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Brockway Engineering
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PROJECT: 962-01-2007

SUBJECT: Hydraulic analysis of headgate & culvert, estimate of capacity
Becko Construction / Permit 01-7103

DATE: August 10, 2007
FROM: C. G. Brockway

The point of diversion for permit 01-07103 consists of a concrete headwall with a canal gate to a 30" steel culvert running 40 feet through an embankment and discharging to the body of water known as Gem Lake Harbor. This feature was an old gravel pit which is now filled with water from the Snake River at the point of diversion. The headgate is located within the pool created by Gem State Dam 3.2 miles downstream.

The measured discharge through the culvert on June 21, 2007 was 10.63 cfs. This measurement was made with a current meter about 0.25 miles downstream of the headgate at a concrete box culvert. Seepage from the lake is assumed to be minimal between the headgate and the measurement point. At the time of the measurement, both the inlet and outlet of the culvert were fully submerged and the surveyed water surface drop was 0.14 feet.

The discharge in the Snake River on June 21, 2007 was 5770 cfs. Data from the USGS streamflow gauge 13057155, located 11.4 miles upstream of Gem Lake Harbor, indicates that the daily flow for the period of record 10/1/1987 through 8/9/2007 had a mean of 5809 cfs and a standard deviation of 4430 cfs. Thus, the 6/21/2007 measurements were made during a period of approximately average flow in the river, and the capacity of the headgate and culvert would be greater at higher river stage. The stage is held relatively constant by the dam, but does fluctuate as evidenced by water marks on the concrete headwall. The apparent normal high water mark (not the extreme high water mark) was measured to be 1.05 feet higher than the water level on 6/21/2007.

Because the culvert is submerged, the hydraulic analysis consists of a straightforward head loss computation and the discharge depends only on the difference in water level from upstream to downstream. As a check of the reasonableness of the flow measurement, a theoretical analysis was performed using Darcy-Weisbach friction with $f = 0.015$, an entrance loss coefficient of 0.5, an exit loss coefficient of 1.0, and a total head loss of 0.14 feet. This analysis yields a theoretical discharge of 11.17 cfs, which is within 5% of the measured discharge.

Since the discharge is a function only of the head loss across the culvert, a calibrated discharge equation can be defined using the measured head loss and flow:

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$$Q = K\sqrt{\Delta h}$$

Substituting $\Delta h = 0.14$ and $Q = 10.63$ yields $K = 28.41$. (This equation is equivalent to the Darcy-Weisbach analysis described above with all head loss parameters aggregated into a single coefficient and calibrated to match the observed data).

As noted above, at the normal high river level the elevation at the headgate is estimated to be 1.05 feet greater than on 6/21/07. However, due to backwater from the river affecting the outlet of the lake, the depth downstream of the culvert will also increase. A well-defined high water mark on the box culvert indicates a water level 0.3 feet greater. Therefore, the net head is expected to be $1.05 - 0.3 = 0.75$ feet greater than on 6/21/07, and the net head at this high water condition would be $0.14 + 0.75 = 0.89$ feet.

Using the above equation, the discharge with $\Delta h = 0.89$ feet would be 26.8 cfs. This is the best estimate of the capacity of the diversion works during a normal high water condition in the Snake River.

Existing water right permit 01-07103 allows a diversion rate of 1.0 cfs, so the new permit application should list 25.8 cfs.