# Calculating flow between two wells

Assume steady state and consider the flow between two wells penetrating a confined aquifer of thickness b, one injecting and one producing at the same rates. How will water flow between the wells? How long will it take a tracer introduced to the injection well to reach the producing well? How long before the injected tracer concentration in the producing well reaches 75% of the injected concentration?

These are non-trivial questions to answer, so we are asking you to give us the answers.

Consider a single well pumping at rate Q:

 The Darcy flux at r is V=2rb Q. Thus:

  (1)

Ground water flow is linear so we can add the h for two wells. If these wells are on the x-axis at +xo and –Xo, the total head is:

 . (2)

Note the vertical axis is the z-axis and this equation describes the head around the well as a function of x and y. **Explain** how this is derived from (1c) and why the denominator contains 4 rather than 2.

The attached pages from DeWiest gives some useful illustrations and shows that the flow lines are radial very near each well and are follow circular flow paths from the injection to the production well.

Use (1a) and (2) to determine the Darcy velocity between the injection and production wells along the x-axis. Divide this expression by porosity,  to get the fluid velocity, and integrate 1/v from the injections well at –xo to the production well at +xo to get the shortest travel time between these two wells. You should find the shortest travel time To:

  (3)

Now examine the figure last figure. Assuming the flow in or out of each well is uniform around the wellbore, you can see that streamlines leaving at various angles enclose various fractions of the flow into or out of a well. For example, 75% of the flow from the injection well represents all the flow from the vector pointing to the production well to an angle of 45 pointing away from that well, as shown in the last figure. Using (2) you could of course determine how long it takes to travel the circular 75% streamline. The work has been done for you. You can see from the plot that water traveling along the 75% flowline will reach the production well in 20.1To. Not shown, the travel time along the 90% flowline is 1212 To.

Suppose that b=10 m, xo=423 m, =0.25, and Q=50 m3/hr. Find To from (3). Plot log T/ To against the percent arrival (on the x-axis). **How long** from the injection of tracer will the first tracer arrive in the production well? **How long** before the concentration of tracer in the production well is 50% of the injected concentration? **How long** for 90% arrival? **Comment** on what this means for cleaning up contaminants from the subsurface.

