State of Idaho
DEPARTMENT OF WATER RESOURCES
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December 2, 2011

C. L. "BUTCH" OTTER
Governor

GARY SPACKMAN
Interim Director

Big Bend Trout
Attn: Leo Ray
PO Box 479
Hagerman, ID 83332

RE: Big Bend Ditch Broad Crested Weir Measurement Device

Mr. Ray,

On November 15, 2011 Idaho Department of Water Resource (Department) staff visited the site of the Big Bend Ditch broad crested weir (BCW) and identified potential design and installation issues with the measuring device. The attached memorandum dated November 18, 2011 provides a detailed summary of their findings and recommendations. This letter is written to notify you that the device was found to be non-standard and potentially inadequate for measuring flow rates in the Big Bend ditch over the range of anticipated flows. Two options for ensuring the measurement is accurate are described below. Please contact us within 14 days of the data of this letter to discuss your plan to pursue one of the options below.

Option #1 – Replace the measuring device with an appropriately designed and correctly installed standard measuring device.

If you choose to replace the current device with a standard measuring device, the Department can assist you in reviewing the design and installation to ensure the device will perform adequately.

Option #2 – Retain the existing device and attempt to develop a rating curve over the range of flow.

The Department recognizes that some expense has already been incurred in the design, construction and installation of the existing device and that the possibility exists that the existing measurement device can be used to provide reliable measured flows if a relationship can be developed between stage and flowrate. Under this option, you would agree to let the Department take a series of current meter measurements at the existing device over the course of the next year and use those measurements to develop a rated section, if possible. Note that if the measurements indicate a poor relationship between flowrate and stage at the device, you will be required to replace the device with a standard measuring device as described in Option #1.

Additionally, if you decide to move forward with the attempt to develop a rated section at the current device, the Department requires the following:

- Provide design, or preferably as-built, plans of the existing measurement device.
- Provide a rating curve for the existing measurement device.
- Seal the interstitial space between the edge of the existing measurement device and the existing concrete channel walls, with consideration given to the possible future removal of the device.

- Ensure the device is level and plumb and that the staff gage zero mark is level with the sill.
- Provide wall anchors for the device in the event the Department determines the device is moving within the channel.
- Clear the existing channel of debris, sediment, and vegetative matter upstream of the device, at a minimum distance equal to several feet upstream of the staff gage.

The Department looks forward to your cooperation in this matter. If you have any questions or concerns please contact me by telephone at (208) 287-4956 or by email at nick.miller@idwr.idaho.gov.

Respectfully,

Nick Miller, PE
Water Distribution Section Manager

Encl.

Cc:
Big Bend Irrigation and Mining Co – PO Box 334, Hagerman, ID 83332
Frank Irwin, Watermaster WD36A – 711 East Ave N, Hagerman, ID 83332
Stuart Van Greuningen – IDWR, Boise

To: Stuart Van Greuningen

From: Mat Weaver, PE

Date: November 18, 2011

RE: Field evaluation of Big Bend Ditch Broad Crested Weir Measurement Device

Observed Field Conditions

On November 15, 2011 I visited the site of the Big Bend Ditch broad crested weir (BCW) in the company of Cindy Yenter, Stuart Van Greuningen, and Dan Nelson. While on site we measured the nominal dimensions of the measurement device, took photos of the measurement device, and conducted a current meter measurement of the flows in the Big Bend ditch just upstream of the BCW.

A FlowTracker current meter was used to measure a flow rate in the Big Bend ditch during the site visit of 39.8 cfs with an uncertainty of 2.2%. For a full summary of the measurement details refer to the attached Discharge Measurement Summary document (Page 1 of 4 only). Approximately 4 feet upstream of the device there is a staff gage mounted to the side of the concrete ditch wall to measure the depth of water over the sill of the BCW. During the site visit a staff gage reading of 1.20 +/- 0.02 feet was observed.

In addition, during the site visit we collected field measurements of the as-built conditions of the BCW, which included a width of 10.00 feet, a sill length of 3.00 feet, a sill height of 1.90 feet, and a ramp convergence length of 6.50 feet. Refer to the attached sketch of the BCW and the observed as-built dimensions. The width of the concrete channel upstream of the BCW was measured at 10.50 feet. The following observations were also made which likely affect the accuracy and operability of the device to an unspecified degree.

- Sediment and matted vegetative material with a depth of 3-4 inches observed at toe of weir.
- The high water line indicates high flow water in the channel overtops lateral structural supports.
- Observed gaps between the outside edges of the BCW and the channel walls of ~3-inches.

Evaluation of Existing BCW

Based upon the findings of the site visit I analyzed the adequacy of the device for measuring flows using WinFlume32.[1] My analysis indicates that as the BCW was built, there is a fatal flaw in the dimensions of the device that do not allow for the accurate measurement of water in the channel. This is due to the inability of the device to establish critical flow over the sill at flows in excess of 23.2 cfs. Refer to attached 'Summary of Evaluation of Flume Design' for complete analysis summary (2 pages).[2]

Assuming a width of 10.00 feet, a ramp convergence length of 7.25 feet, and a sill length of 3.00 feet, a sill height of 2.9 feet would be required to measure the flows observed during the site visit (39.8 cfs) with an accuracy of 10.0% or less. This would result in an upstream water surface elevation of approximately 4.1 feet, which provides a freeboard of approximately -0.1 feet over the existing top of channel wall. Refer to attached 'Summary of Evaluation of Flume Design' for complete analysis summary (2 pages).[3]

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[1] Analysis was conducted with WinfFlume32 v1.05.0031, a software package created by the Bureau of Reclamation for the design and calibration of long-throated flumes and broad crested weirs.

[2] Summary document with unique path reference: D:...\Basin 36\Big Bend Ditch\BigBendBCW_fail.flm – Revision 3.

[3] Summary document with unique path reference: D:...\Basin 36\Big Bend Ditch\BigBendBCW_pass.flm – Revision 3.

Recommendations

In my limited time evaluating the matter I was unable to come up with a BCW configuration that does not lead to the overtopping of the existing channel walls at the measured flow rate. However, other measurement devices are feasible for the channel as it is currently constructed. I have preliminarily identified three possible measurement options and I would recommend pursing one of the following courses of action in developing a means of accurately and reliably measuring flows in the ditch.

1. **Rated Section:** There is close agreement between the measured flow rate and the flow rate predicted by an extrapolation of the stage-discharge relationship developed by WinFlume32 for the range of flow rates that the existing device adequately measures (i.e. 10-23 cfs). This suggests that a rated section might be established at the location of the BCW measurement device that can accurately measure flows. A series of 6-8 staff gage readings and corresponding current meter measurements over the course of the next year, over the entire range of flows, would confirm the viability of developing a rated section to measure flows. Prior to an attempt to establish a rated section the measurement device should be sealed to the channel walls and the ramp of the BCW and the channel just upstream of the device should be cleaned of all debris. Refer to the attached figure titled 'Big Bend BCW As-Built Rating Curve' for graphical depiction of the rating curve and current meter measurement.
2. **Submerged Orifice:** A submerged orifice represents a second potentially viable measurement option that I have briefly explored. A submerged orifice with a 9 foot width, 1.5 foot height, and a suppressed bottom, can pass a flow rate of 40 cfs with a head loss of approximately 0.32 feet. These findings suggest that the submerged orifice could potentially measure flows up to 40 cfs without overtopping the channel walls. A more detailed exploration and design of this option is required to determine what the freeboard and channel flow conditions would be upstream and downstream of a submerged orifice.
3. **Doppler Flow Meter (DFM):** A DFM is yet another device that could be installed in the channel to measure flows. The Doppler flow meter has the advantage of requiring almost no head to measure flows; therefore, the installation of a DFM would not lead to the overtopping of the channel walls by ditch water. Further site investigation is required to determine the optimal location to deploy a DFM.

Discharge Measurement Summary

Date Generated: Wed Nov 16 2011

File Information	
File Name	BGBND1.WAD
Start Date and Time	2011/11/15 15:30:26

Site Details	
Site Name	
Operator(s)	MDW

System Information	
Sensor Type	FlowTracker
Serial #	P1765
CPU Firmware Version	3.2
Software Ver	2.11

Units	(English Units)
Distance	ft
Velocity	ft/s
Area	ft^2
Discharge	cfs

Discharge Uncertainty

Category	ISO	Stats
Accuracy	1.0%	1.0%
Depth	0.1%	0.2%
Velocity	0.9%	1.9%
Width	0.1%	0.1%
Method	1.7%	-
# Stations	2.3%	-
Overall	**3.2%**	**2.2%**

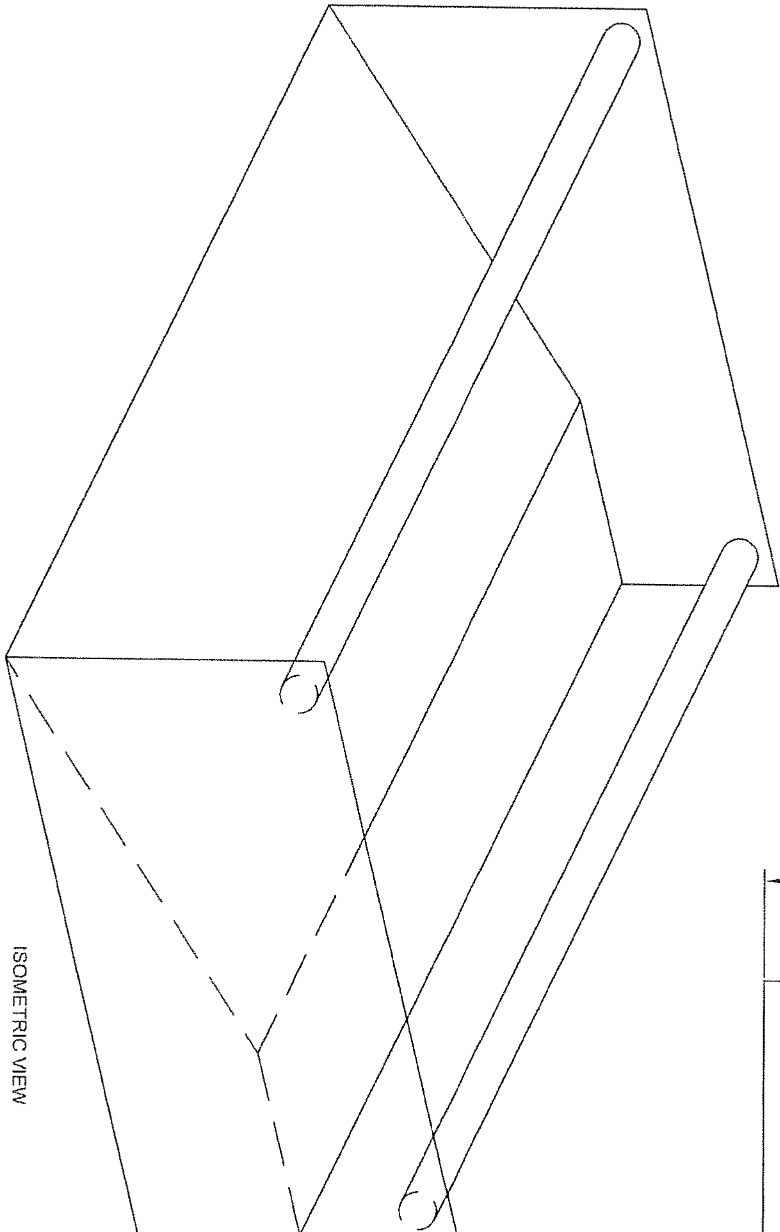
Summary

Averaging Int.	20	# Stations	22
Start Edge	LEW	Total Width	10.500
Mean SNR	8.1 dB	Total Area	29.300
Mean Temp	59.06 °F	Mean Depth	2.790
Disch. Equation	Mid-Section	Mean Velocity	1.3596
		Total Discharge	**39.8353**

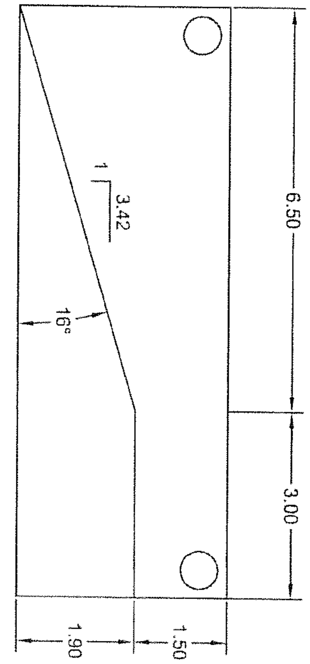
Measurement Results

St	Clock	Loc	Method	Depth	%Dep	MeasD	Vel	CorrFact	MeanV	Area	Flow	%Q
0	15:30	13.60	None	2.900	0.0	0.0	0.0000	1.00	0.9511	0.725	0.6895	1.7
1	*15:30*	*13.10*	*0.6*	*2.900*	*0.6*	*1.160*	*0.9511*	*1.00*	*0.9511*	*1.450*	*1.3791*	*3.5*
2	15:31	12.60	0.6	2.900	0.6	1.160	1.0213	1.00	1.0213	1.450	1.4809	3.7
3	15:32	12.10	0.6	2.800	0.6	1.120	0.9167	1.00	0.9167	1.400	1.2833	3.2
4	15:33	11.60	0.6	2.700	0.6	1.080	1.2077	1.00	1.2077	1.350	1.6304	4.1
5	*15:34*	*11.10*	*0.6*	*2.700*	*0.6*	*1.080*	*1.0663*	*1.00*	*1.0663*	*1.350*	*1.4395*	*3.6*
6	*15:34*	*10.60*	*0.6*	*2.700*	*0.6*	*1.080*	*1.3258*	*1.00*	*1.3258*	*1.350*	*1.7899*	*4.5*
7	*15:36*	*10.10*	*0.6*	*2.750*	*0.6*	*1.100*	*1.2969*	*1.00*	*1.2969*	*1.375*	*1.7833*	*4.5*
8	15:37	9.60	0.6	2.800	0.6	1.120	1.2490	1.00	1.2490	1.400	1.7485	4.4
9	*15:38*	*9.10*	*0.6*	*2.800*	*0.6*	*1.120*	*1.1230*	*1.00*	*1.1230*	*1.400*	*1.5722*	*3.9*
10	15:39	8.60	0.6	2.800	0.6	1.120	1.3041	1.00	1.3041	1.400	1.8257	4.6
11	15:40	8.10	0.6	2.900	0.6	1.160	1.6198	1.00	1.6198	1.450	2.3486	5.9
12	15:40	7.60	0.6	3.000	0.6	1.200	1.3268	1.00	1.3268	1.500	1.9902	5.0
13	15:41	7.10	0.6	3.000	0.6	1.200	1.5558	1.00	1.5558	1.500	2.3337	5.9
14	15:42	6.60	0.6	3.000	0.6	1.200	1.6257	1.00	1.6257	1.500	2.4385	6.1
15	15:42	6.10	0.6	3.000	0.6	1.200	1.4849	1.00	1.4849	1.500	2.2274	5.6
16	15:43	5.60	0.6	2.900	0.6	1.160	1.5207	1.00	1.5207	1.450	2.2049	5.5
17	15:43	5.10	0.6	2.900	0.6	1.160	1.7477	1.00	1.7477	1.450	2.5341	6.4
18	15:44	4.60	0.6	2.900	0.6	1.160	1.8028	1.00	1.8028	1.450	2.6140	6.6
19	15:44	4.10	0.6	2.900	0.6	1.160	1.6867	1.00	1.6867	1.450	2.4456	6.1
20	15:45	3.60	0.6	2.800	0.6	1.120	1.4829	1.00	1.4829	1.400	2.0760	5.2
21	15:45	3.10	None	0.000	0.0	0.0	0.0000	1.00	0.0000	0.000	0.0000	0.0

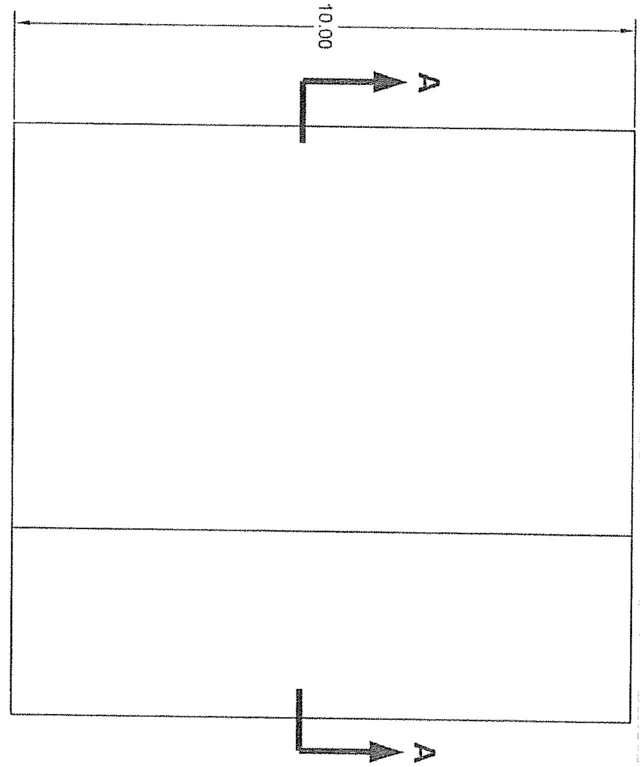
Rows in italics indicate a QC warning. See the Quality Control page of this report for more information.



ISOMETRIC VIEW



SECTION A-A VIEW



PLAN VIEW

BIG BEND IRR. DITCH BCW FIELD MEASUREMENTS

SCALE: NTS

DATE: 11/16/2011

DRAFTED BY: MDW

1

1

User: Mathew Weaver WinFlume32 - Version 1.05.0031
D:...\Basin 36\Big Bend Ditch\BigBendBCW_fail.Flm - Revision 3
Big Bend Ditch BCW
Printed: 11/16/2011 3:27:35 PM

SUMMARY EVALUATION OF FLUME DESIGN

Design is NOT acceptable, but may be improved.
One error or warning.

EVALUATION OF FLUME DESIGN FOR EACH DESIGN REQUIREMENT

Ok. Froude number at Qmax = 0.124 Maximum allowed = 0.500

Ok. Freeboard at Qmax = 0.923 ft Minimum allowed = 0.500 ft

Not Ok. Tailwater at Qmax = 3.788 ft Maximum allowed = 2.903 ft
Submergence Protection at Qmax = -0.885 ft
Improve by: Increase contraction at Qmax (raise crest and/or reduce width of cc
Alternately: Add downstream ramp, if applicable

Ok. Tailwater at Qmin = 1.464 ft Maximum allowed = 2.329 ft
Submergence Protection at Qmin = 0.865 ft

Ok. Head at Qmax = 1.177 ft Minimum for accuracy = 0.351 ft
Expected discharge measurement uncertainty at Qmax = ±3.49 %

Ok. Head at Qmin = 0.480 ft Minimum for accuracy = 0.351 ft
Expected discharge measurement uncertainty at Qmin = ±7.43 %

WARNING MESSAGES AND DESIGN SUGGESTIONS

WARNING MESSAGES AT MAXIMUM DISCHARGE:
- FATAL: Submergence exceeds modular limit. Critical flow will not occur.

CONTROL SECTION DATA

Section shape = RECTANGULAR
Bottom width = 10.000 ft
Sill Height, p1 = 1.900 ft

DESIGN CRITERIA

Structure Type: Stationary Crest
Freeboard design criterion: Freeboard >= 0.500 ft
Allowable discharge measurement errors for a single measurement:
At minimum discharge: ±10%
At maximum discharge: ±10%
Head detection method: Staff gage in stilling well, Fr=0.5
Expected measurement uncertainty = ±0.022966 ft
Design discharges and associated tailwater levels:
Minimum discharge = 10.000 cu. ft/s Minimum tailwater depth = 1.464 ft

Maximum discharge = 40.000 cu. ft/s   Maximum tailwater depth = 3.788 ft
Bed drop at structure site = 0.100 ft
Tailwater calculation method: Manning's equation using n and S
Manning's n = 0.0250
Hydraulic gradient = 0.000100 ft/ft

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 ±4.3%

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 Qmin and Qmax 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.

User: Mathew Weaver WinFlume32 - Version 1.05.0031
D:...\Basin 36\Big Bend Ditch\BigBendBCW_pass.Flm - Revision 4
Big Bend Ditch BCW
Printed: 11/16/2011 4:00:13 PM

SUMMARY EVALUATION OF FLUME DESIGN

Design is acceptable.

EVALUATION OF FLUME DESIGN FOR EACH DESIGN REQUIREMENT

Ok. Froude number at Qmax = 0.081 Maximum allowed = 0.500

Ok. Freeboard at Qmax = 0.913 ft Minimum allowed = 0.500 ft

Ok. Tailwater at Qmax = 3.788 ft Maximum allowed = 3.868 ft
Submergence Protection at Qmax = 0.079 ft

Ok. Tailwater at Qmin = 1.464 ft Maximum allowed = 3.318 ft
Submergence Protection at Qmin = 1.854 ft

Ok. Head at Qmax = 1.187 ft Minimum for accuracy = 0.351 ft
Expected discharge measurement uncertainty at Qmax = ±3.47 %

Ok. Head at Qmin = 0.481 ft Minimum for accuracy = 0.351 ft
Expected discharge measurement uncertainty at Qmin = ±7.41 %

CONTROL SECTION DATA

Section shape = RECTANGULAR
Bottom width = 10.000 ft
Sill Height, p1 = 2.900 ft

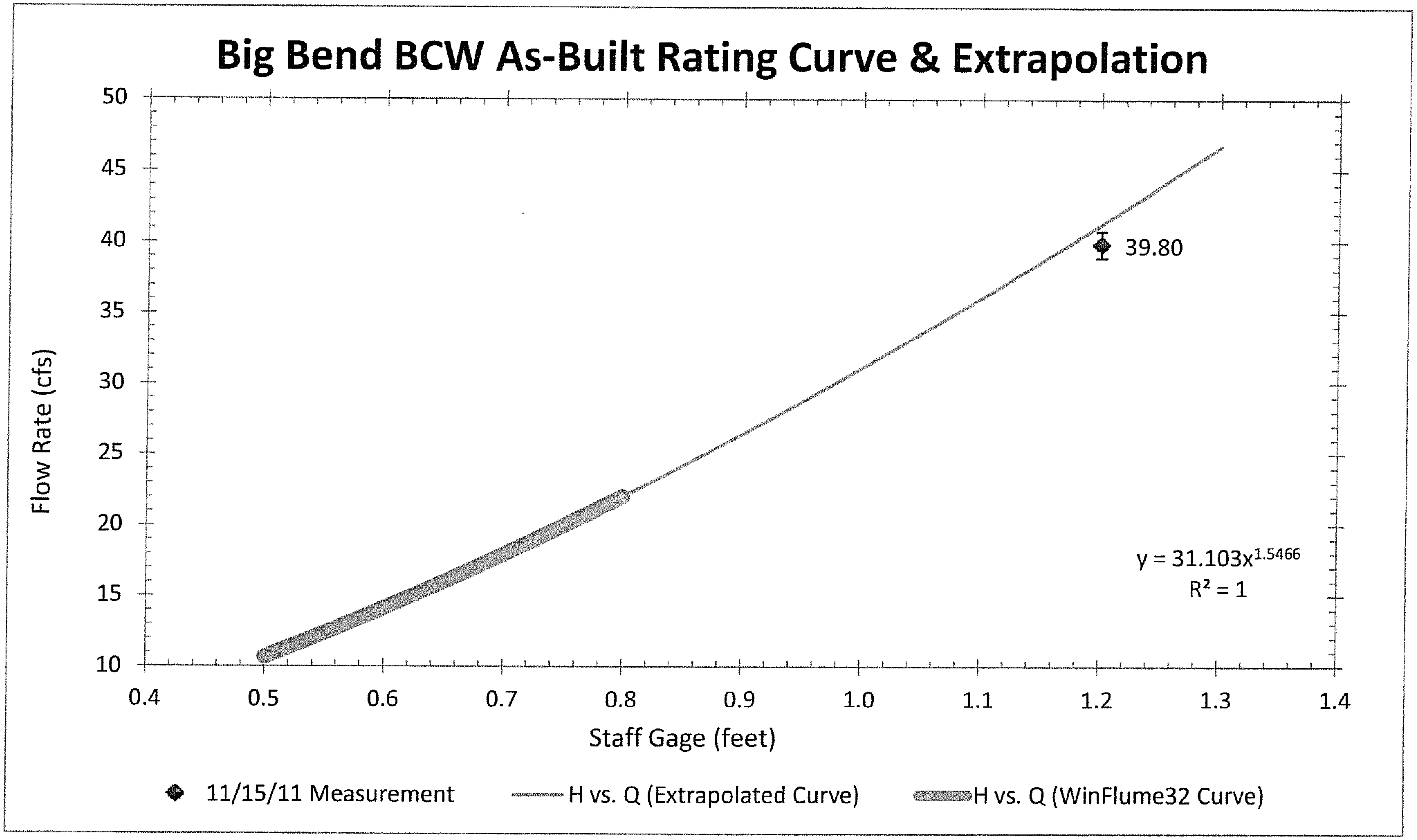
DESIGN CRITERIA

Structure Type: Stationary Crest
Freeboard design criterion: Freeboard >= 0.500 ft
Allowable discharge measurement errors for a single measurement:
At minimum discharge: ±10%
At maximum discharge: ±10%
Head detection method: Staff gage in stilling well, Fr=0.5
Expected measurement uncertainty = ±0.022966 ft
Design discharges and associated tailwater levels:
Minimum discharge = 10.000 cu. ft/s Minimum tailwater depth = 1.464 ft
Maximum discharge = 40.000 cu. ft/s Maximum tailwater depth = 3.788 ft
Bed drop at structure site = 0.100 ft
Tailwater calculation method: Manning's equation using n and S
Manning's n = 0.0250
Hydraulic gradient = 0.000100 ft/ft

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 ±4.3%

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 Qmin and Qmax 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.


Big Bend BCW As-Built Rating Curve & Extrapolation
Flow Rate (cfs)
50
45
40
35
30
25
20
15
10
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
Staff Gage (feet)
39.80
y = 31.103x^1.5466
R² = 1
11/15/11 Measurement
H vs. Q (Extrapolated Curve)
H vs. Q (WinFlume32 Curve)