

Testing the Effects of Cloud Seeding in Wyoming

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After several years of well-below normal snowpack in the mountains of Wyoming and less than average summertime precipitation, conservation districts in the state began to consider avenues to augment increasingly limited water supplies. In summer 2004, noting the long-term existence of cloud seeding programs in nearby western states, Area V of the Wyoming Association of Conservation Districts asked the Wyoming Water Development Commission (WWDC) to fund a feasibility study on increasing Wyoming water supplies through similar means.

The Commission approved and the legislature funded a \$100,000 study, and a request for proposals was issued. Three mountain ranges were specified for inclusion: the Medicine Bow Range in the southeast, the nearby Sierra Madres in the south-central, and the Wind River Range in the west-central part of the state (see map). Watersheds potentially affected include the Green, Wind-Bighorn, and North Platte rivers. Additional water in the Wind-Bighorn Basin would eventually flow north into the Missouri system. Runoff increases in the North Platte Basin would ultimately reach water-short western Nebraska. Augmented flows in the Green River Basin would feed into the Colorado River Basin, a possibility that has caught the attention of some Lower Basin states' water managers.

Weather Modification Inc. (WMI), a North Dakota-based firm, was selected

to conduct the feasibility study. WMI in turn subcontracted with the National Center for Atmospheric Research (NCAR) to numerically model the airflow over the mountains and recommend an initial design for an operational program. Numerous meetings were conducted in

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communities in and near the proposed project areas to gauge public opinion and to engage state, federal, and tribal entities. The study, completed in January 2005, found ample indication that supercooled cloud water is often not converted to precipitation, and a plan to implement a pilot program was devised.

The Wyoming Project is Born

After vigorous discussions by the state legislature over the funding proposal developed by WWDC, an appropriation of \$8.8 million was approved, and the Wyoming Five-Year Weather Modification Pilot Project was born. The program is unique in several ways. First, funding for the full five-year period was appropriated at once, ensuring project continuity. Second, the state recognized the value of independent project evaluation. WMI makes the seeding decisions and conducts all seeding operations, while NCAR

designs and evaluates the program. Third, WWDC acknowledged early on that local, state, federal, and tribal interests must be involved and engaged in the program from the outset. Unlike strictly operational cloud seeding projects, the Wyoming Pilot Project also includes plans for detailed analytical and predictive modeling of clouds and precipitation, as well as atmospheric aerosol and cloud physics measurements. These studies provide evidence that can establish the cause-and-effect of seeding. Few programs include such efforts because of their cost, but their inclusion is essential to improve the physical understanding of cloud and precipitation processes and the effects of seeding on these processes.

A technical advisory team involving the following agencies and sub-agencies provided input into project design, safeguards, and operations: Medicine Bow-Routt, Shoshone, and Bridger-Teton national forests; the U.S. Forest Service's Capital City Coordinator and Rocky Mountain Research Station; U.S. Geological Survey; Bureau of Land Management; USDA Natural Resources Conservation Service; National Weather Service; Wyoming's State Engineer's Office, Department of Environmental Quality, Game and Fish Department, and Department of Transportation; and the University of Wyoming Department of Atmospheric Science. This team has contributed significantly to the project, and team members have also learned much about cloud seeding technology.

Because of differences in climate, topography, amount of wilderness area, and the presence of tribal lands, the three mountain ranges were grouped into two target areas. One target, the Medicine Bow and Sierra Madre Ranges (MB-SM), contains only limited wilderness area, no tribal lands, and lies wholly within the Medicine Bow-Routt National Forest. The second, the Wind River Range, contains vast wilderness areas, is nearly one-third tribal lands, and includes land in both the Bridger-Teton and Shoshone national forests. Initial efforts consequently focused on the simpler MB-SM area.

Getting Ready

Almost all locations suitable for ground-based seeding in this area lie within the Medicine Bow-Routt National Forest, so an environmental analysis was required before the Forest Service would issue special-use permits for siting the equipment. Winter 2005-2006 was to have been the first season for seeding in the five-year project, but the environmental analysis quickly expanded beyond the scope originally envisioned, even in the “simpler” target area. WMI retained the services of Arcadis-Greystone, who performed a biological assessment, prepared a biological evaluation and management of indicator species report, and consulted with the Fish and Wildlife Service regarding ten federally listed threatened and endangered species.

While environmental analysis was underway, an instrumented aircraft, weather balloons, and microwave radiometers probed the clouds over and near both potential targets, gathering important aerosol, thermodynamic, and microphysical background data. A new high-performance computer was assembled at NCAR to begin high resolution numerical modeling of airflow, clouds, and precipitation.

Natural snow and soil samples were collected and analyzed by the Desert Research Institute of the University of Nevada for silver content, the primary component of the silver-iodide seeding agent proposed for the program. Approval to conduct airborne seeding



Locations of cloud seeding target areas in Wyoming.

was obtained for the MB-SM target area, and limited test seeding was conducted over the Medicine Bow Range. The Sierra Madre was not seeded at all, in case ongoing environmental studies show additional background chemistry (silver) measurements are needed in an unseeded region.

The Green Light at Last

Finally, special-use permits for siting equipment were issued by the Medicine Bow-Routt National Forest in August 2006 for the 2006-2007 season, just weeks before winter weather began to affect the preferred generator sites at higher elevations. WMI crews sprang into action, quickly deploying ground-based facilities at approved locations in the MB-SM. Several snowfalls caused delays, but by early December 2006, all 12 ground-based sites in the two ranges were established. Though this was several weeks after the scheduled November 15 start date, the generators are to be operational for the remainder of the 2006-2007 winter season, through March.

Seeding is scheduled to begin in a randomized manner designed by NCAR to account for natural storm variability

and other statistical errors, but high-resolution precipitation gauges to be used for evaluation were still being deployed in early January. Preliminary test seeding began in January to test equipment and practice the procedures that will be used to effectively randomize the seeding. Many seasons of data will be required for results to be statistically meaningful.

Progress is somewhat slower in the Wind River target area. Although a special-use application for siting ground-based generators near the Wind River Range was submitted to the Bridger-Teton and Shoshone National Forests in June 2006, as of December, WMI was unaware of any formal Forest Service action on the application. The project shifted focus slightly, and WMI began siting ground-based seeding apparatus around the southern perimeter of the Wind River Range on state-owned and private lands not requiring Forest Service approval. Five sites are in place, allowing initial seeding tests to begin in the southern Wind River Range during the 2006-2007 season. Additional sites on federal lands in the Wind River Range remain a possibility, pending permit approval.

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