D.W. KOZERA, INC.

PROFESSIONAL ENGINEERS & GEOLOGISTS

August 10, 2018

Hekemian & Company, Inc.
505 Main Street
Annapolis, Maryland 21403

Attn: Mr. Christopher P. Bell, Senior Vice President
(cbell@hekemian.com)

Re: Response to Review Letter Dated July 31, 2018 by ORR Partners Regarding 444 Maple Avenue, West Vienna, Virginia (DWK Contract Number 14107.D)

Dear Mr. Bell:

We agree with the conclusions stated in the ORR Partners review letter dated July 31, 2018, which states the following:

- Stormwater discharge permitting requirements must be followed.
- If the Developer intends to install an active dewatering system for use during construction, we recommend the Town require a more definitive submission for review.
- No further study is necessary if passive dewatering is used.
- We do not expect impacts to the surrounding properties due to the permanent underslab drainage.

However, their letter raised the following two questions:

1. The formula used in the calculation for the draw down radius. We apologize for the confusion this created; the analysis used is to model the 'system' (underslab drainage) as a single well with an equivalent radius of the building footprint. See attached excerpt from "Construction Dewatering and Groundwater Criteria," Powers, et.al, 2007. This method does not assume a fully penetrating well, but estimates flow quantities and radius of influence for a given system drawdown. In this case, the entire building subdrainage system is considered a single well, and the drawdown was 5 feet. Hydraulic conductivity values were derived from actual field slug tests, and submitted October 17, 2014. These tests indicated that the hydraulic conductivity ranged from 4.0 to 16.9 gpd/ft^2. For the purpose of the above referenced analysis, 10 gpd/ft^2 was used. The conclusions reached by our analysis and by the ORR Partners that "it is unlikely that the permanent underslab drawing, system will have any noticeable effect on the existing water table," are in agreement.

2. The second issue raised by the Orr Partners letter, was that localized dewatering would be required for installation of foundations. It is our experience that on projects in the residual soil profile with excavations that extend to depths less than 10 feet below the water table, 'Passive Sumps' are utilized. While some shoring (excavation support) may be required for excavations deeper than 4 feet, the groundwater is typically managed by a sump pump placed within the footing excavation. This is a temporary condition which is required only until the foundation concrete is placed, typically one day for individual footings or several days for an elevator mat. The use of these localized sumps does not allow sufficient time for a steady state groundwater condition to develop. As the flow velocity into these localized sumps is less than 5 feet/day, the water table surrounding the footing excavation will be depressed only slightly in the one or two days the sumps operate. There is insufficient dewatering time for these sump pumps to affect the regional groundwater table. Again, the conclusion reached by ORR Partners is that as long as the 'Passive Sump' system is used to install foundations, no impact to surrounding properties is expected is in agreement with our analysis.

Sincerely,
D.W. KOZERA, INC.

David W. Kozera, P.E.
Commonwealth of Virginia No. 0402011857
Expiration: 06-30-2019

COMMONWEALTH OF VIRGINIA
DAVID W. KOZERA
NO.
PROFESSIONAL ENGINEER

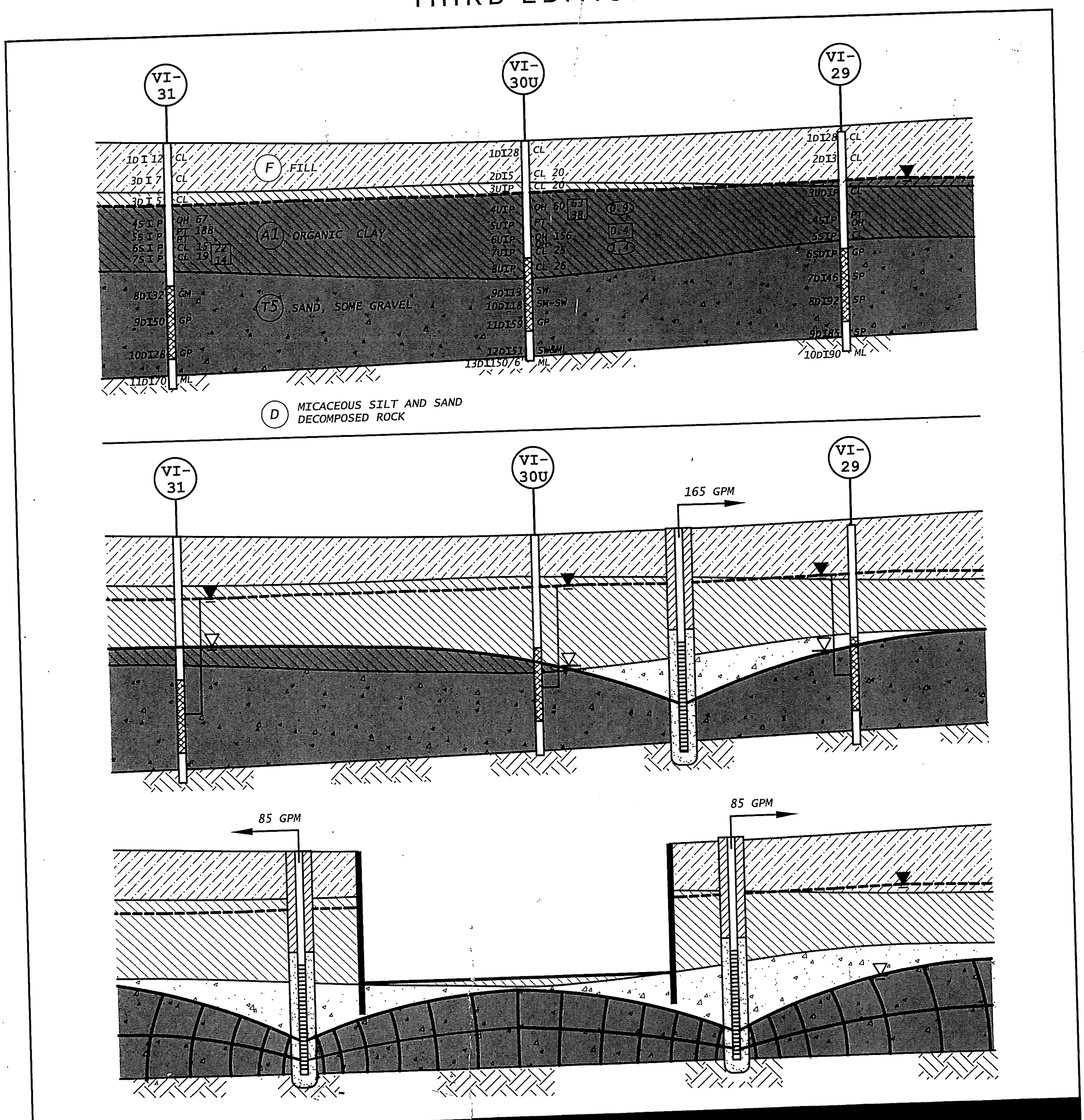
Enclosure: 'Excerpt from Construction Dewatering and Groundwater Criteria'

J. PATRICK POWERS • ARTHUR B. CORWIN
PAUL C. SCHMALL • WALTER E. KAECK

Construction Dewatering and Groundwater Control

NEW METHODS AND APPLICATIONS

THIRD EDITION



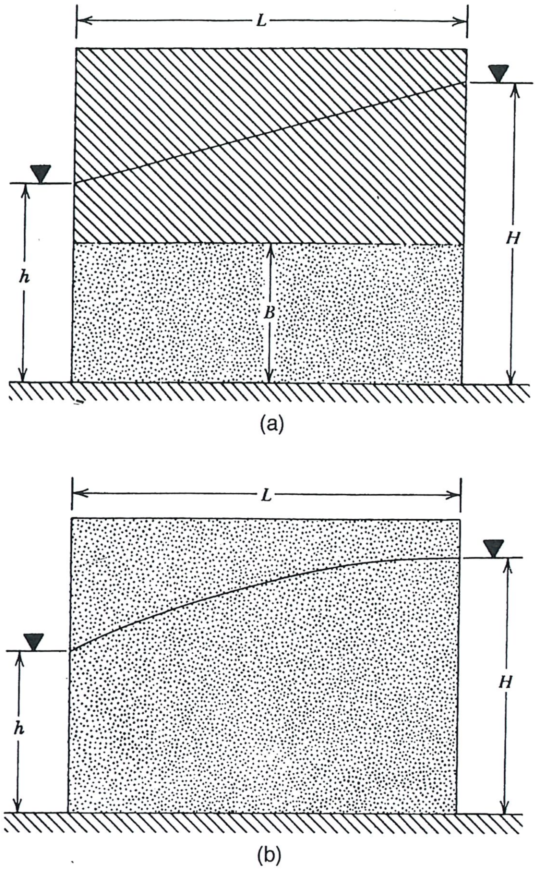


Figure 6.6 Flow from a single line source to a drainage trench of infinite length. (a) Confined aquifer (b) Water table aquifer.

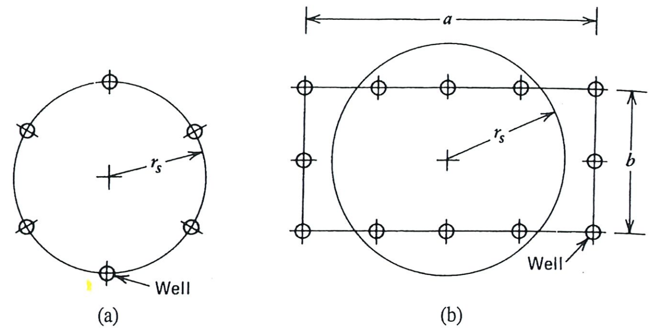


Figure 6.7 Approximation of equivalent radius r_s (a) Circular systems. (b) Rectangular systems.

source on one side. For the confined aquifer in Fig. 6.6a, the flow from one side per unit length of trench is given by

$$\frac{Q}{x} = \frac{KB(H - h)}{L} \tag{6.6}$$

For the water table aquifer of Fig. 6.6b

$$\frac{Q}{x} = \frac{K(H^2 - h^2)}{2L} \tag{6.7}$$

Section 6.5 discusses the use of the drainage trench equations 6.6 and 6.7 in analyzing long, narrow dewatering systems.

6.5 THE SYSTEM AS A WELL: EQUIVALENT RADIUS r_s

Many problems can be analyzed by assuming the entire system acts as a single large well of radius r_s. The assumption is of greatest validity with a circular system of closely-spaced wells, as in Fig. 6.7a. Rectangular systems as in Fig. 6.7b are assumed to act as a circular system of the same enclosed area:

$$r_s = \sqrt{\frac{ab}{\pi}} \tag{6.8}$$

Some analysts prefer to consider a rectangular system to act as a circular system with the same perimeter:

$$r_s = \frac{a + b}{\pi} \tag{6.9}$$

Either Eq. 6.8 or 6.9 gives reasonable approximations when the wells are spaced closely, when R_0 is great in relation to r_s, and when the ratio a/b is less than about 1.5. If the wells are widely spaced, the actual Q will be significantly higher than that estimated for the equivalent well.

If the system contains only a few widely spaced wells, or if R_0 is small, then the system should probably be analyzed by the method of cumulative drawdowns discussed in Section 6.12 or by a numerical groundwater model (Chapter 7).

For long, narrow systems where the ratio a/b is large, a combined analytical model can be constructed, using both Eqs. 6.3 and 6.9. Figure 6.8 shows such a system of closely-spaced wells for dewatering a trench excavation of length x. The wells are staggered on both sides at a distance r_s from the center of the trench. The northward and southward flow from the line sources at distance L can be approximated from the trench Eqs. 6.6 or 6.7. However, these equations assume drainage trenches of infinite length. Since the length

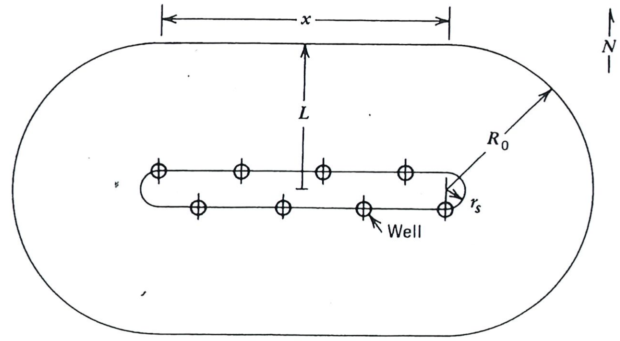


Figure 6.8 Approximate analysis of long, narrow systems.

of the actual system is finite, the end effects must be considered. This can be done by assuming that at each end of the system there is a flow equal to one half the flow to a circular well of radius r_s. The total flow to the system may be approximated by adding Eqs. 6.1 and 6.6 for a confined aquifer, or Eqs. 6.3 and 6.7 for a water table aquifer:

$$Q = \frac{2\pi KB(H-h)}{\ln R_0/r_s} + 2\left[\frac{xKB(H-h)}{L}\right] \quad (6.10a)$$

$$Q = \frac{\pi K(H^2-h^2)}{\ln R_0/r_s} + 2\left[\frac{xK(H^2-h^2)}{2L}\right] \quad (6.10b)$$

While the total Q from this model is usually a reliable approximation, it is obvious that the wells at the ends of the system will pump more than those in the center if spacing is constant. In practice, systems used to dewater trenches and tunnels are often leapfrogged as the excavation continuously progresses, so a given well will, at times, be anywhere in the system. It is good practice therefore to design each well and its pump for the high capacity it will yield when near the end of the system. When the well is near the center of the system its pump can be throttled. Similarly, when using wellpoints they can be spaced uniformly and wellpoints near the center can be tuned as described in Section 19.9.

6.6 RADIUS OF INFLUENCE R_0

The equivalent radius of influence R_0 that appears in the various analytical models is a mathematical convenience. As discussed in Section 5.3, the sum of the recharge to the aquifer is assumed to create an effect similar to that of a constant source on a vertical cylindrical surface at R_0. Thus, the concept is, to a degree, nebulous. Because R_0 appears as a log function in Eqs. 6.1–6.5, precision in estimating it is not necessary when analyzing flow from a circular source. However, in Eqs. 6.6 and 6.7 the distance to the line source L (a similar concept to R_0) is proportional to Q. We have seen apparent R_0 vary from 100 to 100,000 ft (30 to 30,000 m) on various projects, depending on aquifer transmissivity, storage coefficient, pumping time, and other factors. The literature cites instances of R_0 of even greater magnitude. So, the possibility of significant error exists.

The most reliable means of estimating R_0 is by Jacob analysis of a pumping test, as described in Chapter 9. Only this method will reveal recharge from other aquifers and the degree of connection with surface water bodies. It is necessary also to extrapolate from the conditions existing during the pumping test to others that may occur within the life of the dewatering system. We have seen the Q of a dewatering system increase by 20, 40, or even 100% during high river stages, particularly when accompanied by inundation of large surface areas of the flood plain (Section 5.3).

Lacking a pumping test, it is necessary to make rough approximations of R_0 from topography and areal geology, or from estimated aquifer parameters. In an ideal aquifer, without recharge, R_0 is a function of the transmissivity, the storage coefficient and the duration of pumping. By adapting the Jacob formula (Eq. 4.5), we can estimate the order of magnitude of R_0 without recharge as follows:

$$R_0 = r_s + \sqrt{\frac{Tt}{C_4 C_s}} \quad (6.11)$$

Units to be used in this equation are given in Table 4.3. For values of the constant C_4 in Eq. 6.11, see Table 4.3. Where r_s is small in relation to R_0, r_s can be neglected. Equation 6.11 is for a confined aquifer rather than a water table aquifer, but the error in R_0 is small as long as the proper value of C_s is used. The value for pumping time t is selected from schedule or cost considerations regarding the time available to accomplish the result.

The value computed for R_0 by Eq. 6.11 should be reduced on the basis of judgments as to possible recharge. It is apparent from Eq. 6.11 that R_0 computed for a typical confined aquifer (C_s = 0.001 to 0.0005) will be some 14 to 140 times greater than that in a clean sand water table aquifer ($C_s = 0.2$) with the same transmissivity and pumped for the same time. Experience confirms that large values for R_0 are typical of confined aquifers. An empirical relationship developed by Sichart and Kryieleis [6-6] gives R_0 as a function of drawdown H-h and K:

$$R_0 = 3000(H-h)\sqrt{K} \quad (6.12)$$

Where H-h is in feet and K is in meters per second. Theoretically, R_0 is independent of drawdown and is related to pumping time, which does not appear in the Sichart relationship. Nevertheless, the formula has produced reasonable values in some situations.

In many problems, the source of water is conveniently approximated by a vertical line source at distance L from the center of the system, rather than the vertical cylindrical source at R_0. A line source will produce the same flow to a well as a circular source at twice the distance. For use in equilibrium equations 6.1 and 6.3,

$$R_0 = 2L \quad (6.13)$$

Section 10.3 discusses estimates of the distance L to a line source based on topography and geology.

6.7 HYDRAULIC CONDUCTIVITY K AND TRANSMISSIVITY T

The analytical models assume an isotropic homogeneous aquifer. When transmissivity T is determined by Jacob analysis of a pumping test, it is an *equivalent isotropic transmissivity* T_i, or the transmissivity of an isotropic aquifer, that will perform in a similar manner to the natural aquifer of interest. The thickness B of the aquifer can be estimated from soil borings or inferred from the geology, and the equivalent isotropic hydraulic conductivity K_i can be computed from Eq. 4.1: