January 15, 2010

VIA ELECTRONIC FILING

Honorable Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

RE: Don Pedro Project (FERC Project No. 2299); Report of Turlock and Modesto Irrigation Districts on *Oncorhynchus mykiss* Monitoring pursuant to the Federal Energy Regulatory Commission's April 3, 2008 Order (123 FERC ¶ 62,012) Regarding Article 58

Dear Secretary Bose:

In its April 3, 2008 Order (123 FERC ¶ 62,012) on Ten-Year Summary Report under Article 58 ("Order"), the Federal Energy Regulatory Commission ("Commission" or "FERC") directed the Turlock and Modesto Irrigation Districts ("Districts") to file a report on results of specified *Oncorhynchus mykiss (O. mykiss)* monitoring by January 15, 2010.

Specifically, Ordering Paragraph (C) (5) of the Order states, in pertinent part, as follows:

> (5) By January 15, 2010, the Districts shall file a report with the Commission that includes the results of the O. mykiss monitoring. The report shall include a discussion of the results and, for Commission approval, recommendations for O. mykiss protection and/or for additional O. mykiss monitoring. The report shall be prepared in consultation with the NMFS, the USFWS, and the CDFG. The Districts shall allow the agencies 30 days to provide comments on the report prior to filing the report with the Commission. The report shall include the agencies' comments and the Districts' response to any such comments.

The report that reviews 2008-2009 and other *O. mykiss* monitoring and provides recommendations is provided in Attachment 1 hereto. A separate annual report on 2009 population estimate surveys is provided in Attachment 5 hereto.

The Districts' used the same procedure for soliciting agency comments as was done in September 2009 for study plans required under FERC's July 16, 2009 Order (128 FERC ¶ 61,035). The documentation of consultation is as follows:

- The Districts distributed their draft *O. mykiss* report to the pertinent agencies on December 7, 2009, for the 30-day agency comment period (Attachment 2 hereto is a copy of the transmittal letter). Comments/recommendations from the CDFG were provided on January 5, 2010 (Attachment 3 hereto). NMFS (Habitat Conservation Division) submitted an undated filing to the Commission on December 24, 2009, requesting a time extension for comments; the Commission has not acted on that request. USFWS did not provide the Districts with any comments/recommendations.

- The Districts' response to the CDFG comments/recommendations is provided in Attachment 4 hereto.

The Districts will conduct the 2008 Order-required *O. mykiss* studies in 2010, subject to the identified permitting issues, unless the studies are modified by the Commission.

Sincerely,

Tim Ford

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Attachments:
Attachment 1. Ford, T., and S. Kirihara. 2010. Tuolumne River *Oncorhynchus mykiss* monitoring report. Prepared by Turlock Irrigation District/Modesto Irrigation District, California and Stillwater Sciences, Berkeley, California for Federal Energy Regulatory Commission, Washington, D.C.
Attachment 2. Draft Report Transmittal Letter (dated December 7, 2009)
Attachment 3. CDFG Comments on Monitoring Report (dated January 5, 2010)
Attachment 4. Districts' Response to CDFG Comments on Monitoring Report
Attachment 5. Stillwater Sciences. 2009. March and July 2009 population size estimates of *Oncorhynchus mykiss* in the lower Tuolumne River. Prepared by Stillwater Sciences, Berkeley, California for Turlock Irrigation District and Modesto Irrigation District.

Attachment 1
2010 *O. mykiss* Monitoring Report

Tuolumne River *Oncorhynchus mykiss* Monitoring Report

Submitted in compliance with Ordering Paragraph (C) (5) of the April 3, 2008 FERC Order on Ten-Year Summary Report under Article 58 for Project No. 2299

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January 2010

Suggested citation: Ford, T., and S. Kirihara. 2010. Tuolumne River *Oncorhynchus mykiss* monitoring report. Prepared by Turlock Irrigation District/Modesto Irrigation District, California and Stillwater Sciences, Berkeley, California for Federal Energy Regulatory Commission, Washington, D.C. January.

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SUMMARY

This report to the Federal Energy Regulatory Commission (FERC) is submitted in compliance with Ordering Paragraph (C) (5) of the April 3, 2008 Order on Ten-Year Summary Report under Article 58 for Project 2299. That Order required the Modesto and Turlock irrigation districts (Districts) to file a report by January 15, 2010 on the results of specific Tuolumne River *Oncorhynchus mykiss* (*O. mykiss* – rainbow trout/steelhead) monitoring efforts contained in a July 2007 study plan submitted to FERC and as modified by the Order.

The Districts implemented snorkel surveys during July 11–16, 2008, March 16–25, 2009, and July 9–14, 2009 to estimate *O. mykiss* abundance in the Tuolumne River downstream of La Grange Dam. The July 2009 *O. mykiss* juvenile population estimate of 3,475 was higher than the July 2008 estimate of 2,472 juveniles, but within the 95% confidence interval (CI) of the estimates in these two years. The July 2009 *O. mykiss* adult population estimate of 963 was also higher than the July 2008 estimate of 643, with both results within their respective 95% CI in these two years as well. The March 2009 surveys found very few *O. mykiss* of either size range, with a population estimate of only 63 juveniles and 170 adults.

Variable summer flow releases at La Grange in the dry years of 2008 and 2009 averaged about 100 cfs, with higher flows on the warmest forecasted days; March 2009 flow rates were about 170 cfs. River habitats were mapped over a 22-mile reach and observed *O. mykiss* were within the upper 11 river miles. For all three surveys, most juveniles (< 150 mm fork length) and adults (≥ 150 mm fork length) were found in riffle habitats, within the upstream heads of run habitats, and throughout pool (head, body, tail) habitats. Estimates of juvenile Chinook salmon (*O. tshawytscha*) abundance were also made and much higher summer numbers were present in July 2009 than in July 2008.

Survey results of relative *O. mykiss* utilization of restored habitats are inconclusive to date. This is in part due to the inability to conduct two other *O. mykiss* studies in the 2008 Order (testing for anadromy and adult tracking) as the necessary scientific collection permit applications for sampling were not approved by the California Department of Fish and Game. In addition, several anticipated gravel augmentation projects were not implemented, so fewer sites were available for evaluation of changes in habitat use or densities. However, *O. mykiss* records from the following Tuolumne River fisheries monitoring programs are included:

- Seining surveys conducted between January and May of most years since 1983.
- Snorkel surveys conducted in June/July and at other times of year in most years since 1986, except in years with high flows (1995, 1998, 2005, and 2006).
- Rotary screw trap monitoring conducted between January and May of most years since 1999.

Monitoring programs and general results from other San Joaquin River tributaries for *O. mykiss* are reviewed and recommendations for near-term *O. mykiss* protection measures and monitoring in the Tuolumne River are included.

1 BACKGROUND AND PURPOSE

The Modesto and Turlock irrigation districts (Districts) filed a Ten-Year Summary Report on March 25, 2005 (TID/MID 2005) to meet a requirement of the July 31,1996 Federal Energy Regulatory Commission (FERC) license amendment for the Don Pedro Project (FERC #2299). This report to FERC is submitted in compliance with Ordering Paragraph (C) (5) of the FERC April 3, 2008 "Order on Ten-Year Summary Report under Article 58" which stated:

> *By January 15, 2010, the Districts shall file a report with the Commission that includes the results of the O. mykiss monitoring. The report shall include a discussion of the results and, for Commission approval, recommendations for O. mykiss protection and/or for additional O. mykiss monitoring. The report shall be prepared in consultation with the NMFS, the USFWS, and the CDFG. The Districts shall allow the agencies 30 days to provide comments on the report prior to filing the report with the Commission. The report shall include the agencies' comments and the Districts' response to any such comments.*

Oncorhynchus mykiss (*O. mykiss)* applies to rainbow trout, in which any ocean-going individuals are commonly termed "steelhead". On March 19, 1998 (63 FR 13347), the National Marine Fisheries Service (NMFS) first listed the California Central Valley steelhead Evolutionarily Significant Unit as threatened under the Federal Endangered Species Act and issued a new final rule listing the Central Valley steelhead Distinct Population Segment on January 5, 2006 (71 FR 834). The Tuolumne River watershed was among those extending south from the Mokelumne River within the "Southern Sierra Nevada Diversity Group" range for *O. mykiss* identified by Lindley et al. (2007). More recently, Garza and Pearse (2008) found in a genetic evaluation of *O. mykiss* that Central Valley populations appeared to be largely introgressed with imported Northern California (coastal) stocks through their use in hatchery operations.

The FERC Order of April 3, 2008 and its July 16, 2009 *Order on Rehearing, Amending License, Denying Late Intervention, Denying Petition and Directing Appointment of a Presiding Judge for a Proceeding on Interim Measures* (July 16, 2009 Order) both recounted the history of *O. mykiss*-related issues and actions relative to the Project. Those actions included a draft limiting factors analysis for Tuolumne River salmonids (Mesick et al. 2007) that included recommendations for developing abundance estimates, habitat use surveys, and anadromy determination of resident *O. mykiss*. Those recommendations were conceptually used to develop the Districts' FERC Study Plan (TID/MID 2007; *O. mykiss* excerpt is Appendix A of this report) that was prepared in response to a December 20, 2006 FERC staff request. The April 3, 2008 Ordering Paragraph (C) also contained the following:

> *(C) The Districts shall implement their proposed O. mykiss monitoring plan, filed March 20, 2007, and revised July 16, 2007, with the following modifications:*
>
> *(1) The Districts, beginning in 2008, shall conduct population estimate surveys using two-phase snorkel surveys calibrated by electrofishing to determine population abundance by habitat type. The Districts' proposed population estimate survey shall be modified to include February and March, in addition to June and July sampling periods,*

unless agreed upon otherwise by the National Marine Fisheries Service (NMFS), the U.S. Fish and Wildlife Service (USFWS), and the California Department of Fish and Game (CDFG);

(2) The Districts shall conduct their proposed sampling testing for anadromy in juvenile and adult O. mykiss beginning in 2008;

(3) The Districts shall conduct their proposed adult O. mykiss tracking study beginning in January 2009;

(4) Any changes to the O. mykiss monitoring methods or schedules shall be filed for Commission approval and include the comments of the agencies on the changes. Any change to the methods or schedules shall not be implemented until approved by the Commission

The April 3, 2008 Order also stated (page 27), "Additionally, the Districts should use any applicable *O. mykiss* data from the Stanislaus, Merced, Mokelumne, and Calaveras Rivers in the development and refinement of their *O. mykiss* monitoring and resulting analysis." The *O. mykiss* study plan elements contained in the Districts' proposed Study Plan of July 16, 2007 (Appendix A) noted that the ability to conduct the studies as described was contingent upon necessary permits being issued by the fishery agencies. The Districts' letters of July 3, 2008 and March 31, 2009 notified FERC of the permitting status for each study. Sampling permit applications for 2009 *O. mykiss* anadromy and acoustic tracking studies were not approved (items 2 and 3 above). As a result, only the population estimate studies (item 1 above) proceeded. However, since a permit modification for an increase in the allowed incidental take associated with the electrofishing calibration component of the population estimate studies also was not approved, the proposed electrofishing element was not conducted and the population estimates were based upon snorkel surveys only.

The study documents produced pursuant to the April 3, 2008 Order to date include:

- an initial detailed *O. mykiss* population estimate study plan (Stillwater Sciences 2008a) that was submitted to FERC on July 3, 2008 for their July 2008 survey;
- a report on the July 2008 population size estimate (Stillwater Sciences 2008b) that was submitted as part of the Districts' 2008 annual report to FERC (TID/MID 2009);
- a study plan for the 2009 population estimate surveys (Stillwater Sciences 2009a); and
- a report on the March and July 2009 survey results (Stillwater Sciences 2009b).

Both 2008 and 2009 were drier year types in which summer flows were voluntarily increased above minimum required flow rates. Those designated rates of 50 cfs in 2008 and 75 cfs in 2009 were increased to an actual flow average of 100 cfs for the June 10 to September 30, 2008 period (Ford and Kirihara 2009a) and to an actual flow average of 105 cfs for the June 16 to August 31, 2009 period (Ford and Kirihara *in prep*). Bracketing that 2009 period, during June 1–15 and September 1–30, the scheduled minimum flow requirements were 95 cfs or higher. Both summers had variable flow operations in which higher flows were provided during hotter forecasted air temperature periods.

This report contains:

- a summary and discussion of results of the completed April 3, 2008 Order *O. mykiss* monitoring activities, including consideration of *O. mykiss* monitoring from the Mokelumne, Calaveras, Stanislaus, and Merced rivers;
- an updated compilation of other Tuolumne River *O. mykiss* data since the last Districts' summary (Ford and Kirihara 2008); and
- recommendations for *O. mykiss* protection and for additional *O. mykiss* monitoring.

2 MONITORING RESULTS AND DISCUSSION

2.1 Tuolumne River Population Estimate Surveys 2008-2009

Stillwater Sciences conducted "bounded counts" population estimate surveys for *O. mykiss* in July 2008, March 2009, and July 2009 using snorkeling in a two-phase survey design after Hankin and Mohr (2001) to sample within different habitats found downstream of La Grange Dam (Stillwater Sciences 2008b, 2009b). General survey reaches were from river mile (RM) 51.8–29.5 (March 2009) and from RM 51.8–39.6 (July 2008/2009) (Figure 1). Prior to the snorkel surveys, float surveys were conducted to map seven habitat types (riffle, run head, run body, run tail, pool head, pool body, and pool tail) and document length, width, depth, and substrate composition of the habitat units. A subset of sampling units of each habitat type had single-pass snorkel surveys conducted and a portion of those were selected for multi-pass calibration sampling. A total of 42 sampling units were selected for either single pass or multi-pass snorkel surveys in July 2008, 66 habitat units were selected in March 2009, and 31 units were selected in July 2009.

The *O. mykiss* observed were recorded in 50 mm increments and classified as young-of-the-year (YOY)/juveniles of < 150 mm total length (TL) or as adults ≥ 150 mm TL. Table 1 contains the counts and estimates, grouped by life stage and habitat type; Figure 2 includes the counts and estimates with the 95% confidence intervals. Based upon the maximum count from all dive passes in each sampled unit, 128 YOY/juveniles and 41 adults (sum total of 169) were observed in July 2008, 5 YOY/juveniles and 7 adults (sum total of 12) were observed in March 2009, and 641 YOY/juveniles and 105 adults (sum total of 746) were observed in July 2009. For all surveys, most juveniles and adults were found in riffle, run heads or pool (head, body, tail) habitats.

Using a bounded counts population estimator, the counts were expanded to estimates of 2,472 YOY/juveniles and 643 adults (sum total of 3,115) in July 2008, 63 YOY/juveniles and 170 adults (sum total of 233) in March 2009, and 3,475 YOY/juveniles and 963 adults (sum total of 4,438) in July 2009. Due to the low counts in March 2009, the *O. mykiss* bounded counts population estimator was derived from counts of the March 2009 Chinook salmon (*O. tshawytscha*) juveniles (< 150 mm TL). The comparable juvenile Chinook salmon maximum counts (population estimates) were 96 (2,636) in July 2008, 4,281 (39,563) in March 2009, and 4,696 (29,389) in July 2009, respectively. The reaches in which *O. mykiss* were observed were RM 41.8-51.8 (July 2008), RM 43.0-51.5 (March 2009) and RM 41.9-51.8 (July 2009).

Additional information on *O. mykiss* and juvenile Chinook salmon densities and distribution, temperature conditions, and comparison with other June snorkel studies are in Stillwater Sciences (2008b, 2009b).

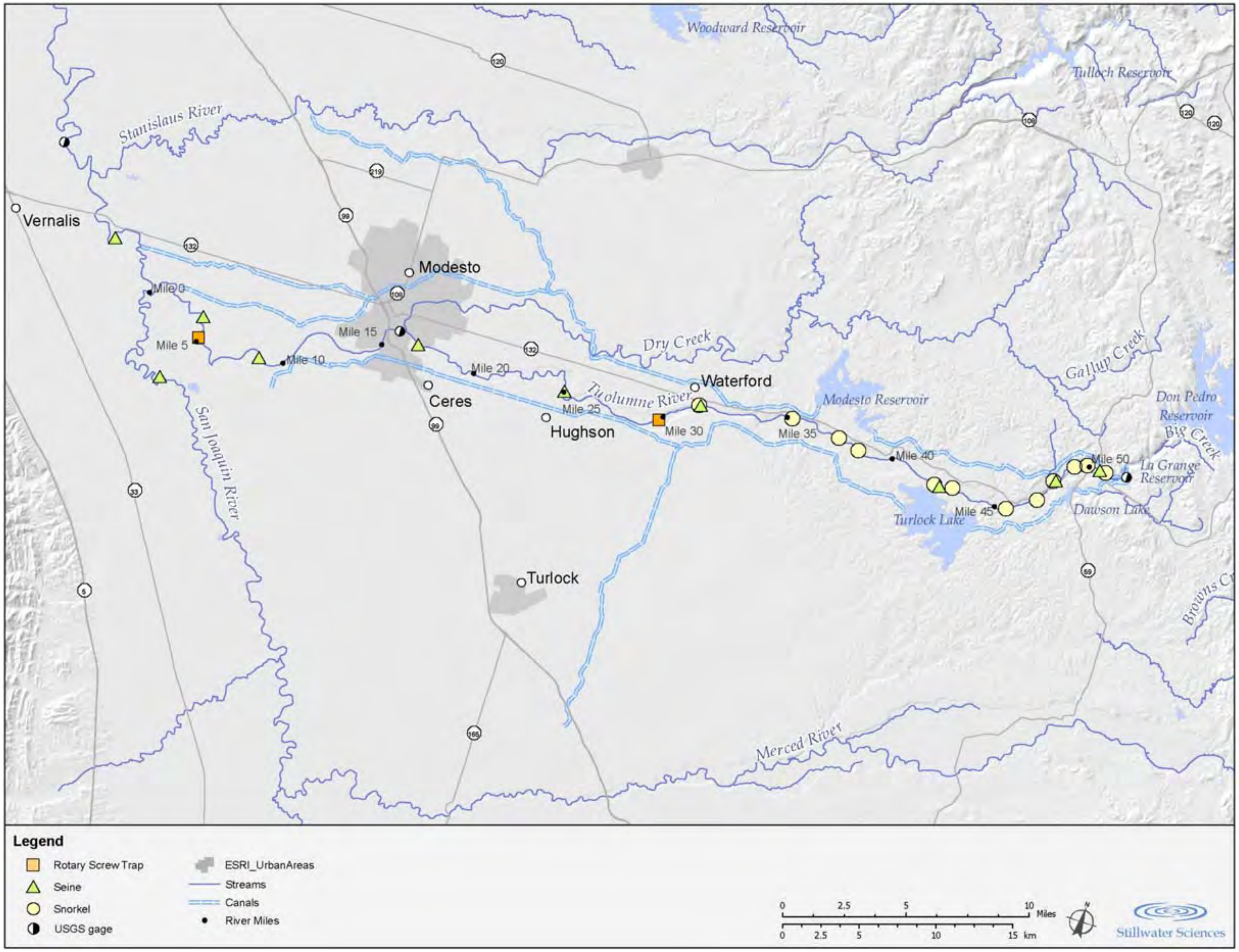


Figure 1. Lower Tuolumne River and reference locations.

Table 1. *O. mykiss* bounded count population estimates by fish length and habitat type in July 2008, March 2009, and July 2009.

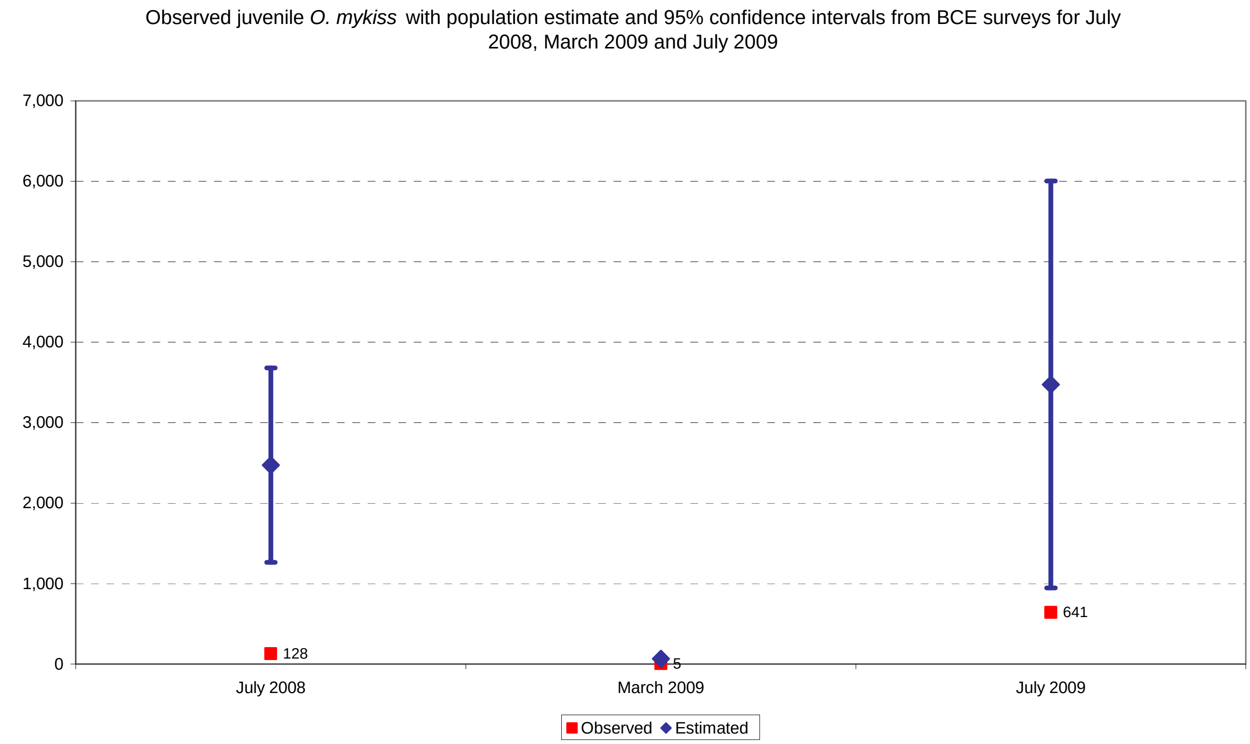
Habitat	*O. mykiss* < 150 mm				*O. mykiss* ≥ 150 mm			
July 2008								
	Obs.[1]	Est.	St. dev.	95% CI[2]	Obs.[1]	Est.	St. dev.	95% CI[2]
Pool head	12	20	8.2	12–36	17	45	13.8	18–72
Pool body	0	--	--	--	3	24	21.5	3–66
Pool tail	1	2	1.9	1–6	0	--	--	--
Riffle	65	1,428	263.6	911–1,944	13	226	142.5	13–505
Run head	45	162	243.6	45–639	2	30	19.8	2–68
Run body	5	860	501.6	5–1,843	6	319	161.4	6–635
Run tail	0	--	--	--	0	--	--	--
Total	128	2,472	616.9	1,263–3681	41	643	217.7	217–1,070
March 2009								
Habitat	*O. mykiss* < 150 mm				*O. mykiss* ≥ 150 mm			
	Obs.[1]	Est.[3]	St. dev.	95% CI[2]	Obs.[1]	Est.[4]	St. dev.	95% CI[2]
Pool head	0	--	--	--	1	≥1	--	--
Pool body	0	--	--	--	0	--	--	--
Pool tail	0	--	--	--	0	--	--	--
Riffle	5	63	--	--	6	170	86.3	6–339
Run head	0	--	--	--	0	--	--	--
Run body	0	--	--	--	0	--	--	--
Run tail	0	--	--	--	0	--	--	--
Total	5	63	--	--	7	170	86.3	7–339
July 2009								
Habitat	*O. mykiss* < 150 mm				*O. mykiss* ≥ 150 mm			
	Obs.[1]	Est.[4]	St. dev.	95% CI[2]	Obs.[1]	Est.	St. dev.	95% CI[2]
Pool head	4	≥4	---	--	23	26	0.0	26–26
Pool body/tail	304	1,382	898.2	304–3,143	16	147	56.8	36–259
Riffle	279	1,528	893.5	279–3,279	48	428	131.0	171–684
Run head	35	265	49.8	168–363	10	206	123.4	10–448
Run body/tail	19	299	240.5	19–771	8	156	170.6	8–490
Total	641	3,475	1,290.5	945–6,004	105	963	254.4	464–1,461

1 Largest numbers seen in any single dive pass for each unit, summed over units. Note that because of the potential for the same fish to be assigned to different size classes on subsequent passes, summation of the largest numbers assigned to individual (50 mm) size bins yields may overestimate total fish observed.

2 Nominal confidence intervals (CI) calculated as ± 1.96 standard deviations (SD). SD and CI undefined for multiple pass units with identical dive counts. The observed number of fish was used as the lower bound of the CI in the cases where the lower 1.96 SD yielded a lower value than the observed number.

3 Estimate for *O. mykiss* juveniles in riffles based on the expansion used for Chinook juveniles in riffles, no uncertainty data provided.

4 Estimate for *O. mykiss* adults in pool head not included in overall population estimate due to lack of multiple pass data.



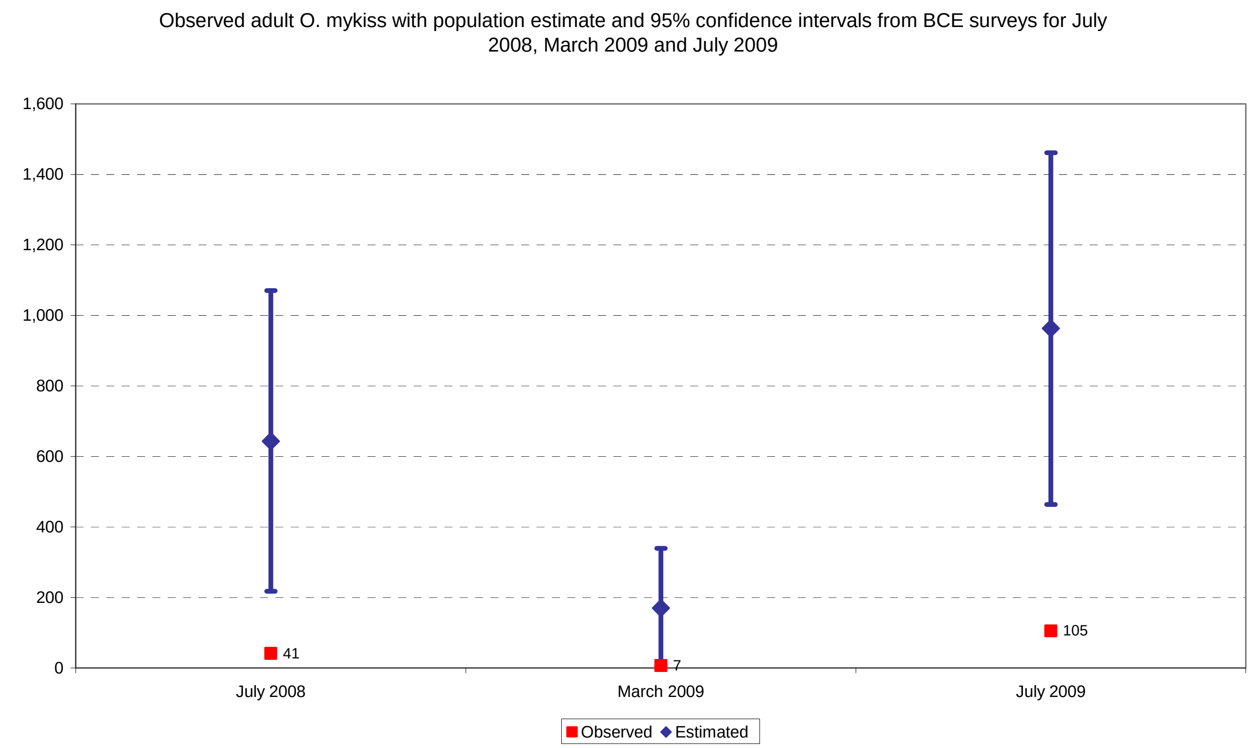


Figure 2. Juvenile and adult *O. mykiss* observed number and population estimates for July 2008, and March and July 2009.

2.2 Other Tuolumne River *O. mykiss* Data

Annual seine survey results are summarized in Ford and Kirihara (2009b). Surveys in recent years were conducted at two-week intervals mainly from January through May. A total of eight Tuolumne River sites were sampled each survey period. In the 2008 seine survey, four *O. mykiss* fry (28-49 mm FL) were caught between 29 April to 13 May at Old La Grange Bridge (RM 50.5) and at Riffle R5 (RM 48.0). The 2009 survey caught seven *O. mykiss* (26-70 mm FL) from March 10- May 5 at RM 48.0-50.5. Low catch numbers of YOY/juveniles *O. mykiss* upstream of RM 42 are typical in the seine monitoring (Table 2, Figure 3).

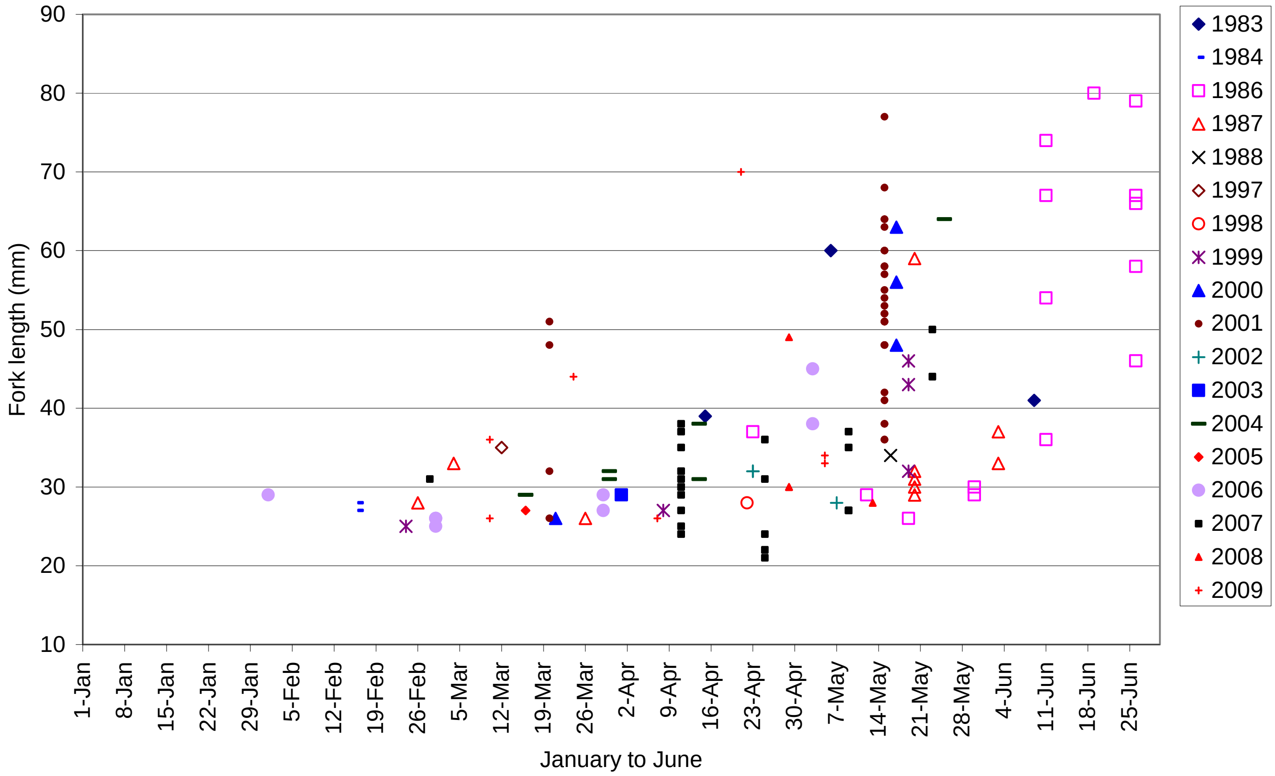


Figure 3. All measured *O. mykiss* caught from Old La Grange Br. (RM 50.5) to Tuolumne River Resort (RM 42.2) during the 1983 to 2009 Tuolumne seining surveys.

Tuolumne River rotary screw trap (RST) monitoring began in 1995 at Shiloh Road (RM 3.4). In 1998, upstream traps began to be utilized. RST site locations and sampling duration have varied over the years and are summarized by Palmer and Sonke (2008). The RST sites have been located near Waterford, CA (RM 29.8) and at Grayson (RM 5.2) since 2006. Like the seine monitoring, there are relatively few *O. mykiss* caught in the RST sampling, but larger *O. mykiss* from about 200–350 mm FL are captured in some years. In 2008 a total of nine *O. mykiss* (58 to 268 mm FL) were captured, with one juvenile (105 mm FL) captured in 2009 at the Waterford RST site. Fewer O. mykiss are captured in the Grayson RST: two adult sized fish in 2008 (200 and 224 mm FL) and none in 2009. Figure 4 shows the size and timing of the RST catches of YOY/juveniles and adult sized *O. mykiss* from 1999–2009.

Table 2. Tuolumne River seining locations (1983–2009) with number of *O. mykiss* caught.

Site	Location	River Mile	1983 [1]	1984 [1]	1985 [1]	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	Old La Grange Bridge	50.5	3	8	X	10	6	1	X	X	X	X	X			X	X	X	3	X	1	2	X	1	1	2	X	4	3
2	Riffle 4B	48.4				5	2	X	X	X	X				X	X	X	1								2			
3	Riffle 5	47.9					2	X	X	X	X	X	X	X					1	3	42	1	X	3	X		8	X	4
4	Tuolumne River Resort	42.4						X	X	X	X	X	X	X	X	X	1	X	1	1	2	X	1	3	X	4	14	X	X
5	Turlock Lake State Rec. Area	42.0	X	X	X	X	X																						
6	Reed Gravel	34.0				X	X	X	X	X	X																		
7	Hickman Bridge	31.6	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8	Charles Road	24.9					X	X	X	X	X	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X
9	Legion Park	17.2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
10	Riverdale Park / Venn	12.3 / 7.4					X	X	X	X	X								X	X	X	X	X	X	X	X	X	X	X
11	McCleskey Ranch	6.0				X	X	X	X	X	X	X	X	X															
12	Shiloh Bridge	3.4	X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

[1] CDFG seining

X = Locations that were sampled with no *O. mykiss* captured

Table 3. Tuolumne River snorkel survey locations (1982–2009) with number of *O. mykiss* observed.

	1982	1984		1985	1986		1987			1988					1989				1990				1991		1992	
	AUG	APR	AUG	MAR	JUL	AUG	JAN	APR	OCT	MAY	JUN	JUL	AUG	SEP	MAY	JUN	JUL	SEP	MAY	JUN	JUL	SEP	JUN	SEP	JUN	SEP
LOCATIONS																										
Riffle A3/A4 (RM 51.6)			27	2		6			X	X				X	X	X	X	X	X	X	X	X	X	X	1	X
Riffle A7 (RM 50.7)			26			13			X						X	X		X	X		X					
Riffle 1A (RM 50.4)								X									X									
Riffle 2 (RM 49.9)	X		X			25	X	X		X				X	X			X	X	X		X	X	X	X	X
Riffle 3B (RM 49.1)																										
Riffle 4B (RM 48.4)	X	12		X	5	10																				
Riffle 5B (RM 48.0)	2	X	X	X		10	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Riffle 7 (RM 46.9)																										
Riffle 9 (RM 46.4)										X				X	X			X		X		X	X	X	X	X
Riffle 12 (RM 45.8)																										
Riffle 13A-B (RM 45.6)																										
Riffle 17A2 (RM 44.4)																										
Riffle 21 (RM 42.9)																										
Riffle 23B-C (RM 42.3)										X				X	X			X		X		X	X	X	X	X
Riffle 24 (RM 42.0)					X																					
Riffle 26 (RM 40.9)																										
Riffle 27(RM 40.3)																										
Riffle 30B (RM 38.5)																										
Riffle 31 (RM 38.1)																										
Riffle 33 (RM 37.8)										X				X	X			X		X		X				
Riffle 35A (RM 37.0)																										
Riffle 36A (RM 36.7)																										
Riffle 37 (RM 36.2)								X																		
Riffle 39-40 (RM 35.4)										X				X	X			X		X		X	X	X	X	X
Riffle 41A (RM 35.3)																										
Riffle 46 (RM 34.0)					X		X																			
Riffle 52B (RM 32.2)										X				X												
Riffle 57-58 (RM 31.5)		X		X											X			X		X		X	X	X	X	X
Charles (RM 24.9)										X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X
Total O.mykiss	2	12	53	2	5	64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Table 3 (continued)

	1993				1994			1995	1996	1997	1999	2000	2001		2002		2003		2004			2005	2006	2007		2008	2009
	MAY	JUN	JUL	OCT	MAY	JUL	OCT	NOV	JUL	JUN	JUN	JUN	JUN	SEP	JUN	SEP	JUN	SEP	JUN	AUG	SEP	SEP	SEP	JUN	SEP	JUN	JUN
LOCATIONS																											
Riffle A3/A4 (RM 51.6)	X	X	X	X		X	X	X		4										5							
Riffle A7 (RM 50.7)	X	X	X	X	X			1	**X**	2	14	14	7	3	5	1	66	16	12	6	11	10	115	106	75	76	80
Riffle 1A (RM 50.4)	X	X		X					**51**			3								4							
Riffle 2 (RM 49.9)	X	X		X		X	X		**91**	2	X		3	3	1	4	8	2	23	2	7	7	15	34	16	9	12
Riffle 3B (RM 49.1)									**138**	X	31	14	8	1	11	1	5	21	22	5	7	6	66	45	12	78	27
Riffle 4B (RM 48.4)	X								**55**											8							
Riffle 5B (RM 48.0)	X		X		X	X	X	2	**45**	X	10	19	4	2	3	X	6	10	11	15	6	36	54	92	10	21	11
Riffle 7 (RM 46.9)									4	X	15	52	4	X	5	2	14	9	13	5	2	2	106	22	7	13	6
Riffle 9 (RM 46.4)	X	X		X		X	X													3							
Riffle 12 (RM 45.8)												5															
Riffle 13A-B (RM 45.6)	X											20	3	X	2	4	1	6	5	13	X	46	103	15	57	24	4
Riffle 17A2 (RM 44.4)												14															
Riffle 21 (RM 42.9)									X			27	2	3	1	X	X	6	5	9	7	15	32	10	10	11	0
Riffle 23B-C (RM 42.3)			X		X					X	9	4	X	X	X	X	1	1	X	1	X	14	27	5	7	X	2
Riffle 24 (RM 42.0)	X							X																			
Riffle 26 (RM 40.9)												4															
Riffle 27(RM 40.3)												2															
Riffle 30B (RM 38.5)											X				X	X											
Riffle 31 (RM 38.1)												2	X	X			X	X	X	X	X	1	21	12	4	X	X
Riffle 33 (RM 37.8)																											
Riffle 35A (RM 37.0)									X			X			X	X	X	X	X	X	X	2		X	X	X	X
Riffle 36A (RM 36.7)	X		X		X				X	X	X												4				
Riffle 37 (RM 36.2)												X	X	X													
Riffle 39-40 (RM 35.4)		X		X		X	X																				
Riffle 41A (RM 35.3)												X	X	X	X	X	X	X	X	X	X	X	X	2	X	X	X
Riffle 46 (RM 34.0)												X															
Riffle 52B (RM 32.2)												X															
Riffle 57-58 (RM 31.5)	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
Charles (RM 24.9)		X		X			X																				
Total O.mykiss	0	0	0	0	0	0	0	3	**384**	8	79	180	31	12	28	12	101	71	91	76	40	139	543	343	198	232	142

Note: 1996 data in bold type was collected by CDFG using different survey methods that are not comparable

X = Locations that were sampled with no *O. mykiss* observed

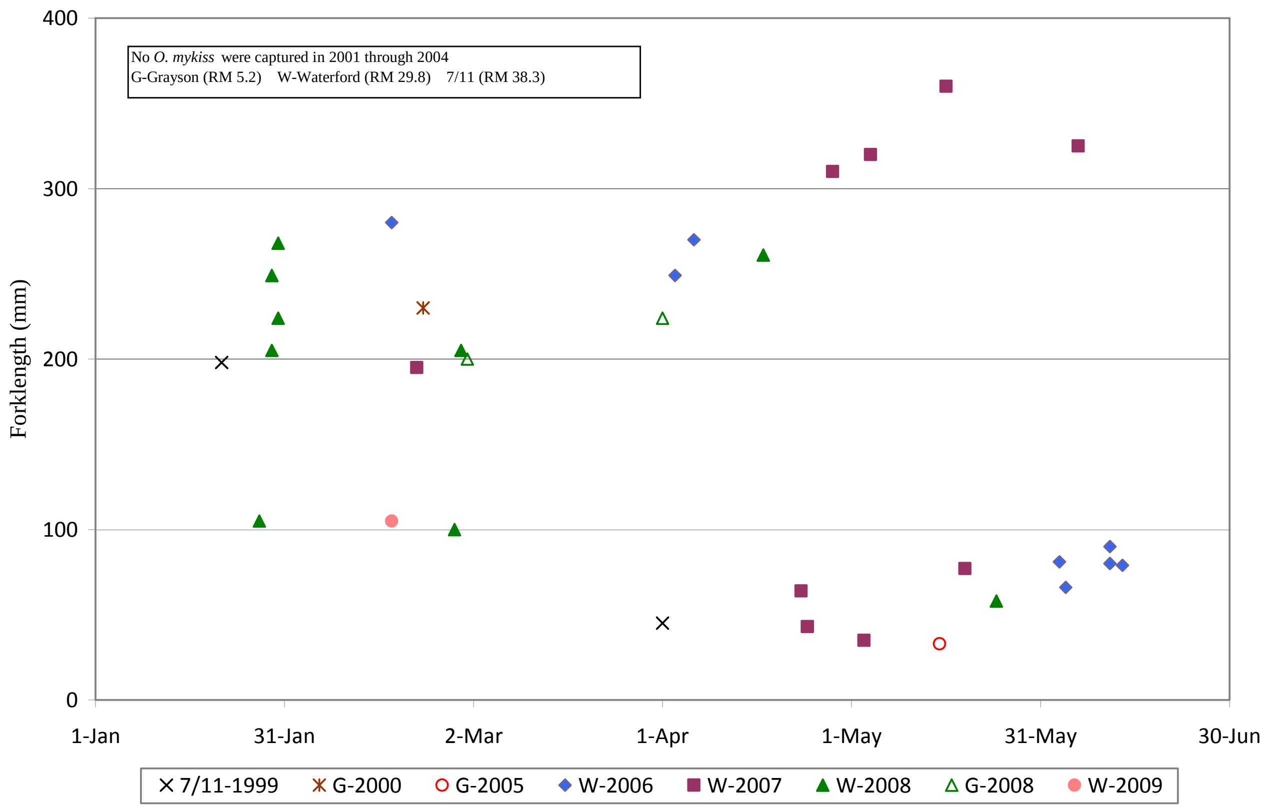
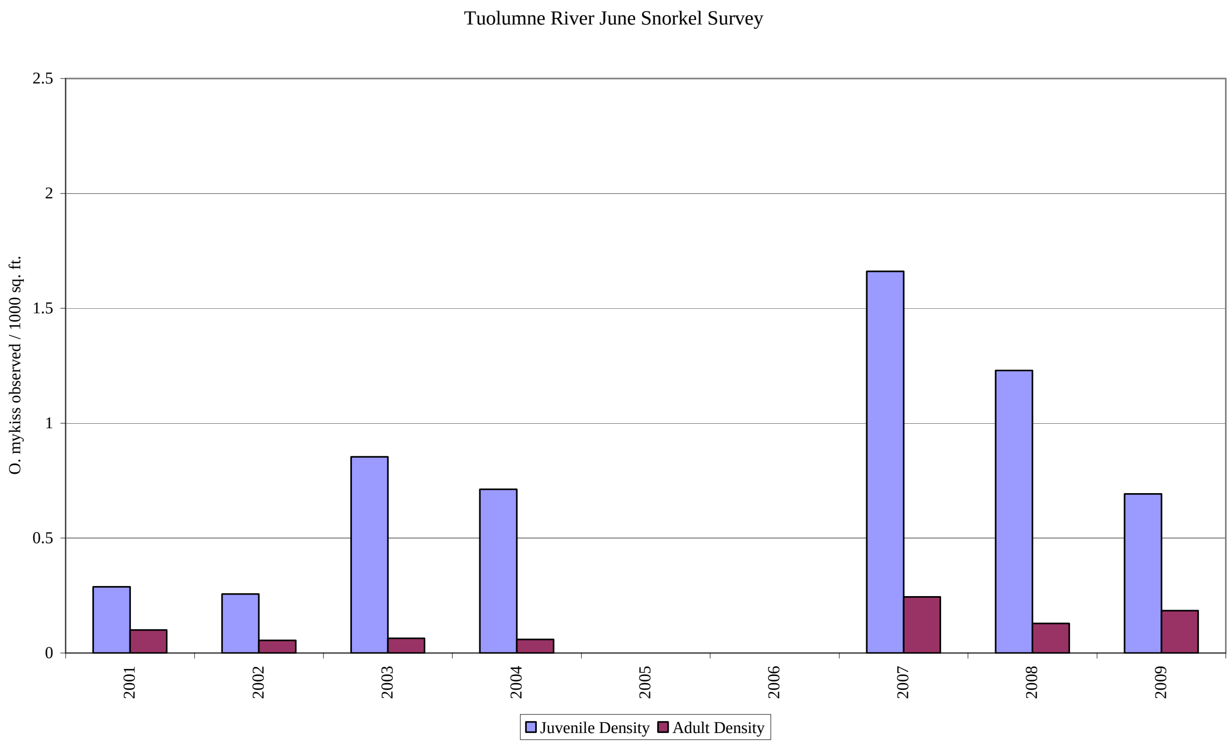


Figure 4. Tuolumne River rotary screw trap captures of *O. mykiss* from 1999 to 2009.

Other Tuolumne River snorkel surveys provide most of the *O. mykiss* information prior to 2008 and results are summarized in Ford and Kirihara (2009c). Table 3 has the month and locations surveyed, and the *O. mykiss* counts if any were observed. Early summer snorkel surveys (June/July) in the Tuolumne River have been conducted in most years since 1986, except in years with high flows (1995, 1998, 2005, 2006), and have been relatively standardized since 2001. These reference count (or "index") surveys also obtain fish density for YOY/juveniles (<150 mm TL) and adults (≥150 mm TL) using the areas searched at each snorkeling site. For the recent years with paired early and late summer surveys between 2001–2009, Figure 5 shows that June density of juvenile *O. mykiss* was much higher than for adults, with September surveys showing higher adult *O. mykiss* density than juveniles in some years. The highest observed *O. mykiss* density indices have generally been observed upstream of RM 42 (Figure 6). Water temperatures recorded at most snorkel locations with *O. mykiss* have ranged from about 51.8–71.6ºF (11–22ºC) (Figure 7).

A previous compilation of Tuolumne River *O. mykiss* records (Ford and Kirihara 2008) has been updated with 2008–2009 records from seine, RST, and snorkel monitoring programs (Appendix B).



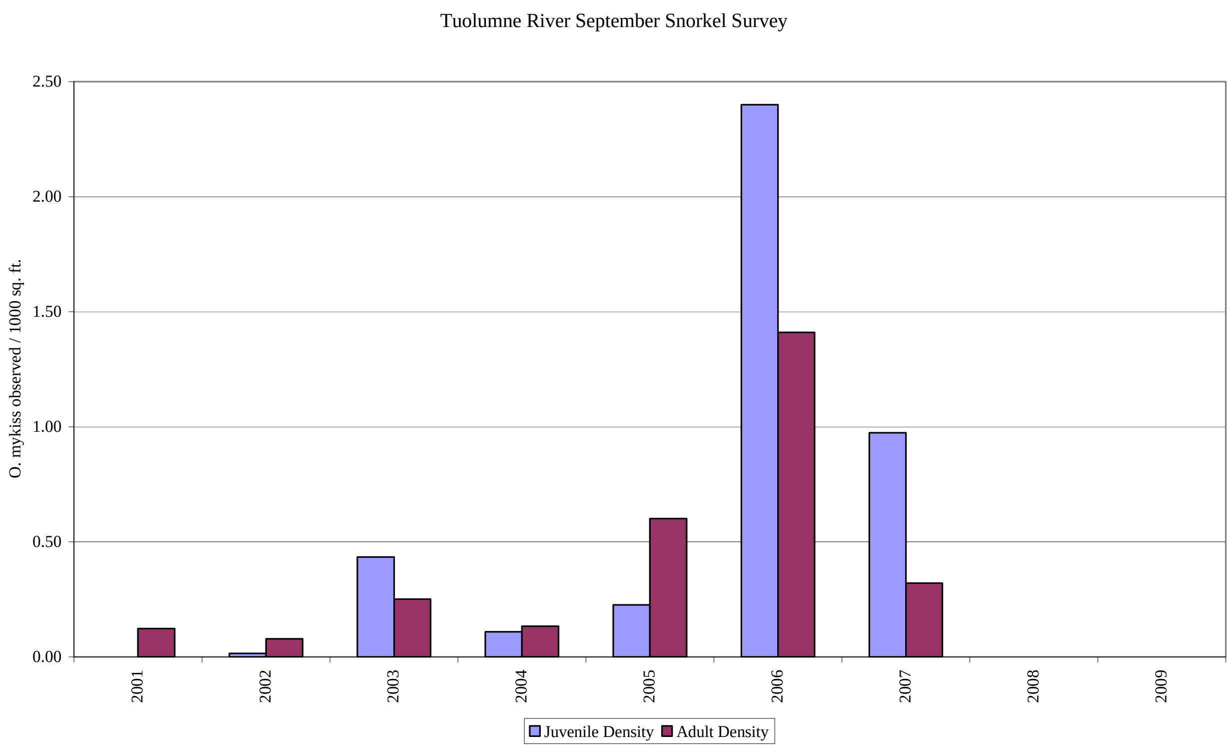


Figure 5. Density of juvenile (< 150 mm TL) and adult (=>150 mm TL) *O. mykiss* in Tuolumne River June and September snorkel surveys.

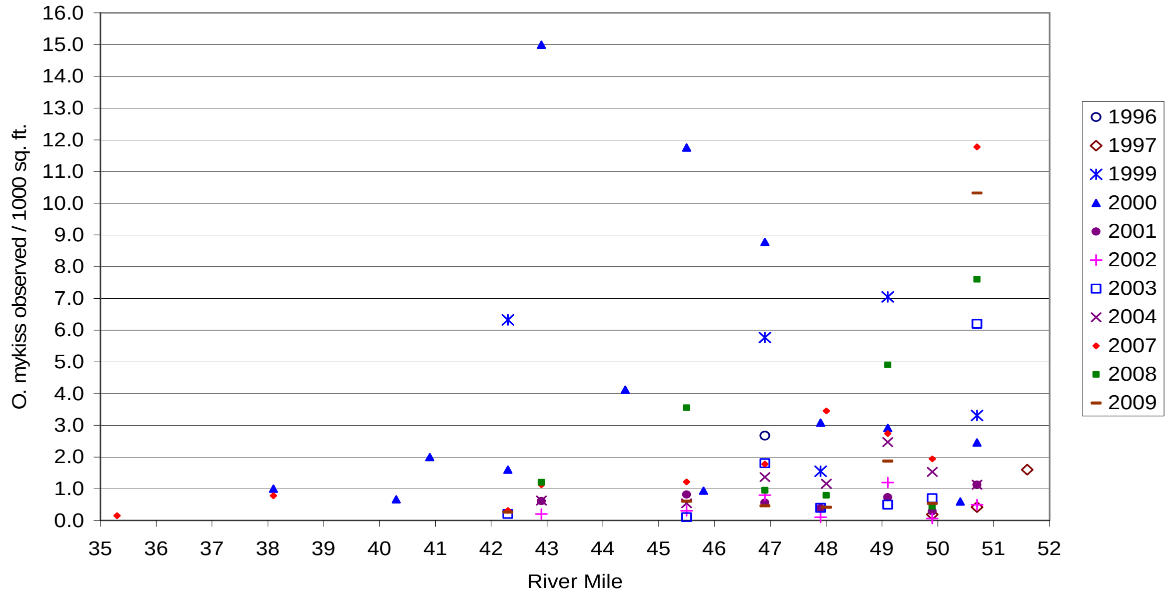


Figure 6. Density indices of *O. mykiss* in 1996–2009 Tuolumne River June/July snorkel surveys.

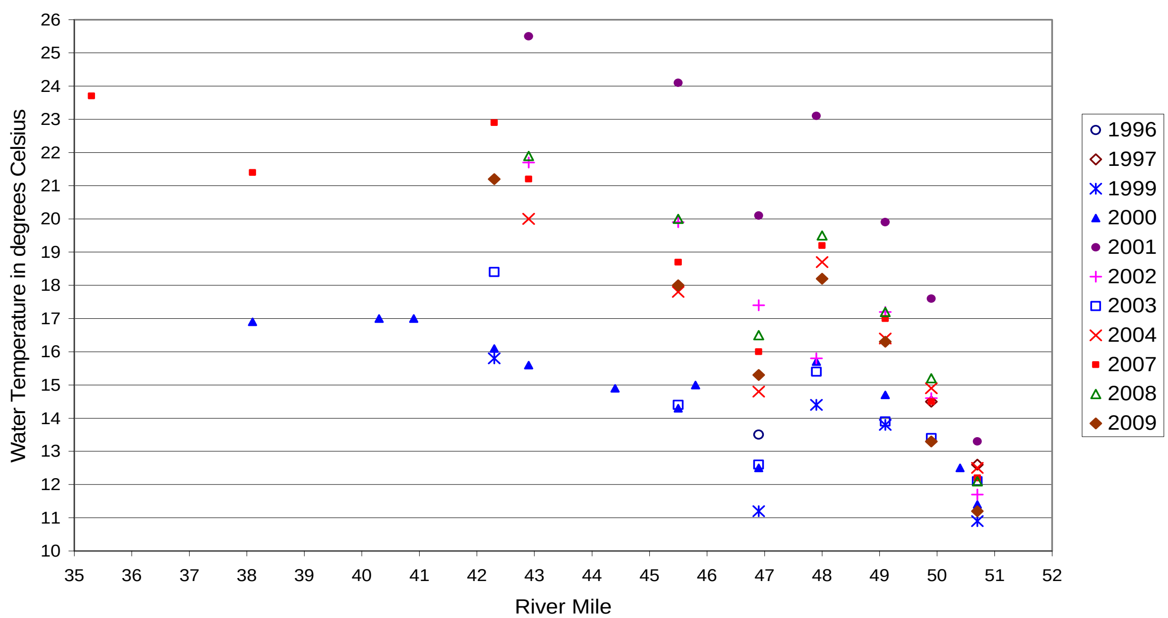


Figure 7. Water temperature where *O. mykiss* were observed in 1996–2009 Tuolumne River June/July snorkel surveys.

2.3 Habitat Restoration Monitoring

Few habitat restoration projects (gravel additions) have been implemented in the primary spawning reach of the Tuolumne River upstream of RM 40 since the gravel losses and fine sediment impacts associated with the 1997 floods (TID/MID 2005). Gravel addition projects were completed in riffle habitats between RM 50–51 (Riffles A7, 1A, 1B) in 2003 and between RM 43.0–43.2 (Bobcat Flat) in 2005. Other planned gravel additions by the Districts were not implemented due to CDFG opposition. Stillwater Sciences (2009b) reviewed the limited results to date from observations of habitat use made during the 2008–2009 the population estimate surveys. Habitat types surveyed in restoration sites were riffle, run head, and pool head with both YOY/juveniles and adult *O. mykiss* observed in restoration sites; juvenile *O. mykiss* had a relatively high use of riffle habitat at restoration sites.

3 *O. MYKISS* MONITORING IN OTHER SAN JOAQUIN RIVER TRIBUTARIES

O. mykiss monitoring programs from Eilers (2008) and other sources were reviewed for other San Joaquin River tributaries: Mokelumne, Calaveras, Stanislaus and Merced Rivers (Figure 8). In general, the monitoring efforts and reporting differ among the streams, in some cases are sporadic, and also vary in duration and type.

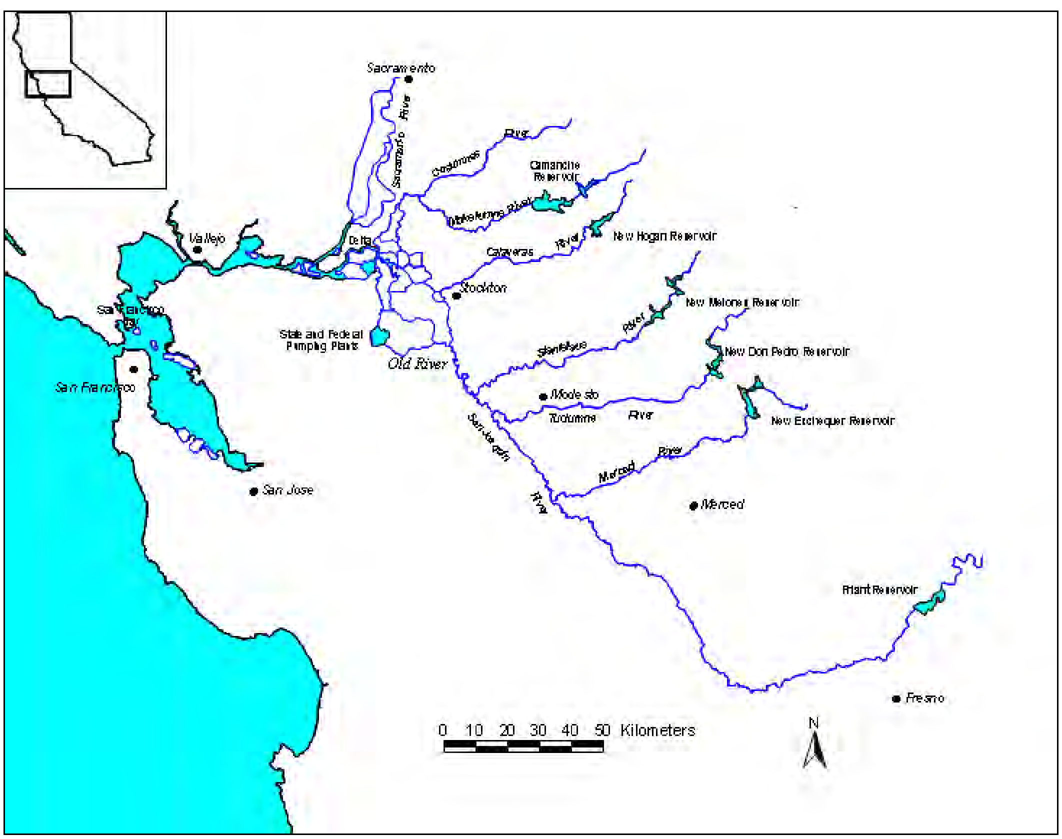


Figure 8. San Joaquin River and tributaries.

3.1 Mokelumne River

The Mokelumne *O. mykiss* population is mainly the product of an intensive hatchery program run by CDFG downstream of Camanche Dam (RM 63.8); data on adult trapping at the hatchery has been collected since 1963. Pagliughi (2008) was the source of most *O. mykiss* information summarized for the Mokelumne River. Historically, the first *O. mykiss* trapped at the hatchery arrives as early as October and as late as early January. Peak spawning activity occurs between December and January, with the last trapped fish arriving between February and March of most years. In addition, upstream adult migration monitoring conducted at Woodbridge Dam at RM 39 using videography as well as live trapping shows that peak adult *O. mykiss* migration occurs between September and February. Data on rearing and emigration of juvenile *O. mykiss* is obtained using seine, electrofishing, RST, bypass, and ladder trap monitoring. Juvenile *O. mykiss* passage downstream of Woodbridge Dam occurs between December and July, peaking in April/May (monitoring is not conducted between August and December). Smolts are also captured at Woodbridge Dam between December and July, with peak outmigration occurring between December and March. In addition, acoustic tagging of age 1+ *O. mykiss* was initiated in 2007 to examine behavior and movement of hatchery and naturally produced fish (Eilers, 2008).

3.2 Calaveras River

A review of accounts of *O. mykiss* in the Calaveras River reported steelhead are still present downstream of New Hogan Dam at RM 42, although some migration/passage issues are present (Marsh 2007). An RST has operated at Shelton Road (RM 28) from December through May since 2002 where smolt-sized *O. mykiss* have been documented each year with the majority caught from December to May and juveniles are generally observed from early March into June (Stockton East Water District, *unpublished data*). Snorkel surveys in 2002 found the following: *O. mykiss* <100 mm predominantly were in the upper reaches below New Hogan Dam with highest densities in early April; densities of *O. mykiss* 100–199 mm increased from summer through fall; *O. mykiss* >200 mm had highest densities in riffle/glide habitat during summer and in pool habitat during fall (Stillwater Sciences 2004).

3.3 Stanislaus River

Primary weir and RST monitoring results for *O. mykiss* were from FISHBIO Environmental, Oakdale, CA. Adult *O. mykiss* are monitored at the camera-mounted fish counting weir at RM 31.5 that has been operated intermittently since 2002, usually from September to December or January. The annual number of adult *O. mykiss* counted moving upstream through the weir has ranged from one to seventeen during 2005–2008. About 40% of those fish were identified as hatchery fish having clipped adipose fins. *O. mykiss* are also seasonally monitored at RSTs located at Oakdale (RM 40—beginning in 1993) and at Caswell (RM 9—beginning in 1995); the size and timing of the *O. mykiss* catch is shown in Figure 9. Eilers (2008) reported that *O. mykiss* were also monitored from 2002–2007 at sites from Goodwin Dam (RM 58.3) to Oakdale (RM 40) utilizing snorkel surveys conducted two times each month; results of 2002–2004 efforts were presented in Kennedy and Cannon (2005). Ongoing studies are also examining relationships of habitat availability (through mapping) and utilization by juveniles at various flows employing snorkeling, seining, and electrofishing (Eilers 2008). Generalized life stage timing for the Stanislaus River is shown in Table 4.

Table 4. Generalized *O. mykiss* life stage timing for Stanislaus River—darker shading indicates peak use.

Life Stage	Fall			Winter			Spring			Summer		
	September	October	November	December	January	February	March	April	May	June	July	August
Central Valley Steelhead												
Adult Upstream Migration	▒	■	■	■	■	■	▒				▒	▒
Adult Spawning				▒	■	■	■					
Egg incubation and Fry Emergence					■	■	■	■	▒			
Juvenile Rearing	■	■	■	■	■	■	■	■	■	■	■	■
Yearling Smolt Emigration					▒	■	■	■	■	▒		

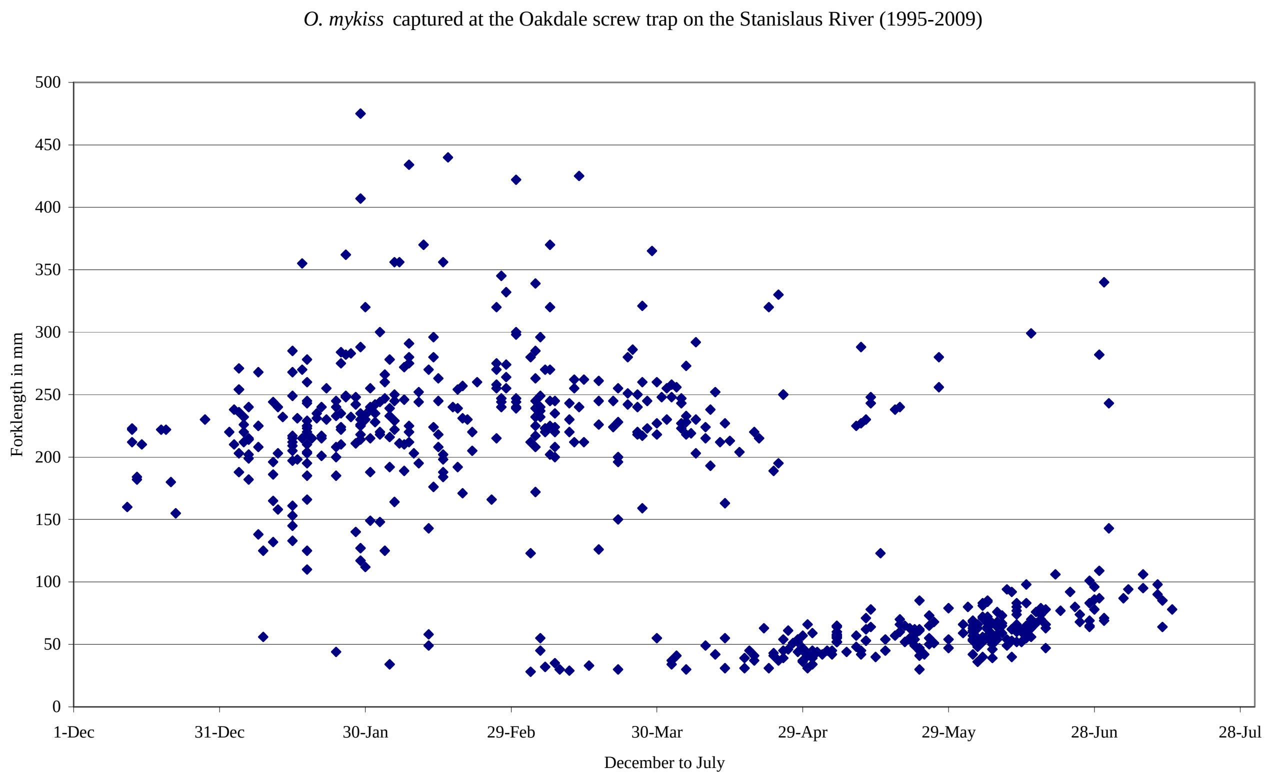
Notes

1. Adapted with modifications from NMFS 2009 - Fig. 5-21, pg 200

2. Dark Shading = Peak activity; Medium Shading = Potential activity

3.4 Merced River

RST monitoring has been intermittently conducted at RM 40 near Hopeton since 1999, downstream at RM 12.2 near Hagaman Park (1998–2003), and at RM 2 near Hatfield State Park (2007–2009). *O. mykiss* results from the RST sampling were not located, with the exception that none were caught at the RM 2 RST in 2007 (Montgomery, et al. 2007). An extensive two-year survey of native and non-native fish assemblages conducted over multiple events during 2006–2008 using snorkel surveys, seining, backpack electrofishing, and boat electrofishing found relatively few *O. mykiss*, all within a 7-mile reach below Crocker-Huffman Dam at RM 51.9 (Stillwater Sciences 2008c).



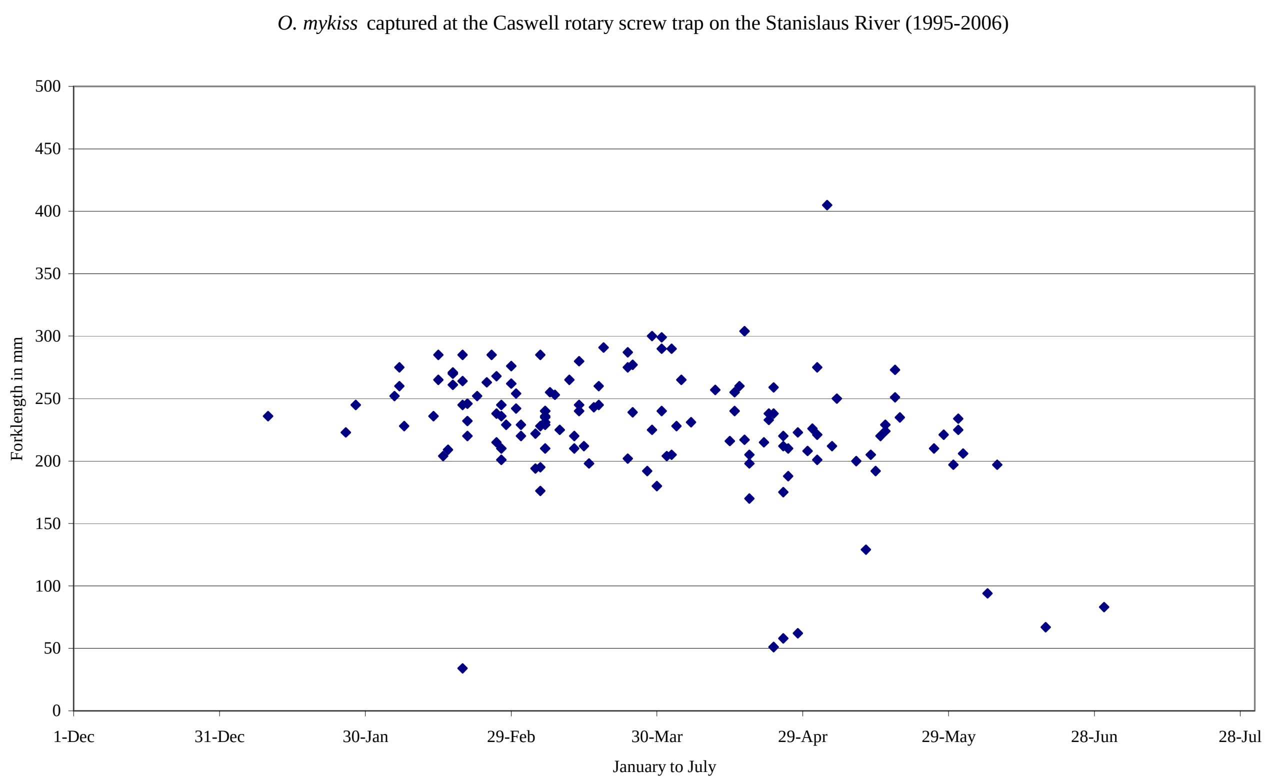


Figure 9. Forklength distribution of *O. mykiss* captured at Oakdale (1995–2009; preliminary data - FISHBIO) and Caswell (1995–2006; U.S. Fish and Wildlife Service data) rotary screw traps on the Stanislaus River

4 RECOMMENDATIONS FOR PROTECTION MEASURES AND MONITORING

In its July 16, 2009 Order, the Commission requested consideration of whether interim measures may be necessary to protect fishery resources on the Tuolumne pending Project relicensing. As part of the proceedings following the July 16, 2009 Order, the Districts provided a report on August 24, 2009 of proposed additional voluntary protective measures intended to benefit fishery resources in the Tuolumne River pending relicensing, including *O. mykiss*. Below it is recommended from those measures, as well as others, the following *O. mykiss* protection and monitoring actions.

Recommended protection measures are:

- Continue augmented summer flows in dry year types. This measure is intended to maintain or increase the extent of cool water habitat present in the river downstream of La Grange Dam (RM 51.8) during years similar to recent dry water year types. For example:
    - During periods when the existing FERC minimum instream flow requirement is 75 cfs, provide additional flows to maintain an average of about 110 cfs at the La Grange Gage (USGS 11289650).
    - During periods when the existing FERC minimum flow requirement is 50 cfs, provide additional flows to maintain an average of about 100 cfs.
- Continue variable summer flow operations in dry year types. A range of variable supplemental flows would provide higher flows on days with elevated National Weather Service forecasted air temperatures at Modesto (such as 100°F or greater), in addition to maintaining higher than required base flows. These flow operations are designed to evaluate the dynamics of air temperatures and flow changes in relation to downstream water temperature conditions and modeled projections. For example:
    - In water years when the FERC minimum instream flow requirement is 75 cfs, an augmented seasonal flow averaging about 110 cfs should be used, with variable flows within a range of about 100–130 cfs.
    - In water years when the FERC minimum instream flow requirement is 50 cfs, an augmented seasonal flow averaging about 100 cfs should be used, with variable flows depending upon air temperatures within a range of about 95–115 cfs.
- Fine sediment management. The Districts should continue to support state and federal regulatory efforts to minimize, and mitigate for, impacts of excessive fine sediment inputs to the river from poor land management practices in the watershed upstream of RM 39 (i.e., Peaslee Creek drainage).
- Habitat restoration. The Districts should continue to support implementation of previously identified gravel augmentation projects within the primary spawning reach downstream of

La Grange Dam (RM 40–52). These projects are consistent with the 1995 FERC Settlement Agreement (TID/MID 1996), the Habitat Restoration Plan for the lower Tuolumne River Corridor (McBain & Trush 2000), and the Tuolumne River Coarse Sediment Management Plan (McBain & Trush 2004). The Districts should continue to seek previously approved California Bay-Delta Authority funding and possibly other potential funding sources, such as the San Francisco Public Utilities Commission.

Recommended monitoring actions are:

- Population estimate surveys. The Districts should continue summer population estimate surveys using snorkel methods in 2010–2011 during July only and within the approximate reach of RM 40–52 where *O. mykiss* have been routinely observed. Sampling at flows greater than 350 cfs would be subject to postponement or cancellation as needed for safety purposes.

- Reference count snorkel surveys. The Districts should conduct reference count snorkel surveys at historical snorkeling sites on an expanded schedule during 2010 and 2011: June, September, and 1–2 surveys conducted between January and April. As described above, sampling at higher than typical flows, if they occur, would be subject to postponement or cancellation as needed for safety purposes.

- Adult *O. mykiss* tracking study. The Districts should conduct the adult tracking study in 2010–2011. This study is intended to document habitat use, movement patterns, in-river migration rates, and possibly spawning locations of acoustically tagged adult *O. mykiss* in the Tuolumne River. The pending scientific collection permit application for 2010 has identified implanting acoustic tags in up to 20 adult *O. mykiss* in each year. Study fish would primarily be obtained by angling within the winter/spring (Jan–Jun) period, with potential use of study fish captured at the Waterford RST. Three fixed station hydrophone locations as well as mobile tracking would be utilized for determining movement and habitat utilization.

- Routine Monitoring. The Districts should conduct the following routine monitoring activities in 2010-2011 for the purpose of maintaining the long-term comparative information of the Tuolumne River fisheries monitoring program:

    - Seining and screw trapping in winter/spring (January-May) to document size, abundance, migration, and distribution of juvenile salmonids and other fish species in the Tuolumne and San Joaquin Rivers

    - Year-round thermograph monitoring and analysis of flow/temperature conditions.

- Reporting. The Districts should continue to produce annual reports of monitoring results for 2010–2011 and annual compilation of *O. mykiss* records, including from other Tuolumne fishery monitoring programs (e.g., seine, screw trap); CDFG or other agencies could augment that summary by providing any additional relevant *O. mykiss* data (prior CDFG records available to the Districts were through mid-2004). It is also intended that this report and the annual reports would supplant the proposed 2012 report of the 2007 study plan.

It should be noted that the previously proposed anadromy study of the 2007 study plan has not been supported by the fishery agencies due to the lethal sampling needed to obtain otoliths. The completion of a recent otolith evaluation that included Tuolumne River samples identified low proportions of anadromous *O. mykiss* (Zimmerman et al. 2009). In any case, the Districts should re-examine specific *O. mykiss* monitoring elements beyond 2011 with the fishery resource agencies.

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Appendix A

Excerpt from Tuolumne River Fisheries Study Plan
Don Pedro Hydroelectric Project (FERC No. 2299)

Turlock Irrigation District and Modesto Irrigation District

JULY 13, 2007

IV. STEELHEAD PRESENCE/PROTECTION

Identified FERC Issue:
The original FERC Letter requests that the size and habitat needs of the *O. mykiss* population in the Tuolumne River be determined. FERC also requests monitoring to document the absence or presence of anadromous *O. mykiss* (steelhead) of the population. FERC requests additional study elements to determine the flow and habitat needs of steelhead if they are present in the Tuolumne River population. Studies should include comparisons to steelhead data from nearby rivers.

Districts' Issue Assessment:
The Districts consider questions regarding habitat needs of anadromous *O. mykiss* to be the same as habitat needs of resident *O. mykiss*. Although agency monitoring (McEwan 2001) has detected small self-sustaining populations of steelhead in the Stanislaus, Mokelumne, and Calaveras rivers to the north of the Tuolumne, studies of otoliths from both live *O. mykiss* captures and carcasses recovered by CDFG to date have not indicated that the Tuolumne River has a self-sustaining steelhead population (TID/MID 2005a). In addition, Mokelumne and Calaveras river steelhead are dominated by hatchery-origin non-native Central Valley steelhead stock.

Neither the Districts nor their consultants have been able to obtain the necessary regulatory authorization under Section 10 of the Endangered Species Act (ESA) to perform steelhead tracking studies or to determine habitat preferences. Also, no permits have been made available for sacrificial sampling of *O. mykiss* to determine anadromy by micro-chemical analysis of otoliths. Therefore, without explicit Fish Agency support for these sampling programs it may not be possible to address the steelhead issue requested in the original FERC letter utilizing currently available methods of study mandated to protect the anadromous form of *O. mykiss* under the ESA. .

In accordance with the 1995 FSA, TID has proceeded with development of an irrigation only diversion at RM 26 and the Turlock Area Drinking Water Project (now called Turlock Regional Surface Water Supply Project). Assuming that a mutually agreeable multi-party funding arrangement can be achieved for the capital and annual operation and maintenance costs of the fish-only portion of the supplemental irrigation water project, then diversions for supplemental irrigation water at RM 26 could possibly begin by June 1, 2009. Commercial operation of the Regional Project is estimated to begin in 2011. It is anticipated that diversions for the Regional Project could initially add up to 50 cfs of additional flow during the summer of all water year types, with a maximum capacity of near 100 cfs depending on project demands and available multi-party funding for supplemental irrigation water diversions.

Hypotheses:
Whether or not a self-sustaining steelhead population is present in the lower Tuolumne River and because any anadromous and resident *O. mykiss* in upstream areas have the same habitat requirements as Chinook Salmon, the Districts believe the identified issue is best addressed by documenting the relative abundance and the habitat requirements of *O. mykiss* present in the Tuolumne River in order to test the following hypotheses:

> Hypothesis 1: Summertime distribution of suitable habitat by observed life stages of *O. mykiss* is related to ambient river water temperature.
>
> Hypothesis 2: Habitat use by *O. mykiss* juveniles and adults observed in the Tuolumne River occurs at the same density in both restored and nearby reference sites.
>
> Hypothesis 3: A self-sustaining population of anadromous *O. mykiss* (steelhead) is present on the Tuolumne River.

The Districts have long documented the presence of *O. mykiss* in the Tuolumne River (TID/MID 2005a). As noted in the 2005 Ten Year Summary Report, FERC began informal consultation with NOAA Fisheries and the Districts in 2003 regarding steelhead issues. That consultation was followed by several information requests and submittals by the Districts. Hypotheses No. 1 is partially addressed with past summertime snorkel observations that show *O. mykiss* distribution and habitat use has extended downstream by several miles in response to the increased flows under the flow schedules in the 1996 FERC Order (TID/MID 2005a).

As described under Habitat Restoration, a number of ongoing monitoring activities are underway to assess Hypotheses No. 1 and No. 2 above. The Coarse Sediment Management Plan (Report 2004-12, TID/MID 2004) included conceptual designs with appropriate gravel sizes and habitat features intended to provide favorable spawning and feeding stations for *O. mykiss*. These habitat design recommendations have also been included in the recently completed Bobcat Flat/RM 43 restoration projects as well as coarse sediment augmentation projects planned for implementation in 2007–2008.

Building upon pre-project and post-project monitoring of suitable in-channel rearing habitat at the SRP-9 and GMR-I restoration project sites (McBain & Trush and Stillwater Sciences 2006), the hypotheses above will be examined by comparisons of observed life stages of *O. mykiss* at constructed and planned gravel augmentation sites relative to reference riffles in each of three years of the current TRTAC monitoring program (CDFG Grant No. ERP-04-S04). Surveys will be conducted using electrofishing, snorkel, and seining methods as allowed by the fish agencies. Lastly, further fine scale habitat suitability mapping will be conducted adjacent to gravel augmentation sites under a pending amendment of the Coarse Sediment Transfusion Project (CDFG Grant No. ERP-02-P29).

Recommended Approach and Methods:
As described above, there are several ongoing monitoring programs related to post-project monitoring of completed and planned restoration projects. Each program has its own set of inter-related hypotheses and performance metrics that range from geomorphic and fluvial processes, to the fishery resource objectives discussed in the FERC public meeting on July 25, 2006; and on to broader issues of riparian and ecosystem functioning and NEPA/CEQA compliance. At this time, the Districts believe that the projects that have been initiated to date will address the monitoring issues above. Below the Districts describe analyses and additional monitoring activities to address the identified hypotheses:

1) <u>Summer Population Estimate</u>. The proposed surveys make use of a two-phase sampling approach using bounded count population estimates (Hankin and Mohr 2001) from snorkel and electrofishing surveys of representative habitat types within areas where *O. mykiss* have been frequently observed during the summer in the lower Tuolumne River (approximately RM 52-40). In the first phase, 24 sampling units will be selected to span the major habitat types (i.e., riffles, runs, pools) represented in the river. These sites will be surveyed using standard snorkel survey techniques (Edmundson et al. 1968, Hankin and Reeves 1988, McCain 1992, Dolloff et al. 1996) and calibrated to electrofishing techniques described by Reynolds (1996) and Beechie et al (2005). Where possible, block nets will be used to prevent migration in and out of the sample site and will facilitate an accurate assessment of the sample population. In the second phase, four sites of each habitat type will be randomly selected for an additional three survey passes using a combination of snorkel and electrofishing surveys. Limited backpack electrofishing outside of spawning and rearing areas for Chinook salmon is currently permitted under the CDFG 4d permit program, with a Section 10 permit pending with NMFS. Sample methods may be modified depending upon permitting restrictions. In all, this represents 60 dive passes to be conducted by 2–4 divers over 3–4 days. Analysis methods will generally follow the estimators described in Hankin and Mohr (2001) with population estimates on a habitat unit, length and areal basis from

the existing Tuolumne River GIS. The surveys will be conducted during summers 2007 through 2011.

2) Sampling of *O. mykiss* for Anadromy. As a means of testing Hypothesis No. 3, the Districts will seek permits for scientific collection of *O. mykiss* samples for a period of four years (2008–2011). Contingent upon permitting support from NMFS and CDFG, the Districts will collect otoliths from up to 10 percent of all juvenile *O. mykiss* captured during river-wide seining, RST monitoring, and electrofishing for subsequent otolith analysis using micro-chemical testing of Sr:Ca ratio within growth rings (Zimmermann 2005). Adult *O. mykiss* will be captured during spring in two surveys using hook and line sampling. Otoliths will be collected from a subset of adult *O. mykiss*. Analysis of otoliths from adults will be used to determine the proportions of resident and anadromous *O. mykiss*. Analysis of otoliths from adults will be used to indicate the proportion of resident and anadromous *O. mykiss*. Analysis of juvenile otoliths will be used to determine maternal anadromy and steelhead spawning within the Tuolumne River.

3) Adult *O. mykiss* Tracking Study. Contingent with permitting approval, habitat use and needs of adult *O. mykiss* will be assessed in a 2-year acoustic tracking study performed in conjunction with other tracking studies under Instream Flows and Predator Control. Adult fish will be captured by angling and acoustic tags surgically implanted, followed by both passive (using fixed hydrophones) and active monitoring (using mobile hydrophones). As a means of addressing future habitat restoration projects, Hypothesis No. 2 will be examined by determining habitat associations and potential spawning locations of *O. mykiss* within the river. The tracking study will be performed from approximately January 1 through March 31 of each study year.

4) Synthesize Results of Past and Ongoing Studies by 2012. Using all of the past and ongoing monitoring studies described above, the Districts will synthesize the results of ongoing studies and the above new surveys and studies to compare *O. mykiss* abundance and distribution at habitat restoration sites implemented between 2001 and 2009. Increased downstream extent of rearing habitat will be compared to pre- and post-project assessments at gravel augmentation sites (CDFG Grant No. ERP-02-P29) and previous surveys to address the hypotheses above. To the extent feasible, pertinent steelhead data from nearby rivers will be used as a means of informing the development of potential restoration and management actions in the future.

Table 4. Summary of methods, metrics, and schedule to examine Steelhead Presence/Protection issue

Approach	**Methods**	**Metrics**	**Schedule**	**Report Progress/Product**
1. Summer Population Estimate	Two-phase snorkel surveys calibrated by electrofishing.	Population abundance by habitat unit type	June and July 2008-2011	Data reports and preliminary analysis with annual FERC reports (2008–2011). Complete analysis by 7/1/2012.
2. Sampling of *O. mykiss* for Anadromy	Collect otoliths from juvenile and adult *O. mykiss.*	Micro-chemical testing of Sr:Ca ratio within otolith growth rings	2008–2011	Data reports and preliminary analysis with annual FERC reports (2007–2011). Complete analysis by 7/1/2012.
3. Adult *O. mykiss* Tracking Study	Acoustic tagging of adult *O. mykiss* during winter. Monitor riverwide movement and habitat use in conjunction with other acoustic tracking studies under Instream Flows and Predator Control.	Movement patterns and habitat associations	January through March 2008–2009	Data reports and preliminary analysis with annual FERC reports (2009–2010). Complete analysis by 7/1/2012.
4. Synthesize Results of Past and Ongoing Studies by 2012, including information from nearby rivers	Compare *O. mykiss* abundance and distribution at habitat restoration sites implemented between 2001 and 2009. Assess downstream extent of rearing habitat and compare to pre- and post project studies.	Change in distribution and abundance of *O. mykiss*	2008–2011	Data reports and preliminary analysis with annual FERC reports (2008–2011). Complete analysis by 7/1/2012.

Appendix B

TID/MID *O. mykiss* Records

***O. mykiss* observations in the Tuolumne River (TID/MID)**

Method	Location	River Mile	Date	#	Fork Length (mm) [1]
Snorkel	R5	48.0	08/01/82	2	350
Seine (DFG)	OLGB	50.5	04/15/83	1	39
Seine (DFG)	OLGB	50.5	05/06/83	1	60
Seine (DFG)	OLGB	50.5	06/09/83	1	41
Seine (DFG)	OLGB	50.5	02/16/84	4	?
Seine (DFG)	OLGB	50.5	03/01/84	2	?
Stranding	R4B	48.4	03/16/84	4	25-30
Snorkel (spring)	R4B-5	48.0-48.4	04/11/84	12	150-300
Snorkel	RA3	51.6	08/10/84	27	100-200
Snorkel	RA7	50.7	08/10/84	26	?
Snorkel (spring)	RA3	51.6	03/21/85	2	300,350
Seine	R4B	48.4	04/23/86	1	37
Seine	OLGB	50.5	05/12/86	1	29
Seine	OLGB	50.5	05/19/86	1	26
Seine	OLGB	50.5	05/30/86	1	29
Seine	R4B	48.4	05/30/86	1	30
Seine	OLGB	50.5	06/11/86	2	36,54
Seine	R4B	48.4	06/11/86	2	74,67
Seine	R4B	48.4	06/19/86	1	80
Seine	OLGB	50.5	06/26/86	5	46,66,79,58,67
Snorkel	R4B	48.4	07/01/86	5	40-80
Snorkel	RA3	51.6	08/14/86	6	5(100-160), (350)
Snorkel	RA7	50.7	08/14/86	13	70-150
Snorkel	R2	49.9	08/14/86	25	<175
Snorkel	R4B	48.4	08/14/86	10	<175
Snorkel	R5	48.0	08/14/86	10	<175
Seine	R4B	48.4	02/26/87	1	28
Seine	R4B	48.4	03/04/87	1	33
Seine	OLGB	50.5	03/26/87	1	26
Mark-Recap.	R4A	48.8	05/14/87	1	88
Seine	R5	48.0	05/20/87	2	59,32
Seine	OLGB	50.5	05/20/87	3	31,30,29
Stranding	RA4	51.6	06/01/87	7	29-35
Stranding	R5	48.0	06/02/87	5	62-92
Seine	OLGB	50.5	06/03/87	2	33,37
Seine	OLGB	50.5	05/16/88	1	34
Electro	R2	49.9	05/30/90	1	73
Snorkel	RA3	51.6	06/09/92	1	150
Snorkel (late fall)	RA7	50.7	11/30/95	1	250
Snorkel (late fall)	R5	48.0	11/30/95	2	220,250
Snorkel	R7	46.9	07/03/96	4	90-110
Seine	TRR	42.2	03/12/97	1	35
Snorkel	RA3	51.6	06/25/97	4	200,250,250,300
Snorkel	RA7	50.7	06/25/97	2	250,400
Snorkel	R2	49.9	06/25/97	2	250
Seine	R4B	48.4	04/22/98	1	28
RST 7/11	7/11	38.5	01/21/99	1	198
Seine	TRR	42.2	02/24/99	1	25
RST 7/11	7/11	38.5	04/01/99	1	45
Seine	R5	48.0	04/08/99	1	27
Seine	OLGB	50.5	05/19/99	3	32,43,46
Snorkel	RA7	50.7	06/15/99	14	70-110
Snorkel	R3B	49.1	06/15/99	31	70-100
Snorkel	R5	48.0	06/15/99	10	4(75-100), 6(220-300)
Snorkel	R7	46.9	06/16/99	15	75-130
Snorkel	R23B-C	42.3-42.4	06/16/99	9	80-130
Seine	TRR	42.2	03/21/00	1	26
Angling	R3B, R13B	49.1, 45.5	04/12/00	2	385,355
Seine	R5	48.0	05/17/00	3	48,56,63
Snorkel	RA7	50.7	06/05/00	14	50-120
Snorkel	R1A	50.4	06/05/00	3	60,70,80
Snorkel	R3B	49.1	06/05/00	14	11(70-110), 200,225,250
Snorkel	R5	48.0	06/05/00	19	14(50-110), 5(200-350)
Snorkel	R7	46.9	06/21/00	52	47(45-100), 5(225-350)
Snorkel	R12	45.8	06/06/00	5	250-350
Snorkel	R13A	45.6	06/06/00	20	19(60-110), 200
Snorkel	R17A2	44.4	06/06/00	14	75-120
Snorkel	R21	42.9	06/06/00	27	25(70-110), 225,250
Snorkel	R23C	42.3	06/06/00	4	70,80,90,225
Snorkel	R26	40.9	06/07/00	4	150-225
Snorkel	R27	40.3	06/07/00	2	275,325
Snorkel	R31	38.1	06/07/00	2	200,325

[1] estimated total length for snorkel data

O. mykiss **observations in the Tuolumne River (TID/MID)**

Method	Location	River Mile	Date	#	Fork Length (mm) [1]
Seine	OLGB	50.5	03/20/01	1	26
Seine	R5	48.0	03/20/01	1	32
Seine	TRR	42.2	03/20/01	2	48,51
Seine	R5	48.0	05/15/01	41	(36-77)
Snorkel	RA7	50.7	06/18/01	7	70-95
Snorkel	R2	49.9	06/18/01	3	75,80,90
Snorkel	R3B	49.1	06/18/01	8	4(120-160), 4(180-200)
Snorkel	R5	48.0	06/18/01	4	80,140,160,280
Snorkel	R7	46.9	06/19/01	4	90,90,100,150
Snorkel	R13B	45.5	06/19/01	3	90,130,160
Snorkel	R21	42.9	06/19/01	2	120,150
Snorkel	RA7	50.7	09/18/01	3	160,270,300
Snorkel	R2	49.9	09/18/01	3	225,280,330
Snorkel	R3B	49.1	09/18/01	1	280
Snorkel	R5	48.0	09/18/01	2	275,300
Snorkel	R21	42.9	09/19/01	3	190,225,275
Seine	OLGB	50.5	04/23/02	2	32,32
Seine	R5	48.0	05/07/02	1	28
Snorkel	RA7	50.7	06/11/02	5	70-80
Snorkel	R2	49.9	06/11/02	1	225
Snorkel	R3B	49.1	06/11/02	11	60-120
Snorkel	R5	48.0	06/12/02	3	160,300,380
Snorkel	R7	46.9	06/12/02	5	100, 4(140-160)
Snorkel	R13B	45.5	06/12/02	2	120,140
Snorkel	R21	42.9	06/12/02	1	125
Snorkel	RA7	50.7	09/24/02	1	400
Snorkel	R2	49.9	09/24/02	4	300,330,420,480
Snorkel	R3B	49.1	09/24/02	1	200
Snorkel	R7	46.9	09/25/02	2	150,225
Snorkel	R13B	45.5	09/25/02	4	110,160,200,220
Seine	TRR	42.3	04/01/03	1	29
Snorkel	RA7	50.7	06/18/03	66	65(45-140), (350)
Snorkel	R2	49.9	06/18/03	8	5(120-130), 300,325,420
Snorkel	R3B	49.1	06/18/03	5	110-150
Snorkel	R5	48.0	06/18/03	6	5(90-120), 370
Snorkel	R7	46.9	06/19/03	14	13(80-125), 375
Snorkel	R13B	45.5	06/19/03	1	390
Snorkel	R23C	42.3	06/19/03	1	90
Snorkel	RA7	50.7	09/17/03	16	15(45-60), 210
Snorkel	R2	49.9	09/17/03	2	200,350
Snorkel	R3B	49.1	09/17/03	21	16(60-80), 180,200,220,325,475
Snorkel	R5	48.0	09/17/03	10	9(60-70), 325
Snorkel	R7	46.9	09/18/03	9	125-225
Snorkel	R13B	45.5	09/18/03	6	60, 190,210,225,300,330
Snorkel	R21	42.9	09/18/03	6	5(190-225), 320
Snorkel	R23C	42.3	09/18/03	1	210
Seine	OLGB	50.5	03/16/04	1	29
Seine	TRR	42.3	03/16/04	1	29
Seine	TRR	42.3	03/30/04	2	31,32
Seine	R5	48.0	04/14/04	2	31,38
Seine	R5	48.0	05/25/04	1	64
Snorkel	RA7	50.7	06/16/04	12	11(50-80), 420
Snorkel	R2	49.9	06/16/04	23	20(80-130), 180,320,400
Snorkel	R3B	49.1	06/16/04	22	21(80-130), 480
Snorkel	R5	48.0	06/16/04	11	9(90-130), 300,370
Snorkel	R7	46.9	06/17/04	13	110-140
Snorkel	R13B	45.5	06/17/04	5	110-125
Snorkel	R21	42.9	06/17/04	5	110-130
Snorkel	RA3/A4	51.6	08/03/04	5	170-275
Snorkel	RA7	50.7	08/03/04	6	120-200
Snorkel	R1A	50.5	08/03/04	4	300-425
Snorkel	R2	49.9	08/03/04	2	290,320
Snorkel	R3B	49.1	08/04/04	5	140,150,160,350,525
Snorkel	R4B	48.4	08/04/04	8	7(90-200),350
Snorkel	R5	48.0	08/04/04	15	60, 14(150-225)
Snorkel	R7	46.9	08/04/04	5	140-160
Snorkel	R10	46.2	08/05/04	3	340,400,450
Snorkel	R13B	45.5	08/05/04	13	100-210
Snorkel	R21	42.9	08/05/04	9	100-170
Snorkel	R23C	42.3	08/05/04	1	200
Snorkel	RA7	50.7	09/15/04	11	40-110
Snorkel	R2	49.9	09/15/04	7	100, 6(200-380)
Snorkel	R3B	49.1	09/15/04	7	4(60-110), 360,400,425
Snorkel	R5	48.0	09/15/04	6	45, 5(140-360)
Snorkel	R7	46.9	09/16/04	2	180,300
Snorkel	R21	42.9	09/16/04	7	4(160-180), 3(280-310)

[1] estimated total length for snorkel data

***O. mykiss* observations in the Tuolumne River (TID/MID)**

Method	Location	River Mile	Date	#	Fork Length (mm) [1]
Seine	OLGB	50.5	03/16/05	1	27
RST	GRAYSON	5.2	05/14/05	1	33
Snorkel	RA7	50.7	09/20/05	10	4(110-180), 6(350-500)
Snorkel	R2	49.9	09/20/05	7	(225-420)
Snorkel	R3B	49.1	09/20/05	6	(180-460)
Snorkel	R5	48.0	09/20/05	36	30(110-200) 6(230-480)
Snorkel	R7	46.9	09/21/05	2	160,260
Snorkel	R13B	45.5	09/21/05	46	10(70-150) 36(160-260)
Snorkel	R21	42.9	09/21/05	15	3(120-130) 12(175-250)
Snorkel	R23C	42.3	09/21/05	14	120,130, 12(160-225)
Snorkel	R31	38.0	09/22/05	1	300
Snorkel	R35A	37.1	09/22/05	2	120,130
Seine	TRR	42.2	02/01/06	1	29
RST	WATERFORD	29.8	02/16/06	1	280
Seine	TRR	42.2	03/01/06	3	25,26,26
Seine	R4B	48.4	03/29/06	2	27,29
RST	WATERFORD	29.8	04/02/06	1	249
RST	WATERFORD	29.8	04/05/06	1	270
Seine	OLGB	50.5	05/03/06	2	38,45
RST	WATERFORD	33.5	06/02/06	1	81
RST	WATERFORD	33.5	06/04/06	1	66
RST	WATERFORD	33.5	06/10/06	2	80,90
RST	WATERFORD	33.5	06/12/06	1	79
Snorkel	RA7	50.7	09/19/06	115	102(100-180) 13(200-420)
Snorkel	R2	49.9	09/19/06	15	(250-400)
Snorkel	R3B	49.1	09/19/06	66	39(100-160) 27(180-525)
Snorkel	R5	48.0	09/19/06	54	20(100-150) 34(160-450)
Snorkel	R7	46.9	09/20/06	106	76(50-150) 30(170-440)
Snorkel	R13B	45.5	09/20/06	103	82(50-160) 21(180-300)
Snorkel	R21	42.9	09/20/06	32	14(100-160) 18(180-420)
Snorkel	R23C	42.3	09/20/06	27	10(100-150) 17(160-220)
Snorkel	R31	38.0	09/21/06	21	(60-160)
Snorkel	R36A	36.7	09/21/06	4	(60-70)
RST	WATERFORD	29.8	02/01/07	1	-
RST	WATERFORD	29.8	02/20/07	1	195
Seine	TRR	42.2	02/28/07	1	31
Seine	R5	48.0	04/11/07	3	25,27,37
Seine	TRR	42.2	04/11/07	7	(24-38)
RST	WATERFORD	29.8	04/22/07	1	64
RST	WATERFORD	29.8	04/23/07	1	43
Seine	TRR	42.2	04/25/07	5	21,22,24,31,36
RST	WATERFORD	29.8	04/27/07	1	310
RST	WATERFORD	29.8	05/02/07	1	35
RST	WATERFORD	29.8	05/03/07	1	320
Seine	R5	48.0	05/09/07	3	27,27,37
Seine	TRR	42.2	05/09/07	1	35
RST	WATERFORD	29.8	05/15/07	1	360
RST	WATERFORD	29.8	05/18/07	1	77
Seine	R5	48.0	05/23/07	2	44,50
RST	WATERFORD	29.8	06/05/07	1	325
Snorkel	RA7	50.7	06/26/07	106	101(60-110) 5(240-480)
Snorkel	R2	49.9	06/26/07	34	26(70-100) 8(230-420)
Snorkel	R3B	49.1	06/26/07	45	36(60-120) 9(260-440)
Snorkel	R5	48.0	06/26/07	92	79(50-150) 13(250-480)
Snorkel	R7	46.9	06/27/07	22	16(80-125) 6(280-380)
Snorkel	R13B	45.5	06/27/07	15	15(70-140)
Snorkel	R21	42.9	06/27/07	10	10(80-160)
Snorkel	R23C	42.3	06/27/07	5	4(120-140) (350)
Snorkel	R31	38.0	07/03/07	12	12(90-160)
Snorkel	R41A	35.3	07/03/07	2	(160,180)
Snorkel	RA7	50.7	09/18/07	75	70(40-160) 5(250-380)
Snorkel	R2	49.9	09/18/07	16	7(100-140) 9(220-480)
Snorkel	R3B	49.1	09/18/07	12	4(100-130) 8(290-500)
Snorkel	R5	48.0	09/18/07	10	3(120-160) 7(300-450)
Snorkel	R7	46.9	09/19/07	7	7(280-420)
Snorkel	R13B	45.5	09/19/07	57	57(100-170)
Snorkel	R21	42.9	09/19/07	10	9(110-170) (320)
Snorkel	R23C	42.3	09/19/07	7	7(120-150)
Snorkel	R31	38.0	09/20/07	4	4(280-360)

[1] estimated total length for snorkel data

***O. mykiss* observations in the Tuolumne River (TID/MID)**					
Method	**Location**	**River Mile**	**Date**	**#**	**Fork Length (mm) [1]**
RST	WATERFORD	29.8	01/26/08	1	105
RST	WATERFORD	29.8	01/28/08	2	205,249
RST	WATERFORD	29.8	01/29/08	2	224,268
RST	WATERFORD	29.8	02/26/08	1	100
RST	WATERFORD	29.8	02/27/08	1	205
RST	GRAYSON	5.2	02/28/08	1	200
RST	GRAYSON	5.2	03/31/08	1	224
RST	WATERFORD	29.8	04/16/08	1	261
Seine	OLGB	50.5	04/29/08	3	30,30,49
Seine	OLGB	50.5	05/13/08	1	28
RST	WATERFORD	29.8	05/23/08	1	58
Snorkel	RA7	50.7	06/17/08	76	74(50-120) (425,480)
Snorkel	R2	49.9	06/17/08	9	(90) 8(230-450)
Snorkel	R3B	49.1	06/17/08	78	75(60-120) (140,300,320)
Snorkel	R5	48.0	06/17/08	21	17(70-100) (140,300,320,400)
Snorkel	R7	46.9	06/18/08	13	12(70-140) (450)
Snorkel	R13B	45.5	06/18/08	24	24(70-140)
Snorkel	R21	42.9	06/18/08	11	5(70-140) 6(160-300)
RST	WATERFORD	29.8	02/17/09	1	105
Seine	OLGB	50.5	03/10/09	1	26
Seine	R5	48.0	03/10/09	1	36
Seine	R5	48.0	03/24/09	1	44
Seine	OLGB	50.5	04/07/09	1	26
Seine	R5	48.0	04/21/09	1	70
Seine	OLGB	50.5	05/05/09	1	34
Seine	R5	48.0	05/05/09	1	33
Snorkel	RA7	50.7	06/16/09	80	80(40-120)
Snorkel	R2	49.9	06/16/09	12	5(70-90) 7(160-500)
Snorkel	R3B	49.1	06/16/09	27	19(60-150) 8(160-500)
Snorkel	R5	48.0	06/16/09	11	11(160-400)
Snorkel	R7	46.9	06/17/09	6	2(140) 4(160-170)
Snorkel	R13B	45.5	06/17/09	4	4(90-120)
Snorkel	R23C	42.3	06/17/09	2	120,130

[1] estimated total length for snorkel data

Attachment 2
Draft Report Transmittal Letter

TURLOCK IRRIGATION DISTRICT
333 EAST CANAL DRIVE
POST OFFICE BOX 949
TURLOCK, CALIFORNIA 95381
(209) 883-8300

Don Pedro Dam and Powerhouse

December 7, 2009 (via e-mail)

Tim Heyne
California Dept. of Fish and Game
P.O. Box 10
La Grange, CA 95329

Kim Webb
U.S. Fish and Wildlife Service
2800 Cottage Way, W-2605
Sacramento, CA 95825

Maria Rea
National Marine Fisheries Service
650 Capitol Mall, Suite 8-300
Sacramento, CA 95814-4708

RE: FERC Project 2299 – Tuolumne River *Oncorhynchus mykiss* monitoring report

Dear Fishery Agency representatives:

The accompanying draft report is presented to you in compliance with Ordering Paragraph (C) (5) of the April 3, 2008 FERC *Order on Ten-Year Summary Report under Article 58* (Order) for Project No. 2299. In accordance with the Order, please send me your comments on this draft report within 30 days following the date of this transmittal. The Order requires the Districts to file this report with agency comments by January 15, 2010.

In addition, the recently completed report on 2009 population estimate surveys is available at http://tuolumnerivertac.com/documents.htm. That report is referenced as Stillwater Sciences 2009b in the subject report.

This transmittal sheet, along with the draft report, is also being sent electronically to parties of the Project 2299 proceeding identified in the July 16, 2009 FERC Order (page 8, Paragraph 13). Please contact me at 209-883-8375 if you have any questions.

Sincerely,

Tim Ford

Tim Ford
Aquatic Biologist

Cc: Modesto Irrigation District, City and County of San Francisco, U.S. Department of the Interior, San Francisco Bay Area Water Users Association, Stanislaus Flyfishermen, Friends of the Tuolumne, Conservation Groups

Attachment 3
CDFG Comments on Monitoring Report

California Natural Resources Agency
DEPARTMENT OF FISH AND GAME
Central Region
1234 East Shaw Ave.
Fresno, CA 93710
http://www.dfg.ca.gov

ARNOLD SCHWARZENEGGER, *Governor*
John McCamman, *Acting Director*

January 5, 2010 (via e-mail)

Tim Ford
Aquatic Biologist
Turlock Irrigation District
333 East Canal Drive
Turlock, CA 95380

Subject: Comments for FERC Project 2299 – Tuolumne River *Oncorhynchus mykiss* monitoring report December 2009

Dear Mr. Ford:

The California Department of Fish and Game (Department) has reviewed the Turlock and Modesto Irrigation District's (Districts) Tuolumne River *Oncorhynchus mykiss* (*O. mykiss*) Monitoring Report which was prepared in compliance with ordering paragraph (C) (5) of the April 3, 2008 Order on Ten-Year Summary Report under Article 58 for project 2299. The Department provides the following comments.

The Department believes that the monitoring resulting in the December 2009 Tuolumne River *Oncorhynchus mykiss Monitoring* report was not adequate for generating a statistically valid population estimate. The 2009 population estimate was generated through snorkel surveys that were conducted during March and July. The Department believes that the intensity and frequency of snorkel surveys must be increased to adequately monitor the *O. mykiss* population throughout the year.

The Department believes that the Districts' did not demonstrate a clear relationship between river temperatures and *O. mykiss* density and distribution within the 2009 monitoring report. The Department requests that the Districts' compare population densities and river temperature data at each survey site for the current study year and include this data within the monitoring reports.

The Department feels that the Districts' current monitoring efforts are inadequate for determining the population size and habitat needs of *O. mykiss* in the Tuolumne River.
The Department encourages the implementation of more monitoring studies such as conducting **monthly** snorkel surveys in order to get an accurate representation of the river population throughout the year, extending the duration of the Districts' Alaskan weir video monitoring observations through June each year in order to monitor *O. mykiss* migration, and modification of the Districts' previously proposed acoustic tagging study. The Department can provide recommendations to the Districts' for modifying the acoustic tagging study design.

The Department appreciates the opportunity to provide comments to the December 2009 Tuolumne River *Oncorhynchus mykiss* monitoring report. If you have any questions regarding these comments, please contact Ms. Jennifer O'Brien, Fisheries Biologist at (209) 853-2533 ext. 3#.

Sincerely,

Tim Heyne
Senior Environmental Scientist

cc: Kim Webb
U.S. Fish and Wildlife
2800 Cottage Way, W-2605
Sacramento, CA 95825

Maria Rea
National Marine Fisheries Service
650 Capitol Mall, Suite 8-300
Sacramento, CA 95814-4708

Tuolumne River Technical Advisory Committee
Via email

Attachment 4
Response to CDFG Comments

Comment 1. ***"The Department believes that the monitoring resulting in the December 2009 Tuolumne River Oncorhynchus mykiss Monitoring report was not adequate for generating a statistically valid population estimate."***

Response: We respectfully disagree that the estimates are not statistically valid and affirm that the stated estimates accurately reflect, with appropriate confidence bounds, the reach-wide population sizes for the sampled periods. Although potential violations of Hankin and Mohr (2001) assumptions were noted for larger pool and run-type habitats in the 2008 and 2009 population estimate reports[1, 2], other methodologies such as mark-recapture were discarded in the 2007 FERC Study Planning process due to sampling permit restrictions under the Endangered Species Act (ESA) for Central Valley Steelhead. As a consequence, the potential bias and resulting confidence intervals may be seen as the best available methodology that maintains existing ESA protections of California Central Valley Steelhead while meeting the intent of the FERC approved Study Plan. We note that CDFG did not provide alternative methodologies for development of population estimates in their comments on the 2007 FERC Study Plan. Nor has the increased take limits required for planned electrofishing calibration surveys been permitted to date, so the methods employed have been limited to those allowed by the resource agencies.

Comment 2. ***"The 2009 population estimate was generated through snorkel surveys that were conducted during March and July. The Department believes that the intensity and frequency of snorkel surveys must be increased to adequately monitor the O. mykiss population throughout the year."***

Response: The meaning of "adequately monitor" is not clear. While we agree that increasing the sampling frequency could potentially improve (narrow) the confidence bounds and provide other useful information, we disagree that the sampling effort and frequency should be increased. As a general indication, narrowing the existing confidence intervals by one-half would require an expansion in the winter (or summer) surveys by at least a factor of four. This would represent a significant and expensive expansion to the sampling frequency described in the April 3, 2008 FERC Order. Further, the increased number of dive days in the river (7–10 days per survey, depending upon the length of the surveyed reach) would also likely extend outside the targeted sampling conditions. As reported, the intensive March population estimate survey that was completed in 2009 found extremely few *O. mykiss*, so our recommendations in the report propose that additional reference count snorkel surveys be conducted instead to document river-wide distribution and habitat use.

---

[1] Stillwater Sciences. 2008. Population size estimates of resident *O. mykiss* in the Lower Tuolumne River. Prepared for the Turlock Irrigation District and the Modesto Irrigation District by Stillwater Sciences, Berkeley, CA. October.

[2] Stillwater Sciences. 2009. March and July 2009 population size estimates of *Oncorhynchus mykiss* in the Lower Tuolumne River. Prepared for the Turlock Irrigation District and the Modesto Irrigation District by Stillwater Sciences, Berkeley, CA. November.

Comment 3. ***"The Department believes that the Districts' did not demonstrate a clear relationship between river temperatures and O. mykiss density and distribution within the 2009 monitoring report. The Department requests that the Districts' compare population densities and river temperature data at each survey site for the current study year and include this data within the monitoring reports."***

Response: We note that the primary purpose of these surveys was to provide a population estimate under the April 3, 2008 FERC Order. However, it was identified on page 5 in the *O. mykiss* monitoring report that detailed information on river temperature and *O. mykiss* density and distribution was contained in the 2008 population estimate report (specifically Section. 4.2.1 and Figure 6) and the 2009 population estimate report (specifically Section 4.3 and Figure 9). Both of these reports are accessible at the Tuolumne River Technical Advisory Committee website (http://tuolumnerivertac.com/documents.htm); the 2008 report was included in the annual Article 58 filing in March 2009 and availability of the cited 2009 report was identified in the December 7, 2009 transmittal letter. The monitoring report also contains information on water temperature, distribution, and density results from other June/July snorkel surveys conducted since 1996 (Figures 6 and 7). While a general decrease in fish density with increasing water temperature was observed for the July 2008 and 2009 population estimate surveys, other potential factors related to density and distribution such as microhabitat and spawning gravel availability were discussed. It should be noted that the March 2009 population estimate survey also recorded the same general distribution with distance from La Grange Dam at a time when higher water temperatures were presumably not a limiting factor. The raw data on fish captures, areas, and corresponding river temperatures in each sampling unit are provided as technical appendices in the 2008 and 2009 population estimate reports should CDFG staff wish to conduct further analyses.

Comment 4. ***"The Department feels that the Districts' current monitoring efforts are inadequate for determining the population size and habitat needs of O. mykiss in the Tuolumne River. The Department encourages the implementation of more monitoring studies such as conducting monthly snorkel surveys in order to get an accurate representation of the river population throughout the year, extending the duration of the Districts' Alaskan weir video monitoring observations through June each year in order to monitor O. mykiss migration, and modification of the Districts' previously proposed acoustic tagging study. The Department can provide recommendations to the Districts' for modifying the acoustic tagging study design."***

Response: As stated above, we disagree that the current monitoring efforts are inadequate for determining the population size of *O. mykiss* in the Tuolumne River and question whether more population surveys in each year are warranted, especially given the large effort and expense involved in obtaining each independent estimate. We have proposed adding several reference count snorkel surveys in each year to document river-wide distribution and habitat use on a seasonal basis. In addition, we have proposed adding seining and screw trapping to the study plan to continue the *O. mykiss* information developed from those monitoring efforts.

With regards to use of the Alaska weir, which has been implemented on an initial basis for Chinook salmon (*O. tshawytscha*) monitoring within the September–December 2009 period, the extended use of a counting weir through June would be an extremely expensive way to record an expected low number of upstream *O. mykiss* migrants. That is based on the low numbers of adults observed in the March 2009 snorkel surveys and the low numbers observed in the Stanislaus and Tuolumne river weir monitoring to date. Further, it will be practically impossible to maintain continuous operations from a counting weir under high storm or pulse flow conditions when anadromous *O. mykiss* could migrate up the Tuolumne River. This would limit the usefulness in any counts using this methodology.

Lastly, we agree that evaluation of habitat needs of *O. mykiss* could be better determined if the acoustic tag studies were allowed to proceed, as the Districts were prepared to do in January 2009 per the April 3, 2008 FERC Order. The acoustic tag studies were intended to provide more detailed information regarding fish movement and habitat associations than could be accomplished using the snorkel survey methodologies in the 2008 and 2009 population estimate surveys. This described monitoring action already includes modified aspects provided by resource agencies. We are encouraged that pending ESA permit requests are currently being processed by CDFG and/or National Marine Fisheries Service. We welcome CDFG assistance in obtaining Section 4(d) or Section 10 permit approvals required to start conducting this important work soon in 2010.

Attachment 5
O. mykiss Population Size Estimate Report
March and July 2009

March and July 2009 Population Size Estimates of *Oncorhynchus mykiss* in the Lower Tuolumne River

Prepared for
Turlock Irrigation District
333 East Canal Drive
Turlock, CA 95380

and

Modesto Irrigation District
1231 11th St
Modesto, CA 95354

Prepared by
Stillwater Sciences
2855 Telegraph Ave., Suite 400
Berkeley, CA 94705

November 2009

Stillwater Sciences

Stillwater Sciences. 2009. March and July 2009 population size estimates of *Oncorhynchus mykiss* in the Lower Tuolumne River. Prepared for the Turlock Irrigation District and the Modesto Irrigation District by Stillwater Sciences, Berkeley, CA. November.

SUMMARY

In both mid-March and mid-July 2009, population size estimates of *Oncorhynchus mykiss* were developed in the lower Tuolumne River in accordance with the 3 April 2008 Delegated Order issued by the Federal Energy Regulatory Commission (FERC) implementing elements of a study plan previously developed in coordination with California Dept. of Fish and Game (CDFG), National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) biologists, and submitted to FERC on 16 July 2007.

Snorkel surveys were conducted during daylight hours from 16 to 25 March and from 9 to 14 July 2009 to estimate *O. mykiss* population size within the Tuolumne River. In addition to snorkel survey observations of *O. mykiss*, data for Chinook salmon (*O. tshawytscha*) and other species was also collected. Snorkel surveys were conducted using a two-phase survey design to sample seven different habitat strata (i.e., riffle, run head, run body, run tail, pool head, pool body, and pool tail) found downstream of La Grange Dam at river mile (RM) 51.8 using habitat typing from that used in the July 2008 surveys. The study reaches extended from RM 51.8 to RM 29.0 in March and from RM 51.8 to RM 41.7 near Turlock Lake State Recreation Area in July. The sampling units were delineated by habitat-typing surveys performed in June 2008 (down to RM 39.5) and March 2009 (from RM 39.5 down to RM 29.0). A total of 66 out of all 340 habitat units were selected for either single pass or multi-pass snorkel surveys in March 2009. A total of 31 of 136 units in the study reach upstream of RM 39.5 were selected for either single pass or multi-pass snorkel surveys in July 2009.

O. mykiss population estimates

Based upon the maximum count obtained over all dive passes in each sampled unit, 5 young-of-the-year (YOY)/juvenile (< 150 mm FL) and 7 adult (> 150 mm FL) (sum total of 12) *O. mykiss* were observed in March 2009, and 641 YOY/juvenile (< 150 mm FL) and 105 adult (> 150 mm FL) (sum total of 746) *O. mykiss* were observed along the study reach in July 2009. For both surveys, most juveniles and adults were found in riffle or pool habitats. Using a bounded counts population estimator (necessarily derived from Chinook salmon data due to low *O. mykiss* counts in multiply-dived sampling units) for the March 2009 survey period, a population estimate of approximately 63 juvenile and 170 adult *O. mykiss* were present within the study reach (RM 51.8–29.0). Using the same estimator (derived from *O. mykiss* counts) for the July 2009 survey period, approximately 3,475 juvenile and 963 adult *O. mykiss* were present within the study reach (RM 51.8–41.7).

The July 2009 *O. mykiss* juvenile population estimate of 3,475 was apparently higher than the July 2008 estimate of 2,472 juveniles, but within the 95% confidence interval (CI) of the estimates in these two years (945–6,004 and 1,263–3,681 juveniles estimated in 2009 and 2008, respectively). The July 2009 *O. mykiss* adult population estimate of 963 was also slightly higher than the July 2008 estimate of 643, with both results within their respective 95% CI in these two years (464–1,461 and 217–1,070 adults estimated in 2009 and 2008, respectively).

Chinook salmon population estimates

For Chinook salmon encountered during the March and July 2009 snorkel surveys, a maximum count of 4,281 juveniles (< 150 mm FL) were observed during March within all habitat types along the study reach and a maximum count of 4,696 juvenile Chinook salmon were observed in all habitat types during the July 2009 survey. This corresponded to bounded count population

estimates of 39,563 Chinook salmon (95%CI: 34,861–44,265) during the March 2009 surveys, and 29,389 (95%CI: 19,068–39,711) during July 2009. By comparison, the July 2009 juvenile population estimate of 29,389 was much higher than the July 2008 estimate of 2,636. There were also 6 adult salmon observed in July 2009 as compared to 2 in July 2008.

Other species

A combination of native minnows (hardhead and Sacramento pikeminnow), along with native Sacramento sucker accounted for approximately 90% of observed non-salmonid fish for both the March and July sampling periods, while non-native centrarchid species (largemouth bass, smallmouth bass, bluegill, and green sunfish) accounted for the second largest group of non-salmonids. Most centrarchids occurred toward the downstream end of the study reach where water temperatures were greater, while native minnows and suckers were found throughout the reaches in both sampling periods.

Relationship between Temperature and O. mykiss habitat use

To test the hypothesis that the summertime distribution of suitable habitat by observed life stages of *O. mykiss* is related to ambient river water temperature, water temperature data from thermographs deployed in the Tuolumne River were compared to juvenile and adult *O. mykiss* density along the study reach. The data show that temperatures increased in the downstream direction, from 12.6ºC (54.6°F) to 24.8ºC (76.7°F) (maximum weekly average temperature [MWAT]), and that *O. mykiss* density of both adult and juveniles decreased along this same gradient. However, other factors are present that may also explain these relative abundance distributions. Although the longitudinal distribution of *O. mykiss* was similar for both the March and July surveys, the lower number of *O. mykiss* observations in March 2009 coupled with low water temperatures (maximum observed <17.0 °C [62.6 °F]) precluded any meaningful associations with temperature.

O. Mykiss habitat use at Restoration sites

A second hypothesis that habitat use by *O. mykiss* juveniles and adults observed in the Tuolumne River occurred at the same density in both restored and nearby reference sites was tested based on observed densities of *O. mykiss* juveniles and adults in habitat types (riffle, run head, and pool head) common to both groups in the July survey. For juveniles, this comparison showed riffle habitat use at upstream restoration sites was slightly greater than that of other riffle habitats. Juvenile habitat use within run head habitats was similar or reduced at the restoration sites in comparison to reference sites, with relatively low use of pool head habitat. For adults, this comparison showed a potential reduction of habitat use of riffle habitat at restoration sites, with similar use of run head habitat, and insufficient data for a comparison of pool head habitats.

Comparison of June and July 2009 Survey Results

A comparison was made of *O. mykiss* and juvenile Chinook data collected during the July 2009 survey to routine snorkel survey data collected during June 2009 by TID/MID. The comparison shows a similar longitudinal trend, with overall decreasing densities in the downstream direction for both species. Along the study reach common to both surveys, a total of 112 *O. mykiss* juveniles and 30 adults were observed in the June snorkel survey, while 600 juveniles and 101 adults were observed in the July survey. A total of 1,897 juvenile Chinook were seen in the June survey with 4,423 seen in July 2009.

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1 INTRODUCTION

Routine fisheries monitoring surveys for the Don Pedro Project (FERC Project No. 2299) by the Turlock Irrigation District (TID) and Modesto Irrigation District (MID) have long documented the presence of *Oncorhynchus mykiss* in the lower Tuolumne River (TID/MID 2005). Summer snorkel surveys, conducted in most years since 1988, have documented an increased *O. mykiss* presence and relative abundance that is associated with the more consistent and higher summer flows provided since 1997 (TID/MID 2008).

On 19 March 1998, the National Marine Fisheries Service (NMFS) first listed the Central Valley steelhead as threatened under the Endangered Species Act (ESA). After several court challenges, NMFS issued a new final rule relisting the Central Valley steelhead on 5 January 2006 (71 FR 834). In a separate process resulting from terms of the 1996 FERC license amendment for the Project, NMFS staff provided input to a draft limiting factors analysis for Tuolumne River salmonids (Mesick et al. 2007) and included recommendations for developing abundance estimates, habitat use surveys, and anadromy determination of resident *O. mykiss*. These recommendations were conceptually used to develop the Districts' FERC Study Plan (TID/MID 2007), which was the subject of a 3 April 2008 FERC Order. As part of the Order, the Districts were required to conduct population estimate surveys in winter (February/March) and summer (June/July), with the first surveys starting in summer 2008 to determine *O. mykiss* population abundance by habitat type.

The Districts first submitted a detailed *O. mykiss* population estimate study plan (Stillwater Sciences 2008a) to FERC on 3 July 2008 to provide information on the abundance and habitat requirements within the lower Tuolumne River. A report on the July 2008 population size estimate (Stillwater Sciences 2008b) was submitted as part of the Districts' 2008 annual report to FERC (TID/MID 2009). An updated study plan (Stillwater Sciences 2009b) was prepared for the 2009 population estimate surveys, which is attached to this report as Appendix A. In addition to providing data to develop population size estimates under current conditions, the study plan examined the following hypotheses:

> <u>Hypothesis 1</u>: Summertime distribution of suitable habitat by observed life stages of *O. mykiss* is related to ambient river water temperature.
>
> <u>Hypothesis 2</u>: Habitat use by *O. mykiss* juveniles and adults observed in the Tuolumne River occurs at the same density in both restored and nearby reference sites.

The *O. mykiss* snorkel surveys employed a two-phase sampling approach for the development of a reach-wide population estimate (Hankin and Mohr 2001) in the lower Tuolumne River. Survey sites were selected using a stratified random sampling approach, where the strata were major habitat types. In March, the overall sampling "universe" from which sampling strata were delineated extended from near La Grange Dam at river mile (RM) 51.8 to RM 29.5 downstream of Waterford (Figure 1). In July, the survey reach was from RM 51.8 to near Turlock State Recreation Area at RM 41.7, which extended downstream of areas where *O. mykiss* were observed (Riffle 23C at RM 42.3) during the routine June 2009 snorkel surveys (Ford and Kirihara 2009).

The two-phase stratified sampling design involved snorkeling pre-selected habitat units (e.g., riffle, run, pool, etc.) multiple times in order to quantify the variance associated with density and subsequent population estimates. As in a typical Phase I sampling approach, primary snorkel surveys (Edmundson et al. 1968, Hankin and Reeves 1988, McCain 1992, Dolloff et al. 1996) were conducted across a subset of the all habitat units. In Phase II, approximately 20–70% of each habitat type sampled was randomly selected for replicated surveys by repeated dive counts.

The methods presented by Stillwater Sciences (2008) discussed using a combined approach of both repeated dive counts and electrofishing. Current ESA permit restrictions for both NMFS Section 10(a)(1)(A) permit No's 1280 (TID) and 1282 (Stillwater) did not allow sufficient incidental take to conduct the second-phase surveys using electrofishing. Consequently, the surveys utilized only snorkel surveys, as provided for in the 2007 study plan and identified in letters provided by the Districts to FERC dated 3 July 2008 and 31 March 2009.

2 METHODS

2.1 Habitat Characterization

2.1.1 Habitat mapping

We produced habitat maps from an analysis of past habitat surveys, historical and more recent aerial photographs, and recent field surveys superimposed within a geographic information system (GIS). Field maps for the March and July 2009 snorkel surveys were created using an orthorectified aerial photo and accompanying Light Detection and Ranging (LiDAR) topographic data from 21 September 2005 recorded at river flows of 321 cfs. Preliminary sampling unit boundaries of common habitat features (pools, riffles, and runs) were estimated from the LiDAR and bathymetric data between RM 52–38 within GIS by calculating locations corresponding to major water depth transitions (Table 2-1)

Table 2-1. Coarse-scale habitat types used during snorkel surveys.

Habitat type	Description[a]	Approximate depth
Riffle	Shallow with swift flowing, turbulent water. Partially exposed substrate dominated by cobble or boulder. Gradient moderate (less than 4%).	0–4 ft
Run	Fairly smooth water surface, low gradient, and few flow obstructions. Mean column velocity generally greater than one foot per second (fts^{-1}).	4–10 ft
Pool	Slow flowing, tranquil water with mean column water velocity less than 1 fts^{-1}.	>10 ft

[a] Major habitat types determined based upon observed hydraulic conditions (McCain 1992, Thomas and Bovee 1993, Cannon and Kennedy 2003)

As an initial validation of these coarse scale habitat types, we compared the habitat types mapped in July 2008 (Appendix B) with previous habitat type maps (Appendix C) developed by McBain and Trush (2004) between 1999–2001 on a base-layer map corresponding to a wetted perimeter of 622 cfs flown on 20 May 20 1991. Appendix C shows major habitat types (i.e., riffle, run, pool) encountered during the 1999–2001 surveys along with past and planned gravel introduction locations included in the *Tuolumne River Coarse Sediment Management Plan* (McBain and Trush 2004).

In general, habitat typing shown by McBain and Trush (Appendix C) indicates larger proportions of "pool" habitat types than those determined during this effort (Appendix B), which reserved the pool habitat designation for water depths greater than 10 ft. Additionally, because *O. mykiss* tend to congregate at transitions between habitat types, Appendix B shows a further division of pool and run body habitats into smaller, transitional habitat sampling units (pool head, pool tail, run head, and run tail) based upon location of slope channel slope break at the upstream and downstream end of the unit. For the July 2009 surveys, pool tail habitats were consolidated into the pool body habitat. This action was based on low use of the pool tail habitats as discrete sampling units in the prior surveys (July 2008 and March 2009) and results in a reduced number of habitat units having low potential for use by salmonids available for habitat selection, thereby increasing the number of sampling units having a higher potential use, while not eliminating them from the area surveyed (see Section 2.2.1 for a complete description of survey unit selection).

2.1.2 Habitat data collection

On 7–8 July 2008 and 10-13 February 2009, float surveys were conducted to further refine and validate the preliminary habitat maps (Appendix B) described above at flows of approximately 106 cfs and 168 cfs, respectively. In addition to refining the locations and sizes of potential habitat sampling units, we collected habitat data (Table 2-2) at several locations within each sampling unit. Starting at upstream end of the study reach just downstream of La Grange Dam (Figure 1), we assigned habitat units a natural sequence order (NSO), a number, beginning with NSO 001, and incremented this identifier at each habitat transition (e.g., NSO 001 pool head, NSO 002 pool body, etc). We located and marked the upstream and downstream end of each unit on field maps, recorded location with a handheld GPS unit, and tied flagging labeled with the date, unit number, and habitat type.

Table 2-2. Habitat data collected at each unit.

Parameter	Method	Metric/Descriptor	Method reporting limit
Natural Sequence Order (NSO – Habitat unit #)	N/A	NSO-1, NSO-2, NSO-3, …	N/A
Latitude/Longitude	Handheld GPS receiver	UTM	N/A
Habitat type	Visual estimation	See Table 2-1	N/A
Average unit width	Horizontal distance	Meters (feet) (measured at multiple transects)	0.01 m (0.1 ft)
Average unit length	Horizontal distance	Meters (feet)	0.01 m (0.1 ft)
Maximum/minimum depth	Vertical distance	Meters (feet)	0.15 m (0.5 ft)
Bed substrate composition	Visual estimation	Bedrock, boulder, cobble, gravel, organic, sand, silt	10%
Cover type	Visual estimation	None, boulder, cobble, IWM, bedrock ledges, overhead vegetation, aquatic vegetation	10%

Note that although the base layer of the 2009 habitat maps corresponds to a 2005 air photo at flows of 321 cfs, in order to provide a more accurate channel edge boundary for the March and

July 2009 surveys, the channel edge of the habitat unit boundaries shown in Appendix B correspond to a wetted perimeter of 96 cfs previously digitized from air photos taken on taken on 19 January 1991. Because the estimated wetted perimeter of the habitat unit boundaries did not vary more than a few feet in most cases at these two flows, the channel edge boundary for 96 cfs was used for both the March and July 2009 surveys. For each habitat unit shown, habitat unit length and width were subsequently determined in GIS. Appendix D shows accompanying field habitat data collected in all habitat units mapped, including maximum depth and average width (usually at 1/3 and 2/3 of the unit's length), bed substrate composition, and instream cover type.

2.2 Snorkel Surveys

2.2.1 Study design and survey unit selection

After habitat typing and collecting habitat data in all units, a subset of units of each habitat type was selected for single-pass snorkel surveys. The survey units were selected to balance the habitat sampling unit replication, total available number of units to draw from, coverage of at least 10% of the total length of a given habitat type, as well as sampling effort. The selection process involved random selection of one of the most upstream units of each habitat type, followed by a systematic uniform sampling of the remaining units in the study reach. After the first dive pass was completed, a tab was then pulled to determine if the unit was included in the second phase of sampling.

For the March 2009 surveys, a subset of 9 units was selected for each of the 7 habitat types, with the exception of the riffle habitat type for which 12 units were selected to capture habitat use at particular gravel augmentation projects (Table 2-3). In July 2009, a subset of 5–8 sampling units was selected from each of 5 habitat types (Table 2-4). As in the March 2009 surveys, additional units for riffle (2), pool head (1), and run head (1) habitat types were selected to capture habitat use at restoration sites. Habitats were grouped with the pool body and run tail habitats located immediately upstream for the July surveys.

Table 2-3. Sample unit selection and survey count for March 2009.

Habitat	Phase I dives		Phase II survey	
	Initial units	Passes	Repeat units	Passes
Riffle	12	1	2	2
Pool head	9	1	2	2
Pool body	9	1	2	2
Pool tail	9	1	2	2
Run head	9	1	2	2
Run body	9	1	2	2
Run tail	9	1	2	2
Total	**66**		**28**	

Table 2-4. Sample unit selection and survey count for July 2009.

Habitat	Phase I dives		Phase II survey	
	Initial units	Passes	Repeat units	Passes
Riffle	8	1	2	2
Pool head	6	1	2	2
Pool body /tail	5	1	2	2
Run head	7	1	2	2
Run body /tail	5	1	2	2
Total	**31**		**20**	

2.2.2 Snorkel data collection

Snorkel surveys were conducted during daylight hours from 16 to 25 March and 9 to 14 July 2008, respectively. A two-phase survey design was used to survey the various riffle, run, and pool strata. For the first phase, single-pass dive surveys were conducted by a four-person team. Sampling units were sampled from downstream to upstream in dive lanes using a zigzag pattern, passing fish and allowing them to escape downstream of the diver. If fish were observed to escape upstream, the diver took care to avoid counting these individuals twice. Divers recorded the type, length, and number of fish (Table 2-5). Total lengths were estimated in 50 mm size ranges (called "bins") using markings on dive slates to correct for underwater size distortion.

Table 2-5. Fish data collected within each unit during snorkel surveys.

Parameter	Method	Metric/Descriptor	Method reporting limit
Date; start and end time	N/A	Day/month/year; hour/minute	N/A
Number of individuals	Visual estimation	Number	1
Fish length	Visual estimation	Millimeter	50 mm bins

The second phase of sampling required the collection of fish count and size data during each of two subsequent passes through a selected habitat unit. These data were later used to extrapolate dive counts to total population estimates. The Phase 2 dive pass replication was reduced from 3 passes in July 2008 to 2 passes in March and July 2009. This adjustment was made to reduce sampling effort within particular sampling units while increasing the overall sample unit coverage in 2009. Lastly, occurrence of other non-salmonid native and non-native fish species was recorded as presence/absence and abundance.

2.3 Water Quality and Flow

At fish sampling locations, in addition to noting the type, length, and number of fish (Section 2.2), we collected spot measurements of *in situ* water quality data (temperature, dissolved oxygen, and conductivity) using a pre-calibrated multi-probe (YSI 85, Yellow Springs Instruments, Yellow Springs, OH) (Table 2-6). Dissolved oxygen probes were recalibrated each day and checked for accuracy in the laboratory against concentrations measured in aerated tap water. Changes in underwater visibility were monitored horizontally using a Secchi disk oriented both toward and away from the sun. Daily average flow data for each day were obtained from the stream gage below the La Grange powerhouse at RM 51.8 (USGS No. 11289650).

Table 2-6. Water quality data collected during snorkel surveys.

Parameter	Method	Metric/Descriptor	Method reporting limit
Temperature	EPA 170.1	°C	0.1 °C
Dissolved oxygen	SM 4500-O	mg/L	0.01 mg/L
Conductivity	SM 2510A	umhos/cm	1.0 umhos/cm
Visibility	Secchi depth	meters (feet)	0.01 m (0.1 ft)

2.4 Water and Air Temperatures

From Spring 1987 to present, TID/MID has collected water temperature data from various locations in the lower Tuolumne River using recording thermographs. These are currently Hobo Pro V2 thermographs (OnSet Computer Corporation, Bourne, MA) housed in protective cases and placed near shore in areas deep enough to avoid dewatering. The thermographs measured and stored water temperature data at one-hour intervals, and these data were historically and are currently downloaded at least twice a year.

Water temperature data collection during July 2009 also included spot measurements taken during snorkel surveys. The measurements were recorded over the course of the day as divers moved further downstream; as such, it was anticipated that these water temperatures would not be as representative as hourly thermograph recordings. The data do provide a general description of relative temperature conditions during dive surveys.

Regional air temperature data were obtained from the National Weather Service (NWS) station at Modesto Airport near RM 18. Water and air temperature data for the June through July 2009 period are presented in this report (Figures 2a and 2b).

2.5 Data analysis

2.5.1 Bounded counts population estimate

Water quality and fish observation counts were summarized by habitat unit type and initial density estimates were calculated based upon the area searched within each habitat unit sampled. In addition to comparisons of fish density between habitat types, the density estimates and uncertainties were propagated across the unsampled areas for an overall population estimate.

Population estimates were made for each stratum and size class using the general methods of Hankin and Mohr (2001). For units receiving multiple dives, the bounded counts formulae are used to produce an estimate of the unit population and an estimate of the variance of this estimate. Specifically, when there are r passes, and the counts of these are sorted in increasing order as $m_1 \le m_2 \le \ldots \le m_r$, the population is estimated as

$$\tilde{y}_B = m_r + (m_r - m_{r-1}),$$

and the mean squared error of this is estimated as

$$\tilde{\text{MSE}}(\tilde{y}_B) = (m_r - m_{r-1})^2.$$

The total population of multiply dived units is estimated as the sum of the bounded-counts estimates for the individual units. The total population of the survey region is estimated by expanding this, first to *all* dived units (singly or multiply dived) on the basis of mean dive counts, and then to all units (dived or undived) on the basis of area. An estimator of the variance of this is constructed from estimates of the mean-squared errors of the bounded-counts estimates for the multiply dived individual units, and the variance of the bounded-counts estimates around their common mean. The final formulae are included in Hankin and Mohr (2001). A nominal confidence interval for each stratum and size class was calculated formally as

$\hat{Y} \pm 1.96\sqrt{\hat{V}}$, where $\hat{Y}$ and $\hat{V}$ are the mean and variance estimates, *except* that the lower bound of this interval was "trimmed" to the number of fish actually observed.

2.5.2 Comparisons with June 2009 TID/MID snorkel surveys

Data collected during the July 2009 snorkel surveys (9–14 July) were compared to routine snorkel survey data collected during 16–18 June 2009 (Ford and Kirihara 2009). Although the sampled areas of these surveys differ, these data were collected only a few weeks prior to the data collected for this report, allowing for a general comparison of presence/absence and the relative proportions of larger and smaller size classes of *O. mykiss* and Chinook salmon in habitat units sampled during both surveys. Further, although TID/MID has sampled the same locations since 2001, we limit our comparison to the June 2009 data as these are the most directly comparable. There were no routine snorkel survey data available for comparison with the March 2009 snorkel surveys.

3 RESULTS

3.1 Habitat Characterization

3.1.1 March 2009

For the total reach surveyed in March 2009 (RM 51.8–29.5), riffle and run body habitat types were the most abundant habitat types present; however, the run body habitat type occupied more than half of the total length of channel along the study reach, followed by riffles at 20.9% of the total reach length (Table 3-1). Pool bodies, while less abundant than other habitat types (e.g., run head and tail), occupied the third greatest length of channel. Run heads and tails, despite being abundant, accounted for only 11.3% of the total reach length. Habitat maps and data for the entire study reach are shown in Appendices B and D. The longitudinal distribution of the area of each of the major habitat types within bins of 2 river miles is shown in Figure 3 and Figure 4a presents the distribution of each of the major habitat types sampled in March 2009.

Table 3-1. Summary of habitat types from RM 51.8 to 29.0, March 2009.

Habitat type	Count	% by count	Total length (ft)	Total length (mi)	% reach length	Area (ft^2)
Riffle	76	22.4	25,272	4.8	20.9	1,998,678
Pool head	15	4.4	1,409	0.3	1.2	111,375
Pool body	22	6.5	13,824	2.6	11.4	1,667,595
Pool tail	17	5.0	2,040	0.4	1.7	180,194
Run head	69	20.3	7,214	1.4	6.0	628,214
Run body	75	22.1	64,809	12.3	53.6	6,616,752
Run tail	66	19.4	6,392	1.2	5.3	600,497
Total	**340**	**100**	**120,960**	**22.9**	**100**	**11,803,306**

3.1.2 July 2009

For the total reach surveyed in July 2009 (RM 51.8–41.7), "run body/tail" habitat type was the most abundant and occupied the greatest length of channel along the study reach, followed by riffles (Table 3-2). The "pool body/tail" habitat type, while less abundant than other habitat types (e.g., run head), occupied the third greatest length of channel. Other transitional habitat types (e.g., run head and pool head) accounted for only 4.6 % of the total reach length. Habitat maps and data for the entire study reach are shown in Appendices B and D. The longitudinal distribution of the area of each of the major habitat types within bins of 2 river miles is shown in Figure 3 and Figure 4b presents the distribution of each of the major habitat types sampled in July 2009.

Table 3-2. Summary of habitat types from RM 51.8 to 41.7, July 2009.

Habitat type	Count	% by count	Total length (feet)	Total length (miles)	% reach length	Area (ft^2)
Riffle	30	22.1	12,678	2.4	23.7	1,109,569
Pool head	6	4.4	619	0.1	1.2	51,140
Pool body/tail	9/6	11.0	7,522	1.4	14.0	990,349
Run head	27	19.9	1,806	0.3	3.4	176,108
Run body/tail	32/26	42.6	30,915	5.9	57.7	3,120,036
Total	**136**	**100**	**53,540**	**10.1**	**100**	**5,447,202**

3.2 Water Quality and Flow

As water quality data were collected exclusively within units chosen for snorkel survey, data are presented by river mile, rather than by NSO, or summarized for the entire reach (Table 3-3 and Table 3-4). Water quality data for habitat units selected for snorkel surveys are shown in Appendix E.

Because of the strong influence of ambient air temperatures (Sullivan et al. 1990), temperatures of water released from the cold water pool of Don Pedro Reservoir increase in a downstream direction for both the spot measurements (Table 3-4) and in the continuous thermograph record during both the March and July survey periods (Appendix F). Note that the water temperature ranges shown in Table 3-3 and Table 3-4 represent changes over the course of the sampling day, and do not include nighttime temperatures or lows that are shown at representative thermograph locations in Appendix F.

3.2.1 March 2009

Daily average flow during the March 2009 survey period ranged from 165–170 cfs. In general, dissolved oxygen concentration was high due to the low water temperatures. Horizontal visibility was much lower at the most downstream location due to local turbidity sources.

Table 3-3. Range of water quality data collected at snorkel sites during fish surveys in March 2009.

River miles	Sample date	Flow (cfs)[1]	Water temp °C [°F]	DO (mg/L)	Horizontal visibility (ft)	Specific conductivity (uS/cm)
51.6−50.4	16 March	170	10.2–11.9 [50.4–53.4]	10.0−11.7	8–10	41.9–42.5
50.1−47.0	17 March	170	11.7–14.5 [53.1–58.1]	9.1−11.1	7–12	42.0–46.4
46.9−45.1	18 March	170	11.5–13.8 [52.7–56.8]	10.6−12.1	8–9	46.0–49.3
45.0−43.0	19 March	170	13.2–15.4 [55.8–59.7]	11.1−12.3	7–13	49.3–51.9
43.2−42.9	20 March	170	13.7–15.6 [56.7–60.1]	10.7−11.9	9–11	48.3–52.4
39.6−38.1	22 March	167	13.6–14.3 [56.5–57.7]	9.9−10.7	8–10	67.9–72.3
38.1−36.2	23 March	167	12.4–14.2 [54.3–57.6]	11.0−11.5	10–11	69.9–70.6
36.8−36.2	25 March	168	14.2–14.5 [57.6–58.1]	11.2−12.1	9–10	70.6–72.8
34.0−31.7	24 March	165	13.1–15.3 [55.6–59.5]	11.1−12.5	11–12	71.4–73.7
29.5	21 March	170	17.3 [63.1]	10.5	5	85.2

[1] Daily average flow data are measured from the stream gauge below La Grange powerhouse at RM 51.8 (USGS No. 11289650).

3.2.2 July 2009

Daily average flow during the July 2009 survey period ranged from 99–110 cfs. In general, dissolved oxygen concentration decreased with increasing temperatures along the same gradient, while specific conductivity increased. Horizontal and vertical visibility also decreased in the downstream direction.

Table 3-4. Range of water quality data collected at snorkel sites during fish surveys in July 2009.

River miles	Sample date	Flow (cfs)[1]	Water temp °C [°F]	DO (mg/L)	Horizontal visibility (ft)	Specific conductivity (uS/cm)
51.8−51.6	11 July	99	11.8–11.8 [53.2–53.2]	12.0−12.0	21–21	35.5–35.5
50.6−50.1	9 July	99	12.0–15.6 [53.6–60.1]	11.8−12.1	16–16	36.2–37.3
49.7−48.0	10 July	100	14.3–18.0 [57.7–64.4]	11.4−12.1	13–16	37.3–38.7
47.0−45.7	12 July	99	16.7–19.5 [62.1–67.1]	11.1−11.4	9–12	39.5–40.5
45.0−44.5	13 July	100	19.5–21.5 [67.1–70.7]	11.1−11.3	8–8	41.4–42.2
43.2−41.9	14 July	110	21.5–23.1 [70.7–73.6]	9.9−11.0	9–10.5	43.7–48.3

[1] Daily average flow data are measured from the stream gauge below La Grange powerhouse at RM 51.8 (USGS No. 11289650).

3.3 Water and Air Temperature

The daily average water temperature for all thermographs and the daily minimum, maximum, and average air temperature (from the NWS station at the Modesto Airport) are shown in Appendix F. The range of daily averages, instantaneous maximum temperature, maximum weekly average temperature (MWAT), and the seven-day average of daily maximum temperature (7dayMAX) for the 16–25 March and 9–14 July study periods was determined, and all three metrics for both periods showed a similar trend of increasing in the downstream direction. The MWAT is the seven-day rolling average of average daily temperatures, and describes ambient water temperature conditions over the previous week. It is a standard used in water quality studies and total maximum daily load (TMDL) estimations of allowable temperature. The 7dayMAX is the seven-day rolling average of the daily maximum temperatures, and is a potentially more accurate indicator of conditions affecting survival and growth of salmonids (Sullivan et al. 2000, Stillwater Sciences 2002).

3.3.1 March 2009

During the March 2009 survey period, water temperature data collected by thermographs followed similar trends to spot temperature data collected during snorkel surveys, showing an increase in the downstream direction (Table 3-5). Along the study reach, the MWAT increased from 11.0°C (51.7°F) at Riffle A7 to 15.1°C (59.1°F) at the Ruddy Gravel site (Table 3-5). The 7dayMAX temperature ranged from 12.0°C (53.5°F) at the Riffle A7 location to 16.4°C (61.4°F) at the Ruddy Gravel site. The hourly, mean weekly average (MWAT), and 7dayMAX water temperatures for Riffle A7 (RM 50.8), Riffle 13B (RM 45.5), Roberts Ferry Bridge (RM 39.6), Ruddy Gravel (RM 36.5), and the Waterford RST (RM29.8) from 1 February to 31 March 2009 are presented graphically in Appendix F.

Table 3-5. Maximum weekly average temperature, seven-day average of daily maximum temperatures, and instantaneous maximum temperatures recorded by thermographs in the survey reach of the lower Tuolumne River during March 2009.

Monitoring location	RM	MWAT ºC [°F] (week ending)	7dayMAX ºC [°F] (week ending)	Instantaneous maximum ºC [°F] (date)
Riffle A7	50.8	11.0 [51.7] (23 March)	12.0 [53.5] (21 March)	12.5 [54.6] (20 March)
Riffle 13B	45.5	13.0 [55.5] (22 March)	14.0 [57.1] (21 March)	14.5 [50.8] (20 March)
Roberts Ferry Bridge	39.6	14.5 [58.1] (22 March)	15.8 [60.5] (22 March)	16.6 [61.8] (20 March)
Ruddy Gravel	36.5	15.1 [59.1] (22 March)	16.4 [61.4] (22 March)	15.4 [59.7] (22 March)
Waterford RST[1]	29.8	14.2 [58.0] (17 March)	15.1 [59.2] (17 March)	16.8 [62.3] (17 March)

Note: Thermographs used have a reported error of ±0.2°C.

[1] Waterford RST data available 16-17 March only.

The average daily Modesto Airport air temperatures over the study period ranged from 10.6 to 18.3 ºC (51.0 to 65.0 °F) with a high temperature of 26.1 °C (79.0 °F) (Table 3-6). The warmest day of March occurred just after the study period on 28 March with an average daily temperature of 18.9 °C (66.0 °F) (Figure 2a) and a daily high temperature of 27.2 °C (81 °F).

Table 3-6. Daily average, minimum, and maximum air temperature recorded at the NWS station at the Modesto Airport during the March 2009 snorkeling study period.

Date	Average air temperature ºC [°F]	Minimum air temperature ºC [°F]	Maximum air temperature ºC [°F]
16 March 2009	15.0 [59]	8.3 [47]	21.7 [71]
17 March 2009	16.1 [61]	10.0 [50]	21.7 [71]
18 March 2009	16.7 [62]	10.0 [50]	22.8 [73]
19 March 2009	18.3 [65]	10.6 [51]	26.1 [79]
20 March 2009	17.8 [64]	10.6 [51]	24.4 [76]
21 March 2009	13.9 [57]	8.9 [48]	18.9 [66]
22 March 2009	11.7 [53]	7.2 [45]	15.6 [60]
23 March 2009	10.6 [51]	5.0 [41]	16.1 [61]
24 March 2009	12.2 [54]	2.8 [37]	21.1 [70]
25 March 2009	14.4 [58]	5.6 [42]	23.3 [74]

Hourly water temperature for several monitoring stations along the length of the study reach and daily air temperature from the Modesto Airport station was compared (Figure 2a). With flow being stable throughout period, Figure 2a shows that at the upstream-most monitoring station, water and air temperature are more independent of each other than at thermographs located farther downstream. That is, water temperature becomes more influenced by air temperature in the downstream direction, with water and air temperature peaks and troughs occurring at the same times of day at the downstream monitoring site at Roberts Ferry Bridge (RM 39.6).

3.3.2 July 2009

During the July 2009 survey period, water temperature data collected by thermographs followed similar trends to spot temperature data collected during snorkel surveys, which showed a general increase in the downstream direction (Table 3-7). Along the study reach, the MWAT increased from 12.6°C (54.6 °F) at Riffle A7 to 22.3°C (72.2 °F) at Roberts Ferry Bridge (Table 3-7). The 7dayMAX temperature ranged from 14.1°C (57.4 °F) at the Riffle A7 location to 23.9°C (75.1 °F) at the Roberts Ferry Bridge. The hourly, mean weekly average (MWAT), and 7dayMAX water temperatures for Riffle A7 (RM 50.8), Riffle 3B (RM 49.0), Riffle 13B (RM 45.5), Riffle 21 (RM 42.9), and Roberts Ferry Bridge (RM 39.6) from 1 June to 31 July 2009 are presented graphically in Appendix F.

Table 3-7. Maximum weekly average temperature, seven-day average of daily maximum temperatures, and instantaneous maximum temperatures recorded by thermographs in the survey reach of the lower Tuolumne River during July 2009.

Monitoring location	RM	MWAT ºC [°F] (week ending)	7dayMAX ºC [°F] (week ending)	Instantaneous maximum ºC [°F] (date)
Riffle A7	50.8	12.6 [54.6] (14 July)	14.1 [57.4] (09 July)	14.4 [58.0] (13 July)
Riffle 3B	49.0	15.2 [59.3] (14 July)	17.6 [63.7] (14 July)	18.0 [64.3] (13 July)
Riffle 13B	45.5	18.8 [65.8] (14 July)	20.1 [68.3] (14 July)	20.8 [69.5] (14 July)
Riffle 21	42.9	20.8 [69.5] (14 July)	22.4 [72.3] (14 July)	23.5 [74.2] (14 July)
Roberts Ferry Bridge	39.6	22.3 [72.2] (14 July)	23.9 [75.1] (14 July)	24.8 [76.7] (14 July)

Note: Thermographs used have a reported error of ±0.2°C.

The average daily Modesto Airport air temperatures over the study period ranged from 23.3 to 28.3 ºC (74.0 to 83.0 °F) with a high temperature of 38.9 °C (102 °F) (Table 3-8). The warmest day of July occurred just after the study period on 19 July with an average daily temperature of 32.2 °C (90 °F) and a daily high temperature of 41.7 °C (107 °F) (Figure 2b).

Table 3-8. Daily average, minimum, and maximum air temperature recorded at the NWS station at the Modesto Airport during the July 2009 snorkeling study period.

Date	Average air temperature ºC [°F]	Minimum air temperature ºC [°F]	Maximum air temperature ºC [°F]
9 July 2009	24.4 [76.0]	16.1 [61.0]	32.2 [90.0]
10 July 2009	23.3 [74.0]	13.9 [57.0]	32.8 [91.0]
11 July 2009	25.6 [78.0]	18.9 [66.0]	32.2 [90.0]
12 July 2009	26.7 [80.0]	19.4 [67.0]	33.9 [93.0]
13 July 2009	26.7 [80.0]	17.2 [63.0]	36.1 [97.0]
14 July 2009	28.3 [83.0]	17.8 [64.0]	38.9 [102.0]

Hourly water temperature for several monitoring stations along the length of the study reach and daily air temperature from the Modesto Airport station was compared (Figure 2b). After flow reductions in mid-June, Figure 2b shows that at the upstream-most monitoring station, water temperature remains low throughout the period and is more independent of air temperatures than at thermographs located farther downstream. That is, water temperature becomes more influenced by ambient air temperature in the downstream direction, with water and air temperature maxima and minima occurring at the same times of day at the site located farthest downstream at Roberts Ferry Bridge (RM 39.6).

3.4 Snorkel Surveys

3.4.1 March 2009

3.4.1.1 *O. mykiss* observations

During the March 2009 survey period, we observed 12 *O. mykiss* ranging from 0–499 mm (50 mm size bins) based upon maximum counts of all dive passes in each sampling unit (Table 3-9, Table 3-10 and Appendix G). Five of these fish were juveniles in the 50–99 mm size category, and the other 7 observed were in the adult (>150 mm) size classes (Table 3-9 and Table 3-10). The *O. mykiss* were observed in 6 different habitat units (NSOs) from RM 51.5 to RM 43.0, and all fish were observed in riffles with the exception of one adult in the 400–449 size category that was observed in a pool head habitat type (Table 3-9 and Table 3-10). Juveniles were observed in two riffle habitat units at RM 51.5 and RM 43.2. Adults were found in riffle habitat units at RM's 50.6, 48.0, and 43.0 along the pool head habitat unit at RM 49.7. There were no juvenile or adult *O. mykiss* observations made in the 38 habitat units sampled over the lower 14 miles of the study reach.

Table 3-9. Maximum count of *O. mykiss* by NSO, March 2009 (data are divided into 50 mm total length size classes).

RM	Unit ID (NSO)	Habitat	Multiple pass survey (Y/N)	0-49 mm	50-99 mm	100-149 mm	150-199 mm	200-249 mm	250-299 mm	300-349 mm	350-399 mm	400-449 mm	450-499 mm
51.6	4	Pool head	N										
51.6	5	Pool body	N										
51.5	6	Pool tail	N										
51.5	7	Riffle	N		2								
50.6	14	Riffle	N							1		3	
50.6	15	Run head	N										
50.5	16	Run body	N										
50.4	17	Run tail	N										
50.1	22	Riffle	N										
49.7	27	Pool head	N										1
49.6	28	Pool body	N										
49.6	29	Pool tail	N										
48.0	53	Riffle	Y							1			
47.0	58	Run head	Y										
46.9	59	Run body	N										
46.9	60	Run tail	Y										
45.3	82	Run head	N										
45.1	83	Run body	N										
45.1	84	Run tail	Y										
45.0	86	Pool head	N										
44.9	87	Pool body	N										
44.9	88	Pool tail	Y										
44.6	97	Riffle	N										
43.2	107	Riffle	N		3								
43.2	108	Run head	N										
43.1	109	Run body	N										
43.1	110	Run tail	N										
43.0	111	Riffle	Y					1					

RM	Unit ID (NSO)	Habitat	Multiple pass survey (Y/N)	0-49 mm	50-99 mm	100-149 mm	150-199 mm	200-249 mm	250-299 mm	300-349 mm	350-399 mm	400-449 mm	450-499 mm
43.0	112	Pool head	Y										
43.0	113	Pool body	Y										
43.0	114	Pool tail	N										
42.9	118	Riffle	N										
39.6	157	Run head	N										
39.5	158	Run body	Y										
39.5	159	Run tail	N										
39.4	160	Riffle	N										
38.9	168	Riffle	N										
38.7	175	Riffle	N										
38.1	188	Pool head	N										
38.1	189	Pool body	N										
38.1	190	Pool tail	N										
38.1	192	Pool head	Y										
38.0	193	Pool body	N										
38.0	194	Pool tail	Y										
36.9	214	Pool head	N										
36.9	215	Pool body	N										
36.9	216	Pool tail	N										
36.8	218	Run head	N										
36.6	219	Run body	Y										
36.6	220	Run tail	N										
36.2	230	Pool head	N										
36.2	231	Pool body	Y										
36.2	232	Pool tail	N										
34.0	259	Run head	Y										
34.0	260	Run body	N										
33.9	261	Run tail	N										
33.4	271	Pool head	N										

RM	Unit ID (NSO)	Habitat	Multiple pass survey (Y/N)	0-49 mm	50-99 mm	100-149 mm	150-199 mm	200-249 mm	250-299 mm	300-349 mm	350-399 mm	400-449 mm	450-499 mm
33.2	272	Pool body	N										
33.2	273	Pool tail	N										
31.9	287	Run head	N										
31.7	288	Run body	N										
31.7	289	Run tail	N										
29.5	324	Riffle	N										
29.5	325	Run head	N										
29.5	326	Run body	N										
29.5	327	Run tail	N										
Total (maximum unit count of all passes)				**0**	**5**	**0**	**0**	**1**	**0**	**2**	**0**	**3**	**1**

Table 3-10. Maximum count of *O. mykiss* by habitat type, March 2009 (data are divided into 50 mm total length size classes).

Habitat	0-49 mm	50-99 mm	100-149 mm	150-199 mm	200-249 mm	250-299 mm	300-349 mm	350-399 mm	400-449 mm	450-499 mm	Total (max. unit count of all passes)
Pool body											**0**
Pool head										1	**1**
Pool tail											**0**
Riffle		5			1		2		3		**11**
Run body											**0**
Run head											**0**
Run tail											**0**
Totals by size class	**0**	**5**	**0**	**0**	**1**	**0**	**2**	**0**	**3**	**1**	**12**

3.4.1.2 *O. mykiss* population estimate

Table 3-11 shows the March 2009 *O. mykiss* population estimate for the lower Tuolumne River by length (<150 mm for YOY and juvenile; >150 mm for adults) and habitat type using the method of bounded counts (Hankin and Mohr 2001) for the study reach from RM 51.8 to RM 29.0. From an observed 5 YOY/juveniles and 7 adult *O. mykiss* in March 2009, we estimated a population of 63 YOY/juveniles (no 95% CI available), and 170 adults (with a 95% CI of 12-222), for an overall population estimate of 233 (Table 3-11). Since all *O. mykiss* were observed in riffles with the exception of one adult observed in a pool head; population estimates were only generated for the riffle habitat type. In addition, since the riffle observations for juvenile *O. mykiss* did not include a sufficient number of observations from multiple-pass sites (used to develop an expansion factor), the population estimate for these fish was based on an expansion factor (Hankin and Mohr 2001) developed without a 95% CI by using the variance from corresponding observations of juvenile Chinook salmon within riffle habitat units in the March 2009 surveys.

Table 3-11. *O. mykiss* March 2009 bounded count population estimates between RM 51.8 and 29.0 by fish length and habitat type.

Habitat	***O. mykiss*** < 150 mm				***O. mykiss*** ≥ 150 mm			
	Obs.[1]	**Est.[2]**	**St. dev.**	**95% CI[3]**	**Obs.[1]**	**Est.[3]**	**St. dev.**	**95% CI[4]**
Pool head	0	--	--	--	1	≥1	--	--
Pool body	0	--	--	--	0	--	--	--
Pool tail	0	--	--	--	0	--	--	--
Riffle	5	63	--	--	6	170	86.3	6–339
Run head	0	--	--	--	0	--	--	--
Run body	0	--	--	--	0	--	--	--
Run tail	0	--	--	--	0	--	--	--
Total	**5**	**63**	**--**	**--**	**7**	**170**	**86.3**	**7–339**

[1] Largest numbers seen in any single dive pass for each unit, summed over units. Note that because of the potential for the same fish to be assigned to different size classes on subsequent passes, summation of the largest numbers assigned to individual (50 mm) size bins yields may overestimate total fish observed.

[2] Estimate for *O. mykiss* juveniles in riffles based on the expansion used for Chinook juveniles in riffles, no uncertainty data provided.

[3] Estimate for *O. mykiss* adults in pool head not included in overall population estimate due to lack of multiple pass data to develop an expansion factor.

[4] Nominal confidence intervals calculated as + 1.96 standard deviations.

3.4.1.3 Chinook salmon observations

Table 3-12 and Table 3-13 show the number of Chinook salmon observed within the study reach during the March 2009 surveys, based on the maximum count by pass. Most Chinook salmon were YOY and juveniles found within the 0–49 and 50–99 mm size classes. These salmon were seen in 42 different sampling units ranging from RM 51.6 to RM 31.7 (Table 3-12) and all habitat types (Table 3-13).

Table 3-12. Maximum counts of juvenile Chinook salmon by size class and sampling unit, March 2009.

River mile	Sampling unit (NSO)	Habitat type	Multiple pass survey (Y/N)	0–49 mm	50–99 mm
51.6	4	Pool head	N	80	45
51.6	5	Pool body	N		
51.5	6	Pool tail	N	6	4
51.5	7	Riffle	N	250	119
50.6	14	Riffle	N	910	505
50.6	15	Run head	N	112	144
50.5	16	Run body	N	149	208
50.4	17	Run tail	N	71	50
50.1	22	Riffle	N	32	12
49.7	27	Pool head	N		60
49.6	28	Pool body	N		
49.6	29	Pool tail	N		7
48.0	53	Riffle	Y	80	110
47.0	58	Run head	Y	30	15
46.9	59	Run body	N	2	
46.9	60	Run tail	Y	6	
45.3	82	Run head	N		
45.1	83	Run body	N	2	3
45.1	84	Run tail	Y		
45.0	86	Pool head	N		
44.9	87	Pool body	N		15
44.9	88	Pool tail	Y		35
44.6	97	Riffle	N	31	103
43.2	107	Riffle	N	65	80
43.2	108	Run head	N	7	
43.1	109	Run body	N	180	241
43.1	110	Run tail	N		2
43.0	111	Riffle	Y	41	42
43.0	112	Pool head	Y	26	24
43.0	113	Pool body	Y		
43.0	114	Pool tail	N		
42.9	118	Riffle	N	7	14
39.6	157	Run head	N		
39.5	158	Run body	Y		

River mile	Sampling unit (NSO)	Habitat type	Multiple pass survey (Y/N)	0–49 mm	50–99 mm
39.5	159	Run tail	N		2
39.4	160	Riffle	N		1
38.9	168	Riffle	N	10	8
38.7	175	Riffle	N	1	
38.1	188	Pool head	N		
38.1	189	Pool body	N		
38.1	190	Pool tail	N		
38.1	192	Pool head	Y		
38.0	193	Pool body	N		60
38.0	194	Pool tail	Y		
36.9	214	Pool head	N		1
36.9	215	Pool body	N		
36.9	216	Pool tail	N		
36.8	218	Run head	N		
36.6	219	Run body	Y		9
36.6	220	Run tail	N		10
36.2	230	Pool head	N		
36.2	231	Pool body	Y		
36.2	232	Pool tail	N		
34.0	259	Run head	Y	34	21
34.0	260	Run body	N	3	2
33.9	261	Run tail	N	17	12
33.4	271	Pool head	N	8	
33.2	272	Pool body	N	7	
33.2	273	Pool tail	N	4	
31.9	287	Run head	N	55	13
31.7	288	Run body	N	56	18
31.7	289	Run tail	N	10	5
29.5	324	Riffle	N		
29.5	325	Run head	N		
29.5	326	Run body	N		
29.5	327	Run tail	N		
Total (max. unit count of all passes)				**2,292**	**2,000**

Table 3-13. Maximum counts of juvenile Chinook salmon by size class and habitat type, March 2009.

Habitat	0–49 mm	50–99 mm	Total (maximum unit count of all passes)
Pool body	7	75	82
Pool head	114	130	244
Pool tail	10	46	56
Riffle	1,427	994	2,421
Run body	392	481	873
Run head	238	193	431
Run tail	104	81	185
Totals by size class	**2,292**	**2,000**	**4,292**

Divers also observed four adult Chinook salmon (500–850 mm) within the study reach. The adult Chinook salmon observations were made at four separate sampling units between RM 51.5 and RM 36.6. Because the adult salmon were found within single pass dive units within riffle, run body, and pool body habitat units, no expansion was possible using the Hankin and Mohr (2001) methodology. The complete Chinook salmon observation data by pass are shown in Appendix G.

3.4.1.4 Chinook salmon population estimate

Table 3-14 shows the March 2009 Chinook salmon population estimate for the lower Tuolumne River by length (<150 mm for YOY and juvenile; >150 mm for adults) and habitat type using the method of bounded counts (Hankin and Mohr 2001). Out of an estimated 39,563 juveniles, we estimated a 95% confidence interval of 34,861–44,265 (Table 3-14). The data show that the greatest estimated abundance of YOY and juvenile Chinook salmon occurred in riffles (Table 3-14). Although observations of adult Chinook salmon were considered incidental, a population estimate of 126 was developed with a 95% confidence interval of 2–318 (Table 3-14).

Table 3-14. Chinook salmon March 2009 bounded count population estimates by fish length and habitat type.

Habitat	Chinook salmon < 150 mm				Chinook salmon ≥ 150 mm			
	Obs.[1]	**Est.**[2]	**St. dev.**[3]	**95% CI**[4]	**Obs.**[1]	**Est.**[2]	**St. dev.**	**95% CI**[4]
Pool head	244	602	--	--	0	--	--	--
Pool body	82	≥82	--	--	1	≥1	--	--
Pool tail	56	160	78.0	56–313	0	--	--	--
Riffle	2,411	30,580	1,873.9	26,907–34,253	1	≥1	--	--
Run head	430	3,671	452.7	2,783–4,558	0	--	--	--
Run body	873	≥873	--	--	2	126	98.1	2–318
Run tail	185	4,550	1425.8	1,756–7,345	0	--	--	--
Total	**4,281**	**39,563**	**2,399.1**	**34,861–44,265**	**4**	**126**	**98.1**	**2–318**

[1] Largest numbers seen in any single dive pass for each unit, summed over units. Note that because of the potential for the same fish to be assigned to different size classes on subsequent passes, summation of the largest numbers assigned to individual (50 mm) size bins yields may overestimate total fish observed.
[2] Estimate for pool and run body habitat types for juvenile salmon as well as riffle habitats for adult salmon not included in overall population estimate due to lack of multiple pass data to develop an expansion factor.

[3] Standard deviation and confidence intervals undefined for multiple pass units with identical dive counts.
[4] Nominal confidence intervals calculated as + 1.96 standard deviations.

3.4.1.5 Non-salmonid observations

Several other fish species were observed and counted during the March 2009 survey period (Table 3-15). Most other fish seen within the study reach were native species in the minnow (*Cyprinidae*) and sucker (*Catostomidae*) families. A combination of hardhead and Sacramento pikeminnow, along with Sacramento sucker accounted for 87.7%. Other observed non-salmonid fish included centrarchids (largemouth bass, smallmouth bass, bluegill) (4.1%), sculpin (0.5%), lamprey (0.2%), and unidentified species (7.5%). Most centrarchids occurred toward the downstream end of the study reach where water temperatures were warmer, while native minnows and suckers were found throughout the reach. The complete non-salmonid fish observation data are in Appendix G.

Table 3-15. Maximum counts of non-salmonid species by sampling unit (NSO), March 2009.

RM	Sampling unit (NSO)	Habitat	BG	BASS	LMB	SMB	STP	SC	HH/PM	SS	LAM	UNK
51.6	4	Pool head								1		
51.5	7	Riffle								3		
50.6	14	Riffle								21		
50.6	15	Run head								6		
50.5	16	Run body								30		1
50.4	17	Run tail								2		
50.1	22	Riffle								7		
49.7	27	Pool head								3		
49.6	28	Pool body								15		
48.0	53	Riffle						3		10		
47.0	58	Run head								12		
46.9	59	Run body							2	1		
45.3	82	Run head			5				5	9		
45.1	83	Run body			1				2			
45.0	86	Pool head							7	1		
44.9	87	Pool body							1			
44.9	88	Pool tail			1				2			
44.6	97	Riffle							8	9		
43.2	107	Riffle							19	4		
43.2	108	Run head							2	9		
43.1	109	Run body							117	6		
43.1	110	Run tail							3	6		
43.0	111	Riffle							4	4		
43.0	112	Pool head						1	7	2	1	
43.0	113	Pool body							81	100		
43.0	114	Pool tail							3			
42.9	118	Riffle								2		
39.6	157	Run head								14		
39.5	158	Run body			1	2	1		3	53		70
39.5	159	Run tail								20		

RM	Sampling unit (NSO)	Habitat	BG	BASS	LMB	SMB	STP	SC	HH/PM	SS	LAM	UNK
39.4	160	Riffle			1				13			3
38.9	168	Riffle						1		6		
38.1	189	Pool body			1				2	4		
38.1	192	Pool head								1		
38.0	193	Pool body			1					17		
36.9	215	Pool body							1	35		
36.8	218	Run head								9		
36.6	219	Run body		1	1	2			1	12		
36.2	231	Pool body								1		1
34.0	259	Run head				1				30		
34.0	260	Run body				1			1	30		
33.9	261	Run tail								2		
33.4	271	Pool head		3								
33.2	272	Pool body			1							
33.2	273	Pool tail									1	
31.9	287	Run head							1	40		
31.7	288	Run body				1				46		
31.7	289	Run tail							1			
29.5	324	Riffle								1		
29.5	325	Run head	10			1				4		
29.5	326	Run body	1									
29.5	327	Run tail	3		1							
Total (all sampled units)			**14**	**4**	**14**	**8**	**1**	**5**	**286**	**588**	**2**	**75**

BG = bluegill; BASS = unidentified bass; LMB = largemouth bass; SMB = smallmouth bass; STP = striped bass; SC = sculpin species; HH/PM = hardhead/Sacramento pikeminnow; SS = Sacramento sucker; LAM = lamprey species; UNK = unknown

3.4.2 July 2009

3.4.2.1 *O. mykiss* observations

During the July 2009 survey period, we observed 796 *O. mykiss* ranging from 0–499 mm (50 mm size bins) based upon maximum counts of all dive passes in each sampling unit (Table 3-16, Table 3-17). The majority of these fish (686) were YOY/juvenile (<150 mm), with a total of 110 adults (>150 mm) observed (Figure 5). Complete fish observation data by NSO and dive pass is presented in Appendix G.

The *O. mykiss* were observed in 23 different habitat units (NSOs) from RM 51.8 to RM 41.9 and in all habitat types (Table 3-16 and Table 3-17). Habitat use and reach-wide distribution of YOY/juvenile and adult *O. mykiss* differed, with the maximum count from dive passes (Figure 6a) and fish densities (Figure 5b) highest in riffle and pool body/tail habitats for juvenile size classes (<150mm) and higher counts and densities of adult size classes (>150 mm) in riffle and pool head habitats. Juvenile size classes were also observed in run head transitional habitat downstream of riffles, with lower densities in run bodies and pool habitats. Adult-size classes were observed in transitional run head habitats as well as within pool and run body/tail habitats in slightly lower numbers and densities (Figure 6a and Figure 6b).

Adult fish habitat use was concentrated at upstream habitat units (above RM 48.0) and primarily occurred at riffle (four NSOs) and transitional pool head (four NSOs) and run head (two NSOs) habitats (Table 3-16 and Figure 7). Juvenile fish habitat use was more uniformly distributed from upstream to downstream and occurred primarily at riffle habitat units, although the highest count was from a single pool body/tail sampling unit (NSO 5/6 at RM 51.6) (Table 3-17 and Figure 8).

Table 3-16. Maximum count of *O. mykiss* by NSO, July 2009 (data are divided into 50 mm total length size classes).

RM	Unit ID (NSO)	Habitat	Multiple pass survey (Y/N)	0-49 mm	50-99 mm	100-149 mm	150-199 mm	200-249 mm	250-299 mm	300-349 mm	350-399 mm	400-449 mm	450-499 mm
51.8	1	Pool head	N					2				8	4
51.7	2/3	Pool body/tail	N							1	2	1	
51.6	4	Pool head	Y							2	2		
51.6	5/6	Pool body/tail	Y	45	188	100			2		2		
50.6	14	Riffle	N		13	35	3				1		
50.6	15	Run head	N			2							
50.3	19	Run head	N						3		1		
50.1	20/21	Run body/tail	Y		4	1		1	3	1		1	
50.1	22	Riffle	Y	5	47	43			2	1	1		
49.7	27	Pool head	N		2	1	1		1	2			
49.6	28/29	Pool body/tail	N		8	2	5	3					
49.2	33	Riffle	N		11	17	6	6	5	3		1	
49.2	34	Run head	N		21	5	3		1	1			
49.1	35/36	Run body/tail	N										
48.2	49	Riffle	N		25	40	2	4	6		1		
48.0	54	Pool head	N					1		1			
47.0	58	Run head	Y		2	5	1						
46.9	59/60	Run body/tail	N										
45.7	74	Riffle	N	2	6	5	1						
45.7	75	Run head	Y		1								
45.7	76/77	Run body/tail	N										
45.0	86	Pool head	Y										
44.9	87/88	Pool body/tail	N										
44.5	101	Riffle	Y		9	15	3						
43.2	108	Run head	N										
43.1	109/110	Run body/tail	Y		5	12	5						
43.0	111	Riffle	N		1	6	2						
43.0	112	Pool head	N		1								

RM	Unit ID (NSO)	Habitat	Multiple pass survey (Y/N)	0-49 mm	50-99 mm	100-149 mm	150-199 mm	200-249 mm	250-299 mm	300-349 mm	350-399 mm	400-449 mm	450-499 mm
43.0	113/114	Pool body/tail	Y										
41.9	132	Riffle	N			1		1					
41.9	133	Run head	N										
Total (maximum unit count of all passes)				**52**	**344**	**290**	**32**	**18**	**23**	**12**	**10**	**11**	**4**

Table 3-17. Maximum count of *O. mykiss* by habitat type, July 2009 (data are divided into 50 mm total length size classes).

Habitat	0-49 mm	50-99 mm	100-149 mm	150-199 mm	200-249 mm	250-299 mm	300-349 mm	350-399 mm	400-449 mm	450-499 mm	Total (max. unit count of all passes)
Pool body/tail	45	196	102	5	3	2	1	4	1		**359**
Pool head		3	1	1	3	1	5	2	8	4	**28**
Riffle	7	112	162	17	11	13	4	3	1		**330**
Run body/tail		9	13	5	1	3	1		1		**33**
Run head		24	12	4		4	1	1			**46**
Totals by size class	**52**	**344**	**290**	**32**	**18**	**23**	**12**	**10**	**11**	**4**	**796**

3.4.2.2 *O. mykiss* population estimate

Table 3-18 shows the July 2009 *O. mykiss* population estimate for the lower Tuolumne River by length (<150 mm for YOY and juvenile; >150 mm for adults) and habitat type using the method of bounded counts (Hankin and Mohr 2001). Out of an estimated 3,475 juveniles and 963 adults *O. mykiss* in July 2009 (an overall population estimate of 4,438), we estimated a 95% confidence interval of 945–6,004 and 464–1,461 for YOY/juvenile and adults, respectively (Table 3-18). As discussed above, the data show that the greatest estimated abundance of YOY and juvenile *O. mykiss* occurred in riffles, despite observing the highest count in the pool body/tail habitat type (Figure 6a).

The relative differences between population estimates and observed fish counts are due to differences in habitat unit areas (e.g., run body/tail habitat units occupying approximately 20 times more habitat area than run head units (Table 3-2). This results in higher population estimates in some habitat types even though the observed counts may be lower than those found in other habitat types. In July 2009, juvenile and adult population estimates were shown to be highest in riffle habitat units (Table 3-18).

Table 3-18. *O. mykiss* July 2009 bounded count population estimates by fish length and habitat type.

Habitat	O. mykiss < 150 mm				O. mykiss ≥ 150 mm			
	Obs.[1]	Est.[2]	St. dev.	95% CI[3]	Obs.[1]	Est.	St. dev.	95% CI[3]
Pool head	4	≥4	---	--	23	26	0.0	26–26
Pool body/tail	304	1,382	898.2	304–3,143	16	147	56.8	36–259
Riffle	279	1,528	893.5	279–3,279	48	428	131.0	171–684
Run head	35	265	49.8	168–363	10	206	123.4	10–448
Run body/tail	19	299	240.5	19–771	8	156	170.6	8–490
Total	**641**	**3,475**	**1,290.5**	**945–6,004**	**105**	**963**	**254.4**	**464–1,461**

[1] Largest numbers seen in any single dive pass for each unit, summed over units. Note that because of the potential for the same fish to be assigned to different size classes on subsequent passes, summation of the largest numbers seen assigned to individual (50 mm) size bins may overestimate total fish observed.
[2] Estimate for *O. mykiss* juveniles in pool head habitats not included in overall population estimate due to lack of multiple pass data to develop an expansion factor.
[3] Nominal confidence intervals calculated as + 1.96 standard deviations. Standard deviation and confidence intervals undefined for multiple pass units with identical dive counts.

3.4.2.3 Chinook salmon observations

Divers observed a large number of juvenile Chinook salmon within the study reach during July 2009 as well as small numbers within the adult size classes (>150 mm). Salmon were seen in 25 different sampling units from RM 51.6 to RM 41.9 (Table 3-19) and all habitat types (Table 3-20). Most salmon were juveniles found within the 50–99 mm size class.

Table 3-19. Maximum counts of juvenile Chinook salmon by size class and sampling unit, July 2009.

River mile	Sampling unit (NSO)	Habitat type	Multiple pass survey (Y/N)	0–49 mm	50–99 mm	100–149 mm
51.8	1	Pool head	N			
51.7	2/3	Pool body/tail	N			
51.6	4	Pool head	Y			
51.6	5/6	Pool body/tail	Y	250	292	
50.6	14	Riffle	N	570	1,410	120
50.6	15	Run head	N	30	55	
50.3	19	Run head	N		480	20
50.1	20/21	Run body/tail	Y	116	249	
50.1	22	Riffle	Y	24	139	
49.7	27	Pool head	N		3	3
49.6	28/29	Pool body/tail	N		100	2
49.2	33	Riffle	N		97	6
49.2	34	Run head	N	95	325	5
49.1	35/36	Run body/tail	N			
48.2	49	Riffle	N	32	89	7
48.0	54	Pool head	N	1		
47.0	58	Run head	Y		2	2
46.9	59/60	Run body/tail	N			
45.7	74	Riffle	N	3	35	3
45.7	75	Run head	Y		1	
45.7	76/77	Run body/tail	N		11	
45.0	86	Pool head	Y		4	
44.9	87/88	Pool body/tail	N		3	
44.5	101	Riffle	Y	4	69	18
43.2	108	Run head	N			
43.1	109/110	Run body/tail	Y		10	2
43.0	111	Riffle	N		1	
43.0	112	Pool head	N		2	
43.0	113/114	Pool body/tail	Y			
41.9	132	Riffle	N	1	19	4
41.9	133	Run head	N		2	
Total (Max. unit count of all passes)				**1,126**	**3,398**	**192**

Table 3-20. Maximum counts of juvenile Chinook salmon by size class and habitat type, July 2009.

Habitat	0–49 mm	50–99 mm	100–149 mm	Total (maximum unit count of all passes)
Pool body/tail	250	395	2	647
Pool head	1	9	3	13
Riffle	634	1859	158	2,651
Run body/tail	116	270	2	388
Run head	125	865	27	1,017
Totals by size class	**1,126**	**3,398**	**192**	**4,716**

Divers observed a total of six adult Chinook salmon at three separate sampling units in the upper portion of the study reach between RM 51.6 and 50.6. A total of four adults were seen in a riffle habitat unit (NSO 14), with one adult each was observed in a pool head (NSO 4) and a pool body/tail (NSO 5/6) habitat unit. The complete Chinook salmon observation data by pass are shown in Appendix G.

3.4.2.4 Chinook salmon population estimate

Table 3-21 shows the July 2009 Chinook salmon population estimate for the lower Tuolumne River by length (<150 mm for YOY and juvenile; >150 mm for adults) and habitat type using the method of bounded counts (Hankin and Mohr 2001). Out of an estimated 29,389 juveniles and 11 adult Chinook salmon in July 2009 (an overall population estimate of 29,400), we estimated a 95% confidence interval of 19,068–39,711 and 6–26 for YOY/juvenile and adults, respectively (Table 3-21). The data show that the greatest estimated abundance of YOY and juvenile Chinook salmon occurred in riffles, with the greatest estimated abundance of adults in the pool body/tail habitat type (Table 3-21).

Table 3-21. Chinook salmon July 2009 bounded count population estimates by fish length and habitat type.

Habitat	Chinook salmon < 150 mm				Chinook salmon ≥ 150 mm			
	Obs.[1]	Est.	St. dev.	95% CI[2]	Obs.[1]	Est.[2]	St. dev.	95% CI[3]
Pool head	13	62	35.8	13–132	1	2	1.2	1–4
Pool body/tail	635	2,890	1,616.2	635–6058	1	9	7.7	1–24
Riffle	2,643	15,157	13,863.8	12,445–17,869	4	≥4	---	--
Run head	1,017	5,610	0.8	5,609–5,612	0	--	---	--
Run body/tail	388	5,670	4,817	388–15111	0	--	---	--
Total	**4,696**	**29,389**	**5,266.1**	**19,068–39,711**	**6**	**11**	**7.8**	**6–26**

[1] Largest numbers seen in any single dive pass for each unit, summed over units. Note that because of the potential for the same fish to be assigned to different size classes on subsequent passes, summation of the largest numbers assigned to individual (50 mm) size bins may overestimate total fish observed.
[2] Estimate adult salmon within riffle habitats for adult salmon not included in overall population estimate due to lack of multiple pass data to develop an expansion factor.
[3] Nominal confidence intervals calculated as ± 1.96 standard deviations.

3.4.2.5 Non-salmonid observations

Several other fish species were observed during the July study period (Table 3-22). Most fish seen within the study reach were native species in the minnow (*Cyprinidae*) and sucker (*Catostomidae*) families. A combination of cyprinids (hardhead and Sacramento pikeminnow), along with Sacramento sucker accounted for 91.2% of observed non-salmonid fish, while non-native centrarchids (largemouth bass, smallmouth bass, and unidentified bass) accounted for approximately 7.3%, and sculpin for the remaining 1.5%. Most centrarchids occurred toward the downstream end of the study reach where water temperatures were warmer, while native minnows and suckers were found throughout the reach. The complete non-salmonid fish observation data are in Appendix G.

Table 3-22. Maximum counts of non-salmonid species by sampling unit (NSO), July 2009.

RM	Sampling unit (NSO)	Habitat	BASS	LMB	SMB	SC	HH/PM	SS
51.7	2/3	Pool body/tail					2	4
51.6	5/6	Pool body/tail						2
50.6	14	Riffle				3	1	22
50.6	15	Run head						2
50.3	19	Run head						2
50.1	20/21	Run body/tail				9	2	6
50.1	22	Riffle						15
49.7	27	Pool head					1	3
49.6	28/29	Pool body/tail				1	1	12
49.2	33	Riffle						1
49.2	34	Run head					5	5
49.1	35/36	Run body/tail					2	1
48.2	49	Riffle					6	17
48.0	54/55	Pool head/tail		6	4		9	35
47.0	58	Run head					35	2
46.9	59/60	Run body/tail		1			6	15
45.7	74	Riffle					2	
45.7	75	Run head		1			46	3
45.7	76/77	Run body/tail					25	3
45.0	86	Pool head					7	4
44.9	87/88	Pool body/tail					45	
44.5	101	Riffle		1	3	1	17	9
43.2	108	Run head		2			2	7
43.1	109/110	Run body/tail	13	23	4		38	25
43.0	111	Riffle		1			31	1
43.0	112	Pool head					6	
43.0	113/114	Pool body/tail		6	1		62	1
41.9	132	Riffle		1			228	15
41.9	133	Run head		2			66	2
Total (all sampled units)			**13**	**44**	**12**	**14**	**645**	**214**

BASS = Black bass; LMB = large mouth bass; SMB = small mouth bass;
HH/PM = heardhead/pikeminnow; SS = Sacramento sucker

4 DISCUSSION

4.1 Bounded Counts Study Assumptions

It should be noted that the bounded counts method was developed for use in smaller stream systems (Hankin and Mohr 2001) and applying the methodology to a larger system such as the Tuolumne River is only feasible provided key assumptions are satisfied. One critical assumption of the bounded counts approach is that all individuals have an equal probability of being observed. As noted above, this assumption may be challenged in locations with large numbers of juvenile Chinook salmon, due to low visibility conditions in deeper pool habitats, as well as low visibility due to light and background turbidity variations within the river between seasons or from upstream to downstream. For these reasons, the resulting population estimates may be low-biased.

A second assumption of the bounded counts method is that observation efficiency is not 100%, so the number of fish seen in any single dive pass is, in general, an underestimate of the true number of fish present. For a closed population where fish do not migrate into or out of the unit between dives, the maximum number of fish seen over multiple passes is a low-biased estimator of the true population. However, because we subsampled larger habitat units at some locations, for run habitat types in particular, the resulting density expansions may have introduced a high-biased estimate of the true population size since fish are able to migrate freely into and out of the searched area due to the lack of habitat boundaries relevant to the sampled fish (e.g., riffle transitions).

4.2 Variations in *O. mykiss* Population Estimates

4.2.1 March 2009

Overall, the March 2009 population estimate of 44 juvenile *O. mykiss* (< 150 mm) and 117 adults (>150 mm) was low, with very low representation of juvenile size classes relative to adults (Table 3-11). Although the higher numbers of Chinook salmon juveniles observed during the March 2009 surveys (Table 3-13) may have resulted in misidentification of some *O. mykiss* within the same area, the low numbers of juvenile *O. mykiss* observed is consistent with a winter-spring spawning period that begins in February (Moyle 2002). The low number of adult *O. mykiss* observed during March 2009 may be attributed to potential causes such as:

1. Adult *O. mykiss* have a heterogeneous (i.e., "patchy") distribution and it appears that future winter sampling efforts should be conducted in the same reach as summer surveys, upstream of Roberts Ferry Bridge (RM 39.5), unless other information (e.g., from angling or tracking) identifies whether habitat use is distributed farther downstream.
2. Adult *O. mykiss* may be more furtive in winter, swimming into or occupying deeper portions of pools or out of range of the diver visibility, which is also reduced in winter due to lower light levels and increased turbidity. Nighttime dive surveys could be considered in future surveys, since low light situations tend to reduce the startle reflex of *O. mykiss*.
3. Lastly, adult *O. mykiss* may be altogether absent from the survey reach because they have migrated downstream of RM 29. This could be confirmed by any of: a) catch and release angling outside of the survey reach, b) capture, implantation of acoustic tags and tracking

as provided in the TID/MID (2007) study plan, or c) video observations at the Districts Alaska type counting weir recently deployed at RM 24 in September 2009.

4.2.2 July 2009 and July 2008

The July 2009 population estimate of 4,438 fish indicates a relatively high proportion of juvenile *O. mykiss* (3,475) relative to adults (963) (Table 3-18), with these proportions similar to historical June-July routine snorkel surveys conducted by the Districts (Ford and Kirihara 2009). In comparison to the July 2008 results of 2,472 juvenile and 643 adult *O. mykiss* (Stillwater Sciences 2008), the 2009 results indicate a slight increase in population levels at similar flow levels (approximately 100 cfs for sample dates in both July 2008 and July 2009). Juvenile *O. mykiss* population estimates would be expected to vary from year-to-year due to the large number of potential eggs deposited by each additional female spawner. However, the apparent increases in both juvenile and adult populations are within the 95% confidence intervals of the 2008 and 2009 estimates, with 95% CIs for juvenile *O. mykiss* ranging from 945–6,004 and 1,263–3,681, and for adults ranging from 464–1,461 and 217–1,070 in 2009 and 2008, respectively.

4.3 *O. mykiss* Distribution in Relation to Water Temperature

4.3.1 March 2009

During the March 2009 snorkel surveys, water temperatures remained below 15°C throughout most the study reach and only exceeded 17°C at the lowest sampling unit (RM 29.5) on 21 March 2009. These temperature conditions are not thought to particularly affect the distribution of *O. mykiss*. The few *O. mykiss* observed were found at or upstream of RM 43.0, similar to the 2008–2009 summer surveys. As discussed above in Section 4.2, presence/absence of *O. mykiss* downstream of the study reach could be confirmed by any of: a) catch and release angling outside of the survey reach, b) capture, implantation of acoustic tags and tracking as provided in the TID/MID (2007) study plan, or c) video observations at the Districts Alaska type counting weir recently deployed at RM 24 in September 2009.

4.3.2 July 2009

To test Hypothesis #1 that summertime distribution of observed life stages of *O. mykiss* across suitable habitat is related to ambient river water temperature, we compared water temperature data taken from thermographs to fish density in the sampled units. The data show that temperatures increase in the downstream direction (Section 3.3.2, Table 3-7) and that the density of adult *O. mykiss* (>150 mm) decreased along this same gradient (Figure 9). In habitat units where fish were seen, density of adult fish was greatest just downstream of La Grange Dam and decreased markedly in the downstream direction, especially below RM 48.0. Pool heads occupy the least amount of channel area (Table 3-2) and are also more concentrated in upstream locations (Figure 3), so adult fish presence here may indicate a preference for pool head habitats or a preference for cooler water (<21 °C [69.8 °F]). We sampled six pool heads throughout the reach (Appendix G), and found no adult fish (>150 mm) within this habitat type downstream of NSO 54 (RM 48.0), suggesting that water temperature and possibly microhabitat elements such as cover type are a stronger determinant of longitudinal distribution of *O. mykiss* than mesohabitat type. It may also be that spawning activity primarily occurs in upstream areas and may influence the general distribution of both adults and juveniles. Smaller fish were observed in a similar pattern with highest densities upstream of RM 48 and decreasing overall in a downstream direction (Figure 9).

The greatest density of YOY and juvenile *O. mykiss* occurred in pool body/tail and riffle habitats (Figure 6b). The occurrence of juveniles in pool body/tail habitat is somewhat of an anomaly since only one of the five pool body/tail units sampled represented 97% of total observations, and only one other pool body/tail habitat had juveniles present. Juveniles are likely not found in this habitat type at downstream locations for a number of reasons, including predation, territorial exclusion by the larger size classes of *O. mykiss*, lower habitat use preference for rearing (based on depth, velocity, cover, and food supply), as well as increasing thermal conditions. A better indication of juvenile distribution in relation to water temperature is the observations of juveniles in riffle habitats. Juveniles were found in seven out of eight riffle habitats sampled, indicating a strong preference for this habitat type. Juveniles were only excluded at the lower most riffle unit sampled (RM 41.9), however the densities of juveniles decreases further downstream of the dam (Figure 8). When compared with the distribution of adult *O. mykiss*, this may indicate that adults are better able to move upstream toward cooler habitats than YOY and juvenile *O. mykiss*.

4.4 Habitat Associations of *O. mykiss* and Chinook salmon Observations

4.4.1 March 2009

Table 4-1 and Table 4-2 show the range of cover and substrate components observed during habitat mapping for each habitat type where *O. mykiss* and Chinook salmon were present during the March 2009 surveys. Variations in cover types and amounts were limited in all NSOs, with higher percentages of the “No Cover” class found throughout the reach (Appendix D-2). For this reason, the cover results do not provide a meaningful basis for establishing a relationship with habitat use by juveniles or adults of either species. Chinook salmon juveniles were the most observed salmonid during the surveys and were observed primarily in riffle and transitional pool head and run head habitats where higher percentages of cobble were reported (Table 4-1).

Table 4-1. Cover and substrate type found in snorkeled habitat units with *O. mykiss* present during the March 2009 snorkel surveys.

	Pool body	Pool head	Pool tail	Riffle	Run body	Run head	Run tail
Cover type range (%)							
Boulder		0–10		5–10			
Wood		0–0		0–5			
Ledge		0–0		0–10			
Overhang		0–5		5–10			
Aquatic vegetation		0–0		0–0			
No cover		85–85		80–95			
Substrate type range (% covering channel bed)							
Bedrock		0–20		0–0			
Boulder		0–20		10–30			
Cobble		10–60		60–70			
Gravel		0–40		10–30			
Sand		0–10		0–10			
Silt		0–0		0–0			
Organic		0–0		0–0			

Table 4-2. Cover and substrate type found in snorkeled habitat units with Chinook salmon present during the March 2009 snorkel surveys.

	Pool body	Pool head	Pool tail	Riffle	Run body	Run head	Run tail
Cover type range (%)							
Boulder	0–0	0–10	0–10	5–10	0–0	0–10	0–0
Wood	0–5	0–5	0–0	0–5	0–5	0–0	0–0
Ledge	0–0	0–0	0–0	0–10	0–0	0–0	0–0
Overhang	0–5	0–5	0–5	5–10	5–10	0–5	5–10
Aquatic vegetation	0–30	0–30	0–5	0–5	0–50	0–0	0–20
No cover	70–90	65–100	85–100	80–100	35–100	90–100	80–100
Substrate type range (% covering channel bed)							
Bedrock	10–20	20–50	10–40	0–0	0–10	0–0	0–0
Boulder	0–0	10–20	20–30	10–30	10–20	0–10	10–20
Cobble	20–60	20–50	30–60	50–70	20–60	40–70	20–60
Gravel	20–30	10–70	10–50	10–40	10–40	20–50	20–60
Sand	20–30	10–20	10–20	0–10	10–40	0–10	20–50
Silt	0–10	0–0	0–0	0–0	0–0	0–0	0–0
Organic	0–0	0–0	0–0	0–0	0–0	0–0	0–0

4.4.2 July 2009

Table 4-3 and Table 4-4 show the range of cover and substrate components observed during habitat mapping for each habitat type where *O. mykiss* and Chinook salmon were present during the July 2009 surveys. As in March 2009, variations of cover types and amounts were limited in all NSOs, with higher percentages of no cover found throughout the reach (Appendix D-2). Therefore cover results do not provide a meaningful basis for establishing a relationship with habitat use by juveniles or adults of either species. The *O. mykiss* and Chinook salmon were observed primarily in riffle and transitional pool head and run head habitats where higher percentages of cobble were reported (Table 4-3).

Table 4-3. Cover and substrate type found in snorkeled habitat units with *O. mykiss* present during the July 2009 snorkel surveys.

	Pool body/tail	Pool head	Riffle	Run body/tail	Run head
Cover type range (%)					
Boulder	0–10	5–10	5–10	0–0	5–10
Wood	0–0	0–5	0–0	0–0	0–0
Ledge	0–0	0–0	0–10	0–0	0–0
Overhang	0–5	0–5	5–10	0–5	0–10
Aquatic vegetation	10–20	10–20	0–5	0–0	0–10
No cover	80–90	65–100	80–95	95–95	85–100
Substrate type range (% covering channel bed)					
Bedrock	20–50	10–50	0–10	0–0	0–0
Boulder	20–40	10–50	10–20	10–20	10–20
Cobble	10–40	30–60	40–70	60–60	50–70
Gravel	0–10	5–30	20–50	20–30	20–40
Sand	5–10	5–10	0–10	0–0	0–10
Silt	0–0	0–0	0–0	0–0	0–0
Organic	0–0	0–0	0–0	0–0	0–0

Table 4-4. Cover and substrate type found in snorkeled habitat units with Chinook salmon present during the July 2009 snorkel surveys.

	Pool body/tail	Pool head	Riffle	Run body/tail	Run head
Cover type range (%)					
Boulder	10–10	10–10	5–10	0–0	5–10
Wood	5–5	5–5	0–0	0–0	0–0
Ledge	0–0	0–0	10–10	0–0	0–0
Overhang	5–5	5–10	5–10	5–10	5–10
Aquatic vegetation	10–10	30–30	5–5	0–0	10–10
No cover	85–90	65–100	80–95	90–95	85–100

	Pool body/tail	Pool head	Riffle	Run body/tail	Run head
Substrate type range (% covering channel bed)					
Bedrock	20–50	20–50	10–10	0–0	15–15
Boulder	20–20	10–20	10–20	10–20	10–20
Cobble	25–60	30–60	40–70	60–60	45–70
Gravel	10–20	5–30	20–50	20–30	20–40
Sand	2–20	5–10	10–10	10–10	10–10
Silt	0–0	0–0	0–0	0–0	0–0
Organic	0–0	0–0	0–0	0–0	0–0

4.5 Habitat Use at Restored and Reference Sites by *O. mykiss* and Chinook salmon

Hypothesis #2 states that the density of *O. mykiss* juveniles and adults is the same in restored sites as in nearby reference sites in the Tuolumne River. This hypothesis was originally formulated with the intention of testing habitat use at planned gravel augmentation sites. However, other than the CDFG gravel addition projects near Old La Grange Bridge, completed from 2001–2003, and the joint Tuolumne River Technical Advisory Committee/Friends of the Tuolumne (FOT) gravel augmentation at Bobcat Flat (RM 43) in 2005, no further gravel augmentation projects have been implemented since that time. This has limited the potential sampling replications and statistical power to detect any differences between restored and reference sites.

As a means to evaluate habitat use of these restoration sites, observed densities of *O. mykiss* juveniles and adults were compared at the three habitat types that were sampled within the restoration sites to the same habitat types surveyed elsewhere in July 2009. The low number of *O. mykiss* observations in March 2009 do not allow for meaningful comparisons. Figure 10 shows the *O. mykiss* density of juveniles and adults at pool head, riffle, and run head habitats types sampled in July 2009 from sampling units found at both the restoration sites and from all similar sample units within the study reaches upstream of RM 40.0. For juvenile *O. mykiss* the densities show a relatively high use of riffle habitat at restoration sites when compared with other riffle sampling units; a relatively lower use of run head habitat at the upstream restoration sites; and an overall low density in pool head habitats throughout the reach (Figure 10). For adult *O. mykiss* the density at riffle habitats is potentially reduced at restoration sites, with similar densities at run head habitats, and insufficient data for comparison at pool head habitats.

A similar evaluation was done using juvenile Chinook salmon. Figures 11 and 12 show juvenile Chinook densities as sampled in March 2009 and July 2009, respectively for the same three habitat types. In March 2009, juvenile Chinook densities at the restoration sites were greater in each of the habitat types when compared to the reference sampling units (Figure 11). In July 2009, juvenile Chinook densities either exceeded or were similar to the reference units (Figure 12). Considering the similar habitat preferences for juvenile *O. mykiss* and juvenile Chinook salmon, it appears that salmonid use of restoration sites is similar, or possibly enhanced within riffle habitats, when compared with nearby reference sites. Additional replication through either an increased number of gravel augmentation sites, or an increased number of survey events would be needed to improve the statistical power enough to detect whether significant differences in habitat use exist.

4.6 Comparison to June 2009 TID/MID Snorkel Surveys

Results from the July 2009 snorkel data were compared to observations made during the June 2009 TID/MID snorkel survey data (Ford and Kirihara 2009) for the sampled reach common to both surveys and within habitat units surveyed during both sampling events (Table 4-5 and Table **4-6**). July 2009 data are observations from the first pass of the multiple pass bounded count estimation method to allow a direct comparison to June 2009 data (Ford and Kirihara 2009), which came from single pass snorkel surveys that employ catch-per-unit-effort (CPUE) methodology. Note that TID/MID snorkel surveys are not conducted in March, precluding comparison with the March 2009 surveys.

Table 4-5. Salmonid observations in June (single pass) and July (first pass) 2009 in the reach sampled during both studies.

June 2009 snorkel survey					July 2009 snorkel survey				
Location	RM	<150 mm *O. mykiss* count	>150 mm *O. mykiss* count	<150 mm *O. tshawytscha* count	Habitat Unit (NSO)	RM	<150 mm *O. mykiss* count	>150 mm *O. mykiss* count	<150 mm *O. tshawytscha* count
Riffle A7 - R23C	50.7–42.3	112	30	1,897	1–136	51.8–41.7	600	101	4,423

Table 4-6. Salmonid counts and estimated densities in June (single pass) and July (first pass) 2009 for units snorkeled during both dates.

Location	RM	June 2009 snorkel survey									July 2009 snorkel surveys								
		Site	Habitat type	Area (ft^2)	<150 mm *O. mykiss*		>150 mm *O. mykiss*		<150 mm *O. tshawytscha*		Habitat unit (NSO)	Habitat type	Area (ft^2)	<150 mm *O. mykiss*		>150 mm *O. mykiss*		<150 mm *O. tshawytscha*	
					#	#/ft^2	#	#/ft^2	#	#/ft^2				#	#/ft^2	#	#/ft^2	#	#/ft^2
Riffle A7	50.6	1	Riffle	3,750	50	0.0133	0	0	700	0.186	14	Riffle	46,670	46	0.0010	4	0.0001	2,100	0.045
		2	Run	4,000	30	0.0075	0	0	700	0.175	15	Run Head	13,760	2	0.0001	0	0	85	0.006
Riffle 3B	49.1	1	Riffle	4,400	6	0.0014	6	0.0014	82	0.019	33	Riffle	69,509	28	0.0004	21	0.0003	105	0.002
		2	Run-Riffle	10,000	13	0.0013	2	0.0002	250	0.025	34–36	Run Head, Body/Tail	33,758	26	0.0008	5	0.0002	425	0.013
Riffle 7	46.9	2	Run	7,000	0	0	0	0	0	0	59/60	Run Body/Tail	47,827	0	0	0	0	0	0
Riffle 21	42.9	1	Riffle	5,000	0	0	0	0	6	0.001	111	Riffle	10,077	7	0.0007	2	0.0002	1	0.0001
		2	Run-Pool	6,000	0	0	0	0	1	0.0002	112–114	Pool Head, Body/Tail	36,556	1	0.0000	0	0	2	0.0001

4.6.1 *O. mykiss* observations

A total of 112 *O. mykiss* juveniles and 30 adults were observed in June 2009, while 600 juveniles and 101 adults were observed in July 2009, a ratio of adults to juveniles of approximately 1:4 and 1:6, respectively for the two surveys. The between-site comparison shows similar longitudinal trends, with juvenile and adult *O. mykiss* density generally decreasing in the downstream direction (Table 4-6), the same trend observed in the July surveys (Table 4-6 and Figure 6). In the June and July surveys, the greatest abundance of *O. mykiss* occurred within riffles near RM 50.6 (Table 4-6). In June, 50 juveniles were observed at the upstream end of Riffle A7 (Site 1, NSO 14) while 46 were observed at this location in July. In June, 30 juveniles were seen in the run habitat below Riffle A7 (Site 2); however, only 2 juveniles were seen in the run head habitat (NSO 15) at this location in the July surveys. Adult *O. mykiss* abundance was similarly low for both time periods within and near the Riffle A7 site and for sites downstream, with 0 fish observed in June and only 4 fish observed in July. For sites within and near Riffles 3B and 21, the counts of juvenile and adult *O. mykiss* were greater in July 2009 than in June 2009. No juvenile or adult *O. mykiss* were observed within the vicinity of Riffle 7 for either the June or July 2009 surveys.

It should be noted that the June 2009 data were collected from sites established in past years and targeted based on prior years' data as likely areas of relatively high *O. mykiss* abundance. The area surveyed during the July surveys was greater (by an order of magnitude in most cases) than in June (Table 4-6). The June survey method, which reoccupies the same habitat units and areas on an annual basis, produces a yearly index with which to evaluate yearly trends, assuming reoccupied habitat units and areas are representative of the entire reach. The method of bounded counts estimation used in July 2009 produces a population estimate, with appropriate confidence intervals, that, due to the incorporation of multiple passes in each unit and greater area searched in each unit and along the reach, can be used to evaluate habitat- and reach-wide distribution patterns.

4.6.2 Chinook salmon observations

A total of 1,897 Chinook salmon juveniles were observed June, while 4,423 juveniles observed in July (Table 4-5). Three times as many Chinook salmon juveniles were observed at riffle habitat (Site 1, NSO 14) of Riffle A7 in July than in June; however, a greater number of juveniles were observed at the run habitat (Site 2) in June than in the run head habitat (NSO 15) in July (Table **4-6**). Greater numbers of Chinook salmon juveniles were observed within Sites 1 and 2 of Riffle 3B (NSO 33–35) for July than June. Relatively few juveniles were observed within the vicinity of Riffles 7 and 21 during both the June and July 2009 sampling periods (Table 4-6). Although a stream-type life history strategy is not believed to be common for Chinook salmon in the Tuolumne River, the presence of juveniles in mid-summer indicates that conditions (e.g., water temperature, food availability) in summer 2009 were suitable for survival in upper portions of the reach.

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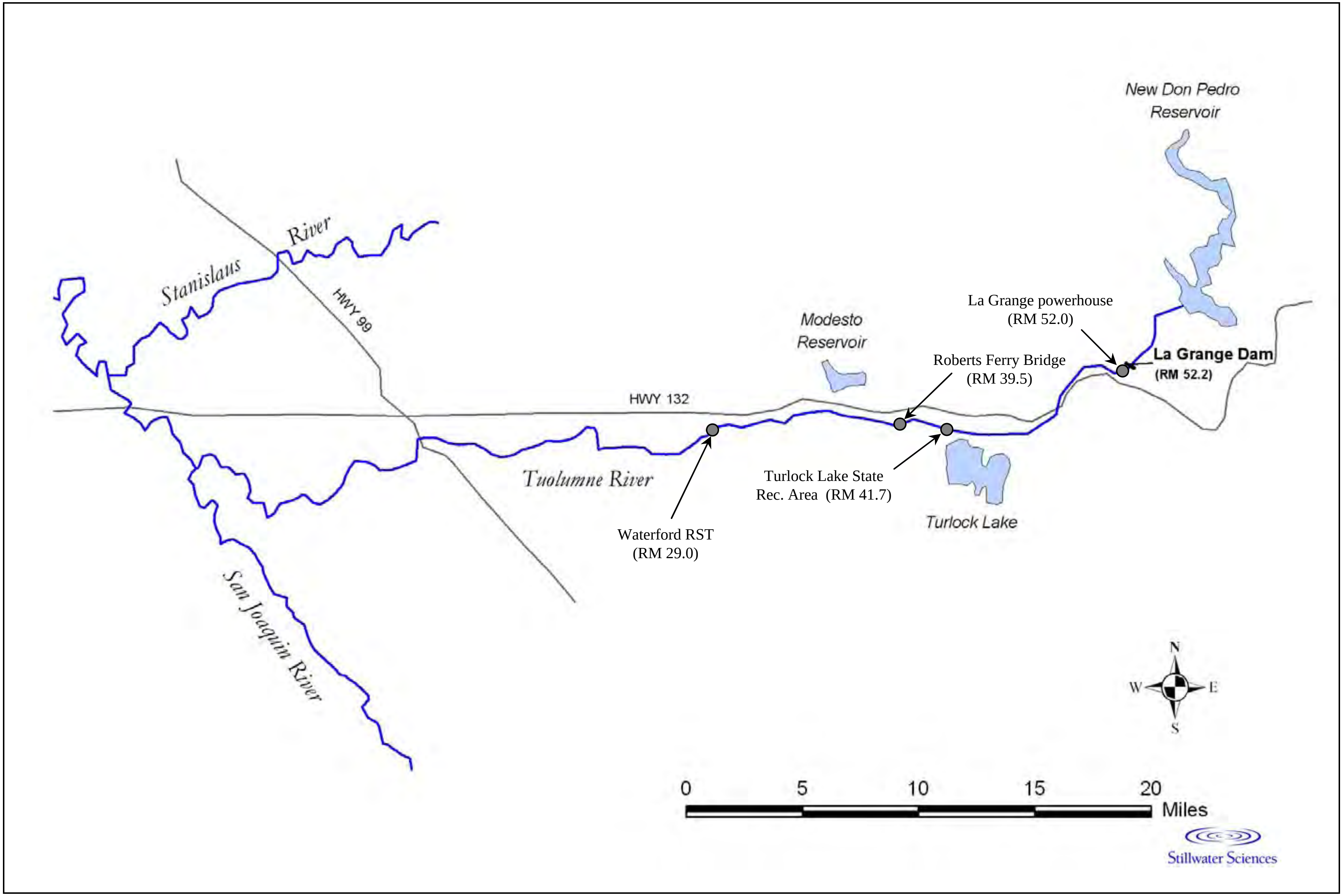

Figure 1. Survey reach for March and July 2009 *O. mykiss* snorkel surveys in the lower Tuolumne River.

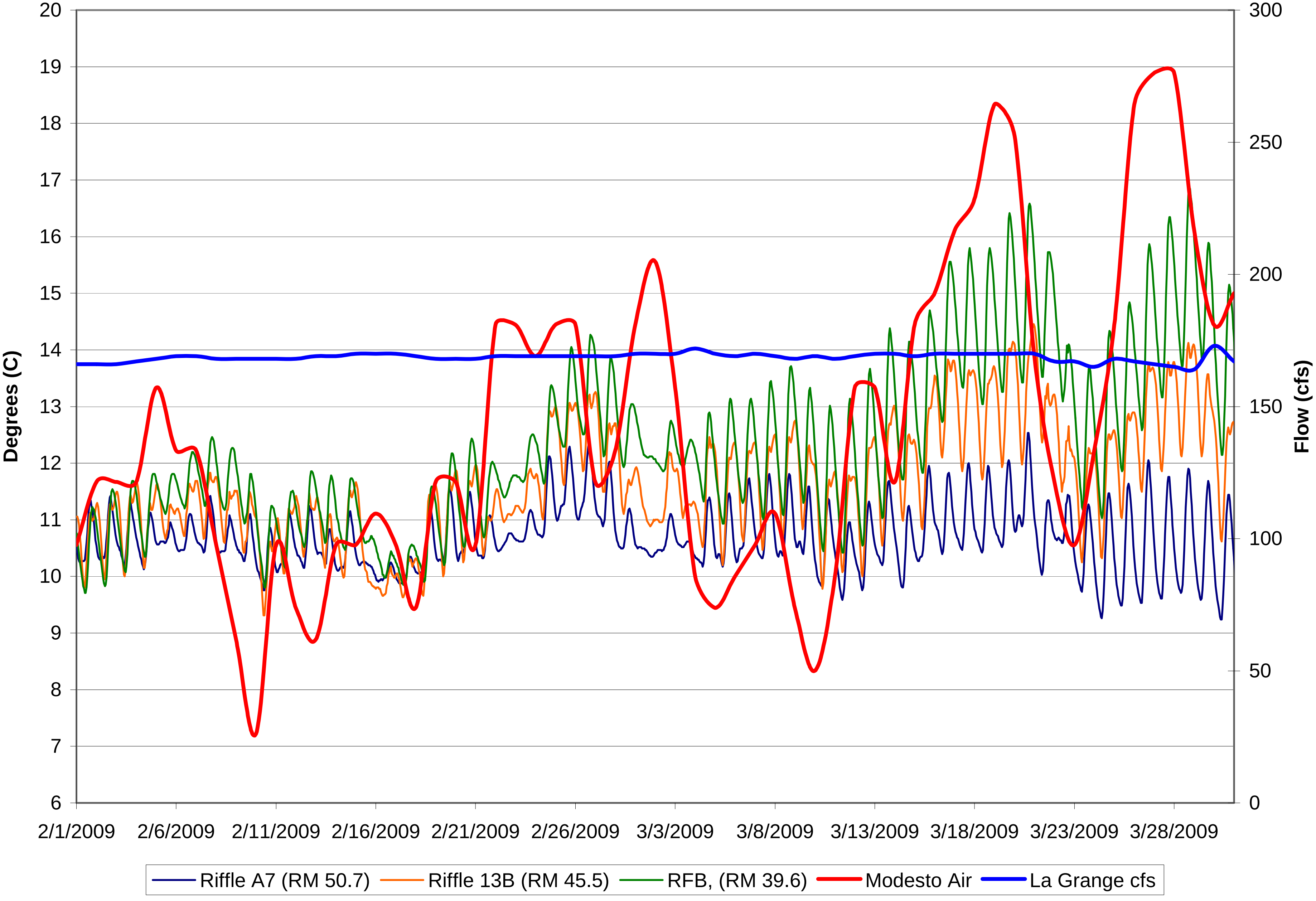

Figure 2a. Hourly water temperature, daily average air temperature, and daily average flow for the study reach from 1 February to 31 March 2009.

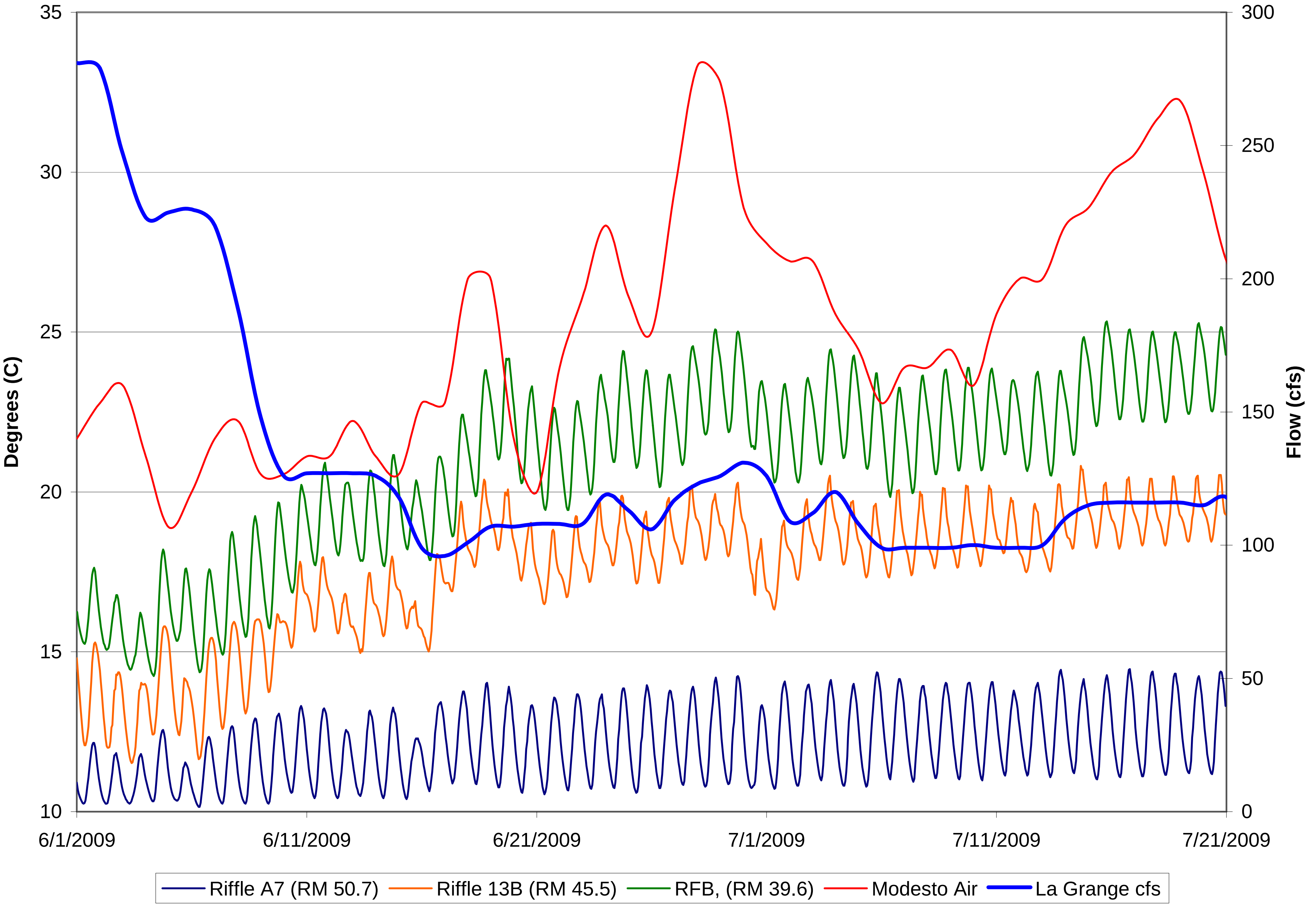

Figure 2b. Hourly water temperature, daily average air temperature, and daily average flow for the study reach from 1 June to 21 July 2009.

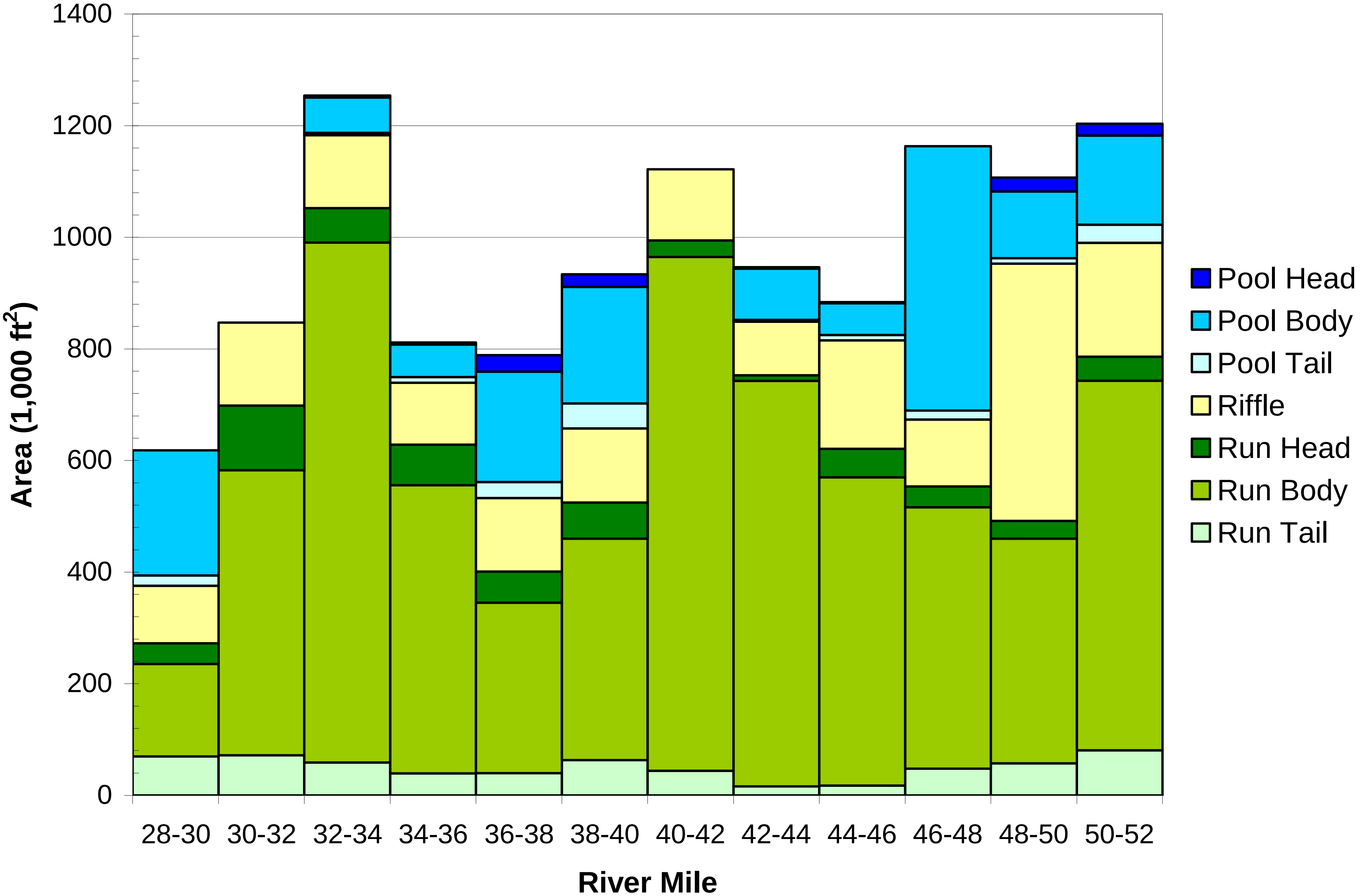

Figure 3. Longitudinal distribution of major habitat type areas by river mile in the lower Tuolumne River (RM 52–30) for March and July 2009 surveys.

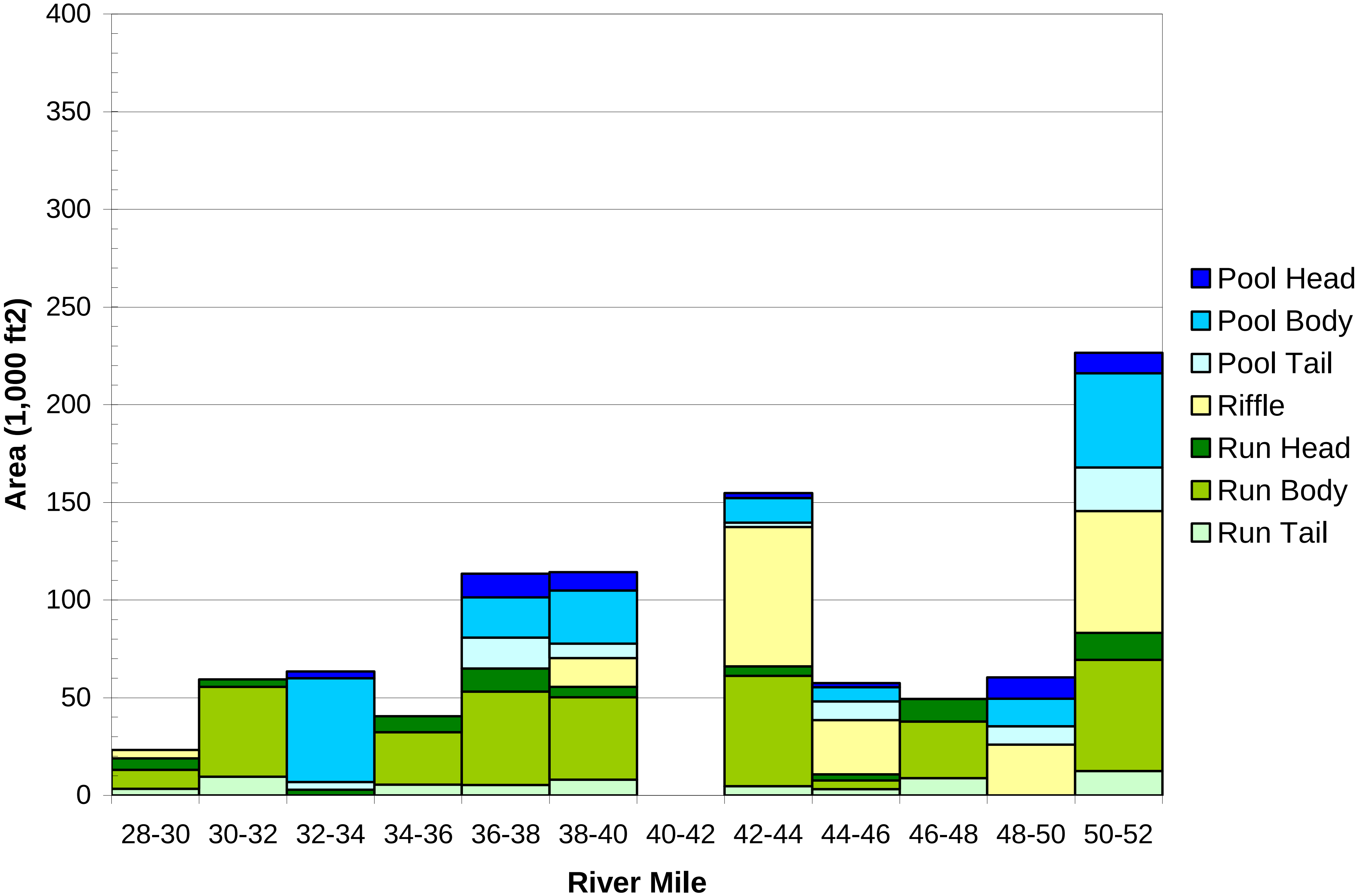

Figure 4a. Longitudinal distribution of major habitat type areas sampled by river mile in the lower Tuolumne River (RM 52–30) for March 2009 survey**.**

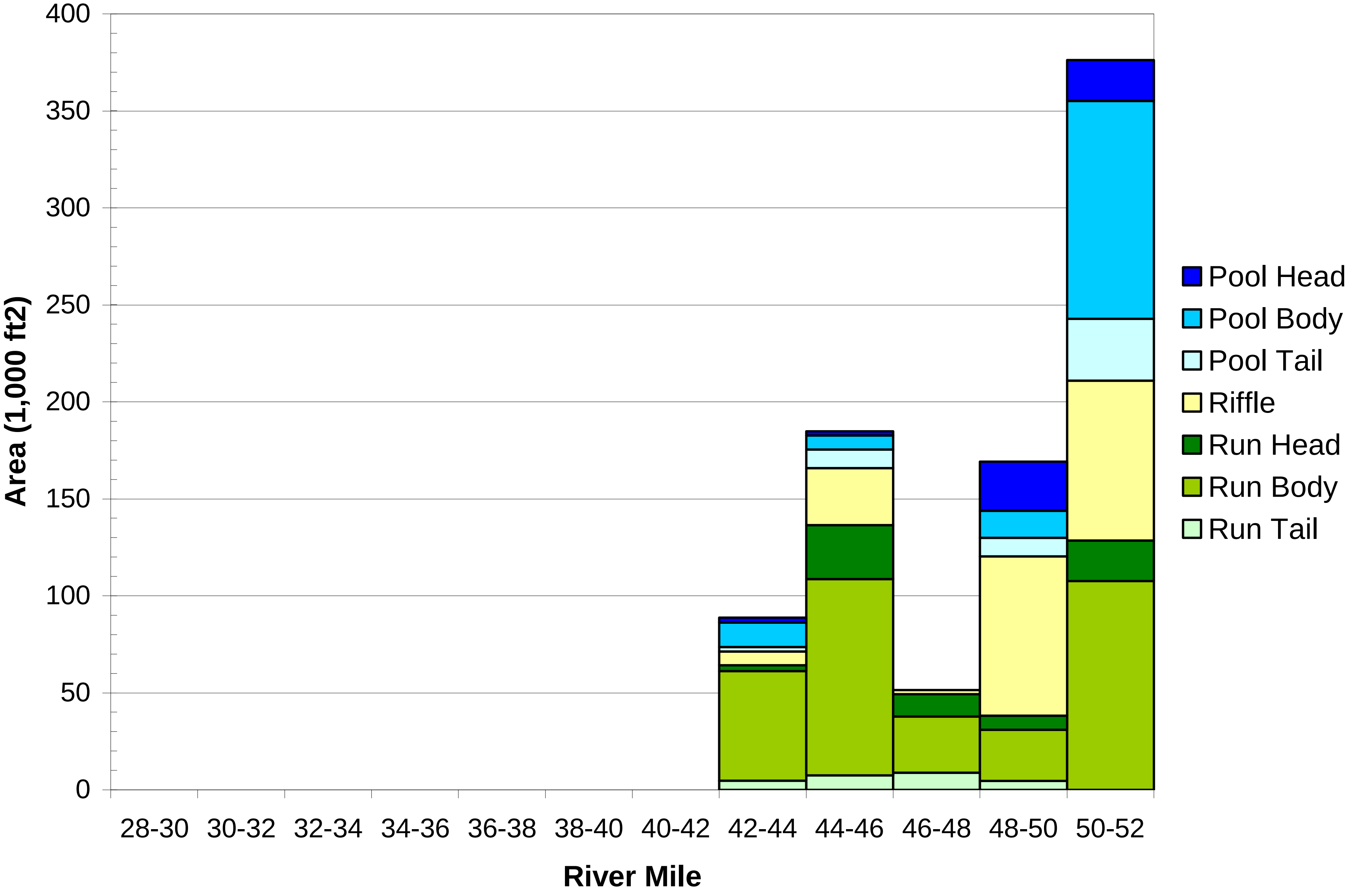

Figure 4b. Longitudinal distribution of major habitat type areas sampled by river mile in the lower Tuolumne River (RM 52–30) for July 2009 survey.

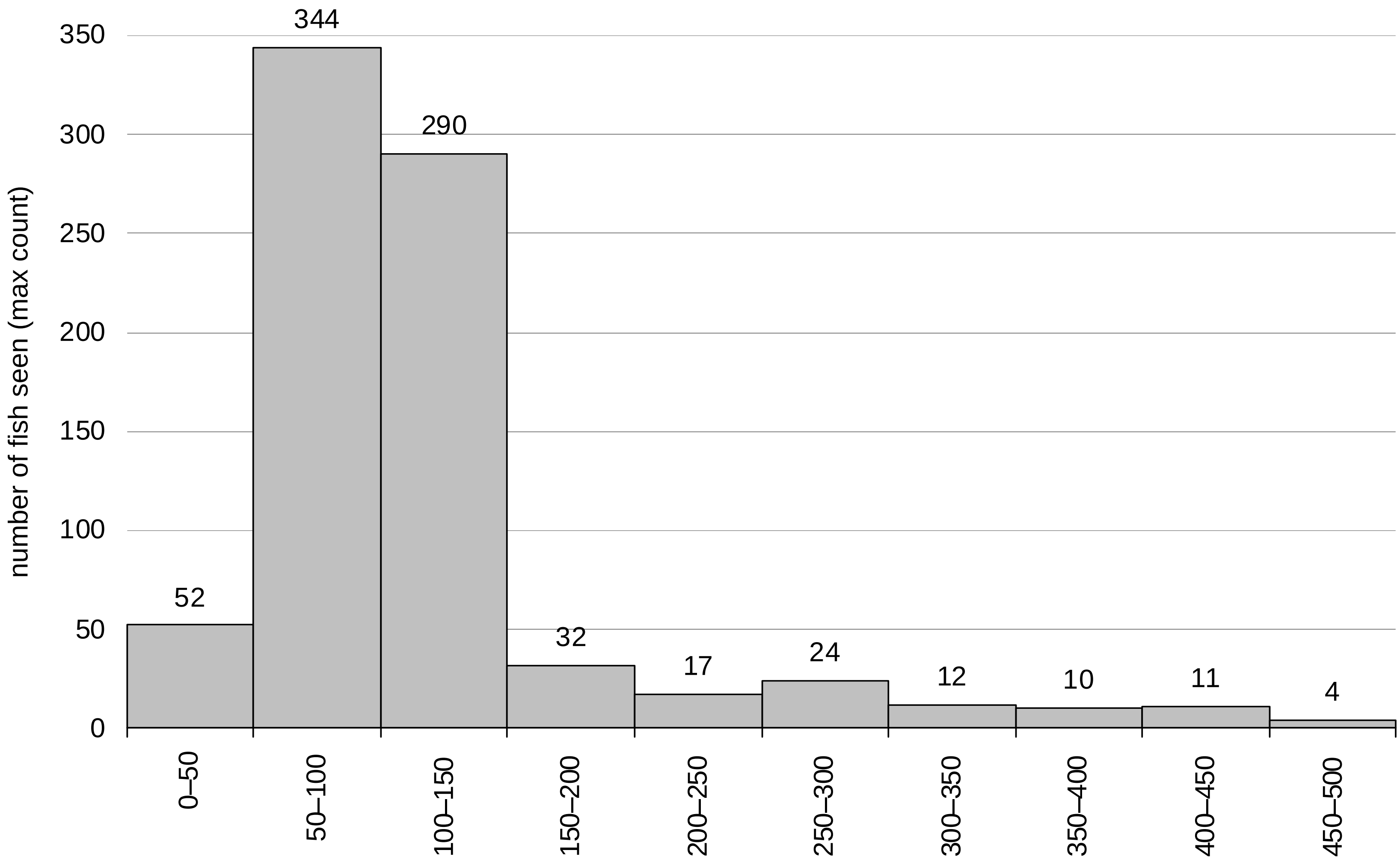

Figure 5. Size distribution of *O. mykiss* observed in Tuolumne River snorkel surveys, July 2009. For units receiving multiple passes, the count is from the pass with the largest count for that size class.

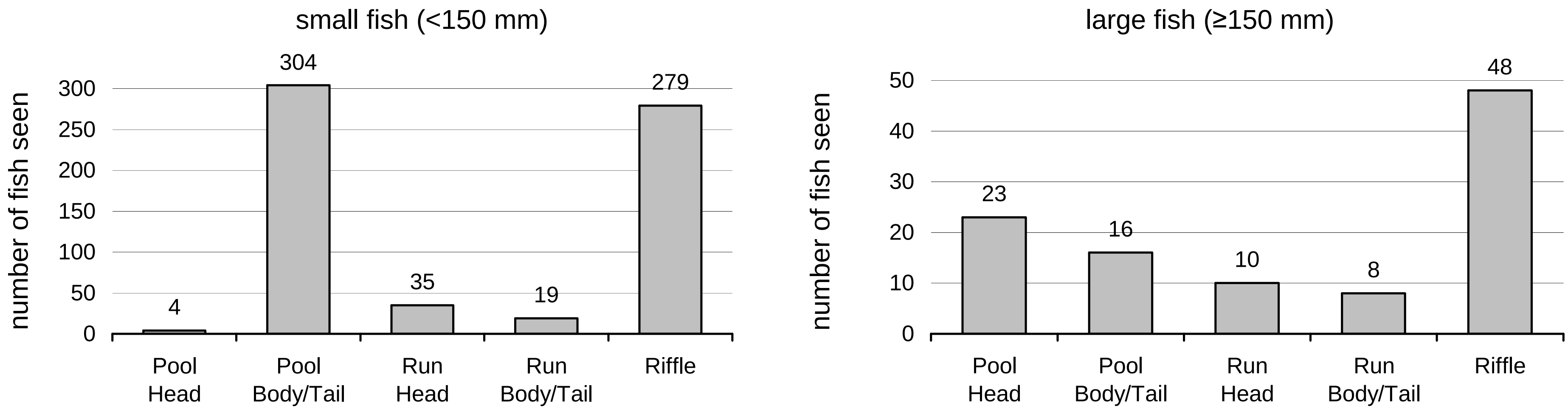

Figure 6a. Distribution of observed *O. mykiss* counts among habitat types, by size class. For units receiving multiple passes, the count is from the pass with the largest count.

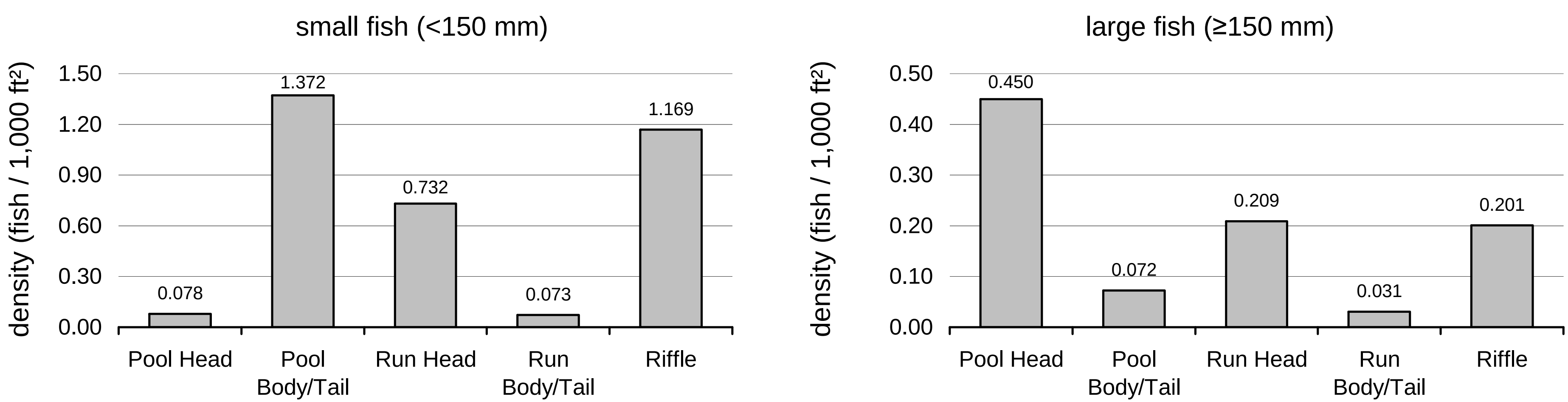

Figure 6b. Distribution of observed *O. mykiss* density based on maximum count among habitat types, by size class.

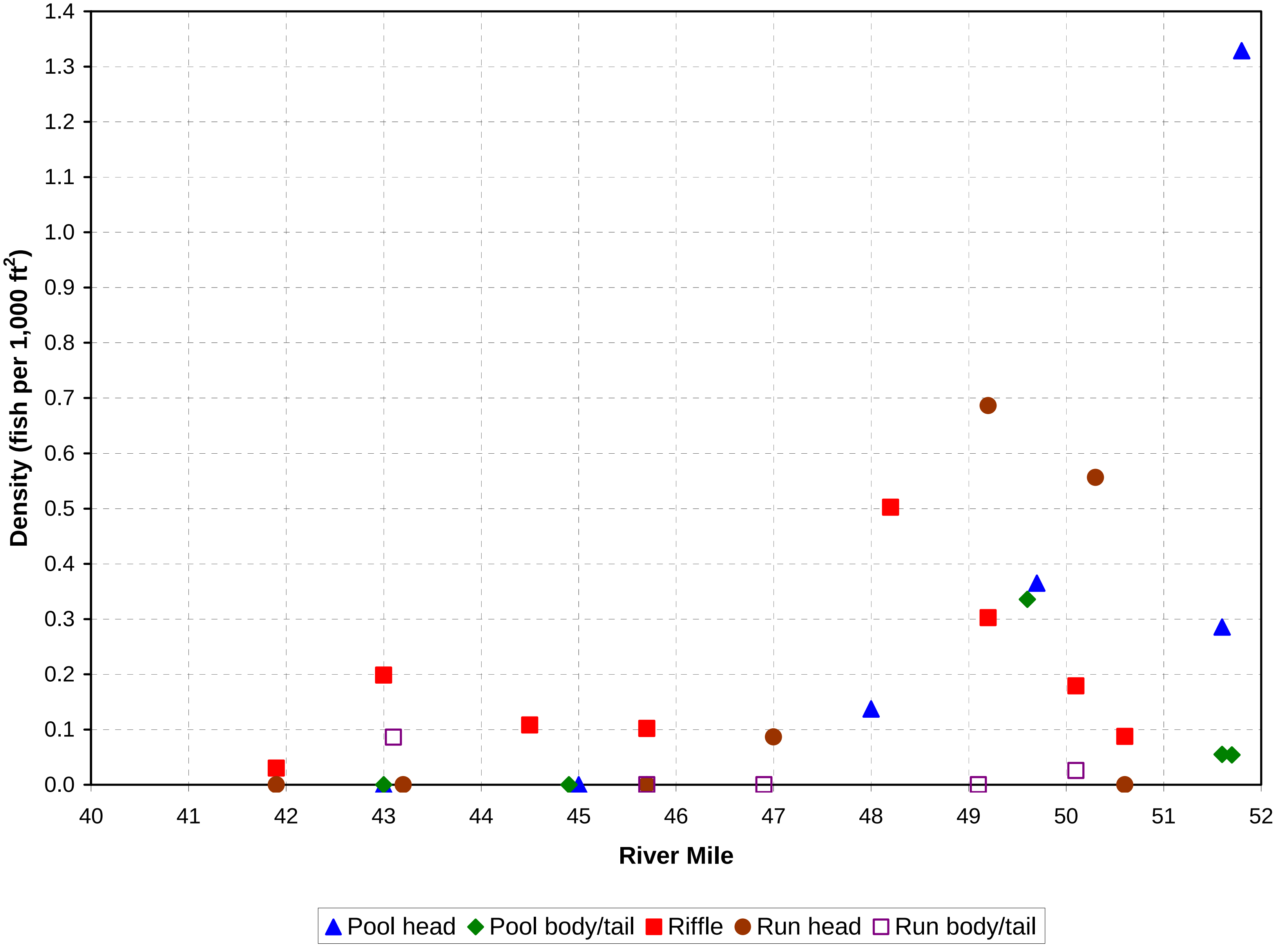

Figure 7. July 2009 adult *O. mykiss* density by river mile based upon maximum count in sampling units of each habitat type.

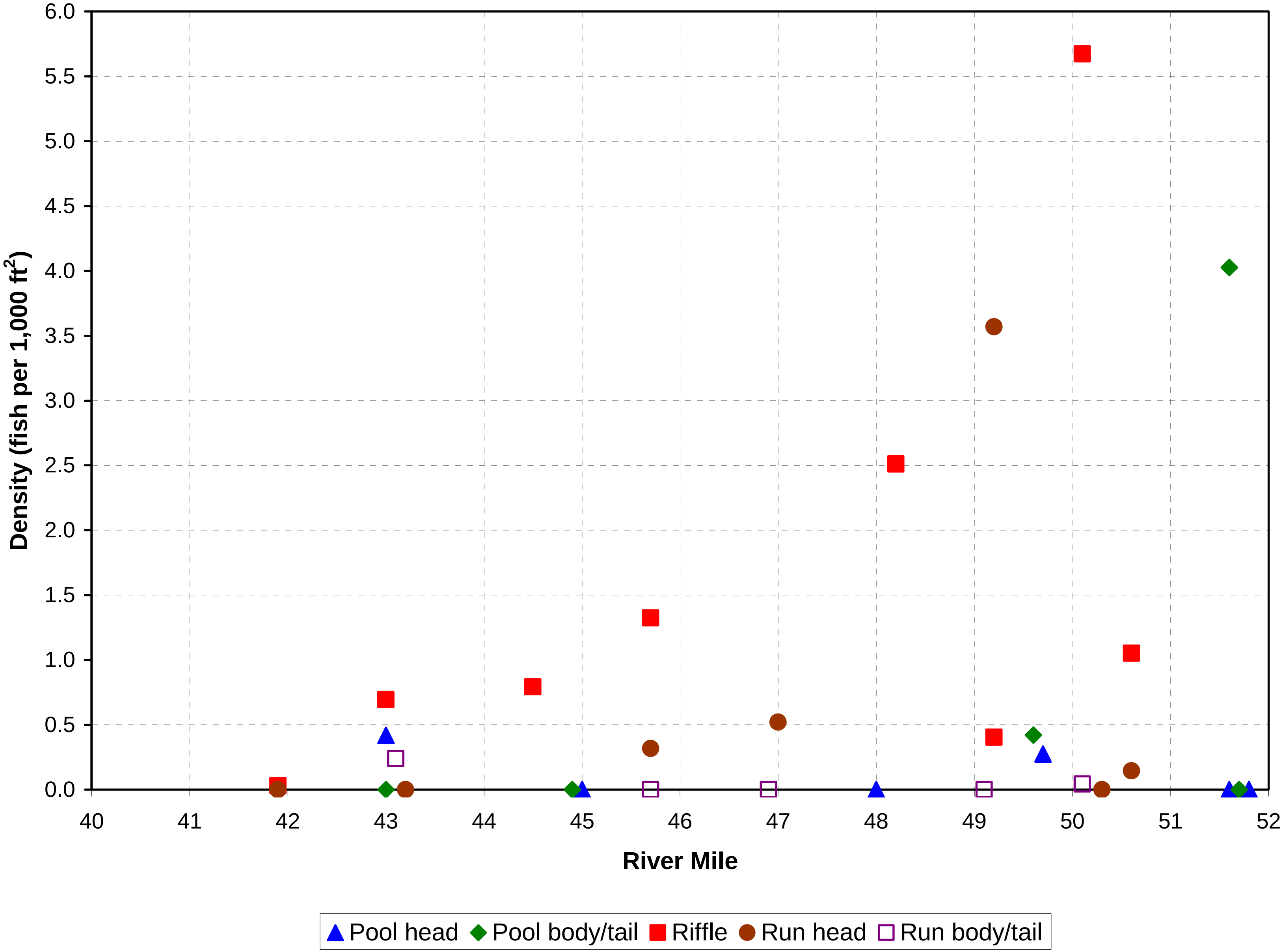

Figure 8. July 2009 juvenile *O. mykiss* density by river mile based upon maximum count in sampling units of each habitat type.

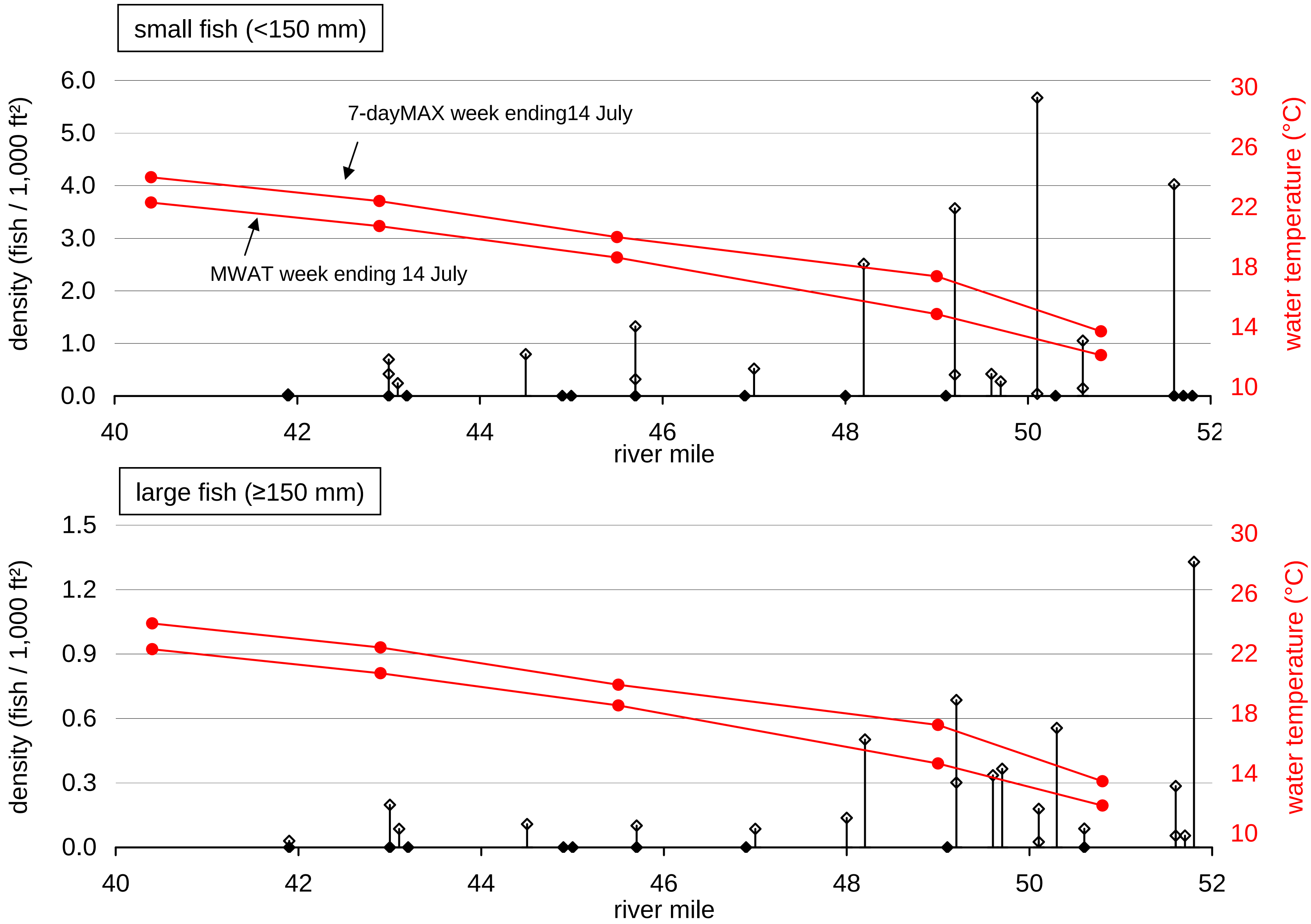

Figure 9. Longitudinal distribution of observed *O. mykiss* and water temperature in the lower Tuolumne River, July 2009. Solid diamonds are observed zeros, open diamonds are observed non-zero values.

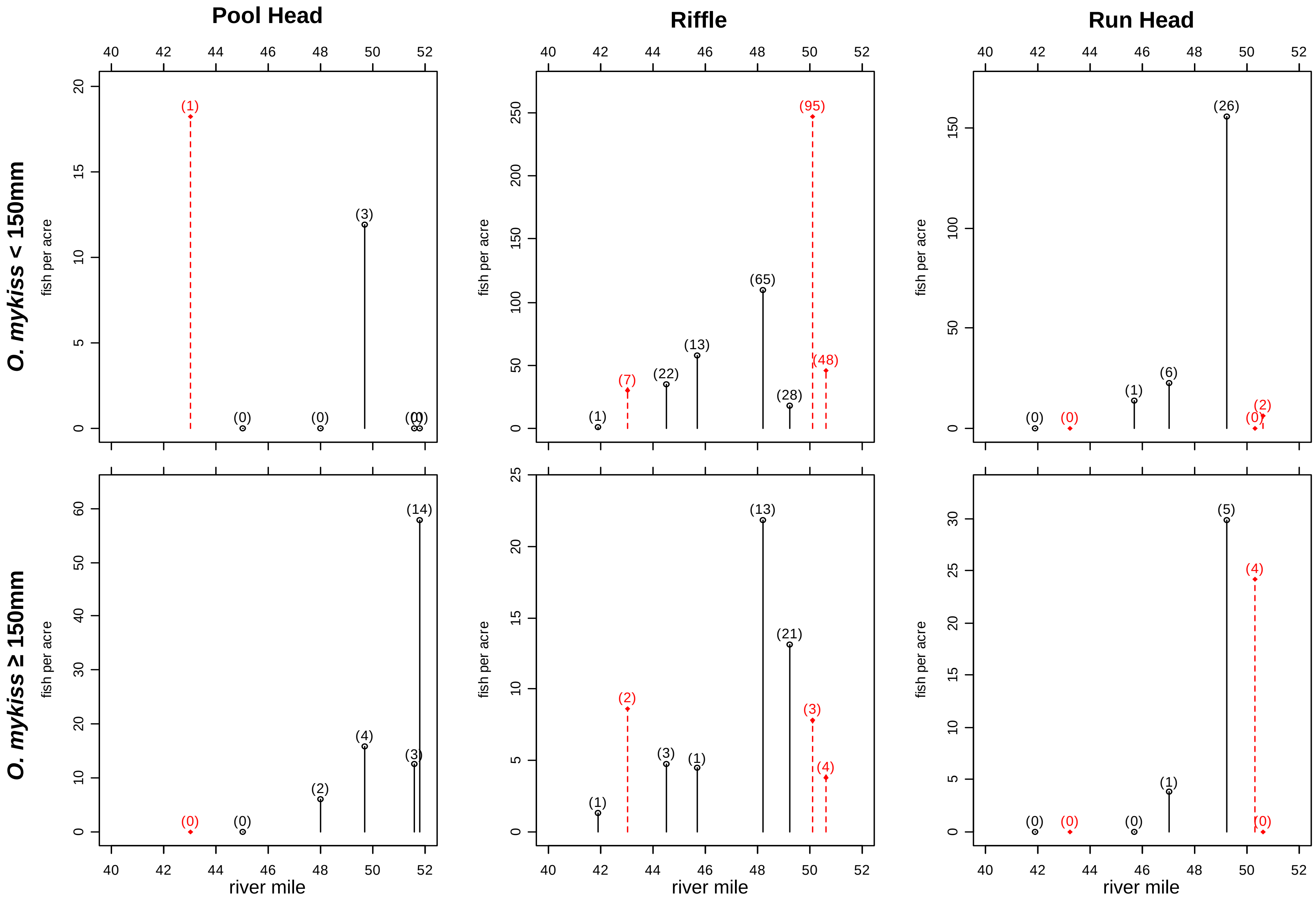

Figure 10. Observed densities of *O. mykiss* in individual sampling units in the July 2009 surveys. Densities are maximum dive counts (in parenthesis) divided by the area sampled. Restoration sites are shown with broken lines (FOT [RM 43.0], CDFG 2001 [RM 50.3], CDFG 2003 [RM 50.6]). Non-restoration sites are shown with solid lines.

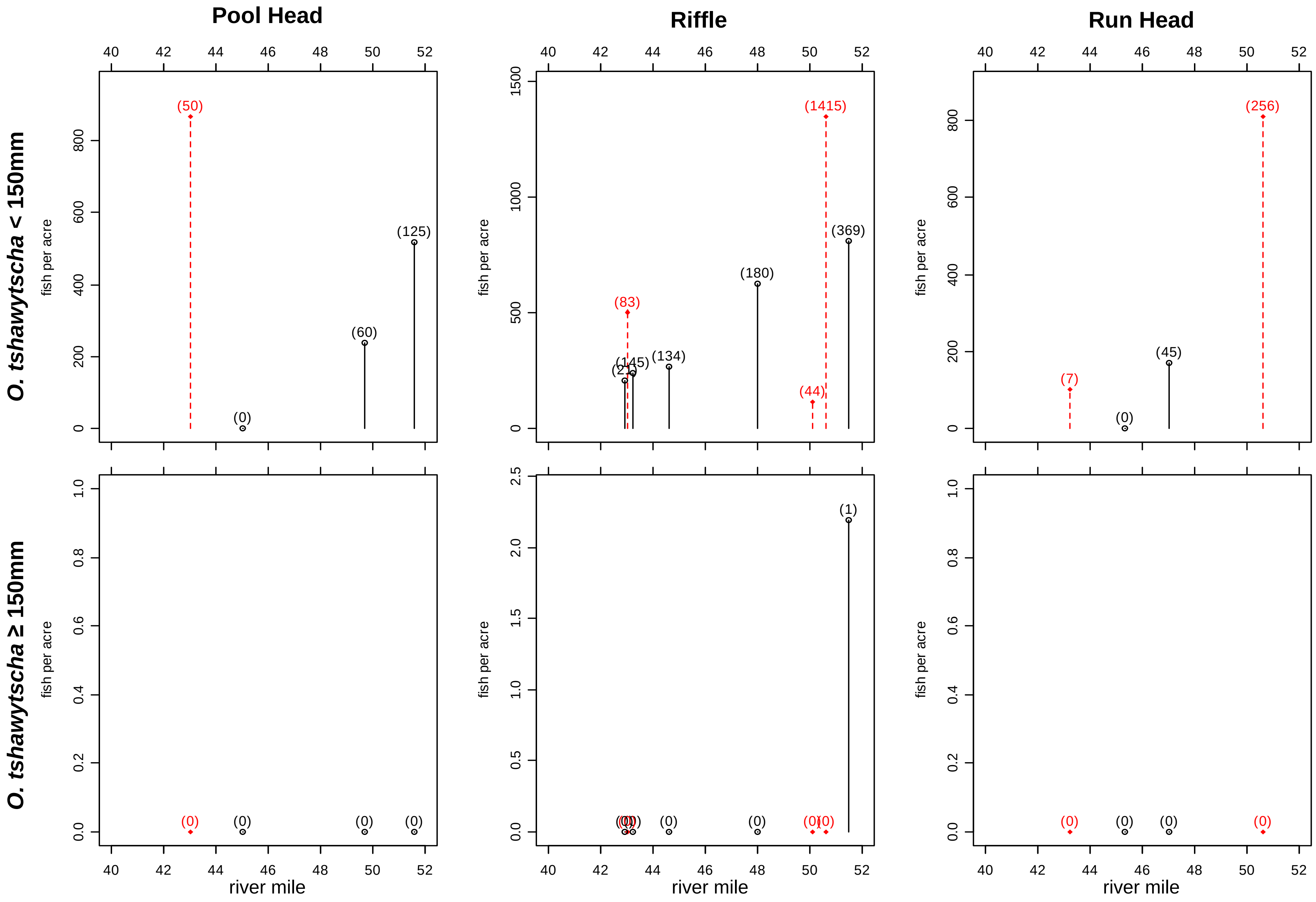

Figure 11. Observed densities of *O. tshawytscha* in individual sampling units in the March 2009 surveys. Densities are maximum dive counts (in parenthesis) divided by the area sampled. Restoration sites are shown with broken lines (FOT [RM 43.0], CDFG 2001 [RM 50.3], CDFG 2003 [RM 50.6]). Non-restoration sites are shown with solid lines.

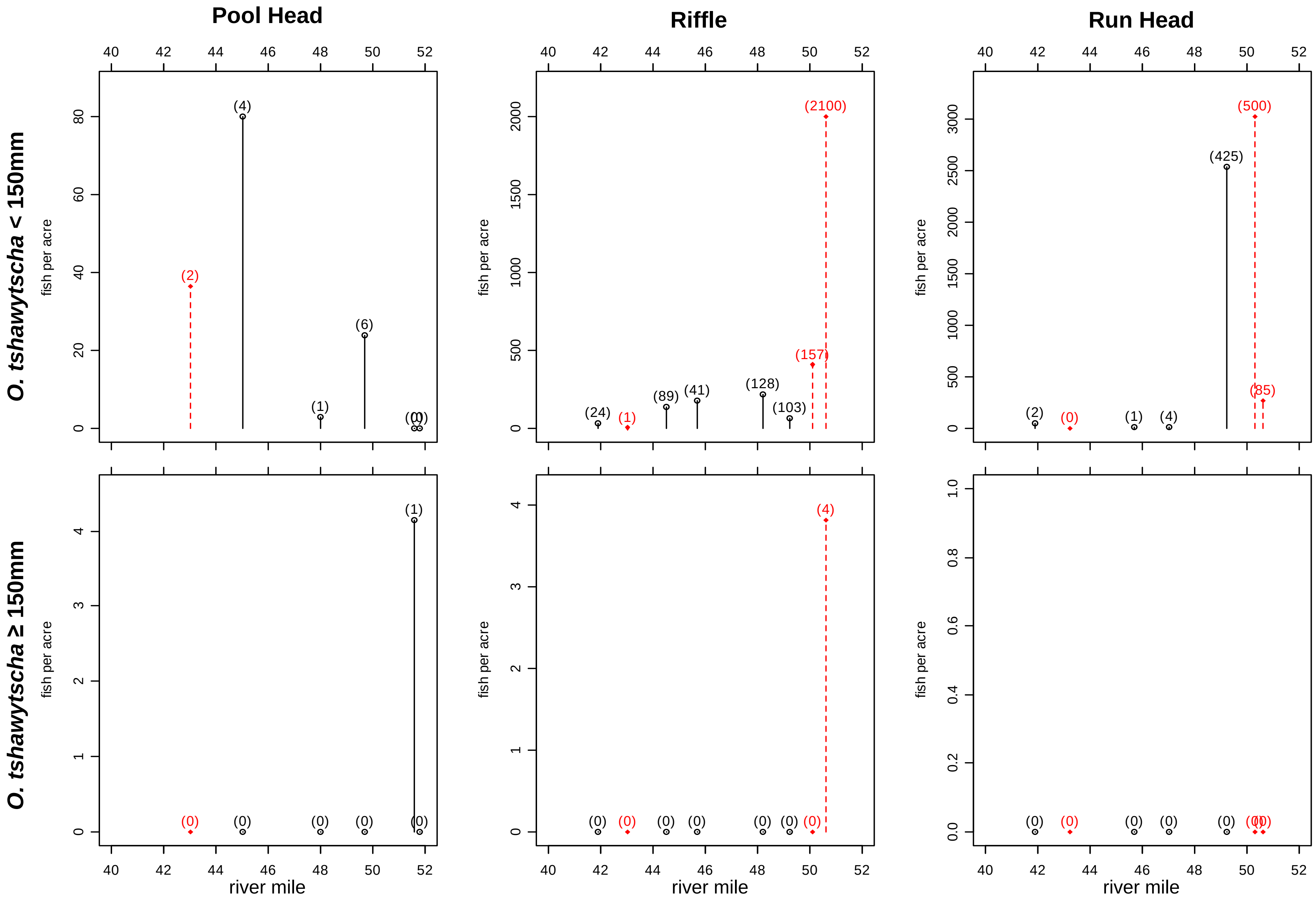

Figure 12. Observed densities of *O. tshawytscha* in individual sampling units in the July 2008 surveys. Densities are maximum dive counts (in parenthesis) divided by the area sampled. Restoration sites are shown with broken lines (FOT [RM 43.0], CDFG 2001 [RM 50.3], CDFG 2003 [RM 50.6]). Non-restoration sites are shown with solid lines.

Appendices

Appendix A: Study Plan for 2009 surveys

Study Plan for Population Size Estimates of *O. mykiss* in the lower Tuolumne River

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Appendices

Appendix A Lower Tuolumne River Habitat Mapping and Habitat Types from RM 52-40
Appendix B Preliminary Habitat Mapping and Habitat Types in the lower Tuolumne River from RM 40-30

1 BACKGROUND AND PURPOSE

Fisheries monitoring for the Don Pedro Project (FERC Project No. 2299) by the Turlock Irrigation District (TID) and Modesto Irrigation District (MID) has long documented the presence of *Oncorhynchus mykiss (O. mykiss)* in the lower Tuolumne River (TID/MID 2005). On March 19, 1998 the National Marine Fisheries Service (NMFS) first listed the Central Valley steelhead as threatened under the Endangered Species Act (ESA). After several court challenges, NMFS issued a new final rule relisting the Central Valley steelhead on January 5, 2006 (71 FR 834). In a separate process regarding terms of the 1996 FERC license amendments for the Project, NMFS staff provided input to a draft limiting factors analysis for Tuolumne River salmonids (Mesick et al 2007) and included recommendations for developing abundance estimates, habitat use surveys and anadromy determination of resident *O. mykiss*. These recommendations were conceptually used to develop the Districts FERC Study Plan (TID/MID 2007) which was the subject of an April 3, 2008 FERC Order. As part of the Order, the Districts are required to conduct population estimate surveys in summer (June/July) and winter (February/March), starting in summer 2008 to determine *O. mykiss* population abundance by habitat type.

The purpose of the proposed *O. mykiss* population surveys is to provide population size estimates over several sampling seasons of differing environmental conditions to determine habitat use and needs within the lower Tuolumne River. The surveys will be used to examine the following hypotheses:

> <u>Hypothesis 1</u>: Summertime distribution of suitable habitat by observed life stages of *O. mykiss* is related to ambient river water temperature.
>
> <u>Hypothesis 2</u>: Habitat use by *O. mykiss* juveniles and adults observed in the Tuolumne River occurs at the same density in both restored and nearby reference sites.

As recommended by Stillwater Sciences (Stillwater), the surveys will employ a two-phase sampling approach of potential *O. mykiss* habitat using snorkel surveys for the development of a "bounded count" population estimate (Hankin and Mohr 2001). Although the methodology presented below discusses both repeated dive counts and calibration by depletion electrofishing, current ESA permit restrictions for both NMFS Section 10(a)(1)(A) permit No's 1280 (TID) and 1282 (Stillwater) do not allow sufficient incidental take to conduct the second phase surveys at this time using electrofishing. Discussions with NMFS permitting staff and Stillwater have occurred since submittal of the 2007 FERC Study Plan, resulting in a pending formal request to NMFS by Stillwater for modification of Permit 1282 (see Section 6 below). The Section 10 Permit 1280 issued to TID in 2005 authorized only up to 5 juvenile *O. mykiss* annually by electrofishing that was further restricted to River Mile 25–30 during September to November. Thus that permit is not applicable or adequate to the season, location, and fish numbers needed to conduct the electrofishing for this population estimate study. Consequently, the July 2008 survey was conducted using snorkel surveys only as provided for in the 2007 study plan. It is not anticipated that the pending permit amendment request will be resolved prior to the winter 2009 survey, as such this will be conducted using snorkel surveys. If the pending amendment request is resolved prior to July 2008, then summer 2009 surveys will be conducted using the combined method presented below.

2 FIELD SAMPLING AND DATA COLLECTION

The two-phase stratified sampling design involves snorkeling pre-selected habitat units (e.g., riffle, run, pool, etc.) multiple times in order to quantify the variance associated with density and subsequent population estimates. Habitat units are selected using stratified random sampling where the habitat types possess a pre-determined probability of occurrence within areas where *O. mykiss* have been frequently observed during the summer in the lower Tuolumne River, extending from approximately river mile (RM) 52–40 during summers and potentially extending to near the city of Waterford (RM 30) during colder winter conditions.

In a typical Phase 1 sampling approach, primary snorkel surveys (Edmundson et al. 1968, Hankin and Reeves 1998, McCain 1992, Dolloff et al. 1996) will be conducted across a subset of all habitat units. In Phase 2, approximately 20–70% of each habitat type sampled will be randomly selected for replicated surveys by either repeated dive counts or depletion electrofishing (Reynolds 1996). Although the bounded counts methodology was developed for use in smaller stream systems (Hankin and Mohr 2001), applying the methodology to a larger system such as the Tuolumne River is feasible provided key assumptions are satisfied. A critical assumption of the bounded counts approach is that all individuals have a chance of being observed. This may not be practically attainable due to the depths of some of the in-channel mining pits and also potentially due to low visibility conditions occurring at downstream locations or due to winter-time sediment inputs during rain events. Hankin and Mohr (2001) found that their survey designs were suitable for coho salmon (*O. kisutch*), but they were less confident about applying the methodology to *O. mykiss* juveniles because the fish's furtive nature may violate the assumption that all fish have an observation probability >0. Sampling sites and methods may be modified following initial surveys because local conditions cannot be anticipated and may dictate the use of other schedules, locations, or techniques. Stillwater Sciences will notify TID, FERC, and permitting authorities if substantive changes in the study design, methods or schedule are anticipated.

2.1 Habitat Typing

On-the-ground mapping of potential habitat for *O. mykiss* will be delineated on digital ortho-rectified aerial photographs and information from previous habitat mapping efforts. Appendices A and B shows preliminary habitat units from RM 52–30 based upon habitat mapping conducted by Stillwater Sciences (2008) between La Grange Dam (RM 52) and Roberts Ferry Bridge (RM 40) (Appendix A) as well as preliminary habitat units from RM 40 to Waterford (RM 30) based upon mapping conducted by McBain & Trush (2004) and EA Engineering (1997) shown in Appendix B. The Appendix B habitat maps will be updated for flow and morphological characteristics in the field in late February and late June in each year. The final habitat maps will delineate all potential *O. mykiss* habitats according to the major types listed in Table 1, as well as transitional habitats that may be preferentially used by various size classes (i.e., pool heads, pool bodies, pool tails, run heads, run bodies, run tails, and riffles).

Table 1. Coarse scale habitat types to be used during snorkel surveys

Habitat Type	Description[a]	Approximate Depth
Riffle	Shallow with swift flowing, turbulent water. Partially exposed substrate dominated by cobble or boulder. Gradient moderate (less than 4%).	0–4 ft
Run	Fairly smooth water surface, low gradient, and few flow obstructions. Mean column velocity generally greater than one foot per second (fts^{-1}).	4–10 ft
Pool	Slow flowing, tranquil water with mean column water velocity less than 1 fts^{-1}.	>10 ft

[a]Major habitat types determined based upon observed hydraulic conditions (McCain 1992, Thomas and Bovee 1993, Cannon and Kennedy 2003)

A Geographic Information System (GIS) will be used to update and refine habitat maps prior to thorough field verification of flow, depth, and habitat conditions in the river. Within each reach, individual habitat units will be digitized as two-dimensional features of varying shapes, or polygons, where each unit is a discrete functional habitat, as defined above. This approach is consistent with the general techniques of McCain (1992), Thomas and Bovee (1993), and Cannon and Kennedy (2003) and allows a flexible approach to evaluating habitat and habitat use patterns at a scale that can be easily delineated given available data, readily depicted, and is ecologically meaningful for aquatic species.

Habitat units will be assigned a natural sequence order (NSO), starting at one which is the first unit at the upstream end of the site, and a habitat type unit number (1…N pools, runs and riffles). The maximum depth, length and width (usually at 1/3 and 2/3 of the units length) will be recorded and flagging tied at both upstream and downstream ends of units to be surveyed. Pertinent information such as date, unit number, and type is included on the flag. Lastly, the upper and lower end of each unit will be located by GPS and mapping from previous efforts will be verified or updated.

2.2 Sample Site Selection

After all potential habitat units are typed and all pertinent information recorded, a subset of each habitat unit type will be selected for single-pass snorkel surveys. Although additional units may be selected at gravel augmentation and other in-channel restoration sites (See Hypothesis 2), selection for sampling proceeds by random selection of the starting sampling unit in the upper survey section, followed by a systematic uniform sampling of the remaining units in the survey reach. For example, every 3rd, 4th or larger selection interval will be used to distribute the selected units uniformly across the survey reach.

Because the total length of river sampled affects the confidence bounds of the resulting *O. mykiss* population estimates, at least 10% of the total length of a given habitat type and a minimum of 5 units of each type will be sampled. Based upon preliminary habitat mapping and median unit lengths of various habitat types, Table 2 shows that 63 sampling units for the winter surveys will be selected from representative locations between RM 52–30 to meet the minimums above. This estimate further assumes that, since detailed habitat type mapping has not been conducted from RM 40–30, habitat type distribution and median length from RM 40–30 are similar to RM 52–40, as determined by summer 2008 habitat type mapping (Stillwater Sciences 2008). The exact number sampled will be determined after random selection of the habitat units prior to study implementation.

During summer, an estimated 35 units will be selected for single-pass snorkel survey from representative locations between RM 52–40 (Table 2). For both winter and summer surveys, the number and location of habitat units may be adjusted if initial systematic sampling does not allow the study to adequately to test Hypothesis 2.

Table 2. Estimated number of sampling units that will meet study design assumption of sampling at least 10% of the total length of a given habitat type.

Habitat Type	**Total length (ft) RM 52-40[a]**	**Estimated total length (ft) RM 40-30[b]**	**Estimated total length (ft) RM 52-30**	**Median length (ft)[c]**	**# of units to be sampled Winter 2009 RM 52-30[d]**	**Estimated sampled Length Winter 2009**	**# of units to be sampled Summer 2009 RM 52-40[d]**	**Estimated sampled Length Summer 2009**
Riffle	14,320	13,590	27,910	322	9	10%	5	11%
Pool head	619	618	1,237	106	9	77%	5	86%
Pool body	6,741	6,795	13,536	393	9	26%	5	29%
Pool tail	781	618	1,399	124	9	80%	5	79%
Run head	2,067	1,853	3,920	51	9	12%	5	12%
Run body	37,350	35,829	73,179	843	9	10%	5	11%
Run tail	2,393	2,471	4,864	54	9	10%	5	11%
Total	**64,271**	**61,775[e]**	**126,046**		**63**		**35**	

[a]From Stillwater Sciences (2008)
[b]Assumes same proportion of habitat types as from RM 52-40
[c]Assumes median habitat unit lengths from RM52-40 are proportional to median lengths along RM 40-30.
[d]Assumes at least 10% of the total length of each habitat type will be sampled; Estimates based upon 10% of the total length of a habitat type by median habitat unit length to determine a minimum number of units
[e]Actual river length from RM 40-30

2.3 Sampling Period

Winter sampling will begin in late February with systematic random selection of habitat units from RM 52-30, based upon summer 2008 maps (Appendix A) and previous habitat typing between RM 40–30 (Appendix B). Following habitat selection, Stillwater will use single-pass snorkel surveys and second phase calibration surveys within units of each type to develop uncertainty and bias estimates. Second phase sampling will be conducted using multi-pass snorkel surveys and/or depletion electrofishing methods as allowed under applicable permits (See Section 6).

Summer sampling will use habitat maps from RM 52–40 developed in summer 2008 (Appendix A). Although no additional habitat mapping is anticipated following winter 2009 surveys, habitat unit flagging will be established in advance of each snorkel survey effort and seasonal changes in habitat distribution may force revision of habitat type maps, specifically the upper and lower boundaries of habitat units and/or channel margins, prior to summer 2009 surveys.

2.4 Measurement Parameters and Sampling Methods

Multiple parameters will be measured in order to meet the objectives for this study (Table 3). Photos and GPS locations will be taken at each site, and site locations identified on GIS maps corresponding to mapped aquatic habitat units. General site information recorded at fish sampling locations will include site name, GPS coordinates, time, date, and crew member names. *In situ* water quality parameters (Temperature, dissolved oxygen, and conductivity) will be collected using a pre-calibrated multi-probe (YSI 85, Yellow Springs Instruments, Yellow Springs, OH). Underwater visibility will also be estimated into the sun and away from the sun using a Secchi disk to monitor any changes in visibility. Dissolved oxygen probes will be recalibrated at each site and checked for accuracy against concentrations measured in Winkler titrations (Grasshoff et al 1983) at the beginning and end of the sampling effort using a dissolved oxygen test kit.

Table 3. Measurement parameters and methods for snorkel surveys

Parameter	Method	Metric/Descriptor	Method Reporting Limit
Habitat Typing Attributes			
Natural sequence order (Reach ID – Habitat unit #)	N/A	A-1, A-2, A-3, …	N/A
Latitude/Longitude	Handheld GPS receiver	UTM	N/A
Habitat type	Visual estimation	See Table 1	N/A
Average unit width	Horizontal distance	meters (feet) (measured at multiple transects)	3 ft (1 m)
Average unit length	Horizontal distance	meters (feet)	3 ft (1 m)
Maximum/minimum depth	Vertical distance	meters (feet)	1 ft (0.3 m)
Bed substrate composition	Visual estimation	bedrock, boulder, cobble, gravel, organic, sand, silt	10%
Cover type	Visual estimation	none, boulder, cobble, IWM, bedrock ledges, overhead vegetation, aquatic vegetation	10%
Field Data During Snorkel Surveys			
Temperature	EPA 170.1	°C	0.1 °C
Dissolved Oxygen	SM 4500-O	mg/L	0.0 mg/L
Conductivity	SM 2510A	umhos/cm	1.0 umhos/cm
Visibility	Secchi depth	meters (feet)	0.01 m (0.1 ft)
Date/Start time/End time	N/A	Day/month/year	N/A
Number of Individuals	Visual estimation	Number	1
Fish length – snorkeling	Visual estimation	millimeter	50 mm
Fish length – electrofishing	Fork length	millimeter	1 mm
Weight - electrofishing	Electronic balance	gram	0.1 g

2.4.1 Snorkel Surveys

Snorkel surveys will be conducted during daylight hours (7:00am–5:00pm winter; 6:00am–8:00pm summer). A two phase survey design will be used to survey the seven different strata (Table 4). At the first phase, single-pass dive surveys will be conducted by a four to five person crew depending upon river flows and underwater visibility. Sampling units will generally be sampled from downstream to upstream in dive lanes using a zigzag pattern, passing fish and allowing them to escape downstream of the diver. If fish are observed to escape upstream, the diver will take care to avoid counting these fish twice. Divers will record their observations of pertinent attributes (Table 3) and numbers of *O. mykiss* and Chinook salmon (*O. tshawtscha*) observed; with fish lengths to be estimated in 50 mm size ranges using a scale model or markings on the slates to correct for underwater size distortion. After the first dive pass is completed a tab is then pulled to determine if the unit is included in the second phase of sampling.

Table 4. Preliminary sample unit selection and survey count.

	Winter 2009				Summer 2009			
	Phase I Dives		Phase II Survey		Phase I Dives		Phase II Survey	
Habitat	Initial Units	Passes	Repeat Units	Passes	Initial Units	Passes	Repeat Units	Passes
Riffle	9	1	2	2	5	1	2	2
Pool head	9	1	2	2	5	1	2	2
Pool body	9	1	2	2	5	1	2	2
Pool tail	9	1	2	2	5	1	2	2
Run head	9	1	2	2	5	1	2	2
Run body	9	1	2	2	5	1	2	2
Run tail	9	1	2	2	5	1	2	2
	Total	63	Total	28	Total	35	Total	28

The second phase of sampling collects data that will later be used to extrapolate dive counts to total population estimates by three passes of either repeated dive counts or depletion electrofishing. Ideally, if the count of *O. mykiss* from the Phase 1 snorkel survey is less than or equal to 20 individuals then three additional dive passes are made. If electrofishing is permitted, all units with a count of juvenile *O. mykiss* counts greater than 20 individuals will be surveyed by electrofishing. Lastly, occurrence of other native and non-native fish species will be recorded as presence/absence.

2.4.2 Electrofishing at Riverine Sites

If employed during the summer 2009 survey, electrofishing will be conducted by a 4 person crew during the daylight hours (6:00am-8pm) following the dive surveys. Ideally, 3-pass electrofishing will be used on all second phase dive units where the first dive pass exceeded 20 *O. mykiss*. Dive units that require electrofishing for dive calibration will be completed as soon as possible after the dive survey.

Shallow water habitat may be sampled using back pack electrofishing units while deep water habitat may be sampled using a boat electrofishing unit. Back pack electrofishing in shallow waters less than 3–4 ft depth will be conducted using two or more Smith-Root back pack electrofishers (Model LR-24 or Model 12 with 11-inch anode rings and standard “rat-tail” cathodes). Boat electrofishing may be used in deeper riverine habitats using a boat mounted Smith Root 1.5 KVA electrofishing unit. To ensure the health of all fish captured during electrofishing, all electrofishing will be conducted in accordance with NMFS (2000) electrofishing guidelines and an electrofishing logbook will be maintained and updated at each sampling site.

Depending upon river flows and depth, electrofishing will use block nets placed at the upstream and downstream ends of the unit to be fished, taking care to avoid disturbance of the unit during net set-up. Block nets will be set up where possible to prevent fish from moving out of the unit. If block nets are not feasible, then a snorkeler may be stationed at the upstream end of a unit to observe any fish moving out of the unit.

First pass electrofishing will proceed slowly and deliberately upstream from the downstream end of the unit; members of an electrofishing crew will move to the top and back down to the bottom working closely together. To maintain equal effort on subsequent passes, electrofishing time (seconds) will be recorded to allow for any adjustments in sampling effort. A fourth pass will be conducted if one of the following applies:

1. The number of *O. mykiss* caught on the 2^{nd} pass exceeds the number of *O. mykiss* caught on the 1^{st} pass.
2. The number of *O. mykiss* caught on the 3^{rd} pass is greater than or equal to 25 percent of number caught on the 2^{nd} pass.

The procedure may be modified in riffle habitats to facilitate capture of shocked fish in fast water. In the riffle strata, a pass consists of a sweep from the top to the bottom of the unit. Depending on the water velocity, block nets may or may not be set at the upstream end of riffle units.

2.4.3 Fish Handling Protocols

Any fish captured during electrofishing surveys will be processed, and information collected regarding species identification, fork length (FL, mm), weight (g), and, if applicable, notes on general condition. All fish will be rapidly retrieved using dip nets and placed immediately into aerated live wells or buckets with water. Large fish will be kept separate from juvenile fish to avoid confinement predation. Fish will be identified to species and origin (hatchery or wild stock) where possible. Fish that are weighed and measured will be anesthetized using clove oil to minimize handling stress. After all fish are identified, counted, and measured, fish will be held for approximately 10 minutes, until they show signs of "normal" swimming patterns and behavior.

2.5 Hypothesis Testing

The purpose of the proposed *O. mykiss* population surveys is to provide population size estimates over several sampling seasons of differing environmental conditions to determine habitat use and needs within the lower Tuolumne River. The surveys will be used to examine the following hypotheses:

> Hypothesis 1: Summertime distribution of suitable habitat by observed life stages of *O. mykiss* is related to ambient river water temperature.
>
> Hypothesis 2: Habitat use by *O. mykiss* juveniles and adults observed in the Tuolumne River occurs at the same density in both restored and nearby reference sites.

While the selection for sampling proceeds by random selection of the starting sampling unit in the upper survey section, followed by a systematic uniform sampling of the remaining units in the survey reach, additional units adjacent to or near restoration sites may be non-randomly selected to provide treatment and control locations to test Hypothesis 2, especially during winter 2009 surveys when low ambient river water temperatures obviate the need to test Hypothesis 1.

2.6 Field Work Notification

To ensure field staff safety and to satisfy scientific collecting permit requirements, the parties listed in Table 5 will be notified in advance of the proposed sampling in as required to confirm sampling dates.

Table 5. Field Work Notification

Contact	Affiliation	Address	Phone and Email
Tim Ford	TID	333 East Canal Dr. Turlock, CA 95380	209.883.8275 tjford@tid.org
Tim Heyne	CDFG	P.O. Box 10 La Grange, CA 95329	209.853.2533 x1# theyne@dfg.ca.gov
Jeffery Jahn	NMFS	777 Sonoma Ave. Rm 325 Santa Rosa, CA 95404	707.575.6097 Jeffrey.Jahn@noaa.gov

Prior to mobilization, planned river operations by the Districts will be checked to determine if fish sampling would be safe under the anticipated flow and all parties will be notified of any delay or modification to the sampling schedule.

3 QUALITY ASSURANCE

The objective of data collection for this Project is to produce data that represent as closely as possible, *in situ* conditions of the Tuolumne River with respect to river flow conditions, water quality, abundance and habitat use by *O. mykiss*. To meet this objective, field sampling, sample preparation, and analysis will follow general guidelines outlined in USEPA (2002) by ensuring that:

- the project's objectives, hypotheses and data quality objectives are identified and agreed upon,
- the intended measurements and methods are consistent with project objectives,
- the assessment procedures are sufficient for determining if data of the type and quality needed and expected are obtained, and
- any potential limitations on the use of the data can be identified and documented.

Aquatic environments are inherently variable, but management decisions must be based on a data from a limited number of locations and often collected in short time periods. How well the information collected represent the reach or river-wide fish population depends upon a systematic approach to quality assurance.

3.1 Data Quality Objectives for Measurement Data

The data quality parameters used to assess the acceptability of the data are precision, accuracy, representativeness, comparability, and completeness. Precision measures the reproducibility of measurements under a given set of conditions. Analytical precision is limited to water quality and physical habitat characteristics (Table 6). Accuracy is an expression of the degree to which a measured or computed value represents the true value. Field accuracy is controlled by adherence to sample collection procedures.

Table 6. Data quality objectives for field parameters

Parameter	Units	Accuracy	Precision	Completeness
Dissolved Oxygen	mg/L	$\pm$ 0.5	10%	90%
Temperature	^{o}C	$\pm$ 0.5	5%	90%
Conductivity	umhos/cm	$\pm$ 5%	$\pm$ 5%	90%
Depth	meters	$\pm$ 0.2	N/A	N/A
Visibility (Secchi)	meters	$\pm$ 0.05	N/A	N/A

- Representativeness expresses the degree to which data accurately and precisely represent an environmental condition. For this study, monitoring site selection will be conducted based on physical habitat attributes. Additionally, specific measurement parameters have been identified as relevant based on numerous studies indicating factors associated with species distribution.

- Comparability expresses the confidence with which one data set can be evaluated in relation to another data set. For this biological assessment, comparability of data will be established through the use of standard analytical methodologies and reporting formats.

- The project goal for completeness, a measure of the amount of data that is determined to be valid in proportion to the amount of data collected, will be 90% for analytical water quality parameters. The data quality objective for completeness for all components of this study is 90%.

3.2 Training Requirements/Certification

Specialized training is required for the proposed sampling activities, however none of the sampling activities require outside certification from an agency or another entity. Required permits for biological sampling are discussed in Section 5. Field crews will be staffed by a variety of qualified personnel, which due to the nature of extended field activities, will necessarily be rotated in and out of the field.

3.3 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

To ensure proper equipment performance in the field, maintenance and operational procedures, including preventative maintenance, will be performed on all YSI multiprobes (temperature, dissolved oxygen, and conductivity). YSI maintenance will be recorded in a logbook with the date the maintenance was performed and the initials of the technician. When the instruments are not deployed, the calibration or storage cup will be used to protect sensors from damage and desiccation.

3.4 Instrument Calibration and Frequency

Field probes used for field sampling will be calibrated prior to use, midway through each sampling event, and at the end of each sampling event. Measurement devices for conductivity will be checked against a standard whose source is different than that selected for calibration. Dissolved oxygen will be checked against aerated water whose oxygen content is established by the Winkler method (Grashoff et al 1983). Temperature does not require calibration because of the unvarying nature of the temperature sensor and its conditioning circuitry.

3.5 Reconciliation with Data Quality Objectives

If data do not meet the project's specifications, the following actions will be taken. First, the task leaders working with the field crew leaders (in some cases they will be the same person) will review the errors and determine if the problem is equipment failure, calibration/maintenance techniques, or monitoring/sampling techniques. They will suggest corrective action. If the problem cannot be corrected by training, revision of techniques, or replacement of supplies/equipment, then the task leaders will review the data quality objectives (DQOs) and determine if the DQOs are feasible. If the specific DQOs are not achievable, they will determine whether the specific DQO can be relaxed, or if the parameter should be eliminated from the monitoring program.

3.6 Data Management

All field data will be amassed in a quality-checked database and summarized. QA checks will be applied to all data before data entry and data will be stored on Stillwater Sciences servers. Full backup of data from all offices is done on a weekly basis, while differential backup (files that have changed since the last full backup) is done on a nightly basis. The backup process is accomplished with a Fast Tape Library and backup processes are completed during off-peak hours. Two sets of tapes are taken offsite by two Information Technology (IT) staff members on a weekly basis to ensure recovery in case of failure or catastrophe.

4 DATA ANALYSIS

Data analysis will be conducted to summarize *in situ* water quality and fish counts in each sampling strata. Bounded counts or depletion estimators will be used to determine populations and linear density for each sampled unit, together with estimates of uncertainty. In addition to comparisons of fish density between sampling strata, the density estimates and uncertainties will be propagated across the unsampled areas for an overall population estimate. Exploratory multiple regression analysis will also be used to determine relationships between fish density and recorded habitat variables.

5 REPORTING

A data report will be prepared for use with permitting authorities that includes: date, time, and location of sampling activities; species and number of species collected; and a copy of field data sheets. Results of the winter 2009 surveys will be transmitted to TID electronically within three weeks of the survey completion (April/May 2009). A client review draft of the technical report covering the results of both winter and summer 2009 surveys will be submitted to TID by August 24, 2009. Assuming an internal and Agency review comments are received within one and three weeks of issuance of the client review and Agency review drafts, respectively, the Agency review draft will be available by September 8, 2009 and final report will be complete by October 16, 2009.

6 PERMITTING REQUIREMENTS

Stillwater Sciences will maintain the following permits to sample fish populations that may be present:

- NMFS Section 10(a)(1)(A) permit 1282
- California Department of Fish and Game individual Scientific Collection Permits.

A NMFS Section 10(a)(1)(A) permit 1282 has been obtained and all NMFS guidelines (e.g., notification, data gathering, preservation) will be followed if any Central Valley steelhead are captured. Under that existing NMFS permit, electrofishing is limited to an authorized incidental take of 40 juvenile *O. mykiss* and the <5% unintentional mortality limit, and no adults. An amendment to the sampling description was submitted to NMFS on June 2, 2008 with increased take limits for handling electrofishing of 100 adults and 200 juveniles at an unintentional mortality rate of <10%. Mr. Jeffrey Jahn of NMFS will be notified at least two weeks prior to applicable sampling to confirm sampling dates and locations. Electrofishing under an amended permit will be suspended in the event that the authorized incidental take limits were exceeded and all subsequent calibration surveys would be made by repeat dive surveys. Annual reporting will be provided to Mr. Jeffrey Jahn of NMFS by March 1, of each year.

CDFG Scientific Collecting Permits (SCPs) will be maintained for species potentially present in the project area. CDFG guidelines (e.g., notification, data gathering, and preservation) will be followed if special-status species are captured and the CDFG 24-hr dispatch (916.446.0045) will be notified should unrelated events result in fish kills.

No intentional mortality or removal of special-status species from the wild is included in this study plan. In the event unintentional mortality occurs beyond the take permit limits, NMFS staff will be contacted within 24 hrs and a fin-clip will be provided to the Salmonid Genetic Repository. CDFG will also be contacted to determine the disposition of the individual specimen and whether the individual may be retained for otolith analysis.

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Appendix B: 2008 Habitat Maps


Run Body
NSO 009
NSO 008
Run Head
NSO 007
Riffle
NSO 006
Pool Tail
NSO 005
Pool Body
NSO 004
Pool Head
Pool Tail
NSO 003
NSO 002
Pool Body
NSO 001
Pool Head
Riffle
RM 52
Pool Tail
Pool Body
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 01
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet

Run Body
NSO 012
RM 51
NSO 011
Pool Body
NSO 010
Run Tail
NSO 009
Run Body
NSO 008
Run Head
NSO 007
Riffle
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 02
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet


CDFG GRAVEL INTRODUCTION RIFFLE A7
NSO 015
Run Head
NSO 014 Riffle
NSO 013
Run Tail
NSO 016
Run Body
NSO 012
Run Body
RM 51
Pool Body
NSO 011
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 03
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet


CDFG GRAVEL INTRODUCTION RIFFLE 1A/1B
NSO 024 Run Body
RM 50
NSO 023 Run Head
Riffle
NSO 022
NSO 021 Run Tail
NSO 020
Run Body
NSO 019 Run Head
NSO 018
Riffle
NSO 017 Run Tail
Run Body
NSO 016
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 04
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet


NSO 028
NSO 027
Pool Body
Pool Head
Pool Tail
NSO 026
Riffle
Run Head
NSO 029
NSO 030
Run Tail
NSO 025
NSO 031
Run Body
NSO 024
Run Body
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 05
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet
N


NSO 032
Run Tail
NSO 031
Run Body
NSO 033
Riffle
Riffle
NSO 041
Run Tail
NSO 039
NSO 040
Run Body
NSO 037
Run Head
NSO 038
Riffle
Run Tail
NSO 036
NSO 035
Run Body
RM 49
NSO 034
Run Head
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 06
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet

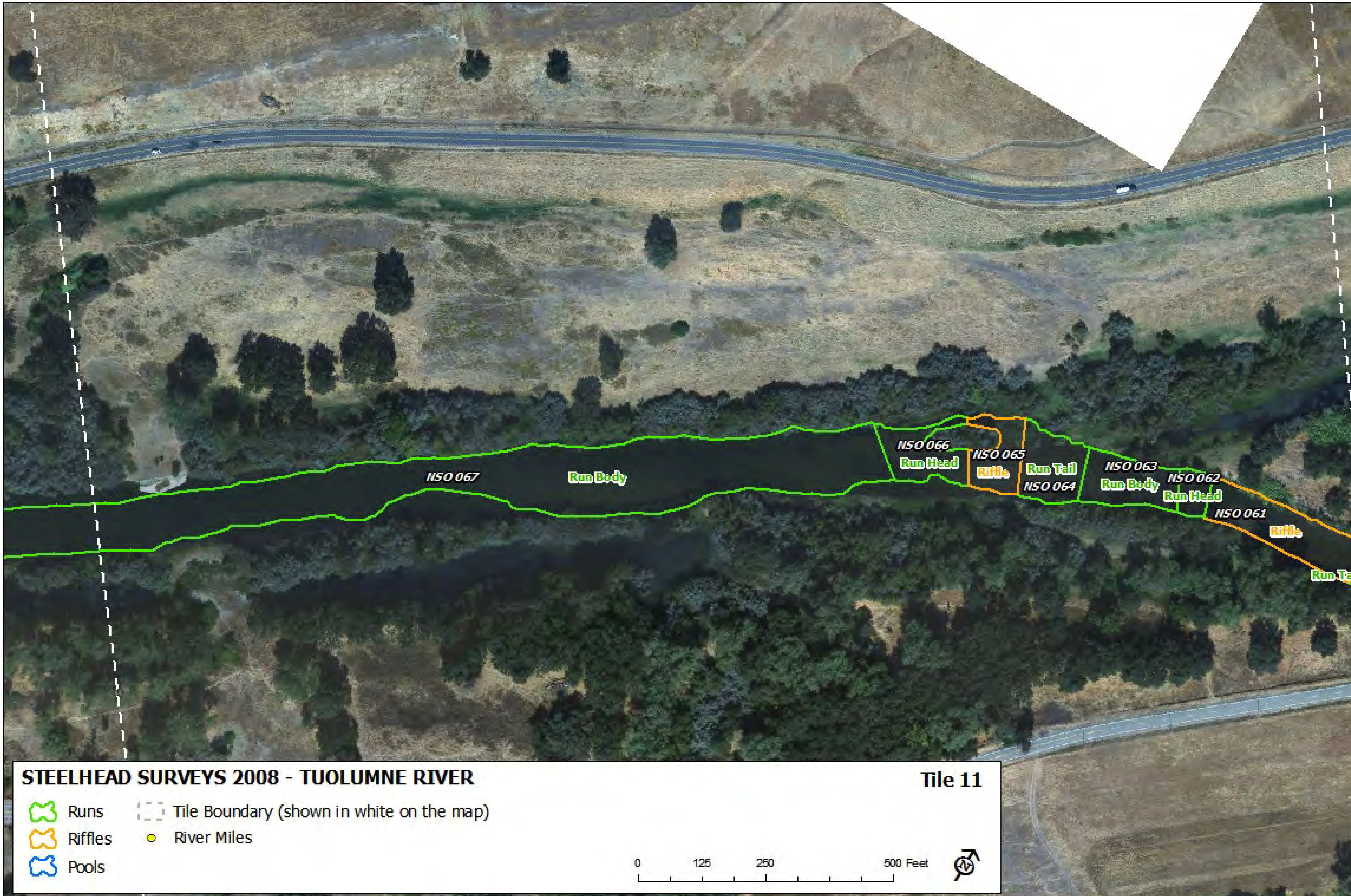

NSO 042
Run Head
NSO 043
Run Body
NSO 041
Riffle
NSO 044
Run Tail
Run Head
NSO 045
Riffle
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 07
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet

STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER

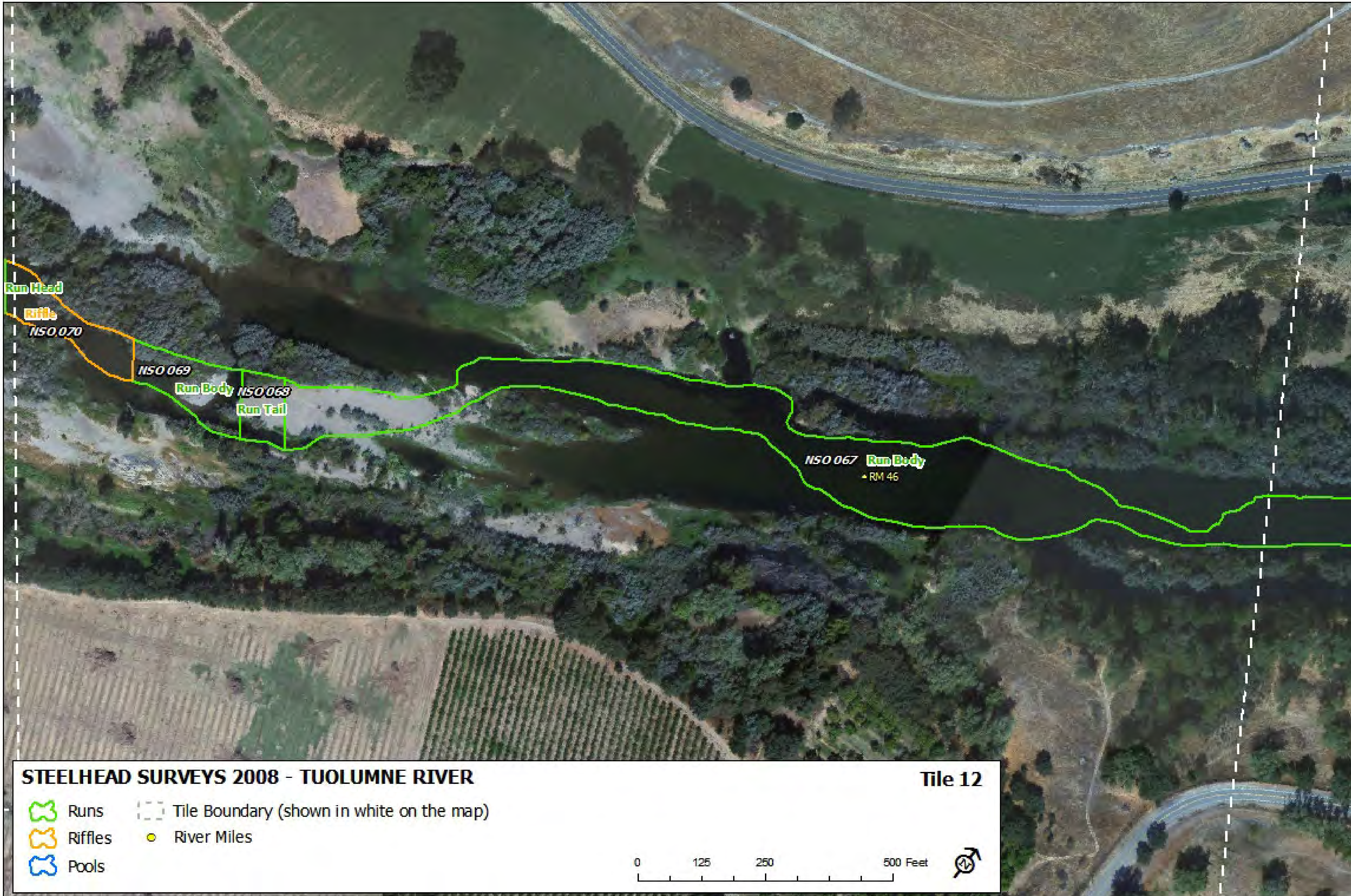
Tile 08


NSO 055
Pool Body
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 09
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet


NSO 055 Pool Body
NSO 056
Pool Tail
RM 47
NSO 057
Riffle
NSO 058
Run Head
NSO 059
Run Body
Run Tail
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 10
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet



NSO 067
Run Body
NSO 066
Run Head
NSO 065
Riffle
Run Tail
NSO 064
NSO 063
Run Body
NSO 062
Run Head
NSO 061
Riffle
Run Tail
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 11
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet


Run Head
Riffle
NSO 070
NSO 069
Run Body
NSO 068
Run Tail
NSO 067
Run Body
RM 46
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 12
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet

STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER **Tile 13**

Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles

0 125 250 500 Feet


NSO 089
Riffle
NSO 088
Pool Tail
NSO 087
Pool Body
NSO 086
Pool Head
Riffle
NSO 085
NSO 084
Run Tail
RM 45
NSO 083
Run Body
Run Head
NSO 082
Pool Body
NSO 081
NSO 080
Run Body
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 14
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet
N


NSO 101
Riffle
NSO 100
NSO 099
NSO 098
Run Tail
Run Body
Run Head
NSO 097
Riffle
Run Tail
NSO 096
Run Body
NSO 095
NSO 094
Run Head
Riffle
NSO 093
Run Tail
NSO 091
Run Body
NSO 090
Run Head
NSO 089
Riffle
Run Head
NSO 103
Run Body
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 15
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet
N


NSO 104
Pool Body
Run Body
NSO 103
RM 44
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 16
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet


STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 17
NSO 106
Run Tail
Riffle
NSO 107
NSO 105
Run Body
Pool Body
NSO 104
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet


FOT BOBCAT FLAT RESTORATION SITE
RM 43
NSO 110
Run Tail
NSO 111
Riffle
NSO 112
Pool Head
NSO 113
Pool Body
NSO 114
Run Head
NSO 115
Pool Tail
NSO 116
NSO 117
Run Body
NSO 118
Run Tail
Riffle
NSO 119
Run Head
NSO 120
Run Body
NSO 109
Run Body
NSO 108
Run Head
NSO 107
Riffle
NSO 106
Run Tail
NSO 105
Run Body
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 18
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet

STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER

Tile 19

Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles

0 125 250 500 Feet


NSO 128
NSO 129 Riffle
Run Head
Riffle
NSO 131
NSO 132
Run Tail
NSO 130 Run Body
NSO 133
Run Head
NSO 134
Run Body
NSO 135
Run Tail
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 20
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0 125 250 500 Feet


NSO 138 Run Body
NSO 137
Run Head
NSO 136
Riffle
NSO 135
Run Tail
NSO 134
Run Body
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 21
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet
N

STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER

Tile 22

Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles


Riffle
Run Tail
NSO 150
Run Body
NSO 149
Run Head
NSO 148
Riffle
NSO 147
Run Tail
Run Body
NSO 146
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 23
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet
N


NSO 154
RM 40
Run Body
NSO 153
Run Head
Riffle
NSO 152
NSO 151
Run Tail
Run Body
NSO 150
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER
Tile 24
Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles
0
125
250
500 Feet

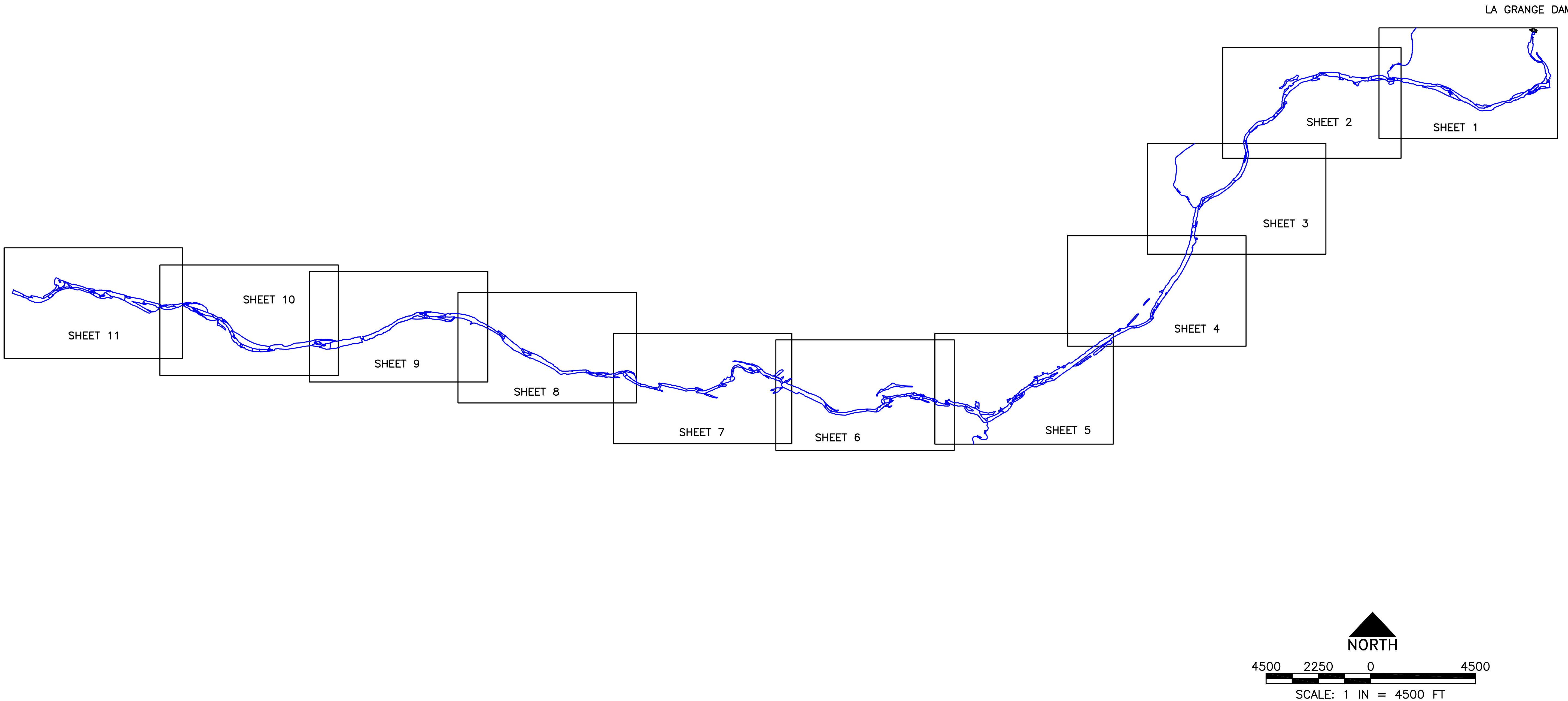
STEELHEAD SURVEYS 2008 - TUOLUMNE RIVER

Tile25

Runs
Riffles
Pools
Tile Boundary (shown in white on the map)
River Miles

0 125 250 500 Feet

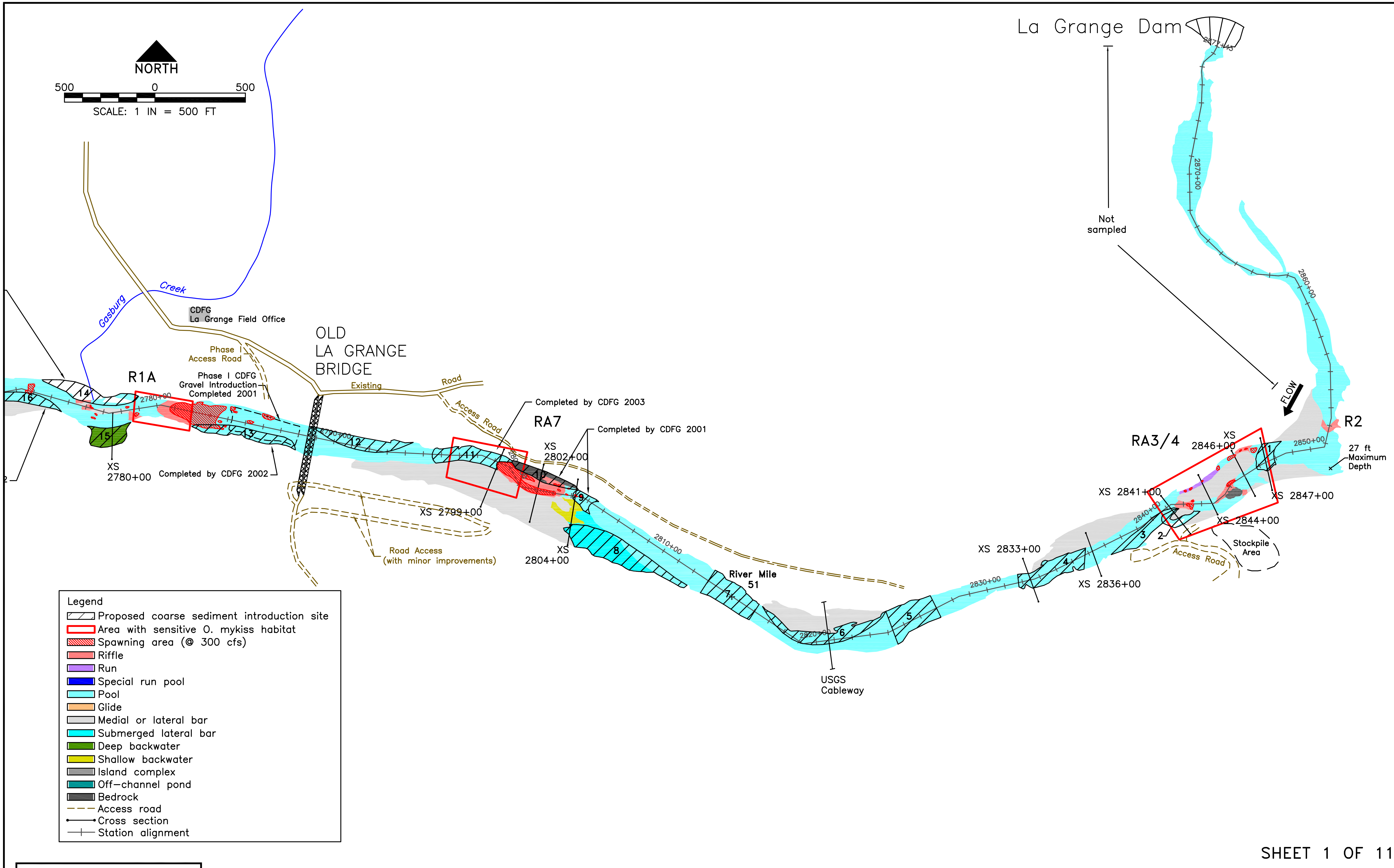
Appendix C: 2004 Habitat Maps



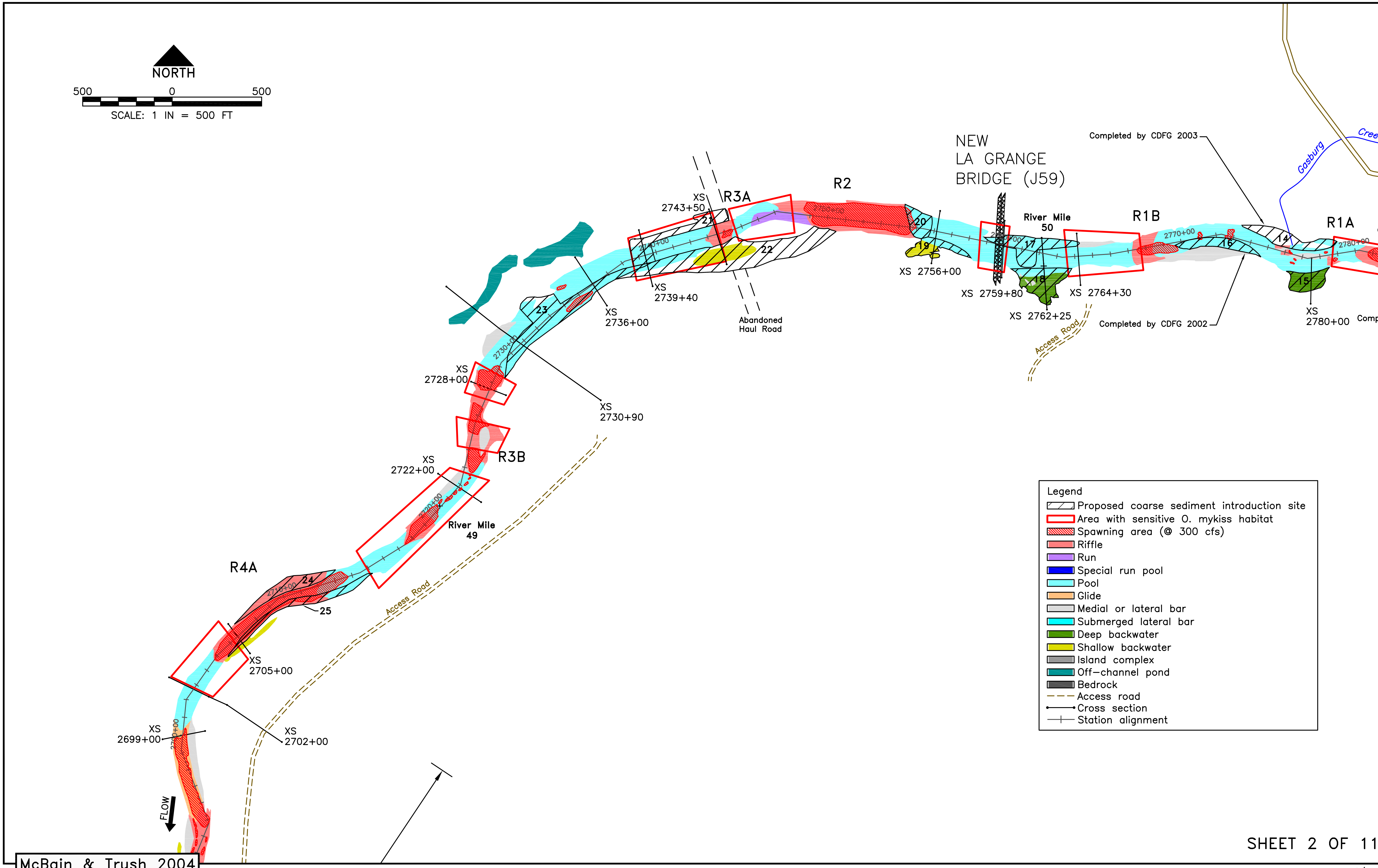
TUOLUMNE RIVER HABITAT MAP SHEET INDEX

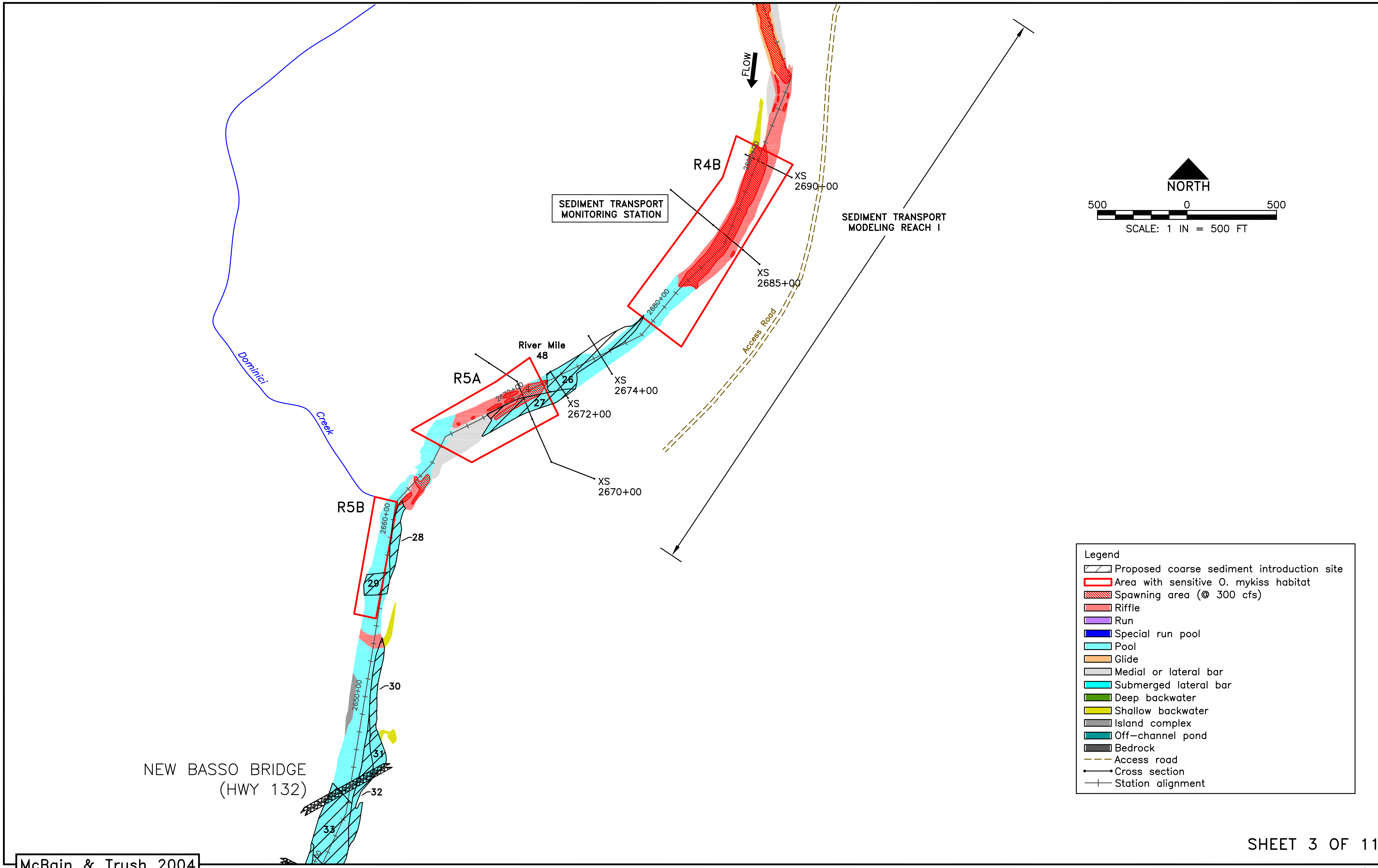
McBain & Trush 2004

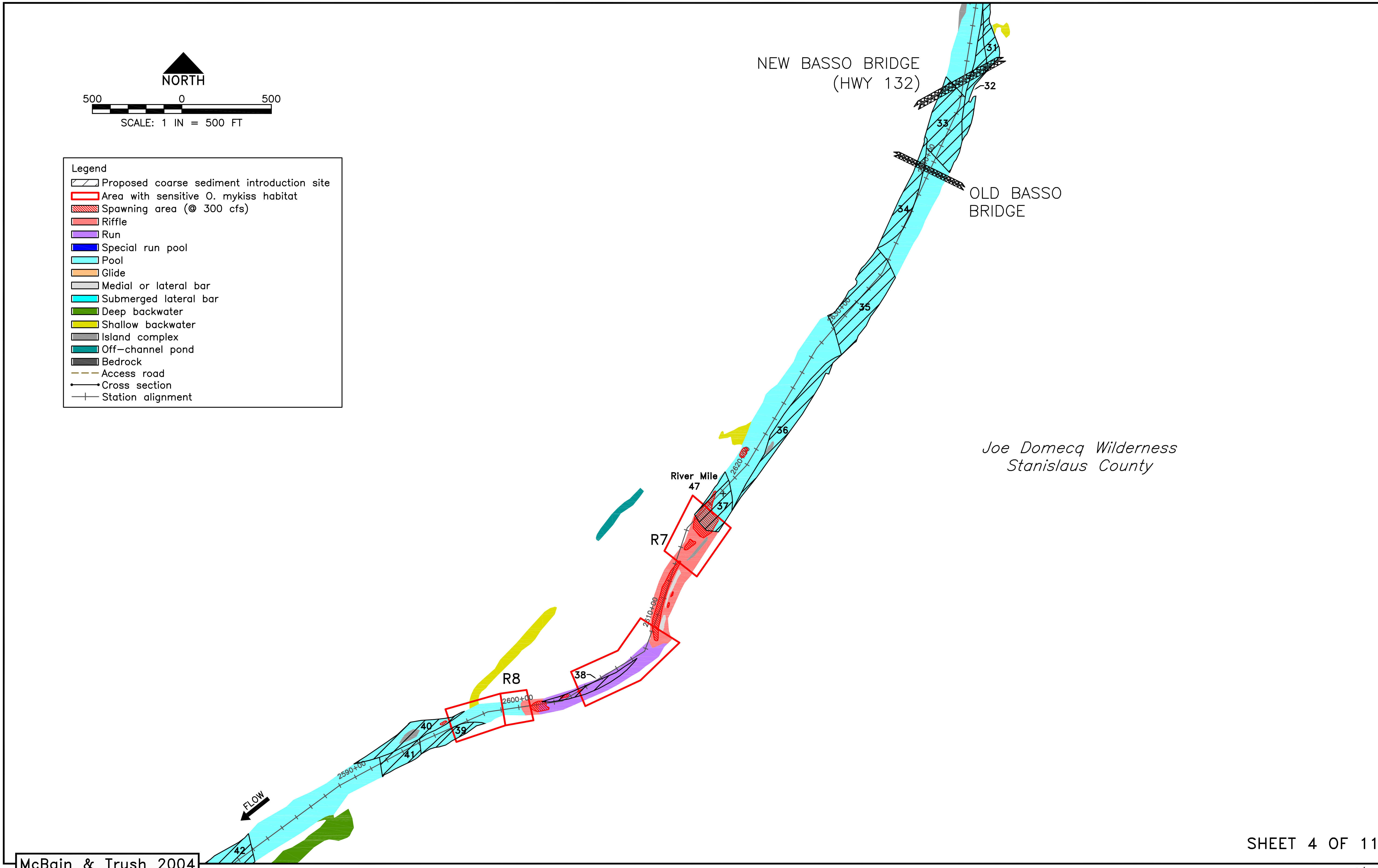
6/11/04


NORTH
500 0 500
SCALE: 1 IN = 500 FT
La Grange Dam
Not sampled
FLOW
R2
27 ft Maximum Depth
2850+00
2860+00
2870+00
RA3/4
XS 2846+00
XS 2841+00
XS 2847+00
XS 2844+00
Stockpile Area
Access Road
2840+00
XS 2833+00
XS 2836+00
2830+00
USGS Cableway
River Mile 51
2820+00
2810+00
RA7
Completed by CDFG 2003
Completed by CDFG 2001
XS 2802+00
XS 2799+00
XS 2804+00
Road Access (with minor improvements)
Access Road
Existing Road
OLD LA GRANGE BRIDGE
2790+00
Completed by CDFG 2002
Phase I Access Road
Phase I CDFG Gravel Introduction Completed 2001
CDFG La Grange Field Office
Gasburg Creek
R1A
2780+00
XS 2780+00
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off–channel pond
Bedrock
Access road
Cross section
Station alignment
SHEET 1 OF 11
McBain & Trush 2004

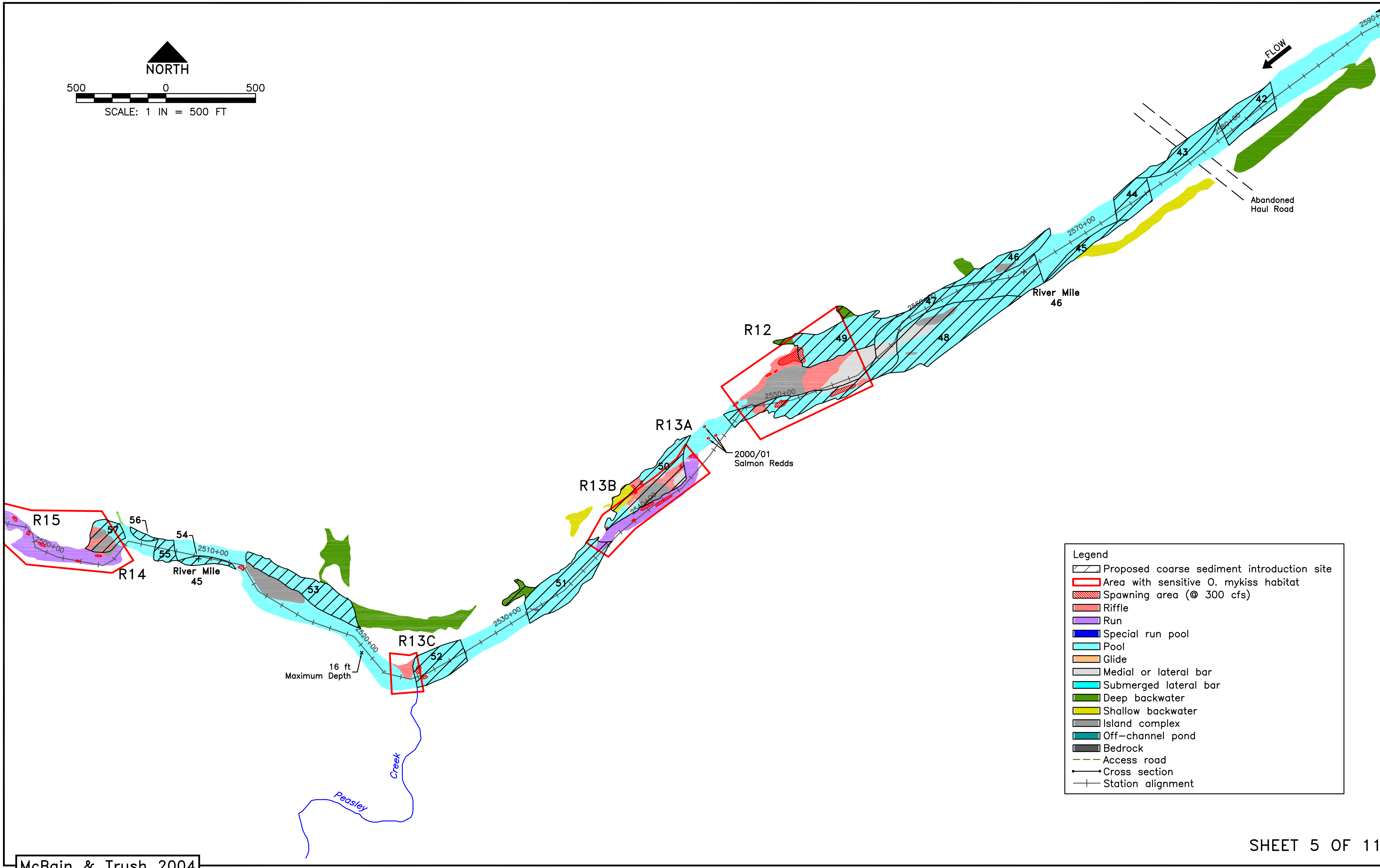
6/11/04

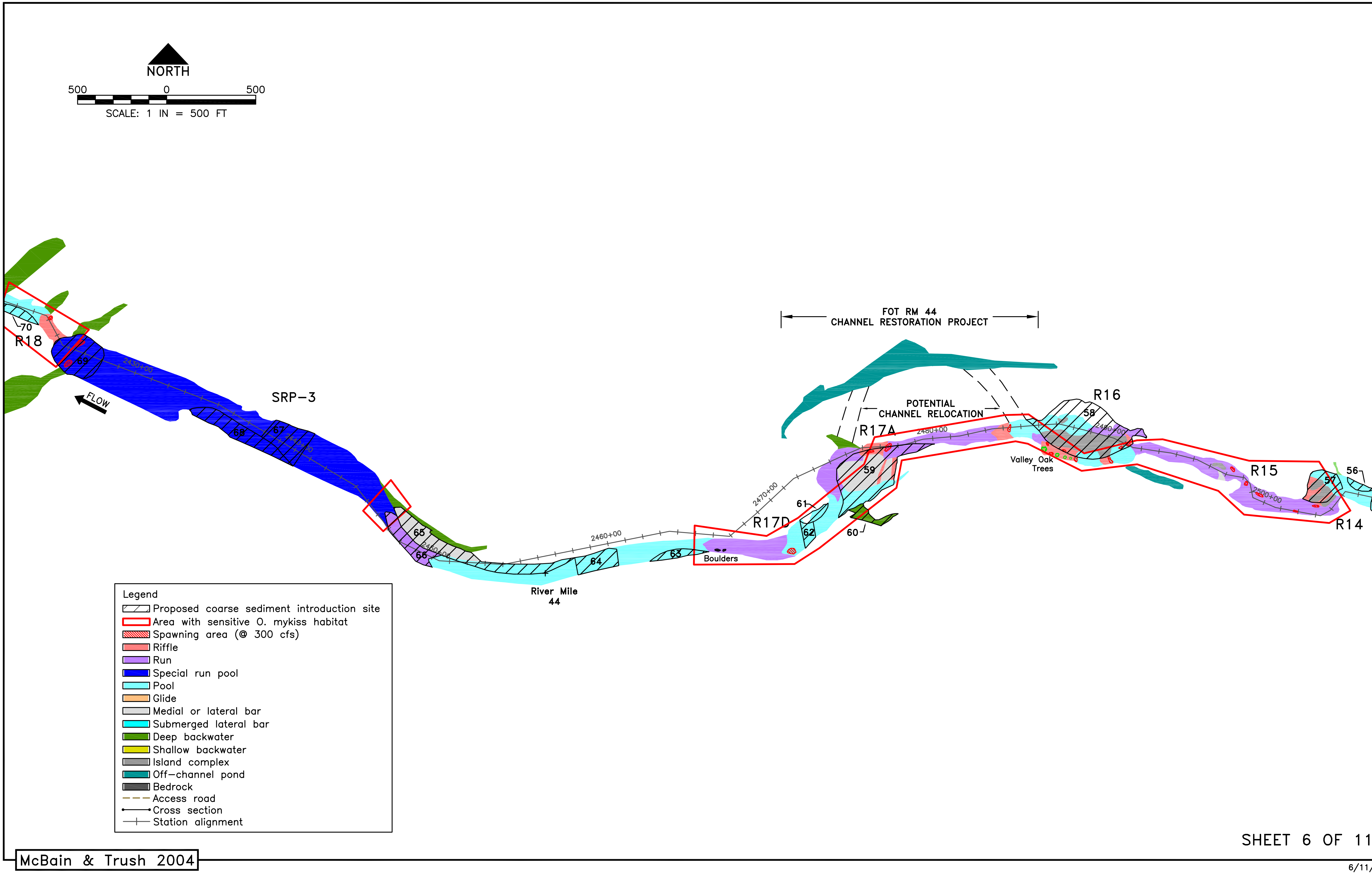

NORTH
500 0 500
SCALE: 1 IN = 500 FT
NEW LA GRANGE BRIDGE (J59)
Completed by CDFG 2003
Completed by CDFG 2002
Gasburg Creek
R1A
R1B
R2
R3A
R3B
R4A
River Mile 50
River Mile 49
XS 2780+00
XS 2764+30
XS 2762+25
XS 2759+80
XS 2756+00
XS 2743+50
XS 2739+40
XS 2736+00
XS 2730+90
XS 2728+00
XS 2722+00
XS 2705+00
XS 2702+00
XS 2699+00
Abandoned Haul Road
Access Road
Access Road
Access Road
FLOW
14
15
16
17
18
19
20
21
22
23
24
25
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off–channel pond
Bedrock
Access road
Cross section
Station alignment
SHEET 2 OF 11
McBain & Trush 2004
6/11/04


FLOW
R4B
XS 2690+00
XS 2685+00
SEDIMENT TRANSPORT MONITORING STATION
SEDIMENT TRANSPORT MODELING REACH I
NORTH
500 0 500
SCALE: 1 IN = 500 FT
Access Road
River Mile 48
R5A
XS 2674+00
XS 2672+00
XS 2670+00
26
27
Dominici Creek
R5B
28
29
30
31
32
33
NEW BASSO BRIDGE (HWY 132)
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off-channel pond
Bedrock
Access road
Cross section
Station alignment
SHEET 3 OF 11
McBain & Trush 2004


NORTH
500
0
500
SCALE: 1 IN = 500 FT
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off–channel pond
Bedrock
Access road
Cross section
Station alignment
NEW BASSO BRIDGE
(HWY 132)
OLD BASSO
BRIDGE
Joe Domecq Wilderness
Stanislaus County
River Mile
47
R7
R8
31
32
33
34
35
36
37
38
39
40
41
42
2620+00
2610+00
2600+00
2590+00
FLOW
SHEET 4 OF 11
McBain & Trush 2004

6/11/04


NORTH
500 0 500
SCALE: 1 IN = 500 FT
FLOW
Abandoned Haul Road
River Mile 46
River Mile 45
R12
R13A
R13B
R13C
R14
R15
2000/01 Salmon Redds
16 ft Maximum Depth
Peasley Creek
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
2500+00
2510+00
2520+00
2530+00
2540+00
2550+00
2560+00
2570+00
2580+00
2590+00
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off–channel pond
Bedrock
Access road
Cross section
Station alignment
SHEET 5 OF 11
McBain & Trush 2004


NORTH
500 0 500
SCALE: 1 IN = 500 FT
FOT RM 44
CHANNEL RESTORATION PROJECT
POTENTIAL
CHANNEL RELOCATION
SRP-3
FLOW
R18
70
69
68
67
2430+00
2440+00
66
65
2450+00
64
63
2460+00
River Mile
44
Boulders
R17D
62
61
60
59
2470+00
R17A
2480+00
R16
58
2490+00
Valley Oak
Trees
R15
2500+00
R14
57
56
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off-channel pond
Bedrock
Access road
Cross section
Station alignment
SHEET 6 OF 11
McBain & Trush 2004
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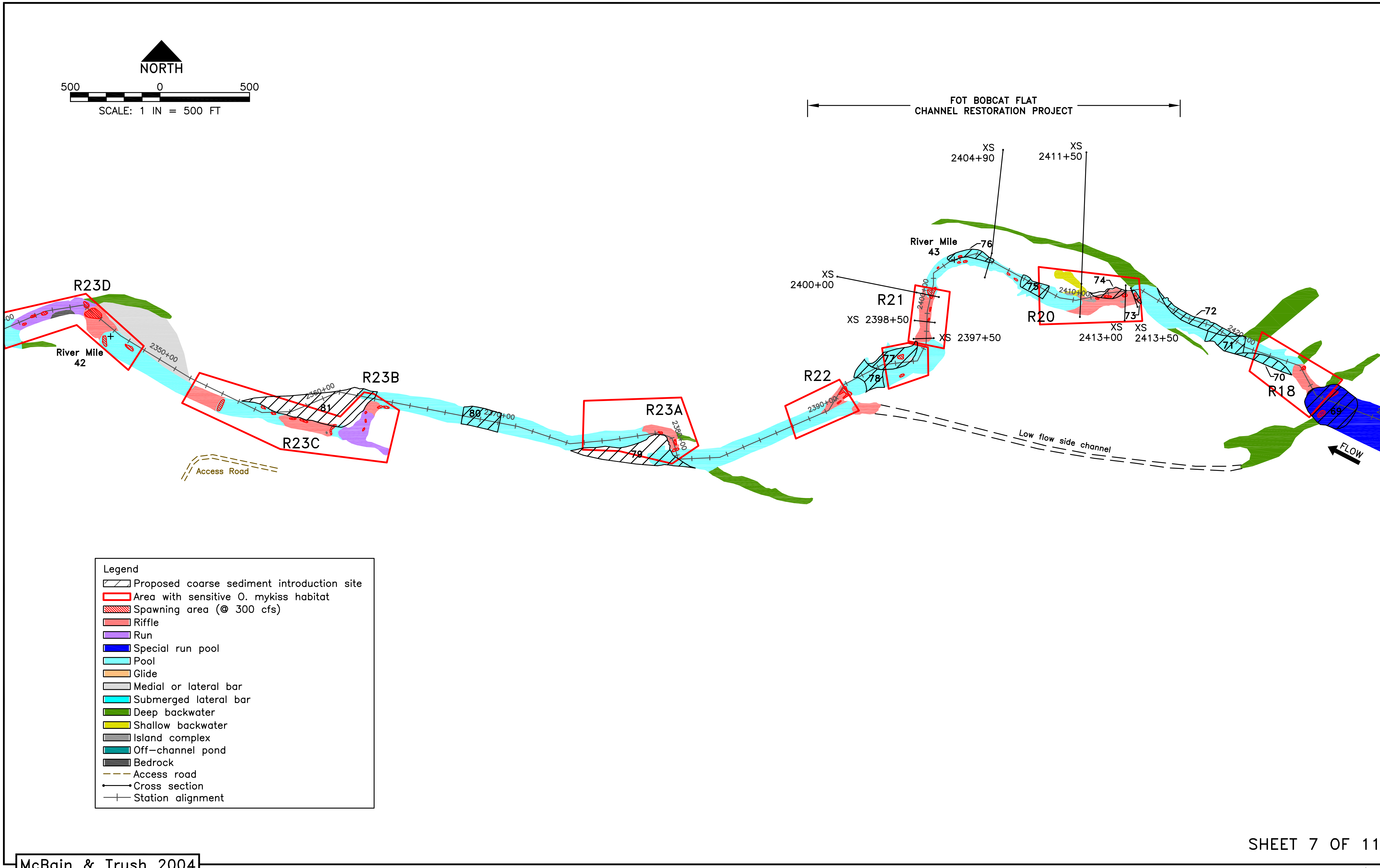
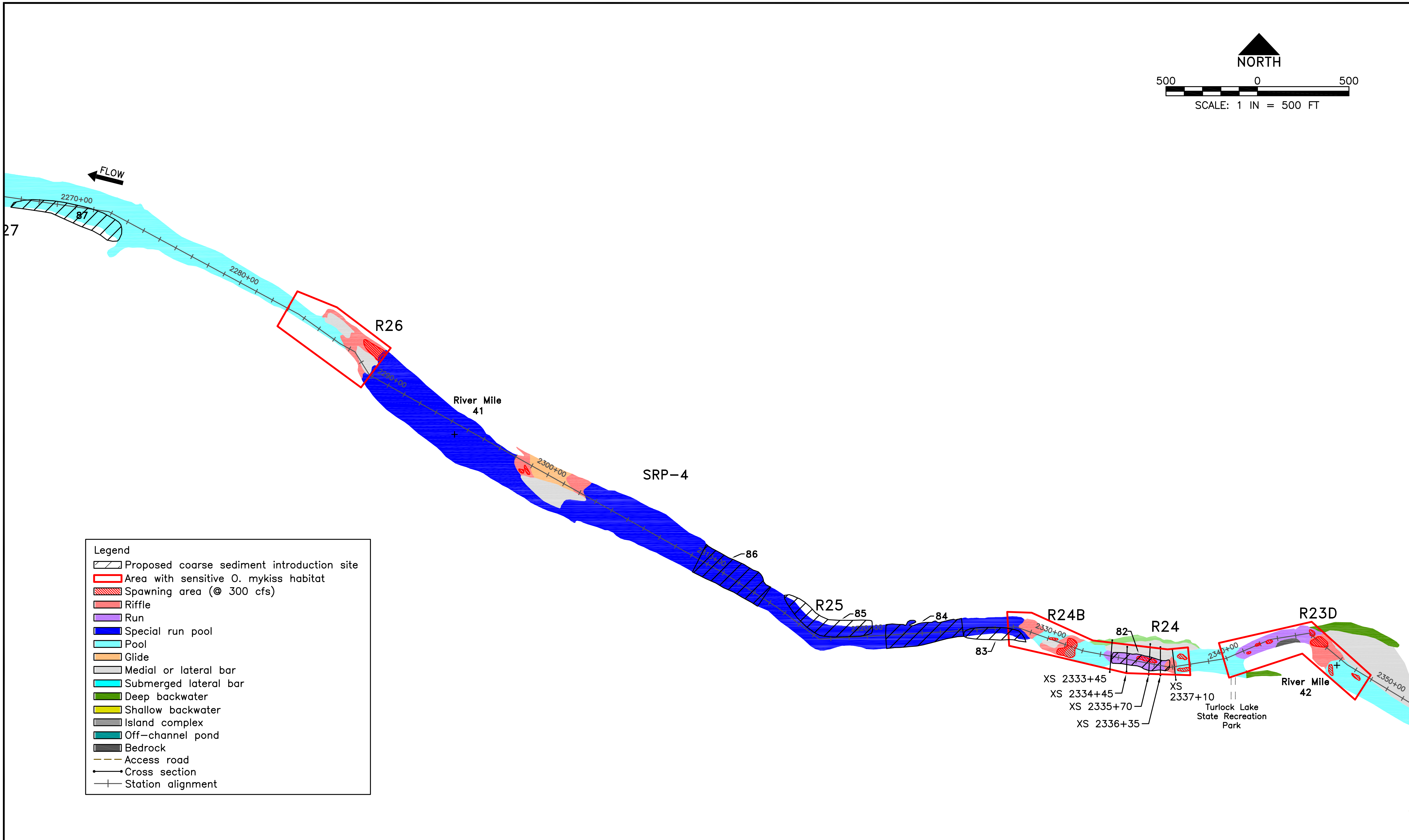

NORTH
500
0
500
SCALE: 1 IN = 500 FT
FOT BOBCAT FLAT
CHANNEL RESTORATION PROJECT
XS
2404+90
XS
2411+50
River Mile
43
XS
2400+00
R21
XS 2398+50
XS 2397+50
R20
74
73
XS
2413+00
XS
2413+50
72
71
70
R18
69
FLOW
76
75
77
78
R22
Low flow side channel
R23A
79
80
R23B
81
R23C
R23D
River Mile
42
2350+00
2360+00
2370+00
2380+00
2390+00
2400+00
2410+00
2420+00
Access Road
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off–channel pond
Bedrock
Access road
Cross section
Station alignment
SHEET 7 OF 11
McBain & Trush 2004



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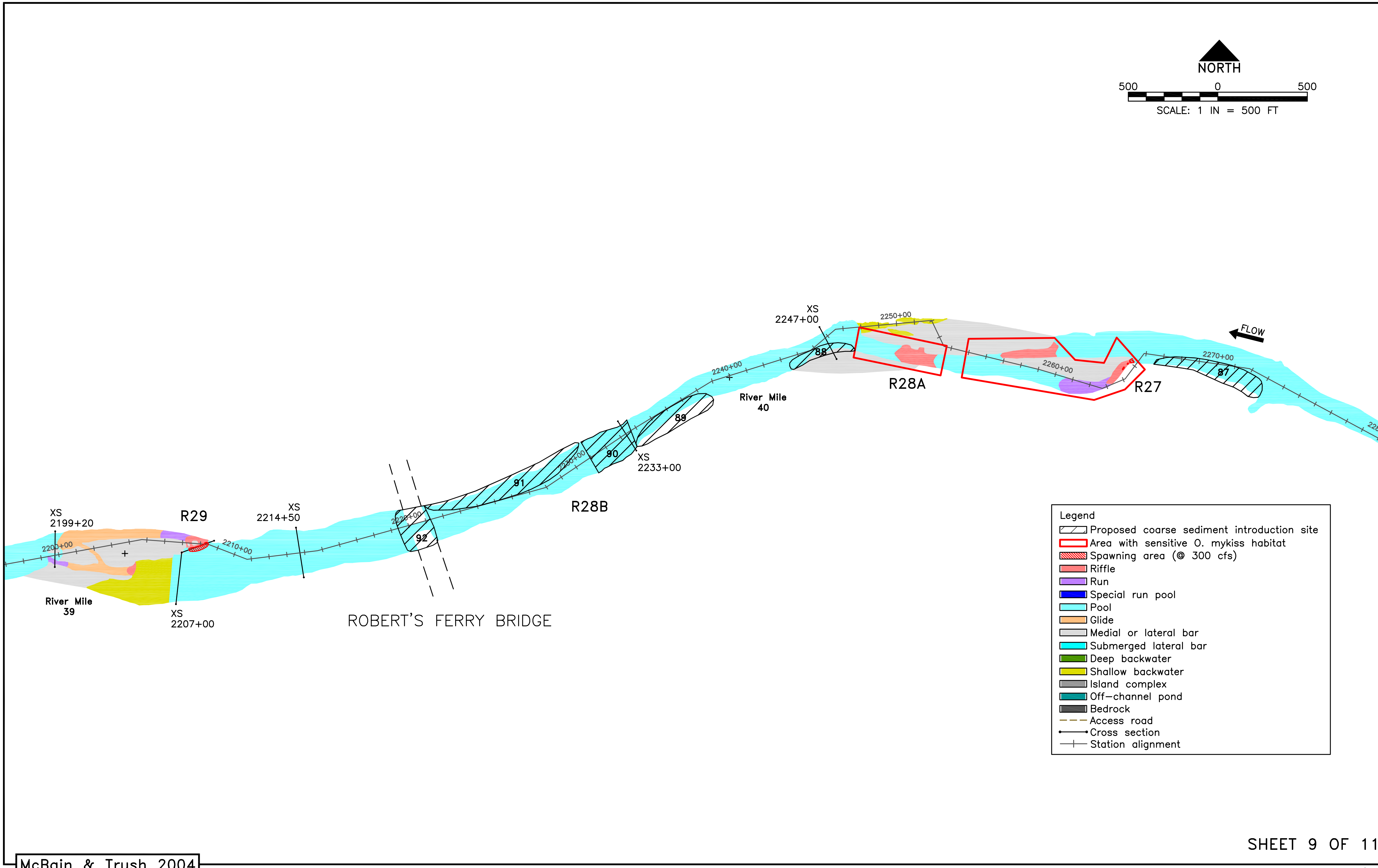
NORTH
500 0 500
SCALE: 1 IN = 500 FT
FLOW
XS 2199+20
R29
XS 2214+50
2200+00
2210+00
River Mile 39
XS 2207+00
2220+00
92
ROBERT'S FERRY BRIDGE
91
2230+00
90
R28B
XS 2233+00
89
2240+00
River Mile 40
XS 2247+00
88
2250+00
R28A
2260+00
R27
2270+00
87
2280+00
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off–channel pond
Bedrock
Access road
Cross section
Station alignment
SHEET 9 OF 11
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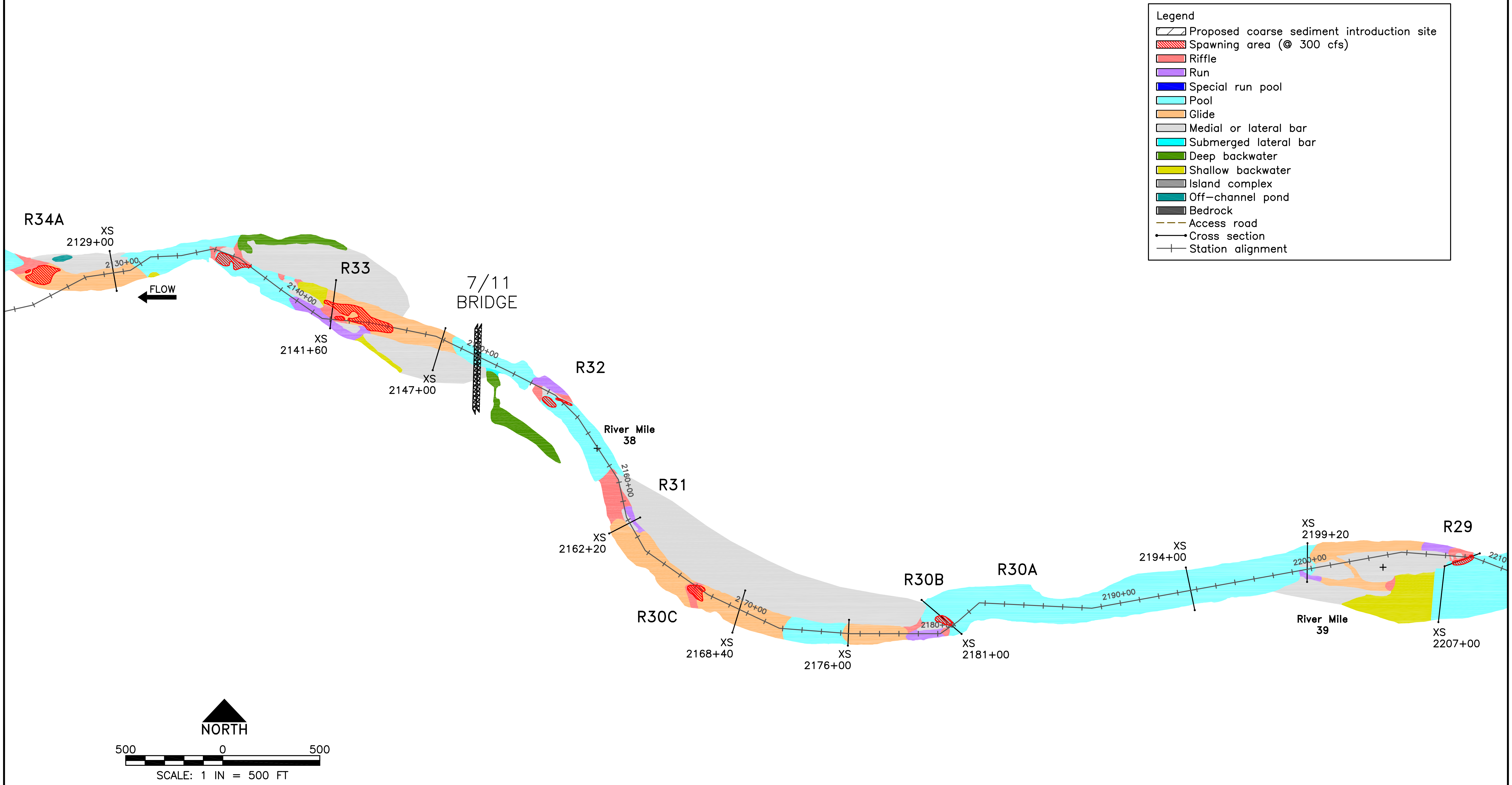

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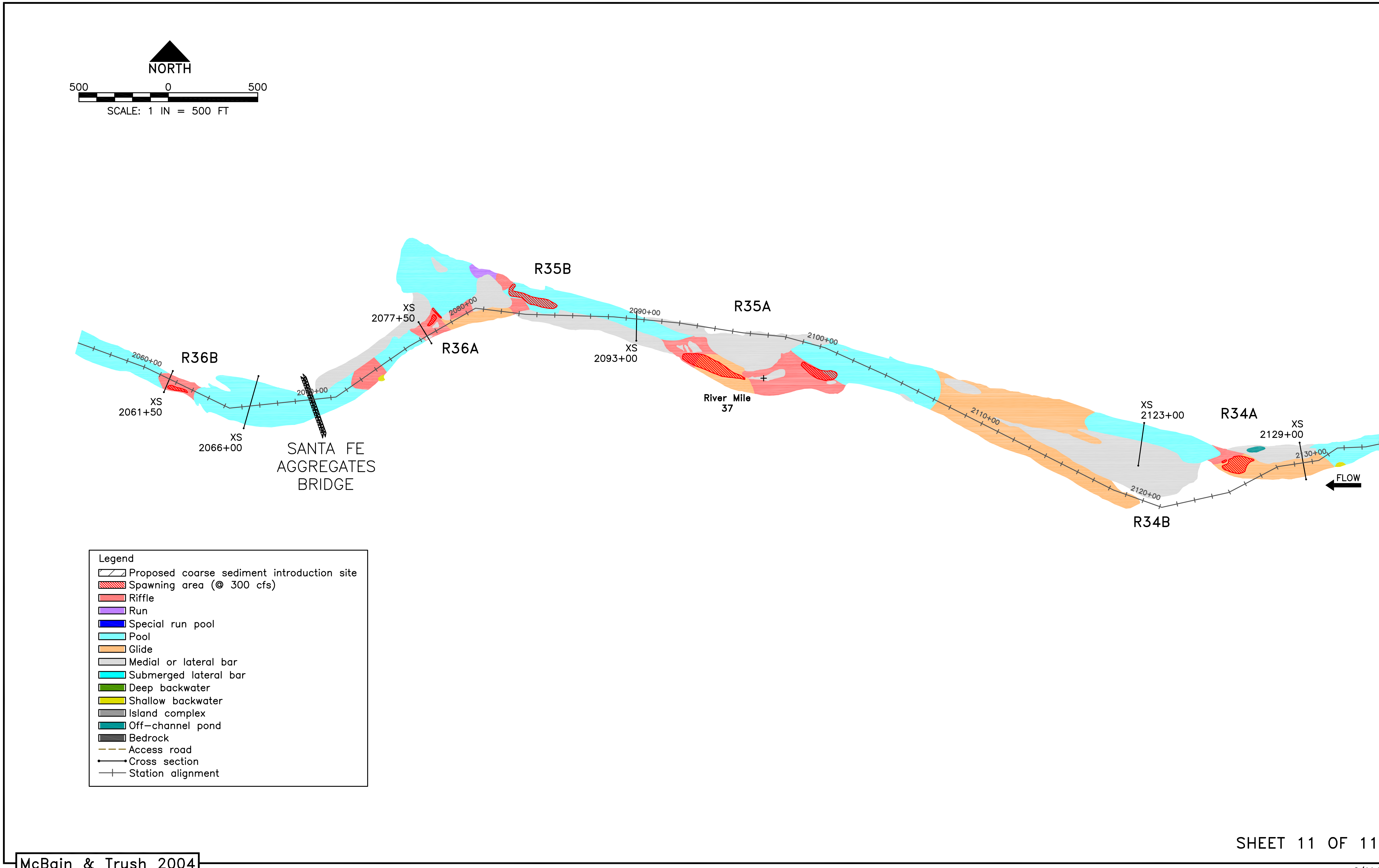
NORTH
500
0
500
SCALE: 1 IN = 500 FT
R35B
R35A
R36A
R36B
R34A
R34B
XS 2077+50
XS 2093+00
XS 2061+50
XS 2066+00
XS 2123+00
XS 2129+00
2060+00
2070+00
2080+00
2090+00
2100+00
2110+00
2120+00
2130+00
SANTA FE AGGREGATES BRIDGE
River Mile 37
FLOW
Legend
Proposed coarse sediment introduction site
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off–channel pond
Bedrock
Access road
Cross section
Station alignment
SHEET 11 OF 11
McBain & Trush 2004
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Appendix D: Habitat Data

Table D-1. Physical habitat types and dimensions of surveyed areas in the lower Tuolumne River (RM 52–40).

Habitat unit (NSO)	RM	March 2009 survey site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
1	51.8		140	75	10,537	5.0	8.0	Pool head
2	51.7		450	143	64,161	18.0	28.0	Pool body
3	51.7		157	61	9,600	1.5	3.0	Pool tail
4	51.6	Yes	85	124	10,506	3.0	5.0	Pool head
5	51.6	Yes	393	129	50,702	18.0	25.0	Pool body
6	51.5	Yes	250	89	22,309	4.0	6.0	Pool tail
7	51.5	Yes	292	68	19,851	3.0	6.0	Riffle
8	51.4		117	82	9,562	5.0	6.0	Run head
9	51.1		2047	97	199,103	6.0	8.0	Run body
10	51.0		182	86	15,733	3.5	4.5	Run tail
11	50.9		457	99	45,397	10.0	16.0	Pool body
12	50.8		843	128	107,699	4.0	7.0	Run body
13	50.8		93	86	7,988	1.5	3.0	Run tail
14	50.6	Yes	708	65	45,670	1.5		Riffle
15	50.6	Yes	161	85	13,760	6.0	7.0	Run head
16	50.5	Yes	704	132	92,609	5.0	8.0	Run body
17	50.4	Yes	59	146	8,600	2.5	3.0	Run tail
18	50.3		941	130	121,948	1.5	2.0	Riffle
19	50.3		59	109	7,193	4.0	8.0	Run head
20	50.1		848	151	107,630	3.0	4.0	Run body
21	50.1		70	119	8,333	1.5	2.0	Run tail
22	50.1	Yes	132	127	16,750	1.0	1.5	Riffle
23	50.0		93	133	12,379	4.0	6.0	Run head
24	49.9		1007	199	200,462	4.0	8.0	Run body
25	49.8		274	154	42,115	2.0	4.0	Run tail
26	49.7		527	139	72,991	1.5	2.0	Riffle
27	49.7	Yes	127	86	10,955	4.0	6.0	Pool head
28	49.6	Yes	161	89	14,345	6.0	9.0	Pool body
29	49.6	Yes	112	85	9,490	1.5	2.5	Pool tail
30	49.6		50	110	5,520	3.0	5.0	Run head
31	49.3		1440	115	166,115	2.5	3.5	Run body
32	49.3		132	137	18,071	2.0	2.5	Run tail
33	49.2		552	126	69,509	1.5	2.5	Riffle
34	49.2		112	65	7,283	2.0	3.0	Run head
35	49.1		321	82	26,475	3.0	5.0	Run body
36	49.1		44	103	4,532	1.5	2.0	Run tail
37	49.1		78	97	7,594	1.5	2.0	Riffle
38	49.1		43	83	3,559	2.0	3.5	Run head
39	49.1		240	81	19,424	2.5	4.0	Run body
40	49.0		23	95	2,180	2.5	3.0	Run tail
41	48.8		1080	114	122,953	1.5	3.0	Riffle

Habitat unit (NSO)	RM	March 2009 survey site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
42	48.8		36	97	3,505	1.5	2.0	Run head
43	48.7		749	93	69,528	2.5	4.0	Run body
44	48.7		39	110	4,304	2.0	3.0	Run tail
45	48.4		1275	117	149,495	1.5	2.0	Riffle
46	48.4		92	102	9,378	1.5	2.0	Run head
47	48.3		915	111	101,397	3.5	5.0	Run body
48	48.2		153	127	19,368	1.5	2.0	Run tail
49	48.2		346	75	25,887	1.5	2.0	Riffle
50	48.2		40	60	2,392	2.0	2.0	Run head
51	48.1		380	53	20,027	5.0	8.0	Run body
52	48.1		114	56	6,430	3.0	3.5	Run tail
53	48.0	Yes	234	54	12,554	1.5	2.0	Riffle
54	48.0		164	89	14,569	5.0	7.0	Pool head
55	47.2		4036	143	579,150	7.0	15.0	Pool body
56	47.2		136	115	15,575	1.5	2.5	Pool tail
57	47.1		740	80	58,852	1.5	2.0	Riffle
58	47.0	Yes	136	85	11,535	2.0	3.0	Run head
59	46.9	Yes	472	76	36,067	4.0	6.0	Run body
60	46.9	Yes	137	86	11,760	1.5	2.5	Run tail
61	46.9		318	81	25,666	1.0	2.0	Riffle
62	46.9		64	85	5,428	1.5	2.0	Run head
63	46.8		188	90	16,848	2.0	3.0	Run body
64	46.8		126	131	16,480	1.0	2.5	Run tail
65	46.8		100	123	12,268	0.8	1.5	Riffle
66	46.8		153	96	14,675	1.5	2.0	Run head
67	46.0		3829	97	370,148	4.0	6.0	Run body
68	46.0		89	133	11,835	1.5	2.0	Run tail
69	45.9		234	95	22,286	4.0	7.0	Run body
70	45.9		277	76	21,181	1.5	2.0	Riffle
71	45.9		61	93	5,701	2.0		Run head
72	45.8		243	94	22,751	2.5	3.5	Run body
73	45.8		125	64	7,976	1.5	2.0	Run tail
74	45.7		243	40	9,820	0.8	1.8	Riffle
75	45.7		90	35	3,141	1.5	2.0	Run head
76	45.7		88	50	4,433	1.5	4.0	Run body
77	45.7		32	99	3,153	1.5	2.0	Run tail
78	45.6		675	109	73,797	1.5	2.0	Riffle
79	45.6		85	178	15,127	1.5	2.0	Run head
80	45.4		1040	120	124,357	3.5	5.0	Run body
81	45.3		301	101	30,519	7.0	11.0	Pool body
82	45.3	Yes	126	220	27,658	2.0	3.0	Run head
83	45.1	Yes	1182	97	114,144	4.0	6.0	Run body
84	45.1	Yes	94	113	10,640	1.5	5.0	Run tail
85	45.0		394	52	20,673	1.5	2.0	Riffle

Habitat unit (NSO)	RM	March 2009 survey site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
86	45.0	Yes	53	41	2,181	2.0	3.0	Pool head
87	44.9	Yes	101	71	7,213	5.0	8.0	Pool body
88	44.9	Yes	80	121	9,661	3.0	4.0	Pool tail
89	44.8		734	59	43,114	1.5	2.5	Riffle
90	44.8		22	107	2,350	0.8	1.5	Run head
91	44.8		318	62	19,745	1.5	2.5	Run body
92	44.8		15	25	368	1.0	1.5	Run tail
93	44.7		100	30	3,032	1.5	2.0	Riffle
94	44.7		47	26	1,217	1.0	1.5	Run head
95	44.7		248	67	16,708	4.0	8.0	Run body
96	44.7		34	87	2,950	1.5	2.0	Run tail
97	44.6	Yes	417	52	21,741	1.5	2.5	Riffle
98	44.6		20	49	984	2.0	2.5	Run head
99	44.6		203	53	10,740	3.0	4.0	Run body
100	44.5		20	59	1,182	1.0	1.5	Run tail
101	44.5		472	59	27,744	1.5	2.0	Riffle
102	44.5		10	68	681	2.0	2.5	Run head
103	43.9		3209	82	261,993	3.0	3.0	Run body
104	43.7		683	144	98,065	6.0	15.0	Pool body
105	43.3		2173	146	316,376	4.0	6.0	Run body
106	43.3		50	110	5,487	1.5	2.0	Run tail
107	43.2	Yes	326	81	26,534	1.5	2.0	Riffle
108	43.2	Yes	41	74	3,020	1.0	2.0	Run head
109	43.1	Yes	906	62	56,464	2.5	6.0	Run body
110	43.1	Yes	36	49	1,771	2.0	2.5	Run tail
111	43.0	Yes	238	42	10,077	0.8	1.2	Riffle
112	43.0	Yes	50	48	2,392	1.5	2.5	Pool head
113	43.0	Yes	159	166	26,397	5.0	7.0	Pool body
114	43.0	Yes	46	169	7,767	1.5	5.0	Pool tail
115	43.0		33	154	5,097	2.0	3.0	Run head
116	42.9		309	124	38,258	4.0	10.0	Run body
117	42.9		18	84	1,518	1.0	1.5	Run tail
118	42.9	Yes	77	57	4,403	1.0	2.0	Riffle
119	42.9		31	45	1,395	2.0	2.5	Run head
120	42.7		978	87	84,726	1.0	8.0	Run body
121	42.7		12	78	932	1.5	2.5	Run tail
122	42.7		89	48	4,288	1.0	3.0	Riffle
123	42.7		18	55	991	2.5	3.0	Run head
124	42.4		1571	77	120,609	2.0	5.0	Run body
125	42.4		69	96	6,600	1.5	2.0	Run body
126	42.3		227	55	12,478	1.0	3.0	Riffle
127	42.3		84	23	1,953	1.5	4.0	Run body
128	42.3		265	32	8,417	1.5	2.3	Riffle
129	42.2		25	28	699	1.5	3.0	Run head

Habitat unit (NSO)	RM	March 2009 survey site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
130	42.1		1066	62	65,871	2.0	4.0	Run body
131	42.0		53	60	3,196	1.0	1.5	Run tail
132	41.9		521	64	33,202	1.0	1.5	Riffle
133	41.9		41	46	1,877	2.0	2.5	Run head
134	41.8		940	82	77,063	2.0	4.0	Run body
135	41.8		47	96	4,525	0.8	1.5	Run tail
136	41.7		300	90	27,080	0.8	1.5	Riffle
137	41.7		59	70	4,133	1.5	2.0	Run head
138	41.2		2512	123	308,848	3.0	6.0	Run body
139	41.2		125	151	18,858	1.0	1.3	Run tail
140	41.1		312	107	33,422	1.0	1.5	Riffle
141	41.1		102	163	16,604	1.5	2.0	Run head
142	41.0		666	185	122,933	2.0	4.5	Run body
143	41.0		83	182	15,121	0.8	1.3	Run tail
144	40.9		189	32	6,116	0.8	1.5	Riffle
145	40.9		62	39	2,425	1.5	2.0	Run head
146	40.5		2207	101	223,893	5.0	9.0	Run body
147	40.5		54	53	2,861	1.5	2.0	Run tail
148	40.4		638	53	33,978	1.5	2.5	Riffle
149	40.4		37	83	3,076	1.5	2.0	Run head
150	40.3		502	94	47,268	2.5	4.0	Run body
151	40.3		34	81	2,767	1.0	1.5	Run tail
152	40.2		503	53	26,860	0.8	1.5	Riffle
153	40.2		51	68	3,462	1.5	2.0	Run head
154	39.7		2569	123	317,216	3.0	7.0	Run body
155	39.7		26	142	3,699	1.5		Run tail
156	39.7		219	91	19,859	0.8	1.0	Riffle
157	39.6	Yes	86	62	5,294	3.0	4.0	Run head
158	39.5	Yes	857	97	82,763	6.0	6.6	Run body
159	39.5	Yes	98	81	7,993	2.5	3.0	Run tail
160	39.4	Yes	84	62	5,246	1.0	1.5	Riffle
161	39.4		123	41	5,102	3.5	4.5	Run head
162	39.3		713	50	35,662	5.0	7.5	Run body
163	39.3		151	80	12,041	3.5	5.0	Run tail
164	39.2		104	98	10,131	1.0	1.5	Riffle
165	39.2		93	117	10,818	3.5	4.0	Pool head
166	38.9		1496	90	134,259	6.5	9.9	Pool body
167	38.9		99	91	9,033	3.0	4.0	Pool tail
168	38.9	Yes	73	92	6,682	1.5	3.0	Riffle
169	38.9		76	108	8,227	4.0	5.0	Run head
170	38.8		498	77	38,331	5.5	7.2	Run body
171	38.8		121	83	10,096	7.0	10.5	Pool body
172	38.8		87	98	8,506	3.0	4.0	Run head
173	38.7		324	85	27,545	4.0	5.0	Run body

Habitat unit (NSO)	RM	March 2009 survey site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
174	38.7		99	100	9,935	3.0	4.0	Run tail
175	38.7	Yes	61	118	7,163	1.5	2.3	Riffle
176	38.6		148	105	15,607	2.5	3.5	Run head
177	38.6		219	91	19,976	4.0	4.8	Run body
178	38.6		115	57	6,513	2.0	2.5	Run tail
179	38.5		412	55	22,840	1.2	2.0	Riffle
180	38.5		75	68	5,113	4.0	6.0	Run head
181	38.4		657	39	25,600	4.0	5.0	Run body
182	38.3		205	68	13,869	8.5	10.5	Pool body
183	38.3		183	66	12,189	4.5	10.5	Pool tail
184	38.3		129	102	13,154	2.5	6.0	Run head
185	38.2		137	139	18,966	2.0	2.5	Run body
186	38.2		134	149	19,976	2.0	2.0	Run tail
187	38.2		285	143	40,886	1.0	1.5	Riffle
188	38.1	Yes	86	93	7,964	2.5	4.0	Pool head
189	38.1	Yes	235	81	19,027	6.0	10.0	Pool body
190	38.1	Yes	55	145	7,947	2.5	4.0	Pool tail
191	38.1		89	115	10,283	1.0	2.0	Riffle
192	38.1	Yes	46	89	4,147	4.0	6.0	Pool head
193	38.0	Yes	378	83	31,490	8.0	13.0	Pool body
194	38.0	Yes	81	91	7,365	2.0	3.5	Pool tail
195	38.0		63	64	4,010	3.0	3.5	Run head
196	37.9		271	72	19,591	4.0	5.5	Run body
197	37.9		84	92	7,736	3.0	3.5	Run tail
198	37.8		227	75	17,099	2.0	2.5	Riffle
199	37.8		115	42	4,779	4.0	4.5	Pool head
200	37.7		926	78	72,513	4.0	6.6	Pool body
201	37.6		114	117	13,311	3.0	4.0	Pool tail
202	37.6		163	97	15,857	0.8	1.5	Riffle
203	37.6		130	88	11,423	2.0	3.0	Run head
204	37.5		618	91	55,953	2.5	3.5	Run body
205	37.4		102	77	7,851	2.0	3.0	Run tail
206	37.3		769	50	38,658	1.7	2.5	Riffle
207	37.3		99	58	5,710	2.5	4.0	Run head
208	37.1		916	57	51,803	3.5	4.5	Run body
209	37.1		58	52	3,054	2.0	3.0	Run tail
210	37.0		266	40	10,767	1.5	2.0	Riffle
211	37.0		127	36	4,530	5.0	7.0	Run head
212	36.9		370	80	29,741	5.5	7.6	Run body
213	36.9		85	98	8,321	2.0	3.0	Run tail
214	36.9	Yes	70	83	5,779	3.0	5.0	Pool head
215	36.9	Yes	126	58	7,330	7.0	10.5	Pool body
216	36.9	Yes	94	48	4,471	4.0	5.0	Pool tail
217	36.8		357	60	21,436	1.5	2.0	Riffle

Habitat unit (NSO)	RM	March 2009 survey site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
218	36.8	Yes	157	75	11,815	3.0	4.0	Run head
219	36.6	Yes	675	97	65,353	3.0	6.0	Run body
220	36.6	Yes	62	86	5,313	3.0	4.0	Run tail
221	36.6		178	74	13,173	1.0	1.5	Riffle
222	36.6		181	71	12,919	3.0	5.0	Run head
223	36.4		1047	90	94,576	6.5	8.3	Run body
224	36.3		115	97	11,107	3.0	3.5	Run tail
225	36.3		224	92	20,644	1.5	2.0	Riffle
226	36.3		69	79	5,484	2.0	2.5	Run head
227	36.3		213	65	13,878	2.0	2.5	Run body
228	36.2		70	58	4,092	1.5	2.0	Run tail
229	36.2		74	54	4,022	1.2	2.0	Riffle
230	36.2	Yes	89	72	6,363	4.0	9.8	Pool head
231	36.2	Yes	175	131	22,846	6.0	12.3	Pool body
232	36.2	Yes	106	107	11,336	4.0	6.0	Pool tail
233	36.1		211	78	16,529	2.0	3.0	Pool head
234	35.7		2458	72	177,862	9.0	13.4	Pool body
235	35.6		210	53	11,010	3.0	3.5	Pool tail
236	35.5		353	97	34,136	1.0	1.5	Riffle
237	35.5		368	126	46,431	2.0	3.0	Run head
238	35.2		1394	100	139,804	3.5	7.0	Run body
239	35.2		48	84	4,006	3.0	4.0	Run tail
240	35.2		81	79	6,351	2.0	3.0	Riffle
241	35.2		70	60	4,157	3.0	4.0	Run head
242	35.2		74	68	5,054	4.5	5.8	Run body
243	35.1		62	65	3,996	1.5	2.0	Run tail
244	35.1		501	54	27,305	2.0	3.0	Riffle
245	35.0		79	82	6,466	1.5	2.5	Run head
246	35.0		302	65	19,636	2.0	3.0	Run body
247	35.0		114	31	3,548	1.5	2.0	Run tail
248	34.9		62	50	3,125	1.5	2.0	Riffle
249	34.9		151	50	7,602	3.0	4.0	Run head
250	34.7		1255	62	78,340	3.5	7.0	Run body
251	34.6		351	66	23,058	6.5	10.5	Pool body
252	34.6		119	82	9,791	3.0	4.0	Pool tail
253	34.5		293	77	22,628	1.0	2.0	Riffle
254	34.5		61	63	3,879	8.0	12.0	Pool head
255	34.4		445	79	35,344	4.0	8.0	Pool body
256	34.1		1722	91	157,333	3.0	4.0	Run body
257	34.1		137	81	11,136	1.5	2.0	Run tail
258	34.1		130	70	9,152	1.0	1.5	Riffle
259	34.0	Yes	103	79	8,137	2.0	2.5	Run head
260	34.0	Yes	452	59	26,907	2.5	3.5	Run body
261	33.9	Yes	142	38	5,468	1.5	2.0	Run tail

Habitat unit (NSO)	RM	March 2009 survey site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
262	33.8		505	32	16,314	1.0	1.5	Riffle
263	33.8		86	53	4,509	2.0	2.5	Run head
264	33.8		265	52	13,757	3.0	3.5	Run body
265	33.8		59	57	3,342	2.0	2.5	Run tail
266	33.7		524	43	22,663	2.0	4.0	Riffle
267	33.6		241	67	16,237	3.0	4.0	Run head
268	33.5		690	116	79,804	2.5	5.0	Run body
269	33.4		231	79	18,336	1.0	2.0	Run tail
270	33.4		163	63	10,208	1.0	1.5	Riffle
271	33.4	Yes	49	74	3,588	6.0	7.5	Pool head
272	33.2	Yes	898	71	63,477	9.0	12.0	Pool body
273	33.2	Yes	102	39	3,988	2.0	3.0	Pool tail
274	33.2		190	55	10,514	1.0	1.5	Riffle
275	33.2		103	71	7,311	1.5	2.5	Run head
276	33.1		343	105	35,908	2.0	2.5	Run body
277	33.1		136	118	16,054	1.5	2.0	Run tail
278	33.0		312	62	19,368	1.0	1.5	Riffle
279	33.0		209	35	7,298	3.5	6.0	Run head
280	32.1		4454	174	776,561	5.5	9.2	Run body
281	32.1		143	124	17,763	4.0	5.5	Run tail
282	32.0		293	100	29,228	1.0	1.5	Riffle
283	32.0		163	107	17,489	2.5	3.0	Run head
284	32.0		294	86	25,244	3.5	4.0	Run body
285	31.9		41	86	3,565	2.0	3.7	Run tail
286	31.9		290	87	25,317	1.0	2.0	Riffle
287	31.9	Yes	157	43	6,710	2.5	3.0	Run head
288	31.7	Yes	838	55	45,952	3.5	5.0	Run body
289	31.7	Yes	112	85	9,543	2.5	3.0	Run tail
290	31.6		181	100	18,051	1.0	2.0	Riffle
291	31.6		148	108	15,990	4.0	5.5	Run head
292	31.5		475	89	42,320	5.0	6.0	Run body
293	31.5		154	62	9,597	1.5	2.5	Run tail
294	31.5		175	74	13,012	1.0	1.5	Riffle
295	31.4		210	100	21,058	3.0	4.5	Run head
296	31.3		567	87	49,612	4.0	5.5	Run body
297	31.3		139	54	7,465	2.5	4.0	Run tail
298	31.2		538	44	23,863	1.5	2.5	Riffle
299	31.2		122	70	8,583	3.5	4.5	Run head
300	31.1		240	61	14,568	3.5	5.0	Run body
301	31.1		41	72	2,974	2.0	3.0	Run tail
302	31.1		206	66	13,664	1.3	2.0	Riffle
303	31.1		98	75	7,324	3.0	4.0	Run head
304	30.7		1892	85	160,847	4.0	5.5	Run body
305	30.7		200	102	20,508	1.5	2.5	Run tail

Habitat unit (NSO)	RM	March 2009 survey site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
306	30.6		113	83	9,452	1.2	2.0	Riffle
307	30.6		113	69	7,775	2.0	3.5	Run head
308	30.5		513	74	37,874	3.5	6.5	Run body
309	30.5		157	95	14,947	2.5	3.5	Run tail
310	30.4		259	37	9,478	1.0	2.0	Riffle
311	30.4		71	40	2,836	2.5	3.0	Run head
312	30.4		188	47	8,790	2.5	3.0	Run body
313	30.4		59	49	2,887	1.5	3.0	Run tail
314	30.2		946	43	40,519	1.2	2.0	Riffle
315	30.2		263	49	12,952	2.5	3.0	Run head
316	30.1		123	60	7,371	2.5	5.0	Run body
317	30.1		52	71	3,674	2.0	3.0	Run tail
318	30.1		189	298	56,219	1.5	2.0	Riffle
319	30.0		329	171	56,219	2.0	3.0	Run head
320	29.7		1444	155	224,395	5.0	8.0	Run body
321	29.7		68	59	3,978	3.0	4.0	Run tail
322	29.6		681	329	223,763	11.0	15.7	Pool body
323	29.6		222	84	18,626	3.0	7.0	Pool tail
324	29.5	Yes	109	38	4,188	1.0	2.0	Riffle
325	29.5	Yes	110	55	6,041	4.0	5.0	Run head
326	29.5	Yes	190	51	9,726	3.0	4.0	Run body
327	29.5	Yes	52	63	3,270	2.0	3.0	Run tail
328	29.5		70	58	4,066	1.2	2.0	Riffle
329	29.4		88	40	3,575	3.5	4.0	Run head
330	29.4		301	53	15,958	3.5	4.5	Run body
331	29.4		169	79	13,387	1.5	2.5	Run tail
332	29.3		192	168	32,257	1.2	2.0	Riffle
333	29.3		131	139	18,145	2.0	3.8	Run head
334	29.2		402	110	44,240	3.0	5.0	Run body
335	29.2		51	135	6,896	2.0	3.5	Run tail
336	29.2		247	92	22,792	1.0	1.5	Riffle
337	29.1		103	88	9,057	2.5	3.0	Run head
338	29.1		168	89	14,954	3.5	4.5	Run body
339	29.0		331	127	42,219	2.0	2.5	Run tail
340	29.0		447	90	40,119	1.5	2.0	Riffle

Table D-2. Percent cover and type for habitat units within the study area.

River mile	Habitat unit (NSO)	Habitat type	Habitat survey date	No cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aquatic vegetation (%)
51.8	1	Pool head	7/8/2008	90	5			5	
51.7	2	Pool body	7/8/2008	80					20
51.7	3	Pool tail	7/8/2008	100					
51.6	4	Pool head	7/8/2008	100					
51.6	5	Pool body	7/8/2008	90					10
51.5	6	Pool tail	7/8/2008	100					
51.5	7	Riffle	7/8/2008	90	5			5	
51.4	8	Run head	7/8/2008	85				5	10
51.1	9	Run body	7/8/2008	60	10				30
51.0	10	Run tail	7/8/2008	90					10
50.9	11	Pool body	7/8/2008	50					50
50.8	12	Run body	7/8/2008	45	5				50
50.8	13	Run tail	7/8/2008	90				10	
50.6	14	Riffle	7/8/2008	80	10		10		
50.6	15	Run head	7/8/2008	90	10				
50.5	16	Run body	7/8/2008	95				5	
50.4	17	Run tail	7/8/2008	90				5	
50.3	18	Riffle	7/8/2008	90	5				5
50.3	19	Run head	7/8/2008	90					10
50.1	20	Run body	7/8/2008	95				5	
50.1	21	Run tail	7/8/2008	90	5			5	
50.1	22	Riffle	7/8/2008	95					5
50.0	23	Run head	7/8/2008	95				5	
49.9	24	Run body	7/8/2008	95				5	
49.8	25	Run tail	7/8/2008	95				5	
49.7	26	Riffle	7/8/2008	90	5			5	
49.7	27	Pool head	7/8/2008	85	10			5	
49.6	28	Pool body	7/8/2008	85	10			5	
49.6	29	Pool tail	7/8/2008	85	10			5	
49.6	30	Run head	7/8/2008	100					
49.3	31	Run body	7/8/2008	95		5			
49.3	32	Run tail	7/8/2008	95				5	
49.2	33	Riffle	7/8/2008	90	5			5	
49.2	34	Run head	7/8/2008	85	5			10	
49.1	35	Run body	7/8/2008	85	5			10	
49.1	36	Run tail	7/8/2008	95				5	
49.1	37	Riffle	7/8/2008	95				5	
49.1	38	Run head	7/8/2008	90		5		5	
49.1	39	Run body	7/8/2008	90	5			5	
49.0	40	Run tail	7/8/2008	95				5	
48.8	41	Riffle	7/8/2008	95				5	
48.8	42	Run head	7/8/2008	75				5	20
48.7	43	Run body	7/8/2008	90				10	

River mile	Habitat unit (NSO)	Habitat type	Habitat survey date	No cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aquatic vegetation (%)
48.7	44	Run tail	7/8/2008	95				5	
48.4	45	Riffle	7/8/2008	90				10	
48.4	46	Run head	7/8/2008	90				10	
48.3	47	Run body	7/8/2008	90				10	
48.2	48	Run tail	7/8/2008	90				10	
48.2	49	Riffle	7/8/2008	90				10	
48.2	50	Run head	7/8/2008	90		5		5	
48.1	51	Run body	7/8/2008	95	5				
48.1	52	Run tail	7/8/2008	95	5				
48.0	53	Riffle	7/8/2008	95				5	
48.0	54	Pool head	7/8/2008	85	10			5	
47.2	55	Pool body	7/8/2008	85	10			5	
47.2	56	Pool tail	7/8/2008	95				5	
47.1	57	Riffle	7/8/2008	100					
47.0	58	Run head	7/8/2008	100					
46.9	59	Run body	7/8/2008	95				5	
46.9	60	Run tail	7/8/2008	90				10	
46.9	61	Riffle	7/8/2008	95				5	
46.9	62	Run head	7/8/2008	90				10	
46.8	63	Run body	7/8/2008	95				5	
46.8	64	Run tail	7/8/2008	95				5	
46.8	65	Riffle	7/8/2008	95				5	
46.8	66	Run head	7/8/2008	100					
46.0	67	Run body	7/8/2008	95				5	
46.0	68	Run tail	7/8/2008	95				5	
45.9	69	Run body	7/8/2008	100					
45.9	70	Riffle	7/8/2008	90				10	
45.9	71	Run head	7/8/2008	95				5	
45.8	72	Run body	7/8/2008	95				5	
45.8	73	Run tail	7/8/2008	100					
45.7	74	Riffle	7/8/2008	95				5	
45.7	75	Run head	7/9/2008	90				10	
45.7	76	Run body	7/9/2008	90				10	
45.7	77	Run tail	7/9/2008	100					
45.6	78	Riffle	7/9/2008	95				5	
45.6	79	Run head	7/9/2008	85				5	10
45.4	80	Run body	7/9/2008	80	15			5	
45.3	81	Pool body	7/9/2008	40		5		5	50
45.3	82	Run head	7/9/2008	45				5	50
45.1	83	Run body	7/9/2008	35		5		10	50
45.1	84	Run tail	7/9/2008	75		5		20	
45.0	85	Riffle	7/9/2008	70		5		25	
45.0	86	Pool head	7/9/2008	85		5		10	
44.9	87	Pool body	7/9/2008	90		5		5	
44.9	88	Pool tail	7/9/2008	95					5

River mile	Habitat unit (NSO)	Habitat type	Habitat survey date	No cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aquatic vegetation (%)
44.8	89	Riffle	7/9/2008	90				10	
44.8	90	Run head	7/9/2008	90		5		5	
44.8	91	Run body	7/9/2008	100					
44.8	92	Run tail	7/9/2008	85				15	
44.7	93	Riffle	7/9/2008	80				20	
44.7	94	Run head	7/9/2008	90				10	
44.7	95	Run body	7/9/2008	100					
44.7	96	Run tail	7/9/2008	95				5	
44.6	97	Riffle	7/9/2008	90				10	
44.6	98	Run head	7/9/2008	95				5	
44.6	99	Run body	7/9/2008	95				5	
44.5	100	Run tail	7/9/2008	95				5	
44.5	101	Riffle	7/9/2008	95				5	
44.5	102	Run head	7/9/2008	100					
43.9	103	Run body	7/9/2008	90				10	
43.7	104	Pool body	7/9/2008	65				5	30
43.3	105	Run body	7/9/2008	65				5	30
43.3	106	Run tail	7/9/2008	90				5	5
43.2	107	Riffle	7/9/2008	85		5		10	
43.2	108	Run head	7/9/2008	95				5	
43.1	109	Run body	7/9/2008	95				5	
43.1	110	Run tail	7/9/2008	90				10	
43.0	111	Riffle	7/9/2008	95				5	
43.0	112	Pool head	7/9/2008	65		5			30
43.0	113	Pool body	7/9/2008	60		10			30
43.0	114	Pool tail	7/9/2008	70		25		5	
43.0	115	Run head	7/9/2008	70		20		10	
42.9	116	Run body	7/9/2008	100					
42.9	117	Run tail	7/9/2008	95				5	
42.9	118	Riffle	7/9/2008	95				5	
42.9	119	Run head	7/9/2008	95				5	
42.7	120	Run body	7/9/2008	95				5	
42.7	121	Run tail	7/9/2008	95				5	
42.7	122	Riffle	7/9/2008	90				5	5
42.7	123	Run head	7/9/2008	95				5	
42.4	124	Run body	7/9/2008	95				5	
42.4	125	Run body	7/9/2008	95				5	
42.3	126	Riffle	7/9/2008	80				20	
42.3	127	Run body	7/9/2008	100					
42.3	128	Riffle	7/9/2008	75	5	5		15	
42.2	129	Run head	7/9/2008	90				10	
42.1	130	Run body	7/9/2008	90				10	
42.0	131	Run tail	7/9/2008	95				5	
41.9	132	Riffle	7/9/2008	95				5	
41.9	133	Run head	7/9/2008	95				5	

River mile	Habitat unit (NSO)	Habitat type	Habitat survey date	No cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aquatic vegetation (%)
41.8	134	Run body	7/9/2008	95				5	
41.8	135	Run tail	7/9/2008	95				5	
41.7	136	Riffle	7/9/2008	95				5	
41.7	137	Run head	7/9/2008	90				10	
41.2	138	Run body	7/9/2008	100					
41.2	139	Run tail	7/9/2008	95				5	
41.1	140	Riffle	7/9/2008	95				5	
41.1	141	Run head	7/9/2008	80					20
41.0	142	Run body	7/9/2008	95				5	
41.0	143	Run tail	7/9/2008	95				5	
40.9	144	Riffle	7/9/2008	95				5	
40.9	145	Run head	7/9/2008	100					
40.5	146	Run body	7/9/2008	65				10	25
40.5	147	Run tail	7/9/2008	85				15	
40.4	148	Riffle	7/9/2008	70				30	
40.4	149	Run head	7/9/2008	75				5	20
40.3	150	Run body	7/9/2008	100					
40.3	151	Run tail	7/9/2008	100					
40.2	152	Riffle	7/9/2008	95				5	
40.2	153	Run head	7/9/2008	100					
39.7	154	Run body	7/9/2008	95				5	
39.7	155	Run tail	7/9/2008	95				5	
39.7	156	Riffle	2/10/2009	95					5
39.6	157	Run head	2/10/2009	100					
39.5	158	Run body	2/10/2009	80					20
39.5	159	Run tail	2/10/2009	80					20
39.4	160	Riffle	2/10/2009	95					5
39.4	161	Run head	2/10/2009	95					
39.3	162	Run body	2/10/2009	95				5	
39.3	163	Run tail	2/10/2009	95				5	
39.2	164	Riffle	2/10/2009	95					5
39.2	165	Pool head	2/10/2009	100					
38.9	166	Pool body	2/10/2009	90					10
38.9	167	Pool tail	2/10/2009	100					
38.9	168	Riffle	2/10/2009	100					
38.9	169	Run head	2/10/2009	100					
38.8	170	Run body	2/10/2009	100					
38.8	171	Pool body	2/10/2009	90				5	5
38.8	172	Run head	2/10/2009	95				5	
38.7	173	Run body	2/10/2009	95				5	
38.7	174	Run tail	2/10/2009	100					
38.7	175	Riffle	2/10/2009	100					
38.6	176	Run head	2/10/2009	100					
38.6	177	Run body	2/10/2009	100					
38.6	178	Run tail	2/10/2009	100					

River mile	Habitat unit (NSO)	Habitat type	Habitat survey date	No cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aquatic vegetation (%)
38.5	179	Riffle	2/10/2009	100					
38.5	180	Run head	2/10/2009	90					10
38.4	181	Run body	2/10/2009	100					
38.3	182	Pool body	2/10/2009	80					20
38.3	183	Pool tail	2/10/2009	90				5	5
38.3	184	Run head	2/10/2009	100					
38.2	185	Run body	2/10/2009	100					
38.2	186	Run tail	2/10/2009	100					
38.2	187	Riffle	2/10/2009	95				5	
38.1	188	Pool head	2/10/2009	95				5	
38.1	189	Pool body	2/11/2009	90					10
38.1	190	Pool tail	2/11/2009	100					
38.1	191	Riffle	2/11/2009	100					
38.1	192	Pool head	2/11/2009	90					10
38.0	193	Pool body	2/11/2009	70					30
38.0	194	Pool tail	2/11/2009	100					
38.0	195	Run head	2/11/2009	100					
37.9	196	Run body	2/11/2009	100					
37.9	197	Run tail	2/11/2009	100					
37.8	198	Riffle	2/11/2009	100					
37.8	199	Pool head	2/11/2009	85		15			
37.7	200	Pool body	2/11/2009	100					
37.6	201	Pool tail	2/11/2009	100					
37.6	202	Riffle	2/11/2009	100					
37.6	203	Run head	2/11/2009	100					
37.5	204	Run body	2/11/2009	100					
37.4	205	Run tail	2/11/2009	100					
37.3	206	Riffle	2/11/2009	100					
37.3	207	Run head	2/11/2009	100					
37.1	208	Run body	2/11/2009	100					
37.1	209	Run tail	2/11/2009	100					
37.0	210	Riffle	2/11/2009	100					
37.0	211	Run head	2/11/2009	100					
36.9	212	Run body	2/11/2009	100					
36.9	213	Run tail	2/11/2009	100					
36.9	214	Pool head	2/11/2009	100					
36.9	215	Pool body	2/11/2009	100					
36.9	216	Pool tail	2/11/2009	100					
36.8	217	Riffle	2/11/2009	100					
36.8	218	Run head	2/11/2009	100					
36.6	219	Run body	2/11/2009	100					
36.6	220	Run tail	2/11/2009	100					
36.6	221	Riffle	2/11/2009	100					
36.6	222	Run head	2/11/2009	100					
36.4	223	Run body	2/11/2009	100					

River mile	Habitat unit (NSO)	Habitat type	Habitat survey date	No cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aquatic vegetation (%)
36.3	224	Run tail	2/11/2009	100					
36.3	225	Riffle	2/11/2009	100					
36.3	226	Run head	2/11/2009	100					
36.3	227	Run body	2/11/2009	100					
36.2	228	Run tail	2/11/2009	100					
36.2	229	Riffle	2/11/2009	100					
36.2	230	Pool head	2/11/2009	100					
36.2	231	Pool body	2/11/2009	100					
36.2	232	Pool tail	2/11/2009	100					
36.1	233	Pool head	2/11/2009	100					
35.7	234	Pool body	2/11/2009	100					
35.6	235	Pool tail	2/11/2009	100					
35.5	236	Riffle	2/11/2009	100					
35.5	237	Run head	2/11/2009	100					
35.2	238	Run body	2/11/2009	100					
35.2	239	Run tail	2/12/2009	95				5	
35.2	240	Riffle	2/12/2009	100					
35.2	241	Run head	2/12/2009	100					
35.2	242	Run body	2/12/2009	100					
35.1	243	Run tail	2/12/2009	100					
35.1	244	Riffle	2/12/2009	100					
35.0	245	Run head	2/12/2009	95				5	
35.0	246	Run body	2/12/2009	95				5	
35.0	247	Run tail	2/12/2009	100					
34.9	248	Riffle	2/12/2009	100					
34.9	249	Run head	2/12/2009	95		5			
34.7	250	Run body	2/12/2009	100					
34.6	251	Pool body	2/12/2009	75				5	20
34.6	252	Pool tail	2/12/2009	100					
34.5	253	Riffle	2/12/2009	95				5	
34.5	254	Pool head	2/12/2009	100					
34.4	255	Pool body	2/12/2009	100					
34.1	256	Run body	2/12/2009	100					
34.1	257	Run tail	2/12/2009	95				5	
34.1	258	Riffle	2/12/2009	100					
34.0	259	Run head	2/12/2009	100					
34.0	260	Run body	2/12/2009	100					
33.9	261	Run tail	2/12/2009	100					
33.8	262	Riffle	2/12/2009	100					
33.8	263	Run head	2/12/2009	100					
33.8	264	Run body	2/12/2009	100					
33.8	265	Run tail	2/12/2009	100					
33.7	266	Riffle	2/12/2009	100					
33.6	267	Run head	2/12/2009	100					
33.5	268	Run body	2/12/2009	100					

River mile	Habitat unit (NSO)	Habitat type	Habitat survey date	No cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aquatic vegetation (%)
33.4	269	Run tail	2/12/2009	100					
33.4	270	Riffle	2/12/2009	100					
33.4	271	Pool head	2/12/2009	100					
33.2	272	Pool body	2/12/2009	70					30
33.2	273	Pool tail	2/12/2009	100					
33.2	274	Riffle	2/12/2009	100					
33.2	275	Run head	2/12/2009	100					
33.1	276	Run body	2/12/2009	95					5
33.1	277	Run tail	2/12/2009	100					
33.0	278	Riffle	2/12/2009	100					
33.0	279	Run head	2/12/2009	100					
32.1	280	Run body	2/12/2009	60					40
32.1	281	Run tail	2/12/2009						
32.0	282	Riffle	2/12/2009						
32.0	283	Run head	2/12/2009						
32.0	284	Run body	2/12/2009						
31.9	285	Run tail	2/12/2009						
31.9	286	Riffle	2/12/2009						
31.9	287	Run head	2/12/2009						
31.7	288	Run body	2/12/2009						
31.7	289	Run tail	2/12/2009						
31.6	290	Riffle	2/12/2009						
31.6	291	Run head	2/12/2009						
31.5	292	Run body	2/12/2009						
31.5	293	Run tail	2/12/2009						
31.5	294	Riffle	2/12/2009	100					
31.4	295	Run head	2/12/2009	100					
31.3	296	Run body	2/12/2009	100					
31.3	297	Run tail	2/12/2009	100					
31.2	298	Riffle	2/12/2009	100					
31.2	299	Run head	2/13/2009	100					
31.1	300	Run body	2/13/2009	100					
31.1	301	Run tail	2/13/2009	100					
31.1	302	Riffle	2/13/2009	100					
31.1	303	Run head	2/13/2009	100					
30.7	304	Run body	2/13/2009	100					
30.7	305	Run tail	2/13/2009	90					10
30.6	306	Riffle	2/13/2009	100					
30.6	307	Run head	2/13/2009	100					
30.5	308	Run body	2/13/2009	100					
30.5	309	Run tail	2/13/2009	100					
30.4	310	Riffle	2/13/2009	85				15	
30.4	311	Run head	2/13/2009	100					
30.4	312	Run body	2/13/2009	100					
30.4	313	Run tail	2/13/2009	100					

River mile	Habitat unit (NSO)	Habitat type	Habitat survey date	No cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aquatic vegetation (%)
30.2	314	Riffle	2/13/2009	90				10	
30.2	315	Run head	2/13/2009	100					
30.1	316	Run body	2/13/2009	100					
30.1	317	Run tail	2/13/2009	100					
30.1	318	Riffle	2/13/2009	100					
30.0	319	Run head	2/13/2009	100					
29.7	320	Run body	2/13/2009	70					30
29.7	321	Run tail	2/13/2009	90					10
29.6	322	Pool body	2/13/2009	100					
29.6	323	Pool tail	2/13/2009	100					
29.5	324	Riffle	2/13/2009	100					
29.5	325	Run head	2/13/2009	95	5				
29.5	326	Run body	2/13/2009	85					15
29.5	327	Run tail	2/13/2009	100					
29.5	328	Riffle	2/13/2009	100					
29.4	329	Run head	2/13/2009	100					
29.4	330	Run body	2/13/2009	100					
29.4	331	Run tail	2/13/2009	100					
29.3	332	Riffle	2/13/2009	90				10	
29.3	333	Run head	2/13/2009	100					
29.2	334	Run body	2/13/2009	100					
29.2	335	Run tail	2/13/2009	100					
29.2	336	Riffle	2/13/2009	100					
29.1	337	Run head	2/13/2009	100					
29.1	338	Run body	2/13/2009	90					10
29.0	339	Run tail	2/13/2009	100					
29.0	340	Riffle	2/13/2009	100					

Table D-3. Substrate types for habitat units within the study area.

River mile	NSO #	Habitat type	Habitat survey date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
51.8	1	Pool head	7/8/2008	10	50	40				
51.7	2	Pool body	7/8/2008	50	40	10				
51.7	3	Pool tail	7/8/2008	20	30	50				
51.6	4	Pool head	7/8/2008	50	20	30				
51.6	5	Pool body	7/8/2008	50	20	25		5		
51.5	6	Pool tail	7/8/2008	40	30	30				
51.5	7	Riffle	7/8/2008		30	60	10			
51.4	8	Run head	7/8/2008		20	60	10	10		
51.1	9	Run body	7/8/2008	15	15	60	10			
51.0	10	Run tail	7/8/2008			60	30	10		
50.9	11	Pool body	7/8/2008	20	10	50		20		
50.8	12	Run body	7/8/2008	20	10	50		20		
50.8	13	Run tail	7/8/2008			60	30	10		
50.6	14	Riffle	7/8/2008			60	30	10		
50.6	15	Run head	7/8/2008		10	50	40			
50.5	16	Run body	7/8/2008	10	10	60	20			
50.4	17	Run tail	7/8/2008		20	60	20			
50.3	18	Riffle	7/8/2008		20	60	20			
50.3	19	Run head	7/8/2008		20	60	20			
50.1	20	Run body	7/8/2008		20	60	20			
50.1	21	Run tail	7/8/2008		20	60	20			
50.1	22	Riffle	7/8/2008		20	60	20			
50.0	23	Run head	7/8/2008		20	60	20			
49.9	24	Run body	7/8/2008		60	20	20			
49.8	25	Run tail	7/8/2008		40	40	20			
49.7	26	Riffle	7/8/2008		20	60	20			
49.7	27	Pool head	7/8/2008	20	20	40	10	10		
49.6	28	Pool body	7/8/2008	20	20	40	10	10		
49.6	29	Pool tail	7/8/2008	10	20	60	10			
49.6	30	Run head	7/8/2008		20	60	20			
49.3	31	Run body	7/8/2008		20	60	20			
49.3	32	Run tail	7/8/2008		10	70	20			
49.2	33	Riffle	7/8/2008		10	70	20			
49.2	34	Run head	7/8/2008		10	70	20			
49.1	35	Run body	7/8/2008		10	70	20			
49.1	36	Run tail	7/8/2008		10	70	20			
49.1	37	Riffle	7/8/2008		10	70	20			
49.1	38	Run head	7/8/2008		10	70	20			
49.1	39	Run body	7/8/2008		10	70	20			
49.0	40	Run tail	7/8/2008		10	70	20			
48.8	41	Riffle	7/8/2008		10	70	20			
48.8	42	Run head	7/8/2008		10	70	20			
48.7	43	Run body	7/8/2008		40	40	20			

River mile	NSO #	Habitat type	Habitat survey date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
48.7	44	Run tail	7/8/2008		40	40	20			
48.4	45	Riffle	7/8/2008		20	60	20			
48.4	46	Run head	7/8/2008		10	40	50			
48.3	47	Run body	7/8/2008		10	50	40			
48.2	48	Run tail	7/8/2008		10	70	20			
48.2	49	Riffle	7/8/2008		10	70	20			
48.2	50	Run head	7/8/2008		10	70	20			
48.1	51	Run body	7/8/2008	20	10	50	20			
48.1	52	Run tail	7/8/2008	20	10	50	20			
48.0	53	Riffle	7/8/2008		10	70	20			
48.0	54	Pool head	7/8/2008	20	10	60	5	5		
47.2	55	Pool body	7/8/2008	20	10	60	5	5		
47.2	56	Pool tail	7/8/2008		10	70	20			
47.1	57	Riffle	7/8/2008		10	70	20			
47.0	58	Run head	7/8/2008		10	70	20			
46.9	59	Run body	7/8/2008	20	10	50	20			
46.9	60	Run tail	7/8/2008		20	60	20			
46.9	61	Riffle	7/8/2008		10	70	20			
46.9	62	Run head	7/8/2008		10	70	20			
46.8	63	Run body	7/8/2008		10	70	20			
46.8	64	Run tail	7/8/2008		10	60	30			
46.8	65	Riffle	7/8/2008		10	60	30			
46.8	66	Run head	7/8/2008		10	50	30	10		
46.0	67	Run body	7/8/2008		20	50	20	10		
46.0	68	Run tail	7/8/2008		10	70	20			
45.9	69	Run body	7/8/2008		10	70	20			
45.9	70	Riffle	7/8/2008			20	70	10		
45.9	71	Run head	7/8/2008			30	40	30		
45.8	72	Run body	7/8/2008			40	40	20		
45.8	73	Run tail	7/8/2008			40	50	10		
45.7	74	Riffle	7/8/2008			40	50	10		
45.7	75	Run head	7/9/2008		10	60	20	10		
45.7	76	Run body	7/9/2008		10	60	20	10		
45.7	77	Run tail	7/9/2008		10	60	20	10		
45.6	78	Riffle	7/9/2008			70	20	10		
45.6	79	Run head	7/9/2008		10	10	30	50		
45.4	80	Run body	7/9/2008	20	20	30		30		
45.3	81	Pool body	7/9/2008	30	20	20		30		
45.3	82	Run head	7/9/2008			10	30	50	10	
45.1	83	Run body	7/9/2008	10	20	50	10	10		
45.1	84	Run tail	7/9/2008		10	70	20			
45.0	85	Riffle	7/9/2008		10	60	30			
45.0	86	Pool head	7/9/2008		10	60	30			
44.9	87	Pool body	7/9/2008			60	20	20		
44.9	88	Pool tail	7/9/2008			60	20	20		

River mile	NSO #	Habitat type	Habitat survey date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
44.8	89	Riffle	7/9/2008		20	60	20			
44.8	90	Run head	7/9/2008			40	50	10		
44.8	91	Run body	7/9/2008		10	60	30			
44.8	92	Run tail	7/9/2008		10	60	30			
44.7	93	Riffle	7/9/2008			60	30	10		
44.7	94	Run head	7/9/2008			60	30	10		
44.7	95	Run body	7/9/2008							
44.7	96	Run tail	7/9/2008			40	10	50		
44.6	97	Riffle	7/9/2008		10	50	40			
44.6	98	Run head	7/9/2008		10	50	40			
44.6	99	Run body	7/9/2008		10	40	40	10		
44.5	100	Run tail	7/9/2008		10	40	40	10		
44.5	101	Riffle	7/9/2008	10	10	50	30			
44.5	102	Run head	7/9/2008		10	50	30	10		
43.9	103	Run body	7/9/2008	40	10	30	10	10		
43.7	104	Pool body	7/9/2008	20	10	20		50		
43.3	105	Run body	7/9/2008	20	10	20		50		
43.3	106	Run tail	7/9/2008		10	60	20	10		
43.2	107	Riffle	7/9/2008		10	60	30			
43.2	108	Run head	7/9/2008		10	60	20	10		
43.1	109	Run body	7/9/2008		10	60	30			
43.1	110	Run tail	7/9/2008		10	60	30			
43.0	111	Riffle	7/9/2008		10	60	30			
43.0	112	Pool head	7/9/2008		10	50	30	10		
43.0	113	Pool body	7/9/2008		10	50	30	10		
43.0	114	Pool tail	7/9/2008		10	50	30	10		
43.0	115	Run head	7/9/2008		10	50	30	10		
42.9	116	Run body	7/9/2008		10	60	30			
42.9	117	Run tail	7/9/2008		10	60	30			
42.9	118	Riffle	7/9/2008		10	60	30			
42.9	119	Run head	7/9/2008		20	50	30			
42.7	120	Run body	7/9/2008		20	50	30			
42.7	121	Run tail	7/9/2008		10	60	30			
42.7	122	Riffle	7/9/2008		10	50	40			
42.7	123	Run head	7/9/2008		10	50	40			
42.4	124	Run body	7/9/2008		10	50	40			
42.4	125	Run body	7/9/2008		10	50	40			
42.3	126	Riffle	7/9/2008		10	50	40			
42.3	127	Run body	7/9/2008	50		40	10			
42.3	128	Riffle	7/9/2008	15	10	50	20	5		
42.2	129	Run head	7/9/2008	15	10	50	20	5		
42.1	130	Run body	7/9/2008		10	60	30			
42.0	131	Run tail	7/9/2008		10	50	40			
41.9	132	Riffle	7/9/2008		15	50	35			
41.9	133	Run head	7/9/2008	15	15	45	25			

River mile	NSO #	Habitat type	Habitat survey date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
41.8	134	Run body	7/9/2008	15	15	40	20	10		
41.8	135	Run tail	7/9/2008		10	60	30			
41.7	136	Riffle	7/9/2008		10	60	30			
41.7	137	Run head	7/9/2008	15	10	50	25			
41.2	138	Run body	7/9/2008	15	10	50	25			
41.2	139	Run tail	7/9/2008		10	60	20	10		
41.1	140	Riffle	7/9/2008		10	50	30	10		
41.1	141	Run head	7/9/2008		10	50	30	10		
41.0	142	Run body	7/9/2008		10	50	30	10		
41.0	143	Run tail	7/9/2008		10	60	20	10		
40.9	144	Riffle	7/9/2008		10	60	20	10		
40.9	145	Run head	7/9/2008		10	50	40			
40.5	146	Run body	7/9/2008		50	20		30		
40.5	147	Run tail	7/9/2008		10	60	30			
40.4	148	Riffle	7/9/2008		10	50	40			
40.4	149	Run head	7/9/2008		10	50	30	10		
40.3	150	Run body	7/9/2008							
40.3	151	Run tail	7/9/2008		20	50	30			
40.2	152	Riffle	7/9/2008		20	50	30			
40.2	153	Run head	7/9/2008		20	50	30			
39.7	154	Run body	7/9/2008	20	10	50	10	10		
39.7	155	Run tail	7/9/2008		10	50	40			
39.7	156	Riffle	2/10/2009			50	40	10		
39.6	157	Run head	2/10/2009			30	20	50		
39.5	158	Run body	2/10/2009			30	20	50		
39.5	159	Run tail	2/10/2009			30	20	50		
39.4	160	Riffle	2/10/2009			50	40	10		
39.4	161	Run head	2/10/2009		10	50	30	10		
39.3	162	Run body	2/10/2009		10	50	30	10		
39.3	163	Run tail	2/10/2009	5		55	30	10		
39.2	164	Riffle	2/10/2009			50	40	10		
39.2	165	Pool head	2/10/2009			30	60	10		
38.9	166	Pool body	2/10/2009			20	50	30		
38.9	167	Pool tail	2/10/2009			50	40	10		
38.9	168	Riffle	2/10/2009			50	40	10		
38.9	169	Run head	2/10/2009			60	25	15		
38.8	170	Run body	2/10/2009			30	40	30		
38.8	171	Pool body	2/10/2009		5	60	20	15		
38.8	172	Run head	2/10/2009			60	30	10		
38.7	173	Run body	2/10/2009			60	30	10		
38.7	174	Run tail	2/10/2009			60	30	10		
38.7	175	Riffle	2/10/2009			60	30	10		
38.6	176	Run head	2/10/2009			60	30	10		
38.6	177	Run body	2/10/2009			60	30	10		
38.6	178	Run tail	2/10/2009			60	30	10		

River mile	NSO #	Habitat type	Habitat survey date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
38.5	179	Riffle	2/10/2009			60	30	10		
38.5	180	Run head	2/10/2009			50	20	30		
38.4	181	Run body	2/10/2009			60	30	10		
38.3	182	Pool body	2/10/2009		5	45	20	30		
38.3	183	Pool tail	2/10/2009		5	60	20	15		
38.3	184	Run head	2/10/2009			60	30	10		
38.2	185	Run body	2/10/2009			70	20	10		
38.2	186	Run tail	2/10/2009			60	30	10		
38.2	187	Riffle	2/10/2009			70	20	10		
38.1	188	Pool head	2/10/2009			60	30	10		
38.1	189	Pool body	2/11/2009		5	60	25	10		
38.1	190	Pool tail	2/11/2009			60	20	10	10	
38.1	191	Riffle	2/11/2009			70	20	10		
38.1	192	Pool head	2/11/2009			50	20	20	10	
38.0	193	Pool body	2/11/2009	20		20	30	30		
38.0	194	Pool tail	2/11/2009			40	40	20		
38.0	195	Run head	2/11/2009			50	40	10		
37.9	196	Run body	2/11/2009			60	30	10		
37.9	197	Run tail	2/11/2009			60	30	5	5	
37.8	198	Riffle	2/11/2009			60	30	10		
37.8	199	Pool head	2/11/2009			60	30	10		
37.7	200	Pool body	2/11/2009	10			60	30		
37.6	201	Pool tail	2/11/2009			5	75	20		
37.6	202	Riffle	2/11/2009	5		5	80	10		
37.6	203	Run head	2/11/2009			10	60	20	10	
37.5	204	Run body	2/11/2009			30	60	10		
37.4	205	Run tail	2/11/2009			40	60			
37.3	206	Riffle	2/11/2009			40	60			
37.3	207	Run head	2/11/2009			50	40	10		
37.1	208	Run body	2/11/2009			50	40	10		
37.1	209	Run tail	2/11/2009			50	50			
37.0	210	Riffle	2/11/2009			60	40			
37.0	211	Run head	2/11/2009			50	40	10		
36.9	212	Run body	2/11/2009			10	60	30		
36.9	213	Run tail	2/11/2009			20	70	10		
36.9	214	Pool head	2/11/2009			20	70	10		
36.9	215	Pool body	2/11/2009			20	50	30		
36.9	216	Pool tail	2/11/2009			10	60	30		
36.8	217	Riffle	2/11/2009			30	60	10		
36.8	218	Run head	2/11/2009			40	50	10		
36.6	219	Run body	2/11/2009			20	40	40		
36.6	220	Run tail	2/11/2009			20	60	20		
36.6	221	Riffle	2/11/2009			30	60	10		
36.6	222	Run head	2/11/2009			40	60			
36.4	223	Run body	2/11/2009			20	60	20		

River mile	NSO #	Habitat type	Habitat survey date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
36.3	224	Run tail	2/11/2009			30	60	10		
36.3	225	Riffle	2/11/2009			30	60	10		
36.3	226	Run head	2/11/2009			30	60	10		
36.3	227	Run body	2/11/2009			30	60	10		
36.2	228	Run tail	2/11/2009			30	60	10		
36.2	229	Riffle	2/11/2009			30	60	10		
36.2	230	Pool head	2/11/2009			30	60	10		
36.2	231	Pool body	2/11/2009			30	60	10		
36.2	232	Pool tail	2/11/2009			20	60	20		
36.1	233	Pool head	2/11/2009				80	20		
35.7	234	Pool body	2/11/2009	25		20	40	15		
35.6	235	Pool tail	2/11/2009			30	60	10		
35.5	236	Riffle	2/11/2009			30	60	10		
35.5	237	Run head	2/11/2009			30	60	10		
35.2	238	Run body	2/11/2009		5	15	20	60		
35.2	239	Run tail	2/12/2009			30	60	5	5	
35.2	240	Riffle	2/12/2009			35	60	5		
35.2	241	Run head	2/12/2009			35	60	5		
35.2	242	Run body	2/12/2009			30	65	5		
35.1	243	Run tail	2/12/2009			20	80			
35.1	244	Riffle	2/12/2009			20	60	20		
35.0	245	Run head	2/12/2009			20	70	10		
35.0	246	Run body	2/12/2009			40	50	10		
35.0	247	Run tail	2/12/2009			20	70	10		
34.9	248	Riffle	2/12/2009			10	80	10		
34.9	249	Run head	2/12/2009			20	70	10		
34.7	250	Run body	2/12/2009	5		25	60	10		
34.6	251	Pool body	2/12/2009	40		20	20	20		
34.6	252	Pool tail	2/12/2009	30		30	20	20		
34.5	253	Riffle	2/12/2009	5		30	65			
34.5	254	Pool head	2/12/2009	40		10	20	30		
34.4	255	Pool body	2/12/2009			30	50	20		
34.1	256	Run body	2/12/2009			30	60	10		
34.1	257	Run tail	2/12/2009			40	60			
34.1	258	Riffle	2/12/2009			30	60	10		
34.0	259	Run head	2/12/2009			40	50	10		
34.0	260	Run body	2/12/2009			30	40	30		
33.9	261	Run tail	2/12/2009			30	50	20		
33.8	262	Riffle	2/12/2009			30	60	10		
33.8	263	Run head	2/12/2009			40	60			
33.8	264	Run body	2/12/2009			40	50	10		
33.8	265	Run tail	2/12/2009			40	60			
33.7	266	Riffle	2/12/2009			40	50	10		
33.6	267	Run head	2/12/2009			10	70	20		
33.5	268	Run body	2/12/2009			20	40	40		

River mile	NSO #	Habitat type	Habitat survey date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
33.4	269	Run tail	2/12/2009			20	50	30		
33.4	270	Riffle	2/12/2009			30	60	10		
33.4	271	Pool head	2/12/2009			40	40	20		
33.2	272	Pool body	2/12/2009	10		20	30	30	10	
33.2	273	Pool tail	2/12/2009			40	50	10		
33.2	274	Riffle	2/12/2009			40	50	10		
33.2	275	Run head	2/12/2009			50	40	10		
33.1	276	Run body	2/12/2009			25	60	5	10	
33.1	277	Run tail	2/12/2009			40	50	10		
33.0	278	Riffle	2/12/2009			20	70	10		
33.0	279	Run head	2/12/2009			20	40	40		
32.1	280	Run body	2/12/2009				50	50		
32.1	281	Run tail	2/12/2009	No data collected						
32.0	282	Riffle	2/12/2009	No data collected						
32.0	283	Run head	2/12/2009	No data collected						
32.0	284	Run body	2/12/2009	No data collected						
31.9	285	Run tail	2/12/2009	No data collected						
31.9	286	Riffle	2/12/2009	No data collected						
31.9	287	Run head	2/12/2009	No data collected						
31.7	288	Run body	2/12/2009	No data collected						
31.7	289	Run tail	2/12/2009	No data collected						
31.6	290	Riffle	2/12/2009	No data collected						
31.6	291	Run head	2/12/2009	No data collected						
31.5	292	Run body	2/12/2009	No data collected						
31.5	293	Run tail	2/12/2009	No data collected						
31.5	294	Riffle	2/12/2009			40	50		10	
31.4	295	Run head	2/12/2009			20	70	10		
31.3	296	Run body	2/12/2009			10	60	30		
31.3	297	Run tail	2/12/2009			10	60	30		
31.2	298	Riffle	2/12/2009			30	60	10		
31.2	299	Run head	2/13/2009			40	50	10		
31.1	300	Run body	2/13/2009			30	40	30		
31.1	301	Run tail	2/13/2009			30	60	10		
31.1	302	Riffle	2/13/2009			30	60	10		
31.1	303	Run head	2/13/2009	10		40	40	10		
30.7	304	Run body	2/13/2009	10		40	40	10		
30.7	305	Run tail	2/13/2009			40	40	20		
30.6	306	Riffle	2/13/2009			40	50	10		
30.6	307	Run head	2/13/2009			40	50	10		
30.5	308	Run body	2/13/2009			40	50	10		
30.5	309	Run tail	2/13/2009			40	50	10		
30.4	310	Riffle	2/13/2009			30	50	20		
30.4	311	Run head	2/13/2009			30	60	10		
30.4	312	Run body	2/13/2009			40	50	10		
30.4	313	Run tail	2/13/2009		5	35	50	10		

River mile	NSO #	Habitat type	Habitat survey date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
30.2	314	Riffle	2/13/2009			30	60	10		
30.2	315	Run head	2/13/2009			30	60	10		
30.1	316	Run body	2/13/2009			30	60	10		
30.1	317	Run tail	2/13/2009			30	60	10		
30.1	318	Riffle	2/13/2009			40	50	10		
30.0	319	Run head	2/13/2009			5	15	80		
29.7	320	Run body	2/13/2009				30	70		
29.7	321	Run tail	2/13/2009				30	70		
29.6	322	Pool body	2/13/2009				20	80		
29.6	323	Pool tail	2/13/2009				30	70		
29.5	324	Riffle	2/13/2009			30	60	10		
29.5	325	Run head	2/13/2009			40	60			
29.5	326	Run body	2/13/2009				20	80		
29.5	327	Run tail	2/13/2009				60	40		
29.5	328	Riffle	2/13/2009			30	70			
29.4	329	Run head	2/13/2009			20	60	10	10	
29.4	330	Run body	2/13/2009			10	70	20		
29.4	331	Run tail	2/13/2009			10	70	20		
29.3	332	Riffle	2/13/2009			10	80	10		
29.3	333	Run head	2/13/2009			10	70	20		
29.2	334	Run body	2/13/2009			20	70	10		
29.2	335	Run tail	2/13/2009			10	70	20		
29.2	336	Riffle	2/13/2009			10	80	10		
29.1	337	Run head	2/13/2009			10	60	30		
29.1	338	Run body	2/13/2009	15		30	30	25		
29.0	339	Run tail	2/13/2009	40		20	20	20		
29.0	340	Riffle	2/13/2009	20		10	60	10		

Appendix E: Water Quality Data

Table E-1. Water quality data for the habitat units selected for snorkel sampling, March 2009.

RM	NSO	Habitat type	Sample date	Start time	Water temperature (C)	DO (ppm)	Specific conductivity (mS)	Horizontal visability (ft)	Vertical visability (ft)	Average depth (ft)	Maximum depth (ft)
51.6	4	Pool head	16-Mar	12:00	10.8	10.42	42.0	10	--	3.5	5.0
51.6	5	Pool body	16-Mar	11:20	10.8	10.42	42.0	10	17.0	9.0	29.0
51.5	6	Pool tail	16-Mar	11:00	10.8	10.42	42.0	10	--	5.0	9.0
51.5	7	Riffle	16-Mar	10:09	10.2	9.99	42.1	10	--	3.5	7.0
50.6	14	Riffle	16-Mar	15:00	11.9	11.71	41.9	8	--	1.0	2.5
50.6	15	Run head	16-Mar	14:30	11.9	11.71	41.9	8	--	3.0	4.5
50.5	16	Run body	16-Mar	13:30	11.8	10.03	42.5	8	--	6.0	9.5
50.4	17	Run tail	16-Mar	13:15	11.8	10.03	42.5	8	--	2.5	3.5
50.1	22	Riffle	17-Mar	11:20	11.7	9.07	42.0	12	--	1.0	2.0
49.7	27	Pool head	17-Mar	12:20	12.4	10.49	43.6	8	--	4.0	9.0
49.6	28	Pool body	17-Mar	12:00	12.4	10.49	43.6	8	8.0	6.0	15.0
49.6	29	Pool tail	17-Mar	11:50	12.4	10.49	43.6	8	--	1.5	3.0
48.0	53	Riffle	17-Mar	14:38	14.5	11.12	44.5	10	--	1.0	2.0
47.0	58	Run head	17-Mar	16:28	13.7	10.91	46.4	7	--	2.5	3.5
46.9	59	Run body	18-Mar	10:55	11.5	10.55	46.0	8	--	3.5	7.0
46.9	60	Run tail	18-Mar	11:35	11.5	10.55	46.5	8	--	1.7	3.0
45.3	82	Run head	18-Mar	15:05	13.8	12.14	49.3	9	--	6.0	11.0
45.1	83	Run body	18-Mar	14:20	13.8	12.14	49.3	9	--	5.0	10.0
45.1	84	Run tail	18-Mar	13:45	13.8	12.14	49.3	9	--	4.5	6.0
45.0	86	Pool head	19-Mar	11:53	13.2	11.08	49.3	12	--	0.7	1.5
44.9	87	Pool body	19-Mar	11:54	13.2	11.08	49.3	12	--	4.5	6.0
44.9	88	Pool tail	19-Mar	11:15	13.2	11.08	49.3	12	--	2.0	4.5
44.6	97	Riffle	19-Mar	13:22	13.9	11.64	50.0	7	--	2.0	4.0
43.2	107	Riffle	19-Mar	15:18	15.1	12.31	50.9	13	--	1.0	3.0
43.2	108	Run head	20-Mar	15:32	15.6	11.85	51.5	10	--	3.0	5.0
43.2	108	Run head	19-Mar	15:15	15.1	12.31	50.9	13	--	2.0	4.5
43.1	109	Run body	20-Mar	14:43	15.6	11.85	51.5	10	--	3.5	7.0
43.1	110	Run tail	20-Mar	14:40	15.6	11.85	51.5	10	--	2.5	3.5

RM	NSO	Habitat type	Sample date	Start time	Water temperature (C)	DO (ppm)	Specific conductivity (mS)	Horizontal visability (ft)	Vertical visability (ft)	Average depth (ft)	Maximum depth (ft)
43.0	111	Riffle	20-Mar	11:13	14.5	10.68	48.3	9	--	1.0	3.0
43.0	112	Pool head	19-Mar	16:43	15.4	12.08	51.9	9	--	1.0	2.0
43.0	113	Pool body	20-Mar	13:20	15.2	11.38	51.8	10	--	6.0	11.0
43.0	114	Pool tail	20-Mar	12:18	15.2	11.38	51.8	10	--	4.0	7.0
42.9	118	Riffle	20-Mar	10:30	13.7	10.55	52.4	11	--	0.8	2.0
39.6	157	Run head	22-Mar	11:22	13.8	10.14	67.1	9	--	2.0	3.5
39.5	158	Run body	22-Mar	11:35	13.7	9.85	70.3	9	--	5.0	6.5
39.5	159	Run tail	22-Mar	10:43	13.7	9.85	70.3	9	--	1.5	3.0
39.4	160	Riffle	22-Mar	10:35	13.6	9.9	68.3	9	--	1.0	3.0
38.9	168	Riffle	22-Mar	14:00	14.3	10.6	67.9	10	--	0.8	3.0
38.7	175	Riffle	22-Mar	14:30	14.3	10.62	68.5	10	--	1.2	2.5
38.1	188	Pool head	22-Mar	15:24	14.1	10.73	68.7	8	--	1.5	2.5
38.1	189	Pool body	22-Mar	15:14	14.1	10.73	68.7	8	--	4.5	9.5
38.1	190	Pool tail	22-Mar	15:10	14.1	10.73	68.7	8	--	0.8	1.5
38.1	192	Pool head	23-Mar	11:24	12.4	10.95	69.9	10	--	3.0	9.0
38.0	193	Pool body	23-Mar	11:11	12.4	10.95	69.9	10	--	5.0	15.0
38.0	194	Pool tail	23-Mar	10:55	12.4	10.95	69.9	10	--	2.0	3.5
36.9	214	Pool head	23-Mar	13:25	13.4	11.45	70.3	11	--	1.5	4.0
36.9	215	Pool body	23-Mar	13:20	13.4	11.45	70.3	11	--	5.0	15.0
36.9	216	Pool tail	23-Mar	13:15	13.4	11.45	70.3	11	--	1.0	3.0
36.8	218	Run head	25-Mar	12:36	14.5	12.14	72.8	9	--	3.0	4.5
36.6	219	Run body	25-Mar	11:09	14.5	12.14	72.8	9	--	4.5	11.3
36.6	220	Run tail	25-Mar	12:56	14.5	12.14	72.8	9	--	1.7	5.0
36.2	230	Pool head	23-Mar	15:12	14.2	11.16	70.6	10	--	4.0	8.0
36.2	231	Pool body	25-Mar	14:19	14.2	11.16	70.6	10	--	5.0	12.0
36.2	232	Pool tail	23-Mar	15:00	14.2	11.16	70.6	10	--	2.0	4.0
34.0	259	Run head	24-Mar	11:32	13.1	11.1	71.6	12	--	3.0	4.0
34.0	260	Run body	24-Mar	11:08	13.1	11.26	71.4	12	--	2.5	3.5
33.9	261	Run tail	24-Mar	10:55	13.1	11.26	71.4	12	--	0.5	2.5

RM	NSO	Habitat type	Sample date	Start time	Water temperature (C)	DO (ppm)	Specific conductivity (mS)	Horizontal visability (ft)	Vertical visability (ft)	Average depth (ft)	Maximum depth (ft)
33.4	271	Pool head	24-Mar	15:10	15.0	12.27	71.5	12	--	3.0	10.0
33.2	272	Pool body	24-Mar	14:39	15.0	12.27	71.5	12	--	4.5	10.8
33.2	273	Pool tail	24-Mar	14:28	15.0	12.27	71.5	12	--	1.8	3.5
31.9	287	Run head	24-Mar	17:07	15.3	12.51	73.7	11	--	3.0	4.0
31.7	288	Run body	24-Mar	16:42	15.3	12.51	73.7	11	--	4.0	8.0
31.7	289	Run tail	24-Mar	16:36	15.3	12.51	73.7	11	--	0.8	3.5
29.5	324	Riffle	21-Mar	16:28	17.3	10.53	85.2	5	--	1.5	2.0
29.5	325	Run head	21-Mar	16:19	17.3	10.53	85.2	5	--	2.5	3.5
29.5	326	Run body	21-Mar	16:12	17.3	10.53	85.2	5	--	3.0	4.5
29.5	327	Run tail	21-Mar	16:07	17.3	10.53	85.2	5	--	2.5	3.5

Table E-2. Water quality data for the habitat units selected for snorkel sampling, July 2009.

RM	NSO	Habitat type	Sample date	Start time	Water temperature (C)	DO (ppm)	Specific conductivity (mS)	Horizontal visability (ft)	Vertical visability (ft)	Average depth (ft)	Maximum depth (ft)
51.8	1	Pool head	11-Jul	12:17	11.8	12.0	35.5	21.0	5.0	3.5	5.0
51.7	2	Pool body	11-Jul	11:52	11.8	12.0	35.5	21.0	28.0	20.0	35.0
51.6	4	Pool head	11-Jul	10:57	11.8	12.0	35.5	21.0	6.0	3.5	6.0
51.6	5	Pool body	11-Jul	9:57	11.8	12.0	35.5	21.0	26.5	12.0	26.5
50.6	14	Riffle	9-Jul	10:45	12.0	11.8	36.2	16.0	4.0	1.5	4.0
50.6	15	Run head	9-Jul	10:35	12.4	11.7	36.3	16.0	4.0	2.0	4.0
50.3	19	Run head	9-Jul	11:35	14.8	12.1	36.6	16.0	8.0	5.0	8.0
50.1	20	Run body	9-Jul	11:05	14.8	12.1	36.6	16.0	8.0	2.5	8.0
50.1	22	Riffle	9-Jul	15:51	15.6	12.0	37.3	16.0	2.5	0.5	2.5
49.7	27	Pool head	10-Jul	12:00	14.9	11.8	37.3	13.0	3.5	2.0	3.5
49.6	28	Pool body	10-Jul	11:52	14.9	11.8	37.3	13.0	18.0	6.0	18.0
49.2	33	Riffle	10-Jul	10:42	14.6	11.6	37.8	13.0	4.0	1.0	4.0
49.2	34	Run head	10-Jul	10:16	14.3	11.4	38.2	13.0	3.0	1.5	3.0
49.1	35	Run body	10-Jul	10:07	14.3	11.4	38.2	13.0	6.5	2.5	6.5
48.2	49	Riffle	10-Jul	14:20	18.9	12.1	38.5	16.0	3.0	1.0	3.0
48	54	Pool head	10-Jul	13:41	18.0	12.2	38.7	16.0	7.5	4.0	7.5
47	58	Run head	12-Jul	12:09	16.7	11.1	39.5	9.0	4.0	2.0	4.0
46.9	59	Run body	12-Jul	11:54	16.7	11.1	39.5	9.0	6.5	3.5	6.5
45.7	74	Riffle	12-Jul	15:05	19.5	11.4	40.5	12.0	1.5	0.5	1.5
45.7	75	Run head	12-Jul	14:40	19.5	11.4	40.5	12.0	2.0	1.0	2.0
45.7	76	Run body	12-Jul	14:35	19.5	11.4	40.5	12.0	2.5	1.5	2.5
45	86	Pool head	13-Jul	12:12	19.5	11.1	41.4	8.0	9.0	5.0	9.0
44.9	87	Pool body	13-Jul	12:06	19.5	11.1	41.4	8.0	9.0	3.0	9.0
44.5	101	Riffle	13-Jul	13:18	21.5	11.3	42.2	8.0	3.0	1.5	3.0
43.2	108	Run head	14-Jul	15:59	23.1	11.0	43.7	9.0	3.5	2.0	3.5
43.1	109	Run body	14-Jul	12:37	23.1	11.0	43.7	9.0	4.5	2.0	4.5
43	111	Riffle	14-Jul	12:27	23.1	11.0	43.7	9.0	2.5	1.0	2.5
43	112	Pool head	11-Jul	15:28	21.9	10.5	43.9	6.0	2.5	1.5	2.5

RM	NSO	Habitat type	Sample date	Start time	Water temperature (C)	DO (ppm)	Specific conductivity (mS)	Horizontal visability (ft)	Vertical visability (ft)	Average depth (ft)	Maximum depth (ft)
43	113	Pool body	11-Jul	15:02	21.9	10.5	43.9	6.0	9.0	4.0	9.0
41.9	132	Riffle	14-Jul	10:50	21.5	9.9	48.3	10.5	3.0	1.5	3.0
41.9	133	Run head	14-Jul	10:46	21.5	9.9	48.3	10.5	3.0	2.0	3.0

Appendix F: Water Temperature Data

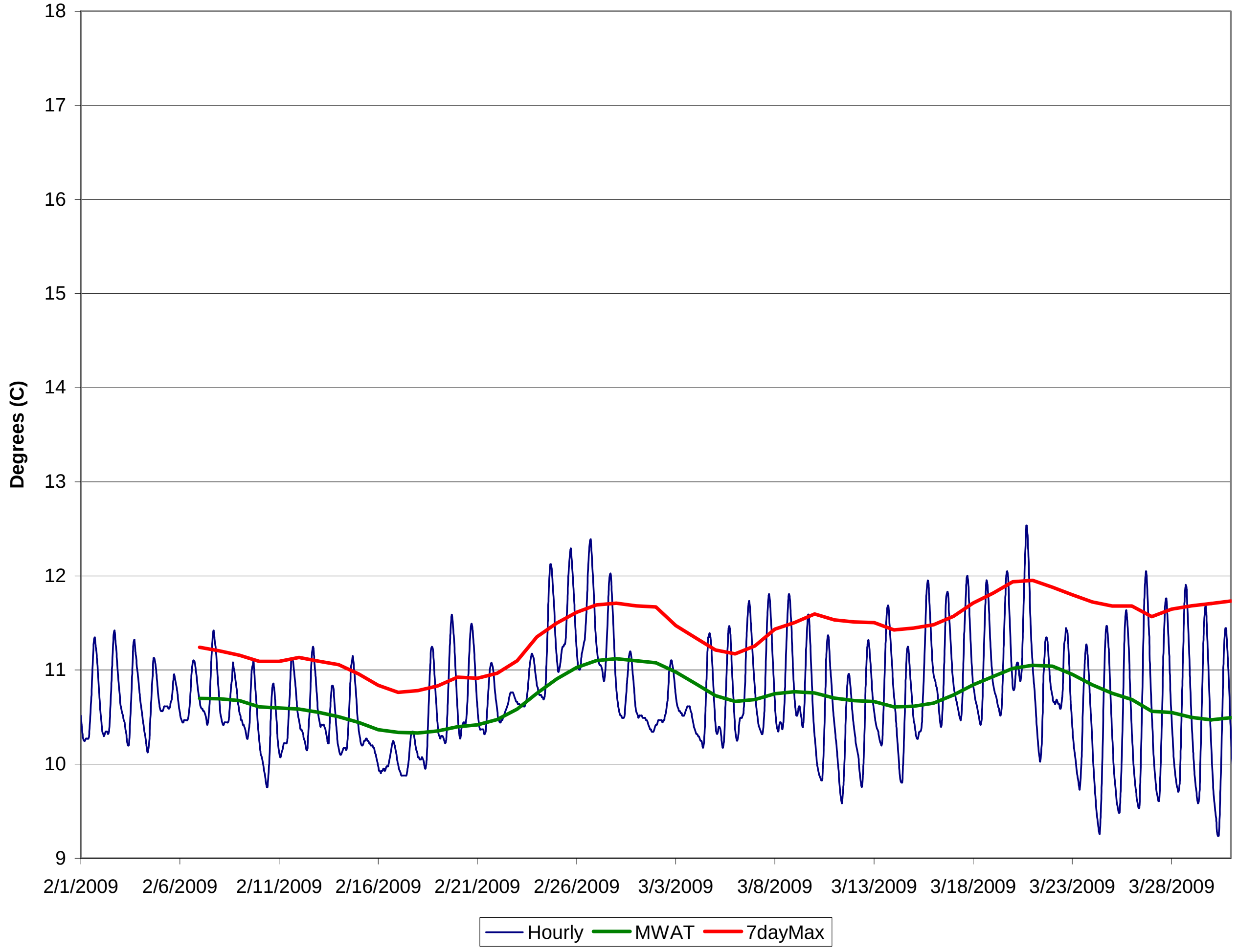

Figure F-1. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Riffle A7 (RM 50.8), February–March 2009.

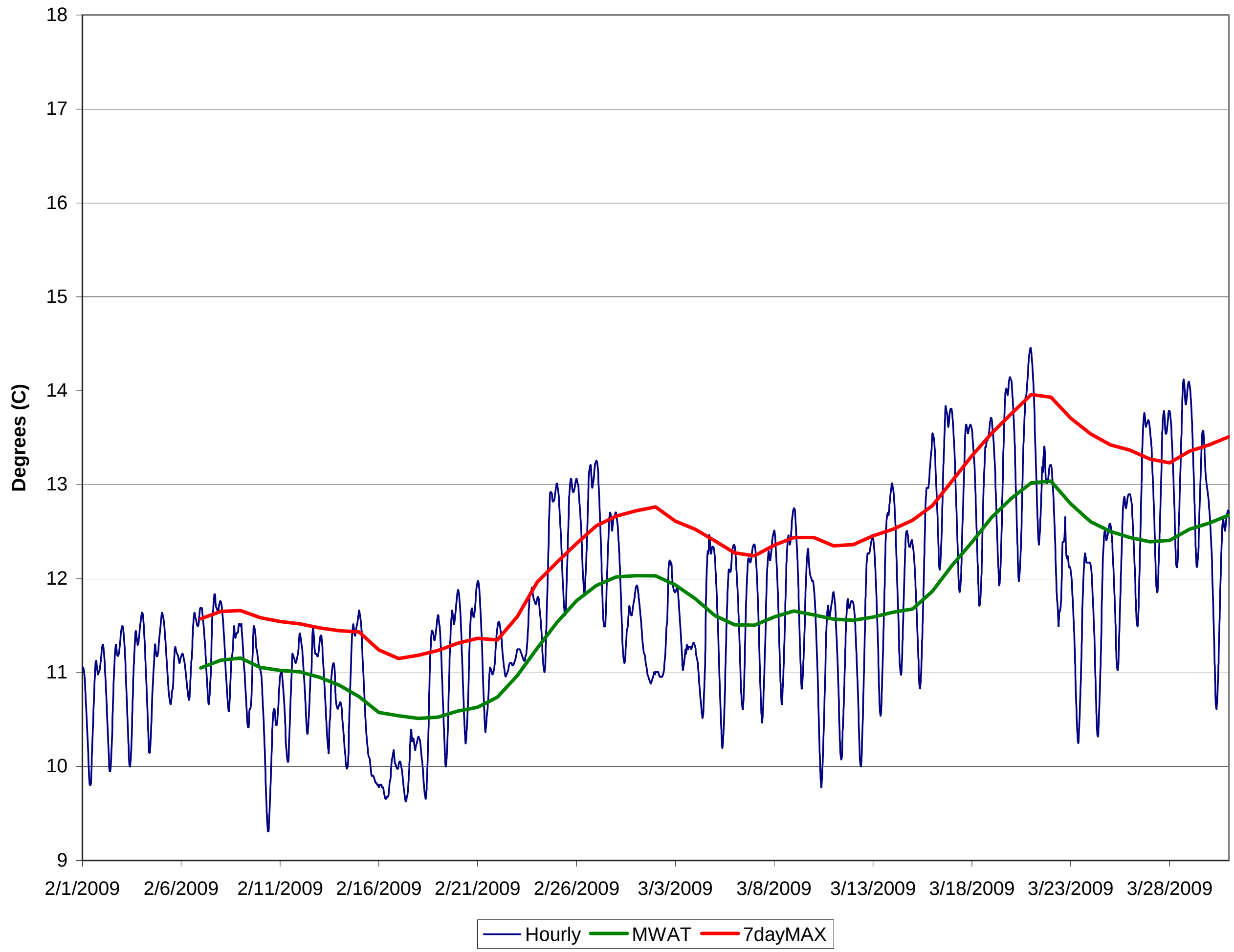

Figure F-2. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Riffle 13B (RM 45.5), February–March 2009.

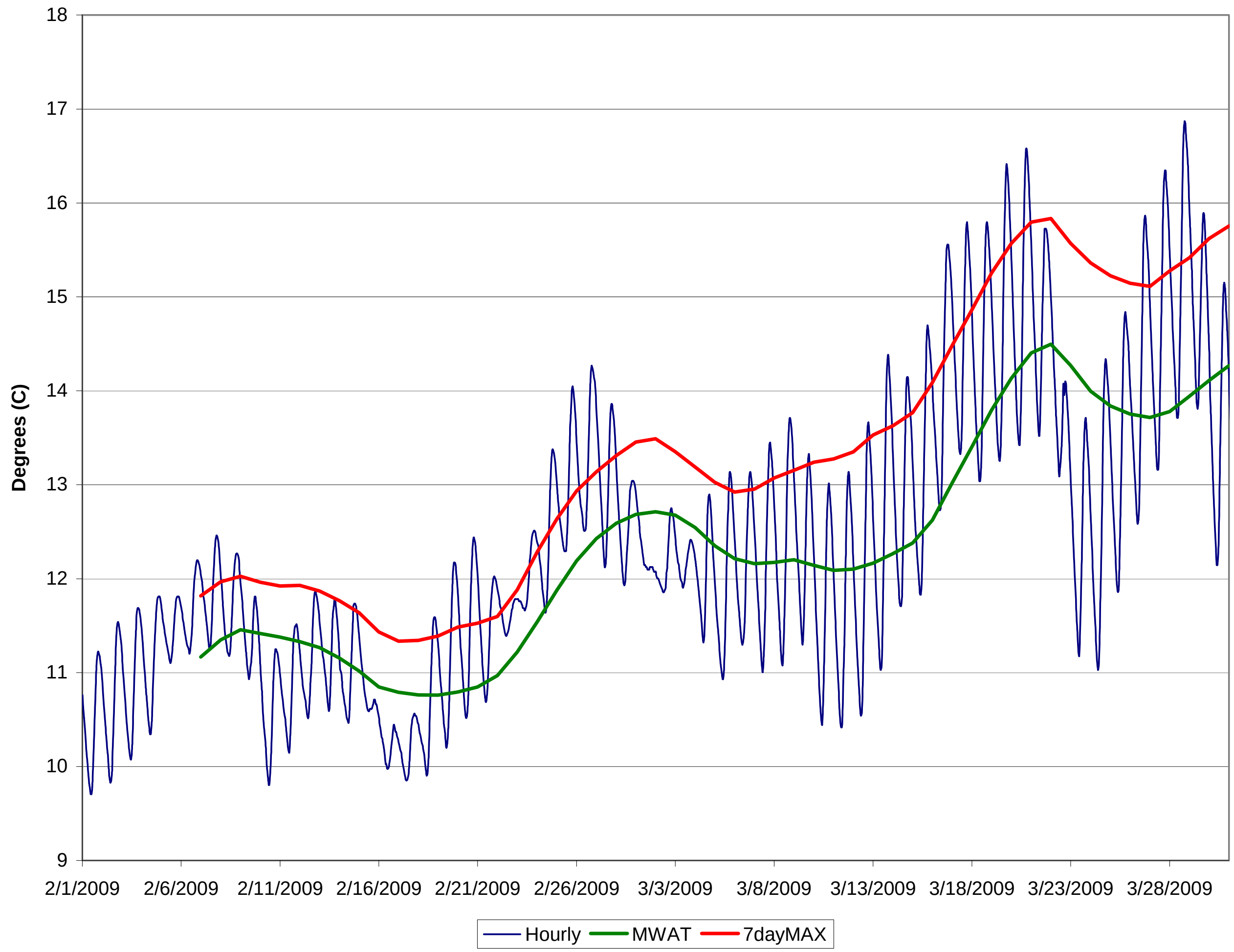

Figure F-3. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Roberts Ferry Bridge (RM 39.6), February–March 2009.

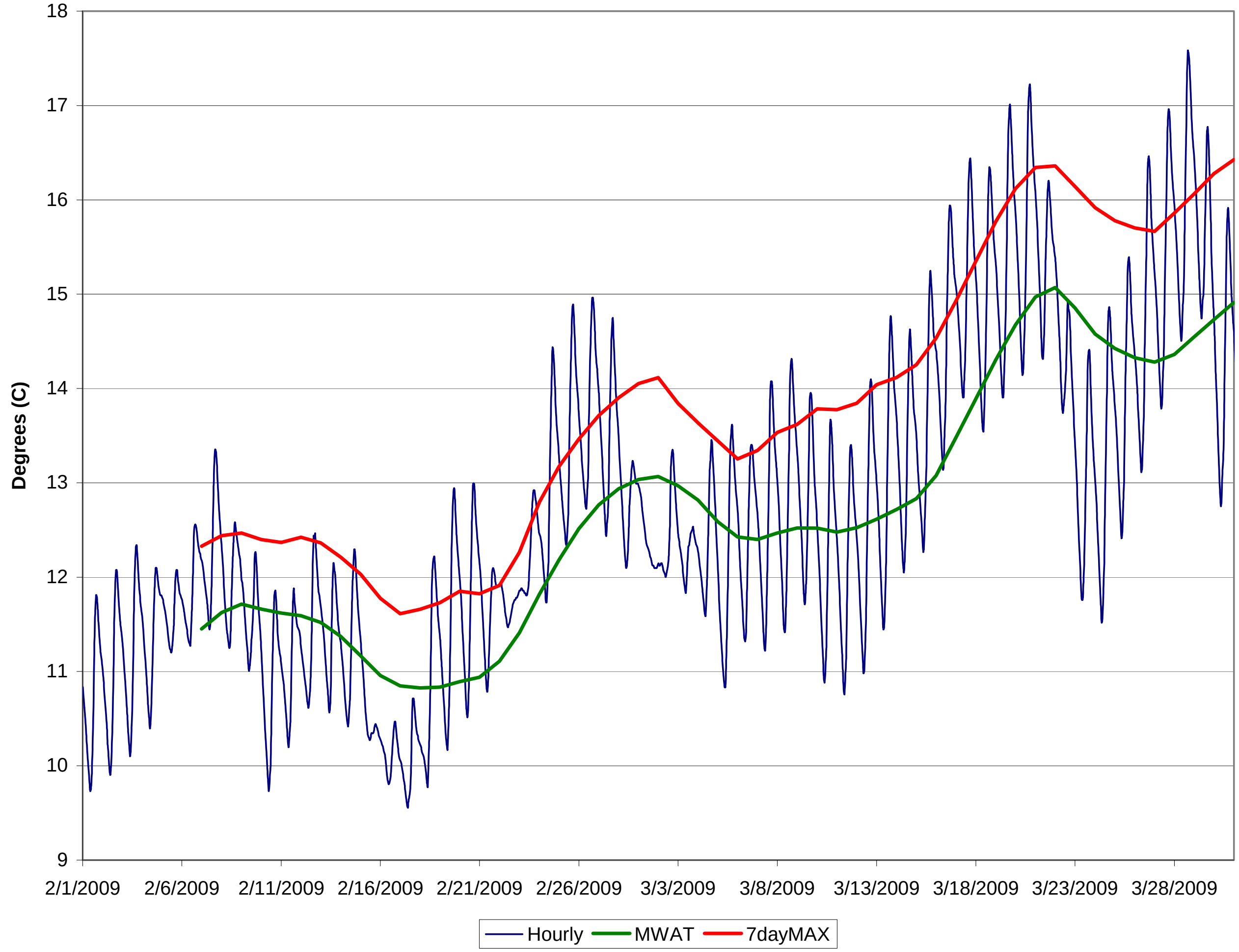

Figure F-4. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Ruddy Gravel (RM 36.5), February–March 2009.

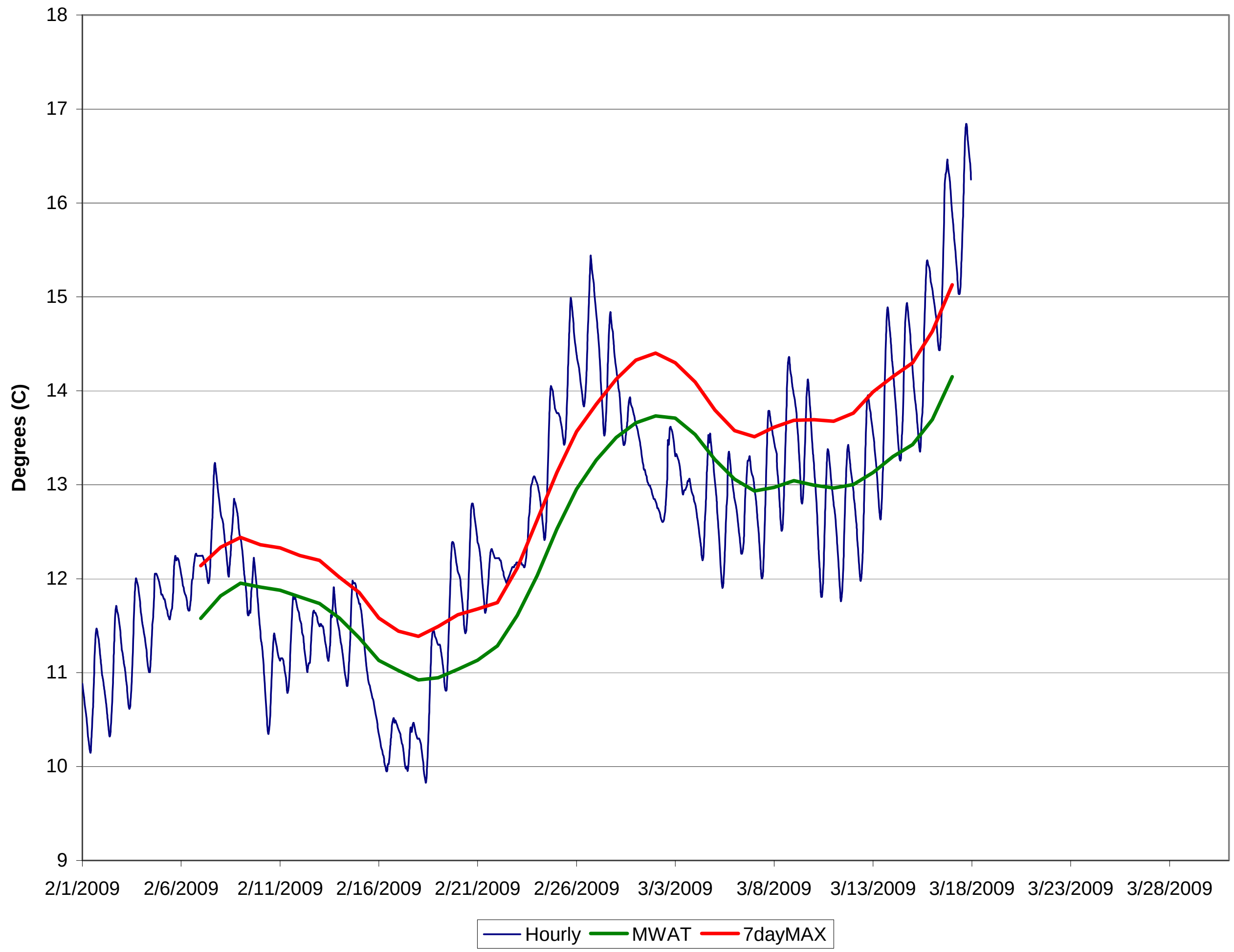

Figure F-5. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Waterford RST (RM 29.8), February–March 2009.

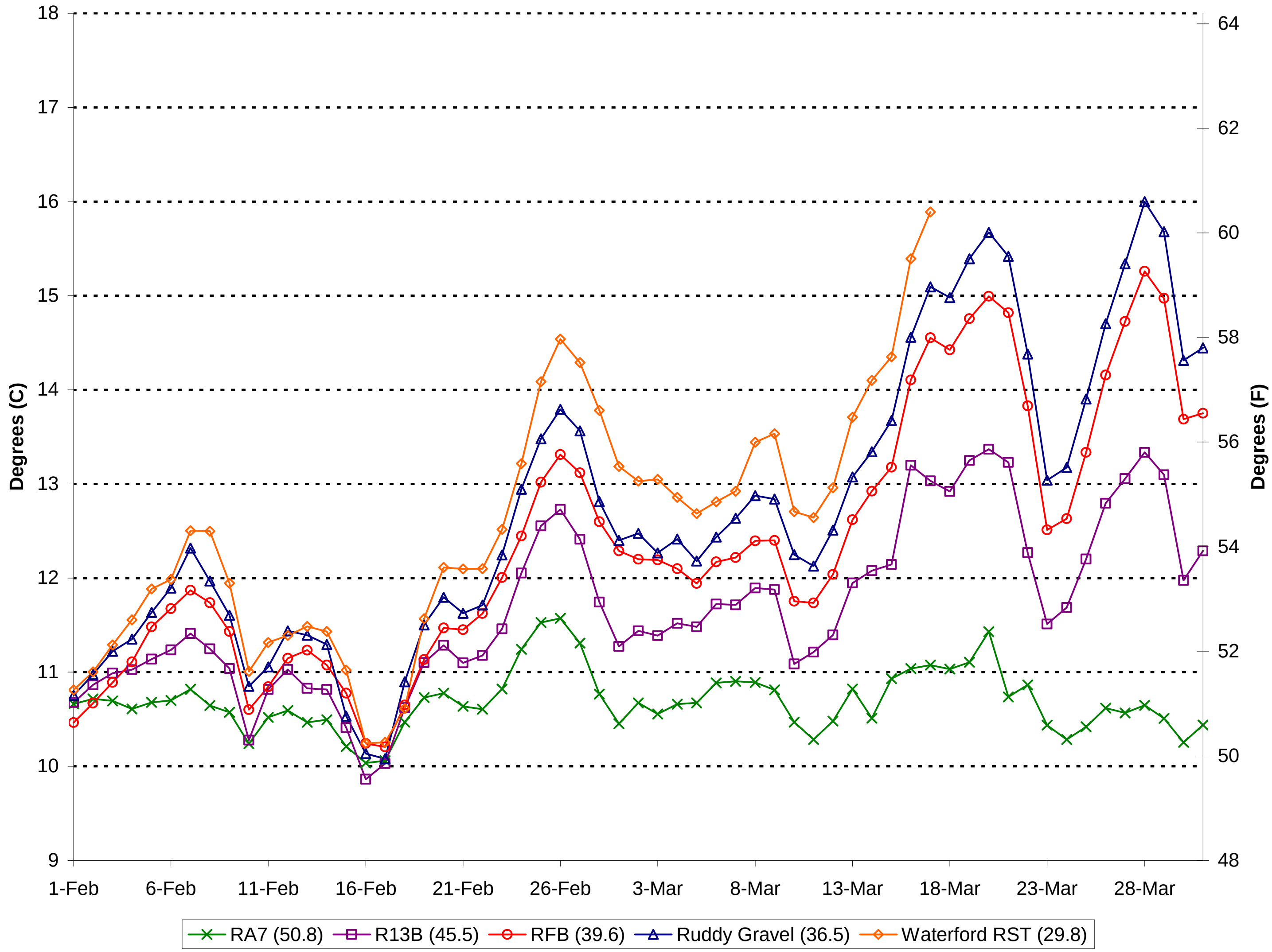

Figure F-6. Average daily water temperature from thermographs, February–March 2009.

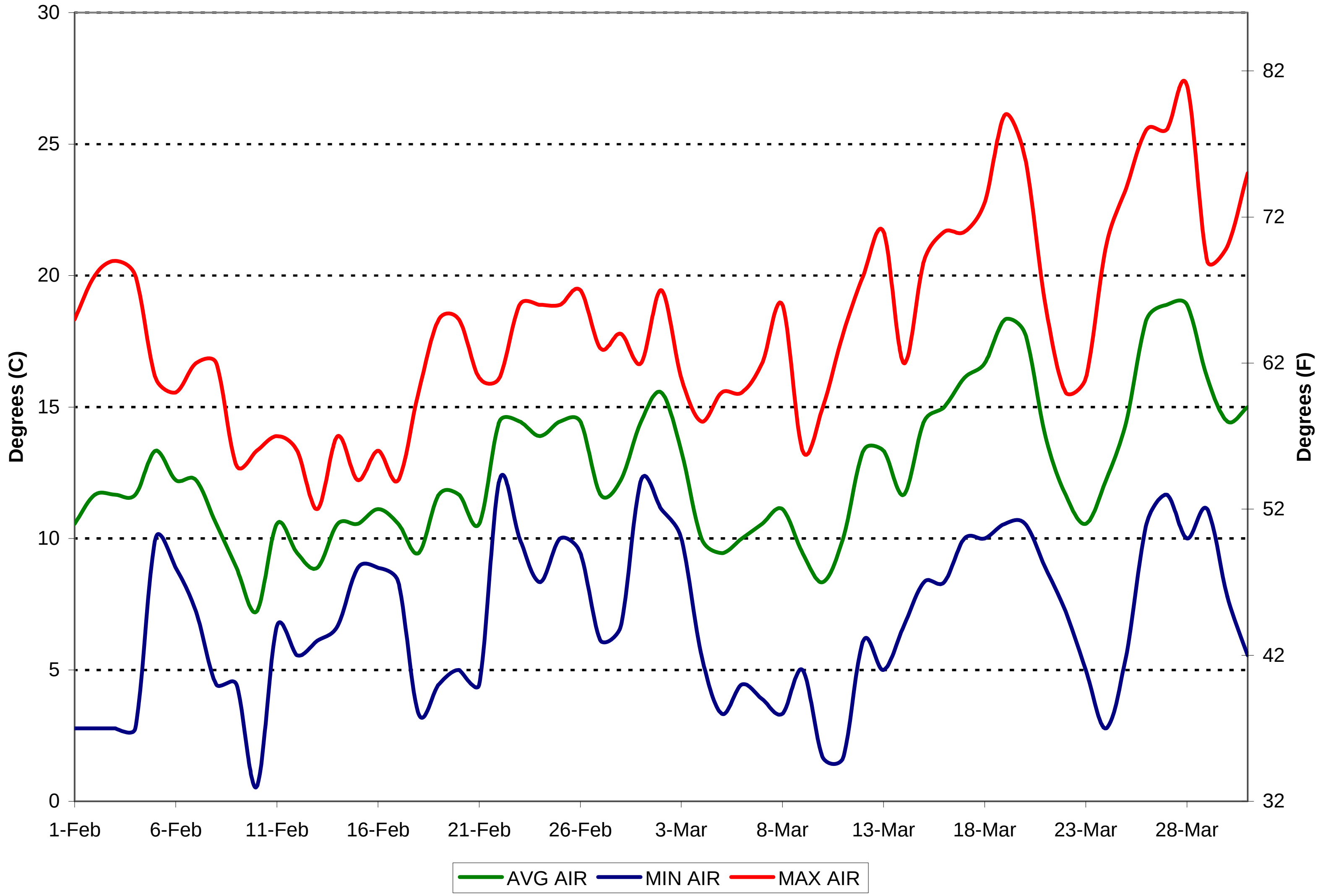

Figure F-7. Daily average, minimum, and maximum air temperature at the Modesto Airport, February-March 2009.

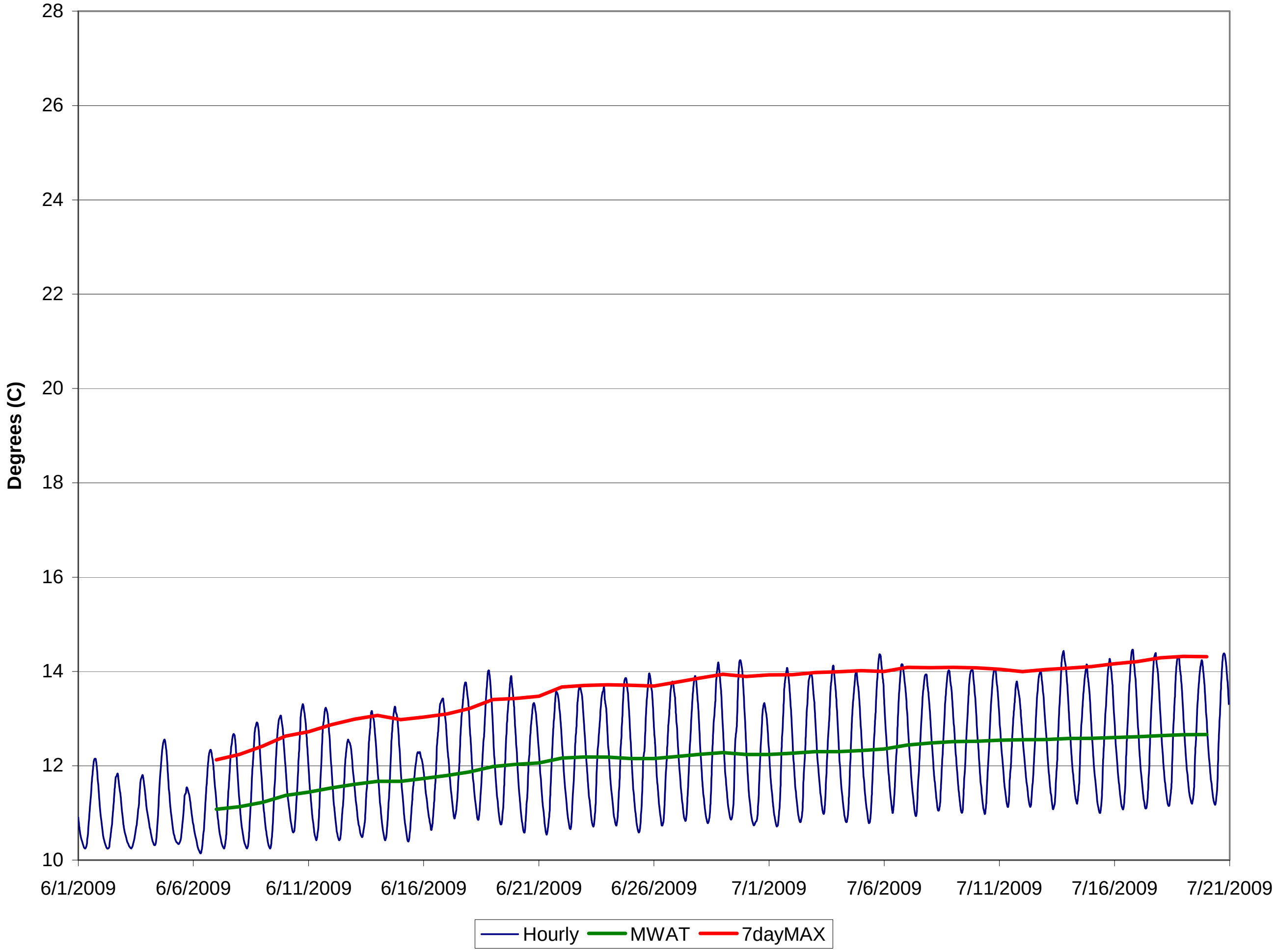

Figure F-8. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Riffle A7 (RM 50.8), June–July 2009.

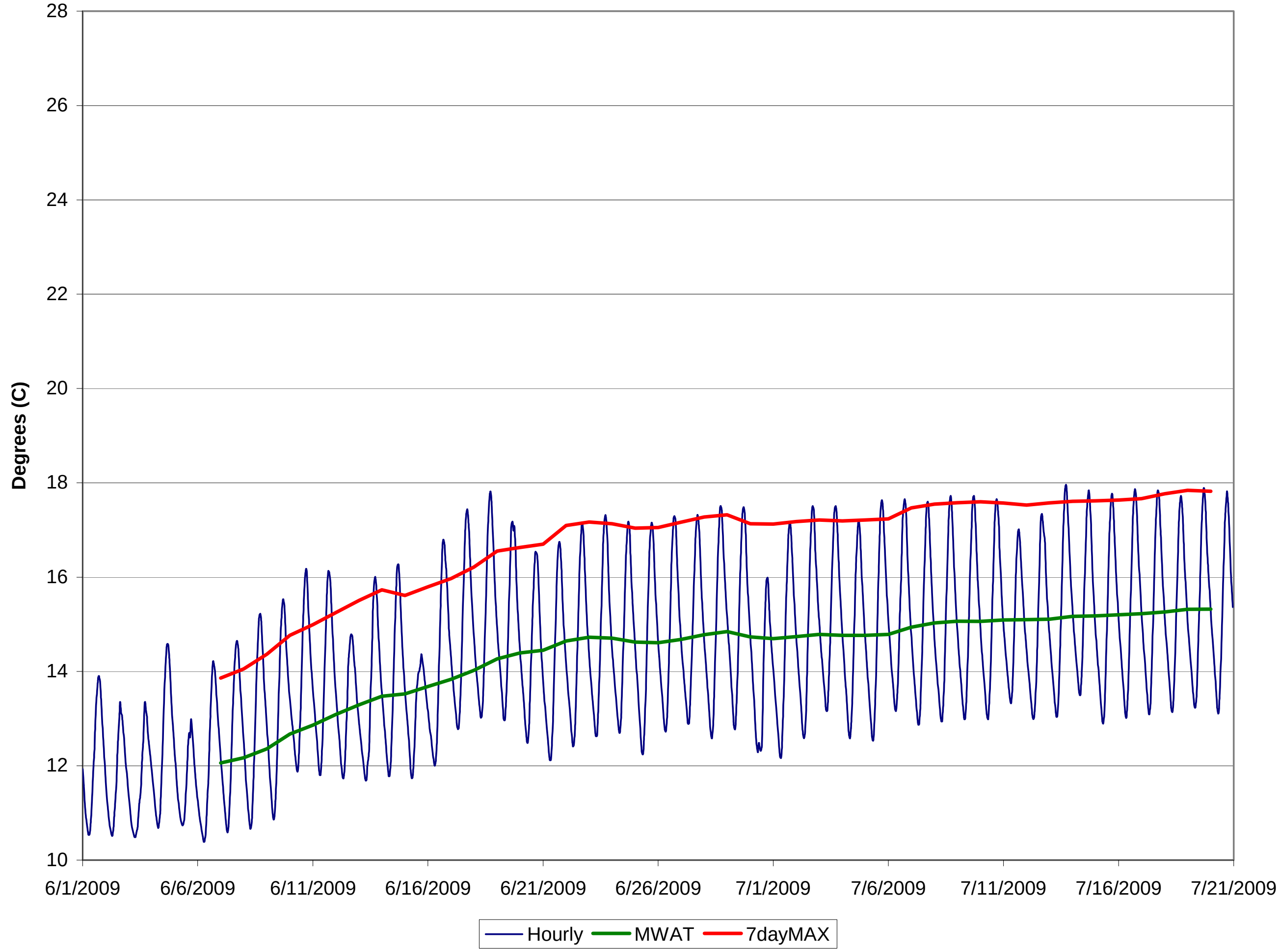

Figure F-9. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Riffle 3B (RM 49.0), June–July 2009.

Figure F-10. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Riffle 13B (RM 45.5), June –July 2009.

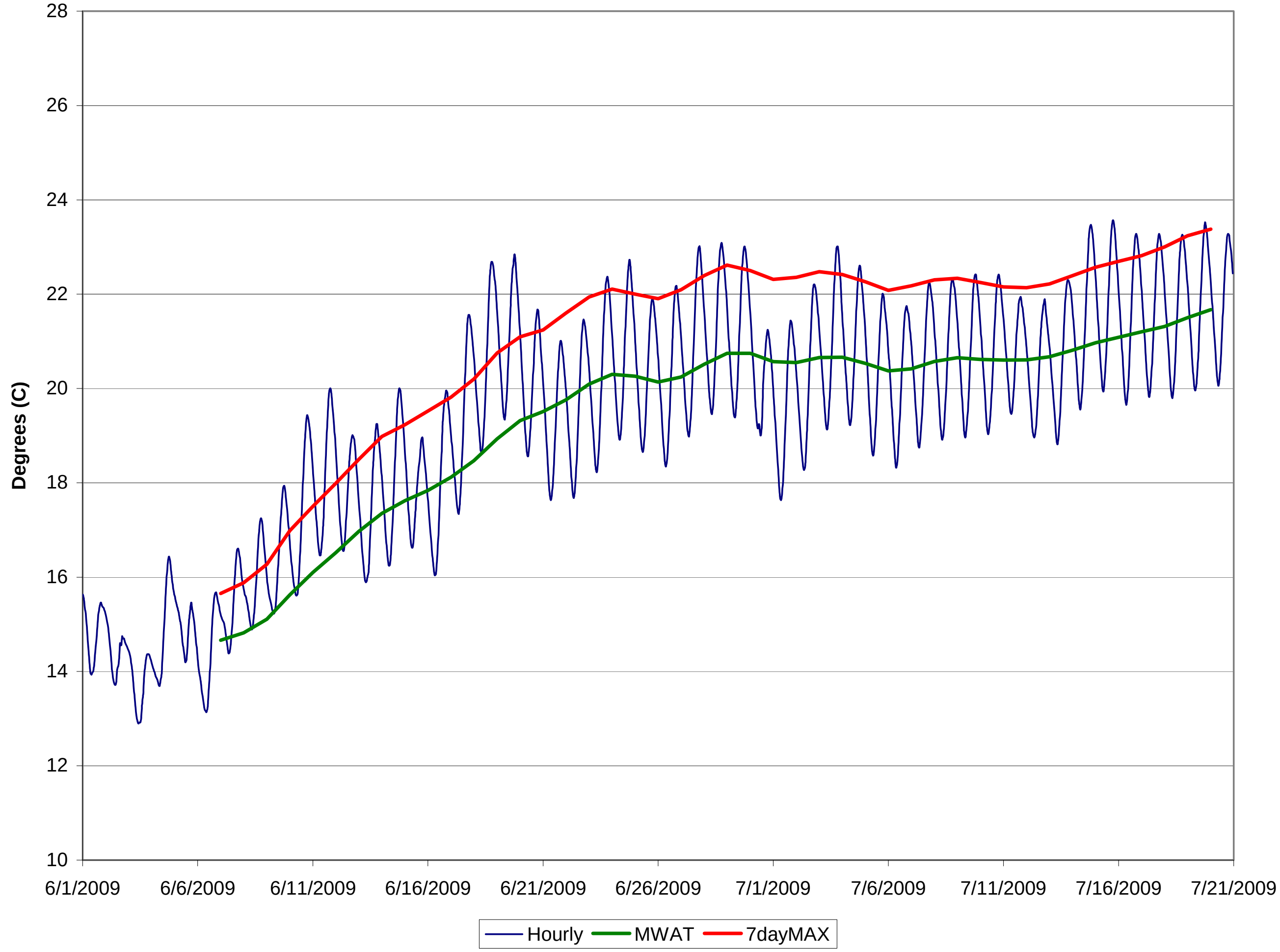

Figure F-11. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Riffle 21 (RM 42.9), June–July 2009.

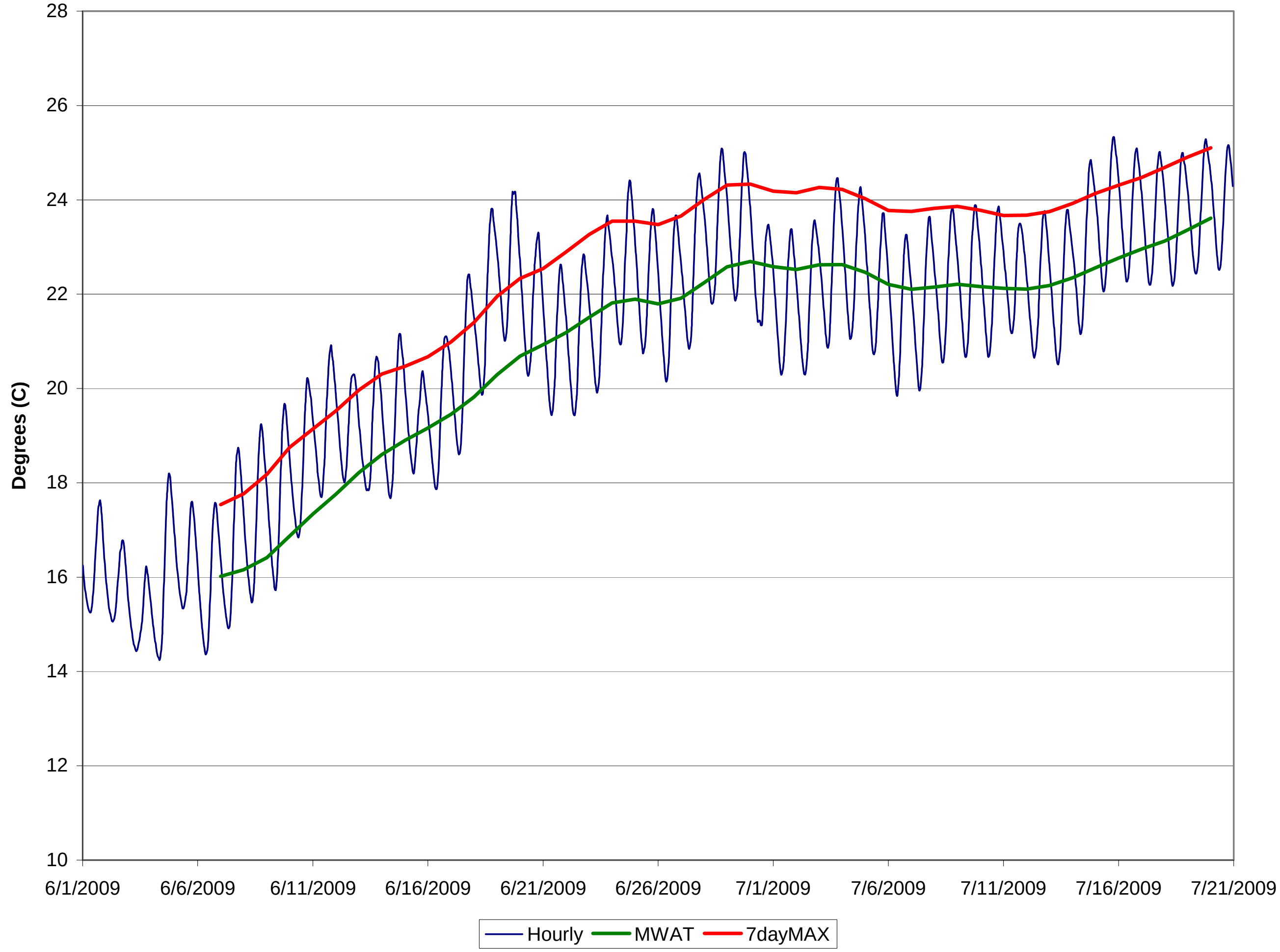

Figure F-12. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Roberts Ferry Bridge (RM 39.6), June–July 2009.

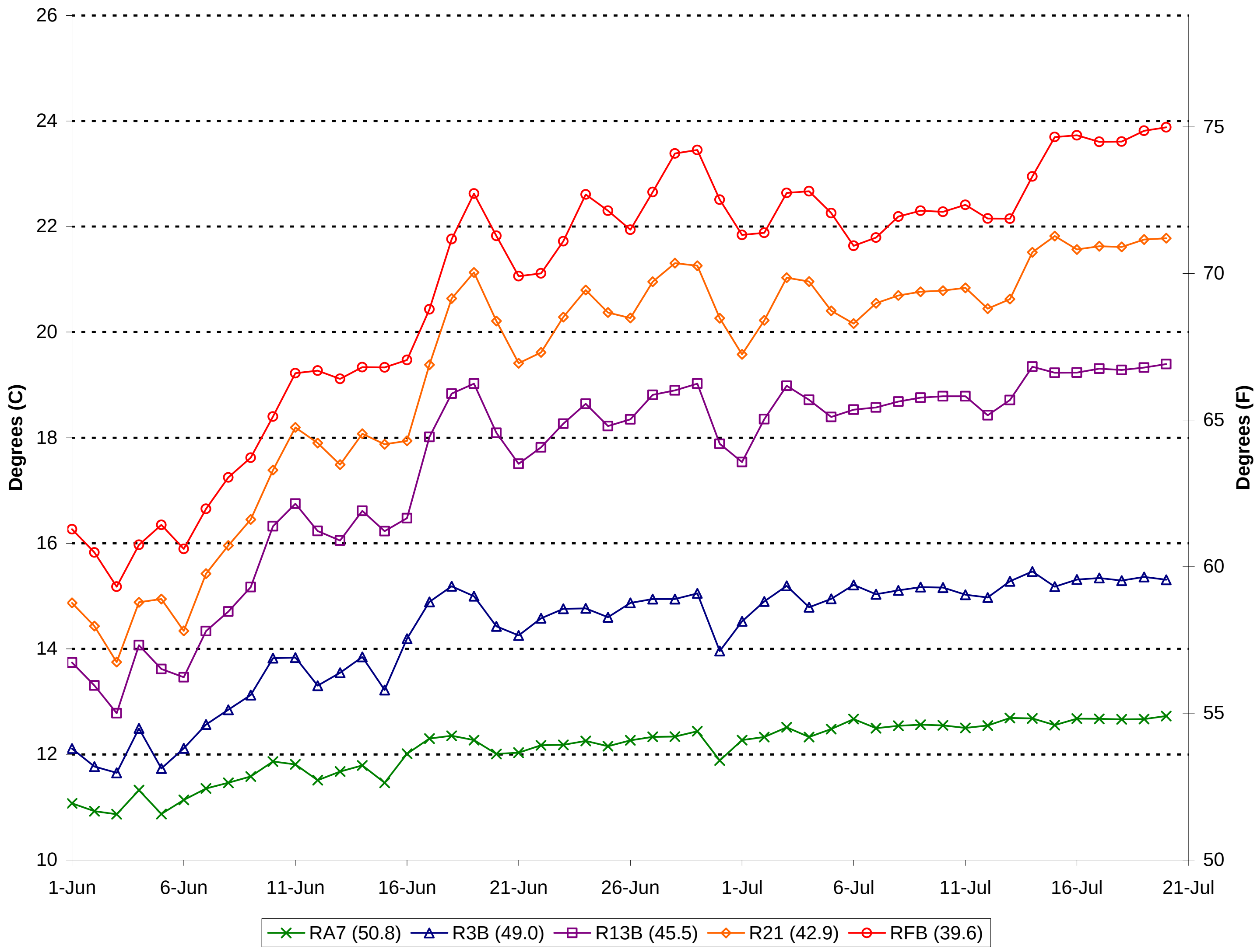

Figure F-13. Average daily water temperature from thermographs, June–July 2009.

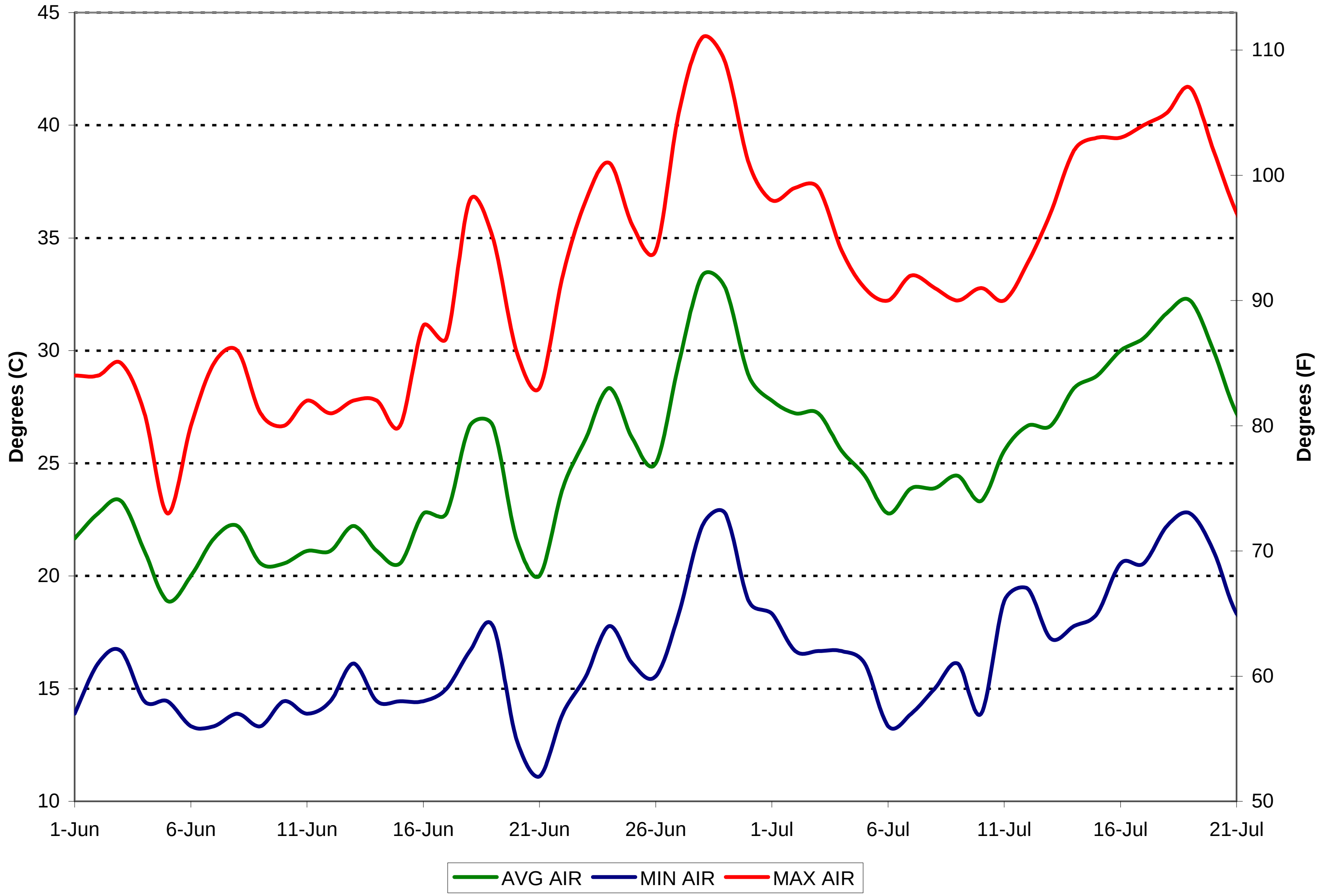

Figure F-14. Daily average, minimum, and maximum air temperature at the Modesto Airport, June-July 2009.

Appendix G: Fish Observation Data

Table G-1. *O. mykiss* observation data for the study area, March 2009.

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
51.6	4	Pool head	S	1	0	--
51.6	5	Pool body	S	1	0	--
51.5	6	Pool tail	S	1	0	--
51.5	7	Riffle	S	1	2	50–99
50.6	14	Riffle	S	1	1	300–349
50.6	14	Riffle	S	1	3	400–449
50.6	15	Run head	S	1	0	--
50.5	16	Run body	S	1	0	--
50.4	17	Run tail	S	1	0	--
50.1	22	Riffle	S	1	0	--
49.7	27	Pool head	S	1	1	450–499
49.6	28	Pool body	S	1	0	--
49.6	29	Pool tail	S	1	0	--
48.0	53	Riffle	M	1	1	300–349
48.0	53	Riffle	M	2	0	--
48.0	53	Riffle	M	3	1	300–349
47.0	58	Run head	M	1	0	--
47.0	58	Run head	M	2	0	--
47.0	58	Run head	M	3	0	--
46.9	59	Run body	S	1	0	--
46.9	60	Run tail	M	1	0	--
46.9	60	Run tail	M	2	0	--
46.9	60	Run tail	M	3	0	--
45.3	82	Run head	S	1	0	--
45.1	83	Run body	S	1	0	--
45.1	84	Run tail	M	1	0	--
45.1	84	Run tail	M	2	0	--
45.1	84	Run tail	M	3	0	--
45.0	86	Pool head	S	1	0	--
44.9	87	Pool body	S	1	0	--
44.9	88	Pool tail	M	1	0	--
44.9	88	Pool tail	M	2	0	--
44.9	88	Pool tail	M	3	0	--
44.6	97	Riffle	S	1	0	--
43.2	107	Riffle	S	1	3	50–99
43.2	108	Run head	S	1	0	--
43.2	108	Run head	S	1	0	--
43.1	109	Run body	S	1	0	--
43.1	110	Run tail	S	1	0	--

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
43.0	111	Riffle	M	1	1	200–249
43.0	111	Riffle	M	2	0	--
43.0	111	Riffle	M	3	0	--
43.0	112	Pool head	M	1	0	--
43.0	112	Pool head	M	2	0	--
43.0	112	Pool head	M	3	0	--
43.0	113	Pool body	M	1	0	--
43.0	113	Pool body	M	2	0	--
43.0	113	Pool body	M	3	0	--
43.0	114	Pool tail	S	1	0	--
42.9	118	Riffle	S	1	0	--
39.6	157	Run head	S	1	0	--
39.5	158	Run body	M	1	0	--
39.5	158	Run body	M	2	0	--
39.5	158	Run body	M	3	0	--
39.5	159	Run tail	S	1	0	--
39.4	160	Riffle	S	1	0	--
38.9	168	Riffle	S	1	0	--
38.7	175	Riffle	S	1	0	--
38.1	188	Pool head	S	1	0	--
38.1	189	Pool body	S	1	0	--
38.1	190	Pool tail	S	1	0	--
38.1	192	Pool head	M	1	0	--
38.0	193	Pool body	S	1	0	--
38.0	194	Pool tail	M	1	0	--
38.0	194	Pool tail	M	2	0	--
38.0	194	Pool tail	M	3	0	--
36.9	214	Pool head	S	1	0	--
36.9	215	Pool body	S	1	0	--
36.9	216	Pool tail	S	1	0	--
36.8	218	Run head	S	1	0	--
36.6	219	Run body	M	1	0	--
36.6	219	Run body	M	2	0	--
36.6	219	Run body	M	3	0	--
36.6	220	Run tail	S	1	0	--
36.2	230	Pool head	S	1	0	--
36.2	231	Pool body	M	1	0	--
36.2	232	Pool tail	S	1	0	--
34.0	259	Run head	M	1	0	--
34.0	259	Run head	M	2	0	--
34.0	259	Run head	M	3	0	--

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
34.0	260	Run body	S	1	0	--
33.9	261	Run tail	S	1	0	--
33.4	271	Pool head	S	1	0	--
33.2	272	Pool body	S	1	0	--
33.2	273	Pool tail	S	1	0	--
31.9	287	Run head	S	1	0	--
31.7	288	Run body	S	1	0	--
31.7	289	Run tail	S	1	0	--
29.5	324	Riffle	S	1	0	--
29.5	325	Run head	S	1	0	--
29.5	326	Run body	S	1	0	--
29.5	327	Run tail	S	1	0	--

Table G-2. *O. mykiss* observation data for the study area, July 2009.

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
51.8	1	Pool head	S	1	2	200–250
51.8	1	Pool head	S	1	8	400–450
51.8	1	Pool head	S	1	4	450–500
51.7	2	Pool body	S	1	1	300–350
51.7	2	Pool body	S	1	2	350–400
51.7	2	Pool body	S	1	1	400–450
51.6	4	Pool head	M	1	2	300–350
51.6	4	Pool head	M	1	1	350–400
51.6	4	Pool head	M	2	1	300–350
51.6	4	Pool head	M	2	2	350–400
51.6	4	Pool head	M	3	1	300–350
51.6	4	Pool head	M	3	1	350–400
51.6	5	Pool body	M	1	36	0–50
51.6	5	Pool body	M	1	60	100–150
51.6	5	Pool body	M	1	2	350–400
51.6	5	Pool body	M	1	188	50–100
51.6	5	Pool body	M	2	30	0–50
51.6	5	Pool body	M	2	90	100–150
51.6	5	Pool body	M	2	2	350–400
51.6	5	Pool body	M	2	174	50–100
51.6	5	Pool body	M	3	45	0–50
51.6	5	Pool body	M	3	100	100–150
51.6	5	Pool body	M	3	2	250–300
51.6	5	Pool body	M	3	2	350–400
51.6	5	Pool body	M	3	144	50–100
50.6	14	Riffle	S	1	35	100–150
50.6	14	Riffle	S	1	3	150–200
50.6	14	Riffle	S	1	1	350–400
50.6	14	Riffle	S	1	13	50–100
50.6	15	Run head	S	1	2	100–150
50.3	19	Run head	S	1	3	250–300
50.3	19	Run head	S	1	1	350–400
50.1	20	Run body	M	1	1	100–150
50.1	20	Run body	M	1	1	200–250
50.1	20	Run body	M	1	4	50–100
50.1	20	Run body	M	2	1	300–350
50.1	20	Run body	M	2	1	400–450
50.1	20	Run body	M	3	3	250–300
50.1	22	Riffle	M	1	3	0–50

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
50.1	22	Riffle	M	1	29	100–150
50.1	22	Riffle	M	1	2	250–300
50.1	22	Riffle	M	1	1	300–350
50.1	22	Riffle	M	1	43	50–100
50.1	22	Riffle	M	2	5	0–50
50.1	22	Riffle	M	2	43	100–150
50.1	22	Riffle	M	2	2	250–300
50.1	22	Riffle	M	2	1	300–350
50.1	22	Riffle	M	2	47	50–100
50.1	22	Riffle	M	3	3	0–50
50.1	22	Riffle	M	3	40	100–150
50.1	22	Riffle	M	3	1	350–400
50.1	22	Riffle	M	3	43	50–100
49.7	27	Pool head	S	1	1	100–150
49.7	27	Pool head	S	1	1	150–200
49.7	27	Pool head	S	1	1	250–300
49.7	27	Pool head	S	1	2	300–350
49.7	27	Pool head	S	1	2	50–100
49.6	28	Pool body	S	1	2	100–150
49.6	28	Pool body	S	1	5	150–200
49.6	28	Pool body	S	1	3	200–250
49.6	28	Pool body	S	1	8	50–100
49.2	33	Riffle	S	1	17	100–150
49.2	33	Riffle	S	1	6	150–200
49.2	33	Riffle	S	1	11	200–300
49.2	33	Riffle	S	1	3	300–350
49.2	33	Riffle	S	1	1	400–450
49.2	33	Riffle	S	1	11	50–100
49.2	34	Run head	S	1	5	100–150
49.2	34	Run head	S	1	3	150–200
49.2	34	Run head	S	1	1	250–300
49.2	34	Run head	S	1	1	300–350
49.2	34	Run head	S	1	21	50–100
49.1	35	Run body	S	1	0	--
48.2	49	Riffle	S	1	40	100–150
48.2	49	Riffle	S	1	2	150–200
48.2	49	Riffle	S	1	4	200–250
48.2	49	Riffle	S	1	6	250–300
48.2	49	Riffle	S	1	1	350–400
48.2	49	Riffle	S	1	25	50–100
48.0	54	Pool head	S	1	1	200–250

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
48.0	54	Pool head	S	1	1	300–350
47.0	58	Run head	M	1	1	150–200
47.0	58	Run head	M	2	4	100–150
47.0	58	Run head	M	2	2	50–100
47.0	58	Run head	M	3	5	100–150
46.9	59	Run body	S	1	0	--
45.7	74	Riffle	S	1	2	0–50
45.7	74	Riffle	S	1	5	100–150
45.7	74	Riffle	S	1	1	150–200
45.7	74	Riffle	S	1	6	50–100
45.7	75	Run head	M	1	0	--
45.7	75	Run head	M	2	0	--
45.7	75	Run head	M	3	1	50–100
45.7	76	Run body	S	1	0	--
45.0	86	Pool head	M	1	0	--
45.0	86	Pool head	M	2	0	--
45.0	86	Pool head	M	3	0	--
44.9	87	Pool body	S	1	0	--
44.5	101	Riffle	M	1	15	100–150
44.5	101	Riffle	M	1	3	150–200
44.5	101	Riffle	M	1	4	50–100
44.5	101	Riffle	M	2	14	100–150
44.5	101	Riffle	M	2	1	150–200
44.5	101	Riffle	M	2	3	50–100
44.5	101	Riffle	M	3	13	100–150
44.5	101	Riffle	M	3	1	150–200
44.5	101	Riffle	M	3	9	50–100
43.2	108	Run head	S	1	0	--
43.1	109	Run body	M	1	12	100–150
43.1	109	Run body	M	1	5	150–200
43.1	109	Run body	M	1	1	50–100
43.1	109	Run body	M	2	8	100–150
43.1	109	Run body	M	2	1	150–200
43.1	109	Run body	M	2	4	50–100
43.1	109	Run body	M	3	9	100–150
43.1	109	Run body	M	3	1	150–200
43.1	109	Run body	M	3	5	50–100
43.0	111	Riffle	S	1	6	100–150
43.0	111	Riffle	S	1	2	150–200
43.0	111	Riffle	S	1	1	50–100
43.0	112	Pool head	S	1	1	50–100

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
43.0	113	Pool body	M	1	0	--
43.0	113	Pool body	M	2	0	--
43.0	113	Pool body	M	3	0	--
41.9	132	Riffle	S	1	1	100–150
41.9	132	Riffle	S	1	1	200–250
41.9	133	Run head	S	1	0	--

Table G-3. *O. tshawyschta* observation data for the study area, March 2009.

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
51.6	4	Pool head	S	1	80	0–49
51.6	4	Pool head	S	1	45	50–99
51.6	5	Pool body	S	1	0	--
51.5	6	Pool tail	S	1	6	0–49
51.5	6	Pool tail	S	1	4	50–99
51.5	7	Riffle	S	1	250	0–49
51.5	7	Riffle	S	1	1	500–549
51.5	7	Riffle	S	1	119	50–99
50.6	14	Riffle	S	1	910	0–49
50.6	14	Riffle	S	1	505	50–99
50.6	15	Run head	S	1	112	0–49
50.6	15	Run head	S	1	144	50–99
50.5	16	Run body	S	1	149	0–49
50.5	16	Run body	S	1	1	500–549
50.5	16	Run body	S	1	208	50–99
50.4	17	Run tail	S	1	71	0–49
50.4	17	Run tail	S	1	50	50–99
50.1	22	Riffle	S	1	32	0–49
50.1	22	Riffle	S	1	12	50–99
49.7	27	Pool head	S	1	60	50–99
49.6	28	Pool body	S	1	0	--
49.6	29	Pool tail	S	1	7	50–99
48.0	53	Riffle	M	1	60	0–49
48.0	53	Riffle	M	1	105	50–99
48.0	53	Riffle	M	2	70	0–49
48.0	53	Riffle	M	2	110	50–99
48.0	53	Riffle	M	3	80	0–49
48.0	53	Riffle	M	3	100	50–99
47.0	58	Run head	M	1	12	0–49
47.0	58	Run head	M	1	3	50–99
47.0	58	Run head	M	2	30	0–49
47.0	58	Run head	M	2	15	50–99
47.0	58	Run head	M	3	30	0–49
47.0	58	Run head	M	3	11	50–99
46.9	59	Run body	S	1	2	0–49
46.9	60	Run tail	M	1	0	--
46.9	60	Run tail	M	2	4	0–49
46.9	60	Run tail	M	3	6	0–49
45.3	82	Run head	S	1	0	--

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
45.1	83	Run body	S	1	2	0–49
45.1	83	Run body	S	1	3	50–99
45.1	84	Run tail	M	1	0	--
45.1	84	Run tail	M	2	0	--
45.1	84	Run tail	M	3	0	--
45.0	86	Pool head	S	1	0	--
44.9	87	Pool body	S	1	15	50–99
44.9	87	Pool body	S	1	1	650–699
44.9	88	Pool tail	M	1	7	50–99
44.9	88	Pool tail	M	2	35	50–99
44.9	88	Pool tail	M	3	35	50–99
44.6	97	Riffle	S	1	31	0–49
44.6	97	Riffle	S	1	103	50–99
43.2	107	Riffle	S	1	65	0–49
43.2	107	Riffle	S	1	80	50–99
43.2	108	Run head	S	1	7	0–49
43.2	108	Run head	S	1	50	0–49
43.2	108	Run head	S	1	30	50–99
43.1	109	Run body	S	1	180	0–49
43.1	109	Run body	S	1	241	50–99
43.1	110	Run tail	S	1	2	50–99
43.0	111	Riffle	M	1	41	0–49
43.0	111	Riffle	M	1	42	50–99
43.0	111	Riffle	M	2	34	0–49
43.0	111	Riffle	M	2	36	50–99
43.0	111	Riffle	M	3	30	0–49
43.0	111	Riffle	M	3	24	50–99
43.0	112	Pool head	M	1	26	0–49
43.0	112	Pool head	M	1	24	50–99
43.0	112	Pool head	M	2	26	0–49
43.0	112	Pool head	M	2	22	50–99
43.0	112	Pool head	M	3	22	0–49
43.0	112	Pool head	M	3	20	50–99
43.0	113	Pool body	M	1	0	--
43.0	113	Pool body	M	2	0	--
43.0	113	Pool body	M	3	0	--
43.0	114	Pool tail	S	1	0	--
42.9	118	Riffle	S	1	7	0–49
42.9	118	Riffle	S	1	14	50–99
39.6	157	Run head	S	1	0	--
39.5	158	Run body	M	1	0	--

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
39.5	158	Run body	M	2	0	--
39.5	158	Run body	M	3	0	--
39.5	159	Run tail	S	1	2	50–99
39.4	160	Riffle	S	1	1	50–99
38.9	168	Riffle	S	1	10	0–49
38.9	168	Riffle	S	1	8	50–99
38.7	175	Riffle	S	1	1	0–49
38.1	188	Pool head	S	1	0	--
38.1	189	Pool body	S	1	0	--
38.1	190	Pool tail	S	1	0	--
38.1	192	Pool head	M	1	0	--
38.0	193	Pool body	S	1	60	50–99
38.0	194	Pool tail	M	1	0	--
38.0	194	Pool tail	M	2	0	--
38.0	194	Pool tail	M	3	0	--
36.9	214	Pool head	S	1	1	50–99
36.9	215	Pool body	S	1	0	--
36.9	216	Pool tail	S	1	0	--
36.8	218	Run head	S	1	0	--
36.6	219	Run body	M	1	1	800–849
36.6	219	Run body	M	2	0	--
36.6	219	Run body	M	3	9	50–99
36.6	220	Run tail	S	1	10	50–99
36.2	230	Pool head	S	1	0	--
36.2	231	Pool body	M	1	0	--
36.2	232	Pool tail	S	1	0	--
34.0	259	Run head	M	1	19	0–49
34.0	259	Run head	M	1	7	50–99
34.0	259	Run head	M	2	28	0–49
34.0	259	Run head	M	2	21	50–99
34.0	259	Run head	M	3	34	0–49
34.0	259	Run head	M	3	20	50–99
34.0	260	Run body	S	1	3	0–49
34.0	260	Run body	S	1	2	50–99
33.9	261	Run tail	S	1	17	0–49
33.9	261	Run tail	S	1	12	50–99
33.4	271	Pool head	S	1	8	0–49
33.2	272	Pool body	S	1	7	0–49
33.2	273	Pool tail	S	1	4	0–49
31.9	287	Run head	S	1	55	0–49
31.9	287	Run head	S	1	13	50–99

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
31.7	288	Run body	S	1	56	0–49
31.7	288	Run body	S	1	18	50–99
31.7	289	Run tail	S	1	10	0–49
31.7	289	Run tail	S	1	5	50–99
29.5	324	Riffle	S	1	0	--
29.5	325	Run head	S	1	0	--
29.5	326	Run body	S	1	0	--
29.5	327	Run tail	S	1	0	--

Table G-4. *O. tshawyschta* observation data for the study area, July 2009.

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
51.8	1	Pool head	S	1	0	--
51.7	2	Pool body	S	1	0	--
51.6	4	Pool head	M	1	0	--
51.6	4	Pool head	M	2	1	>600
51.6	4	Pool head	M	3	0	--
51.6	5	Pool body	M	1	250	0–50
51.6	5	Pool body	M	1	280	50–100
51.6	5	Pool body	M	2	230	0–50
51.6	5	Pool body	M	2	275	50–100
51.6	5	Pool body	M	3	230	0–50
51.6	5	Pool body	M	3	1	400–450
51.6	5	Pool body	M	3	292	50–100
50.6	14	Riffle	S	1	2	>600
50.6	14	Riffle	S	1	570	0–50
50.6	14	Riffle	S	1	120	100–150
50.6	14	Riffle	S	1	2	500–600
50.6	14	Riffle	S	1	1410	50–100
50.6	15	Run head	S	1	30	0–50
50.6	15	Run head	S	1	55	50–100
50.3	19	Run head	S	1	20	100–150
50.3	19	Run head	S	1	480	50–100
50.1	20	Run body	M	1	38	0–50
50.1	20	Run body	M	1	136	50–100
50.1	20	Run body	M	2	116	0–50
50.1	20	Run body	M	2	249	50–100
50.1	20	Run body	M	3	94	0–50
50.1	20	Run body	M	3	197	50–100
50.1	22	Riffle	M	1	17	0–50
50.1	22	Riffle	M	1	68	50–100
50.1	22	Riffle	M	2	24	0–50
50.1	22	Riffle	M	2	123	50–100
50.1	22	Riffle	M	3	18	0–50
50.1	22	Riffle	M	3	139	50–100
49.7	27	Pool head	S	1	3	100–150
49.7	27	Pool head	S	1	3	50–100
49.6	28	Pool body	S	1	2	100–150
49.6	28	Pool body	S	1	100	50–100
49.2	33	Riffle	S	1	6	100–150
49.2	33	Riffle	S	1	97	50–100

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
49.2	34	Run head	S	1	95	0–50
49.2	34	Run head	S	1	5	100–150
49.2	34	Run head	S	1	325	50–100
49.1	35	Run body	S	1	0	--
48.2	49	Riffle	S	1	32	0–50
48.2	49	Riffle	S	1	7	100–150
48.2	49	Riffle	S	1	89	50–100
48.0	54	Pool head	S	1	1	0–50
47.0	58	Run head	M	1	2	100–150
47.0	58	Run head	M	1	2	50–100
47.0	58	Run head	M	2	2	100–150
47.0	58	Run head	M	2	2	50–100
47.0	58	Run head	M	3	0	--
46.9	59	Run body	S	1	0	--
45.7	74	Riffle	S	1	3	0–50
45.7	74	Riffle	S	1	3	100–150
45.7	74	Riffle	S	1	35	50–100
45.7	75	Run head	M	1	0	--
45.7	75	Run head	M	2	1	50–100
45.7	75	Run head	M	3	1	50–100
45.7	76	Run body	S	1	11	50–100
45.0	86	Pool head	M	1	0	--
45.0	86	Pool head	M	2	0	--
45.0	86	Pool head	M	3	4	50–100
44.9	87	Pool body	S	1	3	50–100
44.5	101	Riffle	M	1	2	0–50
44.5	101	Riffle	M	1	18	100–150
44.5	101	Riffle	M	1	69	50–100
44.5	101	Riffle	M	2	4	0–50
44.5	101	Riffle	M	2	13	100–150
44.5	101	Riffle	M	2	54	50–100
44.5	101	Riffle	M	3	4	0–50
44.5	101	Riffle	M	3	11	100–150
44.5	101	Riffle	M	3	67	50–100
43.2	108	Run head	S	1	0	--
43.1	109	Run body	M	1	1	100–150
43.1	109	Run body	M	1	6	50–100
43.1	109	Run body	M	2	2	100–150
43.1	109	Run body	M	2	10	50–100
43.1	109	Run body	M	3	2	100–150
43.1	109	Run body	M	3	5	50–100

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
43.0	111	Riffle	S	1	1	50–100
43.0	112	Pool head	S	1	2	50–100
43.0	113	Pool body	M	1	0	--
43.0	113	Pool body	M	2	0	--
43.0	113	Pool body	M	3	0	--
41.9	132	Riffle	S	1	1	0–50
41.9	132	Riffle	S	1	4	100–150
41.9	132	Riffle	S	1	19	50–100
41.9	133	Run head	S	1	2	50–100

Table G-5. Non-salmonid fish observation data for the study area, March 2009.

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
51.6	4	Pool head	S	1	Sacramento sucker	1	300–400
51.6	4	Pool head	S	1	Sacramento sucker	1	50–75
51.5	7	Riffle	S	1	Sacramento sucker	6	50–75
50.6	14	Riffle	S	1	Sacramento sucker	3	25–50
50.6	14	Riffle	S	1	Sacramento sucker	41	400–450
50.6	14	Riffle	S	1	Sacramento sucker	12	400–500
50.6	14	Riffle	S	1	Sacramento sucker	4	50–75
50.6	14	Riffle	S	1	Salmonid sp.	2	--
50.6	15	Run head	S	1	Sacramento sucker	8	350–400
50.6	15	Run head	S	1	Sacramento sucker	11	400–500
50.5	16	Run body	S	1	Sacramento sucker	47	300–400
50.5	16	Run body	S	1	Sacramento sucker	20	400–500
50.5	16	Run body	S	1	Unknown	1	25–50
50.4	17	Run tail	S	1	Sacramento sucker	2	50–75
50.1	22	Riffle	S	1	Sacramento sucker	7	150–200
49.7	27	Pool head	S	1	Sacramento sucker	2	300–350
49.7	27	Pool head	S	1	Sacramento sucker	3	400–500
49.6	28	Pool body	S	1	Sacramento sucker	15	400–500
49.6	28	Pool body	S	1	Sacramento sucker	1	--
48.0	53	Riffle	M	1	Sacramento sucker	10	400–600
48.0	53	Riffle	M	2	Sacramento sucker	4	400–600
48.0	53	Riffle	M	2	Sculpin sp.	1	--
48.0	53	Riffle	M	3	Sacramento sucker	6	400–600
48.0	53	Riffle	M	3	Sculpin sp.	3	75–100

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of coun t	Size range
48.0	53	Riffle	M	3	Sculpin sp.	1	--
48.0	53	Riffle	M	3	Sacramento sucker	1	--
47.0	58	Run head	M	1	Sacramento sucker	12	350–500
47.0	58	Run head	M	1	Sacramento sucker	1	--
47.0	58	Run head	M	2	Sacramento sucker	10	350–500
47.0	58	Run head	M	2	Sacramento sucker	2	75–100
47.0	58	Run head	M	3	Sacramento sucker	4	25–50
47.0	58	Run head	M	3	Sacramento sucker	10	350–500
47.0	58	Run head	M	3	Sacramento sucker	2	500–600
47.0	58	Run head	M	3	Sacramento sucker	2	75–100
46.9	59	Run body	S	1	Hardhead/ Pikeminnow	2	400–450
46.9	59	Run body	S	1	Sacramento sucker	1	--
45.3	82	Run head	S	1	Largemouth bass	5	300–400
45.3	82	Run head	S	1	Hardhead/ Pikeminnow	8	400–500
45.3	82	Run head	S	1	Sacramento sucker	9	400–600
45.3	82	Run head	S	1	Sacramento sucker	4	40–500
45.3	82	Run head	S	1	Hardhead/ Pikeminnow	1	50–75
45.1	83	Run body	S	1	Hardhead/ Pikeminnow	10	100–125
45.1	83	Run body	S	1	Hardhead/ Pikeminnow	2	125–150
45.1	83	Run body	S	1	Hardhead/ Pikeminnow	6	50–75
45.1	83	Run body	S	1	Hardhead/ Pikeminnow	20	75–100
45.1	83	Run body	S	1	Largemouth bass	1	--
45.1	83	Run body	S	1	Hardhead/ Pikeminnow	2	--
45.0	86	Pool head	S	1	Hardhead/ Pikeminnow	2	100–150
45.0	86	Pool head	S	1	Hardhead/ Pikeminnow	7	25–50

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
45.0	86	Pool head	S	1	Hardhead/ Pikeminnow	5	50–100
45.0	86	Pool head	S	1	Hardhead/ Pikeminnow	2	75–100
45.0	86	Pool head	S	1	Sacramento sucker	1	--
44.9	87	Pool body	S	1	Hardhead/ Pikeminnow	1	--
44.9	88	Pool tail	M	1	Hardhead/ Pikeminnow	1	--
44.9	88	Pool tail	M	2	Hardhead/ Pikeminnow	4	100–150
44.9	88	Pool tail	M	2	Hardhead/ Pikeminnow	15	25–50
44.9	88	Pool tail	M	2	Largemouth bass	1	--
44.9	88	Pool tail	M	3	Hardhead/ Pikeminnow	4	100–150
44.9	88	Pool tail	M	3	Hardhead/ Pikeminnow	20	25–50
44.9	88	Pool tail	M	3	Hardhead/ Pikeminnow	7	50–100
44.9	88	Pool tail	M	3	Hardhead/ Pikeminnow	1	--
44.6	97	Riffle	S	1	Sacramento sucker	9	400–600
44.6	97	Riffle	S	1	Hardhead/ Pikeminnow	94	50–100
44.6	97	Riffle	S	1	Sacramento sucker	1	--
43.2	107	Riffle	S	1	Hardhead/ Pikeminnow	5	100–125
43.2	107	Riffle	S	1	Hardhead/ Pikeminnow	2	125–150
43.2	107	Riffle	S	1	Sacramento sucker	4	400–500
43.2	107	Riffle	S	1	Sacramento sucker	3	400–600
43.2	107	Riffle	S	1	Hardhead/ Pikeminnow	19	75–100
43.2	108	Run head	S	1	Hardhead/ Pikeminnow	20	100–150
43.2	108	Run head	S	1	Hardhead/ Pikeminnow	30	100–200
43.2	108	Run head	S	1	Sacramento sucker	9	300–500
43.2	108	Run head	S	1	Sacramento sucker	9	400–600
43.1	109	Run body	S	1	Hardhead/ Pikeminnow	60	100–200

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
43.1	109	Run body	S	1	Hardhead/ Pikeminnow	20	150–200
43.1	109	Run body	S	1	Sacramento sucker	6	500–600
43.1	109	Run body	S	1	Hardhead/ Pikeminnow	117	50–75
43.1	109	Run body	S	1	Hardhead/ Pikeminnow	39	75–100
43.1	110	Run tail	S	1	Sacramento sucker	8	500–600
43.1	110	Run tail	S	1	Hardhead/ Pikeminnow	3	50–100
43.0	111	Riffle	M	1	Sacramento sucker	4	400–500
43.0	111	Riffle	M	2	Hardhead/ Pikeminnow	4	50–100
43.0	111	Riffle	M	2	Hardhead/ Pikeminnow	1	--
43.0	111	Riffle	M	3	Hardhead/ Pikeminnow	3	150–200
43.0	112	Pool head	M	1	Hardhead/ Pikeminnow	3	25–50
43.0	112	Pool head	M	1	Hardhead/ Pikeminnow	7	50–75
43.0	112	Pool head	M	2	Hardhead/ Pikeminnow	3	25–50
43.0	112	Pool head	M	2	Hardhead/ Pikeminnow	2	50–75
43.0	112	Pool head	M	2	Sacramento sucker	2	50–75
43.0	112	Pool head	M	2	Lamprey sp.	1	--
43.0	112	Pool head	M	3	Hardhead/ Pikeminnow	4	25–50
43.0	112	Pool head	M	3	Hardhead/ Pikeminnow	2	50–75
43.0	112	Pool head	M	3	Sculpin sp.	1	--
43.0	113	Pool body	M	1	Sacramento sucker	100	0–25
43.0	113	Pool body	M	1	Hardhead/ Pikeminnow	3	150–200
43.0	113	Pool body	M	1	Hardhead/ Pikeminnow	5	250–300
43.0	113	Pool body	M	1	Sacramento sucker	3	300–500
43.0	113	Pool body	M	1	Hardhead/ Pikeminnow	80	50–100
43.0	113	Pool body	M	1	Hardhead/ Pikeminnow	1	--

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
43.0	113	Pool body	M	1	Sacramento sucker	1	--
43.0	113	Pool body	M	2	Hardhead/ Pikeminnow	3	250–300
43.0	113	Pool body	M	2	Hardhead/ Pikeminnow	62	50–100
43.0	113	Pool body	M	2	Hardhead/ Pikeminnow	1	--
43.0	113	Pool body	M	2	Hardhead/ Pikeminnow	1	--
43.0	113	Pool body	M	2	Sacramento sucker	1	--
43.0	113	Pool body	M	3	Hardhead/ Pikeminnow	3	100–200
43.0	113	Pool body	M	3	Hardhead/ Pikeminnow	6	150–200
43.0	113	Pool body	M	3	Hardhead/ Pikeminnow	5	200–300
43.0	113	Pool body	M	3	Sacramento sucker	3	300–500
43.0	113	Pool body	M	3	Hardhead/ Pikeminnow	50	50–100
43.0	113	Pool body	M	3	Hardhead/ Pikeminnow	1	--
43.0	113	Pool body	M	3	Hardhead/ Pikeminnow	1	--
43.0	113	Pool body	M	3	Sacramento sucker	1	--
43.0	114	Pool tail	S	1	Hardhead/ Pikeminnow	3	100–150
42.9	118	Riffle	S	1	Sacramento sucker	2	400–600
39.6	157	Run head	S	1	Sacramento sucker	14	400–600
39.5	158	Run body	M	1	Hardhead/ Pikeminnow	2	350–450
39.5	158	Run body	M	1	Sacramento sucker	30	400–600
39.5	158	Run body	M	1	Hardhead/ Pikeminnow	2	500–600
39.5	158	Run body	M	1	Largemouth bass	1	--
39.5	158	Run body	M	1	Hardhead/ Pikeminnow	2	--
39.5	158	Run body	M	1	Smallmouth bass	1	--
39.5	158	Run body	M	1	Unknown	50	--
39.5	158	Run body	M	2	Smallmouth bass	2	300–350

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
39.5	158	Run body	M	2	Hardhead/ Pikeminnow	3	350–450
39.5	158	Run body	M	2	Sacramento sucker	53	400–600
39.5	158	Run body	M	2	Largemouth bass	2	--
39.5	158	Run body	M	2	Hardhead/ Pikeminnow	1	--
39.5	158	Run body	M	2	Smallmouth bass	1	--
39.5	158	Run body	M	2	Unknown	20	--
39.5	158	Run body	M	3	Hardhead/ Pikeminnow	2	350–400
39.5	158	Run body	M	3	Sacramento sucker	2	400–500
39.5	158	Run body	M	3	Sacramento sucker	53	400–600
39.5	158	Run body	M	3	Largemouth bass	1	--
39.5	158	Run body	M	3	Hardhead/ Pikeminnow	2	--
39.5	158	Run body	M	3	Smallmouth bass	2	--
39.5	158	Run body	M	3	Striped bass	1	--
39.5	158	Run body	M	3	Unknown	70	--
39.5	159	Run tail	S	1	Sacramento sucker	20	0–50
39.4	160	Riffle	S	1	Hardhead/ Pikeminnow	15	150–200
39.4	160	Riffle	S	1	Unknown	3	50–100
39.4	160	Riffle	S	1	Largemouth bass	1	--
39.4	160	Riffle	S	1	Hardhead/ Pikeminnow	1	--
38.9	168	Riffle	S	1	Sacramento sucker	5	400–600
38.9	168	Riffle	S	1	Sacramento sucker	6	500–600
38.9	168	Riffle	S	1	Sculpin sp.	1	--
38.1	189	Pool body	S	1	Hardhead/ Pikeminnow	2	200–250
38.1	189	Pool body	S	1	Sacramento sucker	4	400–500
38.1	189	Pool body	S	1	Largemouth bass	1	--

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
38.1	189	Pool body	S	1	Sacramento sucker	1	--
38.1	192	Pool head	M	1	Sacramento sucker	1	--
38.0	193	Pool body	S	1	Sacramento sucker	3	300–350
38.0	193	Pool body	S	1	Sacramento sucker	17	400–600
38.0	193	Pool body	S	1	Largemouth bass	1	--
36.9	215	Pool body	S	1	Sacramento sucker	35	400–600
36.9	215	Pool body	S	1	Sacramento sucker	18	500–600
36.9	215	Pool body	S	1	Hardhead/ Pikeminnow	1	--
36.8	218	Run head	S	1	Sacramento sucker	9	400–600
36.6	219	Run body	M	1	Hardhead/ Pikeminnow	2	300–400
36.6	219	Run body	M	1	Hardhead/ Pikeminnow	5	300–500
36.6	219	Run body	M	1	Sacramento sucker	6	300–600
36.6	219	Run body	M	1	Hardhead/ Pikeminnow	2	400–600
36.6	219	Run body	M	1	Sacramento sucker	7	400–600
36.6	219	Run body	M	1	Black bass	1	--
36.6	219	Run body	M	1	Largemouth bass	2	--
36.6	219	Run body	M	2	Hardhead/ Pikeminnow	2	300–500
36.6	219	Run body	M	2	Sacramento sucker	5	400–600
36.6	219	Run body	M	2	Hardhead/ Pikeminnow	1	--
36.6	219	Run body	M	3	Smallmouth bass	2	200–300
36.6	219	Run body	M	3	Hardhead/ Pikeminnow	7	300–350
36.6	219	Run body	M	3	Hardhead/ Pikeminnow	5	300–400
36.6	219	Run body	M	3	Hardhead/ Pikeminnow	6	300–500
36.6	219	Run body	M	3	Sacramento sucker	6	300–600
36.6	219	Run body	M	3	Sacramento sucker	12	400–600

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
36.6	219	Run body	M	3	Hardhead/ Pikeminnow	3	50–75
36.6	219	Run body	M	3	Hardhead/ Pikeminnow	1	--
36.2	231	Pool body	M	1	Sacramento sucker	1	--
36.2	231	Pool body	M	1	Unknown	1	--
34.0	259	Run head	M	1	Sacramento sucker	35	300–600
34.0	259	Run head	M	1	Smallmouth bass	1	--
34.0	259	Run head	M	2	Sacramento sucker	3	300–600
34.0	259	Run head	M	2	Smallmouth bass	1	--
34.0	259	Run head	M	2	Sacramento sucker	1	--
34.0	259	Run head	M	3	Smallmouth bass	1	--
34.0	259	Run head	M	3	Sacramento sucker	1	--
34.0	260	Run body	S	1	Sacramento sucker	30	300–600
34.0	260	Run body	S	1	Hardhead/ Pikeminnow	2	--
34.0	260	Run body	S	1	Smallmouth bass	1	--
33.9	261	Run tail	S	1	Sacramento sucker	2	300–350
33.4	271	Pool head	S	1	Black bass	3	300–400
33.2	272	Pool body	S	1	Largemouth bass	1	--
33.2	273	Pool tail	S	1	Lamprey sp.	1	--
31.9	287	Run head	S	1	Sacramento sucker	17	400–600
31.9	287	Run head	S	1	Sacramento sucker	40	400–700
31.9	287	Run head	S	1	Hardhead/ Pikeminnow	1	--
31.7	288	Run body	S	1	Sacramento sucker	35	400–650
31.7	288	Run body	S	1	Sacramento sucker	46	400–700
31.7	288	Run body	S	1	Smallmouth bass	1	--
31.7	289	Run tail	S	1	Hardhead/ Pikeminnow	1	--

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
29.5	324	Riffle	S	1	Sacramento sucker	1	--
29.5	325	Run head	S	1	Bluegill	10	150–200
29.5	325	Run head	S	1	Sacramento sucker	4	400–600
29.5	325	Run head	S	1	Bluegill	1	--
29.5	325	Run head	S	1	Smallmouth bass	1	--
29.5	326	Run body	S	1	Bluegill	1	--
29.5	327	Run tail	S	1	Bluegill	3	50–75
29.5	327	Run tail	S	1	Largemouth bass	1	--

Table G-6. Non-salmonid fish observation data for the study area, July 2009.

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
51.7	2	Pool body	S	1	Hardhead/ Pikeminnow	2	300–400
51.7	2	Pool body	S	1	Hardhead/ Pikeminnow	2	--
51.7	2	Pool body	S	1	Sacramento sucker	4	400–500
51.7	2	Pool body	S	1	Sacramento sucker	1	--
51.6	5	Pool body	M	1	Sacramento sucker	2	0–50
51.6	5	Pool body	M	3	Sacramento sucker	2	0–50
50.6	14	Riffle	S	1	Hardhead/ Pikeminnow	1	--
50.6	14	Riffle	S	1	Sculpin sp.	2	0–50
50.6	14	Riffle	S	1	Sculpin sp.	1	50–100
50.6	14	Riffle	S	1	Sacramento sucker	4	0–50
50.6	14	Riffle	S	1	Sacramento sucker	8	200–400
50.6	14	Riffle	S	1	Sacramento sucker	22	400–600
50.6	15	Run head	S	1	Sacramento sucker	2	200–400
50.3	19	Run head	S	1	Sacramento sucker	2	400–500
50.1	20	Run body	M	1	Hardhead/ Pikeminnow	1	400–500
50.1	20	Run body	M	1	Hardhead/ Pikeminnow	1	--
50.1	20	Run body	M	1	Sacramento sucker	20	0–50
50.1	20	Run body	M	1	Sacramento sucker	17	200–300
50.1	20	Run body	M	1	Sacramento sucker	30	300–400
50.1	20	Run body	M	1	Sacramento sucker	12	400–500
50.1	20	Run body	M	1	Sacramento sucker	18	50–100
50.1	20	Run body	M	1	Sacramento sucker	1	--
50.1	20	Run body	M	2	Hardhead/ Pikeminnow	3	400–500
50.1	20	Run body	M	2	Sculpin sp.	9	0–100
50.1	20	Run body	M	2	Sacramento sucker	6	0–100

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
50.1	20	Run body	M	2	Sacramento sucker	10	100–150
50.1	20	Run body	M	2	Sacramento sucker	19	200–300
50.1	20	Run body	M	2	Sacramento sucker	36	300–400
50.1	20	Run body	M	2	Sacramento sucker	2	400–500
50.1	20	Run body	M	2	Sacramento sucker	42	50–100
50.1	20	Run body	M	3	Hardhead/ Pikeminnow	2	300–400
50.1	20	Run body	M	3	Sculpin sp.	8	0–100
50.1	20	Run body	M	3	Sculpin sp.	1	50–100
50.1	20	Run body	M	3	Sacramento sucker	4	0–100
50.1	20	Run body	M	3	Sacramento sucker	30	0–50
50.1	20	Run body	M	3	Sacramento sucker	15	200–300
50.1	20	Run body	M	3	Sacramento sucker	27	300–400
50.1	20	Run body	M	3	Sacramento sucker	20	400–500
50.1	20	Run body	M	3	Sacramento sucker	60	50–100
50.1	22	Riffle	M	1	Sacramento sucker	7	0–50
50.1	22	Riffle	M	1	Sacramento sucker	1	50–100
50.1	22	Riffle	M	2	Sacramento sucker	7	0–50
50.1	22	Riffle	M	2	Sacramento sucker	3	50–100
50.1	22	Riffle	M	3	Sacramento sucker	8	0–50
50.1	22	Riffle	M	3	Sacramento sucker	15	50–100
49.7	27	Pool head	S	1	Hardhead/ Pikeminnow	1	--
49.7	27	Pool head	S	1	Sacramento sucker	3	0–50
49.7	27	Pool head	S	1	Sacramento sucker	1	300–400
49.7	27	Pool head	S	1	Sacramento sucker	3	50–100
49.6	28	Pool body	S	1	Hardhead/ Pikeminnow	2	--
49.6	28	Pool body	S	1	Sculpin sp.	1	50–100

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
49.6	28	Pool body	S	1	Sculpin sp.	1	--
49.6	28	Pool body	S	1	Sacramento sucker	12	400–500
49.2	33	Riffle	S	1	Sacramento sucker	1	0–100
49.2	34	Run head	S	1	Hardhead/ Pikeminnow	1	100–200
49.2	34	Run head	S	1	Hardhead/ Pikeminnow	2	300–400
49.2	34	Run head	S	1	Hardhead/ Pikeminnow	5	50–100
49.2	34	Run head	S	1	Sacramento sucker	4	0–50
49.2	34	Run head	S	1	Sacramento sucker	6	50–100
49.1	35	Run body	S	1	Hardhead/ Pikeminnow	2	300–400
49.1	35	Run body	S	1	Sacramento sucker	1	--
48.2	49	Riffle	S	1	Hardhead/ Pikeminnow	2	100–150
48.2	49	Riffle	S	1	Hardhead/ Pikeminnow	8	100–200
48.2	49	Riffle	S	1	Hardhead/ Pikeminnow	6	50–100
48.2	49	Riffle	S	1	Sacramento sucker	17	300–500
48.2	49	Riffle	S	1	Sacramento sucker	3	400–600
48.2	49	Riffle	S	1	Sacramento sucker	6	50–100
48.0	54	Pool head	S	1	Largemouth bass	8	100–200
48.0	54	Pool head	S	1	Hardhead/ Pikeminnow	2	100–200
48.0	54	Pool head	S	1	Hardhead/ Pikeminnow	7	200–300
48.0	54	Pool head	S	1	Hardhead/ Pikeminnow	2	400–500
48.0	54	Pool head	S	1	Hardhead/ Pikeminnow	1	50–100
48.0	54	Pool head	S	1	Hardhead/ Pikeminnow	4	100–200
48.0	54	Pool head	S	1	Smallmouth bass	4	100–200
48.0	54	Pool head	S	1	Smallmouth bass	1	--
48.0	54	Pool head	S	1	Sacramento sucker	41	300–500
48.0	54	Pool head	S	1	Sacramento sucker	6	400–500

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
47.0	58	Run head	M	1	Hardhead/ Pikeminnow	63	100–200
47.0	58	Run head	M	1	Hardhead/ Pikeminnow	3	200–300
47.0	58	Run head	M	1	Hardhead/ Pikeminnow	7	50–100
47.0	58	Run head	M	1	Sacramento sucker	22	100–200
47.0	58	Run head	M	1	Sacramento sucker	1	200–300
47.0	58	Run head	M	1	Sacramento sucker	4	300–400
47.0	58	Run head	M	1	Sacramento sucker	20	400–600
47.0	58	Run head	M	1	Sacramento sucker	10	50–100
47.0	58	Run head	M	2	Hardhead/ Pikeminnow	6	0–100
47.0	58	Run head	M	2	Hardhead/ Pikeminnow	3	100–150
47.0	58	Run head	M	2	Hardhead/ Pikeminnow	45	100–200
47.0	58	Run head	M	2	Hardhead/ Pikeminnow	4	200–300
47.0	58	Run head	M	2	Sacramento sucker	2	0–100
47.0	58	Run head	M	2	Sacramento sucker	14	100–200
47.0	58	Run head	M	2	Sacramento sucker	12	400–600
47.0	58	Run head	M	2	Sacramento sucker	2	500–600
47.0	58	Run head	M	2	Sacramento sucker	3	50–100
47.0	58	Run head	M	3	Hardhead/ Pikeminnow	3	0–100
47.0	58	Run head	M	3	Hardhead/ Pikeminnow	51	100–200
47.0	58	Run head	M	3	Hardhead/ Pikeminnow	1	200–300
47.0	58	Run head	M	3	Sacramento sucker	13	0–100
47.0	58	Run head	M	3	Sacramento sucker	5	100–200
47.0	58	Run head	M	3	Sacramento sucker	3	300–400
47.0	58	Run head	M	3	Sacramento sucker	5	400–600
47.0	58	Run head	M	3	Sacramento sucker	4	500–600
47.0	58	Run head	M	3	Sacramento sucker	2	50–100

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
46.9	59	Run body	S	1	Largemouth bass	1	200–300
46.9	59	Run body	S	1	Hardhead/ Pikeminnow	4	100–200
46.9	59	Run body	S	1	Hardhead/ Pikeminnow	6	200–300
46.9	59	Run body	S	1	Hardhead/ Pikeminnow	3	500–600
46.9	59	Run body	S	1	Hardhead/ Pikeminnow	5	50–100
46.9	59	Run body	S	1	Sacramento sucker	10	200–300
46.9	59	Run body	S	1	Sacramento sucker	15	400–600
46.9	59	Run body	S	1	Sacramento sucker	15	50–100
45.7	74	Riffle	S	1	Hardhead/ Pikeminnow	14	0–100
45.7	74	Riffle	S	1	Hardhead/ Pikeminnow	22	100–200
45.7	74	Riffle	S	1	Hardhead/ Pikeminnow	6	50–100
45.7	75	Run head	M	1	Hardhead/ Pikeminnow	6	100–200
45.7	75	Run head	M	1	Largemouth bass	1	100–200
45.7	75	Run head	M	1	Hardhead/ Pikeminnow	52	0–100
45.7	75	Run head	M	1	Hardhead/ Pikeminnow	29	100–200
45.7	75	Run head	M	1	Hardhead/ Pikeminnow	2	300–400
45.7	75	Run head	M	1	Hardhead/ Pikeminnow	30	50–100
45.7	75	Run head	M	1	Sacramento sucker	7	0–100
45.7	75	Run head	M	1	Sacramento sucker	36	100–200
45.7	75	Run head	M	1	Sacramento sucker	5	200–300
45.7	75	Run head	M	2	Hardhead/ Pikeminnow	2	0–100
45.7	75	Run head	M	2	Hardhead/ Pikeminnow	7	100–200
45.7	75	Run head	M	2	Hardhead/ Pikeminnow	48	0–100
45.7	75	Run head	M	2	Hardhead/ Pikeminnow	20	0–200
45.7	75	Run head	M	2	Hardhead/ Pikeminnow	48	100–200

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
45.7	75	Run head	M	2	Hardhead/ Pikeminnow	7	200–300
45.7	75	Run head	M	2	Hardhead/ Pikeminnow	2	300–400
45.7	75	Run head	M	2	Sacramento sucker	2	0–100
45.7	75	Run head	M	2	Sacramento sucker	47	100–200
45.7	75	Run head	M	2	Sacramento sucker	2	200–300
45.7	75	Run head	M	3	Hardhead/ Pikeminnow	9	0–100
45.7	75	Run head	M	3	Hardhead/ Pikeminnow	5	100–200
45.7	75	Run head	M	3	Largemouth bass	1	100–200
45.7	75	Run head	M	3	Hardhead/ Pikeminnow	54	0–100
45.7	75	Run head	M	3	Hardhead/ Pikeminnow	71	100–200
45.7	75	Run head	M	3	Hardhead/ Pikeminnow	2	200–300
45.7	75	Run head	M	3	Hardhead/ Pikeminnow	2	300–400
45.7	75	Run head	M	3	Sacramento sucker	5	0–100
45.7	75	Run head	M	3	Sacramento sucker	10	0–200
45.7	75	Run head	M	3	Sacramento sucker	35	100–200
45.7	75	Run head	M	3	Sacramento sucker	6	200–300
45.7	76	Run body	S	1	Hardhead/ Pikeminnow	40	0–100
45.7	76	Run body	S	1	Hardhead/ Pikeminnow	21	100–200
45.7	76	Run body	S	1	Hardhead/ Pikeminnow	12	50–100
45.7	76	Run body	S	1	Sacramento sucker	30	0–100
45.7	76	Run body	S	1	Sacramento sucker	10	100–200
45.0	86	Pool head	M	1	Hardhead/ Pikeminnow	79	0–100
45.0	86	Pool head	M	1	Hardhead/ Pikeminnow	38	100–200
45.0	86	Pool head	M	1	Hardhead/ Pikeminnow	10	200–300
45.0	86	Pool head	M	1	Sacramento sucker	3	100–200
45.0	86	Pool head	M	2	Hardhead/ Pikeminnow	60	0–100

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
45.0	86	Pool head	M	2	Hardhead/ Pikeminnow	50	100–200
45.0	86	Pool head	M	2	Hardhead/ Pikeminnow	8	200–300
45.0	86	Pool head	M	2	Hardhead/ Pikeminnow	1	--
45.0	86	Pool head	M	2	Sacramento sucker	4	100–200
45.0	86	Pool head	M	2	Sacramento sucker	1	200–300
45.0	86	Pool head	M	3	Hardhead/ Pikeminnow	70	0–100
45.0	86	Pool head	M	3	Hardhead/ Pikeminnow	34	100–200
45.0	86	Pool head	M	3	Hardhead/ Pikeminnow	4	200–300
45.0	86	Pool head	M	3	Hardhead/ Pikeminnow	2	300–400
45.0	86	Pool head	M	3	Hardhead/ Pikeminnow	1	--
45.0	86	Pool head	M	3	Sacramento sucker	2	0–100
45.0	86	Pool head	M	3	Sacramento sucker	3	100–200
44.9	87	Pool body	S	1	Hardhead/ Pikeminnow	65	0–100
44.9	87	Pool body	S	1	Hardhead/ Pikeminnow	20	100–200
44.9	87	Pool body	S	1	Hardhead/ Pikeminnow	1	200–300
44.9	87	Pool body	S	1	Hardhead/ Pikeminnow	1	300–400
44.5	101	Riffle	M	1	Hardhead/ Pikeminnow	5	100–200
44.5	101	Riffle	M	1	Largemouth bass	1	100–200
44.5	101	Riffle	M	1	Hardhead/ Pikeminnow	124	0–100
44.5	101	Riffle	M	1	Hardhead/ Pikeminnow	81	100–200
44.5	101	Riffle	M	1	Hardhead/ Pikeminnow	8	200–300
44.5	101	Riffle	M	1	Sculpin sp.	1	0–100
44.5	101	Riffle	M	1	Sacramento sucker	7	0–100
44.5	101	Riffle	M	1	Sacramento sucker	9	100–200
44.5	101	Riffle	M	1	Sacramento sucker	2	200–300
44.5	101	Riffle	M	1	Sacramento sucker	3	300–500

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
44.5	101	Riffle	M	1	Sacramento sucker	1	400–500
44.5	101	Riffle	M	1	Sacramento sucker	4	50–100
44.5	101	Riffle	M	1	Sacramento sucker	2	--
44.5	101	Riffle	M	2	Hardhead/ Pikeminnow	3	100–200
44.5	101	Riffle	M	2	Largemouth bass	1	100–200
44.5	101	Riffle	M	2	Hardhead/ Pikeminnow	93	0–100
44.5	101	Riffle	M	2	Hardhead/ Pikeminnow	86	100–200
44.5	101	Riffle	M	2	Hardhead/ Pikeminnow	17	200–300
44.5	101	Riffle	M	2	Smallmouth bass	1	100–200
44.5	101	Riffle	M	2	Smallmouth bass	1	--
44.5	101	Riffle	M	2	Sacramento sucker	12	0–100
44.5	101	Riffle	M	2	Sacramento sucker	9	100–200
44.5	101	Riffle	M	2	Sacramento sucker	1	200–300
44.5	101	Riffle	M	2	Sacramento sucker	1	400–500
44.5	101	Riffle	M	2	Sacramento sucker	2	400–600
44.5	101	Riffle	M	2	Sacramento sucker	1	50–100
44.5	101	Riffle	M	3	Hardhead/ Pikeminnow	7	100–200
44.5	101	Riffle	M	3	Largemouth bass	1	100–200
44.5	101	Riffle	M	3	Hardhead/ Pikeminnow	111	0–100
44.5	101	Riffle	M	3	Hardhead/ Pikeminnow	64	100–200
44.5	101	Riffle	M	3	Hardhead/ Pikeminnow	13	200–300
44.5	101	Riffle	M	3	Smallmouth bass	3	100–200
44.5	101	Riffle	M	3	Sacramento sucker	9	0–100
44.5	101	Riffle	M	3	Sacramento sucker	7	100–200
44.5	101	Riffle	M	3	Sacramento sucker	1	200–300
44.5	101	Riffle	M	3	Sacramento sucker	1	400–500

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
44.5	101	Riffle	M	3	Sacramento sucker	3	400–600
44.5	101	Riffle	M	3	Sacramento sucker	3	50–100
43.2	108	Run head	S	1	Hardhead/ Pikeminnow	11	100–200
43.2	108	Run head	S	1	Hardhead/ Pikeminnow	4	200–300
43.2	108	Run head	S	1	Largemouth bass	2	0–100
43.2	108	Run head	S	1	Hardhead/ Pikeminnow	9	100–200
43.2	108	Run head	S	1	Hardhead/ Pikeminnow	8	200–300
43.2	108	Run head	S	1	Sacramento sucker	7	400–500
43.1	109	Run body	M	1	Hardhead/ Pikeminnow	38	0–100
43.1	109	Run body	M	1	Hardhead/ Pikeminnow	12	100–200
43.1	109	Run body	M	1	Hardhead/ Pikeminnow	8	0–100
43.1	109	Run body	M	1	Hardhead/ Pikeminnow	80	100–200
43.1	109	Run body	M	1	Hardhead/ Pikeminnow	53	200–300
43.1	109	Run body	M	1	Hardhead/ Pikeminnow	14	300–400
43.1	109	Run body	M	1	Hardhead/ Pikeminnow	3	400–500
43.1	109	Run body	M	1	Largemouth bass	3	0–100
43.1	109	Run body	M	1	Largemouth bass	22	100–200
43.1	109	Run body	M	1	Largemouth bass	9	200–300
43.1	109	Run body	M	1	Largemouth bass	2	300–400
43.1	109	Run body	M	1	Hardhead/ Pikeminnow	114	0–100
43.1	109	Run body	M	1	Hardhead/ Pikeminnow	182	100–200
43.1	109	Run body	M	1	Hardhead/ Pikeminnow	75	200–300
43.1	109	Run body	M	1	Hardhead/ Pikeminnow	10	300–400
43.1	109	Run body	M	1	Hardhead/ Pikeminnow	4	400–500
43.1	109	Run body	M	1	Black bass	10	100–200
43.1	109	Run body	M	1	Sacramento sucker	27	100–200

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
43.1	109	Run body	M	1	Sacramento sucker	9	200–300
43.1	109	Run body	M	2	Hardhead/ Pikeminnow	18	0–100
43.1	109	Run body	M	2	Hardhead/ Pikeminnow	12	0–100
43.1	109	Run body	M	2	Hardhead/ Pikeminnow	47	100–200
43.1	109	Run body	M	2	Hardhead/ Pikeminnow	61	200–300
43.1	109	Run body	M	2	Hardhead/ Pikeminnow	26	300–400
43.1	109	Run body	M	2	Largemouth bass	11	0–100
43.1	109	Run body	M	2	Largemouth bass	23	100–200
43.1	109	Run body	M	2	Largemouth bass	14	200–300
43.1	109	Run body	M	2	Largemouth bass	1	300–400
43.1	109	Run body	M	2	Hardhead/ Pikeminnow	118	0–100
43.1	109	Run body	M	2	Hardhead/ Pikeminnow	168	100–200
43.1	109	Run body	M	2	Hardhead/ Pikeminnow	46	200–300
43.1	109	Run body	M	2	Hardhead/ Pikeminnow	11	300–400
43.1	109	Run body	M	2	Hardhead/ Pikeminnow	3	400–500
43.1	109	Run body	M	2	Black bass	13	100–200
43.1	109	Run body	M	2	Smallmouth bass	4	100–200
43.1	109	Run body	M	2	Sacramento sucker	25	0–100
43.1	109	Run body	M	2	Sacramento sucker	10	100–200
43.1	109	Run body	M	2	Sacramento sucker	25	200–300
43.1	109	Run body	M	2	Sacramento sucker	11	300–400
43.1	109	Run body	M	2	Sacramento sucker	4	400–500
43.1	109	Run body	M	3	Hardhead/ Pikeminnow	9	0–100
43.1	109	Run body	M	3	Hardhead/ Pikeminnow	18	100–200
43.1	109	Run body	M	3	Hardhead/ Pikeminnow	22	0–100
43.1	109	Run body	M	3	Hardhead/ Pikeminnow	120	100–200

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
43.1	109	Run body	M	3	Hardhead/ Pikeminnow	67	200–300
43.1	109	Run body	M	3	Hardhead/ Pikeminnow	11	300–400
43.1	109	Run body	M	3	Largemouth bass	13	0–100
43.1	109	Run body	M	3	Largemouth bass	23	100–200
43.1	109	Run body	M	3	Largemouth bass	11	200–300
43.1	109	Run body	M	3	Largemouth bass	2	300–400
43.1	109	Run body	M	3	Hardhead/ Pikeminnow	115	0–100
43.1	109	Run body	M	3	Hardhead/ Pikeminnow	134	100–200
43.1	109	Run body	M	3	Hardhead/ Pikeminnow	104	200–300
43.1	109	Run body	M	3	Hardhead/ Pikeminnow	11	300–400
43.1	109	Run body	M	3	Hardhead/ Pikeminnow	2	400–500
43.1	109	Run body	M	3	Black bass	6	0–100
43.1	109	Run body	M	3	Smallmouth bass	2	0–100
43.1	109	Run body	M	3	Smallmouth bass	4	100–200
43.1	109	Run body	M	3	Smallmouth bass	1	200–300
43.1	109	Run body	M	3	Sacramento sucker	11	0–100
43.1	109	Run body	M	3	Sacramento sucker	19	100–200
43.1	109	Run body	M	3	Sacramento sucker	19	200–300
43.1	109	Run body	M	3	Sacramento sucker	4	300–400
43.0	111	Riffle	S	1	Hardhead/ Pikeminnow	15	0–100
43.0	111	Riffle	S	1	Hardhead/ Pikeminnow	5	100–200
43.0	111	Riffle	S	1	Largemouth bass	1	--
43.0	111	Riffle	S	1	Hardhead/ Pikeminnow	16	0–100
43.0	111	Riffle	S	1	Hardhead/ Pikeminnow	20	100–200
43.0	111	Riffle	S	1	Hardhead/ Pikeminnow	6	200–300
43.0	111	Riffle	S	1	Sacramento sucker	1	400–600

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
43.0	112	Pool head	S	1	Hardhead/ Pikeminnow	6	100–200
43.0	112	Pool head	S	1	Hardhead/ Pikeminnow	5	100–300
43.0	112	Pool head	S	1	Hardhead/ Pikeminnow	2	50–100
43.0	112	Pool head	S	1	Hardhead/ Pikeminnow	1	--
43.0	113	Pool body	M	1	Hardhead/ Pikeminnow	32	100–200
43.0	113	Pool body	M	1	Hardhead/ Pikeminnow	10	200–300
43.0	113	Pool body	M	1	Hardhead/ Pikeminnow	2	300–400
43.0	113	Pool body	M	1	Largemouth bass	1	0–100
43.0	113	Pool body	M	1	Largemouth bass	6	100–200
43.0	113	Pool body	M	1	Hardhead/ Pikeminnow	48	100–200
43.0	113	Pool body	M	1	Hardhead/ Pikeminnow	20	100–300
43.0	113	Pool body	M	1	Hardhead/ Pikeminnow	13	200–300
43.0	113	Pool body	M	1	Hardhead/ Pikeminnow	5	300–400
43.0	113	Pool body	M	1	Smallmouth bass	1	--
43.0	113	Pool body	M	1	Sacramento sucker	10	100–200
43.0	113	Pool body	M	2	Hardhead/ Pikeminnow	45	100–200
43.0	113	Pool body	M	2	Hardhead/ Pikeminnow	21	200–300
43.0	113	Pool body	M	2	Hardhead/ Pikeminnow	2	300–400
43.0	113	Pool body	M	2	Largemouth bass	5	0–100
43.0	113	Pool body	M	2	Largemouth bass	9	100–200
43.0	113	Pool body	M	2	Largemouth bass	1	50–100
43.0	113	Pool body	M	2	Hardhead/ Pikeminnow	44	100–200
43.0	113	Pool body	M	2	Hardhead/ Pikeminnow	21	100–300
43.0	113	Pool body	M	2	Hardhead/ Pikeminnow	8	200–300
43.0	113	Pool body	M	2	Hardhead/ Pikeminnow	5	300–400

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
43.0	113	Pool body	M	3	Hardhead/ Pikeminnow	2	100–200
43.0	113	Pool body	M	3	Hardhead/ Pikeminnow	27	100–200
43.0	113	Pool body	M	3	Hardhead/ Pikeminnow	5	200–300
43.0	113	Pool body	M	3	Hardhead/ Pikeminnow	4	300–400
43.0	113	Pool body	M	3	Largemouth bass	3	0–100
43.0	113	Pool body	M	3	Largemouth bass	9	100–200
43.0	113	Pool body	M	3	Largemouth bass	2	50–100
43.0	113	Pool body	M	3	Hardhead/ Pikeminnow	46	100–200
43.0	113	Pool body	M	3	Hardhead/ Pikeminnow	11	200–300
43.0	113	Pool body	M	3	Hardhead/ Pikeminnow	2	300–400
41.9	132	Riffle	S	1	Hardhead/ Pikeminnow	90	0–100
41.9	132	Riffle	S	1	Hardhead/ Pikeminnow	45	100–200
41.9	132	Riffle	S	1	Hardhead/ Pikeminnow	8	0–100
41.9	132	Riffle	S	1	Hardhead/ Pikeminnow	43	100–200
41.9	132	Riffle	S	1	Hardhead/ Pikeminnow	19	200–200
41.9	132	Riffle	S	1	Hardhead/ Pikeminnow	30	200–300
41.9	132	Riffle	S	1	Hardhead/ Pikeminnow	10	300–400
41.9	132	Riffle	S	1	Largemouth bass	1	100–200
41.9	132	Riffle	S	1	Largemouth bass	1	--
41.9	132	Riffle	S	1	Hardhead/ Pikeminnow	100	0–100
41.9	132	Riffle	S	1	Hardhead/ Pikeminnow	105	100–200
41.9	132	Riffle	S	1	Hardhead/ Pikeminnow	72	200–300
41.9	132	Riffle	S	1	Hardhead/Pikeminn ow	5	300–400
41.9	132	Riffle	S	1	Sacramento sucker	12	100–200
41.9	132	Riffle	S	1	Sacramento sucker	15	200–300

RM	NSO	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
41.9	132	Riffle	S	1	Sacramento sucker	4	400–600
41.9	133	Run head	S	1	Hardhead/ Pikeminnow	40	0–100
41.9	133	Run head	S	1	Hardhead/ Pikeminnow	3	0–100
41.9	133	Run head	S	1	Hardhead/ Pikeminnow	20	100–200
41.9	133	Run head	S	1	Hardhead/ Pikeminnow	8	200–300
41.9	133	Run head	S	1	Largemouth bass	2	0–100
41.9	133	Run head	S	1	Hardhead/ Pikeminnow	12	0–100
41.9	133	Run head	S	1	Hardhead/ Pikeminnow	31	100–200
41.9	133	Run head	S	1	Hardhead/ Pikeminnow	8	200–300
41.9	133	Run head	S	1	Hardhead/ Pikeminnow	1	--
41.9	133	Run head	S	1	Sacramento sucker	6	0–100
41.9	133	Run head	S	1	Sacramento sucker	28	200–400
41.9	133	Run head	S	1	Sacramento sucker	8	400–600