Example 3.6 APPLICATION OF THEIS

A 375-m square excavation is to be dewatered by the installation of four wells at the corners. Point A is in the middle and Point B is on one side equidistant from two of the wells. For an allowable pumping period of 24 hours, determine the pumping rate required to produce a minimum drawdown of 4 m everywhere within the limits of the excavation. The confined aquifer has a transmissivity of 2×10^{-4} m²/s and a storage factor of 7×10^{-5}.

Solution. By symmetry, we expect the maximum drawdown to be at either A or B, so we must determine which of them is limiting. We will use the Theis equations (below) to determine the flow rate Q necessary to create a 4 m drawdown at A and B.

$$s = \left(\frac{Q}{4\pi T}\right)\mathrm{W}(u), \quad \text{and} \quad u = \frac{r^2 S}{4Tt}$$

a) Determine the required pumping rate for 4 m drawdown at A. Using r, S, T, and t, find u with the second equation above, then determine W(u) from Table 3.2, and solve the first equation for Q.

$$r = \sqrt{2}\frac{375}{2} = 265 \text{ m}$$

$$u = \frac{(265\text{m})^2(7 \times 10^{-5})}{(4)(2 \times 10^{-4}\text{m}^2/\text{sec})(24\text{hr})(3600\text{sec}/\text{hr})} = 0.071$$

$$\mathrm{W}(u) = 2.14$$

and each well contributes 25%,

$$Q = \frac{1}{4}\frac{s}{W(u)}(4\pi T) = \frac{(4\text{m})}{(4)(2.14)}(4)(\pi)(2 \times 10^{-4}\text{m}^2/\text{sec})$$

$$Q = 1.17 \times 10^{-3} \text{ m}^3/\text{s} = 4.23 \text{ m}^3/\text{hr for each well}$$

b) Determine drawdown at B using the flowrates calculated above. Drawdown at B is a combination of two wells 187.5 m from B and two wells at $r = \sqrt{187.5^2 + 375^2}$ m = 419 m from B. For the closer two wells:

$$u = \frac{(187.5\text{m})^2(7 \times 10^{-5})}{(4)(2 \times 10^{-4}\text{m}^2/\text{sec})(24\text{hr})(3600\text{sec}/\text{hr})} = 0.036$$

$$\mathrm{W}(u) = 2.79$$

and the drawdown produced by the closer two wells is:

$$s = 2\frac{(1.17 \times 10^{-3}\text{m}^3/\text{sec})}{(4)(\pi)(2 \times 10^{-4}\text{m}^2/\text{sec})}(2.79) = 2.60 \text{ m}$$

For the two farther wells,

$$u = \frac{(419\text{m})^2(7 \times 10^{-5})}{(4)(2 \times 10^{-4}\text{m}^2/\text{sec})(24\text{hr})(3600\text{sec}/\text{hr})} = 0.18 \Rightarrow \mathrm{W}(u) = 1.34$$

$$s = 2\frac{(1.17 \times 10^{-3}\text{m}^3/\text{sec})}{(4)(\pi)(2 \times 10^{-4}\text{m}^2/\text{sec})}(1.34) = 1.25 \text{ m}$$

Summing over all four wells, the total drawdown at B = 2.60 + 1.25 = 3.85 m. Thus, the drawdown at B is less than at A, so requiring a 4 m drawdown at B will automatically meet the criteria at Point A, and over the entire site. Since s and Q are linearly related, multiplying the above calculated Q by (4 m/3.85 m) will give us a drawdown of 4 m at B. Therefore Q = 4.4 m³/hr will keep the construction site dry.