HYDROLOGIC AND CHEMICAL DATA FROM AN EXPERIMENT TO EXAMINE TEMPORAL VARIABILITY IN WATER SAMPLES FROM SCREENED WELLS ON CAPE COD, MASSACHUSETTS

Edited By Thomas E. Reilly

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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To Obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square foot (ft^2)	0.0929	square meter
acre	0.4047	square hectometer
gallon (gal)	3.785	liters
cubic foot per second (ft^3/s)	0.02832	cubic meter per second

Temperature is given in degrees Celsius (^{o}C), which can be converted to degrees Fahrenheit (^{o}F) by use of the following equation:

$$^{o}F = 1.8(^{o}C) + 32$$

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

Abbreviated water-quality units used in this report: Chemical concentrations and water temperature are given in metric units. Chemical concentration is given in milligrams per liter (mg/L) or micrograms per liter (µm/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is the same as concentrations in parts per million.

Specific conductance of water is expressed in microsiemens per centimeter at 25 degrees Celsius (µS/cm). This unit is equivalent to micromhos per centimeter at 25 degrees Celsius (µmho/cm), formerly used by the U.S. Geological Survey.

HYDROLOGIC AND CHEMICAL DATA FROM AN EXPERIMENT TO EXAMINE TEMPORAL VARIABILITY IN WATER SAMPLES FROM SCREENED WELLS ON CAPE COD, MASSACHUSETTS

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ABSTRACT

An experiment was designed to evaluate the changing chemical composition of the water pumped from a well screened in a physically and chemically heterogenous aquifer. Well F453-63, at the U.S. Geological Survey Toxic-Substances Hydrology research site located on Cape Cod, Massachusetts, was selected because it was known that the screen penetrated both the oxic and anoxic zones of the sewage plume from the Otis Air Base sewage-disposal sand beds. The experiment was conducted on August 12, 1992. Well F453-63 was sampled over time as it was pumped continuously, and three multilevel samplers were used to document the vertical distribution of selected chemicals in the ground water in the immediate vicinity of the well. All water samples collected during the experiment were analyzed in the field for specific conductance and pH. The samples were subsequently analyzed for concentrations of ferrous iron (Fe^{+2}), total iron, boron, calcium, chloride, phosphorus, potassium, magnesium, manganese, sodium, zinc, and nitrogen species (including nitrous oxide, ammonium, nitrite and nitrate). The results of these chemical analyses along with appropriate physical measurements of the site and aquifer material are documented in this data report.

INTRODUCTION

by Thomas E. Reilly

Water that enters a well through a well screen is derived from layers of porous material. These layers have different thicknesses and areal extents and can be characterized by different physical properties, such as hydraulic conductivity, and chemical properties. Layers defined by one property may not coincide with those defined by a different property. The water withdrawn from the well is a composite of the waters present in these different layers along the length of the screen. The length of well screens can span vertical distances shorter than 1 foot or longer than a hundred feet. The rate of water withdrawn from each layer is variable and depends on the hydraulic conductivity, screen placement, pump-intake placement, and other factors.

Wilson and Rouse (1983), Rivett and others (1990), Gibs and Imbrigiotta (1990), Reilly and Gibs (1993), and others have observed that chemical concentrations of various constituents can change in the water discharging from a well over the time of sampling. Reilly and Gibs (1993) simulated a hypothetical system to illustrate that the composition of water discharging over time from a physically and chemically heterogeneous aquifer can change over time depending on the distribution of the chemical constituents of the water and the hydraulic conductivity of the aquifer. They showed that changes over time are not necessarily due to the evacuation of the stagnant water in the well casing but can also be due to the transport of the chemical constituents through the aquifer to the well.

The purpose of this report is to present the data collected from an experiment performed at Cape Cod, Mass., to test the hypotheses that (1) the observed concentration of constituents in the water sampled from a screened well is due to the flux of these constituents into the well as determined by the hydraulic conductivity and chemical distribution near the well, and (2) the flux of these constituents can change during pumping due to the flow and transport of the chemicals in the aquifer near the screen.

EXPERIMENTAL DESIGN

by Thomas E. Reilly and Denis R. LeBlanc

The experiment was designed to evaluate the changing chemical composition of the water discharged from a well screened in a physically and chemically heterogenous aquifer. Well F453-63, at the U.S. Geological Survey Toxic-Substances Hydrology research site located on Cape Cod, Massachusetts, was selected because it was known that the screen penetrated both the oxic and anoxic zones of the sewage plume from the Otis Air Base sewage-disposal sand beds (fig. 1). The ground-water chemistry differs in the oxic and anoxic zones (Kent and others, 1994), thereby providing a heterogeneous chemical environment along the screened interval of well F453-63. Three multilevel samplers were installed near well F453-63 to describe the chemical distribution in the immediate vicinity of the screened well (fig. 2).

WELL AND MULTILEVEL SAMPLER INSTALLATION

by Stephen P. Coppola and Denis R. LeBlanc

Well F453-63 is constructed of 2.067-inch inside-diameter (ID) flush-jointed threaded polyvinyl chloride (PVC) pipe with four sections of 9-ft-long 0.010-inch-slotted PVC screens (Appendix 1).

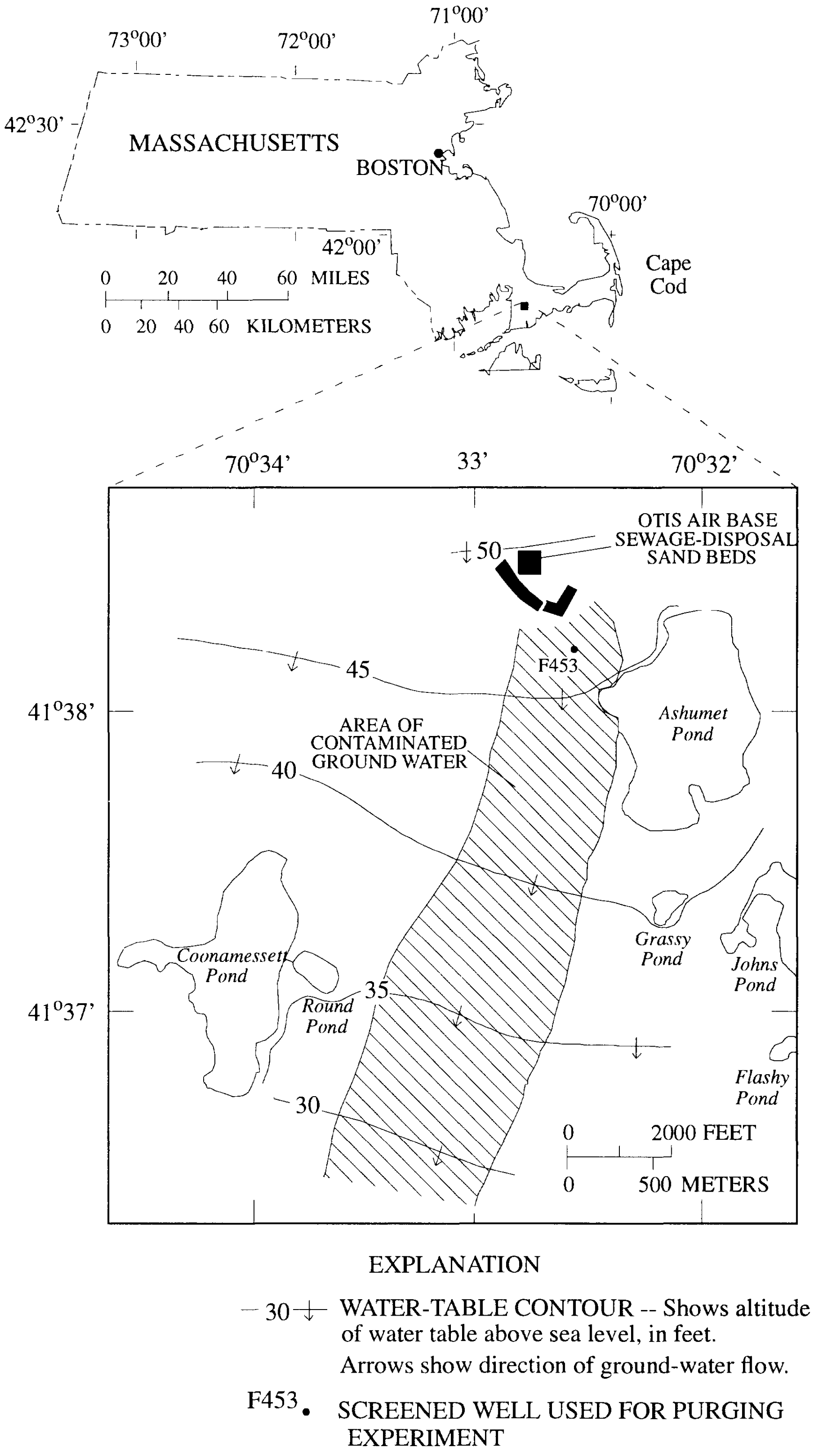

Figure 1. Ground-water study site on Cape Cod, Massachusetts, showing the location of the contaminant plume and the screened well used in the well-purging experiment.

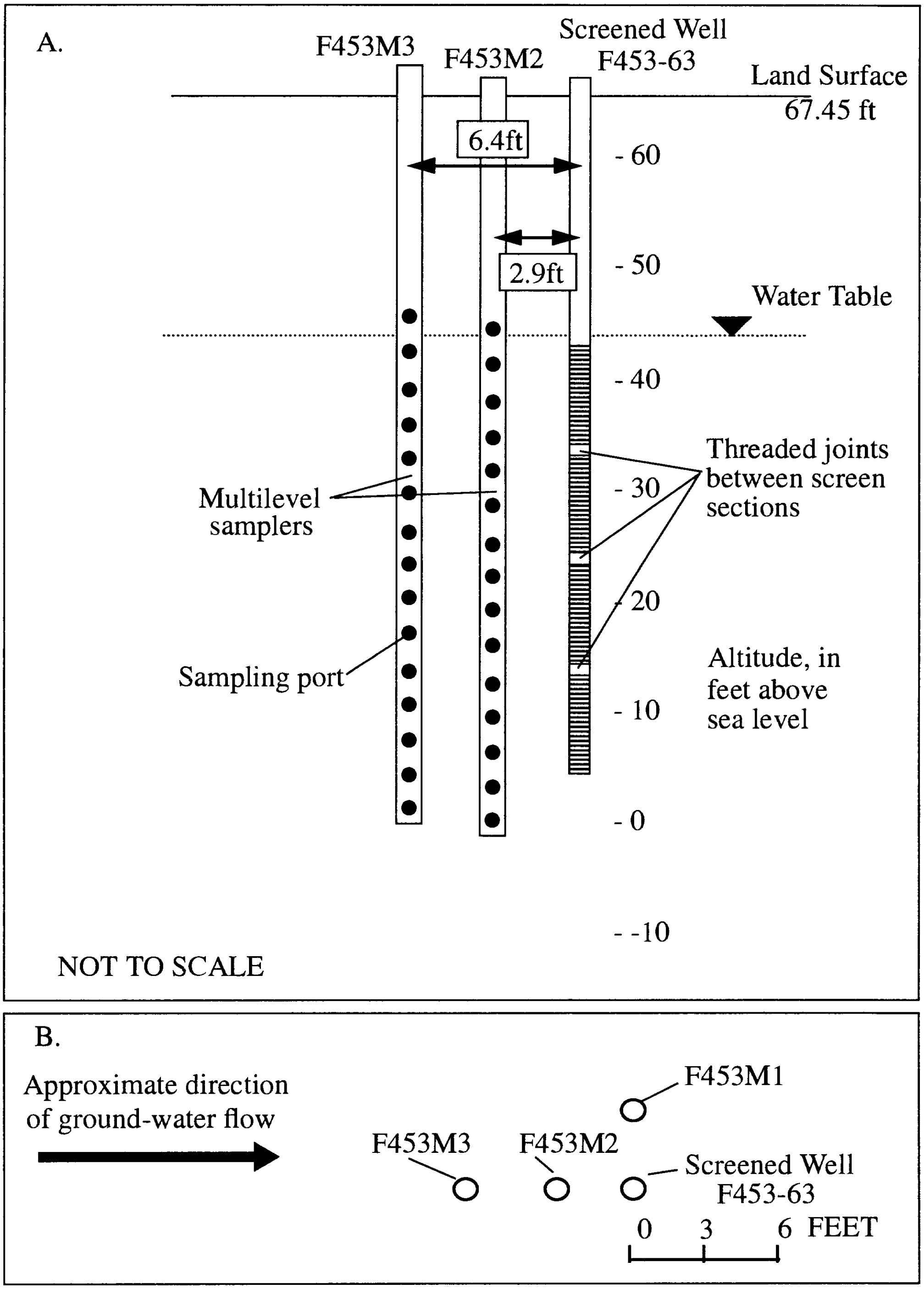

Figure 2. Diagram of well and multilevel sampler layout for well-purging experiment: A. cross-sectional view, B. Plan view.

The screen extends from an altitude of 4.7 to 43.7 ft above sea level. The well was installed by a drive-and-wash technique to minimize disturbance of the aquifer around the well (Morin and others, 1988). The initial water-table altitude was 44.33 ft above sea level at the time of the test. The volume of water residing in the casing and screened section of the well is approximately 0.923 ft^3.

Three multilevel samplers were installed near well F453-63 (fig. 2). The samplers were installed by a drive-and-wash technique described by LeBlanc and others (1991). Each multilevel sampler consists of 15 color-coded polyethylene tubes (0.25-inch outside diameter); however, only 13 or 14 ports on each sampler were located in the saturated zone at the time of the experiment. The tubes run from land surface down the inside of a 1.25-inch ID PVC casing and out holes spaced every 3.3 ft drilled through the PVC. The open, down-hole end of each tube is screened with a fine nylon fabric secured with stainless steel wire.

DISTRIBUTION OF HYDRAULIC CONDUCTIVITY

by Kathryn M. Hess

The horizontal hydraulic conductivity along well F453-63 ranges from 78 to 969 ft/d. These values of hydraulic conductivity were estimated by means of a field hydraulic test that is a modification of a standard aquifer test where by a well is pumped and the drawdown is observed in the well. A highly sensitive, impeller flowmeter is used to measure the discharge within the well at various points along the screened interval instead of measuring only the total discharge flowing from the pumped well as is done in a standard aquifer test. The gain in discharge between two flowmeter measurement points is related to the hydraulic conductivity of the aquifer over that interval. Rehfeldt and others (1989) presented the details of this method.

The result of this hydraulic test is a profile of hydraulic conductivity which shows the small-scale vertical variability in horizontal hydraulic conductivity along the screened interval. The 70 values of hydraulic conductivity estimated at approximately half-foot intervals for well F453-63 are given in Appendix 2. The screened interval in this well covers 39 ft; this long-screened well was installed specifically for this hydraulic test. The three breaks in the hydraulic-conductivity profile indicate the locations of short unscreened sections containing the threaded joints of the casings.

These hydraulic-conductivity data for well F453-63 are a subset of 668 values estimated in wells within 100 feet of each other estimated by the flowmeter method and previously used to statistically quantify the variability of hydraulic conductivity in the aquifer (Hess and others, 1992). The measured hydraulic-conductivity values are similar to those estimates previously reported for this sand and gravel aquifer based on the results of an aquifer test (Garabedian and others, 1988), a natural-gradient tracer test (LeBlanc and others, 1991), grain-size analyses (LeBlanc, 1984), and permeameter measurements of cores (Wolf, 1988). The horizontal-hydraulic-conductivity data vary by more than one order of magnitude (78 to 969 ft/d) over a vertical interval of less than 40 feet.

WELL PUMPING SYSTEM AND MEASUREMENT OF PUMPING RATE AND WATER LEVELS

by Denis R. LeBlanc, Paul L. Provencher, Scott A. Boutilier, and Thomas E. Reilly

The experiment was conducted on August 12, 1992. Well F453-63 was sampled over time as it was pumped continuously, and the multilevel samplers were used to document the vertical distribution of selected chemicals in the ground water in the immediate vicinity of the well. A variable-rate submersible Keck[1] pump (model SP-81 with Teflon discharge tubing) was set 0.6 ft below the static water level in well F453-63 (about 0.1 ft above the top of the screen). The continuous discharge from the screened well was measured 15 times during the 5-hour experiment by means of a graduated cylinder; discharge ranged from 0.047 to 0.051 ft^3/min, indicating that a volume equivalent to one casing volume was pumped about every 20 minutes. Water-level measurements were made before pumping, just prior to the end of the test, and 30 minutes after the end of the test. Drawdown in the pumped well, measured with a steel tape, was 0.02 ft after 5 hours of pumping and was approximately zero 30 minutes after the end of the test.

CHEMICAL ANALYSES OF WATER SAMPLES

The long-screened well F453-63 was pumped for 5 hours. The first sample was collected 5 minutes after discharge began. Samples were then collected every 10 minutes for the first 2 hours, and every 15 minutes for the remaining 3 hours. Water samples were collected from the three multilevel samplers before and after the test to observe any changes in concentrations in the immediate vicinity of the well screen. Multilevel sampler F453M2 was also sampled halfway through the experiment. All water samples were analyzed in the field for specific conductance and pH. The samples were subsequently analyzed for concentrations of ferrous iron (Fe^{+2}), total iron, boron, calcium, chloride, phosphorus, potassium, magnesium, manganese, sodium, zinc, and nitrogen species (including nitrous oxide, ammonium, nitrite and nitrate).

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[1] The use of brand names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Water samples were collected from the pumped well in a 1-L polyethylene bottle that had been rinsed twice with the pumped water prior to collection of the sample. Part of the sample was decanted immediately onsite into a 60-mL bottle and preserved for later analysis of Fe^{+2}. The remainder of the sample was split as soon as possible at a nearby field laboratory later in the day into other bottles for separate analysis of specific constituents. The sample for nitrous oxide was collected by filling a 30-mL syringe directly from the discharge tubing from the pump and injecting the water from the syringe into a sealed serum bottle.

Water samples were collected from the multilevel samplers by pumping each port separately with a peristaltic pump fitted with Norprene tubing that could be connected directly to the sampler tubes. About 400 mL, about twice the volume of water standing in the tube of the deepest port, was pumped first, and this water was used to rinse a 1-L polyethylene bottle. The bottle was then filled to the top, and the sample was split into other bottles for specific analyses as described for the pumped-well samples. The sample for nitrous oxide was collected by filling the 30-mL syringe directly from the Norprene tubing on the peristaltic pump.

Immediate splitting of all the samples from the 1-L polyethylene bottle (not just the Fe^{+2}) and analysis of pH and specific conductance would have been possible. However, samples warmed quickly on the hot summer day and measurement of the temperature-sensitive parameters was difficult. An additional consideration was that 968 sample bottles needed to be filled (some filtered and preserved) and it was impossible to process the samples as quickly as they were collected. It was decided before the test was begun that the stable climate and sample preparation facilities in the nearby laboratory would produce more consistent pH measurements, and keep sample splitting and preparation manageable. The samples were handled in the nearby laboratory as quickly as possible, and all samples were split and the specific conductance and pH analyzed within hours after collection. However, for stability considerations, the ferrous iron (Fe^{+2}) sample was filtered and preserved immediately on site.

Measurement of specific conductance and pH

by Denis R. LeBlanc and Thomas E. Reilly

At the nearby field laboratory, 60-mL polyethylene bottles for specific conductance and pH analyses were rinsed once with the sample from the 1-L bottles and filled. The pH sample bottle was overfilled so that there was no headspace. The samples were allowed to come to room temperature and were analyzed later the same day.

The specific conductance was measured with a HACH model 44600 conductivity meter. The probe was rinsed with the sample and inserted directly into the bottle to make the measurement. The specific conductance measurements for the pumped well are given in Appendix 3 and for multilevel samplers F453M1, F453M2, and F453M3 are given in Appendix 4a, 4b, and 4c, respectively.

The pH was measured with a Beckman model 011 meter and an Orion 81-72B pH probe. The pH probe was inserted directly into the sample bottle, and the millivolt reading was recorded after it stabilized (usually within 3 to 4 minutes). The millivolt readings were then converted to pH using a relation between millivolts and pH that had been determined with standards for each set of samples. The relation was obtained by linear regression of measurements of the millivolt readings of standard buffer solutions (pH 4 and 7) before and after each set of samples (each set usually consisted of all samples from a multilevel sampler at a given time of collection) against the known pH of the buffers. The pH measurements for the pumped well are given in Appendix 3 and for multilevel samplers F453M1, F453M2, and F453M3 are given in Appendix 4a, 4b, and 4c, respectively.

Chemical analysis of ferrous iron

by Kimberly W. Bussey and Douglas B. Kent

Samples for ferrous iron were collected and acidified on site. Within 5 minutes of the collection of the water sample in a 1-L bottle, about 40 to 50 mL of sample was filtered (0.45 μm filter) into a 60-mL bottle that had been rinsed with about 10 mL of filtered sample. To reduce the rate of oxidation of Fe^{+2}, samples were acidified with 100 μL of 6N hydrochloric acid (HCl). These samples were then analyzed within 2 weeks using spectrophotometric determination.

Samples were diluted with deionized water, to fall within a concentration range of 0 to 1 ppm, at a ratio of 1:50 into smaller vials. The total volume of solution was 10 mL. To each vial, 0.4 mL of Ferrozine reagent (1.5 mM) and 1 mL of buffer solution were added. The absorbance was determined at 562 nm wavelength in 1 cm cells. Standards were run before and after groups of about 8 to 14 samples. The absorbance measured was corrected for minor instrument drift and then converted to concentration by a linear regression that was determined from the standards run before and after each set. The ferrous iron concentrations are given in Appendix 5 and Appendix 6 for the pumped well and the multilevel samplers, respectively.

Chemical analysis of boron, calcium, iron, magnesium, manganese, phosphorus, potassium, sodium, and zinc

by Linda D. Anderson

The samples for the cation determinations were collected in 60 mL bottles and acidified. This entailed rinsing the bottle with sample from the 1-L bottle, rinsing the filter with the sample, filtering the sample (0.45 µm filter) into bottle, and then adding 100 µL HCL (6N trace-metal grade) to the sample. The samples were refrigerated and sent to the laboratory. The analyses were done using an Inductively Coupled Plasma Spectrophotometer (Thermal Jarrel Ash, ICAP-AES 61). Detection limits are listed in Appendix 7. Analytical precision for all the elements except sodium and potassium is less than 2 percent (2σ, relative standard deviation) except near the detection limit, where deviations increase to about 10 percent. Analytical precision for sodium is 10 percent and for potassium is 25 percent. The cation results for the water from the pumped well are given in Appendix 8. The results for multilevel samplers F453M1, F453M2, and F453M3 are given in Appendices 9a, 9b, and 9c, respectively.

Chemical analysis of nitrous oxide, ammonium, nitrate, and nitrite

by Myron H. Brooks

Nitrate, nitrite, ammonium, and nitrous oxide determinations were performed on all water samples. Water samples for nitrate, nitrite, and ammonium analyses were filtered (0.45 µm filter) from the 1-L bottle, and the filtrate was collected in 60-mL bottles. The water sample for nitrate and nitrite analysis was preserved by freezing, and the sample for ammonium analysis was preserved by addition of 200 µL of concentrated sulfuric acid. A sample for nitrous oxide analysis was collected in a 50-mL serum bottle capped with a butyl-rubber stopper. The bottle contained 330 µL of 12.5 N NaOH as a preservative. The water sample was collected by filling a 30-mL syringe using positive pressure supplied by the Keck or peristaltic pump, outfitting the syringe with a 22-gauge needle, adjusting the volume of the syringe to 25 mL, and injecting the sample through the butyl-rubber stopper.

Nitrate, nitrite, and ammonium concentrations were measured by using automated colorimetric methods. Nitrate concentrations were measured by cadmium reduction followed by diazotization with sulfanilamide and coupling with N-(1-napthyl) ethylenediamine; nitrite concentrations were measured by the same technique without the cadmium reduction. Ammonium concentrations were measured by reaction with hypochlorous acid and salicylate in the presence of nitroferricyanide. Detection limits, precision, and accuracy for all three analytical techniques were estimated by Antweiler and others (in press). Nitrous oxide concentrations were measured by injecting headspace samples into a gas chromatograph equipped with an electron capture detector. The instrument was calibrated with standard gas mixtures, and aqueous concentrations were calculated on the basis of empirical solubility relations. Precision of this method was estimated from replicate analysis to be 0.33 µM. The nitrogen species concentrations in the water from the pumped well are given in Appendix 5, and from the multilevel samplers F453M1, F453M2, and F453M3, in Appendices 10a, 10b, and 10c, respectively.

Chemical analysis of chloride

by Raymond L. Van Hoven and Rosalynd A. Williams

The water samples for chloride analysis were obtained from the 1-L bottles. The samples were filtered (0.45 µm filter) into 60-mL bottles. The analyses were done by ion chromatography using a Dionex Series 4000i instrument with suppressed conductivity detection and an eluent degas module operating under standard conditions for inorganic-ion analysis. Calibration standards of 12.5, 25.0, and 50.0 mg/L were prepared by serial dilution of a 1,000 mg/L stock solution. Analytical precision under the selected operating conditions was evaluated by six replicate analyses of a 25 mg/L standard. The relative standard deviation was 0.5 percent. The estimated detection limit is 25 µg/L.

All samples were filtered through an in-line 0.2 µm Nuclepore polycarbonate filter during the injection. A calibration standard was run after every five samples to correct for any calibration drift. Chloride concentrations for the water from the pumped well are given in Appendix 5, and from the multilevel samplers F453M1, F453M2, and F453M3, in Appendix 11.

SUMMARY

An experiment was conducted on August 12, 1992, to examine the concentration of various chemical constituents during purging of a 2-inch well with a 39-ft-long screened interval. The purpose of the experiment was to examine the hypothesis that the distributions of hydraulic conductivity and chemical concentrations near a well affect the concentrations in water pumped from the well as it is purged. The data collected and the results of the chemical analysis of the water samples are presented in this data summary report.

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APPENDICES

Appendix 1. -- Construction information for well F453-63

Land-surface altitude, in feet above sea level: 67.45 ft
MP (Measuring Point) height: 1.50 ft
MP altitude: 68.95 ft

Well has four lengths of 0.010-inch-slotted screen that are nominal 2-inch ID PVC pipe with flush-jointed threaded connections.

Screen Section No.	Depth below land surface, in ft		Depth below MP, in ft		Altitude, in ft	
	Top	Bottom	Top	Bottom	Top	Bottom
1	23.78	32.78	25.28	34.28	43.67	34.67
2	33.82	42.79	35.32	44.29	33.63	24.66
3	43.83	52.80	45.33	54.30	23.62	14.65
4	53.78	62.75	55.28	64.25	13.67	4.70

Appendix 2. Hydraulic conductivities along well F453-63 as estimated by the flowmeter method

Interval Altitude, in ft			Hydraulic Conductivity	Interval Altitude, in ft			Hydraulic Conductivity
Top	Bottom	Middle	in ft/d	Top	Bottom	Middle	in ft/d
43.57	42.45	43.0	293	23.46	22.97	23.2	413
42.45	41.96	42.2	518	22.97	22.44	22.7	413
41.96	41.44	41.7	969	22.44	21.95	22.2	305
41.44	40.94	41.2	754	21.95	21.46	21.7	345
40.94	40.45	40.7	257	21.46	20.96	21.2	181
40.45	39.96	40.2	261	20.96	20.44	20.7	279
39.96	39.44	39.7	215	20.44	19.95	20.2	500
39.44	38.94	39.2	180	19.95	19.46	19.7	372
38.94	38.45	38.7	304	19.46	18.96	19.2	471
38.45	37.96	38.2	287	18.96	18.44	18.7	360
37.96	37.47	37.7	137	18.44	17.95	18.2	97.0
37.47	36.94	37.2	251	17.95	17.45	17.7	78.1
36.94	36.45	36.7	111	17.45	16.96	17.2	208
36.45	35.96	36.2	89.8	16.96	16.44	16.7	145
35.96	35.47	35.7	90.6	16.44	15.94	16.2	151
35.47	34.94	35.2	340	15.94	15.45	15.7	159
34.94	34.45	34.7	177	15.45	14.96	15.2	177
33.46	32.94	33.2	256	14.96	14.44	14.7	258
32.94	32.45	32.7	625	13.45	12.96	13.2	370
32.45	31.95	32.2	399	12.96	12.43	12.7	159
31.95	31.46	31.7	360	12.43	11.94	12.2	234
31.46	30.94	31.2	192	11.94	11.45	11.7	282
30.94	30.45	30.7	219	11.45	10.96	11.2	257
30.45	29.95	30.2	200	10.96	10.47	10.7	358
29.95	29.46	29.7	221	10.47	9.94	10.2	488
29.46	28.94	29.2	236	9.94	9.45	9.7	282
28.94	28.44	28.7	267	9.45	8.96	9.2	287
28.44	27.95	28.2	329	8.96	8.46	8.7	298
27.95	27.46	27.7	297	8.46	7.94	8.2	244
27.46	26.94	27.2	353	7.94	7.45	7.7	162
26.94	26.44	26.7	491	7.45	6.96	7.2	134
26.44	25.95	26.2	326	6.96	6.46	6.7	118
25.95	25.46	25.7	239	6.46	5.94	6.2	193
25.46	24.93	25.2	321	5.94	5.45	5.7	191
24.93	24.44	24.7	387	5.45	5.02	5.2	208

Appendix 3. -- Change in pH and specific conductance over time in water from well F453-63, August 12,1992

Time	pH	Specific Conductance (μS/cm)
1035	6.22	329
1040	6.32	330
1050	6.33	337
1100	6.33	332
1110	6.31	331
1120	6.32	331
1130	6.32	331
1140	6.31	331
1150	6.31	330
1200	6.30	329
1210	6.30	329
1220	6.30	330
1230	6.29	333
1245	6.29	330
1300	6.29	327
1315	6.26	328
1330	6.29	325
1345	6.29	329
1400	6.31	327
1415	6.27	326
1430	6.29	327
1445	6.29	327
1500	6.29	330
1515	6.30	327
1530	6.25	328

Appendix 4a. Measurements of pH and specific conductance in water from multilevel sampler F453M1.

F453M1 Port Altitude, in ft	pH		Specific conductance (µS/cm)	
	Before Test	After Test	Before Test	After Test
44.90	ns[a]	ns	ns	ns
42.90	5.67	5.78	125	128
39.60	5.76	5.99	342	350
36.30	5.95	6.15	383	386
33.00	5.98	6.21	410	409
29.70	6.05	6.33	409	410
26.40	5.84	6.02	406	406
23.10	6.08	6.31	364	365
19.80	5.68	5.95	307	306
16.50	6.44	6.58	348	345
13.20	6.52	6.64	357	354
9.90	6.49	6.61	342	330
6.60	6.52	6.62	338	336
3.30	6.50	6.56	311	310
0.00	6.47	6.49	322	324

a. not sampled

Appendix 4b. Measurements of pH and specific conductance in water from multilevel sampler F453M2.

F453M2 Port Altitude, in ft	pH			Specific Conductance (µS/cm)		
	Before Test	During Test	After Test	Before Test	During Test	After Test
45.08	ns[a]	ns	ns	ns	ns	ns
43.08	6.01	5.66	5.85	87	90	92
39.78	5.78	5.77	5.72	310	319	323
36.50	5.91	5.91	5.83	393	393	395
33.20	5.97	5.97	5.86	422	423	425
29.90	6.04	6.07	5.88	412	414	415
26.59	5.67	5.69	5.60	408	408	410
23.29	6.16	6.17	6.00	371	370	371
19.99	5.80	5.81	5.80	306	305	308
16.50	6.43	6.46	6.24	337	351	348
13.20	6.51	6.52	6.29	344	357	350
9.90	6.47	6.48	6.20	327	339	330
6.60	6.51	6.52	6.12	331	337	334
3.30	6.47	6.46	6.15	309	318	317
0.00	6.45	6.46	6.01	322	329	330

a. not sampled

Appendix 4c. Measurements of pH and specific conductance in water from multilevel sampler F453M3.

F453M3 Port Altitude, in ft	pH		Specific Conductance (µS/cm)	
	Before Test	After Test	Before Test	After Test
47.72	ns[a]	ns	ns	ns
44.42	ns	ns	ns	ns
41.12	5.87	5.65	248	251
37.74	5.95	5.75	402	406
34.44	6.00	5.86	409	410
31.14	6.05	5.91	427	428
27.82	6.17	6.00	370	371
24.52	5.62	5.58	328	327
21.22	5.90	5.79	282	283
17.92	6.44	6.24	343	354
14.62	6.49	6.28	341	349
11.32	6.43	6.25	322	340
8.02	6.44	6.25	322	330
4.72	6.45	6.26	314	322
1.42	6.44	6.23	338	346

a. not sampled

Appendix 5. -- Concentrations of chloride, ferrous iron and nitrogen species over time in the water from well F453-63.

Time	Chloride (mg/L)	Nitrous Oxide (μM)	Ammonium (μg/L-N)	Nitrite (mg/L-N)	Nitrate (mg/L-N)	Ferrous Iron (mg/L)
1035	37.5	5.0	370	0.01	3.16	2.8
1040	37.3	4.2	460	0.02	2.27	8.0
1050	36.7	5.1	420	0.06	3.08	8.4
1100	36.5	5.1	400	0.08	3.69	7.9
1110	36.4	5.6	600	0.09	3.92	7.9
1120	36.1	5.3	510	0.09	2.82	7.6
1130	36.8	5.4	490	0.10	4.31	7.9
1140	36.1	5.5	490	0.10	4.35	7.4
1150	35.8	5.2	370	0.10	4.66	7.3
1200	36.1	6.0	370	0.10	4.73	8.1
1210	35.9	5.4	520	0.10	5.12	7.0
1220	35.8	5.4	360	0.10	5.02	7.0
1230	36.2	5.6	380	0.12	4.38	7.0
1245	36.0	5.8	360	0.10	4.98	7.0
1300	35.5	5.5	530	0.10	5.08	6.8
1315	35.7	5.8	310	0.11	4.67	6.2
1330	35.2	5.5	470	0.10	5.00	6.0
1345	35.4	5.1	430	0.11	4.94	6.1
1400	35.5	5.3	440	0.10	4.97	6.4
1415	35.2	5.3	310	0.10	5.04	6.3
1430	35.3	5.5	320	0.11	4.74	6.0
1445	35.4	5.0	330	0.10	4.82	6.2
1500	35.4	5.7	310	0.11	4.93	5.8
1515	35.0	5.1	350	0.10	5.11	6.2
1530	35.3	5.7	na[a]	na	na	5.4

[a] not analyzed

Appendix 6. Ferrous iron concentrations in water from multilevel samplers.

F453M1 Port Altitude, in ft	Ferrous Iron (mg/L)		F453M2 Port Altitude, in ft	Ferrous Iron (mg/L)			F453M3 Port Altitude, in ft	Ferrous Iron (mg/L)	
	Before Test	After Test		Before Test	During Test	After Test		Before Test	After Test
44.90	ns[a]	ns	45.08	ns	ns	ns	47.72	ns	ns
42.90	0.0	0.0	43.08	0.0	0.0	0.0	44.42	ns	ns
39.60	0.0	0.0	39.78	0.0	0.0	0.0	41.12	0.0	0.0
36.30	0.0	0.0	36.50	0.0	0.0	0.0	37.74	0.0	0.0
33.00	0.0	0.0	33.20	0.0	0.0	0.0	34.44	0.0	0.0
29.70	0.0	0.0	29.90	0.0	0.0	0.0	31.14	0.0	0.0
26.40	0.0	0.0	26.59	0.0	0.0	0.0	27.82	0.0	0.0
23.10	0.0	0.0	23.29	0.0	0.0	0.0	24.52	0.0	0.0
19.80	0.0	0.0	19.99	0.0	0.0	0.0	21.22	0.0	0.0
16.50	15.5	15.9	16.50	16.3	16.7	17.4	17.92	11.4	14.8
13.20	14.4	15.3	13.20	14.6	14.9	15.1	14.62	12.9	15.5
9.90	17.6	17.9	9.90	16.4	17.2	17.9	11.32	12.7	16.3
6.60	15.4	16.4	6.60	17.2	17.5	18.6	8.02	13.7	17.6
3.30	17.0	17.7	3.30	17.2	17.7	18.8	4.72	12.5	16.5
0.00	19.5	20.5	0.00	20.5	20.9	20.6	1.42	15.4	21.0

a. not sampled

Appendix 7. Detection limits for cation analyses.

Element	Detection limit (mg/L)
Boron	0.01
Calcium	0.01
Iron	0.01
Magnesium	0.04
Manganese	0.01
Phosphorus	0.1
Potassium	0.4
Sodium	0.1
Zinc	0.01

Appendix 8. -- Cation concentrations in milligrams per liter over time in water from well F453-63.

Time	Boron	Calcium	Iron	Potassium	Magnesium	Manganese	Sodium	Zinc	Phosphorous
1035	0.38	7.63	2.32	8.	2.3	0.28	43.	bd[a]	0.3
1040	0.37	7.12	6.48	8.	2.2	0.25	42.	bd	1.2
1050	0.35	7.64	7.18	7.	2.4	0.26	41.	bd	1.5
1100	0.34	7.84	7.46	8.	2.5	0.26	41.	bd	1.6
1110	0.34	8.04	7.32	8.	2.6	0.27	41.	bd	1.6
1120	0.34	8.11	7.31	8.	2.6	0.27	41.	bd	1.6
1130	0.34	8.04	7.04	8.	2.6	0.27	40.	bd	1.6
1140	0.34	8.08	6.84	8.	2.6	0.27	40.	bd	1.5
1150	0.34	8.24	6.97	8.	2.6	0.27	42.	bd	1.5
1200	0.34	8.21	6.87	8.	2.6	0.27	41.	bd	1.6
1210	0.34	8.28	6.73	8.	2.6	0.27	40.	bd	1.5
1220	0.34	8.36	7.11	8.	2.7	0.28	42.	bd	1.6
1245	0.36	7.68	7.35	7.	2.4	0.26	41.	bd	1.5
1300	0.34	8.44	6.71	8.	2.7	0.27	39.	bd	1.6
1315	0.34	8.73	6.07	8.	2.8	0.28	39.	bd	1.4
1330	0.33	8.51	6.39	8.	2.7	0.27	39.	bd	1.5
1345	0.33	8.87	6.09	8.	2.8	0.28	39.	bd	1.4
1400	0.34	8.59	6.24	8.	2.7	0.28	38.	bd	1.5
1415	0.34	8.66	6.36	8.	2.7	0.28	39.	bd	1.5
1430	0.34	8.95	6.08	8.	2.8	0.28	39.	bd	1.5
1445	0.34	8.80	6.36	8.	2.8	0.28	38.	bd	1.6
1500	0.34	9.12	6.17	8.	2.9	0.29	41.	bd	1.5
1515	0.33	8.88	6.33	8.	2.8	0.28	39.	bd	1.6
1530	0.34	9.00	5.81	8.	2.8	0.28	39.	0.01	1.5

a. below detection limit

Appendix 9a. Concentrations of cations in water from multilevel sampler F453M1.

F453M1 Port Altitude, in ft	Boron (mg/L)		Calcium (mg/L)		Iron (mg/L)		Potassium (mg/L)		Magnesium (mg/L)	
	Before Test	After Test	Before Test	After Test	Before Test	After Test	Before Test	After Test	Before Test	After Test
44.90	ns[a]	ns	ns	ns	ns	ns	ns	ns	ns	ns
42.90	bd[b]	0.08	4.09	3.98	0.03	0.01	3.	2.	2.0	1.8
39.60	0.14	0.31	16.3	15.8	0.03	0.01	9.	8.	4.9	4.5
36.30	0.16	0.34	18.0	17.2	0.03	0.02	10.	8.	5.5	5.0
33.00	0.17	0.35	19.3	18.2	0.03	0.01	11.	9.	6.5	5.9
29.70	0.19	0.35	17.5	16.4	0.02	0.01	12.	10.	6.9	6.4
26.40	0.23	0.40	11.9	11.7	0.03	0.01	22.	19.	4.1	3.8
23.10	0.21	0.38	12.7	12.4	0.04	0.09	14.	11.	4.5	4.2
19.80	0.21	0.36	3.08	3.00	0.10	0.06	13.	10.	0.9	0.8
16.50	0.19	0.36	7.00	7.03	13.0	13.5	7.	6.	2.0	1.9
13.20	0.20	0.37	6.46	6.47	12.0	12.7	6.	5.	2.0	1.9
9.90	0.20	0.36	7.66	7.46	12.9	13.7	7.	5.	2.2	2.1
6.60	0.19	0.36	6.75	6.83	9.12	10.7	10.	7.	2.4	2.2
3.30	0.16	0.33	6.21	6.19	13.1	13.8	6.	5.	2.4	2.2
0.00	0.15	0.32	6.99	6.93	15.1	15.5	5.	4.	2.0	1.9

a. not sampled
b. below detection limit

Appendix 9a. Concentrations of cations in water from multilevel sampler F453M1 (continued).

F453M1 Port Altitude, in ft	Manganese (mg/L)		Sodium (mg/L)		Zinc (mg/L)		Phosphorous (mg/L)	
	Before Test	After Test	Before Test	After Test	Before Test	After Test	Before Test	After Test
44.90	ns	ns	ns	ns	ns	ns	ns	ns
42.90	0.03	0.03	13.	13.	bd	0.01	0.2	0.1
39.60	0.46	0.43	34.	35.	bd	bd	1.6	1.6
36.30	0.51	0.47	37.	40.	bd	bd	0.5	0.5
33.00	0.55	0.50	40.	41.	bd	bd	0.3	0.3
29.70	0.41	0.37	41.	45.	bd	bd	0.1	0.1
26.40	0.56	0.53	44.	46.	0.01	bd	bd	bd
23.10	0.38	0.35	40.	43.	0.01	bd	bd	bd
19.80	0.17	0.16	44.	44.	bd	bd	bd	bd
16.50	0.26	0.25	46.	47.	0.01	bd	3.0	3.1
13.20	0.26	0.24	50.	52.	0.01	bd	3.4	3.5
9.90	0.27	0.25	44.	44.	0.01	bd	2.2	2.6
6.60	0.24	0.23	45.	44.	0.01	bd	1.5	2.0
3.30	0.24	0.22	40.	41.	0.03	bd	2.3	2.6
0.00	0.31	0.29	41.	41.	0.02	bd	1.5	1.6

Appendix 9b. Concentrations of cations in water from multilevel sampler F453M2.

F453M2 Port Altitude, in ft	Boron (mg/L)			Calcium (mg/L)			Iron (mg/L)		
	Before Test	During test	After Test	Before Test	During test	After Test	Before Test	During test	After Test
45.08	ns[a]	ns	ns	ns	ns	ns	ns	ns	ns
43.08	bd[b]	0.03	0.04	2.10	2.09	2.17	0.01	bd	bd
39.78	0.12	0.30	0.29	14.4	13.9	14.1	0.02	bd	bd
36.50	0.17	0.32	0.33	19.1	18.0	18.6	0.04	bd	0.02
33.20	0.17	0.34	0.34	19.8	18.8	19.2	0.03	0.02	0.01
29.90	0.18	0.35	0.34	17.2	16.1	16.6	0.03	bd	0.02
26.59	0.25	0.41	0.40	11.4	10.7	11.0	0.05	0.05	0.01
23.29	0.22	0.36	0.37	13.6	12.7	13.1	0.04	0.06	0.02
19.99	0.21	0.37	0.36	3.70	3.70	3.91	0.08	0.00	0.01
16.50	0.21	0.36	0.36	7.10	6.87	6.96	11.0	12.8	12.2
13.20	0.18	0.37	0.38	7.29	6.09	6.33	13.7	11.1	11.4
9.90	0.21	0.36	0.35	6.44	6.94	7.22	11.7	13.8	14.3
6.60	0.18	0.36	0.34	7.45	7.13	7.41	9.18	10.6	14.5
3.30	0.15	0.34	0.33	7.41	6.05	6.22	15.7	14.0	12.8
0.00	ns	0.32	0.32	ns	6.94	7.15	ns	15.1	16.7

a. not sampled

b. below detection limit

Appendix 9b. Concentrations of cations in water from multilevel sampler F453M2 (continued).

F453M2 Port Altitude, in ft	Potassium (mg/L)			Magnesium (mg/L)			Manganese (mg/L)		
	Before Test	During test	After Test	Before Test	During test	After Test	Before Test	During test	After Test
45.08	ns	ns	ns	ns	ns	ns	ns	ns	ns
43.08	2.	1.	1.	1.6	1.5	1.6	0.02	0.02	0.02
39.78	9.	7.	7.	4.3	4.0	4.1	0.39	0.38	0.37
36.50	10.	8.	8.	5.7	5.1	5.3	0.51	0.48	0.48
33.20	11.	9.	9.	6.8	6.3	6.4	0.54	0.51	0.50
29.90	11.	10.	10.	6.8	6.3	6.4	0.39	0.37	0.36
26.59	23.	20.	18.	3.6	3.3	3.4	0.62	0.57	0.56
23.29	12.	11.	10.	5.6	5.1	5.3	0.32	0.29	0.29
19.99	11.	9.	9.	1.1	1.0	1.1	0.19	0.18	0.18
16.50	6.	6.	5.	2.0	1.8	1.9	0.28	0.24	0.23
13.20	7.	6.	6.	2.3	1.8	1.8	0.26	0.24	0.24
9.90	7.	6.	5.	1.9	2.1	2.2	0.26	0.24	0.23
6.60	9.	8.	8.	2.8	2.5	2.6	0.25	0.23	0.24
3.30	5.	4.	4.	1.7	2.0	2.0	0.36	0.24	0.23
0.00	ns	4.	4.	ns	1.5	1.6	ns	0.33	0.33

Appendix 9b. Concentrations of cations in water from multilevel sampler F453M2 (continued).

F453M2 Port Altitude, in ft	Sodium (mg/L)			Zinc (mg/L)			Phosphorous (mg/L)		
	Before Test	During test	After Test	Before Test	During test	After Test	Before Test	During test	After Test
45.08	ns	ns	ns	ns	ns	ns	ns	ns	ns
43.08	8.7	9.3	9.9	0.01	bd	bd	bd	bd	bd
39.78	31.	32.	33.	0.02	0.02	0.02	1.5	1.5	1.5
36.50	38.	38.	40.	bd	bd	bd	0.7	0.6	0.7
33.20	39.	42.	42.	bd	bd	bd	0.2	0.2	0.2
29.90	40.	44.	43.	bd	bd	bd	0.1	0.1	0.1
26.59	42.	45.	46.	bd	bd	bd	bd	0.1	bd
23.29	39.	41.	42.	bd	bd	bd	bd	bd	bd
19.99	44.	47.	46.	bd	bd	bd	bd	bd	bd
16.50	44.	45.	47.	0.01	0.01	0.01	1.8	2.5	2.2
13.20	42.	50.	51.	bd	bd	bd	2.8	3.0	3.1
9.90	48.	43.	45.	bd	bd	0.01	3.1	3.0	3.0
6.60	40.	40.	43.	bd	bd	0.02	0.9	1.4	2.6
3.30	39.	41.	44.	bd	bd	0.01	1.5	2.5	2.1
0.00	ns	40.	45.	ns	bd	0.01	ns	1.3	1.7

Appendix 9c. Concentrations of cations in water from multilevel sampler F453M3.

F453M3 Port Altitude, in ft	Boron (mg/L)		Calcium (mg/L)		Iron (mg/L)		Potassium (mg/L)		Magnesium (mg/L)	
	Before Test	After Test	Before Test	After Test	Before Test	After Test	Before Test	After Test	Before Test	After Test
47.72	ns[a]	ns	ns	ns	ns	ns	ns	ns	ns	ns
44.42	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
41.12	0.23	0.22	9.70	9.73	bd[b]	bd	5.	6.	2.9	3.0
37.74	0.34	0.33	18.0	18.1	bd	0.03	9.	9.	5.9	6.0
34.44	0.35	0.34	17.5	17.8	bd	0.02	10.	9.	6.2	6.2
31.14	0.40	0.39	17.6	17.8	bd	0.03	11.	10.	6.2	6.2
27.82	0.38	0.38	11.5	11.8	bd	0.01	11.	10.	5.7	5.9
24.52	0.38	0.37	6.56	6.80	0.03	0.07	9.	9.	1.8	1.9
21.22	0.38	0.37	1.15	1.23	0.36	0.53	12.	11.	0.29	0.29
17.92	0.38	0.37	5.84	6.04	4.78	8.38	5.	5.	1.7	1.7
14.62	0.40	0.40	6.30	6.52	7.51	9.22	5.	5.	2.0	2.0
11.32	0.36	0.37	6.55	6.78	10.7	11.2	6.	6.	2.1	2.1
8.02	0.34	0.34	6.89	7.11	11.4	12.9	5.	5.	2.1	2.1
4.72	0.35	0.34	5.55	5.77	7.74	11.3	4.	4.	1.8	1.8
1.42	0.33	0.32	6.97	7.23	12.9	16.4	4.	4.	1.7	1.7

a. not sampled
b. below detection limit

Appendix 9c. Concentrations of cations in water from multilevel sampler F453M3 (continued).

F453M3 Port Altitude, in ft	Manganese (mg/L)		Sodium (mg/L)		Zinc (mg/L)		Phosphorous (mg/L)	
	Before Test	After Test	Before Test	After Test	Before Test	After Test	Before Test	After Test
47.72	ns	ns	ns	ns	ns	ns	ns	ns
44.42	ns	ns	ns	ns	ns	ns	ns	ns
41.12	0.08	0.07	27.	29.	0.06	0.03	0.9	0.9
37.74	0.56	0.54	41.	42.	bd	bd	0.3	0.4
34.44	0.41	0.38	41.	41.	bd	bd	0.2	0.2
31.14	0.52	0.50	45.	45.	bd	bd	bd	bd
27.82	0.27	0.26	42.	41.	bd	bd	bd	bd
24.52	0.35	0.35	44.	45.	bd	bd	bd	bd
21.22	0.06	0.06	42.	43.	bd	bd	bd	bd
17.92	0.20	0.20	50.	53.	bd	bd	0.9	2.0
14.62	0.23	0.23	50.	51.	bd	bd	1.5	2.1
11.32	0.24	0.23	43.	45.	bd	bd	2.1	2.2
8.02	0.26	0.26	41.	41.	bd	bd	1.6	2.1
4.72	0.22	0.22	44.	46.	bd	bd	0.6	1.6
1.42	0.33	0.33	43.	45.	bd	bd	0.6	1.6

Appendix 10a. Concentrations of Nitrous Oxide, Ammonium, Nitrite, and Nitrate in water from multilevel sampler F453M1.

F453M1 Port Altitude, in ft	Nitrous Oxide (μM)		Ammonium (μg/L-N)		Nitrite (mg/L-N)		Nitrate (mg/L-N)	
	Before Test	After Test	Before Test	After Test	Before Test	After Test	Before Test	After Test
44.90	ns[a]	ns	ns	ns	ns	ns	ns	ns
42.90	0.17	0.20	bd[b]	bd	bd	bd	3.47	3.34
39.60	4.8	4.7	bd	bd	bd	bd	14.96	15.61
36.30	8.8	9.0	bd	bd	0.19	0.18	18.45	16.80
33.00	7.2	7.4	bd	bd	0.32	0.33	18.06	15.89
29.70	4.0	3.6	bd	bd	0.40	0.39	15.94	15.73
26.40	25.	25.	bd	bd	0.47	0.46	15.28	14.04
23.10	20.	24.	bd	bd	0.51	0.54	8.03	7.65
19.80	0.17	0.20	bd	bd	bd	bd	4.14	3.52
16.50	0.08	bd	650.	700.	bd	bd	bd	0.09
13.20	0.08	bd	790.	850.	bd	bd	bd	bd
9.90	bd	bd	640.	670.	bd	bd	bd	bd
6.60	bd	bd	1700.	1700.	bd	bd	bd	bd
3.30	bd	bd	1100.	900.	bd	bd	bd	bd
0.00	bd	0.06	1100.	1100.	bd	bd	bd	bd

a. not sampled

b. below detection limit

Appendix 10b. Concentrations of Nitrous Oxide, Ammonium, Nitrite, and Nitrate in water from multilevel sampler F453M2.

F453M2 Port Altitude, in ft	Nitrous Oxide (µM)			Ammonium (µg/L-N)			Nitrite (mg/L-N)			Nitrate (mg/L-N)		
	Before Test	During Test	After Test	Before Test	During Test	After Test	Before Test	During Test	After Test	Before Test	During Test	After Test
45.08	ns[a]	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
43.08	0.21	0.13	0.21	bd[b]	bd	bd	0.03	0.02	bd	0.93	1.20	1.39
39.78	3.0	2.6	2.6	bd	bd	bd	0.03	0.02	bd	12.8	13.5	11.8
36.50	7.2	7.7	7.4	bd	bd	bd	0.20	0.20	0.18	19.1	18.9	18.5
33.20	6.0	5.9	5.9	bd	bd	bd	0.37	0.36	0.34	16.9	18.9	16.2
29.90	0.60	0.67	0.74	bd	bd	bd	0.47	0.46	0.43	17.7	17.7	17.1
26.59	26.	24.	25.	bd	bd	bd	0.52	0.51	0.49	16.1	14.9	14.0
23.29	20.	20.	20.	bd	bd	bd	0.65	0.64	0.63	8.19	7.97	7.05
19.99	1.5	2.4	2.8	bd	bd	bd	0.06	0.05	0.04	4.05	3.92	3.46
16.50	bd	bd	bd	690.	760.	860.	bd	bd	bd	bd	bd	bd
13.20	bd	0.06	0.06	770.	720.	720.	bd	bd	bd	bd	bd	bd
9.90	bd	bd	0.06	630.	600.	710.	bd	bd	bd	bd	bd	bd
6.60	bd	0.08	bd	1400.	1300.	1300.	bd	bd	bd	bd	bd	bd
3.30	bd	0.03	bd	770.	710.	730.	bd	bd	bd	bd	bd	bd
0.00	bd	bd	0.07	1100.	1100.	1200.	bd	bd	bd	bd	bd	bd

[a] not sampled
[b] below detection limit

Appendix 10c. Concentrations of Nitrous Oxide, Ammonium, Nitrite, and Nitrate in water from multilevel sampler F453M3.

F453M3 Port Altitude, in ft	Nitrous Oxide (µM)		Ammonium (µg/L-N)		Nitrite (mg/L-N)		Nitrate (mg/L-N)	
	Before Test	After Test	Before Test	After Test	Before Test	After Test	Before Test	After Test
47.72	ns[a]	ns	ns	ns	ns	ns	ns	ns
44.42	ns	ns	ns	ns	ns	ns	ns	ns
41.12	0.80	0.77	bd[b]	bd	bd	bd	9.20	9.44
37.74	11.	14.	bd	bd	0.31	0.31	19.3	19.4
34.44	0.69	0.79	bd	bd	0.35	0.35	20.0	19.2
31.14	10.	10.	bd	bd	0.52	0.52	17.4	17.4
27.82	20.	21.	bd	bd	0.57	0.57	9.35	9.55
24.52	16.	16.	bd	bd	0.23	0.26	7.87	7.64
21.22	0.06	0.07	bd	bd	bd	bd	bd	bd
17.92	bd	0.05	650.	920.	bd	bd	bd	bd
14.62	bd	bd	680.	660.	bd	bd	bd	bd
11.32	bd	bd	950.	830.	bd	bd	bd	bd
8.02	bd	bd	1300.	1300.	bd	bd	bd	bd
4.72	0.05	0.03	960.	1100.	bd	bd	bd	bd
1.42	0.05	0.07	1400.	1400.	bd	bd	bd	bd

a. not sampled
b. below detection limit

Appendix 11. Chloride concentrations in water from multilevel samplers.

F453M1 Port Altitude, in ft	Chloride (mg/L)		F453M2 Port Altitude, in ft	Chloride (mg/L)			F453M3 Port Altitude, in ft	Chloride (mg/L)	
	Before Test	After Test		Before Test	During Test	After Test		Before Test	After Test
44.90	ns[a]	ns	45.08	ns	ns	ns	47.72	ns	ns
42.90	18.1	17.3	43.08	16.1	15.9	15.8	44.42	ns	ns
39.60	31.7	31.1	39.78	31.6	31.6	31.4	41.12	28.2	27.6
36.30	34.7	33.6	36.50	36.1	33.9	34.1	37.74	37.4	35.7
33.00	39.0	37.4	33.20	40.9	39.2	38.9	34.44	40.3	37.4
29.70	42.3	40.3	29.90	42.2	39.8	39.6	31.14	43.6	41.8
26.40	43.2	40.3	26.59	43.1	41.0	41.1	27.82	38.9	37.8
23.10	39.2	38.6	23.29	39.2	37.3	37.8	24.52	39.4	38.4
19.80	40.2	39.2	19.99	38.2	38.0	38.3	21.22	38.8	36.0
16.50	39.8	38.7	16.50	38.4	36.6	38.0	17.92	38.9	37.2
13.20	38.6	36.6	13.20	35.2	37.4	36.9	14.62	36.6	37.1
9.90	37.7	36.6	9.90	37.3	36.8	36.7	11.32	36.4	35.1
6.60	37.2	36.4	6.60	37.8	37.1	36.4	8.02	35.3	35.9
3.30	32.4	32.0	3.30	33.7	33.4	33.2	4.72	32.8	32.8
0.00	33.4	33.2	0.00	34.8	34.0	34.0	1.42	34.7	32.6

a. not sampled

*U.S. G.P.O.:1994-301-077:19