SYSTEM OPERATIONAL REQUEST: #2021-1

WALLA WALLA DISTRICT

The following State, Federal, and Tribal Salmon Managers have participated in the preparation and support this SOR: Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration, Nez Perce Tribe, Yakama Nation, Confederated Tribes of the Colville Reservation, Spokane Tribe of Indians, and the Columbia River Inter-Tribal Fish Commission.

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FROM: Charles Morrill, FPAC Chair

DATE: February 2, 2021

SUBJECT: Dworshak Load Shaping

SPECIFICATIONS: The fishery managers recommend cessation of within day load shaping operations at Dworshak Dam.

JUSTIFICATION: Within day load shaping operations at Dworshak Dam were implemented January 25 – 29, 2021 (Attachment 1) with likely impacts to treaty and non-treaty fisheries, ESA-listed juvenile fall Chinook, hatchery operations, and riverine ecological function. Daily load shaping operations occur when water releases through turbines are minimized during periods of low power demand (market value), typically nighttime, and subsequently increased when demand (market value) is high, typically daytime. Daily load shaping operations have not been implemented at Dworshak dam since 1986 and consideration for contemporary use was not coordinated with Fishery Managers.

Flow increases were started each day about 4:00am, with peak flows occurring between 8:00am and 5:00pm. Base flows were ~1,600cfs and peak discharges were ~9,700cfs. These flow fluctuations occur in the North Fork Clearwater River with very little delay, however flows in downstream areas (i.e. Spaulding) do not increase until 10:00am, with peak flows reached by 1:00pm (Figures 1 and 2). Flows from the Clearwater River upstream of its confluence with the North Fork Clearwater River were ~2,900cfs. The load shaping releases nearly tripled flows in the lower Clearwater River.

End of month Flood Risk Management (FRM) pool elevation targets have guided project discharges for several decades, increases in discharge are typical over the last several days of the month to reach FRM target elevation. The Dworshak Dam January FRM elevation was 1,533 feet. Holding Dworshak discharge at minimum flows (1,600cfs) for most of January resulted in a pool elevation on January 24 of 1,534.8 feet. After the five days of load shaping operations, Dworshak pool elevation was at 1,531.7 feet (1.3 feet lower than the FRM target).

Corps of Engineers' January final snowpack estimates for the North Fork Clearwater basin was 117%. Their February final snowpack estimate is 100% of average. The current forecast from the NOAA River Forecast Center (RFC) is 88% of average.

Impacts on Treaty and Non-Treaty Fisheries

Nez Perce Tribe treaty fisheries for steelhead in the Clearwater river drainage typically occur from August through March, with substantial effort and harvest occurring in the North Fork Clearwater River. The Tribe expects that most of the harvest of steelhead in the Clearwater drainage occurs at this on-Reservation fishery area in the North Fork Clearwater (between the mouth and the Dworshak Dam) during this time of year.

Generally, 75% of the Tribe's harvest of steelhead from the North Fork Clearwater River occurs in January through March. It is expected that dramatic fluctuations in flow discharge that results from power peaking operations will affect Nez Perce treaty catch rates of steelhead. Fishery effort and harvest effectiveness will likely be impacted to some degree by the changes in Dworshak Dam flow. The degree of impact is not known at this time, given we do not have experience with these types of daily flow discharges and how that affects the fishery.

We would expect that these flow fluctuations--as dramatic the amplitude and timing of them--will in all likelihood change fish movement and behavior as well as those of the tribal members

who may be fishing during these kind of operations. This will disrupt treaty fishing at a critical time and area when tribal members are fishing for steelhead for food and other uses.

Flow fluctuations would be experienced by fishers in the North Fork Clearwater River with very little delay, however tribal fishers and sport anglers in downstream areas (i.e. Spaulding) would not experience flow increases until 10:00am with peak flows reached by 1:00pm (Figures 1-3). Water level increased 2 feet during that period.

Impacts on Juveniles

ESA listed fall Chinook salmon spawn throughout the Clearwater River basin, including but not limited to, the North Fork Clearwater River and Clearwater River downstream of Orofino. Fall Chinook spawning generally occurs when river flows, including Dworshak releases, are at their lowest level. As such, Dworshak release fluctuations, after December, do not create a redd dewatering risk. However, flow fluctuations after fall Chinook fry emerge from the gravel can impact juvenile rearing location and survival. Emergence timing is influenced by spawning date and water temperature, with fry emerging between late January and May. The earliest emergence occurs from redds in the North Fork Clearwater and areas immediately downstream of the confluence of the North Fork Clearwater River and Clearwater rivers (Attachment 2[1]). The 2020 CRSO Biological Opinion (Page 629, Table 2.5-11) did <u>not</u> assess daily load shaping operations, concluding "The proposed changes to reservoir operations at Dworshak Dam will not affect the functioning of water quantity in the spawning and rearing areas". Counter to the BiOp assessment of effects on critical habitat, the load following operation substantially alters water quantity in rearing areas.

Impacts on Hatcheries

Four hatchery facilities operate in the Clearwater basin downstream of Dworshak Dam. The water quantity and quality of Dworshak releases impact three of these hatcheries.

<u>Big Canyon Fall Chinook Acclimation Ponds (FCAP)</u> – This fall Chinook acclimation site uses portable water intake tubes that are highly influenced by river volume and require adjustments as flows change. After the facility is set up in March, intake hoses are manually adjusted by staff, hoses are extended into the river as flows drop and shortened as flows increase. Load shaping flows would increase risk of pump failure and risk of acclimation staff injury.

<u>Dworshak Hatchery</u> – The primary water intake for Dworshak Hatchery pulls water from the North Fork Clearwater River, downstream of Dworshak Dam. Abrupt flow increases dislodge algae and other materials which then accumulate on intake screens and requires continual cleaning by hatchery staff for hours after the flow change. The intensity of screen cleaning may decrease if flow changes are repeated daily, but will still require close monitoring. In addition, some dislodged algae makes it into the fish rearing vessels and may be a contributing factor in disease outbreaks.

[1] Analysis of the 2020 spawn timing and redd distribution, and 2021 emergence timing is ongoing. Temperature Unit (TU) accumulation is very similar to that observed in 2016/17. Redd surveys in the North Fork Clearwater were canceled due to weather conditions.

Nez Perce Tribal Hatchery (NPTH) - The Clearwater River is the primary water source for Nez Perce Tribal Hatchery; Dworshak released water influences the NPTH water temperature. Fluctuating water volumes from Dworshak Dam increases the variably in lower Clearwater River water temperatures requiring additional monitoring and potentially manipulation of NPTH water temperature with chillers.

Impacts on Riverine Ecological Function

Load following operations cause abrupt changes in water velocity and water levels with widely documented negative impacts on many aspects of river ecosystems (Cushman 1985; Melcher et al. 2017). For example, these type of operations can alter fish habitat use (e.g., Scruton et al. 2003) and growth rates (e.g., Korman and Campana 2009), change patterns of macroinvertebrate drift (e.g., Miller and Judson 2014), and decrease primary production (e.g., Hall et al. 2015).

References

Cushman, R. M. 1985. Review of ecological effects of rapidly varying flows downstream from hydroelectric facilities. North American Journal of Fisheries Management 5:330-339.

Hall, R. O., C. B. Yackulic, T. A. Kennedy, M. D. Yard, E. J. Rosi-Marshall, N. Voichick, and K. E. Behn. Turbidity, light, temperature, and hydropeaking control primary productivity in the Colorado River, Grand Canyon. Limnology and Oceanography 60:512-526.

Korman, J. and S. E. Campana. 2009. Effects of hydropeaking on nearshore habitat use and growth of age-0 rainbow trout in a large regulated river. Transactions of the American Fisheries Society 138:76-87.

Melcher, A. H., T. H. Bakken, T. Friedrich, F. Greimel, N. Humer, S. Schmutz, B. Zeiringer, and J. A. Webb. 2017. Drawing together multiple lines of evidence from assessment studies of hydropeaking pressures in impacted rivers. Freshwater Science 36:220-230.

Miller, S. M., and S. Judson. 2014. Responses of macroinvertebrate drift, benthic assemblages, and trout foraging to hydropeaking. Canadian Journal of Fisheries and Aquatic Sciences 71: 675-687.

Scruton, D. A., L. M. N Ollerhead, K. D. Clarke, C. Pennell, K. Alfredsen, A. Harby, and D. Kelley. 2003. The behavioural response of juvenile Atlantic salmon (Salmo salar) and brook trout (Salvelinus fontinalis) to experimental hydropeaking on a Newfoundland (Canada) river. River Research and Applications 19:577-587.

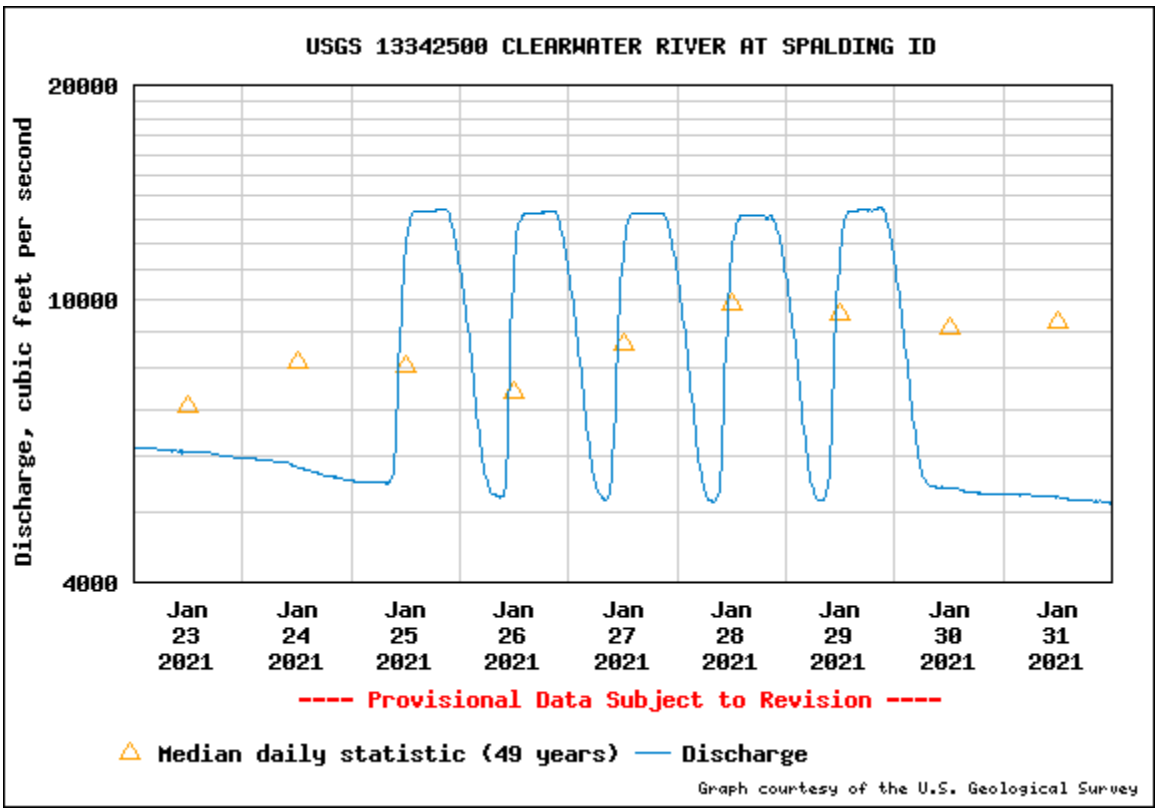

Figure 1. Discharge of the Clearwater River at Spaulding, ID (USGS data - https://waterdata.usgs.gov/id/nwis/uv/?site_no=13342500&PARAmeter_cd=00065,00060,00010).

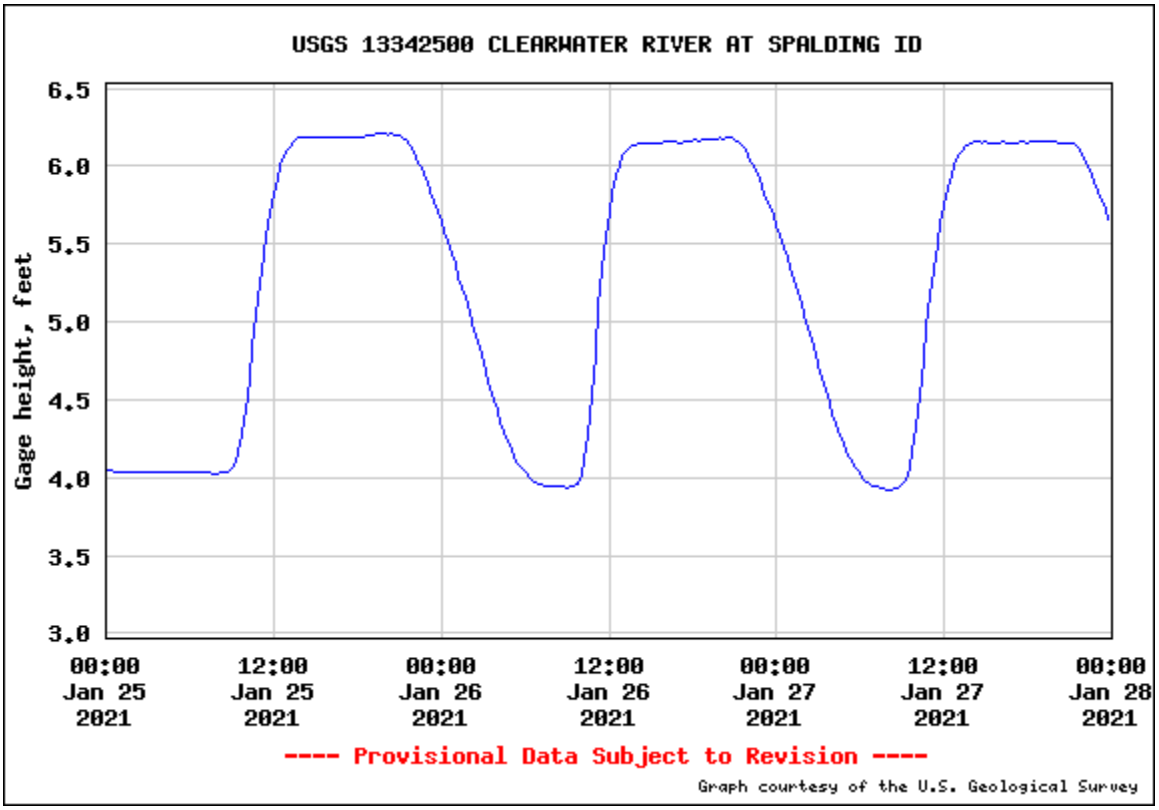

Figure 2. Gage height measured for the Clearwater River at Spaulding, ID showing the timing of water level increases.

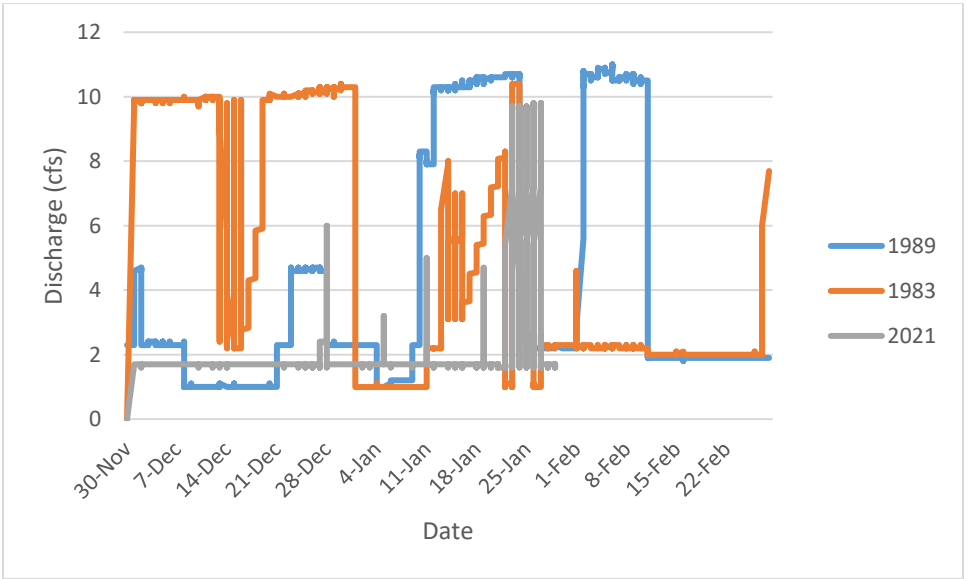

Figure 3. Winter operations in 2021 compared to 1983-1984 (load following period) and 1989-1990 (post-load following period).

Attachment 1

Increased Dworshak Operation Summaries Jan 25-29,2021

Monday Jan 25, 2021

Hour	Total Outflow kcfs	Generation Flow kcfs	Spill kcfs	Forebay Elevation	Tailwater Elevation	Average Head	Peck Gage Elevation
1	1.70	1.60	0.00	1534.85	970.80	564.05	4.67
2	1.70	1.60	0.00	1534.82	970.79	564.03	4.67
3	1.70	1.60	0.00	1534.83	971.19	563.64	4.67
4	3.70	3.60	0.00	1534.82	973.61	561.21	4.67
5	5.40	5.30	0.00	1534.81	975.25	559.56	5.40
6	7.20	7.10	0.00	1534.78	976.51	558.27	6.13
7	8.40	8.30	0.00	1534.73	977.70	557.03	6.73
8	9.70	9.60	0.00	1534.67	978.03	556.64	7.15
9	9.60	9.50	0.00	1534.63	977.97	556.66	7.49
10	9.60	9.50	0.00	1534.58	978.02	556.56	7.49
11	9.60	9.50	0.00	1534.54	977.99	556.55	7.49
12	9.60	9.50	0.00	1534.47	978.00	556.47	7.47
13	9.60	9.50	0.00	1534.42	977.99	556.43	7.47
14	9.70	9.60	0.00	1534.37	978.04	556.33	7.47
15	9.70	9.60	0.00	1534.30	978.04	556.26	7.47
16	9.70	9.60	0.00	1534.27	978.11	556.16	7.50
17	9.50	9.40	0.00	1534.22	977.29	556.93	7.50
18	8.10	8.00	0.00	1534.19	976.66	557.53	7.50
19	7.10	7.00	0.00	1534.15	975.90	558.25	7.50
20	5.40	5.30	0.00	1534.13	975.03	559.10	7.02
21	3.60	3.50	0.00	1534.13	972.49	561.64	6.69
22	1.60	1.50	0.00	1534.13	970.85	563.28	5.52
23	1.60	1.50	0.00	1534.14	970.79	563.35	5.52
24	1.60	1.50	0.00	1534.14	970.77	563.37	4.74
AVG	6.46	6.36	0.00	1534.46	975.33	559.14	6.50
MAX	9.70	9.60	0.00	1534.85	978.11	564.05	7.50
MIN	1.60	1.50	0.00	1534.13	970.77	556.16	4.67

Tuesday Jan 26, 2021

Hour	Total Outflow kcfs	Generation Flow kcfs	Spill kcfs	Forebay Elevation	Tailwater Elevation	Average Head	Peck Gage Elevation
1	1.60	1.50	0.00	1534.14	970.78	563.36	4.55
2	1.60	1.50	0.00	1534.16	970.78	563.38	4.55
3	1.60	1.50	0.00	1534.15	970.77	563.38	4.55
4	2.20	2.10	0.00	1534.15	972.59	561.56	4.55
5	4.60	4.50	0.00	1534.13	975.00	559.13	4.63
6	7.30	7.20	0.00	1534.10	976.63	557.47	4.63
7	8.40	8.30	0.00	1534.09	977.60	556.49	6.70
8	9.70	9.60	0.00	1534.02	978.01	556.01	7.09
9	9.60	9.50	0.00	1533.97	977.86	556.11	7.44
10	9.60	9.50	0.00	1533.91	977.98	555.93	7.46
11	9.70	9.60	0.00	1533.88	978.02	555.86	7.46
12	9.60	9.50	0.00	1533.84	978.02	555.82	7.46
13	9.70	9.60	0.00	1533.78	978.06	555.72	7.46
14	9.70	9.60	0.00	1533.75	978.09	555.66	7.46
15	9.70	9.60	0.00	1533.69	978.02	555.67	7.46
16	9.70	9.60	0.00	1533.63	978.02	555.61	7.46
17	9.50	9.40	0.00	1533.59	977.30	556.29	7.49
18	8.10	8.00	0.00	1533.55	976.62	556.93	7.49
19	7.10	7.00	0.00	1533.53	976.02	557.51	7.49
20	5.40	5.30	0.00	1533.52	974.77	558.75	6.99
21	3.60	3.50	0.00	1533.52	972.94	560.58	6.13
22	1.70	1.60	0.00	1533.52	970.88	562.64	5.49
23	1.60	1.50	0.00	1533.52	970.79	562.73	5.49
24	1.60	1.50	0.00	1533.54	970.77	562.77	4.75
AVG	6.37	6.27	0.00	1533.82	975.26	558.56	6.34
MAX	9.70	9.60	0.00	1534.16	978.09	563.38	7.49
MIN	1.60	1.50	0.00	1533.52	970.77	555.61	4.55

Wednesday Jan 27, 2021

Hour	Total Outflow kcfs	Generation Flow kcfs	Spill kcfs	Forebay Elevation	Tailwater Elevation	Average Head	Peck Gage Elevation
1	1.60	1.50	0.00	1533.54	970.80	562.74	4.56
2	1.60	1.50	0.00	1533.54	970.77	562.77	4.56
3	1.70	1.60	0.00	1533.54	971.38	562.16	4.56
4	3.70	3.60	0.00	1533.53	973.53	560.00	4.56
5	5.50	5.40	0.00	1533.51	975.21	558.30	5.36
6	7.20	7.10	0.00	1533.48	976.52	556.96	6.09
7	8.30	8.20	0.00	1533.42	977.54	555.88	6.71
8	9.70	9.60	0.00	1533.39	977.95	555.44	6.71
9	9.70	9.60	0.00	1533.32	978.02	555.30	7.46
10	9.60	9.50	0.00	1533.29	977.96	555.33	7.48
11	9.60	9.50	0.00	1533.24	977.98	555.26	7.45
12	9.70	9.60	0.00	1533.18	978.01	555.17	7.45
13	9.60	9.50	0.00	1533.12	977.97	555.15	7.45
14	9.70	9.60	0.00	1533.08	978.05	555.03	7.45
15	9.70	9.60	0.00	1533.02	978.01	555.01	7.45
16	9.70	9.60	0.00	1533.00	978.02	554.98	7.45
17	9.60	9.50	0.00	1532.90	977.41	555.49	7.47
18	8.10	8.00	0.00	1532.90	976.62	556.28	7.47
19	7.10	7.00	0.00	1532.86	975.91	556.95	6.95
20	5.30	5.20	0.00	1532.85	974.70	558.15	6.63
21	3.50	3.40	0.00	1532.86	972.40	560.46	6.08
22	1.70	1.60	0.00	1532.85	970.81	562.04	5.44
23	1.60	1.50	0.00	1532.85	970.74	562.11	5.44
24	1.70	1.60	0.00	1532.86	970.76	562.10	4.68
AVG	6.47	6.37	0.00	1533.17	975.29	557.88	6.37
MAX	9.70	9.60	0.00	1533.54	978.05	562.77	7.48
MIN	1.60	1.50	0.00	1532.85	970.74	554.98	4.56

Thursday Jan 28, 2021

Hour	Total Outflow kcfs	Generation Flow kcfs	Spill kcfs	Forebay Elevation	Tailwater Elevation	Average Head	Peck Gage Elevation
1	1.60	1.50	0.00	1532.86	970.74	562.12	4.51
2	1.60	1.50	0.00	1532.86	970.73	562.13	4.51
3	1.80	1.70	0.00	1532.86	971.52	561.34	4.53
4	3.70	3.60	0.00	1532.85	973.68	559.17	4.53
5	5.50	5.40	0.00	1532.83	975.37	557.46	5.35
6	7.20	7.10	0.00	1532.78	976.41	556.37	5.35
7	8.30	8.20	0.00	1532.75	977.39	555.36	6.70
8	9.80	9.70	0.00	1532.69	978.00	554.69	7.07
9	9.70	9.60	0.00	1532.64	977.96	554.68	7.45
10	9.60	9.50	0.00	1532.59	977.96	554.63	7.45
11	9.70	9.60	0.00	1532.55	977.95	554.60	7.45
12	9.70	9.60	0.00	1532.50	978.04	554.46	7.45
13	9.70	9.60	0.00	1532.46	978.01	554.45	7.45
14	9.70	9.60	0.00	1532.39	977.99	554.40	7.42
15	9.70	9.60	0.00	1532.36	978.05	554.31	7.42
16	9.80	9.70	0.00	1532.30	978.04	554.26	7.42
17	9.70	9.60	0.00	1532.26	977.63	554.63	7.44
18	8.20	8.10	0.00	1532.22	976.77	555.45	7.44
19	7.10	7.00	0.00	1532.18	975.78	556.40	7.38
20	5.40	5.30	0.00	1532.15	975.17	556.98	7.38
21	3.70	3.60	0.00	1532.13	972.85	559.28	6.61
22	1.70	1.60	0.00	1532.14	970.88	561.26	6.10
23	1.60	1.50	0.00	1532.17	970.77	561.40	6.10
24	1.60	1.50	0.00	1532.15	970.77	561.38	4.72
AVG	6.50	6.40	0.00	1532.49	975.35	557.13	6.47
MAX	9.80	9.70	0.00	1532.86	978.05	562.13	7.45
MIN	1.60	1.50	0.00	1532.13	970.73	554.26	4.51

Friday Jan 29, 2021

Hour	Total Outflow kcfs	Generation Flow kcfs	Spill kcfs	Forebay Elevation	Tailwater Elevation	Average Head	Peck Gage Elevation
1	1.70	1.60	0.00	1532.18	970.81	561.37	4.72
2	1.70	1.60	0.00	1532.16	970.79	561.37	4.55
3	1.70	1.60	0.00	1532.17	971.20	560.97	4.55
4	3.70	3.60	0.00	1532.15	973.55	558.60	4.61
5	5.40	5.30	0.00	1532.15	975.11	557.04	4.61
6	7.20	7.10	0.00	1532.12	976.25	555.87	4.61
7	8.30	8.20	0.00	1532.07	977.53	554.54	6.12
8	9.80	9.70	0.00	1532.01	978.01	554.00	6.71
9	9.70	9.60	0.00	1531.96	977.99	553.97	7.50
10	9.60	9.50	0.00	1531.92	977.96	553.96	7.52
11	9.70	9.60	0.00	1531.87	978.07	553.80	7.52
12	9.70	9.60	0.00	1531.83	977.99	553.84	7.52
13	9.70	9.60	0.00	1531.78	977.99	553.79	7.52
14	9.70	9.60	0.00	1531.74	978.06	553.68	7.52
15	9.70	9.60	0.00	1531.67	978.01	553.66	7.52
16	9.80	9.70	0.00	1531.60	978.03	553.57	7.52
17	9.60	9.50	0.00	1531.56	977.50	554.06	7.51
18	8.30	8.20	0.00	1531.54	976.84	554.70	7.57
19	7.50	7.40	0.00	1531.50	975.83	555.67	7.57
20	5.50	5.40	0.00	1531.49	975.05	556.44	7.13
21	3.70	3.60	0.00	1531.47	973.20	558.27	6.87
22	2.00	1.90	0.00	1531.49	971.14	560.35	6.87
23	1.70	1.60	0.00	1531.50	970.76	560.74	5.61
24	1.60	1.50	0.00	1531.50	970.76	560.74	4.96
AVG	6.54	6.44	0.00	1531.81	975.35	556.46	6.45
MAX	9.80	9.70	0.00	1532.18	978.07	561.37	7.57
MIN	1.60	1.50	0.00	1531.47	970.76	553.57	4.55

Attachment 2

TO: Technical Management Team

FR: Nez Perce Tribe Department of Fisheries Resources Management and the Idaho Fish and Wildlife Conservation Office, U. S. Fish and Wildlife Service

RE: Fall Chinook Salmon Fry Emergence Timing along the Clearwater River lower reach – 2016/2017 post-season update

DATE: December 7, 2017

This is an update to our September 26, 2016 and March 18, 2017 memorandums on the timing of fall Chinook salmon fry emergence downstream of Dworshak Dam, specific to actual 2016/17 river temperatures that occurred during the entire incubation period. We previously had put together of a range of fry emergence timing estimates for fall Chinook salmon in the Clearwater River lower reach. That reach extends from the confluence of the North Fork Clearwater (N.F.) down to the upper end of the east arm of Lower Granite Reservoir. We also estimated fry emergence timing within the North Fork Ahsahka Islands stretch that extends from Dworshak Dam to the Ahsahka Island complex that is situated at the mouth of the North Fork Clearwater River and the upper end of the Clearwater River lower reach. In the March 18 memo, we estimated fry emergence using river temperatures that was similar during initial 2016/2017 fall Chinook incubation water temperatures (03/06/2009 to 06/01/2009). Actual temperature data after 03/06/17 was warmer than 2009 temperatures which resulted in earlier emergence timing estimates in the Clearwater River lower reach and to a lesser extent in the North Fork Ahsahka Island stretch.

Spatial Distribution of Redds

Manned helicopter flights that covered the Clearwater River lower reach and the North Fork Ahsahka Island stretch were made on 09/28/2016, 10/10/2016, 10/24/2016, and 11/07/2016. Redds constructed after 11/07/2016 were not counted because scheduled flights were canceled due to inclement weather. However, redds constructed after the last flight on 11/07/2016 were estimated and spawning in near completion by 11/30/2016 which we assumed as the last spawn date. To estimate potential redds missed on the mainstem Clearwater and N.F., we averaged previous 5 years' actual counts up to 07 November and calculated a percentage of overall redds counted to that date (average of 0.573), then applied that percentage to 1,900 to get an estimate of 3,316 redds, or 1,416 redds missed. We believe this is a conservative estimate since conditions were only "good" on 07 November and redds in deep water spawning areas were difficult to see.

Of the estimated total of 3,316 redds, 92.2% (n = 3,058) and 7.8% (n = 258) were estimated along the Clearwater River lower reach and the North Fork Ahsahka Islands stretch, respectively. Of the 258

redds estimated along the North Fork Ahsahka Islands stretch, 93.4% (n = 241) were counted around the islands, and 6.6% (n = 17) were estimated along the North Fork Clearwater River.

Mean Daily Water Temperature

Mean daily temperature data were downloaded for the period 09/28/2016 to 06/30/2017 from the USGS Spalding gauge located along the lower end of the Clearwater River lower reach and from Dworshak Dam water quality monitor for the N.F. Clearwater River.

The amount of influence water released from Dworshak Dam has on developing embryos along the North Fork Ahsahka Islands stretch is dependent on where the redds are located. Redds located along the North Fork Clearwater River, and the north channel of the islands, are highly affected by Dworshak Dam operation compared to the redds located on southern, eastern, and western portions of the islands. The actual temperatures the embryos are exposed to have not been measured. For the purpose of this analysis, the redds were treated as one group and it was assumed that water temperature measured in the tailrace of Dworshak Dam represented the incubation temperatures in the redds. Likewise, water column temperatures measured at the Spalding gauge was assumed to represent incubation temperatures in the lower river.

Fry Emergence Timing in 2017

Emergence timing of fry was estimated separately for the Clearwater River lower reach and the North Fork Ahsahka Islands stretch by flight date. Starting on a given flight date, the daily mean water temperatures (^{0}C) were summed forward in time until the date that 1,000 temperature units were accumulated (i.e., the estimated fry emergence date). The number of redds counted during a given flight over each of the two spawning locations was divided by the 2016 total redd count made downstream of Dworshak Dam. The resulting quotients were assumed to be directly proportional to the number of fry produced, and are referred to hereafter as "percentages of the modeled fry population."

The percentages of the modeled fry population that were estimated to emerge from redds along the North Fork Ahsahka Islands stretch paired with estimated emergence dates were 0.6% on 01/25/2017 (the onset), 2.1% on 02/16/2017 (the peak), 1.7% on 03/16/2017, 0.1% on 04/14/2017 and 3.3% on 05/23/2017 (close to completion; Figure 1).

The percentages of the modeled fry population that were estimated to emerge from redds along the Clearwater River lower reach paired with estimated emergence dates were 2.2% on 03/16/2017 (close to the onset), 4.0% on 04/10/2017, 9.7% on 04/30/2017, 36.9% on 05/16/2017, and 39.4% on 06/03/2017 (close to completion; Figure 1).

Another view of the same fry emergence data as a cumulative percentage in each of the North Fork Ahsahka Islands stretch and the Clearwater River lower reach is presented in Figure 2.

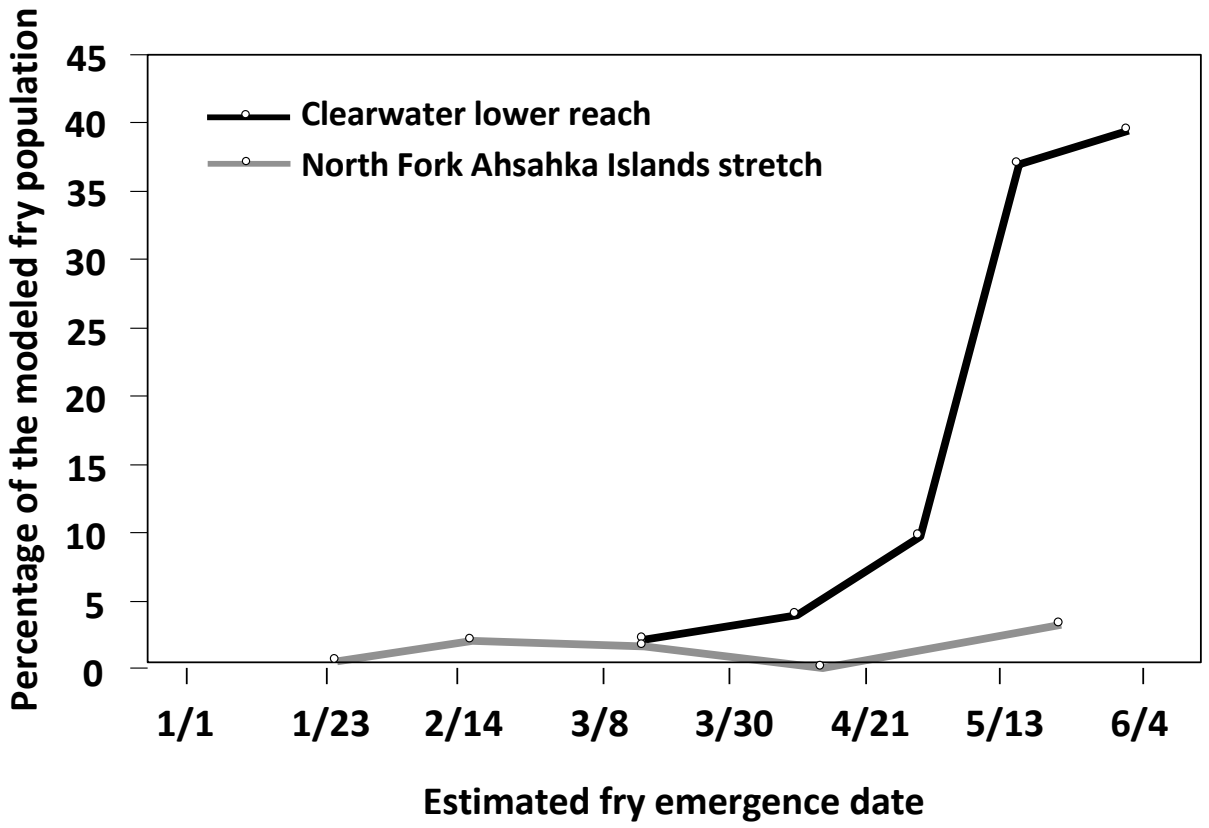

Figure 1.—The percentage of the modeled fall Chinook salmon fry population downstream of Dworshak Dam (y axis) plotted against estimated dates of emergence from redds (x axis) counted along the Clearwater River lower reach, and the North Fork Ahsahka Islands stretch, 2017. (See the text for specific percentage-date pair values).

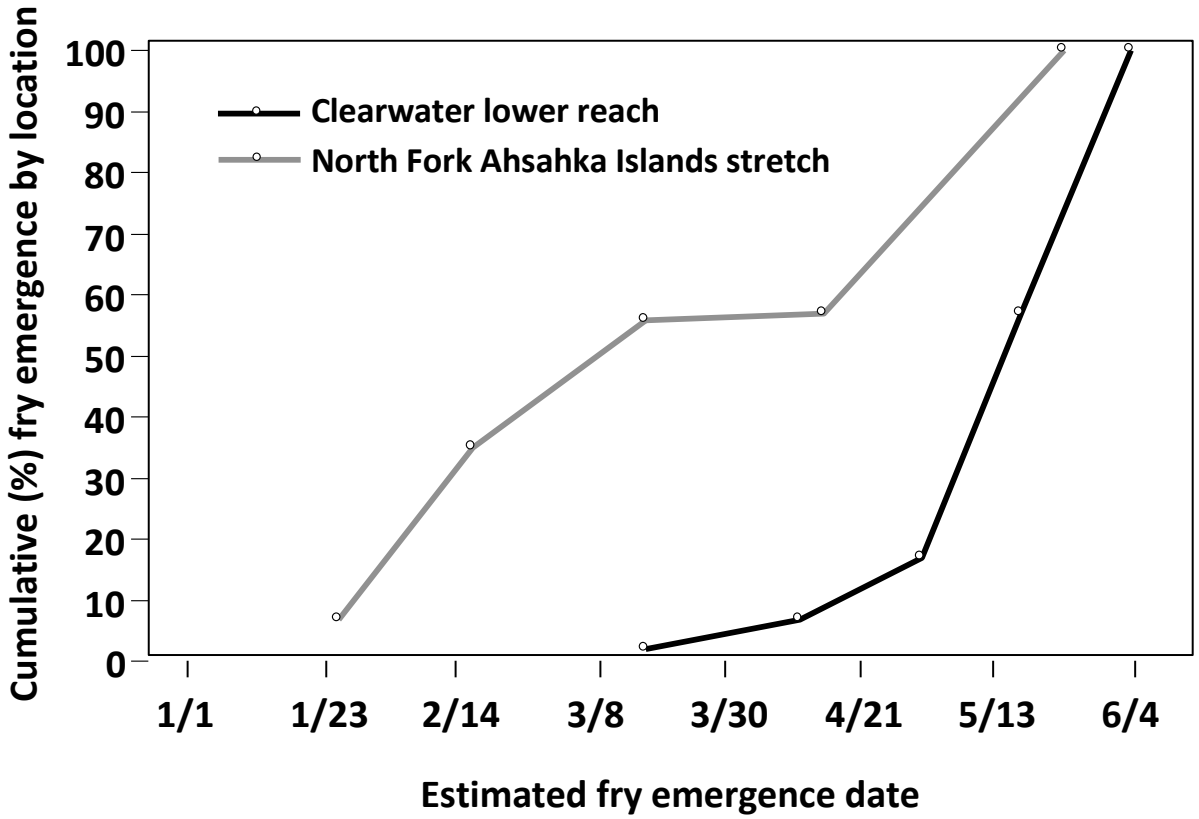

Figure 2.—The cumulative (%) emergence distributions modeled for fall Chinook salmon fry downstream of Dworshak Dam (y axis) plotted separately for the Clearwater River lower reach, and the North Fork Ahsahka Islands stretch against estimated emergence dates from redds (x axis), 2017.