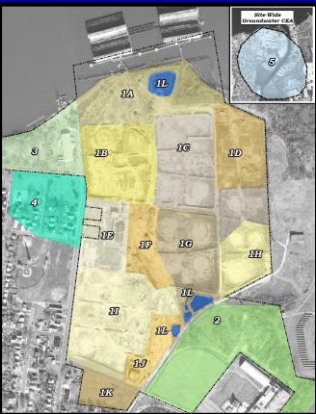


SYSTEM DESIGN ENHANCEMENTS OF A DUEL-PHASE EXTRACTION SYSTEM FOR THE CLEANUP OF HEAVY FUEL OILS

Private Client, Paulsboro, New Jersey

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SITE BACKGROUND



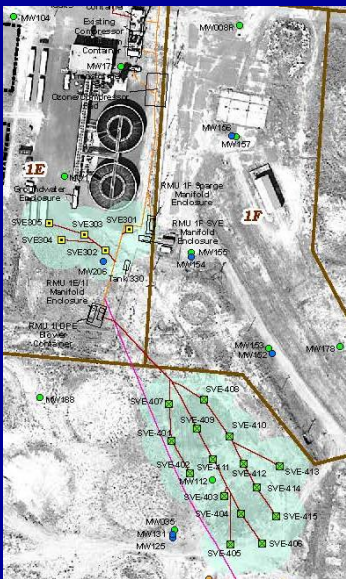
- Former petroleum & chemical storage terminal
- 100 acres on Delaware River
- Active redevelopment as a marine terminal
- Remedial Management Unit 1-I was used for fuel oil ASTs
- Unconsolidated coarse sandy aquifer with some silt lenses
- Depth to water in area of 12' – 15'
- Seasonal GW fluctuation of ~ 2'
- Hydraulic conductivity > 100 ft/day
- Groundwater velocity > 1 ft/day

REMEDIAL IMPACTS/OBJECTIVES

- Heavy LNAPL impacts in smear zone
 - Below former ASTs
 - Weathered #6 oil
 - Density 0.98 g/cc
 - Viscosity 103,569 centipoise @70° F
- Minimal dissolved COC
- Current thickness difficult to measure (~ 2 – 3 feet)
- Objective to reduce LNAPL to residual, immobile thickness (< 0.3 feet)

REMEDY APPROACH – MULTI-PHASE EXTRACTION

- High vacuum recovery of vapor, groundwater, LNAPL
- Vacuum applied through drop tubes in extraction wells
- LNAPL separated from groundwater for disposal
- Vapor treatments through existing thermal oxidizer
- Groundwater treatment through existing groundwater treatment plant
- 15 extraction wells
- 50' Radius of Influence
- 750 scfm @ 18" Hg capacity
- 15 gpm sustained flow
- Constructed by National Environmental Systems



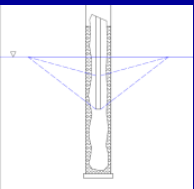
REMEDY DESIGN CHALLENGES

- High viscosity and density of LNAPL
- Minimizing groundwater extraction
 - High hydraulic conductivity
 - High porosity/permeability/infiltration
- Emulsification of oil during extraction and separation
- Balancing flows between extraction points

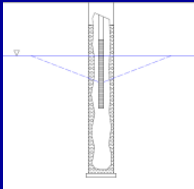


DESIGN FEATURES

- Dual rotary claw blowers
 - Large process flow at high vacuum
 - Approximately 750 SCFM @ 18" Hg capacity
 - Flexibility to operate at highly variable vacuums and extraction rates
- Drop tubes for extraction fitted with 2' of 20-slot screen
 - Vacuum loss across slotted screen
 - Flow/vacuum balanced between extraction wells
 - Air/liquid extraction continuous and balanced
 - Variable depth with minimal drop-tube adjustments
 - Only 2 drop tube adjustments to target deeper zone over 12 months



Traditional drop tube
Slug Flow/Surging Water Level



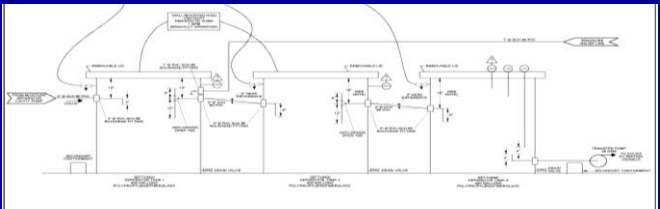
Slotted drop tube
Continuous Flow/Consistent Drawdown

- Odor/vapor control on separator tanks
 - Small diameter tubing attached to the extraction blower inlet
 - PID to continuously read VOCs in building



DESIGN FEATURES (CONT)

- Settling tanks with a gravity system used as OWS
 - High viscosity and density of LNAPL
 - LNAPL emulsifies under high vacuum
 - Three 400-gallon tanks
 - Minimum 60 minutes separation time based on max flow rate
 - LNAPL sorbed to fine-grained material
 - Coalescing bag filters as polish
 - LNAPL skimmed with high viscosity peristaltic pump after separation



SYSTEM OPERATIONS/PERFORMANCE

- Set drop tubes based on water table
 - Lower drop tubes over time to target deeper smear zone
- High methane/TPH influent at startup decreased over time
 - Increase vacuum/decrease dilution air over time
 - 6" – 14" Hg operating vacuum
 - Air/water extraction rates balanced with applied vacuum
- Separated oil from Settling Tank 1 and 2 pumped into storage tanks for recycling
- After 12 months of operation
 - 1,046,160 gallons of groundwater pumped
 - 3-4 gpm consistent total flow rate
 - Approximately 9,000 lbs of TPH mass removed in vapor phase
 - Approximately 500 scfm operating flow rate
 - 1,545 gallons of #6 oil recovered
 - LNAPL Transmissivity 5-20 ft²/day

PATH FORWARD

- Monitor LNAPL recovery rate and transmissivity over time
 - No decrease in recovery rate yet seen
- Adjust drop tubes to target deeper smear zones
 - Take advantage of seasonal water tables

