2003 EPA Science Forum
Partnering to Protect Human Health and the Environment

Preventing Contamination of Public Water Supply Wells using Computerized Modeling and Mapping Tools

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Year of Water: Thirty Years of Progress Through Partnering

An ounce of prevention
is worth a pound of cure.
Henry deBracton's-Delegibus (c. 1240)

Keep your models as simple
as possible --- but not simpler.
-Albert Einstein

The Issue

People of the United States rely on ground water as a source of drinking water because: (1) ground water occurs almost everywhere beneath the land surface; and (2) the natural processes in the soil and subsurface provide barriers to contamination. However, some chemicals have been shown to be resistant to degradation (e.g. MTBE a gasoline additive), and some chemicals have simply overwhelmed the aquifer capability to assimilate contaminants (e.g. NO_3 nitrate from fertilizer). It makes sense for domestic water-supply systems to avoid water quality problems by managing the land around the well that contributes recharge water to the well. This is an activity of the Wellhead Protection Program required by the Safe Drinking Water Act.

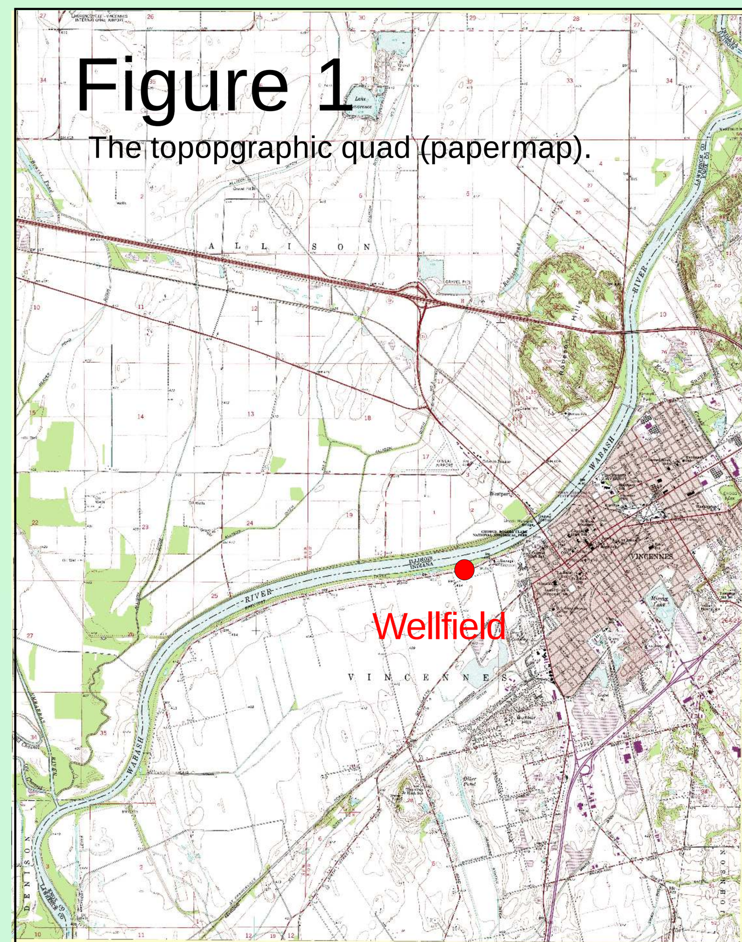
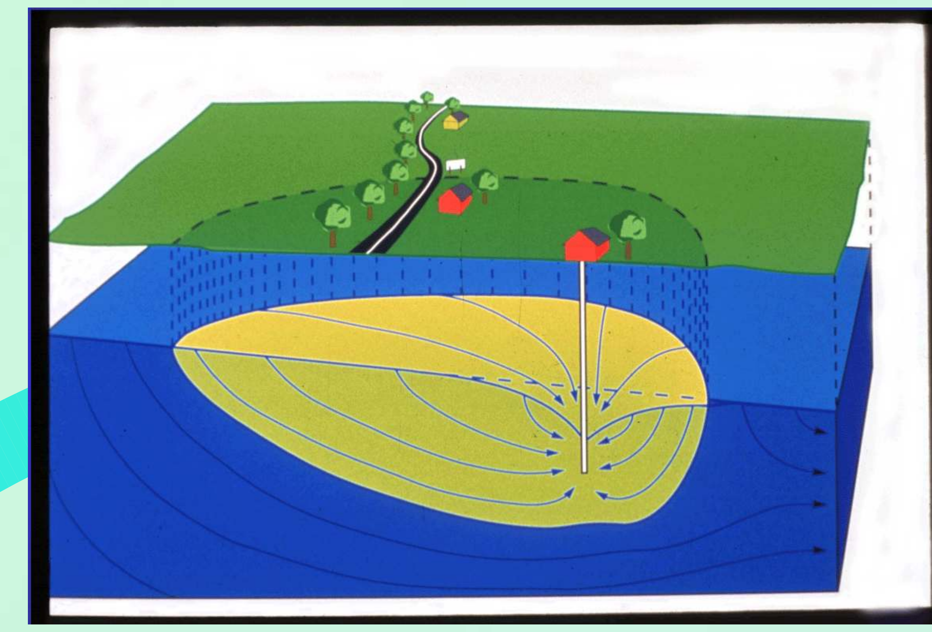


Figure 1
The topopgraphic quad (papermap).



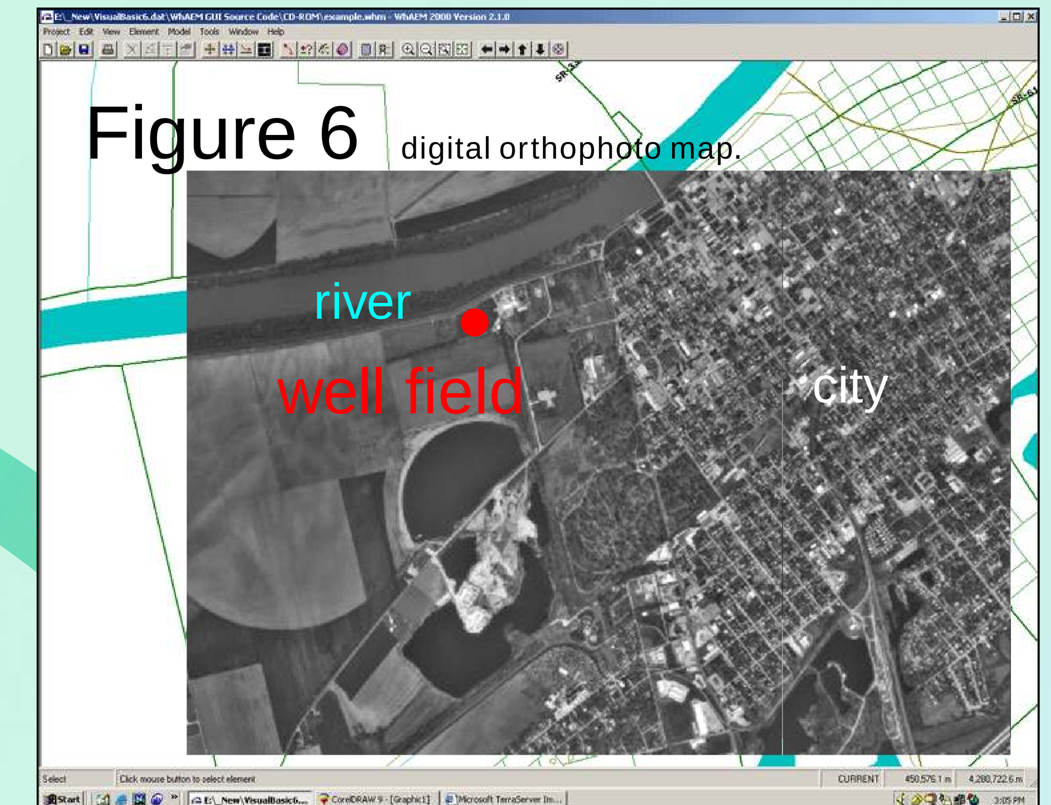
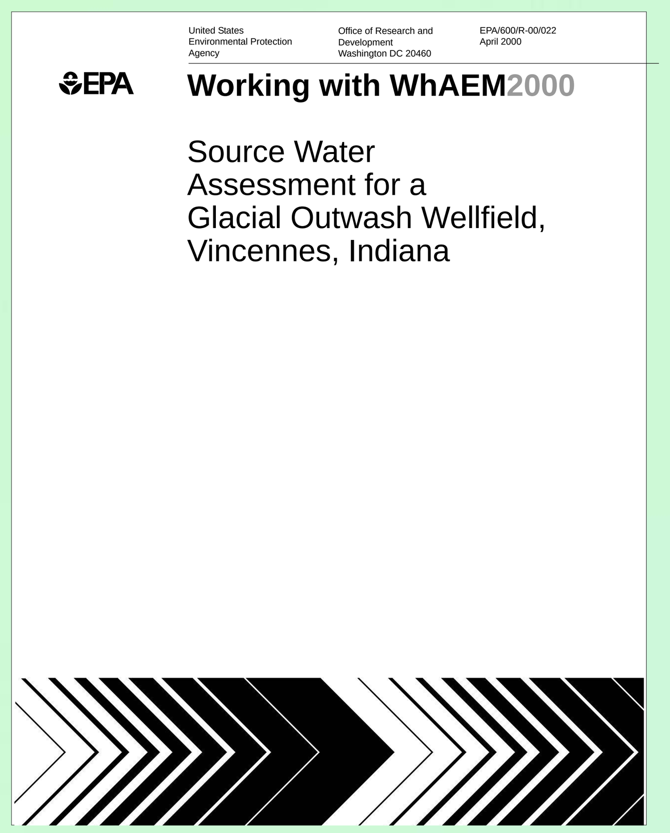


Figure 6 digital orthophoto map.


Working with WhAEM2000

Source Water
Assessment for a
Glacial Outwash Wellfield,
Vincennes, Indiana

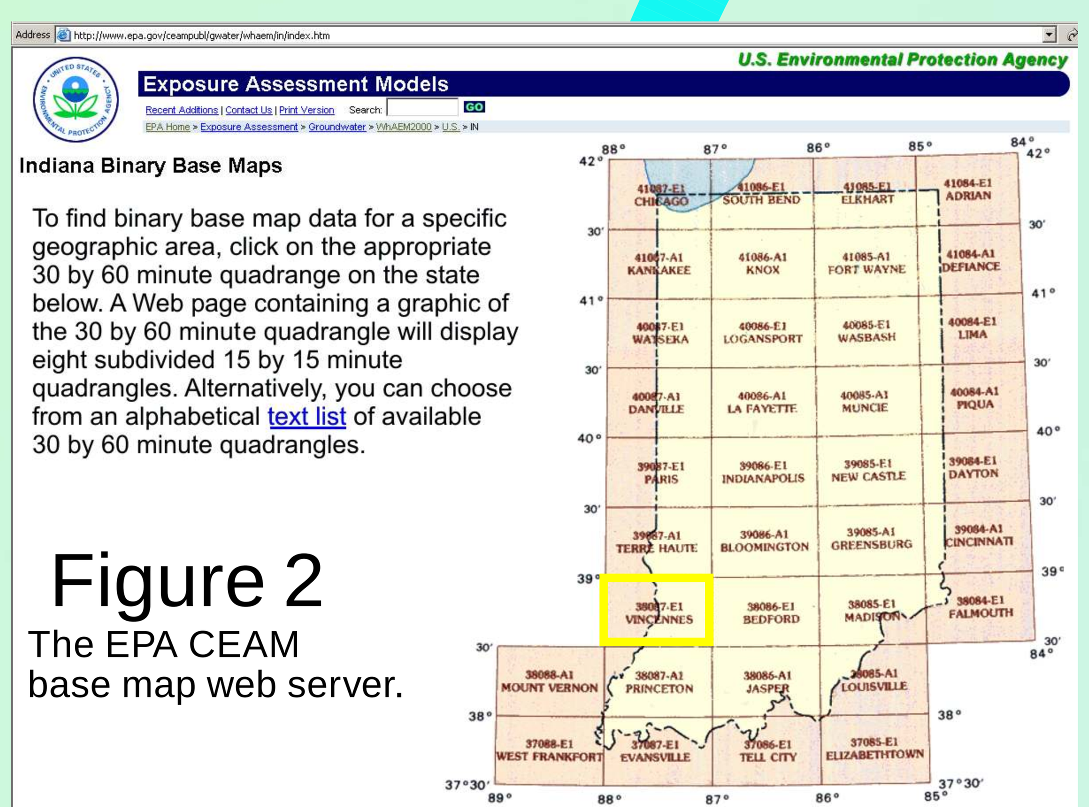
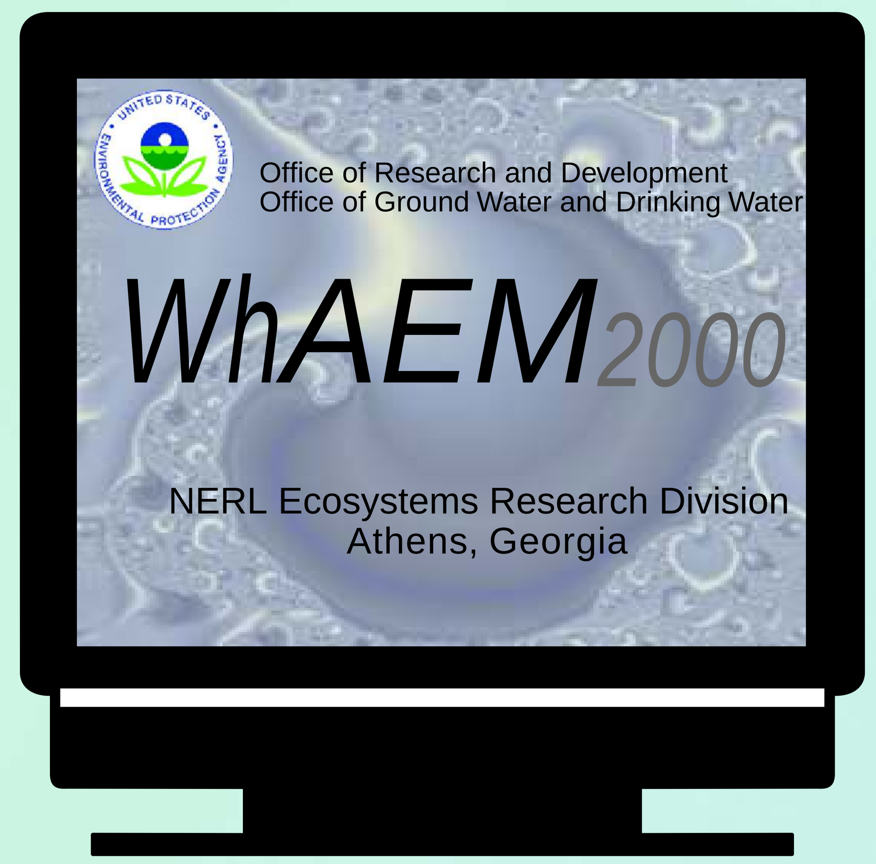


Figure 2
The EPA CEAM
base map web server.



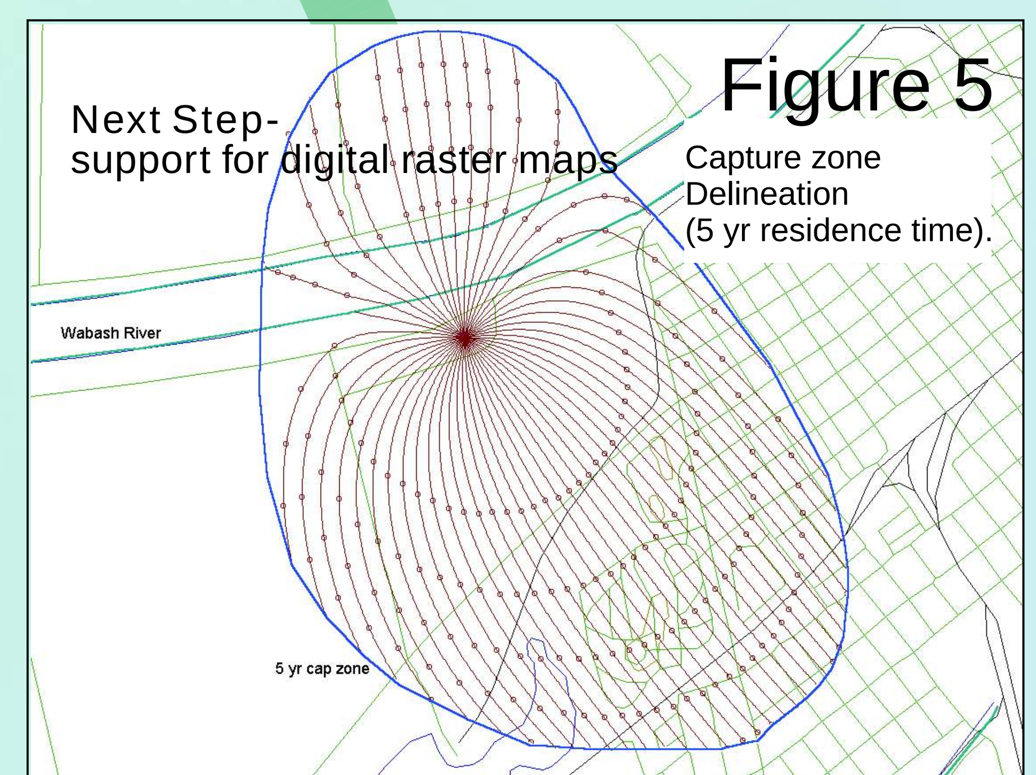


Figure 5
Capture zone
Delineation
(5 yr residence time).

Acknowledgements

The software development team includes Haitjema Consulting, LLC, Bloomington, IN; Computer Sciences Corp, Athens, GA; and WHPA Inc, Bloomington, IN.

The project is supported by the Office of Ground Water and Drinking Water, Washington DC (James Hamilton, Marilyn Ginsberg, Denise Coutlakis, Mike Muse, Roy Simon, Jamie Bourne, Joan Harrigan Farrelly - Branch Chief, Bill Diamond - DIv Director).

Software and Documentation are available from:
http://www.epa.gov/athens/software/whaem/index.html

The Impact

It is anticipated that managing the potential for leaks and spills of contaminants in the properly delineated source water protection zone will result in better water quality at the well and at the faucet for millions of Americans. This project and theWhAEM2000 software continues to support this goal. The software is public domain and open source and can be downloaded at
http://www.epa.gov/athens/software/whaem/index.html.

What are the next steps for this research? In the short term, we plan to add expanded base map capability so that the survey of potential threats can be assisted by aerial photographs (e.g., USGS digital orthophoto quads). See Figure 6. In the long term, we plan to strengthen the ground water/surface water interactions capabilities of the software, and help evaluate when a well is considered under the direct influence of surface water.

TheApproach

We developed a computer modeling system called WhAEM2000 assist in the delineation of protection areas around public water supply wells. The capabilities of this system are demonstrated here using the case study for Vincennes, Indiana as described in the report "Working with WhAEM2000" (EPA/600/R-00/022). The system runs on standard windows PCs and is designed to be user friendly. The system provides an interactive computer aided design environment for the delineation of recharge contributing areas based on radius methods, well in uniform-flow solutions, and geo hydrologic modeling methods. Protection areas are designed with and overlaid upon US Geological Survey Digital Line Graph (DLG) or other electronic base maps (See Figure1). Base maps for the USA and the WhAEM 2000 installation software are available for download from the EPA Center for Exposure Assessment Modeling (CEAM) website (See Figure 2). The resulting WhAEM2000 basic design environment, with base maps for roads, rivers, and topography contours, is shown for Vincennes in Figure 3.

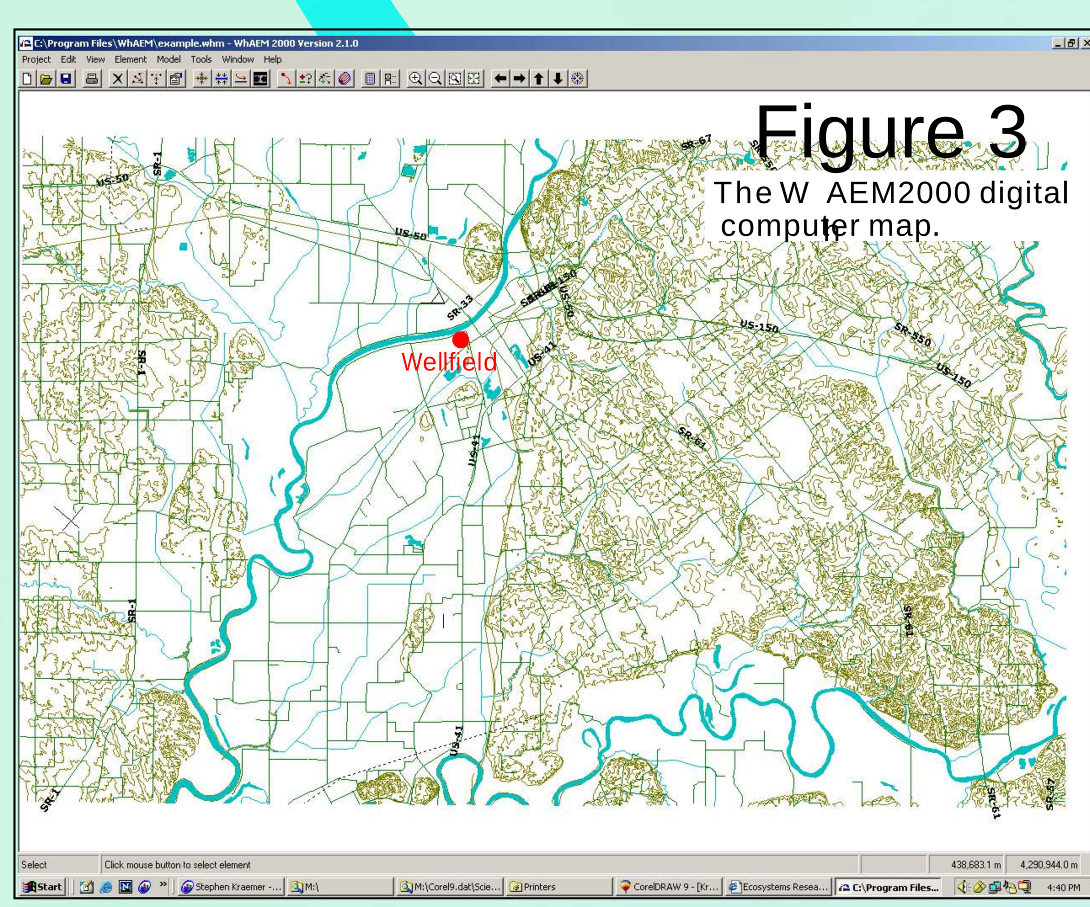


Figure 3
The W AEM2000 digital computer map.

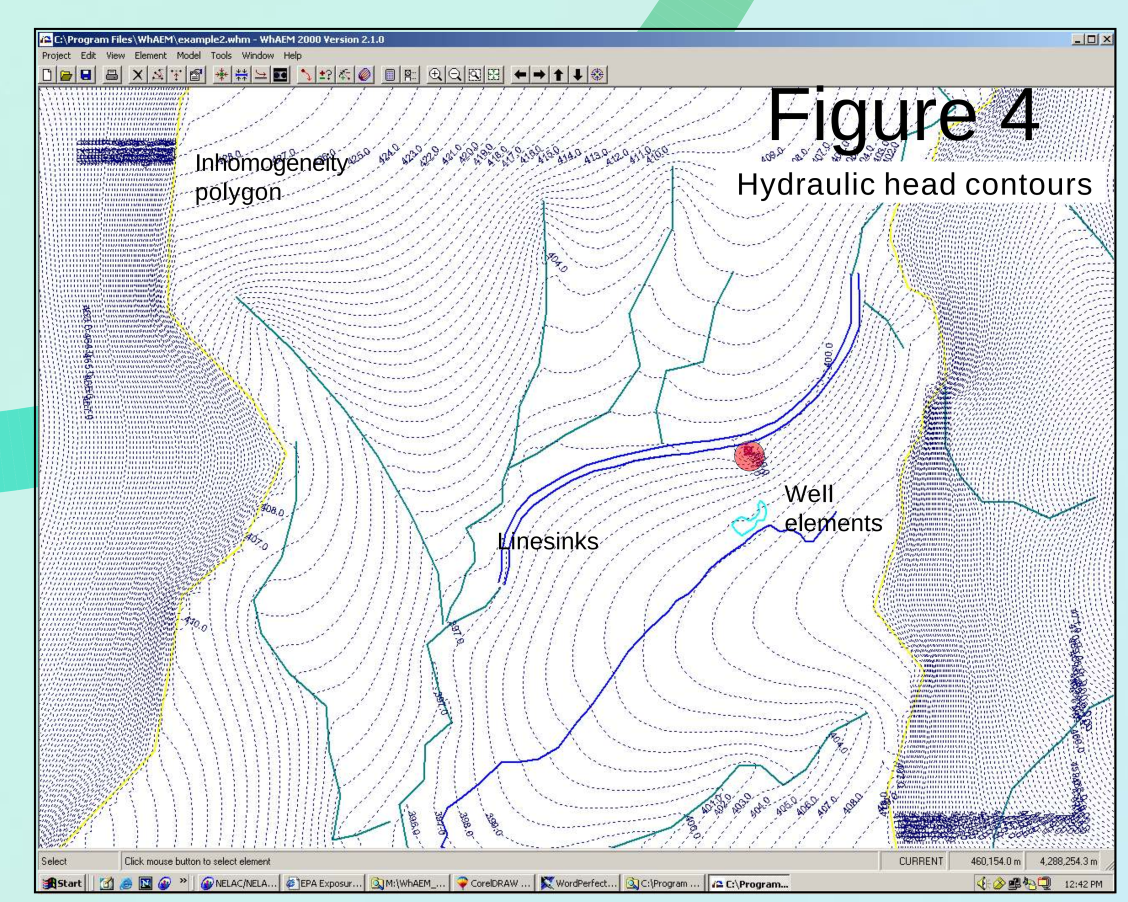


Figure 4
Hydraulic head contours

The Approach cont'd

Geo hydrologic modeling for steady pumping wells, including the influence of hydrological boundaries, such as rivers, recharge, no-flow boundaries, and in homogeneity zones, is accomplished using the state-of-the-art numerical modeling technique known as the analytic element method. Point sinks are superimposed to represent the pumping wells, line-sinks are superimposed to represent the rivers, and inhomogeneity polygons are used to represent differences in aquifer properties, such as the higher hydraulic conductivity associated with the outwash sediments of the major river valley. The solution gives the hydraulic head contours or the water table elevation. See Figure 4.From this solution reverse gradient lines can be traced from the pumping center and cut off after a given residence time, in our example 5 years, effectively delineating the capture zones. See Figure 5.

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