One Water One Watershed

…A United Voice for the Santa Ana River Watershed

OWOW Steering Committee Members

Brenda Dennstedt, Convener | SAWPA Commissioner
T. Milford Harrison, SAWPA Commissioner
Vicente Sarmiento, Orange County Supervisor
Karen Spiegel, Riverside County Supervisor
Jesse Armendarez, San Bernardino County Supervisor
James Hessler, Altman Plants
Garry W. Brown, Orange County Coastkeeper
William Ruh, Regional Water Quality Control Board
Deborah Robertson, Mayor, City of Rialto
Wes Speake, Councilmember, City of Corona
Nicholas Dunlap, Mayor, City of Fullerton

THIS MEETING WILL BE CONDUCTED IN A HYBRID FORMAT, OFFERING BOTH VIRTUAL PARTICIPATION AND IN-PERSON ATTENDANCE, PROVIDING AN OPPORTUNITY FOR PUBLIC COMMENT. ALL VOTES TAKEN WILL BE CONDUCTED BY ORAL ROLL CALL.

Meeting Access Via Computer (Zoom):	Meeting Access Via Telephone:
• https://sawpa.zoom.us/j/83454132920	• 1 (669) 900-6833
• Meeting ID: 834 5413 2920	• Meeting ID: 834 5413 2920

REGULAR MEETING OF THE OWOW STEERING COMMITTEE

SAWPA, 11615 STERLING AVENUE, RIVERSIDE, CA 92503

THURSDAY, SEPTEMBER 26, 2024 – 11:00 A.M.

AGENDA

1. **CALL TO ORDER | PLEDGE OF ALLEGIANCE (Brenda Dennstedt, Convener)**

2. **ROLL CALL**

3. **PUBLIC COMMENTS**

   Members of the public may address the Committee on items within the jurisdiction of the Committee; however, no action may be taken on an item not appearing on the agenda unless the action is otherwise authorized by Government Code §54954.2(b).

   Members of the public may make comments in-person or electronically for the Committees' consideration by sending them to publiccomment@sawpa.gov with the subject line "Public Comment". Submit your electronic comments by 5:00 p.m. on Wednesday, September 25, 2024. All public comments will be provided to the Chair and may be read into the record or compiled as part of the record. Individuals have a limit of three (3) minutes to make comments and will have the opportunity when called upon by the Committee.

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4. ITEMS TO BE ADDED OR DELETED

Pursuant to Government Code §54954.2(b), items may be added on which there is a need to take immediate action and the need for action came to the attention of the Santa Ana Watershed Project Authority subsequent to the posting of the agenda.

5. CONSENT CALENDAR

All matters listed on the Consent Calendar are considered routine and non-controversial and will be acted upon by the Committee by one motion as listed below.

A. APPROVAL OF MEETING MINUTES: MARCH 28, 2024, AND MAY 23, 2024 5
Recommendation: Approve as posted.

6. INFORMATIONAL ITEMS

A. SANTA ANA RIVER WATERSHED SUSTAINABILITY ASSESSMENT (SC#2024.10) 15
Presenter: Haley Gohari
Recommendation: Receive and file.

B. INTEGRATED CLIMATE ADAPTATION AND RESILIENCY PROGRAM REGIONAL RESILIENCE PLANNING AND IMPLEMENTATION GRANT PROGRAM: DEVELOPMENT OF THE SANTA ANA RIVER WATERSHED CLIMATE ADAPTATION AND RESILIENCE PLAN - WORKFLOW (SC#2024.11) 31
Presenter: Rachel Gray
Recommendation: Receive and file.

C. SANTA ANA RIVER TRAIL AND PARKWAY UPDATE (SC#2024.12) 45
Presenter: Ian Achimore
Recommendation: Receive and file.

D. SANTA ANA RIVER WATERSHED CLOUD SEEDING PILOT PROGRAM: YEAR 1 SUMMARY (SC#2024.13) 65
Presenter: Rachel Gray
Recommendation: Receive and file.

7. GENERAL MANAGER REPORT

8. CHAIR'S COMMENTS/REPORT

9. COMMITTEE MEMBERS' COMMENTS

10. REQUEST FOR FUTURE AGENDA ITEMS

11. ADJOURNMENT

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PLEASE NOTE:
Americans with Disabilities Act: Meeting rooms are wheelchair accessible. If you require any special disability related accommodations to participate in this meeting, please contact (951) 354-4220 or zramirez@sawpa.gov. Notification at least 48 hours prior to the meeting will enable staff to make reasonable arrangements to ensure accessibility for this meeting. Requests should specify the nature of the disability and the type of accommodation requested.

Materials related to an item on this agenda submitted to the Committee after distribution of the agenda packet are available for public inspection during normal business hours at the SAWPA office, 11615 Sterling Avenue, Riverside, and available at www.sawpa.org, subject to staff's ability to post documents prior to the meeting.

Declaration of Posting

I, Zyanya Ramirez, Executive Assistant II for the Santa Ana Watershed Project Authority declare that on September 19, 2024, a copy of this agenda has been uploaded to the SAWPA website at www.sawpa.gov and posted at the SAWPA office, 11615 Sterling Avenue, Riverside, California.

2024 OWOW Steering Committee Regular Meetings

Fourth Thursday of Every Other Month (January, March, May, July, September, November)
(Note: All meetings begin at 11:00 a.m., unless otherwise noticed, and are held at SAWPA.)

January 1/25/24 Regular Committee Meeting [cancelled]	**March** 3/28/24 Regular Committee Meeting
May 5/23/24 Regular Committee Meeting	**July** 7/25/24 Regular Committee Meeting [cancelled]
September 9/26/24 Regular Committee Meeting	**November** 11/21/24* Regular Committee Meeting*

* Meeting date adjusted due to conflicting holiday.

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OWOW STEERING COMMITTEE

REGULAR MEETING MINUTES

March 28, 2024

Committee Members	
Santa Ana Watershed Project Authority Representatives	
Brenda Dennstedt, Convener, Western Municipal Water District	Present
T. Milford Harrison, San Bernardino Valley Municipal Water District	Present
County Supervisor Representatives	
Vicente Sarmiento, Orange County Board of Supervisors	Absent
Karen Spiegel, Riverside County Board of Supervisors	Absent
Jesse Armendarez, San Bernardino County Board of Supervisors	Present
County Municipal Representatives	
Deborah Robertson, Mayor, City of Rialto	Present
Wes Speake, Councilmember, City of Corona	Absent
Nicholas Dunlap, Mayor Pro Tem, City of Fullerton	Absent
Business Community Representative	
James Hessler, Director of West Coast Operations, Altman Plants	Present
Environmental Community Representative	
Garry W. Brown, President, Orange County Coastkeeper	Absent
Regional Water Quality Control Board Representative	
William Ruh, Regional Water Quality Control Board [11:05 a.m.]	Present

Others Present	
SAWPA COMMISSIONERS:	Bruce Whitaker, Denis Bilodeau, Jasmin Hall, Gil Botello
SAWPA STAFF:	Ian Achimore, Jeff Mosher, John Leete, Marie Jauregui, Melissa Bustamonte, Pete Vitt, Rachel Gray, Sara Villa, Zyanya Ramirez
OTHERS PRESENT:	Andrew D. Turner, Lagerlof LLP; Chris Jones, San Bernardino Valley Municipal Water District; Christy Suppes, Orange County Public Works; David Lawrence, Big Bear Area Regional Wastewater Agency; Lisa Fernandez; Manuel Escamilla, County of Orange; Melissa Matlock, Western Municipal Water District; Toyasha Sebbag, City of Rialto.

The OWOW Steering Committee meeting was called to order at 11:00 a.m. by Brenda Dennstedt, Convener, at the Santa Ana Watershed Project Authority, 11615 Sterling Avenue, Riverside, CA 92503.

1. CALL TO ORDER | PLEDGE OF ALLEGIANCE

2. ROLL CALL

3. PUBLIC COMMENTS

There were no public comments; there were no public comments received via email.

4. ITEMS TO BE ADDED OR DELETED

5. CONSENT CALENDAR

A. APPROVAL OF MEETING MINUTES: NOVEMBER 16, 2023

B. GRANT ADMINISTRATION UPDATE

MOVED, approve the Consent Calendar.

Result:	**Adopted by Roll Call Vote**
Motion/Second:	Milford/Ruh
Ayes:	Armendarez, Dennstedt, Harrison, Hessler, Robertson, Ruh
Nays:	None
Abstentions:	None
Absent:	Brown, Dunlap, Sarmiento, Speake, Spiegel

6. BUSINESS ITEMS

A. GRANT FUNDED PROJECT HIGHLIGHTS: REPLENSIH BIG BEAR PROJECT (SC#2024.1)

David Lawrence, General Manager of the Big Bear Area Regional Wastewater Agency (BBARWA), provided a PowerPoint presentation titled Replenish Big Bear contained in the agenda packet on pages 33-50.

The Replenish Big Bear project involves upgrading the BBARWA wastewater treatment plant, laying around 7 miles of pipeline, and building a new pump station in Bear Valley. The upgraded plant will benefit Big Bear Valley, recognized as a "disadvantaged community," by providing a new water source. Additionally, it will supply water to the Stanfield Marsh Wildlife and Waterfowl Preserve, supporting habitat sustainability and educational activities for the community and visitors. BBARWA hosted an Open house; about 240 residents attended.

Mr. Lawrence noted that a lesson learned from implementing the project was the slowdown caused by the reeducation process for new board members. He thanked the Committee for their support.

Committee member Hessler inquired about the disposal of brine pellets resulting from the Reverse Osmosis process. Mr. Lawrence responded, explaining their exploration of various markets for resale or donation, with a priority on identifying reuse possibilities. Following this, Convener Dennstedt commended BBARWA for their efforts and applauded the successful turnout at their recent Open House event. She sought clarification regarding community feedback, to which Mr. Lawrence indicated minor concerns from a few community members regarding project costs, microplastics, and PFAS, but noted that these concerns were addressed through during their presentation.

This item was for discussion purposes; no action was taken on Agenda Item No. 6.A.

B. <u>INTEGRATED CLIMATE ADAPTATION AND RESILIENCY PROGRAM REGIONAL RESILIENCE PLANNING AND IMPLEMENTATION GRANT PROGRAM AWARD AND DEVELOPMENT OF THE SANTA ANA RIVER WATERSHED CLIMATE ADAPTATION AND RESILIENCE PLAN (SC#2024.2)</u>

Rachel Gray provided a presentation titled Round 1 Regional Resilience Grant Program Award – Santa Ana River Watershed Climate Adaptation Plan (SARWCRP) contained in the agenda packet on pages 53-66.

SAWPA, along with co-applicants Soboba Band of Luiseño Indians (Soboba) and the Inland Southern California Climate Collaborative (ISC3), successfully secured a $644,190 grant from the Governor's Office of Planning and Research (OPR) for the development of SARWCARP. Soboba will contribute expertise in Tribal Perspective and Tribal Engagement, while ISC3 will primarily focus on Stakeholder and Community Engagement. The planning process will be overseen by two groups: the Watershed Resilience Community Advisory Panel (WRCAP) and the Watershed Resilience Technical Advisory Committee (WRTAC). These groups will facilitate implementation planning by ensuring that the appropriate stakeholders and partners are included in resilience portfolios. The phases of SARWCARP development were presented, highlighting Community and Stakeholder Engagement, Vulnerability Assessment, Adaptation Analysis, and Implementation Planning.

A grant term timeline was presented. SAWPA is working toward the executing grant application and sub-agreements. An RFP is scheduled for release within the next month to aid in plan development.

This item was for discussion purposes; no action was taken on Agenda Item No. 6.B.

C. <u>OVERVIEW OF HEADWATERS RESILIENCY PARTNERSHIP AND FOREST FIRST JOINT PRESENTATION BETWEEN SAWPA AND SAN BERNARDINO VALLEY MUNICIPAL WATER DISTRICT (SC#2023.9)</u>

Ian Achimore provided a presentation titled Forest First and Headwaters Resiliency Partnership Overview, contained in the agenda packet on pages 73-79. An overview of the Forest First partnership between SAWPA, the Cleaveland National Forest, and the San Bernardino National Forest was given. The Forest First next steps include ongoing coordination with national forests to identify mutually beneficial projects, regular engagement with the forest service for operations and monitoring activities like stream water quality and aerial imagery, involving additional partners such as downstream water agencies and municipalities, and collaborating with national forests on the Santa Ana River Watershed Climate Adaptation and Resilience Plan.

Chris Jones, from San Bernardino Valley Municipal Water District, provided a presentation titled Headwaters Resiliency Partnership, contained in the agenda packet on pages 81-95. An overview of the headwaters management efforts was provided.

This item was for discussion purposes; no action was taken on Agenda Item No. 6.C.

D. <u>WEATHER MODIFICATION PILOT PROGRAM UPDATE (SC#2024.4)</u>

Rachel Gray provided a presentation titled Santa Ana River Weather Modification Pilot Program Status Update, contained in the agenda packet on pages 99-121. A brief background on the beginning of the Weather Modification Pilot Program (Pilot Program) was provided. The pilot project began on November 15, 2023.

SAWPA is working with the Desert Research Institute (DRI) on the validation aspect of the Pilot Program. DRI will independently review the cloud seeding pilot operations and verify the resulting increases in precipitation and stream flows.

This item was for discussion purposes; no action was taken on Agenda Item No.6.D.

7. GENERAL MANAGER REPORT

No additional comments.

8. CHAIR'S COMMENTS/REPORT

No additional comments.

9. COMMITTEE MEMBERS' COMMENTS

Committee member Robertson would like to provide a future presentation to this Committee regarding the Inland Empire Utilities Agency and the City of Rialto's recycled water collaboration efforts.

10. REQUEST FOR FUTURE AGENDA ITEMS

There were no comments.

11. ADJOURNMENT

The meeting ended at 12:29 p.m.

APPROVED: September 26, 2024

____
Brenda Dennstedt, Convener

Attest:

____
Zyanya Ramirez, Executive Assistant II

One Water One Watershed

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OWOW STEERING COMMITTEE

REGULAR MEETING MINUTES

MAY 23, 2024

Committee Members	
Santa Ana Watershed Project Authority Representatives	
Brenda Dennstedt, Convener, Western Municipal Water District	Present
T. Milford Harrison, San Bernardino Valley Municipal Water District	Present
County Supervisor Representatives	
Vicente Sarmiento, Orange County Board of Supervisors	Absent
Karen Spiegel, Riverside County Board of Supervisors	Absent
Jesse Armendarez, San Bernardino County Board of Supervisors	Absent
County Municipal Representatives	
Deborah Robertson, Mayor, City of Rialto	Absent
Wes Speake, Councilmember, City of Corona	Present
Nicholas Dunlap, Mayor Pro Tem, City of Fullerton	Absent
Business Community Representative	
James Hessler, Director of West Coast Operations, Altman Plants	Present
Environmental Community Representative	
Garry W. Brown, President, Orange County Coastkeeper	Absent
Regional Water Quality Control Board Representative	
William Ruh, Regional Water Quality Control Board	Present

Others Present	
SAWPA COMMISSIONERS:	Bruce Whitaker, Jasmin Hall, Gil Botello
SAWPA STAFF:	Ian Achimore, Jeff Mosher, Marie Jauregui, Pete Vitt, Rachel Gray, Rick Whetsel; Sara Villa, Zyanya Ramirez
OTHERS PRESENT:	Adekunle Ojo, San Bernardino Valley Municipal Water District; Amber Smalley, Riverside County; Andrew D. Turner, Lagerlof LLP; Christy Suppes, Orange County Public Works; Eddie Lin, Inland Empire Utilities Agency; Melissa Matlock, Western Municipal Water District; Toyasha Sebbag, City of Rialto.

The OWOW Steering Committee meeting was called to order at 11:00 a.m. by Convener Brenda Dennstedt, Convener, at the Santa Ana Watershed Project Authority, 11615 Sterling Avenue, Riverside, CA 92503.

1. CALL TO ORDER | PLEDGE OF ALLEGIANCE

2. ROLL CALL

3. PUBLIC COMMENTS

There were no public comments; there were no public comments received via email.

4. ITEMS TO BE ADDED OR DELETED

5. CONSENT CALENDAR

A. APPROVAL OF MEETING MINUTES: MARCH 28, 2024

B. PROPOSITION 1 STATUS UPDATE (SC#2024.5)

Due to lack of quorum, Agenda Item No. 5 will be brought before the Committee for consideration at a future meeting.

6. BUSINESS ITEMS

A. INTEGRATED CLIMATE ADAPTATION AND RESILIENCY PROGRAM REGIONAL RESILIENCE PLANNING AND IMPLEMENTATION GRANT PROGRAM: DEVELOPMENT OF THE SANTA ANA WATERSHED CLIMATE ADAPTATION AND RESILIENCE PLAN (SC#2024.6)

Rachel Gray provided a PowerPoint presentation titled Round 1 Regional Resilience Grant Program – ClimateShed Resilience contained in the agenda packet on pages 37-46.

In the OWOW Steering Committee meetings held on July 27, 2023, and November 16, 2023, staff outlined a strategy to enhance the One Water One Watershed (OWOW) Plan with a new Regional Climate Adaptation and Resilience Plan (Plan). This Plan aims to address climate risks such as drought and wildfire by defining watershed-scale vulnerabilities, developing adaptation strategies, and creating a portfolio of resilience projects. Stakeholder input will be crucial throughout the adaptation analysis phase, with the Watershed Resilience Technical Advisory Committee (WRTAC) focusing on programmatic approaches and prioritization criteria, while the Watershed Resilience Community Advisory Panel (WRCAP) will ensure community engagement. The goal is to integrate equity outcomes for underrepresented communities and forge broad-based partnerships to advance shared interests across the watershed.

Staff applied for and received grant funding from the Integrated Climate Adaptation and Resiliency Program Regional Resilience Planning and Implementation Grant Program. This funding will support multi-beneficial projects aimed at increasing watershed resilience. The regional Plan will highlight the interconnectivity of projects, considering affordability and climate vulnerabilities faced by underrepresented communities, and establish connections between resilience initiatives and equitable outcomes. The RRGP will invest in capacity building, planning, and project implementation to address climate risks. Both the WRTAC and WRCAP will guide the planning process, incorporating a range of perspectives to ensure effective and collaborative resilience strategies.

Jeff Mosher pointed out that the plan is not a SAWPA plan, it is designed for member agencies and aims to position everyone in the watershed for future state grants.

This item was for discussion purposes; no action was taken on Agenda Item No. 6.A.

B. <u>OVERVIEW OF GRANT APPLICATION FOR INTEGRATED CLIMATE ADAPTATION AND RESILIENCY PROGRAM ADAPTATION PLANNING FUNDING (SC#2024.7)</u>

Ian Achimore provided a presentation titled Overview of Grant Application for Integrated Climate Adaptation and Resiliency Program Adaptation Planning Funding contained in the agenda packet on pages 49-60.

SAWPA staff is applying for a grant from the Governor's Office of Planning and Research (OPR) Integrated Climate Adaptation and Resiliency Program's (ICARP) Adaptation Planning Grant Program (APGP), with a submission deadline of June 3, 2024. This grant supports tribal, local, and regional climate-related planning, aids in identifying climate resilience priorities, and funds resilient infrastructure projects statewide. The grant amounts range from $100,000 to $650,000, with a total of $9,500,000 available, and no local match is required.

The grant application aligns with state priorities and aims to secure future funding opportunities. The proposed project is the Santa Ana River Watershed Regional Invasive Species Management Plan (the plan), focusing on addressing the invasive species Arundo donax (Giant reed). The project will include public outreach on invasive species, analysis of their ecological impacts, creation of a strategic plan and workgroup, and aerial mapping for monitoring. The plan aims to request $650,000 in funding and is scheduled to start in December 2024 and finish in December 2026. Removing Arundo donax is expected to save approximately 20 acre-feet of water per year.

Jeff Mosher noted that the grant application, approved by the SAWPA Commissioners, is part of ongoing watershed-wide Arundo management efforts, aimed at accessing regional climate adaptation funding. He stressed the need for a regional approach, as previous efforts have been fragmented. Mr. Achimore added that they are recruiting partners for the plan, with mapping showing more work is needed than initially thought. The plan will form a regional coalition and create a workgroup and strategic plan to coordinate efforts across multiple entities. The application is due June 3, 2024, with awards expected by summer 2024.

Committee member Milford Harrison raised concerns about focusing on studies instead of immediate Arundo removal, questioning why efforts aren't solely on removal. Mr. Mosher explained that while individual projects have been done, a regional approach has been missing. He noted that some organizations, like OCWD, have been active, but others, like the Army Corps of Engineers, are just becoming interested. He also mentioned that CAL FIRE has its own program, and a regional collaboration would be more effective. Committee member Harrison then asked if Arundo travels past Seven Oaks Dam, and Jeff replied that it's being investigated, but the dam likely acts as a barrier, making it logical to start removal efforts there. Committee member Speake agreed, stressing the importance of proper Arundo removal and treatment, especially after storms.

Convener Brenda Dennstedt added that Arundo is fast-growing, abrasive, highly flammable, and consumes large amounts of water. Committee member Harrison suggested that using drones would be a good method for monitoring and treating the plant, with Mr. Mosher agreeing that the master plan would incorporate advanced methods.

This item was for discussion purposes; no action was taken on Agenda Item No. 6.B.

C. SANTA ANA RIVER WATERSHED WEATHER MODIFICATION PILOT PROGRAM UPDATE (SC#2024.8)

Rachel Gray provided a presentation titled Santa Ana River Watershed Weather Modification Pilot Program Status Update contained in the agenda packet on pages 125-154.

On July 19, 2022, the SAWPA Commission awarded contracts to North American Weather Consultants Inc. for the Santa Ana River Watershed Weather Modification Pilot Project and to the Desert Research Institute (DRI) for independent validation of the project. The four-year pilot, running from November 15 to April 15 each winter starting in 2023, focuses on cloud seeding in four target areas to increase snow precipitation. Since the project's initiation in August 2022, site access agreements were secured, biological surveys were completed, and cloud seeding units were installed. The first operational year began in November 2023, with 12 storms seeded, and lessons learned included improved communication with fire departments, public transparency, and equipment troubleshooting.

DRI is conducting independent validation of the cloud seeding project, focusing on evaluating operations, analyzing snow chemistry, calculating the snow-water equivalent, conducting statistical analyses, and assessing stream flow impacts to measure the effectiveness of increasing precipitation and stream flows. Results are expected in June, with snow reports from ski resorts contributing to the analysis. A draft schedule will be ready in June, and mobilization for year two will begin once the results are available.

Committee member Bill Ruh asked if there was a plan to inform local cities about cloud seeding. Jeff Mosher responded that they are notifying the county supervisors, but specific outreach to individual cities isn't planned beyond making the information available. Convener Brenda Dennstedt emphasized the importance of being prepared to answer questions from the public.

This item was for discussion purposes; no action was taken on Agenda Item No. 6.C.

D. DISADVANTAGED COMMUNITIES INVOLVEMENT PROGRAM: RESOLUTION REGARDING 2021 URBAN AND MULTI-BENEFIT DROUGHT RELIEF GRANT PROGRAM SET-ASIDE FUNDING (SC#2024.9)

Rick Whetsel provided a presentation titled DWR DACI Program Set-Aside Funding, 2021 Urban and Multi-benefit Drought Relief Grant Program, contained in the agenda packet on pages 159-172.

The SAWPA Commission authorized the submission of a portfolio of water infrastructure projects for up to $5 million in Proposition 1 IRWM Disadvantaged Community Involvement (DACI) Grant Set-Aside funding, as part of the 2021 Urban and Multi-benefit Drought Relief Grant Program. These projects aim to improve water supplies in disadvantaged communities, addressing drought impacts and protecting public health and wildlife. Approved projects include installation of a new water tank by Box Springs Mutual Water Company, rehabilitation of wells for the City of Colton, Devore Water Company, Marygold Mutual Water Company, and the City of Fullerton, with completion dates ranging from 2023 to 2024. While most projects are on schedule, delays have occurred in Colton and Fullerton due to unexpected issues. To mitigate delays, SAWPA is working with project partners and the Department of Water Resources (DWR) to extend the grant timeline to June 2026 and to replace the City of Colton's project with one of similar scope and benefit.

Committee member Milford Harrison thanked everyone on staff and noted that progress on the projects is excellent. He inquired about the likelihood of getting an extension from DWR. Mr. Whetsel responded that preliminary discussions with DWR indicate they are generally supportive of the extension. The extension agreement has been submitted, but approval is taking some time.

This item was for discussion purposes; no action was taken on Agenda Item No.6.D.

7. GENERAL MANAGER REPORT
No additional comments.

8. CHAIR'S COMMENTS/REPORT
No additional comments.

9. COMMITTEE MEMBERS' COMMENTS
Convener Brenda Dennstedt proposed discussing the organization of a walkthrough of one of the projects at a future OWOW Steering Committee meeting. Jeff Mosher agreed and said they would send out a few options for consideration.

10. REQUEST FOR FUTURE AGENDA ITEMS
There were no comments.

11. ADJOURNMENT
The meeting ended at 12:16 p.m.

APPROVED: September 26, 2024

____
Brenda Dennstedt, Convener

Attest:

____
Zyanya Ramirez, Executive Assistant II

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OWOW STEERING COMMITTEE MEMORANDUM NO. 2024.10

DATE: September 26, 2024

TO: OWOW Steering Committee

SUBJECT: Santa Ana River Watershed Sustainability Assessment

PREPARED BY: Haley Gohari, Associate Project Manager

RECOMMENDATION
Receive and File.

DISCUSSION
The Santa Ana River Watershed Sustainability Assessment (Assessment) was developed to provide feedback to decision-makers and stakeholders of the One Water One Watershed (OWOW) Plan regarding how well the six Plan goals are being achieved across the watershed. The six Plan goals from the recently adopted OWOW Plan Update 2018 are (numbers do not indicate ranking of importance):

1. Achieve resilient water resources through innovation and optimization.
2. Ensure high-quality water for all people and the environment.
3. Preserve and enhance recreational areas, open space, habitat, and natural hydrologic function.
4. Engage with members of disadvantaged communities (DAC) to diminish environmental injustices and their impacts on the watershed.
5. Educate and build trust between people and organizations.
6. Improve data integration, tracking, and reporting to strengthen decision making.

The Sustainability Assessment was a component of the California Water Plan Update 2018 (CWP 2018). The effort by the Department of Water Resources (DWR) was to develop indicators to evaluate sustainable water management. In 2018, SAWPA developed qualitative metrics to evaluate the efforts of the watershed in the OWOW Plan Update 2018. SAWPA published the SAR Watershed Sustainability Assessment in 2020. As the Assessment was updated, it was intended to maintain consistency in the indicator definitions and datasets analyzed so changes over time were understood. The ratings represented the watershed's effectiveness in the pursuit of sustainability. The Assessment's ratings reflected trends (that is, scores are relative to past performance) instead of scoring each indicator on its relationship to a desired condition.

SAWPA staff is reviewing the current indicators and data sources and is working with SAWPA member agencies to develop a revised set of watershed indicators. The vision for these indicators moving forward is to establish quantifiable performance indicators that highlight the implementation of water resource management strategies and communicate the health and functionality of the SAR Watershed.

The purpose is to communicate watershed health and functionality, demonstrate effective, efficient, and mindful management of resources throughout the watershed, highlight data integrations, tracking, and reporting as a collaborative effort, and to educate and build trust between public and organizations.

The goals for the indicators are as follows:
- Qualitative
- Straight Forward
- Informative
- Accessible, Frequent Data for updates/maintenance (annually)
- Support our Member Agencies' work
- Accurate representation
- Demonstrates effective water resource management
- Resource for watershed agencies and state agencies

CRITICAL SUCCESS FACTORS
- Continued support from SAWPA's OWOW Steering Committee's decision-making authority as a means of ensuring trust, transparency, and external communications.
- Data and information needed for decision-making is available to all.

RESOURCE IMPACTS
SAWPA internal funding.

Attachments:
1. PowerPoint Presentation

SANTA ANA WATERSHED PROJECT AUTHORITY

Sustainability Assessment Review and Proposed Update

Agenda Item 6.A.

Haley Gohari

Associate Project Manager

September 26, 2024

Overview

- Review 2018-2020 background information on SAR Watershed Assessment (using indicators)
- Review working vision and need for indicators
- Review proposed approach to update indicators
- Review 12 current indicators (and proposed actions)
- Next Steps

Background (2018-2020)

The Sustainability Outlook was a component of the California Water Plan Update 2018 (CWP 2018). The effort by DWR was to develop indicators to evaluate sustainable water management.

In 2018, SAWPA developed qualitative metrics to evaluate the efforts of the watershed in the OWOW Plan Update 2018.

SAWPA published the SAR Watershed Sustainability Assessment in 2020.

As the Assessment was updated, it was intended to maintain consistency in the indicator definitions and datasets analyzed so changes overtime were understood.

The ratings represented the watershed’s effectiveness in the pursuit of sustainability.

The Assessment’s ratings reflected trends (that is, scores are relative to past performance) instead of scoring each indicator on its relationship to a desired condition.

SAR Watershed Sustainability Assessment: *Working Vision*

Establish quantifiable **performance indicators** that highlight the implementation of water resource management strategies and communicates the health and functionality of the SAR Watershed.

Goals for Indicators

- Qualitative
- Straight Forward
- Informative
- Accessible, Frequent Data for updates/maintenance (annually)
- Support our Member Agencies' work
- Accurate representation
- Demonstrates effective water resource management
- Resource for watershed agencies and state agencies

Purpose for Indicators in SAR Watershed

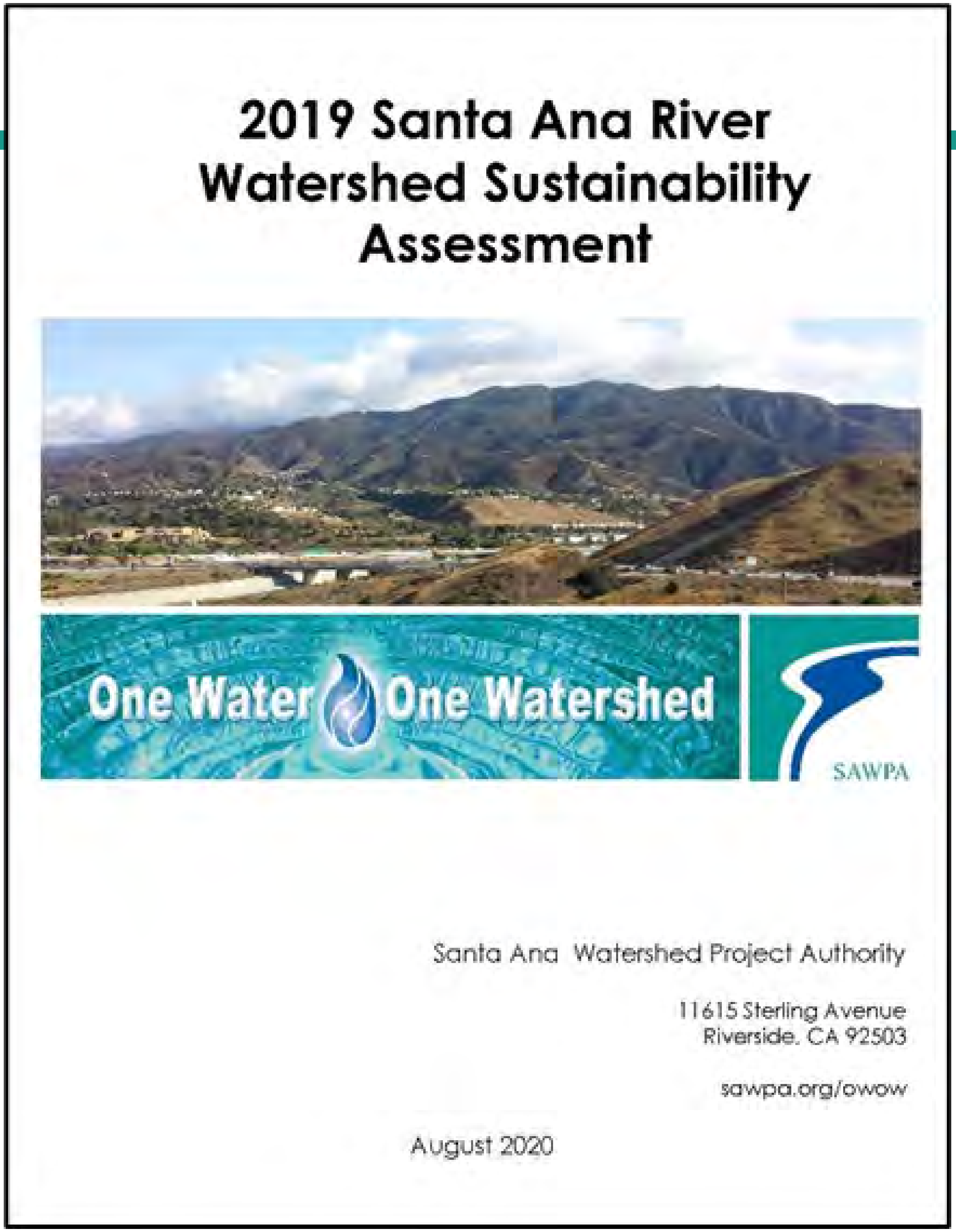
- Communicates watershed health and functionality to stakeholders
- Demonstrates the effective, efficient, and mindful management of resources throughout the watershed
- Highlight data integration, tracking, and reporting as a collaborative effort
- Educate and build trust between public and organizations

Proposed Approach to Updating Indicators

1. Review 12 indicators in 2020 Assessment
2. Investigate possible new indicators (and data sources)
3. Develop climate resiliency indicators in CARP process
4. Develop approach for communicating results (e.g., Dashboard)

Review Current Indicators

1. Maximization of locally-managed supplies
2. Efficiency of Outdoor Water Use
3. Maintenance of GW Salinity at Target Levels
4. Safety of Water Contact Recreation
5. Abundance of Riparian Vegetation
6. Abundance of Conserved Open Space
7. Equitable Access to Clean Drinking Water
8. Equitable Implementation of Climate Change Adaptation
9. Collaboration for more effective outcomes
10. Adoption of a Watershed Ethic
11. Broaden access to data for decision making
12. Participation in an open data process



Summary of Recommendations

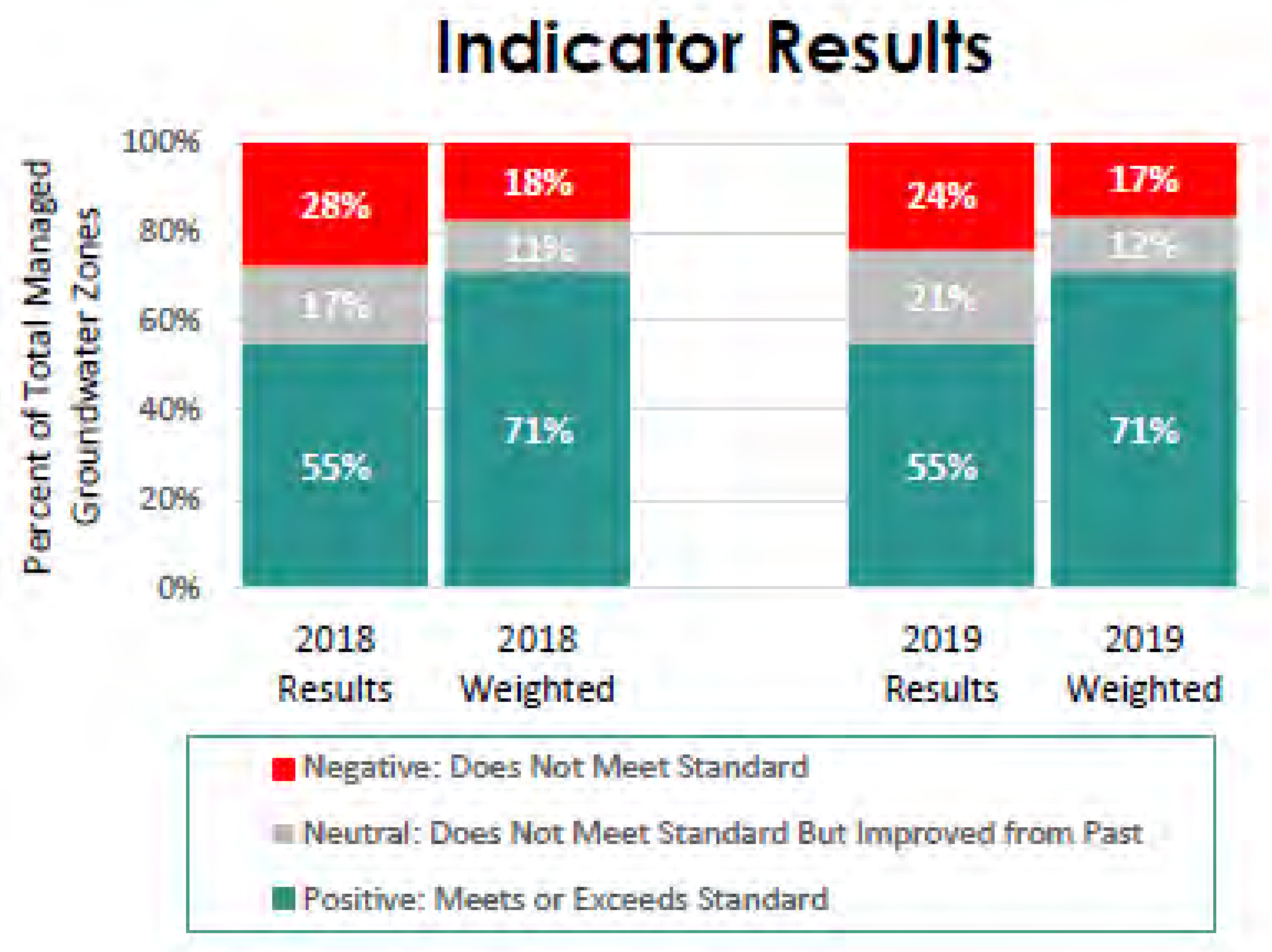
Maximization of locally-managed supplies	Data to Inform Two New Indicators: Potable Water Delivered Annually & Imported Water Supply Annually
Efficiency of Outdoor Water Use	Reconfigure Methodology; Evaluate Data Sources
Maintenance of GW Salinity at Target Levels	Reconfigure Methodology
~~Safety of Water Contact Recreation~~	No Longer Meaningful
Abundance of Riparian Vegetation	Reconfigure Methodology; Evaluate Data Sources
~~Abundance of Conserved Open Space~~	No Longer Meaningful; No Comparable Data Source
~~Equitable Access to Clean Drinking Water~~	No Longer Meaningful
Equitable Implementation of Climate Change Adaptation	Reconfigure during CARP
~~Collaboration for more effective outcomes~~	No Longer Meaningful
Adoption of a Watershed Ethic	Rename: Annual Avg GPCD
~~Broaden access to data for decision making~~	No Longer Meaningful; No Comparable Data Source
~~Participation in an open data process~~	No Longer Meaningful; No Comparable Data Source

Indicator #3: Maintenance of Groundwater Salinity at Target Levels

- **Purpose:** Demonstrate effective water resources management efforts that have improved watershed-wide water quality

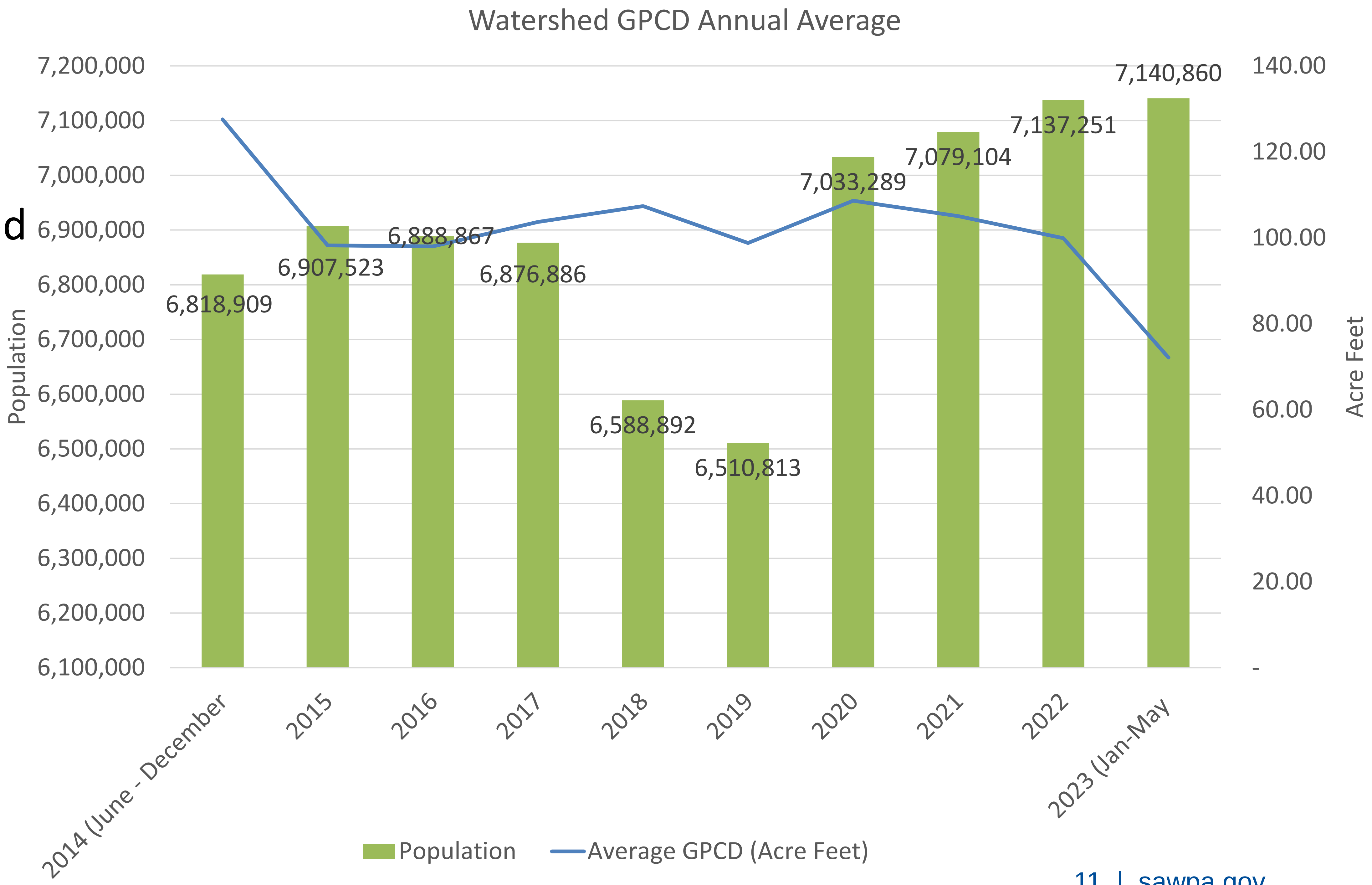
- **Recommendation:**
  - New Methodology: Average trends in average watershed concentrations for TDS and TIN, displayed separately, year over year.
  - Rename indicator

- **Data Source:** Basin Monitoring Program Task Force Ambient Water Quality data



Indicator #10: Adoption of a Watershed Ethic

- **Purpose:** Shows impact of water conservation efforts by Watershed as GPCD declines even with Population increasing over time.
- **How It's Measured:** Gallons of water used per person per day.
- **New Data Source:** DWR Urban Water Supplier WUE Data
- **Recommendation:**
  - New Methodology: Calculate Annual Average GPCD as trendline overlay of watershed population counts
  - Rename indicator



Conceptual Ideas for New Indicators

Water Supply

- Groundwater Recharged, by type
- Recycled Water (Total Treated)
- Recycled Water (Discharged to Surface Water)
- Imported Water (Split from #1)
- Desalinated Water Totals (and Recharged)
- Stormwater Captured
- Stormwater Recharged
- Reservoir levels
- Surface Water Flows

Water Quality

- Desalinated Water Volume

Environmental

- *Arundo donax*/Invasive Species Removal
- Maintained wetlands

Climate

- Number of Daily Average Temperatures over 100 degrees
- Monthly Precipitation Totals, year over year
- Annual Wildfire Incidents Count

Next Steps…

- Finalize analyses and provide determinations for current set of indicators
- Develop potential list of indicators and applicable data sources
- Work with SAWPA member agencies and watershed stakeholders to identify and select indicators

Thank You

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OWOW STEERING COMMITTEE MEMORANDUM NO. 2024.11

DATE: September 26, 2024

TO: OWOW Steering Committee

SUBJECT: Integrated Climate Adaptation and Resiliency Program Regional Resilience Planning and Implementation Grant Program: Development of the Santa Ana River Watershed Climate Adaptation and Resilience Plan - Workflow

PREPARED BY: Rachel Gray, Water Resource and Planning Manager

RECOMMENDATION
Receive and File.

DISCUSSION
Staff is developing a strategy to supplement the One Water One Watershed (OWOW) Plan with a Regional Climate Adaptation and Resilience Plan (Plan). The Plan would define watershed-scale climate risks and vulnerabilities, develop climate adaptation strategies, develop a portfolio of planned and potential resiliency projects, connect the equity outcomes for underrepresented communities, and strengthen broad-based partnerships that advance shared interests across the watershed.

Staff applied for grant funding from OPR for the Integrated Climate Adaptation and Resiliency Program Regional Resilience Planning and Implementation Grant Program and was chosen to receive grant funding.

The Plan would advance multi-beneficial projects with a diverse range of stakeholders with a common goal to increase resilience in the watershed. The regional Plan would daylight the interconnectivity of individual and regional projects and demonstrate the upstream/downstream benefits while building on types of stakeholders engaged in the plan development. The regional Plan would also consider affordability risks and underrepresented communities related to climate vulnerabilities and establish a clear connection between resilience initiatives and equitable outcomes. This effort would provide benefits to a wide array of stakeholders (member agencies, utilities, cities, communities) and provide a mechanism for future funding from a variety of funding sources for implementation of projects that advance watershed resilience.

Over multiple funding rounds, the RRGP will invest funding into regions advancing resilience and responding to their regions' greatest climate risks through three major activities: capacity building, planning (including identifying climate resilience priorities), and project implementation.

The roles of each entity are described below:

- SAWPA (lead applicant) brings a proven track record of working with public agencies in the region; developing, tracking and implementing large-scale grant programs; and supporting integrated water resources management in the SARW. SAWPA will provide administrative and technical oversight of the project.

- ISC3 (co-applicant) brings a proven track record of connecting and building the capacity of local government, utilities, and CBOs across the region. ISC3 is responsible for managing CBOs and soliciting community feedback in the watershed.

- Soboba (co-applicant) brings a proven track record supporting integrated water resources management planning and engaging with tribal communities. Soboba will provide the tribal perspective on climate vulnerabilities, underlying risk factors, and identifying adaptation strategies in support of tribal communities.

- Consultant: facilitate agency engagement and provide support to co-applicants, develop plan by performing a data request and implementing an engagement strategy.

Near-Term Schedule:

Task	Timeline
Execute Grant Agreement	July 2024
Execute MOU and Sub-Grantee Agreements	September 2024
Approval for RFP	October/November 2024
Consultant Selection	December 2024

CRITICAL SUCCESS FACTORS

- Leverage existing information for the benefit of SAWPA, its members, and other stakeholders.

- Active participation of a diverse group of stakeholders representing counties, cities, and water districts, as well as the tribal communities and the regulatory, community-based, and environmental justice communities who integrate the different interests in the watershed beyond political boundaries. Ensuring all perspectives are heard and valued during the development of the regional climate adaptation and resilience plan.

- SAWPA has a strong reputation and sufficient capacity within SAWPA staff for strategic facilitation, planning, communication, leadership, and community engagement.

RESOURCE IMPACTS

The Santa Ana River Watershed Project Authority has been selected as a Round 1 Grantee for the Regional Resilience Grant Program (RRGP) award of $644,190 for the Santa Ana River Watershed Climate Adaptation and Resilience Plan. There will be no financial impact on member agencies except for staff time in responding to SAWPA staff information requests.

Attachments:

1. PowerPoint Presentation

SANTA ANA WATERSHED PROJECT AUTHORITY

SAWPA

Development of the Santa Ana River Watershed Climate Adaptation and Resilience Plan - Workflow

Agenda Item No. 6.B.

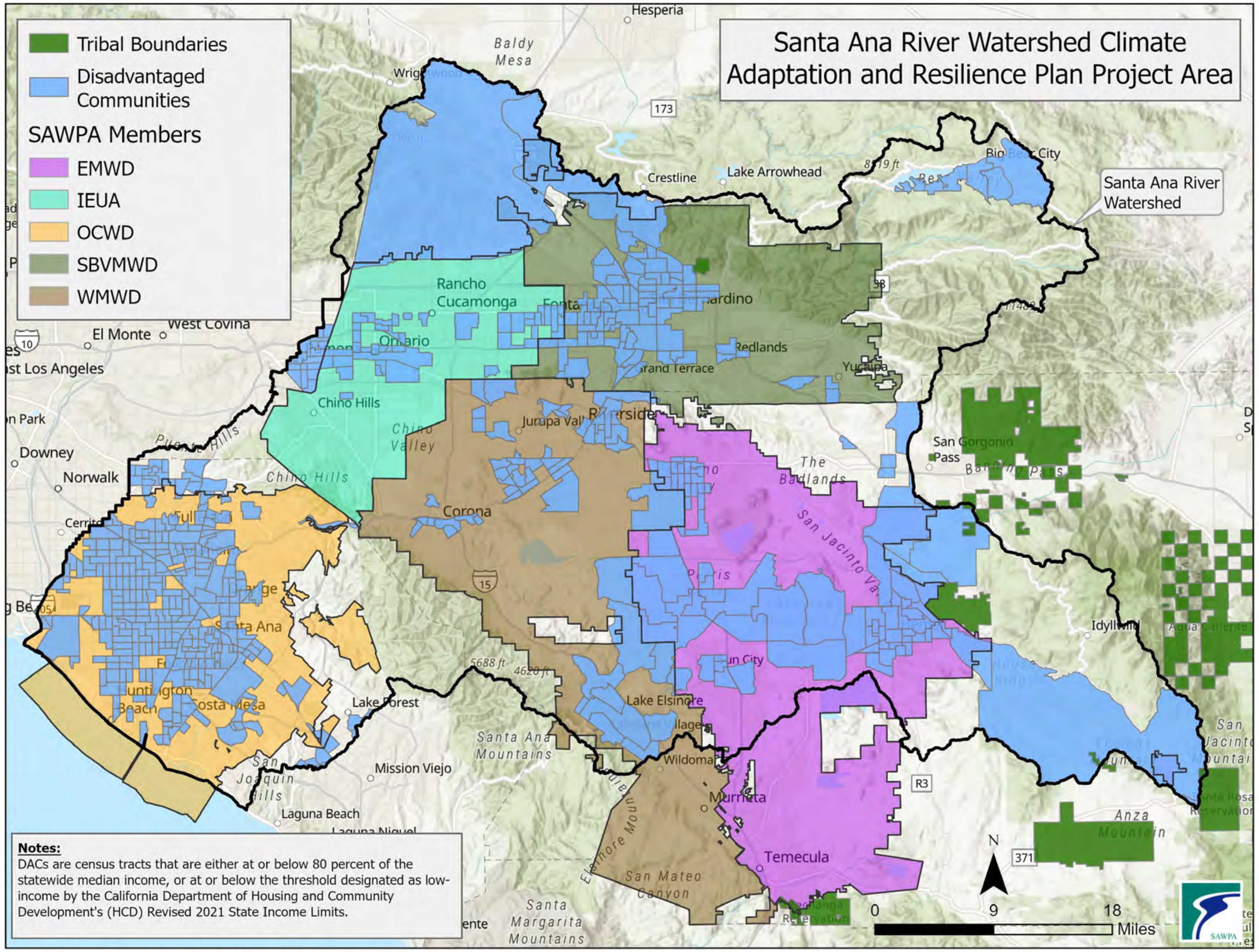
Rachel Gray

Water Resources and Planning Manager

September 26, 2024

Agenda

- Purpose of CARP
- Benefits of CARP
- Roles
- Project Components
- Project Deliverables



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Purpose

- Develop a community-informed, stakeholder-driven, and implementation focused Climate Adaptation and Resilience Plan in support of funding regional planning and implementation projects that address the impacts of climate change risks

Benefits of CARP

Advance watershed resiliency

Define watershed-wide climate risks and vulnerabilities

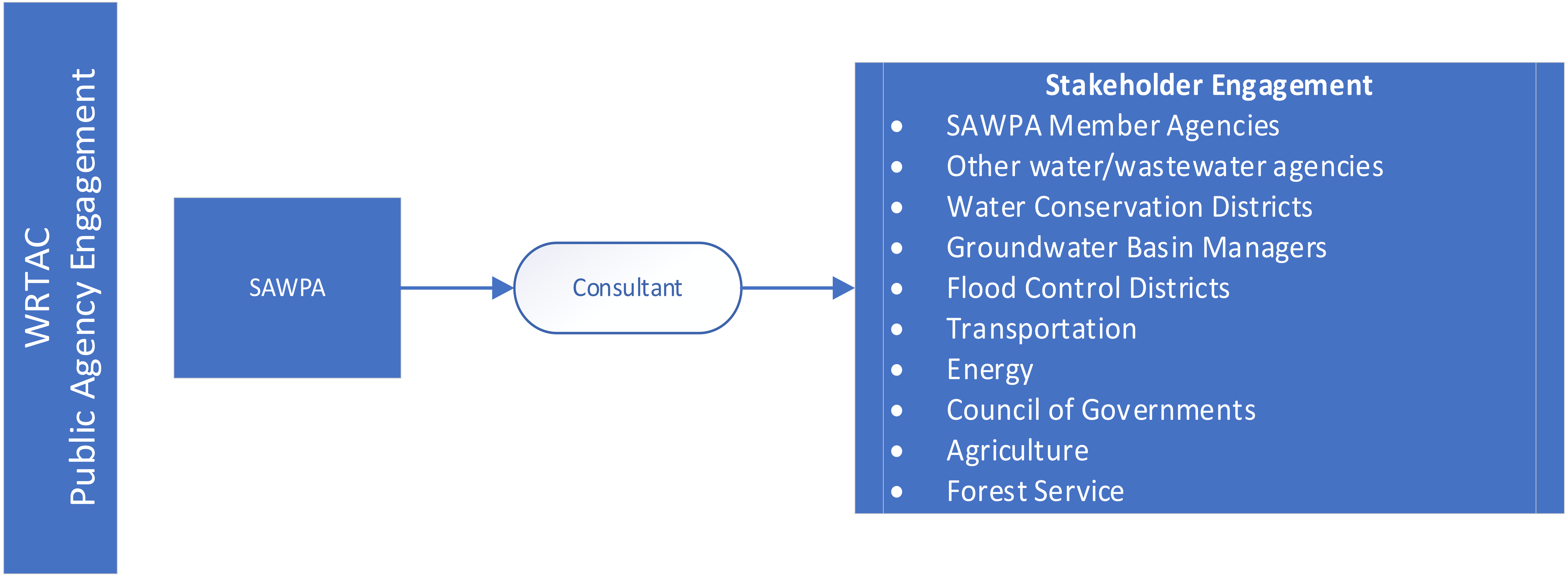
Develop local and regional climate adaptation strategies

Enhance multi-jurisdictional collaboration

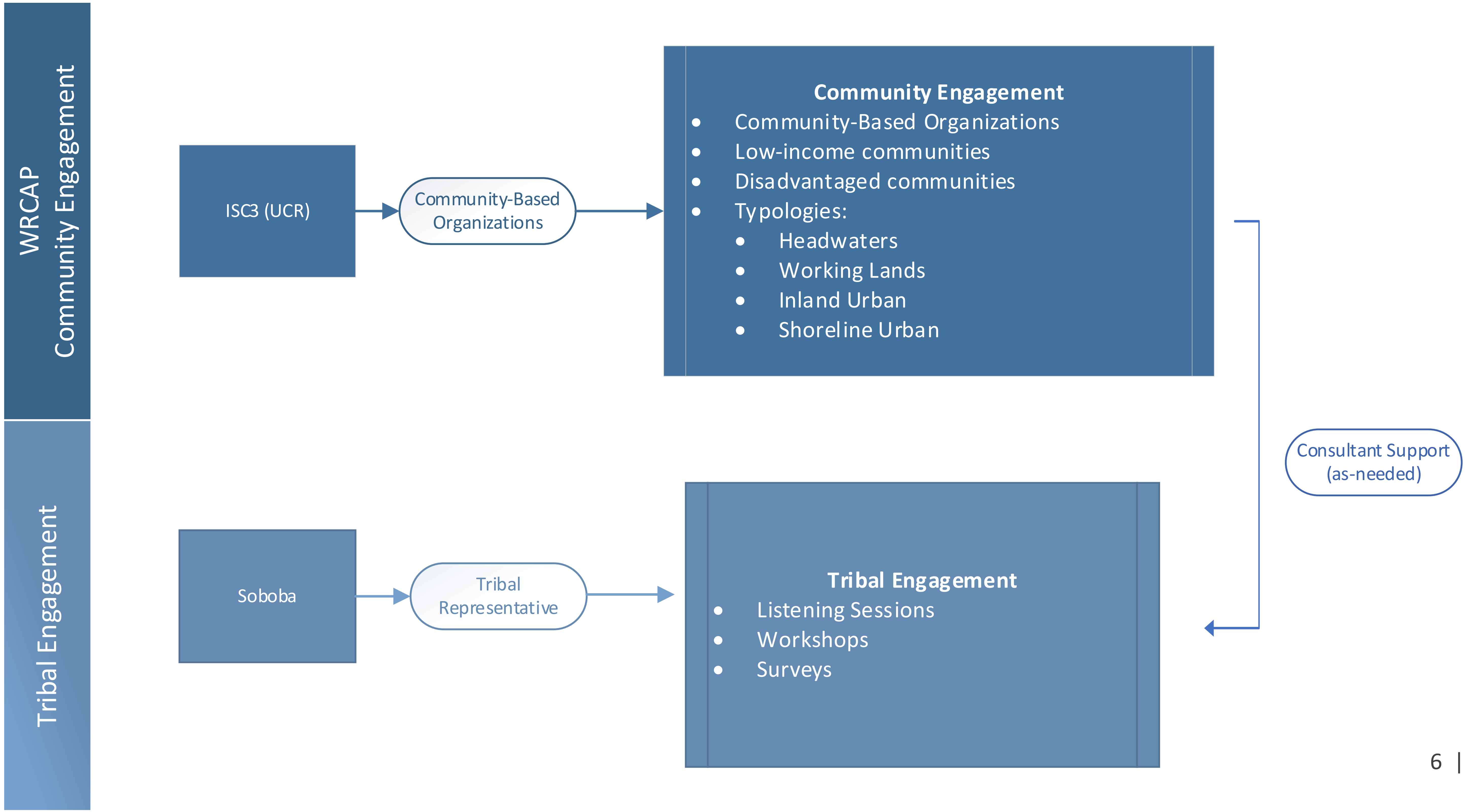
Provide a mechanism for future funding:

- Implement member agency projects
- Implement regional projects

Roles

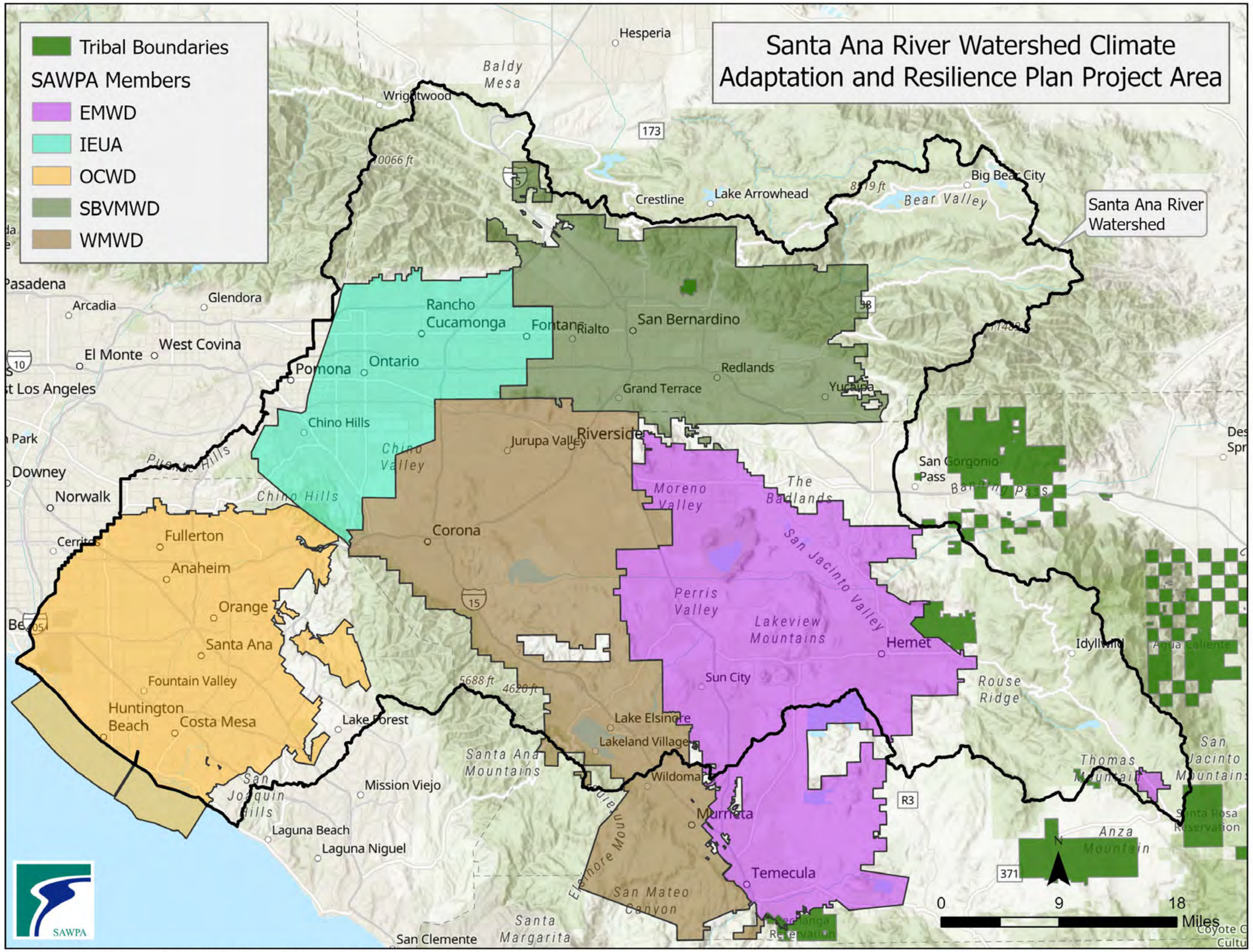

WRTAC
Public Agency Engagement
SAWPA
Consultant
Stakeholder Engagement
SAWPA Member Agencies
Other water/wastewater agencies
Water Conservation Districts
Groundwater Basin Managers
Flood Control Districts
Transportation
Energy
Council of Governments
Agriculture
Forest Service

Roles


WRCAP
Community Engagement
Tribal Engagement
ISC3 (UCR)
Community-Based Organizations
Community Engagement
Community-Based Organizations
Low-income communities
Disadvantaged communities
Typologies:
Headwaters
Working Lands
Inland Urban
Shoreline Urban
Consultant Support (as-needed)
Soboba
Tribal Representative
Tribal Engagement
Listening Sessions
Workshops
Surveys

Soboba

- Tribal Engagement Plan:
  - Tribal Elders
  - Talking Circles
  - Tribal Conferences
- Tribal perspectives on climate vulnerabilities and underlying risk factors that influence sensitivity to climate hazards
- Enhance Soboba's Vulnerability Assessment and Climate Adaptation Analysis (nature-based solutions
- Project builds capacity for tribal engagement



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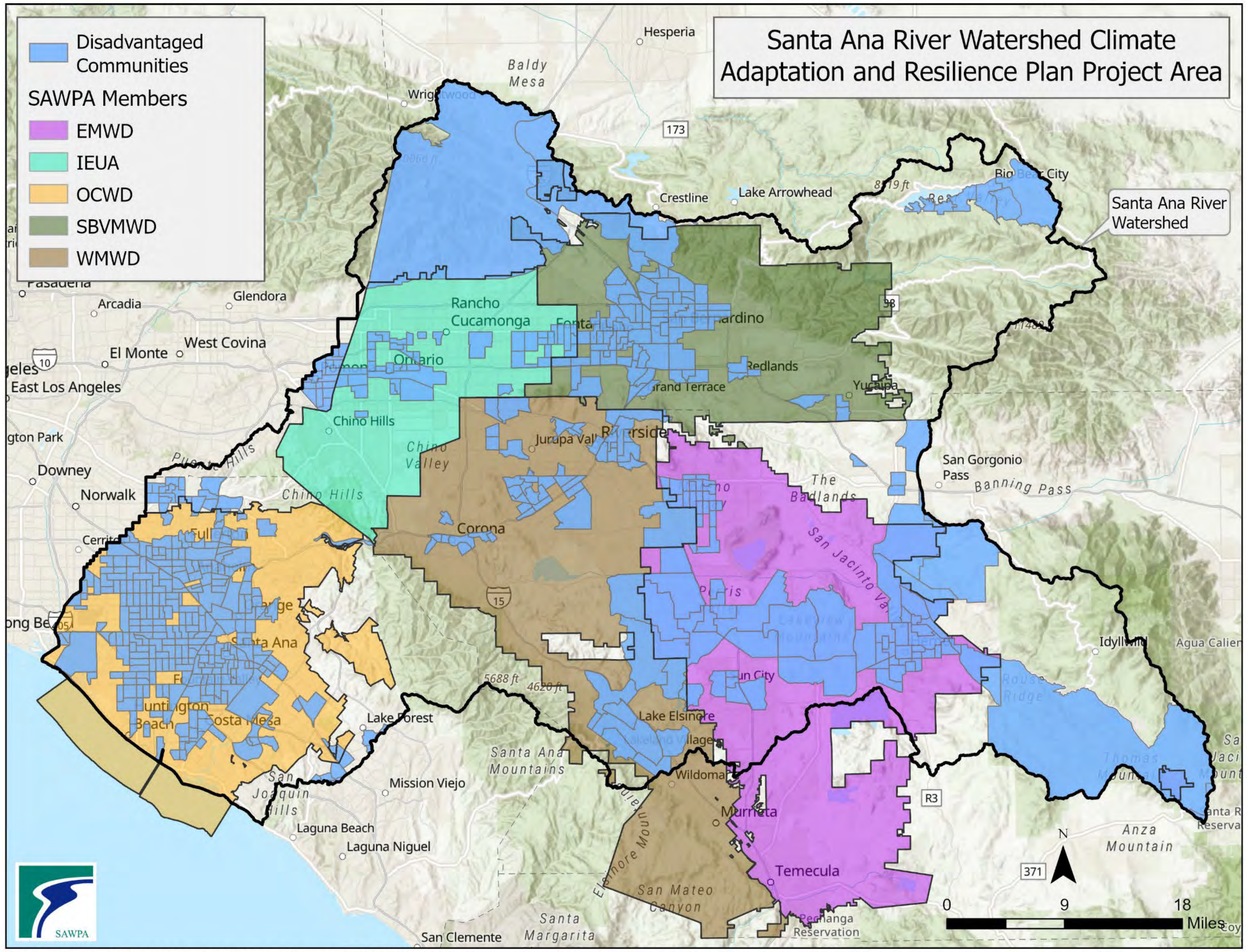
Inland Southern California Climate Collaborative (ISC3)/UCR

- Community Engagement Plan:
  - CBOs
  - Surveys
- Community Outreach:
  - California Rural Water Association
  - Orange County Coast Keepers (including the Inland Empire Water Keepers Program)
  - Santa Ana Watershed Association
  - Climate Action Campaign
  - Accelerate Neighborhood Climate Action
  - R-NOW



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Consultant RFP

- Public Agency Engagement
- Workplan
- Data Request
- Climate Risks
- Climate Vulnerabilities
- Adaptation Analysis
- Resilience Portfolios
- Funding Strategies
- Implementation Plan
- CARP

Public Agency Engagement
(Consultant)

Stakeholders

- SAWPA Member Agencies
- Water/Wastewater Agencies
- Water Conservation Districts
- Groundwater Basin Managers
- Flood Control Districts
- Transportation
- Energy
- Council of Governments
- Agriculture
- Forest Service

Task 1: PM

- Workplan
- Meetings: Kickoff, Project Coordination

Task 2: Engagement

- Climate Risks
- Climate Vulnerabilities
- Adaptation Strategies
- Outreach: Workshops, Surveys

Task 3: Vulnerability Assessment

- Climate Threats (localized and regional)
- Social vulnerabilities
- Watershed vulnerabilities

Linkages

Task 4: Adaptation Analysis

- Resilience Goals and Vision
- Catalog and Characterize Adaptation Options
- Resilience Benefits

Task 5: Implementation Plan

- Resilience Portfolios
- Performance Metrics/Measurements
- Funding Strategy
- Roadmap for implementation

Task 6: Plan Development

- CARP development and approval

Near-Term Tasks

July 2024	August 2024	October 2024	November 2024	December 2024
• Executed Grant Agreement (OPR/SAWPA)	• Execute Sub-Grantee Agreements • Execute MOU	• Release RFP for Professional Consultant Services	• Consultant Selection and Contracting	• Work Plan • Engagement Plan • First Engagement Touchpoint: Climate Risks and Vulnerabilities

SARWCARP Grant Term Timeline

Year	2024												2025												2026											
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Grant Agreement Execution																																				
Consultant RFP Posting																																				
Consultant Proposal Review and Selection																																				
Grant Period Anticipated																																				
SARWCARP Development Process																																				
Apply for RRGP Implementation Grants																																				

Thank You

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OWOW STEERING COMMITTEE MEMORANDUM NO. 2024.12

DATE: September 26, 2024

TO: OWOW Steering Committee

SUBJECT: Santa Ana River Trail and Parkway Update

PREPARED BY: Ian Achimore, Senior Watershed Manager

RECOMMENDATION
Receive and file.

DISCUSSION
From 2006 to 2018, a memorandum of understanding (MOU) was active among the counties of Orange, Riverside, and San Bernardino, cities in the three counties, the Wildlands Conservancy, and SAWPA. This MOU (which was amended twice), was created to facilitate planning, project implementation, reporting and accountability amongst the various entities related to the Santa Ana River Trail and Parkway (SARTP). The parkway is defined as the land within 0.5-mile of the mainstem of the Santa Ana River. The Santa Ana River Trail is envisioned as an approximately 100-mile-long trail that runs from lands within the San Bernardino National Forest to the River's outlet at Huntington Beach.

Under the MOU, SAWPA has participated in a planning group called the SARTP Policy Advisory Group (PAG) which included elected representatives from the MOU members. SAWPA was involved in the SARTP staff-level workgroup from 2006 to 2018 and led the administration of the staff-level workgroup in 2013. The PAG is now discontinued and has been replaced by the Advisory Group to the California Coastal Conservancy. The staff-level workgroup meets occasionally, as needed.

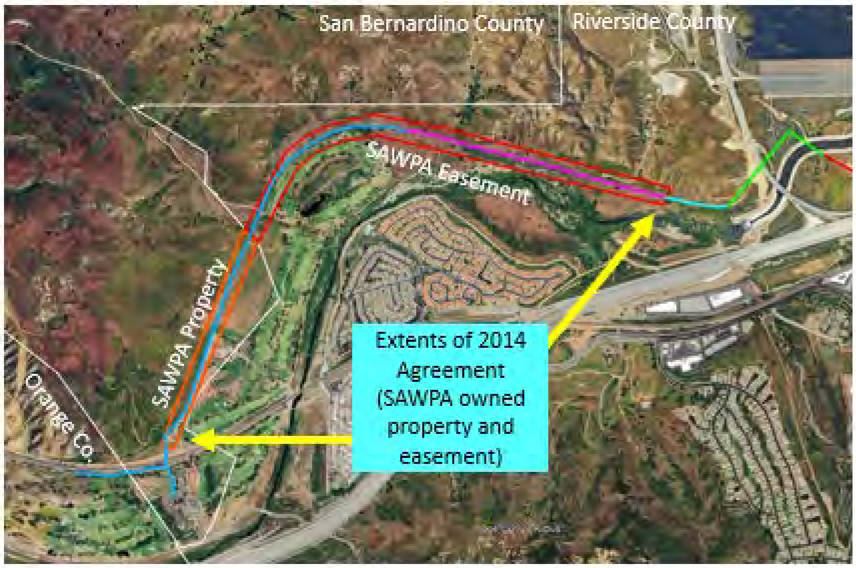
This change came about due to Senate Bill 1390, passed in 2014 which created the Santa Ana River Conservancy (SARCON). SARCON is administered by the California Coastal Conservancy (a State agency) and per the legislation is charged with developing a SARTP implementation plan and creating an Advisory Group comprised of local leaders that have decision-making authority.

SAWPA has the following role in the SARTP and Advisory Group:

- SAWPA has a member on the Advisory Group to the Coastal Conservancy; the current member is Commissioner T. Milford Harrison of San Bernardino Valley Municipal Water District.
- In 2014, a 25-year long operations and maintenance agreement was signed by SAWPA with Riverside County Regional Park and Open-Space District (RivCo Parks) for the segments of the trail (see map below).
- SAWPA coordinates with RivCo Parks on certain trail segment (shown in map as blue lines) construction.

- In 2024, the SAWPA PA 24 Committee approved staff preparing license agreements with AT&T and Southern California Edison to assist in their relocation of utilities within SAWPA property to assist with trail segment (shown in maps as blue lines) construction.

Map of Prado/Green River Golf Course Segment of SARTP



Potential areas for SAWPA to assist with related to the SARTP include:

- Look at large SARTP projects before the Advisory Group to see if there are opportunities to expand the multi-benefit aspects of the projects.
    - Often the focus of SARTP projects is public access, but SAWPA's expertise in water resources can be helpful.
- Assist with outreach to the Federal/State legislatures on SARTP funding needs.
- Assist counties with coordination with property owners who are water agencies on trail construction.
- Lead development of a SARTP website. A website could provide construction updates.

CRITICAL SUCCESS FACTORS
Leverage existing information for the benefit of SAWPA, its members, and other stakeholders.

RESOURCE IMPACTS
None.

Attachments:
1. PowerPoint Presentation

SANTA ANA WATERSHED PROJECT AUTHORITY

Santa Ana River Trail and Parkway Update

OWOW Steering Committee Meeting
Item No. 6.C.
Ian Achimore
Senior Watershed Manager
September 26, 2024

Recommendation

- Receive and file.

Original Purpose of Santa Ana River Trail and Parkway (SARTP) Partnership

- In 1976, the Secretary of Interior deemed portions of the trail in Orange and San Bernardino counties as the “Santa Ana River National Recreational Trail”

- In 2000, the Santa Ana River Symposium backed by the Wildlands Conservancy, National Park Service, and San Bernardino County was held

- In 2006, a MOU was executed to facilitate planning, project implementation, reporting and accountability between SAWPA, the three counties along the Santa Ana River, and the Wildlands Conservancy

- Through the MOU, a policy advisory group (PAG) of elected officials was created, as well as a technical advisory committee of staff.
    - The MOU has been extended two times and expired per direction from PAG in 2018.

New Purpose of SARTP Partnership

- In 2014, Senate Bill 1390 created the Santa Ana River Conservancy (SARCON) which is taking an active role in SARTP completion.
- SARCON (administered by the California Coastal Conservancy), is charged with developing a SARTP implementation plan and creating an Advisory Group comprised of local leaders that have decision-making authority.
- SARTP Implementation Plan was released in 2018 with feedback from SAWPA, member agencies, counties, cities, non-profits and state/federal agencies.

About the Advisory Group

- The Advisory Group, which meets quarterly and has no limit to the amount of members, provides two major functions:

  - Provides local decision-making authority and expertise to guide the Coastal Conservancy as the State agency implements the SARTP Plan and funds various projects that have been highlighted in the SARTP Plan.

  - Provides feedback and information to the Legislature on SARTP funding or assistance as well as existing projects underway.

SARTP Plan Cover

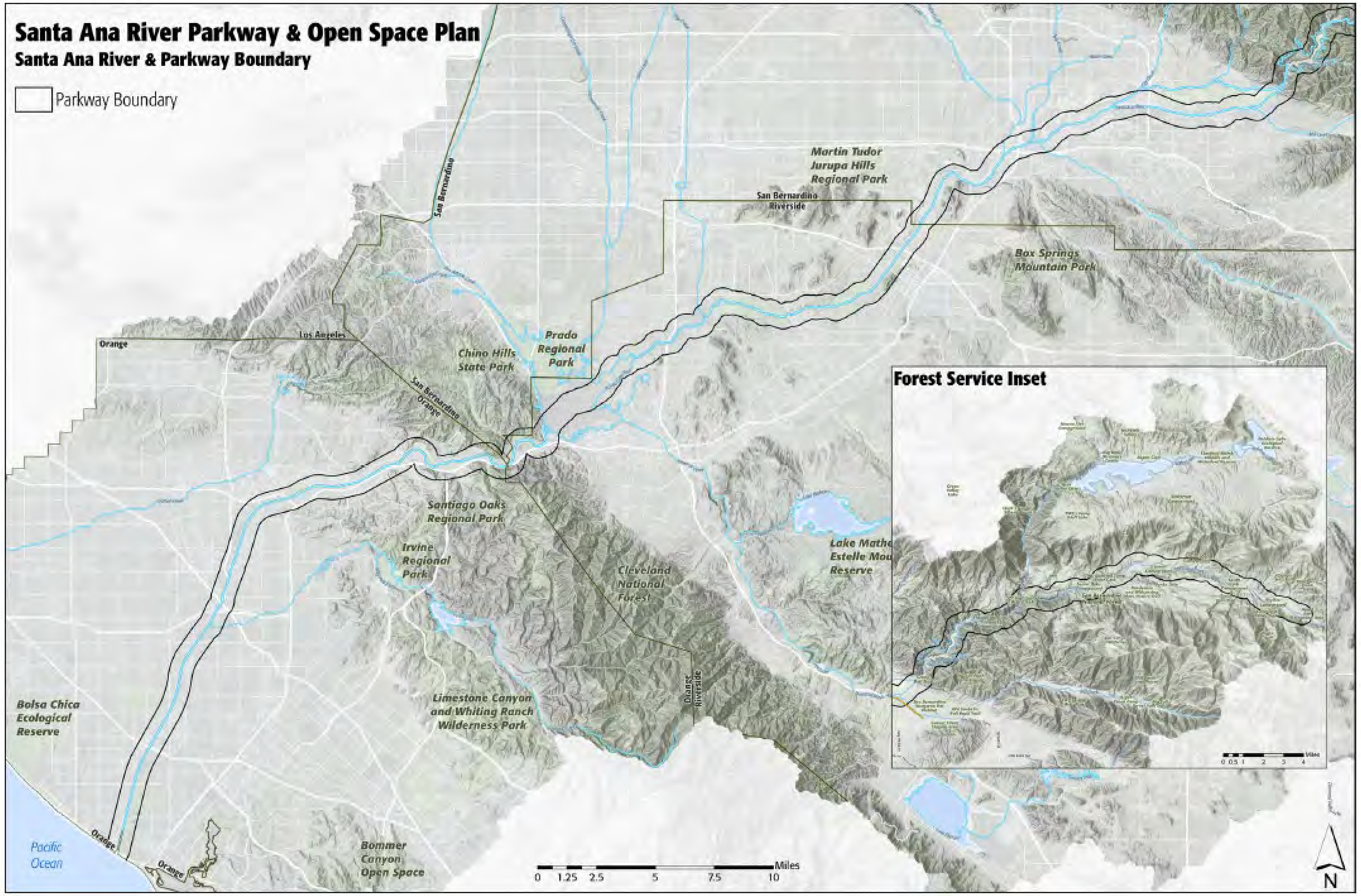
Advisory Group Members (Approved April 2024)

Advisory Group (AG) Member	Title	Representing
Patricia Lock Dawson, Chair of AG	Mayor	City of Riverside
T. Milford Harrison, Vice Chair of AG	Commissioner	SAWPA
Ray Hiemstra, Secretary of AG	Associated Director	Orange County Coastkeeper
Doug Chaffee	Supervisor, 4th District	County of Orange
Dawn Rowe	Supervisor, 3rd District	County of San Bernardino
Karen Spiegel	Supervisor, 2nd District	County of Riverside
Jim Steiner	Councilmember	Corona City
Erin Edwards*	Councilmember	Riverside City
Denise Davis	Councilmember	Redlands City
Stephen Faessel	Councilmember	Anaheim City
Rod Butler	City Manager	Jurupa Valley City
Beahta Davis	Director	San Bernardino Regional Parks
Pam Passow	Director	Orange County Parks
Kyla Brown	Director	Riverside Regional Parks
Frazier Haney	Executive Director	The Wildlands Conservancy
Nicole Padron	Co-Executive Director	Rivers and Lands Conservancy
Rebecca O’Conner	Co-Executive Director	Rivers and Lands Conservancy
Michael Wellborn	Board President	Friends of Harbors, Beaches and Parks

*Not currently on City Council

Trail and Parkway Boundary

Santa Ana River Parkway, defined as the lands within 0.5-mile of the main stem of the Santa Ana River, as shown in the Figure.



SAWPA’s Past Role

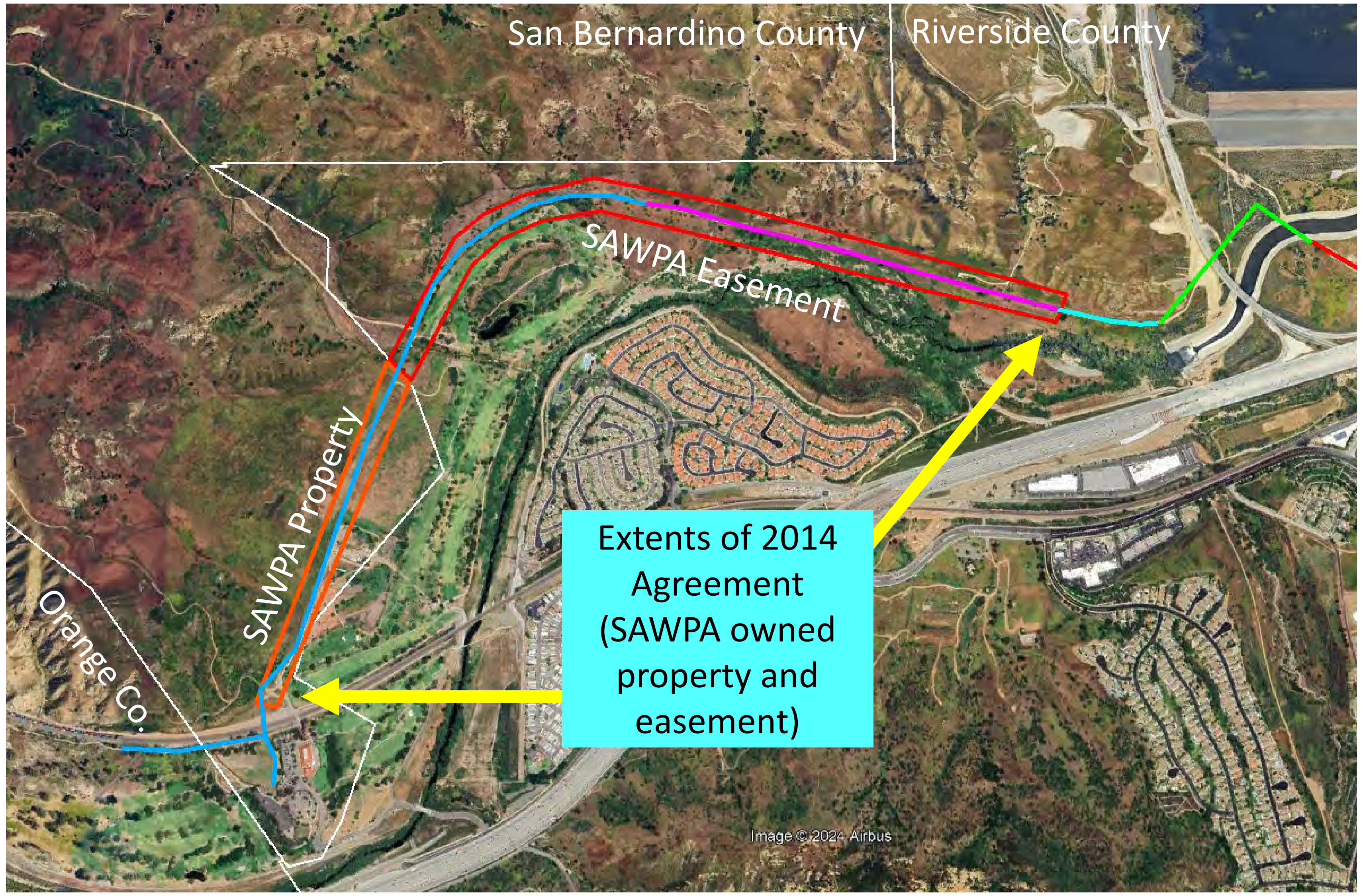
- In 2006, SAWPA hosted a website on the trail partnership.
- SAWPA worked on a recreational trails map for the entire length of the Santa Ana River.
- The staff-level workgroup coordinated on Proposition 50 grant funding in 2006. Ultimately, Riverside County Regional Parks submitted an application for a Proposition 50 grant. Grant funding was received.
- SAWPA hosted Santa Ana River Trail and Parkway staff-level workgroup meetings in 2012.

8

SAWPA's Current Role

- SAWPA has a member on the Advisory Group to the Coastal Conservancy; the current member is Commissioner T. Milford Harrison of SBVMWD
- In 2014, a 25-year long operations and maintenance agreement was signed by SAWPA with RivCo Parks for the segments of the trail (see map).
- SAWPA coordinates with RivCo Parks on trail segment (shown in map as blue lines) construction.
- In 2024, the SAWPA PA 24 Committee approved staff preparing license agreements with AT&T and Southern California Edison to assist in their relocation of utilities within SAWPA property to assist with trail segment (shown in maps as blue lines) construction.

Map of Prado/Green River Golf Course Segment of SARTP



Trail Segments Remaining to Be Constructed

Completion Date of Overall Trail To Be Determined

Orange County = 3 miles

Riverside County = 10 miles

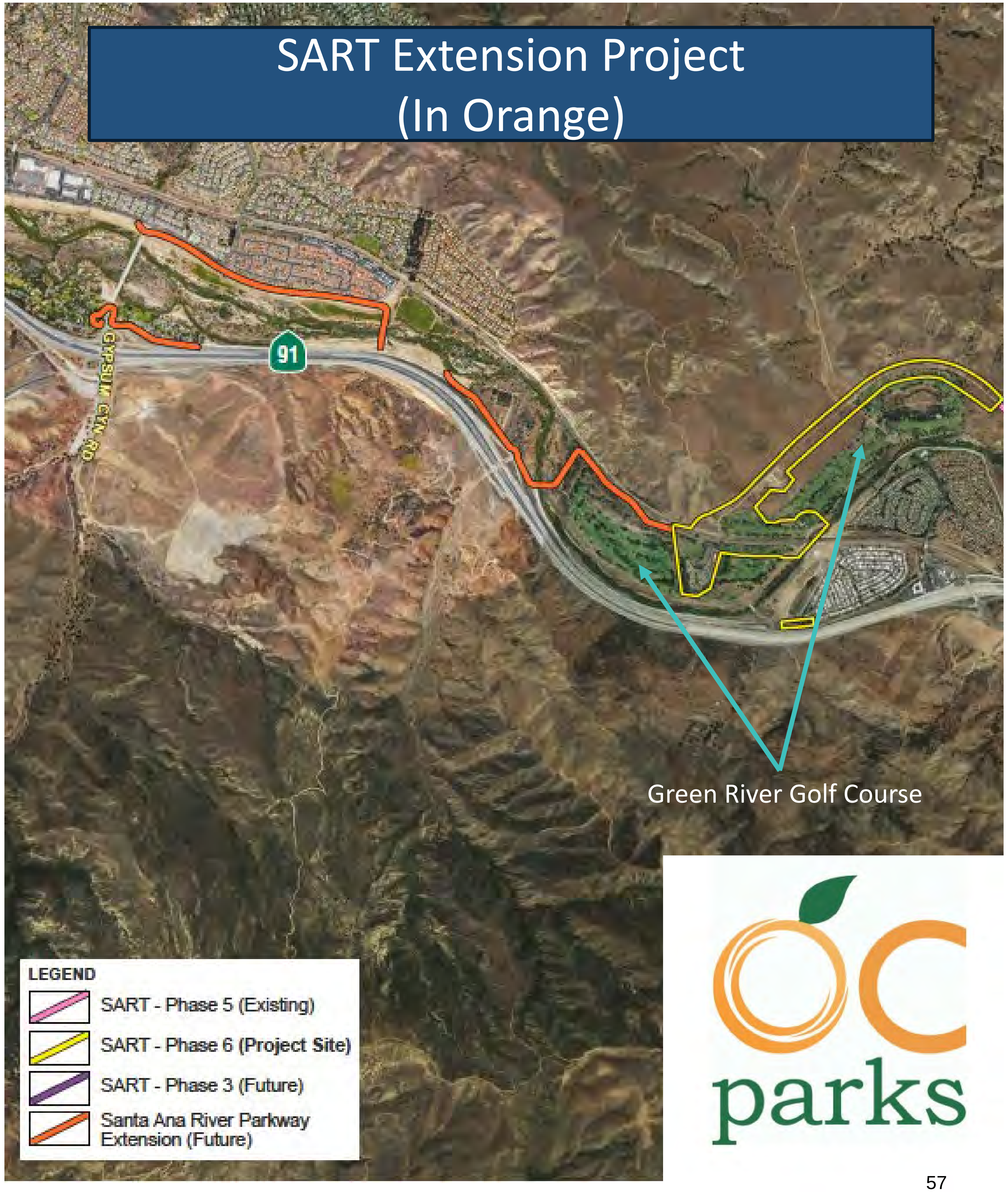
San Bernardino County = 20 miles

Trail Map – Orange County

- Several segments (known as the "SART Extension Project") near Yorba Linda and the Green River Golf Course that have completed design in January 2022

- Grant application submitted by Orange County Parks on September 11, 2024, to Coastal Conservancy for $250,000 to fund a phasing plan, updated cost estimate and regulatory permits Extension Project

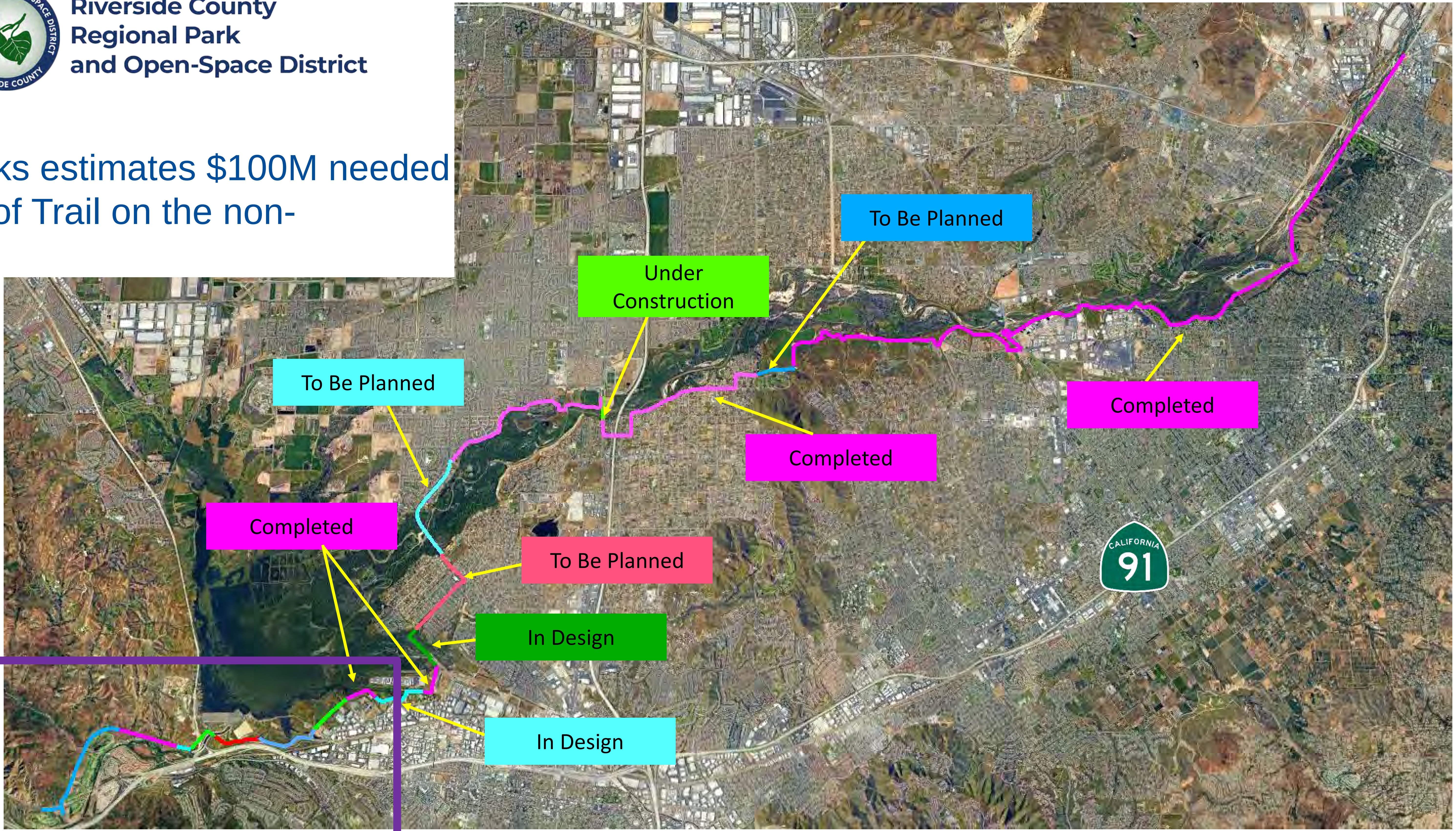
- Construction schedule of Extension Project is TBD. County plans to apply for future funding for construction as well



Trail Map – Riverside County

Riverside County Regional Park and Open-Space District

Riverside County Parks estimates $100M needed to finish construction of Trail on the non-completed segments.



More Detail on These Segments Next Slide

Santa Ana River Trail – Prado Area

Riverside County
Regional Park
and Open-Space District

Santa Ana River Trail – San Bernardino County

- SART 3 (3.8 miles): Construction will resume after bird nesting season in September and is anticipated to be finished in December 2025.

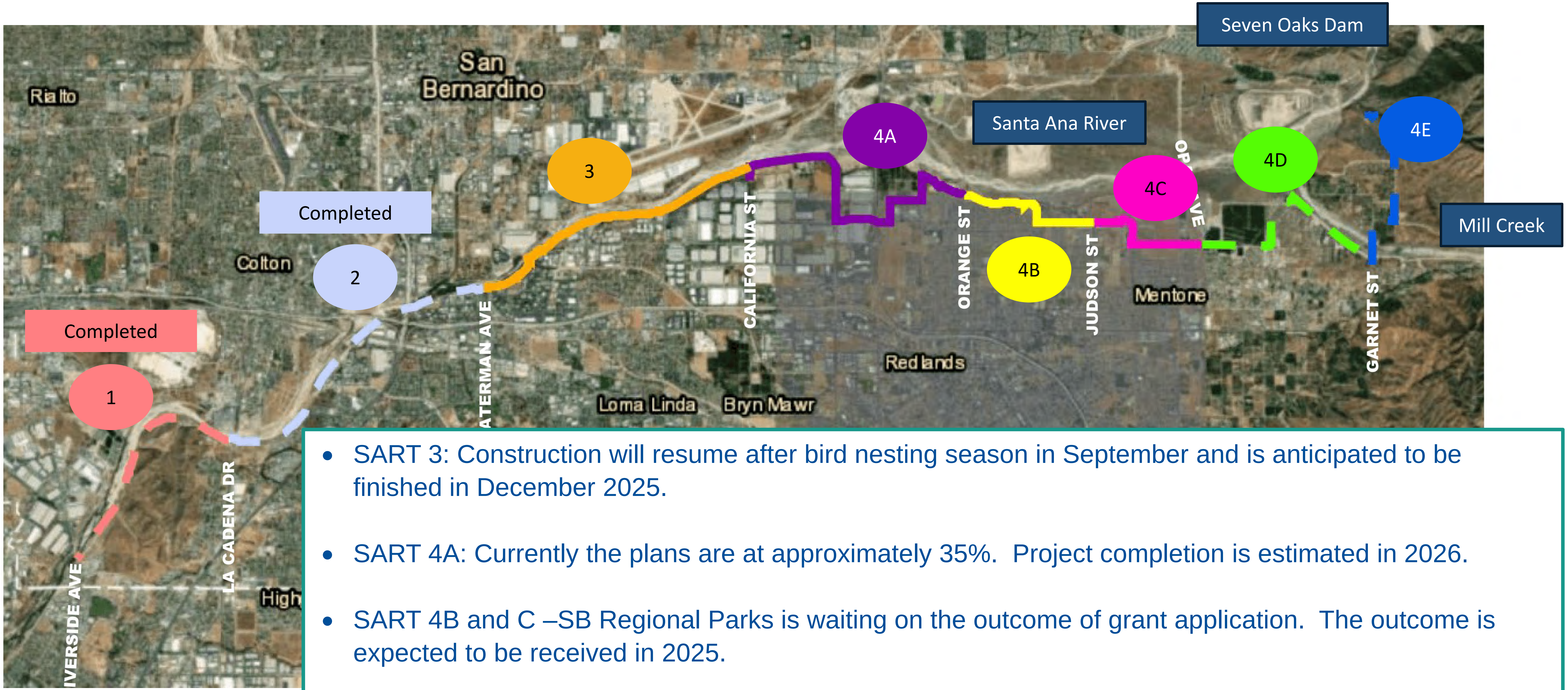
- SART 4A: (3.9 miles) Currently the plans are at approximately 35%. Project completion is estimated in 2026.

- SART 4B and C – (3.3 miles) SB Regional Parks is waiting on the outcome of its Active Transportation Program grant application. The outcome is expected to be received in 2025.

- SART 4D and E – No work has been started.

Santa Ana River Trail
Groundbreaking Ceremony
(January 31, 2024)

Trail Map – San Bernardino County



- SART 3: Construction will resume after bird nesting season in September and is anticipated to be finished in December 2025.
- SART 4A: Currently the plans are at approximately 35%. Project completion is estimated in 2026.
- SART 4B and C –SB Regional Parks is waiting on the outcome of grant application. The outcome is expected to be received in 2025.
- SART 4D and E – No work has been started.

Potential Future Role for SAWPA

- Review large SARTP projects before the Advisory Group to see if there are opportunities to expand the multi-benefit aspects of the projects.
    - Often the focus of SARTP projects is public access, but SAWPA's expertise in water resources can be helpful.
- Assist with outreach to the Federal/State legislatures on SARTP funding needs.
- Assist with grant application for project implementation.
- Assist counties with coordination with property owners who are water agencies on trail construction.
- Lead development of a SARTP website. A website could provide construction updates.

Questions?

Thank You

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OWOW STEERING COMMITTEE MEMORANDUM NO. 2024.13

DATE: September 26, 2024

TO: OWOW Steering Committee

SUBJECT: Santa Ana River Watershed Cloud Seeding Pilot Program: Year 1 Summary

PREPARED BY: Rachel Gray, Water Resources and Planning Manager

RECOMMENDATION
Receive and File.

DISCUSSION
On July 19, 2022, the SAWPA Commission authorized an award of contract with North American Weather Consultants, Inc. (NAWC) to conduct the Santa Ana River Watershed Cloud Seeding Pilot Program operations. Subsequently, the SAWPA Commission authorized an award to the Board of Regents of the Nevada System of Higher Education on behalf of the Desert Research Institute (DRI) for the independent validation of the Santa Ana River Watershed Cloud Seeding Pilot Project.

The Pilot Program is a four-year project spanning the four winter seasons starting in 2023 and running between November 15 and April 15 for each season. The operations are based on past work described in the SAWPA feasibility study published in 2020, updated seeding site analysis, and reflects requirements from CEQA, and comments from SAWPA member agency staff and other stakeholders. The focus of the Pilot Program will be on seeding the four higher elevation target areas identified in the feasibility study surrounding the watershed with an emphasis on increasing precipitation in the form of snow.

Kickoff of the four-year Pilot Program began in August 2022, the following tasks occurred in preparation for the start of Year 1 Operations (November 15, 2023 – April 15, 2024):

Task	Date
Site Access Agreements (11 proponents/ 15 units)	August 2022 – August 2023
Operations Plan (project communication, operational criteria, and suspension criteria)	January – October 2023
Communications Plan	July – November 2023
Preliminary Biological Surveys	July 31, 2023
45-Day Public Notice Submission	September 28, 2023
Final Biological Surveys (10 days before construction)	October 5 – 9, 2023
Equipment Set Up, Propane Tank Delivery, and Equipment Testing	October 9 – 20, 2023
Operator Training	October 23 – 27, 2023

Task	Date
Program Kick Off Meeting	November 1, 2023
FY23-24 Program Start	November 15, 2023
Notification to Local Fire Departments	December 2023 – January 2024
FY23-24 Program End	April 15, 2024
Equipment Collected (summer storage)	May 30, 2024

Year 1 Annual Operations Report for the period November 15, 2023 – April 15, 2024, is attached for your review, a summary of the findings is listed below:

- Sites were selected that were as close to locations from the feasibility study (SAWPA, 2020). In several instances, project sponsors located close to the feasibility study's proposed site locations were selected for installation of the ground-based cloud seeding units.
- Two changes that were made for the Pilot Program that were different than what was presented in the feasibility study (SAWPA, 2020) included the addition of another CNG unit for the Northwest (NW) Target Area, and the switch of one of the CNG sites for the Southeast (SE) Target Area to an AHOGS site, as it was determined that this area may benefit from convective lines pushing in from the coast. This increased the total number of seeding units from 14 to 15, with 12 CNG units and three AHOGS units.
- Meteorological data and models used in seeding operations are acquired from a wide variety of sources, including some subscriber services. This information includes radar data, satellite data (e.g., visible, infrared, water vapor) weather forecast model data, surface observations, rawinsonde (weather balloon) upper-air soundings, and weather cameras. NAWC's meteorologists have access to all meteorological products on a 24-hour basis, allowing for continued monitoring so that seeding operations can be performed at any time of the day or night. The wide variety of available meteorological data products and information provides the data necessary for meteorologists to determine when conditions are appropriate for cloud seeding.
- The 2023-2024 season was active, with 20 storm event periods. Of these, operations of cloud seeding occurred for 13 storm events. Seasonal precipitation is presented in Table 4-2 for selected precipitation gauges within the target areas.
- A total of 13 seeded storm events occurred over a combined period of 22 days. CNG hours and flare usage are documented for each unit during each storm event (Tables 4-1a, b, NAWC, July 2024).
- A total of 2135.25 hours of seeding time from all CNG units was recorded, amounting to 17,092 g of silver iodide (AgI) used for seeding for the season.
- A total of 32 AgI flares were used from the AHOGS units, totaling 640 g of AgI.
- One suspension period occurred during the season; from February 3-8, 2024, as a significant Atmospheric River event affected much of California bringing abundant mountain snow and heavy lower elevation rainfall resulting in significant flooding in some areas.
- A second period of active weather in mid-March 2024 also saw no seeding activity; this was not due to suspension criteria being enacted, but instead due to a wind flow pattern

that the Pilot Program was not set up for as earlier studies showed the pattern to be a rare occurrence.

- Summary of materials used for each unit for each storm event is documented and includes CNG runtime hours and number of flares, AgI used in grams, and acetone used in gallons.

The Pilot Program began on November 15, 2023, and ended on April 15, 2024, for the first operational year. Recommendations based on lessons learned during the first year of operations include:

- Send notices to fire departments in advance of the start of Year 2 Operations.
- Field technician local to the project area is identified and trained to be able to service CNGs and AHOHS units.
- Regularly troubleshoot cloud seeding units for optimal equipment operation.
- Consideration should be given to moving one of the NW1 and NW2 sites further northwest closer to the NW Target area.
- Considerations should be given to the possibility of installing seeding sites on the east and northeast sides of the NE and SE target areas to account for this pattern, with the understanding that these sites may rarely be activated.
- Be transparent with the public about technical studies conducted for cloud seeding.
- Maintain effective communication with sponsors to mitigate site access issues.
- Train backup site operators for continuous unit operations.
- Collaborate with Flood Control Districts for environmental insights.
- Understand the impact of successive storms on infrastructure.

SAWPA is also coordinating the Pilot Program planning with Desert Research Institute (DRI) on the validation competent of the project. DRI is conducting an independent review of the cloud seeding pilot operations and validating the increases in precipitation and stream flows. Results will be presented in late August 2024. Validation tasks include the following:

1. Task 1: Evaluate NAWC Operations
2. Task 2: Snow Chemistry – collect baseline and seeded snow samples
3. Task 3: Calculating the Seeding Snow-Water Equivalent: Assessing precipitation as rainfall and snowfall
4. Task 4: Target/Control Statistical Analysis
5. Task 5: Stream Flow Analysis

Tentative schedule for completion of Year 1 activities and implementation of Year 2 activities is outlined below:

Calendar Years	2024									2025			
Task	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**
Project Validation:													
Review NAWC Operations													
Snow Chemistry: Lab Analysis and Report													
Snow Water Equivalent													
Target-Control Evaluation													

Calendar Years	2024									2025			
Task	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**
Stream Flow Analysis	■	■	■	■	■	■							
Draft Validation Report					■	■	■						
Surface Water Modeling Contract Award								■	■				
Project Operations:													
Annual Report				■	■								
Mobilization							■	■					
Operator Site Training							■						
Year 2 Operations								■	■	■	■	■	■

CRITICAL SUCCESS FACTORS

- Successful implementation of an integrated regional water resource plan that reflects the watershed management needs of the public and the environment.
- Data and information needed for decision-making is available to all.

RESOURCE IMPACTS

In April 2023, SAWPA was notified by the Department of Water Resources (DWR) that the SAWPA Santa Ana River Weather Modification Pilot Program will receive a grant valued at $861,400 under the Proposition 1 Round 2 funding program. Local funding has been secured totaling $94,000. Project operations and validation study costs are budgeted and reflected in the FYE 23-24, FYE 24-25, FYE 25-26 and FYE 26-27 SAWPA Budgets.

Attachments:

1. PowerPoint Presentation
2. Annual Cloud Seeding Report

Santa Ana River Watershed Cloud Seeding Pilot Program: Year 1 Summary

Agenda Item No. 6.D.
Rachel Gray
Water Resources and Planning Manager
September 26, 2024

Recommendation

- Receive and file the Santa Ana River Watershed Annual Cloud Seeding Report for the 2023-2024 Operational Season.

First Year Annual Cloud Seeding Report Outline

1. The Science Behind Cloud Seeding
2. Program Design and Implementation
   - Differences between the feasibility study and actual project design
3. 2023-2024 Season Operations
   - Seeded Storms: occurrence and justification
   - Unseeded Storms: occurrence and justification
   - Storms project design unable to capture
   - Operational issues encountered
4. Implementation of Suspension Criteria
5. Findings and Recommendations for Future Operational Seeding Years


Annual Cloud Seeding Report

Santa Ana Watershed Project Authority

Cloud Seeding Pilot Program

2023-2024 Winter Season

Prepared For:

Santa Ana Watershed Project Authority

Prepared By:

Todd Flanagan

North American Weather Consultants, Inc

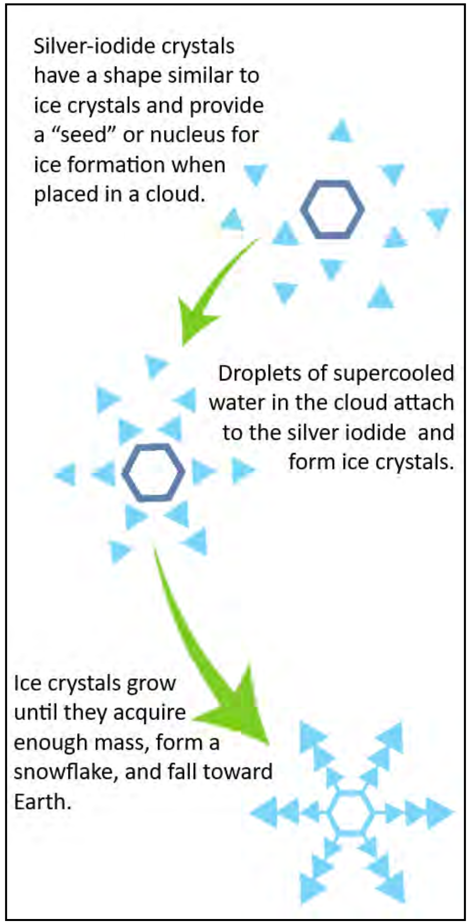
8180 S. Highland Dr., Suite B-2

Sandy, Utah 84093

July 2024

The Science Behind Cloud Seeding

- The cloud-seeding process aids precipitation formation by enhancing ice crystal production in clouds. When the ice crystals grow sufficiently, they become snowflakes and fall to the ground.
- Silver iodide (AgI) has been selected for its environmental safety and efficiency in producing ice in clouds because of its structural similarity to natural ice crystals.
- Based on decades of experience, the use of silver iodide for the purpose of cloud seeding has been shown to be safe for people and the environment. The potential environmental impacts of silver iodide have been studied extensively and represents a negligible risk to the environment.



Benefits of Cloud Seeding

Increase of 5% to 15% in precipitation, increasing runoff/streamflow in the Santa Ana River, mitigating the negative effects of climate change.

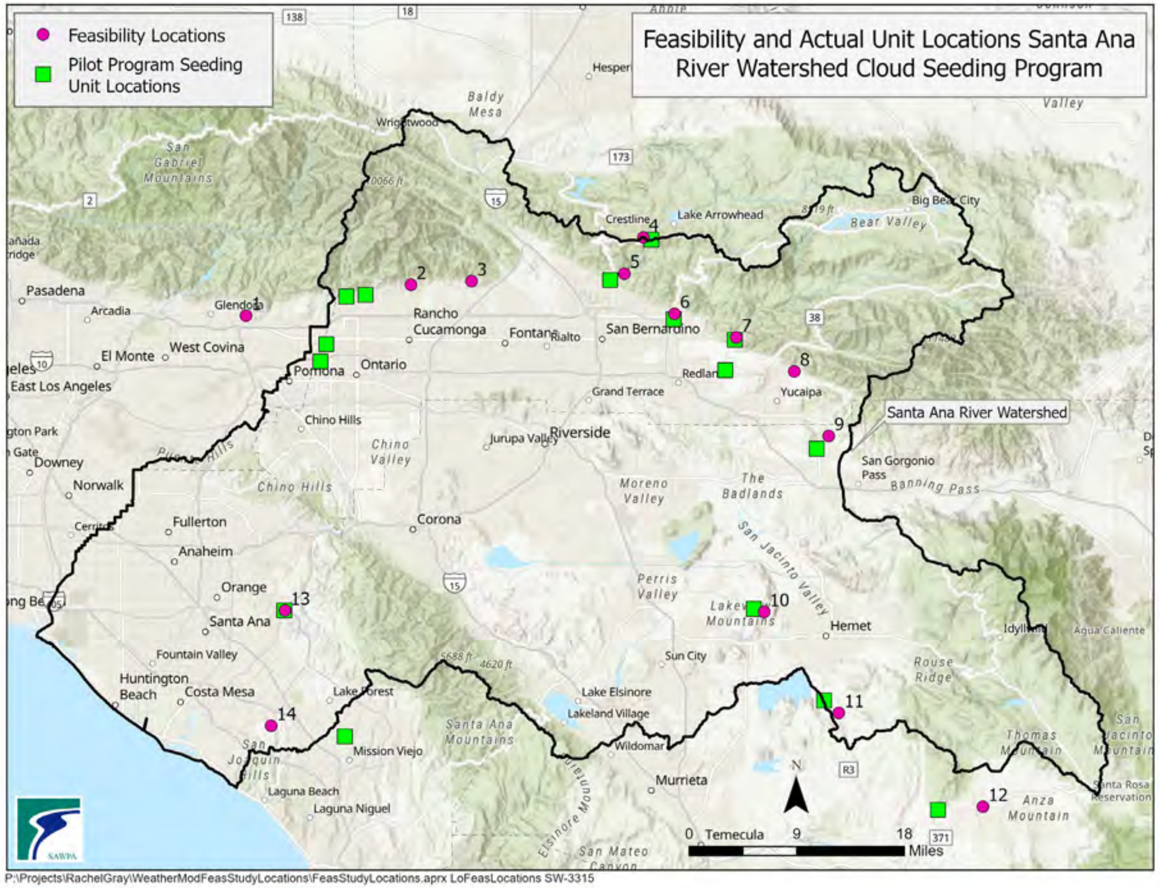
Increase in water supply for the region, enhancing groundwater recharge, and reducing reliability on imported water.

Increase in snowpack for snow season recreational activities.

Provide new source of water

Program Design: Update from Feasibility Study

- Sites were selected that were as close to locations from the feasibility study (SAWPA, 2020).
- Two changes that were made for the Pilot Program that were different than what was presented in the feasibility study (SAWPA, 2020) included:
  - The addition of one CNG unit for the Northwest (NW) Target Area
  - The switch of one of the CNG sites for the Southeast (SE) Target Area to an AHOGS unit, as it was determined that this area may benefit from convective lines pushing in from the coast.
- This increased the total number of seeding units from 14 to 15, with 12 CNG units and 3 AHOGS units.

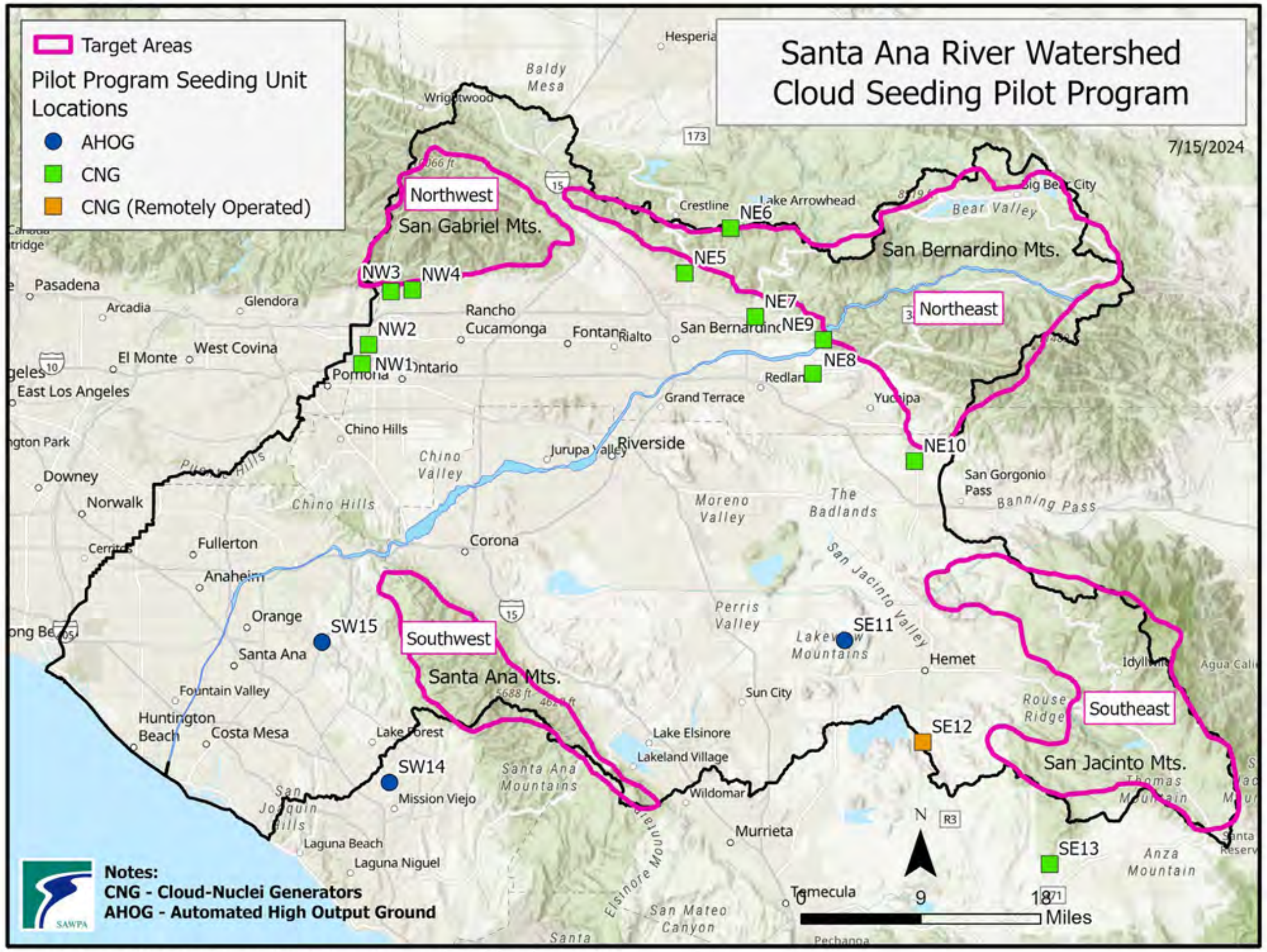


Program Implementation Tasks

These tasks occurred in preparation, during operations, and post-operations for Year 1

Task	Date
Site Access Agreements (11 proponents / 15 units)	August 2022 – August 2023
Operations Plan (project communication, operational criteria, and suspension criteria)	January – October 2023
Communications Plan	July – November 2023
Preliminary Biological Surveys	July 31, 2023
45-Day Public Notice Submission	September 28, 2023
Final Biological Surveys (10 days before construction)	October 5 – 9, 2023
Equipment Set Up, Propane Tank Delivery, and Equipment Testing	October 9 – 20, 2023
Operator Training	October 23 – 27, 2023
Program Kick Off Meeting	November 1, 2023
FY23-24 Program Start	November 15, 2023
Notification to Local Fire Departments	December 2023 – January 2024
FY23-24 Program End	April 15, 2024
Equipment Collected (summer storage)	May 30, 2024

Program Implementation

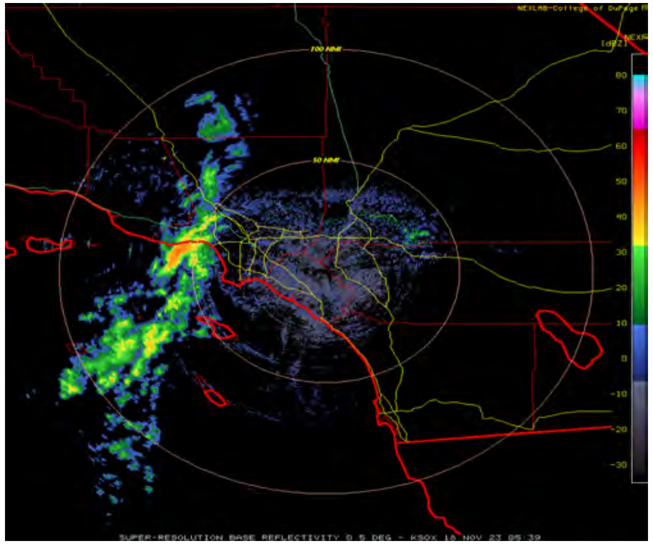


AHOGS unit located at site SW14

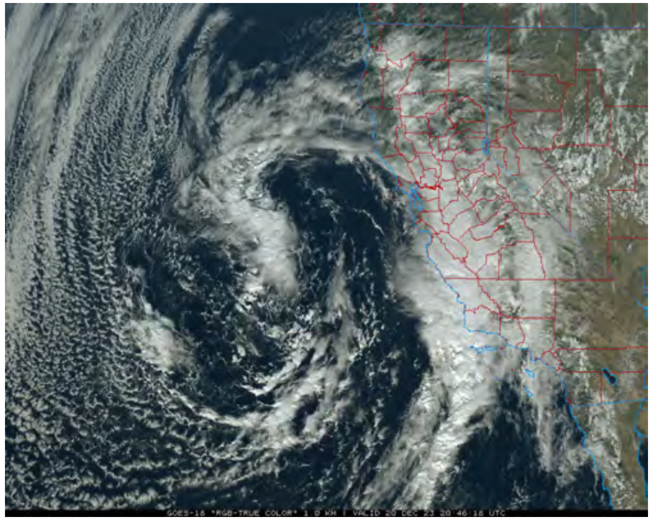
CNG unit with propane tank at site NE10

Weather Data and Models

- Radar data
- Satellite data (e.g., visible, infrared, water vapor)
- Weather forecast model data
- Surface observations
- Rawinsonde (weather balloon) upper-air soundings
- Weather cameras



Weather radar image from Santa Ana (KSOX) during a storm event on November 18, 2023, at 2139 PST (0539 UTC). The scale on the right shows reflectivity (power of returned echoes from reflecting off hydrometeors), which indicates precipitation intensity.



Visible spectrum satellite image on December 20, 2022, at 1246 PST (2046 UTC) showing an area of low pressure centered off the California coast with an area of enhanced cloudiness, the frontal boundary, pushing into southern California around Point Conception.

2023-2024 Operations Summary

- Program design worked well with the weather patterns observed during the season
- The 2023-2024 season was active, with **20 storm event periods**
- **13 seeded storm events** over a total of 22 days
- A total of 2135.25 hours of seeding time from CNG units was recorded, amounting to **17,092 g** of silver iodide (AgI) used
- A total of **32 AgI flares** were used from the AHOGS units, totaling **640 g of AgI**

Date	Number of Seeded Storms	Duration of Storms	Total Duration (days)
November 2023	1	Two consecutive days	2
December 2023	2	Two two-day storm events	4
January 2024	3	• One one-day storm event & • Two two-day storm events overlapping	4
February 2024	2	• One one-day storm event & • One two-day storm event	3
March 2024	3	Three two-day storm events	6
April 2024	2	• One one-day storm event & • One two-day storm event	3

2023-2024 Operations Summary

Units	Storm Periods	Nov 17-18	Dec 21-22	Dec 29-30	Jan 3	Jan 20-21	Jan 21-22	Feb 1	Feb 20-21	Mar 6-7	Mar 23-24	Mar 30-31	Apr 5	Apr 13-14
CNGs (Hours of Generator Runtime)	NW1			23	6.5		*	10	16.75	16	22	30	12.75	7*
	NW2			23	7		*	9	16.25	*	20.25	*	9.25	7*
	NW3	11.25	22	21	5.75	*	*	23.5	19.5	14	22.5	26.75	8.5	24.75
	NW4	13.25	20.75	22		*	*	23	19.75	14	22.5	27.75	8.5	25
	NE5		26.5	21.25	8.75	17.25	24.5	*	*	17	22.75	31.25	12.25	25.5
	NE6		21.5	9	12.25	17	14.25	11.75	18.25	14	18	31.25	14	20.25
	NE7		22.75	21	9	17	*	*	23	17.75	22.75	31.25	12.5	25.5
	NE8		22.25	18.75	9.75	18.5	23.25	7.75	*	15	20.5	*	13	25
	NE9		23	18.75	9.5	18.25	23.25	8	20.5	*	20.25	32.25	12.75	25.5
	NE10		24.25	21.25	9.25	17.75	24.75	23.5	24.25	18.75	22.5	31.25	12.25	25.25
	SE12		8.75	5.5	9.75	*	*	14		17	4.75*	33	9	
	SE13		19	6.5	8	15.25	24.5	12.25		12.75	18.25	32.75	12.75	
AHOGS (Flares)	SE11		5		2		4	1				1	1	
	SW14		1	3		1	3			1		2	2	
	SW15						*			2			1	2

*** Units were not operated or operated at a reduced level due to operational issues.**

2023-2024 Storm Summary (1/2)

Storm Period	Seeded/Not Seeded	Justification
November 15, 2023	Not Seeded	Airmass accompanying the storm system was warm
November 17-18, 2023	Seeded	Moisture was confined primarily to the western parts of the NW target area. Temperatures cooled but not enough for seeding efforts to be effective.
November 30, 2023	Not Seeded	Presence of low-level stable layer prevent seeding plumes from rising above it.
December 19-22, 2023	Seeded	Fair Seedability
December 29-20, 2023	Seeded	Good Seedability
January 3, 2024	Seeded	Good Seedability
January 7, 2024	Not Seeded	Poor Seedability: strong winds would produce long and narrow seeding plumes that were not likely to nucleate before passing the target areas
January 20-22, 2024	Seeded	Fair to Good Seedability

2023-2024 Storm Summary (2/2)

Storm Period	Seeded/Not Seeded	Justification
February 1, 2024	Seeded	Very Good Seedability
February 3-8, 2024	Not Seeded	Suspension Criteria Enacted: Poor to Good Seedability
February 19-21, 2024	Seeded	Good Seedability
February 26, 2024	Not Seeded	Poor Seedability: water temperatures and shallow moisture
March 2-3, 2024	Not Seeded	Poor Seedability: stable layer, warmer temperatures, strong winds
March 6-7, 2024	Seeded	Fair becoming Excellent Seedability
March 14-18, 2024	Not Seeded	Poor Seedability: north to northeast winds
March 23-24, 2024	Seeded	Good Seedability
March 30-31, 2024	Seeded	Good Seedability
April 5, 2024	Seeded	Excellent Seedability
April 13-14, 2024	Seeded	Poor to Fair, then Fair to Good Seedability

2023-2024 Suspension Criteria

- One suspension period was enacted due to a significant Atmospheric River event
- February 3 through February 8, 2024
- Over 15 inches of rainfall in some locations
- Over seven feet of snow in some locations
- Conditions resulted in abundant mountain snow and heavy lower elevation rainfall resulting in significant flooding in some areas.

Site	Name	Nov 2023	Dec 2023	Jan 2024	Feb 2024	Mar 2024	Apr 2024	Season Total
1	Upper Day Canyon	0.95	0.90	2.28	7.92	2.33	1.02	15.40
2	Deer Creek Dam	1.26	1.89	2.76	19.77	9.80	3.23	38.71
3	Cable Canyon	1.38	2.96	2.40	12.29	8.08	2.20	29.31
4	Oak Creek Canyon	1.41	1.70	2.24	13.07	6.14	2.44	27.00
5	Big Bear City Airport	0.66	0.53	1.38	7.44	1.78	2.14	13.93
6	Camp Angelus	0.99	1.57	2.91	12.32	4.65	1.50	23.94
7	Oak Glen Watershed	2.01	1.58	3.07	12.72	6.06	1.89	27.33
8	Idyllwild NWS	1.48	1.35	4.45	9.41	5.43	1.74	23.86
9	Hurkey Creek	0.98	0.54	2.65	5.49	3.16	1.14	13.96
10	Upper Silverado Canyon	0.24	1.94	1.02	4.96	7.25	1.34	16.75
11	Riverside Muni Airport	0.17	0.86	1.68	6.94	2.38	0.14	12.17
12	Hemet	0.87	0.80	1.94	4.33	1.69	0.67	10.30

2023-2024 Findings and Recommendations

A period of active weather in mid-March 2024 saw no seeding activity due to positioning of the storm system east of the area resulted in a prolonged period of north to northeast flow with precipitation, the project design did not account for these conditions and meteorological analysis during the feasibility study indicated this to be a rare occurrence.

Consider installing seeding sites on the east and northeast sides of the NE and SE target areas to account for this pattern, with the understanding that these sites may rarely be activated.

HYSPLIT modeling revealed that, at times, sites NW1 and NW2 produced seeding plumes that did not impact the nearby target areas

Consider moving one of the NW1 and NW2 sites further northwest closer to the NW Target area.

2023-2024 Findings and Recommendations

Mechanical Issues

Field technician local to the project area identified and trained to be able to service CNGs and AHOHS units.	Regularly troubleshoot cloud seeding units for optimal equipment operation.

Equipment Operators

Train backup site operators for continuous unit operations.

Logistical Issues

Maintain effective communication with sponsors to mitigate site access issues.

2023-2024 Findings and Recommendations

Obtain input on environmental conditions from Flood Control District and Watershed Agencies

- Collaborate with Flood Control Districts for environmental insights.
- Understand the impact of successive storms on infrastructure.

Communication

- Be transparent with the public about technical studies conducted for cloud seeding.
- Send notices to fire departments in advance of the start of Year 2 Operations.

Pilot Program Schedule

Pilot Program Schedule

• First Year Summary Report	July 2024
• Project Validation Tasks	August 2024
• Year 2 Equipment Mobilization	October 2024
• Year 2 Operations – Start	November 15, 2024

Questions

Annual Cloud Seeding Report

Santa Ana Watershed Project Authority
Cloud Seeding Pilot Program
2023-2024 Winter Season

Prepared For:

Santa Ana Watershed Project Authority

Prepared By:

Todd Flanagan

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Sandy, Utah 84093

July 2024

Table of Contents

The Science Behind Cloud Seeding

The Science

The cloud-seeding process aids precipitation formation by enhancing ice crystal production in clouds. When the ice crystals grow sufficiently, they become snowflakes and fall to the ground.

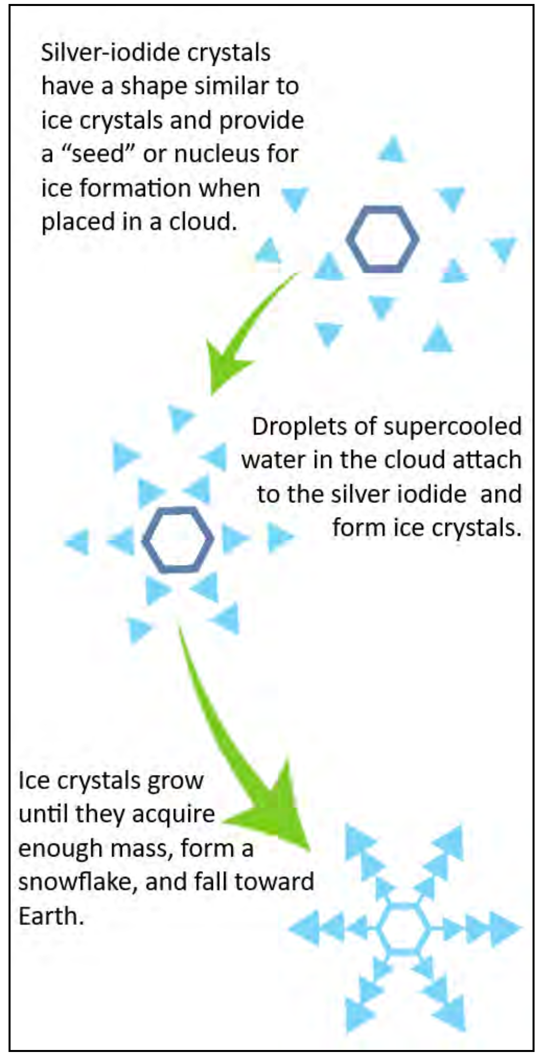
Silver iodide (AgI) has been selected for its environmental safety and superior efficiency in producing ice in clouds. Silver iodide adds microscopic particles with a structural similarity to natural ice crystals. Ground-based and aircraft-borne technologies can be used to add particles to the clouds.

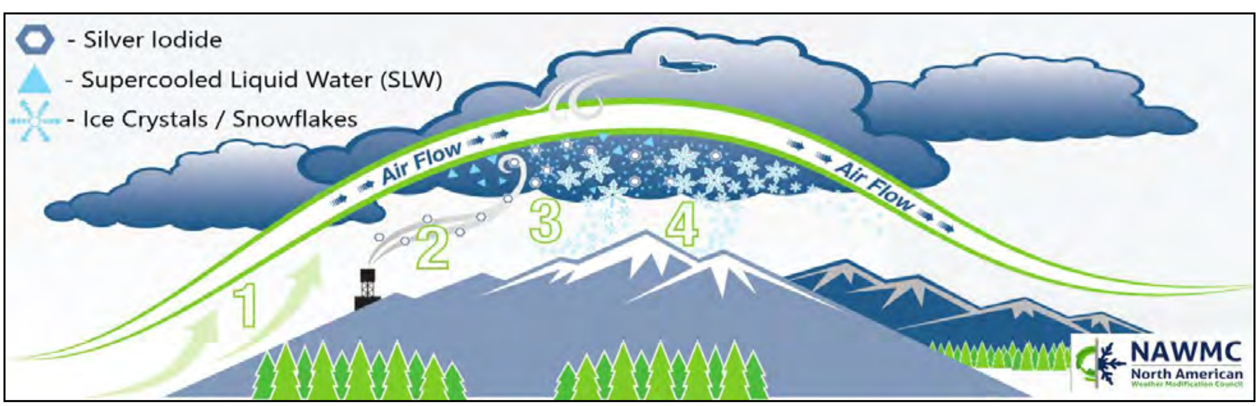
Safety

Research has documented that cloud seeding with silver iodide aerosols shows minimal impacts on the environment. Iodine is a trace element present in some foods and is added to some types of salt. Silver is both inert and naturally occurring. The amounts of silver released are far less than background silver already present in unseeded areas.

Effectiveness

Numerous studies performed by universities, professional research organizations, private utility companies, and weather modification providers have conclusively demonstrated the ability for silver iodide to augment precipitation under the proper atmospheric conditions.





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EXECUTIVE SUMMARY

The first season of the Santa Ana Watershed Project Authority's (SAWPA) Cloud Seeding Pilot Program (Pilot Program) began on November 15, 2023, and continued through April 15, 2024. The program focused on precipitation enhancement efforts to increase snowpack and rainfall for runoff in four designated target areas in the mountains within the Santa Ana River Watershed (SARW); three of these areas (San Gabriel, San Bernardino, and San Jacinto Mountains) were designated for snowpack enhancement above 3000 feet mean sea level (MSL). The fourth area (Santa Ana Mountains) was intended for rainfall and runoff above 2000 feet MSL near the coast. Fifteen ground-based cloud seeding site units were deployed in the SARW: 12 Cloud Nuclei Generators (CNGs) and three Automatic High-Output Ground Seeding (AHOGS) units. A map of the program target areas and ground-based cloud seeding units are shown in Figure 1.

The 2023-2024 season was active, with 20 storm event periods. Of these, operations of cloud seeding occurred for 13 storm events. The storms were distributed relatively evenly across the season, with one "dry period" during the first three weeks of December 2023. A total of 13 seeded storm events occurred over a combined period of 22 days. A total of 2135.25 hours of seeding time from all CNG units was recorded, amounting to 17,082 g of silver iodide (AgI) used for seeding for the season. Additionally, a total of 32 AgI flares were used from the AHOGS units, totaling 640 g of AgI. One suspension period occurred during the season; from February 3-8, 2024, as a significant Atmospheric River event affected much of California bringing abundant mountain snow and heavy lower elevation rainfall resulting in significant flooding in some areas. There were also some severe weather events that included damaging winds, hail and tornadoes; none of these affected the SARW project area. A second period of active weather in mid-March 2024 also saw no seeding activity; this was not due to suspension criteria being enacted, but instead due to a wind flow pattern that the Pilot Program was not set up for as earlier studies showed the particular pattern to be a rare occurrence.

With the conclusion of the season, a review of all aspects of the Pilot Program was performed to assess the seeding operations, as well as identify areas where improvements can be made for future years. Recommendations for the Pilot Program going forward are presented at the end of the report.

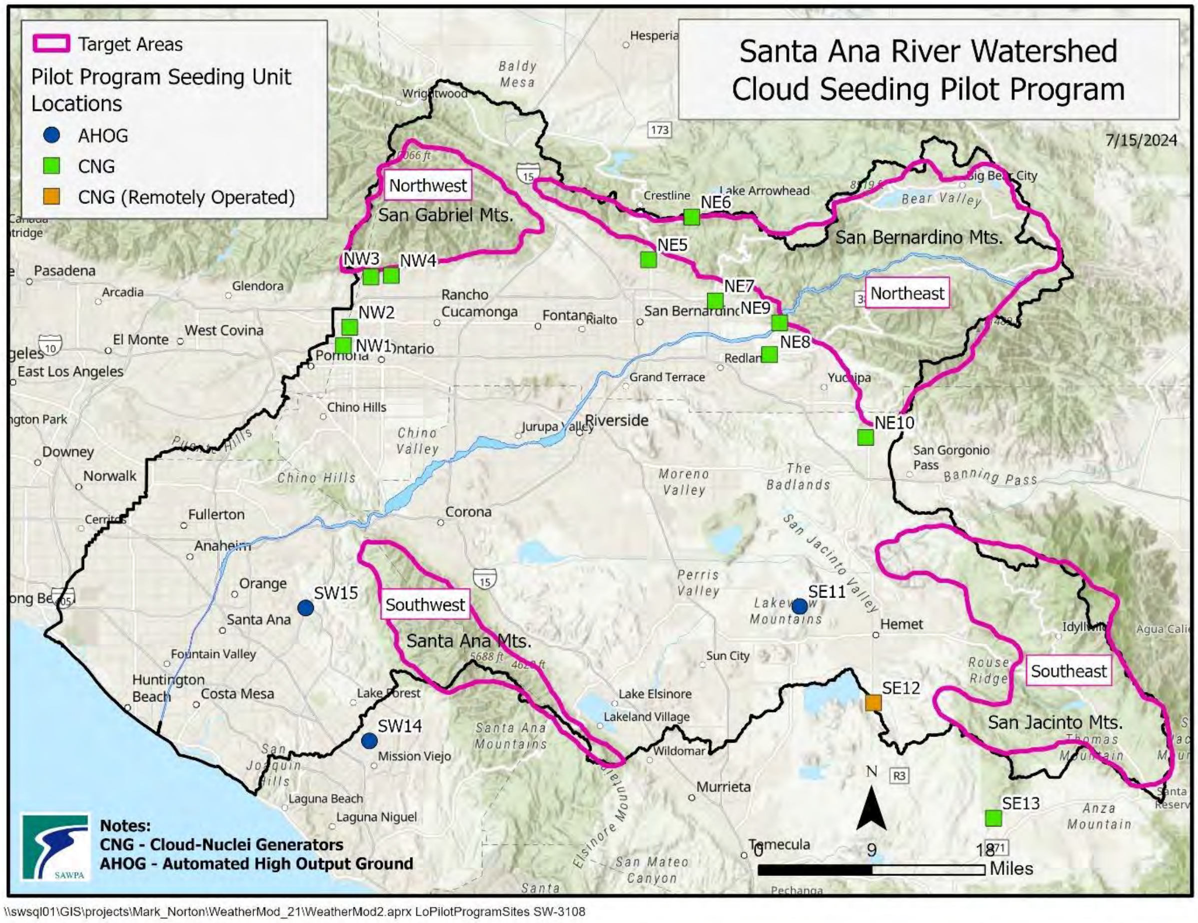

Figure 1. **SARW Cloud Seeding Pilot Program Project Area, consisting of 15 ground-based seeding units and four target areas (Northeast, Northwest, Southeast, and Southwest).**

1.0 INTRODUCTION

The Santa Ana Watershed Project Authority (SAWPA) is conducting a four-year Cloud Seeding Pilot Program (Pilot Program) in the Santa Ana River Watershed (SARW). The primary purpose of the Pilot Program is to validate the benefits of weather modification within the SARW, specifically within designated target areas, with the goal of producing additional precipitation – primarily snowfall in the higher elevations of the target areas and rainfall for some lower elevation target areas – resulting in additional runoff/streamflow for recharge as stormwater into groundwater basins. Using the results from the Santa Ana Watershed Weather Modification and Feasibility Study (SAWPA 2020) regarding the potential for a precipitation enhancement program in the watershed, a program was designed and implemented to conduct precipitation enhancement operations, with the 2023-2024 winter serving as the first season for the Pilot Program which ran from November 15, 2023, through April 15, 2024.

The duration of the first season was a five-month period with 15 ground-based cloud seeding units installed and utilized for cloud seeding operations. The target areas are located within four mountain ranges located within the Santa Ana Watershed and surrounding the Inland Empire, specifically at locations above 3000 feet MSL for three of the target areas (San Gabriel (northwest), San Bernardino (northeast), and San Jacinto Mountains (southeast)) where snowfall occurs each winter, and above 2000 feet MSL for the southwest target area (Santa Ana Mountains) which sees rain (snow on rare occasions).

This report covers the first season of cloud seeding activities for the Pilot Program during the 2023-2024 winter season. Section 2 discusses the program design used for the Pilot Program and subsequent equipment installation. Section 3 provides information on the meteorological data used to conduct operations of the Pilot Program. Section 4 reviews the storm events and seeding operations from the first operational season. A summary and recommendations for future seasons are provided in Section 5.

SAWPA has contracted with the Desert Research Institute (DRI) to conduct the validation of the additional precipitation and runoff of the Pilot Program, which will be provided in an independent report. The Pilot Program is operated consistent with the needs of the validation study.

2.0 PROJECT DESIGN

2.1 Background

In 2020, SAWPA completed a weather modification feasibility study for the Santa Ana River Watershed (SARW) located in southwest California (SAWPA, 2020). In the study, four potential target areas – mountainous regions within the SARW and surrounding the Inland Empire – were identified for cloud seeding operations that could contribute to seasonal runoff and streamflow. Storm events from five winter seasons were analyzed and detailed climatology was developed. Based on the climatological assessment, an array of seeding sites for the four target areas was created, established on their common upwind location from their intended target areas.

Two methods of ground-based cloud seeding were considered. The first method incorporates manually operated ground-based Cloud Nuclei Generators (CNGs), which burn a solution of silver iodide (AgI). The CNGs create a continuous plume of seeding material that provides broad coverage over primarily mountainous terrain through orographic lift. The second method of seeding from the ground incorporates proprietary units called Automatic High Output Ground Seeding (AHOGS) systems. These remotely operated units use burn-in-place flares that release a high concentration of AgI rapidly and are ideal for seeding convective bands with high concentrations of supercooled liquid water (SLW) and strong turbulence.

Additionally, aerial seeding was assessed, with two flight tracks developed for the two northern target areas. The use of a plane allows for the immediate release of seeding agents such as AgI at the most desirable location within a cloud. Though highly effective, aerial seeding can be cost prohibitive and requires special permits and approvals from the Federal Aviation Administration (FAA).

With both ground and aerial seeding design completed, advanced computer modeling was utilized for a subset of the previously analyzed storm events to model the movement of seeding plumes from both ground and air, with adaptations made to seeding unit location and flight tracks until results indicated successful dispersion of seeding agents over the target areas for a variety of storm conditions. Estimated increases in precipitation and streamflow were determined, and costs were estimated to calculate a benefit to cost ratio for the proposed program. It was determined that the program, as designed, would be technically feasible, with a ground-only program having a benefit to cost ratio of 10:1. The feasibility study concluded with a recommendation to implement a ground-only program and eventually expand into a ground and aerial program as needs for additional water supply increase.

Based on the results of the feasibility study, SAWPA approved a four-year pilot program to evaluate the potential benefits of cloud seeding in the watershed.

2.2 Seedability Criteria

Under the Pilot Program selective cloud seeding is conducted during winter storm events, which is the most efficient and cost-effective method. Selective seeding is conducted only during specific time periods and in specific locations where cloud seeding is likely to be effective. This decision is based on several criteria which determine the seedability of the storm. These criteria involve the characteristics of the atmosphere including temperature, stability, and wind flow, both in and below the clouds. The moisture content of the atmosphere, including cloud types and occurrence of supercooled liquid water (SLW) are crucial factors during seeding operations. Certain heavier storm periods may not be seeded due to factors which make the storm naturally efficient at producing precipitation. Other storm periods can be deemed unfavorable due to several factors including temperature, stability, or wind direction. The use of this focused seeding method has yielded consistently favorable results with very high cost/benefit ratios for projects conducted in the western United States.

The general criteria are as follows:

- Cloud bases are below the mountain barrier height.
- Low level wind speed and direction that would favor the transport of silver iodide seeding material, from its release locations into the target area.
- The absence of low-level inversions or stable layers that would restrict the vertical movement of silver iodide from the surface to the -5°C level (23°F) or colder.
- Temperatures at the 700 millibar (mb) level are warmer than -15°C (5°F)
- Presence of convective bands (for AHOGS usage) or distinct convective cells

The design of operational programs is also be based upon prior research programs that provided positive indications of increases in precipitation, to the extent that the research results are representative of the operational programs' conditions. This assumes research results from one location are transferable to the operational program's target area(s), a reasonable assumption if the topography and climate of the two areas are similar. This philosophy has worked well for additional programs in California, for example, Santa Barbara, Fresno (Kings River), Los Angeles (San Gabriel Mountains), and Upper American River Basin.

Building on the above criteria, a checklist of operational criteria to be considered on a storm-by-storm basis was developed, and it is presented as a tracking table in Table 2-1. This checklist was completed for each storm event and is provided in Appendix A.

Table 2-1
Operational Criteria Checklist/Tracking Table

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.		
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).		
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.		
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.		
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.		
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).		
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused		

2.3 Project Setup and Equipment

The design of the Pilot Program was based on the feasibility study (SAWPA, 2020). Locating the ground-based units entailed site visits and discussions with various public agencies, as well as private landowners. Program site sponsors entered into land lease/operator agreements wherein ground-based cloud seeding units would be installed on their property securely, and individuals within these agencies/sponsors would serve as operators.

Thirteen ground-based units were located on properties owned by watershed utilities and two of the units were installed and operated by private landowners, who also entered into land lease/operator agreements. Site review was performed at all locations to determine if site preparation work, such as concrete, grading or ground preparation work were needed to be done prior to unit installation and if additional site securing (e.g., fencing) was needed.

A biologist conducted preliminary and final biological surveys in July and October 2023, respectively, in response to the mitigation measures outlined in the Mitigation Monitoring and Reporting Plan based on the Initial Study and Mitigated Negative Declarations (IS/MND) prepared following a CEQA (California Environmental Quality Act) evaluation (SAWPA, 2022). No significant findings were identified by the biologist and mobilization/installation was scheduled for October 2023.

Sites were selected that were as close to locations from the feasibility study (SAWPA, 2020). In several instances, project sponsors located close to the feasibility study's proposed site locations were selected for installation of the ground-based cloud seeding units. Figure 2.1 shows the location of the seeding unit sites that were selected and the locations of the target areas of interest. Two changes that were made for the Pilot Program that were different than what was presented in the feasibility study (SAWPA, 2020) included the addition of another CNG unit for the Northwest (NW) Target Area, and the switch of one of the CNG sites for the Southeast (SE) Target Area to an AHOGS site, as it was determined that this area may benefit from convective lines pushing in from the coast. This increased the total number of seeding units from 14 to 15, with 12 CNG units and three AHOGS units. Table 2-2 provides information on site location and elevation above MSL.

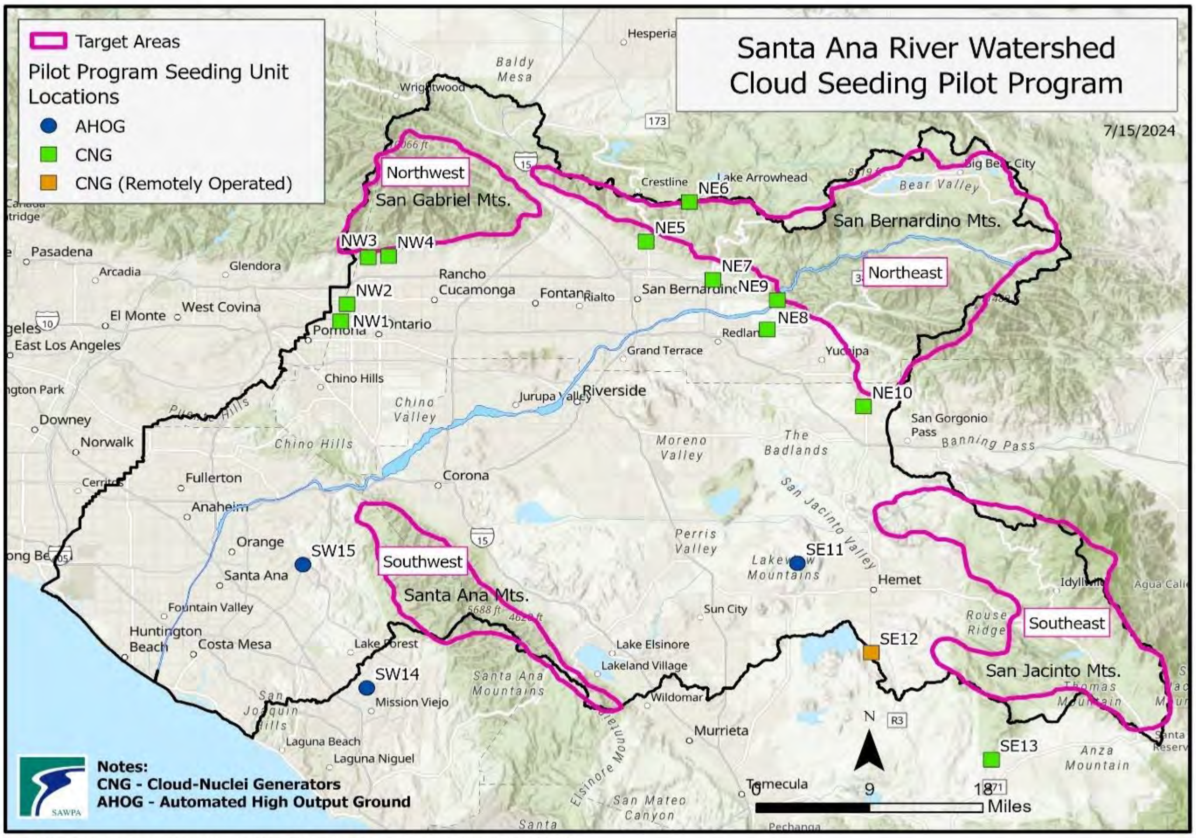

Figure 2.1. **Map of Target Areas and Ground-Based Seeding Site Locations. Legend denotes the type of cloud seeding unit.**

Table 2-2
Seeding Site Locations

Site	Name	Latitude (N)	Longitude (W)	Elevation (feet)
NW1	Chino Basin WCD Montclair #4	34° 04.75’	117° 42.31’	1030
NW2	Chino Basin WCD Upland/College Heights	34° 06.03’	117° 41.81’	1239
NW3	San Antonio Water Co. – East	34° 09.66’	117° 38.44’	2174
NW4	San Antonio Water Co. – West	34° 09.50’	117° 40.24	2250
NE5	San Bernardino – Sycamore WP	34° 10.81’	117° 16.96’	1599
NE6	Rimforest	34° 13.77’	117° 13.35’	5654
NE7	SBVMWD Highland/Summertrail Place	34° 07.96’	117° 11.39’	1435
NE8	SBVWCD Mentone/Mill Creek	34° 04.24’	117° 06.86’	1841
NE9	SBVWCD Santa Ana Dam	34° 06.45’	117° 06.04’	1963
NE10	San Gorgonio Pass WA – Cherry Valley	33° 58.52’	116° 58.89’	2830
SE11**	EMWD N – Balher Booster	33° 46.83’	117° 04.39’	2189
SE12*	EMWD S – Searle Tank II	33° 40.17’	116° 58.26’	1867
SE13	Lakeshore	33° 32.17'	116° 48.32’	3681
SW14**	El Toro WD – Reservoir	33° 37.35’	117° 40.15’	624
SW15**	EOCWD	33° 48.19’	117° 48.83’	288

* Remote CNG ** AHOGS unit

Two forms of ground-based seeding units were utilized for operations. The first and primary unit used in the Pilot Program were Cloud Nuclei Generators (CNGs), which use propane as a fuel source and contain a silver iodide (AgI) solution that burns when ignited and disperses AgI particles into the air. The solution is designed to be a fast-acting nucleation agent via the condensation-freezing mechanism versus the slower contact nucleation mechanism. This is important as some of the mountain barriers/portions of the Target Areas are relatively narrow. Figure 2.2 shows one of the manually operated CNG units.

Figure 2.2. Cloud Nuclei Generator (CNG) on the left side with propane tank at site NE10.

The second method of ground-based cloud seeding is designed to target convective cells that are developing and/or moving across the area, primarily as bands of convective cells. Quick, high-output amounts of AgI are desired for these elements to induce a positive seeding effect, as convective cells do contain supercooled liquid water (SLW), and in some cases at fairly high concentrations. Most convective bands observed will be associated with a cold front, but in some instances short convective lines develop in areas of convergence not associated with a front, and these can be targeted as well. For these situations, units that hold high-output silver iodide flares, called Automatic High Output Ground Seeding (AHOGS) systems are used.

AHOGS consist of flare trees that hold the high output flares, a camera and battery that allows for remote operation of the unit. Each flare on the tree is housed within a cylinder called a spark arrestor, which prevents any wayward sparks from the burning flares from dropping to the ground but allows the particles in the smoke to freely disperse. When convective bands or cells approach, the unit is activated and flares are burned depending on the size and intensity of the convection as indicated on radar, and convective currents or inflow/updrafts ahead of the convection carry the silver iodide particles upward into the cloud where they activate. Figure 2.3 shows one of the AHOGS units. AHOGS target convective cells, so their intended effect is to increase the rainfall and potentially help capture stormwater runoff that can be recharged into local groundwater basins, in the case of this specific unit, within or near the Southwest (SW) Target Area. Two other AHOGS units were utilized, one also in Orange County situated to target the SW area as well, and a third west of San Jacinto, which targets either the Southeast (SE) or Northeast (NE) areas.

Figure 2.3. Automatic High Output Ground Seeding (AHOGS) unit located at site SW14.

2.4 Personnel

Several individuals were tasked with running the program during the first season:

Todd Flanagan – Chief Meteorologist/Project Manager

Todd Flanagan served as the dedicated project meteorologist, managing the daily operations. Weekly forecasts for the program area were prepared by the meteorologist, with more focused and detailed daily forecasts ahead of and during storm events that also informed site operators of their need to be ready for activation. When seedable storm systems approached the project area, the meteorologist was tasked with contacting the operators to start/stop their respective units and field any additional necessary contact with them. Run times of all units were tracked and recorded, as well as meteorological conditions and operational notes pertaining to the storm event. Archiving of meteorological data and whether seeding occurred or not was completed. Seeding event reports as well as monthly reports on operations were completed and disseminated. As the project manager, ensuring that all components of the project were maintained in full operational readiness was the main task; this included making sure all ground-based cloud seeding units were properly serviced and kept in operational status, and any problems or malfunctions were communicated with the Technical Director and field technicians.

Jared Smith – Technical Director/Field Technician

Jared Smith served as the main contact on issues relating to contracts, site reconnaissance and site improvements, subcontractor coordination as well as a coordinator with all technicians. He sometimes served as the field technician when needed, but primarily advised the other field technicians from NAWC on issues related to servicing of the ground-based cloud seeding units when needed.

Carver Cammans/Parker Wall – Field Technicians

Carver Cammans and Parker Wall are both field technicians employed by NAWC and were dispatched from Utah to the SARW when needed during the season to trouble-shoot and address any problems with the cloud seeding units, refill CNGs with seeding solution and replace flares in the AHOGS.

Seeding Unit Operators

Operations of the cloud seeding units were directed by the meteorologist/project manager and any problems that were encountered during start-up or shutdown of the units were reported to the meteorologist/project manager by the site operators. A total of 11 manually operated CNGs were operated during the Pilot Program. Four manual CNGs were operated by three site sponsor staff that housed the units on their properties. Five manual CNGs were operated by a NAWC-contracted operator to operate units that were housed on site sponsor properties. Two manual CNGs were operated by two private landowners who housed the units on their respective properties. Three AHOGS units and one remotely operated CNG unit were operated by the meteorologist.

2.5 Suspension Criteria

Suspension criteria are used to ensure the safety of the public and property. Project-specific procedures for the suspension of cloud seeding operations are evaluated for all storms. Those criteria are provided in Appendix B. During the 2023-2024 seeding program, there was one period wherein a program suspension was deemed necessary; in early February 2024, a significant Atmospheric River event affected much of California, including the SAWPA program. Unusually heavy precipitation was expected and given the considerable risk for flooding, it was determined that seeding operations would not be beneficial to the area, particularly as the storms during this period were already producing precipitation (both rain and snow) at maximum efficiency. Further information about this storm period can be found in the Operations section (Section 4) of this report.

3.0 WEATHER DATA AND MODELS USED IN SEEDING OPERATIONS

Meteorological information is acquired from a wide variety of sources, including some subscriber services. This information includes radar data, satellite data (e.g., visible, infrared, water vapor) weather forecast model data, surface observations, rawinsonde (weather balloon) upper-air soundings, and weather cameras. NAWC's meteorologists have access to all meteorological products on a 24-hour basis, allowing for continued monitoring so that seeding operations can be performed at any time of the day or night. The wide variety of available meteorological data products and information provides the data necessary for meteorologists to determine when conditions are appropriate for cloud seeding.

Figures 3.1 – 3.7 show examples of a subset of the available weather information that was used in this decision-making process during the 2023-24 winter season. In Figure 3.1, radar imagery from Santa Ana, California (KSOX) is shown. Radar data provides the meteorologist with information about coverage and intensity of precipitation, measured by the amount of the radar's beam which reflects off hydrometeors (i.e., precipitation) and returns to the radar.

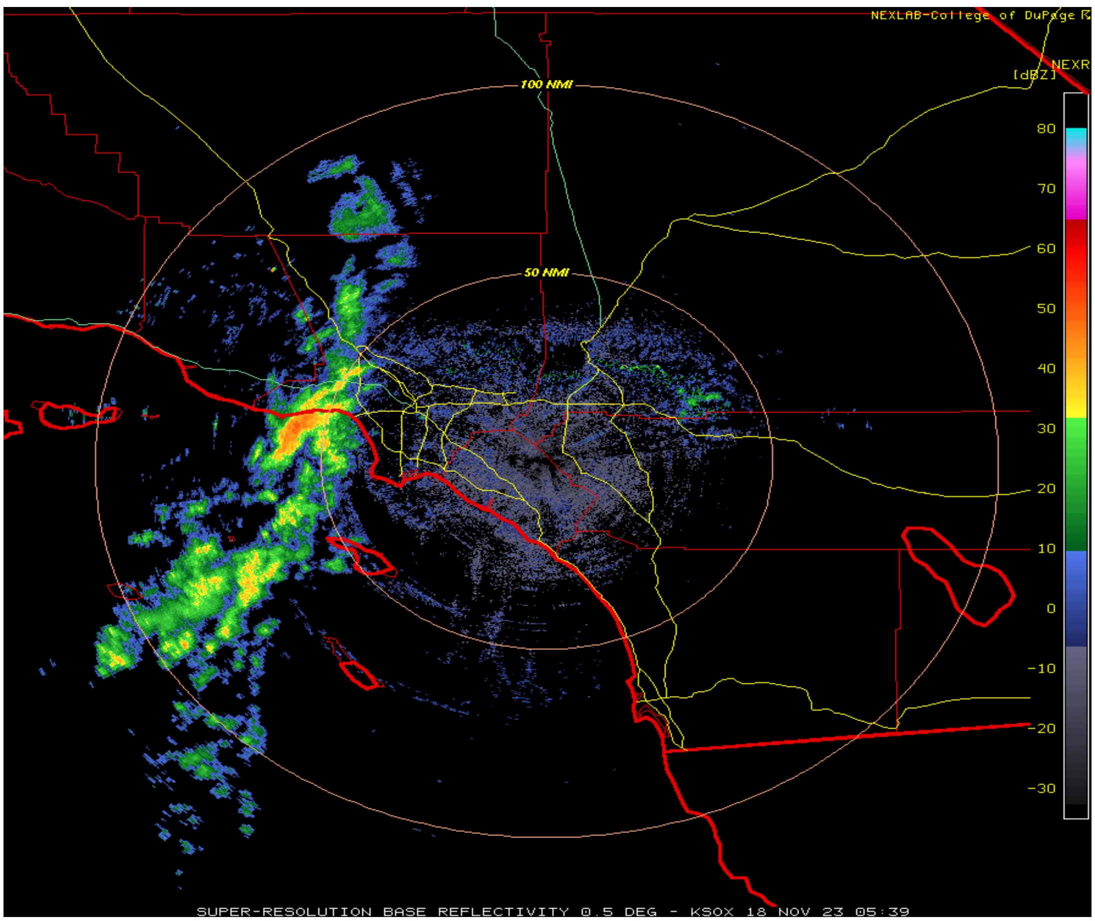

Figure 3.1. **Weather radar image from Santa Ana (KSOX) during a storm event on November 18, 2023, at 2139 PST (0539 UTC). The scale on the right shows reflectivity (power of returned echoes from reflecting off hydrometeors), which indicates precipitation intensity.**

Figure 3.2 shows a visible spectrum satellite image wherein clouds are visible because of the sunlight; visible imagery can show various cloud types (cumulus, stratus, etc.) embedded within storm systems, which may, for example, allow the meteorologist to determine if any convection is present which may benefit from using AHOGS flares for cloud seeding.

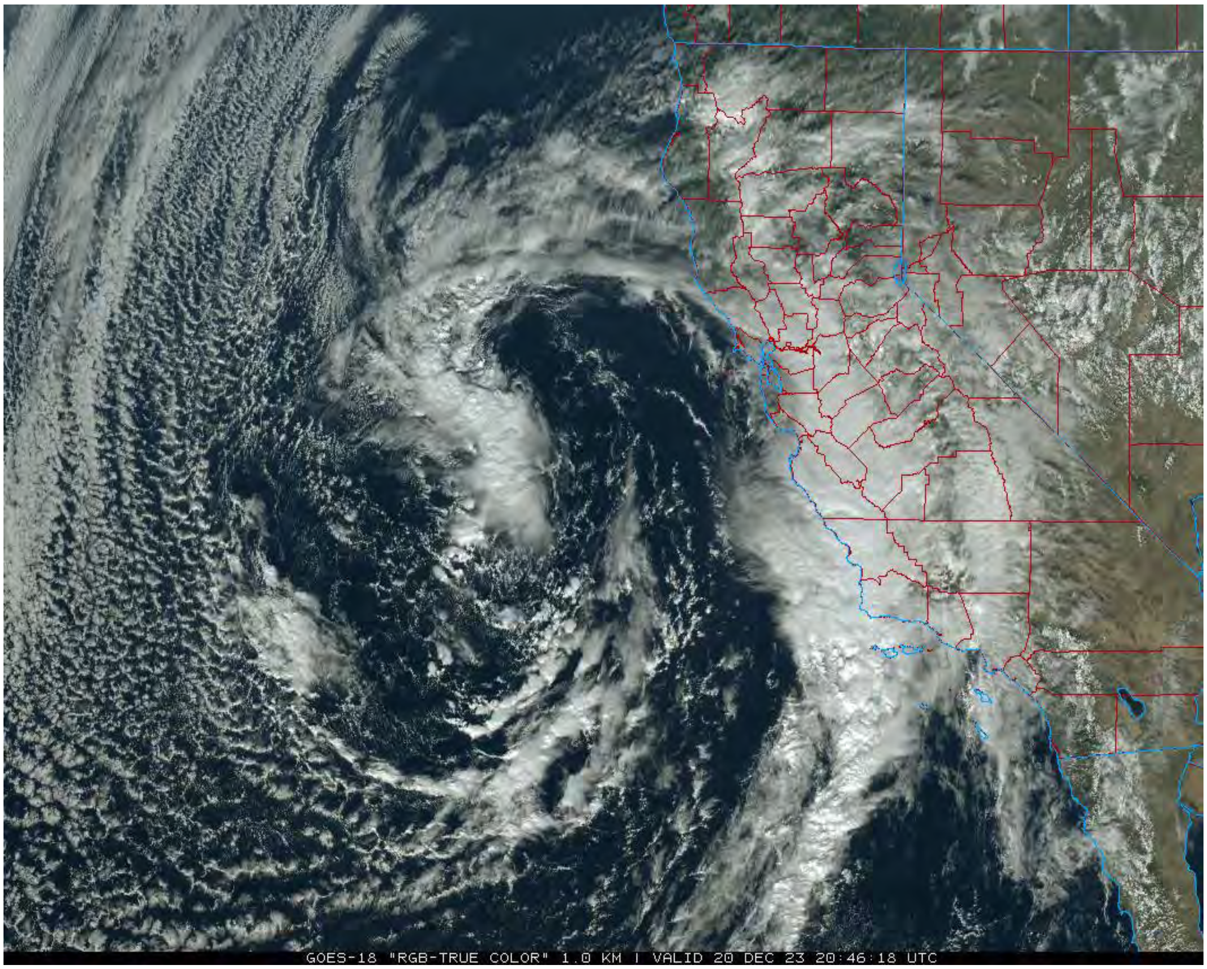

Figure 3.2. Visible spectrum satellite image on December 20, 2022, at 1246 PST (2046 UTC) showing an area of low pressure centered off the California coast with an area of enhanced cloudiness, the frontal boundary, pushing into southern California around Point Conception.

Another type of satellite imagery is shown in Figure 3.3: a water vapor satellite image. Water vapor imagery is important in showing areas of greater moisture content as well as regions of dry air. They can also reveal shortwave disturbances via swirls in the water vapor that may not appear in visible or infrared satellite imagery.

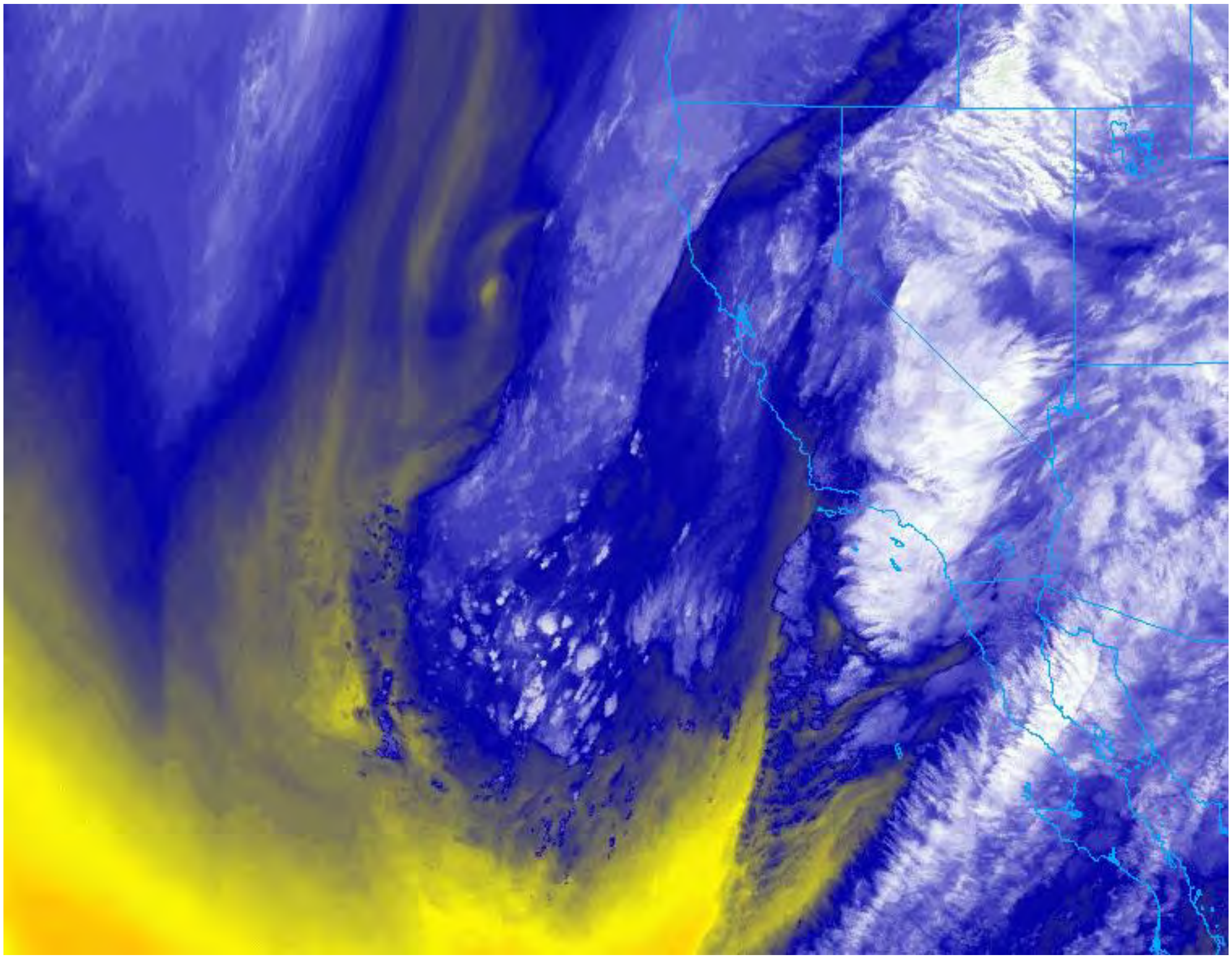

Figure 3.3. Water vapor satellite image on February 5, 2024, at 2201 PST (0601 UTC) showing concentration of atmospheric water vapor across the western United States and adjacent eastern Pacific. In the above picture, dry air is indicated by the yellow and orange colors, while moisture is shown in blue and white (white indicating the greatest amount of water vapor).

Figure 3.4 shows a surface observation map via MesoWest over the Inland Empire and adjacent mountain areas. Surface observations, which include temperature, dewpoint, wind speed and direction, cloud cover and precipitation and barometric pressure are very important as they can help the meteorologist identify features such as areas of convergence (looking at winds), moisture pooling (e.g., higher dewpoints in one area vs. another), mixing and location of fronts (changes in temperature and wind).

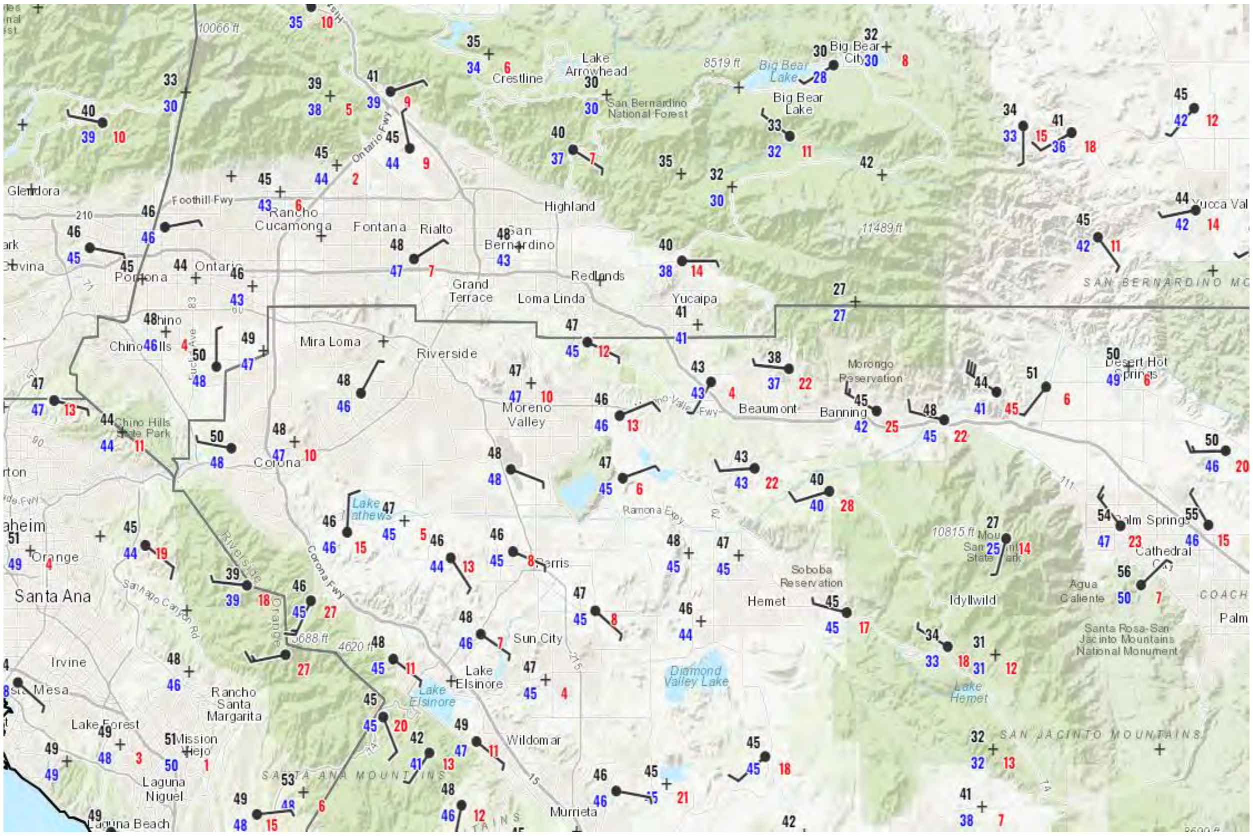

Figure 3.4. **MesoWest surface observation data map centered on the Inland Empire on February 6, 2024, at 1330 PST. In the above picture, black numbers represent temperature, blue are dewpoint, red are wind gusts, and the stick/barbs indicate wind speed and direction from which the wind is blowing. Courtesy of NWS/NOAA, https://www.wrh.noaa.gov/map/?obs=true&wfo=sgx .**

Figure 3.5 shows an example of an upper air weather balloon sounding or rawinsonde from San Diego (NKX). Soundings are important for the meteorologist as they can show the thermal profile of the airmass over the location sampled, which is important in cloud seeding as the presence of stable layers (i.e., temperature constant or increasing with height) can determine whether or not seeding plumes would be able to rise to cloud base, and how these plumes might travel as they rise and flow with the given winds at a particular altitude.

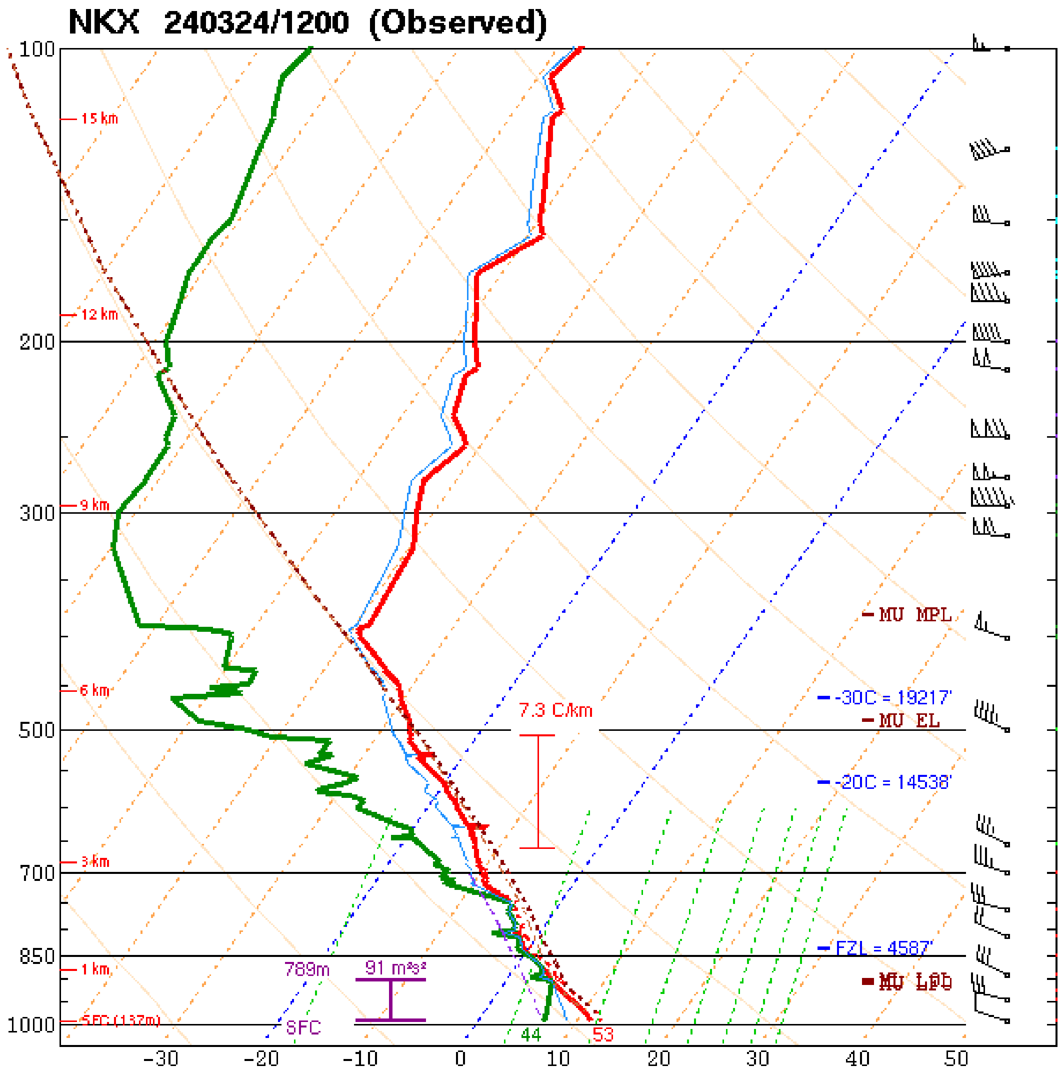

Figure 3.5. **Weather balloon/rawinsonde sounding from San Diego (NKX), valid at 12Z/1700 PDT on March 24, 2024, showing temperature (red line), dewpoint (green line) and wind speed/direction (right side barbs) from the surface to 100 mb (approximately 52,000 feet MSL). Courtesy of Storm Prediction Center website, https://www.spc.noaa.gov.**

Global and regional forecast models are a cornerstone of modern weather forecasting, and a crucial tool for operational meteorologists. These models forecast a variety of parameters at various levels of the atmosphere, including winds, temperatures, moisture, and surface parameters such as accumulated precipitation. Figure 3.6 is an example of a display from the Global Forecast System **(GFS)** model. Other models used on a daily basis during the Pilot Program include **but are not limited to** the European Center for Medium-Range Weather Forecast **(ECMWF)** model, High-Resolution Rapid Refresh **(HRRR)** model, North American Model **(NAM)**, and National Blend of Models **(NBM),** the last being a blend of both National Weather Service (NWS) and non-NWS numerical weather prediction model data. Figure 3.7 shows a forecast from the HRRR model for supercooled liquid water (SLW), the primary target of seeding operations.

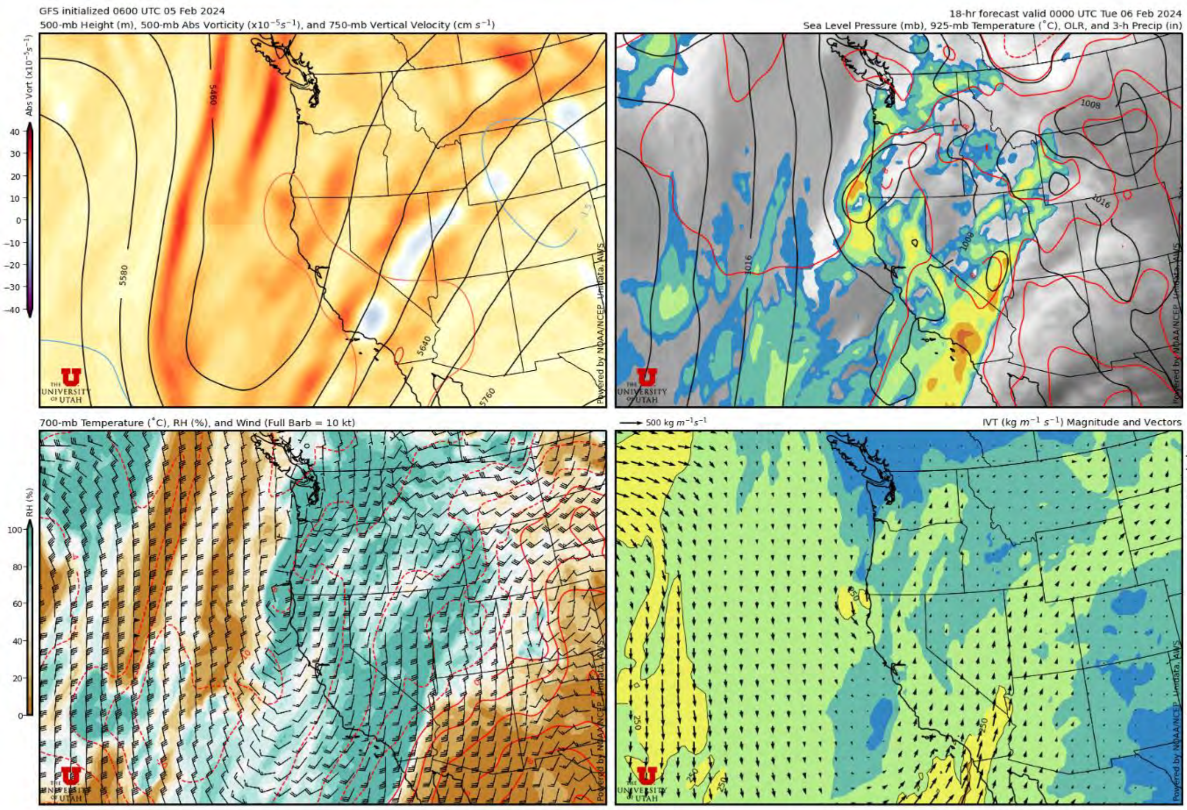

Figure 3.6. **GFS (Global Forecast Systems) model forecast (4-panel plot) valid 1600 PST (0000 UTC) on February 5, 2024. Courtesy of University of Utah weather website, https://weather.utah.edu .**

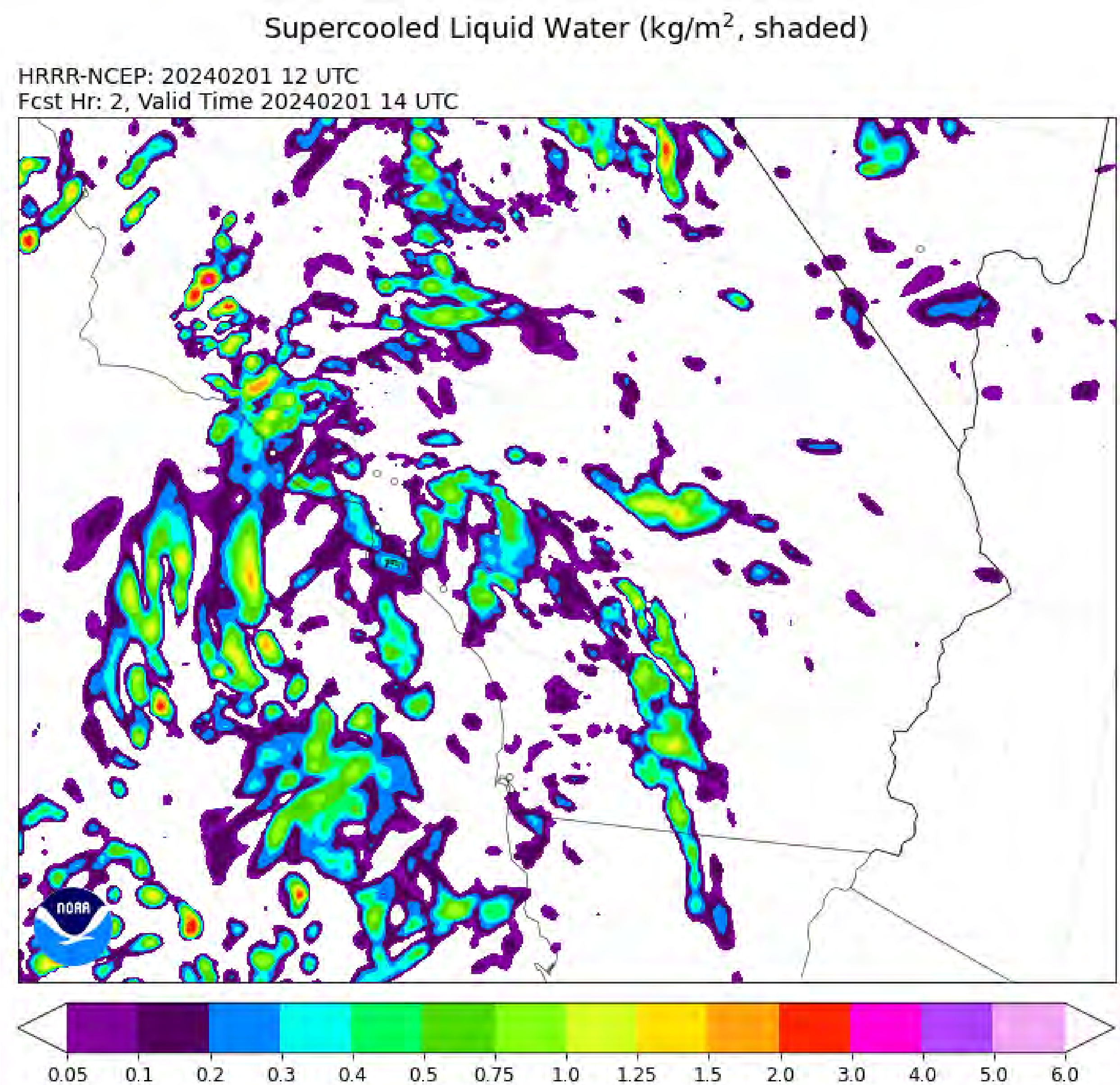

Figure 3.7. **Two-hour forecast of Supercooled Liquid Water (SLW) over southern California, valid at 0600 PST (1400 UTC) on February 1, 2024. Shading indicates concentration of SLW (kg SLW per m^2 of air). Data courtesy of NOAA GSL's HRRR website, https://rapidrefresh.noaa.gov/hrrr .**

Figures 3.8 and 3.9 illustrate the predictions of ground-based seeding plume dispersion for the SAWPA program using the National Oceanic and Atmospheric Administration's (NOAA) HYSPLIT (**HY**brid **S**ingle-**P**article **L**agrangian **I**ntegrated **T**rajectory) model. This model provides forecasts of the horizontal and vertical spread of a plume from potential ground-based seeding sites in real-time, based on wind and temperature fields contained in the weather forecast models.

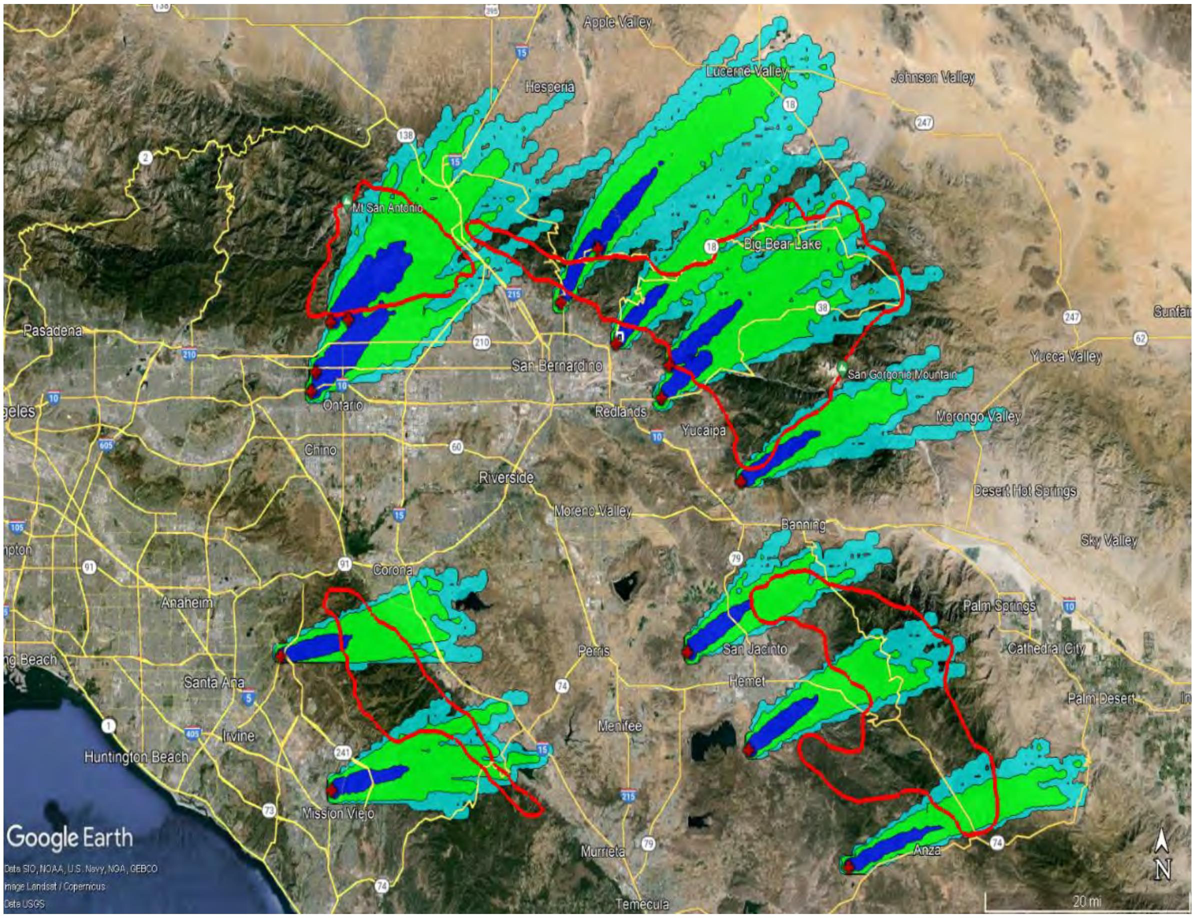

Figure 3.8. **HYSPLIT 1-hour horizontal plume dispersion forecast from SAWPA's seeding units for a storm event, valid on April 5, 2024, at 1300 PDT. Colors indicate the concentration of particles, blue being the greatest concentration followed by green and cyan.**

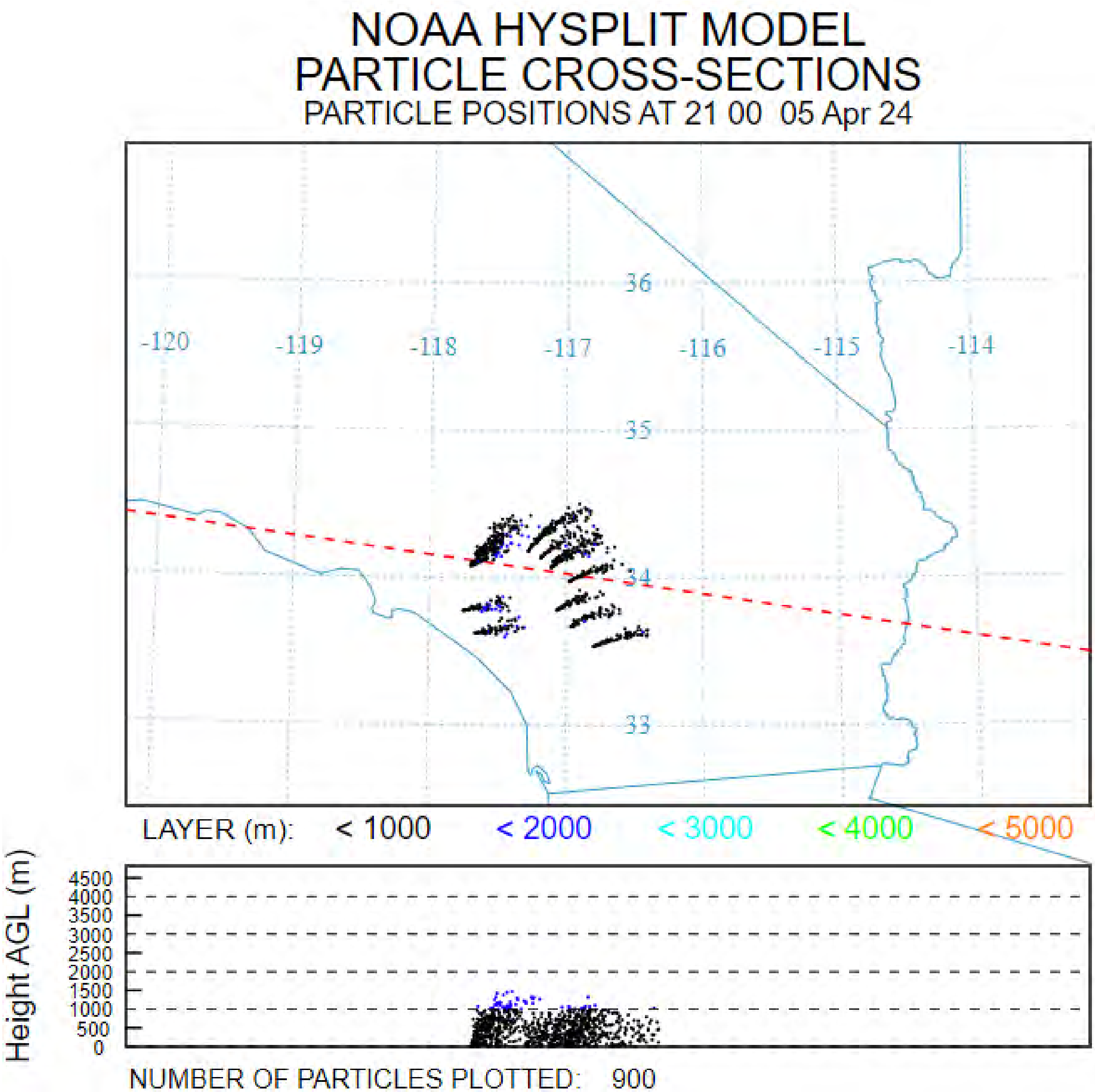

Figure 3.9. **HYSPLIT 1-hour horizontal (top) and vertical (bottom) plume dispersion from SAWPA's seeding units for same storm event and time as in Figure 3.8.**

4.0 OPERATIONS

The 2023-2024 cloud seeding Pilot Program began on November 15, 2023, and ended on April 15, 2024. During the season, there were 13 seeded storm events over a total of 22 days, broken down as follows:

Date	Number of Seeded Storms	Duration of Storms	Total Duration (days)
November 2023	1	Two consecutive days	2
December 2023	2	Two two-day storm events	4
January 2024	3	One one-day storm event; and Two two-day storm events, overlapping	4
February 2024	2	One one-day storm event; and One two-day storm event	3
March 2024	3	Three two-day storm events	6
April 2024	2	One one-day storm event; and One two-day storm event	3

A cumulative 2135.25 hours of seeding time from 12 CNG units occurred, along with a combined 32 AgI flares from the three AHOGS units. Table 4-1a and 4-1b show the dates and hours of CNG usage and flare burn during the season.

Table 4-1a
CNG hours and AHOGS flare usage November 2023 through February 1, 2024

	Nov 17-18	Dec 21-22	Dec 29-30	Jan 3	Jan 20-21	Jan 21-22	Feb 1
NW1			23.00	6.50		*	10.00
NW2			23.00	7.00		*	9.00
NW3	11.25	22.00	21.00	5.75	*	*	23.50
NW4	13.25	20.75	22.00		*	*	23.00
NE5		26.50	21.25	8.75	17.25	24.50	*
NE6		21.50	9.00	12.25	17.00	14.25	11.75
NE7		22.75	21.00	9.00	17.00	*	*
NE8		22.25	18.75	9.75	18.50	23.25	7.75
NE9		23.00	18.75	9.50	18.25	23.25	8.00
NE10		24.25	21.25	9.25	17.75	24.75	11.50
SE12		8.75	5.50	9.75	*	*	14.00
SE13		19.00	6.50	8.00	15.25	24.50	12.25
SE11		5 flares		2 flares		4 flares	1 flare
SW14		1 flare	3 flares		1 flare	3 flares	
SW15						*	

*** Units were not operated or operated at a reduced level due to operational issues.**

Table 4-1b
CNG hours and AHOGS flare usage February 20, 2024 through April 2024

	Feb 20-21	Mar 6-7	Mar 23-24	Mar 30-31	April 5	April 13-14
NW1	16.75	16.00	22.00	30.00	12.75	7.00*
NW2	16.25	*	20.25	*	9.25	7.00*
NW3	19.50	14.00	22.50	26.75	8.50	24.75
NW4	19.75	14.00	22.50	27.75	8.50	25.00
NE5	*	17.00	22.75	31.25	12.25	25.50
NE6	18.25	14.00	18.00	31.25	14.00	20.25
NE7	23.00	17.75	22.75	31.25	12.50	25.50
NE8	*	15.00	20.50	*	13.00	25.00
NE9	20.50	*	20.25	32.25	12.75	25.50
NE10	24.25	18.75	22.50	31.25	12.25	25.25
SE12		17.00	4.75*	33.00	9.00	
SE13		12.75	18.25	32.75	12.75	
SE11				1 flare	1 flare	
SW14		1 flare		2 flares	2 flares	
SW15		2 flares			1 flare	2 flares

*** Units were not operated or operated at a reduced level due to operational issues.**

Precipitation during the season was above normal. A strong El Niño signal was present in the Equatorial Pacific, and this may have affected the intensity of storms impacting southern California particularly during the middle portion of the season. Table 4-2 shows precipitation for selected sites within the four-target-area program, and Figure 4.1 shows a map of the locations of the precipitation sites.

Table 4-2
Seasonal Precipitation for the SAWPA Program Area

Site	Name	Nov 2023	Dec 2023	Jan 2024	Feb 2024	Mar 2024	Apr 2024	Season Total
1	Upper Day Canyon	0.95	0.90	2.28	7.92	2.33	1.02	15.40
2	Deer Creek Dam	1.26	1.89	2.76	19.77	9.80	3.23	38.71
3	Cable Canyon	1.38	2.96	2.40	12.29	8.08	2.20	29.31
4	Oak Creek Canyon	1.41	1.70	2.24	13.07	6.14	2.44	27.00
5	Big Bear City Airport	0.66	0.53	1.38	7.44	1.78	2.14	13.93
6	Camp Angelus	0.99	1.57	2.91	12.32	4.65	1.50	23.94
7	Oak Glen Watershed	2.01	1.58	3.07	12.72	6.06	1.89	27.33
8	Idyllwild NWS	1.48	1.35	4.45	9.41	5.43	1.74	23.86
9	Hurkey Creek	0.98	0.54	2.65	5.49	3.16	1.14	13.96
10	Upper Silverado Canyon	0.24	1.94	1.02	4.96	7.25	1.34	16.75
11	Riverside Muni Airport	0.17	0.86	1.68	6.94	2.38	0.14	12.17
12	Hemet	0.87	0.80	1.94	4.33	1.69	0.67	10.30

Figure 4.1. **Location of precipitation sites from Table 4-2. Red outlines are the four target areas.**

4.1 Storm Summaries

NOVEMBER 2023

November 15 (no seeding)

An upper low was sitting off the coast of central California, and a subtropical jet with associated moisture was feeding into the underside of the low. A shortwave disturbance emanating from the low ejected out across southern California during the afternoon and evening bringing periodic heavy showers and isolated thunderstorms. Given the subtropical nature of the airmass over southern California, temperatures aloft were quite warm, with 700 mb (approximately 10,000 feet MSL) temperatures of +4°C/+5°C (39-41°F) measured on the morning and afternoon balloon soundings from San Diego. Because of the warm air, seeding operations were not able to take place. Figure 4.2 shows a radar image during the early part of the event, centered on the Inland Empire (KF70 is Murrieta/Temecula airport; KHMT is Hemet Ryan Airport).

Seedability: POOR. Although wind flow was ideal for targeting and moisture availability was good, the airmass accompanying the storm system was warm, with temperatures above freezing at 700 mb / 10,000 feet MSL. For this reason, seeding operations would have had no effect and were not conducted.

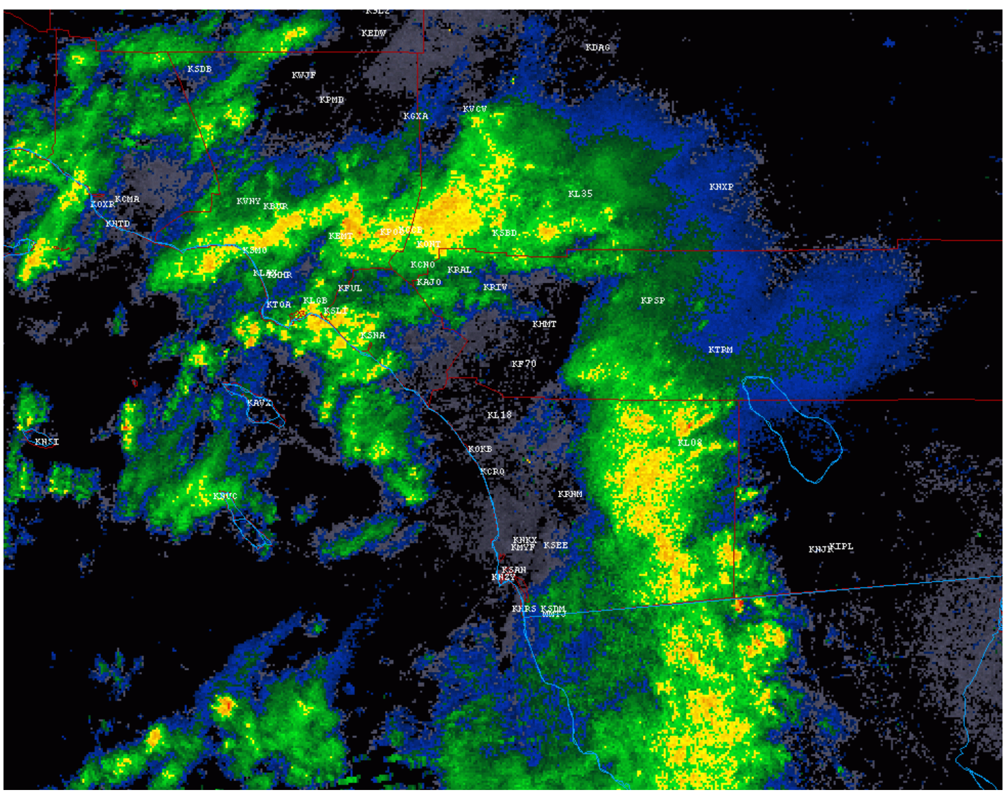

Figure 4.2. **Radar image from 1945Z (1145 PST) on November 15 showing numerous showers across the SAWPA WM PP area. Image courtesy of College of DuPage webpage, https://weather.cod.edu**

November 17-18

An upper low located several hundred miles west of the California coast was in the process of evolving into an open trough of low pressure and starting to shift northeast toward the central and northern California coast. The southern extent of the trough was forecast to swing across the project area from late evening of November 17 into the afternoon of November 18 bringing cooler mid-level temperatures and moisture that would be marginally sufficient for potential seeding operations. Two CNG sites, NW3 and NW4 were activated late evening of November 17/early morning of November 18 in anticipation of more favorable conditions arriving for seeding operations. The map of the location of the active sites is shown in Figure 4.3, and Figure 4.4 shows the presence of modeled supercooled water adjacent to the NW Target area. Two other nearby sites were not activated as HYSPLIT modeling indicated the plumes from these other sites (NW1/NW2) would remain south of the NW Target area. As it turned out, temperatures aloft did not cool sufficiently and moisture availability was less than forecast, so although both sites ran for 11-13 hours, it is unlikely any effects from seeding occurred. Infrared satellite imagery showing some of the shower activity during the event is shown in Figure 4.5.

Seedability: POOR. Moisture was confined primarily to the western parts of the area. Two of four sites in the northwest portion of the area were activated with the expectation – based on forecast models – that temperatures aloft, which were too warm at the start of the storm would cool sufficiently such that seeding operations would become more ideal. Temperatures did eventually cool, but not enough for seeding efforts to be effective.

Problems/issues: None.

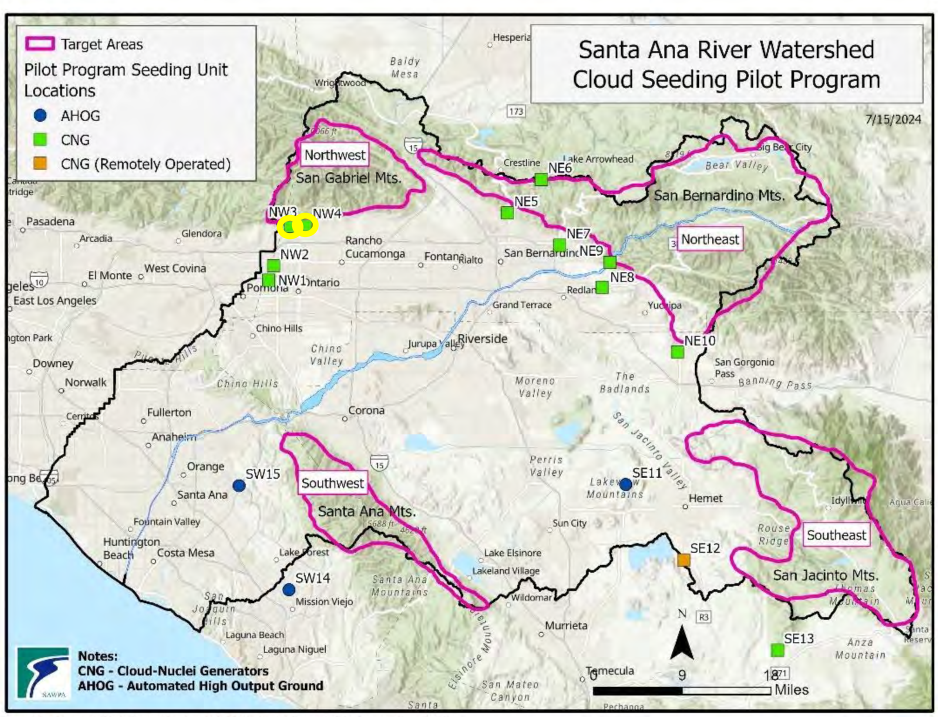

Figure 4.3. **Map showing active seeding sites on November 17-18, 2023, indicated by yellow circles.**

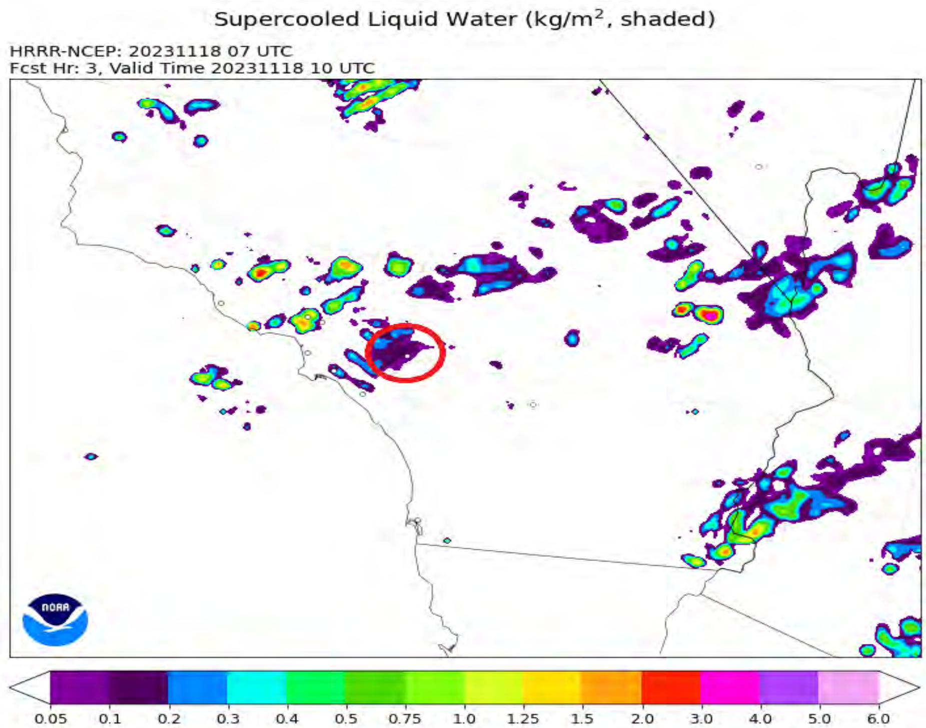

Figure 4.4. **HRRR model run from 07Z/Nov 18 (2300 PST Nov 17) showing marginal amounts of SLW (Supercooled Liquid Water) across southwestern San Bernardino County (in red circle), valid at 0200 PST on Nov 18. Image courtesy of NOAA's HRRR model page, https://rapidrefresh.noaa.gov/hrrr .**

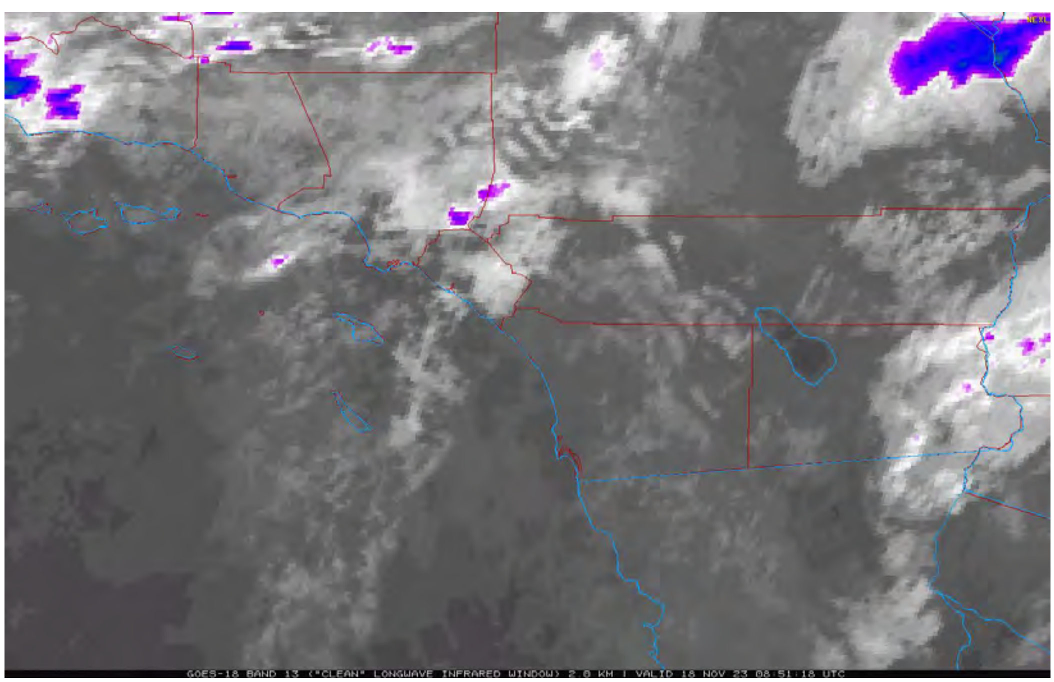

Figure 4.5. **Infrared satellite imagery from 0051 PST on November 18 centered on Inland Empire. Image courtesy of College of DuPage website.**

November 30 (no seeding)

A weak upper-level disturbance moved across central and southern California during the afternoon and evening hours. Although moisture was limited, the storm had some decent upper-level dynamical forcing thanks to the presence of an upper-level jet stream oriented in a northwest-southeast fashion across central and southern California. Because of the jet stream dynamics, scattered showers and thunderstorms were able to develop along the southern edge of the San Bernardino mountains and move southeast across the Inland Empire. Later in the evening a few short-lived showers and thunderstorms managed to develop southwest of Big Bear Lake and, again, move southeast out over the Inland Empire. Mid-level temperatures were just a bit below freezing which was marginally sufficient for seeding operations, however a small stable layer of air around 800 mb (approximately 6500-7000 feet MSL) as sampled on the late afternoon San Diego sounding was in place, which would prevent seeding plumes from rising above it. As such, no seeding operations took place. Figure 4.6 shows a lightning strike map from the evening of the event.

Seedability: POOR. Although mid-level temperatures were marginally ideal for seeding operations, wind flow suggested only eastern areas would see ideal targeting of any seeding plumes, and the presence of a low-level stable layer indicated that rising seeding plumes would not be able to reach high enough for any seeding effects to occur.

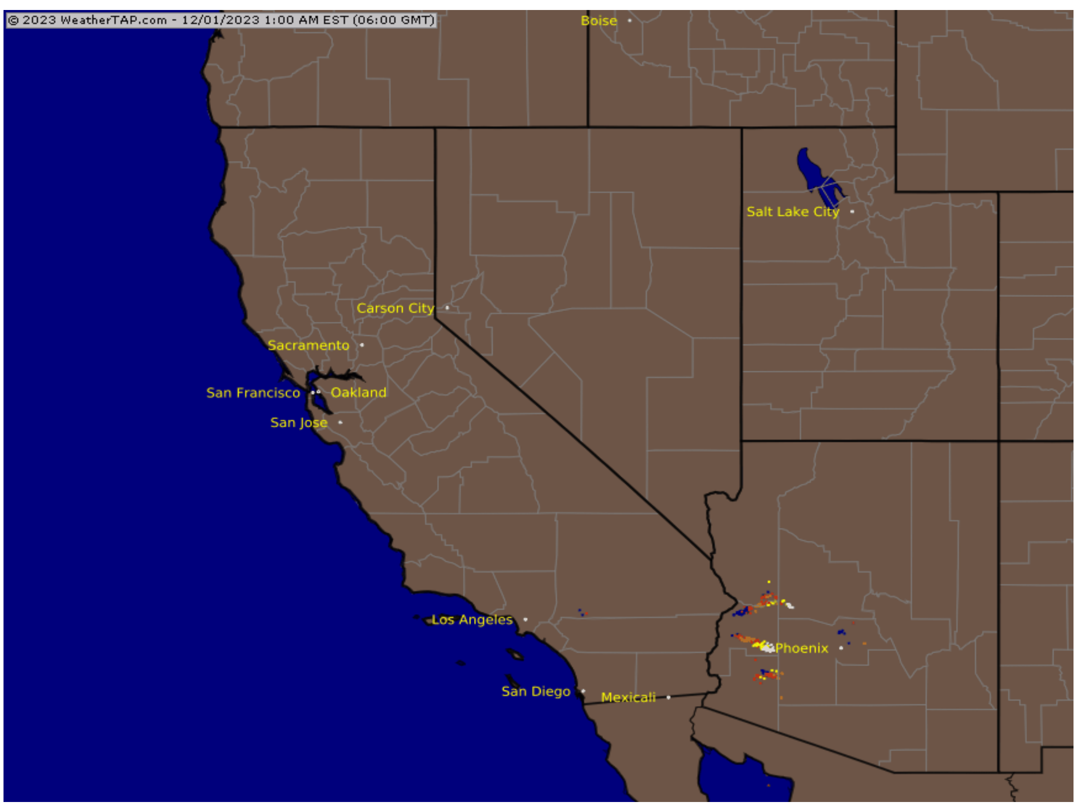

Figure 4.6. Lightning strikes, valid at 2200 PST on November 30. Note isolated strikes in SW San Bernardino County. Color coding indicates strikes were 90-120 minutes old.

DECEMBER 2023

December 19-22

Moist onshore flow set up on December 19 in response to a trough of low pressure and developing upper-level low off the Pacific Northwest coast. Mild temperatures and scattered showers moved across the area, but conditions were too warm and stable for seeding operations at this time. Over the course of the next couple of days, the upper low continued to develop, dropping southward several hundred miles west of the California coast while maintaining moist, stable onshore flow across the project area along with periodic rounds of showers. Figure 4.7 shows a visible satellite image taken at 1421 PST on December 20. As the low reached waters west/southwest of the project area on the afternoon of December 21, more substantial precipitation was poised to push into southern California, along with cooler temperatures aloft. Seeding sites were activated during the late afternoon/evening of December 21, with 9 of 11 manual CNGs activated for the storm; the two Chino Basin sites (NW1/NW2) were not used as HYSPLIT modeling indicated plumes missing the target areas. The remote CNG (SE12) was activated shortly after midnight. As the wave of rain and embedded convection pushed onshore into Orange County, one flare was fired from the AHOGS (SW14). SW15 was not utilized due to improper targeting based on wind direction. Figure 4.8 shows a radar image from 0145 PST on December 22 as the main wave of precipitation was pushing into the area. Seeding continued through the overnight hours as rain and higher elevation snow. As the low moved closer to the coast on the morning and early afternoon of December 22, daytime heating of the now unstable airmass allowed for scattered convective cells to develop and move northwestward. Some of this activity neared the AHOGS site near Hemet, and five flares were burned. A PIREP (PIlot REPort) over Banning/descending into Palm Springs during this time confirmed the presence of supercooled water (reported as moderate rime icing) over the area. Location of all active sites during the event is shown in Figure 4.9.

Seedability: FAIR. Mid-level temperatures were warm to start but as the system neared, temperatures cooled to marginally ideal levels. Moisture availability was good during the seeded portion of the storm. Wind flow was poor to start, then as the main portion of the low arrived the flow pattern improved for better targeting.

Problems/issues: None.

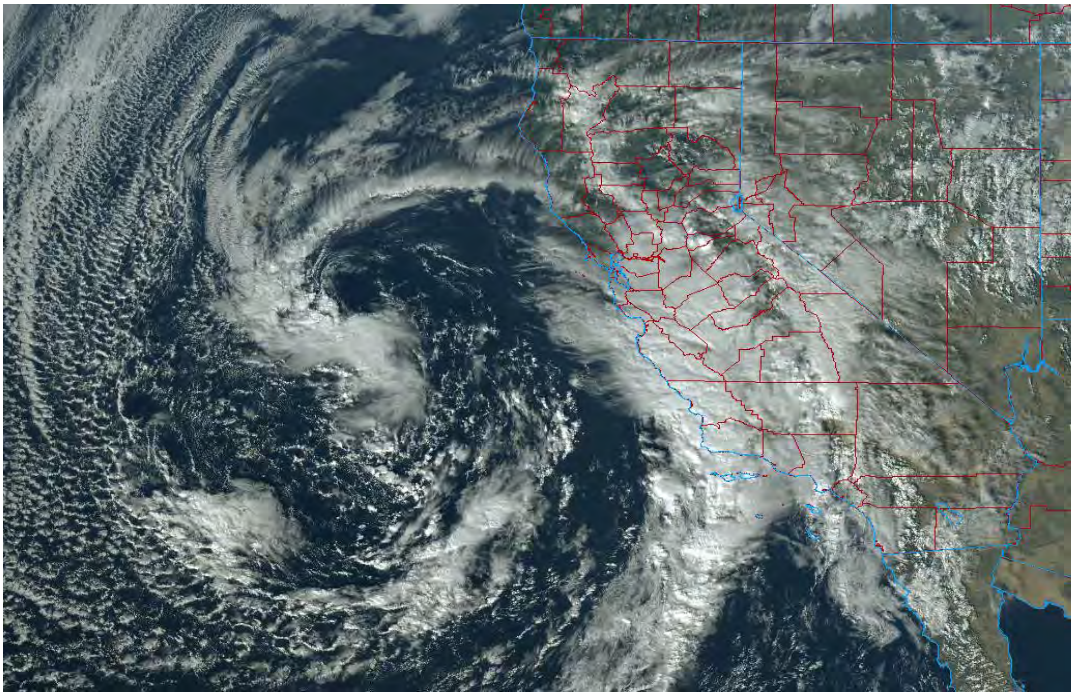

Figure 4.7. **Visible satellite image from 1421 PST on December 20 shows the location of the upper low west of the central California coast. Image from College of DuPage Weather.**

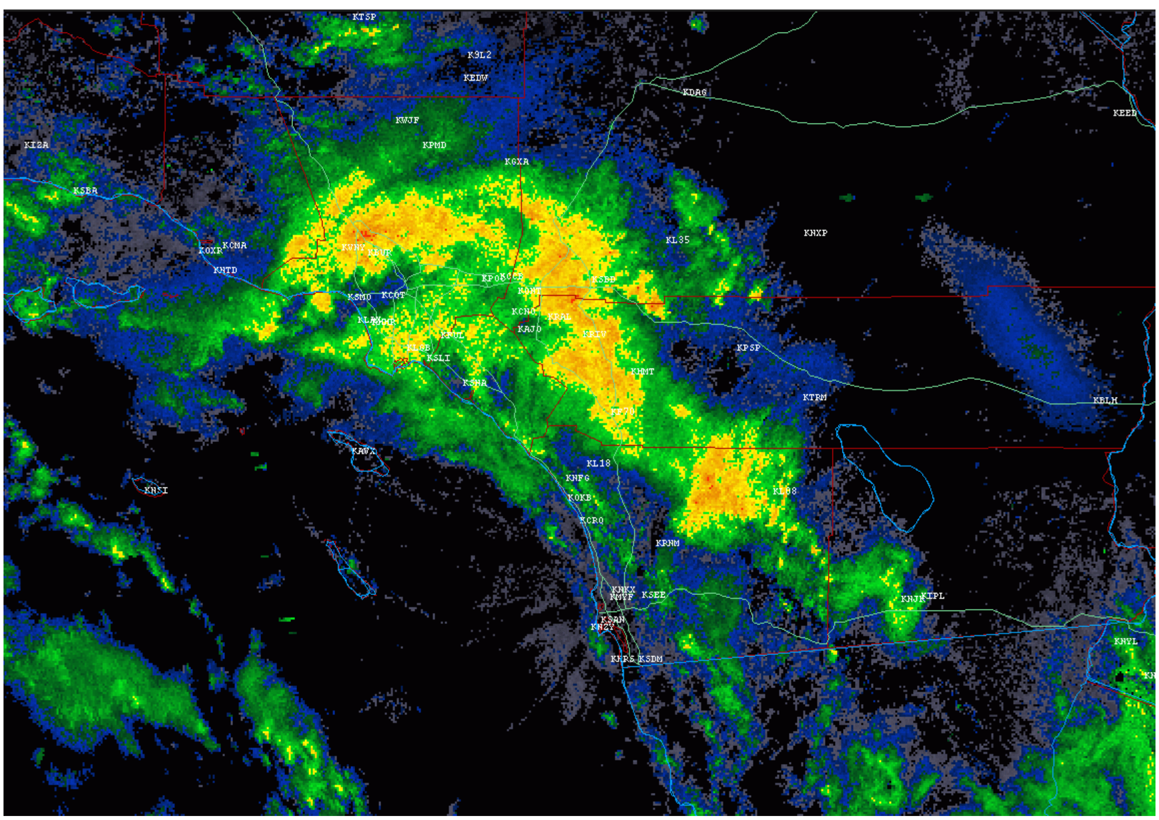

Figure 4.8. **Radar image from 0145 PST on December 22 showing precipitation over the area Image courtesy of College of DuPage Weather.**

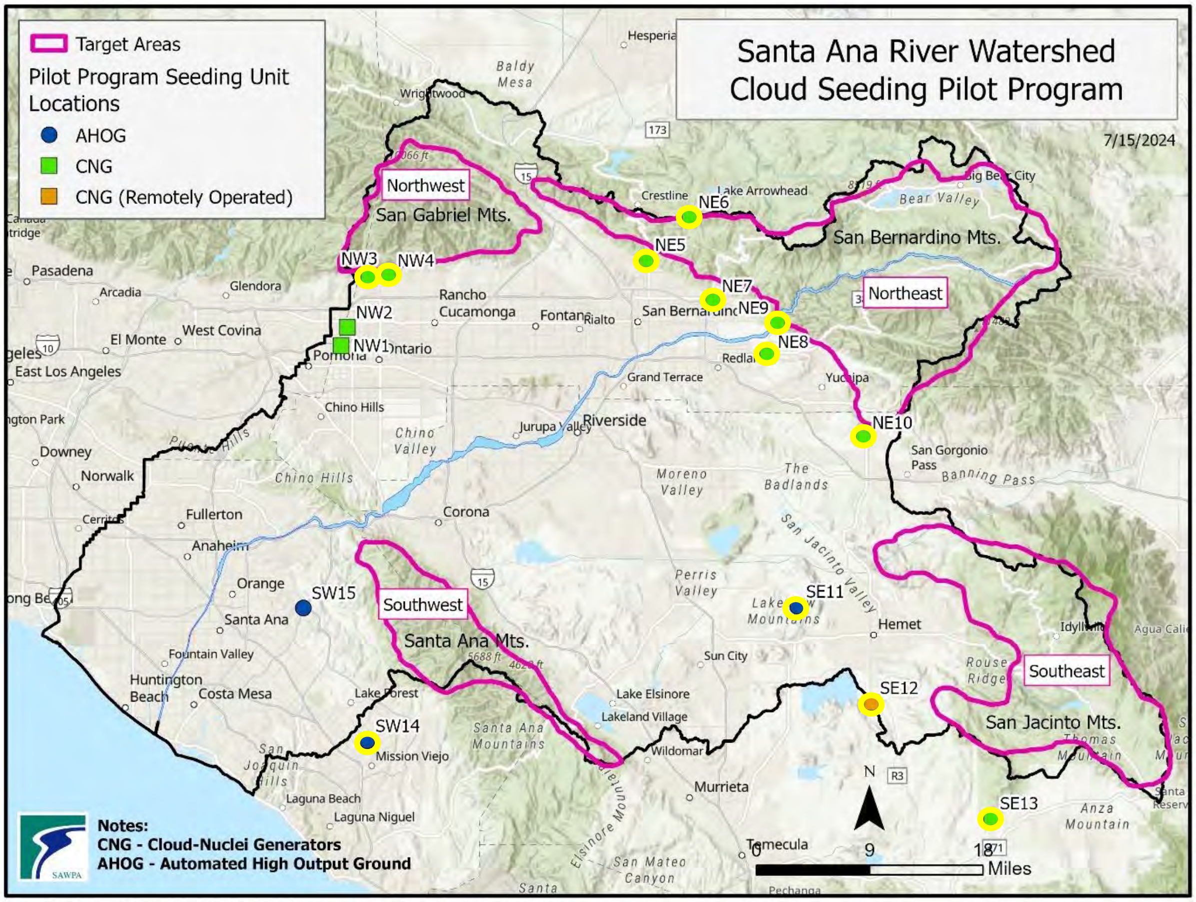

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Figure 4.9. **Map showing active seeding sites on December 21-22, 2023, indicated by yellow circles.**

<u>December 29-30</u>

An extensive trough of low pressure was positioned from west of British Columbia southward to west of southern California on December 29. The trough approached the coast during the evening hours, with rain spreading in from the west overnight. All CNG sites were activated during the evening of December 29/morning of December 30. The frontal band reached the western edge of the project area between 0500 and 0600 PST on December 30 and pushed across the area during the morning. HRRR modeling indicated the presence of supercooled liquid water (SLW), an image of which is shown in Figure 4.10. As the band pushed into Orange County, two flares were fired from the El Toro AHOGS site. Precipitation continued through the morning, with most activity out of the area by early afternoon. A few convective cells developed in Orange County just before 1400 PST and one additional flare was burned at El Toro as the cells passed by. With no other activity expected, all operations were halted. Figure 4.11 shows the location of all active sites during the event.

Seedability: GOOD. Just ahead of the frontal band that moved across the area, a stout inversion was in place at 850 mb / 5000 feet MSL that would have prevented seeding plumes from rising above that level, in addition to mid-level temperatures being too warm. The inversion mixed out with the arrival of the frontal band and mid-level temperatures cooled, resulting in improving seeding conditions. Afternoon convection also provided for a few seeding opportunities with an AHOGS unit in Orange County.

Problems/issues: Operators at sites NW2 and NE7 indicated smelling propane when turning off sites at end of storm event. Notified respective propane companies who investigated and fixed leaks near valves.

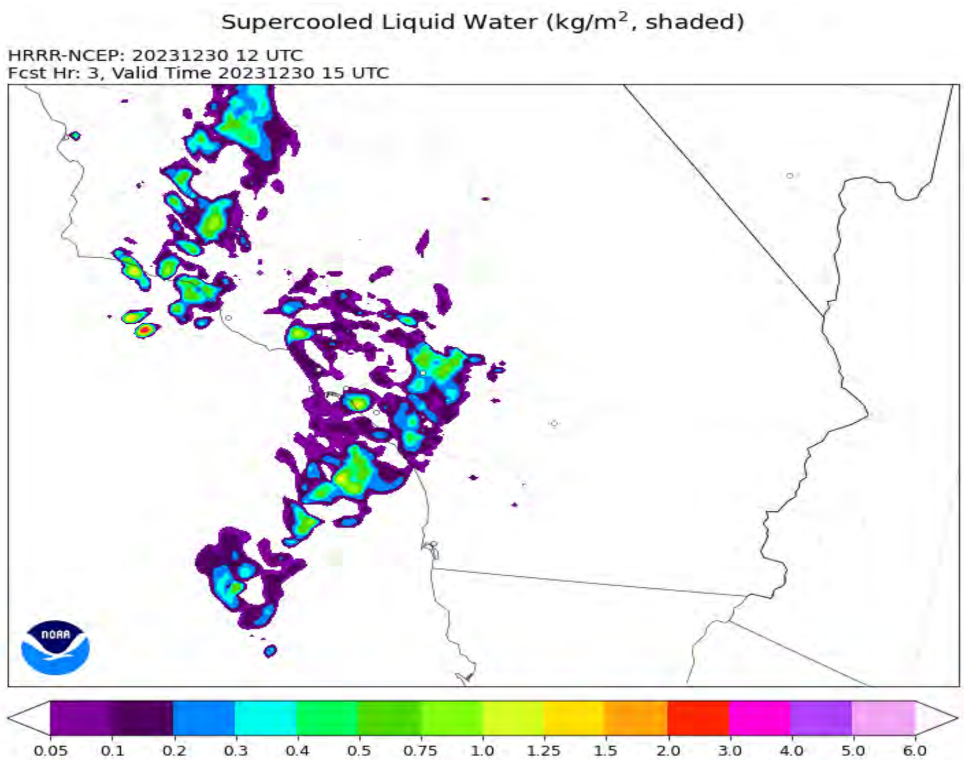

Figure 4.10. HRRR model showing supercooled liquid water (SLW) over western SAWPA area at 0700 PST on December 30.

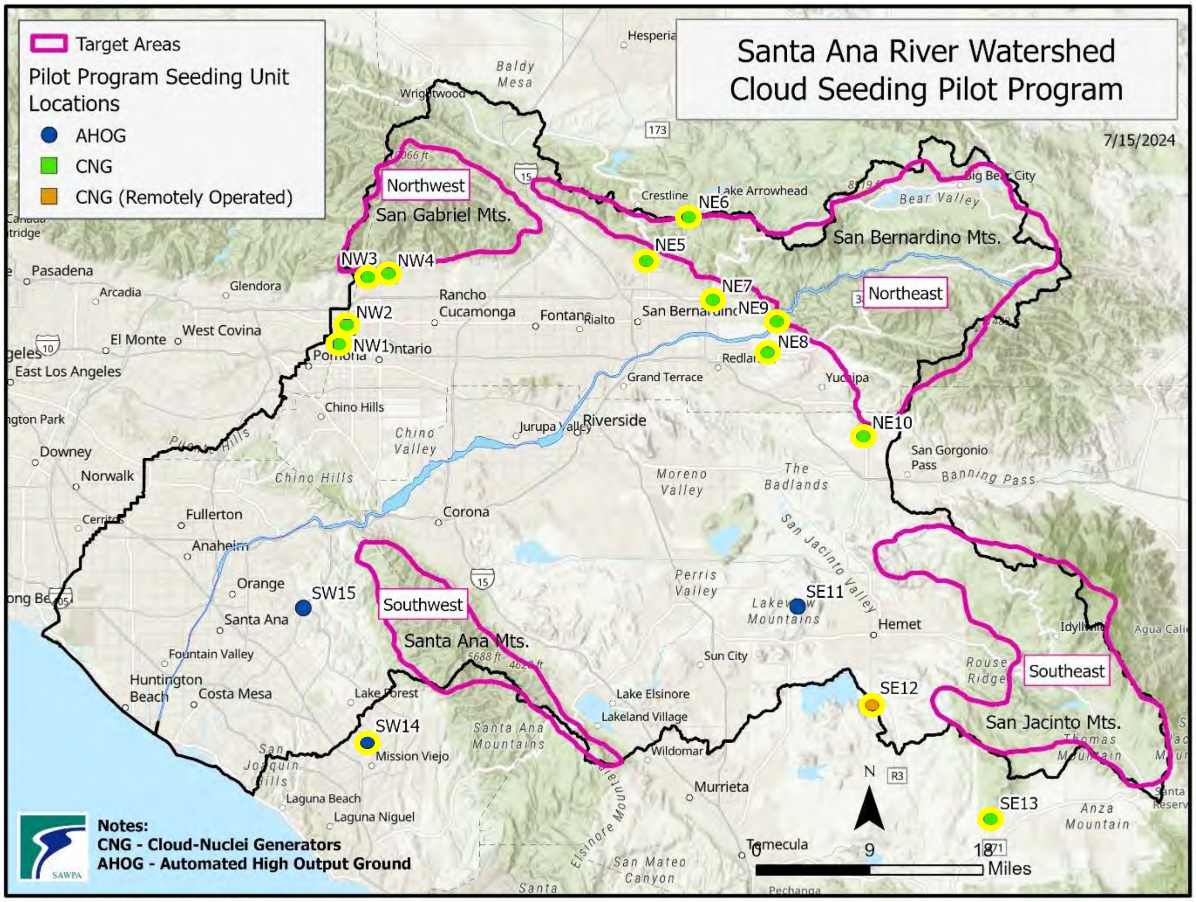

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Figure 4.11. Map showing active seeding sites on December 29-30, 2023, indicated by yellow circles.

JANUARY 2024

January 3

Late in the evening of January 2, a trough of low pressure extended from west of British Columbia southward into the eastern Pacific with the base of the trough several hundred miles west of Point Conception. Very cold air aloft accompanied the trough, with 500 mb (approx. 18,000 feet MSL) temperatures around -30°C near the core, and 700 mb (approx. 10,000 feet MSL) temperatures were -7°C to -8°C. Figure 4.12 shows an infrared satellite image depicting the trough west of California. Moisture was lacking with this system, however upper-level diffluent flow (the spreading of winds laterally) in the southeast quadrant of the trough, which would move across southern California, was increasing lift across this region and compensating for the lower moisture content. At midnight on January 3, a cold front accompanied by a band of precipitation, was located from northeastern California to near Bakersfield to Santa Barbara, with motion east and southeast toward the project area. Before dawn, the frontal band reached the western parts of the project area, by which time all but one CNG site was active. The front and its associated precipitation moved across all target areas during the morning hours, with the back edge of the band exiting the eastern areas by 1100 PST. Figure 4.13 shows radar imagery from 0745 PST while the band was lying across the entire area. With a combination of daytime heating and the cold core of the trough moving overhead during the afternoon hours, the airmass across the area became slightly unstable, and scattered convective cells began to develop across the San Bernardino Mountains (NW/NE target areas) with a motion to the east-southeast. Scattered rain showers/higher elevation snow showers and even thunderstorms moved across the eastern parts of the project area through late afternoon before tapering off. Two flares from the SE11 AHOGS site were used for seeding during this period as convection approached this site. Figure 4.14 shows all active sites during the storm period.

Seedability: GOOD. Mid-level temperatures cooled to ideal levels (i.e., below -5°C) with the frontal band that moved across the area. Wind flow was ideal for proper targeting until the tail end of the storm event. Moisture availability was marginal, with precipitable water (PWAT) values between 0.55-0.60".

Problems/issues: Operator at NE9 noted solution leak when turning off CNG. Passed info on to field technician in Utah who visited shortly after and repaired leak. Operator unable to get access to NW4 due to condition of the access road.

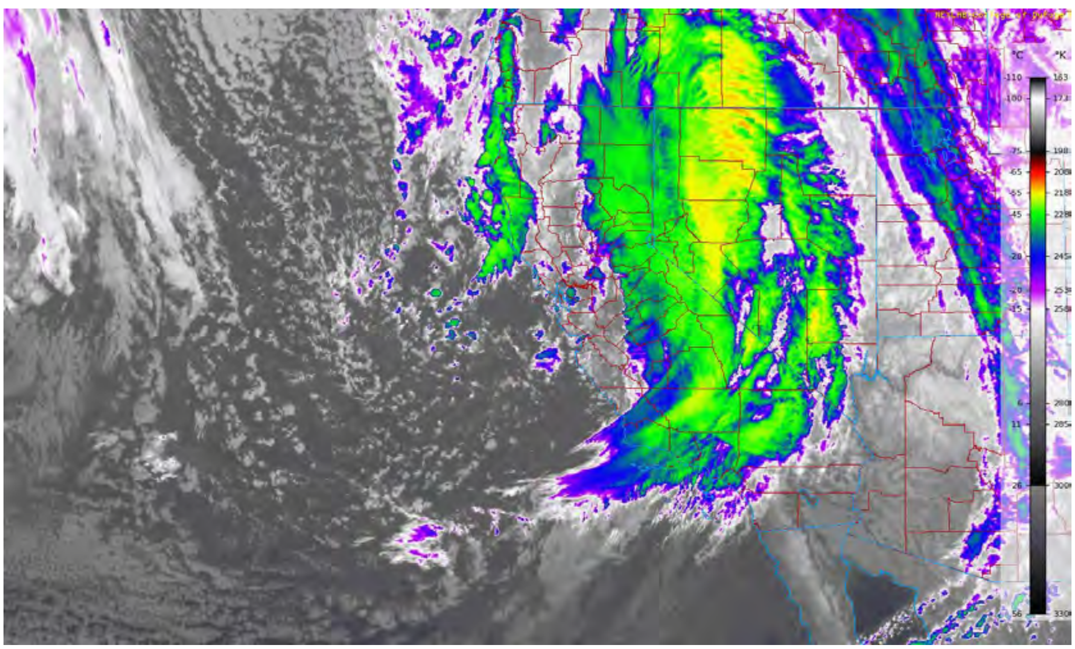

Figure 4.12. Infrared satellite image from 0121 PST on January 3 shows the location of trough west of the California coast with the frontal band on the east side of the trough. Image from College of DuPage Weather.

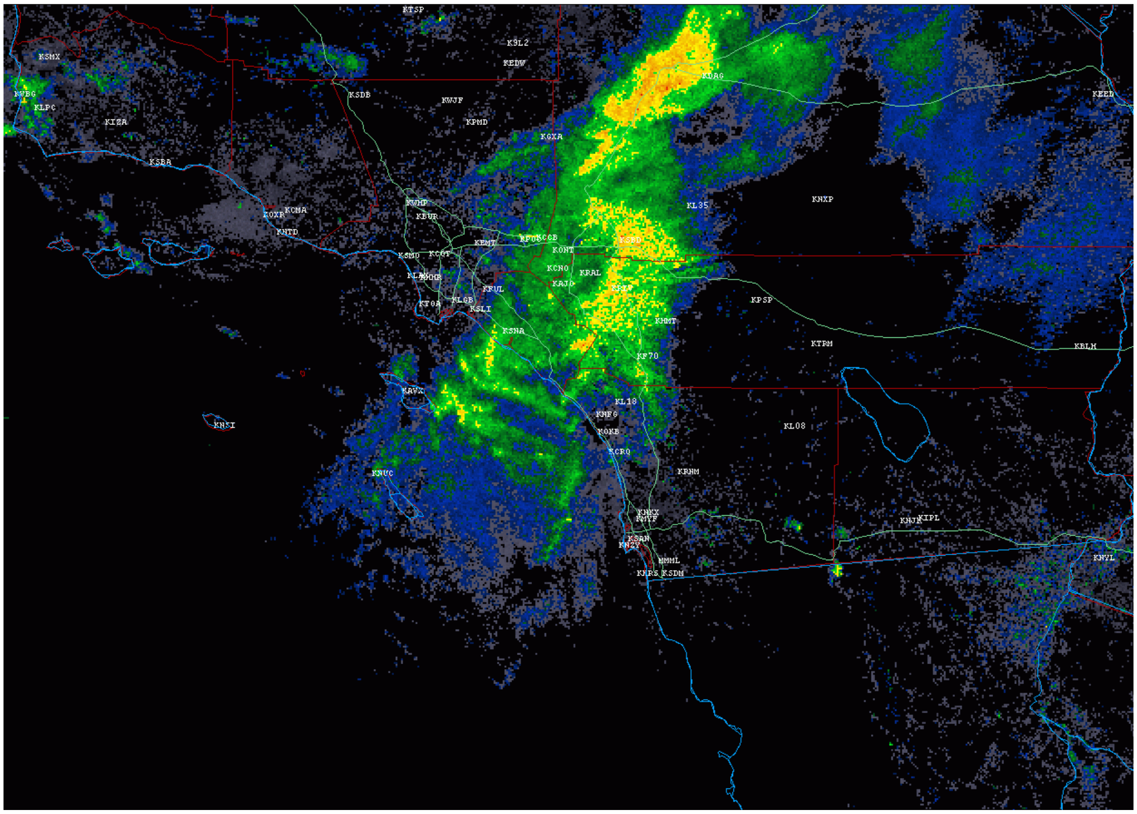

Figure 4.13. **Radar image from 0745 PST on January 3 showing frontal band over the area. Image courtesy of College of DuPage Weather.**

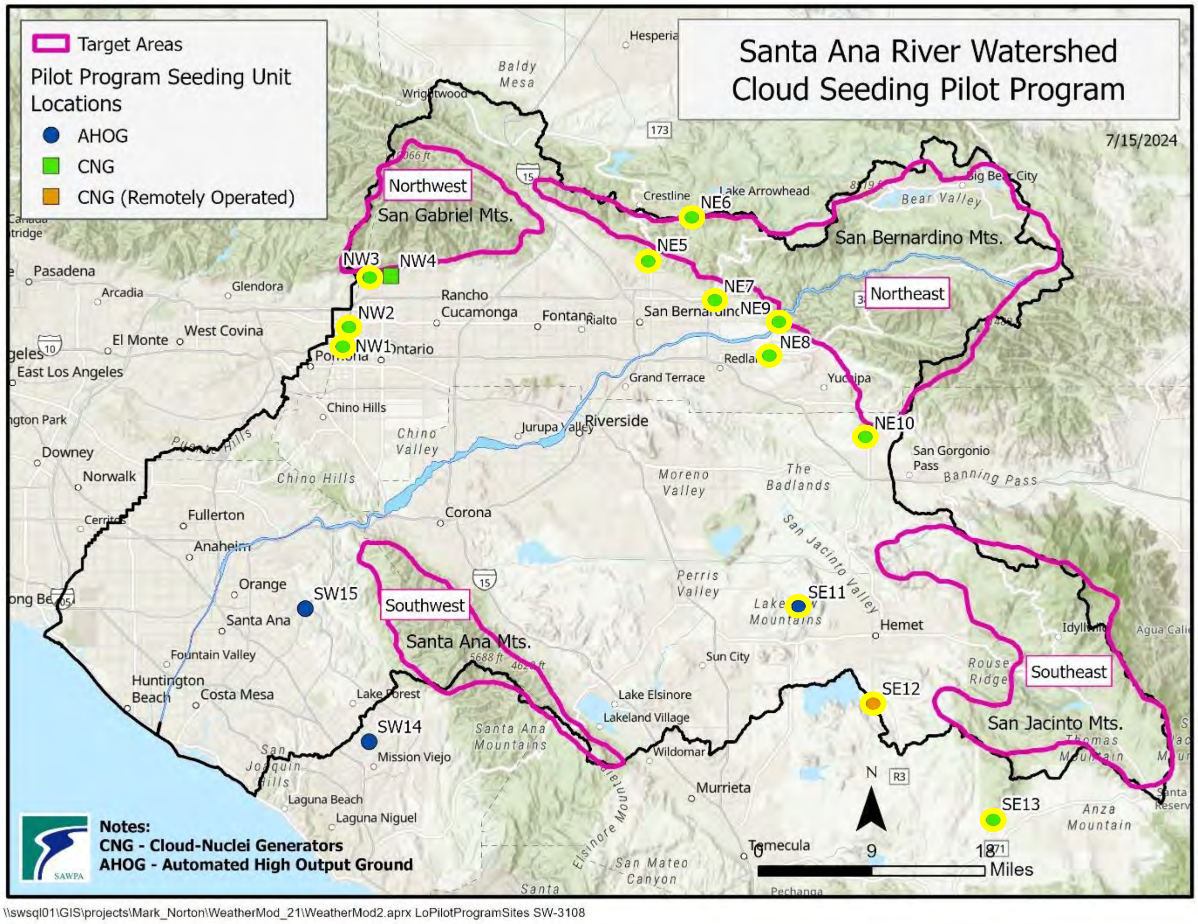

Figure 4.14. **Map showing active seeding sites on January 3, 2024, indicated by yellow circles.**

__January 7 (no seeding)__

An inside slider was moving southeast through the interior of California accompanied by a tight pressure gradient and some moisture, with rain and mountain snow showers being observed in some areas of the project area. Winds associated with the system were strong, with High Wind Warnings in place for the San Bernardino and Riverside County mountains where wind gusts exceeded 60 mph, peaking at 92 miles per hour (mph) at Burns Canyon. Winds in the Inland Empire and other lower elevation sites were frequently exceeding 40 mph. Because of the stronger winds in place, seeding operations were not conducted as targeting would not be appropriate. Figure 4.15 is a radar image from the overnight hours of January 7 as some precipitation moved across portions of the project area.

Seedability: POOR. Strong winds were in place, and any seeding units that would have been activated would have produced very long and narrow seeding plumes that would likely not nucleate before passing the target areas.

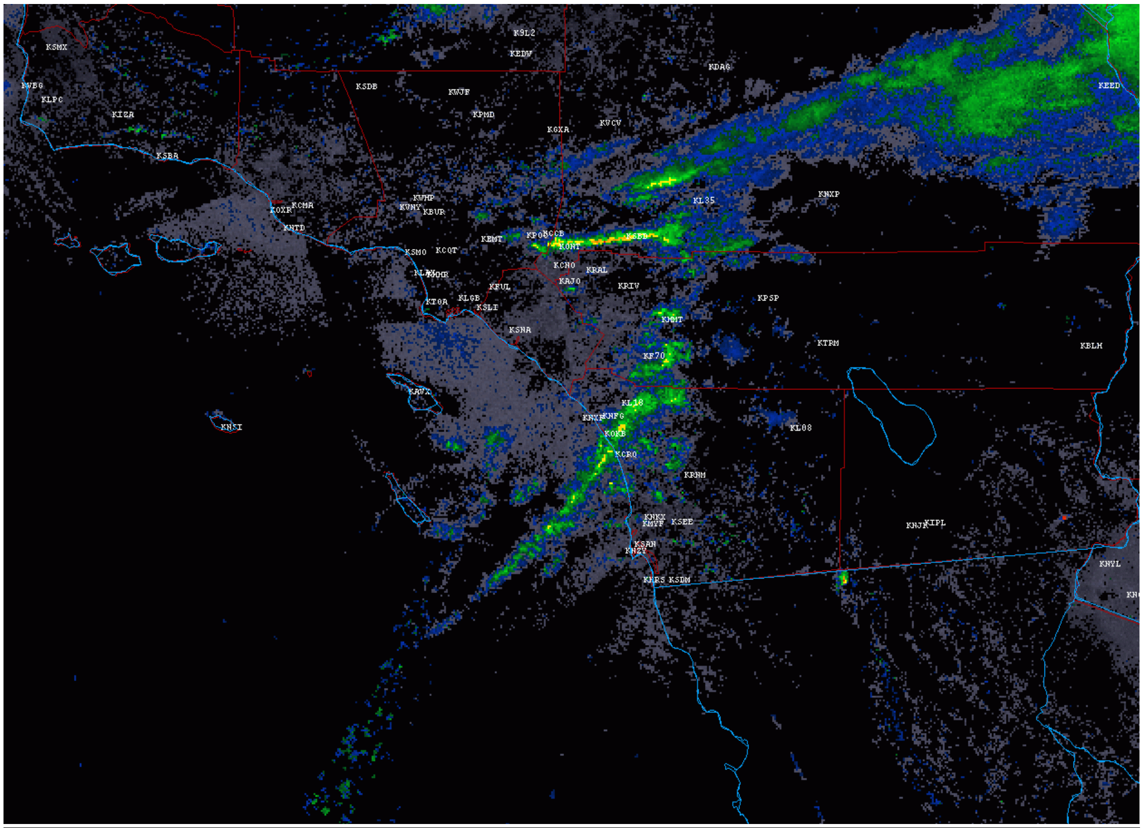

Figure 4.15. **Radar image from 0230 PST on January 7 showing scattered showers moving across portions of the SAWPA area.**

<u>January 20-22</u>

A trough of low pressure was located across the West Coast. Several shortwave disturbances embedded within the flow of the trough were poised to move across southern California, with the first one arriving during the late morning hours of January 20. No seeding operations with the CNGs were conducted with this first wave as the morning sounding from San Diego indicated a stable airmass below 6000 feet and 700 mb temperatures were warm, at +1°C. However, weak convective cells began developing just offshore from Orange County during the noon hour and approached the coast; one flare was fired from the AHOGS unit (SW14) at 1251 assuming any convective currents near this activity would be sufficient to draw the AgI plume up into the cloud. Figure 4.16 shows a visible satellite image just prior to the moment of seeding from SW14 AHOGS unit. The first wave of precipitation exited to the east by evening. The late afternoon (January 20) sounding from San Diego indicated that 700 mb temperatures had cooled to -3°C and weak stability remained, though less than earlier in the day, along with an increase in precipitable water. Snow levels were around 7000-7500 feet. The next shortwave disturbance within the trough was pushing into Los Angeles County at mid evening. Ahead of this, with better conditions in place for seeding, several sites were activated for the NE and SE target areas; the remote generator SE11 was not able to start because earlier rainfall had soaked the ignitor, preventing it from sparking a flame. Figure 4.17 shows the sites active for this part of the storm period. Precipitation entered the western parts of the project area prior to midnight and continued to move east across the area into the overnight period, with activity exiting to the east with the shortwave after 21/0300 PST. Radar imagery during this time is shown in Figure 4.18. Sites were turned off during the morning of January 21, and for the remainder of the afternoon and evening, a few showers moved across the area with little accumulation.

The next, and final shortwave disturbance within the trough began to move into southern California around Santa Barbara County during the evening hours of January 21. Prior to this system's arrival, several CNGs were re-activated. Steady precipitation arrived in the western portions of the project area at 0400 early on January 22, spreading across the entire area by daybreak. Rain and higher elevation snow continued through the morning, with snow levels remaining around 7000-7500 feet. After the steady precipitation ended over western areas, isolated convective development occurred just offshore, moving into Orange County between 1030 and 1100 for which two flares were burned from the SW14 AHOGS unit. Later in the afternoon, additional convective development occurred over the eastern areas and four flares were burned from the SE11 AHOGS site between 1520 and 1550 PST as a short line of moderate to heavy convection moved across the eastern areas. Figure 4.19 shows a camera snapshot of a flare burning from the SE11 AHOGS site during this time period. One more flare was burned at the SW14 site shortly after 1600 as additional showers moved across parts of Orange County. All activity ended early in the evening. Figure 4.20 shows the sites that were active for this disturbance.

Seedability: FAIR to GOOD. Temperatures at 700 mb were generally between 0°C and -3°C; while cooler temperatures aloft would be more ideal, convective currents were likely able to loft seeding plumes to cooler temperatures. Wind flow was good for proper targeting except for the Chino Basin sites where plumes were shown to be missing the target areas. Moisture availability was good with PWAT values between 0.75" and 1.10".

Problems/issues: Sponsors for sites NW3/NW4 changed the locks without informing the operator. As a result, the operator did not have the key for the gate during the weekend and was unable to access the sites to activate the units. These sites did not run for either wave of precipitation. Site NE7 ran low on propane and only ran for the first wave of precipitation. Remote site SE12 had a wet ignitor and could not light the CNG, so it did not run for storm event. Sites NW1/NW2, which were not run for first wave of precipitation as HYSPLIT modeling indicated plumes not targeting target area, were more ideal for second wave but, as copper line sleeving was still not completed, did not run for this portion of storm as well. Finally, connection to the AHOGS unit SW15 could not be established due to an inadequate power supply, as multiple cloudy days had kept the battery on the low side.

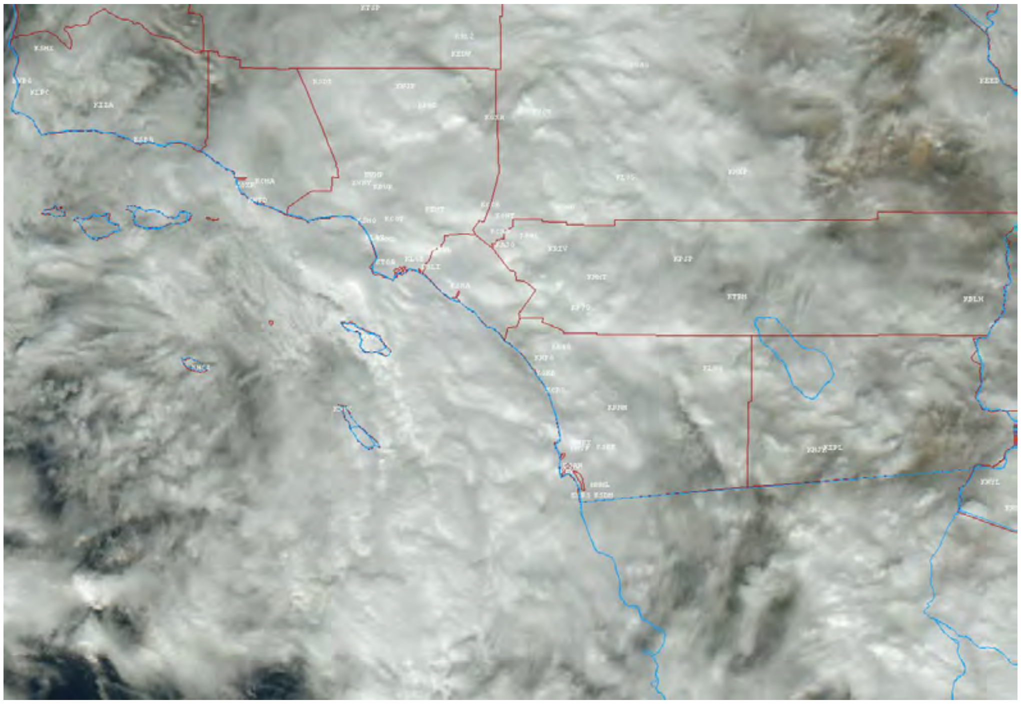

Figure 4.16. **Visible satellite image from 1241 PST on January 20, prior to the firing of a flare from the El Toro AHOGS unit in Orange County.**

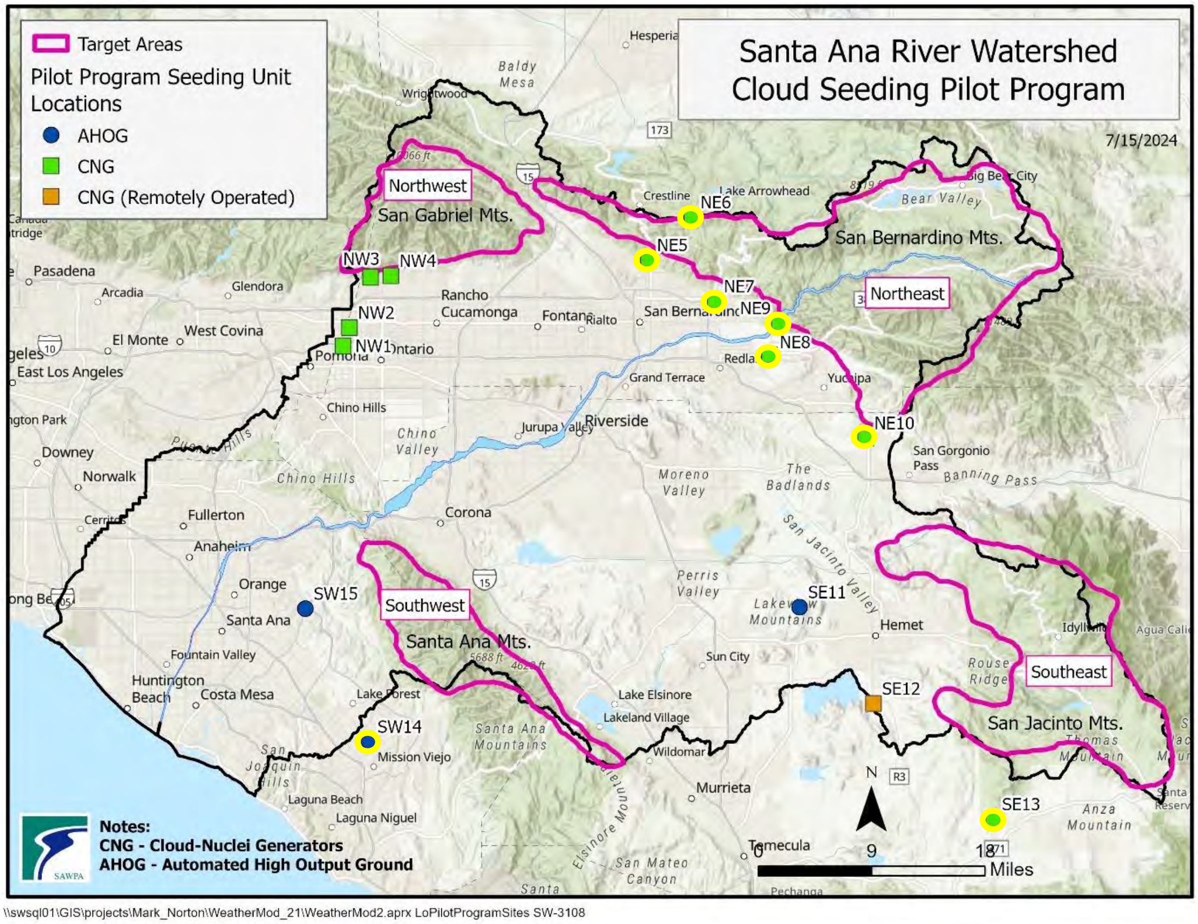

Figure 4.17. **Map showing active seeding sites on January 20-21, 2024, indicated by yellow circles.**

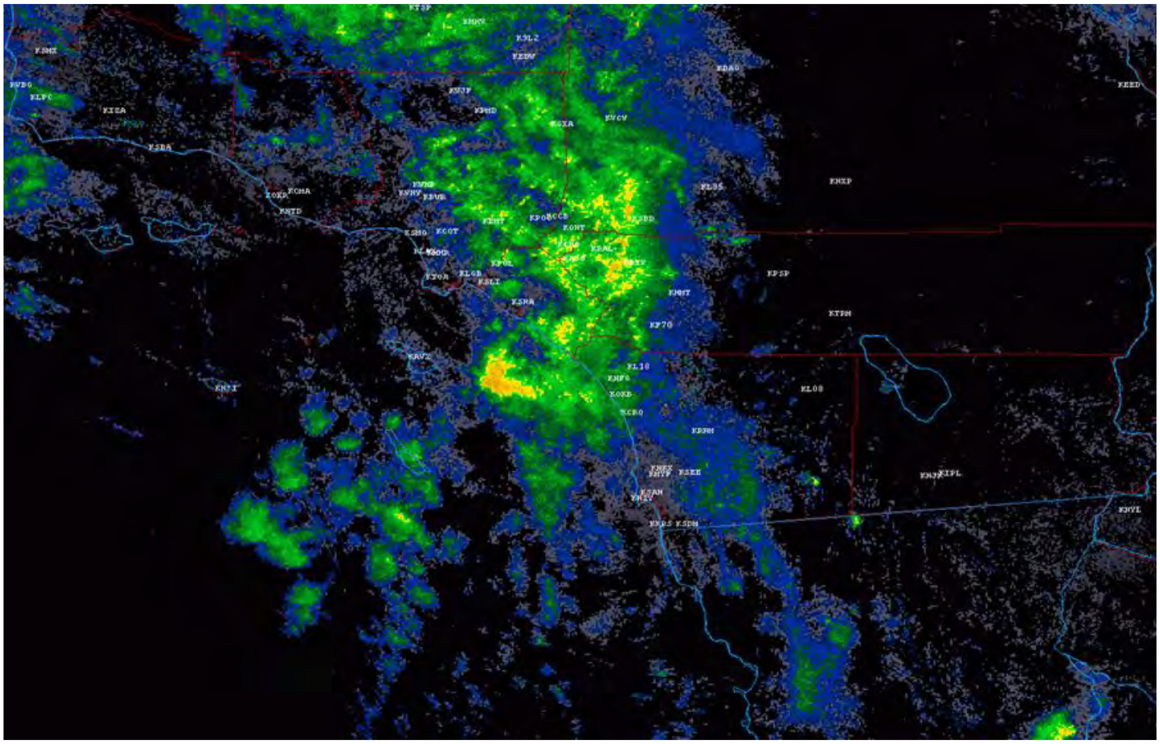

Figure 4.18. Radar image from 0015 PST on January 21.

Figure 4.19. Camera snapshot of flare burning from SE11 AHOGS site at 1548 PST on January 22, 2024.

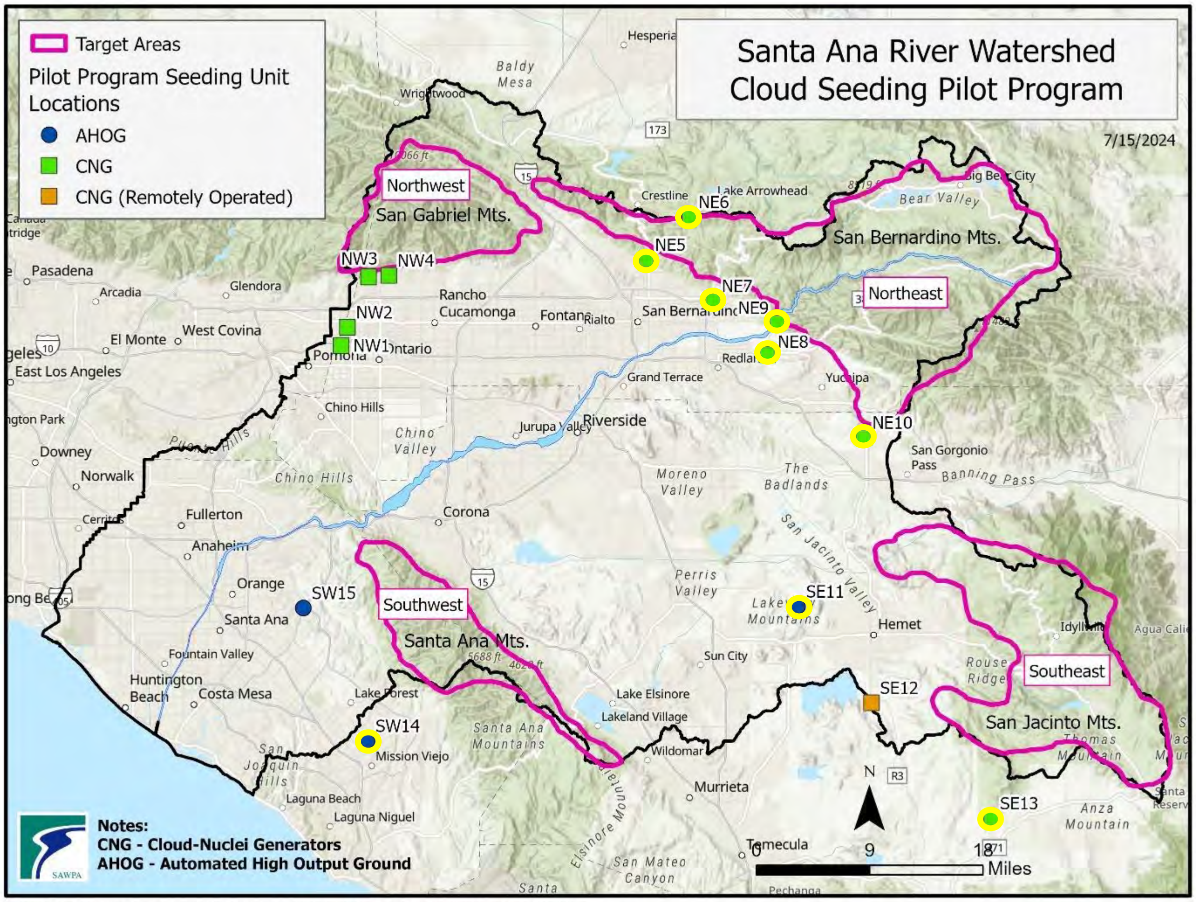

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Figure 4.20. Map showing active seeding sites on January 21-22, 2024, indicated by stars.

FEBRUARY 2024

<u>February 1</u>

A powerful low pressure center was located off the Pacific Northwest coast, with its attendant trough and cold front extending southward to west of southern California. Strong south and southwesterly flow was in place ahead of the front, which arrived in the western parts of the project area around 0400. Snow levels started out around 6500 feet ahead of the frontal band, with heavy snow above 7000 feet. CNGs were activated beginning the evening prior for NW3/4 sites and for the remainder of the sites during the early part of the event. As the morning progressed, the band moved across the entire area bringing moderate to heavy rainfall and higher elevation snow. Figure 4.21 shows a visible satellite image depicting the frontal band over the area during the latter part of the morning, and Figure 4.22 is a radar image from the same time. Precipitation continued into the afternoon hours, tapering off to showers by mid-afternoon, and mostly ending by early evening. CNG sites were shut off by early evening. However, later in the evening, an area of scattered showers and thunderstorms developed across the northwest part of the SAWPA area and moved southeast. One flare was burned from SE11 AHOGS site. Figure 4.23 shows the sites active during the storm.

Seedability: VERY GOOD. Ahead of and immediately at the beginning of the precipitation, temperatures were above freezing with a substantial stable layer below cloud base. This quickly evolved to more ideal conditions as temperatures quickly cooled behind the leading edge of the precipitation and mixing eroded the stable layer. Additionally, wind flow was ideal, with seeding plume dispersion from the sites properly targeting the target areas, and diffluent flow aloft was aiding in lift of these plumes.

Problems/issues: Propane company had not been able to get to sites NE5/NE7 as driver called in sick, and these sites did not run for this storm event due to inadequate propane supply. Leak found at SE13, which was fixed by operator. When the operator went to shut off site NE10, they noticed a weak flame and low flow, but the CNG was still running. The operator notified the field technician.

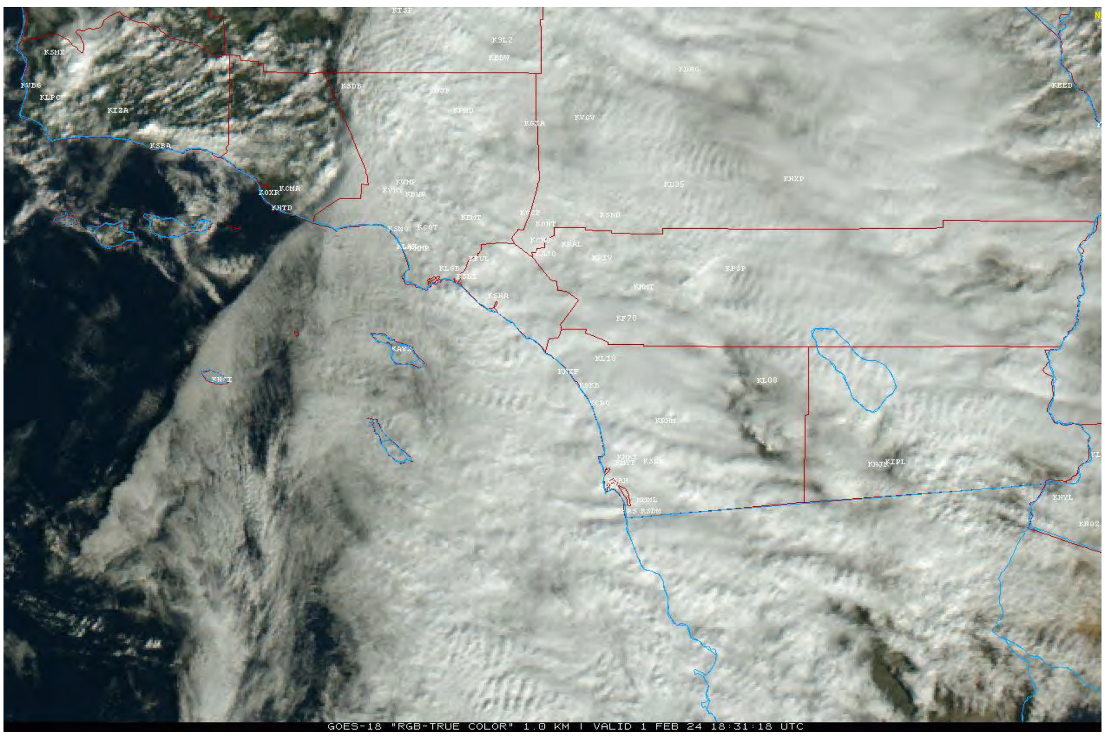

Figure 4.21. **Visible satellite image from 1031 PST on February 1 showing the frontal band and accompanying precipitation moving across southern California. Image from College of DuPage Weather, https://weather.cod.edu/satrad/ .**

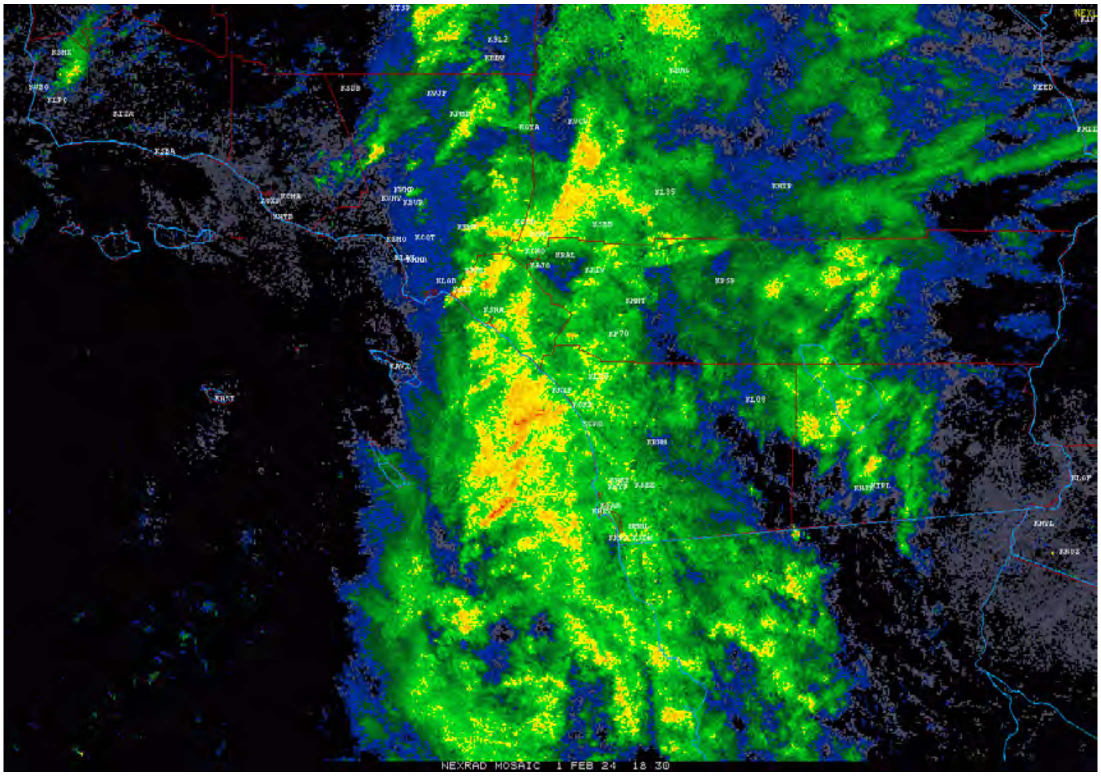

Figure 4.22. **Radar image from 1030 PST on February 1 showing frontal band over the area. Image courtesy of College of DuPage Weather.**

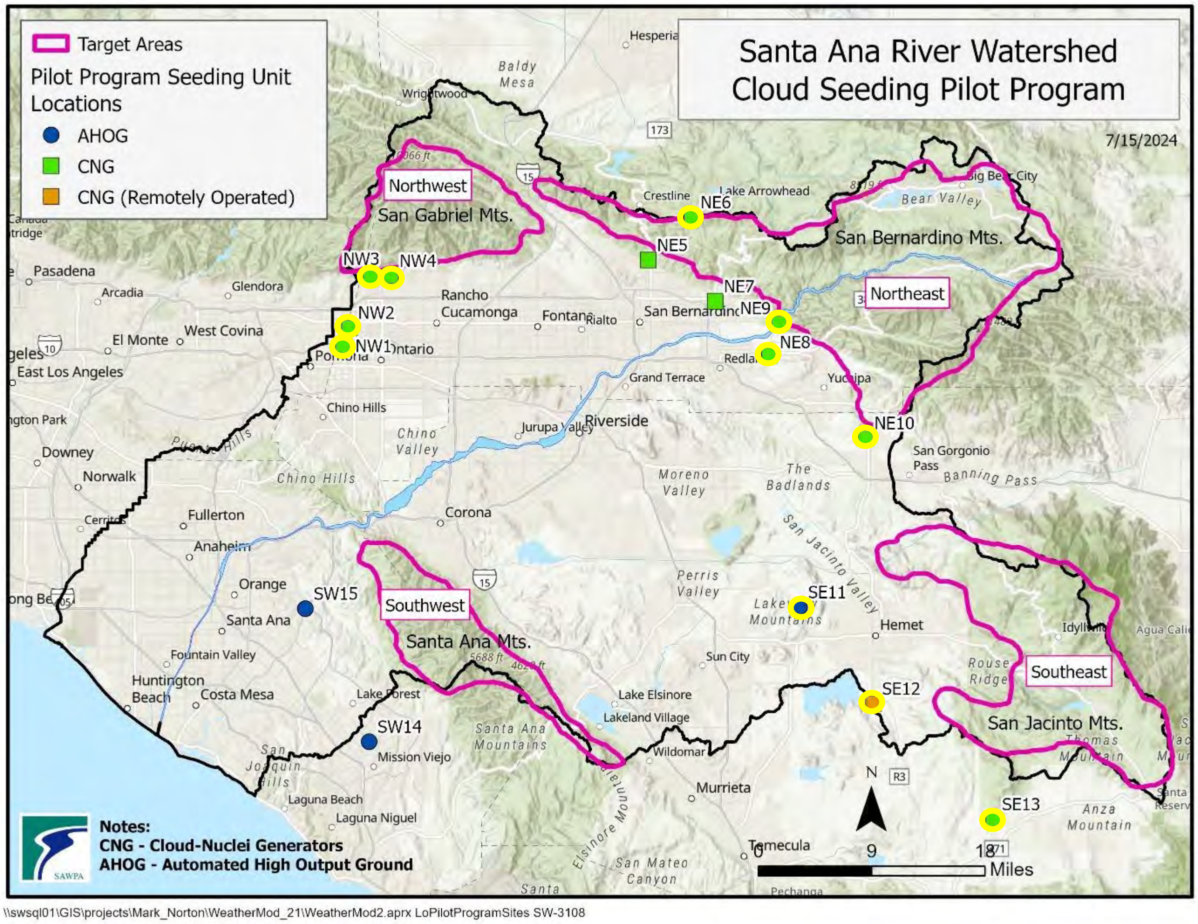

Figure 4.23. Map showing active seeding sites on February 1, 2024, indicated by yellow circles.

<u>February 3-8 (no seeding)</u>

A well-advertised Atmospheric River event began to unfold on February 3 as a large upper trough was located in the northeastern Pacific. The trough began to pull copious amounts of subtropical moisture into itself and then direct the moisture into California, accompanied by several shortwave disturbances that enhanced lift as they moved across southern California. Once the stream of moisture and associated moderate to heavy rain (and higher elevation snow) arrived late in the afternoon of the 4th, it continued almost unabated for nearly 48 hours, first as a southwest-to-northeast band of precipitation, gradually re-orienting to a nearly north-south band as the trough moved closer to the coast. Figure 4.24 is a water vapor satellite imagery from the early afternoon of February 5, clearing showing subtropical moisture flowing into southern California ahead of a sharp trough of low pressure. Figure 4.25 shows an infrared satellite image taken at 2200 PST on February 5 showing moisture band solidly over the project area. Figure 4.26 shows the corresponding radar image. By late afternoon/early evening of February 6, the main band of precipitation had shifted east of the area with westerly flow and scattered rain/higher elevation snow showers moving across the area. The showery regime pattern continued into the morning hours of February 7 before a brief break in the precipitation occurred as the main trough of low pressure was finally shifting east of the area. Figure 4.27 shows three-day precipitation totals for California as compiled by Weather Prediction Center. A strong shortwave disturbance on the backside of the trough moved southeast along the central coast during the afternoon hours, arriving in southern California in the evening with an attendant cold front sweeping across the area. The front brought a line of heavy showers and thunderstorms along with strong wind gusts and lowering snow levels to 4000 feet. Figure 4.28 shows a radar image from 2200 PST on February 7, just as the cold front arrived at the western edge of the SAWPA area. Flood advisories and a Severe Thunderstorm Warning were issued during the frontal passage. Scattered mainly light to moderate showers continued mainly in the mountains in the post-frontal airmass, gradually tapering off by the evening of February 8. Precipitation during the event was significant and very heavy, with **the highest total of 15.48 inches of rain** falling at Middle Fork Lytle Creek in the NW Target area, and **several locations in the NE and NW Target areas seeing upwards of 10 inches of rain.** In terms of snow, the multi-day event produced **80-97 inches of snow** at Snow Valley near Running Springs in the NE Target area, with **60 inches** at Bear Mountain Snow Summit and **56 inches** at Mt Baldy in the NW Target area.

Because of the threat of excessive precipitation and subsequent effects of such (flooding, mudslides, etc.), seeding operations were suspended for this storm event.

<u>Seedability</u>: POOR initially, becoming GOOD. Most of the storm event was warm as the source region for the moisture/air was subtropical, although high elevations were cold enough for snow, where copious amounts fell. The latter part of the event – from about February 6-8 – saw improved conditions for seeding with colder temperatures aloft, although the suspension remained in place due to the excessive amount of rain occurring at lower elevations.

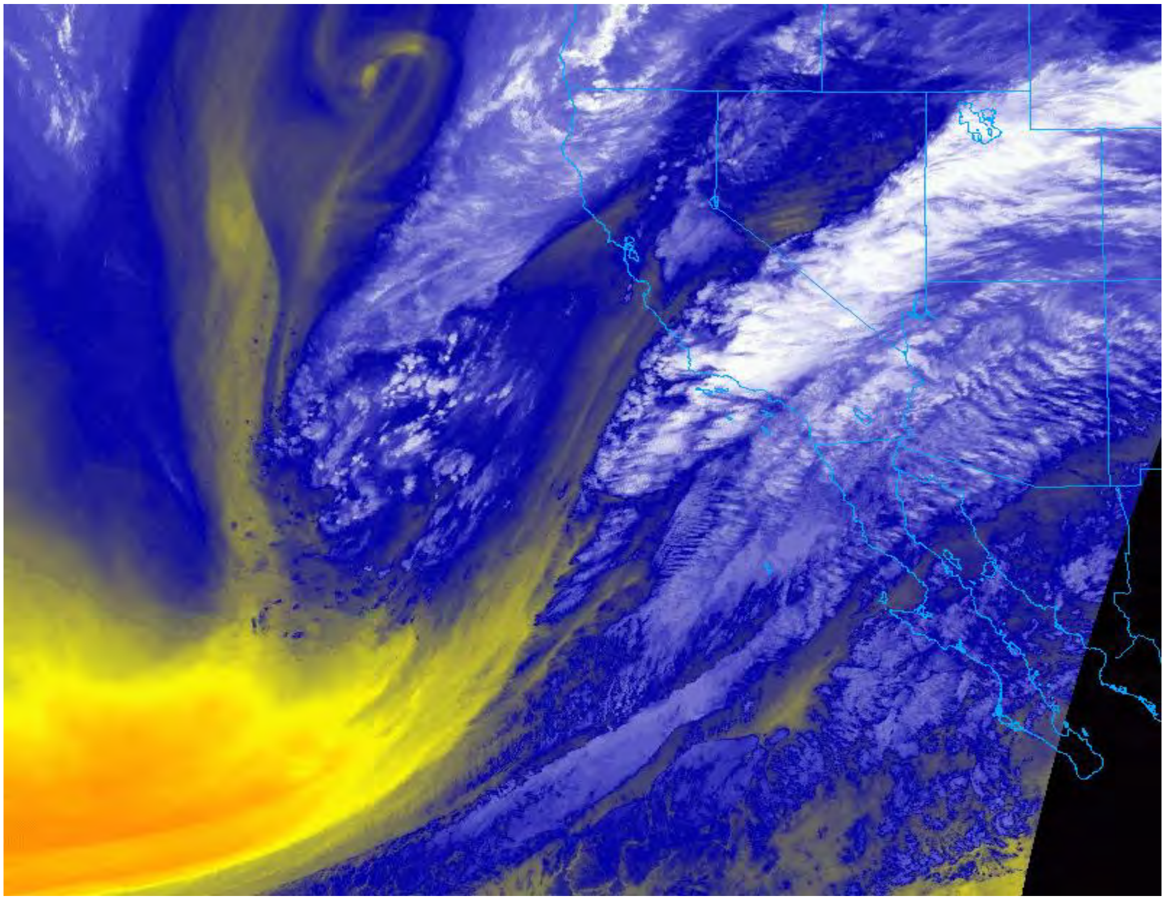

Figure 4.24. **Water vapor imagery from 1251 PST on February 5, 2024, showing subtropical moisture (blue/white shading) flowing into southern California ahead of trough.**

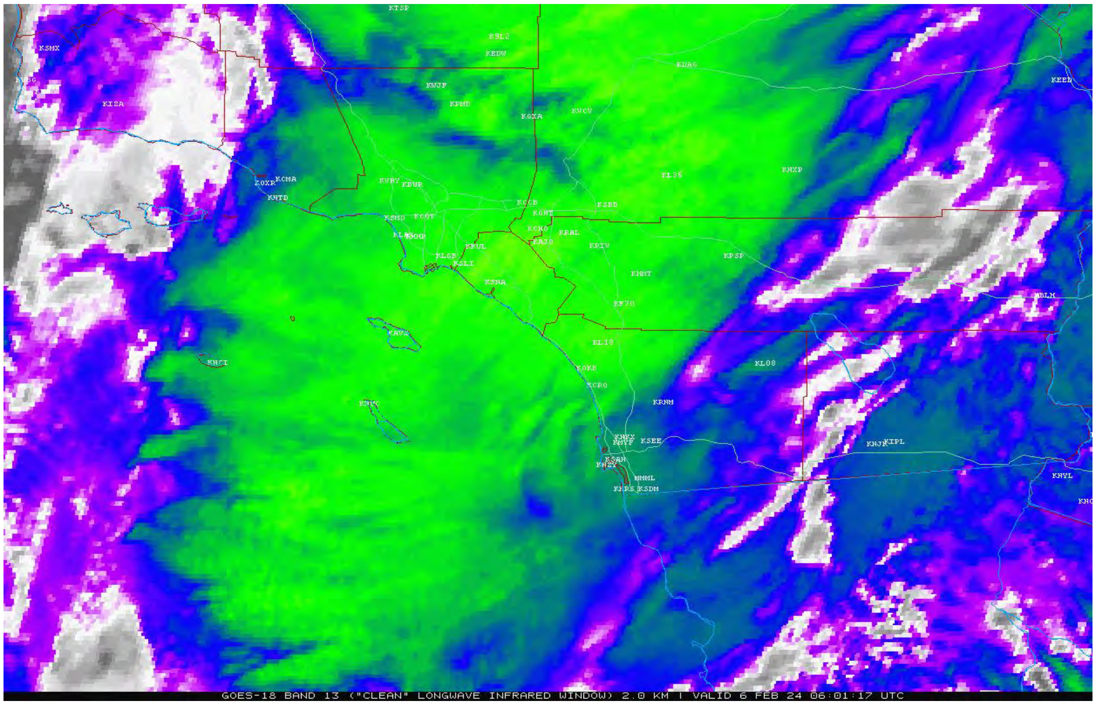

Figure 4.25. **Infrared satellite image from 2200 PST on February 5 showing colder cloud tops (green color indicating cloud top temperatures -45°C to -50°C) over the area.**

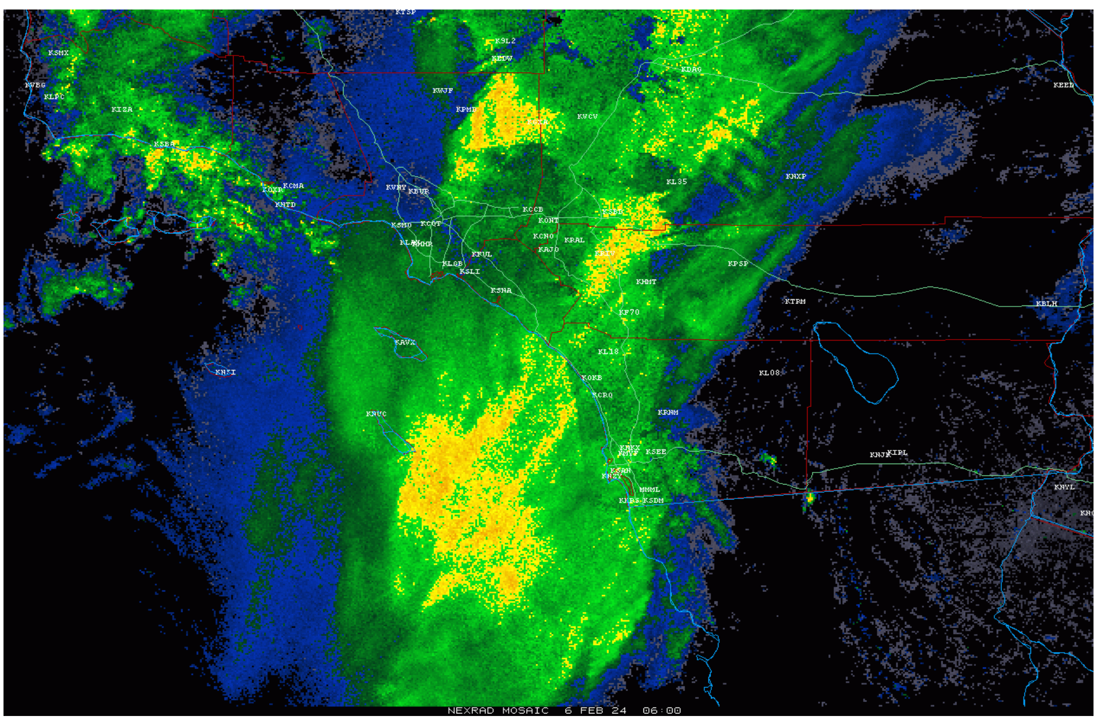

Figure 4.26. **Radar image from 2200 PST on February 5 showing precipitation band over the area.**

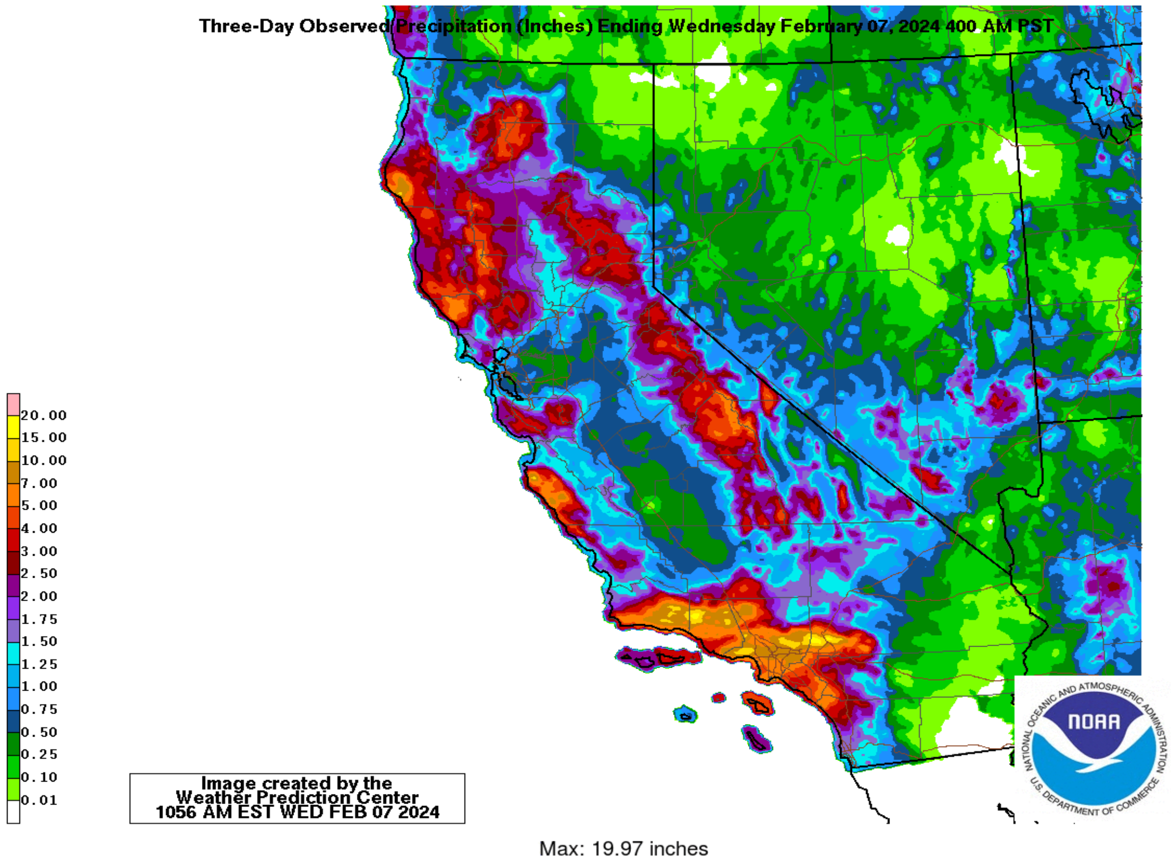

Figure 4.27. **Three-day precipitation totals for California, valid at 0400 PST on February 7, 2024.**

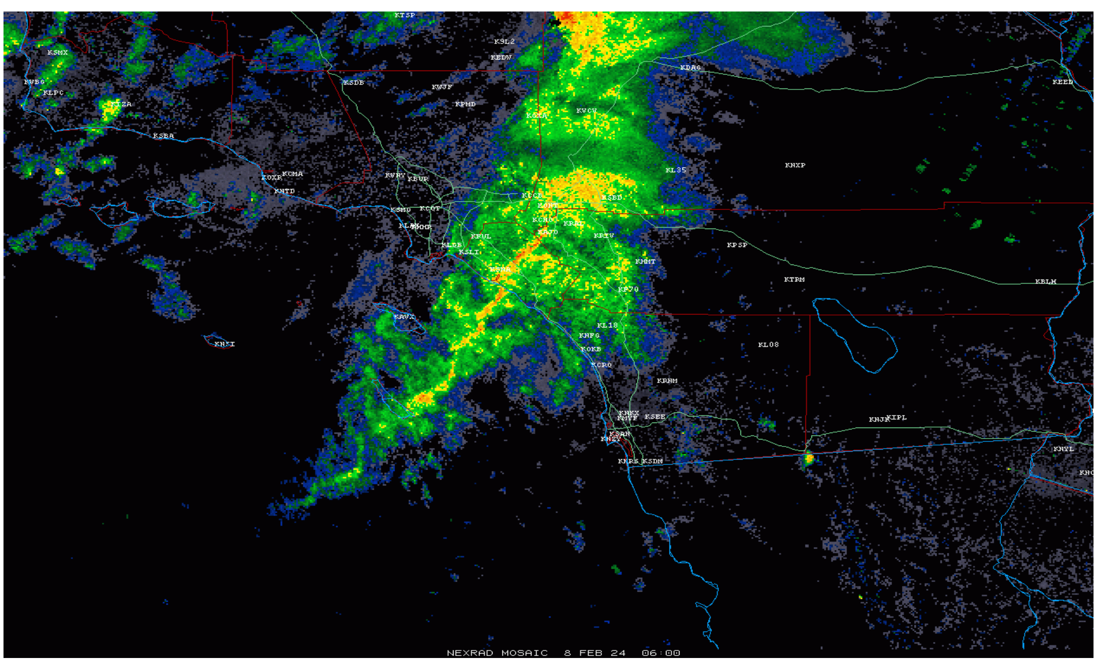

Figure 4.28. **Radar image from 2200 PST on February 7 showing the cold front at the western edge of the SAWPA area.**

February 19-21

A large upper level low and associated trough were in the eastern Pacific on the morning of February 19. A plume of moisture within a strong jet stream was affecting the Central Coast and portions of southern California west of the area. As the trough pushed slowly east, this moist plume reached the project area during the afternoon with snow above 8000 feet. Area soundings indicated a relatively warm airmass in place (700 mb temperatures were around 0°C) with stable conditions which were not conducive for seeding. Precipitation had remained light through early evening, but by mid-evening, another shortwave disturbance embedded within the jet stream approached the coast with precipitation rates and coverage increasing through the rest of the evening and overnight. Rain and higher elevation snow continued into February 20. The morning sounding from San Diego indicated decreasing stability and slowly cooling mid-level temperatures, while upstream conditions suggested improved seeding potential. This improvement was confirmed by the San Diego sounding in the late afternoon of February 20. Given the continuation of precipitation and increased ideal conditions for seeding transpiring across the area, CNG sites were activated in the afternoon. Rain and higher elevation snow continued into the evening with activity waning during the overnight period, only to increase once again just before dawn as the cold front and core of the upper-level trough began to push across the area. Figure 4.29 shows the probability of icing (indicative of supercooled water) at 9000 feet MSL valid at 2208 PST on February 20; note the higher probabilities in place over southwestern California. Figure 4.30 is a radar image from 0425 PST on February 21. Rain and mountain snow tapered off during the morning, with some wraparound showers continuing into the afternoon before ending in the evening. Figure 4.31 shows the active sites during the storm. **Note that no seeding was done for the SW target area as AHOGS were not to be used due to antecedent moist soil conditions, and modeled plume dispersion indicated that none of the sites would properly target the SE Target area.**

Seedability: GOOD. The first part of the storm event on February 19 – early February 20 saw mid-level temperatures near freezing along with a rather chaotic wind field and some stable layers present that would hinder seeding plumes from rising to cloud base. As the event progressed, additional ideal seeding conditions began to move in on the evening of February 20 with mid-level temperatures cooling to -3°C/-4°C and wind flow becoming more uniformly southwesterly areawide; additionally, any stable layers were able to get mixed out so that seeding plumes were able to rise to cloud base.

Problems/issues: The propane company was unable to reach site NE5 due to wet ground from recent excessive rain and would try again after the storm concludes. At site NE8, a solution leak could not be fixed by the operator, so the site was left off and the field technician was informed.

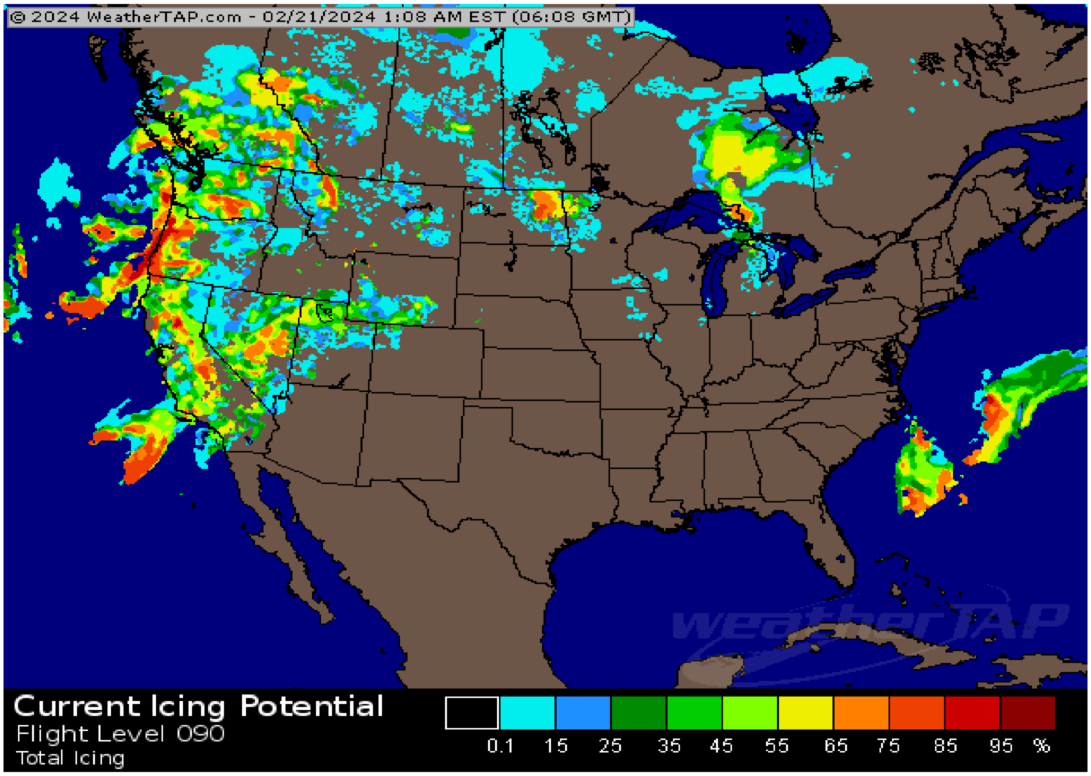

Figure 4.29. **Potential for icing at 9000 feet MSL, given as a percent probability. Courtesy of Weathertap.com website.**

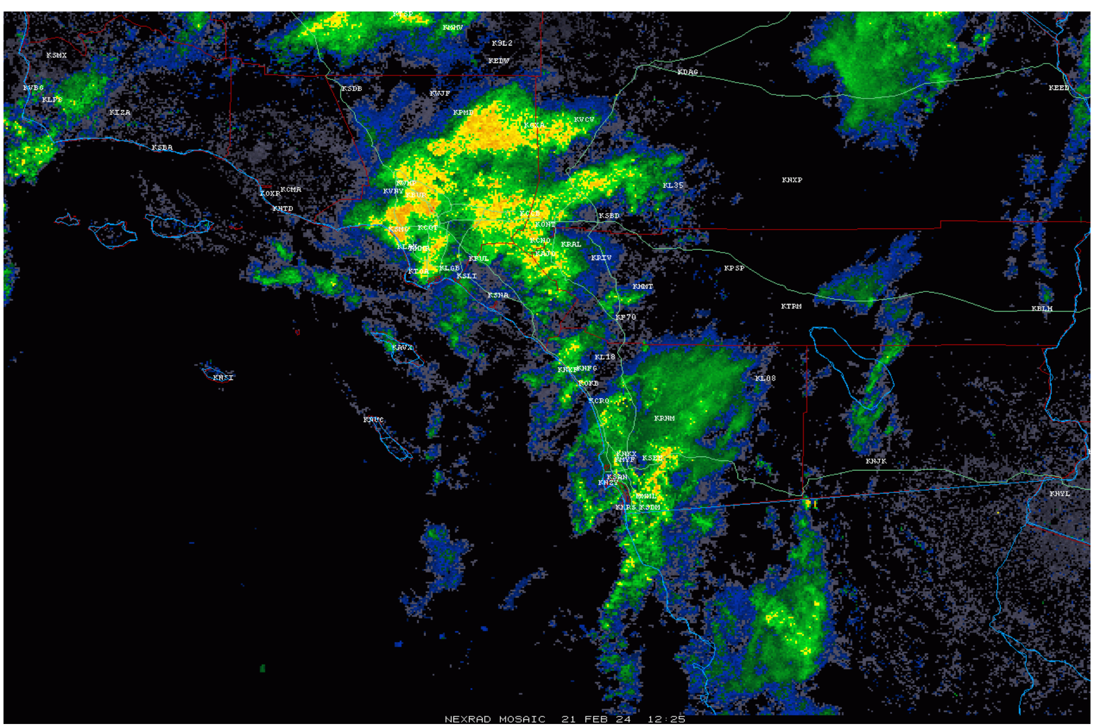

Figure 4.30. **Radar image from 0425 PST on February 21, the back end of the storm period but the most seedable portion of the storm.**

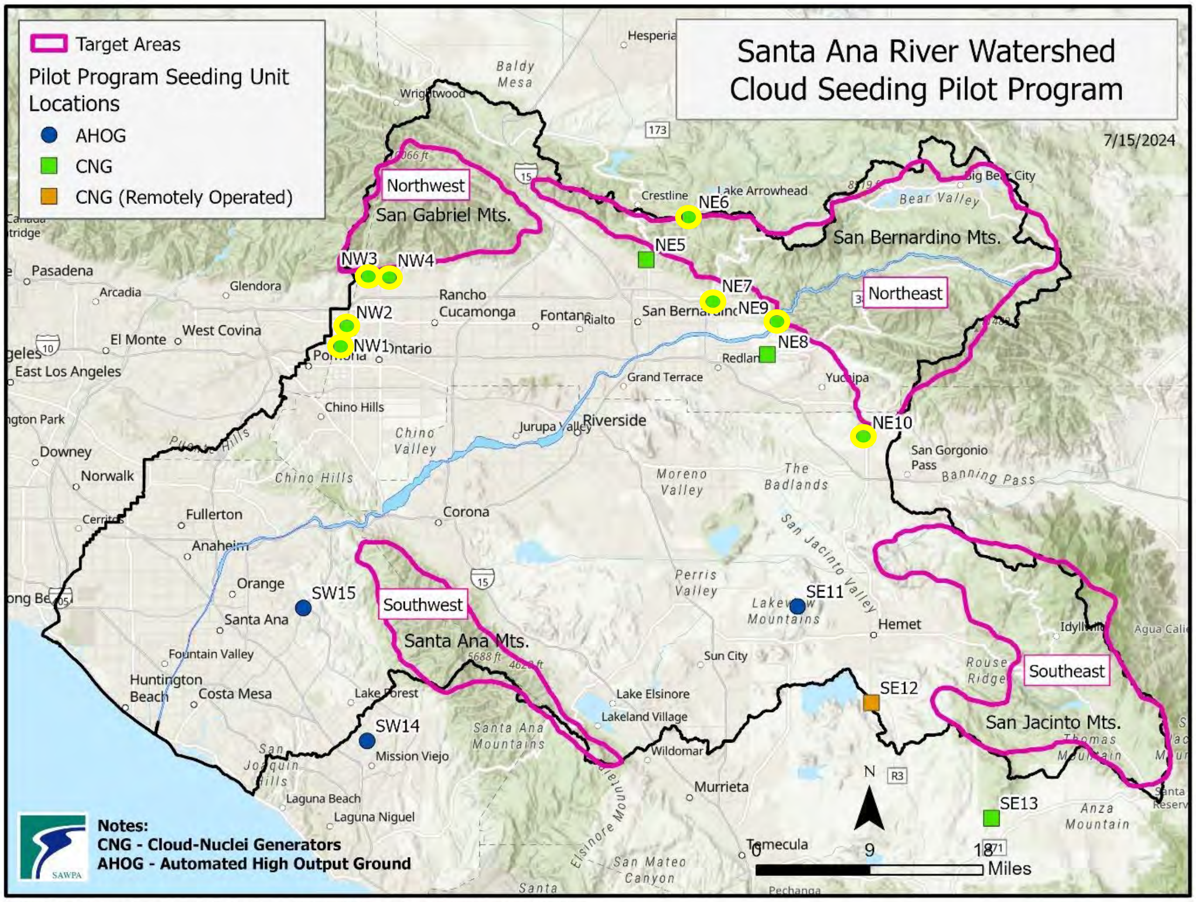

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Figure 4.31. **Map showing active seeding sites on February 20-21, 2024, indicated by yellow circles.**

February 26 (no seeding)

An upper-level low west of the area was attempting to push showers into the project area during the day but was battling forcing from a passing trough of low pressure north of the area. Although showers did eventually push into and across the area during the day and into the early evening hours, most of the moisture was below 8000 feet with little snow above that. Because of the lack of moisture for areas that would see snow, seeding operations were not viable for this event. Figure 4.32 shows a visible satellite image from the afternoon.

Seedability: POOR. The moisture was shallow and below 8000 feet, which did not bode well for snowfall in the mountains. Temperatures aloft were near freezing, and lightly warmer than what is ideal for seeding operations.

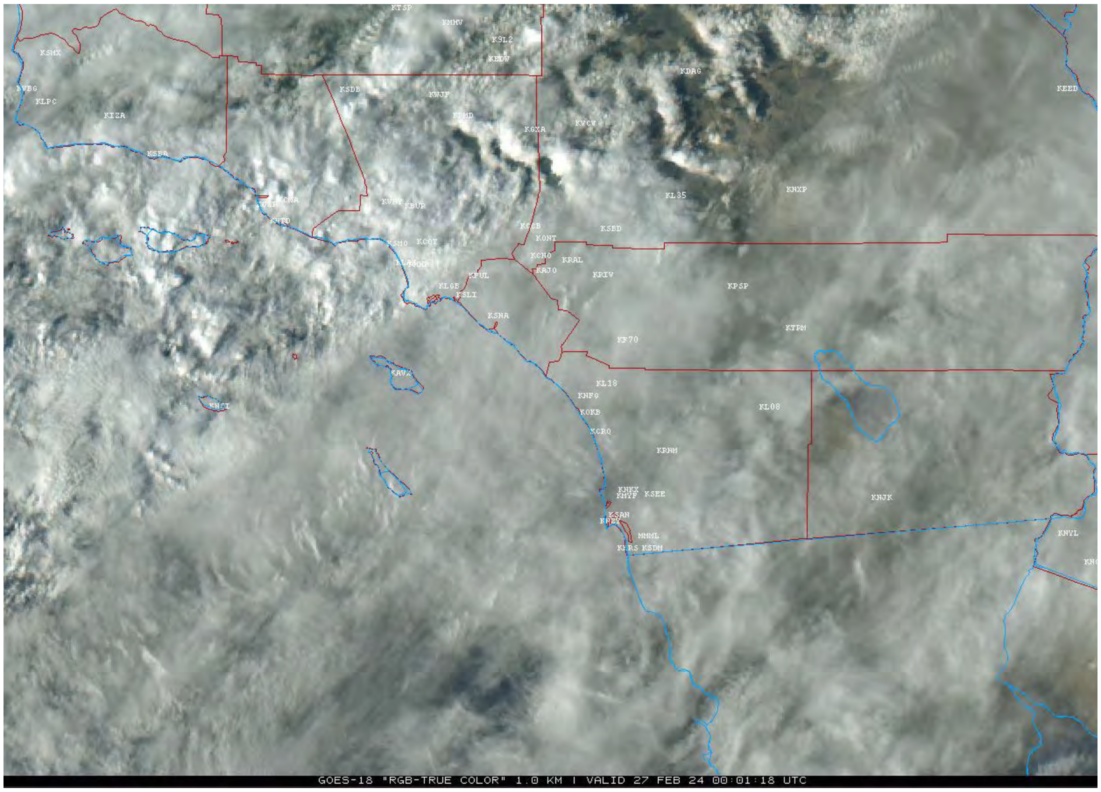

Figure 4.32. Visible satellite imagery from 1600 PST on February 26, during the latter part of the storm.

MARCH 2024

March 2-3 (no seeding)

A trough of low pressure was located over the West Coast states, with southern California situated at the base of the trough. Strong southwesterly flow was in place with mountain areas as well as San Gorgonio Pass seeing sustained 35-50 mph winds with gusts to 90 mph. Some moisture was advecting in on the southwesterly flow with precipitable water (PWAT) levels around 0.75-0.85 inches as measured on the San Diego soundings. Scattered showers, with snow above 5000-6000 feet moved across the area from the morning of March 2 through the early morning of March 3. The soundings from San Diego also revealed stable layers in the lower atmosphere between 5000 and 10,000 feet. The combination of the stable layers and strong winds precluded seeding operations from taking place. Figure 4.33 shows the effects of strong winds and stable layers present in southern California during the event, with wave clouds developing downwind of the mountains.

Seedability: POOR. Strong winds in the area would produce long, thin seeding plumes from the units that would likely overshoot the target areas. Additionally, balloon soundings indicated a stable layer from 5000-10,000 ft which would prevent seeding plumes from rising. Finally, mid-level temperatures were close to freezing, which is a little warmer than ideal for seeding operations.

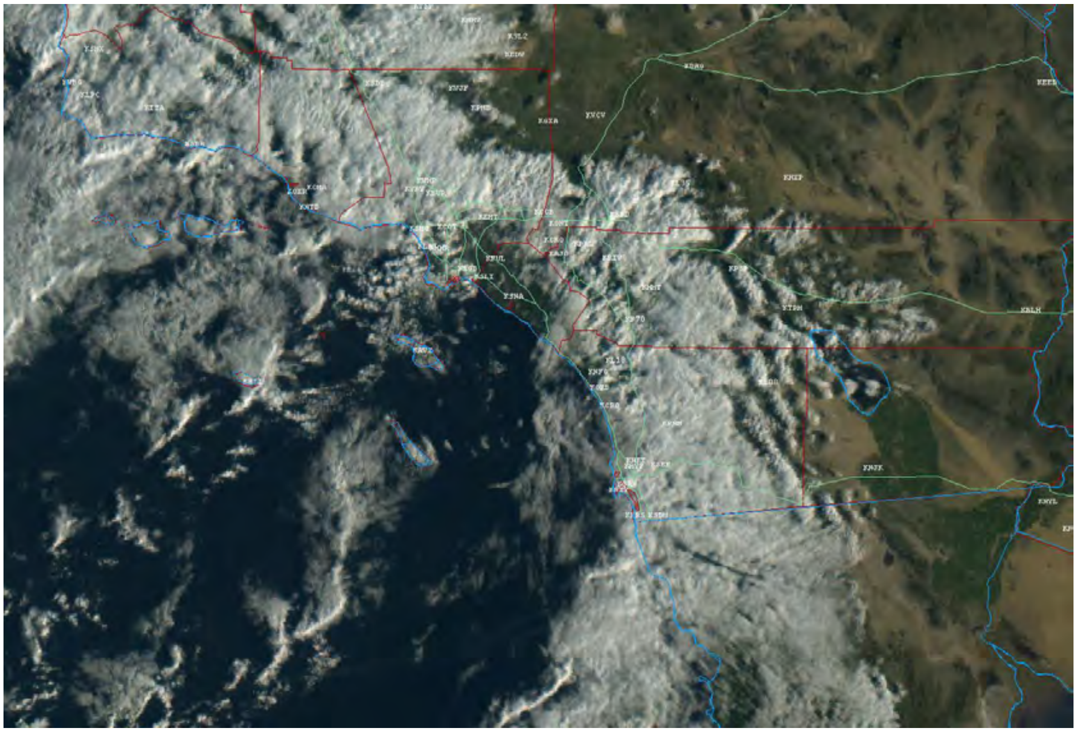

Figure 4.33. Visible satellite image from 0756 PST on March 2 showing wave clouds downwind of the southern California mountains due to strong winds and stable layers. Image from College of DuPage Weather.

<u>**March 6-7**</u>

On March 6, low pressure was located a couple hundred miles west of Point Conception. On the forward side of the low, lift and ample moisture (San Diego PWAT 0.51" early morning sounding) was poised to spread across the area in conjunction with a pocket of cold air aloft associated with the low. The low and its components moved across southern California during the afternoon and evening hours with showers. Figure 4.34 shows a visible satellite image from mid-afternoon on March 6. Figure 4.35 shows a radar image from early evening on March 6. Seeding operations began in the afternoon hours and continued overnight. Snow levels started out around 6000 feet but lowered to 5000 feet by the night of March 6 and remained there. As the low passed just south of the project area, showers began to taper off and by dawn on March 7, had ended with drier northwest flow moving into the area. Figure 4.36 shows the sites used for seeding during the event. Later in the afternoon and early evening on March 7, scattered thunderstorms developed north and northwest of the area and moved southward through the project area, with the main impacts to the Inland Empire. AHOGS and CNGs were not in the correct locations for targeting this activity, so seeding operations for this part of the storm event did not occur.

Seedability: FAIR, becoming EXCELLENT. At the beginning of the event there was a temperature inversion around 850 mb, but all other factors for seeding – temperature, moisture availability, and winds – were fair to good for seeding operations. As the storm progressed, the inversion quickly mixed out and temperatures continued to cool to -6°C. While precipitation amounts remained on the lower side, the conditions in place became amenable to seeding operations.

Problems/issues: When the operator at NW2 started the CNG, it started leaking solution. The operator could not fix it, so the unit did not operate, and the field technician was notified. Similarly, at NE9, a leak was found after starting the CNG and could not be fixed, so the unit did not operate during the storm period.

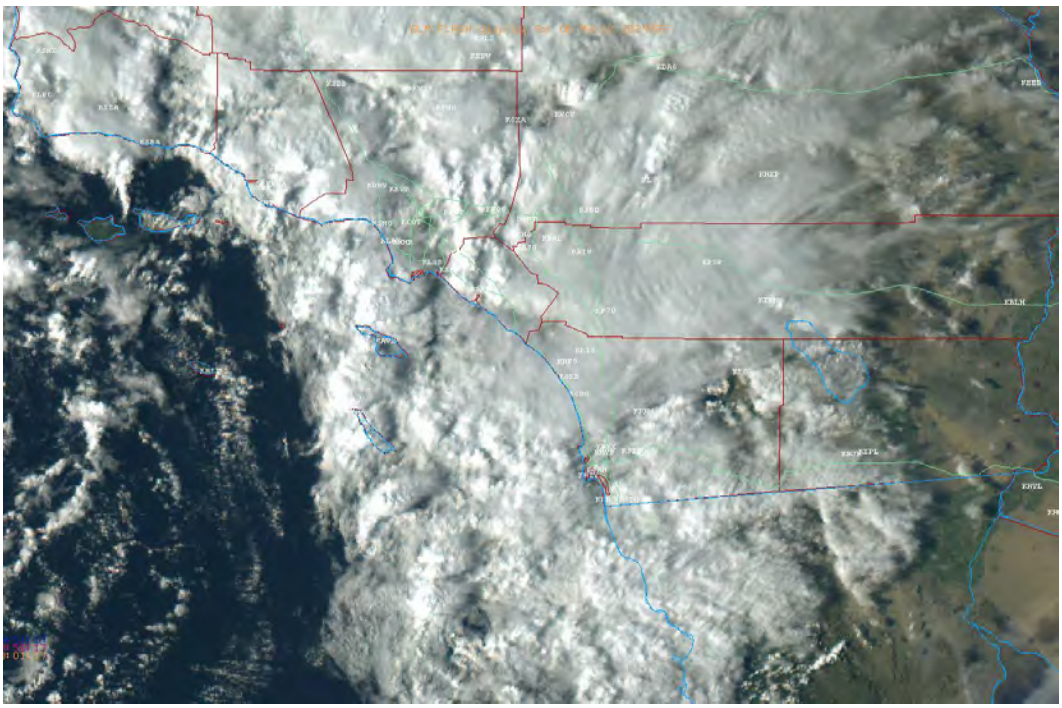

Figure 4.34. **Visible satellite image from 1601 PST on March 6, showing convective clouds over the area.**

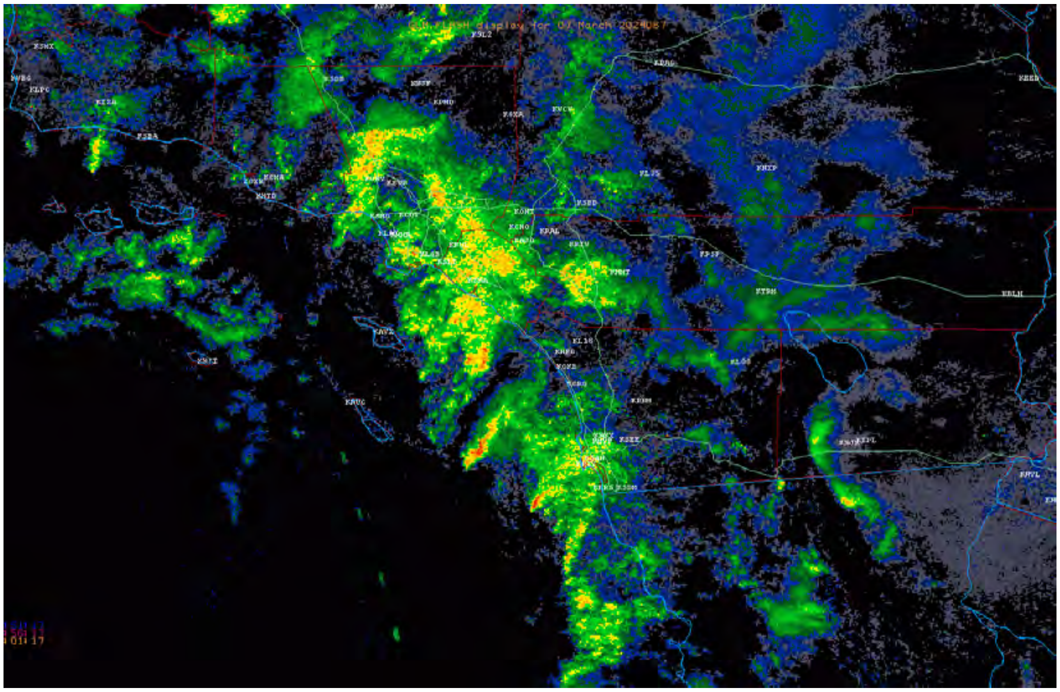

Figure 4.35. Radar image from 1805 PST on March 6, showing light to moderate showers across the area. Image taken from College of DuPage Weather website.

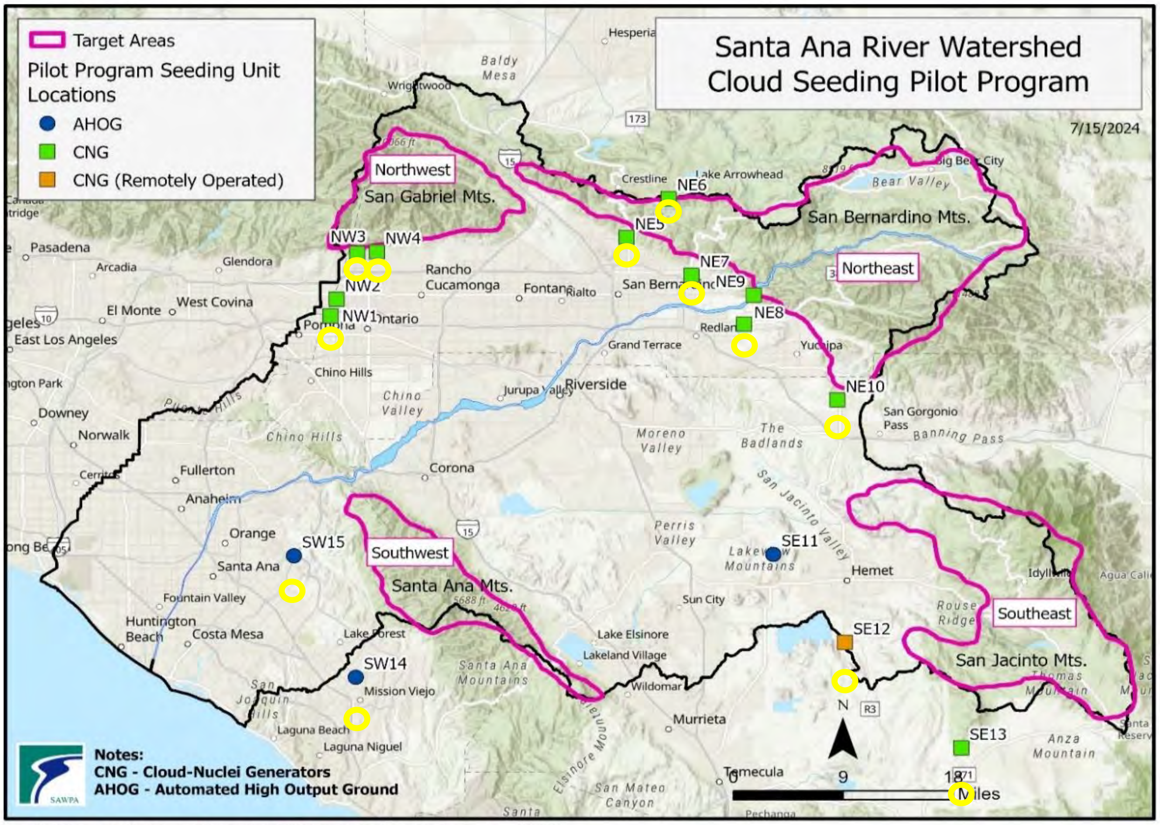

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Figure 4.36. Map showing active seeding sites on March 6-7, 2024, indicated by yellow circles.

March 14-18 (no seeding)

An atypical weather pattern set up during this four-day period, with an upper low getting cutoff from the main flow and sitting over the Desert Southwest, roaming around Arizona and southeast California. This placement put the Pilot Program under north/northeast flow throughout the period. With occasional disturbances rotating around the low, these features were accompanied by waves of showers (rain/snow) moving across primarily the mountain areas as shown in Figure 4.37; in the latter part of the period, heavier showers and thunderstorms moved across the entire area. Figure 4.38 shows lightning strikes during the late afternoon/early evening of March 15. Given that the program was designed to seed storm events for which wind flow was southeasterly, southerly, southwesterly, westerly or northwesterly, no seeding operations took place due to the predominant north to northeast flow. Snow totals in the mountains were impressive, with 1-2 feet in the higher portions of the NE target area.

Seedability: POOR (wind flow/direction). The primary hindrance to seeding operations was the wind flow across the project area due to the placement of the upper low and how its circulation affected the area, with mainly north to northeast winds, a setup not conductive to targeting as seeding units are all located south through west of the respective target areas. Despite the favorable precipitation amounts reported across the area, seeding operations would not have been able to target properly.

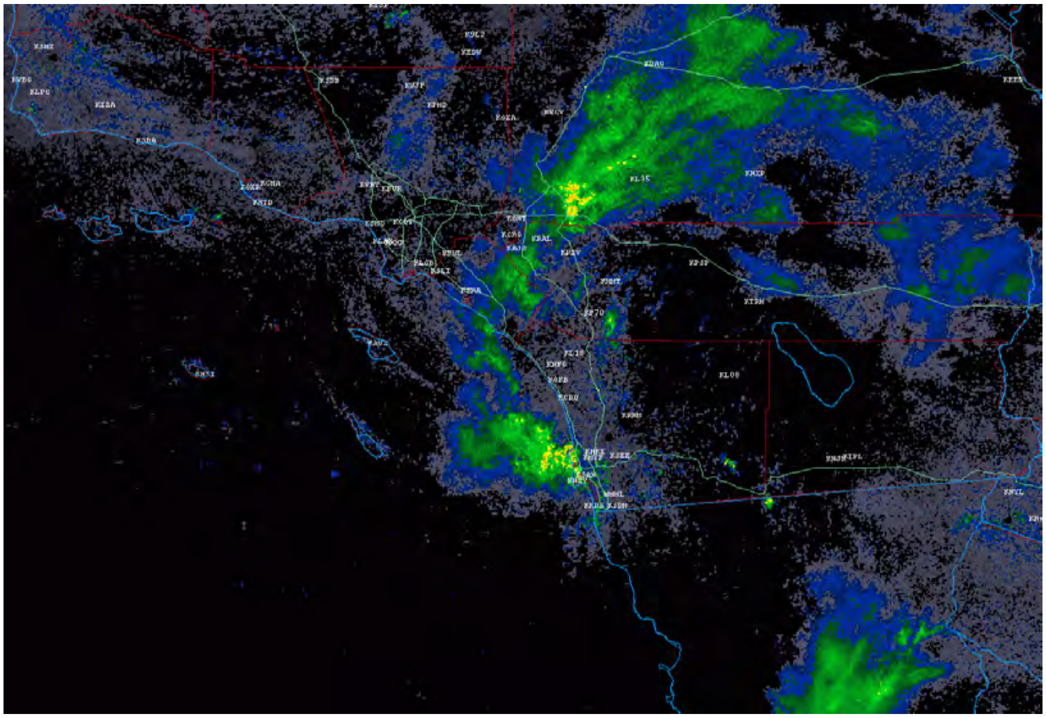

Figure 4.37. Radar image from 0010 PDT on March 15, showing moisture flowing into the San Bernardino County Mountains from the northeast, with additional showers along the San Diego County coast.

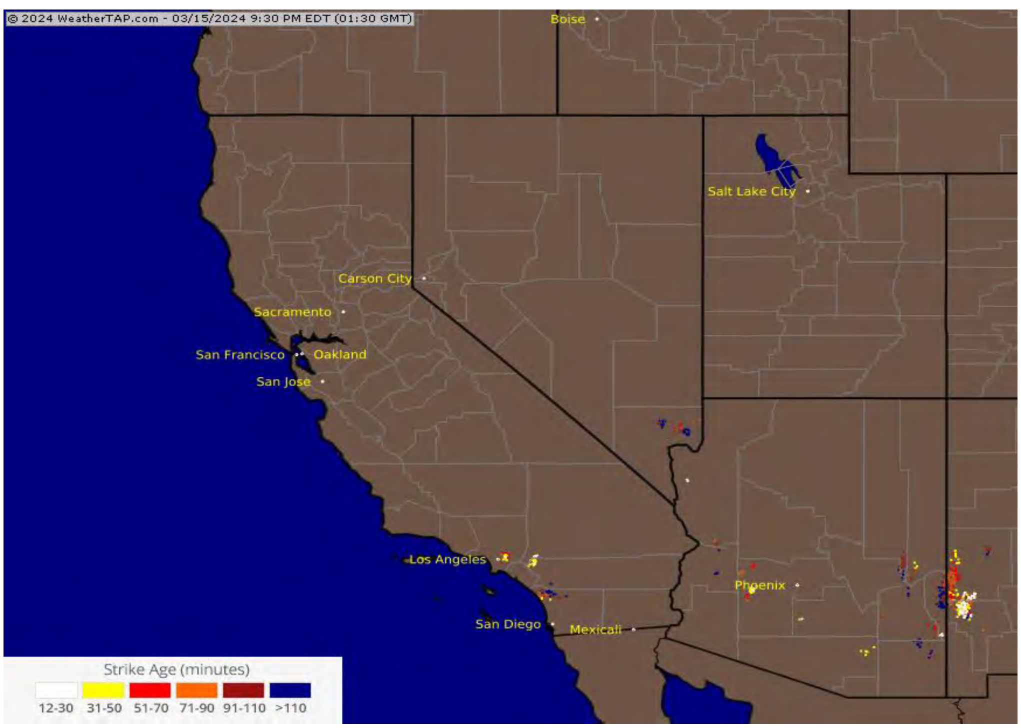

Figure 4.38. Map showing lightning strikes over the southwest United States as of 1830 PDT on March 15. Legend explains color coding of strikes. Note the strikes in and near the SAWPA Project area. Image courtesy of WeatherTap, https://www.weathertap.com/ .

March 23-24

An upper-level low was located off the Oregon coast on the morning of March 23, with the associated trough extending southward into waters west of southern California. Shown in Figure 4.39, the early morning sounding from San Diego showed the presence of a significant stable layer at 5000 feet ahead of the cold front, and as such any seeding activity would have to wait until this layer mixed out before seeding plumes could reach their intended target areas. The frontal band arrived during the mid to late morning hours with rain and higher elevation snow above 7000 feet. Behind the front, the airmass was more mixed and a bit unstable, and this is when seeding operations began for this storm event. Rain/snow showers and isolated thunderstorms continued through the afternoon hours, as shown in Figure 4.40. Winds were strong in the mountains, with gusts of 65-70 mph and this continued through the night, along with isolated to scattered rain and snow showers primarily affecting the eastern half of the project area. By the early morning of March 24, most activity had tapered off with just isolated mountain snow showers, but even these tapered off by mid-morning, and seeding operations were terminated. A late push of moderate to strong thunderstorms affected the northwestern parts of the project area, but their south to southeastward motion did not lead to the use of any of the AHOGS units. Figure 4.41 shows all active seeding sites for the storm event.

Seedability: GOOD. A stable layer/inversion existed early on around 5000 feet MSL but this did weaken/mix out as the storm progressed across the area. Wind flow was good for seeding plumes to target their respective areas for most of the storm event. Mid-level temperatures were a little warm at the start of the event but cooled to -4°C late in the day on March 23, and further to -10°C the following morning.

Problems/issues: Upon starting up site NE9, the operator reported that the CNG appeared to be lightly releasing solution; lowering the flow pressure fixed this. A few hours after starting up, remote site SE12 went out and could not get restarted. A visit later revealed a clogged nozzle that needed to be cleared.

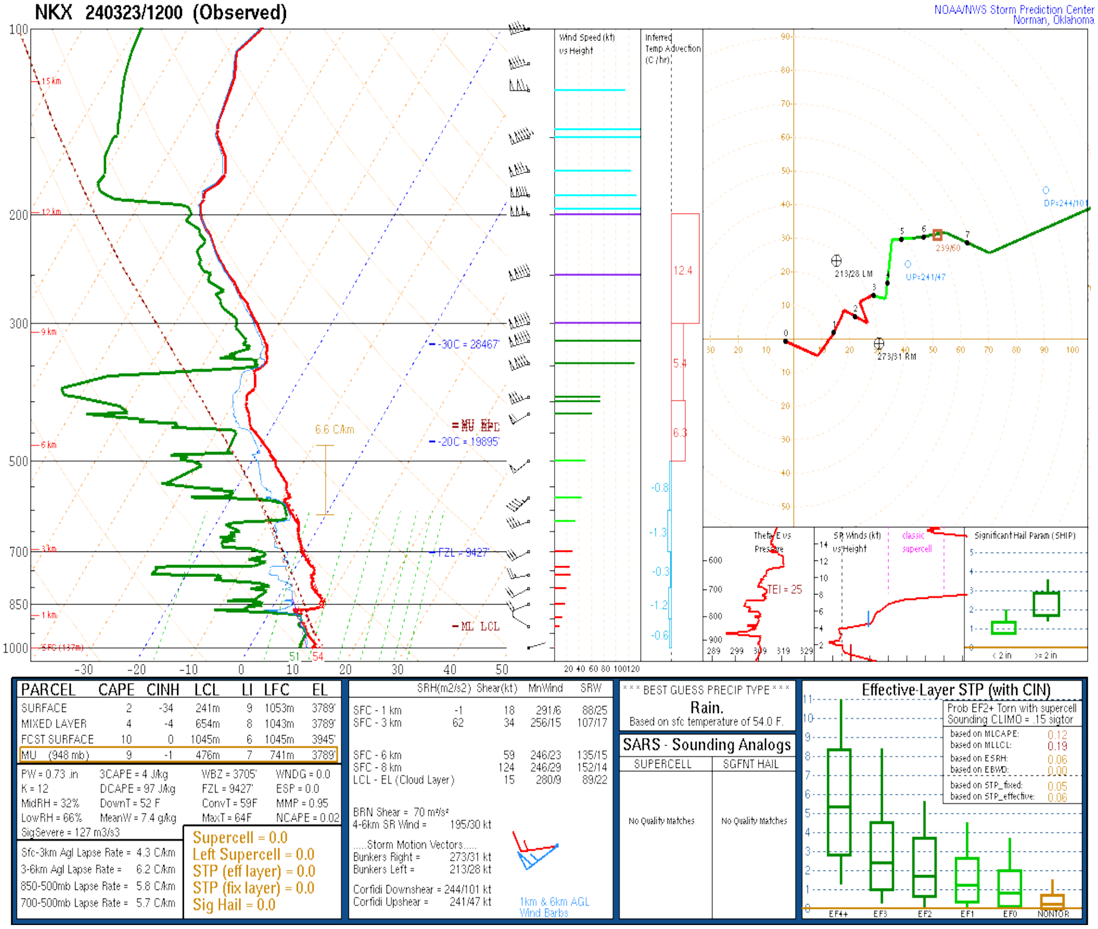

Figure 4.39. **Upper air balloon sounding from San Diego from 12Z (5 AM PDT) on March 23. Of interest is the upper left panel, showing the temperature (red line) and dewpoint (green line) with height. Note the abrupt turn to the right of the temperature profile at 850 mb and the abrupt left turn of the dewpoint profile, signifying a strongly stable/dry layer. Image courtesy of Storm Prediction Center website, https://www.spc.noaa.gov/ .**

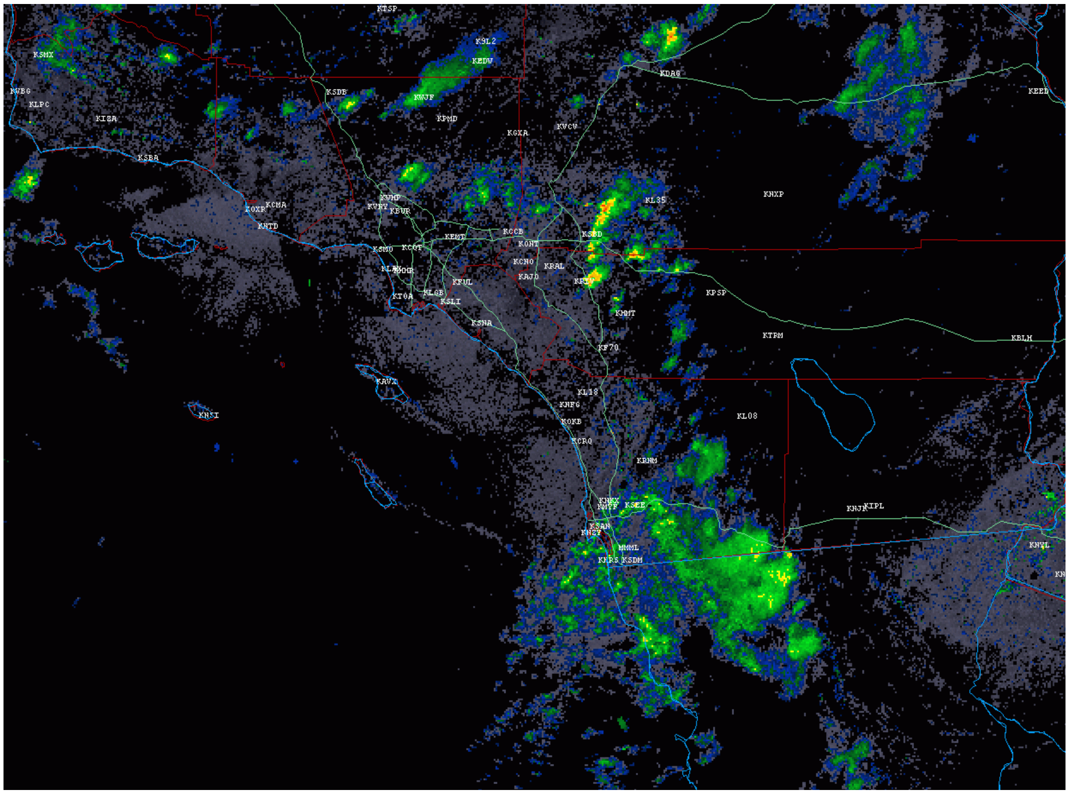

Figure 4.40. Radar image from 1540 PDT on March 23, showing scattered showers and even a small band of thunderstorms affecting the SAWPA area.

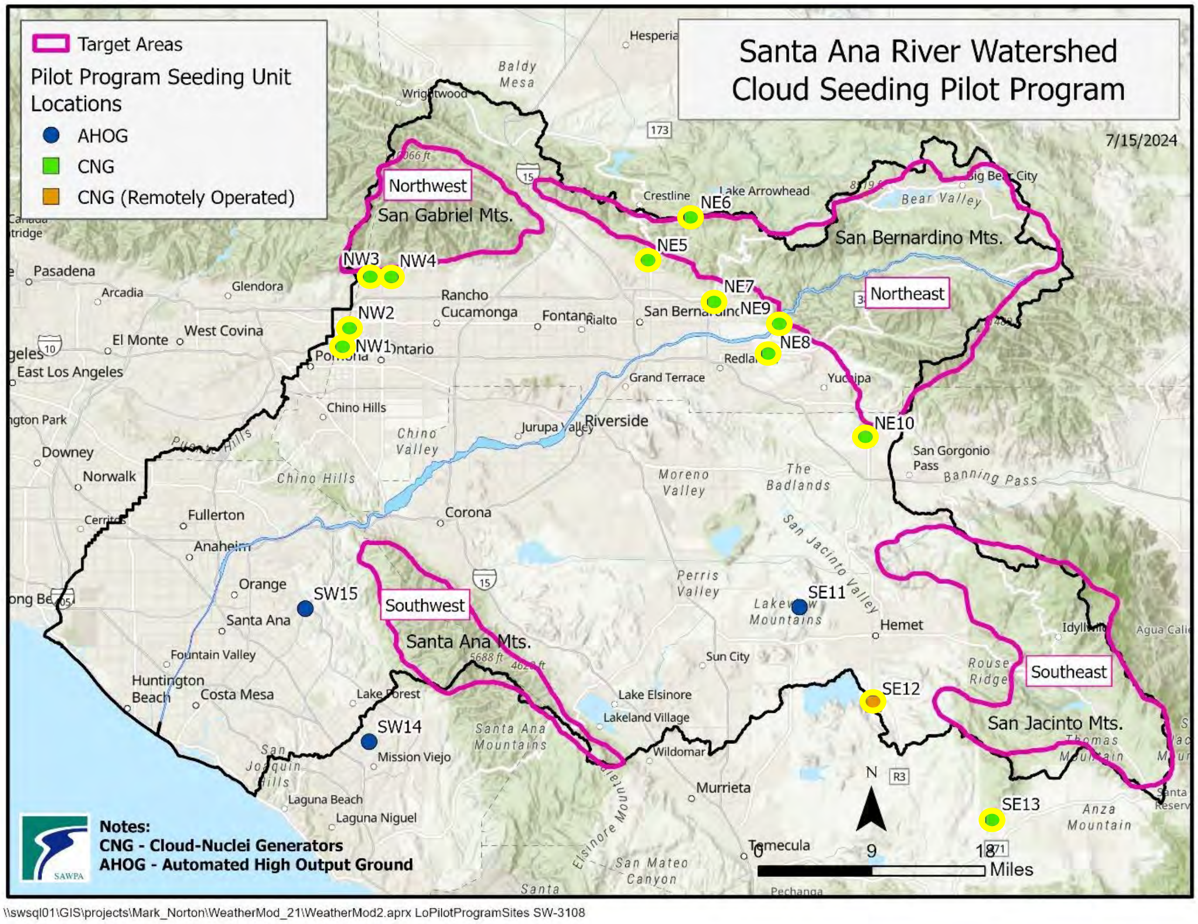

Figure 4.41. **Map showing active seeding sites on March 23-24, 2024, indicated by stars.**

March 30-31

A deep, cold upper-level low was located off the central California coast on the morning of March 30. A shortwave disturbance accompanied by a cold front was rotating around the south side of the low and moved across southern California during the morning and afternoon hours with a band of moderate to locally heavy rain and higher elevation snow. Figure 4.42 shows a radar image from mid-morning of March 30 as the cold front was crossing the area, with snow levels lowering behind the front to around 4500 feet, evidence of which was seen on the Lake Gregory (4554 feet) webcam showing heavy snow falling. Once the band of precipitation exited to the east by late afternoon, there was a period during the evening where a dry slot moved in, and precipitation was at a relative lull. In the evening, convective cells, including thunderstorms, hovered offshore with a few light showers making their way inland. The upper low was located west-southwest of Point Conception, as shown in Figure 4.43, and continuing to move southward. During the overnight period, showers moved inland across much of the area with snow showers in the mountains. By dawn on March 31, the upper low was located southwest of Los Angeles and was beginning to make a turn toward the east to move toward the coast. Scattered rain and snow showers continued to spread across the area during the morning and early afternoon hours, with low level winds becoming less conducive for proper targeting as the afternoon progressed. Seeding sites were gradually shut off in the afternoon. Figure 4.44 shows the active seeding sites for the March 30-31 event.

Seedability: GOOD. Despite the presence of weak stable layers at times and moderate winds, all other parameters for seeding were ideal, including mid-level temperatures, wind direction and moisture availability.

Problems/issues: Two sites, NW2 and NE8 were left off during the storm event due to low solution levels.

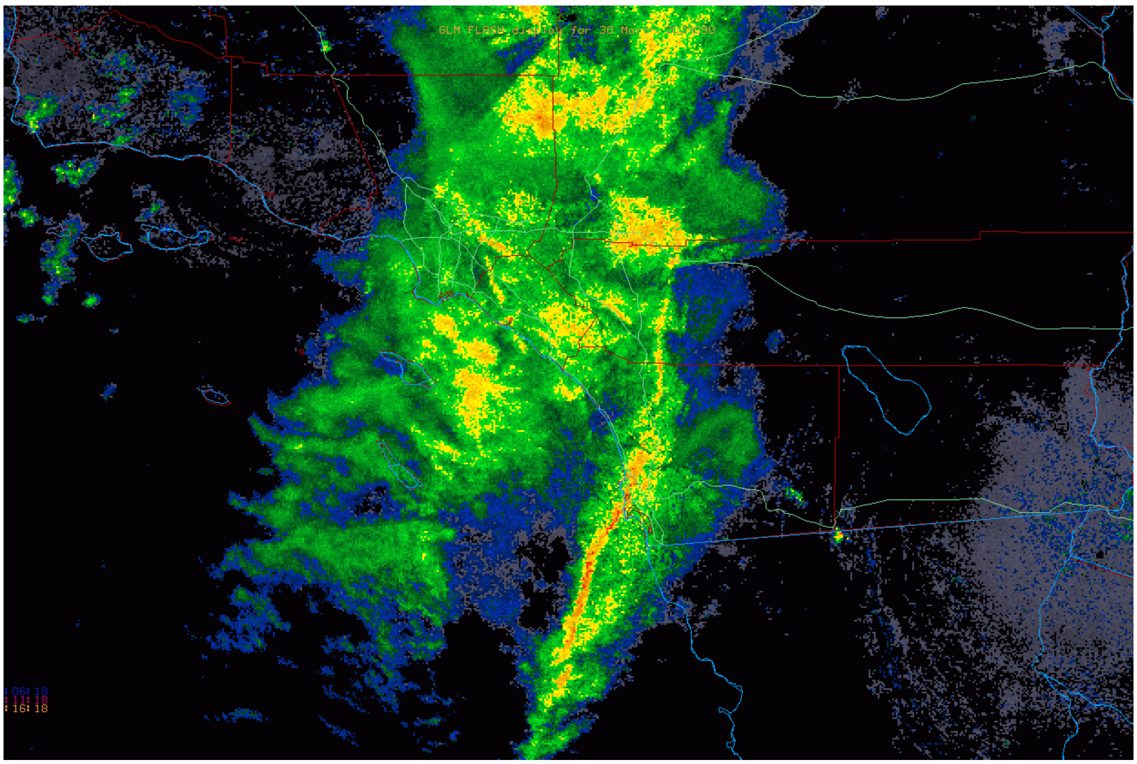

Figure 4.42. Radar image from 0920 PDT on March 30. The cold front can be seen on radar as a fine line stretching from near San Bernardino southward through San Diego and offshore.

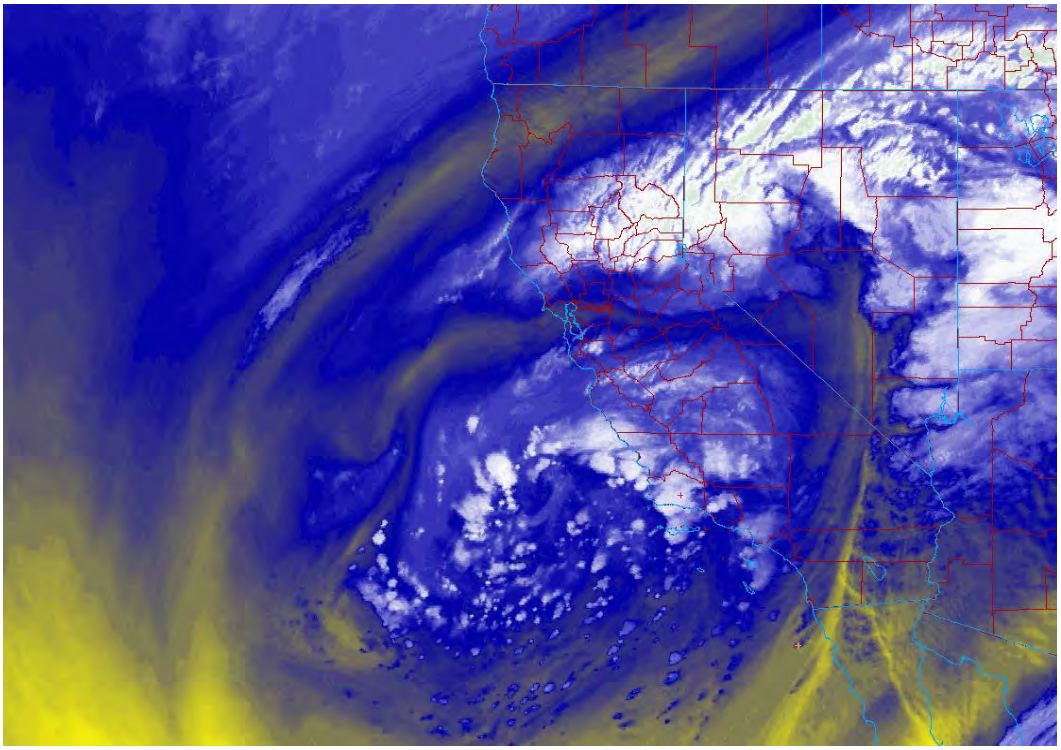

Figure 4.43. **Water vapor satellite image from 2151 PDT on March 30, showing the upper low centered to the west-southwest of Point Conception, with abundant convective cells around the low.**

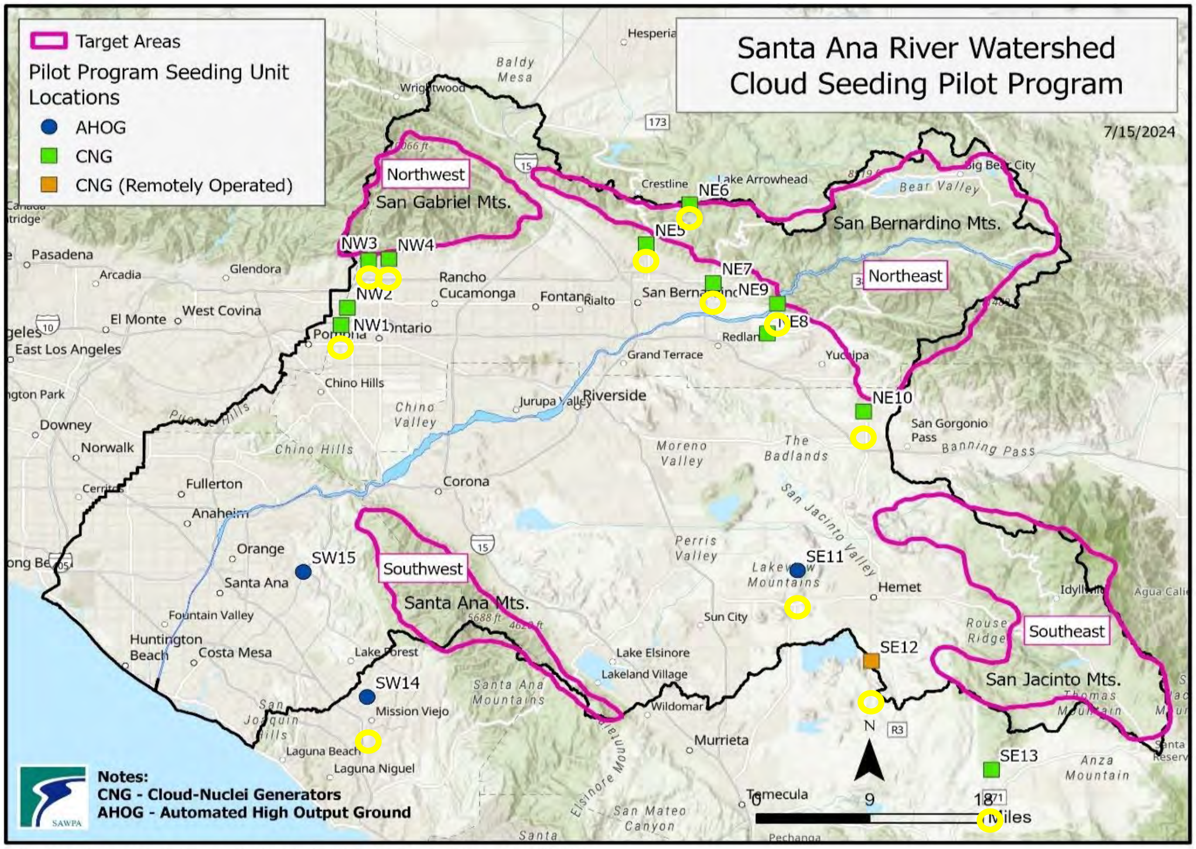

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Figure 4.44. **Map showing active seeding sites on March 30-31, 2024, indicated by yellow circles.**

APRIL 2024

April 5

An upper-level low was located over northern California early in the morning, with the associated trough lying across most of the state. Very cold air aloft associated with the trough had spread across the project area and was helping to destabilize the airmass. Scattered rain and higher elevation snow showers moved across the area from early morning through the afternoon and into the evening hours before tapering off. Figure 4.45 shows a visible satellite image from the morning of April 5, and Figure 4.46 shows a convectively active radar across the project area during the afternoon. Snow levels were low because of the cold air associated with the trough, with snow falling to 3000 feet. Snowfall in the mountains was generally 2-4 inches or less. Figure 4.47 shows which sites were used for seeding during the storm event.

Seedability: EXCELLENT. As the storm began, mid-level temperatures were very favorable, with the morning sounding on April 5 showing a temperature of -11°C at 700 mb. Moisture levels were on the low side but adequate for producing accumulating precipitation. Wind flow was good for proper targeting of the four areas. Convection was seeded with AHOGS flares as they moved across the area.

Problems/issues: None.

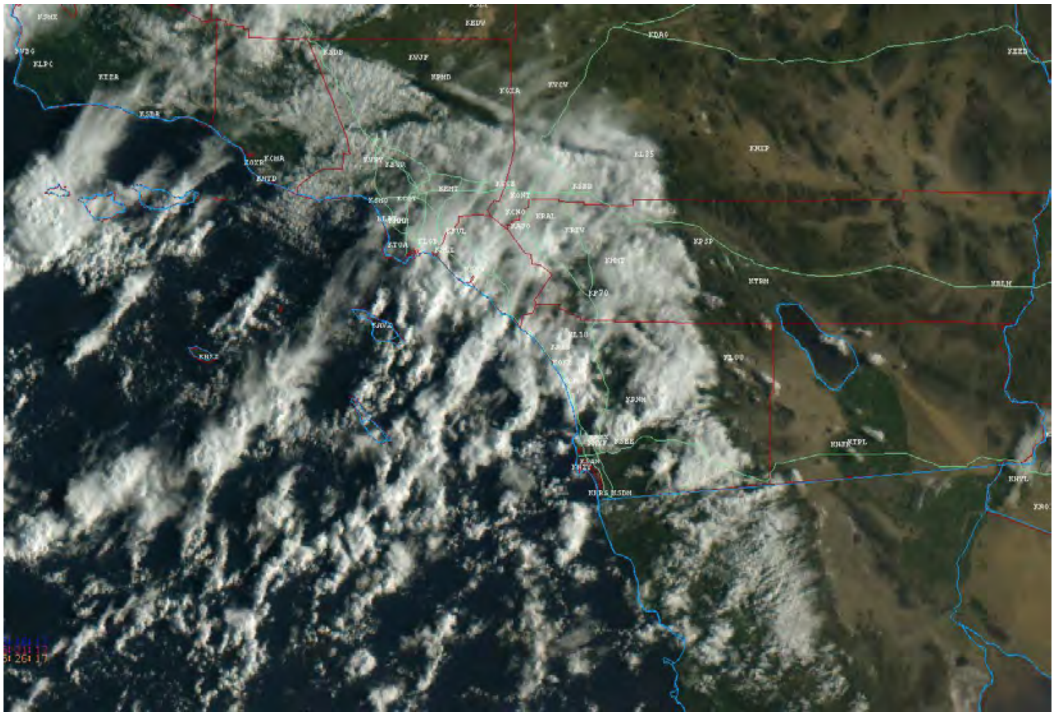

Figure 4.45. Visible satellite image from 0831 PDT on April 5, showing convective clouds over portions of the SAWPA area. Image taken from College of DuPage Weather website.

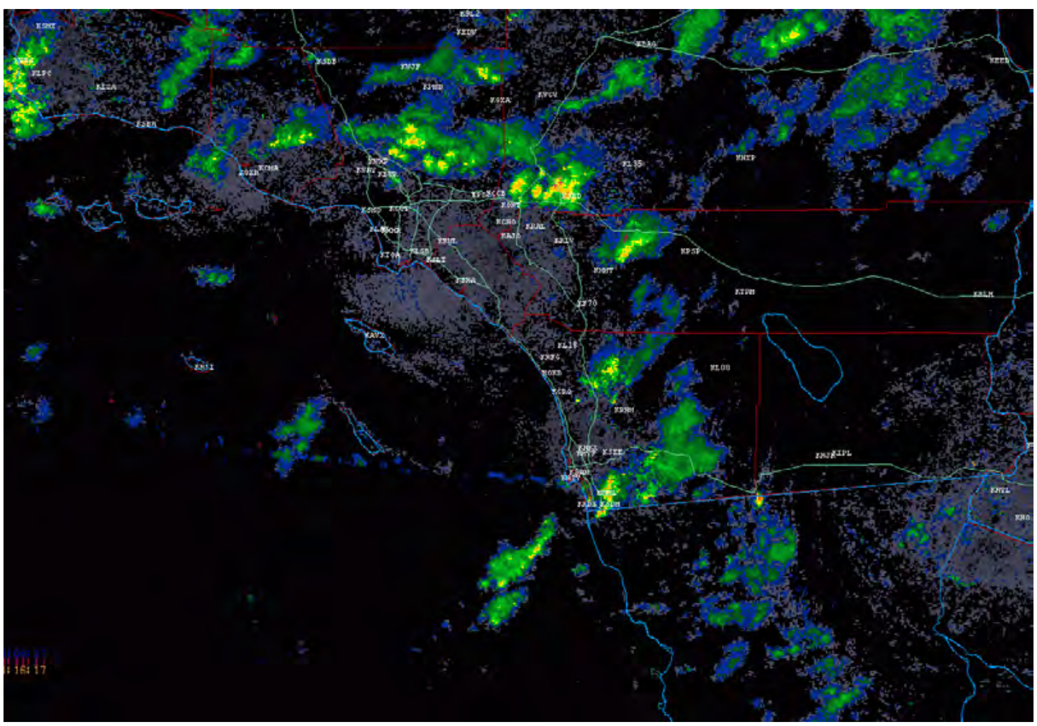

Figure 4.46. Radar image from 1420 PDT on April 5, showing scattered showers and isolated thunderstorms across three of the four SAWPA target areas. Image taken from College of DuPage Weather website.

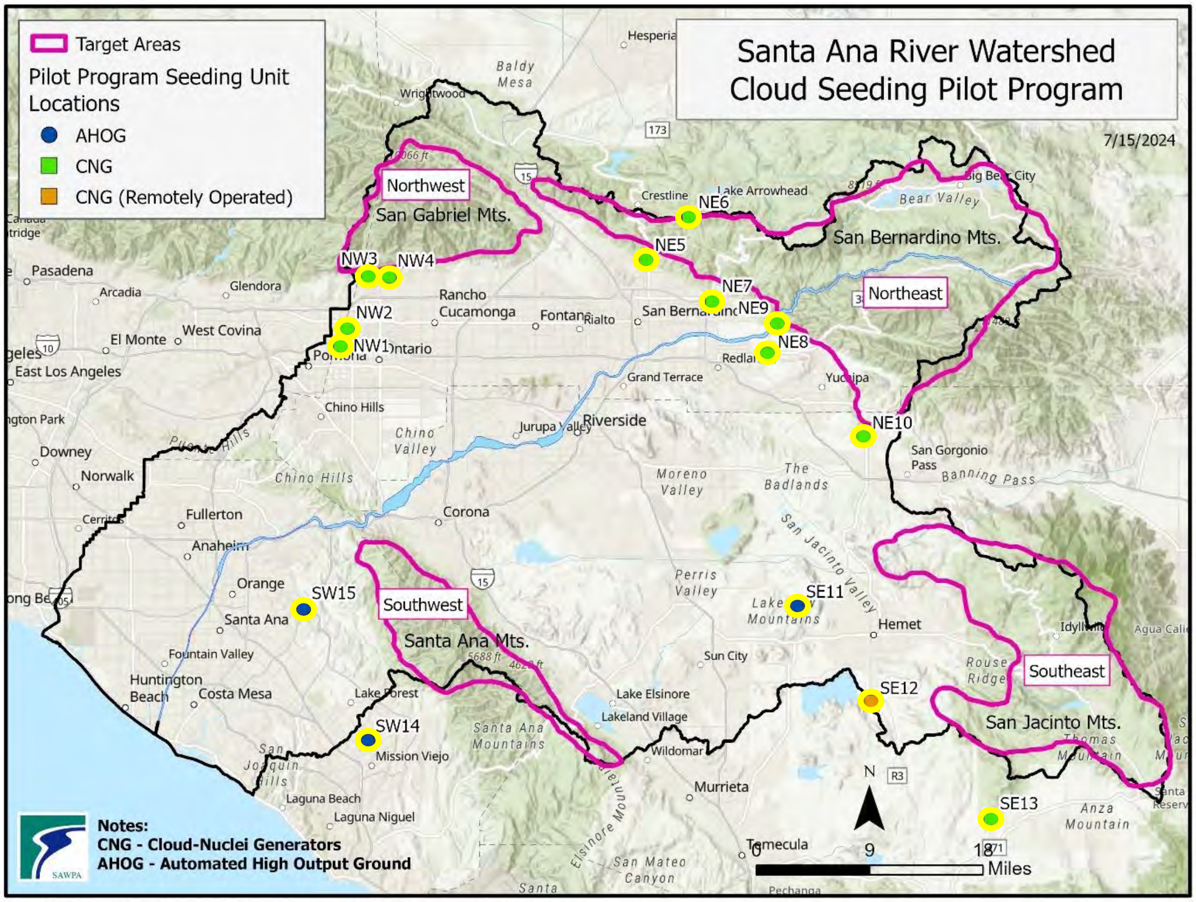

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Figure 4.47. Map showing active seeding sites on April 5, 2024, indicated by yellow circles.

April 13-14

An upper low approached the Bay area during the afternoon hours of April 13. A lobe of energy rotating cyclonically/counterclockwise around the low moved across southern California during the afternoon and evening hours accompanied by a wave of showers within southwest flow. Figure 4.48 shows radar imagery during this portion of the event. Snow levels with this first round of precipitation were around 6500 feet, but colder air behind this wave of showers helped lower snow levels to 4500 feet. There was a break in the precipitation during the overnight hours as the first lobe of energy pushed east of the area. The upper low moved into northern and central California on April 14 and began to weaken. A second lobe of energy rotating around the low moved across southern California during the afternoon and early evening hours. With the colder air aloft in place, a few isolated thunderstorms mixed in with the moderate showers that developed and moved across the project area. Figure 4.49 shows radar imagery during this portion of the event. A couple of flares were burned at the SW15 AHOGS site. Activity with this second impulse ended during the evening as it pushed east of the area. Figure 4.50 shows all active seeding sites during the storm event.

Seedability: POOR to FAIR first wave, FAIR to GOOD second wave. Initially, temperatures were rather warm (+1°C at 700 mb) and a significant inversion was in place as observed on the sounding from San Diego, indicative of the seeding plumes having difficulty reaching cloud base. As the storm continued and the colder portion moved closer, temperatures became more favorable at -3°C (though still marginal for seeding) and stable layers/inversions were mostly mixed out. Also, the SE target area was not in a position for favorable targeting from the seeding units and, as such, sites SE11-13 were not activated.

Problems/issues: NW1 and NW2 were not activated for the first wave of precipitation. Initially, the operator said they could turn them on, but later informed meteorologist, after the event had started, that they were not going to be able to get to the sites. The operator was able to start and stop both sites during the second wave of precipitation.

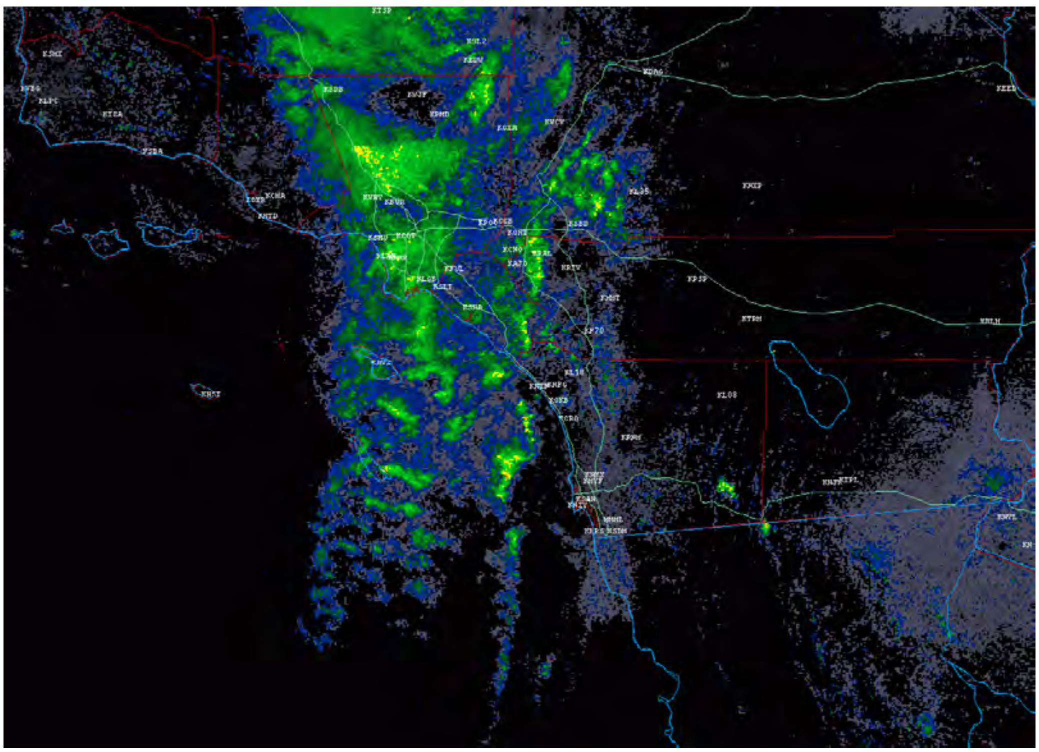

Figure 4.48. **Radar image from 1945 PDT on April 13 showing first wave of showers moving into the SAWPA area.**

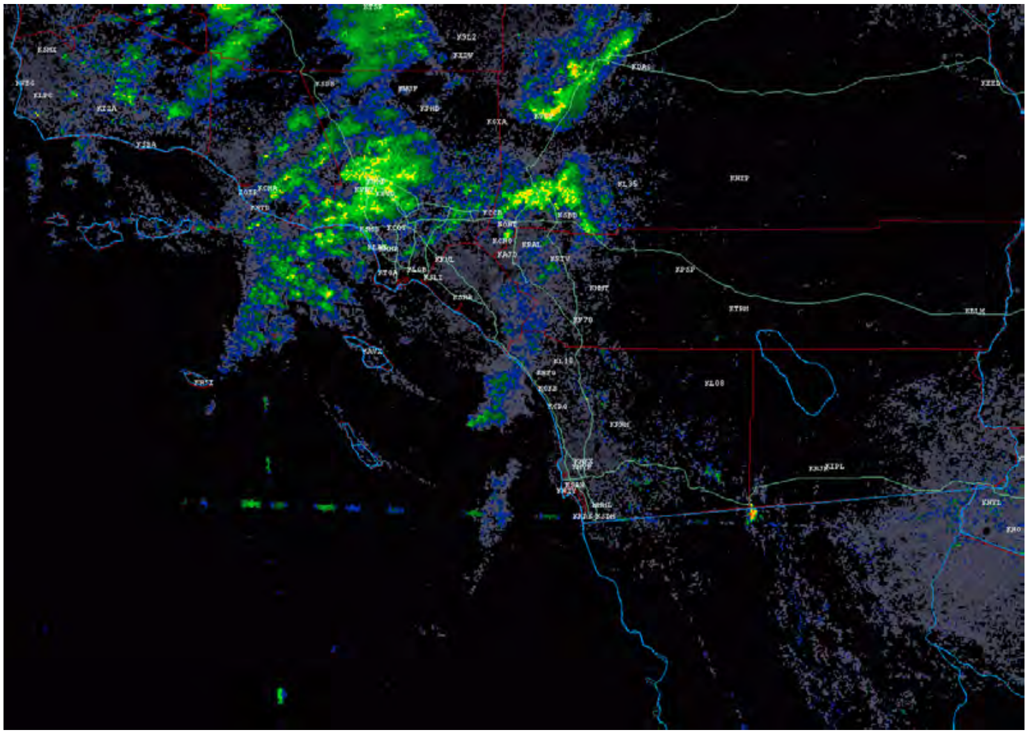

Figure 4.49. **Radar image from 1415 PDT on April 14 showing the second wave of showers moving into the SAWPA area.**

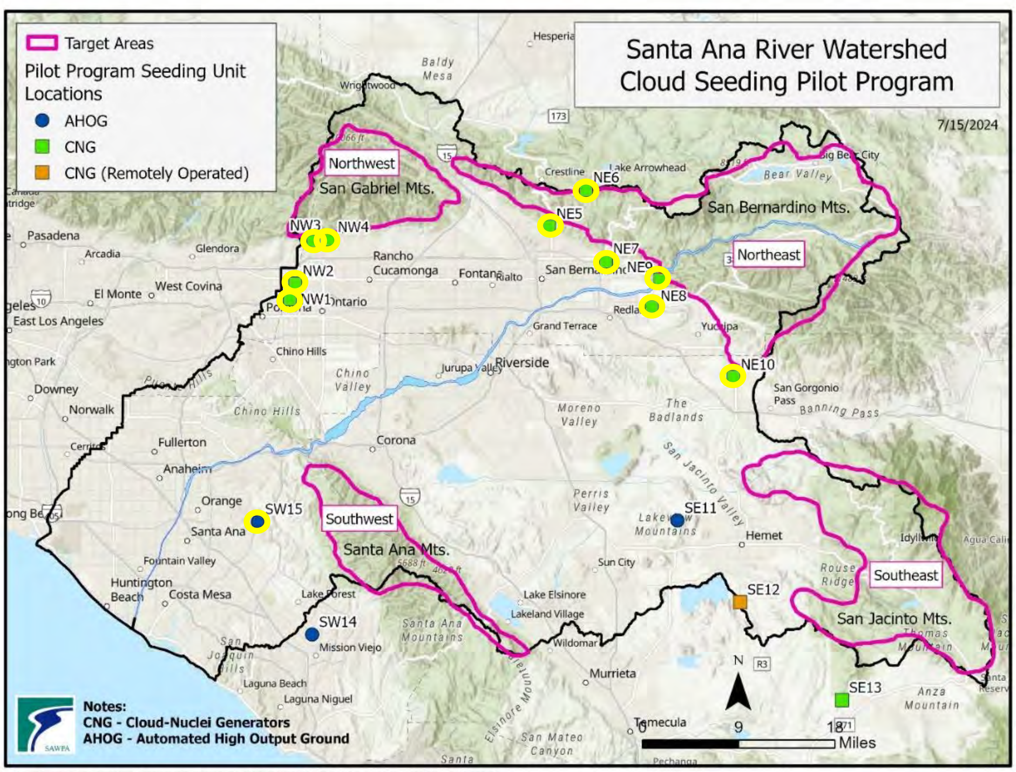

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Figure 4.50. **Map showing active seeding sites on April 13-14, 2024, indicated by yellow circles.**

4.2 Summary of Materials Used

November 2023

Date	Location	Time on	Time off	Total Hours	AgI (g)	Acetone (gal)
17-18-Nov	NW3	18/0045	18/1200	11.25	90	1.41
	NW4	17/2330	18/1245	13.25	106	1.66

November Total	**24.50**	**196**	**3.07**
Season	**24.50**	**196**	**3.07**

December 2023

Date	Location	Time on	Time off	Total Hours	AgI (g)	Acetone (gal)
21-22-Dec	NW3	21/1815	22/1615	22.00	176	2.75
	NW4	21/1845	22/1530	20.75	166	2.59
	NE5	21/1630	22/1900	26.50	212	3.31
	NE6	21/1900	22/1630	21.50	172	2.69
	NE7	21/2045	22/1930	22.75	182	2.84
	NE8	21/1615	22/1430	22.25	178	2.78
	NE9	21/1545	22/1445	23.00	184	2.88
	NE10	21/2015	22/2030	24.25	194	3.03
	SE12	22/0030	22/0915	8.75	70	1.09
	SE13	21/1830	22/1330	19.00	152	2.38

Date	Location	Time on	Time off	Total Hours	AgI (g)	Acetone (gal)
29-30-Dec	NW1	29/1630	30/1530	23.00	184	2.88
	NW2	29/1615	30/1515	23.00	184	2.88
	NW3	29/1715	30/1415	21.00	168	2.63
	NW4	29/1645	30/1445	22.00	176	2.75
	NE5	29/1845	30/1600	21.25	170	2.66
	NE6	30/0530	30/1430	9.00	72	1.13
	NE7	29/1915	30/1615	21.00	168	2.63
	NE8	29/1800	30/1245	18.75	150	2.34
	NE9	29/1815	30/1300	18.75	150	2.34
	NE10	29/1945	30/1700	21.25	170	2.66
	SE12	30/0700	30/1230	5.50	44	0.69
	SE13	30/0600	30/1230	6.50	52	0.81

December Total	**421.75**	**3374**	**52.72**
Season	**446.25**	**3570**	**55.79**

Date	Location	First Flare	Last Flare	Total Flares	AgI (g)
21-22-Dec	SE11	22/1115	22/1220	5	100
	SW14	22/0046	22/0046	1	20

Date	Location	First Flare	Last Flare	Total Flares	AgI (g)
30-Dec	SW14	30/0550	30/1400	3	60

December Total	**9**	**180**
Season	**9**	**180**

January 2024

Date	Location	Time on	Time off	Total Hours	AgI (g)	Acetone (gal)
Jan 03	NW1	0545	1215	6.50	52	0.81
	NW2	0530	1230	7.00	56	0.88
	NW3	0630	1215	5.75	46	0.72
	NE5	0730	1615	8.75	70	1.09
	NE6	0515	1730	12.25	98	1.53
	NE7	0745	1645	9.00	72	1.13
	NE8	0600	1545	9.75	78	1.22
	NE9	0630	1600	9.50	76	1.19
	NE10	0830	1745	9.25	74	1.16
	SE12	0630	1615	9.75	78	1.22
	SE13	0600	1400	8.00	64	1.00

Date	Location	Time on	Time off	Total Hours	AgI (g)	Acetone (gal)
Jan 20-21	NE5	20/1600	21/0915	17.25	138	2.16
	NE6	20/1515	21/0815	17.00	136	2.13
	NE7	20/1630	21/0930	17.00	136	2.13
	NE8	20/1345	21/0815	18.50	148	2.31
	NE9	20/1415	21/0830	18.25	146	2.28
	NE10	20/1730	21/1015	17.75	142	2.22
	SE13	20/1700	21/0815	15.25	122	1.91

Date	Location	Time on	Time off	Total Hours	AgI (g)	Acetone (gal)
Jan 21-22	NE5	21/1830	22/1900	24.50	196	3.06
	NE6	22/0500	22/1915	14.25	114	1.78
	NE8	21/1900	22/1815	23.25	186	2.91
	NE9	21/1915	22/1830	23.25	186	2.91
	NE10	21/1915	22/2000	24.75	198	3.09
	SE13	21/1915	22/1945	24.50	196	3.06

January Total	**351.00**	**2808**	**43.88**
Season	**797.25**	**6378**	**99.66**

Date	Location	First Flare	Last Flare	Total Flares	AgI (g)
Jan 03	SE11	1635	1645	2	40

Date	Location	First Flare	Last Flare	Total Flares	AgI (g)
Jan 20	SW14	1250	1250	1	20

Date	Location	First Flare	Last Flare	Total Flares	AgI (g)
Jan 22	SE11	1523	1548	4	80
	SW14	1042	1603	3	60

Jan Total	**10**	**200**
Season	**19**	**380**

February 2024

Date	Location	Time on	Time off	Total Hours	AgI (g)	Acetone (gal)
Jan 31-Feb 01	NW1	01/0645	01/1645	10.00	80	1.25
	NW2	01/0715	01/1615	9.00	72	1.13
	NW3	31/1730	01/1700	23.50	188	2.94
	NW4	31/1715	01/1615	23.00	184	2.88
	NE6	01/0515	01/1700	11.75	94	1.47
	NE8	01/0700	01/1445	7.75	62	0.97
	NE9	01/0715	01/1515	8.00	64	1.00
	NE10	01/0730	01/1900	11.50	92	1.44
	SE12	01/0415	01/1815	14.00	112	1.75
	SE13	01/0615	01/1830	12.25	98	1.53

Date	Location	Time on	Time off	Total Hours	AgI (g)	Acetone (gal)
Feb 20-21	NW1	20/1715	21/1000	16.75	134	2.09
	NW2	20/1745	21/1000	16.25	130	2.03
	NW3	20/1600	21/1130	19.50	156	2.44
	NW4	20/1630	21/1215	19.75	158	2.47
	NE6	20/1530	21/0945	18.25	146	2.28
	NE7	20/1445	21/1345	23.00	184	2.88
	NE9	20/1315	21/0945	20.50	164	2.56
	NE10	20/1415	21/1430	24.25	194	3.03

February Total	**289.00**	**2312**	**36.13**
Season	**1086.25**	**8690**	**135.78**

Date	Location	First Flare	Last Flare	Total Flares	AgI (g)
Feb 01	SE11	2255	2255	1	20

February Total	**1**	**20**
Season	**20**	**400**

March 2024

Date	Location	Time on	Time off	Total Hours	AgI (g)	Acetone (gal)
Mar 06-07	NW1	06/1700	07/0900	16.00	128	2.00
	NW3	06/1730	07/0730	14.00	112	1.75
	NW4	06/1700	07/0700	14.00	112	1.75
	NE5	06/1545	07/0845	17.00	136	2.13
	NE6	06/1500	07/0500	14.00	112	1.75
	NE7	06/1515	07/0900	17.75	142	2.22
	NE8	06/1430	07/0530	15.00	120	1.88
	NE10	06/1445	07/1000	18.75	150	2.34
	SE12	06/1415	07/0715	17.00	136	2.13
	SE13	06/1715	07/0600	12.75	102	1.59

Date	Location	Time on	Time off	Total Hours	AgI (g)	Acetone (gal)
Mar 23-24	NW1	23/1315	24/1115	22.00	176	2.75
	NW2	23/1345	24/1000	20.25	162	2.53
	NW3	23/1245	24/1115	22.50	180	2.81
	NW4	23/1215	24/1045	22.50	180	2.81
	NE5	23/1345	24/1230	22.75	182	2.84
	NE6	23/1430	24/0830	18.00	144	2.25
	NE7	23/1415	24/1300	22.75	182	2.84
	NE8	23/1215	24/0845	20.50	164	2.56
	NE9	23/1230	24/0845	20.25	162	2.53
	NE10	23/1515	24/1345	22.50	180	2.81
	SE12	23/1400	23/1845	4.75	38	0.59
	SE13	23/1415	24/0830	18.25	146	2.28

Date	Location	Time on	Time off	Total Hours	AgI (g)	Acetone (gal)
Mar 30-31	NW1	30/0800	31/1400	30.00	240	3.75
	NW3	30/1145	31/1430	26.75	214	3.34
	NW4	30/1115	31/1500	27.75	222	3.47
	NE5	30/0845	31/1600	31.25	250	3.91
	NE6	30/0745	31/1500	31.25	250	3.91
	NE7	30/0915	31/1630	31.25	250	3.91
	NE9	30/0700	31/1515	32.25	258	4.03
	NE10	30/0945	31/1700	31.25	250	3.91
	SE12	30/0530	31/1430	33.00	264	4.13
	SE13	30/0615	31/1500	32.75	262	4.09

March Total	**700.75**	**5606**	**87.59**
Season	**1787.00**	**14,296**	**223.38**

Date	Location	First Flare	Last Flare	Total Flares	AgI (g)
Mar 06	SW14	1526	1526	1	20
	SW15	1514	1523	2	40

Date	Location	First Flare	Last Flare	Total Flares	AgI (g)
Mar 30-31	SE11	31/1029	31/1029	1	20
	SW14	30/0706	30/0722	2	40

March Total	**6**	**120**
Season	**26**	**520**

April 2024

Date	Location	Time on	Time off	Total Hours	AgI (g)	Acetone (gal)
Apr 05	NW1	0630	1915	12.75	102	1.59
	NW2	0630	1545	9.25	74	1.16
	NW3	0930	1800	8.50	68	1.06
	NW4	0945	1815	8.50	68	1.06
	NE5	0730	1945	12.25	98	1.53
	NE6	0615	2015	14.00	112	1.75
	NE7	0745	2015	12.50	100	1.56
	NE8	0645	1945	13.00	104	1.63
	NE9	0645	1930	12.75	102	1.59
	NE10	0830	2045	12.25	98	1.53
	SE12	1000	1900	9.00	72	1.13
	SE13	0615	1900	12.75	102	1.59

Date	Location	Time on	Time off	Total Hours	AgI (g)	Acetone (gal)
Apr 13-14	NW1	14/1200	14/1900	7.00	56	0.88
	NW2	14/1230	14/1930	7.00	56	0.88
	NW3	13/1745	14/1830	24.75	198	3.09
	NW4	13/1815	14/1915	25.00	200	3.13
	NE5	13/1845	14/2015	25.50	204	3.19
	NE6	13/1745	14/0600	12.25	98	1.53
	NE6	14/1245	14/2045	8.00	64	1.00
	NE7	13/1915	14/2045	25.50	204	3.19
	NE8	13/1715	14/1815	25.00	200	3.13
	NE9	13/1700	14/2130	25.50	204	3.19
	NE10	13/2015	14/2130	25.25	202	3.16

April Total	**348.25**	**2786**	**43.53**
Season	**2135.25**	**17,082**	**266.91**

Date	Location	First Flare	Last Flare	Total Flares	AgI (g)
Apr 05	SE11	1346	1346	1	20
	SW14	0835	0856	2	40
	SW15	0802	0802	1	20

Date	Location	First Flare	Last Flare	Total Flares	AgI (g)
Apr 14	SW15	1545	1608	2	40

April Total	**6**	**120**
Season	**32**	**640**

5.0 CONCLUSIONS AND RECOMMENDATIONS

The first season of precipitation enhancement for the Santa Ana River Watershed Cloud Seeding Pilot Program began on November 15, 2023, and continued through April 15, 2024. A total of 13 storm events were seeded over a total period of 22 days within the operational season, with 2135.25 hours of seeding runtime from 12 ground-based CNG units and 32 silver iodide (AgI) flares deployed from three AHOGS units. The 2023-2024 season saw above normal precipitation across southern California including the project area. One suspension period was enacted due to a significant Atmospheric River event that occurred from February 3 through February 8, 2024, and brought over 15 inches of rainfall to some locations along with over seven feet of snow in others. During the operations of the Pilot Program, mechanical and logistical issues were encountered at a few of the sites during the season.

Overall, the 2023-2024 season showed that the program design for the Santa Ana River Watershed Cloud Seeding Pilot Program worked well with the weather patterns observed during the season and should continue for future seasons. There were a few operational occurrences during the season that were not anticipated, but these should be used as learning opportunities that could allow for adjustments to the program for future seasons. These are discussed in the following paragraphs.

During the first weeks of the Pilot Program, there were three incidents where local fire departments were contacted by local public members regarding a visible flame burning from the ground-based CNG units. This occurrence was perceived as fires burning in the hills since the public was not aware that there were instead active CNG units. Local fire departments were contacted and notified about the presence and locations of the CNG units within their service area initially through phone calls, followed by a memorandum developed by SAWPA. The memorandum allowed the local fire departments to respond appropriately to any future public inquiries/calls regarding the units**. It is recommended that for future seasons, these memorandums be re-issued to all fire departments near the locations of the seeding units, including the AHOGS sites prior to the start of the seeding season.**

The field technicians that helped troubleshoot mechanical issues and repair the seeding units during the season, as well as replenish seeding solution and flares, were dispatched from NAWC's main office in Utah, often at short notice. There were a couple of instances where logistics had minor impacts on operations. **For future seasons, it is strongly recommended that a field technician local to the SARW Project Area be trained and provided with all necessary information and supplies to service both CNGs and AHOGS.** Periodic operation of the sites to ensure units are working properly was conducted during the season, and this should continue, particularly if a couple of weeks pass without operation. These site "tests" should occur more frequently, our recommendation is to test them once per week when storms are not anticipated.

The 2023-2024 season demonstrated that the seeding sites selected worked well with most of the storm systems that affected the project area. Overall, the sites appeared to be effective at targeting their seeding material properly into the nearby target areas, and it is recommended that most sites remain for the following season. However, there are a couple of considerations regarding the current site locations. Throughout the season, HYSPLIT modeling revealed that, at times, sites NW1 and NW2 produced seeding plumes that did not impact the nearby target areas; also, these same sites are located very close to each other (i.e., 1.5 miles apart). **For future seasons, consideration should be given to moving one of the sites further northwest closer to the NW Target area. R**egarding site location, there was a four-day storm event in mid-March that had reasonably good conditions for seeding except for one main parameter, that being wind flow; the positioning of the storm system east of the area resulted in a prolonged period of north to northeast flow with precipitation, a setup that was not accounted for when designing the program as meteorological analysis during the feasibility study indicated this to be a rare occurrence. Given that this storm event did produce abundant precipitation in the mountains, this could be viewed as a missed opportunity. **Considerations should be given to the possibility of installing seeding sites on the east and northeast sides of the NE and SE target areas to account for this pattern, with the understanding that these sites may rarely be activated.**

REFERENCES

SAWPA, 2020. Santa Ana Watershed Weather Modification and Feasibility Study Final Report, prepared for the Santa Ana Watershed Project Authority, prepared by North American Weather Consultants, Inc., Riverside, CA, November 27, 2020.

SAWPA, 2022. Santa Ana River Watershed Weather Modification Project Initial Study & Mitigated Negative Declaration, prepared for the Santa Ana Watershed Project Authority, prepared by Catalyst Environmental Solutions, Riverside, CA, June 2022.

APPENDIX A

STORM EVENT CRITERIA TABLES 2023-24

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	N	The airmass with this storm was too warm for seeding operations.
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).		Convective regime suggests AHOGS, but too warm.
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	N	Supercooled water too high in cloud (see "D")
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	N	Temps at 700 mb were +4°C to +5°C.
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	N	Stable low levels as measured on soundings.
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	N	Supercooled water too high in cloud (see "D")
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	Y	Winds were blowing from sites to target areas

November 17-18, 2023

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	N	Although temperatures eventually became marginally ideal, moisture did not.
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).		Had there been more moisture, may have had both CNGs and AHOGS.
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	N	Clouds not very tall/thick, and moisture appeared to be lacking.
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	N/Y	Not favorable at start of storm, became marginally favorable towards end of event.
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	N/Y	Stability layers in place near ground but did mix out.
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	N	Had there been more moisture, may have had nucleation/precipitation
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	Y	Winds were favorable although perhaps a bit low as far as speed.

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	N	
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).	Y/N	Convective cells that were mainly over the valley
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	Y/N	Most clouds remained on the shallow side, but some clouds did appear to have sufficient depth; some SLW
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	Y	700 mb temps were -2°C to -4°C
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	N	Afternoon sounding showed shallow stable layer
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	Y	
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	Y/N	Winds started out favorable but became unfavorable

December 21-22, 2023

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	Y	
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).	Y	Used both CNGs and AHOGS
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	Y	
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	Y/N	
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	Y/N	There were stable layers initially, but these mixed out eventually
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	y	
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	Y/N	Upper low positioning provided an uncommon flow pattern, but it was workable.

December 29-30, 2023

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	Y	
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).	Y	Used all CNGs and flares from El Toro AHOGS unit.
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	Y	
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	N/Y	Warm at start of storm event, cooled to more ideal values during storm.
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	N/Y	Stable layers present initially, mixed out later on.
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	Y	
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	Y	

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	Y	
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).	Y	Convection and stratiform
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	Y	
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	Y	
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	N/Y	Stable layers present initially.
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	Y	
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	Y	

January 7, 2024

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	N	
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).		AHOGS would have been the main use
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	Y	
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	Y	Temps of -2°C to -6°C were in place at 700 mb.
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	N/Y	Stable layers present initially, then mixed out
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	N	Wind speeds too strong for seeding, especially once plumes reach desired target areas.
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	N	Winds near AHOGS not good for seeding

January 20-21, 2024

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	Y	
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).	Y	Both CNGs and AHOGS were used.
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	Y	
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	N/Y	Temperatures were not ideal with first wave of rain, but cooler temps aloft in place for second/third waves.
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	N/Y	Stable layers present initially, mixed out later
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	Y	
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	N/Y	NW1/2 not favorable, the rest was favorable.

January 21-22, 2024

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	Y	
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).	Y	Both CNGs & AHOGS used for seeding.
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	Y	
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	Y/N	May have been a little warm at times, would like to see at least -3 to -5°C.
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	N/Y	Some early stability issues, mixed out with time.
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	Y	
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	Y	

February 1, 2024

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	Y	Had two sites that did not run because of low propane but this should not have impacted benefit goal.
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).	Y	There were some convective cells, did not use AHOGS due to flood issues
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	Y	Model data and PIREPs indicated presence of SLW.
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	N/Y	Temperatures cooled during event to favorable values
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	N/Y	Stable at start, this eroded during storm
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	Y	Winds were strong in the mountains but not so at lower elevations
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	Y	HYSPLIT did show some plume variability but all of them affected target areas.

February 3-8, 2024

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	N	Storm period already at maximum efficiency.
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).		Both modes present.
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	N/Y	Periods with proper structure, other times not
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	N/Y	Too warm initially, later part of period more ideal temperature-wise
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	N/Y	Some stability issues at times, other times it was unstable.
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	N/Y	Strong winds at times would result in long overshooting plumes
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	Y	

February 20-21, 2024

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	N	
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).	Y	Both modes present, but no seeding with AHOGS due to wet conditions.
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	Y	
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	N/Y	Warm initially, temps cooled with time
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	Y/N	Stable layers present initially, mixed out over time
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	Y	
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	Y	

February 26, 2024

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	N	
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).		Stratiform mainly
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	N	Moisture was confined to 8000 feet MSL and below.
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	N	Temps too warm aloft
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	N/Y	Some stability early
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	Y	
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	Y	

March 2-3, 2024

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	N	
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).		Both modes present
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	Y	
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	N	0°C at 700 mb.
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	N	Significant stability present
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	N	Winds too strong
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	Y	Wind direction was good, just not speed.

March 6-7, 2024

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	Y	
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).	Y	Both CNGs and AHOGS were employed for the storm.
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	Y	
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	Y	
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	N/Y	Weak stable layers present initially
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	Y	
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	Y	

March 14-18, 2024

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	N	
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).		Both modes present.
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	Y	
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	N/Y	Few times where temps at 700 mb were a little too warm for seeding.
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	N/Y	Stable layers appeared from time to time
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	Y	IF the flow had been the opposite direction, nucleation time would have been good
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	N	North to northeast flow, not a direction program is setup for

March 23-24, 2024

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	Y	
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).	Y	Mix of stratiform and convection but convection mainly avoided AHOGS sites.
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	Y	
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	N/Y	Warm initially, cooled as storm progressed
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	Y/N	Significant stable layer at start of storm event
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	Y	
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	Y	

March 30-31, 2024

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	Y	
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).	Y	Both types of seeding units used
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	Y	
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	Y	
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	N/Y	Weak stability first part of storm.
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	Y	
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	Y	

April 5, 2024

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	Y	
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).	Y	Both AHOGS and CNGs were used.
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	Y	
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	N/Y	Warm at start, cooled significantly later on.
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	N/Y	Stable layer present at start of event.
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	Y	
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	Y	

April 13-14, 2024

Criteria ID	Criteria Name	Criteria Description	Storm Met Criteria (Y/N)	Notes from NAWC (Per Storm)
A	Overall Pilot Goal	Maximum benefit for precipitation to the Santa Ana River Watershed and the four target areas.	Y	
B	Storm Type (CNG vs AHOGS)	Convective bands storm systems (lines of showers and thunderstorms) or stratiform storm systems (precipitation areas that are continuous and uniform in intensity).	Y	Both AHOGS and CNGs used for seeding.
C	Favorable Cloud Structure	Cloud type/structure favorable to seeding operations. This includes the presence of significant supercooled liquid water in cloud layers that can be reached by seeding material from available sites; these are determined from aircraft (pilot reports) and radar observations as well as model output.	Y	
D	Favorable Temperature	Temperatures favorable for transporting and mixing of seeding material to suitably cold (below -5°C) favorable cloud regions. This generally means a mountain crest height temperature near or below this value in the respective target areas from stratiform storm situations. In convective situations this temperature criterion is less important.	N/Y	Temps quite mild to start but cooled significantly later on.
E	Absence of Low-Level Layer Interference	No low-level stable layers that would severely restrict the mixing of seeding material to the necessary elevation.	N/Y	Stable layer present at start.
F	Nucleation Time	Sufficient time, given existing wind and temperature parameters, for the nucleation and precipitation process to produce seeding effects within the bounds of intended target area(s).	Y	
G	Site Specific Wind	Favorable wind direction(s) for material from a given site to traverse a reasonable portion of a seeding target area where the intended effects of seeding are being focused	Y	

APPENDIX B

SEEDING SUSPENSION CRITERIA

Certain situations require temporary or longer-term suspension of cloud seeding activities, with reference to well-considered criteria for consideration of possible suspensions, to minimize either an actual or apparent contribution of seeding to a potentially hazardous situation. The ability to forecast (anticipate) and judiciously avoid hazardous conditions is important in limiting any potential liability associated with weather modification and to maintain a positive public image.

There are three primary hazardous situations for the SAWPA program around which suspension criteria have been developed. These are:

- Rain-induced winter flooding
- Burn Scars
- Severe weather

In general, suspension will be considered when a storm is forecasted to be a 1 in 2-year event by magnitude or rainfall rates or in cases such as a series of atmospheric river events. Areas of particular concern include the Inland Empire where infrastructure may be challenged to contain runoff from a severe storm event. Areas with burn scars will be tracked and assessed as part of the multi-year program. Specifics on scenarios wherein suspensions would arise are explained below, but it should be noted that **NAWC's project meteorologists have the authority to temporarily suspend localized seeding operations due to development of hazardous severe weather conditions even if the NWS has not issued a warning**. This would be a rare event, but it is important for the operator to have this latitude.

Flooding Situations

In addition to the possibility of flooding due to extreme rainfall, the potential also exists for wintertime flooding from rainfall on existing snowpack, especially if a lower elevation snowpack exists. Precautions must be taken to ensure accurate forecasting and timely temporary suspension of operations during these potential flooding situations. The objective of suspension under these conditions is to eliminate the real and/or perceived impact of weather modification when any increase in precipitation has the potential of creating or contributing to a significant flood hazard. When a significant rain on snow event is expected, the forecast will be monitored closely to flag the potential for warm storm rain on snow, and coordination between the meteorologist and SAWPA will be appropriate in circumstances where the freezing level is >8,000 feet and the quantitative precipitation forecast (QPF) is > 3 inches in 24 hours. We expect this situation of rain on an existing snowpack to be rare for southern California, yet still possible.

Burn Scars

After a wildfire is contained, a burn scar will form in the impacted area. According to the National Weather Service, the length of time the burn scar remains a threat for debris flow "depends on the severity of the wildfire that occurred as well as how much erosion occurs. It could take many years for vegetation to become reestablished and this is the main factor in slowing the precipitation run off that creates flash flooding and debris flows. Most burn areas will be prone to this activity for at least two years." Following a wildfire, SAWPA will share the impacted areas with NAWC and coordinate the fire severity and extents of the burn scar with the applicable flood control district. If the burn scar is a threat for debris flow, NAWC will not conduct seeding operations that will affect the burn scar area.

Severe Weather

During periods of hazardous weather phenomena associated with both winter orographic and convective precipitation systems it is sometimes necessary or advisable for the National Weather Service (NWS) to issue special weather bulletins advising the public of the weather phenomena. Each phenomenon is described in terms of criteria used by the NWS in issuing special weather bulletins. Those of concern while conducting winter cloud seeding programs include the following:

- **Winter Storm Warnings** – issued by the NWS when it expects heavy snow, along with strong winds/wind chill or freezing precipitation. These are commonly issued during the winter for three of the four target areas, and do not require suspensions unless there are special considerations (e.g., a significant storm that impacts Christmas Eve travel).
- **High Wind Warnings** – issued when sustained winds of 40-45 mph or frequent gusts at or above 58 mph (75 mph above 7000 feet) are expected or occurring.
- **Flash Flood Warnings** – issued by the NWS when flash flooding is imminent or in progress, or a dam break is imminent or occurring.
- **Severe Thunderstorm Warnings** – issued by the NWS when a thunderstorm is expected to produce strong winds in excess of 58 miles per hour (mph) or hail larger than one inch in diameter.

Seeding operations may be suspended when the NWS issues a flood/flash flood warning for or adjacent to one of the target areas; flood advisories, which are issued for primarily nuisance street and small stream flooding, normally will not require a suspension. Since an objective of the cloud seeding program is to increase winter snowfall in the mountainous areas where snow commonly falls, suspensions are not generally necessary when Winter Storm Warnings are issued, unless there are special, extenuating considerations to make, for example, the effect of heavy snowfall at low elevations not typically used to heavy snow that could result in flooding situations upon melting, or heavy snowfall that is forecast to be followed by heavy rainfall over the snowpack which may also result in flooding. There is also the prospect of high winds during storms impeding seeding operations; sustained winds in excess of 30 mph at the sites may result in issues with the CNG flame remaining lit or the actual seeding plumes having long tracks such that the nucleation occurs well after the plume has moved past the target areas.

Flash Flood Warnings are usually issued when intense convective activity causing heavy rainfall is expected, or when moderate rainfall is expected for extended periods. The types of storms that may cause problems are those that have the potential of producing 2-3 inches (or greater) of rainfall in a 24-hour period, especially with high freezing levels (e.g., >8,000 feet MSL). Seeding operations shall be suspended for the duration of the warning period in the affected areas when the **24-hour rainfall is forecast to be greater than 3 inches.**

APPENDIX C

GLOSSARY OF METEOROLOGICAL TERMS

Advection: Movement of an air mass. Cold advection describes a colder air mass moving into the area, and warm advection is used to describe an incoming warmer air mass. Dry and moist advection can be used similarly.

Air Mass/airmass: A term used to describe a region of the atmosphere with certain defining characteristics. For example, a cold or warm air mass, or a wet or dry air mass. It is a fairly subjective term but is usually used in reference to large (synoptic scale) regions of the atmosphere, both near the surface and/or at mid and upper levels of the atmosphere.

Atmospheric River/AR: A long, narrow and transient corridor of strong horizontal water vapor transport that is typically associated with a low-level jet stream ahead of the cold front of a low pressure system. The water vapor in ARs is supplied by tropical and subtropical moisture sources and frequently produces heavy precipitation where they are forced upward, e.g., by mountains or dynamic lifting.

Balloon Sounding: see Sounding.

Cell: in radar usage, a local maximum in radar reflectivity that undergoes a life cycle of growth and decay, having both an updraft and a downdraft region.

Cold-core low: A typical mid-latitude type of low pressure system, where the core of the system is colder than its surroundings. This type of system is also defined by the cyclonic circulation being strongest in the upper levels of the atmosphere. The opposite is a warm-core low, which typically occurs in the tropics.

Cold Pool: An air mass that is cold relative to its surroundings and may be confined to a particular basin.

Condensation: Phase change of water vapor into liquid form. This can occur on the surface of objects (such as dew on the grass) or in mid-air (leading to the formation of clouds). Clouds are technically composed of water in liquid form, not water vapor.

Confluent: Wind vectors coming closer together in a two-dimensional frame of reference (opposite of diffluent). The term convergence is also used similarly.

Convective (or convection): Pertains to the development of precipitation areas due to the rising of warmer, moist air through the surrounding air mass. The warmth and moisture contained in a given air mass makes it lighter than colder, dryer air. Convection often leads to small-scale, locally heavy showers or thundershowers. The opposite precipitation type is known as stratiform precipitation.

Convergence: Refers to the converging of wind vectors at a given level of the atmosphere. Low-level convergence (along with upper-level divergence), for instance, is associated with lifting of the air mass which usually leads to development of clouds and precipitation. Low-level divergence (and upper-level convergence) is associated with atmospheric subsidence, which leads to drying and warming.

Cyclonic Flow: Counter-clockwise motion, primarily around low pressure (cyclone).

Deposition: A phase change where water vapor turns directly to solid form (ice). The opposite process is called sublimation.

Dew point: The temperature at which condensation occurs (or would occur) with a given amount of moisture in the air.

Diffluent: Wind vectors spreading further apart in a two-dimensional frame of reference; opposite of confluent.

Disturbance: see Low pressure, shortwave.

Dry slot: A zone of dry (and usually cloud-free) air that wraps into the southern and eastern parts of a low pressure system; easily viewed on satellite imagery.

Entrain: Usually used in reference to the process of a given air mass being ingested into a storm system.

Evaporation: Phase change of liquid water into water vapor. Water vapor is usually invisible to the eye.

El Niño: A reference to a particular phase of oceanic and atmospheric temperature and circulation patterns in the tropical Pacific, where the prevailing easterly trade winds weaken or dissipate. Often influences mid-latitude patterns as well, such as increased precipitation in southern portions of the U.S. and decreased precipitation further north. The opposite phase is called La Nina.

Front (or frontal zone): Reference to a temperature boundary with either incoming colder air (**cold front**) or incoming warmer air (**warm front**); can sometimes be a reference to a stationary temperature boundary line (stationary front) or a more complex type known as an occluded front (where the temperature change across a boundary can vary in type at different elevations).

Frontal band: A band of clouds/precipitation along a cold or warm front.

Glaciogenic: Ice-forming (aiding the process of nucleation); usually used in reference to cloud seeding nuclei.

GMT (or UTC, or Z) time: Greenwich Mean Time, universal time zone corresponding to the time at Greenwich, England. Pacific Standard Time (PST) = GMT – 8 hours; Pacific Daylight Time (PDT) = GMT – 7 hours.

Graupel: A precipitation type that can be described as "soft hail", that develops due to riming (nucleation around a central core). It is composed of opaque (white) ice, not clear hard ice such as that contained in hailstones. It usually indicates the presence of convective clouds and can be associated with electrical charge separation and occasionally lightning activity.

High Pressure (or Ridge): Region of the atmosphere usually accompanied by dry and stable weather. Corresponds to a northward bulge of the jet stream on a weather map, and to an anti-cyclonic (clockwise) circulation pattern.

Infrared (satellite): imagery sensed in the 3-13 µm wavelength region of the electromagnetic spectrum, usually referring to the thermal infrared region.

Inside Slider: A trough or area of low pressure that moves south-southeast along or parallel to the Sierra Nevada mountains before swinging east into the Great Basin or Desert Southwest. These systems typically do not have much moisture with them but can have cold to very cold air accompanying them. The track of these systems typically brings Santa Ana winds as they increase the northeast-southwest pressure gradient.

Inversion: Refers to a layer of the atmosphere in which the temperature increases with elevation, usually associated with stability.

Jet Stream or Upper-Level Jet (sometimes referred to more generally as the storm track): A region of maximum wind speed, usually in the upper atmosphere that usually coincides with the main storm track in the mid-latitudes. This is the area that also typically corresponds to the greatest amount of mid-latitude synoptic-scale storm development.

La Niña: The opposite phase of that known as El Nino in the tropical Pacific. During La Nina the easterly tropical trade winds strengthen and can lead in turn to a strong mid-latitude storm track, which often brings wetter weather to northern portions of the U.S.

Longwave (or longwave pattern): The longer wavelengths, typically on the order of 1,000 – 2,000+ miles of the typical ridge/trough pattern around the northern (or southern) Hemisphere, typically most pronounced in the mid-latitudes.

Low-Level Jet: A zone of maximum wind speed in the lower atmosphere. Can be caused by geographical features or various weather patterns and can influence storm behavior and dispersion of cloud seeding materials.

Low pressure (or low or trough): Region of the atmosphere usually associated with stormy weather. Corresponds to a southward dip to the jet stream on a weather map as well as a cyclonic (counterclockwise) circulation pattern in the Northern Hemisphere.

Mesoscale: Sub-synoptic scale, about 100 miles or less; this is the size scale of more localized weather features (such as thunderstorms or mountain-induced weather processes).

Microphysics: Used in reference to composition and particle types in a cloud.

Mid-level: the layer of the atmosphere from 10,000-20,000 feet.

Millibar (mb): a unit of pressure equal to 100 newtons per square meter (N/m^2).

MSL (Mean Sea Level): Elevation height reference in comparison to sea level.

Negative (ly) tilted trough: A low-pressure trough where a portion is undercut, such that a frontal zone can be in a northwest to southeast orientation.

Nucleation: The process of supercooled water droplets in a cloud turning to ice. This is the process that is aided by cloud seeding. For purposes of cloud seeding, there are three possible types of cloud composition: Liquid (temperature above the freezing point), supercooled (below freezing but still in liquid form), and ice crystals.

Nuclei: Small particles that aid water droplet or ice particle formation in a cloud.

Orographic: Terrain-induced weather processes, such as cloud or precipitation development on the upwind side of a mountain range. Orographic lift refers to the lifting of an air mass as it encounters a mountain range.

Precipitable Water, or PWAT: The total atmospheric water vapor contained in a vertical column of unit cross-sectional area extending between the surface and top of the atmosphere, expressed in terms of the depth to which that water substance would be if completely condensed and collected in a vessel of the same unit cross-section.

Pressure Heights (e.g., 700 millibars, or mb): Corresponds to approximately 10,000 feet above sea level (MSL); 850 mb corresponds to about 5,000 feet MSL; and 500 mb corresponds to about 18,000 feet MSL. These are standard height levels that are occasionally referenced, with the 700 mb level most important regarding cloud-seeding potential in most of the western U.S.

Positive (ly) tilted trough: A normal U-shaped trough configuration, where an incoming cold front would generally be in a northeast– southwest orientation.

Reflectivity: The density of returned signal from a radar beam, which is typically bounced back due to interaction with precipitation particles (either frozen or liquid) in the atmosphere. The reflectivity depends on the size, number, and type of particles that the radar beam encounters.

Ridge (or High Pressure System): Region of the atmosphere usually accompanied by dry and stable weather. Corresponds to a northward bulge of the jet stream on a weather map, and to an anti-cyclonic (clockwise) circulation pattern.

Ridge axis: The longitude band corresponding to the high point of a ridge.

Rime (or rime ice): Ice buildup on an object (often on an existing precipitation particle) due to the freezing of supercooled water droplets.

Shortwave (or shortwave disturbance): Smaller-scale wave features of the weather pattern typically seen at mid-latitudes, usually on the order of a few to several hundred miles; these often correspond to individual frontal systems.

Silver iodide: A compound commonly used in cloud seeding because of the similarity of its molecular structure to that of an ice crystal. This structure helps in the process of nucleation, where supercooled cloud water changes to ice crystal form.

Sounding: A measurement of the vertical distribution of physical properties of the atmospheric column such as temperature, dewpoint, pressure, wind speed and direction. Soundings are typically conducted by releasing a balloon filled with hydrogen or helium with instrumentation attached that measures different properties as the balloon rises from the surface until it pops at very high altitudes (80-100 kft).

Stable layer: A layer of given thickness in the atmosphere where temperatures are constant with height or rise with height; this results in little to no vertical movement of the air and little to no turbulence/mixing.

Storm Track (sometimes referenced as the Jet Stream): A zone of maximum storm propagation and development, usually concentrated in the mid-latitudes.

Stratiform: Usually used in reference to precipitation, this implies a large area of precipitation that has a fairly uniform intensity except where influenced by terrain, etc. It is the result of larger-scale (synoptic scale) weather processes, as opposed to convective processes.

Sublimation: The phase change in which water in solid form (ice) turns directly into water vapor. The opposite process is deposition.

Subsidence: The process of a given air mass moving downward in elevation, such as often occurs on the downwind side of a mountain range.

Subtropical/subtropics: Referring to the region of the Earth bordering on the tropics, from the Tropic of Cancer/Capricorn (23.5°N/S) to about 35°N/S. **Subtropical moisture** would refer to moisture whose source region is the subtropics. **Subtropical Jet Stream** would refer to a jet stream within the subtropics.

Supercooled: Liquid water (such as tiny cloud droplets) occurring at temperatures below the freezing point (32°F or 0°C).

Synoptic Scale: A scale of hundreds to perhaps 1,000+ miles, the size scale at which high and low pressure systems develop.

Trough (or low pressure system): Region of the atmosphere usually associated with stormy weather. Corresponds to a southward dip to the jet stream on a weather map as well as a cyclonic (counterclockwise) circulation pattern in the Northern Hemisphere.

Trough axis: The longitude band corresponding to the low point of a trough.

Unstable air mass: an air mass wherein a perturbation (wave) increases in magnitude over time. A parcel of air displaced upward in an unstable airmass will continue to rise until it reaches equilibrium. Regions where, if moisture is sufficient, convection can develop if a mechanism (e.g., heating, frontal boundary) is present to initiate lift.

Upper level: The region of the atmosphere above 20 kft and below the tropopause (approx. 60-80 kft).

Upper-Level Jet or Jet Stream (sometimes referred to more generally as the storm track): A region of maximum wind speed, usually in the upper atmosphere that usually coincides with the main storm track in the mid-latitudes. This is the area that also typically corresponds to the greatest amount of mid-latitude synoptic-scale storm development.

Upper level low/trough/disturbance: an area of low pressure located at higher altitudes, e.g., at 700 mb / 10,000 feet MSL or 500 mb / 18,000 feet MSL.

UTC (or GMT, or Z) time: Greenwich Mean Time, universal time zone corresponding to the time at Greenwich, England. Pacific Standard Time (PST) = GMT – 8 hours; Pacific Daylight Time (PDT) = GMT – 7 hours.

Vector: Term used to represent wind velocity (speed + direction) at a given point.

Velocity: Describes speed of an object, often used in the description of wind intensities.

Vertical Wind Profiler: Ground-based system that measures wind velocity at various levels above the radar site.

Wave clouds: Clouds that form on the rising branches of mountain waves created within a stable airmass in strong flow downwind of mountains. On satellite imagery, they appear as spaced bands of clouds parallel to and downwind of the mountain barrier.