# 1.34 WASTE CONTAINMENT AND SITE REMEDIATION TECHNOLOGY
## HOMEWORK 3 – DUE MARCH 12, 2004

You may work together to formulate and discuss approaches to homework problems. However, the work that you submit must be your own. Please state all of your assumptions clearly. The questions are “open-ended” in that they require you to assume certain values and to develop your own approach.

You have done such a good job advising your colleagues and friends about ground-water contamination issues that your fame as an expert in the area has spread to the town of Plainville, Massachusetts. Plainville, which is located approximately 50 miles southwest of Boston, is home to the largest landfill in Massachusetts. The landfill was in operation for 23 years, from 1975 to its capping in 1998. During its operation the landfill accepted both hazardous and municipal waste. In the early 1980s, a ground-water contamination plume was discovered emanating from the southwest corner of the landfill. Approximately 80,000 people derive their drinking water from the aquifer system underlying the landfill, so the plume and ground-water conditions around the landfill have been extensively monitored: first by Clarence Welti Associates, who installed a series of monitoring wells labeled “CD”; second by Goldberg-Zoino & Associates, who installed a series of monitoring wells labeled “GZ”; and lastly by Eckenfelder Inc., who installed a series of monitoring wells labeled “MW”, a series of piezometers labeled “PZ”, and a series of surface-water monitoring stations labeled “S”.

The locals are horribly confused about all of the information presented to them by the various consulting firms, and they are worried that the plume has reached the local lake—Lake Mirimichi—and therefore could cause serious health and ecological problems. They don’t trust the local Department of Environmental Protection (DEP) representative and are seeking independent advice. They know that the contaminant plume is emanating from the corner of the landfill closest to MW-9S and MW-9R. They have come to you with the map, borehole logs, and tabulated data provided on the following pages, and they are asking for your help. You decide to undertake the following:

1. Use the ground-water elevation at the monitoring wells to construct a rough contour map of hydraulic head in the vicinity of the landfill. Then, use this map to plot the likely flow pathway of a contaminant particle released from the contaminant source as identified above. Will this pathway transport the contaminant particle toward the lake? Use your map to estimate the average hydraulic gradient along this pathway.

2. Use the borehole logs provided to plot a cross section of the stratigraphy of the subsurface between the landfill and the lake. This cross section can just consider conditions along a straight line drawn between MW-9S, CD-5, GZ2-1 and GZ-2-5. From this cross section, identify the two main soil and rock strata in the subsurface at the site.

3. Look at the screened interval for the monitoring wells where the contaminant 1,4-dichlorobenzene has been detected and divide the wells into wells monitoring conditions in the upper aquifer and wells monitoring conditions in the lower aquifer. Use this information to estimate contours of contaminant concentration in both the upper and lower aquifer. Compare these two sets of contours and draw some conclusions about connectivity between the two aquifers. Also, comment on whether or not the locals were right to be concerned about the contamination of their lake.

4. The local DEP representative tells you that source concentration of 1,4-dichlorobenzene is estimated at 35 $\mu$g/l. The representative also tells you that Eckenfelder has found out that the hydraulic conductivity of the upper aquifer is 103 ft/day, while its porosity is 0.15. Assuming a retardation factor of $R_d$ = 1 for the contaminant, how long do you think that the landfill has been leaking this chemical? You may assume that the source has been constant for all of this time. Recall from Lecture 3 that for simple 1-D transport, the analytical solution to the advection-dispersion equation at $c/c_o$ = 0.5 is pretty straightforward. Does your answer make any sense, given that the landfill has been in operation for 25 years at the time of monitoring? If you ignore diffusive transport, what do you estimate is a reasonable value for $\alpha_L$ in the upper aquifer?

5. The locals have been told that 1,4-dichlorobenzene is toxic to fish above concentration levels of 25 $\mu$g/l. They want to know when they should transfer all of the fish from the lake to ponds that they are constructing in their back gardens. What do you advise them?

6. Eckenfelder and the DEP representative are getting fed up with what they perceive to be your interference. However, the EPA is very impressed by your advice to the citizens. Therefore, you are put in charge of contaminant monitoring in the upper aquifer at the site. The available budget limits you to monitoring at 15 wells. These can be existing wells (preferable by the EPA), or completely new wells. You are also given a budget to undertake any geophysical survey that you specify at the site. Where do you place the 15 ground-water monitoring wells, and what, if any, geophysical survey do you request to be undertaken (and why)? (Note, that in formulating this answer, you might like to consider that monitoring wells often double as ground-water extraction wells in “pump-and-treat” remediation schemes, thereby saving everybody time and money ).

**Ground-water Level Data – Plainville Landfill 8/15/96**

| Well Identification | Water Elevation (ft, NVGD) |
|---|---|
| CD-5 | 163.12 |
| MW-9S | 166.01 |
| GZ-5 | 183.97 |
| GZ-6 | 183.48 |
| GZ-7 | 174.95 |
| GZ-10A | 162.88 |
| MW-10 | 162.01 |
| GZ-11B | 163.75 |
| GZ-12 | 164.06 |
| GZ-16 | 169.92 |
| GZ2-6 | 158.96 |
| MW18 | 184.63 |
| MW19 | 223.79 |
| MW20 | 221.04 |
| MW21 | 174.35 |
| DMW-3 | 199.21 |
| DMW-4 | 207.36 |
| DMW-5 | 209.49 |
| DMW-6 | 209.52 |
| PZ-28 | 159.89 |
| PZ-29 | 158.88 |
| PZ-30 | 158.45 |
| PZ-31 | 170.57 |
| Lake Mirimichi | 158.51 |
| Cranberry Bogs | 183.75 |
| Rabbit Hill Pond | 176.49 |

**Ground-water-quality Sampling Results – June 1997**

Contaminant: 1,4-dicholorobenzene
Federal MCL 75 μg/l; Massachusetts MCL 5 μg/l.
MDL = 5 μg/l
ND = non-detect

| Well Identification | Result (μg/l) |
|---|---|
| CD-5 | 31.8 |
| CD-5A | 32.8 |
| GZ-10 | 21.7 |
| GZ2-1R | 20.4 |
| GZ2-5 | 18.2 |
| GZ2-6 | 18.7 |
| MW-9S | 34.2 |
| GZ-10A | 14.7 |
| GZ-17 | 8.0 |
| GZ2-6R | 15.4 |
| MW-9R | 31.1 |
| GZ2-4 | ND |
| GZ2-3 | ND |
| GZ2-2 | ND |
| GZ-9 | ND |
| MW-21R | ND |
| GZ-9A | ND |