2022 National Collegiate Soil Judging Contest Handbook

The Ohio State University
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The Ohio State University

USDA United States Department of Agriculture

PREFACE

This handbook provides information about the 2022 National Collegiate Soil Judging Contest. This manual provides the rules, scorecard instructions, and additional information about the contest. Much of the material comes from previous handbooks created and edited by the coaches and official judges of Regions 1, 2, 3, and 5, with some modification. The handbook has been adapted to the soils and landscapes of central Ohio for this version. Other references used to develop this handbook include: Chapter 3 of the *Soil Survey Manual* (Soil Survey Division Staff, 1993), *Field Book for Describing and Sampling Soils,* version 3.0 (Schoeneberger et al., 2012), *Soil Taxonomy* (Soil Survey Staff, 1999), *Keys to Soil Taxonomy* 12th Edition (Soil Survey Staff, 2014), *Illustrated Guide to Soil Taxonomy* (Soil Survey Staff, 2014), and *National Soil Survey Handbook* (Soil Survey Staff, 2011). In keeping with recent contests, emphasis is placed on fundamentals such as soil morphology, taxonomy, and soil-landscape relationships.

We welcome the teams to central Ohio and hope the contest provides both an educational and rewarding experience. Many thanks to those who helped with preparations and funding for this event. The contest is hosted by The Ohio State University and is a cooperative effort with the USDA Natural Resources Conservation Service and the Ohio Department of Agriculture. We thank the volunteers and landowners that made this event possible.

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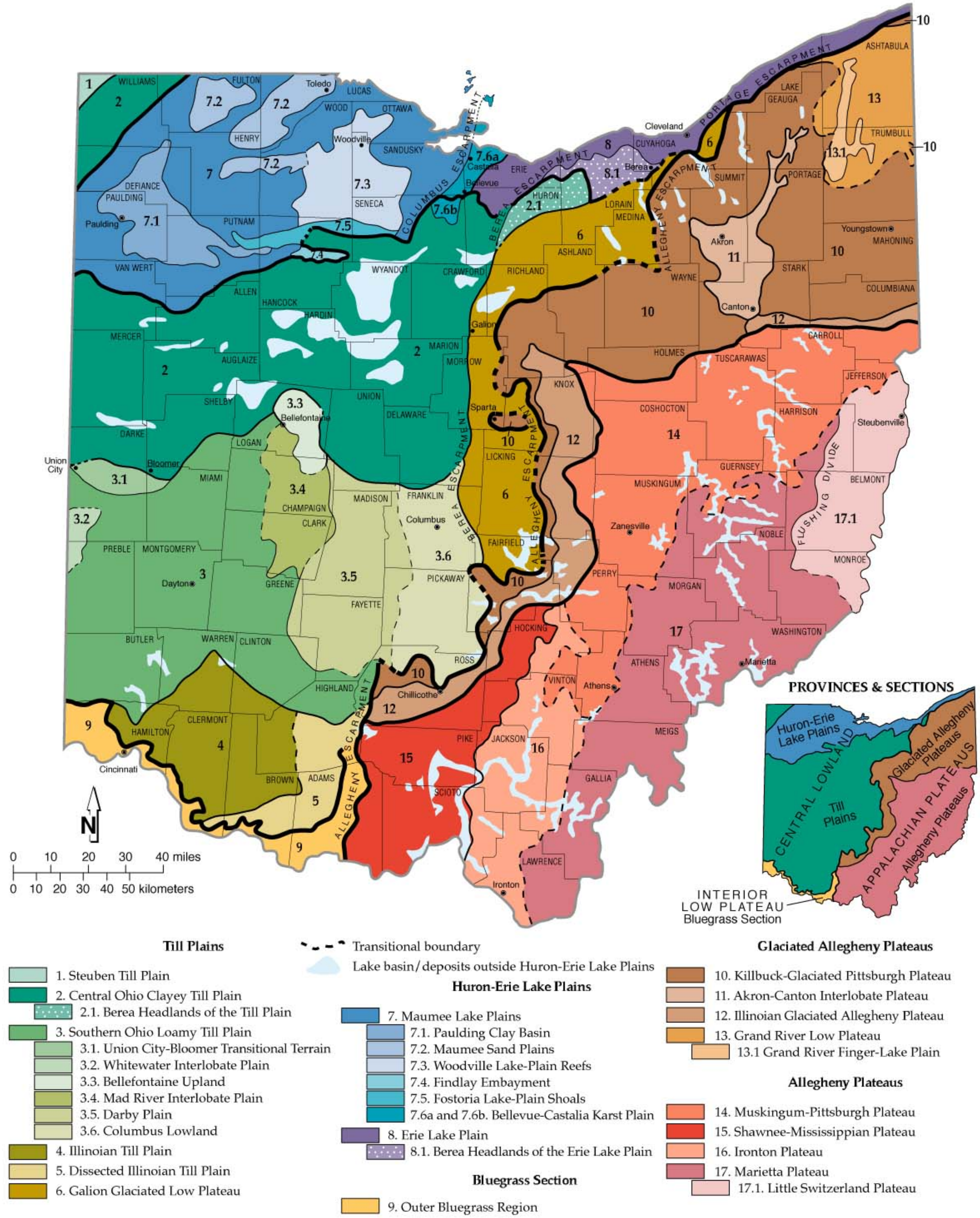

Ohio Division of Geological Survey. 1998. Physiographic Regions of Ohio: Ohio Department of Natural Resources, Division of Geological Survey. Original Scale 1:2,200,000. Contest practice is located in tri-county area of Union, Champaign and Logan Counties, northwest of Columbus, Ohio.

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INTRODUCTION

Soil judging provides an opportunity for students to study soils through direct experience in the field. Students learn to describe soil properties, identify different kinds of soils and associated landscape features, and interpret soil information for agriculture and other land uses. These skills are developed by studying a variety of soils formed from a wide range of parent materials and vegetation in different topographic settings. Students gain an appreciation for soil as a natural resource by learning about soils and their formation. We all depend on soil for growing plants, crops, and range for livestock; building materials; replenishing water supplies; and waste disposal. If we do not care for our soils, loss of productivity and environmental degradation will follow. By understanding more about soils and their management through activities like soil judging, we stand a better chance of conserving soil and other natural resources for future generations.

Students in soil judging participate in regional and national contests held annually in different states. These contests are an enjoyable and valuable learning experience, giving students an opportunity to obtain a first-hand view of soils and land use outside their home areas. As an activity within the American Society of Agronomy and the Soil Science Society of America, soil judging in the United States is divided into seven regions. The 2022 National Contest is hosted for Region 1 by The Ohio State University. Region 1 includes Connecticut, Massachusetts, Pennsylvania, Delaware, New Hampshire, Maine, New Jersey, Rhode Island, Maryland, New York, and Vermont. Ohio was previously in Region 1 but has recently joined Region 3. Collegiate soil judging originated in the southeastern United States in 1956. Today, students from over 40 universities are involved with soil judging. Long-term sponsorship and cooperation come from the Students of Agronomy, Soils, and Environmental Sciences (SASES), the American Society of Agronomy (ASA), the Crop Science Society of America (CSSA), the Soil Science Society of America (SSSA) and the United States Department of Agriculture Natural Resource Conservation Service (USDA-NRCS).

This handbook is organized into several sections that describe the format and content of the contest. The contest involves soil description and interpretation at sites by students, who record their observations on a scorecard (see Appendix C). The sections of content in this handbook follow the organization of soil and related information given on the scorecard. Those sections include morphology, soil profile characteristics, site characteristics, soil classification, and site interpretations.

CONTEST RULES, SCORING, AND PROCEDURES

The contest will be held on Friday and Saturday, April 22nd and 23rd, 2022, and will consist of five sites (three individually judged sites and two team-judged sites). At each site, a pit will be excavated, ideally 150cm to 200cm deep unless bedrock is encountered, and control areas will be designated for the measurement of horizon depths and boundaries. The control area will constitute the officially scored profile and must remain <u>undisturbed</u> and <u>unblocked</u> by contestants. The control area will be a minimum of 50 cm wide, delineated on each side with flagging and/or spray paint, and have a metric tape fixed in place with nails. All official depths should be judged using the provided tape.

A card will be at each pit detailing the site number, number of horizons to be described, profile depth to be described, depth to a nail in the third horizon, flooding frequency, and ponding frequency for the overall site, in addition to the percent organic carbon, and base saturation, for each horizon. Any additional information or laboratory data deemed necessary for taxonomic classification will also be displayed on the pit card. A maximum of six horizons will be described at each pit. A marker (e.g., nail or golf tee) will be placed randomly in the third horizon, which will be used as a check depth to ensure the tape has not moved throughout the week (it should match the depth listed on the pit card) and to assist contestants in delineating horizons. A pit/site monitor at each site will enforce the rules, answer any questions, keep time limits, clean soil from the base of the pit as needed and/or requested, and ensure all contestants have an equal opportunity to judge the soil.

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PIT T1

Number of horizons 6
Depth to be described 105 cm
Nail in 3rd horizon @ 35 cm

HORIZON	OC (%)	BS (%)
1	2.89	38.2
2	0.87	36.9
3	0.73	33.3
4	0.64	52.2
5	0.52	57.5
6	0.25	75.0

Flooding: NONE Ponding: NONE

Figure 1 (left): A card will be posted for each pit detailing the site number, number of horizons, depth to be described, and depth to a nail somewhere in the third horizon. OC%, and BS%, for each horizon will be provided, along with Flooding and Ponding frequency for the site. Additional information may also be provided if necessary, for classification.

Figure 2 (right): The control area will be ≥50cm wide, delineated on each side with flagging and/or spray paint, and have a metric tape fixed in place in the center. A nail will be placed randomly in the 3rd horizon.

For individual judging, a team is typically comprised of four contestants from each participating university, but can consist of as few as three members. Each team coach must designate the four official contestants at least 24 hours prior to the start of the individual contest. Each university will be allowed one team for the team judging portion of the contest. All team members can participate in team judging.

All score cards will be graded by hand. In order to avoid ambiguity, all contestants are urged to write clearly and use only those abbreviations provided. Ambiguous and unrecognizable answers will receive no credit. Designated abbreviations or the corresponding, clearly written terminology will be graded as correct responses.

Contestants provide the following materials for their use:

- clipboard
- pencil (not ink pen)*
- soil knife (durable and sturdy)
- Munsell Color Charts (10R to 5Y and gley charts)
- water bottle
- calculator
- containers for soil samples
- 2 mm sieve
- clinometer or Abney level
- hand lens
- tape measure
- hand towel
- rock hammer
- acid bottle (10% HCl) (optional) (If flying, please host for HCl upon arrival.)

*A number 2 pencil is required because of the waterproof paper used for the scorecards. An ink pen will not work when the scorecards are wet.

This contest will be closed to all notes, written, and electronic materials other than a set of reference materials that will be provided to each contestant at the contest. The provided materials are included at the end of this handbook as Appendix B.

A clinometer, sturdy knife, and color book will be provided at each pit for emergency situations, as well as extra water, and blank scorecards. **Contestants are not allowed to have mobile phones during the contest under any circumstances. Smart watches and other similar electronic devices are also prohibited. If a contest official sees a cell phone or other prohibited device, that contestant will be disqualified for both the individual and team events.**

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Contestants will be allowed sixty (60) minutes to judge each individual site. The time in and out of the pit for the individually-judged sites will be as follows: 5 minutes in/out, 5 minutes out/in, 10 minutes in/out, 10 minutes out/in, and 30 minutes free time for all to finish. The contestants who are first “in” and “out” will switch between individual pits to allow all contestants to be first in or first out for at least one pit. Two members of each team will describe the left pit face and the other two team members will describe the right pit face. *NOTE: This timing schedule may be modified depending on the number of teams and contestants participating. However, each individual will have at minimum 60 minutes at each site.*

For team judging, there will be duplicate pits for each team-judged contest site or else we will have a large pit with two control sections that will allow two teams to be in the pit at the same time. If two control sections per pit are used, each team will be responsible for making sure that the other team will not be able to hear their discussions. This timing scheme for group judging has two teams assigned to a control section at a given time. It allows 50 minutes total for each pit with a 10-minute time period between site rotations. Within each 50-minute judging session, we will have a rotation of 10 minutes in/out, 10 minutes out/in, 10 minutes in/out, 10 minutes out/in, and 10 minutes of free time. During the 10 minutes each team is in the pit, there will be no limit on the number of judgers allowed. They will be allowed to enter and exit the pit as they wish during their time allotted in the pit. During the free time, any judger can enter or exit the pit but only three per team will be allowed in the pit at one time in order to avoid crowding of the other team that will be sharing the pit/control section. *NOTE: This timing schedule may be modified depending on the number of teams and contestants participating. However, each team will have a minimum of 50 minutes at each site, including at least 20 minutes alone in the pit.*

Each site will have its own scorecard designated by a unique color. Each individual or team contestant will be given a packet during the contest that contains color-coded scorecards corresponding to each site, along with a set of reference materials. Students must correctly enter the pit number on their scorecard. Scorecard entries must be recorded according to the instructions for each specific feature to be judged (see following sections of the handbook). Only one response should be entered in each blank, unless otherwise specified. The official judges may decide to recognize more than one correct answer or to allow partial credit for alternative answers. Entries for soil morphology may be recorded using the provided abbreviations or as a complete word. Contestants should enter the depth of the last horizon (if a boundary) or a dash to specify a completed response.

The overall team score will be the aggregate of the top three individual scores for each of the three individually-judged profiles plus the scores from the two team-judged pits. In the case where a team is comprised of only three members, all individual scores will count towards the team’s overall score. Individual scores will be determined by summing the three site scores for each contestant (Table 1). The team score for individual judging is then added to the scores for the group pits to determine the overall team score.

Table 1. Example team score calculation for individual sites.

INDIVIDUAL	SITE 1	SITE 2	SITE 3	TOTAL	
A	**232**	**241**	**254**	727	Scores used for individual ranking
B	**261**	**262**	**313**	836	
C	208*	**277**	251*	736	
D	**275**	234*	**289**	798	
Total	768	780	856	**2404** = Team score for individual judging	

** Lowest score is not used to determine team score.*

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The clay content of the third horizon at a specified individually-judged site (Site 1) will be used to break ties in both team and individual scores. In order to break a tie in team scores, the mean clay content will be calculated from the estimates provided by all members of a given team. The team with the mean estimate closest to the actual value will receive the higher placing. If this method does not break the tie, the next lowest horizon of the same site will be used in the same manner until the tie is broken. In the event of a tie in individual scores, the clay content of the tie breaker horizon will be compared to that estimated by each individual. The individual with the estimate closest to the actual value will receive the higher placing. If this does not break the tie, the next lowest horizon at the same will be used in the same manner until the tie is broken.

Final contest results will be announced at an awards ceremony directly following the contest. Every effort will be made to avoid errors in determining the contest results. However, the results presented at the awards ceremony are final. Trophies will be awarded to the top teams overall, the top teams in the team judging competition, and the top individuals. All aspects concerning eligibility, location, time, and procedures will be governed by provision of the "Rules of the National Collegiate Soils Contest" revised in 2018 by the Students of Agronomy, Soils, and Environmental Science, or a document of similar intent that replaces the above document. The most current version can be found online at:
https://www.agronomy.org/files/students/contests/2019-national-collegiate-soils-contest-rules-web.pdf

SCORECARD INSTRUCTIONS

The scorecard (attached at the end of this guidebook as Appendix C) consists of five parts: A. Soil Morphology; B. Soil Profile Characteristics; C. Site Characteristics; D. Soil Classification; and E. Site Interpretations. Numbers in parentheses after each item in a section indicate the points scored for one correct judgment. If a pedon has more than one parent material or diagnostic subsurface horizon, five points will be awarded for each correct answer. In these sections of the scorecard, negative credit (minus 5 points for each extra answer, with a minimum score of zero for any section) will be used to reduce guessing. More than one entry in other items of the scorecard will be considered incorrect and will result in no credit for that item.

A. SOIL MORPHOLOGY

For entering answers in the morphology section of the scorecard, the provided standard abbreviations (see Abbreviations page) may be used or the word(s) may be written out. Abbreviations or words that are ambiguous or may be interpreted as an incorrect answer will not receive credit. The Munsell color notation (e.g., 10YR 4/2) should be used and not the color names. If spaces on the scorecard for the soil morphology section do not require an answer (e.g., if no matrix concentrations are present in a horizon), a dash or blank in those spaces will be considered correct. The *Field Book for Describing and Sampling Soils (version 3.0, 2012)*, Chapter 3 of the *Soil Survey Manual* (1993) entitled, “Examination and Description of Soils”, and Chapter 18 of *Keys to Soil Taxonomy* 12th Edition (2014) entitled “Designations for Horizons and Layers” should be used as a guide for horizon symbols and descriptions.

Designations of Horizons

The number of horizons to be described and the total depth of soil to judge will be provided on an information card or sheet for each site. Narrow transitional horizons (< 10 cm thick) should be regarded as a gradual boundary, and the center used as the measuring point for the boundary depth. Horizons that can be thinner than 10 cm and should be described are A or E horizons. These horizons must be at least 2.5 cm thick to be described. O horizons will not be described for this contest.

Capital letters are used to designate master horizons (or in some cases, transition horizons; Table 2). Lower case letters are used as suffixes to indicate specific characteristics of the master horizon and layers. Arabic numerals are used both as suffixes to indicate vertical subdivisions within a horizon or layer and as prefixes to indicate lithological discontinuities. Prime symbols following master horizons are used to indicate repeating layers separated by a different horizon and carets are used before the master horizon to indicate human transported materials.

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Table 2. Accepted horizon designators for scorecard Section A and their descriptions.

Horizon Designation	Description
Prefix	Lithological discontinuities will be shown by the appropriate **Arabic numeral(s)** or Caret (^) symbol (included in Master Horizon box). If no discontinuities exist in the profile, enter a dash. A dash or blank will receive credit where there is no prefix on the master horizon and should be used in lieu of the Arabic number one, which will receive no credit.
Master	The appropriate master horizon (**A, E, B, C, and R**), as well as any transitional horizons (e.g., **EB**) or horizons having dual properties of two master horizons (e.g., **B/E, B and E**) should be entered as needed. Primes (′) are added after the master horizon on the lower of two horizons having identical master and subordinate distinction designations, but which are separated by a different kind of horizon (e.g. **B′t** is correct, Bt′ is not). Carets (**^**) are added before the master horizon to indicate human transported materials (HTM). Carets should be added to all horizons that have been human transported.
Subordinate Distinction (Subscript)	Enter the appropriate lower case letter or letters, according to the definitions given in Chapter 18 of *Keys to Soil Taxonomy* (2014). For this contest the horizon subordinate distinctions will likely include, but are not limited to: **b, d, g, p, r, t, u, x, and w**. If used in combination, the subscripts must be written in the correct sequence in order to receive full credit. If a subordinate distinction (subscript) is not applicable, enter a dash in the box.
Number	**Arabic numerals** are used as suffixes to indicate vertical subdivisions within a horizon or layer. Sequential sub-horizons having the same master horizon and subordinate distinction designations should be numbered to indicate the vertical sequence. Where no suffixes are required, a dash should be entered on the scorecard. Note that the numbering of vertical subdivisions within a horizon is not interrupted at a lithological discontinuity if the same master horizon and subordinate distinction is used in both materials (e.g., Bt1-Bt2-2Bt3-2Bt4).

Boundary

Depth of Lower Boundary

Boundary depths are determined (in centimeters) from the mineral soil surface to the middle of the lower boundary of each horizon (if an O horizon is present, measurements begin at the base of the O horizon). For a reference as to the position of the soil surface, the depth from the soil surface to the nail placed randomly in the third horizon is posted on the pit card. Total soil profile depth to be described will also be given on the pit information card or sheet.

If the total soil profile depth corresponds to the lower boundary of the last horizon, the horizon boundary depth should be recorded. Otherwise, a dash or the total soil profile depth with a + sign (e.g., 100+) should be entered on the scorecard. Note that boundary depths should be judged from the tape measure anchored to the pit face and vertical to the nail within the control section. Measurements of boundary depth should be made in the undisturbed area of the pit reserved for this purpose. Therefore, *for horizons with wavy boundaries, the boundary depth at the tape should be recorded rather than an estimate of the middle of the wavy boundary across the control section.*

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Boundary measurements should be made at the center of the boundary separating the two horizons, particularly when the boundary distinctness is not abrupt. Answers for lower boundary depths will be considered correct if within the following limits above or below the depth determined by the official judges: for **abrupt** (including *very abrupt*) boundaries +/- 1 cm; for **clear** boundaries +/- 3 cm; for **gradual** boundaries +/- 8 cm; and for **diffuse** boundaries +/- 16 cm.

If a lithic or paralithic contact occurs at or above the specific judging depth, the contact should be marked as a subsurface feature in Part D of the scorecard and should be considered in evaluating the hydraulic conductivity, effective rooting depth, and water retention. Otherwise, the lowest horizon should be assumed to extend to a depth of up to 200 cm for all relevant evaluations. When a lithic or paralithic contact occurs within the specified judging depth, the contact should be considered as one of the requested horizons, and the appropriate horizon nomenclature should be applied (e.g., Cr or R). However, morphological features of Cr or R layers need not be provided in Part A of the scorecard. If the contestant gives morphological information for a designated Cr or R layer, the information will be ignored and **will not** count against the contestant's score. If contestants are unsure if a layer is a Cr, they are encouraged to complete the morphological information for that layer. Lab data (% organic carbon, % base saturation) will not be provided for Cr or R layers, but will instead be dashed on the pit card.

Distinctness of Boundary

The distinctness of boundaries separating various soil horizons must be described if they fall within the designated profile depth indicated by the official judges for each site. Categories of distinctness of soil boundaries are shown in Table 3. Very abrupt boundaries will be considered abrupt for the purposes of the contest.

Table 3. Soil horizon boundary distinctness categories.

Category	Symbol	Boundary Distinctness
Abrupt	**A**	< 2 cm
Clear	**C**	2 to < 5 cm
Gradual	**G**	5 to < 15 cm
Diffuse	**D**	≥ 15 cm

No boundary distinctness designator should be given for the last horizon, unless a lithic or paralithic contact exists at the lower boundary. A dash is acceptable for distinctness of the last horizon to be described when a lithic or paralithic contact is not present.

Texture

Contestants will determine soil texture clay percentages and classes by hand. The official judges will primarily use laboratory data to determine the soil texture clay % and class.

Percent Clay

Clay percentage estimates should be entered in the space provided. Answers within +/- 5% of the official value will be given full credit.

Percent Course Fragments

Estimates of the volume percentage of coarse fragments should be made for each horizon and entered in the appropriate column. Estimates should be made within the no-pick zone. If there are no coarse fragments present then "0" is the only acceptable answer. If there are more than 0% coarse fragments present then a numerical estimate is required. In the case of horizons with coarse fragments present, answers within plus or minus 5% of the official values will be given full credit. If 2% coarse fragments are present, the correct answer range would be 1 – 7%.

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Coarse Fragment Modifier

Modifications of texture classes are required whenever coarse fragments > 2 mm occupy more than 15% of the soil volume. Adjectives are used based on the size of the coarse fragments according to Table 4 below. For a mixture of sizes (e.g. both gravels and stones present), the largest size class is generally named. A smaller size class is named only if its quantity (%) exceeds 2 times the quantity (%) of a larger size class. The total rock fragment volume is used (i.e. sum of all the separate size classes) to determine which modifier goes with the fragment term (e.g. none, very, or extremely). See Table 5 for modifiers and their associated percentages. For example, a horizon with 30% gravel and 14% stones (44% total fragments) would be named very gravelly (**GRV**), but only 20% gravel and 14% stones (34% total fragments) would be named stony (**ST).**

Table 4. Rock fragment modifier size and shape requirements and symbols.

Size (diameter)	Adjective	Symbol
Spherical or equiaxial		
0.2 to 7.5 cm	Gravelly	**GR**
7.6 to 25.0 cm	Cobbly	**CB**
25.1 to 60 cm	Stony	**ST**
>60 cm	Bouldery	**BD**
Flat		
0.2 to 15 cm	Channery	**CH**
15.1 to 38.0 cm	Flaggy	**FL**
38.1 to 60 cm	Stony	**ST**
>60 cm	Bouldery	**BD**

Table 5. Rock fragment modifiers by percent rock fragment (> 2mm) present by volume.

Percent rock* (by volume)	Rock fragment modifier
< 15%	No special term used with the soil textural class. Enter a dash <u>or</u> leave blank.
15 to 35 %	Use size adjective **“gravelly, cobbly, stony, bouldery, channery,** or **flaggy”**
35 to 60 %	Use “**very (V)** + gravelly, cobbly, stony, bouldery, channery, or flaggy”
60 to 90 %	Use “**extremely (X)** + gravelly, cobbly, stony, bouldery, channery, or flaggy”
> 90%	Use **“coarse fragment noun”** as the coarse fragment term (e.g., boulders or **BD**) and dash <u>or</u> leave blank the soil texture class and the % clay boxes.

**Note: Assume all rock fragments do not slake in water and are at least partly cemented.*

Texture Class

Soil texture classes are those defined in the *Soil Survey Manual* (1993). Any deviation from the standard nomenclature will be considered incorrect (e.g., silty loam). Sandy loam, loamy sand, and sand should be further specified if the soil is dominated by a particular sand size other than medium sand (see list under Abbreviations). Very coarse sand should be included with coarse sand for this contest.

Color

Munsell soil color charts are used to determine the <u>moist</u> soil matrix color for each horizon described. Color must be designated by hue, value, and chroma. Space is provided to enter the hue, value, and chroma for each horizon

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separately on the scorecard. At the discretion of the official judges, more than one color may be given full credit. Color is to be judged for each horizon by selecting soil material to represent that horizon. The color of the surface horizon will be determined on a moist, rubbed (mixed) sample. For lower horizons (in some soils this will also include the lower portion of the epipedon), selected peds should be collected from near the central part of the horizon and broken to expose the matrix. If peds are dry, they should be moistened before the matrix color is determined. Moist color is that color when there is no further change in soil color when additional water is added. For Bt horizons with continuous clay films, care should be taken to ensure that the color of a ped interior rather than a clay film is described for the matrix color.

The dry color will be provided by the contest host if it may affect the classification of a horizon. For the purposes of this contest, horizons meeting the minimum percent organic carbon criteria for mollic epipedons will be assumed to also meet the minimum dry color values required for mollic epipedons.

Structure

Soil structure refers to the aggregation of primary soil particles into secondary compound groups or clusters of particles. These units are separated by natural planes, zones, or surfaces of weakness. Dominant type (formerly called shape) and grade of structure for each horizon are to be judged. If the horizon lacks definite structural arrangements or if there is no observable aggregation, **"0 (structureless)"** should be recorded in the grade column and either **"MA (massive)"** or **"SGR (single grain)"** (whichever is appropriate) should be recorded in the type column.

If various types of structure exist within the horizon, contestants should record the type and grade of structure that is most common. Compound structure (e.g., prismatic parting to angular or subangular blocky structure) is common in the horizons of many soils. In this case, structure having the stronger grade should be described. If the structures are of equal grade, the structure type with the largest peds should be described. The term "blocky" always requires a modifier, either angular or subangular blocky. Blocky will not receive credit if used alone.

Grade

The grade of structure is determined by the distinctness of the aggregates and their durability (Table 6). Expression of structure grade is often moisture dependent and so may change with drying of the soil.

Table 6. Soil structure grades, symbols and descriptions.

Grade	Symbol	Description
Structureless	**0**	That condition in which there is no observable aggregation or no definite, orderly arrangement of natural lines of weakness.
Weak	**1**	Soil breaks into a very few poorly formed, indistinct peds, most of which are destroyed in the process of removal. Type of structure is barely observable in place. Clay coatings, if present, are thin and ped interiors look nearly identical to outer surfaces.
Moderate	**2**	Soil contains well-formed, distinct peds in the disturbed soil when removed by hand. They are moderately durable with little unaggregated material. The type of structure observed in the undisturbed pit face may be indistinct.
Strong	**3**	Durable peds are very evident in undisturbed soil of the pit face with very little or no unaggregated material when peds are removed from the soil. The peds adhere weakly to one another, are rigid upon displacement, and become separated when the soil is disturbed.

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Type

Types of soil structure are described below (Table 7) and on page 2-53 in *Field Book for Describing and Sampling Soils, version 3.0, 2012*.

Table 7. Soil structure types, symbols and descriptions.

Type	Symbol	Description
Granular	**GR**	Spheroids or polyhedrons bounded by curved planes or very irregular surfaces, which have slight or no accommodation to the faces of surrounding peds. For the purposes of this contest crumb structure is included with granular structure.
Subangular Blocky	**SBK**	Polyhedron-like structural units that are approximately the same size in all dimensions. Peds have mixed rounded and flattened faces with many rounded vertices. These structural units are casts of the molds formed by the faces of the surrounding peds.
Angular Blocky	**ABK**	Similar to subangular blocky but block-like units have flattened faces and many sharply angular vertices.
Platy	**PL**	Plate-like with the horizontal dimensions significantly greater than the vertical dimension. Plates are approximately parallel to the soil surface**. Note: this does not apply to weathered rock structure.**
Prismatic	**PR**	Prism-like with the two horizontal dimensions considerably less than the vertical. Vertical faces are well defined and arranged around a vertical line with angular vertices. The structural units have angular tops.
Columnar	**COL**	Same as prismatic but with rounded tops or caps.
Massive	**MA**	No structure is apparent and the material is coherent. The individual units that break out of a profile have no natural planes of weakness.
Single grain	**SGR**	No structure is apparent. Soil fragments and single mineral grains do not cohere (e.g., loose sand). In some cases where weak cohesive/adhesive forces with water exist, some seemingly cohesive units can be removed. However, under very slight force, they fall apart into individual particles.
Rock-controlled fabric	**RCF**	Horizons having structure inherited from parent material will be designated "rock-controlled fabric" (RCF) to differentiate the geologic structure from pedogenic structure. While this structure is not considered pedogenic in nature, it does impact hydraulic properties and is therefore important to recognize. Rock-controlled fabric is given a grade of 0 to indicate the lack of pedogenic structure development. This structure designation should only be used in A or C horizons in thinly bedded fluvial sediments or in C horizons weathered from bedrock.

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Consistence

Soil consistence refers to the resistance of the soil to deformation or rupture at a specified moisture level and is a measure of internal soil strength. Consistence is largely a function of soil moisture, texture, structure, organic matter content, and type of clay, as well as adsorbed cations. As field moisture will affect consistence, contestants should use their personal judgment to correct for either wet or dry conditions on the day of the contest. These corrections also will be made by the official judges. Contestants should judge the rupture resistance of moist soil (midway between air-dry and field-capacity) for a ped or soil fragment from each horizon as outlined in the *Field Book for Sampling and Describing Soils, 2012* and Table 8.

Table 8. Moist rupture resistance classes, symbols and descriptions.

Class	Symbol	Description
Loose	**L**	Soil is non-coherent (e.g., loose sand).
Very Friable	**VFR**	Soil crushes very easily under very slight force (gentle pressure) between thumb and finger but is coherent when pressed.
Friable	**FR**	Soil crushes easily under slight force (gentle to moderate pressure) between thumb and forefinger and is coherent when pressed.
Firm	**FI**	Soil crushes under moderate force (moderate pressure) between thumb and forefinger, but resistance to crushing is distinctly noticeable.
Very Firm	**VFI**	Soil crushes or breaks only when strong force is applied between thumb and all fingers on one hand.
Extremely Firm	**EF**	Soil cannot be crushed or broken by strong force between thumb and all fingers but can be by applying moderate force between hands.
Slightly Rigid	**SR**	Soil cannot be crushed by applying moderate force between hands but can be by standing (entire body weight on one foot) on the structural unit.
Rigid	**R**	Soil cannot be crushed by standing on it with one body weight but can be if moderately hit with hammer.
Very Rigid	**VR**	Soil requires heavy, strong blow(s) with hammer to crush.

Soil Features

Redoximorphic Features

Redoximorphic (redox, RMF) features are caused by the reduction and oxidation of iron and manganese associated with soil wetness/dryness and NOT rock color. Characteristic color patterns are created by these processes. Redox features are colors in soils resulting from the concentration (gain) or depletion (loss) of pigment when compared to the soil matrix color. Reduced iron (Fe^{2+}) and manganese (Mn^{2+}) ions may be removed from a soil if vertical or lateral fluxes of water occur. Wherever iron and manganese are oxidized and precipitated, they form either soft masses or hard concretions and nodules. Redox features are used for identifying aquic conditions and determining soil wetness class. Movement of iron and manganese as a result of redox processes in a soil may result in redoximorphic features that are defined as follows:

a. Redox concentrations – These are zones of apparent pedogenic accumulation of Fe-Mn oxides, and include: nodules and concretions (firm, irregular shaped bodies with diffuse to sharp boundaries; masses (soft bodies of variable shapes in the soil matrix; zones of high chroma color (“red” for Fe and “black” for Mn); and pore linings (zones of accumulation along pores). Dominant processes involved are chemical dissolution and precipitation; oxidation and

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reduction; and physical and/or biological removal, transport and accrual.

b. Redox depletions – These are zones of low chroma (2 or less) and normally high value (4 or more) where either Fe-Mn oxides alone or Fe-Mn oxides and clays have been removed by eluviation.

For this contest, the presence of redox features will be indicated by an assessment of Abundance and Contrast of visible features as defined in Table 9. If there are no visible features, Abundance and Contrast should be marked with a dash. For horizons exhibiting depleted matrix colors (e.g. Bg), depletions should only be recorded if they are lower chroma and/or value than the gleyed matrix.

For the purposes of the contest, only depletions of chroma 2 or less and value of 4 or more will be described and used in identifying depth to seasonal high water table and "Aqu-" suborders. Low chroma (≤ 2) in the soil may be due to drainage, parent material, or other features. However, parent material variations and other such features should not be considered in evaluating soil wetness or soil drainage characteristics. Colors associated with the following features will not be considered as redox features: carbonates, concretions, nodules, krotovinas, rock colors, roots, or mechanical mixtures of horizons such as B horizon materials in an Ap horizon. Redox features can be retained as relic features in soils (now called "mottles") from prior soil moisture regimes. A soil must have current hydrologic conditions (e.g., water table, landscape position, etc.) needed for redox features to be identified in this contest. *If no redox features are present, enter dashes in Abundance and Contrast sections.* Specific definitions may be found in *Soil Taxonomy* (1999) in the "Aquic Conditions" section of "Other Diagnostic Soil Characteristics.

If there are multiple depletions or concentrations describe the ones in greatest abundance. If they are of equal abundance describe the one with the greatest contrast. If they are of equal abundance and contrast, describe the one that has the largest feature.

Table 9 Descriptors for Redoximorphic Features

Class	Symbol	Description
Abundance		
Few	**F**	Occupies < 2 % of the horizon.
Common	**C**	Occupies 2 to 20 % of the horizon
Many	**M**	Occupies > 20 % of the horizon
Contrast		
Faint	**F**	Evident only on close examination
Distinct	**D**	Readily seen but contrasts only moderately with the matrix
Prominent	**P**	Contrasts strongly with the matrix. Commonly the most obvious color feature in the horizon.

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B. SOIL PROFILE CHARACTERISTICS

Hydraulic Conductivity

In this contest, the vertical, saturated hydraulic conductivity of the surface horizon (Hydraulic Conductivity/ Surface Horizon) and the most limiting horizon (Hydraulic Conductivity/Limiting Layer) within the depth specified to be described by the official judges will be estimated. "Limiting layer" refers to the horizon or layer with the slowest hydraulic conductivity. <u>If a lithic or paralithic contact occurs at or above the specified judging depth and depletions are present in the overlying horizon, the hydraulic conductivity for the limiting layer is low.</u> In some soils, the surface horizon is the limiting horizon with respect to saturated hydraulic conductivity. In this case, the surface hydraulic conductivity would be reported in two places on the scorecard. For a discussion of factors affecting hydraulic conductivity, refer to the *Soil Survey Manual* (1993).

The hydraulic conductivity classes, flow estimates, and descriptions of included soil textural classes and profile features for each hydraulic conductivity class used in this contest are found in Table 10.

Table 10: Hydraulic conductivity classes, flow rates and descriptions.

Class	Hydraulic Conductivity	Description
High	>10 µm/s	Textures of **coarse sand, sand, fine sand, very fine sand, loamy coarse sand, loamy sand, loamy fine sand, loamy very fine sand, and coarse sandy loam**; *or* Horizons containing large quantities of rock fragments and insufficient fines to fill many voids between the fragments are also in this class.
Moderate	0.1 to 10 µm/s	Includes those **materials excluded from “High” and “Low” classes**.
Low	< 0.1 µm/s	Includes: 1) Textures of **clay, silty clay, and sandy clay** that have **moderate, weak, or massive structure** 2) **Silty clay loams and clay loams** that have **weak or massive structure** 3) **Densic horizons** (e.g. Cd) and **Fragipans** (e.g. Bx) 4) **Cr or R** layers **where** the **horizon directly above contains >2% redoximorphic depletions or a depleted matrix** due to saturation and reduction (value ≥4 with chroma ≤2).

Effective Soil Depth

The depth of soil to a root restricting layer, or effective soil depth, is the depth of soil that can be easily penetrated by plant roots. Soil materials must be loose enough so that roots do not experience severe physical resistance and yet fine enough to hold and transmit moisture. Horizons that provide physical impediments to rooting limit the effective depth of the soil. For this contest, materials considered restrictive to plant roots include: lithic and paralithic contacts, cemented layers (e.g. petrocalcic horizons), fragipans, and densic (Cd) layers. The depth to a restricting layer is measured from the mineral soil surface (excluding O horizons). The presence or absence of roots may be helpful in determining the effective soil depth, but should not be used as the sole indicator. In many cases, the plants growing at the site may be shallow rooted or, conversely, a few roots may penetrate into or through the restrictive layer, particularly along fractures or planes of weakness, but any roots should be >10cm apart for the layer to be considered restrictive. A soil is considered very deep if no root restricting layers appear in the upper 150 cm (Table 11). If the profile is not visible to a depth of 150 cm, or if you are requested to describe a soil only to a shallower depth, then

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you may assume that the conditions present in the last horizon described extend to 150 cm (unless a lithic or paralithic contact occurs at the judging depth).

Table 11. Soil depth classifications based upon depth to restrictive feature.

Depth Class	Depth to Restrictive Feature
Very shallow	<25 cm
Shallow	25 to <50 cm
Moderately deep	50 to <100 cm
Deep	100 to <150 cm
Very deep	≥150 cm

Available Water Holding Capacity

Available water holding capacity refers to the soil water held between -33 kPa (field capacity) and -1500 kPa (permanent wilting point), which approximates the range of available water for plants. This depends on the effective depth of rooting, the texture of the fine earth fraction (< 2 mm) (Table 12), and the content of rock fragments in the soil.

Table 12. Soil texture and water retention difference values.

Texture class	Water retention (cm water / cm soil)
All sands and loamy coarse sand	0.04
Loamy sand, loamy fine sand, loamy very fine sand, and coarse sandy loam	0.10
Sandy loam, fine sandy loam, sandy clay loam, clay loam, sandy clay, silty clay, and clay	0.14
Loam, silty clay loam	0.17
Very fine sandy loam, silt loam, silt,	0.20

The amount of available water stored in the soil is calculated for the top 150 cm of soil or to a root-limiting layer, whichever is shallower. Total available water holding capacity is calculated by summing the amount of water held in each horizon (or portion of a horizon if it extends below 150 cm). If the depth designated for describing soil morphology is less than 150 cm, contestants should assume that the water retention properties of the last horizon extend to 150 cm or to the top of a lithic or paralithic contact, if either feature is observed at a depth shallower than 150 cm. If a horizon or layer is restrictive to roots, this horizon and all horizons below should be excluded when calculating the available water holding capacity.

Rock fragments are assumed to hold no water that is available for plant use. If a soil contains rock fragments, the volume occupied by the rock fragments must be estimated and the available water holding capacity corrected accordingly. For example, if a silt loam A horizon is 25 cm thick and contains coarse fragments occupying 10% of this volume, the available water holding capacity of that horizon would be 4.5 cm of water rather than 5.0 cm (25 cm * 0.20 cm water/cm soil * 90% fine fraction = 4.5 cm).

Once the water retention difference is calculated for the appropriate soil profile depth, the water retention class can be determined using Table 13. An example water retention difference calculation and classification for a theoretical soil profile can be found in Table 14.

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Table 13. Available water classes based upon amount of plant available water to 150 cm.

Water Retention Class	Plant available water (cm water / 150 cm soil)
Very low	<7.5 cm
Low	7.5 to <15.0 cm
Medium	15 to <22.5 cm
High	≥22.5 cm

Table 14. Sample of calculation of available water holding capacity (AWHC) for a theoretical profile.

Horizon	Depth (cm)	Texture class	Rock fragment (%)
A	20	SL	5
Bt1	60	CL	10
Bt2	80	L	10
2C	150	S	50

Horizon	Horizon thickness (cm)		Water Retention		Rock Fragment Correction		cm of water per horizon
A	20	*	0.14	*	0.95	=	2.66
Bt1	40	*	0.14	*	0.90		5.04
Bt2	20	*	0.17	*	0.90	=	3.06
2C	70	*	0.04	*	0.50	=	1.4
					Total	**=**	**12.16**
					Class	**=**	**low**

Soil Wetness Class

In this contest, students will determine whether hydric soil conditions are present, and use depth to the estimated seasonal high water table to determine the wetness class for non-hydric soils. The depth to seasonal high water table will be determined based on soil wetness classes as defined in the *Soil Survey Manual* (1993) (Table 15). Soil wetness is a reflection of the rate at which water is removed from the soil by both runoff and percolation. Position, slope, infiltration rate, surface runoff, hydraulic conductivity (permeability), and redoximorphic features are significant factors influencing the soil wetness class. For this contest, students will mark Hydric and recognize indicators A11, A12, F2, F3, F6, F7, and F8 to identify hydric soils as defined in *Field Indicators of Hydric Soils in the United States* (2018).

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Table 15. Simplified definitions of hydric soil indicators for the contest region

A Indicators - For all soils:	
A11. Depleted Below Dark Surface.	A dark (3/2 or darker) A and/or O horizon underlain by a Eg, Btg, Bg, or Cg horizon starting at ≤ 30 cm.
A12. Thick Dark Surface.	A thick (at least 15 cm) dark (2.5/1 or 2/1) A and/or O horizon underlain by a Eg, Btg, Bg, or Cg. Anything between 30 cm and the depleted matrix must be must be 3/1, 2.5/1, or 2/1 in color.
F Indicators – Used for non-sandy soils (i.e. sandy loams and finer)	
F2. Loamy Gleyed Matrix.	A gleyed matrix (color occurs on the gleyed pages) within 30 cm of the surface.
F3. Depleted Matrix.	A Eg, Btg, Bg, or Cg horizon ≥ 5 cm thick starting in the upper 10 cm, or ≥ 15 cm thick starting within 25 cm of the mineral soil surface.
F6. Redox Dark Surface.	A dark (3/2 or darker) A horizon at least 10 cm thick that has 5% or more D or P redox concentrations if color is 3/2 or 2/2, and ≥ 2% D or P concentrations if color is 3/1 or darker 1 or 0 chroma.
F7. Depleted Dark Surface.	A dark (3/1 or darker 1 or 0 chroma) A horizon at least 10 cm thick that has 10% or more depletions, or (3/2 or darker 2 chroma with 20% or more depletions.
F8. Redox Depressions.	In closed depressions, 5% or more D or P redox concentrations within the upper 10 cm of the soil.

For non-Hydric soils, students will identify Soil Wetness Class as indicated by the depth to the seasonal high water table as defined by the presence of gleying and/or redoximorphic features (chroma ≤ 2 and value ≥ 4) with a prominent or distinct contrast, or any contrast and an abundance of common or many. The key below will be used for this contest.

Table 16. Soil wetness classes based upon depth to pertinent wetness features

Class	Depth to wetness features including RMF and gleying (from soil surface)
1	>150 cm
2	>100 to 150 cm
3	>50 to 100 cm
4	>25 to 50 cm
5	≤25 cm

Soil Organic Carbon Pool

Soils store the largest amount of carbon of any of the terrestrial ecosystems. The quantities are referred to as pools or stocks. For comparative purposes pools are typically calculated to a meter or to the upper boundary of lithic or paralithic materials. The following formula is used to calculate the SOC pool in kg m^{-2} for each horizon that is completely or partially within the upper 100 cm of the soil (or to the upper boundary of lithic or paralithic materials) using the thickness (T) of the horizon, measured in cm; the SOC content of the rock-free soil, measured

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in percent; the bulk density (BD) of the horizon, measured in g cm^{-3}; and the rock fragment content (RF) of the horizon, measured in percent:

$$SOC = (T) \times (SOC) \times (BD) \times (100 - RF) \times 0.001$$

The final factor, 0.001, is a unit conversion factor. SOC content data will be provided for each horizon. Horizon thickness and rock fragment content are to be measured or estimated. The following general relationships between horizon and bulk density will be used to estimate the bulk density of each horizon. For combination horizons, choose the bulk density value for the horizon whose properties dominate the horizon.

Table 17. Estimated bulk density values for morphological horizons

Horizon	A	Ap, AB, AE, E, EB	Bw, Bg, BA, BE	Bt, Btg, BC, BCt	C, CB	Bx, Btx, Cd
Bulk density (g cm^{-3})	1.1	1.2	1.4	1.5	1.6	1.8

For example, if a Bw horizon is 30 cm thick with an SOC content of 0.5% and contains rock fragments that occupy 20% of its volume, the SOC pool of the horizon would be 30 cm x 0.5% x 1.4 g cm^{-3} x (100-20)% x 0.001 = 1.68 kg m^{-2} SOC.

The total SOC pool is calculated by summing the amount of SOC in each horizon or portion of horizon. The classes for SOC pool of the upper 100 cm of the soil are:

Very low. Less than 5 kg m^{-2} SOC

Low. 5 to <10 kg m^{-2} SOC

Moderate. 10 to < 15 kg m^{-2} SOC

High. 15 kg m^{-2} SOC or greater

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C. SITE CHARACTERISTICS

Landform

A landform is a physical, recognizable form or feature of the Earth's surface that usually has a characteristic shape and is produced by natural causes. Parent materials are often associated with particular landforms. Only one landform should be identified at each site. Contestants should select the landform that best describes the situation. Landforms that will be recognized in this contest are found in Table 16.

Table 18. Landforms found in the central Ohio contest area and their descriptions.

Landform	Description
Upland	Upland refers to geomorphic landforms, not otherwise designated, that are generally above present-day valleys, and which may be underlain by residual (bedrock), colluvial, glacial till or pedisediment parent materials.
Depression	A basin within an upland that is not directly connected to an integrated surface drainage system. Surface accumulations of organic-enriched soil and redoximorphic features are commonly found in these areas, but are not necessary for identification.
Terrace	A step-like surface or platform adjacent to a stream valley that represents a remnant of an abandoned floodplain. Where occurring in valley floors, this landform is commonly smooth, having low relief, and may or may not be dissected by an under-fitted stream. Terraces consist of a relatively level surface, cut or built by a stream and a steeper descending slope (scarp or riser). Older terraces may be dissected by later erosion. In Central Ohio, most terraces were formed during early Holocene deglaciation when pro-glacial streams carried much larger water volumes and significantly higher and coarser sediment loads than current streams; these materials are generally identified as outwash. More rarely, terrace represents the former shoreline of either a nonglacial, glacial, or proglacial lake.
Floodplain	A nearly level alluvial plain that borders a stream and is subject to flooding unless artificially protected. The floodplain refers to the lowest level(s) associated with a stream valley and is sometimes referred to as bottom soil, stream bottom, or first bottom. Sediments may or may not be stratified. Soils found in a floodplain position normally have little profile development beneath the A horizon. If coarse fragments are present, they are normally rounded or subrounded.
Constructed	A landform that is a function of the placement of human transported materials.

Parent Material

Parent material refers to the material in which soils form. Parent materials include bedrock, various kinds of sediments, and "pre-weathered" materials. Soils may be developed in more than one parent material, and this should be indicated on the scorecard. For this contest, **a parent material should be ≥30 cm thick if it is on the surface or ≥10 cm thick if at least 30 cm below the soil surface to be indicated** on the scorecard. Multiple parent materials are common for the soils of central Ohio (Table 17). A different parent material should only be indicated for the bottom horizon if at least 10 cm of material is located above the depth to be described.

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Table 19. Parent materials found in central Ohio and their descriptions.

Parent	Description
Alluvium	Alluvium consists of sediment transported and deposited by running water and is commonly associated with floodplains. As moving water sorts sediment by particle size, these materials are often stratified. Rock fragments are often rounded in shape. In this contest, alluvium is used to recognize material of fluvial (stream) origin.
Residuum	Residuum is bedrock that has weathered in place into an unconsolidated state. Rock fragments tend to be oriented in relation to the fabric of the bedrock. Bedrock types typically observed in the contest area include sandstone, shale, mudstone, chert, dolomite, and limestone.
Colluvium	Colluvium consists of sediment that has accumulated on hillslopes, usually but not always near the base of slopes (i.e., footslopes), in depressions, or along small upland intermittent streams. This material is unconsolidated material transported or moved by gravity and by local, unconcentrated runoff that accumulates on or near the base of the slopes. The sediment is typically a poorly sorted mixture of particle sizes. These materials can occur on shoulder, backslope, and most commonly on footslope and toeslope positions. The material is of local origin.
Lacustrine Deposits	Lacustrine sediments accumulated in relatively low-flow water environments which may, or may not, have been reworked by currents. In central Ohio these sediments may have formed in sub-glacial or pro-glacial lakes as well as more recent lakes. Textures are typically silt loam, silt, or fine sand.
Glacial Till	Glacial till was deposited by and underneath or in front of a glacier and consists dominantly of unsorted and unstratified materials or sediments transported by glacial ice and deposited without extensive reworking by meltwater. The lithology and composition reflect the material over which the glaciers passed. Generally, till consists of transported and mixed debris with sand, silt, clay, and rock fragments that vary in size from small gravels to large boulders. Coarse fragments are typically subangular to very angular. Tills deposited at the base of a forward moving glacier are often referred to as basal or lodgment tills. They are almost always dense and often exhibit a platy structure. In general, materials that are contained within the ice or carried on top of the ice and are deposited in place as the ice melts are referred to as ablation or friable till. Ablation tills are friable to loose in consistence and tend to be coarser textured than associated dense tills.
Outwash	Outwash is material deposited by glacial meltwater. In central Ohio these materials have a diverse range of sorting, from well-sorted sand and gravel to material with a finer matrix, but always include coarse fragments indicating reworking by water. For the purposes of this contest, outwash includes ice-contact deposits.
Pedisediment	Pedisediment is a layer of water transported material, eroded from upslope (local) areas such as the shoulder and backslope of an erosional slope, and deposited further downslope. Pedisediment is typically transported by slope-wash processes. For this contest, pedisediment is used to distinguish local water transported material from alluvium deposited on floodplains by fluvial (stream) systems, and can include older deposits (such as early Holocene), as well as more recent (e.g. post-cultural) deposits.
Loess	Loess is an eolian material formed by the accumulation of wind-blown silt. Most loess deposits have particle size typically in the 20–50 micrometer range and were deposited during periods of deglaciation.

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Human Transported Materials	Human transported materials (HTM) consist of layers of material that have been transported to the current location by humans. This includes more intensive earth moving activities than traditional plowing methods, such as home or road construction. HTM often contain stratified layers, human artifacts, buried topsoil horizons, and densic layers from compaction by equipment.

Slope

Slope refers to the inclination of the ground surface and has length, shape, and gradient. Gradient is usually expressed in percent slope and is the difference in elevation, in length units, for each one hundred units of horizontal distance. Slope may be measured by an Abney level or by a clinometer. Slope classes are based on the gradient. The percentage limits for slope classes pertinent for central Ohio topography are indicated on the scorecard. Stakes or markers will be provided at each site for determining slope and the slope should be measured between these two markers. The tops of the markers will be placed at the same height, but it is the responsibility of the contestant to make sure that they have not been disturbed. If the slope measurement falls on the boundary between two slope classes, contestants should mark the steeper class on the scorecard. *Contestants may want to write the actual slope value in the margin of the scorecard to aid in the completion of the interpretations section.*

Hillslope Profile Position

Hillslope position represents the two-dimensional geomorphic segment of the topography on which the soil is located (Table 18). These slope components have characteristic geometries and greatly influence soils through differences in slope stability, water movement, and other slope processes. Not all profile elements may be present on a given hillslope. The landscape unit considered when evaluating hillslope profile position should be relatively large and include the soil pit and/or the area between the slope stakes. Minor topographic irregularities are not considered for this contest. Note that you could also have a backslope and a footslope component in an upland depression. Illustrations of simple hillslope profile components can be found in Figure 4.

Table 20. Hillslope profile positions recognized in this contest and their general descriptions.

Hillslope Position	Description
Summit	Highest level of an upland landform with a relatively gentle, planar slope, typically less than 2%. The summit is often the most stable part of a landscape. Not every hillslope has a summit, as some hillslopes have shoulders at the crest of the hill.
Shoulder	Rounded (convex-up) hillslope component below the summit. The shoulder is the transitional zone from the summit to the backslope and is erosional in origin.
Backslope	Steepest slope position that forms the principal segment of many hillslopes. The backslope is commonly linear along the slope, is located between the shoulder and the footslope positions, and is influenced by a mix of erosional and depositional processes.
Footslope	Slope position at the base of a hillslope that is generally formed by deposition of sediments originating on the slopes above. The footslope should be concave and located at the base of gentle to steep slopes.

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Toeslope	Lowest landform component that extends away from the base of the hillslope. Toeslopes typically have a slope <2%.
None (gradient <2%)	This designation should only be used when the slope at the site is < 2%, and the site is not in a well-defined example of one of the slope positions given above (e.g., within a terrace or floodplain of large extent).

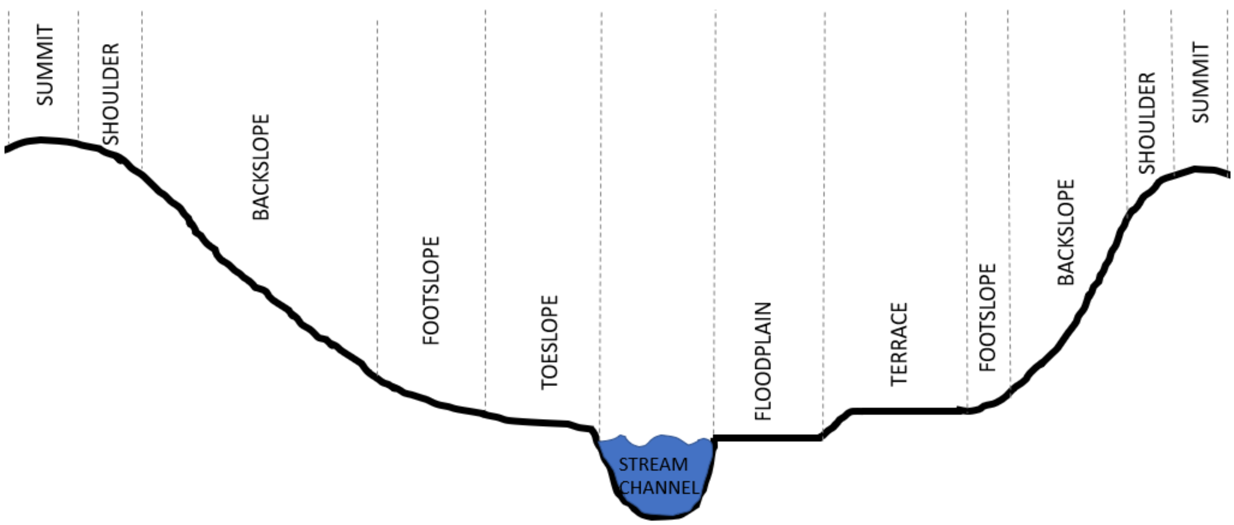

Figure 4. *Hillslope profile components of a typical landscape.*

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Surface Runoff

Surface runoff refers to the relative rate at which water is removed by overland flow. Soil characteristics, management practices, climatic factors (e.g., rainfall intensity), vegetative cover, and topography determine the rate and amount of runoff. In this contest, six runoff classes as described in the *Soil Survey Manual* (1993) will be used (Table 19). Contestants should consider vegetative cover quantity and quality to determine the runoff class. **Where good vegetative cover (bare soil generally not visible below cover) OR an O horizon is present, contestants should mark the next slower surface runoff class (up to very low).** Contestants should mark Ponded for sites in a depression with no surface runoff. Brief descriptions of the six runoff classes used in this contest can be found in Table 20.

Table 21. Surface runoff classes in relation to slope and surface hydraulic conductivity.

	Limiting hydraulic conductivity within 50 cm of soil surface* *(move one class lower for good vegetative cover, unless class is very low or ponded)*		
	High	**Moderate**	**Low**
Depression	Ponded	Ponded	Ponded
0-<2% slope	Very low	Low	Medium
≥2-6% slope	Low	Medium	High
≥6-12% slope	Medium	High	Very high
≥12% slope	High	Very high	Very high

Table 21. Surface runoff classes and descriptions.

Runoff Class	Description
Ponded	Added water flows away very slowly and free water lies on the soil surface for very long periods. Most of the water enters and passes through the soil or evaporates.
Very low	Added water flows away so slowly that free water lies on the surface for long periods. Much of the water enters and passes through the soil or evaporates. Fairly open and porous soils in which the water enters immediately are also considered to have very low runoff. Soils with very low runoff are commonly nearly level to gently sloping depending on the surface hydraulic conductivity.
Low	Added water flows away so slowly that free water covers the soil for brief, periods or a large part enters the soil in the case of sandy or porous soils. Soils with low runoff can be found in nearly level to strongly sloping depending on the surface hydraulic conductivity (See Table 19). There is usually little or no erosion problem.
Medium	Added water flows away at such a rate that moderate amounts enter the soil and free water lies on the surface for a very brief period. These soils are usually gently sloping or moderately sloping, but can be found in all slope classes depending on the surface hydraulic conductivity.

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High	A large portion of added water moves rapidly over the surface with only a small part entering the soil. These soils may be on gently sloping to steep slopes depending on the surface hydraulic conductivity.
Very high	A small part of the added water enters the soil and surface water runs off as fast as it is added. These soils are on moderately sloping to steep slopes depending on the surface hydraulic conductivity.

Soil Erosion Potential

Soil erosion potential refers to the likelihood of soil erosion by water. The potential for future erosion losses is influenced mainly by the texture of the surface soil and the amount of surface runoff at a site. Soil erosion potential is estimated using Table 21. Very fine, fine, and coarse sand-modified textural classes are included with their medium sand equivalent classes.

Note: The following erosion table assumes granular structure or structureless - single grained in the surface horizon and that the soil is bare, although in this contest there is no adjustment if that is not the case.

Table 22. Soil erosion potential classes in relation to surface runoff and surface horizon texture.

	Surface Horizon Texture			
Surface Runoff	**S, LS**	**SCL, SC**	**SL, CL, C, SIC**	**L, SI, SIL, SICL**
Ponded	Very Low	Very Low	Very Low	Very Low
Very low	Very Low	Very Low	Low	Medium
Low	Very Low	Low	Medium	Medium
Medium	Very Low	Low	Medium	High
High	Low	Medium	High	Very High
Very high	Medium	High	Very High	Very High

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D. SOIL CLASSIFICATION

The reference used in this section is *Keys to Soil Taxonomy,* 12th Edition (Soil Survey Staff, 2014). For pictures and illustrations for soil classification, see the *Illustrated Guide to Soil Taxonomy* (Soil Survey Staff, 2014). Only the diagnostic horizons and features, orders, suborders, and great groups that exist or are plausible for mineral soils in the contest area are included on the scorecard. The % organic C and base saturation will be provided for each horizon at each site; other data will be provided if critical for soil classification.

The contest area of falls within the zone dominated by udic moisture regime. For the purposes of the competition, the default soil moisture regime will be assumed to be udic, unless the the soil demonstrates aquic conditions.

The following discussion of specific diagnostic horizons and taxa includes abbreviated and summarized definitions. Complete definitions and classification keys are available in *Keys to Soil Taxonomy*, 12th Edition (Soil Survey Staff, 2014). In most cases, the simplified criteria provided here will lead to the same classification as the complete definitions, but in the occasional case that the two do not agree, the complete definitions will be used in determining official answers. Classification in an "Aqu-" suborder will be done based solely on the simplified definitions provided in this manual and the included simplified keys.

Epipedons

The kind of epipedon will be determined for each judged soil. If the soil meets the moist color, base saturation, thickness, lack of stratification, and organic carbon criteria for a mollic epipedon, contestants should assume all other criteria for the mollic epipedon and Mollisols are met. If contestants select more than one epipedon, no points will be given even if the correct epipedon is checked.

An epipedon is a diagnostic horizon that forms at the surface. Only one epipedon can be present in mineral soils. An epipedon is not synonymous with an A horizon (e.g., a mollic epipedon may include part of the B horizon). To avoid changes in classification due to plowing, the properties of an epipedon should be determined after the soil has been mixed to a depth of 18 cm.
Below is a simplified description of the epipedons potentially present in the contest area:

1) Mollic - thick, dark colored surface with high base status that exhibits soil structure.
    a. Structure cannot be both massive and hard when dry.
    b. Does not contain rock structure or fine stratification in more than ½ of the volume.
    c. Color value is ≤ 3 moist and ≤ 5 dry. Chroma is ≤ 3 moist.
    d. B.S. ≥ 50% by NH_4OAc sum of bases.
    e. OC ≥ 0.6% (1% OM).
    f. Thickness requirement
        i. ≥ 10 cm if underlain directly by R or Cr horizon.
        ii. 18 to 25 cm and ≥1/3 of the thickness between the soil surface and (1) the upper depth of pedogenic carbonates if pedogenic carbonates occur <75 cm below soil surface (e.g., if pedogenic carbonates occur at 60 cm, the thickness requirement = 20 cm); *or* (2) the lower boundary of the deepest of an argillic, cambic, or natric horizon if it occurs <75 cm below soil surface.
        iii. ≥ 25 cm for all other situations.
2) Ochric - an epipedon not classified as mollic.
3) None – No epipedon present (e.g. surface truncation due to erosion or human alteration)

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Diagnostic Subsurface Horizons or Features

Contestant should mark all diagnostic subsurface horizons and features present in a given profile. If no diagnostic subsurface horizon or feature is present, contestants should mark "none" for full credit. Five points are awarded for each correct answer and five points subtracted for each extra answer, with a minimum of score of zero available for this section.

Diagnostic subsurface horizons form below the soil surface. They can be exposed at the surface rarely due to truncation. Typically, diagnostic subsurface horizons are B horizons, but may include parts of A or E horizons. Diagnostic subsurface horizons or features potentially present in the contest area include:

1) Albic - an eluvial horizon in which clay and Fe have been removed 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. Has value and chroma of 3/1, 3/2, 4/2, 4/1, 5/1, 5/2, 6/3, 6/2, 6/1, 7/3, 7/2, 7/1, 8/3, 8/2, or 8/1. At least 85% of the horizon volume must meet these criteria.

   E, E/B

2) Argillic - contains illuvial clay.
   a. >7.5 cm thick (>15 cm thick if sandy or sandy-skeletal)
   b. Must contain a significant clay increase ("clay bulge").
      i. If eluvial horizon has <15% clay, must have ≥3% absolute increase (e.g., from 10 to 13%).
      ii. If eluvial horizon has 15 - 40% clay, must have a relative increase of ≥20% (x1.2).
      iii. If eluvial horizon has >40% clay, must have ≥8% absolute increase (e.g., from 42 to 50%).
   c. For this contest, we will not consider transitional horizons as part of the argillic
   d. Exhibits clay films or clay bridging of sand grains.

   Bt, Btx, Btg, etc.

3) Cambic - has features representing weak genetic soil development (alteration) without illuvial accumulations or extreme weathering.
   a. ≥15 cm thick
   b. Texture that is VFS, LVFS, or finer *(**≠ S or LS**… also ≠ COS, FS, LCOS, LFS)*
   c. Evidence of alteration
      i. Contains soil structure or lacks rock structure in >50% of the volume, *and*
      ii. If redox depletions occur < 50 cm
         1. Colors that do not change on exposure to air
         2. Gray colors for one of the following situations
            a. Value of 3 or less and chroma of 0, *or*
            b. Value of 4 or more and chroma of 1 or less, *or*
            c. Any value with chroma of 2 or less and redox concentrations, *or*
      iii. If redox depletions do not occur < 50 cm, one of the following situations
            a. Higher chroma, higher value, redder hue, or higher clay content than the underlying horizon or an overlying horizon.
            b. Removal of carbonates or gypsum.
   d. Is not part of an epipedon or another diagnostic subsurface horizon
   e. Is not part of an Ap horizon

   Bw, Bg,

4) Abrupt textural change – characterized by a considerable increase in clay content within a very short vertical distance.
   a. Clay content of argillic, is ≥ 8%
   b. Clay content of argillic *either*:
      i. Doubles within 7.5 cm if clay content of epipedon or eluvial horizon is <20% (e.g., an increase from 8 to 16%); *or*
      ii. Increases by ≥ 20% (absolute) within 7.5 cm (e.g., an increase from 24 to 44%) and some part of the horizon is ≥ double the clay content of the epipedon or eluvial horizon

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5) Fragipan – root- and water-restrictive subsoil layer that is firm and brittle but not cemented. Air-dry fragments mostly slake in water, thus confirming the absence of a cementing agent. Fragments are firm or harder when dry. When moist, they have a brittle manner of failure when increasing pressure is applied (they rupture suddenly rather than deform gradually). Many fragipans have vertical ped surfaces coated with light-colored eluvial material that form a polygonal pattern when viewed in cross-section on a horizontal plane. The streaks commonly surround brittle, browner material that has redoximorphic features in the form of iron-manganese accumulations. Most fragipans restrict water movement, and water perches above them.
   a. Thickness is > 15 cm.
   b. Layer has evidence of pedogenesis (e.g., it is not simply mechanically compacted).
   c. Layer has structure that does not allow roots to penetrate at spaces less than 10 cm apart, or it is massive.
   d. Layer is not cemented (air-dry fragments mostly disintegrate when submerged in water).
   e. In > 60% of volume, peds are firm or hard and brittle when moist.

   Bx, Btx

6) Densic materials – root-restrictive, non-cemented, dense, and compact layers that do not meet the definition of any diagnostic horizon (e.g., a fragipan). Densic materials are not cemented, so an air-dry fragment will disintegrate in water. Spaces where roots can penetrate are more than 10 cm apart. Densic materials occur naturally in materials such as glacial till. However, they can also result from human activities that cause significant compaction of unconsolidated soil material (natural or human- transported).

   Cd

7) Lithic contact - the contact between soil and a coherent underlying material that is impractical to dig with a spade. The underlying material cannot include diagnostic soil horizons. Usually, it is strongly cemented material like hard limestone or hard sandstone.

   R

8) Lithologic discontinuity - major changes in texture or mineralogy that represent differences in lithology. Often, it is change in parent material, but sometimes a lithological discontinuity can occur in layers of alluvium.

9) Paralithic contact - the contact between soil and paralithic materials that are weakly cemented (can dig with difficulty with a spade) and root limiting. Any roots follow cracks that are >10 cm apart. Usually, it is partially weathered or weakly consolidated bedrock such as sandstone, siltstone, shale, or mudstone.

   Cr

10) None – no diagnostic subsurface horizon or feature

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Classification to the Order, Suborder, and Great Group Level

This is a simplified key for soils in the central Ohio contest area based on Keys to Soil Taxonomy (12th ed.), intended for a quick reference for use in soil judging. The keys follow a "fall-out-first" principle. Be aware that diagnostic features not described in the area and less common variations of taxonomic requirements have been left out of the key for brevity. It will not lead to a correct classification in every case, but should be adequate in most cases.

In this key, "gleyed" means matrix colors have value ≥4 and chroma ≤ 2 because of saturation and reduction (Bg, Btg, Cg, etc.). This includes reduced, depleted and gleyed matrix. Redox depletions must have value ≥4 and chroma ≤ 2.

1. **Mollisols** – Mollic epipedon **AND** base saturation (BS)>50% in all horizons above a root limiting layer (RLL), 180 cm, or 125 cm below the top of an argillic, whichever is shallowest.
   - **a. Albolls -** have an argillic (or natric) horizon and an albic horizon with a lower boundary below 18 cm underlying the mollic and redox concentrations/depletions within 100 cm or the soil surface
     - **i. Argialboll**s
   - b. **Aquoll**s **–** Redox depletions within 50 cm of the surface, AND gleyed matrix within 50 cm of the surface or immediately below mollic epipedon
     - **i. Argiaquols** – have an argillic horizon
     - **ii. Epiaquols** – have gleyed horizons over non-gleyed horizons within judging depth
     - **iii. Endoaquolls** – other Aquolls
   - c. **Rendolls** – Within or directly below a mollic epipedon of < 50 cm thickness, have calcium carbonate equivalent ≥ 40 %, and no argillic hoizon
     - **i. Haprendolls**
   - d. **Udolls** – other Mollisols
     - **i. Argiudolls** – have an argillic horizon
     - **ii. Hapludolls** – other Udolls
2. **Alfisols –** Argillic horizon and greater than or equal to 35% base saturation at the check depth
   - a. **Aqualfs –** redox features in all horizons between 25 cm and 40 cm **AND** gleyed matrix in the upper 12.5 cm of argillic (Btg)
     - **i. Fragiaqualfs –** have a fragipan
     - **ii. Epiaqualfs** – perched water table (gleyed horizons over non-gleyed horizons)
     - **iii. Endoaqualfs –** Other Aqualfs
   - b. **Udalfs** – Other Alfisols
     - **i. Fragiudalfs** - have a fragipan
     - **ii. Hapludalfs** – other Udalfs
3. **Inceptisols** – Within 100 cm, a cambic horizon, or a mollic epipedon
   - a. **Aquepts** – gleyed matrix at ≤50 cm
     - **i. Fragiaquept**s – have a fragipan
     - **ii. Epiaquepts** – episaturation, gleyed horizons over non-gleyed horizons
     - **iii. Endoaquepts** – other Aquepts
   - b. **Udepts** – Other Inceptisols
     - **i. Fragiudept**s – have a fragipan
     - **ii. Eutrudepts**– other Udepts that have a base saturation of 60% or more in one or more horizons at a depth between 25 and 75 cm form the mineral soil surface or directly above a root limiting layer at shallower depth
     - **iii. Distrudepts** – other Udepts
4. **Entisols** - other soils
   - a. **Aquents** – gleyed matrix at ≤50 cm

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i. **Fluvaquents** – 0.2% OC at 125 cm OR irregular decrease in OC with depth
ii. **Epiaquents** – episaturation, gleyed horizons over non-gleyed horizons witin judging depth
iii. **Endoaquents –** other Aquents

b. **Psamments** - have less than 35% rock fragments and a texture class of loamy fine sand or coarser in all layers within the particle-size control section
   i. **Quartzipsamments** – more than 90% resistant minerals in silt and sand fraction of PSCS
   ii. **Udipsamments** - other Psamments

c. **Fluvents** – 0.2% OC at 125 cm **OR** irregular decrease with OC with depth
   i. **Udifluvents**

d. **Orthents – Other Entisols**
   i. **Udorthents**

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Family Particle Size

Depth of Particle-Size Control Section

Contestants should select the proper depth of the family particle-size control section based on the soil properties present in the judged profile from those listed below, using the "fall-out-first" principle. If two choices on the scorecard yield the exact same depth range, either choice will be considered correct.

(1) Soils <36 cm to root-limiting layer (RLL)........ **0 to RLL**

(2) Soils with an argillic horizon

- (a) Strongly contrasting particle sizes within or below the argillic and within 100 cm of the surface: Deepest of:........ **Upper 50 cm of the argillic**
  - .... **Top of the argillic to 100 cm if no RLL at <100 cm**
  - .... **Top of the argillic to RLL**
- (b) Argillic horizon is > 50 cm thick........ **Upper 50 cm of the argillic**
- (c) Argillic horizon is < 50 cm thick........ **All of the argillic**

(3) All other soils

- (a) Top depth is:........ **25 cm OR lower depth of Ap**, whichever is deeper
- (b) Lower depth is:........ **100 cm OR RLL**, whichever is shallower

Family Particle-Size Class

Once the family particle-size class control section for the soil profile has been determined, contestants should calculate the weighted percentage sand, silt, clay, and, if needed, rock fragment content within that control section. The family particle-size class can then be determined using the guide listed below (also see textural triangles in Appendix A). Contestants should know when to select only the three broad particle size classes, the skeletal classes, and when to use the seven more specific particle size classes. If two or more strongly contrasting particle-size classes are present within the control section, name the two most contrasting classes.

1) Sandy: texture is S or LS
2) Loamy: texture is LVFS, VFS, or finer with clay < 35%
   - a) Coarse-loamy: ≥ 15% FS or coarser + < 18% clay
   - b) Fine-loamy: ≥ 15% FS or coarser + 18-34% clay
   - c) Coarse-silty: < 15% FS or coarser + < 18% clay
   - d) Fine-silty: < 15% FS or coarser + 18-34% clay
3) Clayey: ≥ 35% clay
   - a) Fine: 35- 59% clay
   - b) Very-fine: ≥ 60% clay
4) Sandy-skeletal: ≥ 35% coarse fragments + sandy particle size class
5) Loamy-skeletal: ≥ 35% coarse fragments + loamy particle size class
6) Clayey-skeletal: ≥ 35% coarse fragments + clayey particle size class
7) Contrasting particle size classes - transition zone < 12.5 cm thick
   e.g. Clayey (or clayey-skeletal) over sandy, or Loamy (or loamy-skeletal) over clayey with absolute difference of 25% clay

NOTE: Subclasses of the loamy and clayey particle size classes will always be used unless a root limiting layer occurs within 50 cm or is a part in a strongly-contrasting particle size class.

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E. SITE INTERPRETATIONS

There are considerable pressures for urban and peri-urban development in central Ohio. Some of the most important non-agricultural interpretations are for residential and commercial buildings, local roads, and on-site wastewater treatment and distribution systems.

The table in this guidebook for making soil interpretations for buildings with basements and local roads and streets are partially extracted and modified from the National Soil Survey Handbook (NSSH). Only those characteristics which commonly pose restrictions on the use of soils of this area are listed for your use in evaluation. The most restrictive soil property determines the limitation rating. In cases where the base of the pit does not extend to the depth indicated in the following tables (i.e. 150 cm), one should assume that the lowest horizon in the pit extends to the depth of interest. If there are moderate or severe limitations indicate the soil or site limitations by the number from the "Factors Affecting Use" column.

The soil interpretations involve the determination of the degree of limitation within each soil for a specific use. The most restrictive property determines the limitation rating. In cases where the judging depth does not extend to the required interpretive depth (e.g., 150 cm for some criteria), contestants should assume that the lowest horizon in the pit extends to the depth of interest (unless a lithic or paralithic contact occurs at the judging depth). Use the following tables to determine the degree of limitation and limiting reason number for each interpretation. The first most-limiting reason listed in the table should be marked on the scorecard, except for onsite wastewater treatment systems, where multiple limiting conditions should be recorded if they co-occur at the shallowest depth..

For interpretations for onsite wastewater treatment systems, which are based on Ohio Department of Health rules, and "Suitability of Ohio Soils for Treating Wastewater" (Mancl and Slater, 2013), record the limiting condition number from Table 25 (column 1), and mark the depth to the *shallowest* limiting condition and appropriate recommended soil-based treatment system (Table 25). Do not mark a depth if flooding is a limitation. If multiple limiting conditions occur at the shallowest depth, record multiple limiting condition numbers. If no limiting condition is present, record a dash in the Limitation # field.

Table 23. Criteria for evaluating soil limitations for Dwellings with Basements: Adapted from NSSH and modified for contest purposes.

	Degree of Limitation		
Factors Affecting Use	Slight	Moderate	Severe
1. Flooding or ponding frequency	None	Very rare or rare	Occasional to Very frequent
2. Slope (pct)	<6	6 - <20	≥20
3. Depth to seasonally high water table (cm) and/or hydric soils	>180	75-180	<75 and/or hydric
4. Shrink-swell: texture of most limiting horizon (25-100 cm depth)	S, LS, SL, L, SIL	CL, SICL, SCL	SIC, SC, C
5. Depth to paralithic material (Cr) (cm)	>150	100 - 150	<100
6. Depth to hard rock (R) (cm)	>180	100 - 180	<100

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Table 24. Criteria for local roads and streets: Adapted from NSSH and modified for contest purposes.
For potential frost heaving average textures between 25 and 100 cm.

	Degree of Limitation		
Factors Affecting Use	Slight	Moderate	Severe
1. Flooding or ponding frequency	None	Very rare or rare	Occasional to Very frequent
2. Slope (pct)	<6	6 - <20	≥20
3. Depth to seasonally high water table (cm) and/or hydric soils	>75	30-75	<30 and//or hydric
4. Depth to hard bedrock (R) (cm)	>180	100 - 180	<100
5. Potential frost heaving			
Hydric soils and wetness class 5	-	Sandy-skeletal, Sandy	Others
Wetness class 1-4	Sandy-skeletal, Sandy	Loamy -skeletal, Coarse-loamy, Fine-loamy, Clayey-skeletal, Clayey, Fine, Very-fine	Coarse-silty, Fine-silty

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Table 25. Criteria for evaluating soil limitations for Onsite Wastewater Treatment Systems: Adapted from Ohio Department of Health Rules and Mancl and Slater (2013)

Limiting Condition	Criterion	Recommended System
1. Seasonal high water table and/or hydric soils	< 15 cm and/or hydric 15 cm to < 30 cm 30 cm to 90 cm > 90 cm	None Pretreatment/irrigation Mound System Traditional leach field
2. Low permeability layer: fine texture with limited connected structural pores	Low limiting layer hydraulic conductivity due to texture/structure < 15 cm 15 cm to < 30 cm 30 cm to 90 cm > 90 cm	None Pretreatment/irrigation Mound System Traditional leach field
3. Low permeability layer: hard dense layers	Low limiting layer hydraulic conductivity due to fragipan, densic materials, paralithic or lithic materials < 15 cm 15 cm to < 30 cm 30 cm to 90 cm > 90 cm	None Pretreatment/irrigation Mound System Traditional leach field
4. Excessive permeability and groundwater contamination risk: coarse textured horizons	High limiting layer hydraulic conductivity < 15 cm 15 cm to < 30 cm 30 cm to 90 cm > 90 cm	None Pretreatment/irrigation Mound System Traditional leach field
5. Excessive permeability and groundwater contamination risk: fractured bedrock	Bedrock with visible connected voids. Only mark where limestone or dolomite bedrock with voids less than 25 cm apart on average is present in the described profile.	None if present
6. Slope	< 20% ≥ 20%	Not considered limiting None
7. Flooding and/or ponding	Occasional or higher frequency	None if present

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SITE and ROTATION PROCEDURES

Each site will have its own scorecard indicated by a unique color. Each contestant will be given a packet during the contest that has scorecards. Extra copies of the scorecard will be available at each site for emergencies. The information posted at each site will include scorecard color information.

Individual Sites

A full contestant number is as follows: 1ALi. The "1" (1-21) is the team number and the "A" (A-D) is the contestant indicator. L or R indicates whether the left or the right face is to be judged. Lastly, there is an "i" or "o." This designates whether the contestant starts in or out first at the first site.

Each contestant will be in the pit first at least one time and out of the pit first at least one time during the individual part of the contest. In addition, two team members of each team will describe the left face and two team members will describe the right face.

REFERENCES

1. Mancl, K.M and Slater, B.K. 2013. Suitability of Ohio Soils for Treating Wastewater. OSU Extension, Agriculture and Natural Resources. Bulletin. 896.
2. Schoenberger, P.J., Wysocki, D.A., Benham, E.C., and Broderson, W.D. (editors), 2012. Field Book for Describing and Sampling Soils, Version 3.0. Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.
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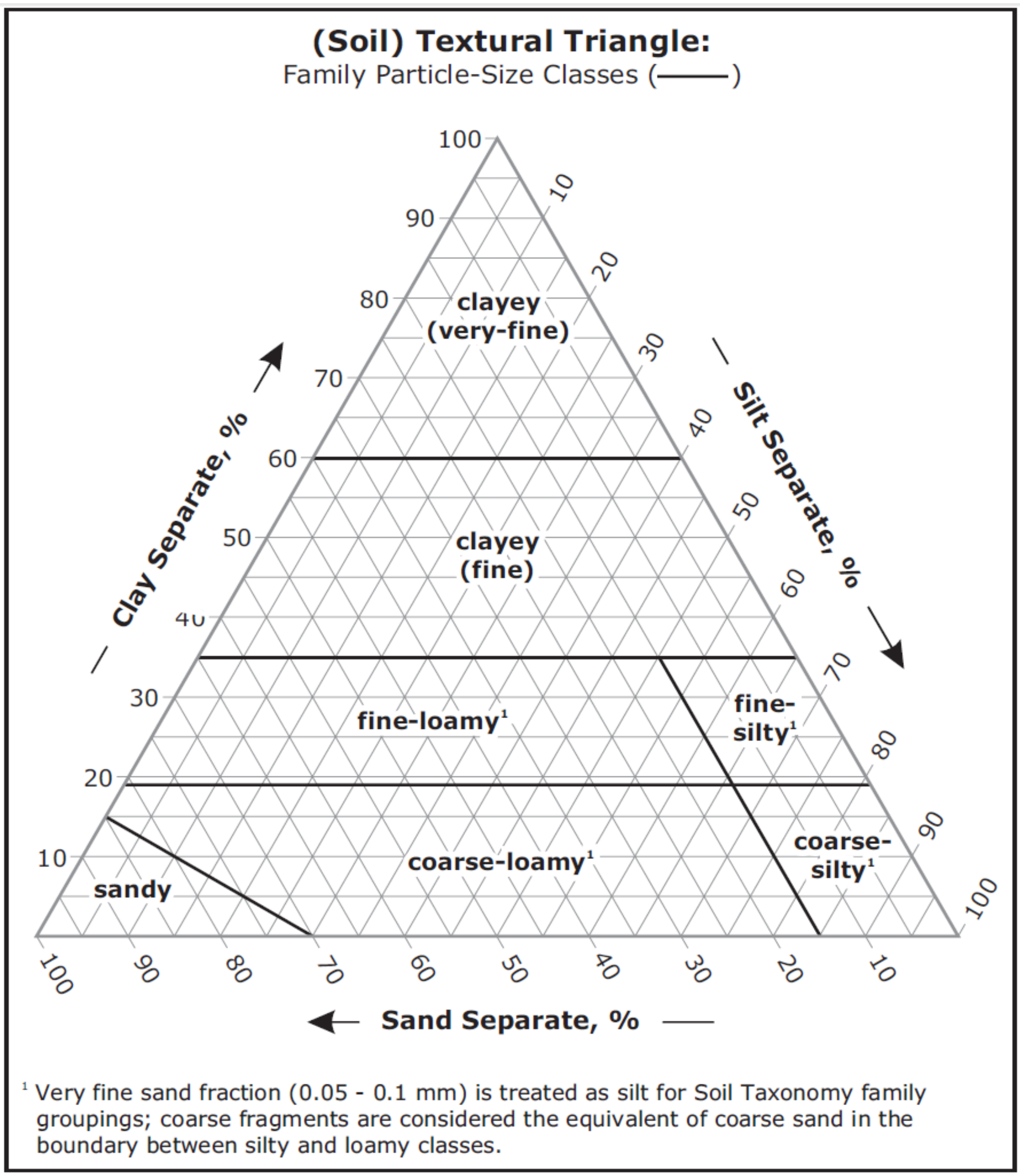
7. United States Department of Agriculture, Natural Resources Conservation Service. 2018. Field Indicators of Hydric Soils in the United States, Version 8.2. L.M. Vasilas, G.W. Hurt, and J.F. Berkowitz (eds.). USDA, NRCS, in cooperation with the National Technical Committee for Hydric Soils.

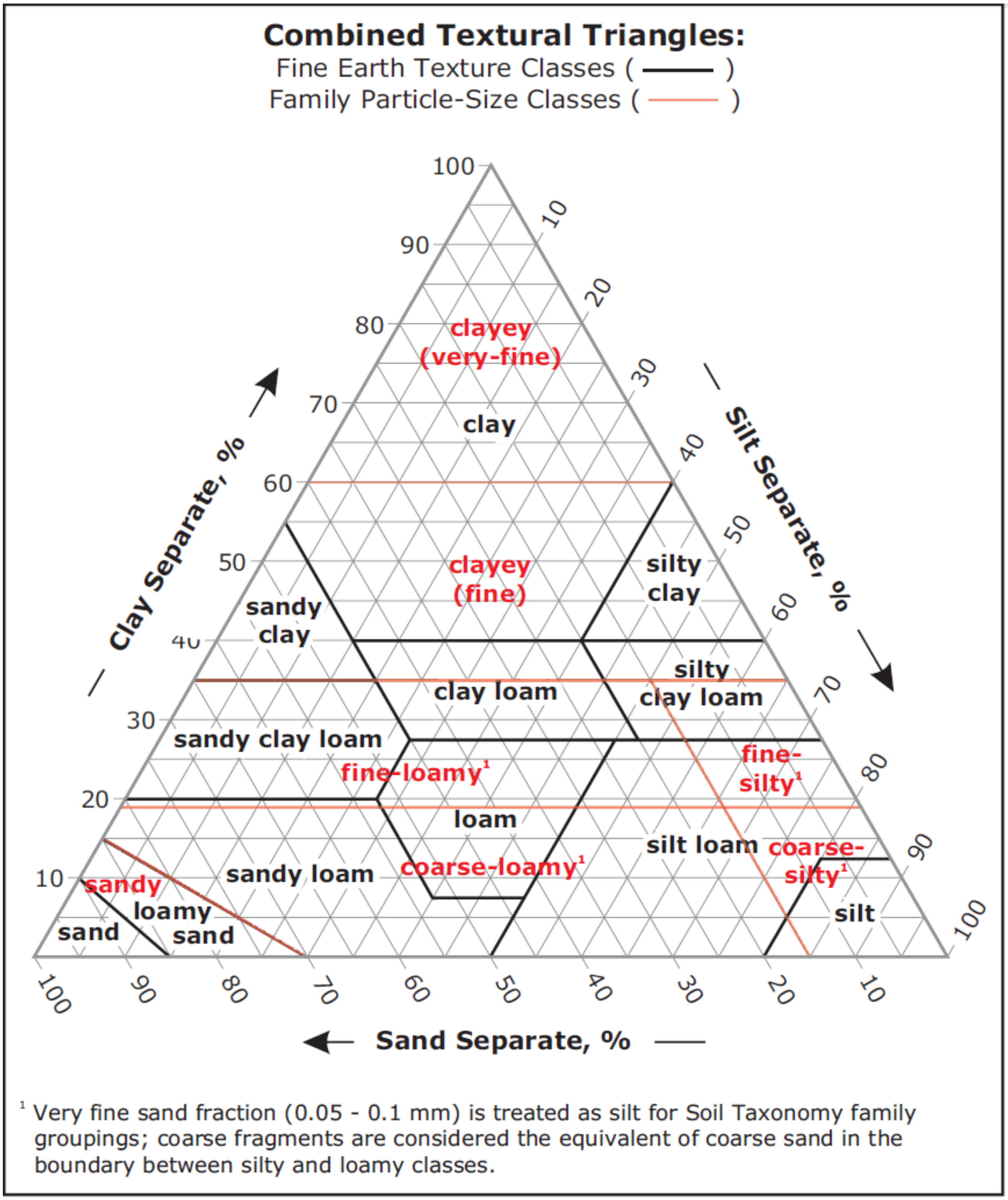
APPENDIX A - Supplemental materials

(not provided or allowed for use in the contest)

Textural Family Triangle



Combined Textural and Particle-Size Family Triangle



APPENDIX B - Reference materials for contest use

(Provided as a packet to contestants)

Table 12. Soil texture and water retention difference values.

Texture class	Water retention (cm water / cm soil)
All sands and loamy coarse sand	0.04
Loamy sand, loamy fine sand, loamy very fine sand, and coarse sandy loam	0.10
Sandy loam, fine sandy loam, sandy clay loam, clay loam, sandy clay, silty clay, and clay	0.14
Loam, silty clay loam	0.17
Very fine sandy loam, silt loam, silt,	0.20

Table 15. Simplified definitions of hydric soil indicators for the contest region

A Indicators - For all soils:	
A11. Depleted Below Dark Surface.	A dark (3/2 or darker) A and/or O horizon underlain by a Eg, Btg, Bg, or Cg horizon starting at ≤ 30 cm.
A12. Thick Dark Surface.	A thick (at least 15 cm) dark (2.5/1 or 2/1) A and/or O horizon underlain by a Eg, Btg, Bg, or Cg. Anything between 30 cm and the depleted matrix must be must be 3/1, 2.5/1, or 2/1 in color.
F Indicators – Used for non-sandy soils (i.e. sandy loams and finer)	
F2. Loamy Gleyed Matrix.	A gleyed matrix (color occurs on the gleyed pages) within 30 cm of the surface.
F3. Depleted Matrix.	A Eg, Btg, Bg, or Cg horizon ≥ 5 cm thick starting in the upper 10 cm, or ≥ 15 cm thick starting within 25 cm of the mineral soil surface.
F6. Redox Dark Surface.	A dark (3/2 or darker) A horizon at least 10 cm thick that has 5% or more D or P redox concentrations if color is 3/2 or 2/2, and ≥ 2% D or P concentrations if color is 3/1 or darker 1 or 0 chroma.
F7. Depleted Dark Surface.	A dark (3/1 or darker 1 or 0 chroma) A horizon at least 10 cm thick that has 10% or more depletions, or (3/2 or darker 2 chroma with 20% or more depletions.
F8. Redox Depressions.	In closed depressions, 5% or more D or P redox concentrations within the upper 10 cm of the soil.

Table 17. Estimated bulk density values for morphological horizons

Horizon	A	Ap, AB, AE, E, EB	Bw, Bg, BA, BE	Bt, Btg, BC, BCt	C, CB	Bx, Btx, Cd
Bulk density (g cm^{-3})	1.1	1.2	1.4	1.5	1.6	1.8

Table 21. Surface runoff classes in relation to slope and surface hydraulic conductivity.

	Limiting hydraulic conductivity within 50 cm of soil surface* *(move one class lower for good vegetative cover, unless class is very low or ponded)*		
	High	**Moderate**	**Low**
Depression	Ponded	Ponded	Ponded
0-<2% slope	Very low	Low	Medium
≥2-6% slope	Low	Medium	High
≥6-12% slope	Medium	High	Very high
≥12% slope	High	Very high	Very high

Table 22. Soil erosion potential classes in relation to surface runoff and surface horizon texture.

modified for contest purposes.

	Surface Horizon Texture			
Surface Runoff	**S, LS**	**SCL, SC**	**SL, CL, C, SIC**	**L, SI, SIL, SICL**
Ponded	Very Low	Very Low	Very Low	Very Low
Very low	Very Low	Very Low	Low	Medium
Low	Very Low	Low	Medium	Medium
Medium	Very Low	Low	Medium	High
High	Low	Medium	High	Very High
Very high	Medium	High	Very High	Very High

Table 23. Criteria for evaluating soil limitations for Dwellings with Basements: Adapted from NSSH and modified for contest purposes.

Factors Affecting Use	Degree of Limitation		
	Slight	Moderate	Severe
1. Flooding or ponding frequency	None	Very rare or rare	Occasional to Very frequent
2. Slope (pct)	<6	6 - <20	≥20
3. Depth to seasonally high water table (cm) and/or hydric soils	>180	75-180	<75 and/or hydric
4. Shrink-swell: texture of most limiting horizon (25-100 cm depth)	S, LS, SL, L, SIL	CL, SICL, SCL	SIC, SC, C
5. Depth to paralithic material (Cr) (cm)	>150	100 - 150	<100
6. Depth to hard rock (R) (cm)	>180	100 - 180	<100

Table 24. Criteria for local roads and streets: Adapted from NSSH and modified for contest purposes. For potential frost heaving average textures between 25 and 100 cm.

	Degree of Limitation		
Factors Affecting Use	Slight	Moderate	Severe
1. Flooding or ponding frequency	None	Very rare or rare	Occasional to Very frequent
2. Slope (pct)	<6	6 - <20	≥20
3. Depth to seasonally high water table (cm) and/or hydric soils	>75	30-75	<30 and//or hydric
4. Depth to hard bedrock (R) (cm)	>180	100 - 180	<100
5. Potential frost heaving			
Hydric soils and wetness class 5	-	Sandy-skeletal, Sandy	Others
Wetness class 1-4	Sandy-skeletal, Sandy	Loamy - skeletal, Coarse-loamy, Fine-loamy, Clayey-skeletal, Clayey, Fine, Very-fine	Coarse-silty, Fine-silty

Table 25. Criteria for evaluating soil limitations for Onsite Wastewater Treatment Systems: Adapted from Ohio Department of Health Rules and Mancl and Slater (2013)

Limiting Condition	Criterion	Recommended System
1. Seasonal high water table and/or hydric soils	< 15 cm and/or hydric 15 cm to < 30 cm 30 cm to 90 cm > 90 cm	None Pretreatment/irrigation Mound System Traditional leach field
2. Low permeability layer: fine texture with limited connected structural pores	Low limiting layer hydraulic conductivity due to texture/structure < 15 cm 15 cm to < 30 cm 30 cm to 90 cm > 90 cm	None Pretreatment/irrigation Mound System Traditional leach field
3. Low permeability layer: hard dense layers	Low limiting layer hydraulic conductivity due to fragipan, densic materials, paralithic or lithic materials < 15 cm 15 cm to < 30 cm 30 cm to 90 cm > 90 cm	None Pretreatment/irrigation Mound System Traditional leach field
4. Excessive permeability and groundwater contamination risk: coarse textured horizons	High limiting layer hydraulic conductivity < 15 cm 15 cm to < 30 cm 30 cm to 90 cm > 90 cm	None Pretreatment/irrigation Mound System Traditional leach field
5. Excessive permeability and groundwater contamination risk: fractured bedrock	Bedrock with visible connected voids. Only mark where limestone or dolomite bedrock with voids less than 25 cm apart on average is present in the described profile.	None if present
6. Slope	< 20% ≥ 20%	Not considered limiting None
7. Flooding and/or ponding	Occasional or higher frequency	None if present

Classification to the Order, Suborder, and Great Group Level

1. **Mollisols** – Mollic epipedon **AND** base saturation (BS)>50% in all horizons above a root limiting layer (RLL), 180 cm, or 125 cm below the top of an argillic, whichever is shallowest.
   a. **Albolls -** have an argillic (or natric) horizon and an albic horizon with a lower boundary below 18 cm underlying the mollic and redox concentrations/depletions within 100 cm or the soil surface
      i. **Argialboll**s
   b. **Aquoll**s – Redox depletions within 50 cm of the surface, AND gleyed matrix within 50 cm of the surface or immediately below mollic epipedon
      i. **Argiaquols** – have an argillic horizon
      ii. **Epiaquols** – have gleyed horizons over non-gleyed horizons within judging depth
      iii. **Endoaquolls** – other Aquolls
   c. **Rendolls** – Within or directly below a mollic epipedon of < 50 cm thickness, have calcium carbonate equivalent ≥ 40 %, and no argillic hoizon
      i. **Haprendolls**
   d. **Udolls** – other Mollisols
      i. **Argiudolls** – have an argillic horizon
      ii. **Hapludolls** – other Udolls
2. **Alfisols –** Argillic horizon and greater than or equal to 35% base saturation at the check depth
   a. **Aqualfs –** redox features in all horizons between 25 cm and 40 cm **AND** gleyed matrix in the upper 12.5 cm of argillic (Btg)
      i. **Fragiaqualfs –** have a fragipan
      ii. **Epiaqualfs** – perched water table (gleyed horizons over non-gleyed horizons)
      iii. **Endoaqualfs –** Other Aqualfs
   b. **Udalfs** – Other Alfisols
      i. **Fragiudalfs** - have a fragipan
      ii. **Hapludalfs** – other Udalfs
3. **Inceptisols** – Within 100 cm, a cambic horizon, or a mollic epipedon
   a. **Aquepts** – gleyed matrix at ≤50 cm
      i. **Fragiaquept**s – have a fragipan
      ii. **Epiaquepts** – episaturation, gleyed horizons over non-gleyed horizons
      iii. **Endoaquepts** – other Aquepts
   b. **Udepts** – Other Inceptisols
      i. **Fragiudept**s – have a fragipan
      ii. **Eutrudepts**– other Udepts that have a base saturation of 60% or more in one or more horizons at a depth between 25 and 75 cm form the mineral soil surface or directly above a root limiting layer at shallower depth
      iii. **Distrudepts** – other Udepts
4. **Entisols** - other soils
   a. **Aquents –** gleyed matrix at ≤50 cm
      i. **Fluvaquents** – 0.2% OC at 125 cm OR irregular decrease in OC with depth
      ii. **Epiaquents** – episaturation, gleyed horizons over non-gleyed horizons witin judging depth
      iii. **Endoaquents –** other Aquents
   b. **Psamments -** have less than 35% rock fragments and a texture class of loamy fine sand or coarser in all layers within the particle-size control section
      i. **Quartzipsamments** – more than 90% resistant minerals in silt and sand fraction of PSCS
      ii. **Udipsamments** - other Psamments
   c. **Fluvents** – 0.2% OC at 125 cm **OR** irregular decrease with OC with depth
      i. **Udifluvents**

d. **Orthents – Other Entisols**
   i. **Udorthents**

Family Particle Size

Depth of Particle-Size Control Section

Contestants should select the proper depth of the family particle-size control section based on the soil properties present in the judged profile from those listed below, using the "fall-out-first" principle. If two choices on the scorecard yield the exact same depth range, either choice will be considered correct.

(1) Soils <36 cm to root-limiting layer (RLL)........ **0 to RLL**

(2) Soils with an argillic horizon

   (a) Strongly contrasting particle sizes within or below the argillic and within 100 cm of the surface: Deepest of:........ **Upper 50 cm of the argillic**
   .... **Top of the argillic to 100 cm if no RLL at <100 cm**
   .... **Top of the argillic to RLL**

   (b) Argillic horizon is > 50 cm thick........ **Upper 50 cm of the argillic**

   (c) Argillic horizon is < 50 cm thick........ **All of the argillic**

(3) All other soils

   (a) Top depth is:........ **25 cm OR lower depth of Ap**, whichever is deeper

   (b) Lower depth is:........ **100 cm OR RLL**, whichever is shallower

Family Particle-Size Class

Once the family particle-size class control section for the soil profile has been determined, contestants should calculate the weighted percentage sand, silt, clay, and, if needed, rock fragment content within that control section. The family particle-size class can then be determined using the guide listed below (also see textural triangles in Appendix A). Contestants should know when to select only the three broad particle size classes, the skeletal classes, and when to use the seven more specific particle size classes. If two or more strongly contrasting particle-size classes are present within the control section, name the two most contrasting classes.

1) Sandy: texture is S or LS
2) Loamy: texture is LVFS, VFS, or finer with clay < 35%
   a) Coarse-loamy: ≥ 15% FS or coarser + < 18% clay
   b) Fine-loamy: ≥ 15% FS or coarser + 18-34% clay
   c) Coarse-silty: < 15% FS or coarser + < 18% clay
   d) Fine-silty: < 15% FS or coarser + 18-34% clay
3) Clayey: ≥ 35% clay
   a) Fine: 35- 59% clay
   b) Very-fine: ≥ 60% clay
4) Sandy-skeletal: ≥ 35% coarse fragments + sandy particle size class
5) Loamy-skeletal: ≥ 35% coarse fragments + loamy particle size class
6) Clayey-skeletal: ≥ 35% coarse fragments + clayey particle size class
7) Contrasting particle size classes - transition zone < 12.5 cm thick
   e.g. Clayey (or clayey-skeletal) over sandy, or Loamy (or loamy-skeletal) over clayey with absolute difference of 25% clay

NOTE: Subclasses of the loamy and clayey particle size classes will always be used unless a root limiting layer occurs within 50 cm or is a part in a strongly-contrasting particle size class.

ABBREVIATIONS

Modifiers for Coarse Fragments							
Gravelly	**GR**	Cobbly	**CB**	Stony	**ST**	Bouldery	**BD**
Channery	**CH**	Flaggy	**FL**	Very*	**V**	Extremely*	**X**

*Used to modify rock fragment terms as needed

Texture	Symbol	Texture	Symbol
Coarse sand	**COS**	Sandy Loam	**SL**
Sand	**S**	Loam	**L**
Fine sand	**FS**	Sandy clay loam	**SCL**
Very fine sand	**VFS**	Silt loam	**SIL**
Loamy coarse sand	**LCOS**	Silt	**SI**
Loamy sand	**LS**	Silty clay loam	**SICL**
Loamy fine sand	**LFS**	Clay loam	**CL**
Loamy very fine sand	**LVFS**	Sandy clay	**SC**
Coarse sandy loam	**COSL**	Silty clay	**SIC**
Fine sandy loam	**FSL**	Clay	**C**
Very fine sandy loam	**VFSL**		

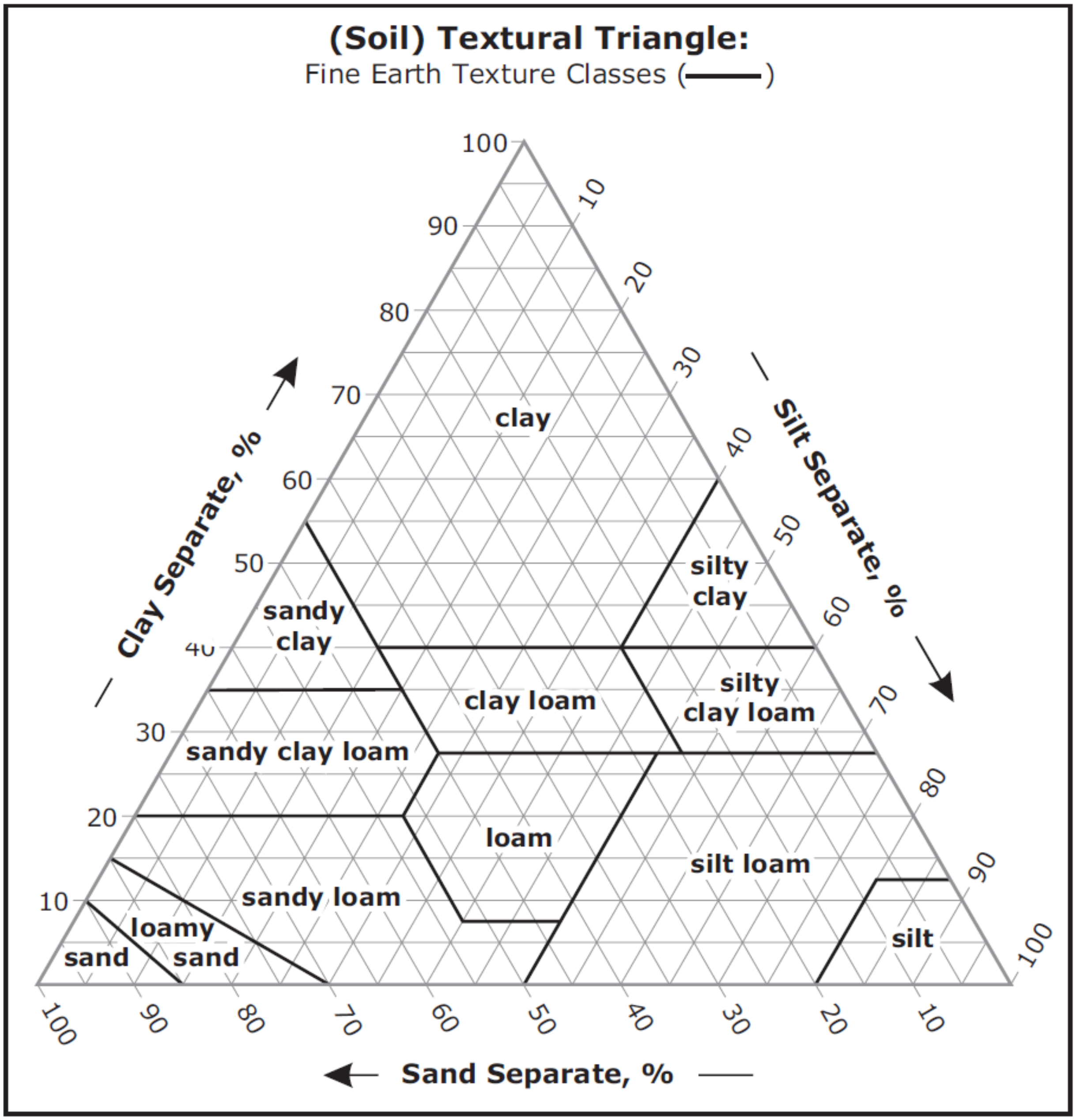
Distinctness of Boundary							
Abrupt	**A**	Clear	**C**	Gradual	**G**	Diffuse	**D**

Structure (Grade)							
Structureless	**0**	Weak	**1**	Moderate	**2**	Strong	**3**

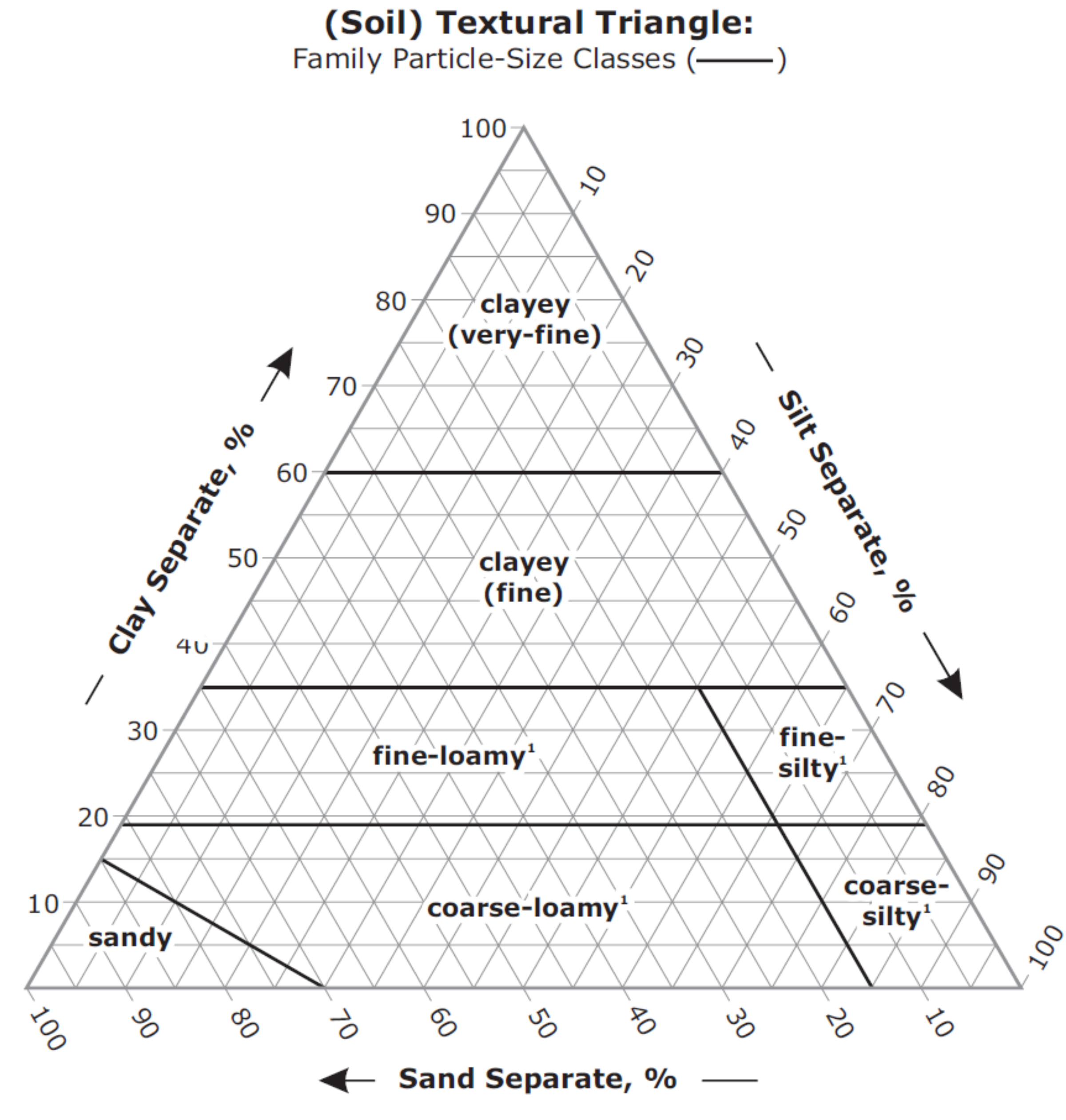
Structure Type (Shape)	
Angular blocky	**ABK**
Columnar	**COL**
Granular	**GR**
Massive	**MA**
Platy	**PL**
Prismatic	**PR**
Single grain	**SGR**
Subangular blocky	**SBK**
Rock controlled fabric	**RCF**

Moist Consistence	
Loose	**LO**
Very friable	**VFR**
Friable	**FR**
Firm	**FI**
Very firm	**VFI**
Extremely Firm	**EF**
Slightly rigid	**SR**
Rigid	**R**
Very rigid	**VR**

Textural Triangle



Family Particle Size Triangle



[1] Very fine sand fraction (0.05 - 0.1 mm) is treated as silt for Soil Taxonomy family groupings; coarse fragments are considered the equivalent of coarse sand in the boundary between silty and loamy classes.

APPENDIX C - Scorecard

SCORECARD
2022 National Collegiate Soils Contest
The Ohio State University, Columbus OH
April 19-23 2022

THE OHIO STATE UNIVERSITY

A. ______ ______
B. ______ ______
C. ______ ______
D. ______ ______
E. ______ ______
Total: ______ ______

Contestant ____________________

Site ____________
No. of Horizons ____________
Depth to be described ________ cm
Nail in 3rd horizon @ ________ cm

A. Morphology **Score:**______

Horizonation				Boundary		Texture				Color			Structure		Cons.	Redoximorphic Features				Score
																Concentrations		Depletions		
Pre.	Master	Sub.	No.	Lower depth (cm)	Dist.	Clay %	%CF	CF Mod.	Class	Hue	Val.	Chr.	Grade	Type	Moist Rupt. Res.	Abund.	Contrast	Abund.	Contrast	
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	40

B. Soil Profile Characteristics **Score:**______

Hydraulic Conductivity (10)	Effective Soil Depth (5)	Available Water Holding Capacity (5)	Soil Wetness Class (5)	Soil OC Pool (5)
Surface (5): ______ High ______ Moderate ______ Low Limiting Layer (5): ______ High ______ Moderate ______ Low	______ Very Shallow <25 cm ______ Shallow 25 to <50 cm ______ Mod. Deep 50 to <100 cm ______ Deep 100 to <150 cm ______ Very Deep ≥150 cm	______ Very Low <7.5 cm ______ Low 7.5 to <15.0 cm ______ Moderate 15.0 to <22.5 cm ______ High ≥22.5 cm	______ Hydric Indic. ______ ______ Class 1 ≥ 150 cm ______ Class 2 >100 to 150 cm ______ Class 3 > 50 to 100 cm ______ Class 4 > 25 to 50 cm ______ Class 5 ≤ 25 cm	kg m-2 ______ V. Low <5 ______ Low 5-<10 ______ Moderate 10-<15 ______ High ≥ 15

C. Site Characteristics Score:_______

Landform (5)	Parent Material (5 each)	Position of Site (5)	Slope Gradient (5)	Surface Runoff (5)	Erosion Potential (5)
_____ Upland _____ Depression _____ Terrace _____ Floodplain _____ Constructed	_____ Alluvium _____ Residuum _____ Colluvium _____ Lacustrine deposits _____ Glacial Till _____ Outwash _____ Pedisediment _____ Loess _____ Human transported materials	_____ Summit _____ Shoulder _____ Backslope _____ Footslope _____ Toeslope _____ None	_____ 0 to <2% _____ ≥2 to 6% _____ ≥6 to 12% _____ ≥12 to 20% _____ ≥20 to 30%	_____ Ponded _____ Very Low _____ Low _____ Medium _____ High _____ Very High	_____ Very Low _____ Low _____ Medium _____ High _____ Very High

D. Soil Classification Score:_______

Epipedons (5)	Subsurface Horizons and Features (5 each)	Order (5)	Suborder (5)	Great Group (5)	Particle-Size Control Section (5)	Family Particle-Size Class (5)
_____ Mollic _____ Ochric _____ None	_____ Albic _____ Argillic _____ Cambic _____ Densic materials _____ Fragipan _____ Abrupt text. change _____ Lithic Contact _____ Lith. Discontinuity _____ Paralithic Contact _____ None	_____ Alfisols _____ Entisols _____ Inceptisols _____ Mollisols	_____ Alb _____ Aqu _____ Fluv _____ Orth _____ Psamm _____ Rend _____ Ud	_____ Argi _____ Dystr _____ Endo _____ Eutr _____ Epi _____ Fluv _____ Fragi _____ Hapl/Hap _____ Quartzi _____ Udi	_____ Mineral soil surface to root-limiting layer _____ All of the argillic _____ Upper 50 cm of argillic _____ Upper boundary of argillic to 100 cm _____ Upper boundary of argillic to root-limiting layer _____ 25 to 100 cm _____ 25 cm to root-limiting layer _____ Lower boundary of Ap to 100 cm _____ Lower boundary of Ap to root-limiting layer _____ Other	_____ Sandy-skeletal _____ Coarse-loamy _____ Loamy-skeletal _____ Fine-loamy _____ Clayey-skeletal _____ Coarse-silty _____ Sandy _____ Fine-silty _____ Loamy _____ Fine _____ Clayey _____ Very-fine *Note: For strongly contrasting classes, indicate upper class with a "1" and lower class with a "2".*

E. Site Interpretations Score:_______

Dwellings With Basements	Onsite Wastewater Treatment Systems		Roads and Streets
Rating (3) _____ Slight _____ Moderate _____ Severe Reason # (2):_______ *Dashed when "Slight"*	Depth to Limitation (2) _____ < 15 cm and/or hydric _____ 15 cm to < 30 cm _____ 30 cm to 90 cm _____ > 90 cm Limitation # (2): _______	Recommended System (1) _____ None _____ Pretreatment/irrigation _____ Mound System _____ Traditional leach field	Rating (3) _____ Slight _____ Moderate _____ Severe Reason # (2):_______ *Dashed when "Slight"*