

**OPERATIONAL PLAN
FOR
WEATHER MODIFICATION PROJECT
WESTERN KANSAS WEATHER MODIFICATION**

2014

**Submitted by
WESTERN KANSAS GROUNDWATER
MANAGEMENT DISTRICT NO. 1**

1.0 GENERAL DESCRIPTION OF THE DISTRICT

Western Kansas Groundwater Management District #1 (WKGMD #1) is planning to conduct a cloud seeding program in Southwestern and West-Central Kansas in 2014. This is a continuation of the project WESTERN KANSAS WEATHER MODIFICATION PROGRAM that has been conducted during the growing seasons from 1975 through 2013. In 2014, 3 Western Kansas counties entered into an agreement with WKGMD #1 to jointly finance weather modification operations. Planning and management responsibilities rest with the WKGMD #1 at Scott City. Daily decision-making and execution of this operational plan will be the responsibility of the Meteorologist.

The primary objective of the program is to conduct rain augmentation and hail suppression operations from **April 16th through September 15th 2014**. Operations in the specified area will be accomplished by (1) direct injection of dry ice into clouds, (2) vaporizing ice-forming nucleants into cloud base updrafts (both as a liquid solution and as a solid pyrotechnic), and (3) pyrotechnic generation of hygroscopic nuclei into cloud base updrafts.

A secondary objective is to acquire data related to seeding operations and storm activity. The data will be stored in a form suitable for later analysis.

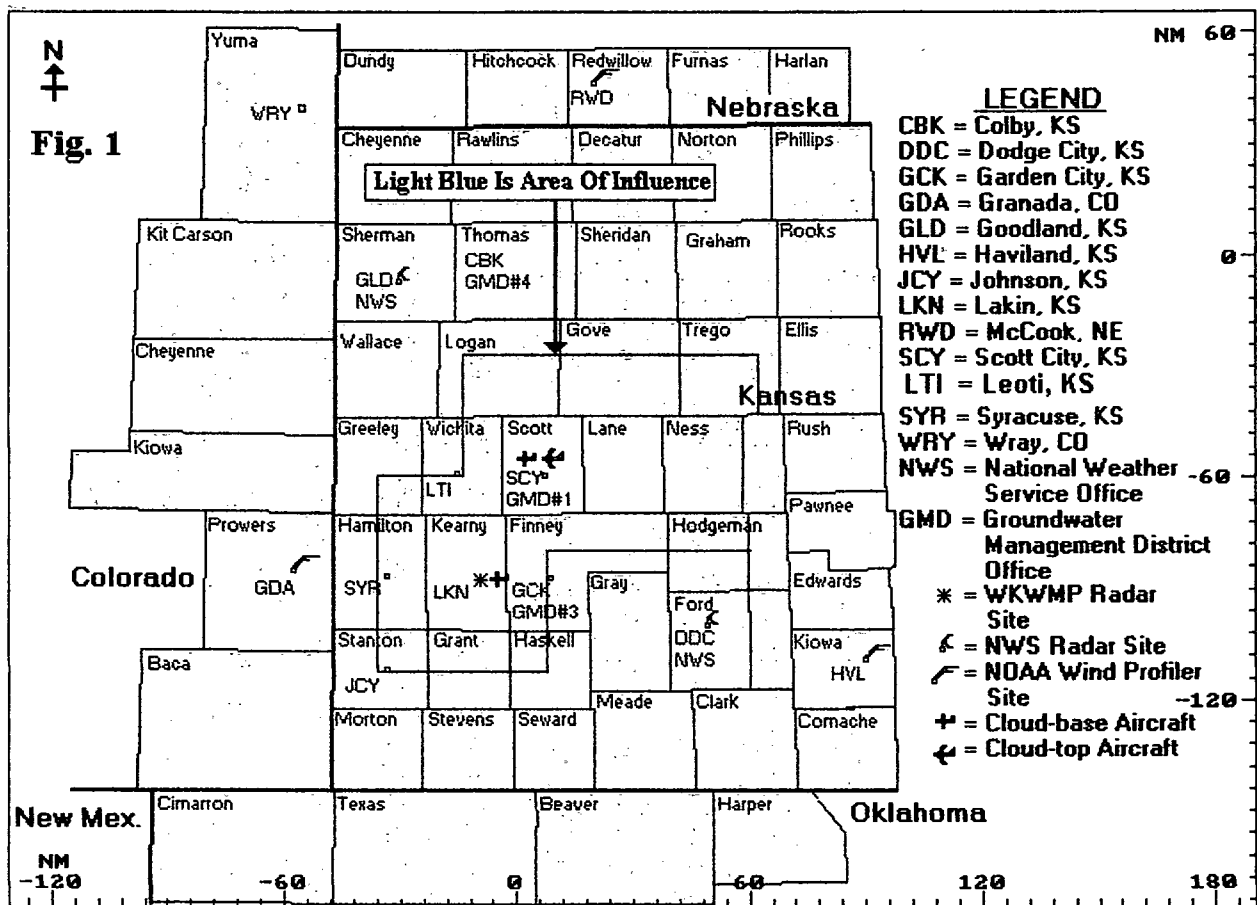
2.0 OPERATING AREA

2.1 Primary Target Area

The primary cloud seeding target area is comprised of the unshaded group of counties that are surrounded by the shaded area of influence shown on page 2, Figure 1.

2.2 Area of Influence

In the normal conduct of seeding operations it is expected that seeding material released will occur upwind of the intended target area and that some of the seeding effects may extend downwind of the primary target. From the foregoing, when considering prevailing winds, it can reasonably be expected that the area of influence would be approximately 10 miles upwind and 25 miles downwind of the primary target shown as the shaded area on page 2, Figure 1.



3.0 EQUIPMENT AND FACILITIES

3.1 Operations Center

Primary operations and control activities will be conducted in the project field headquarters located at the Kearny County Airport in Lakin. This building will accommodate the weather analysis function and serve as the project field office.

3.2 Seeding Aircraft

Two single-engine Piper Comanche aircraft will be used for updraft (cloud base) seeding, whereas on-top seeding will be conducted by a twin-engine Piper Cheyenne aircraft. All aircraft are currently owned and maintained by WKGMD #1. It is proposed that cloud base aircraft will be located at the airfields in Scott City and Lakin. The cloud top aircraft will be based in Scott City.

All aircraft will operate in the FAA "Restricted" category and certified airworthy under the appropriate FAA regulations.

3.3 Seeding Devices

All cloud base aircraft will be equipped with a Carley-type silver iodide-acetone burning generator mounted on each wing tip. The cloud base aircraft will operate from **April 16th through September 15th, 2014**. Each generator will dispense a three percent (by weight) silver iodide solution at a rate of (2.0 gallons per hour). All of the cloud base aircraft will also carry a special holding rack attached to the trailing edge of both wings, each of which is capable of carrying 12 pyrotechnic devices (flares) of the end-burning, burn-in-place variety. These flares are designed to produce hygroscopic ice-forming nuclei, which promote the condensation-freezing-coalescence process within clouds.

Another pyrotechnic device produces purely hygroscopic nuclei and is used in rainfall augmentation in generally smaller, "warm" clouds. These devices are end-burning and burn-in-place in the wing racks. The nuclei produced by the hygroscopic flares promote rapid hygroscopic growth into larger water droplets within clouds which subsequently falls, scavenging other drops along its path.

The cloud-top aircraft will serve as the direct injection seeding aircraft. It will dispense dry ice at a rate of 2.27 kg (5 lb) per minute into new-growth cloud turrets. This aircraft will be equipped with a full complement of avionics and weather avoidance radar for night IFR flights.

3.4 Seeding Material

When silver iodide complexes are burned by seeding aircraft at cloud bases, ice-forming nuclei are generated in updrafts while seeding both for hail suppression and rainfall augmentation. Seeding dispersal will be continuous while in areas of updrafts of approximately 200 feet per minute, or more.

Similarly, nuclei from pure hygroscopic material will be generated continuously in some seeding cases. The most important property of such nuclei is that they vigorously attract cloud water and water vapor to themselves and rapidly grow to become relatively large water droplets eliminating the need for those nuclei to ascend very far into sub-freezing cloud levels before producing the desired effect from clouds.

In both the above cases the aircraft will travel the full length of the updraft in the zones of "new growth" to obtain maximum dispersion of the seeding in use within the updraft volume. See Figure 2 on page 5.

Dry ice (CO₂) will be the exclusive seeding material used by the on-top aircraft. Dry ice pellets are approximately 20 mm in size (0.4 inch) and will be dispensed from a flight level equivalent to -10 C. Dispersal will be continuous while over, or in, new-growth clouds being treated both for hail suppression and rainfall augmentation.

3.5 Communications

Ground-to-air communications will be accomplished using VHF multi-com transmitters operating on a frequency of 122.925 MHz. The Project Manager will utilize this frequency to communicate with the aircraft.

Two commercial telephone lines will be installed at the field headquarters. The lines will be used in the following manner:

- (a) public line
- (b) DSL data line dedicated to accessing meteorological information

All personnel in the program will be furnished communications particulars for all of the other personnel associated with the program. In addition, each pilot will obtain a cell phone for his local area to keep with them at all times when away from a commercial phone.

SEEDING A TYPICAL AIR-MASS STORM

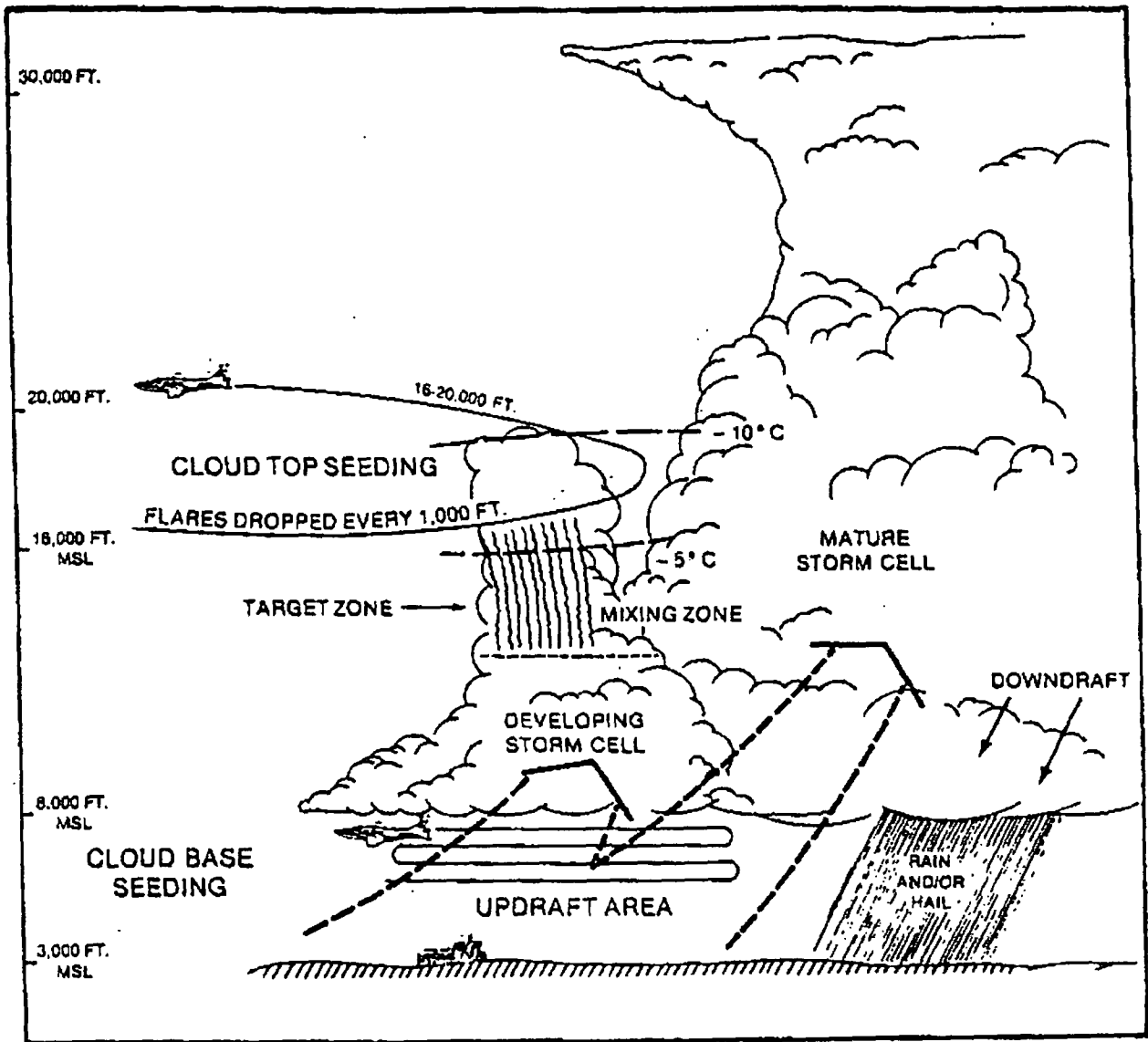


Fig. 2

3.6 Weather Radar

Storm monitoring and seeding control will be with an Internet-based radar software program at the Lakin field headquarters. The radar program has multiple products necessary for prompt storm interpretation along with the capability to show distance and direction from the radar to the given cloud system.

3.7 Other Data Collection Equipment

Weather data are collected from two sources:

(1) **DUATS** (Direct User Access Terminal System) - the federally provided flight planning service provided to all pilots. Among the weather data collected by modem from DUATS are surface observations, forecasts for surface stations, upper air prognostications, weather warnings and synoptic discussions.

(2) **INTERNET** - the same upper air data, satellite data and standard charts prepared by the National Weather Service are available on a timely basis. Updated data also appear frequently on a host of web sites. One such hourly update obtained is of wind profilers at Granada, CO and HaviLand, KS thereby providing us important and timely wind profiles of the atmosphere at both the eastern and western sides of our target area. Another important update available every 15 minutes is of cloud satellite imagery.

4.0 PLANNING RESPONSIBILITIES

4.1 Policy Board

A decision and policy making board may become established in order to ensure that the desires of the local users are considered in the proposed weather modification operations. If established, this board would be comprised of one representative from each of the participating counties plus the Manager for the Western Kansas Groundwater Management District #1. Kansas Water Office personnel will serve as state liaison to the policy board. The meteorologist, being the licensee, also will act as the technical advisor.

The policy board may meet periodically, or confer through telephone calls, during the season as needed to assess the operations and determine future policy. The members would be responsible for keeping the Operations Center advised of soil moisture and crop condition changes as well as seeding priority changes for their respective counties. In addition, they would be asked to provide input on the suspension of seeding and reports of weather-related conditions that have occurred in their counties.

4.2 General Priorities

Since the same organization and resources are used to accomplish both rain augmentation and hail suppression, priorities will be adjusted by the Policy Board as necessary, depending on soil moisture and crop vulnerability to hail damage. Since rainfall stimulation and hail reduction both result from a discretionary decision-making process during the period of operations, emphasis will be on hail reduction; rain augmentation will be a secondary objective. Seeding to increase rainfall may be performed first, but often the storm day transitions with the atmosphere becoming more unstable making necessary a change of seeding mode into hail suppression. Similarly, at the end of hail suppression operations rainfall stimulation can often be performed for a period of time before all seedable convective clouds collapse.

5.0 SEEDING OPERATIONS

The responsibility for day-to-day seeding decisions rests with the meteorologist. The decisions will be based on priority guidelines set by the WKGMD #1 Board of Directors or on existing meteorological conditions. The basic meteorological criteria used to initiate or suspend seeding operations are outlined in the following paragraphs.

5.1 Seeding Criteria

The criteria for selecting suitable cloud systems for seeding will be based on an assessment of a multiple number of meteorological parameters. All significant cloud systems will be examined for seeding potential. Seeding will be initiated on the basis of the general criteria listed in Table 1 on page 10.

5.2 Suspension Criteria

Seeding to increase rain either will not be initiated, or will be suspended when excessive rain is likely to occur. The Project Manager will take cognizance of the sociological aspects of seeding when severe storms are forecasted or when they are in progress. However, hail suppression operations will be conducted when beneficial results appear attainable as long as flying safety is not jeopardized.

Rain augmentation operations will be suspended when soil moisture is adequate, as determined by the Policy Board. Also, no seeding will be initiated at times the Policy Board determines weather modification activities are not beneficial to a particular area.

In the event there is a threat of damaging floods from excessive rainfall in the project area or in the area of influence, no seeding will be initiated. If seeding is in progress, it will be suspended by the Project Manager as soon as the hazardous potential becomes known.

5.3. Meteorological Data

Since 1995 the Internet has played an increasingly important role as a supplier of meteorological data to the Western Kansas Weather Modification Program. The types and sources of all meteorological data routinely available to the field headquarters include:

- a. Hourly observations - DUATS and Internet
- b. Aviation Terminal Forecasts – DUATS and Internet
- c. Severe Weather Warnings - DUATS and public news media
- d. Synoptic Surface and Upper Air Analyses - DUATS and Internet
- e. Operating Area Storm Data - Weather Radar System
- f. Satellite Pictures - Internet, public TV

In addition to the DUATS, Internet and other weather providers, late-breaking severe weather warnings are often relayed to us through the local law enforcement center.

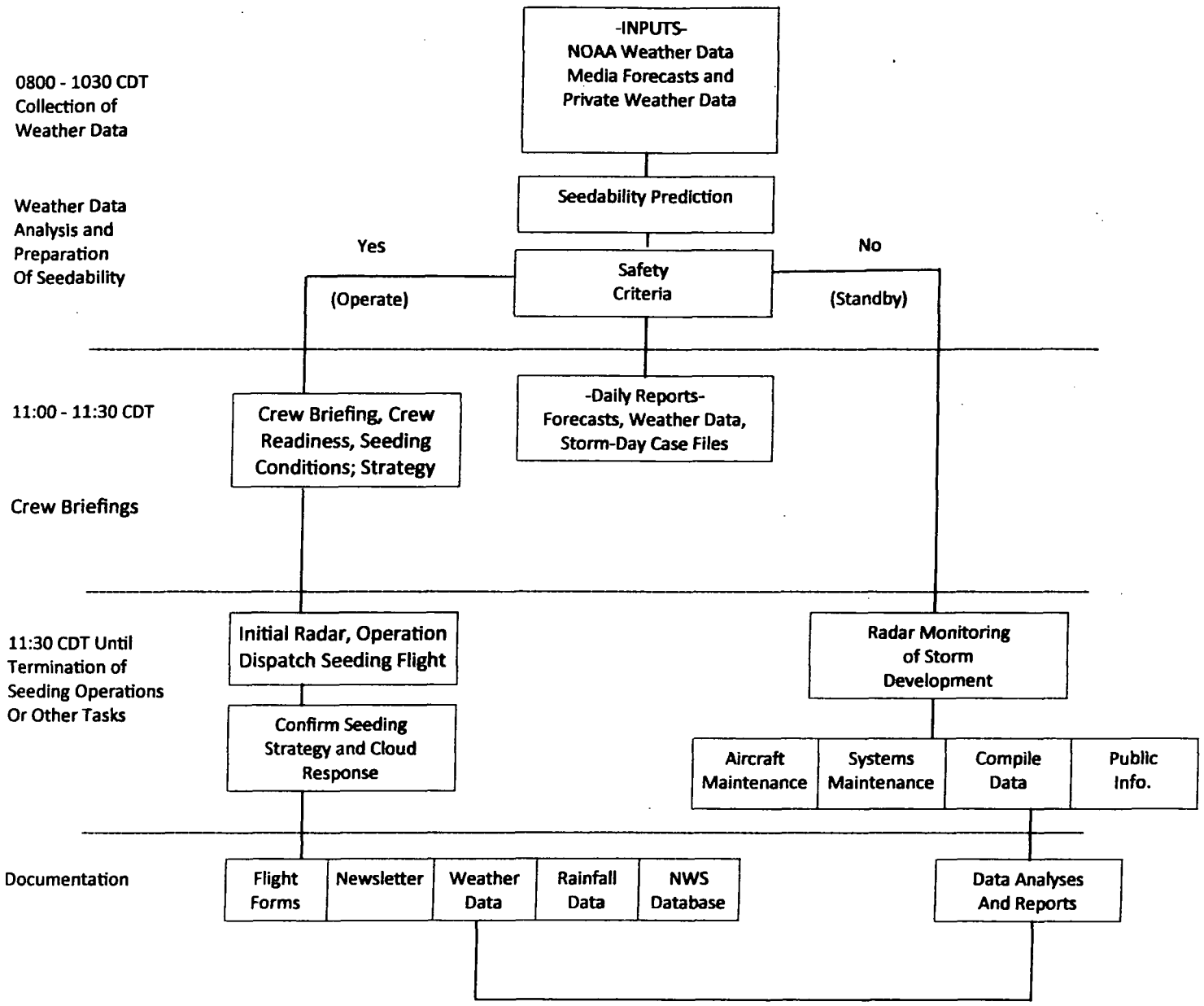
5.4 Seedability Forecasts - Daily Operating Decisions

Each day seedability forecasts will be prepared by the Project Manager using the information available from the sources listed in paragraph 5.3. The criteria described in paragraphs 5.1 and 5.2 will serve as a guide in making the seed, no-seed decision.

Normally, by 11:00 a.m., CDT, sufficient data are available to provide an indication of the weather conditions that will affect the project area for the next 24 hours. At this time the seeding plans for the day will be telephoned to aircrews individually, or as a group. If seeding operations are expected, the crews will be given details about standby status, seeding strategy and expected duration of operations. If no seeding is expected on a given day, crews will be placed on an appropriate readiness status, always subject to immediate recall in the event of unpredicted weather. Figure 3, page 11, shows a flow chart of events that take place on a normal day.

The initial daily operational decisions are made on the basis of forecast information, satellite data, and related upper air data. While the data inputs are very useful in working out crew schedules and seeding strategy, in the end the final seeding strategy is worked out in "real-time" by the meteorologist, his observations, radar information and pilot observations.

OPERATIONS FLOW CHART



Although particular emphasis will be on the May-June period before wheat harvest and while corn development is still in a relatively early growth stage, it can also apply to some highly active storm days in the months of July and August. In addition, pyrotechnics will be burned into updraft areas at the discretion of the Program Manager.

6.0 SAFEGUARDS AGAINST HAZARDOUS EFFECTS

Although weather modification in itself is not directly hazardous, there are certain precautions that should be taken against potentially contributing hazards in the area of aircraft flight safety and severe weather.

To ensure appropriate and safe operations, the following policies will apply:

- (a) All pilots will be selected on the basis of integrity, experience and airmanship.
- (b) Prior to commencing seeding operations, pilots will be briefed on FAA traffic control and coordination procedures as they apply to the project.
- (c) All project aircraft will be certified air-worthy in accordance with the appropriate FAA regulations.
- (d) The meteorologist will attempt to keep pilots informed of storm developments that could be hazardous to them and, where appropriate, they will provide them with navigational directions needed to avoid any potential hazards observed on radar. However, pilots will always retain the final authority in all matters pertaining to flying safety including decisions to take off or to terminate any mission whenever it is judged by him that operations cannot be conducted safely. Pilots will advise the Program Manager when they elect not to position themselves as suggested or directed for seeding purposes by the Manager.

7.0 EXPECTED EFFECTS ON THE ENVIRONMENT

Based on studies of weather modification programs in states such as California, Colorado, Arizona, Texas, Florida and both South and North Dakota, this project does not involve any high degree of risk of harm to land, property, health or ecology.

8.0 METHODS OF EVALUATION

Although the scope and design of the proposed operational program does not make provisions for the extensive evaluation of seeding results, storm and operating data will be retained in a form suitable for later analysis. In 1994, 2006, and 2007, the Kansas Water Office (KWO) completed economic evaluations of the Project for hail suppression and, separately, an evaluation of rainfall augmentation. These evaluations used a Double Ratio test as the preferred method to compare a group of "Control" counties in Northwest Kansas and Eastern Colorado to six Western Kansas "Target" counties. The 1994 and 2006 evaluations both showed a reduction in crop-damaging hail of 27% and 35% respectively with both evaluations indicating no significant effect on rainfall.

8.1 Data used to Monitor Daily Operations

- (a) Radar data, archived by the NWS, can be used for later correlation with storm damage and aircraft positions.
- (b) Each pilot will record on a flight form:
 - (1) Engine start and stop time
 - (2) Cloud base altitude, updraft speed and temperature
 - (3) All changes of direction are tracked by GPS.
 - (4) All changes in amounts of seeding agent being dispensed (one or two generators being used)
 - (5) Location at least every 15 minutes
 - (6) Gust fronts encounters
- (c) Each pilot will verbally inform the Program Manager of:
 - (1) Cloud base altitude, updraft speed and temperature
 - (2) All changes in amounts of seeding agent being dispensed (one or two generators being used)
 - (3) Gust fronts encountered
- (d) Flight track data are recorded from a Garmin GPS systems and e-mailed to the Operations Center for documentation required under State permit.

Flight form information is e-mailed to the field headquarters in Lakin as soon as practical after flight operations. If this is not possible, the forms will be mailed no later than Friday, each week.

8.2 Data Collected for Analysis

(a) Seeding locations and amounts

(b) All entries will be in Central Daylight Time. Since all possess Global Positioning Systems (GPS) capability, aircraft directions will reference the magnetic compass relative to the radar-housed field headquarters at Lakin; distance will be recorded in nautical miles from those respective headquarters.

8.3 Other Reports Used to Monitor Seeding Effects

(a) One of the important functions of the WKGMD #1 Board members is to make continuing assessments of the impact of the seeding program in each one's area of representation.

(b) Western Kansas Rainfall Reporting Network

9.0 RECORDS AND REPORTS

In addition to the meteorological reports and operating logs specified in this plan, the following listed reports will be prepared:

9.1 Daily Log of Weather Modification Activities, Form KWM#3

Submitted to: (1) Chairman WKGMD#1
(2) Director, Kansas Water Office

Due date: Monthly, by the 15th day of each month

9.2 Verbal Report of Seeding Operations and the meteorologist's assessment of the results of the program.

Submitted to: (1) Chairman WKGMD#1

Due date: 30 days after the end of the project

9.3 Final Report of Seeding Operations and the Program Manager's assessment of the results of the program.

Submitted to:(1) Chairman, WKGMD#1
(2) Director, KWO
(3) Director, Colorado Water Board
(4) Oklahoma Water Resources Board

Due date: 90 days after the end of the project

9.4 NOAA Initial Report of Weather Modification Activities, NOAA Form 17-4

Submitted to: U.S. Dept. of Commerce
NOAA
Office of Oceanic and Atmospheric Research

Due date: 10 days prior to beginning seeding

9.5 NOAA Final Activity Report, NOAA Form 17-4A

Submitted to: U.S. Dept. of Commerce
NOAA
Office of Oceanic and Atmospheric Research

Due date: 45 days after end of project

NOTES: (1) The meteorologist generally produces a weekly newsletter for general distribution. The newsletter divides into two section: (a) General Interest - where various updates, results of analyses and items thought maybe to be of a interest to the general public are made known, sometime related to weather modification, and (b) Operations - in which is reported the daily cloud seeding operations---areas, times of seeding, etc.

The WKWM website address is: <http://www.gmd1.org/index-3.html>

The WKWM e-mail address at the Lakin field headquarters is: hailman@pld.com

10.0 PERSONNEL DIRECTORY

President, Board of Directors Western Kansas Groundwater Management District #1	Greg Graff Marienthal Kansas 67863
District Manager Western Kansas Groundwater Management District #1	Jan King PO Box 604 Scott City, Kansas 67871 (620) 872-5563
Program Director Western Kansas Weather Modification Program	Kyle Spencer PO Box 604 Scott City, Kansas 67871 (620) 872-5431
Meteorologist & Licensee Western Kansas Weather Modification Program	Walter Geiger III PO Box 254 Kearny County Airport Lakin, Kansas 67860 (620) 355-6913/14
State Liaison	Kansas Water Office 109 SW 9th St., Suite 200 Topeka, KS 66612 (785) 296-3185
State Liaison	Colorado Water Conservation Board 1313 Sherman Street Room 721 Denver CO 80203
State Liaison	Oklahoma Water Resources Board 3800 North Classen Blvd. Oklahoma City, OK 73118