OVERVIEW OF FIELD TECHNIQUES:
SOIL AND GROUNDWATER ASSESSMENT

I. Drilling and Test Borings: The Primary Tool of Subsurface Investigation.

A. Background Information and Protocol

1. Objective: what is the goal of the drilling project.
    a. Regulatory Directives
    b. Assessment Parameters
    c. Results of Phase I Preliminary Investigation
    d. Known problems, hot spots and target areas
    e. Soil? Groundwater? or Both?

2. Preliminary Drilling Information
    a. Base map with engineering specs., boring/well locations
    b. Site Reconnaissance
    c. Property lines, ownership, authorization
    d. Preliminary surveying of reference points
    e. State and Local Drilling Permits?

3. Prescribed Health and Safety Protocol
    a. Potential Hazardous Situations to Personnel
    b. Personal Protective Equipment
        (1) coveralls, respirators, gloves, boots??

    c. Drilling Safety
        (1) Buried pipelines, waterlines, gaslines, electric
        (2) Overhead clearance, electrical wires
        (3) Buried tanks? Drums? Explosive Conditions?

II. Drilling Methods: Varies According to Goals and Geologic Conditions

A. Hollow Stem Auger
1. Penetration to 75-100 Ft depth
2. Excellent for unconsolidated materials
3. Sampling and Devices and Well Materials Lowered Through Drill Stem
4. Commonly used in environmental/engineering applications

B. Cable Tool (percussion Drilling)
1. Weighted Chisel Bit on End of Cable, Lift and fall drilling method
2. Percussion of bit during fall breaks rock apart
    a. rock or unconsolidated material may be drilled
3. Cuttings removed from hole by bailer method
4. Drill hole must be cased to prevent collapse

C. Hydraulic Rotary
1. Rotary action of sharpened drill bit
2. Drill cuttings removed from hole by circulating fluids
3. Hydrostatic pressure of drill mud keeps hole from collapsing

4. Commonly used in deeps wells of oil and gas industry

D. Air Rotary
   1. Rotary action of sharpened drill bit
   2. Cuttings removed from hole by circulation of compressed air down through drill string
   3. Fast and relatively cheap
   4. Casing need to keep unconsolidated materials open
   5. Drawback: in sensitive situations, traces of compressor oil may enter the system (checked by air filters)

E. Air Hammer-Percussion
   1. Jack-hammer type drilling method
   2. Air circulated to remove cuttings from hole
   3. Effective in very hard crystalline rock terrains

F. Combination Percussion-Hammer/Casing Advance System
   1. Simultaneous air-hammer drilling with steel casing advanced down borehole ("ODEX", "TUBEX")
   2. Drill cuttings removed via air and double walled casing system
   3. Good for difficult drilling conditions where hole stability is problem (e.g. Mine Spoil with sandstone boulders)

III. Other Types of "Holes in the Ground"

A. Backhoe Trenching
   1. With a large piece of equipment may extend to 25 Ft depth

B. Hand-dug Soil Pits

C. Hand Augering (down to 20 Ft if you're lucky)

D. Motorized Post-Hole Diggers ("Beaver Augers")

E. Direct-Push Drive Points
   1. New technology for environmental industry
   2. Replaces hole drilling, hammer hardened steel drive points directly into subsurface
   3. Casing allows sampling of groundwater
   4. Good for unconsolidated/shallow applications
   5. Limited diameter, to several inches

IV. Geological Sampling Techniques

A. Soil Sampling By Hollow-Stem Auger/Split Spoon Sampler
   1. Spoon sampler lowered through hollow-stems
   2. Allows unaltered sample to be taken prior to advancing drill stem (unconsolidated materials only)
   3. Sampler generally 2 ft in length, driven into unconsolidated materials by hammer (140 # Wt. dropped 30 inches)
      a. "Blow Counts": no. of hammer blows required to drive sampler 6 inches in depth
      b. Gives thumbnail idea of material density/compaction
      c. 50 blows with no penetration = "refusal"
   4. Samples retrieved at prescribed depths for geologic description and/or chemical analysis, physical/engineering testing

B. Thin-walled Sampler ("Shelby Tubes")
1. Samples collected in tubes driven into unconsolidated sediments
2. Shelby tubes used for soils engineering testing

a. vertical permeability

C. Rotary Drill Cuttings (Air/Mud)
1. Rock/sediment cuttings retrieved and logged by geologist
a. depth, lithology, color, physical character
2. Samples may be bagged and archived for later examination

D. Coring
1. Coring device removes cylinder of rock for geologic description
2. Only good recovery technique for detailed geologic analysis

E. Field Screening of Soil and Sediment Samples for contamination
1. Rapid chemical field tests ("Hach Kits for PCB's, metals, pH)
2. Organic Vapor Detectors (hydrocarbon contamination)
3. Visual inspection/odors, anomalous color, chemical reactions

F. Sample collection, archiving, shipment to lab for analysis
1. Chain-of-Custody Protocol, EPA sampling technique protocol
2. Documentation of sample handling and analysis (legal ramification)

V. Precautions Against Cross-Contamination and "Induced Contamination"
A. Systematic Decontamination Procedures
1. Constant cleaning and washing of all sampling materials
2. Constant attention to sample handling (glove disposal, etc.)
3. Avoid moving "contaminated" equipment from location to location
B. Steam-Cleaning of Drill Equipment
1. "Steam-Genie": mobile pressurized steam washer (hot water shower)
2. Cleaning of drill rig, drill rods, samplers, bits, materials
3. Decon Pad: designated area for cleaning of materials and collection of wash waters
a. Disposal Protocol for Wash Waters?

C. Induced Contamination Pathways during Drilling Process
1. Drilling Fluid Additives/Recirculated Fluids
2. Water Recirculated in Drill Hole to Clean Hole
3. Compressor Oil from Air-Rotary
4. Drilling Muds/Grout
5. Drilling Lubricants/Antifreeze

** constant attention to what is put in hole, and how might it cause a chemical overprint on the system... eliminate "false positives" ** Law Suits Prevail!

VI. Monitoring Well Construction

A. Considerations
1. Use of well (sampling only?, water depth measure? pumping/recovery?)

2. Depth of well (20 ft? 100's of feet?)

B. Well Components

1. "Slotted Screen" - porous slotted pipe that allows water to enter monitoring well
2. "Riser Pipe" - solid pipe of same diameter as screen, "rises" access hole to surface
3. Pipe Couplings
    a. No glues/adhesives used (deteiorate, potential contaminant)
    b. Threaded pipe joins, to join lengths of riser/screen
4. Outer Formation Casing- necessary to use casing to prevent hole collapse
5. "Sand Pack": coarse, clean porous material used to "pack" screen to serve as filter, prevent formation collapse on scree
6. "Bentonite Seal": impermeable clay sealant used to seal the annular space around riser, generally set above screen to seal off screened/ water-bearing horizon.
7. "Grout Seal": cement-bentonite mixture used to seal riser pipe to the surface, prevents upper level leakage into well.
8. Upper Protective Casing: steel cover for well assembly to prevent damage, locking to prevent unwanted access/environmental espionage.

See attached diagrams of typical monitoring well installation *

C. Types of Well Materials

1. selected dependent upon geologic/chemical conditions, depth of well
2. Types of materials
    a. PVC, stainless steel, teflon
        (1) Stainless and teflon are chemically non-reactive, but expensive
        (2) PVC is useful and cheapest, but may actually dissolve in cases of organic solvents, or melt under high temperatures (exothermic reactions)
    b. Sand Pack: clean silica sand, of variable grain-size depending on screen slot size
    c. Bentonite Seal: Powdered or pelletized bentonite, expands upon hydration to form impermeable barrier
    d. Cement Grout Mix: usually 5% Bentonite-95% cement slurry, bentonite used to temper cement, prevent fracture

D. Well Completion

1. Well Development
    a. Initially well may be "clouded" with silt/drill cuttings
    b. Development involves pumping, bailing, removal of water from well to remove dirt and debris
    c. Well development also cleans sand pack and surrounding formation to enhance water production
    d. Development of well until water is clear and of constant pH/conductivity

2. Special Problems
    a. Grout Contamination

(1) Many problems if cement grout leaks into well
(2) Make sure a good bentonite seal is on well
(3) Very little grout/cement in well will cause water impacts (>pH (up to 12-13), K, Ca, Na, Ba, > conductivity)
(4) Requires a lot of work to clean aquifer/well of grout impacts, may render well useless

3. Other Development Techniques
   a. Overpumping, bail-surge techniques
   b. well surging: plunger method of causing turbulence to clean screen/sand pack

4. Final Well Data
   a. Elevation control, surveying, map location, GIS entries
   b. Well completion diagram showing installation details
      (1) depths, problems, diameters, materials
   c. Well Development Report

VII. Sampling of Monitoring Well
   A. Strict protocol according to EPA standards, extensive documentation of how and why well was sampled... Lawsuits Prevail!
   B. Preliminary Details
      1. What wells to be sampled?, location maps, keys, equipment
      2. What are wells being sampled for?
         a. Chemical Parameters to be Analyzed by Lab?
         b. Field Parameters to be Checked by Field Personnel
         c. Acquire Labe Sample Bottles According to Protocol
         d. How many samples to be collected, sample volumes?
      3. Establishment of Prescribed Sampling Plan
         a. Sample protocol, special considerations/techniques?
         b. Health and Safety Precautions: HASP
            (1) personal protection equipment (gloves, coveralls, goggles, respirator, etc.)
            (2) Access permits, authorization, dangerous conditions
         c. Decon and cleanliness: How to keep samples and yourself from being cross-contaminated?

   C. Preparing Well for Sampling
      1. Opening well, removing well caps, allowing well to equilibrate with atmospheric pressures
      2. Measuring of Static Water Level (M-scope, water level detector)
      3. Sounding total depth of well (check for collapse/obstructions)
      4. Purging of Well
         a. removal of stagnant well water to encourage fresh aquifer flow into well
         b. Generally: 3-5 well volumes extracted prior to sampling
         c. Allow well to recover sufficiently to collect sample
         d. Disposal of purged water?

D. Water Sampling Devices
    1. Bailer (PVC, teflon, stainless steel: contaminant specific)
    2. Pumps
        a. submersibles, suction-lift, bladder pumps

E. Cleanliness/Cross-contamination
    1. clean, clean, clean
    2. begin with "clean" wells, end with "dirty"
    3. wash everything all the time, dispose of all contaminated materials
    4. Dedidicated sampling equipment (bailers, pumps left in well... can get expensive)

F. Sample Handling
    1. Bottle/container management; Chain of custody
    2. Preservatives for specific chemical parameters
        a. refrigeration, acids, sodium hydroxide

G. Field Parameters
    1. temperature, pH, dissolved oxygen, conductivity
    2. Field gas chromatograph?
    3. portable vapor analyzers?
    4. Hack Kits: various metals, PCB's etc.

H. Quality Control: Samplers to Lab
    1. Chain of Custody Records
    2. Document everything done and said
    3. Protocol checklist procedures
    4. Lab Checks
        a. Trip blanks, spiked samples
    5. Sampler Checks
        a. "field blanks" to check cleanliness/decon.

VIII. Overview of Health and Safety Procedures

A. Routine Safety
    1. Drilling
        a. Trips, falls, stupid tricks
        b. Select a safe and knowledgable drilling contractor
        c. Preliminary site orientation
        d. Underground Utilities
        e. Buried Objects
        f. Overhead Lines
        g. Basic safety equipment: hard hat, goggles, steel toes
        h. Drill Rigs and Falling Objects
    2. Basic Safe Lifting Techniques for Field "Grunts"
    3. Excavations: anything >5 Ft deep requires retaining device

B. Procedures for Contaminated Sites
    1. Eliminate Pathways of Contamination into Body
        a. Personal Protective Equipment

    2. Know what you're walking into, chemistry, LD50's, toxicity

3. Keep eye out for toxic effects
    a. Local, acute
    b. Systemic acute
    c. Local Chronic
    d. Systemic chronic

4. NIOSH Guidelines to Chemical Hazards
    a. Substances/compound I.D.
    b. Permissible Exposure Limit (here's a good one)
    c. Health Hazards (MSDS sheets)
    d. Monitoring equipment (radiation badges, gas detectors, geiger counter)

5. Fire/explosive conditions
6. Confined space hazards (Oxygen-deficient conditions)
7. Personal Protective Equipment
    a. Respirators
    b. Supplied Air: SCBA's
    c. Protective, chemical resistant clothing/boots
8. USEPA Levels of Protection
    a. Level A: Encapsulating Suit, SCBA/supplied air
    b. Level B: Splash suit, SCBA/supplied air, gloves, boots
    c. Level C: Splach suit, gas mask, boots, gloves
    d. Level D: coveralls, boots
9. Dangerous Situations: "Just Say No" to drillers, clients and managers. If things look unsafe, they probably are.

C. Health and Safety Training
    1. 40 OSHA training/certification
    2. 8-hr OSHA refresher/update annually
    3. Documentation kept with you to enter a site

D. Personal Decontamination
    1. Dispose of all contaminated clothing and boots
    2. never eat/drink on site
    3. wash, scrub, clean ... decon. yourselt and equipment
    4. Decon. Stations: from dirty to clean away from work site

E. Health Monitoring
    1. Blood Tests
    2. Radiation testing
    3. Regular Check-ups