



## ZONE 3 ADVISORY COMMITTEE

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San Luis Obispo County Flood Control and Water Conservation District

### AGENDA

Thursday, July 21, 2022 6:30 P.M.  
Oceano Community Services District  
1655 Front Street, Oceano, California 93445

- I. CALL TO ORDER AND ROLL CALL
- II. PUBLIC COMMENT  
This is an opportunity for members of the public to address the Committee on items that are not on the Agenda
- III. OFFICER ROTATIONS
  - A. Committee Chair rotating from at Member at Large to City of Arroyo Grande Representative
  - B. Committee Vice-Chair rotating from City of Arroyo Grande to City of Grover Beach Representative
- IV. APPROVAL OF MEETING MINUTES
  - A. May 19, 2022 – [Attachment 1](#)
- V. OPERATIONS REPORT
  - A. Water Plant Operations, Reservoir Storage, Downstream Releases - [Verbal Update](#)
  - B. Projected Reservoir Levels – [Attachment 2](#)
  - C. May, June (10%), & June (20%) Monthly Operations Report – [Attachment 3](#)
- VI. INFORMATION ITEMS
  - A. Conservation and LRRP Entitlement Reductions – [Verbal Update](#)
  - B. Intake vs Storage Chart – [Attachment 4](#)
  - C. Cloud Seeding Seasonal Report – [Attachment 5](#)
  - D. Contract Changes – [Verbal Update](#)
- VII. CAPITAL PROJECTS UPDATE
  - A. Bi-Monthly Update – [Attachment 6](#)
- VIII. ACTION ITEMS (No Subsequent Board of Supervisors Action Required)
  - A. Endorse Entitlement Reductions to 20% Retroactive to April 1<sup>st</sup> 2022.
- IX. ACTION ITEMS (Board of Supervisors Action is Subsequently Required)
- X. FUTURE AGENDA ITEMS
  - A. Contract Changes
  - B. Cloud Seeding
  - C. Low Reservoir Response Plan (LRRP)



## ZONE 3 ADVISORY COMMITTEE

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San Luis Obispo County Flood Control and Water Conservation District

### XI. COMMITTEE MEMBER COMMENTS

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Next Regular Meeting is Tentatively Scheduled for  
September 15, 2022 at 6:30 PM at City of Grover Beach Council Chambers  
Agendas accessible online at [www.slocounty.ca.gov/pw/zone3](http://www.slocounty.ca.gov/pw/zone3)

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**SAN LUIS OBISPO COUNTY FLOOD CONTROL  
AND WATER CONSERVATION DISTRICT  
ZONE 3 ADVISORY COMMITTEE  
DRAFT MEETING MINUTES  
THURSDAY May 19, 2022**

**I. Call to Order and Roll Call** -- The Zone 3 Advisory Committee Meeting was called to order at 6:32 PM at the City of Pismo Beach by Shirley Gibson. County Public Works Utilities Division Senior Engineer and Secretary to the Advisory Committee, Nola Engelskirger, called roll. Quorum was present. Members in attendance were:

- Kristen Barneich, City of Arroyo Grande
- Karen Bright, City of Grover Beach
- Marcia Guthrie, City of Pismo Beach
- Shirley Gibson, Oceano Community Services District
- Brian Talley, Agriculture Member
- Ron Reilly, At Large Member

**II. Public Comment** – This is an opportunity for members of the public to address the Committee on items that are not on the Agenda. No public comment.

**III. Approval of Meeting Minutes**

**A. March 17, 2022 Regular Meeting (Attachment 2 of the Agenda Packet) – Member Reilly motioned to approve, Second by Member Guthrie.** Member Gibson requested roll call vote. *Motion passed.*

**IV. Operations Report**

**A. Water Plant Operations, Reservoir Storage, Downstream Releases** – Amber Cordova, Administrative Assistant at the Lopez Water Treatment Plant, indicated: Lopez Lake elevation was 465.8 feet; storage 13,810 acre-feet (AF), which is 28% capacity; rainfall to date, since July 1, 2021, was 12.9 inches; plant production was 2.3 million gallons per day (MGD); downstream release was 1.9 MGD; and State Water was at 2.6 MGD.

**B. Projected Reservoir Levels (Attachment 3 of the Agenda Packet)** – Review of the Lopez Reservoir Projections Chart. Anticipating to hit next trigger point under LRRP of 10,000 AF by October 7, 2022. Note that this is two weeks past previous projections; water conservation efforts are successfully extending projected water supply.

**C. March and April Monthly Operations Report (Attachment 4 of the Agenda Packet)** Review of the monthly operations reports with the Committee.

No public comment was given.

**V. Information Items**

**A. 3rd Quarter Budget Status –** County Public Works Finance Admin. Services Manager, Jenny Morgan, provided an update on the 3<sup>rd</sup> Quarter Budget Status (Attachment 5 of the Agenda Packet). The \$7.4M budget is broken into three categories: Routine Operations & Maintenance, Non-Routine Operations & Maintenance, and Capital Outlay. At the end of the third quarter, 46% of the total annual budget had been expended.

Total Budget	Expenses through Q3	Balance Available	% of Budget Expended
7,459,542	3,432,229	4,027,313	46%

**Routine O&M:** This category has a budget of \$4.4M. At the end of the third quarter, 67% of the annual budget has been expended, resulting in approximately \$1.4M available for the remainder of the year. Expenses in this category are on target with budgeted levels.

Total Budget	Expenses through Q3	Balance Available	% of Budget Expended
4,401,146	2,964,801	1,436,345	67%

**Non-Routine O&M:** This category has a budget of approximately \$1.7M. At the end of the third quarter, 13% of the annual budget has been expended, resulting in an available balance of roughly \$1.5M for the remainder of the year. Unspent budget for most of the efforts in this category will be carried forward into next year to allow the continuation to work.

Total Budget	Expenses through Q3	Balance Available	% of Budget Expended
1,732,666	231,863	1,500,803	13%

**Capital Outlay:** This category has a budget of just over \$1.32M. At the end of the second quarter, expenses were 16% of the annual budget, resulting in approximately \$1M available for the remainder of the year. At the end of the year, unspent budget will be carried forward into next year to continue the projects through completion, however, savings from completed projects may be allocated to other approved projects.

Total Budget	Expenses through Q3	Balance Available	% of Budget Expended
1,325,730	235,566	1,090,164	18%

No public comment was given.

## **Other Agency Involvement/Impact**

The agencies involved are: City of Arroyo Grande, City of Grover Beach, City of Pismo Beach, Oceano Community Services District, and County Service Area 12. Subcontractors of CSA 12 include Port San Luis Harbor District and Avila Beach Community Services District.

## **Financial Consideration**

All agencies are current on their payments. The first installment billings for the FY 2022-23 have been mailed out and payments are due July 1, 2022.

## **VI. Capital Projects Update**

**Bi-Monthly Update (Attachment 6 of the Agenda Packet)** – Updates were provided on the various capital projects (Attachment 6 of the Agenda Packet). Most projects had no changes or updates that could be provided.

- **Tesla Battery Storage (No Change)**
  - Doing Startup testing to be prepared for PGE approval of plan to operate (PTO)
  - Budget – Free
  
- **Spillway Assessment and Investigation**
  - Met with DSOD and GEI to go over work plan
  - DSOD to provide comments on work plan
  - Remainder of project ~ minimum of \$300,000
  
- **Geotechnical Testing & Seismic Alternatives Study of Terminal Reservoir Dam (No Change)**
  - Negotiating Task 1 Items
  - Budget ~\$500,000
  
- **Fault Zone Risk Assessment for Dam Left Abutment (No Change)**
  - Developing work order to satisfy the recommendations of the assessment
  - Budget ~\$40,000
  
- **Lopez WTP Safety Upgrades (No Change)**
  - Staff are looking into additional consultants to do a lifeline system within the membrane building.
  - Multiple consultants have reviewed the project, but none have quoted the project.
  - Budget ~\$53,000
  
- **Cathodic Protection Repair Project**
  - Preparing BID documents
  - Budget ~\$449,933

- **Equipment Storage Building**
  - Preparing bidding documents for equipment storage building
  - Plan to issue an invitation to bid by the end of the Month
  - Budget ~\$90,000
  
- **CO2 Injection System (No Change)**
  - Negotiating Bulk CO2 contract
  - PO issued for equipment
  - Budget ~\$256,000
  
- **Sludge Bed Curtain Wall Rehabilitation (No Change)**
  - ~\$50,000 per initial quote

No Public comment was given.

**VII. Action Items (No Subsequent Board of Supervisors Action Required)**

Reallocation of District Designated Reserves - \$350,000 of Cloud Seeding reserves were rolled into “Public Safety related to water quality and quantity purposes” funds for FY 2022-23. **Motion by Member Barneich, second by Member Bright.** Member Gibson requested roll call vote of approval. ***Motion passed, Reallocation of District Designated Reserves.***

**VIII. Action Items (Board of Supervisors Action is Subsequently Required)**

**IX. Future Agenda Items**

**X. Committee Member Comments**

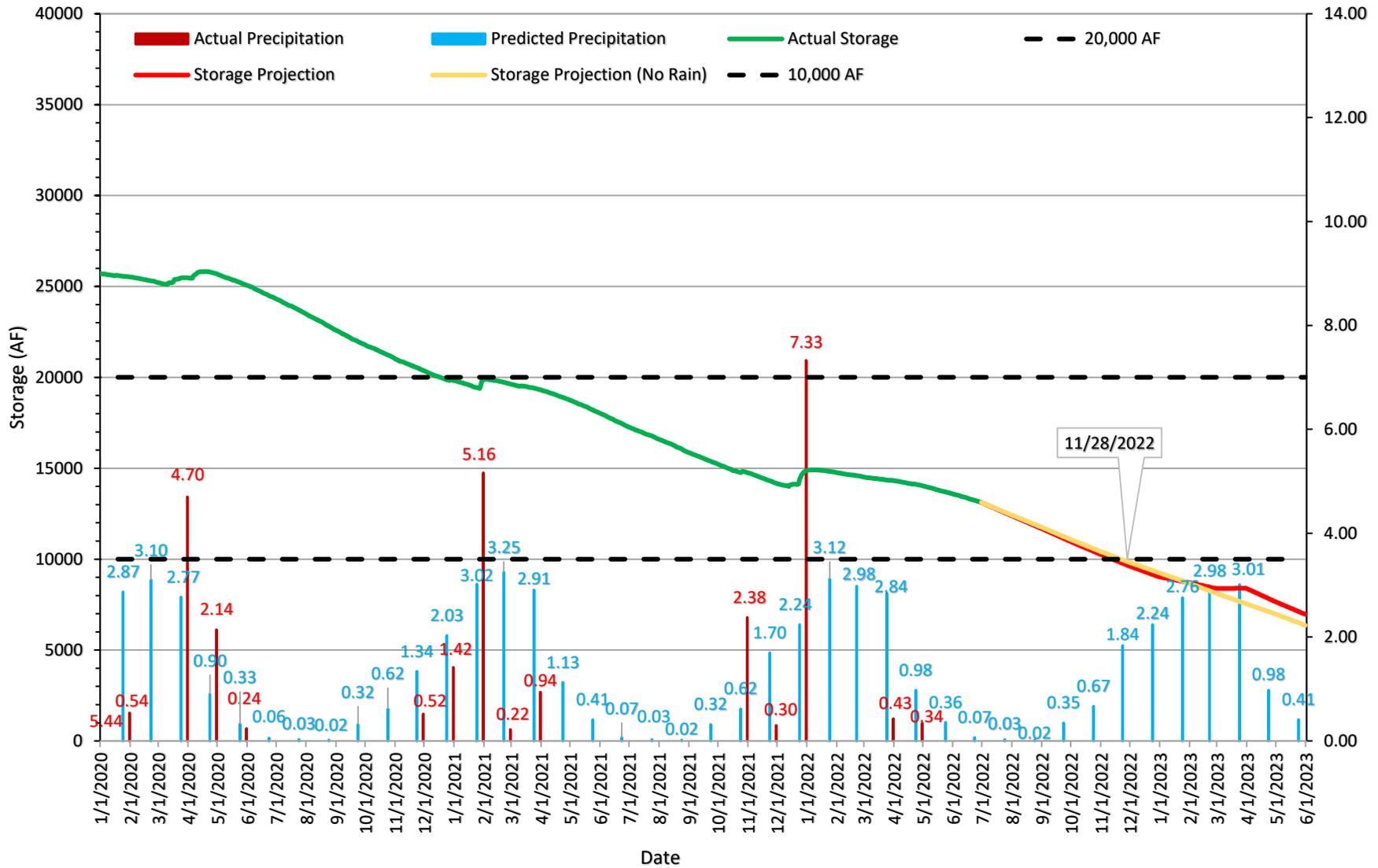
**Committee requested a summary report of Cloud Seeding efforts completed during Winter of 2021-22. Additionally, the Committee also requested this Cloud Seeding summary report be annually recurring as long as there is participation in the program.**

**Meeting Adjourned at 7:00 PM**

Respectfully Submitted,

Amber Cordova  
County of San Luis Obispo Public Works Department

# LOPEZ RESERVOIR STORAGE PROJECTION



Reservoir Storage = Current Storage + Inflow - Outflow

Outflow = Agency Usage + Downstream Releases

Agency Usage: is based on 2010-2021 average monthly deliveries

Predicted Inflow: is dependent on the predicted rainfall obtained from longrangeweather.com

Inflow is affected by antecedent soil conditions and factored into the model. Rainstorms will produce less inflow during the dry months than during the rainy season when the soil is saturated.

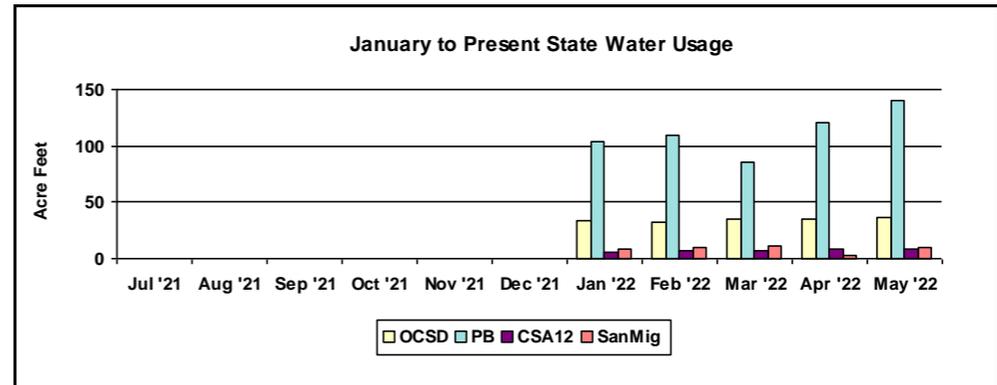
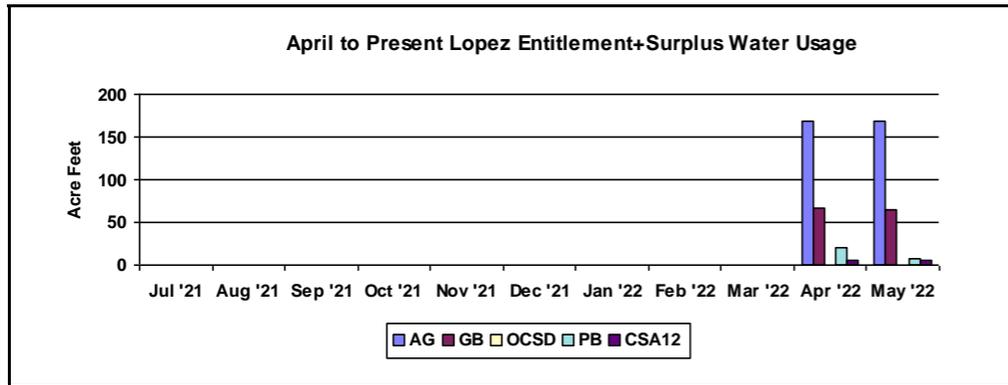
The model is based on a polynomial regression (concave in shape). Therefore the concave **Storage Projection Graph** will fall below the linear **Storage Projection with No Rain Graph** during months of low predicted rainfall.

# San Luis Obispo County Flood Control and Water District

## Zone 3 - Lopez Project - Monthly Operations Report

### May, 2022

Contractor	Lopez Water Deliveries											State Water Deliveries						Total Water Deliveries This Month							
	Entl.	Surplus Water Declared	Surplus Requested	Total Available Water	This Month				April to Present				Annual Request	This Month			January to Present								
					Entitlement		Surplus		Entitlement		Surplus			Total		Usage	% of Annual Request		SWP Deliveries	Change in Storage	Usage	% of Annual Request	SWP Deliveries		
					Usage	%	Usage	%	Usage	%	Usage	%													
Arroyo Grande	2061	742.10	742.10	2803	167.96	8.1%	0.00	0.0%	336.71	16.3%	0.00	0.0%	336.71	12.0%										167.96	
Oceano CSD	272.7	102.50	102.50	375	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	750	36.73	4.9%					172.40	23.0%		36.73
Grover Beach	720	204.20	204.20	924	64.90	9.0%	0.00	0.0%	131.69	18.3%	0.00	0.0%	131.69	14.2%										64.9	
Pismo Beach	802.8	300.80	300.80	1104	28.47	3.5%	0.00	0.0%	28.47	3.5%	0.00	0.0%	28.47	2.6%	1240	140.00	11.3%					558.91	45.1%		147.49
CSA 12	220.5	82.40	82.40	303	12.57	5.7%	0.00	0.0%	12.57	5.7%	0.00	0.0%	12.57	4.1%	96	8.50	8.9%					36.83	38.4%		14.73
San Miguelito															120	9.27	7.7%					40.65	33.9%		9.27
<b>Total</b>	<b>4077</b>	<b>1432.00</b>	<b>1432.00</b>	<b>5509</b>	<b>246.58</b>	<b>6.0%</b>	<b>0.00</b>	<b>0.0%</b>	<b>509.44</b>	<b>12.5%</b>	<b>0.00</b>	<b>0.0%</b>	<b>509.44</b>	<b>9.2%</b>	<b>2206</b>	<b>194.50</b>	<b>8.8%</b>	<b>251</b>	<b>56.50</b>			<b>808.79</b>	<b>36.7%</b>	<b>868.00</b>	<b>441.08</b>
														Last Month Stored State Water		<b>662.53</b>			This Month Stored State Water		<b>719.03</b>				



Note: Deliveries are in acre-feet. One acre foot = 325, 850 gallons or 43, 560 cubic feet. Safe yield is 8,730 acre-foot

"Year to Date" is January to present for State water, April to present for Lopez deliveries, and July to present for rainfall.

Lopez Dam Operations		This Month	Year to Date		
Lake Elevation (full at 522.37 feet)		465.17		Difference (feet)	-57.20
Storage (full at 49200 acre feet)		13579		% Full	27.6%
Rainfall		0	12.51		
Downstream Release (4200 acre feet/year)		184.44	363.97		
Spillage (acre feet)		0	0.00		

**Comments:**

- 1) Oceano supplied water to Canyon Crest via Arroyo Grande's Edna turn out. A total of 2.22 AF delivered to Canyon Crest was added to Oceano's water usage this month and 2.22 AF was subtracted from Arroyo Grande's usage this month.
- 2) Lopez Water Deliveries are now operated under the Low Reservoir Response Plan (LRRP). In August 2021 TAC requested a 10% entitlement reduction (retroactive to April 2021) in anticipation of reaching the 15,000 AF trigger of the LRRP. Entitlements shown represent a 10% reduction.
- 3) Surplus water shown is actually "Carry Over" water as designated in the LRRP.
- 4) On April 2022, the County presented the Stored State Water minus evaporation losses dating back to the January 1, 2015 water recharacterization. On December 31, 2021 the calculated Stored State Water minus evaporation losses was 659.82 AF. Evaporation losses will be presented annually.

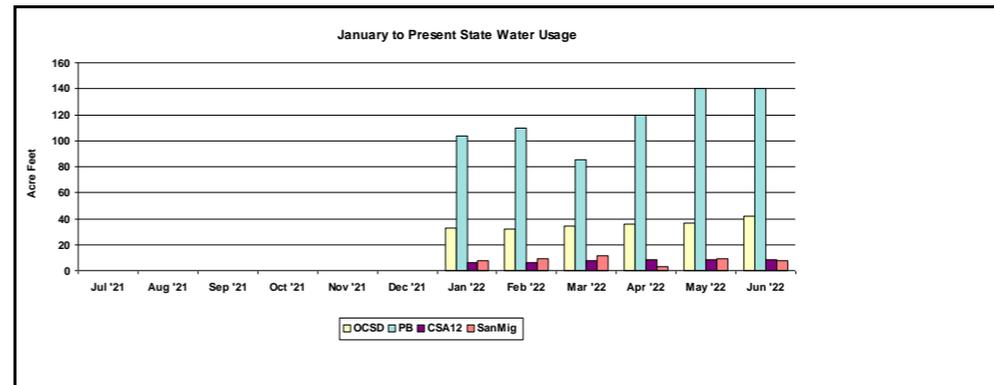
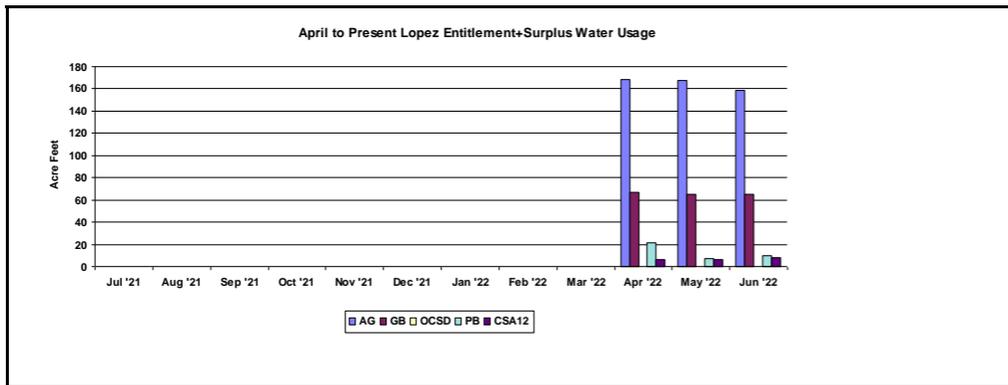


# San Luis Obispo County Flood Control and Water District

## Zone 3 - Lopez Project - Monthly Operations Report

### June, 2022

Contractor	Lopez Water Deliveries											State Water Deliveries						Total Water Deliveries This Month							
	Entl.	Surplus Water Declared	Surplus Requested	Total Available Water	This Month				April to Present				Annual Request	This Month					January to Present						
					Entitlement		Surplus		Entitlement		Surplus			Total		Usage	% of Annual Request		SWP Deliveries	Change in Storage	Usage	% of Annual Request	SWP Deliveries		
					Usage	%	Usage	%	Usage	%	Usage	%		Usage	%										
Arroyo Grande	2061	742.10	742.10	2803	158.91	7.7%	0.00	0.0%	495.62	24.0%	0.00	0.0%	495.62	17.7%										158.91	
Oceano CSD	272.7	102.50	102.50	375	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	750	41.74	5.6%					214.14	28.6%		41.74
Grover Beach	720	204.20	204.20	924	64.96	9.0%	0.00	0.0%	196.65	27.3%	0.00	0.0%	196.65	21.3%											64.96
Pismo Beach	802.8	300.80	300.80	1104	9.86	1.2%	0.00	0.0%	38.33	4.8%	0.00	0.0%	38.33	3.5%	1240	140.00	11.3%					698.91	56.4%		149.86
CSA 12	220.5	82.40	82.40	303	7.63	3.5%	0.00	0.0%	20.20	9.2%	0.00	0.0%	20.20	6.7%	96	8.50	8.9%					45.33	47.2%		16.13
San Miguelito															120	7.78	6.5%					48.43	40.4%		7.78
<b>Total</b>	<b>4077</b>	<b>1432.00</b>	<b>1432.00</b>	<b>5509</b>	<b>241.36</b>	<b>5.9%</b>	<b>0.00</b>	<b>0.0%</b>	<b>750.80</b>	<b>18.4%</b>	<b>0.00</b>	<b>0.0%</b>	<b>750.80</b>	<b>13.6%</b>	<b>2206</b>	<b>198.02</b>	<b>9.0%</b>	<b>237</b>	<b>38.98</b>	<b>1006.81</b>	<b>45.6%</b>	<b>1105.00</b>	<b>439.38</b>		
											Last Month Stored State Water			<b>719.03</b>				This Month Stored State Water			<b>758.01</b>				



Note: Deliveries are in acre-feet. One acre foot = 325, 850 gallons or 43, 560 cubic feet. Safe yield is 8,730 acre-foot

"Year to Date" is January to present for State water, April to present for Lopez deliveries, and July to present for rainfall.

Lopez Dam Operations		This Month	Year to Date		
Lake Elevation (full at 522.37 feet)		463.91		Difference (feet)	-58.46
Storage (full at 49200 acre feet)		12122		% Full	24.6%
Rainfall		0	12.51		
Downstream Release (4200 acre feet/year)		178.92	542.89		
Spillage (acre feet)		0	0.00		

**Comments:**

- 1) Oceano supplied water to Canyon Crest via Arroyo Grande's Edna turn out. A total of 2.18 AF delivered to Canyon Crest was added to Oceano's water usage this month and 2.18 AF was subtracted from Arroyo Grande's usage this month.
- 2) Lopez Water Deliveries are now operated under the Low Reservoir Response Plan (LRRP). In June 8, 2022 TAC requested a 20% entitlement reduction (retroactive to April 2022) in anticipation of reaching the 10,000 AF trigger of the LRRP. Entitlements shown represent a 20% reduction.
- 3) Surplus water shown is actually "Carry Over" water as designated in the LRRP.
- 4) On April 2022, the County presented the Stored State Water minus evaporation losses dating back to the January 1, 2015 water recharacterization. On December 31, 2021 the calculated Stored State Water minus evaporation losses was 659.82 AF. Evaporation losses will be presented annually.

2002 Bathometric Survey			Comments	Available water between intakes (acft)	
Intake #	Elevation	Storage acft			
Crest	522.6	49177		acft	
1	507.6	36774		12403	Crest to intake one storage
2	492.6	26506		10268	intake 1 to intake 2 storage
3	477.6	18583		7923	intake 2 to intake 3 storage
4	462.6	12655		5928	intake 3 to intake 4 storage
5	447.6	7913		4742	intake 4 to intake 5 storage
Minimum Pool	433.18	4000	Minimum Pool should be able to deliver 6.0 MGD. Don't know for how long		
6	432.6	4279		3634	intake 5 to intake 6 storage
7	417.6	1751	Last intake, actually have to pump anything below this elevation	2528	Intake 6 to intake 7 storage
				1506	Intake 7 to 36" BFV center line
36" BFV	401	245		48932	useable water?

# Annual Cloud Seeding Report

Lake Lopez Watershed  
2021-2022 Winter Season

**Prepared For:**

County of San Luis Obispo,  
Department of Public Works

**Prepared By:**

David Yorty  
Garrett Cammans

North American Weather Consultants, Inc.

8180 S. Highland Dr., Suite B-2

Sandy, Utah 84093

May 2022



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## **EXECUTIVE SUMMARY**

For the 2021-2022 winter season, cloud seeding operations were conducted to enhance precipitation in the Lopez Lake drainage in San Luis Obispo County. A ground-based seeding location (Arroyo Grande) was utilized for specifically for this area. Seeding was also conducted from other sites when conditions were favorable, including Mt. Lospe and Berros Peak. The formal operational period began December 1, 2021 and ended April 15, 2022. An extension of the program was offered by NAWC in order to seed a storm that was forecasted to impact the watershed on April 21<sup>st</sup>. This extension was offered at no additional fixed cost, NAWC only requested the reimbursement of flares used for this storm.

The cloud seeding equipment used in this program is of a proprietary design and uses high output cloud seeding flares. The equipment is designed to be operated remotely via cellular link. This equipment was designed specifically for cloud seeding operations on the California coastline, where storms are characterized by high values of super cooled liquid water. Operations for the project were directed by David Yorty, a NAWC meteorologists, who is a certified weather modification manager by the Weather Modification Association (WMA). Coordination of all seeding activities was maintained with Mr. David Spiegel with the County of San Luis Obispo Department of Public Works.

As with the prior season. The ENSO (El Niño-Southern Oscillation) phase was classified as a La Nina again during the 2021-2022 winter season. Precipitation in San Luis Obispo County and around the rest of the Central Coast was again well below normal for the season. Rainfall from the beginning of the water year (September 1, 2021) through April 2022 is summarized in Table E-1.

**Table E-1**  
**2021-2022 Monthly Precipitation (Inches)**  
**For Locations near the Lopez Lake Target Area**

Location	December	January	February	March	April	December – April Total	Percent of Normal (April 30)
<b>Arroyo Grande Creek</b>	6.37	0.10	0.06	0.84	0.47	7.84	56%
<b>Davis Peak</b>	9.81	0.08	0.19	1.58	0.67	12.33	80%
<b>Lopez Dam</b>	8.45	0.04	0.00	0.86	0.47	9.82	65%
<b>Salinas Dam</b>	9.29	0.12	0.00	1.10	0.48	10.99	63%
<b>Santa Margarita</b>	7.49	0	0.04	1.19	0.59	9.42	50%
<b>SLO Reservoir</b>	9.86	0	0.00	0.86	0.51	11.31	56%
<b>Upper Lopez</b>	10.51	0.04	0.00	0.55	0.55	11.65	65%

### **Climate Overview**

As reported last year, every ten years, the National Oceanic and Atmospheric Association (NOAA) releases a summary of various U.S. weather conditions for the past three decades to determine average values for a variety of conditions, including, temperature and precipitation. This is known as the U.S. Climate normal, with a 30-year average, representing the “new normal” for our climate. These 30-year normal values can help to determine a departure from historic norms and identify current weather trends.

The recently released 30-year average ranges from 1990 – 2020. Images in Figures E1 and E2 show how each 30-year average for the past 120 years compares to the composite 20<sup>th</sup> century average for temperature and precipitation.

For the western U.S., the 1990-2020 average shows much warmer than average temperatures, in comparison to the 100-year 20<sup>th</sup> century average. When comparing precipitation for the past 30 years to both the previous 30-year average and the 1901-2000 average, the American Southwest (including portions of Utah, Arizona, California and Nevada) has seen as much as a 10% decrease in average annual precipitation.

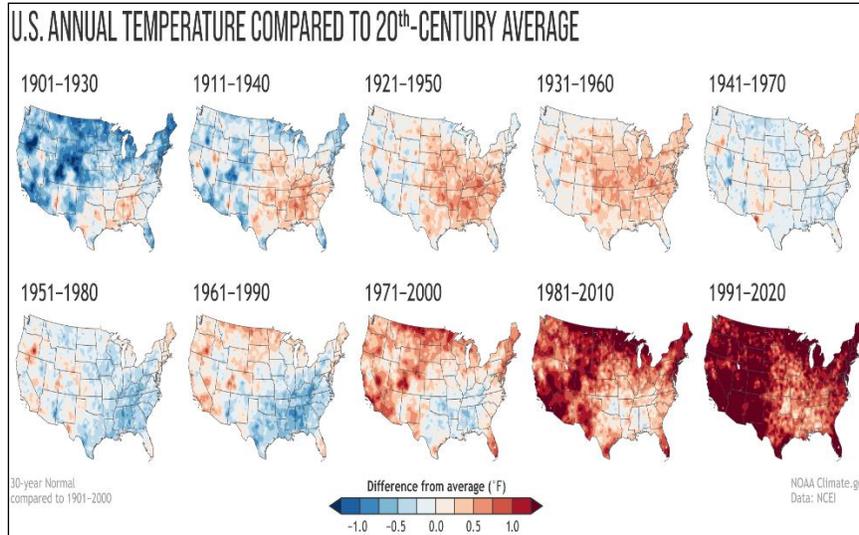


Figure E1

U.S. Annual Temperature compared to 20<sup>th</sup>-Century Average

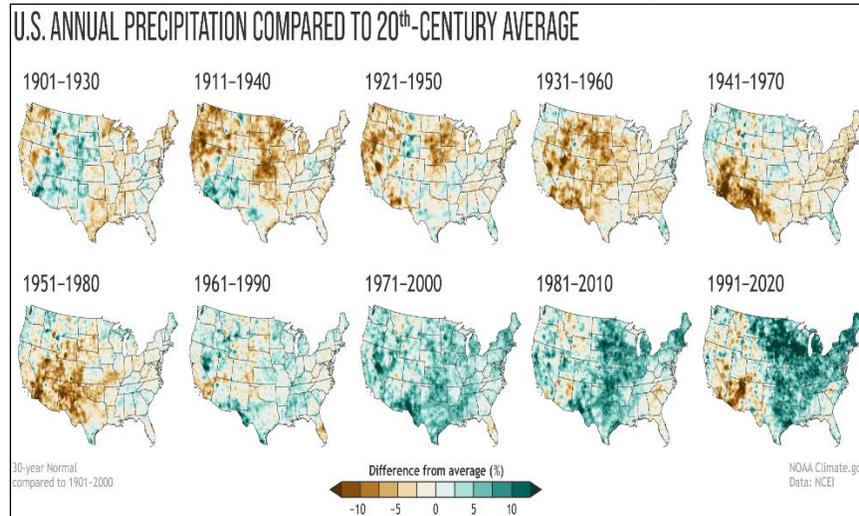


Figure E2

U.S. Annual Precipitation compared to 20<sup>th</sup>-Century Average

The 2022 water year was no exception to the general drying trend experienced over the past 30 years. Severe drought conditions engulfed the southwestern region of the United States. Reservoir storage for the California Region was only 50% of average at the end of April. Similar reservoir shortages are currently impacting Nevada, Utah, Arizona, New Mexico, Oklahoma and Texas after the uncharacteristically dry winter season. Figure E-3 shows reservoir conditions by US region, as recorded by the USDA.



**Figure E3** Regional reservoir storage as of April 30<sup>th</sup> 2022

### Cloud Seeding Overview

Seeding opportunities occurred on 7 days during the 2021-2022 operational season. Five of these were in December, with one additional seeded event in March. A total of 41 flares were successfully burned to target the Lopez Lake watershed, releasing an estimated 656 grams of AgI. Unfortunately, no seeding opportunities occurred during January or February. There were no seeding suspensions during the season.

Based on NAWC’s evaluations of nearby programs with longer history in San Luis Obispo and Santa Barbara Counties, ground-based seeding is significantly more efficient than aerial seeding. It is NAWC’s recommendation that the Agency continue the ground-only operational cloud seeding project with the current NAWC design. This design can and should be modified as needed for specific winter seasons and to account for any changes to climatic conditions, or special circumstances such as burn areas.

# **1. INTRODUCTION**

## **1.1 Program History**

North American Weather Consultants (NAWC) conducted its first season of cloud seeding operations during the 2019-2020 winter season with the County of San Luis Obispo Department of Public Works. The Agency issued a Request for Proposals (RFP) on September 16, 2019 for a cloud seeding program of up to three seasons duration. NAWC was awarded this contract on December 17, 2019. NAWC, with headquarters in Sandy, Utah, conducted a 4.5-month cloud seeding program for the Agency from this current season from December 1, 2021 through April 15, 2022. Although NAWC's original proposal included both airborne and ground-based seeding, the ground-based portion of the program has been utilized more frequently than aircraft due to budgetary constraints.

For the 2021-22 season, seeding was conducted from four ground-based sites. This includes Arroyo Grande, Berros Peak, Mt. Lospe, and Harris Grade (shown on the map in Section 3.0). All of the seeding sites contained Automated High Output Ground Seeding (AHOGS) systems. These systems use flares with high concentrations of silver iodide, dispersed through remote means (cellular data connection) to introduce seeding agents into storms systems. All seeding decisions were made by a Weather Modification Association (WMA) certified project meteorologist with a Master's degree in meteorology.

## **1.2 Seasonal Weather Summary**

The ENSO (El Niño-Southern Oscillation) phase was classified as a La Nina once again during the 2021-2022 winter season. Precipitation in and around the Central Coast in general was well below normal this season. Rainfall from the beginning of the water year (September 1, 2021) through April 30 ranged from roughly 50-80% of the average total weather year values. Table 1-1 shows precipitation amounts from several stations in San Luis Obispo County.

**Table E-1**  
**2021-2022 Monthly Precipitation (Inches)**  
**For Locations near the Lopez Lake Target Area**

<b>Location</b>	<b>December</b>	<b>January</b>	<b>February</b>	<b>March</b>	<b>April</b>	<b>December – April Total</b>	<b>Percent of Normal (April 30)</b>
<b>Arroyo Grande Creek</b>	6.37	0.10	0.06	0.84	0.47	7.84	56%
<b>Davis Peak</b>	9.81	0.08	0.19	1.58	0.67	12.33	80%
<b>Lopez Dam</b>	8.45	0.04	0.00	0.86	0.47	9.82	65%
<b>Salinas Dam</b>	9.29	0.12	0.00	1.10	0.48	10.99	63%
<b>Santa Margarita</b>	7.49	0	0.04	1.19	0.59	9.42	50%
<b>SLO Reservoir</b>	9.86	0	0.00	0.86	0.51	11.31	56%
<b>Upper Lopez</b>	10.51	0.04	0.00	0.55	0.55	11.65	65%

Figure 1.1 is a drought monitor comparison for April 13, 2021 and April 5, 2022. These two maps are similar in that nearly all of the state has at least severe drought (D2) and approximately a third to half of the state has extreme drought (D3). In general, extreme drought conditions have expanded to include more coastal areas and have become slightly less extreme in the southern Sierra and desert areas east of there, since spring of 2021.

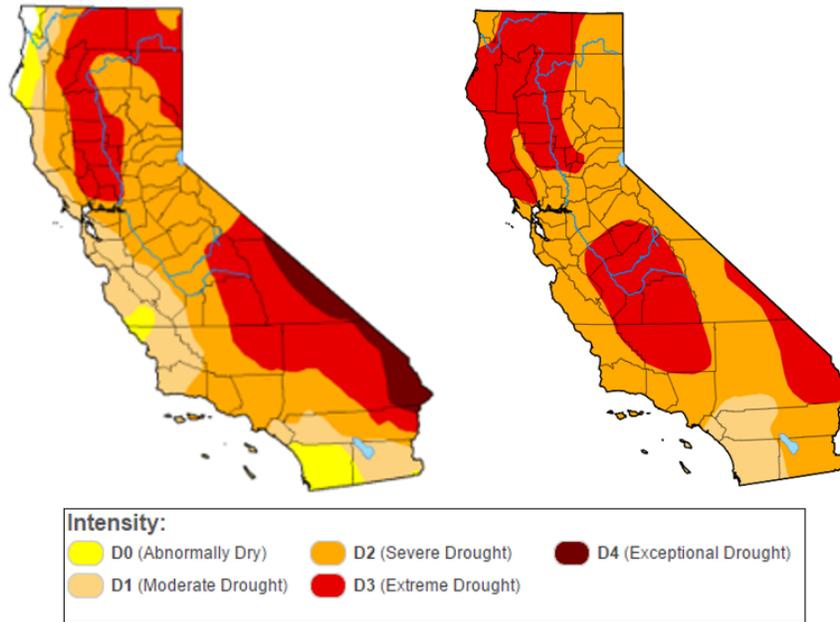


Figure 1.1 U.S. Drought Monitor Conditions for California for April 13, 2021 (left) and April 5, 2022 (right)

### 1.3 Report Terms and Acronyms

Table 1-2  
Project Acronyms and Descriptions

Acronym	Description	Acronym	Description
AHOGS System	Automated High Output Ground Seeding System	NCAR	National Center for Atmospheric Research
ALERT Network	Automated Local Evaluation in Real Time Network	NOAA	National Oceanic and Atmospheric Association
HYSPLIT	Hybrid Single Particle Lagrangian Integrated Trajectory (Model)	READY	Real-Time Environmental Applications and Display System
AFB	Air Force Base	ICE	Ice Crystal Engineering
AFWA	Air Force Weather Agency	NAWC	North American Weather Consultants
FAA	Federal Aviation Administration	NEXRAD	Next Generation Radar
ARL	Air Resources Laboratory	NWS	National Weather Service
CSU	Colorado State University	PDT	Pacific Daylight Time
ENSO	El Nino Southern Oscillation	PST	Pacific Standard Time
FACE	Florida Area Cumulus Experiment	SBCWA	Santa Barbara County Water Agency
FSL	Forecast System Laboratory	SLW	Supercooled Liquid Water
HRRR	High Resolution Rapid Refresh	WMA	Weather Modification Association
GMT	Greenwich mean time	WRF	Weather Research and Forecasting

## **2. CLOUD SEEDING RESEARCH AND MECHANISMS**

Two scientific mechanisms have been described concerning the potential to augment precipitation with cloud seeding. One of these involves increasing an individual cloud's efficiency in producing precipitation, while another potential (resultant) effect of this is the enhancement of cloud development in the individual cloud or within the larger system, leading to additional precipitation. The first mechanism has often been referred to as the *static* seeding hypothesis, while the second relies upon *dynamic* effects of cloud growth. In many situations, both processes could be operative, whereby a cloud's precipitation efficiency is increased, and the cloud is made to grow larger due to seeding.

Clouds contain water vapor, water droplets and frequently ice crystals if cloud temperatures drop below freezing. Discoveries in the late 1940's established that microscopic particle of silver iodide, cause super cooled water droplets to freeze (Vonnegut, 1947). Moisture in a cloud deck will remain aloft unless it congregates and forms snowflakes that are heavy enough to overcome the storms natural updrafts. Pure water, can remain liquid and therefore suspended in a cloud deck until temperatures as cold as  $-17^{\circ}$  C. Silver iodide can speed up this process of freezing, congregating, forming a snowflake and falling as precipitation, by acting as a catalyst for the freezing of liquid water well above  $-17^{\circ}$  C. Through this process, silver iodide can therefore enhance a storms natural productivity by making the snow flake formation process more efficient. These supercooled water droplets are the normal targets of most present-day cloud seeding programs. More on this in future sections.

### **2.1 Precipitation Processes**

There are two basic mechanisms that produce precipitation: collision-coalescence and ice formation. The collision-coalescence process is defined as the growth of raindrops by the merging and/or colliding of cloud drops and small precipitation particles. This process is especially important for the rainfall process in tropical climates, but it can also be a factor in the formation of rainfall in more temperate climates like those found in Santa Barbara County. Ice formation or nucleation, as described in the Bergeron-Findeisen theory, consists of a process in which precipitation particles may form within a mixed cloud, which is one composed of both ice crystals and liquid water drops. In such clouds the ice crystals can gain mass by deposition (water vapor turning directly to ice) at the expense of the liquid drops surrounding the ice crystals, by accumulation of these water drops (riming). Upon attaining sufficient weight, the ice crystal would typically fall to the ground as snow if the surface temperatures are at or below freezing, or melt and fall as raindrops if the surface temperatures are warmer than freezing. This Bergeron-Findeisen process is important in the production of snow and rain in the more temperate climates like those found in Santa Barbara County. The presence of supercooled water droplets in clouds is usually the focus of cloud seeding efforts.

## 2.2 Ice Nucleation

As discussed in the previous section, clouds often contain liquid cloud droplets at sub-freezing temperatures. These droplets are termed supercooled. The natural tendency is for these droplets to freeze, but to do so at temperatures warmer than  $-39^{\circ}\text{C}$  they need to encounter an impurity. There are a variety of particles present in the atmosphere that possess the ability to cause these supercooled droplets to freeze. In this context, these particles are known as freezing nuclei or ice nuclei. Research has demonstrated that certain types of natural particles (for example, dust or salt particles, and even a certain type of bacteria) in the atmosphere often serve as freezing nuclei. The conversion of a supercooled water droplet into an ice crystal is referred to as nucleation. It is known that the nucleating efficiency of these naturally occurring freezing nuclei increases with decreasing temperatures. It has also been established that naturally occurring freezing nuclei active in the temperature range of approximately  $-5$  to  $-15^{\circ}\text{C}$  are relatively rare. Research has also shown that minute (microscopic) particles of silver iodide begin to act effectively as freezing nuclei at temperatures colder than  $-5^{\circ}\text{C}$  (Dennis, 1980). Some more recently developed seeding formulations show nucleation at temperatures as warm as  $-4^{\circ}\text{C}$ . Silver iodide is the agent most commonly used to seed clouds when relying on the ice nucleation process.

There are two types of ice nucleation: condensation-freezing and contact. In condensation freezing, a nucleus first serves as a condensation nucleus in forming a cloud droplet. At temperatures of approximately  $-5^{\circ}\text{C}$  or colder these same nuclei can serve as freezing nuclei. In other words, under the right conditions, a nucleus can a) aid condensation, forming a cloud droplet and b) then promote freezing on the same nucleus, forming an ice crystal. Contact nucleation, as the name implies, means that a freezing nucleus must come in physical contact with a supercooled cloud droplet, thus causing it to freeze if the temperature of the cloud droplet is cold enough for the freezing nuclei to be active. Contact nucleation can be a relatively slow process compared to condensation-freezing nucleation, which can be quite rapid, on the order of one to a few minutes.

## 2.3 Impacts of Silver Iodide Seeding

Since a scarcity of natural ice nuclei commonly exists in the atmosphere at temperatures in the range of  $-5$  to  $-15^{\circ}\text{C}$ , many clouds may be inefficient in converting water droplets into ice crystals. The addition of silver iodide nuclei to these cloud regions can produce additional ice crystals, which, under the right conditions, grow into snowflakes and fall out of the cloud as either snow or rain. Rain is produced by the melting of such snowflakes when they fall through warmer air near the ground. This increase in efficiency is usually referred to as a *static* seeding effect.

In the process of converting supercooled cloud droplets into ice crystals, additional heat is added to the cloud due to the release of the latent heat of fusion. This additional heat may increase the buoyancy of air within the clouds, resulting in a *dynamic* effect. This postulated *dynamic* effect was the basis for a National Oceanic and Atmospheric Association (NOAA) research program conducted in Florida known as the Florida Area Cumulus Experiment (FACE). Two different phases of FACE 1, 1970-76 and FACE 2, 1978-80 (Woodley et al., 1983) indicated increases in area-wide rainfall, but results fell short of strict statistical acceptance criteria. Rainfall increases from seeded convection bands in the Santa Barbara II research program (Brown et al., 1974) were attributed to both *static* and *dynamic* effects. NAWC conducted this research program in Santa Barbara County with funding from the Naval Weapons Center at China Lake.

#### **2.4 Santa Barbara II Research Program**

There was an early research program conducted in Santa Barbara County, termed Santa Barbara I, which was conducted from 1957-1960 and was sponsored by various organizations including the State of California, The University of California, Santa Barbara and Ventura counties, the National Science Foundation, the U.S. Weather Bureau, and the U.S. Forest Service. This program employed randomized seeding during storm periods using ground-based silver iodide nuclei generators. Results from this research program suggested precipitation increases of 45% in some areas but were not statistically significant. Further information about this program can be found in Appendix A of this report.

A second research program conducted in the county was known as the Santa Barbara II program, which was conducted during the winter seasons of 1967 to 1973. Santa Barbara II was conducted in two primary phases. Phase I consisted of the release of silver iodide from a ground site located near 2,600 feet MSL in the Santa Ynez Mountains northwest of Santa Barbara. These silver iodide releases were made as convection bands passed overhead. The releases were conducted on a random seed or no-seed decision basis in order to obtain baseline non-seeded, natural, rainfall information for comparison. A large network of recording precipitation gauges was installed for the research program (Figure 2.1). The amount of precipitation that fell from each seeded or non-seeded convection band was determined at each precipitation gauge location. Average convection band precipitation for seeded and non-seeded events was calculated for each rain gauge location. Figure 2.2 shows the results of seeding from the ground as contours of the ratios of average seeded band precipitation to the non-seeded band precipitation.

Ratios greater than 1.0 are common in Figure 2.2. A ratio of 1.50 would indicate a 50 percent increase in precipitation from seeded convection bands. The increase was shown to be statistically significant in this study, unlike in Santa Barbara I. The reasoning for the difference in statistical significance between these studies can be found in Appendix B. The high ratios in southwestern Kern County are not significant in terms of amounts of additional rainfall since the

convection bands (both seeded and non-seeded) rapidly lose intensity as they enter the San Joaquin Valley. In other words, a high percentage applied to a low base amount does not yield much additional precipitation. These apparent effects may be due to delayed ice nucleation (compared to other seeding methods), which would be expected with the type of seeding flares used in this experiment which operated by contact nucleation, a relatively slow process.

The low amounts of natural precipitation in southwest Kern County results from evaporation in downslope flow in the winter storms that affect this area. Such predominant downslope flow areas are frequently known as rain-shadow areas in the lee of mountain ranges. Figure 2.3 dramatically exhibits this feature from the coastal mountains in Central and Southern California, which are wet, to the San Joaquin and Imperial Valleys, which are relatively dry. The 1.5 ratios along the backbone of the Santa Ynez Mountains are, however, significant in terms of rainfall amounts since this area receives higher natural precipitation during winter storms due to upslope flow. This upslope flow is also known as an orographic effect and accounts for many mountainous areas in the west receiving more precipitation than adjoining valleys, especially downwind valleys. It was concluded that convection band precipitation was increased over a large area using this ground-based seeding approach.

In a similar experiment, phase II employed an aircraft to release silver iodide (generated by silver iodide - acetone wing tip generators) into the convection bands as they approached the Santa Barbara County coastline west of Vandenberg Air Force Base. The convection bands to be seeded were also randomly selected. Figure 2.4 provides the results. Again, a large area of higher precipitation amounts is indicated in seeded convection bands compared to non-seeded convection bands. Notice the westward shift of the effect in this experiment versus the ground-based experiment. This result is physically plausible since the aircraft seeding was normally conducted off the coastline in the vicinity of Vandenberg Air Force Base (for example, west of the ground-based release point), which is further upwind. Material released from the ground also takes some amount of time to reach the  $-5^{\circ}$  C level in cloud, depending on vertical mixing of the atmosphere.

A study of the contribution of convection band precipitation to the total winter precipitation in Santa Barbara County and surrounding areas was conducted in the analysis of the Santa Barbara II research program. This study indicated that convection bands contributed approximately one-half of the total winter precipitation in this area (Figure 2.5). If it is also assumed that all convection bands could be seeded in a given rainy season and that a 50 percent increase was produced, the result would be a 25 percent increase in total rainy season precipitation when these assumptions are correct (although this could be a somewhat optimized situation). Two NAWC reports (Thompson et al., 1988 and Solak et al., 1996) provided a more precise

quantification of the optimal seasonal seeding increases that might be expected at Juncal and Gibraltar Dams of 18-22%, respectively, from seeding convection bands.

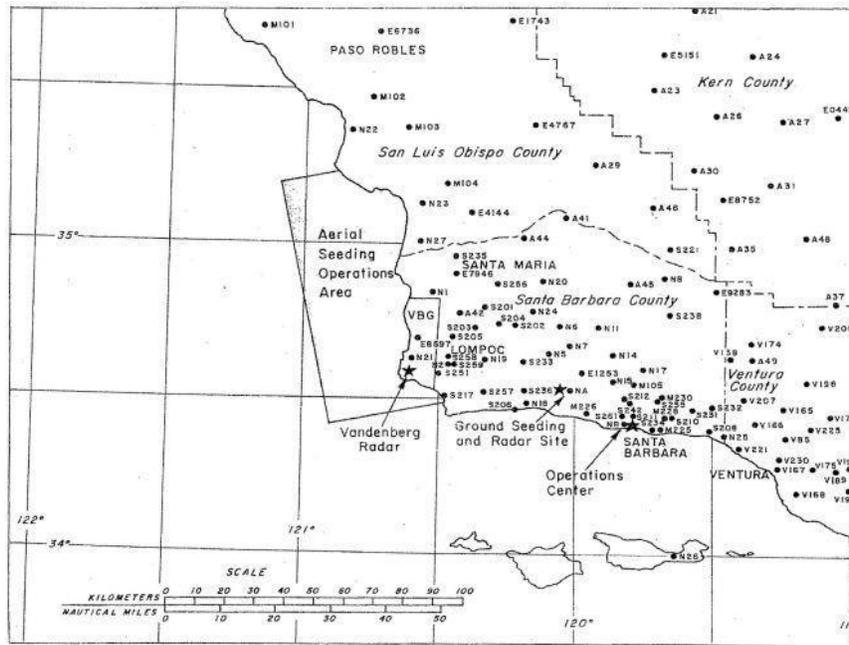


Figure 2.1 Santa Barbara II project map with rain gauge locations, radar and seeding sites.

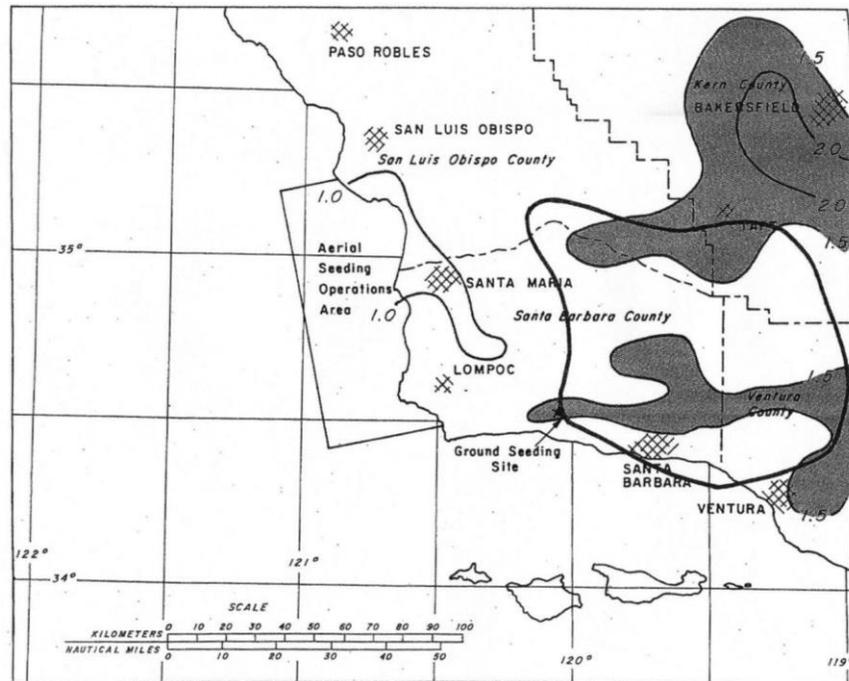


Figure 2.2 Seeded/Not-Seeded Ratios of band precipitation for Phase I.

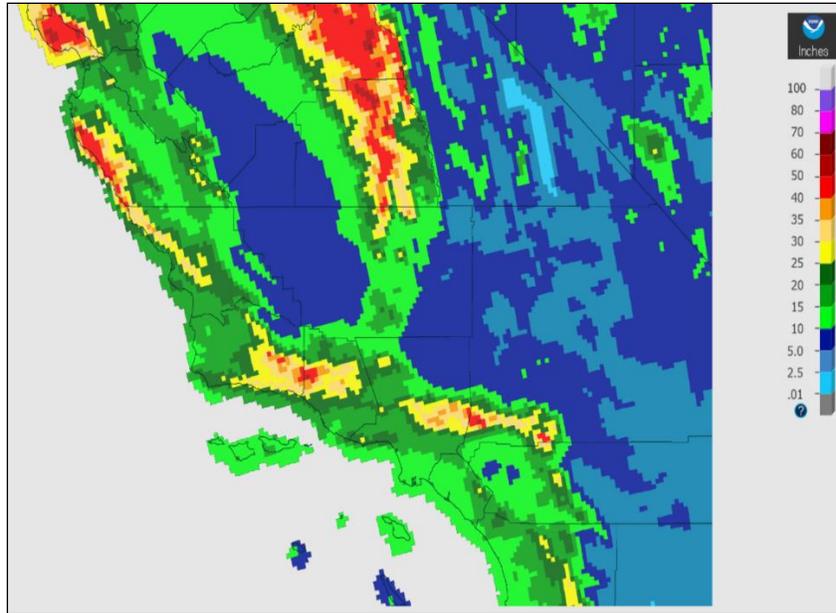


Figure 2.3 Annual average precipitation (inches), Southern California 1980-2010.

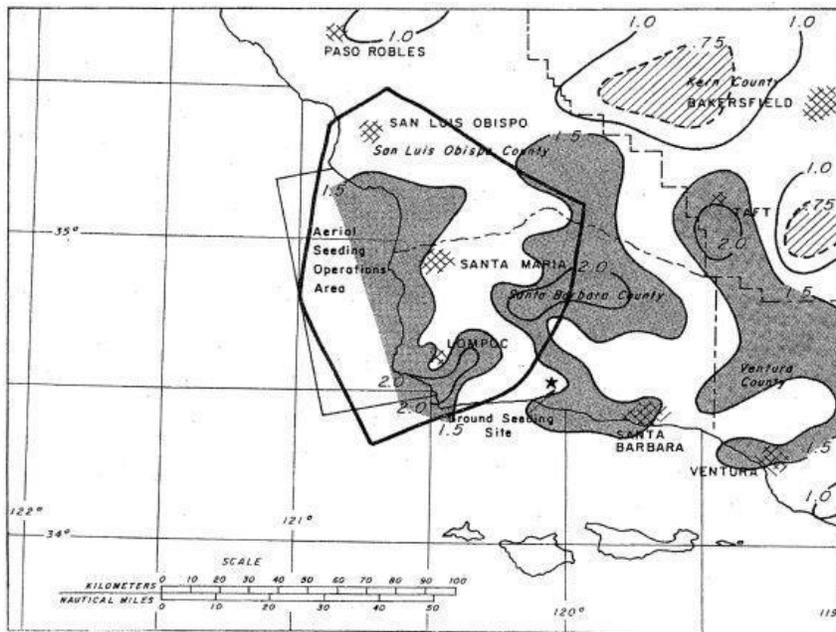
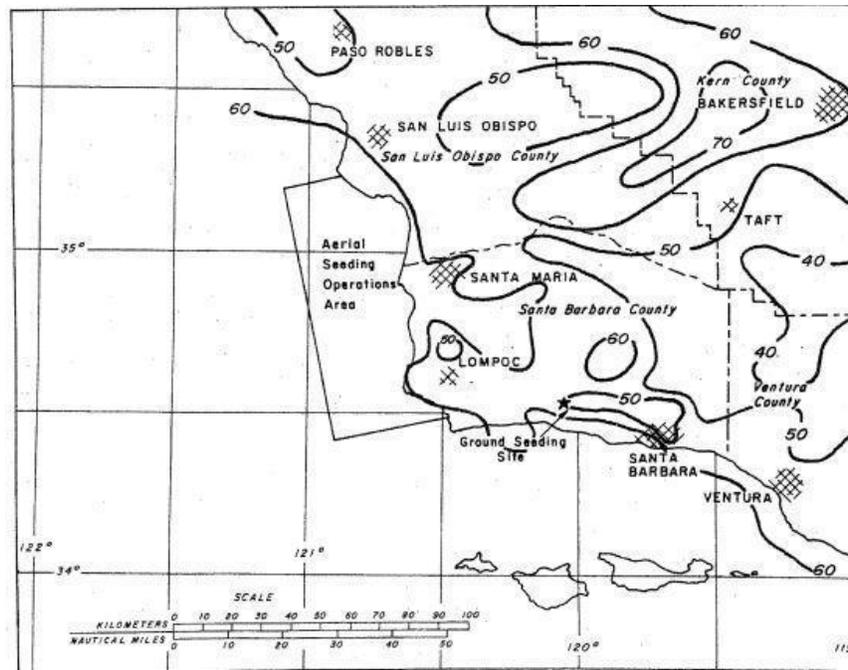


Figure 2.4 Seeded/Not-Seeded ratios of band precipitation for Phase II aerial operations, 1970-74 seasons.



**Figure 2.5** Approximate percentage of winter precipitation occurring in convection bands, 1970-74 seasons.

For illustration purposes, Figure 2.6 provides a sequence of six radar images of a convection band as it moved into Santa Barbara County on April 11, 2010. The radar images are from the Vandenberg AFB radar site. Table 2-1 provides 30-minute interval rainfall values observed at Orcutt during the passage of this convection band. The highest 15-minute rainfall total (not shown in the table) was 0.35 inches between 1725 and 1740 PDT during the passage of the heaviest portion of the band, corresponding to the time period between the 2<sup>nd</sup> and 3<sup>rd</sup> images in the sequence. Short-duration rainfall rates peaked at close to 2 inch per hour for a brief period around 1730 PDT. Rainfall rates then averaged around a quarter inch per hour or less during the remainder of the event (after about 1800 PDT).

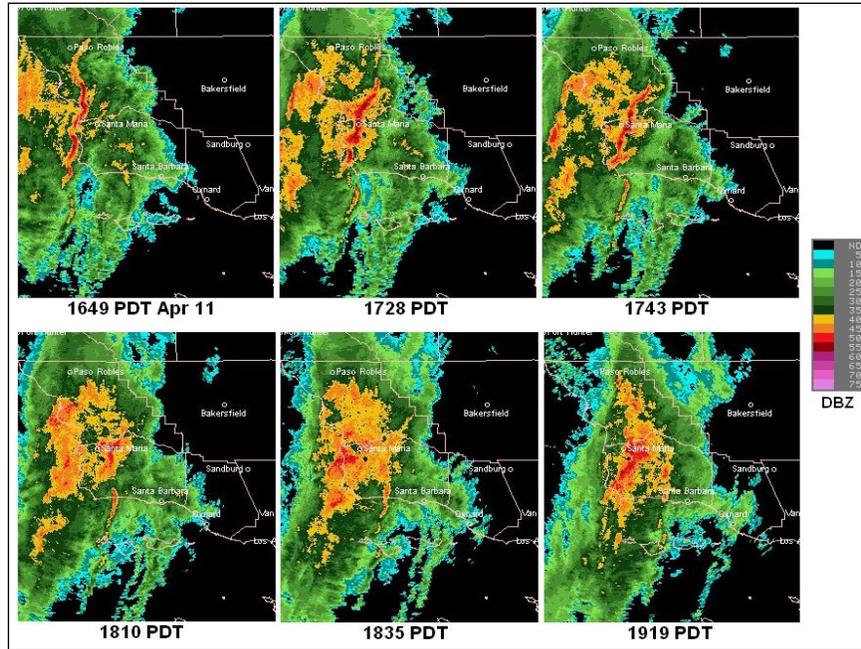


Figure 2.6 Frontal convective band passing over Santa Barbara County on April 11, 2010.

**Table 2-1**  
**Short Duration Rainfall Amounts at**  
**Orcutt During Storm Event in Figure 2.6**

Time Period (PDT)	1630 - 1700	1700 - 1730	1730 - 1800	1800 - 1830	1830 - 1900	1900- 1930	1930 - 2000
Precipitation (inches)	0.03	0.26	0.35	0.12	0.10	0.12	0.02

In summary, earlier research conducted in Santa Barbara County indicated that convective bands are a common feature of winter storms that impact Santa Barbara County and that those bands contribute a significant proportion of the rainy season precipitation. In addition, research has indicated that these bands contain supercooled liquid cloud droplets, the target of most modern-day cloud seeding activities (Elliott, 1962). Seeding these bands with silver iodide either from the ground or air increases the amount of precipitation received at the ground. These bands are typically oriented in a general north to south fashion (for example, northeast to southwest, northwest to southeast) as they move from west to east. It is common to have at least one convective band per winter storm with as many as three or four per storm on occasion. One band is usually associated with a primary cold frontal passage through the county. Frequently, these frontal bands are the strongest, longest-lasting bands during the passage of a storm. Other bands may occur in either pre-frontal or post-frontal situations. The duration of these bands over a fixed location on the ground can vary from less than one hour to several hours.

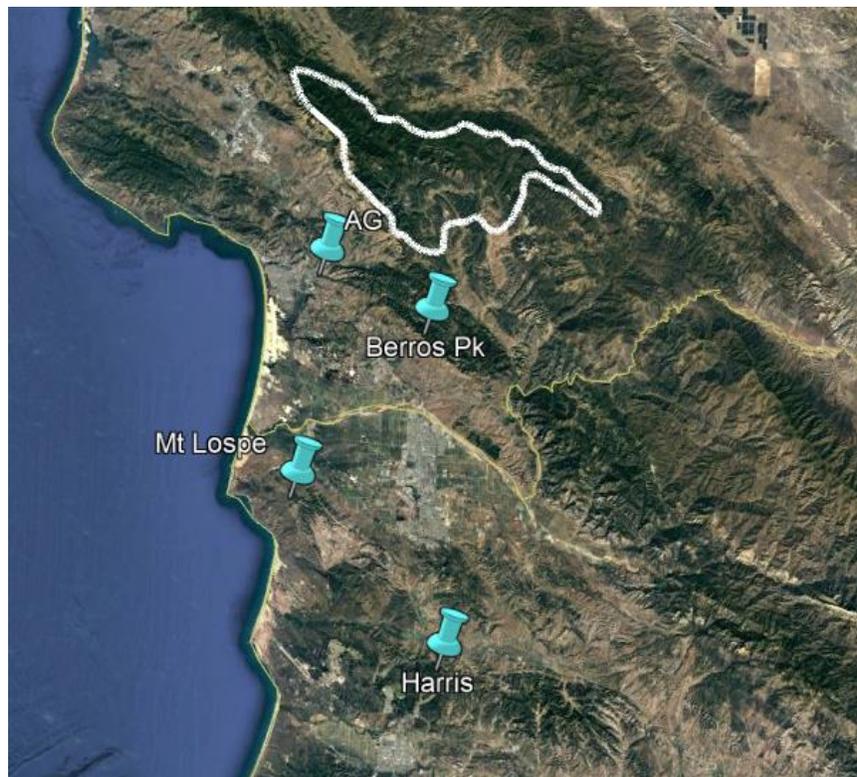
**Table 2-1**  
**Short Duration Rainfall Amounts at Orcutt During Storm Event in Figure 2.6**

<b>Time Period (PDT)</b>	<b>1630 - 1700</b>	<b>1700 - 1730</b>	<b>1730 - 1800</b>	<b>1800 - 1830</b>	<b>1830 - 1900</b>	<b>1900- 1930</b>	<b>1930 - 2000</b>
<b>Precipitation (inches)</b>	0.03	0.26	0.35	0.12	0.10	0.12	0.02

In summary, earlier research conducted in Santa Barbara County indicated that convective bands are a common feature of winter storms that impact this region and that those bands contribute a significant proportion of the rainy season precipitation. In addition, research has indicated that these bands contain supercooled liquid cloud droplets, the target of most modern day cloud seeding activities (Elliott, 1962). Seeding these bands with silver iodide either from the ground or air increases the amount of precipitation received at the ground. These bands are typically oriented in a general north to south fashion (for example, northeast to southwest, northwest to southeast) as they move from west to east. It is common to have at least one convective band per winter storm with as many as three or four per storm on occasion. One band is usually associated with a primary cold frontal passage through the county. Frequently, these frontal bands are the strongest, longest-lasting bands during the passage of a storm. Other bands may occur in either pre-frontal or post-frontal situations. The duration of these bands over a fixed location on the ground can vary from less than one hour to several hours.

### 3. PROGRAM DESIGN

The winter cloud seeding program is conducted for the Lopez Lake watershed in San Luis Obispo County. The target area and available seeding sites are depicted in Figure 3.1. The objective of the program was to seed all suitable storm systems affecting the target area that contained organized convective bands, unless precluded by previously established suspension criteria as discussed in Section 5.0.



**Figure 3.1** Project area and ground-based high-output flare site locations that were used for the Lopez Lake target during the 2021-2022 season

Some generalized seeding criteria that NAWC uses to help determine whether an approaching storm contains suitable conditions for seeding.

- Organized storm, with the primary target storms that consist of convective bands.
- 700 mb (approximately 10,000) temperatures between about -5 and -17° C.
- 700 mb wind directions favorable for transporting seeding materials over the target areas.
- No suspension criteria met that would prohibit safe operations

It has always been NAWC's philosophy that the design of our operational programs should be based upon prior research programs that provided positive indications of increases in precipitation, to the extent that the research results are considered to be representative of the

operational programs' conditions (this assumes research results from one location are transferable to the operational program's target area).

As a result of the research described in section 2 of this report, NAWC believes the best program design for a winter cloud seeding program in Santa Barbara County and southern San Luis Obispo County to be one that relies primarily on an effective ground strategy, paired to, when funding allows, a comprehensive areal program.

The development of AHOGS for this, and other California programs, came in an effort to maximize the effectiveness of ground-based seeding for program areas where high yield and highly convective coastal storms are present. The AHOGS allow NAWC to use the same high concentration dispersion flares (previously only used on the wings of planes), from the ground. This combines the financial efficiency of ground-based operations, with the operational effectiveness of high output seeding methods.

#### **4. EQUIPMENT, PROCEDURES AND PERSONNEL**

Each operational cloud seeding program relies upon a mix of suitable equipment, customized procedures and qualified personnel. These elements were described in a comprehensive Operations Plan for the Santa Barbara program for the 2021-2022 winter season. Various components of this plan are discussed below.

##### **4.1 Weather Radar**

The Vandenberg AFB radar site has been utilized for the operation of the cloud seeding program since 2001. It provides information on precipitation location and intensity, as well as wind speed and direction within the precipitation echoes and a large array of additional products. The radar step-scans through 14 different elevation angles in a 6-minute period. The maximum range for the detection of precipitation echoes is 143 miles from the radar. These radar systems are operated and maintained by the National Weather Service (NWS). The NWS radar sites have dual polarization capability in recent years, which provides the ability for the radar to differentiate between various hydrometeor (precipitation) types and identify non-weather phenomenon such as insects, dust, and ground clutter.

##### **4.2 AHOGS Ground-Based Seeding Systems**

The Automated High Output Ground Seeding Systems (AHOGS) allow automated, focused, high-output seeding releases from strategic ridgeline locations under program control from the project operations center with the proper computer software and password. These systems give the project meteorologist the ability to conduct intensive seeding of convection rain bands as they track into and across the project area under different wind flow regimes.

Each AHOGS site is controlled via a modem and can be connected via the internet where the LoggerNet software is installed. This software allows the user to manage the flare seeding operations and allows monitoring and reporting of AHOGS site status information, such as flare inventory and battery voltage. The project meteorologist has the option of firing flares individually in real time, or to order batch firing of any number of flares at selectable intervals at each site, e.g., three flares at 15-minute intervals, beginning at any selected time.

NAWC utilized a total of three custom AHOGS sites for the 2021-2022 winter season to affect the Lopez Lake target area. NAWC believes higher elevation seeding sites to be somewhat more effective since the base of the convective bands may not reach lower elevations during their passage over the target area. Such conditions could result in the lack of transport of the seeding agent into effective regions within the bands. Location is important since the effects of seeding will occur downwind (generally east through north of the site location). The existing sites were selected as ones that would offer potential targeting of seeding effects under the most common lower-level wind flow regimes experienced with the passage of convective bands the area. Table 4-1 provides location and elevation information for the AHOGS sites.

**Table 4-1  
AHOGS Site Locations**

<b>Location</b>	<b>Latitude (N)</b>	<b>Longitude (W)</b>	<b>Elevation (ft.)</b>
<b>Arroyo Grande</b>	35.119	-120.567	300
<b>Mt. Lospe</b>	34.897	-120.595	1570
<b>Berros Peak</b>	35.062	-120.437	1610

These systems were designed for intensive seeding of convection bands using high-output pyrotechnic flares. Each AHOGS consists of the following primary onsite components:

- Two flare masts, which hold a total of 32 fast-acting seeding flares.
- Spark arrestors that enclose each flare.
- A control mast with an environmentally sealed control box containing a cellular phone communications system, digital firing sequence relays/controller, data logger and system battery.
- A solar system to maintain site power.
- Cellular phone antenna.
- A video camera to provide project meteorologists with on the ground storm visuals and to allow them to observe flare ignitions.

The pyrotechnic flares used at the AHOGS sites produce high-output, fast-acting silver iodide complexes during a burn time of approximately 3-4 minutes. Even though the cloud seeding program is conducted during the winter season, there can still be periods when the ground cover

may be dry. Weed abatement and ground care is performed prior to the onset of each season, and periodically throughout the season as needed. Spark arrestors are placed over the flares to keep embers from reaching the ground. Figures 4.1 and 4.2 provide photos from one of the video cameras that show seeding flares burning in both day and night conditions. Figure 4.3 shows a close up of the spark arrestors and Figure 4.4 shows a flare burning inside a spark arrestor.



**Figure 4.1** Flare burning at an AHOGS site during daytime conditions



**Figure 4.2** Flare burning at an AHOGS site at night



**Figure 4.3** Close-up of spark arrestors



**Figure 4.4** Flare burning inside a spark arrestor

The site video cameras are very useful during seeding operations since they allow the project meteorologist to verify the firing of flares. If a malfunction were to occur, the project meteorologist could substitute another flare. Some site photos can be seen in Figures 4.5 – 4.6.



**Figure 4.5** Photo of the Mt. Lospe AHOGS site



**Figure 4.6** Photo of the Berros AHOGS site

### **4.3 Operations Center**

NAWC's corporate headquarters in Sandy, Utah served as the operations center for the program. The project meteorologist's computers have the LoggerNet software necessary to activate the AHOGS sites. A variety of meteorological data are used to assist in decision-making, as described in the following section.

#### **4.4 Weather Forecasts and Meteorological Data Acquisition**

NAWC project meteorologists were responsible for the determination of when seedable conditions were present and whether seeding suspension criteria were met. Coordination between NAWC's project meteorologist and Mr. David Spiegel, of the San Luis Obispo County Department of Public Works, was involved in the decision-making process. NAWC's project meteorologists were also responsible for archiving relevant weather data (for example, local NEXRAD radar displays, satellite photos and rainfall data) from each event. Examples are shown in Section 5.0, which discusses last season's operations.

A variety of weather information is available online that was used to forecast approaching storms, observe weather conditions during storms as they passed through Santa Barbara County and document conditions of interest (to seeding decisions) or of concern, for example those related to suspension criteria. Some of these useful products include:

- Upper-air data, from both forecast models and observations such as rawinsondes. Typically wind speed, direction, and temperature and moisture data are available at important levels such as the surface, 850, 700, and 500 mb.
- Weather radar data which allow the meteorologists to view many important parameters before and during seeding operations, with scans at 5 to 6 minute intervals.
- Satellite imagery including visible, infrared, and water vapor presentations updated at intervals ranging from 5 minutes to one hour.
- Hourly observed precipitation data from ALERT rain gauge networks, as well as streamflow data.

#### **4.5 Seeding Procedures**

NAWC's conceptual model of the dynamics of the convection bands is that they are similar to convective bands that can occur in other parts of California during winter storms and other parts of the U.S. when a frontal structure is involved. The primary low to mid-level inflow to these bands is usually along the leading edge of the bands. These inflow regions are the areas containing stronger updrafts, and are also the development and accumulation zones of supercooled liquid cloud droplets. Consequently, this is the desired region for the introduction of the seeding material. This would mean that flares burned at the ground sites would be timed to occur as the leading edge of the bands, as determined by the Vandenberg AFB NEXRAD radar, approached the ground sites. Low-level winds from the surface up to roughly the  $-5^{\circ}$  C level are considered for targeting of seeding effects, as well as the avoidance of seeding over areas that meet any suspension criteria. The HYSPLIT model, discussed in Section 6.0, was also used in real time to help forecast seeding material dispersion from available sites.

#### **4.6 Suspension Criteria**

Suspension criteria were developed jointly between the County and NAWC personnel to serve as safeguards to avoid seeding during situations of extreme weather or adverse hydrologic conditions. Previously, special criteria had been developed and implemented following large fire events within the target areas. Since 1989, different types of suspension criteria for this project have been adopted and amended annually as needed. Cloud seeding suspension criteria were invoked whenever the National Weather Service (NWS) issued a severe storm, or flood warning that affected any part of the project area. Appendix B contains the suspension criteria for the 2021-2022 seeding program. Seeding suspension criteria were monitored during some of the heavier precipitation periods, although some of the heavier precipitation event periods did not coincide with seeding operations since they did not meet NAWC's generalized seeding criteria (Table 3-1). There were no seeding suspensions during the season.

#### **4.7 Personnel**

The following agencies and personnel were responsible for the conduct of the 2021-2022 cloud seeding program.

**San Luis Obispo County**  
**Department of Public Works**

Mr. David Spiegel, P.E.

**North American Weather Consultants**

Mr. Garrett Cammans, President  
Mr. David Yorty, primary Project Meteorologist  
Mr. Cole Osborne, back-up Program Meteorologist  
Mr. Tom Segura, Local Equipment Technician

## 5. OPERATIONS

All operations were conducted in accordance with established suspension criteria, which were developed for a variety of situations, such as high intensity rainfall, flood warnings and streamflow discharge. Suspension criteria can be found in Appendix B.

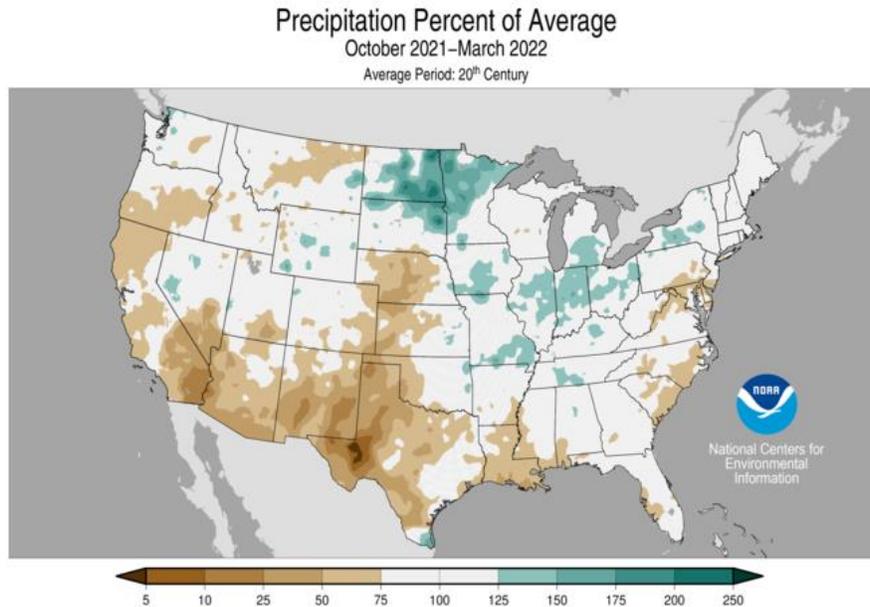
The 2021-2022 winter season was characterized by a La Niña phase of the El Niño Southern Oscillation (ENSO). Table 5-1 shows the evolution of the ENSO 3.4 region index throughout the season. A value of -0.5 or less indicates La Niña conditions present and a value of +0.5 or more indicates that El Niño conditions are present. Values between -0.5 and +0.5 are considered neutral. The observed values this season were indicative of the La Niña ENSO phase, as shown in the table, and were essentially identical to the indices of the 2020-2021 season.

**Table 5-1**  
**December 2021 – April 2022 ENSO Values**

<b>December - February</b>	<b>January - March</b>	<b>February - April</b>
-1.0	-0.9	-1.0

### 5.1 **Summary of the 2021-2022 Winter Season Rainfall**

San Luis Obispo County rainfall for the 2021-2022 season was again below normal, averaging about two-thirds of the total water year average as of April 30. Above normal precipitation occurred in December, with most other months being below normal. January and February brought very little precipitation, generally under a quarter inch to the target areas. Precipitation in much of the southwestern U.S. was below average during the October 2021 – March 2022 period, as shown in Figure 5.1.



**Figure 5.1**      **October 2021 – March 2022 percent of normal precipitation**

December brought well above normal rainfall to the County, with totals generally over twice the December average. There were five seeded storm events, which was by far the majority of the operations that occurred this season.

January precipitation was well under 10% of the monthly average, and there no seeded events.

February was the driest month of the season with precipitation of only about 1 to 4% of the monthly average, and no seeding opportunity.

March precipitation was somewhat more reasonable but still very low, ranging from about 30-50% of the monthly normal. The vast majority of this occurred in a significant (and seeded) storm event on March 28, the only seeding opportunity of the month.

April provided one more seeding opportunity, with a special extension to seed an April 21 storm event at no additional cost except for the seeding flares used.

Figures 5.2 - 5.6 show a month by month glance at percent normal monthly precipitation patterns this season for the United States.

Precipitation Percent of Average  
December 2021  
Average Period: 20<sup>th</sup> Century

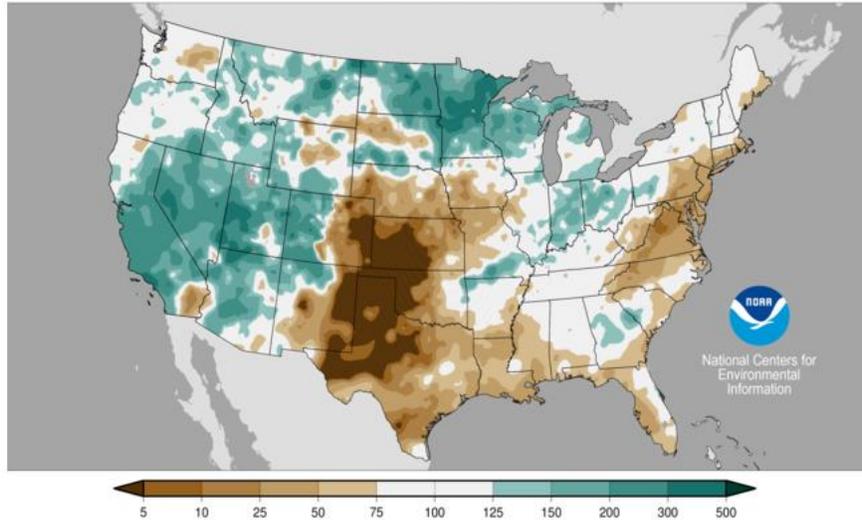


Figure 5.2 December 2021 Percent of Normal Precipitation

Precipitation Percent of Average  
January 2022  
Average Period: 20<sup>th</sup> Century

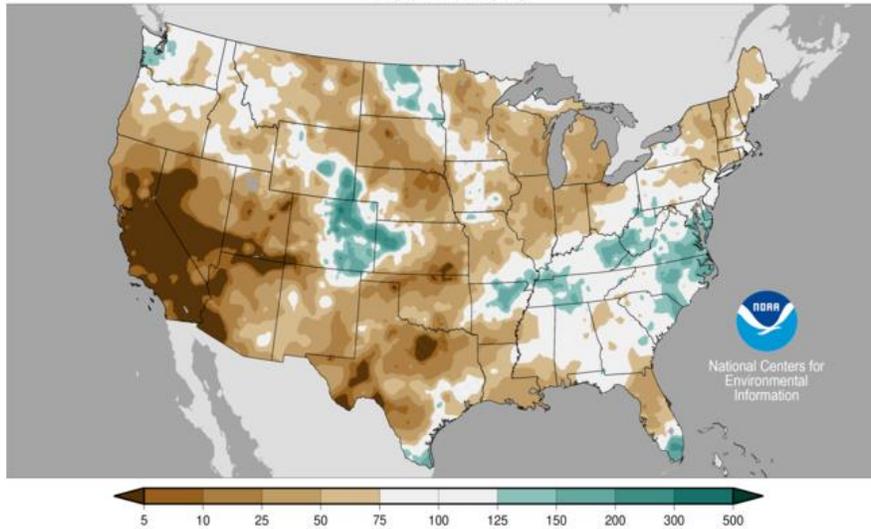


Figure 5.3 January 2022 Percent of Normal Precipitation

Precipitation Percent of Average  
February 2022  
Average Period: 20<sup>th</sup> Century

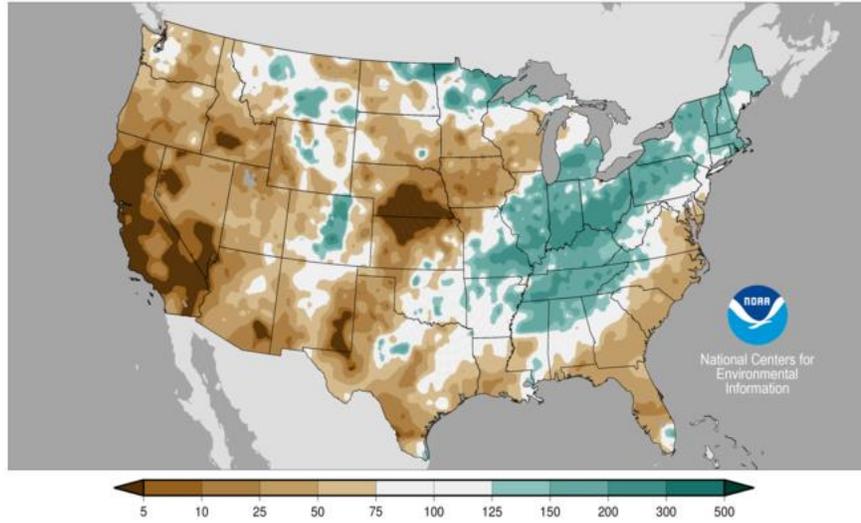


Figure 5.4 February 2022 Percent of Normal Precipitation

Precipitation Percent of Average  
March 2022  
Average Period: 20<sup>th</sup> Century

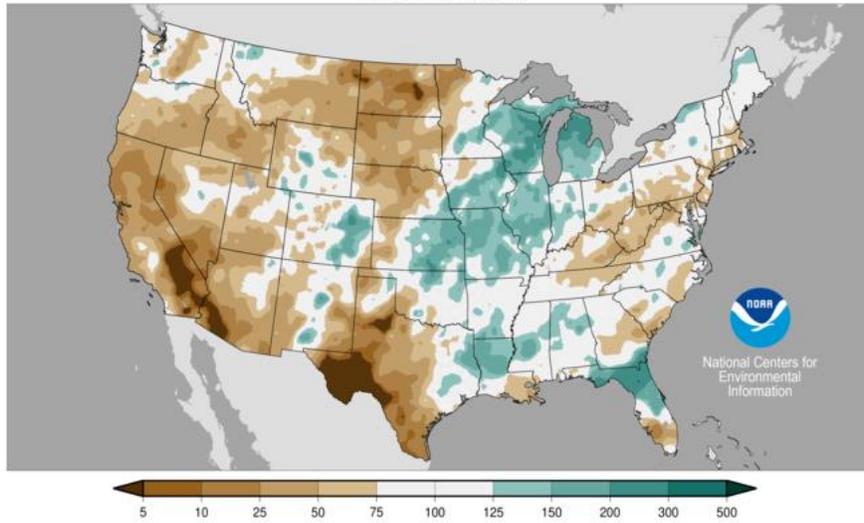
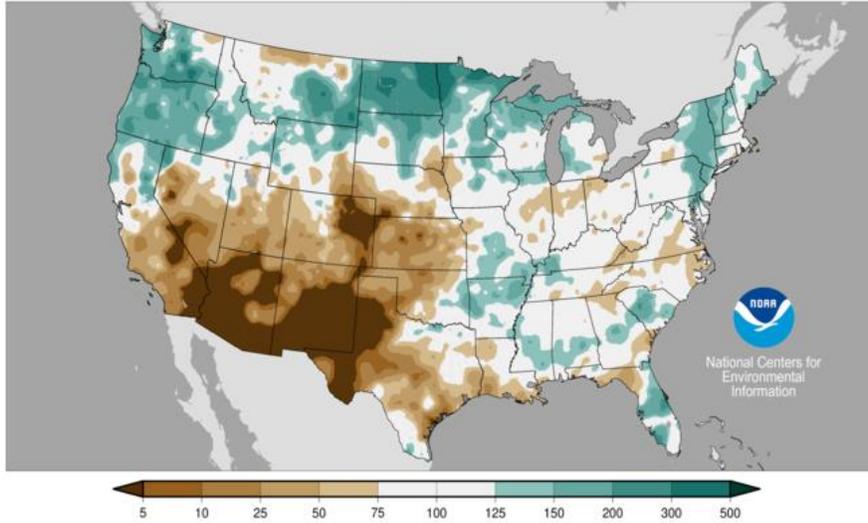


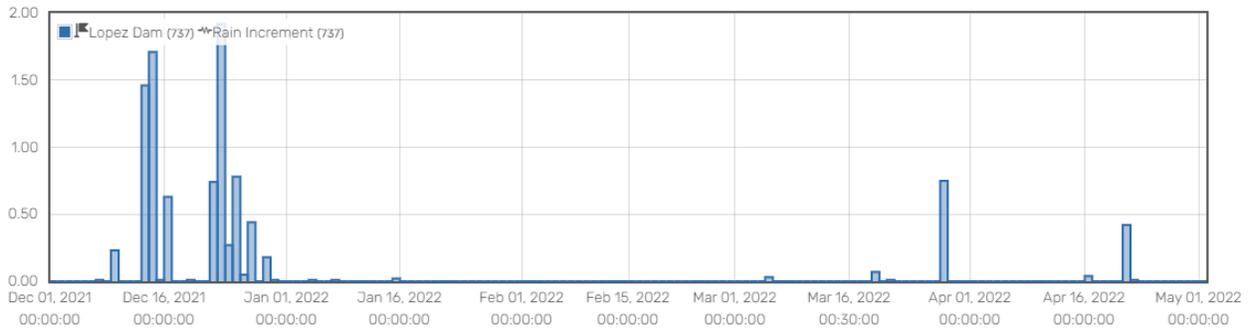
Figure 5.5 March 2022 Percent of Normal Precipitation

Precipitation Percent of Average  
 April 2022  
 Average Period: 20<sup>th</sup> Century

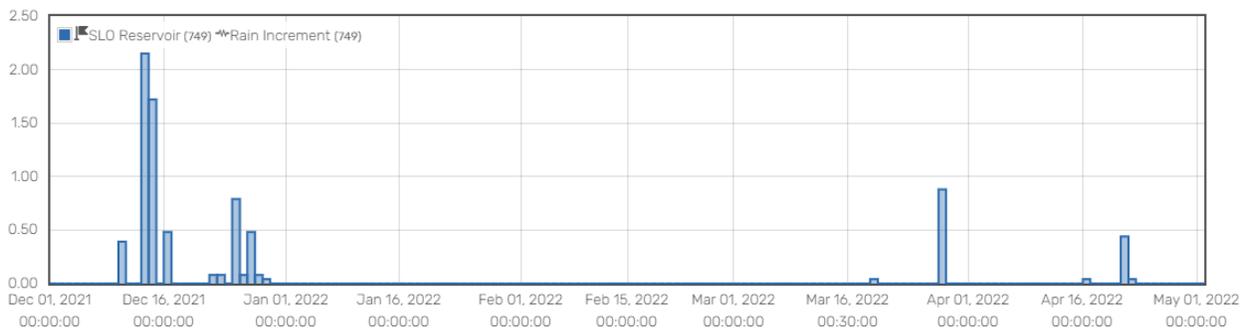


**Figure 5.6** April 2022 percent of normal precipitation

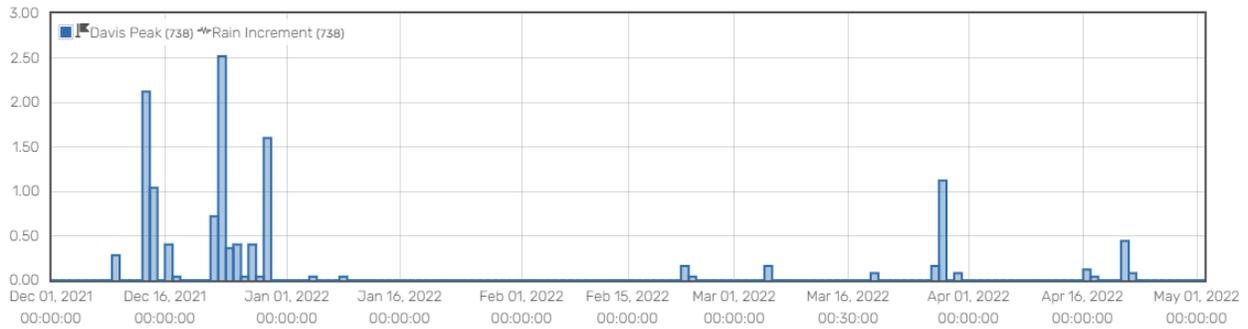
Figures 5.7 through 5.10 provide graphical depictions of rainfall events for the period of December 1, 2020 through March 31, 2021, for three different sites in and near the Lopez Lake target. Note that each graph is scaled according to the range of values observed at that site.



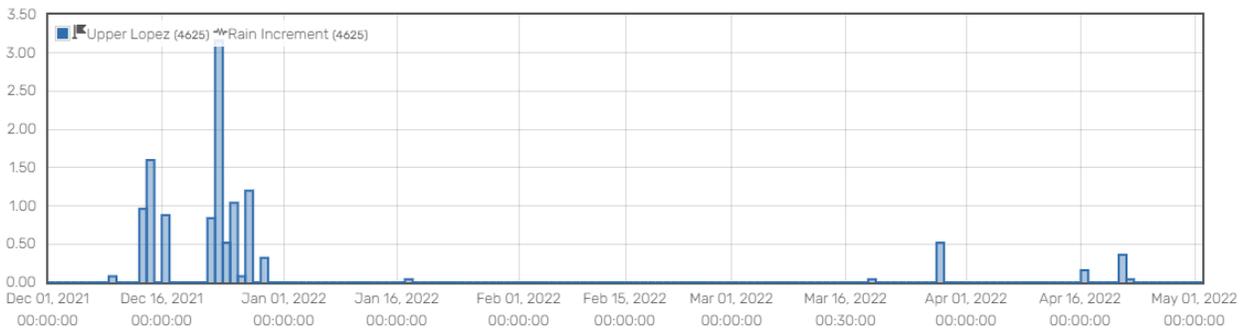
**Figure 5.7** Lopez Dam Daily Rainfall (8 am to 8 am) – December 1, 2021 to May 1, 2022



**Figure 5.8** SLO Reservoir Daily Rainfall (8 am to 8 am) - December 1, 2021 to April 1, 2022



**Figure 5.9 Davis Peak Daily Rainfall (8 am to 8am) – December 2021 to April 1, 2022**



**Figure 5.10 Upper Lopez Daily Rainfall (8am to 8am) December 1, 2021 – April 1, 2022**

**5.2 Hydrologic Conditions During the 2021-2022 Winter Season**

In Figure 5.10, it can be seen that during most of the winter season, little to no runoff occurred on Lopez Creek near Arroyo Grande. The December storm events generated runoff at this gauge, with small spikes from the events on March 28 and April 21.

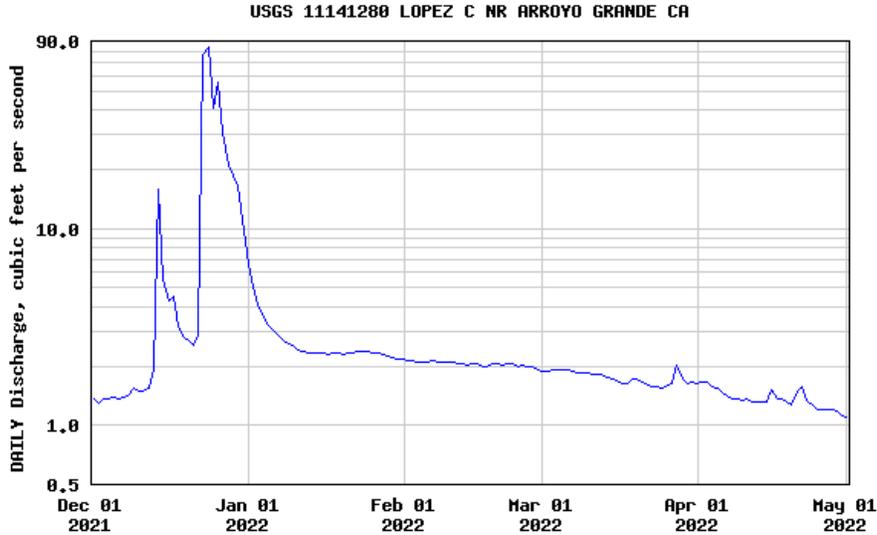


Figure 5.10 Streamflow on Lopez Creek near Arroyo Grande from December 1 to May 1

### 5.3 Summary of Operations during the 2021-2022 Winter Season

Table 5-3 summarizes flares used at the various seeding sites during the current season.

Table 5-3  
Flare Usage

Date	Arroyo Grande	Mt. Lospe	Berros Pk	Harris Grade
Dec 9	1			
Dec 14	7			
Dec 24	2			
Dec 25	7			
Dec 27	3			
Dec 29	2			
Mar 28		8	7	1
Apr 21	4			

Due to the uncharacteristically dry January through March period, NAWC extended operations free of charge, in order to seed the storm on April 21<sup>st</sup>. When budgets allow, a longer seasonal operational period is encouraged, in order to take advantage of such late season productive storms.

### 5.4 Storm Events of the 2020-2021 Winter Season

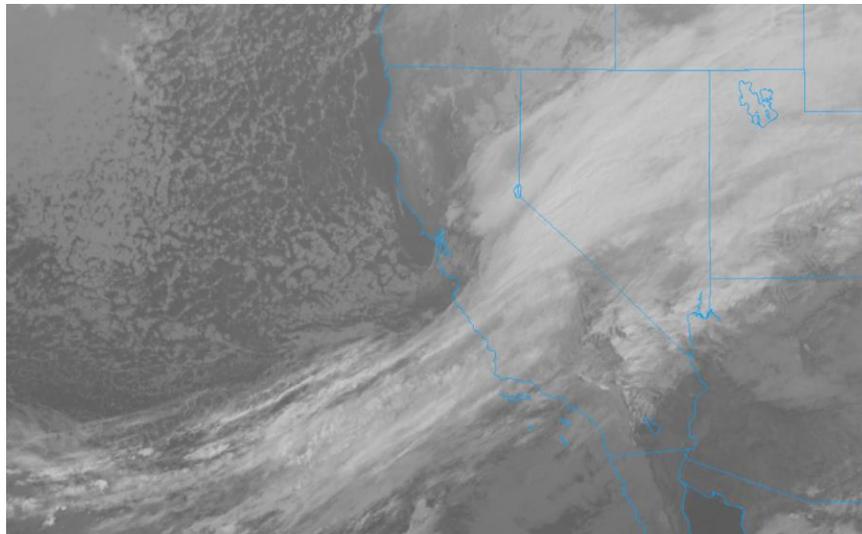
This section describes the storm events that affected the Lake Lopez watershed area during the 2021-2022 operational period. A general discussion of the meteorology accompanying each event is given, followed by a description of the seeding operations (if any). Wind directions, when provided, are always reported in the direction from which the wind is blowing (e.g., a southerly wind means the wind is blowing from the south toward the north). Wind speeds are usually

reported in nautical miles per hour (knots), with 1 knot equal to 1.15 miles per hour. Figures shown in the storm summaries may include the following:

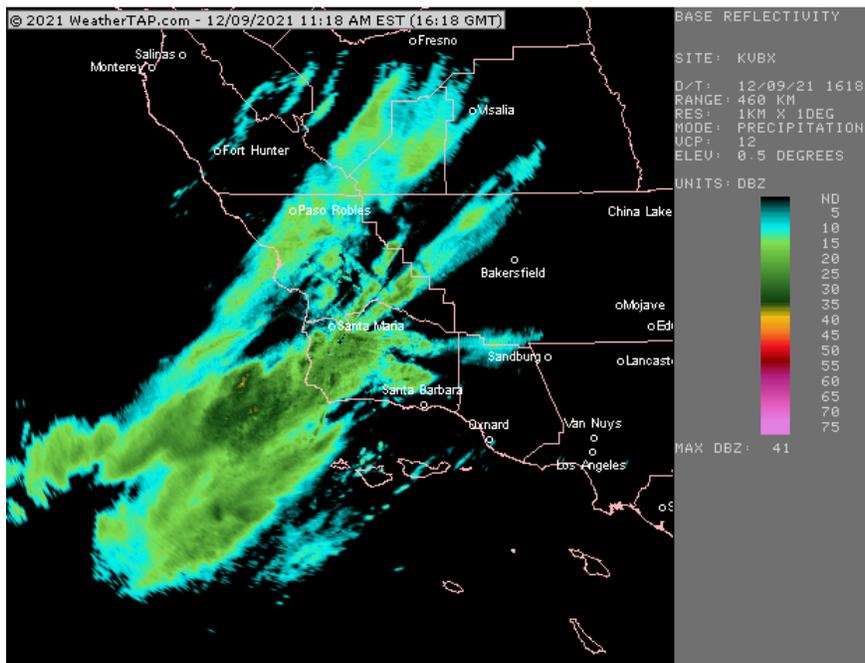
- Satellite images, including infrared (IR), water vapor (WV), or visible. Infrared images provide information during both the day and night which primarily consists of the cloud top temperatures. Water vapor can be useful when determining where upper level dry or moist air exists, and visible satellite images can be helpful for observing cloud structure.
- National Weather Service NEXRAD radar images, showing reflectivity values associated with precipitation near the times when seeding occurred. These images give an indication of the type, intensity, and extent of precipitation during seeding periods. Wind direction and velocity are also observed by the radar through the Doppler feature, which is part of the NEXRAD design. Plots of winds with height in 1000-foot increments are available with a 6-minute time resolution from NEXRAD radars. These displays are called Velocity Azimuth Displays (VAD).
- Skew-T upper-air soundings from Vandenberg AFB. The skew-T sounding is a plot of temperature, dew point, and winds vs. height, observed by a radiosonde (balloon borne weather instrument). This sounding information is useful for analyzing various parameters of the atmosphere, providing temperature and moisture profiles and convection potential. Soundings are available twice daily at 0400 and 1600 PST. The 700-mb (approximately 10,000 feet) temperatures are frequently reported in the following storm summaries. NAWC typically prefers to see these temperatures at -5° C or colder during seeded periods since silver iodide becomes effective as a seeding agent between -4°C and -5°C. The closer the height of the -5°C level is to the ground seeding sites, the quicker a seeding effect will begin to be produced in the convection elements embedded in the convective bands. These convective elements transport the seeding material vertically from the ground seeding sites to colder temperatures aloft.

#### **December 9, 2021**

A frontal precipitation band brought mostly light precipitation, with some modest cloud liquid water values in this band as it moved into San Luis Obispo County beginning around 0800 PST. Winds were from the west to northwest with a significant northerly component at lower to mid levels. For this reason, seeding operations were not possible for the Lopez Lake area in this event. Figures 5.11-12 include a satellite and radar image during this event. Precipitation totals were light, generally a quarter inch or less with this system.



**Figure 5.11** Infrared satellite image at 0726 PST December 9



**Figure 5.12** Vandenberg NEXRAD base reflectivity at 0818 PST December 29

### December 13-14, 2021

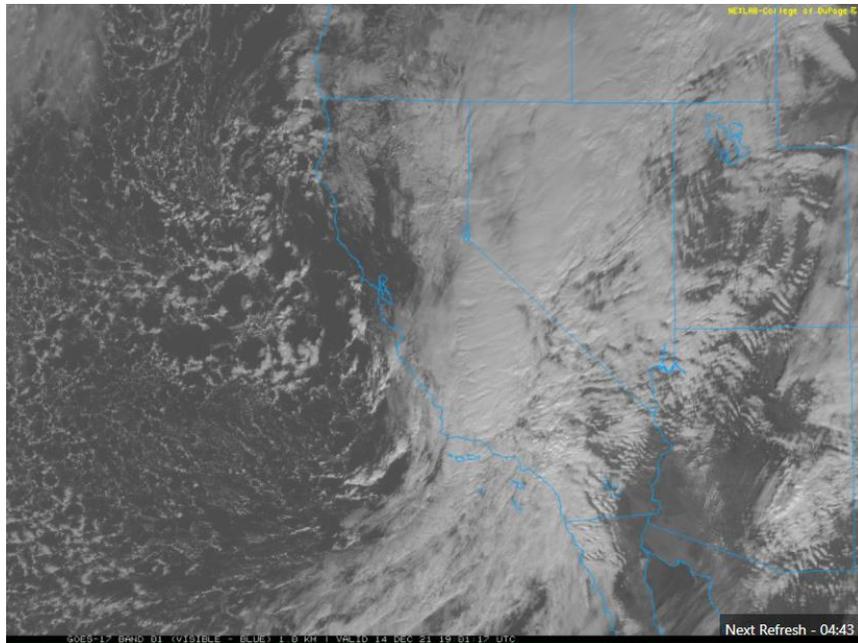
A major storm event affect most of California during the December 13-14 period. Early in the event the  $-5^{\circ}$  C level was up near 650 mb (about 12,000 feet) with strong south-southwesterly winds near 50 knots near and just below that elevation. There is also a significant stable layer below this at times, which would prevent any seeding material from reaching the  $-5^{\circ}$  C in these conditions. By the morning of December 14, good coverage of rainfall continued with precipitation totals in many mountainous areas exceeding 2" of rainfall. By early to mid-morning lower level winds had shifted to the northwest with a shallow surface frontal boundary, although

mid-upper level winds remained strong southwesterly until later in the morning. HYSPLIT forecasts of seeding plumes (Figure 5.13), as well as surface observations showed a lower level shift to the northwest already at 13Z (0500 PST). The main frontal band and 700 mb level cold front arrived around 18Z (1000 PST).

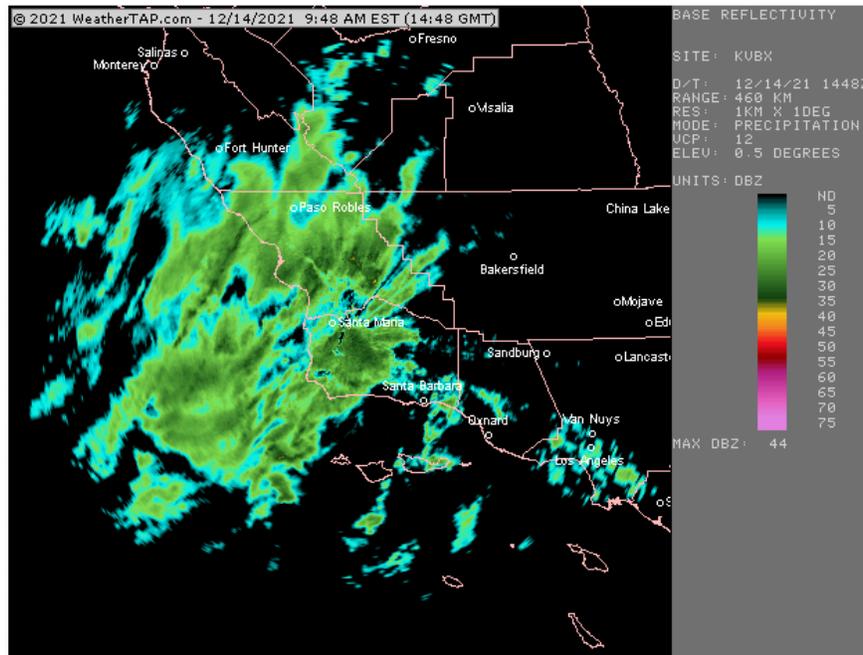
Figure 5.14 is a visible spectrum satellite image of the system on December 14. Seeding began at the Arroyo Grande site a little after 0800, continuing for a couple of hours until winds had shifted to west-northwest. The overall structure of this storm consisted of a broad area of moderate precipitation with subtle embedded bands, although convection did not appear to be particularly strong. Thus, seeding was limited to the latter portion of the event when temperatures cooled aloft, mixing improved and at least some convective activity was present. Hourly precipitation amounts with these bands were generally around a quarter inch in the target areas. Figures 5.15-16 show a radar reflectivity image and a Velocity Azimuth Display (VAD) time/height wind cross section during this time. Figure 5.17 is another radar image near the end of operations, and Figure 5.18 is a regional map of precipitation totals with this storm.



**Figure 5.13** HYSPLIT 1-hr plume dispersion forecast ending at 14Z (0600 PST) December 14



**Figure 5.14** Visible spectrum satellite image at 1101 PST December 14



**Figure 5.15** Vandenberg radar reflectivity at 0648 PST December 14, early in the period of seeding operations

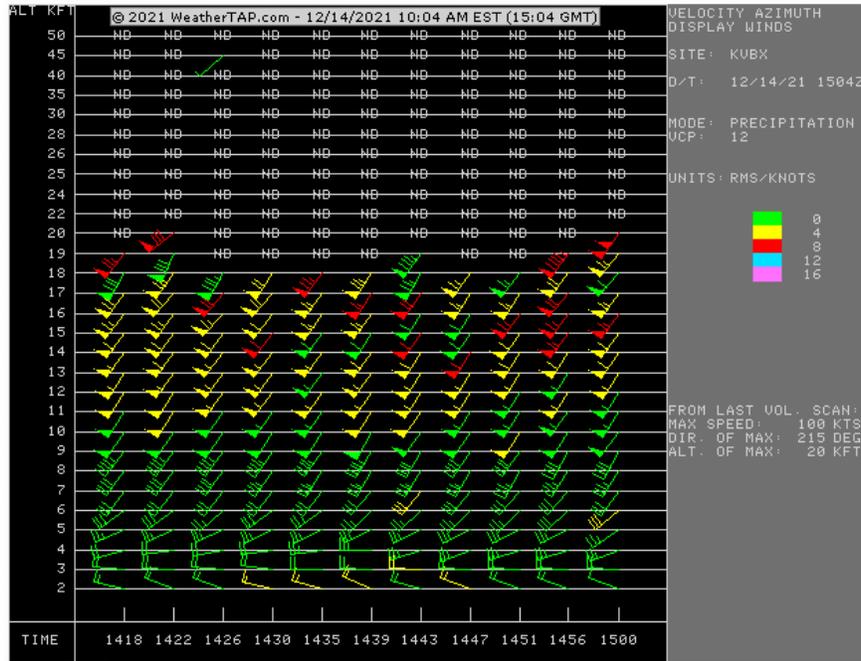


Figure 5.16 Radar VAD wind profile ending 0700 PST December 14

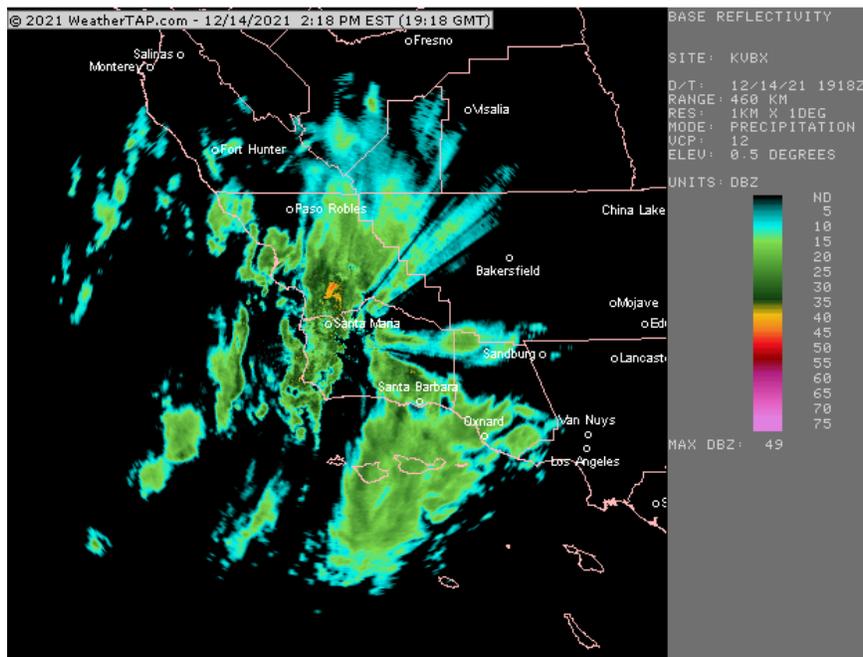


Figure 5.17 Vandenberg radar image at 1118 PST



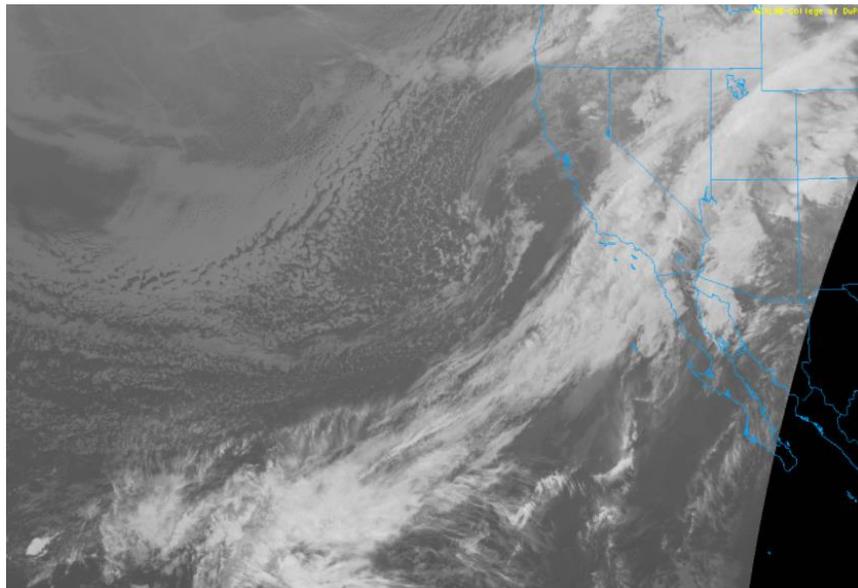
Figure 5.18 Regional 24-hour rainfall totals for December 13-14

### December 22-24, 2021

A large trough in the eastern Pacific developed a deep subtropical moisture tap during this time period, leading to a fairly prolonged period of moderate rainfall along the central coast of California. Most of this event consisted of broad areas of stratiform rainfall with some embedded stable layers and a high -5 C level close to 12,000 feet, so that cloud seeding opportunity was limited to very late in the event. A regional radar image on the evening of December 22 shows the broad area of moderate rainfall covering the central coast (Fig 5.19). Figure 5.20 is a satellite image of this system on the evening of December 23, showing some connection to moisture in the tropics and subtropics and the main trough center well offshore near the latitude of SLO County.



**Figure 5.19** Radar image at 1652 PST on December 22, early in the precipitation event



**Figure 5.20** Infrared satellite image at 1826 PST December 23

As a broad band of rainfall developed over the area on December 23, rainfall rates increased to near 0.25"/hr in some areas favored by terrain and mostly under 0.2"/hr elsewhere. The 24-hour totals exceeded 2 inches in many mountainous areas. A broad subtropical moisture plume remained over the area with warm temperatures aloft in south-southwest flow.

Behind the primary moisture plume, the main core of the trough moved onshore during the night of December 23-24 with convective showers developing. 700 mb temperatures cooled somewhat, to below  $-4^{\circ}\text{C}$  with winds from the south-southwest. Between 0400 and 0500 PST, convective showers moved onshore in SLO County with some additional cooling aloft. Two flares were used at Arroyo Grande to target the Lopez Lake area, at 0432 and 0452 PST. Showers were fairly slow moving at this point so that only the Arroyo Grande site was used to target the Lopez Lake area. Figure 5.21 is a HYSPLIT plume forecast for 10Z (0200 PST, a couple of hours prior to operations) along with a radar VAD wind profile during that time in Figure 5.22. Figure 5.23 is a radar image during the main period of seeding operations.



**Figure 5.21** HYSPLIT plume forecast ending 0200 PST December 24

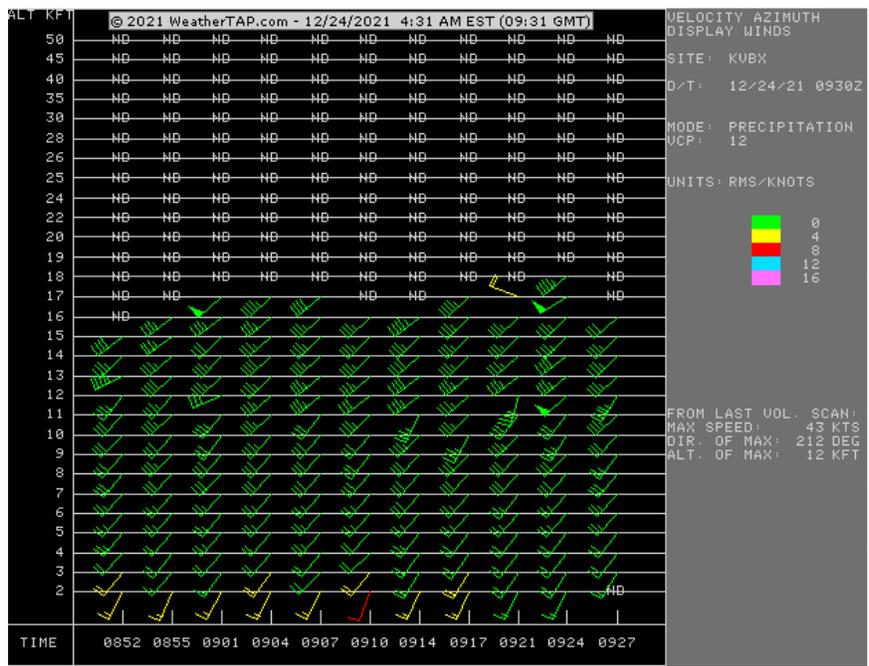


Figure 5.22 Vandenberg radar VAD wind profile ending 0127 PST December 24

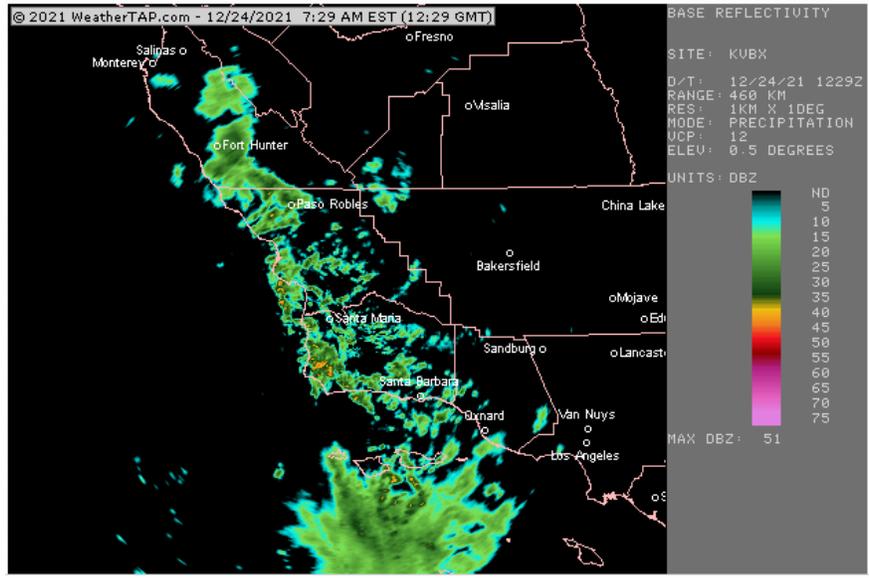
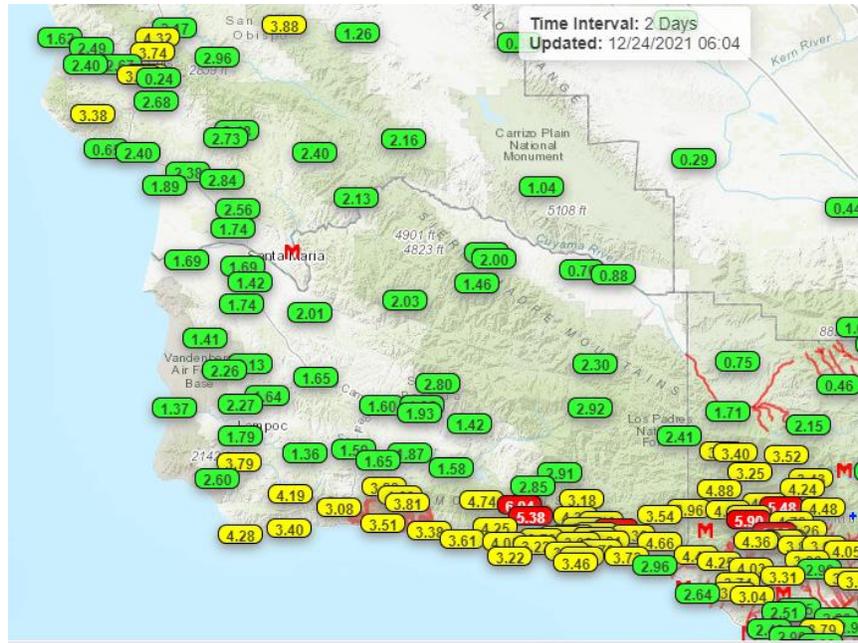


Figure 5.23 Vandenberg radar image at 0429 PST December 24

By 0600 PST December 24, showers had basically ended with only light/spotty activity remaining. Winds gradually shifted from the southwest to the northwest after this as the trough axis passed the area. Figure 5.24 shows 2-day rainfall totals for this event.



**Figure 5.24** 2-day rainfall totals ending 0600 PST on December 24

**December 25, 2021**

A very cold trough was centered near the Washington coast on December 25, with a frontal zone approaching central California in the afternoon. There were multiple convective bands located offshore. Temperatures were colder during this period, near  $-8^{\circ}\text{C}$  initially and falling to below  $-10^{\circ}\text{C}$  later in the event.

At 1700 PST the first band was progressing onshore into SLO County, with seeding at Arroyo Grande beginning just before 1700 PST in a south-southwesterly wind pattern (Figure 5.25). Winds veered from just east of southerly at the surface to southwest at 700 mb. Precipitation rates were around a quarter inch per hour with this initial band, shown in Figure 5.26.

By 2000 PST the main band had moved out of the area, with a small secondary band approaching the coast. An additional flare was used as this secondary band moved onshore, before winds became westerly with its arrival. Figure 5.27 shows this band moving into the area, along with a radar VAD wind profile during this time (Figure 5.28). A third, very thin band approached the coast later in the evening (Figure 5.29) but winds were not suitable for seeding at that point. A total of seven flares were used to seed the Lopez Lake area in this event, and rainfall amounts were around three-quarters of an inch in the vicinity of the target area (Figure 5.30).

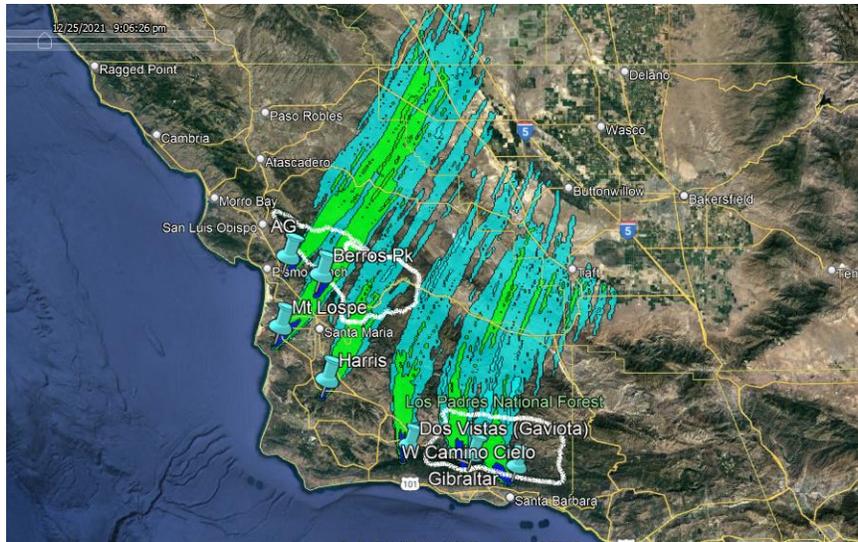


Figure 5.25 HYSPLIT 1-hour plume forecast for 04Z (2000 PST December 25)



Figure 5.26 Radar image at 1859 PST December 25

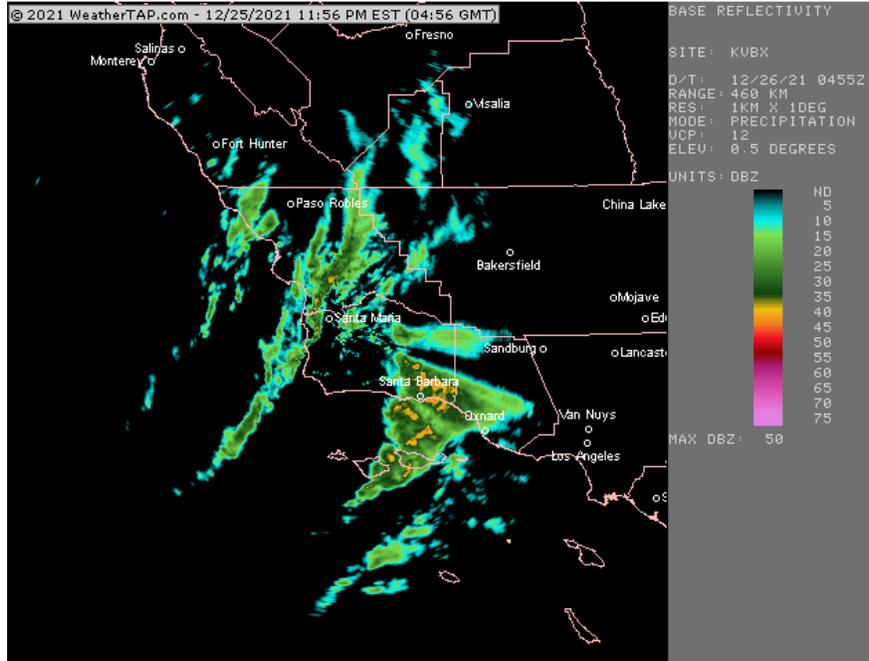


Figure 5.27 Radar image at 2056 PST December 25 with second band entering the County

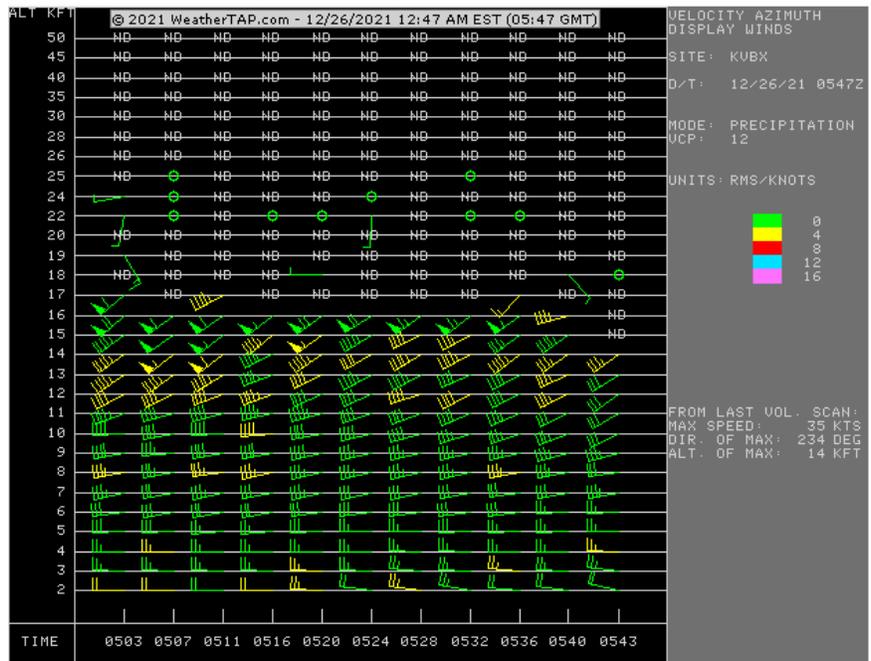


Figure 5.28 Vandenberg radar VAD wind profile ending 2143 PST December 25

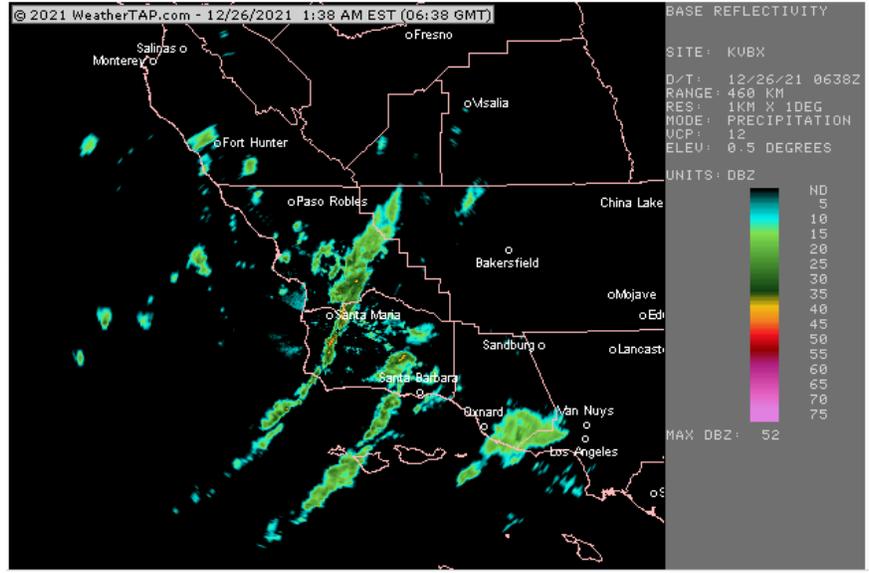


Figure 5.29 Radar image at 2238 PST December 25 with third band moving into the Twitchell area

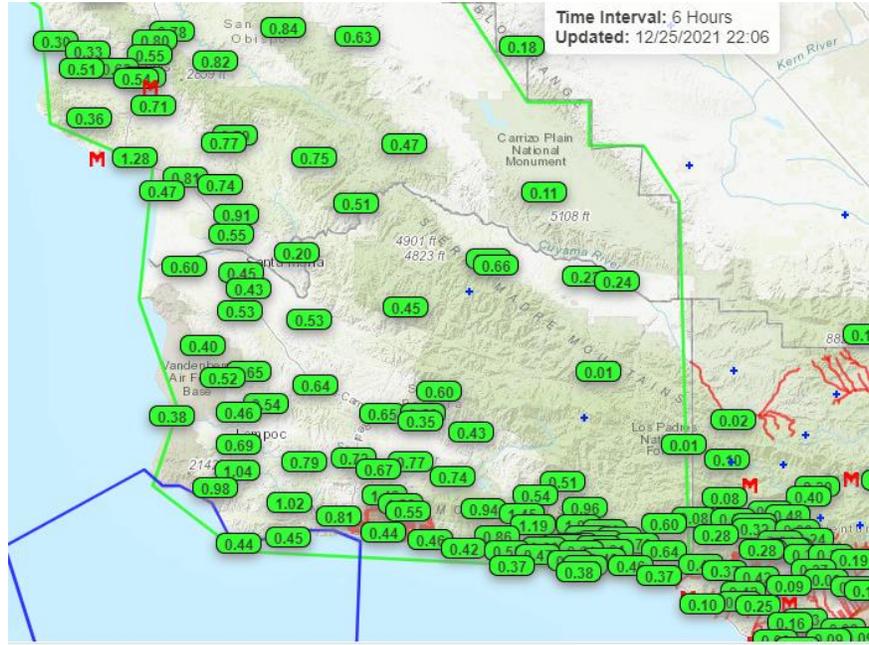


Figure 5.30 Storm totals map for December 25

**December 27, 2021**

A system moving southeastward along the central California coast on December 27 brought some convective showers and bands to SLO County, with a generally westerly wind pattern at 700 mb and more southerly near the surface. The 700 mb temperature was around -8° C. A morning satellite image near the beginning of this event is shown in Figure 5.31.

Some fairly localized areas of convective showers were seeded during the morning hours, using seeding flares at 0852 and 0929 PST (Figure 5.32). The main frontal band of showers arrived just before midday with another flare used at 1126 PST. Figure 5.33 is a radar image near that time period, and Figure 5.34 a corresponding radar VAD wind profile. The main band was accompanied by a shift to west-northwesterly winds which became out of range for seeding after the third flare was used. Rainfall rates with the main frontal band were around 0.25"/hour and rainfall totals average around a half inch in the target area (Figure 5.35).

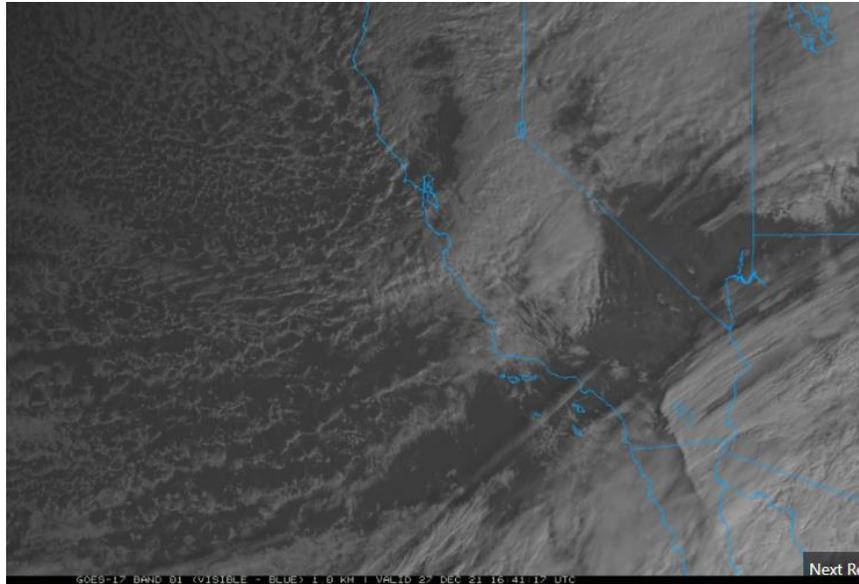


Figure 5.31 Satellite image, visible spectrum at 0841 PST December 27

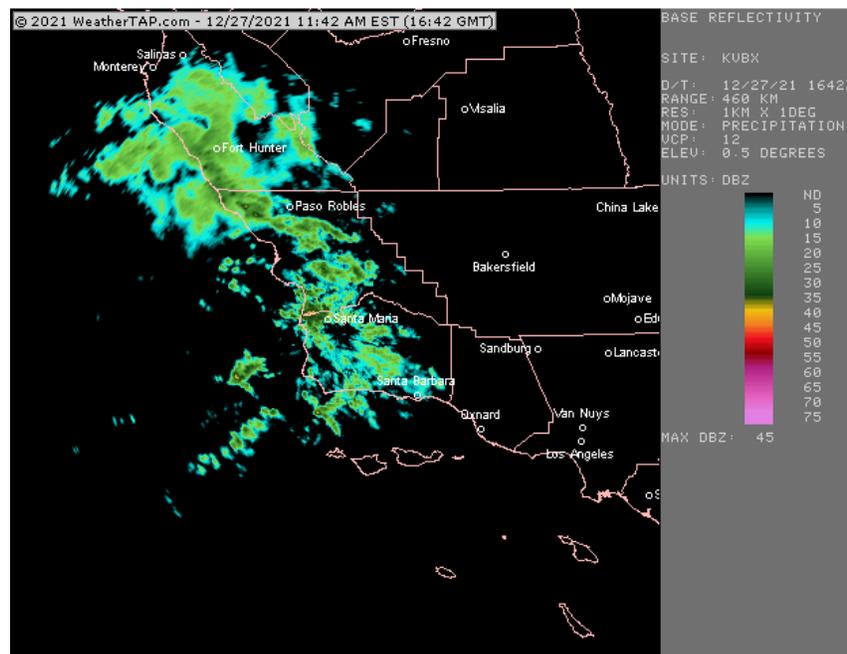


Figure 5.32 Vandenberg radar at 0842 PST December 27

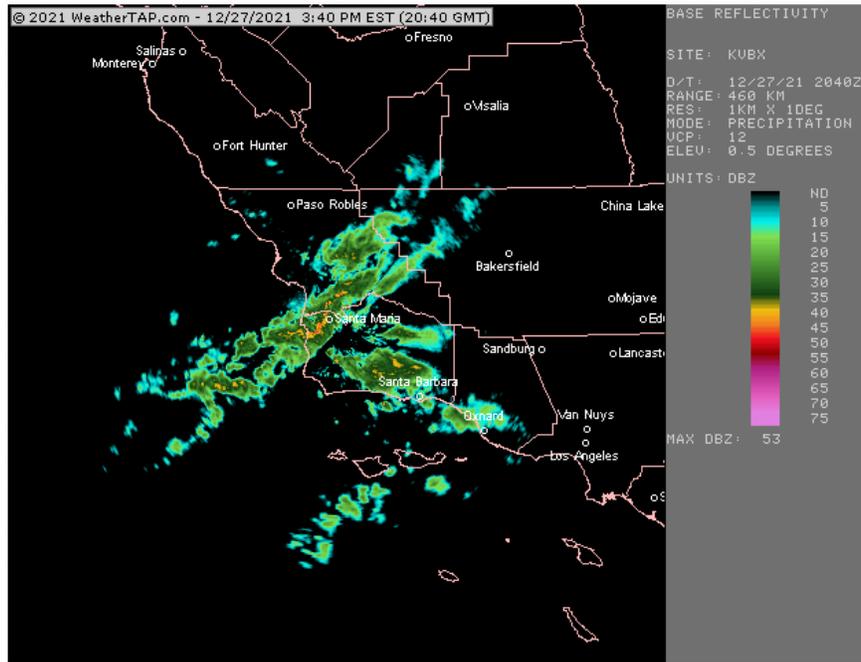


Figure 5.33 Vandenberg radar at 1240 PST December 27

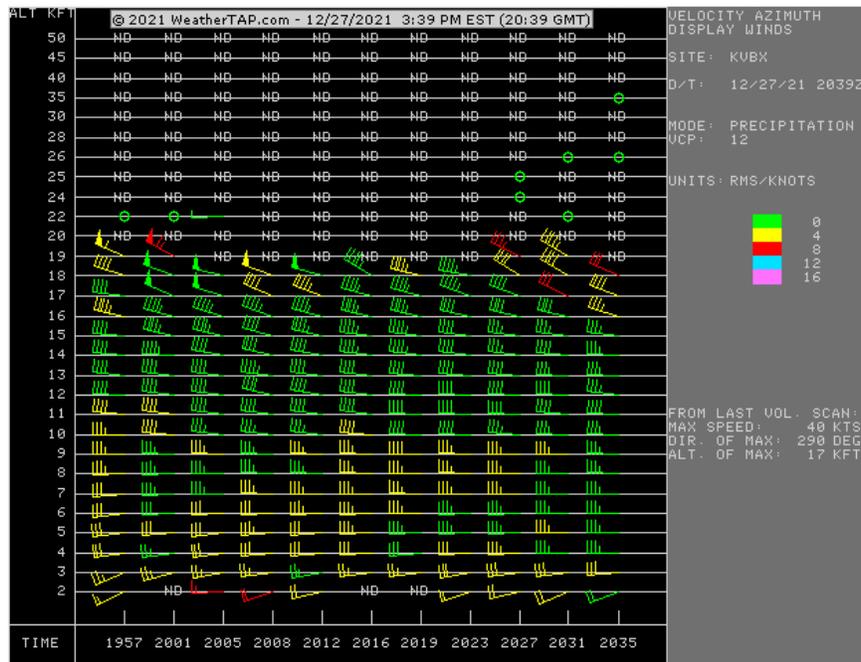


Figure 5.34 Vandenberg radar VAD wind profile ending 1239 MST December 27

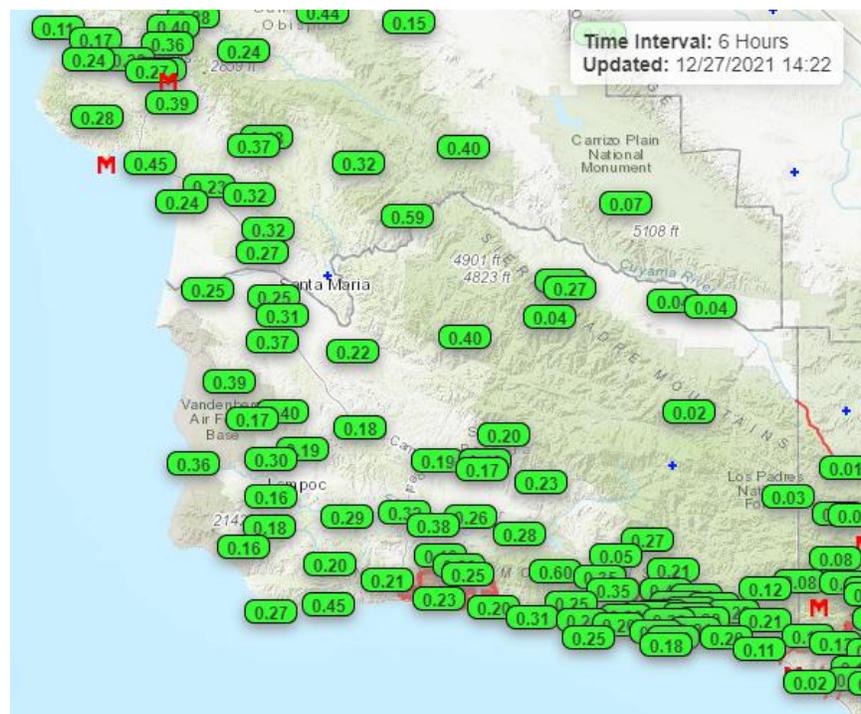


Figure 5.35 Rainfall totals on December 27

### December 29-30, 2021

A trough of low pressure moved southeastward along the California coastline on December 29 and became a weak closed low centered just south of the Central Coast region by December 30. Precipitation with this system was generally light and disorganized, but there was a weak band

on the morning of the 29<sup>th</sup> that were seeded (Figure 5.36). Two flares were used at Arroyo Grande at 0738 and 0756 PST. Clouds became fairly shallow and broken by later in the day with the main area of rainfall becoming established well to the east/southeast of the area by later on the 29<sup>th</sup> and through the 30<sup>th</sup> of December. The 700 mb temperature was around -4° C during most of this event. Rainfall totals were generally around a quarter of an inch.

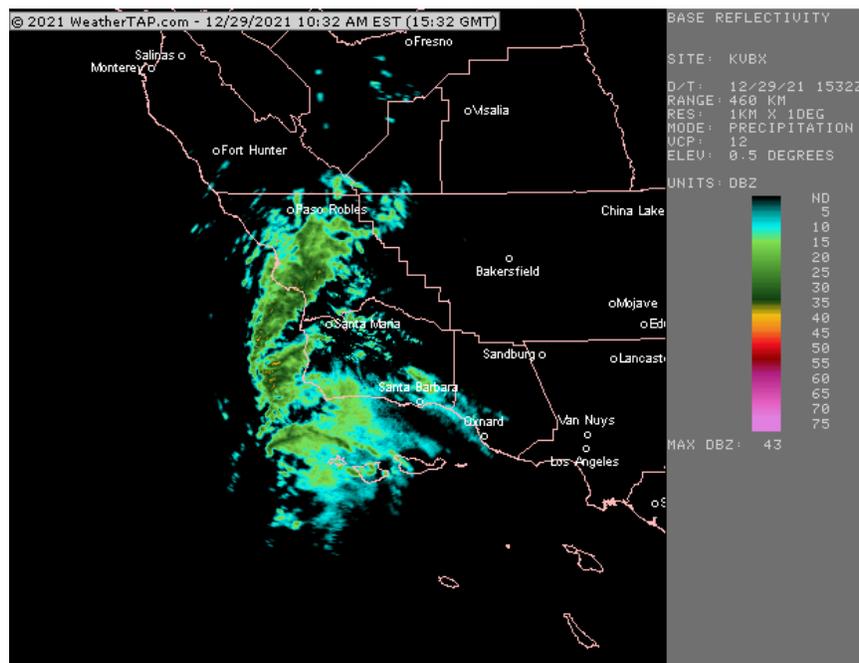
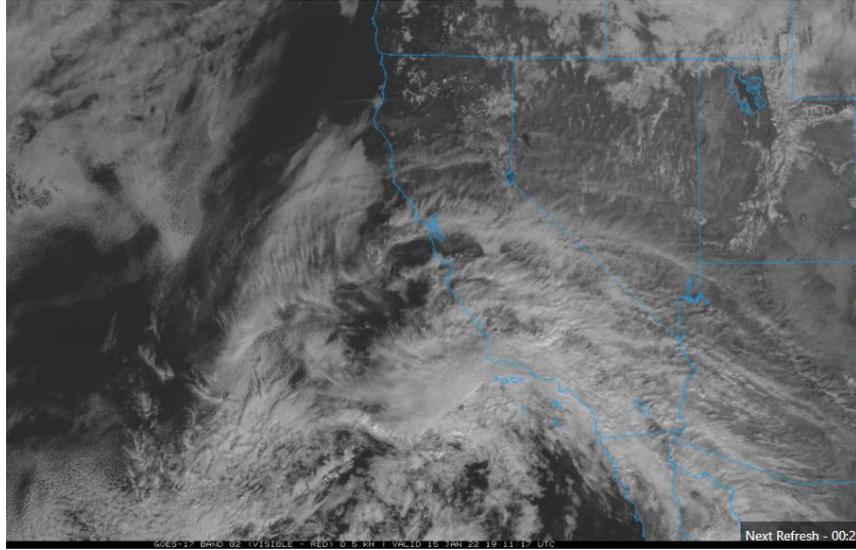


Figure 5.36 Vandenberg radar at 0732 PST December 29 as a weak band was over SLO County

### January 15, 2022

A closed low centered well to the southwest of the area brought some subtropical moisture northward into the central coast region. As of 1100 PST, a weak band of mostly elevated showers was crossing the area with winds generally light or SE near the surface and southerly aloft. The antecedent air mass was very dry per 12Z Vandenberg sounding and precipitation was mainly produced by a mid/high cloud deck with echoes as high as about 30k feet, and mostly evaporating in lower and mid levels of the atmosphere. The 700 mb temperature was generally in the -3 to -5° C range within the precipitation band across this area. Precipitation totals were very minimal, with only localized values of a few hundredths of an inch and no seeding opportunity.

Figure 5.37 is a visible spectrum satellite image around the time that the band of precipitation (mostly aloft) crossed the area, and Figure 5.38 a corresponding regional radar image.



**Figure 5.37** Visible spectrum satellite image at 1111 PST on January 15

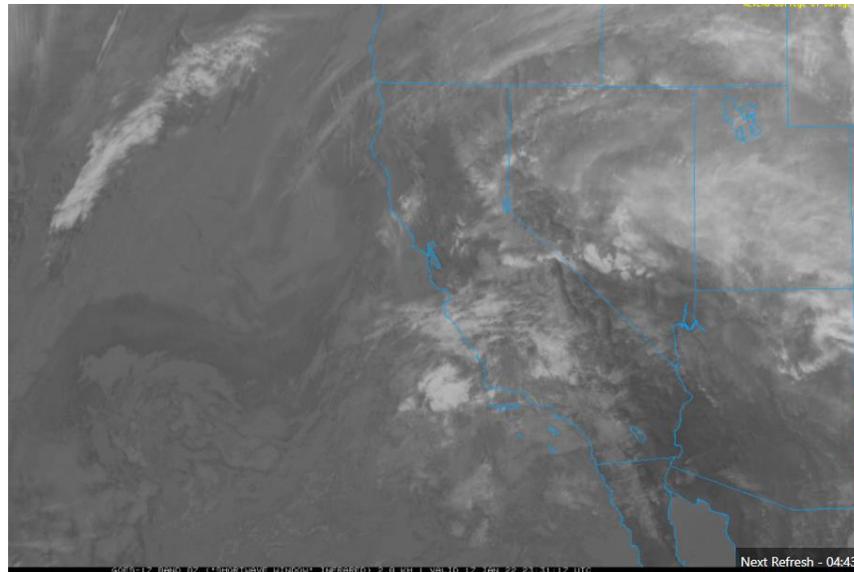


**Figure 5.38** Regional radar reflectivity at 1112 PST January 15

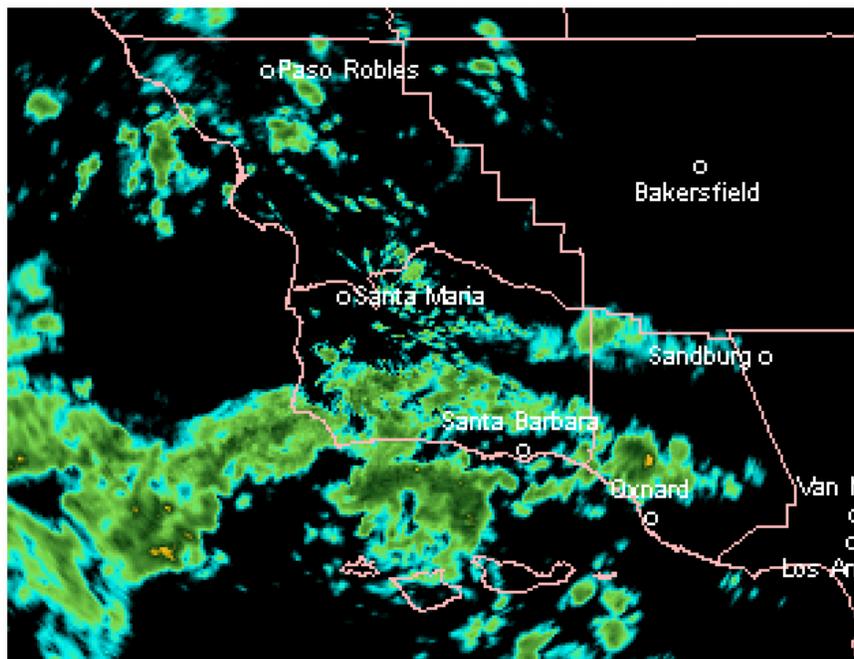
### **January 17, 2022**

The closed low which had brought very minimal shower activity on the 15<sup>th</sup> remained off the coast until late on January 17, when it moved onshore in the central/southern coastal CA region. The structure of this system was quite similar to before, although the air mass was somewhat more saturated as it finally moved onshore and the 700 mb temperature was around -4 C. Figure 5.39 is an infrared satellite image of this weak system on the afternoon of the 17<sup>th</sup>. This placed the freezing level near 7,500 feet elevation and the -5 C level close to 11,000 feet. A few bands of light showers affected the area during the late afternoon and evening, with generally very light

precipitation amounts. Figures 5.40-41 show radar reflectivity and a VAD profile respectively during the event. Figure 5.42 shows 24-hour precipitation totals ending on the evening of January 17.



**Figure 5.39** Infrared satellite image at 1531 PST January 17



**Figure 5.40** Vandenberg radar image at 1746 PST January 17

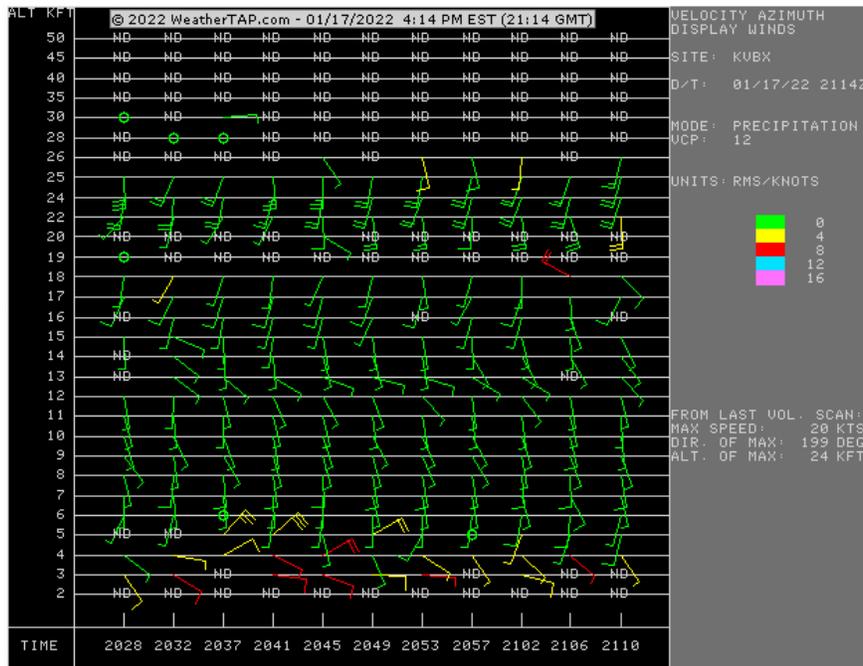


Figure 5.41 Vandenberg VAD profile from somewhat earlier, at 1310 PST

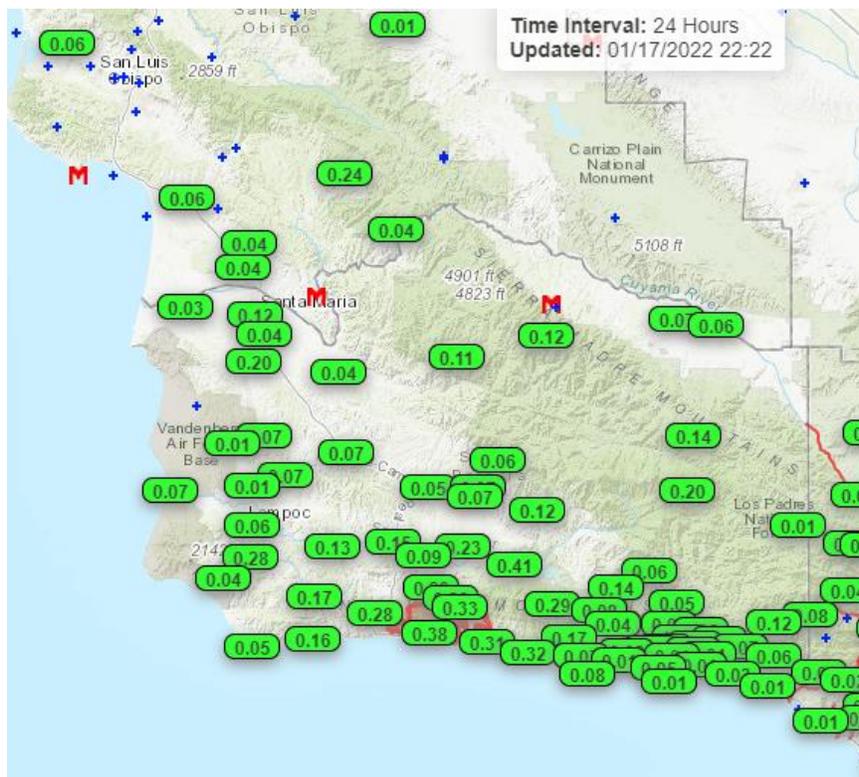
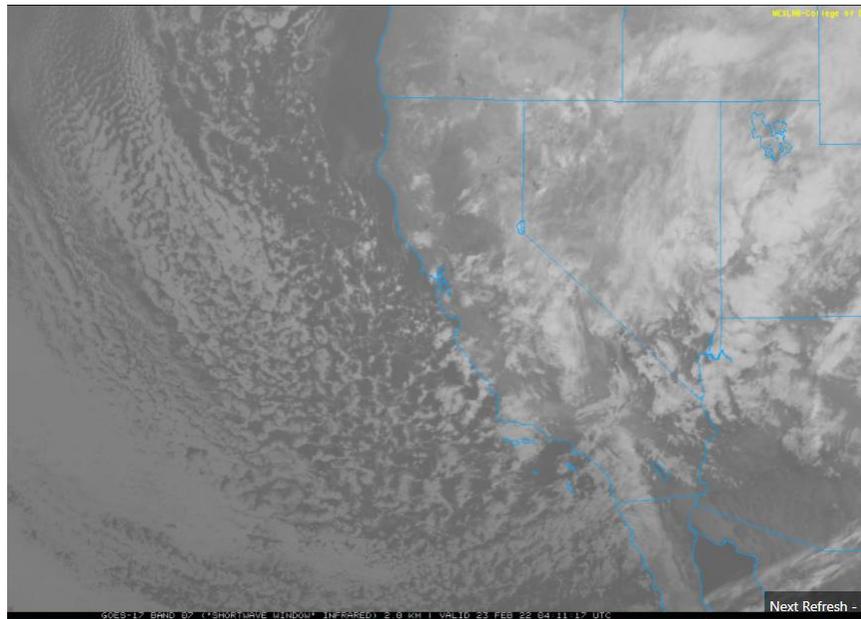


Figure 5.42 Area precipitation total for the previous 24 hours ending on the evening of January 17

## February 22, 2022

A large and very cold trough was centered over California and Nevada on February 22. Only limited moisture existed with this system, and 700 mb temperatures fell to near -15 to -16 C over northern/central California within the core of the trough. Winds were west-northwesterly across the Central Coast region with 700 mb temperatures dropping from about -8 to -15 C with frontal passage in the afternoon and evening. Spotty convective showers were observed during the afternoon and evening hours, with total precipitation amounts generally under 0.1" in the target areas. Precipitation amounts were below a threshold for precipitation to contribute to any runoff, given dry conditions the past 6 weeks or more (and a dry forecast after the event), and winds were generally outside of a favorable range for seeding the target areas. Given these conditions, no seeding operations were conducted.

Figure 5.43 is an infrared satellite image at 2011 PST, showing the position of the trough and patchy clouds associated with convective type showers. Figure 5.44 shows a corresponding regional weather radar image during this time, and Figure 5.45 is a map of precipitation totals on February 22.



**Figure 5.43** Infrared satellite image at 2011 PST February 22

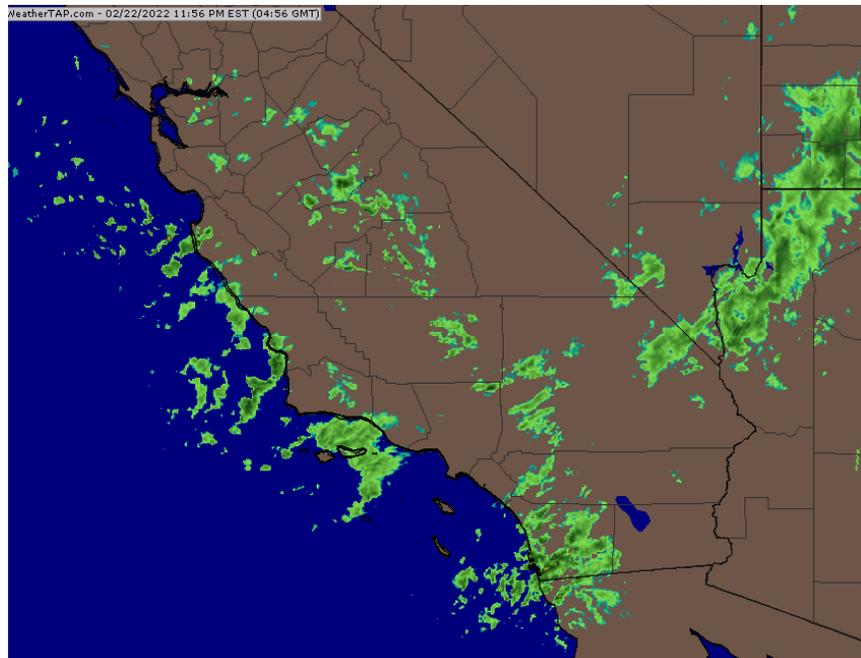


Figure 5.44 Regional radar image at 2056 PST February 22

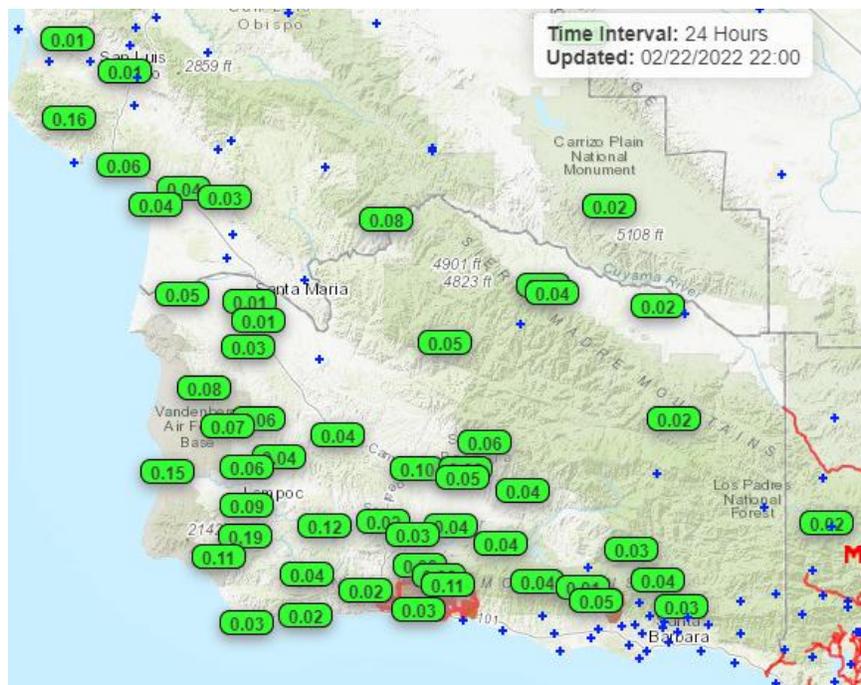
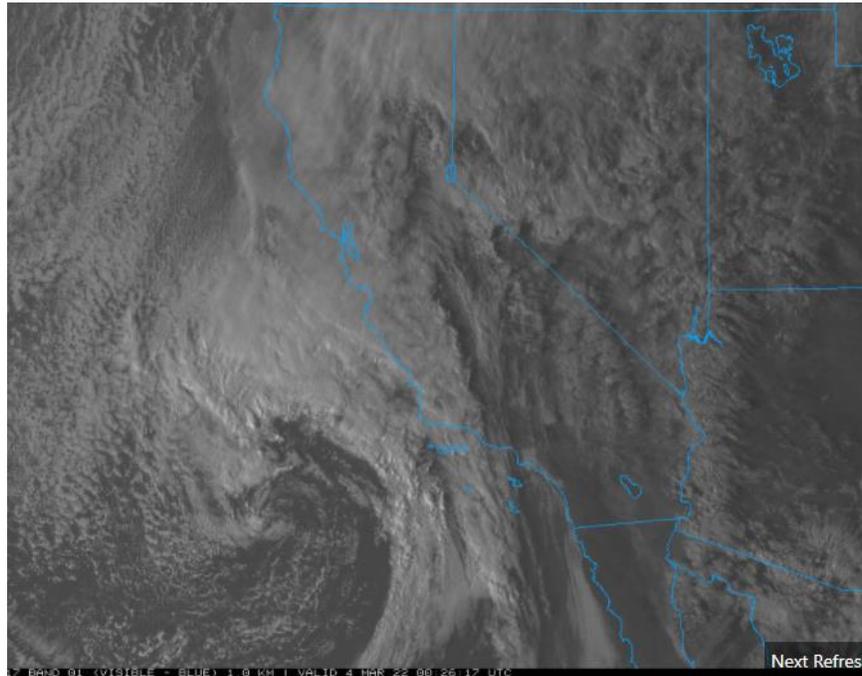


Figure 5.45 Map of 24-hour precipitation totals on the night of February 22

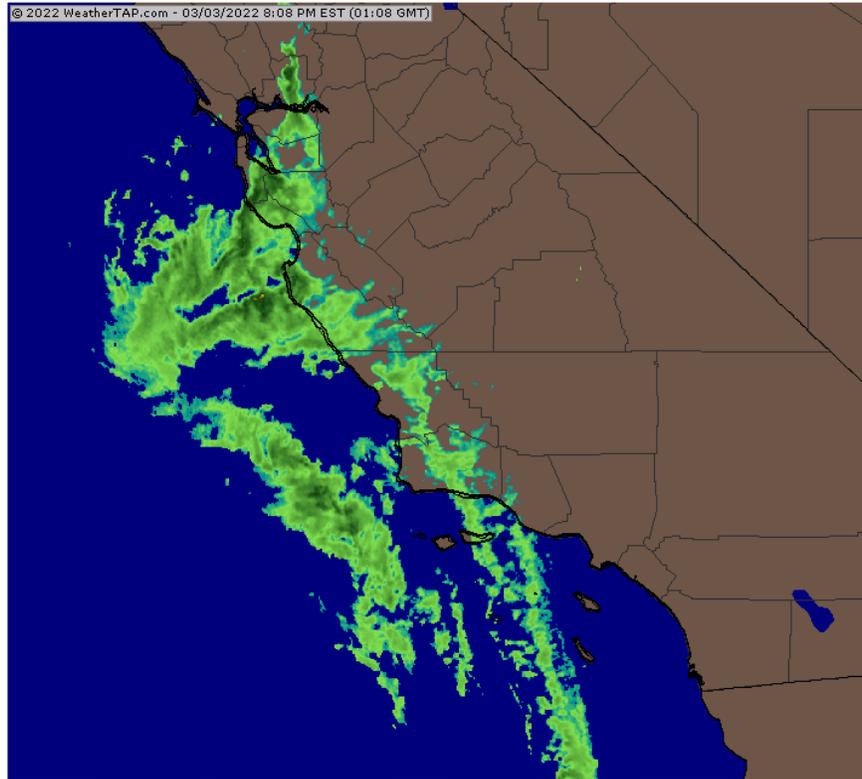
**March 3, 2022**

A closed low developed offshore on March 3, centered west-southwest of the Central Coast area. Extensive mid and high clouds developed with some high-based weather radar echoes late afternoon, and low-level winds becoming westerly with a shallow onshore flow. By 2200 PST,

bands of light showers existed aloft with high bases and precipitation evaporating above the surface. By early on March 4, the closed low moved onshore in far southern California with some light rain there. Rainfall maps indicated zero totals or only trace amounts for the central coast area with this event. Figures 5.46-47 are satellite and radar images, respectively, from the afternoon/evening of March 3 as this closed low was located well offshore.



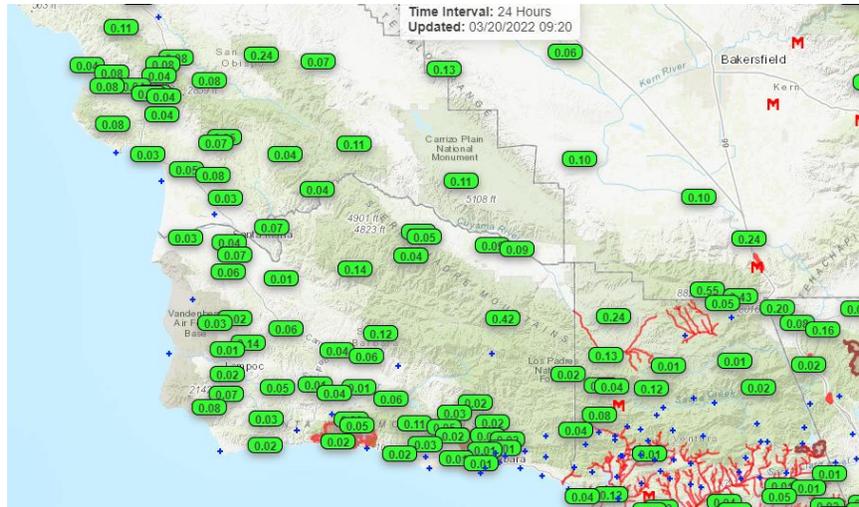
**Figure 5.46** Visible spectrum satellite image at 1626 PST March 3



**Figure 5.47** Regional radar image at 1708 PST March 3

### **March 20, 2022**

A trough moved onshore late on the 19<sup>th</sup> mostly affecting the Pacific Northwest and northern California. The tail end of a frontal band affected the central coast area after about 1900 PDT Mar 19, with winds abruptly shifting to the northwest with its arrival. The Vandenberg radar was in clear air mode at the time. Precipitation amounts were mostly under 0.10" in the target areas with some higher totals in mountainous areas further inland, favoring the northern slope areas. Based on the light amounts (unfortunately not significant enough to contribute to runoff) and northwesterly wind pattern, no seeding flares were used. Skies cleared by early on March 20. Figure 5.48 shows storm totals during this very brief event.



**Figure 5.48**      **Precipitation totals on the night of March 19-20**

**March 28, 2022**

A deep and vigorous closed trough was centered off the central California coast early on the morning of March 28, with an initial precipitation band beginning to move onshore by 0200 PDT. This first band brought moderate precipitation and strong southerly winds, around 40-50 knots at 700 mb with the 700 mb temperature falling from about -3 to -5 C in the band. Given the strong winds and relatively warm temperatures, seeding parameters were poor initially. The primary band of rainfall early on the 28<sup>th</sup> contained only hints of convective elements, and otherwise appeared basically stratiform. This band was quite broad (roughly 70 miles wide) and contained rainfall rates of 0.25"/hour or more at times with southeasterly winds near the surface and strong southerly winds aloft. Based on these wind speeds and a high -5 C level, seeding would not likely be effective in this initial band. Rainfall totals with this first band (generally during a 4-hour period) were approximately 0.50 – 1.00" in most areas. Figure 5.49 is a satellite image of this storm system off the coast early on March 28. Figure 5.50 is a radar image of the initial precipitation band crossing the area, and Figure 5.51 a corresponding vertical wind profile in that band.

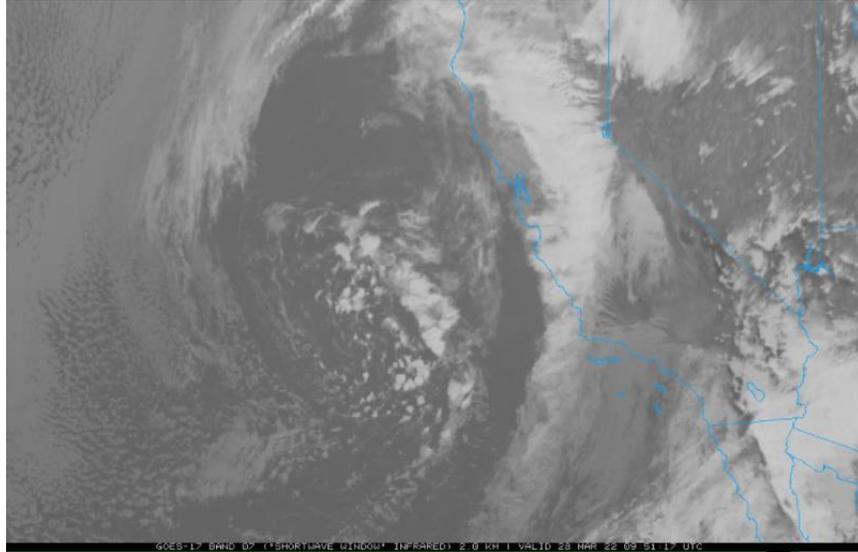


Figure 5.49 Infrared satellite image at 0251 PDT March 28

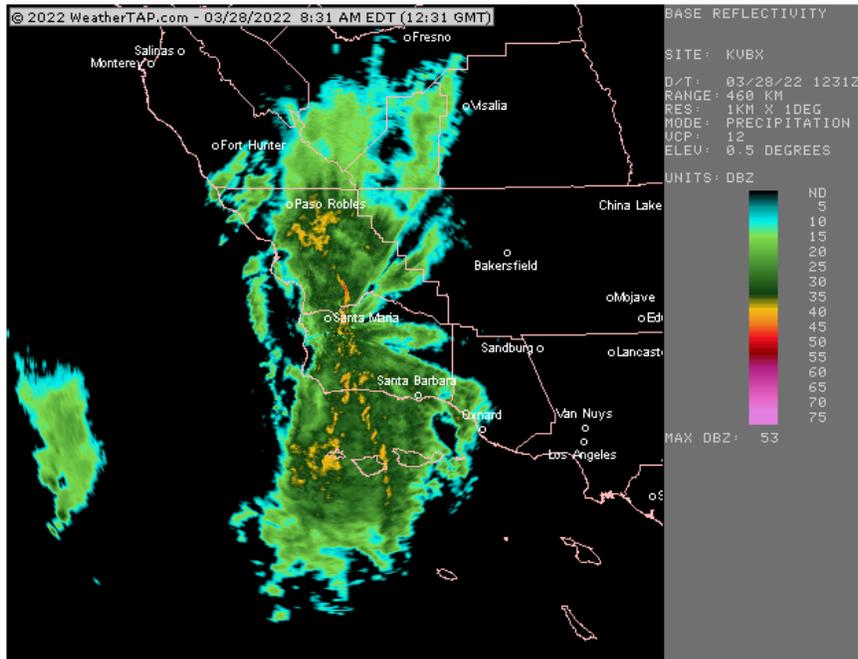
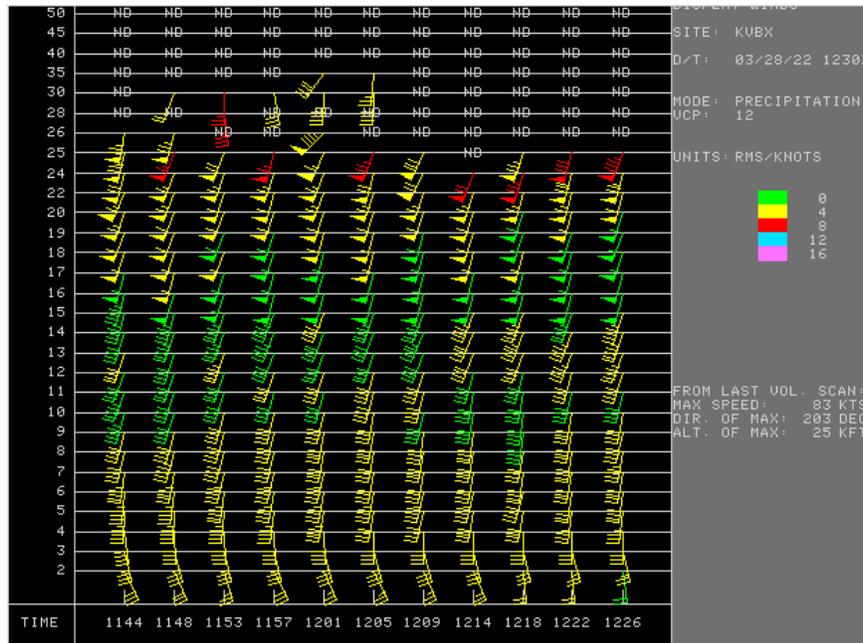
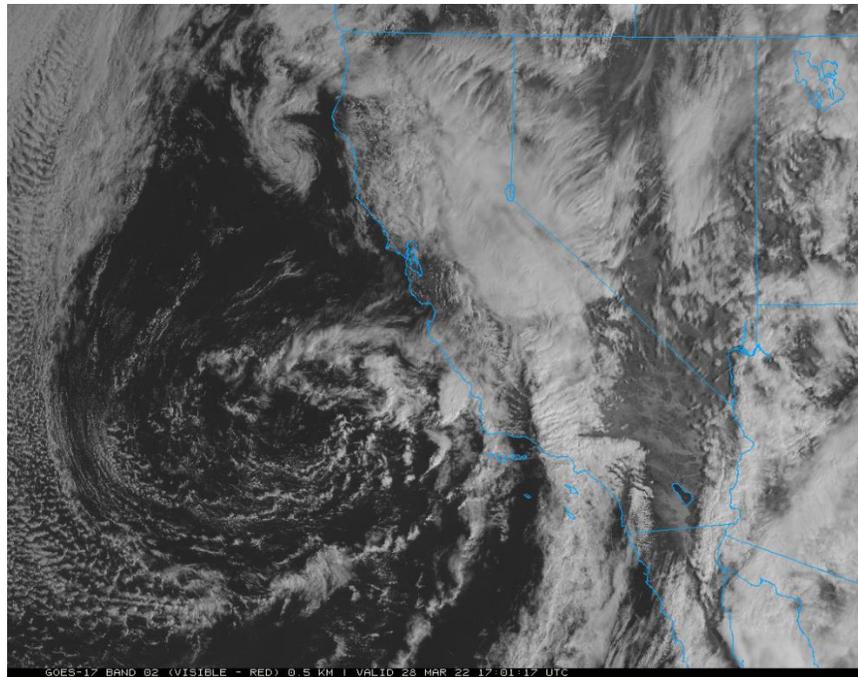


Figure 5.50 Vandenberg radar image at 0531 PDT March 28

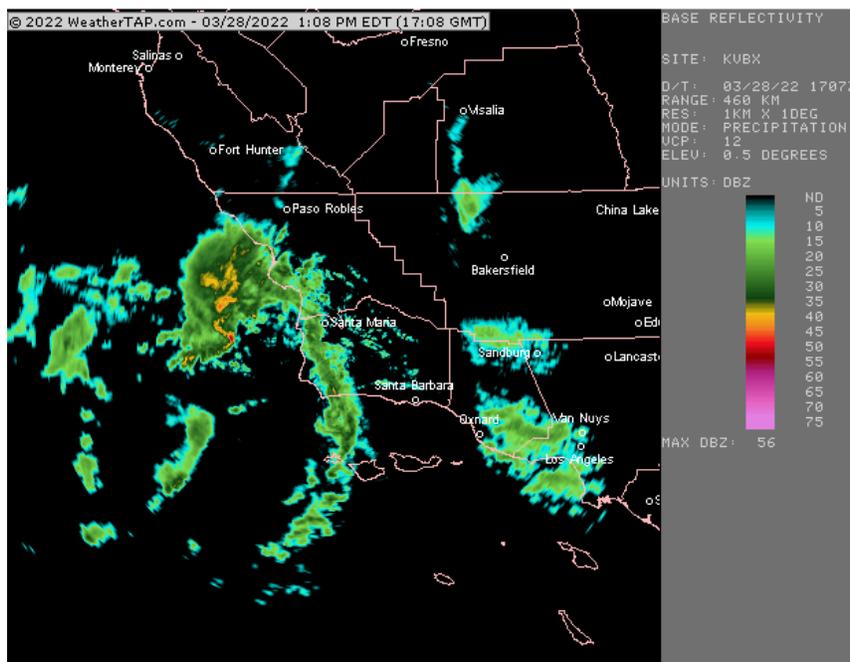


**Figure 5.51 Radar vertical wind profile ending 0526 PDT March 28**

By 1000 PDT, a much weaker precipitation band approached from the southwest with nearly due southerly winds at lower several thousand feet of the atmosphere, as the core region of the trough approached the coast. The 700 mb temperature dropped to about -7 C in this area of the trough per model data, with winds south-southwest at that level. Winds were quite southerly initially, such that the Mt. Lospe and Berros Peak sites were most favorable for the Lake Lopez target area. There was too strong of a southerly wind component to utilize the Arroyo Grande site during this time. Figure 5.52 is a satellite image near the time this second band arrived, and Figure 5.53 a corresponding radar image near that time.



**Figure 5.52** Visible spectrum satellite image at 1001 PDT March 28



**Figure 5.53** Vandenberg radar image at 1008 PDT March 28

By 1230, scattered small convective showers develop in northwest SB and southwest SLO counties, moving north. Clouds looked good on camera feed from the seeding sites, with fairly low bases. At 1300 PDT, a developing northeast-southwest oriented band of showers was moving into the western part of SB County. This band remained near to just offshore through the

afternoon hours, with a band of fairly strong convective cells just off the west coast of SB County, intersecting southwestern SLO County. Seeding was conducted using the Mt. Lospe and Berros Peak sites during the afternoon, as the precipitation band was essentially stalled in the vicinity of these sites and affected most of the Lake Lopez area as well. The Arroyo Grande site remained to the north of this band and was not in a good position to use. Figure 5.54 is a satellite image during the afternoon as a precipitation band was located near the coast. Figure 5.55 is a corresponding radar image.

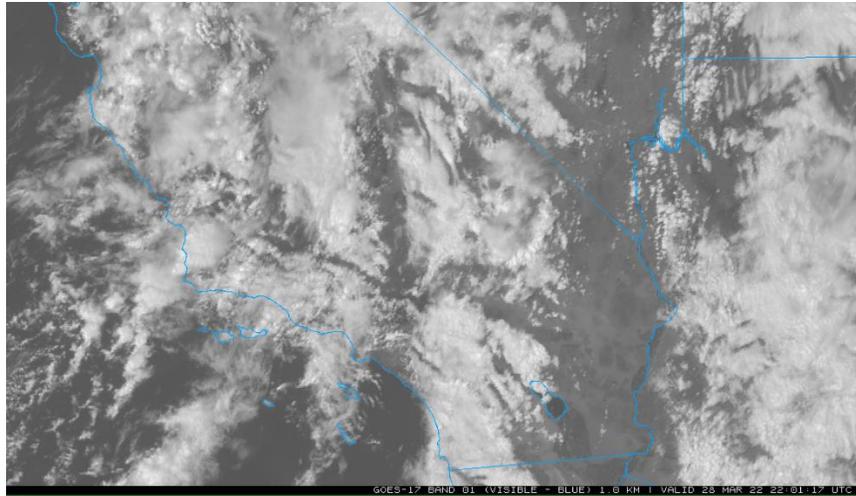


Figure 5.54 Visible spectrum satellite image at 1501 PDT March 28

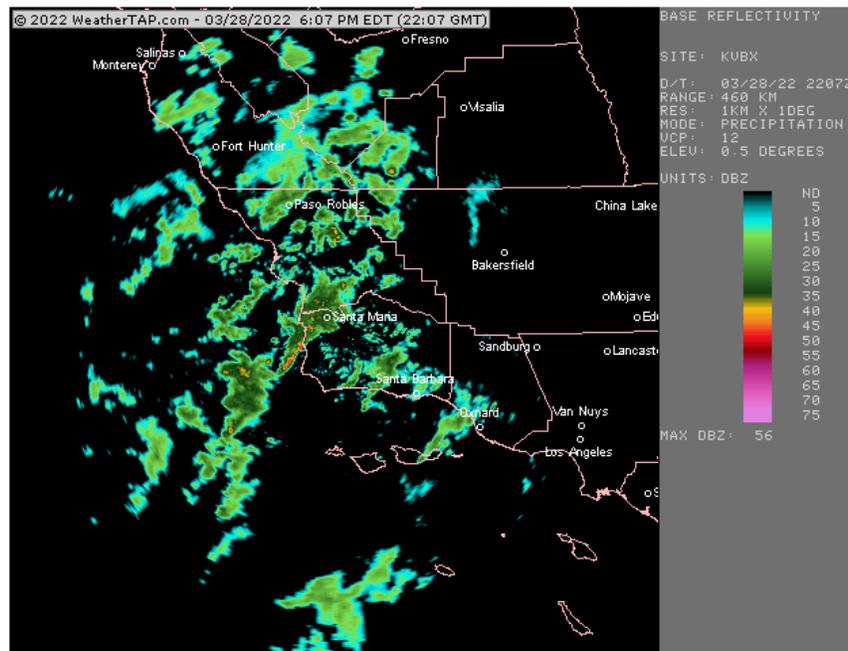
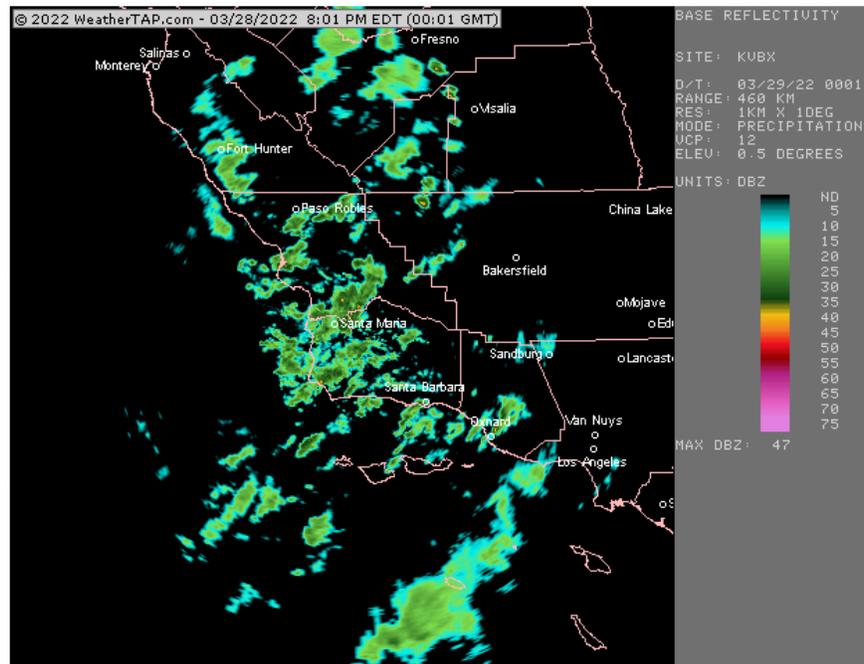


Figure 5.55 Radar image at 1507 PDT March 28

By 1700, showers became much more disorganized (Figure 5.56) with southerly flow near surface and southwest flow aloft, with main upper low center just west of Santa Barbara County and slowly drifting eastward. Seeding ended at this time and winds became essentially light and variable at lower levels. Average rainfall rates in most areas through the afternoon hours remained under 0.10"/hour, although with some locally much heavier rates in the vicinity of the narrow precipitation band. 700 mb temperatures remained near -7 C. Winds shifted to the northwest during the evening hours with showers gradually coming to an end at that point.



**Figure 5.56 Radar image at 1701 PDT March 28**

A summary of flare times for the Lake Lopez target area during this event is shown below (PDT):

Harris Grade 1002

Mt Lospe 1007, 1308, 1350, 1427, 1442, 1457, 1513, 1542

Berros Peak 1015, 1227, 1455, 1510, 1542, 1602, 1637

#### **April 21, 2022**

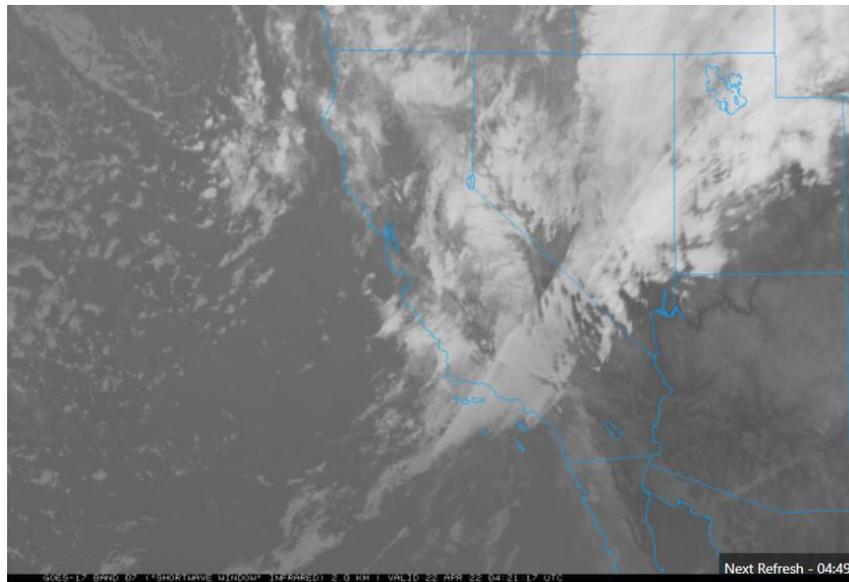
A large trough of low pressure moved onshore in California on April 21, with a frontal precipitation band slowly working its way southward along the coast. The base of the trough extended southward to the Central Coast area by late in the day and brought some precipitation during the evening hours. The seeding program was extended (at no additional cost except for the seeding flares used) to allow seeding during this event.

By 2100 PDT, an area of showers with embedded convection began to move onshore in southwestern SLO County. Figures 5.57 and 5.58 show a satellite and radar image, respectively, as this activity began to move onshore. There was an apparent circulation center offshore west of Santa Barbara County as is observed in these images. Winds were from the west-southwest, and seeding began at Arroyo Grande to affect the Lopez Lake target area. HYSPLIT plots were not available for this event (data was not successfully downloaded, perhaps because of a NOAA server upgrade affecting some data products that week).

Rainfall amounts with this initial band were mostly 0.25 – 0.40" in roughly an hour, although locally higher. 700 mb temperatures averaged near -6 C in the area of the frontal precipitation band per model data, with slightly colder temperatures behind it.

Around 2240 another area of light showers moved onshore in SLO County. These were weak and disorganized, but another flare was used at the AG site with some shower development currently in that area.

Precipitation totals overall were around a half inch in and around the target area. Figure 5.59 shows rainfall totals across the area. Winds turned west to northwest with only isolated showers overnight, with seeding ending before 2300 PDT. A total of 4 flares were used to target the Lopez Lake watershed in this event.



**Figure 5.57** Infrared satellite image at 2121 PDT April 21

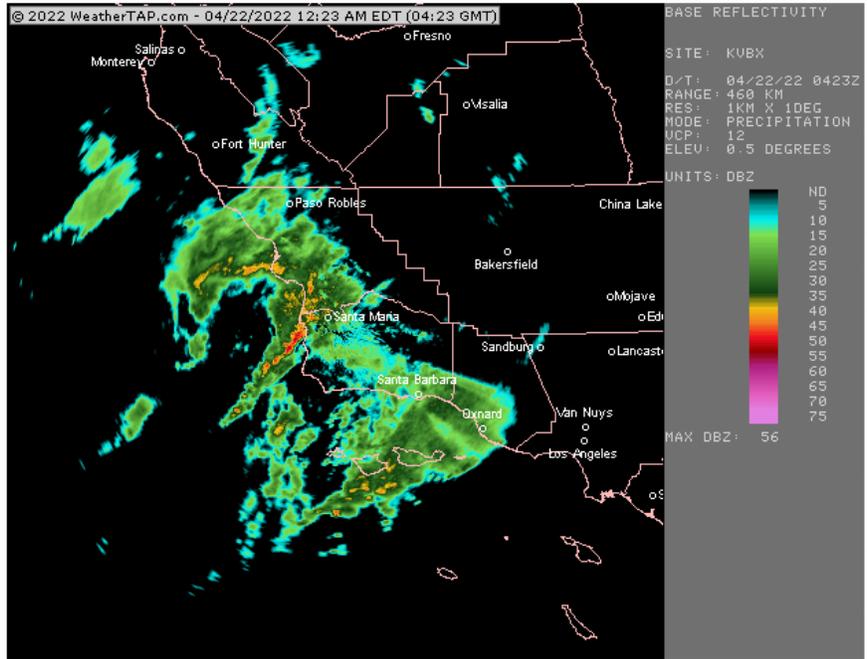


Figure 5.58 Vandenberg radar image at 2123 PDT April 21

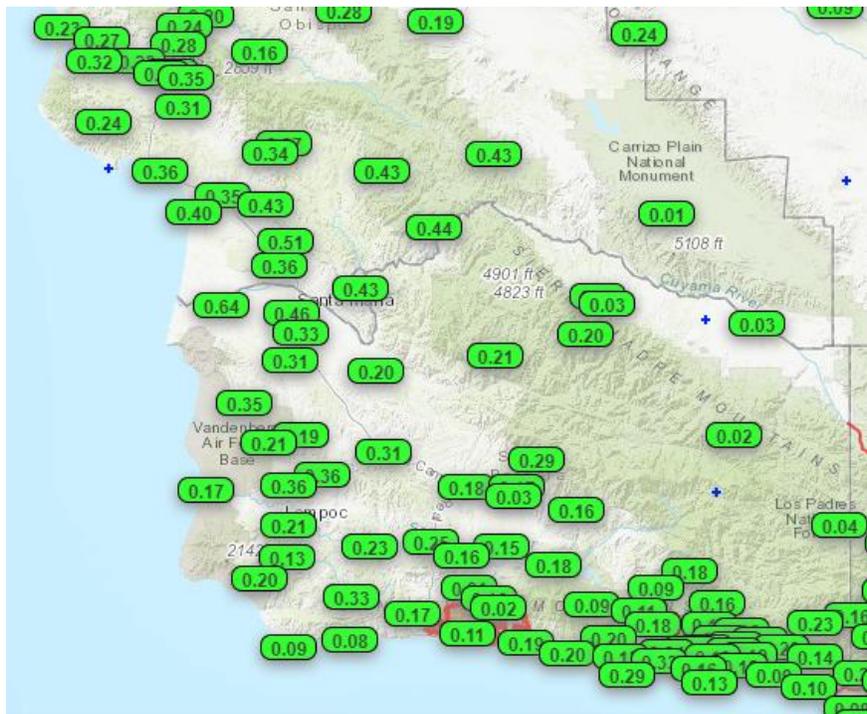


Figure 5.59 Precipitation amounts across the area

## 6. COMPUTER MODELING AND OTHER METEOROLOGICAL DATA

NAWC uses a number of forecasting models as well as a specialized particle dispersion model. The forecasting models including global models like the GFS as well as regional models including the NAM and the WRF. These models help NAWC track the development of storms and predict when storms with appropriate seeding conditions will impact the target area. As the storm approaches these models are viewed in conjunction with satellite and radar imagery. The most productive portions of a convective storm can be relatively short lived, it is therefore essential that flares are burned at the correct time.

Dispersion models are used in a number of industries to predict the transmission of particulates in a given medium. The Hybrid Single-Particle Lagrangian Integrate Trajectory (HYSPLIT) model, was designed to predict the flow of airborne particulates based on current weather patterns. This model uses real-time and predictive meteorological data, and calculates the most probable path of particles dispersed from a specific location. NAWC has been granted access to this tool by the National Oceanic and Atmospheric Administration (NOAA) to assist with our execution and evaluation of current and future cloud-seeding programs.

Figure 6.1 shows a 4-panel GFS forecast during a storm event on March 28, 2022, which gives a good overview of forecast precipitation in a 3-hour period (lower right) as well as moisture, winds, and temperatures at the 700 mb level (lower left). Figure 6.2 is a somewhat higher resolution 3-km NAM forecast of simulated radar reflectivity for 1700 PDT on March 28.

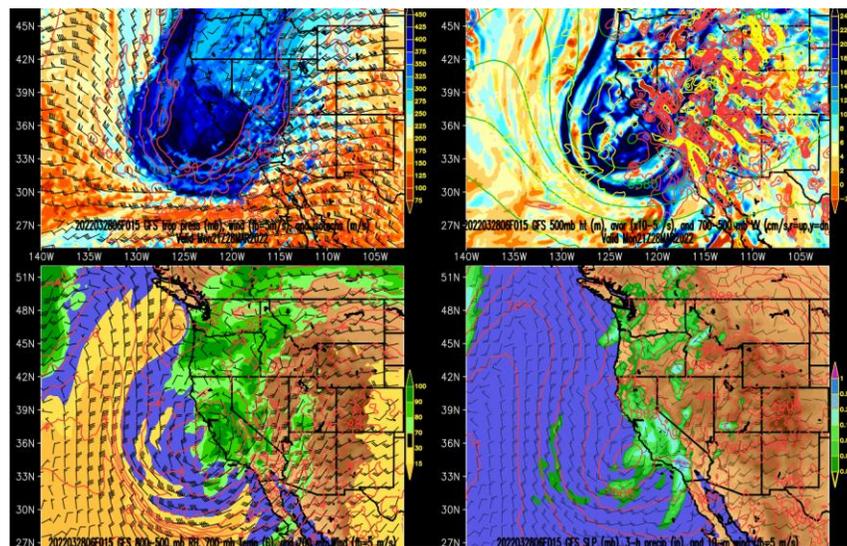
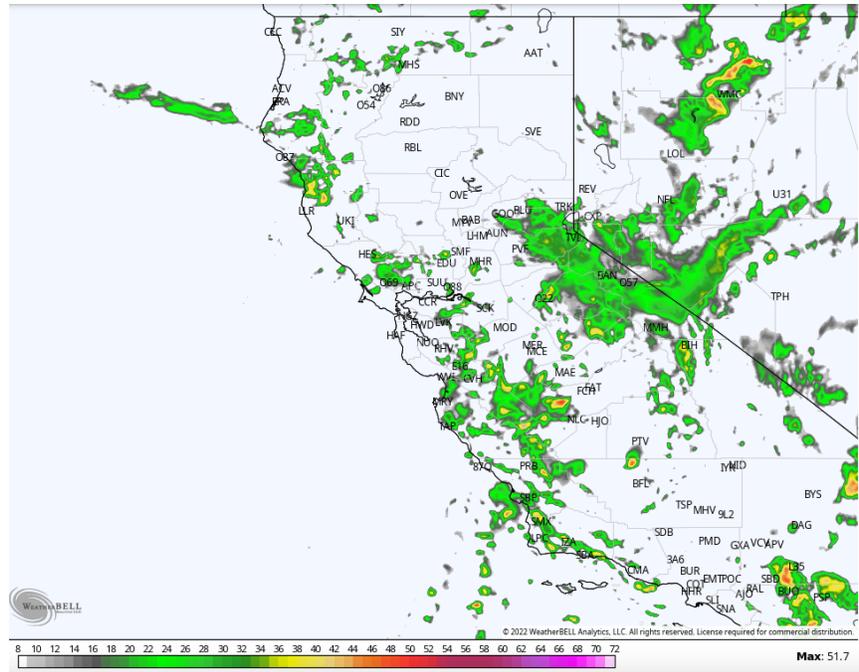


Figure 6.1 GFS model forecast (4-panel) on the afternoon of March 28, 2022 showing various meteorological parameters. These include precipitation, winds, and temperatures shown in the lower panels.



**Figure 6.2 NAM 3-km forecast of simulated radar reflectivity at 1700 PDT March 28**

Figure 6.3 shows HYSPLIT model output for this same seeded event on the afternoon of March 28. The colors in Figure 6.3 represent the concentration of the seeding material in the plume, with the highest concentrations shown dark blue followed by green and aqua representing lesser concentrations near the edges of the plume.

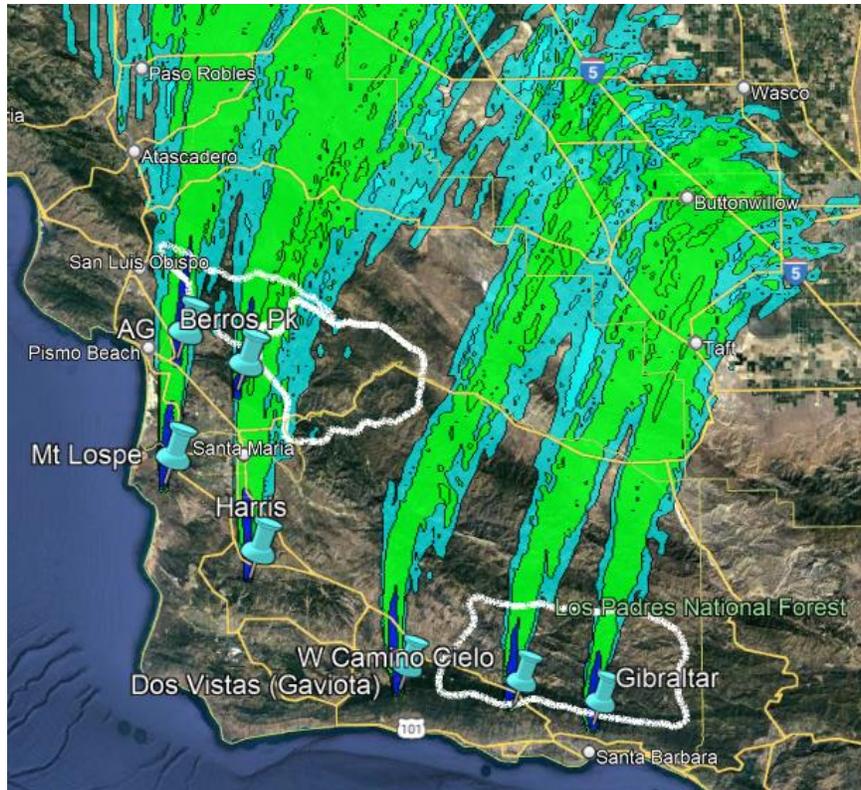


Figure 6.3 HYSPLIT Model output for seeding operations on March 28, 2022

The depiction provided in Figure 6.3 is of the predicted transport of seeding plumes during a seeded storm event. The HYSPLIT plume depictions are of the initial transport and diffusion phase of the plumes. Once the silver iodide has interacted with the super cooled liquid water droplets to instigate the formation of snow flakes, the dispersion will no longer follow the predicted path, as the snowflakes will begin to fall out of the cloud as soon as they are heavy enough. **NOTE: HYSPLIT models were ran with all sites for both Santa Barbara and San Luis Obispo collectively as some of the Santa Barbara sites were used to see Lopez Lake when conditions were appropriate).**

It is important to remember that though a HYSPLIT model run may display dispersion plumes from all sites, during actual operations its likely only some of the more favorable sites were used. For the case displayed above seeding primarily occurred from Harris Grade, with some lesser seeding occurring from Gibraltar. The HYSPLIT model plume forecasts are typically used in making seeding decisions when the wind directions or speeds provided questionable seeding conditions. Seeding plumes that adequately cover portions of the target area are only one consideration, as all other meteorological parameters must also prove favorable for seeding.

Another real-time data source that is frequently used in the operation of this program is the Vandenberg Air Force Base (VBG) NEXRAD weather radar. Figure 6.4 provides an example from

the March 28, event with the corresponding vertical wind profile (VAD) data in Figure 6.5. The plot in Figure 6.5 shows UTC time (x axis, bottom) and elevation above sea level in thousands of feet (y axis, left). The winds between the elevation of a ground-based seeding site and the height of the  $-5^{\circ}\text{C}$  level can be quickly assessed visually from the VAD plot, giving the meteorologist a good estimate of the directional (horizontal) transport of seeding material.

In addition, the dual-polarized capability of the weather radar can be used to examine plots of precipitation types (such as rain, snow, hail, graupel) in specific cases where this may be useful to the meteorologist.

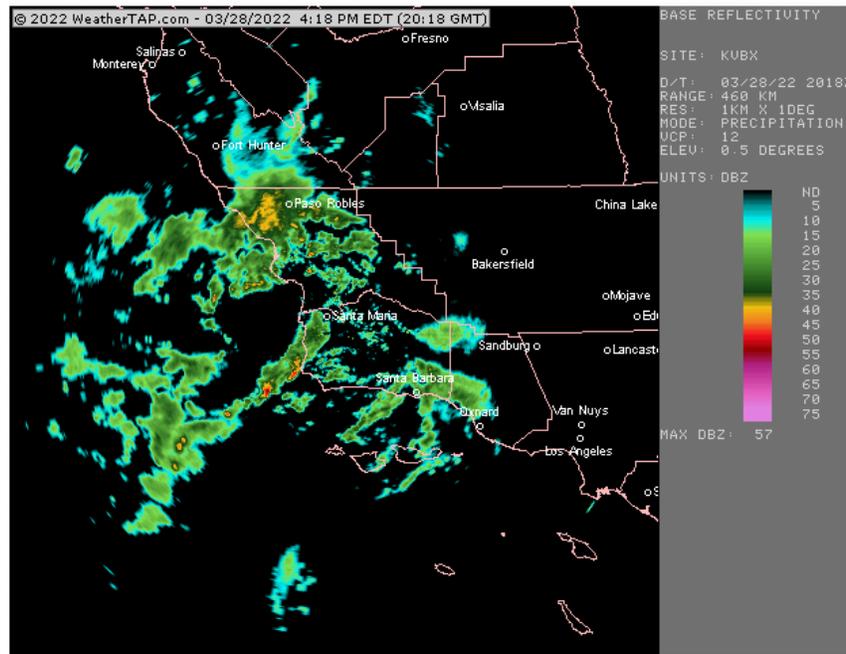
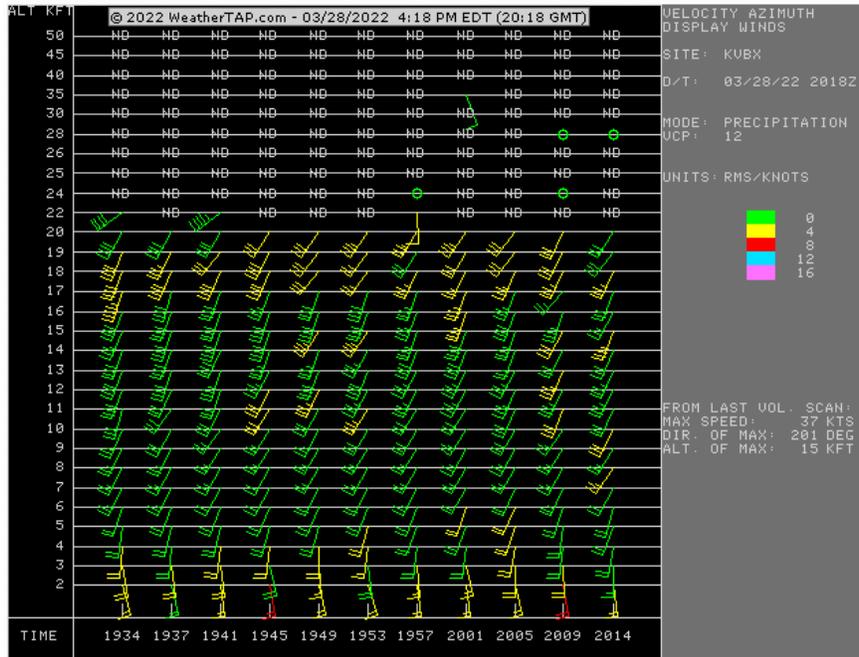


Figure 6.4 VBG radar reflectivity at 1318 PDT on March 28, 2022



**Figure 6.5** VBG vertical VAD wind profile from radar data, ending 1314 PDT on March 28

In addition to these sources, various other weather products such as satellite images, surface data, and upper-air (weather balloon) soundings are often examined by the meteorologist, in support of the seeding program. Additional examples of these are shown in the storm period summaries in the Operations section of the report.

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## 8. **APPENDIX A**

### **BACKGROUND ON CLOUD SEEDING IN SANTA BARBARA COUNTY**

There is a long history of cloud seeding programs being conducted in Santa Barbara County. Some of these have been research programs, while others have been operational programs. The research programs have been conducted to better understand winter storm systems that impact Santa Barbara County and also to attempt to evaluate the potential impacts of cloud seeding, especially in terms of any additional rainfall that can be attributed to the cloud seeding activities. Some of these research programs employed randomization techniques whereby approximately one-half of the seedable events were deliberately left unseeded in order to provide data for comparison with the seeded events. Operational programs have been conducted with the primary objective being to maximize the amount of rainfall produced through the cloud seeding activities. As a consequence, randomization is typically not employed with operational programs since the goal is to produce the maximum impact, not to demonstrate that cloud seeding “works” or to document the amount of the cloud seeding increases. Programs in the County date back to the early 1950s, the result of the pioneering work done in the field of weather modification in the late 1940s by Drs. Vincent Schaefer and Bernard Vonnegut.

Table 1 provides a summary of the research programs conducted in Santa Barbara County. There were also some early operational programs conducted in the 1950s and a later program in 1978. The 1978 program was conducted due to drought conditions. The design of the current program is based upon the results obtained from the Santa Barbara research program Phase I and II. Table 2 provides a summary of some of the earlier operational programs.

**Table 1**  
**Summary of Santa Barbara Research Programs**

Name	Time Period	Study Area	Sponsor(s)	Design	Results
Santa Barbara I	1957-1960	Higher Elevations of Santa Barbara and Ventura Counties	State of California, University of California, Santa Barbara County, Ventura County, National Science Foundation, U.S. Weather Bureau, U.S. Forest Service	Randomized seeding using ground-based silver iodide generators	Indications of a 45% increase, but results were not statistically significant (Neyman, et al, 1960) (Elliott, et al, 1962)
Water Balance of Orographic Clouds	1960-1963	Santa Ynez and San Gabriel Mountain Ranges	National Science Foundation	Analysis of Precipitation and Rawinsonde data during winter storms	Approximately one quarter of the orographically produced condensate fell as precipitation in the two mountain areas. More precipitation is produced in unstable versus stable air masses
Convection Band Study	1960-1963	Santa Barbara County	National Science Foundation	Analysis of Precipitation and Rawinsonde data during winter storms	The discovery that convection bands are a common feature of winter storms. Bands 20-40 miles wide centered some 30 to 60 miles apart Elliott and Hovind, 1964
Santa Barbara II: Phase I	1967-1971	Santa Barbara County	Naval Weapons Center, China Lake, California	Randomized seeding of winter convection bands from a single ground site using high output silver iodide flares	Increases in convection band precipitation as high as 50%, several sites statistically significant Brown et al, 1974
Santa Barbara II: Phase II	1970-1974	Santa Barbara County	Naval Weapons Center, China Lake, California	Randomized seeding of winter convection bands using aircraft	Increases in convection band precipitation as high as 100%, several sites statistically significant Brown et al, 1974

**Table 2 Summary of Earlier Santa Barbara Operational Programs**

Time Period	Target Area	Sponsor	Design	Results
1950-1953, 1955	South Coast, Santa Ynez Basin, Cuyama Valley	Santa Barbara County Water Agency	Ground Based Silver Iodide Generators	Estimated 1.35 to 5.09-inch increases for 1955 program
1978	North-east portion of Santa Barbara County	Santa Barbara County	Ground based, high output silver iodide flares	Estimated increases of approximately 40%

The Santa Barbara County Water Agency (Agency) completed a number of tasks during 1981 designed to reactivate cloud seeding activities within the County. These tasks included: 1) preparation of a Negative Declaration Statement (#81-ND-87), 2) conducting a public hearing (December 10, 1981), and 3) obtaining a Weather Resource Management permit from the California Department of Water Resources. North American Weather Consultants (NAWC) was awarded an initial contract from the Agency (dated January 11, 1982) to conduct an operational cloud seeding program during the remainder of the 1982 winter season. Periodic contracts were awarded to NAWC by the Agency to continue these operational programs in a nearly continuous fashion through the 1997 Water Year.

Atmospherics, Inc. of Fresno, California was awarded a contract to conduct an operational program during the 1998 Water Year. Weather Modification, Inc., of Fargo, North Dakota, was awarded a contract by the Agency to conduct operational programs for the 1999 through 2001 Water Years. NAWC, under contract with the Agency, resumed its conduct of operations for the County during the winter of 2001-2002. This program utilized a revised project design based upon the highly successful results of earlier research conducted by NAWC (e.g., Santa Barbara II phase I and phase II experiments). The Agency renewed NAWC's contract to conduct the cloud seeding operations for the 2002-03 winter season. The Agency released an RFP for another three-year program during the early summer of 2003. NAWC was awarded this contract, which resulted in operations being conducted during the 2003-2004, 2004-2005 and 2005-2006 rainy seasons. The revised design, originally implemented during the 2001-2002 rainy season, was utilized in conducting these programs. The Agency released another RFP for a three-winter program during the spring of 2007. NAWC was again selected to perform this work, which would include both ground and airborne seeding. A large fire impacted substantial portions of the upper Santa Ynez watershed during the summer of 2007 (the Zaca fire). As a consequence, the Agency decided that no cloud seeding would be conducted during the 2007-2008 winter season in the Upper Santa

Ynez watershed. The Agency decided to conduct a program designed to only affect the Twitchell watershed. The Agency expanded the program for the 2009-2010 program to include both the Twitchell and Upper Santa Ynez watersheds although restrictions were in place to avoid seeding impacts in some recent burn areas (La Brea, Jesusita, Gap and Tea fires). The Agency released another RFP for a three-winter program during the summer of 2011. NAWC was again selected to perform this work, which would include both ground and airborne seeding. Only ground seeding was conducted during the 2011-2012 and 2012-2013 rainy seasons. The Agency released another RFP for a three-winter program during the summer of 2014. NAWC was again selected to perform this work, which would include both ground and airborne seeding for the 2014-2015 through the 2016-2017 rainy seasons. NAWC has continued to operate this program, utilizing only ground-based sites in many seasons due to budgetary constraints. Table 3 provides a summary of NAWC operations since 1981.

Research has demonstrated that properly conducted cloud seeding programs offer an environmentally safe and cost-effective means of augmenting precipitation from winter storms. NAWC conducted a study for the Santa Barbara County Water Agency (Thompson and Griffith, 1987), which assessed the precipitation augmentation potential from seeding wintertime cloud bands moving over Santa Barbara County. That assessment covered a sixty-one (61) year period (1920-1980). A follow-on study (Solak, et al., 1996) covered the period from 1981 through 1994, applying the same analysis methods. A key conclusion of these studies was that, under average conditions, seasonal precipitation could be optimally enhanced by 18 to 22 percent at Juncal and Gibraltar Dams through seeding of all appropriate precipitation bands from October through April. Seasonal increases of that magnitude could add as much as 4.5 to 5.0 inches of precipitation to the average seasonal total. Realizing the importance and benefit of this additional rainfall, the water purveyors of Santa Barbara County, under the administrative leadership of the County's Water Agency and/or the Flood Control District have sponsored a cloud seeding program in all water years since 1982, with the exception of 1985-1986 and 2007-2008. The 1985-1986 and 2007-2008 programs were canceled due fires which produced large burn scars in the project areas, which, in turn, created concerns about the potential for excessive erosion and mudslides.

Availability of fresh water in adequate supplies is obviously of paramount importance. Local precipitation has been the major source of water for most areas of California. As part of Santa Barbara County's water resource development and management strategies, cloud seeding operations have been routinely utilized to augment natural precipitation, helping to stabilize annual fresh water supplies. Cloud seeding for precipitation enhancement has been shown to be an effective tool, which carries a very attractive long-term benefit/cost ratio. **Table 3**

**Historical Operational Cloud Seeding Periods in Santa Barbara County,  
Water Year 1982 to Present**

OPERATIONAL PERIOD	TARGET AREA	REMARKS
Jan 15-Apr 15, 1982	Santa Barbara County except South Coast	Airborne seeding, weather radar support provided by Vandenberg Air Force Base. Ground based pyrotechnic flare firing at Tranquillion Park.
Dec 1, 1982-Jan 26, 1983	Santa Barbara County except South Coast	Airborne and ground based pyrotechnic seeding suspended in late January due to heavy rainfall and Lake Cachuma approaching capacity.
Mar 1, 1984-Apr 30, 1984	North County	Airborne seeding and ground based pyrotechnic seeding.
Nov 1, 1984-Apr 30, 1985	Santa Barbara County except South Coast	Airborne seeding and ground based pyrotechnic seeding.
1985-1986		No program due to burn areas in San Luis Obispo and Ventura Counties
Nov 1, 1986-Mar 31, 1987	Santa Barbara County except South Coast	Airborne seeding. Ground based pyrotechnic seeding replaced with two ground-based silver iodide generators (Mt. Lospe and Sudden).
Nov 1, 1987-Mar 31, 1988	Santa Barbara County except South Coast	Airborne seeding. Implementation of remotely controlled ground-based silver iodide generators began (Mt. Lospe). The use of a computerized targeting model (GUIDE) began.
Nov 1, 1988-Apr 30, 1989	Santa Barbara County except South Coast	Provision of a project specific weather radar was initiated. Airborne seeding. Four manual generator sites (Gaviota, La Cumbre, Sudden, Graham Ranch) and one remote site (Mt. Lospe). Dedicated weather radar.
Nov 1, 1989-Apr 30, 1990	Santa Barbara County except South Coast	Airborne seeding. Four manual generator sites and one remote site. Special project suspension criteria developed for lower Santa Ynez River flow below Bradbury Dam. Dedicated weather radar.
Nov 1, 1990-Apr 30, 1991	Santa Barbara County except South Coast	Special targeting criteria adopted for Painted Cave burn area. Lower Santa Ynez flow suspension criteria continued. Airborne seeding. Three remotely controlled ground generators (Sudden, La Cumbre and Graham Ranch). One ground based manual site (Gaviota). Dedicated weather radar.

OPERATIONAL PERIOD	TARGET AREA	REMARKS
Nov. 1, 1991-Apr 21, 1992	Santa Barbara County except South Coast	Targeting restrictions continued for Painted Cave burn area plus Santa Ynez River flow. Airborne seeding. Four remotely controlled and one manually operated ground-based silver iodide generators. Dedicated weather radar.
Dec. 1, 1992-Mar 31, 1993	Santa Barbara County except South Coast plus a portion of the Twitchell Drainage in southern San Luis Obispo County.	Cachuma Reservoir spilled for the first time since the 1982-83 winter season. Santa Ynez River flow restrictions continued. New suspension criteria for Twitchell Reservoir inflow adopted. Provision made for acquisition of weather satellite information. Dedicated weather radar.
Dec. 17, 1993-Apr 18, 1994	Santa Barbara County except South Coast plus a portion of the Twitchell Drainage in southern San Luis Obispo County.	Targeting restrictions imposed for the Marre burn area. Santa Ynez River flow and Twitchell Reservoir inflow restrictions continued. Airborne seeding. Six remote generators. Dedicated weather radar.
Nov. 15, 1994-Mar 24, 1995	Santa Barbara County except South Coast plus a portion of the Twitchell Drainage in southern San Luis Obispo County.	Targeting restrictions continued for the Marre burn area. Santa Ynez River flow and Twitchell Reservoir inflow restrictions continued. Airborne seeding. Six remote generators. Cachuma spilled. Dedicated weather radar.
Dec. 14, 1995 - Mar. 13, 1996	Santa Barbara County except South Coast plus a portion of the Twitchell Drainage in southern San Luis Obispo County.	Targeting restrictions for Marre burn area removed. Santa Ynez River flow and Twitchell Reservoir inflow restrictions continued. Continued airborne seeding. 6 remote and 2 manual generators. Dedicated weather radar.
Dec. 9, 1996 - Mar. 22, 1997	Santa Barbara County except South Coast plus a portion of the Twitchell Drainage in southern San Luis Obispo County.	Santa Ynez River flow and Twitchell Reservoir inflow restrictions continued. Airborne seeding. Six remote generators. Two manual generators. Dedicated weather radar.
Nov. 15, 1997-Apr. 30, 1998	Santa Barbara County except South Coast plus a portion of the Twitchell Drainage in southern San Luis Obispo County.	Work performed by Atmospheric, Inc. of Fresno, California. Program onset delayed, operated Jan. 1-Feb. 1, 1998. Program suspended on Feb. 2, 1998 and terminated Mar. 15, 1998 (extremely wet watersheds)
Dec. 15, 1998-Mar. 31, 1999	Santa Barbara County except South Coast plus a portion of the Twitchell Drainage in southern San Luis Obispo County.	Work performed by Weather Modification, Inc. of Fargo, North Dakota.

OPERATIONAL PERIOD	TARGET AREA	REMARKS
Dec. 15, 1999-Apr. 5, 2000	Santa Barbara County except South Coast plus a portion of the Twitchell Drainage in southern San Luis Obispo County.	Work performed by Weather Modification, Inc. of Fargo, North Dakota.
Dec. 8, 2000-Mar. 31, 2001	Santa Barbara County except South Coast plus a portion of the Twitchell Drainage in southern San Luis Obispo County.	Work performed by Weather Modification, Inc. of Fargo, North Dakota.
Dec. 20, 2001 - Mar. 22, 2002	Portions of Santa Barbara and southern San Luis Obispo Counties, emphasizing upper and middle Santa Ynez watershed and lower Twitchell watershed	Revised project design implemented, including airborne seeding and three automated high-output ground-based flare seeding (AHOGS) sites. Custom software utilized to combine NEXRAD and aircraft track data for use in operations.
Nov. 7, 2002 - May 2, 2003	Portions of Santa Barbara and southern San Luis Obispo Counties, emphasizing upper and middle Santa Ynez watershed and lower Twitchell watershed	Airborne seeding and three automated high-output ground-based flare seeding (AHOGS) sites. Custom software utilized to combine NEXRAD and aircraft track data for use in operations.
Nov. 15, 2003 - Apr. 15, 2004	Portions of Santa Barbara and southern San Luis Obispo Counties, emphasizing upper and middle Santa Ynez watershed and lower Twitchell watershed	Airborne seeding and three automated high-output ground-based flare seeding (AHOGS) sites. Custom software utilized to combine NEXRAD and aircraft track data for use in operations.
Nov. 15, 2004 - Apr. 15, 2005	Portions of Santa Barbara and southern San Luis Obispo Counties, emphasizing upper and middle Santa Ynez watershed and lower Twitchell watershed	Airborne seeding and four automated high-output ground-based flare seeding (AHOGS) sites. Custom software utilized to combine NEXRAD and aircraft track data for use in operations. WxWorx display in aircraft cockpit of aircraft location, underlying terrain and current NEXRAD radar data.
Nov. 15, 2005 - Apr. 5, 2006	Portions of Santa Barbara and southern San Luis Obispo Counties, emphasizing upper and middle Santa Ynez watershed and lower Twitchell watershed	Airborne seeding and five automated high-output ground-based flare seeding (AHOGS) sites. Custom software utilized to combine NEXRAD and aircraft track data for use in operations. WxWorx display in aircraft cockpit of aircraft location, underlying terrain and current NEXRAD radar data.

OPERATIONAL PERIOD	TARGET AREA	REMARKS
Nov. 15, 2006 - Mar. 31, 2007	Portions of Santa Barbara and southern San Luis Obispo Counties, emphasizing upper and middle Santa Ynez watershed and lower Twitchell watershed	Airborne seeding and five automated high-output ground-based flare seeding (AHOGS) sites. WxWorx display in aircraft cockpit of aircraft location, underlying terrain and current NEXRAD radar data.
2007-2008 Winter Season	No Operations	Zaca Fire
Nov. 15, 2008 – Apr. 15, 2009	Twitchell watershed located in portions of northern Santa Barbara and southern San Luis Obispo Counties.	Revised project design partially implemented consisting of three high-output ground-based flare-seeding (AHOGS) sites. No aircraft seeding.
Nov. 15, 2009 – Apr. 15, 2010	Portions of Santa Barbara and southern San Luis Obispo Counties, emphasizing upper and middle Santa Ynez watershed and lower Twitchell watershed	Revised project design partially implemented consisting of five high-output ground-based flare-seeding (AHOGS) sites. No aircraft seeding.
Nov. 15, 2010 – Mar. 31, 2011	Portions of Santa Barbara and southern San Luis Obispo Counties, emphasizing upper and middle Santa Ynez watershed and lower Twitchell watershed	Revised project design implemented consisting of airborne seeding and six high-output ground-based flare-seeding (AHOGS) sites.
Dec. 1, 2011 – Apr. 22, 2012	Portions of northern Santa Barbara and southern San Luis Obispo Counties	Revised project design targeting only the northern (Huasna – Alamo) area, using three high-output ground-based flare seeding (AHOGS) sites.
Dec. 1, 2012 – Mar. 15, 2013	Portions of Santa Barbara and southern San Luis Obispo Counties, emphasizing upper and middle Santa Ynez watershed and lower Twitchell watershed	Revised project design implemented consisting of six high-output ground-based flare-seeding (AHOGS) sites.
Nov. 15, 2013 – Apr. 15, 2014	Portions of Santa Barbara and southern San Luis Obispo Counties, emphasizing upper and middle Santa Ynez watershed and lower Twitchell watershed	Revised project design implemented consisting of airborne seeding and six high-output ground-based flare-seeding (AHOGS) sites.

OPERATIONAL PERIOD	TARGET AREA	REMARKS
Nov. 15, 2014 – Apr. 15, 2015	Portions of Santa Barbara and southern San Luis Obispo Counties, emphasizing upper and middle Santa Ynez watershed and lower Twitchell watershed	Revised project design implemented consisting of airborne seeding and six high-output ground-based flare-seeding (AHOGS) sites.
Nov. 1, 2015 – Apr. 30, 2016	Portions of Santa Barbara and southern San Luis Obispo Counties, emphasizing upper and middle Santa Ynez watershed and lower Twitchell watershed	For the first time in the history of the program, a six month long operational period occurred. This included six months of ground seeding and four months of aerial seeding.
Nov. 1, 2016 – Apr. 30, 2017	Portions of Santa Barbara and southern San Luis Obispo Counties, emphasizing upper and middle Santa Ynez watershed and lower Twitchell watershed	Airborne seeding and six high-output ground-based flare-seeding (AHOGS) sites. Four of the Six AHOGS units were replaced with newly manufactured units that contained updated electronics and video cameras. Meteorological guidance for aircraft seeding operations conducted from Sandy, Utah. In all previous seasons the meteorologist was stationed in Santa Barbara or Santa Maria for the duration of the seeding programs. A new aircraft tracking system known as Spider Tracks was employed.
Nov. 15, 2017- Apr. 15, 2018	Portions of northern Santa Barbara and southern San Luis Obispo Counties	Revised project design targeting only the northern (Huasna – Alamo) area, using three high-output ground-based flare seeding (AHOGS) sites. No seeding in the Upper Santa Ynez Watershed due to Whitter Burn area. Introduction of the in-house HRRR model for cloud seeding guidance.
Nov. 15, 2018 – Apr. 15, 2019	Portions of northern Santa Barbara and southern San Luis Obispo Counties	Revised project design targeting only the northern (Huasna – Alamo) area, using two high-output ground-based flare seeding (AHOGS) sites. No seeding in the Upper Santa Ynez Watershed due to Whitter and Thomas Burn areas. Continued use of the in-house HRRR script model for cloud seeding guidance.
Dec. 1, 2019 – Apr. 15, 2020	Portions of northern Santa Barbara and southern San Luis Obispo Counties	Operational cloud seeding for only the northern (Huasna – Alamo) area using AHOGS sites. No seeding in the Upper Santa Ynez Watershed. Installation of a new site in southern San Luis Obispo County named Berros Peak.

OPERATIONAL PERIOD	TARGET AREA	REMARKS
Dec. 1, 2020 – Apr. 15, 2021	Portions of northern Santa Barbara and southern San Luis Obispo Counties	Operational cloud seeding for only the northern (Huasna – Alamo) area using AHOGS sites. No seeding in the Upper Santa Ynez Watershed.
Dec. 1, 2021 – Mar. 31, 2022	Portions of northern Santa Barbara and southern San Luis Obispo Counties	Operational cloud seeding using AHOGS sites for both the northern (Twitchell, or Twitchell) and the Upper Santa Ynez Watershed.

## 9. **APPENDIX B**

### **2021-2022 CLOUD SEEDING PROGRAM SUSPENSION CRITERIA**

#### **A. General Criteria for the Entire Project Area in San Luis Obispo Counties**

Whenever the National Weather Service (NWS) issues a severe storm, precipitation, flood warning or flash flood warning that affects any part of the project area, the project meteorologist shall suspend operations which may affect that part. Operations will be suspended at least for the period that the warning is in effect.

The Project Meteorologist or District/Agency personnel shall retain independent authority to suspend cloud seeding operations for any part, or all of the project area in the event that unforeseen conditions develop during storm events which in their best judgment have the potential to cause flooding or other adverse conditions anywhere within the project area.



## ZONE 3 Lopez Project

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San Luis Obispo County Flood Control and Water Conservation District

**TO:** Zone 3 Advisory Committee

**FROM:** David Spiegel, PE

**DATE:** July 21, 2022

**SUBJECT:** Zone 3 Projects Update

### Project Updates:

- Tesla Battery Storage (No Change)
  - Doing Startup testing to be prepared for PGE approval of plan to operate (PTO)
  - Budget – Free
  
- Spillway Assessment and Investigation
  - DSOD comments received.
  - Meeting with Consultant to review DSOD comments scheduled for 7/27
  - Remainder of project ~ minimum of \$300,000
  
- Geotechnical Testing & Seismic Alternatives Study of Terminal Reservoir Dam
  - Negotiating Task 1 Items
  - Budget ~\$500,000
  
- Lopez WTP Safety Upgrades (No Change)
  - Staff are looking into additional consultants to do a lifeline system within the membrane building.
  - Multiple consultants have reviewed the project, but none have quoted the project.
  - Budget ~\$53,000
  
- Cathodic Protection Repair Project
  - JDH Corrosion Consultants, Inc. provided 95% drawing set.
  - JDH Corrosion Consultants, Inc. to provide 100% drawing set by the end of the week.
  - Preparing BID documents
  - Submitted encroachment permit applications
  - Obtained authorization from the Board of Supervisors to advertise the project
  - Budget ~\$449,933
  
- Equipment Storage Building
  - Bid opening on 7/14/2022
  - All bids were overbudget
  - Budget ~\$90,000



## ZONE 3 Lopez Project

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San Luis Obispo County Flood Control and Water Conservation District

- CO2 Injection System (No Change)
  - Negotiating Bulk CO2 contract
  - PO issued for equipment
  - Budget ~\$256,000
- Sludge Bed Curtain Wall Rehabilitation (No Change)
  - ~\$50,000 per initial quote

### **Completed Projects**

- Disinfection Alternatives Study
- Fault Zone Risk Assessment for Dam Left Abutment
- Leak at Main Dam outlet works building
- Replacement of Hach Turbidimeter
- Repairs to Terminal Dam Spillway
- Lopez Terminal Dam Monument Survey
- Domestic Tank Repairs
- Lopez Water Treatment Plant Rack 1 Membrane Replacement
- Fault Zone Risk Assessment for Dam Left Abutment