

MEMO

To: Tim Luke

From: Mat Weaver MW

Date: September 10, 2010

RE: Upper Worm Creek Injection Channel - Preliminary Water Measurement Device Design Summary

This memo is a summary of the preliminary design I conducted regarding a compound broad-crested weir for the measurement of water on the inter-drainage diversion channel between the Cub River and Upper Worm Creek. At this time, the compound broad crested weir described in this memo is the only device I have considered in detail. Potential design alternatives for future consideration include a compound (v-notch/Cipolletti) weir or a packaged Doppler flow meter system located at the existing bridge. Tim Luke collected the site information used for preliminary design on April 25, 2010 and August 11, 2010 his information is summarized in the appendix. MAY

Compound Broad Crested Weir Design Summary

I have proposed a cast in-place reinforced concrete structure. The structure is a compound broad crested weir, which was designed with the assistance of WinFlume32 V1.05.0031 - a software package provided by the USDA Bureau of Reclamation specifically for the support of design and calibration of long-throated flumes and broad-crested weirs. The proposed water measurement device has a width of 20 feet, a length of 33 feet, and a height within the concrete channel of 5 feet. A 1.0% slope is designed into the device approximating the existing bed slope of the natural channel. Please refer to the appendix for design drawings of the device including plan, elevation, section, and isometric details. The device was designed to measure flow rates from 5-90 CFS. The device was designed with a flow rate measurement tolerance of 5% of measured flow. If all assumptions of the design software are met, at the minimum design flow (5 CFS) the device will measure flow rates with an accuracy of +/- 5.0% and at the maximum design flow (90 CFS) the device will measure flow rate with an accuracy of +/- 2.3%. At maximum design flow the depth of water in the device will be 3.2 feet, this provides a freeboard of 1.8 feet to the top of the device, it is unknown what freeboard will be provided within the natural channel. At maximum design flow the tailwater depth in the channel immediately downstream of the device will be 0.64 feet. Included in the appendix is the design summary report for this device as generated by WinFlume.

Preliminary Cost Estimate

My preliminary cost estimation was limited to the raw materials of concrete, concrete ad-mixes (fiber mesh) and concrete reinforcement (#4 bar). My estimates do not include any labor associated with the installation of the device. I estimate the completed volume of the device will be approximately 31 cubic-yards. I recommend that approximately 1,220 LF of #4 rebar be used for the control of cracking associated with the seasonal changes in temperature that will affect the device (aesthetic not structural steel). The total estimated material cost is approximately \$4,000. Refer to the appendix for a detailed cost break down.

Appendix

1. Site Data Summary
2. Proposed Water Measurement Device Preliminary Design Details
3. WinFlume Design Summary Documentation
4. Detailed Material Cost Breakdown

Cub River – Worm Creek Inter-Drainage Connection
Site Data – Collected by Tim Luke on 8/11/10 & 5/25/10

Channel Width: 25 feet

Channel Bed Slope: $(6.2-5.86)/39 = 0.87\% \sim 1.0\%$

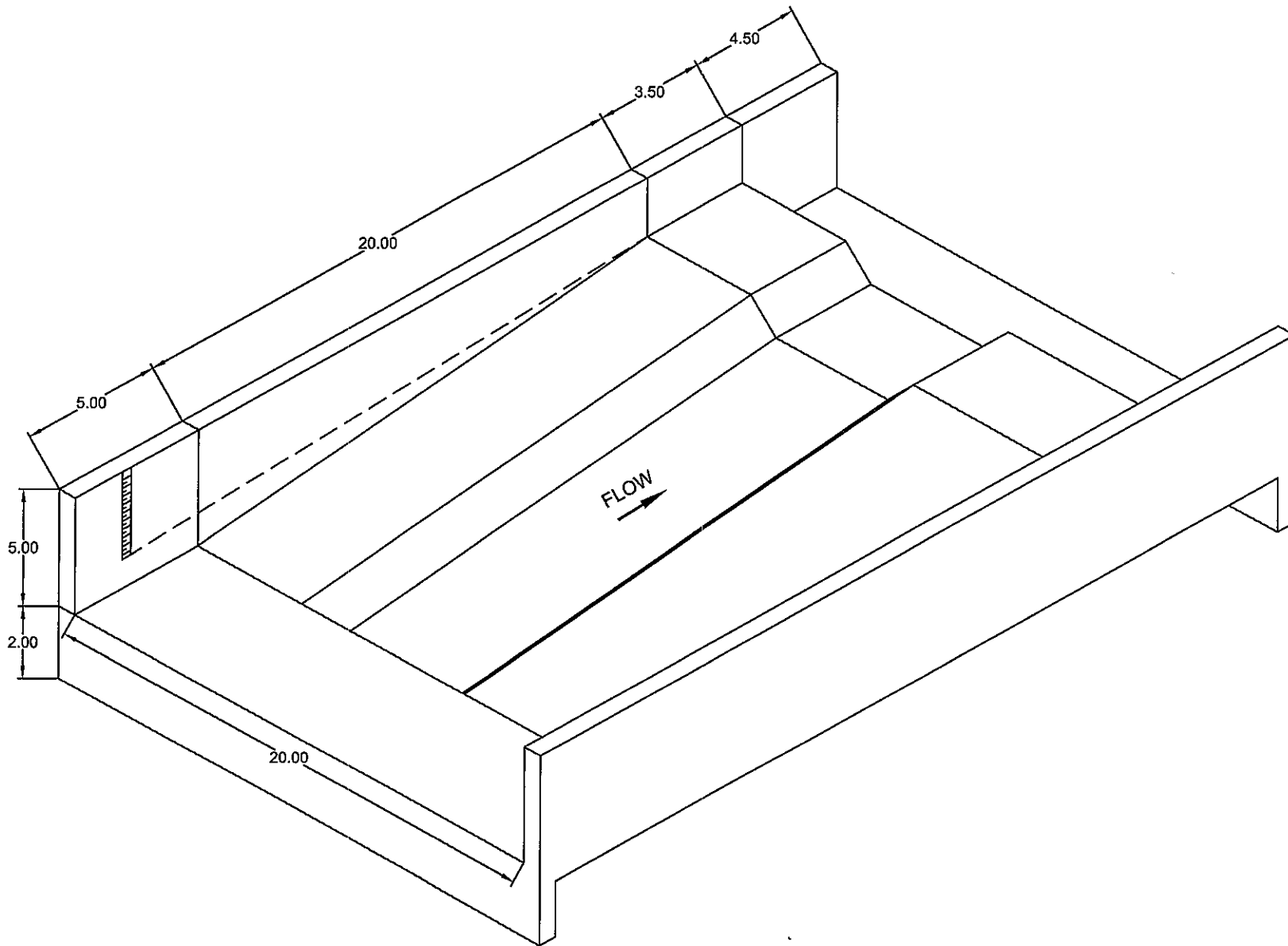
Maximum Design Flow Rate: 90 CFS

Minimum Design Flow Rate: 10 CFS

Minimum Channel Flow Rate: 1-2 CFS

Site Pics:





WEIR - ISOMETRIC VIEW

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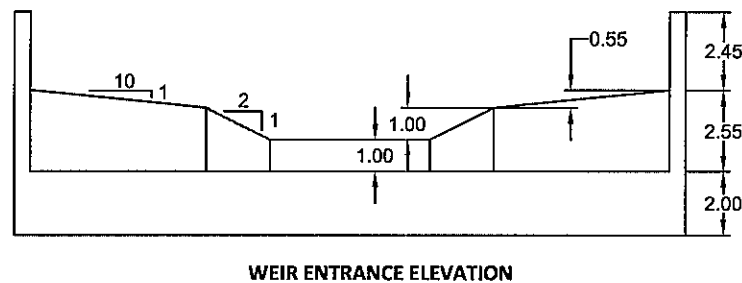
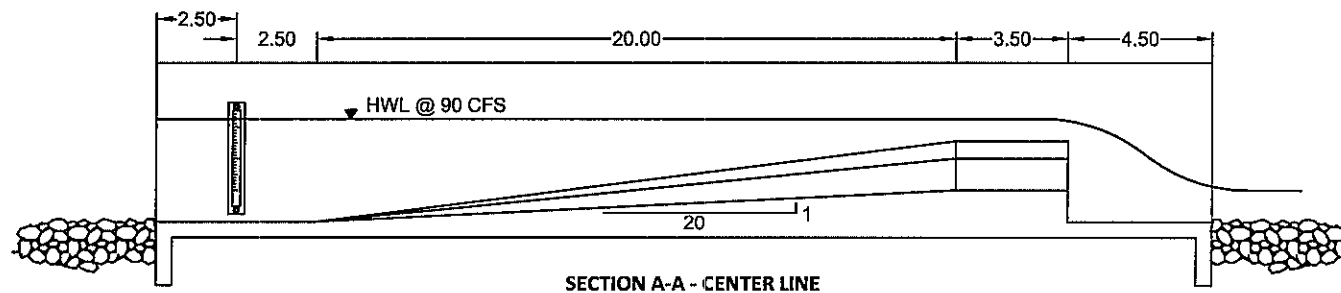
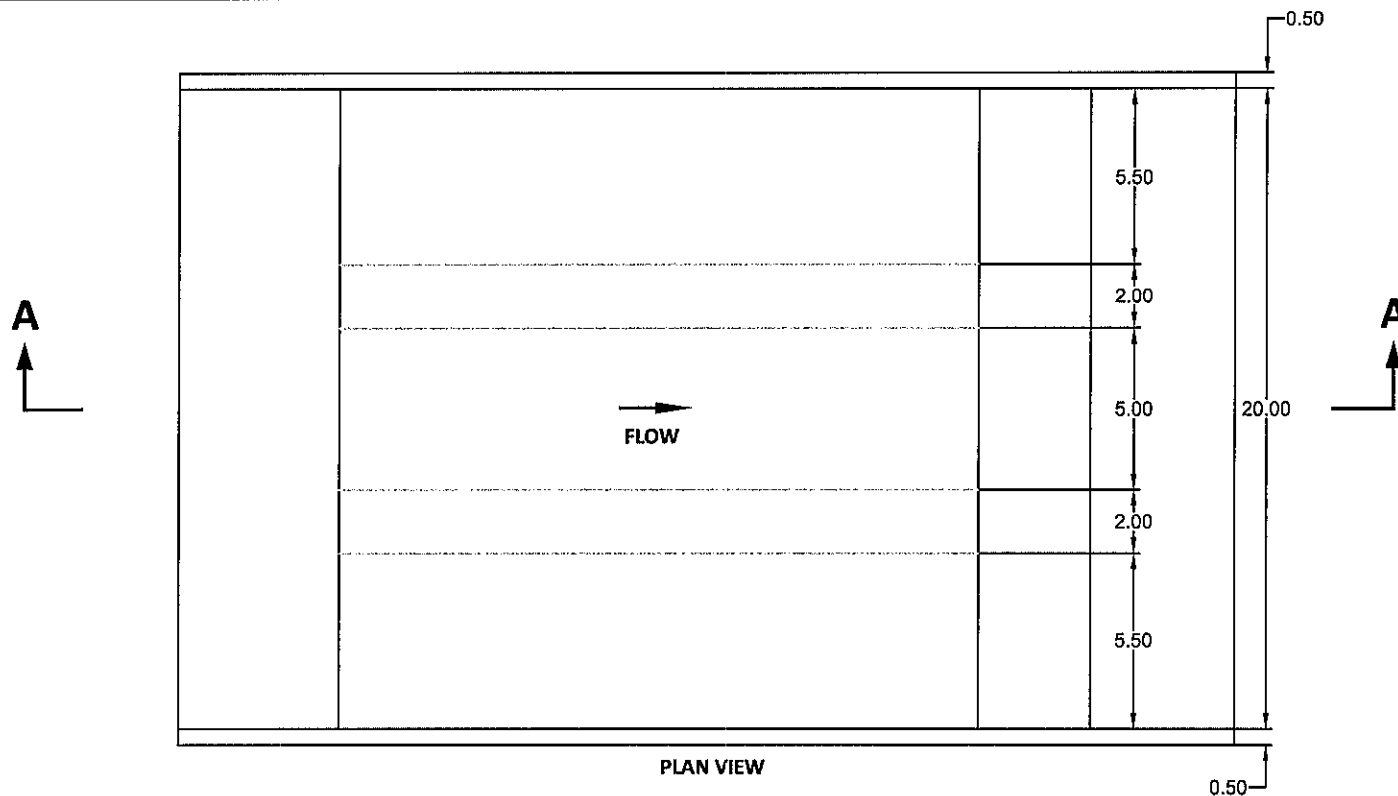
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WORM CREEK COMPOUND BROAD-CRESTED WEIR

SCALE: N.T.S.



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DATE: 9/10/10

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MDW

**WORM CREEK COMPOUND
BROAD-CRESTED WEIR**

SCALE: N.T.S.

User: Mathew Weaver WinFlume32 - Version 1.05.0031
D:...\Cub R - Worm Cr Connection\Worm Cr Injection.Flm - Revision 4
Worm Creek Injection
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SUMMARY EVALUATION OF FLUME DESIGN

Design is NOT acceptable, but may be improved.

EVALUATION OF FLUME DESIGN FOR EACH DESIGN REQUIREMENT

Ok. Froude number at Qmax = 0.136 Maximum allowed = 0.500
Ok. Freeboard at Qmax = 1.762 ft Minimum allowed = 1.000 ft
Ok. Tailwater at Qmax = 0.638 ft Maximum allowed = 2.897 ft
Submergence Protection at Qmax = 2.258 ft
Ok. Tailwater at Qmin = 0.110 ft Maximum allowed = 1.300 ft
Submergence Protection at Qmin = 1.189 ft
Ok. Head at Qmax = 2.238 ft Minimum for accuracy = 0.640 ft
Expected discharge measurement uncertainty at Qmax = $\pm 2.31\%$
Not Ok. Head at Qmin = 0.454 ft Minimum for accuracy = 0.456 ft
Expected discharge measurement uncertainty at Qmin = $\pm 5.02\%$

Improve by: Increase contraction at Qmin (reduce base-width of control section)
Alternately: Increase allowable uncertainty at Qmin

CONTROL SECTION DATA

Section shape = COMPLEX TRAPEZOID
External trapezoid bottom width = 20.000 ft
Internal bottom width = 5.000 ft
Internal sill height, D1 = 0.000 ft Internal trapezoid depth, D2 = 1.000 ft
Side slopes: Lower = 2.00:1 Middle = 10.00:1 Upper = 0.00:1
Sill Height, p1 = 1.000 ft

DESIGN CRITERIA

Structure Type: Stationary Crest
Freeboard design criterion: Freeboard ≥ 1.000 ft
Allowable discharge measurement errors for a single measurement:
At minimum discharge: $\pm 5\%$
At maximum discharge: $\pm 5\%$
Head detection method: Staff gage, Fr < 0.1
Expected measurement uncertainty = ± 0.013123 ft
Design discharges and associated tailwater levels:
Minimum discharge = 5.000 cu. ft/s Minimum tailwater depth = 0.110 ft
Maximum discharge = 90.000 cu. ft/s Maximum tailwater depth = 0.638 ft
Tailwater calculation method: Manning's equation using n and S
Manning's n = 0.0150

ESTIMATED UNCERTAINTY OF TOTALIZED OR AVERAGED FLOW

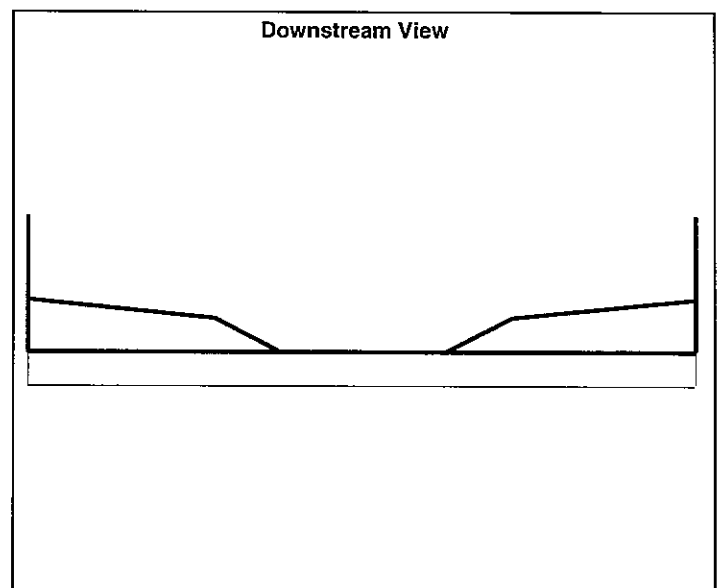
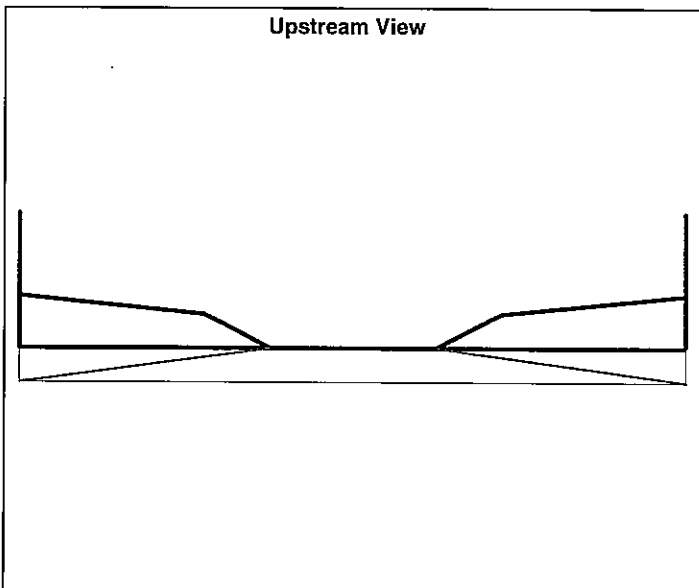
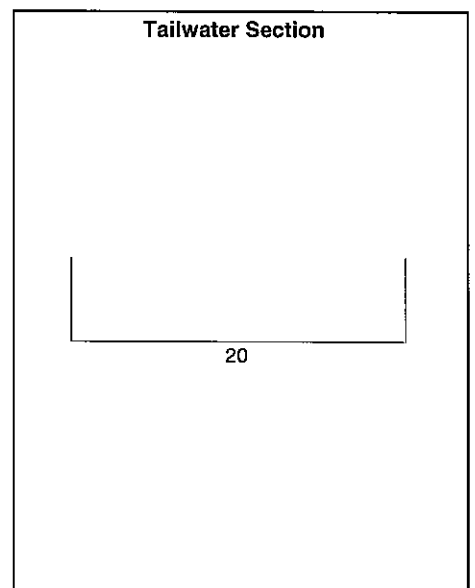
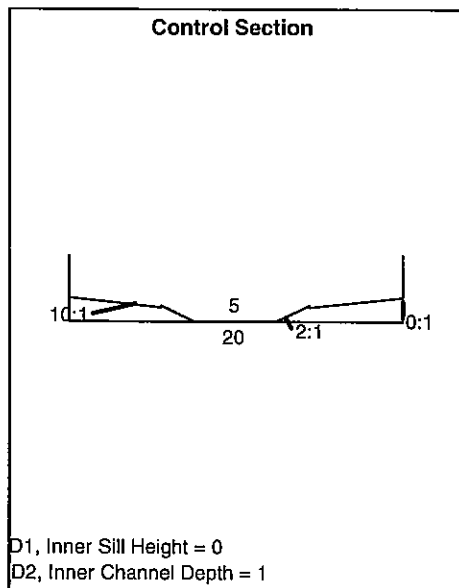
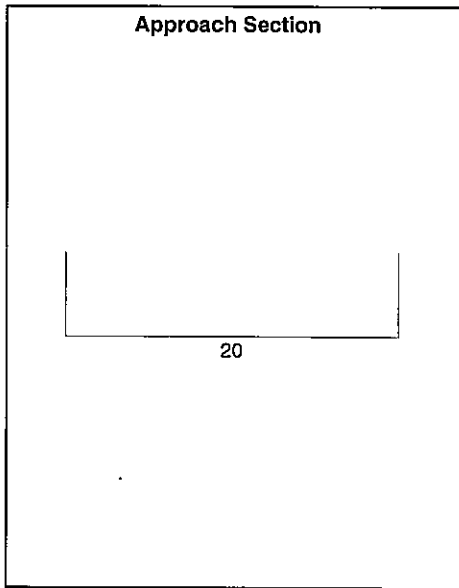
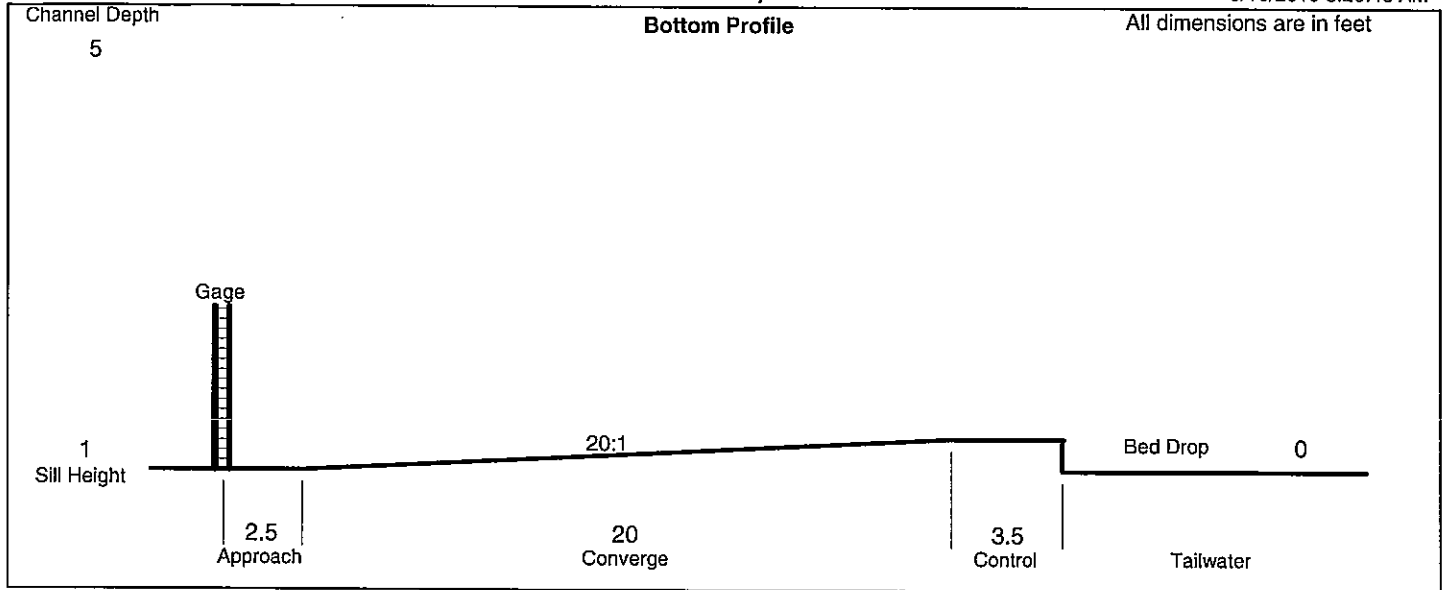
With measurements made every 1 second, for a duration of 1 second,
the estimated uncertainty of totalized or averaged flow is $\pm 2.5\%$

NOTE: The uncertainty given above is ONLY an estimate. It is most useful for making a comparative evaluation of competing design alternatives. The estimate assumes that there is a relatively uniform distribution of flows between Q_{min} and Q_{max} during the averaging period. If the distribution of flows is not relatively uniform, the uncertainty associated with one or a few large flows will dominate, negating most of the uncertainty improvement normally obtained through averaging and totalizing.

Worm Creek Injection - Revision 4

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Worm Creek Measurement Device Materials Cost Estimate Summary

Description	Total Units		Unit Cost		Total Cost
3,500 PSI Concrete*	31	CY	\$ 87.00	/CY	\$ 2,697.00
Fiber Mesh Concrete Ad-Mixture	31		\$ 7.00	Each	\$ 217.00
Cement Delivery Fuel Surcharge	4		\$ 8.00	\Delivery	\$ 32.00
#4 Rebar**	1220	LF	\$ 0.36	\LF	\$ 439.20
Rebar Delivery Charge	1		\$ 25.00	\Delivery	\$ 25.00
Sub Total:					\$ 3,410.20
Tax (6%):					\$ 204.61
10% Contingency:					\$ 361.48
Total:					\$ 3,976.29

*Concrete and concrete ad-mixtures were quoted by Staker & Parson Co. based in Logan, UT as of 9/10/10. Contact Ed Hernandez at (435) 230-0293. Concrete is delivered to the site in cement mix trucks with a delivery volume capacity of 9 CY.

**Concrete reinforcement material was quoted by Intermountain Concrete Specialties based in Logan, UT as of 9/10/10. Contact Travis (435) 787-8755. #4 bar is sold in 20-foot sticks, price does not include cutting and/or forming.