

Quality Assurance Project Plan

Icicle Creek Synoptic Flow Study



June 2026

Prepared for:

The Washington State Department of Ecology and Chelan County Department
of Natural Resources

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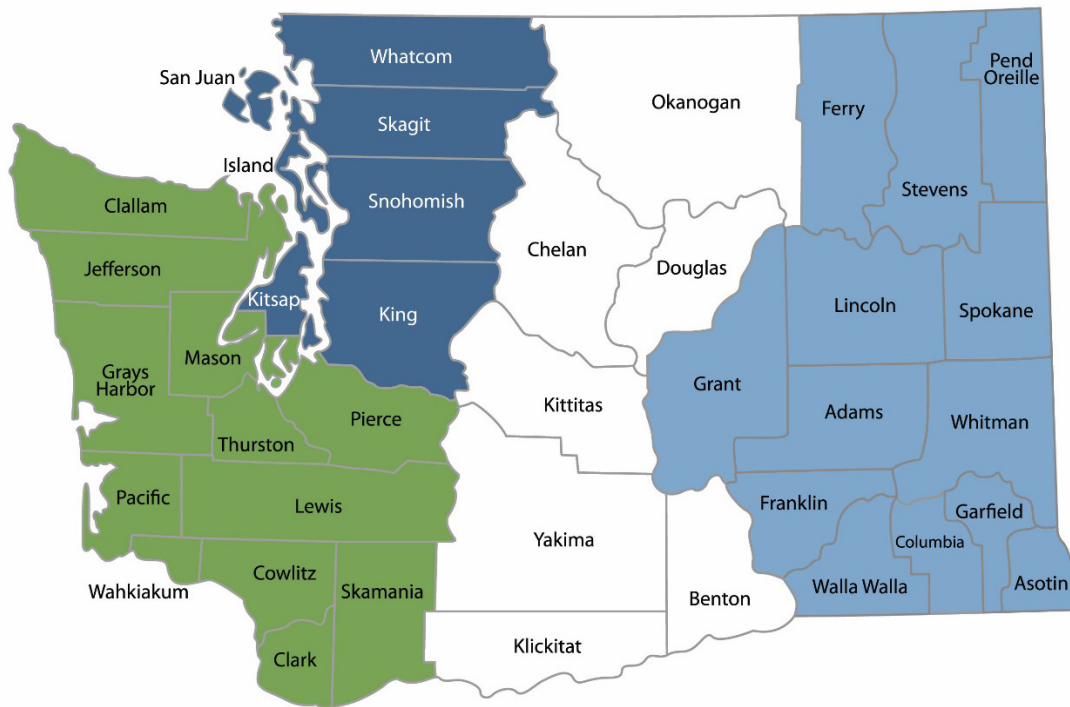
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Northwest	Island, King, Kitsap, San Juan, Skagit, Snohomish, Whatcom	PO Box 330316 Shoreline, WA 98133	206-594-0000
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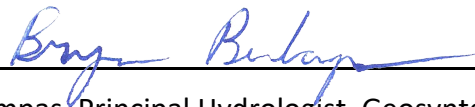
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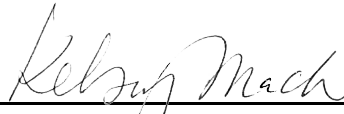
Icicle Creek Synoptic Flow Study

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1.0 Background and Project Description

This Quality Assurance Project Plan (QAPP) for the Icicle Creek Synoptic Flow Study (Study) outlines procedures for performing a synoptic flow study on Icicle Creek located near Leavenworth in Chelan County, Washington. This QAPP was generally prepared in accordance with the Washington State Department of Ecology's (Ecology's) Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies (Ecology 2004) and Quality Management Plan Version 5 (Ecology 2020).

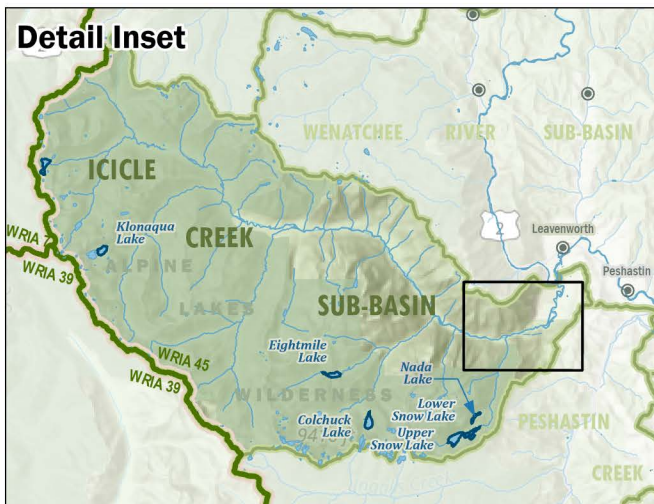
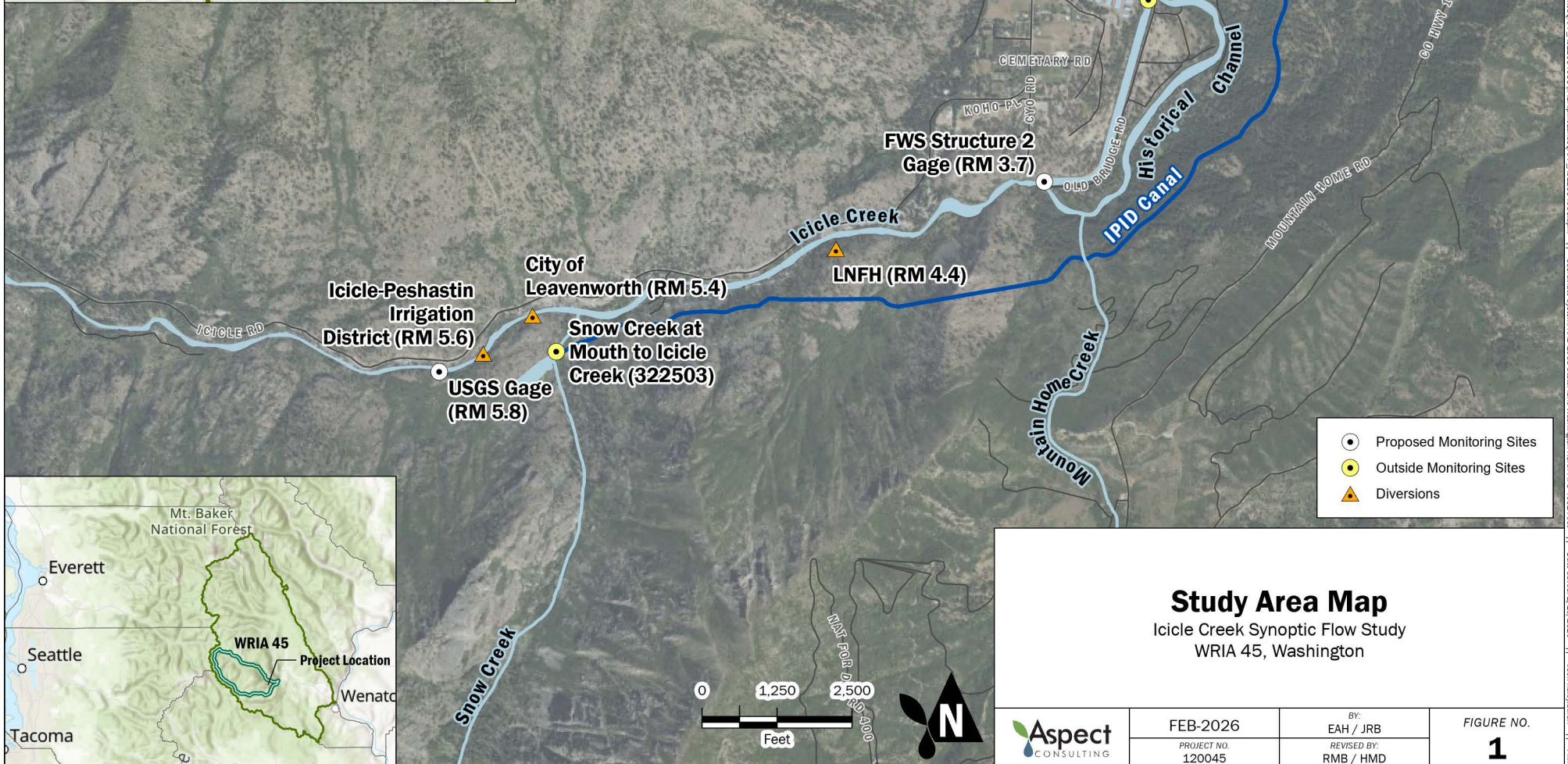
The multi-stakeholder Icicle Working Group (IWG) is comprised of diverse agricultural, conservation, and recreational interests; tribal governments; and local, state, and federal agencies that developed the Icicle Creek Water Resource Management Strategy (Icicle Strategy).² The Icicle Strategy was developed by consensus of IWG members and established several guiding principles, including improvement of instream flow in Icicle Creek, among others. The Icicle Strategy outlines several actions intended to support a target flow of 100 cubic feet per second (cfs) during low-flow periods in nondrought years and 60 cfs in drought years in lower Icicle Creek, as measured at the Leavenworth National Fish Hatchery (LNFH) Structure No. 2, located at River Mile (RM) 3.7 within what is referred to as the "historical channel." Existing flow gages on Icicle Creek and associated data are managed and maintained by three agencies: United States Geological Survey (USGS), United States Fish and Wildlife Service (FWS), and Ecology. The location of Structure No. 2 and existing gages is provided on Figure 1 (attached).

The IWG Streamflow Management Subcommittee is currently preparing an update to the existing lake release protocol document, which will outline recommendations for managing releases from Icicle-Peshastin Irrigation District (IPID) and FWS lakes located in the Alpine Lakes Wilderness (alpine lakes). This effort is being completed as a part of the larger Decision Support Tool development, which is intended to inform timing and design of projects geared towards improving instream flows.

The synoptic flow study proposed under this QAPP entails collection of discrete discharge measurements at up to five locations between the USGS gage upstream of Structure No. 2, and the Ecology gage downstream of Structure No. 2 (study reach). Measurements will be collected over two separate events, under two different flow conditions, and with discharge measurements being collected at all locations in a single event.

The primary purpose of the data collection and data analysis detailed in this QAPP is to better define the hydrology of the Icicle Creek system in the area directly upstream and downstream of Structure No. 2, located in the historical channel of Icicle Creek (Figure 1), particularly during low-flow periods. The results of this Study will help interpretate continuous flow data collected by other agencies at existing gages on Icicle Creek and ultimately inform management of lake releases by the IWG Streamflow Management Subcommittee, as well as implementation of other instream flow projects being performed as a part of the Icicle Strategy.

² <https://apps.ecology.wa.gov/publications/documents/1812016.pdf>



Study Area Map

Icicle Creek Synoptic Flow Study
WRIA 45, Washington

	FEB-2026	BY: EAH / JRB	FIGURE NO. 1
	PROJECT NO. 120045	REVISED BY: RMB / HMD	

The efforts under this QAPP are funded by Grant Number WROCR-2527-ChCoNR-00068 from Ecology's Office of Columbia River, and a WaterSMART grant through the United States Bureau of Reclamation.

1.1 Study Area and Project History

The study reach, monitoring locations, and key features are shown on the attached map (Figure 1). The major losses along the study reach include the IPID diversion (RM 5.7), the City of Leavenworth (City) diversion (RM 5.7), and the LNFH diversion (RM 4.5)³. The major gains along the study reach are Snow Creek (RM 5.1), the two LNFH outfalls (RM 2.7)⁴. These major inputs and outputs are all monitored via their respective agencies/organizations. In addition to the fish bypass, IPID also has two operational spills along the study reach⁵.

The objectives of this Study are to better define the hydrology and water budget of the Icicle Creek system in the area directly upstream and downstream of the historical channel during low-flow conditions. Although the Icicle Creek has a high concentration of flow gages compared to other tributary streams in the state, review of past flow measurements from existing gages, particularly the Structure No. 2 and Ecology gages, indicates key gaps in our understanding of the system that have implications for streamflow management (Geosyntec 2026).

For example, our current understanding is that during the low-flow season the primary gain to the system between the Structure No. 2 gage and the Ecology gage is the discharge from the LNFH outfalls. Therefore, the combined flow measured at the LNFH outfalls and the Structure No. 2 gage should be roughly equal to the flow measured at the Ecology gage; however, comparing the differences in flows at those gages for the 2024 low-flow period (July through October) against the outfall discharge measurements, as shown on Figure 2 below, demonstrates frequent significant discrepancies with unknown causes. For instance, the data indicate that in early July, flows at the Ecology gage are approximately 30 cfs higher than expected and in early September, flows at the Ecology gage are approximately 40 cfs lower than expected. This specific discrepancy was presented to the IWG for discussion and no known causes were able to be identified.

There are also known concerns with the ability to take accurate flow readings at Structure 2, particularly at low-flow periods. This Study aims to limit confounding variables by collecting discrete measurements at multiple locations along the study reach, over a single event using common instrumentation and consistent field staff.

³ Based on a review of Ecology's Water Rights Tracking System database, there are also several small domestic and irrigation diversions on Icicle Creek or tributaries. Little is known about these diversions, but the total instantaneous diversion authority is low (0.29 cfs) and therefore these are considered non-significant for the purpose of this Study.

⁴ Mountain Home Creek and other small perennial/intermittent streams are mapped along the study reach; however, the contribution from these sources during baseflow conditions is thought to be minimal. City and IPID diversions both have small fish bypass reaches.

⁵ Snow Creek Spill (0.3 miles from intake), and Mountain Home Spill (1.9 miles from intake)

The results of this Study will aid in interpretation of continuous flow data collected by other agencies at existing gages on Icicle Creek, and ultimately inform development and management of instream flow projects being performed as part of the Icicle Strategy.

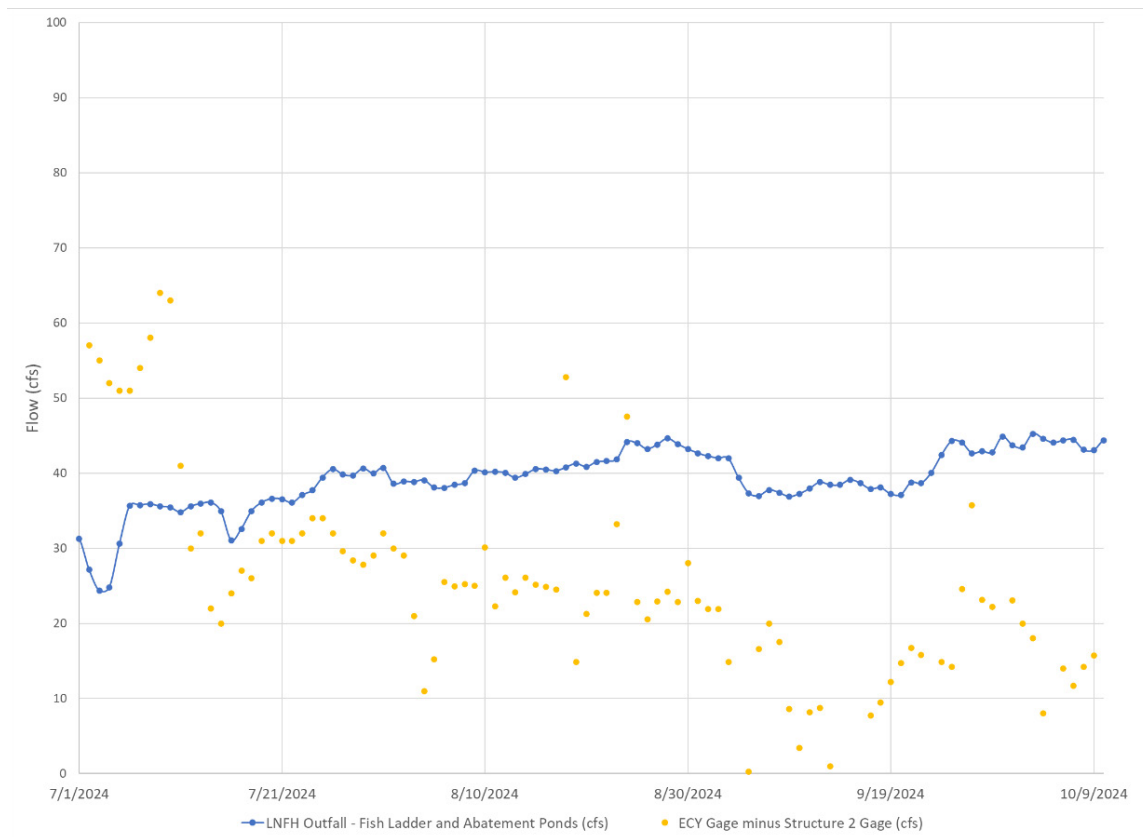


Figure 2 LNFH Outfall Discharge vs. Flow Difference Between ECY and Structure No. 2 Gage

To accomplish the Study objectives, we propose to collect and analyze synoptic discharge measurements at up to five proposed locations during low-flow conditions (between July and October 2026), as well as retrieve and analyze flow measurements collected by other agencies/organizations during the 2026 season.

1.2 Instrumentation and Monitoring

Two synoptic flow monitoring events are proposed at up to five locations along Icicle Creek using an Acoustic Doppler Current Profiler (ADCP) or Acoustic Doppler Velocimeter (ADV) flow meter. The three main proposed discharge monitoring locations correspond to existing continuous streamflow gages managed by other agencies, listed from most downstream to most upstream:

- **Location 1: Ecology Gage 45B070 (RM 2.2).**⁶ This gage is located directly downstream of the historical channel and LNFH return flows and is the control point for stream flow targets established under the Icicle Creek Instream Flow Rule (Washington Administrative Code [WAC] Chapter 173-545). Continuous and discrete discharge measurements have

⁶ <https://apps.ecology.wa.gov/continuousflowandwq/StationDetails?sta=45B070>

been collected at this site starting in 2007 through current day. In 2025, daily mean reported flows ranged between 2,810 and 54.1 cfs.

- **Location 2: FWS Structure No. 2 Gage (RM 3.7).** This gage is located at the beginning of the historical channel (a critical low-flow reach of Icicle Creek) and is downstream of the major diverters on the creek: IPID, LNFH, and the City. The gage does not include flows through the hatchery channel, which are not present during the low-flow season. This is the primary control point currently referenced by the IWG in management of instream flows in Icicle Creek, and measurement of the instream flow benefit from Icicle Strategy projects. Continuous and discrete discharge measurements have been collected at this site starting in 2010 through current day. A detailed description of this site, as provided by FWS, is included in Appendix A. In 2025, daily mean reported flows during the release season ranged between 255 and 24 cfs.

FWS maintains this monitoring location as a part of the requirements under the National Oceanic and Atmosphere Administration (NOAA) National Marine Fisheries Service Endangered Species Act Section 7(a)(2) Biological Opinion.

- **Location 3: USGS Gage 12458000 (RM 5.8).⁷** This is the only flow gage located upstream of the main diversions on Icicle Creek. This site has the longest period of flow measurements of all the gages on Icicle Creek. Continuous and discrete discharge measurements have been collected at this site between 1936 and now, with a period of no measurements between 1972 and 1992. In 2025, daily mean reported flows ranged between 11,448 and 66.3 cfs.

Based on the findings from the first data collection event, the project team will consider whether adding up to two additional monitoring locations is necessary for the second deployment to address remaining gaps in understanding. Any new monitoring site would be located along the study reach on Icicle Creek (i.e., downstream of the USGS gage and upstream of the Ecology gage) and should meet the characteristics of a good flow measurement location as discussed below.

In addition to the data measured by the respective agencies at the gages listed above, this Study will also use continuous flow measurements from gages along the study reach managed by other agencies/organizations as discussed below, including the following: LNFH Outfall 1, LNFH Outfall 2, IPID diversion, City diversion, and FWS Snow Creek tributary gage.

Because the LNFH outfall flows are a significant component of the water budget during low-flow conditions, we propose to visit the LNFH outfall monitoring setup with FWS staff to improve our understanding and considerations for data interpretation.

Other data and information collected will include site observations, field notes, and photographs. Key elements of data collection activities at the monitoring locations are listed below. Each proposed monitoring site is accessible via maintained roads.

Field personnel will use a SonTek RS5 ADCP meter (or equivalent) or a SonTek FlowTracker2 ADV meter (or equivalent) to collect discrete flow measurements at each of the monitoring locations.

⁷ <https://waterdata.usgs.gov/monitoring-location/USGS-12458000/>

The ADCP meter will be deployed via a tethered system across the stream on a structure like the



Figure 3 SonTek RS5 ADCP Meter with Torrentboard TBX and SonTek FlowTracker2

SonTek RS5 Torrentboard TBX as depicted on Figure 3 below. The ADV will be deployed on a topset rod and measurements will be collected by wading across the transect as shown on the photo below. The flow monitoring instrument should be selected based on ability to collect accurate measurements in the observed site conditions and instrumentation limitations (i.e., stream depth and velocity) to meet quality objectives. General criteria for deciding on the appropriate measurement method are described in Section 4. To the extent feasible, the same instrumentation should be used across monitoring locations for consistency.



Photo: FlowTracker2 Monitoring Setup

Monitoring is targeted to occur over the low-flow period of 2026, historically aligning with the months of July through October. Monitoring at each location will include coordination with all agencies managing associated flow gages (Ecology, USGS, FWS) to ensure site access, share information, and avoid operational disruptions. None of the proposed monitoring locations are within the National Wilderness Area, so permits through the United States Forest Service will not be required. The proposed monitoring activities will not require any other permits.

2.0 Organization and Schedule

The following key individuals will be involved in planning for and conducting the data collection efforts:

- **Kelsey Mach, Geosyntec Project Manager:** Kelsey has supported the Chelan County Natural Resources Department (CCNRD) with technical and project management support for the Icicle Strategy and other projects over the last 4 years. Kelsey will oversee Geosyntec technical support staff and facilitate coordination between Geosyntec and CCNRD.
- **Bryan Berkompas, Geosyntec Technical Lead:** Bryan is a Principal Hydrologist with over 25 years of experience collecting and analyzing stream discharge measurements, including 3 years with the FlowTracker2 and experience with other ADCP flow meters. Bryan will be trained on the SonTek RS5 prior to field deployment, then he will direct data collection activities and data analysis and perform senior technical review prior to reporting.
- **Kathryn Shirley, Geosyntec Field Staff:** Kathryn has provided technical support in the field, with experience performing and analyzing stream discharge measurements including with a FlowTracker2. Kathryn will be trained on the SonTek RS5 prior to deployment and support CCNRD as needed for field data collection and analysis.
- **Matt Holland, CCNRD Field Staff:** Matt has several years of experience collecting stream discharge measurements using a variety of methodologies, including the SonTek RS5 and FlowTracker2. Matt will support the field data collection and analysis for this Study.
- **Mary Jo Sanborn, CCNRD Project Lead:** Mary Jo will oversee Study efforts on behalf of CCNRD as the Icicle Strategy grant project lead.
- **Ingrid Ekstrom, Ecology Grant Manager:** Ingrid will provide review of the project final reporting.
- **Mike Anderson, Ecology:** Mike is the main point of contact for prior coordination for flow monitoring at the Ecology gage site, and for questions related to the reported flow data.
- **Mary Lindenberg, FWS:** Mary is the main point of contact for prior coordination for flow monitoring at the Structure No. 2 gage site, and for questions related to the reported flow data.
- **Kevin Wright, USGS:** Kevin is the main point of contact for prior coordination for flow monitoring at the USGS gage site, and for questions related to the reported flow data.

Monitoring will occur during two data collection events over the low-flow period of 2026, historically aligning with the months of July through October. The anticipated schedule for the Study period is provided below as Table 1.

Table 1 Anticipated Schedule for Study Period

Month	Activity
February 2026 to July 2026	Finalize QAPP, Acquire or Rent Equipment, Coordinate with Data Collection Agencies
July to October 2026	Data Collection (two events)
October to December 2026	Data Entry, Verification, and Analysis
January 2027	Environmental Information Management Submittal, Coordination with Data Collection Agencies, Final Report Submittal

2.1 Schedule Constraints

Site access is not limited during the proposed monitoring period. Schedule constraints include approval of the QAPP, coordination with data collection agencies to access monitoring locations, wildfire and air quality conditions, acquiring flow monitoring equipment from the vendor, and flow conditions in the stream. If needed, the effort outlined in this scope may be completed in the 2027 season.

3.0 Quality Objectives

Measurement Quality Objectives (MQOs) define the required level of data accuracy and precision necessary to meet the overall goals of the Study. These objectives were developed to collect data of sufficient quality to support validation of measurements collected.

To meet the Study objectives, all data collected must adhere to reasonable and clearly defined quality standards. This includes collecting field measurements that are accurate, repeatable, and representative of actual site conditions. The accuracy specifications for field instrumentation used in this Study are provided in Table 2.

Table 2 Monitoring Field Equipment Information

Parameter	Equipment/Method	Accuracy	Resolution	Range
Velocity	ADCP Meter (SonTek-RS5)	1% or ± 0.002 m/s (± 0.0066 ft/s)	0.001 m/s (0.003 ft/s)	± 5.0 m/s (± 16.4 ft/s)
Water Level	ADCP Meter (SonTek-RS5)	1% or ± 0.005 m (± 0.016 ft)	--	0.1-6.0 m (0.33-19.7 ft)
Velocity	ADV Meter (SonTek FlowTracker2)	$\pm 1.0\%$ of measured velocity	0.0001 m/s (0.0003 ft/s)	$\pm 0.001 - 4.0$ m/s (± 0.003 to 13 ft/s)
Water Level	ADV Meter (SonTek FlowTracker2)	0.1 ft (rod)	0.1 ft (rod)	--
Water Stage	Staff Plate	0.02 ft	0.02 ft	--

Notes: ft: feet; ft/s: feet per second; m: meter; m/s: meters per second

The MQOs for the proposed discharge measurements will consist of qualitative and quantitative assessments.

The qualitative assessment is intended to be consistent with Ecology Standard Operating Procedures (SOPs) EAP056 Section 6.12 and USGS Techniques and Methods 3-A8, and is based on factors like channel condition at the transect, velocity patterns, change in stage during measurement, wind and weather conditions, and number of measurement points, etc. The qualitative assessment will determine if the physical conditions within the transect at the time of the measurement were “excellent,” “good,” “fair,” or “poor.”

The quantitative assessment will make use of internal uncertainty calculations performed by the FlowTracker2 and SonTek RS5 and replicate measurements at one of the monitoring locations during each field event. Both the FlowTracker2 and SonTek RS5 use the International Organization for Standardization (ISO) 748 method (ISO 2007) to estimate an overall measurement uncertainty percentage. Uncertainty of 5% or less would be considered excellent, and between 5% and 13% would be considered usable. If the uncertainty is greater than 13%, the measurement should be discarded and repeated in the field, adjusting the transect or methods as needed to reduce the uncertainty.

The replicate measurement will be compared with the initial measurement using the relative percentage difference (RPD). A RPD of 5% or less represents a “good” rating. An RPD between 5%

and 13% will be “qualified” but still deemed usable for the purpose of this Study, although a replicate should be recollected if time allows to get a better reading. Data with an RPD of greater than 13% will be deemed invalid and the replicate should be re-collected as needed with the goal of collecting a higher quality measurement. At an upper flow rate of 60 cfs for Structure No. 2, a 5% difference equates to 3.0 cfs, while a 13% difference equates to 7.8 cfs. This range in error is considered reasonable for the purpose of this Study and is less than the relative discrepancies in flow presented above on Figure 2 (i.e., 10 to 40 cfs).

3.1 Outside Data

Data collected by outside agencies will be used for the purpose of this Study. These measurements will contribute to our holistic understanding of the Icicle Creek system along the study reach. While we do not have control over the quality of this outside data, many of the data sets are collected and managed in accordance with robust quality control and monitoring plans. Details regarding the MQOs, field procedures, and data analysis can be found in the individual plans referenced below.

USGS Gage

- Surface-Water Quality-Assurance Plan for the U.S. Geological Survey Washington Water Science Center Version 1.1, Open-File Report 2016-1020 (Mastin 2017)⁸.

Ecology Gage

- Quality Assurance Monitoring Plan: Streamflow Gaging Network (Ecology 2005)⁹.

FWS Structure No. 2, Snow Creek, LNFH Outfall 1 and LNFH Outfall 2 Gages

- Leavenworth National Fish Hatchery Complex Hydrologic Data Collection and Management Plan, included as Appendix B (LNFH 2025).
- Detailed site descriptions provided by FWS are included in Appendix A.

IPID and the City also measure their diversions as required under WAC 173-173¹⁰. WAC 173-173 specifies that *“At any flow rate measured by the measuring system, i.e., the measuring device plus any secondary equipment such as data recorders, the system shall register not less than ninety percent, nor more than one hundred ten percent, of the water actually passing through the system.”* Therefore, the measurements collected by IPID and the City should meet the MQOs discussed above. IPID and City staff responsible for flow measurements will be consulted to understand methods and quality considerations. This may include site visits to the respective measurement locations and diversions during field deployments.

Additional information on the outside data sets, as provided by the owners, is provided below:

- **IPID Diversion:** According to Levi Jantzer (IPID manager), IPID collects continuous diversion measurements at a reinforced concrete canal upstream of the fish screen and

⁸ <https://pubs.usgs.gov/of/2016/1020/ofr20161020.pdf>

⁹ <https://apps.ecology.wa.gov/publications/documents/0503204.pdf>

¹⁰ <https://app.leg.wa.gov/waC/default.aspx?cite=173-173>

bypass reach (constructed in 2023) using a Flowline DL10 ultrasonic look down sensor to measure stage, which is converted to flow using a stage-discharge curve. The IPID Manager regularly checks the flow rating by measuring flows in the diversion channel adjacent to the flow monitoring

equipment and adjustments are made to ensure that the data accurately reflects what is diverted.¹¹

- **City Diversion:** According to Chris Klancke from the City of Leavenworth, the City measures continuous diversions (instantaneous and cumulative) using a Siemens Sitrans FM Mag 5000 within the influent pipe at their water treatment plant facility located at 7201 Icicle Road in Leavenworth, Washington. Daily measurements are then recorded in their supervisory control and data acquisition (SCADA) system.

As discussed above, there are three main locations along the IPID canal where water returns to the system within the study reach (Fish Bypass, Snow Creek Spill, and Mountain Home Spill). These spillways help IPID staff regulate flows within their system to meet operational demand. The spills within the study reach are not gaged and cannot be easily measured given structural constraints; however, as part of the Comprehensive Water Conservation Plan (Anchor QEA 2018), a water balance model of the IPID canals system was developed. The model was informed by synoptic flow measurements along the canal, flow measurement from a network of staff gages at weirs in key canal sections, and reasonable assumptions for deliveries and system losses. During low flow conditions such as proposed for this study, the spill quantities at the newly installed (2023) fish bypass are generally the same or less than the previous fish bypass modelled by Anchor¹².

This model was adopted by IPID, based on its consistency with observations in the field. The spillways (including the fish screen bypass) were estimated to fall between 3.4 to 5.8 cfs, less than 5% of the total IPID diversion. The IPID spills therefore represent a small component of the overall water balance (within the MQO).

IPID has a dedicated “ditch rider” for each canal division who is responsible for visually inspecting the canal system and recording water levels at key staff gages throughout the system on a daily basis. To reduce uncertainties related to the IPID spills, the study team will communicate with IPID staff during each field deployment to refine our understanding of spill quantities during the monitoring period. This approach is considered appropriate to meet the study goals given the limited component of the water balance and the infrastructure modifications that would be required to measure the spills.

All of the agencies and organizations listed above are members of the IWG and are invested in the success of the Icicle Strategy. Coordination with the above agencies/organizations was performed before preparing this QAPP and will be performed before field deployment and data collection where needed for site access. Coordination will also be performed to retrieve data

¹¹ The flow measured at the IPID diversion does not include flow from the main flume spill.

¹² Per communication with Levi Jantzer, IPID Manager

from the associated gages and monitoring points, and where necessary to aid in understanding and interpreting the data for the purpose of this Study.

4.0 Study Design

This section provides the specific design details for collecting and analyzing data for the Study. Two synoptic flow monitoring events are proposed at up to five locations along Icicle Creek upstream and downstream of the historical channel using an ADCP or ADV flowmeter.

Measurements will be collected over two separate events under two different flow conditions, with discrete discharge measurements collected at a minimum of three locations and up to five locations during each data collection event. Ideally, flow conditions during monitoring should be less than or equal to 60 cfs at Structure No. 2 as reported via the NOAA website for that gage (or Ecology gage if Structure No. 2 real-time readings are not available). For each event, there should be at least 10 cfs difference between flow conditions at Structure No. 2; therefore, events are likely to be separated by several weeks.

The use of an ADCP meter, such as the SonTek RS5, is primarily driven by conservative safety considerations at the highest possible flow conditions for the Study. The SonTek RS5 enables flow measurements without requiring personnel to wade into potentially hazardous conditions, significantly reducing risk during field operations. In addition to its safety benefits, the SonTek RS5 complies with federal and state standards for hydrologic data collection and delivers high-accuracy flow measurements in variable terrain. Its ability to operate independently without continuous connectivity makes it uniquely suited for remote sites with no service. Therefore, the SonTek RS5 is designated as the primary data collection device for this Study; however, if wading conditions are determined to be safe, or site conditions are not ideal for the SonTek RS5 based on stream depth and velocity, the SonTek FlowTracker2 (or equivalent ADV meter) will be used in as an alternative to the SonTek RS5. Where feasible, all measurements collected for each event should be collected with the same instrument.

The synoptic discharge measurements collected at each location will be compared for a given event to establish system inputs and outputs (i.e., differences in flow) between locations. Outside measurements (as discussed above), including flows at existing stream gages and system inputs/outputs, will also be incorporated in the analysis for corresponding periods to inform whether any unknown gains or losses to the system are occurring along the study reach.

Based on the findings from this Study, a Phase 2 study may be recommended to evaluate any remaining uncertainties which warrant further investigation.

4.1 Sampling Locations and Frequency

Sampling locations consist of three locations on Icicle Creek as detailed in Table 3 below, and up to two additional locations as needed. Proposed monitoring locations are shown on the attached map (Figure 1). Photos of the proposed monitoring locations are included in Appendix C.

Discrete discharge measurements will be collected with a flow meter (as described above) at each location, generally in line with the cross section of the existing flow gage station where relevant and to the extent feasible.

Table 3 Monitoring Locations

Location	Monitoring Location	River Mile	Accessed Via	Latitude/Longitude
1	Ecology Gage 45B070	2.2	E Leavenworth Road	47.563575, -120.6677
2	Structure No. 2 Gage	3.7	Chalet Lane	47.549472, -120.679108
3	USGS Gage 12458000	5.8	Icicle Road	47.54092147, -120.720059

Based on the findings from the first data collection event, the project team will review the data as described above and consider whether adding up to two additional monitoring locations is necessary to address remaining gaps in our understanding in relation to unknown system gains/losses. Any new monitoring site would be located along the study reach (i.e., downstream of the USGS gage and upstream of Structure No. 2), and the new sites should meet the characteristics of a good flow measurement transect to the extent feasible as described in Ecology's SOP EAP056 Section 6.4 "Selecting a Cross Section."

Flow measurements should be collected at each location over two separate events, with a difference of at least 10 cfs between flow conditions for each event as determined based on the real-time readings reported from Structure No. 2 (or the Ecology gage if Structure No. 2 real-time readings are not available). Completing two synoptic measurements over different flow conditions will provide an opportunity to add additional flow monitoring locations if needed during the second event, and inform whether the stream budget changes under different flow conditions.

4.2 Possible Challenges and Contingencies

Anticipated challenges that may interfere with data collection include the following:

- Inability to access monitoring sites due to weather conditions (i.e., rain, low visibility).
- Delays in project scheduling or site access. The project team will coordinate early with FWS regarding access to the Structure No. 2 site and the outfall locations.
- Equipment failure due to technical issues. The project team will test and calibrate the field equipment prior to deploying it to the site in accordance with the manufacturer's recommendations. Backup batteries will be brought to the field.
- Delivery time for receiving purchased equipment. CCNRD owns a FlowTracker2 meter and will place the order for purchase of the SonTek RS5 well in advance of the proposed field monitoring. The equipment will be funded through the County's Bureau of Reclamation WaterSMART grant and Ecology's Office of Columbia River funding.
- Flow conditions outside of the targeted range. CCNRD will work with the Icicle Strategy Streamflow Management Committee to coordinate the timing of lake releases around field deployments so that measurements occur at target flow rates.

5.0 Field Procedures

This section outlines general procedures to be followed for field deployments.

5.1 Invasive Species Evaluation

Field staff will follow Ecology's SOP EAP070¹³, minimizing the spread of invasive species (Ecology 2023). At the end of each field visit, field staff will inspect and clean field gear and equipment by removing any visible soil, vegetation, vertebrates, invertebrates, plants, algae, or sediment in accordance with the SOP. If necessary, a dedicated scrub brush will be used. This process will continue until all equipment is clean.

5.2 Measurement and Sampling Procedures

The procedures used in this Study are typical for any hydrological investigation. SOPs to be followed are publicly available in digital format online and include the following:

- Standard Operating Procedures EAP056, Version 1.3 – Measuring and Calculating Stream Discharge (Ecology 2018a)
- Standard Operating Procedures EAP057, Version 1.1 – Conducting Stream Hydrology Site Visits (Ecology 2018b)
- Quality Assurance Monitoring Plan: Streamflow Gaging Network, Publication No. 05-03-204 (Ecology 2005)
- Quality-Assurance Plan for Discharge Measurements Using Acoustic Doppler Current Profilers, Scientific Investigations Report 2005-5183 (Oberg et. al. 2005)
- Discharge Measurements at Gaging Stations, Techniques and Methods 3-A8 (USGS 2010)
- Surface-Water Quality-Assurance Plan for the U.S. Geological Survey Washington Water Science Center, Open-File Report 2016–1020 (Mastin 2017)
- ISO 748:2007 Hydrometry – Measurement of liquid flow in open channels using current-meters or floats¹⁴
- Measuring discharge with acoustic Doppler current profilers from a moving boat, USGS Techniques and Methods 3A-22 (Mueller and Wagner 2009)

Field procedures for using the SonTek RS5 ADCP meter or SonTek FlowTracker2 will follow manufacturer-recommended protocols to maintain data quality and equipment integrity. Prior to deployment, all equipment will be inspected for damage, batteries will be fully charged, and the SonTek RSQ software and FlowTracker software will be installed and updated on a field laptop. Where appropriate, system settings, including GPS mode, cell size, and ping rate, will be configured in advance.

¹³ <https://apps.ecology.wa.gov/publications/documents/2403204.pdf>

¹⁴ A new version of ISO 748 was released in 2021, but the FlowTracker2 uses methodology from the 2007 version.

Measurements will be conducted by performing transects across the stream or river with the equipment, with real-time monitoring of velocity profiles, depth, and data quality warning indicators pre-programmed within the equipment. All data will be downloaded, backed up, and reviewed for quality assurance in accordance with Section 6 of this QAPP before leaving each field site.

In addition to the flow meter readings, stream stage readings should be recorded from the locations with existing staff gages at the beginning and end of each discharge reading. For monitoring Locations 1 through 3, discharge measurements are to be collected at approximately the same stream transect as the existing staff gages.

Additional information specific to the SonTek RS5 and SonTek FlowTracker2 are provided below.

SonTek RS5 ADCP Meter

The SonTek RS5 is a compact, high-frequency ADCP meter designed for measuring water velocity and discharge in open channel environments as demonstrated on Figure 5 below.

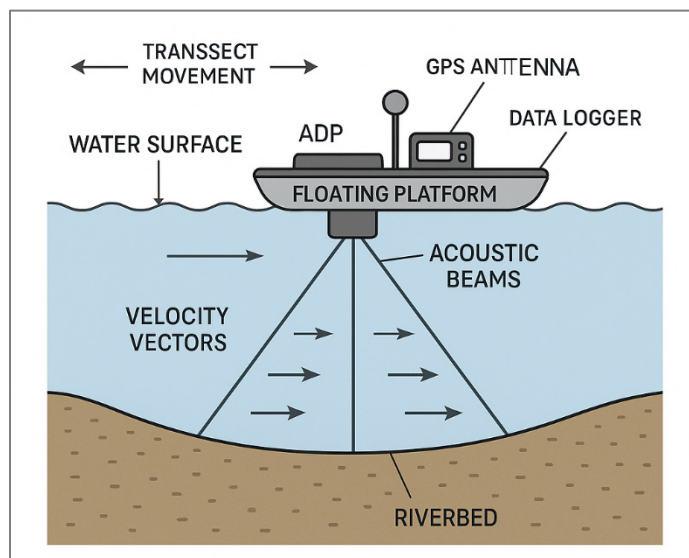


Figure 4 Illustration of SonTek RS5 ADCP Meter

The unit combines data from multiple sensors including multi-beam Doppler velocity measurements and depth data. The SonTek RS5 is typically deployed on a floating platform, such as the HydroBoard II Micro, and operated using SonTek's RSQ software.

The SonTek RS5 uses five acoustic beams, four slanted for velocity profiling and one vertical for depth measurement, operating at 3.0 megahertz. The sensor employs SmartPulse+® technology to dynamically adjust between broadband and pulse-coherent processing, optimizing data quality across a range of flow conditions. The SonTek RS5 is a monostatic system, using the same transducers for both transmitting and receiving acoustic signals. Water velocity is calculated from Doppler shifts, with sound speed corrections based on internal temperature sensors and user-defined salinity (assumed negligible in freshwater systems).

Antennas and sensors will be securely connected, and a Bluetooth connection will be established with the laptop and RSQ software. Operators will verify system diagnostics, GPS signal strength, and compass calibration using RSQ's SmartPage interface. The SonTek RS5 will be deployed at each monitoring point using a tethered system attached to the non-motorized flotation device securing the ADCP. Two field personnel, one stationed on each bank, are required to maintain the SonTek RS5's position throughout the measurement. During deployment, the SonTek RS5 is moved across the channel in a series of transects, with real-time data collected and visualized in the RSQ software.

The methodology used for the SonTek RS5 will be to collect flow measurements across multiple transects and average the measurements as detailed below.

Field Procedures Checklist – SonTek RS5

The following are steps to be taken by field staff to collect quality data:

1. Site Arrival and Setup

- Confirm site access and safety conditions.
- Check environmental conditions (depth, flow, obstructions).
- Unpack and inspect equipment.
- Confirm adequate memory on laptop and backup USB.
- Identify and mark the measurement cross-section across the stream or channel.
- Attach sensor and tethering cables securely to the platform.
- Power on the SonTek RS5 and ensure Bluetooth connection with the field tablet or laptop.
- Review measurement settings:
 - Transect type (moving boat or stationary)
 - Cell size and number of cells
 - Ping rate and averaging time
- Calibrate the SonTek RS5 internal compass. For in-depth steps on the compass calibration procedures, please refer to Appendix A Section 7.5.4 of the SonTek RS5 manual.
- Set project metadata (site name, operator, date, etc.).

2. System Initialization and Calibration

- Launch RSQ software, select “New Data Collection” then “Stationary” when prompted, then connect to the SonTek RS5. Verify the connection status is “Good” to “Excellent” (>-85 decibel-milliwatts).
- Enter and verify necessary information for the Pre-measurement Setup Checklist.¹⁵ Sections within the checklist include:
 - System Information

¹⁵ A site template can be uploaded and selected when completing the Setup Checklist.

- Site Information:
 - Site name
 - Station number
 - Location
 - Operator
 - Vessel
 - Measurement number
 - Gage Height Information
 - Comments
- Perform the System Test prior to each discharge measurement to check ACDP functionality for reliable and accurate data collection.
- Enable QC window via the Window tab of the Main Toolbar.
- Verify battery level, time, and compass calibration.
- Perform diagnostic tests (i.e., Beam Check).

3. System and Edge Configuration

- Verify values input for parameter configuration prior to arrival on-site as they directly affect the final discharge calculation. Configuration parameters are listed below:
 - Transducer depth
 - Screening distance
 - Salinity (~0-0.5 for freshwater)
 - Temperature override
 - Sound speed override
 - Magnetic declination (magnetic declination angle)
 - GPS X Offset¹⁶
 - GPS Y Offset
 - Coordinate System
 - Depth Reference
 - Track Reference
- Measure the distance from the start and end edge position of the SonTek RS5 to the edge of the water. Edge measurements will be performed for both the left and right banks for each transect; measured distances will be recorded in the coordinating section of the field sheet.

¹⁶ GPS X/Y Offset input is not necessary if the GNSS/GPS antenna is located directly above the SonTek RS5 system.

- Input the distance values under the Edge Configuration Section. Check that auto-edge profiles are enabled within this section.

4. Data Collection

- Begin by reading the staff plate and recording both the staff plate value and the time of measurement initiation on the field sheet.
- Position the sensor at the Start Edge of the transect. Keep the sensor as stationary as possible. Click OK to begin data collection for the Start Edge.
- Collect readings from at least two separate depth levels (vertical cells) in the water column. With the auto-edge feature enabled, the RSQ software will collect 10 samples then automatically switch to measure the transect.
- Collect measurements per the guidance provided in the user manuals.
- Once the sensor reaches the end of the edge of the opposite bank, follow the same procedures to measure the End Edge as for the Start Edge.
- Maintain vessel direction perpendicular to the direction of flow.
- During active data collection, continually monitor QA/QC functions of the RSQ software for data accuracy and consistency.
- Collect readings from at least four transects (two in each direction). Each transect should take a minimum of 720 seconds of active measurement time to complete.

5. Post-Measurement Tasks

- Check that each discharge measurement is within 5% of the mean of all measurements. If any measurement differs by more than 5%, then four additional transects should be measured and all eight measurements averaged for the final flow.
- Record field notes (weather, flow conditions, anomalies).
- Photograph the site and equipment setup.
- Download and back up data files (.rs5, .csv, .kml, etc.).

6. Equipment Breakdown

- Power off equipment and disconnect all components.
- Dry and clean the equipment.
- Pack equipment securely for transport.

SonTek FlowTracker2

The SonTek FlowTracker2 will be used as an alternative method for collecting flow measurements. Discharge will be measured using the mid-section method, the default discharge equation applied in FlowTracker2. The FlowTracker2 defaults to using the 0.6 method, which assumes that mean vertical velocity occurs at 60% below the surface depth but can be adjusted to measure at 0.2 and 0.8 depths as well. We will use 0.6 method for depths

less than 2.5 feet and the 0.2/0.8 method for depths of 2.5 feet or greater. Stream velocity will be measured at a minimum of 20 stations across the channel. A reel tape marked in tenths of feet should be used for measuring station locations across the channel section. The tape should begin on the left bank looking downstream. Velocity measurements should be taken from left to right and set to average values recorded over a 40-second interval. The left bank measurement location will be identified at the initial station location, while the right bank measurement location will be identified at the final station location. Each bank edge measurement (i.e., distance to the bank) should be entered with the corresponding water depth. All instances when a measurement could not be performed within the established transect should be recorded under *Additional Observations* on the field sheet.

Transect locations should be selected to minimize turbulence, avoid eddies, and be wadable for the stream conditions encountered. Locations where water flows beneath an overhanging stream bank should also be avoided. The location along the reel tape and the corresponding water depth will be entered into the FlowTracker2 prior to each measurement. A minimum of 20 velocity measurements should be collected within the channel section.

Following collection of all velocity and depth measurements along the stream, discharge will be calculated by the FlowTracker2 using the Mid-Section Method (Rantz 1982), demonstrated below from the FlowTracker2 user manual¹⁷.

$$Q = \sum \bar{v}_0 d_0 \left(\frac{b_1 - b_0}{2} \right) + \bar{v}_1 d_1 \left(\frac{b_2 - b_0}{2} \right) + \bar{v}_n d_n \left(\frac{b_{n+1} - b_{n-1}}{2} \right)$$

Edge	Open water	Open Water
------	------------	------------

where, $\bar{v}$ is the average velocity in the vertical or at the station,
 d is the water depth measured at the station,
 b is the location of the station.

Field Procedures Checklist for FlowTracker2

The following are steps to be taken by field staff for quality data collection:

1. Site Arrival and Setup

- Confirm site access and safety conditions.
- Check environmental conditions (depth, flow conditions, obstructions).
- Unpack and inspect equipment.
- Confirm adequate memory on laptop and backup USB.
- Identify and mark the measurement cross-section across the stream or channel.
- Confirm safe wading conditions. The FlowTracker2 will only be used if water depth and wading are deemed safe by field personnel.

¹⁷ geotechnv.com/Manuals/SonTek_Manuals/sontek_flowtracker2_manual.pdf

- Inspect and assemble equipment to check that the FlowTracker2 handheld unit and wading rod are clean, fully charged, and properly connected.
- Power on the FlowTracker2.

2. System Initialization and Diagnostic Check

- Perform a Beam Check prior to start of measurement.

3. System and Edge Configuration

- Review site settings, which include channel type, units, and velocity averaging settings.

4. Data Collection

- Begin by reading the staff plate and recording both the staff plate value and the time of measurement initiation on the field sheet.
- Determine the left bank water's edge and enter a depth of 0 feet. Find the closest station with sufficient depth for sensor and record a second measurement.
- Collect depth and velocity measurements from at least 20 stations across the transect.
 - Discharge measurements should have no more than 5% of the total discharge at any single station and may require additional measurements in areas of greater depth and/or velocity. The final in-water station should be in water with sufficient depth for the sensor as close as possible to the far water's edge.
- Close out measurement with by recording the distance to the right bank's edge of water.
- Record both the staff plate value and the time on the field sheet.
- Use the FlowTracker2 display to review velocity profiles to confirm that velocity is being measured accurately at different depths across the channel.
- Assess channel and measurement conditions relative to qualitative MQO and review ISO uncertainty percentages in software.
- Collect a replicate measurement for at least one location per event. Calculate the relative percentage difference (RPD) for the replicate measurement where applicable.

5. Post-Measurement Tasks

- Record field notes (weather, flow conditions, anomalies).
- Photograph the site and equipment setup.
- Download and back up data files (.rs5, .csv, .kml, etc.).

6. Equipment Breakdown

- Power off equipment and disconnect all components.

- Dry and clean the equipment.
- Pack equipment securely for transport.

5.3 Outlier Resolution

Outliers may be observed in individual velocity measurements collected across a given stream transect and are almost exclusively due to substrate altering the flow at the measured depth/location. If outliers in velocity (i.e., significantly greater or lower velocity measurements at a given location across the transect) are observed based on professional judgement and prior flow monitoring experience, field personnel should use the 0.2/0.8 method to capture the mean velocity (as detailed above), move the sensor slightly left or right along the cross section, or consider moving the cross section up or downstream if feasible.

5.4 Data Verification and Validation

Data verification will occur during each field mobilization. Measurements will be reviewed in real-time via the equipment screen or field laptop to observe for outliers or errors given by the equipment software. Validation will be achieved by performing at least one replicate flow measurement in the field at one location for each deployment immediately after the initial flow measurement, along with documenting real-time conditions via notes and photographs during each measurement to be able to understand if changes in conditions may have impacted data quality. Where measurements are collected using the SonTek RS5, validation will be performed by comparing individual transect flow measurements to the average of those flow measurements as described above. Replicate flow measurements are further described in Section 6.2.

5.5 Data Quality (Usability) Assessment

A data usability assessment will occur in the field by looking for outliers (as described above), observing error messages provided by the equipment software, and comparing replicate measurements in real time as described in Section 6. Replicate measurements will be used to calculate the RPD, which will be compared to the MQOs established in Table 3 of this QAPP.

6.0 Quality Control

This section describes the actions to be taken before and during a field campaign to evaluate quality control. These actions are both quantitative and qualitative, requiring on-the-fly judgement from experienced field staff. Data collected in the field will be reviewed in real-time and following each deployment to check that equipment is functioning as expected and resulting measurements are in line with the MQOs. Where feasible, all measurements collected at each location should be collected with the same instrument for comparability across measurements. If equipment is not functioning as expected, troubleshooting will occur in the field and equipment will be calibrated, fixed, or replaced at the following mobilization, if needed.

Specific quality control procedures (both in field and out of field), along with corrective actions for each data collection method, are described below and summarized in Table 4.

Table 4 Quality Control Procedures

Data Type	Out of Field		In Field	
	Action	Frequency	Action/Correction	Frequency
Flow Measurements	Check equipment battery level and functionality. Charge batteries and replace equipment as needed.	Prior to each mobilization	Perform replicate flow measurement of discharge. If RPD >8%, troubleshoot equipment, collect third measurement. If third measurement has an RPD >8% of both other measurements, troubleshoot cross section location/geometry and use alternative instrumentation if feasible.	One monitoring location, once each deployment for mid-section method only
			Compare individual transect measurements to average. If a single measurement is >5% of average, perform four additional transect measurements.	For RS5 measurement locations
			Look for outliers in individual velocity measurements based on professional judgement. If outliers are observed, measurements should be recollected. For the FlowTracker2, where velocity outliers are observed, mean velocity measurements should be collected using the 0.2/0.8 method for that location, or the location should be adjusted slightly left or right. If outliers are thought to be related to cross section conditions, move the cross section upstream or downstream if feasible.	Each individual measurement along a transect
	Upgrade firmware and check flow meters.	Per manufacturer recommendations	Perform Beam Check.	Each field deployment
			Review QA/QC functions in software. If errors are flagged, investigate and correct as needed in accordance with user manual.	Throughout data collection
Water Level	Replicate measurement.	Each measurement	Perform a replicate measurement. If replicate is > +/- 0.1 ft of reading, take third replicate measurement.	For each staff plate reading

6.1 Steps in Preparation of Field Work

The following are steps to be taken prior to field deployment to collect quality data using both the SonTek RS5 and SonTek FlowTracker2:

1. Equipment Inspection

- Inspect the equipment for physical damage or wear.
- Check cables, connectors, and mounting hardware (e.g., HydroBoard II Micro).
- Check that the GPS antenna and Bluetooth module are intact and functional (where relevant).

2. Battery and Power

- Fully charge the SonTek RS5's 18650 lithium-ion battery.
- Bring spare batteries (AA for FlowTracker2) and a charger for SonTek RS5 if extended use is expected.

3. Software/Firmware Setup

- Install or update RSQ software and FlowTracker2 software on field laptop or tablet.
- Verify that the SonTek RS5 and FlowTracker2 firmware is up to date and compatible with software.

4. System Configuration

- Connect to the SonTek RS5 via Bluetooth using RSQ software.

5. Field Documentation

- Prepare field data sheets or digital forms (see Appendix D for example field form).

6. Safety and Logistics

- Confirm access to Structure No. 2 location with FWS.
- Check weather forecasts and seasonal access windows.
- Pack personal protective equipment and communication devices.

7. Backup and Redundancy

- Bring a backup data storage device (e.g., USB drive or external hard drive).
- Bring an extra field laptop.

6.2 Steps Taken in Field

Field procedures developed to collect quality data are detailed in Section 5.2. QA/QC functions built into the software will be used as a quality control measure, as well as comparing individual velocity and depth measurements for outliers, and taking replicate discharge measurements. Outlier resolution is described in Section 5.3.

Selecting a Cross Section

As detailed in Section 3, a qualitative assessment should be completed for each cross section location consistent with Ecology's SOP EAP056 Section 6.12 and USGS Techniques and Methods 3-A8 to qualify the physical conditions within the transect at the time of the measurement as "excellent," "good," "fair," or "poor." The field forms included in Appendix D provide a list of considerations when completing a qualitative assessment of a cross section for easy field reference.

QA/QC Built-in Functions

The QA/QC functions built into the RSQ software are exhibited as the following warnings or errors:

- System setup parameters
- Compass
- Stationary Moving-Bed Analysis (SMBA) method measurement
- Transect
- GPS
- System operation
- Post-processing

Field staff will check the RSQ software for these warnings or errors throughout the data collection process.

Replicate Measurements

As close in time and location to the first measurement as possible, field personnel will repeat the same steps outlined in Section 5.2 to perform a replicate flow measurement at one or more of the monitoring locations for each deployment. Replicate measurements will only be collected at locations where the mid-point method is used. Using the original and replicate measurements, the RPD should be calculated using the equation provided below where M1 is the original measurement and M2 is the replicate measurement.

$$RPD = \frac{M1 - M2}{(M1 + M2)/2} \times 100\%$$

If the RPD is greater than 8%, the equipment should be checked for errors and the monitoring location should be evaluated for potential conditions that might be interfering with flow measurements. Once equipment errors and monitoring setup issues have been corrected or ruled out, a third measurement should be collected. If the third measurement has an RPD greater than 8% of *both* the other two measurements, flow measurements should be collected using the alternative method (SonTek RS5) if conditions allow, or the measurement cross section should be adjusted.

As detailed above, for locations where the SonTek RS5 is used (i.e., when the mid-point method is not used), discharge measurements for each transect should be within 5% of the mean of all four measurements. If there is a known and unavoidable condition impacting the quality of the measurements, it should be noted in the field form. If any measurement differs by more than 5%, then four additional transects should be measured and all eight measurements averaged for the final flow.

7.0 Data Management Procedures

Flow data collected from instruments such as the SonTek RS5 or FlowTracker2 will include velocity profiles, water levels, discharge measurements, and associated metadata for each location and deployment. These data will be saved in .csv format or equivalent and documented in field notes. All data will be reviewed for completeness and accuracy following each field mobilization and prior to final analysis.

All data collected under this QAPP will be submitted annually to Ecology's Environmental Information Management (EIM) database by January 31 of the following year, using Study ID: WROCR-VER1-00015.

8.0 Reporting and Field Activity Assessments

This section describes the reporting and analysis for this Study.

8.1 Discharge Measurements

Following the conclusion of the data collection, a comprehensive data compilation will be conducted in accordance with Section 7 and the schedule outlined in Section 2. All data collected under this QAPP will be submitted annually to Ecology's EIM database by January 31 of the following year, using Study ID: WROCR-VER1-00015. The annual data submittal will include the following components:

- SonTek RS5 ADP discharge measurements with qualifications where appropriate, average velocity profiles, and average stage.
- FlowTracker2 discharge measurements with qualifications where appropriate, depths, velocities, discharge, and cross-sectional area (if used).
- All field activities documented in field logs, including date, time, personnel, equipment used, and site-specific observations. These logs will be reviewed after each mobilization to assess data quality, identify any issues with equipment or procedures, and inform adaptive improvements for future fieldwork. Any deviations from standard procedures or anomalies encountered during data collection will be noted and addressed in the final data review and reporting process.

8.2 Data Analysis

The synoptic discharge measurements at each location will be compared for a given deployment to quantify system gains and losses between locations. Measurements retrieved from outside agencies will be reviewed as a part of the water budget for the study reach. Any uncertainties resulting from this analysis (i.e., significant unexplained gains or losses observed) will be discussed with the IWG to determine potential causes. Any specific considerations regarding data quality or methods provided by an agency or organization regarding their reported measurements will be considered in the analysis. Findings from this analysis may result in a recommendation for a Phase 2 of work to resolve any remaining uncertainties. The findings from this Study, including any Phase 2 recommendations, will be summarized in a report and provided to Ecology by February of the following year.

9.0 References

- Anchor QEA. 2018. *Comprehensive Water Conservation Plan*. Prepared for Icicle and Peshastin Irrigation Districts under the direction of Trout Unlimited. August.
- Ecology. 2004. *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*. Washington State Department of Ecology. Publication No. 04-03-030. <https://fortress.wa.gov/ecy/publications/summarypages/0403030.html>
- Ecology. 2005. *Quality Assurance Monitoring Plan: Streamflow Gaging Network*. Washington State Department of Ecology. Publication No. 05-03-204. Prepared by Steve Butkus. August.
- Ecology. 2018a. *Standard Operating Procedures EAP056, Version 1.3 – Measuring and Calculating Stream Discharge*. <https://apps.ecology.wa.gov/publications/documents/1803203.pdf>
- Ecology. 2018b. *Standard Operating Procedures EAP057, Version 1.2 – Conducting Stream Hydrology Site Visits*. <https://apps.ecology.wa.gov/publications/documents/1903209.pdf>
- Ecology. 2020. *Quality Management Plan Version 5*. Washington State Department of Ecology. Publication No. 20-03-014. <https://apps.ecology.wa.gov/publications/documents/2003014.pdf>
- Ecology. 2023. *Standard Operating Procedures EAP070, Version 2.4 – Minimize the Spread of Invasive Species*. <https://apps.ecology.wa.gov/publications/documents/2403204.pdf>
- Geosyntec. 2026. *Draft 2025 Trust Water Donations for Icicle Peshastin Irrigation District and Leavenworth National Fish Hatchery*. Geosyntec Consultants, Inc. May 4.
- ISO. 2007. “Hydrometry — Measurement of liquid flow in open channels using current meters or floats.” International Organization for Standardization. 748:2007.
- LNFB. 2025. *Complex Hydrologic Data Collection and Management Plan*. Leavenworth National Fish Hatchery. (see Appendix B).
- Mastin, M. 2017. *Surface-Water Quality-Assurance Plan for the U.S. Geological Survey Washington Water Science Center*. Open-File Report 2016–1020 Version 1.1. U.S. Geological Survey, Washington. <https://pubs.usgs.gov/of/2016/1020/ofr20161020.pdf>
- Mueller, D.S., and C.R. Wagner. 2009. “Measuring Discharge with Acoustic Doppler Current Profilers from a Moving Boat.” *United States Geological Survey Techniques and Methods 3A-22*. Chapter 22 of Book 3, Section A. https://pubs.usgs.gov/tm/3a22/pdf/tm3a22_lowres.pdf
- Oberg, K., S. Morlock, and W. Caldwell. 2005. “Quality-Assurance Plan for Discharge Measurements Using Acoustic Doppler Current Profilers” *U.S. Geological Survey*. Scientific Investigations Report 2005-5183. https://pubs.usgs.gov/sir/2005/5183/SIR_2005-5183.pdf
- Rantz, S. E. et al. 1982. “Measurement and Computation of Streamflow: Volume 1, Measurement of Stage and Discharge” *U.S. Geological Survey*. Geological Survey Water-Supply Paper 2175.
- USGS. 2010. *Discharge Measurements at Gaging Stations, Techniques and Methods 3-A8*. U.S. Geological Survey. <https://pubs.usgs.gov/publication/tm3A8>

10.0 Appendices

- A Site Descriptions – FWS Gages
- B LNFH Hydrologic Data Collection and Management Plan (2025)
- C Monitoring Site Photos
- D Field Forms

APPENDIX A

Descriptions for FWS Flow
Monitoring Sites

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION**

1. REFUGE/HATCHERY NAME:

Leavenworth NFH

2. SITE NAME:

Leavenworth NFH Discharge at Fish Ladder (Outfall 1)

3. SITE NUMBER:

322501

4. PURPOSE OF GAGE:

The purpose of this gage is to provide information on water flow out of the hatchery at the Parshall flume at bottom of fish ladder. Measurement of water discharges to Icicle Creek from the hatchery is required by the EPA's Clean Water Act, National Pollution Discharge Elimination System (Permit WA0001902). Data is collected as part of water rights Certificate 1824 requirement to report water diversions to WA Department of Ecology.

5. DESCRIPTIVE LOCATION OF SITE:

Site is located at the east end of Fish Hatchery Road, below the bridge, at the confluence of the Historical and Hatchery Channels of Icicle Creek.

T.24N, R.17E, Sec 23, NE1/4, SE1/4

Decimal Degrees NAD83

Latitude: 47.558045 Longitude: -120.672277

Road Log:

Proceed west of Leavenworth on State Highway 2. Turn south on Icicle Road for 2.2 miles to the Leavenworth NFH and turn left at Fish Hatchery Road. Drive 0.3 mi to the building on the left near the spillway. The fish ladder is just south of the road near Icicle Creek.

6. SUMMARY OF GAGE SYSTEM:

Discharge is measured with a 3' concrete Parshall Flume. Water level is recorded with an ultrasonic open channel flow meter FM8000 by Flomotion Systems. The stilling well sensor is Model NO FM8000, Serial No CS50SB17J009 and the flume installed sensor is Model No FM8000, Serial No CS50SB17J003. Measurement equipment is housed in a wooden shelter mounted on the flumes stilling well. Data is transferred to the SCADA system and recorded in a file created each month. Flomotion equipment communicates with SCADA PLC installed at location and communicates via WiFi to main PLC.

7. DESCRIPTION OF RECORDING SYSTEM:

Equipped with Flomotion Systems ultrasonic water level sensor. Data is communicated to the SCADA system and recorded in a log file.

8. REFERENCE GAGE:

Green paint mark located on the wall at the flume's measuring point.

9. REFERENCE MARKS:

The reference mark is a brass cap located in the SW corner of the concrete slab of the Hatchery's adult holding ponds.

10. DATA COLLECTION:

Stage and discharge data is transmitted and stored at the Hatchery SCADA system. No check flow measurements are made due to safety restrictions in the channel. Data is downloaded periodically and brought to FWS Regional Office Water Resources Branch to be stored in the WISKI Hydrologic Database.

11. ESTABLISHMENT:

The gaging system was established by the personnel in the Water Resources Branch in the Division of Engineering

on 4/30/1994

12. HISTORY:

Established: 4/30/1994; Installed Stevens datalogger and pressure transducer.
TSI installed the Siemens Ultrasonic water level sensor.

December 2017 Two Flomotion Systems Ultrasonic water level sensors installed

13. FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

14. DESCRIPTION OF CHANNEL:

The channel is a 3' Parshall Flume with concrete bottom and sides. The flume is at the end of a fish ladder. At high flows in Icicle Creek the flume becomes submerged, therefore flow calculations are too high and not representative of flow conditions.

15. DESCRIPTION OF CONTROL:

Flume crest at 0.0 ft gage datum.

16. WINTER FLOW:

Ice may form in winter.

17. LOCATION AND TYPE OF DIVERSIONS:

18. LOCATION AND TYPES OF REGULATIONS:

19. LAND STATUS:

Land owned by FWS

21. COOPERATING AGENCIES:

None

22. USGS TOPO MAP:

Blewett, WA, Leavenworth, WA, 7-5' Quadrangle

PREPARED BY: James King July 25, 2008

UPDATED BY: Mary Lindenberg 03/02/2017

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION**

REFUGE/HATCHERY NAME:

Leavenworth NFH

SITE NAME:

Leavenworth NFH Discharge at Abatement Ponds (Outfall 2)

SITE NUMBER:

322502

PURPOSE OF GAGE:

To monitor flow out of the Pollution Abatement Ponds in accordance with EPA's Clean Water Act, National Pollution Discharge Elimination System (Permit WA0001902).

DESCRIPTIVE LOCATION OF SITE:

Site is located at the north end of the Leavenworth NFH and is composed of two separate abatement ponds each with their own monitoring equipment. Sites are located in a locked fenced-in enclosure. Keys are available from Leavenworth NFH staff. The box with the equipment has a combo lock.

Combo Lock Code: 0190

T.24N, R.17E, Sec 23, NE1/4, SE1/4

Decimal Degrees Datum NAD83

Latitude: 47.559798 Longitude: -120.672298

SUMMARY OF GAGE SYSTEM:

Discharge at both ponds is measured by recording water level on a 15 minute logging interval in relation to a 90 degree v-notch weir. Discharge is calculated with a v-notch weir equation. Stage monitoring equipment is located in a small wooden box gage house on top of a plastic pipe stilling well located on the discharge sides of each pond.

DESCRIPTION OF RECORDING SYSTEM:

The new pollution abatement pond, located furthest away from Icicle Creek (PAP 1), includes a Sutron 9210 datalogger SN 1110102, model # 9210-0000-2B and a shaft encoder SN#1011887 and model#86 0540 400 DTR with an 18in circumference beaded wire pulley. Telemetry equipment includes a Raveon Radio Modem (Model# RV-M7-UA, SN 163514107884), a Polyphasor Lightning Arrestor (ISB50LN-C2), and a YAGI LAIRD Gold antenna 430-450 MHz (SN 09231613)

The older pollution abatement pond, located nearest Icicle Creek (PAP 2), also uses a Sutron 9210 datalogger SN 1110311, model # 9210-0000-2B and a shaft encoder SN#1011891, and model#86 0540 400 DTR with an 18in circumference beaded wire pulley. Telemetry equipment includes a Raveon Radio Modem (Model# RV-M7-UA, SN 163514108000), a Polyphasor Lightning Arrestor (ISB50LN-C2), and a YAGI LAIRD Gold antenna 430-450 MHz (SN 09231613)

Both sites are powered by a 12v 34Ah battery, which is powered by Mini DC-UPS Phoenix Contact, which is plugged into 120v outlet power supply.

REFERENCE GAGE:

PAP1 uses a reference gage etched onto the v-notch weir (0 – 1.5'). To improve measurement accuracy changes to the gage height should be made during low flows.

PAP2 uses a reference gage etched onto the v-notch weir (0 – 1.5'). To improve measurement accuracy changes to the gage height should be made during low flows.

REFERENCE MARKS:

None. V-notch weir is removed periodically and the staff marking on the weir changes when the weir is moved. The recorded value is reset when the v-notch is replaced.

DATA COLLECTION:

Data is telemetered to the hatchery SCADA system and recorded. No check discharge measurements are collected for either PAP. Discharge is determined at the SCADA computer. The Water Resources Branch has not supported data collection or data management for this site since 2020. The data for this site is managed solely by the Hatchery.

ESTABLISHMENT:

V-notch weir installed in new Pollution Abatement Pond (PAP1) and logging began in the new pollution abatement pond during 7/2011.

HISTORY:

2011 90 degree V-notch weir installed along with stilling well and Stevens monitoring equipment in the new PAP. Still well and Stevens monitoring equipment install in the old PAP.
Stevens AXSYS Datalogger S/N 162680K
Stevens A/F Stand Alone Encoder S/N 153382-95D
Feb 2012 Installed new Sutron SDR dataloggers for the float/pulley systems in both Pollution Abatement ponds.
- Sutron SDR SN (1107173) in PAP 1 (newer PAP)
- Sutron SDR SN (1107182) in PAP 2 (older PAP)
May 2012 90 degree V-notch weir installed in old PAP pond.
Sept 2016 SDR replaced with Sutron 9210 and Shaft Encoders
Oct 2016 Antenna and radio modem installed at both measurement locations. New Sutron firmware V3.19.0.10
Jun 2017 Solar panel upgraded to 20 watts to account for additional power drainage from the radio.
Oct 2018 Mini DC-UPS installed for power supply.

FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

Reset gage after every cleaning of abatement pond or when the v-notch weir and boards are moved.
If required clean v-notch and check for leaks around boards during visit

DESCRIPTION OF CHANNEL:

Gravel and concrete pond.

DESCRIPTION OF CONTROL (FLUME, WEIR, ETC.)

90 degree aluminum 18 inch v-notch weir made by Rickly. Frame was built by Leavenworth NFH staff.

WINTER FLOW:

The ponds may freeze during the winter but free flow near the weir is still possible. The stilling wells may also freeze.

LOCATION AND TYPE OF DIVERSIONS:

N/A

LOCATION AND TYPES OF REGULATION:

N/A

LAND STATUS:

Land owned by USFWS

COOPERATING AGENCIES:

None

USGS TOPO MAP:

Leavenworth, WA

PREPARED BY: K.Kannarr

DATE: 7/2011

UPDATED BY: M Lindenberg

DATE: 10/2018

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION**

REFUGE/HATCHERY NAME:

Leavenworth NFH

SITE NAME:

Snow Creek Mouth at Icicle Creek

SITE NUMBER:

322503

PURPOSE OF GAGE:

To monitor flow from the Upper Snow Lakes basin and monitor flow just downstream of diversion point for the Icicle and Peshastin Irrigation District. The difference between measurements at this site and measurements at Snow Creek Diversion (322504 – currently no measurement by FWS) represent the amount of water removed from Snow Creek by the irrigation district. Under contract No. Ilr-1383 we are required to monitor surface water diversions from Snow Creek.

DESCRIPTIVE LOCATION OF SITE:

UTM Zone 10 N

Northing: 5267888 Easting: 672148

Decimal Degrees Datum NAD83

Latitude: 47.541954 Longitude: -120.711796

Located just below the diversion point for Icicle and Peshastin Irrigation District on Snow Creek. The concrete weir is located approximately 1000 ft south of Snow Creek's confluence with Icicle Creek.

Road Log:

Proceed west of Leavenworth on State Highway 2. Turn south on Icicle Road and follow the road to the Snow Lakes trailhead. Hike the Snow Lakes trail a few hundred yards until you cross an irrigation canal. After crossing the canal hike west 300 ft until you reach Snow Creek and the cement weir. Datalogger is in a galvanized steel shelter. Shelter locked with brass combo lock (**Combination: 0190**).

SUMMARY OF GAGE SYSTEM:

Discharge is measured at a cement combination weir. The weir is a combination of a v-notch weir for low flows and a broad crested weir for large flows. Head is measured by a float-pulley system hooked up to a Sutron SDR datalogger (SN 1206494).

DESCRIPTION OF RECORDING SYSTEM:

Sutron Stage Discharge Recorder(SDR) (SN#1206494) set to a 15min recording interval. SDR, charge controller and battery are housed in a small metal instrument shelter above a small diameter stilling well. Recorder is powered by a 12v 18 amp hr. battery (2018) and solar panel that is mounted to a pole that is mounted to the weir structure.

REFERENCE GAGE:

Outside staff gage is located on concrete stem well just below the instrument shelter. Staff gage reading of 0.00 is 0.10 ft above the main weir crest.

REFERENCE MARKS:

RP 1: Top upstream bolt head on outside staff plate.

Elevation relative to Gage Datum: 3.273

RP 2: Converted from RM3: Bolt head inside stilling well shelter. Colored black with sharpie.

Elevation relative to Gage Datum: 5.475

RM 4: Lagbolt 5-6 inches out of concrete on north side of IPID Snow Creek conveyance, 10 feet downstream of stepladder.

Elevation relative to Gage Datum: 8.149

RM 5: Bolt holding IPID bridge bracket on west side of ditch and north side of bridge and I-beam
Elevation relative to Gage Datum: 5.538

RM 6: chiseled Square in corner of concrete ~ 6 feet south of stilling well.
Elevation relative to Gage Datum: 4.919

RM 1: Discontinued: Lagbolt head in tree trunk west side of creek. Second tree south of control structure
Elevation relative to Gage Datum: 5.431

RM 2: Discontinued: Lagbolt head in tree trunk west side of creek. First tree south of control structure.
Elevation relative to Gage Datum: 5.446

DATA COLLECTION:

Prior to 2003 data were collected once a year. In the summer of each year (usually June or July) the refuge turns on the Snow Lake Outlet to supplement flow in Icicle Creek with cool, clean water. In the fall (usually September or October) hatchery staff return to the outlet drain to turn it off. During this time the datalogger was downloaded and the station is decommissioned for the winter. Starting in 2003, the datalogger at the Snow Creek mouth is setup for the season and will continue in place. The monitoring equipment was deployed for year-round monitoring, coupled with multiple site visits annually.

ESTABLISHMENT:

The Stevens AXSYS datalogger was installed in July 1997.

HISTORY:

1940's	Snow Lake tunnel and outlet drain constructed
1993	R.W. Beck and Associates develop rating curve for combination weir
1997	Steven's datalogger installed. Begin twice annual visits to site by Water Resources Branch staff.
2003	Datalogger left in place over winter.
Nov. 2004	Battery is dead and removed for winter of 2004/05.
Mar. 2005	Battery replaced and station setup for year.
Oct 2006	New battery installed
Nov. 2006	Large flood in Snow Creek. Measurements shifted from rating afterwards
Aug 2006	Rehab to IPID flume on Snow Creek.
June 2009	New battery installed.
Jan 2011	Stilling well pipes opened and cleaned out.
Sept 2011	New battery installed.
May 2012	New Sutron SDR datalogger installed (05/14/2012)
Feb 2013	New Sutron SDR datalogger installed replacing previous Sutron SDR
Oct 2015	Levels run, RM4, 5, 6 established
July 2018	Battery replaced
Oct 2023	IPID updated their diversion infrastructure and ran the aqueduct too close to the stilling well making it annoyingly frustrating to access
Oct 2023	Solar panel replaced

FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

- Run levels.
- Obtain more low flow and high flow measurements.
- Flush intake
- Remove rocks in front of weir

DESCRIPTION OF CHANNEL:

Channel has been filled in by boulders moved downstream from high flows and debris flows. It was determined during the 3/28/18 site visit beavers have dammed a portion of the pond above the station and is creating a side channel. The side channel flows into Snow Creek on the left bank approximately 5-10 ft above the weir. This is a big concern because the side channel is causing the bank to erode and the concrete wall to disintegrate.

DESCRIPTION OF CONTROL:

Control is the cement broad crested weir spanning the Snow Creek channel.

WINTER FLOW:

Flow continues through the winter. Stilling subject to icing during winter months.

LOCATION AND TYPE OF DIVERSIONS:

A wood flume operated by the Icicle and Peshastin Irrigation district is immediately upstream of this site. The water resources branch historically operated a monitoring station on this flume (Site No. 322504).

LOCATION AND TYPES OF REGULATIONS:

LAND STATUS:

Land owned by FWS

COOPERATING AGENCIES:

None

USGS TOPO MAP:

Blewett, WA

PREPARED BY:

Ron Thomasson

1994

UPDATED BY:

Mary Lindenberg

February 2024

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION**

REFUGE/HATCHERY NAME:

Leavenworth NFH

SITE NAME:

Icicle Creek at Structure 2

SITE NUMBER:

322525

PURPOSE OF GAGE:

The purpose of the gage is the continuous measurement of stage above structure 2 to calculate discharge through the radial gate structure and into Icicle Creek Historical Channel. Measurement at this location is required through NOAA Biological Opinion to understand discharge in the Historical Channel of Icicle Creek.

DESCRIPTIVE LOCATION OF SITE:

Decimal Degrees NAD83

Latitude: 47.549494 Longitude: -120.679117

Road Log:

Proceed west of Leavenworth on State Highway 2. Turn south on Icicle Road for 2.2 miles to the Leavenworth NFH and turn left at Fish Hatchery Road. From the gated hatchery entrance proceed straight 0.16 miles to the hatchery channel bridge. After crossing the hatchery bridge follow the road as it runs parallel to the hatchery channel until it terminates at the Structure 2 bridge.

SUMMARY OF GAGE SYSTEM:

Water level is measured by a Pressure Transducer SN# 1105029; Model # 56-0135-25-1 and Sutron 9210 datalogger Model # 9210-0000-2B, SN 1110307. A flexible electrical conduit protects the pressure transducer line to a 2 inch PVC pipe in the old pump well on the left bank of structure 2. Power is supplied by two 30-watt solar panels and two 12 volt DC 75 amp hour batteries. Charge is maintained by an ASC 1218 12 volt 8 Amp charge controller manufactured by Specialty Concepts Inc. Telemetry equipment includes a Raveon Modem (Model # RV-M7-UA, SN 16359017611, FCCID 8RS-RV), a Polyphasor Lightning Arrestor (ISB50LN-C2), and a YAGI LAIRD Gold antenna 430-450 MHz (SN 09231613). Additional telemetry equipment to satellite communications is through a Sutron Satlink SN# 1607199, Model#SL3-I-IR with a GOES Yagi UHF, 401-402 MHz. Radial gate opening values are measured with (installed by BOR) Two Rieker Inclonometers Model# H4360 measure the opening of the radial gate. Power to the Raveon Modem is limited by a solid state relay controlled by a basic program.

One wire weight gage is located on structure 2. A flat bladed screwdriver and the lock combo 0190 are required to open the bubbler enclosure.

DESCRIPTION OF RECORDING SYSTEM:

Stage is recorded at a 15 minute logging interval by a Sutron 9210 Datalogger. Site visit data is entered into field sheets and stored on record at the Portland Regional Office and Q drive. Data is downloaded with a full size SD Card transferred to the Water Resources Office of Portland USFWS and Q Drive. Data is also transferred to SCADA system via radio modem to the Leavenworth Operations Computer. Data is also relayed to WISKI Hydrologic Database via satellite telemetry using the NOAA HADS system.

REFERENCE GAGE:

The reference gage measurement was performed from a wire weight gage located on the left bank of structure 2 from its installment in Sept 2009 until the cantilevered wire weight gage was installed and leveled in Oct 2011. Starting March 2015 the stage is referenced to the LEW Wire Weight Gage. Between Oct 2011 and Oct 2014 the cantilevered wire weight gage located at the center of structure 2 will be used as the reference gage. Continue to note the measured values from both the cantilevered wire weight gage and the wire weight gage on the left bank. Datum is NAVD88, Geoid 2003 1127.926' Do not use the old staff plates that are bolted to upstream end and downstream end of structure 2.

REFERENCE MARKS:

RM1 - Pump (top bolt painted white) Elevation: 21.663 ft (1149.589')
RM2 - Nail or Control Point or pin; Loose - DO NOT USE! Elevation: 18.627 ft (1146.55')
RM3 - Rail Base do not know location (only used in 1st level survey 09/2009). Elevation: 19.053 ft
RM4 - Rounded bolt head on radial gate spool end - most upstream Left Bank. Elevation: 21.045 ft (1148.971')
RM5 - Described as top of O.S. Upstream right bank @ 9.990. Used on 09/2009. Elevation: 14.038 ft
RM6 - Rounded bolt head on LEW radial gate spool end - most south and west bolt. Elevation: 21.051 ft (1148.977')
RM7 - Fence post base screw and nut. 4th post from LEW. LEW and downstream screw. Elevation: 19.142 ft (1147.068')
RP1 - LEW Wire weight gage - bar back. Elevation: 22.336 ft (1150.292')
RP2 - LEW Wire weight gage - bar front. Elevation: 22.365 ft
RP3 - Dam Walkway on ds side of LEW port to sill. Elevation: ~ 10.000 ft

DATA COLLECTION:

Water stage data is collected 3-5 times a year and entered into appropriate spreadsheets by Water Resources Branch staff. Data is processed and stored in WISKI Hydrologic Database. Water Resources Region 1 staff visit for maintenance 3-5 times a year.

ESTABLISHMENT:

Wire weight gage was installed September 2009. Removed in October 2014 and Reinstalled in March 2015. Cantilevered Wire Weight Gage was installed on October 2011 and removed October 2014.

HISTORY:

2009 Wire weight gage was installed and leveled in September 2009.
2010 Pressure transducer was installed in the pump well on the left bank October 2010.
2011 Sutron Accubar Continuous Flow Bubbler System installed and operational 9/20/2011.
2011 Cantilevered wire weight gage was installed and leveled for use by Oct 2011.
2012 March - Universal battery (UB12550) 12v; 55 Ah installed
2012 March - Bubbler replaced with loan from J Humphreys SN 904026
2012 October - Levels survey, determined NAVD88 Datum elevation with line survey from PGS CP 71
2013 April - J Humphreys bubbler replaced with repaired FWS bubbler.
2013 September - Replaced desiccant, run levels.
2014 September - Levels run
2014 October - removed WWG and Cantilevered WWG and Sutron Bubbler
2015 March - Reinstalled WWG, run levels and Sutron 9210 and Pressure Transducer
2015 October - Run levels
2016 October - Install radio modem and telemetry equipment, New Sutron firmware V3.19.0.10 w/Modbus Comm
2017 Sept - Inclometers installed in each bay, installed basic program
2018 Sept - Satlink installed, large batteries 2- 75 amp-hour batteries installed
2019 Sept - Installed basic program to limit Raveon modem from using battery power
2021 July - Flow calculation basic program installed in 9210 for satellite transmission
2024 Sept - New Inclometers installed in each bay

FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

Check Levels

Install a cantilevered wire weight gage

DESCRIPTION OF CHANNEL:

Boulder, cobble, gravel and sand above and below structure 2. No vegetation. Structure 2 is concrete lined. Immediately upstream of Structure 2 Icicle creek may split and flow down the Hatchery Channel during higher flows.

DESCRIPTION OF CONTROL:

The control is a dual bay radial gate. Each bay is 16 feet wide. This control acts as a broad crested weir when critical depth water levels are lower than radial gate height and as a radial gate when critical depth water levels are greater than radial gate height. The critical depth is the depth of water flowing over the weir crest and is usually lower than stage-measured water levels. Flow backs up into the Hatchery Channel at about 2.5 feet of stage or when water levels reach the top of the radial gate.

WINTER FLOW:

Flow is irregular at all times of the year. Surface water will freeze around structure 2 but flow will continue. Water may or may not flow down the hatchery channel.

LOCATION AND TYPE OF DIVERSIONS:

Structure 2 is in the path of the natural channel of Icicle Creek and its historical channel. A large canal, approximately 300 feet wide, was dredged in the 1930s to allow flow away from the historical channel into the hatchery channel. Water backs up into the hatchery channel at flows greater than 280 CFS. Flows will continue to fill the hatchery channel until about 800 CFS is measured at Structure 2, at which point waters will spill over the weir at the end of the hatchery channel and rejoin with Icicle Creek. Flows are limited in passing structure 2 through the two 16' bays at 5 feet in height.

LOCATION AND TYPES OF REGULATIONS:

NOAA Biological Opinion

LAND STATUS:

Land owned by USFWS

COOPERATING AGENCIES:

US Bureau of Reclamation

USGS TOPO MAP:

Leavenworth, WA

PREPARED BY: K. Kannarr September 2011

UPDATED BY: M Lindenberg September 2024

APPENDIX B

LNFH Hydrologic Data Collection
and Management Plan
(2025)

Leavenworth National Fish Hatchery Complex

Hydrologic Data Collection and Management Plan

2025

Introduction

The Water Resources Branch (WRB) in the regional office in Portland, OR provides hydrologic monitoring, data management, and water use reporting for the Leavenworth National Fish Hatchery Complex, including Leavenworth and Winthrop hatcheries. This document will serve as a resource and guideline for continued monitoring, data management and water use reporting through FY 2024.

Purpose

The purpose of this document is to outline the requirements for hydrologic monitoring and reporting for Leavenworth NFH Complex. This document covers the current data collection, management, and reporting efforts made by the Water Resources Branch to date.

The hatchery complex is required to monitor at numerous hydrologic locations due to four types of regulations or contracts;

- 1) Washington Department of Ecology Revised Code RCW 90.03.360
 - a. Order No. DE 02WRCR-3724 for Leavenworth Hatchery Water Right Certificate 1824;
 - b. Order No. DE 02WRCR-4018 for Winthrop Hatchery Water Right Certificates G4-08664C (GWC7209-A), G4-11685C (GWS7590-A), S4-00705C (CS4-SWC848);
- 2) a contract between the United States and the Icicle and Peshastin Irrigation Districts (IPID) (Contract Ilr-1383, August 5, 1941);
- 3) EPA's Clean Water Act, National Pollution Discharge Elimination System (Permit WA0001902);
- 4) NOAA's, National Marine Fisheries Service, Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation, NMFS Consultation Number: WCR-2017-7345.

The regulatory orders and the contract are herein referred to as Ecology, the FWS/IPID contract, the EPA NPDES permit, and the NOAA NMFS Biological Opinion.

Data Collection Requirements

Leavenworth NFH

The WRB monitors flow inputs to and outputs from the hatchery, flows on Icicle Creek in the Historical Channel and above Structure 1, releases from Snow Lakes and flows on Snow Creek. Table 1 lists each monitoring location along with other pertinent attributes. Figures 1 and 2 are maps displaying the locations of each monitoring site at Leavenworth hatchery. Monitoring sites measuring inflows into the hatchery include one surface water inflow site that withdraws waters off Icicle Creek at Structure 1 and seven groundwater wells that withdraw from the aquifer.

Three regulatory orders require the hatchery to monitor its surface water inflow at Structure 1. The EPA NPDES permit requires monitoring of the flow input from groundwater wells and the monitoring of flow released from the hatchery and returned to Icicle Creek. Release flow sites include one large flow release site called Outfall 1 near the fish ladder and the combined flow from two pollution abatement ponds called Outfall 2. The WRB reports data from Outfall 1/Fish Ladder to Ecology for water rights requirements.

The NOAA's NMFS Biological Opinion requires monitoring of sites that measure flows in the Historical and Hatchery channels of Icicle Creek. The FWS/IPID contract mandates the monitoring of releases from Snow Lakes and flows in Snow Creek.

Table 1. Regulatory order requiring monitoring for each station; including real-time data availability, and data management location.

Site Number	Site Name	Parameter	Real-Time Telemetry	Data Management Location	Regulatory Requirement
Leavenworth NFH					
322501	Discharge at Fish Ladder (Outfall 1)	discharge	Radio - SCADA*	LNFH Operations Computer/WISKI	NPDES [‡] , Ecology [#]
322502	Pollution Abatement Pond (Outfall 2)	discharge	Radio - SCADA*	LNFH Operations Computer/WISKI®	NPDES [‡]
322503	Snow Creek at Mouth	discharge	None	WISKI Database	NOAA NMFS BiOp ^{**} , IPID Contract [†]
322505	Nada Lake Outlet	discharge	None	WISKI Database	NOAA NMFS BiOp ^{**} , IPID Contract [†]
322506	Snow Lake Outlet	discharge/volume	None	WISKI Database	NOAA NMFS BiOp ^{**} , IPID Contract [†]
322507	Snow Creek at Snow Lake Inlet	discharge	None	WISKI Database	IPID Contract [†]
322508	Production Well No. 1	well discharge, level, temperature	Radio - SCADA	LNFH Operations Computer/WISKI®	NPDES [‡] , Ecology [#]
322510	Production Well No. 3	well discharge, level, temperature	Radio - SCADA	LNFH Operations Computer/WISKI®	NPDES [‡] , Ecology [#]
322511	Production Well No. 4	well discharge, level, temperature	Radio - SCADA	LNFH Operations Computer/WISKI®	NPDES [‡] , Ecology [#]
322512	Production Well No. 5	well discharge, level, temperature	Radio - SCADA	LNFH Operations Computer/WISKI®	NPDES [‡] , Ecology [#]
322513	Production Well No. 6	well discharge, level, temperature	Radio - SCADA	LNFH Operations Computer/WISKI®	NPDES [‡] , Ecology [#]
322514	Production Well No. 7	well discharge, level, temperature	Radio - SCADA	LNFH Operations Computer/WISKI®	NPDES [‡] , Ecology [#]
322517	Production Well No. 2	well discharge, level, temperature	Radio - SCADA	LNFH Operations Computer/WISKI®	NPDES [‡] , Ecology [#]
322525	Historical Channel of Icicle Creek at Structure 2	discharge	Radio - SCADA*, Satellite Telemetry	LNFH Operations Computer/WISKI	NOAA NMFS BiOp ^{**}
322527	Hatchery Channel of Icicle Creek at Spillway	discharge	None	WISKI Database	NOAA NMFS BiOp ^{**}
322533	LNFH Icicle Creek Diversion Intake at Structure 1	discharge	Modem - SCADA*	LNFH Operations Computer/WISKI®	NOAA NMFS BiOp ^{**} , NPDES [‡] , Ecology [#]
NA	Icicle Creek at Structure 1	discharge	NA	NA	NOAA NMFS BiOp ^{**} , NPDES [‡]
Winthrop NFH					
326501	Foghorn Ditch Diversion Pipeline (Winthrop use only)	discharge	None	WISKI Database	Ecology [#]
326502	12" Pipeline at Infiltration Gallery 1	discharge	None	WISKI Database	Ecology [#]
326503	10" Pipeline at Infiltration Gallery 1	discharge	None	WISKI Database	Ecology [#]
326504	24" Pipeline at Infiltration Gallery 2	discharge	None	WISKI Database	Ecology [#]
326505	16" Pipeline at Infiltration Gallery 2	discharge	None	WISKI Database	Ecology [#]
326506	Foghorn Ditch Diversion from Methow River (all users)	discharge	Modem - SCADA	WISKI Database	Ecology [#]
326507	10" Pipeline at Infiltration Gallery 3	discharge	None	WISKI Database	Ecology [#]

326508	Bypass Channel	discharge	None	WISKI Database	Ecology [#]
<p>*Required Real-time Data Availability</p> <p>[#]Washington Department of Ecology Revised Code RCW 90.03.360 (Order No. DE 02WRCR-3724 and DE 02WRCR-4018) for Water Right Certificates</p> <p>[†]Contract between the United States and the Icicle and Peshastin Irrigation Districts (IPID) (Contract Ilr-1383, August 5, 1941)</p> <p>[‡]EPA's Clean Water Act, National Pollution Discharge Elimination System (Permit WA0001902)</p> <p>^{**}NOAA's, National Marine Fisheries Service, Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation, NMFS Consultation Number: WCR-2017-7345</p> <p>@The Water Resources Branch does not manage this data in WISKI, only historical data can be obtained from WISKI.</p>					

Real-time Data Requirements

The NOAA Biological Opinion requires monitoring of and real-time data availability of Icicle Creek flows above Structure 1. Real-time data availability means providing data that is accessible within 12 hours of the measurement time. Unfortunately, there are constraints limiting the ability of accurately monitor flow of Icicle Creek above Structure 1, due to a lack of sites with suitable conditions for monitoring. As an alternative, the combination or subtraction of monitoring data from nearby flow monitoring sites, made available real-time, can represent Icicle Creek flows above Structure 1. For example, the flow diverted from Icicle Creek at Structure 1 combined with flows downstream on Icicle Creek at Structure 2 can be used to represent flows on Icicle Creek at Structure 1. Although at times, waters that backup at Structure 2 and flow down the Hatchery Channel of Icicle Creek adds a complication that is not accounted for in determining flow above Structure 1. This can occur when flows are high or when operations lower the radial gate in the Historical Channel. During these scenarios, the alternative method of determining Icicle Creek flow above Structure 1 is accomplished by subtracting the combined production well discharge from the flow monitoring site on Icicle Creek at East Leavenworth Bridge provided by Washington Department of Ecology. Therefore, in order to abide by NOAA Biological Opinion that requires monitoring of and real-time data availability of Icicle Creek flows about Structure 1, real-time data from the diversion at Structure 1, Icicle Creek at Structure 2, and the production well sites are available real-time to the hatchery operations computer. In addition, the flow data of Icicle Creek at the East Leavenworth Bridge is available real-time through the Washington Department of Ecology website (<https://fortress.wa.gov/ecy/eap/flows/station.asp?wria=45>).

Figure 1. Map of monitoring stations for the Leavenworth NFH.

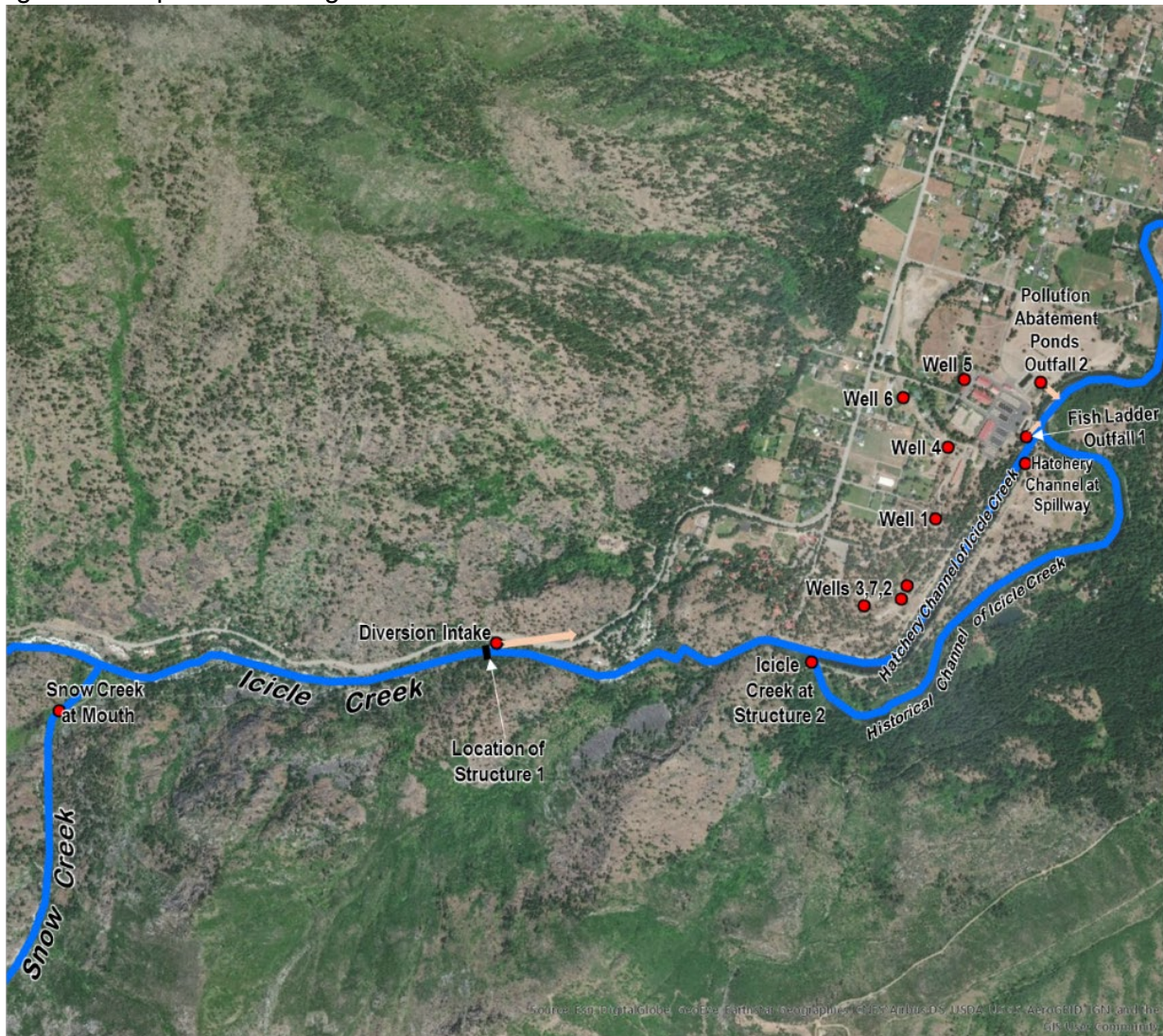


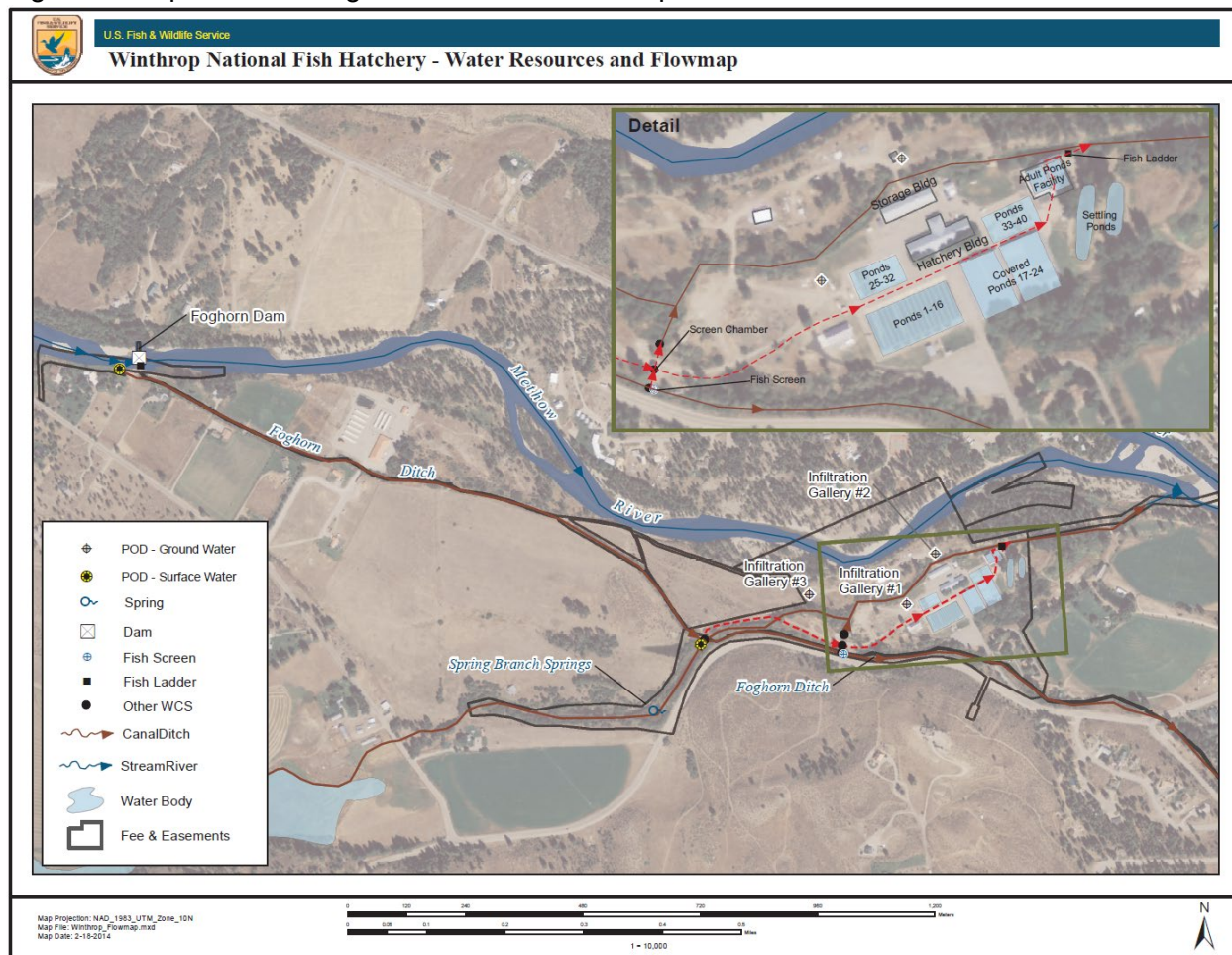
Figure 2. Map of monitoring stations in the alpine lakes area near Leavenworth NFH.



Winthrop NFH

The WRB monitors the Bypass Channel and provides data to the hatchery for their requirement to report to Ecology. The hatchery monitors and collects data from the Foghorn ditch diversions and the three infiltration galleries. The hatchery records the data for Foghorn ditch and the three infiltration galleries, then submits the data to the WRB annually. The WRB reports water rights usage on the Foghorn ditch and the infiltration galleries to Ecology.

Figure 3. Map of monitoring stations at the Winthrop NFH.



Data Collection and Management Protocols for Each Monitoring Site

This section will cover a description of each site, the site visit protocol, and data management protocol. Site descriptions, located in appendix A, cover more information on sites beyond that explained in this section. The site description identifies the location, equipment, data collection, history, maintenance required, survey levels, and more, depending on the type of data collected. Site visits are a physical act of visiting each site to conduct maintenance checks, QA/QC checks, and data download. Each site may require 5-6 site visits a year with specific checks on various parameters measured by various equipment.

Data management is the consistent process of storing supporting documents collected during the site visit and the process of reviewing, editing, and storing data for future use and analysis. Data management includes supporting documents like data files downloaded from dataloggers, instantaneous monitoring checks like water level measurements from staff plates, and discharge

measurements, as well as metadata like photographs, field sheets, and other supporting files. All this information and data should be stored on the IFW1-PDXR-100 Station Network site folder location in the Regional Office. Processing data files involves naming and organizing files in a consistent manner, uploading the data to the database, and managing those data in the database, which includes data validation, checking, and other quality assurance procedures. The Water Resources Branch in the Pacific Region uses KISTERS WISKI database to manage hydrologic data. Data are imported into WISKI that was downloaded from the hatchery's SCADA system or from various dataloggers and instrumentation files, depending on the monitoring site. Each site includes an annual "Station Analysis" that describes the process and methods to apply corrections to the data. More information on the Station Analysis is explained in the Records Management section.

Records Management – Data Processing

The computation of records involves the analysis of field observations and field measurements compared with continuous data, the determination of stage-discharge relations, adjustment and application of those relations, and systematic documentation of the applied methods and decisions. Data processing is an intensive process that is too detailed to be covered in this document. Monitoring data is processed, managed, and stored in the Hydrologic Database - WISKI (Water Information Systems KISTERS).

Concerns of Data Management

Sites with real-time data stored on the Leavenworth hatchery operations computer are shown in Table 1. It is important to note that the data on the operations computer has not been reviewed or edited for accuracy. Data errors include instrumentation drift or malfunction, or interruption of communication to the SCADA system. Instrument drift occurs often and requires a data comparison between the recorded measurement and an independent, instantaneous measurement or observation. A discrepancy between the two measurements means the recorded data will require adjustment. An interruption of communication to the SCADA system can occur due to malfunction of the recording instrumentation or the communications equipment. When this occurs, rather than record blank values, the data viewing application on the operations computer continues to log the last recorded value until a new value is received. This will appear as a flat-line in a graph of the data. The erroneous data will either need to be corrected or removed. These errors must be corrected or managed outside of the SCADA system using established data management protocols. The Water Resources Branch in the regional office uses KISTERS WISKI database to correct, store, and manage its hydrologic data and we recommend that the hatchery continue that practice.

LNFH Diversion Intake at Structure 1:

The Water Resources Branch does not manage data from these sites in WISKI anymore. Data is managed from the Operations computer. Historical supporting documents are stored in the IFW1-PDXR-100 Station Networks folders in the regional office. Historical data were processed in WISKI to remove data spikes and incorrect data.

Historical data can be accessed in WISKI. Historical data was managed based on the following description:

This surface water flow site measures the flow of water diverted off Icicle Creek and pulled by gravity to a pipeline conveying water to the hatchery for fish production. This is the most difficult site to manage because of the instrumentation requirements, the fact that sediment accumulates, and the channel profile changes frequently. A Sontek acoustic Doppler velocity meter (ADVM) measures stage and velocity, which along with area, provides the means to calculate flow. The ADVM communicates through a Sutron 9210 datalogger to submit flow data via voicemodem to the hatchery SCADA system.

This site should be visited 5-6 times a year. Site visits entail a physical inspection of the datalogging equipment and power system and the ADVM for obstructions of velocity and stage acoustic signals. The site visit data collection involves comparing ADVM measured stage and water level at the reference point, measuring the channel profile to calculate area, and conducting a discharge measurement. See the site visit instructions document for further detail. Data is downloaded from the ADVM.

The data management protocol entails saving raw data files, discharge measurement files, field sheets, and photos in their respective locations in IFW1-PDXR-100 Station Network site location (322533). See the ADVM Index Velocity Method Instructions for more detail on data management process. The data are updated and processed in the WISKI Database to calculate flow.

Production Wells:

Seven production wells withdraw water from the aquifer below the hatchery. A transducer measures water level and temperature and a flow meter measures discharge. The data is telemetered to the hatchery SCADA system via radio modem and viewed through the Operations Computer System.

Ideally, the production well sites should be checked for accuracy of temperature, water level, and flow. Hatchery staff collected water level checks, but as of late this task has not continued. Temperature checks are necessary to ensure accuracy.

The Water Resources Branch does not manage data from these sites in WISKI anymore. Data is managed from the Operations computer. Historical supporting documents are stored in the IFW1-PDXR-100 Station Networks folders in the regional office. Historical data were processed in WISKI to remove data spikes and incorrect data.

LNFH Discharge at Fish Ladder (Outfall 1):

This flow site measures the combined effluent from the majority of the hatchery releases to Icicle Creek. At times, the flow will also include releases from the fish ladder. This monitoring location includes a Parshall flume, where stage is measured and flow is calculated from an equation. The water levels are transmitted to the SCADA system at the hatchery and viewed on the operations computer where the stage is then used to calculate flow released to Icicle Creek.

This data are then downloaded from the SCADA system and processed in the WISKI Database to remove data spikes and incorrect data. Additionally, high Icicle Creek flows causes flume submergence. Data measured during flume submergence depicts a higher flow rate than the real flow rate. Supporting documents are stored in the IFW1-PDXR-100 Station Networks folders in the regional office.

LNFH Discharge at Pollution Abatement Pond (Outfall 2):

This flow monitoring site measures hatchery release to Icicle Creek from two pollution abatement ponds. The flow from each pond combines into one discharge release flow to Icicle Creek. A V-notch weir is set above stop logs at the drain location of each pollution abatement

pond. A shaft encoder measures stage, which records to a 9210 datalogger every 15 minutes. A radio transmits water levels from each pollution abatement pond to the SCADA system and viewed on the operations computer. Flow released from each pond is calculated from stage. Data is downloaded from the 9210 datalogger.

The Water Resources Branch does not manage data from these sites in WISKI anymore. Data is managed from the Operations computer. Historical supporting documents are stored in the IFW1-PDXR-100 Station Networks folders in the regional office. Historical data were processed in WISKI to remove data spikes and incorrect data.

Historical data can be accessed in WISKI. Historical data was managed based on the following description:

This site should be visited 5-6 times a year. Site visits entail a physical inspection of the datalogging equipment and power system, and the V-notch weir for obstructions or impediments to flow. The V-notch weir is read for stage, which is recorded and compared with the shaft encoder stage value. If the stage on the V-notch weir is different from the shaft encoder then the stage is changed on the datalogger to reflect the stage measured on the V-notch weir. Data is downloaded from the datalogger. The stage is checked every couple of months to verify accuracy of the shaft encoder and the datalogger should be updated with the new value. In addition to regular drift of instrument, when the V-notch weir and stop logs are removed to drain the pond and the pond is refilled then the datalogger will need to be set to the new stage value.

The data management protocol entails saving raw data files, discharge measurement files, field sheets, and photos in their respective locations in IFW1-PDXR-100 Station Network site location (322502). Data management of this site includes managing data from two separate stage recorders. Data is downloaded from two separate 9210s and uploaded to the WISKI Database and processed to calculate flow.

Historical Channel of Icicle Creek at Structure 2:

This stream-gaging site measures flow of Icicle Creek at the start of the Historical Channel of Icicle Creek. A radial gate consisting of two separate bays controls the flow into the Historical Channel. A pressure transducer measures the water levels and the Sutron 9210 datalogger records the data. In addition, the 9210 datalogger records radial gate openings for each bay. Water levels and radial gate openings are transmitted to the SCADA system via radio. Flow calculation requires both water levels and the radial gate opening and is viewable on the operations computer. The data is also transmitted via satellite to the WISKI database.

This site should be visited 3 times a year. Site visits entail a physical inspection of the datalogging equipment and power system, the radial gate, the wire-weight gage (WWG), and the pressure transducer. The WWG measures stage, which is compared to the value measured by the pressure transducer. The stage value in the datalogger is changed if needed. The radial gate openings should be measured and compared with the data from the inclinometers but that cannot be done safely so radial gate openings cannot be verified for accuracy. It is important to take a photo to document the radial gate openings and the Icicle Creek flow. Once every couple of years, conduct a differential levels survey to ensure WWG has not migrated from the previously set datum.

The data management protocol entails saving raw data files, discharge measurement files, field sheets, and photos in their respective locations in IFW1-PDXR-100 Station Network site location (322525). Data is downloaded from the 9210 datalogger and uploaded to the WISKI Database and processed to calculate flow.

Hatchery Channel of Icicle Creek at Spillway:

This stage and flow monitoring site measures stage in the Hatchery Channel and calculates flow past the broad-crested weir at the end of the Hatchery Channel. When flows are prevented from moving past Structure 2 the waters back up into the Hatchery Channel and at times spill over the weir. Sutron Bubbler and combined datalogger records stage with a non-submersible pressure transducer.

This site should be visited 5-6 times a year. Site visits entail a physical inspection of the datalogging equipment, power system, the broad-crested weir, the wire-weight gage (WWG), and the pressure transducer. The WWG measures stage, which is compared to the stage measured by the pressure transducer. The stage value recorded at the Sutron Bubbler is changed to match the WWG if needed. A broad-crested weir equation calculates the flow. The cantilevered WWG was installed in summer 2018 and may be subject to moving, therefore, every year the levels are run and the WWG is surveyed to determine movement and a change in datum.

The data management protocol entails saving raw data files, discharge measurement files, field sheets, and photos in their respective locations in IFW1-PDXR-100 Station Network site location (322527). Data is downloaded from the 9210 datalogger and uploaded to the WISKI Database and processed to calculate flow.

Snow Creek at Mouth:

This stream-gaging site measures flow past a combined broad-crested and v-notch weir in Snow Creek just above its confluence with Icicle Creek. A shaft encoder measures stage in a stilling well. Stage is recorded to the SDR datalogger.

This site should be visited 5-6 times a year. Site visits entail a physical inspection of the stilling well, the datalogging equipment and power system, and the combined broad-crested V-notch weir for obstructions or impediments to flow. Comparing water levels in the stilling well and the creek ensures the connection between the two. A discharge measurement is collected every visit. The stage should be checked every couple of months for drift in accuracy of the shaft encoder and the datalogger should be updated with the new value. The staff plate datum requires a differential level check to occur every few years, or when there are obvious visual cues to changes in the staff position.

The data management protocol entails saving raw data files, discharge measurement files, field sheets, and photos in their respective locations in IFW1-PDXR-100 Station Network site location (322503). Data is downloaded from the datalogger and uploaded to the WISKI Database and processed to calculate flow.

Snow Lakes Outlet:

This flow monitoring site measures water level changes in Upper Snow Lake and the flow released from the Outlet valve that drains the lake. A pressure transducer measures the water level of the lake from the pipe pressure at the Outlet valve, and a Sutron 9210 datalogger records the pressure transducer value. When the valve is opened to release water from the lake to the Nada Lake basin, the degrees of opening is recorded. The opening of the valve opening and the lake stage are used calculate flow released from the valve.

This site should be visited at least 2-3 times a year. Site visits consist of visiting the outlet valve equipment in the tunnel to check the pressure gage against the values measured by the

pressure transducer. If it is early in the season, and lake levels have reached within +/- 2-3 feet of the top of the dam then measure the water level at the dam to compare with the pressure gage values. Whenever the valve is opened or changed the opening is recorded so that it can be used to calculate flow.

The data management protocol entails saving raw data files, discharge measurement files, field sheets, and photos in their respective locations in IFW1-PDXR-100 Station Network site location (322506). Data is downloaded from the datalogger and uploaded to the WISKI Database and processed to calculate flow.

Nada Lake Outlet:

This stream-gaging site measures flow through a Parshall flume of waters released from the outlet that drains Nada Lake into the Snow Creek drainage. A shaft encoder measures stage in a stilling well. Stage is recorded and logged at the datalogger.

This site should be visited at least 2-3 times a year. Site visits entail a physical inspection of the datalogging equipment and power system, and the flume for obstructions or impediments to flow. Comparing water levels in the stilling well and at the staff plate in the creek ensures the connection between the two. A discharge check is measured at least once a year or more if possible. The stage should be checked to verify accuracy of the shaft encoder, and the datalogger should be updated with the new value if different between the stage and shaft encoder. The staff plate datum requires a differential level check to occur every few years, or when there are obvious visual cues to changes in the staff position.

The data management protocol entails saving raw data files, discharge measurement files, field sheets, and photos in their respective locations in IFW1-PDXR-100 Station Network site location (322505). Data is downloaded from the datalogger and uploaded to the WISKI Database and processed to calculate flow.

Snow Creek Inlet to Upper Snow Lakes:

This streamgaging site measures flow in Snow Creek before it drains into Upper Snow Lake. Streamflow passes over a broad-crested weir. A shaft encoder measures stage and a datalogger records stage values.

This site should be visited at least 2-3 times a year. Site visits entail a physical inspection of the datalogging equipment and power system, and the broad-crested weir for obstructions or impediments to flow. This site contains a stilling well and the stage of the inside of the stilling well is compared with the stage from reference points set to measure stage in the creek to ensure there is connection between the two water bodies. A discharge measurement is performed at least once a year. The stage should be checked every couple of months due to drift in accuracy of the shaft encoder and the datalogger should be updated with the new value. The reference point datum requires a differential level check to occur every few years.

The data management protocol entails saving raw data files, discharge measurement files, field sheets, and photos in their respective locations in IFW1-PDXR-100 Station Network site location (322507). Data is downloaded from the datalogger and uploaded to the WISKI Database and processed to calculate flow.

Bypass Channel:

This stream-gaging site measures flow past a makeshift rock riffle control. An bubbler measures stage in the channel. Stage is recorded to the SDR datalogger.

This site should be visited 5-6 times a year. Site visits entail a physical inspection bubbler, the datalogging equipment and power system, and the rock riffle for changes to obstructions or impediments to flow. A discharge measurement is collected every visit. The stage should be checked every couple of months for drift in accuracy of the bubbler and the datalogger should be updated with the new value. The staff plate datum requires a differential level check to occur every few years, or when there are obvious visual cues to changes in the staff position.

The data management protocol entails saving raw data files, discharge measurement files, field sheets, and photos in their respective locations in IFW1-PDXR-100 Station Network site location (326508). Data is downloaded from the datalogger and uploaded to the WISKI Database and processed to calculate flow.

Appendix A. Site Descriptions in numeric order of site number

UNITED STATES DEPARTMENT OF THE INTERIOR FISH AND WILDLIFE SERVICE REGION 1 SITE DESCRIPTION

1. **REFUGE/HATCHERY NAME:**
Leavenworth NFH
2. **SITE NAME:**
Hatchery Discharge at Fish Ladder (Outfall 1)
3. **SITE NUMBER:**
322501
4. **PURPOSE OF GAGE:**
The purpose of this gage is to provide information on water flow out of the hatchery at the Parshall flume at bottom of fish ladder. Measurement of water discharges to Icicle Creek from the hatchery is required by the EPA's Clean Water Act, National Pollution Discharge Elimination System (Permit WA0001902). Data is collected as part of water rights Certificate 1824 requirement to report water diversions to WA Department of Ecology.
5. **DESCRIPTIVE LOCATION OF SITE:**
T.24N, R.17E, Sec 23, NE1/4, SE1/4

Decimal Degrees NAD83
Latitude: 47.558045 Longitude: -120.672277

Road Log:
Proceed west of Leavenworth on State Highway 2. Turn south on Icicle Road for 2.2 miles to the Leavenworth NFH and turn left at Fish Hatchery Road. Drive 0.3 mi to the building on the left near the spillway. The fish ladder is just south of the road near Icicle Creek.
6. **SUMMARY OF GAGE SYSTEM:**
Discharge is measured with a 3' concrete Parshall Flume. Water level is recorded with an ultrasonic open channel flow meter FM8000 by Flomotion Systems. The stilling well sensor is Model NO FM8000, Serial No CS50SB17J009 and the flume installed sensor is Model No FM8000, Serial No CS50SB17J003. Measurement equipment is housed in a wooden shelter mounted on the flumes stilling well. Data is transferred to the SCADA system and recorded in a file created each month. Flomotion equipment communicates with SCADA PLC installed at location and communicates via WiFi to main PLC?
7. **DESCRIPTION OF RECORDING SYSTEM:**
Equipped with Flomotion Systems ultrasonic water level sensor. Data is communicated to the SCADA system and recorded in a log file.
8. **REFERENCE GAGE:**
Green paint mark located on the wall at the flume's measuring point.
9. **REFERENCE MARKS:**
The reference mark is a brass cap located in the SW corner of the concrete slab of the Hatchery's adult holding ponds.
10. **DATA COLLECTION:**

Data is collected and stored at the Hatchery SCADA system. Data is downloaded periodically and brought to FWS Regional Office Water Resources Branch to be stored in WISKI.

11. ESTABLISHMENT:

The gaging system was established by the personnel in the Water Resources Branch in the Division of Engineering on 4/30/1994

12. HISTORY:

Established: 4/30/1994; Installed Stevens datalogger and pressure transducer.
TSI installed the Siemens Ultrasonic water level sensor.

December 2017 Two Flomotion Systems Ultrasonic water level sensors installed

13. FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

Clean algae from parshall flume
fix disconnect from downstream water level measurement pipe

14. DESCRIPTION OF CHANNEL:

The channel is a 3' Parshall Flume with concrete bottom and sides. The flume is at the end of a fish ladder. At high flows in Icicle Creek the flume is submerged and flow calculations are not accurate.

15. DESCRIPTION OF CONTROL:

Flume crest at 0.0 ft gage datum.

16. WINTER FLOW:

Ice may form in winter.

17. LOCATION AND TYPE OF DIVERSIONS:

18. LOCATION AND TYPES OF REGULATIONS:

19. LAND STATUS:

Land owned by FWS

21. COOPERATING AGENCIES:

None

22. USGS TOPO MAP:

Blewett, WA, Leavenworth, WA, 7-5' Quadrangle

PREPARED BY: James King July 25, 2008

UPDATED BY: Mary Lindenberg 03/02/2017

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION**

REFUGE/HATCHERY NAME:

Leavenworth NFH

SITE NAME:

Leavenworth NFH Discharge at Abatement Ponds (Outfall 2)

SITE NUMBER:

322502

PURPOSE OF GAGE:

To monitor flow out of the Pollution Abatement Ponds in accordance with EPA's Clean Water Act, National Pollution Discharge Elimination System (Permit WA0001902).

DESCRIPTIVE LOCATION OF SITE:

Site is located at the north end of the Leavenworth NFH and is composed of two separate abatement ponds each with their own monitoring equipment. Sites are located in a locked fenced-in enclosure. Keys are available from Leavenworth NFH staff.

Decimal Degrees Datum NAD83

Latitude: 47.559798 Longitude: -120.672298

SUMMARY OF GAGE SYSTEM:

Discharge at both ponds are measured by recording water level on a 15 minute logging interval in relation to a 90 degree v-notch weir. Stage discharge monitoring equipment is located in a small wooden box gage house on top of a plastic pipe stilling well located on the discharge sides of each pond.

DESCRIPTION OF RECORDING SYSTEM:

The new pollution abatement pond, located furthest away from Icicle Creek (PAP 1), includes a Sutron 9210 datalogger SN 1110102, model # 9210-0000-2B and a shaft encoder SN#1011887 and model#86 0540 400 DTR with an 18in circumference beaded wire pulley. Telemetry equipment includes a Raveon Radio Modem (Model# RV-M7-UA, SN 163514107884), a Polyphasor Lightning Arrestor (ISB50LN-C2), and a YAGI LAIRD Gold antenna 430-450 MHz (SN 09231613)

The older pollution abatement pond, located nearest Icicle Creek (PAP 2), also uses a Sutron 9210 datalogger SN 1110311, model # 9210-0000-2B and a shaft encoder SN#1011891 , and model#86 0540 400 DTR with an 18in circumference beaded wire pulley. Telemetry equipment includes a Raveon Radio Modem (Model# RV-M7-UA, SN 163514108000), a Polyphasor Lightning Arrestor (ISB50LN-C2), and a YAGI LAIRD Gold antenna 430-450 MHz (SN 09231613)

Both sites are powered by a 12v 34Ah battery, which is powered by Mini DC-UPS Phoenix Contact, which is plugged into 120v outlet power supply.

REFERENCE GAGE:

PAP1 uses a reference gage etched onto the v-notch weir (0 – 1.5'). In order to improve measurement accuracy changes to the gage height should be made during low flows.

PAP2 uses a reference gage etched onto the v-notch weir (0 – 1.5'). In order to improve measurement accuracy changes to the gage height should be made during low flows.

REFERENCE MARKS:

None. V-notch weir is removed periodically and the staff marking on the weir changes when the weir is moved. The recorded value is reset when the v-notch is replaced.

DATA COLLECTION:

Data is telemetered to the hatchery SCADA system and recorded.

ESTABLISHMENT:

V-notch weir installed in new Pollution Abatement Pond (PAP1) and logging began in the new pollution abatement pond during 7/2011.

HISTORY:

2011	90 degree V-notch weir installed along with stilling well and Stevens monitoring equipment in the new PAP. Still well and Stevens monitoring equipment install in the old PAP. Stevens AXSYS Datalogger S/N 162680K Stevens A/F Stand Alone Encoder S/N 153382-95D
Feb 2012	Installed new Sutron SDR dataloggers for the float/pulley systems in both Pollution Abatement ponds.
	- Sutron SDR SN (1107173) in PAP 1 (newer PAP) - Sutron SDR SN (1107182) in PAP 2 (older PAP)
May 2012	90 degree V-notch weir installed in old PAP pond.
Sept 2016	SDR replaced with Sutron 9210 and Shaft Encoders
Oct 2016	Antenna and radio modem installed at both measurement locations. New Sutron firmware V3.19.0.10
Jun 2017	Solar panel upgraded to 20 watts to account for additional power drainage from the radio.
Oct 2018	Mini DC-UPS installed for power supply.

FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

Reset gage after every cleaning of abatement pond or when the v-notch weir and boards are moved.
If required clean v-notch and check for leaks around boards during visit

DESCRIPTION OF CHANNEL:

Gravel and concrete pond.

DESCRIPTION OF CONTROL (FLUME, WEIR, ETC.)

90 degree aluminum 18 inch v-notch weir made by Rickly. Frame was built by Leavenworth NFH staff.

WINTER FLOW:

The ponds may freeze during the winter but free flow near the weir is still possible. The stilling wells may also freeze.

LOCATION AND TYPE OF DIVERSIONS:

N/A

LOCATION AND TYPES OF REGULATION:

N/A

LAND STATUS:

Land owned by USFWS

COOPERATING AGENCIES:

None

USGS TOPO MAP:

Leavenworth, WA

PREPARED BY: K.Kannarr

DATE: 7/2011

UPDATED BY: M Lindenberg

DATE: 10/2018

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION**

REFUGE/HATCHERY NAME:

Leavenworth NFH

SITE NAME:

Snow Creek Mouth at Icicle Creek

SITE NUMBER:

322503

PURPOSE OF GAGE:

To monitor flow from the Upper Snow Lakes basin and monitor flow just downstream of diversion point for the Icicle and Peshastin Irrigation District. The difference between measurements at this site and measurements at Snow Creek Diversion (322504 – currently no measurement by FWS) represent the amount of water removed from Snow Creek by the irrigation district. Under contract No. Ilr-1383 we are required to monitor surface water diversions from Snow Creek.

DESCRIPTIVE LOCATION OF SITE:

UTM Zone 10 N

Northing: 5267888 Easting: 672148

Decimal Degrees Datum NAD83

Latitude: 47.541954 Longitude: -120.711796

Located just below the diversion point for Icicle and Peshastin Irrigation District on Snow Creek. The concrete weir is located approximately 1000 ft south of Snow Creek's confluence with Icicle Creek.

Road Log:

Proceed west of Leavenworth on State Highway 2. Turn south on Icicle Road and follow the road to the Snow Lakes trailhead. Hike the Snow Lakes trail a few hundred yards until you cross an irrigation canal. After crossing the canal hike west 300 ft until you reach Snow Creek and the cement weir. Datalogger is in a galvanized steel shelter. Shelter locked with brass combo lock (**Combination: 0190**).

SUMMARY OF GAGE SYSTEM:

Discharge is measured at a cement combination weir. The weir is a combination of a v-notch weir for low flows and a broad crested weir for large flows. Head is measured by a float-pulley shaft encoder system hooked up to a Sutron SDR datalogger (SN 1206494).

DESCRIPTION OF RECORDING SYSTEM:

Sutron Stage Discharge Recorder(SDR) (SN#1206494) set to a 15min recording interval. SDR, charge controller and battery are housed in a small metal instrument shelter above a small diameter stilling well. Recorder is powered by a 12v 8.5 amp hr. battery (9/2011) and solar panel that is mounted to a tree upstream of the gage.

REFERENCE GAGE:

Outside staff gage is located on concrete stem well just below the instrument shelter. Staff gage reading of 0.00 is 0.10 ft above the main weir crest.

REFERENCE MARKS:

RP 1: Top upstream bolt head on outside staff plate.

Elevation relative to Gage Datum: 3.273

RP 2: Converted from RM3: Bolt head inside stilling well shelter. Colored black with sharpie.
Elevation relative to Gage Datum: 5.475

RM 4: Lagbolt 5-6 inches out of concrete on north side of IPID Snow Creek conveyance, 10 feet downstream of stepladder.
Elevation relative to Gage Datum: 8.149

RM 5: Bolt holding IPID bridge bracket on west side of ditch and north side of bridge and I-beam
Elevation relative to Gage Datum: 5.538

RM 6: chiseled Square in corner of concrete ~ 6 feet south of stilling well.
Elevation relative to Gage Datum: 4.919

RM 1: Discontinued: Lagbolt head in tree trunk west side of creek. Second tree south of control structure
Elevation relative to Gage Datum: 5.431

RM 2: Discontinued: Lagbolt head in tree trunk west side of creek. First tree south of control structure.
Elevation relative to Gage Datum: 5.446

DATA COLLECTION:

Prior to 2003 data were collected once a year. In the summer of each year (usually June or July) the refuge turns on the Snow Lake Outlet to supplement flow in Icicle Creek with cool, clean water. At this time the datalogger at the Snow Creek mouth is setup for the season. In the fall (usually September or October) hatchery staff return to the outlet drain to turn it off. During this time the datalogger was downloaded and the station is decommissioned for the winter. Currently the monitoring equipment is run all year and downloaded during site visits.

ESTABLISHMENT:

The Stevens AXSYS datalogger was installed in July 1997.

HISTORY:

1940's	Snow Lake tunnel and outlet drain constructed
1993	R.W. Beck and Associates develop rating curve for combination weir
1997	Steven's datalogger installed. Begin twice annual visits to site by Water Resources Branch staff.
2003	Datalogger left in place over winter.
Nov. 2004	Battery is dead and removed for winter of 2004/05.
Mar. 2005	Battery replaced and station setup for year.
Oct 2006	New battery installed
Nov. 2006	Large flood in Snow Creek. Measurements shifted from rating afterwards
Aug 2006	Rehab to IPID flume on Snow Creek.
June 2009	New battery installed.
Jan 2011	Stilling well pipes opened and cleaned out.
Sept 2011	New battery installed.
May 2012	New Sutron SDR datalogger installed (05/14/2012)
Feb 2013	New Sutron SDR datalogger installed replacing previous Sutron SDR
Oct 2015	Levels run, RM4, 5, 6 established

FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

Run levels. Levels due.
Obtain more low flow and high flow measurements.

Flush intake
Remove rocks in front of weir

DESCRIPTION OF CHANNEL:

Channel has been filled in by boulders moved downstream from high flows and debris flows. It was determined during the 3/28/18 site visit beavers have dammed a portion of the pond above the station and is creating a side channel. The side channel flows into Snow Creek on the left bank approximately 20 ft above the weir. This is a big concern because the side channel is causing the bank to erode and the concrete wall to disintegrate.

DESCRIPTION OF CONTROL:

Control is the cement broad crested weir spanning the Snow Creek channel.

WINTER FLOW:

Flow continues through the winter. Stilling subject to icing during winter months.

LOCATION AND TYPE OF DIVERSIONS:

A wood flume operated by the Icicle and Peshastin Irrigation district is immediately upstream of this site. The water resources branch historically operated a monitoring station on this flume (Site No. 322504).

LOCATION AND TYPES OF REGULATIONS:

None

LAND STATUS:

Land owned by FWS

COOPERATING AGENCIES:

None

USGS TOPO MAP:

Blewett, WA

<i>PREPARED BY:</i>	Ron Thomasson	1994
<i>UPDATED BY:</i>	Joanne Wallis	Feb 2018

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION**

*****Note: A USGS top set wading rod and a rope marked every 0.5ft is located at 322506*****

1. REFUGE/HATCHERY NAME:

Leavenworth NFH

2. SITE NAME:

Snow Creek at Nada Lake Outlet

3. SITE NUMBER:

322505

4. PURPOSE OF GAGE:

To monitor flow out of Nada Lake. Water released from the Snow Lake Outlet flows into Nada Lake before entering Snow Creek. The Service is required to monitor our contribution to Icicle Creek from Snow Lake under a contract with the Icicle and Peshastin Irrigation District (No. Ilr-1383). To help determine the volume of water released from Snow Lake we need to monitor outflows from Nada Lake.

5. DESCRIPTIVE LOCATION OF SITE:

UTM Zone 10 N Northing: 5262959 Easting: 670724

Modified Parshall flume downstream of small dam at Nada Lake's outlet.

Road Log:

Proceed west of Leavenworth on State Highway 2. Turn south on Icicle Road and follow the road to the Snow Lakes trailhead. Hike the Snow Lakes trail until you reach the first campground at the outlet of Nada Lake. Cross the dam and hike 150 ft downstream to the flume. The hike is strenuous and will take approximately 4.0 hours up and 3.0 hours down. Alternatively, the hatchery may be willing to hire a helicopter for the day to make a trip up to Snow Lakes.

6. SUMMARY OF GAGE SYSTEM:

Discharge is measured by a modified Parshall flume. The flume is not built to the exact Parshall specifications.

7. DESCRIPTION OF RECORDING SYSTEM:

Sutron SDR datalogger (SN 1107176) set to a one-hour logging interval. SDR is equipped with an 18-inch circumference pulley and beaded cable. A new 12V high amp hour battery was installed (10/2012) and re-wired to the current solar panel and Sun Saver 6 charge controller.

8. REFERENCE GAGE:

The reference gage is a staff gage mounted in the cement wall of the Parshall Flume. There is no inside staff gage. A measurement from the right side lip of the stilling well may be taken as an inside staff gage measurement. This point has yet to be surveyed in and should only be considered approximately 0.015ft lower than RM3.

9. REFERENCE MARKS:

RM 1: Top of angle iron on LEW on downstream end of flume throat. Rod set on angle iron corner closest to staff gage.

Elevation relative to gage datum: 3.980 ft

RM 2: Top of angle iron on REW, downstream end of flume throat. Rod set on angle iron corner closest to gage house.

Elevation relative to gage datum: 3.999 ft

RM 3: Top of bolt head inside gage house, colored black with sharpie marker

Elevation: 5.352 ft

10. DATA COLLECTION:

Pre-2003 the site was visited twice a year and data is collected once a year. In the summer of each year (usually June or July) the hatchery turns on the Snow Lake Outlet to supplement flow in Icicle Creek with cool, clean water. At this time the datalogger at Nada Lake is setup for the season. In the fall (usually September or October) hatchery staff return to the outlet drain to turn it off, the datalogger is downloaded, and the site is decommissioned for the winter.

11. ESTABLISHMENT:

Flume was constructed at an unknown date. The Stevens AXSYS datalogger (SN 160518-98H) was installed in July 1998.

12. HISTORY:

1940's Snow Lake tunnel and outlet drain constructed

1992-3 New stilling well and staff gage installed. Jack Bjork (project engineer) develops modified Parshall flume rating for site, based on one measurement.

2004 Rating Curve RC1.2 was developed based on flow measurements collected during the last six years.

2005 New deep-cycle sealed lead acid battery installed at site. Rating 1.1 developed emphasizing measurements from the last three years. The rating was used to estimate flow for last six years.

2006 New deep-cycle battery installed. Stevens data removed and High Sierra telemetry system installed for test of early warning capabilities. Establish RC1.4 as preferred curve for the site.

2011 Stevens Datalogger and Encoder installed along with a new 12v 8Ah battery; large moss build-up removed from entire flume.

2012 Sutron SDR installed to replace Stevens system (6/27/2012). New battery installed (10/2/2012) to provide better winter power supply.

2013, 2014, 2015 Battery replaced every year.

2016 Survey Levels run, battery replaced in June.

13. FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

Continue flow measurements for both high and low flow.

14. DESCRIPTION OF CHANNEL:

Upstream of the flume the channel is through exposed bedrock. Water leaks through or flows over Nada Lake outlet structure to maintain flow all year. Velocities upstream of flume are very low prior to opening Snow Lake Valve. The Nada Lake Outlet structure was replaced (before 2011) and currently there are no additional restrictions to flow in place at the structure.

15. DESCRIPTION OF CONTROL:

Control is a concrete flume built across the entire length of the channel. Moss growth is a problem

at the site, and accumulates over time and should be cleaned regularly.

16. WINTER FLOW:

Flow continues through the winter months via leakage from Nada Lake Dam. Stilling well may freeze in winter.

17. LOCATION AND TYPE OF DIVERSIONS:

Gage is located immediately downstream of Nada Lake Dam.

18. LOCATION AND TYPES OF REGULATIONS:

N/A

19. LAND STATUS:

FWS owned

21. COOPERATING AGENCIES:

None

22. USGS TOPO MAP:

Blewett, WA

PREPARED BY: R. Thomasson

DATE: 1994

UPDATED BY: M. Lindenberg

DATE: 2016

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION**

1. REFUGE/HATCHERY NAME:

Leavenworth NFH

2. SITE NAME:

Snow Lake Outlet at Snow Lake Tunnel

3. SITE NUMBER:

322506

4. PURPOSE OF GAGE:

To monitor flow from Upper Snow Lake drain. Water is added to Icicle Creek through the Snow Creek Basin. Under a contract with the Icicle and Peshastin Irrigation District (No. Ilr-1383) we are required to monitor Snow Lake contributions to Snow Creek.

5. DESCRIPTIVE LOCATION OF SITE:

UTM Zone 10 N Northing: 5261851 Easting: 669686

Located inside Snow Lake Tunnel at the Snow Lake outlet drain. Need code 0190 to access tunnel through gate. Pressure transducer is mounted in a standpipe inside the tunnel above the main outlet valve.

Road Log:

Proceed west of Leavenworth on State Highway 2. Turn south on Icicle Road and follow the road to the Snow Lakes trailhead. Hike the Snow Lakes trail past Nada Lake until you start to ascend a steep set of switchbacks. About half way up these switchbacks look for a faint trail leading towards the base of a cliff above Nada Lake. Follow this trail to the base of the cliff and the outlet drain shelter. It is a strenuous climb of approximately 3.5 hrs. to the shelter. Alternatively, hope that the hatchery is willing to hire a helicopter for the day to make a trip up there.

Mileage:

Travel 292 to miles to the Snow Lakes Trailhead just east of Leavenworth, WA on Icicle Road. Hike up the Snow Lakes Trail for 6 miles (3700 ft elevation gain) to the Snow Lakes Outlet Tunnel. Hike up another 0.5 miles to the Upper and Lower Snow Lakes dam.

6. SUMMARY OF GAGE SYSTEM:

Pressure transducer screws into a 2-inch standpipe that is connected to the main outlet pipeline. A 100 PSI gage (+/- ~ 2 PSI) is also mounted to the standpipe. This serves as a reference gage for the pressure transducer. Because the datalogger records in feet, the PSI gage reading must be converted (Head = PSI x 2.307).

7. DESCRIPTION OF RECORDING SYSTEM:

Sutron 9210 (SN 1110343) set to 4-hr. recording interval coupled to an Instrumentation Northwest PS9800 Pressure Transmitter (SN. 92006). Pressure Transducer has 0 – 100 PSIG range, and outputs in 4-20 mA. Recorder is powered by a 12V Stevens gel cell battery and Solar Panel. The outer valve that controls water flow from the pipe has a very rough scale that indicates the amount in degrees that it is open. Use a pocket tape to obtain a better approximation of degrees open, the calculations for an exact opening are stored with camping supplies at 322506.

8. REFERENCE GAGE:

The reference gage is a 100 psi pressure gage mounted on the standpipe with the pressure

transducer. PSI displayed on the pressure gage are multiplied by 2.307 to convert the pressure to feet.

The pressure transducer valve elevation is approximately 4796 ft above sea level based on R.W. Beck and Associate's report. This elevation was calculated by Jack Bjork using the Snow Lakes storage curve which shows the elevation of the Snow Lake dam at 4983 ft (187 feet (81.06 PSI) above pressure gage).

The pressure gage sits about 11.3 ft above the centerline of the outlet pipe.

9. REFERENCE MARKS:

N/A

10. DATA COLLECTION:

Data is collected one to two times per year. In the summer of each year (usually July) the refuge turns on the Snow Lake Outlet to supplement flow in Icicle Creek. Prior to the hatchery opening the outlet, WRB visits the site to ensure the logger is working properly. In the fall (usually early October) hatchery staff return to the outlet drain to turn it off. Either during or shortly after the fall visit, the datalogger is visited again to download data and change the collection interval to 4 hours for the winter.

11. ESTABLISHMENT:

The Stevens AXSYS datalogger (SN 160515-98H) was installed in July 1998 with Instrumentation Northwest transducer (SN 52008). At some point the transducer was changed. A new Stevens AXSYS datalogger was installed in July 2004. A Sutron Monitor datalogger was installed in July 2010 replacing the Steven AXSYS datalogger.

12. HISTORY:

1940's	Snow Lake tunnel and outlet drain constructed
1993	R.W. Beck and Associates develop rating curve for 28.25 in tube valve
1998	Steven's datalogger and pressure transducer installed. Begin twice annual visits to site by Water Resources Branch staff.
1999	New Instrumentation Northwest Pressure Transducer installed
2001	New 20.00 inch butterfly valve installed on outlet.
2003	Datalogger and pressure transducer left in place over winter. Stevens datalogger breaks after this.
2004	New Stevens datalogger installed. In Fall pressure transducer removed and sent to manufacturer for calibration.
2005	More frequent visits to site. New 12 v / 18 amp battery installed in fall
2009	Pressure transducer, datalogger, and battery removed in October 2009. Wires from PT to logger corroded. Could not repair in field. Sent in pressure transducer to Instrumentation Northwest for calibration check.
2010	Installed checked pressure transducer (Instrumentation Northwest) and new Sutron Monitor datalogger.
2018	Replaced a Monitor 4 with a second Monitor 1 datalogger

2019	Replaced Monitor 1 with a Sutron 9210; pressure transducer sent in for calibration check
2021	Replaced solar panel

13. FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

Replace desiccant tube and connection or at least the connection
Extra wire is needed to mount the data logger enclosure to the wood railing

14. DESCRIPTION OF CHANNEL:

N/A

15. DESCRIPTION OF CONTROL:

Flow through the drain is controlled by the 20 inch butterfly outlet valve.

16. WINTER FLOW:

Flow through this pipeline is only when the hatchery opens the outlet. Typically between June and October.

17. LOCATION AND TYPE OF DIVERSIONS:

None

18. LOCATION AND TYPES OF REGULATIONS:

This pipeline is a drain installed on Upper Snow Lake. The lake fills each winter. When this drain is opened the water level in the lake drops accordingly.

19. LAND STATUS:

Land owned by FWS

21. COOPERATING AGENCIES:

None

22. USGS TOPO MAP:

Blewett, WA

PREPARED BY: Ron Thomasson

DATE: 1994

UPDATED BY: M. Lindenberg 8/2021

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION**

1. REFUGE/HATCHERY NAME:

Leavenworth NFH

2. SITE NAME:

Snow Creek at Inlet to Snow Lake

3. SITE NUMBER:

322507

4. PURPOSE OF GAGE:

To monitor flow into Upper Snow Lake. Under a contract with Icicle and Peshastin Irrigation District (No. Ilr-1383) the Service is required to monitor inflows to Snow Lake while USFWS diverts water from Snow Lake.

5. DESCRIPTIVE LOCATION OF SITE:

UTM Zone 10 N Northing: 5260878 Easting: 668432

Broad-crested weir built on Snow Creek, upstream of bridge crossing the creek at its mouth on Snow Lake.

Road Log:

Proceed west of Leavenworth on State Highway 2. Turn south on Icicle Road and follow the road to the Snow Lakes trailhead. Hike the Snow Lakes trail until you reach where Snow Creek enters Snow Lake. Cross a log bridge on Snow Creek and follow footpath approximately 100 ft upstream to the weir. It is a strenuous climb up to the inlet to Snow Lake that will take approximately 4+ hrs.

Mileage:

The hike to Snow Creek Inlet at Snow Lake is approximately 7.5 miles one way.

6. SUMMARY OF GAGE SYSTEM:

Discharge is measured by recording water levels hourly. A stage-discharge relationship has been developed to relate water levels to discharge. Weir acts as broad-crested weir at low flows and sharp-crested weir at higher flow.

7. DESCRIPTION OF RECORDING SYSTEM:

Sutron SDR (SN 1107180) with encoder with a pulley-float system. Recorder is powered by a 12V gel cell battery and Solar Panel.

8. REFERENCE GAGE:

The reference gage is the stilling well shelter floor adjacent to RM1. The original outside staff gage was bent during the flood of 11/6/06. All reference marks are set to the original gage datum of this outside staff gage.

9. REFERENCE MARKS:

RM 1: Top of bolt on interior of stilling well shelter. Bolt is colored black and located on the right side of the stilling well shelter. Elevation: 5.076 ft gage datum

RM2: Point on rock in middle of trail. Exactly 14.7 ft behind gage house. Elevation: 5.591 ft gage datum

RM3: Lag bolt in base of tree with solar panel in it.	Elevation: 4.266 ft gage datum
RM4: Lag bolt in base of tree about 20 ft upstream of tree with RM3. One of 2 living trees growing immediately adjacent to each other.	Elevation: 7.196 ft gage datum
Top of old staff gage (no longer valid)	Elevation: 2.922 ft gage datum
RP1: Lower bolt on large boulder near weir	Elevation: 0.817 ft gage datum
RP2: Upper bolt on large boulder near weir	Elevation: 2.243 ft gage datum
RP3: Rebar (closest to stream) upstream of gabion in front of stilling well	Elevation: 1.479 ft gage datum
RP4: Rebar (furthest from stream) upstream of gabion in front of stilling well	Elevation: 1.479 ft gage datum
RP5: Bolt on rock wall across stream from stilling well; 6 feet upstream of weir	Elevation: 1.232 ft gage datum

10. DATA COLLECTION:

The site is typically visited at least twice a year: Once prior to snowmelt runoff and again in the fall, after Upper Snow Lake has been turned off. To facilitate data collection through the winter months, the logging interval is switched to 4 hour intervals.

11. ESTABLISHMENT:

Weir was constructed in 1993.

12. HISTORY:

1940's	Snow Lake tunnel and outlet drain constructed
1993	Broad-crested weir installed. R.W. Beck and associates develop theoretical rating
1998	Stevens AXSYS Datalogger (SN 160518-98H) installed.
2005	New rating curve developed based on flow measurements collected during the last 6 years.
	New marine deep-cycle battery installed.
Nov. 2006	Large flood event bent outside gage and tilted stilling well. Rating shifted after this event.
2012	Sutron SDR Datalogger installed to replace the Stevens AXSYS Datalogger
2016	New battery installed; levels survey and 5 instream reference points installed.

13. FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

Continue making flow measurements
Patch seep around gabion at stilling well – probably not going to happen
High flow measurements

14. DESCRIPTION OF CHANNEL:

Step-pool, cobble-bed mountain stream. Steep gradient. Water is very clear and cold. Measurements take place near the upstream end of the stilling pool. Lots of turbulent flow in channel at cross section, including eddies.

15. DESCRIPTION OF CONTROL:

Control is an 8-inch concrete weir built across the channel. Weir crest sits about 1 ft above the channel bed although less on the edges. Debris occasionally gets stuck on the weir crest.

16. WINTER FLOW:

Flow continues through the winter months. Snow and ice make visiting the site unreasonable and unsafe. Stilling well is subject to freezing during this time.

17. LOCATION AND TYPE OF DIVERSIONS:

None

18. LOCATION AND TYPES OF REGULATIONS:

N/A

19. LAND STATUS:

Land owned by FWS

21. COOPERATING AGENCIES:

None

22. USGS TOPO MAP:

Blewett, WA

PREPARED BY: Ron Thomasson

DATE: 1994

UPDATED BY: M Lindenberg 7/2016

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION**

1. REFUGE/HATCHERY NAME:

Leavenworth NFH

2. SITE NAME:

Production Well No. 1 at Leavenworth NFH

3. SITE NUMBER:

322508

4. PURPOSE OF GAGE:

The purpose is to monitor discharge, water level, and temperature at Well No. 1 at the Leavenworth NFH. Monitoring at this location is required by EPA's Clean Water Act, National Pollution Discharge Elimination System (Permit WA0001902)). Water use at Well No. 1 is reported under water right No. 3103-A. Additionally, water levels at the well have been recorded in the past for use in hydrogeologic analyses at the hatchery.

5. DESCRIPTIVE LOCATION OF SITE:

UTM Zone 10 N

Latitude: 47.556954

Longitude -120.674615

Well and pump are located in Well house west of the Hatchery Channel of Icicle Creek on Leavenworth NFH property.

Road Log:

Proceed west of Leavenworth on State Highway 2. Turn south on Icicle Road for 2.2 miles to the Leavenworth NFH and turn left at Fish Hatchery Road.

6. SUMMARY OF GAGE SYSTEM:

Pumping rate is measured by Siemens brand mag meter 5100W series (serial number:). The temperature and water level is measured with a KPSI brand pressure transducer (model number: 700s17aoa025, serial number: 1004001).

7. DESCRIPTION OF RECORDING SYSTEM:

The well discharge, water level, and temperature are recorded every 15 minutes into a file at the alarm computer at the Leavenworth NFH break room. All the production wells and the Fish Ladder Outfall 1 data are recorded in the same file. A new file is created every month. Water levels at the well are taken approximately weekly using an electric tape and measuring from the top of the 12" casing. Static water level measurements are recorded at least 12 hours after pumping has ceased. Data is entered in logbooks provided by the Water Resources Branch. Additionally, the hatchery records water levels into a spreadsheet (WellStatus.wk3.wkb). The spreadsheet is sent to Water Resources Branch staff annually to complete water reporting requirements for the State of Washington.

8. REFERENCE GAGE:

Measuring point for water level measurements is the top of the 12" well casing. Water level transducer measurement point is 57 (1085.09 ft) feet deep. Maximum pumping level is 51 feet (1091.84 ft) and pump is 61 feet deep. Elevation of the m.p. is 1142.84 ft MSL (datum?).

9. REFERENCE MARKS: N/A

10. DATA COLLECTION:

Files with 15 minute water level, temperature, and discharge data are collected every two months to quarterly depending on whether there is a technician dedicated to the hydrology work. The files are sent to the Water Resources Branch in the Regional Office to be stored in the WISKI database.

11. ESTABLISHMENT:

12. HISTORY:

Pre- 1994	Prior to 1994 water level measurements made with manometer.
1994	May – Levels run
Post-1995	Measurements made with electric tape.
1998	In-line meter installed on pipeline common to Wells 1, 2, 3, and 7
8/2010	Siemens brand magnetic meter installed for Well No. 1 only

13. FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

Use Panametrics meter to confirm flow rate from pump
QA temperature checks

14. DESCRIPTION OF WELL:

12" casing. 77.5' deep. (See well log in blue folder).

15. DESCRIPTION OF CONTROL:

N/A

16. WINTER FLOW:

Hatchery uses water from this well intermittently year-round.

17. LOCATION AND TYPE OF DIVERSIONS:

Well is equipped with line shaft turbine pump with variable frequency speed to adjust lower speeds in the case of lower water levels.

18. LOCATION AND TYPES OF REGULATIONS:

Pump is controlled by a SCADA system operated at the LNF Hatchery computer or at pump house.

19. LAND STATUS:

Land owned by FWS

21. COOPERATING AGENCIES:

None

22. USGS TOPO MAP:

Leavenworth, WA

PREPARED BY: Paul Rauch

DATE: 1994

UPDATED BY: M Lindenberg May 2012

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION**

1. REFUGE/HATCHERY NAME:

Leavenworth NFH

2. SITE NAME:

Production Well No. 2 at Leavenworth NFH

3. SITE NUMBER:

322517

4. PURPOSE OF GAGE:

The purpose is to monitor discharge, water level, and temperature at Well No. 2 at the Leavenworth NFH. Monitoring at this location is required by EPA's Clean Water Act, National Pollution Discharge Elimination System (Permit WA0001902)). Water use at Well No. 2 is reported under water right Claim No. 012009. Additionally, water levels at the well have been recorded in the past for use in hydrogeologic analyses at the hatchery.

5. DESCRIPTIVE LOCATION OF SITE:

UTM Zone 10 N

Latitude: 47.5526

Longitude -120.6758

Well and pump are located in Well house west of the Hatchery Channel of Icicle Creek on Leavenworth NFH property.

Road Log:

Proceed west of Leavenworth on State Highway 2. Turn south on Icicle Road for 2.2 miles to the Leavenworth NFH and turn left at Fish Hatchery Road.

6. SUMMARY OF GAGE SYSTEM:

Pumping rate is measured by a Siemens 5100w series Magnetic Flowmeter. Water level and temperature are measured by a KPSI Transducer model #700s17aoa025; serial #0900858. The meter flow rate, totalizer, water level and temperature readings are recorded approximately weekly by Leavenworth NFH staff. Static water level measurements are recorded at least 12 hours after pumping has ceased.

7. DESCRIPTION OF RECORDING SYSTEM:

The well discharge, water level, and temperature are recorded every 15 minutes into a file at the alarm computer at the Leavenworth NFH break room. All the production wells and the Fish Ladder Outfall 1 data are recorded in the same file. A new file is created every month. Water levels at the well are taken approximately weekly using an electric tape and measuring from the top of the 12" casing. Static water level measurements are recorded at least 12 hours after pumping has ceased. Data is entered in logbooks provided by the Water Resources Branch. Additionally, the hatchery records water levels into a spreadsheet (WellStatus.wk3.wkb). The spreadsheet is sent to Water Resources Branch staff annually to complete water reporting requirements for the State of Washington.

8. REFERENCE GAGE:

Measuring point for water level measurements is the top of the well casing. Water level transducer measurement point is 76.5 (1068.12 ft) feet deep. Maximum pumping level is 67 feet (1074.12 ft) and pump is 77 feet deep). Elevation of the m.p. is 1141.12 ft MSL (datum?).

9. REFERENCE MARKS:

N/A

10. DATA COLLECTION:

Files with 15 minute water level, temperature, and discharge data are collected every two months to quarterly depending on whether there is a technician dedicated to the hydrology work. The files are sent to the Water Resources Branch in the Regional Office to be stored in the WISKI database.

11. ESTABLISHMENT: na

12. HISTORY:

Pre- 1994	Prior to 1994 water level measurements made with manometer.
1994	May – Levels run
Post-1995	Water level measurements made with electric tape.
1998	In-line meter installed on pipeline common to Wells 1, 2, 3, and 7. In-line meter installed on Well 2.
2010	KPSI 700 series transducer and Siemens 5100w magnetic flowmeter installed 8/2010.

13. FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

Use Panametrics meter to confirm flow rate from pump
QA temperature checks

14. DESCRIPTION OF WELL:

12" casing. 94.4' deep. (See well log in blue folder).

15. DESCRIPTION OF CONTROL:

N/A

16. WINTER FLOW:

Hatchery uses water from this well intermittently year-round.

17. LOCATION AND TYPE OF DIVERSIONS:

Well is equipped with line shaft turbine pump with variable frequency speed to adjust lower speeds in the case of lower water levels.

18. LOCATION AND TYPES OF REGULATIONS:

Pump is controlled by a SCADA system operated at the LNF Hatchery computer or at pump house.

19. LAND STATUS:

Land owned by USFWS

21. COOPERATING AGENCIES:

None

22. USGS TOPO MAP:

Leavenworth, WA

PREPARED BY: Paul Rauch

DATE: 1994

UPDATED BY: K. Kannarr January 2011

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION**

1. REFUGE/HATCHERY NAME:

Leavenworth NFH

2. SITE NAME:

Production Well No. 3 at Leavenworth NFH

3. SITE NUMBER:

322510

4. PURPOSE OF GAGE:

The purpose is to monitor discharge, water level, and temperature at Well No. 3 at the Leavenworth NFH. Monitoring at this location is required by EPA's Clean Water Act, National Pollution Discharge Elimination System (Permit WA0001902)). Water use at Well 3 is reported under water right Claim No. 012008. Additionally, water levels at the well have been recorded in the past for use in hydrogeologic analyses at the hatchery.

5. DESCRIPTIVE LOCATION OF SITE:

UTM Zone 10 N

Latitude: 47.5517

Longitude -120.6773

Well and pump are located in Well house west of the Hatchery Channel of Icicle Creek on Leavenworth NFH property.

Road Log:

Proceed west of Leavenworth on State Highway 2. Turn south on Icicle Road for 2.2 miles to the Leavenworth NFH and turn left at Fish Hatchery Road.

6. SUMMARY OF GAGE SYSTEM:

Pumping rate is measured by Siemens brand mag meter 5100W series (serial number:). The temperature and water level is measured with a KPSI brand pressure transducer (model number: 700s17aoa025, serial number: 0811395).

7. DESCRIPTION OF RECORDING SYSTEM:

The well discharge, water level, and temperature are recorded every 15 minutes into a file at the alarm computer at the Leavenworth NFH break room. All the production wells and the Fish Ladder Outfall 1 data are recorded in the same file. A new file is created every month. Water levels at the well are taken approximately weekly using an electric tape and measuring from the top of the 12" casing. Static water level measurements are recorded at least 12 hours after pumping has ceased. Data is entered in logbooks provided by the Water Resources Branch. Additionally, the hatchery records water levels into a spreadsheet (WellStatus.wk3.wkb). The spreadsheet is sent to Water Resources Branch staff annually to complete water reporting requirements for the State of Washington.

8. REFERENCE GAGE:

Measuring point for water level measurements is near the top of the well casing on the lower lip of a 2" side pipe. Water level transducer measurement point is 77.83 (1074.11 ft) feet deep. Maximum pumping level is 65 feet (1080.94 ft) and pump is 75 feet deep. Elevation of the m.p. is 1145.94 ft MSL (datum?).

9. REFERENCE MARKS:

N/A

10. DATA COLLECTION:

Files with 15 minute water level, temperature, and discharge data are collected every two months to quarterly depending on whether there is a technician dedicated to the hydrology work. The files are sent to the Water Resources Branch in the Regional Office to be stored in the WISKI database.

11. ESTABLISHMENT: N/A

12. HISTORY:

Survey notes mention an "old" well 3. Not sure when this was abandoned and when the current well was drilled.

Pre- 1994 Prior to 1994 water level measurements made with manometer.

1994 May – Levels run

Post-1995 Water level measurements made with electric tape.

1998 In-line meter installed on pipeline common to Wells 1, 2, 3, and 7. In-line meter installed on Well 3.

8/2010 Siemens brand magnetic meter installed for Well No. 3 only

13. FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

Use Panametrics meter to confirm flow rate from pump
QA temperature checks

14. DESCRIPTION OF WELL:

Well is 12" diameter extending a total of 92-ft below ground surface. Screened intervals begin at 20-ft below ground surface. See attached well log.

15. DESCRIPTION OF CONTROL:

N/A

16. WINTER FLOW:

Hatchery uses water from this well intermittently year-round.

17. LOCATION AND TYPE OF DIVERSIONS:

Well is equipped with line shaft turbine pump with variable frequency speed to adjust lower speeds in the case of lower water levels.

18. LOCATION AND TYPES OF REGULATIONS:

Pump is controlled by a SCADA system operated at the LNF Hatchery computer or at pump house.

19. LAND STATUS:

Land owned by FWS

21. COOPERATING AGENCIES:

None

22. USGS TOPO MAP:

Leavenworth, WA

PREPARED BY: Paul Rauch

DATE: 1994

UPDATED BY: Mary Lindenberg May 2012

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION**

1. REFUGE/HATCHERY NAME:

Leavenworth NFH

2. SITE NAME:

Production Well No. 4 at Leavenworth NFH

3. SITE NUMBER:

322511

4. PURPOSE OF GAGE:

The purpose is to monitor discharge, water level, and temperature at Well No. 4 at the Leavenworth NFH. Monitoring at this location is required by EPA's Clean Water Act, National Pollution Discharge Elimination System (Permit WA0001902)). Water use at Well 4 is reported under water right G4-27115C. Additionally, water levels at the well have been recorded in the past for use in hydrogeologic analyses at the hatchery.

5. DESCRIPTIVE LOCATION OF SITE:

UTM Zone 10 N

Latitude: 47.5570

Longitude -120.6746

Well and pump are located in Well house west of the Hatchery Channel of Icicle Creek on Leavenworth NFH property.

Road Log:

Proceed west of Leavenworth on State Highway 2. Turn south on Icicle Road for 2.2 miles to the Leavenworth NFH and turn left at Fish Hatchery Road.

6. SUMMARY OF GAGE SYSTEM:

Pumping rate is measured by Siemens brand mag meter 5100W series (serial number:). The temperature and water level is measured with a KPSI brand pressure transducer (model number: 700s17aoa025, serial number: 0811703).

7. DESCRIPTION OF RECORDING SYSTEM:

The well discharge, water level, and temperature are recorded every 15 minutes into a file at the alarm computer at the Leavenworth NFH break room. All the production wells and the Fish Ladder Outfall 1 data are recorded in the same file. A new file is created every month. Water levels at the well are taken approximately weekly using an electric tape and measuring from the top of the 12" casing. Static water level measurements are recorded at least 12 hours after pumping has ceased. Data is entered in logbooks provided by the Water Resources Branch. Additionally, the hatchery records water levels into a spreadsheet (WellStatus.wk3.wkb). The spreadsheet is sent to Water Resources Branch staff annually to complete water reporting requirements for the State of Washington.

8. REFERENCE GAGE:

Measuring point for water level measurements is near the top of the well casing on the lower lip of a 2" side pipe. Water level transducer measurement point is 88.5 (1057.15 ft) feet deep. Maximum pumping level is 81 feet (1064.57 ft) and pump is 91 feet deep. Elevation of the m.p. is 1145.57 ft MSL (datum?).

9. REFERENCE MARKS:

N/A

10. DATA COLLECTION:

Files with 15 minute water level, temperature, and discharge data are collected every two months to quarterly depending on whether there is a technician dedicated to the hydrology work. The files are sent to the Water Resources Branch in the Regional Office to be stored in the WISKI database.

11. ESTABLISHMENT: na

12. HISTORY:

Pre- 1994	Prior to 1994 water level measurements made with manometer
1994	May – Levels run
Post-1994	Water level measurements made with electric tape.
1998	In-line meter installed on Well 4.
1/2009	Siemens brand magnetic meter installed

13. FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

Use Panametrics meter to confirm flow rate from pump
QA temperature checks

14. DESCRIPTION OF WELL:

Well is 16" diameter casing extending a total of 237-ft below ground surface. Screened and perforated intervals begin at 60-ft below ground surface. See attached well log.

15. DESCRIPTION OF CONTROL:

N/A

16. WINTER FLOW:

Hatchery uses water from this well intermittently year-round.

17. LOCATION AND TYPE OF DIVERSIONS:

Well is equipped with line shaft turbine pump with variable frequency speed to adjust lower speeds in the case of lower water levels.

18. LOCATION AND TYPES OF REGULATIONS:

Pump is controlled by a SCADA system operated at the LNF Hatchery computer or at pump house.

19. LAND STATUS:

Land owned by FWS

21. COOPERATING AGENCIES:

None

22. USGS TOPO MAP:

Leavenworth, WA

PREPARED BY: Paul Rauch

DATE: 1994

UPDATED BY: Mary Lindenberg May 2012

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION**

1. REFUGE/HATCHERY NAME:

Leavenworth NFH

2. SITE NAME:

Production Well No. 5 at Leavenworth NFH

3. SITE NUMBER:

322512

4. PURPOSE OF GAGE:

The purpose is to monitor discharge, water level, and temperature at Well No. 5 at the Leavenworth NFH. Monitoring at this location is required by EPA's Clean Water Act, National Pollution Discharge Elimination System (Permit WA0001902)). Water use at Well No. 5 is reported under water right No. G4-27115. Additionally, water levels at the well have been recorded in the past for use in hydrogeologic analyses at the hatchery.

5. DESCRIPTIVE LOCATION OF SITE:

UTM Zone 10 N

Latitude: 47.5591

Longitude -120.6758

Well and pump are located in Well house west of the Hatchery Channel of Icicle Creek on Leavenworth NFH property.

Road Log:

Proceed west of Leavenworth on State Highway 2. Turn south on Icicle Road for 2.2 miles to the Leavenworth NFH and turn left at Fish Hatchery Road.

6. SUMMARY OF GAGE SYSTEM:

Pumping rate is measured by a S+B Systems Specialist in-line flow meter (SN# C-004306). The temperature and water level is measured with a KPSI brand pressure transducer (model number: 700s17aoa050, serial number: 0807589).

7. DESCRIPTION OF RECORDING SYSTEM:

The well discharge, water level, and temperature are recorded every 15 minutes into a file at the alarm computer at the Leavenworth NFH break room. All the production wells and the Fish Ladder Outfall 1 data are recorded in the same file. A new file is created every month. Water levels at the well are taken approximately weekly using an electric tape and measuring from the top of the 12" casing. Static water level measurements are recorded at least 12 hours after pumping has ceased. Data is entered in logbooks provided by the Water Resources Branch. Additionally, the hatchery records water levels into a spreadsheet (WellStatus.wk3.wkb). The spreadsheet is sent to Water Resources Branch staff annually to complete water reporting requirements for the State of Washington.

8. REFERENCE GAGE:

Measuring point for water level measurements is near the top of the well casing on the lower lip of the access port. Water level transducer measurement point is 100 (1028.04 ft) feet deep. Maximum pumping level is 114 feet (1014.04 ft) and pump is 124 feet deep. Elevation of the m.p. is 1128.04 ft MSL (datum?).

9. REFERENCE MARKS:

N/A

10. DATA COLLECTION:

Files with 15 minute water level, temperature, and discharge data are collected every two months to quarterly depending on whether there is a technician dedicated to the hydrology work. The files are sent to the Water Resources Branch in the Regional Office to be stored in the WISKI database.

11. ESTABLISHMENT: NA

12. HISTORY:

Pre- 1994	Prior to 1994 water level measurements made with manometer.
1994	May – Levels run
Post-1994	Water level measurements made with electric tape.
1998	In-line meter installed on Well 5.

13. FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

Use Panametrics meter to confirm flow rate from pump
QA temperature checks

14. DESCRIPTION OF WELL:

Well is 20" diameter casing extending a total of 279-ft below ground surface. Screened and perforated intervals begin at 250-ft below ground surface. See attached well log.

15. DESCRIPTION OF CONTROL:

N/A

16. WINTER FLOW:

Hatchery uses water from this well intermittently year-round.

17. LOCATION AND TYPE OF DIVERSIONS:

Well is equipped with line shaft turbine pump with variable frequency speed to adjust lower speeds in the case of lower water levels.

18. LOCATION AND TYPES OF REGULATIONS:

Pump is controlled by a SCADA system operated at the LNF Hatchery computer or at pump house.

19. LAND STATUS:

Land owned by FWS

21. COOPERATING AGENCIES:

None

22. USGS TOPO MAP:

Leavenworth, WA

PREPARED BY: Paul Rauch

DATE: 1994

UPDATED BY: Mary Lindenberg May 2012

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION**

1. REFUGE/HATCHERY NAME:

Leavenworth NFH

2. SITE NAME:

Production Well No. 6 at Leavenworth NFH

3. SITE NUMBER:

322513

4. PURPOSE OF GAGE:

The purpose is to monitor discharge, water level, and temperature at Well No. 6 at the Leavenworth NFH. Monitoring at this location is required by EPA's Clean Water Act, National Pollution Discharge Elimination System (Permit WA0001902)). Water use at Well No. 6 is reported under water right No. G4-27115. Additionally, water levels at the well have been recorded in the past for use in hydrogeologic analyses at the hatchery.

5. DESCRIPTIVE LOCATION OF SITE:

UTM Zone 10 N

Latitude: 47.5582

Longitude -120.6780

Well and pump are located in Well house west of the Hatchery Channel of Icicle Creek on Leavenworth NFH property.

Road Log:

Proceed west of Leavenworth on State Highway 2. Turn south on Icicle Road for 2.2 miles to the Leavenworth NFH and turn left at Fish Hatchery Road.

6. SUMMARY OF GAGE SYSTEM:

Pumping rate is measured by a S+B Systems Specialist in-line flow meter (SN# C-004305). The temperature and water level is measured with a KPSI brand pressure transducer (model number: 700s17aoa050, serial number: 0708393).

7. DESCRIPTION OF RECORDING SYSTEM:

The well discharge, water level, and temperature are recorded every 15 minutes into a file at the alarm computer at the Leavenworth NFH break room. All the production wells and the Fish Ladder Outfall 1 data are recorded in the same file. A new file is created every month. Water levels at the well are taken approximately weekly using an electric tape and measuring from the top of the 12" casing. Static water level measurements are recorded at least 12 hours after pumping has ceased. Data is entered in logbooks provided by the Water Resources Branch. Additionally, the hatchery records water levels into a spreadsheet (WellStatus.wk3.wkb). The spreadsheet is sent to Water Resources Branch staff annually to complete water reporting requirements for the State of Washington.

8. REFERENCE GAGE:

Measuring point for water level measurements is the lower lip of a 2" side pipe near the top of the casing. Water level transducer measurement point is 101 (1028.04 ft) feet deep. Maximum pumping level is 84 feet (1044.04 ft) and pump is 94 feet deep. Elevation of the m.p. is 1148.31 ft MSL (datum?).

9. REFERENCE MARKS:

N/A

10. DATA COLLECTION:

Files with 15 minute water level, temperature, and discharge data are collected every two months to quarterly depending on whether there is a technician dedicated to the hydrology work. The files are sent to the Water Resources Branch in the Regional Office to be stored in the WISKI database.

11. ESTABLISHMENT: na

12. HISTORY:

Pre- 1994	Prior to 1994 water level measurements made with manometer.
1994	May – Levels run
Post-1994	Water level measurements made with electric tape.
1998	In-line meter installed on Well 6.

13. FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

Use Panametrics meter to confirm flow rate from pump
QA temperature checks

14. DESCRIPTION OF WELL:

Well is 14” diameter casing extending a total of 170-ft below ground surface. Screened and perforated intervals begin at 102-ft below ground surface. See attached well log.

15. DESCRIPTION OF CONTROL:

N/A

16. WINTER FLOW:

Hatchery uses water from this well intermittently year-round.

17. LOCATION AND TYPE OF DIVERSIONS:

Well is equipped with line shaft turbine pump with variable frequency speed to adjust lower speeds in the case of lower water levels

18. LOCATION AND TYPES OF REGULATIONS:

Pump is controlled by a SCADA system operated at the LNF Hatchery computer or at pump house

19. LAND STATUS:

Land owned by FWS

21. COOPERATING AGENCIES:

None

22. USGS TOPO MAP:

Leavenworth, WA

PREPARED BY: Paul Rauch

DATE: 1994

UPDATED BY: Mary Lindenberg May 2012

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION**

1. REFUGE/HATCHERY NAME:

Leavenworth NFH

2. SITE NAME:

Production Well No. 7 at Leavenworth NFH

3. SITE NUMBER:

322514

4. PURPOSE OF GAGE:

The purpose is to monitor discharge, water level, and temperature at Well No. 7 at the Leavenworth NFH. Monitoring at this location is required by EPA's Clean Water Act, National Pollution Discharge Elimination System (Permit WA0001902)). Water use at Well No. 7 is reported under water right No. G4-27115. Additionally, water levels at the well have been recorded in the past for use in hydrogeologic analyses at the hatchery.

5. DESCRIPTIVE LOCATION OF SITE:

UTM Zone 10 N

Latitude: 47.5582

Longitude -120.6780

Well and pump are located in Well house west of the Hatchery Channel of Icicle Creek on Leavenworth NFH property.

Road Log:

Proceed west of Leavenworth on State Highway 2. Turn south on Icicle Road for 2.2 miles to the Leavenworth NFH and turn left at Fish Hatchery Road.

6. SUMMARY OF GAGE SYSTEM:

Pumping rate is measured by Siemens brand mag meter 5100W series (serial number:). The temperature and water level is measured with a KPSI brand pressure transducer (model number: 700s17aoa030, serial number: 0800359).

7. DESCRIPTION OF RECORDING SYSTEM:

Hatchery staff record water levels and flow readings at the well approximately weekly. Data is entered in logbooks provided by the Water Resources Branch. Additionally, the hatchery records water levels and flow rates in a spreadsheet (WellStatus.wk3.wkb). The spreadsheet is sent to Water Resources Branch staff annually to complete water reporting requirements for the State of Washington.

8. REFERENCE GAGE:

Measuring point for water level measurements is the lower lip of a 1.5" side pipe near the top of the casing. Water level transducer measurement point is 68 (1077.73 ft) feet deep. Maximum pumping level is 68 feet (1077.73 ft) and pump is 78 feet deep. Elevation of the m.p. is 1145.73 ft MSL (datum?).

9. REFERENCE MARKS:

N/A

10. DATA COLLECTION:

Files with 15 minute water level, temperature, and discharge data are collected every two months to quarterly depending on whether there is a technician dedicated to the hydrology work. The files are sent to the Water Resources Branch in the Regional Office to be stored in the WISKI database.

11. ESTABLISHMENT:

12. HISTORY:

Pre- 1994	Prior to 1994 water level measurements made with manometer.
1994	May – Levels run
Post-1994	Water level measurements made with electric tape.
2011	Siemens brand magnetic meter installed

13. FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

Use Panametrics meter to confirm flow rate from pump
QA temperature checks

14. DESCRIPTION OF WELL:

Well is 14” diameter casing extending a total of 115-ft below ground surface. Screened and perforated intervals begin at 72-ft below ground surface. See attached well log.

15. DESCRIPTION OF CONTROL:

N/A

16. WINTER FLOW:

Hatchery uses water from this well intermittently year-round.

17. LOCATION AND TYPE OF DIVERSIONS:

Well is equipped with line shaft turbine pump with variable frequency speed to adjust lower speeds in the case of lower water levels.

18. LOCATION AND TYPES OF REGULATIONS:

Pump is controlled by a SCADA system operated at the LNF Hatchery computer or at pump house.

19. LAND STATUS:

Land owned by FWS

21. COOPERATING AGENCIES:

None

22. USGS TOPO MAP:

Leavenworth, WA

PREPARED BY: Paul Rauch

DATE: 1994

UPDATED BY: Mary Lindenberg May 2012

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION**

REFUGE/HATCHERY NAME:

Leavenworth NFH

SITE NAME:

Historical Channel of Icicle Creek at Structure 2

SITE NUMBER:

322525

PURPOSE OF GAGE:

The purpose of the gage is the continuous measurement of stage above structure 2 to calculate discharge through the radial gate structure and into Icicle Creek Historical Channel. Measurement at this location is required through Washington Department of Ecology issuance of the EPA's Clean Water Act 401 Certification.

DESCRIPTIVE LOCATION OF SITE:

Decimal Degrees NAD83

Latitude: 47.549494 Longitude: -120.679117

Road Log:

Proceed west of Leavenworth on State Highway 2. Turn south on Icicle Road for 2.2 miles to the Leavenworth NFH and turn left at Fish Hatchery Road. From the gated hatchery entrance proceed straight 0.16 miles to the hatchery channel bridge. After crossing the hatchery bridge follow the road as it runs parallel to the hatchery channel until it terminates at the Structure 2 bridge.

SUMMARY OF GAGE SYSTEM:

Water level is measured by a Pressure Transducer SN# 1105029; Model # 56-0135-25-1 and Sutron 9210 datalogger Model # 9210-0000-2B, SN 1110307. A flexible electrical conduit protects the pressure transducer line to a 2 inch PVC pipe in the old pump well on the left bank of structure 2. Power is supplied by a small solar panel and a 12 volt DC 10 amp hour battery. Charge is maintained by an ASC 1218 12 volt 8 Amp charge controller manufactured by Specialty Concepts Inc. Telemetry equipment includes a Raveon Modem (Model # RV-M7-UA, SN 16359017611, FCCID 8RS-RV), a Polyphasor Lightening Arrestor (ISB50LN-C2), and a YAGI LAIRD Gold antenna 430-450 MHz (SN 09231613). Additional telemetry equipment to satellite communications is through a Sutron Satlink SN# , Model#SL3-I-IR with a GOES Yagi UHF, 401-402 MHz. Radial gate opening values are measured with (installed by BOR) Two Rieker Inclonometers Model# H4360 measure the opening of the radial gate. One wire weight gage is located on structure 2. A flat bladed screwdriver and the lock combo 0190 are required to open the bubbler enclosure.

DESCRIPTION OF RECORDING SYSTEM:

Stage is recorded at a 15 minute logging interval by a Sutron 9210 Datalogger. Leavenworth NFH staff record stage approximately monthly. Site visit data is entered into field sheets and stored at Leavenworth NFH. Data is downloaded with a full size SD Card transferred to the Leavenworth NFH server and sent electronically to the Water Resources Office of Portland USFWS. Data is also transferred to SCADA system via radio modem.

REFERENCE GAGE:

The reference gage measurement was performed from a wire weight gage located on the left bank of structure 2 from its installment in Sept 2009 until the cantilevered wire weight gage was installed and leveled in Oct 2011. Starting March 2015 the stage is referenced to the LEW Wire Weight Gage. Between

Oct 2011 and Oct 2014 the cantilevered wire weight gage located at the center of structure 2 will be used as the reference gage. Continue to note the measured values from both the cantilevered wire weight gage and the wire weight gage on the left bank. Datum is NAVD88, Geoid 2003 1127.926' Do not use the old staff plates that are bolted to upstream end and downstream end of structure 2.

REFERENCE MARKS:

RM1 - Pump (top bolt painted white) Elevation: 21.663 ft (1149.589')
RM2 - Nail or Control Point or pin; Loose - DO NOT USE! Elevation: 18.627 ft (1146.55')
RM3 - Rail Base do not know location (only used in 1st level survey 09/2009). Elevation: 19.053 ft
RM4 - Rounded bolt head on radial gate spool end - most upstream Left Bank. Elevation: 21.045 ft (1148.971')
RM5 - Described as top of O.S. Upstream right bank @ 9.990. Used on 09/2009. Elevation: 14.038 ft
RM6 - Rounded bolt head on LEW radial gate spool end - most south and west bolt. Elevation: 21.051 ft (1148.977')
RM7 - Fence post base screw and nut. 4th post from LEW. LEW and downstream screw. Elevation: 19.142 ft (1147.068')
RP1 - LEW Wire weight gage - bar back. Elevation: 22.336 ft (1150.292')
RP2 - LEW Wire weight gage - bar front. Elevation: 22.365 ft
RP3 - Dam Walkway on ds side of LEW port to sill. Elevation: ~ 10.000 ft

DATA COLLECTION:

Water stage data is collected every month, entered into appropriate spreadsheets by Leavenworth NFH staff. Data is submitted in electronic form to the Water Resources Branch. Data is stored in WISKI. Water Resources region 1 staff visit for maintenance 3-6 times a year.

ESTABLISHMENT:

Wire weight gage was installed September 2009. Removed in October 2014 and Reinstalled in March 2015. Cantilevered Wire Weight Gage was installed on October 2011 and removed October 2014.

HISTORY:

2009 Wire weight gage was installed and leveled in September 2009.
2010 Pressure transducer was installed in the pump well on the left bank October 2010.
2011 Sutron Accubar Continuous Flow Bubbler System installed and operational 9/20/2011.
2011 Cantilevered wire weight gage was installed and leveled for use by Oct 2011.
2012 March - Universal battery (UB12550) 12v; 55 Ah installed
2012 March - Bubbler replaced with loan from J Humphreys SN 904026
2012 October - Levels survey, determined NAVD88 Datum elevation with line survey from PGS CP 71
2013 April - J Humphreys bubbler replaced with repaired FWS bubbler.
2013 September - Replaced desiccant, run levels.
2014 September - Levels run
2014 October - removed WWG and Cantilevered WWG and Sutron Bubbler
2015 March - Reinstalled WWG, run levels and Sutron 9210 and Pressure Transducer
2015 October - Run levels
2016 October - Install radio modem and telemetry equipment, New Sutron firmware V3.19.0.10 w/Modbus Comm
2017 Sept - Inclinometers installed in each bay
2018 Sept - Satlink installed

FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

Check Levels

DESCRIPTION OF CHANNEL:

Boulder, cobble, gravel and sand above and below structure 2. No vegetation. Structure 2 is concrete lined. Immediately upstream of Structure 2 Icicle creek may split and flow down the Hatchery Channel during higher flows.

DESCRIPTION OF CONTROL:

The control is a dual bay radial gate. Each bay is 16 feet wide. This control acts as a broad crested weir when water levels are lower than radial gate height and as a radial gate when water levels are greater than radial gate height.

WINTER FLOW:

Flow is irregular at all times of the year. Surface water will freeze around structure 2 but flow will continue. Water may or may not flow down the hatchery channel.

LOCATION AND TYPE OF DIVERSIONS:

N/A

LOCATION AND TYPES OF REGULATIONS:

Unknown

LAND STATUS:

Land owned by USFWS

COOPERATING AGENCIES:

None

USGS TOPO MAP:

Leavenworth, WA

PREPARED BY: K. Kannarr September 2011

UPDATED BY: M Lindenberg September 2018

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION**

REFUGE/HATCHERY NAME:

Leavenworth NFH

SITE NAME:

Hatchery Channel at Spillway

SITE NUMBER:

322527

PURPOSE OF GAGE:

The primary purpose of the gage is to measure the height of water that is immediately upstream of the spillway crest to determine the discharge over the spillway in accordance with requirements of the NOAA's, National Marine Fisheries Service, Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation, NMFS Consultation Number: WCR-2017-7345.

DESCRIPTIVE LOCATION OF SITE:

UTM Zone 10 T, Datum NAD 83
Easting: 675134 Northing: 5269725

Decimal Degrees Datum NAD83
Latitude: 47.557233 Longitude: -120.672007

Road Log:

Proceed west of Leavenworth on State Highway 2. Turn south on Icicle Road for 2.2 miles to the Leavenworth NFH and turn left at Fish Hatchery Road. From the entrance gate proceed straight 0.16 miles to the hatchery channel bridge. After crossing the bridge follow the paved road 0.06 miles, the monitoring site is located at the furthest point right bank downstream of the hatchery channel.

SUMMARY OF GAGE SYSTEM:

Water level is measured by a Sutron Accubar Constant Flow Bubbler Model# 56-0133-25-1, SN# 1105026. A flexible electrical conduit protects the bubbler line to its terminus at a Rickly Static Tube. Power is supplied by a 30 watt Aeresco Solar Panel model # BSP-3012 and a 12 volt 34 amp hour battery. Charge is maintained by an ASC 1218 12v 8 Amp charge controller manufactured by Specialty Concepts Inc. A 10ft staff is mounted to an I beam near the right bank A lock (combo 0190) and flat head screwdriver is required to open the gaging equipment.

DESCRIPTION OF RECORDING SYSTEM:

Stage is recorded at a 15 minute logging interval by a Sutron Accubar Constant Flow Bubbler System. Leavenworth NFH staff record stage approximately monthly. Site visit data is entered into field sheets and stored at Leavenworth NFH. Data is downloaded with a full size SD Card transferred to the Leavenworth NFH server and sent electronically to the Water Resources Office of Portland USFWS.

REFERENCE GAGE:

A cantilevered wire weight gage was installed on the right bank bulkhead dam wall. Elevations should be read from the wire weight gage when the hatchery channel fills with water to verify the bubbler record. The old staff plate is mounted to REW bulkhead dam wall and will only be used as a check and for levels and in case new staff plate is inadvertently removed. The 10ft staff plate mounted to an I-beam near the right bank was destroyed spring 2016 and was not repairable. Datum is NAVD88, Geoid 2003 1129.900'.

Weir elevation; 1132.899'

REFERENCE MARKS:

RM 1 is a brass cap located on the top of the right bank buttress of the spillway.
Elevation Relative to Gage Datum: 16.068'
Elevation Relative to NAVDatum: 1145.97'

RM 2 is a brass cap located on the top of the left bank buttress of the spillway.
Elevation Relative to Gage Datum: 16.088'
Elevation Relative to NAVDatum: 1145.988'

RM 3 Upstream top bolt on staff plate attached to bulkhead on right bank of dam wall (near weir crest).
Elevation Relative to Gage Datum: 9.680'
Elevation Relative to NAVDatum: 1139.56'

~~RM 4 is a lag screw installed approximately two feet from the base, on the channel side, of a large pine tree immediately downstream of the gaging unit. Not used anymore because the tree has grown around the brass cap.~~

~~Elevation Relative to Gage Datum: 18.121'
Elevation Relative to NAVDatum: 1148.016'~~

RM 5 is a lag bolt screwed into the post holding the bubbler/datalogger
Elevation Relative to Gage Datum: 17.686'
Elevation Relative to NAVDatum: 1147.768'

RM 6 is cantilevered wire weight gage bar front
Elevation Relative to Gage Datum: 17.980'
Elevation Relative to NAVDatum: 1147.880'

DATA COLLECTION:

Water stage data is collected every month, entered into appropriate spreadsheets by Leavenworth NFH staff. Data is submitted in electronic form monthly and in paper form annually to the Water Resources Branch. Data is stored in WISKI.

ESTABLISHMENT:

The Leavenworth NFH Channel at Spillway site was established in May of 2011.

HISTORY:

1939	Spillway construction
2009?	Staff plate installed on dam bulkhead wall
2011	Reference marks installed March 2011
2011	Sutron Accubar Continuous Flow Bubbler System and temporary cableway installed May 2011.
2011	(Fall) Battery Installed UB 12120 12 12Ah
2011	I-beam and staff plate installed September 2011, levels run
2012	Sutron Accubar removed and fixed (4/30/2012)
2012	(Fall) Crest Stage Gage Installed, Datum line level survey , levels run
2013	Sept levels run, desiccant changed , crest stage gage removed
2013	Sept levels run
2014	Sept levels run
2015	March Staff and bubbler were reset; levels run
2015	Oct levels run
2017	July switched out 10 watt solar panel to 30 watt and battery size to 35 amp-hr
2017	Sept Cantilevered wire weight gage installed and leveled. Levels run. RM5 and RM6 established.

FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

Monitor bubbler during freezing temperatures
Check Level
Crest stage gage
Make static tube end more permanent with 2 inch pipe.
Install a new reference gage

DESCRIPTION OF CHANNEL:

The constructed channel is of uniform dimensions with a straight calm reach. Width is approximately 100 – 125 feet with banks and channel constructed of large boulders and cobbles that have been filled in with finer sand to silt sized sediments. Vegetation lines the channel banks but is not within the channel proper.

DESCRIPTION OF CONTROL:

Control is a broad crested weir.

WINTER FLOW:

Flow is irregular at all times of the year, channel may be dry, pooled below the spillway crest or frozen to approximately one foot thick.

LOCATION AND TYPE OF DIVERSIONS:

N/A

LOCATION AND TYPES OF REGULATIONS:

Unknown

LAND STATUS:

Land owned by USFWS

COOPERATING AGENCIES:

None

USGS TOPO MAP:

Leavenworth, WA

PREPARED BY: K. Kannarr August 2011

UPDATED BY: M. Lindenberg 10/2017

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION**

REFUGE/HATCHERY NAME:

Leavenworth NFH

SITE NAME:

Leavenworth NFH Icicle Creek Diversion Intake

SITE NUMBER:

322533

PURPOSE OF GAGE:

To monitor flow in to the intake house that feeds the pipeline to the Leavenworth NFH. Measurement of flow at this site is required by Washington Department of Ecology Revised Code RCW90.03.360 (Order No. DE 02WRCR-3724) for Water Right Certificate 1824, EPA's Clean Water Act, National Pollution Discharge Elimination System (Permit WA0001902) and NOAA's, National Marine Fisheries Service, Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation, NMFS Consultation Number: WCR-2017-7345.

DESCRIPTIVE LOCATION OF SITE:

UTM Zone 10 N

Northing: Easting:

Located on the left approximately 3.4 miles on Icicle Rd. from Hwy 2. There will be a gated stairway with a dirt turnoff and a road behind a chain leading down to the intake. Walk down the road and down the steps to the Intake debris rack. The connections are located in a small box mounted to a wood panel. The Argonaut-SL is located in the channel between the debris rack and the intake house.

Road Log:

Proceed west of Leavenworth on State Highway 2. Turn south on Icicle Road and follow the road approximately 3.4 miles to a dirt turnout on the left with a gated stairway leading down to the Intake House, park here. A road going upstream leads down to the Argonaut SL access point. You will need the Leavenworth NFH standard gate key.

SUMMARY OF GAGE SYSTEM:

Discharge is measured by an Argonaut-SL SN# E3367 located halfway down the intake channel. The Argonaut is mounted to an adjustable rail and has 30 meters of communication cable that ends at a junction box located on top of the debris rack over the intake channel. The measurement site is located in a channel that can be extremely variable. Under certain conditions multiple adjustments to the Argonaut vertical location and program will need to be made daily for an accurate representation of discharge. Even when properly monitored, the Argonaut may become buried by sediment or the water level may drop below the required height to measure discharge.

DESCRIPTION OF RECORDING SYSTEM:

A SonTek Argonaut-SL SN# E3367 measures velocity along two beams. This data is averaged over a 15 minute interval and combined with channel geometry allows the Argonaut to calculate and record discharge. Power is supplied at the walkway by an AC/DC power inverter connected to a 120V outlet. A Sutron 9210 SN 1009342, MN9210-000-2B records data from the Argonaut to be telemetered via modem Sixnet VT-Modem 2 (self-dialing) IC: 29918926A to the hatchery alarm/SCADA computer. The Sutron is powered by battery that is recharged with a Mini-DC-UPS Phoenix Contact SN 3014120326 OrderN 2866598 that connects to 120V outlet.

REFERENCE GAGE:

Until a reference gage is installed and leveled the top of the concrete wall immediately upstream of the Argonaut is considered to be 6.74 feet from arbitrary zero.

REFERENCE MARKS:

RM1 – brass cap on wall close to ADVN	Elevation: 6.769 ft
RM3 – rebar loop in concrete close to fish ladder	Elevation: 2.933 ft
RM4 – top of bolted angle iron holding the grated walkway nearest the creek	Elevation: 8.020 ft
RM5 – Square notch on Canal wall near ADVN @ 6.74 ft	Elevation: 6.740 ft

DATA COLLECTION:

Data is collected bi-weekly to monthly as conditions permit and require.

ESTABLISHMENT:

The Argonaut was installed March 2011. Previously equipment maintained by TSI had been recording discharge.

HISTORY:

2011	Argonaut installed March 2011
2013	September Levels run
2015	October Levels run
2017	Installed Sutron 9210 to record data for telemetry
2017	Installed Mini –DC-UPS
2017	Installed Sixnet VT- Modem 2 (Michael Smith provided)

FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

- Flow measurements to create a velocity index
- Reference gage
- Frequent geometry profiles
- Constant attention

DESCRIPTION OF CHANNEL:

Canal made of concrete wall up against ~ 12' away from a vertical rock wall. The bottom changes as sediment fills and scours.

DESCRIPTION OF CONTROL:

During the lower flow control is by the Intake valve. As flows increase water will begin to flow over the dam boards located on the downstream side of the Intake house. During high flow water will overtop the Intake channel sides.

WINTER FLOW:

Flow continues through the winter. Surface water will freeze.

LOCATION AND TYPE OF DIVERSIONS:

The Intake channel diverts water from Icicle creek to the pipeline that supplies water to the Leavenworth NFH and the irrigation district.

LOCATION AND TYPES OF REGULATIONS:

Unknown

LAND STATUS:

Land owned by FWS

COOPERATING AGENCIES:

None

USGS TOPO MAP:

Leavenworth, WA

PREPARED BY: K. Kannarr, September 2011

UPDATED BY: Mary Lindenberg December 2017

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1
SITE DESCRIPTION

1. *REFUGE/HATCHERY NAME:*

Winthrop NFH

2. *SITE NAME:*

Bypass Channel

3. *SITE NUMBER:*

326508

4. *PURPOSE OF GAGE:*

This channel serves to return fish to the river that have been diverted into the Foghorn Ditch and to provide attraction flows for returning adult salmon. It may also provide habitat for juvenile salmon. It is part of the water diverted under water right SWC848 and we measure and report on it.

5. *DESCRIPTIVE LOCATION OF SITE:*

Latitude 48.473425, Longitude -120192050 (WGS84) Okanogan County, Washington, on the right bank just downstream of the diversion off of Foghorn Ditch.

Road Log: Begin at the intersection of Riverside Ave (Hwy 20) and Twin Lakes Rd in Winthrop, WA

Mile:	0.0	Head West on Twin Lakes Rd from the intersection with Riverside Ave
	0.5	Turn right at the entrance of Winthrop NFH
	0.7	Proceed through gate and head to the hatchery main office
	0.8	Head West and travel around the uncovered raceways between the main office.
		Take the gravel road after the raceway and cross the trail to the monitoring site

6. *SUMMARY OF GAGE SYSTEM:*

Sutron Bubbler installed inside a metal box on a single 6x6 post. The recorder is referenced to RP1 on a single staff gage. The orifice line runs through a two inch galvanized pipe to the gage pool controlled by a small rock riffle. The recorder is powered by a 12volt 35amp battery, solar panel and solar charge controller.

7. *DESCRIPTION OF RECORDING SYSTEM:*

Sutron non submersible pressure transducer (Bubbler) (SN 1409087) (Model 56-0133-25-1S).

8. *REFERENCE GAGE:*

R.P. #1 is a lag screw in the outside staff gage.

9. *REFERENCE MARKS:*

R.M. #1 is a brass cap in a historic loading platform East of the gage.

Elevation: 4.918 ft. above gage datum (10/05/2018)

R.M. #2 is a bolt in the right bank concrete pad of a large metal pipe crossing the channel just upstream of the gage.

Elevation: 2.772 ft. above gage datum (10/05/2018)

R.M. #3 is a lag screw in a power pole South East of the gage.

Elevation: 3.424 ft. above gage datum (10/05/2018)

10. DATA COLLECTION:

Recorder is serviced by Water Resources staff every 8 - 10 weeks with additional periodic visits during high flows. This is a standard-type USGS gage and therefore, discharge measurements are conducted during visits to develop and maintain a gage-height/discharge relation. Measurements are taken by wading above the gage during all flows. Discharge Measurement/Site Inspection Forms are filed at the regional office. Logged data is downloaded onto flash cards and then processed and stored at the Regional office as well.

11. HISTORY:

June 28, 2017 – Gage installed

October 5, 2018 – Levels ran

12. FUTURE WORK NEEDS (CLEANING, LEVELS, ETC.):

- Monitor rock riffle
- Run levels

13. DESCRIPTION OF CHANNEL:

The channel is well defined with tree lined banks that are relatively straight above and below the control. The bed is firm and composed of gravel and small cobbles. The shape is uniform with a small amount of undercut on the left bank.

14. DESCRIPTION OF CONTROL:

The control is a small rock riffle that is subject to movement.

15. WINTER FLOW:

During winter months the stage/discharge relation may be affected by ice.

16. LOCATION AND TYPE OF DIVERSIONS:

None

17. LOCATION AND TYPES OF REGULATIONS:

Flow is regulated by the Foghorn Ditch diversion.

18. LAND STATUS:

This monitoring site is located on FWS property.

19. COOPERATING AGENCIES:

None

20. USGS TOPO MAP:

PREPARED BY: Kristofor Kannarr

DATE: 01/30/2018

Appendix B. Site Analysis

WATER MONITORING SITE ANALYSIS - WY 2019

SITE NUMBER: 322525

SITE NAME: Historical Channel of Icicle Creek at Structure 2, Leavenworth WA

FACILITY: Leavenworth NFH

EQUIPMENT:

This site is controlled by a radial gate that can open to 5 feet high and is separated into 2 bays that are 16 ft in width. Stage data is collected with a Pressure Transducer and stored in Sutron 9210 datalogger.

GAGE-HEIGHT RECORD: (Raw)

COMPLETENESS OF RECORD:

Record for the year is complete.

DATA STORAGE:

Data Retrieval 20181030.0830: 01/25/2018(1500) – 10/30/2018(0830)

File:

Q:\Stations_Network\322525\322525.2019\Data\322525.20181030.0830\322525_20181030_0830.csv

Data Retrieval 20190423.1611: 10/29/2018(0000) – 04/23/2019(1615)

File:

Q:\Stations_Network\322525\322525.2019\Data\322525.20190423.1611\322525_20190423_1611.csv

Data Retrieval 20190612.1438: 04/23/2019(1630) – 06/12/2019(1030)

File:

Q:\Stations_Network\322525\322525.2019\Data\322525.20190612.1438\322525_20190612_1438.csv

Data Retrieval 20190814.1523: 05/04/2018(0000) – 08/14/2019(1545)

File:

Q:\Stations_Network\322525\322525.2019\Data\322525.20190814.1523\322525_20190814_1523.csv

Data Retrieval 20191009.1455: 06/26/2018(2345) – 10/09/2019(1500)

File:

Q:\Stations_Network\322525\322525.2019\Data\322525.20191009.1455\322525_20191009_1455.csv

GAGE-HEIGHT RECORD: (Edited)

Raw files are assigned the name of the site number, the date collected and sometimes with the time collected (Example 322525_YYYYMMDD_HHmm) and stored in a folder with the same name. Raw files were converted to the ZRXP format before import into WISKI. All files are stored in 100.Original time series. All raw files (before either manual or electronic conversion) are kept in

Q:\Stations_Network\322525\322525.2019\Data. This year data is also recorded in the SCADA system at the alarm computer at the hatchery. Issues at the datalogger cause loss of data that was filled in with data recorded at the alarm computer.

DATUM AND GAGE HEIGHT CORRECTIONS:

Period 07/24/2018 to 10/30/2018: Visit to download data. No gage height correction was applied. WWG: 2.20 ft +/- 0.03 ft, DL: 2.25 DC: -0.04/-0.04. Checkbar at 22.36 ft Data download. Medium branches on right edge of water. Gate 1: 5.18 ft, Gate 2: 0.02 ft MKL

Period 10/30/2018 to 04/23/2019: Visit to download data. Gage height adjusted. WWG: 5.23 ft +/- 0.10 ft, DL: 5.28 DC: -0.05/-0.05. Checkbar at 22.36 ft Data download. A few branches stuck on trash rack. One is 0.3 – 0.4 inches in diameter. MKL

Period 04/23/2019 to 06/12/2019: Visit to download data. Gage height adjusted. 6.70 ft +/- 0.05 ft, DL: 5.28 DC: -0.11/0.00. Checkbar at 22.36 ft Data download. Both radial gates are down and one is closed. Lots of flow up and over the top of the radial gate that is closed. MKL

Period 06/12/2019 to 08/14/2019: Visit to download data. Gage height adjusted. WWG: 0.63 ft +/- 0.01 ft, DL: 0.65 DC: -0.03/-0.00. Checkbar at 22.36 ft Data download. Small branches in flow on REW bay. MKL

Period 08/14/2019 to 10/09/2019: Visit to download data. No gage height correction was applied. WWG: 1.68 ft +/- 0.02 ft, DL: 1.68 DC: -0.02/-0.00. Checkbar at 22.35 ft Data download. Small branches on REW bay and affects approximately 3 feet of flow. MKL

CONTROL:

The site is a radial gate that has two types of flow control. At flows where the water level is less than the opening of the radial gate then the control acts as a weir. When water levels exceed the opening of the radial gate the control is a radial gate. Each radial gate can be operated independently.

RATING/CONTENTS TABLE:

Due to the structure of the site, calculating discharge requires the use of two or more formulas to set the rating curve. Rating curves are made of two formula sections. The lower section is a weir equation that calculates flow when stage at the weir crest is less than radial gate opening. The upper section is a radial gate equation that calculates flow when stage at the weir crest is greater than the radial gate opening. When the radial gate opening is changed then a new rating curve will be set in accordance with the radial gate opening. Calculated flows above 1840 (stage 7.6 ft) when both radial gates are open to 5.00 feet are estimated because there are no measurements to support the calculations.

Rating Curves

Date	Time	Bay 1 Radial Gate Opening (ft)	Bay 2 Radial Gate Opening (ft)	Rating Applied
11/09/2018	0850	5.19	5.11	RG5.00
05/17/2019	0645	4.87	5.21	Transition
05/17/2019	0145	1.57	5.18	RG1.57_1Bay_5.00_1Bay
05/20/2019	0700	1.17	5.18	Transition
05/21/2019	0700	-0.03	1.81	RG1.83_1Bay
06/25/2019	0730	-0.03	2.27	Transition
06/27/2019	0745	0.06	5.11	RG5.00_1Bay
06/28/2019	0700	0.38	5.12	Transition
07/01/2019	1400	5.18	5.11	RG5.00

Rating shifts

No check flow measurements were made. No shifts were applied. Shifts of 0.00 ft were created to apply an estimated quality code when radial gate operations lowered the gates into the flowpath.

REMARKS:

Stage record is considered good. Flow record is considered good throughout the water year except when one or more radial gate is lowered or flow is high enough to be radial gate controlled at the highest radial gate opening. Radial gate openings are estimated and the opening of the lowered radial gates cannot be confirmed for accuracy and flow is estimated during gate lowering operations.

WORKED BY:

Mary Lindenberg

DATE:

12/4/2019

APPENDIX C

Monitoring Site Photos

Photos of the Proposed Icicle Creek Monitoring Locations

Ecology Gage Station 45B070



USGS Gage 12458000



Photos of the Proposed Icicle Creek Monitoring Locations

USFWS Structure No. 2



APPENDIX D

Field Forms

Mid-point Method

Icicle Strategy - Synoptic Flow Study

Project Number: AS1200458D

Date (mm/dd/yyyy):	Weather:
Geosyntec field personnel :	County field personnel :
Other personnel present:	Location:

Measurement Method (Circle): **Sontek-RS5** **SonTek FlowTracker2**

Measurement Location (lat/long):	
Photo taken? Y / N	Transducer depth at start (Sontek-RS5 Only):
Measurement	
Measurement Start Time (hh:mm):	Start Stage (ft):
Measurement End Time (hh:mm):	End Stage (ft):
Left Edge Measurement:	Right Edge Measurement:
Measured Discharge (cfs):	Measurement saved? Y / N

Replicate Measurement 1 (at least one location)	
Measurement Start Time (hh:mm):	Start Stage (ft):
Measurement End Time (hh:mm):	End Stage (ft):
Left Edge Measurement:	Right Edge Measurement:
Measured Discharge (cfs):	Measurement saved? Y / N

RPD:

Replicate Measurement 2 (if needed)	
Measurement Start Time (hh:mm):	Start Stage (ft):
Measurement End Time (hh:mm):	End Stage (ft):
Left Edge Measurement:	Right Edge Measurement:
Measured Discharge (cfs):	Measurement saved? Y / N

RPD:

Notes:

Individual measurement minus average divided by average = relative percent difference

A RPD of 5% represents a "good" rating. If RPD >8% collect second replicate measurement.

Additional Observations or Comments

--

Qualitative Field Assessment of Flow

Cross Section Condition	
Velocity Conditions	
Equipment Operation	
Distribution of flow across sections	
Change in Stage	
Wind	
Overall Assessment:	Excellent Good Fair Poor

Qualitative Conditions	Ideal	Non-Ideal
Cross-section condition	<ul style="list-style-type: none"> -smooth, stable channel -uniform depths across channel -deep enough for equipment" -relatively straight channel -no upstream obstruction altering flow paths 	<ul style="list-style-type: none"> -loose or unstable channel -too shallow for propeller -large rocks or debris affecting flow paths
Velocity	<ul style="list-style-type: none"> -uniform across channel -perpendicular to cross-section -high enough velocity for sensor 	<ul style="list-style-type: none"> -large back-eddies -too fast for accurate depth -turbulent
Equipment	<ul style="list-style-type: none"> - No error warnings - Ideal water depth, no debris 	<ul style="list-style-type: none"> - Error warnings from sensor (variability or angle) - Shallow water or debris interference
Distribution of flow	<ul style="list-style-type: none"> -no single section with more than 5% of the flow 	<ul style="list-style-type: none"> -5-10% in any section=fair ->10%=poor
Change in stage	<ul style="list-style-type: none"> -stable or small change in stage during measurement 	<ul style="list-style-type: none"> -change of more than 0.1 ft. during measurement
Wind	<ul style="list-style-type: none"> -calm or no effect 	<ul style="list-style-type: none"> -wind altering current direction -wind affecting depth measurements

Flow Scan Method (Sontek RS5)

Icicle Strategy - Synoptic Flow Study

Project Number: AS1200458D

Date (mm/dd/yyyy):	Weather:
Geosyntec field personnel :	County field personnel :
Other personnel present:	Location:

Measurement Location (lat/long):	
Photo taken? Y / N	Transducer depth at start (Sontek-RS5 Only):
Transect 1	
Direction (Circle): R to L L to R	
Measurement Start Time (hh:mm):	Start Stage (ft):
Measurement End Time (hh:mm):	End Stage (ft):
Measured Discharge (cfs):	Measurement saved? Y / N

Transect 2	
Direction (Circle): R to L L to R	
Measurement Start Time (hh:mm):	Start Stage (ft):
Measurement End Time (hh:mm):	End Stage (ft):
Measured Discharge (cfs):	Measurement saved? Y / N

Transect 3	
Direction (Circle): R to L L to R	
Measurement Start Time (hh:mm):	Start Stage (ft):
Measurement End Time (hh:mm):	End Stage (ft):
Measured Discharge (cfs):	Measurement saved? Y / N

Transect 4	
Direction (Circle): R to L L to R	
Measurement Start Time (hh:mm):	Start Stage (ft):
Measurement End Time (hh:mm):	End Stage (ft):
Measured Discharge (cfs):	Measurement saved? Y / N

Average of transect measurements (cfs)

--

Individual measurement minus average divided by average = percent difference

If any single measurement is >5% different than the average, repeat 4 transect measurements.

Notes

Stage should be measured from staff plate.

Additional Observations or Comments

--

Qualitative Field Assessment of Flow

Cross Section Condition	
Velocity Conditions	
Equipment Operation	
Distribution of flow across sections	
Change in Stage	
Wind	
Overall Assessment	Excellent Good Fair Poor

Qualitative Conditions	Ideal	Non-Ideal
Cross-section condition	<ul style="list-style-type: none"> -smooth, stable channel -uniform depths across channel -deep enough for equipment" -relatively straight channel -no upstream obstruction altering flow paths 	<ul style="list-style-type: none"> -loose or unstable channel -too shallow for propeller -large rocks or debris affecting flow paths
Velocity	<ul style="list-style-type: none"> -uniform across channel -perpendicular to cross-section -high enough velocity for sensor 	<ul style="list-style-type: none"> -large back-eddies -too fast for accurate depth -turbulent
Equipment	<ul style="list-style-type: none"> - No error warnings - Ideal water depth, no debris 	<ul style="list-style-type: none"> - Error warnings from sensor (variability or angle) - Shallow water or debris interference
Distribution of flow	-no single section with more than 5% of the flow	<ul style="list-style-type: none"> -5-10% in any section=fair ->10%=poor
Change in stage	-stable or small change in stage during measurement	-change of more than 0.1 ft. during measurement
Wind	-calm or no effect	<ul style="list-style-type: none"> -wind altering current direction -wind affecting depth measurements