2003 WATER MONITORING REPORT

April 2004

Prepared for:

South Washington Watershed District

Prepared by:

Washington Conservation District

Memorandum

To: Matt Moore —South Washington Watershed District Administrator
From: Bob Fossum, Wendy Griffin, Karen Kill, Travis Thiel, and Erik Anderson--Washington Conservation District
Date: April 13, 2004
Re: SWWD 2003 Monitoring: MS1, MS2, Powers, 100th Street Station, Fox Run, Tamarack Road, 80th Street, 90th Street, Armstrong Lake, Powers Lake, Bailey Lake, Lake Gages, & Observation Wells

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At the request of the South Washington Watershed District (SWWD), the Washington Conservation District (WCD) conducted stream monitoring at three existing stream monitoring stations (MS1, MS2, and 100th Street), one new stream monitoring station at a different location on Powers Lake, monitored four stormwater sites (Fox Run, Tamarack Road, 80th Street, and 90th Street), monitored water quality and level on Armstrong Lake, monitored level and precipitation on Bailey Lake (at the Lift Station), installed and read nine lake staff gages, and monitored seven groundwater observation wells with additional readings provided by Emmons & Oliver Resources, Inc. The locations of the monitoring sites can be found in Figure 1. The following report summarizes our methods and results for monitoring conducted from January 1 - December 31, 2003. This report and the accompanying data will also be provided in an electronic format.

Stream Sites: MS1, MS2, Powers & 100th Street

Continuous stage, velocity, and discharge measurements were taken every 15 minutes at MS1 from March 25-October 29, 2003, at MS2 from March 20–October 29, 2003, at Powers from August 28-October 27, 2003 and at 100th Street from March 19-October 27, 2003. Precipitation data was also continuously collected at each of these sites during the same time period.

Staff gages were installed and read at each site. Field stage measurements were taken in the outflow culverts. Temperature, dissolved oxygen, and transparency tube measurements were also taken. Flow weighted storm event samples, storm event grab samples, snowmelt grab samples, as well as baseflow composite and grab samples were collected at all stream sites. In addition to these samples, fecal grab samples were also taken or were attempted at all four sites. The samples were analyzed at the Metropolitan Council Environmental Services Lab.

Stage to discharge relationships were developed at all stream sites. When the area-velocity probe was covered with debris, erroneous velocity readings were given. Each site had backup level logger stage recorders that allowed for data collection during periods when the primary equipment was not recording.

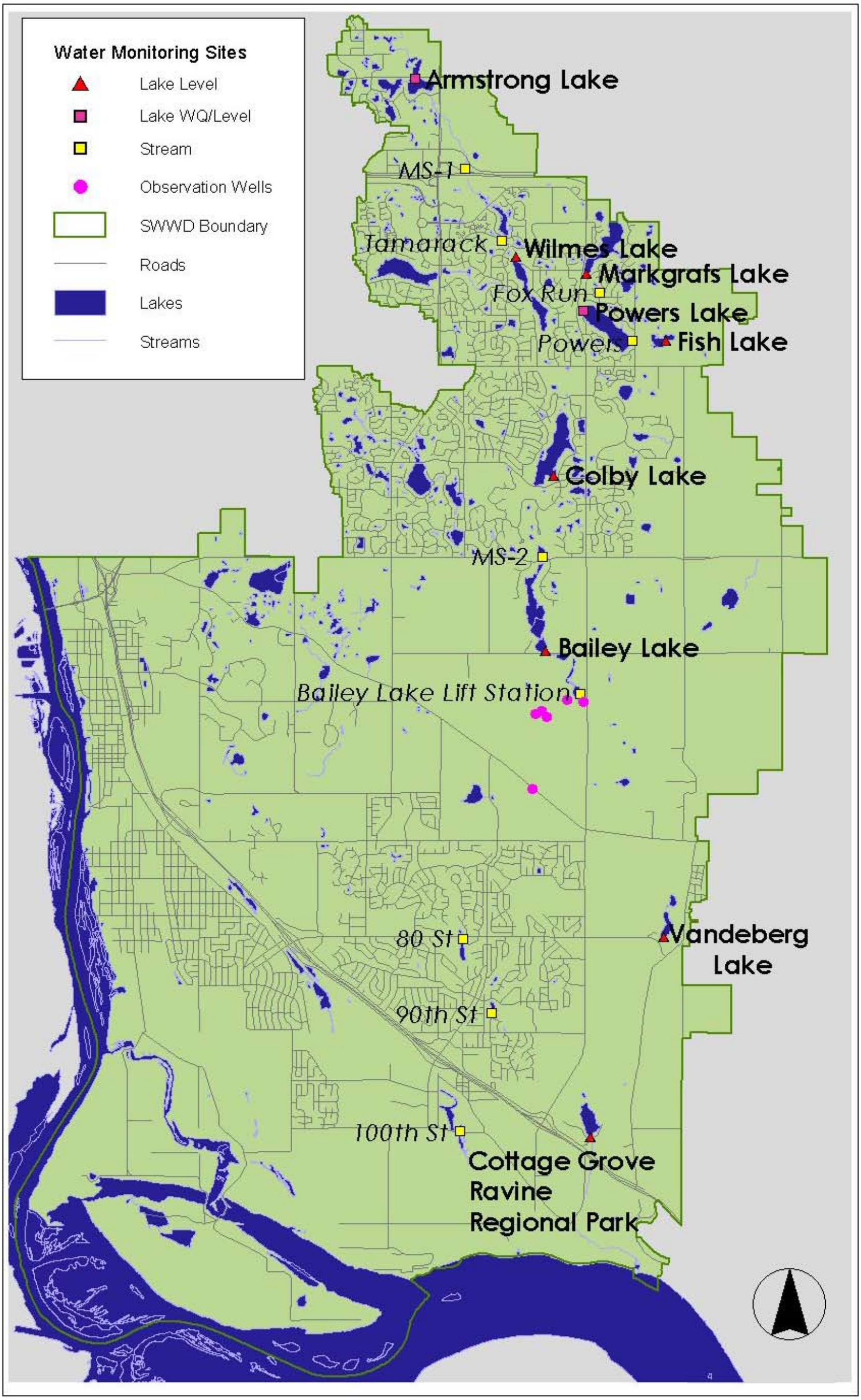
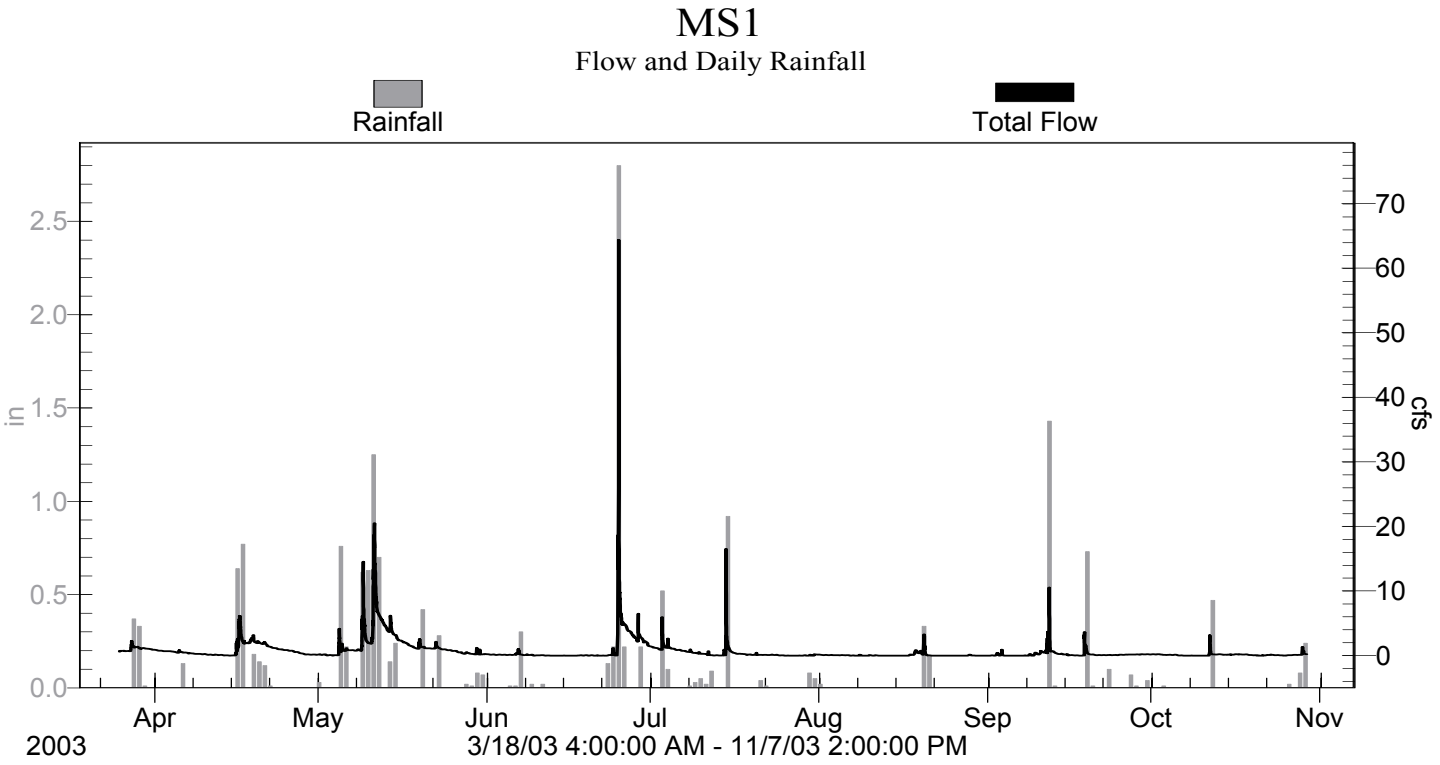


Figure 1. SWWD Water Monitoring Locations

MS1 (I94)

The hydrograph for the MS1 site shows flows between March 25–October 29, 2003 (Figure 2). Total discharge during this period was 11,749,930 cf or 270 acre-ft. The peak discharge—64.42 cfs, was on June 25, 2003 from daily precipitation of 2.80 inches. This was also the highest daily precipitation total for 2003.

Figure 2. MS1 2003 Continuous Flow and Daily Rainfall



Grab and flow weighted composite samples were taken at the MS1 site to determine water quality. Samples were taken during snowmelt and storm runoff, as well as during base flow conditions. The total suspended solids (TSS), total Kjeldahl nitrogen (TKN), total phosphorus (TP), volatile suspended solids (VSS), chemical oxygen demand (COD), and Fecal Coliform concentrations from all collected samples are listed in Table 1. The highest TSS and TP concentrations were collected in a storm composite on June 24, 2003. The highest TKN concentration was collected in a snowmelt grab on March 17, 2003. Metals and other Nitrogen species chemical results are listed in Table 2.

Table 1. MS1 2003 Sample Chemistry Results

Sample Type	Start Date	Start Time	End Date	End Time	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Fecal Coliform (#/100 mL)	COD (mg/L)
Snowmelt Grab	3/17/03	14:15	3/17/03	14:15	18	8	3.70	0.64		82
Storm Composite	3/31/03	10:40	3/31/03	10:40	6	3	0.74	0.10		28
Storm Composite	4/16/03	9:12	4/16/03	16:46	174	26	1.80	0.52		62
Storm Composite	5/4/03	19:18	5/4/03	21:34	225	24	1.70	0.56		77
Storm Composite	5/8/03	23:13	5/9/03	5:51	462	54	1.80	0.60		55
Storm Composite	5/14/03	4:47	5/14/03	6:50	771	40	1.70	0.40		58
Storm Composite	6/24/03	22:52	6/25/03	12:50	1320	152	3.10	1.28		160
Storm Composite	7/3/03	1:23	7/3/03	5:48	393	33	2.00	0.74		63
Storm Composite	7/14/03	18:24	7/15/03	9:31	636	84	1.20	0.56		95
Fecal Grab	7/22/03	11:45	7/22/03	11:45					83	
Base Grab	8/20/03	10:00	8/20/03	10:00	14	6	1.20	0.17		62
Storm Composite	9/11/03	17:33	9/11/03	18:45	156	32	2.20	0.42		151
Storm Composite	9/11/03	20:06	9/11/03	22:24	54	11	1.40	0.40		54
Storm Composite	9/12/03	0:30	9/12/03	2:54	968	66	1.50	0.64		64
Storm Composite	9/18/03	13:26	9/18/03	23:00	107	20	1.30	0.38		53
Average					**379**	**40**	**1.81**	**0.53**	**83**	**76**

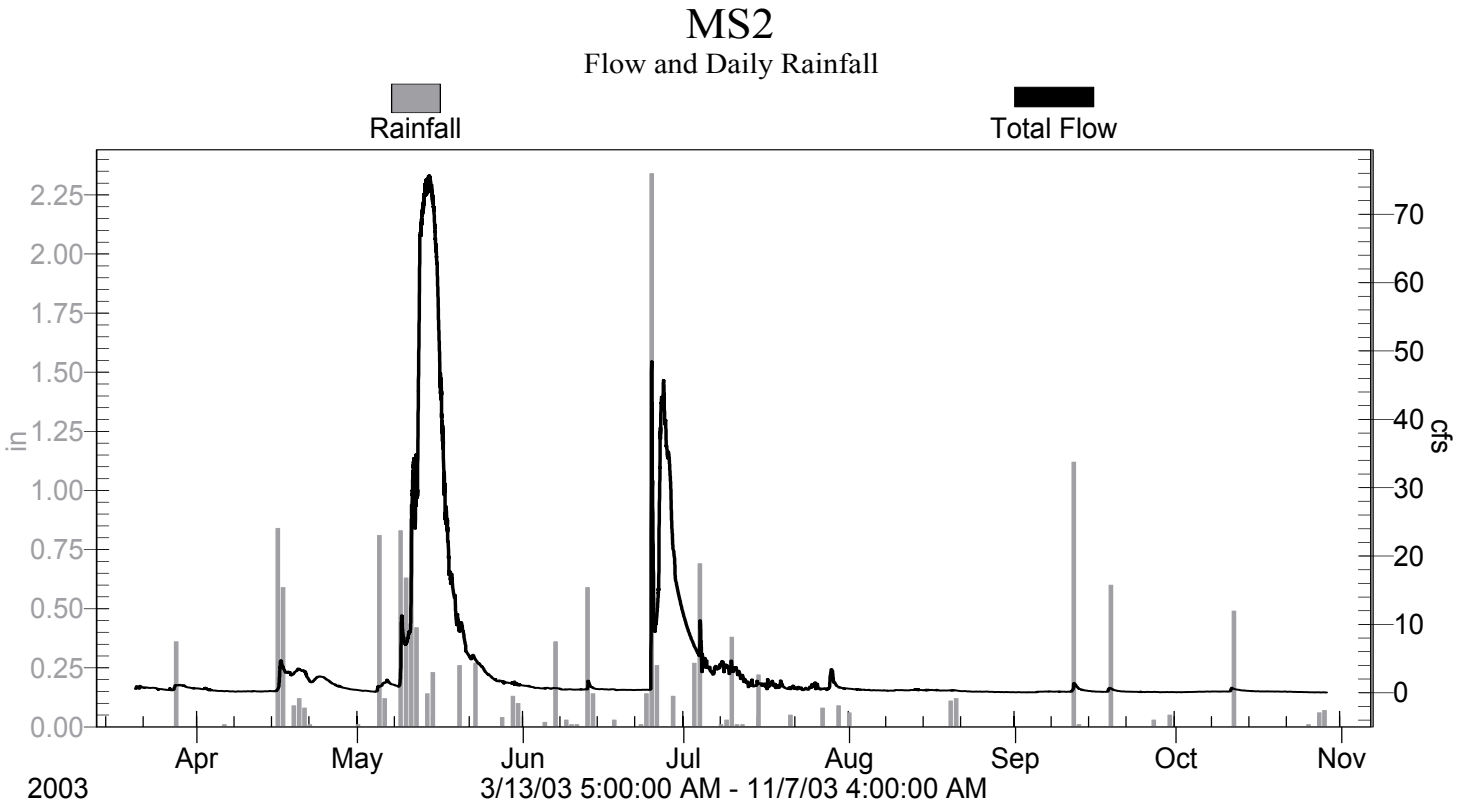
Table 2. MS1 2003 Sample Metals and Nitrogen Species Chemical Results

Sample Type	Start Date	Start Time	End Date	End Time	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)	Nitrite N (mg/L)	Nitrate N (mg/L)	Ammonia Nitrogen (mg/L)
Snowmelt Grab	3/17/03	14:15	3/17/03	14:15	0.0096	0.0046	0.00070	0.0139	0.00006	0.0023	162	0.11	1.43	0.85
Storm Composite	3/31/03	10:40	3/31/03	10:40	0.0021	0.0016	0.00010	0.0033	0.00004	0.0003	89	0.03	0.05	0.02
Storm Composite	4/16/03	9:12	4/16/03	16:46	0.0111	0.0071	0.00540	0.0300	0.00010	0.0089	67	0.03	0.40	0.13
Storm Composite	5/4/03	19:18	5/4/03	21:34	0.0146	0.0080	0.00670	0.0440	0.00130	0.0098	22	0.03	0.34	0.04
Storm Composite	5/8/03	23:13	5/9/03	5:51	0.0130	0.0095	0.00760	0.0360	0.00010	0.0101	26	0.03	0.23	0.11
Storm Composite	5/14/03	4:47	5/14/03	6:50	0.0101	0.0074	0.00610	0.0320	0.00180	0.0070	42	0.03	0.14	0.02
Storm Composite	6/24/03	22:52	6/25/03	12:50	0.0290	0.0240	0.02210	0.0970	0.00040	0.0234	7	0.06	0.37	0.13
Storm Composite	7/3/03	1:23	7/3/03	5:48	0.0126	0.0092	0.00600	0.0400	0.00150	0.0085	21	0.14	0.48	0.23
Storm Composite	7/14/03	18:24	7/15/03	9:31	0.0156	0.0138	0.01220	0.0510	0.00040	0.0150	12	0.08	0.24	0.08
Fecal Grab	7/22/03	11:45	7/22/03	11:45										
Base Grab	8/20/03	10:00	8/20/03	10:00	0.0077	0.0024	0.00050	0.0156	0.00006	0.0022	11	0.06	0.45	0.02
Storm Composite	9/11/03	17:33	9/11/03	18:45	0.0143	0.0064	0.00380	0.0670	0.00020	0.0073	7	0.03	0.05	0.30
Storm Composite	9/11/03	20:06	9/11/03	22:24	0.0071	0.0032	0.00180	0.0210	0.00010	0.0042	5	0.08	0.38	0.21
Storm Composite	9/12/03	0:30	9/12/03	2:54	0.0138	0.0082	0.00530	0.0390	0.00020	0.0097	6	0.09	0.46	0.16
Storm Composite	9/18/03	13:26	9/18/03	23:00	0.0092	0.0057	0.00350	0.0280	0.00020	0.0057	8	0.05	0.35	0.07
Average					**0.0121**	**0.0079**	**0.00584**	**0.0370**	**0.00046**	**0.0082**	**35**	**0.06**	**0.38**	**0.17**

MS2 (Bailey)

The hydrograph for the MS2 site shows flow between March 20 – October 29, 2003 (Figure 3). Total discharge during this period was 65,462,170 cf or 1,503 acre-ft. The highest flow—74.67 cfs occurred on May 13, 2003, from a total rainfall of 2.76 inches between May 9 and May 12. The highest daily rainfall—2.34 inches, was on June 25, 2003, which yielded a discharge of 46.92 cfs.

Figure 3. MS2 2003 Continuous Flow and Daily Rainfall



Grab samples and flow weighted composite samples were taken at the MS2 site. The TSS, TKN, TP, VSS, COD and Fecal Coliform results from all collected samples are listed in Table 3. The highest TSS concentration of 60 mg/L was from the October 11, 2003 storm composite sample. TKN concentrations had a range of 1.30 to 3.00 mg/L. The highest TKN concentrations were from a March 17, 2003 snowmelt grab sample (3.00 mg/L). The highest TP concentration (0.73 mg/L) was from a March 13, 2003 snowmelt grab sample. Metals and other Nitrogen species chemical results are listed in Table 4.

Table 3. MS2 2003 Sample Chemistry Results

Sample Type	Start Date	Start Time	End Date	End Time	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Fecal Coliform (#/100 mL)	COD (mg/L)
Snowmelt Grab	3/17/03	13:45	3/17/03	13:45	10	7	3.00	0.73		61
Storm Grab	3/31/03	10:00	3/31/03	10:00	8	6	1.50	0.13		32
Storm Composite	4/16/03	16:45	4/17/03	9:30	15	9	1.40	0.11		36
Storm Composite	5/6/03	5:15	5/7/03	13:30	11	7	1.30	0.14		46
Storm Composite	5/9/03	2:41	5/10/03	0:26	12	8	1.80	0.18		28
Storm Grab	5/15/03	10:00	5/15/03	10:00	13	12	1.60	0.13		67
Storm Composite	6/25/03	1:11	6/25/03	3:30	27	14	2.00	0.21		46
Fecal Grab	7/22/03	12:00	7/22/03	12:00					10	
Base Composite	7/29/03	9:15	8/31/03	7:30	21	16	2.00	0.13		48
Base Composite	8/7/03	15:26	8/11/03	3:11	26	13	1.70	0.09		31
Base Composite	8/26/03	8:11	8/28/03	12:41	38	18	2.30	0.17		50
Base Composite	9/5/03	9:56	9/9/03	8:26	28	12	1.90	0.15		42
Storm Composite	9/11/03	23:41	9/13/03	19:11	21	9	1.90	0.17		39
Fecal Grab	9/11/03	9:28	9/11/03	9:28					43	
Storm Composite	9/18/03	16:41	9/20/03	5:26	35	16	2.20	0.23		44
Storm Composite	10/11/03	15:56	10/13/03	13:11	60	20	2.50	0.27		55
Average					**23**	**12**	**1.94**	**0.20**	**27**	**45**

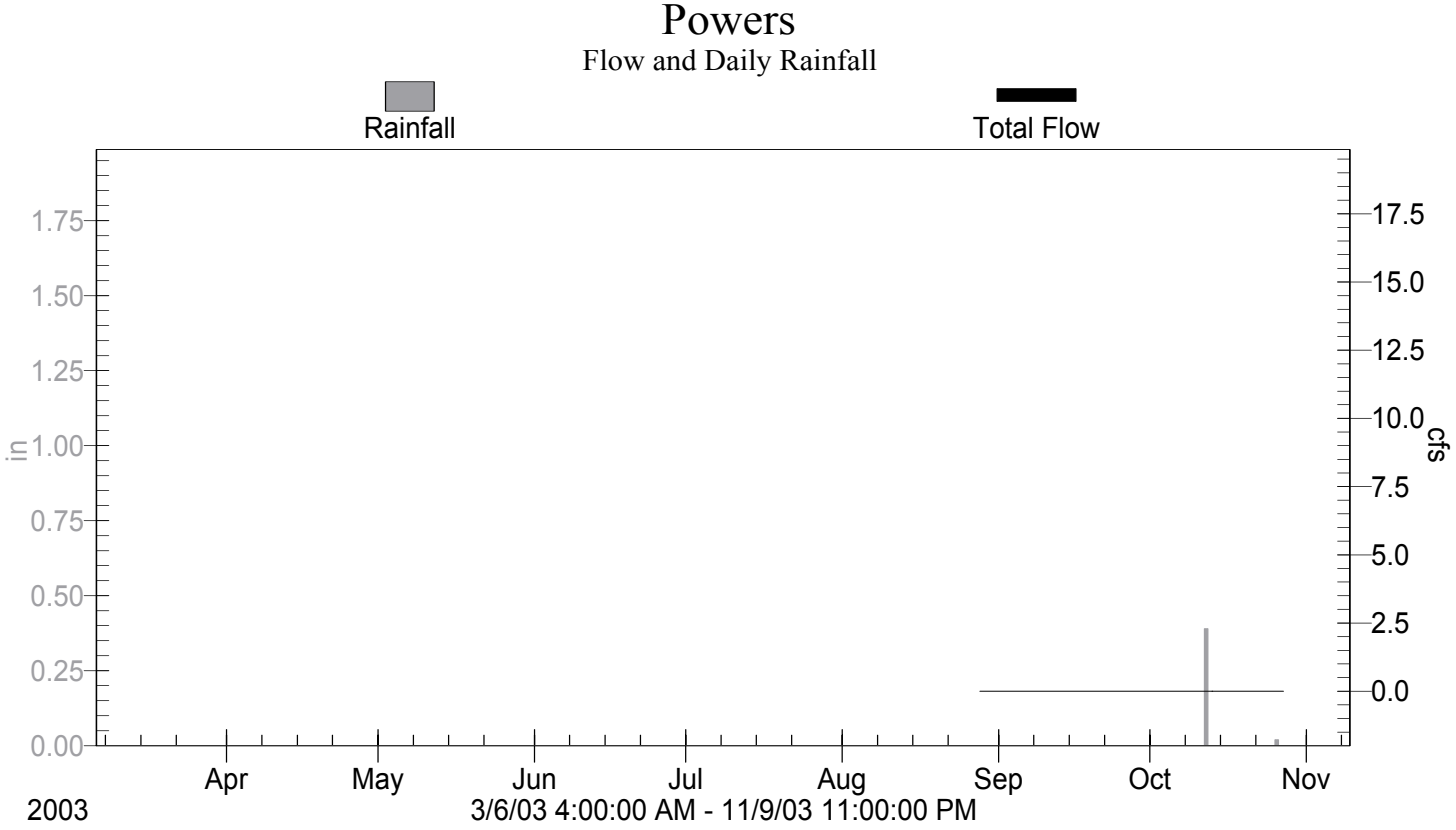
Table 4. MS2 2003 Sample Metals and Nitrogen Species Chemical Results

Sample Type	Start Date	Start Time	End Date	End Time	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)	Nitrite N (mg/L)	Nitrate N (mg/L)	Ammonia Nitrogen (mg/L)
Snowmelt Grab	3/17/03	13:45	3/17/03	13:45	0.0066	0.0015	0.00030	0.0083	0.00004	0.0010	92	0.03	0.69	0.90
Storm Grab	3/31/03	10:00	3/31/03	10:00	0.0028	0.0021	0.00010	0.0037	0.00004	0.0003	61	0.03	0.44	0.33
Storm Composite	4/16/03	16:45	4/17/03	9:30	0.0099	0.0021	0.00040	0.0049	0.00020	0.0004	66	0.03	0.05	0.15
Storm Composite	5/6/03	5:15	5/7/03	13:30	0.0069	0.0018	0.00040	0.0174	0.00210	0.0006	44	0.03	0.05	0.06
Storm Composite	5/9/03	2:41	5/10/03	0:26	0.0143	0.0015	0.00050	0.0062	0.00030	0.0005	36	0.03	0.10	0.33
Storm Grab	5/15/03	10:00	5/15/03	10:00	0.0024	0.0013	0.00010	0.0029	0.00004	0.0002	49	0.03	0.05	0.07
Storm Composite	6/25/03	1:11	6/25/03	3:30	0.0110	0.0018	0.00070	0.0046	0.00020	0.0002	27	0.03	0.10	0.17
Fecal Grab	7/22/03	12:00	7/22/03	12:00										
Base Composite	7/29/03	9:15	8/31/03	7:30	0.0031	0.0018	0.00020	0.0030	0.00050	0.0004	39	0.03	0.05	0.07
Base Composite	8/7/03	15:26	8/11/03	3:11	0.0022	0.0020	0.00020	0.0028	0.00020	0.0003	36	0.03	0.05	0.14
Base Composite	8/26/03	8:11	8/28/03	12:41	0.0019	0.0018	0.00050	0.0042	0.00020	0.0005	36	0.03	0.05	0.02
Base Composite	9/5/03	9:56	9/9/03	8:26	0.0021	0.0020	0.00070	0.0029	0.00009	0.0004	36	0.03	0.07	0.31
Storm Composite	9/11/03	23:41	9/13/03	19:11	0.0018	0.0019	0.00060	0.0035	0.00008	0.0007	35	0.07	0.07	0.46
Fecal Grab	9/11/03	9:28	9/11/03	9:28										
Storm Composite	9/18/03	16:41	9/20/03	5:26	0.0022	0.0026	0.00100	0.0059	0.00010	0.0006	34	0.16	0.15	0.18
Storm Composite	10/11/03	15:56	10/13/03	13:11	0.0027	0.0026	0.00160	0.0068	0.00006	0.0005	33	0.07	1.07	0.39
Average					**0.0050**	**0.0019**	**0.00052**	**0.0055**	**0.00030**	**0.0005**	**45**	**0.05**	**0.21**	**0.26**

Powers Lake New East Tributary

The station at Powers Lake was moved from the Northeast Inlet to the new Eastern inlet. No flow occurred at the new site because the inlet control structure was never opened. Discharge and precipitation was recorded from September 30-Ocotber 27, 2003 (Figure 4). The highest amount of daily precipitation during the recorded season—0.26 inches, was recorded on October 12, 2003. No samples were collected at the new Powers Lake site because no discharge occurred during the monitoring season.

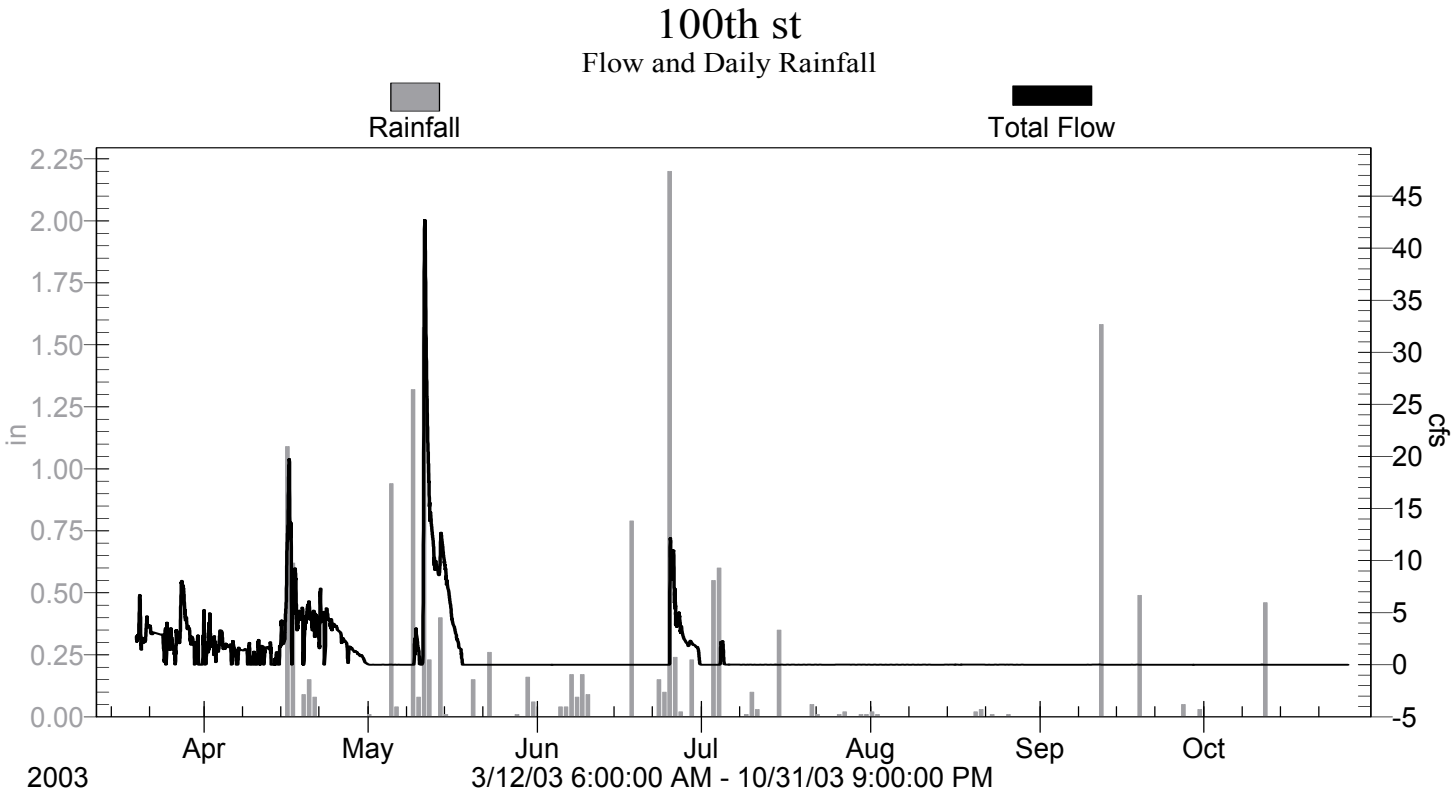
Figure 4. Powers 2003 Flow and Daily Rainfall



100th Street (Cottage Grove)

The hydrograph for the 100th Street site shows flow between March 19-October 27, 2003 (Figure 5). Total discharge during this period was 18,426,050 cf or 423 acre/ft. The highest discharge—42.56 occurred on May 11, 2003, from a total rainfall of 1.57 inches. The rainfall on June 25, 2003 was the highest daily rainfall for the monitoring period, yielding 2.20 inches of rain. Dewatering activities were performed in conjunction with a new sewer system adjacent to the site. These activities reduced and eliminated all baseflow at the site as well as making the recession from the peak flows very abrupt.

Figure 5. 100th Street 2003 Flow and Daily Rainfall



Grab samples and flow weighted composite samples were taken at the 100th Street site. The TSS, TKN, TP, VSS, COD, and Alkalinity results from all collected samples are listed in Table 5. The highest TSS concentration of 29 mg/L was collected in an April 16, 2003 storm composite sample. The highest TP and TKN concentrations of 0.82 mg/L and 4.10 mg/L were collected from a snowmelt grab sample on March 17, 2003. Metals and other Nitrogen species chemicals are listed in Table 6.

Table 5. 100th Street 2003 Sample Chemistry Results

Sample Type	Start Date	Start Time	End Date	End Time	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	COD (mg/L)	Alkalinity (mg/L)
Base Grab	1/22/03	10:00	1/22/03	10:00	4	2	0.31	0.04	15	
BaseGrab	2/18/03	9:00	2/18/03	9:00	4	2	0.31	0.10	9	
Snowmelt Grab	3/17/03	12:45	3/17/03	12:45	14	9	4.10	0.82	88	
Storm Grab	3/31/03	8:50	3/31/03	8:50	11	5	1.00	0.15	22	
Storm Composite	4/16/03	2:57	4/16/03	15:40	29	13	1.50	0.16	26	183
Storm Composite	5/9/03	10:50	5/10/03	8:00	7	3	0.53	0.12	18	
Storm Composite	5/11/03	0:50	5/11/03	4:35	12	6	0.71	0.11	22	
Storm Grab	5/15/03	9:20	5/15/03	9:20	5	3	1.10	0.07	24	
Storm Composite	6/25/03	4:56	6/25/03	10:58	14	8	0.70	0.11	22	
Storm Composite	7/4/03	12:18	7/5/03	1:06	7	8	1.50	0.16	34	
Average					**11**	**6**	**1.18**	**0.18**	**28**	**183**

Table 6. 100th Street 2003 Sample Metals and Nitrogen Species Chemical Results

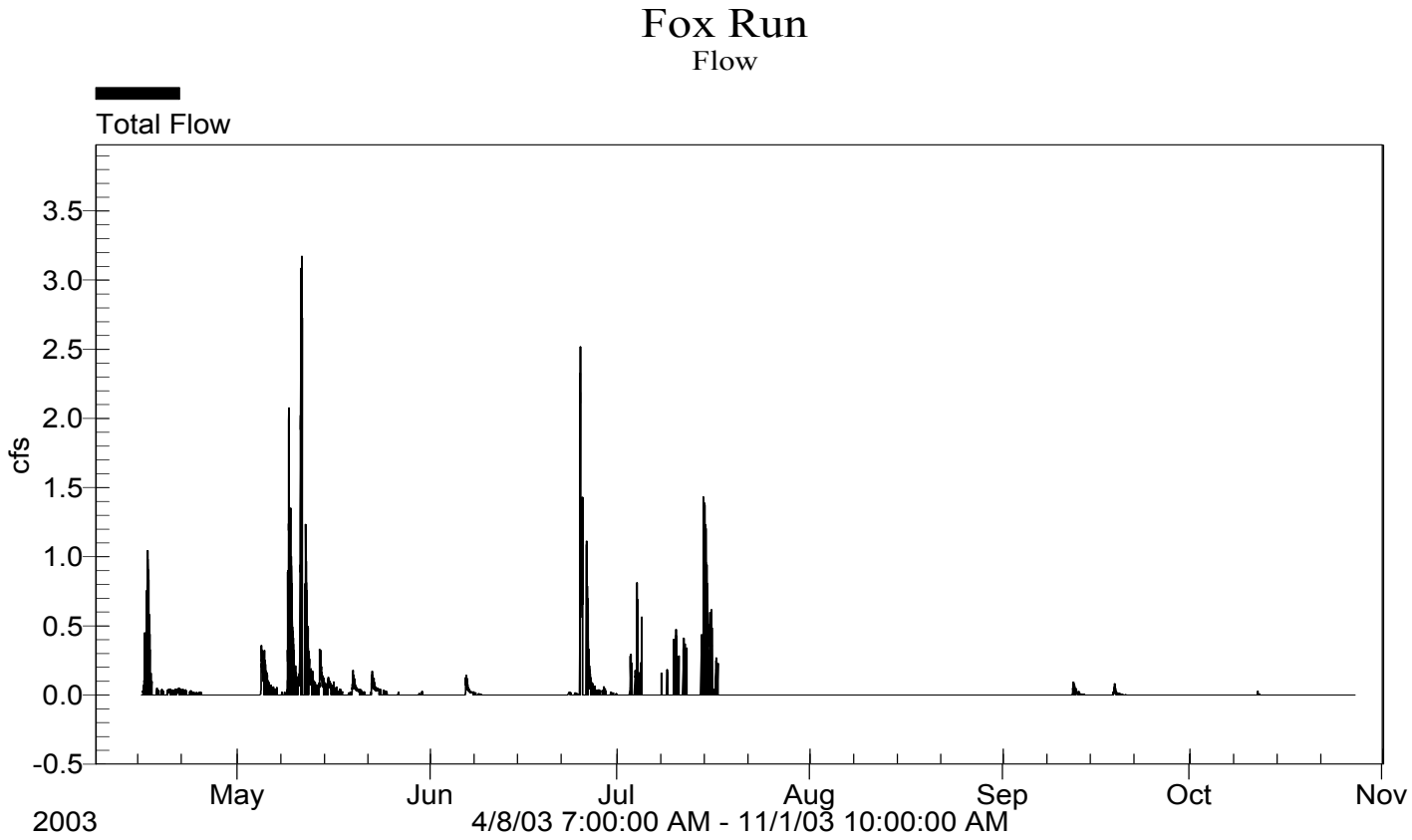
Sample Type	Start Date	Start Time	End Date	End Time	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)	Nitrite N (mg/L)	Nitrate N (mg/L)	Ammonia Nitrogen (mg/L)
Base Grab	1/22/03	10:00	1/22/03	10:00	0.0016	0.0026	0.00007	0.0025	0.00004	0.0003	95	0.03	2.30	0.06
BaseGrab	2/18/03	9:00	2/18/03	9:00	0.0009	0.0016	0.00007	0.0016	0.00004	0.0002	81	0.04	2.03	0.14
Snowmelt Grab	3/17/03	12:45	3/17/03	12:45	0.0088	0.0027	0.00070	0.021	0.00008	0.0014	158	0.06	0.98	1.27
Storm Grab	3/31/03	8:50	3/31/03	8:50	0.0021	0.0025	0.00040	0.0047	0.00004	0.0004	123	0.04	1.15	0.11
Storm Composite	4/16/03	2:57	4/16/03	15:40	0.0035	0.0030	0.00080	0.0094	0.00040	0.0008	134	0.03	1.03	0.15
Storm Composite	5/9/03	10:50	5/10/03	8:00	0.0031	0.0013	0.00060	0.0064	0.00010	0.0010	34	0.03	0.54	0.05
Storm Composite	5/11/03	0:50	5/11/03	4:35	0.0046	0.0016	0.00080	0.0085	0.00010	0.0010	30	0.04	0.51	0.08
Storm Grab	5/15/03	9:20	5/15/03	9:20	0.0027	0.0019	0.00020	0.0043	0.00004	0.0002	75	0.03	0.28	0.17
Storm Composite	6/25/03	4:56	6/25/03	10:58	0.0038	0.0012	0.00140	0.0092	0.00009	0.0007	3	0.03	0.38	0.26
Storm Composite	7/4/03	12:18	7/5/03	1:06	0.0033	0.0016	0.00030	0.0045	0.00020	0.0005	37	0.03	0.06	0.34
Average					**0.0034**	**0.0020**	**0.00053**	**0.0072**	**0.00011**	**0.0007**	**77**	**0.04**	**0.93**	**0.26**

Stormwater Sites: Fox Run, Tamarack Road, 80th Street, 90th Street, and Bailey Lake (at Lift Station)

Fox Run

The Fox Run stormwater recorded stage, velocity, and flow between April 15-October 27, 2003 (Figure 6). The total discharge for this period was 324,032 cf or 7.4 acre-ft. The highest recorded flow was 3.18 cfs on May 11. There was no precipitation gage at this site and no chemistry data was collected at this site.

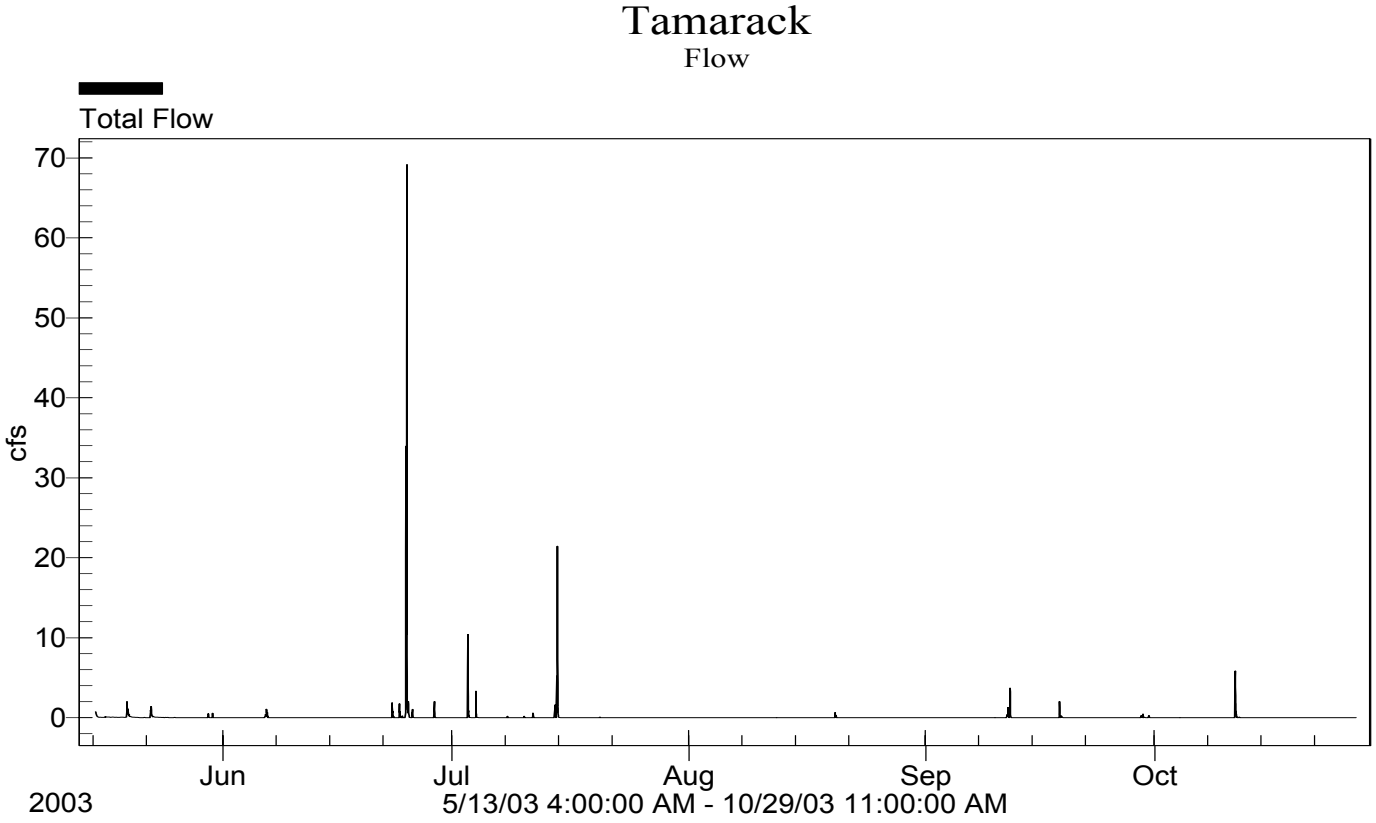
Figure 6. Fox Run 2003 Continuous Flow



Tamarack Road

The Tamarack Road stormwater site recorded stage, velocity, and flow between May 15-October 27, 2003 (Figure 7). The total discharge for this period was 643,227 cf or 14 acre-ft. The highest discharge at this site—69.14 cfs was on June 25, 2003. There was no precipitation gage at this site and no chemistry data was collected at this site.

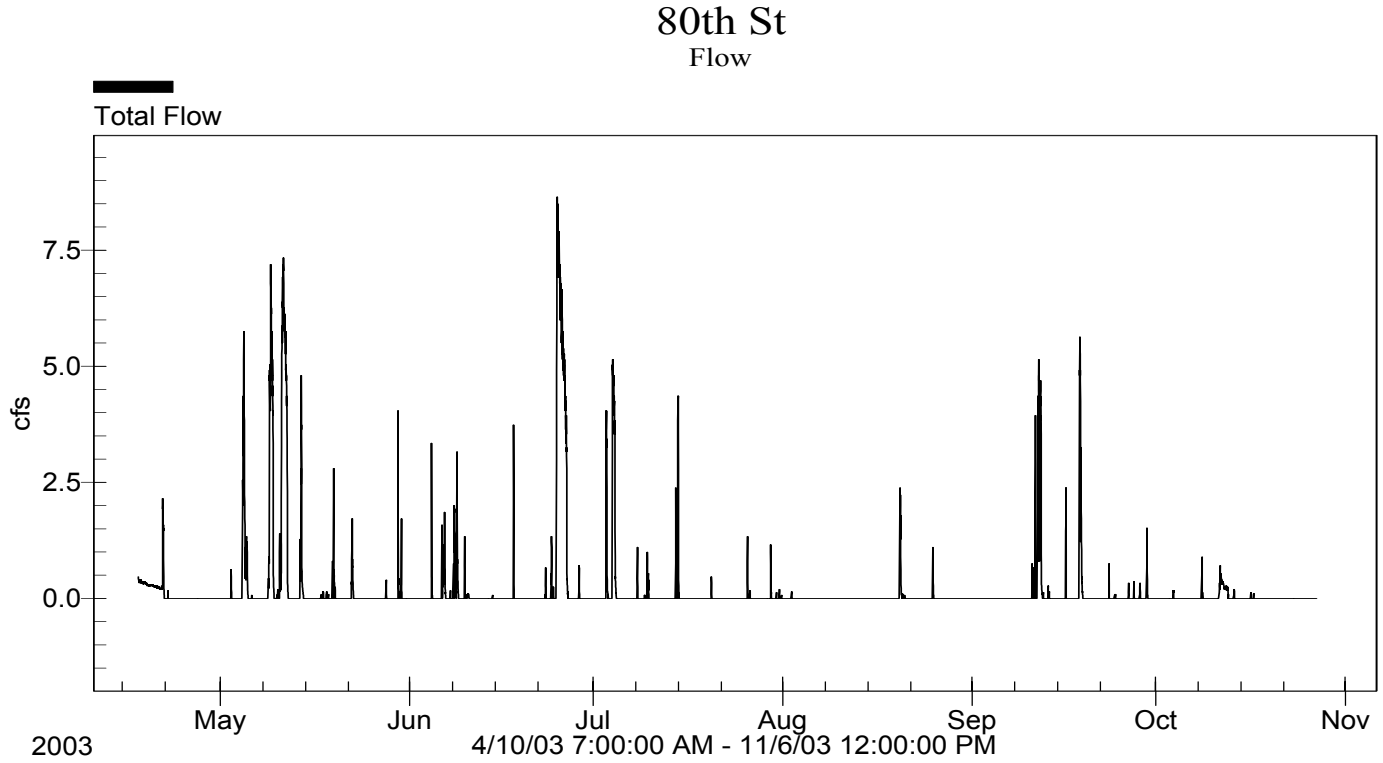
Figure 7. Tamarack Road 2003 Continuous Flow



80th Street

The 80th Street stormwater site recorded stage and flow between April 17-October 27, 2003 (Figure 8). The total discharge for this period was 2,782,247 cf or 63.87 acre-ft. The high flow at this site—8.64 cfs was on June 25, 2003. There was no precipitation gage at this site and no chemistry data was collected at this site.

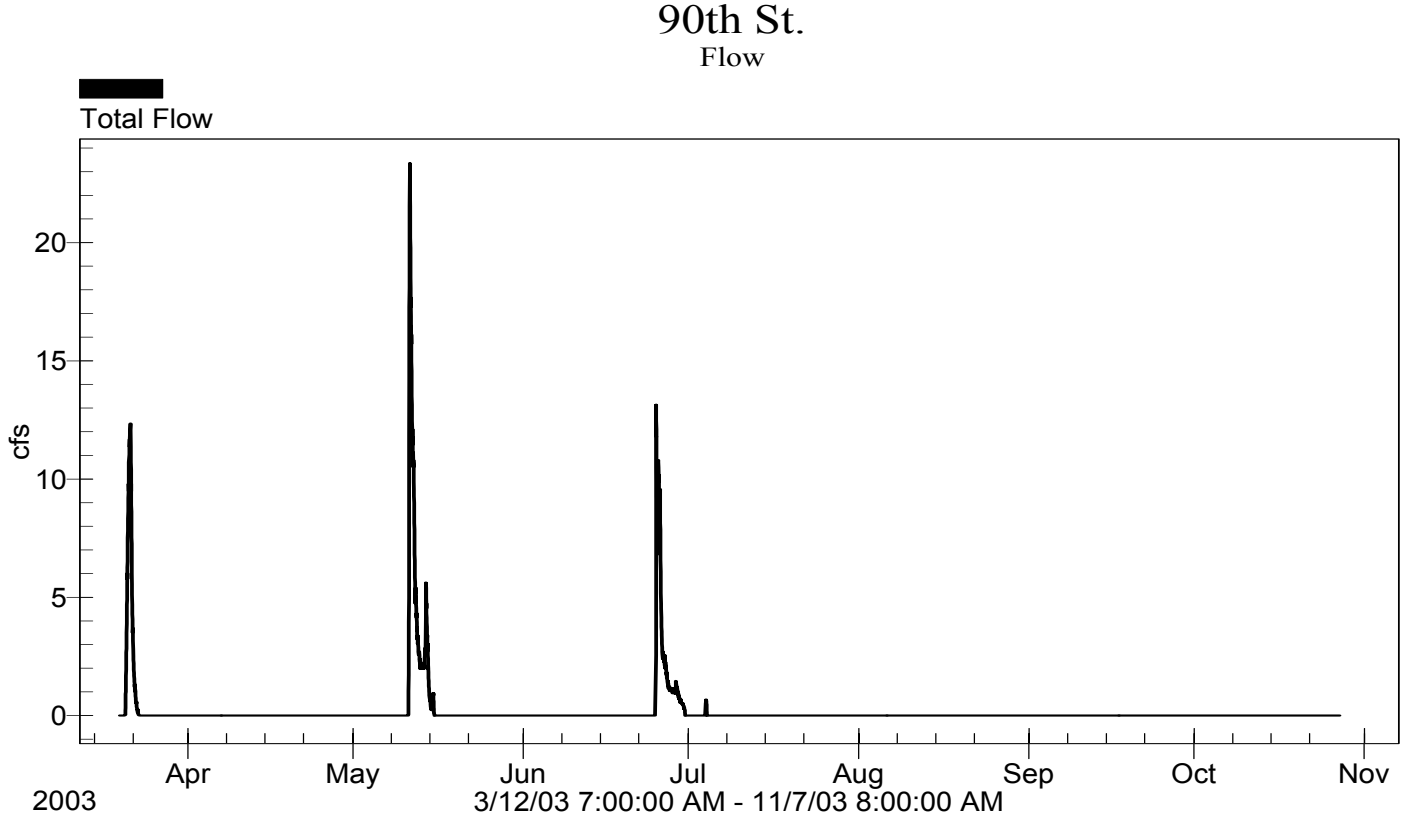
Figure 8. 80th Street 2003 Continuous Flow



90th Street

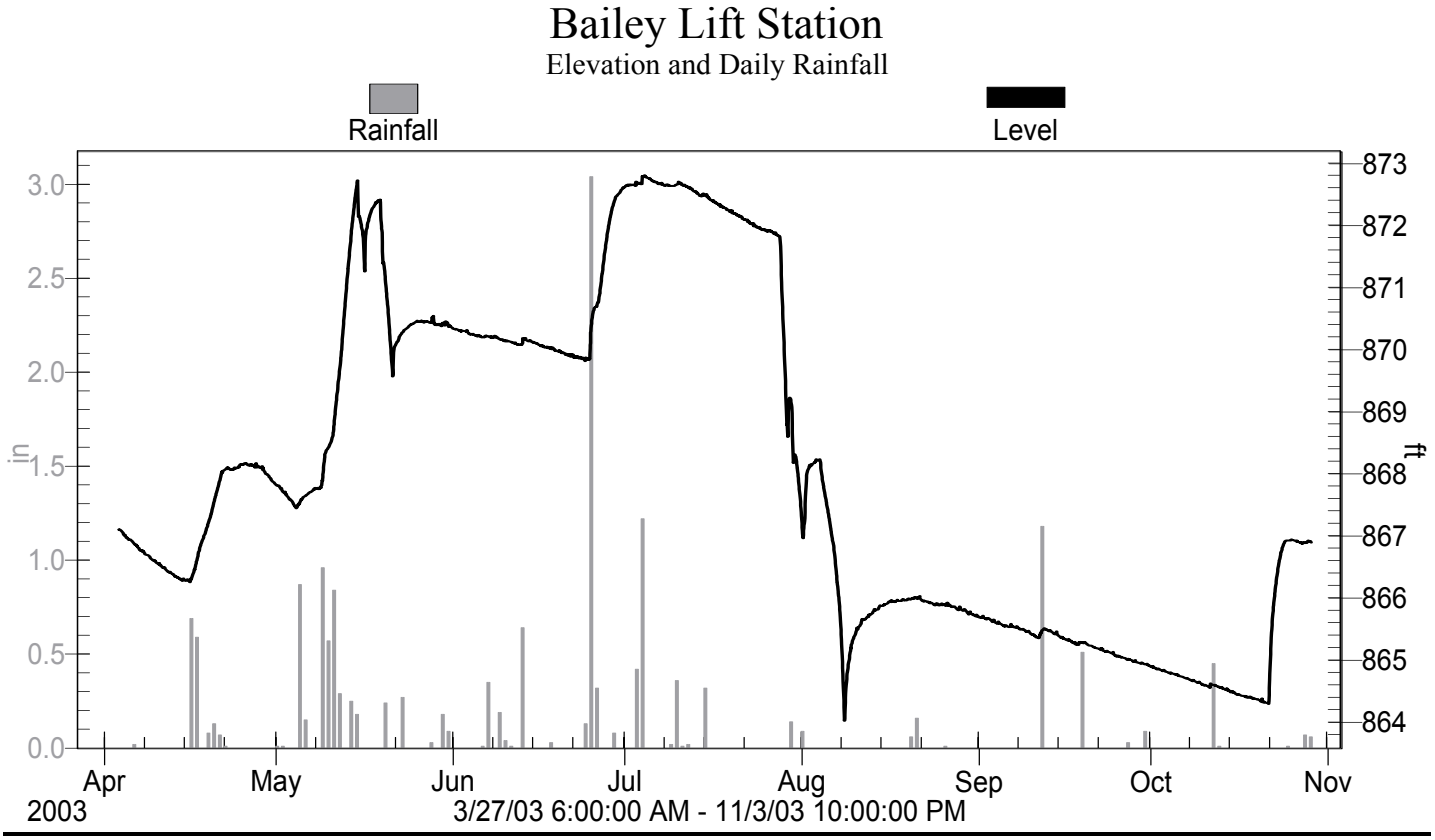
The 90th Street stormwater site recorded stage and flow between March 19-October 27, 2003 (Figure 9). The total discharge for this period was 4,166,310 cf or 96 acre-ft. The highest discharge at this site—26.46 cfs was on August 3, 2002. There was no precipitation gage at this site. No chemistry data was collected at this site.

Figure 9. 90th Street 2003 Continuous Flow



Bailey Lake (at Lift Station)
Continuous stage and precipitation measurements were recorded between April 3-October 29, 2003 at this site (Figure 10). The highest recorded Elevation—872.79 ft., was recorded on July 4, 2003. The average stage during the monitoring season was 868.06 ft. The highest recorded daily precipitation—3.04 inches, was recorded on June 25, 2003.

Figure 10. Bailey Lake (at Lift Station) 2003 Elevation and Daily Precipitation



Armstrong Lake

Vital Statistics:

DNR ID #: 82-0116
LOCATION: NW$^{1/4}$ Section 33 T29N-R21W
MUNICIPALITY: City of Lake Elmo
LAKE SIZE: 28.1 acres (North—7.3 acres, South—20.8 acres)
ORDINARY HIGH WATER MARK: 1019.1 ft

Armstrong Lake was monitored from April 18 to October 14, 2003, in accordance with the Metropolitan Council Citizen-Assisted Monitoring Program (CAMP). Monitoring consisted of 14 biweekly lake gage readings and samplings of Secchi disk, surface total phosphorus, surface total Kjeldahl nitrogen, surface chlorophyll-*a*, and surface total chloride ion. In addition, a temperature and dissolved oxygen profile was taken during each sampling round. The Metropolitan Council Lab analyzed the samples.

Table 7 gives the Armstrong Lake 2003 high, low, and average lake levels. Individual lake level readings are shown in Figure 11.

Table 7. Armstrong 2003 Lake Level

	High	High Date	Low	Low Date	Average
Lake Level (ft)	1019.39	5/12/03	1017.63	9/17/03	1018.30

Figure 11. Armstrong Lake Elevations 2002-03

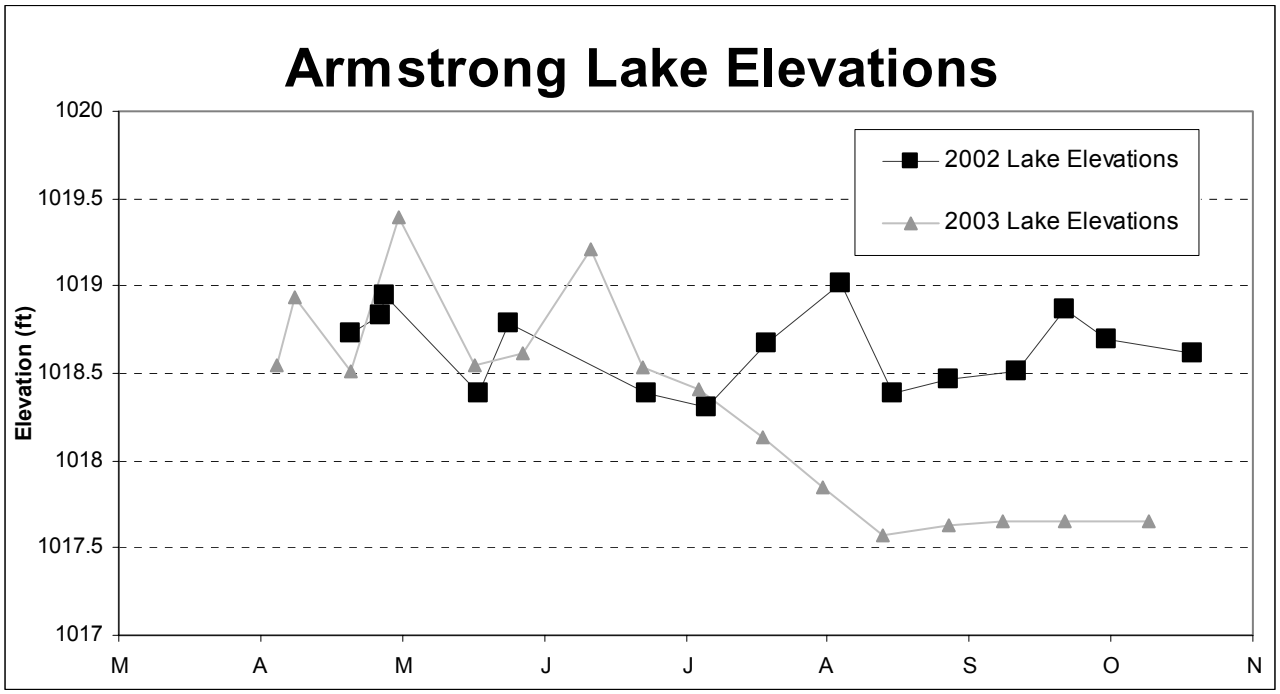


Table 8 gives the 2003 Armstrong Lake monitoring chemistry results for the 2003 water-monitoring season.

Table 8. Armstrong Lake 2003 Monitoring Results

Date	Surface Total Phosphorus (mg/L)	Surface Total Kjeldahl Nitrogen (mg/L)	Chlorophyll *a* (ug/L)	Chloride (mg/L)	Surface Dissolved Oxygen (mg/L)	Surface Temperature (C)
4/18/03	0.099	1.30	47.0	78	8.48	6.20
5/1/03	0.060	1.10	25.0	77	NA	NA
5/12/03	0.088	1.50	31.0	75	7.60	11.30
5/30/03	0.081	0.94	28.0	72	4.27	19.50
6/10/03	0.069	1.40	14.0	71	2.81	20.40
6/26/03	0.128	1.00	13.0	29	4.47	19.50
7/8/03	0.235	1.50	8.0	47	2.02	23.60
7/21/03	0.049	0.67	6.10	69	3.55	22.20
8/5/03	0.068	1.20	14.0	70	3.53	21.60
8/19/03	0.042	1.10	4.7	60	8.80	27.30
9/2/03	0.046	0.91	9.7	77	3.65	19.80
9/17/03	0.064	1.40	13.0	82	4.31	19.40
9/30/03	0.036	1.50	9.3	88	13.27	9.50
10/14/03	0.147	1.80	30.0	93	8.66	12.50
2003 Averages	**0.087**	**1.24**	**18.1**	**71**	**5.80**	**17.91**

Table 9 shows the Armstrong Lake Water Quality Summary. Armstrong Lake showed a slight improvement in water quality in 2003. The lake received an average lake grade of a C- for 2003, compared to a D in 2002.

Table 9. Lake Grade and Trophic Status.

	Trophic Status (2002 Average)	Lake Grade (2002 Average)	Trophic Status (2003 Average)	Lake Grade (2003 Average)
Total Phosphorus (mg/L)	Hypereutrophic	D	Hypereutrophic	D
Chlorophyll-a (ug/L)	Eutrophic	C+	Eutrophic	B-
Secchi disk (ft)	Eutrophic	D	Eutrophic	D
Overall	Eutrophic	D	Eutrophic	C-

Figure 12-16 compare the lake chemistry data and Secchi disk readings. Although there were no statistically significant correlations between water quality parameters, general trends can be noted. There was a weak positive relationship between TKN and Chloride ions: as TKN increased, Total Chloride ion increased. A weak positive correlation was found between Secchi and CLA. As Secchi disk readings increased, CLA increased as well. There was also a weak positive relationship between CLA and Total Chloride ions. As CLA increased, Total Chloride ion also increased. No correlation was found between Secchi and TP, Secchi and TKN, and Secchi and Total Chloride ions as well as between TP and CLA. There was a weak negative relationship between TP and Total Chloride ion. As TP increased, Total Chloride ion decreased. There were strong positive correlations between TKN and TP and TKN and CLA. As TKN increased, both TP and CLA increased. These correlations are further simplified in Table 12.

Figure 12. Secchi, Total Kjeldahl Nitrogen and Chlorophyll-*a*

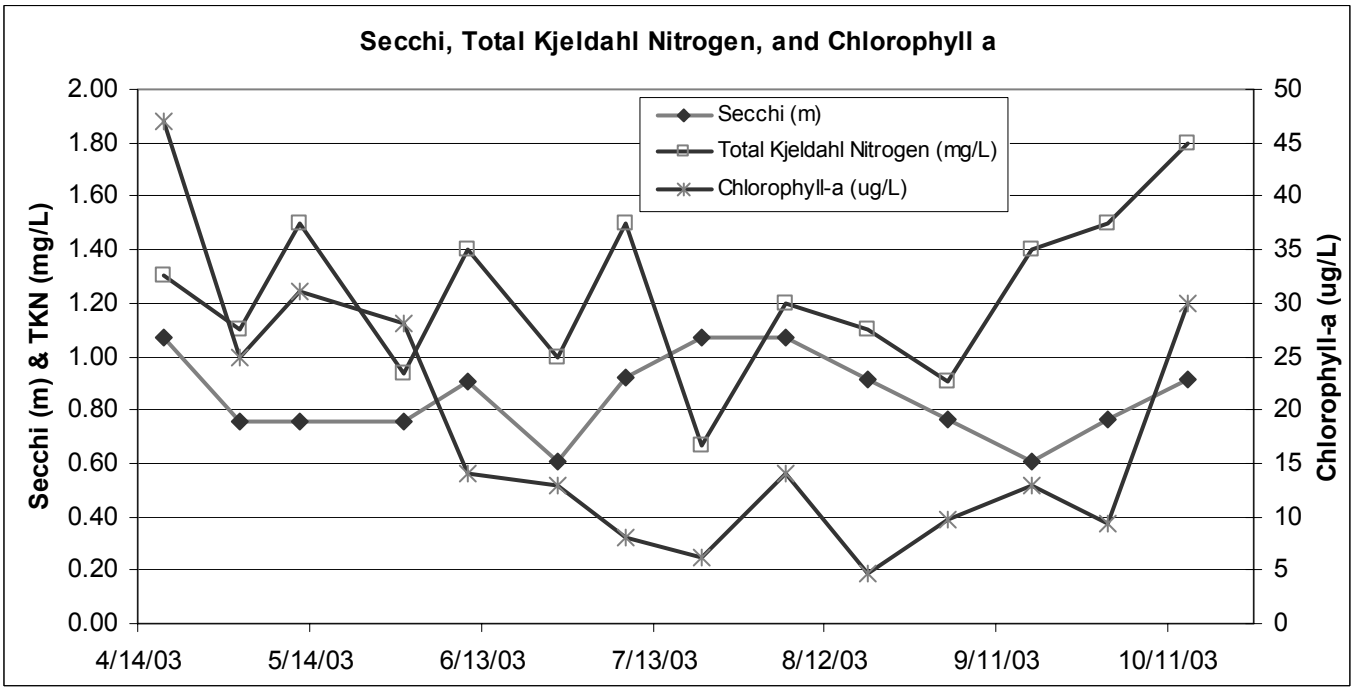


Figure 13. Secchi, Total Kjeldahl Nitrogen, and Total Phosphorus

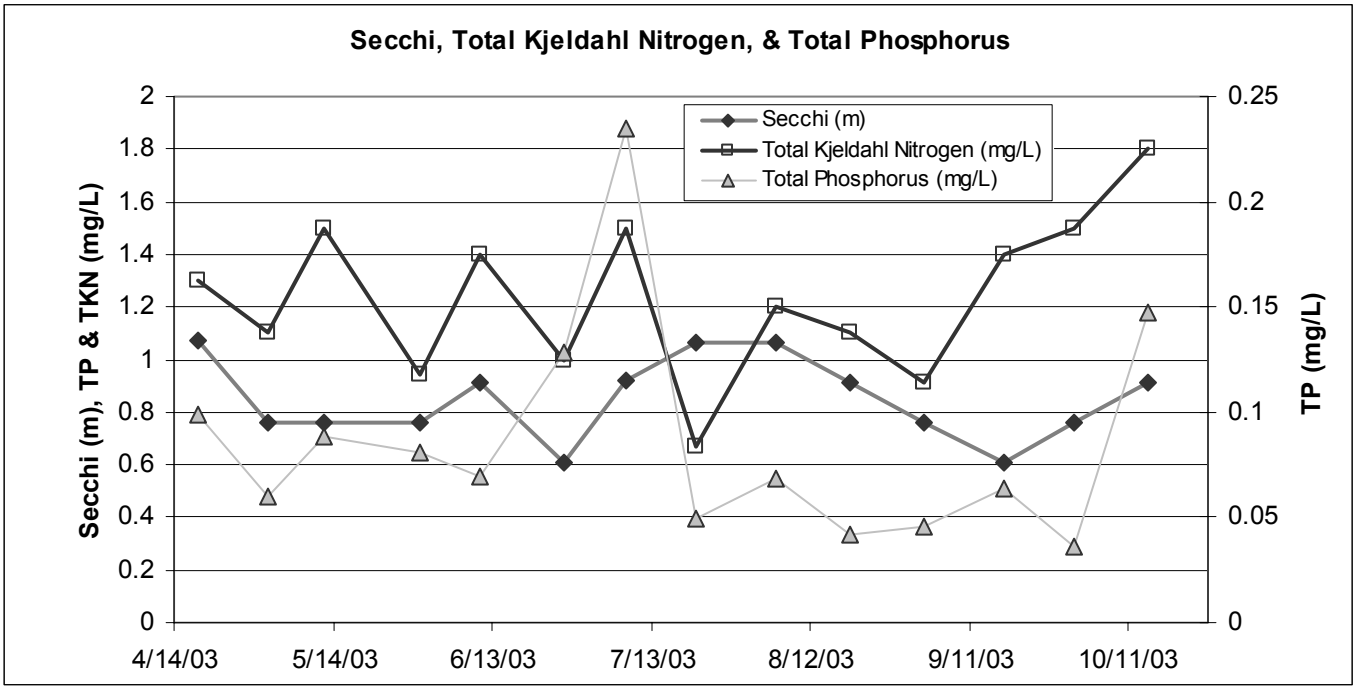


Figure 14. Secchi and Chloride ion

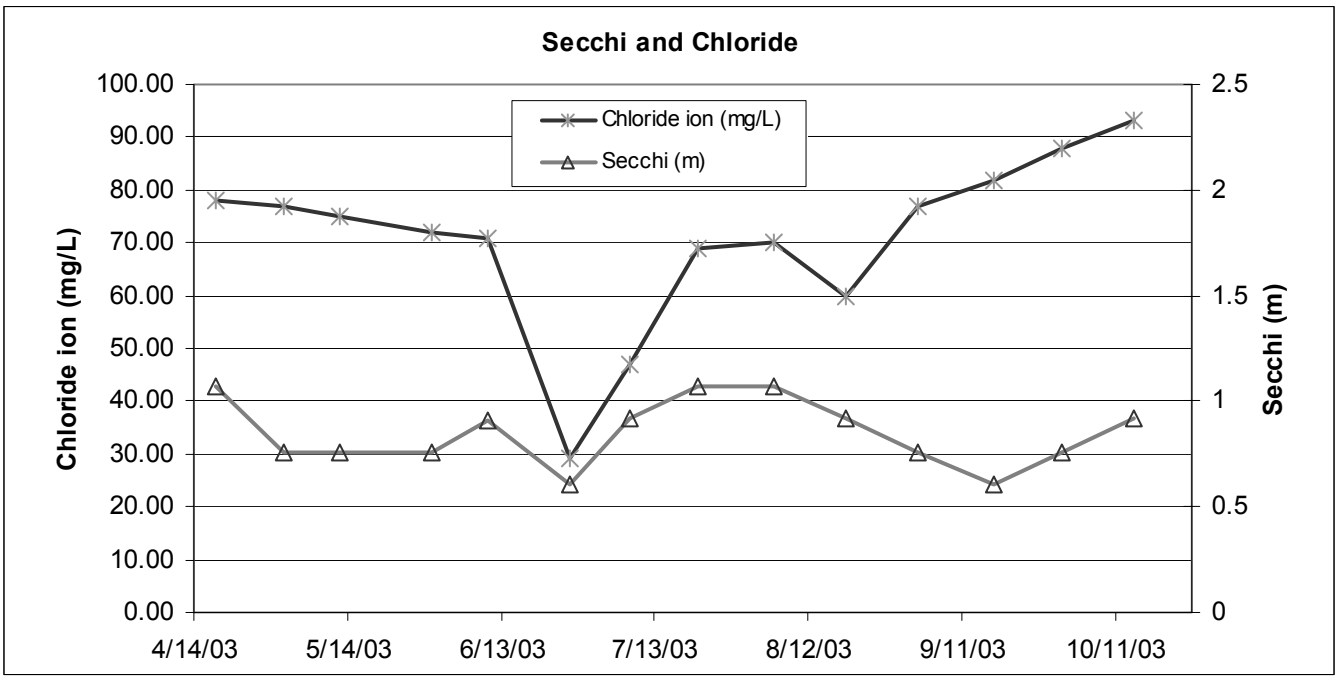


Figure 15. Total Phosphorous and Chlorophyll *a*

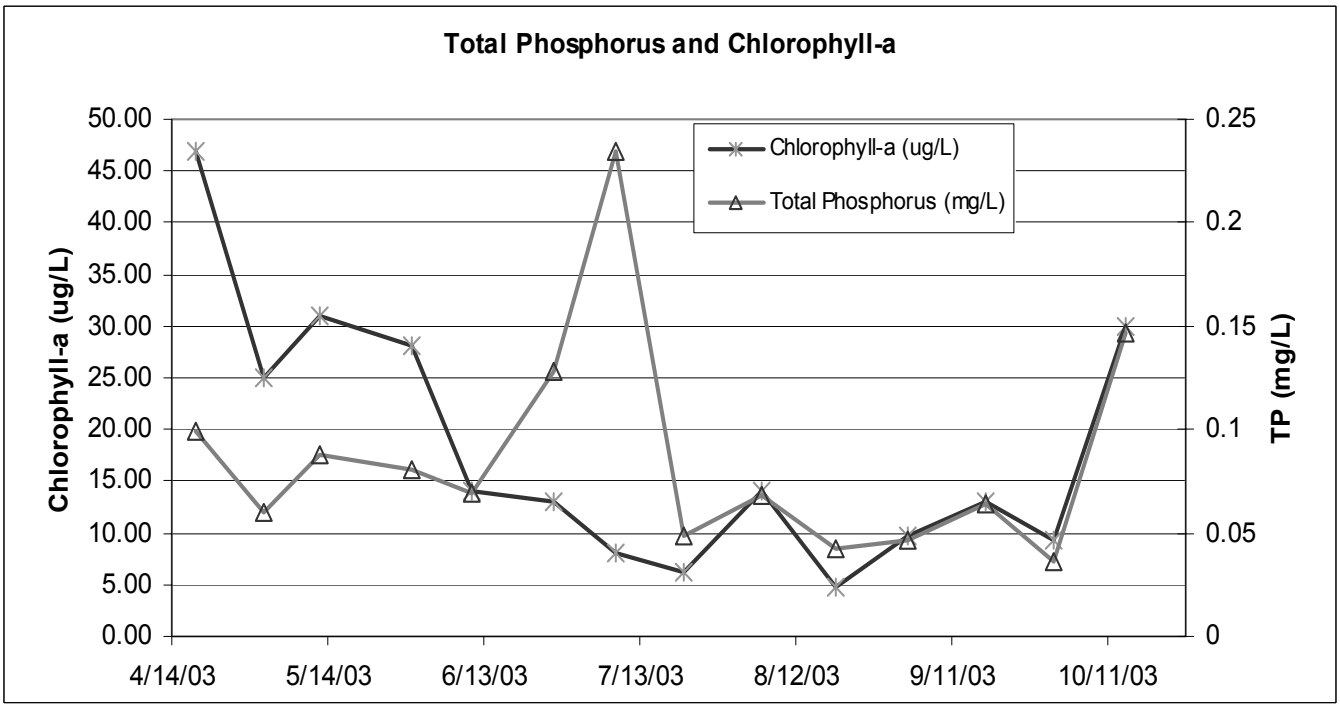


Figure 16. Total Kjeldahl Nitrogen and Chloride ion

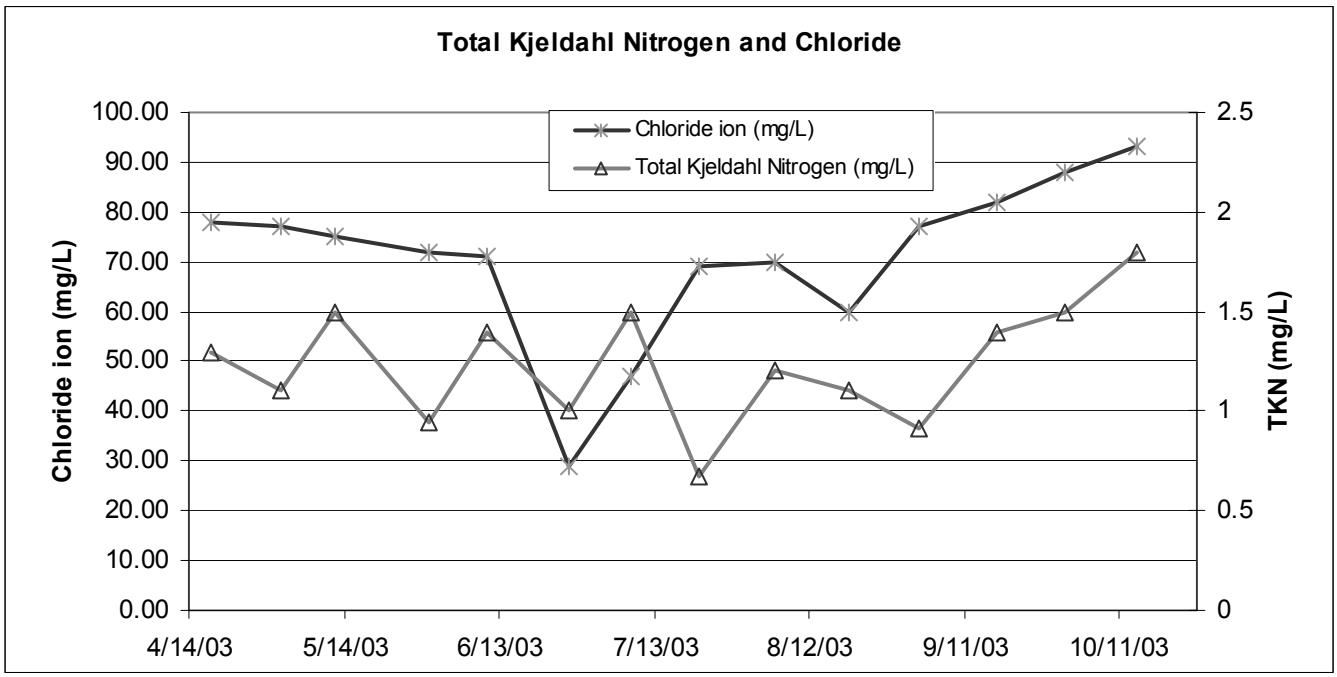


Table 10. Lake Parameter Relationships

	Secchi	TKN	TP	CLA	Chloride
Secchi		None	None	+	None
TKN			**+**	**+**	+
TP				None	--
CLA					+
Chloride					

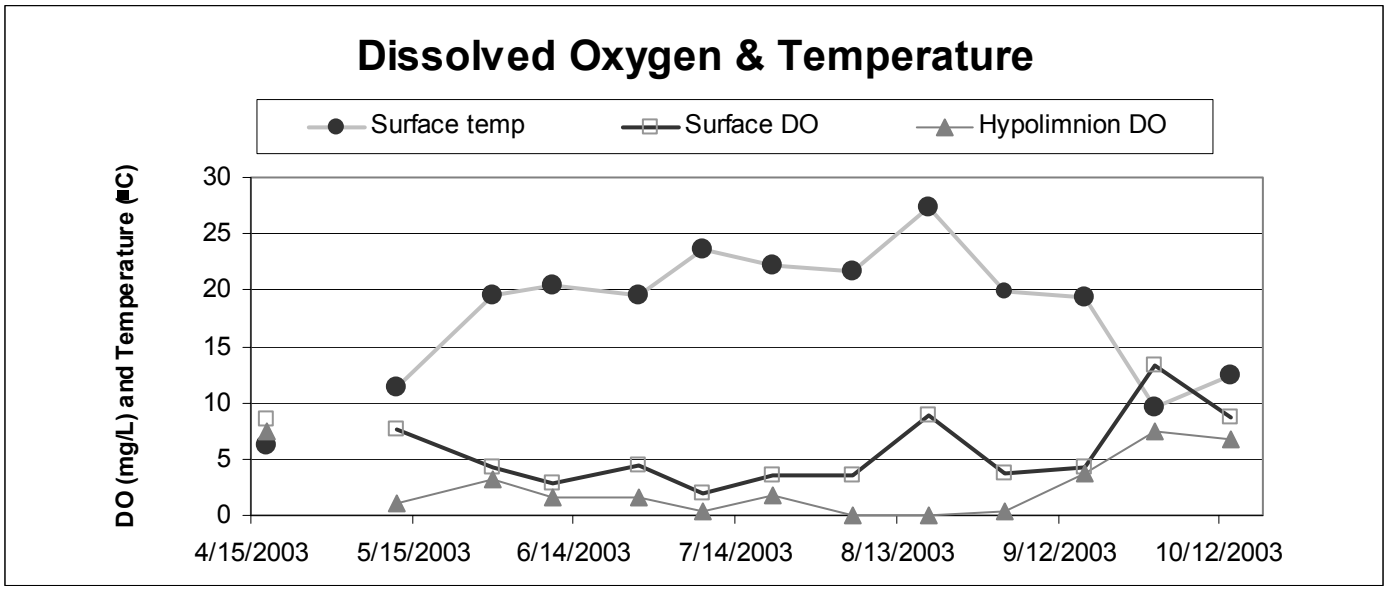
Table 11 lists the dissolved oxygen and temperature profiles. The maximum depth was between 1 and 2 meters. No thermocline was present in the lake. The surface dissolved oxygen and surface temperatures are shown in Figure 17.

Table 11. Dissolved Oxygen and Temperature Profiles

	4/18/03		5/1/03		5/12/03		5/30/03		6/10/03		6/26/03		7/8/03	
Depth (m)	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**
surface	8.48	6.2	NA	NA	7.6	11.3	4.27	19.5	2.81	20.4	4.47	19.5	2.02	23.6
1	7.44	6.2			7.35	11.2	3.22	19.4	1.64	18.8	3.41	19.5	0.5	23.1
2	7.39	6.2			1.13	11.2	3.24	19.4			1.62	19.5	0.38	23

	7/21/03		8/5/03		8/19/03		9/2/03		9/17/03		9/30/03		10/14/03	
Depth (m)	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**	**DO (mg/L)**	**Temp (ºC)**
surface	3.55	22.2	3.53	21.6	8.8	27.3	3.65	19.8	4.31	19.4	13.27	9.5	8.66	12.5
1	1.85	21.7	0.42	21.5	0.09	23.6	0.3	19.8	3.81	19.4	7.54	9.5	6.82	12.5
2			0.01	21.1	0.06	23.1								

Figure 17. Surface Dissolved Oxygen and Surface Temperatures



Powers Lake

Vital Statistics:

DNR ID #: 82-0092
LOCATION: SW$^{1/4}$ Section 11 T28N-R21W
MUNICIPALITY: City of Woodbury
LAKE SIZE: 54 acres
ORDINARY HIGH WATER MARK: 891.3 ft

Powers Lake was monitored from April 18 to October 14, 2003, in accordance with the Metropolitan Council Citizen-Assisted Monitoring Program (CAMP). Monitoring consisted of 14 biweekly lake gage readings and samplings of Secchi disk, surface total phosphorus, surface total Kjeldahl nitrogen, surface chlorophyll-*a*, and surface total chloride ion. In addition, a temperature and dissolved oxygen profile was taken during each sampling round. The Metropolitan Council Lab analyzed the samples.

Table 12 gives the Powers Lake 2003 high, low, and average lake levels. Individual lake level readings are shown in Figure 18.

Table 12. Powers 2003 Lake Level

	High	High Date	Low	Low Date	Average
Lake Level (ft)	889.09	6/2/03	885.56	10/10/03	887.40

Figure 18. Powers Lake Elevations 2002-03

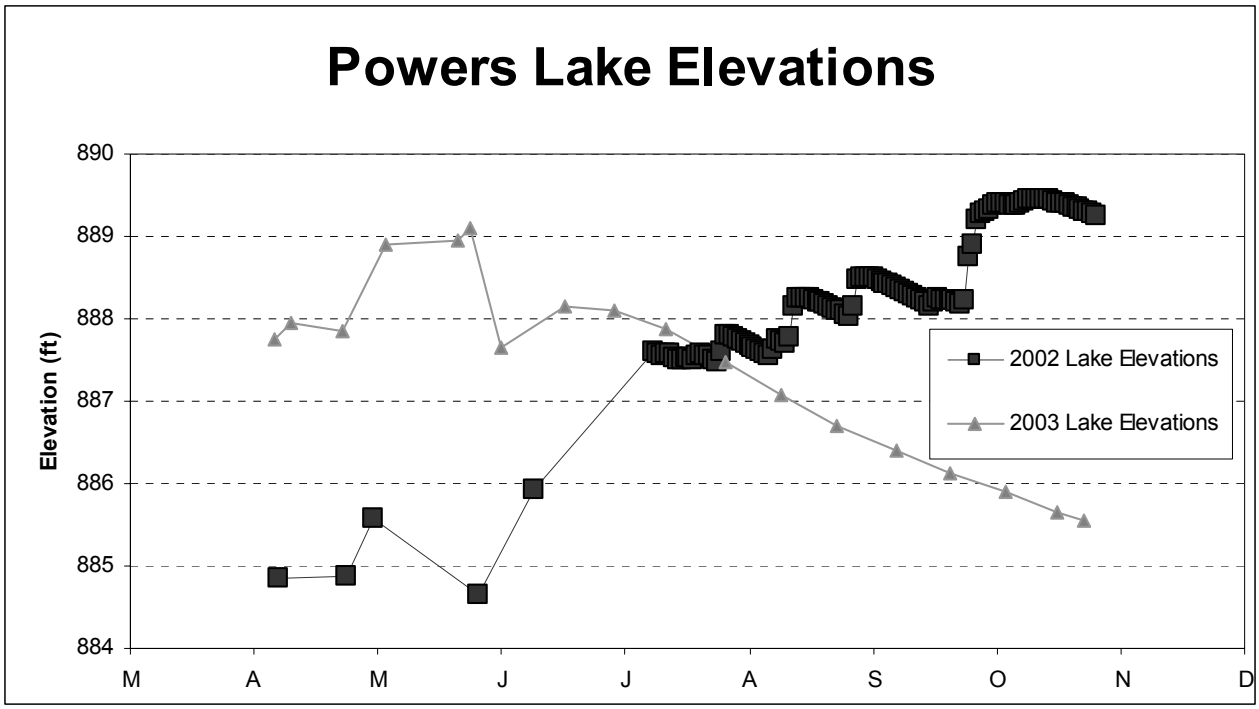


Table 13 gives the 2003 Powers Lake monitoring chemistry results for the 2003 water-monitoring season.

Table 13. Powers 2003 Monitoring Results

Date	Surface Total Phosphorus (mg/L)	Surface Total Kjeldahl Nitrogen (mg/L)	Chlorophyll *a* (ug/L)	Chloride (mg/L)	Surface Dissolved Oxygen (mg/L)	Surface Temperature (C)
4/18/03	0.036	0.82	6.5	30	8.17	8.80
5/1/03	0.023	0.66	3.2	20	NA	NA
5/12/03	0.032	1.00	5.8	27	7.91	12.60
5/30/03	0.070	1.20	9.3	28	5.63	19.80
6/10/03	0.020	0.67	7.8	27	2.58	20.50
6/26/03	0.035	0.82	14.0	26	8.01	22.60
7/8/03	0.032	0.95	15.0	26	8.01	26.00
7/21/03	0.040	1.40	42.0	27	4.93	25.10
8/5/03	0.049	1.10	33.0	27	8.04	24.90
8/19/03	0.019	0.88	25.0	27	9.90	25.70
9/2/03	0.027	0.92	31.0	28	6.77	23.40
9/17/03	0.024	1.10	28.0	28	7.30	21.10
9/30/03	0.036	1.20	27.0	27	7.89	13.40
10/14/03	0.132	1.80	36.0	28	9.38	13.90
2003 Averages	**0.041**	**1.04**	**20.3**	**27**	**7.27**	**19.83**

Table 14 shows the Powers Lake Water Quality Summary. Powers Lake received an average lake grade of a C for 2003.

Table 14. Lake Grade and Trophic Status.

	Trophic Status (2003 Average)	Lake Grade (2003 Average)
Total Phosphorus (mg/L)	Eutrophic	C
Chlorophyll-a (ug/L)	Eutrophic	C+
Secchi disk (ft)	Mesotrophic	C+
Overall	Eutrophic	C

Figure 19-23 compare the lake chemistry data and Secchi disk readings. Although there were no statistically significant correlations between water quality parameters, general trends can be noted. There was a weak negative relationship between Secchi and TKN: as Secchi readings increased TKN decreased. There was a weak positive relationship between TKN and CLA. As TKN increased, CLA also increased. No correlation was found between any of one the parameters with Total Chloride ions as well as no correlation between Secchi and TP. There was a stronger correlation between TKN and TP, TP and CLA, and Secchi and CLA. As TKN increased so did the TP. When the TP increased, the CLA also increased and when the CLA increased, the secchi decreased. These correlations are further simplified in Table 15.

Figure 19. Secchi, Total Kjeldahl Nitrogen and Chlorophyll-*a*

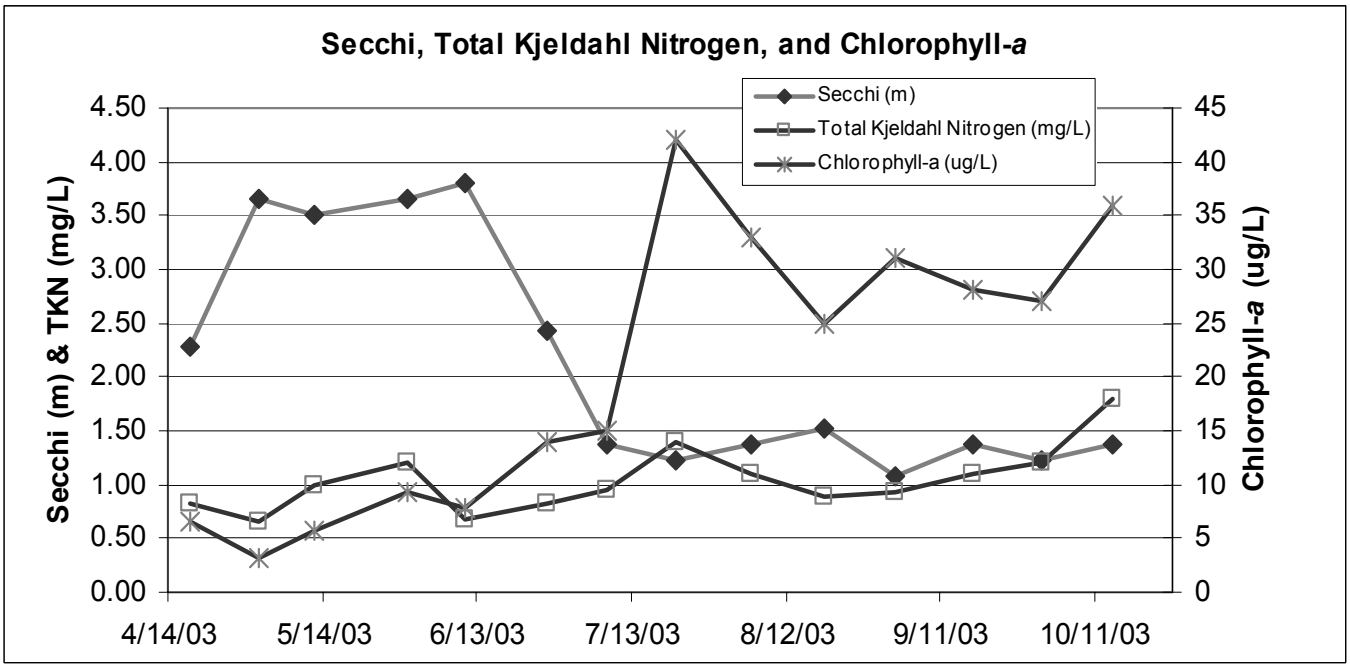


Figure 20. Secchi, Total Kjeldahl Nitrogen, and Total Phosphorus

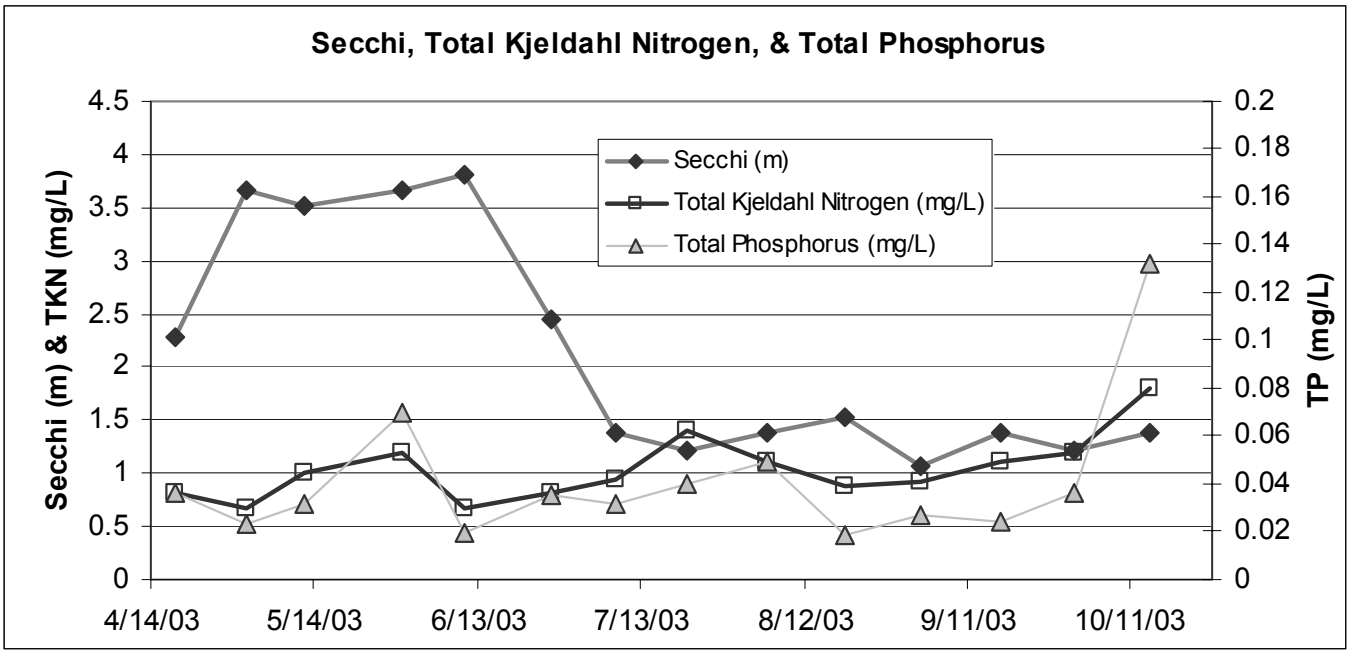


Figure 21. Secchi and Chloride ion

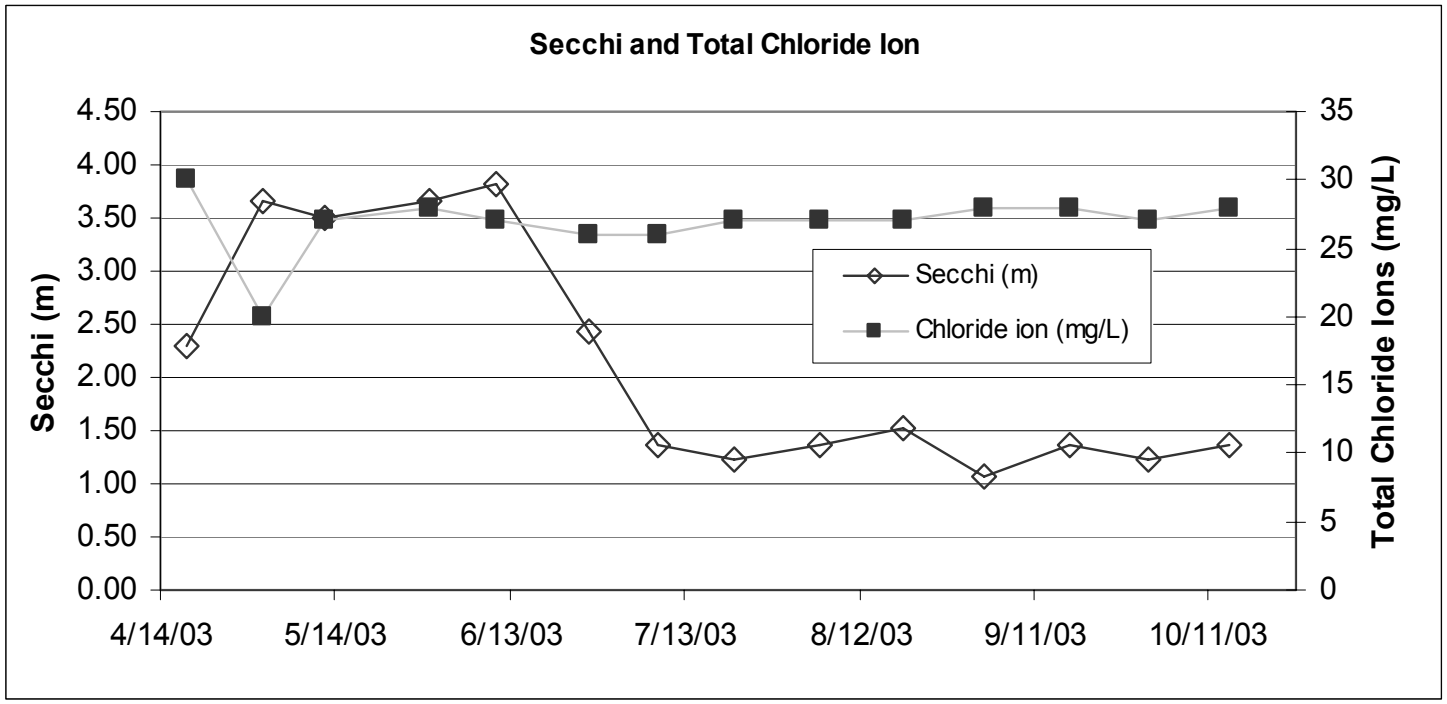


Figure 22. Total Phosphorous and Chlorophyll *a*

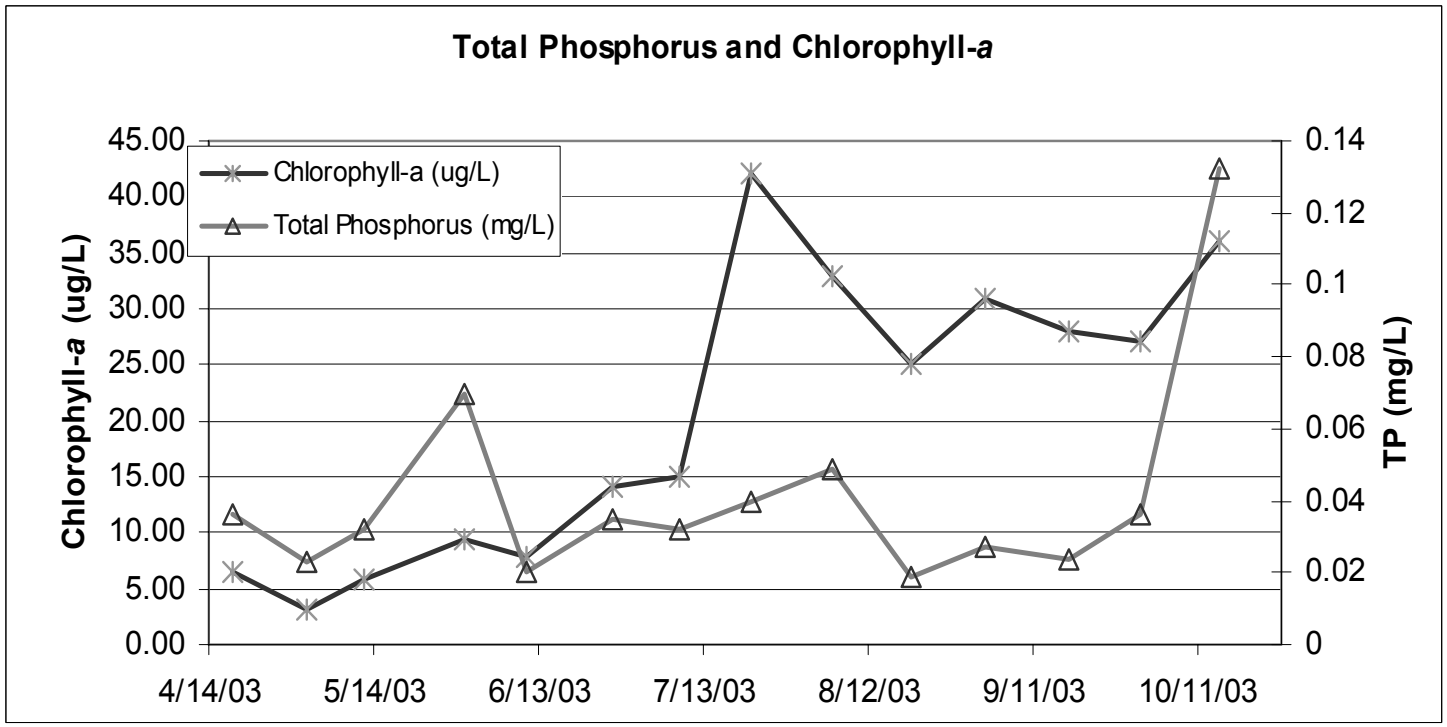


Figure 23. Total Kjeldahl Nitrogen and Chloride ion

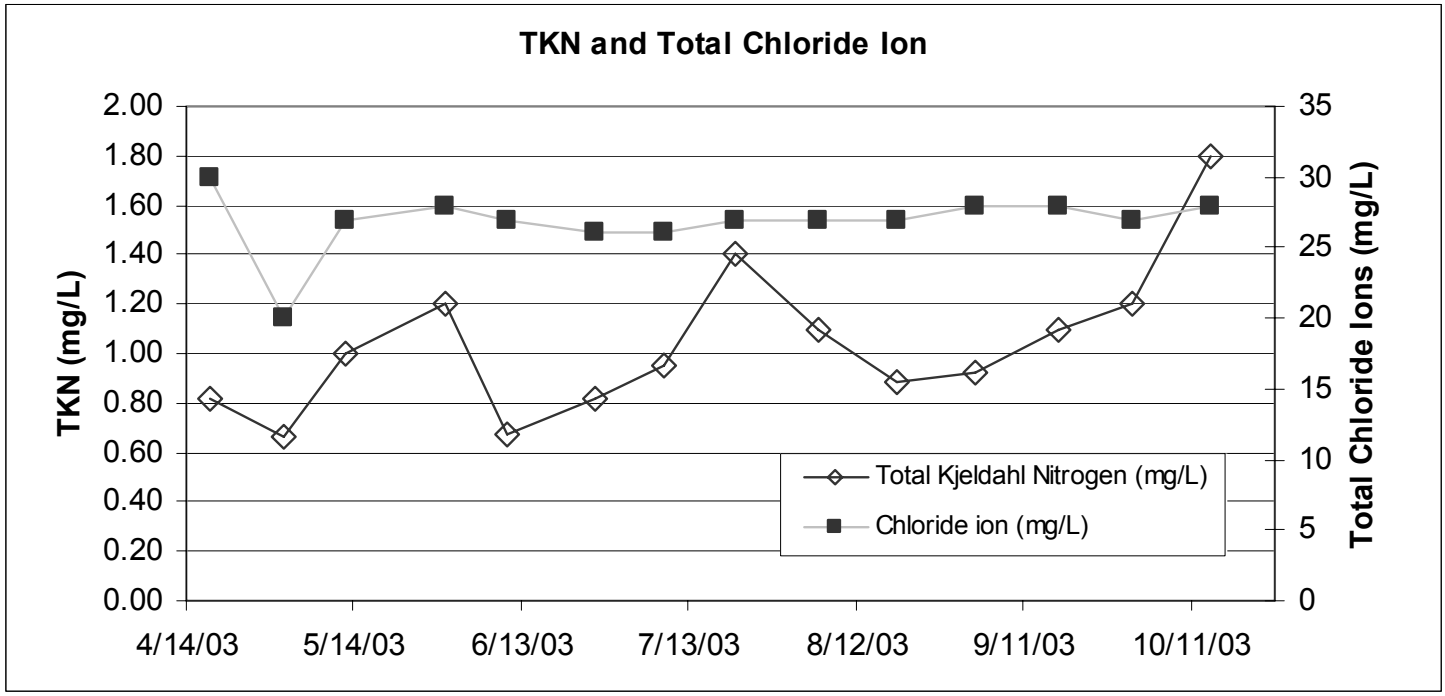


Table 15. Lake Parameter Relationships

	Secchi	TKN	TP	CLA	Chloride
Secchi		--	None	**--**	None
TKN			**+**	**+**	None
TP				+	None
CLA					None
Chloride					

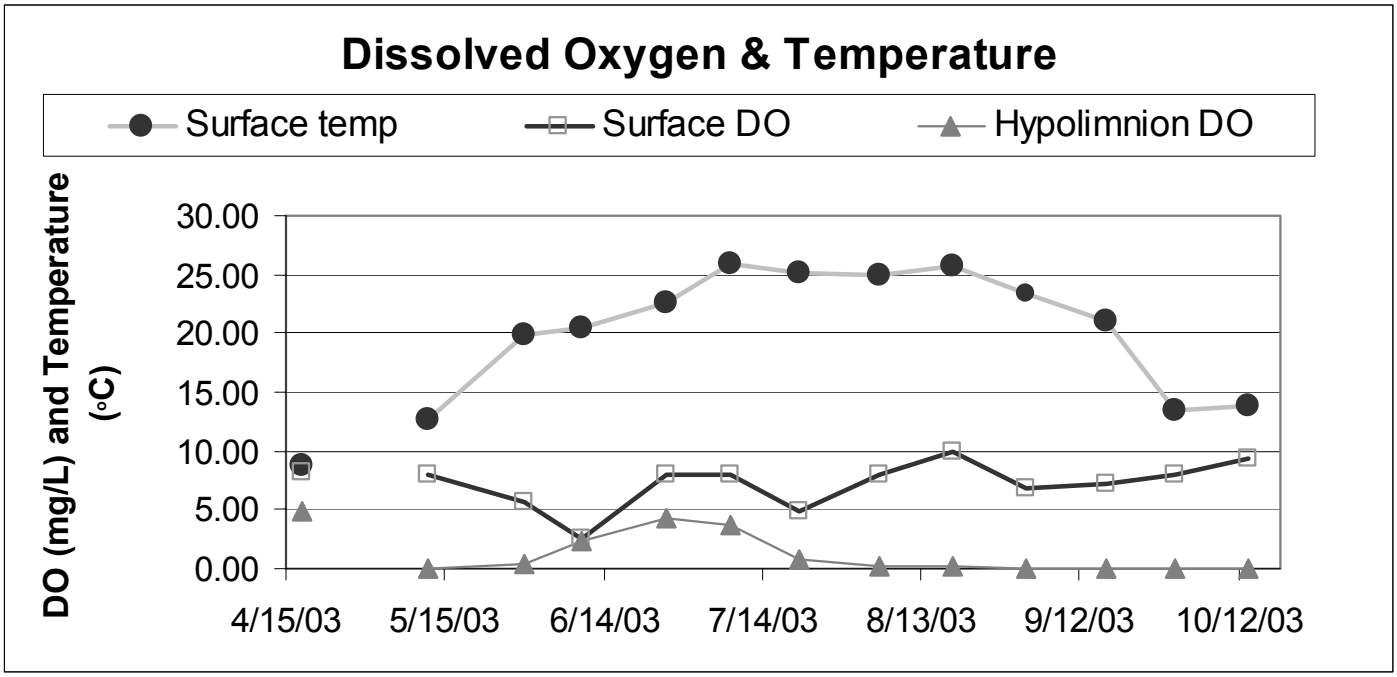
Table 16 lists the dissolved oxygen and temperature profiles. The maximum depth was approximately 12 meters depending on the level of the lake at the time of sampling. A thermocline was present between 6 and 7 meters during the majority of the monitoring season. The surface dissolved oxygen and surface temperatures are shown in Figure 24.

Table 16. Dissolved Oxygen and Temperature Profiles

Date	4/18/03 9:50		5/1/03 15:54		5/12/03 9:15		5/30/03 7:35		6/10/03 14:15		6/26/03 9:30		7/8/03 9:50	
Depth (m)	D.O. (mg/L)	Temp (C)	D.O. (mg/L)	Temp (C)	D.O. (mg/L)	Temp (C)	D.O. (mg/L)	Temp (C)	D.O. (mg/L)	Temp (C)	D.O. (mg/L)	Temp (C)	D.O. (mg/L)	Temp (C)
0	8.17	8.8	NA	NA	7.91	12.6	5.63	19.8	2.58	20.5	8.01	22.3	8.01	26
1	7.92	8.8			7.7	12.5	5.53	19.8	2.57	20.5	7.6	22.4	7.56	26
2	7.89	8.9			7.67	12.5	5.5	19.1	2.64	19.8	7.68	22.5	7.85	26.1
3	7.82	8.8			7.98	12.5	5.71	18.6	2.54	19.3	7.52	22.5	6.78	23.8
4	7.86	8.8			7.84	12.4	5.2	16.5	2.52	18.4	7.62	22.4	3.71	21.8
5	7.75	8.8			7.44	12.3	5.06	15	2.66	16.3	9.01	19	2.61	18.9
6	7.6	7			6.91	11.4	3.77	12.6	2.62	12.8	4.2	15	0.66	15.1
7	7.12	6.4			5.41	9.4	2.4	10.6	2.26	11.3	1.42	13.2	0.56	12
8	6.68	5.9			2.82	7.5	0.34	8.7	1.74	9.3	0.92	11.3	0.45	10.2
9	6.05	5.5			1.35	6.9	0.05	7.9	1.43	8.2	0.46	9	0.37	9.3
10	5.6	5.3			0.66	6.6	0.04	7.3	1.13	7.9	0.28	8.8	0.24	9
11	4.94	5.2			0.24	6.4	0.17	7.1	1	7.7	0.23	8.7	0.22	8.8
12					0.05	6.4	0.17	7	0.76	7.3	0.2	8.3	0.24	8.6
13							0.16	6.9	0.59	7.2	0.19	8.1		
14							0.16	6.9						
15							0.15	6.9						
16							0.15	6.9						

Date	7/21/03 10:50		8/5/03 10:00		8/19/03 11:50		9/2/03 8:30		9/17/03 8:25		9/30/03 13:20		10/14/03 12:30	
Depth (m)	D.O. (mg/L)	Temp (C)	D.O. (mg/L)	Temp (C)	D.O. (mg/L)	Temp (C)	D.O. (mg/L)	Temp (C)	D.O. (mg/L)	Temp (C)	D.O. (mg/L)	Temp (C)	D.O. (mg/L)	Temp (C)
0	4.93	25.1	8.04	24.9	9.9	27.5	6.77	23.4	7.3	21.1	7.89	13.4	9.38	13.9
1	4.92	25	7.77	25	9.78	27.4	6.05	23.5	6.88	21.1	7.77	13.4	9.04	13.8
2	4.62	24.8	7.67	25	9.2	27.1	6.01	23.4	6.92	21.1	7.61	13.4	9.1	13.7
3	0.87	23.7	6.04	24.7	8.11	26.4	5.97	23.4	7	21.1	7.48	13.4	9.31	13.7
4	0.02	22.3	0.23	22.4	0.12	22.5	2.79	23.1	5.89	20.9	7.69	13.4	9.23	13.7
5	0.01	19.9	0.05	18.7	0.65	18.8	0.08	19.1	4.26	20.4	7.52	13.4	3.17	12.5
6	0.03	15.4	0.02	14.9	0.12	15	0.03	14.8	0.03	16.7	7.74	13.4	2.46	12.3
7	0.01	12.2	0.01	12.1	0.01	12	0.03	12	0.03	11.6	7.7	13.4	0.14	12
8	0	10.3	0.01	10.4	0.08	10.1	0.03	10.2	0.02	10.9	2.46	12	0.08	11.8
9	0.01	9.5	0.01	9.5	0.01	9.6	0.01	9.7	0.01	9.9	0.06	9.8	0.05	11.6
10	0.02	9	0	9.1	0.01	9.2	0.01	9.3	0.01	9.4	0.04	9.7	0.03	10.6
11	0.01	8.8	0	8.9	0	9	0.01	9	0.01	9.2	0.03	9.2	0.04	9.8
12			0	8.8	0	8.9	0.01	8.9	0.01	9.1	0.02	9		
13							0.01	8.8						
14														
15														
16														

Figure 24. Surface Dissolved Oxygen and Surface Temperatures



Lake Gages

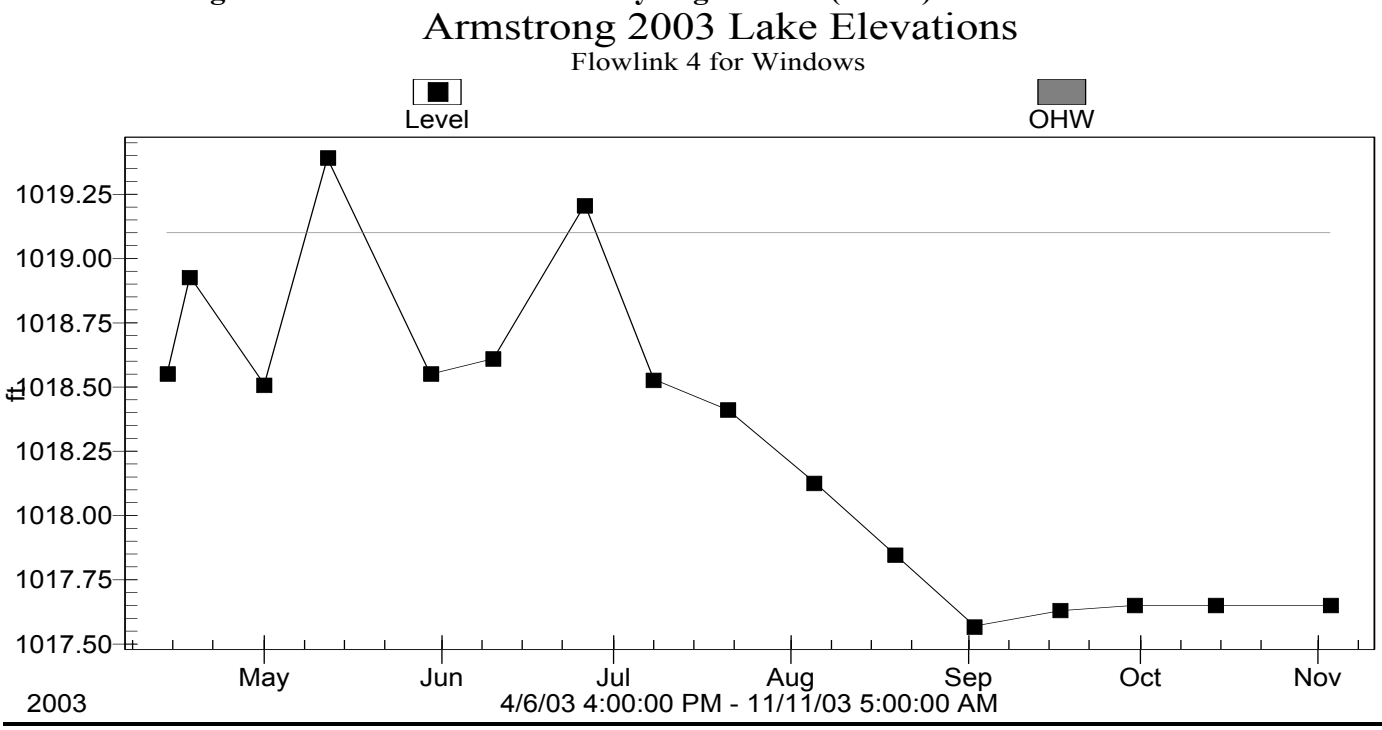
Lake gages were read biweekly on nine lakes in SWWD from April 1-November 3, 2003. Table 17 lists the high, low, range and average elevations for each lake monitored in 2003. Figure 25a-2i shows the fluctuation in elevation for each lake monitored in 2003.

Table 17. SWWD 2003 Lake Gage Readings

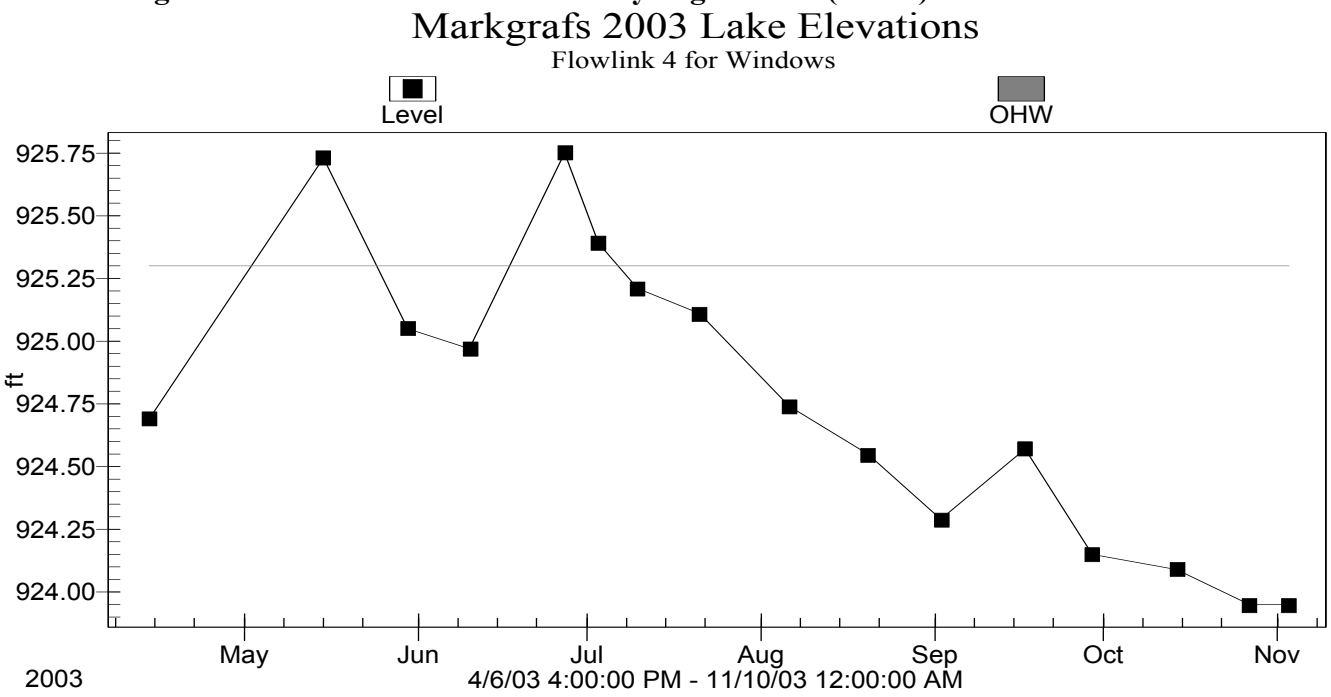
Lake Name	DNR ID#	Dates Monitored	# Readings	Lowest Reading (ft) Date	Highest Reading (ft) Date	Range (ft)	Average Elevation (ft)	OHW (ft)
Cottage Grove Ravine Park	82-0087	4/1/03-11/3/03	16	771.29 4/9/03	771.98 9/29/03	0.69	771.66	770.70
Markgrafs	82-0089	4/1/03-11/3/03	16	923.95 10/27/03	925.75 6/07/03	1.80	924.76	925.30
Wilmes	82-0090	4/1/03-11/3/03	17	900.04 11/3/03	903.56 5/15/03	3.52	901.68	902.60
Powers	82-0092	4/1/03-11/3/03	18	885.56 11/3/03	889.09 6/2/03	3.53	887.40	891.30
Colby	82-0094	4/1/03-11/3/03	16	889.11 11/3/03	891.89 6/27/03	2.78	890.22	891.80
Bailey	82-0456	4/1/03-11/3/03	15	866.28 9/29/03	872.96 5/15/2003 and 7/3/03	6.68	869.08	NA
Armstrong	82-0116-02	4/1/03-11/3/03	16	1017.57 9/2/03	1019.39 5/12/03	1.82	1018.30	1019.10
Vandeberg	82-0084	4/1/03-11/3/03	16	840.85 4/9/03	842.17 7/10/03	1.32	841.73	NA
Fish	82-0093	8/27/03-11/3/03	9	912.79 11/3/03	913.89 8/27/03	1.10	913.32	916.40

Figure 25a-25i. SWWD 2003 Lake Elevations

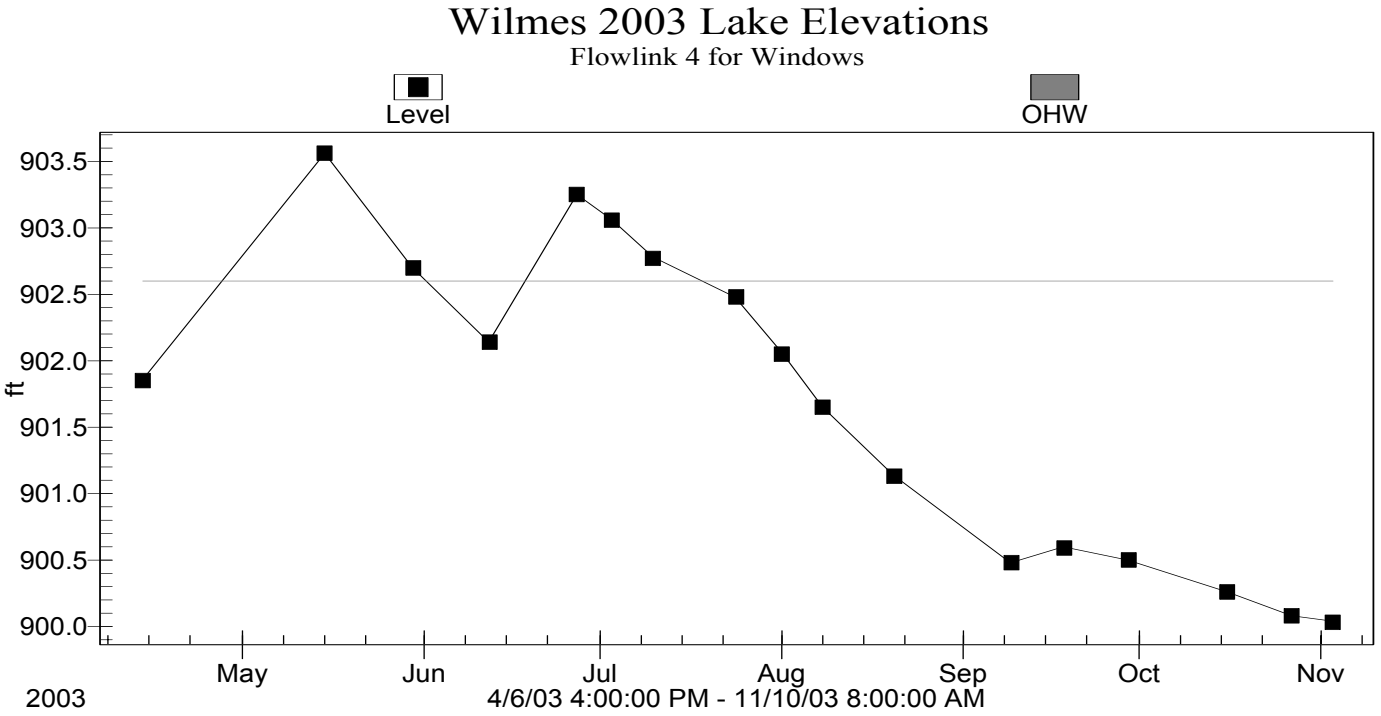
25a. Armstrong Lake Elevations and Ordinary High Water (OHW)



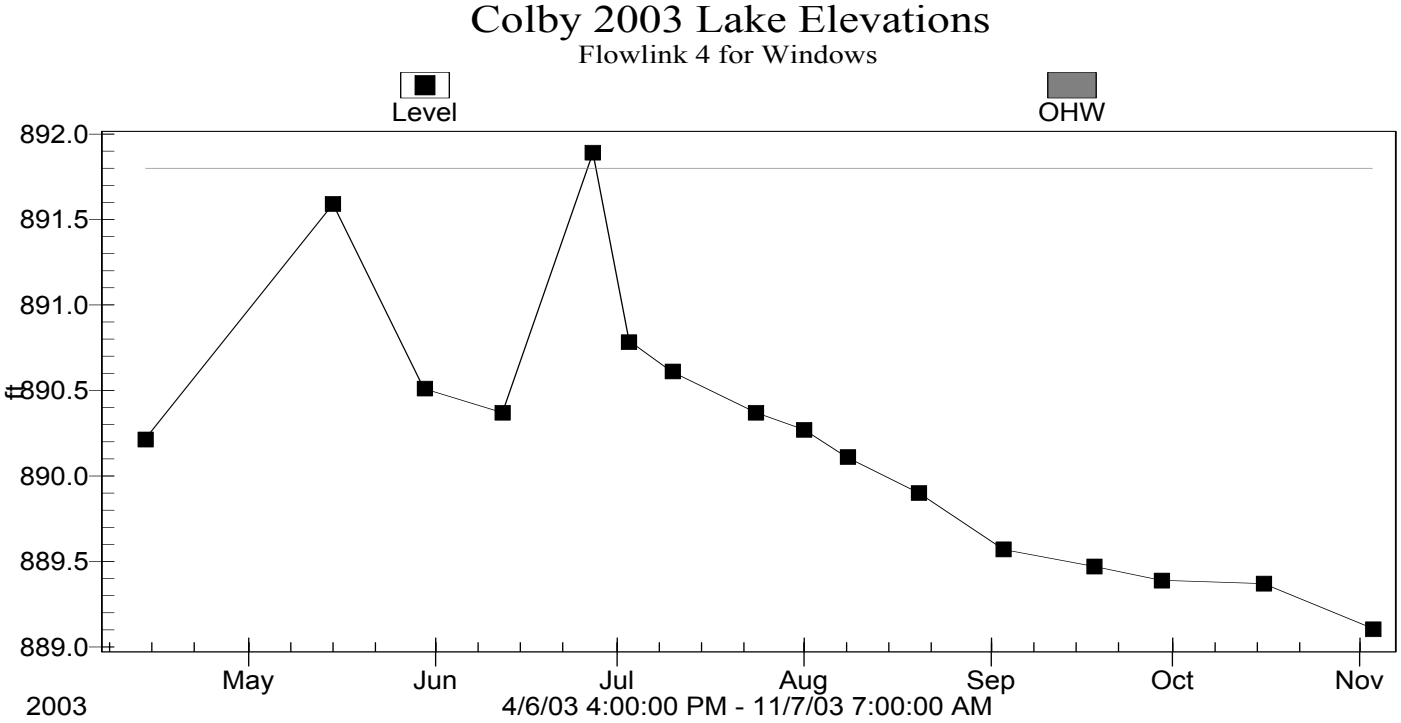
25b. Markgrafs Lake Elevations and Ordinary High Water (OHW)



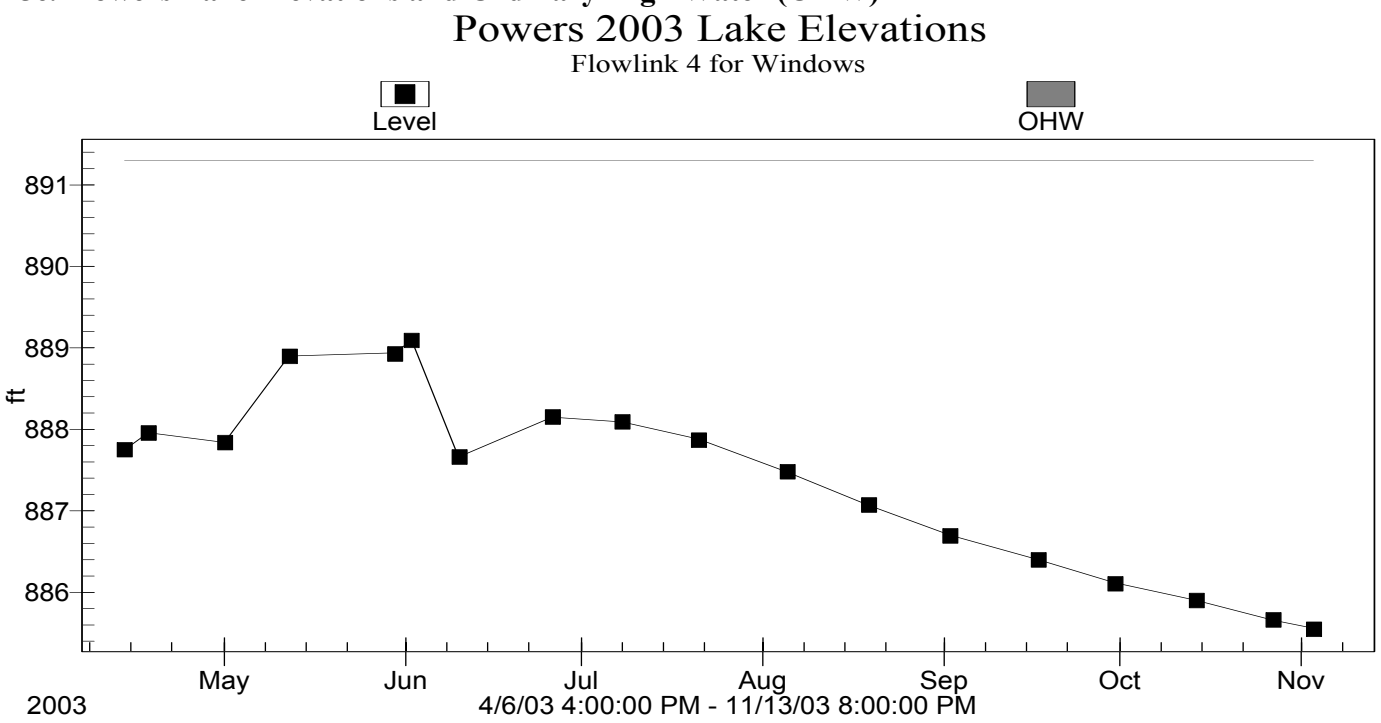
25c. Wilmes Lake Elevations and Ordinary High Water (OHW)



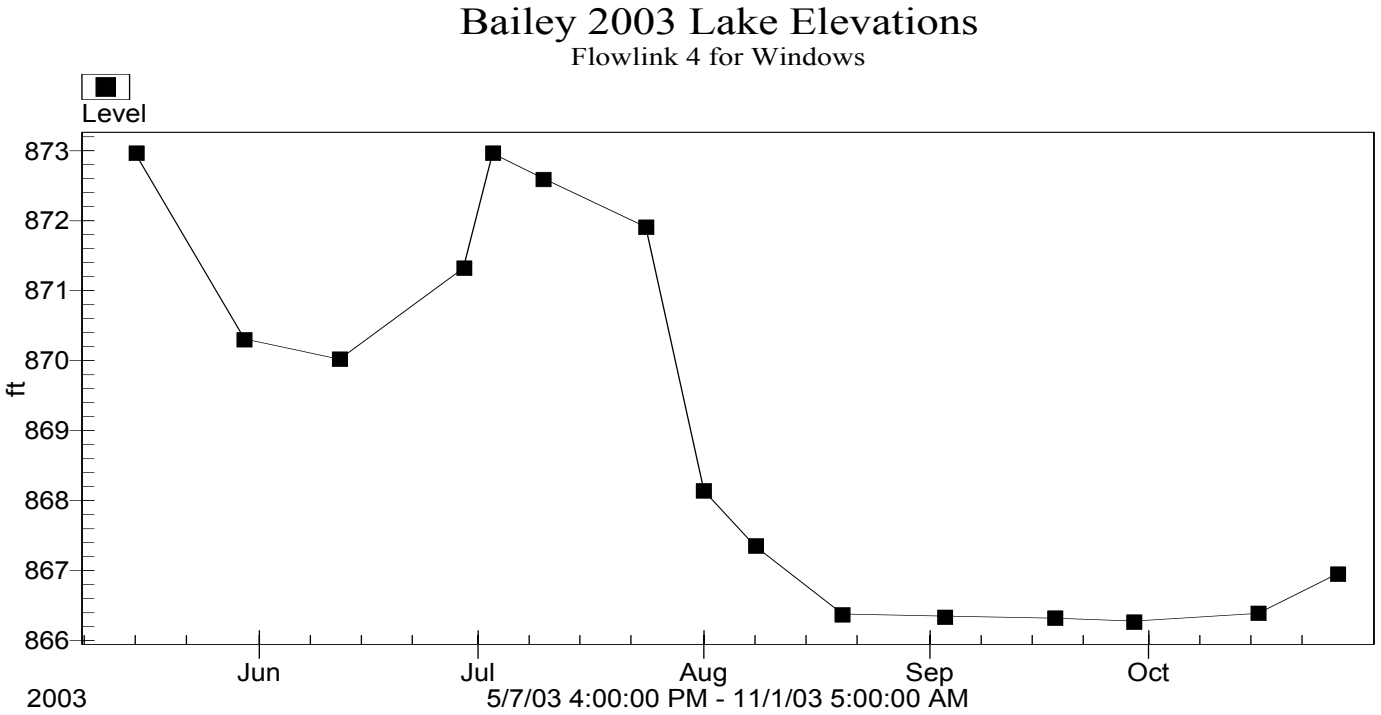
25d. Colby Lake Elevations and Ordinary High Water (OHW)



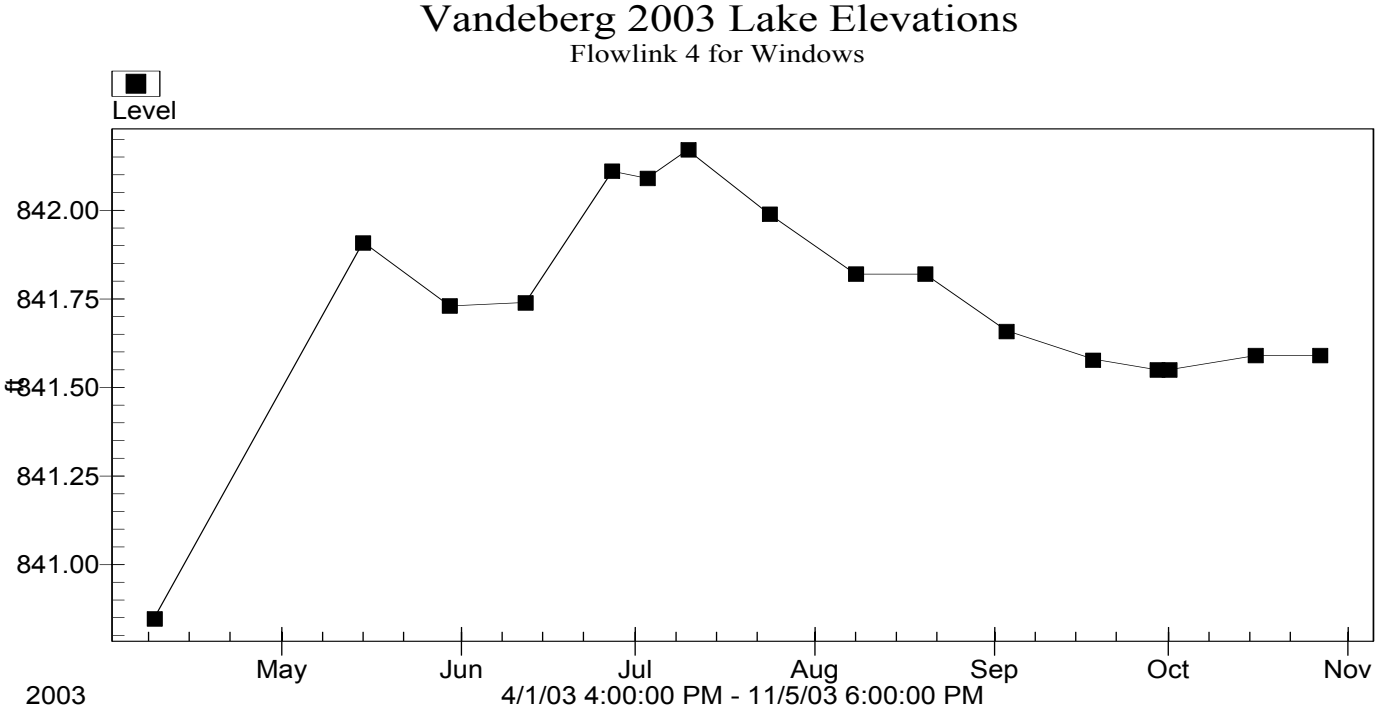
25e. Powers Lake Elevations and Ordinary High Water (OHW)



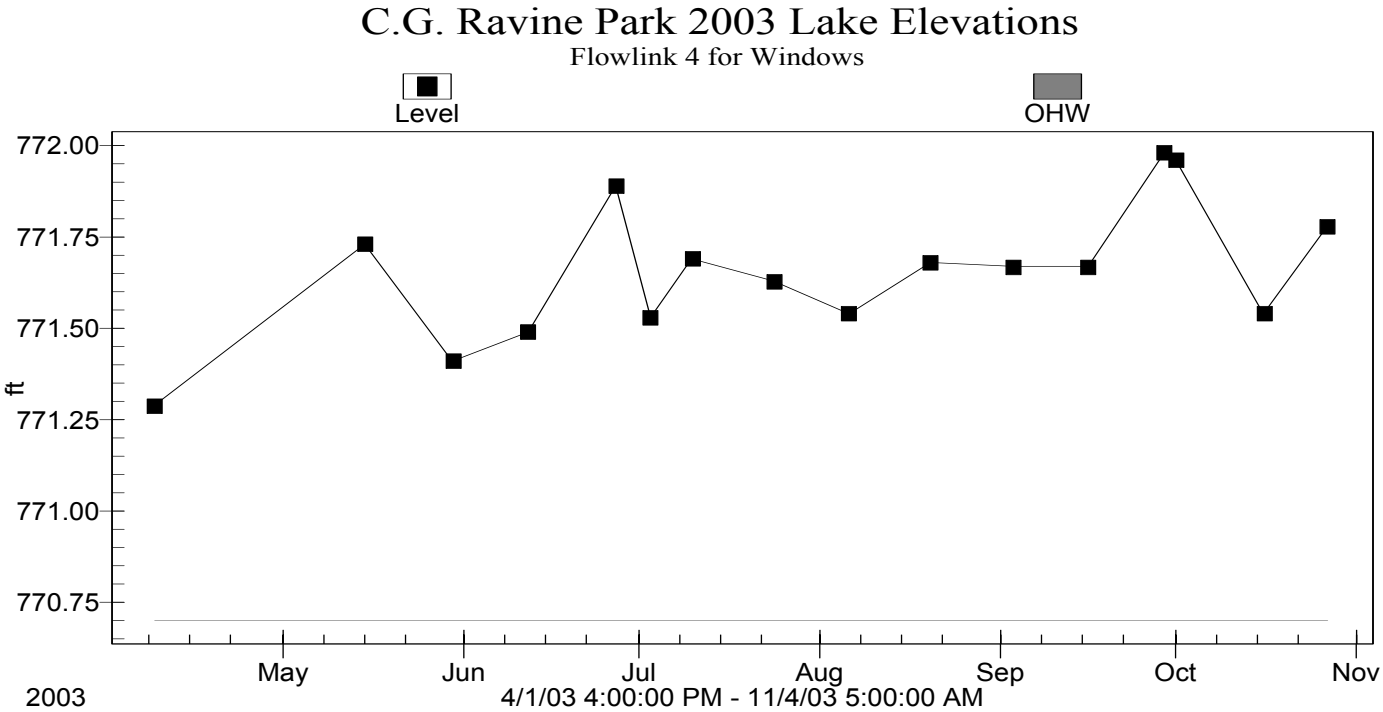
25f. Bailey Lake Elevations



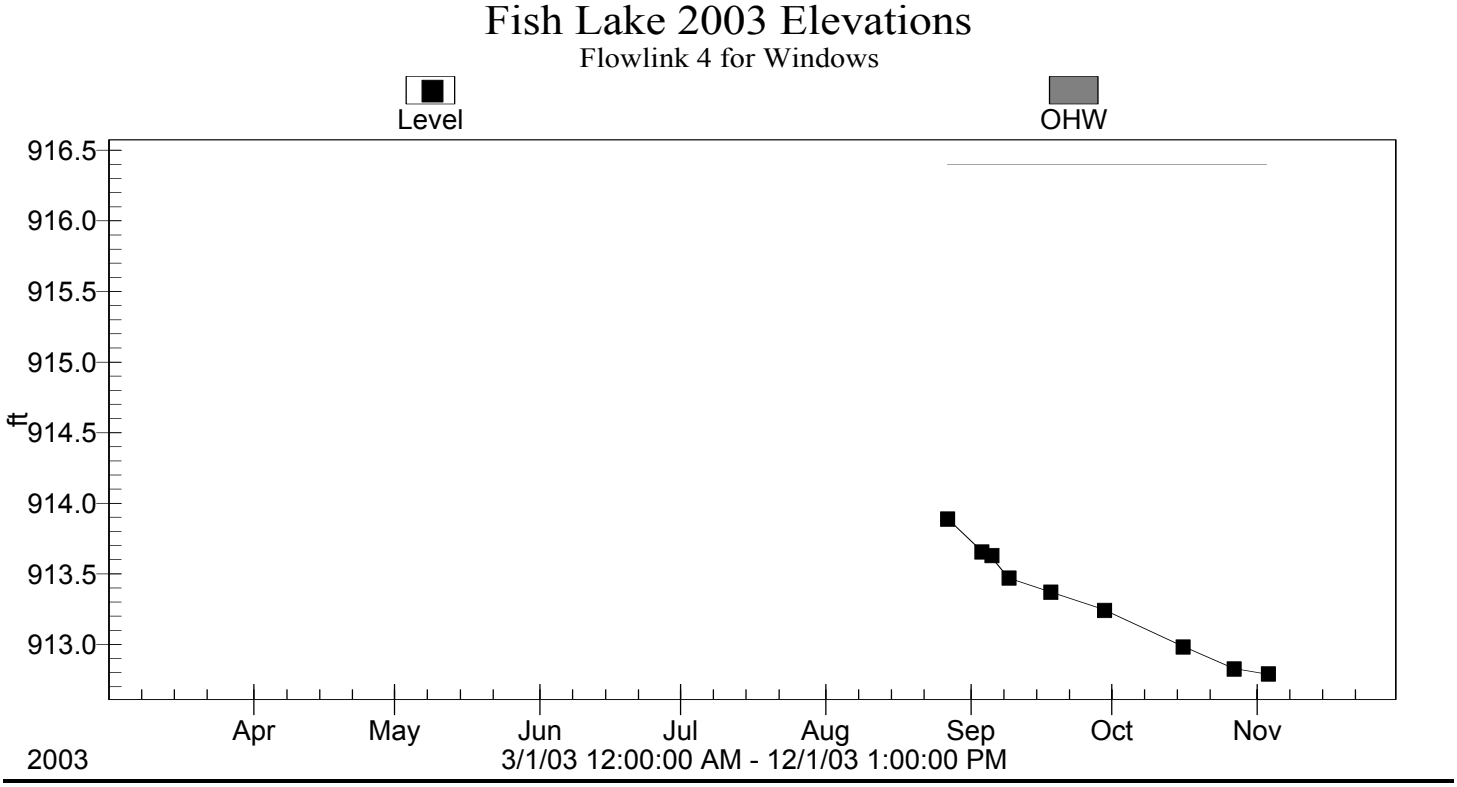
25g. Vandeberg Lake Elevations



25h. Cottage Grove Ravine Park Lake Elevations and Ordinary High Water (OHW)



25i. Fish Lake Elevations and Ordinary High Water (OHW)



Observation Wells

Six observation wells were monitored 9 times and one well was monitored 4,667 times with a datalogger by Emmons & Olivier Resources Inc. and two additional readings were made by the WCD from March 26-December 31, 2003. Table 18 shows the high, low, range and average groundwater elevation during the 2003 monitoring. Figure 26 shows the fluctuation of the groundwater elevations for each well during the 2003 monitoring. Water levels for observation wells were highest in July, August, and October and at their lowest in March, November, and December.

Table 18. SWWD 2003 Observation Well Elevations

Well #	Dates Monitored	# Readings	Surface Elevation (ft)	Lowest Reading (ft) Date	Highest Reading (ft) Date	Range (ft)	Average Elevation (ft)
545602	3/26/03-12/30/03	9	904.39	835.96 12/30/03	840.08 10/27/03	4.12	839.18
545603	3/26/03-12/30/03	9	906.42	8454.91 12/30/03	861.69 7/17/03	6.78	858.79
545604	3/26/03-12/30/03	9	886.60	850.91 12/30/03	856.86 7/17/03	5.95	853.99
616493	3/26/03-12/30/03	4669	917.32	846.67 12/31/03	853.61 8/12/03	1.74	849.64
616494	3/26/03-12/30/03	9	916.61	847.08 12/31/03	852.84 8/20/03	5.76	850.12
616497	3/26/03-12/30/03	9	920.34	869.03 11/26/03	879.45 7/17/03	10.42	871.4
616498	3/26/03-12/30/03	9	913.55	861.70 3/26/03	881.03 7/17/03	19.33	867.24

Figure 26. SWWD 2003 Observation Well Elevations