

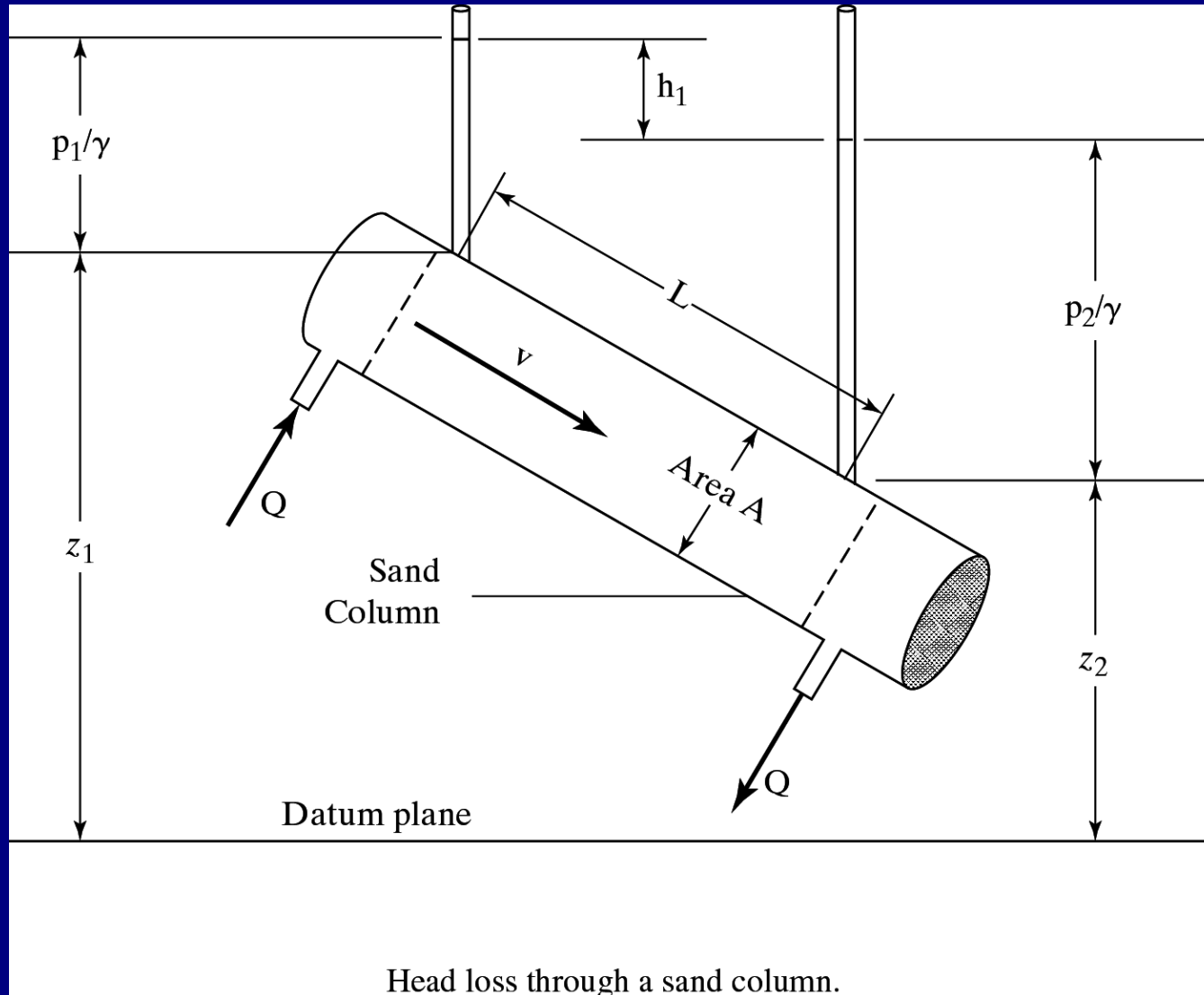
Ground Water Contamination

Modified by H. R. Fuentes After P. B. Bedient

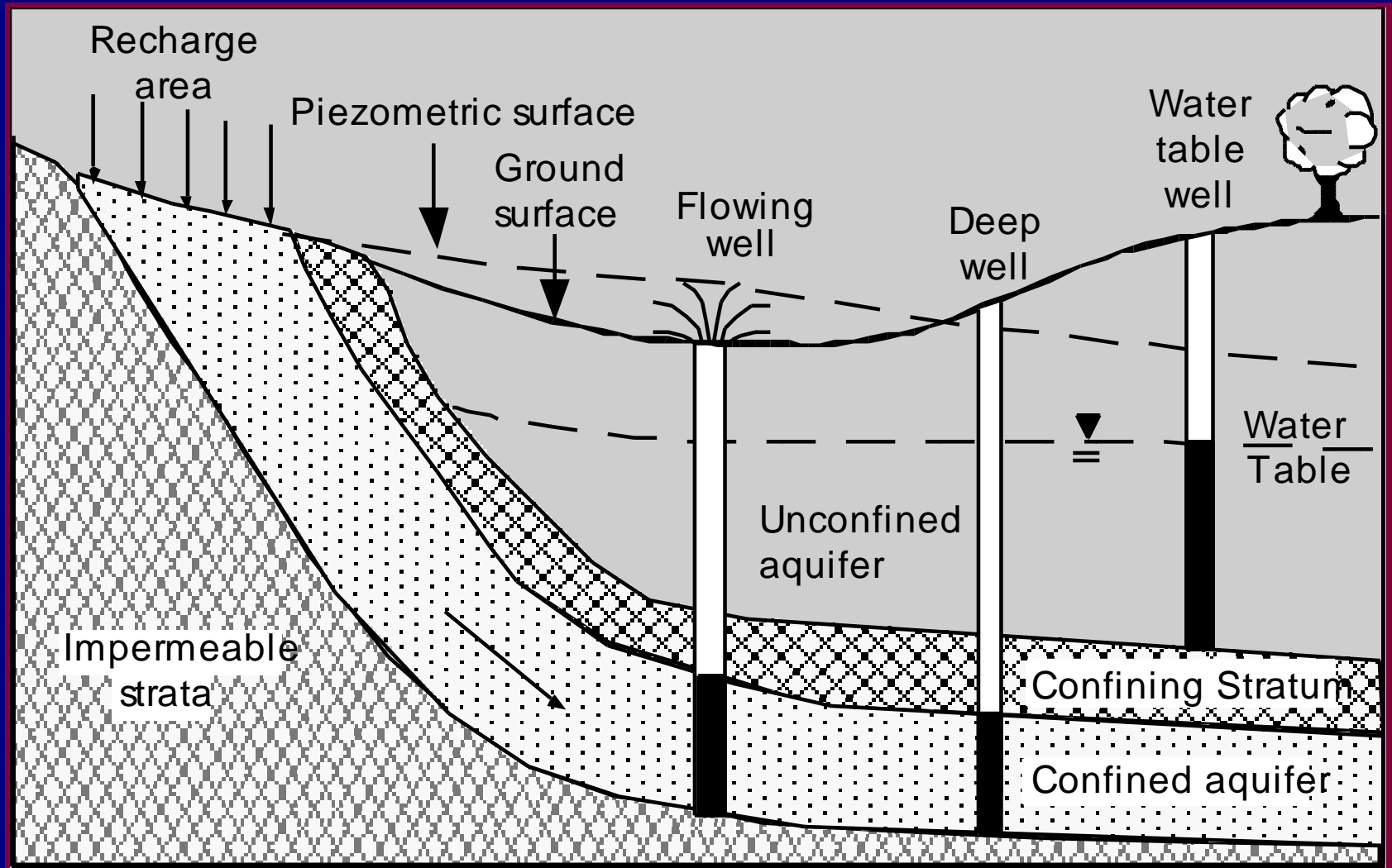
Darcy's Law

$$V = -K \frac{dh}{dl}$$

$$Q = -KA \frac{dh}{dl}$$



Aquifer Systems

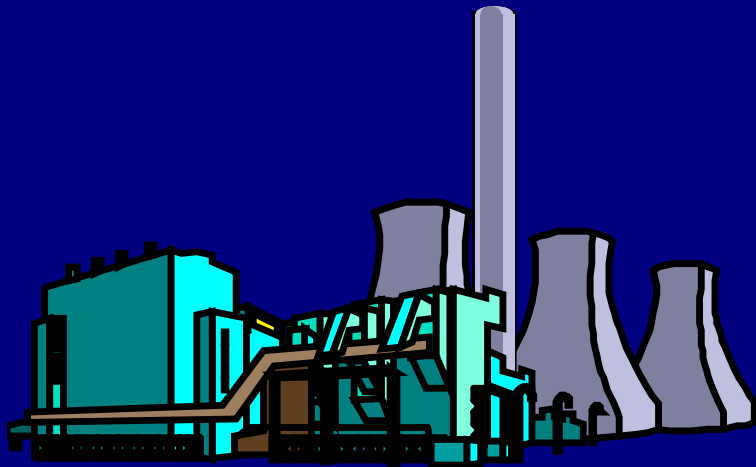


Flow & Transport Processes



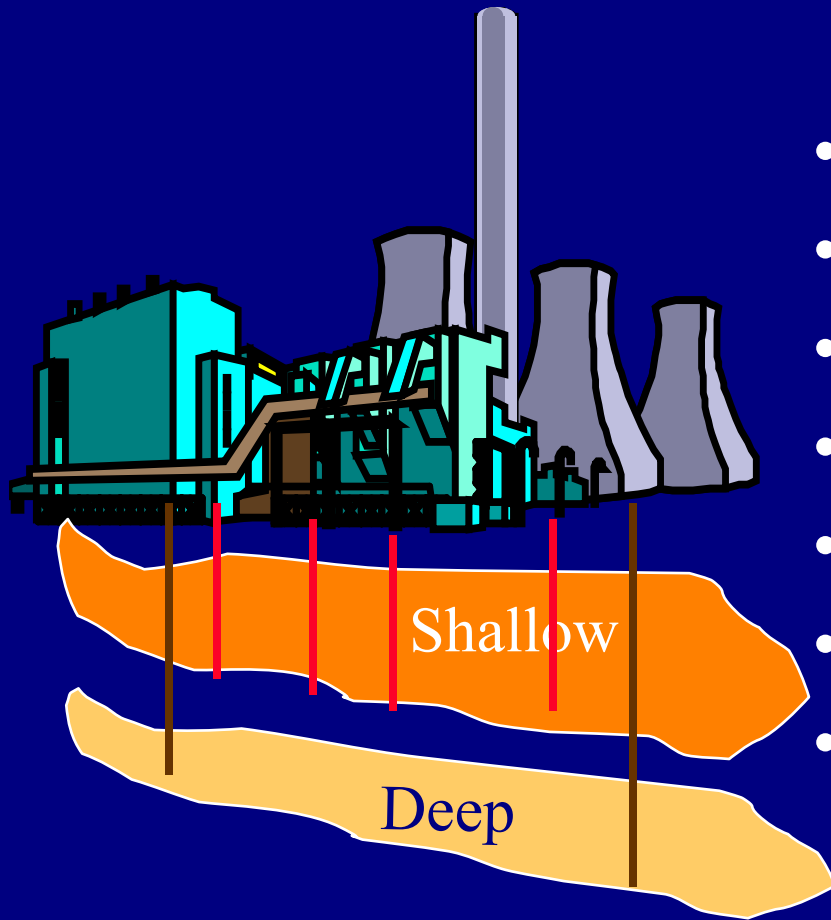
- Physical Transport:
 - Advection
 - Diffusion and dispersion
 - Interphase transfer (e.g., volatilization)
- Transformation (i.e., reactions)
 - Chemical (e.g., oxidation)
 - Biological (e.g., biodegradation)
 - Interphase transfer (e.g., adsorption)
- Applications:
 - Characterization
 - Remediation

Sources of Contamination



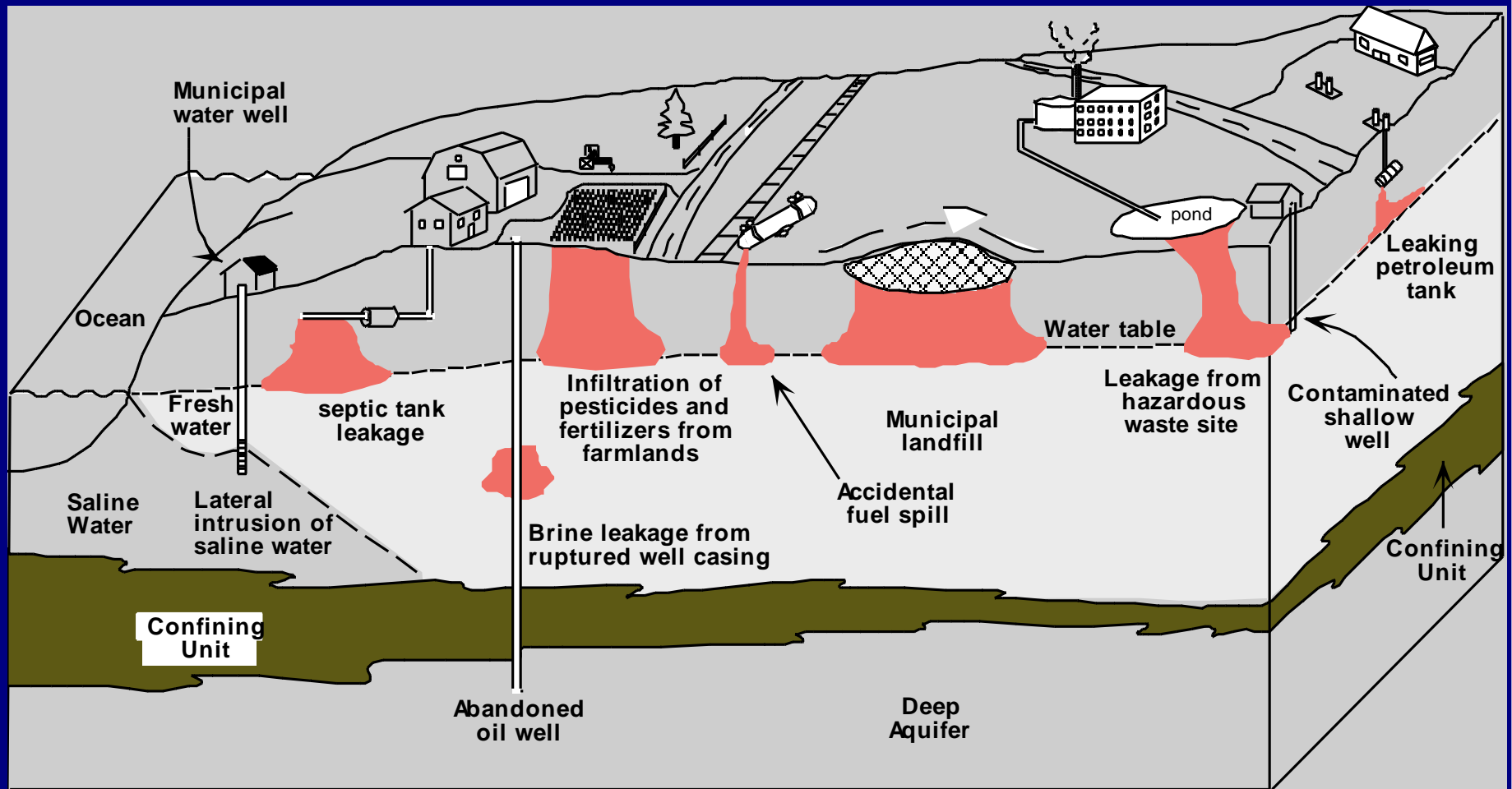
- Natural (e.g., iron leaching)
- Nonpoint sources (e.g. agriculture and runoff)
- Waste disposal
 - Landfills
 - Burials and Dumps
 - Surface impoundments,
 - Injection Wells
- Spills, Leaks and other
 - Industrial facilities
 - Storage tanks and pipes

Areas of Industrial Contamination



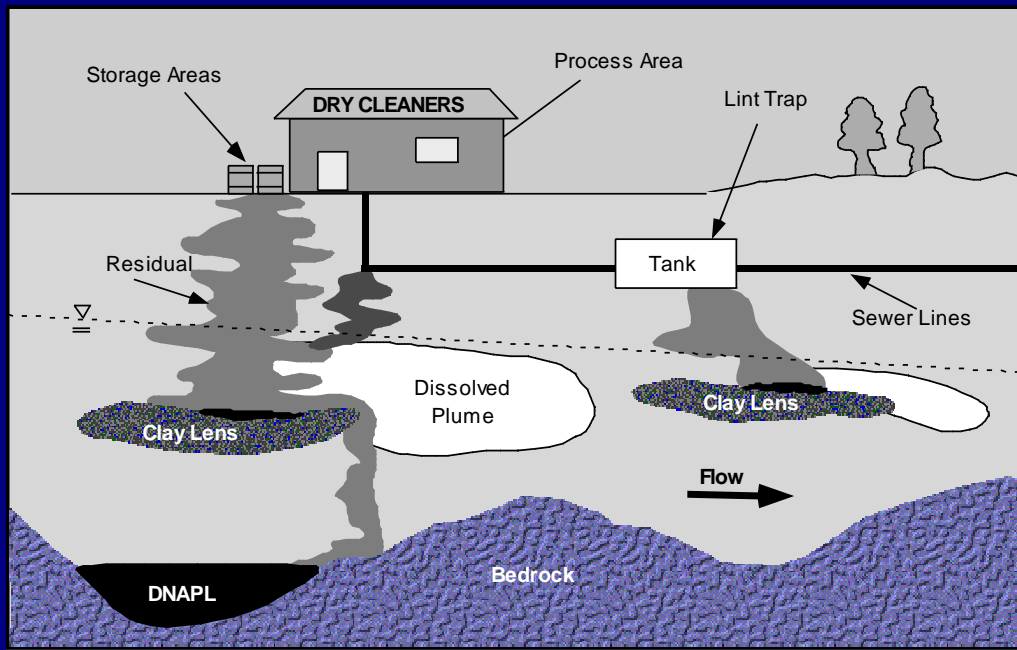
- **Surface soils**
- **Subsurface soils**
- **Shallow ground water**
- **Deep ground water**
- **Vapors above water table**
- **Drinking water wells**
- **Receiving streams/lakes**

Contamination of Ground Water



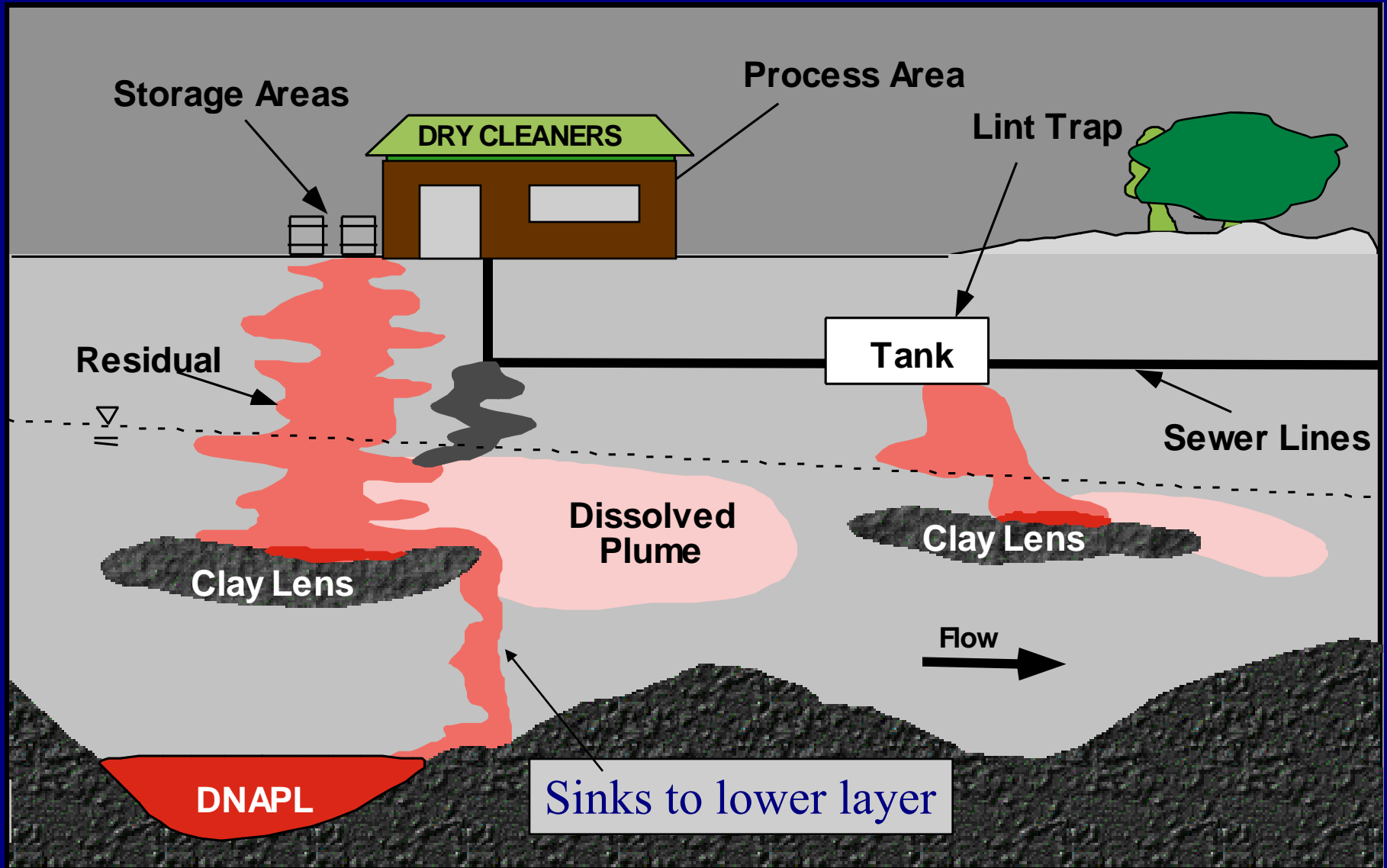
DNAPL

Our Most Difficult Challenge

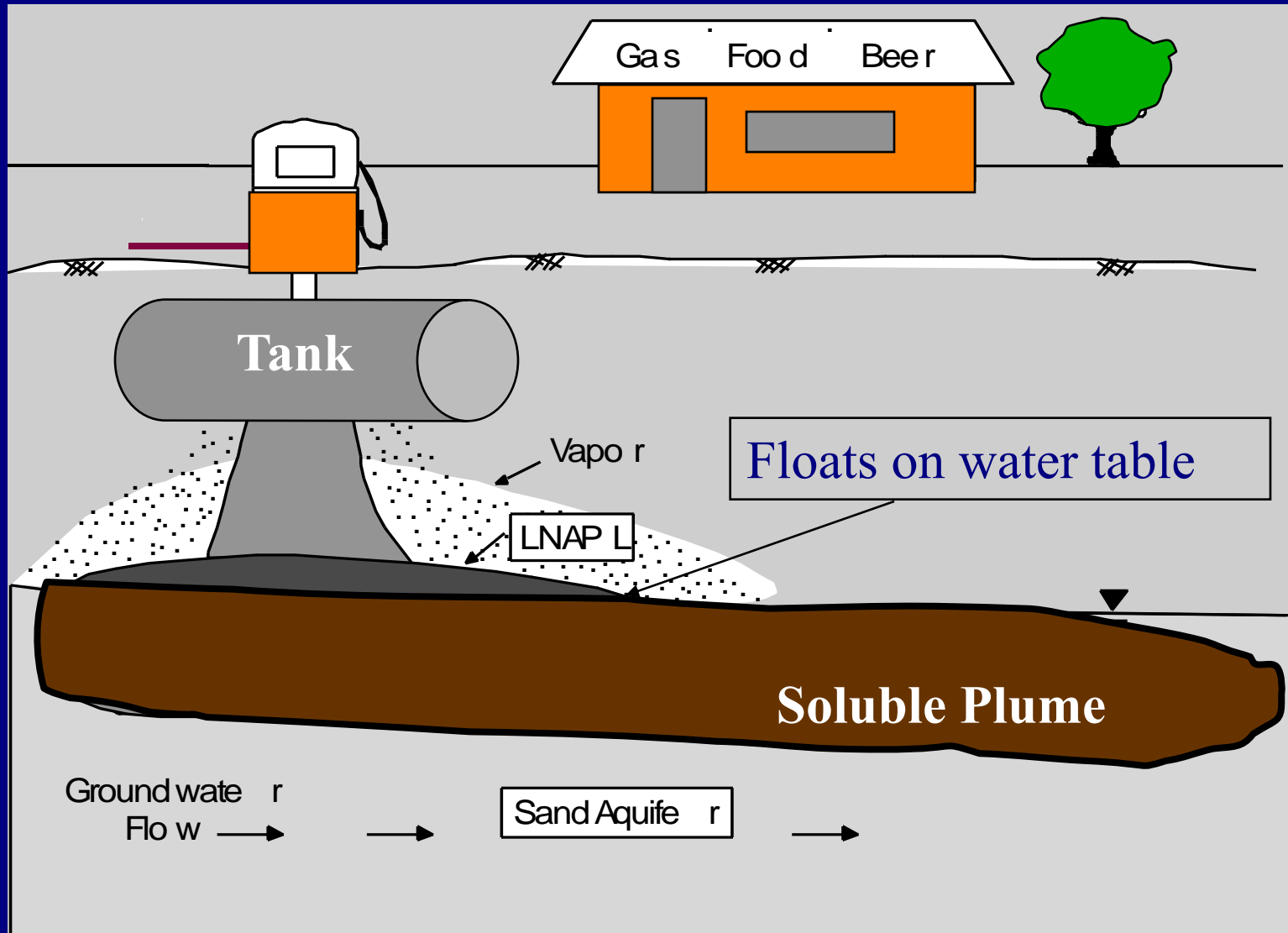


- DNAPL source
- Residual phase
- Trapped on lenses
- Pools in low areas
- Creates soluble plumes for years
- Extremely hard to remediate

Typical DNAPL Spill Zone



Typical Leaking UST - BTEX

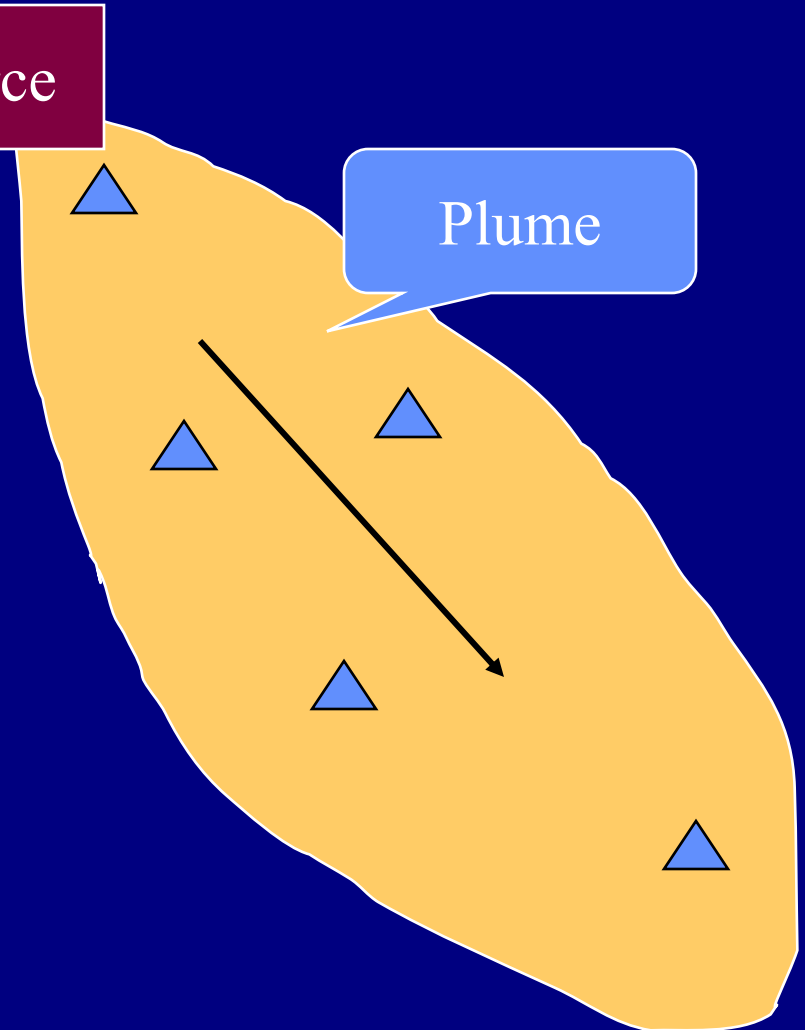


Typical Industrial Site

Source

Plume

- **Buried fuel tanks**
- **Above ground chem tanks**
- **Ponds and Impoundments**
- **Buried drums (older)**
- **Landfill area (hidden)**
- **Waste process area**
- **Receiving streams/lakes**
- **Nearby residential area**



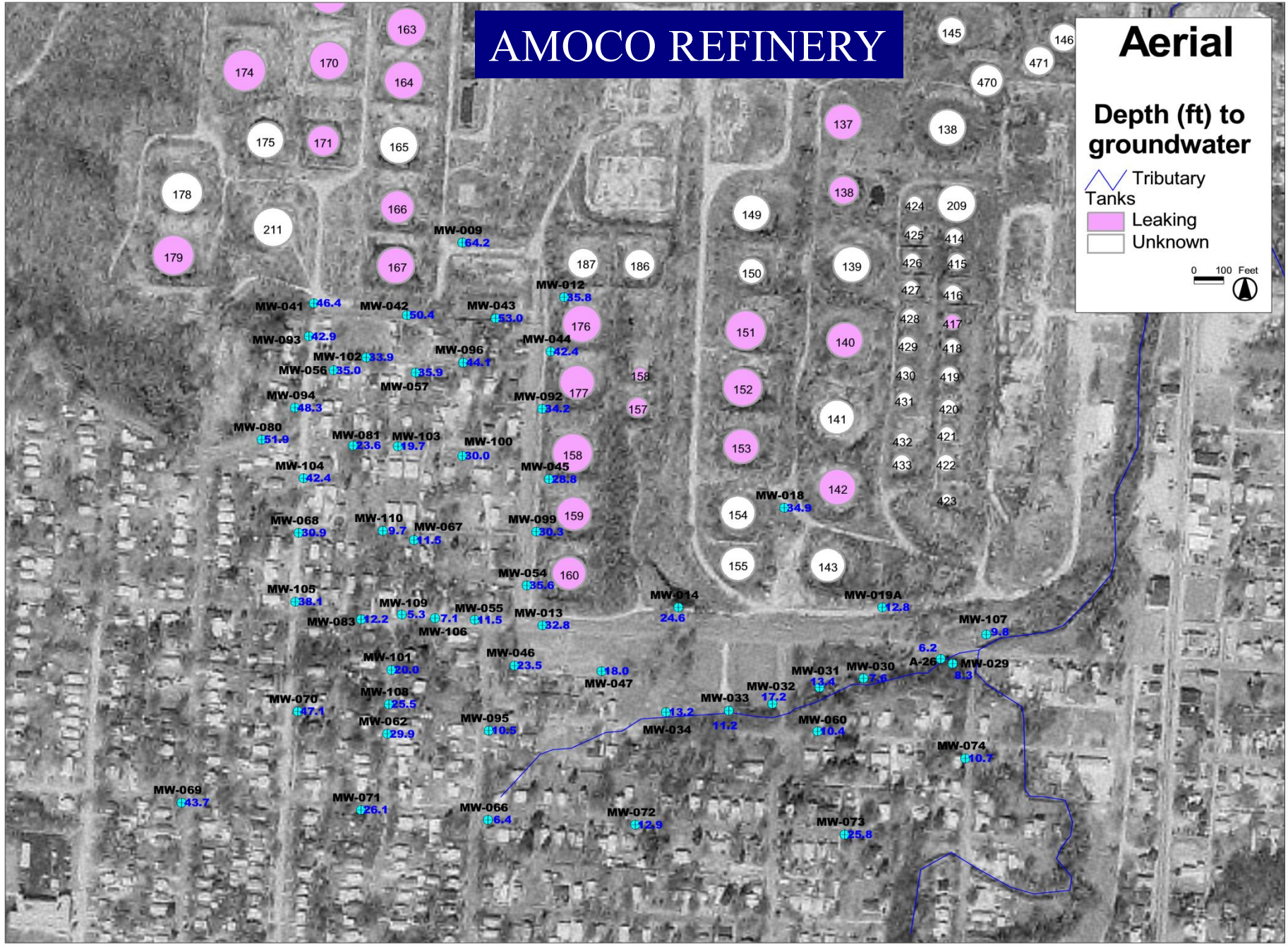
AMOCO REFINERY

Aerial

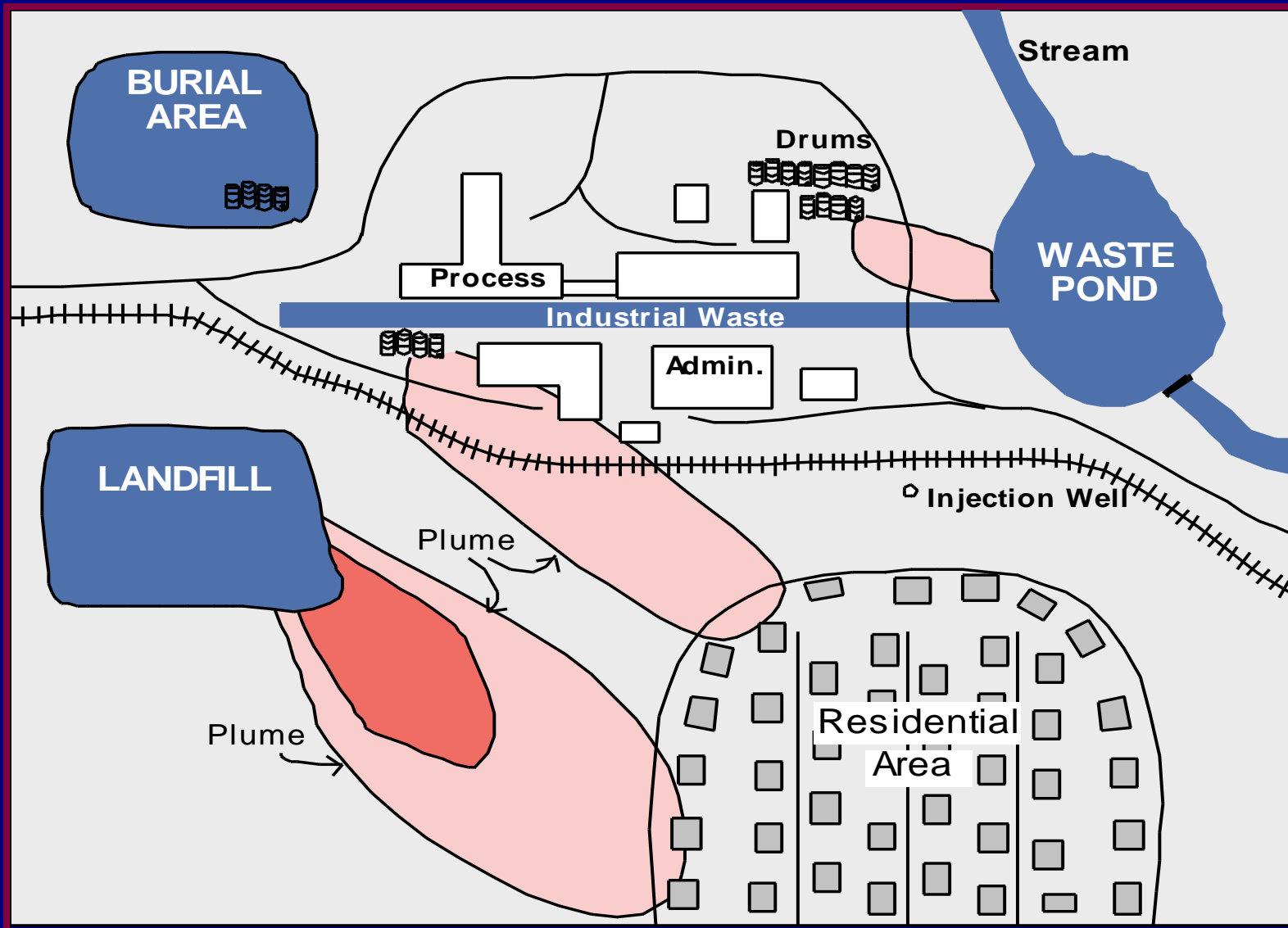
Depth (ft) to groundwater

-  Tributary
-  Leaking Tanks
-  Unknown

0 100 Feet



Typical Contaminated Site



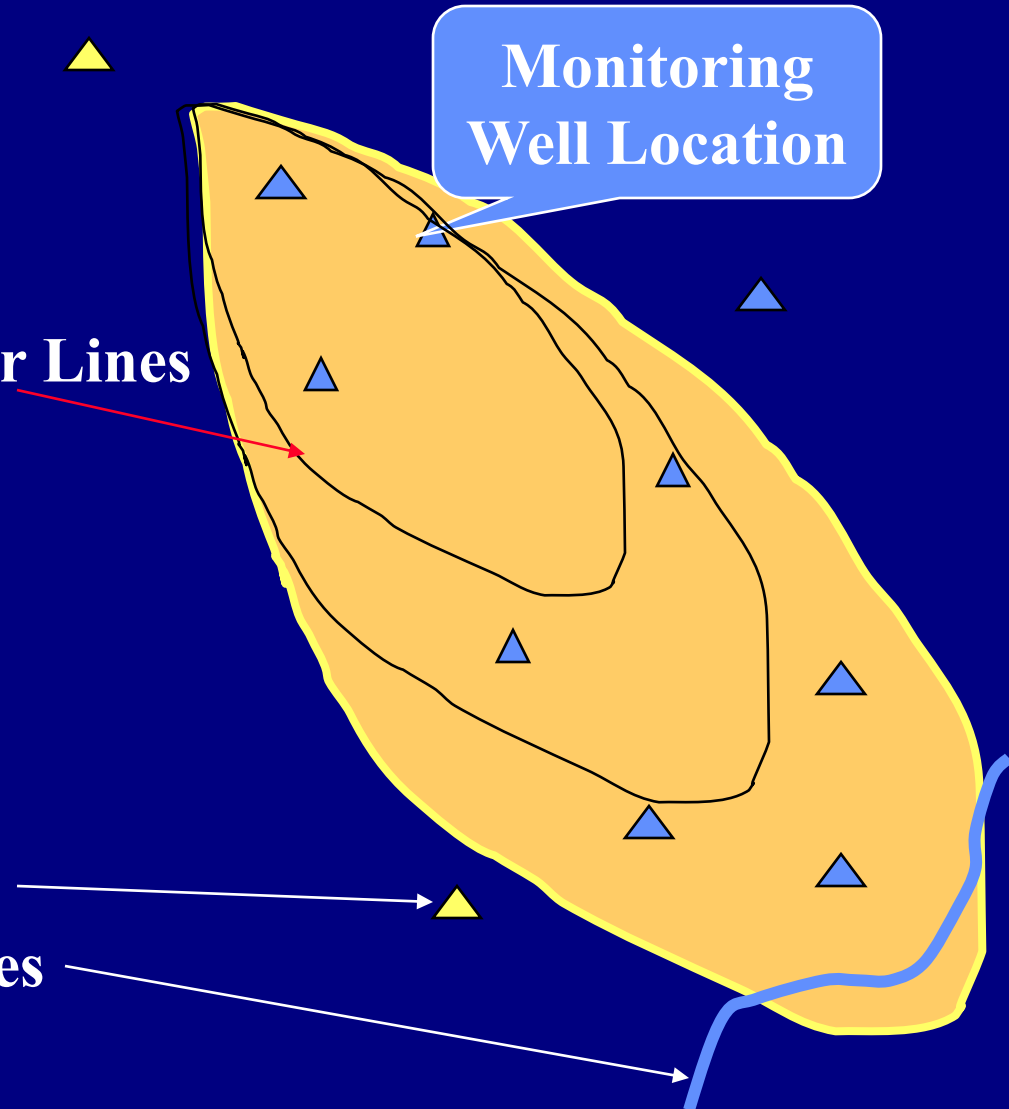
Objectives of a Field Site Study

- **Evaluate:**

- Surface soils
- Subsurface soils
- Shallow ground water
- Deep ground water
- Vapors in subsurface
- Drinking water wells
- Receiving streams/lakes

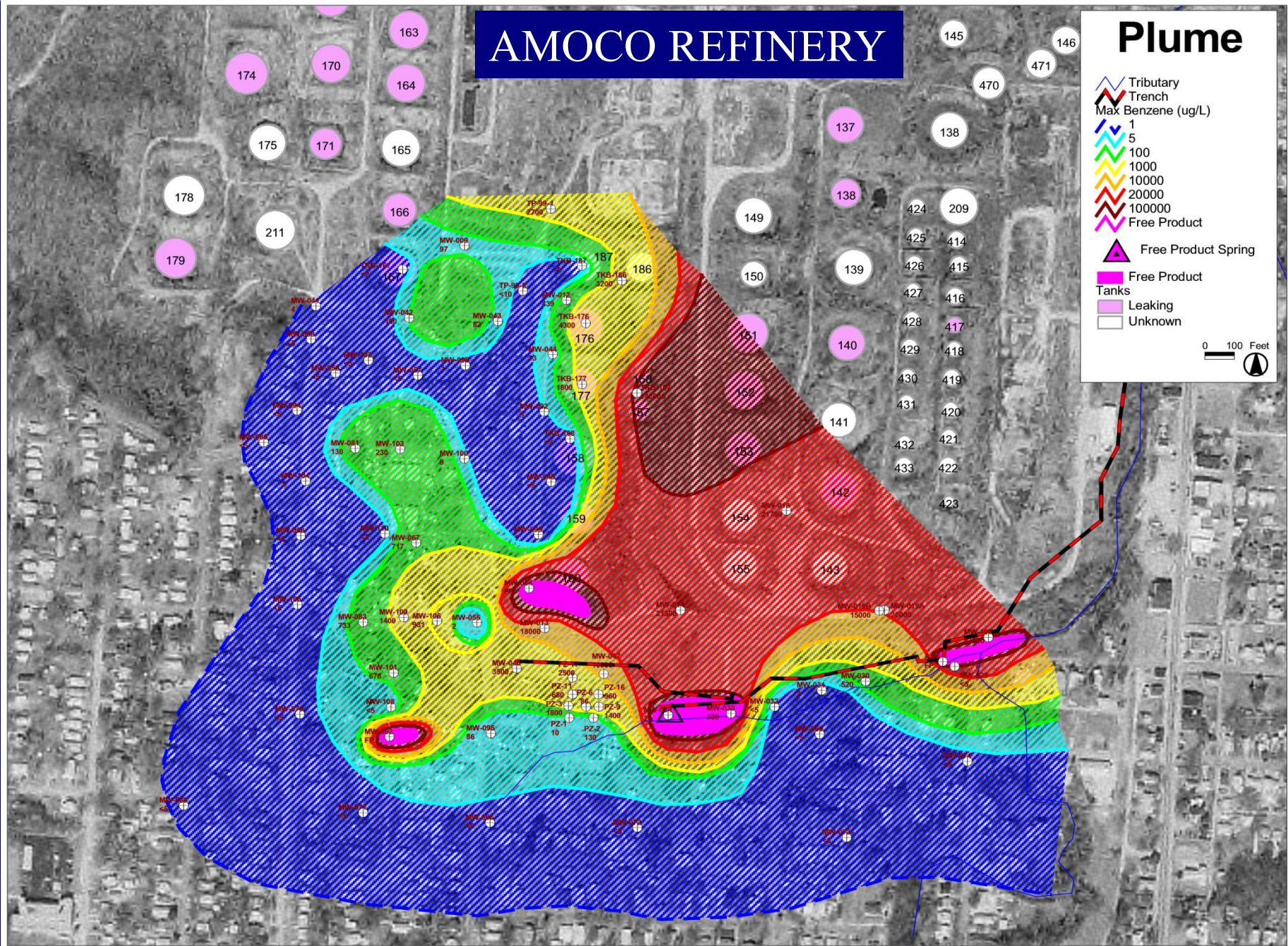
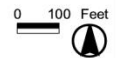
Contour Lines

Monitoring Well Location



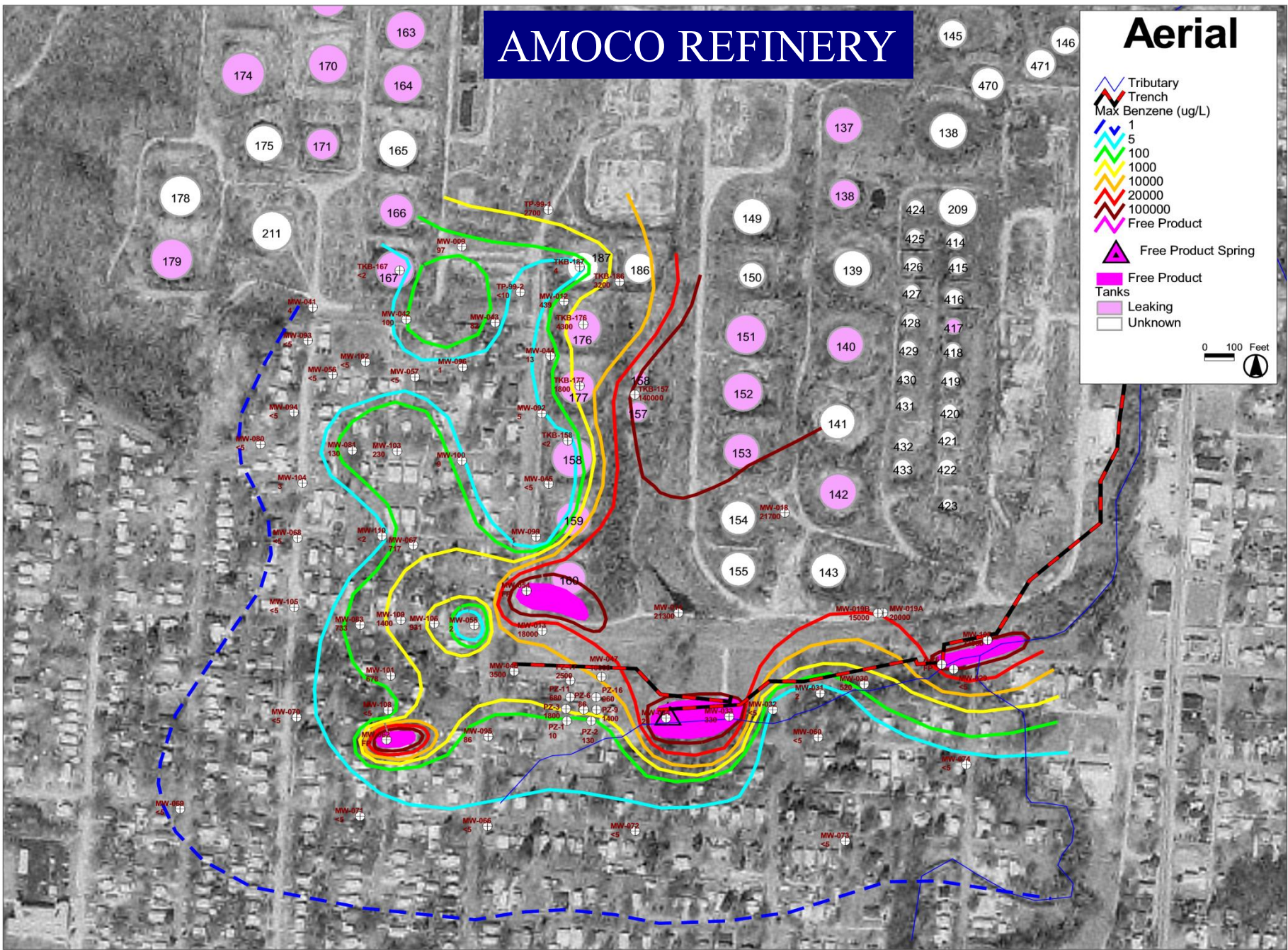
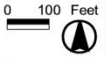
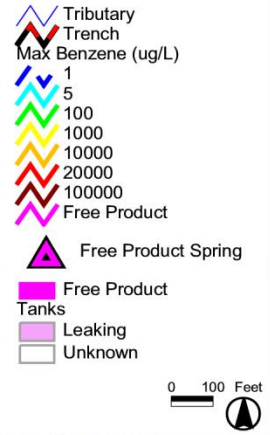
AMOCO REFINERY

Plume



AMOCO REFINERY

Aerial

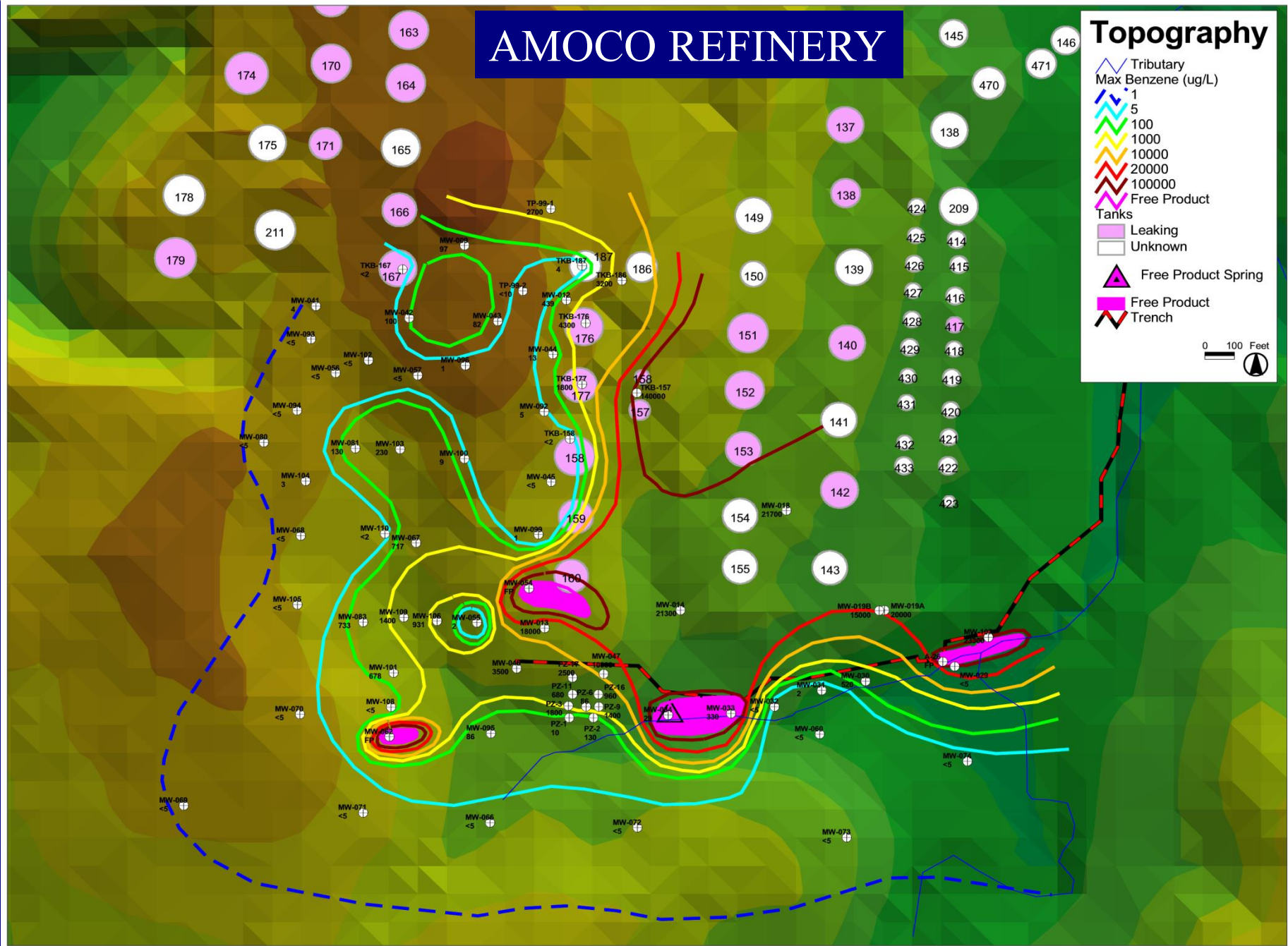


AMOCO REFINERY

Topography

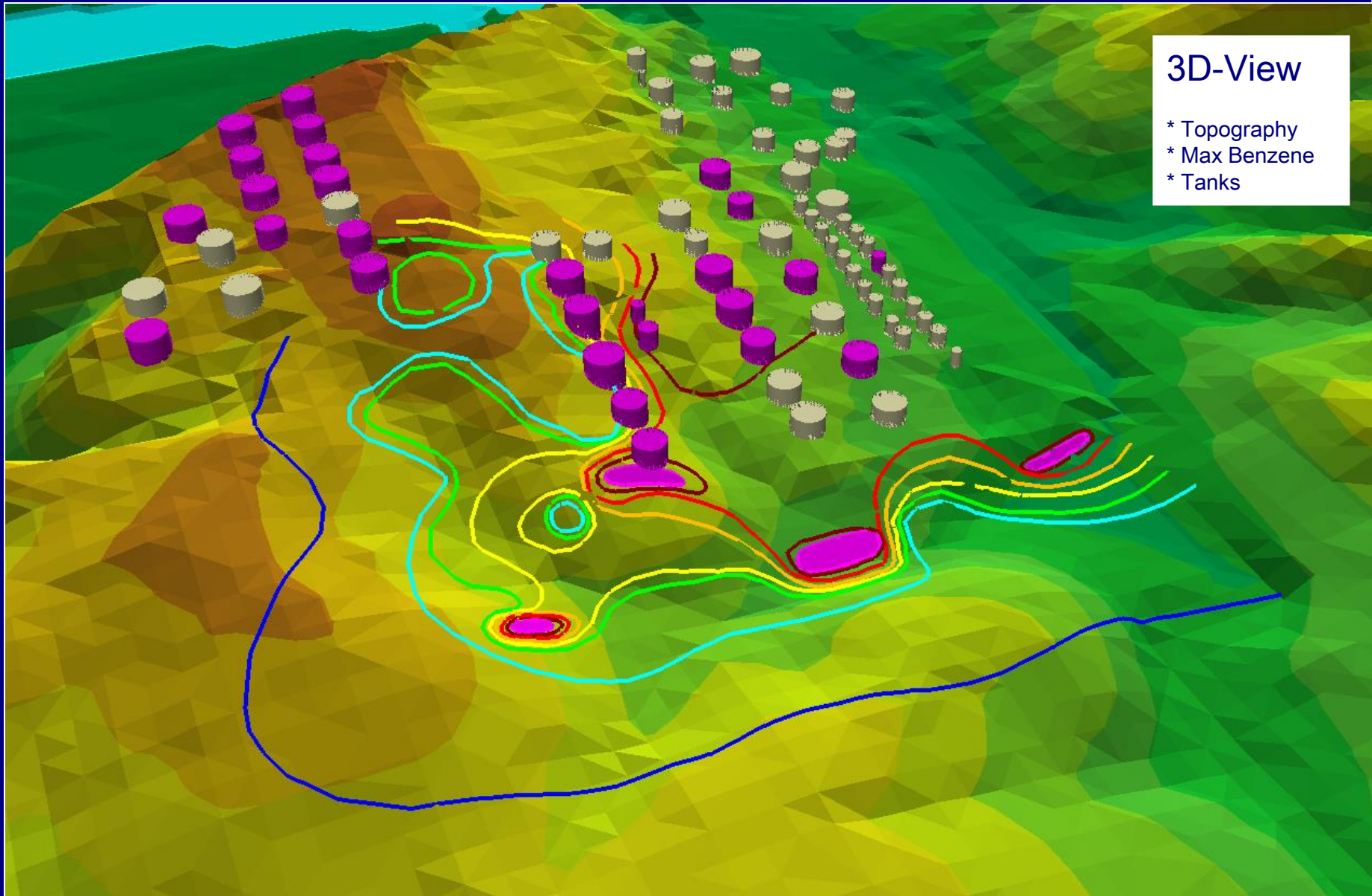
- Tributary
- Max Benzene (ug/L)**
 - 1
 - 5
 - 100
 - 1000
 - 10000
 - 20000
 - 100000
 - Free Product
- Tanks**
 - Leaking
 - Unknown
- Free Product Spring
- Free Product
- Trench

0 100 Feet



3D-View

- * Topography
- * Max Benzene
- * Tanks

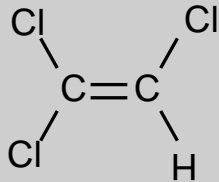
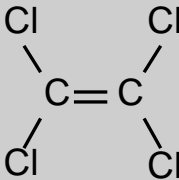
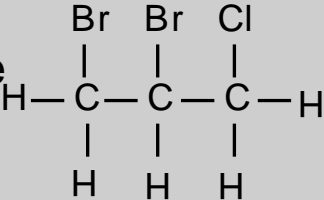
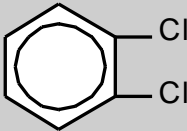


Contaminant Properties Needs


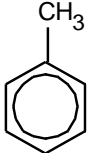
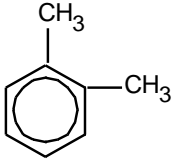
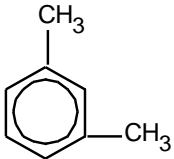

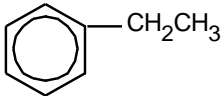
Chlorinated Solvents

Name	Structure	Uses and Other Sources
Trichloromethane (chloroform)	$\begin{array}{c} \text{Cl} \\ \\ \text{Cl} - \text{C} - \text{Cl} \\ \\ \text{H} \end{array}$	Liquid used in manufacture of anesthetics, pharmaceuticals, fluorocarbon refrigerants and plastics. Used as solvent and insecticide. Formed from methane when chlorinating drinking water.
Vinyl chloride (chloroethene)	$\begin{array}{c} \text{H} \quad \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C} = \text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \quad \text{Cl} \end{array}$	Gas used in the manufacture of polyvinyl chloride. End product of microbial degradation of chlorinated ethenes.
Chloroethane	$\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H} - \text{C} - \text{C} - \text{Cl} \\ \quad \\ \text{H} \quad \text{H} \end{array}$	Liquid used to manufacture tetraethyl lead. Degradation product of chlorinated ethanes.
1,2-Dichloroethane	$\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{Cl} - \text{C} - \text{C} - \text{Cl} \\ \quad \\ \text{H} \quad \text{H} \end{array}$	Liquid used to manufacture vinyl chloride. Degradation product of trichloroethane.

Chlorinated Solvents (con't)

Name	Structure	Uses and Other Sources
<u>Trichloroethene</u> (Trichloroethylene)		Solvent used in dry cleaning and metal degreasing. Organic synthesis. Degradation product of tetrachloroethene.
<u>Tetrachloroethene</u> (perchloroethene) (perchloroethylene)		Solvent used in dry cleaning and metal degreasing. Used to remove soot from industrial boilers. Used in manufacture of paint removers and printing inks.
1,2-Dibromo-3-chloropropane (DBCP)		Soil fumigant to kill nematodes. Intermediate in organic synthesis.
o-Dichlorobenzene (1,2-dichlorobenzene)		Chemical intermediate. Solvent. Fumigant and insecticide. Used for industrial odor control. Found in sewage form odor control chemicals used in toilets.

BTEX-Related Compounds

Name	Structure	Molecular Weight	Solubility in Water	Soil-Water Partition Coefficient
Benzene		78.11	<u>1780 mg/L</u>	97
Toluene		92.1	500 mg/L	242
Xylene, ortho		106.17	170 mg/L	363
Xylene, meta		106.17	173 mg/L	182
Xylene, para		106.17	200 mg/L	331
Ethyl benzene		106.17	150 mg/L	622