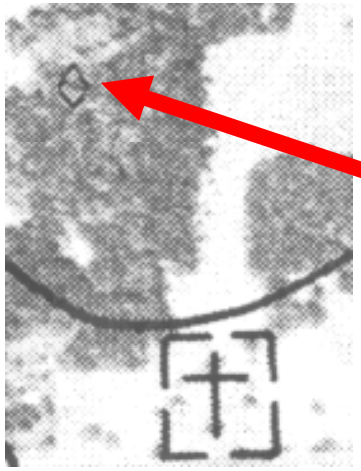
10YR page. Upper right corner indicates excessively drained soils (HSG = A), lower left corner indicates wetlands (HSG = D).

Sparr soil, HSG = C

SHGWT depth 1.5 feet - 3.5 feet B.L.S.

Color photograph of soil in S.E. 1/4 of S04, T19S, R18E, Private property, Citrus County

Notice the presence of many soil mottles at a depth of 36± inches B.L.S..



Per the special (diamond) symbol on the NRCS soils map, this is a potential karst (sinkhole) area.

Naturally occurring Cedar trees are also an indicator of karst topography.

Sparr soil, HSG = C

SHGWT depth 1.5 feet - 3.5 feet B.L.S.

Color profile of soil (Citrus County)

Notice the shallower root depths.

Notice the change in colors at this depth.

Notice the well defined hardpan.

Narcoossee soil, HSG = C

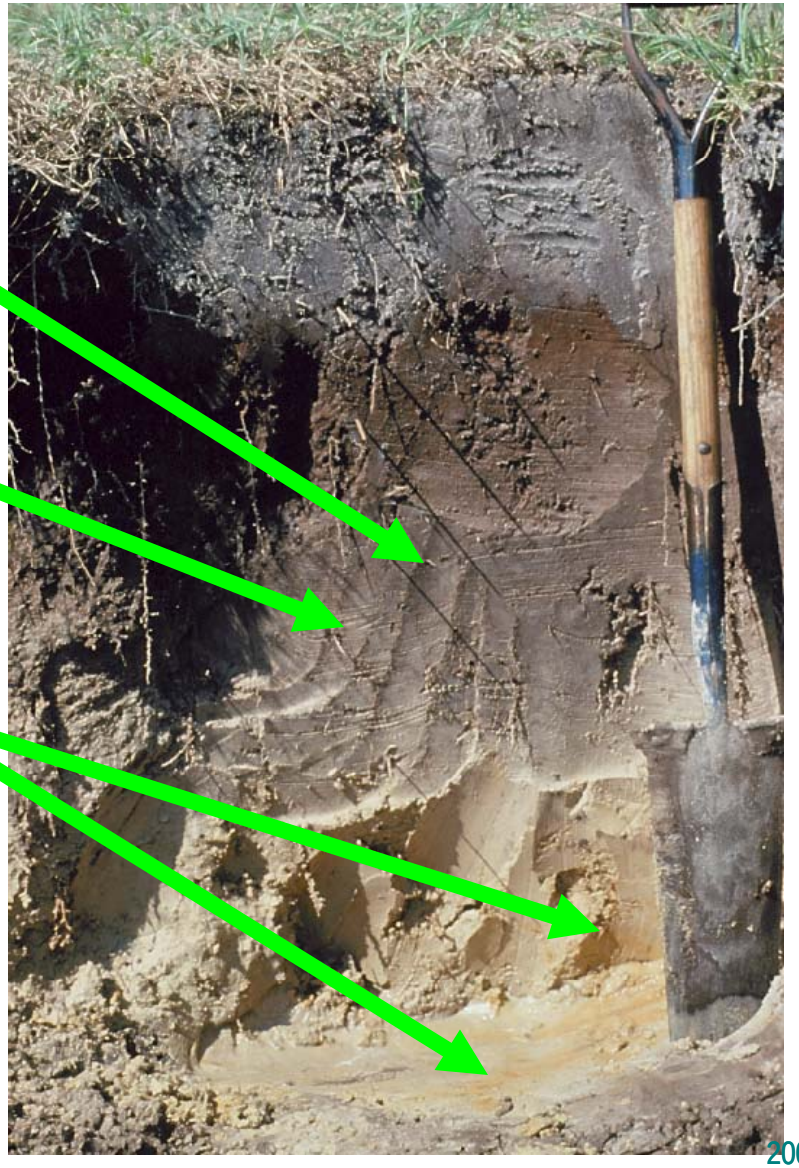
SHGWT depth 2.0 feet - 3.5 feet B.L.S.

Color profile of soil (Pasco County)

Notice the shallower root depths.

Notice the change in colors at this depth.

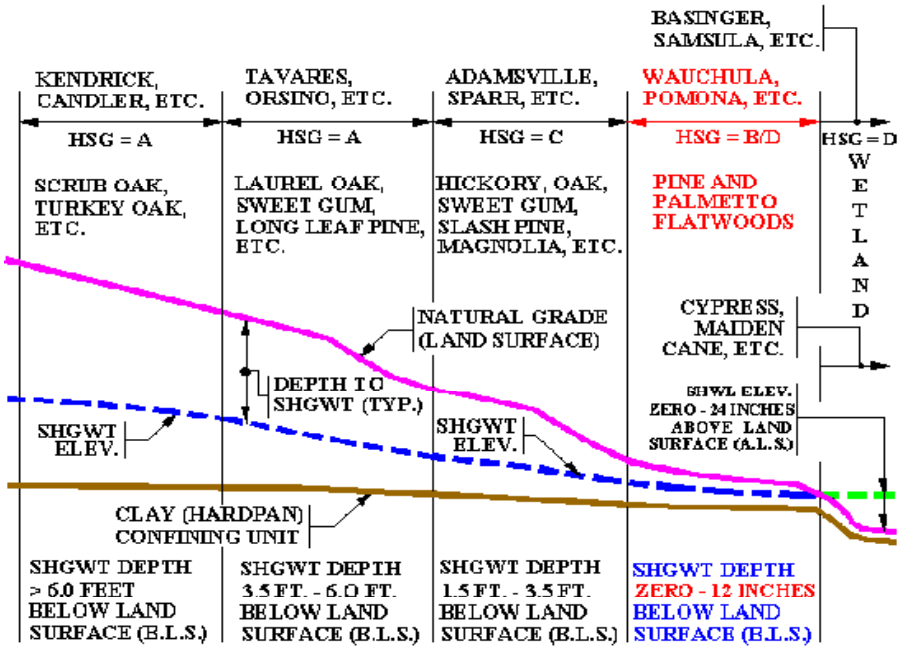
Notice the well defined hardpan.



Pomona soil, HSG = B/D

SHGWT depth 0 inches - 12 inches B.L.S.

Typical pine flatwoods soil. Pomona is a poorly drained soil, with a SHGWT elevation at (or near) the surface.

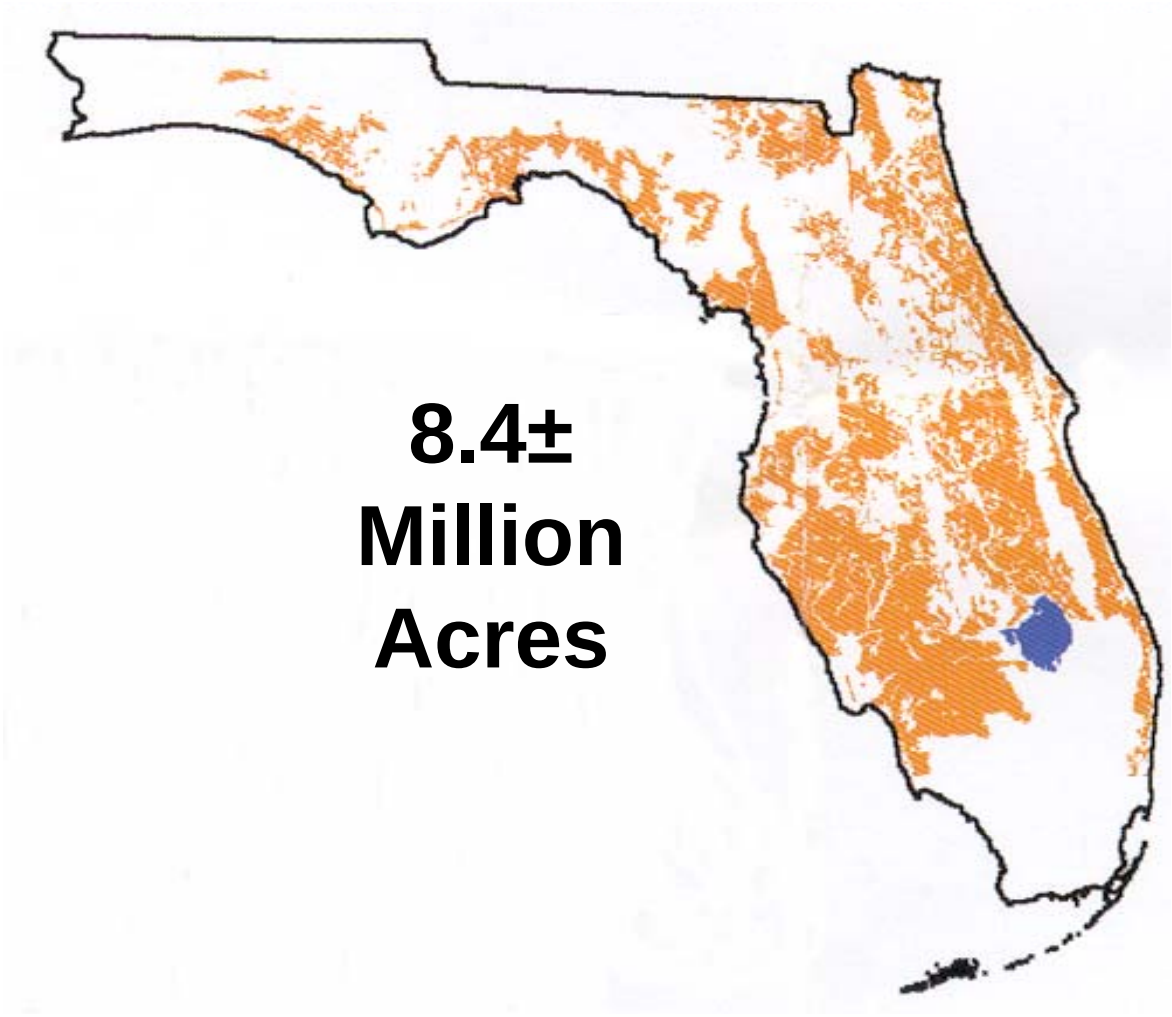


Moving farther down gradient in regard to landscape position.

Refer to the reference material handouts for a copy of the SWFWMD Training Memorandum entitled *"USDA- NRCS Hydrologic Soil Groups and Development Effects"*. For the vast majority of cases, a B/D soil should be considered as a HSG = D.

Generalized location map of Spodosols (i.e. Pine Flatwoods)

Not for site specific use. Refer to the County Soil Surveys for more detailed information.



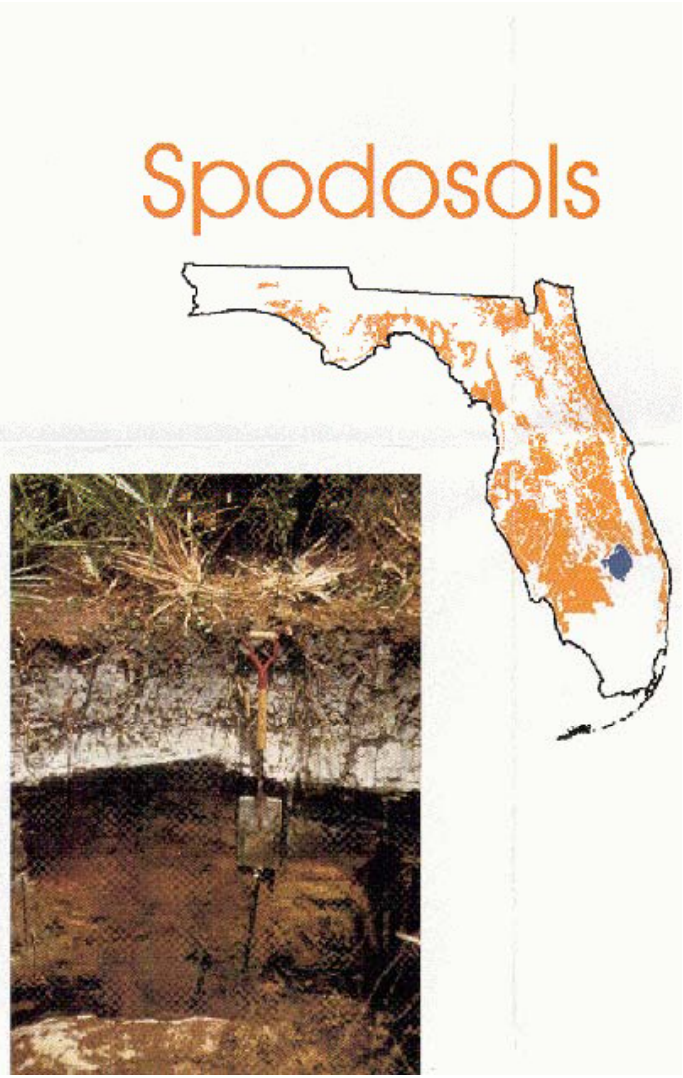
8.4± Million Acres

Most of the "good" land in central and south Florida has already been developed. What is left is wetlands, flood plains and Pine Flatwoods soils (with a SHGWT depth of 0" – 12" B.L.S.).

Definition of Spodosols

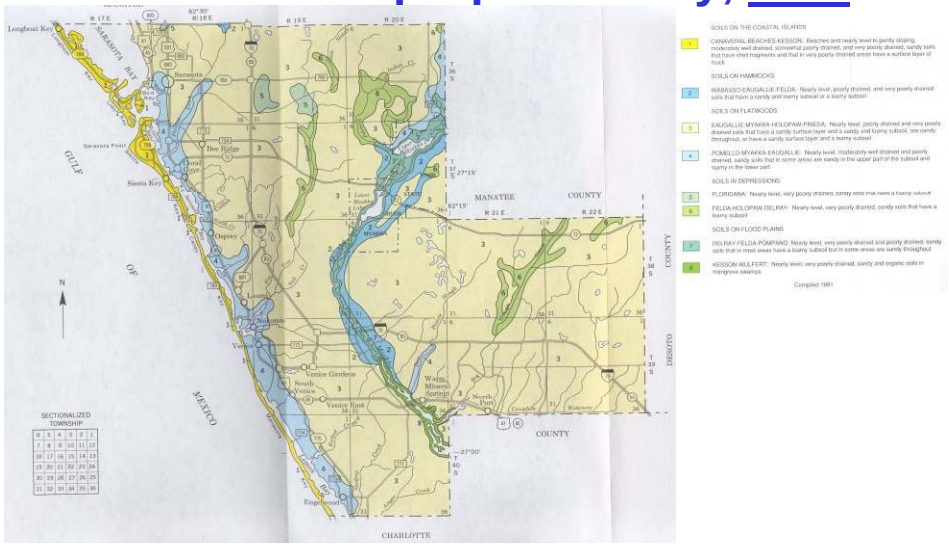
Extent of Pine Flatwoods Soils in Florida – 8.4 Million Acres

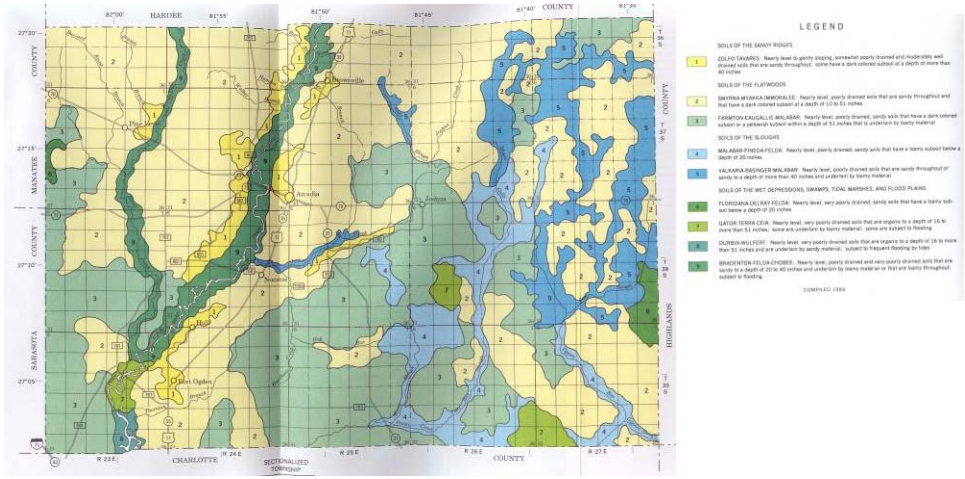
SPODOSOLS are soils that have an accumulation of organic matter and aluminum in a layer (spodic horizon) in the subsoil. Properties include translocated organic matter and aluminum, or organic matter, aluminum, and iron, as amorphous materials forming a spodic horizon. They developed in sandy, acid parent materials. The majority of the Spodosols in Florida are poorly or very poorly-drained, and are widespread in the flatwoods of Florida. Spodosols include the Myakka, Leon, Immokalee, Pomona, and Smyrna soils. The Myakka soil has been designated as the Florida State Soil (see photo). Spodosols cover approximately 8.4 million acres.

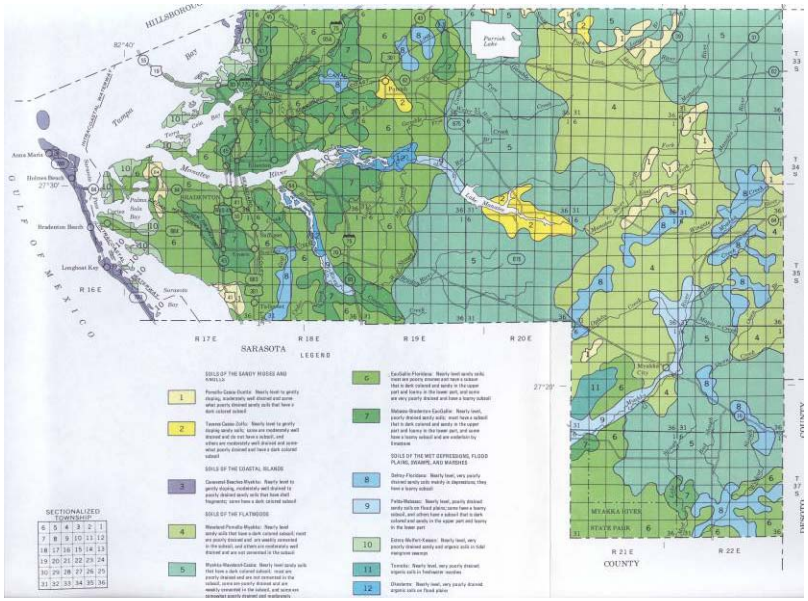


General Soils Map of Sarasota, Manatee and DeSoto Counties

For information purposes only, NOT for detailed site - specific investigations







Note that the majority of these Counties consist of Pine Flatwoods Soils *(poorly drained),* with a SHGWT from 0" – 12" B.L.S.

Special Definition of Soils With Variable HSG Classifications (i.e. A/D, B/D, etc.)

Some soils are listed in the NRCS Soil Surveys as being in more than one HSG. Such soils (indicated as A/D or B/D) are in HSG D in their natural (pre-developed) condition because of high water table conditions that create drainage impedance. If these soils can be effectively drained (and properly maintained) they may be reclassified in a different HSG. For instance, an Ona soil is classified as HSG B/D. This indicates that effectively drained (and maintained) Ona soil can be reclassified as high as HSG B, but it can not be HSG A.

South Florida Flatwoods on Pomona soil

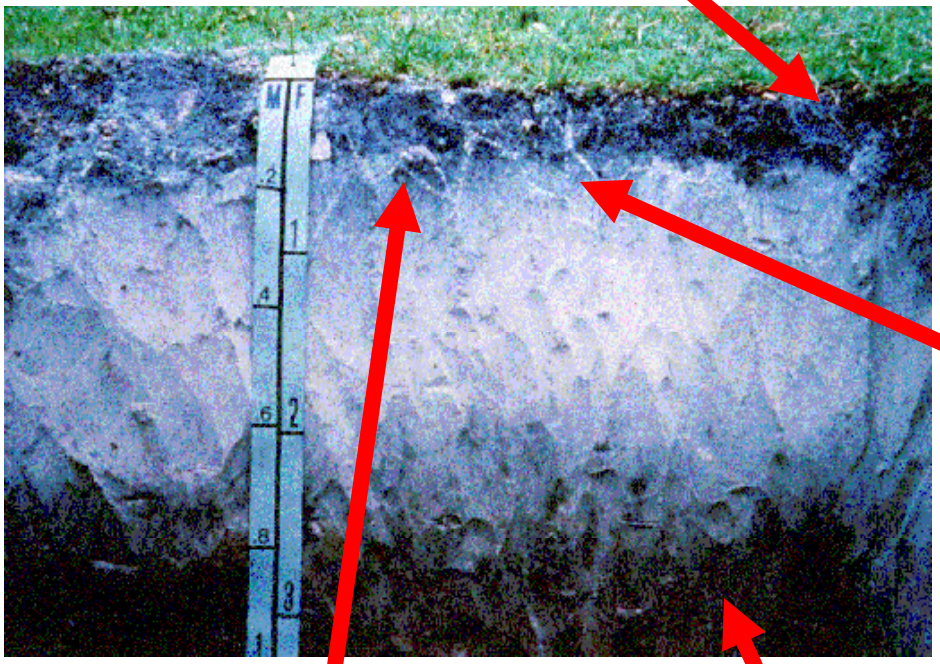
HSG = B/D
SHGWT depth 0 inches - 12 inches B.L.S.
Color landscape photograph, Green Swamp along the Van Fleet Trail, Polk County

Bassinger soil, HSG = B/D

SHGWT depth 0 inches - 12 inches B.L.S.

Color profile of soil

Notice that all of the roots are concentrated at the surface.



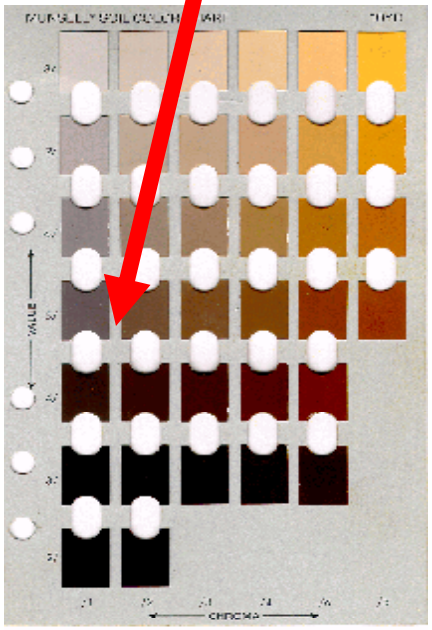
For the vast majority of cases, a B/D soil should be considered as a HSG = D.

Notice the color change at this depth.

"Grey" colors indicate wetness.

Spodic horizon.

Poorly drained, HSG = B/D soils typically fall in this area of the 10YR page.

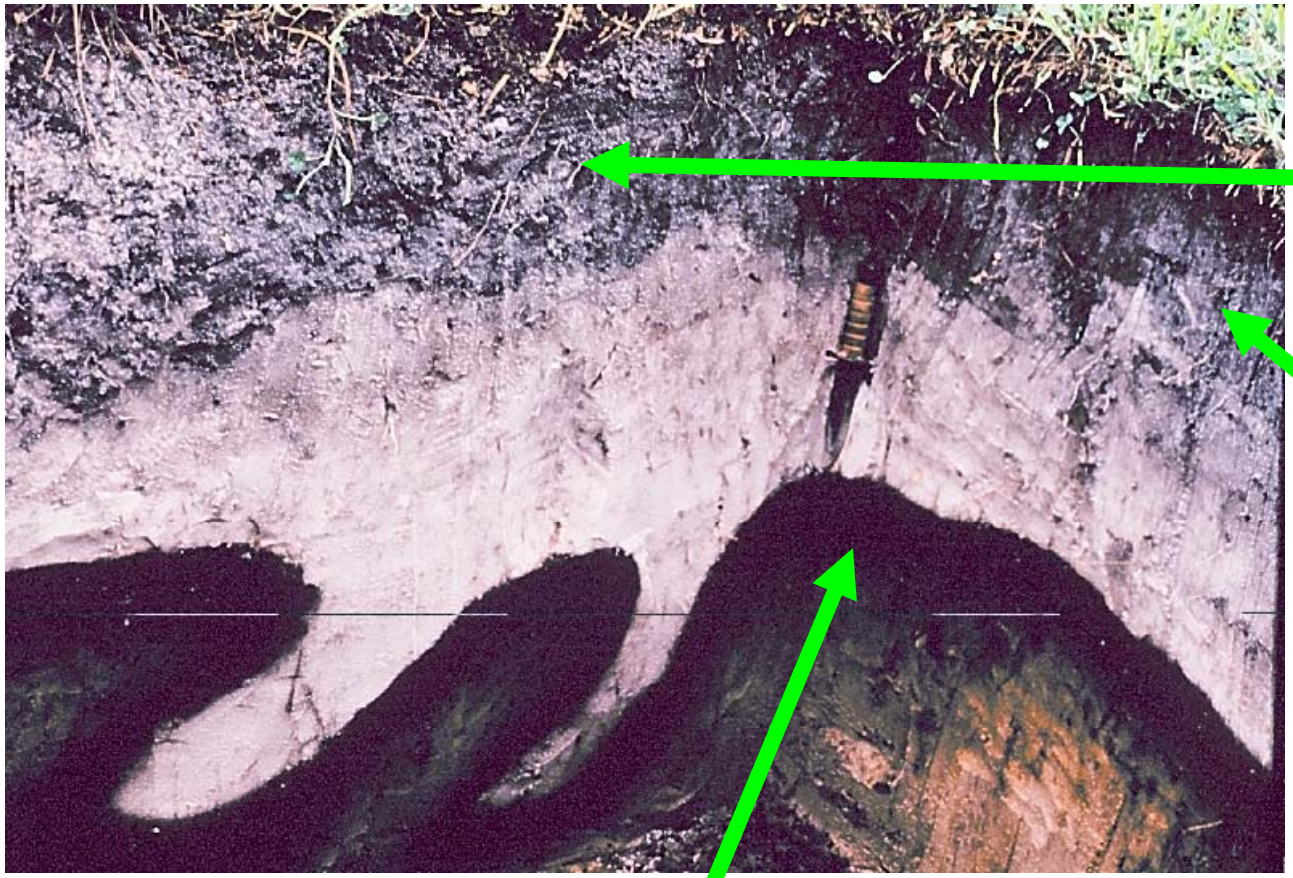


10YR page. Upper right corner indicates excessively drained soils (HSG = A), lower left corner indicates wetlands (HSG = D).

Symrna soil, HSG = B/D

SHGWT depth 0 inches - 12 inches B.L.S.

Color soil profile, Highlands County



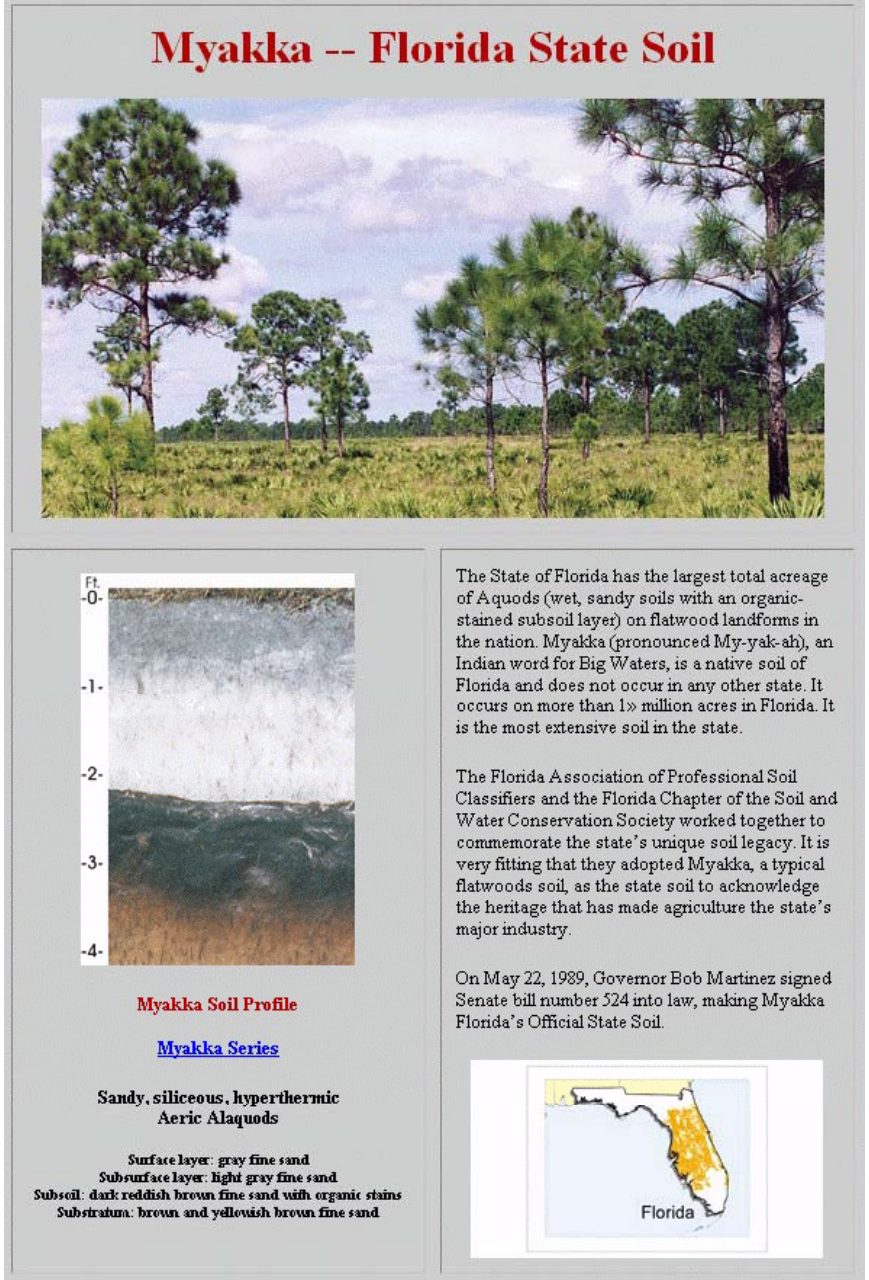
Notice that all of the roots are concentrated at the surface.

"Grey" colors indicate wetness.

Spodic horizon.

Myakka soil, HSG = B/D

SHGWT depth 0 inches - 12 inches B.L.S.



Myakka - This soil is poorly suited to urban development. Wetness is a management concern. Septic tank absorption fields can be maintained above the seasonal high water table by mounding and backfilling with suitable fill material.

The new house pictured above has been elevated to overcome the severe wetness.

DRAINAGE AND PERMEABILITY: Myakka soils are poorly to very poorly drained. They have slow internal drainage and slow to ponded runoff. Permeability is rapid in the A and E horizons and moderate or moderately rapid in the Bh horizon. The water table is at depths of less than 18 inches for 1 to 4 months duration in most years and recedes to depths of more than 40 inches during very dry seasons. Depressional areas are covered with standing water for periods of 6 to 9 months or more in most years.

Flatwoods (colloquial): Broad, linear-relief landforms that have slightly convex relief along flats, depressions, and flood plains and have concave relief along rises and knolls.

Flood plain: A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Myakka soil, HSG = B/D

SHGWT depth 0 inches - 12 inches B.L.S.

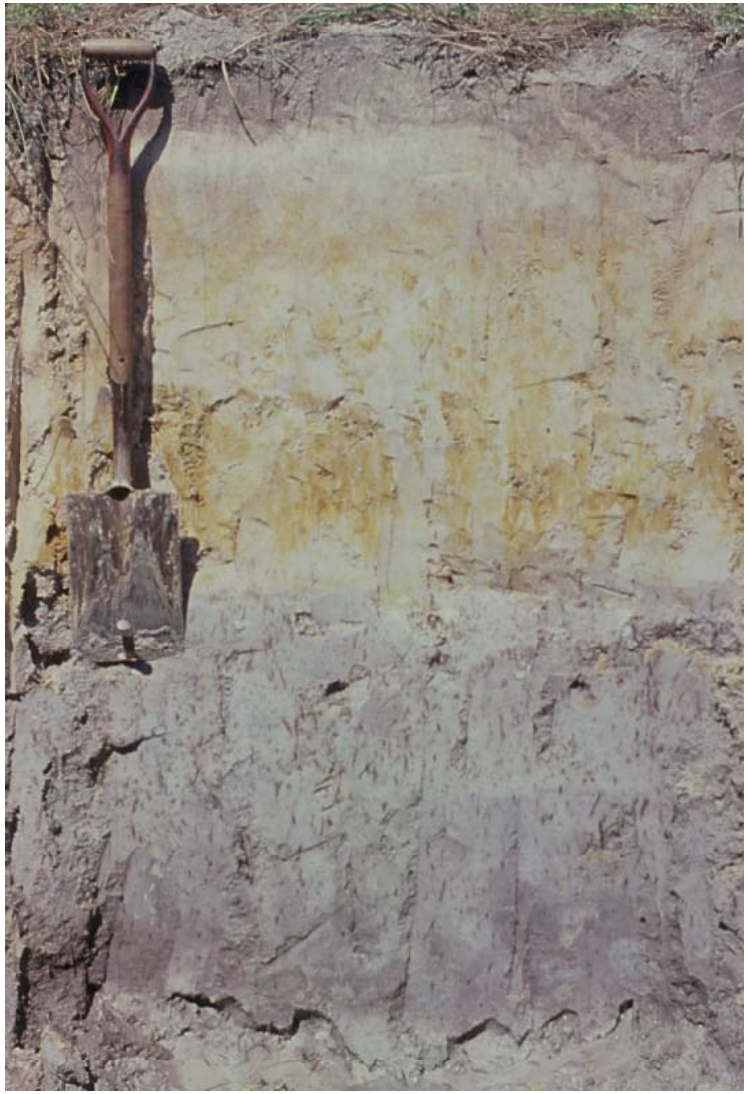
Color soil profile, Polk County

Notice that all of the roots are concentrated at the surface.

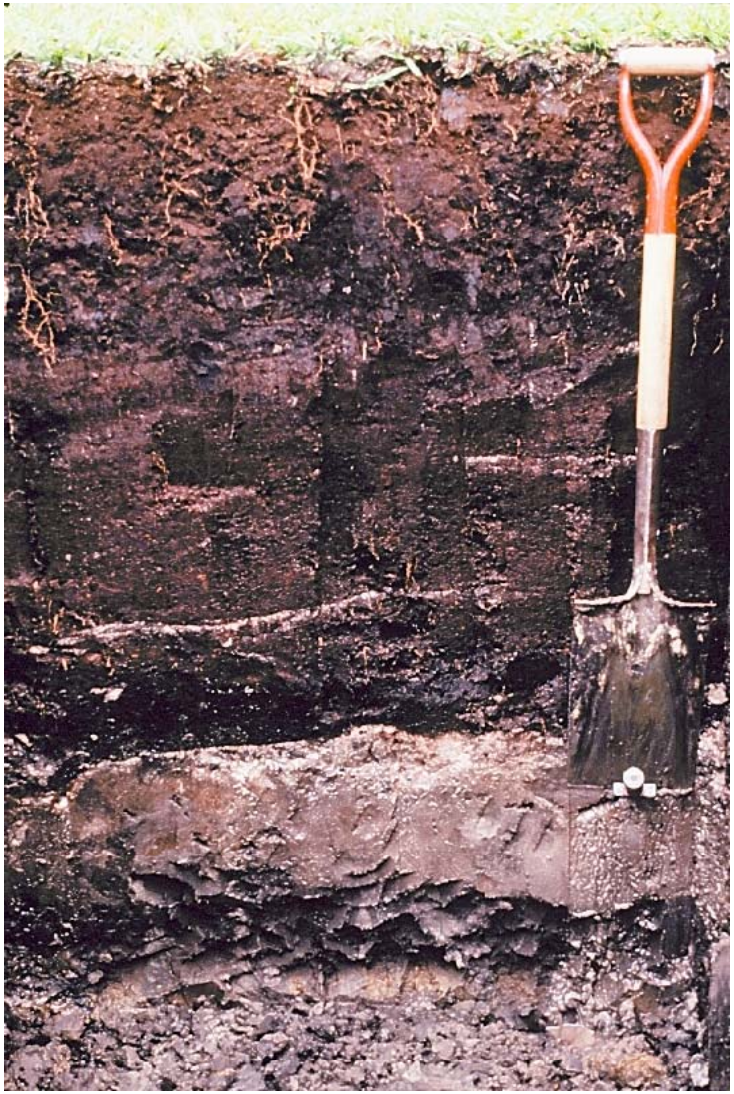
Spodic horizon.

As noted on the previous slide, Myakka is the Florida State Soil.

HSG “D” Soils



Felda, Soil #49, Charlotte County, SHGWT depth +2.0 feet A.L.S. to 1.0 feet B.L.S.



Kaliga, Soil #47, Highlands County, SHGWT depth 0.0 feet to 1.0 feet B.L.S.

Color Landscapes of Wetlands

Maidencane Marsh

Mixed hardwood cypress swamp

Horse Creek flood plain

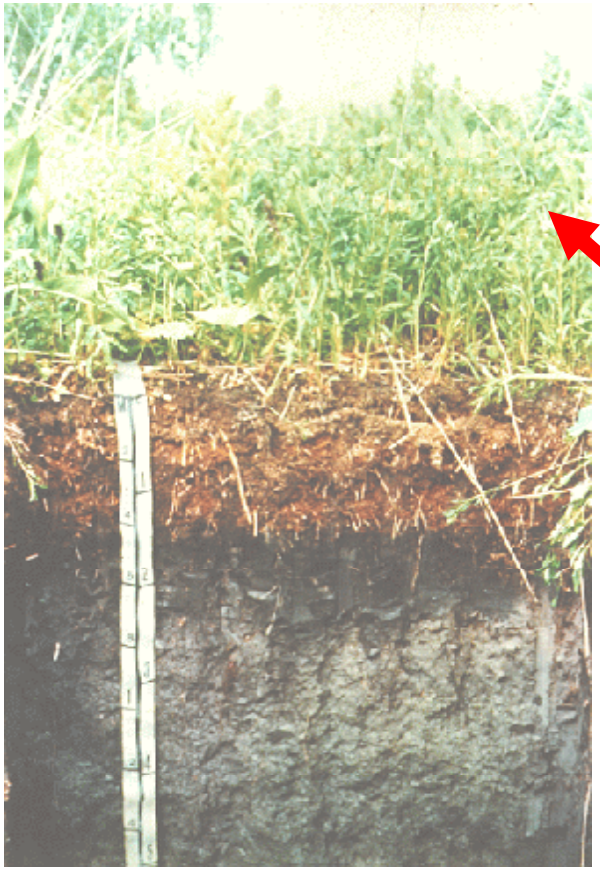
Pickeralweed / Sawgrass Marsh

Lakeshore Cypress fringe

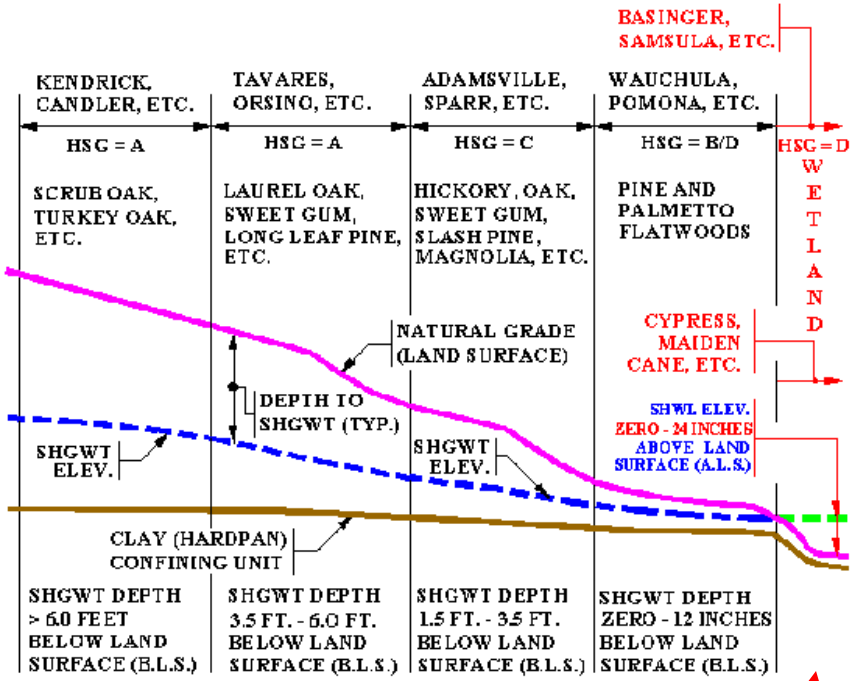
Bayhead

Terra Ceia, HSG = D

SHGWT depth 0 inches - 24 inches ABOVE land surface



Notice the wetlands vegetation.



Terra Ceia is a hydric (wetland) soil, with a SHGWT elevation at (or above) the surface.

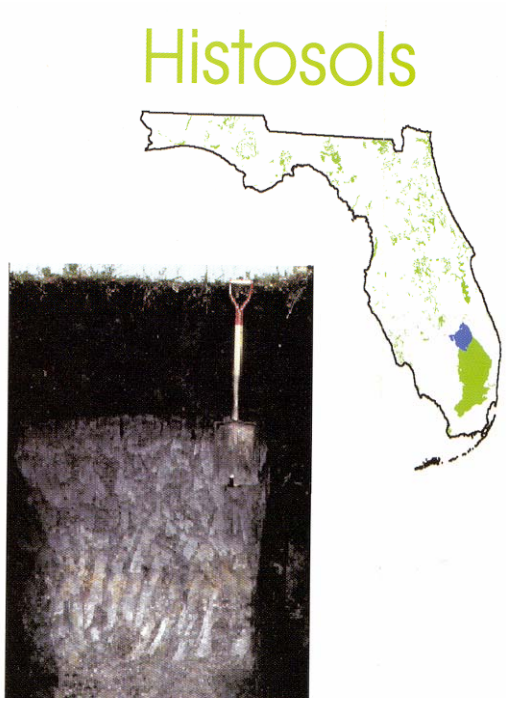
"Bottom of the hill" in regard to landscape position.

Generalized location map of Histolos & Mollisols

Extent of Histolos & Mollisols in Florida – 5.1 Million Acres

Not for site specific use. Refer to the County Soil Surveys for more detailed information.

HISTOSOLS are soils that have organic material that is 40 cm or more in thickness. The underlying materials are sandy to loamy mineral soils, or limestone bedrock. Properties are a very high content of organic carbon. Most Florida Histosols formed from partially decomposed plant remains that accumulated in water. Common very poorly-drained Histosols in Florida include the Lauderhill, Pamlico, Torry, Okeelanta, Terra Ceia, Pahokee, Gator (see photo) and Samsula soils. More common names for Histosols are peats or mucks. Histosols cover approximately 4.0 million acres.

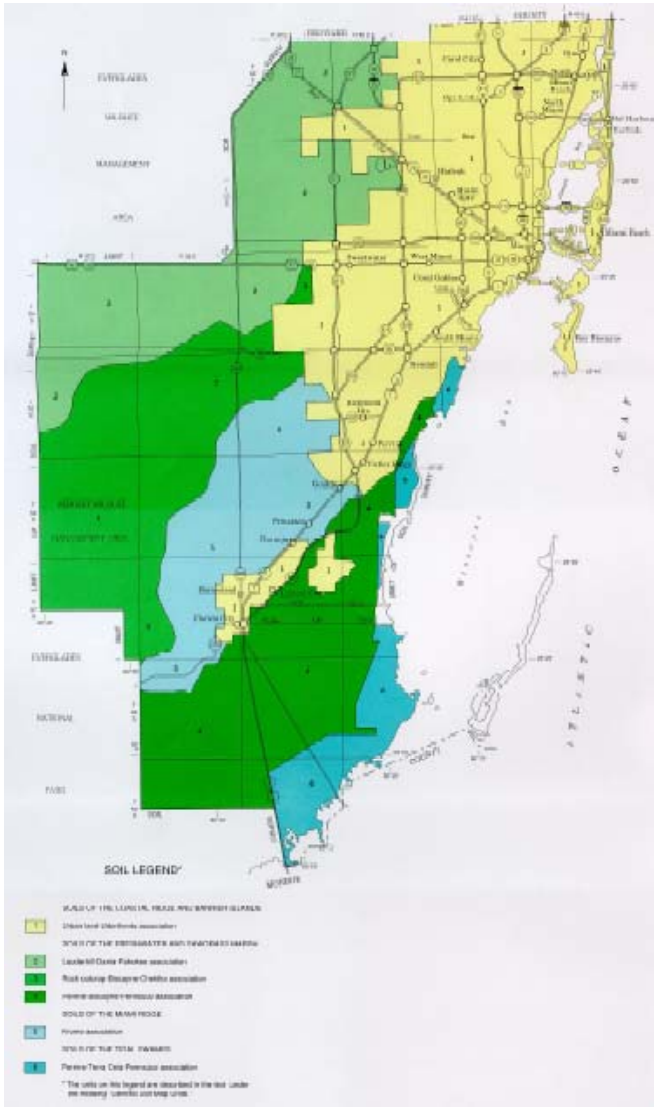


MOLLISOLS are soils that have a thick, very dark-colored surface layer with a high level of organic matter and bases. Many have argillic horizons. Properties associated with a mollic epipedon are a reasonable reserve of plant nutrients (Ca, Mg, K, and sometimes N), massive or weak structures, and very slow permeability. Mollisols in Florida are generally very poorly-drained soils in depressions and floodplains. The more extensive Mollisols include the Anclote, Buccaneer, Chobee (see photo), Delray Yulee, and Floridana soils. Mollisols cover approximately 1.1 million acres.

Alfisols are typically classified as very poorly drained soils, HSG = D, with a SHGWT between 0” to 24” A.L.S.

General Soils Map of Dade County

For information purposes only, NOT for detailed site - specific investigations

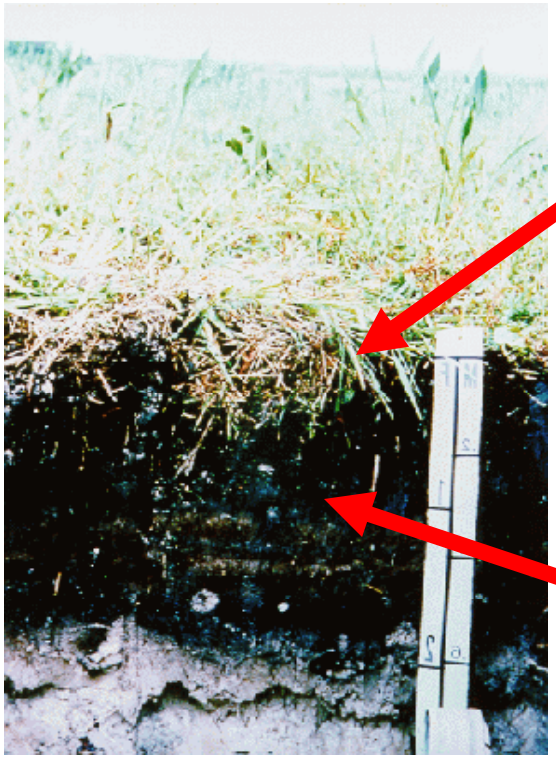


Note that over half of Dade County contains wetland soils (HSG = D) with a SHGWT 0” - 24” A.L.S.

Samsula Muck, HSG = D

SHGWT depth 0 inches - 24 inches ABOVE land surface

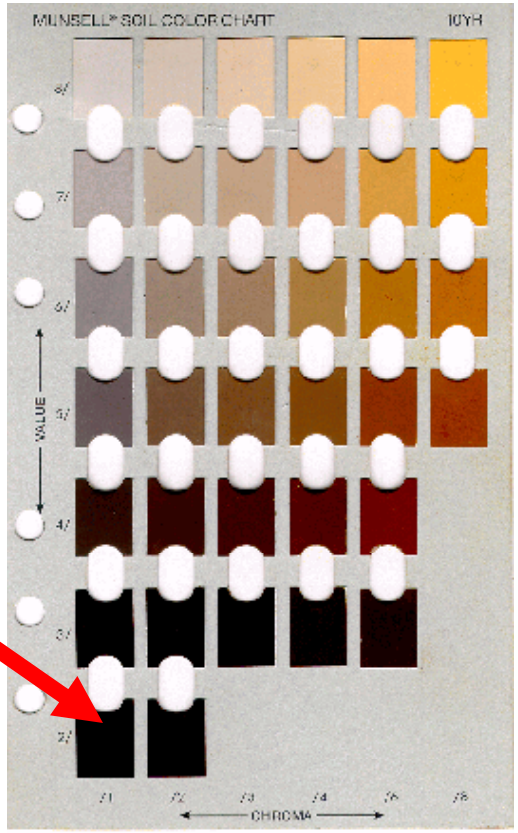
Color profile of soil



Notice that all of the roots are concentrated at the surface.

Hydric (wetland) soils (HSG = D) typically fall in this area of the 10YR page.

Muck



10YR page. Upper right corner indicates excessively drained soils (HSG = A), lower left corner indicates wetlands (HSG = D).

"Black" colors indicate hydric (wetland) soils.

Wetland Inclusion (Felda - depressional, #86) within Pomona Sand (#7)

SHGWT depth 0 inches - 24 inches ABOVE land surface

“Black” colors indicate hydric (wetland) soils.

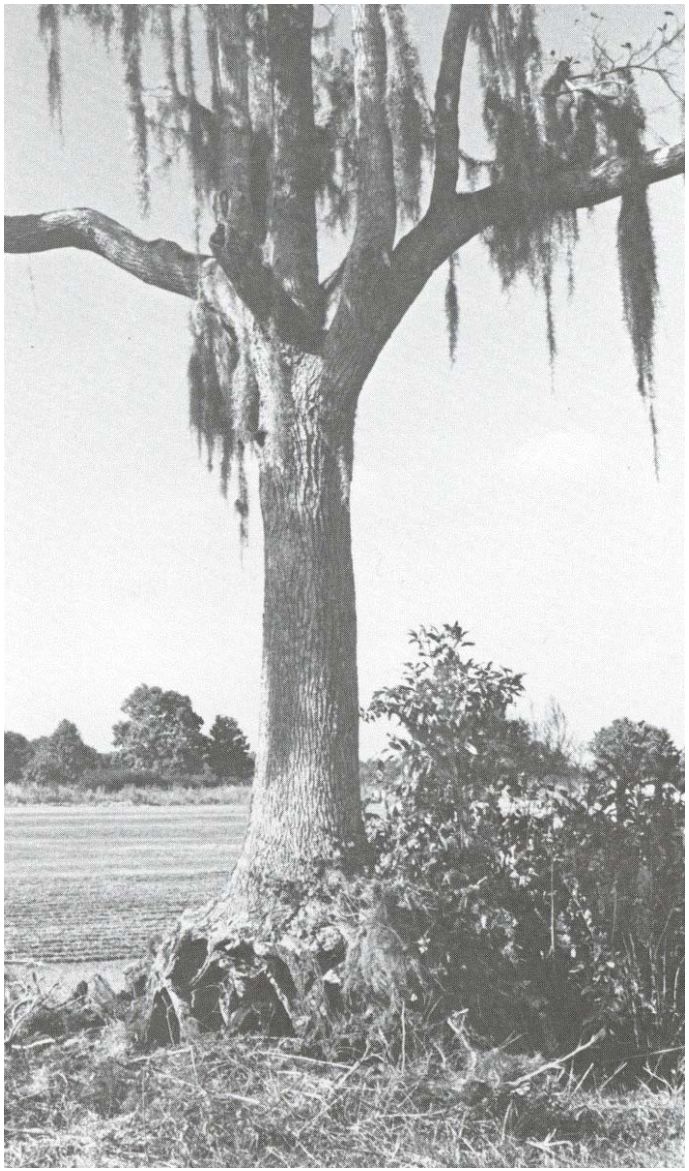
Polk County

Muck, HSG = D
SHGWT is 0" - 24" ABOVE land surface

Color landscape and soil profile in Palm Beach County

Subsidence of Kaliga Muck

(photo taken from page #41 of the Polk County Soil Survey)



Subsidence of Kaliga muck leaves tree roots exposed above the present ground surface.

Flood plain: A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Color landscape photograph showing muck subsidence in Palm Beach County

Additional Soil Profile Slides

Power Point© file name: Additional soil profile slides as of 01-19-05

Presented by Hank Higginbotham, P.E.
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Southwest Florida Water Management District
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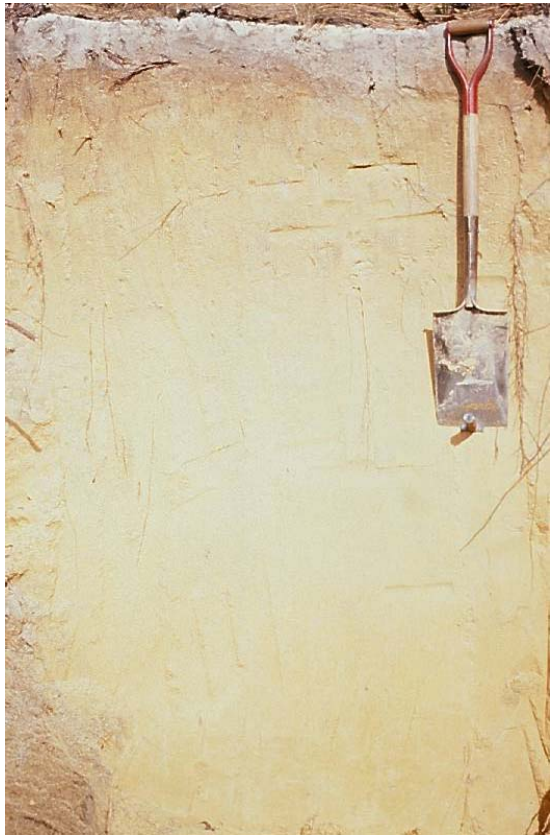
e-Mail: hank.higginbotham@swfwmd.state.fl.us

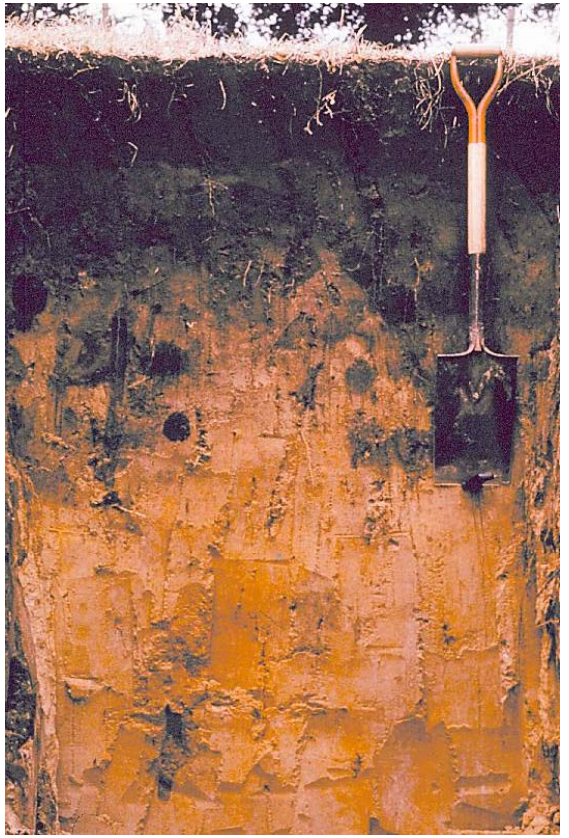
Additional Soil Profile Slides

HSG “A” Soils

Arredondo, Soil #16 & #17, Citrus County, SHGWT depth > 6.0 feet B.L.S.

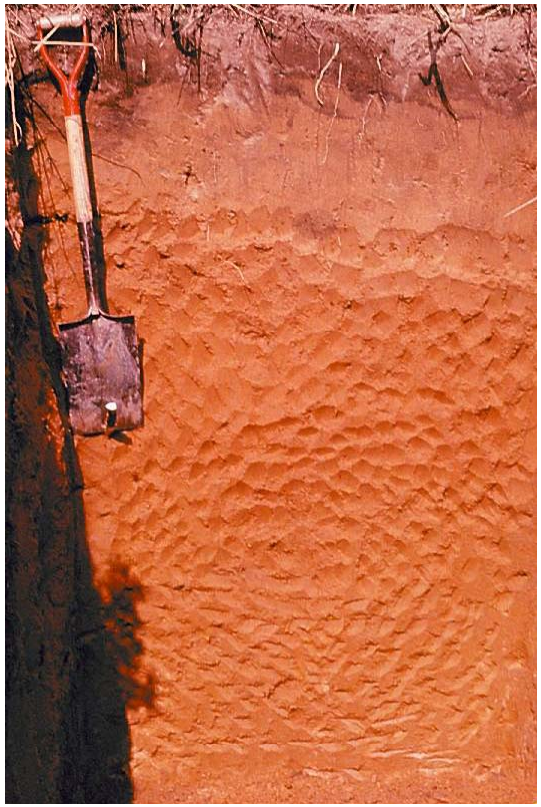


Astatula, Soil#76, Levy County, SHGWT depth > 6.0 feet B.L.S.

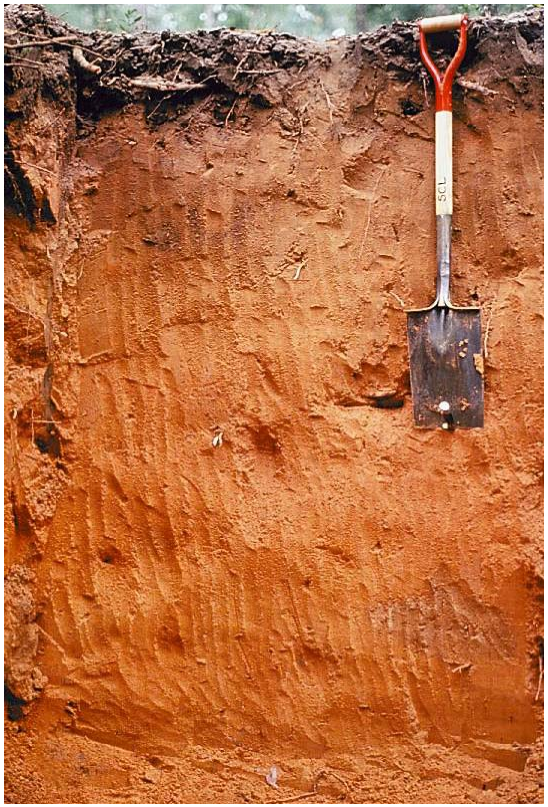


Florahome, Soil #20, Sumter County, SHGWT depth 4.0 feet to 6.0 feet B.L.S.

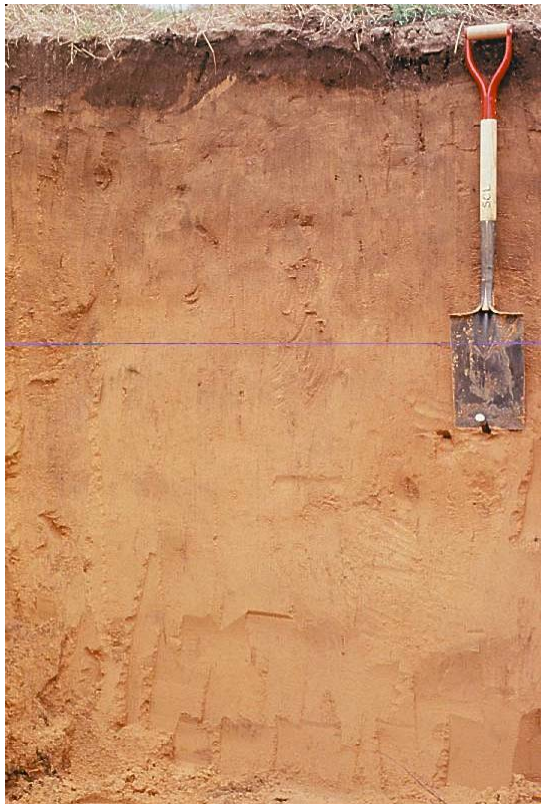
HSG “A” Soils



Kendrick, Soil #18 & #19, Citrus County, SHGWT depth > 6.0 feet B.L.S.



Kendrick, Soil #18 & #19, Citrus County, SHGWT depth > 6.0 feet B.L.S.



Lake, Soil #14 & #15, Citrus County, SHGWT depth > 6.0 feet B.L.S.

Additional Soil Profile Slides

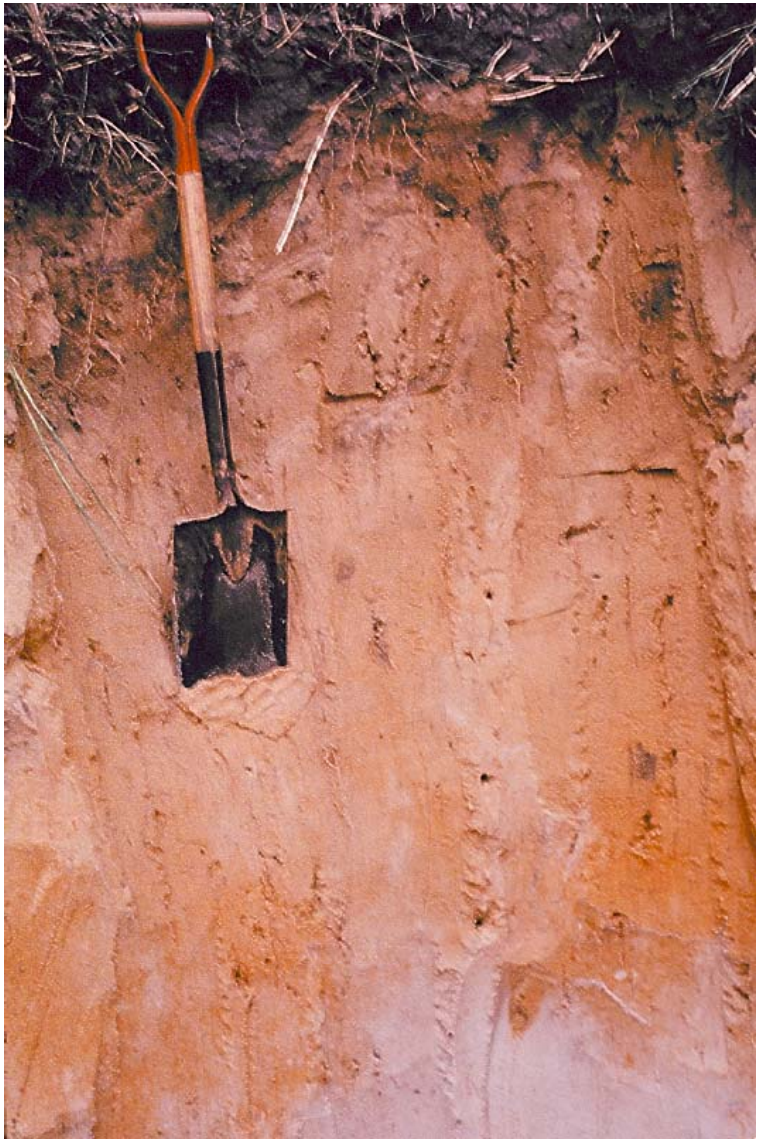
HSG “A” Soils

Paola, Soil #1, Highlands County, SHGWT depth > 6.0 feet B.L.S.

Paola variant, Soil #8, Citrus County, SHGWT depth > 6.0 feet B.L.S.

St. Lucie, Soil #2, Highlands County, SHGWT depth > 6.0 feet B.L.S.

HSG “A” Soils



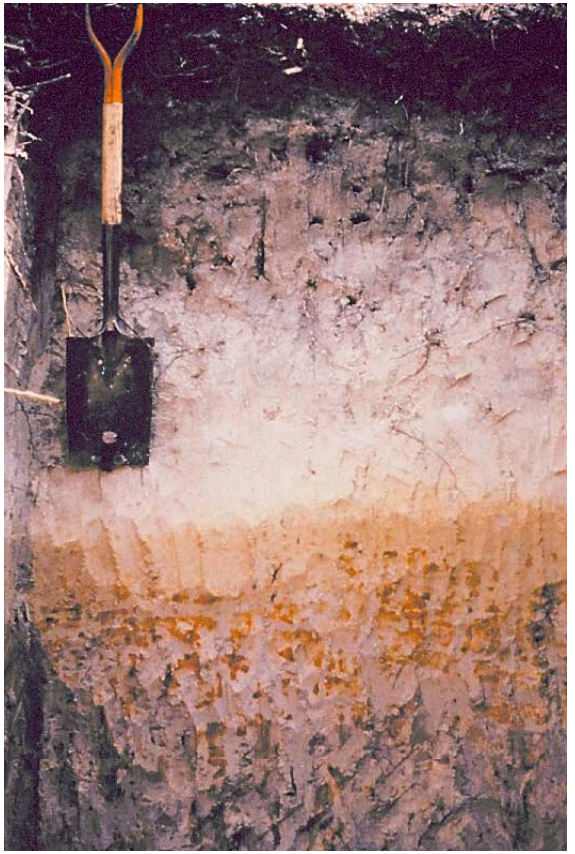
Tavares, Soil #6, Highlands County, SHGWT depth 3.5 feet to 6.0 feet B.L.S.

Additional Soil Profile Slides

HSG “C” Soils

Narcoossee, Soil #26, Pasco County, SHGWT depth 2.0 feet to 3.5 feet B.L.S.

Sparr, Soil #7, Pasco County, SHGWT depth 1.5 feet to 3.5 feet B.L.S.



Sparr, Soil #10, Sumter County, SHGWT depth 1.5 feet to 3.5 feet B.L.S.

Additional Soil Profile Slides

HSG “C” Soils

Sparr, Soil#23, Hardee County, SHGWT depth 1.5 feet to 3.5 feet B.L.S.

Sparr, Soil #31, Citrus County, SHGWT depth 1.5 feet to 3.5 feet B.L.S.

Special Definition of Soils With Variable HSG Classifications (i.e. A/D, B/D, etc.)

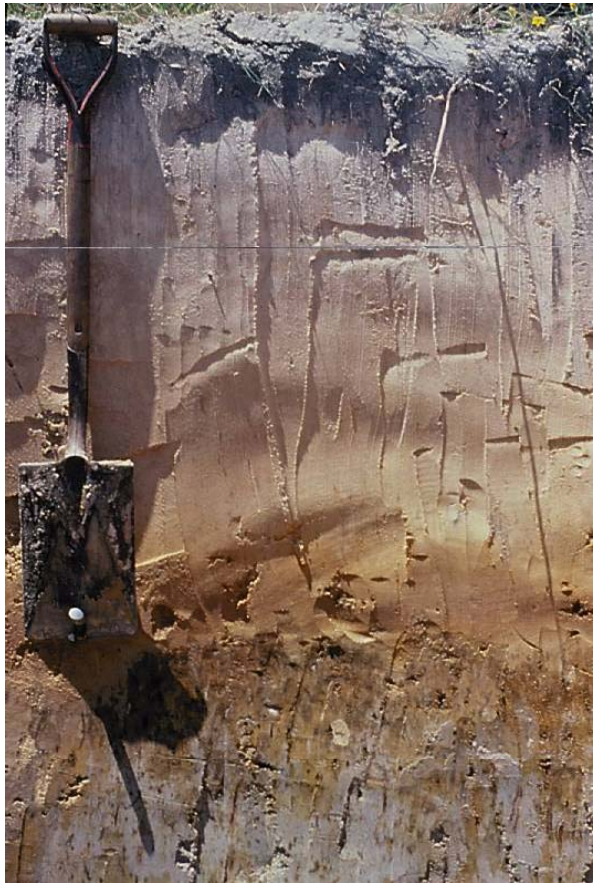
Some soils are listed in the NRCS Soil Surveys as being in more than one HSG. Such soils (indicated as A/D or B/D) are in HSG D in their natural (pre-developed) condition because of high water table conditions that create drainage impedance. If these soils can be effectively drained (and properly maintained) they may be reclassified in a different HSG. For instance, an Ona soil is classified as HSG B/D. This indicates that effectively drained (and maintained) Ona soil can be reclassified as high as HSG B, but it can not be HSG A.

Additional Soil Profile Slides

HSG “B/D” Soils

Eau Gallie, Soil #36, Citrus County, SHGWT depth 0.0 feet to 1.0 feet B.L.S.

Felda varient, Soil 12, Hardee County, SHGWT depth 0.0 feet to 1.0 feet B.L.S.



Malabar, Soil #63, Charlotte County, SHGWT depth 0.0 feet to 1.0 feet B.L.S.

Additional Soil Profile Slides

HSG “B/D” Soils

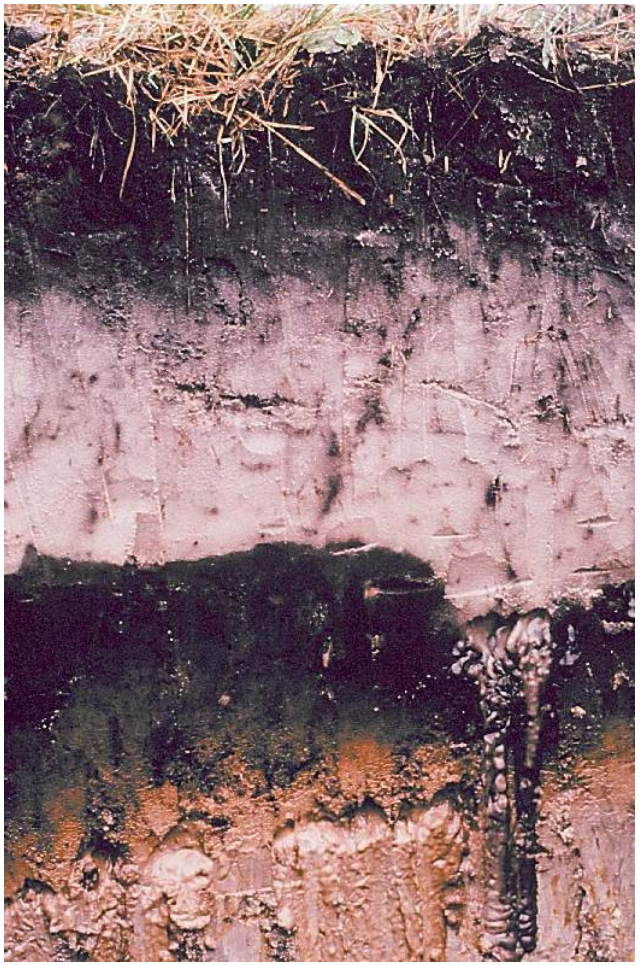
Myakka, Soil #17, Polk County, SHGWT depth 0.0 feet to 1.0 feet B.L.S.

Pomona - Uttic Haplaquads, Soil #2, Pasco County, SHGWT depth 0.0 feet to 1.0 feet B.L.S.

Additional Soil Profile Slides

HSG “B/D” Soils

Smyrna, Soil #39, Highlands County, SHGWT depth 0.0 feet to 1.0 feet B.L.S.

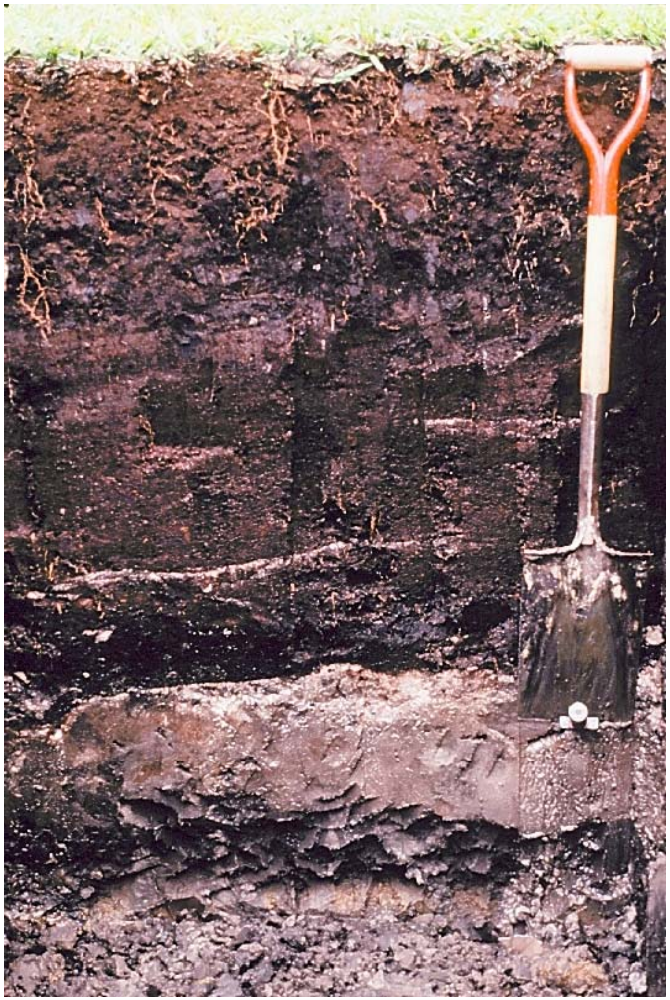


Wauchula, Soil #40, Polk County, SHGWT depth 0.0 feet to 1.0 feet B.L.S.

Additional Soil Profile Slides

HSG “D” Soils

Felda, Soil #49, Charlotte County, SHGWT depth +2.0 feet A.L.S. to 1.0 feet B.L.S.



Kaliga, Soil #47, Highlands County, SHGWT depth 0.0 feet to 1.0 feet B.L.S.

This concludes our presentation – thanks for your attention

Good engineering protects the environment!

Final Questions?

Additional Soil Profile Slides