CALIFORNIA DEPARTMENT OF FISH AND GAME
Northern Region
601 Locust Street
Redding, CA 96001

TECHNICAL MEMORANDUM

February 26, 2009

To: Mr. Mark Stopher, Environmental Program Manager

From: Mr. Mark Hampton, Environmental Scientist

Subject: Preliminary Evaluation of the Hart Bypass as Proposed in Siskiyou County's Congressional Briefing Paper: Solutions and Alternatives for the Klamath River

Introduction

On August 12, 2008, Siskiyou County released a Congressional Briefing Paper: Solutions and Alternatives for the Klamath River. The Congressional Briefing Paper expresses a concern of the County that "Despite much being done through the FERC process and other agencies' interest in the dams, crucial data gaps exist. Most glaringly lacking in research are strategies that could mitigate the dams' impacts to cold water fisheries and water quality. Filling in these "blanks" and diligently exploring all reasonable alternatives gives the necessary assurances that policy and science will not be stampeded."

One of the strategies identified by the County in their Congressional Briefing Paper, apparently as an alternative to dam removal or construction of fish ladders over the dams, is the development of a fish bypass channel (Hart Bypass) around Iron Gate, Copco 1 and Copco 2 Dams. The County alternative suggests that anadromous fish could avoid the dams by migrating up Bogus Creek to the upper reaches of Cold Creek, at which point migrating fish would enter a newly constructed channel or "fish ditch" that would provide fish passage in a downstream direction from Cold Creek to Deer Creek. Deer Creek lies to the east of Cold Creek, in the adjoining watershed, and flows into Copco Reservoir. Once adult salmon and steelhead pass through this "fish ditch" it is anticipated that they would then swim down Deer Creek, approximately 2.2 miles, to Copco Reservoir and continue their migration up the Klamath River.

The purpose of this technical memorandum is to conduct a preliminary analysis of the physical and biological factors that may help decision makers determine whether a project of this type merits additional consideration. To accomplish this purpose, the memorandum provides: 1) a brief physical description of the condition of the three water ways identified in the alternative; 2) a brief discussion of the behavior patterns and

migratory requirements of adult anadromous salmonids; and, 3) draws conclusions as to whether of not the proposed alternative is likely to satisfy these biological requirements. Although Pacific Lamprey (*Lampetra tridentata*) is an important species for tribal and ecological purposes, this analysis is limited to the three anadromous salmonid species, Chinook salmon (*Oncorhynchus tshawtscha*), coho salmon (*Oncoryhchus kisutch*) and steelhead trout (*Oncorhynchus mykiss*). Further, it considers only the migration of adult salmonids. Downstream outmigration of juvenile salmonids is not addressed in this memorandum.

Project Area and Instream Conditions Related to Fish Passage

Bogus Creek is located on the south east side of the Klamath River just downstream of Iron Gate Hatchery (river mile 189.6) in Siskiyou County, California. Bogus Creek is a small third order stream and drains a watershed of approximately 54 square miles. The headwaters of the creek originate in the Klamath National Forest northwest of Willow Creek Mountain (Township 46 N, Range 4 W, Section 23 MDBM) at an elevation of 5,197 feet. The upper reaches of the creek, from its headwater to the confluence of Cold Creek, flows in a northerly direction through a steep sided canyon for about 9.6 miles and has an average stream gradient of approximately 259 feet per mile (4.9%). This upper section provides habitat for steelhead trout and various native and non-native resident species. The steep gradient, smaller channel and reduced stream flows during the spawning season prevent any significant use of this reach by spawning Chinook and coho salmon.

The lower section of Bogus Creek, downstream from the confluence of Cold Creek, generally flows in a westerly direction for an additional 4.88 miles through mostly private lands. The gradient in this reach is more gradual and ranges from about 58 feet per mile to 176 feet per mile (1.1% - 3.3%). The channel width ranges from 3 to 25 feet and averages about 15 feet. Depths range from a few inches over riffles to about 4 feet in the deeper pools. Although the channel is generally bedrock confined, there are some alluvial features that contain suitable cobble and gravel substrates for spawning salmonids.

Prior to the construction of a concrete fish ladder in 1963, a 22 foot high waterfall, located approximately 3.46 miles upstream from the mouth, prevented anadromous salmonids from accessing the creek further upstream. There also are two smaller cascading falls about 4 to 5 feet in height in the lower reach downstream of the fish ladder and adult salmonids are able to pass over these obstacles with little difficulty.

There are no stream gages present on the creek and an accurate description of the annual hydrograph is unavailable. However, flows are generally characteristic of snowmelt hydrograph in the spring. Seasonal rain storms during the late fall and winter can cause large short term (flashy) increases in flow of several hundred cubic feet per second (cfs) within a matter of hours. Numerous springs in the watershed provide consistent base flows during the summer and fall. A small staff gage is present in the lower section of the creek just upstream of the bridge adjacent to Iron Gate Hatchery and a base flow

rating curve for this staff gage has been developed by PacifiCorp and the Department's Klamath River Project. Monitoring of the staff gage by the Department during the late summer and fall indicate that base flows typically range from about 5 cfs in August to 20 cfs in November. Based on only a couple of discharge measurements that have been conducted during the winter and spring, typical base flows during this period are estimated to range between 40 and 60 cfs.

Cold Creek is the largest tributary to Bogus Creek and is a second order stream which drains approximately 10.2 square miles along the eastern boundary of the Bogus Creek watershed. The main branch of the creek is approximately 5 miles in length, and from its headwaters, the creek generally flows in a westerly direction until entering Bogus Creek at stream mile 4.88. The channel width typically ranges from 6 to 8 feet. Depths range from a few inches to 3 feet and averages from 8 to 12 inches. The stream gradient for the lower four miles of the creek is about 206 feet per mile (3.9%). There are numerous springs that contribute cold water to the base flow of Cold Creek under natural conditions. However, as described under the Cold Creek Decree[1] there are several irrigation water rights that divert much of this flow for other beneficial uses. Flows during the winter and spring are primarily provided by rain and snow melt from higher elevations. Cold Creek contributes the majority of flow to Bogus Creek during the late summer and fall, primarily due to flow contributions originating in the springs further upstream.

There are numerous obstacles to upstream migration for adult salmonids within Cold Creek. In 1972, with funding provided by the Wildlife Conservation Board, a Denil-Type fish ladder was constructed to pass fish over a 9 foot high falls located on lower Cold Creek at stream mile 0.6. Construction of this ladder, along with removal of additional debris jams in the creek the following summer, provided steelhead and coho salmon with an additional 1½ miles of spawning and rearing habitat. Currently it appears that anadromous salmonid access to Cold Creek is limited to the lower 2 miles. There is also a permanent diversion structure at stream mile 3.3 (Diversion No. 3 in the Cold Creek Decree) that appears to create another barrier to fish movement. Stream surveys that have been conducted in the past also note the presence of debris jams, low flow, and small channel as factors preventing movement of adult anadromous salmonids further upstream. The proposed location for the "fish ditch" as described in the Congressional Briefing Paper, appears to be near the current location of the Silva-Lennox Ditch near stream mile 4.

There are numerous unanswered questions that would need to be investigated regarding the source, volumes, and availability of water that would be required to effectively pass adult fish through an artificially constructed fish bypass canal at this location. Available water sources in Cold Creek are currently fully appropriated, the details of which are described in the Cold Creek Decree. The amount of water required to provide safe passage for thousands of adult salmon and steelhead through any fish bypass undoubtedly exceeds the amount of water currently available in Cold Creek or Deer Creek. Therefore, an alternate source would have to be obtained, possibly from the upper Klamath River.

[1] Cold Creek Adjudication, Decree No. 29348, Superior Court for Siskiyou County, July 5, 1978.

Such an endeavor would be a major undertaking and would require a substantial investment and additional analysis. Costs and benefits of such a proposal would need to be evaluated and compared to those alternatives already considered in the FERC process.

Deer Creek is located to the east of Cold Creek and generally runs from south to north, parallel to upper Cold Creek, and flows into Copco Reservoir at Keaton Cove. The headwaters of the creek originate below Surveyor's Glade northwest of Eagle Rock Peak in the Klamath National Forest. The creek is a second order stream, is approximately 6.4 miles long, and drains a watershed of about 7.4 square miles. The proposed "fish ditch" would provide a connection from Cold Creek to Deer Creek, at about stream mile 2.2. The gradient in lower Deer Creek, from the location of the proposed fish ditch downstream to Copco Reservoir, is approximately 355 feet per stream mile or 6.7%. Upstream of the proposed "fish ditch" the gradient increases dramatically to 691 feet per stream mile or 13.1%.

Little is known about the annual flow patterns that occur in Deer Creek, and it seems reasonable to assume that the annual hydrograph is based on snow melt. There are several springs that enter the creek from a tributary between steam mile 3 and 3.5, and contributions of these springs may provide some level of base flow stability to the stream during the summer and fall. However, comments submitted by local residents during the Cold Creek Adjudication proceedings, expressed concerns that Deer Creek flows would dry should Cold Creek diversions to Deer Creek cease. Based on these concerns it appears summer base flows in Deer Creek may be very low. Given the relatively short length and high gradients that are present in the watershed, the creek likely experiences rapid increases in flow during heavy rain storms or rain on snow events.

Based on the brief amount of information provided by the County in their Congressional Briefing Paper, the proposed location for the "fish ditch" appears to be near, or slightly upstream of the Silva-Lennox Ditch near stream mile 4. This location is currently beyond the known distribution of anadromous salmonids within Cold Creek and is well upstream of existing barriers to migration. Even if there were no barriers, inadequate stream flows and steep gradient in this reach currently restrict adult salmon and steelhead access to this location. In general, because of their larger size Chinook salmon tend to use larger river systems and tributary streams with adequate depths and flow much greater than those provided in upper Cold Creek. Chinook salmon also require adequate pool depths to leap over falls; pool depth should be equal to or greater than 1 ½ times the height of the falls. These criteria would be difficult to achieve in Cold Creek given the small channel and high gradient. Coho salmon migrations generally occur later in the year than Chinook salmon when stream flows tend to be higher which allows smaller coho salmon to access smaller streams. As a result coho salmon tend to spawn further upstream in smaller tributary streams with gradient generally less than 3%. Stream gradients in upper Cold Creek exceed this value and this is likely one of the factors that limit coho salmon distributions to the lower 2 miles of Cold Creek, well below the proposed location of the "fish ditch." The existing fish ladders, one on Bogus Creek and one on Cold Creek, are likely inadequate in size and flow volume to safely pass large numbers of adult salmon upstream. Additional analysis by experts in fish passage design

requirements should be conducted should a need for a more thorough analysis materialize.

Salmonid Migratory Behavior

Anadromy refers to the life history strategy whereby fish species are born in freshwater, travel to salt water environments to grow, and then return to their natal spawning grounds as adults to spawn, thus completing their life cycle. Anadromous salmonids are famous for their ability to return to their natal spawning grounds after traveling hundreds, if not thousands of miles from their place of birth through a variety of diverse habitats over a period of several years. Over the years extensive studies have been conducted on the migratory homing behavior of anadromous salmonids and conclude that this behavior, once in freshwater, is primarily driven by olfactory (smell) imprinting that occurs during parr smolt transformation as juvenile salmonids emigrate downstream from their natal stream of origin.[2] More recently, Dittman and Quinn (1996)[3] hypothesized that olfactory imprinting in wild salmon is controlled by thyroid endocrine activity which occurs in response to changing environmental conditions and early developmental life stages, not just during parr smolt transformation. This further explains how adult salmon manage to retrace their migration routes through various freshwater streams with differing chemical signatures allowing them to return to their precise origin of birth.

A clear understanding of this behavioral trait is applicable in determining whether or not the proposed Hart Bypass would provide a feasible alternative to provide anadromous fish passage around the lower three hydropower facilities on the Klamath River as suggested by Siskiyou County. Progeny of salmon born in the upper Klamath River would naturally imprint on the chemical signatures they experience during their emigration downstream. This would include those dominant chemical signatures provided first, in their natal stream, followed by those present in the upper Klamath River, the reservoirs, and changing chemical signatures they experience all the way downstream to the estuary. At no time during this emigration would young salmon and steelhead be exposed to those chemical signatures specific to Bogus Creek, Cold Creek, or Deer Creek. Without this specific imprinting experience, returning adult salmon and steelhead would not exhibit a behavioral trait to enter Bogus Creek to complete their migration upstream. Rather, these fish would likely enter Iron Gate Hatchery or remain at the base of Iron Gate Dam. Some of these fish would likely stray into Bogus Creek in

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[2] Hasler, A.D. and W. J. Wisby (1951). Discrimination of stream odors by fishes and relation to parent stream behavior. Am Nat. 85, 223-238.

Cooper, J.C., A.T. Scholz, R.M. Horrall, A.D. Hassler and D.M. Madison. (1976). Experimental confirmation of the olfactory hypothesis with artificially imprinted homing coho salmon (Oncorhynchus kisutch). J. Fish. Res. Bd Can. 33, 703-710.

Scholz, A.T., R. M. Horrall, J.C. Cooper, and A.D. Hasler. (1976). Imprinting to chemical cues: the basis for homestream selection in salmon. Science 192, 1247-1249.

[3] Dittman, A.H. and T. P. Quinn (1996). Homing in Pacific Salmon: mechanisms and ecological basis. School of Fisheries, Univ. Washington. Box 357980, Seattle, WA 98195.

desperation when sexual maturity requires them to spawn before they die. However, there is no evidence to suggest that these fish would actively enter Bogus Creek with the intention of migrating to the upper Klamath River. Therefore, the production potential provided in the Klamath River upstream of the hydropower projects would not be realized through a natural behavior.

Conclusion

The Hart Bypass concept was developed by local citizens of Siskiyou County for consideration as a potential alternative to dam removal or the construction of fish ladders over the lower three hydropower projects as currently required by FERC. This preliminary analysis was limited specifically to the biological feasibility of the proposed Hart Bypass and does not make any comparisons between the potential fishery benefits and impacts related to removal of the dams, or construction of fish ladders around the dams, with this proposal. There has been extensive analysis already conducted during the FERC process in those regards and additional analysis will undoubtedly continue into the future as negotiations continue related to the Agreement in Principle and the Klamath Basin Restoration Agreement.

Based on this preliminary analysis of the current physical constraints, the Hart Bypass does not appear to provide a simple alternative for passage of adult salmon and steelhead populations to the upper Klamath River. The proposed location of the fish bypass channel is currently beyond the known distribution of anadromous fish, and the migration route proposed does not currently provide the channel characteristics or flow volumes necessary to safely pass the large numbers of salmon and steelhead that are anticipated once habitats in the upper Klamath River basin become available. There is little doubt that an alternative source of water would have to be obtained, and that major investments in physical structures would be required to provide adequate fish passage around the three hydropower projects. Such an analysis is well beyond the purpose of this preliminary investigation. Regardless, even if adult salmon were physically capable of negotiating their way around the existing hydropower projects through the Hart Bypass, there is substantial biological evidence that returning adults would not choose to do so given their evolutionary development which is founded on the ability to imprint on chemical signatures through olfactory experiences obtained during their early life history experiences.

Although Siskiyou County states in their Congressional Briefing Paper that "Fish bypass strategies outside of conventional fish ladders have proven successful in other areas of the United States," a search of the literature failed to find any projects similar in nature to the one proposed. Although adult salmon have been shown to move both up and downstream in larger rivers, including the Klamath River, in our effort specific examples of adult salmon migrations swimming up small third and second order streams, crossing to another watershed, and then actively moving downstream to a larger river system could not be found. From a behavioral and evolutionary standpoint, it is doubtful, or extremely rare, that such opportunities exist in nature that would have provided conditions to support development of such an evolutionary strategy.

Although Pacific lamprey were not included in this preliminary analysis, many of the same physical constraints have been described for anadromous salmonids likely apply to this species as well. Should a more detailed analysis of this, or other similar fish passage projects be requested, passage requirements for lamprey should be fully addressed as well.