

Haz Waste: Site Clean-up Methods

- 1. *In-Situ Vadose Zone Soil*
 - SVE, bioventing, phytoremediation
- 2. *In-situ groundwater/aquifer trmt*
 - Bioremediation, Phytoremediation
- 3. *Ex-Situ contaminated gas treatment*
 - incineration, carbon adsorption, biolog.
- 4. *Ex-situ groundwater/soil trmt*
 - Bioremediation, phytoremediation
 - Pump & Treat

Pump and Treat

- Used at 95% of Superfund sites with groundwater contamination [627 sites]
 - Often used in combination with other treatment technologies
- What is it?
 - Use one or more GW pumping wells to draw contaminated GW to surface [PUMP] and then treat the extracted GW [TREAT]

Goals of Pump and Treat

? Restore contaminated water bearing zones by decreasing dissolved contaminant concs to an acceptable level

Goals of Pump and Treat

1. Prevent or contain contaminant migration to protect down-gradient locations
2. Recover LNAPL by drawing free product into recovery wells
3. Use with other technologies
 - Dewater (lower water table) & SVE
 - Use with re-injection for in-situ bioremed.

Extraction Well



Borehole 6-12" dia
Well casing = 4-8" dia
PVC or stainless steel (ss)
Well screen = slotted PVC or ss
Filter pack = coarse to med. sand or fine gravel
Seal: bentonite
Pump: submersible:
4" ~70 gpm; 6" 120 gpm
head to pump to surface
Pneumatic: up to 10 gpm
less fouling problems

P&T pre Dsn Characterization

- Aquifer char.
 - K, aquifer thickness, GW flow direction and gradient, water table fluctuations
- Geologic char.
 - Grain size distribution, porosity, organic content
- Contamination extent
 - Horizontal and vertical (plan & profile)
 - NAPL product
- GW analysis
 - Inorganics (hardness, ions), pH, bacteria

Pumping out GW lowers water table (drawdown)

Use Field Tests to Meas. K

- Pump test, Jacob method:
- Transmissivity, $T = Kb = 2.3Q/4p$ slope
- Storativity, $S = 2.25 T$ to t/r^2

- Storativity, $S =$ amount of water released per unit drop in head per unit area of aquifer, m^3/m^2 , unitless
- Typically 0.005 to 0.4 (related to porosity); smaller #s for confined aquifers
- $S = \rho w g (\alpha + \eta\beta) b$
 - $\alpha =$ compressibility of porous media
 - $\beta =$ compressibility of water
- If low S , quick drawdown responses at wells and in aquifer (generally in confined aquifers)

Design: Capture Zone

- $x = -y / \tan[2p K b i y / Q]$
- As $x \rightarrow 8$, $y_{max} = +Q/2 K b i$
- $x_o = -Q/2p K b i$

Capture Zone example

- Well extraction rate, $Q = 50,000 \text{ ft}^3/\text{d}$
- Aquifer thickness, $b = 30 \text{ ft}$
- Hydraulic conductivity, $K = 1000 \text{ ft/d}$
- Natural hydraulic gradient, $i = 0.006$
- $x_o = -44 \text{ ft}$
- $y_{max} = 277 \text{ ft}$

Multiple well designs

# wells	optimal dist. betw. pairs of wells	width of capture at line of wells ($x=0$)	max width of capture zone (v. lg x)
1	NA	$Q/2bKi$	Q/Kbi
2	$Q/pbKi$	Q/bKi	$2Q/bKi$
3	$2^{0.33}Q / pbKi$	$3Q/2bKi$	$3Q/bKi$

Further Design Equations

- Steady state
 - Modification of the Theim equation can be used for estimating T:
 - $T = 43.08 Q / s_w$
 - where: Q = the constant well discharge in feet³/day.
 - s_w = stabilized drawdown in the well at steady flow in feet.
 - T = transmissivity = K b
 - Applicable to both confined and unconfined zones
 - For unconfined zones, s_w must be corrected to
 - $s_w' = s_w - (s_w^2/2b)$

Further Design Equations

- Non-steady state: Jacob Method
 - $s(r, t) = Q \ln [2.25 T t / r^2 S] / 4 p T$
 - Works for any distance r (including well radius)
 - Time, t, up to steady -state or equilibrium conditions, usually 30-90 days
 - Shorter t with smaller storativity(S)
 - Do not want drawdown at well to leave less than 1-3' of water flow into well
 - If use for unconfined aquifers, use a "corrected" s in the equation:
 - $s_{corrected} = s_{obs} - s_{obs}^2/2b$

Example (cont.)

- What drawdown at the well corresponds to the flowrate of 50,000 ft³/d?
- Given: S = 0.05 (small) [confined aq]
 - Therefore assume t = 30 days
 - Well diameter 6" (r = 0.25')
 - T = Kb = 30,000 ft²/d
- $s(0.25', >30d) = 50,000 \text{ ft}^3/\text{d} * \ln [(2.25*30,000 \text{ ft}^2/\text{d}*30d)/(0.25\text{ft}^2 * 0.05)] \div (4 * p * 30,000 \text{ ft}^2/\text{d})$
- s @ well = 2.7 ft (reasonable)

Treat Pumped GW Ex-Situ

- Air stripping or steam stripping (organics)
- Carbon adsorption (organics)
- Ion exchange (metals, inorganics)
- Chemical oxidation (organics)
- Biological tmt (org; usu. in series w/ others)
- Membrane filtration (reverse osmosis)
- Fluids separation
 - Oil:water sep. for NAPLs
 - Liq/Liq extraction