Title

Closure to Review of GroundWater Quality Monitoring Network Design by Hugo A. Loaiciga, Randall J. Charbeneau, Lorne G. Everett, Graham E. Fogg, Benjamin F. Hobbs, and Shahrokh Rouhani (January, 1992, Vol. 118, No. 1)

Journal

Journal of Hydraulic Engineering, 119(12)

ISSN

0733-9429

Authors

Loaiciga, Hugo A
Everett, Lorne G

Publication Date

1993-12-01

DOI

10.1061/(asce)0733-9429(1993)119:12(1441)

Peer reviewed

J., and Smith, A. R. (1992b). "Recommended administrative/regulatory definition of karst aquifer, principles for classification of carbonate aquifers, and determination of optimum sampling frequency at springs." *Proc., 3rd Hydro., Ecology, Monitoring, and Mgmt. of Ground Water in Karst Terranes Conf.*, National Ground Water Assoc., Dublin, Ohio, 573–635.
Sauter, M. (1992). "Assessment of hydraulic conductivity in a karst aquifer at a local and regional scale." *Proc., 3rd Hydro., Ecology, Monitoring, and Mgmt. of Ground Water in Karst Terranes Conf.*, National Ground Water Assoc., Dublin, Ohio, 39–57.
Seetharamiah, K., Ramamurthy, A. S., and Kisiel, C. C. (1967). Discussion of "Time-series analysis of water-quality data," by Robert V. Thomann, *J. Sanit. Engrg. Div.*, ASCE, 93(6), 264–268.
Smart, C. C. (1988). "Artificial tracer techniques for the determination of the structure of conduit aquifers." *Ground Water*, 26(4), 445–453.
Thomann, R. V. (1967). "Time-series analysis of water-quality data." *J. Sanit. Engrg. Div.*, ASCE, 93(1), 1–23.
Thomann, R. V. (1968). "Closure to "Time-series analysis of water-quality data." *J. Sanit. Engrg. Div.*, ASCE, 94(5), 1020–1022.
Whitfield, P. H. (1986). "Spectral analysis of long-term water quality records." *Statistical aspects of water-quality monitoring*. A. H. El-Shaarawi and R. E. Kwiatkowski, eds., Elsevier, Amsterdam, The Netherlands, 388–403.
Worthington, S. R. H., Davies, G. J., and Quinlan, J. F. (1992). "Geochemistry of springs in temperature carbonate aquifers: recharge type explains most of the variation." *Proc., 5th Colloque d'Hydrogéologie en Pays Calcaire en Milieu Fissuré.* 2, Neuchâtel, Switzerland.

Closure by Hugo A. Loaiciga[10] and Lorne G. Everett[11]

The discussers present a useful extension to the work of the writers of the original paper. The writers believe, however, that the concept of representative elementary volume (REV) used by the discussers is of tangential importance to the original work and, for that matter, to the subject matter of their discussion. The REV concept is useful in defining macroscopic equations of groundwater processes over a fictitiously continuous porous medium. The discussers, somewhat inconsistently, use the REV concept to justify a correct premise: that the temporal sampling frequencies and spatial monitoring scales in karst aquifers with underground conduits must be quite different to those of other consolidated and unconsolidated formations. The latter type of geologic formations were the subject of the original work.

It is clear that underground karstic conduits act as a drainage network with travel times and spatial coverage typical of surface-drainage networks. Plume detection and other ambient monitoring require adequate temporal resolution to avoid the aliasing phenomenon cited by the discussers. Spatial coverage in karstic monitoring is critically important, and one must have an understanding of the interconnectedness and hydraulic characteristics of conduit flow to adequately locate monitoring stations. We argue that the principles of karstic groundwater-quality monitoring advocated by the discussers are a specialized case of what the writers define as the hydrogeologic approach to groundwater-quality monitoring, where groundwater-flow velocities are extreme.

---

[10]Assoc. Prof., Dept. of Geography and Envir. Studies Prog., Univ. of California, Santa Barbara, CA 93106.
[11]Chf. Res. Hydro. and Vice-Pres., Gerathy and Miller, Inc., 200 East Carrillo St., Santa Barbara, CA 93101.

J. Hydraul. Eng., 1993, 119(12): 1441-1442

Karst aquifers are common and particularly susceptible to contamination. Because of this, the contribution of the discussers is meritorious. It addresses a very special and important type of subsurface monitoring.

DIMENSIONALLY HOMOGENEOUS MANNING'S FORMULA[a]

Discussion by B. A. Christensen,[2] Member, ASCE

The author's note on the classic Manning formula and the roughness parameter n customarily associated with that formula is enlightening. It presents some of the classic references that may not be readily available, but it also revives the old controversy about the dimension and proper evaluation of a "fuzz" factor that too long has been shrouded in professional mystique.

By writing Manning's formula in the form of (3) and indicating that $K_n = 1$ when units of the système international are used, and $K_n = 1.486$ in the English unit system, it is quietly assumed that n must have the same numerical value in both systems. Therfore, it seems obvious that n must be dimensionless and that K_n has the dimension length$^{1/3}$ time^{-1}. The simple conversion of the 1 m$^{1/3}$s^{-1} to English units

$$1 \text{ m}^{1/3}\text{s}^{-1} = \left(\frac{1}{0.3048}\right)^{1/3} = 1.486 \text{ ft}^{1/3}/\text{sec} \quad (17)$$

confirms this statement.

In (4), the square root of the acceleration due to gravity g is pulled out of Manning's n. This seems logical since n actually is inversely proportional to g. However, the price paid is a complication of matters. The new Manning's coefficient n_g introduced in this way is not dimensionless, having different numerical values in different unit systems as reflected by the values suggested in Table 1. Also the new coefficient is not easier to estimate than the old. Manning's n and the author's n_g do not have specific physical meanings that would make estimation easy and fairly precise. A highly possible estimation error on n (or n_g) of say 20% is carried over as a relative velocity error of exactly the same magnitude.

Using Nikuradse's equivalent sand roughness k_s, which does have a physical meaning, namely that of a roughness height that it probably is easier to estimate than n (or n_g), may therefore seem to be a better solution than using n or n_g.

By logarithmic regression analysis, Nikuradse's equation for the friction factor f in the turbulent rough flow may be approximated by the power expression

---

[a]September, 1992, Vol. 118, No. 9, by Ben Chie Yen (Paper No. 1891).

[2]Prof. of Civ. Engrg., Univ. of Florida, Gainesville, FL 32611.

J. Hydraul. Eng., 1993, 119(12): 1441-1442