CE 5364 Groundwater Contaminant Transport Exam 1 March 3, 2005

Name_____

I. Verbal Questions (28 points total, 4 points each). Answer 7 of the following 8 questions briefly and concisely. Use complete English sentences when appropriate. Clearly mark the questions you omit.

1. Describe how you can use the areal extent of a groundwater contaminant plume with a known source to estimate the local groundwater velocity.

2. List four transport mechanisms that affect solute migration in groundwater flow.

3. Why are dispersivity values small (~ cm) for lab column tests and large (~ m) for field transport modeling?

4. List four soil characteristics that affect sorption in groundwater solute transport.

5. Define natural attenuation as applied in groundwater contamination studies.

6. Distinguish between the Risk Reduction Standard 1 and Risk Reduction Standard 3 approaches in a risk assessment for a contaminated site as defined in the TNRCC's old Risk Reduction Rule.

7. Calculation of a reference dose for human exposure usually requires mathematical extrapolation of data from animal exposure studies through the use of uncertainty factors. Specifically list four types of uncertainty that these factors represent.

8. Explain the conservative nature of the process of setting an MCL for a contaminant in drinking water based on the use of animal toxicity testing, assuming you are talking to a TV reporter and you have a 60-second sound bite.

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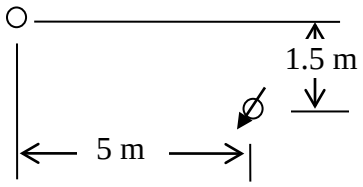
II. Problems (72 points total). Work all three problems. Show your work clearly for full credit. Watch your units!! Clearly mark your answers.

1. (14) The hydraulic gradient in a homogeneous, anisotropic aquifer has a magnitude of 0.0045, with head decreasing in the direction 35° north of east. The hydraulic conductivity tensor is $\overline{K} = \begin{bmatrix} 20 & 6 \\ 6 & 12 \end{bmatrix} m/d$ in the same Cartesian coordinate system. **Find the angle between the specific discharge vector and the head gradient.** (Hint: Use a sketch to keep oriented, and remember the sign on the head gradient.)

2. (28 total) One kilogram of toluene, an aromatic hydrocarbon, was spilled into a well that fully penetrates an aquifer. The toluene immediately dissolved, and mixed completely into the water in the well. The well's effective diameter is 0.60 m and the aquifer has a uniform saturated thickness of 8.5 m. The seepage velocity is 95 m/yr in the x-direction to the west, the longitudinal dispersivity is 3.5 m, and the transverse dispersivity is 0.50 m. The aquifer material has bulk density of 1.6 g/cc, porosity of 0.40, fraction of organic carbon of 1.4 percent, and octanol/water partition coefficient of 130 L/kg. The toluene has a first-order decay rate of 0.021 d^{-1}.

[a] (12) **Find the retardation factor R for toluene in this aquifer.**

[b] (16) A well is located as shown to the west and north of the well with the spill. **Find the time at which the maximum toluene concentration is felt at the second well, and its value in mg/L.**



3. (30 total) A contaminated site has large concentrations of lead, a toxic non-carcinogen with separate RfD values of 5.7×10^{-4} mg/kg-d by inhalation and 6.60×10^{-4} mg/kg-d for ingestion and dermal contact, respectively. On-site concentrations include 350 mg/kg in the soil and 0.042 mg/m^3 in the air. If no action is taken at the site, the off-site workers will be exposed to the soil through ingestion and dermal exposure, and the air concentration through inhalation. Off-site residents will also be at risk through the inhalation pathway at the same concentration as measured on-site.

[a] (15) **Find the intake value in mg/kg-d and hazard quotient for dermal exposure for off-site workers.**

[b] (15) **Find the intake value in mg/kg-d and hazard quotient for inhalation for off-site children residents 6-12 years of age.**