SOIL SAMPLING UTILIZING
HORIZONTAL/DIRECTIONAL DRILLING
METHODS
Directional Control

- The bit is navigated along a prescribed path
- The bore path need not be horizontal or straight
- Bore path is design is based on
  - Allowable bending radius of drill pipe
  - Geology
  - Sample location
  - Surface constraints
Directional Control/Steering

- The drill string is steered by pushing the drill pipe against an asymmetric bit with a hydraulic jet; “duck bill” or bent sub.
- The force against the bit or sub forces the drill pipe in direction of the bit orientation.
- When the entire assembly is rotated, the drill string goes straight.
- A sensor behind the bit sends the direction/orientation of the bit to the surface.
Directional Control/Steering
Locating Technologies

• Several Options Available
  – Walkover/Radio Beacon
  – Wireline
    • Oil Field Technology
    • Short Steering Tool (SST)
  – Gyroscopic

• Selection based on bore path, interference risk, depth and cost

• All methods have ± 0.5 – 2% depth accuracy
Drilling Fluids are Required

• Maintain hole stability
• Remove cuttings
• Limit drilling fluid loss to the formation
• Cool bit and steering tools
Bore Path Geometry

• **Terminology**
  – Entry angle
  – Tangent
  – Radius of curvature (build radius)
  – Horizontal section
  – True vertical depth
  – Measured depth/pipe length
  – Set back – determined by combination of the above
Bore Path Geometry

- True Vertical Depth
- Entry Angle
- Tangent
- Build Radius
- Set Back
- Horizontal/Screen Section
- Total Horizontal Displacement
Drilling Equipment

- Drill rig
- Fluid cleaning/recycling system
- Pipe trailer
- Support vehicles
  - Water truck
  - Crew truck
Small Rig Set Up Area

- 7,000 lb. capacity rig
- 30’ x 50’ area
Soil Sampling

• Goals
  – Obtain representative samples at a predetermined target
  – Challenges
    • Sample location
    • Avoid “scraping” sample from side wall or bottom of borehole
    • Exclude drilling fluids
    • Retain unconsolidated material
    • Quick visual identification
Tooling

- Two types of samplers
  - Set screw/bullet nose
DTD “Bullet” Sampler
Tooling

- Two types of samplers
  - Piston
Tooling

• Sample recovery
  – 2” diameter up to 18” long
  – Standard acetate sleeves allows for visual inspection
Soil Sampling

• Methodology
  – Drill/steer to sampling point
  – Remove drill rod
  – Push sampler to end of bore
  – Obtain sample
  – Pull sampling tool
  – Repeat
Project Sites

• Past Projects
  – DOE Site, OH/building slab
  – Belle Chase, LA/1,000,000 gallon tank
  – Pasco, WA/unlined landfill
  – Belle Chase, LA/concrete revetment
  – Urban Site, CA/occupied housing
  – Industrial Facility, IL/under pond
Soil Sampling Case Study

- Urban location
  - Obtain soil samples under occupied residences
    - Unconsolidated formation
    - Sample locations up to 50’ from entry location and 3’ - 4’ sub slab
    - Drilling fluid containment critical
Case Study - Urban
Case Study – Urban
Case Study – Urban

Diagram showing the location of Building X and the sampling points for Sample 1 at STA 35, with a depth of 2.9' bgs.
Case Study – Urban

- Ten samples obtained
- No impact to residents
- Drilling fluids contained
- Eleven days on site
  - Test event
  - Decon
- $10,000/sample
Case Study – WA Landfill

• Closed mixed waste facility
• Buried stacked drums
• Engineered cap, no liner
• Adjacent to active transfer station
• Challenging drilling conditions
  – Locating interference from drums
  – Soil conditions
Case Study – WA Landfill

Capped Landfill
Case Study – WA Landfill
Case Study – WA Landfill
Case Study – WA Landfill

- 70 soil samples obtained
- 2,290’ total footage drilled
- Over 91,000’ of drill pipe tripped
- $3,560/Sample
In Summary

- The technology is innovative - not experimental
- New tooling provides for sample quality
- Method is expensive and site specific
- Allows for soil samples to be obtained in areas unreachable by traditional vertical/angle drilling
- The technology is innovative – not experimental