Memorandum

To: Matt Moore
From: Mark Doneux, Dan Kalmon, and Karen Muhr —Washington SWCD
Date: May 8, 2001
Re: SWWD 2000 Monitoring: MS1, MS2, WOMP Station, Armstrong Lake, Lake Gages, & Observation Wells

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At the request of the South Washington Watershed District (SWWD), the Washington Soil and Water Conservation District (SWCD) conducted stream monitoring at two existing stream monitoring stations (MS1 and MS2), monitored at a new WOMP stream monitoring station, monitored Armstrong Lake, installed and read lake staff gages, and monitored seven groundwater observation wells. The following report summarizes our methods and results for monitoring conducted from January 1 - December 31, 2000. This report and the accompanying data can also be provided in an electronic format at your request.

Stream Sites: MS1 & MS2

Continuous level measurements were taken every 15 minutes at MS1 from May 17 – October 31, 2000 and at MS2 from May 8 – October 3, 2000. Precipitation data was also continuously collected at each site during the same time period (Figure 1).

There was no measurable baseflow for both the MS1 site and the MS2 site. Continuous discharge measurements were taken also taken every 15 minutes for the same duration as the stage measurements. However, when the probe was covered with debris, erroneous velocity readings were given. There were also some periods when discharge data was not collected due to technical difficulties. Rating curves were developed using reliable level and discharge data (> 0.33 ft for stage and > 0.79 ft for discharge measurements). The rating curve equations were applied to the edited stage data and missing discharge data to present a more complete record of discharge.

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 were collected, as well as baseline grab samples. The samples were brought to the Metropolitan Council Lab for analysis.

Figure 1. SWWD Monitoring Locations

MS1

The hydrograph for the MS1 site shows flows between May 17 - October 31, 2000 (Figure 2). The peak discharge—114.3 cfs, was on August 26th from daily precipitation of 1.75 inches. The highest daily rainfall recorded at MS1 was 2.5 inches on July 10th, which yielded 93.7 cfs. To supplement the rainfall data, daily rainfall data was used from the State Climatology Office high-density network at the closest monitoring location, T28N R21W S6, which is within 1 mile of MS1.

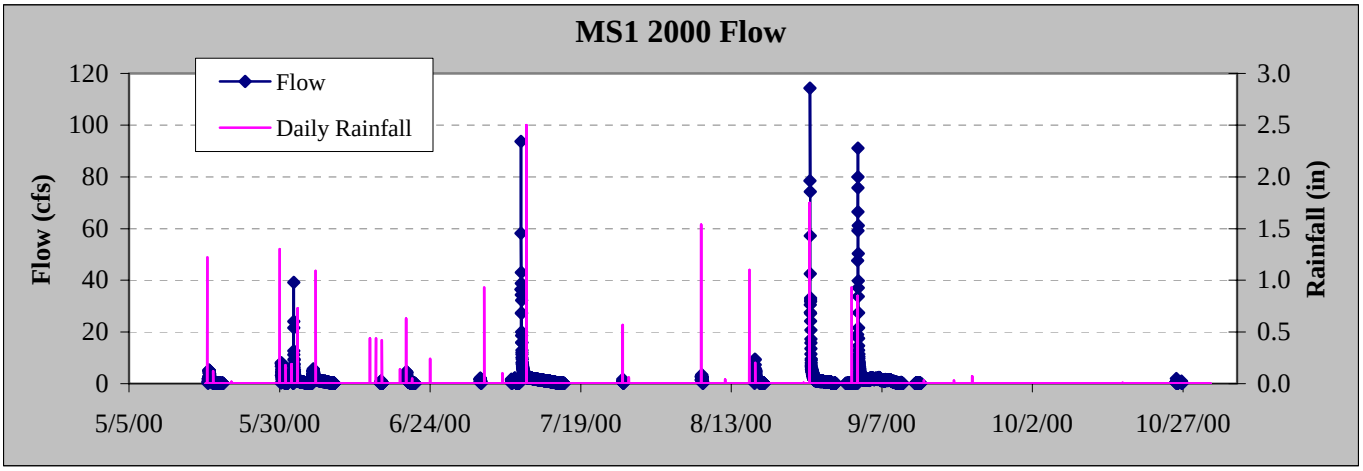

Figure 2. MS1 2000 Continuous Flow

Both grab samples and flow weighted automatic samples were taken at the MS1 site. The TSS, TKN, and TP results from all collected samples are listed in Table 1. The highest TSS, TKN, and TP results all were from samples taken on July 10, 2000.

Table 1. MS1 2000 Sample Chemistry Results

Start Date & Time	End Date & Time	Total Suspended Solids (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Phosphorus (mg/L)
4/21/00 11:30	4/21/00 11:30	7	0.97	0.19
5/8/00 15:15	5/8/00 15:15	33	1.30	0.26
5/12/00 12:25	5/12/00 12:25	7	0.30	0.06
5/16/00 13:50	5/16/00 13:52	5	0.50	0.11
5/18/00 14:30	5/18/00 14:30	20	0.99	0.18
5/30/00 10:50	5/30/00 10:50	46	1.30	0.37
6/5/00 14:00	6/5/00 14:00	10	0.87	0.09
6/14/00 12:30	6/14/00 12:30	<2	0.48	0.05
7/9/00 1:58	7/9/00 2:31	2460	2.10	1.20
7/10/00 15:00	7/12/00 13:00	9	0.83	0.14
7/25/00 9:30	7/25/00 9:30	4	0.47	0.08
8/8/00 12:45	8/8/00 12:45	4	1.20	0.44
8/16/00 10:06	8/17/00 9:50	97	1.40	0.42
8/25/00 10:45	8/25/00 10:45	8	0.28	0.12
8/26/00 1:50	8/26/00 3:29	650	1.90	0.96
9/2/00 23:57	9/3/00 1:40	970	1.70	0.60

Sampling data yielded very few detects for metals and other species of nitrogen. Of the parameters sampled (total lead, total cadmium, total copper, total zinc, and ammonia), only total copper and ammonia are above the MPCA Rule 7050 Water Quality Chronic Standard; total copper exceeded the chronic standard 12 of 13

samples and ammonia exceeded the chronic standard 5 of 15 samples. Only total copper was above the MPCA Rule 7050 Water Quality Maximum Standard; total copper exceeded the maximum standard 10 of 13 samples.

Table 2. MS1 Chemical Parameters Which Exceeded MPCA Water Quality Standards

Date	Copper (mg/L)	Ammonia Nitrogen (mg/L)
04/21/00	0.0160	0.02
05/08/00	0.0082	0.08
05/12/00	0.0046	0.02
05/16/00	0.0068	<0.02
05/18/00	0.0115	0.05
05/30/00	0.0280	<0.02
06/05/00	0.0184	<0.02
06/14/00	0.0199	Not Sampled
07/09/00	0.0129	0.06
07/12/00	0.0125	<0.02
07/25/00	Not Sampled	0.02
08/08/00	Not Sampled	0.03
08/17/00	Not Sampled	~0.02
08/25/00	0.0107	<0.02
08/26/00	0.0109	0.25
09/03/00	0.0110	0.17
Chronic Standard	**0.0064**	**0.040**
Maximum Standard	**0.0092**	**No Standard**

MS2

The hydrograph for the MS2 site shows flow between May 8 – October 3, 2000 (Figure 3). The highest flow—52.4 cfs, and highest daily rainfall—2.24 inches, was on September 3rd. To supplement the rainfall data, daily rainfall data was used from the State Climatology Office high-density network at the closest monitoring location, T28N R21W S6, which is within 6 miles of MS2.

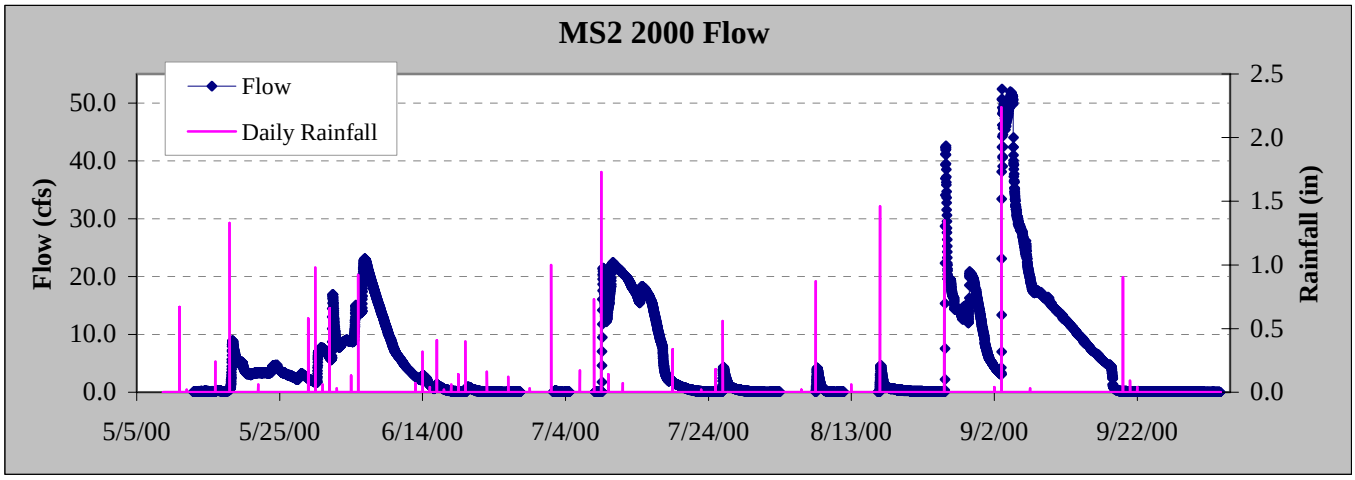

Figure 3. MS2 2000 Continuous Flow

Both grab samples and flow weighted automatic samples were taken at the MS2 site. The TSS, TKN, and TP results from all collected samples are listed in Table 3. The highest TSS, TKN, and TP results all were from samples taken on August 25, 2000.

Table 3. MS2 2000 Sample Chemistry Results

Start Date & Time	End Date & Time	Total Suspended Solids (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Phosphorus (mg/L)
5/8/00 14:00	5/8/00 14:00	23	1.9	0.2
5/16/00 14:20	5/16/00 14:20	10	1.5	0.12
5/18/00 15:15	5/18/00 15:15	21	1.4	0.12
5/30/00 10:15	5/30/00 10:15	18	1.6	0.14
6/1/00 9:20	6/1/00 14:40	24	1.4	0.14
6/5/00 15:15	6/5/00 15:15	13	1.3	0.08
6/14/00 13:50	6/14/00 13:50	14	1.2	0.08
7/10/00 15:30	7/10/00 15:30	19	1.7	0.17
7/25/00 10:15	7/25/00 10:15	24	2.1	0.2
8/8/00 13:45	8/8/00 13:45	18	2.2	0.19
8/16/00 23:30	8/17/00 12:30	19	2.2	0.24
8/25/00 11:25	8/25/00 11:25	18	1.8	0.15
8/25/00 23:00	8/26/00 4:37	57	2.1	0.38
8/29/00 12:26	8/29/00 14:56		1.2	0.17
9/6/00 11:26	9/6/00 20:56	13	1.6	0.13
9/18/00 13:30	9/18/00 13:30	13	0.5	0.05
10/3/00 15:00	10/3/00 15:00	19	1.8	0.15

Sampling data yielded very few detects for metals and other species of nitrogen. Of the parameters sampled (total lead, total cadmium, total copper, total zinc, and ammonia), only total copper and ammonia are above the

MPCA Rule 7050 Water Quality Chronic Standard; total copper exceeded the chronic standard 12 of 15 samples and ammonia exceeded the chronic standard 8 of 17 samples. Only total copper was above the MPCA Rule 7050 Water Quality Maximum Standard; total copper exceeded the maximum standard 7 of 15 samples.

Table 4. MS2 Chemical Parameters Which Exceeded MPCA Water Quality Standards

Date	Copper (mg/L)	Ammonia Nitrogen (mg/L)
05/08/00	0.0051	0.18
05/16/00	0.0055	0.55
05/18/00	0.0068	0.53
05/30/00	0.0217	0.06
06/01/00	0.0133	0.13
06/05/00	0.0135	0.06
06/14/00	0.028	<0.02
07/10/00	0.0099	<0.02
07/25/00	0.0041	<0.02
08/08/00	No Sample	<0.02
08/16/00	No Sample	0.12
08/25/00	0.008	<0.02
08/25/00	0.0151	0.3
08/29/00	0.0118	<0.02
09/06/00	0.0071	~0.03
09/18/00	0.0081	~0.03
10/03/00	0.007	<0.02
Chronic Standard	**0.0064**	**0.04**
Maximum Standard	**0.0092**	**No Standard**

WOMP Station

The Water Outlet Monitoring Program (WOMP) site was monitored 17 times from May 18 – October 24, 2000. A staff gage was installed and read at the site. Field stage measurements were taken in the outflow culvert (Figure 4). Temperature, dissolved oxygen, and transparency tube measurements were also taken. Eight storm grab samples and four baseflow grab samples were collected and brought to the Metropolitan Council Lab for analysis, including a fecal coliform test on two occasions. A few of the chemical parameter results from the samples are listed in Table 5.

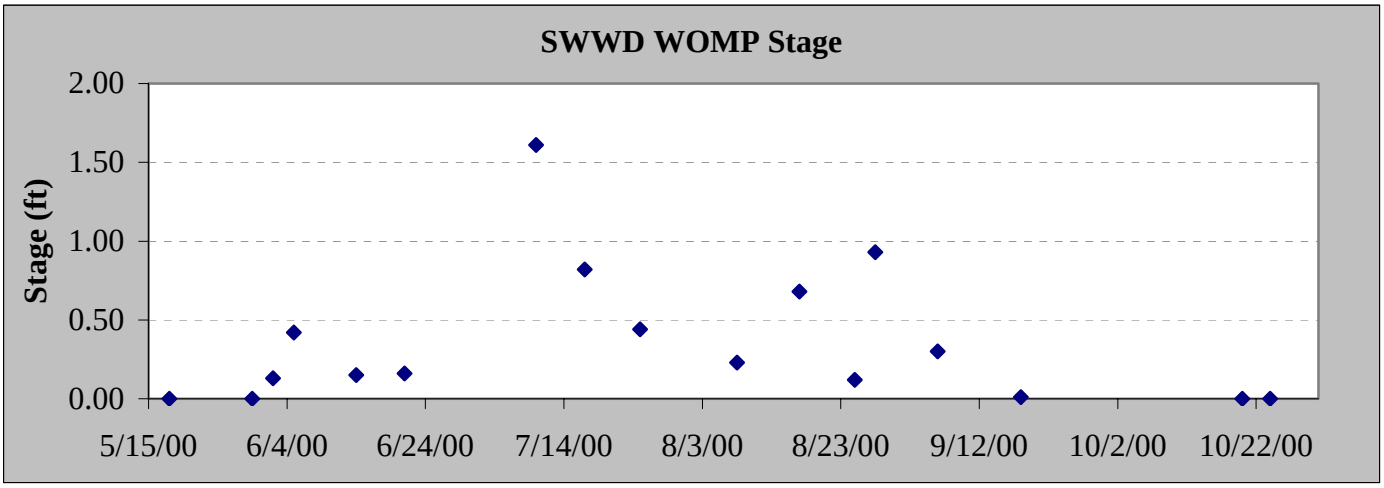

Figure 4. WOMP Culvert Stage in Feet

Table 5. WOMP Site 2000 Sample Chemistry Results

Date/Time	Fecal Coliform (#/100 mL)	Total Suspended Solids (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Phosphorus (mg/L)
6/2/00 12:00		17	2.8	0.20
6/5/00 15:45		9		
6/14/00 14:20		17		
6/21/00 15:30		19	0.64	0.10
7/10/00 16:15		12	1.30	0.21
7/25/00 11:00		3	0.51	0.10
8/8/00 14:15		8	1.00	0.17
8/17/00 15:30	610	19	1.30	0.12
8/25/00 12:10	40	15	0.62	0.13
8/28/00 16:15		3	0.50	0.12
9/6/00 11:45		2	0.33	0.04
9/18/00 14:11		2	0.53	0.06

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 26, 2000, 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, and surface chlorophyll-a. In addition, a temperature and dissolved oxygen profile was taken during each sampling round and the CAMP data sheet was completed. The samples were analyzed by the Metropolitan Council Lab.

There was a significant spike in total phosphorus, total Kjeldahl nitrogen, and chlorophyll-a on August 30, 2000, of 0.87 mg/L, 6.5 mg/L, and 840 ug/L respectively (Figure 6). Field notes state that the conditions were windy during sampling and the lake sediment was stirred up. This may be the cause of such a high result. However, the Secchi disk reading was not significantly different from previous and later readings and the lake still appears to be stratified. Armstrong Lake is hypereutrophic with or without the August 30, 2000, sample (Table 8).

Table 6 gives the 2000 high, low, and average lake levels. (Figure 8 is a lake level chart.) Table 7 gives the 2000 monitoring results. The table also lists the averages for each parameter with and without the August 30 result. Figure 5 compares the Secchi disk readings to the chlorophyll-a results. Overall, as the chlorophyll-a increases, the Secchi disk readings decrease. Figure 6 shows the lake surface chemistry data. Table 8 shows the lake grade and trophic status. Table 9 lists the dissolved oxygen and temperature profiles. The maximum depth was between 1 and 2 meters. The surface dissolved oxygen and surface temperatures are shown in Figure 7.

Table 6. Armstrong Lake Level

	High	High Date	Low	Low Date	Average
Lake Level (ft)	1018.63	5/19/00	1017.85	10/25/00	1018.22

Table 7. Armstrong Lake 2000 Monitoring Results

Date	Surface Total Phosphorus (mg/L)	Surface Total Kjeldahl Nitrogen (mg/L)	Chlorophyll-a (ug/L)	Secchi Disk Depths (m)	Surface Dissolved Oxygen (mg/L)	Surface Temperature (C)
4/18/00	0.05	0.77	13.0	1.07	11.74	6.6
5/19/00	0.06	0.89	20.0	1.07	10.08	18.5
6/7/00	0.07	0.82	24.0	0.76	13.77	18.8
6/19/00	0.03	0.74	6.7	0.92	14.63	21.3
6/28/00	0.04	0.76	7.8	0.91	8.27	22.7
7/19/00	0.11	1.00	29.0	0.76	4.85	21.7
7/26/00	0.07	0.98	26.0	1.22	9.21	24.9
8/8/00	0.06	0.92	17.0	1.07	6.95	24.8
8/24/00	0.06	1.10	33.0	0.92	9.86	25.4
8/30/00	0.87	6.50	840.0	0.76	8.46	23.9
9/11/00	0.08	1.20	33.0	0.76	9.81	23.7
10/2/00	0.08	1.10	40.0	0.76	6.98	16.8
10/10/00	0.06	0.86	25.0	0.92	10.82	7.6
10/26/00	NA	NA	NA	1.07	6.85	15.2
2000 Average	**0.13**	**1.36**	**85.73**	**0.93**	**9.45**	**19.4**
Average w/o 8/30/00	**0.06**	**0.93**	**22.88**	**0.94**	**9.52**	**19.1**

Table 8. Armstrong Lake Water Quality Summary

	Trophic Status (2000 Average)	Lake Grade (2000 Average)	Trophic Status (2000 Average w/o 8/30/00)	Lake Grade (2000 Average w/o 8/30/00)
Total Phosphorus (mg/L)	Hypereutrophic	D	Eutrophic	C
Chlorophyll-a (ug/L)	Hypereutrophic	F	Eutrophic	C
Secchi disk (ft)	Hypereutrophic	F	Hypereutrophic	F
Overall	Hypereutrophic	F+	Hypereutrophic	D+

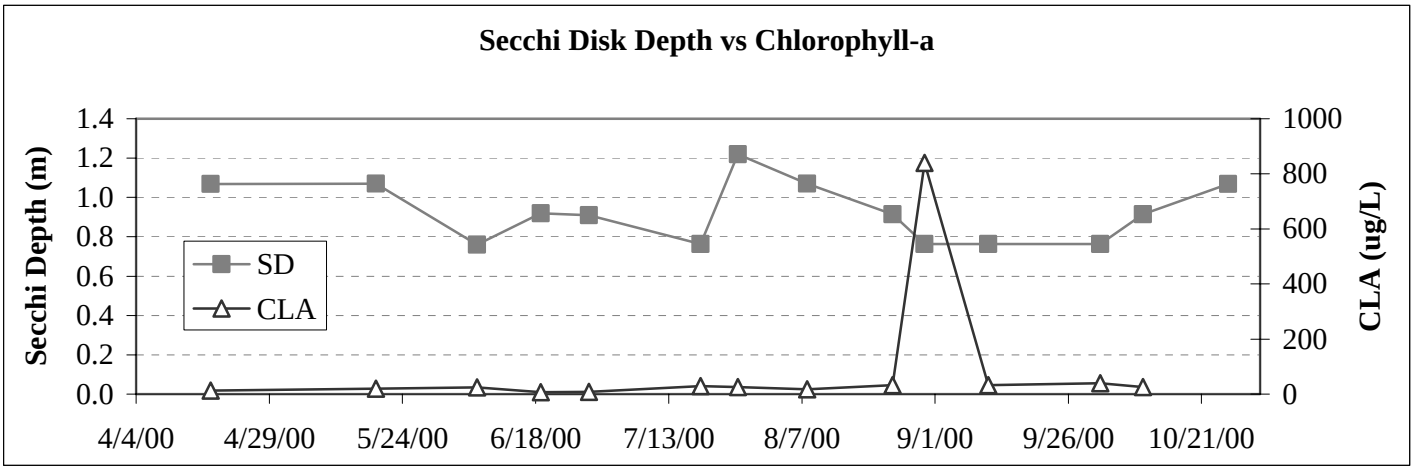

Figure 5. Secchi vs. Chlorophyll-a

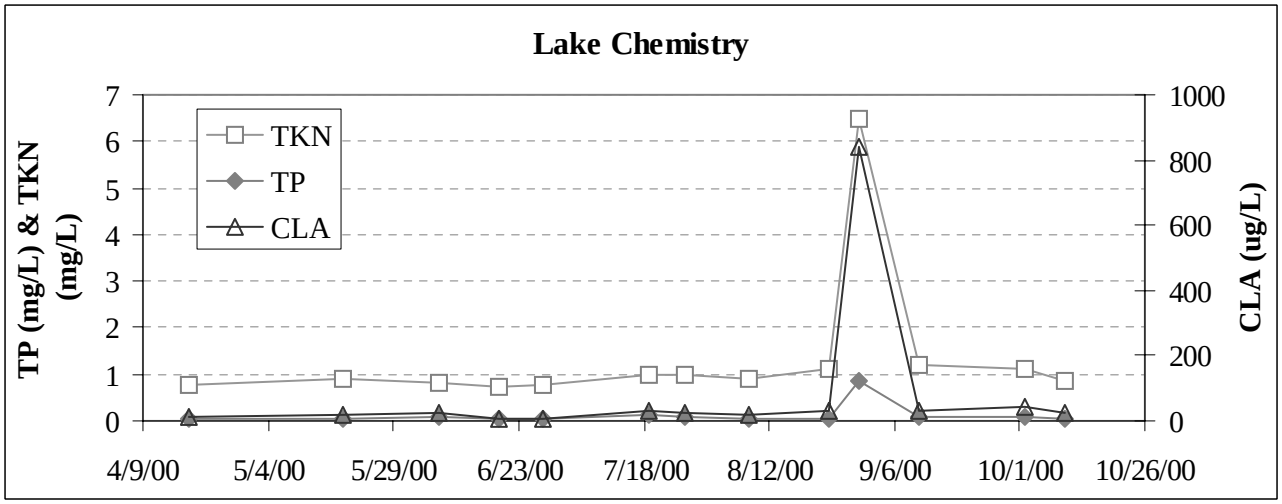

Figure 6. Armstrong Lake 2000 Chemistry Results

Table 9. Dissolved Oxygen and Temperature Profiles

	4/18/00		5/19/00		6/7/00		6/19/00		6/28/00		7/19/00		7/26/00	
Depth (m)	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp
surface	11.7	6.6	10.1	18.5	13.8	18.8	14.6	21.3	8.3	22.7	4.9	21.7	9.2	24.9
1	11.4	6.4	10.2	13.8	13.1	18.7	10.6	19.0	8.2	21.9	0.4	20.6	2.9	23.6
2			10.1	13.5										

	8/8/00		8/24/00		8/30/00		9/11/00		10/2/00		10/10/00		10/26/00	
Depth (m)	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp	DO	Temp
surface	7.0	24.8	9.9	25.4	8.5	23.9	9.8	23.7	7.0	16.8	10.8	7.6	6.9	15.2
1	1.1	23.4	0.5	21.7	2.3	21.4	1.4	21.4	3.6	16.8	1.5	7.7	6.5	15.2
2					0.8	21.2								

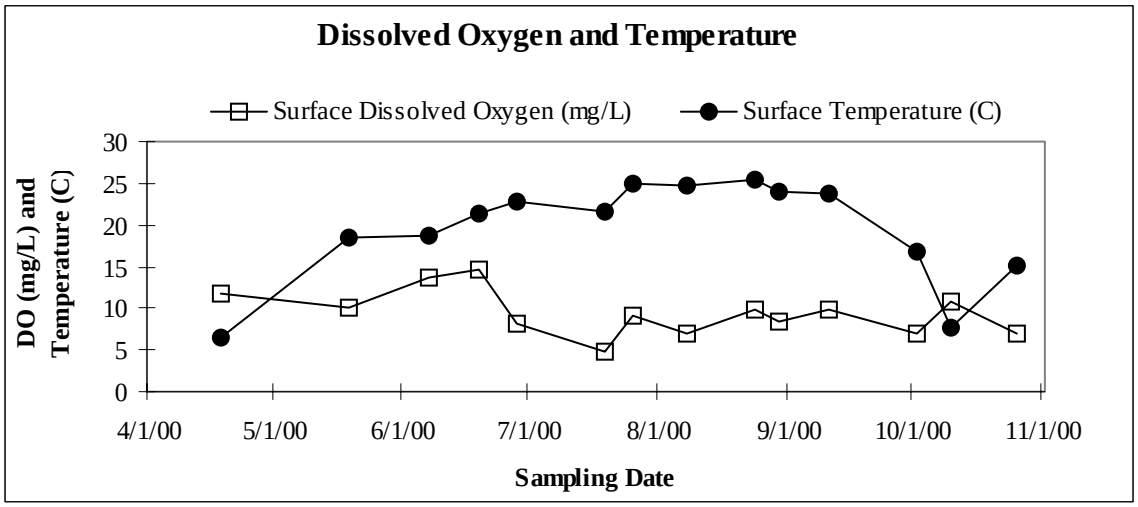

Figure 7. Surface Dissolved Oxygen and Surface Temperatures

Lake Gages

Lake gages were read biweekly on eight lakes in SWWD from March 21-October 25, 2000. Table 10 lists the high, low, range and average elevations for each lake monitored in 2000.
Figure 8 shows the fluctuation in elevation for each lake monitored in 2000.

Table 10. SWWD 2000 Lake Gage Readings

Lake Name	DNR ID#	Dates Monitored	# Readings	High Reading (ft) Date	Low Reading (ft) Date	Range (ft)	Average Elevation (ft)
Cottage Grove Ravine Park	82-0087	3/21/00 - 10/24/00	15	771.68 7/14/00	770.90 5/4/00	0.78	771.18
Marksgraf	82-0089	3/21/00 - 10/25/00	15	925.61 9/7/00	924.43 5/4/00	1.18	924.95
Wilmes	82-0090	3/21/00 - 10/25/00	14	906.67 5/19/00	901.09 4/19/00	5.58	902.63
Powers	82-0092	3/21/00 - 10/11/00	14	885.37 9/7/00	884.55 10/11/00	0.82	884.89
Colby	82-0094	3/21/00 - 10/25/00	15	891.42 9/7/00	889.69 5/4/00	1.73	884.89
Bailey	82-0456	3/21/00 - 10/11/00	13	868.56 7/14/00	865.90 4/19/00	2.66	867.23
Armstrong	82-0116	3/21/00 - 10/25/00	16	1018.63 5/19/00	1017.85 10/25/00	0.78	1018.22
Vandeberg	82-0084	3/21/00 - 10/24/00	23	840.88 3/21/00	839.06 10/24/00	1.82	840.13

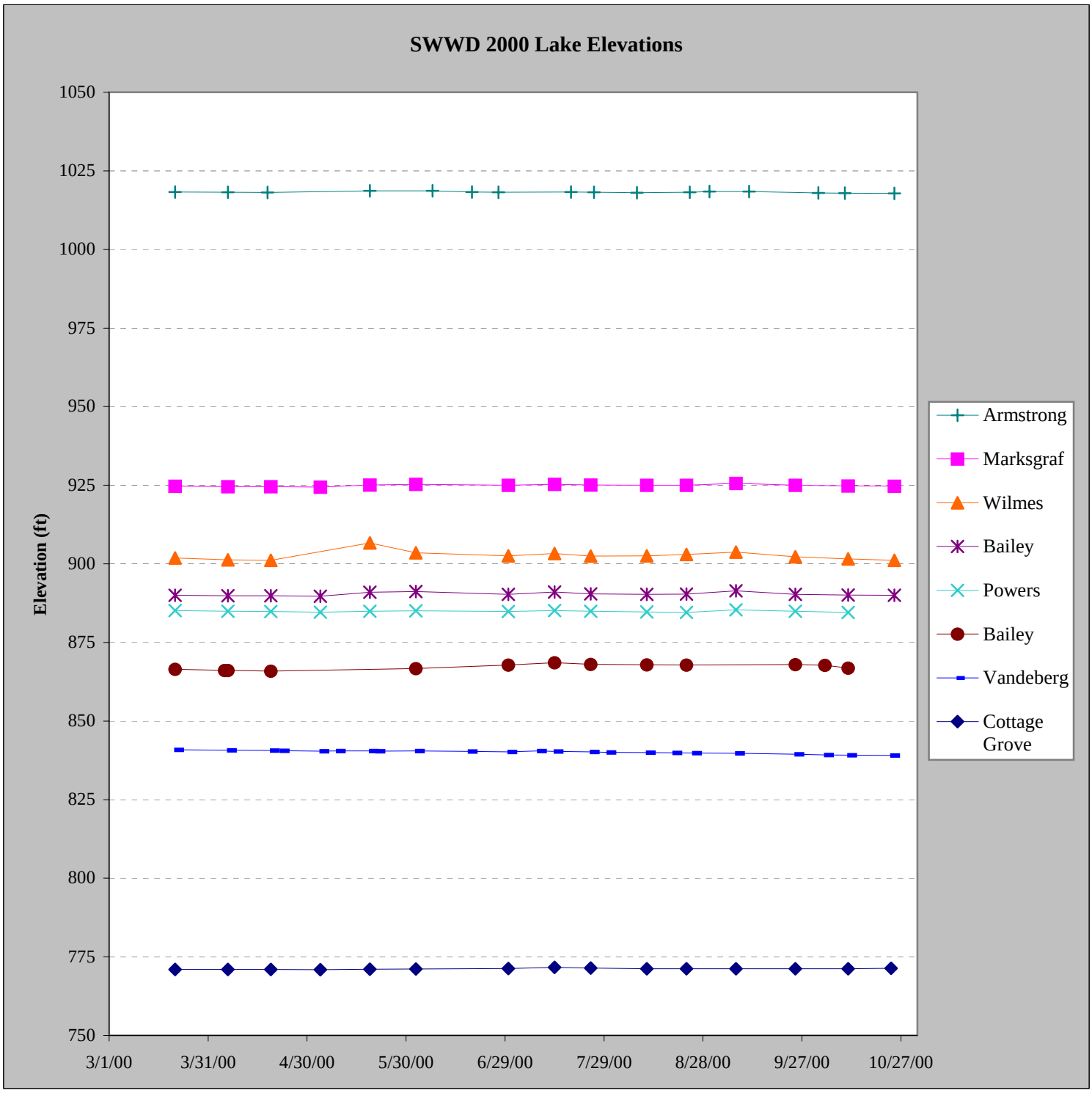

Figure 8. SWWD 2000 Lake Elevations

Observation Wells

Seven observation wells were monitored seven to ten times from March 29-November 29, 2000. Table 11 shows the high, low, range and average depth to water during the 2000 monitoring. Figure 9 shows the fluctuation of depth to water for each well during the 2000 monitoring.

Table 11. SWWD 2000 Observation Wells

Well #	Dates Monitored	# Readings	High Reading (ft) Date	Low Reading (ft) Date	Range (ft)	Average Depth (ft)
616498	3/29/00 - 11/29/00	10	51.44 9/20/00	51.33 4/28/00	0.11	51.39
616497	3/29/00 - 11/29/00	10	51.41 11/29/00	51.26 3/29/00	0.15	51.32
616493	3/29/00 - 11/29/00	10	78.85 8/16/00	76.32 10/31/00	2.53	77.59
616494	3/29/00 – 9/20/00	7	78.15 8/16/00	76.23 4/28/00	1.92	77.33
545603	3/29/00 - 11/29/00	10	58.72 5/24/00	51.86 9/20/00	6.86	56.52
545604	3/29/00 - 11/29/00	10	42.43 5/24/00	35.73 9/20/00	6.70	40.38
545602	3/29/00 - 11/29/00	10	71.20 11/29/00	69.75 4/28/00	1.45	70.54

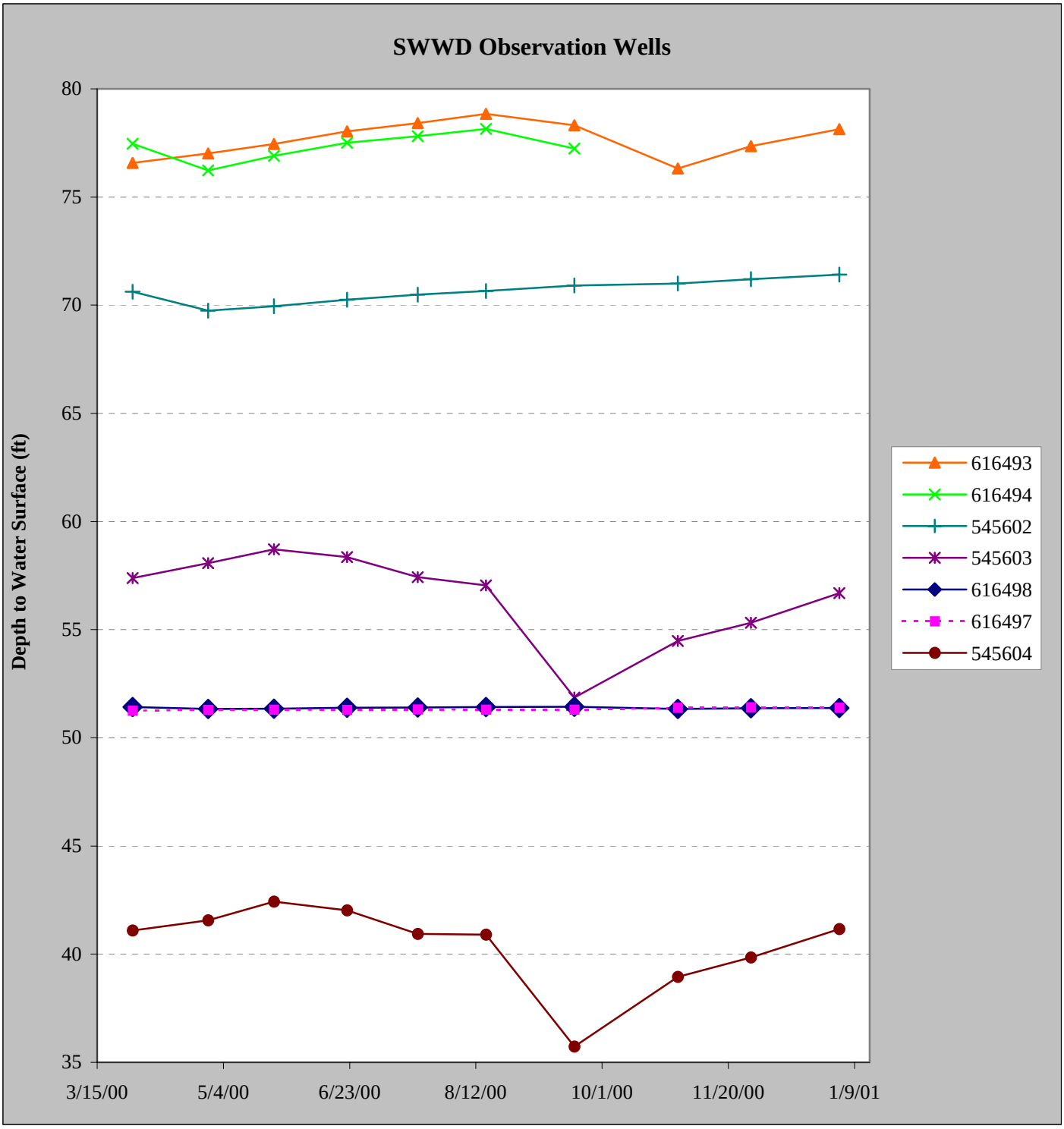

Figure 9. SWWD 2000 Observation Wells