Lost Trail Pass
NADP Site MT97

October 1990 to August 2004

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Introduction

The National Atmospheric Deposition Program (NADP) site at Lost Trail Pass MT97 on the Sula District of the Bitterroot National Forest has been in operation by since October 1, 1990. The Lost Trail Pass site is the only NADP site in Montana operated by the US Forest Service and is the only high elevation NADP site in Montana and Idaho. This report is an update of previous reports (Story 1993, 1994, 1996, 1998, and 2002) and contains all of the data available from the site (through August 2004).

NADP Program

The NADP Program was initiated in 1978 to monitor geographical and temporal trends in the chemical composition of rain and snow (wet deposition) with the primary purpose of acid rain benchmark monitoring. The program was prompted by scientific evidence and public concern in the 1970's that acid rain could be damaging aquatic ecosystems throughout the United States. The program grew steadily though the early 1980's and has stabilized at about 200 sites. The NADP network is used by a wide variety of government administrators and university scientists in monitoring the amounts of atmospheric deposition and effects on agriculture, forests, rangelands, freshwater streams, lakes, and cultural resources. Atmospheric deposition is commonly referred as "acid rain" but can occur as acid snow, fog, or dry deposition. The NADP data from all sites is readily retrievable at the NADP web site at http://nadp.sws.uiuc.edu.

Lost Trail Pass NADP Site

The Lost Trail Pass site is located at 7920 feet in elevation (2414 meters) just south of the NRCS Saddle Mountain SNOTEL site, west and above the Lost Trail Pass Ski Area on the Montana-Idaho border (latitude: longitude of 45 41 30:113 57 56). The site was selected because it is in a high elevation and reasonably accessible area. The primary sources of acid deposition in Idaho and southwest Montana are upwind regional sources from the Southwest. These include copper smelters and coal burning power plants in Arizona, Mexico, and Utah, and industrial/transportation sources in California. During the winters of 1980-1981, 1982-1983, and 1983-1984, the NRCS measured the pH of surface snow at several snow course sites in Montana (Farnes, 1984). Generally the pH measurements in the southwest part of Montana were less than 5.0 pH units while the rest of Montana had snow pH commonly greater than 5.0. The yearly variation in the shapes of the pH zones may be associated with year to year snow distribution patterns. The area around Lost Trail Pass was consistently in the <5 pH snow zone. Lost Trail Pass is in the Bitterroot Range, which has 315 lakes in the Selway Bitterroot Wilderness Area. Many of these lakes have very low acid neutralizing capacity as documented in the USGS R1 lake monitoring program (Story, 1993) and have very limited capacity to buffer acid inputs. North Kootenai Lake (Bitterroot NF) and Shasta Lake (Nez Perce NF) are 2 of the 6 Phase 3 lakes in the R1 ARM Program which have been monitored since 1994 (Story, 1995, 1996, 1999, 2000, and 2002) and Eilers (2003). The Lost Trail Pass site instruments consist of an Aerochem Metrics Model 301 wet/dry sampler, a Belfort recording rain gage, and powered by 4 &12 volt batteries which are charged by 3@0.5 square meter solar panels. The collector and rain gage are mounted on separate originally 8' high platforms (raised to 10' in 1996 due to heavy snowfall) which conform to the NADP protocol of a 5 meter separation between the wet/dry collector and rain gage. Tanya Neidhardt, Sula Ranger District, services the site each Tuesday. The site can be accessed by vehicle in the summer but requires snowmobiles in the winter.

Data Collection and Analysis

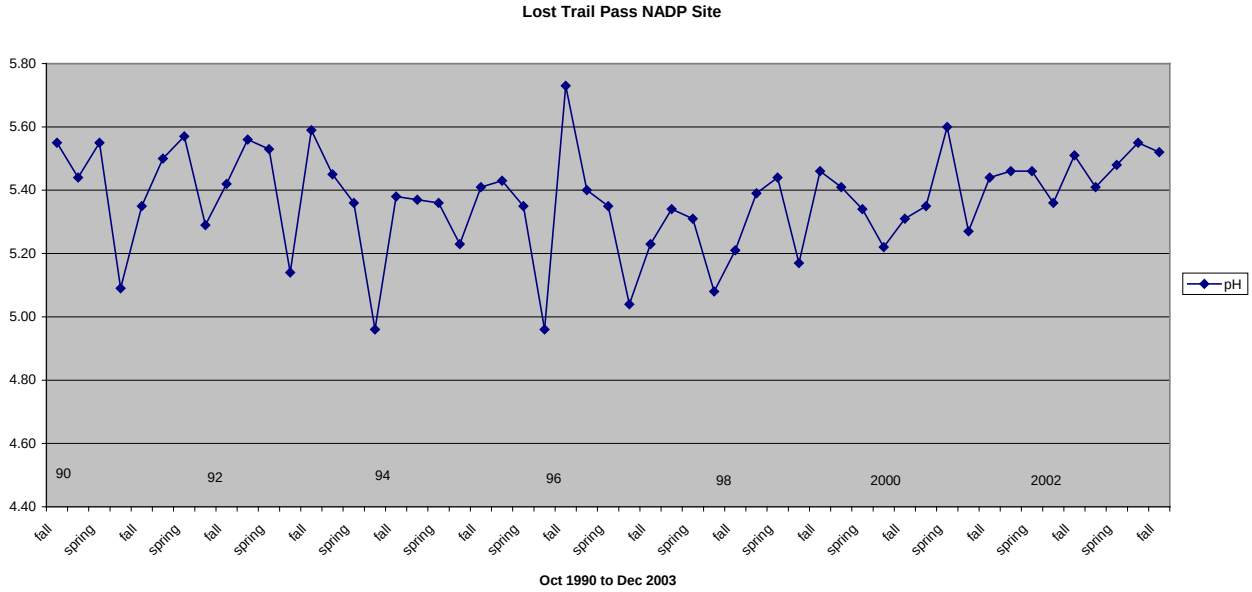
All of the NADP sites, including Lost Trail Pass, are operated according to strict NADP protocols. Sample buckets (3.5 gallons) are exchanged each Tuesday. The pH, conductivity, and sample weight are recorded at the Sula RD warehouse, daily precipitation is recorded on the site from the rain gage strip charts, and the samples are shipped to the Central Analytical Lab (CAL) at the University of Illinois in Champaign (Illinois State Water Survey). The CAL lab analyzes samples from pH, conductivity, calcium, magnesium, potassium, sodium, ammonia, nitrate, chloride, and sulfate. The data is carefully evaluated at the NADP Coordination Office for quality control and consistency. Quality control throughout the CAL and NADP offices is very rigid and consistent. Data is available about 6 months after the samples are analyzed and quality control

checked by the CAL. In preparation of this report, data was downloaded from the NADP web site mentioned previously and entered into the enclosed spreadsheet (Excel) files where statistical evaluation was preformed.

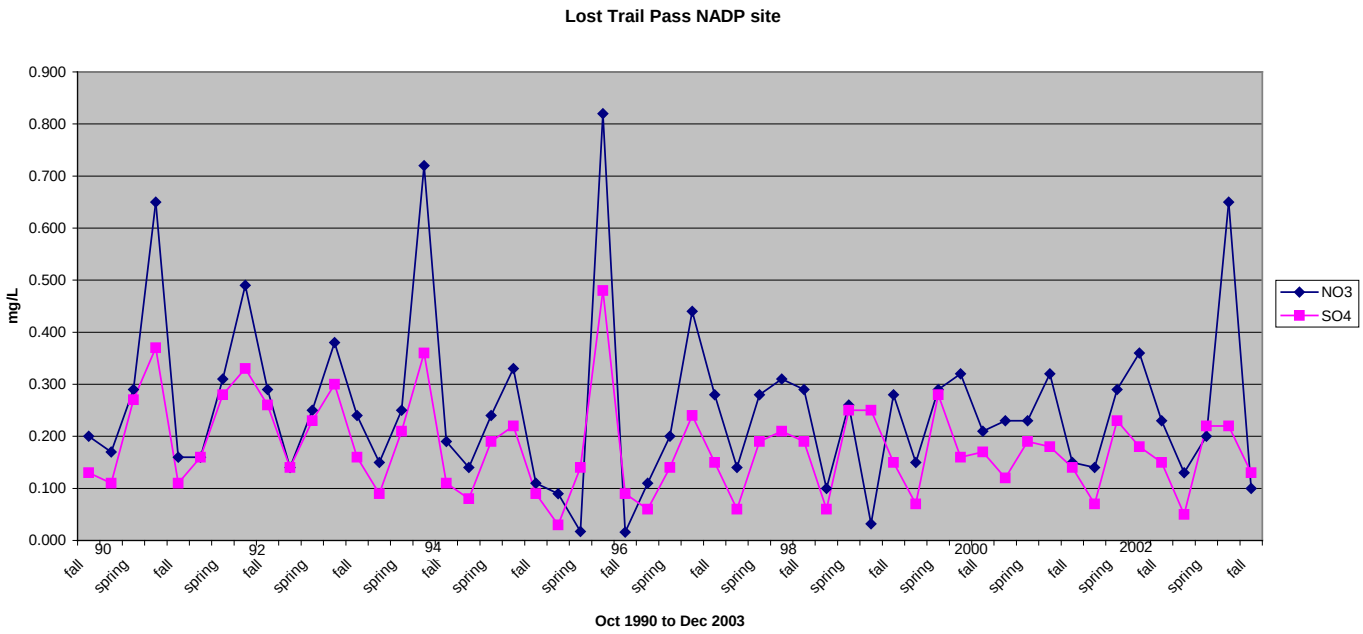
Results and Discussion

All of the Lost Trail Pass data available at the time of this report is displayed by mg/L in the enclosed tables by quarter (Appendix 1) and month (Appendix 2). The mean monthly pH averaged 5.39 during the period of record and ranged from low of 4.88 in August of 1994 and 1997 to a high of 6.52 in March of 2004. The quarterly average pH for the period of record trended slightly downward during the period of record (from 5.49 during 1990-1993, 5.44 during 1990-1995 to 5.33 during 1995-2000) then upward to 5.45 from 2001 to 2004. Too much variability exists in the data to verify a statistical trend.

As mentioned in the 2002 report (Story, 2002) the previous highest average monthly pH of 6.05 in July 1991 was evidently affected by dust "contamination" of light precipitation by a windy rain event which contained base cations from soils (Ca, Mg, K, and Na) of sufficient concentration to raise the pH. March 2004 pH averaged 6.52 which may also be due to dust contamination as March 2004 was fairly dry also. A quarterly graph of pH shown below flattens out the influence of individual months but with the exception of the fall of 1996 illustrates lack a statistical trend in pH for the period of record although the pH line indicates a slight downward trend from 1990 to 1996 and an up trend from 1997 to 2004. A seasonal pattern of lower summer pH and higher winter pH is quite evident.



Of particular interest in chemical analysis of the data is the acid anion sulfate (SO_4) and nitrate (NO_3), which are the main agents of acid rain. Sulfate concentration measurements range from a monthly average low of 0.05 mg/L in several winter months to a high of 0.57 mg/L in August of 1994. Average sulfate for the period of record (1990 to 2004) was 0.21 mg/L, which has dropped from 0.22 mg/L from 1990 to 1992 and 0.23 mg/L from 1990 to 1996. Nitrate concentration measurements range from a monthly average low of 0.08 mg/L in April of 1996 to a high of 4.93 mg/L in July of 2000. The July 2000 high nitrates were probably due to dust since in the very dry month leading up to the August 2000 wildfire outbreak on the Bitterroot NF. No data is available during the peak of the 2000 wildfires since the site was shut down and protected. Average nitrate for the period of record (1990 to 2004) was 0.32 mg/L, which was the same as 0.32 mg/L from 1990 to 1992 and 0.32 mg/L from 1990 to 1996.



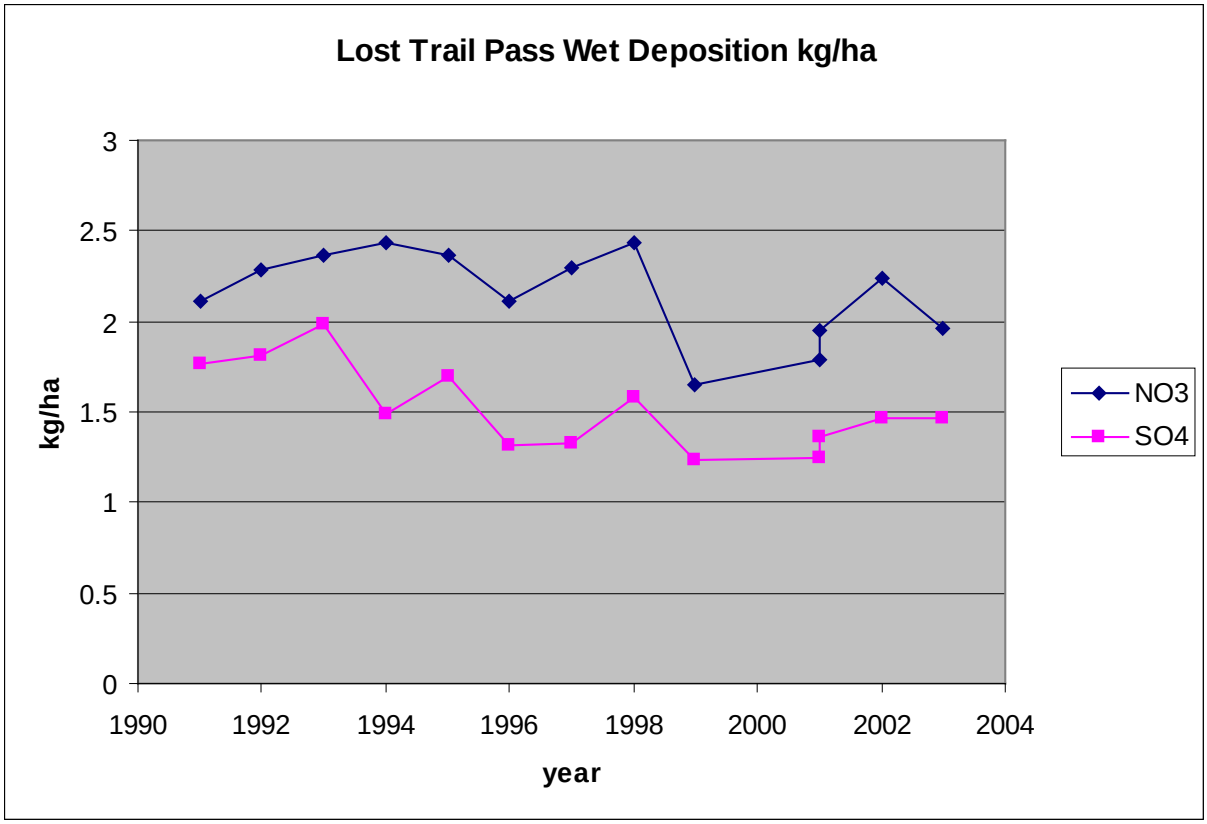
Nitrate (NO_3) and sulfate (SO_4) trends over the period of record are fairly stable for overall monthly and quarterly averages. However, as with pH, a strong and consistent seasonal pattern is quite pronounced with lower concentrations in the winter and higher in the summer. These seasonal patterns are typical of NADP sites nationwide and result from reduced cloud temperatures in the winter which retards the photochemical transformation of SO_2 and NOx emissions to sulfuric and nitric acid. Galbraith (1986) has measured and documented similar seasonal patterns at 4 NADP sites in the Wind River Range in Wyoming. The

Wind River sites have lower pH and higher levels of sulfate and nitrate deposition than Lost Trail Pass, presumably because the sites are closer to the southwest US emission sources. Galbraith (1986) also speculates that the lower winter acid deposition in the Wind River range sites is due to reduced winter cloud temperatures and also the cleaner air masses originating in Canada which dominate winter storm patterns as opposed to the summer southwest wind patterns which can transport emissions form the previously mention sources in Utah, Arizona, Mexico, and California.

Total annual wet deposition, as tabulated below for 1990-2003 is a calculation of concentration times precipitation. Concentrations by month and quarter are tabulated in Appendix 1 and Appendix 2.

Lost Trail Pass NADP Site MT97
Annual Wet Deposition
October 1990 - December 2003

year	Ca kg/ha	Mg kg/ha	K kg/ha	Na kg/ha	NH_4 kg/ha	NO_3 kg/ha	Cl kg/ha	SO_4 kg/ha	total Pcpt cm
1990	0.07	0.02	0.02	0.21	0.1	0.61	0.23	0.4	32.9
1991	0.44	0.07	0.10	0.27	0.38	2.11	0.37	1.77	94.4
1992	0.56	0.07	0.12	0.38	0.35	2.29	0.38	1.81	77.8
1993	0.39	0.06	0.11	0.39	0.43	2.36	0.43	1.98	90.9
1994	0.39	0.06	0.08	0.35	0.6	2.44	0.39	1.49	91.6
1995	0.4	0.06	0.12	0.49	0.58	2.36	0.40	1.70	121.1
1996	0.37	0.05	0.07	0.52	0.38	2.11	0.67	1.31	131.9
1997	0.26	0.04	0.10	0.28	0.33	2.3	0.46	1.33	107.4
1998	0.32	0.04	0.10	0.12	0.4	2.44	0.25	1.58	104.8
1999	0.41	0.06	0.08	0.15	0.38	1.65	0.28	1.24	95.8
2000	0.35	0.03	0.09	0.11	0.32	1.79	0.2	1.25	75.3
2001	0.44	0.05	0.09	0.16	0.46	1.95	0.26	1.36	92.6
2002	0.4	0.04	0.16	0.25	0.61	2.24	0.26	1.47	86.1
2003	0.82	0.09	0.15	0.38	0.49	1.96	0.4	1.47	112.3
avg	0.43	0.06	0.11	0.30	0.44	2.15	0.37	1.52	98.63



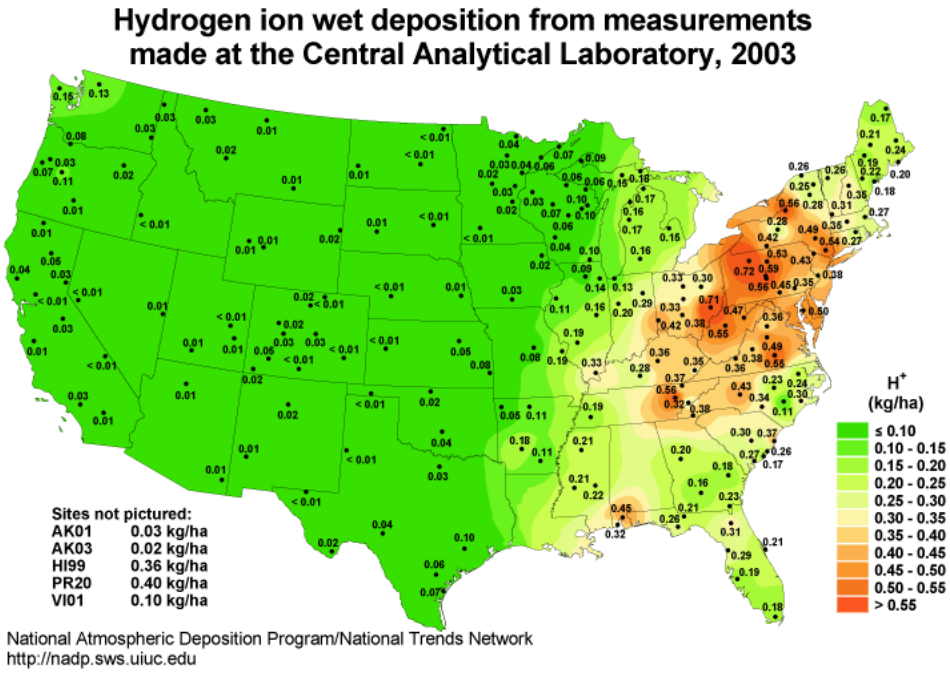
An important parameter in trend analysis and acid deposition ecological significance is total wet deposition of sulfate and nitrate in kilograms/hectare (kg/ha). Annual NO_3 and SO_4 deposition per year is shown above. Wet deposition is a function of total precipitation times concentration and is highly influenced by wet and drought years. In general, sulfate deposition slightly decreased through 2000 with a slight increase from 2000 to 2004. Annual nitrate deposition plots similarly. The slight increase in sulfate and nitrate deposition from 2000 through 2004 may be due primarily to increased precipitation after 2000. The overall lack of increase in nitrate deposition at MT97 is not consistent with overall trends for mobile source (vehicle) emissions in the Western US, which are increasing for NOx emissions (Peterson and Sullivan, 1998). In general NOx emissions are increasing in the Western US due to mobile source as the population grows as well as increasing small industrial facilities (Lynch, 1995, 1996). The slight decrease in overall sulfate deposition is consistent with overall Western US trends as industrial SO_2 sources have decreased. Many of the historic largest Western US SO_2 sources have shut down or are improving air pollution control technology.

Site Comparisons

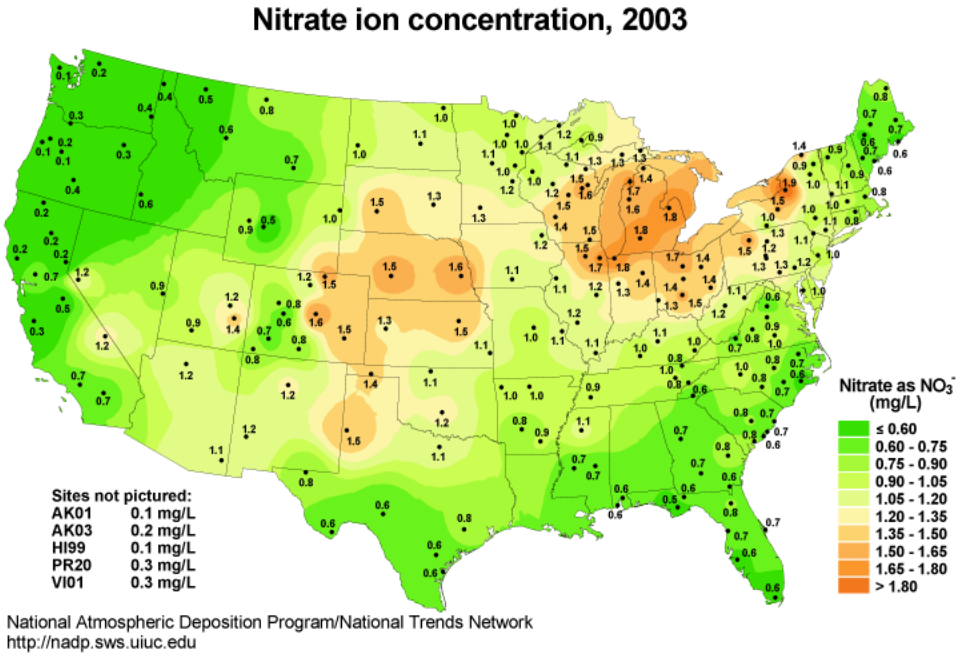
Annual NADP data from 1990 to 2003 for the closest NADP sites shows that the Lost Trail Pass site has lower average SO_4 (0.21 mg/L) and NO_3 (0.32 mg/L) concentrations than any of the surrounding sites. Annual SO_4 (1.7 kg/ha) and NO_3 (2.1 kg/ha) deposition is comparable to WY08 (YNP) and MT07 (Clancy) since precipitation at the Lost Trail Pass site is more than twice as high as any of the other sites.

Site/Management agency	pH	$S0_4$	$N0_3$	NH_4	$S0_4$	$N0_3$	Pcp	elev
		mg/L			kg/ha		cm	meters
WY08 – YNP Tower Falls	5.43	.38	.58	.17	1.43	2.2	29.9	1912
WY06 – BLM Pinedale	5.11	.59	.87	.18	1.7	2.4	28.4	2388
ID03 – NPS Craters of Moon	5.47	.40	.69	.24	.02	.98	29.5	1807
MT97 – Bitterroot NF Lost Trail Pass	5.39	.21	.32	.06	1.5	2.1	98.6	2414
MT07 Clancy (near Helena)	5.21	.43	.56	.12	1.6	2.1	36.9	1448

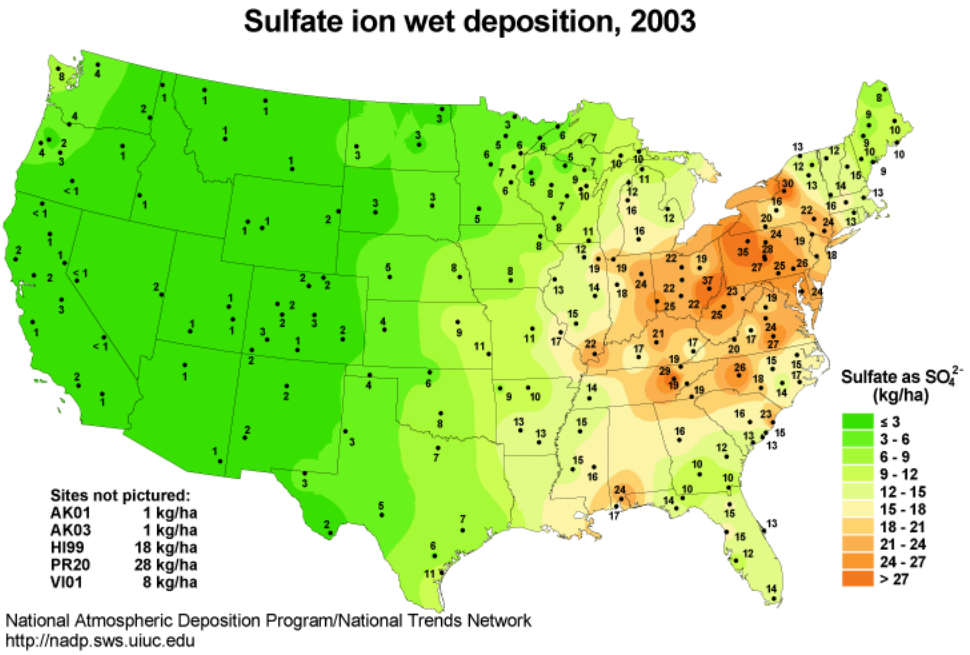
The enclosed graphs from the NADP web site (NADP, 2005) show the nationwide pattern for the year 2003 of lower hydrogen ion deposition (higher pH) in the western US and much higher hydrogen ion deposition (higher pH) in the eastern US. Lost Trail Pass, with an average pH of 5.39 is comparable to other sites in Montana where pH averaged 5.1 to 5.4. The NADP website graphs also show 2003 nitrate ion concentration and sulfate deposition which is the similar pattern of much higher deposition rates in the more industrialized eastern US and relatively low deposition amounts in Idaho and Montana.



Hydrogen ion concentrations as pH from measurements made at the NADP Central Analytical Laboratory, 2003.



Estimated nitrate ion deposition from measurements made at the NADP Central Analytical Laboratory, 2003.



Estimated sulfate ion deposition from measurements made at the NADP Central Analytical Laboratory, 2003.

Monitoring Recommendations

Several previous reports in 1993, 1994, 1996, 1998, and 2002 have recommended that the Lost Trail Pass site be continued through at least a 10 year period to allow a characterization of atmospheric chemistry at a representative high elevation site in the Northern Rockies. The Lost Trail Pass site, in the 15 years of operation (1990 through 2005), has provided very useful information about wet deposition concentration and amounts. The NADP staff are very supportive of the MT97 Lost Trail Pass site since it monitors a large "hole" in the NADP network, and is the only high elevation NADP site in Idaho or Montana. The Lost Trail Pass site has been helpful in evaluating lake chemistry data from the R1ARM sites and was essential in the MAGIC model calibrations of North Kootenai and Shasta lakes (Eilers et.al., 1998) which used precipitation (adjusted by elevation) from the Lost Trail Pass site as assumed wet deposition inputs to the model.

Providing sufficient National Forest system funding remain available, it would be desirable to continue the Lost Trail Pass site at least through 2010, particularly in conjunction with the ongoing Phase 3 lake monitoring at North Kootenai and Shasta lakes in the Selway Bitterroot Wilderness. This recommendation is also consistent with the desirability to continue monitoring with increasing energy development and the apparent trend of increasing nitrate deposition and decreasing sulfate deposition in the Western US.

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Appendix 1. Lost Trail Pass NADP Site MT97 Wet Precipitation Chemistry October 1990 to December 2003, by Quarter.

Year	Quarter	Ca mg/l	Mg mg/l	K mg/l	Na mg/l	NH_4 mg/l	NO_3 mg/l	Cl mg/l	SO_4 mg/l	pH	Cond uS/cm	Pcpt cm
1990	fall	0.03	0.01	0.01	0.06	0.04	0.20	0.08	0.13	5.55	2.60	21.61
1991	winter	0.02	0.00	0.00	0.06	0.01	0.17	0.06	0.11	5.44	2.40	21.77
	spring	0.10	0.01	0.01	0.04	0.08	0.29	0.04	0.27	5.55	3.20	29.92
	summer	0.08	0.01	0.03	0.04	0.07	0.65	0.07	0.37	5.09	5.80	11.15
	fall	0.01	0.00	0.01	0.02	0.16	0.16	0.03	0.11	5.35	2.40	31.01
1992	winter	0.03	0.00	0.01	0.01	0.02	0.16	0.04	0.16	5.50	2.50	23.34
	spring	0.08	0.01	0.01	0.01	0.08	0.31	0.05	0.28	5.57	3.40	17.25
	summer	0.15	0.02	0.04	0.05	0.06	0.49	0.05	0.33	5.29	8.50	15.10
	fall	0.06	0.01	0.01	0.07	0.04	0.29	0.04	0.26	5.42	3.20	19.81
1993	winter	0.03	0.00	0.01	0.04	0.02	0.14	0.04	0.14	5.56	2.90	27.51
	spring	0.06	0.01	0.01	0.03	0.07	0.25	0.04	0.23	5.53	4.00	17.25
	summer	0.04	0.01	0.02	0.05	0.05	0.38	0.05	0.30	5.14	4.60	29.94
	fall	0.05	0.01	0.01	0.05	0.05	0.24	0.05	0.16	5.59	3.10	11.02
1994	winter	0.02	0.00	0.00	0.05	0.05	0.15	0.05	0.09	5.45	2.20	27.81
	spring	0.05	0.01	0.01	0.03	0.08	0.25	0.04	0.21	5.36	3.50	25.43
	summer	0.11	0.01	0.03	0.05	0.12	0.72	0.08	0.36	4.96	7.20	10.99
	fall	0.01	0.00	0.01	0.04	0.04	0.19	0.04	0.11	5.38	2.60	28.98
1995	winter	0.01	0.00	0.00	0.02	0.04	0.14	0.02	0.08	5.37	2.30	27.33
	spring	0.03	0.01	0.00	0.03	0.08	0.24	0.03	0.19	5.36	2.90	34.98
	summer	0.09	0.01	0.04	0.05	0.05	0.33	0.06	0.22	5.23	4.40	17.50
	fall	0.01	0.00	0.01	0.05	0.02	0.11	0.03	0.09	5.41	2.40	29.70
1996	winter	0.01	0.00	0.00	0.03	0.01	0.09	0.03	0.03	5.43	1.90	60.50
	spring	0.03	0.01	0.00	0.04	0.03	0.02	0.05	0.14	5.35	2.90	31.90
	summer	0.15	0.02	0.04	0.19	0.02	0.82	0.27	0.48	4.96	10.10	7.09
	fall	0.03	0.00	0.00	0.03	0.02	0.02	0.04	0.09	5.73	2.80	24.60
1997	winter	0.01	0.00	0.00	0.02	0.02	0.11	0.03	0.06	5.40	2.10	62.80
	spring	0.03	0.00	0.01	0.03	0.04	0.20	0.06	0.14	5.35	3.80	29.09
	summer	0.05	0.01	0.05	0.04	0.04	0.44	0.06	0.24	5.04	5.75	15.61
	fall	0.03	0.00	0.01	0.04	0.04	0.28	0.04	0.15	5.23	3.37	23.54
1998	winter	0.01	0.00	0.00	0.01	0.02	0.14	0.02	0.06	5.34	2.22	25.62

Year	Quarter	Ca mg/l	Mg mg/l	K mg/l	Na mg/l	NH_4 mg/l	NO_3 mg/l	Cl mg/l	SO_4 mg/l	pH	Cond uS/cm	Pcpt cm
	spring	0.05	0.01	0.01	0.02	0.06	0.28	0.03	0.19	5.31	3.27	30.45
	summer	0.05	0.01	0.02	0.02	0.03	0.31	0.03	0.21	5.08	4.70	17.92
	fall	0.02	0.00	0.01	0.01	0.05	0.29	0.02	0.19	5.21	3.89	24.09
1999	winter	0.02	0.00	0.00	0.01	0.02	0.10	0.03	0.06	5.39	2.00	44.80
	spring	0.08	0.01	0.01	0.03	0.08	0.26	0.03	0.25	5.44	3.40	20.90
	summer	0.05	0.01	0.01	0.02	0.08	0.03	0.04	0.25	5.17	4.28	8.70
	fall	0.10	0.01	0.04	0.02	0.04	0.28	0.04	0.15	5.46	3.07	17.90
2000	winter	0.02	0.00	0.00	0.01	0.03	0.15	0.02	0.07	5.41	2.30	39.50
	spring	0.06	0.01	0.02	0.03	0.08	0.29	0.04	0.28	5.34	3.88	17.60
	summer	0.06	0.01	0.02	0.02	0.03	0.32	0.03	0.16	5.22	4.11	6.50
	fall	0.06	0.01	0.01	0.01	0.04	0.21	0.02	0.17	5.31	3.26	18.50
2001	winter	0.05	0.00	0.01	0.01	0.02	0.23	0.03	0.12	5.35	2.89	21.90
	spring	0.07	0.01	0.01	0.01	0.10	0.23	0.03	0.19	5.60	2.79	25.80
	summer	0.06	0.01	0.02	0.03	0.08	0.32	0.04	0.18	5.27	3.94	19.60
	fall	0.04	0.01	0.01	0.02	0.05	0.15	0.03	0.14	5.44	2.60	19.80
2002	winter	0.02	0.00	0.00	0.01	0.02	0.14	0.02	0.07	5.46	2.47	36.30
	spring	0.05	0.01	0.02	0.02	0.10	0.29	0.03	0.23	5.46	3.49	17.80
	summer	0.06	0.01	0.02	0.02	0.08	0.36	0.03	0.18	5.36	3.86	18.30
	fall	0.04	0.01	0.02	0.08	0.05	0.23	0.04	0.15	5.51	3.04	10.90
2003	winter	0.01	0.00	0.01	0.01	0.02	0.13	0.03	0.05	5.41	2.34	39.00
	spring	0.15	0.01	0.01	0.07	0.07	0.20	0.05	0.22	5.48	3.66	36.78
	summer	0.20	0.02	0.03	0.02	0.18	0.65	0.05	0.22	5.55	4.56	5.82
	fall	0.06	0.01	0.05	0.02	0.10	0.10	0.03	0.13	5.52	3.96	22.84

Appendix 2. Lost Trail Pass NADP Site MT97 Wet Precipitation Chemistry October 1990 to August 2004, by Month.

Year	Month	Ca mg/l	Mg mg/l	K mg/l	Na mg/l	NH_4 mg/l	NO_3 mg/l	Cl mg/l	SO_4 mg/l	pH	Cond uS/cm	Pcpt cm
1990	O	0.05	0.01	0.02	0.11	0.06	0.31	0.09	0.20	5.6	3.5	7.8
	N	0.01	0.00	0.00	0.04	0.03	0.15	0.07	0.10	5.5	2.2	12.8
	D	0.02	0.00	0.01	0.07	0.01	0.17	0.06	0.11	5.4	2.4	11.3
1991	J	0.01	0.00	0.00	0.04	0.01	0.18	0.06	0.09	5.4	2.3	6.7
	F	0.03	0.01	0.00	0.05	0.02	0.15	0.06	0.13	5.7	2.8	3.8
	M	0.12	0.02	0.02	0.06	0.10	0.32	0.05	0.25	5.7	3.1	10.2
	A	0.05	0.01	0.01	0.03	0.07	0.26	0.03	0.29	5.4	3.2	10.9
	M	0.15	0.02	0.02	0.03	0.06	0.30	0.05	0.27	5.7	3.3	8.8
	J	0.04	0.01	0.02	0.03	0.01	0.42	0.05	0.20	5.2	4.3	7.6
	J	0.12	0.02	0.15	0.10	0.01	0.05	0.18	0.33	6.1	4.2	1.7
	A	0.13	0.02	0.04	0.04	0.14	0.96	0.08	0.57	5	7.7	1.9
	S	0.04	0.01	0.02	0.02	0.05	0.33	0.14	0.28	5.2	4.3	4.6
	O	0.01	0.00	0.00	0.01	0.01	0.20	0.01	0.13	5.1	3.1	4.0
	N	0.01	0.00	0.01	0.02	0.01	0.13	0.03	0.09	5.4	2	22.5
	D	0.01	0.00	0.01	0.02	0.01	0.10	0.03	0.16	5.4	2.4	11.9
1992	J	0.03	0.00	0.00	0.04	0.02	0.21	0.05	0.18	5.6	2.6	5.5
	F	0.06	0.01	0.01	0.04	0.03	0.21	0.06	0.14	5.8	2.3	6.0
	M	0.06	0.01	0.01	0.04	0.12	0.30	0.04	0.26	5.9	3.1	3.3
	A	0.04	0.01	0.01	0.03	0.04	0.19	0.04	0.19	5.5	2.7	9.6
	M	0.18	0.02	0.02	0.12	0.16	0.59	0.10	0.48	5.6	5.1	4.4
	J	0.18	0.02	0.05	0.05	0.05	0.38	0.06	0.28	5.6	3.9	7.1
	J	0.04	0.07	0.02	0.02	0.07	0.44	0.03	0.32	5.1	4.9	7.1
	A	0.72	0.01	0.11	0.20	0.07	1.68	0.13	0.85	5.1	14.1	1.0
	S	0.07	0.01	0.02	0.14	0.03	0.26	0.05	0.24	5.7	3.1	4.4
	O	0.09	0.00	0.01	0.04	0.06	0.38	0.04	0.32	5.3	3.8	8.4
	N	0.02	0.00	0.01	0.05	0.03	0.16	0.05	0.16	5.4	2.5	7.0
	D	0.02	0.00	0.01	0.03	0.01	0.13	0.05	0.10	5.6	2.1	14.2
1993	J	0.02	0.00	0.00	0.01	0.02	0.14	0.02	0.14	5.5	2.3	8.4
	F	0.07	0.01	0.02	0.09	0.03	0.15	0.05	0.27	5.7	3.5	5.0
	M	0.06	0.01	0.01	0.03	0.07	0.22	0.04	0.21	5.6	2.8	8.2
	A	0.05	0.01	0.01	0.02	0.07	0.22	0.03	0.23	5.6	2.6	13.0
	M	0.1	0.02	0.01	0.05	0.06	0.47	0.05	0.29	5.3	3.9	3.6
	J	0.04	0.01	0.02	0.04	0.04	0.31	0.05	0.22	5.2	3.6	11.9
	J	0.02	0.01	0.03	0.05	0.02	0.32	0.04	0.30	5.1	4.3	10.1

Year	Month	Ca mg/l	Mg mg/l	K mg/l	Na mg/l	NH_4 mg/l	NO_3 mg/l	Cl mg/l	SO_4 mg/l	pH	Cond uS/cm	Pcpt cm
	A	0.09	0.01	0.02	0.07	0.11	0.64	0.09	0.45	5	6.9	7.9
	S	0.06	0.01	0.02	0.06	0.12	0.35	0.06	0.29	5.6	3.6	1.7
	O	0.04	0.00	0.01	0.04	0.03	0.18	0.05	0.12	5.5	3.2	6.2
	N	0.06	0.01	0.01	0.04	0.05	0.31	0.05	0.19	5.8	2.8	3.1
	D	0.02	0.00	0.00	0.05	0.03	0.13	0.07	0.10	5.5	2	11.9
1994	J	0.01	0.00	0.00	0.07	0.09	0.27	0.05	0.13	5.3	2.7	5.9
	F	0.02	0.00	0.00	0.03	0.06	0.12	0.04	0.07	5.5	2.2	10.0
	M	0.05	0.01	0.01	0.06	0.06	0.19	0.04	0.11	5.5	2.5	6.3
	A	0.01	0.00	0.00	0.01	0.04	0.12	0.02	0.15	5.4	3.5	10.0
	M	0.08	0.01	0.01	0.03	0.11	0.38	0.04	0.32	5.3	4.3	9.1
	J	0.09	0.01	0.05	0.04	0.06	0.39	0.06	0.30	5.1	5.3	3.6
	J	0.11	0.01	0.03	0.05	0.13	0.82	0.08	0.37	4.9	7.8	6.5
	A	0.24	0.03	0.04	0.07	0.29	1.28	0.12	0.58	4.9	10.4	0.9
	S	0.18	0.02	0.06	0.03	0.15	0.32	0.05	0.27	5.8	3.7	3.6
	O	0.02	0.00	0.00	0.06	0.06	0.11	0.04	0.10	5.4	2	13.1
	N	0.03	0.00	0.00	0.04	0.02	0.23	0.05	0.11	5.3	3	12.2
	D	0.01	0.00	0.00	0.02	0.03	0.12	0.02	0.07	5.4	2.2	10.3
1995	J	0.01	0.00	0.00	0.02	0.05	0.14	0.02	0.06	5.4	2.2	6.9
	F	0.01	0.01	0.01	0.04	0.12	0.41	0.05	0.35	5.1	5.1	10.1
	M	0.01	0.00	0.00	0.02	0.06	0.21	0.03	0.09	5.4	2.4	9.8
	A	0.05	0.01	0.00	0.03	0.10	0.24	0.03	0.26	5.5	3.2	15.4
	M	0.01	0.00	0.00	0.04	0.05	0.25	0.04	0.15	5.2	3.1	9.8
	J	0.08	0.01	0.04	0.04	0.05	0.29	0.05	0.20	5.2	4.1	10.6
	J	0.16	0.02	0.06	0.09	0.03	0.21	0.06	0.21	5.5	3.6	5.4
	A	0.15	0.02	0.05	0.10	0.01	0.78	0.11	0.38	5	7.7	1.5
	S	0.05	0.01	0.01	0.04	0.05	0.31	0.05	0.22	5.2	4.1	3.8
	O	0.02	0.00	0.01	0.03	0.01	0.14	0.02	0.10	5.3	2.6	7.7
	N	0.01	0.00	0.00	0.07	0.02	0.06	0.03	0.06	5.5	1.9	18.3
	D	0.01	0.00	0.00	0.03	0.03	0.11	0.03	0.03	5.4	2.5	21.8
1996	J	0.01	0.00	0.00	0.02	0.01	0.08	0.03	0.03	5.4	1.8	20.4
	F	0.02	0.00	0.00	0.04	0.01	0.09	0.04	0.04	5.5	1.8	18.3
	M	0.03	0.00	0.00	0.04	0.03	0.22	0.04	0.15	5.4	3.1	8.9
	A	0.03	0.00	0.00	0.05	0.02	0.08	0.07	0.07	5.5	2	11.5
	M	0.03	0.01	0.01	0.04	0.04	0.19	0.05	0.18	5.3	3.6	11.5
	J	0.2	0.02	0.03	0.41	0.07	0.67	0.58	0.41	5	7.8	2.1
	J	0.1	0.02	0.03	0.09	0.08	0.76	0.09	0.44	4.8	9.7	1.3
	A	0.14	0.02	0.05	0.05	0.34	1.01	0.11	0.56	5.1	8	3.8
	S	0.12	0.01	0.01	0.04	0.08	0.35	0.07	0.23	5.3	4	2.8
	O	0.01	0.00	0.01	0.03	0.02	0.13	0.05	0.08	5.3	2.3	6.7
	N	0.02	0.00	0.00	0.02	0.01	0.13	0.02	0.06	5.4	2.2	15.2

Year	Month	Ca mg/l	Mg mg/l	K mg/l	Na mg/l	NH_4 mg/l	NO_3 mg/l	Cl mg/l	SO_4 mg/l	pH	Cond uS/cm	Pcpt cm
	D	0.02	0.00	0.00	0.03	0.03	0.09	0.05	0.06	5.4	2.1	29.6
1997	J	0.01	0.00	0.01	0.01	0.01	0.10	0.03	0.05	5.4	2.1	21.8
	F	0.01	0.00	0.00	0.02	0.02	0.14	0.02	0.08	5.4	2.2	11.3
	M	0.03	0.00	0.00	0.04	0.04	0.16	0.09	0.13	5.4	2.4	14.4
	A	0.03	0.00	0.00	0.02	0.05	0.26	0.03	0.14	5.3	2.8	9.2
	M	0.03	0.01	0.01	0.02	0.03	0.22	0.03	0.14	5.2	3.4	5.9
	J	0.05	0.01	0.04	0.04	0.04	0.39	0.05	0.22	5.1	5.2	7.7
	J	0.10	0.03	0.27	0.03	0.01	0.50	0.09	0.36	5.0	7.1	2.5
	A	0.07	0.01	0.03	0.04	0.04	0.67	0.07	0.32	4.9	8.1	5.4
	S	0.07	0.01	0.02	0.05	0.09	0.54	0.08	0.30	5.1	5.4	3.8
	O	0.03	0.01	0.01	0.04	0.05	0.31	0.04	0.18	5.2	3.8	6.4
	N	0.02	0.00	0.00	0.03	0.01	0.20	0.03	0.09	5.3	2.6	13.4
	D	0.01	0.00	0.00	0.02	0.01	0.13	0.02	0.06	5.4	2.2	5.6
1998	J	0.01	0.00	0.00	0.01	0.01	0.14	0.02	0.05	5.3	2.1	15.3
	F	0.01	0.00	0.00	0.01	0.02	0.19	0.02	0.08	5.3	2.5	4.8
	M	0.05	0.01	0.00	0.02	0.03	0.18	0.03	0.14	5.5	2.5	5.8
	A	0.03	0.00	0.00	0.01	0.08	0.25	0.02	0.19	5.3	3.0	13.6
	M	0.08	0.01	0.03	0.03	0.05	0.35	0.04	0.23	5.3	4.0	11.0
	J	0.03	0.01	0.02	0.01	0.02	0.25	0.02	0.19	5.1	4.3	12.2
	J											2.9
	A	0.12	0.02	0.06	0.05	0.09	0.68	0.08	0.36	5	7.2	2.8
	S	0.06	0.01	0.01	0.02	0.12	0.52	0.04	0.32	5.1	6.9	5.0
	O	0.04	0.01	0.02	0.02	0.08	0.32	0.03	0.29	5.2	6.7	1.7
	N	0.01	0.00	0.00	0.01	0.03	0.22	0.02	0.15	5.3	3.3	17.4
	D	0.01	0.00	0.00	0.01	0.01	0.07	0.02	0.05	5.4	1.9	12.4
1999	J	0.02	0.003	0.00	0.01	0.02	0.10	0.03	0.05	5.6	2.3	17.2
	F	0.03	0.004	0.00	0.01	0.03	0.13	0.03	0.07	5.4	3.3	15.2
	M	0.08	0.01	0.01	0.04	0.04	0.20	0.04	0.08	5.6	3	5.7
	A	0.09	0.01	0.01	0.03	0.09	0.27	0.03	0.25	5.6	4.2	4.4
	M	0.07	0.01	0.01	0.03	0.11	0.29	0.03	0.29	5.6	5	10.9
	J	0.05	0.01	0.01	0.02	0.08	0.31	0.04	0.26	5.3		6.0
	J	0.07	0.01	0.03	0.03	0.01	0.41	0.05	0.21	5.7	4.8	0.7
	A											2.0
	S	0.25	0.03	0.11	0.04	0.08	0.43	0.07	0.29	5.7	5.7	2.0
	O	0.06	0.01	0.02	0.02	0.03	0.23	0.03	0.11	5.9	4.8	2.2
	N	0.04	0.00	0.01	0.01	0.02	0.21	0.02	0.08	6	3.8	13.8
	D	0.02	0.00	0.00	0.01	0.02	0.08	0.02	0.06	5.6	2.2	15.9
2000	J	0.02	0.00	0.00	0.01	0.02	0.14	0.02	0.10	5.8	2.7	15.1
	F	0.02	0.00	0.01	0.01	0.06	0.29	0.03	0.09	5.3	3	8.6
	M	0.02	0.00	0.03	0.04	0.05	0.24	0.05	0.16	5.6	3.7	5.5

Year	Month	Ca mg/l	Mg mg/l	K mg/l	Na mg/l	NH_4 mg/l	NO_3 mg/l	Cl mg/l	SO_4 mg/l	pH	Cond uS/cm	Pcpt cm
	A	0.11	0.01	0.02	0.02	0.17	0.45	0.03	0.42	5.4	5.3	4.7
	M	0.07	0.01	0.01	0.02	0.07	0.27	0.03	0.32	5.3	5.8	7.4
	J	0.05	0.01	0.02	0.01	0.02	0.25	0.03	0.13	5.3	5.2	4.9
	J	2.62	0.24	0.41	0.08	1.27	4.93	0.97	1.87			0.9
	A											0.6
	S	0.06	0.01	0.01	0.01	0.03	0.14	0.03	0.15	5.2	3.9	7.4
	O	0.03	0.00	0.01	0.01	0.05	0.31	0.02	0.19	5.2	4.6	6.7
	N	0.1	0.01	0.02	0.01	0.01	0.14	0.02	0.14	5	4.2	4.4
	D	0.05	0.00	0.01	0.04	0.01	0.21	0.03	0.11	5.3	3.3	9.0
2001	J	0.02	0.005	0.01	0.008	0.01	0.22	0.04	0.11	5.3	3.01	4.00
	F	0.05	0.004	0	0.004	0.06	0.26	0.03	0.13	5.5	2.81	8.89
	M	0.05	0.005	0.01	0.007	0.06	0.19	0.03	0.19	5.5	2.99	8.99
	A	0.07	0.007	0.01	0.006	0.11	0.24	0.02	0.18	5.7	2.6	11.94
	M	0.14	0.015	0.03	0.027	0.08	0.26	0.03	0.25	5.7	2.95	4.88
	J	0.05	0.006	0.02	0.016	0.02	0.19	0.03	0.14	5.3	2.89	9.47
	J	0.07	0.009	0.02	0.02	0.08	0.45	0.05	0.22	5.2	5.04	9.22
	A	--	--	--	--	--	--	--	--	--	--	0.88
	S	0.07	0.007	0.02	0.017	0.06	0.24	0.02	0.33	5.3	4	3.45
	O	0.04	0.005	0.01	0.008	0.03	0.13	0.03	0.12	5.5	2.33	10.8
	N	0.02	0.003	0.02	0.016	0.03	0.14	0.04	0.08	5.5	2.33	5.54
	D	0.01	0.002	0	0.002	0.02	0.11	0.02	0.05	5.5	2.21	14.58
2002	J	0.02	0.001	0	0.001	0.02	0.13	0.02	0.1	5.4	3	15.8
	F	0.04	0.003	0	0.004	0.04	0.22	0.02	0.1	5.5	2.62	5.89
	M	0.05	0.006	0.01	0.01	0.1	0.32	0.03	0.21	5.5	3.35	11.28
	A	0.04	0.005	0.05	0.049	0.1	0.24	0.02	0.24	5.4	3.41	7.51
	M	0.07	0.008	0.01	0.009	0.09	0.29	0.04	0.26	5.4	3.88	8.99
	J	0.06	0.007	0.02	0.022	0.06	0.29	0.03	0.15	5.4	3.45	10.06
	J	--	--	--	--	--	--	--	--	--	--	3.25
	A	0.07	0.007	0.02	0.017	0.21	0.64	0.03	0.3	5.2	5.7	4.95
	S	0.05	0.008	0.02	0.021	0.1	0.27	0.03	0.23	5.4	3.86	3.2
	O	0.02	0.006	0.04	0.042	0.05	0.21	0.03	0.11	5.4	2.83	1.65
	N	0.05	0.006	0.02	0.015	0.04	0.22	0.04	0.13	5.6	2.77	6
	D	0.04	0.005	0.03	0.03	0.04	0.12	0.06	0.07	5.6	2.18	7.54
2003	J	0.01	0.001	0	0.001	0.01	0.13	0.02	0.06	5.4	2.45	14.38
	F	0.01	0.001	0.01	0.008	0.02	0.14	0.04	0.05	5.4	2.26	17.09
	M	0.04	0.004	0	0.003	0.03	0.15	0.03	0.09	5.4	2.52	19.68
	A	0.31	0.027	0.02	0.018	0.1	0.28	0.09	0.38	5.6	4.94	8.64
	M	0.03	0.003	0	0.003	0.05	0.14	0.01	0.13	5.4	3.1	8.46
	J	0.07	0.008	0	0.003	0.03	0.38	0.05	0.2	5	5.5	3.1
	J	--	--	--	--	--	--	--	--	--	--	0.61

Year	Month	Ca mg/l	Mg mg/l	K mg/l	Na mg/l	NH_4 mg/l	NO_3 mg/l	Cl mg/l	SO_4 mg/l	pH	Cond uS/cm	Pcpt cm
	A	0.21	0.019	0.04	0.035	0.2	0.68	0.04	0.22	5.7	4.45	2.11
	S	0.05	0.008	0.04	0.038	0.12	0.44	0.03	0.31	5.1	5.25	2.16
	O	0.05	0.006	0.02	0.019	0.03	0.15	0.04	0.17	5.5	3.5	2.11
	N	0.07	0.018	0.07	0.065	0.01	0.01	0.03	0.08	5.7	2.3	18.57
	D	--	--	--	--	--	--	--	--	--	--	15.37
2004	J	--	--	--	--	--	--	--	--	--	--	14.83
	F	--	--	--	--	--	--	--	--	--	--	5.08
	M	0.12	0.014	0.11	0.108	0.06	0.32	0.2	0.31	6.5	5.1	6.71
	A	0.06	0.005	0	0.001	0.01	0.01	0.04	0.17	5.5	2.3	3.68
	M	0.05	0.005	0.01	0.008	0.05	0.21	0.01	0.2	5.4	3.03	11.38
	J	0.12	0.013	0.02	0.021	0.07	0.41	0.08	0.26	5.3	4.89	3.76
	J	0.08	0.012	0.11	0.109	0.05	0.14	0.06	0.23	5.3	4.58	3.79
	A	0.07	0.01	0.04	0.037	0.05	0.42	0.04	0.22	5.1	5.19	7.92