

TECHNICAL MEMORANDUM

TO: Shelley Keen, manager water rights permits section
FROM: Michele Edl, associate engineer
DATE: March 11, 2011
SUBJECT: Gem Lake Harbor diversion culvert capacity

Introduction

You asked me to evaluate whether or not the culvert diverting water from the Snake River into Gem Lake Harbor has the capacity to divert an additional 25.8 cfs. This is the rate recommended by the field examiner in his supplemental beneficial use report (dated June 28, 2010) for Water Right Permit #01-10542. Permit #01-10542 authorize additional diversion for recreational use. It was instigated to cover the full rate found during the field exam for an earlier water right, Licensed right #01-7103.

The culvert diverts from the Snake River at river mile 793 into an inundated gravel quarry which is now the water feature for Gem Lake Harbor subdivision. The point-of-diversion is sited between two hydroelectric plants operated by the City of Idaho Falls. The Lower Power Plant is upstream of the diversion. Gem State Power Plant is downstream of the diversion. The return from the Gem Lake Harbor back to the Snake River is uncontrolled and is not easily distinguished from Gem Lake, the headwater pool for the Gem State plant.

In his field work, the examiner from Brockway Engineering PLLC, found a flow rate higher than the total authorized by both water rights and he requested guidance from the Department related to seeking a third permit for that additional diversion rate.

This memo summarizes my calculations and conclusion.

Method

I used equations from an accepted methodology for submerged culverts described more fully in US Geological Survey Techniques of Water-Resources Investigations, book 3, chapter A3. (see http://pubs.usgs.gov/twri/twri3-a3/pdf/TWRI_3-A3.pdf).

Based on the field examiners report and photos, I classified this culvert as a submerged outlet, type 4 flow. The entrance velocity, entrance friction loss and exit friction loss are assumed negligible.

(see figure below from TWRI 3-A3, page 5)

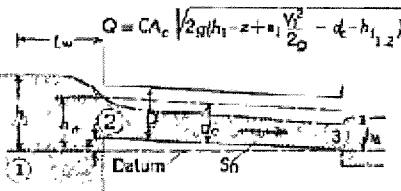
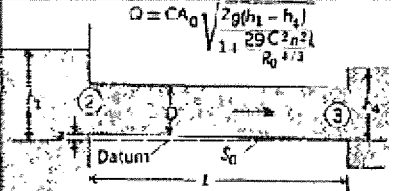
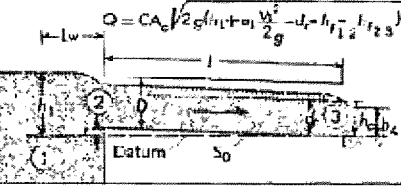
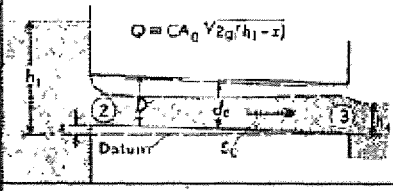
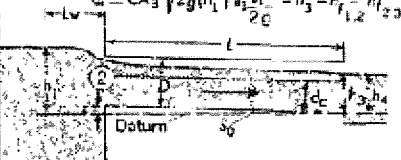
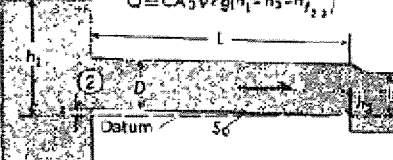
TYPE	EXAMPLE	TYPE	EXAMPLE
1 CRITICAL DEPTH AT INLET $\frac{h_1 - z}{D} < 1.5$ $h_4/h_c < 1.0$ $S_0 < S_c$		4 SUBMERGED OUTLET $\frac{h_1 - z}{D} > 1.0$ $h_4/D > 1.0$	
2 CRITICAL DEPTH AT OUTLET $\frac{h_1 - z}{D} < 1.5$ $h_4/h_c < 1.0$ $S_0 < S_c$		5 RAPID FLOW AT INLET $\frac{h_1 - z}{D} > 1.5$ $h_4/D < 1.0$	
3 TRANQUIL FLOW THROUGHOUT $\frac{h_1 - z}{D} < 1.5$ $h_4/D > 1.0$ $h_4/h_c > 1.0$		6 FULL FLOW FREE OUTFALL $\frac{h_1 - z}{D} > 1.5$ $h_4/D < 1.0$	

Figure 2.—Classification of culvert flow.

The equation for Type 4 Flow is: (below and TWRI 3-A3, page 5, equation 9):

$$Q = CA_0 \sqrt{\frac{2g(h_1 - h_4)}{1 + \frac{29C^2 n^2 L}{R_0^{4/3}}}}$$

where

Q = flow in cfs

C = discharge coefficient. I choose 0.82 for sharp tube

Ao = area of flow at the culvert opening ft²

g = gravitational acceleration constant = 32.2 ft/sec²

h1 = headwater elevation in ft

h4 = tailwater elevation in ft. (h1-h4) is also described as the differential head across the culvert

n = Mannings n. I choose 0.013 for reinforced concrete pipe

L = culvert length in ft. Given as 40 ft.

Ro = hydraulic radius (area of flow/wetted perimeter) in ft

Results

The field examiner found head differentials across the culvert, ($h_1 - h_4$), of 0.945 ft and 0.33 ft on June 17, 2010 and June 22, 2010 respectively.

On June 17, 2010, the examiner measured a flow of 44.6 cfs. Using the assumptions, equation and parameters above, I calculated that the flow based on a head differential of 0.95 ft would be 41.5 cfs.

On June 22, 2010, the examiner measured a flow of 22.4 cfs. Using the assumptions, equation and parameters above, I calculated that the flow based on a head differential of 0.33 ft would be 24.5 cfs.

I assumed no friction for the calculations. Calculated flows should be higher than the measured flows and they are.

Conclusions

The culvert point-of-diversion could provide 26.8 cfs, the total rate permitted by rights 01-7031 and 01-10542 for Gem Lake Harbor.

The capacity of the diversion culvert is limited by the difference in water surface elevations across the culvert. Therefore, I find that the culvert has the capacity to pass more water than has been permitted.