Santa Ana River Watershed Weather Modification Pilot Program
Frequently Asked Questions

Estimated Increases

1. Even if the amount to be produced were measurable, doesn't the Idaho study suggest that the amount of water produced of 1 percent is almost negligible?

    a. The studies that have been done from the Seeded & Natural Orographic Wintertime clouds: the Idaho Experiment (SNOWIE) campaign have been looking at individual storms during that season and not the entire season. While it is true that the SNOWIE cases were set up around normal seeding, they were not typical of actual wintertime seeding in the fact that they were only for a couple hours. They were also only seeded from aircraft, not a combination of aircraft and ground-based seeding. The reduction in seeding time was designed into the experiment so that there would be portions of the storm that the researchers could get information about the natural production of precipitation and then compare that with the changes that occurred after seeding began. Using target-control regression analysis, Idaho Power has concluded on average there is a greater than 10 percent increase in wintertime precipitation over the same target area.

2. Are the estimated increases calculated from assumptions of average rainfall over the target areas?

    a. No. The average rainfall is determined by averaging values at the available precipitation stations. The average projected rainfall was not based on the most recent five seasons. Instead, the study sought to ensure that the program would be cost effective even if there were dry years mixed in with average years. Therefore, five noncontinuous seasons from the past 10 historic years were evaluated. These five selected seasons were selected to represent a modified average that would more accurately represent the benefits of seeding during naturally occurring "dry," "normal" and "wetter" years.

3. Will increasing snowpack in the upper headwaters benefit the water supply downstream of the Santa Ana River?

    a. Yes. Increases in precipitation in the Santa Ana River Watershed yield a roughly 1.15 multiplicative factor on stream flow. For example, a 10 percent increase in precipitation will yield a 15 percent increase in streamflow. Water ways are generally more efficient when more runoff is present, as a smaller percentage of the augmented runoff is lost to soil absorption. Thus, a positive impact down the entire stream/canal network in the Santa Ana Watershed can be predicted.

4. How much increase in precipitation would be expected in densely populated valleys where seasonal rainfall is lower?

    a. The expected increase in populated areas is projected to be dramatically lower, as they are not a primary target for any of the generators. The largest increases would be for areas downwind from the AHOGS in the SW area.

5. Would targeting the SW area increase precipitation in the low-lying area further inland beyond the Santa Ana Mountains?

a. Cloud-seeding to enhance rainfall in the SW target area will have an impact in the more inland areas to the east of the target area. Though we were initially concerned about this “down wind” affect, it became immediately apparent that several SAWPA members have a vested interest in water that falls in this area. Careful examination has occurred to determine when the downwind affects may produce flooding conditions in these areas, and when they would prove beneficial to the watershed.

6. Estimated Precipitation and Streamflow increases in each Target Area for Ground Seeding

a.

Target Area	Seasonal Precip. Increase (inches)	Percent Increase	Avg. Natural Streamflow (AF)	Streamflow Increase (AF)	Percent Increase
NW	0.41	3.5%	25,000	2,043	8.2%
NE	0.49	4.1%	65,000	4,330	6.7%
SW	0.59	3.7%	5,000	447	9.0%
SE	0.49	4.5%	10,000	1,373	13.7%
	TOTAL w/ Ground Only		**105,000**	**8,193**	**7.8%**

7. How many households would 8000 AF support a year?

    a. 16,000 households (based on 0.5 AF per year per household).

Cloud Seeding Events

8. Atmospheric Rivers bring significant amounts of annual precipitation to the area. Would Cloud Seeding be applicable to these events?

    a. Large precipitation events associated with Atmospheric River Events, are generally self-sufficient and large rainfall producers. These hyper productive storms are generally not seeded since they are assumed to be naturally efficient in producing precipitation. When the projected increases from a Weather Modification program were calculated, estimated increases were only applied to storms we deemed seedable. Storms of this nature were not generally considered seedable, meaning no increase for these storms was calculated.

9. What is the temperate range of the water in the clouds that super cooled liquid water can be used for cloud seeding?

    a. The primary target for super cooled liquid water is between -5 and -15 degrees Celsius.

10. Does Cloud Seeding/Ground Seeding require a specific storm to be effective?

    a. There are storm environments that will be targeted to be effective. Wintertime (November-April) will be the main time frame for the ground seeding to be actively targeting storms. Using the technology that's being implemented here, focuses on wintertime storms. Looking at temperatures at different levels within the cloud deck and at forecasted precipitation amounts to consider suitability. Wind directions and speeds, as well as several other meteorological attributes, determine whether a storm would be a good candidate for seeding.

Economic Feasibility

11. Can the quantity of gallons of water to be received for the watershed really be worth the investment in such a program?

    a. Yes. In the Feasibility Study, the consultant provided a benefit to cost analysis for ground-based seeding, which is the method that SAWPA plans to implement in the Pilot Program. In this

analysis, fixed and variable costs were included. The fixed costs represent all predictable expenses, including but not limited to equipment, personnel, travel, licensing and insurance. The variable costs are representative of the weather dependent materials, including ground-based generators (CNGs) burn time, and silver iodide flare consumption.

b. The ASCE 2016 "Guidelines for Cloud Seeding to Augment Precipitation (Chapter 6)" recommend a minimum benefit to cost ratio of 5:1 to justify economic feasibility. This accounts for the natural meteorological variability that will alter program success from year to year. An exclusively ground-based program, as described in this feasibility study, would exceed the ASCE's recommended 5:1 benefit cost ratio with an estimated 10:1 benefit to cost ratio.

c. SAWPA provided its consultant with several estimates for untreated and unpressurized import water resulting in an average calculated watershed wide value of $255 per acre-foot. This is a conservative estimate based on input from SAWPA and its member agencies.

12. Benefit to Cost Estimate for Ground Seeding

a.

Table 5-2

Ground only seeding program, seeding all four target areas.

	Rate	Frequency	
Annual Operations			
Set Up	$ 33,500	1	$ 33,500
Take Down	$ 24,000	1	$ 24,000
Reporting	$ 10,000	1	$ 10,000
Monthly Operations			
Fixed Services	$ 24,500	5	$ 122,500
Variable Items (timed expenses are billed on a per hour basis)			
Ground Flares	$ 110	60	$ 6,600
Generator Run Time	$ 19.50	600	$ 11,700
Flight Time	$ 375	N/A	-
Aerial Flares	$ 110	N/A	-
		TOTAL	**$ 208,300**
		COST PER ACRE-FOOT	**$ 25.42**
		Benefit to Cost	**10.03**

Results and Analysis

13. What scientific proof exists that shows a precipitation increase and not just a naturally formed larger storm?

a. Throughout the past 70 years, numerous evaluation methods have been considered and conducted in areas where operational cloud seeding is being performed. One such evaluation method is "Target vs. Control," which can be conducted over the course of numerous years or decades. This evaluation method involves the creation of a mathematical regression to identify and establish a relationship between the precipitation in a Target Area (TA) and nearby Control Sites (CS). A TA is the location where cloud seeding will occur, in contrast with CS, which are areas free of cloud seeding impacts.

b. After cloud seeding begins, the consultant collects precipitation data for the TA and the CS while monitoring for changes in the precipitation relationship between the two.

c. This evaluation identifies significant changes in precipitation in the TA in comparison to the CS. Because there is some natural variability in precipitation patterns and behavior, a single season's data is insufficient to draw meaningful conclusions. Longer periods – such as a decade

or more – of both seeded and non-seeded seasons can produce estimates with strong statistical significance and confidence. Consultants have performed this type of study for dozens of programs across the American Southwest, many of which have been in operation for well over 10 years, and some for nearly 70 years. Results for these studies have been favorable and significant.

d. Though consistently favorable, it is important to note that these massive data sets and long-term evaluations have provided evidence of strong geographical and environmental variables which affect the success of seeding programs and subsequently the evaluation of the results. Chief amongst these variables are moisture and temperature within storm systems. Programs on the California coastline, where lower-level moisture usually exists in substantial amounts, have consistently outperformed programs that are more inland and further from coastal storm patterns and oceanic moisture. For example, the average increase indications for Utah programs are around 5-8%, while some programs in Santa Barbara County have recorded average seasonal increase estimates of 15% or better.

e. To remove any probability of undue bias on the evaluations in these regions, an independent consultant will be hired for the pilot program to conduct additional evaluations of the seedings. Through additional studies, the independent consultants found results that supported the evaluations.

Safety

14. Is cloud seeding safe for humans and the environment?

    a. Yes. From 50 years of research, there have been no human and environmental effects caused by the cloud seeding agent, silver iodide. In fact, there is more exposure to silver from tooth fillings, and more exposure to Iodide from the salt in our food. The concentration of silver in rainwater or snow from a seeded cloud is on the order of 1000 times less than the EPA Standard.

15. Regarding safety, in general, is it safe for kids to enjoy catching snow flurries on their tongues?

    a. There is no harm to kids catching snowflakes made from this process on their tongues. The amount of ash from the silver iodide that serves as the nuclei of snowflakes isn't above the levels of dust and other particulates in the air. In fact, the snow generated from cloud seeding is perfectly safe to humans and the ecosystem.

16. What is the fate of the acetone in cloud seeding operations?

    a. When burned acetone breaks down immediately to water vapor and CO2. Aside from minutely (inconsequentially) contributing to CO2 emissions, there are no impacts from the burning of acetone.

17. What liabilities is SAWPA expecting to incur because of its cloud seeding program?

    a. The contractor generally assumes first liability in operating agreements, at least within the operator’s insurance thresholds. North American Weather Consultant (NAWC) as an example carries a $2 million general liability binder, and names its clients as additionally insured. Over the course of NAWC’s 70 years of operation there have been no large insurance claims, ever filed.

b. The weather modification operator should operate within pre-determined suspension criteria. Operating within these criteria should protect all parties from possible public complaint or litigation.

c. Weather modification has well defined limits. Unfortunately, weather modification can only marginally increase the performance of precipitation (generally in the 3-10 percent range).

d. The contractor should maintain all equipment and vegetation around the equipment. Our equipment is designed to prevent sparks and embers from reaching the ground, and as an extra precaution NAWC employees perform weed abatement near operational equipment as needed.

18. Is SAWPA willing to list additional water agencies besides SAWPA and its member agencies as additional insured to protect against these liabilities?
    a. This would likely fall on the contractor's responsibility. Though no contractor can reasonably name all water agencies within the area of a program it would be perfectly reasonable to request that the operator name the water agencies who have operator's equipment located on lands owned by the water agency.

19. Is SAWPA willing to defend and indemnify water agencies who help operate equipment against any claims that might arise out of the cloud seeding program?

    a. SAWPA will ensure that an indemnity clause between the water agency and SAWPA or the water agency and the operator exist, indemnifying the water agency from injuries or damages that may result from the operation of the equipment. The only real risk to the water agency for having equipment on their land would be potential damage or injury resulting from the equipment.

Suspension Criteria

20. Has NAWC (or any other weather modification contractor) ever had any liability issues when it comes to seeding operations?

    a. To protect against claims that cloud seeding contributed to hazardous conditions caused by storms, it is mandatory that the cloud seeding program has established comprehensive suspension criteria. Such criteria would indicate when seeding should be terminated or not initiated during certain storm events. In addition, it is recommended that the selected cloud seeding contractor carry liability insurance with an important caveat: "Sponsors shall request weather modification service contractors to provide liability insurance against the effects of operations." (ASCE 2017, section 3.6.1) This special insurance is termed "consequential loss insurance" and is normally not part of ordinary liability insurance". Depending on how this insurance policy is written, it may pay for legal defense costs if a lawsuit is filed against SAWPA or the contractor charging that the cloud seeding contributed to damages caused during a seeded storm or storm sequence. It is also recommended that SAWPA require their selected contractor to name each of its agencies "additional insureds" to their "consequential loss" policy. Details on the previous history of liability and lawsuits in the United States regarding claimed damages from cloud seeding is provided in Section 3.4.1 of ASCE's publication entitled "Guidelines for Cloud Seeding to Augment Precipitation, Third Edition (ASCE 2016).

Cloud Seeding Methods: CNG and AHOGS

21. What are CNGs and AHOGS?

a. CNGs are Cloud Nuclei Generators which are ground seeding units for weather modification. AHOGS are Automated High Output Ground Seeding units. CNGs are manually operated and burn a solution of silver iodide and acetone, creating a continuous plume of seeding material that covers a broad area over mountainous terrain. AHOGS systems are remotely operated units, burning in-place flares that rapidly release a high concentration of silver iodide and are ideal for seeding convective bands with high concentrations of supercooled liquid water and strong vertical updrafts.

22. Is there any chance that the seeding methods could cause wildfires?

    a. The cloud seeding process uses “burn-in-place” flares, meaning the flare never leaves its point of origin. Any embers from the aerial flares will extinguish before they hit the ground because of the elevation. The CNG and AHOGS systems use specialized spark arrestors to catch embers and prevent them from hitting the ground around the installations. In addition, weed reduction is performed to prevent weeds from encroaching on the seeding stations. The AHOGS towers are also equipped with cameras that are used during the seeding process. These systems have been in use (with or without cameras) for almost 30 years without any issues in California.

23. Why are AHOGS used in Orange County versus the CNGs used elsewhere?

    a. AHOGS release a very high concentrated amount of silver iodide in a short period of time. These devices are used in coastal areas where liquid water concentrations are high and there is a lot of turbulence which quickly mix the silver iodide seeding material into the convection bands. These systems are more expensive than traditional ground generators and are therefore used sparingly where the benefit outweighs the added investment.

24. Can you please explain the benefits of placing generators on public land vs private land?

    a. There are a lot of benefits to using public land. The program is insulated from change as private land ownership can change, and landowners may lose the ability or willingness to operate seeding equipment. Often permits will be required when operating on public land, but these permits are generally inexpensive, and the Cloud Seeding Contractor should perform most of the labor involved with obtaining the permits (creating the image files and documentation). Stability is the biggest gain with operating off public land.

25. What is the noise level of the CNG (Cloud Nuclei Generators)?

    a. Essentially none. These are very quiet to operate. They burn like an emergency red flare or like at the level of a propane barbecue.

26. Are they isolated away from the public? Are they in areas near homes or open terrain?

    a. They are not necessarily isolated, but there are no health or safety concerns. Most programs across the Western United States have generators placed at private residences. For this program, the generator sites are being targeted at water agency property for long-term, stable placement.

27. How many hours of operation of the CNGs are needed per year?

    a. The CNGs are estimated to have a total run-time of around 600 hours, with total flare count around 60.

28. Can you please expand on the triggers to operate, the planning to staff and monitor the CNGs?

a. There will be extensive cooperation between the cloud seeding operators and the local agencies who house and operate the equipment. Individuals who operate the equipment, whether it be a member agency, or an employee of the contractor, are compensated for the time to keep that equipment operating throughout the winter season.

29. If a local water district agrees to house and operate one or two of these units is there an opportunity to be reimbursed for staff time to operate?

    a. Yes, there would be.

30. Can the CNGs be outfitted to operate through SCADA controls which would minimize the staff time to travel and operate when triggered?

    a. Yes, it could be. The AHOGS seeding units planned for the coastal areas are operated remotely. For the CNGs, it could be set up and there would be a cost to implement such a SCADA system of remote operation which can be investigated by cloud seeding operators.

31. Total operating time per unit per year is about 20 hours per year?

    a. Yes, this assumes about 13 storms per average season. The seeding units will run about two hours per storm for the heaviest storms. There are some storms that are longer in duration, 12-24 hours but most storms are quick at about 1/2 to 3/4 of an hour, so 20 hours per season is the initial estimate.

32. Why are only ground-based systems being considered for the four-year pilot rather than both aerial seeding and ground-based seeding?

    a. Ground only operations will already have a sizable impact on precipitation, at a significantly reduced cost and a higher benefit to cost.

    b. A simpler and more cost-effective seeding approach is recommended initially to develop momentum, support, and evaluations.

    c. There will be notable complexities with the operation of an aerial program and not all of the Target areas are optimal for aerial seeding. For the pilot, one seeding mode that can benefit all designated target areas is recommended.

33. Can you share technical details related to the operation of the AHOG equipment that may be operated by a water agency on their property?

    a. The AHOG equipment that would be placed on agency land consists of three aluminum masts. The first mast contains a small solar panel and a control system (enclosed in a weatherproof box). The second and third masts are called “flare trees”. These masts house burn-in-place flares (think of a warning flare used by emergency responders). Though there may be competitors' designs, the AHOG equipment has spark arrestors that encase the flares to prevent embers and sparks from reaching the ground. Sometimes cameras are installed to monitor the equipment. The equipment is operated remotely so there is a very limited need to access the equipment.

34. How long will SAWPA want access to the cloud seeding sites?

    a. The program is intended to operate for a 5–6-month period (during the winter). The site would only need to be accessed to refill the flares (2-5 times per season), and possibly for occasional

maintenance or weed abatement (generally not more than 3 times per season including set-up and take down).

b. SAWPA would require the future contractor to decommission and store the equipment off-site during the summer months, so as not to unnecessarily burden the supporting agency during non-operational periods of the year.

Stormwater Quality and Flood Protection

35. How are operations handled in areas where recent wildfires risk abnormally high debris flows?

    a. When large fires occur, an experienced weather modification contractor will work closely with flood districts to determine the best approach for the season or seasons following the fire. Fires can result in some adjustments to suspension criteria in affected areas of the program. The Santa Ana River Watershed's four target areas are well-isolated from each other and are all targeted during different wind regimes.

36. Will suspension criteria impact the effectiveness of the seeding program?

    a. No. In determining when to recommend suspending operations we addressed each of the four target areas differently, based on their locations, proximity to populations, infrastructure, propensity of flooding and probable down-wind affects. It was determined that the Southwest target area required special consideration, after carefully discussing the down-wind areas with the Riverside County Flood Control and Water Conservation District. In the end, elevated suspension criteria were recommended for this location. These criteria, however, target the most severe of storm events, those most likely to overwhelm infrastructure and result in localized flooding or flash flooding. They are based on precipitation levels that typically only occur once every 2-3 years (a once in 2-year event). Probability would indicate that the cloud seeding program would only miss 1 event every two years due to program design to avoid flooding concerns in the downwind area of Riverside County (SW target area), which would have only a marginal impact on the overall program effectiveness. In addition, the other three target areas would likely be seeded during these storm events.

Supplemental Questions

37. Has the Department of Water Resources (DWR) been involved, asked questions, or provided guidance?

    a. SAWPA has informed DWR through the cloud seeding liaison staff that a pilot program is being considered for winter of FY 22-23. The State of CA doesn't issue permits for these programs, but the program will need to comply with CEQA. We're going to be reaching out to the Army Corps of Engineers, Regional Water Quality Control Board, US Forest Service, Flood Control Districts, Native American Tribes, and many other entities, so they're aware of the program and to ensure all questions are answered. Also, DWR has listed precipitation enhancement (cloud seeding) as one of many water resource strategies available under their California Water Plan. Based on feedback from the North American Weather Consultants, the amount of outreach that SAWPA is conducting and continues to conduct for their pilot program is unparalleled compared to other programs across the State.

38. Are there any downrange water rights that locations might assert, from as close as Landers or as distant as Phoenix or Las Vegas?

a. Referring to possible negative side effects of cloud seeding, storm decks that come over off the coast typically drop about 10 percent of their available moisture, cloud seeding increases the productivity of that storm by roughly 5 to 15 percent. So, in essence, a storm will drop 11 percent of its total moisture, as opposed to 10 percent of its total moisture, so most of the moisture is still staying up in the air. In addition, cloud seeding has been shown or demonstrated to have positive downwind effects as far out as 300 miles from the area that's primarily targeted. So, as you look at the desert east of the SAWPA watershed, if anything, there would be positive impacts for up to 300 miles, as well as south of watershed. Essentially, there are no negative impacts long term or far downwind from cloud seeding in each area.

39. What is the purpose of the outreach?

a. To raise awareness in the watershed, including to prepare water agencies/departments and their directors if they get questions from the public on the pilot program.