North Coast Regional Water Quality Control Board

TO: Shasta TMDL File
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DATE: February 10, 2023

SUBJECT: ANALYSIS OF MIKE PODLECH'S MEMO DATED JUNE 13, 2022, REGARDING CDFW INSTREAM FLOW RECOMMENDATIONS FOR THE 2022 READOPTION OF DROUGHT EMERGENCY RECOMMENDATIONS

On June 16, 2022, Darrin Mercier transmitted a memo on behalf of several Shasta River water rights holders for consideration during the June 21, 2022 hearing of the State Water Resources Control Board to consider the 2022 readoption of the Establishment of Minimum Instream Flow Requirements, Curtailment Authority, and Information Order Authority in the Klamath River Watershed (Title 23, Division 3, Chapter 2, sections 875.4, 875.8, 875.9 and Article 23.5, Sections 875, 875.1, 875.2, 875.3, 875.5, 875.6, and 875.7, hereafter Emergency Drought Regulations). According to Mr. Mercier's summary, the Podlech memo concludes that,

> *"Reducing the Yreka flow target to 30 cfs during summer would protect juvenile salmonids while enabling diverters lower in the watershed to exercise their rights and divert water that is, according to best available science, largely unsuitable for juvenile rearing. Then, at the beginning of September, these lower watershed users could reduce or cease their diversion to allow canyon flows to ramp up to CDFW-recommended 50 cfs prior to September 15th and to 75 cfs from September 15-30 to support early fall Chinook migration period. Mr. Podlech also provides justification for reducing early spring flow volumes for minimum drought conditions."*

Mr. Podlech relies primarily on his evaluation of McBain and Trush, Inc, 2014 (M&T) (2014[1]) and Null et al. (2010). M&T (2014) attempted to develop in-stream flow needs for all life stages of salmonids in the Shasta River canyon. To estimate summer needs, M&T (2014) used the following methods.

- 2-D modelling and direct habitat mapping to develop and validate habitat rating curves and to estimate streamflows, which provide extensive, high quality habitat for juvenile salmonids.
- Use of photo documentation to identify hydraulic thresholds in pools and runs capable of providing high quality salmonid rearing habitat for juveniles. a
- Evaluate existing streamflow and daily maximum water temperature data to estimate if recommended streamflows maintain water temperatures below lethal thresholds.

What follows are:

- responses to several key assertions made in the Podlech memo, and
- an analysis that compares temperature metrics derived from the data record that are associated with three different flow scenarios: a baseline drought year (2021), when irrigation was occurring without restriction, resulting in an average flow of 18.5 cfs; an analagous ~30 cfs real-world flow scenario recommended in the Podlech Memo (2018); and the conditions that resulted from the implementation of the 2022 Emergency Drought Regulations, resulting in an average flow of 46.2 cfs.

The Podlech Memo mostly focuses on an area of known cold water refugia colloquially referred to as Salmon Heaven. The North Coast Regional Water Quality Control Board (Regional Water Board) has been collecting water quality data (temperature and dissolved oxygen) in the Shasta River in coordination with the Shasta Valley Resource Conservation District (SVRCD), California Department of Fish and Wildlife (CDFW), and other stakeholders since approximately 1994. The current database contains 7,047,606 temperature measurements, generally collected at 15-minute increments annually between approximately April 1 to September 30 of each year. While data gaps exist, especially in the 1990s and early 2000s, continuity is good for Salmon Heaven, with coverage for the years 2003, 2012 - 2018, and 2020 – 2022 (see Table 1 – Salmon Heaven Data Summary). Due to funding constraints in 2019, collection at the site had to be suspended, but measurement was resumed in 2020.

[1] McBain & Trush, Inc. and Department of Environmental Resources Engineering. Humboldt State Univerity, 2014. Shasta River Canyon Instream Flow Needs Assessment (Final Report). March 7, 2014.

Table 1 – Salmon Heaven Data Summary

Year	Period of Record	Maximum Temperature (°C)	Minimum Temperature (°C)	Average Temperature (°C)
2012	8/3 – 9/27	27.51	14.39	19.97
2013	4/10 – 9/25	29.34	8.57	19.34
2014	3/24 – 10/4	29.49	7.14	18.89
2015	3/24 – 9/30	27.48	7.67	18.24
2016	4/1 – 10/2	27.75	10.52	18.72
2017	4/19 – 10/2	27.24	10.61	19.19
2018	3/28 – 10/2	28.57	8.27	18.48
2020	4/1 – 10/8	28.44	7.85	18.75
2021	3/31 – 9/7	29.41	9.02	19.73
2022	3/31 – 8/31	28.07	7.40	18.35

Responses to Key Assertions in the Podlech Memo

1. Water Temperature Thresholds (Page 4). Mr. Podlech states:

> *"The referenced lethal threshold of…24°C was established by the North coast Regional Water Quality Control Board (NCRWQCB) for the Shasta River TMDL and pertains to Steelhead…Although not discussed in further detail by M&T (2014), these results indicate that even at streamflows of 70 cfs and above, daily maximum water temperature was lethal to steelhead on 32% of monitored days. Considering that a lethal threshold, by definition, needs to be exceeded only once to result in death, that is a high frequency of steelhead mortality events."*

Mr. Podlech is referring to Table 2.4 of the Shasta River TMDL Staff Report which includes the following associated footnote:

> *"The lethal thresholds selected in this table are generally for chronic exposure (greater than seven days). Although salmonids may survive brief periods at these temperatures, they are good benchmarks from the literature for lethal conditions."*

Similarly, Mr. Podlech is refers to M&T (2014) page 60 for a comparable explanation. To clarify, the 24°C threshold represents lethal conditions due to chronic exposures, not an acute, one-time exposure. As such, the predicted fish response to a one-time exposure to the conditions of interest is stress, not lethality. In reality, fish respond to stressful temperatures by seeking colder refugial areas if they exist. Data from M&T (2014) indicate that while 32% of days experienced maximum daily temperatures above 24°C in the Shasta River mainstem, the Salmon Heaven side channel only exceeded these temperatures on 8% of the measured days, indicating a significant thermal difference as compared to the mainstem and the potential to provide thermal refugia when temperature in the mainstem Shasta become lethal.

2. The Podlech Memo correctly states that streamflow alone does not control water temperatures. The Temperature TMDL for the Shasta River elaborates on this point by identifying other controllable factors that contribute to instream temperature exceedances: irrigation tailwater inputs, riparian shade conditions, as well as stream flow. Critical to the stream flow component of temperature impacts is quality of the source water. Since the source water for the Shasta River emanates from high-volume cold-water springs, the modeled TMDL compliance scenario includes an average of 112 cfs of cold water emanating from the mouth of Big Springs Creek. The model indicates that this flow of cold water, combined with a reduction in tailwater and increase in riparian shading results in a 4.14°C reduction in 5-day average maximum temperatures at Salmon Heaven between August 29 and September 4, 2002. Notably, 2.1°C of that total modeled reduction (50.1%) is attributable to flow increases of cold-water spring sources alone[2].

3. Referring to Figure 62 of M&T (2014), which presents modeled daily maximum water temperatures during different flow regimes, the Podlech Memo states:

> *"The wide range of recorded water temperatures at streamflows of less than about 35 cfs, in particular, provide clear indication that seasonality and ambient air temperatures are likely far more important factors than just streamflow".*

   It is true that atmospheric temperatures are a primary driver of instream temperatures. However, ambient air temperature is an environmental condition and not a controllable factor. While ambient air temperatures set the upper and lower bounds of temperature fluctuations that surface water can move between, the thermal mass of water provides the primary inertia against temperature change. The wider range of maximum water temperatures shown in Figure 62 of M&T (2014) demonstrates just that.

   - At lower flows, maximum water temperatures are higher and minimum water temperatures are lower.
   - At higher flows maximum water temperatures are lower and minimum water temperatures are higher.
   - Finally, at approximately 70 cfs maximum water temperatures appear to level off and rarely exceed 24.4°C.

   Based on this information, staff hypothesize that a minimum flow below 35 cfs would be ineffective at preserving supporting water quality conditions for

[2] Butkus, Steve, 2014. NCRWQCB. Memo: Shasta River Temperature TMDL Compliance Targets. December 31, 2014.

salmonids, especially when these lower flows coincide with hot summer days common in the Shasta Valley.

4. The Podlech Memo states:

> *"It is also worth noting that applying the same…analysis used by M&T, the Salmon Heaven Side Channel data points…could be used as evidence that daily maximum temperatures increase steadily from about 35 cfs to 120 cfs, suggesting that lower flows result in more favorable temperatures"*

Analysis of any water temperature model results requires attention to the temperature of the source water applied to the modelling exercise, as this represents an important boundary condition. The boundary conditions established in M&T (2014) are based on the conditions as they existed in their study period. The Podlech Memo is missing the following critical caveats from M&T (2014):

> *"However, we consider this analysis a conservative approach to identifying instream flows that meet water temperature needs because: (1) existing streamflows evaluated in this analysis likely included irrigation return flows and lacked large volumes of cool water from spring sources; (2) measured water temperatures were predominantly mainstem, and did not account for local thermal refugia in the Shasta Canyon; and (3) the instantaneous, daily maximum, water temperature criteria used in the analysis are a more conservative metric than mean weekly or chronic water temperature metrics."*

The Regional Water Board developed, calibrated, and validated a temperature model for the Shasta River system to understand the key variables affecting stream temperature and to test model scenarios that predict compliance with instream temperature water quality objectives. The scenarios tested with this model, as described in the Shasta River Temperature TMDL, specifically modelled increases in flow at discrete locations across the Shasta River, including at Anderson Grade Road, Montague-Grenada Road, Highway A-12, Grenada Irrigation District, Big Springs Creek, and Dwinnell Dam[3]. Measured instream temperatures at each of these points were used as boundary conditions for the model to assess the impacts of increased flow at each point on water temperature. This modelling effort showed decreases in maximum temperature for all scenarios that tested increases in flow and showed the most significant decrease in maximum temperature by increasing flow from the mouth of Big Springs Creek. The full "Compliance Scenario" modeled an average flow from

[3] NCRWQCB, 2006. Staff Report for the Action Plan for the Shasta River Watershed Temperature and Dissolved Oxygen Total Maximum Daily Loads. Chapter 6. Temperature TMDL. June 28, 2006.

the Big Springs Complex of 112 cfs of cold-water remaining instream, full restoration of site potential effective shade from riparian species, and no increase in water temperatures resulting from tailwater return flows. In this scenario, the 5-day average daily maximum water temperature at Salmon Heaven reaches 18.96°C, which could provide suitable habitat for juvenile salmonids to rear in areas of cold water refugia, as has been observed in the past. A 5-day average daily maximum water temperature at Salmon Heaven of 18.96°C would also allow for salmonid survival in the mainstem.

Relevant to the emergency minimum flow numbers, Big Springs Irrigation District is an appropriative groundwater user within the Shasta River Adjudication, thus is considered one of the lowest priority water users and was one of the first to be curtailed. Water quality monitoring results from Big Springs Lake has shown that under curtailment a cold-water signal emanating from the spring source of Big Springs Lake became stronger, indicating increases in spring flow from the Big Springs Complex following curtailment[4]. Curtailments of groundwater use have resulted in an incremental increase in flow from the Big Springs Complex and curtailment of junior downstream surface water diverters has resulted in a portion of that additional cold-water remaining instream as it travels down to the mouth of the Shasta River. This has not only increased the volume of water in the Shasta River, thus increasing the thermal mass of the stream to buffer atmospheric heating, but the source of the increase is the coldest and best quality water in the Shasta River Watershed available in the summer period, decreasing the initial temperature of the water when sunlight exposure begins each morning. These details negate the assumptions made regarding thermal dynamics in the Podlech memo, as neither it nor M&T (2014) account for the quality of increased flows from the Big Springs Complex that result from curtailment, which have positive impacts on water quality. This is demonstrated by the temperature analysis below.

5. The Podlech Memo asserts that the Shasta River canyon does not provide summer rearing for coho and only marginal conditions for steelhead.

On July 27, 2022, a snorkel survey conducted by CDFW identified presence of *Oncorhynchus mykiss* (steelhead) at Salmon Heaven[5]. Maximum daily temperature for this day was 24.59°C, the 7-day rolling average of the maximum temperatures ending on July 27, 2022 was 25.75°C. While these temperatures are above the chronic 7-day daily max threshold for steelhead indicated in the Shasta River TMDL Staff Report, staff hypothesize that the presence of *O. Mykiss* observed within Salmon Heaven indicates the elevated temperatures were not a barrier to the presence of *O. Mykiss*, potentially due to areas of cold-water refugia. Further, the

[4] Willis, Ann, 2021. Big Springs Lake Water Quality Assessment: 2021. February 2022.
[5] CDFW, 2022. Memorandum: Influence of Flow and Temperature on Shasta River Salmonids as Observed Through Snorkel Surveys. January 18, 2022.

Regional Water Board evaluated the factors that could be controlled to reduce daily maximum temperatures to conditions suitable for rearing coho. The Temperature TMDL model predicted that eliminating heated tailwater discharges, maximizing riparian shade, and ensuring an average of 112 cfs of cold water from Big Springs Creek could reduce instream temperatures to provide supporting conditions for coho salmon.

Temperature Analysis

Effects of Emergency Drought Regulations

To assess the impacts of the Emergency Drought Regulations on maximum instream temperatures at Salmon Heaven, Regional Water Board staff reviewed temperature data from the period of July 10 through July 20 in both 2021 (no curtailment) and 2022 (curtailment). The Shasta River TMDL Staff Report indicates multiple sources of instream heating, including:

1. dynamics attributable to atmospheric forcing, which are not controllable, and
2. controllable factors including riparian shading, discharges of hot tailwater, and surface and groundwater diversion resulting in changes in flow. Each of these heat sources for these two time periods are described below. Table 2 summarizes key statistics for this study window.

Atmospheric forcing: Since 2018, the Regional Water Board has coordinated with the SVRCD to maintain a meteorological station adjacent to the USGS gage near Yreka to monitor the riparian microclimate. This atmospheric station records air temperature, relative humidity, solar radiation, wind speed, wind gust, and wind direction on a continuous basis throughout the year. During 2021 and 2022, the average of the daily maximum air temperatures measured at the USGS gage differed by 0.1°C during the study window, (standard deviation of 2.2°C in 2021 and 1.3°C in 2022) providing a point of comparison across years.

Changes in riparian conditions to affect shade: Staff assume that shade resulting from riparian vegetation are comparable across years, since the years are consecutive.

Changes in irrigation tailwater discharges: Discharges of irrigation tailwater are not currently quantifiable, which is a data gap. However, staff hypothesizes that curtailed conditions resulting in more limited surface water irrigation would produce less tailwater discharged to the Shasta River than years without significant curtailments. Under normal irrigation conditions in 2021, it is likely that more tailwater was discharged, resulting in more substantial instream temperature increases.

Changes in flow: Between 2021 and 2022 flow increased during the study window. In 2021, average flow across the study window was 18.5 cfs. In 2022, average flow across the study window was 46.2 cfs. This equates to a flow increase of 27.6 cfs, most likely due to curtailment intended to meet instream flow needs. Notably, one of the first entities curtailed was Big Springs Irrigation District, resulting in an increase in cold water flowing from Big Springs and emanating from the mouth of Big Springs Creek into the

Shasta River. Evidence that curtailing BSID results in increased instream flows in Big Sprigs Creek and the Shasta River is apparent from an analysis of river response to management actions in 2021. Based on data obtained pursuant to the Drought Emergency Regulations in the Shasta River, in 2021 BSID ceased pumping beginning on September 7. It is clear the self-curtailment of Big Springs Irrigation District had a significant impact on flows and water quality. Evidence related to water quality was clearly shown in Willis (2021). Evidence related to flow was clearly described in the declaration of Daniel Worth in BSID vs. California State Water Resource Control Board, as quoted below[6]. Figure 1 show the hydrograph for the Shasta River between September 1, 2021 and September 20, 2021, as recorded at the Grenada Irrigation District's point of diversion, located downstream of the Big Springs Creek confluence with the Shasta River.

> *"More than 30 cfs flow increase was observed after BSID turned off pumping [on September 7, 2021]. There was no significant precipitation, no major inflow from Dwinnell, and no major surface water diversion upstream of SPU to be turned off that could cause any flow increase at that time. As such, nearly all of the flow increase observed after September 7, 2021, until the first rainfall in the last week of October 2021 can be attributed to the reductions of groundwater pumping in the area, including by BSID"*

[6] Declaration of Daniel Worth in Support of State Water Resources Control Board's Response to April 1, 2022 Chambers Order and Supplemental Opposition to Application of Big Springs Irrigation District for a Temporary Restraining Order. Case No. CV 22-317. Superior Court of the State of California. May 5, 2022.

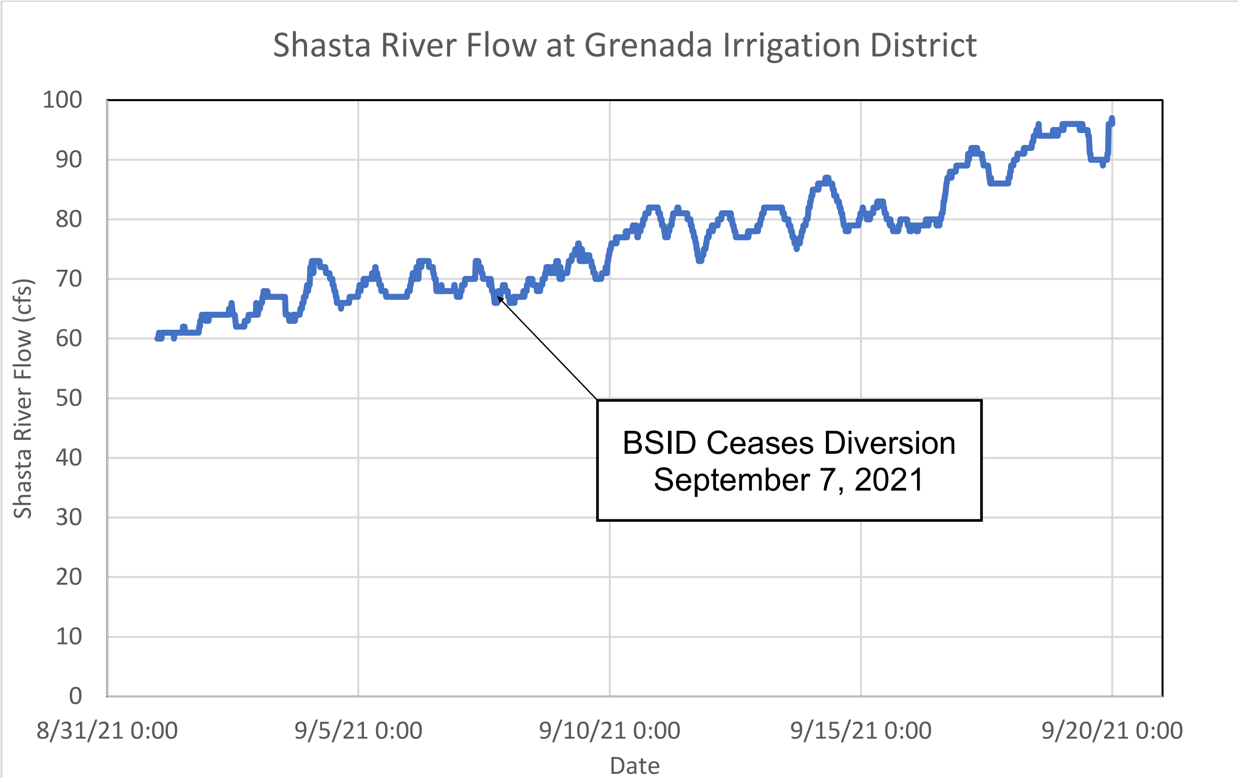

Figure 1 - 2021 Shasta River Flow at Grenada Irrigation Districts Point of Diversion

Changes in instream temperature: During the time period studied, the average of the daily maximum instream temperatures decreased by 1.7°C between 2021 and 2022. Considering the above factors, staff hypothesize that the curtailment of 2022 was at least partially responsible for an additional 27.6 cfs of flow (over the same period in 2021) and was a primary driver of the decrease in temperature measured at Salmon Heaven in 2022. Further, observations confirm that Salmon Heaven provided water quality conditions to support the survival of *O. Mykiss*.

Table 2 – 2021 and 2022 Study Window Comparison of Instream Temperatures at Salmon Heaven (RM 5.6)

2021 - Drought Baseline	Average	Max	Min	stdev	
Daily Maximum Water Temp	27.8	28.6	26.9	0.6	
Water temp (7-day rolling max)	28.1	28.6	27.5	0.4	
Maximum Air Temp	38.7	42.7	35.3	2.2	
Flow	18.5	20.5	16.7	1.3	
2022	Average	Max	Min	stdev	Difference
Daily Maximum Water Temp	26.0	26.6	25.2	0.4	-1.7
Water temp (7-day rolling max)	25.9	26.2	25.2	0.3	-2.2
Maximum Air Temp	38.6	40.3	35.8	1.3	-0.1
Flow	46.2	50.7	40.3	3.2	27.6

Evaluating a 30 cfs Scenario

In order to evaluate the outcomes of a 30 cfs flow target, Regional Water Board staff reviewed the Shasta River hydrograph as measured at the USGS gage to find potential periods of record where flow was approximately 30 cfs that coincided with the simultaneous collection of atmospheric temperature at the USGS gage and instream temperature at Salmon Heaven (see Figure 2 – Shasta River Hydrograph at the USGS Gage, 2017-2022). Based on this review, the period of July 14, 2018 through August 3, 2018 provided an average flow rate of 25.5 cfs, while also exhibiting a comparable average maximum air temperature of 38.6°C. Table 3 Summarizes key statistics during the 2018 study window and how they compare to the 2021 drought baseline.

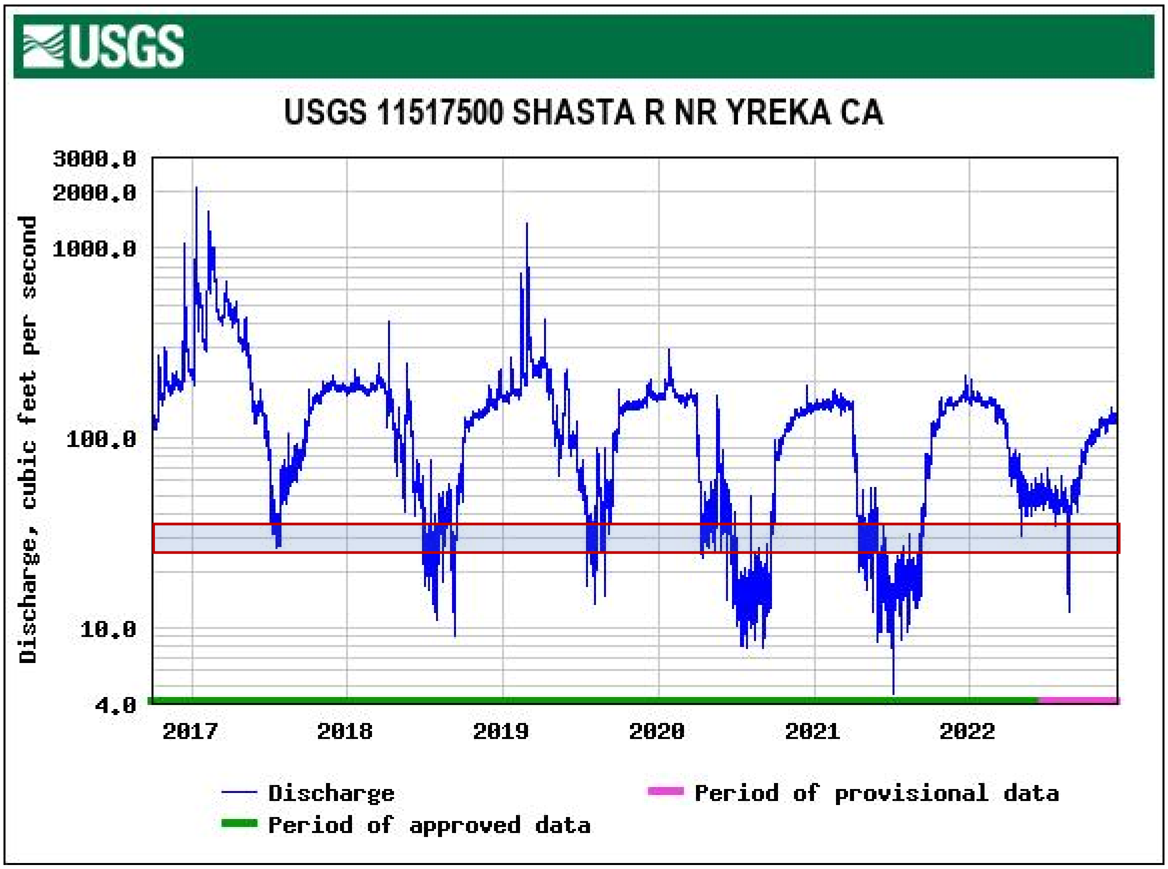

Figure 2 - Shasta River Hydrograph at the USGS Gage, 2017-2022

Changes in riparian conditions to affect shade: As 2018 and 2021 are three years apart, there may have been small increases in riparian shade that could have attributed to more shading in 2021 than existed in 2018. If significant, these changes would have resulted in lower contribution to instream temperatures from direct solar radiation in 2021 than in 2018, decreasing the difference in average maximum temperatures between these two years.

Changes in irrigation tailwater discharges: Tailwater quantities are unknown for both 2018 and 2021, representing a data gap, however one would expect both years to result in similar additions of tailwater as irrigation application between these years was not affected by curtailment. Without additional instream flow volume to prevent dilution and provide additional thermal mass to resist temperature change in 2021 as compared to 2018, it's likely that a similar amount of tailwater would result in more warming in 2021 than 2018.

Changes in flow: In 2018, average flow across the study window was 25.5 cfs, with a maximum flow of 41.3 cfs, a minimum flow of 14.7, and a standard deviation of 6.9 cfs. This standard deviation indicates flows generally ranged between 18.6 cfs and 32.5 cfs. This is more variability in flow than both 2021 and 2022. This coincides with a higher standard deviation in maximum water temperatures, as well, which could provide another line of evidence supporting the relationship of flow and temperature. In 2021, average flow across the study window was 18.5 cfs. This equates to a flow increase, on average, of 6.9 cfs in 2018 relative to 2021.

Changes in instream temperature: During the time period studied, the average of the daily maximum instream temperatures across the time period in 2018 was 1.1°C cooler than 2021. Considering the above factors impacting instream temperature, it appears likely that the additional 6.9 cfs is the primary driver of the decrease in temperature measured at Salmon Heaven. This additional flow would have also likely buffered temperatures to increases resulting from irrigation tailwater inflows.

Table 3 – 2018 and 2021 Study Window Comparison

2021 - Drought Baseline	Average	Max	Min	stdev	
Daily Maximum Water Temp	27.8	28.6	26.9	0.6	
Water temp (7-day rolling max)	28.1	28.6	27.5	0.4	
Maximum Air Temp	38.7	42.7	35.3	2.2	
Flow	18.5	20.5	16.7	1.3	
2018	Average	Max	Min	stdev	2018 - 2021
Daily Maximum Water Temp	26.7	28.6	24.5	1.3	-1.1
Water temp (7-day rolling max)	27.1	28.6	25.6	0.6	-1.0
Maximum Air Temp	38.6	41.2	33.4	2.0	-0.1
Flow	25.5	41.3	14.7	6.9	6.9

Maximum Weekly Maximum Temperature Analysis

Maximum weekly maximum temperatures (MWMT) were evaluated for each of the study windows described above at multiple stations across the Shasta River and charted longitudinally to visualize these differences (See Figure 3 for the chart and Figure 4 for the station locations). MWMT is a metric of the maximum temperature in a series of daily maximum temperatures averaged across a 7-day rolling period[7]. This metric provides an indication of both chronic and acute impacts and is useful because it describes maximum temperatures in a stream without being overly influenced by maximum temperatures of a single day.

[7] Carter, Katharine, 2005. The Effects of Temperature on Steelhead Trout, Coho Salmon, and Chinook Salmon Biology and Function by Life Stage. Implications for the Klamath Basin TMDLs. California Regional Water Quality Control Board. North Coast Region. August 2005.

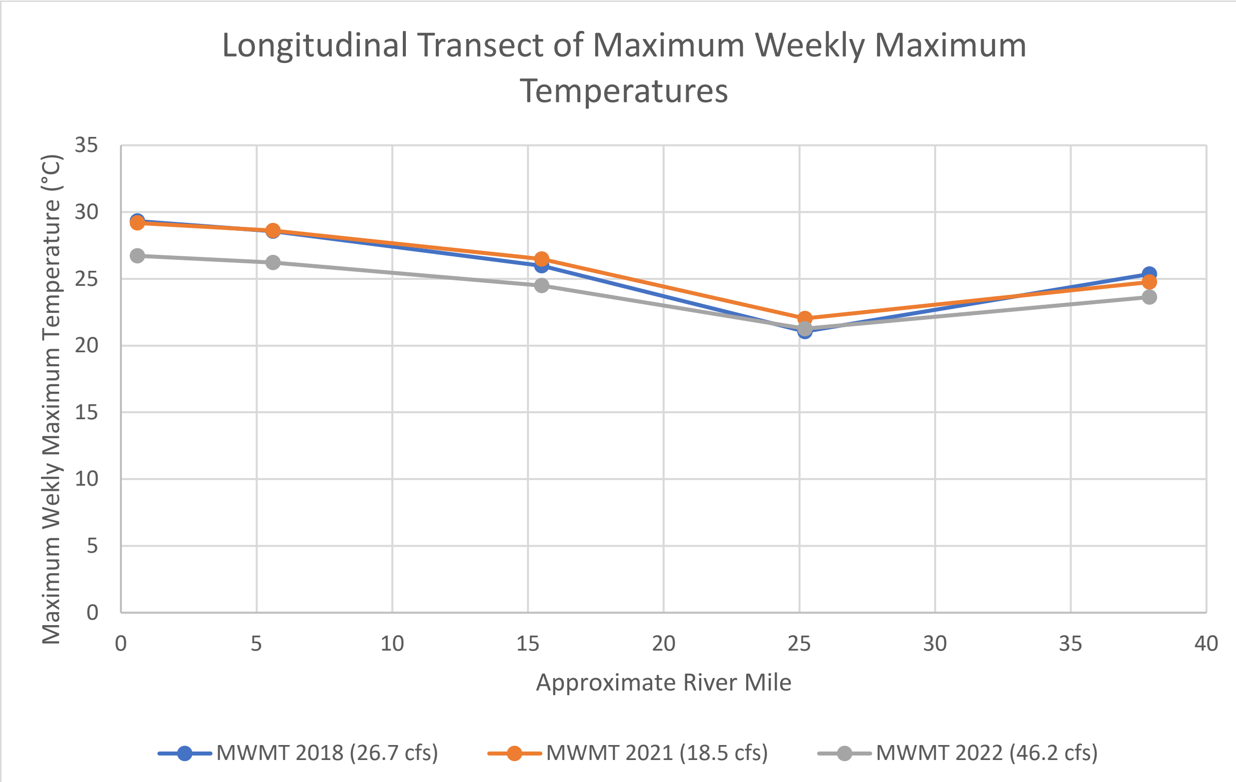

Figure 3 - Longitudinal Analysis of MWMT in the Shasta River Under Different Flow Regimes

These data show the lowest MWMTs across the Shasta River are under the flows resulting from Emergency Drought Regulations, rather than the flow that was most closely comparable to the proposed 30 cfs flow target (25.5 cfs). Interestingly, the MWMTs resulting from a flow averaging 25.5 cfs show little difference in the Shasta River canyon (River Mile 0.61 and 5.6) from the drought baseline period, where flows averaged 18.5 cfs across the study window. Flows resulting from the Emergency Drought Regulations, averaging 46.2 cfs across the study window, resulted in significantly lower temperatures in the Canyon. Staff hypothesizes that the differences in canyon temperatures may reflect the decreased travel time between the cold-water input of Big Springs Creek and the mouth of the Shasta River that results from increasing flow. Decreasing travel time reduces the time that surface water is exposed to solar radiation while traveling between two points, thereby reducing the heating that results from direct sunlight and preserving cold water across a larger areal extent. Temperatures did decrease in 2018 over the 2021 drought baseline at site 105SRV4AT. This site is located downstream of the confluence of Big Springs Creek and the Shasta River and appears to show the direct influence of this cold-water source on instream temperatures. This may indicate higher flow from Big Springs Creek into the Shasta River in 2018 as compared to 2021. The similar reduction observed in 2022 at these same sites may indicate a return to discharges from Big Springs Creek comparable to 2018 following curtailment of Big Springs Irrigation District or an increase in groundwater extraction from the groundwater sources that feed Big Springs from 2018 to 2021. Table 4 summarizes the MWMTs and the temperature differences that result from each flow regime.

Table 4 – MWMT Longitudinal Analysis

		MWMT			Temperature Difference		
Site ID	River Mile	2018 (26.7 cfs)	2021 (18.5 cfs)	2022 (46.2 cfs)	2022 - 2021	2022 - 2018	2018 - 2021
105SRL1DO	0.6	29.32	29.18	26.72	-2.46	-2.60	0.14
105SRTM01	5.6	28.57	28.62	26.21	-2.41	-2.36	-0.05
105SRM1DO	15.5	25.97	26.49	24.49	-2.00	-1.48	-0.52
105SRV4AT	25.2	21.06	22.03	21.27	-0.77	0.21	-0.98
105SRU1DO	37.9	25.35	24.75	23.64	-1.11	-1.71	0.60

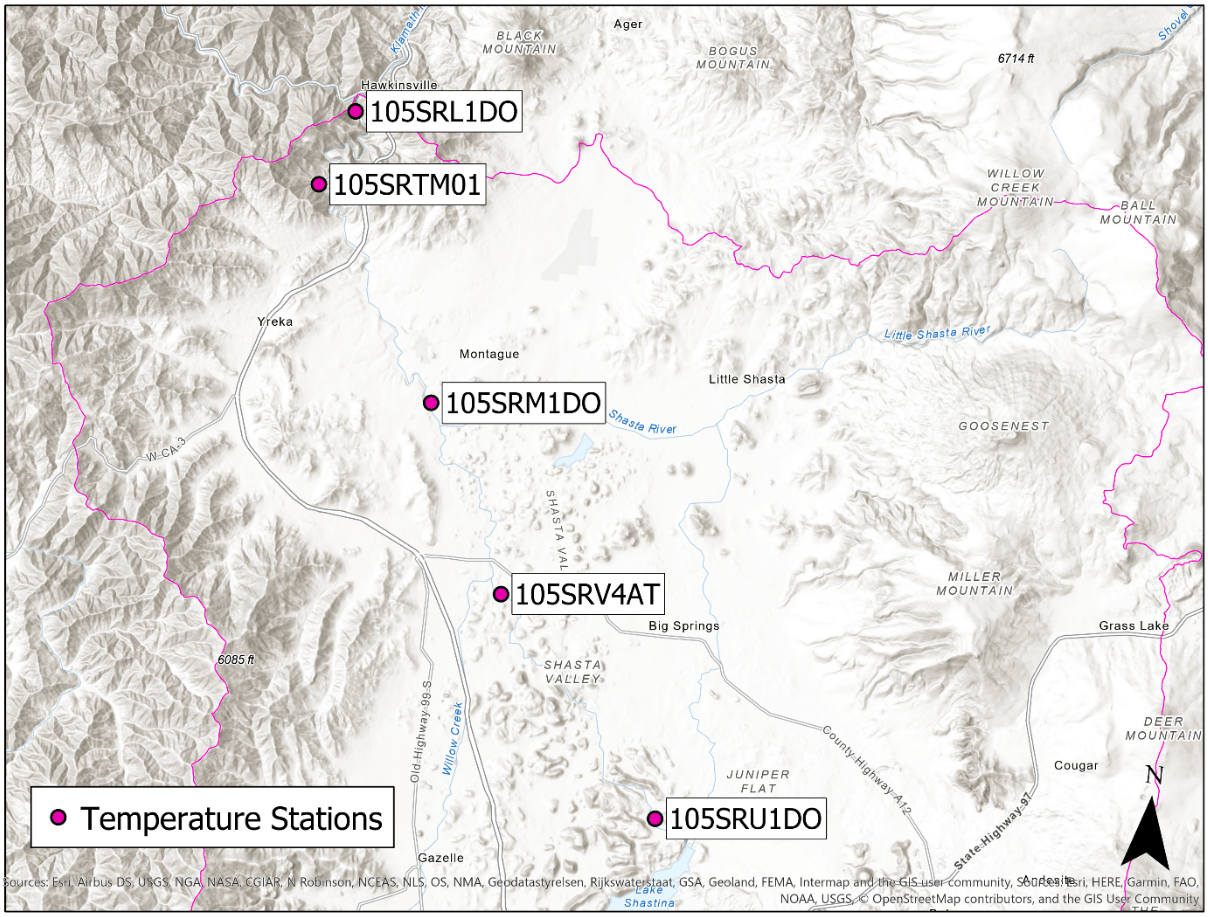

Figure 4 - Water Temperature Station Locations

Conclusion

In Mr. Podlech's memo, he proposes lowering the summer time emergency flow target from 50 cfs to 30 cfs, arguing the best available science supports 30 cfs as a minimally protective flow during very dry years. Based on the analysis presented above, it appears this proposal may reduce daily maximum temperatures over a baseline drought scenario with no flow target, but would not reduce maximum temperatures as much as the current 50 cfs minimum flow called for by the Emergency Drought Regulations. Further, when assessing the impacts of three flow scenarios studied above on MWMTs, a 30 cfs flow appears to have no discernable water quality benefit over a baseline drought scenario, especially downstream of the Big Springs Creek confluence to the mouth of the Shasta River. Also notable is that without emergency flow targets to manage water use, flows in the Shasta River in the study window fell to an average of 18.5 cfs, resulting in the hottest MWMTs across the Shasta River downstream of the Big Springs Creek confluence to the mouth of the Shasta River. This analysis shows that the 50 cfs minimum flow, under comparable atmospheric conditions, provides a 2.41°C reduction in MWMTs at Salmon Heaven, an area with known cold water refugia. These flows also appear to preserve the cold-water inputs from Big Springs Creek by reducing travel time from the Big Springs Creek confluence to the mouth of the Shasta River as well as by reducing the effects of tailwater inputs. When assessing the impacts to the most sensitive beneficial uses within the Shasta River described in the North Coast Regional Water Quality Control Board's Basin Plan[8], (specifically cold freshwater habitat (COLD); rare, threatened, or endangered species (RARE); and spawning, reproduction, and/or early development (SPWN) which relate directly to salmonids present in the Shasta River) preservation of cold water refugia is critically important. Preservation of cold water refugia involves affecting controllable factors within the watershed to ensure adequate flows remain instream, originating from important cold-water sources, to support the thermal mass, volume of cold water, and travel times needed to buffer temperature changes during hot summer days common in the Shasta River. The analysis within this memo confirm that the actions taken by the Emergency Drought Regulations have affected the controllable factor of flow from the Big Springs Complex, allowed a portion of that cold water to remain instream via junior water right curtailments and reduced travel time, and reduced instream temperatures in the Shasta River canyon with greater temperatures benefits upstream of the canyon. Surveys conducted by CDFW in July of 2022 confirmed the presence of *O. Mykiss* at Salmon Heaven*,* providing a line of evidence that conditions within the canyon allowed for survival of one of the target species that the Emergency Drought Regulations aimed to protect during a critically dry year. Based on this analysis, there is no water quality benefit to lowering the summertime minimum flow targets to 30 cfs. Doing so may be detrimental to target species utilizing cold water refugia in the Shasta River canyon by increasing instream temperature and potentially shrinking existing cold water refugia. It also appears that the analysis put forth in the Podlech Memo supports higher flows than what the memo concludes by illustrating that larger temperature fluctuations are possible under low flow conditions.

Beyond these direct conclusions related to the emergency drought regulations, this analysis supports the findings of the TMDL analysis, showing the impact of increased flows from Big Springs Creek on the entire downstream reach of the Shasta River in mid-summer. Finally, in comparing 2022 to 2021 and 2018, this analysis demonstrates that current water diversion practices are causing temperature standard exceedances in the Shasta River watershed.

[8] NCRWQCB, 2018. Water Quality Control Plan for the North Coast Region. Chapter 4. Implementation. Section 4.2.10. Action plan for the Shasta River Watershed Temperature and Dissolved Oxygen Total Maximum Daily Loads. June 2018.