Diel Water Quality Monitoring Within Alameda Creek: 2001

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Introduction

Water quality, particularly water temperature and dissolved oxygen concentrations, have been identified as important environmental factors affecting habitat quality and availability for various lifestages of steelhead. Within a number of smaller streams and creeks, dissolved oxygen concentrations during the spring and summer months have been observed to vary widely between day and night (diel) measurements (e.g., SYTAC 1997). Within streams having low flows during spring and summer months, the abundance and density of filamentous algae may become very high. Many of these small systems are characterized by relatively shallow pools with little or no flushing flow during the summer to remove algal accumulations from the stream. In addition, many of these stream systems are characterized by nutrient inputs that further stimulate algal growth. During the daytime, these algal populations generate oxygen through photosynthesis resulting in high, and in some cases supersaturated, dissolved oxygen concentrations. Metabolism by these algal populations consumes dissolved oxygen during the late night – early morning hours and may result in very low-depressed dissolved oxygen levels that are stressful or result in unsuitable habitat for fish, including juvenile steelhead.

Juvenile steelhead, which would reside and rear within Alameda Creek throughout the spring and summer months, would potentially be subject to depressed dissolved oxygen concentrations resulting in stressful or unsuitable habitat conditions. Dissolved oxygen concentrations below approximately 6 mg/L have been identified as being stressful for juvenile steelhead, particularly under conditions when summer water temperatures are elevated, and contribute to stressful habitat conditions (Barnhardt 1986, Bell 1986). Average daily water temperatures greater than 20 C (68 F) are typically considered to be stressful. Peak daily temperatures greater than 23 C (73 F) are considered to be stressful

and peak temperatures above 25 C (77 F) may result in high levels of stress and/or mortality. Dissolved oxygen concentrations below approximately 4 mg/L are considered to be highly stressful and/or may result in mortality (Barnhardt 1986).

The primary objective of the diel water quality monitoring was to assess habitat suitability during summer months for juvenile steelhead rearing within various reaches of Alameda Creek, with particular emphasis on diel variation and dissolved oxygen concentrations. In addition to the diel water quality monitoring within Alameda Creek described below, additional field surveys and measurements were made to further assess habitat conditions potentially affecting steelhead. Results of these surveys have been documented in separate technical memoranda which include (1) Instream Habitat Typing Within Alameda Creek: August 2001, (2) Alameda Creek Adult Steelhead Passage Surveys, and (3) Air and Water Temperature Monitoring Within Alameda Creek: 2001-2002.

Methods

To evaluate the potential for diel variation in water quality (i.e., dissolved oxygen concentration), five water quality monitoring stations were established (Figure 1) to represent potential water quality conditions along the longitudinal gradient within the mainstem creek. Locations selected for diel water quality monitoring included the flood control reach in the vicinity of Alavarado Boulevard and the Highway 880 overcross (Flood Control 1A; Figure 1). The sampling station was located in an incised low-flow channel characterized as a run habitat with water depths during the summer months typically ranging from approximately 1-2 feet. A second water quality monitoring station was established within the flood control section at Isherwood Park (Isherwood 2B; Figure 1). The water quality station was located within a relatively long pool with water depths exceeding 2 feet during the spring (April-May), but becoming dewatered by June. Station 1B was located near the Niles Canyon Park (Figure 1). The water quality measurements were made within a relatively large pool, having depths throughout the summer months of 2 feet or more. Water quality sampling Station 6A was located in Alameda Creek, adjacent to the Train Museum (Figure 1). The water quality measurement was made in a run-type habitat characterized by summer water depths typically ranging from 1-2 feet. Water quality monitoring Station 16 (Figure 1) was located immediately upstream of the Calaveras Road Bridge in a relatively large pool. During the summer months, low flows resulted in shallow water depths within the pool (typically less than 6 inches) with algal accumulations occurring within the pool during mid- and late-summer. Specific GPS coordinates for the diel water quality stations are presented in Table 1.

Water quality measurements were made during the early morning and late evening hours at the sampling locations at approximately monthly intervals between April and September 2001. Water quality measurements were made in the field using a portable meter (WTW Model Multiline P4) which measures water temperature, dissolved oxygen, pH, and electrical conductivity. The water quality meter was routinely calibrated in

accordance with manufacturer's specifications. In addition, pH and electrical conductivity measurements taken in the field using the portable meter have been periodically verified by water sample measurement in a certified analytical laboratory.

Results

Results of diel water quality measurements are summarized in Table 2 and briefly discussed below.

During the April 28, 2001 survey, diel variation in dissolved oxygen concentration (Table 2) was observed within the flood control channel (Station Isherwood-2B) and within the lower reach of Niles Canyon (Station Park-1B). In general, however, diel water quality measurements during the April survey showed suitable conditions for juvenile steelhead.

Results of the May 29, 2001 diel water quality survey showed that dissolved oxygen concentrations were within the range considered to be suitable for juvenile steelhead at all of the stations sampled (Table 3). Water temperature, particularly during the late afternoon and early evening survey, exceeded 20 C (68 F) at all of the stations sampled, with peak temperatures observed at Isherwood (24.1 C; 75.2 F) within the range where acute mortality for juvenile steelhead would potentially occur.

Water quality sampling during June (Table 4) showed a pattern in which diel dissolved oxygen concentrations were generally within the range considered to be suitable for juvenile steelhead. Water temperature measurements during the June survey were at levels considered to be near the upper range of suitable habitat.

Water quality monitoring during July showed a pattern in which dissolved oxygen concentrations were slightly depressed, particularly at Site 6 A and Site 16 which were within the range considered to be potentially stressful for juvenile steelhead rearing (Table 5). Water temperatures measured during the late afternoon/early evening were in the range (>26 C; 79 F) where acute mortality would be expected for juvenile steelhead (Stations Park-1B and 6A).

Water quality monitoring during August (Table 6) showed a pattern of depressed dissolved oxygen concentrations during the morning and evening at Station 16 (2.3 mg/L), which would be expected to result in highly stressful or lethal conditions for juvenile steelhead. During the late summer, the pool at Station 16 was characterized by very low flow/stagnant conditions, shallow water depth, and an accumulation of filamentous algae. Dissolved oxygen concentrations were also observed to be depressed (4.3-4.4 mg/L) at the sampling site located downstream within the flood control channel (Station FC-1A). As observed in other sampling, diel variation in water temperature, particularly at Sites Park-1B and 6A were within the range resulting in stressful habitat conditions for juvenile steelhead.

Water quality monitoring during September (Table 7) showed severely depressed dissolved oxygen concentrations at Site 16 (1.76 and 1.61 mg/L, respectively during morning and evening sampling), which would result in lethal conditions for juvenile steelhead. The pool at Station 16 was stagnant (no visible surface inflow), had very shallow water depths (6-12 inches) and accumulated mats of filamentous algae. Water temperatures at all of the sites reflected the general seasonal pattern of declining temperatures beginning in the fall.

Discussion

In addition to diel water quality measurements made as part of the reconnaissance field surveys, the Alameda County Water District (ACWD) staff also collect field measurements of water quality parameters within Alameda Creek. A variety of water quality parameters are monitored weekly at various locations within the creek and a number of tributaries. Data from weekly water quality monitoring has been compiled from the ACWD monitoring for the water quality monitoring station located in the lower reaches of Alameda Creek, upstream of rubber dam number 3, during 2000 and 2001. Results of ACWD water quality monitoring have been summarized in Table 8 for pH, electrical conductivity, turbidity, and flow. Results of these water quality measurements are provided as supplemental information for use in assessing water quality conditions potentially affecting habitat suitability for steelhead within the creek. Results of these measurements are consistent with information collected both during the diel water quality monitoring and during water temperature monitoring within the creek demonstrating the occurrence of seasonally elevated temperatures that would affect habitat conditions for steelhead, particularly during the late spring, summer, and early fall within the lower reaches of the creek.

Results of diel water quality monitoring within Alameda Creek have identified both high water temperature and low dissolved oxygen concentration as factors potentially affecting availability and suitability habitat for juvenile steelhead within various reaches of the Alameda Creek mainstem. Peak water temperatures observed at several of the diel water quality monitoring stations were within the range where stress and/or lethal mortality to juvenile steelhead would be anticipated. Similarly, depressed dissolved oxygen concentrations observed at Site 16 would be within the range resulting in lethal mortality to steelhead, although suitable dissolved oxygen concentrations were observed further downstream. The depressed dissolved oxygen concentrations observed at Station 16 (immediately upstream of the Calaveras Road bridge) reflect, in part, low streamflow conditions within the reach during summer months. The pool where dissolved oxygen measurements were made had very low or no visible surface flow during the late summer, was characterized by shallow water depths and growths of filamentous algae. Low summer flow conditions at Station 16 were thought to have reduced the water circulation within the pool and flushing of accumulated algae.

The diel water quality surveys were conducted during the summer 2001 which was a below-normal water year based upon precipitation records at the ACWD Niles rainfall

station. Average precipitation at the Niles rainfall station over the period 1871-2001 was 18.44 inches, while precipitation during water-year 2001 was 16.33 inches. Variation in inter- and intra-annual streamflow represents an important factor affecting water quality conditions at various locations within the creek and the associated quality and suitability of available habitat for juvenile steelhead rearing. The low streamflow conditions observed during this study at Station 16 in late summer, and the associated depressions in dissolved oxygen concentrations, may not be representative of years when summer flows may be higher.

Results of the diel water quality monitoring conducted during the summer 2001 provide additional information regarding various factors potentially affecting steelhead habitat quality and availability for summer rearing. Results of the study, however, are limited to only those environmental conditions and locations within Alameda Creek where monitoring was conducted. As noted above, water quality conditions may vary among years in response to factors such as summer streamflow which could not be evaluated as part of this investigation. Furthermore, diel water quality measurements made as part of this investigation were limited only to selected locations along the mainstem of Alameda Creek. Potentially suitable habitat for juvenile steelhead summer rearing may occur further upstream in the Alameda Creek watershed and/or tributaries to Alameda Creek which were not included as part of this investigation.

Results of the diel water quality studies conducted during the spring and summer, 2001 have identified water quality, both water temperature and dissolved oxygen concentrations, as potential limiting factors affecting habitat quality and suitability for steelhead within portions of Alameda Creek. Results of these water quality measurements reflect the hydrologic and environmental conditions occurring during 2001 and may or may not be representative of instream habitat conditions affecting steelhead over a wider range of condition. Results of the investigation during 2001, however, identify the importance of evaluating water quality conditions, with specific emphasis on summer water temperatures and dissolved oxygen concentrations, as factors to be considered when determining the availability and quality of habitat for steelhead rearing within Alameda Creek, geographic priorities for various types of habitat improvement, and evaluating the overall biological benefits to steelhead that may result from restoration actions.

Acknowledgements

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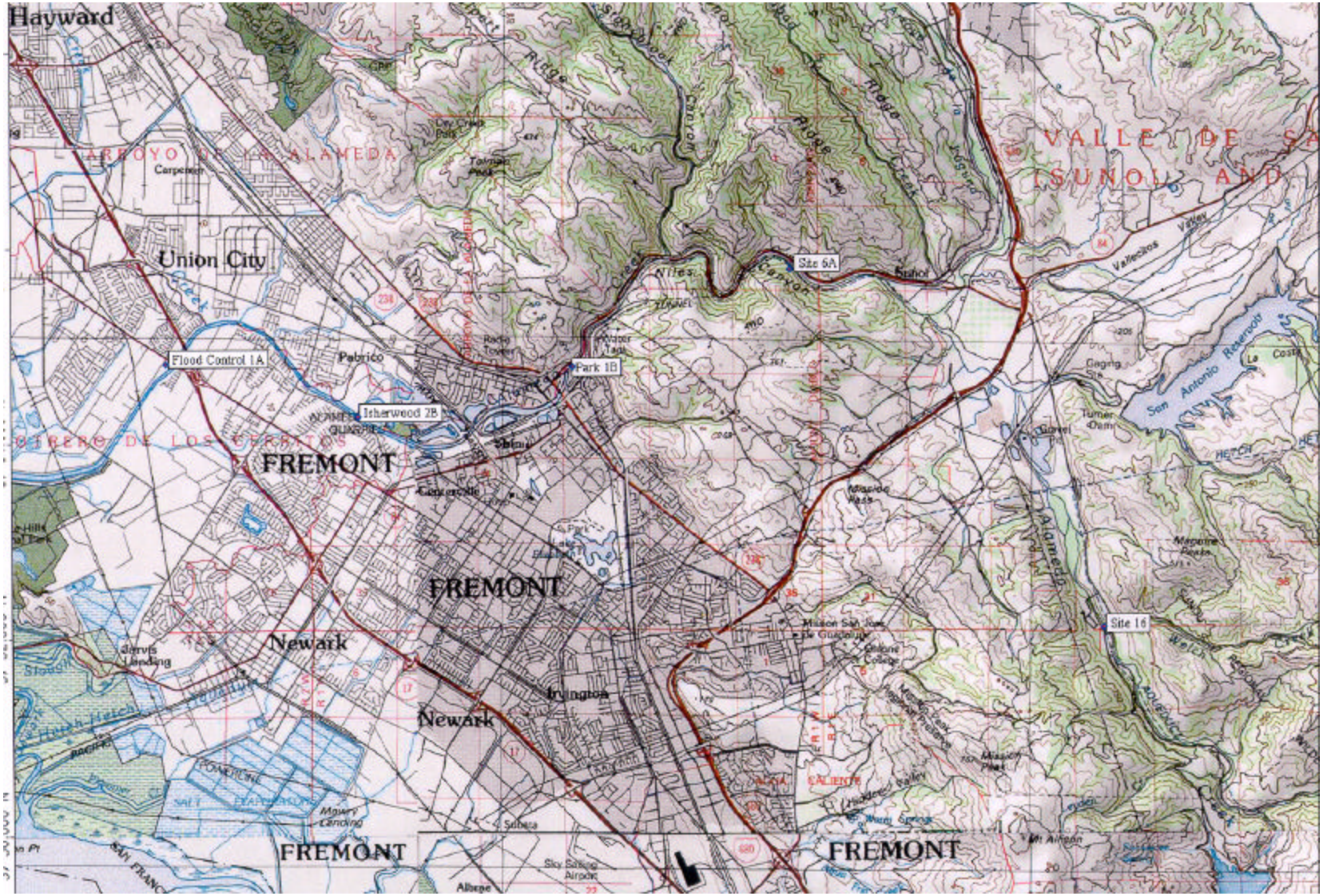

Figure 1. Diel water quality monitoring locations within Alameda Creek.

Table 1. Location of Alameda Creek diel water quality monitoring sites.

Site #	GPS Coordinates	Survey Dates	Comments
Flood Control 1	N 37 34.822 W 122 03.193	4/28, 5/29, 6/25, 7/2, 8/16, 9/27	Park immediately up from perc pond. Near Alvarado Blvd. bridge
Isherwood 2B	N 37 34.274 W 122 00.725	4/28, 5/29, 6/25-DRY	Immediately opposite portable restroom
Park 1B	N 37 34.781 W 121 57.966	4/28, 5/29, 6/25, 7/2, 8/16, 9/27	100' downstream of riffle. Near Niles staging area.
Site 6A	N 37 35.772 W 121 55.175	4/28, 5/29, 6/25, 7/2, 8/16, 9/27	100 feet upstream of concrete/steel structure at corner of parking area. (D/S most parking sites)
16	N 37 32.092 W 121 51.181	4/28, 5/29, 6/25, 7/2, 8/16, 9/27	Upstream of Calaveras Rd. bridge

Table 2. Results of diel water quality monitoring within Alameda Creek - April.

	FC - 1A		Isherwood - 2B		Park - 1B		Site 6A		Site 16	
	Morning	Evening	Morning	Evening	Morning	Evening	Morning	Evening	Morning	Evening
Date: 4/28/01										
Time:	5:10	20:25	5:23	20:10	5:37	19:54	5:51	19:45	6:05	19:30
Temperature (C)	17.3	18.4	15.1	17.2	15.8	18.3	16.6	18.4	15.5	18.1
Dissolved Oxygen (mg/l)	8.03		5.14	10.01	7.75	10.33	7.23	8.09	6.16	9.13
pH	7.68	8.23	7.82	8.22	8.31	8.72	8.18	8.08	8.11	8.49
Electrical Conductivity (? S/cm)	1175	1141	811	805	1041	1004	1078	1086	622	611

Table 3. Results of diel water quality monitoring within Alameda Creek - May.

	FC - 1A		Isherwood - 2B		Park - 1B		Site 6A		Site 16	
	Morning	Evening	Morning	Evening	Morning	Evening	Morning	Evening	Morning	Evening
Date: 5/29/01										
Time:	5:40	20:05	5:50	20:20	6:05	20:40	6:18	20:55	6:30	21:10
Temperature (C)	19.0	21.9	20.3	24.1	19.2	22.5	18.8	23.0	17.5	22.9
Dissolved Oxygen (mg/l)	7.80	9.64	7.39	7.23	7.32	7.28	6.50	6.25	5.56	8.30
pH	7.59	7.69	8.30	8.59	8.25	8.56	7.96	8.39	8.01	8.31
Electrical Conductivity (? S/cm)	1246	1243	730	1333	1082	1073	1085	1070	606	585

Table 4. Results of diel water quality monitoring within Alameda Creek - June.

	FC - 1A		Isherwood - 2B		Park - 1B		Site 6A		Site 16	
	Morning	Evening	Morning	Evening	Morning	Evening	Morning	Evening	Morning	Evening
Date: 6/25/01										
Time:	5:40	20:02			6:03	20:25	6:15	20:36	6:25	20:51
Temperature (C)	19.3	19.9			19.2	21.3	19.1	20.2	17.8	21.4
Dissolved Oxygen (mg/l)	6.38	6.89	DRY	DRY	6.81	7.20	6.48	6.50	5.88	9.22
pH	7.65	7.61			8.36	8.62	8.16	8.23	8.02	8.39
Electrical Conductivity (? S/cm)	1273	1272			1153	1128	1228	1196	579	552

Table 5. Results of diel water quality monitoring within Alameda Creek - July.

	FC - 1A		Isherwood - 2B		Park - 1B		Site 6A		Site 16	
	Morning	Evening	Morning	Evening	Morning	Evening	Morning	Evening	Morning	Evening
Date: 7/2/01										
Time:	5:35	20:05			5:56	20:25	6:07	20:37	6:22	20:54
Temperature (C)	21.4	22.2			22.4	26.4	22.4	26.3	19.1	19.8
Dissolved Oxygen (mg/l)	6.84	5.70	DRY	DRY	7.55	6.21	6.14	5.45	4.08	6.42
pH	7.55	7.52			8.24	8.56	8.17	8.34	7.37	7.57
Electrical Conductivity (? S/cm)	1264	1264			1173	1075	1165	1187	600	604

Table 6. Results of diel water quality monitoring within Alameda Creek - August.

	FC - 1A		Isherwood - 2B		Park - 1B		Site 6A		Site 16	
	Morning	Evening	Morning	Evening	Morning	Evening	Morning	Evening	Morning	Evening
Date: 8/16/01										
Time:	5:38	19:45			5:57	20:05	6:10	20:15	6:26	20:30
Temperature (C)	18.8	20.0			20.5	24.1	20.8	24.4	17.3	17.5
Dissolved Oxygen (mg/l)	4.30	4.40	DRY	DRY	6.50	6.5	10.80	7.00	2.30	2.30
pH	7.80	7.50			8.10	8.70	8.10	8.30	7.40	7.20
Electrical Conductivity (? S/cm)	1299	1299			799	810	865	781	584	620

Table 7. Results of diel water quality monitoring within Alameda Creek - September.

	FC - 1A		Isherwood - 2B		Park - 1B		Site 6A		Site 16	
	Morning	Evening	Morning	Evening	Morning	Evening	Morning	Evening	Morning	Evening
Date: 9/27/01										
Time:	5:55	18:15			6:11	18:33	6:23	18:45	6:35	19:01
Temperature (C)	18.8	18.7	DRY	DRY	18.7	20.6	19.2	20.0	17.8	18.6
Dissolved Oxygen (mg/l)	4.97	5.08			7.10	8.78	6.60	8.38	1.76	1.61
pH										
Electrical Conductivity (? S/cm)										

Table 8. Results of weekly water quality field monitoring by ACWD at the Alameda Creek Water Quality Monitoring Station.

Sampling Date	Sampling Time	pH	Conductivity (uS/cm)	Temperature (C)	Turbidity (NTU)	Flow (cfs)
1/4/00	1422	8.6	973	10.0	4.00	20
1/11/00	1353	8.5	1,019	11.0	5.3	28
1/18/00	1514	8.4	268	13.0		619
1/25/00	1411	8.2	488	14.0	248.00	938
2/1/00	1048	8.4	883	13.0	19.00	57
2/8/00	730	8.7	985	12.0	8.00	44
2/15/00	830	8.3	425	11.1	392.00	50
2/22/00	750	8.4	719	12.2	17.80	130
2/29/00	800	8.4	366	11.7	141.00	1,376
3/6/00	1346	8.2	350	12.0	74.80	1,029
3/14/00	1514	8.4	485	17.0	18.00	427
3/21/00	1424	8.6	685	16.0	5.00	170
3/28/00	819	8.4	831	13.0	3.00	102
4/3/00	1115	8.5	874	17.0	3.00	82
4/11/00	815	8.5	915	15.0	5.38	68
4/18/00	800	8.2	596	13.0	91.10	218
4/25/00	900	8.6	901	14.0	8.95	65
5/2/00	1045	8.0	881	18.0	3.26	59
5/9/00	1045	7.6	770	17.0	10.50	61
5/16/00	1100	7.0	718	15.4	38.80	113
5/23/00	1050	7.7	937	23.0	3.59	32
5/30/00	1120	7.0	946	20.0	3.95	38
6/6/00	1045	6.5	984	18.7	3.35	31
6/13/00	1105	8.3	1,038	20.0	3.04	22
6/20/00	1115	8.4	733	21.0	7.12	47
6/27/00	1045	8.4	1,007	21.0	4.20	28
7/5/00	1050	8.4	706	18.0	7.50	42
7/11/00	1130	8.5	1,045	21.0	4.32	21
7/18/00	1105	8.5	1,034	19.0	8.64	23

Table 8 (cont.)

Sampling Date	Sampling Time	pH	Conductivity (uS/cm)	Temperature (C)	Turbidity (NTU)	Flow (cfs)
7/25/00	1115	8.5	728	20.0	7.00	34
8/1/00	1050	8.5	744	23.0	3.89	32
8/8/00	1020	8.4	695	20.0	4.96	36
8/21/00	1035	8.5	641	19.0	4.25	36
8/29/00	1100	8.5	952	19.0	2.08	19
9/5/00	1110	8.6	754	18.3	5.48	45
9/12/00	900	8.6	1,092	18.0	4.10	22
9/19/00	1045	8.6	735	22.0	4.27	39
9/26/00	1100	8.7	783	19.0	5.43	36
10/3/00	1135	8.8	1,043	18.0	3.95	23
10/10/00	1100	8.6	1,090	17.0	63.90	44
10/17/00	1120	8.8	826	16.0	4.86	44
10/24/00	1105	8.8	738	14.0	5.71	47
10/31/00	1130	8.8	385	12.2	92.10	93
11/7/00	935	8.3	801	13.0	9.95	56
11/14/00	1045	9.3	960	10.0	3.21	43
11/21/00	940	8.9	1,016	10.0	3.56	21
11/28/00	1035	8.1	592	11.0	7.43	53
12/5/00	1050	8.5	736	10.0	3.78	44
12/12/00	1145	8.5	1,008	12.0	18.60	67
12/19/00	1050	9.0	751	10.0	13.70	54
12/26/00	1140	8.2	732	9.0	14.00	62
1/2/01	1545	2.6	980	9.5	6.00	27
1/9/00	1100	9.3	829	9.0	20.60	54
1/16/01	1045	8.0	972	7.0	5.26	21
1/25/01	1000	8.7	650	8.9	34.00	56
2/1/01	1140	8.7	1,010	7.0	7.41	27
2/6/01	850	8.8	1,125	11.0	3.48	30
2/13/01	900	8.6	506	8.0	129.00	187
2/20/01	935	8.7	555	12.0	42.30	152

Table 8 (cont.)

Sampling Date	Sampling Time	pH	Conductivity (uS/cm)	Temperature (C)	Turbidity (NTU)	Flow (cfs)
3/19/01	1045	9.1	1,010	15.0	2.45	63
3/30/01	910	9.1	1,040	15.0	1.74	27
4/5/01	830	9.2	1,130	11.0	1.96	27
4/12/01	815	9.1	970	12.0	4.31	29
4/18/01	800	9.1	1,185	14.0	1.59	19
4/26/01	1100	8.2	1,015	18.6	21.00	26
5/3/01	1100	8.2	930	16.3	3.90	23
5/8/01	1140	8.4	1,050	19.7	1.05	19
5/15/01	1245	8.6	1,095	20.6	2.06	23
5/23/01	1135	8.7	960	21.0	1.92	23
5/31/01	1210	8.9	895	37.1	1.48	19
6/7/01	830	8.2	1,195	21.0	2.18	16
6/14/01	1050	8.3	1,110	20.0	1.56	14
6/21/01	800	8.0	1,139	22.0	1.66	70
6/26/01	1230	8.6	1,150	23.0	1.34	11
6/28/01	830	8.3	1,112	22.0	2.19	14
7/8/01	1230	8.4	1,120	21.5	1.98	10
7/13/01	1315	8.4	1,100	19.1	1.51	9
7/17/01	1100	8.6	1,210	19.7	1.43	10
7/26/01	1230	8.6	1,150	23.0	1.34	11
8/2/01	1015	8.4	1,111	20.0	1.59	11
8/9/01	850	8.2	798	21.0	2.57	24
8/16/01	900	8.5	813	21.0	5.63	24
8/22/01	910	8.4	890	20.0	2.46	31
8/29/01	730	8.5	838	20.0	3.16	34
9/6/01	1315	8.4	860	22.5	3.42	24
9/20/01	1400	8.9	936	20.1	2.10	25
9/26/01	1130	9.0	925	22.5	1.27	34
10/3/01	1008	8.6	974	18.0	2.06	24

Table 8 (cont.)

Sampling Date	Sampling Time	pH	Conductivity (uS/cm)	Temperature (C)	Turbidity (NTU)	Flow (cfs)
11/9/01	1440	9.3	1,100	15.3	2.51	12
11/14/01	1530	8.2	765	17.0	25.62	34
11/20/01	1535	8.5	1,125	14.6	6.37	15
11/29/01	1130	8.0	269	11.6	120.00	102
12/7/01	1115	8.2	810	12.8	13.50	30
12/12/01	1200	8.4	1,180	16.1	3.87	19
12/20/01	1140	8.3	680	11.4	54.10	169
12/26/01	1030	8.3	422	13.0	7.83	177