WATER TEMPERATURE, STREAMFLOW, AND GROUND-WATER ELEVATION IN AND ADJACENT TO THE RUSSIAN RIVER BETWEEN HOPLAND AND GUERNEVILLE, CA FROM 1998-2002

U.S. GEOLOGICAL SURVEY

OPEN FILE REPORT 03-454

Prepared in cooperation with the
SONOMA COUNTY WATER AGENCY

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Marisa H. Cox and Christine Hatch

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Menlo Park, CA

U.S. DEPARTMENT OF THE INTERIOR
GALE NORTON, Secretary

U.S. GEOLOGICAL SURVEY
CHARLES GROAT, Director

For Additional Information
Write to:

Marisa Cox
U.S. Geological Survey
345 Middlefield Rd MS 439
Menlo Park, CA 94025

Copies of this report may be
obtained from the authors or

U.S. Geological Survey
Information Center
Box 25286, MS 517
Denver Federal Center
Denver, CO 80225

TABLE OF CONTENTS

List of Figures

List of Tables

ABBREVIATIONS

°C	degrees Celsius
cm	centimeters
ft	feet
gpm	(U.S.) gallons per minute
Guerneville	USGS Gage number 11467000 “RUSSIAN R NR GUERNEVILLE CA”
Healdsburg	USGS Gage number 11463980 “RUSSIAN R A DIGGER BEND NR HEALDSBURG CA”
Hopland	USGS Gage number 11462500 “RUSSIAN R NR HOPLAND CA”
kg	kilogram
km	kilometer
kPa	kilopascals
m	meters
m3/s	cubic meters per second
mbsb	meters below stream bottom
mi	mile
MP	shallow piezometer
OW	observation well
psi	pounds per square inch
PZ	shallow piezometer
Q	discharge (or pumping) rate in units of volume per time
S	stage
SCWA	Sonoma County Water Agency
SCWA-ERP	Sonoma County Water Agency, Engineering Resource and Planning Division
SCWA-NR	Sonoma County Water Agency, Natural Resource Division
SG	staff gage
T	temperature
TW	test well (prefaced by site abbreviation)
WL	water level (elevation)

CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By[1]	To obtain
	Density	
megagrams per cubic meter (Mg/m^3)	1.	grams per cubic centimeter (g/cm^3)
megagrams per cubic meter (Mg/m^3)	62.4280	pounds per cubic foot (lb/ft^3)
	Length	
kilometer (km)	0.621371	mile (mi)
meter (m)	3.28084	foot (ft)
meter (m)	39.3701	inch (in)
millimeter (mm)	3.93701	hundreths of an inch (1/100 in)
	Rate	
cubic meter per minute (m^3/min)	0.588578	cubic foot per second (ft^3/s)
cubic meter per second (m^3/s)	35.3147	cubic foot per second (ft^3/s)
cubic meter per second (m^3/s)	15850.32	gallon per minute (gpm)
	Volume	
liter (L)	0.264172	gallon (gal)
million cubic meters (106 m^3)	810.710	acre feet (acre-ft)

Degrees Celsius (^oC) can be converted to degrees Fahrenheit (^oF) by using the formula:

$$^oF = [1.8*(^oC)]+32.$$

Sea Level

In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929, formerly called "Sea-Level Datum of 1929"), which is derived from a general adjustment of the first-order leveling networks of the United States and Canada.

[1]Conversion factors given to six significant figures, unless exact.

WATER TEMPERATURE, STREAMFLOW AND GROUND-WATER ELEVATION IN AND ADJANCENT TO THE RUSSIAN RIVER BETWEEN HOPLAND AND GUERNEVILLE, CA 1998 – 2002

By Marisa H. Cox, and Christine Hatch

ABSTRACT

Temperature, water level elevation, stage height, and river discharge data for this report were collected in and adjacent to the Russian River from Hopland to Guerneville, CA over a four-year period from 1998 to 2002 to establish baselines for long-term water quality, water supply and habitat. Data files presented in this report were collected by the USGS and the Sonoma County Water Agency's Engineering Resource and Planning, and Natural Resource Divisions. Temperature data were collected in single-channel submersible microloggers or temperature data were collected simultaneously with water-elevation data in dual-channel down-hole data loggers. Stream stage and streamflow data were collected at USGS stream gaging stations located near Hopland, Healdsburg, and Guerneville over a 130 km reach of the Russian River. During the period of record stream flow ranged from 3 to 1458 m^3/s. Stream temperature ranged from 8 to 29 ^oC while groundwater temperature ranged from 10 to 38 ^oC. Stream stage varied 5 m seasonly, while ground-water level varied 19 m over the same time scale.

INTRODUCTION

The Russian River flows south from Mendocino County into Sonoma County, CA (fig. 1) for approximately 130 km before reaching the Pacific Ocean at Jenner, CA. In this reach of the Russian River northwest of the Santa Rosa Plain, a significant volume of stream water is exchanged with the alluvial aquifer before the river flows to the west.

Stream temperature patterns are important indicators of water and habitat quality. Stream temperature is monitored at all USGS National Water Quality Assessment sites throughout the United States. Recently, researchers have demonstrated that temperature patterns are useful for estimating water exchange between streams and underlying streambed materials. When water level in wells and stream stage are measured concurrently, the combined data maybe used to make quantitative estimates of water fluxes between the stream and the subsurface and to quantify streambed hydraulic properties (e.g., Constantz, 1998, Constantz and others, 2002). In conjunction with water level elevation measurements, temperature data collected in shallow piezometers and deep wells can be used to estimate the rate of streambed seepage, hydraulic conductivity, and conductance of the geologic materials that surround them (Stonestrom and Constantz, 2003). Streambed seepage is of particular interest for water resources management because it constitutes the largest contribution to recharge in many hydrologic basins. Unlike other tracers, daily heat variation is already present in natural systems (diurnal temperature variations can be seen in shallow piezometers and long-term seasonal temperature variations can be seen in deeper wells) and therefore has no environmental concerns associated with its use as a tracer. In addition, temperature data are relatively easy to collect, making this method of estimation of hydraulic properties widely accessible.

Purpose and Scope

Water temperature data, water level elevation, stage height, and river discharge (table 1) are presented in this report. These data were collected in and adjacent to the Russian River from Hopland to Guerneville over a four-year period from 1998 to 2002 by either the USGS or Sonoma County Water Agency's Engineering Resource and Planning, and Natural Resource Divisions (fig. 1). These data provide baseline information that is useful for ongoing, long-term studies of stream and aquifer dynamics. Figure 2 is an example of a typical thermograph for data found in this report. Table 1 lists the sources, sampling locations, and time intervals for the data collected.

Acknowledgments

We would like to thank James Jasperse and Donald Seymour at Sonoma County Water Agency for providing data, funding and support for this project, and Brian Nguyen for help with USGS district data retrieval.

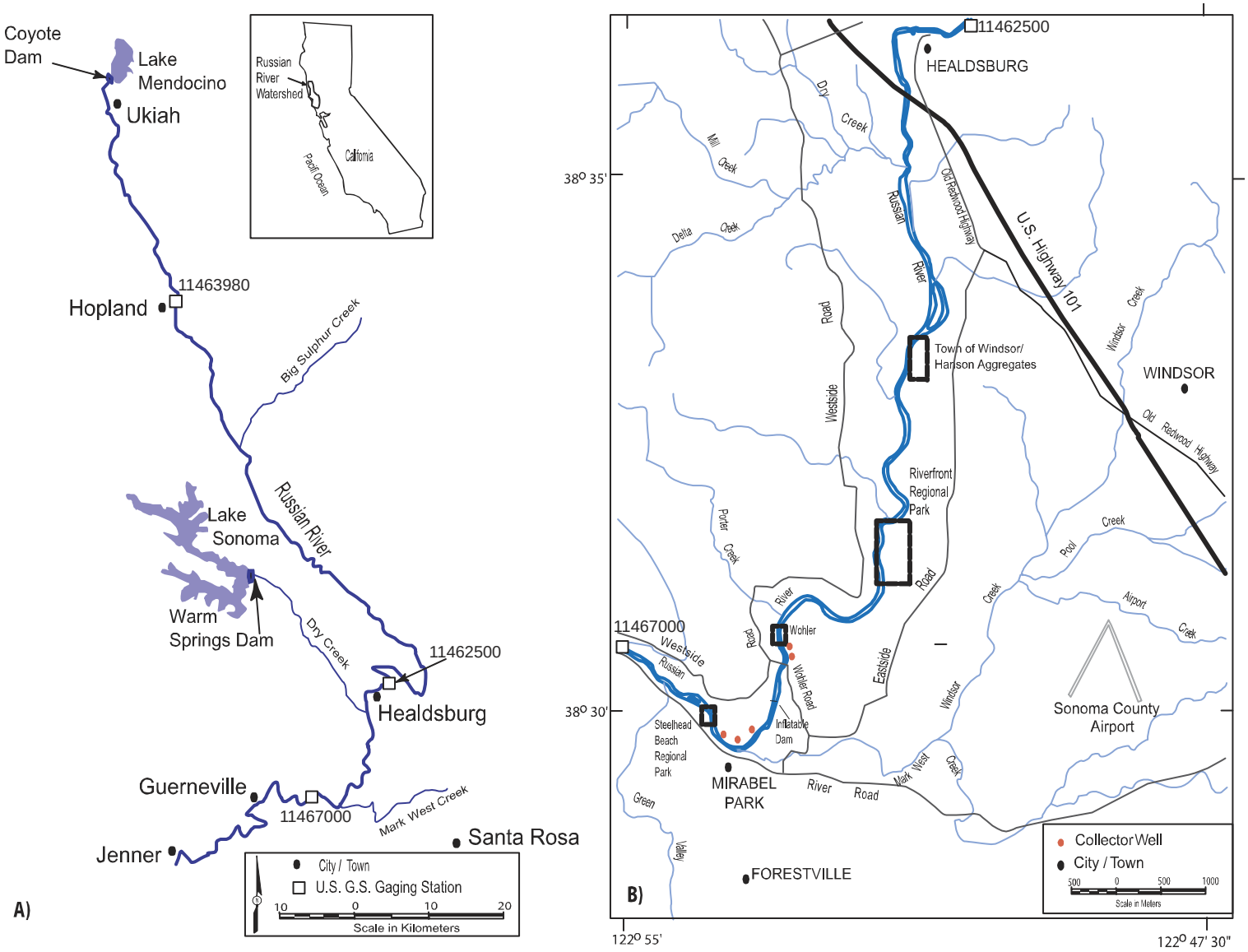

Figure 1. Site Location Map: A) Russian River, Northern Coastal California B) Study reach from Healdsburg to Guerneville, CA

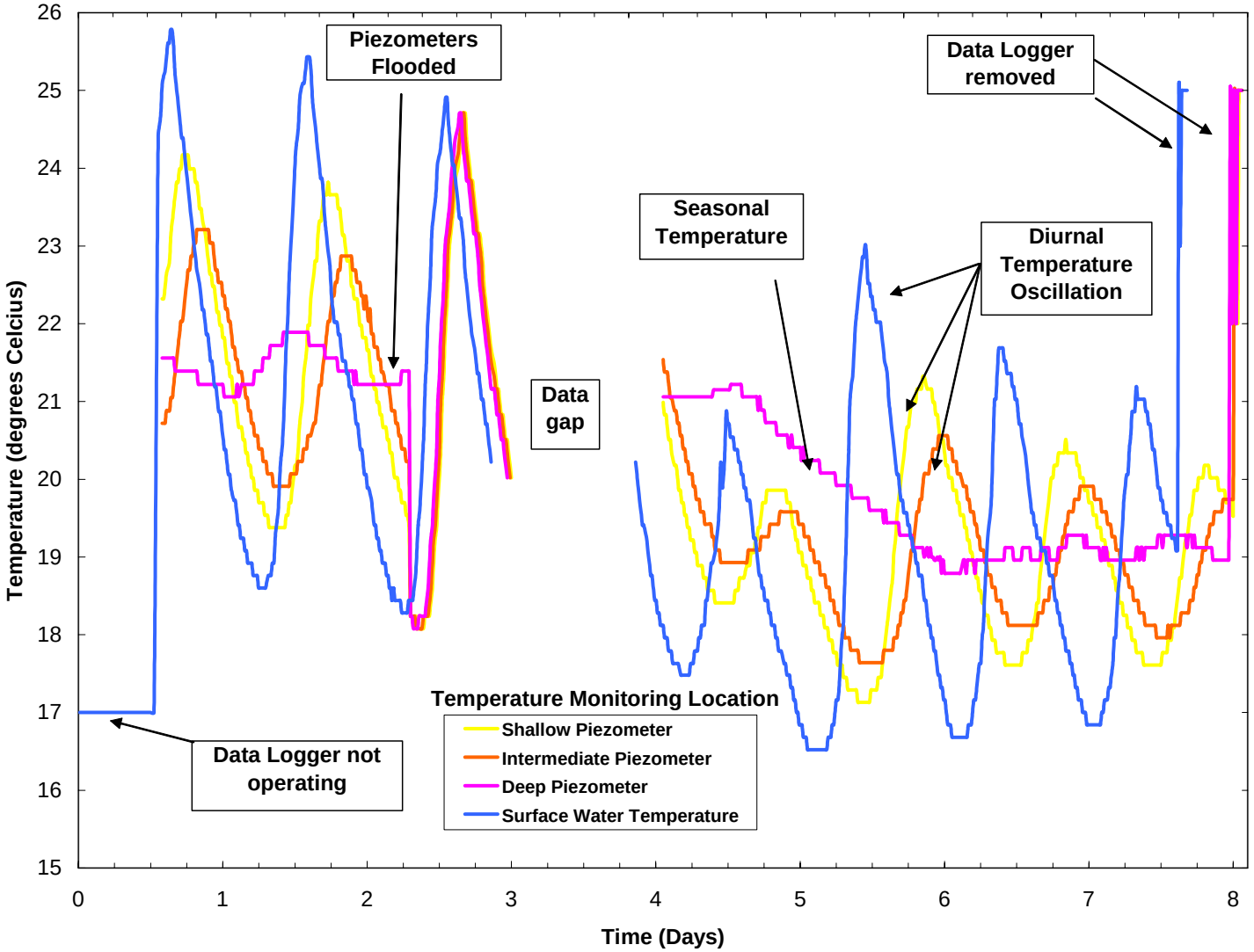

Figure 2. An example data set of temperature collected over time at four locations, three depths in a piezometer plus the overlying surface water.

Table 1. Water temperature, streamflow and ground-water elevations in and adjacent to the Russian River between Hopland and Guerneville, CA

SOURCE	SITE	DATE OF RECORD BEGIN DATE	DATE OF RECORD END DATE	DATA TYPE	FILENAME CURRENT	FILENAME ORIGINAL
(CONSULTANT)	Westside Farms	9/22/1998	9/28/1998	T/WL	WS_19980922.xls	Westside Farms.xls
(CONSULTANT)	Lazy W Ranch	10/11/1998	10/19/1998	T/WL	LW_19981011.xls	Lazy 'W' Ranch_out.xls
(CONSULTANT)	Riverfront Regional Park	10/21/1998	10/27/1998	T/WL	Riverfront_19981021.xls	KSGMP_SGbck.xls
(CONSULTANT)	Riverfront Regional Park	10/26/1998	11/3/1998	T/WL	Riverfront_19981021.xls	Kaiser Sand & Gravel.xls
(CONSULTANT)	Windsor	10/29/1999	11/9/1999	T/WL	WIN_19991029.xls	TW-1mpsg.xls
(CONSULTANT)	Windsor	10/29/1999	11/9/1999	T/WL	WIN_19991029.xls	TW-2mpsg.xls
(CONSULTANT)	Steelhead Beach	9/22/2000	10/9/2000	T/WL	SB_20000922.xls	stelhddata.xls
(CONSULTANT)	Hanson Aggregate	10/29/1999	11/9/1999	T/WL	HA_19991029.xls	HA-OWs.xls
(CONSULTANT)	Hanson Aggregate	10/29/1999	11/9/1999	T/WL	HA_19991029.xls	HA-2mpsg.xls
(CONSULTANT)	Hanson Aggregate	10/29/1999	11/9/1999	T/WL	HA_19991029.xls	HA-1mpsg.xls
SCWA-ERP	Wohler	4/5/2000	2/21/2001	T/WL	WB_20000405.xls	mw9318.xls
SCWA-ERP	Wohler	4/5/2000	2/21/2001	T/WL	WB_20000405.xls	mww9314.xls
SCWA-ERP	Wohler	4/5/2000	2/21/2001	T/WL	WB_20000405.xls	tw1.xls
SCWA-ERP	Wohler	4/5/2000	2/21/2001	T/WL	WB_20000405.xls	tw13.xls
SCWA-ERP	Wohler	4/5/2000	2/21/2001	T/WL	WB_20000405.xls	tw8.xls
SCWA-ERP	Wohler	4/4/2002	11/28/2002	T/WL	WB_20020404.xls	MW-93-18_2002.xls
SCWA-ERP	Wohler	4/4/2002	12/13/2002	T/WL	WB_20020404.xls	MW-93-14_2002.xls
SCWA-ERP	Wohler	4/4/2002	12/18/2002	T/WL	WB_20020404.xls	TW-1_2002.xls
SCWA-ERP	Riverfront Regional Park	4/12/2002	12/7/2002	T/WL	Riverfront_20020412.xls	KSG-OW-1_2002.xls
SCWA-ERP	Riverfront Regional Park	4/12/2002	12/18/2002	T/WL	Riverfront_20020412.xls	LW-04_2002.xls
SCWA-NR	Wohler	6/10/1999	9/16/1999	T	WB_19990610.xls	Wohler temps-1999.xls
SCWA-NR	Wohler	6/1/2000	10/27/2000	T	WB_20000601.xls	Wohler temps-2000.xls
SCWA-NR	Wohler	4/26/2001	11/1/2001	T	WB_20010524.xls	Wohler temps-2001.xls
SCWA-NR	Mirabel	1/21/2002	12/31/2002	T/WL	Mirabel_20020101.xls	SCWA_sonde.xls
SCWA-NR	Wohler	3/9/2002	12/9/2002	T	WB_20020601.xls	2002 Daily bottom.xls
SCWA-NR	Wohler	6/1/2002	10/10/2002	T	WB_20020601.xls	2002 Daily surface.xls
USGS--BRR, WR	Steelhead Beach	9/22/2000	9/28/2000	T	SB_20000928.xls	steelhead2000.02.out.xls
USGS--BRR, WR	Steelhead Beach	9/26/2001	10/10/2001	T	SB_20010926.xls	steelheadwater.xls
USGS--BRR, WR	Steelhead Beach	9/26/2001	10/10/2001	T	SB_20010926.xls	4ftpiezone.xls
USGS--BRR, WR	Steelhead Beach	9/26/2001	10/10/2001	T	SB_20010926.xls	4ftpieztwo.xls
USGS--BRR, WR	Steelhead Beach	9/26/2001	10/10/2001	T	SB_20010926.xls	4ftpiezfour.xls
USGS--BRR, WR	Steelhead Beach	9/26/2001	10/10/2001	T	SB_20010926.xls	8ftpieztwo.xls
USGS--BRR, WR	Steelhead Beach	9/26/2001	10/10/2001	T	SB_20010926.xls	8ftpiezfour.xls
USGS--BRR, WR	Steelhead Beach	9/26/2001	10/10/2001	T	SB_20010926.xls	8ftpiezeight.xls
USGS--BRR, WR	Riverfront Regional Park	6/18/2002	9/9/2002	T	Riverfront_20020618.xls	sn164919_#4.txt
USGS--BRR, WR	Riverfront Regional Park	6/19/2002	9/9/2002	T	Riverfront_20020618.xls	sn142057_#7.txt
USGS--BRR, WR	Riverfront Regional Park	6/19/2002	9/9/2002	T	Riverfront_20020618.xls	sn142062_#5.txt
USGS--BRR, WR	Riverfront Regional Park	6/19/2002	9/9/2002	T	Riverfront_20020618.xls	sn186330_#6.txt

SOURCE KEY:

SCWA - ERP	Sonoma County Water Agency -Engineering Resources Planning
SCWA - NR	Sonoma County Water Agency - Natural Resources
USGS - BRR, WR	USGS -Branch of Regional Research, Western Region
USGS - CA	USGS - California District

DATA TYPES:

T	Temperature Data
WL	Water Level Elevations
Q	Discharge (or Pumping) Data
S	Stage Data

Table 1. Water temperature, streamflow and ground-water elevations in and adjacent to the Russian River between Hopland and Guerneville, CA *(Continued)*

SOURCE	SITE	DATE OF RECORD BEGIN DATE	DATE OF RECORD END DATE	DATA TYPE	FILENAME CURRENT	FILENAME ORIGINAL
USGS--BRR, WR	Wohler (2ft)	6/19/2002	9/9/2002	T	WB_20020619.xls	sn187689_#2.txt
USGS--BRR, WR	Wohler (H2O)	6/19/2002	9/9/2002	T	WB_20020619.xls	sn187695_#3.txt
USGS--BRR, WR	Wohler (1ft)	6/19/2002	9/9/2002	T	WB_20020619.xls	sn187713_#1.txt
USGS--BRR, WR	Wohler (2ft)	9/9/2002	10/31/2002	T	WB_20020619.xls	wohl_sn187689_oct.txt
USGS--BRR, WR	Wohler (1ft)	9/9/2002	10/31/2002	T	WB_20020619.xls	wohl_sn187713_oct.txt
USGS--BRR, WR	Wohler (H2O)	9/9/2002	11/27/2002	T	WB_20020619.xls	wohl_sn187695_nov.txt
USGS--BRR, WR	Wohler (2ft)	10/31/2002	10/31/2002	T	WB_20020619.xls	wohl_sn187689_nov.txt
USGS--BRR, WR	Wohler (1ft)	10/31/2002	11/27/2002	T	WB_20020619.xls	wohl_sn187713_nov.txt
USGS-CA	Guerneville Gage	1/1/1998	12/31/1998	S	Guerneville_20021001.xls	11467000_stage_height_1998.xls
USGS-CA	Guerneville Gage	1/1/1998	12/31/2002	Q	Guerneville_20021001.xls	11467000_q98_02.xls
USGS-CA	Guerneville Gage	1/1/1999	12/31/1999	S	Guerneville_20021001.xls	11467000_stage_height_1999.xls
USGS-CA	Guerneville Gage	1/1/2000	12/31/2000	S	Guerneville_20021001.xls	11467000_stage_height_2000.xls
USGS-CA	Guerneville Gage	1/1/2001	12/31/2001	S	Guerneville_20021001.xls	11467000_stage_height_2001.xls
USGS-CA	Guerneville Gage	1/1/2002	12/31/2002	S	Guerneville_20021001.xls	11467000_stage_height_2002.xls
USGS-CA	Guerneville Gage	1/24/2002	9/30/2002	T	Guerneville_20021001.xls	11467000_temp_uv2.xls
USGS-CA	Guerneville Gage	10/1/2002	12/31/2002	T	Guerneville_20021001.xls	11467000_temp_uv.xls
USGS-CA	Healdsburg Gage	1/1/1998	7/7/1998	S	Healdsburg_20020628.xls	11463980_stage_height_1998.xls
USGS-CA	Healdsburg Gage	7/4/1998	1/11/2000	Q	Healdsburg_20020628.xls	11463980_discharge_mean_excel.xls
USGS-CA	Healdsburg Gage	5/4/1999	10/8/1999	S	Healdsburg_20020628.xls	11463980_stage_height_1999.xls
USGS-CA	Healdsburg Gage	4/5/2000	12/31/2000	S	Healdsburg_20020628.xls	11463980_stage_height_2000.xls
USGS-CA	Healdsburg Gage	5/24/2000	12/12/2002	Q	Healdsburg_20020628.xls	11463980_q98_02.xls
USGS-CA	Healdsburg Gage	1/1/2001	12/31/2001	S	Healdsburg_20020628.xls	11463980_stage_height_2001.xls
USGS-CA	Healdsburg Gage	1/1/2002	12/31/2002	S	Healdsburg_20020628.xls	11463980_stage_height_2002.xls
USGS-CA	Healdsburg Gage	6/23/2002	8/28/2002	T	Healdsburg_20020628.xls	11463980_temp_uv.xls
USGS-CA	Healdsburg Gage	8/29/2002	12/31/2002	T	Healdsburg_20020628.xls	11463980_temp_uv2.xls
USGS-CA	Healdsburg Gage	1/1/2002	12/12/2002	Q	Healdsburg_20020628.xls	11463980_discharge_mean.xls
USGS-CA	Hopland Gage	1/1/1998	12/31/1998	S	Hopland_20011001.xls	11462500_stage_height_1998.xls
USGS-CA	Hopland Gage	1/1/1998	12/31/2002	Q	Hopland_20011001.xls	11462500_q98_02.xls
USGS-CA	Hopland Gage	1/1/1999	12/31/1999	S	Hopland_20011001.xls	11462500_stage_height_1999.xls
USGS-CA	Hopland Gage	1/1/2000	12/31/2000	S	Hopland_20011001.xls	11462500_stage_height_2000.xls
USGS-CA	Hopland Gage	1/1/2001	12/31/2001	S	Hopland_20011001.xls	11462500_stage_height_2001.xls
USGS-CA	Hopland Gage	10/1/2001	10/16/2001	T	Hopland_20011001.xls	11462500_temp_uv.xls
USGS-CA	Hopland Gage	1/1/2002	12/31/2002	S	Hopland_20011001.xls	11462500_stage_height_2002.xls
USGS-CA	Hopland Gage	6/1/2002	7/12/2002	T	Hopland_20011001.xls	11462500_temp_uv2.xls

SOURCE KEY:

SCWA - ERP	Sonoma County Water Agency -Engineering Resources Planning
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USGS - BRR, WR	USGS -Branch of Regional Research, Western Region
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DATA TYPES:

T	Temperature Data
WL	Water Level Elevations
Q	Discharge (or Pumping) Data
S	Stage Data

DATA COLLECTED UNDER THE DIRECTION OF SONOMA COUNTY WATER AGENCY ENGINEERING RESOURCE AND PLANNING SECTION

Temperature and water level elevation data presented in this chapter were collected for Sonoma County Water Agency Engineering Resource and Planning Division (SCWA-ERP) by PES Environmental Inc., Novato, CA. PES was contracted to undertake a hydrologic investigation at Steelhead Beach Regional Park, Westside Farms, Lazy W Ranch, Riverfront Regional Park, and the Town of Windsor/Hanson Aggregate property (fig. 1).

I. Description of Data Collection Methods

At each site various types of wells were constructed. Piezometers and staff gages were installed at all sites. At Westside Farms, Lazy W Ranch and Riverfront Regional Park, three piezometers (MP) were installed to depths of 1.22 m (4 ft), 2.44 m (8 ft), and 3.66m (12 ft) below the bottom of the riverbed. Each piezometer was constructed of 4.45 cm (1 3/4 inch) PVC casing with 30.5 cm (1 ft) long sections of 0.025 cm (0.010 inch) machine slotted well screen. At Lazy W ranch three additional piezometers were installed at depths of 4.72 m (15.5 ft), 6.1 m (20 ft), and 11.89 m (39 ft) with 60.96 cm (2 ft) long sections of 0.51 cm (0.020 inch) machine slotted well screen. The piezometers at Steelhead Beach Regional Park and the Town of Windsor/Hanson Aggregate property were constructed of 3.18 cm (1 ¼ inch) PVC casing with 12.7 cm (5 inch) long sections of 0.025 cm (0.010 inch) machine slotted well screen. Each set of piezometers consited of four piezometers that were installed at depths of 30.5 cm (1 ft), 91.44 cm (3 ft), 1.52 m (5 ft), and 2.44 m (8 ft). A piezometer cluster was installed at Steelhead Beach Regional Park to depths of 1.52 m (5ft) and 2.44 m (8 ft) below the bottom of the riverbed. The piezometers were constructed of 2.54 cm (1 inch) diameter galvanized steel pipe with approximately 12.7 cm (5 inch), long sections of slotted pipe.

Observation wells were installed at each site and constructed of 5.08 cm (2 inch) PVC with 0.051 cm machine slotted well screen. Test wells were installed at Westside Farms, Lazy W Ranch and Riverfront Regional Park. The test wells were constructed of 35.56 cm (14 inch) diameter low carbon steel casing with 12.2 m (40 ft) of 35.56 cm (14 inch) diameter stainless-steel wire wrapped well screen.

Measurements for temperature and water levels were made with the submersible electronic In-Situ Troll, mini Troll, Solinst LT leveloggers, and the In-Situ pressure transducers and temperature probes connected to data loggers. The Troll and mini-Troll are equipped with a Motorola HC11 processor, 16-bit resolution, 1 megabyte of memory and a real-time crystal clock. The Mini-Troll utilizes a silicon temperature sensor which measures within the range of -5°C to 50°C ±0.25°C. Thermal stabilization time is 30 min to 1hr to within 0.1% of full scale, and 1.5 to 2 hr to within 0.05% of full scale. In addition, a pressure sensor (with 21-meter long cable) converts pressure to depth of water above the sensor, using an integrated silicon strain-gauge pressure sensor, which has a range of 21 m (206.8 kPa, 30 psi) / ±0.1% over its full pressure range. Pressure measurements are automatically corrected for barometric pressure via the venting line included in the suspension line. Barometric equilibration time is 5 minutes to within 0.05% of full scale for 304.8 m (1000 ft) of cable. Upon installation, the Trolls are calibrated to its depth below the water surface and programmed for the desired sampling interval.

The LT Leveloggers have a temperature range from -10 ^{o}C to 40 ^{o}C $\pm$ 0.1 ^{o}C over its full temperature range, and a pressure range equivalent to 4.0 $\pm$ 0.02 m of water. Pressure (water level) measurements are corrected for barometric pressure by installing an additional logger outside the well or piezometer at each site to measure atmospheric pressure.

II. Description of Data

At Westside Farms, water level elevations in observation wells show the expected response to pumping: exponential decrease as the pumping test begins and recovery to previous levels when the test is complete. As water levels decrease in WS-OW-3 during the pumping test, water temperature steadily rises to a plateau midway through the test. This same correlation between rising temperature and decreasing water levels is observed in WS-MP-2. In addition, as water levels rise after the test is complete, temperatures drop back to pre-test conditions.

At Lazy W Ranch, water level elevations in observation wells decrease exponentially as the pumping test begins, with greatest drawdown observed in the nearest wells and less drawdown with increasing distance from the test well. Water elevations recover to previous levels when the test is complete. A small rise in temperature is associated with the end of the test in LW-OW-1. In the temperature records from the staff gage and LW-MP-2, the diurnal temperature oscillation is observed, with smaller amplitude in the deeper piezometer. These oscillations are disrupted slightly by the initiation of the pumping test, but appear unaffected by pumping after less than a day.

At Riverfront Regional Park, water level elevation and temperature at the Staff Gage (SG) show a diurnal signal (fig. 3 and table 2). Temperature data from KSG-MP-2 and KSG-MP–3 show a diurnal signal with the deeper KSG-MP-3 having greater amplitude and slightly lower temperatures. Finally, the temperature data from KSG-OW-1 does not exhibit a diurnal signal. Since KSG-OW-1 is much deeper than the shallow piezometers, the temperature signal does not observe the daily oscillations in water levels and temperature, but instead observes the longer term seasonal variations in temperature.

At the Town of Windsor/Hanson Aggregate property only the shallowest piezometers, Win-MP-1a-b, HA-MP-1a, and the staff gages, show a diurnal temperature signal. Temperature data from the observations wells, HA-OW-1 and HA-OW4 show a decrease in temperature with increasing depth. Water levels were influenced in HA-OW-3, HA-OW-4 and TW-MP-1d by the change in pumping rates of the Town of Windsor Municipal Supply wells.

At Steelhead Beach Regional Park Staff Gages and some of the shallowest piezometers show the diurnal temperature signal, while the deeper monitoring wells show a long-term seasonal temperature signal. Of particular interest in this study is that the water level gradient decreases with depth from Staff Gage SB-SG-1 to SB-PZ-1a to SB-PZ-1b to SB-PZ-1c.

Data files are named and organized according to site location and date of record. All records from a single site have been included in one data file.

Westside Farms:

Test Wells	T	WL	Observation Wells	T	WL	Piezometers	T	WL	Data Filename
WS-TW-1		x	WS-OW-1		x	WS-MP-1		x	WS_19980922.xls
			WS-OW-2		x	WS-MP-2	x	x	
			WS-OW-3	x	x	WS-MP-3		x	
Staff Gage			WS-OW-4		x				
WS-SG	x	x	WS-OW-5		x				
			WS-OW-6		x				
			WS-OW-7	x	x				

Lazy W Ranch:

Test Wells	T	WL	Observation Wells	T	WL	Piezometers	T	WL	Data Filename
LW-TW-1		x	LW-OW-1	x	x	LW-MP-1		x	LW_19981011.xls
			LW-OW-2		x	LW-MP-2	x	x	
			LW-OW-3		x	LW-MP-3		x	
Staff Gage						LW-MP-4		x	
LW-SG	x	x				LW-MP-5		x	
						LW-MP-6	x	x	

Riverfront Regional Park:

Test Wells	T	WL	Observation Wells	T	WL	Piezometers	T	WL	Data Filename
KSG-TW-1		x	KSG-OW-1	x	x	KSG-MP-1		x	Riverfront_19981021.xls
			KSG-OW-2		x	KSG-MP-2	x	x	
			KSG-OW-3		x	KSG-MP-3	x	x	
Staff Gage			KSG-OW-4		x				
KSG-SG	x	x	KSG-OW-5		x				
			KSG-OW-6		x				
			KSG-OW-7		x				

Town of Windsor:

Test Wells	T	WL	Observation Wells	T	WL	Piezometers	T	WL	Data Filename
						WIN-MP-1a	x	x	Win_19991029.xls
						WIN-MP-1b	x	x	
						WIN-MP-1c	x	x	
Staff Gage						WIN-MP-1d	x	x	
WIN-SG-1	x	x				WIN-MP-2a	x	x	
WIN-SG-2	x	x				WIN-MP-2b	x	x	
						WIN-MP-2c	x	x	
						WIN-MP-2d	x	x	

Hanson Aggregate

Test Wells	T	WL	Observation Wells	T	WL	Piezometers	T	WL	Data Filename
			HA-OW-1A	x	x	HA-MP-1A	x	x	HA_19991029.xls
			HA-OW-1B	x	x	HA-MP-1B	x	x	
			HA-OW-1C	x	x	HA-MP-1C	x	x	
Staff Gage			HA-OW-2	x	x	HA-MP-1D	x	x	
			HA-OW-3	x	x	HA-MP-2A	x	x	
HA-SG-1	x	x	HA-OW-4A	x	x	HA-MP-2B	x	x	
HA-SG-2	x	x	HA-OW-4B	x	x	HA-MP-2C	x	x	
			HA-OW-4C	x	x	HA-MP-2D	x	x	

Steelhead Beach Regional Park:

Test Wells	T	WL	Observation Wells	T	WL	Piezometers	T	WL	Data Filename
			SB-OW-1a	x	x	SB-PZ-01a	x	x	SB_20000922.xls
			SB-OW-1b	x	x	SB-PZ-01b	x	x	
			SB-OW-1c	x	x	SB-PZ-01c	x	x	
Staff Gage			SB-OW-2a	x	x	SB-PZ-01d	x	x	
			SB-OW-2b	x	x	SB-PZ-02a	x	x	
SB-SG-1	x	x				SB-PZ-02b	x	x	
SB-SG-2	x	x				SB-PZ-02c	x	x	
						SB-PZ-02d	x	x	

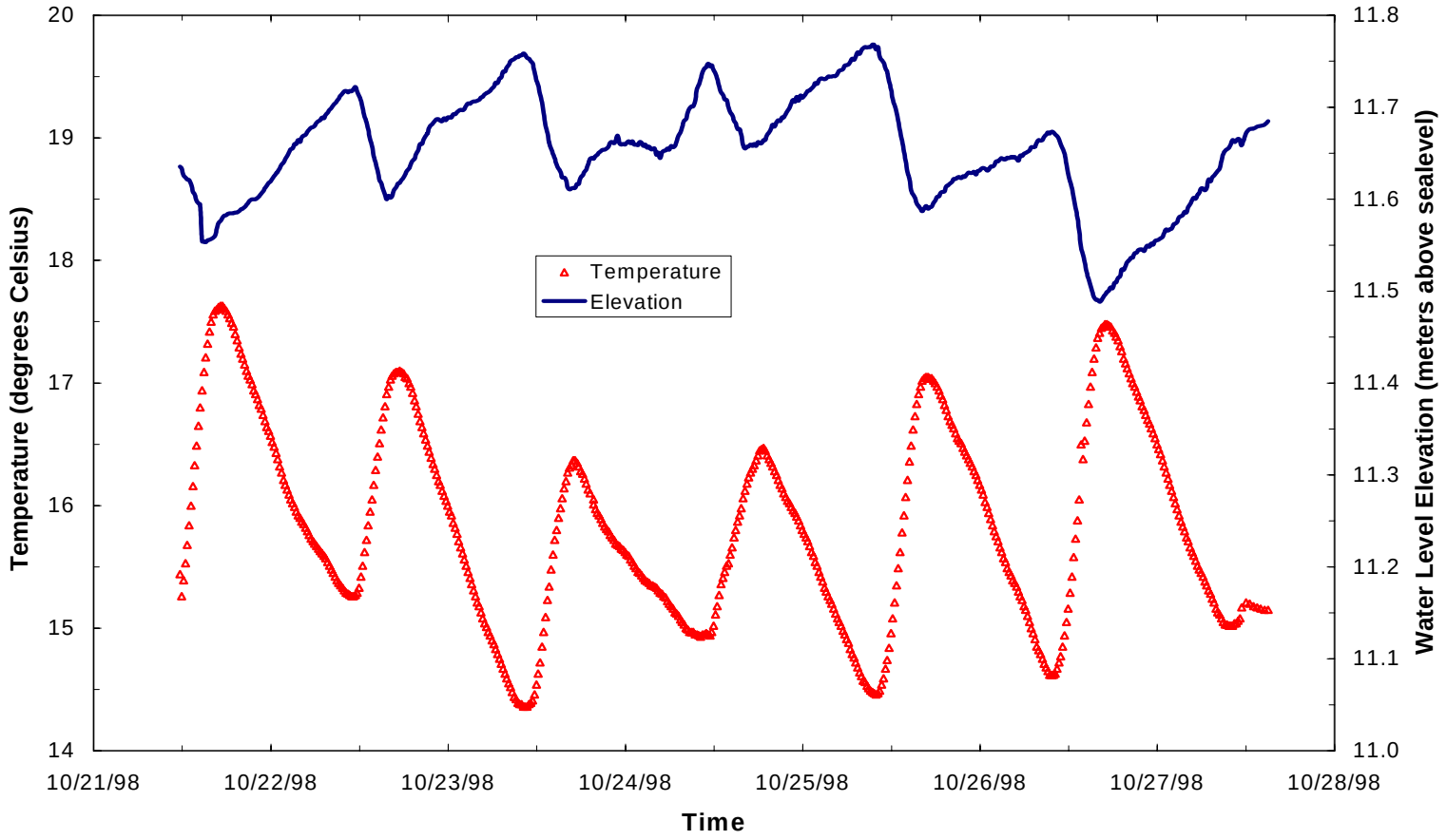

Figure 3. Sample stream thermograph (temperature over time) and stage hydrograph (referenced water depth over time) from Riverfront Regional Park Staff Gage

Table 2. Sample table from data collected under the direction of SCWA-ERP

DATA SOURCE:		**SCWA - ERP (CONTRACTED ENGINEERING FIRM)**	
DATA LOGGER:		**IN-SITU INC. MINI TROLL PRO**	
SITE LOCATION:		**RIVERFRONT (KAISER SAND & GRAVEL)**	**KSG_19981021.xls**
FORMER FILENAME(S):		**Kaiser Sand & Gravel.xls**	**KSGMP_SGbck.xls**
COLLECTION METHOD:		**TEMPERATURE AND PRESSURE SENSOR HUNG IN WELL CASING, CALIBRATED TO "PROBE ELEVATION" DEPTH (BELOW)**	
PERIOD OF	BEGIN:	10/21/1998 11:40	
RECORD	END:	10/27/1998 15:00	
REASON FOR TERMINATION:		**Termination of Study**	
COMMENTS:		Channel [1]	**"OnBoard Temp" Temperature**
(Data considerations)		Channel [2]	**"OnBoard Pressure" Pressure**
			Density: 1.000 g/cm^3
Well Name		**KSG-SG**	**(Staff Gage)**
TOC (top of casing elevation, masl)		**11.838**	
Calibration Depth (meters H_2O)		**10.892**	
Depth to Water (meters)		**0.299**	
Pressure Head (meters H_2O)		**0.648**	

Date Time	KSG-SG Water Elevation meters (amsl)	KSG-SG Temperature (^{o}C)
10/21/1998 11:40	11.64	15.44
10/21/1998 11:55	11.63	15.26
10/21/1998 12:10	11.63	15.39
10/21/1998 12:25	11.62	15.53
10/21/1998 12:40	11.62	15.68
10/21/1998 12:55	11.62	15.84
10/21/1998 13:10	11.62	16
10/21/1998 13:25	11.61	16.16
10/21/1998 13:40	11.61	16.33
10/21/1998 13:55	11.60	16.49
10/21/1998 14:10	11.60	16.65
10/21/1998 14:25	11.59	16.8
10/21/1998 14:40	11.55	16.94
10/21/1998 14:55	11.55	17.09
10/21/1998 15:10	11.55	17.21
10/21/1998 15:25	11.56	17.32
10/21/1998 15:40	11.56	17.42
10/21/1998 15:55	11.56	17.5
10/21/1998 16:10	11.56	17.56
10/21/1998 16:25	11.56	17.59
10/21/1998 16:40	11.57	17.6
10/21/1998 16:55	11.57	17.62
10/21/1998 17:10	11.58	17.63
10/21/1998 17:25	11.58	17.63
10/21/1998 17:40	11.58	17.61
10/21/1998 17:55	11.58	17.59
10/21/1998 18:10	11.58	17.56
10/21/1998 18:25	11.58	17.53

DATA COLLECTED BY SONOMA COUNTY WATER AGENCY BY SONOMA COUNTY ENGINEERING RESOURCE AND PLANNING DIVISION

The Engineering Resource and Planning Division of Sonoma County Water Agency continued monitoring water level elevation and temperature in wells installed in 1998. Data in this section are typically of much longer duration and were collected in order to evaluate seasonal trends in test and observation wells at Riverfront Regional Park, and Wohler Bridge area (fig. 1).

I. Description of Data Collection Methods

Existing wells were used at Riverfront Regional Park and Wohler Bridge area. Temperature measurements were made with Trolls and mini-Trolls.

II. Description of Data

Below Wohler Bridge, SCWA operates an inflatable dam during peak water supply demand months to increase river stage approximately 3 m and passively recharge the alluvial aquifer (fig. 4, 5). This backwater area produces higher temperatures and lower velocities in the river that extend for approximately 2 miles. The streambed of the river at the dam is approximately 10 m, msl (mean seal level). The middle of the screened interval of the Wohler area observation wells is generally in the vicinity of 0 m, msl.

Figure 4. The inflatable dam is constructed of 'automotive-tire' type rubber and is inflated with water. The fish ladders may be seen on either bank downstream of the dam.

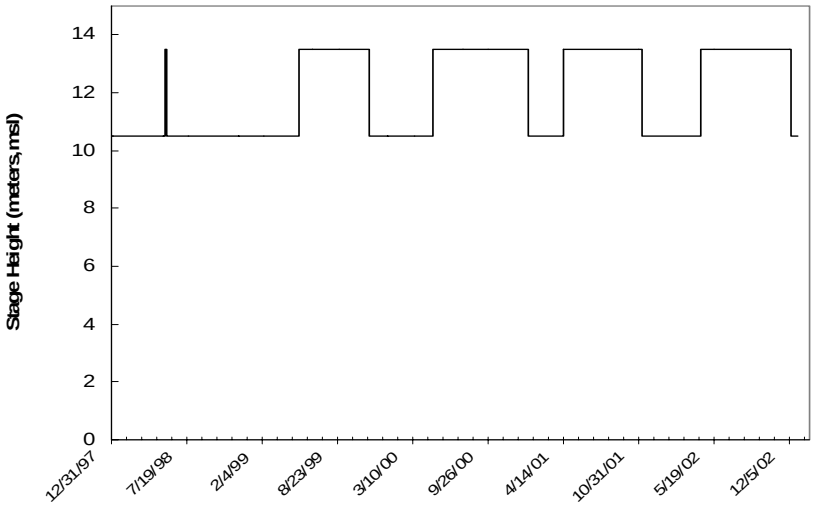

Figure 5. Stream stage above the inflatable Dam shown in figure 4.

At Wohler Bridge area, data were collected during 2000 to 2002. With the exception of TW-8, which maintains a constant temperature throughout the year, all monitoring wells show a broad, long-term temperature response to changing seasonal temperatures. The maximum temperatures in the wells occur in September to October, and minimum temperatures occur in April. MW-93-14 shows a pronounced increase in water level elevation and decrease in temperature when the inflatable dam was lowered in January 2001.

At Riverfront Regional Park a single, long-term data set collected in 2002 at KSG-OW-1 show greater variability in both temperature and water level elevation early in the summer, a gradual decrease throughout the summer, and a single pronounced spike in early November (fig. 6, table 3). One monitoring well at Lazy W Ranch (LW-04) was monitored in 2002, and shows similar behavior.

Data files are named and organized according to site location and date of record. All records from a single site during a single calendar year have been included in one data file.

Riverfront Regional Park:

Test Wells	T	WL	Observation Wells	T	WL	Piezometers	T	WL	Data Filename
			KSG-OW-1	x	x				Riverfront_20020412.xls
			LW-OW-4	x	x				

Wohler Bridge:

Test Wells	T	WL	Observation Wells	T	WL	Piezometers	T	WL	Data Filenames
TW-1	x	x	MW-93-14	x	x				WB_20000405.xls
TW-8	x	x	MW-93-18	x	x				WB_20020404.xls
TW-13	x	x							

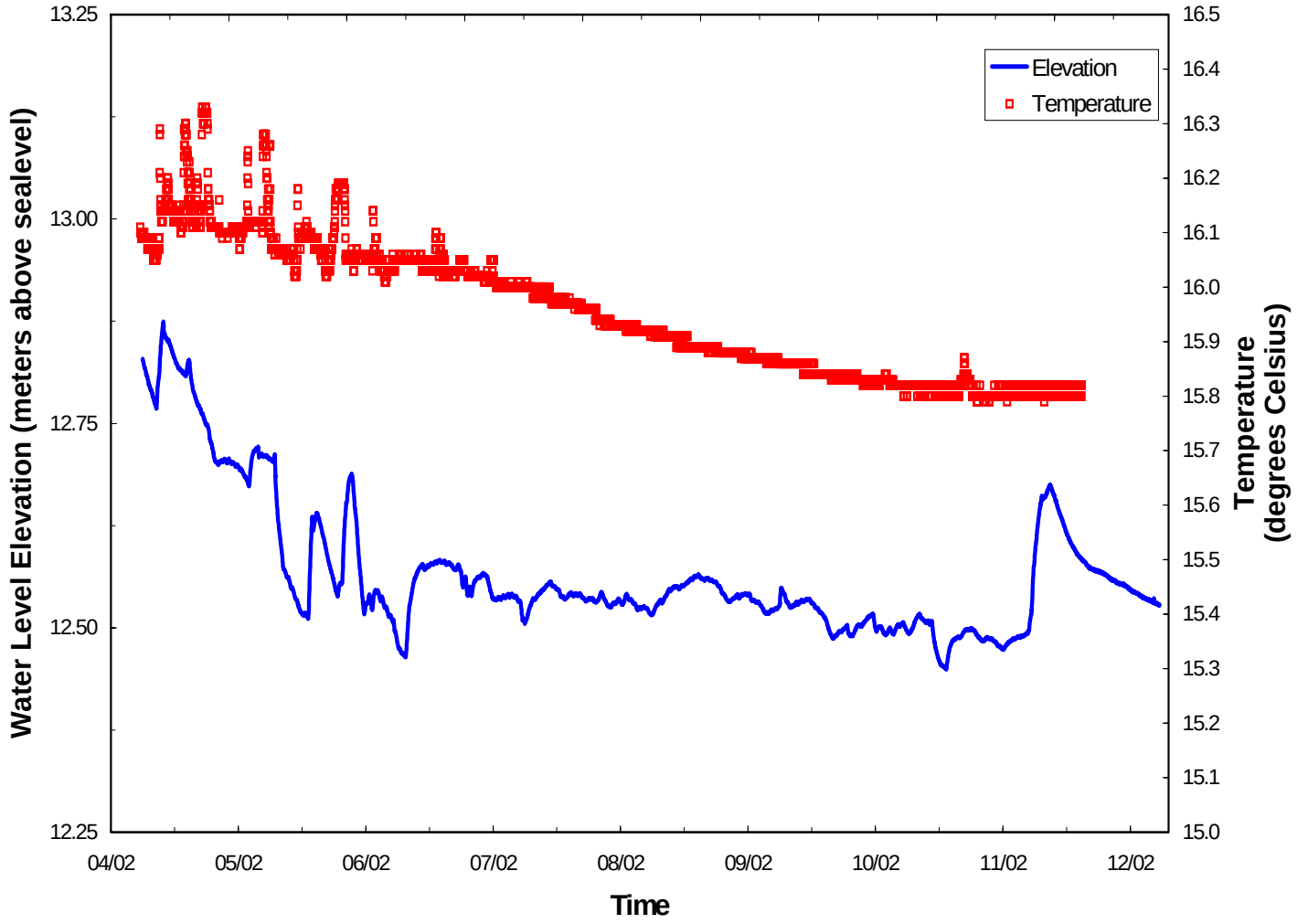

Figure 6. Sample stream thermograph and stage hydrograph for KSG-OW-1

Table 3. Sample table from data collected by SCWA-ERP

DATA SOURCE:		**SCWA - ERP**
DATA LOGGER:		**IN-SITU INC. MINI TROLL PRO sn: 1404**
SITE LOCATION:		**RIVERFRONT REGIONAL PARK KSG_20020412.xls**
FORMER FILENAME(S):		**KSG-OW-1_2002.xls ksg ow1 2002.bin**
COLLECTION METHOD:		**PRESSURE SENSOR HUNG IN WELL CASING, CALIBRATED TO KNOWN DEPTH**
PERIOD OF	BEGIN:	**4/12/2002 12:00**
RECORD	END:	**12/7/2002 22:00**
REASON FOR TERMINATION:		**Mini Troll Logger removed from well**
COMMENTS:		**DataMgr Version 3.11, Firmware version 2.08**
(Data considerations)		**Data gathered using Linear testing**
		Number of data samples: 5747 Latitude: 45 deg.
		Report generated: 12/20/2002 11:31:21
	Channel [1]	**"OnBoard Temp" Temperature**
	Channel [2]	**"OnBoard Pressure" Pressure Range: 30 PSI**
	Well Name	**KSG-OW-1 Density: 1.000 g/cm^3**
	TOC (top of casing elevation, meters)	**22.65 elevation reference NAVD88**
	Calibration Depth (meters H_2O)	**9.82**
	Depth to Water (meters)	
	Pressure Head (meters H_2O)	**9.14**

Date Time	KSG-OW-1 Temperature (^{o}C)	KSG-OW-1 Water Elevation meters (amsl)
4/12/2002 12:00	16.11	12.829
4/12/2002 13:00	16.1	12.827
4/12/2002 14:00	16.1	12.826
4/12/2002 15:00	16.1	12.825
4/12/2002 16:00	16.1	12.824
4/12/2002 17:00	16.1	12.824
4/12/2002 18:00	16.1	12.823
4/12/2002 19:00	16.09	12.821
4/12/2002 20:00	16.09	12.820
4/12/2002 21:00	16.09	12.820
4/12/2002 22:00	16.09	12.818
4/12/2002 23:00	16.1	12.818
4/13/2002 0:00	16.09	12.817
4/13/2002 1:00	16.1	12.817
4/13/2002 2:00	16.09	12.816
4/13/2002 3:00	16.09	12.815
4/13/2002 4:00	16.09	12.814
4/13/2002 5:00	16.09	12.814
4/13/2002 6:00	16.09	12.813
4/13/2002 7:00	16.09	12.811
4/13/2002 8:00	16.09	12.809
4/13/2002 9:00	16.09	12.811

DATA COLLECTED BY SONOMA COUNTY WATER AGENCY NATURAL RESOURCE DIVISION

Data presented in this section are temperature data collected by the Natural Resource Division of the Sonoma County Water Agency (SCWA-NR) at Russian River observation sites between the confluence of the Russian River with Dry Creek and Steelhead Beach Regional Park with Syar being the most upstream site. SCWA-NR began monitoring temperature in the Russian River in order to quantify conditions for fish habitat. Temperature changes associated with water released from dams (often cold) and low flow conditions during the summer months (often warm) are of concern for Russian River fish habitat.

I. Description of Data Collection Methods

Most temperature data were collected using Onset HOBO data loggers. The HOBO logger is a single channel 8-bit data logger that is submersible. The loggers have a temperature range of -20°C to 70°C ±0.7°C at 21°C.

Additional monitoring at the fish screens near the inflatable dam was conducted using a YSI 6820 multi-parameter probe. The YSI 6820 is a self-contained, submersible instrument. The temperature sensor measures a range of temperature from -5 to +45°C with a resolution of 0.01°C and accuracy ±0.15°C, and the pressure sensor has a range equal to 0 to 61 m, with a resolution of 0.001 m and accuracy of ±0.12 m.

II. Description of Data

Temperature records in the middle to lower Russian River area show a dampened diurnal temperature signal (fig.7, table 4) as compared to other sites in this report. One reason for this dampened signal is that many of these monitoring stations are upstream of the inflatable dam.

Data files from this chapter are named and organized according to date of record. While the data files are named “Wohler” and “Mirabel,” they are not limited to those particular areas but rather contain data from a number of monitoring points (listed specifically below) near the area above and below the inflatable dam.

Russian River near Wohler Bridge and Mirabel Dam:

Site No.	Location		Depth(s)	Description	T	WL	Data Filename
	surface	bottom					
3	x	x	1 meter	Glide above Redwood Hole	x		WB_19990610.xls
4	x	x	3.66 meters	Levee Rock Wall (Rip Rap)	x		
5	x	x	0.46 meters	Mirabel Dam	x		

Russian River near Wohler Bridge and Mirabel Dam:

Site No.	Location		Depth(s)	Description	T	WL	Data Filename
	surface	bottom					
3	x	x	0.5, 4.0 meters	Redwood Hole	x		WB_20000601.xls
5	x	x		Mirabel Dam	x		
7	x	x		Steelhead Beach	x		

Russian River near Wohler Bridge and Mirabel Dam:

Site No.	Location		Depth(s)	Description	T	WL	Data Filename
	surface	bottom					
1	x	x		Syar	x		WB_20010524.xls
2	x	x		Benoist	x		
3	x	x	0.5, 4.0 meters	Redwood Hole	x		
4	x	x		Levee Rock Wall (Rip Rap)	x		
5	x	x		Mirabel Dam	x		
6	x			Below Mirabel Dam	x		
7	x	x		Steelhead Beach	x		

Russian River near Wohler Bridge and Mirabel Dam:

Site No.	Location		Depth(s)	Description	T	WL	Data Filename
	surface	bottom					
1	x	x		Syar	x		WB_20020601.xls
2	x	x		Benoist	x		
3	x	x	0.5, 4.0 meters	Redwood Hole	x		
4	x	x		Levee Rock Wall (Rip Rap)	x		
5	x	x		Mirabel Dam	x		
6				Below Mirabel Dam	x		
7	x	x		Steelhead Beach	x		
8		x		(not named)	x		

Mirabel Inflatable Dam:

Description	T	Depth	Data Filename
YSI sonde at Fish Screens	x	x	Mirabel_20020101.xls

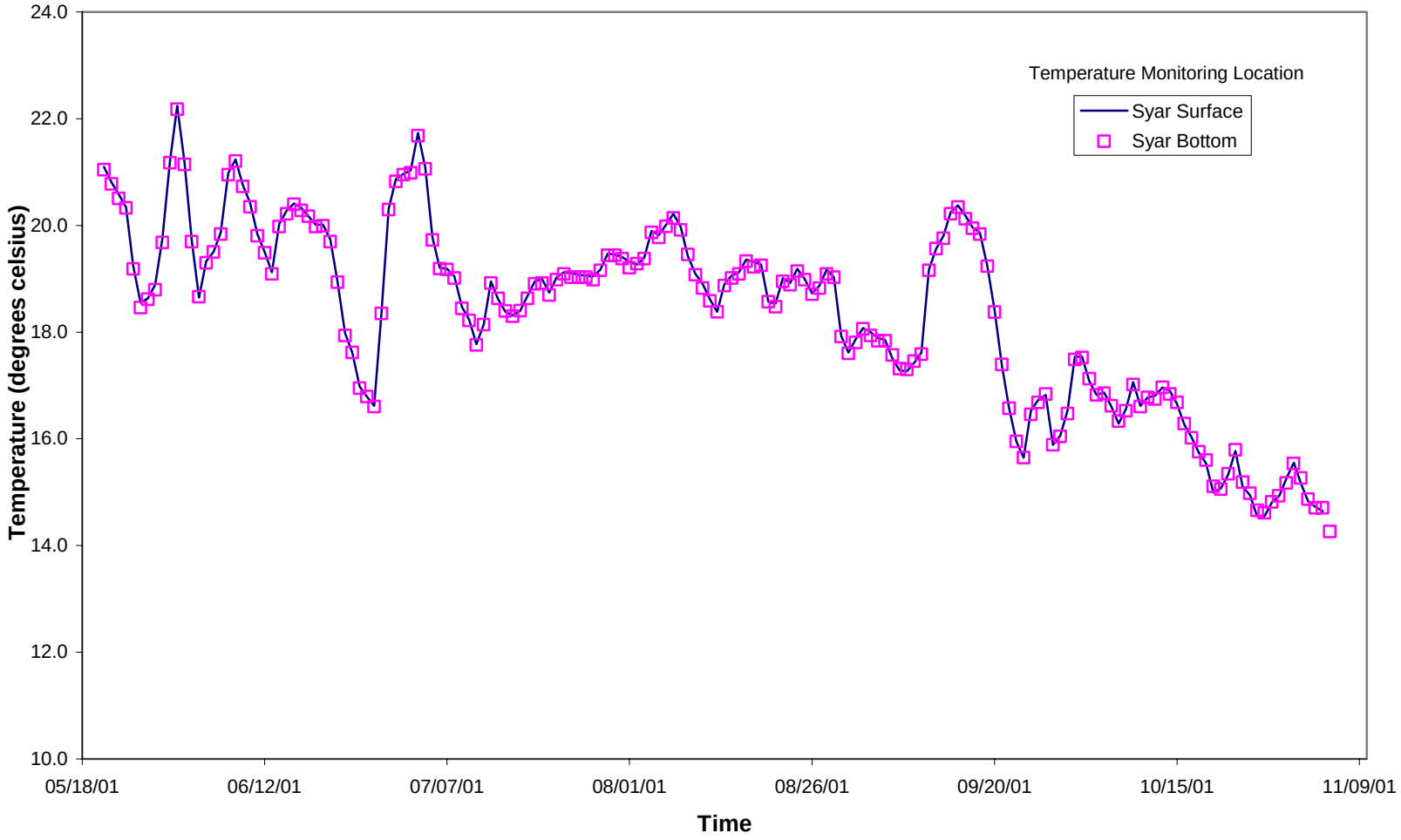

Figure 7. Sample thermograph for surface water sites near Wohler Bridge and Inflatable Dam

Table 4. Sample table from data collected by SCWA-NR

DATA SOURCE:		**SONOMA WATER MANAGEMENT AGENCY - Natural Resource Division**					
DATA LOGGER:		**ONSET HOBO LOGGER**					
SITE LOCATION:		**NEAR WOHLER BRIDGE**					
FORMER FILENAME(S):		**Wohler temps-2001.xls**					
COLLECTION METHOD:		**Hobo Data logger tied into position**					
PERIOD OF	BEGIN:	05/21/01	05/21/01	04/26/01	04/26/01	04/26/01	04/26/01
RECORD	END:	11/04/01	11/04/01	11/04/01	11/04/01	11/04/01	11/04/01
STATION NUMBER:		**1 - surface**	**1 - bottom**	**2 - surface**	**2 - bottom**	**3 - surface**	**3 - bottom**
STATION LOCATION:		Syar Surface	Syar Bottom	Benoist Surface	Benoist Bottom	Redwood Hole surface (0.5 m)	Redwood Hole Bottom (4.0 m)
REASON FOR TERMINATION:			**End of monitoring season**				
COMMENTS:							
(Data considerations)							

STATION 1 Syar Surface Date	**Mean Daily Surface H_2O Temperature (^oC)**	**STATION 1 Syar Bottom Date**	**Mean Daily Surface H_2O Temperature (^oC)**	**STATION 2 Benoist Surface Date**	**Mean Daily Surface H_2O Temperature (^oC)**	**STATION 2 Benoist Bottom Date**	**Mean Daily Surface H_2O Temperature (^oC)**
05/21/01	21.1	05/21/01	21.0450	04/26/01	18.4237	04/26/01	18.1850
05/22/01	20.8	05/22/01	20.7754	04/27/01	18.3292	04/27/01	18.0596
05/23/01	20.6	05/23/01	20.5046	04/28/01	18.1375	04/28/01	17.9158
05/24/01	20.3	05/24/01	20.3300	04/29/01	17.4725	04/29/01	17.1867
05/25/01	19.2	05/25/01	19.1858	04/30/01	18.2833	04/30/01	18.0292
05/26/01	18.6	05/26/01	18.4567	05/01/01	18.7258	05/01/01	18.5512
05/27/01	18.6	05/27/01	18.6150	05/02/01	17.5992	05/02/01	17.4725
05/28/01	18.9	05/28/01	18.7904	05/03/01	17.7271	05/03/01	17.5042
05/29/01	19.8	05/29/01	19.6779	05/04/01	18.3779	05/04/01	18.2029
05/30/01	21.2	05/30/01	21.1742	05/05/01	18.9171	05/05/01	18.6792
05/31/01	22.2	05/31/01	22.1783	05/06/01	19.4083	05/06/01	19.2025
06/01/01	21.2	06/01/01	21.1400	05/07/01	20.1704	05/07/01	19.9158
06/02/01	19.7	06/02/01	19.6942	05/08/01	20.9979	05/08/01	20.8387
06/03/01	18.6	06/03/01	18.6629	05/09/01	21.0133	05/09/01	20.8225
06/04/01	19.3	06/04/01	19.2979	05/10/01	20.6321	05/10/01	20.4092
06/05/01	19.5	06/05/01	19.5042	05/11/01	20.5987	05/11/01	20.4562
06/06/01	19.9	06/06/01	19.8371	05/12/01	19.0096	05/12/01	18.8196
06/07/01	21.0	06/07/01	20.9504	05/13/01	18.8058	05/13/01	18.5679
06/08/01	21.2	06/08/01	21.2037	05/14/01	18.7737	05/14/01	18.5829
06/09/01	20.8	06/09/01	20.7275	05/15/01	19.0746	05/15/01	18.8525
06/10/01	20.4	06/10/01	20.3462	05/16/01	19.5029	05/16/01	19.2971
06/11/01	19.8	06/11/01	19.8058	05/17/01	18.9254	05/17/01	20.9000
06/12/01	19.5	06/12/01	19.4875	05/18/01	18.9254	05/18/01	20.2817
06/13/01	19.1	06/13/01	19.0917	05/19/01	20.9817	05/19/01	20.7912
06/14/01	20.0	06/14/01	19.9796	05/20/01	20.9821	05/20/01	20.7908
06/15/01	20.3	06/15/01	20.2192	05/21/01	21.3967	05/21/01	21.1562
06/16/01	20.4	06/16/01	20.3937	05/22/01	21.1567	05/22/01	20.8704
06/17/01	20.3	06/17/01	20.2829	05/23/01	20.9025	05/23/01	20.6637
06/18/01	20.2	06/18/01	20.1712	05/24/01	20.7271	05/24/01	20.5204
06/19/01	20.0	06/19/01	19.9800	05/25/01	19.6625	05/25/01	19.5033
06/20/01	20.0	06/20/01	19.9958	05/26/01	18.7583	05/26/01	18.5204
06/21/01	19.7	06/21/01	19.6946	05/27/01	18.8687	05/27/01	18.6625
06/22/01	18.9	06/22/01	18.9321	05/28/01	19.1071	05/28/01	18.8217
06/23/01	18.0	06/23/01	17.9333	05/29/01	19.9333	05/29/01	19.7250
06/24/01	17.6	06/24/01	17.6150	05/30/01	21.4608	05/30/01	21.2537
06/25/01	17.0	06/25/01	16.9500	05/31/01	22.6579	05/31/01	22.4021

DATA COLLECTED BY USGS, BRANCH OF REGIONAL RESEARCH, WESTERN REGION

Data presented in this section include temperature data collected by the United States Geologic Survey's Branch of Regional Research, Western Region (USGS, BRR, WR) from Riverfront Regional Park, Wohler Bridge, and Steelhead Beach Regional Park (fig. 1). USGS, BRR, WR conducted individual studies at several sites along the Russian River designed to assess the hydraulic conductivity of the geologic materials in the riverbed.

I. Description of Data Collection Methods

Shallow piezometers were installed in riverbed sediments seasonally with the aid of Sonoma County Water Agency personnel using a hand-held casing hammer. Temperature data were collected by the Onset Optic Stowaway data loggers that were hung inside each piezometer at desired depths (fig. 8). An additional logger was tied to the outside of a piezometer to measure river temperature. Water level elevations were measured a few times by hand.

Figure 8. Installation of a piezometer 1 to 2 m into the streambed and placement of temperature loggers into a nearby piezometer

II. Description of Data

At Steelhead Beach Regional Park three piezometers monitored in 2000 from September 22 to 28 show the expected diurnal signal in the shallowest piezometer, SB-PZ-01a, and a dampened diurnal signal coupled with increased overall temperature with increasing depth to SB-PZ-01c, where only a long-term seasonal temperature signal is observed. In 2001, from September 26 to October 10, three data loggers were hung at different depths in each piezometers with total depths of 1.22 and 2.44 m (4 and 8 ft). Both piezometers were submerged on October 4, and all loggers measured the stream temperature after that date.

At Wohler Bridge in 2001 during the period of record, mean temperature decreases by ~10°C, and the amplitude of the stream, 0.3 and 0.61 m (1-ft and 2-ft) deep signals decrease by almost half (fig. 9, table 5). These records show the diurnal temperature variation, the long seasonal trend, and weekly to bi-weekly variations.

At Riverfront Regional Park the early data show a clear diurnal signal, with markedly smaller amplitude at 0.3 and 0.61 m (1 ft and 2 ft) depths than observed at the Wohler site over the same time period. The period of record at Riverfront Regional Park is shorter in duration due to vandalism and submergence of the piezometers.

Data files are named and organized according to site location and date of record. Many of these temporary piezometers installed for studies reported in this section were not given formal names, and are referred to here by the approximate depth below streambed sediments of the midpoint of their screened interval. Where multiple temperature sensors were suspended in a single piezometer, the approximate depth of the sensor is listed below.

Steelhead Beach Regional Park:

Piezometers	Approximate Screen Depth	T	WL	Data Filename
Piezometer-1a	0.75 meters	x		SB_20000928.xls
Piezometer-1b	2.75 meters	x		
Piezometer-1c	4.75 meters	x		

Steelhead Beach Regional Park:

Piezometers (named by approximate screen depth)	Approximate Sensor Depth	T	WL	Data Filename
	(Surface Water)	x		SB_20010926.xls
1.22m piezometer	0.30 meters	x		
1.22m piezometer	0.61 meters	x		
1.22m piezometer	1.22 meters	x		
	(Surface Water)	x		
2.44m piezometer	0.61 meters	x		
2.44m piezometer	1.22 meters	x		
2.44m piezometer	2.44 meters	x		

Wohler:

Piezometers (named by approximate screen depth)	T	WL	Data Filename
(Surface Water)	x		WB_20020619.xls
0.30m piezometer	x		
0.61m piezometer	x		

Riverfront Regional Park:

Piezometers (named by approximate screen depth)	T	WL	Data Filename
(Surface Water)	x		Riverfront_20020618.xls
0.30m piezometer	x		
0.61m piezometer	x		
1.84m piezometer	x		

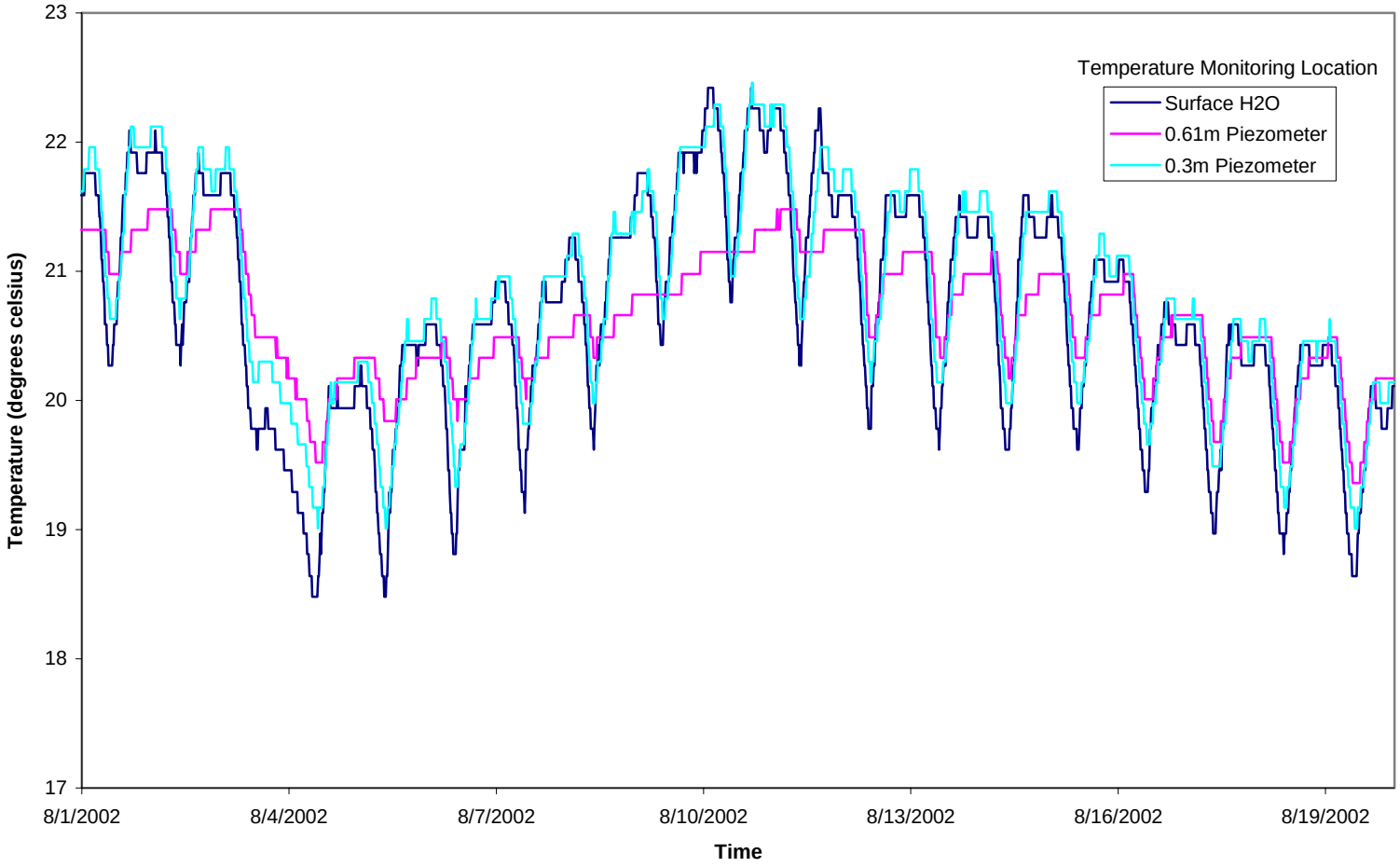

Figure 9. Sample set of 3 thermographs created from temperature measurements in Wohler Shallow Piezometers

Table 5. Sample table from data collected by USGS- BRR, WR

DATA SOURCE:	**USGS, BRR-WR**			
DATA LOGGER:	**ONSET STOWAWAY**			
SITE LOCATION:	**NEAR WOHLER BRIDGE**			
FORMER FILENAME(S):	**sn187695_#3.txt**	**sn187713_#1.txt**		**sn187689_#2.txt**
	wohl_sn187689_nov.txt	**wohl_sn187713_oct.txt**		**wohl_sn187689_oct.txt**
		wohl_sn187713_nov.txt		**wohl_sn187689_nov.txt**
COLLECTION METHOD:	**HUNG IN SHALLOW PVC PIEZOMETERS**			
PERIOD OF BEGIN:	**6/19/2002 15:19**	**6/19/2002 15:15**	**6/19/2002 15:17**	
RECORD END:	**11/27/2002 14:40**	**11/27/2002 15:43**	**10/31/2002 12:10**	
REASON FOR TERMINATION:	**End of Study**	**End of Study**	**Stowaway ran**	
COMMENTS:	**for the season**	**for the season**	**out of batteries**	
(Data considerations)				

sn: 187695 Date Time	Surface H_2O Temperature (^oC)	sn: 187713 Date Time	0.61m Piezometer Temperature (^oC)	sn: 187689 Date Time	0.3m Piezometer Temperature (^oC)
6/19/2002 15:19	23.43	6/19/2002 15:15	23.83	6/19/2002 15:17	22.62
6/19/2002 15:34	22.92	6/19/2002 15:30	22.15	6/19/2002 15:32	23.12
6/19/2002 15:49	23.09	6/19/2002 15:45	22.15	6/19/2002 15:47	23.12
6/19/2002 16:04	23.09	6/19/2002 16:00	22.15	6/19/2002 16:02	23.12
6/19/2002 16:19	23.09	6/19/2002 16:15	22.15	6/19/2002 16:17	23.12
6/19/2002 16:34	23.09	6/19/2002 16:30	22.15	6/19/2002 16:32	23.12
6/19/2002 16:49	23.09	6/19/2002 16:45	22.15	6/19/2002 16:47	23.29
6/19/2002 17:04	23.09	6/19/2002 17:00	22.32	6/19/2002 17:02	23.29
6/19/2002 17:19	23.09	6/19/2002 17:15	22.32	6/19/2002 17:17	23.29
6/19/2002 17:34	23.09	6/19/2002 17:30	22.32	6/19/2002 17:32	23.12
6/19/2002 17:49	23.09	6/19/2002 17:45	22.32	6/19/2002 17:47	23.12
6/19/2002 18:04	23.09	6/19/2002 18:00	22.32	6/19/2002 18:02	23.12
6/19/2002 18:19	23.09	6/19/2002 18:15	22.32	6/19/2002 18:17	23.12
6/19/2002 18:34	23.09	6/19/2002 18:30	22.32	6/19/2002 18:32	23.12
6/19/2002 18:49	23.09	6/19/2002 18:45	22.32	6/19/2002 18:47	23.12
6/19/2002 19:04	22.92	6/19/2002 19:00	22.32	6/19/2002 19:02	23.12
6/19/2002 19:19	22.92	6/19/2002 19:15	22.32	6/19/2002 19:17	23.12
6/19/2002 19:34	22.92	6/19/2002 19:30	22.32	6/19/2002 19:32	23.12
6/19/2002 19:49	22.92	6/19/2002 19:45	22.32	6/19/2002 19:47	23.12
6/19/2002 20:04	22.92	6/19/2002 20:00	22.32	6/19/2002 20:02	22.96
6/19/2002 20:19	22.92	6/19/2002 20:15	22.32	6/19/2002 20:17	22.96
6/19/2002 20:34	22.92	6/19/2002 20:30	22.32	6/19/2002 20:32	22.96
6/19/2002 20:49	22.92	6/19/2002 20:45	22.32	6/19/2002 20:47	22.96
6/19/2002 21:04	22.92	6/19/2002 21:00	22.32	6/19/2002 21:02	22.96
6/19/2002 21:19	22.92	6/19/2002 21:15	22.32	6/19/2002 21:17	22.96
6/19/2002 21:34	22.92	6/19/2002 21:30	22.32	6/19/2002 21:32	22.96
6/19/2002 21:49	22.92	6/19/2002 21:45	22.32	6/19/2002 21:47	23.12
6/19/2002 22:04	22.92	6/19/2002 22:00	22.32	6/19/2002 22:02	23.12
6/19/2002 22:19	22.92	6/19/2002 22:15	22.32	6/19/2002 22:17	23.12
6/19/2002 22:34	22.92	6/19/2002 22:30	22.32	6/19/2002 22:32	23.12
6/19/2002 22:49	22.92	6/19/2002 22:45	22.32	6/19/2002 22:47	23.12
6/19/2002 23:04	22.92	6/19/2002 23:00	22.32	6/19/2002 23:02	23.12
6/19/2002 23:19	22.92	6/19/2002 23:15	22.32	6/19/2002 23:17	23.12

DATA COLLECTED BY THE USGS, CA DISTRICT

Data presented in this section are stage (water level elevation relative to gage-specific datum), mean daily discharge and temperature data from three established USGS gaging stations along the Russian River by the United States Geologic Survey's California District (USGS-CA). The three gaging stations are 11462500, Russian River near Hopland, 11463980, Russian River near Digger Bend (near Healdsburg), and 11467000, Russian River near Guerneville (fig. 10).

I. Description of Data Collection Methods

Stage and discharge measurements are made according to USGS protocol (Buchanan and Somers, 1969). Temperature measurements are made with a YSI 6820 multi-parameter Sonde following the protocol outlined by Radtke and others, 1998.

Figure 10. USGS gage 1467000 located on the right bank of the Russian River near Guerneville, CA. taken from the Hacienda Bridge with railing showing in the lower right of each photograph Details of the telemeter equipment above the gage house is shown in the left image. In the right image, the instrumentation conduit is seen running down the bank into the river.

II. Description of Data

The Russian River hydrographs show trends typical for most north coast rivers in California: the highest discharges are recorded from November to March, when most of the precipitation falls in the region; occasional late storms in April or May produce significant discharges of shorter duration, and the gradual exponential decay from stormflow highs back to baseflow occurs during late spring and summer, reaching the lowest discharges late in summer and early fall (fig. 11, table 6). There is no significant snowmelt influence on discharge in the Russian River basin, so winter (dominantly rain) precipitation forms the bulk of runoff measured. As expected, river temperatures at all three sites show a seasonal decrease from summer to winter in both mean temperature and amplitude of daily change. Temperatures are lowest in the winter months (also concurrent with the highest discharges), and increase in mean and amplitude of daily change from winter to summer. The highest temperatures in the Russian River are not always recorded during the hottest months of the year, but rather when there is the least water flowing in the river.

Data files are named and organized according to site location and date of record. All records from a single site have been included in one data file.

United States Geologic Survey Gaging Stations:

USGS Gage No.	Description	T	S	Q	Data Filename
11463980	RUSSIAN R NR HOPLAND CA	x	x	x	Hopland_20011001.xls
11462500	RUSSIAN R A DIGGER BEND NR HEALDSBURG CA	x	x	x	Healdsburg_20020628.xls
11467000	RUSSIAN R NR GUERNEVILLE CA	x	x	x	Guerneville_20021001.xls

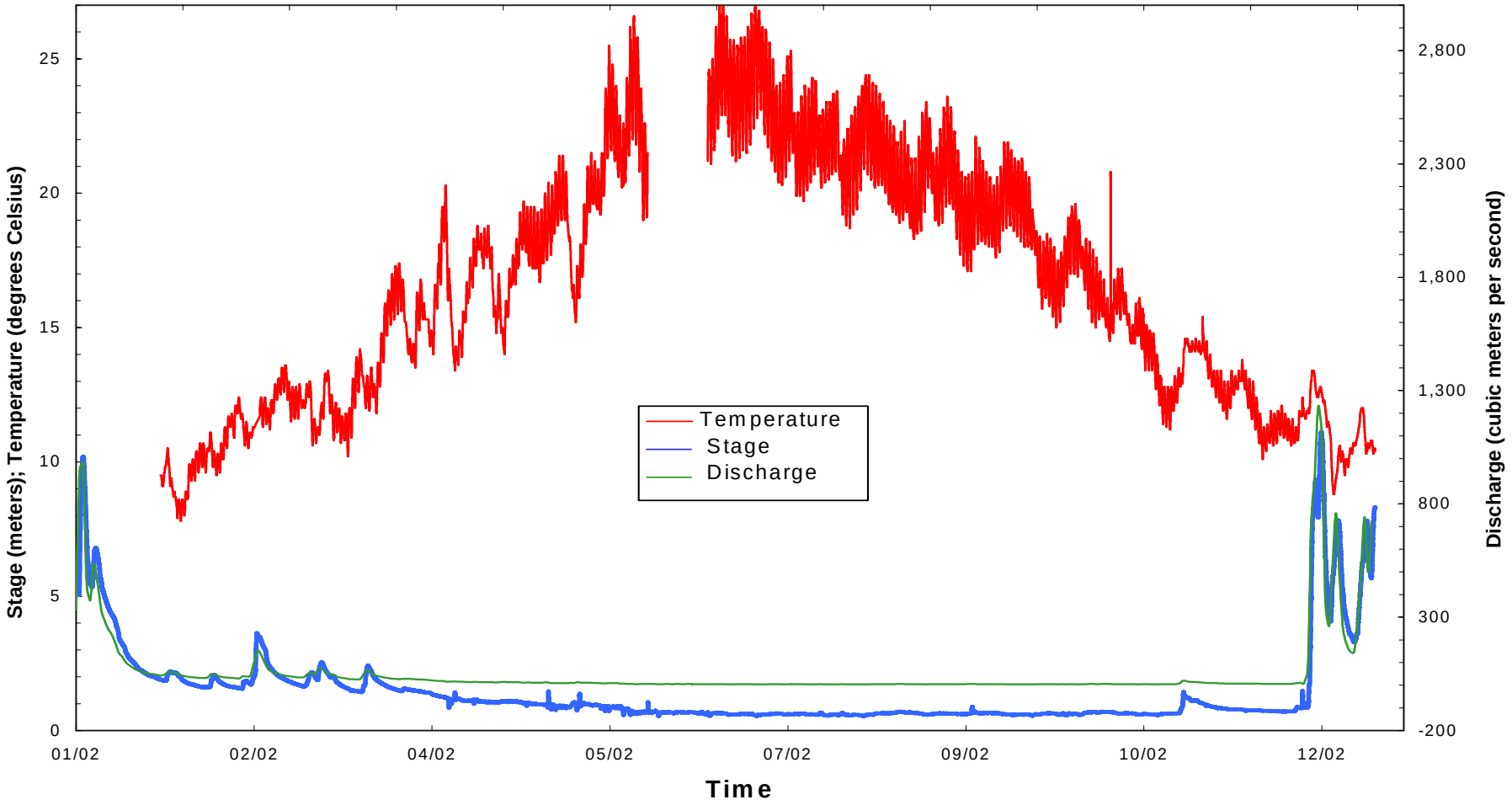

Figure 11. River stage, discharge (streamflow), and thermograph from USGS Gage 11467000

Table 6. Sample table from data collected by USGS, CA District

DATA SOURCE:	**USGS-CA**		
DATA LOGGER:	**Handar 555 FG with DCP, ALERT radio and phone modem**		
SITE LOCATION:	**RUSSIAN R NR GUERNEVILLE CA**		
SITE NUMBER:	**11467000**		
FORMER FILENAME(S):	**11467000_stage_height_1998.xls**	**11467000_temp_uv.xls**	
	11467000_stage_height_1999.xls	**11467000_temp_uv2.xls**	
	11467000_stage_height_2000.xls		
	11467000_stage_height_2001.xls	**11467000_q98_02.xls**	
	11467000_stage_height_2002.xls		
COLLECTION METHOD:	Stage	**Design Analysis H350-L pressure transducer**	
	Discharge	**Direct river velocity and cross-sectional area measurements (for discharge) with a Price Flowmeter, two-wheel boom, Texas boom, or 4-wheeled boom with E-reel and 45.4 kg and/or 68 kg (100 and/or 150 pound) C weights**	
	Temperature	**Thermistor thermometer (calibrated with NIST certified liquid-in-glass sensor)**	
	~~Stage~~	~~Temperature~~	~~Discharge~~
PERIOD OF BEGIN:	**1/1/98 0:00**	**1/24/02 18:01**	**1/1/98**
RECORD END:	**12/31/02 23:45**	**12/31/02 23:45**	**12/31/02**
REASON FOR TERMINATION:	**Sampling continues;**		
COMMENTS: (Data considerations)	**end of reporting period**		

Date Time	1998 Stage (meters)	Date Time	1999 Stage (meters)	Date Time	2000 Stage (meters)	Date Time	2001 Stage (meters)	Date Time	2002 Stage (meters)	Date Time	Surface H2O Temperature (^{o}C)	Date	Mean Daily Discharge (m^3/s)
1/1/98 0:00	1.46	1/1/99 0:00	1.33	1/1/00 0:00	1.00	1/1/01 0:00	0.89	1/1/02 0:00	5.70	1/24/02 18:01	9.5	1/1/98	23.36
1/6/98 0:15	3.55	1/1/99 0:15	1.33	1/1/00 0:15	1.00	1/1/01 0:15	0.89	1/1/02 0:15	5.67	1/24/02 18:16	9.5	1/2/98	36.25
1/6/98 0:30	3.55	1/1/99 0:30	1.33	1/1/00 0:30	1.00	1/1/01 0:30	0.89	1/1/02 0:30	5.64	1/24/02 18:31	9.5	1/3/98	97.69
1/6/98 0:45	3.55	1/1/99 0:45	1.33	1/1/00 0:45	1.00	1/1/01 0:45	0.89	1/1/02 0:45	5.64	1/24/02 18:46	9.5	1/4/98	223.42
1/6/98 1:00	3.55	1/1/99 1:00	1.33	1/1/00 1:00	1.00	1/1/01 1:00	0.89	1/1/02 1:00	5.62	1/24/02 19:01	9.5	1/5/98	140.17
1/6/98 1:15	3.55	1/1/99 1:15	1.33	1/1/00 1:15	1.00	1/1/01 1:15	0.89	1/1/02 1:15	5.57	1/24/02 19:16	9.5	1/6/98	129.97
1/6/98 1:30	3.55	1/1/99 1:30	1.33	1/1/00 1:30	1.00	1/1/01 1:30	0.89	1/1/02 1:30	5.57	1/24/02 19:31	9.5	1/7/98	130.26
1/6/98 1:45	3.56	1/1/99 1:45	1.33	1/1/00 1:45	1.00	1/1/01 1:45	0.89	1/1/02 1:45	5.53	1/24/02 19:46	9.5	1/8/98	112.70
1/6/98 2:00	3.55	1/1/99 2:00	1.33	1/1/00 2:00	0.99	1/1/01 2:00	0.89	1/1/02 2:00	5.52	1/24/02 20:01	9.5	1/9/98	87.78
1/6/98 2:15	3.55	1/1/99 2:15	1.32	1/1/00 2:15	1.00	1/1/01 2:15	0.89	1/1/02 2:15	5.50	1/24/02 20:16	9.5	1/10/98	110.44
1/6/98 2:30	3.55	1/1/99 2:30	1.33	1/1/00 2:30	0.99	1/1/01 2:30	0.89	1/1/02 2:30	5.47	1/24/02 20:31	9.5	1/11/98	151.49
1/6/98 2:45	3.54	1/1/99 2:45	1.33	1/1/00 2:45	0.99	1/1/01 3:00	0.89	1/1/02 2:45	5.52	1/24/02 20:46	9.5	1/12/98	450.24
1/6/98 3:00	3.54	1/1/99 3:00	1.32	1/1/00 3:00	1.00	1/1/01 3:15	0.89	1/1/02 3:00	5.45	1/24/02 21:01	9.5	1/13/98	639.96
1/6/98 3:15	3.52	1/1/99 3:15	1.33	1/1/00 3:15	0.99	1/1/01 3:30	0.89	1/1/02 3:15	5.45	1/24/02 21:16	9.5	1/14/98	390.77
1/6/98 3:30	3.52	1/1/99 3:30	1.32	1/1/00 3:30	0.99	1/1/01 3:45	0.89	1/1/02 3:30	5.42	1/24/02 21:31	9.5	1/15/98	574.83
1/6/98 3:45	3.52	1/1/99 3:45	1.32	1/1/00 3:45	0.99	1/1/01 4:00	0.89	1/1/02 3:45	5.40	1/24/02 21:46	9.5	1/16/98	521.03
1/6/98 4:00	3.50	1/1/99 4:00	1.32	1/1/00 4:00	0.99	1/1/01 4:15	0.89	1/1/02 4:00	5.39	1/24/02 22:01	9.5	1/17/98	399.27
1/6/98 4:15	3.50	1/1/99 4:15	1.32	1/1/00 4:15	0.99	1/1/01 4:30	0.89	1/1/02 4:15	5.38	1/24/02 22:16	9.5	1/18/98	399.27
1/6/98 4:30	3.48	1/1/99 4:30	1.33	1/1/00 4:30	0.99	1/1/01 4:45	0.89	1/1/02 4:30	5.36	1/24/02 22:31	9.5	1/19/98	693.76
1/6/98 4:45	3.48	1/1/99 4:45	1.32	1/1/00 4:45	0.99	1/1/01 5:00	0.89	1/1/02 4:45	5.35	1/24/02 22:46	9.5	1/20/98	549.35
1/6/98 5:00	3.47	1/1/99 5:00	1.32	1/1/00 5:00	0.99	1/1/01 5:15	0.89	1/1/02 5:00	5.32	1/24/02 23:01	9.5	1/21/98	410.59
1/6/98 5:15	3.47	1/1/99 5:15	1.32	1/1/00 5:15	0.99	1/1/01 5:30	0.89	1/1/02 5:15	5.29	1/24/02 23:16	9.5	1/22/98	300.16

REFERENCES CITED

Buchanan, T.J., and Somers, W.P., 1969, Discharge measurements at gaging stations: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A8, 65p.

Constantz, J., Stewart, A.E., Niswonger, R., and Sarma, L., 2002, Analysis of temperature profiles for investigating stream losses beneath ephemeral channels: Water Resources Research, v. 38, no. 12, p. 52-1 to 52-13. (on-line abstract)

Constantz, J., 1998. Interaction between stream temperature, streamflow, and groundwater exchanges in alpine streams: Water Resources Research, v. 34, no. 7, p. 1609-1615.

Radtke, D.B., Kurklin, J.K., and Wilde, F.D., 1998, Field measurement of temperature, *in* National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6, p. T1-T5.

Stonestrom, D.A., and Constantz, J., 2003, Heat as a tool for studying the movement of ground water near streams, U.S. Geological Survey Circlular1260, 96 p.