APPENDIX A4-A

TRANSIT RATE AND VOLUME GUIDELINES FOR ISOKINETIC SAMPLING

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The tables in Appendix A4-A apply to the first complete round-trip transit starting with an empty sampler container. **These tables are valid only if the sampler is emptied between verticals.**

Tables showing:

1. Isokinetic transit rates for a 1-liter bottle sampler with a
   a. 3/16-inch nozzle
   b. 1/4-inch nozzle
   c. 5/16-inch nozzle
2. Isokinetic transit rates for a 3-liter bottle sampler with a
   a. 1/4-inch nozzle
   b. 5/16-inch nozzle
3. a. Minimum volumes for isokinetic sampling with a bag sampler
   b. Isokinetic transit rates for a 3-liter bag sampler with a 1/4-inch nozzle
   c. Isokinetic transit rates for a 3-liter bag sampler with a 5/16-inch nozzle

The designations in the **RATE** column of these tables are defined as follows:

full The reeling or transit rate that fills the sampler to its maximum volume.

-10 tip The reeling or transit rate that will result in a volume in the sampler such that if the sampler nozzle is tipped 10 degrees down from the horizontal, no sample will spill from the nozzle.

fastest The reeling or transit rate that is the fastest rate to avoid compression problems in bottle samplers or to not exceed a transit rate that is more than 0.4 times the stream velocity for bag samplers.

The volume designations in these tables are defined as follows:

max vol. The volume that will be in the sampler when the "full" (see definition above) reeling rate or transit rate is used for the specified stream depth and velocity.

-10 vol. The volume that will be in the sampler when the "-10 tip" (see definition above) reeling or transit rate is used for the specified stream depths and velocity.

min vol. The volume that will be in the sampler when the "fastest" (see definition above) reeling or transit rate is used for the specified stream depth and velocity.

APPENDIX A4-A—Table 1a. Isokinetic transit rates for a 1-liter bottle sampler with a 3/16-inch nozzle

[Transit rates in feet per second; Depth is (water depth) - (unsampled zone); max, maximum; vol, volume; min, minimum; mL, milliliter; --, not applicable]

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)												Max. vol. -10 vol. min. vol.	Volume-min. vol. (mL)
		1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	6.00	7.00	8.00	9.00		
1	full	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.07	0.08	0.09	1,050	919
1	-10 tip	0.02	0.03	0.03	0.04	0.05	0.05	0.06	0.07	0.08	0.10	0.11	0.12	798	667
1	fastest	0.12	0.17	0.21	0.25	0.29	0.33	0.37	0.41	0.50	0.58	0.66	0.74	131	--
2	full	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10	0.12	0.14	0.17	0.19	1,050	807
2	-10 tip	0.04	0.05	0.07	0.08	0.10	0.11	0.12	0.14	0.16	0.19	0.22	0.25	798	555
2	fastest	0.13	0.18	0.22	0.27	0.31	0.36	0.40	0.45	0.54	0.63	0.72	0.81	243	--
3	full	0.05	0.06	0.08	0.09	0.11	0.12	0.14	0.16	0.19	0.22	0.25	0.28	1,050	711
3	-10 tip	0.06	0.08	0.10	0.12	0.14	0.16	0.18	0.20	0.25	0.29	0.33	0.37	798	459
3	fastest	0.14	0.19	0.24	0.29	0.34	0.38	0.43	0.48	0.58	0.67	0.77	0.87	339	--
4	full	0.06	0.08	0.10	0.12	0.14	0.17	0.19	0.21	0.25	0.29	0.33	0.37	1,050	628
4	-10 tip	0.08	0.11	0.14	0.16	0.19	0.22	0.25	0.27	0.33	0.38	0.44	0.49	798	376
4	fastest	0.15	0.21	0.26	0.31	0.36	0.41	0.46	0.51	0.62	0.72	0.82	0.93	423	--
5	full	0.08	0.10	0.13	0.16	0.18	0.21	0.23	0.26	0.31	0.36	0.41	0.47	1,050	555
5	-10 tip	0.10	0.14	0.17	0.20	0.24	0.27	0.31	0.34	0.41	0.48	0.54	0.61	798	303
5	fastest	0.16	0.22	0.27	0.33	0.38	0.44	0.49	0.55	0.66	0.77	0.88	0.99	496	--
6	full	0.09	0.12	0.16	0.19	0.22	0.25	0.28	0.31	0.37	0.43	0.50	0.56	1,050	490
6	-10 tip	0.12	0.16	0.20	0.25	0.29	0.33	0.37	0.41	0.49	0.57	0.65	0.74	798	238
6	fastest	0.17	0.23	0.29	0.35	0.41	0.47	0.52	0.58	0.70	0.81	0.93	1.05	561	--

APPENDIX A4-A—Table 1a. Isokinetic transit rates for a 1-liter bottle sampler with a 3/16-inch nozzle—*Continued*

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)												Max. vol. -10 vol. min. vol.	Volume-min. vol. (mL)
		1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	6.00	7.00	8.00	9.00		
7	full	0.11	0.14	0.18	0.22	0.25	0.29	0.33	0.36	0.43	0.51	0.58	0.65	1,050	432
7	-10 tip	0.14	0.19	0.24	0.29	0.33	0.38	0.43	0.48	0.57	0.67	0.76	0.86	798	180
7	fastest	0.18	0.25	0.31	0.37	0.43	0.49	0.55	0.62	0.74	0.86	0.99	1.11	618	--
8	full	0.12	0.17	0.21	0.25	0.29	0.33	0.37	0.41	0.50	0.58	0.66	0.75	1,050	380
8	-10 tip	0.16	0.22	0.27	0.33	0.38	0.44	0.49	0.54	0.65	0.76	0.87	0.98	798	129
8	fastest	0.19	0.26	0.32	0.39	0.45	0.52	0.58	0.65	0.78	0.91	1.04	1.17	670	--
10	full	0.16	0.21	0.26	0.31	0.36	0.41	0.47	0.52	0.62	0.72	0.83	0.93	1,050	292
10	-10 tip	0.20	0.27	0.34	0.41	0.48	0.54	0.61	0.68	0.82	0.95	1.09	1.23	798	40
10	fastest	0.22	0.29	0.36	0.43	0.50	0.57	0.65	0.72	0.86	1.00	1.15	1.29	759	--
12	full	0.19	0.25	0.31	0.37	0.43	0.50	0.56	0.62	0.75	0.87	0.99	1.12	1,050	218
12	-10 tip	--	--	--	--	--	--	--	--	--	--	--	--	--	--
12	fastest	0.24	0.31	0.39	0.47	0.55	0.63	0.71	0.78	0.94	1.10	1.25	1.41	832	--
14	full	0.22	0.29	0.36	0.43	0.51	0.58	0.65	0.72	0.87	1.01	1.16	1.30	1,050	156
14	-10 tip	--	--	--	--	--	--	--	--	--	--	--	--	--	--
14	fastest	0.26	0.34	0.43	0.51	0.60	0.68	0.77	0.85	1.02	1.19	1.36	1.53	894	--
15	full	0.23	0.31	0.39	0.47	0.54	0.62	0.70	0.78	0.93	1.09	1.24	1.40	1,050	129
15	-10 tip	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15	fastest	0.27	0.35	0.44	0.53	0.62	0.71	0.80	0.89	1.06	1.24	1.42	1.59	922	--

APPENDIX A4-A—Table 1b. Isokinetic transit rates for a 1-liter bottle sampler with a 1/4-inch nozzle

[Transit rates in feet per second; Depth is water depth - unsampled zone; max, maximum; vol, volume; min, minimum; mL, milliliter; --, not applicable]

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)												Max. vol. -10 vol. min. vol.	Volume-min. vol. (mL)
		1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	6.00	7.00	8.00	9.00		
1	full	0.03	0.04	0.05	0.06	0.06	0.07	0.08	0.09	0.11	0.13	0.15	0.17	1,050	918
1	-10 tip	0.04	0.05	0.06	0.07	0.08	0.10	0.11	0.12	0.15	0.17	0.19	0.22	798	667
1	fastest	0.22	0.29	0.37	0.44	0.51	0.59	0.66	0.73	0.88	1.03	1.17	1.32	132	--
2	full	0.06	0.07	0.09	0.11	0.13	0.15	0.17	0.18	0.22	0.26	0.29	0.33	1,050	806
2	-10 tip	0.07	0.10	0.12	0.15	0.17	0.19	0.22	0.24	0.29	0.34	0.39	0.44	798	555
2	fastest	0.24	0.32	0.40	0.48	0.56	0.63	0.71	0.79	0.95	1.11	1.27	1.43	243	--
3	full	0.08	0.11	0.14	0.17	0.19	0.22	0.25	0.28	0.33	0.39	0.44	0.50	1,050	710
3	-10 tip	0.11	0.15	0.18	0.22	0.25	0.29	0.33	0.36	0.44	0.51	0.58	0.65	798	458
3	fastest	0.26	0.34	0.43	0.51	0.60	0.68	0.77	0.85	1.02	1.19	1.36	1.54	340	--
4	full	0.11	0.15	0.18	0.22	0.26	0.29	0.33	0.37	0.44	0.52	0.59	0.66	1,050	626
4	-10 tip	0.15	0.19	0.24	0.29	0.34	0.39	0.44	0.48	0.58	0.68	0.77	0.87	798	375
4	fastest	0.27	0.36	0.46	0.55	0.64	0.73	0.82	0.91	1.09	1.28	1.46	1.64	423	--
5	full	0.14	0.18	0.23	0.28	0.32	0.37	0.41	0.46	0.55	0.64	0.74	0.83	1,050	553
5	-10 tip	0.18	0.24	0.30	0.36	0.42	0.48	0.54	0.61	0.73	0.85	0.97	1.09	798	301
5	fastest	0.29	0.39	0.49	0.58	0.68	0.78	0.87	0.97	1.17	1.36	1.55	1.75	497	--
6	full	0.17	0.22	0.28	0.33	0.39	0.44	0.50	0.55	0.66	0.77	0.88	0.99	1,050	488
6	-10 tip	0.22	0.29	0.36	0.44	0.51	0.58	0.65	0.73	0.87	1.02	1.16	1.31	798	236
6	fastest	0.31	0.41	0.52	0.62	0.72	0.82	0.93	1.03	1.24	1.44	1.65	1.86	562	--

APPENDIX A4-A—Table 1b. Isokinetic transit rates for a 1-liter bottle sampler with a 1/4-inch nozzle—*Continued*

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)												Max. vol. -10 vol. min. vol.	Volume-min. vol. (mL)
		1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	6.00	7.00	8.00	9.00		
7	full	0.19	0.26	0.32	0.39	0.45	0.52	0.58	0.64	0.77	0.90	1.03	1.16	1,050	430
7	-10 tip	0.25	0.34	0.42	0.51	0.59	0.68	0.76	0.85	1.02	1.19	1.36	1.52	798	178
7	fastest	0.33	0.44	0.55	0.65	0.76	0.87	0.98	1.09	1.31	1.53	1.74	1.96	620	--
8	full	0.22	0.29	0.37	0.44	0.52	0.59	0.66	0.74	0.88	1.03	1.18	1.32	1,050	378
8	-10 tip	0.29	0.39	0.48	0.58	0.68	0.77	0.87	0.97	1.16	1.36	1.55	1.74	798	126
8	fastest	0.34	0.46	0.57	0.69	0.80	0.92	1.03	1.15	1.38	1.61	1.84	2.07	672	--
10	full	0.28	0.37	0.46	0.55	0.64	0.74	0.83	0.92	1.10	1.29	1.47	1.66	1,050	288
10	-10 tip	0.36	0.48	0.61	0.73	0.85	0.97	1.09	1.21	1.45	1.69	1.94	2.18	798	37
10	fastest	0.38	0.51	0.63	0.76	0.89	1.01	1.14	1.27	1.52	1.78	2.03	2.28	761	--
12	full	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10	1.32	1.55	1.77	1.99	1,050	214
12	-10 tip	--	--	--	--	--	--	--	--	--	--	--	--	--	--
12	fastest	0.42	0.55	0.69	0.83	0.97	1.11	1.25	1.39	1.66	1.94	2.22	2.50	836	--
14	full	0.39	0.52	0.64	0.77	0.90	1.03	1.16	1.29	1.55	1.80	2.06	2.32	1,050	152
14	-10 tip	--	--	--	--	--	--	--	--	--	--	--	--	--	--
14	fastest	0.45	0.60	0.75	0.90	1.05	1.20	1.36	1.51	1.81	2.11	2.41	2.71	898	--
15	full	0.41	0.55	0.69	0.83	0.97	1.10	1.24	1.38	1.66	1.93	2.21	2.48	1,050	124
15	-10 tip	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15	fastest	0.47	0.63	0.78	0.94	1.10	1.25	1.41	1.57	1.88	2.19	2.50	2.82	926	--

APPENDIX A4-A—Table 1c. Isokinetic transit rates for a 1-liter bottle sampler with a 5/16-inch nozzle

[Transit rates in feet per second; Depth is water depth - unsampled zone; max, maximum; vol, volume; min, minimum; mL, milliliter; --, not applicable]

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)												Max. vol. -10 vol. min. vol.	Volume-min. vol. (mL)
		1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	6.00	7.00	8.00	9.00		
1	full	0.04	0.06	0.07	0.09	0.10	0.12	0.13	0.14	0.17	0.20	0.23	0.26	1,049	918
1	-10 tip	0.06	0.08	0.09	0.11	0.13	0.15	0.17	0.19	0.23	0.26	0.30	0.34	800	668
1	fastest	0.34	0.46	0.57	0.69	0.80	0.92	1.03	1.15	1.38	1.61	1.84	2.07	132	--
2	full	0.09	0.12	0.14	0.17	0.20	0.23	0.26	0.29	0.35	0.40	0.46	0.52	1,049	806
2	-10 tip	0.11	0.15	0.19	0.23	0.26	0.30	0.34	0.38	0.45	0.53	0.60	0.68	800	557
2	fastest	0.37	0.50	0.62	0.74	0.87	0.99	1.12	1.24	1.49	1.74	1.98	2.23	243	--
3	full	0.13	0.17	0.22	0.26	0.30	0.35	0.39	0.43	0.52	0.60	0.69	0.78	1,049	709
3	-10 tip	0.17	0.23	0.28	0.34	0.40	0.45	0.51	0.57	0.68	0.79	0.91	1.02	800	460
3	fastest	0.40	0.53	0.67	0.80	0.93	1.07	1.20	1.33	1.60	1.87	2.13	2.40	340	--
4	full	0.17	0.23	0.29	0.35	0.40	0.46	0.52	0.58	0.69	0.81	0.92	1.04	1,049	626
4	-10 tip	0.23	0.30	0.38	0.45	0.53	0.60	0.68	0.75	0.91	1.06	1.21	1.36	800	376
4	fastest	0.43	0.57	0.71	0.86	1.00	1.14	1.28	1.43	1.71	2.00	2.28	2.57	424	--
5	full	0.22	0.29	0.36	0.43	0.50	0.58	0.65	0.72	0.86	1.01	1.15	1.29	1,049	552
5	-10 tip	0.28	0.38	0.47	0.57	0.66	0.75	0.85	0.94	1.13	1.32	1.51	1.70	800	303
5	fastest	0.46	0.61	0.76	0.91	1.06	1.21	1.37	1.52	1.82	2.13	2.43	2.73	497	--
6	full	0.26	0.35	0.43	0.52	0.60	0.69	0.78	0.86	1.04	1.21	1.38	1.55	1,049	487
6	-10 tip	0.34	0.45	0.57	0.68	0.79	0.91	1.02	1.13	1.36	1.58	1.81	2.04	800	238
6	fastest	0.48	0.64	0.81	0.97	1.13	1.29	1.45	1.61	1.93	2.26	2.58	2.90	562	--

APPENDIX A4-A—Table 1c. Isokinetic transit rates for a 1-liter bottle sampler with a 5/16-inch nozzle—*Continued*

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)												Max. vol. -10 vol. min. vol.	Volume-min. vol. (mL)
		1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	6.00	7.00	8.00	9.00		
7	full	0.30	0.40	0.50	0.60	0.71	0.81	0.91	1.01	1.21	1.41	1.61	1.81	1,049	429
7	-10 tip	0.40	0.53	0.66	0.79	0.92	1.06	1.19	1.32	1.58	1.85	2.11	2.38	800	180
7	fastest	0.51	0.68	0.85	1.02	1.19	1.36	1.53	1.70	2.04	2.38	2.73	3.07	620	--
8	full	0.35	0.46	0.58	0.69	0.81	0.92	1.04	1.15	1.38	1.61	1.84	2.07	1,049	377
8	-10 tip	0.45	0.60	0.75	0.91	1.06	1.21	1.36	1.51	1.81	2.11	2.42	2.72	800	128
8	fastest	0.54	0.72	0.90	1.08	1.26	1.44	1.62	1.80	2.16	2.51	2.87	3.23	672	--
10	full	0.43	0.58	0.72	0.86	1.01	1.15	1.29	1.44	1.73	2.01	2.30	2.59	1,049	287
10	-10 tip	0.57	0.75	0.94	1.13	1.32	1.51	1.70	1.89	2.26	2.64	3.02	3.40	800	38
10	fastest	0.59	0.79	0.99	1.19	1.39	1.59	1.78	1.98	2.38	2.77	3.17	3.57	762	--
11	full	0.47	0.63	0.79	0.95	1.11	1.27	1.42	1.58	1.90	2.22	2.53	2.85	1,049	219
11	-10 tip	--	--	--	--	--	--	--	--	--	--	--	--	--	--
11	fastest	0.60	0.80	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	830	--
12	full	0.52	0.69	0.86	1.04	1.21	1.38	1.55	1.73	2.07	2.42	2.76	3.11	1,049	143
12	-10 tip	--	--	--	--	--	--	--	--	--	--	--	--	--	--
12	fastest	0.60	0.80	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	906	--
13	full	0.56	0.75	0.94	1.12	1.31	1.50	1.68	1.87	2.24	2.62	2.99	3.37	1,049	68
13	-10 tip	--	--	--	--	--	--	--	--	--	--	--	--	--	--
13	fastest	0.60	0.80	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	981	--

APPENDIX A4-A—Table 2a. Isokinetic transit rates for a 3-liter bottle sampler with a 1/4-inch nozzle

[Transit rates in feet per second; Depth is water depth - unsampled zone; max, maximum; vol, volume; min, minimum; mL, milliliter; --, not applicable]

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)												Max. vol. -10 vol. min. vol.	Volume-min. vol. (mL)
		1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	6.00	7.00	8.00	9.00		
2	full	0.02	0.03	0.03	0.04	0.05	0.05	0.06	0.07	0.08	0.10	0.11	0.12	2,832	2,120
2	-10 tip	0.02	0.03	0.04	0.05	0.06	0.06	0.07	0.08	0.09	0.11	0.13	0.14	2,457	1,745
2	fastest	0.08	0.11	0.14	0.16	0.19	0.22	0.24	0.27	0.33	0.38	0.43	0.49	712	--
3	full	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10	0.12	0.14	0.16	0.18	2,832	1,840
3	-10 tip	0.04	0.05	0.06	0.07	0.08	0.09	0.11	0.12	0.14	0.17	0.19	0.21	2,457	1,465
3	fastest	0.09	0.12	0.15	0.18	0.20	0.23	0.26	0.29	0.35	0.41	0.47	0.53	992	--
4	full	0.04	0.05	0.07	0.08	0.10	0.11	0.12	0.14	0.16	0.19	0.22	0.25	2,832	1,597
4	-10 tip	0.05	0.06	0.08	0.09	0.11	0.13	0.14	0.16	0.19	0.22	0.25	0.28	2,457	1,222
4	fastest	0.09	0.13	0.16	0.19	0.22	0.25	0.28	0.31	0.38	0.44	0.50	0.56	1,235	--
5	full	0.05	0.07	0.09	0.10	0.12	0.14	0.15	0.17	0.20	0.24	0.27	0.31	2,832	1,383
5	-10 tip	0.06	0.08	0.10	0.12	0.14	0.16	0.18	0.20	0.24	0.28	0.31	0.35	2,457	1,009
5	fastest	0.10	0.13	0.17	0.20	0.23	0.27	0.30	0.33	0.40	0.47	0.53	0.60	1,449	--
6	full	0.06	0.08	0.10	0.12	0.14	0.16	0.18	0.20	0.25	0.29	0.33	0.37	2,832	1,195
6	-10 tip	0.07	0.09	0.12	0.14	0.17	0.19	0.21	0.24	0.28	0.33	0.38	0.42	2,457	820
6	fastest	0.11	0.14	0.18	0.21	0.25	0.28	0.32	0.35	0.42	0.50	0.57	0.64	1,637	--
7	full	0.07	0.10	0.12	0.14	0.17	0.19	0.21	0.24	0.29	0.33	0.38	0.43	2,832	1,028
7	-10 tip	0.08	0.11	0.14	0.17	0.19	0.22	0.25	0.28	0.33	0.39	0.44	0.50	2,457	653
7	fastest	0.11	0.15	0.19	0.22	0.26	0.30	0.34	0.37	0.45	0.52	0.60	0.67	1,804	--

APPENDIX A4-A—Table 2a. Isokinetic transit rates for a 3-liter bottle sampler with a 1/4-inch nozzle—*Continued*

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)												Max. vol. -10 vol. min. vol.	Volume-min. vol. (mL)
		1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	6.00	7.00	8.00	9.00		
8	full	0.08	0.11	0.14	0.16	0.19	0.22	0.25	0.27	0.33	0.38	0.44	0.49	2,832	878
8	-10 tip	0.09	0.13	0.16	0.19	0.22	0.25	0.28	0.31	0.38	0.44	0.50	0.57	2,457	503
8	fastest	0.12	0.16	0.20	0.24	0.28	0.32	0.36	0.40	0.47	0.55	0.63	0.71	1,954	--
9	full	0.09	0.12	0.15	0.18	0.21	0.25	0.28	0.31	0.37	0.43	0.49	0.55	2,832	743
9	-10 tip	0.11	0.14	0.18	0.21	0.25	0.28	0.32	0.35	0.42	0.50	0.57	0.64	2,457	368
9	fastest	0.12	0.17	0.21	0.25	0.29	0.33	0.37	0.42	0.50	0.58	0.67	0.75	2,089	--
10	full	0.10	0.14	0.17	0.20	0.24	0.27	0.31	0.34	0.41	0.48	0.55	0.61	2,832	620
10	-10 tip	0.12	0.16	0.20	0.24	0.28	0.31	0.35	0.39	0.47	0.55	0.63	0.71	2,457	246
10	fastest	0.13	0.17	0.22	0.26	0.31	0.35	0.39	0.44	0.52	0.61	0.70	0.79	2,212	--
12	full	0.12	0.16	0.20	0.25	0.29	0.33	0.37	0.41	0.49	0.57	0.65	0.74	2,832	408
12	-10 tip	0.14	0.19	0.24	0.28	0.33	0.38	0.42	0.47	0.57	0.66	0.75	0.85	2,457	33
12	fastest	0.14	0.19	0.24	0.29	0.33	0.38	0.43	0.48	0.57	0.67	0.76	0.86	2,424	--
14	full	0.14	0.19	0.24	0.29	0.33	0.38	0.43	0.48	0.57	0.67	0.76	0.86	2,832	229
14	-10 tip	--	--	--	--	--	--	--	--	--	--	--	--	--	--
14	fastest	0.16	0.21	0.26	0.31	0.36	0.42	0.47	0.52	0.62	0.73	0.83	0.93	2,603	--
15	full	0.15	0.20	0.26	0.31	0.36	0.41	0.46	0.51	0.61	0.72	0.82	0.92	2,832	149
15	-10 tip	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15	fastest	0.16	0.22	0.27	0.32	0.38	0.43	0.49	0.54	0.65	0.76	0.86	0.97	2,683	--

APPENDIX A4-A—Table 2b. Isokinetic transit rates for a 3-liter bottle sampler with a 5/16-inch nozzle

[Transit rates in feet per second; Depth is water depth - unsampled zone; max, maximum; vol, volume; min, minimum; mL, milliliter; not applicable]

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)												Max. vol. -10 vol. min. vol.	Volume-min. vol. (mL)
		1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	6.00	7.00	8.00	9.00		
2	full	0.03	0.04	0.05	0.06	0.07	0.09	0.10	0.11	0.13	0.15	0.17	0.19	2,830	2,118
2	-10 tip	0.04	0.05	0.06	0.07	0.09	0.10	0.11	0.12	0.15	0.17	0.20	0.22	2,461	1,749
2	fastest	0.13	0.17	0.21	0.25	0.30	0.34	0.38	0.42	0.51	0.59	0.68	0.76	712	--
3	full	0.05	0.06	0.08	0.10	0.11	0.13	0.14	0.16	0.19	0.22	0.26	0.29	2,830	1,837
3	-10 tip	0.06	0.07	0.09	0.11	0.13	0.15	0.17	0.18	0.22	0.26	0.29	0.33	2,461	1,468
3	fastest	0.14	0.18	0.23	0.27	0.32	0.36	0.41	0.46	0.55	0.64	0.73	0.82	993	--
4	full	0.06	0.09	0.11	0.13	0.15	0.17	0.19	0.21	0.26	0.30	0.34	0.38	2,830	1,593
4	-10 tip	0.07	0.10	0.12	0.15	0.17	0.20	0.22	0.25	0.29	0.34	0.39	0.44	2,461	1,224
4	fastest	0.15	0.20	0.24	0.29	0.34	0.39	0.44	0.49	0.59	0.68	0.78	0.88	1,237	--
5	full	0.08	0.11	0.13	0.16	0.19	0.21	0.24	0.27	0.32	0.37	0.43	0.48	2,830	1,379
5	-10 tip	0.09	0.12	0.15	0.18	0.21	0.25	0.28	0.31	0.37	0.43	0.49	0.55	2,461	1,010
5	fastest	0.16	0.21	0.26	0.31	0.36	0.42	0.47	0.52	0.62	0.73	0.83	0.94	1,451	--
6	full	0.10	0.13	0.16	0.19	0.22	0.26	0.29	0.32	0.38	0.45	0.51	0.58	2,830	1,190
6	-10 tip	0.11	0.15	0.18	0.22	0.26	0.29	0.33	0.37	0.44	0.52	0.59	0.66	2,461	820
6	fastest	0.17	0.22	0.28	0.33	0.39	0.44	0.50	0.55	0.66	0.77	0.88	0.99	1,641	--
7	full	0.11	0.15	0.19	0.22	0.26	0.30	0.34	0.37	0.45	0.52	0.60	0.67	2,830	1,021
7	-10 tip	0.13	0.17	0.21	0.26	0.30	0.34	0.39	0.43	0.52	0.60	0.69	0.77	2,461	652
7	fastest	0.18	0.23	0.29	0.35	0.41	0.47	0.53	0.58	0.70	0.82	0.93	1.05	1,809	--

APPENDIX A4-A—Table 2b. Isokinetic transit rates for a 3-liter bottle sampler with a 5/16-inch nozzle—*Continued*

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)												Max. vol. -10 vol. min. vol.	Volume-min. vol. (mL)
		1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	6.00	7.00	8.00	9.00		
8	full	0.13	0.17	0.21	0.26	0.30	0.34	0.38	0.43	0.51	0.60	0.68	0.77	2,830	870
8	-10 tip	0.15	0.20	0.25	0.29	0.34	0.39	0.44	0.49	0.59	0.69	0.79	0.88	2,461	501
8	fastest	0.18	0.25	0.31	0.37	0.43	0.49	0.55	0.62	0.74	0.86	0.99	1.11	1,960	--
9	full	0.14	0.19	0.24	0.29	0.34	0.38	0.43	0.48	0.58	0.67	0.77	0.86	2,830	734
9	-10 tip	0.17	0.22	0.28	0.33	0.39	0.44	0.50	0.55	0.66	0.77	0.88	0.99	2,461	365
9	fastest	0.19	0.26	0.32	0.39	0.45	0.52	0.58	0.65	0.78	0.91	1.04	1.17	2,096	--
10	full	0.16	0.21	0.27	0.32	0.37	0.43	0.48	0.53	0.64	0.75	0.85	0.96	2,830	610
10	-10 tip	0.18	0.25	0.31	0.37	0.43	0.49	0.55	0.61	0.74	0.86	0.98	1.10	2,461	241
10	fastest	0.20	0.27	0.34	0.41	0.48	0.54	0.61	0.68	0.82	0.95	1.09	1.22	2,220	--
12	full	0.19	0.26	0.32	0.38	0.45	0.51	0.58	0.64	0.77	0.90	1.02	1.15	2,830	396
12	-10 tip	0.22	0.29	0.37	0.44	0.52	0.59	0.66	0.74	0.88	1.03	1.18	1.32	2,461	26
12	fastest	0.22	0.30	0.37	0.45	0.52	0.60	0.67	0.74	0.89	1.04	1.19	1.34	2,435	--
14	full	0.22	0.30	0.37	0.45	0.52	0.60	0.67	0.75	0.90	1.05	1.19	1.34	2,830	215
14	-10 tip	--	--	--	--	--	--	--	--	--	--	--	--	--	--
14	fastest	0.24	0.32	0.40	0.48	0.57	0.65	0.73	0.81	0.97	1.13	1.29	1.45	2,615	--
15	full	0.24	0.32	0.40	0.48	0.56	0.64	0.72	0.80	0.96	1.12	1.28	1.44	2,830	135
15	-10 tip	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15	fastest	0.25	0.34	0.42	0.50	0.59	0.67	0.76	0.84	1.01	1.18	1.34	1.51	2,695	--

APPENDIX A4-A—Table 3a. Minimum volumes for isokinetic sampling with a bag sampler

[The volumes listed below are the minimum volumes that must be collected in a bag sampler to have not exceeded 0.4 times the mean stream velocity. Generally, bag samplers must be operated in water warmer than 7 degrees Celsius and where the velocity is greater than 3 feet per second.]

Water depth minus unsampled zone, in feet	Minimum volume (in milliliters) for the nozzle diameter (inch) shown[1]		
	3/16 inch	1/4 inch	5/16 inch
1	27	48	75
2	54	96	151
3	81	145	226
4	109	193	301
5	136	241	377
6	163	289	452
7	190	338	528
8	217	386	603
9	244	434	678
10	271	483	754
11	298	531	829
12	326	579	904
13	353	627	980
14	380	675	1,055
15	407	724	1,131
20	543	965	1,507
25	678	1,206	1,884
30	814	1,447	2,262
35	950	1,688	2,638
40	1,085	1,930	3,015
45	1,221	2,171	3,392
50	1,357	2,412	3,769
55	1,492	2,653	4,146
60	1,629	2,894	4,524
65	1,764	3,136	4,899
70	1,899	3,377	5,276
75	2,035	3,618	5,653

APPENDIX A4-A—Table 3a. Minimum volumes for isokinetic sampling with a bag sampler— *Continued*

Water depth minus unsampled zone, in feet	Minimum volume (in milliliters) for the nozzle diameter (inch) shown [1]		
	3/16 inch	1/4 inch	5/16 inch
80	2,171	3,859	6,030
85	2,306	4,100	6,407
90	2,442	4,342	6,784
95	2,578	4,583	7,161
100	2,713	4,824	7,537
120	3,257	5,789	9,045
140	3,799	6,754	10,552
160	4,342	7,718	12,060
180	4,884	8,683	13,567
200	5,427	9,650	15,075

[1] Minimum volume = area of nozzle x time in water x mean stream velocity in vertical; minimum volume in milliliters = 15 x 3.14 x 2.54 cubed x nozzle diameter, in inches squared x depth, in feet.

APPENDIX A4-A—Table 3b. Isokinetic transit rates for a 3-liter bag sampler with a 1/4-inch nozzle

[Transit rates in feet per second; Depth is water depth - unsampled zone; max, maximum; vol, volume; min, minimum; mL, milliliter; --, not applicable]

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)												Max. vol. -10 vol. min. vol.	Volume-min. vol. (mL)
		2.50	3.00	3.50	4.00	4.50	5.00	6.00	7.00	8.00	9.00	10.00	12.00		
6	full	0.11	0.13	0.16	0.18	0.20	0.22	0.27	0.31	0.36	0.40	0.44	0.53	2,607	2,318
6	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	290	--
8	full	0.15	0.18	0.21	0.24	0.27	0.30	0.36	0.41	0.47	0.53	0.59	0.71	2,607	2,221
8	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	386	--
10	full	0.19	0.22	0.26	0.30	0.33	0.37	0.44	0.52	0.59	0.67	0.74	0.89	2,607	2,125
10	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	483	--
12	full	0.22	0.27	0.31	0.36	0.40	0.44	0.53	0.62	0.71	0.80	0.89	1.07	2,607	2,028
12	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	579	--
14	full	0.26	0.31	0.36	0.41	0.47	0.52	0.62	0.73	0.83	0.93	1.04	1.24	2,607	1,931
14	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	676	--
16	full	0.30	0.36	0.41	0.47	0.53	0.59	0.71	0.83	0.95	1.07	1.19	1.42	2,607	1,835
16	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	773	--
18	full	0.33	0.40	0.47	0.53	0.60	0.67	0.80	0.93	1.07	1.20	1.33	1.60	2,607	1,738
18	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	869	--
20	full	0.37	0.44	0.52	0.59	0.67	0.74	0.89	1.04	1.19	1.33	1.48	1.78	2,607	1,642
20	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	966	--
22	full	0.41	0.49	0.57	0.65	0.73	0.81	0.98	1.14	1.30	1.47	1.63	1.96	2,607	1,545
22	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	1,062	--

APPENDIX A4-A—Table 3b. Isokinetic transit rates for a 3-liter bag sampler with a 1/4-inch nozzle—*Continued*

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)												Max. vol. -10 vol. min. vol.	Volume-min. vol. (mL)
		2.50	3.00	3.50	4.00	4.50	5.00	6.00	7.00	8.00	9.00	10.00	12.00		
24	full	0.44	0.53	0.62	0.71	0.80	0.89	1.07	1.24	1.42	1.60	1.78	2.13	2,607	1,449
24	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	1,159	--
26	full	0.48	0.58	0.67	0.77	0.87	0.96	1.16	1.35	1.54	1.73	1.93	2.31	2,607	1,352
26	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	1,255	--
28	full	0.52	0.62	0.73	0.83	0.93	1.04	1.24	1.45	1.66	1.87	2.07	2.49	2,607	1,255
28	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	1,352	--
30	full	0.56	0.67	0.78	0.89	1.00	1.11	1.33	1.56	1.78	2.00	2.22	2.67	2,607	1,159
30	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	1,449	--
35	full	0.65	0.78	0.91	1.04	1.17	1.30	1.56	1.81	2.07	2.33	2.59	3.11	2,607	917
35	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	1,690	--
40	full	0.74	0.89	1.04	1.19	1.33	1.48	1.78	2.07	2.37	2.67	2.96	3.56	2,607	676
40	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	1,931	--
45	full	0.83	1.00	1.17	1.33	1.50	1.67	2.00	2.33	2.67	3.00	3.33	4.00	2,607	435
45	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	2,173	--
50	full	0.93	1.11	1.30	1.48	1.67	1.85	2.22	2.59	2.96	3.33	3.70	4.44	2,607	193
50	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	2,414	--
53	full	0.98	1.18	1.37	1.57	1.77	1.96	2.36	2.75	3.14	3.53	3.93	4.71	2,607	48
53	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	2,559	--

APPENDIX A4-A—Table 3c. Isokinetic transit rates for a 3-liter bag sampler with a 5/16-inch nozzle

[Transit rates in feet per second; Depth is water depth - unsampled zone; max, maximum; vol, volume; min, minimum; mL, milliliter; --, not applicable]

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)												Max. vol. -10 vol. min. vol.	Volume-min. vol. (mL)
		2.50	3.00	3.50	4.00	4.50	5.00	6.00	7.00	8.00	9.00	10.00	12.00		
2	full	0.06	0.07	0.08	0.09	0.10	0.12	0.14	0.16	0.19	0.21	0.23	0.28	2,604	2,453
2	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	151	--
4	full	0.12	0.14	0.16	0.19	0.21	0.23	0.28	0.32	0.37	0.42	0.46	0.56	2,604	2,302
4	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	302	--
6	full	0.17	0.21	0.24	0.28	0.31	0.35	0.42	0.49	0.56	0.63	0.70	0.83	2,604	2,151
6	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	453	--
8	full	0.23	0.28	0.32	0.37	0.42	0.46	0.56	0.65	0.74	0.83	0.93	1.11	2,604	2,000
8	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	604	--
10	full	0.29	0.35	0.41	0.46	0.52	0.58	0.70	0.81	0.93	1.04	1.16	1.39	2,604	1,849
10	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	755	--
12	full	0.35	0.42	0.49	0.56	0.63	0.70	0.83	0.97	1.11	1.25	1.39	1.67	2,604	1,698
12	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	906	--
14	full	0.41	0.49	0.57	0.65	0.73	0.81	0.97	1.14	1.30	1.46	1.62	1.95	2,604	1,547
14	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	1,057	--
16	full	0.46	0.56	0.65	0.74	0.83	0.93	1.11	1.30	1.48	1.67	1.86	2.23	2,604	1,396
16	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	1,208	--
18	full	0.52	0.63	0.73	0.83	0.94	1.04	1.25	1.46	1.67	1.88	2.09	2.50	2,604	1,245
18	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	1,359	--

APPENDIX A4-A—Table 3c. Isokinetic transit rates for a 3-liter bag sampler with a 5/16-inch nozzle—*Continued*

Depth (in feet)	Rate	Mean stream velocity in vertical (feet per second)												Max. vol. -10 vol. min. vol.	Volume-min. vol. (mL)
		2.50	3.00	3.50	4.00	4.50	5.00	6.00	7.00	8.00	9.00	10.00	12.00		
20	full	0.58	0.70	0.81	0.93	1.04	1.16	1.39	1.62	1.86	2.09	2.32	2.78	2,604	1,094
20	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	1,509	--
22	full	0.64	0.77	0.89	1.02	1.15	1.28	1.53	1.79	2.04	2.30	2.55	3.06	2,604	943
22	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	1,660	--
24	full	0.70	0.83	0.97	1.11	1.25	1.39	1.67	1.95	2.23	2.50	2.78	3.34	2,604	792
24	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	1,811	--
26	full	0.75	0.90	1.06	1.21	1.36	1.51	1.81	2.11	2.41	2.71	3.01	3.62	2,604	642
26	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	1,962	--
28	full	0.81	0.97	1.14	1.30	1.46	1.62	1.95	2.27	2.60	2.92	3.25	3.90	2,604	491
28	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	2,113	--
30	full	0.87	1.04	1.22	1.39	1.57	1.74	2.09	2.43	2.78	3.13	3.48	4.17	2,604	340
30	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	2,264	--
32	full	0.93	1.11	1.30	1.48	1.67	1.86	2.23	2.60	2.97	3.34	3.71	4.45	2,604	189
32	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	2,415	--
34	full	0.99	1.18	1.38	1.58	1.77	1.97	2.37	2.76	3.15	3.55	3.94	4.73	2,604	38
34	fastest	1.00	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00	4.80	2,566	--
35	full	--	--	--	--	--	--	--	--	--	--	--	--	--	--
35	fastest	--	--	--	--	--	--	--	--	--	--	--	--	--	--

APPENDIX A4-B

QUALITY-CONTROL SAMPLES COLLECTED BY FIELD PERSONNEL FOR WATER-QUALITY STUDIES

Prepared by **F.D. Wilde, U.S. Geological Survey, Reston, Va.; T.L. Schertz, U.S. Geological Survey, Lakewood, Colo.; and S.W. McKenzie, U.S. Geological Survey, Portland, Oreg.**

Appendix A4-B—Quality-control samples collected by field personnel for water-quality studies

[Common types of QC samples are described in this table; the list is not comprehensive. Some terms, descriptions, and purposes for quality-control samples have been compiled and modified from Sandstrom (1990), Horowitz and others (1994), Shelton (1994), Koterba and others (1995), unpublished course notes from "Quality-Control Sample Design and Interpretation," and the following Branch of Quality Systems Technical Memorandums: 90.03, 92.01, 95.01; QC, quality control; Blank-water abbreviations [1]: PBW, pesticide-grade blank water; VBW, volatile-grade blank water, IBW, inorganic-grade blank water]

BLANKS[2] **Quality-control samples used to assess possible source(s) and (or) magnitude of sample contamination**		
Sample type	**General description[3]**	**Purpose[3]**
Ambient blank	Blank water that is exposed to the identical collection and processing areas and time period as environmental samples. The blank water is transferred from the stock-solution container to the same type of bottle used for an environmental sample. The specific mode of exposure to the atmosphere is determined by the QC objective. **Examples:** (*a*) The blank water is transferred to a sample bottle while in the sample-processing chamber used for environmental samples. (*b*) Container such as a sample bottle is prefilled with blank water, opened while in the processing chamber, and exposed to the chamber atmosphere throughout the processing of environmental samples.	Determine analyte concentrations present in the environmental sample that could be attributed to exposure of sample to the ambient atmosphere in which samples are collected, processed, and analyzed. Referring to the general description: Example (*a*) is used to assess concentrations after processing the blank in a manner that mimics collection of the environmental sample. Example (*b*) is used to indicate the maximum analyte concentration that would result from prolonged sample exposure to ambient conditions.
Source-solution blank	Stock solution of PBW, VBW, or IBW that is transferred to a sample bottle in an area of the office laboratory within a controlled atmosphere that is relatively clean and protected with respect to target analytes.	Determine the source of water used for blanks and the degree to which the composition of blank solution could have changed (with respect to target analytes) from time of laboratory certification to time of use.
Trip blank	A sample bottle filled at the laboratory with VBW, PBW, or IBW (usually VBW) that remains unopened and is carried to the field and is stored and shipped with the environmental samples.	Determine whether shipping, storage, and field transport can be a source of sample contamination or cross-contamination.

Appendix A4-B—Quality-control samples collected by field personnel for water-quality studies—*Continued*

BLANKS[2] —Continued Quality-control samples used to assess possible source(s) and (or) magnitude of sample contamination		
Sample type	**General description[3]**	**Purpose[3]**
Equipment blank In this example, the sample referred to as the equipment blank is the same as the filter blank, as the filter assembly is the last component of this sampling-equipment system.	Blank water that is passed sequentially through each component of the equipment system to be used for collecting and processing environmental samples and resulting in a single final blank sample. • Differs from a field blank in that the equipment blank is processed under controlled conditions in an office laboratory and before equipment will be used for field work. Collected annually, unless equipment is in constant use and regularly quality controlled. • Often results in collecting a series of blank samples sequentially, each sample of which represents a different component or combined components of the equipment system used. The blanks generated in such a series are a special case of the generic term that identified the QC sample type. For example, if processing a water sample through a DH-77 sampler, churn splitter, peristaltic pump, and filter assembly, in that order, the following set of samples could be collected to be associated with the equipment blank: - Sampler blank (blank water processed through the DH-77 sampler. - Splitter blank (blank water processed through the sampler and then through a churn splitter). - Pump blank (blank water processed through the sampler, churn splitter, and then through a peristaltic pump system). - Filter blank (blank water processed through the sampler, churn splitter, peristaltic pump system, and through the filter assembly).	• Identify effects of the equipment system used to collect and process samples on analyte concentrations. • Verify adequacy of equipment-cleaning procedures (NFM 3). • Relating to components of the equipment system, assess potential of sample contamination and adequacy of equipment-cleaning procedures associated with each component of the equipment system to be used for field work.

Appendix A4-B—Quality-control samples collected by field personnel for water-quality studies—*Continued*

BLANKS[2] —Continued Quality-control samples used to assess possible source(s) and (or) magnitude of sample contamination		
Sample type	**General description[3]**	**Purpose[3]**
Field-blank system ("The field blank"—see fig. 4-8)	Blank water that is passed through the entire sampling equipment system onsite and subjected to identical collection, processing, preservation, transportation, and storage procedures and laboratory handling as for environmental samples. An identical sequence of procedures is followed as for the equipment blank. • The field blank is processed onsite through clean equipment on the same day as environmental samples: (*a*) directly after the equipment has been field cleaned and before leaving for the next site (NFM 3) or (*b*) at the next site, just before environmental samples for that site are processed. • A set of blanks can be processed and associated with the field blank, analogous to the equipment blank.	Determine the concentrations of target analyte(s) that could be present in environmental sample attributable to field procedures for equipment cleaning and sample handling. Results include effects from laboratory handling. Examples related to (*a*) and (*b*) under General description: (*a*) Check the adequacy of field cleaning procedures (demonstrate that equipment was adequately decontaminated after previous use) (NFM 3); (*b*) Identify contamination of sampling equipment while in transport from office to field site or between field sites, and ambient field conditions at the field site.
Sampler blank	Blank water processed through the same sampler used for environmental samples. (Blanks processed through pump samplers usually are designated pump blanks.)	• Identify effects of sampler on analyte concentrations. • Verify adequacy of cleaning procedures (NFM 3).
Splitter blank	Blank water processed through the same sample-splitting device used to collect or to process environmental samples (such as a churn splitter, cone splitter, or manifold system).	• Identify effects of splitter on analyte concentrations. • Verify adequacy of cleaning procedures (NFM 3).
Pump blank	Blank water processed through the pump-and-tubing system used for environmental samples.	• Identify effects of pump on analyte concentrations. • Verify adequacy of cleaning procedures (NFM 3).
Filter blank	Blank water processed through the filter assembly used for environmental samples. If the filter blank is to represent the same filter media, blank is processed prior to environmental samples.	• Identify effects of filtration assembly on analyte concentrations. • Verify adequacy of cleaning procedures, if a plate or cartridge assembly is used—see NFM 3.

Appendix A4-B—Quality-control samples collected by field personnel for water-quality studies—*Continued*

BLANKS[2] —Continued Quality-control samples used to assess possible source(s) and (or) magnitude of sample contamination		
Sample type	**General description[3]**	**Purpose[3]**
Preservation blank	Blank water that is transferred to a sample bottle and chemically treated with a preservative in an area protected from atmospheric contamination (usually, the office laboratory). The preservative used is from the same lot number used for other QC and environmental samples.	Determine the potential for and magnitude of sample contamination from the chemical treatment to be used to preserve the environmental sample.
Shelf blank ("Hold" blank)	Blank water that is transferred into the same type of bottle used for an environmental sample (usually in the protected environment of the office laboratory) and stored adjacent to stored environmental samples for the same length of time.	Determine the potential for and magnitude of sample contamination from sample storage in a designated area for a designated length of time.
Refrigerator blank	Blank water that is transferred into a sample bottle (usually in the protected environment of the oficelaboratory) and stored adjacent to environmental samples in a refrigerated area for the same length of time.	Determine the potential for and magnitude of sample contamination from sample refrigeration for a designated length of time.

Appendix A4-B—Quality-control samples collected by field personnel for water-quality studies—*Continued*

REPLICATE AND VARIABILITY SAMPLES Quality-Control Samples Used To Assess Field and Laboratory Variability		
Sample type	**General description[3]**	**Purpose[3]**
Replicates (duplicates, triplicates, etc., of sequential, split, concurrent, or other type of replicate)	A set of samples that are collected close in time and space and in a manner so that the samples are thought to be representative of the ambient water composition at the time of collection.	Depending upon its type, a replicate is used to determine variability in some part of the sample collection, processing, and analysis system.
Concurrent replicates	Samples obtained by collecting simultaneously with two or more samplers or by using one sampler and alternating collection of samples into two or more compositing containers (Horowitz and others, 1994).	• Identify and (or) quantify the variability in the system being sampled. • Analysis includes the variability introduced from collection, processing, shipping, and laboratory handling and analysis of the sample.
Sequential replicates	Samples that are collected one after the other and considered virtually identical in composition.	• Identify and (or) quantify the variability introduced from collection, processing, shipping, and laboratory handling and analysis. • Can be designed to indicate temporal variability resulting from consecutive collection of samples.

Appendix A4-B—Quality-control samples collected by field personnel for water-quality studies—*Continued*

REPLICATE AND VARIABILITY SAMPLES —Continued Quality-Control Samples Used To Assess Field and Laboratory Variability		
Sample type	**General description[3]**	**Purpose[3]**
Split replicates	Samples obtained by dividing one sample into two or more subsamples either before or after sample processing and preservations **each of the subsamples is to be analyzed for concentrations of the same constituents or compounds**. Examples: (*a*) A processed and treated sample in a sample bottle is split into two or more aliquots and subjected to identical handling and analysis. (*b*) Environmental water is passed through a splitting device (such as a cone splitter or T-valve) from which subsamples are collected simultaneously and subjected to identical handling and analysis. (*c*) Environmental water is collected into a compositing device from which subsamples are collected sequentially and subjected to identical handling and analysis.	• Assess variability for a given sample matrix. • Compare differences in analyses obtained from the same or separate laboratories. • Analysis includes any variability from splitting and other sample-processing procedures, shipping, and laboratory handling and analysis of the sample.
Reference sample	A laboratory-prepared solution or material whose composition is certified for one or more properties so that it can be used to assess a measurement method or for assigning concentration values of specific analytes.	Tests for bias and variability of the laboratory measurement process.
Spike sample	Environmental("field-matrix spikes") or reference-material sample to which a spike solution has been added in known concentrations and in a manner that does not substantially change the original sample matrix. **Spike solution** is a solution having laboratory-certified concentrations of selected analytes and that is added in known quantities to a sample. [4]	Assess the recovery of target analytes relative to the actual conditions to which samples have been exposed; quantify effects of sample-matrix interferences and analyte degradation on analyte recovery.

Appendix A4-B—Quality-control samples collected by field personnel for water-quality studies—*Continued*

REPLICATE AND VARIABILITY SAMPLES —Continued Quality-Control Samples Used To Assess Field and Laboratory Variability		
Sample type	**General description[3]**	**Purpose[3]**
Blind sample	A sample (typically, reference material) submitted for laboratory analysis with composition known to the submitter but unknown (blind) to the analyst. Every blind sample analyzed should have an associated reference to the source and the preparation procedure.	Test for bias and variability of the laboratory measurement process.

[1]Blank water is a solution that is free of analyte(s) of interest at a specified detection limit and that is used to develop specific types of QC samples. USGS personnel are required to use blank water that has been analyzed and certified to be of a specific grade. Order IBW from the QWSU in Ocala, Fla., via <Ocalaman@usgs.gov>. Order PBW and VBW from NWQL in Arvada, Colo. via <densuppl@usgs.gov>.

[2]Blanks for trace-element analysis have a unique NWQL schedule of analysis, different from that of the environmental sample.

[3]The description of a QC sample depends to some extent on the purpose for which it is collected. The purpose for the QC sample can govern the mode of its collection, processing, and treatment, and the equipment to which it is exposed. Purposes for a specific type of QC sample are varied.

[4]Obtain spike solutions in spike kits for pesticide and volatile organic compound analyses supplied by NWQL.

APPENDIX A4-C

EXAMPLES FROM THE NATIONAL WATER-QUALITY ASSESSMENT PROGRAM RELATED TO PROTOCOLS FOR COLLECTING BLANK SAMPLES AT GROUND-WATER SAMPLING SITES

Modified from Koterba and others, 1995

APPENDIX A4-C. —Table 1. Example of procedure to estimate and collect field volumes of blank solutions

[Modified from Koterba and others, 1995 and based on protocols of the National Water-Quality Assessment Program. Updated information is available on the World Wide Web at the following URL: http://wwwrvares.er.usgs.gov/nawqa/OFR95-399.html. DIW, District deionized water with specific electrical conductance less than 1.0 microsiemens per liter; VBW, volatiles-organic-grade blank water; PBW, pesticide-grade blank water; IBW, inorganic-grade blank water; DOC, dissolved (filtered) organic carbon; gal, gallons; L, liters; ≈, approximately; NWQL, National Water Quality Laboratory; QWSU, Quality of Water Service Unit (Ocala, Fla.); SC, NWQL analytical schedule; LC, NWQL analyte code]

Assumptions: Submersible pump was used to collect the ground-water samples. Equipment just used to collect ground-water samples has been decontaminated, and, except for the pump intake being in a standpipe, is set up on site in the same manner as it was for the collection of ground-water samples.

Blank-solution types and estimate of volumes required[1]

Field blank(s) desired	Required blank-solution type	Minimum volume in gal (L)	Comments
VOCs and DOC[1] or pesticides and DOC	VBW PBW[1]	1.5 (≈6)	Waste 0.5 gal, then collect field blanks; can use DIW to force last of VBW (or PBW) through the system.
VOCs, DOC[1] and pesticides	VBW	2.0 (≈8)	Waste 0.5 gal, then collect field blanks; can use DIW to force last of VBW or PBW through the system.
Major ions and nutrients, or trace elements	IBW	1.0 (≈4)	Waste 0.5 gal, then collect field blanks; can use DIW to force last of the IBW needed through the system.
Major ions and nutrients and trace elements	IBW	1.5 (≈6)	Waste 0.5 gal, then collect field blanks; if necessary, use DIW to force last of the IBW needed through the system.
Combinations of the organics and inorganics above	VBW/PBW and IBW	1.5 to 2.0 (≈6 to ≈8) 1.0 to 1.5 (≈4 to ≈6)	Waste 0.5 gal of the VBW or PBW, then collect organic field blanks. Use IBW to push the VBW or PBW through the system. Waste 0.5 gal. of IBW, then collect inorganic field blanks, using DIW to push the IBW through the system.

[1] NWQL-PBW can not be used for VOC field blanks. Select VBW or PBW for DOC field blanks only after reviewing certification forms of the lot numbers available. A solution blank sample of water from the same lot of NWQL water is used for DOC field blank and poured directly into DOC 125-mL amber sample bottle. Record the lot number of the water used for the solution blank on the ASR form.

APPENDIX A4-C.—Table 2. Example of procedure to collect blank samples with a submersible pump

[Modified from Koterba and others (1995). Updated information is available on the World Wide Web at the following URL: http://wwwrvares.er.usgs.gov/nawqa/OFR95-399.html. DIW, deionized water; VBW, volatiles-grade blank water; PBW, pesticide-grade blank water; IBW, inorganic-grade blank water; VOC, volatile organic compound; QC, quality control]

General Field-Blank Collection Procedure[1]
1. Divide field team duties . Three-person team recommended—two people collect samples in a manner similar to that used to collect ground-water samples; the third person adds blank water to standpipe and controls flow through system, as needed, to facilitate field blank collection. 2. Check flow set-up—from standpipe to sample collection/processing chamber, ensure that adequate volumes of DIW and the required blank water are within easy reach of person stationed at standpipe and arranged in order of collection: VBW first, PBW next, IBW last. 3. Set low flow rate—Once pumping is initiated, set flow (on basis of measurement at chamber outflow) to about 0.1 gal. (500 mL) per minute or less to avoid wasting blank water (150 mL/min or less is recommended for filling VOC vials). 4. Collect blank solutions in prescribed sequence—As solutions are changed, pump operator should change to clean gloves, empty residual solution from standpipe, rinse pump intake and standpipe, individually, at least three times each, with the next solution. Attempt to pump air segment into pump line before adding next solution to standpipe to mark change in solution type. • If air segment can not be used to mark the end of one solution and the beginning of the next, then determine the change in solutions on the basis of the storage volume in line divided by the pumping rate to estimate the time it takes for the solution to travel from the standpipe to the collection/processing chamber. • Pass about 0.5 gallons (approximately 2 L) of blank solution to waste before collecting the QC sample, regardless of whether air segments or timed flow or both are used to assess when the solution arrives at the collection chamber. • Use one type of water to force the last of another type from the sample tubing after all samples that require that blank-water type have been collected, in order to limit the amount of blank water left in the sample tubing.

[1]**Assumptions:** Submersible pump was used to collect the ground-water samples. Organic and inorganic field blanks will be collected. Equipment just used to collect ground-water samples has been cleaned, and, except for the pump intake being in a standpipe instead of a well, is set up on site in the same manner as it was for the collection of ground-water samples. Standpipe has just been cleaned and subsequently rinsed with VBW. If only inorganic field blanks will be collected, rinse the cleaned standpipe with IBW and modify steps 2-4 accordingly.

ISBN 0-607-92183-8