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ENGINEERING RESEARCH

PRELIMINARY REPORT

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RESEARCH

Conducted Concurrently with The Hail Suppression Program

Of The

Weather Modification Company

in 1959 in

Northeastern Colorado

By

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## Introduction

This report is a description of the research conducted by Colorado State University concurrently with the hail suppression program of the Weather Modification Company. Research was conducted at the request of the Directors of the Northeast Colorado Hail Suppression Association. The study began on 15 May 1959 and continued through 15 September 1959. Analyses of basic data are now underway.

## Objectives

1. To attempt to determine if the cloud seeding program was effective in reducing hail intensity.
2. To attempt to determine the effect of the cloud seeding program on precipitation amounts.
3. To gain a better understanding of the physical processes involved in hail occurrences.

## Procedure

During the study the following types of data were collected:

1. Information was obtained from a survey mailed to residents of the area living in or near Sections 8 and 18 in each Township in Colorado between Townships 3 and 12 N and 42-59 W inclusive. Cooperators were requested to report hail occurrences by mail, giving location, time of occurrence, size distribution of hail, and concurrent weather phenomena including precipitation amounts. A total of 389 reports of hail occurrences of this type were received between 15 May and 15 September 1959.
2. Information was obtained from periodic examination of approximately 250 hail indicating devices located in and near the target area. Figure 1 shows the routes along which the devices were located. A total of 358 indicators that had been damaged by hail were examined between 15 May and 15 September.



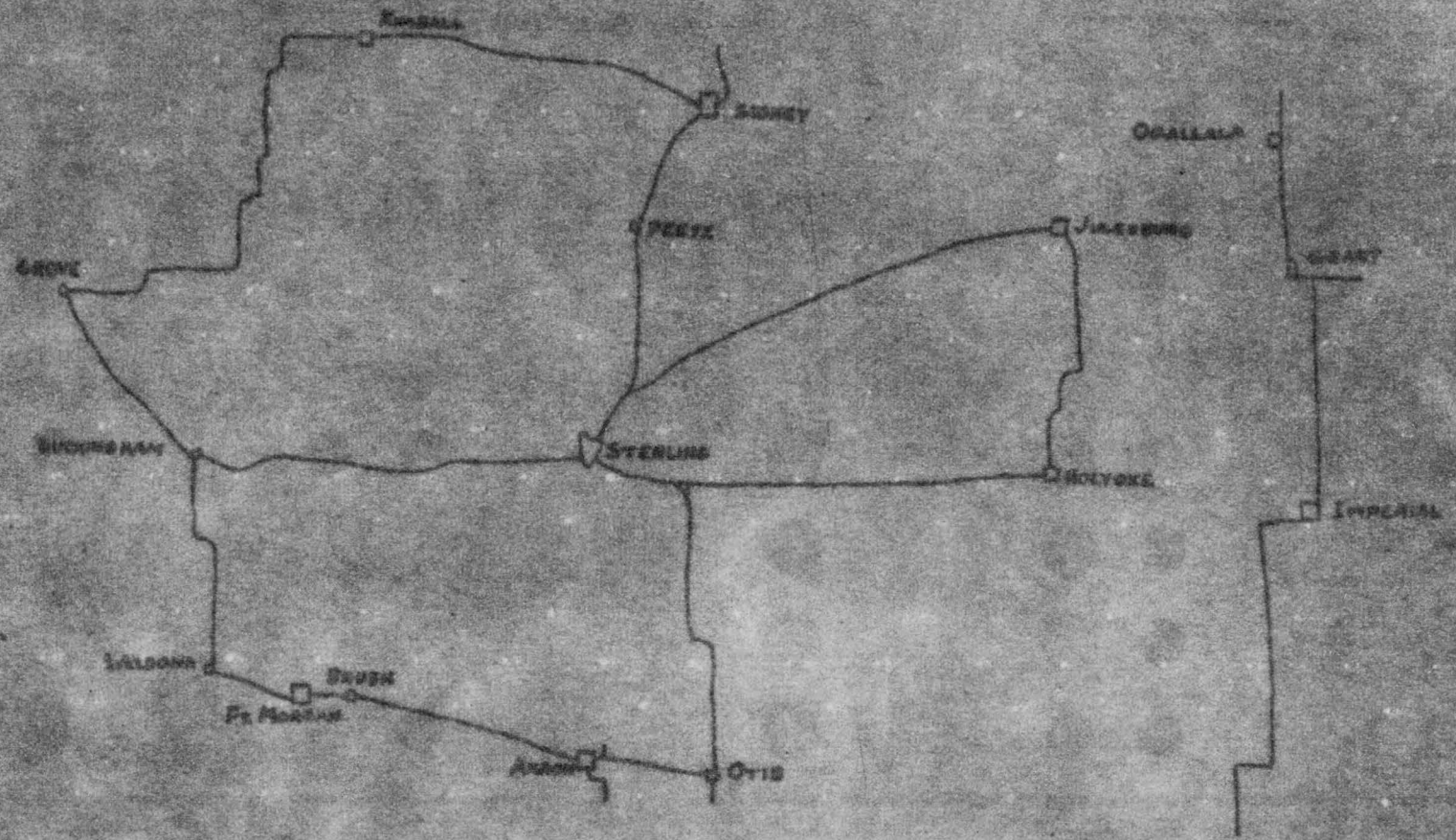


FIG. 1. LOCATION OF ROUTES ALONG WHICH INDICATORS WERE LOCATED

3. Reports of daily precipitation amounts between 15 May and 15 September were received by mail from 92 cooperators.
4. Reports were obtained from the Weather Modification Company on locations and times of ground generator operation, and routes and times of seeding by aircraft.
5. Information on the amount and type of hail damage to sugar beets between 1929 and 1958 was obtained from the Ovid, Sterling, and Fort Morgan districts of the Great Western Sugar Company.
6. Reports of precipitation and other weather phenomena were obtained from U.S. Weather Bureau observation points in and near the area.
7. Information was collected on the value of certain crops produced in the area for preliminary economic analyses of the potential benefits of hail reduction or for precipitation increase.

Damage by hail to the indicators and the mailed-in reports of hail occurrence were interpreted in terms of energy input per unit area. (Ft-lbs per sq ft). This was accomplished by theoretical analysis and laboratory calibration. Details of this method of measuring hail intensity are being reported elsewhere. (1)\*

#### Analyses of Basic Data and Presentation of Results

At the time the study was undertaken, it was emphasized that a one-year study would probably not provide irrefutable proof of effects of the given magnitude resulting from the cloud seeding program. However, it was considered likely that a one-year study could give some indications as to the probable type of effect being produced.

In order to determine the probable effect of the cloud seeding program on hail intensity and precipitation amounts, it is necessary to analyze the basic data by several different methods, to evaluate the results obtained by

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\* Numbers refer to appended references.

each analysis, and then to make a decision as to the most probable effect of the seeding program.

At the time of preparation of this report, the basic data are being analyzed. Until the various analyses are completed, it is not possible to state the degree of confidence that can be ascribed to results of the research.

It is the intention of the writer to complete the analyses of the basic data, and to present the results of the study to one of the technical society meetings early in 1960. As soon as the results are ready for presentation to such a meeting, they will be made available to the officers of the Northeast Colorado Hail Suppression Association.

The type of results anticipated are as follows:

1. A statement as to the probable effect of the seeding program on hail damage and precipitation amounts with supporting evidence and a statement of degree of confidence.
2. An estimate of the possible economic costs or benefits associated with the seeding program.

Some of the factors to be considered in such a cost analysis are included in the following section.

#### Preliminary Economic Analysis

An estimate of the economic benefit that would be associated with an assumed hail suppression effect can be obtained by applying loss experience on sugar beets as obtained from records from the Great Western Sugar Company, to crop production statistics from selected areas of northeast Colorado.

Analysis of the records from the Great Western Sugar Company for the period 1937 to 1939 and 1946 to 1958, indicates an average annual damage to beets of the "heavy damage" category (2) of 15 per cent of the total acres of sugar beets planted for the Ovid, Sterling and Fort Morgan districts of the Great Western Sugar Company (3). Since crop hail insurance rates for winter wheat are twice those for sugar beets (4), it is not unreasonable to

expect an average annual loss to the winter wheat crop of at least the same percentage, that is, 15 per cent.

The production records for winter wheat alone in Logan, Phillips and Sedgwick Counties show an average annual value of over \$15,000,000 for winter wheat produced in the period 1943-57 (5).

Destruction of an average of 15 per cent of this crop each year indicates an average annual dollar loss on winter wheat in Logan, Phillips and Sedgwick Counties in excess of \$2,600,000.

Thus, if the cost of a hail suppression program were \$65,000 annually for these three counties, a reduction in hail loss of  $\frac{\$65,000}{\$2,600,000}$ , or about 2.5 per cent, would give a reduction in dollar loss to winter wheat alone that would be equal to the cost of the seeding program.

A similar analysis can be made on the potential economic value of a change in precipitation amounts that might result from the cloud seeding program. The average summertime precipitation at Sterling is about 10 inches from May to September. If this amount could be increased about 10 per cent, one (1) additional inch depth of precipitation would result. This depth of water on 3400 square miles (the approximate size of the target area for 1959), represents a volume of approximately 180,000 acre-ft. The value of this volume of water would depend to a large extent on the land use within the area where it would be used. For range land a value of \$1.00 per acre-ft might be assumed. The cost of pumping irrigation water from wells can exceed \$10.00 per acre-ft. An average value of \$5.00 per acre-ft is not unreasonable.

Multiplying 180,000 acre-ft by \$5.00 per acre-ft value gives an estimate of \$900,000 potential annual benefit from a 10 per cent precipitation increase over the area of the cloud seeding operation in 1959 in northeastern Colorado.

It should be emphasized that the foregoing estimates of hail suppression effects and precipitation increase are for illustrative purposes only. They are intended to show the potential value of success in attempts at weather modification.

### Indications

The foregoing preliminary economic analysis indicates that only a small hail suppression effect and/or a precipitation increase is required to give a net benefit equal to or greater than the cost of the cloud seeding program.

As the results of the analyses now being performed become available, they must be examined in light of the foregoing economic considerations in order to estimate the costs and benefits associated with the Weather Modification Program.

## REFERENCES

1. Schleusener, Richard A., and Paul C. Jennings. "An energy method of measuring hail intensity". Submitted for publication to the Bulletin of the American Meteorological Society.
2. Garner, Lester. Personal communication: "Damage is Heavy When the damage is so severe that new leaves entirely have to be grown." (Mr. Garner is Manager of the Sterling District of Great Western Sugar Company.)
3. Hodges, Hayden, Jr. "Synoptic patterns associated with hail occurrence in northeastern Colorado", unpublished report CER59HH29; National Science Foundation Research Participation Report. Civil Engineering Section, Colorado State University, 1959.
4. Crop-Hail Insurance Acturial Association. Rates and rules for crop-hail insurance, Colorado, 1959.
5. Colorado Agricultural statistics, 1947-58.