Appendix I

Dworshak Summer Operations

I) INTRODUCTION

In the 2008 water year, Reservoir Control Center (RCC) staff, with technical assistance from the Hydraulics and Hydrology Branch of the Walla Walla District USACE, provided 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 on the North Fork of the Clearwater River. These operations were in accordance with the 2000 and 2004 Biological Opinions (BiOps) for anadromous fish recovery in the Columbia River watershed. As part of this assistance during the summer of 2008, RCC 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. The Walla Walla District (NWW) and the Engineer Research and Development Center (ERDC) provided CE-QUAL-W2 model results showing projected temperatures from Dworshak discharge schedules. Utilizing this information, members of TMT developed recommendations concerning Dworshak outflow rates and temperature targets to meet the objectives outlined in the 2004 BiOp and the 2008 Water Management Plan. These objectives included filling the reservoir to 1600 feet by 30 June (as per agreement in the Regional Forum TMT, the reservoir reached full on 7 July at an elevation of 1599.9 feet); and draft the reservoir for summer temperature and flow augmentation to 1535 ft by 31 August (the reservoir was drafted to 1535.3ft on 31 August). The purpose of the summer temperature and flow augmentation is to improve conditions for fish in the Lower Snake River by reducing water temperatures and increasing water velocities.

Additionally, the 2008 Dworshak Operation Plan describes the use of the Nez Perce Tribe's 200 kaf of water stored in Dworshak Reservoir. The 2008 Dworshak Operational Plan is based on the Agreement between the Corps of Engineers and the Tribe. This agreement's underlying Memorandum of Agreement (MOA) was established between the Tribe, the Corps, NOAA Fisheries, Bonneville Power Administration (BPA) and the State of Idaho and representatives of agencies are referred to as the Dworshak Board. Members of the Dworshak Board presented the 2008 Dworshak Operation Plan to TMT. The Corps operated the reservoir to meet the objectives outlined in the 2008 Dworshak Operation Plan. The 200 kaf was released in September and Dworshak elevation reached 1520.0 feet on 28 September. TMT notes documenting the discussions concerning Dworshak summer draft operations can be found at the website: http://www.nwd-wc.usace.army.mil/tmt/agendas/2008/. The Lower Snake River and Dworshak operational data can be found at http://www.nwd-wc.usace.army.mil/tmt/ under Water Control Data.

II) ACTUAL OPERATIONS

Water is released during the spill season at Dworshak Dam for flow augmentation, temperature regulation and power generation. Flow augmentation water is passed through the powerhouse selector gate, over the spillway, or through the regulating outlet (RO). When the selector gate is set in the undershot mode, water is drawn from the reservoir at a specific elevation: the bottom of the selector gate is at 1435 feet and the bottom of the

penstock is at 1395 feet, allowing a 40 foot swath of water to be released into the powerhouse. 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. When more volume of water must be passed and the generation load is already met, water is passed using the spillway or the RO. The RO elevation of 1353 feet provides cooler water compared to the spillway elevation crest of 1545 feet. Temperature information from the fixed monitoring stations (FMS) as shown on Figure I-1 and forebay temperature strings as shown on Figures I-2 through I-5 along with an understanding of the overshot and undershot modes of operation of the selector gates were used to determine which elevation of water to release to attain the desired temperature.

The management of Dworshak outflows during the summer of 2008 was very different than the operations that have occurred in recent years. The spring freshet in the Columbia and especially Snake Basins was later than usual and was coupled with cooler water temperatures in the lower Snake River. These factors resulted in using Dworshak water more for flow augmentation than temperature control. Water temperature at the Lower Granite tailrace never exceeded 68^{o}F. The following discussion of the 2008 actual operations includes Dworshak flow augmentation and temperature control operations which is outlined in Table I-1. This 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 is an explanation of how the selector gate for each generating unit was positioned during the operation.

Table I-1: Dworshak Flow Augmentation/Temperature Control Operations in 2008.

Operation Start		Operation End		Outflow (kcfs)	Outflow Target Temperature (^{o}F)	Selector Gate Position[1]		
Date	Time (hrs)	Date	Time (hrs)			Small Unit	Small Unit	Big Unit
7 July	1430	11 July	1900	8.3 – 9.6	46.5 – 47.5	O	U	U
11 July	1900	16 July	2200	7.4 – 9.6	46.0 – 47.5	O	O	U
16 July	2200	24 July	1100	12.0 – 12.1	46.0 – 47.5	O	O	U
24 July	1100	25 July	1500	11.4 – 14.0	46.0 – 47.5	U	O	U
25 July	1500	1 Aug	2400	11.6 – 14.4	46.0 – 47.5	U	U	U
1 Aug	2400	12 Aug	1200	13.3 – 14.2	46.0 – 48.0	U	U	U
12 Aug	1200	22 Aug	1600	13.9 – 14.6	46.0 – 48.0	U	U	U
22 Aug	1600	1 Sep	0600	12.5 – 12.6	46.0 – 48.0	U	U	U
1 Sep	0600	5 Sep	2200	10.4 – 10.4	46.0 – 48.0	U	U	U
5 Sep	2200	9 Sep	2100	7.6 – 7.5	46.0 – 48.0	U	U	U
9 Sep	2100	13 Sep	2200	5.0 – 6.0	46.0 – 48.0	U	U	
13 Sep	2200	20 Sep	2200	2.5 – 2.5	46.0 – 48.0	U		
20 Sep	2200	22 Sep	2200	1.4 – 1.6	46.0 – 48.0	U		
22 Sep	2200	23 Sep	1600	2.0 – 2.0	46.0 – 48.0	U		
23 Sep	1600	27 Sep	2200	2.5 – 2.5	46.0 – 48.0	U		
27 Sep	2300	End of Season		1.5 – 1.6	Lowest Possible	U		

[1] U = Undershot, O = Overshot.

This information is shown graphically on Figure I-8.

7 July 2008: Dworshak summer (flow augmentation/temperature control) operations began on 7 July after holding the pool full for the 4th of July weekend. At the 2 July TMT meeting, the Corps agreed to hold full pool through the holiday weekend as requested by CRITFC and the Nez Perce, then to pass inflow until temperature or flow augmentation was needed to achieve temperature and flow targets. Discharge was set at full powerhouse level of 9.5 kcfs which roughly corresponded to inflows. The inflows ranged from 11.6 kcfs on 7 July to 7.0 kcfs on 11 July. Dworshak Hatchery requested discharge temperatures between 45°F and 48°F with 47°F set as a target as temperature, to promote fish growth and less. CEQUAL II modeling did not indicate a need for temperature augmentation below Lower Granite Dam.

11 July 2008: The intake gate for Unit 2 was shifted to overshot operation to increase release temperatures closer to 47°F as requested by the Dworshak Hatchery. Discharge was held constant at 9.5 kcfs.

16 July 2008: Single Trace Prediction (STP) Model results presented to TMT indicated that discharges needed to be increased to an average of 13.1 kcfs to meet the end of August target reservoir elevation of 1535 feet. However, due to spillway gate testing scheduled for the week of 22 July to 25 July, which needed as high as possible pool elevations, the Corps recommended to increase discharges to 12 kcfs until the tests were completed, then increase discharge to 14 kcfs. The recommended operation was supported by the Salmon Managers and CRITFC. The increase in flow was balanced for temperatures between the spillway and RO outlets. Release temperatures continued to target 47°F staying between 46°F and 47.5°F.

24 July 2008: Spillway gate testing was completed on 24 July and discharges were increased to approximately 14 kcfs as determined at the 16 July TMT meeting. Unit 1 (a small unit) was shifted to undershot to offset the warmer water being passed over the spillway, Unit 2 remained in overshot mode and Unit 3 (large unit) remained in undershot mode. Release temperatures continued to target 47°F staying between 46°F and 47.5°F.

25 July 2008: Regulating outlet (RO) gate #2 failed on 24 July at approximately 0800. As a result of the failure, between 500 cfs and 1000 cfs was released from that outlet. At the time of the failure, the only RO bulkhead (used to shut off flow in an emergency) was being used for a seal repair for RO #1. By 25 July the repair had been completed to RO #1 and the bulkhead placed in RO #2 to regain control of the discharge. After regaining control of RO #2, and due to rising discharge temperatures, Unit 2 was shifted to undershot mode which allowed cooler water to be pulled from deeper in the reservoir. After this shift, all units remained in undershot operation for the remainder of the augmentation season.

1 August 2008: The Corps provided CEQUAL II model analysis at the 30 July TMT meeting showing the maximum forecasted temperature in the Lower Granite tailwater reaching 67°F assuming a 14.0 kcfs discharge from Dworshak. The

Corps also reported that due to RO gate #2 failure, there was an increased chance that target elevation of 1535 feet (for flow and temperature augmentation) on 31 August might not be met. It was also noted that meeting the current discharge temperature target may not be possible. With the RO gates not operational (The other two RO gates had the same potential problems and had to be fixed before they could be operated. There were also safety concerns with working on the equipment without a bulkhead available). Because the RO gates were not operational as the pool was drawn down, warmer water was passed over the spillway. This resulted in higher average discharge temperatures. The Salmon Managers decided that spill should be cut before discharge temperatures reached 52^{o}F. The Corps conducted additional modeling to determine when spill would have to be reduced and what the probability of missing the end of August target would be.

12 August 2008: Updates on the status of the RO gates and additional temperature modeling were presented by the Corps at the 6 August TMT meeting. The modeling showed release temperatures might reach 52^{o}F and that the reservoir could be 2 to 3 feet above the 1535 foot end of August target. However, by 12 August RO gates #1 and #3 were returned to limited service. RO #1 had a maximum opening of 1.5 feet because the emergency seal to the gate only extended 2 feet up each side. Although fully operational, RO#3 was only able to be of limited use due to the requirement that RO's 1 and 3 be used in a balanced manner. The use of the RO gates improved release temperatures allowing the Corps to maintain a 14 kcfs discharge.

22 August 2008: At the 13 August TMT meeting, the Corps reported that Dworshak releases were being maximized to the extent possible while staying within 110% TDG requirement and with discharge temperatures below 52 degrees so that the pool would be drawn down to 1535 feet by the end of August. By 22 August the pool was down to 1550 feet, the minimum pool elevation at which the spillway can be used. Discharge was reduced to 12.5 kcfs with 2.3 kcfs being passed through the RO gates. Without the warm spillway water, the release temperatures dropped from 50^{o}F to 46^{o}F.

1 September 2008: Dworshak pool reached 1535.0 feet at 0400 on 1 September. At 0600 on 1 September the discharge was reduced to 10.4 kcfs per the Nez Perce 200 kaf operational plan for 2008 (Nez Perce Plan). Discharge temperatures were increased to a target of 47 degrees. At the 27 August TMT meeting the Corps reported that Lower Granite tailwater temperatures were down to 63.9^{o}F and were continuing decrease, thus ending the need for temperature augmentation.

5 September 2008: Per the Nez Perce Plan discharge was reduced to 8.2 kcfs on 5 September. Release temperatures were maintained at 47^{o}F per the request of the Dworshak Hatchery.

9 September 2008: Per the Nez Perce Plan discharge was reduced to 4.8 kcfs on 9 September. Release temperatures were maintained at 47^{o}F per the request of the Dworshak Hatchery.

13 September 2008: Per the Nez Perce Plan, discharge was reduced to 2.5 kcfs on 13 September. The Corps attempted to maintain release temperatures at 47^{o}F per the request of the Dworshak Hatchery. However, at this flow rate the project was limited to running one unit and has limited control of release temperatures since water can be pulled from only one elevation at a time.

20 September 2008: By the end of the day on 20 September, the pool elevation was down to 1520.4 feet, close to the target of 1520.0 feet. Due to request for as low flows as possible to assist in the recovery of the body of a drowning victim in the Clearwater River, the Corps reduced discharge to 1.3 kcfs.

22 September 2008: Inflows increased over the weekend resulting in an increase in the pool elevation to 1520.7 feet. The body recovery effort was finished so the Corps increased discharge to 2.0 kcfs to draft the pool down to the Nez Perce Plan target elevation of 1520.0 feet.

23 September 2008: Inflows were not receding as forecasted, so discharge was increased to 2.3 kcfs to draft the pool down to the Nez Perce Plan target elevation of 1520.0 feet.

27 September 2008: Due to the Dworshak forebay elevation reaching the desired goal of 1520.0 feet, outflows were reduced to minimum flows of about 1.5 kcfs at hour 2300. This marked the end of the flow augmentation season.

III) FINAL RESULTS

An overview and analysis of the Dworshak flow augmentation and temperature control operations and the resulting effects on the Lower Granite tailwater temperatures are summarized below under items 1 through 3.

1) Overview of Dworshak Flow Augmentation and Temperature Control Operations and Resulting Effects on Lower Granite Tailwater Temperatures

The Dworshak summer flow augmentation and temperature control operations began on 7 July when it was observed that Lower Granite tailwater temperatures were rising and could eventually exceed 68^{o}F. The Corps wanted to stay ahead of the temperature issue at Lower Granite since there is 5 days of travel time between Dworshak and Lower Granite. The spring snow-melt in 2008 was very late with the hydrograph peaking very late in June and unusually high inflows to Dworshak reservoir in the early part of July. The late runoff in the Clearwater River was also observed in other Snake River tributaries. The late runoff resulted in much lower temperatures in the Lower Snake

River. Temperature augmentation operations were not needed from Dworshak until late in July. Even Ice Harbor tailwater temperatures did not exceed 68°F until early August. Lower Granite tailwater temperatures peaked during the week of 11 August with temperatures reaching 67°F. The effect of the Dworshak temperature operations is clearly seen in Figure I-9. This figure indicates how Dworshak water temperature releases affected the Lower Granite tailwater temperatures in order to hold temperatures below 68°F. The impact of the Corps water temperature releases on Lower Granite temperatures is not as pronounced as in previous years, which is due to the high water temperature that were requested by TMT and the Dworshak Hatchery. As shown on Figure I-10, the 2008 Dworshak water release temperatures were significantly higher than 2003 through 2007. The 2008 Dworshak water release temperatures were adequate to keep the Lower Granite tailwater temperatures below 68°F which illustrates that is some years, aggressive Dworshak water release operations for temperature are not always necessary. The Snake River temperatures at Anatone and the Clearwater River at Orofino exceeded 68°F in mid to late July (about the 15th and 24th respectively). However the most significant difference between the 2008 temperature augmentation success versus the operations since 2000 was the volume and timing of the spring runoff. This difference is shown in Table I-2. Overall the summer augmentation flows from Dworshak were very successful in keeping Lower Granite tailwater temperatures below 68°F.

2) Dworshak Flow Augmentation and Temperature Control Operations Analysis

Table I-2 provides a comparison of the 2008 Dworshak operations with the previous eight summer seasons through the year 2000. As indicated, this season's operations were different than the previous seasons in two ways: the number of flow augmentation days and the average temperature of the outflow. The total number of flow augmentation days for 2008 was 82.4, which was more than the nine-year average of 73 days. Years prior to 2004 had less flow augmentation days because the elevation draft limit of 1520 feet was set for 31 August but the 2004 BiOp extended the date for reaching 1520 feet to the end of September (refer to Figure I-11). The duration of the 2008 augmentation was longer than the previous four years because the inflow in September was higher then expected and the 2008 Dworshak Operations Plan which called for a more gradual reduction in flows throughout September. Historically flow augmentation has ended by 20 September, but because inflows were high in September, flow augmentation continued until 27 September when flows were reduced to a minimum flow of 1.4 kcfs. Average inflows in 2008 of 2.8 kcfs were much higher than recent years, and recently exceeded only by the average inflow in 2002 and the overall inflow volume of 455 kaf as compared to an average of 281 kaf. These high flows resulted in an above average flow augmentation volume of 1,668 kaf compared to the average of 1,445 kaf. A significant deviation from previous years is the average temperature of the outflow waters for 2008 of 47.9°F as compared to an overall average of 46.6°F since the year 2000 (refer to Figure I-10). This is a departure from the previous trend of the last five years where colder waters were being utilized to maximize cooling in the Lower Snake River. The 2008 average

outflow temperatures were much more like the years 2000 to 2002 before recent BiOp changes.

Like last year, a noticeable characteristic of this year's operation was the generally cooler water in the Dworshak reservoir's thermocline as compared to the last four seasons. However, the reservoir's epilimnion range (approximately 30 feet below the surface) tended to be as warm as or warmer than the past three years. Figure I-1 provides a thermocline representation of how water temperatures within the Dworshak reservoir changed over the course of the 2008 summer season. Figures I-2 through I-4 provide a comparison of the Dworshak reservoir 2008 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 three years. These graphs show that, over the entire summer season, the thermoclines forebay temperatures in 2008 were about 2^{o} F less than they were in 2007, 2006 and 2005.

3) Lower Snake River Tailwater Temperatures Analysis

Figure I-6 provides a graphic representation of the outflows and tailwater temperatures at Dworshak and tailwater temperatures at all of the Lower Snake River projects from 1 April through 30 September. This figure shows increasing river temperatures as the water moves downriver from Lower Granite Dam. Figure I-7 shows the Dworshak outflow temperatures and flow, temperatures and flows measured upstream on the Clearwater and Snake Rivers at the Orofino an Anatone gages, respectively, and Lower Granite tailwater temperature. These are essentially the temperatures of the flows into the Lower Granite reservoir and the resultant outflow temperatures at the dam itself. Table I-3 provides water temperature characteristics measured at a number of Snake River basin monitoring sites. The highest hourly temperature measured was at the Orofino gage where water temperatures reached 75.4^{o}F on 9 August. Temperatures measured at Anatone were the second highest with peak temperatures, reaching 74.9^{o}F on 17 August. The maximum hourly temperature that occurred at the Lower Granite tailwater was 67.7^{o}F on 17 August, which was lower than last year's peak of 68.7^{o}F on 5 July. Downriver, the peak hourly temperature at Ice Harbor tailwater was 71.0^{o}F. These tables and plots demonstrate that, in spite of the high input temperatures coming from the South Fork of the Clearwater River and the Snake River above Lewiston, ID, the temperature control operations performed using Dworshak outflows were highly successful.

Table I-4 provides the statistics of meeting the Lower Granite tailwater temperature criteria as compared to the previous 12 years. In 2008 Lower Granite tailwater did not exceeded the hourly 68^{o}F criteria. This is a significant improvement in comparison to 2007 with 31 hours of exceedance and 223 hours in 2006, as well as the overall nine year average of 59 hours of exceedance. Another measure of temperature reduction is shown a comparison of the degree (magnitude or length) of temperature criteria exceedance. This degree of exceedance is represented by the "Cumulative Index of Exceedance (CIE)" which is calculated by the sum of the hourly exceedances multiplied by the degree to which the 68^{o} F criteria was exceeded

[CIE = SUM (hours of exceedance) x (Hourly exceedance – 68^{o} F)]. The resulting CIE value for Lower Granite was 0.0 (no exceedances). However, Table I-3 shows that the Anatone and Orofino gages exceeded the 68^{o}F temperature criteria for a greater number of hours than did the Ice Harbor tailwater gage. The CIE at Anatone and Orofino was 3,277.5 and 1,192.2 respectively, compared to the CIE of 734.4 at Ice Harbor tailwater. In 2008, the Snake River contributed much more to temperature issues in the Lower Snake than the Clearwater River and without the cooling water from Dworshak the combined effect of the Snake and the natural flows from the Clearwater River would have resulted in very unfavorable temperature conditions for salmon and steelhead.

IV) CONCLUSION

The Dworshak flow augmentation and temperature control highlights and resulting operational trends are listed below as a general overview of the Dworshak summer operations and its impact on Lower Granite temperatures.

Flow Augmentation and Temperatures

Flow and temperature augmentation operations in 2008 were delayed until 7 July. Due to a late, large spring runoff, spill did not begin until 16 July. These conditions made temperature augmentation very successful with discharge temperatures managed for Dworshak Hatchery needs more than the need to reduce temperatures at Lower Granite tailwater. Operational decisions for summer augmentation flows were driven primarily by meeting end of August and end of September reservoir elevations targets. The failure of RO #2 and the resulting restrictions placed on RO #1 and #3 made it very difficult to discharge sufficient water to meet the target elevations within the requested temperature criteria for Dworshak Hatchery and the lower Snake River. The spring runoff in 2008 was above average for Dworshak and the summer temperatures cooler than normal. During years like 2008, additional efforts should be made to ensure the flow volume targets are met while using the water for as many purposes as possible. The temperature operations in 2008 proved that it is possible to eliminate temperature criteria exceedances below Lower Granite Dam.

Operational Trends

There are several operational trends that can be observed and they are:

- The number of days that augmentation occurs has increased over the last nine years. Before 2003, there was an average of 62 days of augmentation. After 2003, there was an average of 78 days. This represents a 16 day longer flow augmentation period as compared to 2000 – 2002 periods; all due to releases in September as agreed upon in the 2004 BiOp and Nez Perce Tribe's Operation Plan.
- There is a clear relationship between the average outflow temperature and the magnitude of the inflow volume. High water years tend to have higher average

outflow temperatures and low water years tend to have lower average outflow temperatures.

It is unknown whether releasing cooler water from Dworshak produces a permanent effect on the pool's thermocline. The data appears to show a gradual thermocline increase in deep (100 foot and greater) temperatures. Currently there is not enough historical data from the floating temperature strings, which measure the thermoclines, to draw firm conclusions about the long-term reservoir temperatures. The effects from the flow augmentation operation on the overall Dworshak reservoir temperatures needs to be closely monitored in future years.

Table I-2

Dworshak Flow Augmentation / Thermal Reduction Data

Parameter	2000	2001	2002	2003	2004	2005	2006	2007	2008	Average
Flow Augmentation Start Date	6/30/2000 1:00	7/2/2001 6:00	7/8/2002 16:00	7/1/2003 23:00	6/30/2004 8:00	6/30/2005 23:00	6/28/2006 16:00	7/2/2007 10:00	7/7/2008 14:00	--
Flow Augmentation End Date	9/1/2000 1:00	8/30/2001 2:00	9/12/2002 1:00	9/14/2003 23:00	9/20/2004 8:00	9/17/2005 23:00	9/13/2006 22:00	9/16/2007 22:00	9/27/2008 23:00	--
Number of Days of Augmentation	63.0	58.8	65.4	75.0	82.0	79.0	78.3	76.5	82.4	73.4
Beninning Forbay Elevation (ft)	1,598.8	1,587.5	1,599.2	1,600.0	1,599.8	1,600.0	1,599.3	1,599.0	1,599.8	1,598.2
Average Ourflow (kcfs)	11.4	9.5	12.7	9.6	9.5	8.9	9.4	8.8	10.2	10.0
Flow Augmentation Volume (KAF)	1,428	1,115	1,653	1,430	1,548	1,394	1,431	1,334	1,668	1,445
Average Inflow (kcfs)	2.0	1.9	3.5	1.6	2.4	1.5	1.7	0.8	2.8	2.0
Inflow Volume (KAF)	253	227	448	234	395	232	255	30.5	455	281
Outflow minus Inflow (KAF)	1,174	889	1,205	1,196	1,153	1,162	1,176	1,303	1,213	1,163
Seasonal Ave Outflow Temp (C)	9.1	8.8	8.8	7.4	7.7	7.6	7.2	7.5	8.9	8.1
Seasonal Ave Outflow Temp (F)	48.3	47.8	47.8	45.7	45.8	45.7	45.0	45.4	47.9	46.6
Total Cooling Units (KAF-C)	15,688	28,238	18,611	17,998	19,294	17,409	18,493	16,977	18,679	19,043
Total Cooling Units (KAF-F)	28,238	12,517	33,500	32,397	34,729	31,335	33,288	30,558	33,622	30,020

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

Table I-3

Daily Average and Hourly Temperature Exceedance Information
April 1 - September 30, 2008

Location*	24 Hour Average Data			Hourly Data					
	Date of 1st 24hr Average Over 68F	Date of Last 24hr Average Over 68F	Number of Days With 24hr Average Over 68F	Date of 1st Hour Over 68F	Date of Last Hour Over 68F	Number of Hours Over 68F	Cumulative Index of Exceedance (degree-hour)**	Maximum Hourly Temp	Date of Maximum Hourly Temp
ORFI	7/27/08	08/13/08	17	7/25/08	8/13/08	446	1192.2	75.4	8/9/08
DWQI	N/A***	N/A	0	N/A	N/A	0	0	50.8	8/6/08
ANQW	7/17/08	09/08/08	49	7/10/08	9/19/08	1194	3277.5	74.9	8/17/08
LGNW	N/A***	N/A	0	N/A	N/A	0	0.0	67.7	8/17/08
LGSW	8/15/08	08/23/08	6	8/15/08	8/23/08	122	52.0	69.6	8/15/08
LMNW	8/14/08	08/27/08	14	8/11/08	8/28/08	320	194.3	69.5	8/20/08
IDSW	7/27/08	09/02/08	37	7/26/08	9/2/08	813	734.4	71.0	8/20/08
PAQW	8/6/08	08/25/08	12	8/6/08	8/30/08	301	239.8	70.2	8/18/08

* Key to acronyms for location of water quality gages (TW indicates gage is near tailwater of dam): ORFI - Orofino, DWQI - Dworshak TW, LGNW - Lower Granite TW, LGSW - Little Goose TW, LMNW - Lower Monumental TW, IDSW - Ice Harbor TW, PAQW - Pasco, ANQW - Anatone.

**Cumulative Index of Exceedance (CIE): calculated by the sum of the hourly exceedances multiplied by the degree to which the 68F criteria was exceeded [CIE = SUM (hours of exceedance) x (Hourly exceedance – 68 F)].

*** N/A: Not applicable since temperatures did not exceed 68 degrees F.

Table I-4

Lower Granite Tailwater State Temperature Criteria Exceedance Comparison
April 1 - September 30, 1995 - 2008 (Temperature in Degrees Fahrenheit)

Annual Statistics			14-yr Statistics			
Year	Hours of Exceedance	CIE* (degree-hour)	Hours of Exceedance		Cumulative Index of Exceedance (CIE)*	
2008	0	0				
2007	31	8	**Range:**		**Range:**	
2006	223	131	High: 1184 hrs (1998)		High: 2,125 degree-hrs (1998)	
2005	0	0	Low: 0 hrs (2000, 2005		Low: 0 degree-hrs (2000, 2005, 2008)	
2004	7	2				
2003	63	14	**Overall Average:**	221 hrs	**Overall Average:**	249 degree-hrs
2002	17	4				
2001	193	125				
2000	0	0	**Average 1995-1999:**	511 hrs	**Average 1995-1999:**	640 degree-hrs
1999	23	6				
1998	1184	2125	**Average 2000-2008:**	59 hrs	**Average 2000-2008:**	32 degree-hrs
1997	137	56				
1996	526	613				
1995	686	399				

*CIE - Cumulative Index of Exceedance: calculated by the sum of the hourly exceedances multiplied by the degree to which the 68F criteria was exceeded [CIE = SUM (hours of exceedance) x (Hourly exceedance – 68 F)].
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.
During the years 1996 and 1995 the gauges went down for the season on 9/17 and 9/25, respectively, and during 1998 there was 56 hours of data missing from 9/22 - 9/24.

Figure I-1

Dworshak Temperature Profile from a Fixed Temperature String
January - September 2008

Elevation (ft)	1/10/08	1/17/08	1/31/08	2/14/08	2/21/08	3/4/08	3/13/08	3/27/08	4/4/08	4/17/08	4/28/08	5/1/08	5/8/08	5/15/08	5/22/08	5/29/08	6/5/08	6/12/08	6/19/08	6/26/08	7/3/08	7/9/08	7/17/08	7/24/08	7/31/08	8/6/08	8/14/08	8/20/08	8/28/08	9/10/08	9/18/08	Temperature (°F)
1574	35.4	33.8	34.4	39.2	36.2	40.5	40.4	42.5	42.6	51.1	56.5	55.7	55.7	61.1	55.5	62.0	63.8	56.2	61.4	fail	FAIL	FAIL	55.2	FAIL	FAIL	FAIL	76.8	FAIL	FAIL	fail	fail	Air
1549	35.9	34.4	34.9	39.5	36.4	40.7	40.9	42.8	43.1	51.4	56.8	55.1	56.0	60.9	56.2	62.4	48.8	45.8	45.2	44.5	46.5	47.9	49.2	50.8	53.1	69.1	73.7	72.9	67.6	66.8	65.9	
1524	36.7	35.4	36.0	40.0	37.1	41.4	41.0	43.4	44.0	50.9	57.6	53.5	56.0	60.0	56.8	49.4	45.2	44.4	44.2	44.1	45.6	46.6	47.8	48.6	49.2	52.3	55.7	58.1	70.1	67.2	65.9	
1499	42.5	43.7	40.3	40.2	39.9	40.1	41.0	41.9	42.2	54.1	57.0	60.3	56.3	64.7	50.7	45.2	44.0	44.4	44.2	44.4	44.8	45.6	46.5	47.0	47.3	48.9	51.0	52.3	56.1	67.1	66.7	60 to 82
1474	42.8	42.1	40.7	40.5	40.2	40.4	41.0	41.9	42.5	44.7	49.7	47.6	52.6	53.9	44.2	43.8	44.1	44.2	44.4	44.4	44.6	44.8	45.1	45.5	46.1	47.4	48.5	49.4	51.2	55.3	57.0	
1449	42.4	41.6	40.2	39.9	39.6	39.9	40.6	40.6	41.8	44.5	45.7	46.3	46.0	45.3	42.5	43.1	43.1	43.3	43.5	43.7	43.9	43.9	44.1	44.3	44.1	44.4	46.2	46.9	47.9	50.5	51.4	50 to 60
1424	42.2	41.3	40.0	39.5	39.4	39.6	40.0	39.6	40.6	41.9	41.8	39.8	39.9	41.3	41.5	42.4	42.5	42.9	42.6	43.1	43.4	43.3	43.6	43.7	43.3	43.6	44.2	44.4	45.7	47.0	47.8	45 to 50
1399	42.1	41.4	40.0	39.5	39.4	39.6	39.9	39.4	39.5	39.1	39.3	39.0	39.0	39.8	40.3	41.7	42.0	42.4	42.3	42.7	42.8	43.1	43.3	43.4	43.1	43.3	43.6	0.0	43.8	44.6	45.5	40 - 45
1374	40.7	40.3	39.6	39.5	39.6	39.4	39.4	39.3	39.2	38.6	38.9	38.9	38.9	39.4	39.3	40.6	41.4	41.4	42.2	42.0	42.4	42.2	42.5	42.1	42.3	42.7	43.3	43.3	43.2	43.6	43.7	
1349	40.1	39.9	39.6	39.5	39.7	39.4	39.3	39.4	39.3	38.6	39.0	39.0	39.0	39.3	39.4	39.7	40.2	40.5	40.5	41.0	41.0	41.4	41.1	40.9	40.6	41.0	42.3	43.3	42.4	42.3	42.8	37 - 40
1324	39.9	39.7	39.6	39.6	39.6	39.5	39.4	39.5	39.4	38.8	39.1	39.1	39.1	39.2	39.3	39.4	39.7	39.6	40.0	39.8	40.0	40.0	40.0	40.0	39.9	40.0	40.4	41.3	40.2	40.3	40.6	
1299	38.9	38.9	38.9	38.8	39.0	38.7	38.8	38.8	38.7	38.1	38.5	38.4	38.4	38.4	38.7	38.6	38.9	38.7	39.1	38.8	39.0	38.9	39.0	39.1	38.9	39.0	39.2	40.2	39.1	39.0	39.2	
1249	38.9	39.0	38.8	38.9	38.8	38.7	38.7	38.9	38.8	38.2	38.4	38.4	38.5	38.5	38.7	38.7	38.8	38.6	38.9	38.7	38.8	38.7	38.9	38.9	38.7	38.7	38.8	39.1	38.8	38.8	38.8	
1199	38.7	38.6	38.3	38.5	38.4	38.3	38.5	38.6	38.6	37.9	38.2	38.1	38.2	38.2	38.4	38.3	38.4	38.2	38.5	38.3	38.4	38.3	38.5	38.5	38.3	38.3	38.5	38.7	38.5	38.3	38.3	
1149	39.3	39.3	39.2	39.2	39.1	39.0	39.1	39.2	39.2	38.6	38.8	38.9	38.8	38.9	39.1	39.0	39.2	39.0	39.2	38.9	39.0	38.9	39.1	39.1	39.0	38.9	39.1	38.3	39.0	38.9	38.9	
1099	38.5	38.4	38.3	38.4	38.2	38.2	38.2	38.3	38.3	37.9	38.0	38.1	38.0	37.9	38.2	38.1	38.2	37.9	38.2	37.9	38.0	37.9	38.0	38.0	37.9	37.9	38.0	38.9	37.9	37.8	37.8	
1049	39.6	39.6	39.4	39.6	39.4	39.4	39.4	39.5	39.5	39.1	39.5	39.4	39.4	39.3	39.6	39.4	39.6	39.3	39.6	39.4	39.5	39.3	39.5	39.5	39.3	39.3	39.4	37.8	39.3	39.3	39.2	

Date

Figure I-2

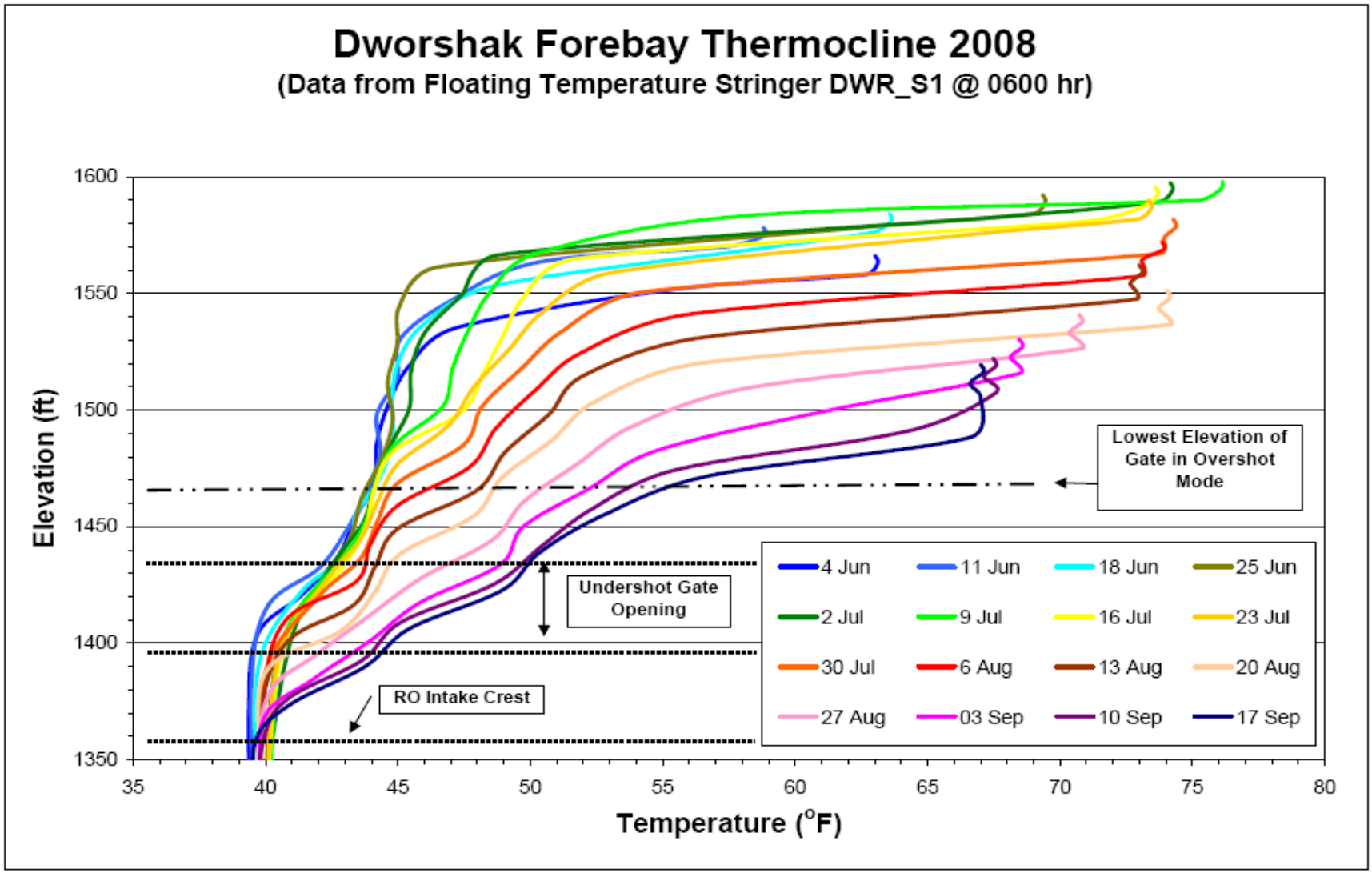
Dworshak Forebay Thermocline 2008
(Data from Floating Temperature Stringer DWR_S1 @ 0600 hr)
Elevation (ft)
1600
1550
1500
1450
1400
1350
35
40
45
50
55
60
65
70
75
80
Temperature (°F)
Lowest Elevation of Gate in Overshot Mode
Undershot Gate Opening
RO Intake Crest
4 Jun
11 Jun
18 Jun
25 Jun
2 Jul
9 Jul
16 Jul
23 Jul
30 Jul
6 Aug
13 Aug
20 Aug
27 Aug
03 Sep
10 Sep
17 Sep

Figure I-3

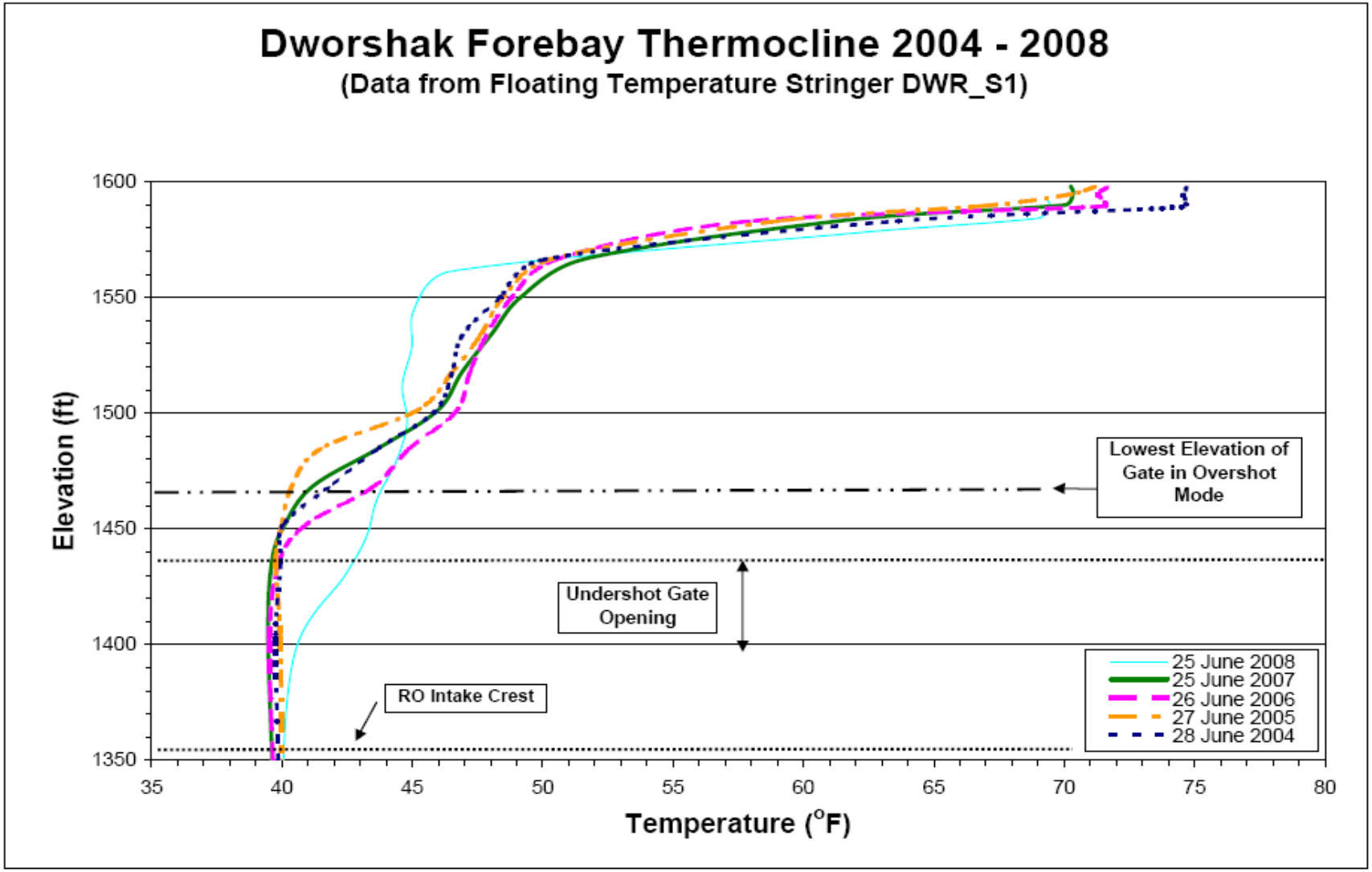
Dworshak Forebay Thermocline 2004 - 2008
(Data from Floating Temperature Stringer DWR_S1)
Elevation (ft)
1600
1550
1500
1450
1400
1350
35
40
45
50
55
60
65
70
75
80
Temperature (°F)
Lowest Elevation of Gate in Overshot Mode
Undershot Gate Opening
RO Intake Crest
25 June 2008
25 June 2007
26 June 2006
27 June 2005
28 June 2004

Figure I-4

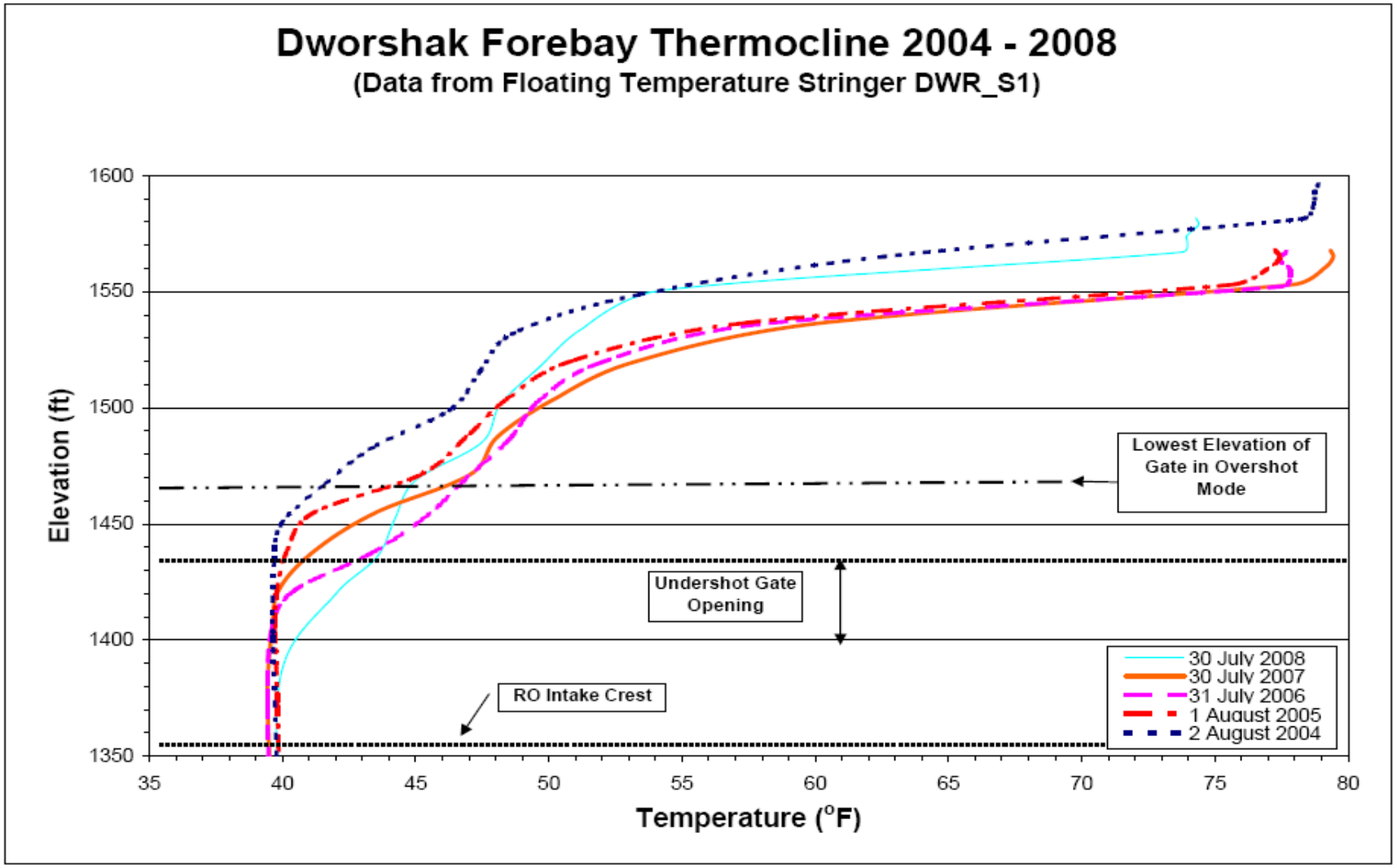
Dworshak Forebay Thermocline 2004 - 2008
(Data from Floating Temperature Stringer DWR_S1)
Elevation (ft)
1600
1550
1500
1450
1400
1350
35
40
45
50
55
60
65
70
75
80
Temperature (°F)
Lowest Elevation of Gate in Overshot Mode
Undershot Gate Opening
RO Intake Crest
30 July 2008
30 July 2007
31 July 2006
1 August 2005
2 August 2004

Figure I-5

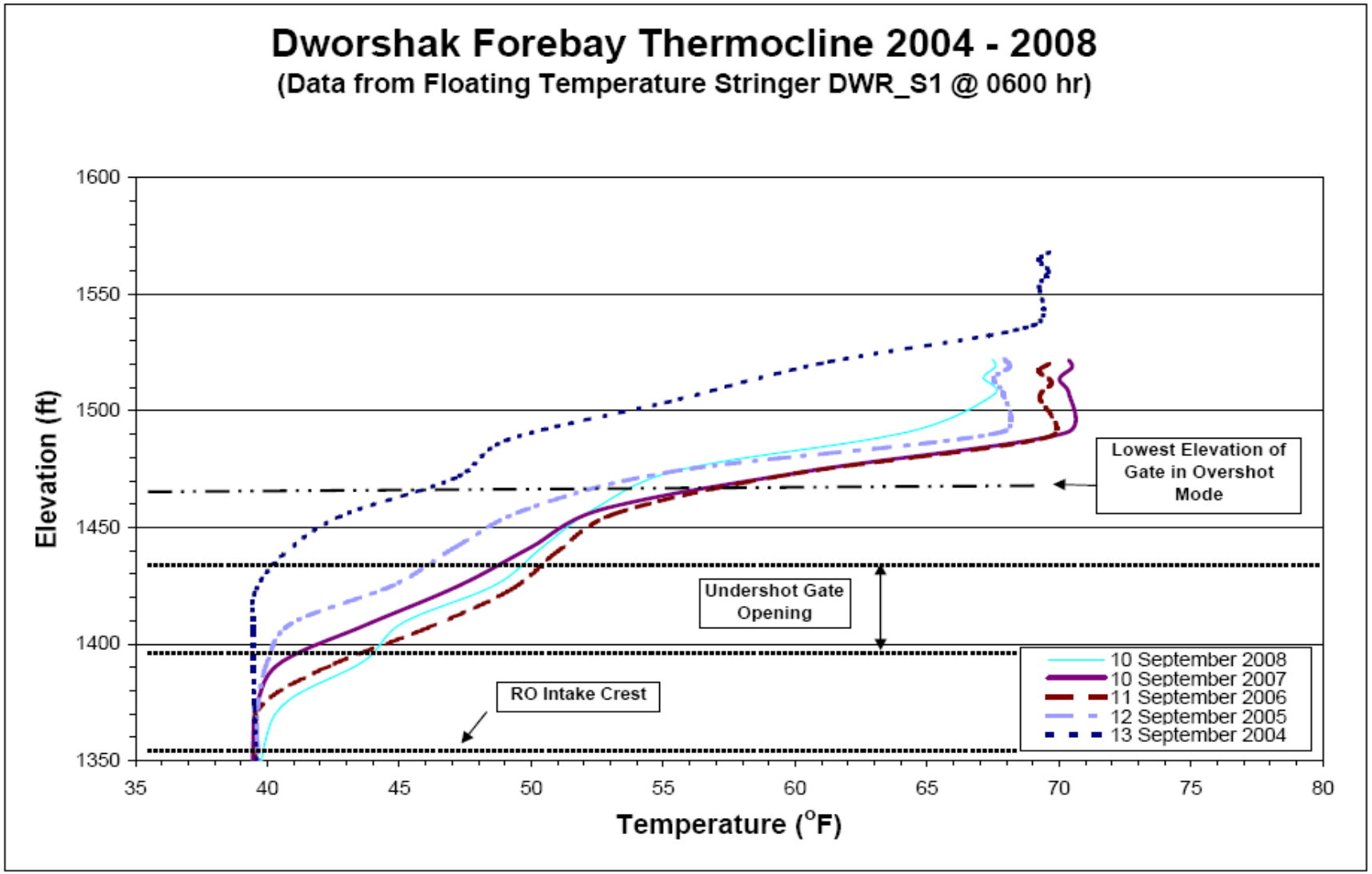
Dworshak Forebay Thermocline 2004 - 2008
(Data from Floating Temperature Stringer DWR_S1 @ 0600 hr)
Elevation (ft)
1600
1550
1500
1450
1400
1350
35
40
45
50
55
60
65
70
75
80
Temperature (°F)
Lowest Elevation of Gate in Overshot Mode
Undershot Gate Opening
RO Intake Crest
10 September 2008
10 September 2007
11 September 2006
12 September 2005
13 September 2004

Figure I-6

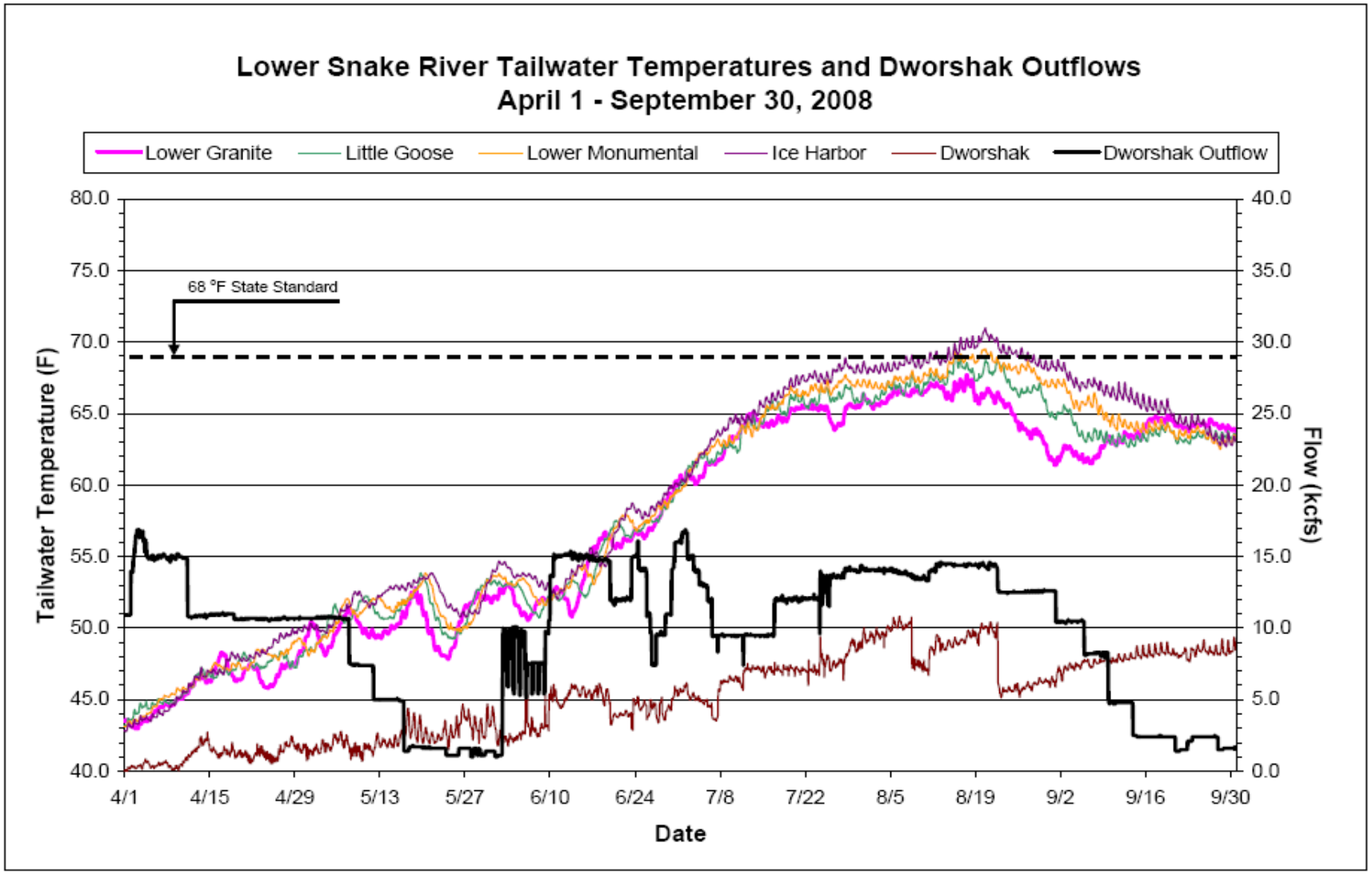
Lower Snake River Tailwater Temperatures and Dworshak Outflows
April 1 - September 30, 2008
Lower Granite
Little Goose
Lower Monumental
Ice Harbor
Dworshak
Dworshak Outflow
68 °F State Standard
Tailwater Temperature (F)
Flow (kcfs)
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
4/1
4/15
4/29
5/13
5/27
6/10
6/24
7/8
7/22
8/5
8/19
9/2
9/16
9/30
Date

Figure I-7

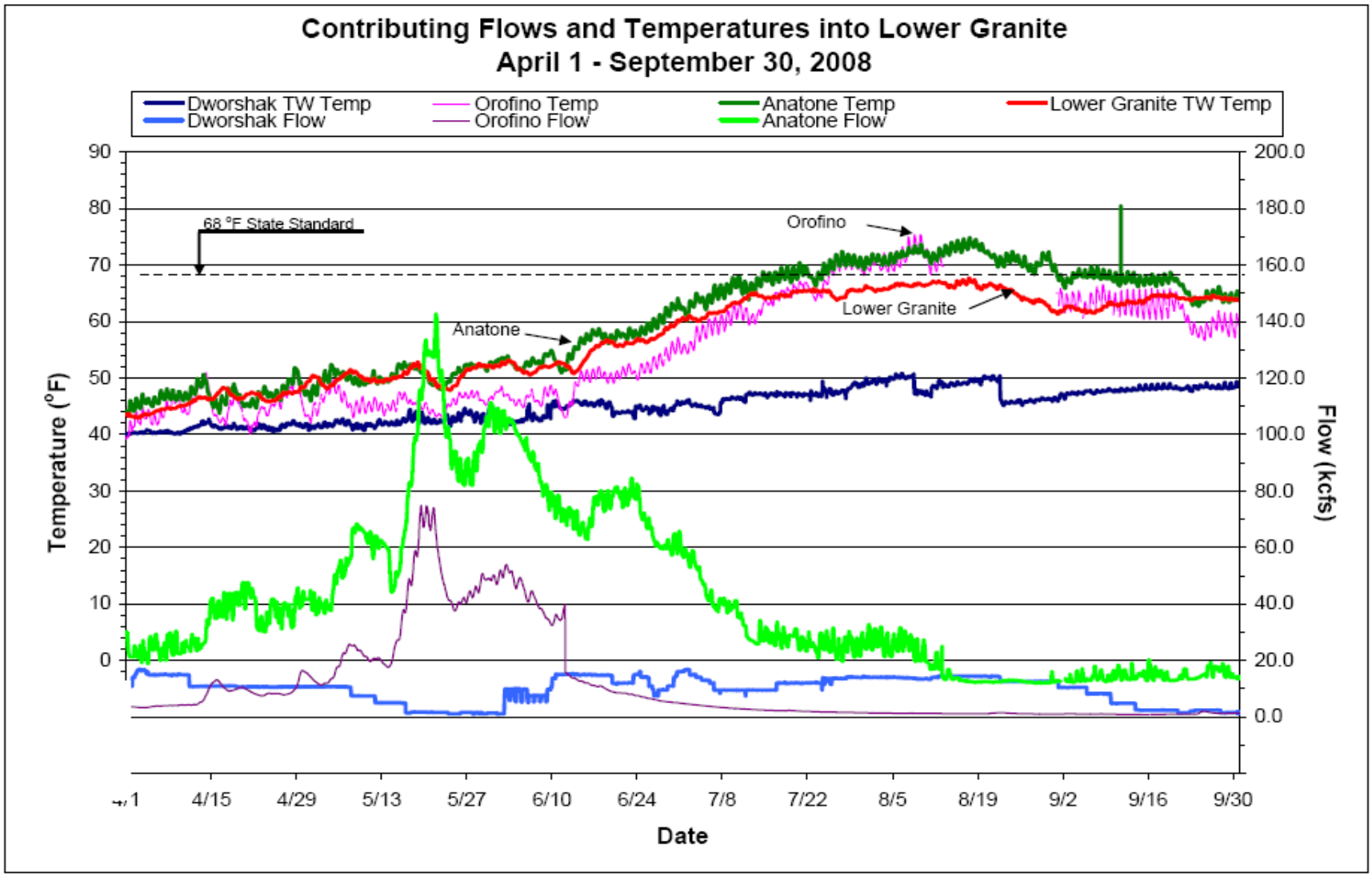
Contributing Flows and Temperatures into Lower Granite
April 1 - September 30, 2008
Dworshak TW Temp
Dworshak Flow
Orofino Temp
Orofino Flow
Anatone Temp
Anatone Flow
Lower Granite TW Temp
68 °F State Standard
Orofino
Anatone
Lower Granite
Temperature (°F)
Flow (kcfs)
Date
4/1
4/15
4/29
5/13
5/27
6/10
6/24
7/8
7/22
8/5
8/19
9/2
9/16
9/30

Figure I-8

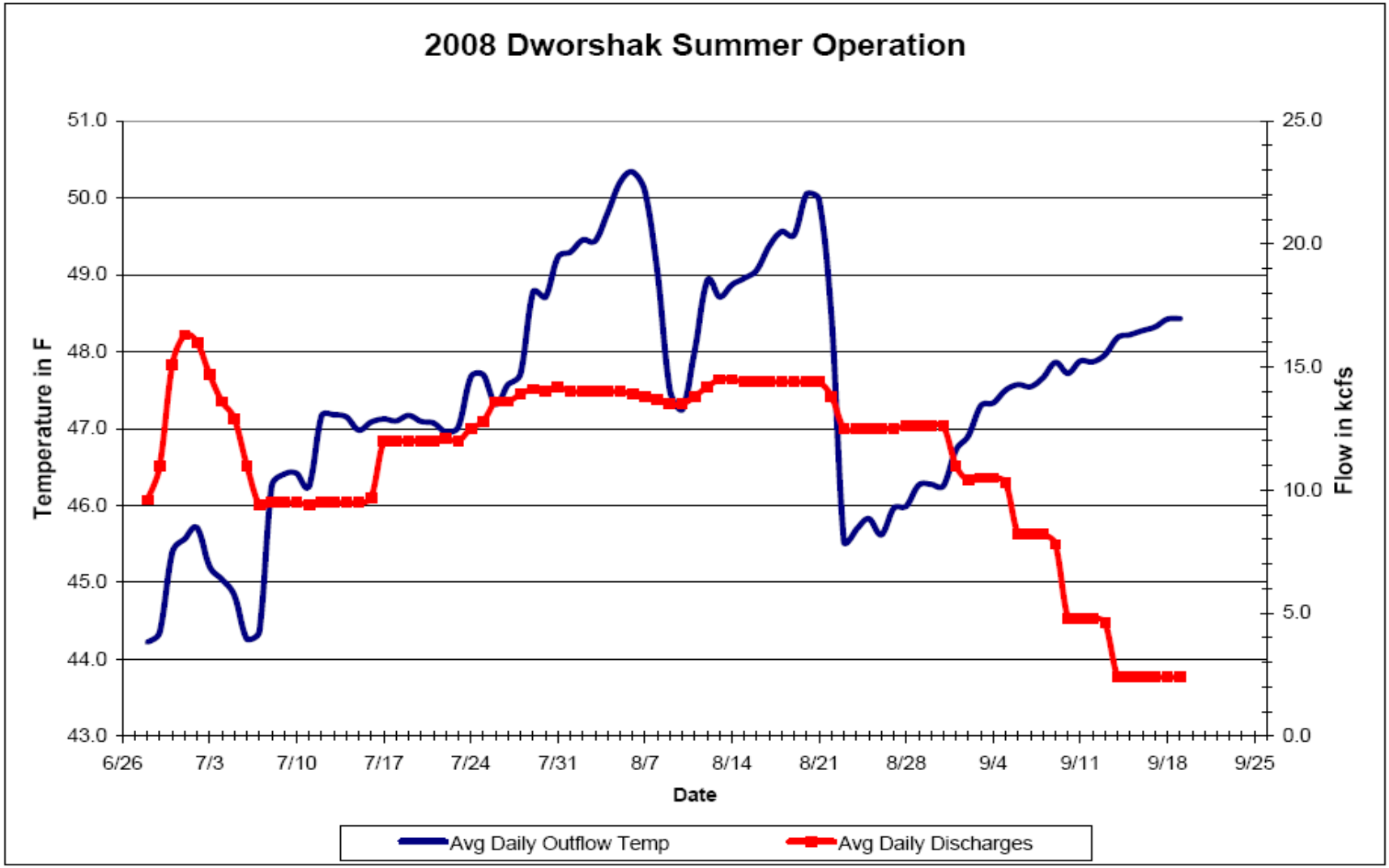
2008 Dworshak Summer Operation
Temperature in F
Flow in kcfs
51.0
50.0
49.0
48.0
47.0
46.0
45.0
44.0
43.0
25.0
20.0
15.0
10.0
5.0
0.0
6/26
7/3
7/10
7/17
7/24
7/31
8/7
8/14
8/21
8/28
9/4
9/11
9/18
9/25
Date
Avg Daily Outflow Temp
Avg Daily Discharges

Figure I-9

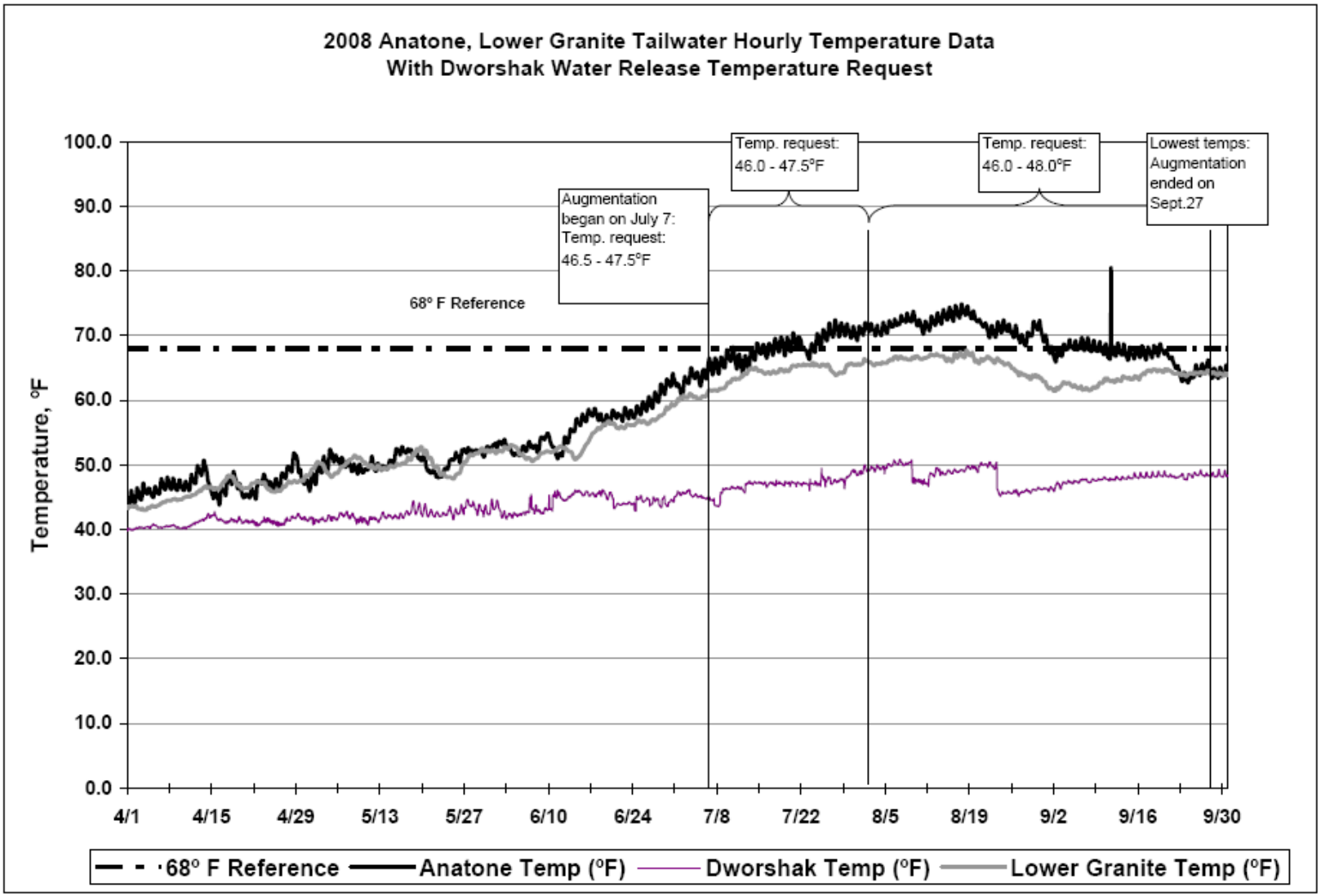
2008 Anatone, Lower Granite Tailwater Hourly Temperature Data
With Dworshak Water Release Temperature Request
Temp. request:
46.0 - 47.5°F
Temp. request:
46.0 - 48.0°F
Lowest temps:
Augmentation
ended on
Sept.27
Augmentation
began on July 7:
Temp. request:
46.5 - 47.5°F
68° F Reference
Temperature, °F
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
4/1
4/15
4/29
5/13
5/27
6/10
6/24
7/8
7/22
8/5
8/19
9/2
9/16
9/30
68° F Reference
Anatone Temp (°F)
Dworshak Temp (°F)
Lower Granite Temp (°F)

Figure I-10

Dworshak Release Temperatures as an Augmentation Seasonal Average, 2000 - 2008

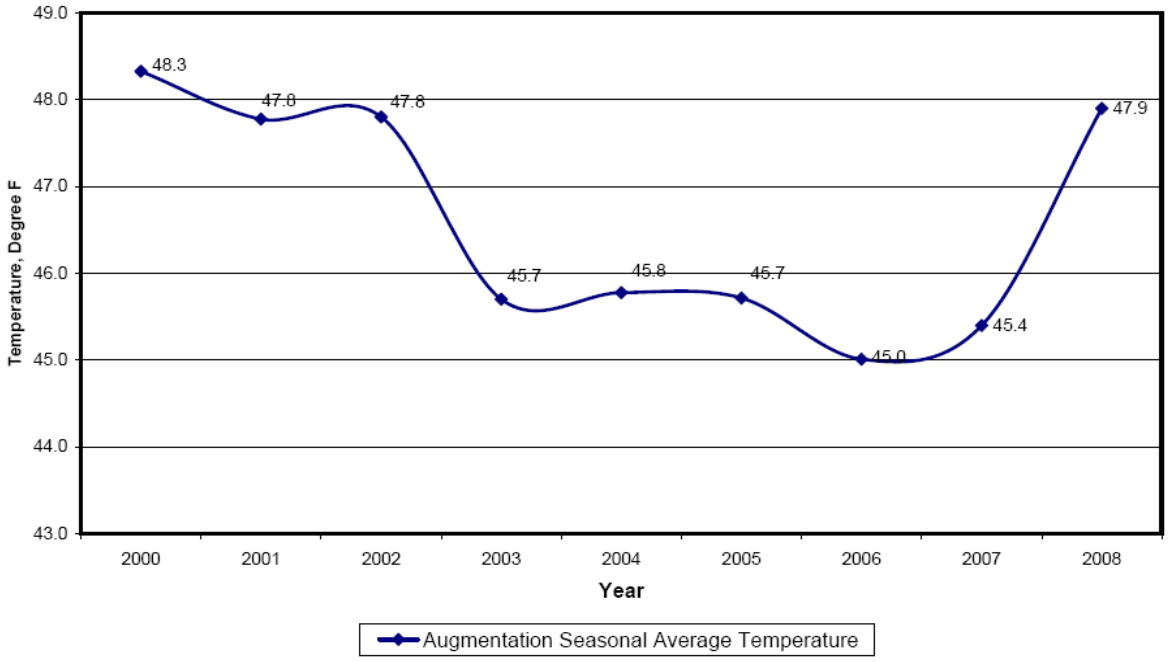

Figure I-11

Dworshak Augmentation Days