Soil Science
Professional Practice Exam

Performance Objectives

Soil Science Society of America's

Council of Soil Science Examiners

Effective November 19, 2012

SOIL SCIENCE PROFESSIONAL PRACTICE PERFORMANCE OBJECTIVES

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FOREWORD

This booklet represents the Performance Objectives (POs) for the Soil Science Professional Practice Examination. The POs presented are the minimal professional competencies needed by the professional soil scientists. These competencies are given as a list of POs. To be considered a minimally qualified professional, an individual must also be knowledgeable of the fundamental performance objectives.

The development of the POs began in 1994 when the Soil Science Society of America (SSSA) asked the practicing soil consultants, state licensing boards, government officials and academicians to collectively develop a nationally applicable set of standards fundamental to the rigorous solution of environmental and agronomic problems. Subsequently, this group evolved into the Council of Soil Science Examiners (CSSE) which refined that original list of standards and continues to refine the list on a systematic basis leading to the most recent 2013 edition. The POs have been developed to assist the student in studying for the Professional Practice Exam. The CSSE is also charged with the development of the examinations required for certification and licensure. The examinations are the product of the balanced application of the POs and can best be studied for by developing a technical understanding of each PO.

The goal of the POs, the examinations and the CSSE is to protect the health and welfare of the public by insuring only competent soil scientists are certified and /or licensed. In doing so, the CSSE repeatedly scrutinized the POs to insure we are testing the most pertinent soils knowledge. In this right, a subcommittee of the CSSE is formed along with an end user group to review and revise the POs on a routine basis culminating in this document.

Soil Science is a dynamic field where new discoveries and approaches continue to occur at a rapid pace. The CSSE encourages comments and suggestions concerning possible modifications to the 2013 edition of the POs. Comments should be sent to: SSSA CSSE, 5585 Guilford Rd., Madison, WI 53711.

The SSSA and CSSE would like to thank the many volunteers who contributed to the continuing refinement of this document. It would not be possible without their dedication to the profession of soil science.

A note on conversions:

Examinees should be able to convert between metric and English units and vice versa, as well as understand SI units. Conversion factors will be provided for questions within the exam.

SOIL CHEMISTRY AND MINERALOGY

Competency Area 1. Solid Phase

1. Explain organo-clay complex formation.

2. Differentiate surface charge characteristics for phyllosilicate and hydrous metal oxides:
    a. relationship to shrink-swell properties.
    b. suitability for design of physical structures.

3. Infer characteristics of the site based on the secondary clay minerals present.

Competency Area 2. Mineral Weathering

1. Know relative weathering rates of primary minerals.

2. Explain climate effects on the progression of weathering in a soil relative to:
    a. soil pH.
    b. organic matter.
    c. soil depth.
    d. salt accumulation.
    e. carbonate accumulation.
    f. leaching of anions and cations.

3. Explain how weathering affects clay content, distribution, and mineralogy in a soil.

Competency Area 3. Sorption and Precipitation Reactions

1. Relate electronegativity to binding strength between ions in solution with colloid surfaces.

2. Describe how differences in sorption strengths of lead, cadmium, chromium, arsenic, and selenium affect their movement through soils.

3. Explain how the following affects the fate of inorganic and organic compounds in soils:
    a. K_{oc}.
    b. half-life.
    c. solubility.
    d. vapor pressure.
    e. ionic form.
    f. K_d.

4. List soil factors that influence the corrosion of concrete and materials containing iron placed in soils.

Competency Area 4. Acidity

1. Know the effect of soil pH on speciation and solubility of:
    a. aluminum.
    b. iron.
    c. chromium.
    d. copper.
    e. zinc.
    f. lead.
    g. phosphorus.
    h. carbonate.
    i. arsenic.
    j. nitrogen

2. Explain the relationship between soil acidity and each of the following gases: SO_2, CO_2, NO_2, and NH_3.

Competency Area 5. Oxidation and Reduction

1. Explain the effect of oxidation-reduction reactions on solubility of:
    a. iron.
    b. manganese.
    c. arsenic.
    d. lead.
    e. phosphorus.

2. Define Eh and how it is measured.

3. Interpret the relationship between pH and Eh.

4. Explain the relationship between microbial activity and Eh.

SOIL FERTILITY

Competency Area 1. Roles of Plant Nutrients and Their Availability in Soils

1. Explain how chelates (organometallic complexes) are used to increase bioavailability of plant nutrients.

2. Identify the relative mobility of essential plant nutrients in the soil.

3. Distinguish between mobile and immobile nutrients in plants.

Competency Area 2. pH

1. Explain the effects of drainage on soil pH in acid sulfate soils.

2. Describe the effects of soil pH and aluminum solubility on plant root growth.

3. Analyze the role of pH in solubility of available nutrients.

Competency Area 3. Acidifying and Liming of Soil

1. Explain the effect of adding pyritic material on soil pH.

2. Explain the effects of gypsum on soil:
    a. pH.
    b. aluminum bioavailability.

3. Explain the effects of organic residue addition and soil organic matter on aluminum bioavailability.

Competency Area 4. Alkaline and Salt Affected Soils

1. Calculate the leaching requirement to ameliorate saline and/or sodic affected soils when provided with water quality and soil salinity data.

2. Prescribe management strategies to mitigate or manage salt accumulation in plant root zones.

3. Describe the effects of gypsum, sulfur and sulfuric acid on chemical and physical properties when remediating saline-sodic or sodic soils.

4. Calculate the gypsum, sulfur or sulfuric acid required to remediate sodic soils given the appropriate data.

5. Understand the toxicity effects of chloride and boron in salt affected soils.

Competency Area 5. Nutrient Sources

1. Calculate the quantity of available nutrients when provided with the nutrient concentrations of organic and inorganic sources.

2. Identify appropriate timing for the application of nutrient sources based on crop physiology, climate and environmental conditions.

Competency Area 6. Nutrient Management

1. Describe the impact of the following on nutrient cycling:
    a. tillage practices.
    b. crop selection.
    c. cropping rotation.
    d. cover crops.
    e. green manure.
    f. controlled burning.
    g. flooding.

2. Evaluate how soil disturbances affect nutrient cycling.

3. Explain how plant removal affects nutrient cycling.

4. Identify the key requirements of a :
    a. nutrient management plan.
    b. comprehensive nutrient management plan.
    c. conservation plan.

5. Explain how irrigation management is important to nutrient management.

6. Explain how drainage water management is important to nutrient management.

Competency Area 7. Soil, Plant Analyses and Interpretations

1. Describe how to use plant tissue analyses in a soil fertility program.

2. Describe how various soil test methods can affect the soil test result.

3. Describe how various soil test methods can affect the interpretation of the soil test result.

SOIL PHYSICS

Competency Area 1. Physical Properties

1. Explain how to mitigate physical limitations of sodic, saline, and saline-sodic soils.

2. Formulate the relationship between the following soil physical properties:
    a. bulk density.
    b. particle density.
    c. porosity.
    d. gravimetric water content.
    e. volumetric water content.

3. Analyze how the following soil physical properties, both individually or in groups, affect soil management:
    a. particle size distribution.
    b. specific surface.
    c. soil structure
        i. crusting.
        ii. aggregate characteristics (size, distribution, stability).
    d. bulk density.
    e. porosity.
    f. mass wetness.
    g. volume wetness.
    h. hydrophobicity.

Competency Area 2. Soil-Water Relationships

1. Calculate a soil water balance given the pertinent information.

2. Apply information from a soil moisture release curve to land management decisions.

3. Determine soil management options given soil moisture and physical property data.

4. Describe how water input affects water table geometry under a land application system.

5. Compare and contrast the following soil water potentials:
    a. total soil-water potential.
    b. gravitational potential.
    c. pressure potential.
    d. matric potential.
    e. osmotic potential.

6. Assess the impact of root water uptake on the soil water potential.

7. Identify and estimate the following vegetation components of the hydrologic cycle:
    a. stemflow.
    b. throughflow.
    c. interception.

8. Describe the effects of the following conditions on evapotranspiration potential:
    a. soil moisture regimes.
    b. ground cover.
    c. vegetative characteristics.
    d. climate/microclimate.

Competency Area 3. Water Movement and Transport Processes

1. Compare and contrast the rate and pattern of water flow in saturated and unsaturated soils.

2. Explain water flow through soil horizons with different hydraulic properties.

3. Identify appropriate conditions for using Darcy's Law.

4. Determine flow rate and/or direction given soil water potentials.

5. Describe the effects of soil texture, structure and matric potential on the following:
    a. hydraulic conductivity.
    b. soil water movement.
    c. plant available water.
    d. water holding capacity.

6. Explain how land use affects water movement, retention and availability.

7. Distinguish between infiltration rate, percolation rate and saturated hydraulic conductivity.

8. Explain how the following affect infiltration:
    a. time from the beginning of rain or irrigation.
    b. hydraulic conductivity.
    c. antecedent soil moisture.
    d. depth of soil.
    e. layered soil.
    f. surface characteristics.
    g. instability of wetting fronts.

9. Explain water movement across landscapes.

Competency Area 4. Soil Temperature

1. Describe how soil characteristics and land use modify soil thermal properties or vice versa.

Competency Area 5. Soil Gases

1. Assess the composition of soil air with respect to the following under different circumstances:
    a. oxygen.
    b. carbon dioxide.
    c. methane.
    d. hydrogen sulfide.
    e. water vapor.
    f. nitrous oxide.

2. Differentiate and explain why soil respiration differs:
    a. in vegetated versus fallow areas.
    b. during different seasons of the year.
    c. throughout different times of the day.
    d. with varying degrees of microbial activity.
    e. with varying degrees of soil moisture content.

3. Compare and contrast movement of soil gases under various atmospheric and climatic conditions.

Competency Area 6. Engineering Properties

1. Compare and contrast the following particle size classification systems:
    a. United States Department of Agriculture (USDA).
    b. American Society for Testing and Materials Unified Soil Classification System (USCS/Unified).
    c. American Association of State Highway and Transportation Officials (AASHTO).

2. Describe shear strength and its relation to soil cohesion and friction forces.

3. Compare and contrast how soil composition affects shear strength.

4. Describe the Proctor Test and interpret its results.

5. Evaluate factors affecting slope stability and soil mass movement hazards.

6. Assess soil compaction under different land use practices, soil texture and moisture conditions.

7. Identify BMPs to minimize soil compaction.

SOIL GENESIS, MORPHOLOGY, AND CLASSIFICATION

Competency Area 1. Soil Forming Factors

1. Evaluate the five soil forming factors influence on soil properties.

2. Relate soil properties to the following parent materials:
    a. alluvium.
    b. colluvium.
    c. till.
    d. eolian sand.
    e. loess.
    f. marine sediments.
    g. residuum.
    h. glacial outwash.
    i. coastal sediments.
    j. lacustrine sediments.
    k. volcanic ash.
    l. human transported materials.

Competency Area 2. Horizon Forming Processes

1. Describe and interpret the soil forming processes given morphologic, hydrologic, and landscape information.

2. Explain the pedogenic processes for a given soil description.

3. Identify how soil forming processes lead to development of diagnostic horizons.

Competency Area 3. Soil Descriptions and Land Use Management

1. Evaluate soil morphologic properties for land use decisions.

2. Interpret the seasonal high water table location using soil morphology.

3. Utilize soil profile descriptions to evaluate and make land use decisions.

Competency Area 4. Soil Classification Concepts

1. Distinguish between endosaturation and episaturation.

2. Integrate soil taxonomic information with soil morphology, genesis, landscapes, and land use decision making.

Competency Area 5. Soil Mapping and Geospatial Information

1. Utilize information found in a modern National Cooperative Soil Survey Report to evaluate a site for potential uses.

2. Identify scale limitations of soil surveys.

3. Describe how to acquire, integrate, and interpret the following:
    a. soil maps.
    b. topographic maps.
    c. wetland inventory maps.
    d. aerial imagery.
    e. remote sensing & satellite data.
    f. bedrock and surficial geology maps.
    g. watershed maps.
    h. land cover inventories.
    i. hydrology maps.
    j. hydrogeology maps.
    k. cultural resources information.
    l. digital elevation models.

4. Utilize geospatial information to develop best management practices (BMP's) for:
    a. vegetation management.
    b. nutrient management.
    c. erosion and sediment control practices.
    d. land reshaping.

5. Utilize geospatial information to develop soil testing protocols.

Competency Area 6. Geomorphology

1. Use soil geomorphic and geologic information to predict soil properties.

2. Describe pedologic and hydrologic properties of the following hillslope positions:
    a. summit.
    b. shoulder.
    c. backslope.
    d. footslope.
    e. toeslope.

3. Differentiate convex, concave, and linear landscape segments and describe their impact on soil and hydrologic properties for land use decisions.

4. Distinguish convergent and divergent flow.

5. Define and delineate the components of a watershed.

Competency Area 7. Soils Forming Environments

1. Analyze how morphological, chemical and physical soil properties result in discrete landscape assemblages in:
    a. forest.
    b. desert.
    c. prairie.
    d. arctic and alpine.
    e. wetlands.
    f. agriculture.
    g. urban.

Competency Area 8. Soil Variability

1. Differentiate between variability arising from natural and anthropogenic processes.

2. Evaluate sampling designs and metrics to assess soil variability across scales.

3. Describe the influence of the following human activities on soil:
    a. mining.
    b. hydrologic attenuation.
    c. land reshaping.
    d. construction.
    e. landfills.
    f. agriculture.
    g. urbanization.

SOIL BIOLOGY AND SOIL ECOLOGY

Competency Area 1. Soil Ecology

1. Describe how a change in soil moisture, temperature, aeration, pH and organic carbon levels will impact populations and activities of key groups of organisms in soil such as:
    a. aerobic organisms.
    b. heterotrophic bacteria and fungi.
    c. autotrophic bacteria involved in the nitrogen and sulfur cycles.
    d. fungi.
    e. anaerobic organisms.

2. Describe how the following affect availability of nutrients to microorganisms:
    a. soil texture.
    b. organic matter content.
    c. plant roots.
    d. pH.

3. Contrast how soil bacteria and soil fungi form stable aggregates in soil.

4. Discuss the dynamic nature of the rhizosphere with reference to:
    a. microbial populations.
    b. nutrient transformation.
    c. phytoremediation.
    d. aggregate development and stability.

5. Compare how soil microbial populations, diversity and activities are affected by the following:
    a. intensive tillage.
    b. flooding.
    c. compaction.
    d. grazing or harvesting of biomass.

6. Discuss the conditions under which one should consider the use of inoculants for leguminous crops.

7. Discuss how mycorrhizal and rhizobial symbioses are affected by soil:
    a. moisture.
    b. aeration.
    c. fertilizer additions.
    d. pH.

8. Discuss how invasive soil organisms affect soil quality (example: invasive earthworms in forested systems).

Competency Area 2. Biological and Biochemical Activities

1. Describe how microbial activities can affect the oxidation status and/or chemical form of the following elements:
    a. arsenic.
    b. iron.
    c. manganese.
    d. mercury.
    e. nitrogen.
    f. selenium.
    g. sulfur.
    h. chromium.

2. Describe how the following soil factors affect the decomposition of organic materials in soil:
    a. pH.
    b. moisture.
    c. temperature.
    d. aeration.
    e. oxidation-reduction potential.
    f. inorganic nutrients.
    g. clay type and amount.
    h. tillage.

3. Given data on organic material composition and efficiency of microbial decomposition, calculate the following:
    a. approximate quantity of organic carbon produced.
    b. nitrogen mineralization or immobilization.
    c. phosphorus mineralization or immobilization.

4. Describe how the nitrification and denitrification processes are affected by soil:
    a. pH.
    b. moisture.
    c. temperature.
    d. aeration.
    e. available carbon.

5. Discuss the conditions under which inorganic nitrogen can be lost from the soil in the nitrogen cycle.

Competency Area 3. Soil Organic Matter

1. Discuss how the exchange capacity of stable soil organic matter is affected by soil acidity.

2. Describe the organic matter mechanisms of retention for nutrients, organic pollutants, and inorganic pollutants.

3. Explain how soil pH affects the organic matter retention for nutrients, organic pollutants, and inorganic pollutants.

4. Discuss the mechanisms by which soil organic matter interacts with the following:
    a. acidity (H^+ or H_3O^+).
    b. aluminum.
    c. essential plant nutrients.
    d. heavy metals.
    e. polar and non-polar pesticides.
    f. xenobiotics.

5. Describe how organic materials of differing age and chemical composition influence the rate of decomposition and stable organic matter formation.

Competency Area 4. Environmental and Agricultural Applications

1. Compare and contrast concepts of environmental modification, bio-augmentation and bioremediation.

2. Describe how to encourage microbial degradation of organic pollutants during the bioremediation of a contaminated soil.

3. Describe how to encourage microbial transformations of inorganic pollutants during the bioremediation of a contaminated soil.

4. Calculate how much nitrogen to add to an organic material to avoid nitrogen immobilization given the C:N ratio of the organic material.

Competency Area 5. Climate Change

1. Examine the soil carbon source-sink relationship between contrasting soil management practices.

2. Define the short- and long-term potential for soil to sequester carbon.

3. Describe soil factors that affect carbon sequestration.

SOIL AND LAND USE MANAGEMENT

Competency Area 1. Erosion and Sediment Control

1. For a given site recommend best management practices (BMP's) for erosion and sediment control.

2. Discuss the use of the latest version of RUSLE in developing management plans.

3. Assess site vulnerability to soil erosion.

4. Appraise limitations of highly erodible land (HEL).

5. Evaluate and prescribe appropriate BMPs that mitigate:
    a. creep.
    b. saltation.
    c. suspension.

6. Identify co-contaminants associated with suspended soil particulates in the air.

7. Develop a conservation land use plan.

8. Describe the effects of land management on the hydrologic cycle and soil erosion.

Competency Area 2. Wetlands and Hydric Soils

1. Specify/describe criteria used to delineate a jurisdictional wetland.

2. Describe characteristics of wetland environments.

3. Describe how to identify hydric soils.

4. Given morphologic information, distinguish hydric soils from non-hydric soils.

5. Identify methods to measure recharge, discharge and saturation in wetlands.

6. Evaluate methods used to avoid, minimize, or mitigate adverse effects to wetlands.

7. Contrast constructed versus restored wetlands for wetland mitigation.

Competency Area 3. Soil Quality and Management

1. Calculate the quantity of carbon sequestered in soil given land management practices and the amount of carbon in the soil amendment.

2. Use bulk density, organic carbon concentration, and soil thickness to calculate the quantity of organic carbon in a soil.

3. Given C:N:P:S ratio, estimate the quantity of P, N, and S sequestered per ton of carbon.

Competency Area 4. Waste Management

1. Describe methods and management for the beneficial use of biosolids, animal wastes, and effluents.

2. Identify major contaminants commonly found in municipal biosolids, industrial wastes, and effluents and how they are regulated by the EPA.

3. Calculate soil amendment rates given appropriate information such as:
    a. biomass requirements.
    b. regulatory requirements.
    c. soil test data.
    d. amendment analysis.
    e. biomass removal.

4. Use $CaCO_3$ equivalent to adjust lime application rate to meet biosolid application recommendations.

5. Calculate application rates of biosolids, effluents, and industrial wastes based on yearly and cumulative identified loading rates.

6. Given site information and soil properties, determine suitability and size of an on-site waste disposal system.

7. Identify best management practices (BMP's) for managing soils contaminated with:
    a. cadmium.
    b. chromium.
    c. lead.
    d. zinc.
    e. nickel.
    f. arsenic.
    g. selenium.
    h. mercury.

8. Describe the fate of human and animal pathogens and waste products introduced into the soil environment.

9. Evaluate capacity of constructed wetlands to mitigate outflow contaminants.

Competency Area 5. Cropland, Rangeland and Field Management

1. Evaluate soil physical, chemical and biological properties as affected by soil tillage and residue management.

2. Describe effects of grazing and overgrazing on rangeland soils.

3. Given information and data, design a nutrient management plan for a concentrated animal feeding operation (CAFO).

Competency Area 6. Water Quality and Management

1. Explain the impact of land application of organic amendments on the biological oxygen demand (BOD) on surface and groundwater.

2. Evaluate the use of soil for treating contaminated water.

3. Describe how suspended soil particulates in air or water affect water quality and human health.

4. Evaluate the impact on surface and groundwater quality of the following land use practices:
    a. agricultural production – crops, animal agriculture feedlot, range.
    b. construction.
    c. waste disposal and remediation.
    d. forestry.
    e. natural habitats.
    f. mine reclamation.
    g. residential development.
    h. urban development.

5. Evaluate techniques for remediation of soils contaminated by chemical leaks and spills.

Competency Area 7. Regulatory and Resource Agencies

1. Know aspects related to soil in Federal Programs pertaining to:
    a. National Pollution Discharge Elimination Systems (NPDES).
    b. Concentrated Animal Feeding Operations/Animal Feeding Operations (CAFOs/AFOs).
    c. Total Maximum Daily Loads (TMDLs).

d. Coastal Zone Management Act.
e. Clean Water Act.
f. National Environmental Policy Act (NEPA).
g. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).
h. Resource Conservation and Recovery Act (RCRA).

2. Compare and contrast the responsibilities of federal agencies with respect to the following programs:
    a. National Pollution Discharge Elimination Systems (NPDES).
    b. Concentrated Animal Feeding Operations/Animal Feeding Operations (CAFOs/AFOs).
    c. Total Maximum Daily Loads (TMDLs).
    d. Coastal Zone Management Act.
    e. Clean Water Act.
    f. National Environmental Policy Act (NEPA).
    g. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).
    h. Resource Conservation and Recovery Act (RCRA).
    i. Swampbuster.

Competency Area 8. Surface Mine and Mine Spoil Reclamation

1. Define the following surface mine and mine spoil reclamation terms:
    a. acid/base accounting.
    b. top soil substitute.
    c. acid forming materials.
    d. toxic forming materials.
    e. acid mine drainage.
    f. sodicity and salinity forming materials.
    g. land reshaping.

2. Calculate the lime requirement based upon the acid/base account.

3. List criteria for selecting topsoil substitute material instead of native soil.

4. Describe the role of a soil scientist in a surface mineral extraction reclamation plan.

5. Describe methods of soil restoration in surface mineral extraction reclamation.

6. List sources of acid in acid mine drainage.

Competency Area 9. Urban and Disturbed Soils

1. Identify common physical and chemical properties and concerns associated with the following fill materials:
    a. fly ash.
    b. bottom ash.
    c. foundry sand.
    d. railroad ties.
    e. concrete.
    f. asphalt.
    g. construction debris.
    h. biosolids.
    i. demolition debris.

2. Compare and contrast characteristics and properties of the following:
    a. native soils.
    b. urban soils.
    c. disturbed soils.

3. Identify common physical properties and chemical soil impacts associated with the following:
    a. organic solvents.
    b. heavy metals.
    c. petroleum waste products.
    d. household waste.
    e. fly ash.
    f. gypsum.

4. Construct a plan to assess soils on a brownfield site and identify soil and environmental characteristics associated with brownfields.

5. Describe procedures to ameliorate site compaction.

6. Evaluate substrate materials for suitability as a topsoil substitute.

Competency Area 10. Forest Soils

1. Explain the effect of compaction on a forest soil.

2. Explain how soil erosion differs for the following forest areas:
    a. logging roads.
    b. landings.
    c. skid trails.
    d. harvested areas.
    e. undisturbed forest.

3. Explain how infiltration differs for the following forest areas:
    a. logging roads.
    b. landings.
    c. skid trails.
    d. harvested areas.
    e. undisturbed forest.

4. Describe nutrient cycling and losses in the following forest management scenarios:
    a. clear cut harvesting.
    b. prescribed burn.
    c. wildfire.
    d. plantation forestry.
    e. undisturbed forest.

5. Explain the effect of forest fires on soil physical, chemical and biological properties such as:
    a. hydrophobicity.
    b. nutrient transformations.
    c. organic horizons.
    d. soil surface.
    e. nitrogen losses.
    f. carbon losses.

6. Explain the effect of prescribed burns on soil physical, chemical and biological properties such as:
    a. hydrophobicity.
    b. nutrient transformations.
    c. organic horizons.
    d. soil surface.
    e. nitrogen losses.
    f. carbon losses.

FIELD AND LABORATORY TECHNIQUES

1. Analyze and evaluate applicable field measurement strategies for determining soil morphological, physical, chemical and biological properties.

2. Analyze and evaluate applicable laboratory measurement strategies for determining soil morphological, physical, chemical and biological properties.

3. Compare and contrast field and laboratory methods of determining soil physical, chemical and biological properties.

4. Describe how to collect a representative sample of the solid, liquid and gas phases in soil.

5. Design and justify a soil sampling strategy for:
    a. disturbed sites.
    b. nutrient management.
    c. reclamation sites.
    d. contaminated sites.
    e. soil mapping.
    f. wetland delineation.
    g. urban environments.
    h. waste management.
    i. site suitability for development.

6. Select and justify sampling methods based on available equipment and soil properties to be evaluated.

7. Evaluate the proper application of the following sampling equipment:
    a. shovel.
    b. auger.
    c. push-probe.
    d. hydraulic probe.
    e. hammer probe.
    f. split-spoon sampler.

8. Evaluate conditions for proper collection and measurement of field samples with the following common instruments:
    a. tensiometer.
    b. constant head permeameter.
    c. piezometer.
    d. core sampler.
    e. infiltrometer.
    f. penetrometer.
    g. pressure transducer.
    h. ground penetrating radar (GPR).

i. time domain reflectometry (TDR).
j. frequency domain reflectometry (FDR).
k. neutron probe/nuclear densitometer.
l. wells.
m. pH meter.
n. electrical conductivity meter.
o. electromagnetic induction meter.
p. turbidimeter/nephelometer.
q. shallow seismic methods.

9. Interpret and apply laboratory and field measurements for data analysis.

10. Understand the application and limitations of data based on analytical methodology.

11. Evaluate analytical data for sources of error and variability.

12. Evaluate sources of error, variability, and potential contamination for soil sample collection and analysis.

13. Understand standard QA/QC protocols for field and laboratory techniques.

ETHICS

1. Understand the obligations a professional soil scientist has to the soil science profession.

2. Describe obligations and limitations a professional soil scientist has to a client and the interests of the client.

3. Describe a professional soil scientist's obligation to protect the confidence of a client.

4. Understand and apply the professional soil scientist's responsibility to maintain professional integrity.

5. Resolve professional and personal conflicts of interest.

6. Explain the role of the professional soil scientist in the protection of the public's health, safety and welfare, and the environment.