Weather Modification Cloud Seeding Evaluation for The San Juan Mountain's Program 2021-2022 WINTER SEASON

<u>Sponsoring Organizations:</u>

West Dolores Telluride Program (WDT):
- Telluride Ski & Golf Company
- Dolores Water Conservancy District
- Montezuma Valley Irrigation Company

Western San Juan Program (WSJ):
- Purgatory Ski Resort
- Dolores Water Conservancy District
- Animas La Plata Water Conservancy District
- New Mexico Interstate Stream Commission

Eastern San Juan Program (ESJ):
- Pine River Irrigation District
- Florida Water Conservancy District
- Florida Consolidated Ditch Company
- San Juan Water Conservancy District
- New Mexico Interstate Stream Commission

All San Juan Mountain Programs:
- Southwestern Water Conservation District
- Colorado Water Conservation Board
- California Six Agency Committee
- Central Arizona Water Conservation District
- Southern Nevada Water Authority
- Metropolitan Water District of Southern California

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Operational Start and Finish Dates, State Permitted (Nov 1 thru April 15)

- WDT - November 8, 2020 – March 13, 2021
- WSJ - November 8, 2020 – February 14, 2021
- ESJ - December 10, 2020- March 14, 2021

Permit Number:
- San Juan Mountains Program (SJM Program) 2020-04

July 2022

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Executive Summary

Western Weather Consultants would like to thank all the program sponsors for their continued participation and commitment to wintertime cloud seeding.

This report summarizes cloud seeding activities undertaken by Western Weather Consultants (WWC) in Water Year 2022. In all, WWC seeded a total of 14 storms covering 27 days and totaling 2,546.99 hours across the San Juan Mountains this past winter. Of the 2,546.99 hours, 774.99 of the hours were used in the WDT area, 1,102.99 hours in the WSJ area and 669.00 were used in the ESJ area. Including the 14 storms and an additional 4 storms that were seeded from the middle of March through April 1 a total of 396.58 hours were seeded using remote operations supplemented with State and Lower Basin funding. All proposed seeding hours were used in all seeding areas this season.

Prior to start the season, the mountains within the SJM Program Target Area were blanketed with snow from a productive late October storm. Unfortunately, as published by NOAA's National Centers for Environmental Information website, November proved to be much above average in temperatures and much below normal for precipitation. This led to a slow start to the cloud seeding season and a quick decrease in the mountain snowpack. November only had a few precipitation events of which none were within the temperature ranges needed for good seeding opportunities. Across the San Juan's there were no seeding events during the month. There was significantly more activity in December as eight weather systems were seeded covering seventeen calendar days and 1,441 hours. NOAA described December as above average to much above average in temperature and above average too much above average in precipitation. The remote generators ran for a total of 234.25 hours in December. NOAA had January above average temperatures and was below too much below average in precipitation. There were no weather systems with seeding opportunities in January. February had three weather systems with seeding opportunities covering six calendar days and 732 hours. Remote operations totaled 81.08 hours in February. The weather pattern for February tended to be near average in temperatures and near too above average in precipitation across the San Juan's. Near to above average temperatures and near average precipitation was observed across the target areas in March. The month of March had three seeding opportunities covering five calendar days and used 374 hours. The remotes were able to seed for a total of 79.25 hours in March. All the contracted seeding hours had been used by the middle of March, but some remote operations did continue through the month and ended with the last seeding operation an April 1st with a short 2-hour run.

All three programs combined produced and estimated 82,469 to 98,400 AF of water with our calculated best estimate of 93,715 AF of water in the snowpack and an additional 5 to 19 inches of snowfall for the surrounding areas and ski resorts. With $287,435 of funding used this year including any of the previous seasons carry forward funds, if any, and remote generator funding the cost per AF of water increased was funded at an approximate cost of $2.92 to $3.49 per AF and $3.07 per AF using our calculated best estimated increase of 93,715 AF for the entire SJM Program.

The seeding completed across the San Juans was calculated to produce an estimated additional 82,469 to 98,400 AF of water with our calculated best estimate of 93,715 AF of water in the snowpack and an additional 5 to 19 inches of snowfall over Telluride and Purgatory Ski Resorts and the surrounding region. With $287,435.00 of combined funding used this year the cost per AF of water increased was funded at an approximate economical cost of $2.92 to $3.49 per AF and $3.07 per AF using our calculated best estimated increase of 93,715 AF. Individually, the WDT Program had an estimated increase of 14,760 AF, the WSJ Program had 45,062 AF of increase and the ESJ had an increase of 33,893 AF.

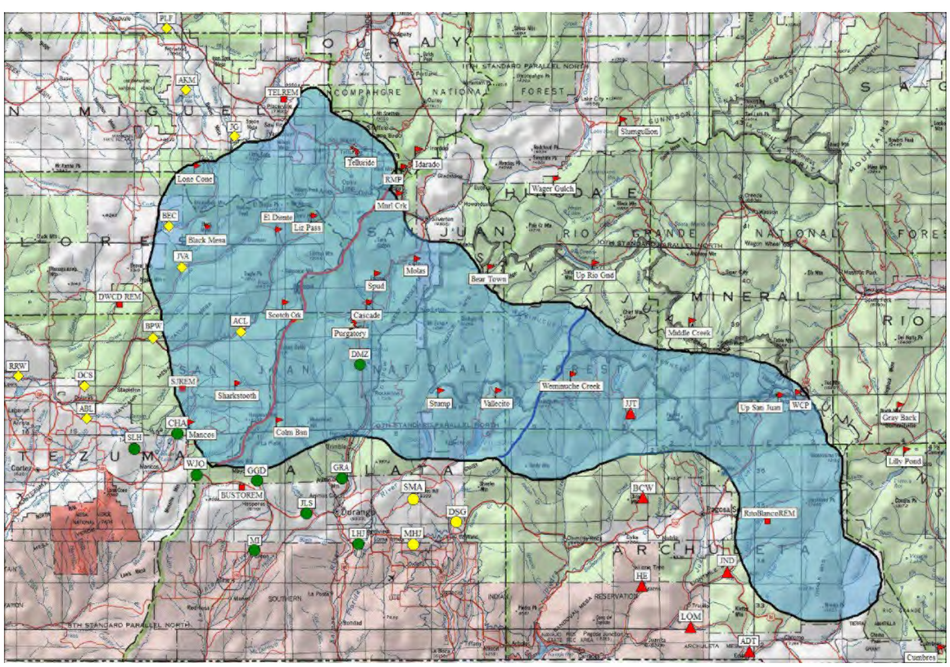
WWC would like all program sponsors to please review the recommendations listed on page 48 and provide comments, suggestions, or any concerns. Again, thank you for your participation in the cloud seeding efforts across the San Juan Mountains.

Please send all questions, suggestions, or comments to: westernweather.eric@gmail.com

INTRODUCTION

Western Weather Consultants, LLC (WWC) is pleased to present to you an evaluation of the 2021-2022 winter cloud seeding operations for the San Juan Mountains Program (SJM Program). Operational seeding events started December 6, 2021, and ended March 10, 2022, with more remotely operated events ending on April 1, 2022, for the SJM program. Within this timeframe, there were 14 cloud seeding events which covered 27 days and utilized 2,546.99 hours. In addition to the contracted hours, there were 396.58 seeding hours provided to the SJM Program using two leased and two purchased DRI remote generators and one Idaho Power generator funded by the State and Lower Basin. The SMJ Program uses 27 manually operated cloud nucleating generators and 5 remotely operated generators

The objective of this program is to increase precipitation through the augmentation of natural precipitation within the project Target Area, to improve early season snowpack for ski resort activities and to increase the high elevation snowpack that replenishes the water supply by improving the potential runoff for water entities. The operational technology and procedure used in this program are derived from other permitted snowpack augmentation programs operated in Colorado. Specifically, the Climax and Wolf Creek research programs, the Colorado River Basin Pilot Project (CRBPP), and the last 46 seasons of winter programs operated by WWC in the Central Colorado and San Juan Mountains.

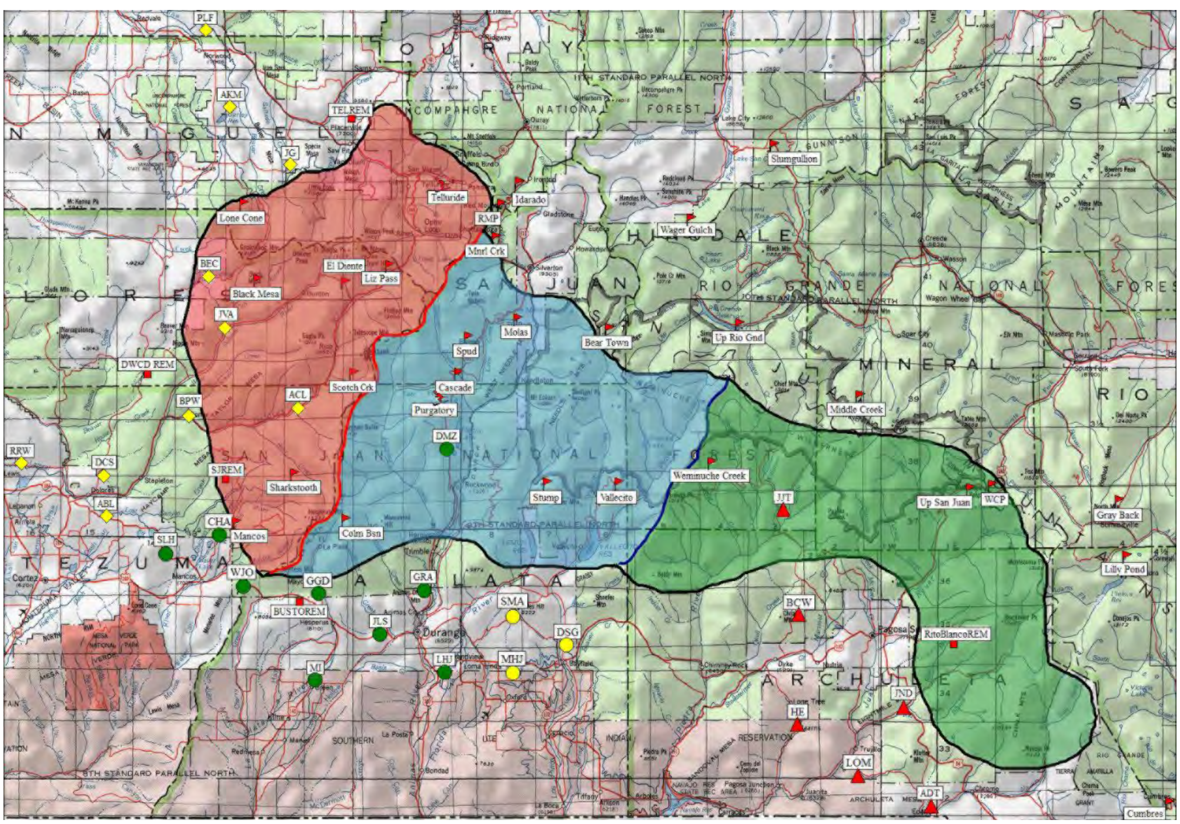


Map of the San Juan Mountains Program

The SJM Program has three separately contracted areas, as shown on Map 1: The West Dolores and Telluride (WDT) “Target Area”, includes river basin drainages in the Upper West Dolores River, Upper San Miguel River, and the Telluride Ski Resort. The Western San Juan (WSJ) Program “Target Area”, includes all river basin drainages from the mainstem of the Dolores River (excluding the west fork of the Dolores River) through the Animas River, and Purgatory Resort. The Eastern San Juan (ESJ) Program “Target Area”, includes the Pine, Florida, Four-Mile Creek, Navajo, Little Navajo, East Fork, and Rio Blanco River drainage basins. These areas are in the San Juan Mountains of Southwest Colorado in all or portions of San Miguel, Dolores, La Plata, Montezuma, San Juan, Archuleta, and Conejos counties within the state of Colorado and are generally above 9,000 ft. MSL. These programs are designed and carefully operated and intended to only impact the defined and permitted Target Areas. The following map shows the intended Target Area along with generator locations (Yellow Diamonds, Green and yellow Circles, Red Triangles and Red Squares) and SNOTEL sites (Red Flags).

Map 1

WDT (Red Shaded Area) WSJ (Blue Shaded Area) ESJ (Green Shaded Area)



Project Information

Data Services

WWC routinely monitors the weather conditions throughout the contracted operating period for time periods of positive cloud seeding potential. Most of the data used comes from the National Weather Service (NWS) websites, University of Wyoming, Pennsylvania and Texas A&M Weather websites, National Center for Atmospheric Research (NCAR) website, and National Oceanic and Atmospheric Administration (NOAA), Pivotalweather.com and Weatherbell.com are used for short and long range model forecasts. Other available resources are the Colorado Department of Transportation (CDOT) website to monitor road conditions and concerns, Colorado Avalanche Information Center (CAIC) for Weather Research Forecasting (WRF) point forecasts, as well as, avalanche and potential avalanche conditions in and around the Target Areas including the Natural Resources Conservation Service (NRCS) website to monitor snowpack in the Target Area as recorded by the network of SNOTELs in Colorado.

From the above listed websites, WWC reviews, and at times, archives weather data such as: surface and upper air data, synoptic surface maps, significant level maps, model forecast data, rawinsonde data, satellite and radar data, surface observations, web cam images, and other forecast aids. This data assists in selecting favorable storms for modification and monitoring suspension criteria.

Snowpack accumulation is monitored from SNOTEL stations within the Target Area and the primary detailed analysis of snow accumulation is completed using these measurements.

Snowpack Suspension Criteria

Evaluations of snowpack water content have indicated that minor flooding and stream flow problems could exist when late winter snowpack Snow Water Equivalent (SWE) reaches 155 percent of normal. More substantial flooding problems can be anticipated when late winter snowpack is more than 175 percent of normal. Since the SJM Program is designed for reasonable levels of snowpack enhancement, seeding operations are suspended in any major portion of a seeding area when one or more of the following occur: 175% of average on

December 1st, 175% of average on January 1st, 165% of average on February 1st, 155% of average on March 1st and 145% of average on April 1st.

Seeding operations may continue in the remaining mountain regions under normal operative procedures. The comparative normal for these snow observation sites is the last 15-year average as published by the NRCS. Seeding operations may be suspended due to high avalanche hazard levels and must be suspended due to extreme avalanche hazard levels for highway corridors, as determined by the CAIC and the NWS Hazardous Weather Statements. The permit holder must suspend all weather modification operations whenever one of the following is issued that impacts any part of the Target Area:

a. An urban or small stream flood advisory.
b. A blizzard warning.
c. A flash flood warning; or
d. A severe thunderstorm warning.

Operations may resume after these statements expire.

WWC corresponds with the County Emergency Managers in the Target Area counties and adjacent counties prior to the first seeding operation of the seeding season. If the Emergency Managers deem additional snowpack would hinder any emergency operations, we would suspend operations as needed in areas as to not impair emergency operations. On October 31st, 2021, Emergency Managers were informed via e-mail to the start date of the 2021-2022 seeding season in Southwest Colorado. This correspondence letter can be viewed in the Emergency Management Coordination section of the report Appendix B.

Equipment and Seeding Criteria

WWC utilizes both manually and remotely operated ground-based cloud nuclei generators. This includes a new “Rocky Mountain” remotely operated generator placed west of Squaretop Mountain East of Pagosa last fall. The manually operated generators use a 4% silver iodide 1.25% sodium iodide solution in acetone. The Remotely operated generators use a similar solution mix produced by DRI. This solution is vaporized in a propane flame at a rate of 5 to 25 grams per hour when weather systems with cloud base temperatures ranging from -5C to -16C, and cloud bases are at least 500 feet lower than the mean mountain crest height come into the target area.

The enhanced snowpack in the Target Area is achieved by producing silver iodide crystals (artificial ice nuclei) from a series of ground-based generators. Table A lists all the generator sites within the San Juan Cloud seeding region.

Table A
Generator Sites

Site	Site Name	Program	Elevation
AKM	Gurley	WDT	7761
JG	Specie Mesa	WDT	8976
PLF	Norwood	WDT	7057
TEL-REM	Hastings Mesa (DRI Remote)	WDT	8825
BEC	Groundhog	WDT-WSJ	8928
DOL-REM	Kinder	WDT	8080
JVA	Dunton	WDT-WSJ	8045
BPW	Stoner	WDT-WSJ	7541
ACL	Dolores River	WDT-WSJ	8227
RRW	Lewis	WDT-WSJ	6950
DCS	Dolores	WDT-WSJ	7577
ABL	Lost Canyon	WDT-WSJ	7181
SLH	Mancos	WSJ-WDT	7123
SJ-REM	Spring Creek (DRI Remote)	WDT-WSJ	8915
CHA	Jackson Lake	WSJ-WDT	8065
WJO	Mancos Hill	WSJ-WDT	8017
GGD	Mayday	WSJ-WDT	8599
BUSTO-REM	Montoya Peak	WSJ-WDT-ESJ	8560
MI	Breen	WSJ-ESJ	7393
GRA	Animas Mountain	WSJ-ESJ	7073
JLS	Wild Cat	WSJ-ESJ	7580
DMZ	Haviland Lake	WSJ-ESJ	8250
LHJ	Grandview	WSJ-ESJ	6905
MHJ	Salt Creek	ESJ-WSJ	6928
SMA	Dry Creek	ESJ-WSJ	7633
DSG	Bayfield	ESJ	7106
HE	Lonetree	ESJ	6928
JJT	Oakbrush Ridge	ESJ	7926
BCW	Chris Mountain	ESJ	8064
PAG-REM	Rito Blanco	ESJ	8554
JND	Turkey Mountain	ESJ	7000
ADT	Coyote Creek	ESJ	7247
LOM	Montezuma Creek	ESJ	6958

Silver iodide crystals are distributed over the Target Area by favorable wind flows during selected storms and cloud systems that are expected to produce increased precipitation over the Target Area. An analysis of low-level wind fields, cloud characteristics, stability parameters, terrain features, and synoptic meteorological features determines which generators will best seed the cloud system over the project area for each seeding opportunity. This analysis also provides a method for adjusting the operation as new weather information becomes available. After selecting which generators will seed a storm, the generator operators are contacted and instructed to turn on their generator at a specific time, operate it at a specific burn rate, and turn it off at a specific time. These instructions are subject to change. Incoming weather data into the office of the weather forecaster allows for continuous monitoring of any changes in conditions and any adjustments or termination of the seeding operation. Table B presents the "Seeding Criteria" used by WWC.

Table B

Western Weather Consultants Seeding Criteria for Winter Cloud Systems

- Cloud bases are at least 500 feet below the mean mountain barrier crest of the Target Area and are forecast to move lower into the beginning and throughout the seeding period. The weather system has clouds that are forecast to have vertical heights and moisture content capable of producing natural precipitation.
- Temperatures at the height of 500 feet below the mean mountain crest within the Target Area are -5 degrees C. (23 degrees F.) or colder and are forecast to become colder if at -5 degrees C.
- Wind directions and speeds from the surface to cloud-base are observed and forecast to favor the movement into the intended Target Area of the silver iodide nuclei being released from the ground-based generator sites.
- There are no stable regions or atmospheric inversions between the surface and cloud-base that would prevent the vertical dispersion of the silver iodide particles from the surface to at least the -5 degrees C. (23 degrees F.) level or colder within the cloud system.
- The temperature at approximately 10,000 feet (700 MB level) is warmer than -16 degrees C. (3 degrees F.)

Seeding Potential and Evaluation

In addition to the specific meteorological criteria utilized to identify a potentially suitable weather event for seeding over the Target Area, we also evaluate the augmentation potential for each weather event selected for seeding. The three equally weighted prime factors in evaluating the augmentation potential of a weather event are the average 24-hour wind direction from the weather event that is moving into the Target Area in the Colorado Mountains, the potential total amount of expected precipitation or precipitable water forecast for a specific weather event and the duration of that weather event.

The first augmentation potential factor for a specific weather event over the Colorado Mountain Ranges is based on the average 24-hour wind direction during the planned seeded portion of the storm system that is moving into the Colorado Mountain's Target Area. The 24-hour average storm wind direction is correlated with the 24-hour seeded precipitation amount that is reported at an observation site in the Target Area. These augmentation potentials are based upon research that WWC completed in 1976 on data from the Colorado River Basin Pilot Project (CRBPP) in 1976 and later in a separate study of the Vail Seeding Program in 2001. On average, these studies indicated that average wind directions during 24-hour seeded portions of weather systems moving into the Colorado Target Region from the indicated directions below had increases in precipitation as indicated below:

North-Northwest	- precipitation increases of 33%
Northwest	- precipitation increases of 25%
West	- precipitation increases of 12%
Southwest	- precipitation increases of 8%
South	- precipitation increases of 5%

The second augmentation potential factor is the precipitable water forecast for a weather event. Southerly weather events usually have warmer cloud base temperatures and can hold greater amounts of precipitable water in the cloud system. These Southerly storm systems can regularly produce two to three inches of equivalent water in the snowfall from this type of system over one to two days. A 5% increase in augmented precipitation will add 0.10 to 0.15 inches of additional water in the snowpack. The climatology of Colorado's winter storms indicated that the mountain regions normally receive about 7 to 8 of these storm types over the winter which produces about 70% of the total water in a winter's snowpack that is available for the spring runoff.

A Northwesterly weather system, on the other hand, may only have around a half inch of precipitable water it produces over a day's duration, and, with a 25% augmentation factor, this system will add an additional 0.13 inches of water in the snow total that it produces. The climatology of Colorado's winter storms also indicated that the mountain regions normally receive about 20 of these storm types over the winter which produces about 30% of the total water in a winter's snowpack that is available for the spring runoff.

The third augmentation potential factor for a specific weather event over the Colorado Mountain Ranges is based on the time duration that the storm system will produce precipitation over the Colorado Mountain's Target Area. A weather system that would produce additional precipitation amounts like the above values for Southerly through Northwesterly storm systems would be given the highest augmentation potential rating of five (5) for seeding operations if all other criteria factors are favorable. A weather system that has the potential to produce about half of the desired increase in a shorter duration of less than a days' time or the full expected additional amount in about a day and a half's time would be rated a three (3). A rating of four (4) would have some or all the three factors between the (3) and (5) ratings. We prefer to seed weather systems that have a rating for seeding potential of (3) or greater for each of the selected seeding operations.

Evaluation of this project and the operational features of all the San Juan Cloud Seeding Program are based upon the findings and experience learned through operating the U.S. Bureau of Reclamation's Colorado River Basin Pilot Project (CRBPP) in the upper San Juan River Basin. The placement of ground-based generators, identification of storm systems with favorable modification potential and concern for public safety and awareness through reasonable operations are some of the refinements incorporated into this wintertime weather modification program. The evaluation of this program has been consistent with research findings from the San Juan CRBPP Program and the Vail Operational Evaluation. Both evaluation studies were completed by WWC.

Based upon the findings of the San Juan CRBPP Program and the Vail Operational Evaluation, precipitation increases ranged from approximately 10 to 20 percent of the total wintertime precipitation were observed. The additional snowpack and water supply have multiple recreational, agricultural, and industrial uses throughout the year for the residence of the project area and downstream water users.

Operational Procedures

Once an approaching storm system has been identified, initiation of the operational procedure occurs in the following order. First, forecasts are compared that are provided by both the North American Mesoscale Forecast System (NAM) model forecast and WRF model forecast for similarities. We look at the Global Forecast Systems (GFS) model forecast for viewing weather events more than 84 hours in the future. Next, we make sure there are no suspension criteria restrictions that would affect the chance for any seeding operations. If there are no restrictions that would suspend an operation, we will then closely follow the storm as it approaches the Target Area, monitoring the storm's characteristics and seeding potential to ensure it will meet the seeding criteria for the initiation of seeding. Once it is determined that a storm can be seeded, we will once again check the CAIC website to ensure no restrictions have been issued, then commence with seeding.

Figure 1

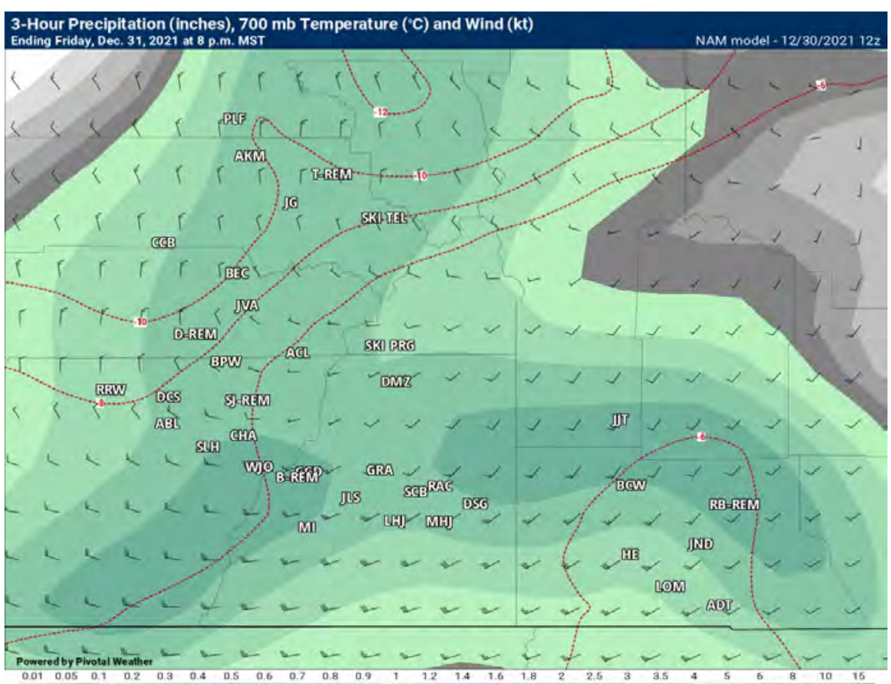


Figure 1. An example of a three-hour forecast chart from Pivotalweather.com showing around two tenths of an inch of precipitation or more forecast to fall in the San Juan Target Areas.

Figure 1 shows a North American Model (NAM) three hour forecast from pivotalweather.com. The Figure shows forecast surface precipitation in southwest Colorado in the San Juan Mountain Target Areas. The colored precipitation legend indicates precipitation amounts and in the San Juan Mountain Target Areas. Precipitation is predicted to be around 0.2 inch for a three-hour period between 5:00 PM and 8:00 PM. 700 MB wind direction and speed as well as temperature increments of two degree are available to aide in seeding decision making. Pivotalweather.com also provides HRRR, GFS, and other model analysis as well as Skew-T and Upper Air plot data.

Figure 2

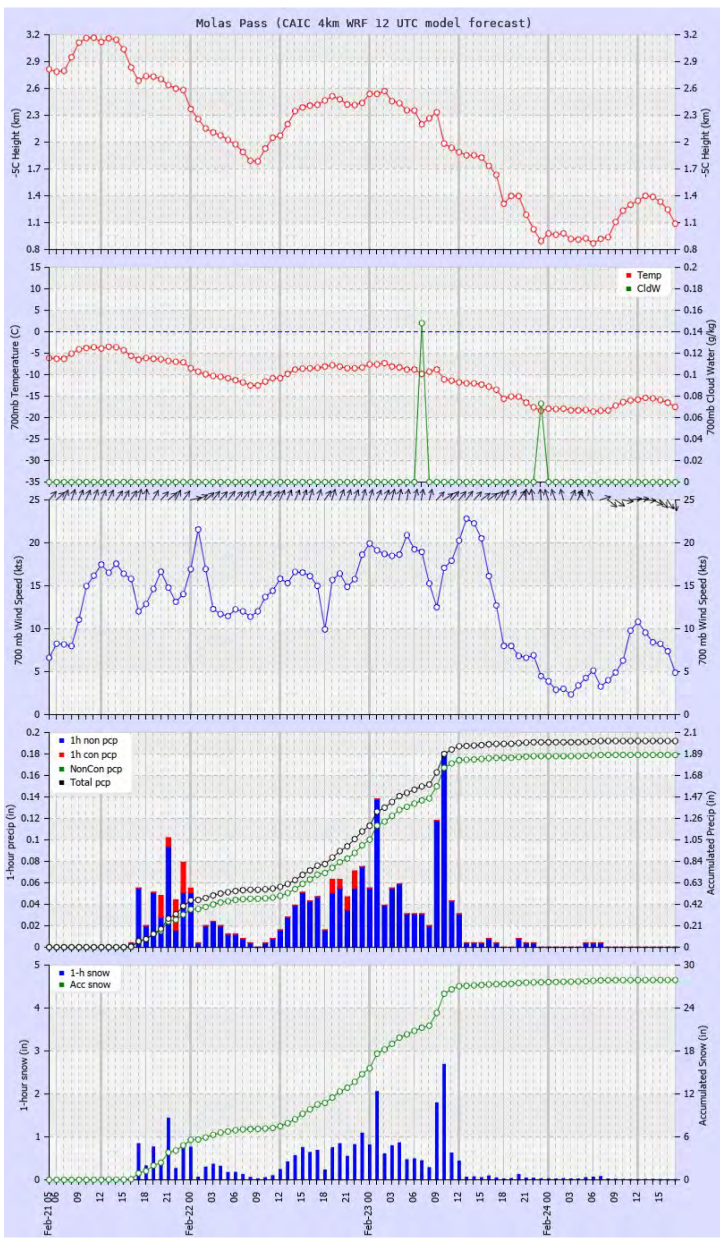


Figure 2. An example of a point forecast based on the WRF model from the CAIC website for Molas Pass.

Timeline charts, like the one from the CAIC website Figure 2, are helpful in providing a quick look at conditions over a specific point. Figure 2 represents conditions at Molas Pass. It shows forecast precipitation, 700 MB temperature, -5 degrees C height, and 700 MB wind speed and direction.

The CAIC has been helpful in working with the cloud seeding industry by providing specific data tailored to the needs of cloud seeding on their website. They provide hourly forecast data based on the WRF model pinpointed to the individual Target Areas. NAM and GFS forecast data are also available as a point forecast for the individual Target Areas. The CAIC also has a Forecast Sounding tool providing a Skew-T diagram for each of the point forecast locations. The point forecast data provided by the CAIC is also available in a text format. Other information found on the CAIC website is the surface weather data that can be used in verifying temperatures, relative humidity values and precipitation in the Target Areas.

The CAIC also provides avalanche suspension information. WWC will suspend seeding operations when data available from the CAIC, in conjunction with CDOT, determines that the highway transportation system is in danger of an avalanche that would be hazardous to the public. Figure 3 is an example of suspension data provided by the CAIC. The website provides a categorical hazard rating, None/ Notice (green), Caution (yellow) and Warning (red), for mountain passes within the San Juan Mountain Target Areas. Each mountain pass includes the date issued and a color-coded rating. In cases where two hazard ratings are listed the CAIC is indicating they are expecting the hazard to advance to the next level of hazard in the next 12 to 24 hours. In the example below the, CAIC has placed the hazard warning for Red Mountain and Cole Bank/Molas Pass to the Warning hazard rating (red) (issued 2-23-2022 2:21 PM). and in the next 12 to 24 hours from the time the hazard rating was issued it expects Wolf Creek Pass to go from Notice to Caution hazard rating (issued 2-21-2022 6:50 AM).

Figure 3

Highway Summary

Printer Friendly

Area	Highway	Hazard	Issued
Cameron Pass	CO 14 - Cameron Pass	Notice	02/22/2022 6:56 PM
Berthoud Pass	US 40 - Berthoud Pass - East	Notice	02/22/2022 7:38 AM
	US 40 - Berthoud Pass - West	Notice	
Loveland Pass	US 6 - Loveland Pass - East	Notice -> Caution	02/22/2022 7:43 AM
	US 6 - Loveland Pass - West	Notice	
Eisenhower Tunnel	I-70 - Eisenhower Tunnel - East	Notice	02/22/2022 7:44 AM
	I-70 - Eisenhower Tunnel - West	Notice	
Vail Pass	I-70 - 10 Mile Canyon	Notice	02/22/2022 7:46 AM
	I-70 - Vail Pass	Notice	
Fremont Pass	CO 91 - Fremont Pass	Notice	02/20/2022 4:33 PM
Battle Mountain	US 24 - Battle Mountain	Notice	02/20/2022 4:33 PM
Independence Pass	CO 82 - Independence Pass - East	Notice	02/14/2022 5:32 AM
	CO 82 - Independence Pass - West	Notice	
Twin Lakes	CO 82 - Twin Lakes	Notice	02/20/2022 4:34 PM
McClure Pass	CO 133 - McClure Pass	Notice -> Caution	02/21/2022 5:25 AM
Glenwood Canyon	I-70 - Glenwood Canyon	None	02/21/2022 5:34 AM
Grand Mesa	CO 65 - Grand Mesa	Notice -> Caution	02/21/2022 5:48 AM
Douglas Pass	CO 139 - Douglas Pass	Notice	02/21/2022 5:38 AM
Slumgullion Pass & North Canyon	CO 149 - Slumgullion Pass & North Canyon	Notice	02/22/2022 7:35 PM
Monarch Pass	US 50 - Monarch Pass	Notice	02/20/2022 4:35 PM
Wolf Creek Pass	US 160 - Wolf Creek Pass - East	Notice -> Caution	02/21/2022 6:50 AM
	US 160 - Wolf Creek Pass - West	Notice -> Caution	
Cumbres & La Manga Passes	CO 17 - Cumbres/La Manga Pass	Notice -> Caution	02/21/2022 6:55 AM
US 550	US 550 - Red Mountain Pass - North	Warning	02/23/2022 2:21 PM
	US 550 - Red Mountain Pass - South	Warning	
	US 550 - Coal Bank/Molas Passes	Warning	
Lizard Head	CO 145 - Lizard Head Pass	Caution	02/22/2022 6:51 AM

Figure 3. An example of a Highway Summary from the CAIC website rating avalanche concerns in the mountain passes near the Target Areas.

In past years the NRCS had provided a website with a map indicating “seed/no seed” suspension data based on snowpack values listed by the SNOTEL network in Colorado. In the example provided in Figure 4 none of the SNOTEL indicators were showing up on the map. For the 2021-22 season we were not able to use this map, but still looked at the NRCS Basin reports to view any concerns for possible suspensions.

Figure 4

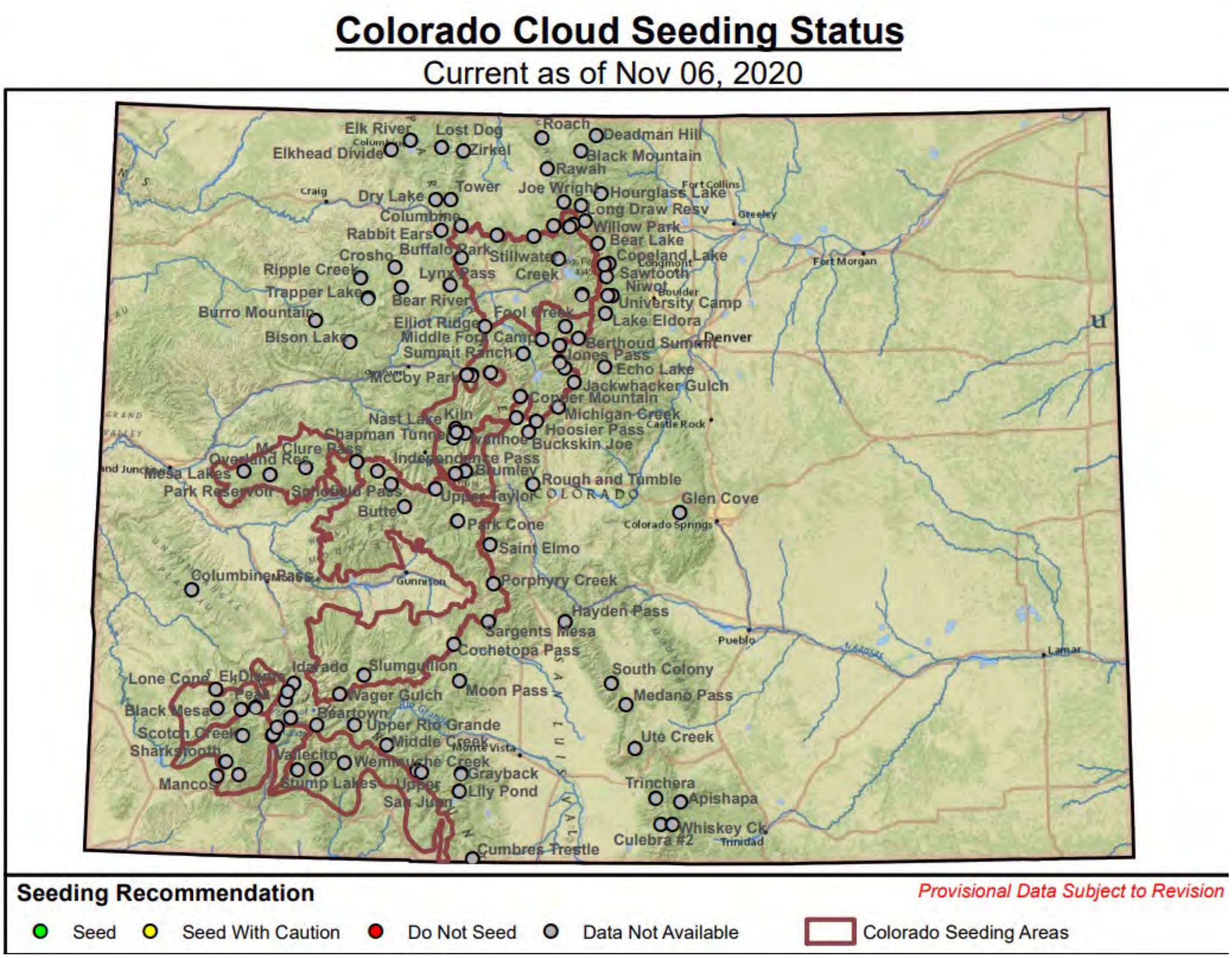


Figure 4. Map provided by the NRCS to WWC, as seed / no seed indicator for suspension criteria.

Figure 4 is an example of the map provided by the NRCS that WWC uses as seed/no seed indicator based upon our suspension criteria relative to the snowpack conditions throughout Colorado. In the example, the green icons indicate “Seed”, yellow icons indicate “Seed with Caution” and red icons indicate “Do Not Seed”. In this example Data was not available so instead WWC would use the daily basin wide reports available from the NRCS to determine if snowpack thresholds have been approached or exceeded. An example of a report from the NRCS shows the Dolores and San Miguel River Basins, San Juan River Headwaters and Animas River Basin.

Figure 5

DOLORES/SAN MIGUEL RIVER BASINS							
Black Mesa	11580	11.5	N/A	*	11.2	N/A	*
El Diente Peak	10000	9.3	9.2	101	9.7	13.3	73
Lizard Head Pass	10200	9.0	9.5	95	7.7	11.3	68
Lone Cone	9600	9.0	11.9	76	9.7	13.8	70
Mancos	10000	6.2	11.1C	56	6.4	12.7C	50
Mineral Creek	10040	9.7	9.8	99	7.2	12.2	59
Red Mountain Pass	11200	13.9	15.0	93	12.7	17.9	71
Scotch Creek	9100	6.6	8.1	81	8.2	12.2	67
Sharkstooth	10720	9.1	14.3R	64	9.9	N/A	*
Basin Index (%)				**82**			**66**
SAN JUAN RIVER HEADWATERS							
Beartown	11600	14.0	16.6	84	13.7	17.5	78
Chamita	8400	6.5	8.0	81	6.4	10.1	63
Lily Pond	11000	11.3	10.4	109	12.5	14.1	89
Middle Creek	11250	14.5	13.1	111	10.6	16.3	65
Stump Lakes	11200	11.1	12.8	87	7.9	14.1	56
Upper San Juan	10200	21.6	21.8	99	22.6	24.4	93
Vallecito	10880	11.3	11.6	97	9.7	13.2	73
Weminuche Creek	10740	13.6	N/A	*	16.5	N/A	*
Wolf Creek Summit	11000	24.5	22.4	109	22.7	22.9	99
Basin Index (%)				**98**			**80**
ANIMAS RIVER BASIN							
Beartown	11600	14.0	16.6	84	13.7	17.5	78
Cascade	8880	7.3	10.3	71	9.8	14.4	68
Cascade #2	8920	6.8	7.7	88	9.3	14.0	66
Columbus Basin	10785	10.7	16.4C	65	10.3	20.1C	51
Mineral Creek	10040	9.7	9.8	99	7.2	12.2	59
Molas Lake	10500	10.6	13.0	82	10.7	14.1	76
Red Mountain Pass	11200	13.9	15.0	93	12.7	17.9	71
Spud Mountain	10660	15.7	17.8	88	13.1	20.7	63
Stump Lakes	11200	11.1	12.8	87	7.9	14.1	56
Basin Index (%)				**84**			**65**

Figure 5. NRCS Basin Snowpack Report, as seed / no seed indicator for suspension criteria.

In the example Figure 5, the first column is the SNOTEL name followed by its elevation, actual SWE, median SWE, and the percent of median SWE. The last 3 columns are the same but for precipitation. WWC approaches the snowpack suspension in two ways. First, if there is a Basin wide suspension WWC will not conduct any seeding within that basin. Second, if there is a partial suspension within a basin such as a river basin below the snowpack suspension criteria and another snowpack reading site reporting above suspension criteria levels WWC would only seed into the areas where snowpack levels were below the criteria levels and will not seed into any area above the criteria level.

The CDOT website is routinely monitored to check road conditions and verify precipitation in the Target Areas. Figure 6 is an example of a CDOT road cam photo that documents accumulated snow on Coal Bank Pass.

Figure 6

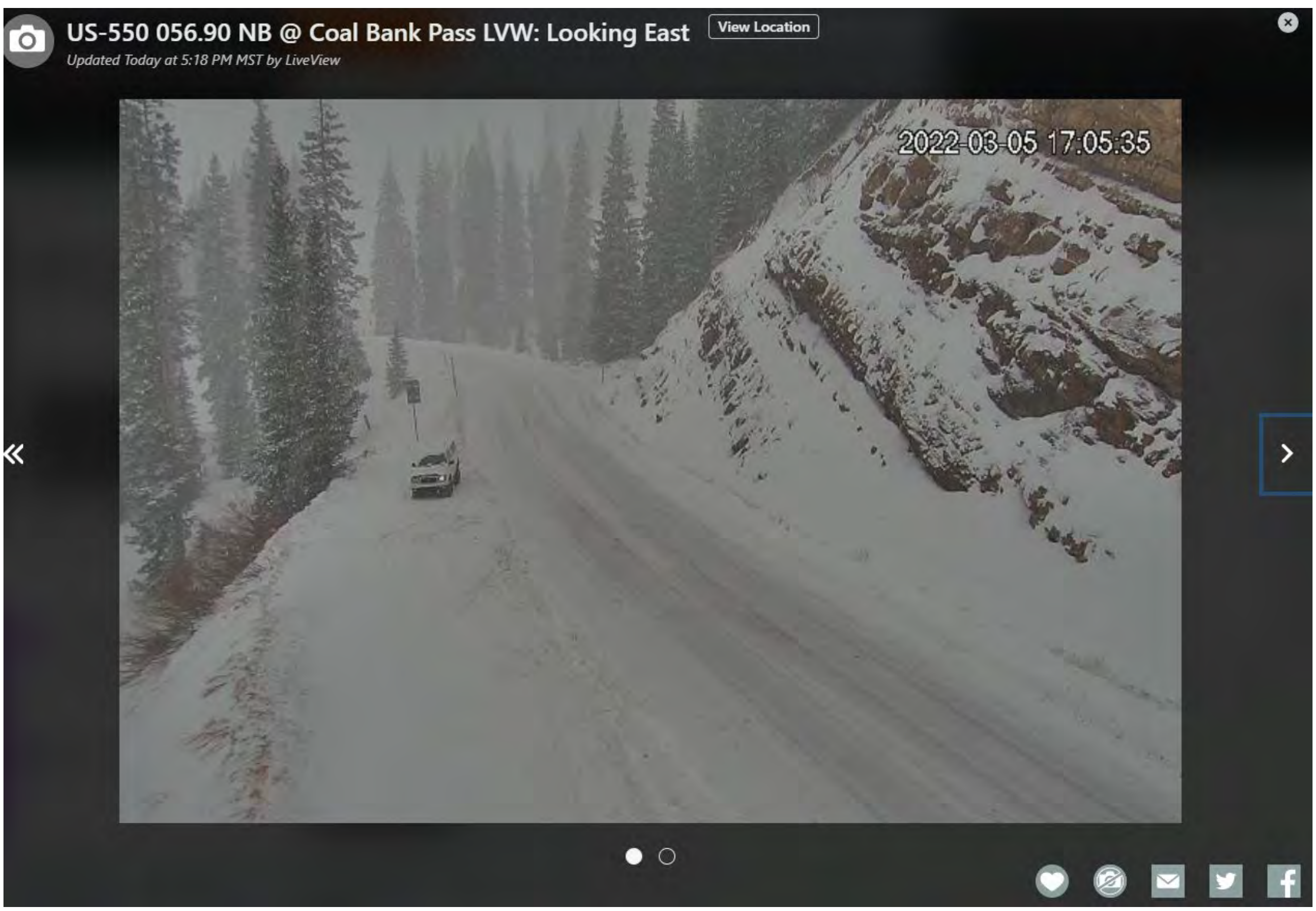


Figure 6. Image from the CDOT website shows that it is snowing on the highway at Coal Bank Pass.

No basin wide suspensions occurred due to snowpack concerns, noted by the NRCS. There was one avalanche suspension implied by the CAIC Cloud Seeder information on 2-23-22, during which, seeding operations were shut down early.

Operational Summary

Within this section, a brief monthly review is given indicating the climatological conditions, as well as any conditions or concerns that may have influenced the timing or operating of any part of the program during the 166-day permitted seeding season. Included with this review are graphs and a few images demonstrating monthly precipitation. The Permits for the San Juan Cloud Seeding Programs allows for seeding beginning the first of November through April 15. Operations for the San Juan Cloud Seeding Programs began on December 6, 2021, and ended on March 10, 2022, with 14 seeding events that covered 27 calendar days within this timeframe.

Appendix A provides a brief meteorological description of each seeding event including a chart showing the operational times the generators were scheduled to operate and may include SNOTEL and Ski Area precipitation data with the intention of relaying the regional coverage of each storm. Not every storm that passed over the Target Area was seeded since not every storm met our seeding criteria. The operational charts included show the actual on and off times for each generator, the number of hours each generator operated, and the amount of silver iodide dispensed by each generator. The totals of hours are displayed at the bottom of the generator operations list. Generator operators are asked to adhere, as close as possible, to the requested operation times. At times, one generator’s usage may be shared with a neighboring cloud seeding contracted area resulting in the generators operation time being split between multiple areas.

Table C, includes the dates of all of the seasons seeding operations, the number of generators utilized per operation, the total number of regular and carry forward hours and the hours used from the CWCB and LCRB funding for the San Juan Mountains Weather Modification Programs.

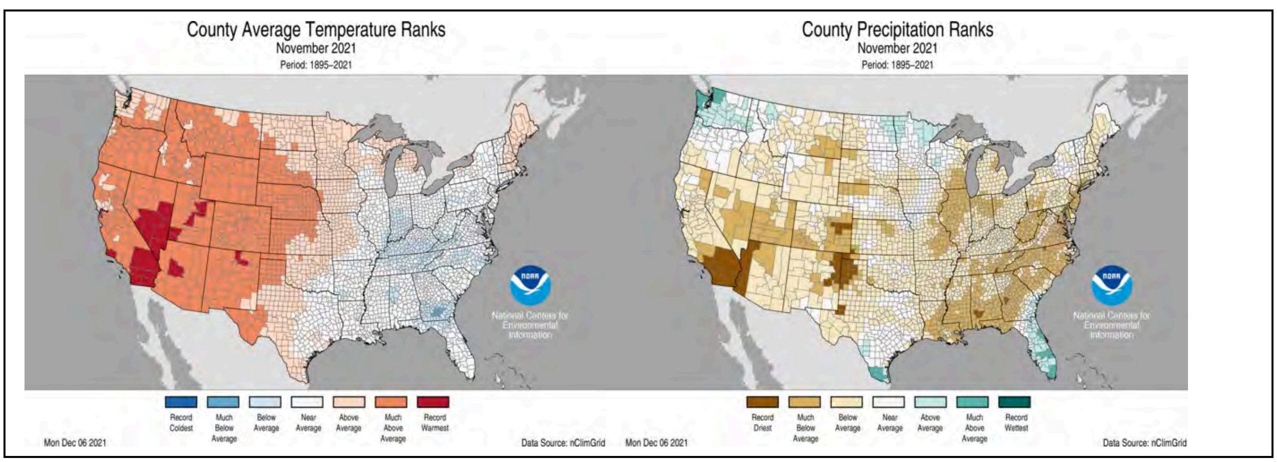
TABLE C

Operational Summary for 2021-2022 Seeding Season
San Juan Mountains Seeding Areas

Event	From	To	Days	# Gen.	WDO Regular & Carry Fwrd Hrs.	TELSKI Regular & Carry Fwrd Hrs.	WSJ Regular & Carry Fwrd Hrs.	PURG Regular & Carry Fwrd Hrs.	ESJ Regular & Carry Fwrd Hrs.	NM Regular & Carry Fwrd Hrs.	WDO CWCB LCRB Hrs.	WSJ CWCB LCRB Hrs.	ESJ CWCB LCRB Hrs.
1	12/6/2021 21:00	12/7/2021 8:00	2	0	10.75	20.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	12/8/2021 17:00	12/8/2021 22:15	1	0	7.37	9.00	7.50	7.37	2.50	15.00	0.00	0.00	0.00
3	12/8/2021 10:00	12/10/2021 10:00	3	0	27.60	51.15	42.62	20.62	43.25	36.25	0.00	0.00	0.00
4	12/15/2021 5:00	12/15/2021 13:00	1	0	10.00	8.00	8.50	8.50	5.00	22.00	0.00	0.00	0.00
5	12/23/2021 21:30	12/25/2021 8:00	3	0	27.00	13.00	31.25	69.25	63.75	38.25	0.00	0.00	0.00
6	12/25/2021 21:30	12/26/2021 15:00	2	0	11.00	0.00	11.00	28.00	37.50	31.50	0.00	0.00	7.50
7	12/27/2021 17:00	12/29/2021 8:15	3	0	73.12	71.12	24.50	97.12	0.00	3.25	0.00	0.00	103.13
8	12/30/2021 16:00	12/31/2021 21:00	2	0	3.15	44.60	22.50	77.63	35.00	0.00	59.75	0.00	93.37
9	2/1/2022 13:00	2/2/2022 17:00	2	0	0.00	21.38	15.37	60.12	0.00	34.75	51.12	0.00	62.75
10	2/16/2022 12:00	2/16/2022 20:00	1	0	9.00	0.00	0.00	4.00	0.00	0.00	27.75	0.00	0.00
11	2/21/2022 15:30	2/23/2022 20:00	3	0	43.00	19.00	72.75	140.37	1.00	1.00	92.25	44.13	32.25
12	3/4/2022 20:00	3/6/2022 11:00	3	0	0.00	0.00	0.00	0.00	0.00	0.00	64.13	232.62	0.00
13	3/9/2022 6:00	3/9/2022 21:00	1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	65.25	0.00
14	3/10/2022 9:00	3/10/2022 15:00	1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00	0.00
		TOTALS	**27**		**221.99**	**258.00**	**236.00**	**513.00**	**188.00**	**182.00**	**295.00**	**354.00**	**299.00**

November 2021 Seeding Operations

Warmer temperatures are typically observed in the onset of storms through November. These warm temperatures can delay the start of seeding and/or prevent the opportunity to seed in some cases. November 2021 was much above average for temperatures and much



below average for precipitation. There were a few small precipitation events in November, but none of them met the seeding criteria which led to no seeding events taking place. The 2021-2022 seeding season started out with high clouds and warm temperatures throughout the area. A ridge of high pressure centered in the Pacific off the coast of Southern California channeled most of the moisture from the Pacific Northwest north of the SMJ target areas for the first few days of the month leaving only small pockets of precipitation in scattered areas.

After a dry summer into fall the NRCS reported 189% of median snowpack in the Dolores and San Miguel River Basins, San Juan River Headwaters were at 127% of median snowpack and the Animas River Basin was at 135% of median snowpack thanks to a late October snowstorm, however, as stated on their report, this analysis may not be a valid measure of the actual conditions for the start of November.

The NRCS chart Figure 7 shows the San Miguel, Dolores, Animas, and San Juan River Basins SWE at 129% of median thanks to some late October precipitation, on November 1, 2021, and a comparison to the previous two water years.

Figure 7

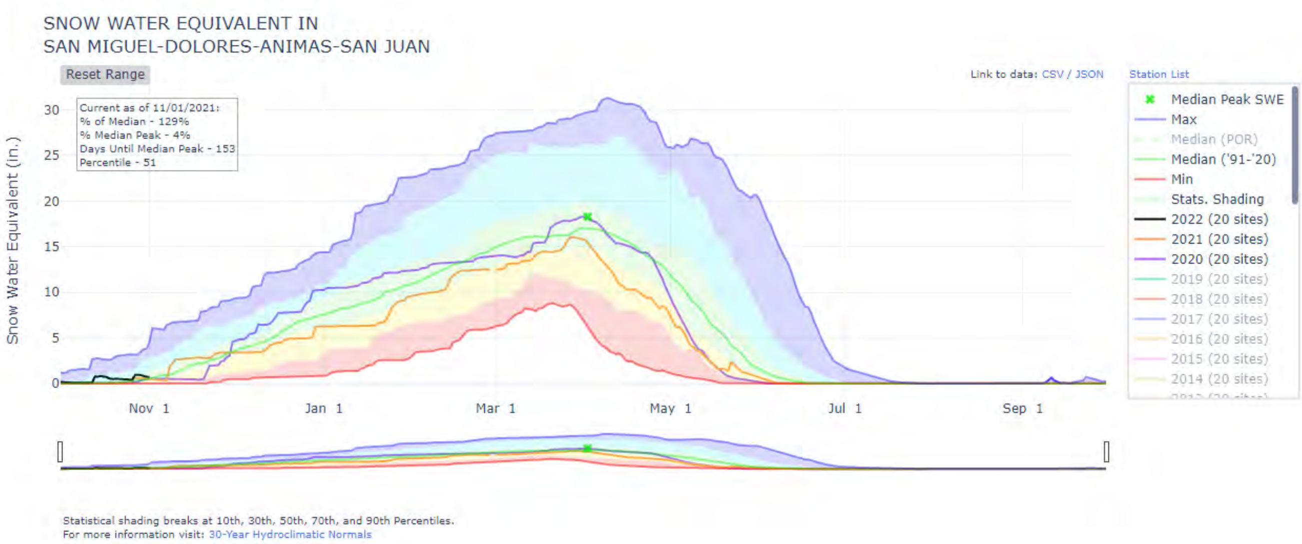


Figure 7. NRCS Chart showing Four Corners area SWE summary.

The precipitation events on November 2nd and 9th through the 10th were all from the southwest and were too warm to be seeded.

By mid-November despite the additional precipitation added to the snowpack the Dolores and San Miguel River Basins SWE dropped to 51% of average, San Juan River Headwaters were at 46% of median snowpack and the Animas River Basin was at 53% of median snowpack.

The NRCS chart Figure 8 shows the San Miguel, Dolores, Animas, and San Juan River Basins SWE at 54% of median on November 15, 2021, and a comparison to the previous two water years.

Figure 8

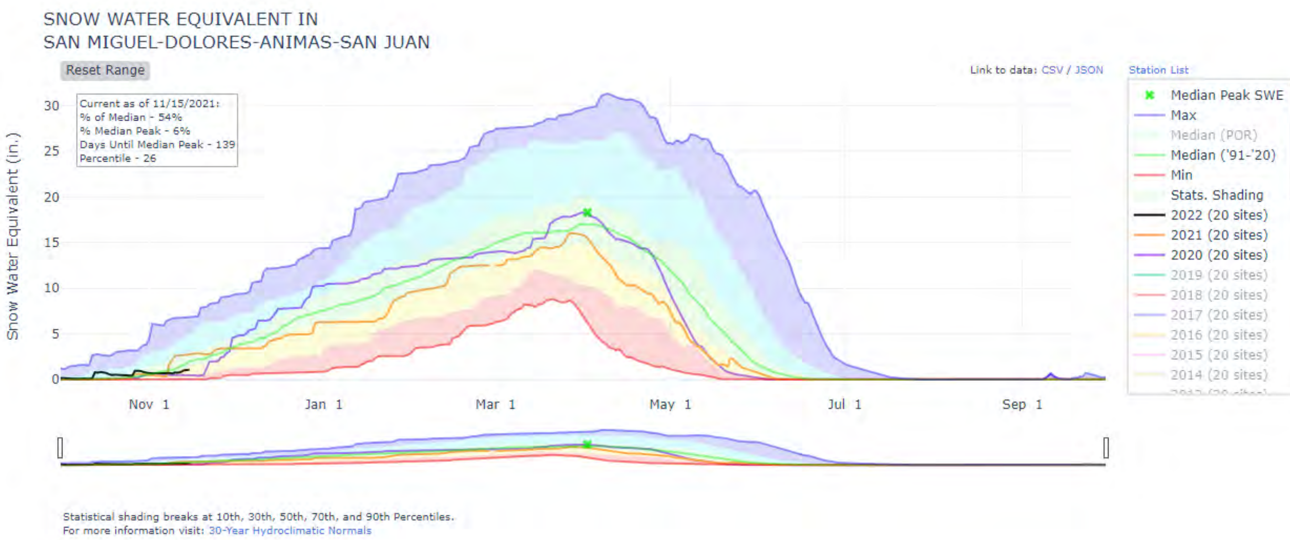


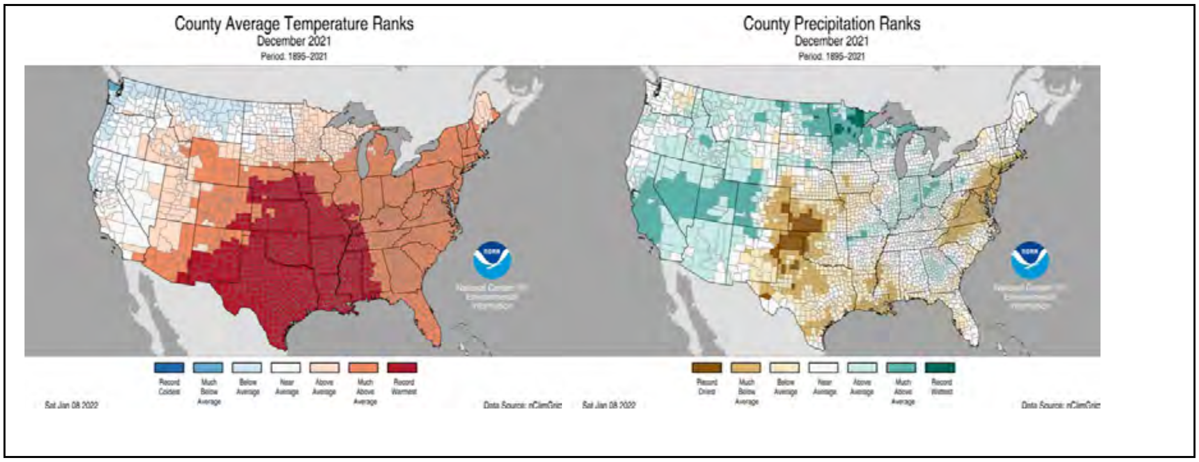
Figure 8. NRCS Chart showing Four Corners area SWE summary.

The second half of November started with about 7 dry days followed by a shortwave storm system over the 23rd to the 24th, again from the southwest and too warm to seed. The final days of November remained dry throughout the southwest.

November ended with the San Miguel / Dolores River Basin at 42% of median SWE and 76% of average precipitation, Animas River Basin at 36% and 65% of median SWE and average precipitation and the San Juan River Basins at 35%, and 59% of median snowpack, and average precipitation per the NRCS SNOTEL snow/precipitation update report November 30th.

December 2021 Seeding Operations

December 2021 was above average to much above average for both temperatures and



precipitation. During the month of December, there were eight weather systems meeting seeding criteria covering seventeen calendar days and 1,441.00 hours of seeding, Table C.

The NRCS chart Figure 9 shows the San Miguel, Dolores, Animas, and San Juan River Basins SWE at 85% of median on December 1, 2021, and a comparison to the previous two water years.

Figure 9

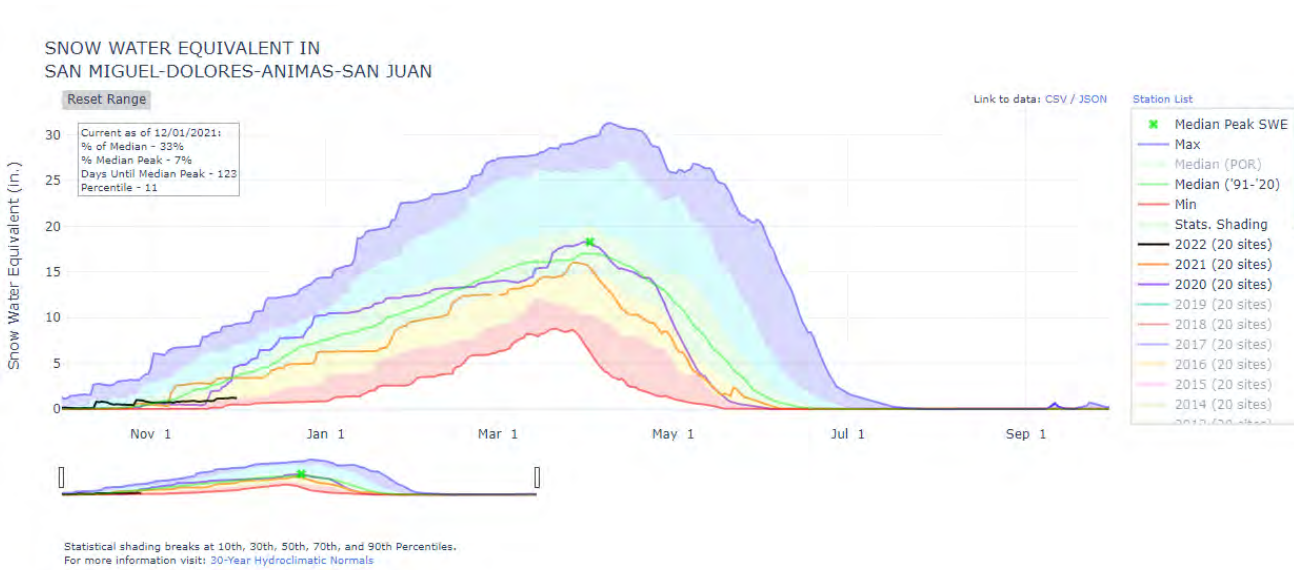


Figure 9. NRCS Chart showing Four Corners area SWE summary.

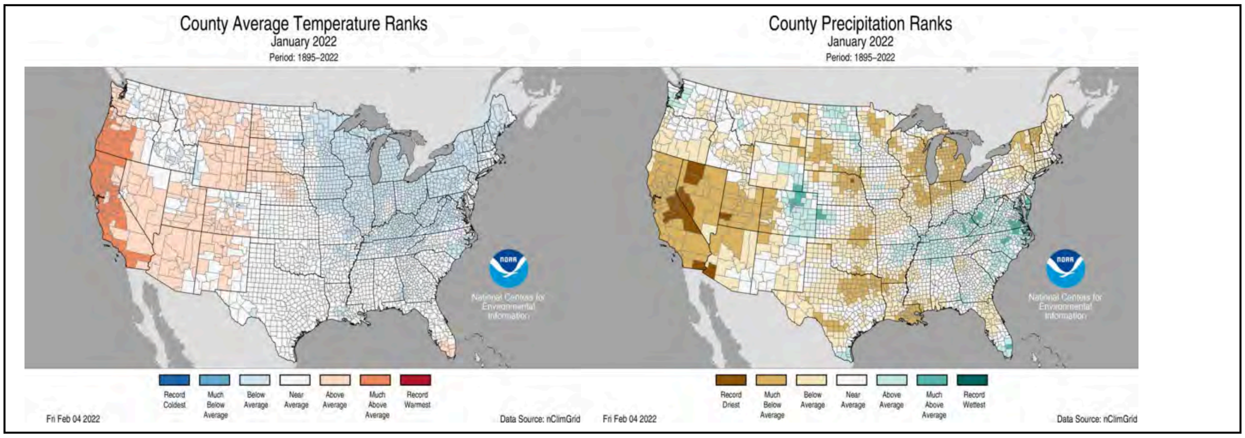
December started out with a continuation of little to no precipitation for the first seven days. On the seventh of December, a series of storms arrived in the San Juan Mountains that provided four of the seven seeding events through the 15th of the month. In those eight days most SNOTELs in the area reported over 2 inches of SWE increases.

By mid-December, the San Miguel / Dolores, Animas, and San Juan River Basins had reported 83%, 81% and 71% of median snowpack, and average precipitation up to 91%, 88% and 74% of average, nearly doubling the % of median SWE from the beginning of the month.

The second half of the month had little precipitation until the 24th when the final three seeding event of the month took place. Most SNOTELs in the target areas reported an additional four inches of needed SWE between the 16th and 31st of the month. December ended with a giant change in overall percentage numbers and closed out with the San Miguel / Dolores, Animas and San Juan River Basins at 133%, 124% and 120% of median snowpack and 117%, 118% and 109% of average precipitation. Telluride Ski Resort reported an 56-inch base the morning of December 31st.

January 2022 Seeding Operations

The overall weather pattern for January 2022 was above average for temperatures and below average to much below average in precipitation across the target areas. The month of January provided zero weather systems with seeding opportunities, Table C.



January provided no seeding opportunities and little precipitation was reported by SNOTELs in the San Juan Mountains. Red Mountain Pass SNOTEL had an increase of .8 inches of SWE for the entire month, most other SNOTELs in the area reported much less from January 1st to the 31st. When a precipitation event did arrive the duration of snowfall, amount of expected precipitation or temperatures would not meet criteria.

By mid-January, the San Miguel / Dolores, Animas, and San Juan River Basins had dropped to 113%, 110% and 114% of median snowpack and 111%, 114% and 107% of total precipitation of average.

The NRCS chart Figure 10 shows the San Miguel, Dolores, Animas, and San Juan River Basins SWE at 128% of median on January15, 2022, and a comparison to the previous two water years.

Figure 10

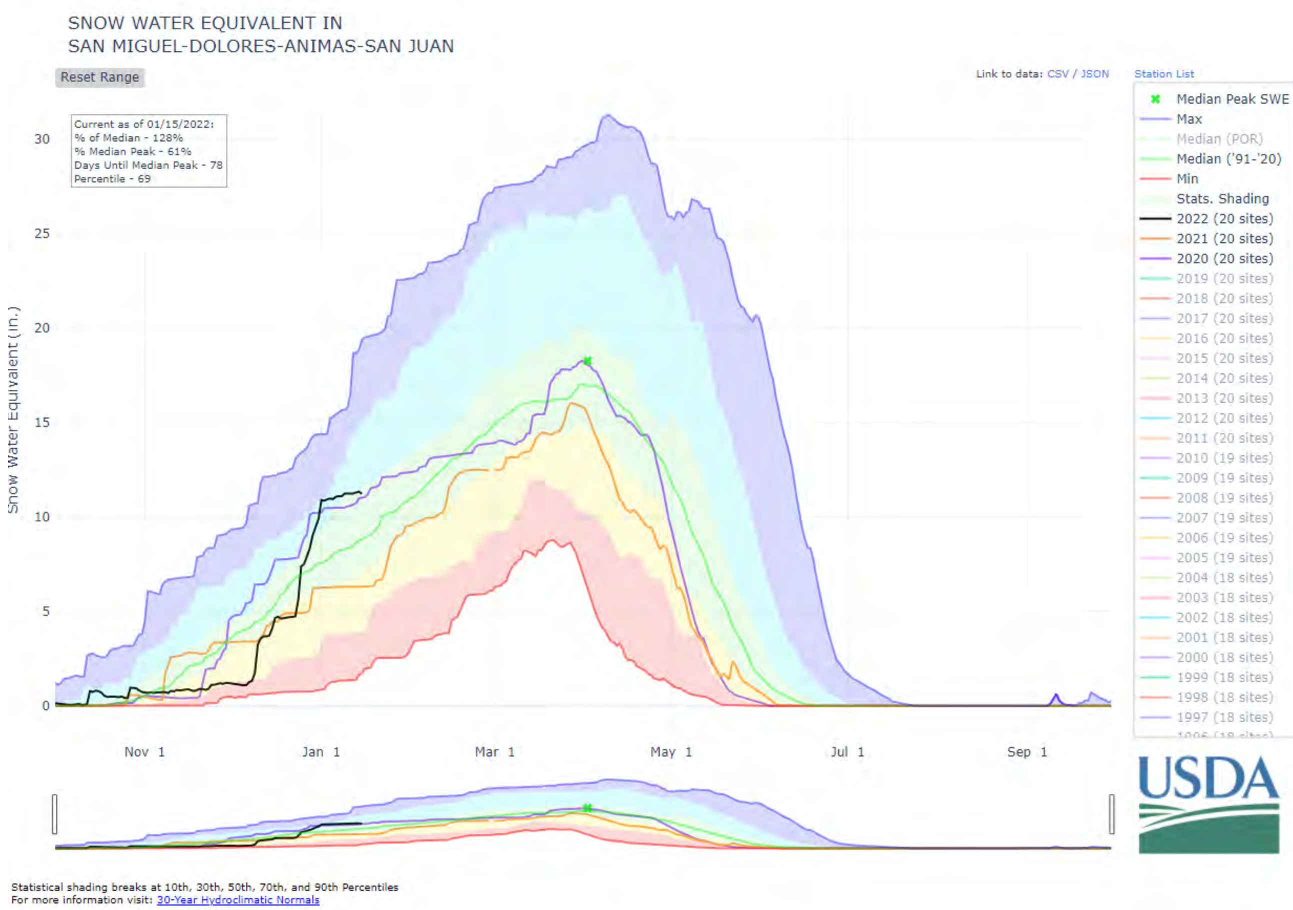
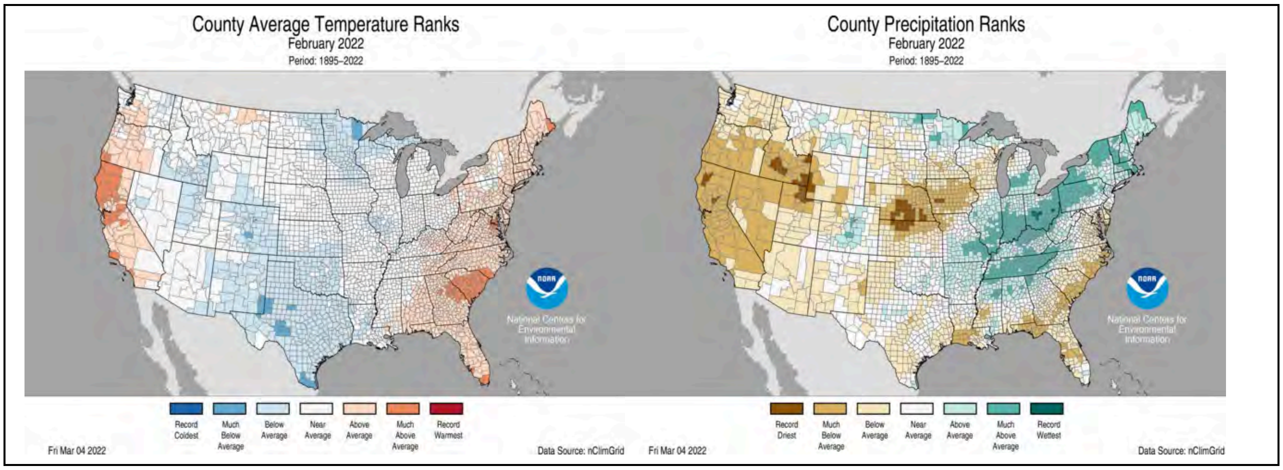


Figure 10. NRCS Chart showing Four Corners area SWE summary.

With little to no additional snowpack brought in towards the end of the month, January realized a slight loss in snowpack ending with 92%, 91% and 99% of median snowpack in the San Miguel / Dolores, Animas and San Juan River Basins and total precipitation down as well to 96%, 98% and 96% of average. Telluride Ski Resort reported a 46-inch base January 31st.

February 2022 Seeding Operations

Overall, February was near average for temperatures and near to above average in precipitation across the target areas.



The month of February provided three weather systems with seeding opportunities covering six calendar days and 732.00 hours of seeding, Table C.

The first half of February provided only one seeding event from the 1st into the 2nd as a mid-level shortwave impacted the area. A couple other precipitation events occurred by mid-month that did not meet seeding criteria. The total of events by mid-month added only 0.4 an inch or less of additional SWE to most SNOTELs in the target areas

By mid-February, the San Miguel / Dolores, Animas, and San Juan River Basins SWE had a slight loss to 86%, 84% and 92% of median and precipitation down slightly to 91%, 90% and 89% of average.

Another relatively short seeding event arrived noon on the 16th only lasting around 8 hours as moisture from the northwest pushed eastward leaving a ridge of high pressure behind. The ridge eventually was pushed out by a large low-pressure system on the 21st that brought in a 3-day seeding event. By the 23rd of the month most SNOTELs were reporting well over an inch of additional SWE setting the CAIC to halt seeding until highways could undergo avalanche mitigation in most areas of highway 550. February ended with another gain in snowpack leaving 95%, 98% and 103% of median SWE in the San Miguel / Dolores, Animas and San Juan River Basins and total precipitation for the three basins at 96% of median Figure 11.

The NRCS chart in Figure 11, shows a comparison of seasonal and monthly precipitation median based on 1991 to 2020 reference period for February.

Figure 11

Report Created: 3/31/2022 2:44:59 PM

Basinwide Summary: March 1, 2022
(Medians based On 1991-2020 reference period)

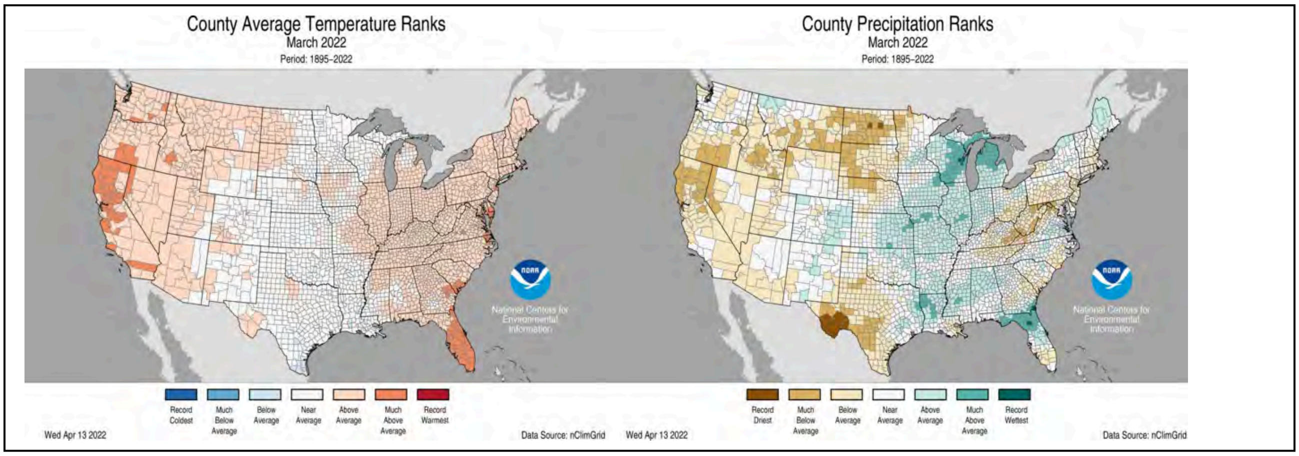
			Monthly Total Precipitation For February 2022					Water Year To Date Precipitation through February 2022				
San Miguel-Dolores-Animas-San Juan	Network	Elevation (ft)	Current (in)	Median (in)	% Median	Last Year (in)	Last Year % Median	Current (in)	Median (in)	% Median	Last Year (in)	Last Year % Median
Beartown	SNOTEL	11600	3.9	3.6	108%	2.2	61%	18.2	19.4	94%	14.3	74%
Black Mesa	SNOTEL	11580	3.1			2.9		16.1			12.2	
Cascade	SNOTEL	8880	3.2	3.4	94%	1.9	56%	14.6	16.9	86%	10.5	62%
Cascade #2	SNOTEL	8920	3.3	3	110%	1.8	60%	14.7	16.4	90%	9.7	59%
Columbine Pass	SNOTEL	9400	2.8	4	70%	4	100%	21.2	17.8	119%	12	67%
Columbus Basin	SNOTEL	10785	3.2	4.6	70%	2.8	61%	19.8	21.3	93%	11.4	54%
El Diente Peak	SNOTEL	10000	2.3	3.6	64%	2.2	61%	13.3	14.8	90%	10.4	70%
Lizard Head Pass	SNOTEL	10200	1.1	2.6	42%	2.2	85%	10.8	11.8	92%	8.6	73%
Lone Cone	SNOTEL	9600	2.5	3.2	78%	2.2	69%	14	15.1	93%	10.5	70%
Mancos	SNOTEL	10000	1.6	2.8	57%	1.9	68%	10.6	14	76%	7.3	52%
Mineral Creek	SNOTEL	10040	2.8	2.7	104%	1.7	63%	14	13.8	101%	8.3	60%
Molas Lake	SNOTEL	10500	2.4	3.4	71%	2.8	82%	17.2	16	108%	11.8	74%
Red Mountain Pass	SNOTEL	11200	3.7	4.2	88%	3.8	90%	18.3	20.4	90%	14.8	73%
Scotch Creek	SNOTEL	9100	2.5	2.8	89%	1.8	64%	12.8	13.8	93%	8.8	64%
Sharkstooth	SNOTEL	10720	3.4	3.4	100%	2.4	71%	19	17.8	107%	10.6	60%
Spud Mountain	SNOTEL	10660	4.6	4.8	96%	3.9	81%	23.5	22.9	103%	14.2	62%
Stump Lakes	SNOTEL	11200	3	3	100%	2.1	70%	13.9	16	87%	9.1	57%
Upper San Juan	SNOTEL	10200	5.1	5.8	88%	3.7	64%	27.2	27.9	97%	23.6	85%
Vallecito	SNOTEL	10880	3	3	100%	1.9	63%	12.6	14.4	88%	10.4	72%
Weminuche Creek	SNOTEL	10740	3.9	3.2	122%	2.6	81%	15	18.6	81%	17.2	92%
Wolf Creek Summit	SNOTEL	11000	6.8	5.6	121%	3	54%	28.8	25.7	112%	23.3	91%
Basin Index					**90%**		**70%**			**96%**		**70%**
# of sites					20		20			20		20

Figure 11. Chart shows precipitation percentages for the SJM region on March 1st.

Telluride Ski Resort reported a base depth of 59 inches at the end of the month.

March 2022 Seeding Operations

Near to above average temperatures and near average precipitation was noticed across the target areas in March.



The month of March had three seeding opportunities covering five calendar days and 374.00 hours of seeding, Table C.

March started under a ridge of high pressure with a continuation of warm and dry days that started around the 25th of February. By the fourth of March the ridge had passed, and a storm system had moved into the area and precipitation began around mid-morning. By early evening conditions had cooled enough to start seeding. A lull in precipitation occurred mid-morning till mid-afternoon on the 5th halting seeding until precipitation rates picked up. By noon on the 6th seeding ended. Most SNOTELs in the area reported an inch or more SWE after the storm had moved on. Seeding for the season had ended after consuming the available seeding hours for the 2021-2022 season following to small events on the 9th and 10th of the month. On the morning of the 15th of March, the San Miguel / Dolores, Animas, and San Juan River Basins SWE had basically no gains, ending at 99%, 101% and 108% of median and precipitation remained about the same at 97% of average over the region.

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The NRCS chart in Figure 12, shows a comparison of seasonal and monthly precipitation median based on 1991 to 2020 reference period for March.

Figure 12

Report Created: 4/26/2022 9:58:13 AM

Basinwide Summary: April 1, 2022
(Medians based On 1991-2020 reference period)

			Monthly Total Precipitation For March 2022					Water Year To Date Precipitation through March 2022				
San Miguel-Dolores-Animas-San Juan	Network	Elevation (ft)	Current (in)	Median (in)	% Median	Last Year (in)	Last Year % Median	Current (in)	Median (in)	% Median	Last Year (in)	Last Year % Median
Beartown	SNOTEL	11600	3.2	2.9	110%	3.9	134%	21.4	21.9	98%	18.2	83%
Black Mesa	SNOTEL	11580	3.9			4.6		20			16.8	
Cascade	SNOTEL	8880	2.6	2.2	118%	3	136%	17.2	18.6	92%	13.5	73%
Cascade #2	SNOTEL	8920	2.6	2.1	124%	3.3	157%	17.3	17.8	97%	13	73%
Columbine Pass	SNOTEL	9400	4.4	3.3	133%	3.6	109%	25.6	21.7	118%	15.6	72%
Columbus Basin	SNOTEL	10785	3.4	3	113%	3.4	113%	23.2	25	93%	14.8	59%
El Diente Peak	SNOTEL	10000	3.1	2.5	124%	3.8	152%	16.4	18.2	90%	14.2	78%
Lizard Head Pass	SNOTEL	10200	1.9	2.1	90%	2.7	129%	12.7	14.8	86%	11.3	76%
Lone Cone	SNOTEL	9600	3	2.6	115%	4.2	162%	17	17.8	96%	14.7	83%
Mancos	SNOTEL	10000	2.5	1.7	147%	3.3	194%	13.1	16.3	80%	10.6	65%
Mineral Creek	SNOTEL	10040	3.1	2.4	129%	2.6	108%	17.1	16.2	106%	10.9	67%
Molas Lake	SNOTEL	10500	3.8	2.7	141%	3.2	119%	21	18.8	112%	15	80%
Red Mountain Pass	SNOTEL	11200	4.4	3.8	116%	5.1	134%	22.7	24.5	93%	19.9	81%
Scotch Creek	SNOTEL	9100	2.8	2.3	122%	3.1	135%	15.6	16	98%	11.9	74%
Sharkstooth	SNOTEL	10720	4	2.2	182%	4.3	195%	23	20	115%	14.9	75%
Spud Mountain	SNOTEL	10660	5	4	125%	5.9	148%	28.5	28.1	101%	20.1	72%
Stump Lakes	SNOTEL	11200	3	2.6	115%	3	115%	16.9	18.6	91%	12.1	65%
Upper San Juan	SNOTEL	10200	4.2	4	105%	5.4	135%	31.4	32.8	96%	29	88%
Vallecito	SNOTEL	10880	2.9	2.3	126%	2.3	100%	15.5	17.2	90%	12.7	74%
Weminuche Creek	SNOTEL	10740	3.2	2.2	145%	3.6	164%	18.2	21.6	84%	20.8	96%
Wolf Creek Summit	SNOTEL	11000	2.2	4.2	52%	4.8	114%	31	30.2	103%	28.1	93%
Basin Index					**119%**		**135%**			**97%**		**77%**
# of sites					20		20			20		20

Figure 12. Chart shows precipitation percentages for the SJM region on April 1st.

Telluride Ski Resort reported a base depth of 69 inches at the end of March.

Remote Generator Operations

For the 2021-2022 winter season the CWCB and LCRB leased three Desert Research Institute's (DRI) remote generators. The Mancos, Telluride and newly placed, Rocky Mountain style, Rito Blanco remotes were all used for seeding in the SJM Program independent from the generators contracted with WWC. Maintenance and supplying of consumables were provided by DRI while WWC conducted operations of these three remotes along with the manually operated generator network.

Two additional remotely controlled generators were used for seeding in the SJM Program, one Idaho Power produced remote installed along the Norwood Highway, and a DRI remote placed on Montoya Peak, just to the west of Hesperus Ski Hill. Operations from this remote could benefit both the WDT and WSJ contracted areas. Funding for these remotes is provided by the Lower Basin States and the CWCB and are independent from all contracted sponsor funding. WWC maintains and operates these two remotes.

Listed below are the run logs for the Telluride, Mancos, Rito Blanco and Busto DRI remote generators and the IPC Dolores remote:

Telluride Remote Operations

start day time	stop day time	hrs	rate	output	set time
12/10/2021 4:00	12/10/2021 8:00	4.00	25	100.00	240
2/2/2022 9:00	2/2/2022 13:20	4.33	25	108.33	260
2/16/2022 15:30	2/16/2022 19:00	3.50	25	87.50	210
3/6/2022 12:00	3/6/2022 17:00	5.00	25	125.00	300
3/7/2022 11:00	3/7/2022 16:00	5.00	25	125.00	300
3/10/2022 10:15	3/10/2022 15:15	5.00	25	125.00	300
3/13/2022 21:00	3/14/2022 3:00	6.00	25	150.00	360
3/16/2022 22:00	3/17/2022 2:00	4.00	25	100.00	240
3/30/2022 9:00	3/30/2022 12:00	3.00	25	75.00	180
4/1/2022 6:00	4/1/2022 8:00	2.00	25	50.00	120

Mancos Remote Operations

12/8/2021 20:00	12/9/2021 0:00	4.00	25	100.00	240
12/9/2021 22:00	12/10/2021 5:00	7.00	25	175.00	420
12/15/2021 3:00	12/15/2021 10:00	7.00	25	175.00	420
12/24/2021 9:15	12/24/2021 18:15	9.00	25	225.00	540
12/26/2021 9:15	12/26/2021 15:00	5.75	25	143.75	345
12/27/2021 18:45	12/29/2021 1:45	31.00	25	775.00	1860
12/31/2021 8:45	12/31/2021 13:35	4.83	25	120.83	290
2/21/2022 20:05	2/22/2022 2:20	6.25	25	156.25	375
2/22/2022 9:00	2/22/2022 22:00	13.00	25	325.00	780
2/23/2022 11:35	2/23/2022 13:25	1.83	25	45.83	110
3/9/2022 8:55	3/9/2022 13:10	4.25	25	106.25	255
3/9/2022 13:55	3/9/2022 23:55	10.00	25	250.00	600

Rito Blanco Remote Operations

start day time	stop day time	hrs	rate	output	set time
12/8/2021 19:45	12/9/2021 0:45	5.00	2	8.60	300
12/10/2021 0:00	12/10/2021 8:00	8.00	25	200.00	480
12/15/2021 4:00	12/15/2021 12:00	8.00	25	200.00	480
12/24/2021 0:00	12/25/2021 2:00	26.00	25	650.00	1560
12/26/2021 8:00	12/26/2021 15:00	7.00	25	175.00	420
12/27/2021 20:00	12/29/2021 2:00	30.00	25	750.00	1800
12/31/2021 8:45	1/1/2022 0:00	15.25	25	381.25	915
2/2/2022 8:35	2/2/2022 17:30	8.92	25	222.92	535
2/22/2022 0:10	2/22/2022 7:10	7.00	25	175.00	420
2/22/2022 9:15	2/22/2022 19:15	10.00	25	250.00	600
2/23/2022 12:00	2/24/2022 3:45	15.75	25	393.75	945
3/6/2022 7:40	3/6/2022 18:10	10.50	25	262.50	630
3/9/2022 15:35	3/10/2022 16:00	24.42	25	610.42	1465

Busto Remote Operations

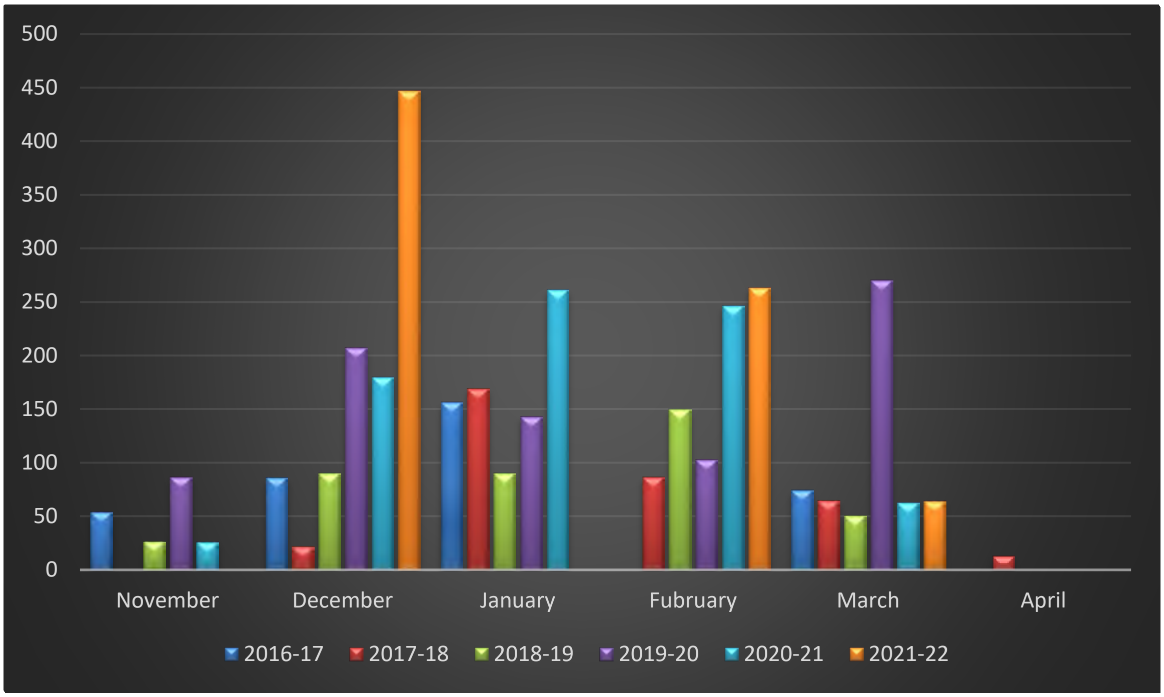
The Busto remote was serviced prior to the start of the seeding season. At this service the ignition unit was replaced as the remote would not light. The service work was completed, and the remote was left in working order after a long session of troubleshooting with the DRI technician. The first attempt to use the Busto remote during the season failed as it would not light. Unable to get back to this remote during the season it was decided to use funds designated for its use for added operations in each of the 3 contract areas. Efforts are in place to have the Busto remote fixed and in working order for the 2022-23 season.

Dolores Remote Operations

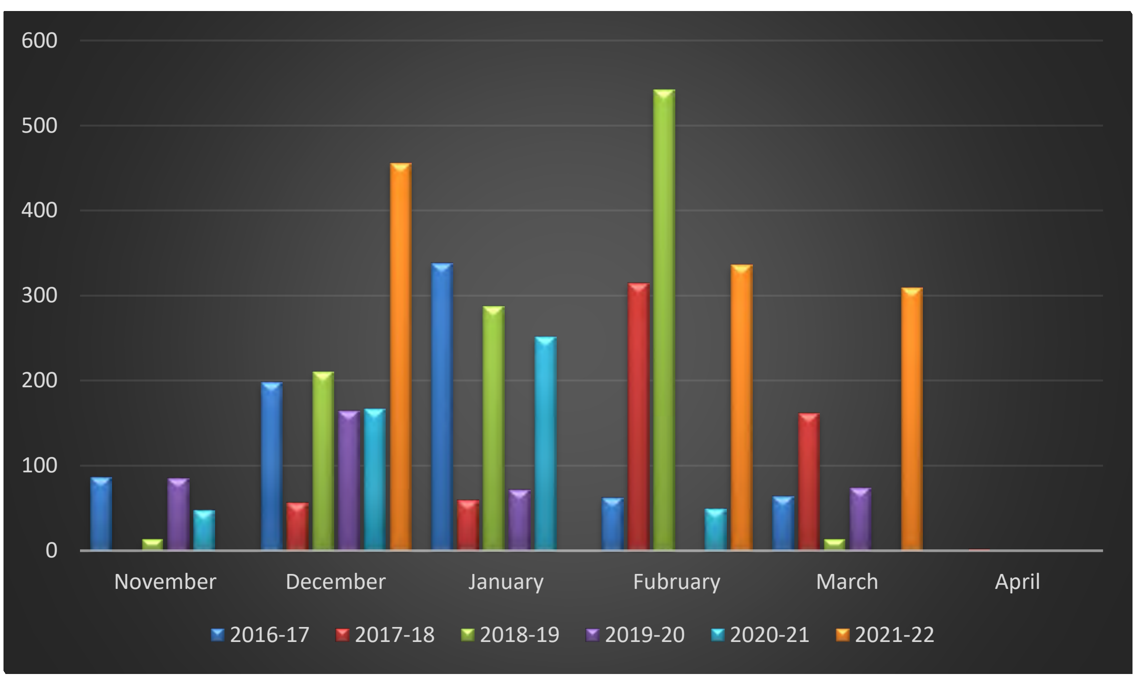
start day time	stop day time	hrs	rate	output	set time
12/8/2021 20:30	12/9/2021 0:00	3.50	19	66.50	210
12/9/2021 23:00	12/10/2021 5:00	6.00	19	114.00	360
12/15/2021 3:00	12/15/2021 8:00	5.00	19	95.00	300
12/15/2021 8:45	12/15/2021 10:00	1.25	19	23.75	75
12/24/2021 9:15	12/24/2021 17:45	8.50	19	161.50	510
12/24/2021 20:00	12/25/2021 0:00	4.00	19	76.00	240
12/26/2021 12:00	12/26/2021 15:00	3.00	19	57.00	180
12/27/2021 18:40	12/28/2021 6:40	12.00	19	228.00	720
12/28/2021 18:00	12/29/2021 4:00	10.00	19	190.00	600
12/31/2021 9:20	12/31/2021 18:30	9.17	19	174.17	550
2/16/2022 15:15	2/16/2022 18:00	2.75	19	52.25	165
2/21/2022 21:30	2/22/2022 5:15	7.75	19	147.25	465
3/5/2022 1:00	3/5/2022 3:05	2.08	19	39.58	125

The following three graphs represent all the contracted seeding hours per month for the 2021-2022 cloud seeding season for each of the three contracted areas and compares them to the past five seasons' monthly hours.

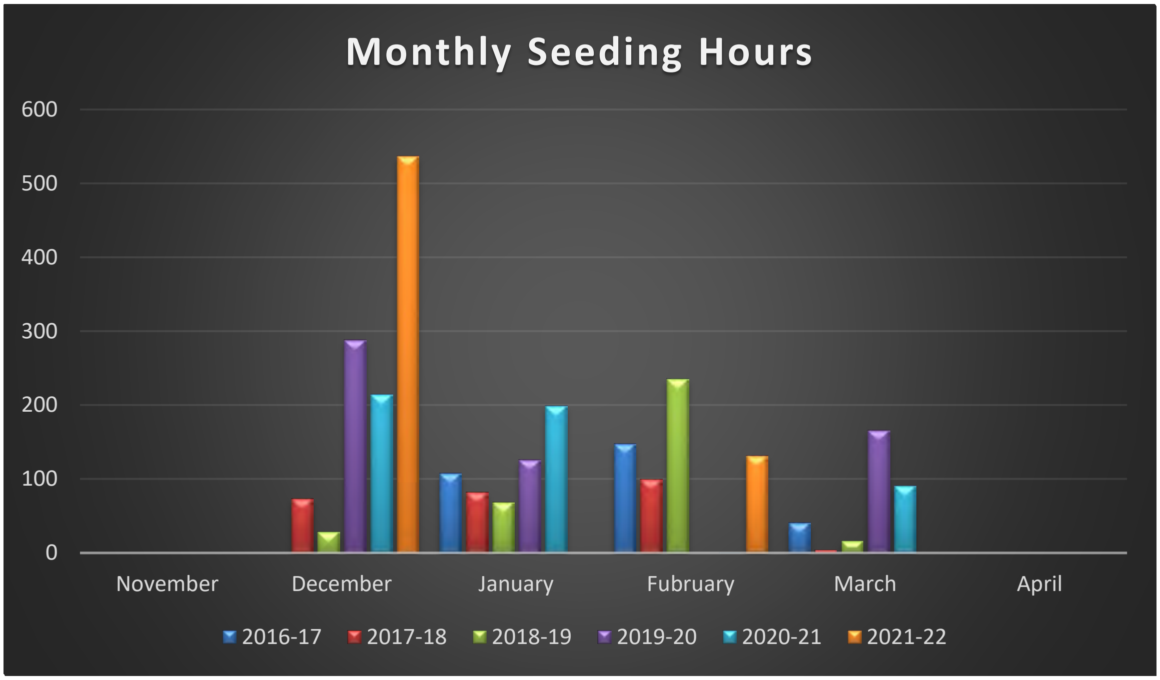
WDT 2016-2022 Monthly Seeding Hours Comparison



WSJ 2016-2022 Monthly Seeding Hours Comparison



ESJ 2016-2022 Monthly Seeding Hours Comparison



Procedures and Methodology for Estimating Precipitation Increases

A Weather Modification Act (Article 20) was enacted by the State of Colorado in 1972. The early versions of this Act required Permit Holders to provide the Program Sponsors with an annual estimate of the precipitation increases produced by the permitted seeding program. This is the reason that WWC developed the detail process that we use to estimate our seeding results. This Act has gone through various amendments and a Sunset Review in 2011. This Act was extended for a seven-year period in 2011 following the completion of the Sunset Review. Earlier rules and regulations were revised effective July 1, 2012. Article 12 of the 2012 revised rules and regulations, annual reports state: “The permit holder must compile annual reports in accordance with section 36-20-117(3), C.R.S. (2011). Annual reporting for ground-based winter operations shall include, at a minimum, target versus control analysis of precipitation or snow water equivalent.”

North American Weather Consultants (NAWC), with headquarters in Sandy, Utah, developed a Target vs. Control evaluation methodology for the San Juan Mountain Cloud

Seeding Programs for Water Year 2013. For Water Year 2021-22, NAWC's services were obtained for the required annual evaluation. NAWC's Target vs. Control Report for the San Juan Mountain Cloud Seeding Programs for WY21-22 is attached as an appendix to this report.

The procedure for estimating the precipitation increases because of cloud seeding in this and previous year's reports is based on two separate seeding program research analyses conducted by WWC. These two programs are the Colorado River Basin Pilot Project (research randomized seeding program), June 1976; and a 10- and 16- Year Data Sets from two separate precipitation sources for the Vail/Beaver Creek Seeding Program (operational seeding program) March 2001.

The two programs used for this evaluation were conducted over the Colorado Mountains utilizing similar seeding applications and weather event identification criteria. Both analyses produced extremely similar seeding response results. The research analyses utilized a conservative estimate of the seeding responses to the associated prevailing wind direction of the storm systems and forms the basis of the process by which we estimate precipitation increases.

In April 2009, Dr. Bernard Silverman did an independent target vs. control evaluation of streams flows from the target regions of the Vail operational cloud seeding program over its period of operations from 1977 to 2005 using ratio statistics and the bias-adjusted regression ratio. The water year (October-September) stream flows expressed in Acre-Feet (AF) from eight (8) Target Area stream basins served as the response variable in this evaluation. The effects of seeding on the eight (8), closely spaced basins in the Vail watershed were evaluated using the controls that give the most precise evaluation results possible with the available data. Evidence for statistically significant seeding effects ranging from 6.3% to 28.8% were found in the stream flows for 5 of the 8 seeding target basins. The three (3) basins that indicated less than statistically significant increases in stream flows were on the northwest and southeast edges of the Vail Target Area. An analysis of the time evolution of these seeding effects suggests that the percentage change in stream flow at each of the target sub-basins was about the same from water year to water year.

The results of this independent evaluation were a mirror reflection of the precipitation evaluation completed by WWC in 2001 for this region where the increases in water content of the snowfall (precipitation) from the cloud seeding operations were in the range of about 8.2%

to 31.3% over the target region. It is expected that the actual runoff from the snowpack in seeded regions will be slightly less than the actual observed precipitation from these seeded areas. Consequently, this independent stream flow evaluation of the Operational Vail Seeding Program confirmed that the precipitation increases can also be observed in the resulting stream flow from the melt of the snowpack in the seeded region.

This is the strongest independent confirmation to date for the precipitation increases resulting from the operational seeding of favorable wintertime cloud systems that ties together the actual seeding operational periods, to the observed increases in precipitation and the associated increases in resulting stream flows.

We have created a precipitation estimating procedure for seeding response increases using SNOTEL precipitation data collected about 1 AM each night for the preceding 24-hour period as follows:

1) Determine the operational seeding time for each seeding event to determine which observed 24-hour precipitation periods represent the event's precipitation. Examples: If a seeding event began a 6 AM and ended the same day at 10 PM, only the SNOTEL precipitation data for that event date will be evaluated for its representative precipitation increase. If a seeding event began at 8 PM on a date and continued until 10 PM the next day, the SNOTEL precipitation data for the starting event date and the next day would both be evaluated for its representative precipitation increase information.

2) Wind direction information is recorded by the WWC forecaster at the initiation of a seeding event and again for each six-hour period or portion thereof during the seeding event. Standard observation or data reporting times by the National Weather Service tend to be around 5 AM, 11 AM, 5 PM and 11 PM MST. If the seeding period goes into a 2nd or 3rd day, each portion of a seeding day or 6-hour period from a full seeding day, will be evaluated for an average wind direction. There will be a wind direction determined for each seeding date by averaging the appropriate 6-hour average directions for that date.

From the studies completed by WWC in 2001 for Vail Associates Inc. and previous information derived from the CRBPP data, referenced in the Project Information Section, there is an average seeding response that has been determined for each specific wind direction.

3) The seeding response factor, from the Seeding Response Model discussed below, is then representative of this specific wind direction. A seeding response factor for the average

24-hour wind direction is multiplied by the 24-hour SNOTEL precipitation total to determine the average precipitation increase for that day at a specific SNOTEL site.

4) This process of determining the daily estimated precipitation increase is then applied for each seeding day in a seeding event for this specific SNOTEL site as the precipitation created by the seeding program. All the daily precipitation increases are then summed up for this specific SNOTEL site for the entire season and this data is plotted on the estimated precipitation increase map in Map 4- Estimated Precipitation Increase across the Target Areas.

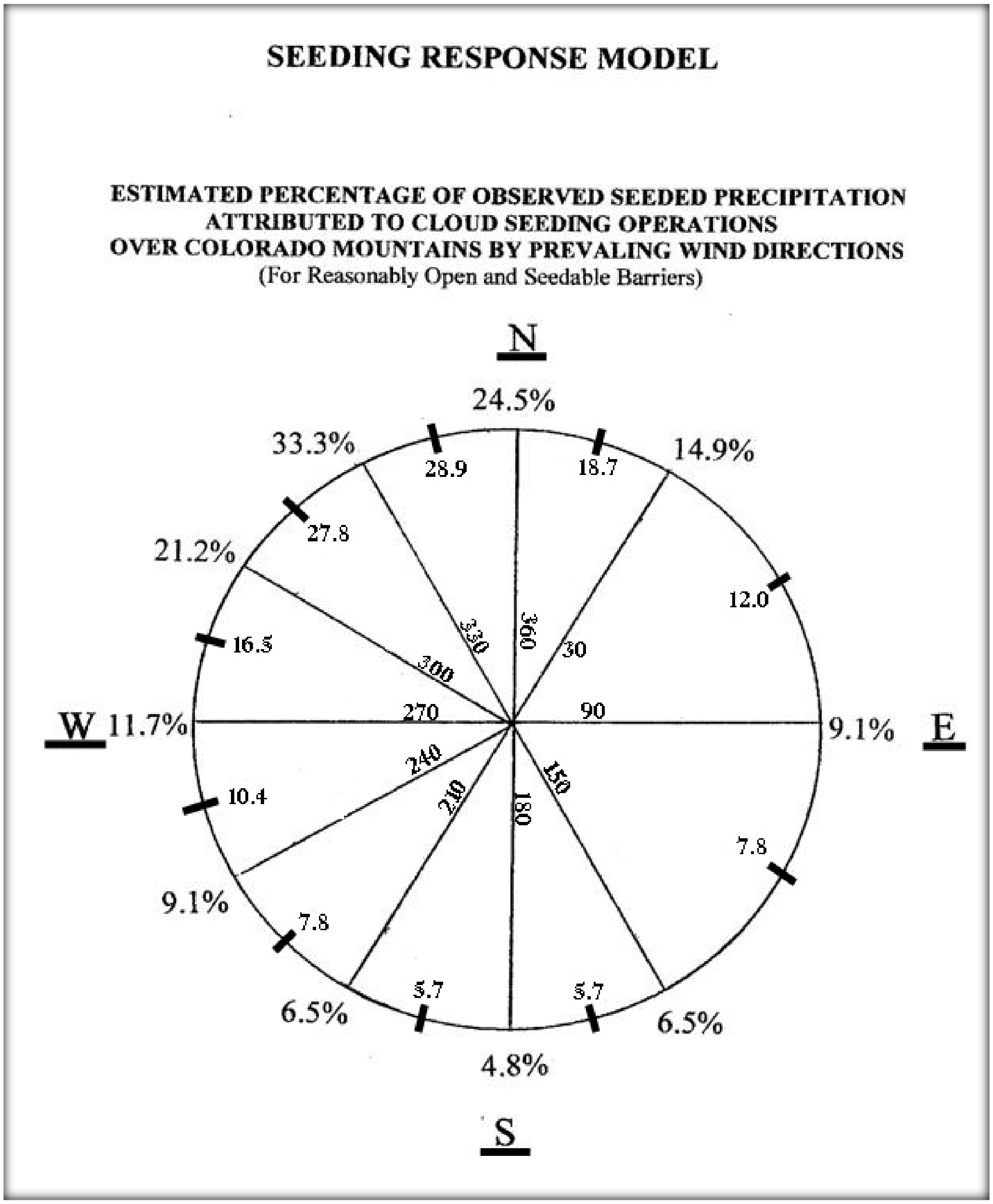
5) This estimating process is then applied to each of the SNOTEL sites that are within and immediately adjacent to the entire target seeding area and each site's total estimated increase is plotted on Map 4- Estimated Precipitation Increase across the Target Areas.

We have included the Seeding Response Model as Image 1. This model shows the estimated seeding response by wind directions as the estimated percentage of observed seeding precipitation attributed to cloud seeding operations over Colorado Mountains by average prevailing targeting wind direction.

We have included this system of estimating the effectiveness of WWC' seeding programs since the 2003-2004 winter season. This procedure of estimating the seeding responses within the Target Region allows the Program Sponsors to see a more detailed evaluation of the estimated increased in precipitation throughout their areas of interest both during the specific storm periods that were seeded and for the entire operational season for each year that the seeding program has operated. This presentation also allows for a more accurate estimate of resulting additional AF of runoff potential each spring during the runoff season for each of the river basins being seeded within the Target Area.

We will continue to provide this estimate of augmented precipitation in our future operational reports as an additional and more detailed method of determining the results of our winter seeding programs.

Image 1



Evaluation of Seeding Results and Effectiveness

An analysis of the San Juan Mountain Cloud Seeding Programs seeding precipitation increase was completed using SNOTEL precipitation sites data from December 6, 2021, through April 1, 2022. The data used was from the SNOTEL sites within and around the San Juan Mountain Cloud Seeding Programs Target Areas. The results are displayed in Table D as follows:

Table D

Estimated Precipitation Increase
Operating Season 12-7-2021 to 4-1-2022

SNOTEL Site Elevation	Normal Precipitation Season	Actual Precipitation Season	Precipitation During Seeding	Estimated Natural Precipitation	Estimated Precipitation Increase % During Seeding	Estimated Precipitation Increase % During Season
	% Normal	% Normal	% Actual	% Normal		
BEARTOWN	14.1	17.0	8.1	7.48	0.62	0.62
11,600' MSL	100.00%	121%	47.65%	53.06%	8.28%	3.78%
BLACK MESA	16.5	16.7	4.9	4.66	0.24	0.24
11,564' MSL	100.00%	101%	29.34%	28.24%	5.21%	1.48%
CASCADE	12.9	14.2	10.7	9.68	1.02	1.02
8,880' MSL	100.00%	110%	75.35%	75.07%	10.49%	7.70%
COLUMBUS BASIN	16.6	18.2	12.6	11.78	0.82	0.82
10,785' MSL	100.00%	110%	69.23%	70.94%	6.99%	4.74%
CUMBRES TRESTLE	15.7	20.5	4.4	4.11	0.29	0.29
10,040' MSL	100.00%	131%	21.46%	26.16%	7.14%	1.45%
EL DIENTE PEAK	12.4	13.1	7.3	6.63	0.67	0.67
10,000' MSL	100.00%	106%	55.73%	53.47%	10.11%	5.39%
GRAYBACK	11.7	12.7	8.2	7.78	0.42	0.42
11,620' MSL	100.00%	109%	64.57%	66.48%	5.42%	3.43%
IDARADO	12.2	11.7	5.3	5.02	0.28	0.28
9,800' MSL	100.00%	96%	45.30%	41.13%	5.62%	2.47%
LILY POND	11.6	13.7	7.1	6.71	0.39	0.39
11,000' MSL	100.00%	118%	51.82%	57.85%	5.80%	2.92%
LIZARD HEAD PASS	9.5	9.5	6.1	5.50	0.60	0.60
10,200' MSL	100.00%	100%	64.21%	57.87%	10.97%	6.78%
LONE CONE	12.2	12.5	1.9	1.80	0.10	0.10
9,600' MSL	100.00%	102%	15.20%	14.78%	5.40%	0.79%
Middle Creek	14.5	15.8	10.8	10.24	0.56	0.56
11,250' MSL	100.00%	109%	68.35%	70.64%	5.43%	3.65%
MINERAL CREEK	10.4	12.6	7.3	6.78	0.52	0.52
10,040' MSL	100.00%	121%	57.94%	65.17%	7.70%	4.32%
MOLAS LAKE	12.5	16.6	12.7	11.48	1.22	1.22
10,500' MSL	100.00%	133%	76.51%	91.86%	10.61%	7.92%
PURGATORY	N/A	N/A	14.06	12.78	1.28	1.28
10,822' MSL	N/A	N/A	N/A	N/A	N/A	9.10%
RED MOUNTAIN PASS	16.2	16.7	8.2	7.59	0.61	0.61
11,200' MSL	100.00%	103%	49.10%	46.86%	8.02%	3.78%
SCOTCH CREEK	11.4	12.4	8.5	7.71	0.79	0.79
9,100' MSL	100.00%	109%	68.55%	67.67%	10.18%	6.76%
SHARKSTOOTH	14.2	18.2	11.2	10.28	0.92	0.92
10,720' MSL	100.00%	128%	61.54%	72.42%	8.92%	5.31%
SLUMGULLION	8.6	8.2	3.8	3.73	0.07	0.07
11,560' MSL	100.00%	95%	46.34%	43.41%	1.78%	0.82%
SPUD MOUNTAIN	19.4	24.1	16.7	15.16	1.54	1.54
10,660' MSL	100.00%	124%	69.29%	78.15%	10.15%	6.82%
STUMP LAKES	12.6	13.4	8.9	8.14	0.76	0.76
11,200' MSL	100.00%	106%	66.42%	64.59%	9.35%	6.02%
TELLURIDE	N/A	N/A	14.6	12.67	1.90	1.90
11,850' MSL	N/A	N/A	N/A	N/A	N/A	13.04%
Upper Rio Grande	5.3	6.2	5.1	4.83	0.27	0.27
9,400' MSL	100.00%	117%	82.26%	91.07%	5.66%	4.61%
Upper San Juan	22.7	26.8	13.5	12.64	0.86	0.86
10,200' MSL	100.00%	118%	50.37%	55.68%	6.82%	3.32%
VALLECITO	11.3	13.2	9.1	8.46	0.64	0.64
10,880' MSL	100.00%	117%	68.94%	74.86%	7.58%	5.11%
WAGER GULCH	8.5	8.1	4.6	4.38	0.22	0.22
11,132' MSL	100.00%	95%	56.79%	51.49%	5.11%	2.84%
WEMINUCHE CREEK	14.0	15.2	8.8	8.28	0.52	0.52
10,749' MSL	100.00%	109%	57.89%	59.15%	6.27%	3.53%
Wolf Creek Summit	21.4	25.4	14.2	13.50	0.70	0.70
11,000' MSL	100.00%	119%	55.91%	63.07%	5.21%	2.85%

*All values other than percentages in the above Table are in inches of water.

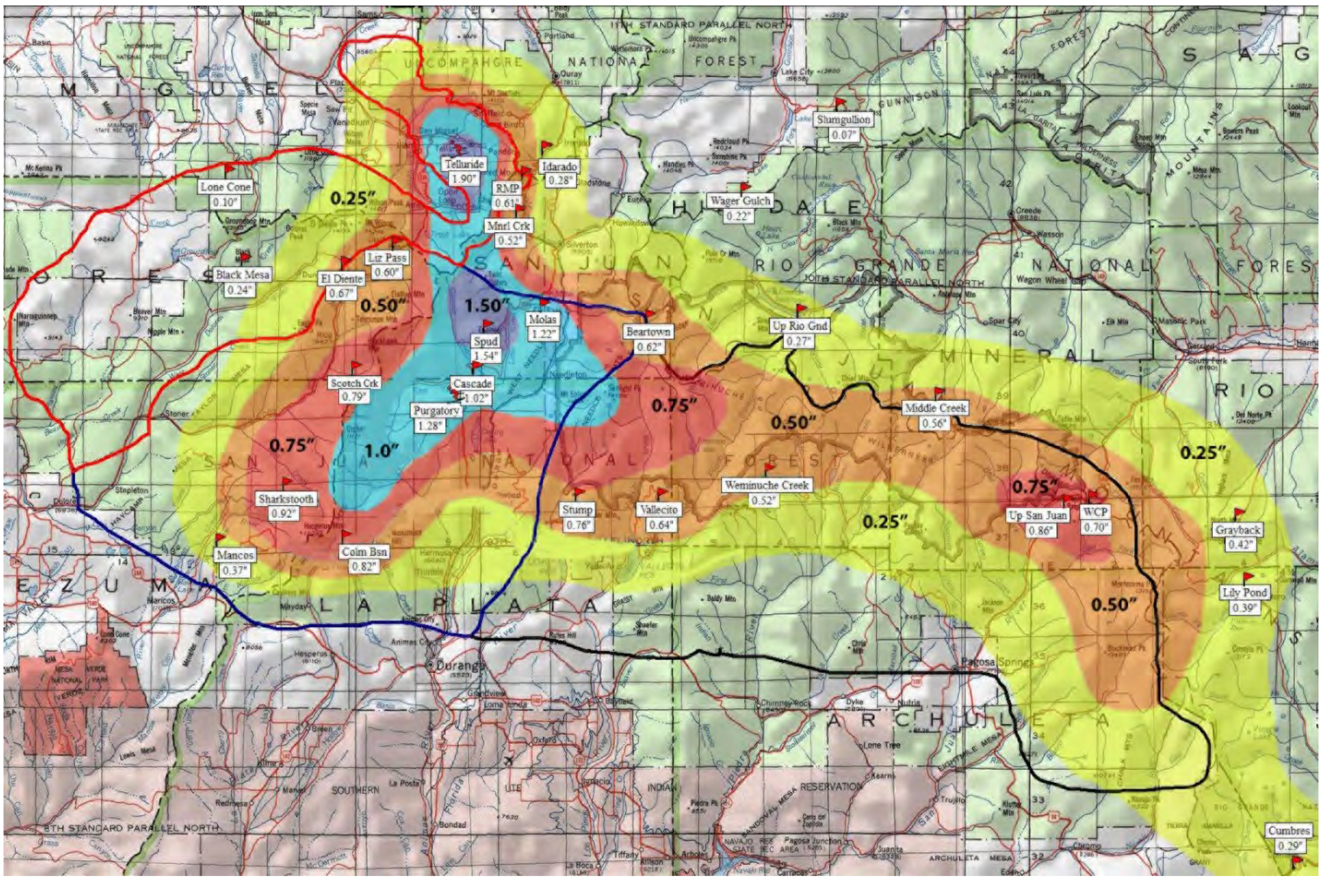
The first column in Table D shows the past ten-year average precipitation amount that has been observed during this seasons' operational period. The second column is the actual precipitation amount observed in inches of water throughout the duration of this winter's seeding program and its percentage of normal. The third column of numbers indicates the amount of precipitation that occurred during the seeding events as a percent of this season's total observed amount. The fourth column of numbers is the calculated amount of natural precipitation during the seeding season that would have occurred without a seeding program (observed precipitation during seeding less the calculated seeding increase for this site) and its percent of normal. The fifth column of numbers is the calculated amount of the precipitation increase during the seeding period and its percentage of the natural precipitation that was seeded. The last column is the estimated increase in precipitation for the season as a percentage of the normal season's precipitation.

The information in Table D and Map 2 is translated into estimated increased water in the snowpack and used to calculate the estimated acre feet of potential additional stream flow from a basin. WWC calculates the square miles primarily above 8,500 feet MSL which is then converted into total acres in that specific basin. The total acres within each basin are multiplied by the average estimated increase factor (inches of increase) derived from the regional SNOTELs for each specific basin. This estimating process may vary by 10 to 15 percent on either side of the basin depending on which side of the basin was more favorably affected by the average targeting winds during a seeding event. This method, as described in the Procedures and Methodology for Estimating Precipitation, in conjunction with the previously stated method to calculate estimated acre feet is used to calculate potential additional stream flow from seeding operations and was also used to estimate both precipitation increases and increased stream flows in the Rocky Mountain Region including the San Juan Programs. This method is based on more conservative increase values derived in WWC's research analysis from the CRBPP and the Vail Region Analysis.

The total additional snowpack water available for runoff resulting from WWC's cloud seeding efforts is plotted on Map 2. This water in the snowpack is convertible to additional inches of snow for the program sponsors with recreational interests. Map 2 shows the SNOTEL sites, the estimated increase in precipitation figures contained in Table D and contour lines denoting estimated increased precipitation from seeding for the Target Area. The San Juan Programs are denoted by a solid red, blue and black line. Map 2 also defines the size of the various regions within the three Target Areas for the calculation of the AF from the precipitation increases.

Map 2

Estimated Precipitation Increase across the 3 San Juan Mountain Target Areas: The Yellow shaded area is a 0.25" increase, Orange = 0.50", Red = 0.75", Blue = 1.0", Purple = 1.5" increase.



Although this evaluation procedure has not had an independent, scientific peer-review, it was presented to the Weather Modification Association at the 2003 annual meeting in Rapid City South Dakota. This calculation method is designed to calculate a precise value for the precipitation or stream flow increase for a specific SNOTEL site or river basin. WWC realizes that without precise data verifications for each seeded event, these numbers are "professional best estimates", and the actual calculated results could likely vary by as much as 10% to 15% higher or lower based upon the effects of the seeding for each storm event. A complete write up of the evaluation procedures and augmentation potential factors can be found in both the Project Information “Seeding Potential and Evaluation” section on page 12, and the “Evaluation of Seeding Results and Effectiveness” section on page 40.

As a result, the estimated increased water in the snowpack in Acre Feet (AF) of water for each of the basins seeded in and around the San Juan Program Target Areas for the 2021 - 2022 Program as follows:

WDT Program Estimated Increase

West Dolores River Basin– 170 Sq. Miles X 0.13” = 1,179 AF

San Miguel River Basin – 257 Sq. Miles X .99” = 13,581 AF

Total Area 427 Sq. Miles

Estimate of Total Water Increase – 14,760 AF

The evaluation of the 2021–2022 WDT Weather Modification area produce an estimated additional 12,989 to 15,498 AF of water with our calculated best estimate of 14,760 AF of water in the snowpack and an additional 7.5 to 19 inches of snowfall for Telluride and the surrounding region. With $102,056.00 of the funding used this year including any of the previous seasons carry forward funds, if any, and remote generator funding the cost per AF of water increased was funded at an approximate cost of $6.59 to $7.86 per AF and $6.91 using our calculated best estimated increase of 14,760 AF.

WSJ PROGRAM ESTIMATED INCREASE

Upper Animas River Basin – 659 Sq. Miles X 0.85” = 29,951 AF

Upper La Plata River Basin – 32 Sq. Miles X 0.61” = 1,033 AF

Dolores River Basin – 371 Sq. Miles X 0.71” = 14,078 AF

Total Area 1,062 Sq. Miles

Estimate of Total Water Increase – 45,062 AF

The evaluation of the 2021-2022 WSJ Weather Modification area produced and additional 39,655 to 47,315 AF of water with our calculated best estimate of 45,062 AF of water in the snowpack and an additional 10 to 15 inches of snowfall for Purgatory and the surrounding areas. With $107,463 of the funding used this year including any of the previous seasons carry forward funds, if any, and remote generator funding the cost per AF of water increased was funded at an approximate cost of $2.27 to $2.71 per AF and $2.38 per AF using our calculated best estimated increase of 45,062 AF.

ESJ PROGRAM TARGET AREAS ESTIMATED INCREASE

Upper Florida River Basin – 63 Sq. Miles X 0.56” = 1,897 AF

Upper Pine River Basin – 238 Sq. Miles X 0.73” = 9,318 AF

Four-mile Creek – 35 Sq. Miles X 0.38” = 700 AF

Upper Blanco River Basin – 110 Sq. Miles X 0.57” = 3,316 AF

Navajo & Little Navajo River Basins – 91 Sq. Miles X 0.38” = 1,820 AF

Piedra River Basin – 306 Sq. Miles X 0.45” = 7,398 AF

Upper San Juan River Basin – 213 Sq. Miles X 0.83” = 9,445 AF

Total Area 1,056 Sq. Miles

Estimate of Total Water Increase – 33,893 AF

The evaluation of the 2021-2022 ESJ Weather Modification area produced and additional 29,826 to 35,588 AF of water with our calculated best estimate of 33,893 AF of water in the snowpack and an additional 5 to 9 inches of snowfall for the surrounding areas. With $77,916 of the funding used this year including any of the previous seasons carry forward funds, if any, and remote generator funding the cost per AF of water increased was funded at an approximate cost of $2.19 to $2.61 per AF and $2.30 per AF using our calculated best estimated increase of 33,893 AF.

All three programs combined produced and estimated 82,469 to 98,400 AF of water with our calculated best estimate of 93,715 AF of water in the snowpack and an additional 5 to 19 inches of snowfall for the surrounding areas and ski resorts. With $287,435 of funding used this year including any of the previous seasons carry forward funds, if any, and remote generator funding the cost per AF of water increased was funded at an approximate cost of $2.92 to $3.49 per AF and $3.07 per AF using our calculated best estimated increase of 93,715 AF for the entire SJM Program.

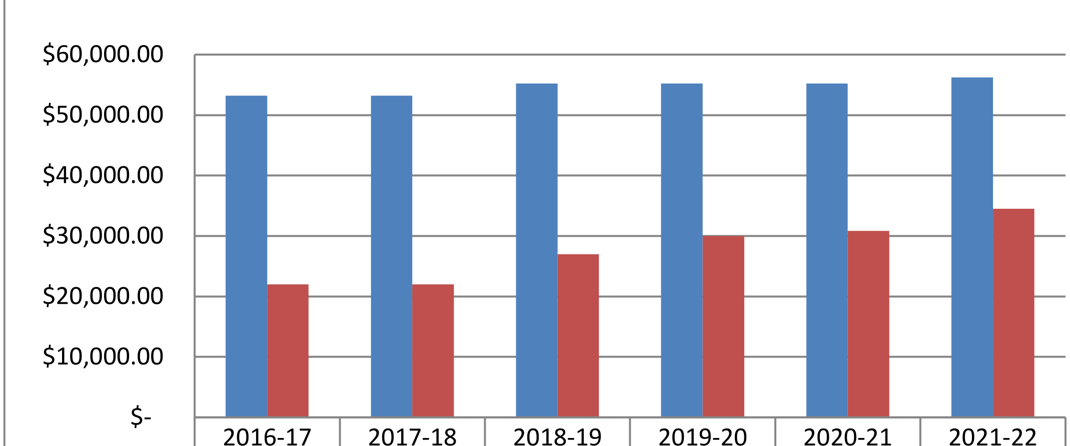
Contracted Funding Sources for the SJM Program

Graphs demonstrating the funding sources for each of the contracting areas in the SJM Program are presented below to show the relative funding support from all the participating entities involved from the 2016-2017 winter season through the 2021-2022 winter season. The additional State and Lower Colorado River Basin funding has primarily been used to extend the seeding operations beyond the time frame the locally funded operations would allow for. The graph only shows the funding that all entities have designated for the seasons shown. Funds designated to be carried forward and funds not used that will be carried forward are not included.

WDT

Over the 2020-21 winter there was no local funding carried forward into the 2021-22 winter season. The funding provided for the 2021-22 season totaled $90,699 of which $87,056 was available for operations. After the completion of the 2021-22 season there were no unused local funds to be carried forward into the 2022-2023 cloud seeding season. In addition to the contracted funding there was $15,000 to support remote operations provided by the State and Lower Basin not included in this graph.

Funding Sources 2016-2022

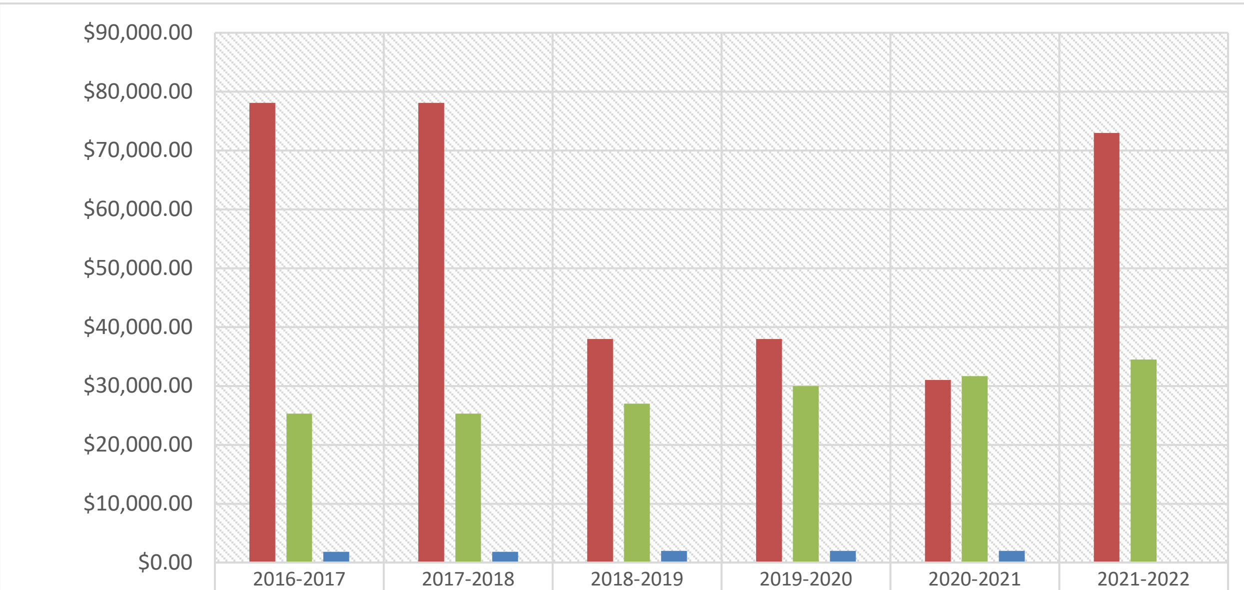


	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Local	$53,200.00	$53,200.00	$55,200.00	$55,200.00	$55,200.00	$56,200.00
State/LCRB	$22,000.00	$22,000.00	$27,000.00	$30,000.00	$30,841.00	$34,499.00

WSJ

Over the 2020-21 winter there was no local funding carried forward into the 2021-22 winter season. The funding provided for the 2021-22 season totaled $107,499 of which $102,463 was available for operations. After the completion of the 2021-22 season there will be no unused local funds to be carried forward into the 2022-2023 cloud seeding season. In addition to the contracted funding there was an additional $5,000 dollars to support remote operations provided by the State and Lower Basin.

Funding Sources 2016-2022

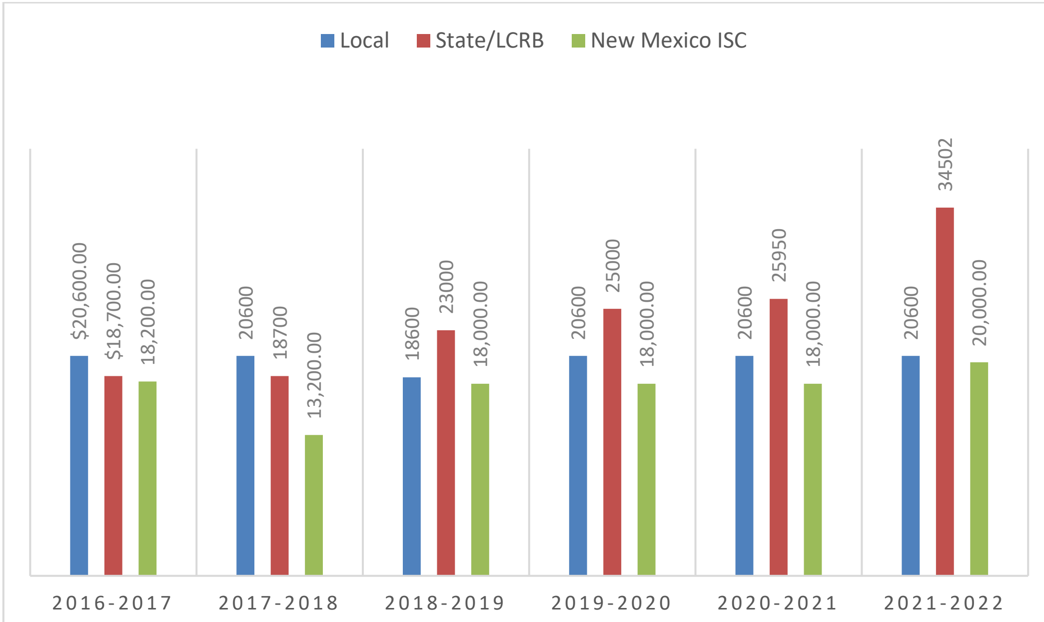


	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022
Local	$78,100.00	$78,100.00	$38,000.00	$38,000.00	$31,000.00	$73,000.00
State/LCRB	$25,300.00	$25,300.00	$27,000.00	$30,000.00	$31,674.00	$34,499.00
New Mexico ISC	$1,800.00	$1,800.00	$2,000.00	$2,000.00	$2,000.00	$0.00

ESJ

Over the 2020-21 winter there was no local funding carried forward into the 2021-22 winter season. The funding provided for the 2021-22 season totaled $75,102 of which $72,916 was available for operations. After the completion of the 2021-22 season there will be no unused local funds to be carried forward into the 2022-2023 cloud seeding season. In addition to the contracted funding there was an additional $5,000 dollars to support remote operations provided by the State and Lower Basin.

Funding Sources 2016-2022



Recommendations

Since Colorado has frequent periods of drought and the variability of the weather patterns from one year to the next, WWC recommends that the program sponsors continue participating in cloud seeding programs on a routine basis each year. Provisions can always be made to suspend or terminate a cloud seeding program in above normal precipitation/snowpack years when additional water may not be beneficial. We recommend this approach for several reasons. First, it cannot be accurately predicted if precipitation during the coming winter season will be above or below normal. Having a cloud seeding program in place takes advantage of each seeding opportunity. Second, seeding in normal to above normal years of precipitation provides additional precipitation resulting in valuable carryover storage in surface reservoirs and/or underground aquifers that can be drawn from during dry years. Third, the continuity of conducting a cloud seeding program each year provides for the planned budgeting of the program and thereby prevents potential difficulties in attempting to obtain special funding during a drought situation. Finally, conducting a cloud seeding program only after the onset of drought conditions may mean fewer cloud seeding opportunities and therefore, less additional precipitation generated from the program. Again, it is our recommendation that the San Juan Mountain Weather Modification Program be continued in the 2022-2023 season.

Ideas voiced from program sponsors and continued discussions over the past few years have led to the following suggestions towards improving the quality and effectiveness of our seeding operations during the up-coming 2022-23 season:

1. There are proposals to ask the CWCB/LCRB to consider funding the permanent installation of new equipment that would benefit the San Juan Programs. High intensity precipitation gauges placed at key locations would better measure and correlate observations at frequently used SNOTEL data sites. This new information will better confirm or measure current precipitation data from evaluation sites and allow WWC to identify precipitation intensity data with the onset of an identifiable seeding affect resulting from the seeding generators being utilized. Remote Icing Sensors placed in key areas would confirm that super cool water is present and help with the onset of seeding operations. Also, to repair existing weather stations and upgrade with some of the aforementioned items. For the price, these options are a good value for the information they would produce.

2. The programs are permitted to run from November 1 thru April 15 each season. It is essential for each participating entity to have funds budgeted to pay for services, initial set up and operations, taking place on both sides of the budgeting year. WWC orders solution for each season based on communication and verbal commitments from the Sponsors in late July, followed by site maintenance and program readiness beginning in September. Initial billing invoices need to be sent out in the middle of September with payment due at the time contracts are finalized. Final contracts need to be signed by the first of October to ensure that the payment for the initial part of the programs can be paid by the middle of October allowing for an on time start to the program.
3. That we continue to work closely with Dolores Water Conservancy District in ongoing discussions to develop a cohesive contracting and invoicing process to ensure cloud seeding operations will begin on time as we progress into the 2022-23 season.

Image 2

Certificate of Liability Insurance for the Cloud Seeding Operations conducted by Western Weather Consultants LLC during the 2021-2022 winter season.

ACORD®

CERTIFICATE OF LIABILITY INSURANCE

DATE (MM/DD/YYYY): 10/27/2021

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must have ADDITIONAL INSURED provisions or be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER
The Buckner Company of Colorado
6400 S Fiddlers Green Circle Suite 950
Greenwood Village CO 80111

CONTACT NAME: Heather [redacted]
PHONE (A/C, No, Ext): 303.756.[redacted]
FAX (A/C, No): 303.756.[redacted]
E-MAIL ADDRESS: Denver@buckner.com

INSURER(S) AFFORDING COVERAGE	NAIC #
INSURER A : Homeland Insurance Company of New York	34452
INSURER B :	
INSURER C :	
INSURER D :	
INSURER E :	
INSURER F :	

INSURED WESTWEA-01
Western Weather Consultants
1102 Co. Rd 220
Durango CO 81303

COVERAGES **CERTIFICATE NUMBER:** 284751014 **REVISION NUMBER:**

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSD	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
A	X COMMERCIAL GENERAL LIABILITY	Y	Y	793011[redacted]	11/1/2021	11/1/2022	EACH OCCURRENCE	$ 2,000,000
	CLAIMS-MADE X OCCUR						DAMAGE TO RENTED PREMISES (Ea occurrence)	$ 100,000
							MED EXP (Any one person)	$ 10,000
							PERSONAL & ADV INJURY	$ 2,000,000
	GEN'L AGGREGATE LIMIT APPLIES PER:						GENERAL AGGREGATE	$ 2,000,000
	X POLICY PRO-JECT LOC						PRODUCTS - COMP/OP AGG	$ 2,000,000
	OTHER:							$
	AUTOMOBILE LIABILITY						COMBINED SINGLE LIMIT (Ea accident)	$
	ANY AUTO						BODILY INJURY (Per person)	$
	OWNED AUTOS ONLY / SCHEDULED AUTOS						BODILY INJURY (Per accident)	$
	HIRED AUTOS ONLY / NON-OWNED AUTOS ONLY						PROPERTY DAMAGE (Per accident)	$
								$
	UMBRELLA LIAB / OCCUR						EACH OCCURRENCE	$
	EXCESS LIAB / CLAIMS-MADE						AGGREGATE	$
	DED RETENTION $							$
	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY Y / N						PER STATUTE / OTH-ER	
	ANYPROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBER EXCLUDED? (Mandatory in NH) N / A						E.L. EACH ACCIDENT	$
	If yes, describe under DESCRIPTION OF OPERATIONS below						E.L. DISEASE - EA EMPLOYEE	$
							E.L. DISEASE - POLICY LIMIT	$
A	Contractor's Pollution			7930115[redacted]	11/1/2021	11/1/2022	Each Pollution Condt Deductible	1,000,000 5,000

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (ACORD 101, Additional Remarks Schedule, may be attached if more space is required)
Certificate holder is Additional Insured per form OBENV GE 346 01 19 including completed operations per General Liability form OBENV GE 351 09 20 on a Primary and Noncontributory basis per OBENV GE 319 11-20. Wavier of Subrogation applies to the General Liability per form OBENV GE 320 11 20.

Appendix A:
Summary by Seeding Event

December 6, 2021

													WDO	WSJ	ESJ
							Primary Target						CWCB	CWCB	CWCB
	Start Day Time	Stop Day Time	Hrs.	Rate	Output	WDO	TELSKI	WSJ	PURG	ESJ	NM		LCRB	LCRB	LCRB
S3	12/6/2021 21:30	12/7/2021 7:30	10.00	12	120.00		10.00								
S45	12/6/2021 21:30	12/7/2021 8:00	10.50	12	126.00	5.25	5.25								
S42	12/6/2021 21:00	12/7/2021 8:00	11.00	12	132.00	5.50	5.50								
		totals	31.50		378.00	10.75	20.75	0.00	0.00	0.00	0.00		0.00	0.00	0.00

Storm Type		Shortwave Trough
Originated		Pacific Coast
Storm Start Date/Time		12/6/2021 21:00
Storm Stop Date/Time		12/7/2021 13:00
Seed Start Date /Time		12/6/2021 21:00
Seed Stop Date/Time		12/7/2021 8:00
Start of Seeding Target Winds		270-280
Start of Seeding Wind Speed		5-10 Knots
Start of Seeding Temperature		-5 C
Wind Shift Date /Time		n/a
End of Seeding Target Winds		290-300
End of Seeding Wind Speed		5-10 Knots
End of Seeding Temperature		-6 C
Number of Generators used		3
Number of Seeding Hours used		31.50
Amount of AgI used		378.00
Start of Seeding SNOTEL Readings for	El Diente	0.03
End of Seeding SNOTEL Readings for	El Diente	0.07
Increase		0.04
Start of Seeding SNOTEL Readings for	Red Mountain	4.10
End of Seeding SNOTEL Readings for	Red Mountain	4.40
Increase		0.30
Forecast Telluride Precipitation		7.1"
Telluride Ski Report		6"
Forecast Purgatory Precipitation		4.4"
Purgatory Ski Report		3"
Notes:	Best precipitation ended mid morning.	

December 8, 2021

												WDO	WSJ	ESJ
							Primary Target					CWCB	CWCB	CWCB
	Start Day Time	Stop Day Time	Hrs.	Rate	Output	WDO	TELSKI	WSJ	PURG	ESJ	NM	LCRB	LCRB	LCRB
S45	12/8/2021 17:00	12/8/2021 22:00	5.00	14	70.00		5.00							
S42	12/8/2021 18:00	12/8/2021 22:00	4.00	14	56.00		4.00							
S41	12/8/2021 17:15	12/8/2021 22:00	4.75	14	66.50	2.37			2.37					
S9	12/8/2021 17:00	12/8/2021 22:00	5.00	14	70.00				5.00					
S65	12/8/2021 17:00	12/8/2021 22:00	5.00	14	70.00	5.00								
S32	12/8/2021 17:00	12/8/2021 22:00	5.00	14	70.00			5.00						
S31	12/8/2021 17:00	12/8/2021 22:00	5.00	14	70.00			2.50		2.50				
S63	12/8/2021 17:15	12/8/2021 22:15	5.00	14	70.00						5.00			
S59	12/8/2021 17:00	12/8/2021 22:00	5.00	14	70.00						5.00			
S33	12/8/2021 17:00	12/8/2021 22:00	5.00	14	70.00						5.00			
		totals	48.75		682.50	7.37	9.00	7.50	7.37	2.50	15.00	0.00	0.00	0.00

Storm Type		Low Pressure System
Originated		Southern California
Storm Start Date/Time		12/8/2021 14:00
Storm Stop Date/Time		12/9/2021 1:00
Seed Start Date /Time		12/8/2021 17:00
Seed Stop Date/Time		12/8/2021 22:15
Start of Seeding Target Winds		250-260
Start of Seeding Wind Speed		10-15 Knots
Start of Seeding Temperature		-5 C
Wind Shift Date /Time		N/A
End of Seeding Target Winds		260-270
End of Seeding Wind Speed		10-15 Knots
End of Seeding Temperature		-7 C
Number of Generators used		10
Number of Seeding Hours used		48.75
Amount of AgI used		682.50
Start of Seeding SNOTEL Readings for	Lone Cone	2.20
End of Seeding SNOTEL Readings for	Lone Cone	2.30
Increase		0.10
Start of Seeding SNOTEL Readings for	Spud Mountain	0.80
End of Seeding SNOTEL Readings for	Spud Mountain	1.00
Increase		0.20
Start of Seeding SNOTEL Readings for	Cumbres Trestle	1.80
End of Seeding SNOTEL Readings for	Cumbres Trestle	2.00
Increase		0.20
Forecast Telluride Precipitation		1.2"
Telluride Ski Report		2"
Forecast Purgatory Precipitation		1.4"
Purgatory Ski Report		2"
Forecast Wolf Creek Precipitation		5.2"
Wolf Creek Ski Report		4"
Notes:		Flurries continued after seeding ended

December 9, 2021

												WDO	WSJ	ESJ
						Primary Target						CWCB	CWCB	CWCB
	Start Day Time	Stop Day Time	Hrs.	Rate	Output	WDO	TELSKI	WSJ	PURG	ESJ	NM	LCRB	LCRB	LCRB
S64	12/9/2021 22:00	12/10/2021 10:00	12.00	16	192.00		12.00							
S3	12/9/2021 21:15	12/10/2021 10:00	12.75	16	204.00		12.75							
S40	12/9/2021 22:00	12/10/2021 10:00	12.00	16	192.00		12.00							
S45	12/9/2021 20:00	12/10/2021 8:00	12.00	16	192.00	4.80	7.20							
S42	12/9/2021 20:00	12/10/2021 8:00	12.00	16	192.00	4.80	7.20							
S41	12/9/2021 20:15	12/10/2021 7:30	11.25	16	180.00			5.63	5.63					
S9	12/9/2021 20:00	12/10/2021 7:00	11.00	16	176.00			5.50	5.50					
S62	12/9/2021 20:00	12/10/2021 6:00	10.00	16	160.00	10.00								
S65	12/9/2021 23:00	12/10/2021 7:00	8.00	16	128.00	8.00								
S12	12/9/2021 20:00	12/10/2021 6:00	10.00	16	160.00			5.00	5.00					
S32	12/9/2021 20:00	12/10/2021 5:00	9.00	16	144.00			4.50	4.50					
S31	12/8/2021 10:00	12/10/2021 6:00	44.00	16	704.00			22.00		22.00				
S26	12/9/2021 20:15	12/10/2021 7:00	10.75	16	172.00					10.75				
S27	12/9/2021 20:30	12/10/2021 7:00	10.50	16	168.00					10.50				
S63	12/9/2021 20:15	12/10/2021 8:30	12.25	16	196.00						12.25			
S59	12/9/2021 20:00	12/10/2021 8:00	12.00	16	192.00						12.00			
S33	12/9/2021 20:00	12/10/2021 8:00	12.00	16	192.00						12.00			
		totals	221.50		3544.00	27.60	51.15	42.62	20.62	43.25	36.25	0.00	0.00	0.00

Storm Type		Deep low-pressure trough
Originated		Pacific Coast
Storm Start Date/Time		12/9/2021 16:00
Storm Stop Date/Time		12/10/2021 9:00
Seed Start Date /Time		12/9/2021 20:00
Seed Stop Date/Time		12/10/2021 10:00
Start of Seeding Target Winds		230-240
Start of Seeding Wind Speed		15-20 Knots
Start of Seeding Temperature		-5 C
Wind Shift Date /Time		12/10/2021 6:00
End of Seeding Target Winds		310-320
End of Seeding Wind Speed		15-20 Knots
End of Seeding Temperature		-13 C
Number of Generators used		17
Number of Seeding Hours used		221.50
Amount of AgI used		3544.00
Start of Seeding SNOTEL Readings for	Lone Cone	3.00
End of Seeding SNOTEL Readings for	Lone Cone	4.10
Increase		1.10
Start of Seeding SNOTEL Readings for	Sharkstooth	2.80
End of Seeding SNOTEL Readings for	Sharkstooth	4.20
Increase		1.40
Start of Seeding SNOTEL Readings for	Cumbres Trestle	2.40
End of Seeding SNOTEL Readings for	Cumbres Trestle	4.90
Increase		2.50
Forecast Telluride Precipitation		12.9"
Telluride Ski Report		23"
Forecast Purgatory Precipitation		12.4"
Purgatory Ski Report		27"
Forecast Wolf Creek Precipitation		28.7"
Wolf Creek Ski Report		26"
Notes:	Temperatures to warm at start of the storm.	

December 15, 2021

												WDO	WSJ	ESJ
						Primary Target						CWCB	CWCB	CWCB
	Start Day Time	Stop Day Time	Hrs.	Rate	Output	WDO	TELSKI	WSJ	PURG	ESJ	NM	LCRB	LCRB	LCRB
S45	12/15/2021 7:00	12/15/2021 10:00	3.00	10	30.00		3.00							
S42	12/15/2021 5:00	12/15/2021 10:00	5.00	10	50.00		5.00							
S9	12/15/2021 6:30	12/15/2021 11:00	4.50	10	45.00			2.25	2.25					
S62	12/15/2021 5:00	12/15/2021 10:00	5.00	10	50.00	5.00								
S65	12/15/2021 6:00	12/15/2021 11:00	5.00	10	50.00	5.00								
S12	12/15/2021 5:00	12/15/2021 13:00	8.00	10	80.00			4.00	4.00					
S32	12/15/2021 6:30	12/15/2021 11:00	4.50	10	45.00			2.25	2.25					
S31	12/15/2021 6:00	12/15/2021 11:00	5.00	10	50.00					5.00				
S63	12/15/2021 5:00	12/15/2021 13:00	8.00	10	80.00						8.00			
S59	12/15/2021 7:00	12/15/2021 13:00	6.00	10	60.00						6.00			
S33	12/15/2021 5:00	12/15/2021 13:00	8.00	10	80.00						8.00			
		totals	62.00		620.00	10.00	8.00	8.50	8.50	5.00	22.00	0.00	0.00	0.00

Storm Type		Low Pressure Trough
Originated		Southern California
Storm Start Date/Time		12/14/2021 22:00
Storm Stop Date/Time		12/15/2021 16:00
Seed Start Date /Time		12/15/2021 5:00
Seed Stop Date/Time		12/15/2021 13:00
Start of Seeding Target Winds		250-260
Start of Seeding Wind Speed		25-30 Knots
Start of Seeding Temperature		-6 C
Wind Shift Date /Time		12/15/2021 10:00
End of Seeding Target Winds		260-270
End of Seeding Wind Speed		10-15 Knots
End of Seeding Temperature		-13 C
Number of Generators used		11
Number of Seeding Hours used		62.00
Amount of AgI used		620.00
Start of Seeding SNOTEL Readings for	El Diente	4.70
End of Seeding SNOTEL Readings for	El Diente	4.90
Increase		0.20
Start of Seeding SNOTEL Readings for	Spud Mountain	5.50
End of Seeding SNOTEL Readings for	Spud Mountain	5.70
Increase		0.20
Start of Seeding SNOTEL Readings for	Wolf Creek	8.90
End of Seeding SNOTEL Readings for	Wolf Creek	9.40
Increase		0.50
Forecast Telluride Precipitation		6.3"
Telluride Ski Report		5"
Forecast Purgatory Precipitation		6.2"
Purgatory Ski Report		6"
Forecast Wolf Creek Precipitation		8.0"
Wolf Creek Ski Report		7"
Notes:	Flurries continued after seeding ended mostly in ESJ	
	Temperatures to warm at beginning of storm	

December 23, 2021

												WDO	WSJ	ESJ
						Primary Target						CWCB	CWCB	CWCB
	Start Day Time	Stop Day Time	Hrs.	Rate	Output	**WDO**	**TELSKI**	**WSJ**	**PURG**	**ESJ**	**NM**	**LCRB**	**LCRB**	**LCRB**
S42	12/24/2021 8:00	12/24/2021 21:00	13.00	12	156.00		13.00							
S41	12/24/2021 8:00	12/24/2021 18:30	10.50	12	126.00			5.25	5.25					
S9	12/24/2021 8:00	12/24/2021 22:00	14.00	12	168.00			7.00	7.00					
S62	12/24/2021 8:00	12/24/2021 22:00	14.00	12	168.00	14.00								
S65	12/24/2021 8:00	12/24/2021 21:00	13.00	12	156.00	13.00								
S12	12/24/2021 8:00	12/24/2021 22:00	14.00	12	168.00			7.00	7.00					
S32	12/24/2021 8:00	12/25/2021 8:00	24.00	12	288.00			12.00	12.00					
S13	12/24/2021 8:00	12/25/2021 8:00	24.00	12	288.00				24.00					
S37	12/24/2021 8:00	12/24/2021 22:00	14.00	12	168.00				14.00					
S57	12/24/2021 7:00	12/24/2021 22:00	15.00	12	180.00					15.00				
S31	12/24/2021 8:00	12/24/2021 22:15	14.25	12	171.00					14.25				
S26	12/23/2021 22:00	12/24/2021 22:00	24.00	12	288.00					24.00				
S27	12/23/2021 21:30	12/24/2021 8:00	10.50	12	126.00					10.50				
S63	12/23/2021 22:00	12/24/2021 22:00	24.00	12	288.00						24.00			
S59	12/24/2021 8:00	12/24/2021 22:15	14.25	12	171.00						14.25			
		totals	242.50		2910.00	27.00	13.00	31.25	69.25	63.75	38.25	0.00	0.00	0.00

Storm Type		Upper level low pressure system
Originated		Southern California
Storm Start Date/Time		12/23/2021 16:00
Storm Stop Date/Time		12/25/2021 7:00
Seed Start Date /Time		12/23/2021 21:30
Seed Stop Date/Time		12/25/2021 8:00
Start of Seeding Target Winds		230-240
Start of Seeding Wind Speed		20-25 Knots
Start of Seeding Temperature		-5 C
Wind Shift Date /Time		n/a
End of Seeding Target Winds		250-260
End of Seeding Wind Speed		10-15 Knots
End of Seeding Temperature		-9 C
Number of Generators used		15
Number of Seeding Hours used		242.50
Amount of AgI used		2910.00
Start of Seeding SNOTEL Readings for	El Diente	3.40
End of Seeding SNOTEL Readings for	El Diente	5.20
Increase		1.80
Start of Seeding SNOTEL Readings for	Columbus Basin	6.70
End of Seeding SNOTEL Readings for	Columbus Basin	10.10
Increase		3.40
Start of Seeding SNOTEL Readings for	Cumbres Trestle	6.10
End of Seeding SNOTEL Readings for	Cumbres Trestle	11.30
Increase		5.20
Forecast Telluride Precipitation		11.2"
Telluride Ski Report		12"
Forecast Purgatory Precipitation		17.5"
Purgatory Ski Report		19"
Forecast Wolf Creek Precipitation		30.7"
Wolf Creek Ski Report		23"
Notes:	Flurries continued after seeding ended mostly in ESJ	
		Temperatures warm at start of storm.

December 26, 2021

												WDO	WSJ	ESJ
							Primary Target					CWCB	CWCB	CWCB
	Start Day Time	Stop Day Time	Hrs.	Rate	Output	WDO	TELSKI	WSJ	PURG	ESJ	NM	LCRB	LCRB	LCRB
S41	12/26/2021 6:00	12/26/2021 14:00	8.00	12	96.00			4.00	4.00					
S9	12/26/2021 6:30	12/26/2021 14:00	7.50	12	90.00			3.75	3.75					
S62	12/26/2021 6:00	12/26/2021 12:00	6.00	12	72.00	6.00								
S65	12/26/2021 7:00	12/26/2021 12:00	5.00	12	60.00	5.00								
S12	12/26/2021 6:00	12/26/2021 12:30	6.50	12	78.00			1.63	4.88					
S32	12/26/2021 6:30	12/26/2021 13:00	6.50	12	78.00			1.62	4.87					
S13	12/26/2021 6:00	12/26/2021 13:00	7.00	12	84.00				3.50	3.50				
S37	12/26/2021 6:00	12/26/2021 13:00	7.00	12	84.00				3.50	3.50				
S57	12/26/2021 6:00	12/26/2021 13:00	7.00	12	84.00				3.50	3.50				
S26	12/25/2021 22:00	12/26/2021 15:00	17.00	10	170.00					17.00				
S27	12/25/2021 21:30	12/26/2021 15:00	17.50	10	175.00					10.00				7.50
S63	12/25/2021 22:00	12/26/2021 6:00	8.00	10	80.00						8.00			
S63	12/26/2021 8:30	12/26/2021 15:00	6.50	10	65.00						6.50			
S59	12/25/2021 22:00	12/26/2021 15:00	17.00	10	170.00						17.00			
		totals	126.50		1386.00	11.00	0.00	11.00	28.00	37.50	31.50	0.00	0.00	7.50

Storm Type		Low Pressure Trough
Originated		Pacific Coast
Storm Start Date/Time		12/25/2021 22:00
Storm Stop Date/Time		12/26/2021 16:00
Seed Start Date /Time		12/25/2021 21:30
Seed Stop Date/Time		12/26/2021 15:00
Start of Seeding Target Winds		200-210
Start of Seeding Wind Speed		15-20 Knots
Start of Seeding Temperature		-5 C
Wind Shift Date /Time		12/26/2021 11:00
End of Seeding Target Winds		250-260
End of Seeding Wind Speed		10-15 Knots
End of Seeding Temperature		-10 C
Number of Generators used		13
Number of Seeding Hours used		126.50
Amount of AgI used		1386.00
Start of Seeding SNOTEL Readings for	Red Mountain	9.70
End of Seeding SNOTEL Readings for	Red Mountain	10.20
Increase		0.50
Start of Seeding SNOTEL Readings for	Spud Mountain	9.50
End of Seeding SNOTEL Readings for	Spud Mountain	10.10
Increase		0.60
Start of Seeding SNOTEL Readings for	Wolf Creek	14.70
End of Seeding SNOTEL Readings for	Wolf Creek	15.90
Increase		1.20
Forecast Telluride Precipitation		4.4"
Telluride Ski Report		4"
Forecast Purgatory Precipitation		4.9"
Purgatory Ski Report		8"
Forecast Wolf Creek Precipitation		19.3"
Wolf Creek Ski Report		9"
Notes:	Snow flurries continued in the region till morning	

December 27, 2021

												WDO	WSJ	ESJ
						Primary Target						CWCB	CWCB	CWCB
	Start Day Time	Stop Day Time	Hrs.	Rate	Output	WDO	TELSKI	WSJ	PURG	ESJ	NM	LCRB	LCRB	LCRB
S45	12/28/2021 17:00	12/29/2021 8:00	15.00	10	150.00		15.00							
S42	12/27/2021 18:00	12/28/2021 11:00	17.00	10	170.00		17.00							
S42	12/28/2021 17:00	12/29/2021 8:00	15.00	10	150.00		15.00							
S41	12/27/2021 17:00	12/28/2021 11:00	18.00	10	180.00	4.50	4.50		9.00					
S41	12/28/2021 17:00	12/29/2021 8:15	15.25	10	152.50	7.62	7.62							
S9	12/27/2021 17:00	12/28/2021 11:00	18.00	10	180.00	4.50	4.50		9.00					
S9	12/28/2021 17:00	12/29/2021 8:00	15.00	10	150.00	7.50	7.50							
S62	12/27/2021 17:00	12/28/2021 11:00	18.00	10	180.00	18.00								
S65	12/27/2021 20:00	12/28/2021 12:00	16.00	10	160.00	16.00								
S65	12/28/2021 17:00	12/29/2021 8:00	15.00	10	150.00	15.00								
S12	12/27/2021 18:00	12/28/2021 11:00	17.00	10	170.00			4.25	12.75					
S12	12/28/2021 17:00	12/29/2021 8:00	15.00	10	150.00			3.75	11.25					
S32	12/27/2021 18:00	12/28/2021 11:00	17.00	10	170.00			4.25	12.75					
S32	12/28/2021 17:00	12/29/2021 8:00	15.00	10	150.00			3.75	11.25					
S13	12/28/2021 15:00	12/29/2021 8:00	17.00	10	170.00			4.25	12.75					
S37	12/28/2021 15:00	12/29/2021 8:00	17.00	10	170.00			4.25	12.75					
S57	12/28/2021 15:00	12/29/2021 6:15	15.25	10	152.50									15.25
S61	12/28/2021 15:00	12/29/2021 6:00	15.00	10	150.00									15.00
S31	12/28/2021 16:30	12/29/2021 6:15	13.75	10	137.50				5.62					8.13
S26	12/27/2021 19:00	12/28/2021 11:00	16.00	10	160.00									16.00
S26	12/28/2021 18:00	12/29/2021 8:00	14.00	10	140.00									14.00
S27	12/27/2021 20:00	12/28/2021 12:00	16.00	10	160.00									16.00
S27	12/28/2021 18:00	12/29/2021 8:00	14.00	10	140.00									14.00
S59	12/28/2021 22:00	12/29/2021 6:00	8.00	10	80.00						3.25			4.75

Storm Type		Series of shortwave troughs
Originated		Pacific Coast
Storm Start Date/Time		12/27/2021 16:00
Storm Stop Date/Time		12/29/2021 8:00
Seed Start Date /Time		12/27/2021 17:00
Seed Stop Date/Time		12/29/2021 8:15
Start of Seeding Target Winds		210-220
Start of Seeding Wind Speed		20-25 Knots
Start of Seeding Temperature		-8 C
Wind Shift Date /Time		12/28/2021 4:00
End of Seeding Target Winds		260-270
End of Seeding Wind Speed		10-15 Knots
End of Seeding Temperature		-15 C
Number of Generators used		16
Number of Seeding Hours used		372.25
Amount of AgI used		3722.50
Start of Seeding SNOTEL Readings for	El Diente	5.70
End of Seeding SNOTEL Readings for	El Diente	6.80
Increase		1.10
Start of Seeding SNOTEL Readings for	Sharkstooth	8.80
End of Seeding SNOTEL Readings for	Sharkstooth	10.60
Increase		1.80
Start of Seeding SNOTEL Readings for	Wolf Creek	16.40
End of Seeding SNOTEL Readings for	Wolf Creek	18.80
Increase		2.40
Forecast Telluride Precipitation		11.0"
Telluride Ski Report		11"
Forecast Purgatory Precipitation		15.7"
Purgatory Ski Report		16"
Forecast Wolf Creek Precipitation		32.2"
Wolf Creek Ski Report		37"
Notes:		Flurries continued throughout the day

December 30, 2021

												WDO	WSJ	ESJ
						Primary Target						CWCB	CWCB	CWCB
	Start Day Time	Stop Day Time	Hrs.	Rate	Output	WDO	TELSKI	WSJ	PURG	ESJ	NM	LCRB	LCRB	LCRB
S42	12/30/2021 16:00	12/31/2021 20:00	28.00	12	336.00		16.80					11.20		
S41	12/30/2021 16:00	12/31/2021 15:30	23.50	12	282.00		23.50							
S9	12/30/2021 16:00	12/31/2021 20:00	28.00	12	336.00		4.30					23.70		
S62	12/30/2021 16:00	12/31/2021 20:00	28.00	12	336.00	3.15						24.85		
S12	12/30/2021 17:00	12/31/2021 21:00	28.00	12	336.00			11.20	16.80					
S32	12/30/2021 16:00	12/31/2021 20:00	28.00	12	336.00			11.20	16.80					
S13	12/30/2021 16:00	12/31/2021 12:00	20.00	12	240.00				20.00					
S37	12/30/2021 16:00	12/31/2021 8:00	16.00	12	192.00				16.00					
S57	12/30/2021 21:00	12/30/2021 21:15	0.25	12	3.00			0.10	0.15					
S61	12/30/2021 16:00	12/31/2021 20:00	28.00	12	336.00					6.00				22.00
S31	12/30/2021 17:30	12/31/2021 21:00	27.50	12	330.00				7.88					19.62
S18	12/31/2021 11:00	12/31/2021 20:00	9.00	12	108.00									9.00
S19	12/31/2021 11:00	12/31/2021 20:00	9.00	12	108.00									9.00
S20	12/30/2021 17:15	12/31/2021 20:00	26.75	12	321.00									26.75
S21	12/31/2021 13:00	12/31/2021 20:00	7.00	12	84.00									7.00
S27	12/30/2021 16:00	12/31/2021 21:00	29.00	12	348.00					29.00				
		totals	336.00		4032.00	3.15	44.60	22.50	77.63	35.00	0.00	59.75	0.00	93.37

Storm Type		Deep Low Pressure Trough
Originated		Pacific Coast
Storm Start Date/Time		12/30/2021 15:00
Storm Stop Date/Time		1/1/2022 5:00
Seed Start Date /Time		12/30/2021 16:00
Seed Stop Date/Time		12/31/2021 21:00
Start of Seeding Target Winds		230-240
Start of Seeding Wind Speed		10-15 Knots
Start of Seeding Temperature		-7 C
Wind Shift Date /Time		12/31/2021 21:00
End of Seeding Target Winds		310-320
End of Seeding Wind Speed		5-10 Knots
End of Seeding Temperature		-13 C
Number of Generators used		16
Number of Seeding Hours used		336.00
Amount of AgI used		4032.00
Start of Seeding SNOTEL Readings for	El Diente	7.20
End of Seeding SNOTEL Readings for	El Diente	8.30
Increase		1.10
Start of Seeding SNOTEL Readings for	Spud Mountain	12.50
End of Seeding SNOTEL Readings for	Spud Mountain	14.10
Increase		1.60
Start of Seeding SNOTEL Readings for	Cumbres Trestle	15.80
End of Seeding SNOTEL Readings for	Cumbres Trestle	17.00
Increase		1.20
Forecast Telluride Precipitation		12.1
Telluride Ski Report		12"
Forecast Purgatory Precipitation		13.9"
Purgatory Ski Report		18"
Forecast Wolf Creek Precipitation		33.1"
Wolf Creek Ski Report		26"
Notes:	Wind shifted out of seedable range late evening	

February 1, 2022

												WDO	WSJ	ESJ
							Primary Target					CWCB	CWCB	CWCB
	Start Day Time	Stop Day Time	Hrs.	Rate	Output	WDO	TELSKI	WSJ	PURG	ESJ	NM	LCRB	LCRB	LCRB
S64	2/1/2022 20:00	2/2/2022 7:00	11.00	12	132.00		10.50					0.50		
S3	2/1/2022 19:45	2/2/2022 7:15	11.50	12	138.00		10.88					0.62		
S40	2/1/2022 20:00	2/2/2022 7:00	11.00	12	132.00							11.00		
S42	2/1/2022 18:00	2/2/2022 7:00	13.00	12	156.00							13.00		
S41	2/1/2022 18:00	2/2/2022 7:00	13.00	12	156.00							13.00		
S9	2/1/2022 18:00	2/2/2022 7:00	13.00	12	156.00							13.00		
S12	2/1/2022 18:00	2/2/2022 7:00	13.00	12	156.00			3.25	9.75					
S32	2/1/2022 18:00	2/2/2022 7:00	13.00	12	156.00			3.00	10.00					
S13	2/1/2022 18:00	2/2/2022 7:00	13.00	12	156.00				13.00					
S37	2/1/2022 18:00	2/2/2022 7:00	13.00	12	156.00			3.25	9.75					
S15	2/1/2022 19:30	2/2/2022 7:00	11.50	12	138.00			2.87	8.62					
S61	2/1/2022 19:00	2/2/2022 7:00	12.00	12	144.00			3.00	9.00					
S18	2/1/2022 20:00	2/2/2022 10:00	14.00	12	168.00									14.00
S19	2/1/2022 20:00	2/2/2022 10:00	14.00	12	168.00									14.00
S21	2/1/2022 19:45	2/2/2022 10:15	14.50	12	174.00									14.50
S26	2/1/2022 14:00	2/2/2022 17:00	27.00	12	324.00						6.75			20.25
S59	2/1/2022 13:00	2/2/2022 17:00	28.00	12	336.00						28.00			
		totals	245.50		2946.00	0.00	21.38	15.37	60.12	0.00	34.75	51.12	0.00	62.75

Storm Type		Mid-level shortwave trough
Originated		Southern California
Storm Start Date/Time		2/1/2022 14:00
Storm Stop Date/Time		2/2/2022 17:00
Seed Start Date /Time		2/1/2022 13:00
Seed Stop Date/Time		2/2/2022 17:00
Start of Seeding Target Winds		240-250
Start of Seeding Wind Speed		5-10 Knots
Start of Seeding Temperature		-6 C
Wind Shift Date /Time		1/2/2022 5:00
End of Seeding Target Winds		320-330
End of Seeding Wind Speed		10-15 Knots
End of Seeding Temperature		-15 C
Number of Generators used		18
Number of Seeding Hours used		260.50
Amount of AgI used		3126.00
Start of Seeding SNOTEL Readings for	Lizard Head	9.40
End of Seeding SNOTEL Readings for	Lizard Head	9.60
Increase		0.20
Start of Seeding SNOTEL Readings for	Spud Mountain	14.70
End of Seeding SNOTEL Readings for	Spud Mountain	15.20
Increase		0.50
Start of Seeding SNOTEL Readings for	Wolf Creek	23.70
End of Seeding SNOTEL Readings for	Wolf Creek	24.90
Increase		1.20
Forecast Telluride Precipitation		4.0"
Telluride Ski Report		5"
Forecast Purgatory Precipitation		7.3"
Purgatory Ski Report		6"
Forecast Wolf Creek Precipitation		23.9"
Wolf Creek Ski Report		15"
Notes: Seeding ended when temps became to cold and winds shifted NE		

February 16, 2022

													WDO	WSJ	ESJ
							Primary Target						CWCB	CWCB	CWCB
		Start Day Time	Stop Day Time	Hrs.	Rate	Output	WDO	TELSKI	WSJ	PURG	ESJ	NM	LCRB	LCRB	LCRB
AKM	S64	2/16/2022 15:00	2/16/2022 20:00	5.00	12	60.00							5.00		
JG	S3	2/16/2022 12:45	2/16/2022 20:00	7.25	12	87.00							7.25		
PLF	S40	2/16/2022 15:15	2/16/2022 20:00	4.75	12	57.00	4.75								
JVA	S42	2/16/2022 12:00	2/16/2022 20:00	8.00	12	96.00	4.25						3.75		
BPW	S41	2/16/2022 12:15	2/16/2022 20:00	7.75	12	93.00				2.00			5.75		
ACL	S9	2/16/2022 12:00	2/16/2022 20:00	8.00	12	96.00				2.00			6.00		
			totals	40.75		489.00	9.00	0.00	0.00	4.00	0.00	0.00	27.75	0.00	0.00

Storm Type		Mid-level longwave trough
Originated		Pacific Northwest
Storm Start Date/Time		2/16/2022 12:00
Storm Stop Date/Time		2/16/2022 19:00
Seed Start Date /Time		2/16/2022 12:00
Seed Stop Date/Time		2/16/2022 20:00
Start of Seeding Target Winds		260-270
Start of Seeding Wind Speed		10-15 Knots
Start of Seeding Temperature		-5 C
Wind Shift Date /Time		2/16/2022 17:00
End of Seeding Target Winds		350-360
End of Seeding Wind Speed		5-10 Knots
End of Seeding Temperature		-7 C
Number of Generators used		6
Number of Seeding Hours used		40.75
Amount of AgI used		489.00
Start of Seeding SNOTEL Readings for	Red Mountain	13.10
End of Seeding SNOTEL Readings for	Red Mountain	13.30
Increase		0.20
Start of Seeding SNOTEL Readings for	Spud Mountain	15.10
End of Seeding SNOTEL Readings for	Spud Mountain	15.40
Increase		0.30
Forecast Telluride Precipitation		0.8"
Telluride Ski Report		5"
Forecast Purgatory Precipitation		0.8"
Purgatory Ski Report		2"
Forecast Wolf Creek Precipitation		1.8"
Wolf Creek Ski Report		6"
Notes:		Flurries continued after seeding ended

February 21, 2022

												WDO	WSJ	ESJ
						Primary Target						CWCB	CWCB	CWCB
	Start Day Time	Stop Day Time	Hrs.	Rate	Output	**WDO**	**TELSKI**	**WSJ**	**PURG**	**ESJ**	**NM**	**LCRB**	**LCRB**	**LCRB**
S42	2/21/2022 17:00	2/22/2022 19:00	26.00	12	312.00		19.00					7.00		
S42	2/22/2022 19:00	2/23/2022 16:00	21.00	10	210.00							21.00		
S41	2/21/2022 17:00	2/22/2022 19:00	26.00	12	312.00	4.00						22.00		
S41	2/22/2022 19:00	2/23/2022 16:00	21.00	10	210.00							21.00		
S9	2/21/2022 17:00	2/22/2022 19:00	26.00	12	312.00	26.00								
S9	2/22/2022 19:00	2/22/2022 20:45	1.75	10	17.50							1.75		
S9	2/23/2022 11:30	2/23/2022 16:00	4.50	10	45.00							4.50		
S62	2/21/2022 20:00	2/22/2022 22:00	26.00	12	312.00	13.00						13.00		
S62	2/23/2022 14:00	2/23/2022 16:00	2.00	10	20.00							2.00		
S12	2/21/2022 19:00	2/22/2022 7:00	12.00	12	144.00			12.00						
S12	2/23/2022 7:00	2/23/2022 16:00	9.00	10	90.00								9.00	
S32	2/21/2022 15:30	2/22/2022 11:00	19.50	12	234.00			13.87					5.63	
S32	2/22/2022 18:00	2/22/2022 22:00	4.00	10	40.00								4.00	
S32	2/23/2022 7:00	2/23/2022 16:00	9.00	10	90.00								9.00	
S13	2/21/2022 19:00	2/22/2022 22:00	27.00	12	324.00			17.88	9.12					
S13	2/23/2022 7:00	2/23/2022 15:30	8.50	10	85.00				8.50					
S37	2/21/2022 19:00	2/22/2022 7:00	12.00	12	144.00				12.00					
S37	2/22/2022 10:00	2/22/2022 19:00	9.00	12	108.00				8.01				0.99	
S37	2/22/2022 19:00	2/23/2022 16:30	21.50	10	215.00				21.50					
S57	2/21/2022 19:00	2/22/2022 19:00	24.00	12	288.00				24.00					
S57	2/22/2022 19:00	2/23/2022 15:45	20.75	10	207.50				10.74				10.01	
S61	2/21/2022 19:00	2/22/2022 9:00	14.00	12	168.00			14.00						
S61	2/22/2022 16:15	2/23/2022 15:15	23.00	10	230.00			15.00	2.50				5.50	
S31	2/21/2022 19:00	2/22/2022 9:30	14.50	12	174.00				14.50					
S31	2/22/2022 10:00	2/23/2022 15:30	29.50	10	295.00				29.50					
S18	2/23/2022 12:30	2/23/2022 20:00	7.50	10	75.00					1.00				6.50
S19	2/23/2022 13:00	2/23/2022 20:00	7.00	10	70.00									7.00
S20	2/23/2022 12:15	2/23/2022 20:00	7.75	10	77.50									7.75
S21	2/23/2022 13:00	2/23/2022 20:00	7.00	10	70.00									7.00
S63	2/22/2022 13:00	2/22/2022 18:00	5.00	12	60.00						1.00			4.00
		totals	445.75		4939.50	43.00	19.00	72.75	140.37	1.00	1.00	92.25	44.13	32.25

Storm Type		Large Low Pressure System
Originated		Pacific Northwest
Storm Start Date/Time		2/21/2022 15:00
Storm Stop Date/Time		2/23/2022 22:00
Seed Start Date /Time		2/21/2022 15:30
Seed Stop Date/Time		2/23/2022 20:00
Start of Seeding Target Winds		210-220
Start of Seeding Wind Speed		15-20 Knots
Start of Seeding Temperature		-6 C
Wind Shift Date /Time		n/a
End of Seeding Target Winds		230-240
End of Seeding Wind Speed		10-15 Knots
End of Seeding Temperature		-15 C
Number of Generators used		16
Number of Seeding Hours used		445.75
Amount of AgI used		4939.50
Start of Seeding SNOTEL Readings for	Red Mountain	13.50
End of Seeding SNOTEL Readings for	Red Mountain	16.30
Increase		2.80
Start of Seeding SNOTEL Readings for	Spud Mountain	15.40
End of Seeding SNOTEL Readings for	Spud Mountain	19.00
Increase		3.60
Start of Seeding SNOTEL Readings for	Stump Lake	10.60
End of Seeding SNOTEL Readings for	Stump Lake	13.00
Increase		2.40
Forecast Telluride Precipitation		16.9"
Telluride Ski Report		31"
Forecast Purgatory Precipitation		19.6"
Purgatory Ski Report		45"
Forecast Wolf Creek Precipitation		40.0"
Wolf Creek Ski Report		30"
Notes:	Seeding ended early due to Colorado Avalanche Center Warning	

March 4, 2022

												WDO	WSJ	ESJ
							Primary Target					CWCB	CWCB	CWCB
	Start Day Time	Stop Day Time	Hrs.	Rate	Output	WDO	TELSKI	WSJ	PURG	ESJ	NM	LCRB	LCRB	LCRB
S42	3/4/2022 20:00	3/5/2022 7:00	11.00	12	132.00							11.00		
S42	3/5/2022 14:00	3/6/2022 11:00	21.00	10	210.00							21.00		
S41	3/4/2022 20:00	3/5/2022 7:00	11.00	12	132.00							5.50	5.50	
S41	3/5/2022 13:45	3/6/2022 7:45	18.00	10	180.00							18.00		
S9	3/5/2022 14:15	3/6/2022 10:00	19.75	10	197.50							8.63	11.12	
S12	3/4/2022 21:00	3/5/2022 7:00	10.00	12	120.00								10.00	
S12	3/5/2022 15:00	3/6/2022 11:00	20.00	10	200.00								20.00	
S32	3/4/2022 21:00	3/5/2022 7:00	10.00	12	120.00								10.00	
S32	3/5/2022 15:00	3/6/2022 11:00	20.00	10	200.00								20.00	
S13	3/4/2022 21:00	3/5/2022 6:00	9.00	12	108.00								9.00	
S13	3/5/2022 15:00	3/6/2022 11:00	20.00	10	200.00								20.00	
S37	3/4/2022 21:00	3/5/2022 6:00	9.00	12	108.00								9.00	
S37	3/5/2022 15:00	3/6/2022 11:00	20.00	10	200.00								20.00	
S15	3/4/2022 21:00	3/5/2022 6:00	9.00	12	108.00								9.00	
S15	3/5/2022 15:00	3/6/2022 11:00	20.00	10	200.00								20.00	
S57	3/5/2022 15:00	3/6/2022 11:00	20.00	10	200.00								20.00	
S61	3/5/2022 15:00	3/6/2022 11:00	20.00	10	200.00								20.00	
S31	3/4/2022 21:00	3/5/2022 6:00	9.00	12	108.00								9.00	
S31	3/5/2022 15:00	3/6/2022 11:00	20.00	10	200.00								20.00	
		totals	296.75		3123.50	0.00	0.00	0.00	0.00	0.00	0.00	64.13	232.62	0.00

Storm Type		Low Pressure System
Originated		Southern California
Storm Start Date/Time		3/4/2022 12:00
Storm Stop Date/Time		3/6/2022 19:00
Seed Start Date /Time		3/4/2022 20:00
Seed Stop Date/Time		3/6/2022 11:00
Start of Seeding Target Winds		250-260
Start of Seeding Wind Speed		15-20 Knots
Start of Seeding Temperature		-5 C
Wind Shift Date /Time		N/A
End of Seeding Target Winds		260-270
End of Seeding Wind Speed		5-10 Knots
End of Seeding Temperature		-11 C
Number of Generators used		11
Number of Seeding Hours used		296.75
Amount of AgI used		3123.50
Start of Seeding SNOTEL Readings for	El Diente	11.20
End of Seeding SNOTEL Readings for	El Diente	12.20
Increase		1.00
Start of Seeding SNOTEL Readings for	Spud Mountain	18.90
End of Seeding SNOTEL Readings for	Spud Mountain	20.50
Increase		1.60
Forecast Telluride Precipitation		7.5"
Telluride Ski Report		12"
Forecast Purgatory Precipitation		8.6"
Purgatory Ski Report		17"
Notes:		Seeding delayed due to warm temps
		Flurries continued after seeding ended

March 9, 2022

												WDO	WSJ	ESJ
							Primary Target					CWCB	CWCB	CWCB
	Start Day Time	Stop Day Time	Hrs.	Rate	Output	WDO	TELSKI	WSJ	PURG	ESJ	NM	LCRB	LCRB	LCRB
S9	3/9/2022 9:00	3/9/2022 21:00	12.00	10	120.00								12.00	
S12	3/9/2022 9:00	3/9/2022 19:00	10.00	10	100.00								10.00	
S32	3/9/2022 9:00	3/9/2022 18:45	9.75	10	97.50								9.75	
S13	3/9/2022 9:00	3/9/2022 18:00	9.00	10	90.00								9.00	
S37	3/9/2022 6:00	3/9/2022 18:00	12.00	10	120.00								12.00	
S15	3/9/2022 9:00	3/9/2022 16:30	7.50	10	75.00								7.50	
S61	3/9/2022 9:00	3/9/2022 14:00	5.00	10	50.00								5.00	
		totals	65.25		652.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	65.25	0.00

Storm Type		Low Pressure System
Originated		Pacific Northwest
Storm Start Date/Time		3/9/2022 4:00
Storm Stop Date/Time		3/10/2022 1:00
Seed Start Date /Time		3/9/2022 6:00
Seed Stop Date/Time		3/9/2022 21:00
Start of Seeding Target Winds		250-260
Start of Seeding Wind Speed		5-10 Knots
Start of Seeding Temperature		-8 C
Wind Shift Date /Time		N/A
End of Seeding Target Winds		260-270
End of Seeding Wind Speed		20-25 Knots
End of Seeding Temperature		-11 C
Number of Generators used		7
Number of Seeding Hours used		65.25
Amount of AgI used		652.50
Start of Seeding SNOTEL Readings for	Spud Mountain	21.10
End of Seeding SNOTEL Readings for	Spud Mountain	21.40
Increase		0.30
Start of Seeding SNOTEL Readings for	Columbus Basin	19.00
End of Seeding SNOTEL Readings for	Columbus Basin	19.20
Increase		0.20
Forecast Telluride Precipitation		7.6"
Telluride Ski Report		13"
Forecast Purgatory Precipitation		2.1"
Purgatory Ski Report		4"
Forecast Wolf Creek Precipitation		2.9"
Wolf Creek Ski Report		7"
Notes:		Seeding for Purgatory, WSJ
Precip rates dropped off after 9pm, would pick up later on the 10th		

March 10, 2022

												WDO	WSJ	ESJ
						Primary Target						CWCB	CWCB	CWCB
	Start Day Time	Stop Day Time	Hrs.	Rate	Output	WDO	TELSKI	WSJ	PURG	ESJ	NM	LCRB	LCRB	LCRB
S12	3/10/2022 9:00	3/10/2022 15:00	6.00	10	60.00								6.00	
S32	3/10/2022 9:00	3/10/2022 15:00	6.00	10	60.00								6.00	
		totals	12.00		120.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.00	0.00

Storm Type		Low Pressure System
Originated		Pacific Northwest
Storm Start Date/Time		3/10/2022 8:00
Storm Stop Date/Time		3/10/2022 17:00
Seed Start Date /Time		3/10/2022 9:00
Seed Stop Date/Time		3/10/2022 15:00
Start of Seeding Target Winds		270-280
Start of Seeding Wind Speed		5-10 Knots
Start of Seeding Temperature		-10 C
Wind Shift Date /Time		2/13/2021 21:00
End of Seeding Target Winds		260-270
End of Seeding Wind Speed		5-10 Knots
End of Seeding Temperature		-11 C
Number of Generators used		2
Number of Seeding Hours used		12.00
Amount of AgI used		120.00
Start of Seeding SNOTEL Readings for	Columbus Basin	19.60
End of Seeding SNOTEL Readings for	Columbus Basin	19.80
Increase		0.20
Start of Seeding SNOTEL Readings for	Spud Mountain	21.60
End of Seeding SNOTEL Readings for	Spud Mountain	21.70
Increase		0.10
Forecast Telluride Precipitation		0.8"
Telluride Ski Report		2"
Forecast Purgatory Precipitation		0.9"
Purgatory Ski Report		0"
Forecast Wolf Creek Precipitation		6.5"
Wolf Creek Ski Report		6"
Notes:		End of seeding hours for the season

Appendix B:
Emergency Management Coordination

Emergency Management Directors

Rodney King	Conejos County
Art Whittner	Rio Grande County
Terry Wetherill	Mineral County Sheriff's Office
Phil Graham	Hinsdale County
Jim Donovan	San Juan County
Mike Le Roux	Archuleta County
Shawna Legarza	La Plata County
Terry Hoecker	City of Durango
Bobby Woelz	Saguache County
Jim Spratlen	Montezuma County
Keith Keesling	Dolores County
Henry Mitchell	San Miguel County
Scott Hawkins	Montrose County
Glenn Boyd	Ouray County
Justin Perry	City of Ouray
Tim Chinn	City of Montrose
Don Brockus and Gina Perino	Southern Ute Indian Tribe
Meredith Nichols	Region Field Managers
Drew Patersen	Region Field Managers
Tom Mcnamara	Region Field Managers
Christe Coleman	Region Field Managers
David Osborn	Region Field Managers
Treste Huse	National Weather Service
Aldis Strautins	National Weather Service
Ethan Greene	CAIC
Russ Schumacher	CSU Colorado Climate Center

Email to emergency managers:

Greetings,

We will officially start the 2021-2022 winter cloud seeding programs November 1st, 2021 and expect all operations to end April 15th, 2022. We are sending this email, and attached operational plan, to City and County Emergency Managers in and around our cloud seeding Target Areas. We have very strict guidelines as to when cloud seeding is suspended set by the State of Colorado. The suspension criteria are mostly governed by snowpack percentages at specific times of the month and avalanche concerns. I know there also may be specific emergency situations that affect your city, or County that would be cause for suspending operations for a specific time period. Please let me know when any emergency type situation arises this winter that additional snow from seeding operations may hinder your ability to remedy the situation and to request a suspension. Also please contact Andrew Rickert at the Colorado Water Conservation Board with any request for suspending operations when one is needed. Andrew's Office phone is 303-866-3441 ext. 3209, cell phone is 720-651-1918.

Please feel free to contact us with any questions or concerns.

Email to NWS, CAIC, CSU Colorado Climate Center:

Greetings,

As per the new rules and regulations for Colorado weather modification adopted in July 2012, I am required to notify the local National Weather Service weather forecast office of weather modification operations.

We will officially start the 2021-2022 winter cloud seeding programs November 1st, 2021 and expect all operations to end April 15th, 2022. We have very strict guidelines as to when cloud seeding is suspended set by the State of Colorado. The suspension criteria are mostly governed by snowpack percentages at specific times of the month and avalanche concerns, as well as when the NWS forecast office puts out a hazardous weather statement that impacts any part of the target area. The type of statement we monitor for are urban or small stream advisory, blizzard warnings, flash flood warnings and severe thunderstorm warnings.

I wanted to give you our contact information in the event you may have questions or need to pass information pertaining to a severe weather event.

Additional information on weather modification, including all current programs and target areas can be found on the CWCB website.

http://cwcb.state.co.us/WATER-MANAGEMENT/WATER-PROJECTS-PROGRAMS/Pages/%c2%adWeatherModificationProgram.aspx

Please feel free to contact us with any questions or concerns.

Email to CWCB:

Greetings Andrew,

I wanted to notify you that I have sent the Weather Modification Notification letter to the Emergency Management groups, NWS, NOAA, CSU Climate, CAIC and Program Participants.

We look forward to another successful year!

Thank you,

Alisa Hjermstad, Western Weather Consultants

Also included in the emergency managers email was the operational plan:

San Juan Mountains Program (SJM Program) 2021-2022 Winter Cloud Seeding Program

Includes seeding for the following regions:
West Dolores and Telluride (WDT)
Western San Juan's (WSJ)
Eastern San Juan's (ESJ)

- WDT Sponsors: Dolores Water Conservancy District, Montezuma Valley Irrigation Company, Southwestern Water Conservation District and Telluride Skiing Co and Colorado Water Conservation Board.
- WSJ Sponsors: Purgatory Ski Area, Animas La Plata Water Conservancy District, Dolores Water Conservancy District, Southwestern Water Conservation District and New Mexico Interstate Stream Commission.
- ESJ Sponsors: Pine River Irrigation District, Florida Water Conservancy District, Florida Consolidated Ditch Company, San Juan Water Conservancy District, Southwestern Water Conservation District and New Mexico Interstate Stream Commission.

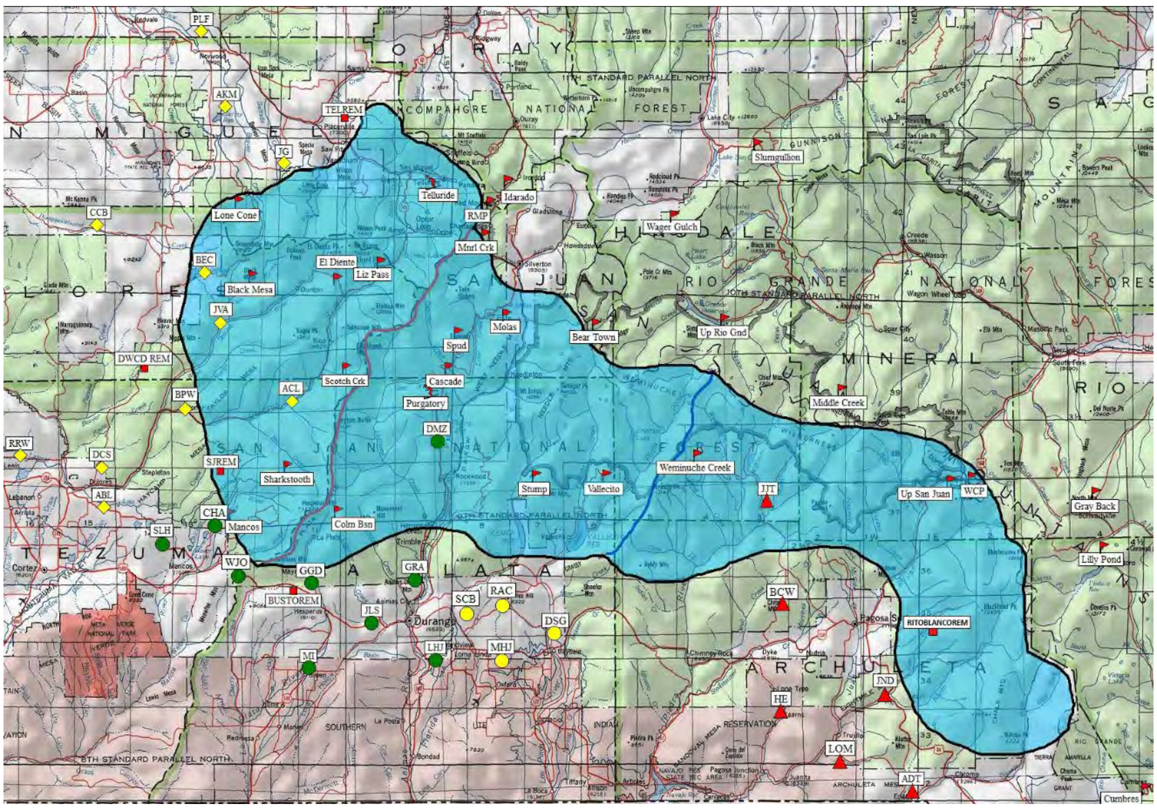
State of Colorado Weather Modification Permit # (2020-04)

Operational Plan

The 2021-2022 SJM Program is permitted to operate from November 1, 2021, to April 15, 2022, and will be operated by Western Weather Consultants LLC (WWC). Seeding can begin December 1, 2021, for non-ski area participants. Seeding for Telluride and Purgatory Ski Resorts may commence as early as November 1, 2021. An extension of the program may be implemented if funding is available and if there are appropriate seeding opportunities. At all times, WWC shall operate the SJM Program in compliance with all applicable State and Federal laws and regulations governing weather modification activities and other applicable laws. Up to 40 Cloud seeding Nuclei Generators (CNG) can be used for the SJM Program.

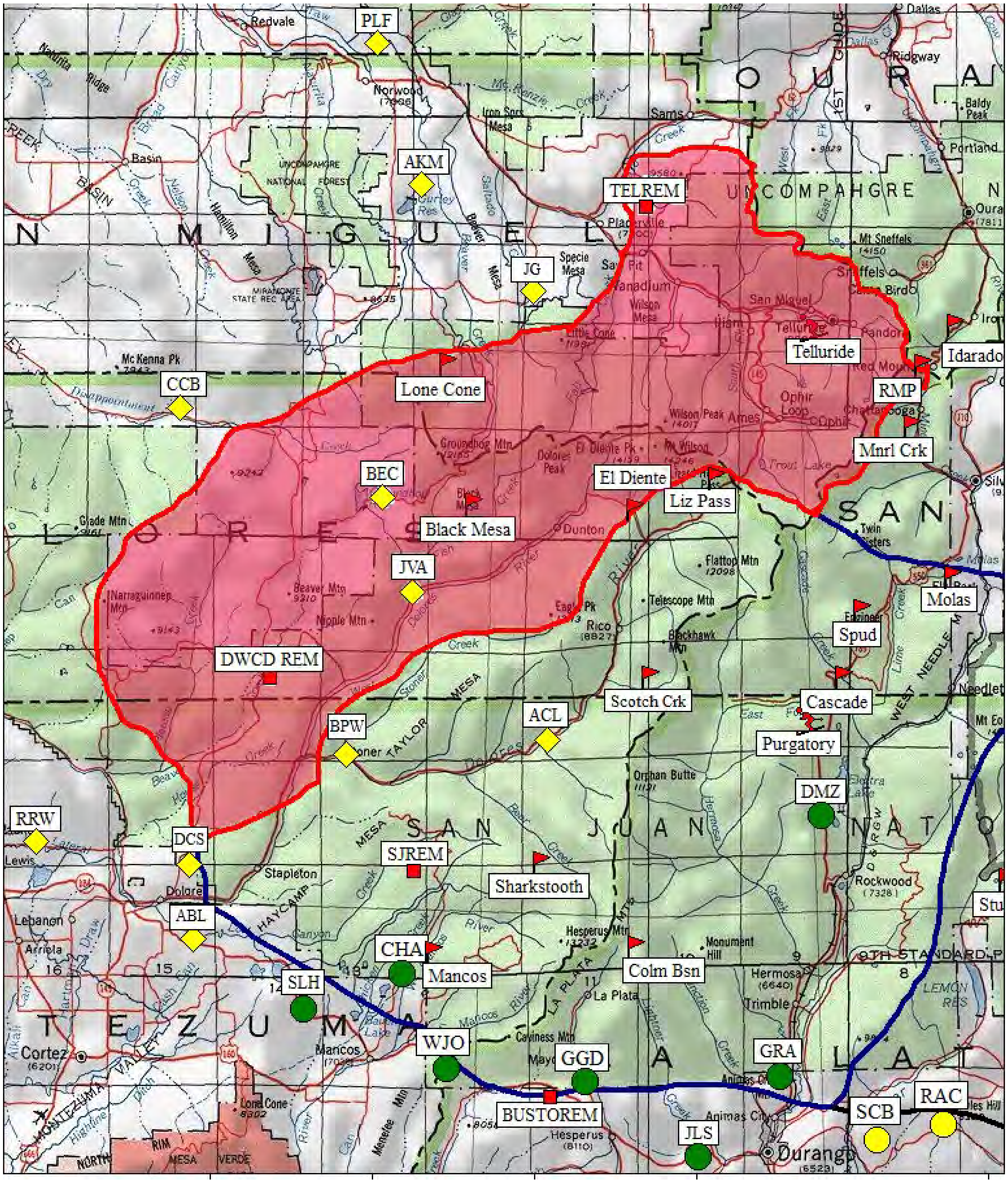
Target Area

The primary target area for the SJM Program is defined as follows: The San Juan Mountains above 8,500 feet mean sea level mainly targeting the upper regions of the West Dolores, San Miguel, Dolores, La Plata, Animas, Florida, Pine, San Juan and Blanco River Basins as well as Telluride and Purgatory Ski Resorts. The SJM Program is designed, operated, and intended to affect only the Target Area. Manual Generator locations are denoted by yellow diamonds, green circles, yellow circles, and red triangles on the map. Remote generators are shown as red squares and red flags indicate a SNOTEL location.



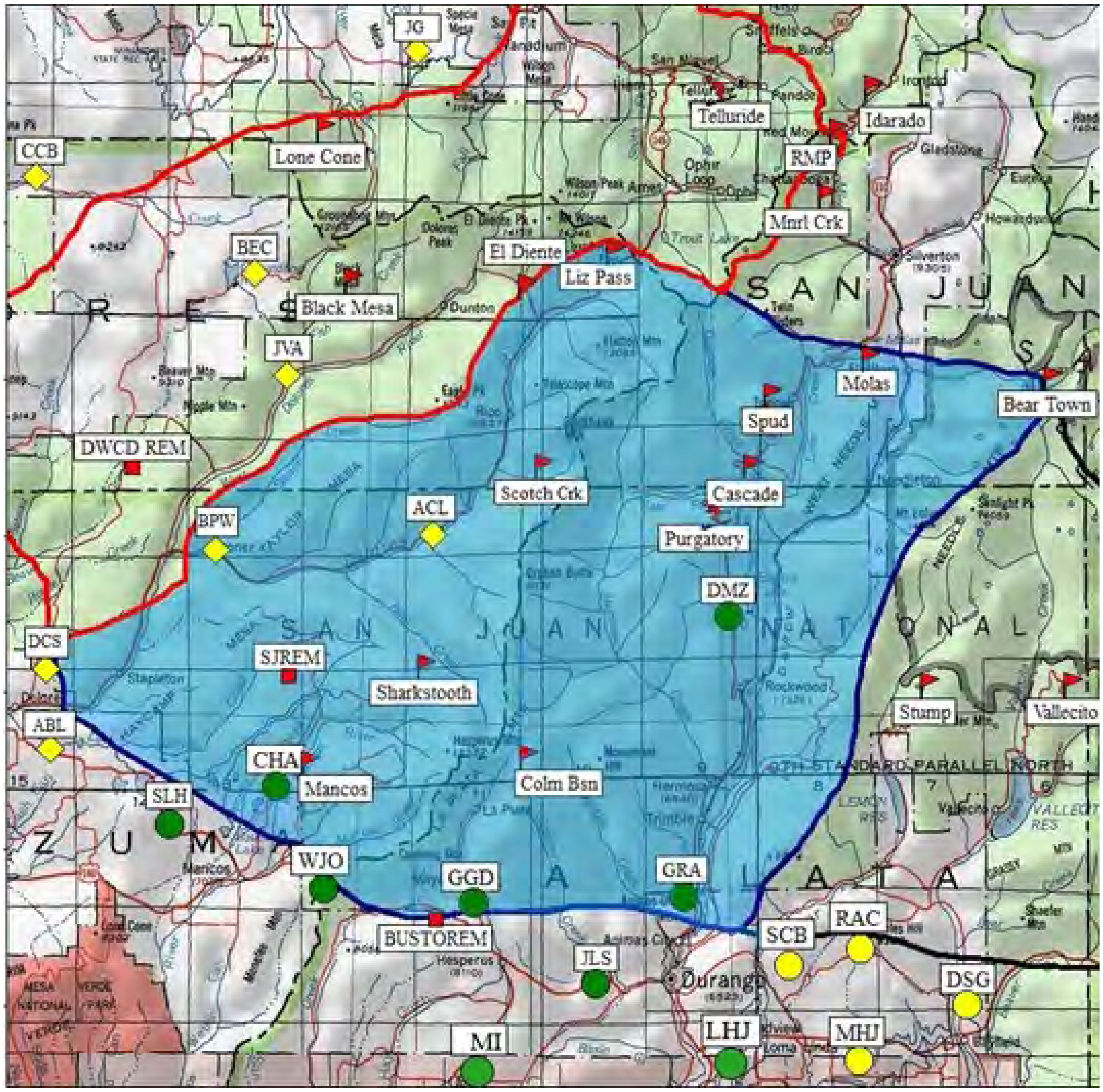
WDT Area Map

Yellow diamonds are the primary generators used for the WDT area while a few of the locations marked with green circles can be used as well.



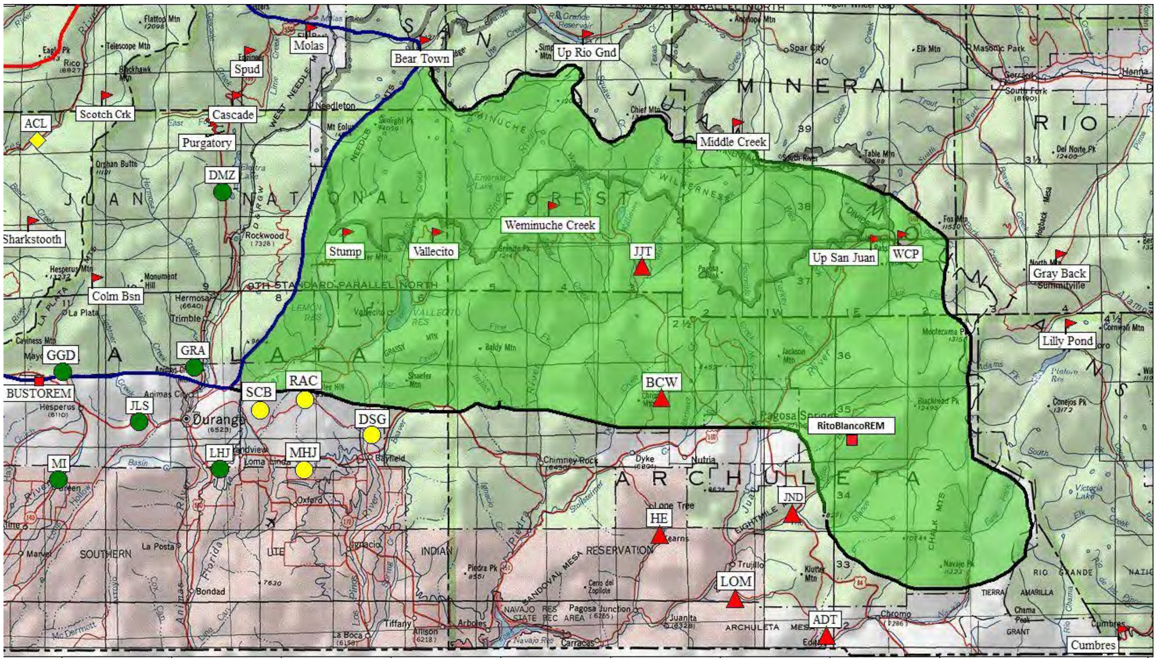
WSJ Area Map

Green circles on the map are the primary generators used for the WSJ area while the locations with yellow diamonds, yellow circles and the red squares can be used, as well.



ESJ Area Map

Red triangles and yellow circles are primary sites used for the ESJ area. The sites marked by green circles (DMZ, JLS, GRA, GGD and WJO) can also be used.



Operational Procedure

The operational procedures used to enhance snowpack in the selected target areas is to produce plumes of silver iodide crystals (artificial cloud nuclei) at rates between 5 and 28 grams per hour from multiple ground based CNGs to be diffused by favorable wind flows into selected storms or cloud types suitable for precipitation increases meeting the seeding criteria over the Target Area. An analysis of low-level wind fields, cloud characteristics, stability parameters, terrain features, and synoptic meteorological features will determine the network of generators which will best seed the cloud system over the Target Area for each favorable weather system and will provide a method for adjusting the network as new weather information becomes available. Seeding events will be limited to those portions of selected favorable weather systems that have expected or forecasted precipitation rates and associated augmentation potentials capable of producing additional precipitation at least at the rate of one-tenth an inch of water or more per 24 hours of seeded duration. Any selected favorable weather events with the augmentation rate stated above that is expected to last less than 6 hours require prior approval by the Manager of the SWCD, and or Andrew Rickert with the CWCB. Seeding for the ski areas is exempt from the 6-hour minimum storm duration if the storm is forecast to produce the required precipitation amount of water over 24 hours.

With a “best” initial network to seed an established weather system, the generator operators are notified to turn on their generator at a specific time and operate them at a specific burn rate. On the same call, they will be given a specific turn-off time, this could be subject to change if the meteorologist at WWC notices significant changes in the weather system during the seeding event. Incoming weather data into the forecast office allows a continuous monitoring of any changes in conditions and any adjustments or termination in the seeding operation. Following each seeding operation, each generator operator who was instructed to operate the nuclei generator will submit a written report on the actual observation times; verify the seeding rates and note weather observations or operational discrepancies during the required operating period. No aircraft will be used for seeding for this Program. The seeding criteria WWC uses for seeding operations are as follows:

- Cloud bases are at least 500 feet below the mean mountain barrier crest of the Target Area and are forecast to move lower in elevation from the onset of seeding and continue throughout the seeding period. The weather system has clouds that are forecast to have vertical heights and moisture content capable of producing natural precipitation.
- Temperatures at the height of 500 feet below the mean mountain crest within the Target Area are -5 degrees C. (23 degrees F.) or colder and are forecast to become colder if at -5 degrees C.
- Wind directions and speeds from the surface to cloud-base are observed and forecast to favor the movement into the intended Target Area of the silver iodide nuclei being released from the ground-based generator sites.
- There are no stable regions or atmospheric inversions between the surface and cloud-base that would prevent the vertical dispersion of the silver iodide particles from the surface to at least the -5 degrees C. (23 degrees F.) level or colder within the cloud system.
- The temperature at approximately 10,000 feet (700 MB level) is warmer than -16 degrees C. (3 degrees F.)

Generator Locations

site	Site Name	Program	Latitude	Longitude	Elevation
AKM	Gurley	WDT			7761
JG	Specie Mesa	WDT			8976
PLF	Norwood	WDT			7057
TELREM	Hastings Mesa (DRI Remote)	WDT			8825
CCB	Dissappointment Valley	WDT-WSJ			6970
BEC	Groundhog	WDT-WSJ			8928
DOLREM	Kinder	WDT			8080
JVA	Dunton	WDT-WSJ			8045
BPW	Stoner	WDT-WSJ			7541
ACL	Dolores River	WDT-WSJ			8227
RRW	Lewis	WDT-WSJ			6950
DCS	Dolores	WDT-WSJ			7577
ABL	Lost Canyon	WDT-WSJ			7181
SLH	Mancos	WSJ-WDT			7123
SJREM	Spring Creek (DRI Remote)	WDT-WSJ			8915
CHA	Jackson Lake	WSJ-WDT			8065
WJO	Mancos Hill	WSJ-WDT			8017
GGD	Mayday	WSJ-WDT			8599
BUSTOREM	Montoya Peak	WSJ-WDT-ESJ			8560
MI	Breen	WSJ-ESJ			7393
GRA	Animas Mountain	WSJ-ESJ			7073
JLS	Wild Cat	WSJ-ESJ			7580
DMZ	Haviland Lake	WSJ-ESJ			8250
LHJ	Grandview	WSJ-ESJ			6905
MHJ	Salt Creek	ESJ-WSJ			6928
RAC	Dry Creek	ESJ-WSJ			7633
DSG	Bayfield	ESJ			7106
SCB	Rincon Ridge	ESJ-WSJ			7845
HE	Lonetree	ESJ			6928
JJT	Oakbrush Ridge	ESJ			7926
BCW	Chris Mountain	ESJ			8064
PAGREM	Rito Blanco	ESJ			8554
JND	Turkey Mountain	ESJ			7000
ADT	Coyote Creek	ESJ			7247
LOM	Montezuma Creek	ESJ			6958

WWC routinely monitors the weather conditions throughout the contracted operating period for systems with cloud seeding potential. Most of the data used comes from the National Weather Service (NWS) websites, University of Wyoming, Pennsylvania and Texas A&M Weather websites, National Center for Atmospheric Research (NCAR) website, and National Oceanic and Atmospheric Administration (NOAA), Pivotalweather.com for short and long-range model forecasts. There are numerous forecasting websites available beyond the previously listed that are used as well, but these tend to be the preferred forecasting sites. Other available resources are the Colorado Department of Transportation (CDOT) website to monitor road conditions and concerns, Colorado Avalanche Information Center (CAIC) for Weather Research Forecasting (WRF) point forecasts, as well as avalanche and potential avalanche conditions in and around the Target Area including the Natural Resources Conservation Service (NRCS) website to monitor snowpack in the Target Area as recorded by the network of SNOTELs in Colorado. Snowpack accumulation is monitored from SNOTEL stations within the Target Area and the first detailed analysis of snow accumulation is completed using these measurements.

From these sites, we review and, at times, archive, weather data such as: surface and upper air data, synoptic surface maps, significant level maps, model forecast data, rawinsonde data, satellite and radar data, surface observations, web cam images, and other forecast aids. This data assists in selecting favorable storms for modification and monitoring suspension criteria.

Suspension Criteria

The proposed Suspension Criteria provides safeguards to the program to ensure that risks associated with cloud seeding have been addressed. WWC will retain the right to suspend operations during any period if the weather system is determined detrimental. Facilities will be maintained to gather and analyze weather data providing a continuing weather watch. WWC will maintain communications with the Program Sponsors, the National Weather Service (NWS), the U.S. Forest Service and the Department of Natural Resources / Colorado Water Conservation Board regarding potential adverse conditions. The forecast and operations center of WWC will monitor on a seven day per week basis the weather patterns over Colorado and the Western United States during the winter operating period. Meteorologists permitted by the State of Colorado to operate weather modification programs will determine if weather events are suitable for precipitation augmentation by cloud seeding.

Prior to initiating any seeding operations, a thorough hazard analysis will be evaluated a potential weather system judged suitable for seeding will be evaluated for its potential to develop into a blizzard, severe storm, or heavy precipitation possibly associated with a potential for major avalanche episode. Also, the effects of the weather event on ranching, agriculture, wildlife, highway travelers, municipal interests and industry will also be considered. This evaluation will be concentrated upon those areas to be seeded along with considerations of potential adverse effects to adjacent areas which may be influenced by augmented precipitation. No seeding will be initiated during a period determined to have a high potential hazard evaluation. Once a seeding operation has been initiated, monitoring of existing and forecast weather conditions will continue throughout the duration of the seeding operation. All new meteorological information will be assessed as well as generator reports from generator operators, the State Patrol, and field maintenance personnel in the seeded areas. The Colorado Avalanche Information Center (CAIC) has modified its website to include a "Cloud Seeder" avalanche hazard level suspension criteria page for all mountain passes in Colorado. Levels of Notice, Caution, and Warning are assigned to the passes with warning being used as a trigger for temporary suspension of neighboring generators. Changing weather conditions that would indicate the onset of potentially severe or hazardous weather conditions will result in the suspension of seeding operations throughout the duration of these potentially hazardous weather conditions. Snowpack accumulation will be monitored from SNOTEL stations from all SNOTEL sites within the target area and the first detailed analysis of snow accumulation will be completed using these measurements. Evaluations of snowpack indicate that minor flooding and stream flow problems can exist when late winter snowpack reaches 155% of normal. More substantial flooding problems can be anticipated when late winter snowpack is more than 175% of normal.

Since the SJM Program is designed for reasonable levels of snowpack enhancement for an outlook of adequately abundant summertime water supply for storage use, we propose to suspend seeding operations in any major portion of a seeding area when one or more of the following takes place: Snow Water Equivalent Thresholds exceed the following: 175% of average on December 1st, 175% of average on January 1st, 165% of average on February 1st, 155% of average on March 1st and 145% of average on April 1st. The following link can be used to see a map which will show the snowpack percentages of normal:

https://www.wcc.nrcs.usda.gov/ftpref/states/co/snow/state/daily/co_cloud_seed.pdf

The CWCB Director or his or her designee will determine where and how snowpack water equivalents are to be measured, including at selected "SNOTEL" sites. The CWCB Director or his or her designee may permit weather modification operations to continue in a portion of the operation target area where snowpack water equivalents are below these suspension criteria percentages, if the operation will not impact the area where snowpack water equivalents are above these suspension criteria percentages. These thresholds are designed to keep the seeding effect to within the realm of natural variability of the local climate as measured at each SNOTEL station. This comparative normal for these representative snow observation sites will be the long-term Snow Water Equivalent Medians data set from 1981 through 2010 as published by the Natural Resources Conservation Service (NRCS). WWC must suspend all weather modification operations whenever one of the following is issued by the NWS Hazardous Weather Statements that impacts any part of the Target Area:

a. An urban or small stream flood advisory.
b. A blizzard warning.
c. A flash flood warning; or
d. A severe thunderstorm warning.

Operations may resume after these statements expire.

As required by the "Colorado Weather As required by the "Colorado Weather Modification Rule and Regulations" effective July 1, 2012, WWC notifies the local NWS weather forecast office, CAIC, the County emergency managers, and the CSU Colorado Climate Center of intended weather modification activities and provide WWC's contact information prior to the 2021-2022 season of weather modification operations.

Contact Information

Manager
Larry Hjermstad
970-247-8813
970-946-6328
westernweather.larry@gmail.com

Assistant Manager
Mike Hjermstad
970-259-9850
970-946-6324
westernweather@gmail.com

Director of Field Operations
Eric Hjermstad
833-216-1820
westernweather.eric@gmail.com

Appendix C:

Target vs. Control Report (NAWC 2021-22)

Target/Control Evaluation Of Three Southwest Colorado Winter Cloud Seeding Programs

Prepared For:

Southwestern Water Conservation District

Dolores Water Conservancy District

Prepared By:

David Yorty

Garrett Cammans

North American Weather Consultants, Inc.

8180 S. Highland Dr., Suite B-2

Sandy, Utah 84093

July 2022

EXECUTIVE SUMMARY

Winter weather modification programs have been conducted in portions of Colorado for a number of years, with the goal of increasing winter storm precipitation.

There are three cloud seeding programs being conducted in Southwest Colorado with various target areas and sponsors, utilizing ground-based silver iodide cloud nuclei generators. The operations periods are generally from November – March during the history of the program, and from December – March during the current season. A Weather Modification Act in the State of Colorado specifies that annual reporting for ground-based winter operations shall include, at a minimum, target versus control analysis of precipitation or snow water equivalent for programs operating in the state.

A target/control evaluation approach was developed by North American Weather Consultants (NAWC) for the Colorado programs, utilizing SNOTEL data sites in the seeding target areas and at control sites outside these areas. These include linear and multiple-linear regressions based on November - February SNOTEL precipitation and March 1 SNOTEL snow water content. After developing the initial equations in 2013, NAWC has applied these equations to the seeded seasons, up through the current water year, of the various southwestern Colorado seeding programs to provide estimates of seeding effects. The application of a total of 18 total equations (6 equations for each of three separate programs) to SNOTEL precipitation and snow water equivalent data yields a variety of estimates which can be compared and summarized, providing a more complete and reliable analysis than would the use of just one or two such equations.

The composite of all results for the Telluride/San Miguel (also called the West Dolores) seeding program results in an estimate of a 6% seasonal increase in precipitation/snow water content. This would amount to approximately 0.7" of water equivalent annually.

For the Western San Juan program, a seasonal increase of around 2% has been indicated, suggesting an increase of about 0.2" of water equivalent.

For the Eastern San Juan program, composite results suggest about a 4% seasonal increase of precipitation/snowfall, amounting to approximately 0.7" of additional water equivalent annually.

1.0 INTRODUCTION

A Weather Modification Act (Article 20) was enacted by the State of Colorado in 1972. This Act has gone through various amendments and a sunset review in 2011. These rules and regulations were revised in 2012, becoming effective on July 1, 2012. The Colorado Water Conservation Board (CWCB) administers Colorado's Weather Modification Program, which issues weather modification permits, monitors weather modification activities and keeps the public informed about the state's weather modification programs. Colorado has conducted weather modification operations and research since the 1950's.

The 2012 revised rules and regulations state that: "The permit holder must compile annual reports in accordance with section 36-20-117(3), C.R.S. (2011). Annual reporting for ground-based winter operations shall include, at a minimum, target versus control analysis of precipitation or snow water equivalent. The permit holder must provide the Director with a written annual report that evaluates the weather modification operation within 90 days of concluding its operations season." The requirement for the conduct of a target/control analysis was added in 2012.

1.1 Background on Cloud Seeding Programs in Southwest Colorado

There are three ongoing cloud seeding programs being conducted in Southwest Colorado with different target areas and sponsors. These programs were developed following the completion of the Colorado River Basin Project (CRBPP) which was a Bureau of Reclamation sponsored project conducted in the San Juan Mountains during the water years of 1971 through 1975. The oldest of these programs is targeting the Western San Juan Mountains (WSJ). Immediately to the east is a program being conducted in the Eastern San Juans (ESJ). The third program is located in the Telluride/San Miguel drainage basin (TSM), also known as West Dolores or Telluride. The Southwestern Water Conservancy District (SWCD) headquartered in Durango, Colorado is serving as the lead agency on these programs. Figure 1.1 provides a map of the three target areas. Table 1-1 provides the seeded seasons by water year. The Southwestern Water Conservancy District, headquartered in Durango, Colorado, sent a request, dated August 10, 2012, to North American Weather Consultants (NAWC) to submit a proposal to develop target/control evaluation techniques for the three southwestern Colorado operational cloud seeding programs. NAWC's proposal was accepted which led to the development of an original target/control evaluation covering these three target areas (Griffith and Yorty, 2013).

Ground based silver iodide generators is the seeding method that has been used for all three programs. Operational periods have varied over time as indicated in Table 1-1. In more recent years the months of November through March have been seeded. The goal of these seeding programs is to increase the natural snowpack accumulations in the target areas. Enhanced snowpack leads to enhanced spring and summer streamflow. The primary beneficiaries of enhanced streamflow are irrigated agricultural interests, although there are other secondary beneficiaries both near and further removed from the target areas such as recreational interests, municipal water suppliers and hydroelectric generation utilities. An additional goal in the TSM program is to increase the snow at the Telluride Ski area to enhance skiing operations and has also been a factor in the WSJ program regarding the Purgatory Ski area.

1.2 Addition of Water Year 2021 Evaluation Results

NAWC in its initial proposal, offered as an option an annual update of the estimated results of the three programs following the completion of each operational season. As in previous seasons, the SWCD exercised this option to include the most recent winter season in an updated report. This report is submitted to fulfill this request.

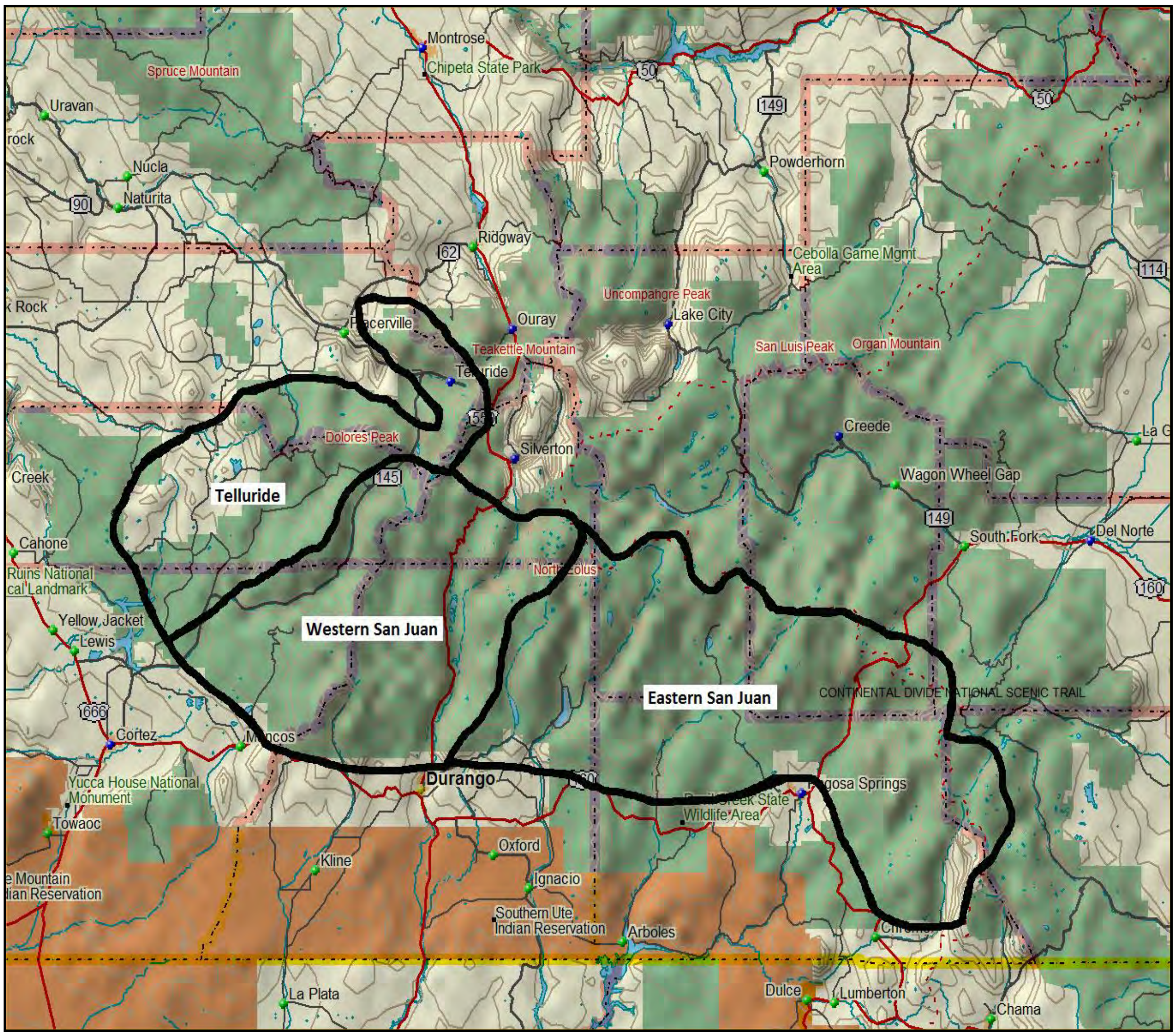


Figure 1.1 Location of the Three Target Areas

Table 1-1
Western and Eastern San Juans, and Telluride/San Miguel Seeded Water Years
(Months abbreviated by first letter)

Water Year	W. San Juan	E. San Juan	Telluride/ San Miguel
1976	--	JFM	--
1977	--	NDJF	--
1978	NDJFM	NDJFM	NDJFM
1979	NDJ	--	NDJ
1980	NDJ	--	NDJF
1981	NDJF	--	NDJFM
1982	NDJFM	--	NDJFM
1983	NDJ	--	--
1984	NDJ	--	--
1985	NDJ	--	--
1991	--	--	--
1997	--	--	NDJ
1998	--	--	NDJ
1999	--	--	NDJ
2000	--	--	NDJ
2001	NDJ	--	NDJ
2002	NDJ	--	NDJ
2003	NDJF	NDJF	NDJF
2004	NDJF	NDJF	NDJF
2005	NDJ	NDJ	--
2006	NDJFM	NDJFM	--
2007	NDJFM	NDJFM	NDJFM
2008	NDJFM	NDJFM	NDJFM
2009	NDJFM	NDJFM	NDJFM
2010	NDJFM	NDJFM	NDJFM
2011	NDJFM	NDJFM	NDJFM
2012	NDJFM	NDJFM	NDJFM
2013	NDJFM	DJF	NDJFM
2014	NDJFM	JFM	NDJFM
2015	NDJFMA	DJFMA	NDJFMA
2016	NDJFMA	DJFMA	NDJFMA
2017	NDJFM	JFM	DJM
2018	DJFMA	DJFM	NDJFMA
2019	NDJFM	DJFM	NDJFM
2020	NDJFM	NDJFM	NDJFM
2021	NDJFM	NDJFM	NDJFM
2022	DJFM	DJFM	DJFM

Note: Colorado River Basin Pilot Project (CRBPP) seeded period excluded from consideration.

2.0 REGRESSION EQUATION DEVELOPMENT PROCESS

Two basic types of regression equations were utilized in the target/control evaluations: linear and multiple linear regression equations.

For the simpler linear equation approach, seasonal averages for both the target and control areas are used. The generic linear regression equation is y = ax + b where x is the independent variable (control area), y is the dependent variable (target area), a is the slope of the regression line and b is the value of the y intercept of the equation. A best fit for the historical years is the output of the application of this technique.

Both techniques typically produce a straight line or a linear prediction, although non-linear terms or data transforms terms can be applied to the data (for example, log transform) which may result in non-linear predictions. The software used to produce these equations provides important information beyond establishing the regression equation. Two of the more useful statistics in this regard are the correlation coefficient r of the regression equation (which can also be expressed as an r^2 value), and the standard deviation of the individual season results when utilizing the regression equation. In a perfect correlation, the r value would be 1.0.

The multiple linear regression technique (hereafter referred to as multiple regression) differs from the linear technique in that each control site is considered individually. The multiple regression approach compares each control site seasonal average individually with the target area average seasonal value to develop a relationship. An alternative form of the multiple linear regression equation can use group averages as individual control variables. The resulting equation includes a separate coefficient associated with each control site or variable, as well as an offset y-intercept.

In the development of target/control regression equations, the normal process is to first select a set of target sites for each data type (such as precipitation, snow, etc.). Section 4.0 discusses the selection of the target and potential control sites that were utilized to develop the final regression equations. Site history including period of record and any missing data, as well as double-mass plot comparisons between sites (Section 4.6) are used in selecting these target sites. The data is obtained from Snow Telemetry (SNOTEL) automated sites and manual snowcourses. Ideally, the target sites will be well-distributed within the target area to provide a representative sample.

More details regarding initial development of the target/control regression equations are presented in NAWC report number 13-2 (Griffith and Yorty, 2013).

2.1 Overview of Final Regression Equations and Site Locations

Table 2-1 summarizes some general characteristics of the historical regression equations that were developed. Equations were developed separately for each target area including Telluride/San Miguel, Western San Juan Mountains, and Eastern San Juan Mountains). It should be noted that some measurement sites were utilized as target sites for more than one of these target areas, due to their location at or near the edge of an individual target area boundary. For each of these target areas, three basic equations were developed. One equation utilizes SNOTEL precipitation data only, another utilizes SNOTEL snow water equivalent data only, and a third utilizes both SNOTEL snow water equivalent as well as pre-SNOTEL snow data at sites where this is available. Utilizing mixed snow data types allows for a longer historical (non-seeded) regression period, with many of these sites having a manual snow course data history back to at least the early 1960s. The number of historical years on which each regression equation is based varies due to the differing seeding history of each target area. The set of target and control sites used for a given target area also varies among the three regression equations (each using differing data types), based on selection of appropriate data that was based on double-mass plots and on the overall degree of correlation obtained for each target/control set.

For the precipitation regression equations, two different time periods were considered, November through January (three months) and November through February (4 months) since the months actually seeded have varied historically from three to four months and more recently up to five months. All the snow water content regression equations were based on March 1st data.

Finally, for each of the linear regression equations developed as described, a multiple linear equation was developed using the same target and control sites. Due to the somewhat limited length of the historical (non-seeded) data period, as well as storm track considerations, the multiple linear analysis technique applied to these evaluations consisted of two independent control variables. Each of these variables is based on an average of a group of control sites, with sites north of the target areas used for one of these averages and sites to the south used for the other average value. The multiple linear regression equation relates each of these two control site averages to the target site average for a particular area.

The result of applying these analysis techniques is a total of 18 regression equations: three target areas times three data types (SNOTEL November – February precipitation totals, SNOTEL April 1 snow, mixed April 1 snow data) times two equation types (linear and multiple linear). Although this seems rather complex, the seeding season observed/predicted results based on a number of different equations allows one to obtain a much more complete, and hopefully accurate, picture of the true range of seeding effects from this type of non-randomized program. The number of variations utilized in this report was reduced slightly by considering only the November – February SNOTEL precipitation totals, and not the November – January totals which were included in the first report.

Figure 2.1 shows the target areas and the target sites that were used. The corresponding Table (2-2) contains detailed information for these sites. A few target sites were utilized in regression equations for more than one target area, due to their location near target area boundaries. Similarly, Figure 2.2 shows control site locations and Table 2-3 contains information specific to those sites.

Table 2-1
Summary of Regression Equations
TSM = Telluride/San Miguel; WSJ = Western San Juans; ESJ = Eastern San Juans

Evaluation Type	Number of seasons in historical regression	Average elevation of target sites	Average elevation of control sites	R value for linear, multilinear equations	Standard deviation of seeded year observed/predicted ratios: linear and multilinear
TSM Precipitation Nov-Feb, SNOTEL only	11	10,250	9,680	0.908 0.920	0.076 0.095
TSM Snow Mar 1, SNOTEL only	11	10,250	9,680	0.944 0.947	0.112 0.104
TSM Snow Mar 1, Mixed Data Types	22	9,950	9,160	0.941 0.941	0.130 0.122
WSJ Precipitation Nov-Feb, SNOTEL only	15	10,007	9,505	0.930 0.931	0.069 0.073
WSJ Snow Mar 1, SNOTEL only	15	10,077	9,680	0.936 0.937	0.099 0.105
WSJ Snow Mar 1, Mixed Data Types	26	9,860	9,160	0.926 0.928	0.145 0.148
ESJ Precipitation Nov-Feb, SNOTEL only	15	10,922	9,680	0.904 0.921	0.157 0.147
ESJ Snow Mar 1, SNOTEL only	15	10,930	9,680	0.867 0.889	0.167 0.151
ESJ Snow Mar 1, Mixed Data Types	24	10,733	9,575	0.915 0.927	0.332 0.185

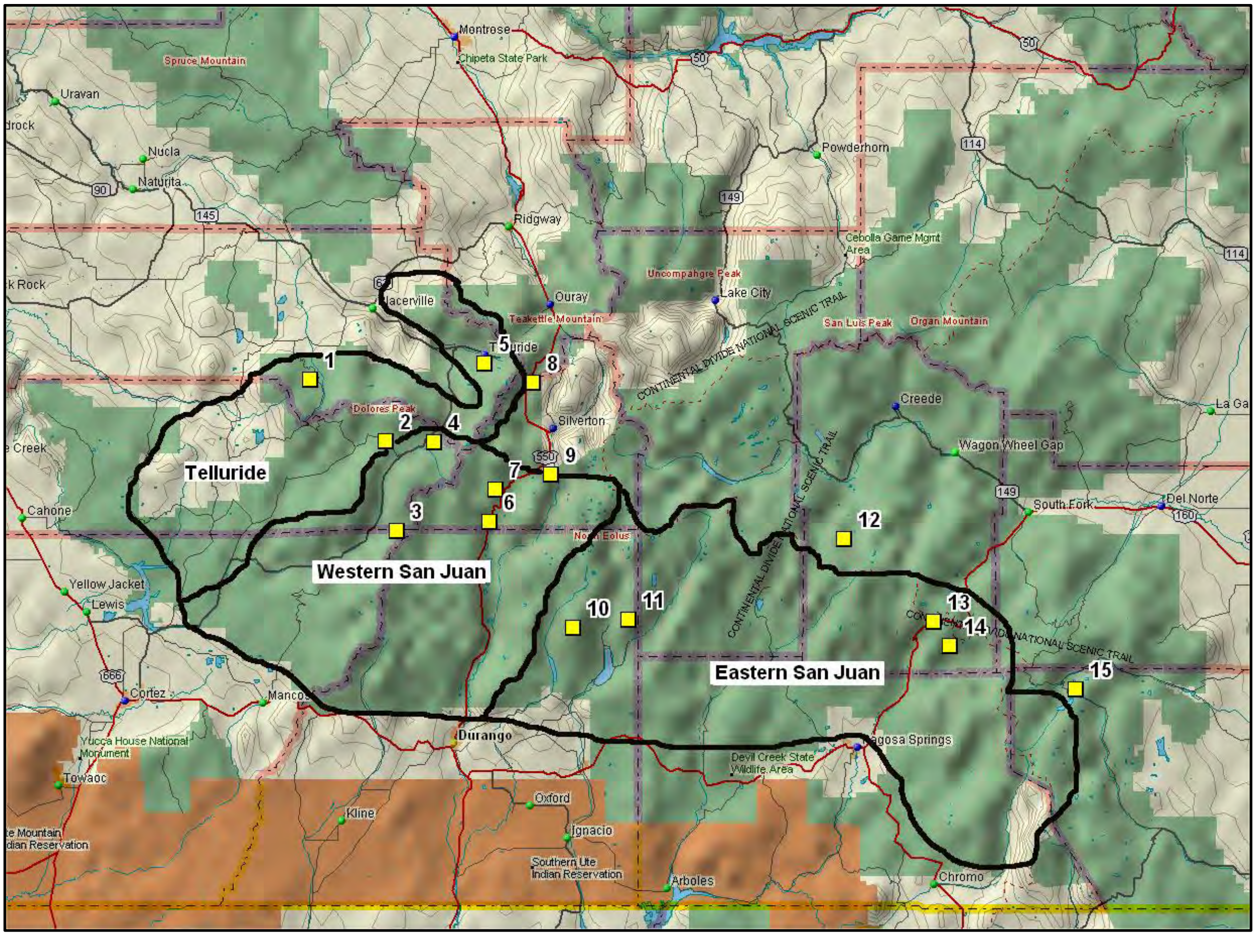


Figure 2.1 **Target sites used in regression equations; site numbers correspond to those in Table 2-2**

Table 2-2
Target Site Information
TSM = Telluride/San Miguel; WSJ = Western San Juan; ESJ = Eastern San Juan
Evaluation Type A = SNOTEL precipitation; B = SNOTEL snow; C = mixed snow

Number on map	Site Name	Latitude	Longitude	Elevation	Records Begin	Target Area(s)	Evaluation Type(s)
1	Lone Cone	37°53’	-108°11’	9,600	1981, 1961	TSM	A,B,C
2	El Diente Peak	37°47’	-108°01’	10,000	1987*	TSM, WSJ	A,B
3	Scotch Creek	37°38’	-108°00’	9,100	1987*	WSJ	A,B
4	Lizard Head Pass	37°47’	-107°55’	10,200	1981, 1961	TSM, WSJ	A,B,C
5	Telluride snowcourse	37°55’	-107°48’	8,800	1936	TSM	C
6	Cascade	37°39’	-107°48’	8,880	1979, 1936	WSJ	A,B,C
7	Spud Mountain	37°42’	-107°47’	10,660	1987, 1951	WSJ	A,B
8	Red Mountain Pass	37°53’	-107°42’	11,200	1981, 1961	TSM	A,B,C
9	Molas Lake	37°44’	-107°40’	10,500	1987*, 1951	WSJ	B,C
10	Stump Lakes	37°28’	-107°37’	11,200	1987*	WSJ, ESJ	A,B
11	Vallecito	37°29’	-107°30’	10,880	1987*, 1981	ESJ	A
12	Middle Creek	37°37’	-107°02’	11,250	1981, 1979	ESJ	A,B
13	Upper San Juan	37°29’	-106°50’	10,200	1979, 1936	ESJ	A,B,C
14	Wolf Creek Summit	37°28’	-106°48’	11,000	1987*, 1961	ESJ	A,B,C
15	Lily Pond	37°22’	-106°32’	11,000	1981, 1949	ESJ	A,B,C

*Estimates were made for 1986 at sites where data began in 1987

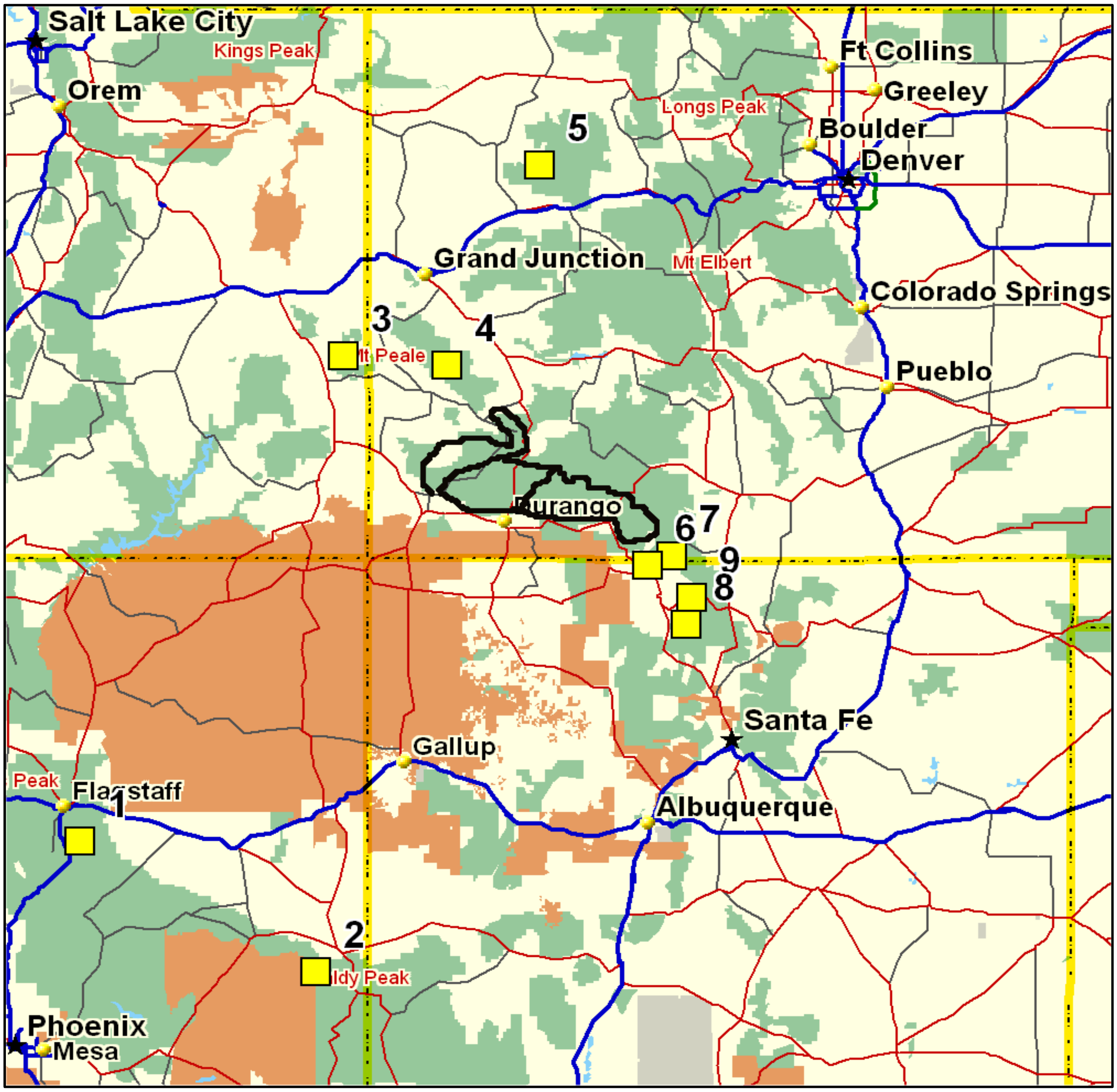


Figure 2.2 Control sites used in regression equations; site numbers correspond to those in Table 2-3

Table 2-3
Control Site Information
TSM = Telluride/San Miguel; WSJ = Western San Juan; ESJ = Eastern San Juan
Evaluation Type A = SNOTEL precipitation; B = SNOTEL snow; C = mixed snow

Reference on map	Site Name	Latitude	Longitude	Elevation (feet)	Record Began	Target Areas	Evaluation Type(s)
1	Mormon Mtn, AZ	34°56'	-111°31'	7,500	1983, 1950	TSM, WSJ	C
2	Baldy, AZ	33°59'	-109°30'	9,125	1983, 1950	WSJ	A
3	La Sal Mtn, UT	38°29'	-109°16'	9,560	1982, 1956	TSM, WSJ, ESJ	A,B,C
4	Columbine Pass, CO	38°25'	-108°22'	9,400	1987*	TSM, WSJ, ESJ	A,B
5	Burro Mtn, CO	39°52'	-107°35'	9,400	1982, 1936	TSM, WSJ, ESJ	A,B,C
6	Chamita, NM	36°57'	-106°39'	8,400	1980, 1961	TSM	A
7	Cumbres Trestle, CO	37°01'	-106°27'	10,040	1981, 1961	TSM, WSJ, ESJ	A,B,C
8	Bateman, NM	36°31'	-106°19'	9,300	1980, 1961	TSM, WSJ, ESJ	C
9	Hopewell, NM	36°43'	-106°16'	10,000	1980, 1972	TSM, WSJ, ESJ	B (TSM, WSJ) A,B (ESJ)

* Data estimated for 1986 at sites with data that began in 1987

The following sections contain detailed regression equation information for each target area, including the historical period used in the analysis, target and control sites, the linear and multiple linear regression equations, and the associated correlations and standard deviations of observed/predicted ratios. Note that each linear regression equation contains a coefficient term, which is multiplied by the control site average value, and an offset (either positive or negative) which is a constant. Each multiple linear regression equations contain a separate coefficient for each control site, plus an offset. In some cases, in the multiple linear regression equations, a control site may have a negative coefficient associated with it. This does not mean that particular control site is not useful in the equation (or that it is poorly correlated to the target area by itself), but merely that the multiple linear regression has an enhanced ability to predict target area precipitation based on observed patterns in the individual control site data during the historical period, based on complex inter-relationships between these sites and the target area site averages. The units for all values are in inches (either accumulated precipitation or snow water content).

2.2 Regression Equations for Telluride/San Miguel (also known as the West Dolores/Telluride target area)

This section summarizes the regression relationships that were developed. Figures 2.1 and 2.2 provide maps of the locations of the target and control sites used in each of the following equations.

2.2.1 TSM SNOTEL-Only Precipitation Evaluation, November – February Totals

Historical period: Water Years 1986-1996 (11 seasons)

Target Sites: Lizard Head Pass, Lone Cone, El Diente Peak, Red Mountain Pass

Control Sites: Columbine Pass, Cumbres Trestle, Burro Mountain, La Sal Mountain (UT), Hopewell (NM)

Linear Regression Equation:

T = 0.827C + 0.911 (Equation 1, TSM SNOTEL Nov-Feb precipitation linear)

In this equation, T is the predicted target site average November – February precipitation, and C is the control site average.

The r-value for Equation 1 is 0.908, and the standard deviation of the seeded year observed/predicted ratios is 0.076.

Multiple Linear Regression Equation:

T = 0.906 (Control Group 1) + 0.062 (Control Group 2) - 0.249

(Equation 2, TSM SNOTEL Nov-Feb precipitation multiple linear)

In this equation, Control Group 1 is the average of Columbine Pass, Burro Mountain, and La Sal Mountain SNOTEL precipitation data. Similarly, Control Group 2 is the average of Cumbres Trestle and Hopewell SNOTEL precipitation data. All values used in equations 1 and 2 are based on the November – February precipitation totals at the corresponding sites.

The r-value for Equation 2 is 0.920, and the standard deviation of the historical year observed/predicted ratios is 0.095. In this case, the linear regression equation generated a lower (better) standard deviation of the seeding year ratios (0.076 vs 0.095) than did the multiple linear equation, which implies less background "noise" which can obscure the seeding effects.

2.2.2 TSM SNOTEL-Only Snow Evaluation, March 1 Data

Historical period: Water Years 1986-1996 (11 seasons)

Target Sites: Lizard Head Pass, Lone Cone, El Diente Peak, Red Mountain Pass

Control Sites: Columbine Pass, Cumbres Trestle, Burro Mountain, La Sal Mountain (UT), Hopewell (NM)

Linear Regression Equation:

T = 0.979C – 1.203 (Equation 3, TSM SNOTEL snow linear)

In this equation, T is the predicted target site average March 1 snow water equivalent, and C is the control site average.

The r-value for Equation 3 is 0.944, and the standard deviation of the seeded year observed/predicted ratios is 0.112.

Multiple Linear Regression Equation:

T = 0.726(Control Group 1) + 0.298 (Control Group 2) – 1.241

(Equation 4, TSM SNOTEL snow multiple linear)

In this equation, Control Group 1 is the average of Columbine Pass, Burro Mountain, and La Sal Mountain SNOTEL snow data. Similarly, Control Group 2 is the average of Cumbres Trestle and Hopewell SNOTEL snow data. All values used in these equations are based on March 1 snow water equivalent data at the corresponding sites.

The r-value for Equation 4 is 0.947, and the standard deviation of the historical year observed/predicted ratios is 0.104 (similar to that for the corresponding linear regression equation).

2.2.3 TSM Mixed Snow Evaluation, March 1 Data

Historical period: Water Years 1961-1969, 1976-1977, 1986-1996 (22 seasons)

Target Sites: Lizard Head Pass, Lone Cone, Red Mountain Pass, Telluride snowcourse

Control Sites: Cumbres Trestle, Burro Mountain, La Sal Mountain (UT), Bateman (NM), Mormon Mountain (AZ)

Linear Regression Equation:

T = 0.950C + 1.237 (Equation 5, TSM mixed snow data linear)

In this equation, T is the predicted target site average March 1 snow water equivalent, and C is the control site average.

The r-value for Equation 5 is 0.941, and the standard deviation of the seeded year observed/predicted ratios is 0.130.

Multiple Linear Regression Equation:

T = 0.415(Control Group 1) + 0.540 (Control Group 2) + 1.211

(Equation 6, TSM mixed snow data multiple linear)

In this equation, Control Group 1 is the average of Burro Mountain, and La Sal Mountain snow data. Similarly, Control Group 2 is the average of Cumbres Trestle, Bateman, and Mormon Mountain snow data. All values used in these equations are based on March 1 snow water equivalent data at the corresponding sites.

The r-value for Equation 6 is 0.941, and the standard deviation of the historical year observed/predicted ratios is 0.122. This standard deviation in the results is a little lower, but similar to the corresponding linear regression equation.

2.3 Regression Equations for the Western San Juan Target Area

2.3.1 WSJ SNOTEL-Only Precipitation Evaluation, November – February Totals

Historical period: Water Years 1986-2000 (15 seasons)

Target Sites: Cascade, Lizard Head Pass, El Diente Peak, Scotch Creek, Stump Lakes, Spud Mountain

Control Sites: Columbine Pass, Cumbres Trestle, Burro Mountain, La Sal Mountain (UT), Baldy (AZ)

Linear Regression Equation:

T = 1.023C – 0.566 (Equation 7, WSJ SNOTEL Nov-Feb precipitation linear)

In this equation, T is the predicted target site average November – February precipitation, and C is the control site average.

The r-value for Equation 7 is 0.930, and the standard deviation of the seeded year observed/predicted ratios is 0.069.

Multiple Linear Regression Equation:

T = 0.713(Control Group 1) + 0.346(Control Group 2) – 1.066

(Equation 8, WSJ SNOTEL Nov-Feb precipitation multiple linear)

In this equation, Control Group 1 is the average of Columbine Pass, Burro Mountain, and La Sal Mountain SNOTEL precipitation data. Similarly, Control Group 2 is the average of Cumbres Trestle and Baldy SNOTEL precipitation data. All values used in equations 9 and 10 are based on the November – February precipitation totals at the corresponding sites.

The r-value for Equation 8 is 0.931, and the standard deviation of the historical year observed/predicted ratios is 0.073, similar to that for the linear regression.

2.3.2 WSJ SNOTEL-Only Snow Evaluation, March 1 Data

Historical period: Water Years 1986-2000 (15 seasons)

Target Sites: Cascade, Lizard Head Pass, El Diente Peak, Scotch Creek, Molas Lake, Stump Lakes, Spud Mountain

Control Sites: Columbine Pass, Cumbres Trestle, Burro Mountain, La Sal Mountain (UT), Hopewell (NM)

Linear Regression Equation:

T = 1.110C – 2.537 (Equation 9, WSJ SNOTEL snow linear)

In this equation, T is the predicted target site average March 1 snow water equivalent, and C is the control site average.

The r-value for Equation 9 is 0.936, and the standard deviation of the seeded year observed/predicted ratios is 0.099.

Multiple Linear Regression Equation:

T = 0.763(Control Group 1) + 0.384 (Control Group 2) – 2.731

(Equation 10, WSJ SNOTEL snow multiple linear)

In this equation, Control Group 1 is the average of Columbine Pass, Burro Mountain, and La Sal Mountain SNOTEL snow data. Control Group 2 is the average of Cumbres Trestle and Hopewell SNOTEL snow data. All values used in these equations are based on March 1 snow water equivalent data at the corresponding sites.

The r-value for Equation 10 is 0.937, and the standard deviation of the historical year observed/predicted ratios is 0.105. This is slightly higher than (although very close to) the standard deviation of 0.099 for these seeded season ratios obtained in the corresponding linear regression (Equation 13).

2.3.3 WSJ Mixed Snow Evaluation, March 1 Data

Historical period: 1961-1969, 1976-1977, 1986-2000 (26 seasons)

Target Sites: Cascade, Lizard Head Pass, Molas Lake

Control Sites: Cumbres Trestle, Burro Mountain, La Sal Mountain (UT), Bateman (NM), Mormon Mountain (AZ)

Linear Regression Equation:

$T = 1.175C – 0.640$ (Equation 11, WSJ mixed snow data linear)

In this equation, T is the predicted target site average March 1 snow water equivalent, and C is the control site average.

The r-value for Equation 11 is 0.926, and the standard deviation of the seeded year observed/predicted ratios is 0.145.

Multiple Linear Regression Equation:

$T = 0.584(\text{Control Group 1}) + 0.611(\text{Control Group 2}) – 0.840$

(Equation 12, WSJ mixed snow data multiple linear)

In this equation, Control Group 1 is the average of Burro Mountain and La Sal Mountain snow data. Control Group 2 is the average of Cumbres Trestle, Bateman, and Mormon Mountain snow data. All values used in these equations are based on March 1 snow water equivalent data at the corresponding sites.

The r-value for Equation 12 is 0.928, and the standard deviation of the historical year observed/predicted ratios is 0.148. This is very similar to the standard deviation of 0.145 for the seeded season ratios obtained in the corresponding linear regression.

2.4 Regression Equations for the Eastern San Juan Target Area

2.4.1 ESJ SNOTEL-Only Precipitation Evaluation, November – February Totals

Historical period: Water Years 1986-2000 (15 seasons)

Target Sites: Upper San Juan, Lily Pond, Wolf Creek Summit, Middle Creek, Stump Lakes, Vallecito

Control Sites: Burro Mountain, Columbine Pass, Cumbres Trestle, La Sal Mountain (UT), Hopewell (NM)

Linear Regression Equation:

T = 1.131C – 0.564 (Equation 13, ESJ SNOTEL Nov-Feb precipitation linear)

In this equation, T is the predicted target site average November – February precipitation, and C is the control site average.

The r-value for Equation 13 is 0.904, and the standard deviation of the seeded year observed/predicted ratios is 0.157.

Multiple Linear Regression Equation:

T = 0.124(Control Group 1) + 0.774 (Control Group 2) + 1.954

(Equation 14, ESJ SNOTEL Nov-Feb precipitation multiple linear)

In this equation, Control Group 1 is the average of Columbine Pass, Burro Mountain, and La Sal Mountain SNOTEL precipitation data. Control Group 2 is the average of Cumbres Trestle and Hopewell SNOTEL precipitation data. All values used in equations 17 and 18 are based on the November – February precipitation totals at the corresponding sites.

The r-value for Equation 14 is 0.921, and the standard deviation of the historical year observed/predicted ratios is 0.147. This standard deviation is a little lower than that for the corresponding linear regression equation (0.157).

2.4.2 ESJ SNOTEL-Only Snow Evaluation, March 1 Data

Historical period: Water Years 1986-2000 (15 seasons)

Target Sites: Upper San Juan, Lily Pond, Wolf Creek Summit, Middle Creek, Stump Lakes

Control Sites: Columbine Pass, Cumbres Trestle, Burro Mountain, La Sal Mountain (UT), Hopewell (NM)

Linear Regression Equation:

T = 1.303C – 1.601 (Equation 15, ESJ SNOTEL snow linear)

In this equation, T is the predicted target site average March 1 snow water equivalent, and C is the control site average.

The r-value for Equation 15 is 0.867, and the standard deviation of the seeded year observed/predicted ratios is 0.167.

Multiple Linear Regression Equation:

T = 0.254(Control Group 1) + 0.848(Control Group 2) – 0.544

(Equation 16, ESJ SNOTEL snow multiple linear)

In this equation, Control Group 1 is the average of Columbine Pass, Burro Mountain, and La Sal Mountain SNOTEL snow data. Control Group 2 is the average of Cumbres Trestle and Hopewell SNOTEL snow data. All values used in equations 21 and 22 are based on March 1 snow water equivalent data at the corresponding sites.

The r-value for Equation 16 is 0.889, and the standard deviation of the historical year observed/predicted ratios is 0.151. This is lower than the standard deviation of the seeded season ratios obtained in the corresponding linear regression (0.167).

2.4.3 ESJ Mixed Snow Evaluation, March 1 Data

Historical period: 1961-1969, 1986-2000 (24 seasons)

Target Sites: Upper San Juan, Lily Pond, Wolf Creek Summit

Control Sites: Cumbres Trestle, Burro Mountain, La Sal Mountain (UT), Bateman (NM)

Linear Regression Equation:

T = 1.761C – 3.827 (Equation 17, ESJ mixed snow data linear)

In this equation, T is the predicted target site average March 1 snow water equivalent, and C is the control site average.

The r-value for Equation 23 is 0.915, and the standard deviation of the seeded year observed/predicted ratios is 0.332. This is a particularly high standard deviation, and may be related to the high negative offset term (- 3.827) and the effect this can have when applied to an extremely dry year (such as water year 1977, which is included as a seeded season).

Multiple Linear Regression Equation:

T = 0.415(Control Group 1) + 1.199(Control Group 2) – 3.181

(Equation 18, ESJ mixed snow data multiple linear)

In this equation, Control Group 1 is the average of Burro Mountain and La Sal Mountain snow data. Control Group 2 is the average of Cumbres Trestle and Bateman snow data. All values used in equations 23 and 24 are based on March 1 snow water equivalent data at the corresponding sites.

The r-value for Equation 18 is 0.927, and the standard deviation of the historical year observed/predicted ratios is 0.185. Although still high, this standard deviation is much lower than that obtained from Equation 17 (0.332). Note that the multiple linear regression equation (18) has a high negative offset term (-3.181) similar to the linear regression. However, it is likely that the multiple linear form of the equation may produce a more realistic value for outlier years (especially very dry years) than does the linear regression in situations like this.

3.0 INDICATED RESULTS FROM PREVIOUS SEEDED SEASONS

3.1 Application of Regression Equations to Seeded Seasons

When applying the historical regression equations to seeded seasons, data should be collected and assimilated in an identical manner as it was for the historical seasons. Even if the seeded period varies from year to year, the same time periods (November – February totals, and March 1 snowpack data) should be used in the analyses. If the seeded period is very short, one may want to consider a-priori whether to include that season in the seeded period analysis.

Applying each regression equation to the appropriate set of data will yield a predicted target area value for each seeded season. These predicted values can then be compared to the actual observed values for each seeded period. For example, the observed/predicted target area ratio and the observed minus predicted "excess" or absolute value of precipitation, can be calculated. It is important to note that an individual year observed/predicted ratio is not considered to be very significant, because year-to-year variability, or "noise, in the target/control relationship will often be of a larger magnitude than the seeding effects during a given season. For this reason, caution should be used in interpreting individual season results, both in terms of the effectiveness of the program in general and in terms of actual seeding results for that particular year. **An observed/predicted ratio of less than 1.0 does not mean seeding was ineffective during that season, or decreased precipitation, but simply that the seeding effect may have been outweighed by a negative anomaly in the target vs. control precipitation pattern. Similarly, an exceptionally high ratio (perhaps 1.3 or higher) should not be interpreted to mean that seeding produced an exceptional increase in precipitation or snowfall during that season, but that a positive anomaly in the target vs. control precipitation pattern may have added to the real seeding effects to result in a high ratio.**

The strength of these evaluations lies in the multi-year results, which become more significant with each additional seeded season. In the calculation of the observed/predicted ratio for the entire collection of seeded seasons, it is desirable to average the control and target values for all the seeded seasons, then apply the regression equation, as opposed to averaging individual ratios. Although both techniques should yield a very similar result, the average of individual season observed/predicted ratios may be affected by any nonlinearity in the ratios between dry and wet seasons. This would give a larger weighting (per precipitation unit) to precipitation occurring in drier years.

3.2 Results of Applying the Regression Equations to the Seeded Seasons

Seeding was conducted for the southwestern Colorado target areas during the months of November - March this past season (Table 3-1). The regression equations, as presented in Section 2.0, were applied to the available seeded season data. This step was taken following the approval of these equations by the program sponsors as noted in Section 2.2. Tables 3-2 through 3-4 summarize the results by individual seasons plus (four different data types and linear or multi-linear regressions) applied to each data type plus the combined values for each of the three target areas. Precipitation results are provided for both the November through January and November through February periods. It should be noted that seeding in many winter seasons did not begin on November 1st but sometimes later in the month. Snow water content results are for March 1st values. Note that current season data are considered provisional at this time, and may potentially be subject to minor changes based on quality control procedures conducted by the NRCS, or in cases where any problems with the corresponding NAWC data files are discovered the following season.

Table 3-1
Western and Eastern San Juans, and Telluride/San Miguel Seeded Water Years

Water Year	Western San Juans	Eastern San Juans	Telluride/ San Miguel
1976	--	JFM	--
1977	--	NDJF	--
1978	NDJFM	NDJFM	NDJFM
1979	NDJ	--	NDJ
1980	NDJ	--	NDJF
1981	NDJF	--	NDJFM
1982	NDJFM	--	NDJFM
1983	NDJ	--	--
1984	NDJ	--	--
1985	NDJ	--	--
1991	--	--	--
1997	--	--	NDJ
1998	--	--	NDJ
1999	--	--	NDJ
2000	--	--	NDJ
2001	NDJ	--	NDJ
2002	NDJ	--	NDJ
2003	NDJF	NDJF	NDJF
2004	NDJF	NDJF	NDJF
2005	NDJ	NDJ	--
2006	NDJFM	NDJFM	--
2007	NDJFM	NDJFM	NDJFM
2008	NDJFM	NDJFM	NDJFM
2009	NDJFM	NDJFM	NDJFM
2010	NDJFM	NDJFM	NDJFM
2011	NDJFM	NDJFM	NDJFM
2012	NDJFM	NDJFM	NDJFM
2013	NDJFM	DJF	NDJFM

Water Year	Western San Juans	Eastern San Juans	Telluride/ San Miguel
2014	NDJFM	JFM	NDJFM
2015	NDJFMA	DJFMA	NDJFMA
2016	NDJFMA	DJFMA	NDJFMA
2017	NDJFM	JFM	DJM
2018	DJFMA	DJFM	NDJFMA
2019	NDJFM	DJFM	NDJFM
2020	NDJFM	NDJFM	NDJFM
2021	NDJFM	NDJFM	NDJFMA
2022	DJFM	DJFM	DJFM

Note: Colorado River Basin Pilot Project excluded from consideration

Table 3-2
Results of Regression Equations Applied to Individual Seasons
Telluride/San Miguel Target Area

Water Year	SNOTEL Precip. Nov-Feb Linear	SNOTEL Precip. Nov-Feb Multiple Linear	SNOTEL Snow Linear	SNOTEL Snow Multiple Linear	Mixed Snow Linear	Mixed Snow Multiple Linear
1978	--	--	--	--	1.05	1.04
1979	--	--	--	--	0.94	0.94
1980	--	--	--	--	0.89	0.90
1981	--	--	--	--	1.17	1.16
1982	--	--	--	--	0.98	0.98
break						
1997	1.08	1.06	1.11	1.10	1.14	1.13
1998	0.92	0.88	0.94	0.91	0.84	0.84
1999	1.12	1.07	1.34	1.33	1.31	1.30
2000	1.10	0.90	1.20	1.11	1.26	1.23
2001	0.95	0.95	1.10	1.12	1.03	1.03
2002	1.04	0.95	1.16	1.12	1.06	1.05
2003	1.01	1.03	0.96	0.95	0.95	0.95
2004	1.03	0.98	1.08	1.07	1.07	1.07
break						
2007	0.99	1.01	1.08	1.07	1.10	1.10
2008	1.05	1.17	1.09	1.13	1.04	1.05

Water Year	SNOTEL Precip. Nov-Feb Linear	SNOTEL Precip. Nov-Feb Multiple Linear	SNOTEL Snow Linear	SNOTEL Snow Multiple Linear	Mixed Snow Linear	Mixed Snow Multiple Linear
2009	1.17	1.20	1.10	1.12	1.03	1.04
2010	0.97	0.97	0.95	0.96	0.81	0.81
2011	1.16	1.12	1.02	0.98	1.05	1.04
2012	1.12	1.11	1.07	1.05	1.20	1.19
2013	1.00	0.97	0.99	0.96	0.94	0.94
2014	1.29	1.23	1.39	1.34	1.38	1.36
2015	1.16	1.29	1.12	1.14	1.11	1.11
2016	1.08	0.97	0.99	0.96	1.06	1.05
2017	1.10	1.18	0.99	1.03	1.01	1.02
2018	1.07	1.14	1.33	1.33	1.01	1.00
2019	1.03	1.00	1.13	1.11	1.08	1.08
2020	1.11	1.10	1.16	1.16	1.11	1.11
2021	1.10	1.14	1.11	1.12	1.03	1.03
2022[2]	0.86	0.87	0.98	0.98	0.94	0.94
Mean[3]	**1.06**	**1.05**	**1.08**	**1.08**	**1.03**	**1.03**
Median[4]	1.08	1.05	1.09	1.10	1.05	1.04
Avg Pcp Excess[5]	0.72”	0.64”	1.06”	1.01”	0.43”	0.44”

[1] This value has changed due to correction of data, or addition of previously missing data

[2] Current season data are considered provisional and may be subject to adjustment

[3] Mathematically, this is not a mean of individual year ratios, but a ratio of the mean of all the observed values over the mean of the predicted values for seeded seasons

[4] Median values represent the midpoint in the set of individual year ratios

[5] The average of observed minus predicted precipitation/snow water values for the seeded seasons, in inches; negative values are associated with any observed/predicted ratios below 1.0

Table 3-3
Results of Regression Equations Applied to Individual Seasons
Western San Juans Target Area

Water Year	SNOTEL Precip. Nov-Feb Linear	SNOTEL Precip. Nov-Feb Multiple Linear	SNOTEL Snow Linear	SNOTEL Snow Multiple Linear	Mixed Snow Linear	Mixed Snow Multiple Linear
1978	--	--	--	--	0.93	0.91
1979	--	--	--	--	1.07	1.09
1980	--	--	--	--	0.91	0.94
1981	--	--	--	--	0.74	0.73
1982	--	--	--	--	0.79	0.79
1983	--	--	--	--	0.70	0.70
1984	--	--	--	--	0.95	0.93
1985	--	--	--	--	0.92	0.95
break						
2001	1.01	1.03	1.17	1.20	1.13	1.16
2002	0.94	0.93	0.92	0.91	0.95	0.93
2003	0.96	0.98	0.85	0.85	0.86	0.87
2004	1.10	1.09	1.06	1.06	1.10	1.11
2005	1.10	1.11	1.14	1.14	1.12	1.15
2006	0.94	0.92	1.01	0.98	1.06	0.98
2007	1.00	1.01	0.90	0.90	0.93	0.93
2008	1.03	1.05	1.05	1.08	1.07	1.11
2009	1.13	1.13	1.00	1.02	1.03	1.05
2010	0.93	0.94	0.92	0.93	0.81	0.83
2011	1.02	1.02	1.03	1.02	1.13	1.12
2012	1.09	1.09	1.06	1.06	1.22	1.21
2013	0.94	0.95	0.88	0.87	0.81	0.81
2014	1.31	1.31	1.36	1.34	1.52	1.46
2015	1.09	1.12	0.93	0.95	0.88	0.89
2016	0.94	0.92	0.91	0.91	1.01	0.99
2017	1.08	1.10	0.97	0.99	1.05	1.08
2018	0.87	0.90	1.16	1.18	0.95	0.95

Water Year	SNOTEL Precip. Nov-Feb Linear	SNOTEL Precip. Nov-Feb Multiple Linear	SNOTEL Snow Linear	SNOTEL Snow Multiple Linear	Mixed Snow Linear	Mixed Snow Multiple Linear
2019	1.01	1.01	1.09	1.08	1.02	1.02
2020	1.03	1.05	1.13	1.14	1.06	1.06
2021	1.02	1.04	1.01	1.03	0.94[1]	0.96
2022[2]	0.99	0.99	0.95	0.95	1.01	1.04
Mean[3]	**1.03**	**1.04**	**1.02**	**1.03**	**0.98**	**0.99**
Median[4]	1.02	1.02	1.01	1.02	0.98	0.97
Avg. Precipitation Excess[5]	0.37”	0.45”	0.27”	0.34”	-0.25”	-0.13”

[1] This value has changed due to correction of data, or addition of previously missing data

[2] Current season data are considered provisional and may be subject to adjustment

[3] Mathematically, this is not a mean of individual year ratios, but a ratio of the mean of all the observed values over the mean of the predicted values for seeded seasons

[4] Median values represent the midpoint in a data set

[5] The average of observed minus predicted precipitation/snow water values for the seeded seasons, in inches; negative values are associated with any observed/predicted ratios below 1.0.

Table 3-4
Results of Regression Equations Applied to Individual Seasons
Eastern San Juans Target Area

Water Year	SNOTEL Precip. Nov-Feb Linear Regression	SNOTEL Precip. Nov-Feb Multiple Linear	SNOTEL Snow Linear Regression	SNOTEL Snow Multiple Linear	Mixed Snow Linear Regression	Mixed Snow Multiple Linear
1976	--	--	--	--	1.20	1.14
1977	--	--	--	--	2.02	1.32
1978	--	--	--	--	0.69	0.75
break						

Water Year	SNOTEL Precip. Nov-Feb Linear Regression	SNOTEL Precip. Nov-Feb Multiple Linear	SNOTEL Snow Linear Regression	SNOTEL Snow Multiple Linear	Mixed Snow Linear Regression	Mixed Snow Multiple Linear
2003	0.88	0.83	0.80	0.78	0.83	0.79
2004	1.20	1.25	1.13	1.12	1.22	1.20
2005	1.37	1.35	1.34	1.32	1.41	1.32
2006	0.79	0.88	0.74	0.84	0.71	0.87
2007	1.11	1.04	0.99	0.98	1.02	0.98
2008	1.17	1.07	1.15	1.04	1.17	1.06
2009	1.13	1.10	0.93	0.87	0.90	0.85
2010	0.99	0.98	0.96	0.93	1.00	0.97
2011	1.01	1.02	1.02	1.09	1.12	1.17
2012	1.07	1.05	1.07	1.10	1.16	1.16
2013	1.05	1.06	0.94	0.98	1.02	1.03
2014	1.28	1.29	1.15	1.22	1.11	1.19
2015	0.93	0.82	0.90	0.82	0.80	0.77
2016	0.92	1.02	0.96	1.00	0.96	0.98
2017	0.95	0.89	0.94	0.86	0.93	0.85
2018	1.15	1.00	1.30	1.20	1.30	1.29
2019	0.99	1.01	1.08	1.10	0.99	0.98
2020	1.04	1.02	1.08	1.05	0.95	0.93
2021	1.21[1]	1.12[1]	1.26	1.19	1.33	1.26
2022[2]	1.03	1.00	1.09	1.08	1.16	1.08
Mean[3]	**1.07**	**1.04**	**1.04**	**1.02**	**1.05**	**1.02**
Median[4]	1.04	1.02	1.05	1.04	1.02	1.03
Avg. Pcp. Excess[5]	1.05”	0.67”	0.78”	0.43”	0.91”	0.40”

[1] This value has changed due to correction of data, or addition of previously missing data

[2] Current season data are considered provisional and may be subject to adjustment

[3] Mathematically, this is not a mean of individual year ratios, but a ratio of the mean of all the observed values over the mean of the predicted values for seeded seasons

[4] Median values represent the midpoint in a data set

[5] The average of observed minus predicted precipitation/snow water values for the seeded seasons, in inches; negative values are associated with any observed/predicted ratios below 1.0.

Table 3-5 summarizes the combined season results that were obtained for the three target areas, as well as some additional parameters such as the r^2 values for the regression equations, the number of historical and seeded seasons in a given evaluation and the amount of seasonal variability (far right column) in the observed/predicted ratios. The evaluations with higher r^2 values for the regression period, a greater number of historical and seeded seasons, and lower variability in the results obtained from seeded seasons, would be expected to produce more reliable long-term results. Note that most of these evaluations now include a similar or greater number of seeded seasons than the number of historical seasons in the regression equation, although some of the historical regression periods are fairly short, for example, 15 years or less.

Section 4.0 discusses the single-season and multi-season results, and Appendix A contains tables showing the data utilized in the development of the regression equations, the seeded period data and results, as well as the regression equation statistics. It should be noted that seeding operations in the Eastern San Juan's target area were limited in both water years 2013 and 2014, and there were some limitations due to suspensions in various portions of the target areas in the 2017 water year. This would be expected to result in lower precipitation increases for these years and in the long-term results to an extent. The implications of the data provided in Tables 3-2 through 3-5 are discussed in the next section.

Table 3-5
Summary of Evaluation Results for Southwest Colorado through Water Year 2021

Target Area	Evaluation Type	r^2	Number of Historical, Seeded Seasons	Overall Observed/ Predicted Ratio	Observed minus Predicted (inches of water)	Median of Ratios	Standard Deviation of Seeded Ratios
Telluride/ San Miguel (or West Dolores / Telluride)	**SNOTEL Nov-Feb Precip. Linear**	0.825	11, 24	1.06	0.72"	1.08	0.092
	SNOTEL Nov-Feb Precip. Multiple	0.846	11, 24	1.05	0.64"	1.05	0.114
	SNOTEL Mar. 1 Snow Linear	0.891	11, 24	1.08	1.06"	1.09	0.122
	SNOTEL Mar. 1 Snow Multiple	0.896	11, 24	1.08	1.01"	1.10	0.119
	Mixed Mar. 1 Snow Linear	0.885	22, 29	1.03	0.43"	1.05	0.128

Target Area	Evaluation Type	r^2	Number of Historical, Seeded Seasons	Overall Observed/ Predicted Ratio	Observed minus Predicted (inches of water)	Median of Ratios	Standard Deviation of Seeded Ratios
	Mixed Mar. 1 Snow Multiple	0.885	22, 29	1.03	0.44”	1.04	0.122
Western San Juan	SNOTEL Nov-Feb Precip. Linear	0.865	15, 22	1.03	0.37”	1.02	0.092
	SNOTEL Nov-Feb Precip. Multiple	0.867	15, 22	1.04	0.45”	1.02	0.095
	SNOTEL Mar. 1 Snow Linear	0.875	15, 22	1.02	0.27”	1.01	0.120
	SNOTEL Mar. 1 Snow Multiple	0.877	15, 22	1.03	0.34”	1.02	0.121
	Mixed Mar. 1 Snow Linear	0.858	26, 30	0.98	-0.25”	0.98	0.160
	Mixed Mar. 1 Snow Multiple	0.861	26, 30	0.99	-0.13”	0.97	0.155
Eastern San Juan	SNOTEL Nov-Feb Precip. Linear	0.816	15, 20	1.07	1.05”	1.04	0.141
	SNOTEL Nov-Feb Precip. Multiple	0.848	15, 20	1.04	0.67”	1.02	0.139
	SNOTEL Mar. 1 Snow Linear	0.752	15, 20	1.04	0.78”	1.05	0.156

Target Area	Evaluation Type	r^2	Number of Historical, Seeded Seasons	Overall Observed/ Predicted Ratio	Observed minus Predicted (inches of water)	Median of Ratios	Standard Deviation of Seeded Ratios
	SNOTEL Mar. 1 Snow Multiple	0.790	15, 20	1.02	0.43”	1.04	0.147
	Mixed Mar. 1 Snow Linear	0.837	24, 22	1.05	0.91”	1.02	0.278
	Mixed Mar. 1 Snow Multiple	0.860	24, 22	1.02	0.40”	1.03	0.179

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4.0 DISCUSSION OF RESULTS

Tables 4-1 through 4-3 summarize the results for the past winter season (top two rows of the table) by three different data types, each with a linear and a multiple linear regression equation estimate. A separate table is provided for each of the three target areas. These tables provide the observed amount of precipitation divided by the predicted amount. Values over 1.0 indicate more precipitation or snow water content occurred than was predicted based on the control site data. Averages are provided for each of the three data types for all of the seeded water years including the 2021 water year (bottom two rows). It should be noted that seeding operations in the Eastern San Juan target area were limited in some years, which would be expected to make the seeding effects in this area more difficult to detect. Also, any significant suspensions of seeding operations (which may occur due to excess snowpack or avalanche issues) will reduce the overall effect of the seeding program for a given season. Either wetter or drier than normal conditions in a given season may also affect the relationship between target and control sites as compared to the historical regression period, although this should not necessarily bias the regression results in either a positive or negative way.

Table 4-1
Observed Over Predicted Amounts for the 2022 Water Year and Averages for all Seeded Water Years,
Telluride/San Miguel (West Dolores/Telluride) Target Area

Equation Type	SNOTEL Precip. Nov. - Feb.	SNOTEL Snow March 1	Mixed Snow March 1
Linear WY 2022	0.86	0.98	0.94
Linear Mean All water years	1.06	1.08	1.03
Multiple Linear WY 2022	0.87	0.98	0.94
Multiple Linear Mean All water years	1.05	1.08	1.03
Average of all long-term evaluation results for this target area	1.06 (+6%), approximately an additional 0.72” of precipitation or snow water equivalent		

Table 4-2

Observed Over Predicted Amounts for the 2022 Water Year and Averages for all Seeded Water Years, <u>Western San Juan Target Area</u>

Equation Type	SNOTEL Precip. Nov. – Feb.	SNOTEL Snow March 1	Mixed Snow March 1
Linear WY 2022	0.99	0.95	1.01
Linear Mean All water years	1.03	1.02	0.98
Multiple Linear WY 2022	0.99	0.95	1.04
Multiple Linear Mean All water years	1.04	1.03	0.99
Average of all long-term evaluation results for this target area	1.02 (+2%), approximately an additional 0.18” of precipitation or snow water equivalent		

Table 4-3

Observed Over Predicted Amounts for the 2022 Water Year and Averages for all Seeded Water Years, <u>Eastern San Juan Target Area</u>

Equation Type	SNOTEL Precip. Nov. - Feb.	SNOTEL Snow March 1	Mixed Snow March 1
Linear WY 2022	1.03	1.09	1.16
Linear Mean All water years	1.07	1.04	1.05
Multiple Linear WY 2022	1.00	1.08	1.08
Multiple Linear Mean All water years	1.04	1.02	1.02
Average of all long-term evaluation results for this target area	1.04 (+4%), approximately an additional 0.71” of precipitation or snow water equivalent		

The water year 2022 results provided in Tables 4-1 through 4-3 are mixed (some greater than and some less than 1.0). There are several likely reasons for this type of single-season variability:

1. The regressions equations provide imperfect predictions. If they were perfect predictions the correlation coefficient and r^2 values would be 1.0. In exceptionally good correlations between target and control areas, we sometimes see r^2 values in the 0.90 to 0.95 range. More common are values in the 0.80 to 0.89 range, which we still consider representative of good correlations. The lower the correlation the higher the variability in the predictions.

2. Early snow melt may deplete the snow water content differently at control and target sites especially if there are differences in terms of elevation or aspect. These differences may lead to over or under predictions in target area snow water content.

3. Precipitation observations (SNOTEL) especially at high elevations near timberline may be influenced by strong winds during storms such that the actual amount of precipitation is less than what it should be. This is a factor both in the historical (non-seeded regression period) data set as well as during the seeded seasons, and so, like the other variables in this list, it can influence the regression results in either a positive or negative direction.

4. Persistent weather patterns during a winter season may impact target and control sites differently since control sites are typically located upwind of the target sites. For example, assume there is less than normal seasonal precipitation in the control sites but there is above normal precipitation at the target sites due to a given type of natural weather pattern during a season. In that case, predictions from a regression equation would likely indicate an increase in target area precipitation, which in reality had little or nothing to do with the fact that cloud seeding was conducted. The opposite case could be true as well, yielding results that do not suggest any seeding effect for that season. This is why multi-season seeding results should be the main focus of these evaluations.

For the reasons discussed in the above, NAWC always focuses on averages obtained from multiple seasons of cloud seeding instead of focusing on individual season's results. Silverman (2007) also concluded that indicated effects from winter cloud seeding programs may take from 10 to 20 or more seasons to stabilize converging on a reasonable estimate of the actual magnitude of the seeding effect. Averaging over a large enough sample size tends to lessen the impact of outliers in the data set perhaps by cancelling out negative and positive impacts of some of the above factors as well as some not mentioned in the above list.

Based on the average of the results presented in Tables 4-1 through 4-3 of this section, the regression equations currently suggest long-term seeding effects ranging from approximately 2% to 6% for these target areas. Calculation of the mean observed/predicted ratio for each target area (based on the six different regression equations for each) yields a mean ratio of 1.06 (+6%) for the Telluride/San Miguel target, 1.02 (+2%) for the Western San Juan target area, and 1.04 (+4%) for the Eastern San Juan target. The aggregate result for all these programs averaged together suggests roughly a 4% seasonal precipitation/snowfall increase due to seeding. Corresponding precipitation increases (observed minus predicted precipitation or snow water content values) indicated are approximately 0.72 inches in the Telluride target area, 0.18 inches in the Western San Juan target area and 0.71 inches in the Eastern San Juan target area in precipitation or snow water equivalent.

Results obtained from other long-term winter orographic cloud seeding programs indicate the apparent results of seeding are variable in the early years of these seeding programs. Some programs begin by indicating positive results. Other programs can begin with the indications of negative (no effects) in their early years. The general trend is that the results tend to stabilize after approximately 15 years. Even though it may take a number of years to reach stabilization, a trend is typically established after some intermediate period (e.g., 5-10 years) that provides a fairly reasonable estimate of seeding effects from well designed and executed winter cloud seeding programs. Since each of the three programs are relatively long-term in nature, the indicated results should be reasonably representative of the average seeding effects.

NAWC published a peer reviewed paper in the Weather Modification Association's *Journal of Weather Modification* entitled: Winter "Cloud Seeding Windows" and Potential Influences of Targeted Mountain Barriers. This paper contains discussions of the types of winter clouds that are considered seedable as well as the potential orientation of mountain barriers that may be related to the occurrence of seedable conditions. This paper may be accessed at www.nawcinc.com/publications.html. The paper suggests that the seeding potential in west – east oriented mountain barriers, like the San Juan Range, may be lower than the more common north-south oriented barriers in the western U.S. If this is the case, it may partially explain the indicated long-term seeding effects that are contained in this report.

The 18 regression equations provided in this report should be applicable to estimate potential effects of seeding in future seeded seasons with some caveats:

- The operational periods typically include the period of November through January or February.
- The target areas remain the same.
- There are no significant missing data.

The mix of the selected target and control sites is maintained (e.g., no target or control sites are discontinued).

To place this discussion of apparent results in perspective, it is perhaps worth noting that the Weather Modification Association's (WMA) Capabilities Statement on Weather Modification (WMA 2011) contains the following regarding winter cloud seeding programs:

"The capability to increase precipitation from wintertime orographic cloud systems has been demonstrated in a number of research experiments. The evolution, growth, and fallout of seeding-induced (and enhanced) ice particles have been documented in several mountainous regions of the western United States. Enhanced precipitation rates up to about 1 mm per hour have been measured in seeded cloud regions. Although conducted over smaller temporal and spatial scales, research results tend to be consistent with evaluations of randomized experiments in larger project areas as well as a substantial and growing number of operational projects. Increases of 5% - 15% in winter season precipitation have been consistently reported in target areas that are effectively treated by cloud seeding projects, and generally accepted by the scientific community. Similar results have been found in both continental and coastal mountain regions. The consistent range of indicated effects in many regions suggests widespread transferability of the estimated results for supercooled orographic clouds."

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WMA, 2011: WMA Statement on Weather Modification Capabilities. Weather Modification Association, Fresno, California.

APPENDIX A

REGRESSION EVALUATION DATA TABLES

Telluride/San Miguel SNOTEL Nov-Feb Precipitation, Linear Regression

Water Year	Control Average	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Historical regression period					
1986	15.6	15.0	13.8	1.09	1.22
1987	13.3	15.0	11.9	1.26	3.06
1988	14.6	10.7	13.0	0.83	-2.25
1989	16.8	15.2	14.8	1.03	0.38
1990	6.8	6.0	6.6	0.91	-0.58
1991	13.8	10.7	12.4	0.86	-1.68
1992	13.5	11.6	12.1	0.96	-0.51
1993	23.9	20.1	20.7	0.97	-0.56
1994	14.2	11.7	12.7	0.92	-1.00
1995	16.5	15.1	14.5	1.04	0.52
1996	14.2	14.1	12.7	1.11	1.40
Regression Mean	14.8	13.2	13.2	1.00	0.00
Seeded Period					
1997	19.8	18.6	17.3	**1.08**	1.31
1998	12.9	10.7	11.6	**0.92**	-0.89
1999	9.9	10.3	9.1	**1.12**	1.12
2000	11.0	11.0	10.0	**1.10**	1.00
2001	12.1	10.4	11.0	**0.95**	-0.58
2002	9.0	8.7	8.4	**1.04**	0.32
2003	11.7	10.7	10.6	**1.01**	0.07
2004	16.4	14.9	14.5	**1.03**	0.40
2007	11.9	10.6	10.8	**0.99**	-0.15
2008	22.5	20.5	19.5	**1.05**	0.99
2009	15.7	16.3	13.9	**1.17**	2.41
2010	15.4	13.3	13.7	**0.97**	-0.36
2011	12.6	13.2	11.3	**1.16**	1.82
2012	12.3	12.4	11.1	**1.12**	1.30
2013	12.4	11.3	11.2	**1.00**	0.05
2014	9.8	11.6	9.0	**1.29**	2.64
2015	11.8	12.3	10.6	**1.16**	1.69
2016	15.5	14.8	13.7	**1.08**	1.09

2017	21.5	20.5	18.7	**1.10**	1.79
2018	7.7	7.8	7.3	**1.07**	0.48
2019	15.2	14.0	13.5	**1.03**	0.43
2020	11.9	12.0	10.7	**1.11**	1.23
2021	10.5	10.6	9.6	**1.10**	0.94
2021	10.5	10.6	9.6	**1.10**	0.94
2022	13.8	10.7	12.4	**0.86**	-1.71
Seeded Mean	13.5	12.8	12.1	**1.06**	0.72
SUMMARY OUTPUT					
Regression Statistics					
Multiple R	**0.908**				
R Square	**0.825**				
	Coefficients				
Intercept	**0.9110**				
X Variable 1	**0.8272**				

Telluride/San Miguel SNOTEL Nov-Feb Precipitation Multiple Linear Regression

Water Year	North Ctrl Group	South Ctrl Group	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Historical regression period						
1986	14.9	16.5	15.0	14.3	1.05	0.69
1987	12.4	14.7	15.0	11.9	1.26	3.10
1988	13.7	16.0	10.7	13.1	0.82	-2.41
1989	15.2	19.3	15.2	14.7	1.03	0.50
1990	7.0	6.6	6.0	6.5	0.92	-0.53
1991	11.8	16.9	10.7	11.5	0.93	-0.82
1992	13.0	14.4	11.6	12.4	0.93	-0.82
1993	21.2	27.9	20.1	20.7	0.97	-0.62
1994	12.8	16.3	11.7	12.4	0.94	-0.72
1995	14.2	19.9	15.1	13.8	1.09	1.22
1996	14.4	14.0	14.1	13.7	1.03	0.41
Regression Mean	13.7	16.6	13.2	13.2	1.00	0.00
Seeded Period						
1997	18.1	22.4	18.6	17.5	**1.06**	1.08
1998	12.7	13.2	10.7	12.1	**0.88**	-1.40
1999	10.2	9.6	10.3	9.6	**1.07**	0.66
2000	13.2	7.8	11.0	12.2	**0.90**	-1.17

Water Year	North Ctrl Group	South Ctrl Group	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
2001	11.4	13.3	10.4	10.9	**0.95**	-0.50
2002	9.8	7.8	8.7	9.1	**0.95**	-0.47
2003	10.8	13.1	10.7	10.4	**1.03**	0.32
2004	15.9	17.1	14.9	15.3	**0.98**	-0.38
2007	10.9	13.4	10.6	10.5	**1.01**	0.13
2008	17.5	30.0	20.5	17.4	**1.17**	3.05
2009	14.1	18.2	16.3	13.6	**1.20**	2.69
2010	14.2	17.3	13.3	13.7	**0.97**	-0.37
2011	12.3	13.1	13.2	11.7	**1.12**	1.44
2012	11.7	13.1	12.4	11.2	**1.11**	1.18
2013	12.2	12.8	11.3	11.6	**0.97**	-0.35
2014	10.1	9.3	11.6	9.5	**1.23**	2.14
2015	9.8	14.8	12.3	9.5	**1.29**	2.81
2016	16.2	14.5	14.8	15.3	**0.97**	-0.48
2017	17.6	27.5	20.5	17.4	**1.18**	3.12
2018	7.2	8.5	7.8	6.8	**1.14**	0.94
2019	14.5	16.4	14.0	13.9	**1.00**	0.04
2020	11.4	12.6	12.0	10.9	**1.10**	1.09
2021	9.7	11.8	10.6	9.3	**1.14**	1.28
2022	12.7	15.5	10.7	12.3	**0.87**	-1.60
Seeded Mean	12.7	14.7	12.8	12.1	**1.05**	0.64
SUMMARY OUTPUT						
Regression Statistics						
Multiple R	**0.920**					
R Square	**0.846**					
	Coefficients					
Intercept	**-0.2485**					
North Ctrl	**0.9058**					
South Ctrl	**0.0625**					

Telluride/San Miguel SNOTEL March 1 Snow Linear Regression

Water Year	Control Average	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Historical regression period					
1986	17.2	15.4	15.6	0.99	-0.23
1987	15.3	16.6	13.8	1.20	2.76
1988	14.2	11.3	12.7	0.89	-1.41
1989	18.4	17.1	16.8	1.02	0.28
1990	6.3	5.2	5.0	1.04	0.21
1991	15.0	10.3	13.4	0.77	-3.14
1992	14.2	13.0	12.7	1.02	0.24
1993	25.0	23.0	23.2	0.99	-0.20
1994	14.8	12.6	13.3	0.95	-0.69
1995	16.7	16.3	15.1	1.08	1.16
1996	14.3	13.9	12.8	1.08	1.02
Regression Mean	15.6	14.0	14.0	1.00	0.00
Seeded Period					
1997	23.1	23.8	21.4	**1.11**	2.35
1998	14.1	11.8	12.6	**0.94**	-0.80
1999	10.4	12.0	8.9	**1.34**	3.04
2000	11.2	11.7	9.7	**1.20**	1.99
2001	13.5	13.2	12.0	**1.10**	1.17
2002	8.7	8.5	7.3	**1.16**	1.17
2003	14.0	11.9	12.5	**0.96**	-0.55
2004	15.9	15.5	14.4	**1.08**	1.10
2007	13.6	13.0	12.1	**1.08**	0.92
2008	22.8	23.0	21.1	**1.09**	1.84
2009	17.6	17.5	16.0	**1.10**	1.54
2010	17.6	15.2	16.0	**0.95**	-0.76
2011	15.2	13.9	13.7	**1.02**	0.21
2012	12.9	12.2	11.4	**1.07**	0.79
2013	13.0	11.4	11.6	**0.99**	-0.16
2014	11.2	13.5	9.7	**1.39**	3.79
2015	11.6	11.3	10.1	**1.12**	1.19
2016	15.5	13.8	14.0	**0.99**	-0.21
2017	23.0	21.2	21.3	**0.99**	-0.12
2018	8.0	8.8	6.6	**1.33**	2.17
2019	16.7	17.0	15.1	**1.13**	1.92
2020	12.4	12.7	10.9	**1.16**	1.79
2021	11.9	11.5	10.4	**1.11**	1.12
2022	14.6	12.9	13.1	**0.98**	-0.25

Water Year	Control Average	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Seeded Mean	14.5	14.1	13.0	**1.08**	1.06
SUMMARY OUTPUT					
Regression Statistics					
Multiple R	**0.9436**				
R Square	**0.8905**				
	Coefficients				
Intercept	**-1.2027**				
X Variable 1	**0.9786**				

Telluride/San Miguel SNOTEL March 1 Snow Multiple Linear Regression

Water Year	North Ctrl Avg	South Ctrl Avg	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Historical regression period						
1986	16.5	18.2	15.4	16.1	0.95	-0.77
1987	13.3	18.4	16.6	13.9	1.19	2.68
1988	12.0	17.6	11.3	12.7	0.89	-1.39
1989	14.1	24.8	17.1	16.4	1.04	0.69
1990	5.7	7.2	5.2	5.1	1.02	0.12
1991	11.3	20.5	10.3	13.0	0.79	-2.74
1992	12.4	17.0	13.0	12.8	1.01	0.14
1993	21.8	29.7	23.0	23.4	0.98	-0.41
1994	12.2	18.7	12.6	13.2	0.96	-0.59
1995	12.3	23.4	16.3	14.6	1.12	1.68
1996	13.7	15.3	13.9	13.3	1.04	0.58
Regression Mean	13.2	19.1	14.0	14.0	1.00	0.00
Seeded Period						
1997	20.2	27.5	23.8	21.6	**1.10**	2.16
1998	13.2	15.4	11.8	13.0	**0.91**	-1.15
1999	9.1	12.2	12.0	9.0	**1.33**	2.95
2000	12.6	9.1	11.7	10.6	**1.11**	1.13
2001	10.4	18.2	13.2	11.7	**1.12**	1.46
2002	8.3	9.4	8.5	7.6	**1.12**	0.94
2003	12.0	17.0	11.9	12.5	**0.95**	-0.59
2004	13.7	19.3	15.5	14.5	**1.07**	1.05
2007	11.8	16.3	13.0	12.2	**1.07**	0.85
2008	16.4	32.5	23.0	20.3	**1.13**	2.66

2009	13.6	23.6	17.5	15.6	**1.12**	1.90
2010	14.6	22.0	15.2	15.9	**0.96**	-0.68
2011	14.5	16.4	13.9	14.2	**0.98**	-0.23
2012	11.8	14.5	12.2	11.6	**1.05**	0.55
2013	12.2	14.3	11.4	11.9	**0.96**	-0.47
2014	10.7	11.9	13.5	10.1	**1.34**	3.44
2015	9.0	15.5	11.3	9.9	**1.14**	1.43
2016	14.2	17.5	13.8	14.3	**0.96**	-0.50
2017	17.0	31.9	21.2	20.6	**1.03**	0.55
2018	6.7	9.9	8.8	6.6	**1.33**	2.20
2019	14.8	19.5	17.0	15.3	**1.11**	1.73
2020	10.7	15.0	12.7	11.0	**1.16**	1.76
2021	9.7	15.1	11.5	10.3	**1.12**	1.23
2022	12.6	17.7	12.9	13.2	**0.98**	-0.31
Seeded Mean	12.5	17.6	14.1	13.0	**1.08**	1.01
SUMMARY OUTPUT						
Regression Statistics						
Multiple R	**0.947**					
R Square	**0.896**					
	Coefficients					
Intercept	**-1.2414**					
North Ctrl	**0.7261**					
South Ctrl	**0.2976**					

Telluride/San Miguel Mixed Snow Linear Regression

Water Year	Control Average	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Historical regression period					
1961	6.8	8.3	7.7	1.08	0.63
1962	18.0	18.0	18.3	0.98	-0.37
1963	8.7	10.6	9.5	1.12	1.10
1964	6.1	7.9	7.1	1.11	0.78
1965	15.9	15.5	16.4	0.95	-0.86
1966	14.8	12.6	15.3	0.82	-2.68
1967	10.4	11.9	11.2	1.06	0.72
1968	13.3	15.9	13.9	1.14	1.97
1969	16.5	17.8	17.0	1.05	0.84
1976	12.5	14.9	13.1	1.14	1.78
1977	3.5	3.7	4.5	0.82	-0.80
1986	13.0	13.9	13.6	1.02	0.28
1987	12.0	15.3	12.6	1.21	2.66
1988	11.9	10.3	12.6	0.82	-2.26

Water Year	Control Average	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
1989	14.5	15.5	15.0	1.04	0.55
1990	5.6	4.7	6.5	0.72	-1.84
1991	11.6	10.1	12.3	0.82	-2.21
1992	12.6	12.8	13.3	0.96	-0.48
1993	20.4	20.4	20.6	0.99	-0.23
1994	11.9	12.1	12.6	0.96	-0.47
1995	14.2	14.7	14.7	1.00	-0.06
1996	11.4	13.0	12.0	1.08	0.97
Regression Mean	12.1	12.7	12.7	1.00	0.00
Seeded Period					
1978	15.2	16.5	15.7	**1.05**	0.73
1979	20.3	19.3	20.5	**0.94**	-1.28
1980	20.8	18.8	21.0	**0.89**	-2.27
1981	5.0	7.0	6.0	**1.17**	0.99
1982	15.7	15.9	16.2	**0.98**	-0.32
1997	18.4	21.4	18.7	**1.14**	2.61
1998	12.9	11.4	13.5	**0.84**	-2.12
1999	7.7	11.3	8.6	**1.31**	2.69
2000	7.7	10.8	8.6	**1.26**	2.25
2001	10.6	11.6	11.3	**1.03**	0.31
2002	6.4	7.8	7.3	**1.06**	0.46
2003	10.6	10.8	11.3	**0.95**	-0.54
2004	12.3	13.9	13.0	**1.07**	0.91
2007	10.7	12.5	11.4	**1.10**	1.13
2008	19.1	20.1	19.4	**1.04**	0.69
2009	14.6	15.5	15.1	**1.03**	0.43
2010	16.0	13.3	16.4	**0.81**	-3.17
2011	11.4	12.7	12.1	**1.05**	0.57
2012	8.8	11.5	9.6	**1.20**	1.91
2013	10.1	10.2	10.8	**0.94**	-0.61
2014	8.2	12.5	9.0	**1.38**	3.45
2015	9.5	11.4	10.3	**1.11**	1.08
2016	11.4	12.7	12.0	**1.06**	0.67
2017	17.9	18.4	18.3	**1.01**	0.11
2018	6.9	7.8	7.8	**1.01**	0.05
2019	13.6	15.3	14.2	**1.08**	1.09
2020	10.0	12.0	10.8	**1.11**	1.20
2021	9.4	10.5	10.2	**1.03**	0.30
2022	11.3	11.3	12.0	**0.94**	-0.75

Water Year	Control Average	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Seeded Mean	12.2	13.2	12.8	**1.03**	0.43
SUMMARY OUTPUT					
Regression Statistics					
Multiple R	**0.941**				
R Square	**0.885**				
	Coefficients				
Intercept	**1.2370**				
X Variable 1	**0.9504**				

Telluride/San Miguel Mixed March 1 Snow Multiple Linear Regression

Water Year	North Ctrl Avg	South Ctrl Avg	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Historical regression period						
1961	6.7	6.9	8.3	7.7	1.08	0.63
1962	17.8	18.2	18.0	18.4	0.98	-0.41
1963	6.9	10.0	10.6	9.4	1.13	1.19
1964	6.2	6.1	7.9	7.1	1.11	0.78
1965	15.1	16.5	15.5	16.4	0.95	-0.86
1966	14.8	14.8	12.6	15.3	0.82	-2.72
1967	10.6	10.3	11.9	11.2	1.06	0.69
1968	14.1	12.8	15.9	14.0	1.14	1.90
1969	14.2	18.1	17.8	16.9	1.05	0.92
1976	10.4	13.9	14.9	13.0	1.14	1.87
1977	2.1	4.4	3.7	4.4	0.84	-0.71
1986	16.4	10.7	13.9	13.8	1.00	0.06
1987	11.8	12.2	15.3	12.7	1.21	2.64
1988	11.7	12.1	10.3	12.6	0.82	-2.27
1989	13.2	15.3	15.5	14.9	1.04	0.58
1990	5.9	5.4	4.7	6.6	0.72	-1.86
1991	10.4	12.4	10.1	12.2	0.82	-2.17
1992	11.7	13.3	12.8	13.2	0.97	-0.45
1993	17.8	22.1	20.4	20.5	0.99	-0.15
1994	11.1	12.5	12.1	12.5	0.96	-0.45
1995	11.5	16.0	14.7	14.6	1.00	0.05
1996	14.8	9.1	13.0	12.2	1.06	0.75
Regression Mean	11.6		12.7	12.7	1.00	0.00
Seeded Period						
1978	17.0	14.1	16.5	15.9	**1.04**	0.59

Water Year	North Ctrl Avg	South Ctrl Avg	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
1979	16.3	23.0	19.3	20.4	**0.94**	-1.12
1980	15.2	24.6	18.8	20.8	**0.90**	-2.03
1981	5.9	4.4	7.0	6.1	**1.16**	0.95
1982	15.1	16.2	15.9	16.2	**0.98**	-0.33
1997	18.8	18.2	21.4	18.8	**1.13**	2.53
1998	13.2	12.7	11.4	13.5	**0.84**	-2.17
1999	9.2	6.7	11.3	8.6	**1.30**	2.61
2000	11.3	5.3	10.8	8.8	**1.23**	2.05
2001	9.3	11.5	11.6	11.3	**1.03**	0.37
2002	7.9	5.4	7.8	7.4	**1.05**	0.37
2003	9.8	11.2	10.8	11.3	**0.95**	-0.51
2004	11.5	12.9	13.9	12.9	**1.07**	0.93
2007	10.0	11.1	12.5	11.4	**1.10**	1.15
2008	13.4	22.9	20.1	19.1	**1.05**	0.94
2009	12.2	16.2	15.5	15.0	**1.04**	0.53
2010	12.5	18.3	13.3	16.3	**0.81**	-3.02
2011	12.3	10.9	12.7	12.2	**1.04**	0.49
2012	9.5	8.4	11.5	9.7	**1.19**	1.85
2013	10.3	10.0	10.2	10.9	**0.94**	-0.64
2014	10.3	6.9	12.5	9.2	**1.36**	3.33
2015	9.1	9.8	11.4	10.3	**1.11**	1.09
2016	12.9	10.4	12.7	12.1	**1.05**	0.56
2017	13.5	20.9	18.4	18.1	**1.02**	0.30
2018	7.3	6.6	7.8	7.8	**1.00**	0.02
2019	13.1	14.0	15.3	14.2	**1.08**	1.09
2020	10.5	9.8	12.0	10.8	**1.11**	1.15
2021	8.6	9.9	10.5	10.1	**1.03**	0.33
2022	9.5	12.5	11.3	11.9	**0.94**	-0.67
Seeded Mean	11.5	12.6	13.2	12.8	**1.03**	0.44
SUMMARY OUTPUT						
Regression Statistics						
Multiple R	**0.9409**					
R Square	0.8854					
	Coefficients					
Intercept	**1.211**					
North Ctrl	**0.4150**					
South Ctrl	**0.5398**					

Western San Juan Target SNOTEL Nov-Feb Precipitation Linear Regression

Water Year	Control Average	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Historical regression period					
1986	14.4	16.9	14.2	1.19	2.74
1987	13.4	16.1	13.1	1.22	2.92
1988	14.1	12.1	13.9	0.87	-1.82
1989	14.6	16.0	14.4	1.11	1.61
1990	6.3	5.7	5.9	0.96	-0.21
1991	13.3	11.0	13.0	0.84	-2.02
1992	13.5	12.1	13.3	0.91	-1.17
1993	22.8	22.4	22.8	0.98	-0.37
1994	12.8	11.9	12.5	0.95	-0.64
1995	15.6	16.2	15.4	1.05	0.71
1996	13.0	13.0	12.7	1.02	0.29
1997	18.5	17.7	18.4	0.97	-0.63
1998	12.4	10.5	12.1	0.86	-1.64
1999	9.2	9.7	8.9	1.10	0.87
2000	10.5	9.5	10.2	0.94	-0.64
Regression Mean	13.6	13.4	13.4	1.00	0.00
Seeded Period					
2001	11.8	11.7	11.5	**1.01**	0.16
2002	8.1	7.3	7.8	**0.94**	-0.43
2003	11.2	10.5	10.9	**0.96**	-0.40
2004	15.3	16.6	15.0	**1.10**	1.50
2005	17.9	19.4	17.7	**1.10**	1.71
2006	8.5	7.7	8.2	**0.94**	-0.47
2007	11.0	10.7	10.6	**1.00**	0.04
2008	21.4	21.9	21.3	**1.03**	0.54
2009	14.7	16.4	14.5	**1.13**	1.84
2010	15.5	14.2	15.3	**0.93**	-1.10
2011	11.9	11.8	11.6	**1.02**	0.24
2012	11.8	12.5	11.5	**1.09**	0.99
2013	12.2	11.3	12.0	**0.94**	-0.71
2014	9.5	12.0	9.2	**1.31**	2.81
2015	10.4	11.0	10.1	**1.09**	0.90
2016	14.8	13.7	14.5	**0.94**	-0.82
2017	19.9	21.5	19.8	**1.08**	1.64
2018	7.5	6.1	7.1	**0.87**	-0.95
2019	14.8	14.7	14.5	**1.01**	0.13
2020	12.1	12.3	11.9	**1.03**	0.40

2021	10.0	9.8	9.7	**1.02**	0.17
2022	12.4	12.0	12.1	**0.99**	-0.11
Seeded Mean	12.9	12.9	12.6	**1.03**	0.37
SUMMARY OUTPUT					
Regression Statistics					
Multiple R	**0.930**				
R Square	**0.865**				
	Coefficients				
Intercept	**-0.5661**				
X Variable 1	**1.0231**				

Western San Juan SNOTEL Nov-Feb Precipitation Multiple Linear Regression

Water Year	North Ctrl Avg	South Ctrl Avg	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Historical regression period						
1986	14.9	13.6	16.9	14.3	1.18	2.61
1987	12.4	15.0	16.1	12.9	1.24	3.13
1988	13.7	14.9	12.1	13.8	0.87	-1.75
1989	15.2	13.7	16.0	14.5	1.10	1.46
1990	7.0	5.3	5.7	5.7	0.99	-0.08
1991	11.8	15.6	11.0	12.7	0.87	-1.72
1992	13.0	14.3	12.1	13.2	0.92	-1.06
1993	21.2	25.3	22.4	22.8	0.98	-0.39
1994	12.8	12.7	11.9	12.5	0.95	-0.62
1995	14.2	17.9	16.2	15.2	1.06	0.93
1996	14.4	10.9	13.0	13.0	1.00	0.04
1997	18.1	19.2	17.7	18.5	0.96	-0.72
1998	12.7	12.0	10.5	12.1	0.86	-1.65
1999	10.2	7.8	9.7	8.9	1.09	0.84
2000	13.2	6.4	9.5	10.6	0.90	-1.05
Regression Mean	13.7	13.6	13.4	13.4	1.00	0.00
Seeded Period						
2001	11.4	12.5	11.7	11.4	**1.03**	0.31
2002	9.8	5.6	7.3	7.9	**0.93**	-0.55
2003	10.8	11.7	10.5	10.7	**0.98**	-0.24
2004	15.9	14.3	16.6	15.2	**1.09**	1.32
2005	16.1	20.6	19.4	17.5	**1.11**	1.90

Water Year	North Ctrl Avg	South Ctrl Avg	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
2006	10.7	5.2	7.7	8.4	**0.92**	-0.71
2007	10.9	11.0	10.7	10.5	**1.01**	0.14
2008	17.5	27.3	21.9	20.8	**1.05**	1.02
2009	14.1	15.8	16.4	14.4	**1.13**	1.93
2010	14.2	17.4	14.2	15.1	**0.94**	-0.92
2011	12.3	11.3	11.8	11.6	**1.02**	0.23
2012	11.7	12.1	12.5	11.5	**1.09**	1.08
2013	12.2	12.3	11.3	11.9	**0.95**	-0.64
2014	10.1	8.7	12.0	9.1	**1.31**	2.85
2015	9.8	11.5	11.0	9.9	**1.12**	1.15
2016	16.2	12.7	13.7	14.8	**0.92**	-1.13
2017	17.6	23.5	21.5	19.6	**1.10**	1.87
2018	7.2	7.9	6.1	6.8	**0.90**	-0.68
2019	14.5	15.2	14.7	14.5	**1.01**	0.14
2020	11.4	13.3	12.3	11.7	**1.05**	0.60
2021	9.7	10.5	9.8	9.5	**1.04**	0.36
2022	12.7	12.0	12.0	12.2	**0.99**	-0.12
Seeded Mean	12.6	13.3	12.9	12.5	**1.04**	0.45
SUMMARY OUTPUT						
Regression Statistics						
Multiple R	**0.931**					
R Square	**0.867**					
	Coefficients					
Intercept	**-1.0663**					
North Ctrl	**0.7131**					
South Ctrl	**0.3464**					

Western San Juan Target SNOTEL March 1 Snow Linear Regression

Water Year	Control Average	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Historical regression period					
1986	17.2	17.8	16.5	1.08	1.33
1987	15.3	18.4	14.5	1.27	3.89
1988	14.2	11.7	13.2	0.88	-1.56
1989	18.4	17.6	17.8	0.98	-0.29
1990	6.3	5.1	4.5	1.14	0.64
1991	15.0	10.8	14.1	0.77	-3.24
1992	14.2	12.3	13.2	0.93	-0.91
1993	25.0	26.3	25.2	1.04	1.12

Water Year	Control Average	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
1994	14.8	12.6	13.9	0.91	-1.23
1995	16.7	16.7	16.0	1.05	0.74
1996	14.3	12.3	13.4	0.92	-1.07
1997	23.1	23.1	23.1	1.00	-0.07
1998	14.1	10.6	13.1	0.81	-2.49
1999	10.4	12.2	9.0	1.36	3.21
2000	11.2	9.8	9.9	0.99	-0.07
Regression Mean	15.3	14.5	14.5	1.00	0.00
Seeded Period					
2001	13.5	14.6	12.5	**1.17**	2.13
2002	8.7	6.6	7.1	**0.92**	-0.59
2003	14.0	11.1	13.0	**0.85**	-1.92
2004	15.9	16.1	15.2	**1.06**	0.91
2005	19.9	22.3	19.6	**1.14**	2.72
2006	9.0	7.6	7.5	**1.01**	0.06
2007	13.6	11.3	12.6	**0.90**	-1.25
2008	22.8	24.0	22.8	**1.05**	1.19
2009	17.6	17.0	17.0	**1.00**	0.07
2010	17.6	15.6	17.0	**0.92**	-1.33
2011	15.2	14.9	14.4	**1.03**	0.48
2012	12.9	12.5	11.7	**1.06**	0.75
2013	13.0	10.6	11.9	**0.88**	-1.38
2014	11.2	13.4	9.9	**1.36**	3.51
2015	11.6	9.5	10.3	**0.93**	-0.77
2016	15.5	13.4	14.7	**0.91**	-1.27
2017	23.0	22.2	23.0	**0.97**	-0.76
2018	8.0	7.3	6.3	**1.16**	0.98
2019	16.7	17.3	16.0	**1.09**	1.37
2020	12.4	12.7	11.2	**1.13**	1.49
2021	11.9	10.7	10.6	**1.01**	0.11
2022	14.6	13.0	13.7	**0.95**	-0.71
Seeded Mean	14.5	13.8	13.5	**1.02**	0.27
SUMMARY OUTPUT					
Regression Statistics					
Multiple R	**0.933**				
R Square	**0.875**				
	Coefficients				
Intercept	**-2.5370**				

Water Year	Control Average	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
X Variable 1	**1.1100**				

Western San Juan Target SNOTEL March 1 Snow Multiple Linear Regression

Water Year	North Ctrl Avg	South Ctrl Avg	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Historical regression period						
1986	16.5	18.2	17.8	16.8	1.06	1.02
1987	13.3	18.4	18.4	14.5	1.27	3.90
1988	12.0	17.6	11.7	13.2	0.89	-1.47
1989	14.1	24.8	17.6	17.5	1.00	0.03
1990	5.7	7.2	5.1	4.4	1.16	0.71
1991	11.3	20.5	10.8	13.7	0.79	-2.91
1992	12.4	17.0	12.3	13.2	0.93	-0.90
1993	21.8	29.7	26.3	25.3	1.04	0.97
1994	12.2	18.7	12.6	13.7	0.92	-1.09
1995	12.3	23.4	16.7	15.6	1.07	1.15
1996	13.7	15.3	12.3	13.6	0.91	-1.29
1997	20.2	27.5	23.1	23.2	0.99	-0.18
1998	13.2	15.4	10.6	13.3	0.80	-2.65
1999	9.1	12.2	12.2	8.9	1.36	3.25
2000	12.6	9.1	9.8	10.3	0.95	-0.55
Regression Mean	13.4	18.3	14.5	14.5	1.00	0.00
Seeded Period						
2001	10.4	18.2	14.6	12.2	**1.20**	2.40
2002	8.3	9.4	6.6	7.2	**0.91**	-0.63
2003	12.0	17.0	11.1	12.9	**0.85**	-1.88
2004	13.7	19.3	16.1	15.1	**1.06**	0.94
2005	16.5	25.0	22.3	19.5	**1.14**	2.82
2006	9.5	8.4	7.6	7.7	**0.98**	-0.16
2007	11.8	16.3	11.3	12.5	**0.90**	-1.22
2008	16.4	32.5	24.0	22.2	**1.08**	1.75
2009	13.6	23.6	17.0	16.7	**1.02**	0.37
2010	14.6	22.0	15.6	16.9	**0.93**	-1.23
2011	14.5	16.4	14.9	14.6	**1.02**	0.25
2012	11.8	14.5	12.5	11.8	**1.06**	0.67
2013	12.2	14.3	10.6	12.1	**0.87**	-1.51
2014	10.7	11.9	13.4	10.0	**1.34**	3.38
2015	9.0	15.5	9.5	10.0	**0.95**	-0.51
2016	14.2	17.5	13.4	14.8	**0.91**	-1.40
2017	17.0	31.9	22.2	22.5	**0.99**	-0.30

Water Year	North Ctrl Avg	South Ctrl Avg	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
2018	6.7	9.9	7.3	6.2	**1.18**	1.12
2019	14.8	19.5	17.3	16.0	**1.08**	1.30
2020	10.7	15.0	12.7	11.2	**1.14**	1.55
2021	9.7	15.1	10.7	10.5	**1.03**	0.27
2022	12.6	17.7	13.0	13.7	**0.95**	-0.68
Seeded Mean	12.3	17.7	13.8	13.5	**1.03**	0.34
SUMMARY OUTPUT						
Regression Statistics						
Multiple R	**0.937**					
R Square	**0.877**					
	Coefficients					
Intercept	**-2.7306**					
North Ctrl	**0.7627**					
South Ctrl	**0.3841**					

Western San Juan Target Mixed Snow Linear Regression

Water Year	Control Average	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Historical regression period					
1961	6.8	6.9	7.3	0.94	-0.45
1962	18.0	18.8	20.5	0.92	-1.68
1963	8.7	10.1	9.6	1.06	0.53
1964	6.1	5.9	6.6	0.89	-0.71
1965	15.9	17.4	18.1	0.96	-0.65
1966	14.8	15.9	16.7	0.95	-0.83
1967	10.4	14.3	11.6	1.23	2.71
1968	13.3	17.8	15.0	1.19	2.81
1969	16.5	20.4	18.8	1.09	1.64
1976	12.5	16.2	14.0	1.15	2.15
1977	3.5	3.3	3.4	0.96	-0.12
1986	13.0	15.9	14.6	1.09	1.32
1987	12.0	15.3	13.5	1.13	1.81
1988	11.9	9.9	13.4	0.74	-3.52
1989	14.5	17.1	16.3	1.05	0.78
1990	5.6	4.7	5.9	0.80	-1.18
1991	11.6	11.1	13.0	0.85	-1.89
1992	12.6	10.7	14.2	0.76	-3.48

Water Year	Control Average	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
1993	20.4	24.5	23.3	1.05	1.16
1994	11.9	12.4	13.4	0.93	-1.00
1995	14.2	15.3	16.0	0.96	-0.72
1996	11.4	13.2	12.7	1.04	0.53
1997	18.4	21.9	21.0	1.04	0.93
1998	12.9	10.1	14.5	0.70	-4.42
1999	7.7	11.9	8.4	1.42	3.53
2000	7.7	9.2	8.4	1.09	0.74
Regression Mean	12.0	13.5	13.5	1.00	0.00
Seeded Period					
1978	15.2	16.1	17.3	**0.93**	-1.13
1979	20.3	24.8	23.2	**1.07**	1.62
1980	20.8	21.7	23.8	**0.91**	-2.09
1981	5.0	3.9	5.3	**0.74**	-1.39
1982	15.7	14.2	17.9	**0.79**	-3.69
1983	16.2	12.8	18.4	**0.70**	-5.61
1984	16.1	17.3	18.3	**0.95**	-1.00
1985	15.3	15.9	17.3	**0.92**	-1.42
2001	10.6	13.4	11.8	**1.13**	1.59
2002	6.4	6.5	6.9	**0.95**	-0.35
2003	10.6	10.2	11.8	**0.86**	-1.65
2004	12.3	15.2	13.9	**1.10**	1.34
2005	15.9	20.2	18.0	**1.12**	2.17
2006	6.8	7.7	7.3	**1.06**	0.43
2007	10.7	11.0	11.9	**0.93**	-0.88
2008	19.1	23.3	21.8	**1.07**	1.50
2009	14.6	16.9	16.5	**1.03**	0.44
2010	16.0	14.6	18.2	**0.81**	-3.53
2011	11.4	14.5	12.8	**1.13**	1.70
2012	8.8	11.9	9.7	**1.22**	2.14
2013	10.1	9.1	11.2	**0.81**	-2.13
2014	8.2	13.7	9.0	**1.52**	4.65
2015	9.5	9.3	10.5	**0.88**	-1.25
2016	11.4	12.8	12.7	**1.01**	0.09
2017	17.9	21.4	20.4	**1.05**	0.93
2018	6.9	7.1	7.4	**0.95**	-0.38
2019	13.6	15.6	15.4	**1.02**	0.24
2020	10.0	11.9	11.2	**1.06**	0.71
2021	9.4	9.8	10.4	**0.94**	-0.58
2022	11.3	12.8	12.7	**1.01**	0.14

Water Year	Control Average	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Seeded Mean	12.5	13.9	14.1	**0.98**	-0.25
SUMMARY OUTPUT					
Regression Statistics					
Multiple R	**0.926**				
R Square	**0.858**				
	Coefficients				
Intercept	**-0.6404**				
X Variable 1	**1.1749**				

Western San Juan Target Mixed Snow Multiple Linear Regression

Water Year	North Ctrl Avg	South Ctrl Avg	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Historical regression period						
1961	6.7	6.9	6.9	7.3	0.95	-0.36
1962	17.8	18.2	18.8	20.6	0.91	-1.79
1963	6.9	10.0	10.1	9.2	1.10	0.89
1964	6.2	6.1	5.9	6.5	0.90	-0.63
1965	15.1	16.5	17.4	18.1	0.97	-0.62
1966	14.8	14.8	15.9	16.8	0.95	-0.91
1967	10.6	10.3	14.3	11.7	1.23	2.67
1968	14.1	12.8	17.8	15.2	1.17	2.61
1969	14.2	18.1	20.4	18.5	1.10	1.93
1976	10.4	13.9	16.2	13.7	1.18	2.49
1977	2.1	4.4	3.3	3.1	1.08	0.25
1986	16.4	10.7	15.9	15.3	1.04	0.67
1987	11.8	12.2	15.3	13.5	1.13	1.82
1988	11.7	12.1	9.9	13.4	0.74	-3.51
1989	13.2	15.3	17.1	16.2	1.06	0.93
1990	5.9	5.4	4.7	5.9	0.80	-1.15
1991	10.4	12.4	11.1	12.8	0.87	-1.71
1992	11.7	13.3	10.7	14.1	0.76	-3.35
1993	17.8	22.1	24.5	23.0	1.06	1.42
1994	11.1	12.5	12.4	13.2	0.93	-0.88
1995	11.5	16.0	15.3	15.6	0.98	-0.32
1996	14.8	9.1	13.2	13.3	0.99	-0.09
1997	18.8	18.2	21.9	21.2	1.03	0.70
1998	13.2	12.7	10.1	14.6	0.69	-4.52
1999	9.2	6.7	11.9	8.6	1.39	3.32
2000	11.3	5.3	9.2	9.0	1.02	0.15

Water Year	North Ctrl Avg	South Ctrl Avg	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Regression Mean	11.8	12.2	13.5	13.5	1.00	0.00
Seeded Period						
1978	17.0	14.1	16.1	17.7	**0.91**	-1.54
1979	16.3	23.0	24.8	22.7	**1.09**	2.13
1980	15.2	24.6	21.7	23.0	**0.94**	-1.30
1981	5.9	4.4	3.9	5.3	**0.73**	-1.45
1982	15.1	16.2	14.2	17.9	**0.79**	-3.68
1983	15.7	16.6	12.8	18.5	**0.70**	-5.62
1984	16.7	15.7	17.3	18.5	**0.93**	-1.22
1985	11.3	17.9	15.9	16.7	**0.95**	-0.83
2001	9.3	11.5	13.4	11.6	**1.16**	1.81
2002	7.9	5.4	6.5	7.1	**0.93**	-0.53
2003	9.8	11.2	10.2	11.7	**0.87**	-1.51
2004	11.5	12.9	15.2	13.8	**1.11**	1.45
2005	12.4	18.2	20.2	17.5	**1.15**	2.68
2006	10.4	4.4	7.7	7.9	**0.98**	-0.13
2007	10.0	11.1	11.0	11.8	**0.93**	-0.78
2008	13.4	22.9	23.3	21.0	**1.11**	2.33
2009	12.2	16.2	16.9	16.1	**1.05**	0.78
2010	12.5	18.3	14.6	17.7	**0.83**	-3.02
2011	12.3	10.9	14.5	13.0	**1.12**	1.52
2012	9.5	8.4	11.9	9.8	**1.21**	2.05
2013	10.3	10.0	9.1	11.3	**0.81**	-2.16
2014	10.3	6.9	13.7	9.3	**1.46**	4.33
2015	9.1	9.8	9.3	10.4	**0.89**	-1.17
2016	12.9	10.4	12.8	13.0	**0.99**	-0.19
2017	13.5	20.9	21.4	19.8	**1.08**	1.56
2018	7.3	6.6	7.1	7.4	**0.95**	-0.38
2019	13.1	14.0	15.6	15.3	**1.02**	0.27
2020	10.5	9.8	11.9	11.2	**1.06**	0.64
2021	8.6	9.9	9.8	10.2	**0.96**	-0.42
2022	9.5	12.5	12.8	12.4	**1.04**	0.44
Seeded Mean	11.6	13.2	13.9	14.0	**0.99**	-0.13
SUMMARY OUTPUT						
Regression Statistics						
Multiple R	**0.928**					
R Square	**0.861**					
	Coefficients					

Water Year	North Ctrl Avg	South Ctrl Avg	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Intercept	**-0.8399**					
North Ctrl	**0.5835**					
South Ctrl	**0.6110**					

Eastern San Juan Target SNOTEL Nov-Feb Precipitation Linear Regression

Water Year	Control Average	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Historical regression period					
1986	15.6	20.8	17.0	1.22	3.75
1987	13.3	16.2	14.5	1.12	1.69
1988	14.6	14.5	15.9	0.91	-1.47
1989	16.8	22.9	18.5	1.24	4.46
1990	6.8	8.3	7.1	1.16	1.17
1991	13.8	14.8	15.1	0.98	-0.27
1992	13.5	13.9	14.7	0.94	-0.89
1993	23.9	25.7	26.4	0.97	-0.75
1994	14.2	14.1	15.5	0.91	-1.45
1995	16.5	18.9	18.0	1.05	0.85
1996	14.2	13.1	15.5	0.84	-2.41
1997	19.8	20.3	21.8	0.93	-1.49
1998	12.9	12.9	14.0	0.92	-1.13
1999	9.9	11.7	10.7	1.10	1.03
2000	11.0	8.8	11.9	0.74	-3.08
Regression Mean	14.5	15.8	15.8	1.00	0.00
Seeded Period					
2003	11.7	11.2	12.7	**0.88**	-1.52
2004	16.4	21.6	18.0	**1.20**	3.57
2005	18.0	27.1	19.7	**1.37**	7.34
2006	9.4	8.0	10.1	**0.79**	-2.09
2007	11.9	14.3	12.9	**1.11**	1.37
2008	22.5	29.2	24.9	**1.17**	4.31
2009	15.7	19.5	17.2	**1.13**	2.27
2010	15.4	16.7	16.9	**0.99**	-0.16
2011	12.6	13.9	13.7	**1.01**	0.20
2012	12.3	14.3	13.3	**1.07**	0.99
2013	12.4	14.1	13.5	**1.05**	0.62
2014	9.8	13.5	10.5	**1.28**	2.97
2015	11.8	11.9	12.7	**0.93**	-0.83
2016	15.5	15.6	17.0	**0.92**	-1.39
2017	21.5	22.7	23.8	**0.95**	-1.08
2018	7.7	9.4	8.2	**1.15**	1.24
2019	15.2	16.5	16.7	**0.99**	-0.13
2020	11.9	13.4	12.8	**1.04**	0.51
2021	10.5	13.7	11.3	**1.21**	2.34
2022	13.8	15.5	15.1	**1.03**	0.45

Water Year	Control Average	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Seeded Mean	13.8	16.1	15.0	**1.07**	1.05
SUMMARY OUTPUT					
Regression Statistics					
Multiple R	**0.904**				
R Square	**0.816**				
	Coefficients				
Intercept	**-0.5641**				
X Variable 1	**1.1306**				

Eastern San Juan Target SNOTEL Nov-Feb Precipitation Multiple Linear Regression

Water Year	North Ctrl Avg	South Ctrl Avg	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Historical regression period						
1986	14.9	16.5	20.8	16.6	1.25	4.19
1987	12.4	14.7	16.2	14.9	1.09	1.29
1988	13.7	16.0	14.5	16.0	0.90	-1.55
1989	15.2	19.3	22.9	18.8	1.22	4.15
1990	7.0	6.6	8.3	7.9	1.05	0.42
1991	11.8	16.9	14.8	16.5	0.90	-1.69
1992	13.0	14.4	13.9	14.7	0.94	-0.83
1993	21.2	27.9	25.7	26.2	0.98	-0.47
1994	12.8	16.3	14.1	16.2	0.87	-2.10
1995	14.2	19.9	18.9	19.1	0.99	-0.22
1996	14.4	14.0	13.1	14.5	0.90	-1.44
1997	18.1	22.4	20.3	21.5	0.94	-1.21
1998	12.7	13.2	12.9	13.7	0.94	-0.85
1999	10.2	9.6	11.7	10.6	1.10	1.09
2000	13.2	7.8	8.8	9.6	0.92	-0.78
Regression Mean	13.7	15.7	15.8	15.8	1.00	0.00
Seeded Period						
2003	10.8	13.1	11.2	13.4	**0.83**	-2.27
2004	15.9	17.1	21.6	17.2	**1.25**	4.38
2005	16.1	20.8	27.1	20.0	**1.35**	7.06
2006	10.7	7.5	8.0	9.1	**0.88**	-1.06
2007	10.9	13.4	14.3	13.7	**1.04**	0.60

Water Year	North Ctrl Avg	South Ctrl Avg	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
2008	17.5	30.0	29.2	27.4	**1.07**	1.81
2009	14.1	18.2	19.5	17.8	**1.10**	1.69
2010	14.2	17.3	16.7	17.1	**0.98**	-0.38
2011	12.3	13.1	13.9	13.6	**1.02**	0.30
2012	11.7	13.1	14.3	13.6	**1.05**	0.73
2013	12.2	12.8	14.1	13.4	**1.06**	0.74
2014	10.1	9.3	13.5	10.4	**1.29**	3.06
2015	9.8	14.8	11.9	14.6	**0.82**	-2.69
2016	16.2	14.5	15.6	15.2	**1.02**	0.38
2017	17.6	27.5	22.7	25.4	**0.89**	-2.71
2018	7.2	8.5	9.4	9.4	**1.00**	0.01
2019	14.5	16.4	16.5	16.4	**1.01**	0.12
2020	11.4	12.6	13.4	13.1	**1.02**	0.26
2021	9.7	11.8	13.7	12.3	**1.12**	1.41
2022	12.7	15.5	15.5	15.5	**1.00**	0.00
Seeded Mean	12.8	15.3	16.1	15.4	**1.04**	0.67
SUMMARY OUTPUT						
Regression Statistics						
Multiple R	**0.921**					
R Square	**0.848**					
	Coefficients					
Intercept	**1.9535**					
North Ctrl	**0.1242**					
South Ctrl	**0.7743**					

Eastern San Juan Target SNOTEL Snow Linear Regression

Water Year	Control Average	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Historical regression period					
1986	17.2	23.0	20.8	1.11	2.22
1987	15.3	23.2	18.4	1.26	4.80
1988	14.2	15.4	16.9	0.91	-1.57
1989	18.4	24.8	22.3	1.11	2.52
1990	6.3	8.2	6.6	1.25	1.63
1991	15.0	16.1	17.9	0.90	-1.83
1992	14.2	17.3	16.9	1.02	0.37
1993	25.0	30.0	30.9	0.97	-0.90
1994	14.8	15.8	17.7	0.89	-1.88
1995	16.7	21.8	20.2	1.08	1.66

Water Year	Control Average	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
1996	14.3	11.4	17.1	0.67	-5.71
1997	23.1	29.4	28.5	1.03	0.91
1998	14.1	13.3	16.8	0.79	-3.47
1999	10.4	18.4	11.9	1.55	6.52
2000	11.2	7.7	13.0	0.59	-5.27
Regression Mean	15.3	18.4	18.4	1.00	0.00
Seeded Period					
2003	14.0	13.2	16.6	**0.80**	-3.38
2004	15.9	21.7	19.2	**1.13**	2.55
2005	19.9	32.7	24.4	**1.34**	8.36
2006	9.0	7.6	10.2	**0.74**	-2.60
2007	13.6	15.9	16.1	**0.99**	-0.18
2008	22.8	32.3	28.1	**1.15**	4.16
2009	17.6	19.8	21.3	**0.93**	-1.46
2010	17.6	20.4	21.3	**0.96**	-0.90
2011	15.2	18.6	18.3	**1.02**	0.30
2012	12.9	16.2	15.2	**1.07**	1.00
2013	13.0	14.4	15.4	**0.94**	-0.95
2014	11.2	15.0	13.0	**1.15**	1.99
2015	11.6	12.1	13.5	**0.90**	-1.36
2016	15.5	17.9	18.6	**0.96**	-0.75
2017	23.0	26.5	28.3	**0.94**	-1.78
2018	8.0	11.5	8.8	**1.30**	2.64
2019	16.7	21.7	20.1	**1.08**	1.55
2020	12.4	15.7	14.6	**1.08**	1.12
2021	11.9	17.5	13.9	**1.26**	3.63
2022	14.6	19.0	17.5	**1.09**	1.50
Seeded Mean	14.8	18.5	17.7	**1.04**	0.78

SUMMARY OUTPUT		
Regression Statistics		
Multiple R	**0.867**	
R Square	**0.752**	
	Coefficients	
Intercept	**-1.6010**	
X Variable 1	**1.3030**	

Eastern San Juan Target SNOTEL Snow Multiple Linear Regression

Water Year	North Ctrl Avg	South Ctrl Avg	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Historical regression period						
1986	16.5	18.2	23.0	19.1	1.20	3.90
1987	13.3	18.4	23.2	18.4	1.26	4.72
1988	12.0	17.6	15.4	17.4	0.88	-2.07
1989	14.1	24.8	24.8	24.1	1.03	0.77
1990	5.7	7.2	8.2	7.0	1.18	1.26
1991	11.3	20.5	16.1	19.7	0.81	-3.65
1992	12.4	17.0	17.3	17.0	1.02	0.31
1993	21.8	29.7	30.0	30.2	1.00	-0.14
1994	12.2	18.7	15.8	18.4	0.86	-2.63
1995	12.3	23.4	21.8	22.4	0.97	-0.56
1996	13.7	15.3	11.4	15.9	0.72	-4.50
1997	20.2	27.5	29.4	27.9	1.05	1.52
1998	13.2	15.4	13.3	15.9	0.84	-2.58
1999	9.1	12.2	18.4	12.1	1.52	6.29
2000	12.6	9.1	7.7	10.4	0.74	-2.67
Regression Mean	13.4	18.3	18.4	18.4	1.00	0.00
Seeded Period						
2003	12.0	17.0	13.2	16.9	**0.78**	-3.64
2004	13.7	19.3	21.7	19.3	**1.12**	2.41
2005	16.5	25.0	32.7	24.9	**1.32**	7.86
2006	9.5	8.4	7.6	9.0	**0.84**	-1.41
2007	11.8	16.3	15.9	16.3	**0.98**	-0.34
2008	16.4	32.5	32.3	31.2	**1.04**	1.12
2009	13.6	23.6	19.8	22.9	**0.87**	-3.06
2010	14.6	22.0	20.4	21.8	**0.93**	-1.45
2011	14.5	16.4	18.6	17.0	**1.09**	1.55
2012	11.8	14.5	16.2	14.7	**1.10**	1.45
2013	12.2	14.3	14.4	14.7	**0.98**	-0.25
2014	10.7	11.9	15.0	12.2	**1.22**	2.72
2015	9.0	15.5	12.1	14.8	**0.82**	-2.74
2016	14.2	17.5	17.9	17.9	**1.00**	-0.02
2017	17.0	31.9	26.5	30.8	**0.86**	-4.30
2018	6.7	9.9	11.5	9.6	**1.20**	1.90
2019	14.8	19.5	21.7	19.7	**1.10**	1.94
2020	10.7	15.0	15.7	14.9	**1.05**	0.79
2021	9.7	15.1	17.5	14.7	**1.19**	2.75
2022	12.6	17.7	19.0	17.6	**1.08**	1.34
Seeded Mean	12.6	18.1	18.5	18.0	**1.02**	0.43

Water Year	North Ctrl Avg	South Ctrl Avg	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
SUMMARY OUTPUT						
Regression Statistics						
Multiple R	**0.889**					
R Square	**0.790**					
	Coefficients					
Intercept	**-0.5440**					
North Ctrl	**0.2541**					
South Ctrl	**0.8482**					

Eastern San Juan Target Mixed Snow Linear

Water Year	Control Average	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Historical regression period					
1961	8.4	9.5	10.9	0.87	-1.39
1962	19.3	29.4	30.2	0.97	-0.80
1963	10.7	15.7	15.0	1.05	0.76
1964	7.5	10.4	9.3	1.12	1.11
1965	18.9	31.7	29.4	1.08	2.33
1966	16.7	27.1	25.5	1.06	1.64
1967	13.1	22.7	19.2	1.18	3.51
1968	14.0	21.4	20.8	1.03	0.54
1969	18.2	26.5	28.1	0.94	-1.64
1986	16.2	24.4	24.7	0.98	-0.38
1987	13.7	22.7	20.3	1.12	2.48
1988	14.1	17.5	21.0	0.83	-3.46
1989	17.1	30.8	26.2	1.17	4.59
1990	5.9	8.8	6.6	1.35	2.27
1991	13.9	19.1	20.6	0.93	-1.50
1992	13.5	19.1	19.9	0.96	-0.81
1993	21.3	34.5	33.7	1.03	0.85
1994	13.7	17.8	20.3	0.87	-2.54
1995	15.9	24.7	24.1	1.03	0.65
1996	13.7	12.9	20.3	0.64	-7.41
1997	20.7	33.3	32.7	1.02	0.63
1998	13.1	15.0	19.2	0.78	-4.23
1999	9.6	20.6	13.1	1.57	7.44
2000	9.6	8.4	13.0	0.64	-4.64
Regression Mean	14.1	21.0	21.0	1.00	0.00

Water Year	Control Average	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Seeded Period					
1976	13.4	23.9	19.8	**1.20**	4.05
1977	3.5	4.8	2.4	**2.02**	2.42
1978	16.5	17.3	25.2	**0.69**	-7.89
2003	12.5	15.0	18.1	**0.83**	-3.14
2004	13.7	24.7	20.3	**1.22**	4.43
2005	17.0	36.9	26.1	**1.41**	10.76
2006	8.5	7.8	11.1	**0.71**	-3.22
2007	12.3	18.1	17.8	**1.02**	0.28
2008	20.6	38.0	32.5	**1.17**	5.50
2009	16.3	22.5	24.9	**0.90**	-2.42
2010	15.3	23.1	23.2	**1.00**	-0.03
2011	13.0	21.2	19.0	**1.12**	2.25
2012	10.7	17.4	15.0	**1.16**	2.38
2013	11.4	16.5	16.2	**1.02**	0.26
2014	10.2	15.8	14.2	**1.11**	1.59
2015	11.4	13.0	16.2	**0.80**	-3.21
2016	14.2	20.4	21.2	**0.96**	-0.81
2017	20.6	30.2	32.5	**0.93**	-2.26
2018	8.1	13.7	10.5	**1.30**	3.19
2019	15.5	23.2	23.5	**0.99**	-0.24
2020	12.4	17.0	18.0	**0.95**	-0.97
2021	10.8	20.3	15.2	**1.33**	5.03
2022	12.9	21.9	18.9	**1.16**	2.97
Seeded Mean	13.1	20.1	19.2	**1.05**	0.91
SUMMARY OUTPUT					
Regression Statistics					
Multiple R	**0.915**				
R Square	**0.837**				
	Coefficients				
Intercept	**-3.8273**				
X Variable 1	**1.7611**				

Eastern San Juan Target Mixed Snow Multiple Linear Regression

Water Year	North ctrl avg	South ctrl avg	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
Historical regression period						
1961	6.7	10.1	9.5	11.7	0.82	-2.15

Water Year	North ctrl avg	South ctrl avg	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
1962	17.8	20.9	29.4	29.2	1.01	0.19
1963	6.9	14.5	15.7	17.0	0.92	-1.31
1964	6.2	8.8	10.4	9.9	1.05	0.54
1965	15.1	22.6	31.7	30.2	1.05	1.53
1966	14.8	18.6	27.1	25.2	1.08	1.96
1967	10.6	15.5	22.7	19.8	1.14	2.87
1968	14.1	13.9	21.4	19.3	1.11	2.04
1969	14.2	22.1	26.5	29.2	0.91	-2.70
1986	16.4	16.1	24.4	22.9	1.06	1.46
1987	11.8	15.6	22.7	20.4	1.11	2.34
1988	11.7	16.5	17.5	21.4	0.82	-3.89
1989	13.2	21.0	30.8	27.4	1.12	3.39
1990	5.9	5.9	8.8	6.3	1.39	2.49
1991	10.4	17.3	19.1	21.9	0.87	-2.80
1992	11.7	15.4	19.1	20.1	0.95	-0.92
1993	17.8	24.9	34.5	34.0	1.02	0.56
1994	11.1	16.4	17.8	21.1	0.85	-3.26
1995	11.5	20.3	24.7	25.8	0.96	-1.11
1996	14.8	12.7	12.9	18.2	0.71	-5.23
1997	18.8	22.7	33.3	31.8	1.05	1.53
1998	13.2	13.0	15.0	17.8	0.84	-2.85
1999	9.2	10.1	20.6	12.7	1.62	7.84
2000	11.3	7.9	8.4	10.9	0.77	-2.52
Regression Mean	12.3	15.9	21.0	21.0	1.00	0.00
Seeded Period						
1976	10.4	16.5	23.9	20.9	**1.14**	2.98
1977	2.1	5.0	4.8	3.6	**1.32**	1.18
1978	17.0	16.0	17.3	23.0	**0.75**	-5.69
2003	9.8	15.2	15.0	19.1	**0.79**	-4.08
2004	11.5	15.9	24.7	20.6	**1.20**	4.08
2005	12.4	21.7	36.9	27.9	**1.32**	8.97
2006	10.4	6.6	7.8	9.0	**0.87**	-1.13
2007	10.0	14.6	18.1	18.4	**0.98**	-0.34
2008	13.4	27.9	38.0	35.8	**1.06**	2.24
2009	12.2	20.5	22.5	26.4	**0.85**	-3.93
2010	12.5	18.2	23.1	23.8	**0.97**	-0.63
2011	12.3	13.6	21.2	18.2	**1.17**	3.01
2012	9.5	11.9	17.4	15.0	**1.16**	2.38
2013	10.3	12.5	16.5	16.0	**1.03**	0.45
2014	10.3	10.2	15.8	13.3	**1.19**	2.47
2015	9.1	13.7	13.0	17.0	**0.77**	-3.96

Water Year	North ctrl avg	South ctrl avg	Target Average	Target Predicted	Obs/Pred ratio	Obs minus Predicted
2016	12.9	15.6	20.4	20.8	**0.98**	-0.42
2017	13.5	27.8	30.2	35.7	**0.85**	-5.45
2018	7.3	9.0	13.7	10.6	**1.29**	3.05
2019	13.1	18.0	23.2	23.7	**0.98**	-0.52
2020	10.5	14.3	17.0	18.3	**0.93**	-1.30
2021	8.6	13.1	20.3	16.1	**1.26**	4.20
2022	9.5	16.4	21.9	20.4	**1.08**	1.54
Seeded Mean	10.8	15.4	20.1	19.7	**1.02**	0.40
SUMMARY OUTPUT						
Regression Statistics						
Multiple R	**0.927**					
R Square	**0.860**					
	Coefficients					
Intercept	**-3.1814**					
North Ctrl	**0.4149**					
South Ctrl	**1.1986**					