URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

Paul A. Hindman, Executive Director
2480 W. 26th Avenue, Suite 156B
Denver, CO 80211-5304

Telephone 303-455-6277
Fax 303-455-7880
www.udfcd.org

TECHNICAL MEMORANDUM

FROM: Ken A. MacKenzie, P.E., UDFCD Master Planning Program Manager

SUBJECT: Estimating Flow through a Partially Submerged Vertical Orifice

DATE: December 31, 2015

In detention basin design, the question has been asked as how to model flow through the 100-year orifice (or through the water quality orifices or any other vertical orifice) when the ponding depth is less than the top of that orifice.

A peer-reviewed technical paper titled *Flow Through Partially Submerged Orifice* has been submitted to the ASCE *Journal of Irrigation and Drainage Engineering* by James CY Guo, Ryan Stitt, and David Mays. While still in draft form, the paper provides a sound mathematical approach to estimating flow through a partially submerged vertical circular orifice.

The reader is encouraged to read *Flow Through Partially Submerged Orifice* by Guo et al. Because of the complexity of setting up the mathematical steps in the approach by Guo et al. however, this technical memorandum suggests a simplified equation that closely matches the results produced by their method.

First, determine the orifice flow resulting when the ponding depth is equal to the top of the circular orifice as:

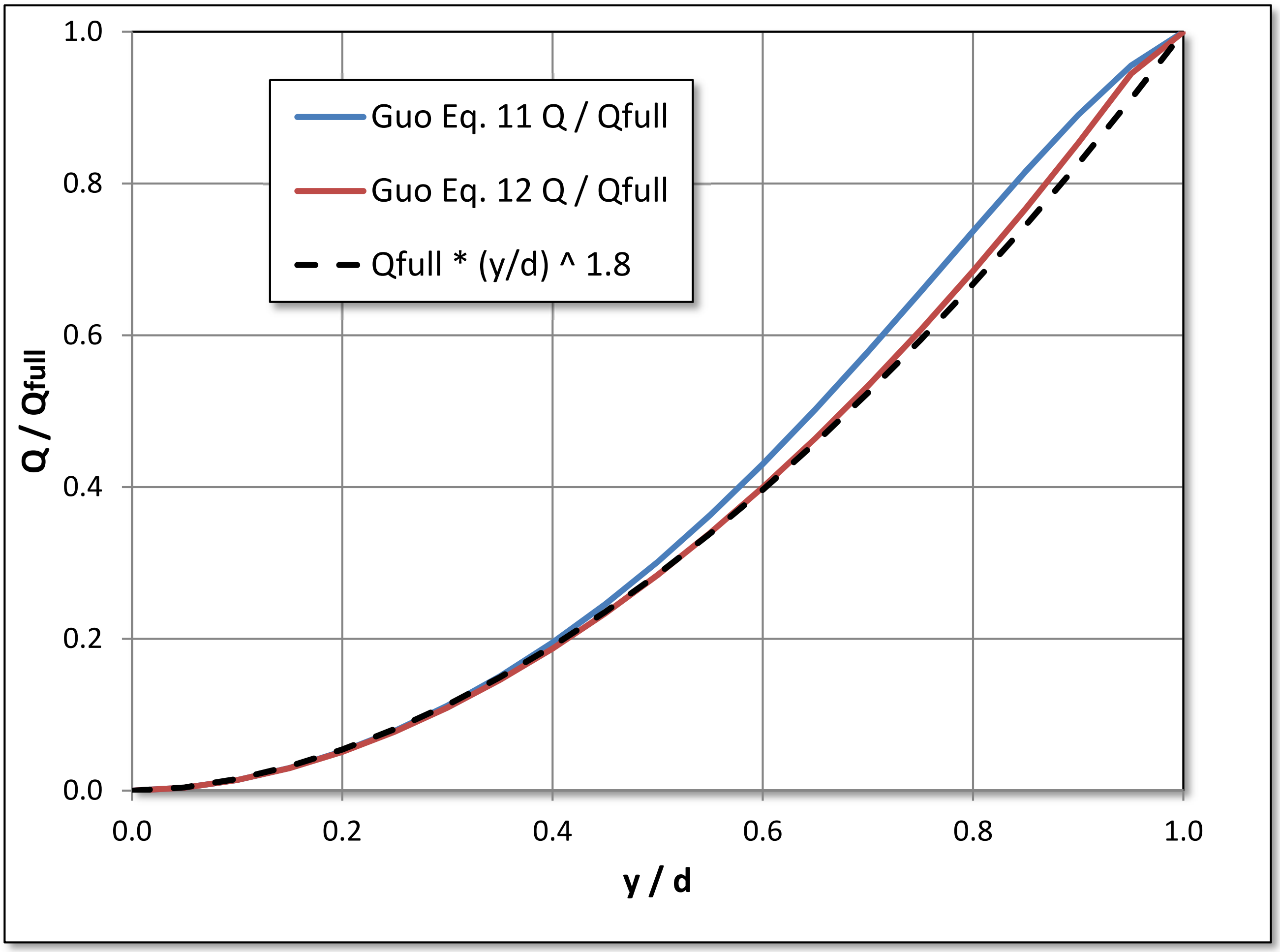
$$Q_{full} = C_d A_o \sqrt{2gd} \quad (1)$$

Where Q_{full} is the orifice flow through a just-full orifice, C_d is the coefficient of discharge (recommended by Guo et al. as 0.53), A_o is the area of the orifice, g is the gravitational constant, and d is the diameter of the orifice (the ponding depth y is in this case equal to d).

Next, calculate the flow through the orifice where the ponding depth y is less than the diameter d as:

$$Q = Q_{full}\left({}^{y}/_{d}\right)^{1.8} \quad (2)$$

The paper by Guo et al. suggests either of two equations (Eq. 11 and Eq. 12) will produce a good approximation of orifice flow, and this was verified in the University of Colorado Hydraulics lab. The results of Equations 1 & 2 in this technical memorandum are compared to Guo's Eq. 11 and Eq. 12 in the following graph.


Guo Eq. 11 Q / Qfull
Guo Eq. 12 Q / Qfull
Qfull * (y/d) ^ 1.8
Q / Qfull
y / d
0.0
0.2
0.4
0.6
0.8
1.0