General Response Action – Removal, Excavation Methods

Presented by: J. R. Schneider/T. A. DeBiase

Location: Shilo Inn, Richland, Washington
Date: June 7, 2011
General Response Action – Removal, Excavation Methods

General Description
• Excavation is advanced by using earthmoving equipment
• Overlying clean soil is removed and stockpiled
• Contaminated soil is removed and disposed
• Clean stockpiled soil is replaced to extent possible
• Excavation sides are sloped or supported
• Methods can be combined to achieve greater excavation depths

Potential Contaminants:
• All

Potential Contaminants:
- U
- Tc99
- I-129
- CrVI
- CCl4

Excavation
Soil for disposal

U, Tc99, I-129, CrVI, CCl4
Three primary methods for deep excavations:

1. Open excavation using sloping or benching
2. Drilling and soil replacement
3. Excavation with braced sidewalls, such as:
   a. Sheet pile walls
   b. Soldier piles wall
   c. Diaphragm walls
   d. Soil nail walls
   e. Cast pile wall
   f. Caisson wall
   g. Other misc methods
Technology - Deep Excavation with Sloping and/or Benching (Open Pit Mining)

General Description

- Excavation is advanced by using earthmoving equipment
- Excavation sides are sloped or benched
- Can be combined with shoring to achieve greater excavation depths

Potential Contaminants:
- All
Technology - Deep Excavation with Sloping and/or Benching (Open Pit Mining)

State of Development
• Mature - uses proven heavy equipment
• Depth is essentially unlimited

Limitations/Development Needs
• Large surface area impacted because of sloped sides and may also impact surface features such as tanks, piping, structures, etc.
• Requires large stockpiles and separate disposal facility

<table>
<thead>
<tr>
<th>Lab Testing Only</th>
<th>Field Testing Only</th>
<th>Limited Field Application</th>
<th>Remediation Ready (limited application)</th>
<th>Remediation Ready</th>
</tr>
</thead>
</table>

100-B-27
Technology - Deep Excavation using Dragline Excavators

General Description

- Excavation is advanced by using large draglines
- Walls are sloped or benched

Potential Contaminants:
- All
Technology - Deep Excavation using Dragline Excavators

Limitations/Development Needs

- Sloped sides & dragline size may impact surface features
- Requires large stockpiles and separate disposal facility
- Cannot practically be combined with shoring
- Equipment availability

<table>
<thead>
<tr>
<th>Lab Testing Only</th>
<th>Field Testing Only</th>
<th>Limited Field Application</th>
<th>Remediation Ready (limited application)</th>
<th>Remediation Ready</th>
</tr>
</thead>
</table>

P&H Cranes/Harnishfeger Corp.
General Description

- Large diameter holes are drilled to remove contamination
- Each hole is backfilled with a low strength soil-cement mixture that does not require compaction

Potential Contaminants:
- All

Bored-Piles.com
Technology - Deep Excavation using Drilling and Soil Replacement

State of Development
• Mature - uses proven heavy equipment
• Large diameter borings have been drilled to over 200 feet at sites that included large cobbles

Limitations/Development Needs
• Large equipment is required
• Large number of borings required to cover a large area or very accurate knowledge of contamination required
• Excavation control is more difficult with greater depth (e.g. achieving vertical borings)
• Requires re-excavation of some previously placed backfill if borings must overlap to remove entire target
General Description

- Steel sheet piling with interlocking grooves at the sides are inserted into soil by hammering or vibrating.
- Excavation uses conventional equipment.

Potential Contaminants:
- All
Technology - Deep Excavation using Sheet Piling

State of Development
- Mature - uses proven equipment and materials
- Maximum depth is about 50 feet
- Walls can be supported or excavation can be stepped to achieve greater depths

Limitations/Development Needs
- Boulders and cobbles can prevent sheet pile insertion
- Wall support may be impractical at great depths

<table>
<thead>
<tr>
<th>Lab Testing Only</th>
<th>Field Testing Only</th>
<th>Limited Field Application</th>
<th>Remediation Ready (limited application)</th>
<th>Remediation Ready</th>
</tr>
</thead>
</table>

Dywidag Systems International/DSI America
Technology - Deep Excavation using Soldier Pile and Lagging Wall

General Description

• Steel H-piles are inserted into soil at regular intervals by driving or by placing in drilled holes
• Timber or steel “lagging” is placed between the piles to support the ground as the excavation is advanced
• Excavation inside wall uses conventional equipment

Potential Contaminants:
  • All

www.retaininglewalldesign.com
Technology - Deep Excavation using Soldier Pile and Lagging Wall

State of Development
- Mature - uses proven equipment and materials
- Maximum depth is about 100 feet
- H-piles usually supported by anchors
- Excavation can be stepped to achieve greater depths

Limitations/Development Needs
- Boulders and cobbles can make vertical control difficult
- Loose material can make lagging insertion difficult

<table>
<thead>
<tr>
<th>Lab Testing Only</th>
<th>Field Testing Only</th>
<th>Limited Field Application</th>
<th>Remediation Ready (limited application)</th>
<th>Remediation Ready</th>
</tr>
</thead>
</table>

Neo Samwoo Vietnam Co., Ltd.
Technology - Deep Excavation using Diaphragm Walls

General Description

- Reinforced concrete wall constructed in panels
- Bentonite slurry is used to support each panel excavation
- Excavation inside wall uses conventional equipment

Potential Contaminants:
- All
Technology - Deep Excavation using Diaphragm Walls

State of Development

• Mature - uses proven heavy equipment
• Maximum depth is about 200 feet
• Wall is usually supported by anchors

Limitations/Development Needs

• Uses highly specialized equipment
• Slurry makes the work somewhat “sloppy”
• Wide corridor (75 - 100 feet) required along wall alignment

StroyInject, Bulgaria
Technology - Deep Excavation using Soil Nail Walls

General Description

- A shallow cut is made, and steel reinforcing bars are inserted into the cut face at regular intervals
- Wire mesh and sprayed-on concrete are applied to protect and support the face (other materials can be used)
- The process is repeated until target depth is reached

Potential Contaminants:
- All

Figure 4
Technology - Deep Excavation using Soil Nail Walls

State of Development
• Mature - uses proven equipment
• Limited to about 30-40 feet
• Excavation can be stepped to achieve greater depths

Limitations/Development Needs
• Requires cohesive soil and unsaturated or minimal water flow conditions

<table>
<thead>
<tr>
<th>Lab Testing Only</th>
<th>Field Testing Only</th>
<th>Limited Field Application</th>
<th>Remediation Ready (limited application)</th>
<th>Remediation Ready</th>
</tr>
</thead>
</table>
Technology - Deep Excavation using Secant Pile Wall

General Description

- Secant pile walls are formed by constructing intersecting drilled reinforced concrete piles
- Piles reinforced with steel reinforcing bars or H-piles

Potential Contaminants:
- All

“Hard/Hard” Wall

“Hard/Soft” Wall
Technology - Deep Excavation using Secant Pile Wall

State of Development
- Mature - uses proven heavy equipment
- Maximum depth for single stage is about 50 feet; walls often anchored
- Excavation can be stepped to achieve greater depths

Limitations/Development Needs
- Vertical alignment control is critical and becomes more difficult with increasing depth and rocky ground

<table>
<thead>
<tr>
<th>Lab Testing Only</th>
<th>Field Testing Only</th>
<th>Limited Field Application</th>
<th>Remediation Ready (limited application)</th>
<th>Remediation Ready</th>
</tr>
</thead>
</table>

USDOT - FHWA
Technology - Deep Excavation using Tangent Pile Wall

General Description
- Same as secant pile walls, except that piles touch but do not intersect

State of Development
- Mature - uses proven heavy equipment
- Maximum depth for single stage is about 50 feet; walls often anchored
- Excavation can be stepped to achieve greater depths

Limitations/Development Needs
- Vertical alignment control is critical and becomes more difficult with increasing depth and rocky ground
- More potential for gaps between piles than with secant pile wall

<table>
<thead>
<tr>
<th>Lab Testing Only</th>
<th>Field Testing Only</th>
<th>Limited Field Application</th>
<th>Remediation Ready (limited application)</th>
<th>Remediation Ready</th>
</tr>
</thead>
</table>

Potential Contaminants:
- All

USDOT - FHWA

U.S. DEPARTMENT OF ENERGY

HNF-49890-VA
Technology - Deep Excavation using Caissons

General Description
• A reinforced concrete box open at the top and bottom is “sunk” into the ground by excavating inside
• More sections can be added on top to go deeper

Potential Contaminants:
• All

Lab Testing Only | Field Testing Only | Limited Field Application | Remediation Ready (limited application) | Remediation Ready

HNF-49890-VA
Technology - Deep Excavation using Caissons

State of Development
• Mature - uses proven heavy equipment
• Can be used where soil contains large boulders that obstruct penetration of driven or bored piles
• Maximum practical depth is about 80 feet

Limitations/Development Needs
• Complex construction; requires large equipment
• Caisson remains in place; area may be limited
• Caissons can hang on cobbles, boulders, dense soil, etc.
• Goes straight down only

Example 1 Acre Site, 200 ft deep:
• The required depth cannot be achieved.

Ward & Burke, Ireland
Technology - Deep Excavation using Jet Grout Walls

General Description
- One to three rows of grouted columns are formed by jetting grout horizontally under high pressure to form a wall
- Reinforcing may be placed in the center of each column

Potential Contaminants:
- All

Portland Cement Association
Technology - Deep Excavation using Jet Grout Walls

State of Development
• Mature - uses proven heavy equipment
• Wall may be laterally supported
• Maximum depth for single stage is about 50 feet; walls often anchored
• Excavation can be stepped to achieve greater depths

Limitations/Development Needs
• Vertical control is critical and becomes more difficult with increasing depth and rocky ground
• Complete mixing may not be achieved, and thus wall may not have required strength

<table>
<thead>
<tr>
<th>Lab Testing Only</th>
<th>Field Testing Only</th>
<th>Limited Field Application</th>
<th>Remediation Ready (limited application)</th>
<th>Remediation Ready</th>
</tr>
</thead>
</table>

Spie Fondation, France
Technology - Deep Excavation using Deep Mixed Walls

General Description

- Multi-auger mixers are used to mix Portland cement grout with in-place soils in panels; panels overlap
- H-piles can be inserted for reinforcement

Potential Contaminants:
- All
Technology - Deep Excavation using Deep Mixed Walls

State of Development
- Mature - uses proven heavy equipment
- Wall may be laterally supported
- Practical limit is about 50 feet
- Excavation can be stepped to achieve greater depths

Limitations/Development Needs
- Generates substantial volumes of excess excavated material due to bulk swell and fluid injection
- Vertical control and panel overlap can be difficult

<table>
<thead>
<tr>
<th>Lab Testing Only</th>
<th>Field Testing Only</th>
<th>Limited Field Application</th>
<th>Remediation Ready (limited application)</th>
<th>Remediation Ready</th>
</tr>
</thead>
</table>
Technology - Deep Excavation using Reinforced Concrete Walls

General Description

- Excavation is temporarily supported using methods such as sheet piles, soils nails, soldier piles, etc.
- Reinforced concrete wall is constructed to support the ground; wall may be anchored into the ground.
- Method usually used for permanent construction.

Potential Contaminants:
- All

<table>
<thead>
<tr>
<th>Lab Testing Only</th>
<th>Field Testing Only</th>
<th>Limited Field Application</th>
<th>Remediation Ready (limited application)</th>
<th>Remediation Ready</th>
</tr>
</thead>
</table>

U.S. DEPARTMENT OF ENERGY

HNF-49890-VA
Technology - Deep Excavation using Reinforced Concrete Walls

State of Development
• Mature - uses proven heavy equipment
• Can remove impacted materials that can be reached

Limitations/Development Needs
• Intended for permanent support

<table>
<thead>
<tr>
<th>Lab Testing Only</th>
<th>Field Testing Only</th>
<th>Limited Field Application</th>
<th>Remediation Ready (limited application)</th>
<th>Remediation Ready</th>
</tr>
</thead>
</table>

HNF-49890-VA
Technology - Deep Excavation using Cofferdams

General Description
- Sheet-pile, tangent pile, secant pile, or diaphragm walls are constructed in circular or rectangular shapes to enclose an earth mass
- Internal bracing or anchoring may be used
- Use to support heavy vertical and horizontal loads (normally used near water bodies)

Potential Contaminants:
- All

Lab Testing Only | Field Testing Only | Limited Field Application | Remediation Ready (limited application) | Remediation Ready

SheetPilesPiling.com
Technology - Deep Excavation using Cofferdams

State of Development
- Mature - uses proven heavy equipment
- Limited to about 40 feet
- Excavation can be stepped to achieve greater depths

Limitations/Development Needs
- Wall is much thicker since it relies on gravity instead of anchors to prevent overturning

CJ Mahan Construction Company
Technology - Deep Excavation using Tunneling

General Description

• Tunnel is created by full-face excavation, boring machine, pipe jacking, or other conventional tunneling technique

• Completely enclosed tunnel except for access openings

Potential Contaminants:

- All

<table>
<thead>
<tr>
<th>Lab Testing Only</th>
<th>Field Testing Only</th>
<th>Limited Field Application</th>
<th>Remediation Ready (limited application)</th>
<th>Remediation Ready</th>
</tr>
</thead>
</table>

TunnelTalk.com
Technology - Deep Excavation using Tunneling

State of Development
• Mature - uses proven heavy equipment
• Access shafts will be required, or tunnels must be sloped
• Can remove impacted materials that can be reached

Limitations/Development Needs
• Large cobbles and boulders will impact the selection of tunneling equipment/techniques
• Excavation of unconsolidated materials can be difficult since material is not self-supporting

<table>
<thead>
<tr>
<th>Lab Testing Only</th>
<th>Field Testing Only</th>
<th>Limited Field Application</th>
<th>Remediation Ready (limited application)</th>
<th>Remediation Ready</th>
</tr>
</thead>
</table>

TunnelTalk.com
Technology – Perched Water Removal

General Description
• Water perched above low-permeability areas within the vadose zone is pumped before it migrates to groundwater
• Wells must be correctly placed to adequately capture the extent of the perched water

Potential Contaminants:
• U, Tc-99, Cr(VI)

Perched Water Extraction Pilot Test at B Complex
Technology – Perched Water Removal

State of Development
• Technology is well proven; currently being deployed in the B Complex

Limitations/Development Needs
• Low flow rates and delays to allow recharge can extend remediation time
• Perched water is ephemeral (transitory)
General Description

- Subsurface water within the unsaturated zone containing mobile contaminants is extracted
- Soil gas with entrained water is extracted from the subsurface through a well using high vacuum to induce high vapor extraction rates

Potential Contaminants:
- All
Technology – Pore Water Extraction

State of Development
• Pore water extraction is being evaluated in a pilot test planned for the 200 East Area of the Hanford Site

Limitations/Development Needs
• Pore water is difficult to completely remove; some contaminants will adsorb to the soil and not move freely with the pore water
• Need to optimize recovery rates and determine the effectiveness in removing pore water held in tighter formations

<table>
<thead>
<tr>
<th>Lab Testing Only</th>
<th>Field Testing Only</th>
<th>Limited Field Application</th>
<th>Remediation Ready (limited application)</th>
<th>Remediation Ready</th>
</tr>
</thead>
</table>

HNF-49890-VA
General Description

- Mobilization of contaminants with water so they can be removed and treated or disposed.
- Surfactants or other chemical additives may be used to enhance solubilization of contaminants.

Potential Contaminants:
- All

In-Situ Soil Flushing using Treated Water (http://www.epa.gov/)
Technology – Soil Flushing

State of Development
• Mature technology for shallow applications

Limitations/Development Needs
• Can only be applied where soil has sufficient permeability to allow circulation and recovery of flushing solution
• Soil heterogeneity can prevent optimum contact and decrease reliability
• Requires flushing through thick vadose zone with effective capture of contaminants in groundwater
General Description

- Recovers uranium by dissolving it with a solution and pumping the solution to the surface for removal. This technology is most widely used for uranium mining in saturated conditions.

Potential Contaminants:

- U
Technology – In Situ Uranium Recovery

State of Development

• Proven technology for in situ uranium mining
• No known applications for to remedy uranium contamination

Limitations/Development Needs

• Technology has not been known to be applied successfully in vadose zone strata above a water table
• Spatial heterogeneity in the subsurface makes complete recovery and control of leachate very difficult using extraction wells