

# FRACTURE TRANSPORT MODEL DESIGN

- FRACTRAN – Simulates 2D Groundwater Flow and Solute Transport in Fractured Porous Media
- Model Dimensions – 1000 ft in Length, 100 ft in Depth
- Hydraulic Gradient – Horizontal 0.05 ft/ft, Vertical 0.01 ft/ft
- Precambrian Phyllite Bedrock Properties
  - Hydraulic Conductivity –  $1 \times 10^{-10}$  cm/sec
  - Porosity – 0.01
  - Longitudinal and Transverse Dispersivity – Zero
- Fracture Properties
  - Aperture – 30 microns
  - Dispersivity – 0.1 m

# SORPTION AND RETARDATION

- Sorption in Porous Media
  - $K_d = \frac{\text{Solute Sorbed on Solid Per Unit Mass of Solid}}{\text{Solute Concentration}}$
  - Units  $L^3/M$  (L/kg)
- Sorption on Fracture Surface
  - $K_a = \frac{\text{Solute Sorbed on Solid Per Unit Area of Solid}}{\text{Solute Concentration}}$
  - Units L (m)
- Measured  $K_d$  Values are Available for Wharf Mine and Published  $K_d$  Values for Other Site are Widely Available
- Measured  $K_a$  Values are Not Available for Wharf Mine and Published  $K_a$  Values are Very Rare

# SORPTION AND RETARDATION

- Published  $K_a$  Values Typically One to Two Orders of Magnitude Smaller than  $K_d$  Values
- Published  $K_a$  Values
  - $1 \times 10^{-3}$  to  $1 \times 10^{-5}$  m (or smaller) for weakly sorbing chemicals
  - $1 \times 10^{-1}$  to  $1 \times 10^{-2}$  m (or larger) for strongly sorbing chemicals
- Calculated Rough Estimate of Arsenic  $K_a$  for Precambrian Phyllite from  $K_d$  Values Assuming Uniform Spherical Particles (60 Mesh)
  - $K_d = 3.0$  L/kg
  - $K_a = 0.0003$  m
  - Probably too Small Based on Published  $K_a$  Values

# SORPTION AND RETARDATION

- Retardation for Porous Media

$$R = 1 + \rho_b / \Phi \times K_d$$

- R becomes larger as  $\Phi$  becomes smaller

- Retardation for Fractures

$$R = 1 + K_a / b \text{ (where } b \text{ is fracture aperture)}$$

- R becomes larger as  $b$  becomes smaller

- R for Precambrian Phyllite

- For 30 microns R is 11.63 m

- For 20 microns R is 17.0 m

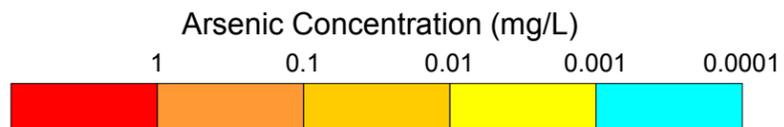
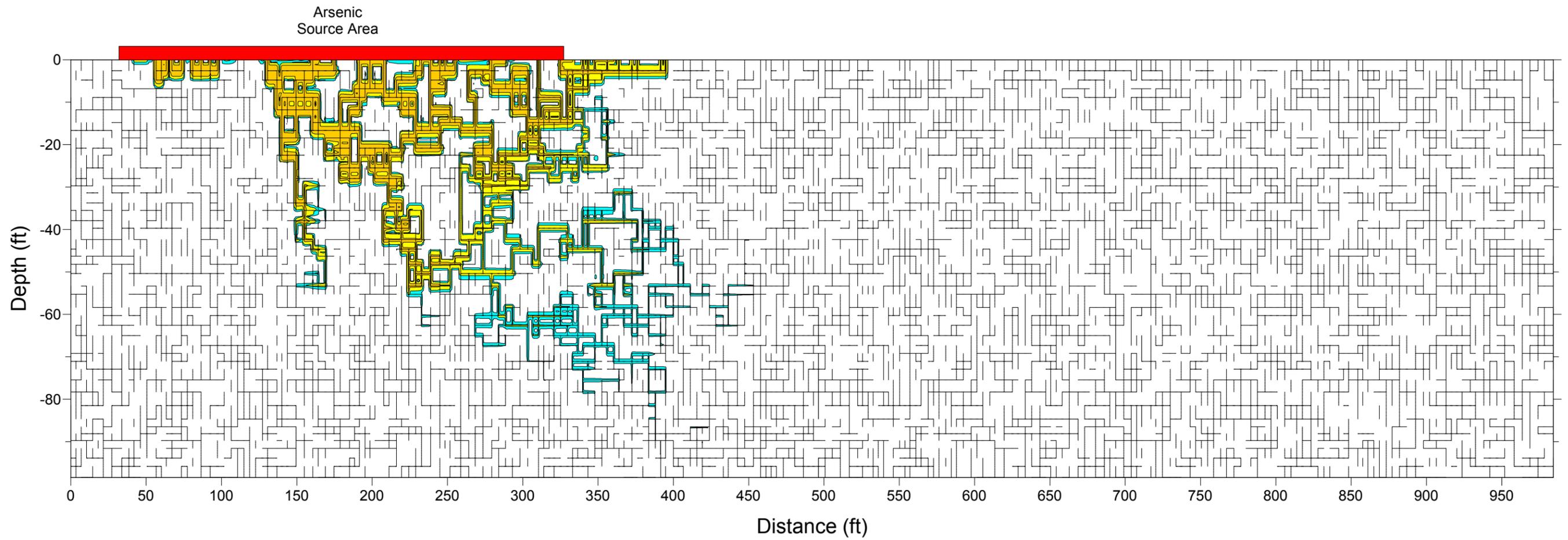


Figure 1  
Arsenic Concentration Solution  
Year 2020  
No Retardation

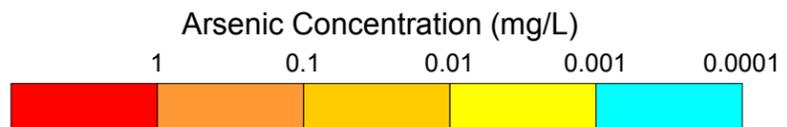
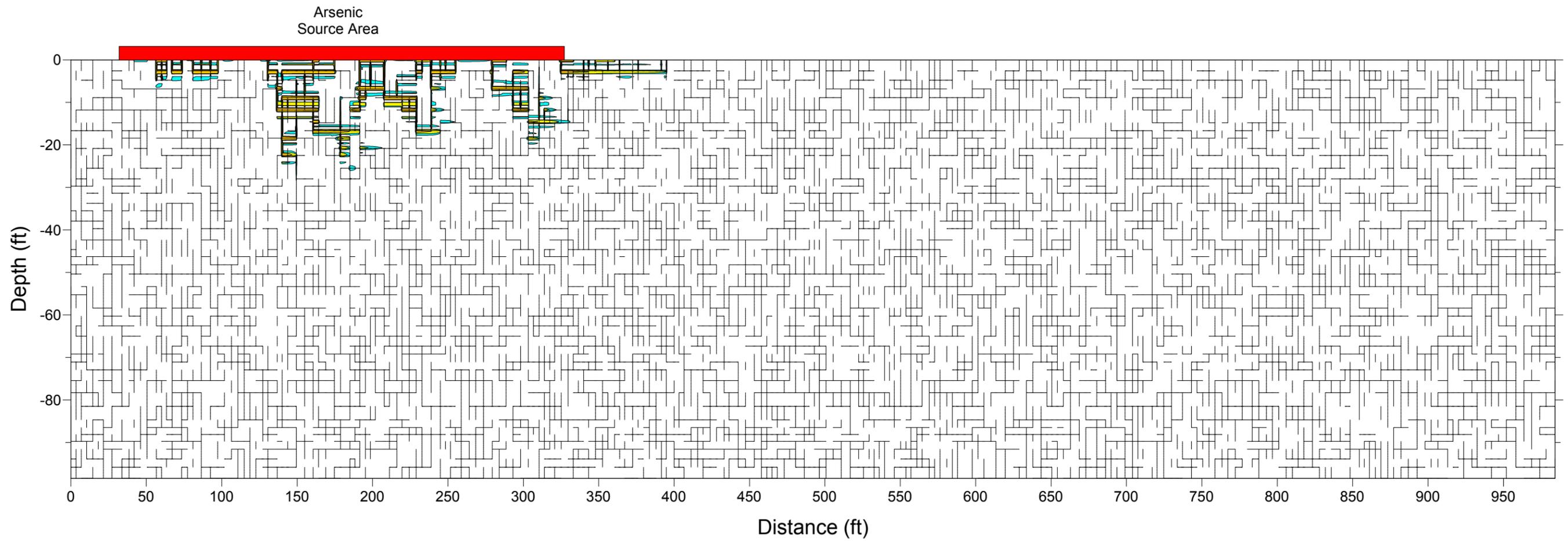


Figure 2  
Arsenic Concentration Solution  
Year 2020  
With Retardation

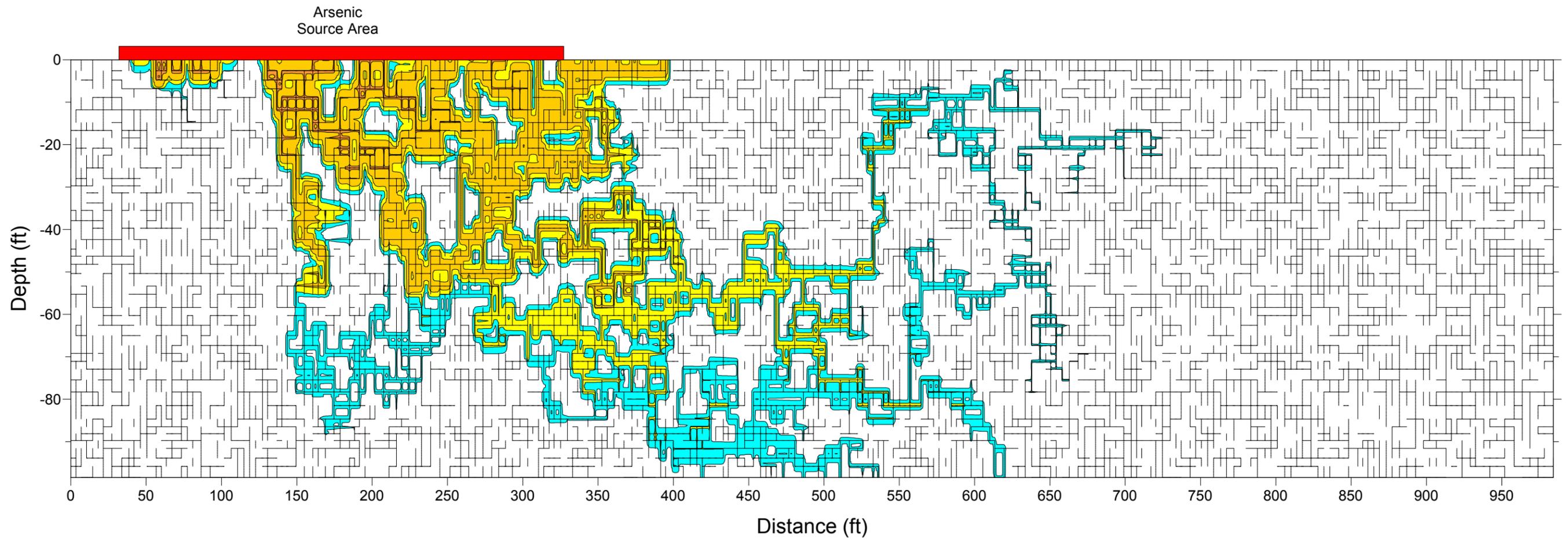


Figure 3  
Arsenic Concentration Solution  
Year 2040  
No Retardation

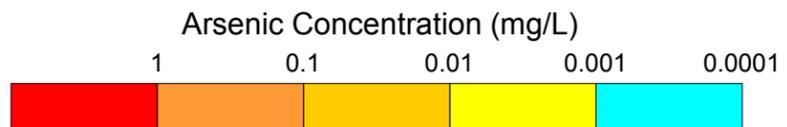
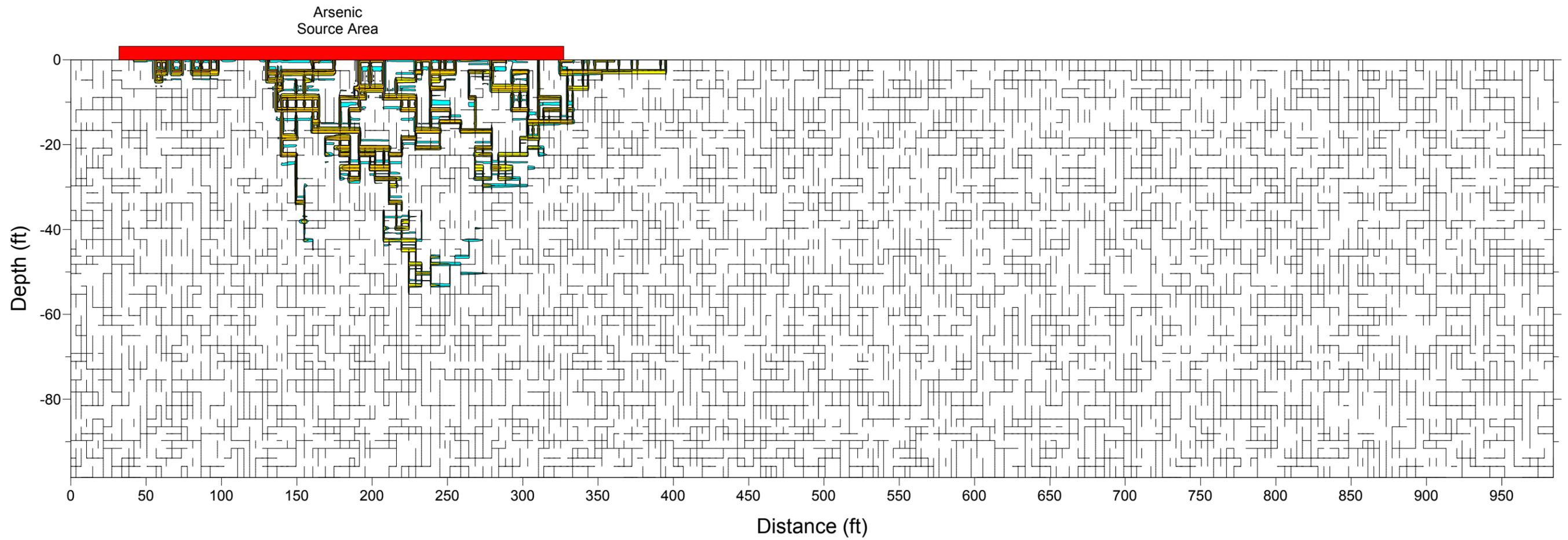


Figure 4  
Arsenic Concentration Solution  
Year 2040  
With Retardation

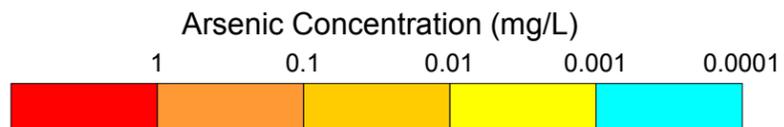
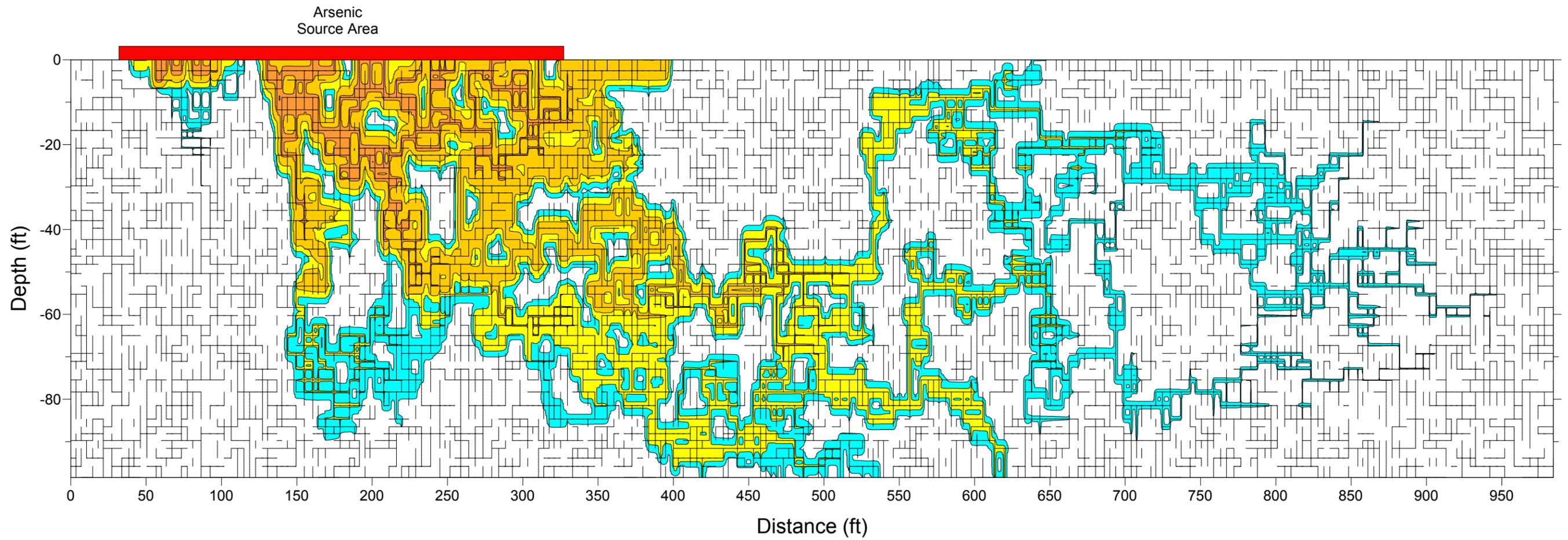


Figure 5  
Arsenic Concentration Solution  
Year 2060  
No Retardation

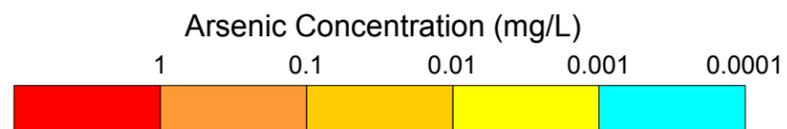
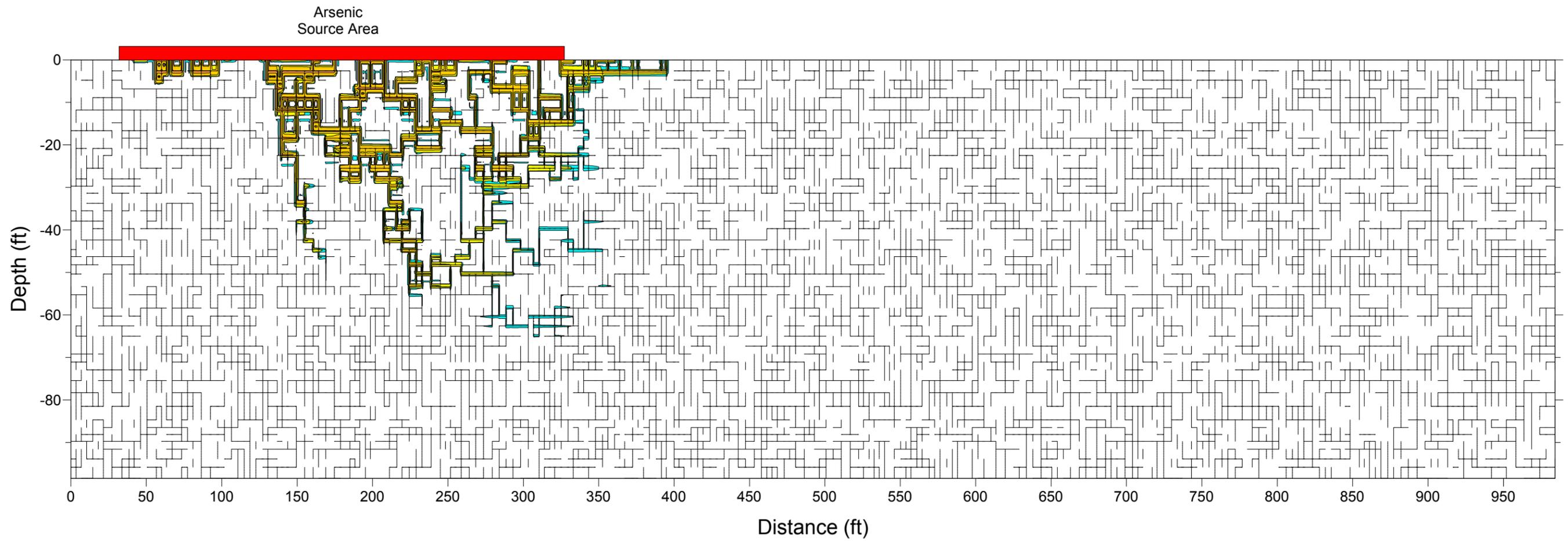


Figure 6  
Arsenic Concentration Solution  
Year 2060  
With Retardation