

Division
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State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Division of Flood Management

**RESULTS OF SNOW ACIDITY SAMPLING
IN CALIFORNIA**

December 1986

LASSEN VOLCANIC NATIONAL PARK
Research Library

Gordon K. Van Vleck
Secretary for Resources
The Resources
Agency

George Deukmejian
Governor
State of
California

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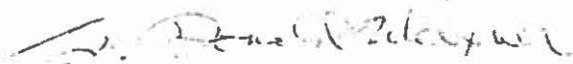
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FOREWORD

During the 1985-86 season, snow surveyors in the California Cooperative Snow Surveys Program field tested the snowpack for acidity while performing their regular snowpack depth and water-content measurements. The purpose of the special sampling was to provide broad coverage of the snow zone in California to see if there appeared to be a widespread problem of snow acidity, or if specific "hot spots" or zones of acidity existed. The field tests of surface-snow acidity were made with small litmus-paper test kits. About 520 snow-course determinations of pH were made from about January 1 through April 1. Field pH values clustered around 5.3, not significantly different from the 5.6 theoretically expected from clean precipitation. The results indicate no widespread acidity problem in the California snowpack, at least not during 1986.



G. Donald Meixner, Chief
Division of Flood Management

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INTRODUCTION

Acid precipitation has posed some problems to aquatic systems in northwestern Europe, particularly Scandinavia, and in northeastern North America. State Air Resources Board surveys have picked up acidic rain or deposition in parts of California as well. Acid precipitation had not been expected to be a problem in the West, but scattered reports of acid rain or snow cast doubt on this earlier conclusion. It is known that a large number of the high Sierra lakes lack natural buffering systems and are vulnerable to acid precipitation.

Because of widespread concern over acid rain, a field survey of snow acidity was conducted during the 1985-86 season by teams participating in the California Cooperative Snow Surveys Program. The purpose of the special sampling was to provide broad coverage of the snow zone in California to determine the existence of either a widespread problem of snow acidity or whether specific "hot spots" or zones of acidity existed. Acid snow would be the frozen version of the acid rain problem.

For more than 50 years, snow gager teams from the Department of Water Resources (DWR), the U. S. Forest Service, Pacific Gas and Electric Company, the U. S. Soil Conservation Service, and many other organizations have measured snow depth and water content in the mountains in order to forecast spring runoff. The regular snowpack measurements are a valuable tool in managing California water supply.

The survey teams carried small plastic tubes and litmus paper indicator sticks. The surveyor filled the tube with surface snow and placed the capped tube in a pocket until the snow melted. He then inserted the litmuspaper stick and checked the color after five to ten minutes. The color was matched against a reference chart and the pH (acidity) level was recorded on the snow notes. The Department furnished the materials for the special survey.



Figure 1. Inserting litmus paper stick into test tube of meltwater.

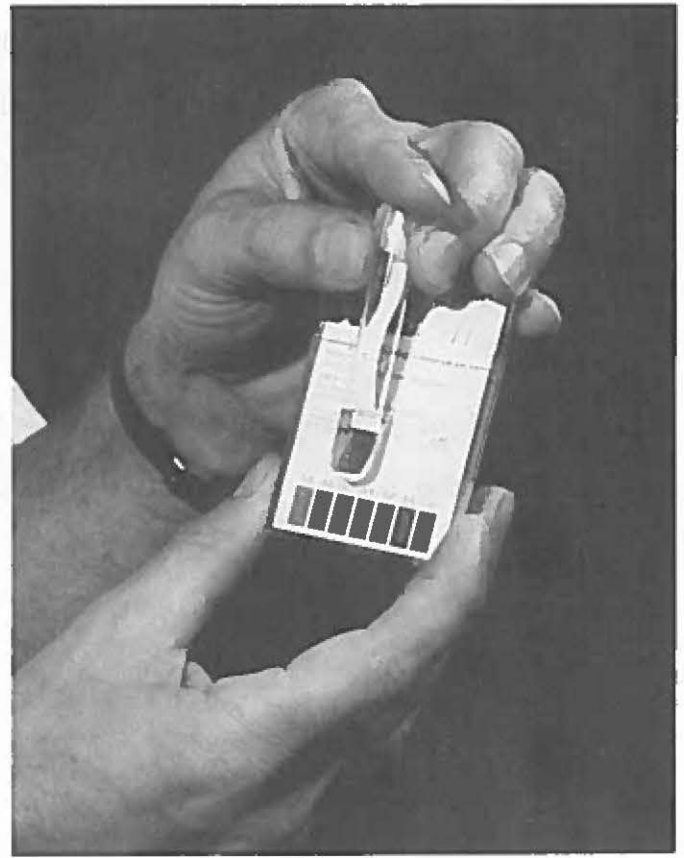


Figure 2. Matching litmus paper stick to color chart on pH kit.

While performing the regular snow measurements at the course, a snow gager would scoop up a test-tube of surface snow, taking care not to contaminate it with hands or gloves. The test tube was capped and allowed to melt in the gager's pocket while work continued. Normally a second sample was taken later on the course also. Normally the samples were taken at the second and ninth snow sampling points. Most snow courses have ten sampling points. A set of the detailed instructions for sampling is included in Appendix B.

Snow acidity was tested during the regular field snow surveys about the first of each month from January through April. Many snow courses are measured about May 1 as well; by then, however, melting is well along, and impurities could be likely to contaminate the surface snow. Therefore, no acidity testing was planned for May 1.

The pH values were clustered around 5.3 with some scattering of samples with lower readings and a few values over 5.5. The distribution of the 522 course reports are listed as follows and also plotted on Figure 3.

	pH	Number	Percent
Under	5.0	6	1
	5.0	45	9
	5.1	30	6
	5.2	84	16
	5.3	285	54
	5.4	47	9
	5.5	17	3
Over	5.5	<u>8</u>	<u>2</u>
Total		522	100

The color bars on the test kit are at pH values of 4.7, 5.0, 5.3, 5.5 and 5.7 (and other values at greater range), so this may have influenced the larger number of 5.0 than 5.1 pH readings. Some readings may have been measurement errors. Soaking the litmus paper too long causes a shift toward the acidic side on many samples. The pair of lowest readings, averaging 4.6, at the Sweetwater Snow Course near Mt. Shasta on February 4 was not evident at the end of the month, when a pH of 5.3 was measured at the same course. The second lowest course average, a pH of 4.7 at Rubicon #1 on the west side of Lake Tahoe, probably includes either a bad reading or one that had been soaked too long for the first sample since the second test was 5.0.

A regional summary follows:

Region	January		February		March		April	
	No.	Avg. pH	No.	Avg. pH	No.	Avg. pH	No.	Avg. pH
Shasta-Trinity	0	--	11	5.2	16	5.3	23	5.3
Stony Creek	0	--	1	5.3	1	5.3	1	5.2
Northern Sierra: Feather-Yuba	13	5.3	11	5.3	24	5.3	20	5.3
Central Sierra: American-Mokelumne	20	5.3	22	5.2	15	5.3	24	5.3
San Joaquin: Stanislaus- San Joaquin	10	5.3	17	5.2	13	5.2	28	5.3
Tulare: Kings-Kern	10	5.4	27	5.3	24	5.4	40	5.2
North Lahontan	3	5.1	28	5.2	29	5.1	28	5.3
South Lahontan	0	--	24	5.2	15	5.3	19	5.3
Santa Ana	0	--	1	5.1	2	5.3	2	5.3

No strong regional trend is apparent, but the North Lahontan average was slightly lower in the March 1 survey. The average represents samples in the Tahoe-Truckee, Carson, and Walker River basins. The average was lowered by a number of 5.0 and 5.1 pH readings from sampling near the end of February. Comparable pH readings of 5.1 were also reported from two Mono Lake basin courses that month. The differences from other regions is small and may not be significant given the accuracy of the method. However, there is a suggestion of a slight acidity shift in the Central Sierra east slope on March 1.

As mentioned previously, only a couple of samples from Southern California were taken in the upper Santa Ana River basin in the San Bernardino mountains. The single snow course report on February 2 showed a hint of acidity at 5.1, but the March 9 and April 5 samples were similar to other areas at a pH of 5.3.

in the spring of 1983. Reported median pH was about 5.6 for the cores, with slightly lower values in the southern Sierra.

Investigator Daniel Dawson tested precipitation from Mammoth Mountain in the 1984-85 season for the Air Resources Board. Most of his snow samples (the ones with appreciable volume) ran from a pH of 5.3 to 5.8, but there was one storm on January 29, 1985, which had a pH of around 4.7. He and other researchers have reported summer rain events that seem to be considerably more acidic.

TEST COMPARISONS OF METHODOLOGY

The field pH tests are not as precise as methods used for specific location studies. One of the questions was the accuracy of the sampling kits. In an attempt to resolve this, several comparison tests of the litmus sticks with laboratory pH meters were made by other researchers. Because melted snow is so pure, accurate determinations of pH can be difficult.

Dr. Neil Berg and associates at the Central Sierra Snow Laboratory made the most extensive checks. Sometimes there were unexplained readings on the instrument as well as the difference between litmus paper and laboratory meter. A complete description of his tests are in Appendix C, but can be summarized as follows:

1. For snow in the mid-5 pH range, the litmus sticks and the meter readings are close, probably within one color increment on the color chart (0.2 to 0.3 pH). The paper strips tend to be slightly more acidic than the meter.
2. Litmus-paper stick readings are not appreciably affected by observer variability. The bulk of the observation differences were only 0.1 pH unit.

These comparisons show that the field acidity tests are generally within one color increment (0.2 to 0.3 units) of matching the laboratory values. The northern group field readings were lower than laboratory readings by about 0.2 units, whereas the southern group averaged nearly the same.

An earlier set of tests by Dr. John Melack's group, who are working with the Air Resources Board, also showed results similar to the northern group tests reported from the Central Sierra Snow Lab, although the differences between laboratory meter and paper were somewhat greater. This test also involved multiple samples of the same snow location in the Emerald Lake area. Results of meter and paper tests at five minutes of soaking were:

Dec 10, 1985	Electrode pH	Paper
Inlet Sample 1	5.02	5.15
2	4.91	5.10
3	5.04	4.55
4	4.97	4.60
5	5.22	4.80
6	5.16	5.20
7	4.99	5.00
8	<u>5.01</u>	<u>5.10</u>
Average	5.04	4.94
<u>Dec 18, 1985</u>		
Parsons Sample 9	5.39	5.20
10	5.40	5.20
11	5.46	5.00
12	5.50	5.30
13	<u>5.36</u>	<u>5.30</u>
Average	5.42	5.20

The multiple samples show a laboratory meter range of about 0.3 pH units on the first set of samples compared to a litmus paper range of 0.6 units. The second

network is sparse in the snow zone, there would be merit in some periodic field sampling from time to time by individual cooperators willing to make such measurements.

ACKNOWLEDGEMENTS

We wish to thank the many snow survey teams who were willing to assume the additional chore of acidity sampling during their regular snow-course measurement work. This made it possible for all of us to learn something more about the current chemical condition of the California snowpack. Special thanks is also extended to Dr. Neil Berg and associates at the Central Sierra Snow Laboratory, who encouraged us with this project.

APPENDIX A

SNOW ACIDITY SAMPLING RESULTS

1985-1986 SEASON

Detailed Tables Showing Results of Field Tests

SNOW ACIDITY SAMPLING RESULTS, 1985-86 SEASON

River Basin and Snow Course	Course No.	Elevation	April 1 Snow Survey				March 1 Snow Survey				February 1 Snow Survey				January 1 Snow Survey						
			pH Readings				pH Readings				pH Readings				pH Readings						
			Date	Low	High	Average	Date	Low	High	Average	Date	Low	High	Average	Date	Low	High	Average			
<u>Shasta River</u>																					
Parks Creek	1	6700	3/31	5.3	5.3	5.3	2/25	5.3	5.3	5.3											
Sweetwater	3						2/25	5.3	5.3	5.3	2/04	4.4	4.7	4.6							
							Basin Average				5.3										
<u>Scott River</u>																					
Middle Boulder 1	5	6600	3/31	5.3	5.3	5.3	2/26	5.3	5.3	5.3	1/30	5.3	5.3	5.3							
Middle Boulder 3	311W	6200	3/31	5.3	5.3	5.3	2/26	5.3	5.3	5.3											
Dynamite Meadow	298W	5700	3/31	5.3	5.3	5.3	2/26	5.3	5.3	5.3	1/30	5.3	5.3	5.3							
Swampy John	285	5500	3/31	5.3	5.3	5.3	2/24	5.3	5.3	5.3	1/27	5.3	5.3	5.3							
			Basin Average				5.3	Basin Average				5.3	Basin Average				5.3				
<u>Trinity River</u>																					
Deadfall Lakes	9	7200					2/25	5.3	5.3	5.3											
Red Rock Mountain	10	6700					2/27	5.3	5.3	5.3											
Bear Basin	11W	6500	3/28	5.2	5.2	5.2	2/27	5.2	5.3	5.3											
Shimmy Lake	12W	6200	3/28	5.0	5.3	5.2	2/27	5.3	5.3	5.3											
Wolford Cabin	13W	6150	3/31	5.3	5.3	5.3															
Highland Lakes	16	6000	3/28	5.3	5.3	5.3	2/27	5.3	5.3	5.3											
Mumbo Basin	15	5700	3/28	5.3	5.3	5.3															
Whalan	14	5400	3/28	5.3	5.3	5.3															
Big Flat	17W	5100	3/28	5.2	5.2	5.2	2/27	5.3	5.3	5.3											
			Basin Average				5.3	Basin Average				5.3									
<u>Sacramento River</u>																					
Mount Shasta	18W	7900	3/25	5.3	5.3	5.3	2/26	5.3	5.3	5.3	1/27	5.3	5.3	5.3							
N. Fork Sacramento	20	6900	3/31	5.3	5.3	5.3															
Sand Flat	19	6800	3/25	5.3	5.3	5.3	2/26	5.3	5.3	5.3	1/27	5.3	5.3	5.3							
Gray Rock Lakes	21	6200	3/31			5.3*															
Slate Creek	22	5600	3/28	5.3	5.3	5.3	2/27	5.3	5.3	5.3											
			Basin Average				5.3	Basin Average				5.3	Basin Average				5.3				
<u>McCloud River</u>																					
Brewer Creek	23	6250	3/25	5.3	5.3	5.3	2/24	5.3	5.3	5.3	1/28	5.0	5.0	5.0							
Stouts Meadow	25	5250	3/31			5.3*					1/30	5.3	5.3	5.3							
Ash Creek	26	5000	3/25	5.3	5.3	5.3															
			Basin Average				5.3					Basin Average				5.2					

*One reading per snow course

SNOW ACIDITY SAMPLING RESULTS, 1985-86 SEASON (cont'd.)

River Basin and Snow Course	Course No.	Elevation	April 1 Snow Survey				March 1 Snow Survey				February 1 Snow Survey				January 1 Snow Survey			
			pH Readings				pH Readings				pH Readings				pH Readings			
			Date	Low	High	Average	Date	Low	High	Average	Date	Low	High	Average	Date	Low	High	Average
<u>American River</u>																		
Upper Carson Pass	106	8500	3/26	5.0	5.0	5.0					1/27	5.3	5.3	5.3	1/2	5.0	5.3	5.2
Lower Carson Pass	331	8400	3/26	5.0	5.0	5.0	2/26	5.3	5.3	5.3	1/27	5.2	5.3	5.2	1/2	5.3	5.3	5.3
Caples Lake	107	8000	3/26	5.0	5.0	5.0	2/26	5.3	5.3	5.3					1/2	5.3	5.3	5.3
Alpha	365	7600	3/27	5.3	5.3	5.3									1/3	5.4	5.4	5.4
Lost Corner Mountain	338	7500	3/27	5.3	5.3	5.3					2/4	5.3	5.4	5.4				
Echo Summit	108	7450	3/28	5.3	5.3	5.3	2/28	5.3	5.3	5.3	1/31	5.3	5.3	5.3	1/2	5.4	5.4	5.4
Lake Audrain	110	7300	3/28			5.3*	2/28	5.3	5.3	5.3	1/31	5.3	5.3	5.3	1/2	5.4	5.4	5.4
Darrington	111	7100	3/28	5.3	5.3	5.3					1/30			5.3*	1/2	5.4	5.4	5.4
Silver Lake	109	7100	3/25	5.4	5.4	5.4	2/25	5.4	5.4	5.4	1/28	5.3	5.3	5.3				
Wrights Lake	316	6900	3/27	5.3	5.3	5.3					2/4	5.1	5.1	5.1				
Phillips	113	6800	3/28	5.2	5.3	5.2									1/2	5.4	5.4	5.4
Lyons Creek	320	6700	3/27	5.3	5.3	5.3					1/30			5.3*	1/3	5.4	5.4	5.4
Tamarack Flat	289	6550													1/2	5.4	5.4	5.4
Wabena Meadows	114	6300	3/27	5.3	5.3	5.3	2/26	5.3	5.3	5.3	2/4	5.3	5.3	5.3	1/7	5.3	5.3	5.3
Miranda Cabin	369	6200	3/27	5.3	5.3	5.3	2/26	5.3	5.3	5.3	2/4	5.0	5.0	5.0	1/7	5.3	5.3	5.3
Onion Creek	120	6100									2/4	4.8	5.1	5.0				
Diamond Crossing	371	6050	3/27			5.3*	2/26	5.3	5.3	5.3	2/4	5.0	5.3	5.2	1/7	5.3	5.3	5.3
Talbot Camp	122	5750					2/26	5.3	5.3	5.3	2/4	5.3	5.3	5.3	1/7	5.3	5.3	5.3
Sixmile Valley	123	5750	4/1	5.3	5.3	5.3												
Strawberry	124	5700													1/2	5.4	5.4	5.4
Robbs Valley	322	5600	4/1	5.3	5.3	5.3	3/1	5.2	5.2	5.2								
Ice House	127	5300					3/1			5.2*	2/1			4.8*				
			Basin Average			5.2	Basin Average			5.3	Basin Average			5.2	Basin Average			5.4
<u>Mokelumne River</u>																		
Highland Meadow	323	8800	4/2	5.3	5.3	5.3									1/3	5.3	5.3	5.3
Tragedy Creek	364	8150	3/27	5.3	5.3	5.3	2/25			5.3*	1/28	5.3	5.3	5.3				
Blue Lake	129	8000									1/29	5.3	5.5	5.4	1/3	5.0	5.3	5.2
Wheeler Lake	131W	7800									1/29	5.3	5.3	5.3	1/3	5.3	5.3	5.3
Pacific Valley	132	7500	4/2	5.3	5.3	5.3					1/29	5.3	5.3	5.3	1/3	5.3	5.3	5.3
Corral Flat	133	7200	3/26	5.5	5.6	5.6	2/26	5.3	5.4	5.4	1/29	5.3	5.3	5.3				
Podesta	363	7200	3/26	5.5	5.5	5.5	2/26	5.3	5.3	5.3	1/29	5.2	5.3	5.3				
Bear Valley Ridge	134	6700													1/3	5.0	5.0	5.0
Lumberyard	135	6500	3/25	5.4	5.4	5.4	2/27	5.3	5.4	5.4	1/29	5.0	5.3	5.2				
Hams Station	136	5500	3/25	5.2	5.2	5.2												
			Basin Average			5.4	Basin Average			5.4	Basin Average			5.3	Basin Average			5.2

*One reading per snow course.

SNOW ACIDITY SAMPLING RESULTS, 1985-86 SEASON (cont'd.)

River Basin and Snow Course	Course No.	Elevation	April 1 Snow Survey				March 1 Snow Survey				February 1 Snow Survey				January 1 Snow Survey			
			pH Readings				pH Readings				pH Readings				pH Readings			
			Date	Low	High	Average	Date	Low	High	Average	Date	Low	High	Average	Date	Low	High	Average
Poison Meadow	204	6800	3/26	5.2	5.4	5.3	2/25	5.2	5.3	5.3								
			Basin Average				Basin Average											
<u>Kings River</u>																		
Bishop Pass	222	11200	3/27			5.4*					1/28			5.3*				
Charlotte Ridge	299	10700	3/31			5.3*					1/25	5.0	5.0	5.0				
Bullfrog Lake	307	10650	4/01			5.3*					1/25	5.3	5.3	5.3				
Blackcap Basin	223W	10300	3/28			5.3*					1/28			5.3*	1/2			5.3*
Rattlesnake Creek	396	9900	3/28			5.3*					1/28			5.3*	1/2			5.5*
Beard Meadow	225W	9800					2/26			5.3*	1/28			5.3*	1/2			5.3*
Upper Burnt Corral	224W	9700	3/28			5.3*	2/26			5.3*	1/27			5.3*	1/2			5.5
Scenic Meadow	397	9650	3/25			5.3*												
Vidette Meadow	309	9500	4/01			5.3*					1/26	5.5	5.5	5.5				
Round Corral	229W	9000	3/27			5.3*					1/29			5.3*	1/2			5.3*
Rowell Meadow	226W	8850	3/25			5.2*												
Woodchuck Meadow	227W	8800	3/27			5.3*					1/29			5.3*				
Long Meadow	232W	8500	3/27			5.3*	2/26			5.3*					1/2			5.5*
Courtright	426	8350					2/26			5.3*					1/2			5.3*
Helms Meadow	230W	8250	3/26			5.3*												
Post Corral Meadow	234W	8200	3/26			5.3*	2/26			5.3*	1/27			5.3*	1/2			5.5*
Dodsons Meadow	308W	8050									1/27			5.3*	1/2			5.3*
Big Meadows	236	7600	3/25			5.3*												
Horse Corral Mdw	237	7600	3/25			5.3*												
Fred Meadow	239	6950	3/26			5.3*	2/26			5.3*	1/27			5.3*	1/2			5.3*
Grant Grove	240	6600					2/28			5.3*								
			Basin Average				Basin Average				Basin Average				Basin Average			
<u>Kaweah River</u>																		
Farewell Gap	292	9500	3/29	5.9	5.9	5.9												
Panther Meadow	243	8600	3/31	5.3	5.3	5.3	3/2	5.5	5.7	5.6	2/2	5.7	5.9	5.8				
Hockett Meadows	244	8500	3/31	5.4	5.4	5.4												
Mineral King	245	8000	3/29	5.5	5.5	5.5												
Giant Forest	246	6400	3/30	4.5	5.0	4.7	3/3			5.3*								
			Basin Average				Basin Average											

*One reading per snow course.

SNOW ACIDITY SAMPLING RESULTS, 1985-86 SEASON (cont'd.)

River Basin and Snow Course	Course No.	Elevation	April 1 Snow Survey				March 1 Snow Survey				February 1 Snow Survey				January 1 Snow Survey			
			pH Readings				pH Readings				pH Readings				pH Readings			
			Date	Low	High	Average	Date	Low	High	Average	Date	Low	High	Average	Date	Low	High	Average
<u>Truckee River</u>																		
Mount Rose (Nev)	334	9000	4/1			5.2*												
Mt. Rose Ski Area	392	8850									1/27	4.7	4.8	4.8				
Independence Lake	86	8450	4/1			5.3*	2/27		5.2*	1/28	5.1	5.2	5.2					
Webber Peak	64	7800	3/25	5.3	5.3	5.3												
Squaw Valley																		
Gold Coast	836	7800									1/27	4.8	5.1	5.0				
Squaw Valley 2	318	7700									1/27	5.1	5.3	5.2				
Independence Camp	88	7000	4/1			5.3*	2/27		5.2*	1/28	5.2	5.2	5.2					
Webber Lake	89	7000	3/25	5.5	5.5	5.5												
Big Meadow	846	7000	4/1			5.3	2/25		5.1*	1/28			5.2*					
Independence Creek	91	6500	4/1			5.3	2/27		5.2*	1/28	5.2	5.2	5.2					
Truckee 2	92	6400	4/1	5.3	5.3	5.3	3/1		5.3*						1/1	5.0	5.0	5.0
			Basin Average			5.3	Basin Average			5.2	Basin Average			5.2				
<u>Lake Tahoe</u>																		
Lake Lucille	96W	8200	3/30	5.3	5.3	5.3	3/2		5.2*									
Rubicon Peak 1	97W	8100	3/30	5.2	5.2	5.2	3/2	4.4	5.0	4.7								
Hagans Meadow	98	8000	4/1			5.2*	2/27		5.1*	1/27	5.2	5.2	5.2					
Marlette Lake	332	8000	4/1	5.2	5.2	5.2	2/25		5.2*	1/28	5.1	5.2	5.2					
Echo Peak	405	7800	4/1			5.3				1/28			5.1*					
Rubicon Peak 2	99	7500	3/30	5.3	5.3	5.3	3/2		5.3*	1/28			5.1*	1/1	5.0	5.2	5.1	
Freel Bench	100	7300	4/1			5.3*	2/27		5.1*	1/28	5.2	5.2	5.2					
Brockway Summit	385	7100	3/29	5.3	5.3	5.3	3/1		5.3									
Ward Creek 2	101	7000								1/28	4.8	5.1	5.0					
Glenbrook 2	333	6900					3/5		5.0*									
Tahoe City Cross	400	6750	4/1	5.3	5.3	5.3	3/1		5.3*					1/1	5.2	5.3	5.2	
Ward Creek 3	376	6750	4/1			5.2*	2/27		5.1*	1/28			5.2*					
Camp Richardson	103	6500					3/5		5.0*									
Upper Truckee	104	6400					2/27		5.2*	1/28			5.2*					
			Basin Average			5.3	Basin Average			5.2	Basin Average			5.2				
<u>Carson River</u>																		
Ebbetts Pass	406	8700	4/1			5.2*	2/25		5.3*	1/27			5.3*					
Wet Meadows	403	8100	4/1			5.2*				1/27			5.2*					
Poison Flat	330	7700					2/25		5.1*	1/27	5.2	5.3	5.2					
Clear Creek	—	7300					2/27	4.7	5.3	5.0								
			Basin Average			5.2	Basin Average			5.1								

*One reading per snow course.

SNOW ACIDITY SAMPLING RESULTS, 1985-86 SEASON (cont'd.)

<u>River Basin and Snow Course</u>	<u>Course No.</u>	<u>Elevation</u>	<u>April 1 Snow Survey</u>				<u>March 1 Snow Survey</u>				<u>February 1 Snow Survey</u>				<u>January 1 Snow Survey</u>			
			pH Readings				pH Readings				pH Readings				pH Readings			
			<u>Date</u>	<u>Low</u>	<u>High</u>	<u>Average</u>	<u>Date</u>	<u>Low</u>	<u>High</u>	<u>Average</u>	<u>Date</u>	<u>Low</u>	<u>High</u>	<u>Average</u>	<u>Date</u>	<u>Low</u>	<u>High</u>	<u>Average</u>
<u>Owens River</u>																		
Rock Creek 1	211	8700					2/27	5.5	5.6	5.6	1/30	5.1	5.2	5.2				
Bishop Park	216	8400	3/28			5.3*												
Mammoth	208	8300	3/24	5.2	5.3	5.2					1/27	5.0	5.3	5.2				
Long Valley South	425	7300	3/26	5.3	5.3	5.3	2/27	5.0	5.2	5.1	1/30	5.2	5.2	5.2				
Long Valley North	424	7200					2/27	5.4	5.4	5.4	1/30	5.2	5.2	5.2				
			Basin Average			5.3	Basin Average			5.3	Basin Average			5.2				
<u>Santa Ana River</u>																		
Lower Big Draw	428W	9600	4/5	5.3	5.3	5.3	3/9	5.3	5.3	5.3								
Christmas Tree Hill	351W	8500					3/9	5.3	5.3	5.3	2/2	5.1	5.1	5.1				
Snow Summit	420	8100	4/5	5.3	5.3	5.3												
			Basin Average			5.3	Basin Average			5.3								

*One reading per snow course.

APPENDIX B

DETAILED INSTRUCTIONS FOR SNOW ACIDITY SAMPLING

Provided to Cooperative Field Teams in
the Snow Acidity Sampling Program

December, 1985

Instructions for Snow Acidity Sampling

1. Obtain two samples per snow course, one near the second point and the other near the second to last point. Select a spot that is free from any apparent contamination, such as pine needles, dirt and snow machine or ski tracks.
2. Uncap the plastic test tube and fill it with surface snow being careful not to touch the snow or the inside of the tube and cap with hands or gloves. Use the cap to force snow into the test tube. If the surface snow is too crusted to scrape a surface sample, break the crust and sample clean snow just underneath the crust as close to the surface as possible.
3. Place the cap on the test tube, then melt the snow with body heat by placing the tube in a shirt or trouser pocket. The cap doesn't always make a watertight seal, so keep the tube upright.
4. Once the samples are melted, at a convenient work point, probably at the end of the snow course, insert one pH color stick into each tube, then recap. After the color sticks have soaked at least 5 minutes but not over 10 minutes, compare them against the reference color code on the box.
5. Both snow gaugers should individually match for color and agree on the pH value. You should interpolate between color bars if the sample lies in between.
6. Enter the readings in the remarks section on the back of the snow course notes; e.g.,
pH test: sample point #2 = 5.4
sample point #9 = 5.7
7. Discard tubes after sampling. Never reuse sampling tubes.

The pH of rain or snow without impurities can vary widely depending on a variety of atmospheric conditions in addition to "pollutants". Once a box of pH color sticks has been opened, it may not keep for future years. If acidity sampling is done next year, the old box should be discarded and a fresh box of sticks should be used.

APPENDIX C

SNOW ACIDITY TEST COMPARISONS

- A. Letter from Dr. Neil Berg summarizing results of the extensive testing of the pH litmus paper sticks and comparisons with laboratory pH meters.
- B. Tests by Air Resources Board contractors done under Dr. John Melack's direction in the Emerald Lake area of the southern Sierra.



United States
Department of
Agriculture

Forest
Service

Pacific Southwest
Forest & Range
Experiment Station

1960 Addison Street
P.O. Box 245
Berkeley, CA 94701

Reply to:

Date: June 13, 1986

Mr. Maurice Roos
Division of Flood Management
Department of Water Resources
P.O. Box 388
Sacramento, California 95802

Dear Mauri:

Thanks for sending Dave Hart and Jim Spence to our project review meeting last week. Their input to the discussion gave me and PSW Station management a better perspective on the operation of Snow Surveys. It appeared also that the discussions with the representatives from the other agencies were informative for Jim and Dave.

Enclosed are three sheets listing measurements of pH by the indicator sticks and our bench pH meter. A primary objective was to compare values from the same sample between the stick(s) and the meter. Secondary objectives were to assess differences in pH readings potentially caused by observer variability and stick exposure time (both in the sample and in the atmosphere).

I draw several conclusions from analysis of the data:

- 1) for snow in the mid-5 pH range, the stick and the meter give adequately "close" readings. There appears to be a bias, in that the meter generally reads slightly higher than the indicator sticks. Except for the comparisons on 3/25/86 the bias is small (0.1 pH units or less), and probably well within the error range of the meter. I don't know why observations 25, 28 and 29 show a wide (1 pH unit) difference between the stick and the meter readings. Sample 25 was exposed to air overnight. This exposure may have confounded the comparison by somehow causing the meter to respond differently than the stick. Sample exposure to air is generally expected to elevate meter readings, and the 6.56 value is relatively high for snow at the Snow Lab. I have no reason to believe that comparisons 28 and 29 are not based on "good" data.

Comparisons 14, 16, 23, and 24, with tap water as the sample liquid, show wide differences between stick and meter readings. While I don't know an





sticks against several meters. To some extent your current procedure for testing the sticks against meters at several laboratories addresses this latter need.

Comments? Suggestions?

Sincerely,

Neil

Neil Berg
Project Leader

Enclosures



OBSERVER EFFECTS

Analysis of Variance of Observer Differences

		Observer Id				
		1	2	3	4	5
Sample Type	Deionized water	5.3	5.3	5.3	5.4	5.3
		5.3	5.3	5.3	5.3	5.5
		5.3	5.3	5.3	5.4	5.3
	Tap water	7	6.8	7	7	7
		7	6.8	7	7	7
		7	6.8	7	7	6.5
	Tap + orange juice	5.5	5.7	5.9	6.1	5.5
		5.5	5.7	6.1	6.0	6.2
		5.5	5.7	6.1	5.9	6.2

Non-significant differences (at 0.05 level) between observers for deionized and tap water samples. Observer differences are significant at the 0.05 level for the tap and OJ samples.

Observer Comparison--Various Sample Types

	Observer	
	1	2
1.	5.3	5.3
2.	5.3	5.3
3.	6.0	5.9
4.	6.1	6.2
5.	6.0	5.9
6.	6.0	6.2
7.	5.6	5.3
8.	5.6	5.3
9.	4.0	4.0
10.	7.0	7.0
11.	6.5	6.5
12.	5.5	5.5

B. Southern Sierra Tests by ARB People

Emerald Lake Area

<u>Sample</u>	<u>Electrode pH, 5 min</u>	<u>Paper pH, 5 min</u>	<u>Paper pH, 20 min</u>
DDI water	5.66	5.20	--
10 ⁻⁴ normal	4.11	4.20	--
10 ⁻⁵ normal	5.15	5.10	--

Inlet snow samples taken December 10, 1985:

1	5.02	5.15	--
2	4.91	5.10	--
3	5.04	4.55	--
4	4.97	4.60	--
5	5.22	4.80	--
6	5.16	5.20	--
7	4.99	5.00	--
8	5.01	5.10	4.20
Average	5.04	4.94	

Parsons snow samples taken December 18, 1985:

9	5.39	5.20	--
10	5.40	5.20	
11	5.46	5.00	
12	5.50	5.30	
13	5.36	5.30	
Average	5.42	5.20	

Comments about use of the paper:

1. It is very subjective.
2. The color is not uniform on the stick.

Edges usually turn a lighter shade than the center. The center tended to give the best estimate on the true pH. Also the color rapidly lightens after about 15 minutes (sample 8).