Sample Application of Visual MODFLOW Flex for Risk Assessment and Remediation Feasibility Design

Keywords

MODFLOW-NWT, Remediation Design, Barrier Boundary, Wall, Horizontal Flow Barrier, (HFB), Pump and Treat, MODPATH, ZONEBUDGET, Extraction Wells, Remediation Wells

Background

The Drumco industrial site is a buried drum disposal area. The site is underlain by an unconfined aquifer, a middle discontinuous confining unit, and a lower semi-confined aquifer. Both the upper and lower aquifers are used as a source of drinking water by homes and industry in the area.

Figure 1: Drumco Site Plan

Buried drums containing industrial degreasing compounds, principally tetrachloroethylene (PCE), were discovered during a routine site investigation in 1994. Additionally, there have been known leaks of gasoline from underground storage tanks. Since that time, considerable time and money have been spent removing the deteriorating drums, characterising the geology and hydrogeology of the site, and determining the extent of contamination.

A major concern is the risk of contamination to the lower aquifer, especially with possible degradation products such as vinyl chloride.

Objectives

This example demonstrates how a calibrated, three-dimensional, steady-state groundwater flow model developed in Visual MODFLOW can be used as a tool for risk assessment and remediation design. This examples demonstrates the use of MODFLOW-NWT, MODPATH and ZoneBudget in order calculate groundwater flow directions, track the movement of the contaminant plume, and calculate an ideal pumping rate for a remediation well.

Risk Assessment and Remediation Design Feasibility

- Using the particle tracking features in Visual MODFLOW, determine whether the local water supply wells are at risk of contamination by the groundwater plume migrating from the Drumco disposal area.
- Examine the effects of installing a pumping well to capture the groundwater plume and determine an optimal well location and pumping rate.

Modeling Approach

One of the problems with conventional pump-and-treat systems is the large volume of slightly contaminated water that is collected. Often the concentrations are too low to treat properly, and the large volumes are difficult to handle. One way to deal with this is to install a low-permeability wall around the contaminated area to contain the contamination, and a low permeability cover to minimize the amount of recharge. This example demonstrates the use of the MODFLOW "Horizontal Flow Barrier" (HFB Boundary or Wall) package. In this example, the barrier wall will be assigned around the contaminated area, for the purpose of reducing the flow of groundwater horizontally through the source of contamination. In addition, a zone of lower recharge rate within the walled area is assigned to simulate a low-permeability cover. The purpose of this cover is to reduce the pumping rate and therefore lower treatment costs.

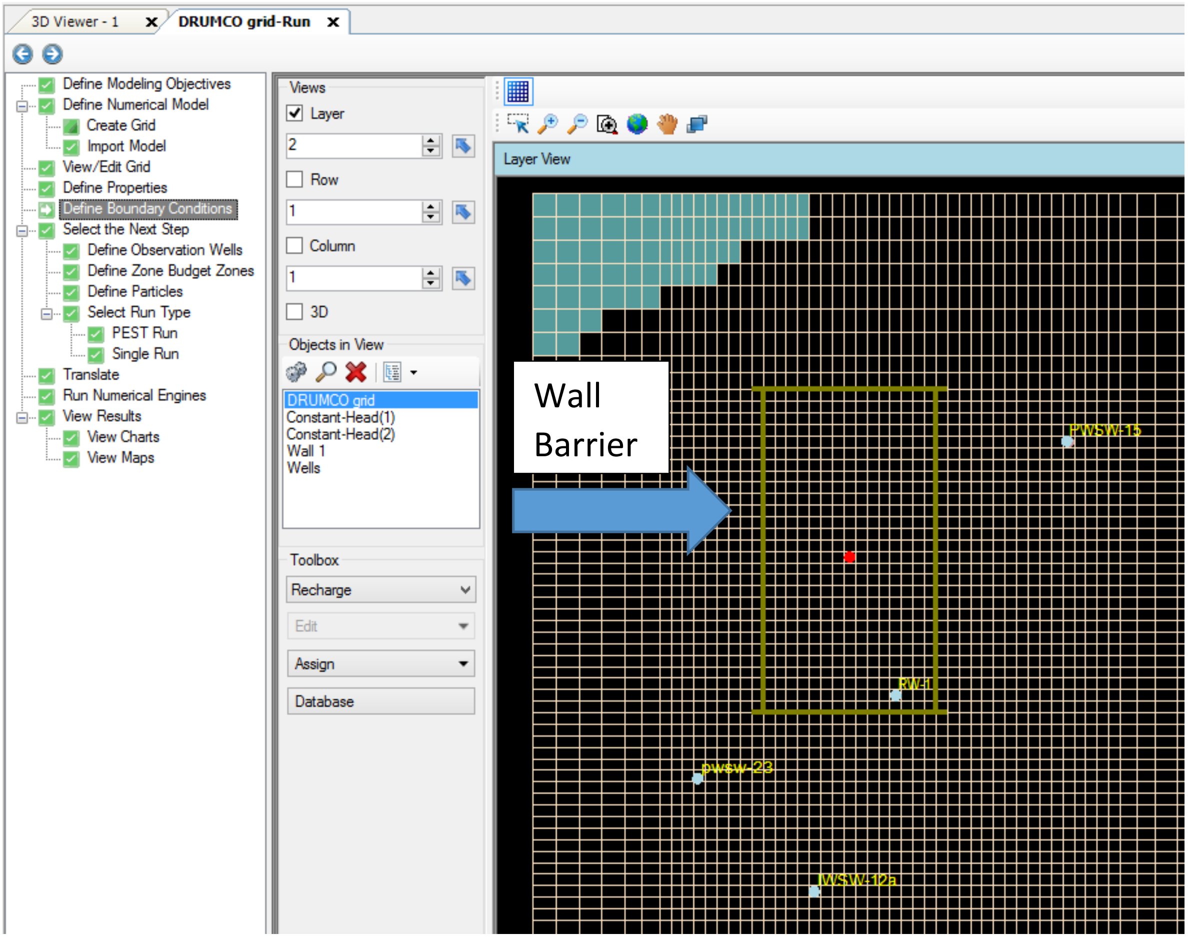

Figure 2: Wall Boundary in Plan View

To minimize problems with numerical instability and to find the optimum pumping rate more quickly, a constant head cell is used to simulate a pumping well in the middle of the enclosure, and a ZoneBudget zone is used for this cell in order to calculate the rate at which water is being removed from the model domain through the constant head. Later on, this can be replaced with a pumping well with the appropriated pumping rate.

Results

The forward and backward particles should be displayed as shown in the following figures. Note that the particle traces indicate that some flow is induced through the barrier wall. This flow is caused by the strong gradient across the northern wall as a result of reducing the water table elevation inside the enclosure.

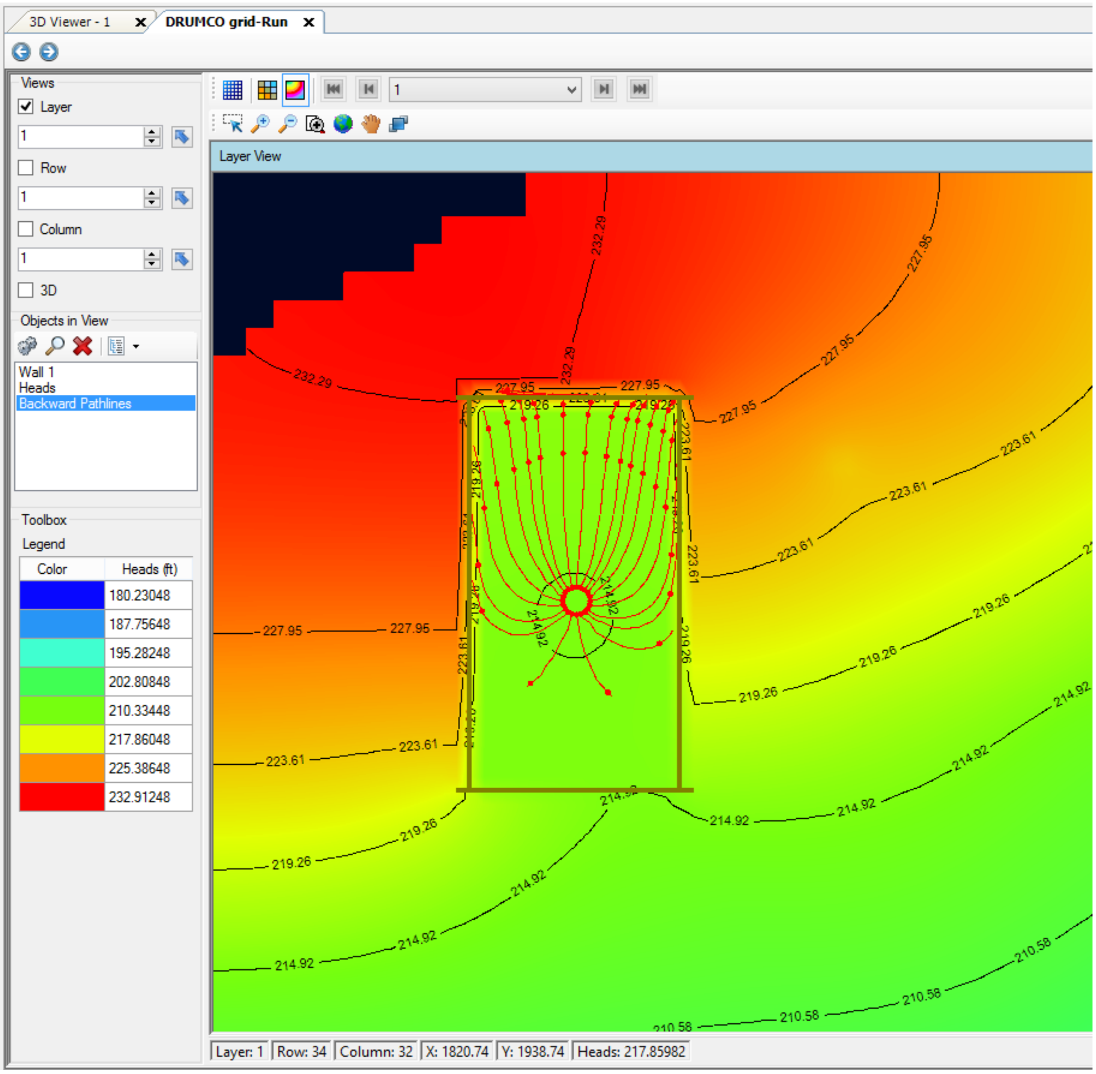

Figure 3: Calculated Heads in Wall Enclosure and Backward Pathlines

An independent ZoneBudget analysis indicates the following sources of water into the enclosure: 60% from flow through the wall; 40% from recharge through the low-permeability cover.

A low water level was specified inside the enclosure to help ensure that an inward gradient would be maintained at the south end of the enclosure. Because the regional water table slopes southward, this results in a large gradient across the northern wall.

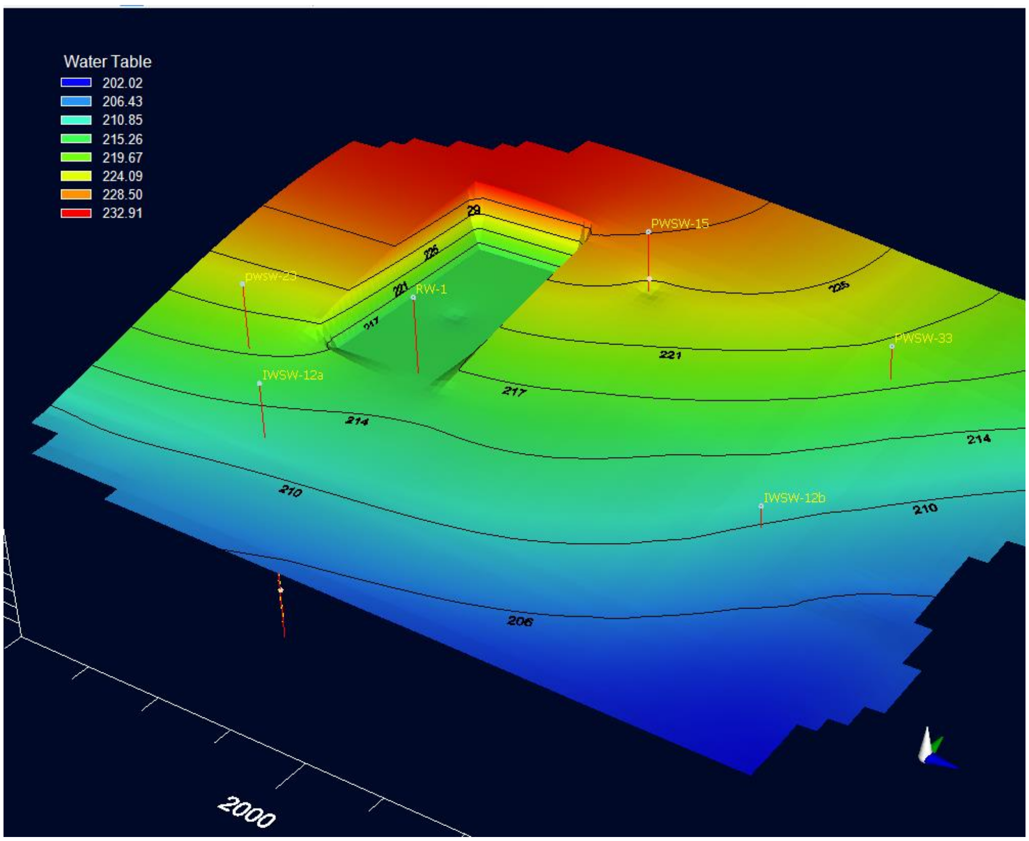

Figure 4: Calculated Water Table; note depression in region of the wall enclosure

These results indicate that the pumping rate can be significantly reduced by surrounding the contamination with a barrier wall and covering it with a low-permeability cover, even though some flow is induced through the wall.

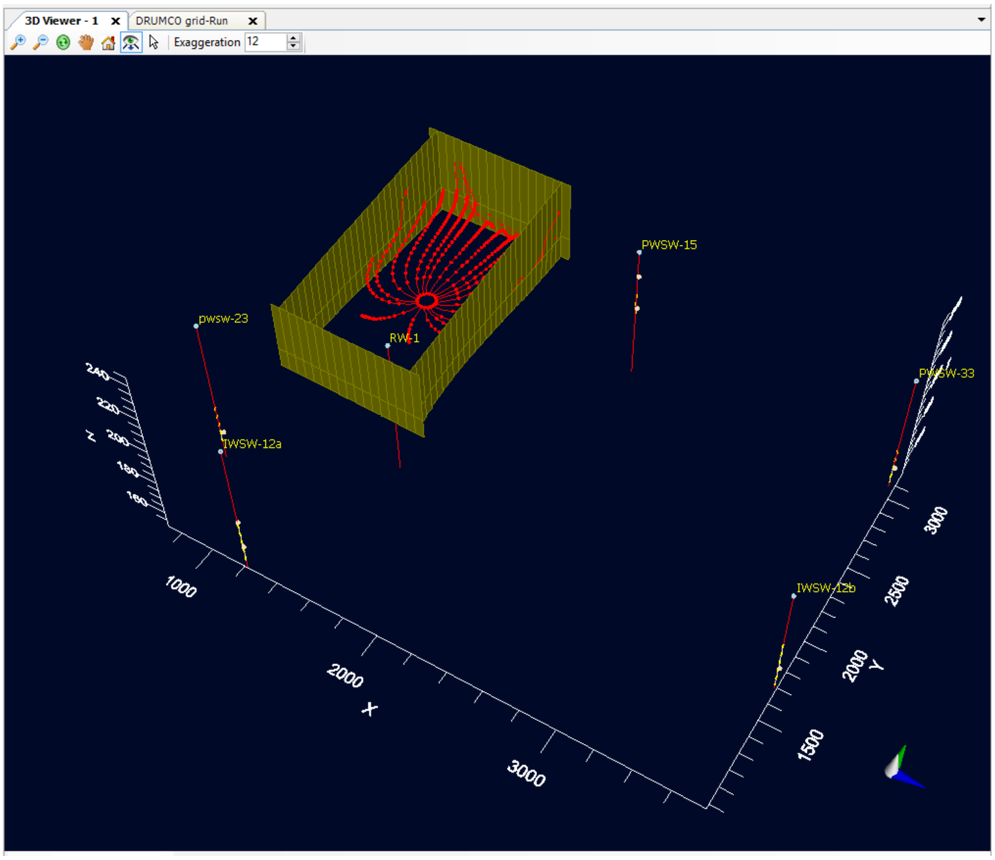

Figure 5: Wall Boundary and Backwards Pathlines