Radial Flow to a Well

1 Introduction

Closed form solutions are available for predicting the drawdown of the piezometric surfaces resulting from flow to a well in a horizontal confined aquifer (see Freeze and Cherry, 1979). If the aquifer properties T (transmissivity), S (storativity), and Q (pumping rate) are known, it is possible to predict the drawdown at any distance from the well at any time after the start of pumping. Comparing such a solution with a SEEP/W analysis makes it possible to verify the axisymmetric and transient features of the software.

2 Feature highlights

GeoStudio feature highlights include:

- Transient and axisymmetric flow
- Comparison with closed form Theis Solution

3 Geometry and boundary conditions

The drawdown $h_0 - h$ is defined by the following equations, known as the Theis Solution:

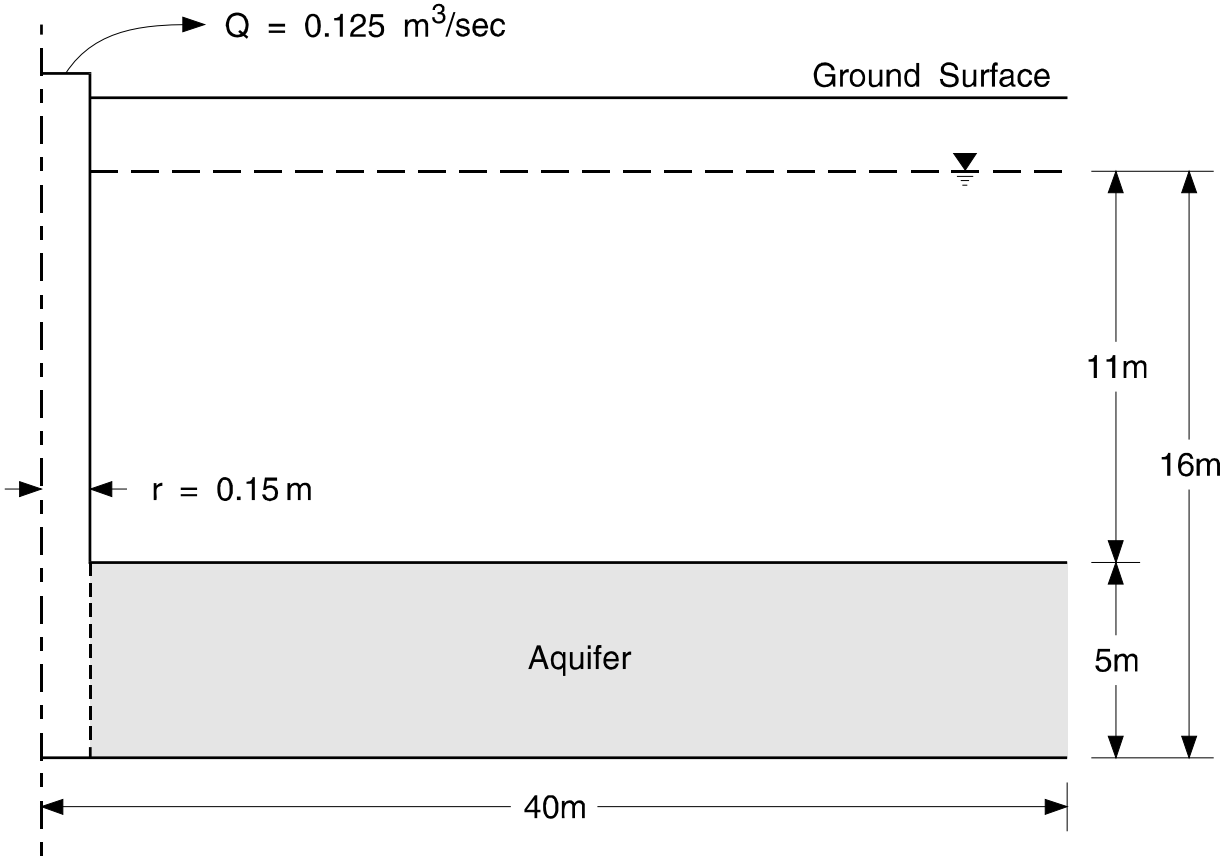
$$(h_0 - h) = \frac{Q}{4\pi T} W(u)$$

$$u = \frac{r^2 S}{4Tt}$$

where:

Q	=	pumping rate
T	=	transmissivity
$W(u)$	=	well function
r	=	distance from well axis
t	=	pumping time
S	=	storativity

In the sketch image below, the aquifer is 5 m thick and the total hydraulic head in the aquifer is 16 m. The aquifer has a storativity of 0.05 and a transmissivity of 0.010 m^2/sec. The well screen is 0.3 m in diameter (0.15 m radius) and extends over the entire depth of the aquifer. The pumping rate Q is assumed to be 0.125 m^3/sec. The model geometry is shown below the sketch.


Q = 0.125 m3/sec
Ground Surface
11m
16m
r = 0.15 m
Aquifer
5m
40m
S = 0.05
T = 0.010 m2/sec


Radial flow to a well
Elevation (m)
Distance (m)
0
10
20
30
40

4 Material properties

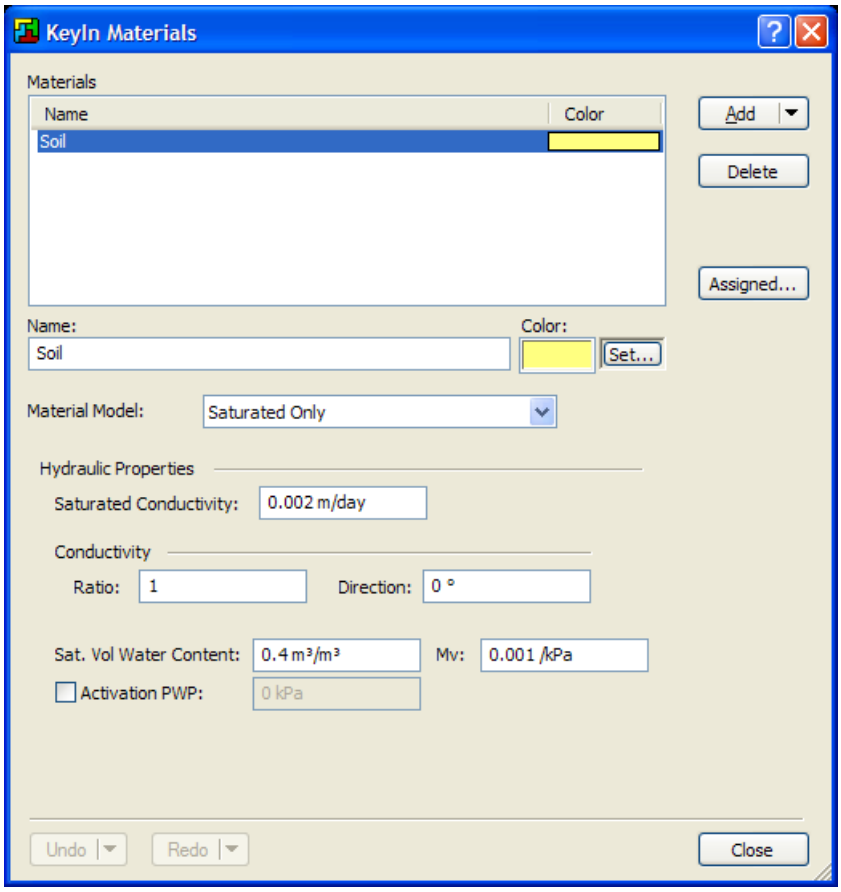
SEEP/W uses the term m_w which is the slope of the volumetric water content curve (or the soil-moisture characteristic curve) to represent the storativity of a material. The value of m_w (slope of the storage curve) corresponding to a storativity S of 0.05 can be calculated as:

$$S_s = S / b$$
$$S_s = 0.05 / 5 = 0.01 \ m^{-1}$$
$$m_w = S_s / \gamma_w$$
$$m_w = 0.01 / 9.81 = 0.001 \ kPa^{-1}$$

SEEP/W uses hydraulic conductivity rather than transmissivity. The hydraulic conductivity corresponding to a transmissivity of 0.010 m^2/sec in a 5 m thick aquifer can be calculated as:

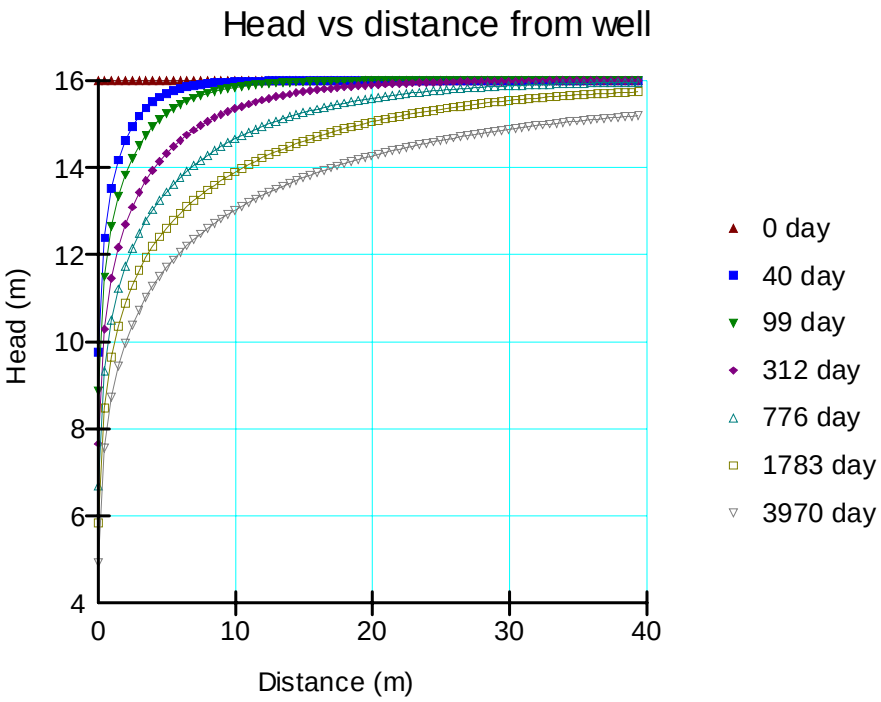
$$k = T / b$$
$$k = 0.010 / 5 = 0.002 \ m / s$$

Since this is a fully saturated problem, the Saturated Only model can be applied, as shown below.



5 Discussion of results

The graph below shows the drawdown curves at various saved times.



The table below compares the total head values as predicted by the Theis solution and the SEEP/W analysis. The agreement between the SEEP/W and closed form solution is very good, especially considering the limited accuracy with which the well function values W(u) can be ascertained from tables.

This example illustrates that SEEP/W can be used to analyze radial flow to a well in terms of the water well industry parameters of transmissivity and storativity.

Comparison of Theis solution and SEEP/W results

Elapsed Time (seconds)	Head 4m from Well (Theis)	Head 4m from Well (SEEP/W)	Head 20m from Well (Theis)	Head 20m from Well (SEEP/W)
10	15.9	15.91	16.0	16.0
30	15.7	15.62	16.0	16.0
70	15.1	15.14	16.0	16.0
150	14.6	14.55	16.0	15.98
310	13.9	13.91	15.9	15.90
630	13.1	13.24	15.7	15.69
1270	12.5	12.57	15.3	15.34
2170	11.9	12.03	14.9	14.98
3070	11.7	11.67	14.6	14.69
3970	11.3	11.39	14.3	14.46