Appendix I

Dworshak Summer Operations

I) 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 on the North Fork of the Clearwater River. These operations are in accordance with the Biological Opinions (BiOp) 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 2007, 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. Also, 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 as part of the drafting of the reservoir from 1599.0 feet on July 2nd to 1530.0 feet on August 30th to 1519.8 feet on September 16th. This summer draft of the Dworshak reservoir met the objectives outlined in the 2004 BiOp, the 2007 Water Management Plan, and the 2007 Operational Plan for the Nez Perce Tribe's 200 kaf of stored water. TMT notes documenting the discussions concerning Dworshak operations can be found at the website: http://www.nwd-wc.usace.army.mil/tmt/agendas/2007/. 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 Monitor Stations (FMS) and forebay temperature strings 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 2007 was similar to operations that have occurred in recent years, continuing with the trend to use cooler water releases for a longer period of time. The following discussion of the 2007 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 was how the selector gate for each generating unit was positioned during the operation.

Table I-1: Dworshak Flow Augmentation/Temperature Control Operations in 2007.

Operation Start		Operation End		Outflow (kcfs)	Ouflow Target Temperature (^oF)	Selector Gate Position[1]		
Date	Time (hrs)	Date	Time (hrs)			Small Unit	Small Unit	Big Unit
2 July	1000	3 July	0600	7.4 – 7.6	44.0 – 45.0	O		O
3 July	0600	3 July	1200	9.4 – 9.5	43.0	O	O	O
3 July	1300	5 July	1400	9.5	43.0	O	U	O
5 July	1400	13 July	1200	11.8 – 12.1	43.0	O	U	O
13 July	1300	14 July	2200	11.8 – 12.1	43.0	U	U	O
14 July	2200	15 July	2200	10.9 – 11.0	43.0	U	U	O
15 July	2300	16 July	0800	9.6	43.0	U	U	U
16 July	0900	11 Aug	2200	9.6 – 10.1	43.0	U	O	U
11 Aug	2300	9 Sep	2300	7.7 – 8.1	45.0 – 46.0		O	U
9 Sep	2400	11 Sep	0930	5.4 – 5.7	49.0 – 50.0		O	U
11 Sep	0930	13 Sep	2200	5.4 – 5.7	45.0 – 47.0			U
13 Sep	2300	16 Sep	2200	2.4 – 2.5	Lowest Possible	U		
16 Sep	2200	End of Season		1.6 – 1.8	Lowest Possible	U		

[1] U = Undershot, O = Overshot.

This information is shown graphically on Figure I-8.

2 July 2007: Dworshak summer (flow augmentation/temperature control) operations began on July 2nd 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 by the Salmon Managers at the July 2nd 0800 FPAC conference call and a recommendation was made to the Action Agencies to increase outflow to 7.4 kcfs by 1000 on the same day. The Corps emailed TMT members to inform them of the recommendation and it was agreed to increase outflow at the Dworshak project to 7.4 kcfs (one large unit and one small unit in overshot mode) and maintain temperatures between 44.0 – 45.0 ° F.

3 July 2007: Due to discussions by the TMT members after the FPAC meeting on July 2nd regarding climbing temperatures at Lower Granite, TMT members requested that Dworshak outflow be increased to full capacity (about 9.5 kcfs) until further notice with a target temperature close to but not less than 43.0° F for the Dworshak Hatchery. Due to slightly increasing outflow temperatures above 43° F at Dworshak Dam, Unit two was switched from overshot to undershot mode in order to keep outflow temperatures closer to the target of 43.0°F.

5 July 2007: Due to extreme high air temperature conditions of 100°F and more in the Snake Basin and a 5-day travel time for cool water to reach Lower Granite from Dworshak, members at the July 5th TMT meeting requested that the Corps increase Dworshak outflows to 12.0 kcfs as soon as possible. This operation

required that the additional 2.5 kcfs flow be spilled through the Regulating Outlet (RO) which would help meet the continued outflow target temperature of 43° F. After a July 9th TMT conference call, members requested to maintain the 12.0 kcfs outflow through July 13th.

13 July 2007: As a result of the July 13th TMT conference call, the Corps decided to continue outflows of 12 kcfs through July 14th at hour 2200 due to the continued hot climatic conditions in the Snake Basin. The continued high outflows combined with switching the small unit to the overshot mode, enabled the target temperature to stay close to 43.0° F without going below. The large unit remained in the overshot mode and the selector gate was adjusted when necessary to meet the temperature goal.

14 July 2007: Outflows were reduced at the Dworshak project by cutting back RO spill from 2.2 to 1.4 kcfs which provided a total outflow of 11.0 kcfs. This action was requested at the July 13th TMT conference call in order to help meet the goal of reaching 1535 feet by August 31st.

15 July 2007: The Dworshak operator reduced outflows to 9.6 kcfs as a response to the July 13th TMT conference call where the Salmon Managers recommended a reduction to full powerhouse at hour 2200. Spill through the RO was cut off which resulted in the desired lower total outflow of 9.6 kcfs. To maintain the target temperature of 43.0°F without the cooler water from the RO spill, the large unit was switched to the undershot mode resulting in all units operating in the lowest gate setting producing the coolest water.

16 July 2007: The small unit's gate setting was switched to the overshot mode thereby releasing warmer water, since the water temperature was about 1.5° F below the target range of 43.0 ° F. At the July 18th TMT meeting and July 25th and Aug 1st TMT conference calls, it was agreed that Dworshak would continue operating at full power house unless climatic conditions changed drastically.

11 August 2007: As requested by the Salmon Managers at the August 8th TMT conference call, Dworshak's total outflow was reduced to 7.8 kcfs due to the decline of temperatures at Lower Granite. During the following four weeks the requested total outflow ranged from 7.7 to 8.0 kcfs (using one big unit in undershot and one small unit in overshot mode). Reduced outflow resulted in Dworshak's temperature increasing to 45.0 – 46.0° F; the small unit in overshot mode was maintained at the lowest gate setting to keep temperatures from further increasing.

30 August 2007: The Dworshak reservoir elevation goal of 1535.0 feet was reached on August 30th at hour 1300. This elevation goal met the objectives outlined in the 2007 Operational Plan for use of the Nez Perce Tribe's 200 kaf.

9 September 2007: At the September 5th Emergency TMT conference call it was requested that Dworshak's total outflow be ramped down to 5.5 kcfs in order to

continue to meet desired temperature releases. The Nez Perce Tribes requested that the temperatures be held at their current levels of 49.0 – 50.0° F. The project operator was instructed to adjust the overshot gate setting for the smaller unit if any warming was needed to reach the desired temperature range.

11 September 2007: Total discharge of 5.5 kcfs was maintained through September 13th by increasing unit 3 to full capacity and taking the small unit off line. Unit 3 continued to operate in the undershot gate setting in order to maintain the current temperatures of 45.0 – 47.0° F.

13 September 2007: Total discharge was decreased to a range of 2.4 – 2.5 kcfs by switching from the large unit 3 to the small unit, while staying in the undershot mode to get the lowest temperatures possible. An error in the temperature control operation occurred on September 14th at hour 0642 due to project maintenance; the operator switched the small unit from the undershot mode to overshot causing a six-hour spike in temperatures up to 61.3° F.

16 September 2007: Due to the Dworshak forebay elevation reaching the desired goal of 1519.8 feet, outflows were reduced to minimum flows of about 1.5 kcfs at hour 2200. The lowest possible temperatures were maintained while in the undershot gate setting. 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 July 2nd when it was observed that Lower Granite tailwater temperatures were rising rapidly and was expected to exceed 68° F within a few days. In response, on July 2nd Dworshak releases were increased to 7.4 kcfs with water temperatures between 44.0 – 45.0° F. Since Lower Granite temperatures continued to climb; on July 3rd flows were increased to 9.4 kcfs with a water temperature of 43° F. Due to extreme high air temperature conditions of 100° F and more in the Snake Basin and a 5-day travel time for Dworshak cool water to reach Lower Granite, Dworshak outflows were increased to 12.0 kcfs on July 5th. As Figures I-7 and I-9 in Appendix I shows, the 12 kcfs with 43° F water temperature releases produced the desired effect of lowering Lower Granite's tailwater below 68° F by July 7th. On July 14th, flow augmentation was reduced to 11 kcfs and then was further reduced to 9.6 kcfs on July 15th. Dworshak water temperatures continued to be between 42.8 and 43.0° F. The operation of 9.6 kcfs and 43° F water released from Dworshak continued until August 11th and produced the desired effects of maintaining the Lower Granite temperature below 68° F as Figures I-7 and I-9 shows. With cooler weather in August and September, Lower Granite tailwater remained under 68° F and

began a gradual decline, therefore, on August 11th the water temperature of Dworshak releases were raised to 45 to 46° F and outflow was reduced to 7.8 kcfs. The Dworshak water temperature began to creep above the 46° F on August 20th as the Lower Granite temperatures were declining. The 7.8 kcfs Dworshak outflow continued until September 9th, when it was reduced to 5.5 kcfs and water temperature of 49 to 50° F continued. On September 13th outflows were reduced to 2.4 kcfs and on September 16th, outflows were reduced again to minimum flows of 1.5 kcfs while the lowest possible temperature of 45° F was maintained. Figures I-8 and I-9 provides a graph of Dworshak summer operations with TMT requested dates for flows and temperatures and Table I-1 provides a list that summarizes the Dworshak operations. TMT's request for specific Dworshak release temperatures and outflows were satisfied during the entire flow augmentation and temperature control operation.

2) Dworshak Flow Augmentation and Temperature Control Operations Analysis

Table I-2 provides a comparison of the 2007 Dworshak operations with the previous seven summer seasons through the year 2000. As shown, this season's operations were fairly similar to the previous seasons. Slight deviations from the eight-year average include the total number of flow augmentation days for 2007 of 76.5, compared to an overall average of 72 days. However, the duration of the 2007 augmentation was shorter than the previous three years since the 2004 BiOp extended the elevation draft limit of 1520 feet from August 31st to September (refer to Figure I-11). Another slight deviation is the average temperature of the outflow waters for 2007 of 45.4° F as compared to an overall average of 46.4°F since the year 2000 (refer to Figure I-10). This has been a trend of the last five years where colder waters are being utilized to provide maximum cooling in the Lower Snake River. In fact, the average outflow temperatures in 2007 were the second coolest with respect to all years since 2000 (2006 was cooler with 45.0° F). 2007 was also a low flow year for the Snake and Clearwater Rivers with below average inflows of 0.8 kcfs compared to the eight year average of 1.9 kcfs, and an overall inflow volume of only 30.5 kaf compared to 259 kaf since 2000. These low flows resulted in a below average flow augmentation volume of 1334 kaf compared to the average of 1417 kaf.

One noticeable characteristic of this year's operation was the generally cooler water in the Dworshak reservoir's thermocline as compared to last season, and warmer water compared to the previous two 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 2007 summer season. Figures I-2 through I-4 provide a comparison of the Dworshak reservoir 2007 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 2007 were about 2° F less than they were in 2006 and greater than those in 2005 and 2004.

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 April 1st through September 30th; this figure shows increasing river temperatures as the water moves downriver of 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 gauges, respectively, and Lower Granite tailwater temperature. These are essentially the temperatures of the flows into 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 Orofino gage where water temperatures reached 83.7° F on July 27th. Temperatures measured at Anatone were the second highest with peak temperatures reaching 75.4° F on July 28th. The maximum hourly temperature that occurred at the Lower Granite tailwater was 68.7° F on July 5th which was down from last year's peak of 69.5° F on July 7th. Downriver the peak hourly temperature at Ice Harbor tailwater was 72.9° F. These tables and plots demonstrate that 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 highly successful.

Table I-4 provides the statistics of meeting the Lower Granite tailwater temperature criteria as compared to previous 12 years. Overall, Lower Granite tailwater exceeded the hourly 68° F criteria for a total of 31 hours compared to 223 hours in 2006 and the overall eight year average of 67 hours of exceedance. Since the peak temperature for Lower Granite was only 68.7° F, the degree to which the criteria was exceeded for 2007 was extremely low. 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° F criteria was exceeded [CIE = SUM (hours of exceedance) x (Hourly exceedance – 68° F)]. The resulting CIE value for Lower Granite was only 8.4. Table I-3 shows that even though Anatone and Ice Harbor tailwaters exceeded the 68° F temperature criteria for a greater number of hours than did Orofino, the CIE at Anatone and Ice Harbor was 7,013 and 4,107 respectively, compared to the CIE of 10,770 at Orofino. Orofino exceeded the criteria to a much greater extent than did the Anatone and Ice Harbor tailwaters.

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

The water temperature at Lower Granite tailwater peaked on July 5 at 68.7° F, three days after flow augmentation began, the highest during the 2007 spill season, and continued just above 68.0° F through July 6th. The Dworshak 43° F water releases combined with

increased flow rates arrived at Lower Granite on approximately July 7th and exerted a cooling influence on Lower Granite tailwater temperature maintaining it just below 68° F until August 1st; refer to Figures I-6 and I-7. The flow from Dworshak averaged 8.8 kcfs (Table I-2) with a range from 2.4 to 12 kcfs for the augmentation period of July 2nd to September 16th, when project discharge dropped to minimum flow of 1.5 kcfs (Table I-1). The water temperatures from the Dworshak release continued between 42.8 and 43.0° F from beginning of flow augmentation on July 2nd through August 11st when it began to gradually rise. Figures I-6 through I-9 show Lower Granite tailwater temperatures cooling as a result of Dworshak outflow changes and release temperatures.

Because of the early cold water releases from Dworshak with aggressive flow rates, the Lower Granite tailwater temperature exceeded the 68° F State standard for a total of only 31 hours, 26 of these hours occurred before the Dworshak flows arrived on July 7th. There was only one day on July 5th were the 24 hour average tailwater temperature at Lower Granite exceeded the state standard as shown on Table I-3. Refer to Table I-4 for more information on Lower Granite temperature exceedances compared to the last 13 years. The Dworshak flow augmentation and temperature control operation proved to be very successful in limiting the number of hourly temperature exceedances at the Lower Granite tailwater.

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 eight years. Before 2003, there was an average of 62 days of augmentation and after 2003, there was an average of 78 days. This represents a 16 day longer flow augmentation period compared to 2000 – 2002 periods, due to releases in September as agreed upon in the 2004 BiOp and Nez Perce Tribe's agreement.
- The overall trend towards cooler water being released from Dworshak reservoir for longer periods of time during summer operations continues and has been used as completely as possible. As a result, the seasonal average outflow temperature for Dworshak during the augmentation period has significantly dropped from 47 to 48° F range during the 2000 – 2002 time periods to the 45° F range during 2003 – 2007, refer to Figure I-10.
- The number of cooler days that the Dworshak release temperatures were between 43° to 44° F increased dramatically from eight days in 2004 to 15 days in 2005, 29 days in 2006, and 31 days in 2007; refer to Figure I-11. This confirms the trend toward releasing cooler water from Dworshak Dam.

It is unknown whether releasing cooler water from Dworshak produces a permanent effect on the pool's thermocline. Currently there is not enough historical data from the floating temperature strings, which measure the thermoclines, to draw a conclusion about the long-term reservoir temperatures. The effects from the flow augmentation operation on the overall Dworshak reservoir temperatures will be closely monitored in years to come.

Table I-2

Dworshak Flow Augmentation / Thermal Reduction Data

Parameter	2000	2001	2002	2003	2004	2005	2006	2007	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	7/2/07 10:00	--
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	9/16/07 22:00	--
Number of Days of Augmentation	63.0	58.8	65.4	75.0	82.0	79.0	78.3	76.5	72
Beginning Forebay Elevation (ft)	1598.8	1587.5	1599.2	1600	1599.8	1600	1599.3	1599.0	1598.0
Average Outflow (kcfs)	11.4	9.5	12.7	9.6	9.5	8.9	9.4	8.8	10.0
Flow Augmentation Volume (KAF)	1428	1115	1653	1430	1548	1394	1431	1334	1417
Average Inflow (kcfs)	2.0	1.9	3.5	1.6	2.4	1.5	1.7	0.8	1.9
Inflow Volume (KAF)	253	227	448	234	395	232	255	30.5	259
Outflow minus Inflow (KAF)	1174	889	1205	1196	1153	1162	1176	1303	1157
Seasonal Ave Outflow Temp (C)	9.1	8.8	8.8	7.4	7.7	7.6	7.2	7.5	8.0
Seasonal Ave Outflow Temp (F)	48.3	47.8	47.8	45.7	45.8	45.7	45.0	45.4	46.4
Total Cooling Units (KAF-C)	15,688	28,238	18,611	17,998	19,294	17,409	18,493	16,977	19,088
Total Cooling Units (KAF-F)	28,238	12,517	33,500	32,397	34,729	31,335	33,288	30,558	29,570

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 (68 F - Water Temp)

Table I-3

Daily Average and Hourly Temperature Exceedance Information
April 1 - September 30, 2007

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 (F)	Date of Maximum Hourly Temp
ORFI	7/1/07	09/07/07	67	6/29/07	9/9/07	1603	10769.7	83.7	7/27/07
DWQI	N/A***	N/A	0	N/A	N/A	0	0	61.3	9/14/07
ANQW	7/1/07	09/16/07	78	6/21/07	9/17/07	1891	7012.7	75.4	7/25/07
LGNW	7/5/07	07/05/07	1	7/5/07	8/2/07	31	8.4	68.7	7/5/07
LGSW	7/9/07	08/12/07	34	7/9/07	8/15/07	781	656.8	70.5	8/5/07
LMNW	7/5/07	09/01/07	59	7/4/07	9/1/07	1402	1999.5	70.6	8/6/07
IDSW	7/9/07	09/14/07	68	7/8/07	9/17/07	1638	4107.0	72.9	8/31/07
PAQW	8/13/07	09/14/07	28	7/29/07	9/16/07	675	455.5	70.1	9/4/07

* 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 - 2007 (Temperature in Degrees Fahrenheit)

Annual Statistics			13-yr Statistics					
Year	Hours of Exceedance	CIE* (degree-hour)	Hours of Exceedance			Cumulative Index of Exceedance (CIE)*		
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)		
2004	7	2						
2003	63	14	**Overall Average:**	238	hrs	**Overall Average:**	268	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 2000-2007:**	67	hrs	**Average 2000-2007:**	35	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 2007

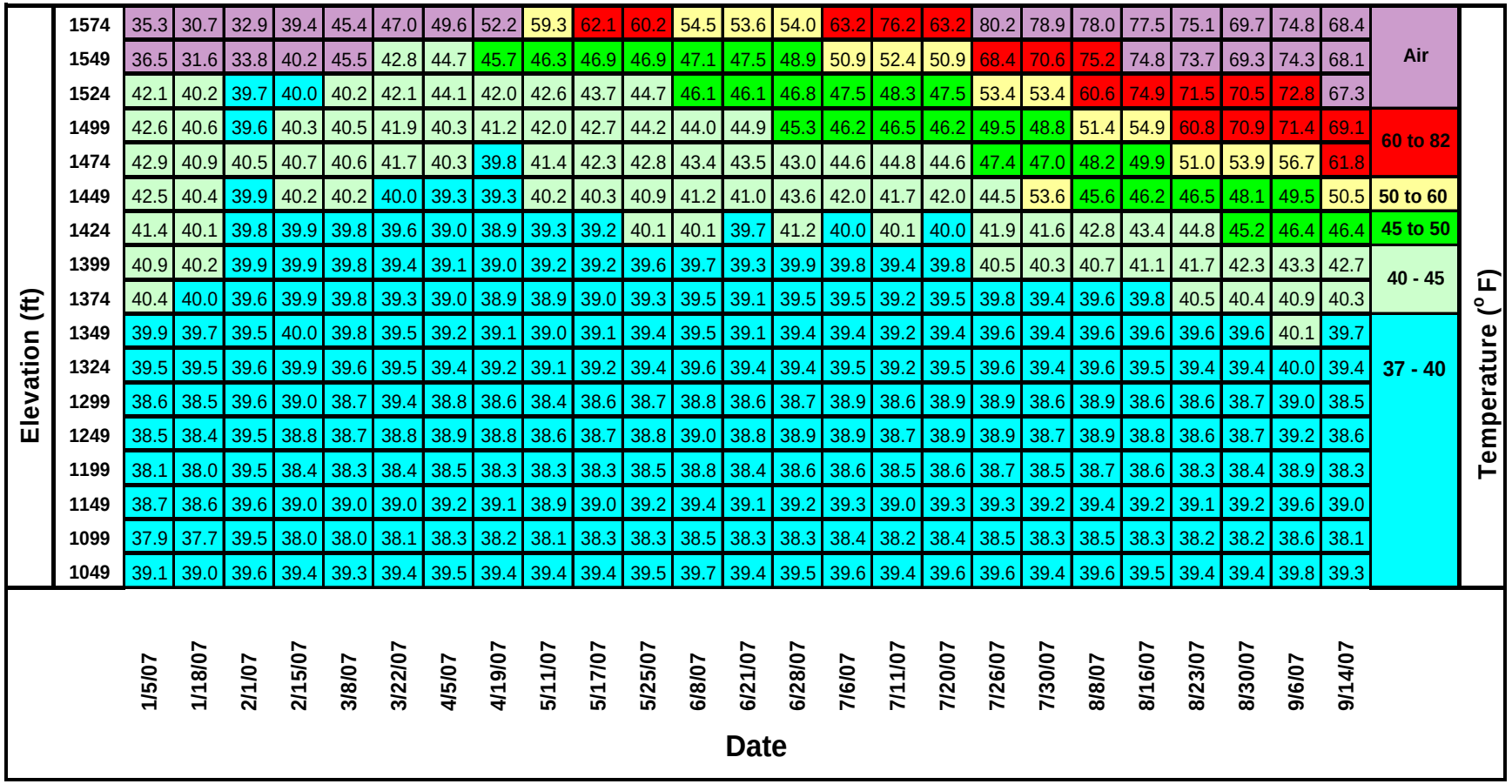

Figure I- 2

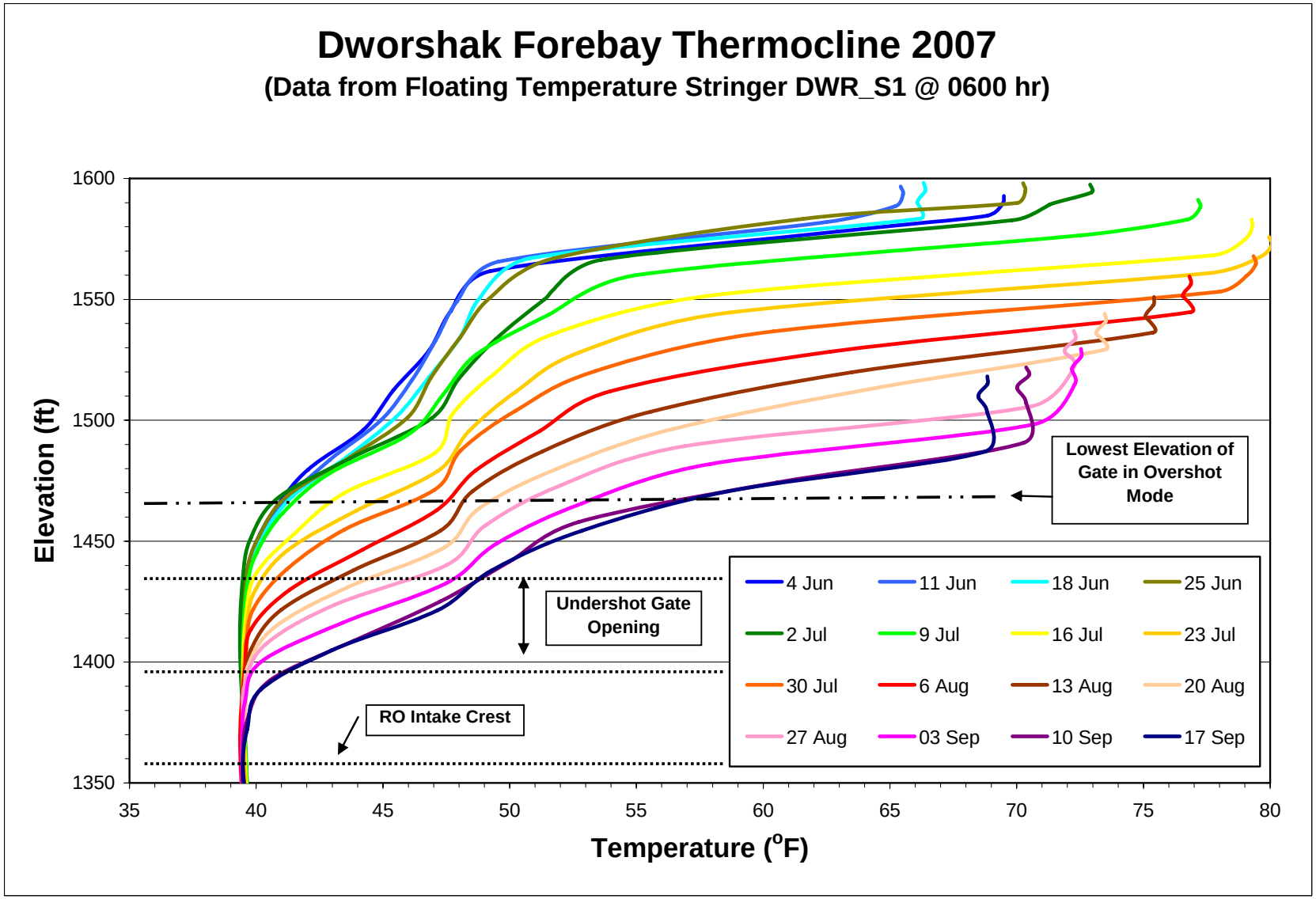
Dworshak Forebay Thermocline 2007
(Data from Floating Temperature Stringer DWR_S1 @ 0600 hr)
Elevation (ft)
1600
1550
1500
1450
1400
1350
35
40
45
50
55
60
65
70
75
80
Temperature (°F)
Lowest Elevation of Gate in Overshot Mode
Undershot Gate Opening
RO Intake Crest
4 Jun
11 Jun
18 Jun
25 Jun
2 Jul
9 Jul
16 Jul
23 Jul
30 Jul
6 Aug
13 Aug
20 Aug
27 Aug
03 Sep
10 Sep
17 Sep

Figure I-3

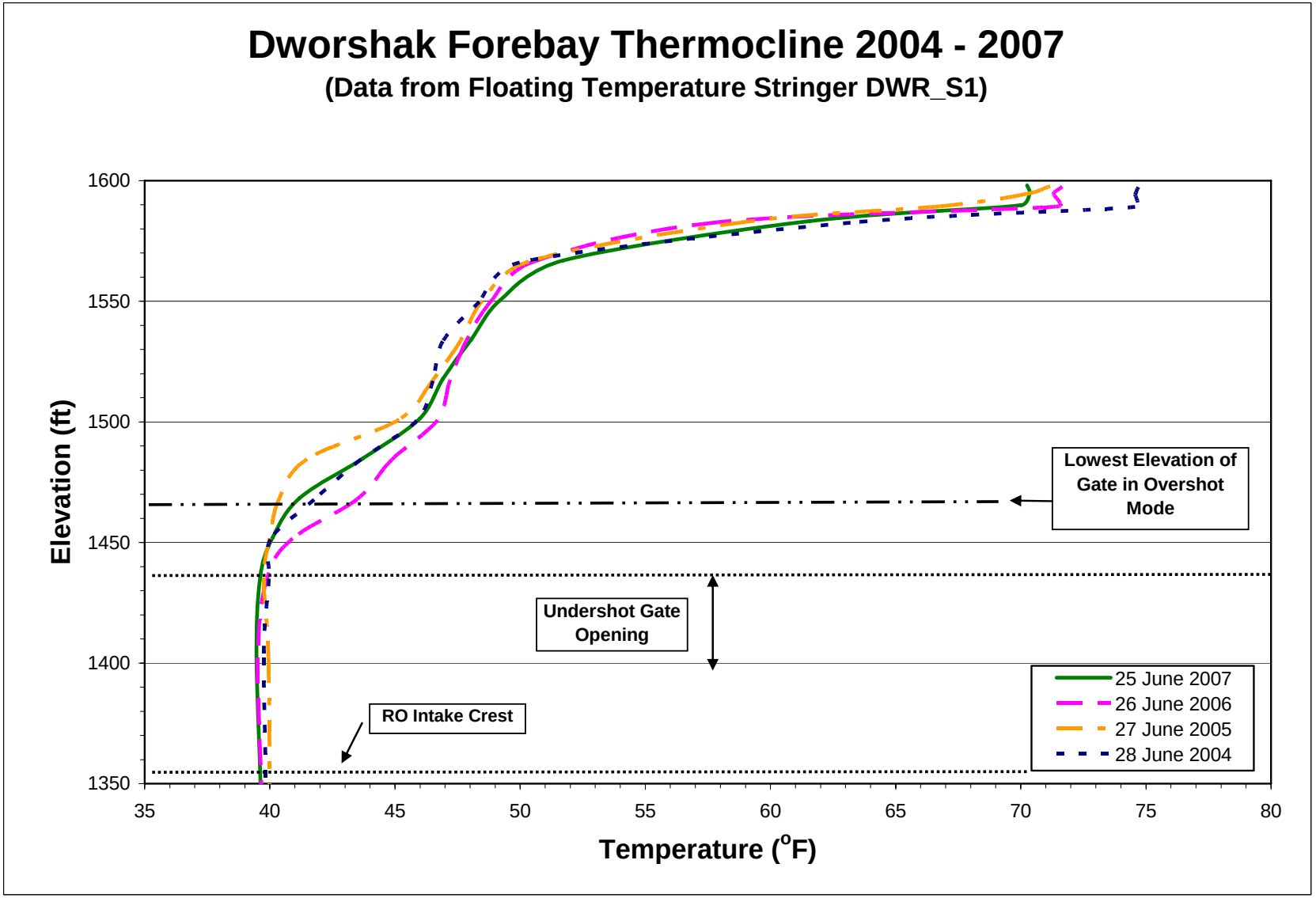
Dworshak Forebay Thermocline 2004 - 2007
(Data from Floating Temperature Stringer DWR_S1)
Elevation (ft)
1600
1550
1500
1450
1400
1350
35
40
45
50
55
60
65
70
75
80
Temperature (°F)
Lowest Elevation of Gate in Overshot Mode
Undershot Gate Opening
RO Intake Crest
25 June 2007
26 June 2006
27 June 2005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

Figure I-4

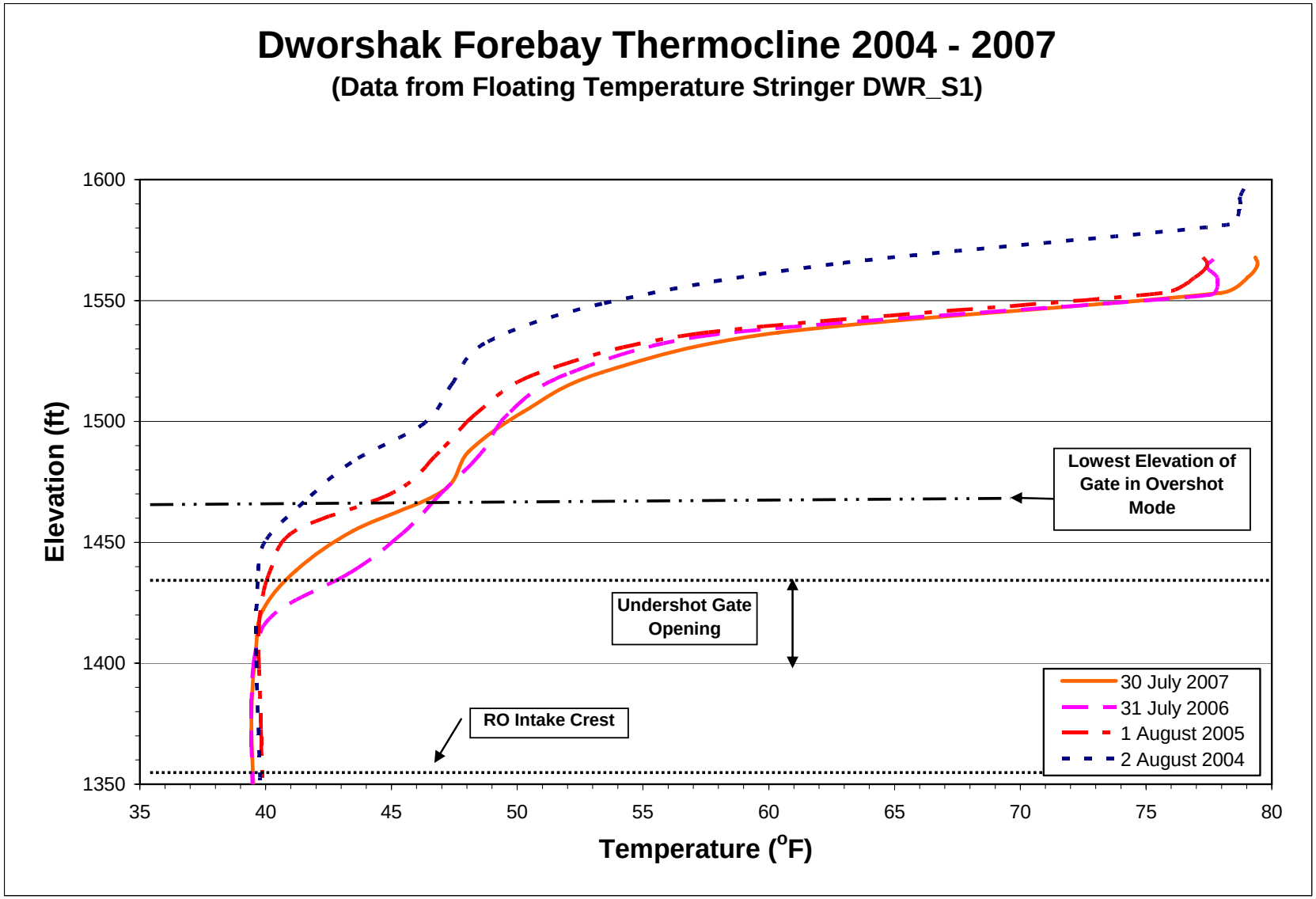
Dworshak Forebay Thermocline 2004 - 2007
(Data from Floating Temperature Stringer DWR_S1)
Elevation (ft)
1600
1550
1500
1450
1400
1350
35
40
45
50
55
60
65
70
75
80
Temperature (°F)
Lowest Elevation of Gate in Overshot Mode
Undershot Gate Opening
RO Intake Crest
30 July 2007
31 July 2006
1 August 2005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

Figure I-5

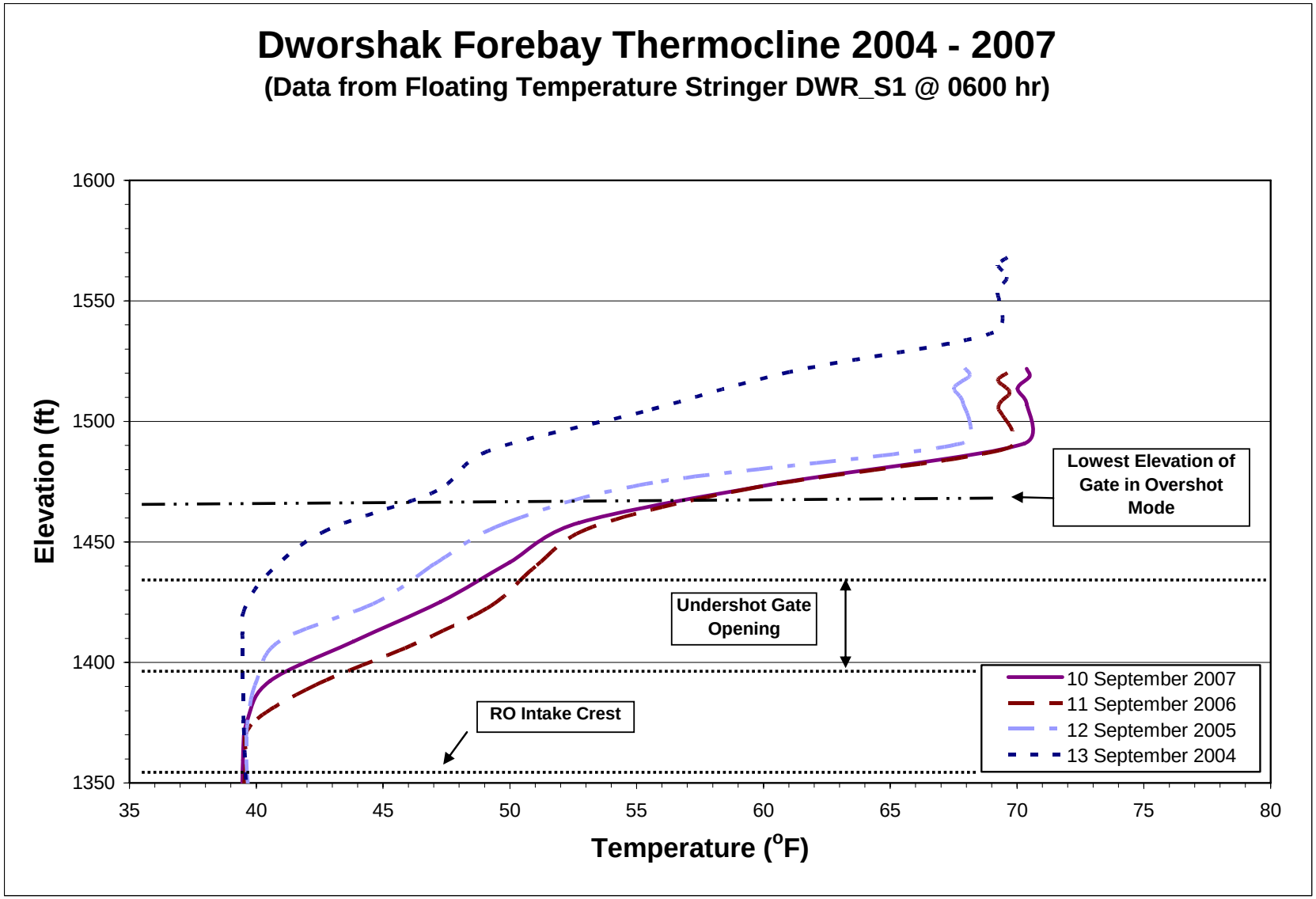
Dworshak Forebay Thermocline 2004 - 2007
(Data from Floating Temperature Stringer DWR_S1 @ 0600 hr)
Elevation (ft)
1600
1550
1500
1450
1400
1350
35
40
45
50
55
60
65
70
75
80
Temperature (°F)
Lowest Elevation of Gate in Overshot Mode
Undershot Gate Opening
RO Intake Crest
10 September 2007
11 September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

Figure I-6

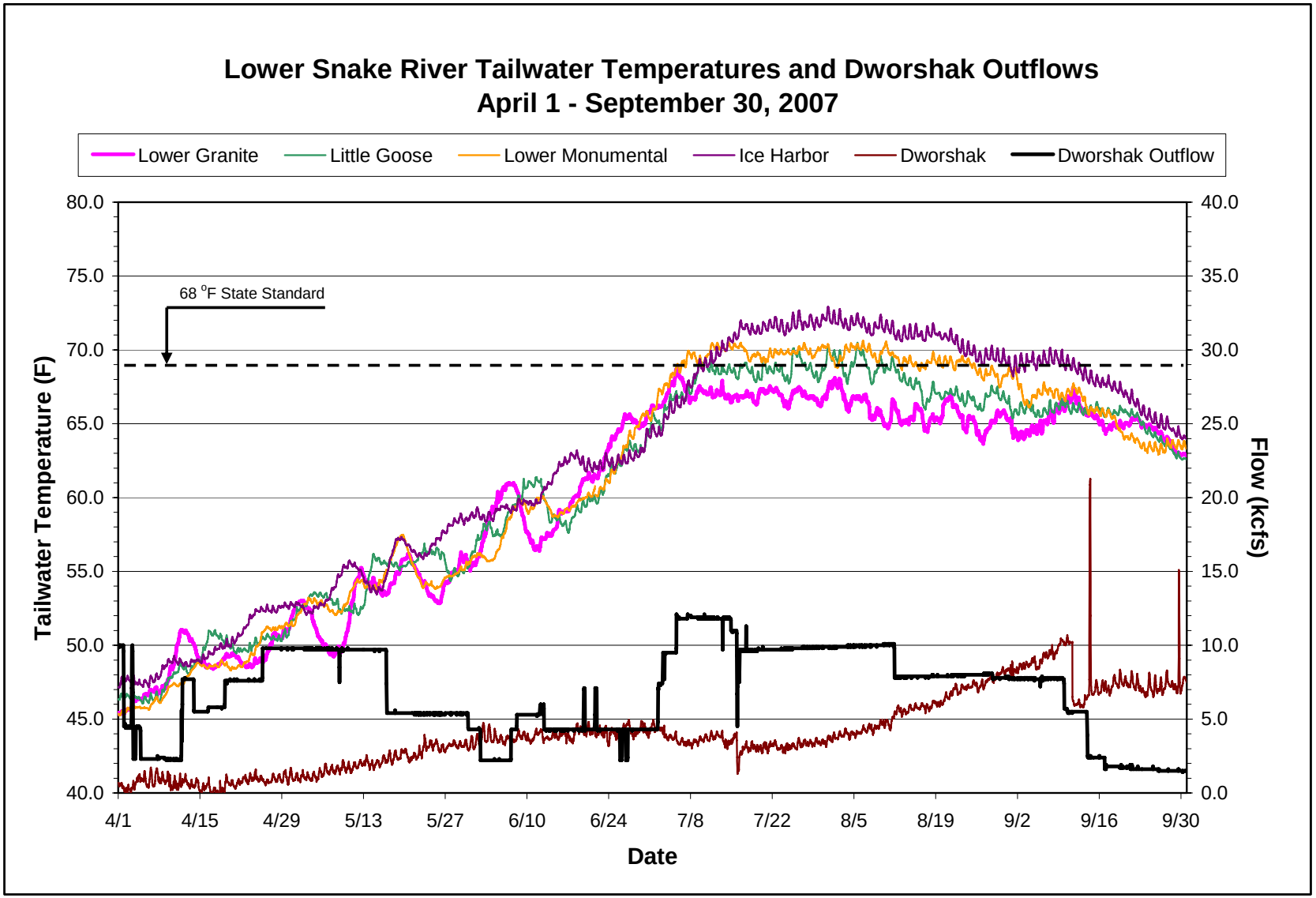
Lower Snake River Tailwater Temperatures and Dworshak Outflows
April 1 - September 30, 2007
Lower Granite
Little Goose
Lower Monumental
Ice Harbor
Dworshak
Dworshak Outflow
68 °F State Standard
Tailwater Temperature (F)
Flow (kcfs)
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
40.0
35.0
30.0
25.0
20.0
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

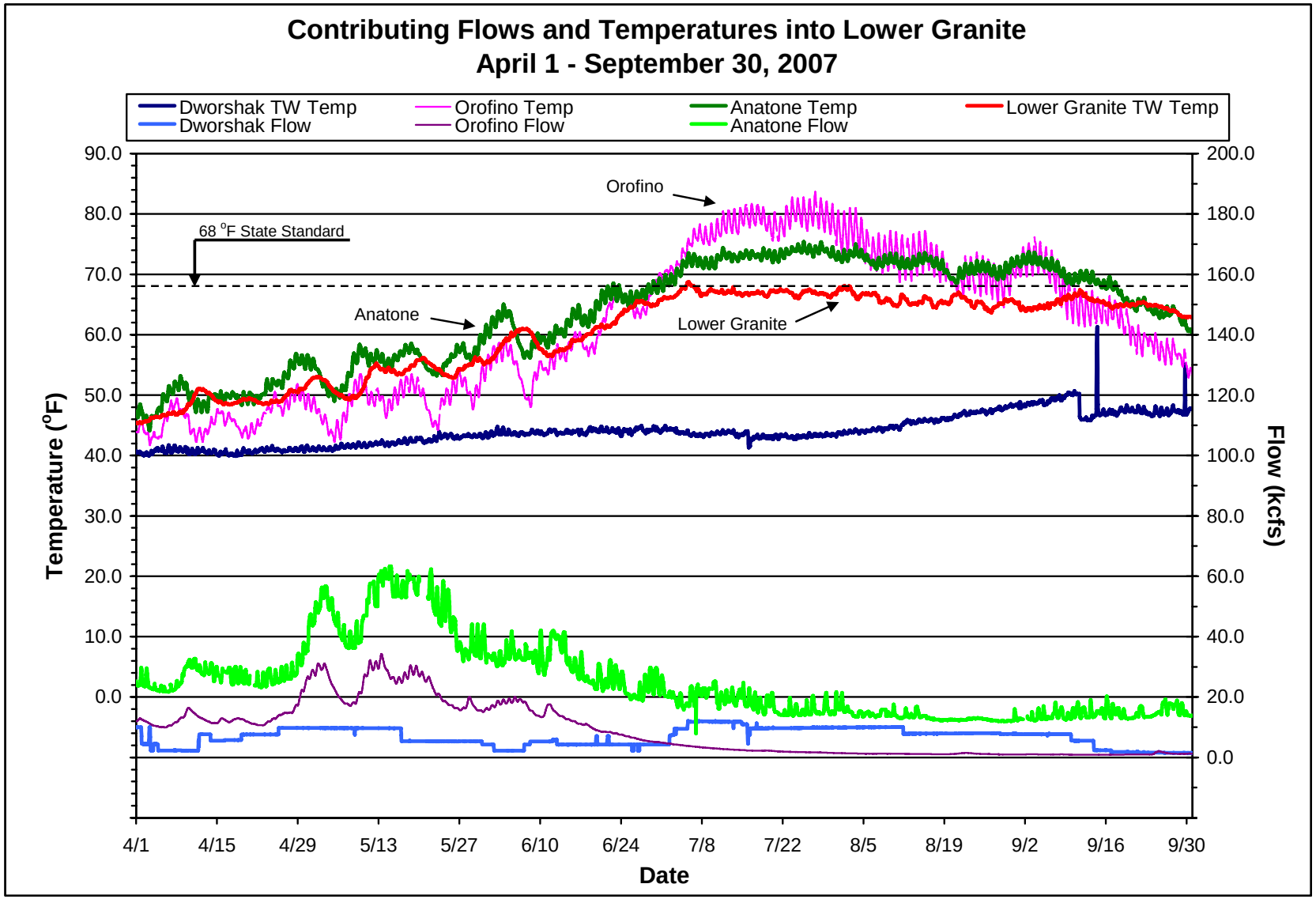
Contributing Flows and Temperatures into Lower Granite
April 1 - September 30, 2007
Dworshak TW Temp
Dworshak Flow
Orofino Temp
Orofino Flow
Anatone Temp
Anatone Flow
Lower Granite TW Temp
Orofino
68 °F State Standard
Anatone
Lower Granite
Temperature (°F)
Flow (kcfs)
Date
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
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

Figure I-8

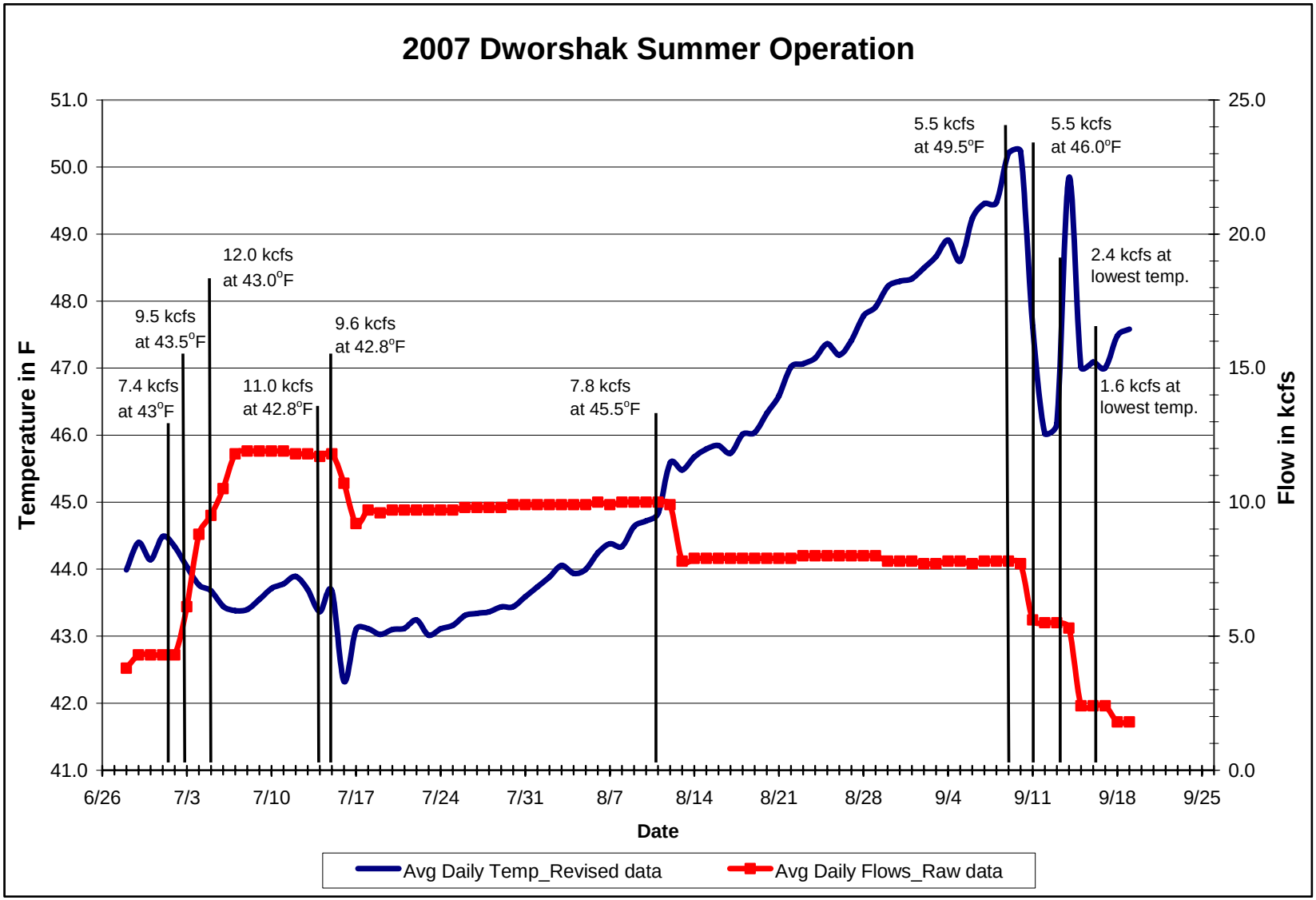
2007 Dworshak Summer Operation
Temperature in F
Flow in kcfs
Date
51.0
50.0
49.0
48.0
47.0
46.0
45.0
44.0
43.0
42.0
41.0
25.0
20.0
15.0
10.0
5.0
0.0
6/26
7/3
7/10
7/17
7/24
7/31
8/7
8/14
8/21
8/28
9/4
9/11
9/18
9/25
7.4 kcfs at 43°F
9.5 kcfs at 43.5°F
12.0 kcfs at 43.0°F
11.0 kcfs at 42.8°F
9.6 kcfs at 42.8°F
7.8 kcfs at 45.5°F
5.5 kcfs at 49.5°F
5.5 kcfs at 46.0°F
2.4 kcfs at lowest temp.
1.6 kcfs at lowest temp.
Avg Daily Temp_Revised data
Avg Daily Flows_Raw data

Figure I-9

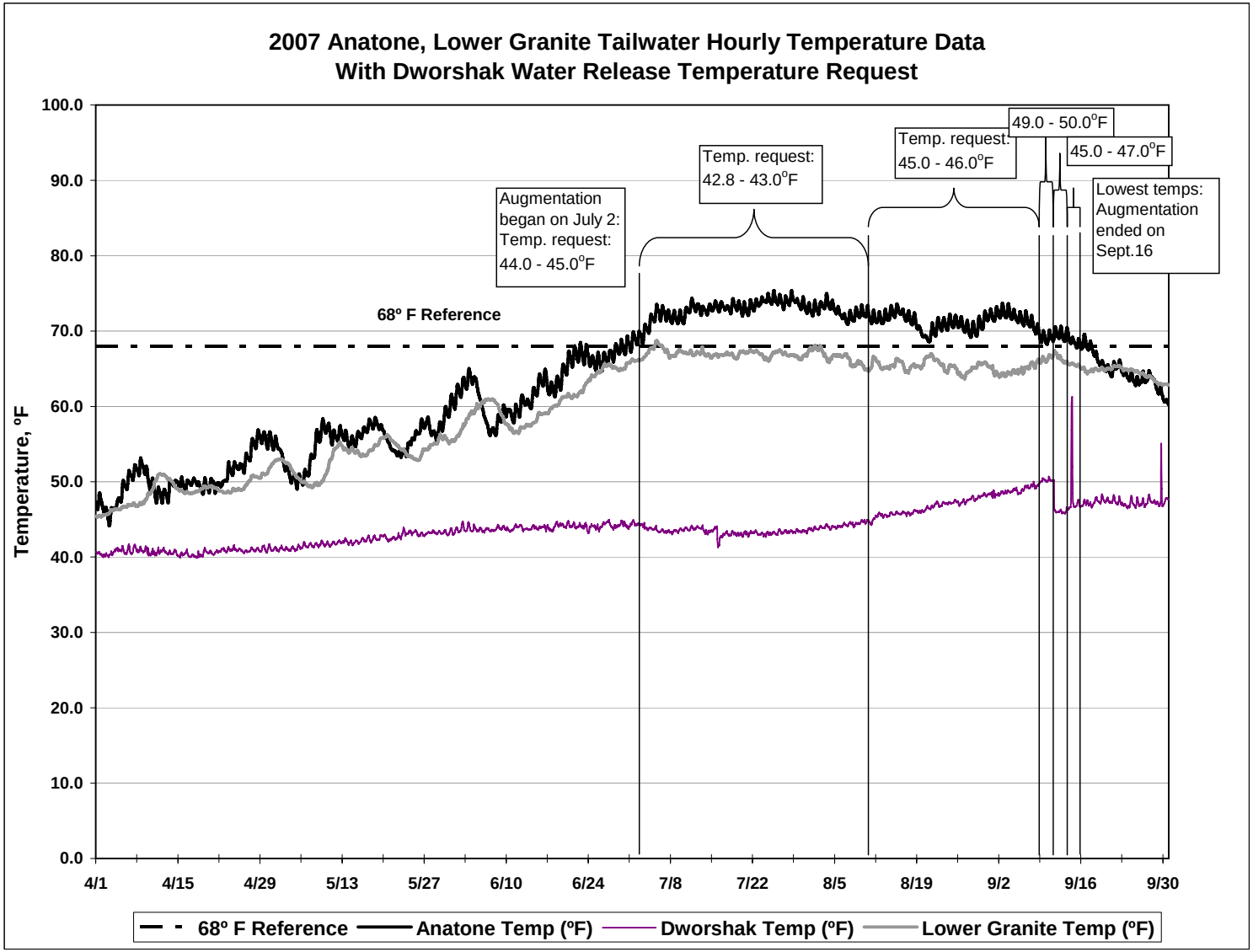
2007 Anatone, Lower Granite Tailwater Hourly Temperature Data
With Dworshak Water Release Temperature Request
Temperature, ºF
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
4/1
4/15
4/29
5/13
5/27
6/10
6/24
7/8
7/22
8/5
8/19
9/2
9/16
9/30
68º F Reference
Augmentation began on July 2: Temp. request: 44.0 - 45.0°F
Temp. request: 42.8 - 43.0°F
Temp. request: 45.0 - 46.0°F
49.0 - 50.0°F
45.0 - 47.0°F
Lowest temps: Augmentation ended on Sept.16
68º F Reference
Anatone Temp (ºF)
Dworshak Temp (ºF)
Lower Granite Temp (ºF)

Figure I-10

Dworshak Release Temperatures
as an Augmentation Seasonal Average, 2000 - 2007

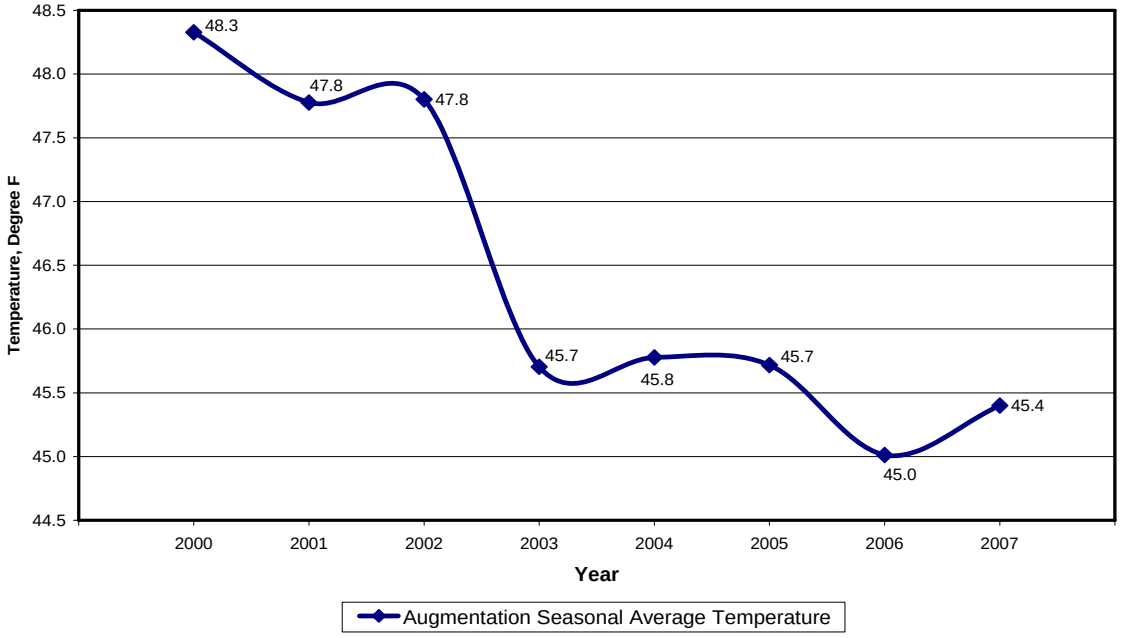

Figure I-11

Dworshak Augmentation Days