U.S. Fish and Wildlife Service

Summary of Icicle Creek Temperature Monitoring, 2012

Mathew Hall

U.S. Fish and Wildlife Service
Mid-Columbia River Fisheries Resource Office
Leavenworth, WA 98826

***On the cover**: Icicle Creek upstream of the Leavenworth National Fish Hatchery. USFWS.*

The correct citation for this report is:

Hall, M. R. 2013. Summary of Icicle Creek Temperature Monitoring, 2012. U.S. Fish and Wildlife Service, Leavenworth WA.

SUMMARY OF ICICLE CREEK TEMPERATURE MONITORING, 2012

Authored by

Mathew Hall

U.S. Fish and Wildlife Service
Mid-Columbia River Fisheries Resource Office
7501 Icicle Road
Leavenworth, WA 98826

Final Report
March 2013

Disclaimers

Any findings and conclusions presented in this report are those of the authors and may not necessarily represent the views of the U.S. Fish and Wildlife Service.

The mention of trade names or commercial products in this report does not constitute endorsement or recommendation for use by the federal government.

SUMMARY OF ICICLE TEMPERATURE MONITORING, 2012

Mathew Hall

U.S. Fish and Wildlife Service
Mid-Columbia River Fisheries Resource Office
7501 Icicle Rd.
Leavenworth WA 98826

Abstract-The Mid-Columbia River Fisheries Resource Office began monitoring temperature in Icicle Creek in 2005. ONSET Hobo Water Temp Pro V2 temperature loggers were deployed to 13 Icicle Creek sites upstream, adjacent to, and downstream of the Leavenworth National Fish Hatchery (LNFH). Water temperatures were recorded hourly. The year 2012 had a mean summer air temperature of 21.0^{o}C. In Icicle Creek, the expected downstream warming occurs, with two exceptions within the operational influence of the LNFH: 1) At the Snow Creek confluence, summer supplementation of water from Snow Lake cools Icicle Creeks mean high 7DADmax by 0.6^{o}C. 2) At the LNFH spillway pool, returned river water is mixed with well water creating an off-channel pool with a high 7DADmax that is, on average, 1.3^{o}C cooler than immediately upstream. This cooling effect is a result of hatchery related operations, and in 2012, was less than in previous years.

Page intentionally left blank for 2-sided printing

Table of Contents

List of Tables

List of Figures

Introduction

This report summarizes water temperature data collected by the Mid-Columbia River Fisheries Resource Office in Icicle Creek and tributaries upstream, adjacent to, and downstream of the Leavenworth National Fish Hatchery (LNFH) in 2012. Most sites are unchanged from previous years, and very little data was lost due to stochastic events.

Study Area

The Icicle Creek watershed drains 55,426 hectares of forested uplands on the eastern flank of the Cascade Mountain range in North Central Washington State. Icicle Creek is 50.8 km long from its headwaters at Lake Josephine (elevation 1423m) to its confluence with the Wenatchee River (elevation 340m) (WRWSC 1998). The upper drainage (approximately upstream of rkm 6.0) is characterized by high basin relief, glaciated cirques, and steep headwalls, with batholithic geology that has little water storage capacity. The lower drainage forms a low sloping basin filled with sand-and-gravel based glacial deposits. Approximately 87% of the watershed is publically owned and maintained by the U.S. Forest Service with 74% of the watershed residing within the Alpine Lakes Wilderness (USFS 1994).

The Icicle Creek watershed receives 305 cm of precipitation at its highest elevations, and 50.8 cm in its lower elevations. There are 14 glaciers and 102 lakes in the watershed that store most of the available precipitation, with glacial melt estimated to generate 21% of Icicle Creek flow during the summer months (Mullen et al. 1992). Stream discharge has been recorded by the U.S. Geological Survey (Gage Station 12458000 at rkm 9.4[1]) from 1936 to 1971 and from 1993 to the present. The average discharge for the period of record is 614 cfs. The minimum and maximum discharges are 44 cfs (November 30, 1936) and 19,800 cfs (November 29, 1995), respectively (USGS 2009).

Icicle Creek has two major water diversions, supplying four user groups, which affect in-stream flow and water temperature (Figure 1). Both diversions occur near the confluence of Snow Creek. At rkm 9.3, just upstream of the Snow Creek confluence, the Icicle Peshastin Irrigation District (IPID) withdraws from 60 to 103 cfs of water from April through September, and the City of Leavenworth withdraws about 2 cfs year around (Montgomery Water Group, Inc. 2004). At rkm 7.2, the Cascades Orchard Irrigation Company (COIC) withdraws 7 cfs from May through September, and the Leavenworth National Fish Hatchery (LNFH) uses 20 to 40 cfs year around. The total amount of water diverted from Icicle Creek during the summer months of June, July, and August, is about 140 cfs, while in the winter months it is about 42 cfs. (Montgomery Water Group, Inc. 2004).

Snow Creek is a major tributary of Icicle Creek, joining at rkm 9.2. Snow Creek drains a series of high mountain lakes, Upper Snow Lake being the largest by volume at approximately 12,450 acre-ft at

[1] All river kilometers (rkm) are approximate.

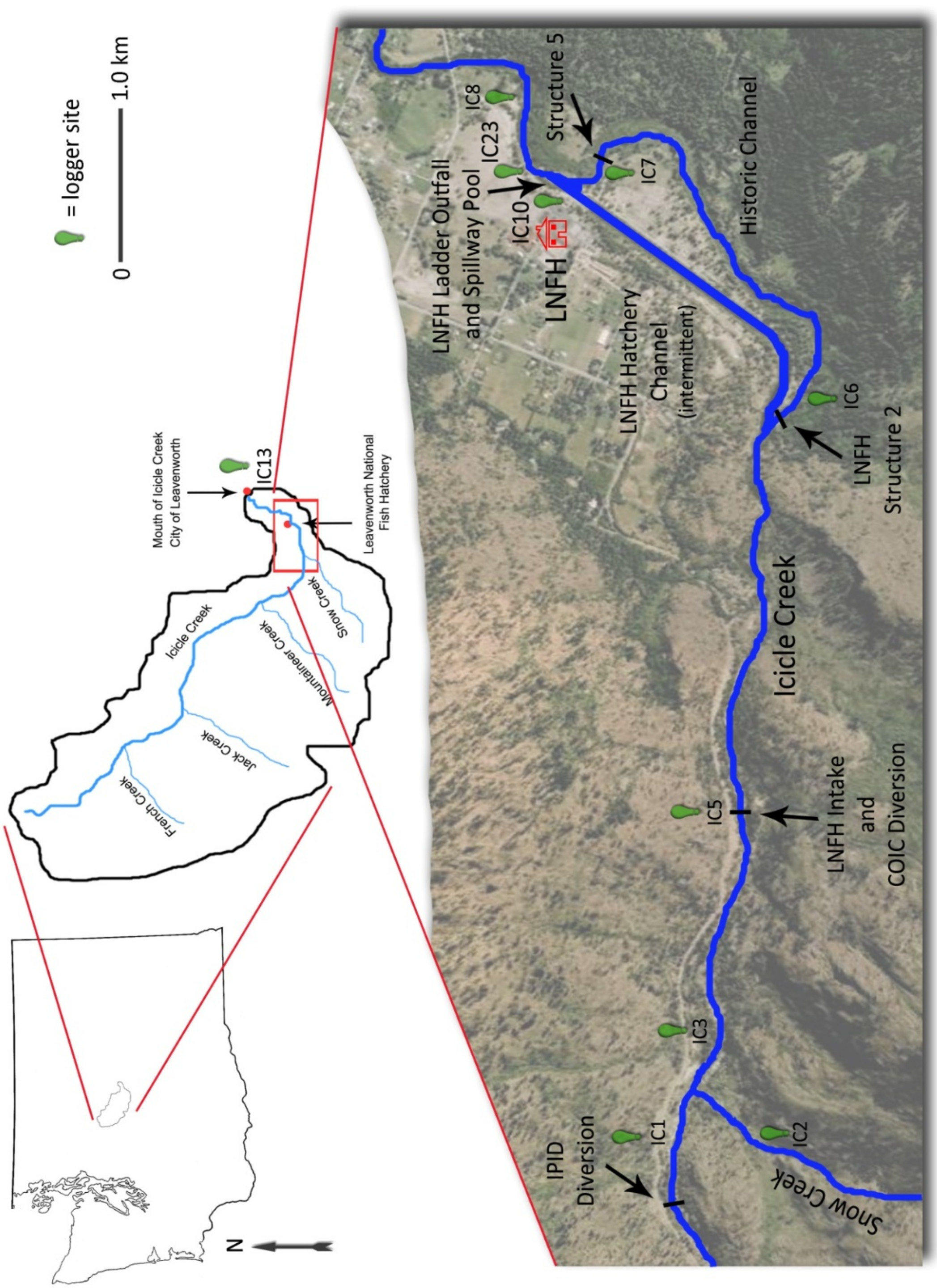

Figure 1. Map of Icicle Creek drainage with *selected* temperature monitoring sites and structures.

full capacity (Anchor QEA 2010). In 1939, the U.S. Bureau of Reclamation installed a valve in the bottom of Upper Snow Lake, allowing the lake to be drained at a controlled rate, and its water to be used to supplement Icicle Creek during low-flow periods. The LNFH has rights to 16,000 acre-ft of water per year from Upper Snow Lake. In a typical year, the valve is opened on 28-July (average 2006-2012, Table 1), delivering up to 60 cfs of water to Snow Creek, and is closed in October. During some low flow periods, supplemented Snow Creek water represents the majority of in-stream flow in Icicle Creek after the IPID diversion.

Table 1. Snow Lake valve openings, adjustments, and closures, and discharge into Snow Creek during those periods, 2006-2012.

Year	Date	Action	Discharge[1]
2012	31-Jul	Valve opened	25 cfs
	10-Aug	Adjustment	Increased to 50 cfs
	28-Aug	Adjustment	Opened from 45 to 53 degrees
	2-Oct	Valve closed	
2011	3-Aug	Valve opened	20 cfs
	12-Aug	Adjustment	Opened to 30+ degrees
	31-Aug	Adjustment	Opened to 47 degrees
	3-Oct	Valve closed	
2010	2-Aug	Valve opened	32 cfs
	13-Aug	Adjustment	Increased to 53 cfs
	27-Aug	Adjustment	Increased to 60 cfs
	4-Oct	Valve closed	
2009	23-Jul	Valve opened	14 cfs
	27-Jul	Adjustment	Increased to 32 cfs
	10-Aug	Adjustment	Increased to 52 cfs
	10-Sep	Adjustment	Increased to 60 cfs
	6-Oct	Valve closed	
2008	29-Jul	Valve opened	25 cfs
	12-Aug	Adjustment	Increased to 60 cfs
	3-Oct	Valve closed	
2007	23-Jul	Valve opened	53 cfs
	3-Oct	Valve closed	
2006	26-Jul	Valve opened	18 cfs
	16-Aug	Adjustment	Increased to 56 cfs
	5-Oct	Valve closed	

[1] Discharge is a function of both valve opening and head pressure (level of the lake). If the valve is left in the same position, discharge will decrease as head pressure decreases. From Fred Wurster memos (2009) and Al Jensen, LNFH, pers. comm.

The LNFH occupies land adjacent to Icicle Creek from approx. rkm 6.1 to rkm 4.1. At rkm 6.1, the Icicle Creek watershed transitions from a steep canyon to a broad valley. Channel classification transitions from B1 upstream of the LNFH Structure 2 to C4 downstream to the mouth (Rosgen 1996).

The LNFH intake is located in Icicle Creek at the shared COIC/LNFH diversion at rkm 7.2, and water is transported to the hatchery via underground piping. The LNFH also uses up to 14.4 cfs of well water to supplement its river supply, and to cool its incubation and rearing water in the summer and warm it in the winter (USFWS 2006).

The LNFH returns water to Icicle Creek in two locations: the adult ladder outfall at rkm 4.3, which drains the adult and juvenile rearing ponds, and the pollution abatement pond at rkm 4.2, which is used to collect and settle effluent from pond cleaning before returning the water to Icicle Creek. The adult ladder outfall represents >95% of the water returned to Icicle Creek from the LNFH. Water release from the pollution abatement pond consists of a "leakage" rate of approx. 1 cfs, and a pulse of about 3 cfs for a few hours per day during routine juvenile pond cleaning (Steve Croci, LNFH, pers. comm.).

Downstream of the LNFH, Icicle Creek meanders for 4.0 rkm through a broad valley of mixed residential and agricultural properties before emptying into the Wenatchee River.

Methods

To begin the 2012 monitoring year, the 13 sites that remained from the 2011 monitoring year were allowed to continuously record through the 2011/2012 winter (see Hall and Henry 2012, Appendix A). The temperature at all sites was recorded with Hobo Water Temp Pro V2 temperature loggers. All loggers recorded the temperature hourly when deployed, and were downloaded via the Hobo Waterproof shuttle. In 2012, the temperature loggers were **not** calibrated. The loggers were last calibrated in May of 2011 (Appendix B).

Air Temperature

For 2012, air temperature data was downloaded from the Washington Department of Ecologies' "River and Stream Flow Monitoring" website (https:/fortress.wa.gov/ecy/wrx/wrx/flows/regions/state.asp, station ID: 45B070, "Icicle Cr. Near Leavenworth"). This monitoring station was installed in November of 2010, and will be a reliable and low maintenance source for air temperature data in the future. Prior to 2012, air temperature data was recorded at the Mid-Columbia River Fisheries Resource Office (rkm 5.0), using the same model of data logger as the Icicle Creek sites. This site was discontinued in 2012 in favor of the Department of Ecologies' data set.

Site Visits

During the 2012 monitoring effort, all sites were visited in April, August, and October. On 2-Apr., all loggers were brought in from the field for downloading and maintenance. The raw data was imported into the HOBOware Pro V2x software to calculate daily minimums, maximums, and means. A 7-Day Average Daily Maximum (7DADmax) was calculated for each site and day using the running average of the previous 7 days. Housings and loggers were cleaned, and cables were inspected for integrity. All loggers were re-deployed on 3-Apr.

On 10-Aug, and again on 18-Oct., all loggers were downloaded remotely with the Hobo Waterproof shuttle. The raw data was handled as per the earlier site visit.

Stochastic Events

On the 2-Apr. site visit, IC6's cable was found broke, and the logger and housing was found buried in sand at the bottom of Icicle Creek. Comparison of IC6's data with that of IC7 (immediately downstream) showed no effect on the temperature recorded during the logger burial (Appendix C). A new cable was installed and the logger was redeployed on 3-Apr.

On the 10-Aug. site visit, IC1's cable was found broke. The logger and housing were found unharmed at the bottom of Icicle Creek. A new cable was installed and the logger and housing were re-deployed on 14-Aug.

Also on the 10-Aug. site visit, IC19 was found to be in shallow water. Suspecting that the shallow water may have introduced undesired solar heating, IC19's data was compared with that of IC1 (immediately downstream). Subsequent analysis showed no effect on the temperature recorded in the months prior to the site visit (Appendix D). IC19's cable was lengthened and the logger was redeployed into deeper water.

On the 18-Oct. site visit, IC19 was again found in shallow water. Suspecting that the shallow water may have introduced undesired solar heating, IC19's data was compared with that of IC1 (immediately downstream). Subsequent analysis determined that the logger was recording warmer temperatures than expected, particularly the daily maximums (Appendix E). As a result, IC19 data from 1-Sept. through 18-Oct. are omitted from this report and should not be used.

Also on the 18-Oct. site visit, IC8s' logger, housing, and cable were not found at the site. As a result, no data was gathered from 8-Aug. until a new logger was deployed on 5-Nov. A new logger was deployed at a different location within the same site, and will retain the same site name (Appendix F).

Results and Discussion

All of the raw data collected from this project are available upon request. Results in this report focus on summer high temperatures, as these are of the most interest to the water users and regulatory agencies. The summer season includes the period of Snow Creek supplementation (beginning 31-Jul in 2012), and the results presented here reflect this effect, unless otherwise noted. For 2012, the maximum 7DADmax (High 7DADmax), maximum temperature reached (High Max.), and dates of occurrence for each site is given in Appendix A. Note that because IC8 is missing data from the critical summer period, High Max. and High 7DADmax were not calculated for that site.

Air Temperature

The mean summer (Jul./Aug.) and High 7DADmax air temperature for 2006-2012 are shown in Figure 2. In 2012, the mean summer air temperature was 21.0^{o}C. The High 7DADmax was 35.3^{o}C, and occurred on 13-Jul. In summary, the environment around Icicle Creek experienced a cooler than average spring season, followed by an average summer (Figure 3).

Icicle Creek

A longitudinal temperature profile for Icicle Creek within the operational influence of the LNFH, using the High 7DADmax for 2012, 2011, and 2009, is shown in Figure 4. The years 2011 and 2009 are used as comparison because they are the coolest and warmest years recently monitored, respectively. This profile demonstrates the condition of Icicle Creek during the warmest period of the years monitored. Note that IC10 is located in the off-channel LNFH spillway pool, and that IC8 has no data for 2012, and IC5 has no data for 2011.

In 2012, Icicle Creek experienced the expected downstream warming, with IC13, at the mouth, being the warmest site within the creek, with a High 7DADmax of 18.2^{o}C and a High Max. of 18.7^{o}C. The coolest site within the *main channel* of Icicle Creek was IC3, downstream of the Snow Creek supplementation. At 17.0^{o}C, this site was slightly cooler than IC19, the uppermost site on Icicle Creek.

Snow Creek Supplementation

Supplementation of Snow Lakes water into Icicle Creek via Snow Creek began on 31-Jul. This is later than the previous average opening date of 28-July (2006-2011), and reflects the cool spring conditions, allowing the snowpack to linger and Icicle Creek flows to remain robust into the summer months. Located in Snow Creek, IC2 had a High 7DADmax of 18.0^{o}C, and a High Max. of 18.5^{o}C. Both of these readings occurred in mid-July, before Snow Lakes supplementation began. After supplementation begins, Snow Creek temperatures decrease continuously for the remainder of the year. This is commensurate with findings from previous years.

IC3, located in Icicle Creek immediately downstream of the Snow Creek confluence, reflects Snow Creek supplementation, with a High 7DADmax and High Max. that is cooler than that of IC1, immediately upstream of the confluence. In 2012, Snow Lake supplementation cooled IC3s' High 7DADmax by 0.6^{o}C when compared to IC1 (Figure 4). This is equal to the average cooling of 0.6^{o}C (range 0.2^{o}C to 1.0^{o}C) for the years 2005-2011.

Spillway Pool and Ladder Outfall

The LNFH spillway pool is an off-channel pool formed by the intermittent use of the Hatchery Canal and the adult ladder outfall, which constitutes >95% of the water returned to Icicle Creek. The returned river water is mixed with well water, which is between 7^{o}C and 9^{o}C, depending on which well is used.

The IC10 and IC11 sites represent different locations within the LNFH spillway pool. IC11 is directly under the LNFH adult ladder drain, while IC10 is on the opposite side of the pool. The temperatures recorded at these two sites have historically been nearly identical, with the average difference of 0.1°C, less than the stated accuracy of the loggers. This trend continues in 2012, and as such, IC10 will be used to represent this site.

IC10 had a High 7DADmax of 16.4°C and a High Max. of 17.3°C. These are the coolest temperatures recorded for these metrics, and reflect the cooling effect of the LNFH return water/well water mixture. In 2012, IC10's High 7DADmax and High Max. were 1.3°C cooler than the IC7 site, immediately upstream (Figure 4). This is less cooling than the average of 2.2°C from 2007-2011.

During the winter, the well water warms the discharged mix by up to 2.9°C when compared with IC7 (Hall and Kelly-Ringel 2011). The summer cooling and winter warming can be directly attributed to the operational influence of the LNFH. During periods of low flow, the spillway pool is distinctly separated from the thalweg of Icicle Creek, and the water mixes slowly. During high flow events, the thalweg of Icicle Creek overcomes its bank- full channel and readily mixes with the spillway pool.

Abatement Pond

The LNFH abatement pond returns about 1cfs of water to Icicle Creek during most of the year. For up to a few hours each day, cleaning activities increase this contribution to no more than 3 cfs (Steve Croci, LNFH pers. com.). The abatement pond return water is expected to be warmer than Icicle Creek due to solar heating over its large surface area, however its flow contribution is small.

In 2011, the LNFH began using a new abatement pond constructed next to the old pond. It will be used while the old pond is refurbished. In the future, both ponds will be available, though only one is expected to be used at a time.

Site IC23 is located at the outfall of the new abatement pond, and in 2012, the High 7DADmax was 16.5°C, and the High Max. was 17.5°C. Both of these events occurred in early August. These temperatures are lower than the averages from 2007-2011 (19.9°C and 21.3°C, respectively).

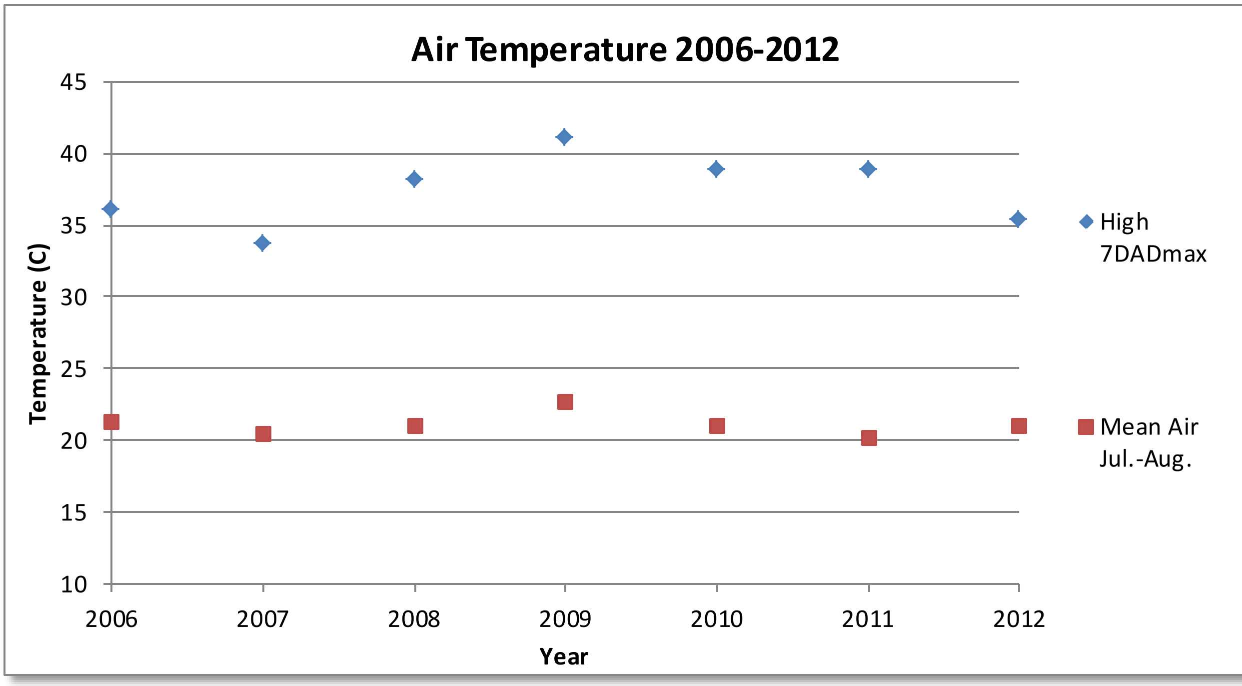

Figure 2. Mean summer and High 7DADmax air temperature for 2006-2012.

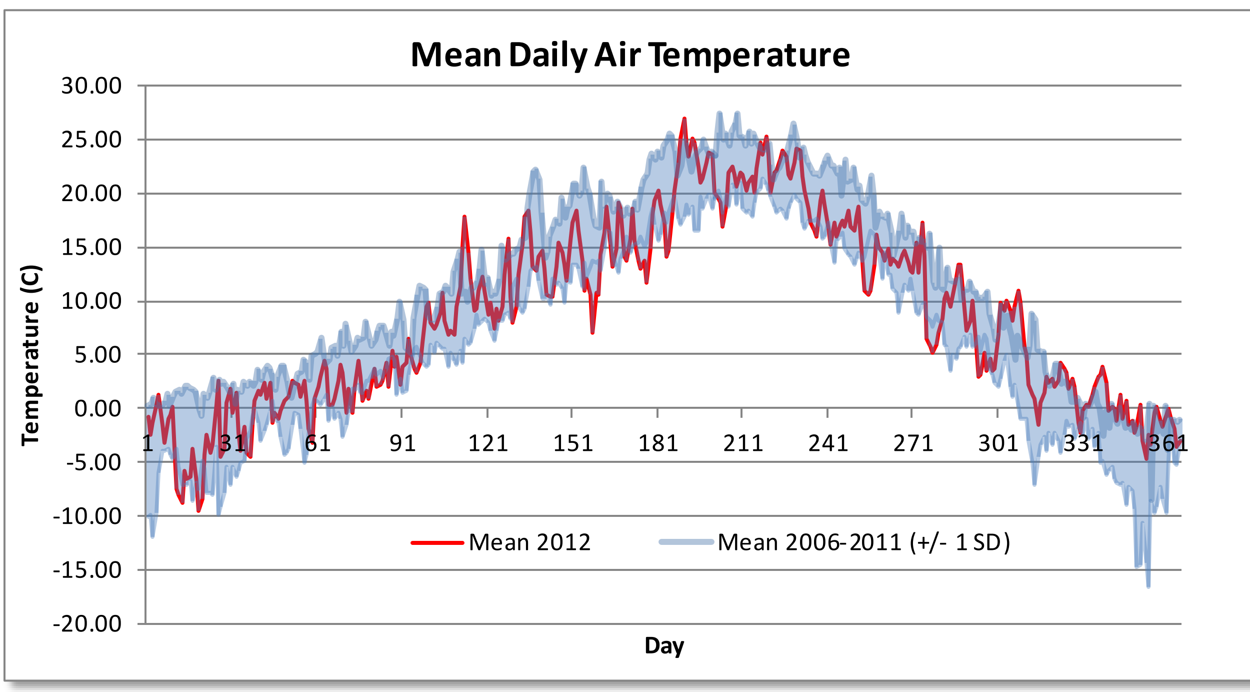

Figure 3. Mean daily Air temperature, 2012 and 2006-2011 (+/- 1 SD).

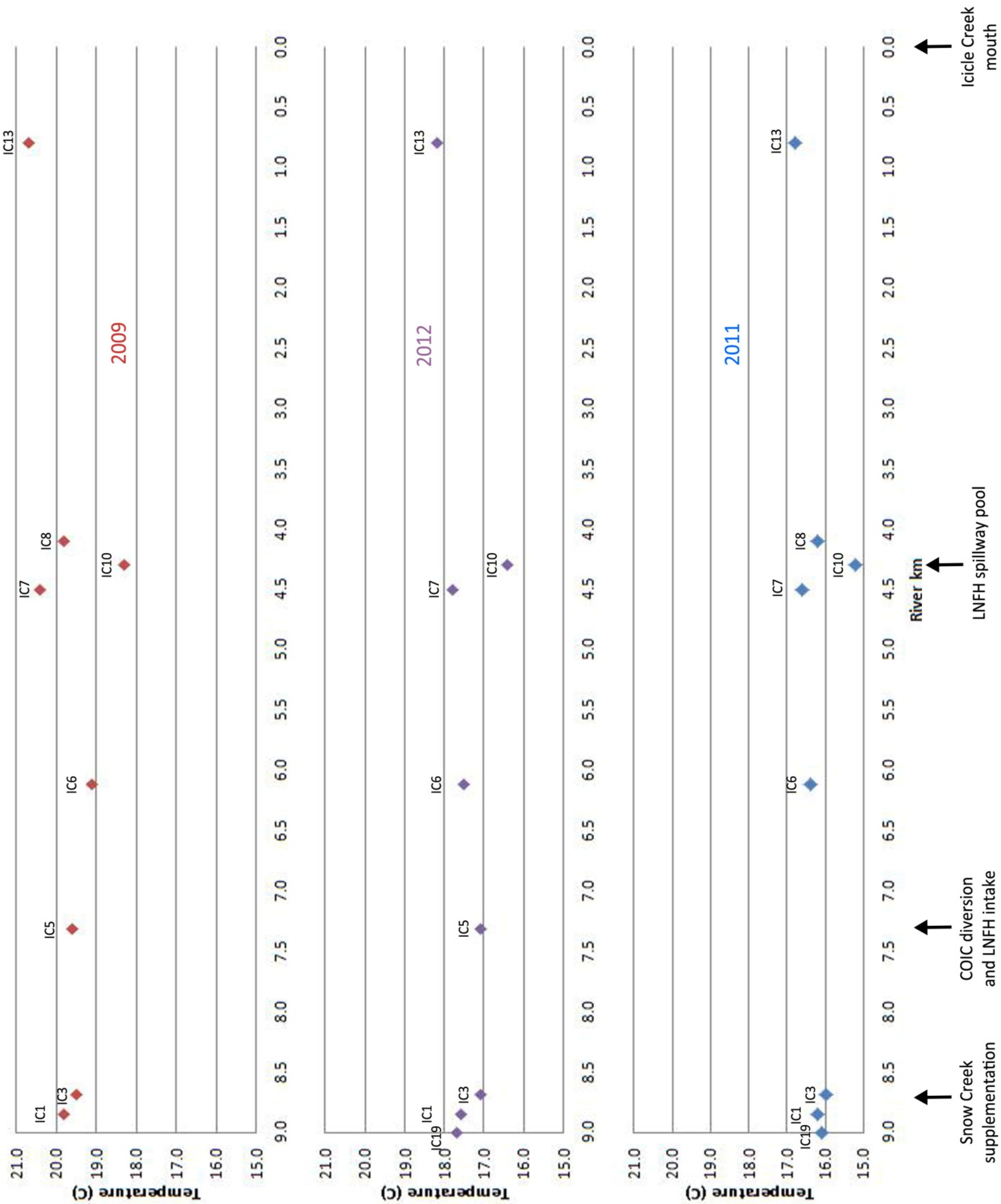

Figure 4. Longitudinal temperature profile for a portion of Icicle Creek using High 7DADmax for 2009 (warmest year), 2012, and 2011 (coolest year).

Literature Cited

Anchor QEA, LLC. 2010. Draft Wenatchee River Basin Water Storage Report-Snow Lakes. 811 Kirkland Ave. Suite 200. Kirkland, Washington 98033

Hall, M. R. and Barb Kelly-Ringel. 2011. Summary of Icicle Creek Temperature Monitoring, 2005-2009. U.S. Fish and Wildlife Service, Leavenworth WA.

Montgomery Water Group, Inc. 2004. Water management plan for Leavenworth National Fish Hatchery. Kirkland, Washington. 17 p.

Mullan, J. W., K. R. Williams, G. Rhodus, T.W. Hillman, and J.D. McIntyre. 1992. Production and habitat of salmonids in Mid-Columbia River tributary streams. U.S. Fish and Wildlife Service, Monograph 1, Leavenworth, Washington.

Rosgen. 1996. Applied River Morphology . Pagosa Springs: Wildland Hydrology Books, 1996.

USFS (U.S. Forest Service). 1994. Icicle Creek stream survey report. Leavenworth Ranger District, Leavenworth, Washington

USFWS (U. S. Fish and Wildlife Service). 2006a. Fish production review of the Leavenworth National Fish Hatchery Complex, 2005. Prepared by M. Cooper. Mid-Columbia River Fishery Resource Office, Leavenworth, Washington. 99 p. http://www.fws.gov/midcolumbiariverfro/pdf/Fish%20Production%20Review%20of%20the%20Leavenworth%20NFH%20Complex,%202005.pdf

USGS (United States Geological Survey). 2009. Stream flow monitoring network. (http://waterdata.usgs.gov/wa/nwis/rt)

WRWSC (Wenatchee River Watershed Steering Committee). 1998. Wenatchee River watershed action plan: a plan containing nonpoint pollution source control and implementation strategies. Chelan County Conservation District, Wenatchee, Washington.

Wurster F. 2009. Technical Memos:2005-2008 Upper Snow Lake Data Review. USFWS, Portland, Oregon.

Personal Communications

Croci, Steve. 2010. Leavenworth National Fish Hatchery. Phone conversation with M. Hall. Dec. 2010.

Jensen, Al. 2011. Leavenworth National Fish Hatchery. E-mail to M. Hall January 31, 2010.

Appendix A: Site Descriptions, High 7DADmax, High Max, and Dates.

Table 2. Site Descriptions, High 7DADmax, High Max., and Dates.

Site ID	Description	River km	Elevation (m)	Years	High 7DADmax (C)	7DADmax-week ending*	High max (C)	High max date*
IC15	Wenatchee River	n/a	339	2011	17.9	30-Aug	18.1	27-Aug
				2012	19.7	20-Aug	20.2	19-Aug
IC13	Icicle Mouth	0.8	334	2007	18.8	29-Jul	19.4	26-Jul
				2008	18.7	19-Aug	19.4	16-Aug
				2009	20.7	3-Aug	21.3	1-Aug
				2010	18.1	18-Aug	18.7	17-Aug
				2011	16.8	29-Aug	17.2	29-Aug
				2012	18.2	19-Aug	18.7	8-Aug
IC23	Abatement Pond outfall	4.2	339	2007	18.0	15-Jul	19.0	4-Aug
				2008	19.4	19-Aug	20.5	19-Aug
				2009	22.0	2-Aug	23.0	29-Jul
				2010	no data	no data	no data	no data
				2011	20.2	7-Jul	22.7	5-Jul
				2012	16.5	9-Aug	17.5	8-Aug
IC8	d/s of LNFH	4.1	339	2005	19.6	31-Jul	20.0	28-Jul
				2006	18.9	27-Jul	19.8	23-Jul
				2007	19.4	26-Jul	18.5	26-Jul
				2008	no data	no data	no data	no data
				2009	19.8	3-Aug	20.3	28-Jul
				2010	no data	no data	no data	no data
				2011	16.2	29-Aug	16.5	29-Aug
				2012	no data	no data	no data	no data
IC11	LNFH at Ladder outfall	4.3	340	2007	16.3	29-Jul	16.8	26-Jul
				2008	16.3	19-Aug	17.0	16-Aug
				2009	18.2	2-Aug	18.7	28-Jul
				2010	no data	no data	no data	no data
				2011	15.3	29-Aug	15.4	25-Aug
				2012	16.6	9-Aug	17.3	5-Aug
IC10	LNFH Spillway pool	4.3	340	2005	16.9	11-Aug	17.7	31-Jul
				2006	no data	no data	no data	no data
				2007	16.2	30-Jul	16.8	26-Jul
				2008	16.2	19-Aug	16.8	16-Aug
				2009	18.3	2-Aug	18.7	28-Jul
				2010	no data	no data	no data	no data
				2011	15.2	29-Aug	15.4	23-Aug

				2012	16.4	18-Aug	17.3	8-Aug
IC7	d/s of Structure 5	4.5	340	2005	no data	no data	no data	no data
				2006	19.4	28-Jul	20.2	23-Jul
				2007	19.3	29-Jul	20.2	28-Jul
				2008	18.2	19-Aug	19.2	16-Aug
				2009	20.4	3-Aug	20.9	1-Aug
				2010	no data	no data	no data	no data
				2011	16.6	29-Aug	16.8	29-Aug
				2012	17.7	19-Aug	18.3	14-Aug
IC6	at LNFH Headgate	6.1	350	2005	20.3	21-Aug	21.0	16-Aug
				2006	19.2	28-Jul	20.2	23-Jul
				2007	17.9	30-Jul	18.8	26-Jul
				2008	17.6	18-Aug	18.6	16-Aug
				2009	19.1	2-Aug	19.6	28-Jul
				2010	17.3	18-Aug	17.7	17-Aug
				2011	16.4	29-Aug	16.5	23-Aug
				2012	17.5	18-Aug	18.2	8-Aug
IC5	LNFH Intake	7.1	356	2011	no data	no data	no data	no data
				2012	17.1	19-Aug	17.8	5-Aug
IC3	d/s of Snow Creek	8.7	392	2005	18.1	31-Jul	18.6	29-Jul
				2006	no data	no data	no data	no data
				2007	17.2	30-Jul	18.2	26-Jul
				2008	no data	no data	no data	no data
				2009	19.5	2-Aug	20.0	28-Jul
				2010	16.4	18-Aug	16.8	17-Aug
				2011	16.0	29-Aug	16.2	25-Aug
				2012	17.0	19-Aug	17.7	5-Aug
IC2	in Snow Creek	n/a	398	2005	16.6	23-Jul	17.4	18-Jul
				2006	17.5	14-Jul	19.0	14-Jul
				2007	18.5	16-Jul	19.7	13-Jul
				2008	15.9	26-Jul	16.7	9-Jul
				2009	18.0	28-Jul	18.7	27-Jul
				2010	17.4	30-Jul	18.3	28-Jul
				2011	15.6	8-Aug	16.4	4-Aug
				2012	18.0	19-Jul	18.5	19-Jul
IC1	u/s of Snow Creek	8.8	410	2005	18.9	31-Jul	19.5	6-Aug
				2006	18.6	27-Jul	19.5	23-Jul
				2007	17.9	29-Jul	18.7	2-Aug
				2008	18.3	19-Aug	19.3	16-Aug
				2009	19.8	2-Aug	20.2	28-Jul
				2010	17.4	18-Aug	18.0	17-Aug
				2011	16.2	29-Aug	16.4	25-Aug
				2012	17.6	20-Aug	18.2	14-Aug

IC19	u/s of IPID at USGS gauge	9.3	435	2011	16.1	29-Aug	16.4	25-Aug
				2012	17.7	19-Aug	18.2	14-Aug

* Date if first occurrence.

Appendix B: Temperature Logger Calibration Protocol

Temperature Logger Calibration/ Testing
Kendall Henry

Prior to deployment, all temperature loggers were tested in two temperature baths representing the extremes of their monitoring conditions, as per Ward 2003.

The baths were made in coolers and had either an aquarium powerhead or air pump/stone added to mix the water and maintain a uniform temperature. The loggers were weighed down by putting the same nuts and bolts that will be used in the field through the hole. The loggers were acclimated to the baths for at least 1/2 hour before temp monitoring began. We used a NIST certified thermometer and a YSI sonde to measure temperature. The loggers were launched to record temp at 5 minute intervals and the YSI and NIST temperatures were noted at the same 5 minute intervals.

The room temperature bath was made by filling a cooler and allowing it to stabilize to room temperature (about 21 C). The ice bath was made using the coldest tap water and 10 ice cube trays of ice. The lid was placed over this cooler except for 1 inch on the side to allow insertion of the thermometer. The ice bath sat for at least 1 hour to allow it to stabilize and become uniform throughout.

After the calibration tests were concluded, the data was downloaded to hobo software and exported to Excel for comparison with the reference thermometer. If the mean absolute value of the difference was greater than 0.2 ° C the thermometers were tested again. If the mean difference was still more than +- 0.2 ° C they were not used in the sampling.

Ward, William J. 2003. Continuous Temperature Sampling Protocols for the Environmental Monitoring and Trends Section. Washington State Department of Ecology, Publication 03-03-052, Olympia, Washington

Appendix C: Stochastic Events – IC6

On the 2-Apr. site visit, IC6's cable was found broke, and the logger and housing was found buried in sand at the bottom of Icicle Creek. Suspecting that the burial of the logger may have affected the data collected, IC6's data was compared with that of IC7, located immediately downstream. A two-sided, unpaired t-test was performed on the maximums, minimums, and means of each logger during the time that IC6 was buried. The t-test showed that maximums, minimums and means were not different between the two loggers (Table C1). The Root Mean Squared Error (RMSE), using the IC7 as the predictor, was very low for all three metrics recorded at the IC6 site (Table C1).

Table 3. Statistical comparison between IC6 and IC7 data during burial of IC6, 2012.

	p-value	RMSE
Maximum	0.912	0.203
Minimum	0.804	0.087
Mean	0.838	0.124

Appendix D: Stochastic Events – IC19

On the 10-Aug. site visit, IC19 was found to be in shallow water. Suspecting that the shallow water may have introduced undesired solar heating, IC19s' data was compared to that of IC1, located immediately downstream. A two-sided, unpaired t-test was performed on the maximums, minimums, and means of each logger during the time IC19 was in shallow water. The t-test showed that maximums, minimums and means were not different between the two loggers (Table D1). The Root Mean Squared Error (RMSE), using the IC1 as the predictor, was very low for all three metrics recorded at the IC19 site (Table D1).

Table 4. Statistical comparison between the IC19 and IC1 data during the summer of 2012.

	p-value	RMSE
Maximum	1.0	0.00
Minimum	0.9	0.04
Mean	1.0	0.03

Appendix E: Stochastic Events – IC19

On the 18-Oct. site visit, IC19 was again found in shallow water. Suspecting that the shallow water may have introduced undesired solar heating, IC19s' data was compared to that of IC1, located immediately downstream. A two-sided, unpaired t-test was performed on the maximums, minimums, and means of each logger during the time IC19 was in shallow water. The t-test showed that maximums were different ($p>0.005$), while the minimums and the means were not different ($p<0.005$, Table E1). The Root Mean Squared Error (RMSE), using the IC1 as the predictor, was high for the maximum and mean values and low for the minimum values recorded at the IC19 site (Table E1).

Table 5. Statistical comparison between the IC19 and IC1 data during the fall of 2012.

	p-value	RMSE
Maximum	0.003	2.69
Minimum	0.649	0.64
Mean	0.084	1.29

Appendix F: Stochastic Events – IC8

On the 18-Oct. site visit, the IC8 logger, housing and cable were found to be missing. This site is in an area of high public use, and vandalism is suspected. To reduce the likelihood of future data loses, a new location was selected for the replacement logger. This new location is near enough to the original location to retain the same "IC8" designation. On 5-Nov., a new logger, housing, and cable were deployed at the new location (Figure F-1).

Figure F-1. Aerial map of the locations of the old and new IC8 logger.

U. S. Fish and Wildlife Service
Mid-Columbia River Fisheries Resource Office
7501 Icicle Road
Leavenworth, WA

March 2013