

Appendix M

Dworshak Summer Operations

D) INTRODUCTION

Each year, the Water Quality Unit (WQU) of the Reservoir Control Center (RCC) provides technical information and analysis to the Regional Forum Technical Management Team (TMT) in support of the Lower Snake River summer flow augmentation and temperature control operations at Dworshak dam. These operations are in accordance with the Biological Opinions for anadromous fish recovery in the Columbia River watershed, the most recent of which was completed in 2004. As part of this assistance during the summer of 2006, the Water Quality Unit provided TMT with Snake and Clearwater River flow rates and water temperatures, Dworshak reservoir thermocline data, and analyses related to impacts of potential operational actions at Dworshak dam. Utilizing this information, members of TMT developed recommendations concerning Dworshak outflow rates and temperature targets as part of the drafting of the reservoir from 1599.3 feet on June 28th to 1520.2 feet on September 13th. TMT notes documenting the discussions concerning Dworshak operations can be found at the website: <http://www.nwd-wc.usace.army.mil/tmt/agendas/2006/>.

A) Actual Operations and Final Results:

The management of Dworshak outflows during the summer of 2006 was similar to operations that have occurred in recent years, continuing with the trend to use cooler releases for a longer period of time. The following discussion of the 2006 actual operations includes: Dworshak flow augmentation and temperature control operations and Lower Snake River tailwater temperatures.

1) Dworshak Flow Augmentation and Temperature Control Operations

Table M-1 (next page) describes the Dworshak flow augmentation and temperature control operations that occurred in 2006. The table provides start and end dates for each operational change, range of outflow rates, and outflow target temperature which occurred during each operational condition. Also included was how the selector gate for each generating unit was positioned during the operation. When the selector gate is set in the undershot mode, water is drawn into the reservoir at a specific elevation (upper edge and lower edges at elevations of 1435 and 1395 ft, respectively). However, when the selector gate is positioned in overshot mode, water can be drawn from the reservoir at varying depths (with the lowest being 1465 feet) up to no shallower than 35 feet below the current surface water elevation.

28 June 2006: Dworshak summer (flow augmentation/temperature control) operations began on June 28th when it was observed that Lower Granite tailwater temperatures were rising rapidly and was expected to exceed 68° F within a few days. The issue was discussed at the June 28th TMT meeting where it was agreed that the project would maintain outflows at 7.4 kcfs (one large unit and one small unit) and reduce temperatures from 48° F to about 43° F. It was also agreed that should the rolling 24-hr average tailwater temperature at Lower Granite exceed 67° F, then the project would go to full powerhouse operations (about 9.5 kcfs).

Table M-1: Dworshak Flow Augmentation/Temperature Control Operations in 2006.

Operation Start		Operation End		Outflow (kcf)	Outflow Target Temperature (°F)	Selector Gate Position [§]		
Date	Time (hrs)	Date	Time (hrs)			Small Unit	Small Unit	Big Unit
28 June	1600	29 June	2200	7.3 – 7.5	42.5 – 43.5	O	--	U
29 June	2200	30 June	1100	9.3 – 9.5	42.5 – 43.5	O	U	U
30 June	1100	4 July	1200	4.2 – 4.3	42.5 – 43.5	O	U	--
4 July	1200	5 July	1100	7.4	42.5 – 43.5	O	--	U
5 July	1100	7 July	1600	9.4 – 9.5	42.5 – 43.5	O	U	U
7 July	1600	July 19	1200	11.2 – 11.4	42.5 – 43.5	O	U	U
19 July	1200	24 July	2100	13.6 – 14.0	42.5-43.5	O	U	U
24 July	2100	31 July	1100	11.9 – 12.0	Lowest Possible	U	U	U
31 July	1100	22 Aug	2200	9.8 – 10.3	Lowest Possible	U	U	U
22 Aug	2200	6 Sep	2200	7.7 – 7.8	Lowest Possible	--	U	U
6 Sep	2200	12 Sep	2200	5.9 – 6.0	Lowest Possible	--	--	U
12 Sep	2200	13 Sep	2200	2.4	Lowest Possible	U	--	--
13 Sep	2200	End of Season		1.5	Lowest Possible	U	--	--

[§] U = Undershot, O = Overshot.

This information is shown graphically on Figure M-7.

29 June 2006: Because the Lower Granite tailwater temperatures exceeded the 67° F trigger criteria set the previous day, Dworshak outflows were increased to full powerhouse (about 9.5 kcf) with a target temperature of 43° F.

30 June 2006: Due to moderating weather conditions and with these conditions expected to continue over the next several days, river temperatures at upstream gauging locations were decreasing (at Anatone and Orofino). Based on this, on a TMT conference call, it was agreed that Dworshak outflows would be decreased from full powerhouse down to about 4.2 kcf (two small units). Outflow temperatures would continue to target 43° F. It was also agreed that the rolling 24-hr average trigger of 67° F for Lower Granite tailwater would remain in effect. An additional trigger of a rolling 24-hr average temperature of 70° F at the Anatone gauge would be in effect at least until July 2nd. If either of these triggers were exceeded, Dworshak outflows would be increased to 7.4 kcf (one large and one small unit).

4 July 2006: In the morning, the 24-hour rolling average temperature at Anatone exceeded the 70° F criteria trigger. As a result, project outflows were increased to 7.4 kcf. The outflow temperature target remained at 43° F.

5 July 2006: After a lengthy discussion of Dworshak operations and upcoming regional weather conditions, it was decided at the TMT conference call on July 5th to increase flows to full powerhouse (~9.4 kcf) with a target temperature of 43° F.

7 July 2006: Due to expected warmer climatic conditions in the region over the next few days, it was recommended at the TMT conference call that Dworshak

flows be increased by about 2 kcfs. Due to the fact that two units were set in undershot mode and one in overshot (with the gate nearly all the way down) was generating outflow temperatures of about 43° F, it was decided to pass this additional water through the regulating outlets rather than spilling over the spillway. The one small unit would remain in an overshot mode and set to achieve an outflow temperature of 43° F.

19 July 2006: Due to expected warmer climatic conditions in the region over the next few days, it was agreed at TMT that outflows through the regulating outlets would be increased to as close to 4.5 kcfs as possible while keeping TDG levels at the Dworshak tailwater gauge below 110% (as per instructions from the Idaho Department of Environmental Quality, the operators targeted 109% TDG).

24 July 2006: At the July 24th TMT meeting, NOAA Fisheries recommended reducing total discharge to 12 kcfs (full powerhouse + 2.3 kcfs through the regulating outlets). Based on information concerning moderating weather conditions, low flows at Orofino, and Anatone and diminishing augmentation volumes remaining in the reservoir, all participating agencies agreed to this operation. With respect to temperatures, it was agreed that all selector gates would be set in undershot mode. While it was uncertain what temperatures would result, it was estimated that the outflow temperatures would be around 42° to 42.5° F. This was acceptable to all participants.

26 July 2006: At the July 26th TMT meeting, it was agreed that Dworshak would continue the current operations through mid-night on July 29th (Friday). At that point, flows would be reduced to 11 kcfs (full powerhouse + about 1.3 kcfs through the regulating outlets). However, during the day on the 29th, the Chair of the Salmon Managers (Russell Keifer, Idaho Department of Fish and Game) requesting that the current operations be maintained through the weekend. The Corps agreed to do so.

31 July 2006: At a TMT Conference Call, the Salmon Managers recommended a reduction to full powerhouse (about 9.5 kcfs) with all selector gates in undershot mode.

22 August 2006: At the August 16 TMT meeting, the Nez Perce tribe, citing uncertainties regarding Snake River water temperatures and continued warm climatic conditions, recommended keeping Dworshak outflows at full powerhouse (about 9.5 kcfs) at the lowest possible temperature (all gates in undershot) until the evening of August 22nd and then reduce flows to 7.7 – 7.8 kcfs at the same outflow temperatures (using one small unit and the big unit, both in undershot). This recommendation was unanimously approved by all Fish Passage Advisory Committee members present at the meeting.

6 September 2006: August 30th meeting, the recommendations of the Dworshak Operations Board were discussed for the operation of Dworshak for the remainder

of the augmentations season. The agreement resulted in keeping Dworshak outflows at about 7.6 kcfs with temperatures between 46.5 and 47.5 until September 6th when flows would be ramped down to about 5.4 (using the one large unit) and keeping it there until the forebay reached 1521 feet. Flow would then be reduced to about 2.4 kcfs for 1 or 2 days until elevation 1520 feet was reached.

12 September 2006: Due to the forebay elevation reaching 1521 feet, flows were reduced to 2.4 kcfs.

13 September 2006: Due to the forebay elevation reaching 1520 feet, flows were reduced to minimum flows (about 1.4 kcfs). This marked the end of the flow augmentation season.

Table M-2 provides a comparison of the 2006 Dworshak operations with the previous seven summer seasons (through the year 2000). As is shown, this season's operations were fairly similar to the previous seasons. Prominent deviations from this average include the total number of days of flow augmentation (78.3 day this year as compared to a seven year average of 71 days) and the temperatures of the outflow waters (45.0° F as compared to a seven year average of 46.9° F). This has been a trend of the last several years where colder waters are being utilized to provide maximum cooling efficiency in the Lower Snake River. In fact, average outflow temperatures in 2006 were the coolest with respect to all years since 2000.

One noticeable characteristic of this years operation was the generally warmer water in the Dworshak reservoir as compared to the previous two seasons. Figure M-1 provides a thermocline representation of how water temperatures within the Dworshak reservoir changed over the course of the 2006 summer season. Figures 2 through 4 provide a comparison of the Dworshak reservoir 2006 thermocline at the beginning of the season (end of June), the middle of the season (end of July), and at the end of the season (middle September) with the thermoclines near those dates from the previous two years. These graphs show that over the entire summer season, the forebay temperatures in 2006 were 2° to 4° F greater than they were in the previous two years. The cause of this is currently unknown. It may simply be that this years climatic conditions were significantly warmer than in the previous two years. It could also be that the act of pulling cold water from depth over the past several years has resulted in a depletion of these waters that lingers through the winter season. If true, and Dworshak outflows are continued to be managed as they have been for the past several years, this could result in a progressive depletion of the cooler waters from the reservoir which would limit the ability to manage downstream water temperatures in the future. This issue needs to be investigated further.

2) Lower Snake River Tailwater Temperatures

Due to rapidly rising tailwater temperatures at Lower Granite dam, the Dworshak flow augmentation/temperature control operations began on June 28th at 1600 hours. Figure M-5 provides a graphic representation of the outflows and tailwater temperatures at Dworshak and tailwater temperatures at all of the Lower Snake River projects from April 1st through September 30th. Figure M-6 shows the Dworshak outflow temperatures, temperatures measured at the Orofino and Anatone gauges, and Lower Granite tailwater temperature. This is essentially the temperatures of the inflows into Lower Granite reservoir and the resultant outflow temperatures at the dam itself. Table M-3 provides water temperature characteristics measured at a number of Snake River basin monitoring sites. The highest hourly temperature measured was at Orofino where water temperatures reached 83.5° F. Temperatures measured at Anatone were the second highest with peak temperatures reaching 77.3° F. The maximum hourly temperature that occurred at the Lower Granite tailwater was 69.5° F. Peak hourly temperature at Ice Harbor tailwater was 72.8° F. Given the high input temperatures coming from the Clearwater River Mainstem and the Middle Snake River, the temperature control operations performed using Dworshak outflows were fairly successful. Figure M-8 shows the temperature request with the resultant temperatures.

Overall, Lower Granite tailwaters exceeded the hourly 68°F criteria for a total of 223 hours, however, since the peak temperature was only 69.5° F, the degree to which the criteria was exceeded was low. This is represented by the “Cumulative Index of Exceedance (CIE).” The CIE is calculated by the sum of the hourly exceedances multiplied by the degree to which the 68° F criteria was exceeded [$CIE = \sum(\text{hours of exceedance}) \times (\text{Hourly exceedance} - 68^\circ \text{ F})$]. Even though Ice Harbor tailwater exceeded the 68° F temperature criteria for a greater number of hours than did the waters at Orofino, the CIE at Orofino was 8,543 whereas only 3,868 at Ice Harbor. Orofino exceeded the criteria to a much greater extent than did the Ice Harbor tailwaters.

Table M-4 provides a comparison of Lower Snake River temperatures as compared to previous years. In 2006, Lower Granite tailwater exceeded the 68° F criteria a total of 223 times. This is the most since the Dworshak flow augmentation/temperature control operations began.

Table M-2

Dworshak Flow Augmentation / Thermal Reduction Data

Parameter	2000	2001	2002	2003	2004	2005	2006	Average
Flow Augmentation Start Date	6/30/00 1:00	7/2/01 6:00	7/8/02 16:00	7/1/03 23:00	6/30/04 8:00	6/30/05 23:00	6/28/06 16:00	--
Flow Augmentation End Date	9/1/00 1:00	8/30/01 2:00	9/12/02 1:00	9/14/03 23:00	9/20/04 8:00	9/17/05 23:00	9/13/06 22:00	--
Number of Days of Augmentation	63.0	58.8	65.4	75.0	82.0	79.0	78.3	71
Beginning Forebay Elevation (ft)	1598.8	1587.5	1599.2	1600.0	1599.8	1600.0	1599.3	--
Average Outflow (kcfs)	11.4	9.5	12.7	9.6	9.5	8.9	9.4	10.3
Flow Augmentation Volume (KAF)	1428	1115	1653	1430	1548	1394	1431	1428
Average Inflow (kcfs)	2.0	1.9	3.5	1.6	2.4	1.5	1.7	2.2
Inflow Volume (KAF)	253	227	448	234	395	232	255	298
Outflow minus Inflow (KAF)	1174	889	1205	1196	1153	1162	1176	1130
Seasonal Ave Outflow Temp (C)	9.1	8.8	8.8	7.4	7.7	7.6	7.2	8.2
Seasonal Ave Outflow Temp (F)	48.3	47.8	47.8	45.7	45.8	45.7	45.0	46.9
Total Cooling Units (KAF-C)	15,688	12,517	18,611	17,998	19,294	17,409	18,493	16,920
Total Cooling Units (KAF-F)	28,238	22,530	33,500	32,397	34,729	31,335	33,288	30,455

Cooling Unit (CU) = The volume weighted amount that outflow waters are less than the State temperature criteria of 68 F.

[i.e. CU = (Outflow Volume in KAF)x(The degree that the temperature of that volume of water is less than 68 F)]

CU = (Volume in KAF) x (Water Temp - 68 F)

Figure M-1

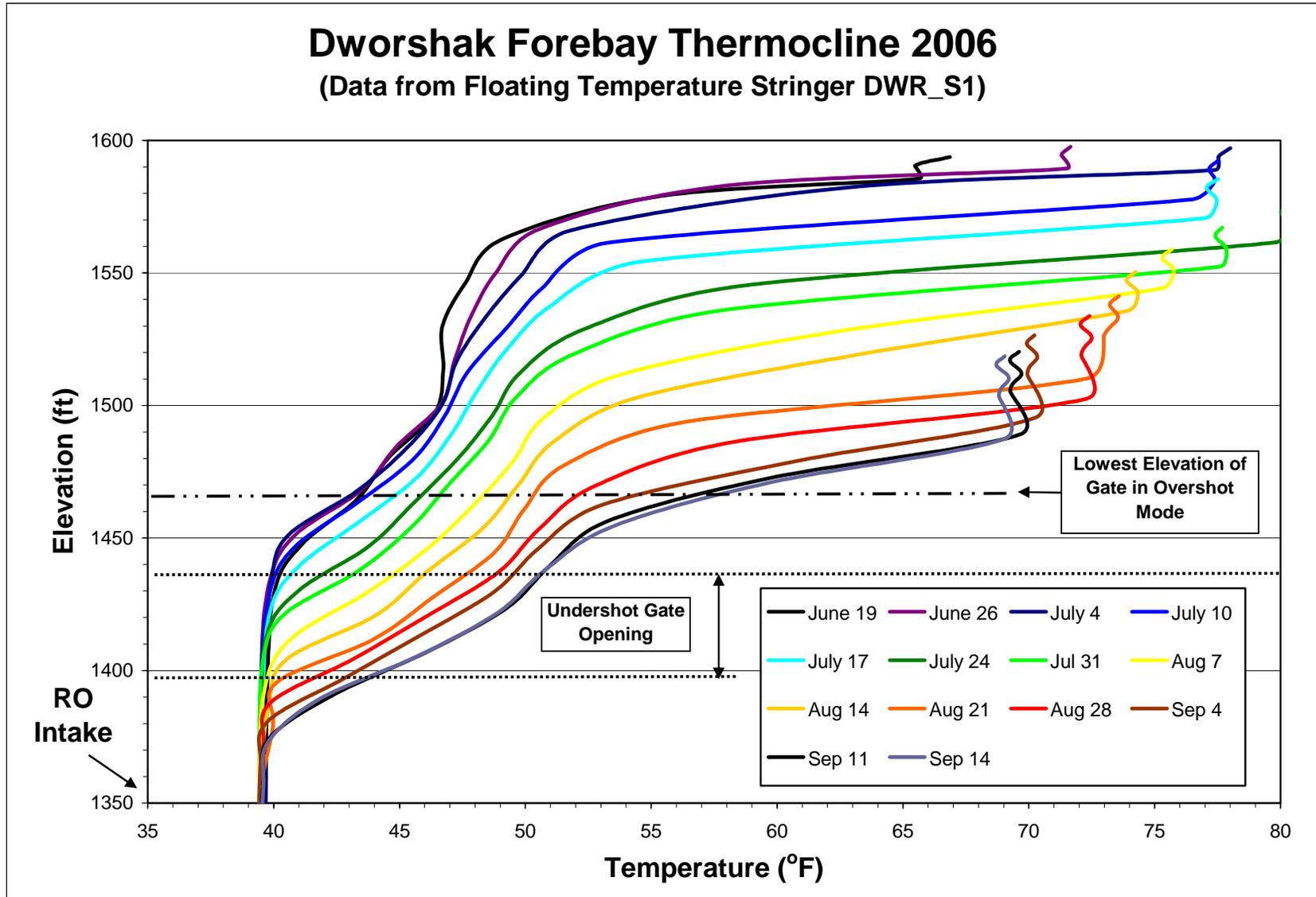


Figure M-2

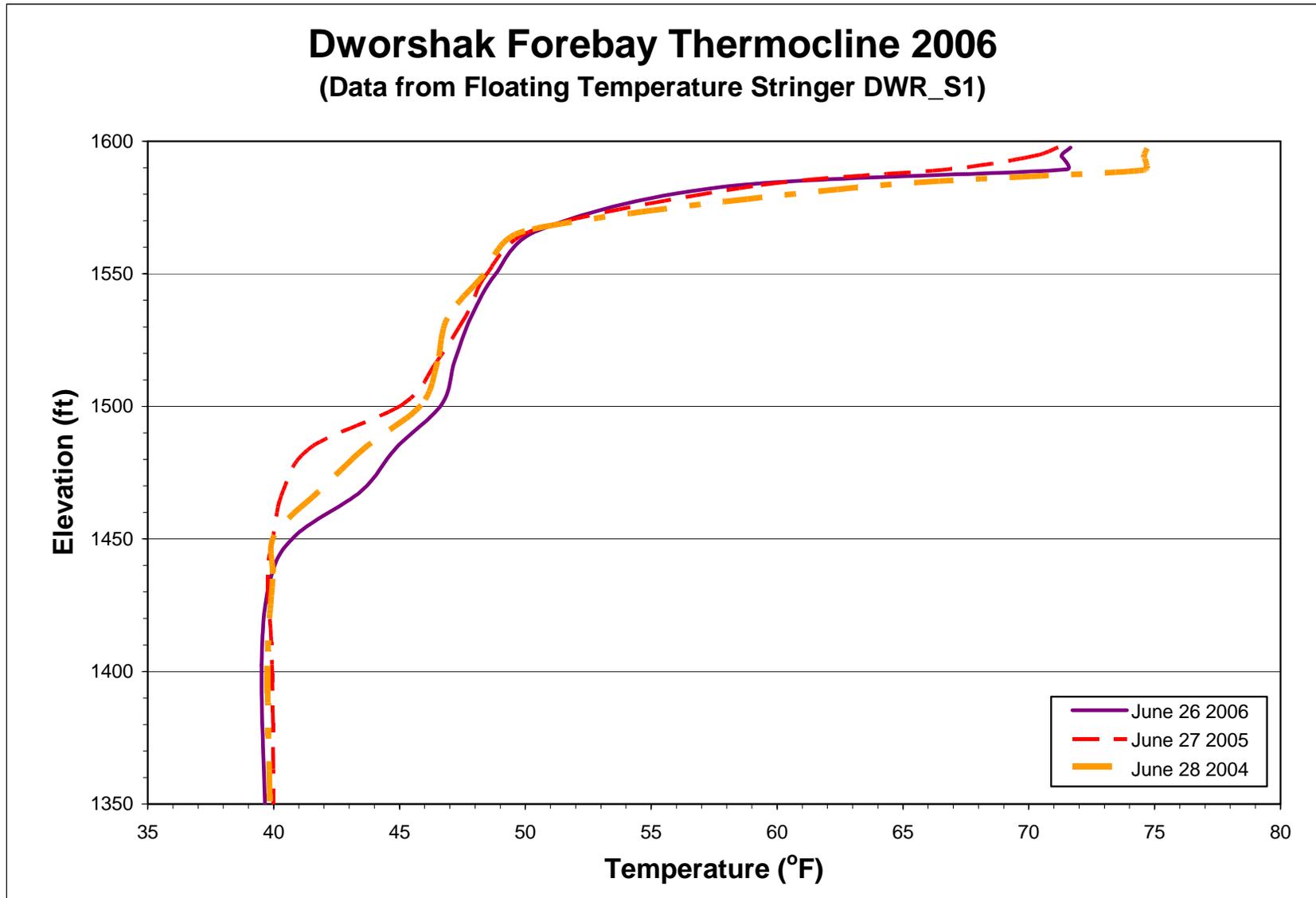


Figure M-3

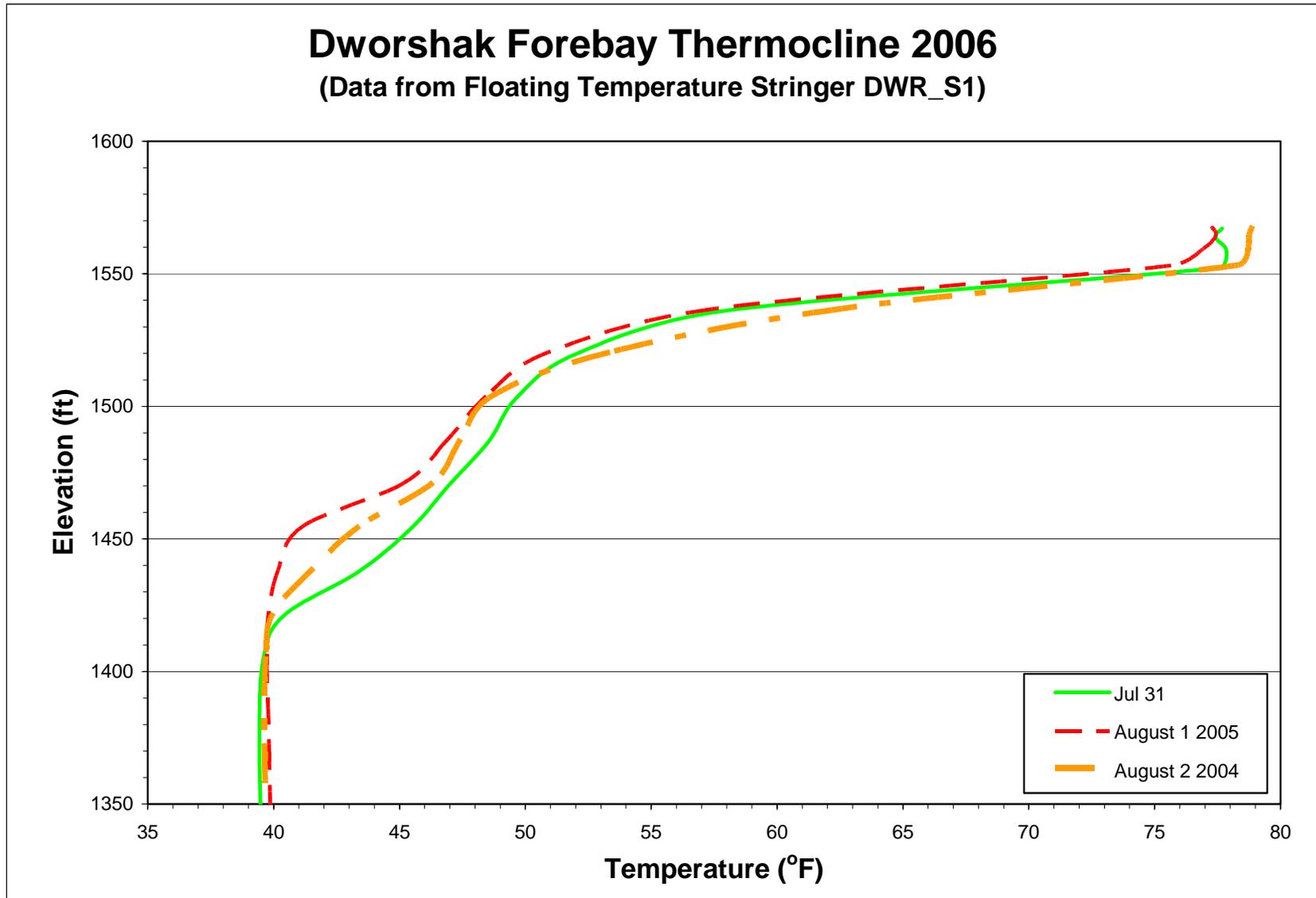


Figure M-4

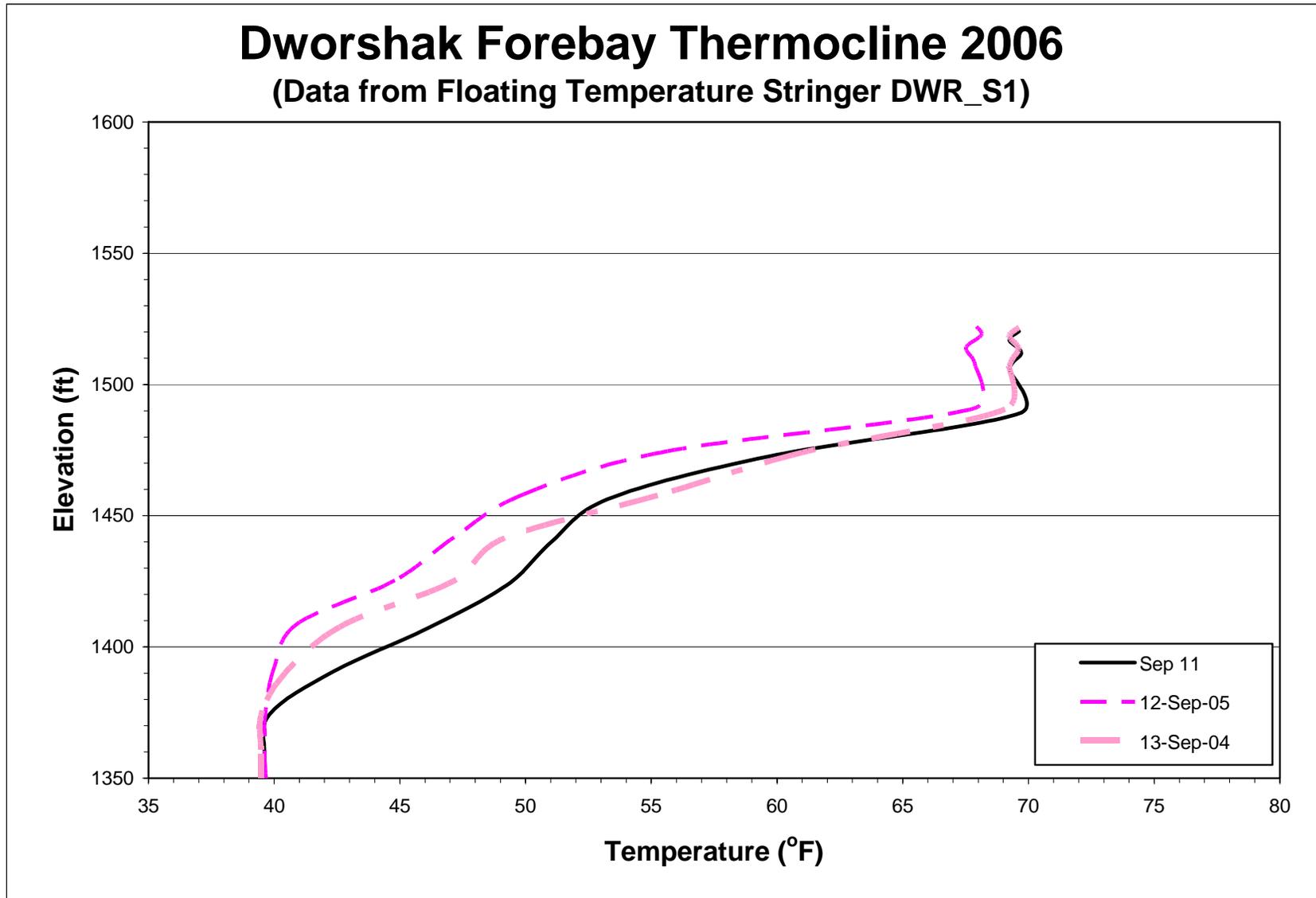
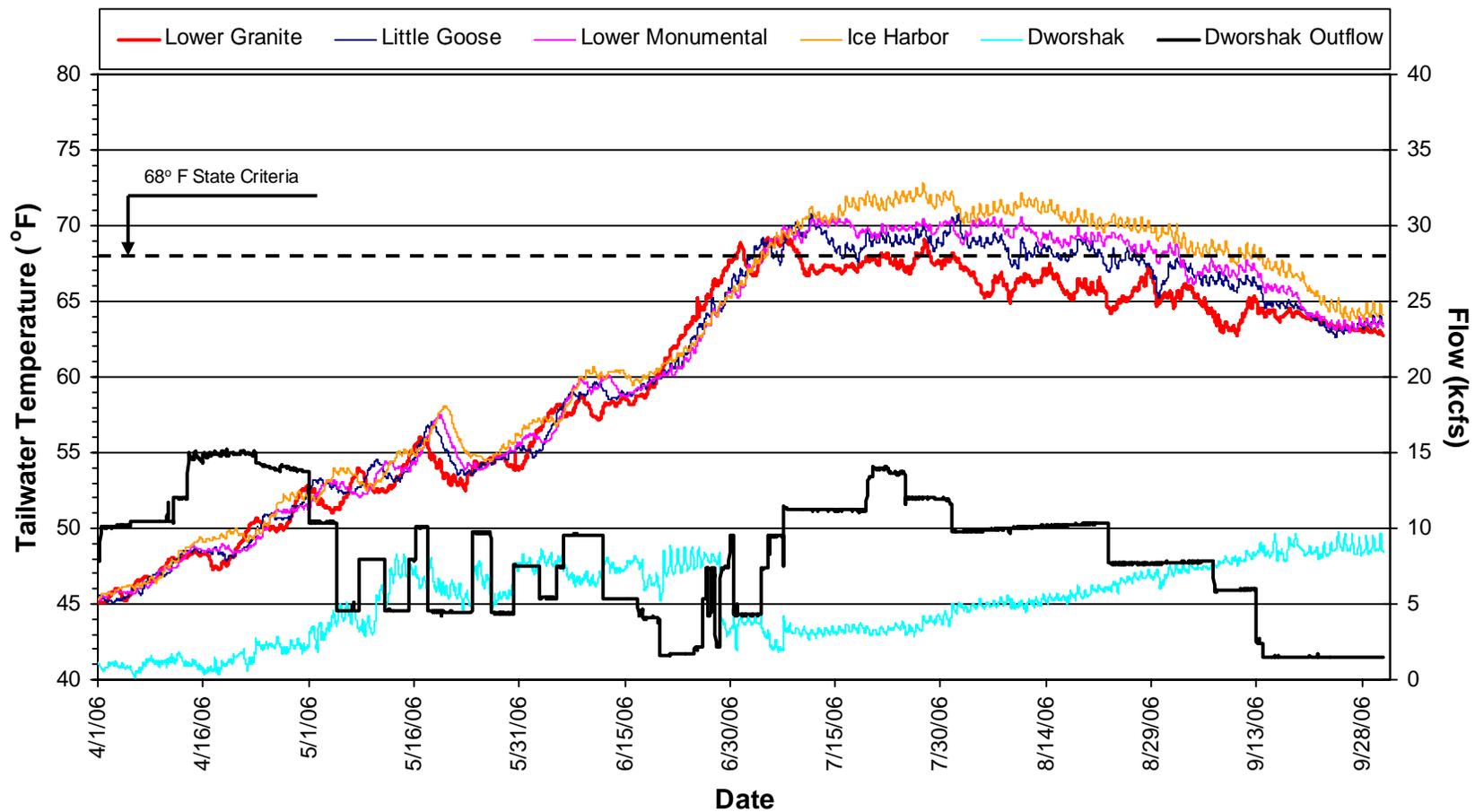


Figure M-5
Dworshak Outflows and Lower Snake River Tailwater Temperatures in 2006
(April 1 - September 30)



**Figure M-6
Lower Granite Inflows and Temperatures in 2006**

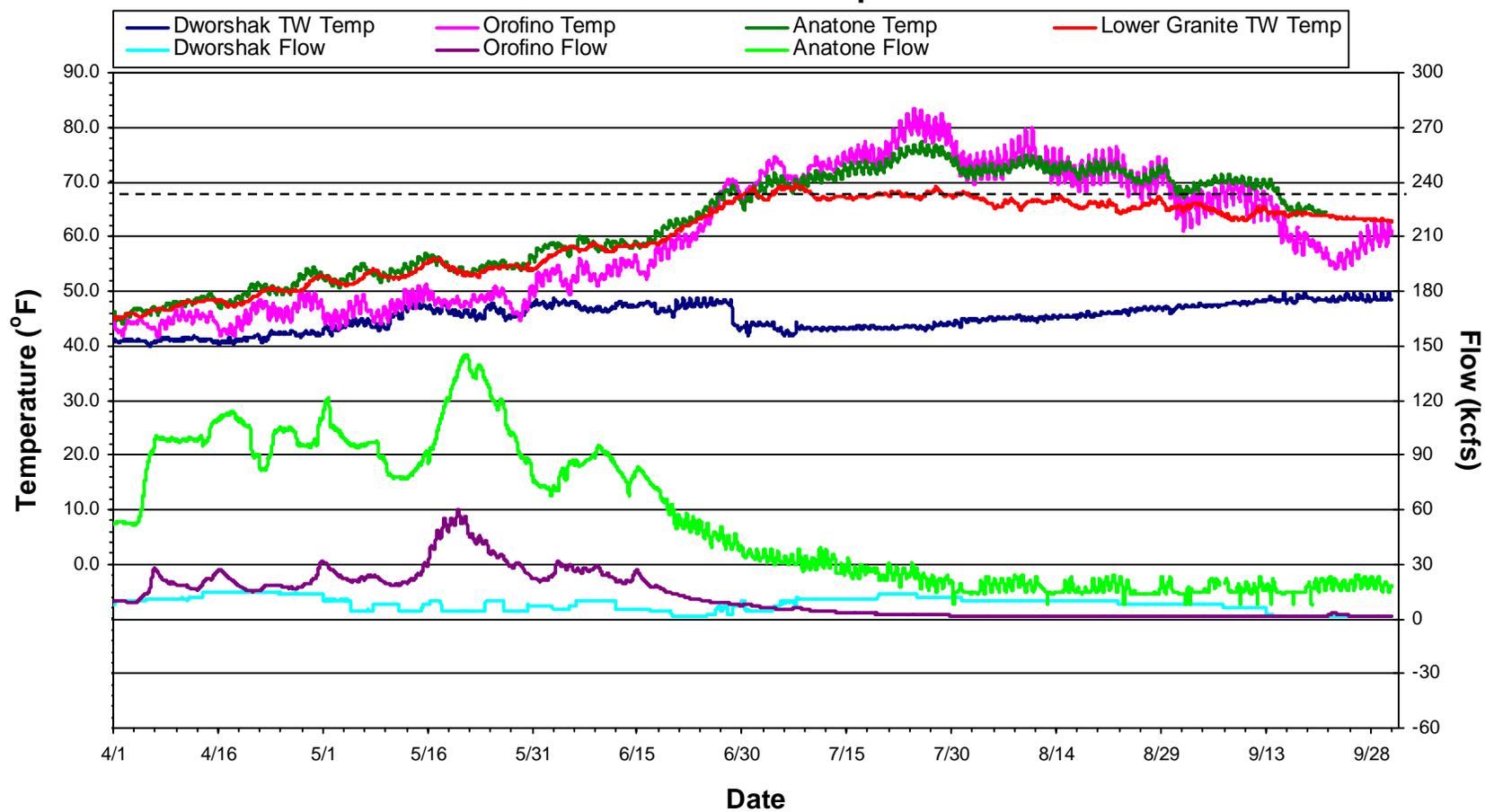


Table M-3
2006, April 1 - September 30
Daily Average and Hourly Temperature Exceedance Information

Location	24 Hour Average Data			Hourly Data					
	Date of 1st 24hr Average Over 68 F	Date of Last 24hr Average Over 68 F	Number of Days With 24hr Average Over 68 F	Date of 1st Hour Over 68 F	Date of Last Hour Over 68 F	Number of Hours Over 68 F	Cumulative Index of Exceedance	Maximum Hourly Temp	Date of Maximum Hourly Temp
ORFI	6/28/06	09/07/06	64	6/27/06	9/12/06	1555	8543.0	83.5	7/24/06
DWQI	NA	NA	0	NA	NA	0	0.0	49.8	9/24/06
ANQW	6/28/06	09/14/06	76	6/27/06	9/14/06	1802	6715.0	77.3	7/25/06
LGNW	7/1/06	07/28/06	8	6/30/06	7/31/06	223	131.0	69.5	7/7/06
LGSW	7/3/06	08/25/06	48	7/2/06	8/27/06	1075	990.0	70.8	7/11/06
LMNW	7/5/06	09/01/06	59	7/4/06	9/1/06	1407	2070	70.6	8/6/06
IDSW	7/5/06	09/13/06	69	7/4/06	9/13/06	1638	3868	72.8	7/27/06
PAQW	7/24/06	09/13/06	38	7/24/06	9/13/06	863	799	70.5	8/22/06

* NA: Not Applicable since temperatures did not exceed 68 F.

**Table M-4
Lower Granite Tailwater State Temperature Criteria Exceedance Comparison
(in Degrees Fahrenheit)**

Annual Statistics			12-yr Statistics		
Year	Hours of Exceedance	Index of Exceedance	Hours of Exceedance	Index of Exceedance	
2006	223	131	Range: High: 981 hrs (1998) Low: 0 hrs (2000, 2005)	Range: High: 1,721 degree-hrs (1998) Low: 0 degree-hrs (2000, 2005)	
2005	0	0			
2004	7	2			
2003	63	14	Average:	249 hrs	Average: 303 degree-hrs
2002	17	4			
2001	172	123	Average 1995-1999:	452 hrs	Average 1995-1999: 552 degree-hrs
2000	0	0			
1999	23	6	Average 2000-2006:	80 hrs	Average 2000-2006: 46 degree-hrs
1998	981	1721			
1997	137	56			
1996	526	613			
1995	593	363			

Note: The Lower Granite tailwater gauge went down on 9/1/97 at 1600 hrs and did not report any further data for the rest of the year. The last temperature recorded was 69.1 F. Therefore, the 1997 Exceedance Index value should be slightly higher.

Figure M-7
2006 Dworshak Summer Operation

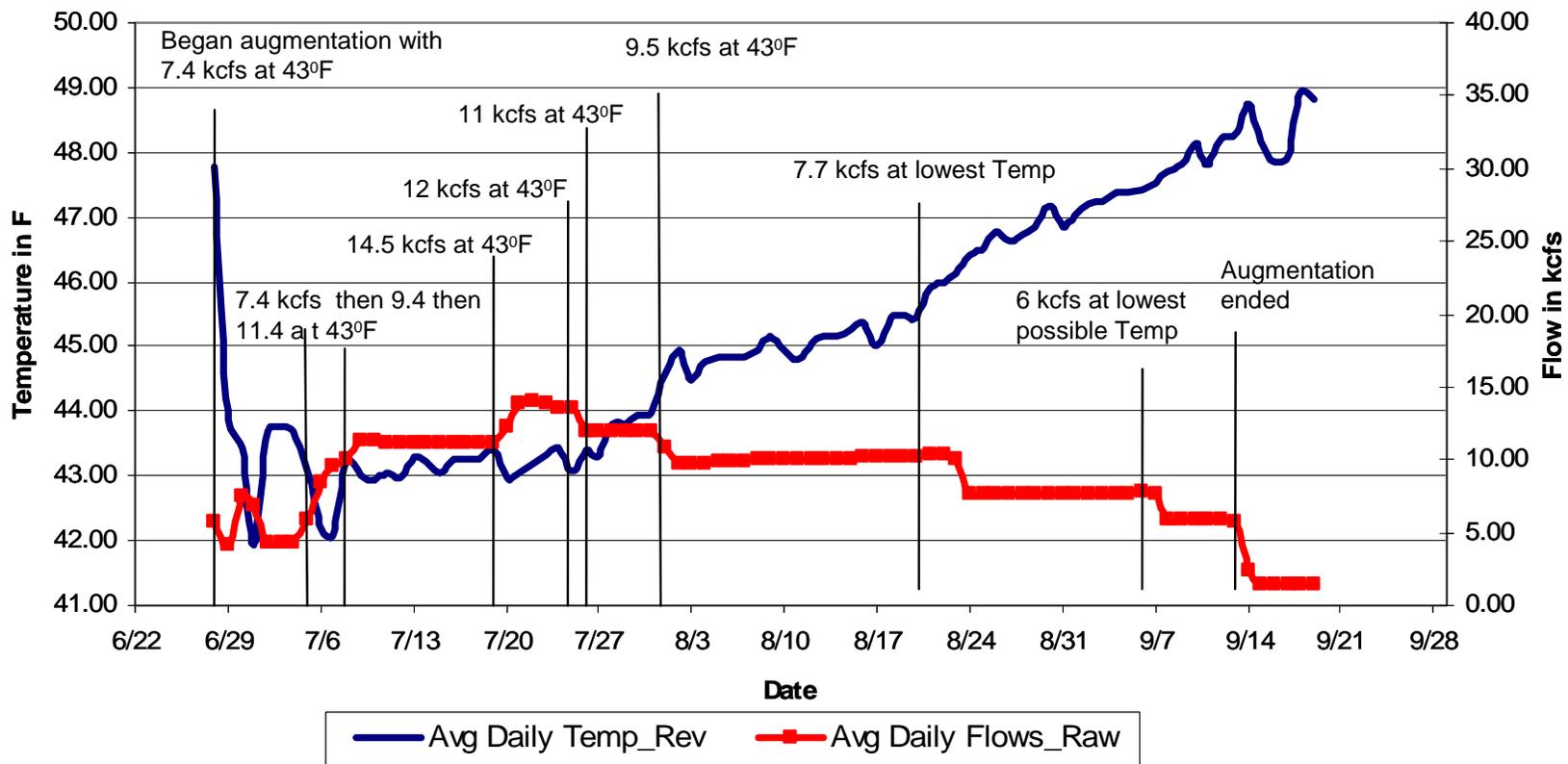


Figure M-8

