## CE 5364 Groundwater Transport Phenomena Summer 2020 Exam 2

You have 2.5 hours (150 minutes) to complete your work on this exam except as modified by a disability. That time does not count the time required to print out the exam pages for you to write on or to scan your work into a single pdf file to email back to Dr. Rainwater. If you don't print out the exam to write your answers, write your answers on your own paper, making sure you identify which answer goes with which question. You can also supplement your own paper if the exam printout is too short for you. Please don't waste time copying the entire problem statement or question, just make sure you show where you are like this, spacing them out on the pages wo you can complete your work. If I can't figure it out, it's wrong.

Format if you provide all your own paper for the exam, and don't write your solutions on your printout of the exam

## Verbal Questions

- 1. followed by your answer
- 2. followed by your answer and so on

## Problems

- [a] followed by your answer
   [b] followed by your answer
   [c] followed by your answer
- 2. followed by your answer
- 3. followed by your answer

The verbal part of the exam is to be completed without any books, notes, old homework, or electronic access to anything or anybody. For the problems, you can use your notes, homeworks, and the provided text pdfs on your computer. You are not allowed to use any other digital or paper aids beyond that list. You can use the typical NCEES calculator that you are used to in our courses. You are also prohibited from making the downloaded exam file available to anyone else at any time or selling it to a coursework collection service like Chegg. You must also sign this academic honor pledge and record the clock time for your beginning and ending of the exam. Once you start the exam, you must continue until you finish, with only short interruption for bathroom needs. I hope you will put it behind you during the 10:00 a.m.-12:30 p.m. time slot so you can get on with your other responsibilities.

## Pledge (copy this by hand if you don't print out the exam) Absolutely required!

On my honor, I have neither given nor receive required.	d any aid on this exam.	I followed all t	he given instructions as
Signature	Start time		Stop time

CE 5364 Groundwater Transport Phenomena Exam 2

August 7, 2020

Name SOLUTION

- I. Verbal questions (60 points total, 4 points each). Answer 15 of the following 18 questions briefly and concisely. Use complete English sentences when appropriate (Explain, Distinguish). Clearly mark the questions that you omit.
- 1. Distinguish between the application of a numerical groundwater transport model as [1] a predictive tool and [2] a screening tool. Which type of model uses takes more effort by the model user?

As a predictive tool, User must know all parameters to sufficiently describe system & predict concentration charge. This is more complex.

As a screen in tool, User doesn't knowning permeneters of system, just wants a quick general i head possibilities

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

We need to understand the subsurface conditions for unsaturated are, saturated are, saguifers to similate the right problem.

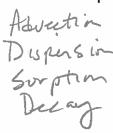
3. Explain how the Groundwater Vistas preprocessor for MT3D allows the user to establish the initial concentration distribution in a simulated domain. Can you use a similar approach for other initial conditions or parameters?

to the concentrations are let up as properties, and con be assigned as individual cell values or with zones. This approach works for all other properties like, K, S, distassintly, porosity, & top / bottom elevations,

4. Explain how Modpath can be used to show the particle travel times values from the initial location of the particle to its exit point from the solution domain.

It is possible to snow the travel times with anowherds and time labels. You have to specify these in OWV

5. List the four solute transport processes that you simulated in your project using MODFLOW and MT3D.



6. List four types of site characterization information we can get through construction and use of a monitoring well.

Subsurface materials - lithology
Subsurface Contamination - analyze soil samples

Depth to waster
Water samples - atralyze

NAPC thickness

Slug tests for K

7. Why is approval of the site investigation work plan required before the investigation begins? Who has to approve the plan for it to be acceptable?

Approved is necessary to make sure the scope of work is appropriate. Regulators must approve the work, as does the client.

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

Technical literature
Lab tests with soil
Methematical estimates from texture
Field measurements

9. Explain the concept of capillary pressure head for water in the unsaturated zone. Why is it negative? Use words, not a picture.

Water it held in the unsaturated fore by capillary forces, and the pressure felt by the water is best than atmospheric -> so. I suction. It is negative because atmospheric is set as O jage.

10. List the three main categories of groundwater and soil remediation used to clean up contaminated sites..

Source control Containment Mass reduction - pumplitreat, biodegrade

11. Explain how the ability of a soil to accept infiltration from a steady rainfall event is affected by the initial moisture content based on your Chemflo experience. What two forces are acting to bring the water into the soil?

If intid moisture content is high, there is less room for the water to enter the soil so less in fluxis allowed.

Gravity & equiling forces.

12. Explain the concept of the entry pressure as applied to DNAPL movement through the capillary fringe.

DNAPL fluid lens must buildup sufficient head Mickness at top of capillary tringe to overcome Surface tension and push the water and air out of the way.

1)0 - brodegratotion

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

Turnevas streated time, the vesiduals can be separate & Lowest unprobate blobs attached to dries ent or soil mozeture. In the saturated tone, the DNAPL vestiduals avesmaller blobs as water dominates the porce space. In the free phile some, The DNAPLIE continuared mobile. Highest

14. Explain how a LNAPL smear zone can develop near the water table. Don't just draw a picture by itself, use words.

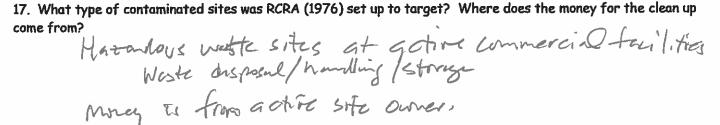
Up 4 down movement of water table moves the LNAPL lens up Adown Residual LNAPLS can be trapped below water table of in copallary fringe,

15. Describe a possible groundwater contaminant situation in which the application of a structural containment barrier would be appropriate. State which type of barrier you would use.

The lover conting layer must be relatively shallow. with Source tome & plume I mit tod in extent. Convert slving wall, piling, growt contacts

 List four remediation technologies that use injection or production of gases in the unsaturated or saturated zones, including identifying the target type of contaminant.

Salvapor go traction?
Brovertry > VOCs
Air spanging Ce-HCC H,



18. What type of contaminated sites was CERCLA (Superfund) set up to target? How was the money to pay for the clean ups to be obtained?

Correct was intended for orphansites contaminated by horarders materials, but The armer had left the site.

The moves was to come from those who owned I managed Theoreste, pursued begally since I managed They had left thesites.

CE 5364 Groundwater Transport Phenomena Exam 2

August 6, 2020

Name SOLUTION

- II. Problems (50 points total). Do all three problems. Show all work clearly for full credit. Clearly identify the answers, and show all your units!
- 1. (28 total) An LPST site has been characterized for subsurface total petroleum hydrocarbons contamination in the soil and groundwater. The impacted aquifer is unconfined, and the subsurface sediments have an average porosity of 0.38 and bulk density of 130  $lb/ft^3$  (2080  $kg/m^3$ ).
- [a] (8) 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. Find (i) the thickness of the free phase LNAPL in the formation in ft and (ii) the volume of LNAPL in the free phase in gallons.

(b) (8) 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. Find the (i) mass of TPH in the unsaturated zone in kg and (ii) the volume of TPH in gallons.

volume of TPH in gallons.

(i) Muz=Cuz Puz tuz=2500 ms (1 ksTPH) (2046) (2544) (3046) (3046)

THE = MVETIM = 2950 Kg = 3690L (1801)

THE TONE TONE

VUZ = 974 gal

[c] (8) A plume of contaminated groundwater has been delineated also. 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. Find (i) the mass of TPH in the saturated zone in kg and (ii) the volume of TPH (not the water) in gallons.

[d] (4) The site owner estimates from inventory checks that 3500 gallons of fuel were lost. Does this estimate compare well with your results? What other fates of the hydrocarbons have not been yet accounted for by parts [a], [b], and [c]?

2. (12) A soil gas characterization at a contaminated site has found the measured concentration of benzene in the soil atmosphere to be 12000 mg/ $m^3$ . Assume that the benzene is part of a fuel mixture that is in equilibrium with the soil atmosphere. The temperature of the soil gas was  $20^{\circ}C$ . Useful information about benzene can be found in the textbook. Find the mole fraction of benzene in the liquid mixture.

A 
$$C_{me} = \frac{X_{a} + \delta_{0} M w_{a}}{RT}$$
 $X_{a} = \frac{C_{RT}}{P_{0}^{2} M w_{a}}$ 

II  $T = \frac{273 + 20}{P_{0}^{2} M w_{a}} = \frac{293 \text{ pc}}{M \text{ mole}^{2} \text{ k}}$ 

II  $R = 0.0821 \frac{L_{atm}}{M \text{ mole}^{2} \text{ k}}$ 

II  $Mw_{q} = 78.11 \frac{3}{m \text{ mole}}$ 

II  $P_{0}^{a} = 60 \text{ mm Ms} \left(\frac{16 \text{ tm}}{760 \text{ mole}^{2} \text{ k}}\right) = 0.076 \text{ ctm}$ 
 $X_{q} = \frac{12000 \frac{M_{q}}{M \text{ o}} \left(\frac{16 \text{ mole}}{1000 \text{ k}}\right) \left(0.0821 \frac{L_{atm}}{M \text{ ode}^{2} \text{ k}}\right) \left(\frac{16}{1000 \text{ mole}^{2} \text{ k}}\right)}{\left(0.079 \text{ ctm}\right) \left(70.11 \frac{3}{90} \text{ le}\right)}$ 
 $X_{q} = 0.047$ 

3. (10) Groundwater samples have been collected quarterly for the last 18 months and analyzed for TCE in ppb. The table below shows the results for one monitoring well. Use the Mann-Kendall test to determine if there is a trend and if the trend is increasing or decreasing. Show all the work below.

Date	TCE (ppb)
3/2019	15
6/2019	12
9/2019	28
12/2019	16
3/2020	10
6/2020	30

Evant 17 Evanth?  Evant 17 Evanth?  Evant 13> Evanth?  Evant 17 Evanth?	12 26 Y N	# 16 N N N N N N N N N N N N N N N N N N	3-2=-1 3-1=2 1-2=-1 1-1=0 1=1	[9]
EVENTS > EVENTA?		e   5 = +11.2 no trend		5