United States Department of the Interior

FISH AND WILDLIFE SERVICE
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To: Guy Chelelat, Engineering Geologist, Regional Water Quality Control Board

From Matt Brown, Fish Biologist

Re: Increase in fine sediment in South Fork Battle Creek

The U.S. Fish and Wildlife Service Red Bluff Fish and Wildlife Office (RBFWO) observed that an unusually large amount of deleterious fine sediment has recently entered the South Fork of Battle Creek. The increase in fine sediment became pronounced this past winter after high flows in December 2014 and February 2015. Fine sediment has filled salmon holding pools and spawning habitats in the South Fork, eliminating almost all useful habitats for adult anadromous salmonids including threatened spring Chinook. Lack of holding pools can result in high levels of predation and stress. Poor quality spawning gravels can result in lack of spawning, mortality from superimposition of redds, and high mortality during incubation. This degradation of habitat is so bad that the RBFWO and the California Department of Fish and Wildlife, with the concurrence of the National Marine Fisheries Service, are currently installing an exclusionary weir to prevent spring Chinook salmon from entering the South Fork.

The RBFWO has conducted numerous surveys in Battle Creek year- round since 1995 to evaluate salmonid populations and their habitat, fish management, restoration actions and hydropower operations. These surveys include: 1) various stream surveys throughout the anadromous reaches of the creek and some upstream reaches. 2) Water temperature monitoring at 32 sites throughout the watershed. 3) Spawning habitat evaluations including sediment size analysis. and 4) juvenile and adult fish trapping. During the course of these and other surveys we have extensive experience in the watershed. Our senior biologists have worked in the watershed for 15 years and most of the field staff has worked in Battle Creek for more than 5 years.

In this memo we provide observations and analysis of the increase in fine sediment in the South Fork: 1) narratives and photo comparisons indicating that sediment is filling pools and infiltrating spawning gravel areas, 2) before-and-after substrate size comparisons demonstrating conversion of spawning gravels to sand beds, 3) daily turbidity measurements taken since September 1998 suggesting that turbidity has increased in recent years and especially in water year 2015, and 4) observations that elevated turbidities are occurring at lower discharge .

1). Narrative and Photo Comparisons

On June 5, 2015, a snorkel survey of Battle Creek, Reach 3 (the South Fork of Battle Creek from Coleman Diversion Dam to North Fork/ South Fork [NF/SF] Battle Creek Confluence) intended to observe and document the locations of live adult chinook salmon was conducted by three Red Bluff Fish and Wildlife Office (RBFWO) employees. One adult chinook salmon was observed during this survey. Observations were made during this survey that there appeared to be a large influx of fine sediments throughout Reach 3. These employees have conducted surveys in this reach for multiple years prior to 2015 and have experience and knowledge with the historical conditions of this section of the creek, typical sediment sizes, and typical areas in which chinook salmon redds are observed. In comparison to conditions prior to 2015, they observed that: 1) holding pools, historic areas of chinook salmon spawning, and interstitial spaces between larger rock substrates had been filled in or blanketed with a layer of sand 2) anecdotally, there was a great reduction in the number of smaller fish (e.g. rainbow trout, riffle sculpin, Sacramento suckers, etc.) and invertebrates observed during the survey, and 3) temperature loggers located at three points in Reach 3 had been buried by sand requiring considerable effort to extract them for download. The employees documented their observations photographically (fig. 1) and immediately reported their perceived change in conditions via e-mail to superiors.

On June 10, an RBFWO employee responsible for collecting temperature data from temperature loggers deployed throughout the Battle Creek watershed was tasked to collect, in addition to temperature data, information on the condition of SF Battle Creek and related tributaries in regards to increased sedimentation. Temperature loggers located at South Dam, South Dam Canal, Soap Creek, Above Soap Creek/ SF Battle Creek Confluence, and Below Soap Creek/ SF Battle Creek Confluence were visited (fig. 2). He noted that there was a considerable increase in sand throughout Battle Creek in this area and significant erosion and evidence of high flows in Soap Creek. This area of the Battle Creek watershed is influenced by effects stemming from the Ponderosa Fire, which occurred in this area 8-31-2012. It should be noted that this area is not available to access by adult chinook salmon due to Coleman Diversion Dam acting as a passage barrier.

The South Dam temperature logger is located less than a half mile downstream of the dam (Lat 40.3693/ Long -121.8010) in a portion of Battle Creek that historically was a moderately deep pool, approximately 2-4 ft. deep in the center (fig. 3A). This area was observed to have been filled with sand (fig. 3B); the employee was unable to extract and download loggers due to depth of sand burying the loggers. A nearby temperature logger located at the origin of the South Dam Canal (Lat 40.3692/ Long -121.7897) was also found to be deeply buried in sand within the canal. The South Dam Canal has been off-line since December 3, 2014, which is the date of the high flow event associated with high precipitation in the Battle Creek watershed. This is corroborated by temperature data downloaded from the South Dam Canal temperature loggers (fig. 4) which shows an alteration in the profile of the thermograph at 12-3-2014 18:30 changing to a smooth line in contrast to the typically diel temperature curve of a properly functioning temperature logger, indicative of the loggers being buried in sand and not accurately reading water temperature. A section of the South Dam Canal flume collapsed in the Devil's Gulch area of the watershed (fig. 2) resulting in a torrent of water and extreme erosion, which washed out the access road to South Dam and washed a large amount of sediment into the creek downstream

of the South Dam temperature loggers (i.e. did not contribute to the high amount of sediment seen at the South Dam temperature logger site). The California Data Exchange Center (CDEC) hydrograph for Battle Creek (station BAT located near Coleman National Fish Hatchery) indicates a maximum stream discharge of 15,300 cfs at 12-3-14 18:30 (fig. 5). CDEC hydrographs for NF Battle Creek (CDEC station BNF) and SF Battle Creek (CDEC station BAS) have incomplete data for this time period, presumably associated with malfunction due to the high water event. Note that the time of peak discharge shown in the CDEC hydrograph coincides with the time at which the temperature data indicates the South Dam Canal failure.

Downstream from South Dam is the confluence of Soap Creek with SF Battle Creek. Temperature loggers are located in Soap Creek approximately 1 mi upstream from the confluence with Battle Creek and two other locations a short distance upstream and another downstream of the confluence in SF Battle Creek. On July 13, an RBFWO employee visited soap creek to photographically document changes to the riparian area associated with high flows during winter 2014/2015. Large trees and understory vegetation have been lost in the riparian area in addition to a dramatic erosion of soils revealing an underlying layer of sedimentary bedrock (fig. 6 A&B). Additionally, an influx of fine sediment was seen in the stream channel resulting in a reduction of depth of pools and runs within Soap Creek (fig. 7 A&B). Similar effects were seen in the area of Bluff Springs on July 9, although it was not documented photographically. Debris created from the loss of riparian vegetation was observed throughout the Soap Creek basin, primarily congregated around structures associated with the Soap Creek Canal system (fig. 8). The Soap Creek Canal system sustained considerable damage as a result of high discharge and debris loads including, but not limited to, damage to metal flumes, loss of walkways adjacent to canal due to erosion of substrate supporting the base of walkways, and damage to gates and other structures of Soap Creek Canal Diversion Dam. The Soap Creek Canal is still functional despite damage, and there is evidence of work in progress to repair the damage in the form of tools left in the area of damaged sites (e.g. pry bars, “come-alongs”, sledge hammers, etc). The area just downstream of the Below Soap Creek/ SF Battle Creek Confluence temperature logger location was photographed May 13, 2014, when the logger was deployed (fig. 9A) and again July 13, 2015 (fig. 9B). From these photographs, you can see a difference in the amount of sand in the creek as well as a reduction in the riparian vegetation on river left. The course of the stream channel has been altered and now runs through an area which previously contained riparian vegetation (fig. 9B, upper left corner). The influx of fine sediment has resulted in a narrowing and reduction of depth in the stream channel.

From July 13 through July 16, snorkel surveys were conducted in NF Battle Creek (Reach 1 from Eagle Canyon Dam to removed Wildcat Dam site and Reach 2 continuing to NF/ SF Battle Creek confluence), SF Battle Creek (Reach 3, previously described), and the upper portion of Battle Creek Mainstem (Reach 4 from NF/ SF Battle Creek confluence to area near “Barn Beat” creek access [Lat 40.4204/ Long -122.0519]). During these surveys, it was noted that in NF Battle creek there was no observable difference in the abundance of fine sediments compared to surveys completed in previous years. In Reach 4, pools and areas of slow moving water had considerable amount of loosely packed fine sediments similar to appearance of those observed in Reach 3. Immediately below the NF/ SF confluence, historically there has been a large pool approximately 4-6 ft deep in which live adult chinook salmon have been observed on multiple occasions during snorkel surveys. This pool has been inundated with fine sediments and is

currently >1 ft. deep (fig. 10), making it unsuitable for use by chinook salmon as a holding pool. The sediment here is very loosely packed, and when walked upon causes one to sink deeply into the sand. Further downstream in Reach 4 below the confluence of Baldwin Creek (adjacent to Darrah Springs State Fish Hatchery), is an area known as Baldwin Pool (fig. 11A&B) which historically is a major holding pool for adult chinook salmon. Although adequate pool habitat still exists around the perimeter of the pool, a large mound of sand is present in the middle of the pool. This area historically has been a deep pool, >10 ft deep in the center; however the volume of the pool has now been greatly reduced due to the influx of fine sediment. The effects of this fine sediment were observed to be considerable for the first two-thirds of the span of Reach 4, with the observed effects reduced for the last third of the reach. No adult chinook salmon were observed in either the NF or the SF of Battle Creek during snorkel surveys. In Reach 4 on the mainstem, approximately 25 chinook salmon were observed in Baldwin Pool. Baldwin pool is typically surveyed by one RBFWO employee observing from the high vantage point, as seen in figure 11, wearing polarized glasses while two other employees snorkel through the pool area. A large number of non-target fish species, such as Sacramento suckers and Sacramento pike minnow, were also observed in Baldwin pool during the observation making a completely accurate count of chinook difficult, although survey members were confident in their approximation. No other chinook salmon were in Reach 4 aside from those in Baldwin Pool.

In conclusion, a large influx of sediment has been observed in SF Battle Creek presumably originating from the area of the Ponderosa fire in the SF Battle Creek watershed. Areas in SF Battle Creek upstream of the influence of the fire, such as SF Battle Creek near the confluence of Panther Creek (Lat 40-3567/ Long -121.7298), have no observable increase in the presence of fine sediments compared to conditions prior to 2015 (fig. 12). Also, NF Battle Creek in the reaches we regularly survey has no observable increase in the amount of fine sediments compared to conditions prior to 2015. The mainstem of Battle Creek shows a marked increase in the amount of fine sediment in the upper portion near the confluence with SF Battle Creek, with this influence gradually decreasing with distance downstream. Tributaries of SF Battle Creek, such as Soap Creek and Bluff Springs, in the area of the watershed effected by the Ponderosa Fire show evidence of riparian vegetation loss, scouring of riparian sediments, and an increase in instream fine sediment. Observations and quantitative investigations by RBFWO are currently underway with further actions planned to document this increase of sediments in the future.

2) 2015 Battle Creek Spawning Gravel Study

The goal of this ongoing study was to quantify the observed change in sediment size in SF, NF and mainstem Battle Creek with focus on the impact to previously documented areas of adult chinook salmon spawning. This was achieved by re-assessing the sediment at known spawning locations and comparing the observations with historic records of of substrate size at these locations.

During snorkel surveys on Battle Creek, RBFWO employees have collected sediment data at a majority of identified salmonid redds. Since 2001, visual assessment of sediment size has been completed on over 800 salmon redds throughout Battle Creek from the upstream fish passage barriers of Eagle Canyon Dam (NF) and Coleman Diversion Dam (SF) to Coleman National Fish Hatchery Barrier Weir. 55 of these spawning areas with the highest historic redd density since

observations began in 2001 were selected systematically for re-assessment, in NF and SF Battle Creek as well as the upper portion of the mainstem near their confluence. Between July 13th and 16th 2015, these 55 spawning areas were visually re-assessed for sediment composition by percent size class. The most upstream of the 16 North Fork sample sites and 29 SF Battle Creek sample sites were identified at river mile 4.39 and 2.48, respectively. The 2.87 river miles in the mainstem of Battle Creek (Reach 4), below the confluence were sampled at 9 locations. We assumed that the presence of greater than 25% of fine sediments 0.1 inch to 1 inch diameter renders a location unsuitable for adult chinook salmon spawning.

Based on this criterion, 81% of sample sites in the North fork were classified as suitable spawning habitat. Two of the three sites classified as unsuitable did not show a significant change from surveys conducted prior to 2015 .

On SF Battle Creek, 3% of sample sites were classified as suitable spawning habitat, all other sample sites had a composition of fine sediments greater than 25%. In the south fork, 27 of the 28 unsuitable sites had a fine sediment composition of greater than 90%. Of the 29 South Fork sample sites, the only suitable site was also the furthest upstream, less than 400 feet from the Coleman Dam.

In the mainstem, 44.4% of sample sites were classified as suitable spawning habitat. 16.6% of the sites less than 1.6 river miles from the confluence were classified as suitable spawning habitat due to high sandy substrate composition. The three sites further than 1.6 river miles from the confluence were classified as suitable spawning habitat. The single suitable location within 1.6 river miles of the confluence was found on a pool tail.

In conclusion high density spawning areas on SF Battle Creek and the NF/SF confluence are no longer suitable for salmonid spawning due to high fine sediment composition. 97% of spawning areas in SF Battle Creek have degraded in recent years, with relatively little change in the NF Battle Creek. In the mainstem reach 66% of the spawning areas have degraded. Initial observations suggest that the upper end of the mainstem has been more impacted by increased sediment than areas further downstream. Further observation of areas downstream of Reach 4 are planned to monitor the effects of sediment as it moves downstream.

3) Turbidity monitoring by the Battle Creek Juvenile Salmonid Monitoring Program (BCJSMP).

The BCJSMP has been collecting environmental data related to downstream juvenile salmonid passage since 1998. One of the metrics collected is turbidity at the time of sample to identify water quality characteristics that may contribute to downstream migration cues. Data used to estimate these averages is comparable in that it only is collected from days when the trap was actively fishing (flows generally below 1,500 cfs). A reading of 30+ NTU’s or Nephelometric Turbidity Units was considered to be high and typically occurred during increased flow events. The highest average turbidity was in 2015.The ratio of annual turbidity to flow was examined to control for differences in rainfall and discharge between years. The ratio of turbidity to flow increased in recent years with 2015 the highest.

During trap sampling from all years prior to the Ponderosa fire, the maximum reading was 35.4 NTU's. Since August 2012, the maximum reading was 832 NTU's during a thunderstorm in May 2015. We think that the increase in turbidity is a result of the August 2012 Ponderosa Fire, subsequent salvage logging and other forest management practices, and highly precipitous "Atmospheric River," rain events in December of 2012 and 2014 within the Battle Creek watershed. We plan to further analyze our data as it becomes available.

4) **Additional turbidity measurements.** Turbidity samples have also been collected when the BCJSMP fish traps were not fishing or during the course of other studies. In some cases samples were taken because turbidities were remarkably high. This data was not used in the previous analysis because sampling effort has increased in recent years due to the increase in turbidity. Many samples taken during high flow events since August 2012 were higher than 832 NTU's. The maximum reading of a non-sampling day in February of 2014 was over 1700 NTU's.

Figure 1: Photograph of historical pool area in Battle Creek Reach 3 filled with sand taken June 5, 2015. This area prior to 2015 was approximately 2-4 ft. deep at comparable stream discharge and contained cobble substrates.

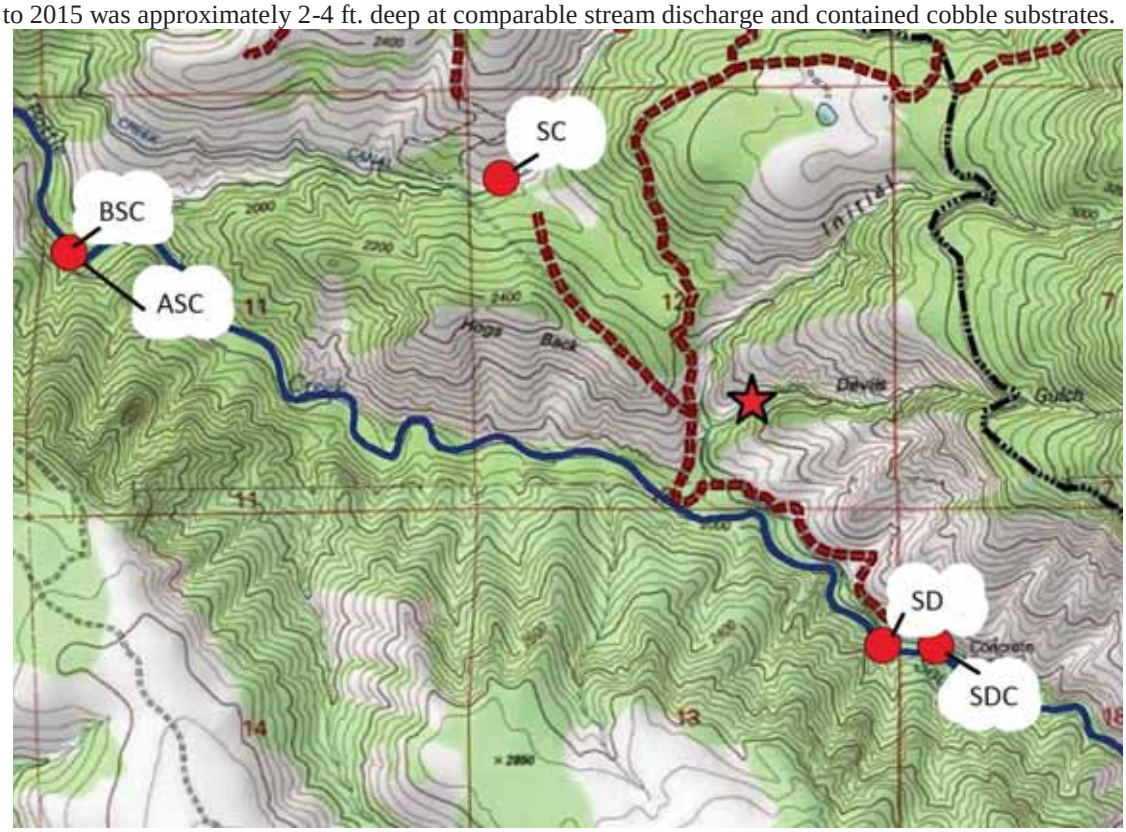

Figure 2: Topographic map of locations of temperature loggers in upper South Fork Battle Creek (blue line) area. BSC= Below Soap Creek Confluence; ASC= Above Soap Creek Confluence; SC= Soap Creek; SD= South Dam; SDC= South Dam Canal. The red star indicates location of South Dam Canal failure. Dotted red line is access road.

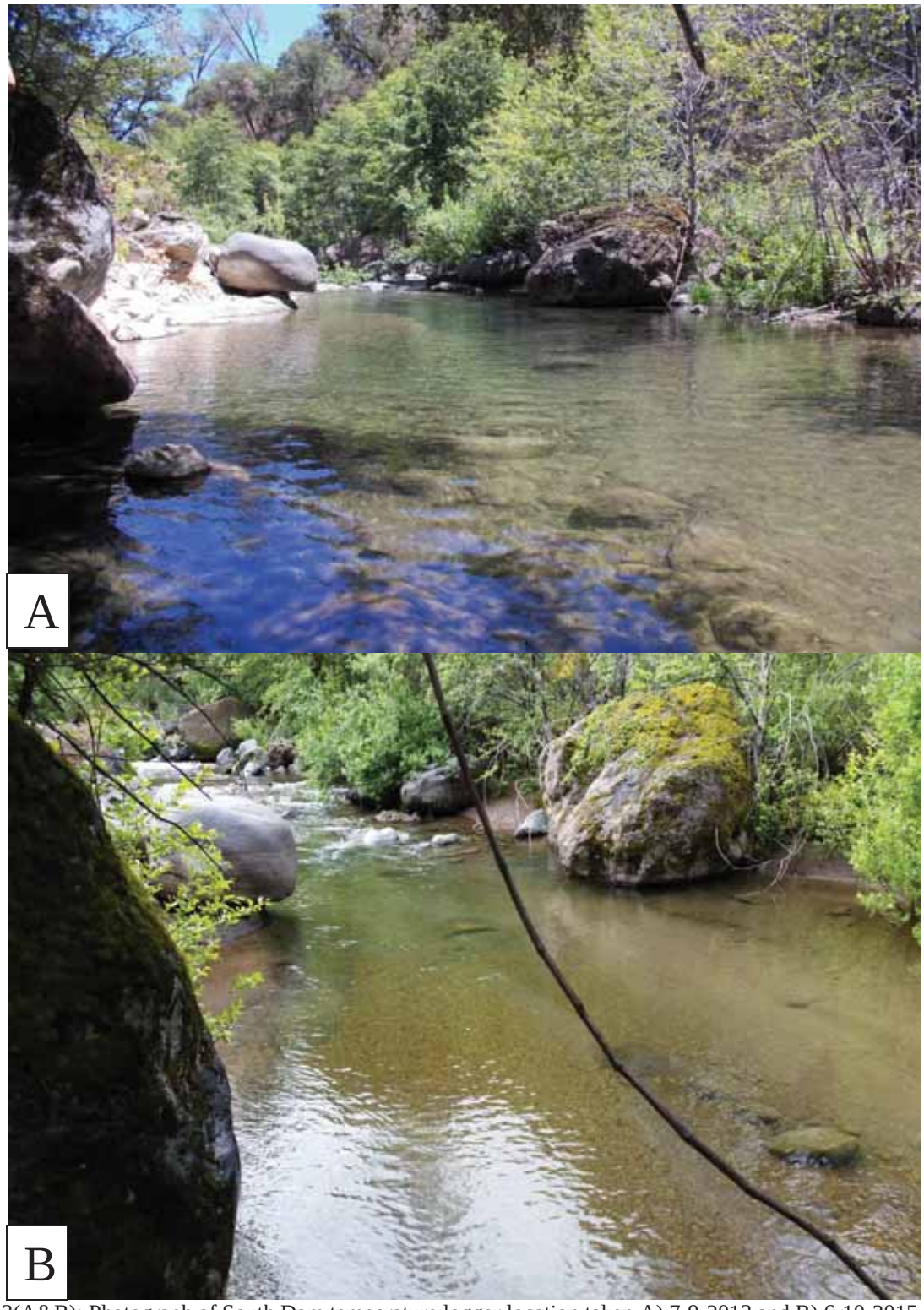

Figure 3(A&B): Photograph of South Dam temperature logger location taken A) 7-9-2013 and B) 6-10-2015 from a comparable location.

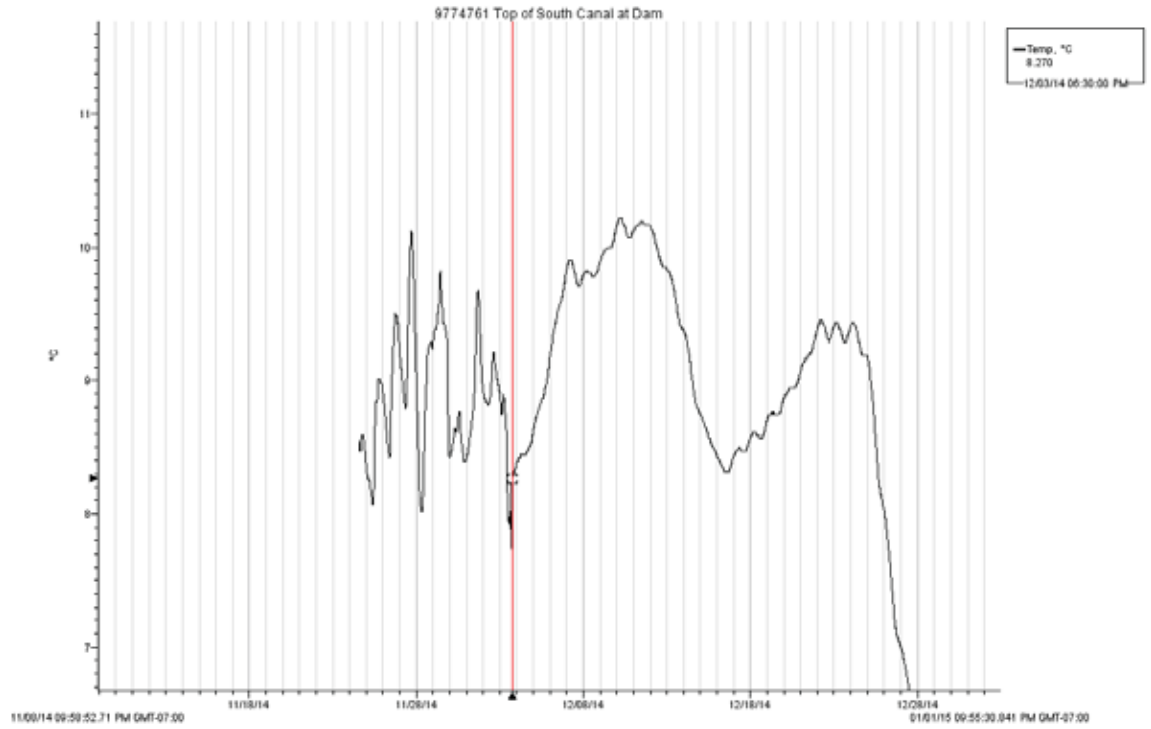

Figure 4: Thermograph of temperature loggers "Top of South Canal at Dam" located at start of South Dam Canal at South Dam (Lat 40.3692/ Long -121.7897). Red vertical line (12-3-14 18:30) indicates time at which South Dam Canal is presumed to have gone off-line and temperature loggers buried by sediment. Note change in the shape of the thermograph past the vertical red line, which is indicative of the temperature logger being buried by sediment.

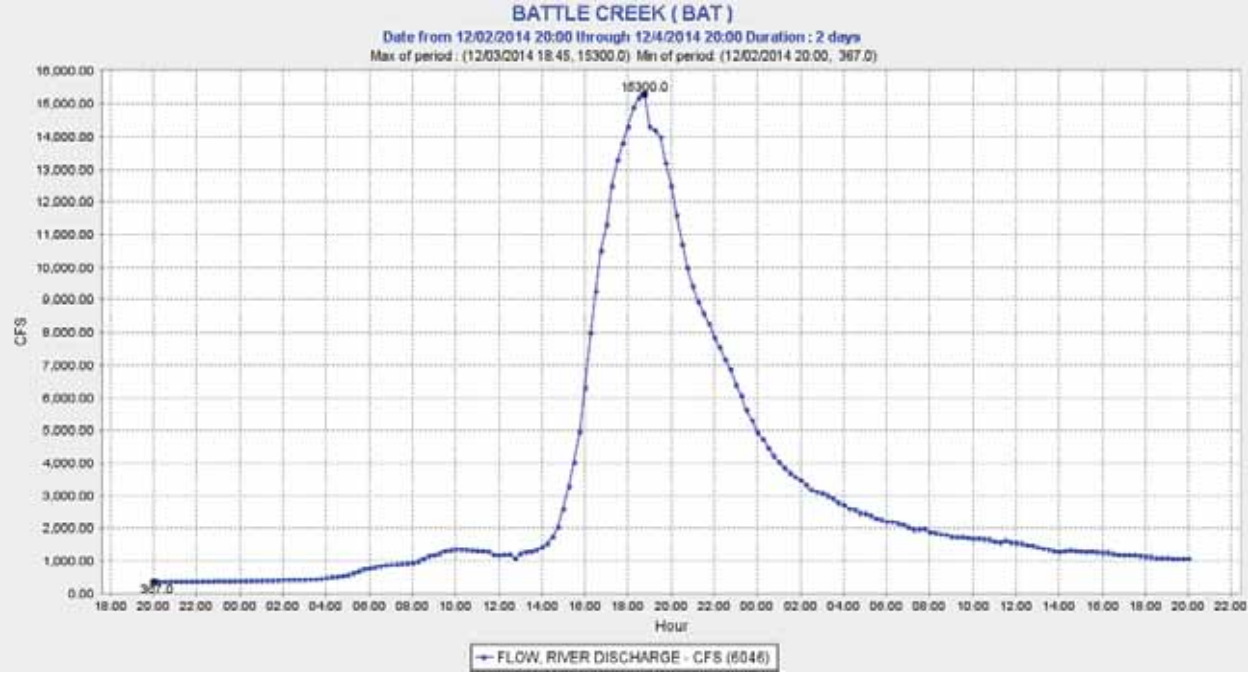

Figure 5: CDEC hydrograph of discharge at Battle Creek (Lat 40.3982/ Long-122.1464) below Coleman Fish Hatchery (Peak Flow 15,300 cfs @12-3-14 18:30)

Figure 6(A&B): Photograph of Soap Creek temperature logger location taken A) 5-13-2014 and B) 7-13-2015 from a comparable location while facing downstream.

Figure 7(A&B): Photograph of Soap Creek temperature logger location taken A) 5-13-2014 and B) 7-13-2015 from a comparable location while facing upstream.


Figure 8: Photograph of Soap Creek Canal and debris associated with riparian vegetation loss in the area. Difference in elevation between walkway atop canal and stream bed is approximately 15 ft.

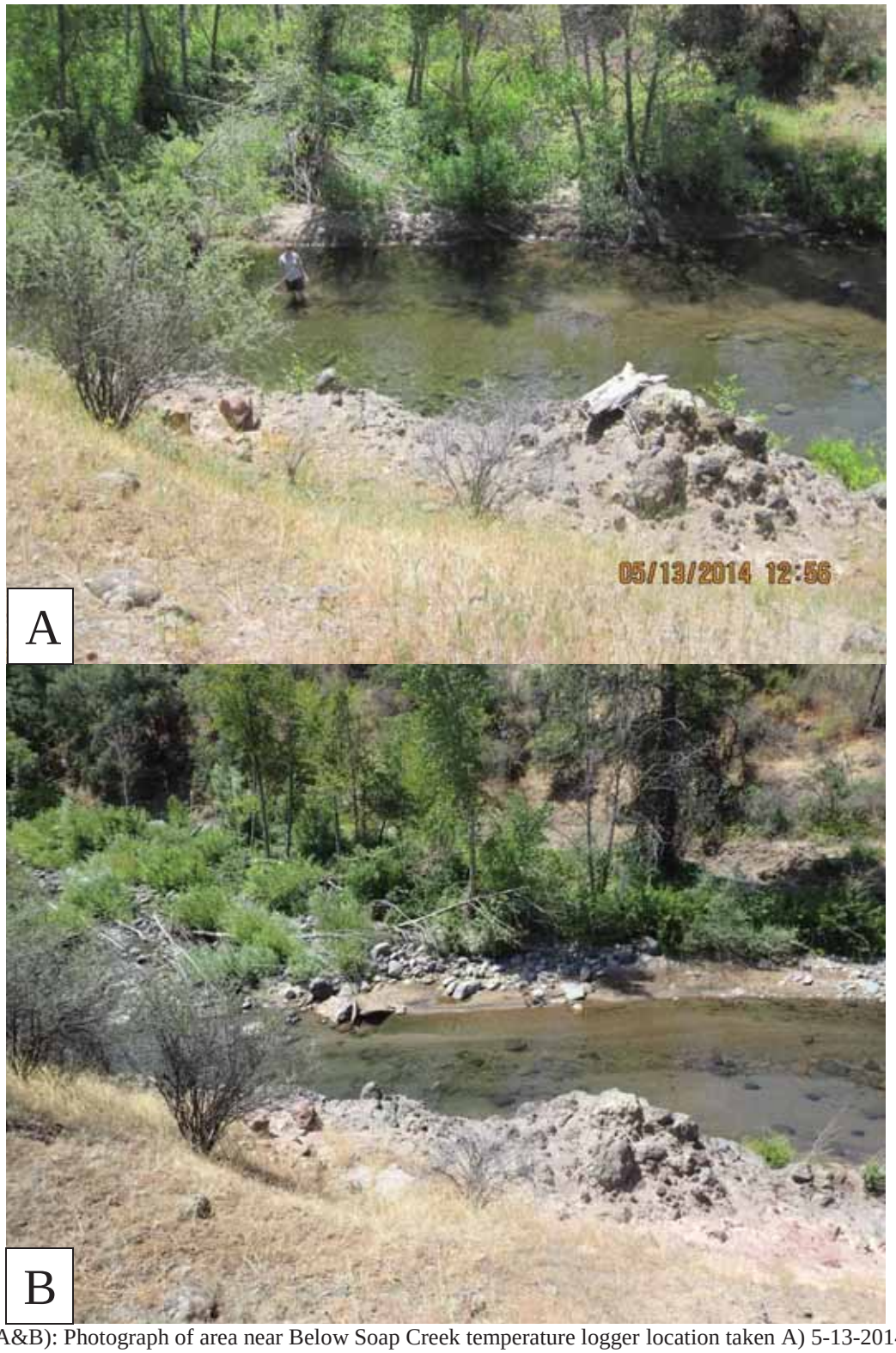

Figure 9(A&B): Photograph of area near Below Soap Creek temperature logger location taken A) 5-13-2014 and B) 7-13-2015 from a comparable location.

Figure 10: Area immediately below NF/ SF Battle Creek confluence, which historically has been a pool habitat. RBFWO employee is illustrating current depth of water in area. (no pre-2015 picture available for comparison)

Figure 11(A&B): Photograph of Baldwin pool taken A) 7-26-2012 and B) 7-16-2015 from a comparable location. RBFWO employees are illustrating depth of pool by standing atop a mound of sand.


Figure 12: Photograph of SF Battle Creek near confluence of Panther Creek taken 7-16-2015 showing stream substrate and lack of influx of sandy sediments (no pre-2015 picture available for comparison).

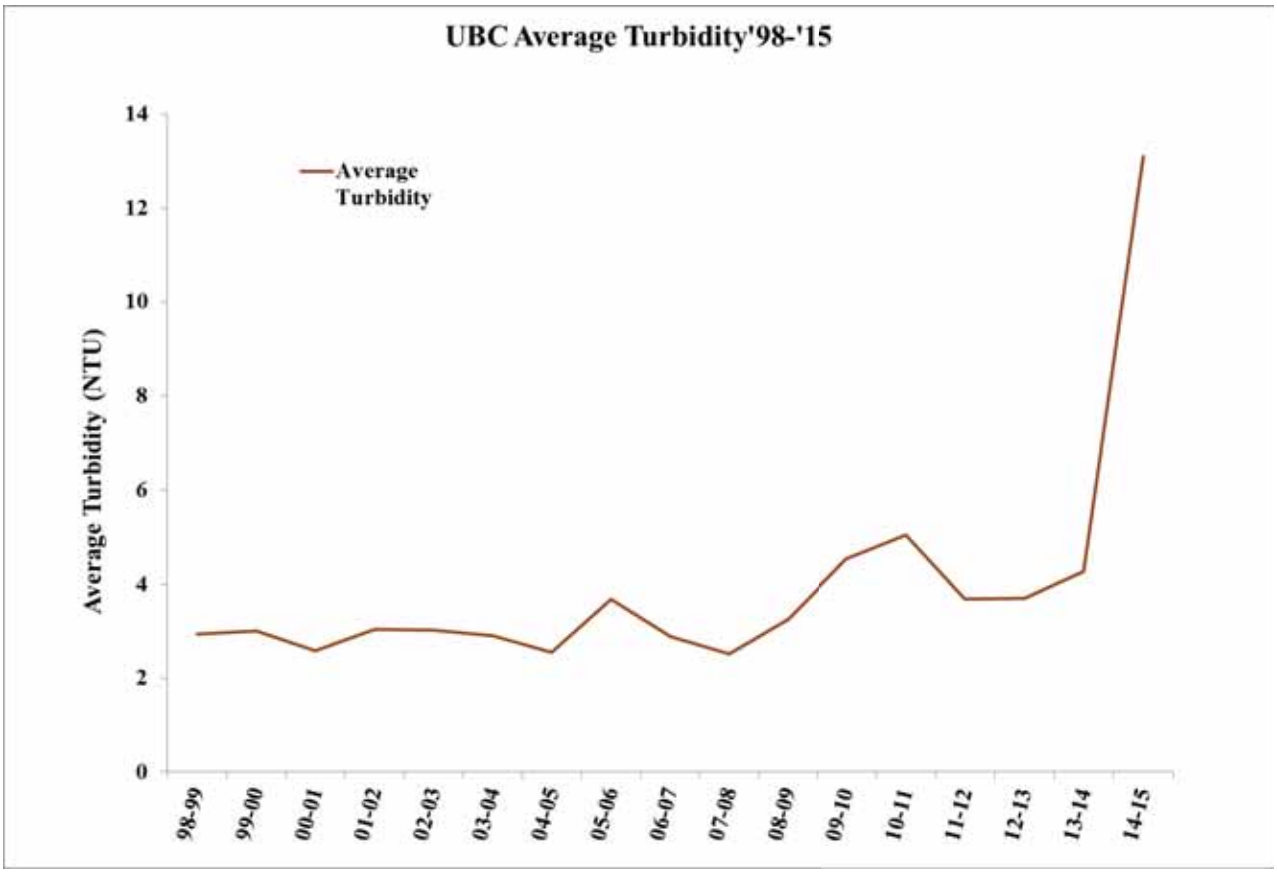

Figure 13. Average turbidities collected at the Upper Battle Creek Rotary Screw Trap near the Coleman National Fish Hatchery and USGS gaging Station 11376550 on Battle Creek River Mile 6.1

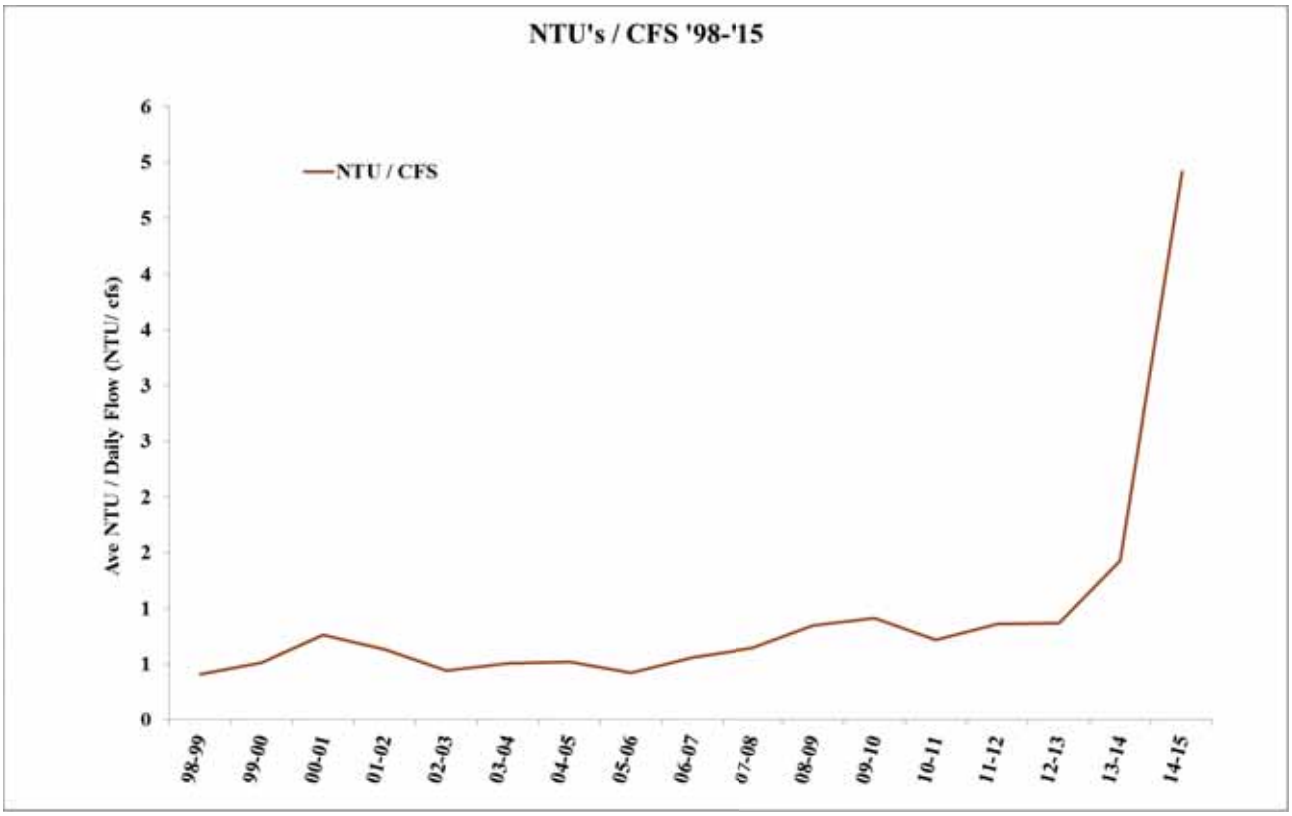

Figure 14. The ration of turbidity to flow (NTU's / CFS) at the Upper Battle Creek Rotary Screw Trap near the Coleman National Fish Hatchery and USGS gaging Station 11376550 on Battle Creek River Mile 6.1