LAKE LEVELS SUBCOMMITTEE
WATERBUDGET REPORT No.4
19 MARCH 2014

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LAKE LEVELS SUBCOMMITTEE WATER
BUDGET REPORT NUMBER FOUR
19 March 2014

Interested parties view the topic of lake water levels historically as a debate between the users of the outflow from Deep Creek Lake (DCL) and the users of the waters in the lake. The Maryland Department of the Environment regulates the outflow from the lake.

The outflow is the subject of Water Appropriation Permit GA1992S009(08). To view the entire permit (12 pages) go to: http://www.mde.maryland.gov/programs/water/water_supply/documents/deep%20creek%20lake/brookfield%20permit-2011jun.pdf .
On page two of the permit, condition number 2 lists the uses of the water: hydroelectric generation, temperature enhancement, whitewater boating enhancement, and the maintenance of minimum flows in the Youghiogheny River. Condition number 14, on page four, outlines the rule band for water levels to afford the users of the lake adequate water for boating purposes. Temperature enhancement releases are not subject to the rule band. Exceptions A through E address maintenance and emergency conditions. According to Article 19 (A), "All white water releases are subject to the Rule Band and operation requirements in 14". There is an exception in 19-II) that permits the annual Friendsville Upper Yough Race on the fourth Saturday in July to go up to one foot below the lower rule band. The Code of Maryland and Rules (COMAR), Natural Resources Code Ann. 5-215.1. (a).1(2013 lists recreation, among other things, as a use for DCL.

There is a wealth of information in the Brookfield Annual Reports. The 2011(2) and2012 (5) Reports present useful data. There were no violations of the lower rule band in 2011, but the Fisheries reported a decline in the fish populations.

According to the Fisheries paper (1) on page 6 of 8, "Threats" contains the statement that "During 2011 and 2012 the trout population densities and standing crops were reduced to levels observed prior to the temperature enhancement plan mainly due to the number and duration of temperature exceedances."

On page 292 (2), 1 June 2011, the daily TER daily sheet calls for a TER because of the 118 cfs flow in the Youghiogheny River at Oakland. The operator notes that he made no release because the plant was undergoing repairs. Without the release the maximum reported stream temperature was 24.10 °C. A temperature vs. time plot is attached (3). Using the current protocol was a failure and would have been a waste of water for the protection of the fisheries.

The Hoyes gage (USGS 03076100) came on line at the end of July in 2011. After that date the discharges correlation with the river temperatures, stream flow and the performance of the protocol will afford valuable insights.

According to Table 2 in the 2011 Brookfield annual report the total time for temperature enhancement releases was 78 hours. Assuming a release rate of 630 cfs for 78 hours equals about 4,000 acre feet. Assuming that the lake stage is at 2460, 4,000 acre-feet is about 1 foot of water for the three month period.

The 26 July 2011 (4) excursion went to 27.29 °C, and was greater than 25 °C for 2 hours and ten minutes. The protocol called for a 2 hr. release at 12:30. The release started at 12:43 and ran until 14:38. Unfortunately the Hoyes gage was not on line to show the release or the base flow at Hoyes. The Oakland gage registered 45 cfs. The temperature vs. time relationship for that excursion is attached.

When the Hoyes gage came on line the plots of temperatures at the Sang Run Bridge and the releases from the plant show several things that are related to how excursions occur. A two turbine release flows about 630 cfs of water into a stream flowing about a tenth of that.

Elementary calorimetric calculations indicate that the colder lake water at ten times the river flow rate should easily lower the temperature and protect the fisheries. The problem lies in the timing. The data plot from the 2011 Brookfield Annual Report (2) for 4 August 2011 (7) shows temperature at Sang Run and the Hoyes flow gage. There is about a two hour delay for flows to reach the Sang Run temperature gage from the power plant. Note: the Hoyes gage is recorded in Eastern Standard Time and the temperature is recorded in Daylight Savings Time.

On 4 August 2011 the protocol called for a two hour release at 1230h. The rising temperature gradient was about one degree Celsius per hour that morning. The duration of the release exceeded the length of the excursion. Note the rapid decrease in temperature about two hours after the release started. At least part of the problem is that the river temperature should be monitored above the plant to control the releases. The use of the temperature gage at the Sang Run Bridge for control is too late…the damage has been done.

Arguments have been made that the river temperature at the plant should not be used because of the influence of the plant leakage. The attached graphs (7), (8), (10) display a predicted response to using the bypass flows to regulate the stream temperatures from the plant to the Sang Run Bridge.

When the temperature at the bridge reaches 22.5 degrees Celsius the bypass valve can be opened to 40 cfs. Using the attached graphs, 7, 8, and 10, there is evidence that it takes more than two hours for the temperature at the bridge to reach 25 degrees Celsius. When the river heats up at a rate greater than one degree Celsius per hour there will likely be an exceedence unless the warming water is diluted with cold water from Deep Creek Lake.

The data plot for 4 August 2011 shows the first temperature excursion for which Hoyes gage data was available. A two hour release began about 1230h. The graph shows the measured effect from that release. The temperature at the Sang Run Bridge reached 26 degrees Celsius by 1400h. The river base flow was about 60 cfs, with no bypass. Calorimetric computations were employed to examine the possible temperatures at the bridge. The argument that the stream heats up between the plant and the bridge is true. However, the temperature record is from the downstream end. Whatever heating that occurs in the reach has already happened. Mixing the cold water in at the upper end of the reach can only lower the temperature. The plot also shows predicted temperatures at the bridge if the release had not occurred.

The following analysis for 2012 is more telling about the ineffectiveness of the current TER protocol. There were 41 TER releases and 15 temperatures above 25°C. That is greater than a thirty-five percent failure rate. The TER Release Data (6) also lists the river base flow at Hoyes, the flow at Oakland, the bypass cfs, the per-cent of bypass valve opening, the time to reach 22.5°C at the bridge, the maximum temperature at the bridge, and the time of peak temperature.

The Oakland USGS flow gage now reports rainfall. There is good monthly correlation between rainfall in Oakland and the rainfall monthly report from Brookfield for 2012 (12).

The river flow charts (9) for the summer months of 2012 show the base flows and the influence of the power plant releases. The TER releases are distinguishable from the whitewater releases by the duration. TER releases are one or two hours, whitewater releases are three hours. Discretionary releases can be of any length that respects the lower rule band.

The 2012 Deep Creek Lake Level chart (11) from the 2012 Brookfield Annual Report is modified to show the summer season and the 2457 level. It shows the effects of a dry summer coupled with no water budget to equitably allocate the resource.

Temperature enhancement releases of about 630 cfs lasted for one to two hours. Instead of using both turbines to control river temperature the bypass could have produced a better result with less water. For the 13 June 2012 excursion a bypass release of 60 cfs for seven hours beginning at 1400h would have avoided the excursion. Using the rising slope and the 22.5°C temperature at the bridge to trigger the bypass would have avoided this excursion. The 13 June 2012 chart illustrates the data.

The 6 July 2012 chart shows the ineffectiveness of the TER releases when the base flow is low and river temperatures are high. The first excursion occurred because the timing was off. The second excursion that day is because the duration was not long enough. Without the TER that day the temperature may have reached 28°C. As it was the first excursion reached 26°C and the second excursion reached a little over 25°C. The two hour release by both turbines at 630 cfs for two hours is 1260 cfs-hrs. The 40 cfs bypass release for ten hours would be 400 cfs-hrs. That is roughly a third the expense in water, and it would have protected the fisheries.

In 2012 there were 40 TER's for a total of 76 hours. Of those three hours were longer than 2 hours. If the three hours are counted as discretionary, the total is 73 hours at 630 cfs. That is the equivalent of about one foot of water at lake elevation 2460.

The two-thirds of a foot of lake water potentially saved could have been used for longer whitewater releases when coupled with discretionary releases that could have been made if the lake levels were above the rule band instead of below it.

The amount of water needed for the temperature enhancement for the fisheries needs to be budgeted for the summer. Assuming that half of the days in the period, say 45 days, required 400 cfs per day, which would make the annual demand for TER 18,000 cfs. Assuming 40 cfs released for ten hours for 45 days the lake would lose 0.4 feet of water at elevation 2460.

Another element to be considered in the water budget is the amount needed to support the white water release schedule in the appropriation permit. The scheduled releases use about 2.8 feet of water at 2460 to meet this demand. That demand could be spread out over the season in the water budget because these demands are scheduled. With a budget no releases would be missed if the water was kept in reserve, along with the TER water reserve above the lower rule band.

The upper rule band needs to be kept above 2459 where it is currently at 2458. In August it needs to be 2461 and 2460 in September. The lower rule band should remain as it is, but the current exceptions for whitewater and TER's can be eliminated with a water budget with proper management.

REFERENCES

(1) Maryland DNR, 6 December 2013, Watershed Characterization, LAKE\DNR\6Dec13 Fisheries Report

(2) Brookfield Annual Report, 2011

(3) 1 JUNE 2011 TEMPERATURE EXCURSION ANALYSIS MADE 17 JANUARY 2014 FROM BROOKFIELD ANNUAL REPORT, NOT TO SCALE, M. C. FRANCE.pdf (attached)

(4) 26 JULY 2011 TEMPERATURE EXCURSION ANALYSIS MADE 17 JANUARY 2014 FROM BROOKFIELD ANNUAL REPORT, NOT TO SCALE, M. C. FRANCE.pdf (Attached)

(5) Brookfield Annual Report, 2012

(6) WB-TER2012.pdf (attached)

(7) 4 AUGUST 2011 TEMPERATURE EXCURSION ANALYSIS MADE 17 JANUARY 2014 FROM BROOKFIELD ANNUAL REPORT, NOT TO SCALE, M. C. FRANCE.pdf (Attached)

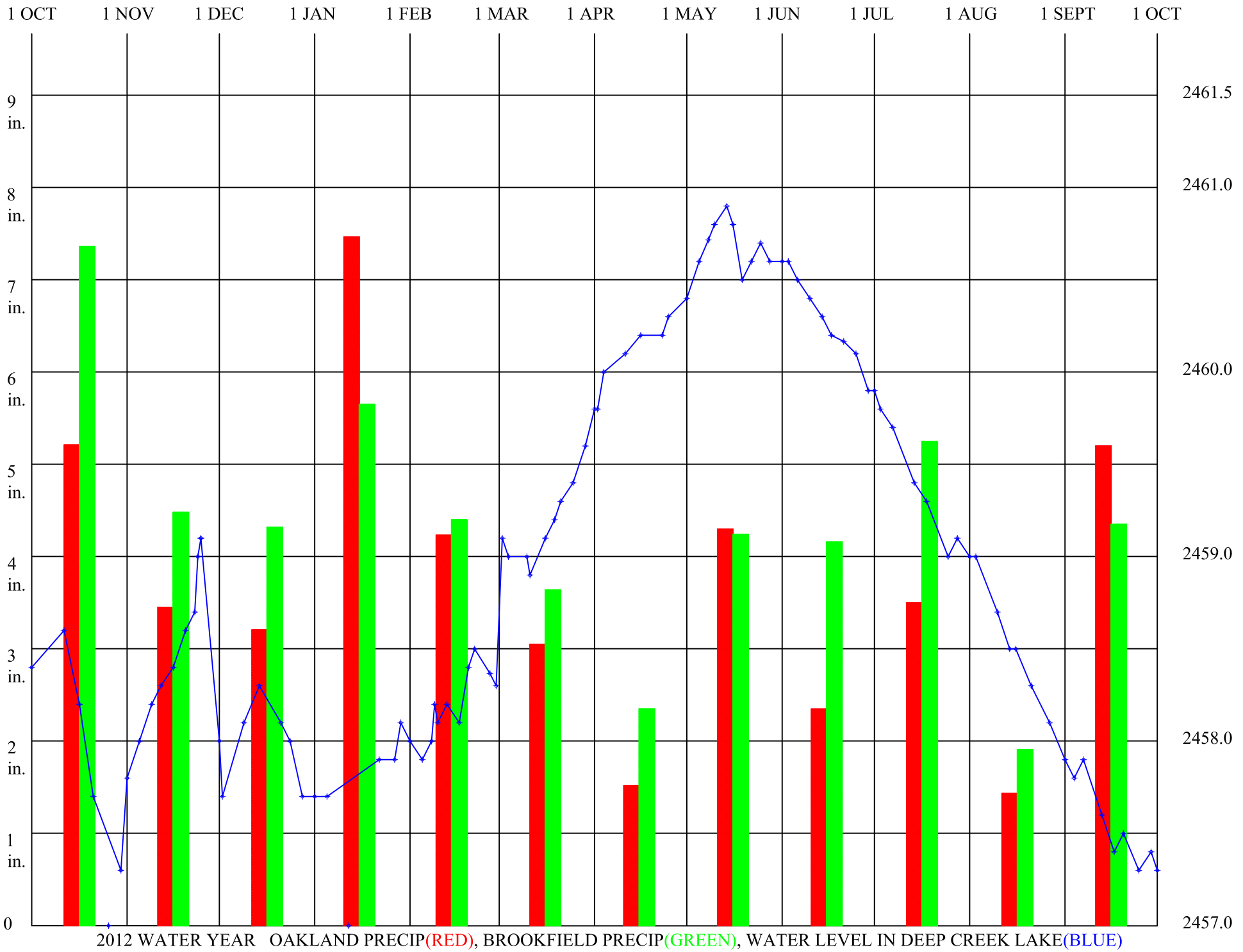
(8) 6JULY2012 TEMPERATURE EXCURSION ANALYSIS MADE 10 MARCH 2014 FROM BROOKFIELD ANNUAL REPORT, NOT TO SCALE, M. C. FRANCE.pdf (attached)

(9) USGS GAGE 03076100 Youghiogheny River at Hoyes Run, Maryland, June-August 2012

(10) 13 JUNE 2012 TEMPERATURE EXCURSION ANALYSIS MADE 10 MARCH 2014 FROM BROOKFIELD ANNUAL REPORT, NOT TO SCALE, M. C. FRANCE.pdf (attached)

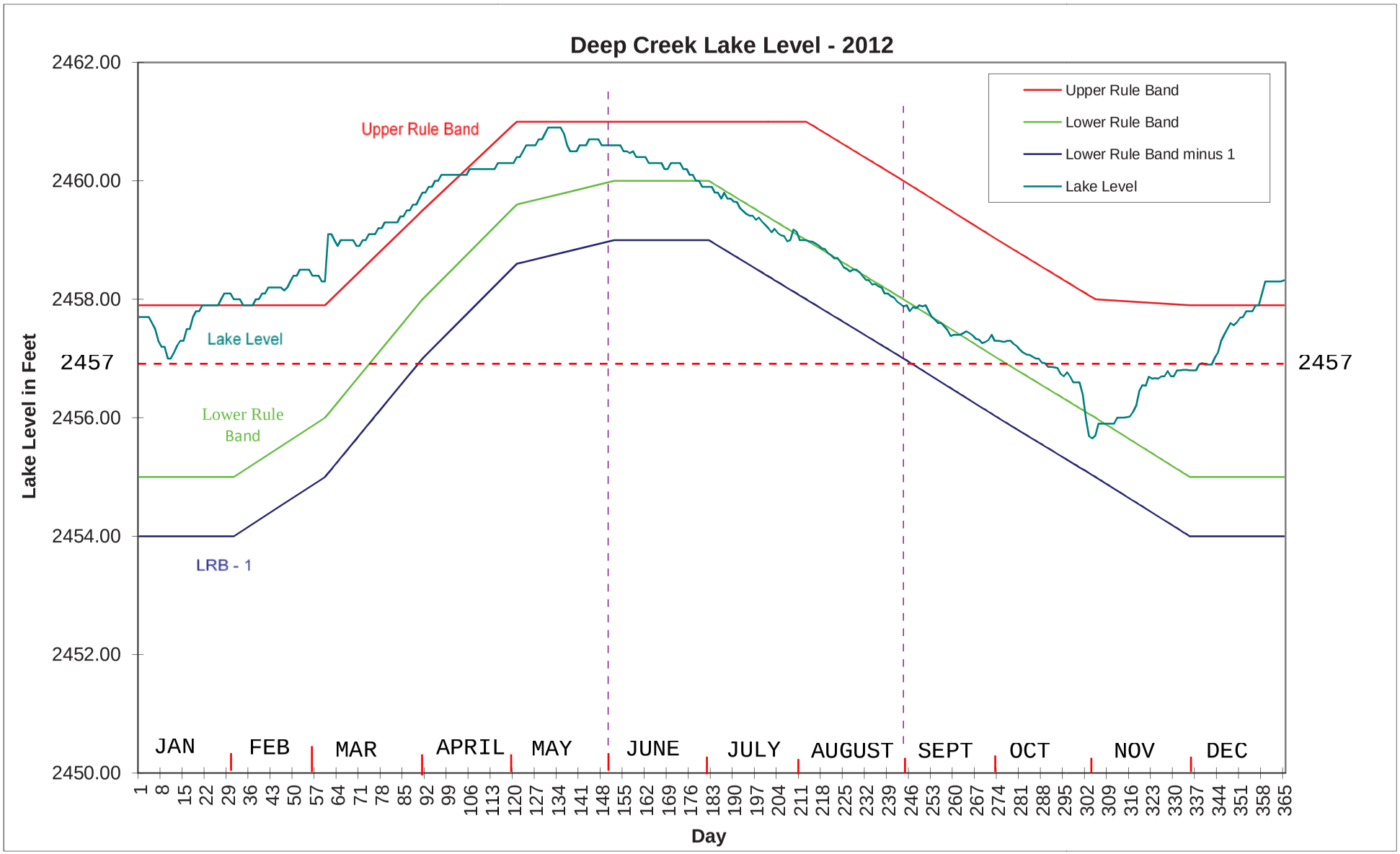
(11) 2012 Lake Levels from 2012 Brookfield Annual Report.pdf (attached)

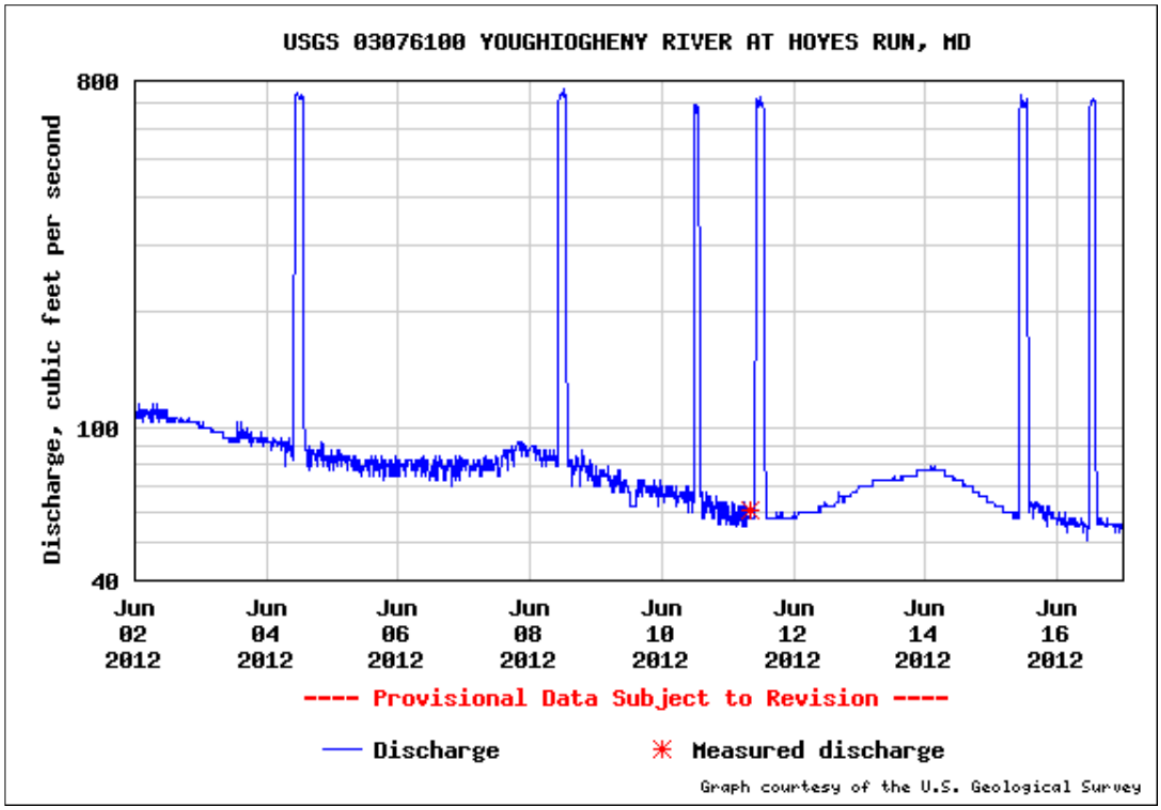
(12) 2012 Water Year Oakland Precipitation Record, Brookfield Precipitation Record, and Water Levels in Deep Creek Lake (attached)

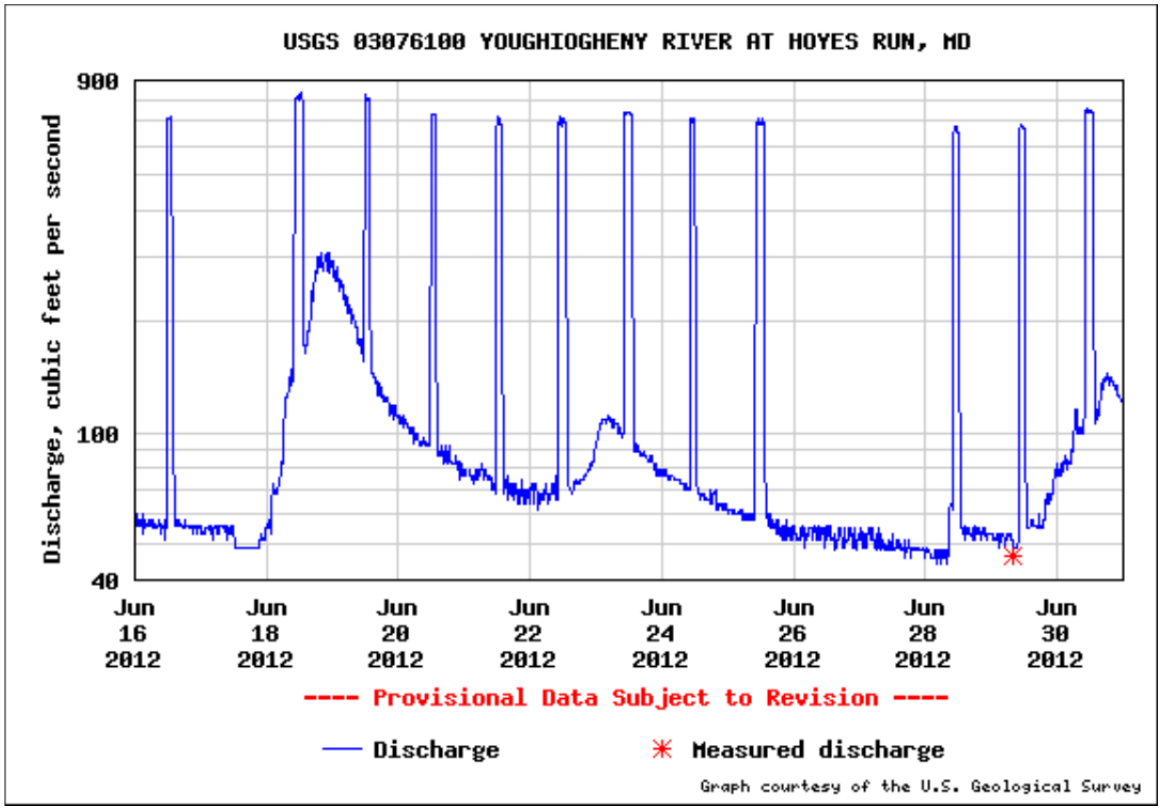


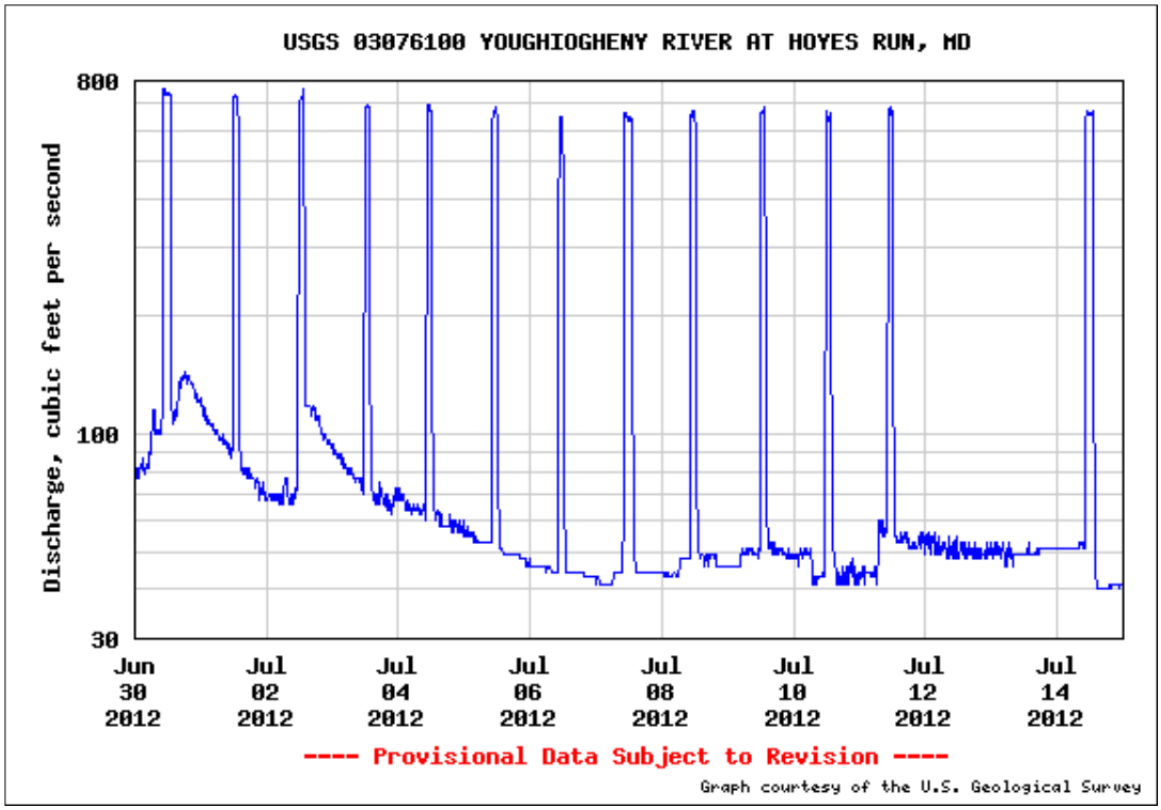
2012 WATER YEAR OAKLAND PRECIP(RED), BROOKFIELD PRECIP(GREEN), WATER LEVEL IN DEEP CREEK LAKE(BLUE)

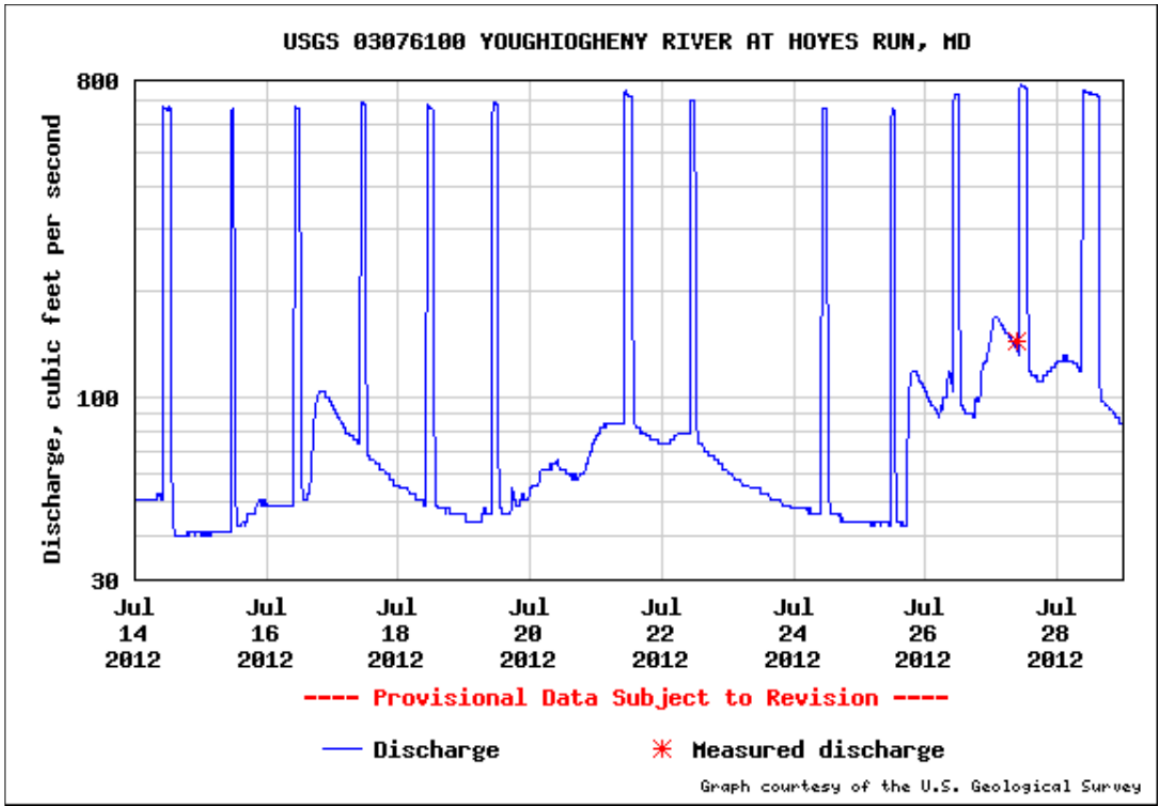
C:\LAKE\WeatherData|oakland\OaklandBrookfieldPrecip-WL-2012WY.dwg

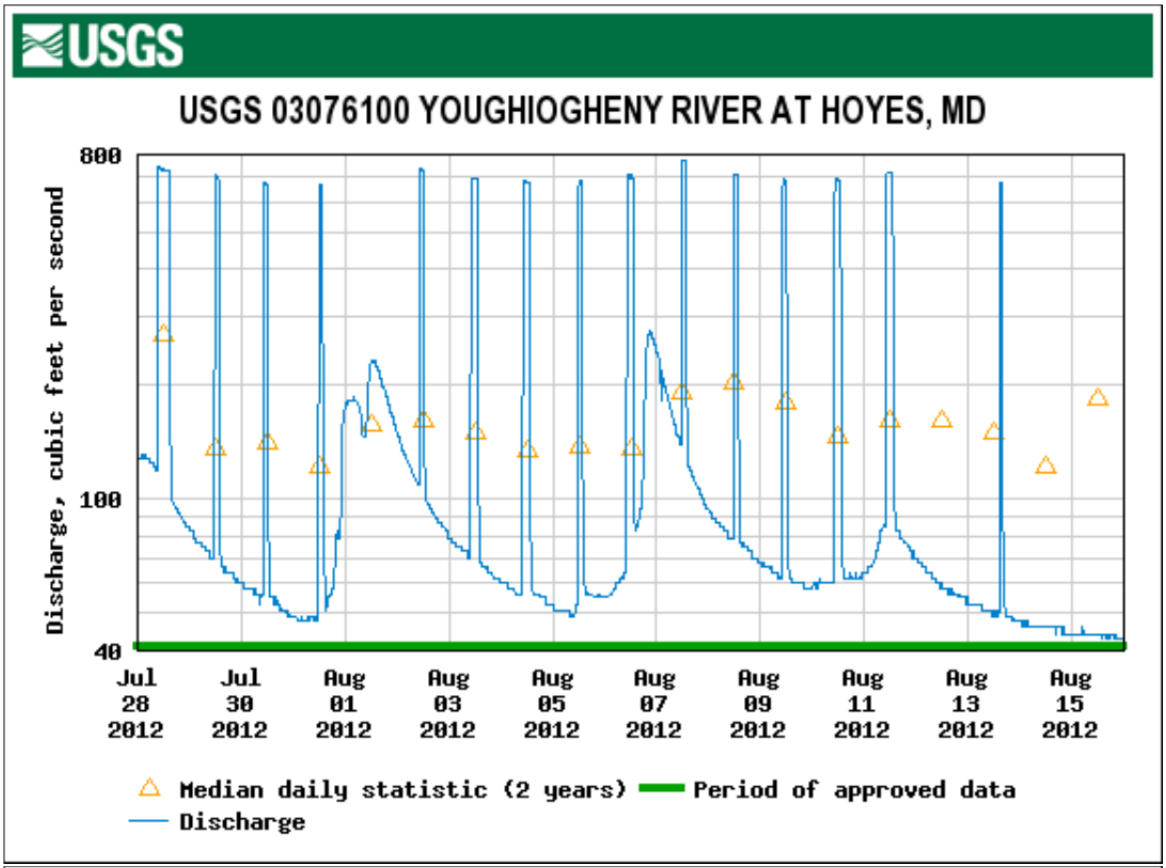

Deep Creek Lake Level - 2012
Upper Rule Band
Lower Rule Band
Lower Rule Band minus 1
Lake Level
Upper Rule Band
Lake Level
Lower Rule Band
LRB - 1
2457
2457
Lake Level in Feet
2462.00
2460.00
2458.00
2456.00
2454.00
2452.00
2450.00
JAN
FEB
MAR
APRIL
MAY
JUNE
JULY
AUGUST
SEPT
OCT
NOV
DEC
1 8 15 22 29 36 43 50 57 64 71 78 85 92 99 106 113 120 127 134 141 148 155 162 169 176 183 190 197 204 211 218 225 232 239 246 253 260 267 274 281 288 295 302 309 316 323 330 337 344 351 358 365
Day

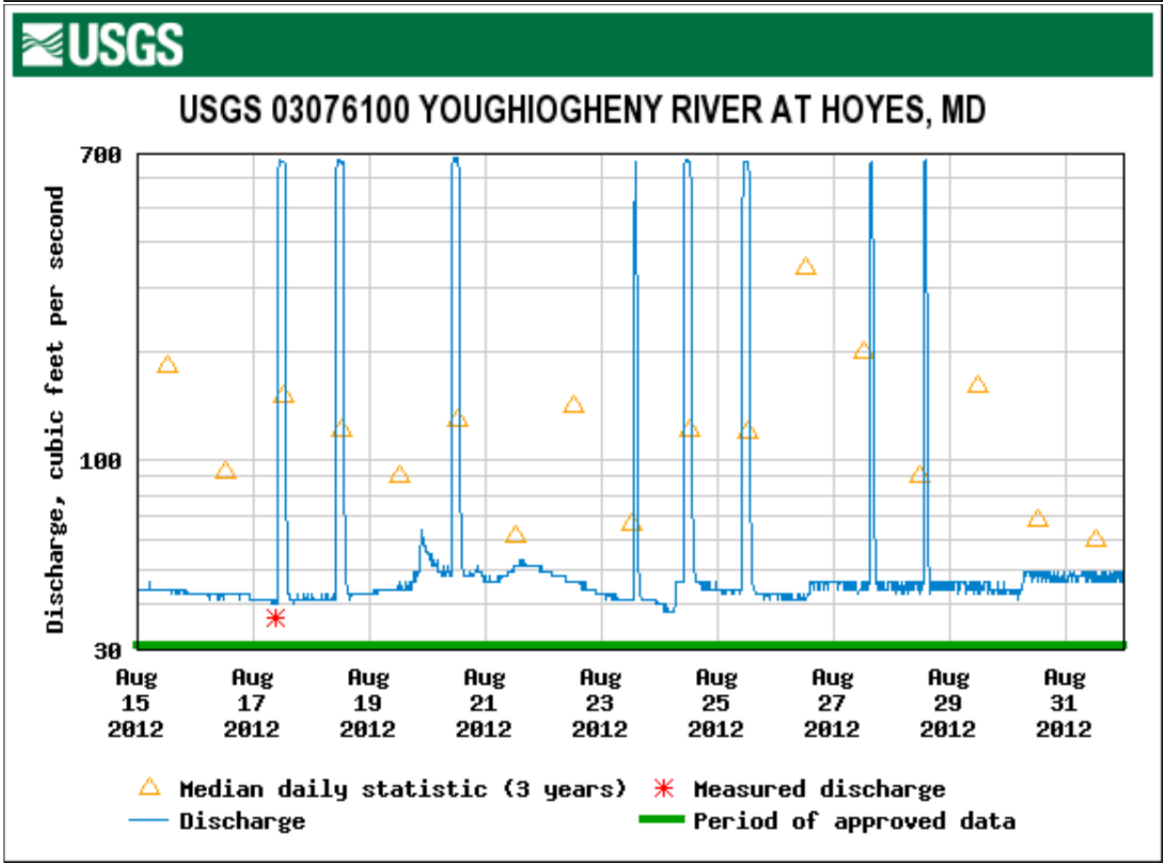

USGS 03076100 YOUGHIOGHENY RIVER AT HOYES RUN, MD
Discharge, cubic feet per second
800
100
40
Jun 02 2012
Jun 04 2012
Jun 06 2012
Jun 08 2012
Jun 10 2012
Jun 12 2012
Jun 14 2012
Jun 16 2012
---- Provisional Data Subject to Revision ----
Discharge
Measured discharge
Graph courtesy of the U.S. Geological Survey


USGS 03076100 YOUGHIOGHENY RIVER AT HOYES RUN, MD
Discharge, cubic feet per second
900
100
40
Jun 16 2012
Jun 18 2012
Jun 20 2012
Jun 22 2012
Jun 24 2012
Jun 26 2012
Jun 28 2012
Jun 30 2012
---- Provisional Data Subject to Revision ----
Discharge
Measured discharge
Graph courtesy of the U.S. Geological Survey


USGS 03076100 YOUGHIOGHENY RIVER AT HOYES RUN, MD
Discharge, cubic feet per second
800
100
30
Jun 30 2012
Jul 02 2012
Jul 04 2012
Jul 06 2012
Jul 08 2012
Jul 10 2012
Jul 12 2012
Jul 14 2012
---- Provisional Data Subject to Revision ----
Graph courtesy of the U.S. Geological Survey


USGS 03076100 YOUGHIOGHENY RIVER AT HOYES RUN, MD
Discharge, cubic feet per second
800
100
30
Jul 14 2012
Jul 16 2012
Jul 18 2012
Jul 20 2012
Jul 22 2012
Jul 24 2012
Jul 26 2012
Jul 28 2012
---- Provisional Data Subject to Revision ----
Discharge
Measured discharge
Graph courtesy of the U.S. Geological Survey


USGS
USGS 03076100 YOUGHIOGHENY RIVER AT HOYES, MD
Discharge, cubic feet per second
800
100
40
Jul 28 2012
Jul 30 2012
Aug 01 2012
Aug 03 2012
Aug 05 2012
Aug 07 2012
Aug 09 2012
Aug 11 2012
Aug 13 2012
Aug 15 2012
Median daily statistic (2 years)
Period of approved data
Discharge

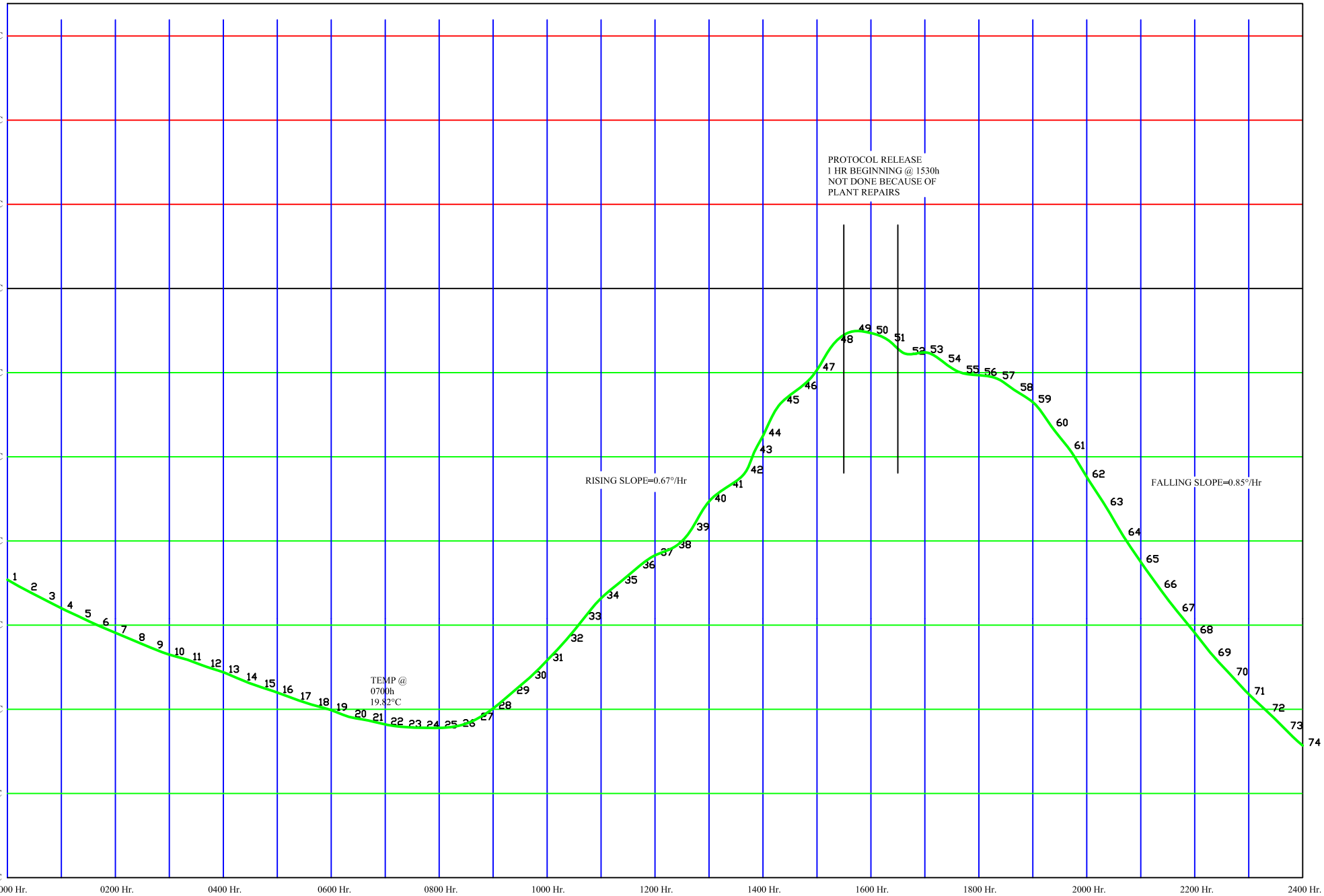

USGS
USGS 03076100 YOUGHIOGHENY RIVER AT HOYES, MD
Discharge, cubic feet per second
700
100
30
Aug 15 2012
Aug 17 2012
Aug 19 2012
Aug 21 2012
Aug 23 2012
Aug 25 2012
Aug 27 2012
Aug 29 2012
Aug 31 2012
Median daily statistic (3 years)
Measured discharge
Discharge
Period of approved data

TER RELEASE DATA 2012

Date	Start Time	Stop Time	Oklnd cfs	Hoyes cfs	Base Flo Hoyescfs	Bypass cfs	% Valve %	22.5° C Time	°Cmax	Peak Time	Line No.
10-Jun	1230	1430	24	68	68	0	0	1350	23.39	1450	1
13-Jun	None		36	70	70	0	0	1350	25.45	1740	2
16-Jun	1230	1430	19	57	57	0	0	1440	22.49	1440	3
19-Jun	1230	1430	87	290	290	0	0	1310	23.32	1420	4
20-Jun	1230	1430	42	105	105	0	0	1225	24.88	1440	5
21-Jun	1230	1430	30	74	74	0	0	1220	24.37	1450	6
24-Jun	1100	1300	29	76	76	0	0	1240	22.45	1240	7
28-Jun	1100	1300	15	49	43	6	27	None	20.82	1250	8
29-Jun	1100	1300	18	51	42	9	32	1150	23.92	1250	9
1-Jul	1230	1445	36	100	100	0	0	1110	25.43	1430	10
2-Jul	1230	1430	65	68	68	0	0	1120	25.72	1440	11
3-Jul	1230	1430	31	85	85	0	0	1100	26.54	1440	12
4-Jul	1100	1300	21	65	85	0	0	1100	24.96	1250	13
5-Jul	1100	1300	17	53	50	3	23	1130	24.11	1250	14
6-Jul	1100	1300	14	46	38	8	30	1015	26.01	*1300	15
7-Jul	1045	1400	12	40	29	11	35	1010	25.52	1250	16
8-Jul	1100	1315	11	41	27	14	39	1015	25.05	1250	17
9-Jul	1230	1430	16	46	34	12	36	1120	26.19	1410	18
10-Jul	1230	1430	19	48	45	3	23	1320	24.43	1450	19
11-Jul	1100	1300	14	41	33	8	30	1245	22.66	1250	20
15-Jul	1200	1300	17	40	34	6	27	1200	23.79	1350	21
16-Jul	1100	1300	57	49	49	0	0	1110	24.41	1250	22
17-Jul	1100	1300	30	90	90	0	0	1030	25.17	1240	23
18-Jul	1100	1300	18	53	50	3	23	1040	25.06	1250	24
19-Jul	1100	1300	17	42	34	8	30	1145	24.25	1250	25
22-Jul	1100	1300	34	71	71	0	0	1210	23.53	1910	26
24-Jul	1100	1300	17	47	41	6	27	None	22	1250	27
25-Jul	1215	1330	69	41	36	5	26	1230	24.76	1430	28
26-Jul	1100	1300	38	100	100	0	0	1110	24.44	1830	29
29-Jul	1230	1430	28	80	80	0	0	1210	25.35	1410	30
30-Jul	1100	1300	20	60	52	0	0	1240	23.23	1840	31
31-Jul	1230	1430	21	48	40	8	30	1310	23.8	1420	32
2-Aug	1100	1300	51	150	150	0	0	1155	24.65	1900	33
5-Aug	1230	1430	22	50	48	2	22	None	22.06	120	34
7-Aug	1230	1430	85	200	200	0	0	1150	24.78	1420	35
8-Aug	1230	1430	42	100	100	0	0	1245	24.5	1430	36
9-Aug	1100	1300	30	66	66	0	0	1150	23.6	1250	37
13-Aug	1530	1630	20	51	51	0	0	1415	25.98	1740	38
23-Aug	1415	1515	13	40	31	9	32	1400	24.74	1640	39
27-Aug	1600	1715	8.7	44	26	18	44	1340	25.64	1800	40
28-Aug	1400	1515	8.2	42	24	18	44	1220	25.5	1600	41
Date	Start	Stop	Oklnd	Hoyes	Base Flo	Bypass	% Valve	22.5° C	°Cmax	Peak	

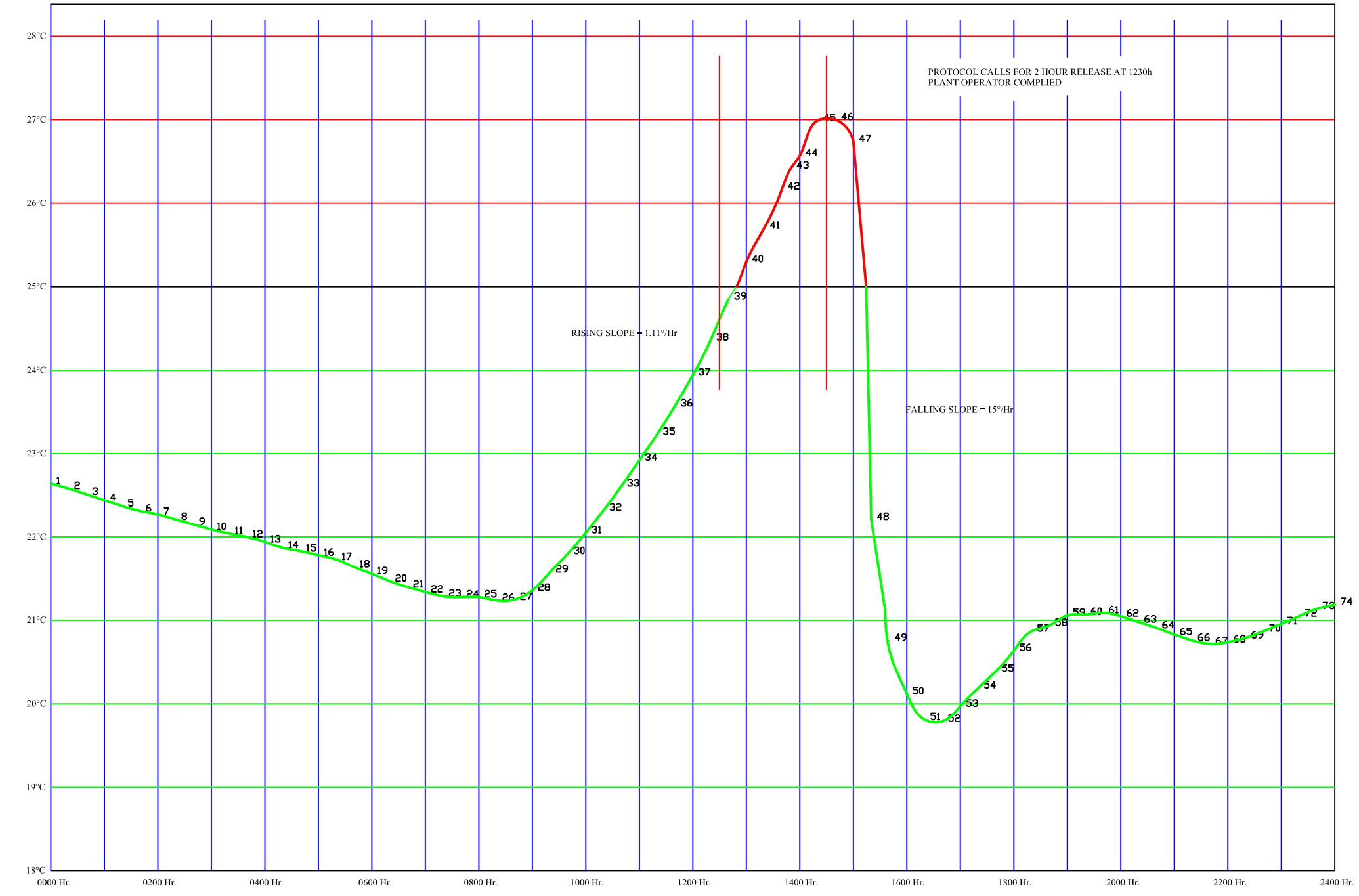
*Second Excursion 6 July @ 1920h, 25.15°C

41 TER DATES, 15 TEMPERATURE EXCURSIONS, ~ 36% OF DAYS



1 JUNE 2011 TEMPERATURE EXCURSION ANALYSIS MADE 17 JANUARY 2014, FROM BROOKFIELD ANNUAL REPORT, NOT TO SCALE M.C. FRANCE

LAKE\Brookfield\TER<SPORE\1June TempVsTime\1JuneTempVsTime.dwg



26 JULY 2011 TEMPERATURE EXCURSION ANALYSIS MADE 17 JANUARY 2014, FROM BROOKFIELD ANNUAL REPORT, NOT TO SCALE M.C. FRANCE

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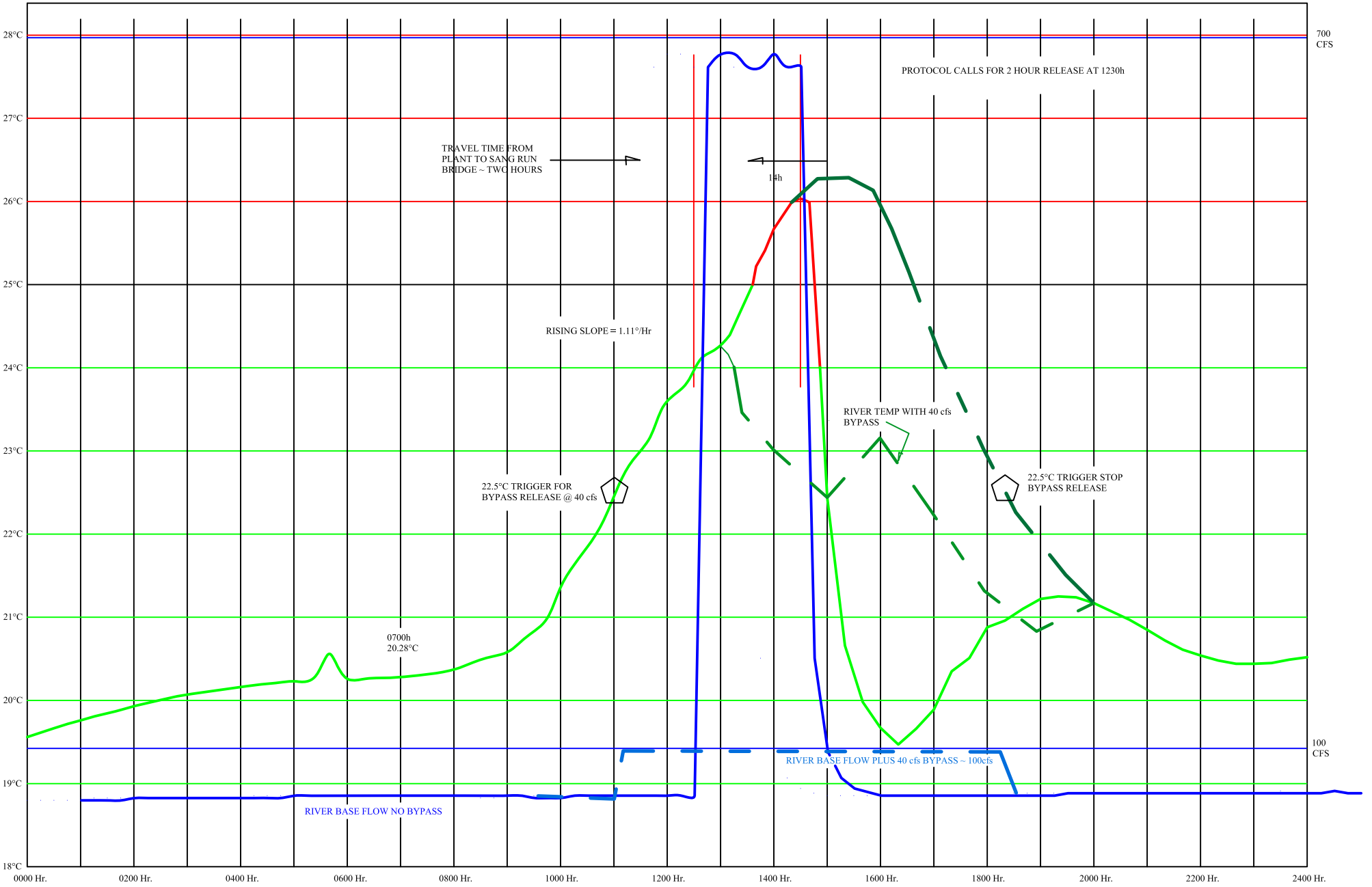

4 AUGUST 2011 TEMPERATURE EXCURSION ANALYSIS MADE 18 Mrch 2014, FROM BROOKFIELD ANNUAL REPORT, NOT TO SCALE M.C. FRANCE

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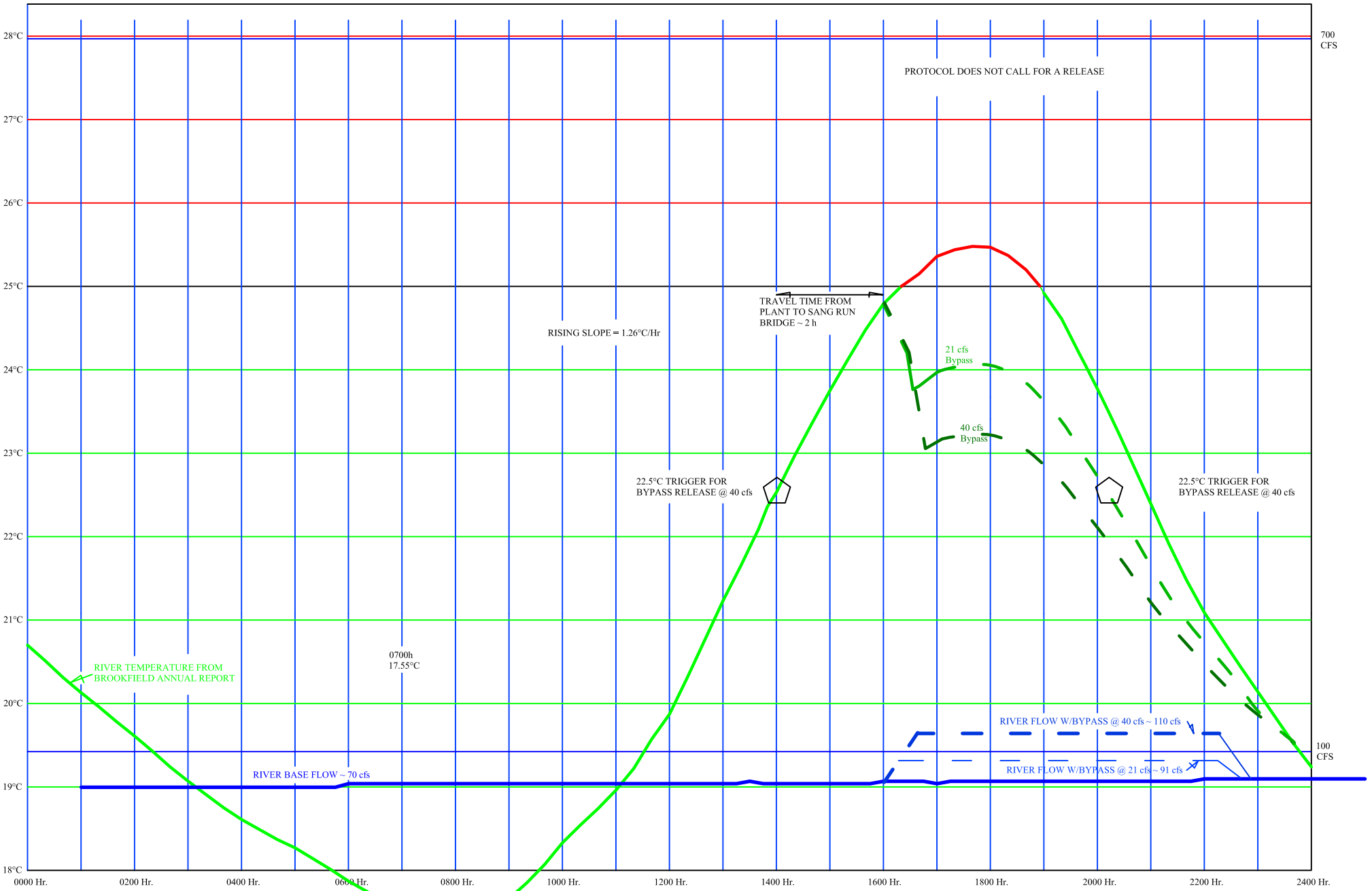
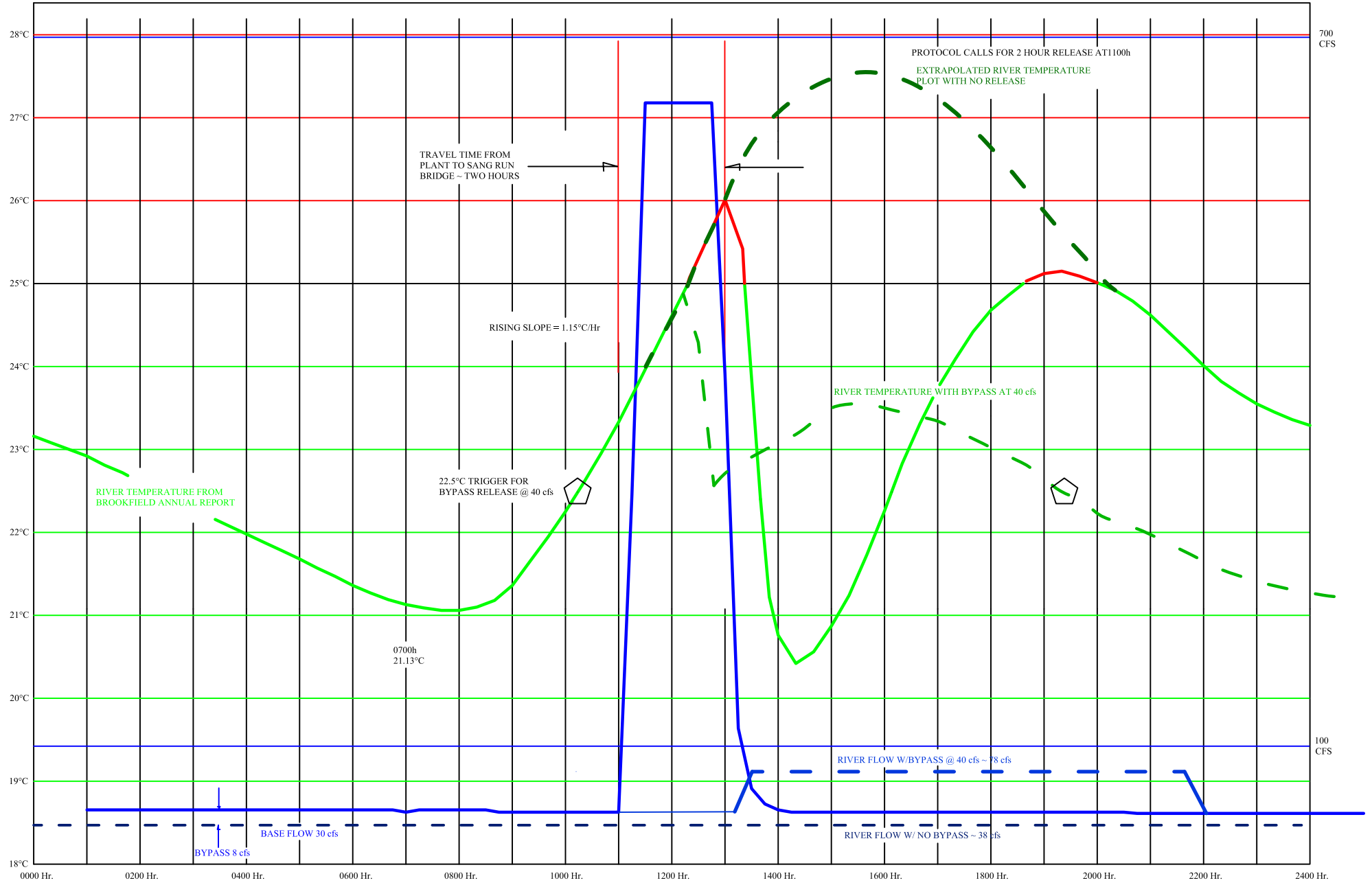


13 JUNE 2012 TEMPERATURE EXCURSION ANALYSIS MADE 15 MARCH 2014, FROM BROOKFIELD ANNUAL REPORT, NOT TO SCALE M.C. FRANCE

LAKE\Brookfield\UER-SPORE\2012\AnalysisBrokfDam13June12\13Jun12 TempVsTime15Mar14.dwg



6 JULY 2012 TEMPERATURE EXCURSION ANALYSIS MADE 15 MARCH 2014, FROM BROOKFIELD ANNUAL REPORT, NOT TO SCALE M.C. FRANCE

L:\AKE\Brookfield\TDR-SPORE\ 2012\analysis\Brkd\Data\6JULY12 \6July12TempVsTime15Mar14.dwg