

PROJECT SKYWATER - A PROGRESS REPORT

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The Bureau of Reclamation's program of Atmospheric Water Resources Management, known as Project Skywater, was begun in 1961. At that time Congress made an appropriation of \$100,000 and gave the Bureau authorization to conduct research "on increasing rainfall by cloud seeding." Support of the program has grown to the extent that funding in FY 1972 is almost \$6.8 million. A map which depicts the location of Project Skywater contractors is given as Figure 1.

Though many questions regarding weather modification remain unanswered and a large amount of research must yet be done, progress has been made and present planning now reflects changing emphasis within Project Skywater. We are now beginning a period of transition in emphasis from winter to summer research, because many key problems remain in summer cumulus seeding and there is an apparent rapid increase in public interest in summer seeding. However, the continuing goal is that of enhancement of water supplies and crop moisture by developing operational cloud seeding techniques which can be used in a beneficial and socially acceptable manner.

The most significant progress has been with regard to development of techniques for seeding winter storm systems. With the conclusion of on-going winter research projects in Montana, Utah, Colorado, and here in the Jemez Mountains of New Mexico, initial but practical techniques will be available for beneficially increasing mountain snowpack. Yet a continuing need exists for the engineering of these techniques towards a more effective system to improve performance and results.

Project Skywater's largest mountain winter seeding program is the Colorado River Basin Pilot Project (CRBPP) in the San Juan Mountains of southwestern Colorado. The project is now concluding the second of four winters' seedings. From 20 to 40 percent of the winter storms have been found favorable for seeding with increases per storm estimated to be in the order of 50 to 100 percent. Preliminary evaluation of the first winter's seeding has confirmed the estimated increases. A contract is now under negotiation which will engage a group, not previously involved in the project, to perform an independent and unbiased comprehensive evaluation of project results including water production/cost analysis. Figure 2 shows the current project status and points out the need for a decision, by about 1975, based on the evaluation report, related findings, and planning results on whether an operational project should be initiated.

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FIGURE 1

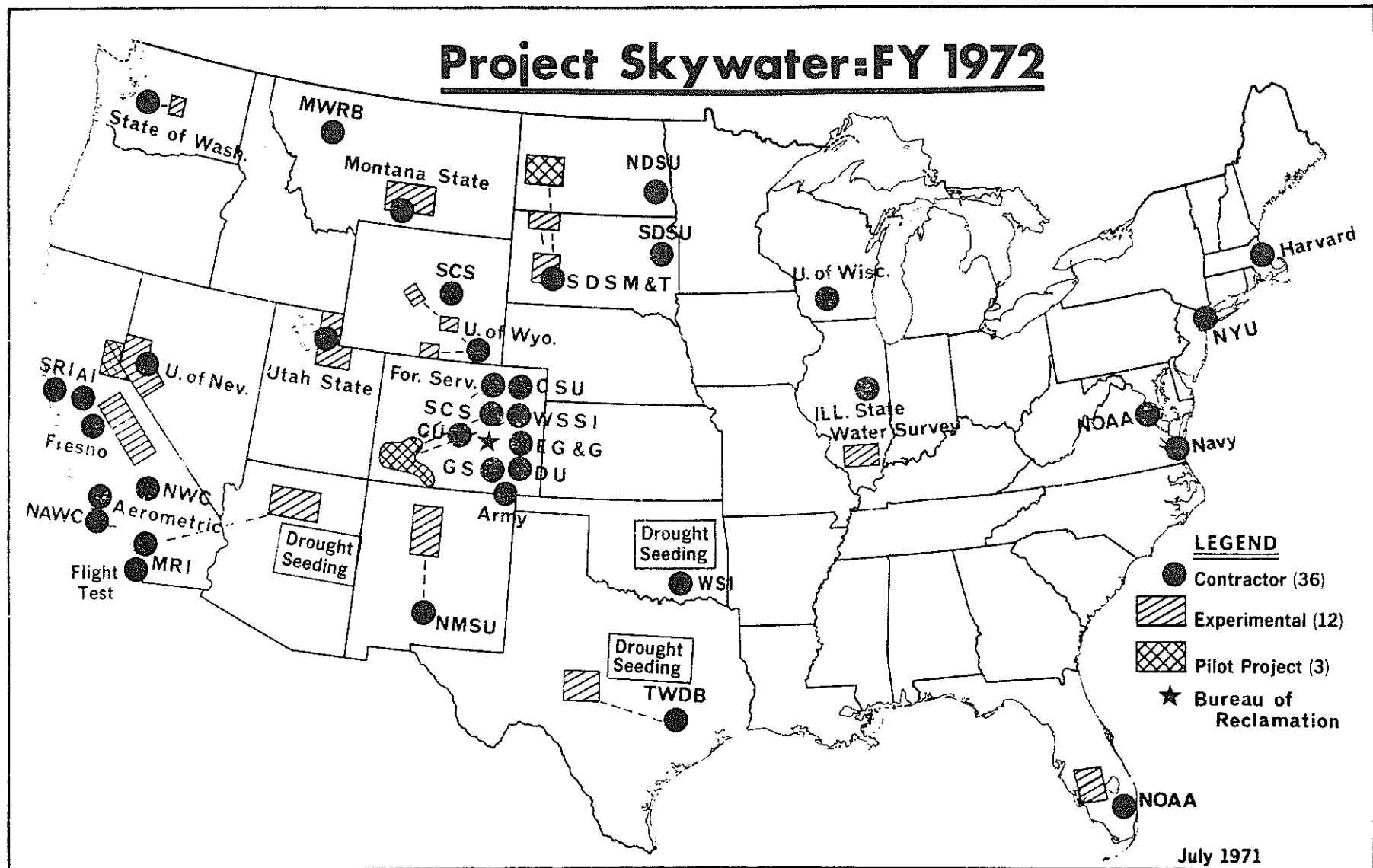
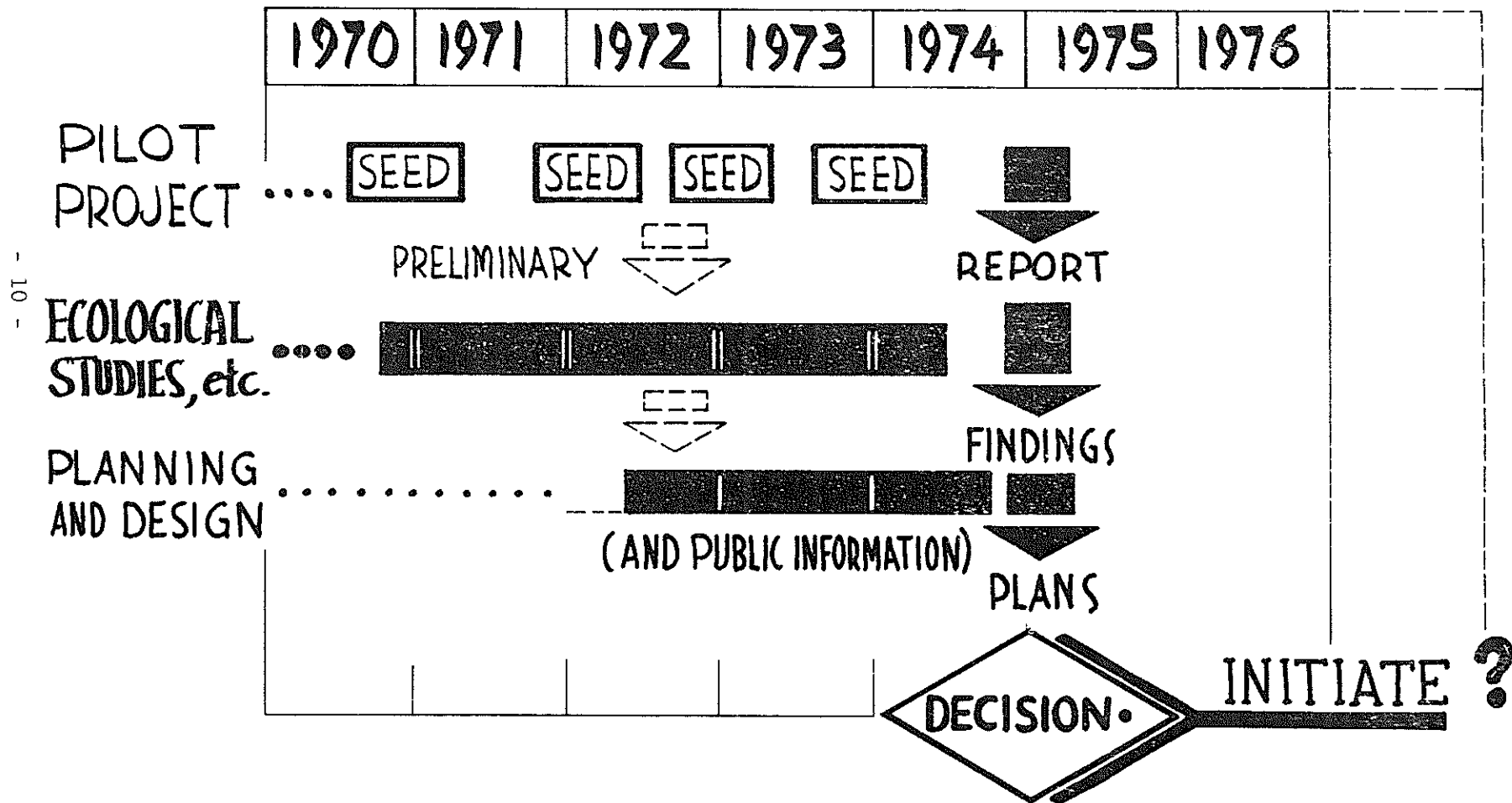


FIGURE 2

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COLORADO RIVER BASIN



A short film about seeding operations in the San Juans, called "Mountain Skywater," was completed just this past February. The film deals in an easily understandable way with cloud seeding, how it is done, avalanche research, and related ecological studies.

Research in seeding summer cumulus, under Project Skywater, has been far less extensive than the winter research. The Institute of Atmospheric Sciences at South Dakota School of Mines and Technology (SDSM&T) is continuing a large randomized seeding field experiment near Rapid City to clarify how salt and silver iodide aircraft seeding influences the precipitation processes in summer convective clouds.

Current planning for a Northern Plains Region is based on the research being done by SDSM&T on the Northern Great Plains Pilot Project in western North Dakota. This pilot project was the subject of Skywater Conference VII held in Denver on March 2-3, 1972. The conference was the latest in the series held by the Bureau to both inform the scientific community and obtain insight about major efforts within Project Skywater. General agreement was reached at the conference that a regional basis for weather modification coordination should be established, but emphasis was placed on having as much local control as practicable. The trend that appears to be developing is for strong locally- and state-supported programs with some as yet undeveloped form of interstate coordination and Federal assistance.

The San Angelo Cumulus Project near San Angelo, Texas, is a 3-year program, initiated in 1971. The project is designed to develop procedures for increasing precipitation from cold clouds by ice-phase seeding and from warm clouds through technology only presently being developed. Hygroscopic seeding materials are used to increase rainfall from warm clouds. This new technique holds great promise for augmenting moisture in the Southern Plains and Southwestern states.

Another Skywater project involved in summer seeding research is a feasibility study of year-around seeding to increase rainfall in Illinois. The study was begun in 1971 by research scientists of the Illinois State Water Survey and will be concluded in 1975. The program is unique in that it will be the first United States project to place primary emphasis on modifying frontal and squall-line storms (the major source of Midwestern precipitation). No actual seeding will take place during this phase of the study. However, if the results provide the justification, a second phase could be an experimental operation. Findings from this research are expected to be an important part of completing the technology for summer seeding.

During the summer of 1971 the Bureau of Reclamation, through Project Skywater, cooperated with the President's Office of Emergency Preparedness and the Governors of Texas, Arizona, and Oklahoma in conducting drought-relief cloud seeding operations in those states. Conditions were favorable for seeding in each of the areas and substantial rainfall did occur. Estimates of the increases attributed to seeding have been made for each of the operations as shown on the following table. However, due to the

short-term nature of the programs, the collection of only limited amounts of data for evaluation was possible. The results do give strong evidence that further research and development in this field can result in large scale benefits.

<u>State</u>	<u>Cost</u>	<u>Increase</u>
Texas	\$ 92,400*	10-15%
Arizona	150,000	15%
Oklahoma	296,000	95,000 a.f.

*plus cost of U.S. Air Force
aircraft operations

The drought-relief operations in Texas and Arizona were each for 1-month periods in June and during late July to early August, respectively, while the Oklahoma operation was conducted for 2 months beginning on August 15, 1971. Two contractors operated in Oklahoma, one using light aircraft for silver iodide seeding and the other performing hygroscopic seeding from a C-97. Each contractor has now completed a report on his operations and the estimated results. Hygroscopic seeding is credited with an additional 70,000 acre-feet of rainfall and the data indicate an addition of 25,000 acre-feet from silver iodide seeding. However, the amount credited to seeding is only a small part of the total rain which fell during the 2-month project. An all-time high of 10.04 inches of recorded rainfall occurred during September at Altus, Oklahoma, located within the project area.

The relative success of last summer's projects by both Project Skywater and by NOAA in Florida has provided the basis for cloud seeding becoming a major consideration for further use in drought-stricken areas. While the Bureau is willing to provide planning and scientific assistance when official requests are made, the program's charter from Congress is limited to performing research. The future operational application of weather modification by the Bureau or other Federal agencies is dependent upon appropriate new legislation which would provide authority and funding, while recognizing the need for continuing the necessary supporting research.

Another important study which will be started this month is a comprehensive evaluation of potential increases from the seeding of winter orographic cloud systems in a number of Western river basins. The increases in precipitation and corresponding streamflow which could have resulted from the use of presently known weather modification techniques over the past 20 years will be determined. The results of the study will become a part of the Western U.S. Water Plan and be made available for future operational planning. One of the major river basins with a high priority to be analyzed in this study is the Rio Grande River Basin here in New Mexico.

Because of the continuing water problems in the Rio Grande Basin and the favorable indications of seeding feasibility from the New Mexico State University and other winter research, the Bureau has included funds in the FY 1973 budget to begin planning for expanded cloud seeding activities in New Mexico.

Although I have made no attempt to bring you up to date on all phases of Project Skywater, I have touched on those items which appear to be of major current interest. In way of summarizing our overall program, the following list separates areas of major interest and some of the participating contractors:

- I. Development of Cloud Seeding Technology
 - A. Winter Research
 - 1. Sierra Range - Fresno State College
 - 2. Bridger Range - Montana State University
 - 3. Reno Area - University of Nevada
 - 4. Jemez Mountains - New Mexico State University
 - 5. Wasatch Mountains - Utah State University
 - 6. Cascade Range - State of Washington
 - 7. Elk Mountain - University of Wyoming
 - B. Summer Research
 - 1. Flagstaff - Meteorology Research, Inc.
 - 2. Florida - NOAA
 - 3. Rapid City - South Dakota School of Mines and Technology
 - 4. San Angelo - Texas Water Development Board
 - 5. Illinois - Illinois State Water Survey
 - C. General Research and Development
 - 1. Aerometric Research, Inc.
 - 2. Colorado State University
 - 3. University of Denver
 - 4. Naval Weapons Center
 - 5. New York University
 - 6. Western Magnum Corporation
- II. Planning Investigations and Other Support
 - A. Background Studies and General Planning
 - 1. Forest Service
 - 2. Montana Department of Natural Resources and Conservation
 - 3. North Dakota State University
 - 4. South Dakota State University
 - 5. University of Wyoming
 - 6. Stanford Research Institute
 - B. Field Support
 - 1. Forest Service
 - 2. Geological Survey
 - 3. Soil Conservation Service
 - 4. Meteorology Research, Inc.
 - C. Environmental Computer Network
 - 1. NOAA
 - 2. Computer Sharing Services
 - 3. AT&T

III. Adaptation of Techniques

- A. Environmental Effects Projects
 - 1. Colorado State University
 - 2. University of Colorado
 - 3. University of Wyoming
- B. Pilot Projects
 - 1. Colorado River Basin
 - a. EG&G, Inc.
 - b. Geological Survey
 - c. Soil Conservation Service
 - d. Western Scientific Services, Inc.
 - 2. North Dakota - South Dakota School of Mines and Technology
 - 3. North Platte
 - a. Soil Conservation Service
 - b. University of Wyoming
 - 4. Pyramid Lake - University of Nevada
- C. Special Studies
 - 1. North American Weather Consultants
 - 2. South Dakota Weather Control Commission

Project Skywater represents a major effort by the United States in an area where the rewards can be high. Progress in the relatively short period of study to date has been significant and present indications of advancing the technology in the future are exciting. A reasonable balance between operational adaptation and continued research should now be achieved and maintained to both utilize present technology and to insure continued future advances in the understanding and development of weather modification.