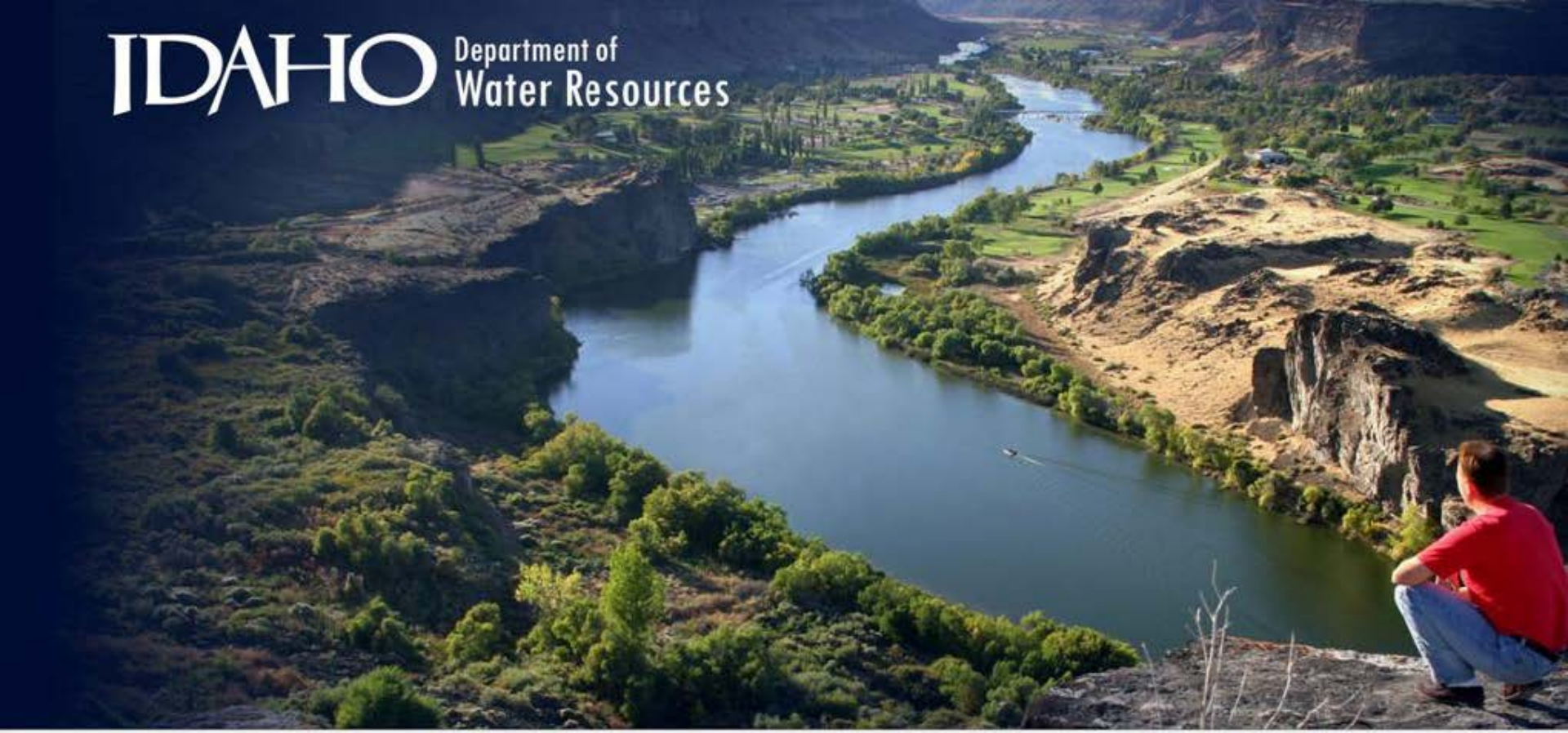


AADF Measuring and Monitoring Plan Review

Presented to Swan Falls Technical Working Group

Presented by: David Hoekema

Date: 09/15/2015

Technical Working Group Recommendations

The Swan Falls Agreement monitoring requirement:

"…entitle the Company to an unsubordinated right of 3900 cfs average daily flow from April 1 to October 31, and 5600 cfs average daily flow from November 1 to March 31 at the Murphy USGS gauging station immediately below Swan Falls."

"Average daily flow, as used herein, shall be based upon actual flow conditions; thus, any fluctuations resulting from the operation of Company facilities shall not be considered in the calculation of the minimum daily stream flows set forth herein."

Technical Working Group Recommendations:

1. **Two approaches** were identified for determining adjusted average daily flow in the Snake River at the Murphy Gaging Station as provided in the partial decrees for the hydropower water rights listed in Section 1.1: the Reservoir-Stage Method and the Flow Method.

Two Methods to Calculate AADF

1) Reservoir Fluctuations:

   Flow Method = Reservoir Stage Method

   $\sum Inflow - \sum Outflow = \Delta S$

2) Lag fluctuations to Murphy Gage

3) Add fluctuations to the Average Daily Flow at the Murphy Gage

Technical Working Group Recommendations:

2. The **Reservoir-Stage Method** was implemented for water years 2011-2013, and **is recommended** for use in 2014 on a trial basis as the primary approach for determining for the adjusted average daily flow at the Murphy Gaging Station. This method requires only reservoir-stage measurements to quantify changes in reservoir storage. By comparison, the Flow Method requires multiple streamflow measurements above and below each reservoir and measurements of other inflows and outflows…. Instrumentation for these measurements are not yet fully installed.

Technical Working Group Recommendations:

3. Reservoir-Stage Method accuracy may be reduced during times of substantial wind-loading. Although the region experiences generally mild wind conditions during low-flow periods in July, intense and shifting winds **may temporarily limit the use of this method**. The Reservoir-Stage Method may also be impacted by wave action and error associated with quantification of reservoir bathymetry. **Additional work is needed to quantify error associated with substantial wind loading.**

Technical Working Group Recommendations:

4. **A spreadsheet tool** was created for calculating the effects of Idaho Power operations on adjusted average daily flows at the Murphy Gaging Station. The spreadsheet tool was used to calculate the adjusted average daily flows at the Murphy Gaging Station for the years 2011, 2012 and, 2013.

Technical Working Group Recommendations:

5. The TWG recommends use of this spreadsheet model for calculating the adjusted average daily flow at the Murphy Gaging Station during the 2014 water year. The TWG also recommends that the implementation of this method be reviewed at the end of 2014, with **possible changes and improvements to be implemented for 2015 and beyond.**

Technical Working Group Recommendations:

6. The TWG recommends that any possible failure to satisfy the minimum-flow water rights held by the IWRB and the hydropower water rights held by Idaho Power as indicated by the adjusted average daily flow calculations using this spreadsheet model **trigger a careful review of measurements, calculations, and potential sources of error and uncertainty during the time that the minimum-flow water rights and the hydropower water rights are not satisfied.**

Technical Working Group Recommendations:

7. The TWG recommends use of a multi-day rolling average (minimum 3-day rolling average) of the adjusted average daily flow to reduce the effects of natural flow variability, measurement error, and method (e.g., routing and attenuation) uncertainty. The multi-day centered average provides a better average for a given day; the trailing multi-day average lags actual fluctuations but can be monitored on a real-time basis. Use of the multi-day rolling average should be used whether or not the minimum-flow water rights held by the IWRB and the hydropower water rights held by Idaho Power are not satisfied.

Technical Working Group Recommendations:

8. The **TWG also recommends frequent manual flow measurements** at the Murphy Gaging Station if Snake River flows approach established minimum flows provided in the partial decrees for the water rights listed in Section 1.1. The manual streamflow measurements will help reduce bias associated with the effects of aquatic growth or changes in channel morphology, thus reducing the level of uncertainty associated with use of the stage-discharge relationship during low flows.

Technical Working Group Recommendations:

9. ….**Travel times and attenuation rates** have not been fully quantified at various flow rates. The TWG recommends that current travel time assumptions be tested and better quantified through analysis of historical data, modeling, and/or tracer studies.
10. TWG recommends analyses of historical flow data and channel hydraulics to quantify how changes in flow caused by Idaho Power operations are **attenuated** as they move downstream.
11. The TWG recommends **quantification of the effects of wind-loading** in Idaho Power reservoirs under different wind conditions.

Technical Working Group Recommendations:

12. **The Flow Method cannot be recommended at the current time** because instrumentation for this method is not yet fully established. Some of the required streamflow measurement stations have not yet been installed and Water District 02 requirements to fully measure and report irrigation diversions will not be fully implemented **until 2016**.

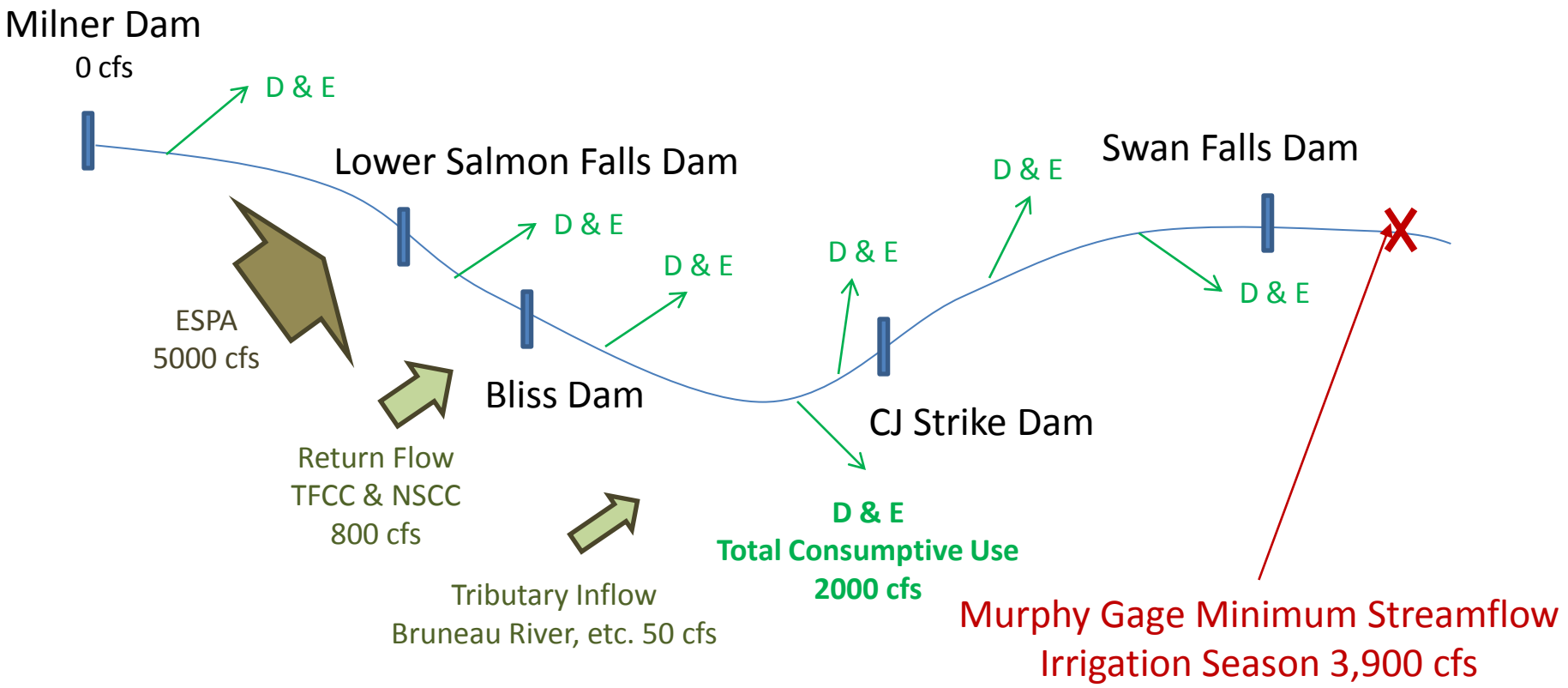
Adjusted Average Daily Flow Review

The Swan Falls Agreement monitoring requirement:

"…entitle the Company to an unsubordinated right of 3900 cfs average daily flow from April 1 to October 31, and 5600 cfs average daily flow from November 1 to March 31 at the Murphy USGS gauging station immediately below Swan Falls."

"Average daily flow, as used herein, shall be based upon actual flow conditions; thus, any fluctuations resulting from the operation of Company facilities shall not be considered in the calculation of the minimum daily stream flows set forth herein."

Conceptual Model:
What constitutes actual flow conditions?



5000 cfs + 800 cfs + 50 cfs – 2000 cfs = 3,850 cfs = Actual Flow Condition

Shortfall = 100 ac-ft

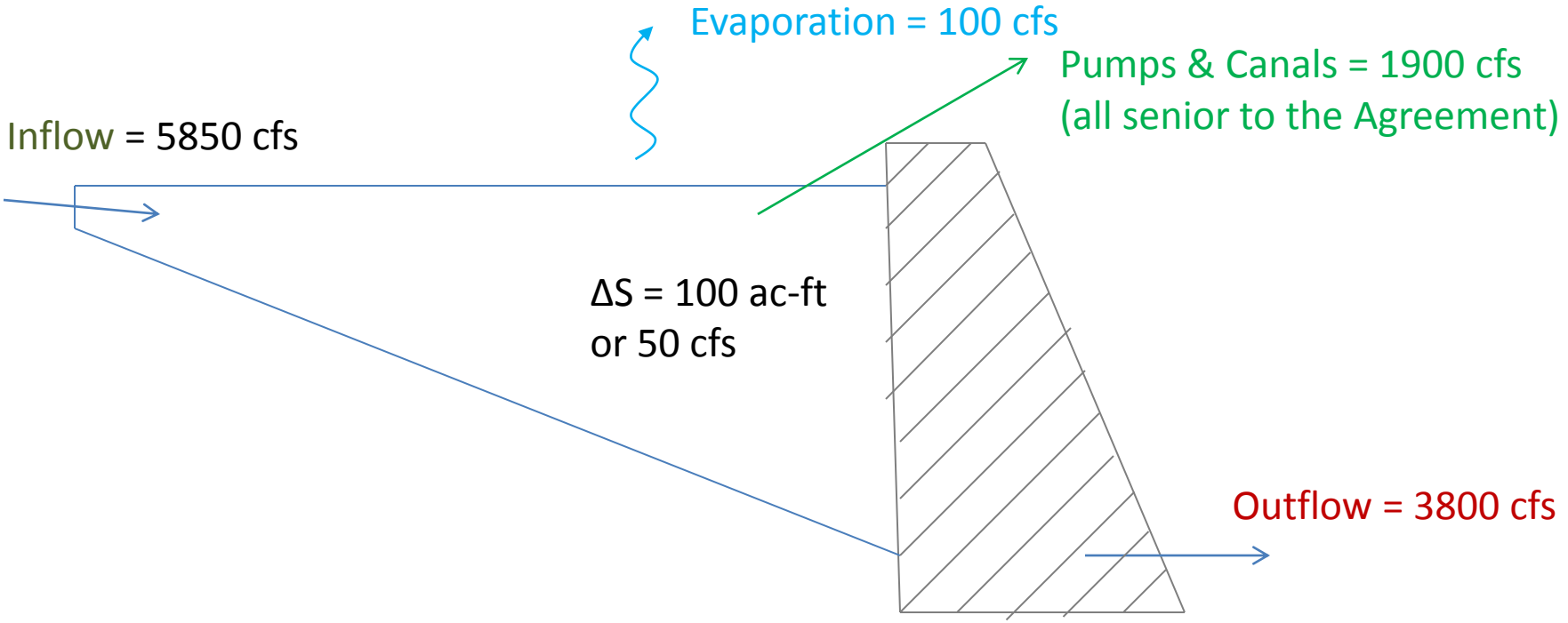
Conceptual Model: What Constitutes a Shortfall?

The only possible causes of a shortfall when flow is not passing Milner is?

- Reduced aquifer outflow (ESPA etc.)
- Reduced tributary inflow
- Reduced return flow (NSCC, TFCC, AFRD2, BWCC, etc.)
- Increased consumptive use within WD#2

- Reservoir operations cannot cause a shortfall

Conceptual Model: Has a shortfall occurred?



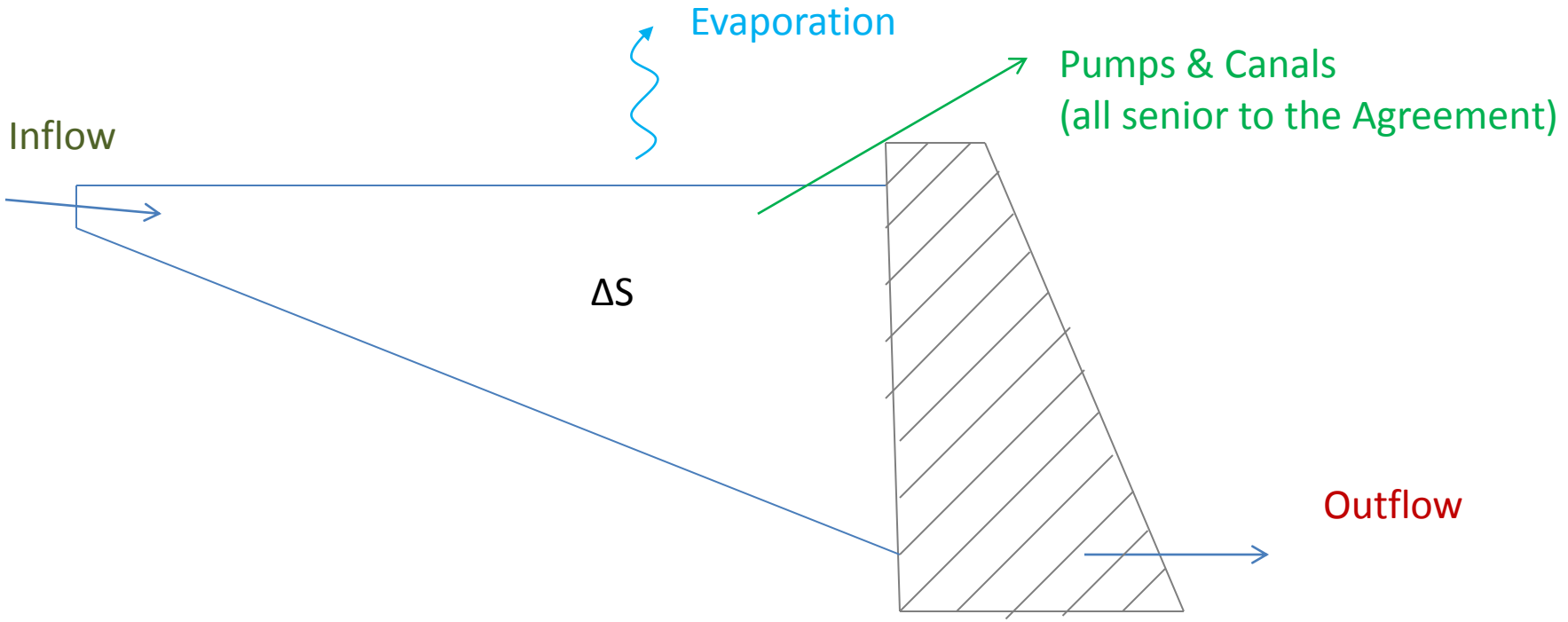
Inflow – Evaporation – Pumps & Canals = **Actual Flow Condition**

5850 cfs – 100 cfs – 1900 cfs = **3850 cfs** = **Actual Flow Condition**

ΔS + Outflow = 50 cfs + 3800 cfs = **3850 cfs** = **Actual Flow Condition**

Shortfall = 100 ac-ft

Conceptual Model



Inflow – Evaporation – Pumps & Canals = ΔS + Outflow = **Adjusted Flow**

Actual Flow Condition = Inflow – Outflow = ΔS + Murphy Gage = Adjusted Flow

Calculation Steps:

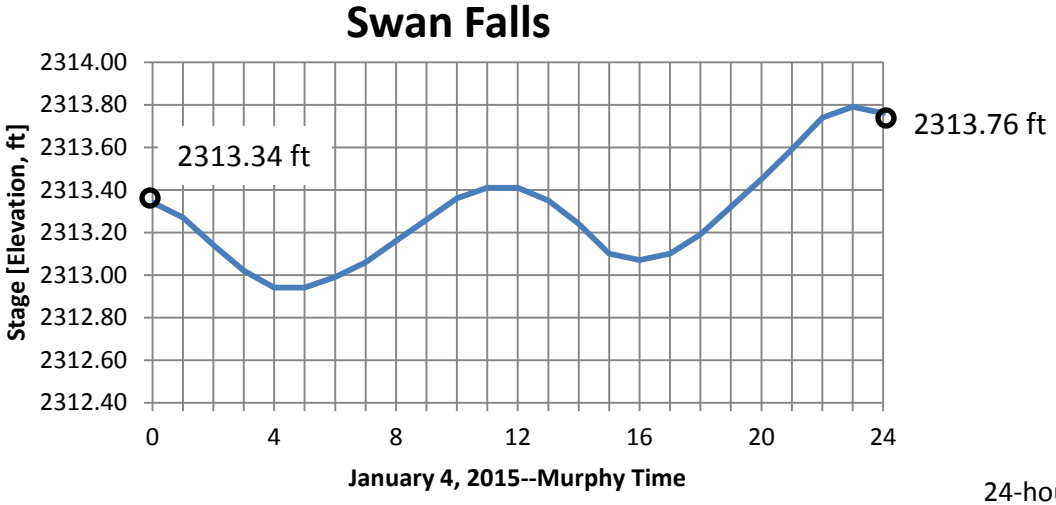
1. Extract hourly headwater data for LSF, Bliss, CJ Strike, and Swan Falls Dam
2. Lag hourly headwater data to Murphy time
3. Calculate the hourly ΔHead (ΔH)
4. Convert hourly ΔH to ΔStorage (ΔS) in cfs
5. Average the hourly, lagged ΔS for each reservoir (ΔS_{total}) over a 24-hour period—*Murphy Time*
6. Extract Daily Flow at Murphy
7. Add ΔS_{total} + Murphy = **Adjusted Flow**
8. *(Subtract IPCo released flow past Milner with appropriate lag)*

Step Five (How does it work?)

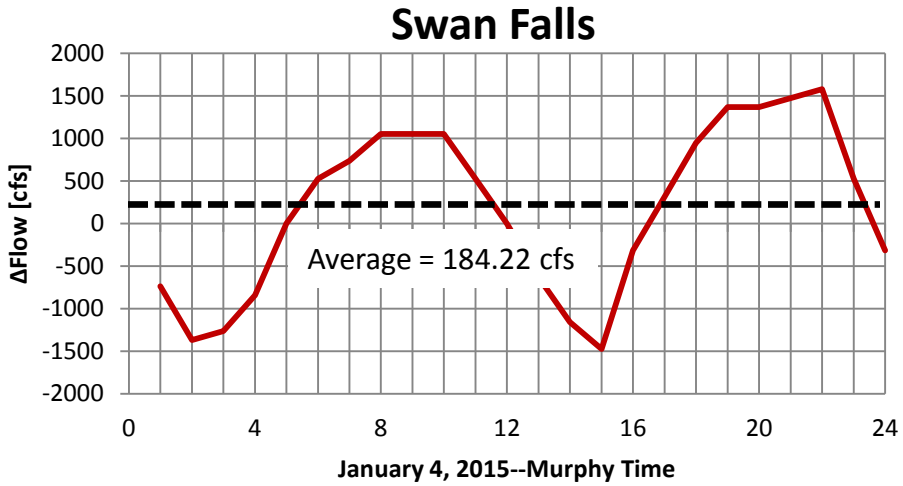
		Headwater					Change in Stage				Change in Flow [cfs]				24-hr Change in Flow				
		Swan Falls	CJ Strike	Bliss	LSF	Hours					870	7500	255	748					
1/4/2015 0:00	0	2313.34	2454.85	2653.89	2797.77	0													
1/4/2015 1:00	1	2313.27	2454.89	2653.88	2797.77	1.00	-0.07	0.04	-0.01	0.00	-736.89	3630.00	-30.85	0.00					
1/4/2015 2:00	2	2313.14	2454.91	2653.88	2797.77	2.00	-0.13	0.02	0.00	0.00	-1368.51	1815.00	0.00	0.00					
1/4/2015 3:00	3	2313.02	2454.93	2653.87	2797.77	3.00	-0.12	0.02	-0.01	0.00	-1263.24	1815.00	-30.86	0.00					
1/4/2015 4:00	4	2312.94	2454.93	2653.86	2797.78	4.00	-0.08	0.00	-0.01	0.01	-842.16	0.00	-30.85	117.66					
1/4/2015 5:00	5	2312.94	2454.93	2653.85	2797.78	5.00	0.00	0.00	-0.01	-0.01	0.00	0.00	-30.86	-45.25					
1/4/2015 6:00	6	2312.99	2454.92	2653.84	2797.79	6.00	0.05	-0.01	-0.01	0.01	526.35	-907.50	-30.85	108.61					
1/4/2015 7:00	7	2313.06	2454.91	2653.83	2797.82	7.00	0.07	-0.01	-0.01	0.03	736.89	-907.50	-30.86	235.32					
1/4/2015 8:00	8	2313.16	2454.90	2653.86	2797.80	8.00	0.10	-0.01	0.03	-0.02	1052.70	-907.50	92.57	-153.86					
1/4/2015 9:00	9	2313.26	2454.89	2653.88	2797.79	9.00	0.10	-0.01	0.02	-0.01	1052.70	-907.50	61.71	-99.56					
1/4/2015 10:00	10	2313.36	2454.88	2653.87	2797.78	10.00	0.10	-0.01	-0.01	-0.01	1052.70	-907.50	-30.86	-99.56					
1/4/2015 11:00	11	2313.41	2454.86	2653.86	2797.77	11.00	0.05	-0.02	-0.01	-0.01	526.35	-1815.00	-30.85	-90.51					
1/4/2015 12:00	12	2313.41	2454.85	2653.87	2797.76	12.00	0.00	-0.01	0.01	-0.01	0.00	-907.50	30.85	-72.41					
1/4/2015 13:00	13	2313.35	2454.89	2653.87	2797.77	13.00	-0.06	0.04	0.00	0.01	-631.62	3630.00	0.00	90.51					
1/4/2015 14:00	14	2313.24	2454.90	2653.86	2797.80	14.00	-0.11	0.01	-0.01	0.03	-1157.97	907.50	-30.85	271.52					
1/4/2015 15:00	15	2313.10	2454.92	2653.83	2797.80	15.00	-0.14	0.02	-0.03	0.00	-1473.78	1815.00	-92.57	27.15					
1/4/2015 16:00	16	2313.07	2454.94	2653.85	2797.81	16.00	-0.03	0.02	0.02	0.01	-315.81	1815.00	61.71	81.46					
1/4/2015 17:00	17	2313.10	2454.91	2653.87	2797.81	17.00	0.03	-0.03	0.02	0.00	315.81	-2722.50	61.71	0.00					
1/4/2015 18:00	18	2313.19	2454.90	2653.85	2797.81	18.00	0.09	-0.01	-0.02	0.00	947.43	-907.50	-61.71	18.10					
1/4/2015 19:00	19	2313.32	2454.89	2653.83	2797.83	19.00	0.13	-0.01	-0.02	0.01	1368.51	-907.50	-61.71	126.71					
1/4/2015 20:00	20	2313.45	2454.87	2653.84	2797.84	20.00	0.13	-0.02	0.01	0.01	1368.51	-1815.00	30.86	117.66					
1/4/2015 21:00	21	2313.59	2454.86	2653.86	2797.81	21.00	0.14	-0.01	0.02	-0.03	1473.78	-907.50	61.71	-262.47					
1/4/2015 22:00	22	2313.74	2454.85	2653.88	2797.80	22.00	0.15	-0.01	0.02	-0.01	1579.05	-907.50	61.71	-72.41					
1/4/2015 23:00	23	2313.79	2454.84	2653.88	2797.78	23.00	0.05	-0.01	0.00	-0.02	526.35	-907.50	0.00	-190.07					ΔStotal
1/5/2015 0:00	24	2313.76	2454.82	2653.88	2797.77	24.00	-0.03	-0.02	0.00	-0.01	-315.81	-1815.00	0.00	-108.61	**184.22**	**-113.44**	**-1.29**	**0.00**	**69.50**
		184.22	**-113.44**	**-1.29**	**0.00**														**69.50**

Step Five (How does it work?)

ΔS = (2313.76 ft - 2313.34 ft) * 870 acres / 1.9835 ac-ft/cfs = 184.22 cfs



24-hour Average(ΔF) = 184.22 cfs



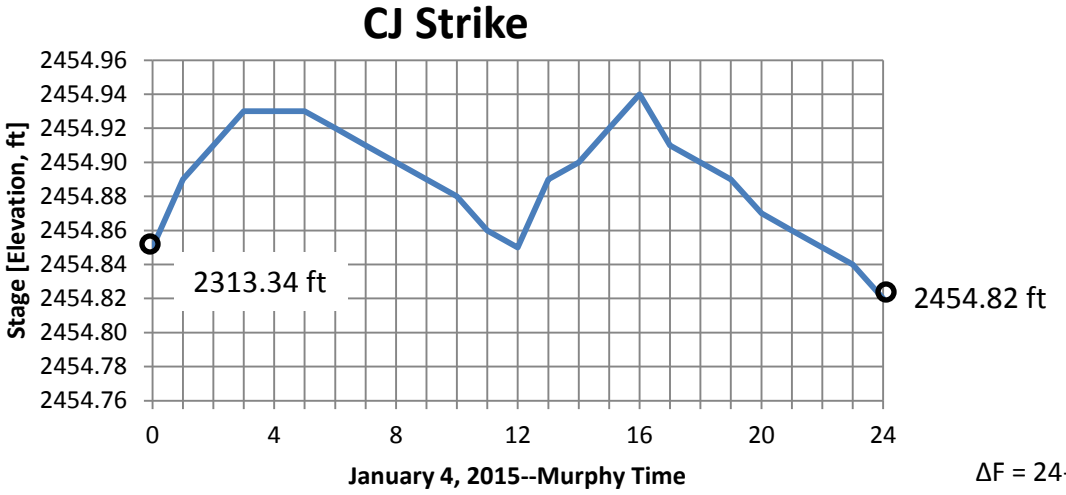
Key Points:

1. Reservoir stage method requires six measurements
    - Murphy Average Daily Flow
    - Swan Falls Stage
    - CJ Strike Stage
    - Bliss Stage
    - Lower Salmon Falls Stage
    - Daily Milner Flow
2. Appropriate Lag to Murphy Time needs further analysis
3. Accuracy of mid-night to mid-night stage measurments in Murphy Time are critical.

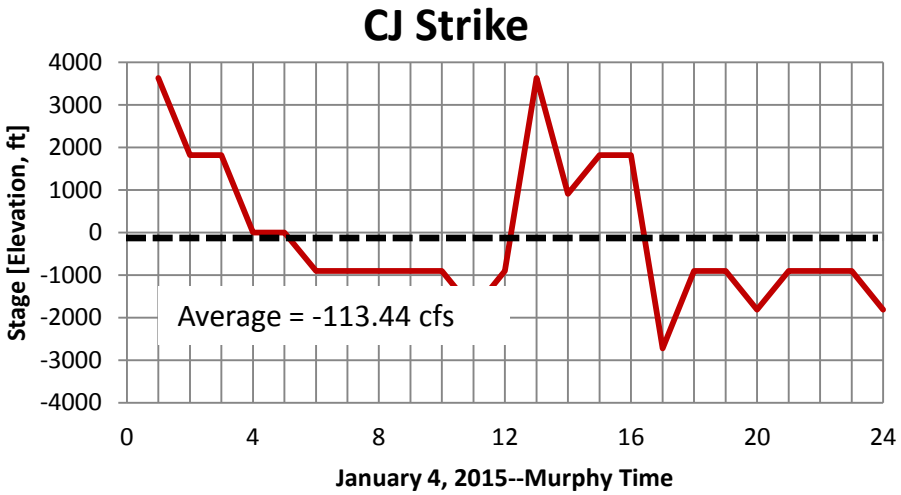
QUESTIONS ?

Step Five (How does it work?)

ΔS = (2454.82 ft - 2454.85 ft) * 7,500 acres / 1.9835 ac-ft/cfs = -113.44 cfs

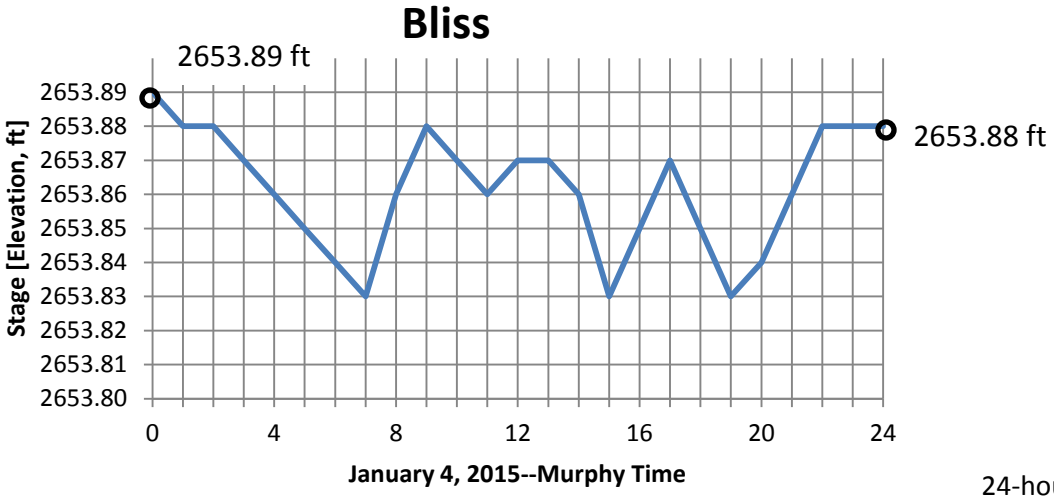


ΔF = 24-hour average(ΔF) = -113.44 cfs

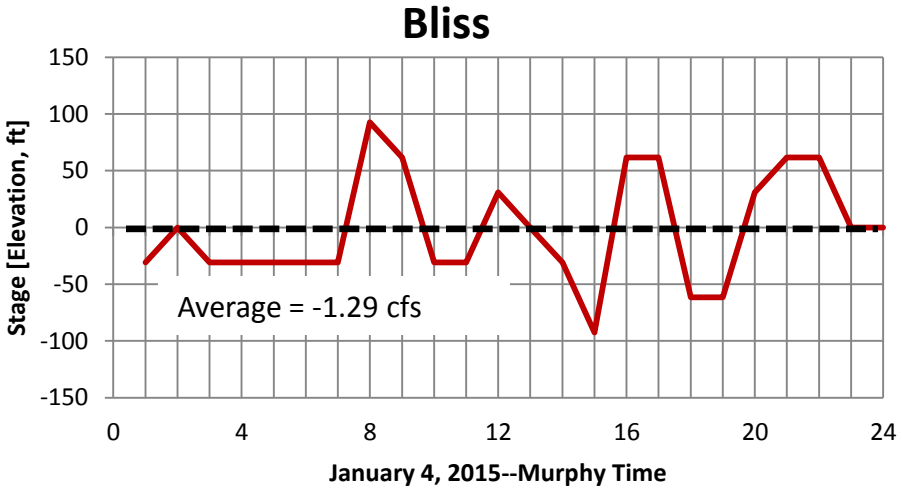


Step Five (How does it work?)

ΔS = (2653.89 ft - 2653.88 ft) * 255 acres / 1.9835 ac-ft/cfs = -1.29 cfs

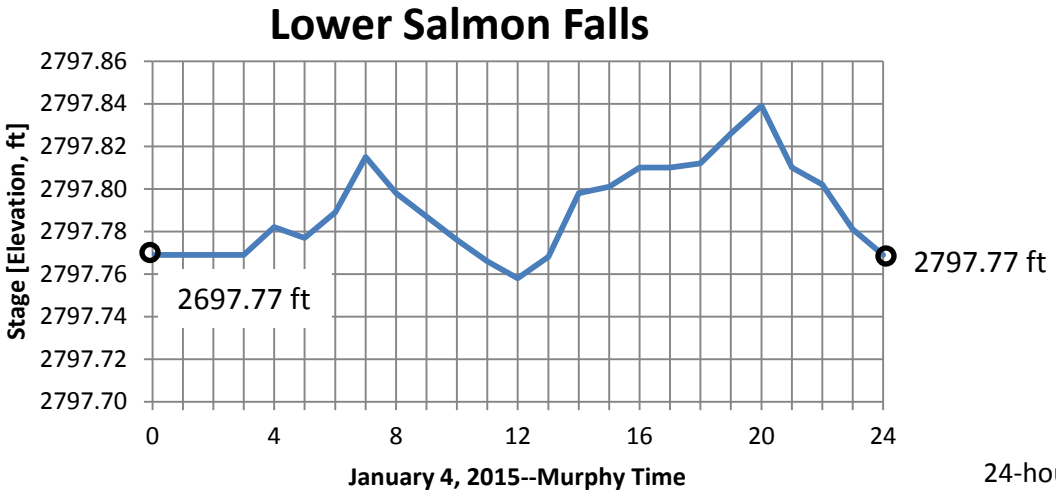


24-hour average(ΔF) = -1.29 cfs

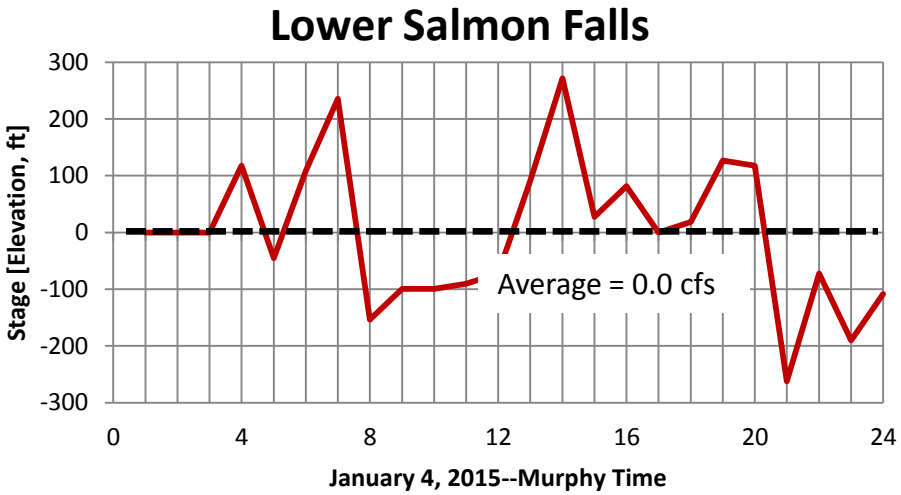


Step Five (How does it work?)

ΔS = (2797.77 ft - 2797.77 ft) * 870 acres / 1.9835 ac-ft/cfs = 0.0 cfs



24-hour average(ΔF) = 0.0 cfs



Proposed Process During Wind Events/gage errors

1) IDWR notifies IPCo a wind even has occurred
2) Both staffs independently correct for wind—timeframe one week
3) Review data together and/or with TWG to determine the shortfall two weeks after event.

IDWR Recommended Actions:

1) Establish a wind correction protocol during low flow
2) Lag and Attenuation Correction
3) Explore Flow Method on CJ
4) Compare Flow Method against a Hybrid Method
5) New gage above CJ?