Mailing Address:
Water Resources Data System
University of Wyoming, Dept 3943
1000 E University Avenue
Laramie, WY 82071

Physical Address:
Wyoming Hall, Room 249
University of Wyoming
Laramie, WY 82071

Phone: (307) 766-6651
Fax: (307) 766-3785

Funding for WRDS and the creation of this electronic document was provided by the Wyoming Water Development Commission (http://wwdc.state.wy.us)

EXECUTIVE SUMMARY

WYOMING • WIND RIVER RANGE
WEATHER MODIFICATION PROGRAM



18
19

Wind River
Mountain Range


WEATHER MODIFICATION INTERNATIONAL
3802 20th Street N.
Fargo, ND 58102

WYOMING WATER DEVELOPMENT COMMISSION
6920 Yellowtail Road
Cheyenne, WY 82002

Cloud Seeding Operations in the Wind River Range of Wyoming 2018-2019 Season

EXECUTIVE SUMMARY

prepared by

Weather Modification International
3802 20th Street North
Fargo, North Dakota 58102

for the

Wyoming Water Development Office
6920 Yellowtail Road
Cheyenne, Wyoming 82002

August 2019

BACKGROUND AND OVERVIEW

Atmospheric water transformed to precipitation is one of the primary sources of fresh water in the world. However, a large amount of water present in clouds never is converted into precipitation that makes it to the ground. This has prompted scientists and engineers to explore the possibility of augmenting water supplies by means of cloud seeding. From 2006 through the spring of 2014, cloud seeding operations in the Wind River Range were conducted within the context of the Wyoming Weather Modification Pilot Project (WWMPP). Eight of the ten ground-based cloud seeding generators used in that project were funded by the Wyoming State Legislature through the Wyoming Water Development Commission (WWDC). The two additional generators were funded by the Lower Colorado River Basin States.

Funding for cloud seeding operations in the Wind River Range for the winter of 2018-2019 was provided in part by the 2018 Wyoming State Legislature's *Omnibus Water Bill – Construction*. The Wyoming State Legislature has mandated that the funding rate for the State will not exceed 20% of total project costs, leaving 80% of the project costs to be split among other Colorado River Basin water users, or interested parties. Funding partners in support of continued weather modification activities in the Wind River Mountains during the winter of 2018-2019 include the Southern Nevada Water Authority, the Central Arizona Project (CAP), the Colorado River Board of California - Six Agency Committee, Genesis Alkali, Ciner Wyoming, Solvay Minerals, TATA Chemicals, and Rocky Mountain Power.

The weather pattern produced below-normal storm frequency, with two seeding events occurring in December 2018, three in January 2019, six in February 2019, but only one in March 2019, for a project total of twelve storms. Seasonal snowpack (snow water equivalents, or SWE) at project end (April 1) varied from 88.7% of the median annual value to 107.9%, but the five-site SNOTEL mean was 103.1%, as only South Pass was below the 30-year median value. All the other SWEs ranged from 105.4% to 107.9%. No suspensions occurred during the 2018-2019 season.

SCIENTIFIC BASIS

Clouds in the lower troposphere form when, in cooling air, water vapor condenses upon cloud condensation nuclei (CCN), forming cloud droplets. After the formation of the cloud droplets, precipitation development in Wyoming winter storms occurs through the formation of ice. However, ice does not form spontaneously at temperatures colder than 32°F (0°C). In the absence of ice nuclei, water can become "supercooled" (supercooled liquid water, SLW), meaning the water in the cloud remains in liquid form at temperatures well below 32°F (0°C). To many persons this is surprising, as we are accustomed to seeing water (at the surface) freeze whenever temperatures fall "below freezing." Freezing happens at the surface because there are lots of substrates (substances or materials) present that encourage freezing, but these substrates are largely absent in the free atmosphere.

Nature's solution to the lack of substrates to encourage the freezing process in clouds comes in the form of tiny particles called *ice nuclei.* Ice nuclei provide microscopic, crystalline "templates" for supercooled liquid water to follow, and thus become the solid form known as ice. The shape of an ice nucleus plays an important role in determining which atmospheric conditions will be better suited for the formation of ice crystals in clouds.

Once ice forms in a cloud, the crystals grow quickly. Initially, growth occurs through water vapor deposition directly on the nascent ice crystal, producing six-sided crystals. Within five minutes, these tiny ice crystals grow large enough to begin to fall. As they fall, growth by deposition continues, but because the ice crystals are heavier than the nearby SLW droplets, they collect them as they fall. Upon contact with the ice crystals, the SLW droplets freeze. As they grow ever larger, the ice crystals may encounter each other and become tangled, forming aggregates known as snowflakes.

When clouds grow colder than about -5°C but do not immediately form ice crystals, they can be treated with silver iodide-based ice nuclei which immediately initiate ice crystal formation, thus starting the ice-phase precipitation process. Ground-based seeding is commonly used in orographic applications, especially when the prevailing wind flow is roughly perpendicular to the mountain range, so that seeding agent is lofted immediately upward into the targeted clouds. This orographic seeding technique was the prime strategy used to seed winter clouds throughout the WWMPP, and continued to be the main approach utilized in the Wind River Range during the operational seeding seasons in the winters since.

In operational seeding, the temperature criterion can be met in warmer conditions as long as some of the ice nuclei still produce ice crystals. This being said, it must be noted that the magnitude of the seeding effectiveness will diminish as temperatures warm. Seeding should not occur when temperatures aloft are warmer than +23°F (-5°C). Widening the temperature window for seeding increases the number of seeding opportunities. Most operational (vs. research) seeding programs use this warmer temperature criterion.

FIELD RESOURCES

Figure 1 provides the ten ground-based generator sites used for the 2018-2019 project. The generator placement was such that individual generators could be activated according to wind direction, and as storms passed and conditions changed. As shown in Figure 1, nine of the ten generator sites wrapped around the western to southwestern side of the mountain range, beginning with the Green River site on the west and ending with the Anderson Ridge site at the extreme southern end.

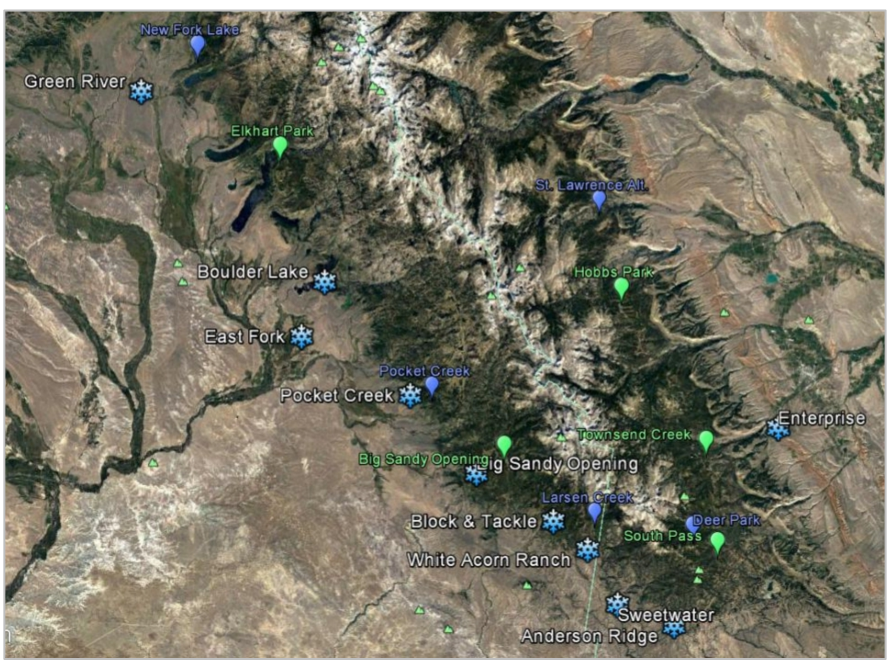

Figure 1. The locations of the ground-based ice nucleus generators are indicated by the snow crystal symbols. The green "balloons" indicate the locations of Natural Resources and Conservation Service (NRCS) snow telemetry (SNOTEL) sites used in monitoring snowpack during the 2018-2019 season. The blue balloons show the locations of additional SNOTELs that were not used because of proximity to sites that were used, or a shorter period of record (they were relatively new sites).

These locations allowed targeting of the range when wind directions were within the southwestern quadrant. The tenth site, Enterprise, allowed targeting when winds were easterly. All sites were on state-owned or private lands. Permissions were established through the Wyoming Office of State Lands and Investments or private memoranda of understanding, accordingly.

Ice Nucleus Generators

The ice nucleus generators were designed and fabricated by WMI. The Wind River Range generators are fully independent, controlled via satellite, and powered by batteries charged by solar power. This provides the ability to site generators at higher elevations, significantly improving delivery of seeding agent to the clouds. Remotely-controlled generators can be activated and deactivated as weather conditions warrant. This results in less seeding agent being dispersed unnecessarily, as can occur with manually operated generators. All of the generator lines and fittings are made of corrosion-resistant stainless steel, necessary when high-performance seeding solutions, (which contain oxidizers) are used. The generators are robust; designed to function in extreme temperatures, winds and precipitation.

Seeding Solution

The high performance seeding solution itself was tested at the Colorado State University Cloud Simulation and Aerosol Laboratory by DeMott (1997). Those tests determined that colder cloud temperatures produce a bigger yield of active ice nuclei per gram of AgI burned. The yield increases markedly from -6°C (+21.2°F) to -8°C (+17.6°F), and even more at -10°C (+14°F). At a cloud temperature of -6°C, 3×10^{11} nuclei are active, 300,000,000,000, or 300 billion. Research studies provide the foundation for the design of operational programs. Operational programs in the western United States commonly commence seeding operations at -5° or -6° (C). As in previous seasons, the 2018-2019 Wind River operations used a temperature criterion of -6°C at 700 hPa (about 10,000 feet above sea level).

Unlike simpler solutions that produce a pure AgI nucleus, this “high performance” solution also contains sodium chloride (salt), which enables it to function by the condensation-freezing mechanism. Nuclei of this type attract water vapor and immediately form water droplets, eliminating the requirement for collisions between ice nuclei and cloud droplets. As soon as the droplets containing these nuclei cool to at least -6°C, freezing results. Unlike the contact-freezing process, the speed at which this type of nucleation occurs *does not* depend upon the density of the water droplets in the cloud. As soon as freezing occurs, the new ice particle can grow by other ice-phase growth processes. The nucleation advantage of the more complex solution used in the Wind River operations is considerable, especially in clouds having lesser liquid water.

Soundings

When necessary, weather balloons were released from the WMI shop in Pinedale to determine whether conditions were suitable for seeding. Each balloon carried a miniaturized weather probe that measured temperature, humidity, and pressure. In addition, the GPS position of the balloon was also obtained. The atmospheric sounding data were recorded and compared to the operating criteria to verify that observed weather conditions were sufficient to initiate cloud seeding procedures.

Shop and Field Site Servicing

Throughout the season WMI maintained a shop in Pinedale, WY that provided storage and served as a staging area for generator service and the preparation and release of weather balloons. The shop housed WMI's 4x4 truck, snowmobiles/trailers, spare generator parts, trouble-shooting equipment, and replacement nitrogen tanks. The Vaisala MW41 rawinsonde system used for the calibration and tracking of the weather balloons was also at the shop, as well as all of the upper air consumables: helium, balloons, and rawinsondes. Internet service was available, allowing immediate sharing of upper air data with other interested parties (NWS, WRDS).

FORECASTING AND OPERATIONAL DECISION-MAKING

Meteorological Data Sources

The bulk of the weather information used for forecasting and weather monitoring was obtained from the Internet. Among these sites were those of RAP Real-Time Weather, the National Center for Environmental Prediction (NCEP), the College of DuPage, European Community satellite imagery, Northern Illinois University, and Unisys. While many of the web-based weather products such as those produced by the National Weather Service (NWS) were publicly available, some data sources were project-specific.

The WWDO radiometer was deployed at a residence near Pinedale, WY. Since the presence of liquid water in the clouds over the target area is essential for successful seeding, and this radiometer calculates integrated liquid water, its observations can be helpful. This season WMI learned from Radiometrics, the manufacturer of the radiometer, that the configuration files installed on the radiometer were for operation in a vertically-pointing (zenith) mode. While additional scan angles had been sampled in previous project seasons, only data from the zenith scan was processed. Radiometrics was asked to provide new calibration files, appropriate for operation at the desired scan angles, but declined, saying the unit and its software are deprecated, and that contemporary configuration files are not compatible with the unit.

Numerical Modeling

WMI continued and expanded project-specific numerical modeling support to the Wind River seeding project for the entire 2018-2019 season.

WRF Modeling. For the 2018-2019 season, WMI performed runs of the Weather Research and Forecasting (WRF) model specifically tailored to the Wind River seeding program, running a 2.5 km resolution grid initialized with the High Resolution Rapid Refresh (HRRR) model and using the North American Model (NAM) for boundary conditions at 3-hour intervals. A large number of graphical outputs were developed specifically to aid the cloud seeding decision-making. An example is shown in Figure 2. Additional examples are provided in the full report.

HYSPLIT Modeling. During the 2018-2019 season WMI ran the Hybrid Single-Point Lagrangian Integrated Trajectory (HYSPLIT) plume dispersion model to establish a better idea of seeding agent plume trajectory. The plume trajectory model was initialized with WRF data and used to help make better-informed seeding decisions. These HYSPLIT plots were output in one-hour increments, with each plot showing forecast locations of plume centerline (the most-dense portions of the plumes) for four hour periods.

Stability throughout the Wind River domain continued to be part of the suite of products generated by the WMI WRF model runs. The meteorologists also considered Froude Number to determine if the plume(s) would go over the range or be blocked by it, and consulted the HYSPLIT plots, which reinforced the other indications. Thus, if cloud and temperature conditions were favorable, seeding would occur only if the seeding agent was likely to reach its intended destinations!

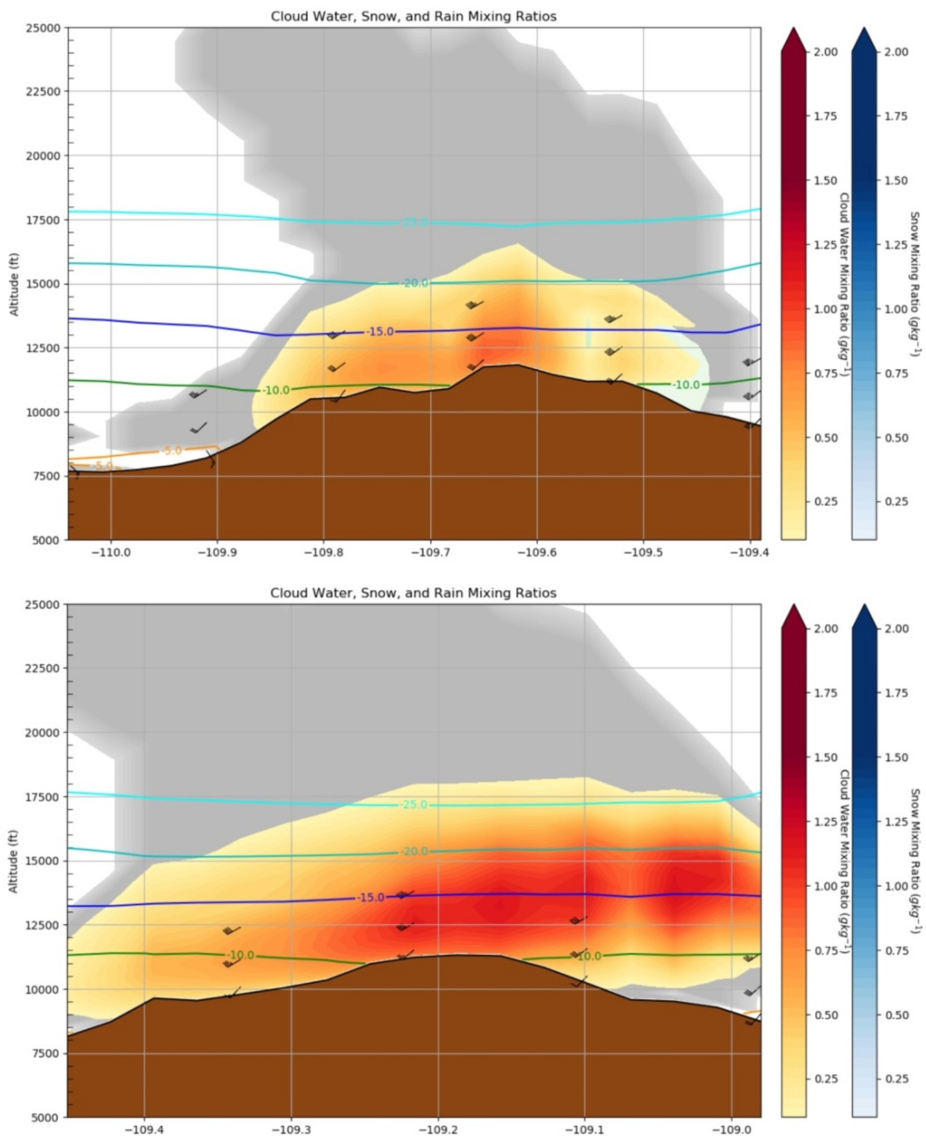

Figure 2. Vertical cross sections through the Green River generator site (top) and the Pocket Creek generator site (bottom), approximately perpendicular to the axis of the Wind River Mountains. West is to the left. Both panels represent predicted cloud water fractions at 13:00 UTC on 4 February 2019, or 6 AM MST. Warm tones indicate the presence of supercooled cloud water, necessary for effective seeding.

Timetables and Routines

If seeding was not underway at dawn, the following daily routine ensued. WMI furnished a daily "first glance" update that provided an outlook into the probability of seeding operations taking place that day. This very simple form, sent to all project personnel, provided an early look at the weather expected each day. Four time periods were specified, from issuance until noon, from noon until sunset, from sunset until midnight, and from midnight until dawn the next day. The probability of seeding operations occurring in each of these time periods was rated by the forecaster as *no chance*, *unlikely*, *possible*, or *probable*. Technicians used this outlook to help inform equipment operation and maintenance decisions. In instances when seeding operations were already active in the morning, the "first glance" outlook would still be issued, reflecting the status of current operations.

The "first glance" update was followed by a much more detailed forecast and weather briefing, typically disseminated to the WWDO and all funding partners by late morning via email. These daily briefings included a summary of the preceding day's weather and seeding activities, a summary of the current synoptic-scale weather pattern, and conditions likely to exist for the next 24 hours in the Wind River Range. Oftentimes weather conditions would vary sufficiently during the day that evening forecast updates were warranted and provided.

The temperature seeding criterion was determined by consulting the most recent prognostic numerical modeling runs. When such consultation yielded uncertain results, that is, temperatures at 700 hPa not clearly -6°C or colder, a weather balloon sounding was released from the Pinedale shop. The presence of SLW was confirmed by the real-time data from the radiometer located near Pinedale, WY. The wind speed and direction were obtained from the numerical models, except when atmospheric soundings were done. When all three conditions were satisfied, seeding was initiated by the meteorologist and the generator technician. The meteorologist would communicate to the technician which generators would be activated, when, and for how long. The length of time a generator was activated depended upon how long weather conditions were expected to remain favorable. Once seeding was initiated, the meteorologist would begin tracking the real-time weather conditions that would impact seeding duration. If wind direction changed, some generators could be deactivated while others would be turned on. When favorable weather conditions ended, the technician would be directed to shut down all remaining active generators.

SEEDING OPERATIONS

Funding was available for four months of operations. Operations began 1 December 2018 to 31 March 2019. Thus, the 2018-2019 project was active for 121 days.

Seeding was conducted on twelve occasions, as enumerated in Table 1. December had two seeding events, January three, February six, and March just one. February was by far the busiest month, accruing 745 generator hours. March was the least active, with just one seeding event, and that using only the Enterprise (east slope) generator. Table 2 summarizes operations by month and provides season totals.

Easterly flow seeding events occurred only once during the 2018-2019 operational season. In total, 23.785 kg of seeding agent were released. Generators were operated for a total of 165:55 hours during the season, accruing a total of 951 generator hours. [Generator hours are calculated by summing the number of hours each generator was operated. For example, six generators operated for five hours yields thirty generator hours.]

TABLE 1. 2018 - 2019 Seeding Events

Date	*Number of Generators Utilized*	*Length of Seeding (hours)*	*Total Generator Hours*	*AgI Released This Date (kg)*	*AgI Monthly Total (Kg)*	*Generator Hours*	*Total Duration of Seeding*
19-Dec-18	7	5:11	36:13	0.948	1.514	39:49	11:15
30-Dec-18	4	6:04	3:36	0.566			
6-Jan-19	6	14:10	84:34	2.178	4.110	159:48	26:46
7-Jan-19	7	9:13	61:44	1.570			
16-Jan-19	4	3:23	13:31	0.362			
3-Feb-19	9	54:40	401:04	10.491	17.978	745:21	121:47
10-Feb-19	6	8:03	43:04	1.113			
13-Feb-19	7	19:38	118:34	3.009			
15-Feb-19	8	4:08	33:03	0.880			
24-Feb-19	6	10:40	53:46	1.460			
25-Feb-19	6	24:38	95:50	2.465			
29-Mar-19	1	6:07	6:07	0.183	0.183	6:07	6:07
Season	12 Events				23.785	951:05	165:55

TABLE 2. Summary of Seeding Events During the 2018 - 2019 Winter Season

Month	*Events ( ) denotes easterly flow*	*Event Averages*		*Seeding Agent (kg)*	
		Number of Generators	*Generator Hours**	*Average Released per Event*	*Total Released*
December	2	6.5	19.9	0.76	1.514
January	3	5.7	53.3	1.37	4.110
February	6	7.0	124.2	3.24	17.978
March	(1)	1.0	6.1	0.18	0.183
Totals/Averages	*11 (1)*	*5.9*	*80.73*	*2.10*	*23.785*

**Generator Hours = sum of the hours each generator was run for each event, e.g., 4 generators each operated for 3.5 hours = 14 generator hours.*

The eleven seeding events that utilized more than one generator were all quality opportunities that used four to nine generators, and were of 3.5 or more hours in duration. Five events were ten hours or longer, and two exceeded twenty hours. One, the storm that began on February 3, set a project record, running for over 54 hours.

Table 3 shows the activity of each of the ten generators on a case-by-case basis. Each seeding event has two rows, the top indicates whether or not each generator was requested (REQ), and the bottom whether or not the generator ran (RAN). Ideally, every time a generator was requested it would run for the entire duration of the event. If a generator was requested to operate, a "Yes", "No", or "Partial" comment would be denoted in the appropriate (RAN) row.

TABLE 3. Ice nucleus generator operations are shown for each of the twelve seeding events during the 2018-2019 season.

Wind River Range			***WR01 Big Sandy***	***WR02 Block & Tackle***	***WR03 White Acorn***	***WR04 Sweetwater***	***WR05 Anderson***	***WR07 Enterprise***	***WR09 Boulder Lake***	***WR10 East Fork***	***WR12 Pocket Creek***	***WR13 Green River***	***#Ggens Called***	***#Ggens Active***
20181219	***WRR0081***	***REQ***	YES	YES	YES	NO	NO	NO	YES	YES	YES	YES	7	
		RAN	YES	YES	YES	NO	NO	NO	YES	YES	YES	YES		7
20181230	***WRR0082***	***REQ***	YES	YES	YES	NO	NO	NO	NO	NO	YES	NO	4	
		RAN	YES	YES	YES	NO	NO	NO	NO	NO	YES	NO		4
20190106	***WRR0083***	***REQ***	YES	YES	YES	NO	NO	NO	YES	YES	YES	NO	6	
		RAN	YES	YES	YES	NO	NO	NO	YES	YES	YES	NO		6
20190107	***WRR0084***	***REQ***	YES	YES	YES	YES	YES	NO	YES	NO	YES	NO	7	
		RAN	YES	YES	YES	PARTIAL	YES	NO	YES	NO	YES	NO		6.75
20190116	***WRR0085***	***REQ***	YES	YES	YES	NO	NO	NO	NO	NO	YES	NO	4	
		RAN	YES	YES	YES	NO	NO	NO	NO	NO	YES	NO		4
20190203	***WRR0086***	***REQ***	YES	YES	YES	YES	YES	NO	YES	YES	YES	YES	9	
		RAN	YES	YES	YES	YES	YES	NO	YES	PARTIAL	YES	NO		7.5
20190210	***WRR0087***	***REQ***	YES	YES	YES	YES	YES	NO	NO	NO	YES	NO	6	
		RAN	YES	YES	YES	YES	YES	NO	NO	NO	PARTIAL	NO		5.25
20190213	***WRR0088***	***REQ***	YES	YES	YES	YES	YES	NO	YES	YES	YES	NO	8	
		RAN	YES	YES	YES	YES	YES	NO	YES	NO	YES	NO		7
20190215	***WRR0089***	***REQ***	YES	YES	YES	YES	YES	NO	YES	YES	YES	NO	8	
		RAN	YES	YES	YES	YES	YES	NO	YES	YES	YES	NO		8
20190224	***WRR0090***	***REQ***	YES	YES	YES	NO	NO	NO	YES	NO	YES	YES	6	
		RAN	YES	YES	YES	NO	NO	NO	YES	NO	YES	YES		6
20190225	***WRR0091***	***REQ***	YES	YES	YES	NO	NO	NO	YES	YES	YES	NO	6	
		RAN	YES	YES	NO	NO	NO	NO	YES	YES	PARTIAL	NO		4.5
20190329	***WRR0092***	***REQ***	NO	NO	NO	NO	NO	YES	NO	NO	NO	NO	1	
		RAN	NO	NO	NO	NO	NO	YES	NO	NO	NO	NO		1
												TOTALS	72	67
													RUN =	93.1%
													FAIL =	6.9%

ZULU DATES ONLY
PARTIAL = > 25% of Expected Runtime

Generator performance for the season was very good, at 93.1% functionality. As Table 3 shows, the problems were scattered among the generators. Five of them, Big Sandy, Block & Tackle, Anderson Ridge, Enterprise, and Boulder Lake, ran flawlessly the whole season. White Acorn, East Fork, and Green River each failed once, while Sweetwater and East Fork each experienced problems (less than a complete run) on one occasion. The Pocket Creek generator failed to complete full runs on during two storms.

Comparisons with Previous Seasons

Comparisons of the five seasons of operational cloud seeding are provided in Tables 4 and 5. In Table 4, the lengths of seeding operations in each month are provided. Each season was different. In terms of actual number of hours with seeding operations, the 2015-2016 season tops the list. However, when one compares the hours of seeding conducted each season (Table 5), the 2016-2017 season was far above the others, 400 hours more than the 2015-2016 season. The 2018-2019 season was the least active, in part due to budget constraints that precluded operations in November and April.

TABLE 4. Hours of Seeding

	Nov	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*Season*
2014-2015	10:13	83:45	24:08	36:47	25:21	20:12	200:26
2015-2016	41:28	66:07	49:56	60:30	62:00	9:54	289:55
2016-2017	NA	120:22	63:12	58:53*	SUSP	NA	242:27
2017-2018	NA	49:37**	23:24	57:25	62:06	NA	192:54
2018-2019	NA	11:15	26:46	121:47	6:07	NA	165:55
Mean	25:50	66:13	37:29	67:04	38:23	15:03	231:26

**Project was suspended on February 11th, 2017.*
***Project started on December 9th, 2017, not December 1st.*

Though the 2017-2018 season had the fewest hours during which seeding has been conducted during a season (Table 4), more seeding hours, that is, more generators were operated during those opportunities (Table 5) than the first season (2014-2015). Viewed another way, it can be said that full advantage is being taken of those opportunities that present themselves. This season saw, by far, the most active February to date.

TABLE 5. Hours of Ice Nucleus Generator Operation

	Nov	***Dec***	***Jan***	***Feb***	***Mar***	***Apr***	***Season***
2014-2015	71:43	377:52	125:51	36:47	219:54	20:12	852:19
2015-2016	86:21	375:03	328:57	180:56	191:31	9:54	1172:42
2016-2017	NA	815:05	396:22	406:57*	SUSP	NA	1618:24
2017-2018	NA	304:53**	156:06	397:31	373:04	NA	1231:34
2018-2019	NA	39:49	159:48	745:21	6:07	NA	951:05
Mean	79:02	382:32	233:25	353:31	197:39	15:03	1218:45

**Project was suspended on February 11th, 2017.*
***Project started on December 9th, 2017, not December 1st.*

It is here noted that since the inception of operational seeding in the Wind River Mountains in the winter of 2014-2015 WMI has significantly improved the guidance available to its meteorological team, especially through numerical modeling products specifically-tailored to assist winter orographic cloud seeding. With these tools, we believe we are now more selective in our operational decision-making. We are also likely more responsive to shorter-term opportunities, and to changing conditions as storms pass.

OUTREACH

Whenever possible, WMI likes to be receptive to requests to educate those showing an interest in our field efforts. This season, WMI was approached by the Pinedale Children's Discovery Center regarding general meteorological aspects of cloud seeding in the Wind River Range. WMI meteorologist Adam Brainard and Center Director Allison Long arranged for local students to visit the WMI shop in Pinedale, WY and learn about the project and upper air soundings, and even to participate in the release of a weather balloon. WMI appreciates being asked to take part in this type of educational outreach, and has gladly conducted such events, which are done with the knowledge and support of the WWDO. It is important to WMI to be receptive to requests to educate those showing an interest in our weather modification efforts.

WMI also presented an update on the 2018-2019 Wind River operational seeding efforts at the Wyoming Weather Modification Technical Advisory Team (TAT) meeting held in Cheyenne, WY on December 6th, 2018. The TAT, initially organized by the WWDO to provide technical advice and support for the WWMPP, is largely comprised of representatives of interested State and Federal agencies. Wyoming agencies include the State Engineer's Office, the Department of Environmental Quality, the Department of Transportation, the University Office of Water Programs, and the Game and Fish Department. Federal agency representation includes several different forests (Bridger-Teton, Shoshone, and Medicine Bow), the U.S. Geological Service, the NWS Riverton and Cheyenne offices, the Bureau of Land Management, and the Natural Resources Conservation Service.

SUMMARY

The 2018-2019 cloud seeding effort in the Wind River Range began on December 1st, 2018, and officially concluded on 31 March 2019, a duration of 121 days (4 months). There were no seeding suspensions during the season.

Twelve seeding events were conducted between December 19th, 2018, and March 29th, 2019. All but one event involved the use of four or more generators, seeding in westerly or southwesterly flow. A total of 23.79 kg of silver iodide was released in the course of 951 hours of generator operations.

The ice nucleus generators operated reliably, seeding as intended over 93% of the time. Five generators operated flawlessly throughout the season, with the few glitches being more or less spread evenly among the others.

In terms of hours of seeding generator operations, the winter was less active than average. In spite of a very active February, the season ranked last (out of the five seasons) in terms of total hours of generator operations. That being said, the 166 hours during which seeding operations were conducted was but 27 hours less than the 193 hours accrued in the 2017-2018 season.