

**Management of Spill at
Bonneville Dam:
Cascades Island TDG
Gauge**

**Water Quality Team
January 17, 2006**

History of TDG Exchange and Monitoring at Bonneville Dam

- Prior to 2002 spill season
 - TDG content in spillway exit channel was consistently greater than 120 %
 - 5 spill bays without flow deflectors (1,2,3,16,17)
 - Spill pattern was highly non-uniform and featured bays without flow deflectors
 - Tailwater station was WRNO (6 miles below dam)
 - TDG levels at WRNO closely* approximate cross sectional average (*not all the time but most of the time)
 - TDG levels in forebay BON typically average 109-111 %
 - Average river TDG saturation released from Bonneville Dam moderated by powerhouse releases (< 120 %)

History of TDG Exchange and Monitoring at Bonneville Dam

- 2002 spill season
 - Spillway flow deflectors added to six bays (1-3, 16-18)
 - Elevation 7 ft based on typical voluntary spill conditions
 - Spill pattern changed to uniform distribution over 18 spill bays
 - TDG content in spillway exit channel was significantly lowered for comparable flows
 - Average cross sectional TDG saturation 120% at 100 kcfs
 - TDG response near the shore line of the spillway exit channel under estimated the average and peak TDG levels for higher spill rates

History of TDG Exchange and Monitoring at Bonneville Dam

- 2003 spill season
 - TDG monitoring near the shoreline of the spillway exit channel was continued.
- 2004
 - Deployment conduit from Cascade Island was extended in an attempt to obtain more representative sample.
 - Conduit weld failed in mid-season and instrument/data lost
 - Replacement instrument was deployed from shore but TDG response was uncharacteristically low
 - Bonneville 2nd powerhouse corner collector operational

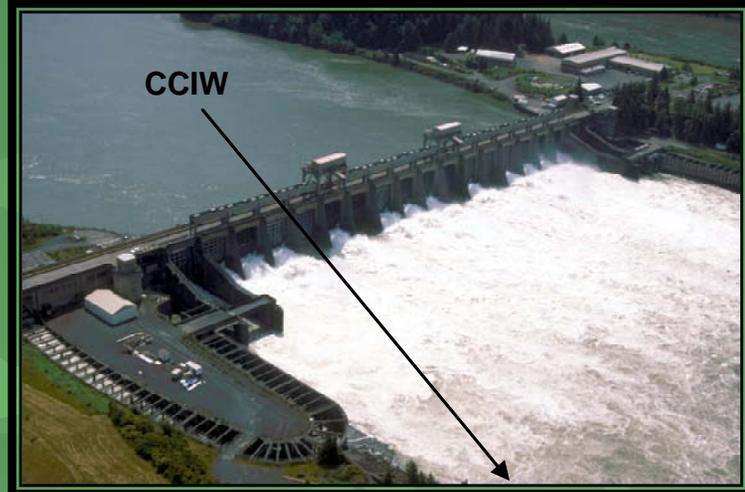
History of TDG Exchange and Monitoring at Bonneville Dam

- 2005 spill season
 - Conduit repaired and Cascade Island station CCIW was adopted as tailwater compliance site
 - Direct measure of project impacts on TDG loading of Columbia River
 - Most comprehensive measure of TDG impact on fisheries habitat
 - Quick TDG response to spill management decisions
 - Consistent with monitoring directives in lower Columbia River TMDL and tailwater FMS at other projects
 - Sampling bias at high spill rates persist
 - CCIW upstream of TDG load introduced from B2CC

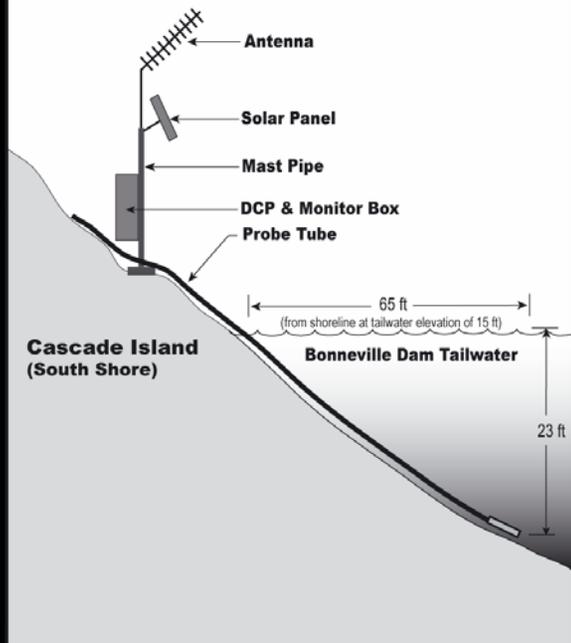
Issue

- TDG levels immediately below the aerated zone depend upon location within the channel and spill rate.
- The location of the Cascades Island TDG gauge under-represents TDG levels within the spillway channel at higher spill rates.

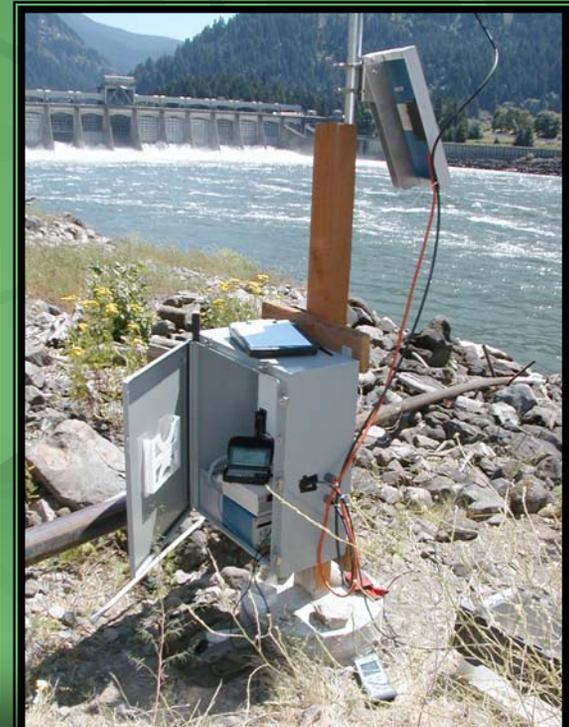
Cascades Island FMS

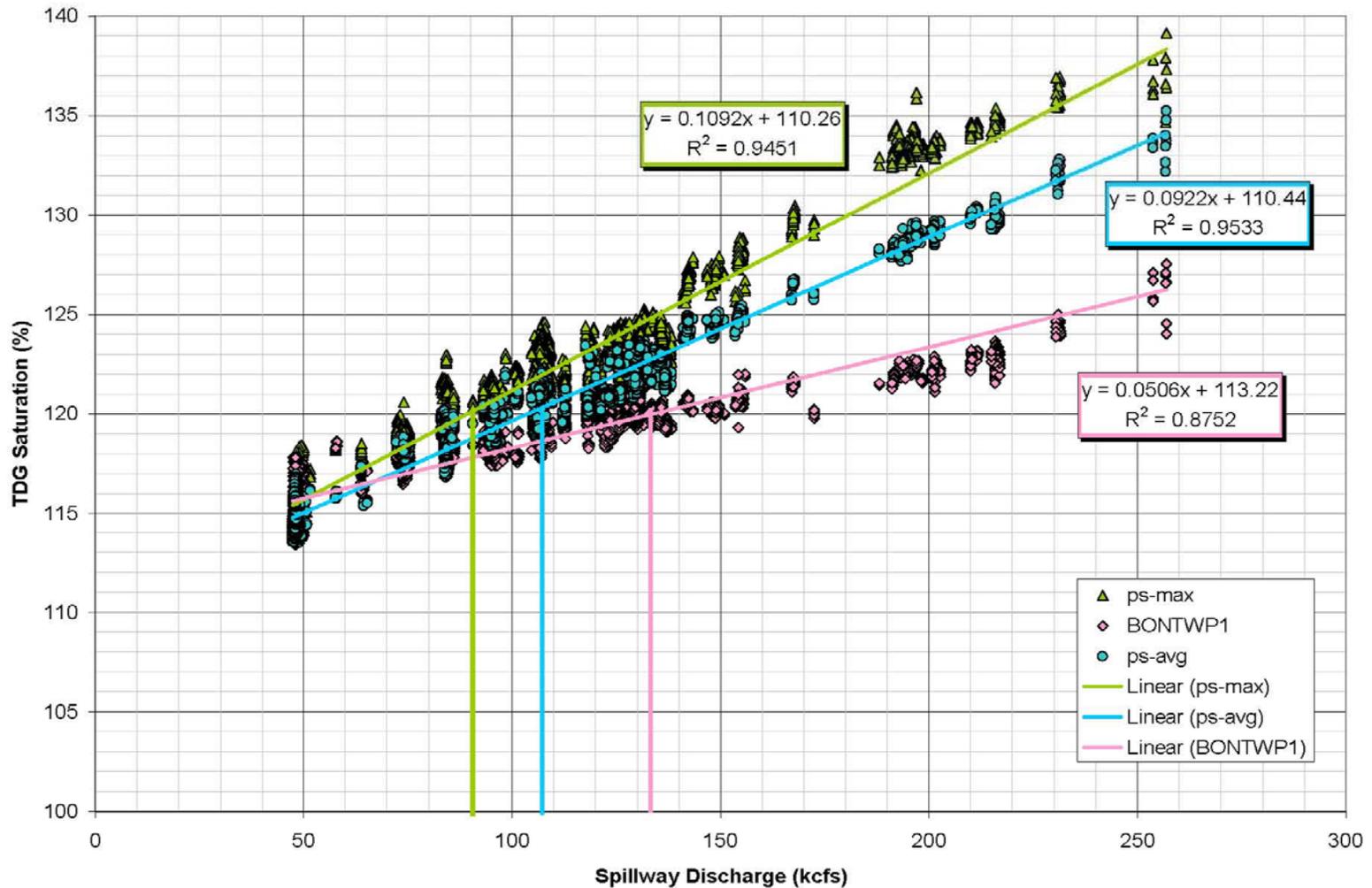


CCIW (Looking Upstream)



Gage Elevation: Fixed
Latitude: 45° 38' 45.2" N
Longitude: 121° 56' 47.2" W
Datum: NAD-83
River: Columbia
River Mile: 145.9
USGS-ID: 453845121564001
Years of Operation: 2004 – Present
River Conditions: Spillway Monitor
Location: This gauge is located within the Bonneville Dam spillway channel on Cascade Island approximately 200 yards downstream of the spill channel.





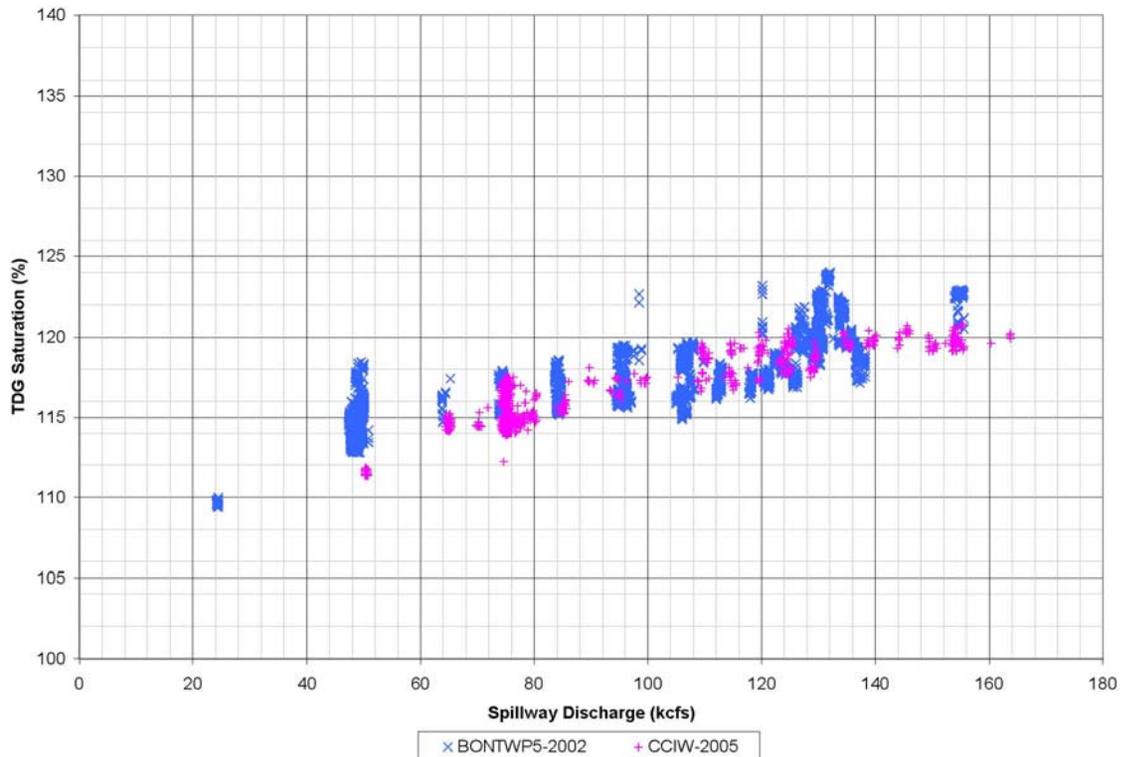
Total Dissolved Gas Saturation in the Bonneville spillway exit channel as a function of spillway discharge, April July, 2002
 (ps-max=maximum cross sectional, ps-avg=average cross sectional, BONTWP1-Bradford Island station)

Note: Spill discharge based on updated spillway rating curve

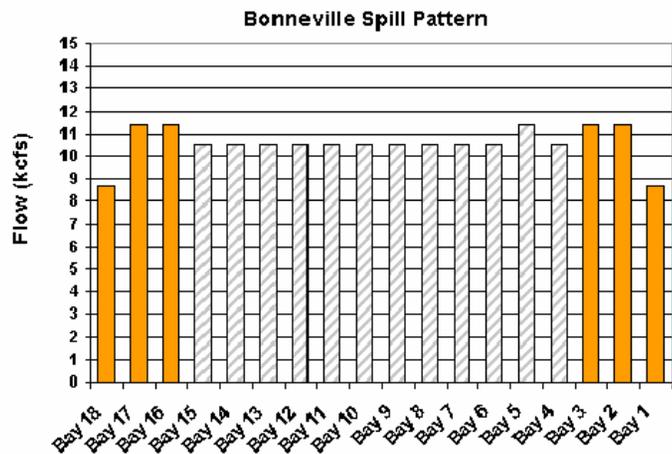
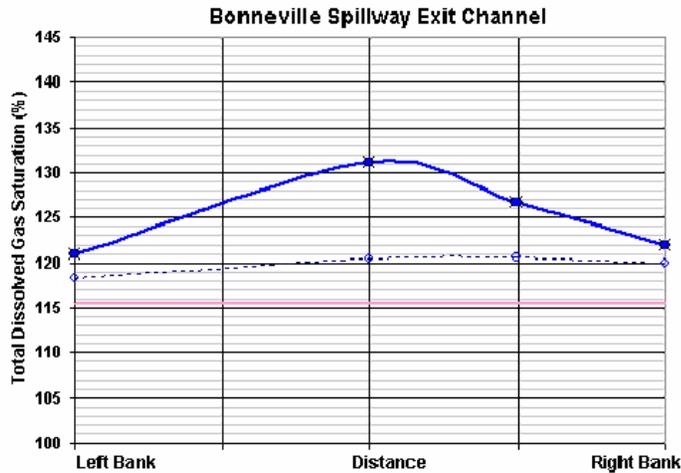
Bonneville Spillway Channel



Comparison of TDG from 2002 Study and CCIW TDG Gauge 2005

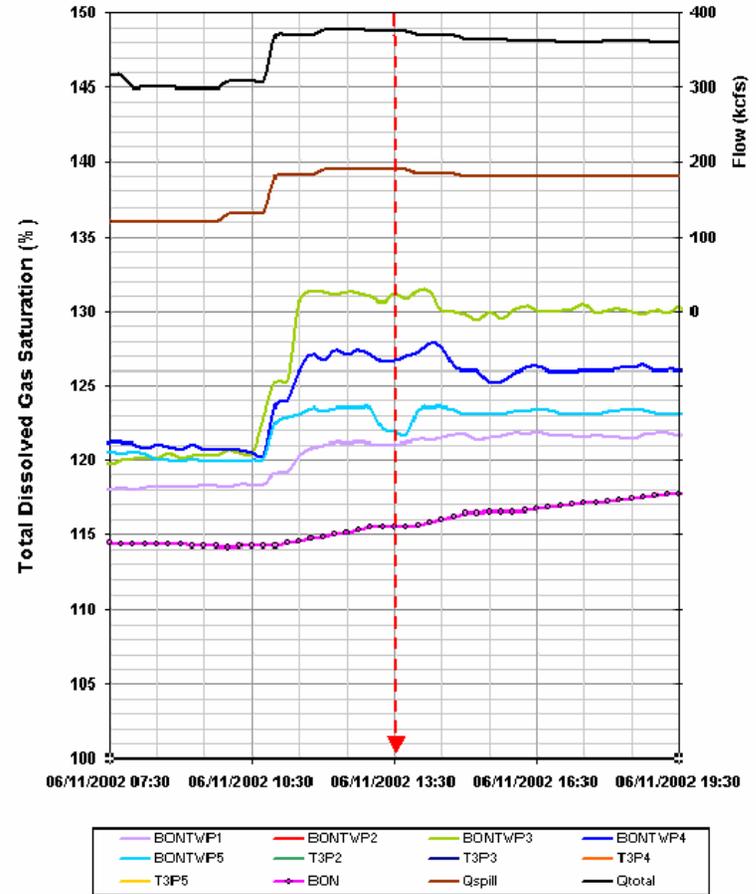


Video of TDG Saturation Across Bonneville Spillway

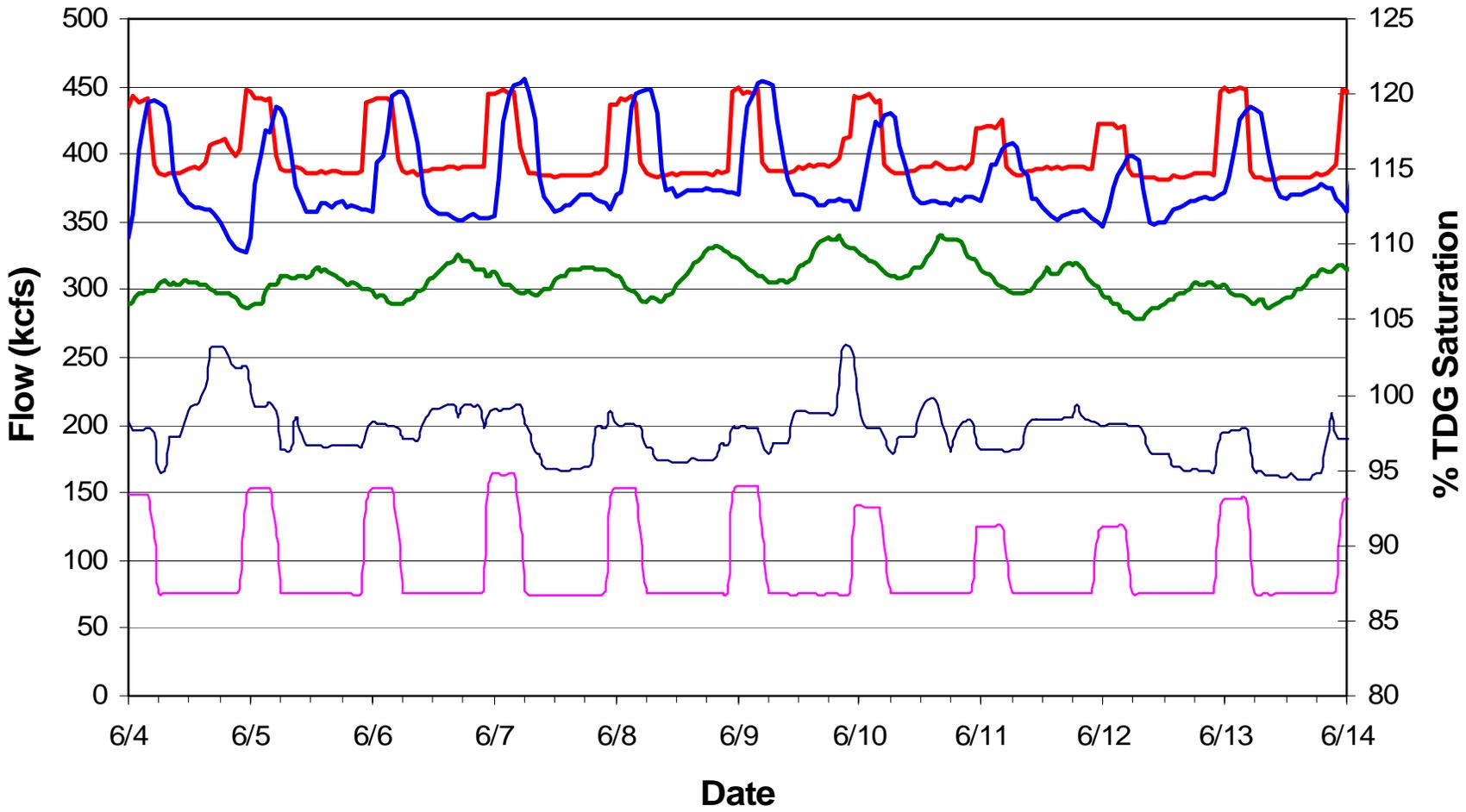


US Army Corps of Engineers
 Coastal and Hydraulics Laboratory

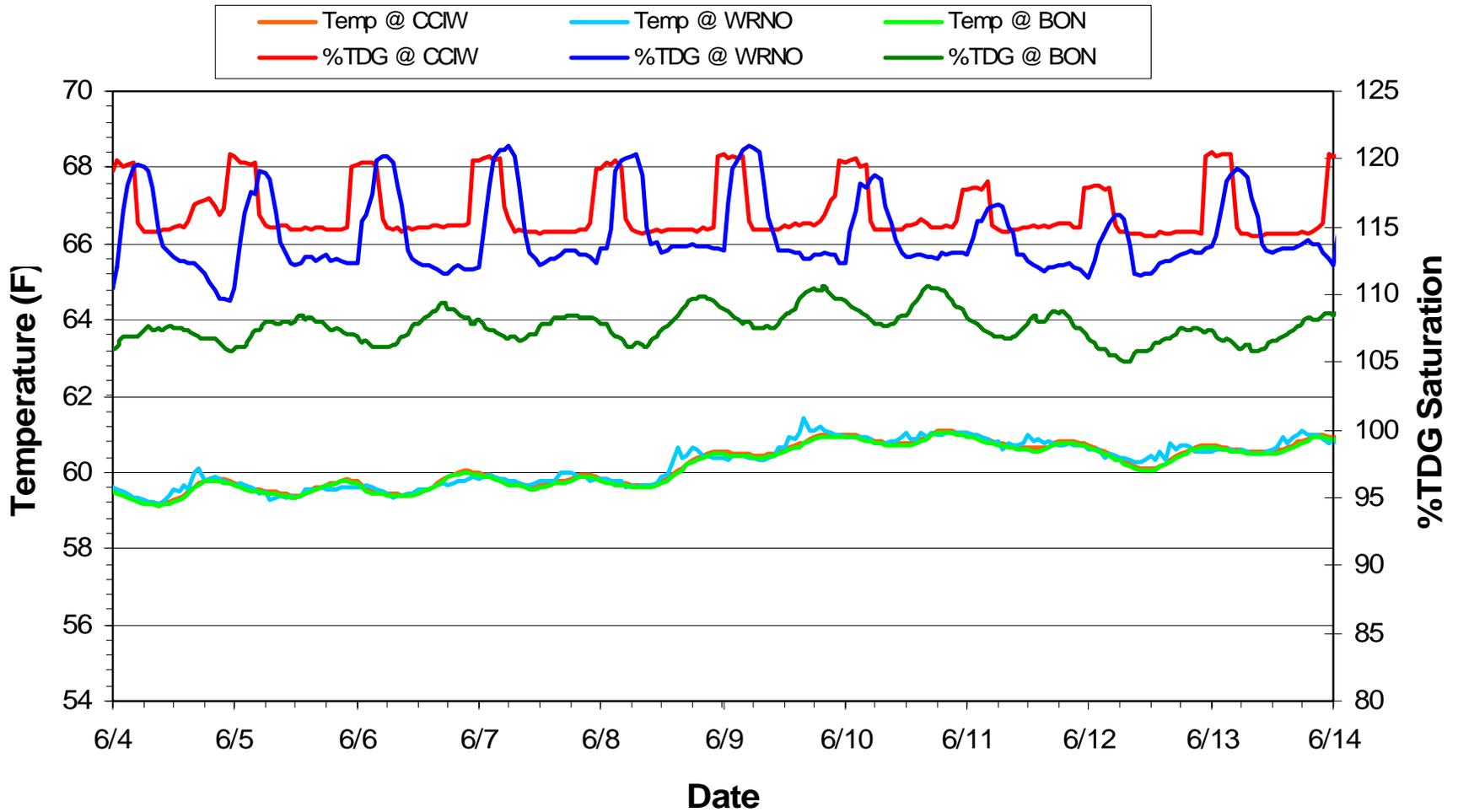
ERDC Coastal and Hydraulics and Environmental Laboratories
 Sponsored by the Portland District



Bonneville Operations and %TDG @ BON, WRNO and CCIW



Water Temperature and %TDG @ CCIW, WRNO, and BON



Question?

At what location should the TDG load allocation at Bonneville be measured?

State of Oregon TDG Standard

- OAR 340-041-0031(2)
 - “Except when stream flow exceeds the ten-year, seven-day average flood, the concentration of total dissolved gas relative to atmospheric pressure at the point of sample collection may not exceed 110 percent of saturation.”
- ODEQ Modification to the TDG Standard
 - Does not make reference to specific monitoring locations (simply refers to “forebay” and “tailwater” only).

State of Washington TDG Standard

- WAC 173-201A-030(1)(c)(iii) (1997) and WAC 173-201A-200(1)(f) (2003)
 - “Total dissolved gas shall not exceed 110 percent of saturation at any point of sample collection.”
- WDOE Adjustment to TDG Standard
 - Does not make reference to specific monitoring locations (simply refers to “forebay” and “tailwater” only).

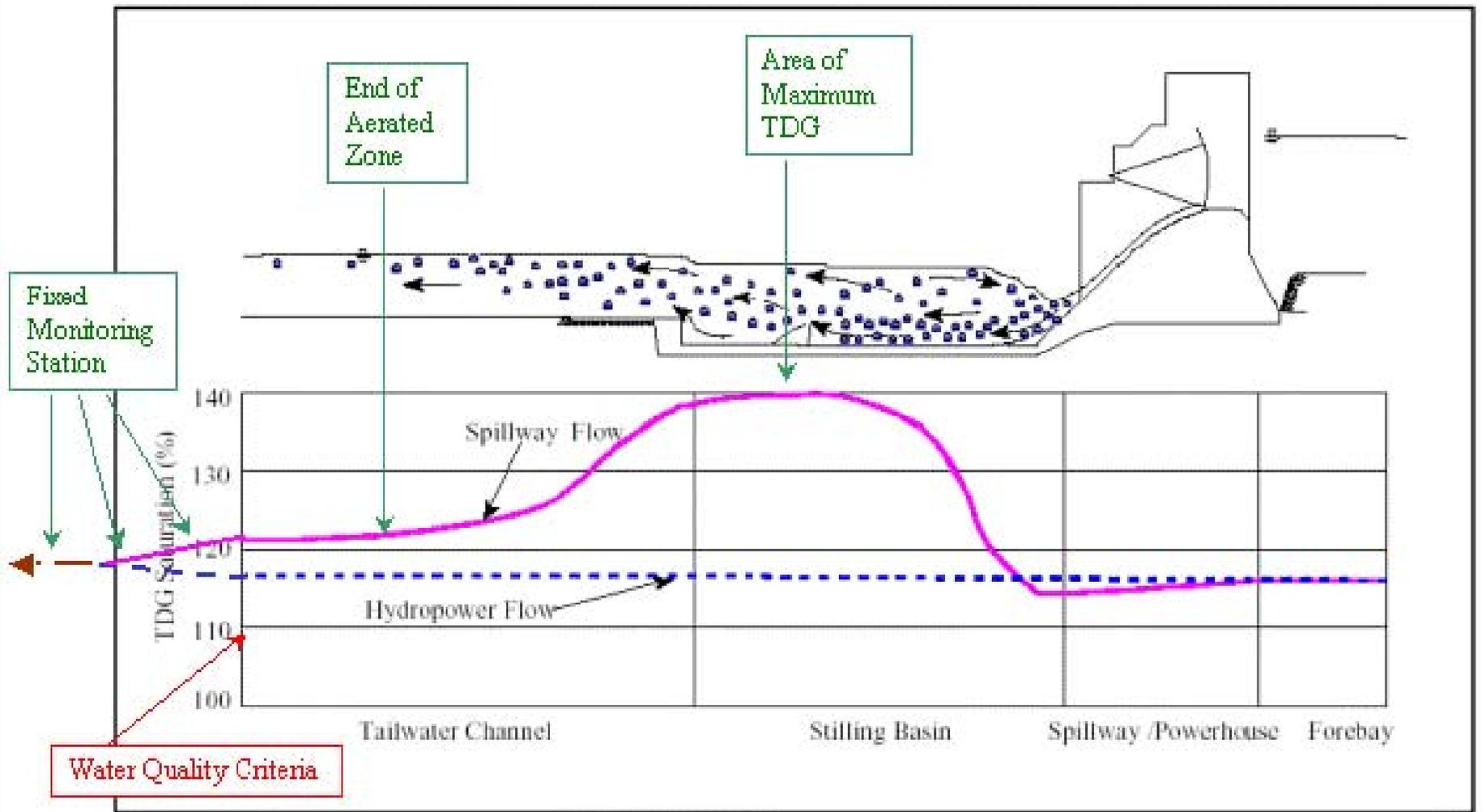
Lower Columbia River TDG TMDL

- “The compliance location for each spill load allocation will be at the end of the aeration zone in the tailrace of each dam, at the location specified in Table 13.”
(page 63)

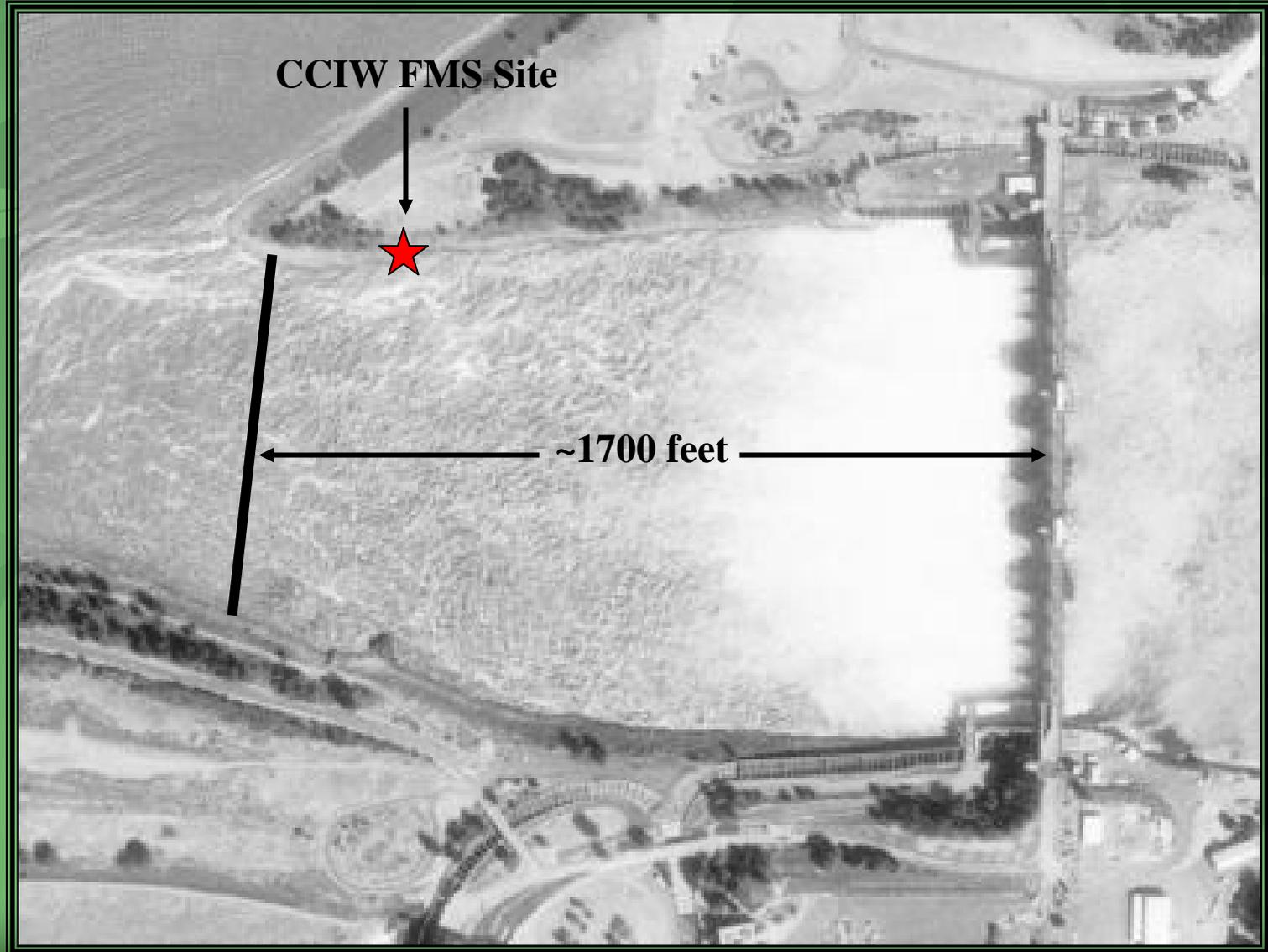


- From Table 13:
Bonneville Dam,
“1700 feet (~ 1/3 mile)
below the end of the
spillway.”

Mixing Zone Provision in TMDL



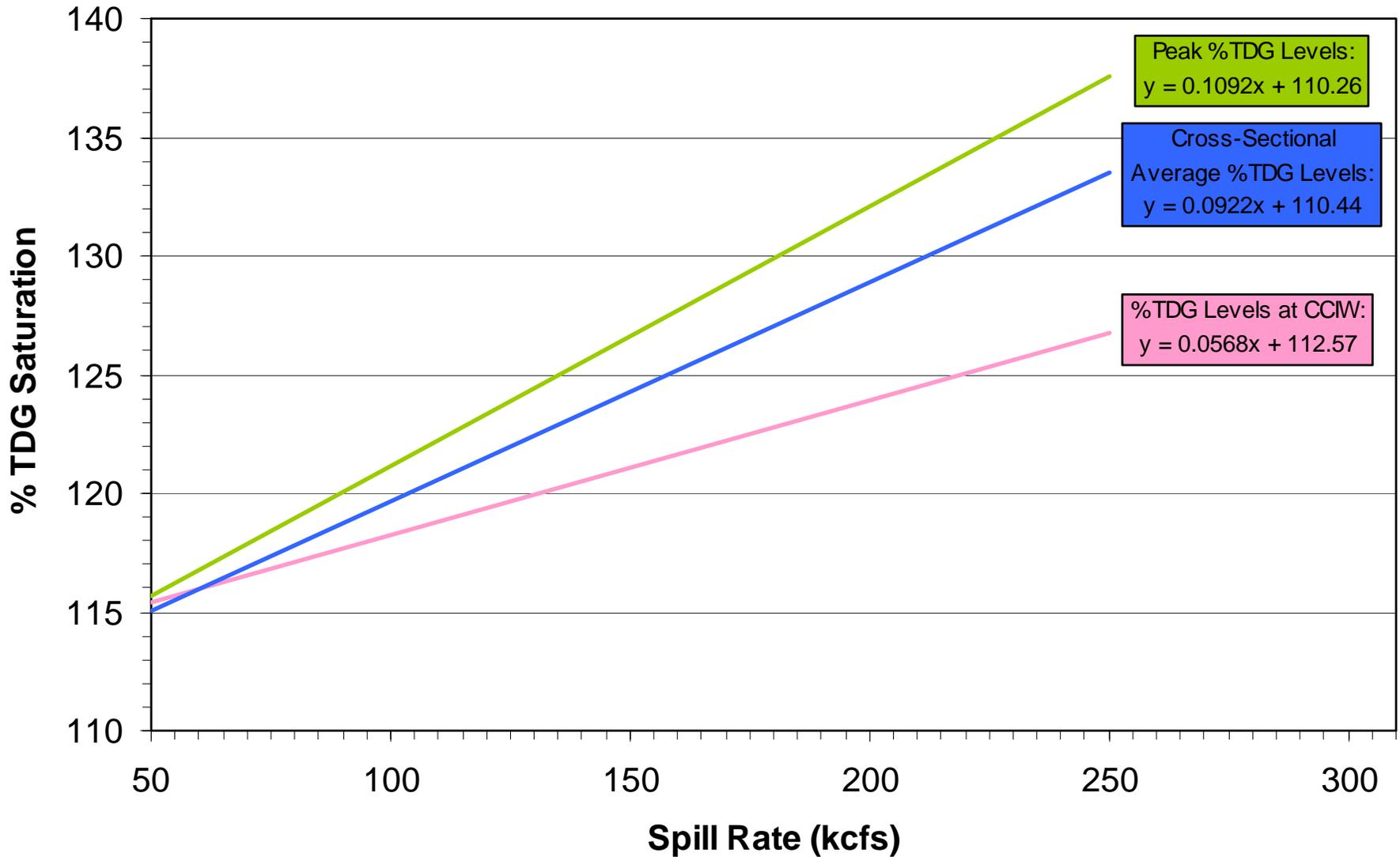
Bonneville Spillway Channel



Lower Columbia TDG TMDL

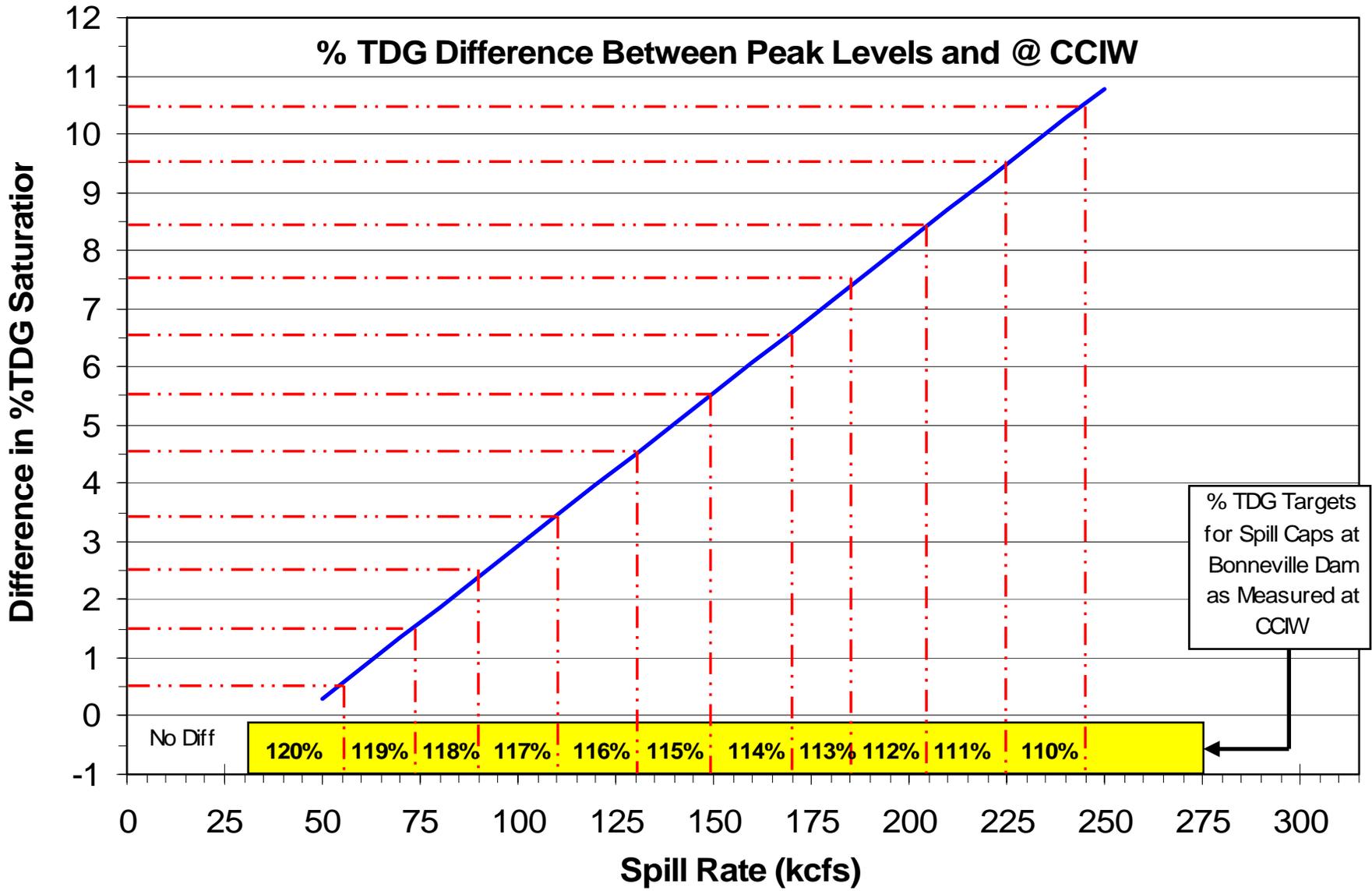
- “Compliance will be determined in two ways:
(1) periodic synoptic surveys, especially after structural changes have been completed, and
(2) continuous monitoring, using a statistical relationship between the continuous monitor and conditions at the compliance location..”
(Monitoring Compliance (p. 63))

Spillway TDG Saturation as a Function of Spillway Discharge (April - July 2002)



Sample TDG Management Criteria for Bonneville Spill

% TDG Difference Between Peak Levels and @ CCIW



% TDG Targets for Spill Caps at Bonneville Dam as Measured at CCIW

Example of Indexing Strategy

(Using Peak %TDG as the Compliance Point to Measure Load Allocation)

Spill Range (kcfs)	%TDG Target @ CCIW
50 – 55	120%
55 – 75	119%
75 – 90	118%
90 – 110	118%
110 – 130	116%
130 – 150	115%

Spill Range (kcfs)	%TDG Target @ CCIW
150 – 170	114%
170 – 185	113%
185 – 205	112%
205 – 225	111%
225 - 245	110%

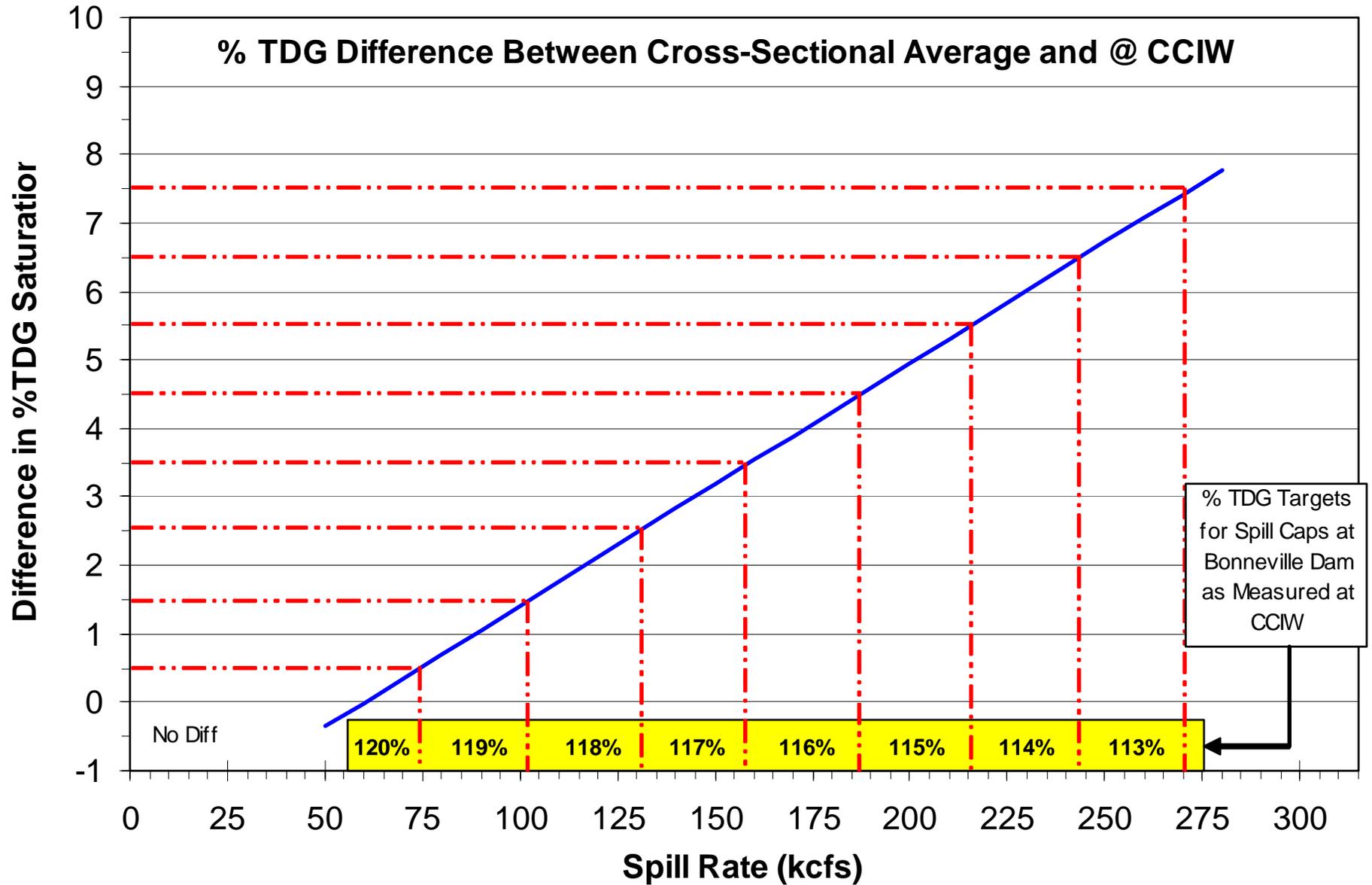
Spill Statistics (2000-2005)

(Nighttime Spill Only)

	2005	2004	2003	2002	2001	2000
<u>Basic Statistics</u>						
n	924	1197	1120	1405	--	1424
Ave	110.3	84.1	108.7	107.0	--	73.0
Max	163.9	167.1	155.0	257.0	--	164.2
Min	50.2	22.2	38.8	24.2	--	22.9
Std Dev	29.9	41.5	26.5	37.1	--	22.0
<u>Percentile Ranking</u>						
0.01	50.3	22.9	48.6	24.6	--	23.4
0.05	65.1	23.4	51.5	48.5	--	34.1
0.1	74.5	23.8	64.5	52.1	--	47.3
0.25	84.9	49.7	92.7	86.1	--	61.1
0.5	114.9	85.9	118.8	106.3	--	72.5
0.75	134.5	117.6	128.8	125.7	--	84.3
0.9	151.3	142.3	135.5	142.4	--	99.3
0.95	154.3	153.9	138.2	191.7	--	111.7
0.99	155.7	161.2	148.0	216.6	--	125.3

Sample TDG Management Criteria for Bonneville Spill

% TDG Difference Between Cross-Sectional Average and @ CCIW



Example of Indexing Strategy

(Using Cross-Sectional Average %TDG as the Compliance Point to Measure Load Allocation)

Spill Range (kcfs)	%TDG Target @ CCIW
50 – 75	120%
75-105	119%
105-130	118%
130-160	117%
160-185	116%
185-215	115%
215-245	114%
245-270	113%

Spill Statistics (2000-2005)

(Nighttime Spill Only)

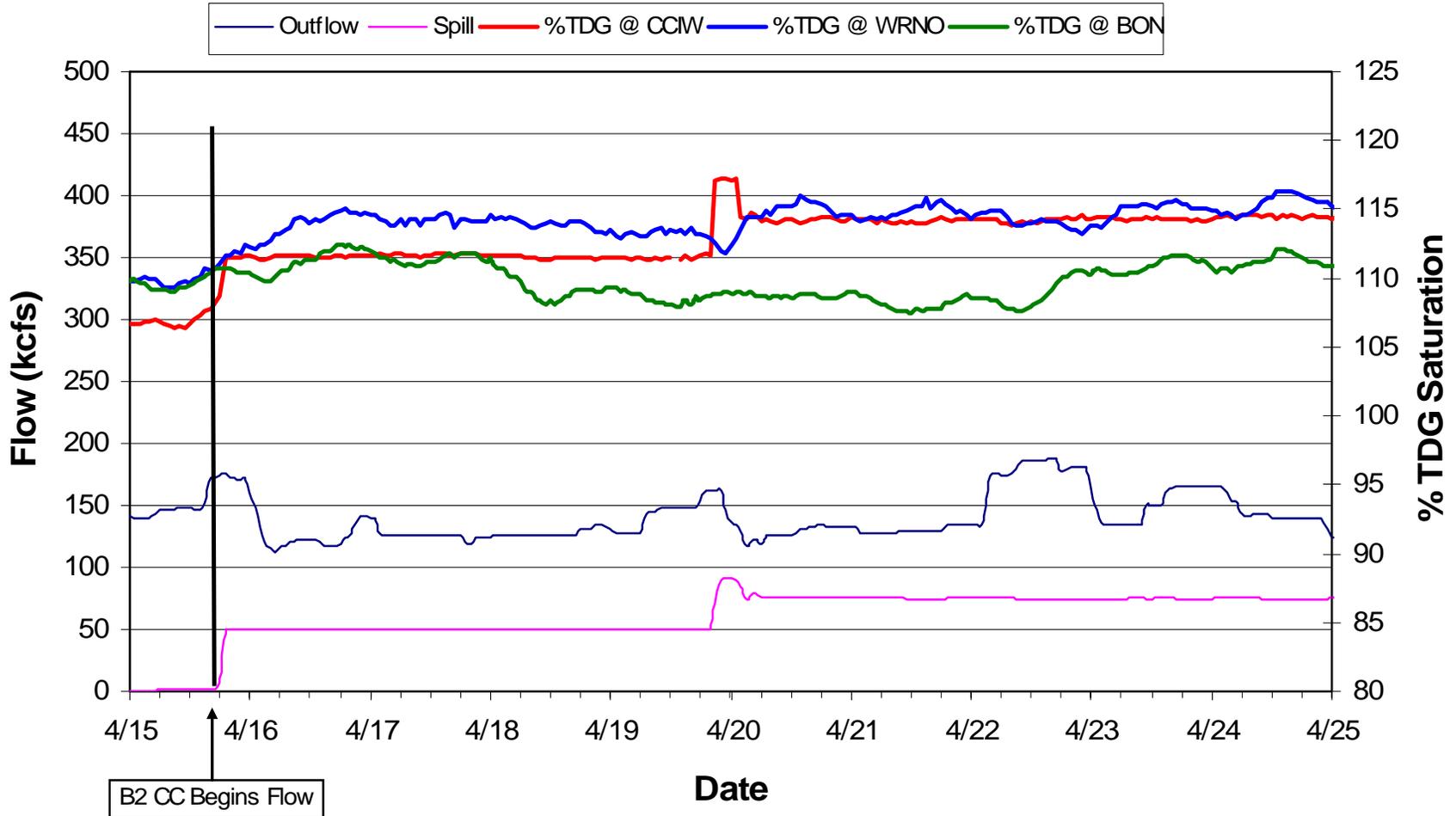
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0.95	154.3	153.9	138.2	191.7	--	111.7
0.99	155.7	161.2	148.0	216.6	--	125.3

Other Issues

- B2 Corner Collector contributes to TDG loading.
- Tailwater Elevation not accounted for in this analysis
 - Higher tailwaters result in greater TDG loading.
 - During study, 13-16 feet.

TDG Levels measured at BON, WRNO and CCIW

Bonneville Operations and %TDG @ WRNO and CCIW



Question?

- How should spill at Bonneville be managed using the Cascades Island TDG gauge?
 - Based on Peak TDG levels (SYSTDG)?
 - Based on Cross-Sectional Average TDG levels (SYSTDG)?
 - Based on TDG levels measured at CCIW?