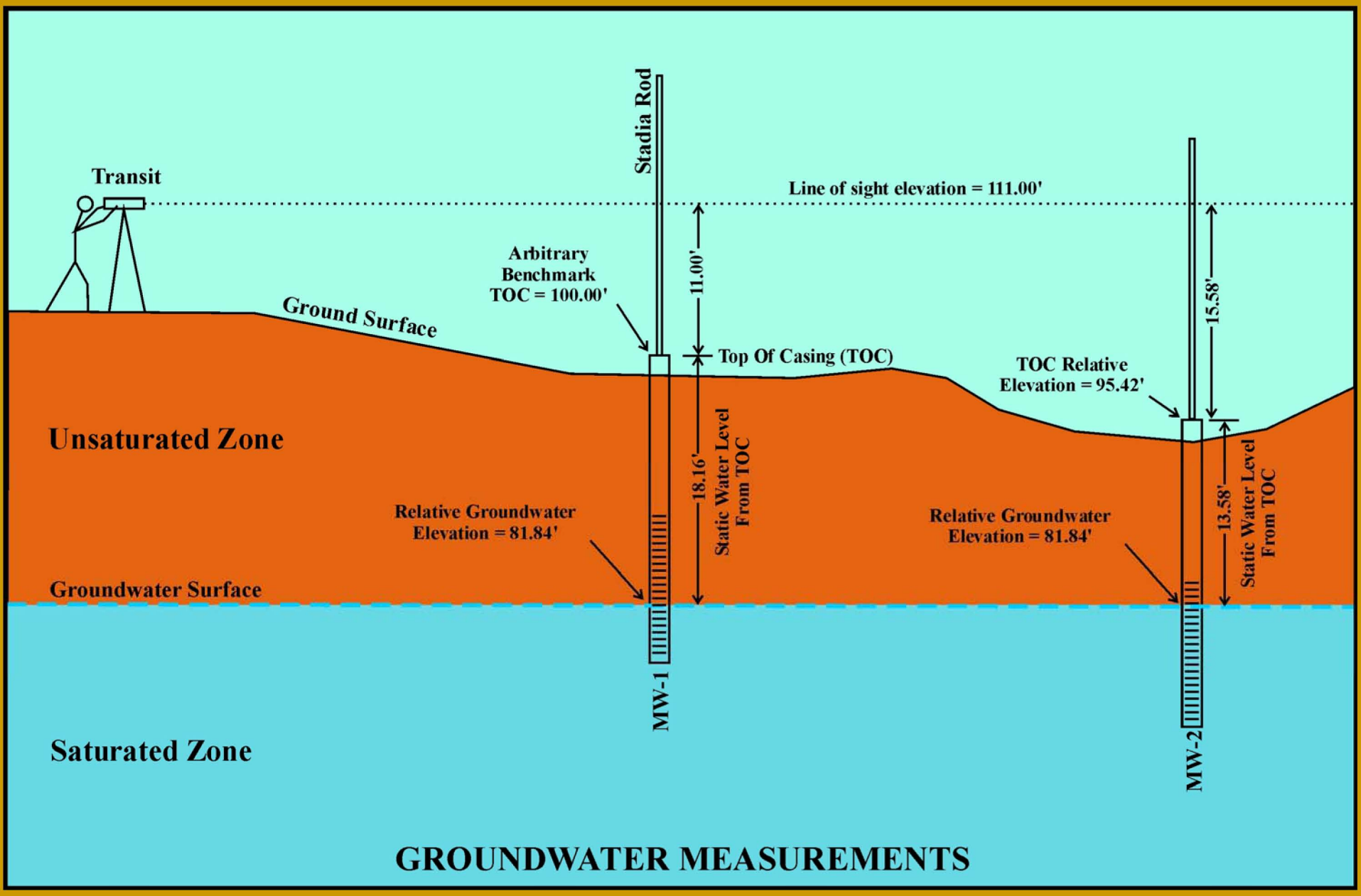
Missouri Department of Natural Resources

# Considerations for Contaminant Transport in Shallow Groundwater

# GROUNDWATER MEASUREMENTS

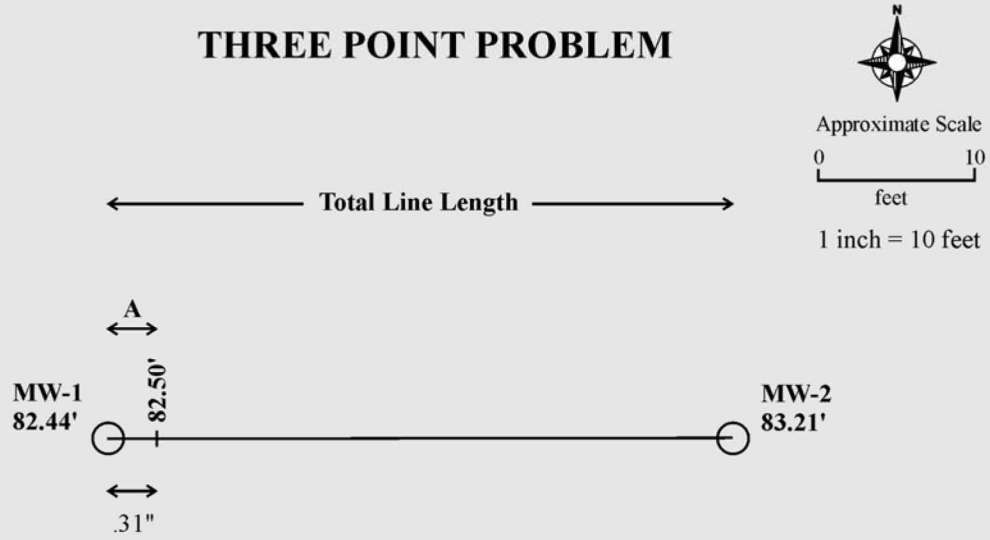



# GROUNDWATER MEASUREMENTS

# PLOTTING GROUNDWATER DATA (Three-Point Problem)

# THREE POINT PROBLEM

# THREE POINT PROBLEM




$$\text{Length Needed} = \frac{\text{Total Line Length}}{\text{Total Elevation Difference}} \text{ (Desired Elevation Difference)}$$

$$\text{Length of A} = \frac{4.00''}{83.21' - 82.44'} (.06') = \frac{4.00''}{.77'} (.06') = .31''$$

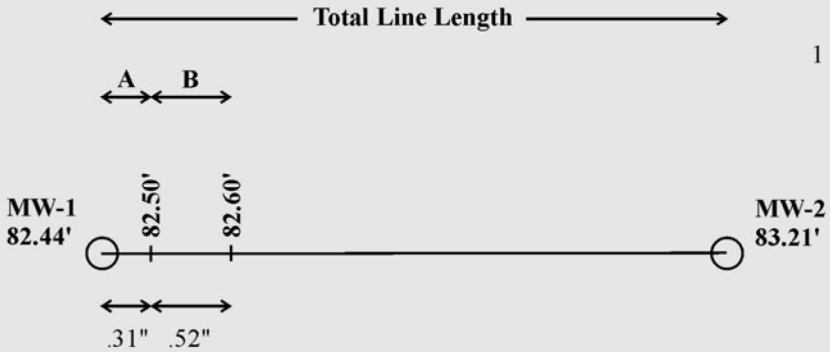
# THREE POINT PROBLEM

Approximate Scale

0 10

feet

1 inch = 10 feet



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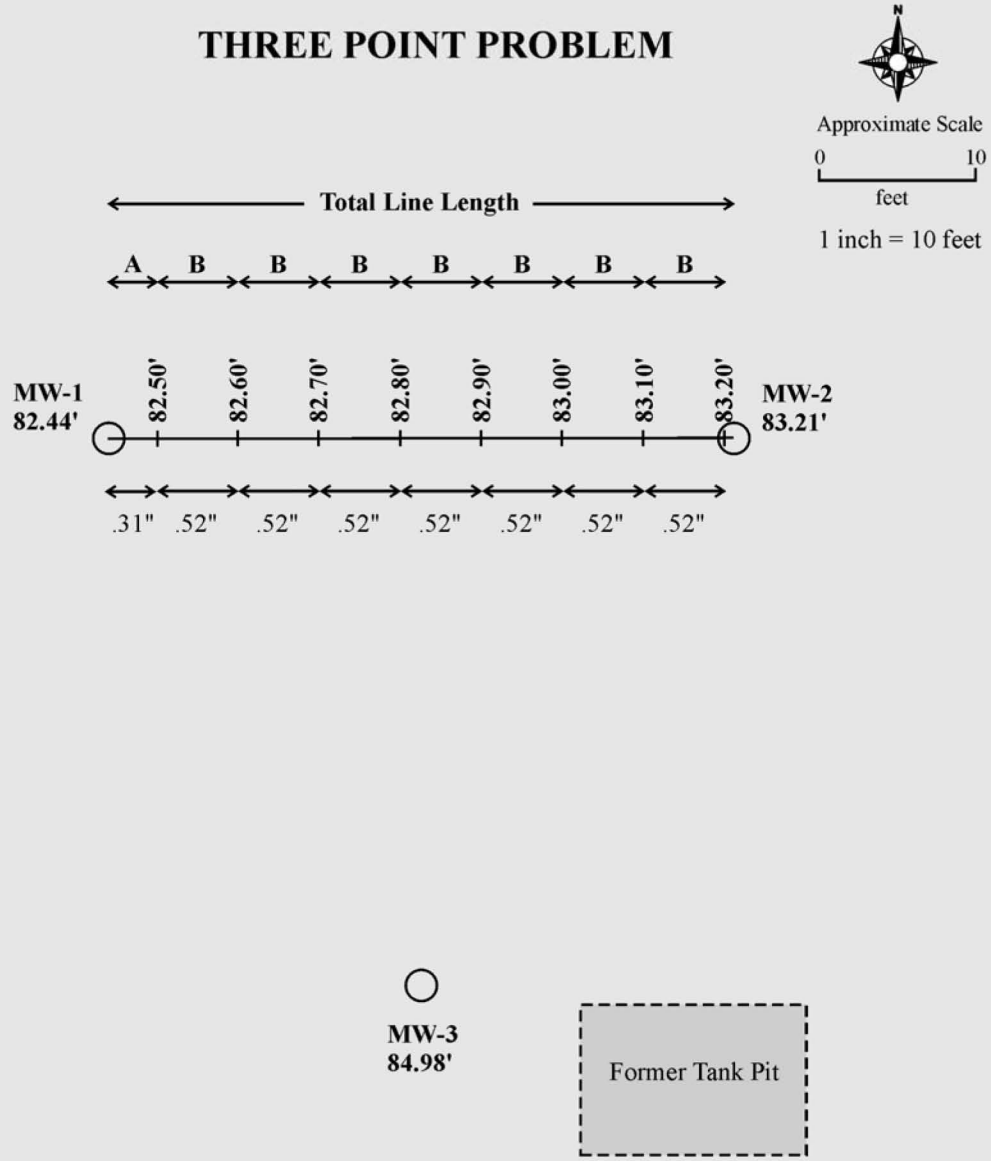
$$\text{Length of A} = \frac{4.00''}{83.21' - 82.44'} (.06') = \frac{4.00''}{.77'} (.06') = .31''$$

$$\text{Length of B} = \frac{4.00''}{83.21' - 82.44'} (.10') = \frac{4.00''}{.77'} (.10') = .52''$$

# THREE POINT PROBLEM

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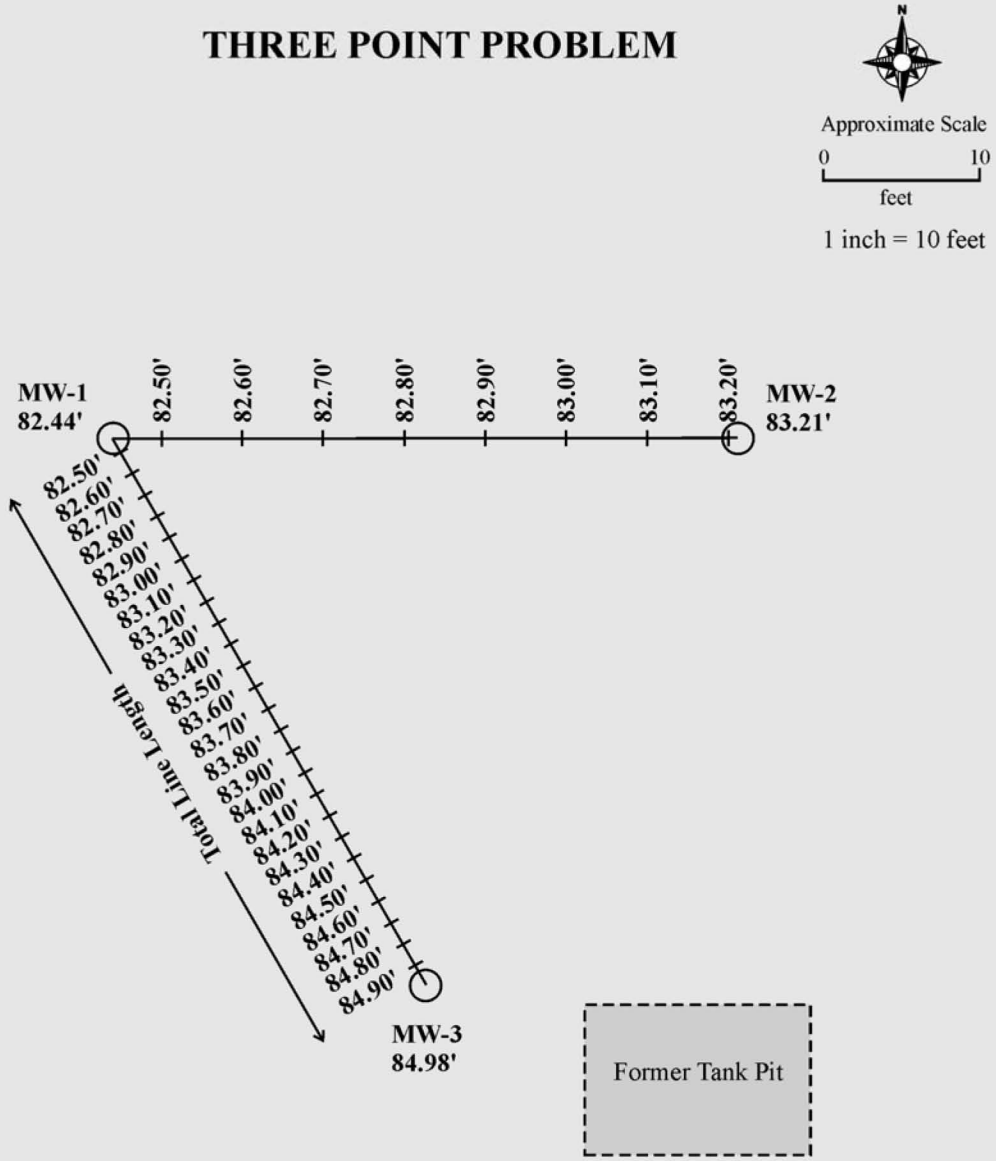
# THREE POINT PROBLEM

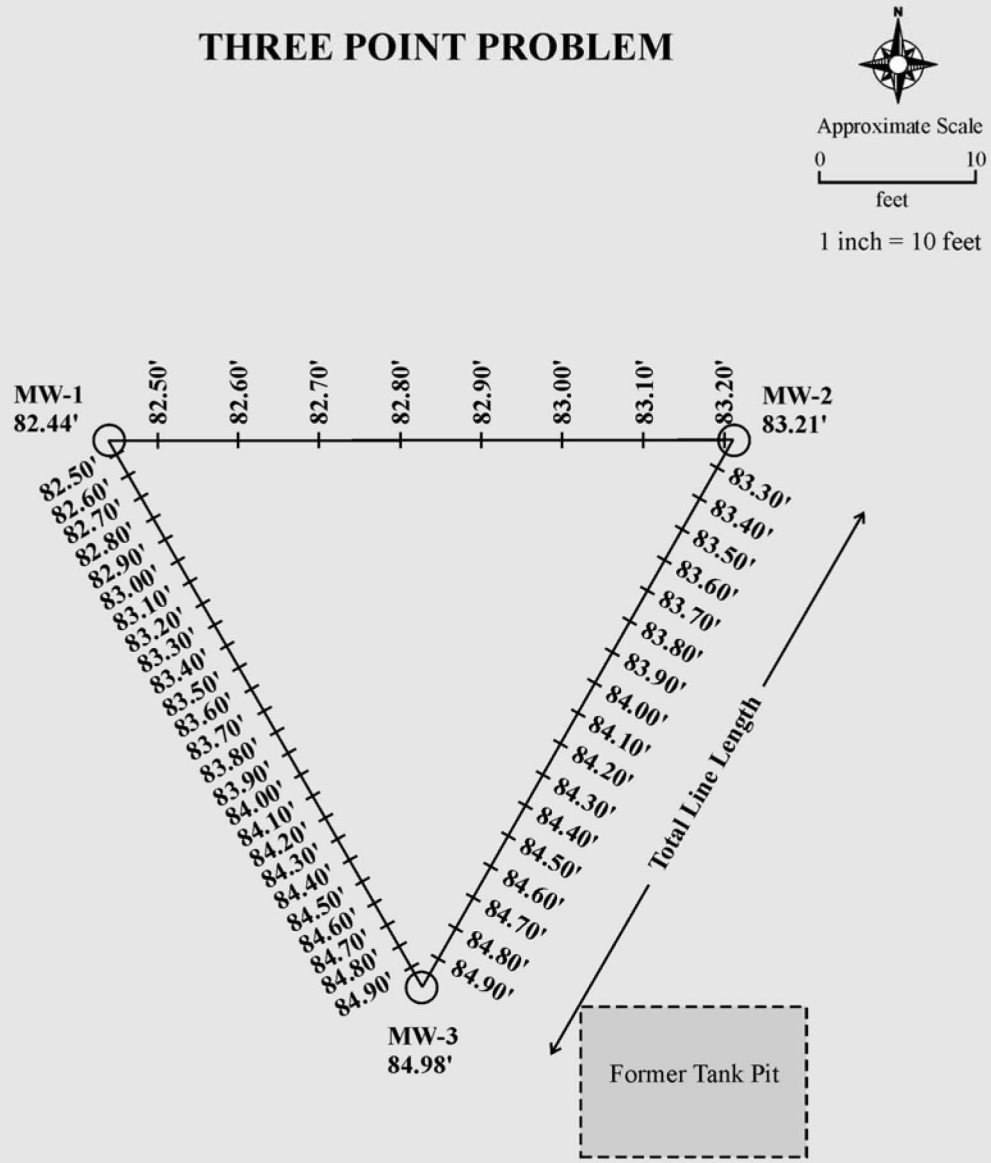



$$\text{Length Needed} = \frac{\text{Total Line Length}}{\text{Total Elevation Difference}} \text{ (Desired Elevation Difference)}$$

$$\text{Length of A} = \frac{4.00''}{84.98' - 82.44'} (.06') = \frac{4.00''}{2.54'} (.06') = .09''$$

$$\text{Length of B} = \frac{4.00''}{84.98' - 82.44'} (.10') = \frac{4.00''}{2.54'} (.10') = .16''$$

# THREE POINT PROBLEM

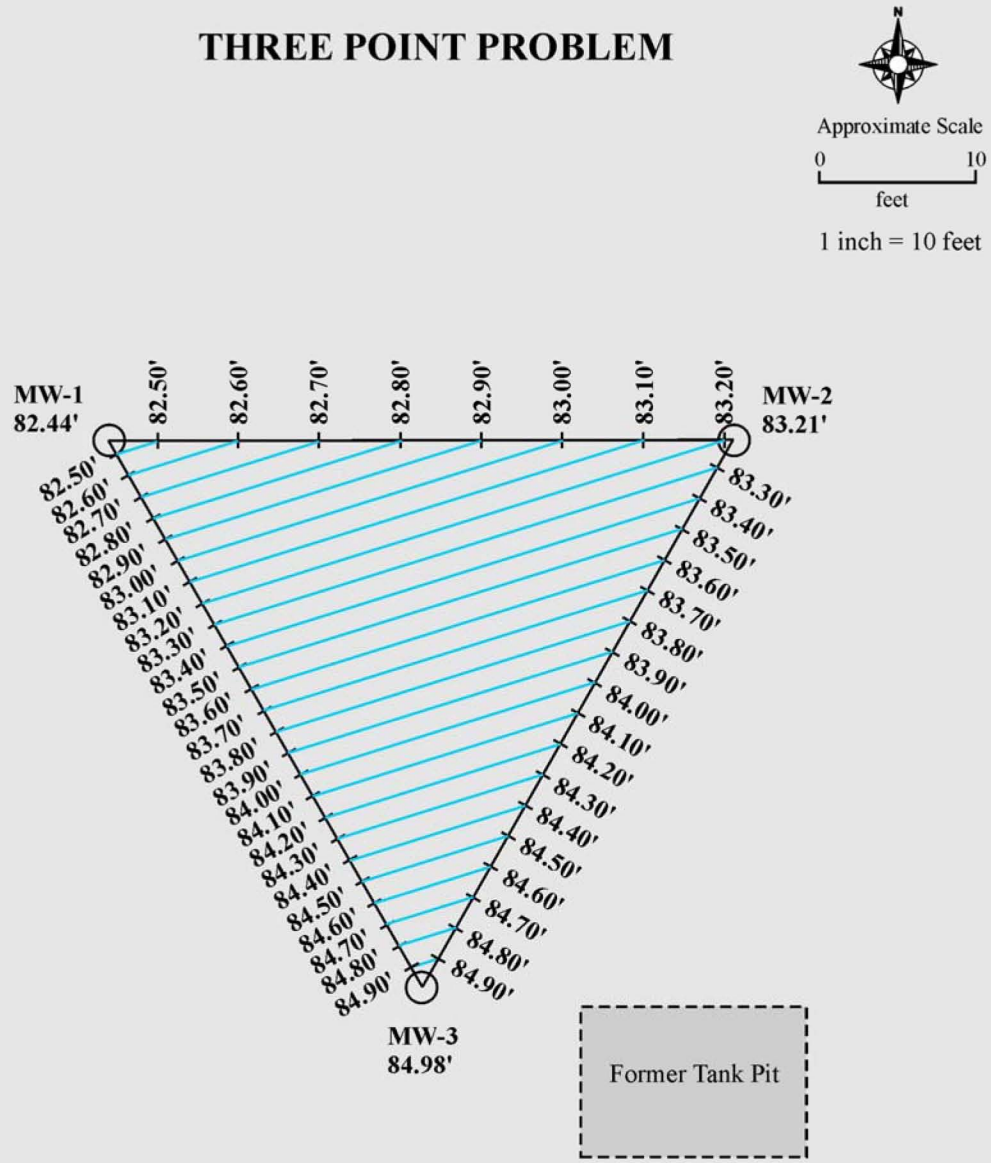



$$\text{Length Needed} = \frac{\text{Total Line Length}}{\text{Total Elevation Difference}} \text{ (Desired Elevation Difference)}$$

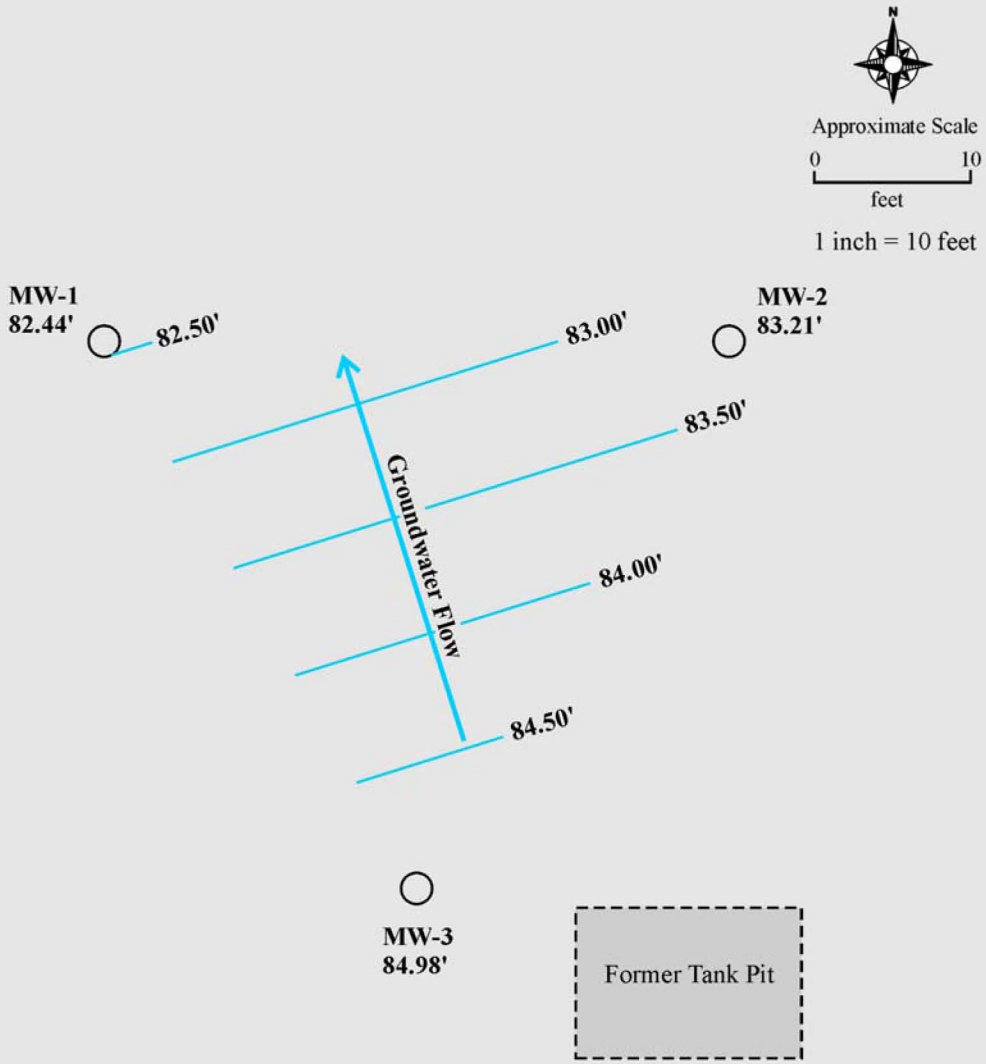
$$\text{Length of A} = \frac{4.00''}{84.98' - 83.21'} (.09') = \frac{4.00''}{1.77'} (.09') = .20''$$

$$\text{Length of B} = \frac{4.00''}{84.98' - 83.21'} (.10') = \frac{4.00''}{1.77'} (.10') = .23''$$

# THREE POINT PROBLEM



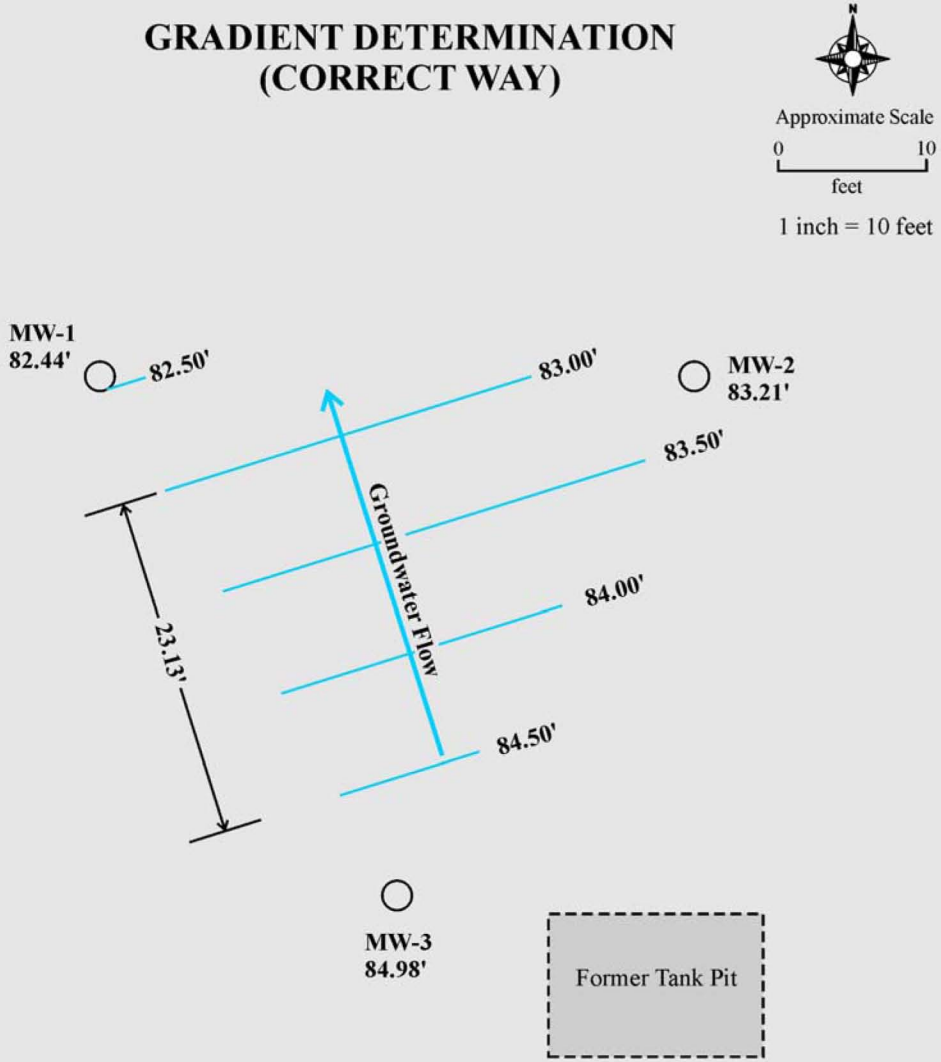
# TYPICAL GROUNDWATER FLOW MAP




# TYPICAL GROUNDWATER FLOW MAP

# MEASURING GROUNDWATER GRADIENT

# GRADIENT DETERMINATION
# (CORRECT WAY)

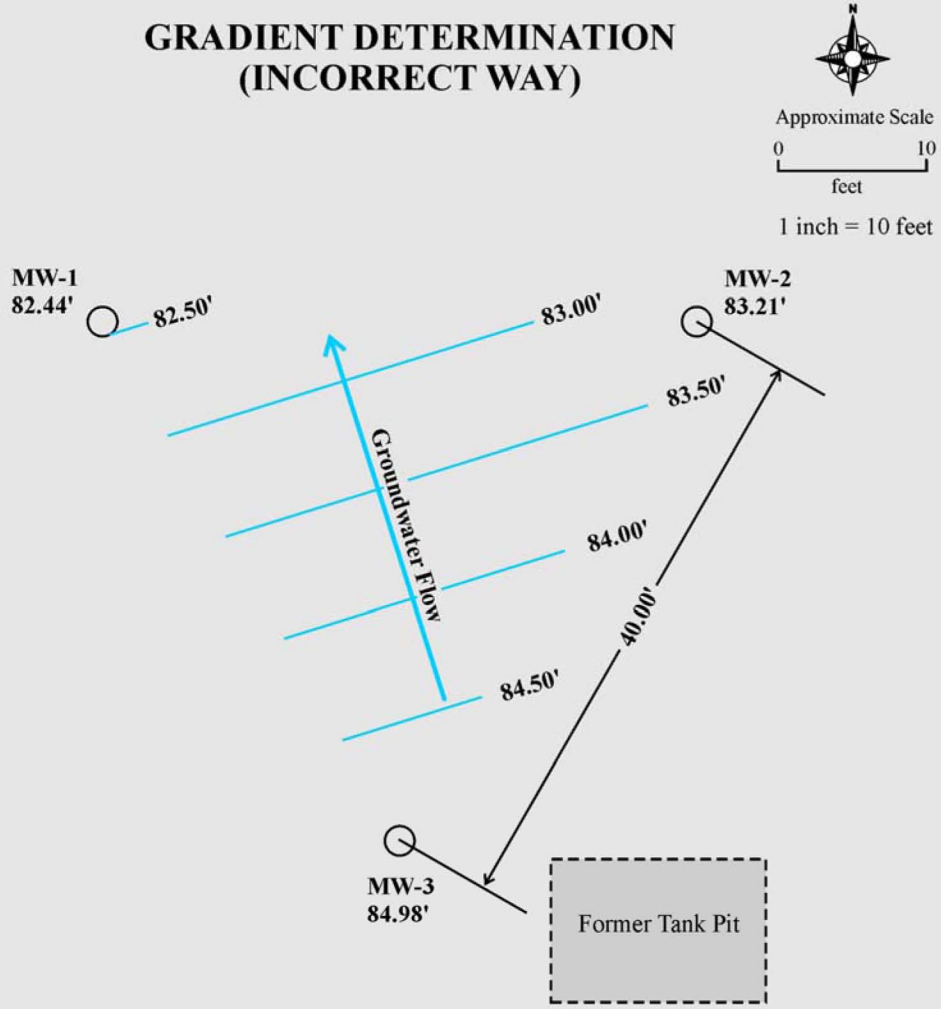



$$\text{Gradient} = \frac{\text{Change in Elevation}}{\text{Distance}} = \frac{\text{Rise}}{\text{Run}}$$

$$\text{Gradient} = \frac{84.50' - 83.00'}{23.13'} = \frac{1.50'}{23.13'} = .06$$

For Every Correct Way……
There Are Many Incorrect Ways

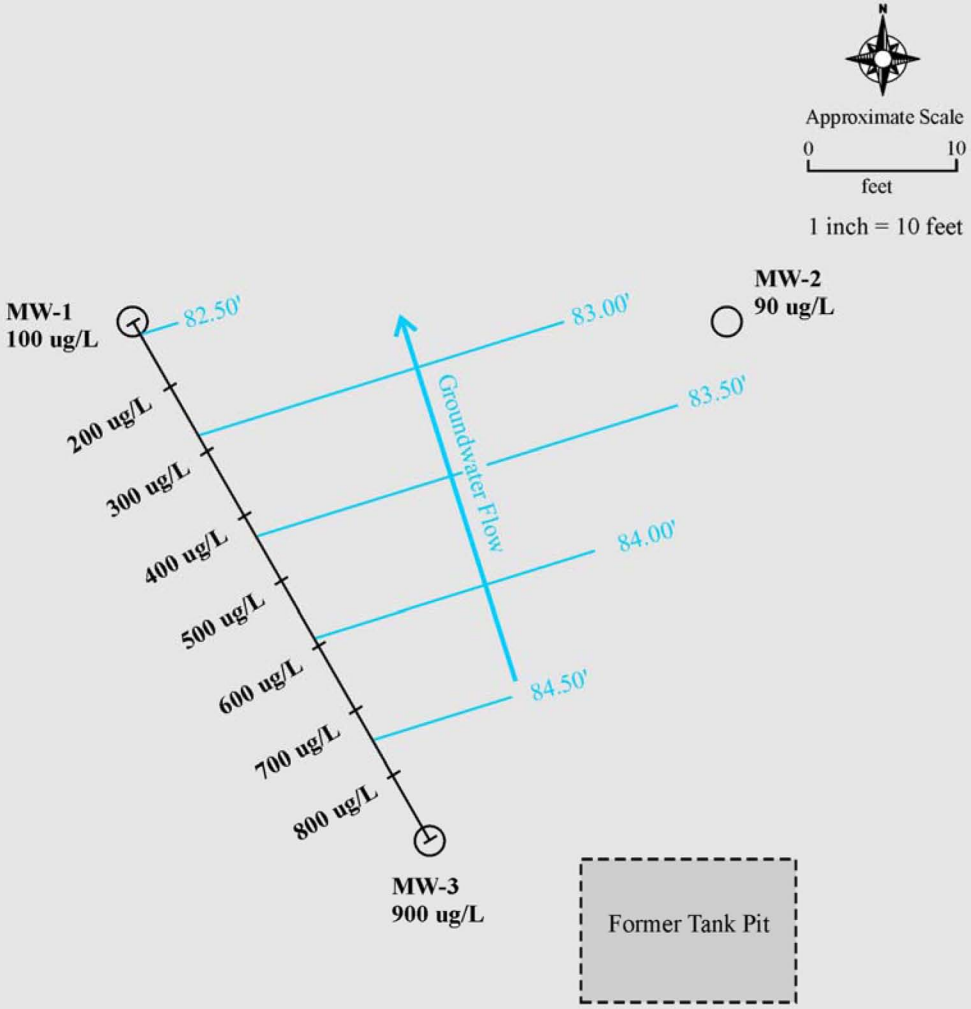
# GRADIENT DETERMINATION
# (INCORRECT WAY)



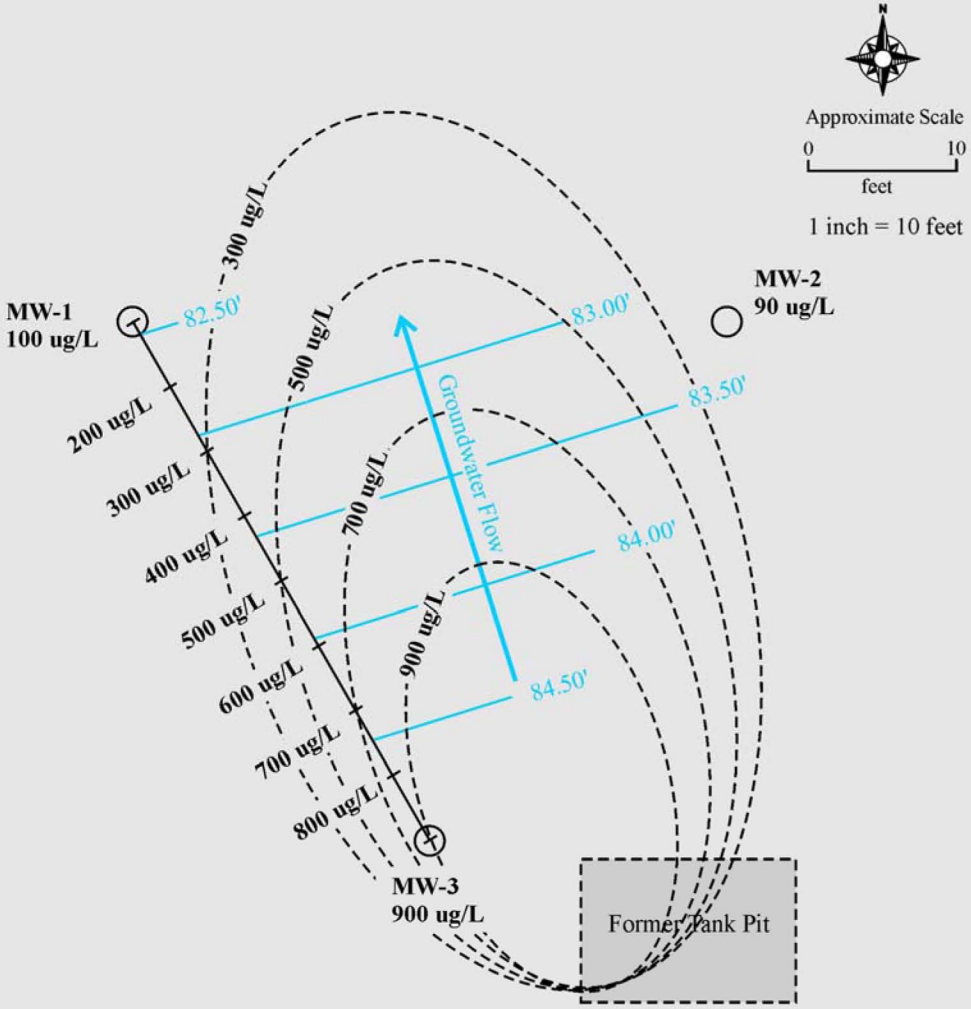

$$\text{Gradient} = \frac{\text{Change in Elevation}}{\text{Distance}} = \frac{\text{Rise}}{\text{Run}}$$

$$\text{Gradient} = \frac{84.98' - 83.21'}{40.00'} = \frac{1.77'}{40.00'} = .04$$

# TYPICAL CONTAMINANT PLUME

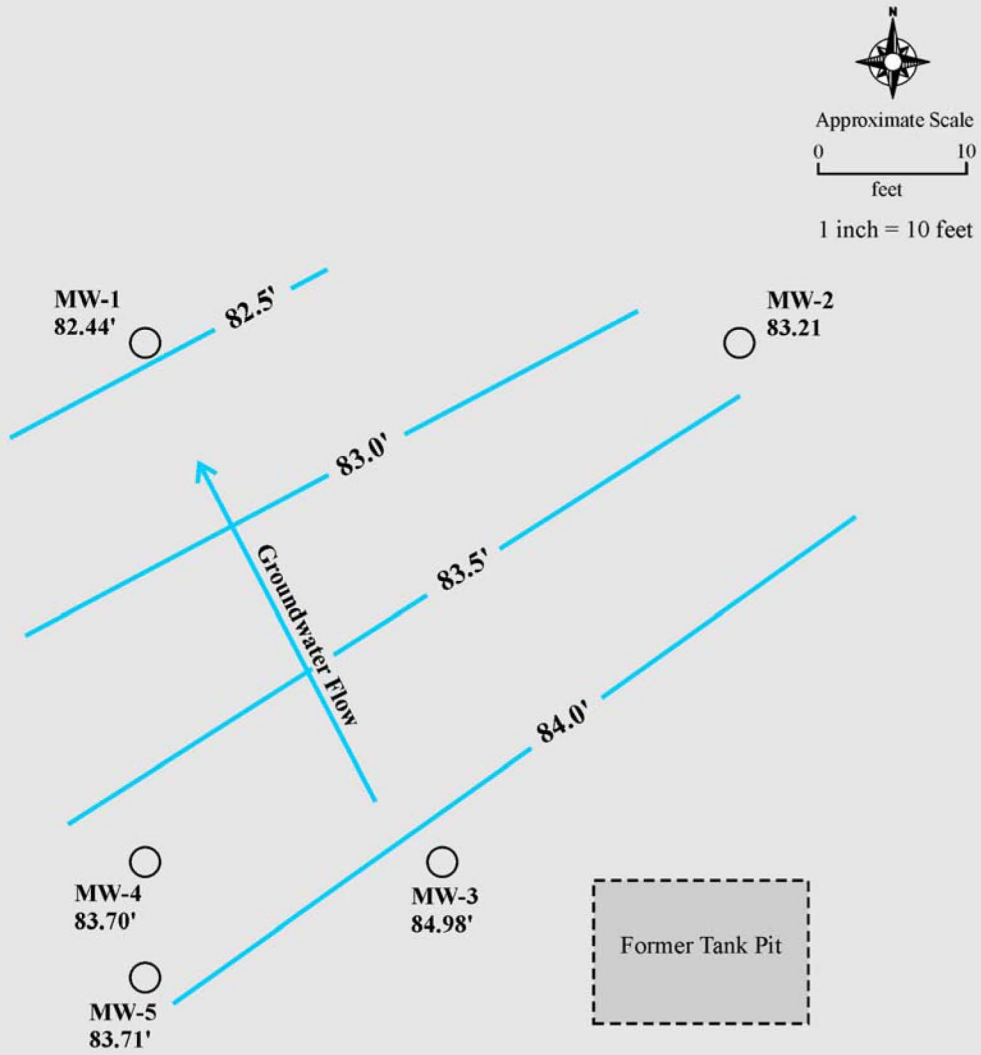



**TYPICAL CONTAMINANT PLUME**

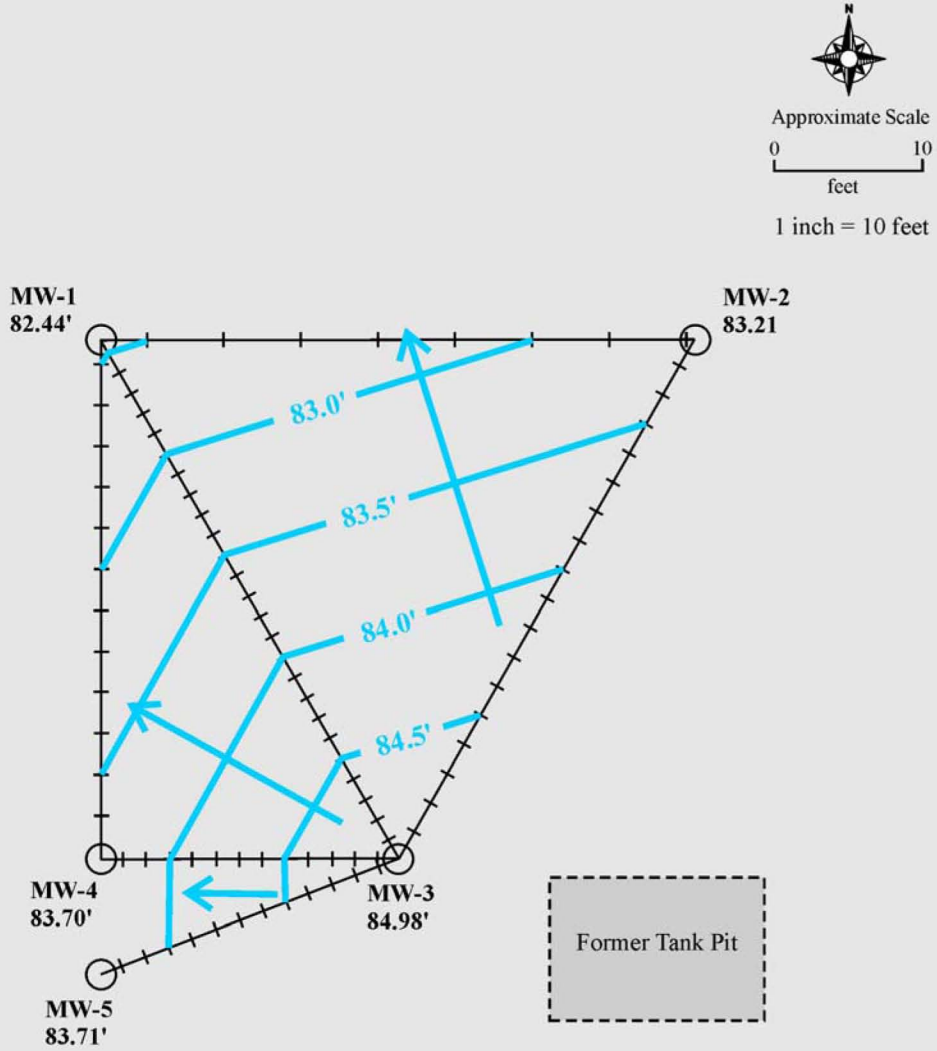



**TYPICAL CONTAMINANT PLUME**

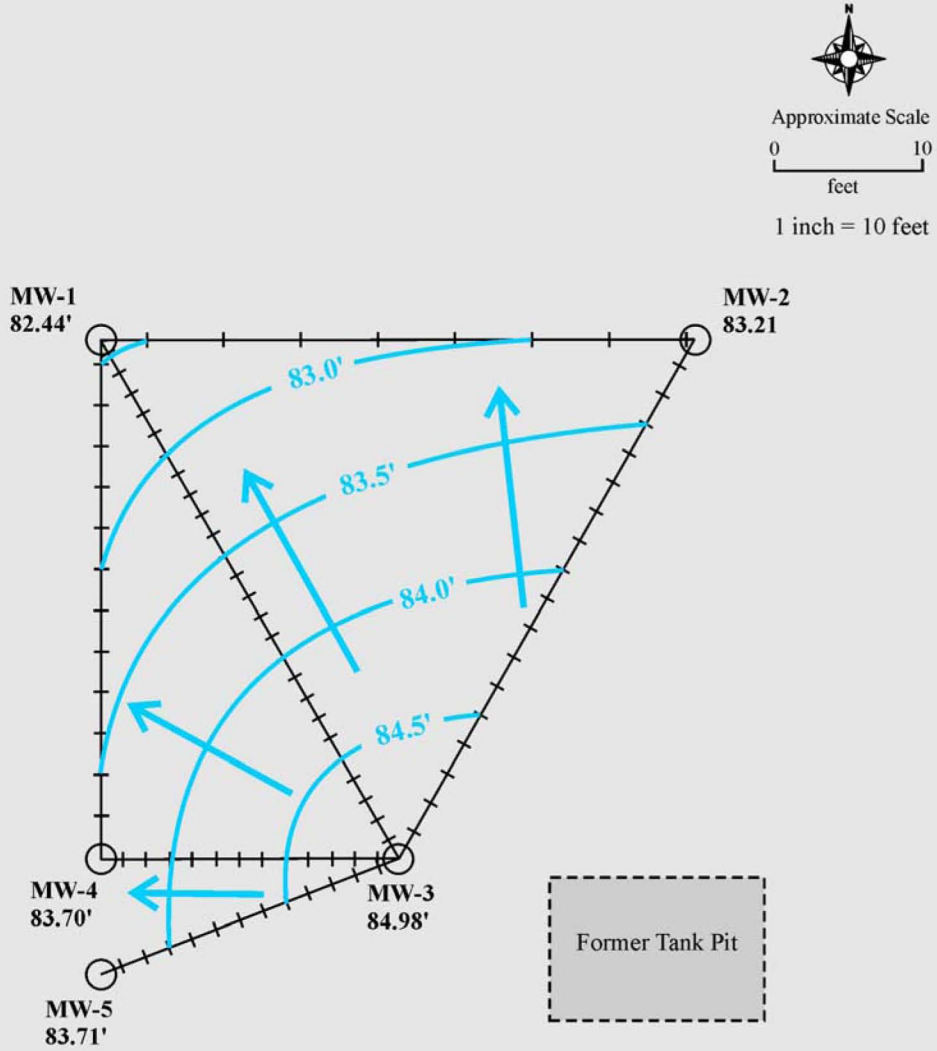
# CONTOURING




**INCORRECT CONTOURING**

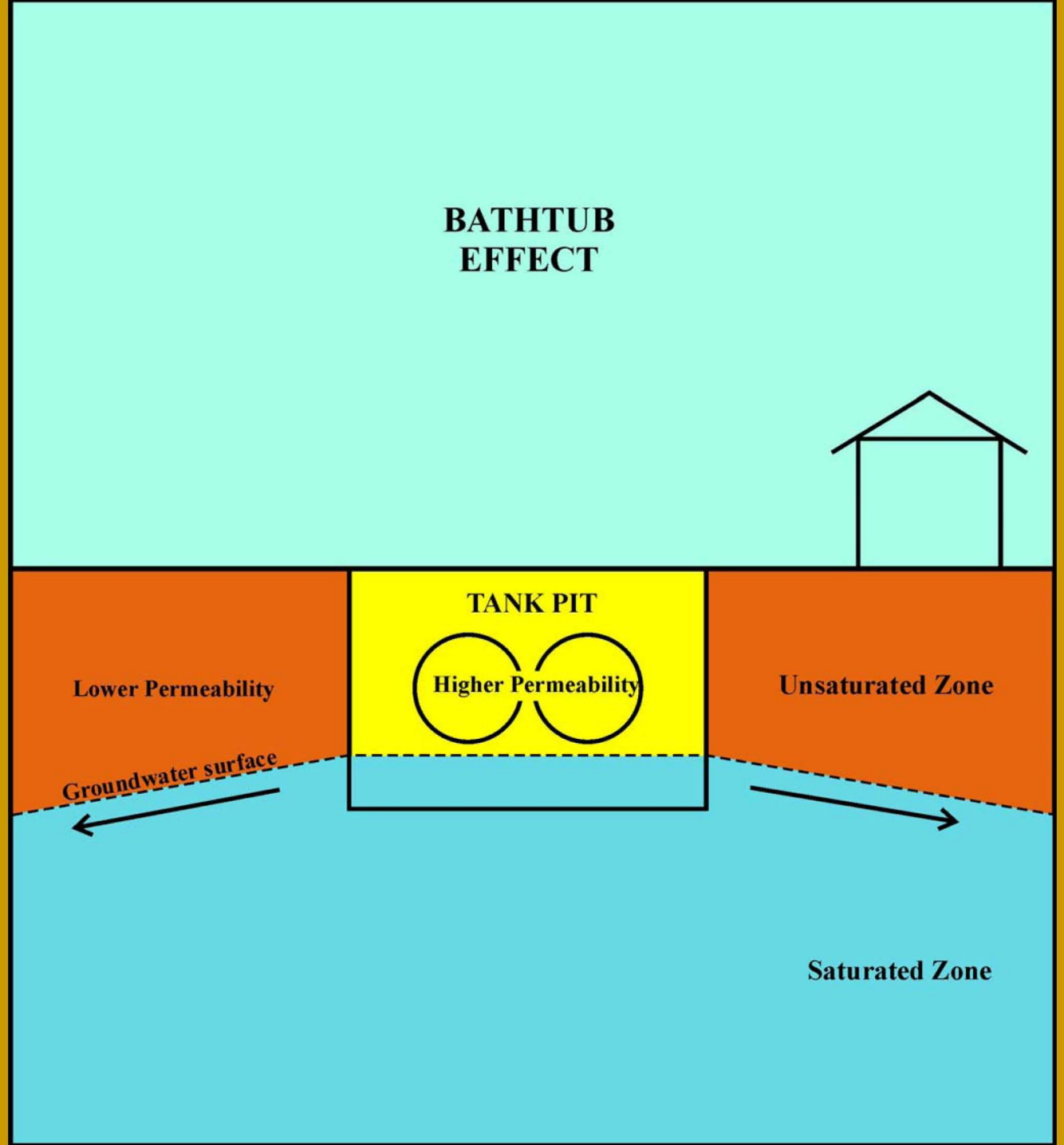


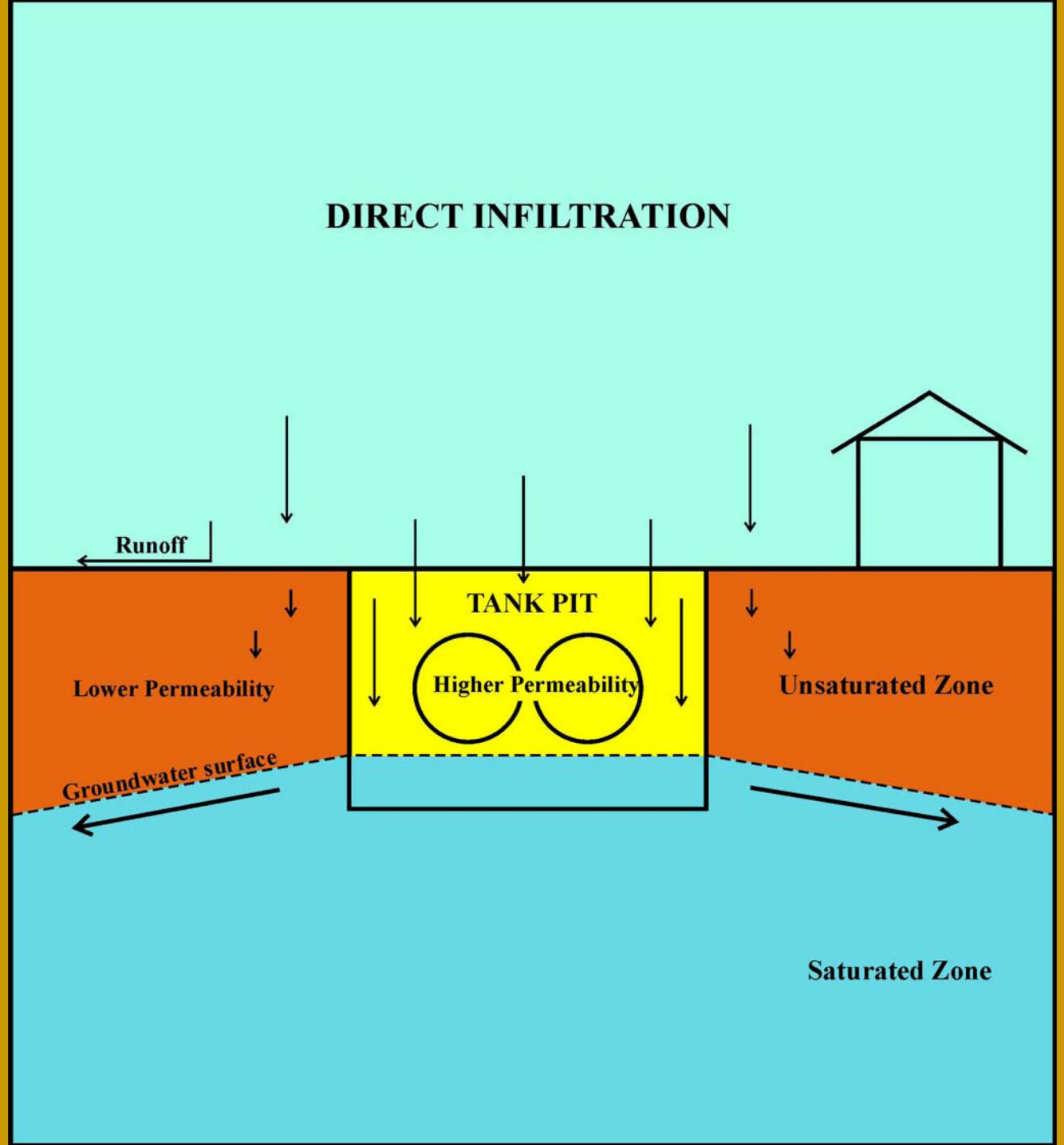

# MULTIPLE THREE POINT PROBLEMS

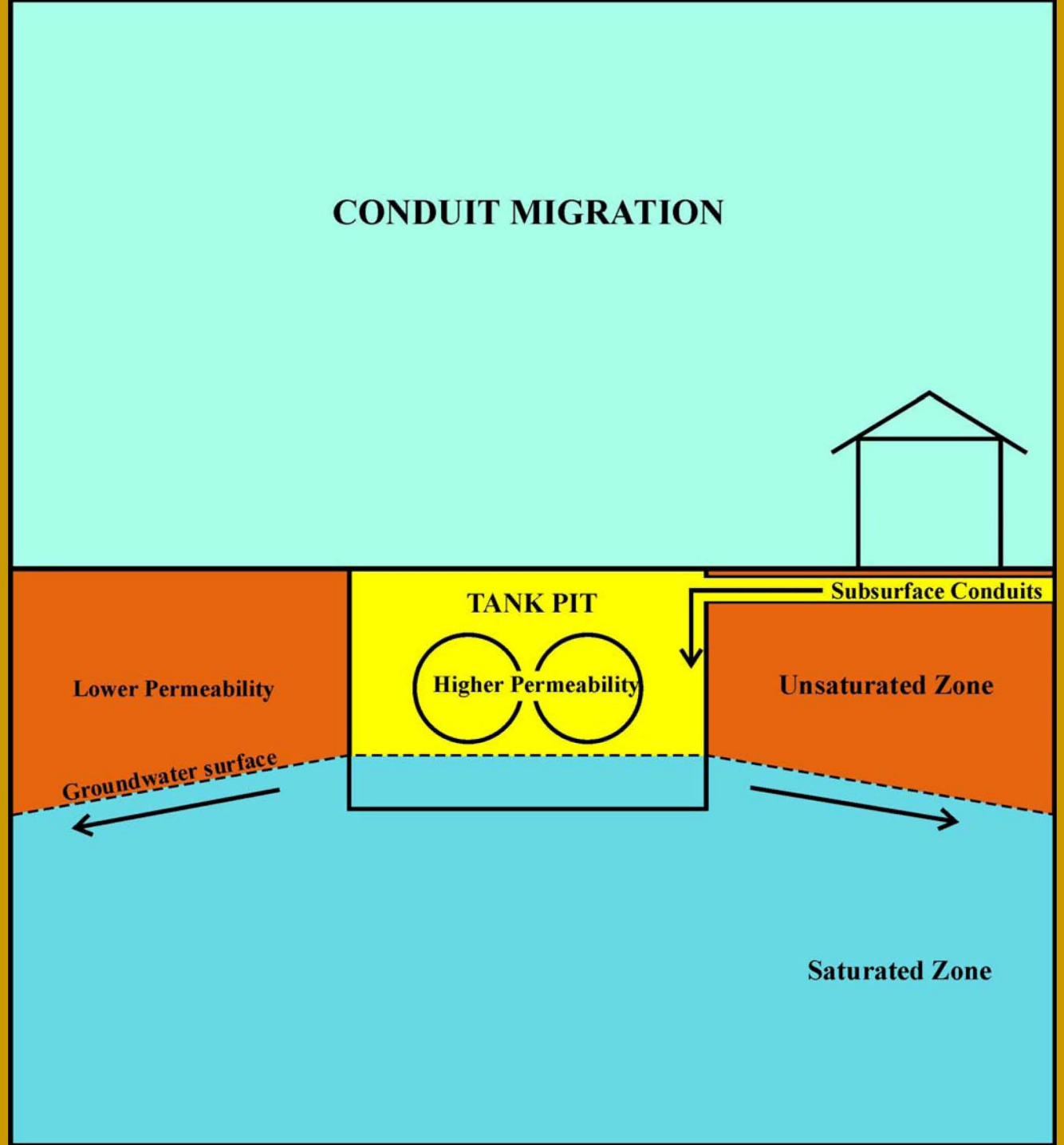



**GROUNDWATER MOUNDING**

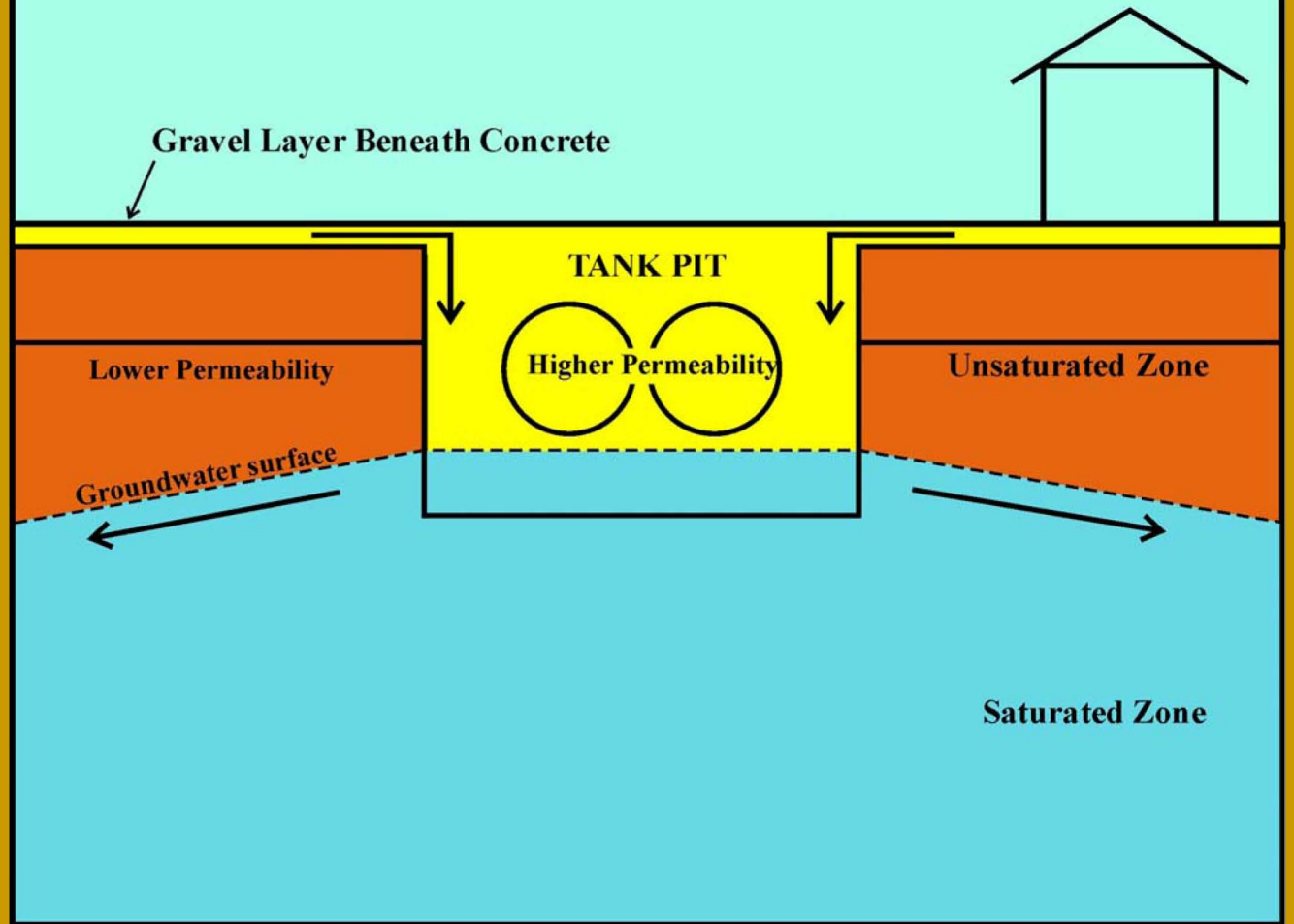
# TANK PIT GROUNDWATER MOUNDING

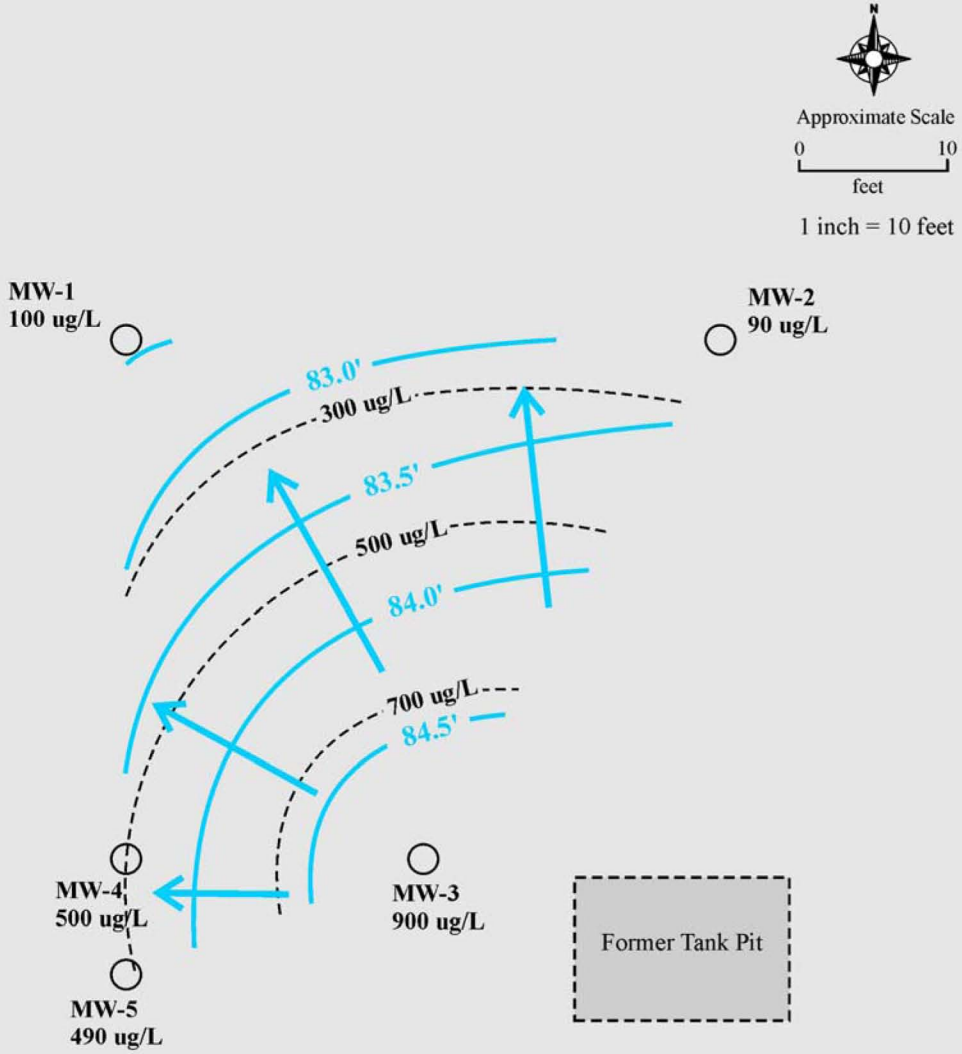

BATHTUB
EFFECT
TANK PIT
Higher Permeability
Lower Permeability
Unsaturated Zone
Groundwater surface
Saturated Zone


DIRECT INFILTRATION
Runoff
TANK PIT
Higher Permeability
Lower Permeability
Unsaturated Zone
Groundwater surface
Saturated Zone

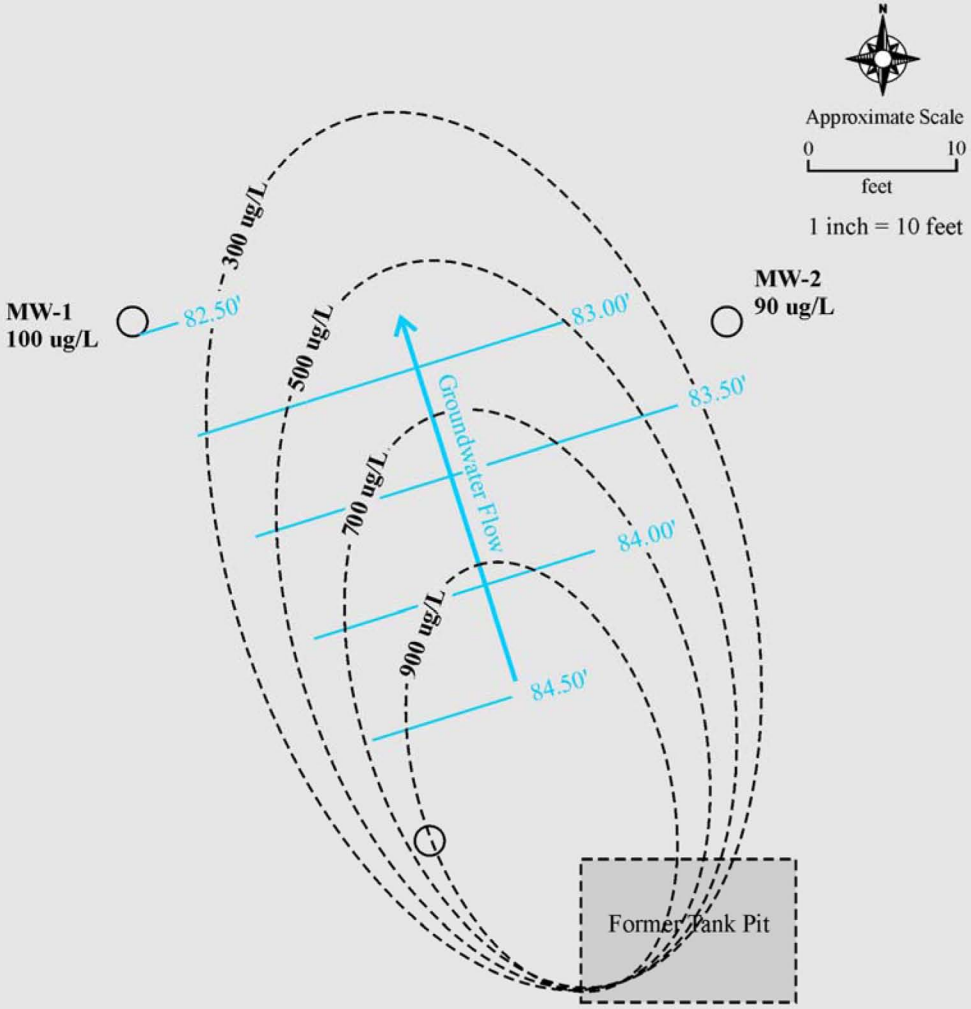

CONDUIT MIGRATION
TANK PIT
Subsurface Conduits
Lower Permeability
Higher Permeability
Unsaturated Zone
Groundwater surface
Saturated Zone

# MIGRATION ALONG HIGH PERMEABILITY LAYERS






**RADIAL FLOW CONTAMINANT PLUME**




**TYPICAL CONTAMINANT PLUME**

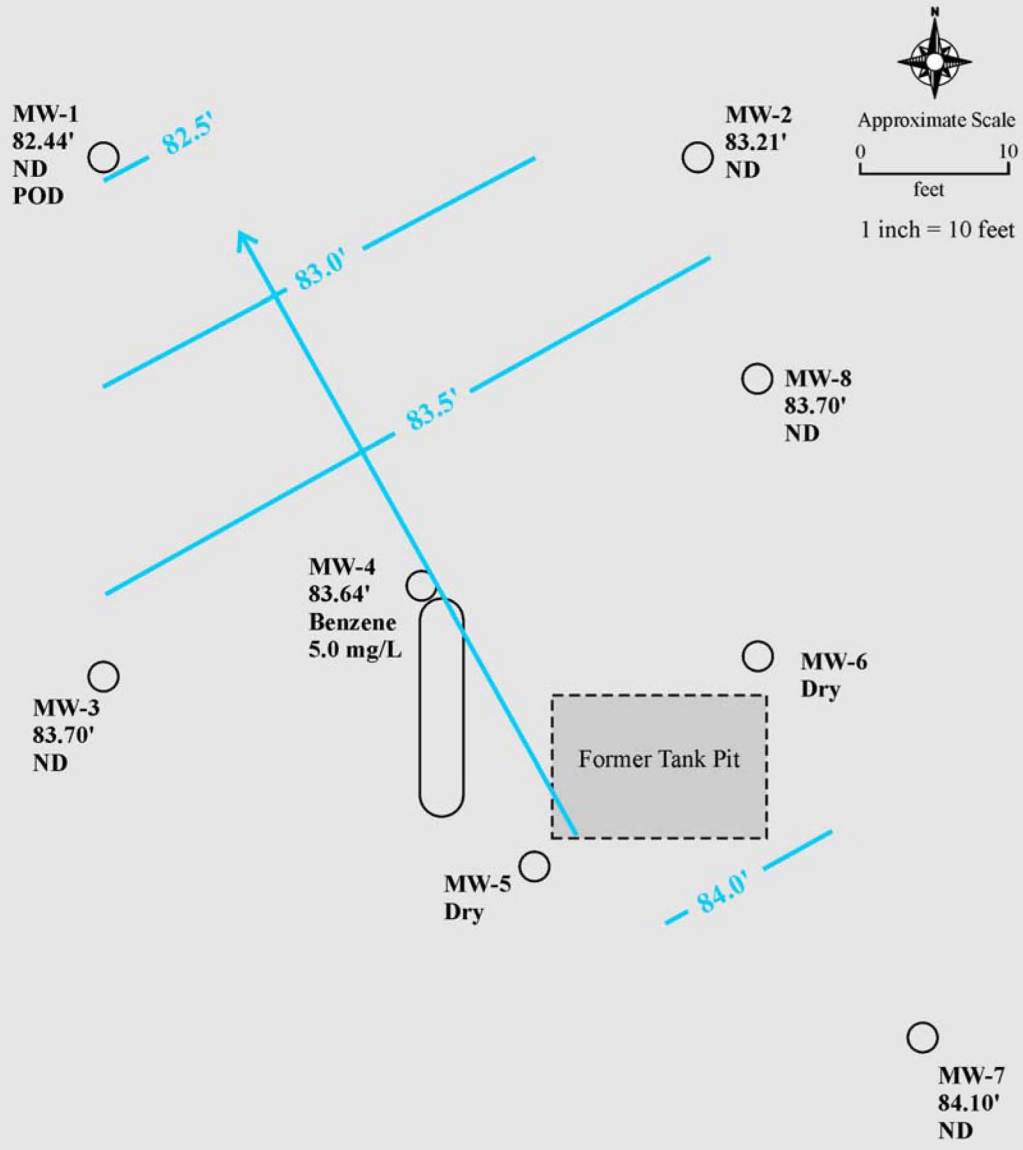
# KARST

SINKHOLES

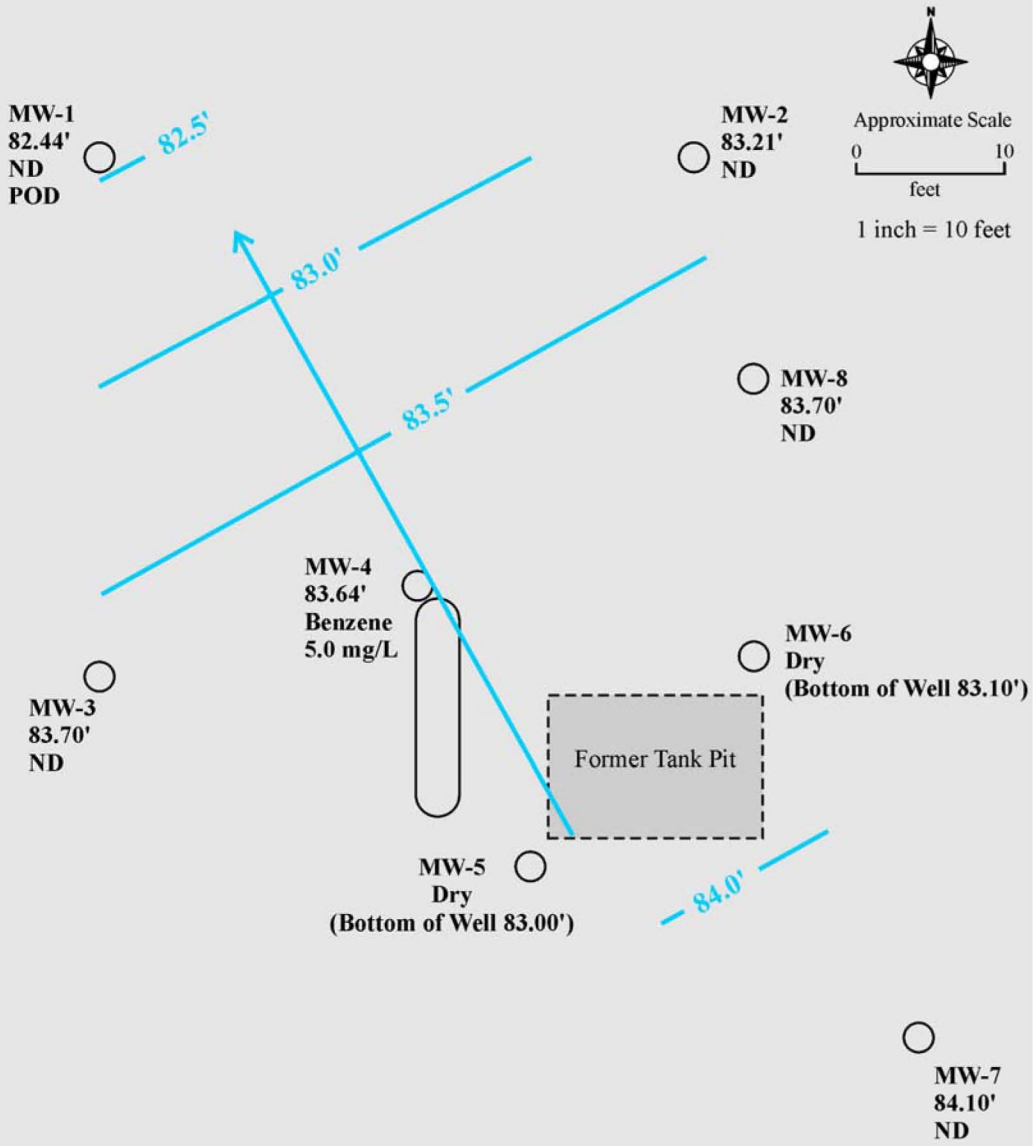
LOSING STREAM

SPRING

SOLUTION ENLARGED FRACTURES

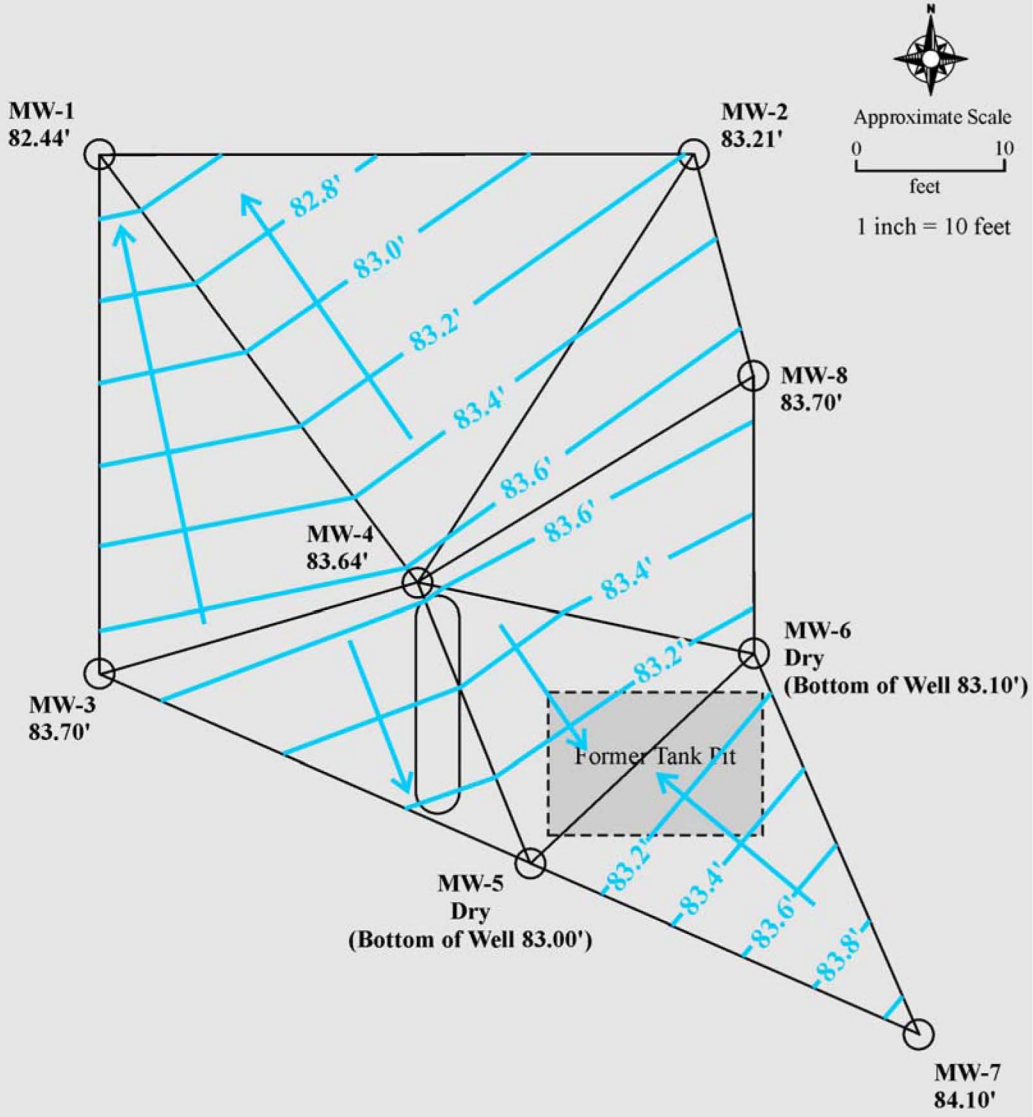

N
Approximate Scale
0
10
feet
1 inch = 10 feet
MW-1
82.44'
ND
POD
82.5'
MW-2
83.21'
ND
83.0'
83.5'
MW-8
83.70'
ND
MW-4
83.64'
Benzene
5.0 mg/L
MW-6
Dry
MW-3
83.70'
ND
Former Tank Pit
MW-5
Dry
84.0'
MW-7
84.10'
ND

**KARST AREA**

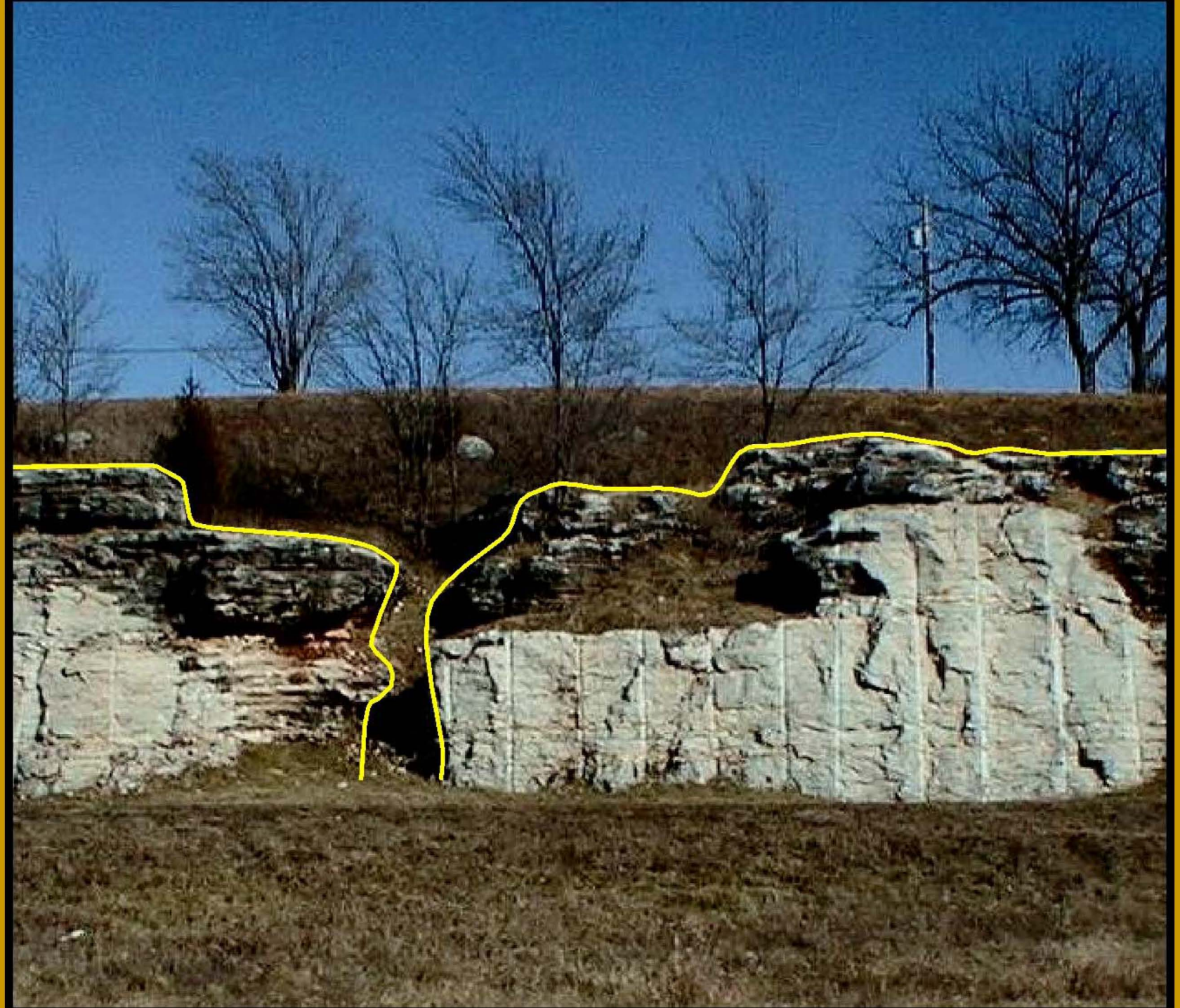


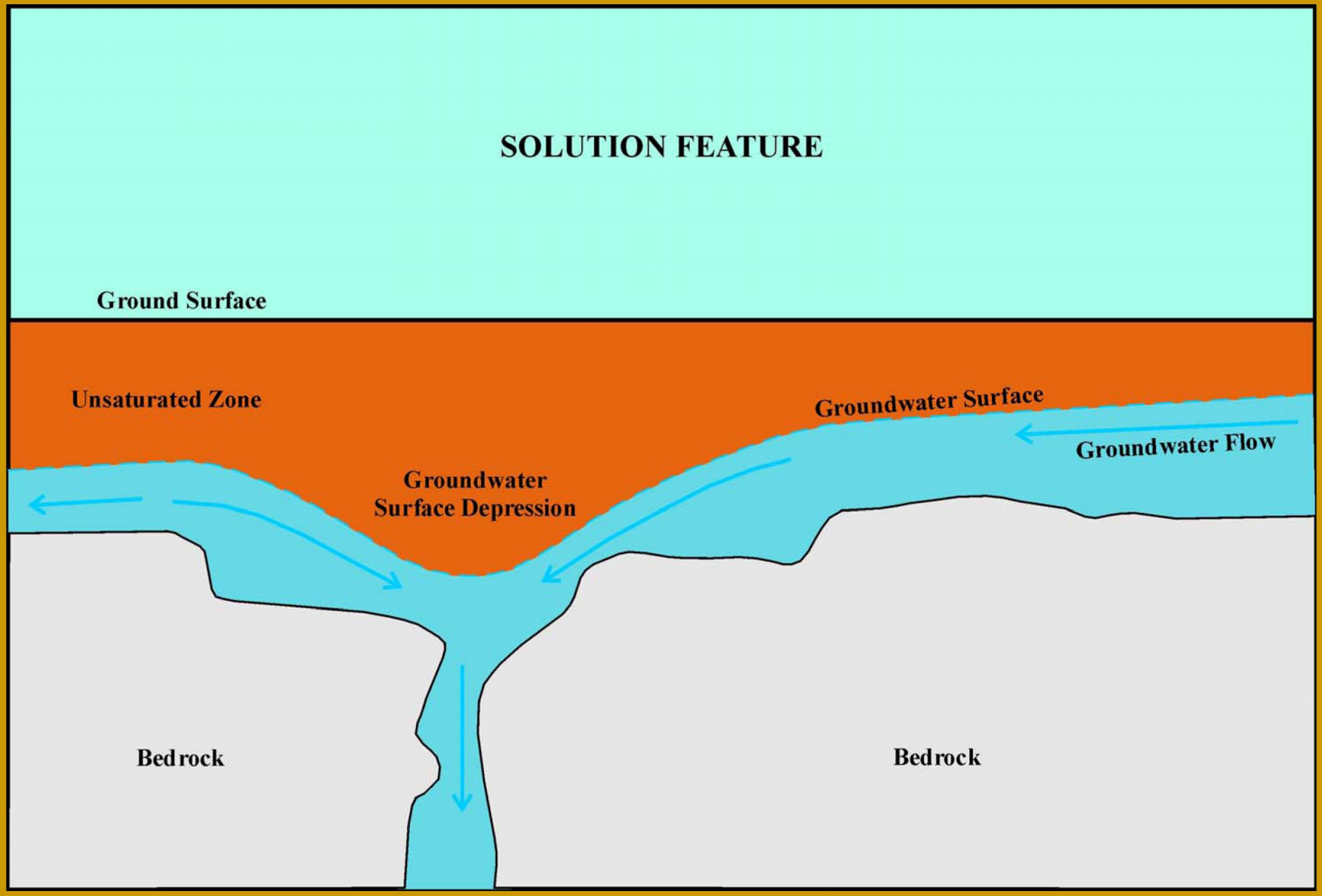

# DRY MONITORING WELL DATA

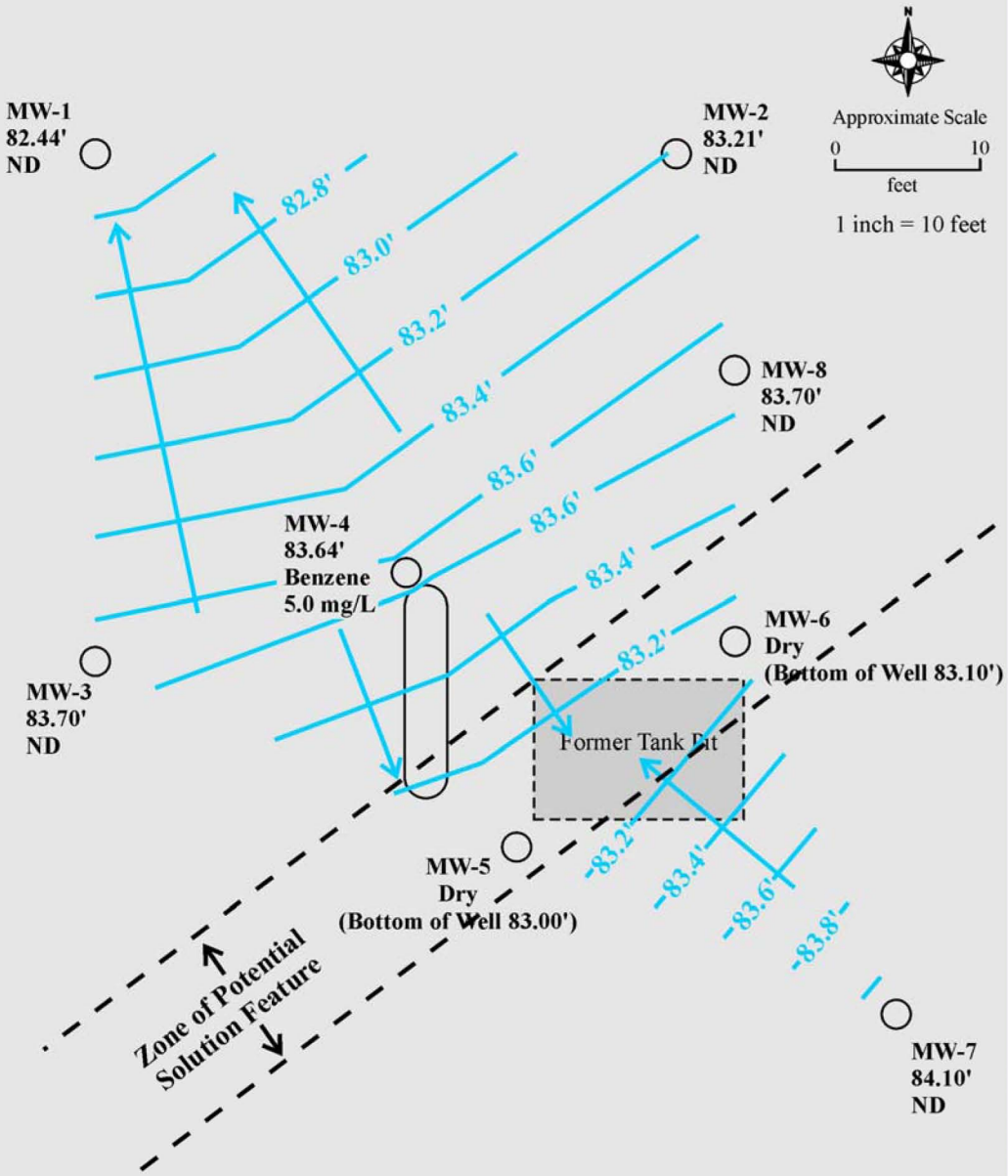
# BACK TO THE THREE POINT PROBLEM




**KARST SITE**
**(Three Point Problems)**

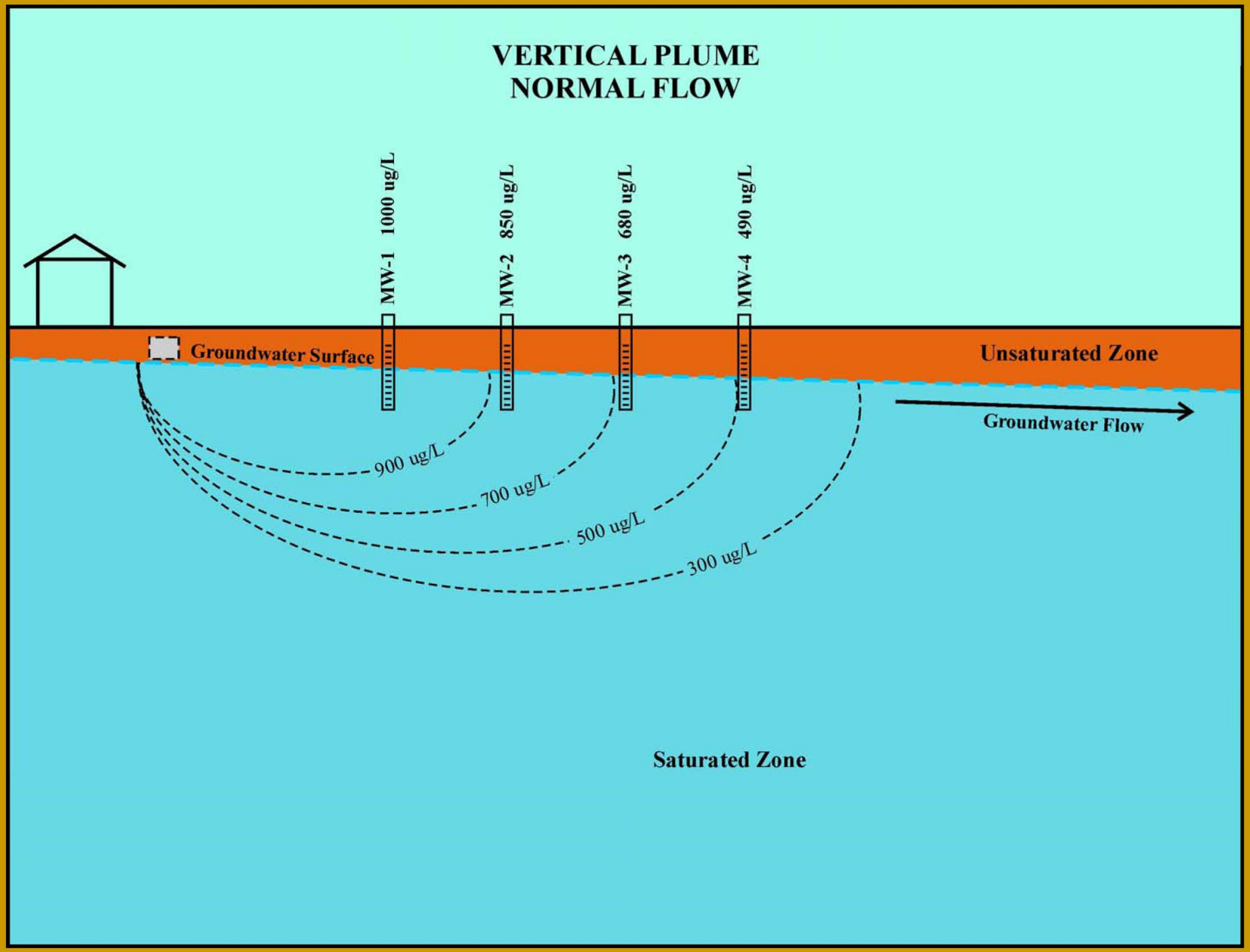



SOLUTION FEATURE
Ground Surface
Unsaturated Zone
Groundwater Surface
Groundwater Flow
Groundwater
Surface Depression
Bedrock
Bedrock

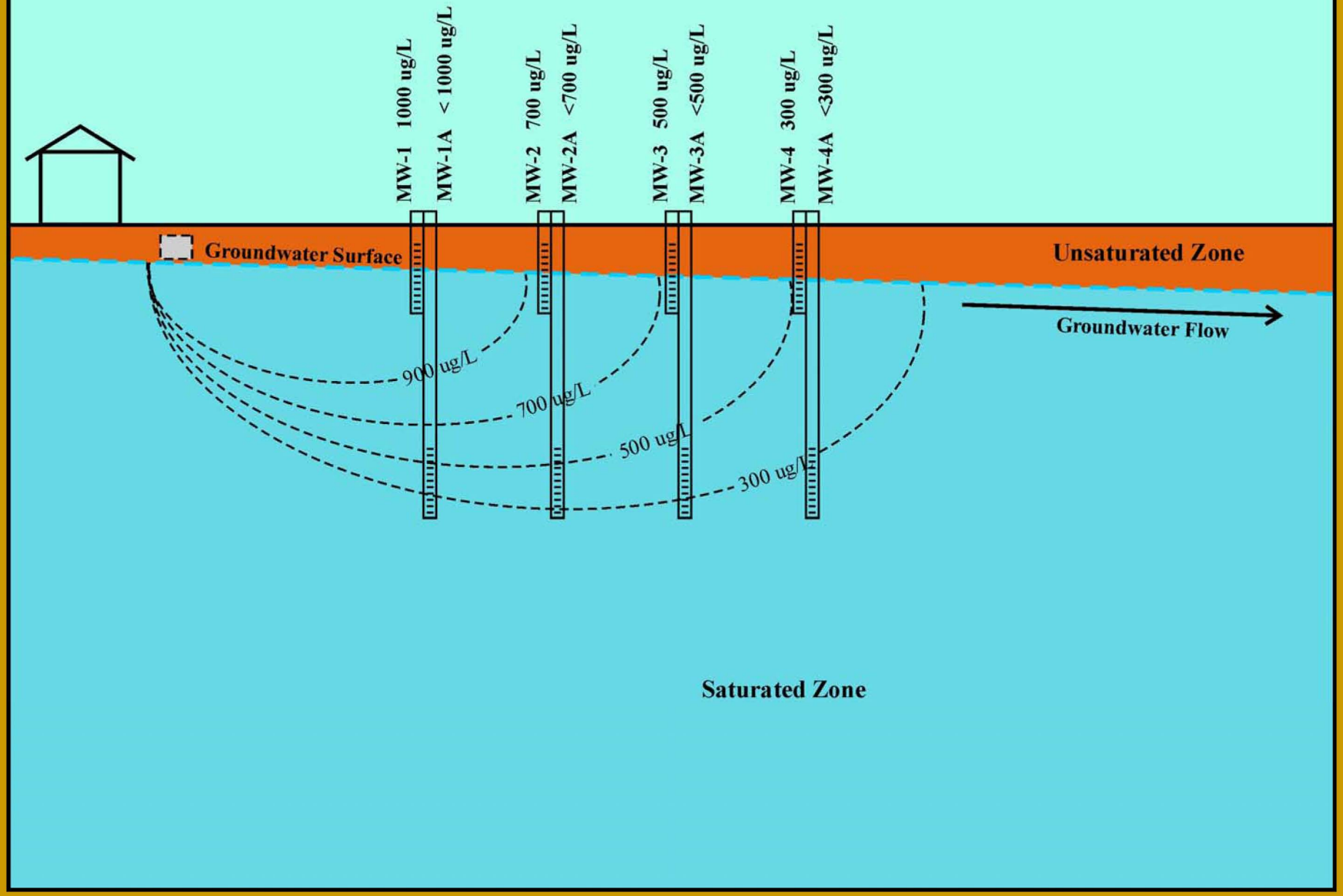


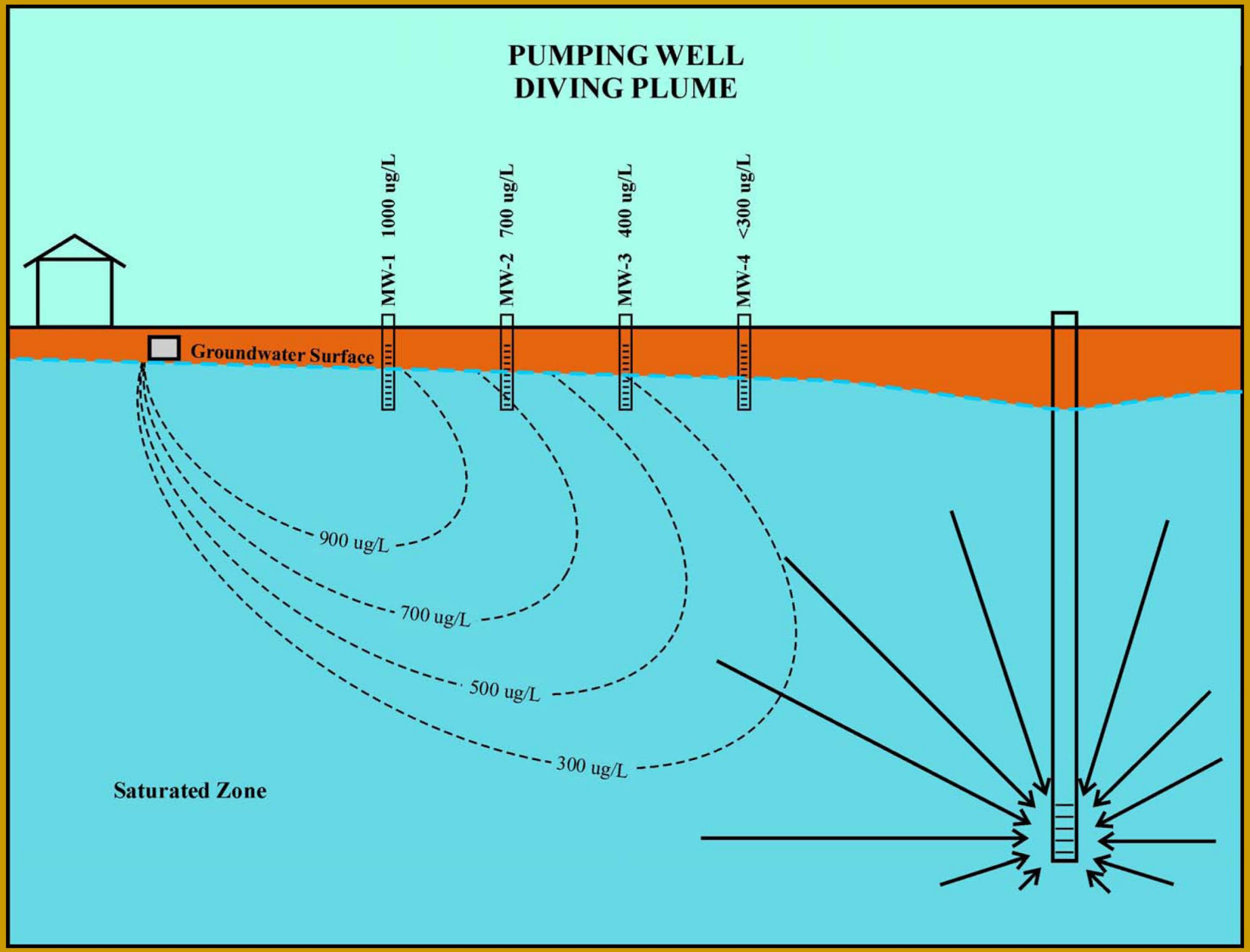

**KARST SITE**
**(Potential Solution Feature)**

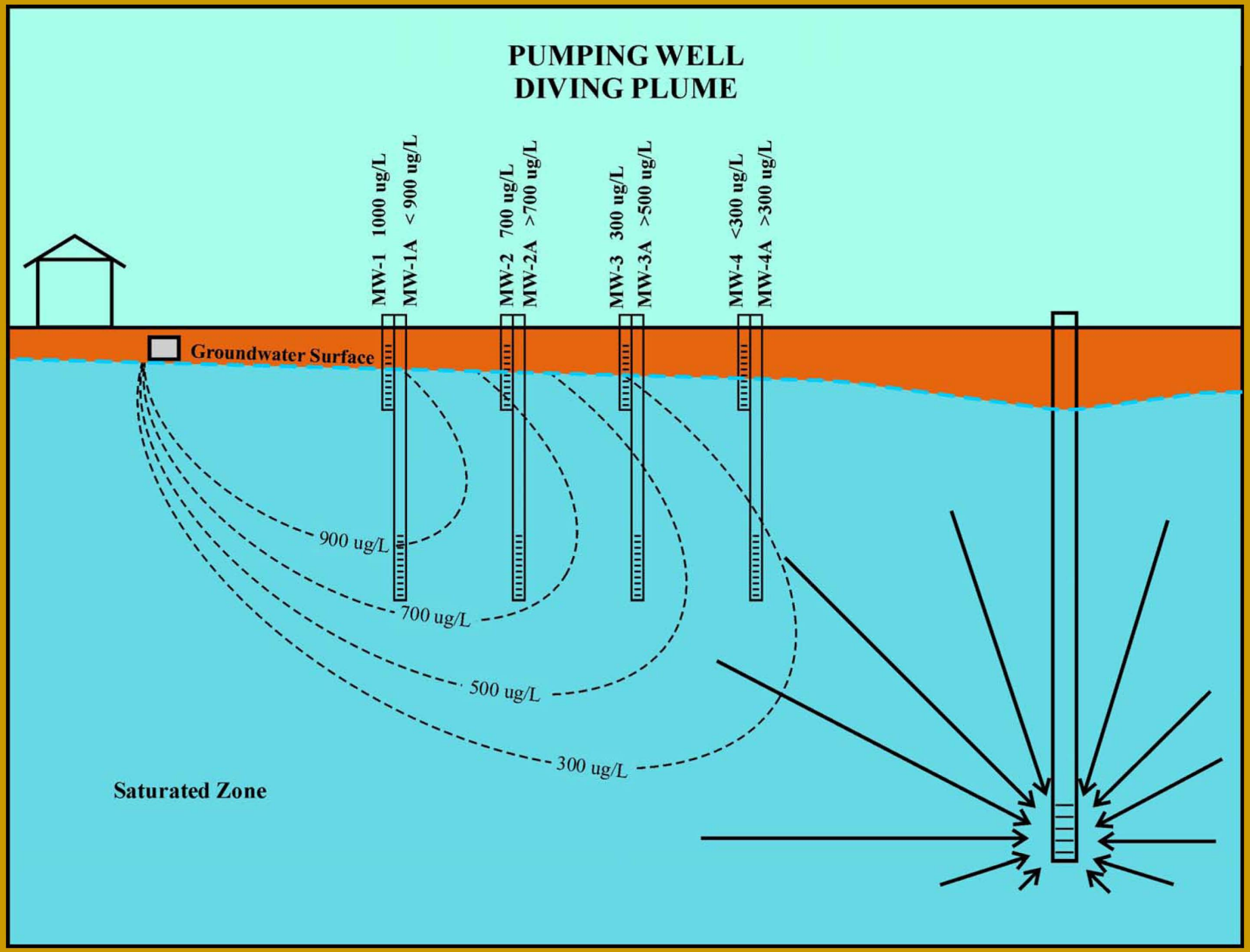
# Vertical Plume Delineation

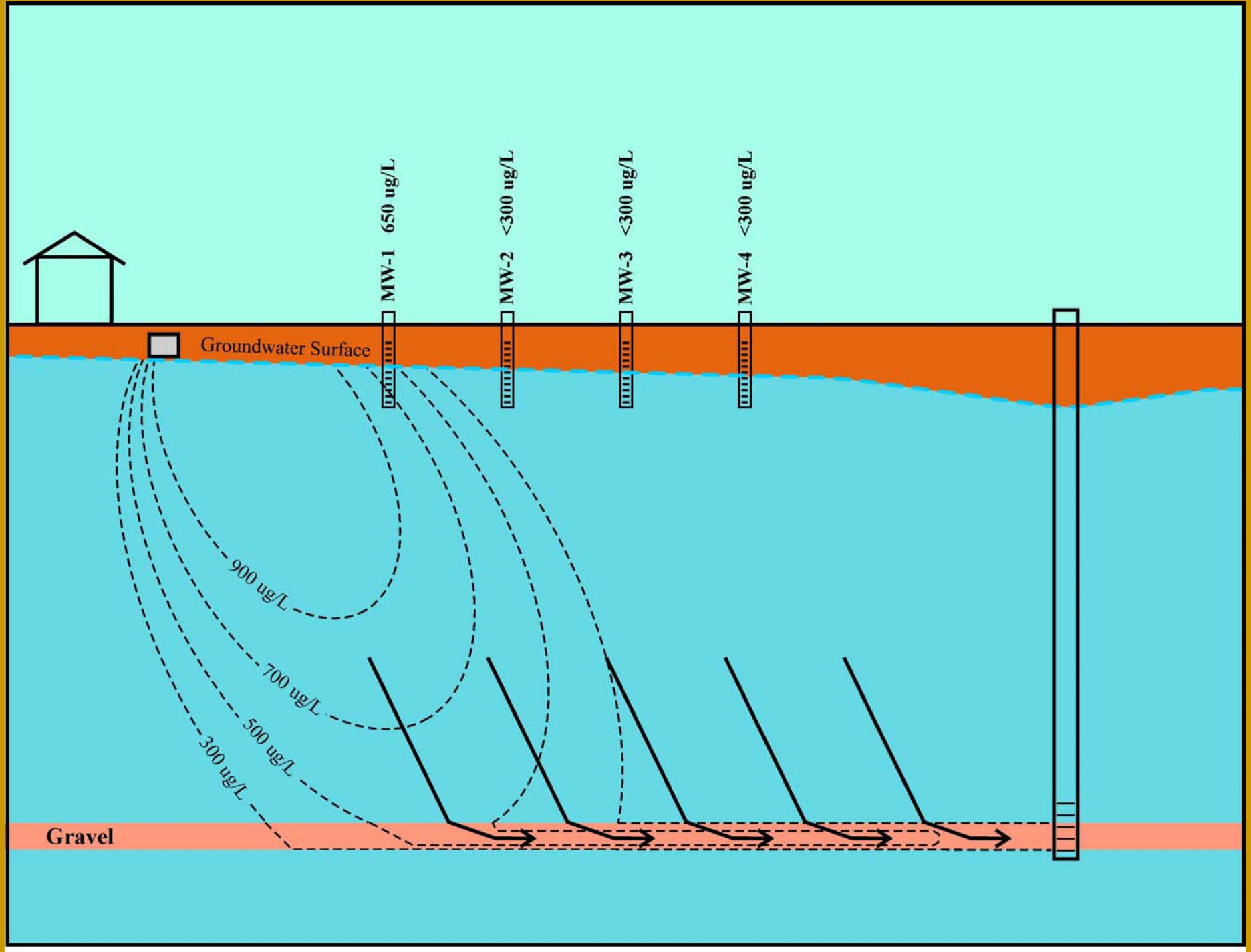
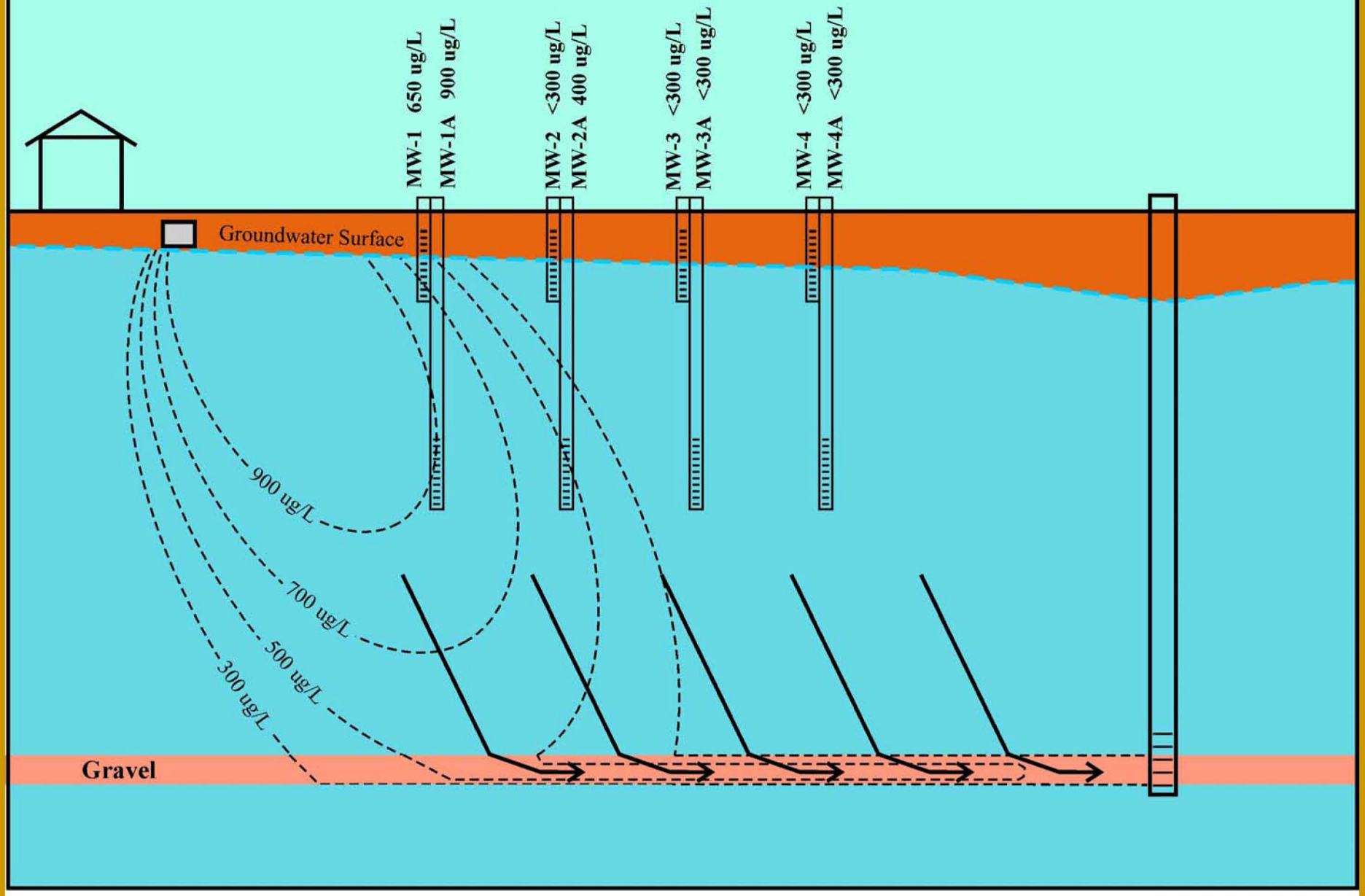

VERTICAL PLUME
NORMAL FLOW
MW-1 1000 ug/L
MW-2 850 ug/L
MW-3 680 ug/L
MW-4 490 ug/L
Groundwater Surface
Unsaturated Zone
Groundwater Flow
900 ug/L
700 ug/L
500 ug/L
300 ug/L
Saturated Zone

# NORMAL FLOW
# NESTED WELLS




PUMPING WELL
DIVING PLUME
MW-1 1000 ug/L
MW-2 700 ug/L
MW-3 400 ug/L
MW-4 <300 ug/L
Groundwater Surface
900 ug/L
700 ug/L
500 ug/L
300 ug/L
Saturated Zone


PUMPING WELL
DIVING PLUME
MW-1 1000 ug/L
MW-1A < 900 ug/L
MW-2 700 ug/L
MW-2A >700 ug/L
MW-3 300 ug/L
MW-3A >500 ug/L
MW-4 <300 ug/L
MW-4A >300 ug/L
Groundwater Surface
900 ug/L
700 ug/L
500 ug/L
300 ug/L
Saturated Zone


MW-1 650 ug/L
MW-2 <300 ug/L
MW-3 <300 ug/L
MW-4 <300 ug/L
Groundwater Surface
900 ug/L
700 ug/L
500 ug/L
300 ug/L
Gravel

# VERTICAL PLUME
# HIGH PERMEABILITY LAYER