APPENDIX F. SYNTHESIS OF PROPOSED INFRASTRUCTURE AND INSTREAM FLOW OPERATIONS

To illustrate the combined function of the infrastructure operations and the instream flow protocols outlined in the conservation program, the hydrographs associated with five storm events in 2017 and 2018 have been recreated and the proposed operations have been applied to those hydrographs. This illustrates how the proposed instream flow operations will work combined with the new fish passage system and crest gates.

In 2017 and 2018, hourly flow data for the Sespe USGS Station 11113000 and the Freeman Diversion were available through flow monitoring devices installed throughout the facility. In addition to the flows, frequent SSC data and downstream percolation rates were also obtained. Turn-outs and flushing operations in these years are similar to what is expected to occur or not occur under the proposed infrastructure operations (CM 1.1.1). The storms were selected based on available hourly flow data and SSC data and they were also selected to represent a variety of storm magnitudes.

In 2017, there were four storms that would have met the Sespe Creek trigger to implement instream flow protocols at the Freeman Diversion for adult upstream migration (Figure F-1). In 2018, there were two storms that would have met the Sespe Creek trigger (Figure F-2).

Figure F-1. Total River Flow Upstream of the Freeman Diversion in the 2017 Rainy Season

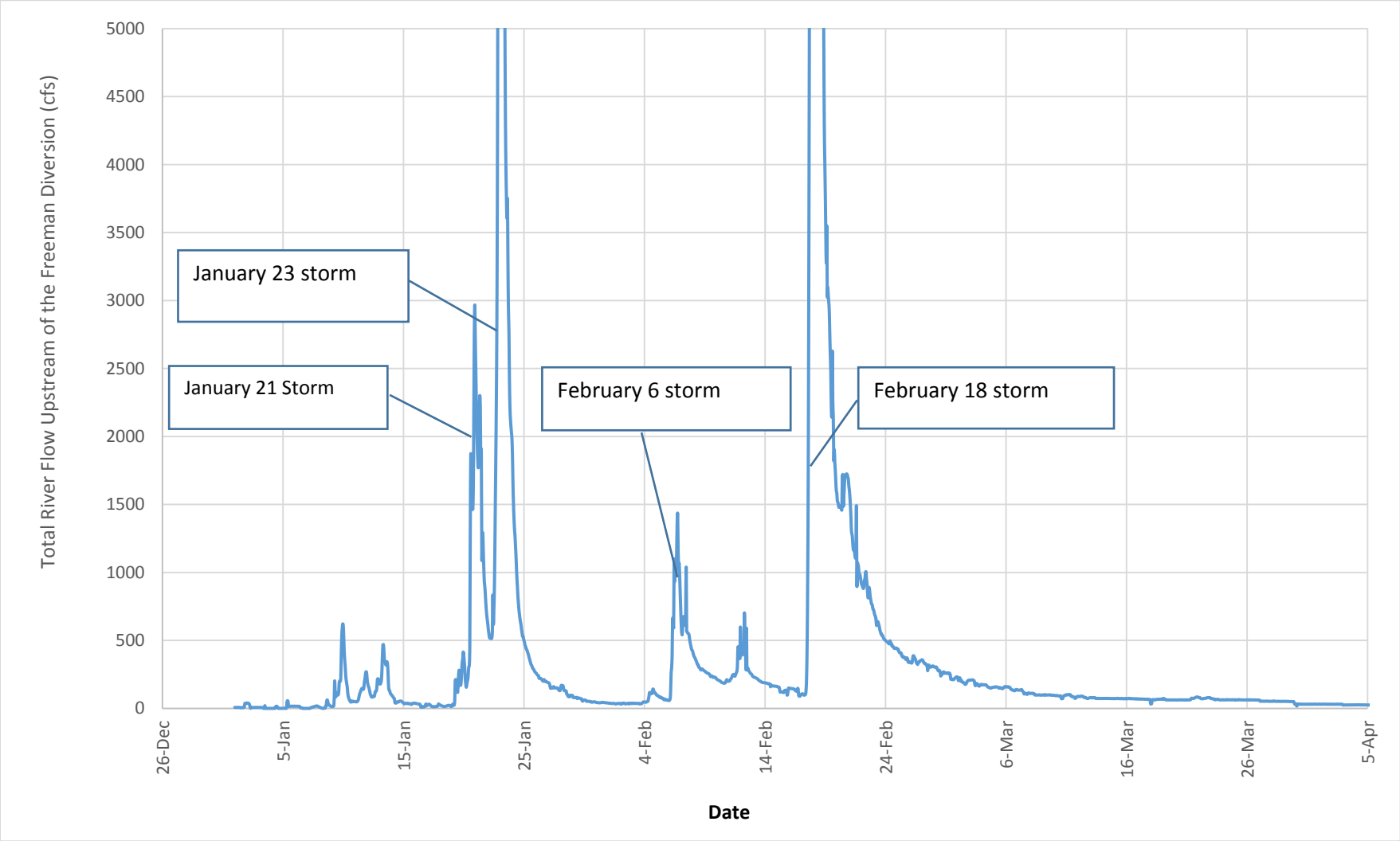
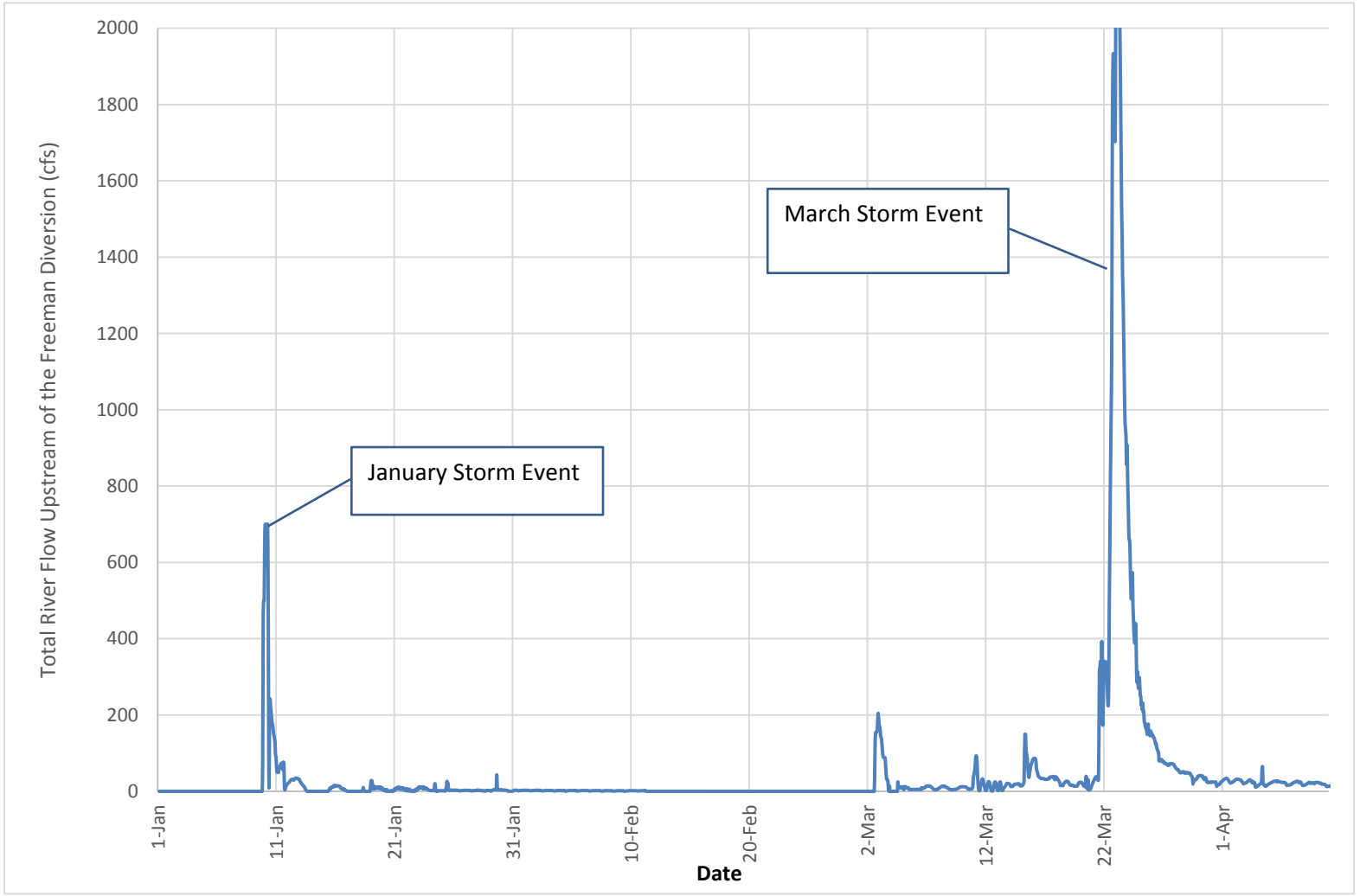


Figure F-2. Total River Flow Upstream of the Freeman Diversion in the 2018 Rainy Season



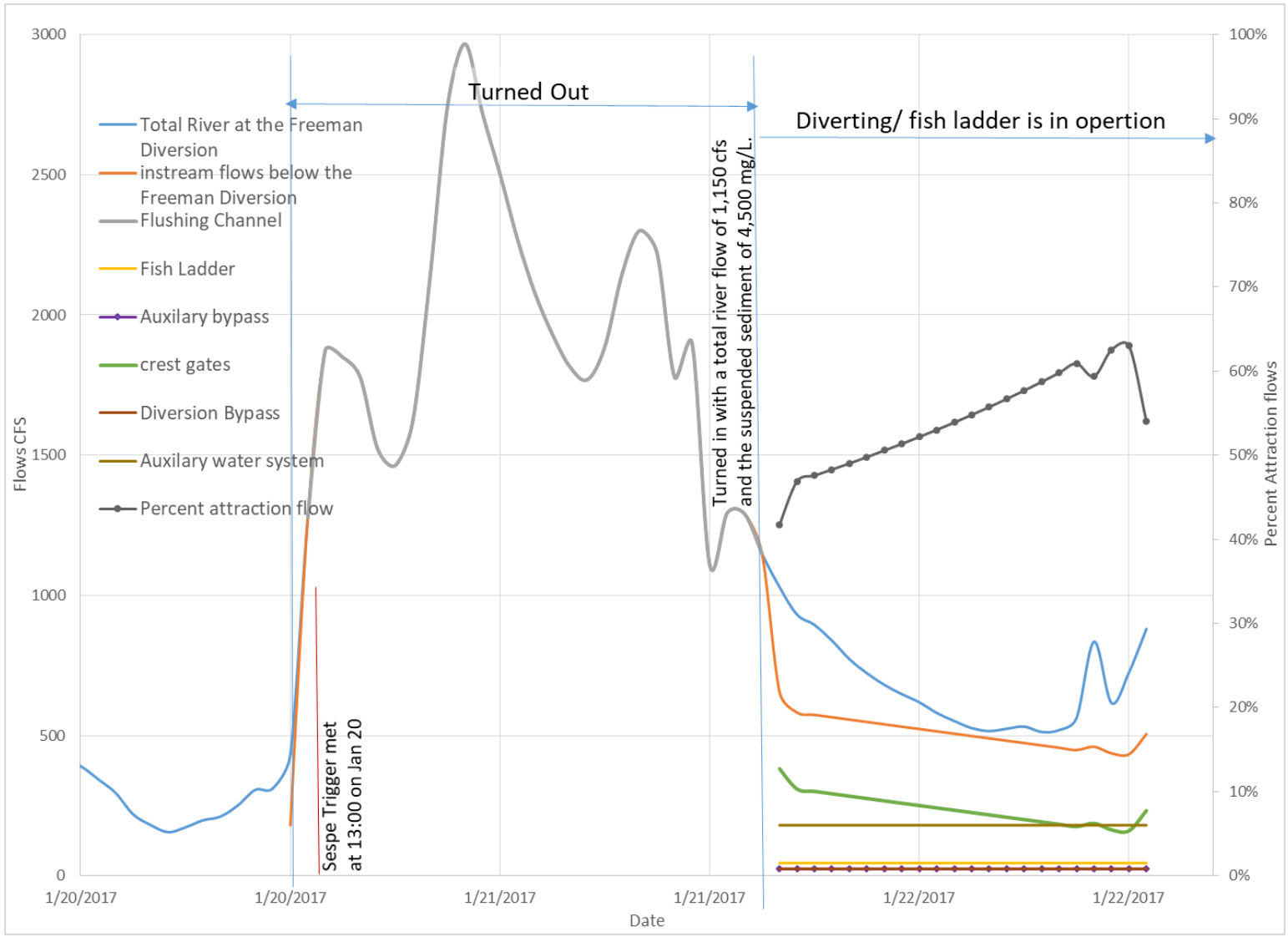
Example 1

Following the January 21, 2017 storm, the AMVFP would have been triggered on the rising limb of the hydrograph (Figure F-3). At the time, SSC in the river was very high (> 4,500 mg/l based on measured total settleable solids). As a result of high SSC, United turned out flows (stopped diverting) at the beginning of the rising limb of the hydrograph and did not commence diverting until the following day when flows receded to 1,030 cfs with SSC in the river measured to be 4,500 mg/L. Diversion and fish ladder operations commenced following the 26-hour period when the river was turned out because of high SSC. Turning out also kept the thalweg of the river along the south bank where the diversion headworks of the facility are located and created a scour zone upstream that allowed space for sediments to accumulate upstream of the headworks once diversions recommenced and United began operating the fish ladder.

Under the proposed operations and in consideration of the hourly January 21, 2017 storm event data (Figure F-3), diversions would have been turned out through the bypass channel. Once total river flow receded to 1,030 cfs and SSC was tolerable for the facility (4,500 mg/L), water diversion would have commenced along with the initiation of fish ladder flows. Following the TRP (CM 1.2.1), United would have been limited to diverting 162 cfs the first hour and then increased to 375 cfs during the second hour. Following turn-in, the instream flows would have been directed through the facility to maximize attraction to the fish ladder. As described in scenario 2c under CM 1.1.1, the order of priority for the flows would have been through the fish ladder (45 cfs), then through the diversion bypass (24 cfs), then through the auxiliary bypass (24 cfs), and finally through the auxiliary water system (180 cfs). The additional flows would have been sent through the crest gates (up to 401 cfs) preventing any cresting over the diversion face in this example. When the fish ladder would have been in operation, attraction flows would have been at least 40 percent and would have gradually increased and fluctuated between approximately 60 percent to 70 percent.

In this example, no flushing would have been required after turn-in.

Figure F-3. Initial Operations of the Freeman Diversion overlaid on the January 21, 2017 Storm



Example 2

While instream flows were still being implemented on the January 23 storm, a larger storm on January 23 created a higher peak than the previous storm and under the MSHCP, it would have retriggered the adult migration instream flow protocols (Figure F-4). United turned out flows (stopped diverting) and stopped fish ladder operations at the beginning of the rising limb of the hydrograph. With the proposed facility and operations, flows would have been directed through the bypass channel and they would have exceeded the capacity of the bypass channel (4,000 cfs). Flows would then be directed through the crest gates (1,595 cfs) and any additional flow during turn-out would have gone over the diversion crest.

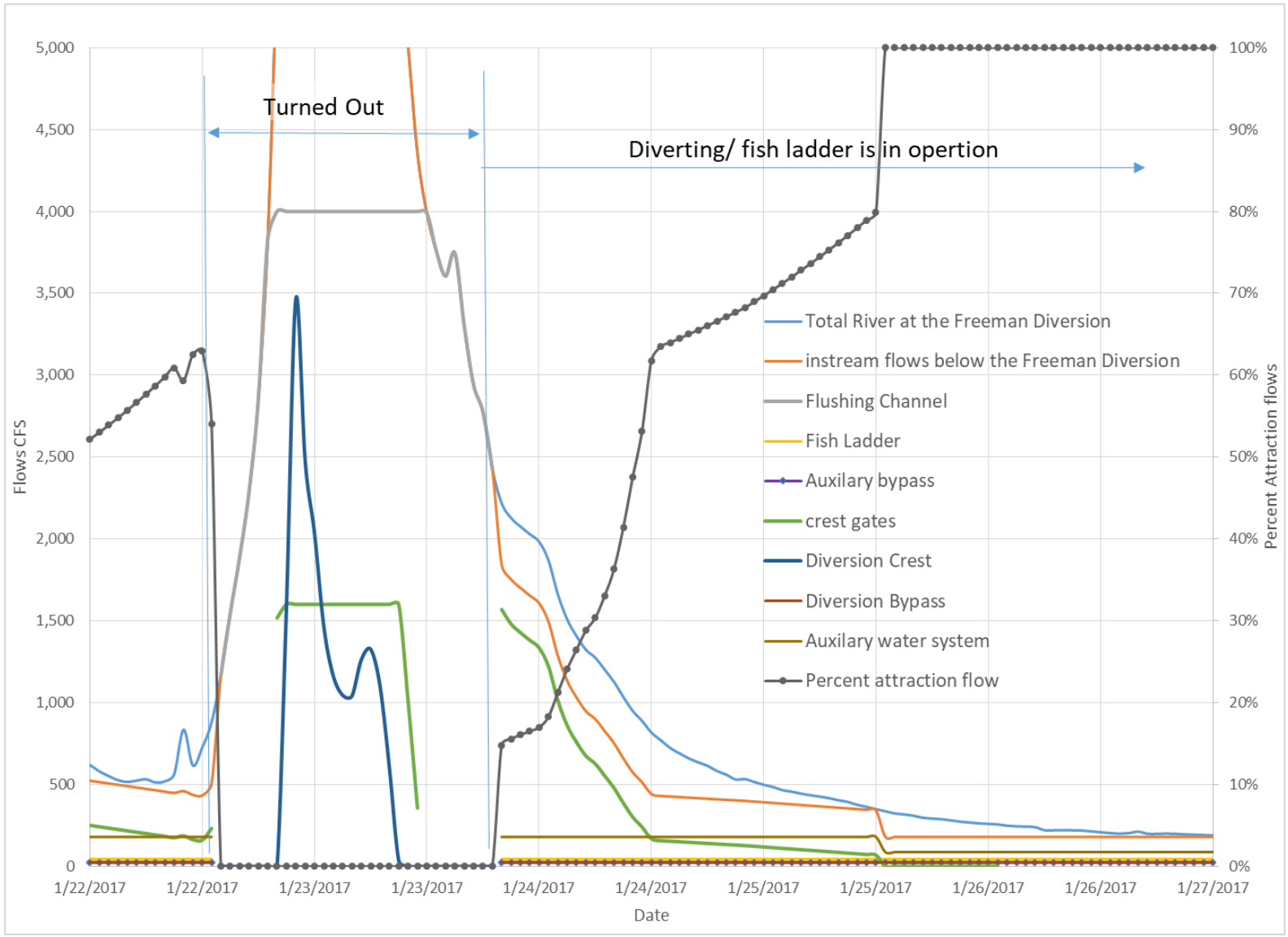
Similar to the bypass channel, operating the crest gates down during the peak of the storm will insure that a channel is maintained for the crest gates upstream to the main flow of the river. Maintaining this channel will be important so that the crest gates can operate at full capacity when needed to increase flows near the fish ladder.

Diversion and fish ladder operations commenced following about 29 hours of turning out. Under the proposed operations, commencing diversion and initiating the fish ladder would have occurred when the total river flow was 2,217 cfs. Following the TRP, United would divert up to 284 cfs the first hour and increase up to 375 cfs during the second hour. Following turn-in, the instream flows would have been directed through the facility as described in scenario 2c under CM 1.1.1. As described in scenario 2c under CM 1.1.1, the order of priority for the flows would have been through the fish ladder (45 cfs), then through the diversion bypass (24 cfs), then through the auxiliary bypass (24 cfs), and finally through the auxiliary water system (180 cfs). The additional flows would have been sent through the crest gates (up to 1,595 cfs). Cresting over the diversion face in this example, would have ceased before the fish ladder would have been operated. When the fish ladder would have been in operation, minimum attraction flow would have been 14 percent of the downstream flows. Within less than two days, the flows downstream recede to a point where all flows would be going through the fish passage system resulting in a 100 percent attraction flow rate of the downstream flows.

When initiating diversions during this storm, the total river flow less the maximum diversion rate of 375 cfs would have exceeded both the AMVFP and the AMBFP, therefore United would have diverted 375 cfs until 2:00 p.m. on January 24, when flows would have receded to a point where the AMVFP would be implemented. As flows in the river decreased, diversions would be reduced until, on May 25 at 2:00 pm, when all the water in the river would have been unable to meet the conditions of the AMVFP. At that time, the AMBFP would have been implemented. At this point the reduction in instream flows would have eliminated all flows through the crest gates and a portion of the AWS. Instream flows would maintain a relatively constant rate of flow to meet the target flows at the critical riffle. During this period, 100 percent of the flows downstream would have passed through the fish passage system.

In this example, no flushing would have been required after turn-in.

Figure F-4. Initial Operation of the Freeman Diversion overlaid on the January 23, 2017 Storm

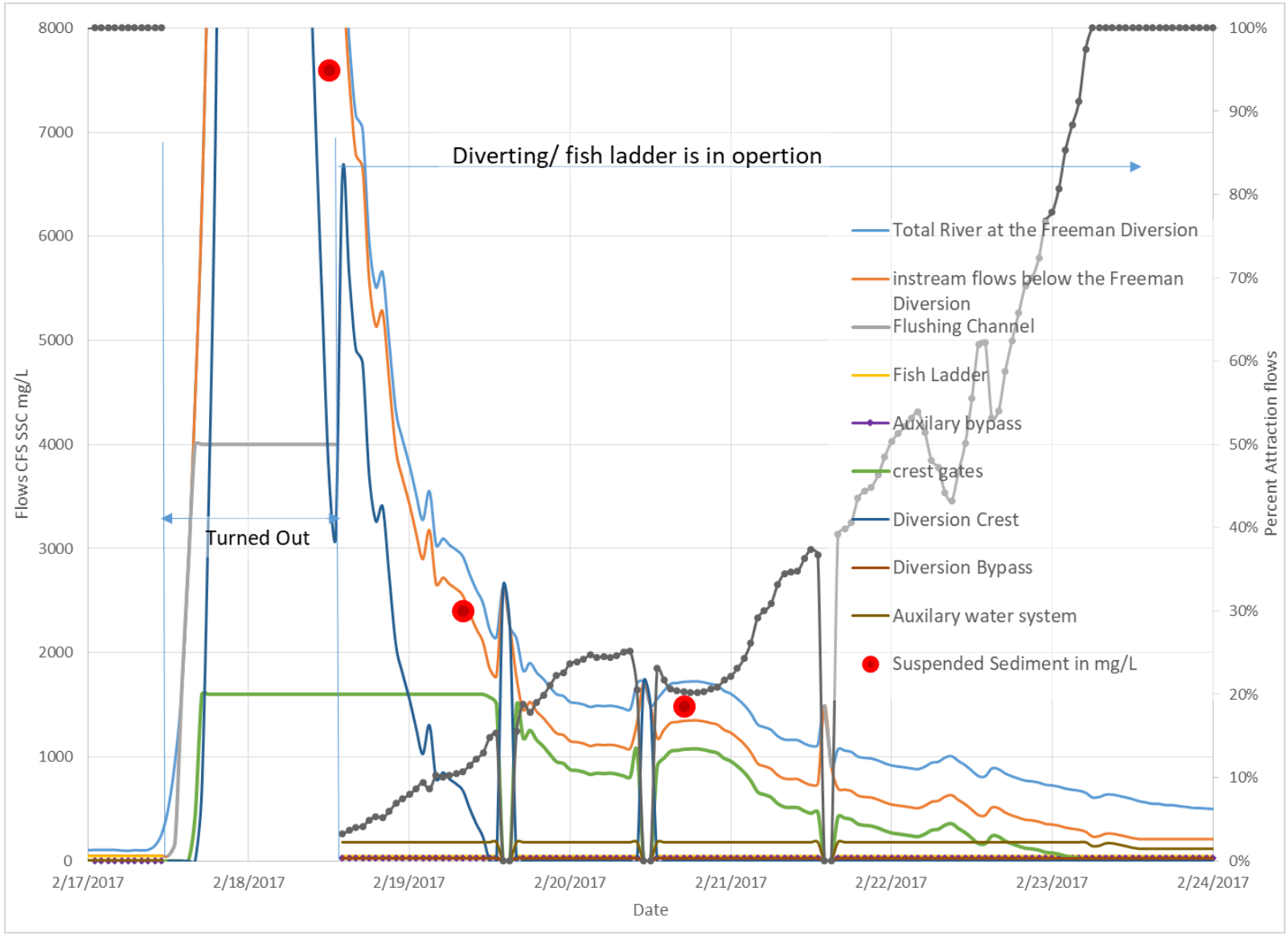


Example 3

The largest storm analyzed peaked on February 18, 2017, with a peak flow of 31,000 cfs (Figure F-5). A storm this size occurs on average once every three years. The AMVFP would have been triggered on the rising limb of the hydrograph at 7:00 pm on February 17th. United would have already turned out prior to the trigger, because SSC was measured at 38,000 mg/L during the ascending limb of the hydrograph. Diversions and fish ladder operations would have resumed the following morning when the SSC had receded to 7,600 mg/L with associated flows at 8,850 cfs. Following the TRP, United would have been able to diverted 375 cfs the first hour. As described in scenario 2c under CM 1.1.1, the order of priority for the flows would have been through the fish ladder (45 cfs), then through the diversion bypass (25 cfs), then through the auxiliary bypass (25 cfs), and finally through the auxiliary water system (160 cfs). The additional flows would have been sent through the crest gates (1,595 cfs) and remaining flows (up to ~6,700 cfs) would have gone over the diversion crest. The ladder would have been in operation approximately 24 hours after turning out and 14 hours after the peak of the storm. Because a large amount of bedload moves during high flows, flushes when diverting and operating the fish ladder are needed to clear the accumulated sediment upstream when total river discharges are typically over 1,000 cfs. As in 2017, these three flushes would be needed during this storm under the future operations. It is likely that the operation of the new crest gates will reduce the need to flush on the receding limb, although for the purpose of this example it is assumed that the need to flush will be the same as in 2017. Each flush takes approximately 2 hours. The total river flow during the flushes ranged from 1,100 to 2,200 cfs. A flush at this magnitude will require the fish passage facility to temporarily halt due to the lowering of the water levels in the forebay. Both the diversion bay and AWS bay gates would be shut down to retain water in the facility for fish that may be in the system. The fish ladder is expected to dewater during a flush making it necessary to have trained personnel at the facility to handle any fish that may be in immediate danger. The proposed vertical slot facility has a smooth floor and should represent significantly lower risk of stranding fish upon dewatering when compared to the angled Denil plates of the existing facility (although risk of stranding will still exist). If a fish is located in a section that may be dewatered, then (if possible) flows would be resumed through that section to allow the fish to pass through the system on its own volition. If resuming flow would cause damage to the system, it would be necessary to physically remove the fish to a safe location. During this storm, ladder operations and instream flows for upstream migration would have occurred for 280 total hours providing migration opportunity. Flushes would have interrupted these operations for approximately 6 hours or 2 percent of the total migration opportunity. Because the total river flow downstream was at high levels, a flush would not be expected to strand fish over dry reaches. Also, the first two flushing events would have occurred at SSC above 1,500 mg/L, when no adult upstream migrating steelhead would be expected to be passing through the fish ladder (Appendix D).

The crest gates would have been in operation for 106 hours of the 346 hours that the ladder would have been in operation. The crest gates will therefore reduce the number of uncontrolled spills over the diversion dam for the time it would have been in operation. If the existing denil ladder operated with the same instream flows, then uncontrolled spills over the diversion dam would have occurred for 328 hours of the 346 hours of operation. The addition of the AWS and the crest gates would reduce the flows over the diversion crest to 22 hours, or a reduction of over 10 times from the old system. When flows are calculated to go over the crest with the proposed facilities, the SSC is expected to exceed 2,000 mg/L. With the proposed facility, for an adult upstream migrant to have arrived at the facility when there were flows over the crest, the fish would have likely had to begin their migration from the ocean during the peak of the storm when SSC exceeded 38,000 mg/L and arrive at the diversion in SSC of no less than 2,000 mg/L, which is unlikely (Appendix D). Once flows subside to below 273 cfs in this event, all of the water will pass through the fish passage system. As flows subside even further, the auxiliary screen water will be reduced. Flows through the bypass systems and the fish ladder will eventually provide all of the instream flows allowing for both upstream and downstream passage.

Figure F-5. Initial Operations overlaid on the February 18, 2017 Storm



Example 4

A large storm event that would have triggered the AMVFP occurred in March 2018 (Figure F-6). Like previous examples presented, the AMVFP was triggered early on the rising limb of the hydrograph on March 22, and flows were turned out due to SSC (19,100 mg/L) for 27 hours. During the turn-out, the roller gate on the bypass channel would have been open and the crest gates would be down to allow for channel maintenance upstream of the facility as previous described.

Diversions and fish ladder operations would have commenced at a SSC of 4,680 mg/L with a flow of about 2,000 cfs. Following the TRP, United would have diverted 284 cfs the first hour and then increased to 375 cfs during the second hour. For the first 24 hours of diversions, the instream flows would have exceeded the minimum flows prescribed in the AMVFP. As a result, diversions of 375 cfs would have been implemented from the second hour of diversions until the flows in the AMVFP exceed the total river flow minus 375 cfs. Adult Migration Variable Flow Plan: During the first 24 hours, the natural recession rate of the instream flows is the same as the natural recession rate in the river less 375 cfs. Operations would program diversions to remain at 375 while the crest gates will modulate to maintain a constant head in the river upstream of the diversion. After 24 hours the flows in the river would recede to a point that the AMVFP exceeds the instream flows minus 375 cfs. As a result, diversions would be reduced so that the flows in the AMVFP are met. Because this recession rate was less than the actual recession rate in the Santa Clara River for this storm, diversions would gradually be reduced to meet the flows in the AMVFP until all the water in the river could not meet the specified flows. Instream flows during the AMVFP would be adjusted on an hourly basis to maintain a smooth hydrograph downstream of the diversion to the maximum extent feasible given the technological capabilities of the SCADA system. These flows would have been implemented for 15 hours until all the water in the river could not meet the conditions of the AMVFP.

Flows during this storm would not have exceeded the capacity of the fish passage system combined with the crest gates, so flows would not be expected to go over the crest of the diversion in this example. Following turn-in and initiation of fish ladder operations, attraction flows would have started at 17 percent then decreased slightly as the hydrograph peaked then increased steadily throughout the receding limb. During the implementation of the AMVFP fish ladder attraction rates would have fluctuated between 14 percent and 69 percent. After two days of fish ladder operation, 100 percent of the instream flows would be going through the fish ladder.

Once flows in the AMVFP could no longer be implemented even with all of the water in the river and none being diverted, the AMBFP would be implemented. Diversions would then resume and all of the instream flows would be bypassed through the fish ladder, AWS, auxiliary bypass, and diversion bypass with no water going over the crest of the diversion or through the crest gates. During this period, diversions would be gradually reduced and generally follow the natural fall in the river until all of the water in the river cannot maintain the flows detailed in the AMBFP. At this time a ramp down of 2/3 of the previous day's average flows would occur. In this storm, the natural recession rate was faster than the 2/3 ramp-down, so the natural recession in the river was used after the first day's ramp down. In this scenario, 100 percent of the instream flows would have passed through the fish passage system resulting in 100 percent attraction flow.

Once the ramp down is complete and there are no more flows going downstream, the diversion bypass would be operated with the fish trap engaged, trapping all smolts and lamprey macrothalmia for relocation in accordance with CM 1.2.5.

Figure F-6. Initial Operations Overlaid on the March 2018 Storm Hydrograph

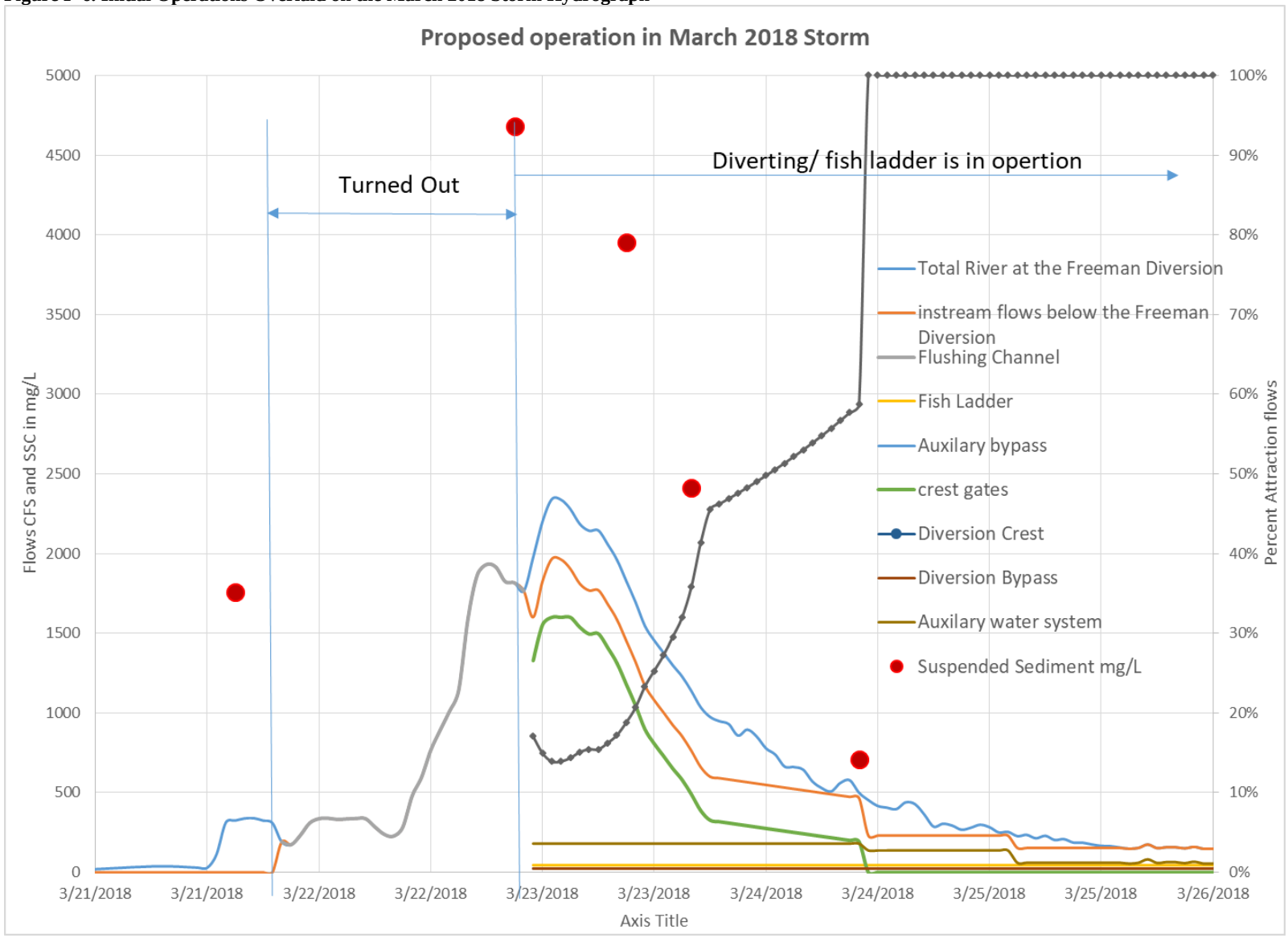


Table 1 summarizes the duration in hours that the various facilities of the existing diversion and the proposed fish passage facility would have been in operation during all of the migration storms in 2017 and 2018. For the two years, the diversion would have been turned out for a total of 122 hours. During this period the fish ladder would not be in operation. Turn outs account for 10.9 percent of the time elevated flows were sufficient to maintain flows downstream for passage. Spills over the crest would have occurred for 22 hours out of the 989 hours that the fish ladder was in operation (2.2 percent of the time the fish ladder is running). In contrast to the existing Denil system, spill over the crest would have occurred for 771 hours of the 989 hours of the proposed operations (78 percent of the time the fish ladder is running). The existing Denil system is capable of passing 80 cfs through the ladder and auxiliary with the remainder potentially going over the crest. Only three flushes would have occurred for the two example years. Flushes translated to 0.5 percent of the time the fish ladder was in operation for the two years analyzed.

Table F-1 Summary of Fish Passage Facility Operation during 2017 and 2018 Migration Storms

	Fish ladder not in operation	When fish ladder is running (Values in Hours)				
Storm Peak	**Turn Outs (Hours)**	**Spill Over Diversion Crest**	**Crest Gates**	**Fish Ladder**	**Auxiliary Water System**	**Bypass Channel (flushes only)**
1/20//2017	27	0	22	22	22	0
1/23/2017	30	0	43	152	104	0
2/5/2017	12	0	8	255	205	0
2/18/2017	26	22	106	346	298	6
1/9/2018	0	0	7	89	26	0
3/22/2018	27	0	42	125	88	0
Grand Total	**122**	**22**	**228**	**989**	**743**	**6**

The ladder would have been in operation for 989 hours throughout 2017 and 2018. The attraction flow exceeded the 10 percent criteria in 979 out of the 989 hours that it ran. The 10 hours where it did not exceed this value, suspended sediment levels ranged from 2,000 mg/L to 7,600 mg/L. Approximately 70 percent of the time the fish passage system contained 100 percent of the instream flows downstream with no flows going over the diversion crest or through the crest gates.