

Quantum Murray LP

Barrier Walls

Which Type and Why?

***Federal Contaminated Sites – Innovative Remediation Solutions Workshop
Banff, AB
October 2008***

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Agenda

- Clay Bentomat Barrier Walls
- Soil Bentonite Admixture / Waterloo Barrier Walls
- Bentonite Slurry Trenches
 - Bentonite Slurry Barrier Walls
 - Funnel and Gate Barrier Walls
 - Slurry Slot Excavation Concrete Barrier Walls
 - Diaphragm Barrier Walls
- Biodegradable Slurry Permeable Reactive Barrier
- One Pass Trenching Barrier or PRB Walls

Confidential Site – Toronto, ON Bentomat Liner Cut-off Wall



The Challenge

- Install 270m vertical impermeable barrier at P/L, at depths from 3-10 mbg in a safe manner that minimized geotechnical and employee risk;
- Design permeability had to be $<10E-8$ m/s;
- Install upgradient drainage and dewatering system















Bentomat Liner Cut-off Wall Advantages

- Allows for variable depth profiles
- Can be manufactured to meet a design permeability up to $10E-12$ m/s
- Relatively inexpensive barrier material, no field welding required as overlap and hydration form continuous barrier
- Simple to install on slopes
- Can be installed without specialized equipment

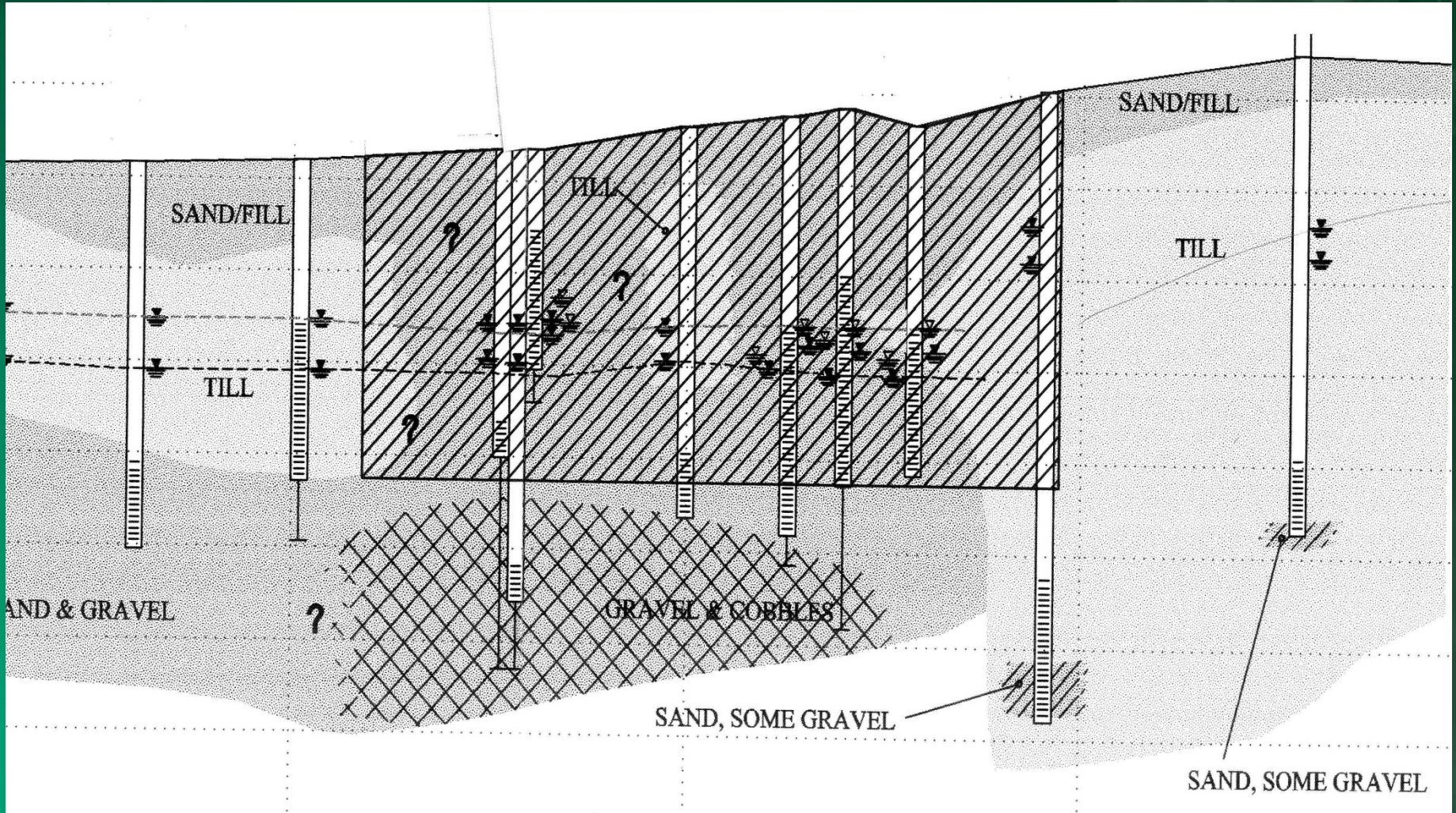
Confidential Site, BC - Design/Build Waterloo Barrier / Soil Bentonite Admixture / Insitu LNAPL Collection System



The Challenge

- Design/install an impermeable barrier to 8.5 mbg adjacent to foreshore in very dense till
- Key barrier into low-permeability sediments to prevent short circuiting
- Design/install 13 LNAPL skimmers package in active railyard to collect LNAPL

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Engineered Fill Cut-off Walls - Advantages

- Allows for variable depth profiles
- Can be engineered for various design permeabilities (10E-7 to 10E-12 m/s)
 - Sand gradation (> fines content lowers permeability; >20%)
 - Bentonite content
 - Compactive effort (90 to 100 SPD)
- Wall thickness can be designed to meet required flow characteristics
- Allows for post-installation testing of barrier material

Waterloo Barrier - Advantages

- Allows for deep barrier wall (up to 20m)
- Tight continuous interlock filled with grout provides barrier integrity
- Can be driven with conventional pile driving equipment
- Can be removed and reused
- Certified for 1x10E-11 m/s

Slurry Excavation – Barrier Walls, PRBs, Funnel and Gate, and Diaphragm Walls



The Challenge

- Install an impermeable barrier or permeable reactive barrier in unconsolidated sediments to depths well below the water table

Slurry Excavation – Barrier Walls, PRBs, Funnel and Gate, and Diaphragm Walls

Slurry Trench Excavation – Basic Principles

- Trench wall stability is maintained by excess head of slurry compound in the trench (slurry level must be maintained above gw level)
- Excess head maintained by minimizing loss of slurry to formation by:
 - Reduced K at trench interface as slurry compound fills voids in formation
 - Monitoring and maintaining viscosity of slurry compound in the trench (temp., % bentonite or guar gum, % sand)
 - Introducing make up slurry
- Bentonite must be completely hydrated in slurry to maintain viscosity and remain available to fill voids at trench wall interface
- Hydraulic conductivity of formation reduced as a result of the introduction of bentonite slurry
- No long term change in K of formation when using guar gum as slurry compound (PRB application)

Slurry Excavation – Barrier Walls, PRBs, Funnel and Gate, and Diaphragm Walls



Field Preparation of Bentonite Slurry

- Water supply conditioned with soda ash to raise pH
- Dry powdered bentonite mixed with water using shear type pumps (mud mixers)
- Slurry re-circulated in baffled mixing tanks for full hydration
- Tested to meet a minimum Marsh cone standard of 38 seconds (viscosity test)
- Pumped to a holding basin and re-circulated in basin

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Field Preparation of Soil-Bentonite Admixture (Trench Backfill)

- Weighing and dry mixing of 50% of the bentonite with sand
- Addition/mixing of the remaining required bentonite in dissolved format (hydration)
- Addition of water to obtain 5"-6" slump test
- Slump test dictates self-placement characteristics of trench backfill

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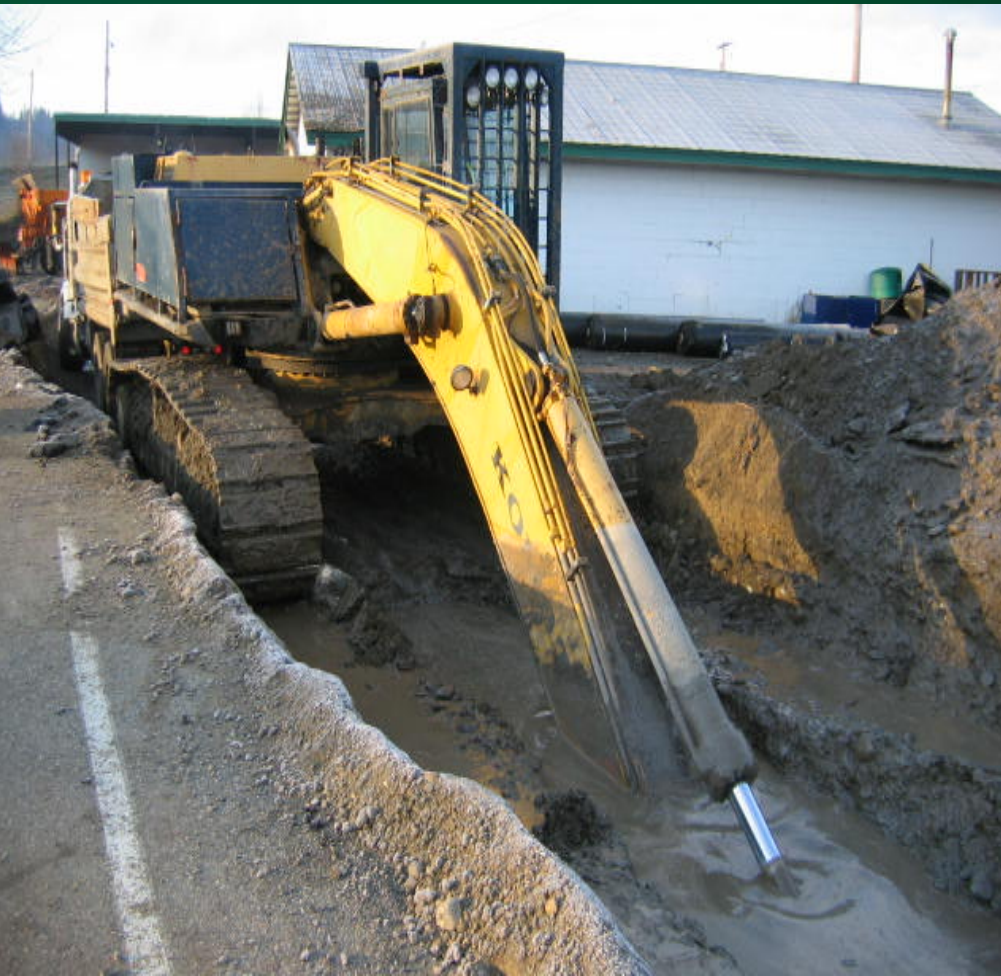
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Trench Excavation and Backfilling

- 1 m deep bench excavated – control slurry and spoil/attain design depth
- 2 excavators working simultaneously excavating and backfilling
- Slurry maintained at ~1mbg (gw @ 3.5mbg)
- ~15 m of trench open at once
- Trench backfill placed (3H:1V) and self compacting
- Continual depth sounding of trench to confirm depth and backfill location

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Bentonite Slurry Trench Funnel and Gate

- 850 lm, maximum 6.0 m deep bentonite slurry trench keyed into up-gradient clay to form the 'funnel'
- Treatment corridor comprising, sediment removal, LNAPL recovery, air sparging and GAC polishing
- Riprap armouring barrier wall for flood protection

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Slurry Slot / Concrete Backfill Barrier Wall

- Excavation shoring in vadose zone
- Slurry slot excavation techniques below the water table
- Backfilling of slots with concrete to form impermeable barrier
- Slurry excavation and backfilling completed on alternating slots to install barrier wall
- Excavate entire centre of site to remove contaminated soil

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Slurry Excavation – Barrier Walls, PRBs, Funnel and Gate, and Diaphragm Walls



Diaphragm Barrier Walls

- Install 2.5 km of diaphragm wall using trench stops to complete works in ~20 m segments
- Bentonite slurry excavation to design depth
- Placement of re-bar and concrete in trench to construct continuous barrier / shoring / foundation wall
- Excavation and drilling of anchors if excavation to remain open
- Excavate entire centre portion of site in slots to remove contaminated soil

Slurry Excavation – Barrier Walls, PRBs, Funnel and Gate, and Diaphragm Walls



Diaphragm Barrier Walls

- Install 2.5 km of diaphragm wall using trench stops to complete works in ~20 m segments
- Bentonite slurry excavation to design depth
- Placement of re-bar and concrete in trench to construct continuous barrier / shoring / foundation wall
- Excavation and drilling of anchors if excavation to remain open
- Excavate entire centre portion of site in slots to remove contaminated soil

Slurry Excavation – Barrier Walls, PRBs, Funnel and Gate, and Diaphragm Walls



Diaphragm Barrier Walls

- Install 2.5 km of diaphragm wall using trench stops to complete works in ~20 m segments
- Bentonite slurry excavation to design depth
- Placement of re-bar and concrete in trench to construct continuous barrier / shoring / foundation wall
- Excavation and drilling of anchors if excavation to remain open
- Excavate entire centre portion of site in slots to remove contaminated soil

Slurry Excavation – Barrier Walls, PRBs, Funnel and Gate, and Diaphragm Walls



Diaphragm Barrier Walls

- Install 2.5 km of diaphragm wall using trench stops to complete works in ~20 m segments
- Bentonite slurry excavation to design depth
- Placement of re-bar and concrete in trench to construct continuous barrier / shoring / foundation wall
- Excavation and drilling of anchors if excavation to remain open
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Slurry Excavation – Barrier Walls, PRBs, Funnel and Gate, and Diaphragm Walls



Permeable Reactive Barrier Walls (metals)

- Excavate 750 lm trench to 18 mbg using guar gum slurry
- Guar gum degrades over time thus restoring normal K
- Simultaneously excavate spoil and backfill with treatment media, ensuring no 'dead zones' in the PRB

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Bentonite Slurry Cut-off Walls - Advantages

- Allows for variable (unknown) depth profiles and direction changes
- Can attain significant depths (limited by machine size)
- Ideal for loose formations with cobbles/gravels (precludes driven barriers)
- Trench backfill can be engineered for various design permeabilities ($10E-7$ to $10E-10$ m/s): Sand gradation and bentonite content
- Wall thickness can be designed to meet required flow characteristics, FOS
- Allows for post-installation testing of barrier material
- Engineered trench backfill material is relatively easy to handle and requires limited specialized equipment to mix and install
- Relatively cost-effective option
- Abundance of technical literature – level of confidence for owners/consultants

One Pass Trenching – Barrier Walls and Permeable Reactive Barriers



- Trenching machine simultaneously excavates trench and installs backfill media
- Can attain depths of ~12 m
- Backfill media must be free running
- Not suitable for dense or cobble formations

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