CE 5364 Groundwater Transport Phenomena
Exam 2 , Fall 2024

Students should write their name on **all sheets of paper**.
Students are permitted to use the internet to help answer questions.
Students are permitted to use their own notes and the textbook.
Students are **forbidden** to **communicate with other people** during the examination.

1. Provide short answers to the following questions:

   a) Distinguish between the application of a numerical groundwater transport model as a predictive tool and as a screening tool. Which type (predicitve or screening) of model use takes more effort by a model user?

   b) Explain why it is important to have a proper conceptual model of the system to be simulated before moving forward to discretization and selection of parameters.

   c) Explain how MODFLOW6 and FloPy allows the user to establish the initial concentration distribution in a similation domain. Is the approach generic to where it can be applied for other initial conditions or parameters?

   d) Describe how one could determine particle travel times from an initial location or the particle until its exit point from the solution domain? Does MODFLOW6 and FloPy have necessary tools to make such calculations?

   e) What are the four types of transport processes that MODFLOW6 readily simulates?

   f) What four types of site characterization information can be obtained from consturction and use of a monitoring well?

   g) Suggest four possible sources of soil characteristic curve data that may be used when describing flow and transport in the unsaturated zone.

   h) Explain the concept of capillary pressure head for water in the unsaturated zone. Why is it negative?

   i) Identify and describe three main categories of groundwater and soil remediation, including approaches for containment, source control, and mass reduction.

   j) Explain the concept of entry pressure as it applies to DNAPL movement through the capillary fringe.

   k) Distinguish between the conditions for DNAPL residuals in the unsaturated zone, saturated zone, and free phase zone. Which zone tends to have the highest DNAPL saturation? Which zone tends to have the lowest?

   l) Describe a possible groundwater contaminant situation in which the application of a structural containment barrier would be appropriate. State what type of barrier you would specify.

2. An LPST site has been characterized for subsurface total petroleum hydrocarbons contamination in ths soil and groundwater. The impacted aquifer is unconfined, and the subsurface sediments have an average porosity of 0.37 and bulk density of 130 $\frac{lb}{ft^3}$(2080 $\frac{kg}{m^3}$)

   The free phase LNAPL (specific gravity = 0.80) has been found in several monitoring wells, and the average thickness of LNAPL in the monitoring wells was 1.50 ft. The estimated extent of the LNAPL lens is about 40 ft. by 60 ft, and the average LNAPL saturation in the lens is estimated at 0.75.

   Determine:

   (a) The thickness of the free phase LNAPL in the formation in ft.

   (b) The volume of LNAPL in the free phase in gallons.

   Residual TPH concentrations in the soil beneath the leaking tank pit were found to average 2500 mg TPH/kg soil. These residuals lie beneath the pit area of 20 ft by 40 ft and extend from the bottom of the pit downward 25 ft to the capillary fringe/water table.

   Determine:

   (a) The mass of TPH in the unsaturated zone in kg.

   (b) The volume of TPH in gallons.

   A plume of contaminated groundwater has also been delkineated. The plume is 200 ft. long, 80 ft. wide and extends across the saturated thickness of the aquifer, which is 80 ft. The average concentration in the plume is 0.50 mg/L.

   Determine:

   (a) The mass of TPH in the saturated zone in kg.

   (b) The volume of TPH (not the water) in gallons.

   The site owner estimates from inventory checks, that 3500 gallons of fuel are lost.

   Determine:

   (a) If this estimate compares well with your results.

   (b) What other fates of hydrocarbons have not been accounted for in the estimates above.

Continued (show work here)

3. Consider the concentration histories in Figure **??**. The elapsed time is the time since the release of the constituients. The observation location is 100 meters away from the source zone.

   Determine:

   (a) The history (A) or (B) that indicates greater dispersive behavior.

   (b) The model that describes the type of transport indicated by the history.

   (c) The pore velocity and apparent dispersion for each history.

Continued (show work here)

4. Figure **??** is a plot of concentration histories of constituients introduced into a 1-meter long column at $t = 0$ *minutes*, $x = 0$ *cm*. Species 1 is known to be conservative and non-reactive (with the aquifer solids).

   Determine:

   a) The specific discharge if the porosity is 0.30.

   b) The distribution coefficients (assume linear, instantaneous, equilibrium adsorbtion isotherms) for species 2, 3, and 4, if the solids density is 2.97 $\frac{g}{cc}$.

   c) An estimate of the dispersion coefficient for species 3

   d) Predict the concentration history for species 3 at $x = 50\ cm$

5. Figure **??** is a schematic of a rectangular excavation cut into surface clay for a sewer pipe which was placed, then backfilled with sand. The hydraulic conductivity of the sand is 20.0 $\frac{ft}{day}$. The hydraulic gradient in the sand is 0.1. The porosity of the sand is 0.30. The longitudinal dispersivity of the sand is 10.0 $\frac{ft}{day}$. The sewer leaks and introduces a steady input of water (that causes the hydraulic gradient) located at the access shaft at a concentration of 1000 $\frac{mg}{L}$ of some constituient. The consituient has a retardation factor of 2.0.

   Determine:

   The concentration 100 feet away from the release in the sand near the school yard 6,16,25,and 75 days after the leak begins.