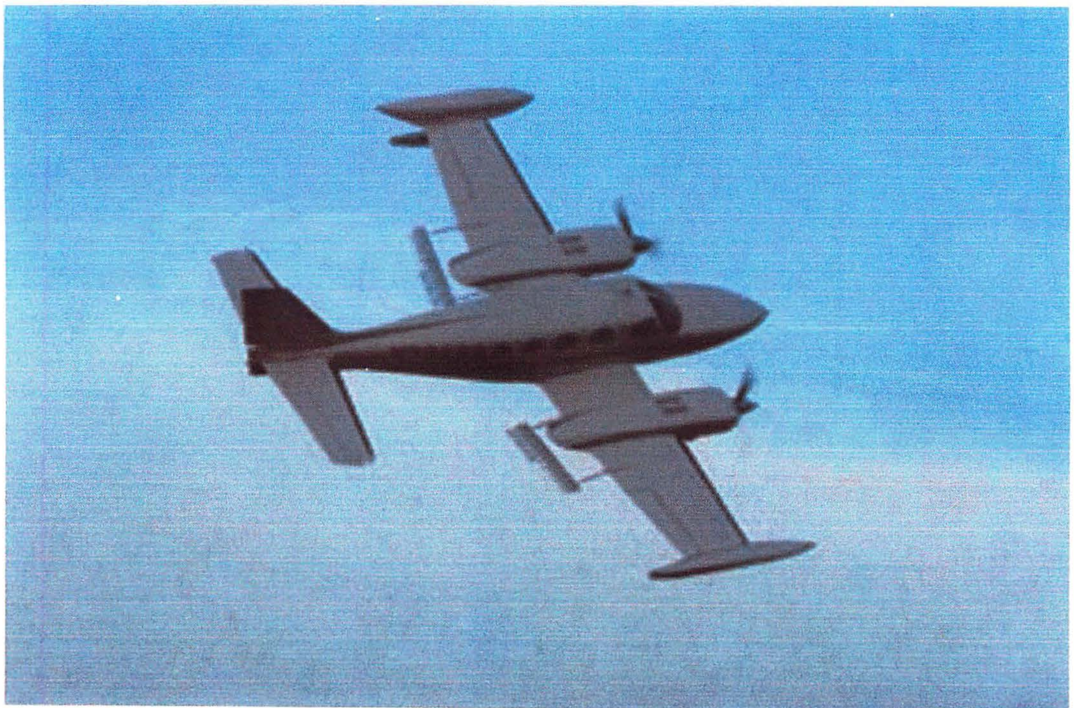
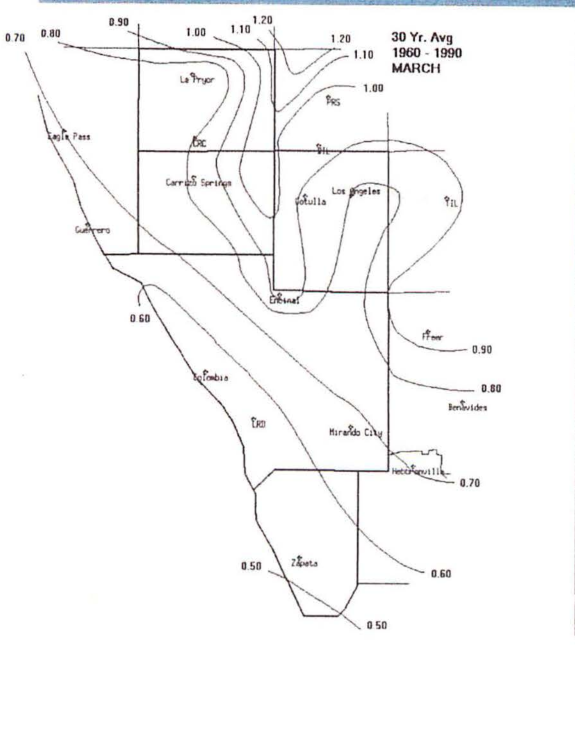
FINAL REPORT – 2002

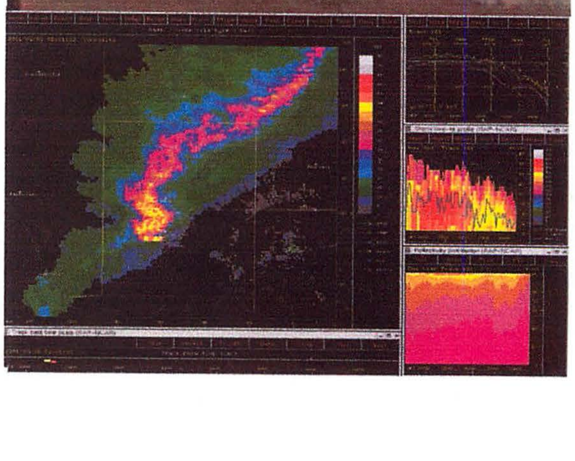
A WEATHER RESOURCES MANAGEMENT PROGRAM

A SUMMARY OF CLOUD SEEDING ACTIVITIES CONDUCTED OVER SIX COUNTIES IN SOUTH TEXAS DURING THE PERIOD 15 MARCH – 15 NOVEMBER 2002

Report prepared for:
Southwest Texas Rain Enhancement Association







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SOUTHWEST TEXAS RAIN ENHANCEMENT ASSOCIATION
2002

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I. WEATHER MODIFICATION BACKGROUND

With some question, the first scientific based rain stimulation proposal may have been by James P. Espy, in the April 5, 1839 issue of the National Gazette and Literary Register of Philadelphia. Espy proposed building large fires thus generating thermal updrafts. James Espy's reasoning was that in an atmosphere with sufficient moisture, cumulus clouds would eventually develop from the warm raising air over the fire to produce rain. No records exist indicating that the proposed scheme led to any field trials, but in the 1880's Congress appropriated $10,000 to conduct field experiments based on an old, widely-held idea that "it always rains after a battle". After the appropriation, tests were conducted utilizing explosive charges carried aloft by balloons. Favorable reports followed after the field tests. In the 1930's, work completed by Tor Bergeron and W. Findeisen led to the concept that clouds may contain both liquid supercooled water and ice crystals existing within the same medium. This led further to the concepts of "warm rain" and "cold rain".

Modern scientific cloud modification was started in the late 1940s in the General Electric Laboratories at Schenectady, New York. Drs. Schaefer, Vonnegut and Langmuir used silver iodide and dry ice for ice nucleating agents during in these early laboratory and field experiments. The ice nucleating agents for cloud seeding have dramatically changed with time. Various formulations of Silver Iodide are still the chemical of choice for rain enhancement and hail suppression today. Other formulations such as carbon dioxide and hygroscopic seeding agents also work for rain enhancement while dry ice works of both rain enhancement and hail suppression.

Prior to 1967, weather modification activities in Texas were unregulated by any governmental entity. The Texas Weather Modification Act of 1967 (Chapter 14 of the Texas Water Code) provided the mechanism for identifying and regulating cloud seeding programs in the State through the issuance of licenses and permits. By 1976, the original Texas Water Development Board had granted licenses to seven firms and issued 27 permits. In more recent years the responsibilities for granting licenses and permits was passed to the Texas Natural Resource Conservation Commission (TNRCC).

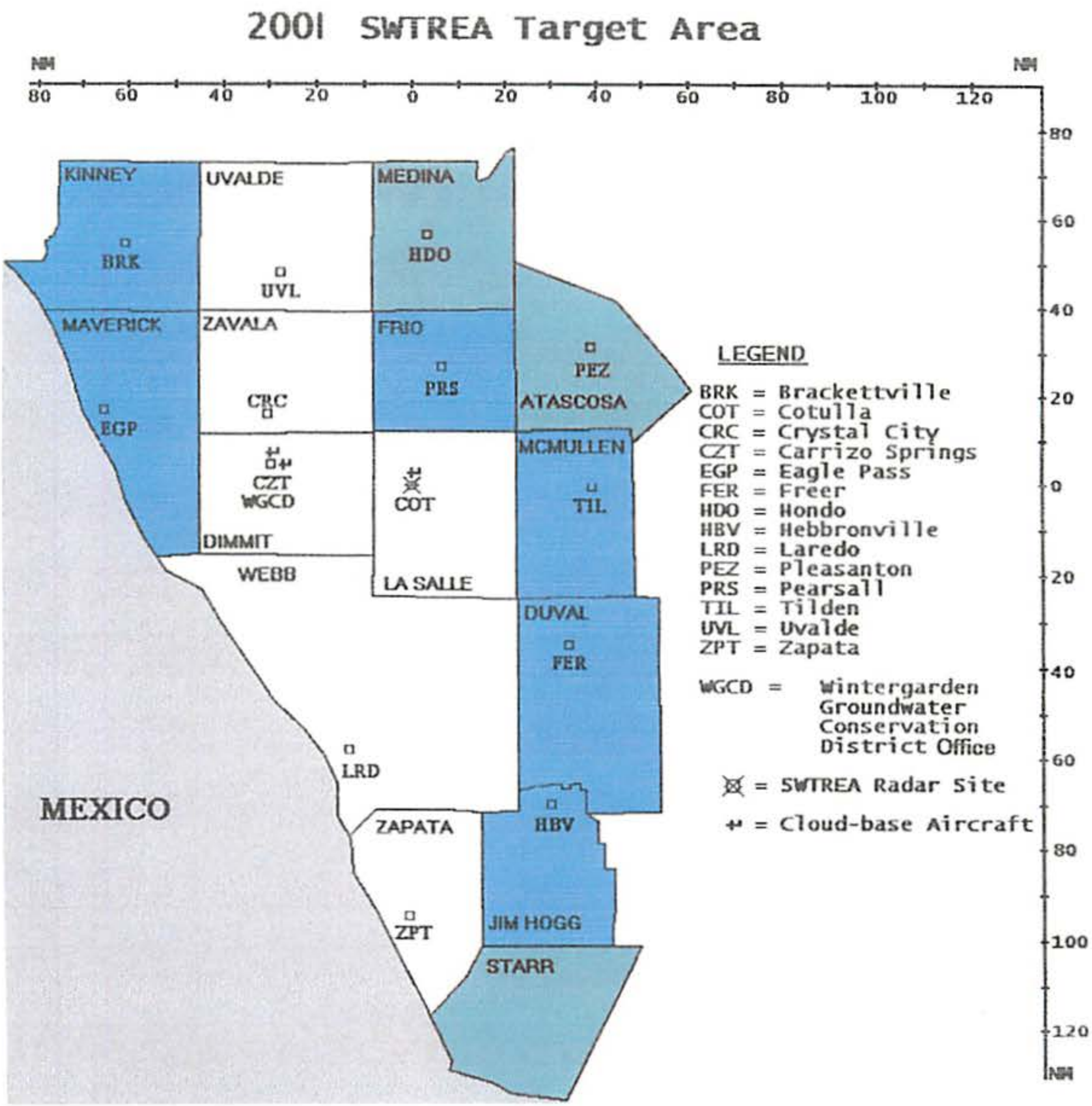
In early December 1998, The Southwest Texas Rain Enhancement Association (SWTREA) circulated a Request For Proposal covering a cloud seeding program targeted to begin in May 1999. Ultimately, Atmospherics Incorporated, Fresno, California won the contract to conduct the seeding project. The counties that were serviced under the umbrella of rain enhancement by the SWTREA were Dimmit, La Salle, Webb, and Zavala Counties. The 1999 SWTREA cloud seeding project was operational during the period 1 May through 31 October and was deemed a success.

During the latter months of 1999, the SWTREA took steps to establish a means for which the association would conduct its own weather modification program instead of relying on services rendered by seeding contractor companies. The Southwest Texas Rain Enhancement purchased a ground-based 5-cm radar, cloud seeding aircraft, systems for acquisition of meteorological data and various cloud seeding devices. The SWTREA also employed a meteorologist and three pilots. The cloud seeding project completed its second year of operations in a seeding season that ran from April 12, 2000 to November 15, 2000. Daytime rain enhancement and hail suppression services were provided to the participating counties in the target area of Dimmit, La Salle, Webb, Zapata and Zavala Counties. During the last month of the season, some nighttime seeding was also carried out for the first time in the history of any cloud seeding project in Texas. The year 2000 project was also deemed a success.

2001 marked the third year of the project and the first full season of 24-hour, 7-day per week seeding readiness. The year represented an aggressive effort of rain enhancement and hail suppression in the same five counties as last year (see target area map Fig. 1). An additional seeding plane was purchased (twin-engine Cessna 340) in an effort to enhance operational readiness of the program, address more seedable clouds and to increase our effectiveness in hail suppression. Only two planes were used however this year.

Steps were taken during the early portion of the season to add an additional pilot to the program so that we could utilize the third plane at the outset of the 2002 season. A pilot was hired and has been in training this year so that he will be in a position to be a pilot-in-command (PIC) for the third plane in 2002. At the same time the decision to hire another pilot was decided, steps were also taken to begin training Mr. Walker, SWTREA program manager, as a "stand-in" pilot for times when a full-time pilot was unavailable for a mission or for ferrying a plane. During mid-season, it was also decided to begin a pilot internship program. It was recognized that in the ever-changing world of weather modification, pilots and meteorologists typically use the experience gained in this field as a stepping stone for jobs that become available in other fields in the future. It is envisioned that at least one intern pilot and one intern meteorologist would be present on the program every year should a pilot or meteorologist decide to move on thus avoiding the creation of a critical vacancy in the project staff. With the meteorologist's decision to transfer his services to another weather modification project in Kansas, the program took steps to hire and train a replacement so that no seeding opportunities will be lost in the seeding season of 2002 due to the absence of a meteorologist. A meteorologist with previous weather modification experience was found late in 2001 and was quickly brought into full time duties. As the 2001 season came to a close, it was extremely evident that this year's seeding efforts were very successful. Details of the results for this year are provided in section B of chapter IV.

2002 marked the fourth year of the project, the second year of 24 hour-a-day operational time. This year marked the second year of operational use of the new Cessna 340, totaling 3 full time aircraft. This year also saw the addition of a sixth county to the target area. Uvalde County was added on May 1 as the Edwards Aquifer Authority rearranged it cloud seeding activities. This brought the project totals to 3 aircraft, 6 available pilots, for 6 counties. The 2002 project ended on November 15th, bringing to a close a fourth successful year of cloud seeding.



II. THE PHYSICAL BASIS FOR CLOUD SEEDING

Even today, scientists still have much to learn about how some clouds grow, mature and dissipate over time, especially very severe storms. During the spring through summer months, rapidly growing convective clouds can become severe rapidly, producing highly destructive hail and surface winds which destroy crops and property, not to mention causing flooding and the occasional tornado. The occurrence of severe weather in South Texas is not nearly as great as in the plains states, but the overall dynamics of a convective storm is the same in both areas. The following is simplified explanations of how convective clouds can grow to become severe and of the generally accepted theory supporting the feasibility of seeding to increase rain and reduce hail.

A convective cloud forms when rising air containing water vapor cools by adiabatic expansion to a temperature at which condensation occurs forming water droplets. Condensation begins first upon microscopic aerosols, or particles, called cloud condensation nuclei (CCN). CCN are relatively abundant in the atmosphere and includes dust, smoke and salt particles. When a collection of these water droplets have grown to sufficient size, they become visible as clouds. In Southern Texas some of the mechanisms causing rising air to form convective clouds are:

(1) Surface heating which returns solar radiation to the atmosphere → warm air rising

(2) Advancing cold and warm frontal systems → forces air to be lifted over its boundary

(3) Relatively cold air in the upper atmosphere sinking into warmer air ahead of it → causes warm, moist air to be displaced and forced upward

(4) Regions of horizontal convergence created by troughing at the earth's surface, or aloft → forces air to rise as it is squeezed together

(5) Convective scale interaction resulting from thunderstorm outflows digging under warm, humid air → acts much like a mini-cold front forcing air ahead of it to lift rapidly (an extremely important mechanism once storms mature and collapse

(6) Sea breeze moving west over the warm earth surface → acts much like thunderstorm outflows or a mini-cold front (storms caused by a sea breeze are only active during daylight hours)

(7) Hurricanes, tropical storms, tropical depressions and tropical waves → promote intense shower and thunderstorm activity because of an unstable, high moisture environment

Other various atmospheric aerosols are present in the atmosphere and known as ice nuclei (IN). These particles, if found in condensed water droplets, enhance droplet freezing. Ice crystals also may form upon IN directly from water vapor.

Despite the abundance of CCN, there is a relative scarcity of IN. In nature, most convective clouds fundamentally lack sufficient numbers of IN which causes clouds to fail to precipitate efficiently, or help form damaging hail. Cloud seeding can usually provide the needed numbers of IN to correct the imbalances found in most cloud systems.

Clouds can be made up of unfrozen water droplets, ice crystals or a combination of both. Within a convective cloud having a portion of it colder than freezing, some of the sub-freezing water droplets remain in a liquid state, termed "supercooled water". Convective clouds often create a condition in which both unfrozen water droplets and ice crystals co-exist simultaneously. It is the supercooled cloud volume that is critical in Southern Texas to the formation of hail and rain (given the absence of tropical systems producing rain in a "warm cloud" environment). Supercooled water can remain unfrozen to as low as -40 C (-40 F) before spontaneously changing to ice. When such spontaneous freezing occurs, it is termed homogeneous nucleation.

Supercooled water droplets containing ice nuclei are the first to freeze. The speed that supercooled water droplets convert into ice crystals increases as cloud temperature decreases. That is, as cloud tops grow higher above the freezing level, ice crystal production normally increases. A process called vapor deposition then starts to have a significant effect within clouds when ice crystals and supercooled water exist in the same medium. Surface pressures over ice crystals are lower than those over water droplets creating a pressure gradient between them that causes liquid to flow from the droplets to the ice crystals reducing the cloud water. They continue growing rapidly feeding on the surrounding water vapor and cloud water from nearby water droplets. Continuous unequal movements of water droplets and ice particles inside convective clouds ensure random collisions of ice and water droplets which promote the processes of coalescence, accretion and aggregation to a greater or lesser extent, all of which increases ice multiplication in clouds.

Coalescence is a process in which the unfrozen water droplets collect other water droplets by impact, freezing occurring after the impact.

Accretion, or riming, occurs when droplets freeze upon impact with cloud ice particles.

Aggregation is the process in which ice particles collect or attach to other ice particles. In advanced stages of cloud growth, ice particles will shatter, coalesce, grow larger and repetitively collide in a complex manner through the processes just mentioned.

When the various sizes of ice particles eventually fall out of the cloud and drop below the freezing level, they begin melting. If melting is not complete, then hail, graupel or snow reaches the ground as precipitation instead of rainfall.

The varied concentration and size of all nuclei present in the atmosphere as well as their chemical and electrical properties all combine in important ways to determine how efficiently a singular cloud or cloud system produces precipitation. An extremely massive amount of water vapor can be present in the atmosphere at any given time, but precipitation will not occur if certain conditions required for the formation of precipitation are absent. This is why the SWTREA is not up flying everyday when clouds are present over the target area. There may be clouds, but certain conditions may not be present to allow precipitation formation even though the clouds overhead "look" seedable. It is important to realize that seeding a non-precipitating cloud that would otherwise remain non-precipitating in its natural state is not going to produce precipitation in a modified state. Weather modification projects are in the business of enhancing rainfall not making rainfall. The cloud must already be precipitating to some degree or exhibit the potential to precipitate before seeding can be effective.

Two cloud types produce all precipitation: "warm clouds" and "cold clouds". A warm cloud is one in which nowhere in its volume is its temperature below freezing producing ice crystals. The warm cloud is characterized most often by relatively slow growth. Cloud water droplets eventually may grow to a sufficient size and weight to fall out of the cloud if given enough time. While falling, cloud droplets collect other cloud droplets by scavenging them along their downward paths. This type of cloud often appears in Southern Texas during mid-summer months but it is not the dominant type of cloud producing precipitation here. However, large size warm-rain drops can be important embryo sources in the production of hail when they merge into the sub-freezing cold clouds and are carried aloft rapidly by updrafts whereupon they freeze and grow larger into hail.

Most important to Southern Texas is the "cold" cloud. Cold clouds have a portion of their volume that has grown into temperatures below freezing. When these clouds form, it is the interaction between the supercooled water drops and ice crystals within the cloud that initiates the process most responsible for producing significant precipitation in Southern Texas. Also, cold clouds tend to be much taller than warm clouds and, therefore, make considerably more moisture available to the eventual precipitation process developing in the cloud.

The hypothesis under which the Southwest Texas Rain Enhancement Association (SWTREA) hail suppression portion of the project operates is called "beneficial competition". The reason hailstones grow to large sizes in thunderstorms is due to the lack of sufficient numbers of IN particles while developing. That insufficiency of IN particles capable of converting to ice crystals causes relatively abundant supercooled cloud water to collect upon the relatively few numbers of ice crystals formed. Too often those ice particles grow into hailstones so large they can't melt before reaching the earth's surface. By vastly increasing the concentration of ice crystals within these ice crystal-deficient clouds, competition for available cloud water strongly increases, thereby preventing hailstones from growing to sizes large enough to damage crops and property. Hail growth and movement within storms, especially very severe ones, can be very complex. Hail damage is determined by the type of property or crop, what stage of growth the crop was in, hail size and whether or not it was wind-driven. The rain enhancement portion of the SWTREA project is also born from the theory of beneficial competition. Typically, non severe clouds contain so few IN particles that only a very small percent of available cloud water is actually converted to rain water. By vastly increasing the concentration of ice crystals with these extremely ice crystal-deficient clouds, competition for available cloud water strongly increases, thereby enhancing nature's relatively non-efficient rain production process.

The rain enhancement and hail suppression seeding agents used by the SWTREA program contain silver iodide in the formulation and are delivered into the updraft zones of growing cumulus clouds by aircraft. Silver iodide (AgI) seeding agents are combusted then vaporized by burning AgI flares and liquid AgI solution from wing tip generators and wing mounted flare racks. AgI seeding agents produce IN particles, which promote ice crystals to form through a process called heterogeneous nucleation. Heterogeneous nucleation is when ice crystal concentrations increase with respect to decreasing temperatures.

Hygroscopic flares were used during the 2002 seeding season on a limited basis during the summer as seabreeze showers entered the western target area. The primary purpose of hygroscopic flares is to increase rainfall while they are of no use for the suppression of hail according to current research. The word "hygroscopic" means water-attracting. The chemicals within a hygroscopic flare produce a particle that has an affinity for moisture. Unlike the silver iodide seeding agents, hygroscopic seeding agents enhance rainfall in warm and cold cloud environments. Silver iodide seeding agents promote additional rainfall in the cold cloud environment.

Seeding agents work within the region of the cloud called the supercooled region. Here, liquid water and solid water coexist in sub-freezing temperatures. It has even been theorized that liquid water exists at –40C but has yet to be documented in nature. Liquid water has been found at –38C in experiments conducted over Texas during the late 1990's. In the supercooled region, there are areas in which the ice crystals that do form tend to grow in characteristic shapes. The shape of the crystal is dependent upon the actual temperature of the water drop at the time the liquid converts to ice. Around –10C the habit of water drops changing to ice crystal is that it forms large ice crystals. Large ice crystals generally grow much faster than needle or column shaped smaller ice crystals. Therefore, to obtain the desired seeding effects each cloud must be treated within the proper time interval, or seeding window, to produce the optimum ice crystal concentration and size in clouds naturally deficient in them. A cloud growing to maturity must be seeded with enough time allowed so that the generated ice nuclei can be lifted by updrafts into and through that appropriate temperature and moisture regime, residing there for a sufficient time to interact with the supercooled cloud water. If the seeding window is missed when conducting rainfall enhancement, clouds may collapse prematurely resulting in a wasted effort. The residence time of a supercooled cloud volume is critical to the success of weather modification.

Convective cloud growth can be modified through a process called the "dynamic effect." If certain atmospheric conditions are met, clouds may be stimulated to grow larger and rain for longer periods than would the case if otherwise left unseeded. For the dynamic effect to be successful, a sufficient amount of seeding agent must quickly be placed into the supercooled portion of the cloud to promote the rapid conversion of cloud water droplets to ice crystals. When the seeding agent delivery is done correctly and within the seeding window of opportunity, the water-to-ice conversion process occurs rapidly. This water-to-ice conversion releases latent heat of fusion on a massive scale thus making the cloud slightly warmer and more buoyant. Also, the cloud updrafts are expected to be invigorated, thereby drawing in greater amounts of water vapor into the cloud supplying more moisture, additional growth, and rainfall. These processes cause the cloud to remain active longer and produce more rain that if left in its natural unseeded state.

The convective cloud systems listed below, and their variations, are most responsible for producing rain and hail in South Texas.

(1) the air-mass thunderstorm complex
(2) the multiple-celled thunderstorm complex
(3) the squall line

Air-mass convective storms are often seen in South Texas during the late spring and summer months. These storms are characterized by having a defined non-precipitation updraft cloud base with associated precipitation shaft. Air-mass storms typically last no longer than one hour but new growth cloud often develops in the updraft area of the parent storm. These storms are not classically known as being severe but they can become strong enough to produce small hail. Isolated air-mass storms account for roughly 40 - 50 percent of the storms seen over the SWTREA target area. Air-mass storms may merge or develop multiple cloud turrets. Once the merger takes place, storm movements can become unpredictable depending on several factors such as storm severity, storm dynamics, cloud height, variability of wind speed and direction with height, terrain effects plus the blocking and steering winds caused by cloud systems upwind. A diagram of the air-mass storm and seeding strategy is provided in figure 3.

SEEDING A TYPICAL AIR-MASS STORM

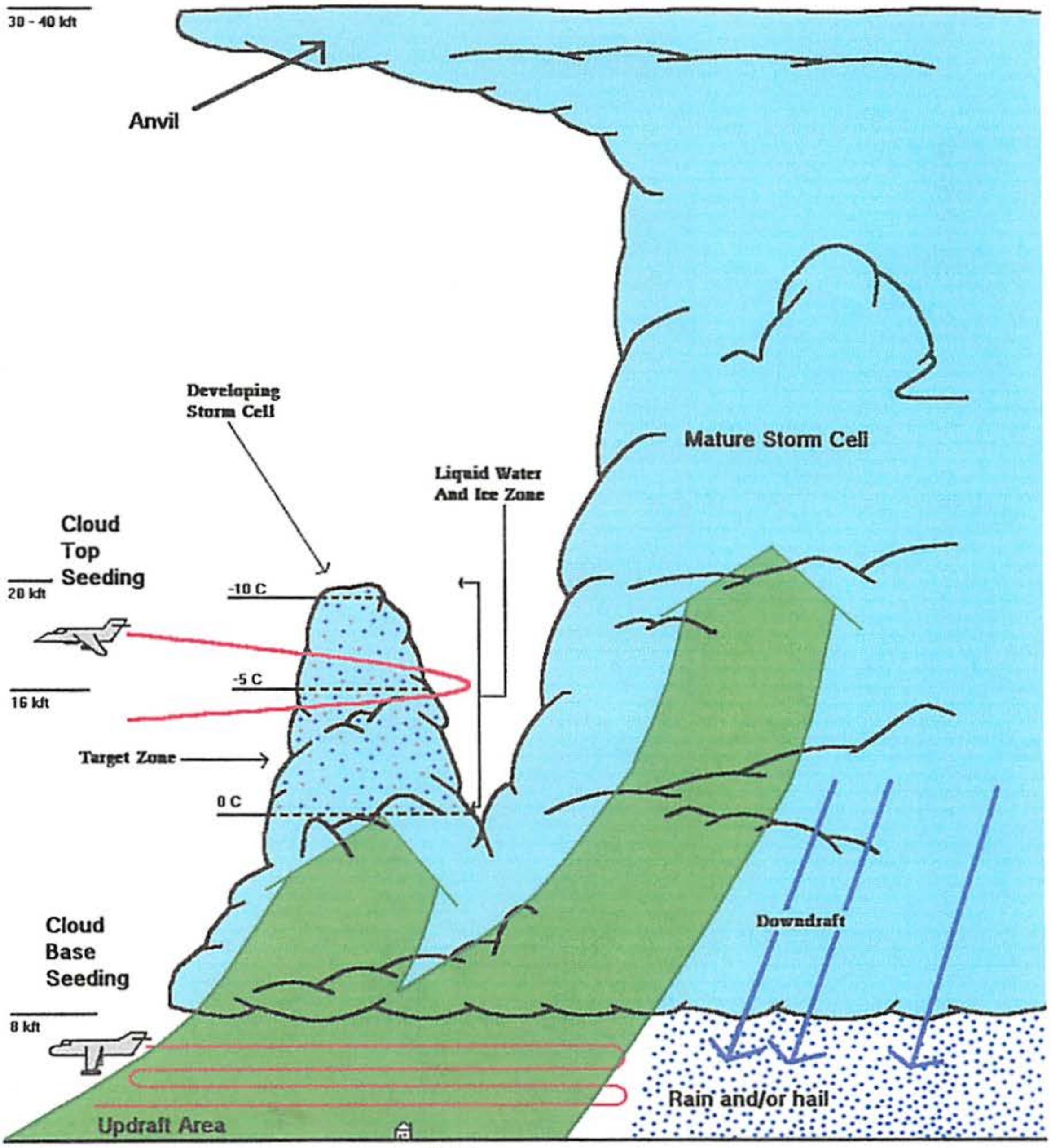


Fig. 3

Air-mass storms often develop or converge with surrounding cloud to produce multi-celled thunderstorm complexes. Typically in South Texas, the multi-celled storms develop on days when the regular air-mass storms are forecasted. The lifetime of multi-celled storms varies greatly from 45 minutes to as long as three hours. Updrafts found on both the air-mass and multi-celled storms are usually on the upwind side but in some situations can be found just about anywhere or areas not normally noted to contain updrafts in a traditional sense. Most often, updrafts pertinent to the hail process are found along the trailing edge or upwind side of the storm below cloud base at some distance behind the precipitation shaft.

Air-mass storms can transition into a line of storms containing multiple cells showing characteristics more similar to those of a squall line. During the gradual development of a squall line type system, cloud base updrafts frequently shift around although they are still found near some of the individual cell elements comprising it making seeding treatment quite difficult at times. Squall line storms are mostly seen during the spring and fall months in South Texas as they ride along cold fronts pushing south through west central Texas. They often last well into the night as they are dynamically driven unlike air-mass storms that form mostly from heating of the day. A diagram of the squall line storm and seeding strategy is provided in figure 4.

SEEDING A TYPICAL SQUALL LINE THUNDERSTORM

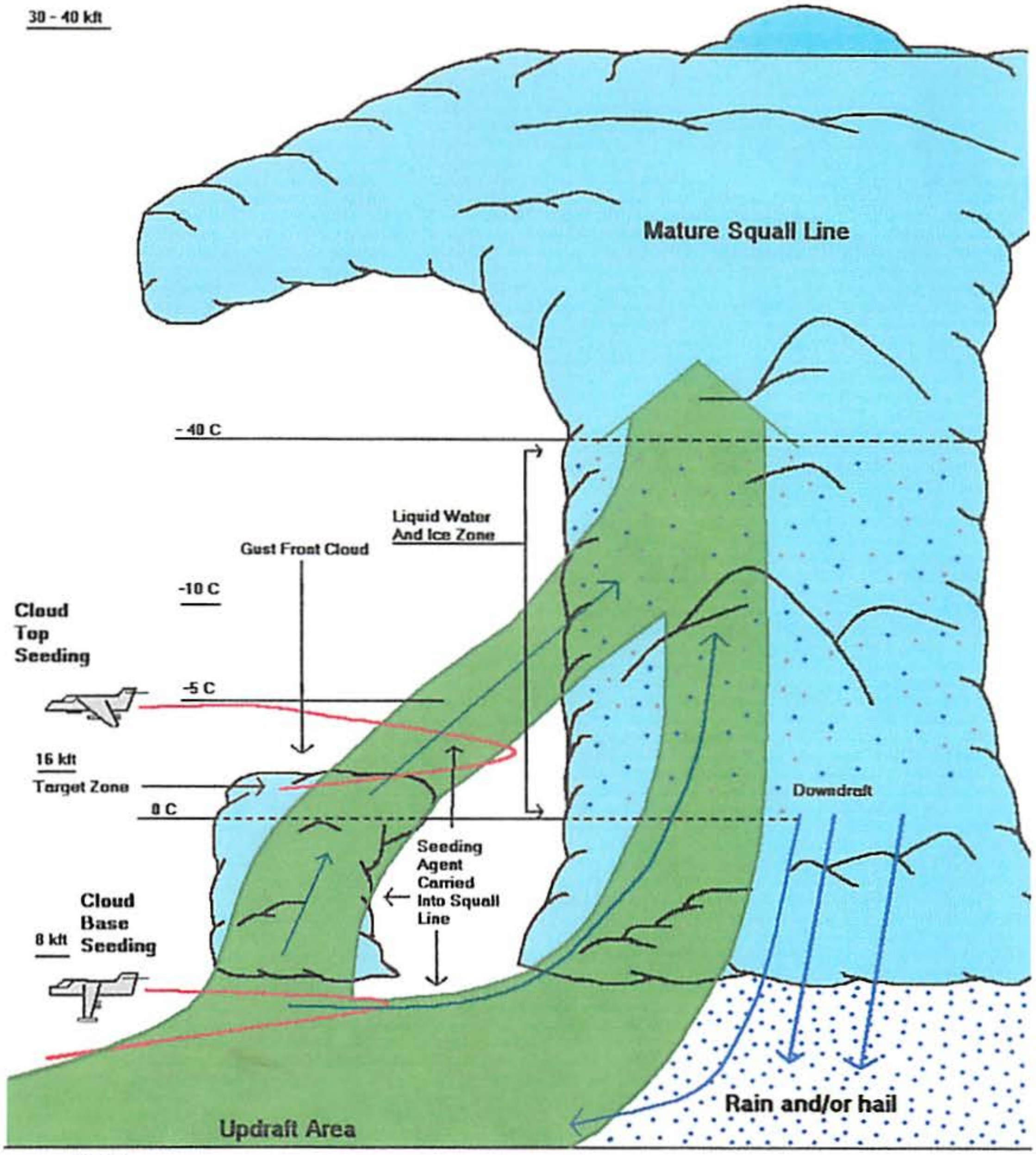


Fig. 4

Under some strong dynamical conditions, singular air-mass storms and/or multi-celled storms may become very large, developing several new growth areas at the same time with distinct cores growing embedded in and around the periphery of the cloud boundary. The dynamical conditions are high atmospheric energy, dense moisture extending from the earth's surface to some level in the atmosphere, strong winds with a change in direction with height, and a lifting force such as a cold front, dryline or intense surface heating. Once all these conditions are in place over a certain area, the ordinary air-mass storm or multi-celled storm may transition into a supercell. The supercell is without a doubt the strongest localized storm on earth exhibiting damaging hail, dangerous lightning, high winds, and torrential rainfall with possible flooding. One characteristic of a supercell is that at some point it begins to turn right and move away from the normal direction of regular clouds. The right turn is brought about as the supercell initiates a self-driving wind environment relative to the direction of the mean steering wind. Supercells can be quite dangerous to seeding aircraft as well as crops and property since hail is capable of being ejected from the cloud at long distances in all directions. Occasionally hail is ejected into the flight paths of seeding aircraft. Supercells produce the most destructive tornadoes, however, not all supercells produce tornadoes. Seeding supercell storms require close attention to detail and safety from both the meteorologist and seeding pilots when working these storms. However, seeding supercells can be safely accomplished with experienced personal even as the supercell is producing tornadoes.

A process called "convective scale interaction" is a term given to the process in which a collapsing storm produces precipitation and downdrafts which promote subsequent new cloud growth. Downdraft air, also called the gust front or outflow boundary, spreads out below the cloud base undercutting the relatively warm, moist air. If moisture is sufficient in the air being lifted above the gust front, it can rise into an unstable atmosphere and grow rapidly into another new severe storm which quickly reaches maturity. Then, that storm collapses producing a strong downdraft, thereby repeating the sequence again and again. Single outflow boundaries have been known to be strong enough to travel 100 – 300 miles, or more, from its parent storm. These outflow boundaries can be seen on satellite pictures as a semi-circular, fan shaped line of clouds known as "arc-clouds." Some of these clouds themselves can develop into large, severe convective storm systems. Single storms, multiple storms, bow-echos, and supercells all have been identified as forming along these gust fronts.

Two, or more, colliding gust fronts frequently create extremely severe storms, although the severe storms are often short lived. Severe aircraft turbulence is frequently found in the gust front air between the parent storm and the leading edge of the gust front. Ahead of the gust front, the air is generally smooth. When gust fronts drop out of high-based clouds, microburst activity occurs, which has been known to flatten buildings, crops and cause aircraft accidents during landing and take-off.

Under some conditions rainfall enhancement over large areas have been produced by seeding atop the leading edge of a gust front as air is lifted over it, which causes only weak cumuliform clouds to form. Updrafts found above gust fronts have a wide variability in updraft speeds from 100 – 500 feet per minute to a more normal 1,000 – 1,500 feet per minute, or more. If this particular condition occurs at night with little threat of hail developing from new storm growth and weak updrafts are prevalent, rainfall enhancement seeding can be highly productive over large areas using wing generators. It is likely under these conditions the dynamic effect is altered, whereas, the static seeding effect is being achieved. In such cases, seeding is altering the cloud's microphysical characteristics. It is likely that hygroscopic seeding above a gust front may also produce good results.

Another storm sequence, particularly frustrating to cloud base seeders, occurs somewhat often. This particular type of storm is often part of a line of storms and it may, or may not, have been seeded. The storm collapses sending out a large gust front, however, there remains strong, new feeder storms attached to the parent storm. While the parent had been obtaining most of the moisture from below cloud base, as the storm collapses it appears that it maintains strong feeder growth due to mid-level convergence and sufficient mid-level moisture which is present.

What makes this storm difficult to seed is that no steady updrafts can be found and what updrafts are found below cloud base are embedded in heavy turbulence along with equally sharp downdrafts. Sustained, steady updrafts are not found; however, above cloud base the feeder cells continue to grow rapidly, eventually producing precipitation cores containing property and crop damaging hail. This type of storm can only be seeded properly above cloud base with cloud-top aircraft.

III. GENERAL OPERATIONS – PROJECT DESIGN

In 1999, the SWTREA was originally designed to be an operational cloud seeding effort to enhance rainfall over participating counties in Southwestern Texas. In 2000, a hail suppression permit was obtained thus changing the seeding protocol of the project. Although the overall objective of weather modification has not changed over the past three years with the exception of the hail permit, slight design changes have been made to better accomplish the program's goals and priorities. The changes made were due mostly to technological innovations, current research and the need to conduct night operations to take advantage of significant weather systems affecting the target area during the night. During the last month of the 2000 operating season, the decision to purchase a third aircraft was made. The aircraft purchase enabled the program to address "on-top" seeding in future years but for the 2001 and 2002 seasons, the plane was used as a third cloud base seeding aircraft in our fleet. Perhaps the current and future research into on-top seeding will yield significant results into the effectiveness of cloud penetrating missions. If those research results come to fruition, it would then be worthwhile for the SWTREA to begin on-top seeding. The logistics of all the SWTREA aircraft will be presented in the aircraft chapter later in this report.

A. PROJECT ORGANIZATIONAL STRUCTURE

The Southwest Texas Rain Enhancement Association (SWTREA) was created by the signing of Interlocal Agreements with The Wintergarden Groundwater Conservation District (WGCD), City of Laredo—Webb County, Zapata County and, starting in 2002, the Edwards Aquifer Authority (Uvalde County). The Association is governed by a Board of Directors who supervises the administration and operation of the Association. Official Bylaws were adopted to authorize and govern the operation of the Association. The Board of Directors is composed of eleven members of which WGCD provides 6 and one at-large, City of Laredo—Webb County provides 2, and Zapata County provides 2. Each county represented must have one director whom must be an elected official of the entity. The Officers of the Board consisting of a Chairman, a Vice-Chairman, a Secretary, and a Treasurer serve two-year terms. Management to SWTREA is furnished by WGCD who employs a General Manager to be chief administrative officer with full authority to manage and operate the affairs of the District and the Association, subject to Board orders. The General Manager is responsible for employing all persons necessary for the proper handling of business and operation. The General Manager delegates duties to the WGCD Secretary/Bookkeeper; SWTREA Meteorologist; SWTREA Pilots and Pilot/A&P Mechanic. A diagram of the organizational structure is provided in figure 5.

B. PROJECT FUNDING STRUCTURE

Funding for the Southwest Texas Rain Enhancement Association (SWTREA) program is accomplished by assessment of funds to each of the Association's member entities on a per acre basis, shared equally by all sponsoring entities. Currently, the Association membership consists of the Wintergarden Groundwater Conservation District [(WGCD) Dimmit, LaSalle, and Zavala Counties], City of Laredo--Webb County, Zapata County, and the Edwards Aquifer Authority (Uvalde County), each of which are bound to the program via Interlocal Cooperation Agreements. Each entity enters an agreement with WGCD who serves as a political subdivision of the State of Texas and furnishes management for operations. The Texas Department of Agriculture (TDA) provides 50% match funds to the program for all expenses and purchases incurred via an interlocal agreement with WGCD, the political subdivision. A diagram of the funding structure is provided in figure 6.

SWTREA Organizational Structure

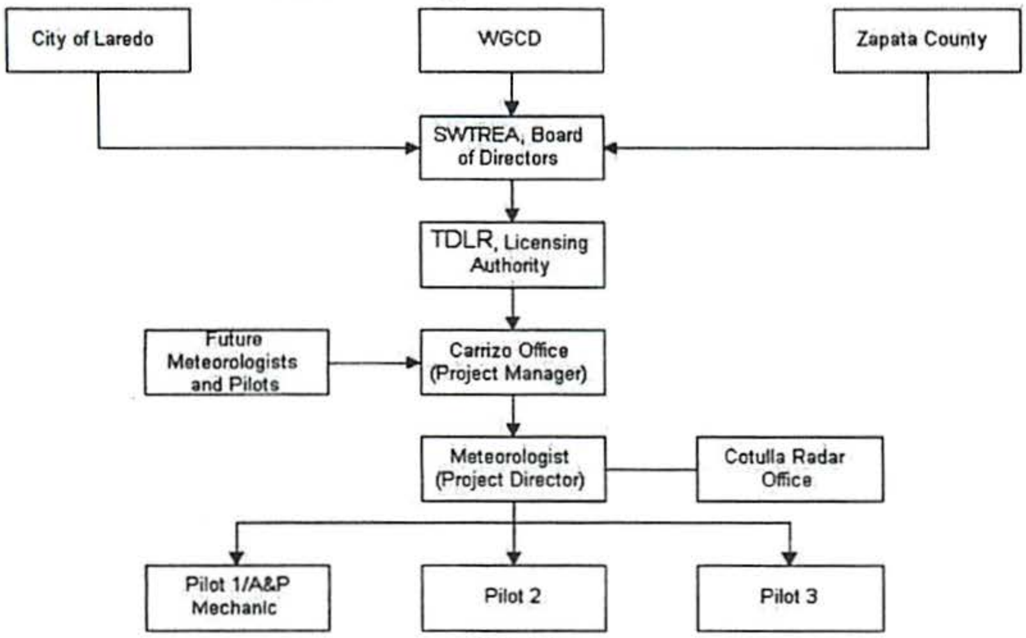
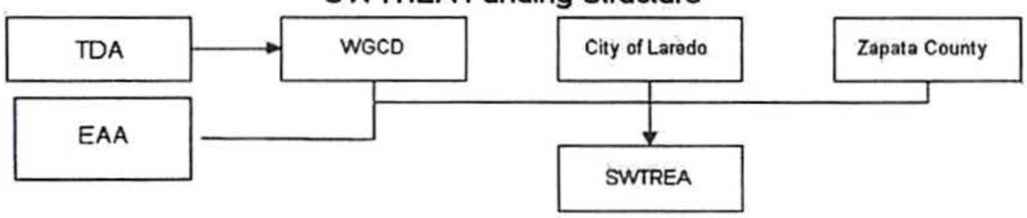


Fig. 5

Fig. 6

SWTREA Funding Structure

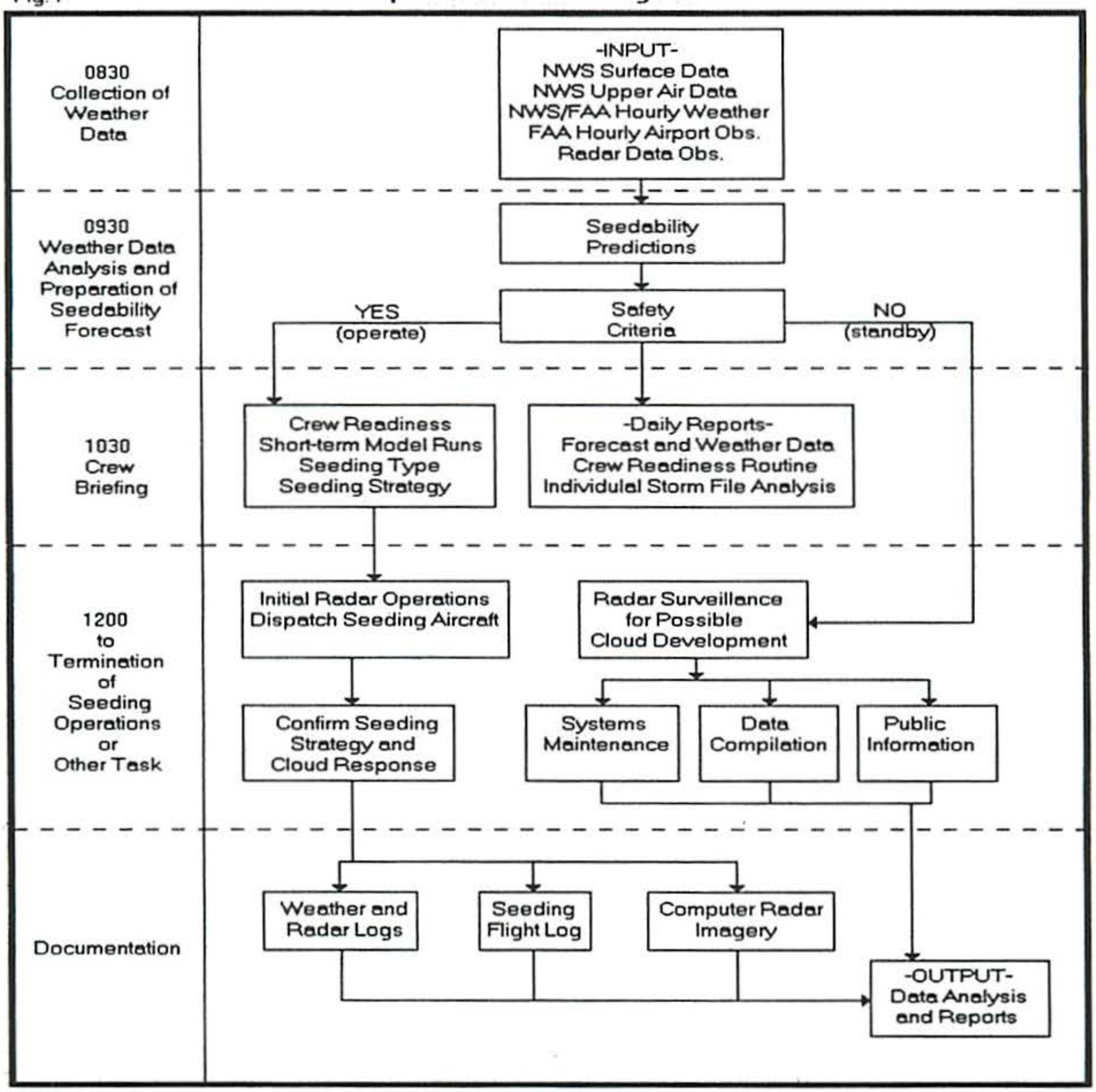


C. WEATHER FORECASTING AND DAILY OPERATIONAL PLANNING

The SWTREA project meteorologist is responsible for the preparation of daily weather forecasts concentrating on the southern region of Texas and northeast Mexico for thunderstorm potential. Early detection of a "thunderstorm environment" is essential for a successful weather modification program as the extra lead-time allows project personnel to prepare properly prior to a seeding mission. Most weather maps and information used to forecast stormy weather becomes available via the Internet during the morning hours around 8:30 a.m. to 9:00 a.m. of each day. The meteorologist analyzes the data to determine if thunderstorms will develop. After it is determined that the atmosphere is conducive to thunderstorm development, the meteorologist will determine how, when and where the first signs of storm development will begin and how long it will last. An outline of the daily operations flow diagram is shown in figure 7.

Fig. 7

Operations Flow Diagram



A major design change in weather surveillance was necessary to enable the project to address nighttime thunderstorms and seeding of those storms. The project was responsible for any and all thunderstorms that threatened the target area no matter what hour. Normally, most projects that conduct both night and day missions have two or more meteorologists who work in shifts to cover the workload. Due to SWTREA having only one meteorologist, the program was able to monitor all night storm opportunities that occurred during the season via shifts, which were set up between the meteorologist and pilots on those nights when weather was expected. Even on those nights when no weather was expected but did occur, at least one member of the staff was awake and aware of the situation. I would like to personally thank all the pilots and the WGCD secretary who aided my efforts in monitoring thunderstorm potential on the many sleepless nights we had this year. Thank you.

Not enough can be said about the growth and dominance of the Internet in providing weather information. The early 1990's marked an explosion for Internet weather products available to both the general public and scientific people. Almost all meteorological information used by the SWTREA comes from the National Weather Service, Storm Prediction Center, University Centers for Atmospheric Research, and many university and public sites via the Internet.

A small host of various media weather products are also very useful to the SWTREA. One media company almost all of us are familiar with is The Weather Channel. The Weather Channel is probably the most viewed channel on television by weather modification personnel. TWC usually does a good job of providing accurate 24-hour-a-day non-stop weather information in the form of regional radar, satellite images, forecasts and immediate information concerning severe weather. However, it should be noted that a radar image displayed on TWC is generally fifteen minutes old. TWC is monitored by SWTREA personnel at home or in other places, but is not at the Cotulla office because cable is not available at the airport. SWTREA personnel also periodically view local television networks for weather information. The Cotulla office utilizes the most powerful Internet-based weather information service available called WeatherTap. WeatherTap is also the primary source for radar images used by all project personnel during pre-operational weather surveillance on nights when weather is expected in the area. WeatherTap provides a variety of important information such as current NEXRAD data for any National Weather Service radar site, satellite and lightning data from around the United States, forecasts, current local observations, aviation weather data, immediate severe weather data and other data. Most of the data provided by WeatherTap is also available in a looping sequence.

D. RADAR SURVEILLANCE AND DISPLAYS

For cloud seeding operations within the target area, a 5cm C-band weather surveillance radar was employed. The radar is located at the SWTREA field office at La Salle County Airport near Cotulla. The digitized system incorporated both a Plan Position Indicator display (PPI) and Range Height Indicator (RHI). The radar has a cloud echo sampling range of 118 nautical miles in a full 360 degree volume scan with receiver sensitivity sufficient to provide a detectable signal with precipitation rates of 1mm/hour at 70 nautical miles. A full volume-scan for echo sampling in 3-D takes roughly 3 minutes at 4 RPM.

The radar system includes two software programs RDAS (Radar Data Acquisition System) and TITAN (Thunderstorm Identification, Tracking, Analysis and Now-Casting). Developed by a group in South Africa with inputs from the National Center for Atmospheric Research in Boulder, Colorado, these computer programs collect, analyze and display up to ten different radar data in real-time, as well as perform and record many functions which are useful for post-analysis of seeding operations. These functions include vertical cross section of any portion of the storm, radar estimated precipitation for 1hr or 24hr intervals, storm reflectivity, Vertically Integrated Liquid (VIL), VIL density, storm movement and a long list of other parameters useful for subsequent evaluations.

Another powerful tool incorporated into the TITAN and RDAS systems is an aircraft tracking device labeled by SWTREA personal as the "black box". This aircraft tracking technology is relatively new as it was developed only a couple of years ago. An electronic specialist from South Africa also developed the black box devices for both the operations office and the seeding aircraft. The black box allows the meteorologist to monitor aircraft positions with respect to storm location as well as distance and radial measurements from the Cotulla field office. The information from the tracking system is overlaid directly onto the operational radar computer screen used for seeding operations. The tracking systems transmit GPS data, as well as time and place of seeding material release. Weather radar incorporating the RDAS and TITAN systems is the most advanced weather monitoring/aircraft tracking system available today for cloud seeding.

Radar observations of cloud motions were used to direct and re-direct all seeding operations. After being directed to the cloud or weather system intended for rain enhancement or hail suppression, pilots aid in the determination of seedability by visually identifying general cloud characteristics and storm severity. Within complex rapidly changing storm systems and/or nighttime operations, weather radar was indispensable in providing assistance to pilots while identifying the preferred seeding areas and dispensing the nucleating material at the proper time and location. Weather radar might best be described as the "big eye in the sky" for seeding operations.

E. NUCLEI DISPENSING SYSTEMS

Two primary systems of dispensing ice nuclei compositions are a part of the SWTREA inventory along with another under consideration in future years.

(1) Burn-In-Place Pyrotechnic Device (BIP)
(2) Airborne Liquid Fuel Generators (ALFG)
(3) ***Under consideration*** – Ejectable Pyrotechnic Seeding Device (EJEC)

The Texas Weather Modification Association (TWMA) has pioneered and developed various airborne systems for dispensing silver iodide ice nuclei compositions throughout the state of Texas and elsewhere. The state association has made new improvements in the last three years with the development of advanced seeding agent formulations as well. The following is a description of both the delivery mechanisms.

Burn-In-Place Pyrotechnic Device (BIP)

Each SWTREA cloud seeding aircraft is equipped with two special wing racks that accommodate a total of 24 or 48 BIP units. The devices each contain forty and eighty grams of effective silver iodide or sodium iodide consumed in about one minute.

They are chosen for use whenever confined strong inflows are identified and high rates of silver iodide or sodium iodide are required as the priority seeding method. The units are electronically ignited from a control console within the aircraft cabin. The only downfall of BIP seeding is that a rather small supply of BIP's are available for any particular seeding mission and the pilot must land often to reload BIP units on severe weather days. The SWTREA currently uses the "RS-3" silver iodide and "SF1" sodium iodide BIP manufactured by the TWMA in San Angelo. The RS-3 is probably the state-of-the-art in BIP's. Unlike most BIP units manufactured elsewhere, the RS-3 is able to convert all of the silver iodide to ice nuclei in less than two minutes when other BIP formulations convert to all ice nuclei in ten minutes. This is a tremendous advantage in that seeding effects are realized much faster and the seeding window of opportunity is lengthened. The SF1 is a brand new experimental salt flare used for hygroscopic research on our program this year. A picture of the BIP unit is displayed in Fig. 8.

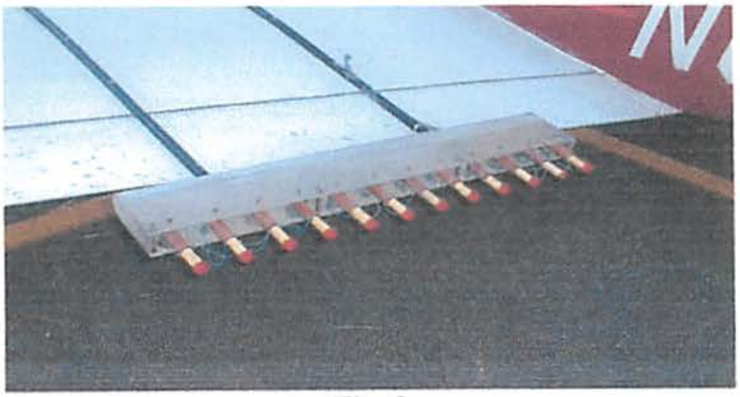


Fig. 8

Airborne Liquid Fuel Generators (ALFG)

Each SWTREA cloud seeding aircraft is equipped with two wing-tip ALFG's. These devices are composed of an air-tank containing nitrogen, liquid tank containing the silver iodide solution and a combustion chamber. The nitrogen is used to compress the liquid silver iodide solution within the liquid tank so that the solution may be forced through a small aperture in the combustion chamber and combusted into usable silver iodide ice nuclei. The ALFG can hold roughly 6.5 gallons of liquid solution and is expelled through the aperture at a rate of 2.5 gallons per hour to produce 6.25 grams of usable silver iodide ice nuclei per minute. The seeding aircraft is able to burn the ALFG's for just under 3 hours continuously at a liquid tank compression of 40 psi.

Fig. 9

During the 2002 operating season, the SWTREA continued using a formulation of liquid silver iodide seeding agent from GFS chemical company in Ohio. The GFS composition is delivered from the company already in liquid solution. Thus, no mixing is required by the user and it has been observed that the "pre-mixed" solution burns much more cleanly and efficiently. However, cleaning of the combustion chamber is required after every seeding day so that the ALFG will work properly for the next seeding mission. ALFG seeding is the preferred method on clouds with weaker updrafts around 100 – 500 feet per minute. The use of ALFG's is also valuable in that a pilot is able to stay on a storm longer then using BIP's alone where the pilot must return to the airport to reload BIP's more frequently. A picture of the ALFG unit is displayed in Fig. 9.

Ejectable Pyrotechnic Seeding Device (EJEC)

Although the SWTREA is currently not using EJEC's on any of the seeding aircraft, the Cessna 340 aircraft will likely be equipped to utilize this seeding method in the future. The EJEC is composed of a special fuselage-mounted rack for holding the ejectable seeding units. The EJEC rack can be fitted to handle 40 – 200 ejectables, each unit having a burn time of 30 seconds and 60 seconds for the 10-gram and 20-gram units respectively. In order to utilize the EJEC's for cloud seeding, the aircraft must be capable of being able to seed clouds "on-top". On-top seeding is not new to weather modification, but takes specially trained personnel with a complete understanding of cloud processes before seeding can safely be accomplished. On-top seeding requires that the aircraft penetrate the feeder cells of a thunderstorm complex to judge the amount of liquid water available. This is especially difficult in it that it requires Instrument Flight (IFR) rather than Visual Flight (VFR) and a pilot well trained in understanding the information displayed on the aircraft radar system. On-top seeding is more dangerous than base seeding but can be accomplished safely with experienced pilots. The SWTREA is considering on-top seeding in the future.

F. CLOUD SEEDING AIRCRAFT

The cloud base seeding aircraft type used in 2002 were:

1-single-engine Piper Aircraft Comanche, PA24-250 (Fig. 10)

1-single-engine Piper Aircraft Comanche, PA24-260

1-twin-engine Cessna Aircraft Cessna 340 (Fig. 11)

The Piper Comanche Aircraft has been a cloud-base aircraft of choice for many weather modification projects around the United States. One big advantage of the aircraft is that it is far more economical over its weather modification rival the Cessna 340. For the purpose of cloud-base seeding, the Comanche performs very well and has the proven track record it its ability to handle the tasks at hand.

Fig. 10

The twin-engine Cessna 340 has become a popular seeding aircraft used on many of the projects in Texas. Although the SWTREA currently uses the plane as a cloud base seeder, the main benefit of the plane is realized when applied to cloud top missions. Because of the pressurized cabin and onboard radar, the aircraft becomes a plane of choice for higher altitude cloud-top storm penetrating missions utilizing ejectable flares.

Fig. 11

All aircraft are equipped with Global Positioning System (GPS) units which allow pilots and meteorologists to precisely reference distance and direction from the radar site. The GPS system is coupled with a telemetry/tracking device that transmits critical information every four seconds to the field office such as GPS coordinates transposed onto the office radar as well as event locations and times for flare and liquid generator usage and aircraft airspeed. The telemetry/tracking device also records the above data onto a memory card labeled by SWTREA employees at the "black box". In the event of lost radio communications with the radar field office, all data contained on the black box is available for retrieval once the aircraft has completed a seeding mission.

All cloud base planes are equipped with 12-position or 24-position, stainless steel wing racks mounted to the trailing edges of the wings, which hold the flares in place as they burn in place to a stub.

The design of the SWTREA is similar to other seeding programs of its kind. The meteorologist makes the decision to launch aircraft, then guides the pilots to the desired seeding positions during operations. Once a pilot arrives at a storm, he confers with the meteorologist and a seeding decision is made. Unless an aircraft runs into emergencies, runs out of seeding agent or is low on fuel, flight termination decisions are made by the meteorologist. SWTREA pilots are trained personnel and most obtain a complete season of seeding experience as a co-pilot prior to flying as pilot-in-command. Communications and teamwork must work well in order for the SWTREA to operate effectively and be successful.

G. COMMUNICATIONS

SWTREA considers a strong and reliable communications network one of the most important components of its weather modification program. For the purposes of communications between pilots and the meteorologist, a dual channel Icom amplified base station is used at the radar office with King dual channel aviation radios used in the seeding aircraft. SWTREA is licensed for two frequencies under FCC regulations for operation of the base station and aircraft radios.

The primary voice frequency used by the program is UHF 122.925 MHz. A backup frequency UHF 122.850 MHz is also used on occasions. Communications systems are used on the project to coordinate radar operations and aircraft seeding flights. Cell phones are also used for communication with pilots prior to seeding missions and forecasts. Interested parties may listen in to the operations with scanners or aircraft band radios.

Equipment has been bought to increase our communications coverage to allow for extended distance coverage beyond our current range. On occasions, communications is lost due to low flight altitudes and/or seeding distant storms beyond our target area. Repositioning of radio equipment at the radar site greatly increased communication range during the 2002 season to cover most of the target area without interruption, even with the increase in the target area.

Much discussion has come about concerning the use of FM radio communications instead of the standard UHF communications used by most weather modification projects in Texas. The SWTREA target area is configured in a rather non-symmetric fashion. The target area runs 151 nautical miles in a north-south fashion and only 76 nautical miles east-west. This configuration is somewhat cumbersome in terms of communication feasibility for a weather modification project. In the hypothetical world, one would much rather have target areas as symmetrical as possible with equal radio signal strength in any direction from the field office. With the installation of the new communications equipment for the 2002 season, the project has sufficient radio coverage for the current target area. However, communications will become a significant issue if any county on the southern or northern boundaries of the current target area wishes to become part of our project. In the event that another county in those said areas wishes to become a part of the project, the use of FM radio communications and a repeater network will become necessary. The SWTREA has already made some unofficial plans for such an action if it should take place.

H. ADMINISTRATIVE AND PUBLIC RELATIONS

There is a continuous stream of paperwork and documentation, which needs to be dealt with during the seeding season. Forecasts are distributed via email to interested parties on a daily basis. Detailed individual seeding reports and climate outlooks are also disseminated on an as needed basis. Monthly summaries are compiled and sent to the TDA and to the head SWTREA office in Carrizo Springs to satisfy their requirements. An initial report and final yearly seeding summary is sent in at the end of the season to the National Oceanic and Atmospheric Administration (NOAA) as well as this final report available to the board of directors and the public at the end of each seeding season. From time to time there are numerous other responses needed, answering public inquiries, researching data, and the large volume of phone calls to the field office during seeding events.

Public relations provide a valuable contribution to this program, long-term. Without the continuing effort to maintain favorable public attention, we run the risk of marginalizing our program. Occasionally, newly elected officials serving as commissioners may not be as well acquainted with our program or its results as some of their predecessors. In order to ensure that the current participating counties feel justified in continuing to support the program, some periodic educational effort is necessary. Typically, most of the public relations efforts are directed toward individuals and groups visiting the radar site and our remote aircraft locations. School classes for some of the group visitations as well as periodic presentations to service organizations and other groups with are spoken to at regularly scheduled meetings or annual meetings. Public relations is one of the top priorities of the SWTREA. The program is always happy and willing to speak at public functions or simply answer questions over the phone. Interested parties can also find program information and real-time radar images on our web page: http://swtrea.tripod.com.

IV. OPERATIONAL SUMMARY - 2002

A. MONTHLY WEATHER AND SEEDING OPERATIONS

March 2002: The 2002 project year started off quietly on the 15th under high pressure. The first, and only, seeding missions for this month came on the 19th, with a spring cold front pushing through the area. Severe weather was reported north of the target area, but no official reports were received inside the target area. Storms stayed in the northern counties as the front progressed southward. High pressure built in behind the front and held down any chances for precip until the 29th/30th. Overnight another cold front pushed through. Since it passed at night, the precipitation was small and weak. The only showers that entered the target area had built up on the mountains in Mexico, and were on their final collapse as they crossed the Rio Grande. Recon flights were flown on these, in case new development occurred, but none such developed.

April 2002: The month of April was a quiet month, unusually strong spring high pressure controlled most of south Texas. A cold front was able to sneak underneath the high and spark some thunderstorms on the 7th. This front quickly retreated back to the north on the 8th. An upper level low was able to dislodge the high from the 14th to the 16th. Some showers were able to develop on the dryline late in the day, but would start to weaken as the sun went down. Storms would also develop on the mountains in Mexico and make a run toward the Rio Grande. The storms that did cross were already quickly weakening. Flights were flown on any new development around these showers. After the 16th, the high pressure built right back into place. This high was as strong as high pressure normally gets in August, with temperatures around south Texas approaching 110 degrees for the last full week of April.

May 2002: May was a normal month in terms of precipitation. But it started as April ended: hot and dry. The high was still in place, but was starting to move. A cold front moved into Texas on the 2nd and stalled from Del Rio to San Antonio. While normally this would be a good setup for rain, it didn't pan out. All precipitation that formed north of the target area and was blown northeastward by the upper level winds. This situation continued until the front retreated late on the 4th. High pressure again rebuilt overhead and stayed until the 9th. The high was then pushed eastward, allowing the dryline from the Panhandle to try to enter from the northwest. The storms reached into Kinney County before stalling and dissipating. The high pressure made a repeat performance until the 13th, when a cold front pushed through the target area during the early morning. Since it went through during the night and early morning, no heat driven convection was firing, thus it went through quietly. A few convective showers developed in the moist air behind the front, but were weak and fairly short-lived. Behind this, high pressure stayed away, allowing for surface moisture to increase substantially. On the 16th, the west Texas dryline got a strong push from an upper level system and was able to cross the target area with widespread showers and thunderstorms right around midnight. With four seeding flights within 4 hours time, this was the busiest day for seeding. The next day, a cold front, also associated with the upper level low, pushed through the target area. Storms were active in the northern target area, while at the same time, seabreeze thunderstorms developed in the southern target area. These storms were able to stay active until heating of the day ceased and the storm's main energy source was cut off. After this front pushed off the coast, high pressure again built over Texas, keeping skies clear and the atmosphere dry. The last week of May was dominated by an upper low that meandered from the four corners area across Texas, finally stalling in Louisiana. This low would have small impulses that would rotate around it into south Texas. Every 24-36 hours, an impulse would rotate across the mountains in Mexico and help carry thunderstorms farther into Texas than usual, or it would interact with the plentiful moisture and spark an isolated thundershower. Any showers that did develop during this time were fairly weak, but had enough inflow into the storm for seeding to occur. These storms would race toward the east and northeast with the upper wind flow.

June 2002: June is normally the second wettest month, right behind May. I've noticed in the last few years that most of this seems to happen during the last week of the month. This year was no exception.

The first precipitation came off the mountains in Mexico on the 4th and 5th. The storm on the fourth wasn't strong, although the storms on the 5th left large amounts of rain for Uvalde County. A cold front pushed through the area on the 6th, with large areas of thunderstorms for the area. These thunderstorms pushed southward out of the area around midnight. Leftover moisture and an old outflow boundary sparked a couple small showers the next day, but these were short-lived. High pressure resumed for a week until the next front arrived on the 14th. Thundershowers initially developed on a prefrontal outflow boundary, but this boundary moved too far ahead of the front and it's main energy source. The main front pushed into the target area just before sunset, bringing with it another round of thundershowers. As the sun set, these cells lost energy and were unable to hold together. High pressure set up for the next 10 days, with only a brief seabreeze shower on the 22nd. Seeding was conducted on it briefly. Then the last week arrived. Another upper level low became cutoff from the main jet stream flow and drifted along the Gulf Coast between New Orleans and Houston. The low started drifting westward toward south Texas, bringing along mid and upper level moisture and lift. This combined with surface moisture and daily heating to spark bands of thundershowers. On the 26th, the band set up north/south roughly from Uvalde to Laredo. On the 27th, a band moved in from the north, while another band developed from Carrizo Springs to Cotulla. Both of these lines moved southeastward. The 28th through the 30th saw larger, more isolated cells drifting indiscriminately through the target area as the low got closer to the target area and upper winds died off.

July 2002: July 2002 will go down in history as one of the wettest ever, and will not be soon forgotten. The upper level low pressure area stalled right over south Texas on the first. Southeast winds added more Gulf of Mexico moisture to the area, while the upper low helped pull moisture from a hurricane in the Eastern Pacific into the mid and upper levels. This led to a widely saturated atmosphere and an abundance of rainfall for the first week. Seeding flights were flown during this time, but became much fewer as flash flood warnings became more widespread as the ground quickly became more and more saturated. Some counties were in warnings for more than 48 hours straight. This continued through the 6th, until another upper low around the Four Corners region helped push it eastward. After this 10 day "event" finally concluded, rainfall measurements over most of the region were 8-15 inches, with some reports over 30 inches. Rivers rose past flood stage for more than a month as upstream water filtered through. Another flooding event happened on the weekend of the 14th. Another upper level low stalled in Texas, while at the surface, a frontal boundary stalled right ver south Texas. Showers and thunderstorms would form on the front, then train along it, giving places along and near the front more flooding rains in a short amount of time. The upper low drifted to the northeast on the 16th, starting a drying out trend. Strong high pressure developed by the 19th, which pushed the next few storm systems well to the north, allowing for some of the previous flooding to recede. This lasted through the end of the month, with only a couple seabreeze seeding flights on the 29th.

August 2002: August 2001 was an unusually moist month. August 2002 was much closer to what a normal August should be like compared to last year. The 4th and 5th saw seabreeze showers develop on the coastal plains and move into the Rio Grande Plains during the evening. A couple flights were flown on the these days. On the 8th-10th, the remnants of Tropical Storm Bertha aided in enhancing the seabreeze boundaries and other outflow boundaries that moved in from storms in the Panhandle. Five flights were operated these days. After these subsided, strong upper level high pressure developed over Texas, completely shutting down all seabreeze activities and resuming hot conditions for Texas. On the 29th and 31st, the high started to break down, allowing a few seabreeze showers to again develop, thus ending the dog days of summer.

September 2002: The conditions for September could be summarized in one word: Fay. Tropical Storm Fay formed in the Gulf of Mexico from the remnants of an upper level low that moved out of Mexico couple days earlier. It had nothing to give a nudge in any one direction, so it drifted for a couple days, then started to slowly drift westward. It made landfall just north of Corpus Christi on the 7th. The remnants of the center proceeded slowly up I-37 to Pleasanton, then drifted southwestward to a point just north of Cotulla, where it sat for a day, then moved down I-35 through Laredo into Mexico on the 10th. All during this time, it dropped excessive amounts of rainfall of 10-

15 inches. A couple seeding flights were done early on the 4th and 5th, before flash flooding became widespread and stopped all seeding attempts. High pressure built in for a couple days, before a frontal boundary/dry line came through the area on the 14-15th and again on the 19th. These went through quickly, with some flights on each of these. After the 19th, upper level high pressure built in. This was fortunate as 2 major hurricanes developed in the Caribbean Sea and followed similar paths into Louisiana. The high pressure helped deflect these storms away from Texas.

October 2002: This October was the second wettest October ever for the state of Texas, trailing only October 1919. The southern branch of the Jet Stream set up right over southern Texas. The first half of the month saw strong areas of low pressure at upper levels move from the four corners region through the Texas Panhandle every 3-4 days. These would drag a surface frontal boundary into south Texas. These fronts would stall and spark showers at regular intervals as moisture crossed from the Pacific into the state. Flights on these fronts were conducted on the 5th, 7th, 8th, and 9th, before flash flood warnings became commonplace and precluded us from seeding. The second half of the month signaled a definite beginning to the autumn season. The jet stream already in place over Texas grew even stronger. This brought more Pacific moisture into Texas. Frontal boundaries continued to move through Texas, except now they were stronger and would push into Mexico instead of stalling in Texas. These fronts would stall in Texas and set up overrunning precipitation. This overrunning stratus rainfall event covered all of the southern half of Texas, contributing even more to the flooding problems from earlier in the summer. Two flights were attempted during this time to see if any smaller areas were seedable. These were done on the 21st and 22nd. Conditions were marginal at best, with almost all convection confined along the front in Mexico.

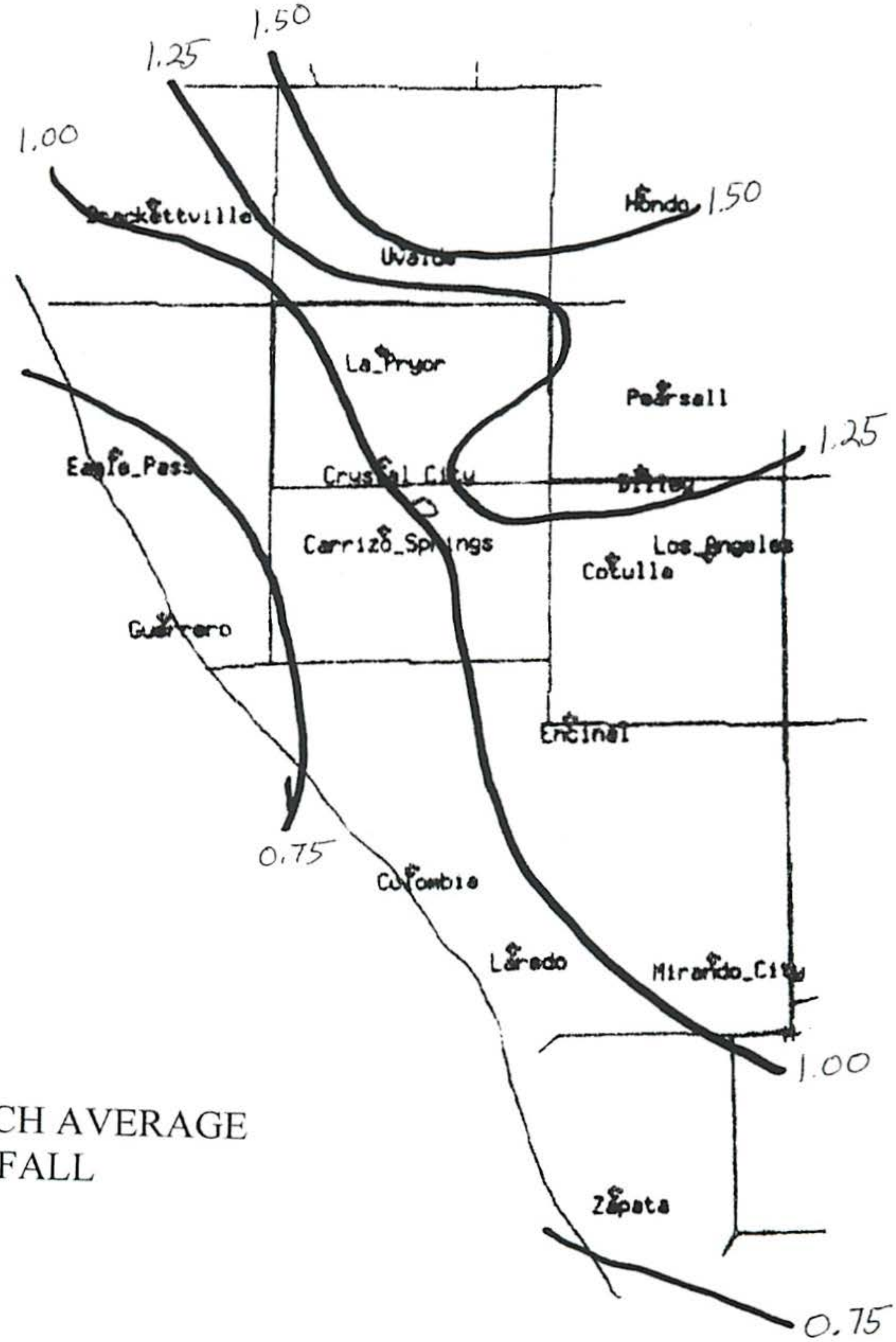
November 2002: October and November were complete opposites this year. The first few days of November continued the soggy and drizzly conditions of October, but that ended abruptly overnight on the 4th. A strong early-winter cold front barreled through Texas, pushing all atmospheric moisture well out to sea. Cold high pressure behind this kept skies completely sunny and the air very arid. Every 4-5 days after this, another cold front would move through Texas. With very weak southerly winds before the fronts, moisture was not able to return across Texas. This kept precipitation from forming as fronts would move through. This continued through the end of the project on the 15th. No seeding flights were flown during this month.

V. SWTREA TARGET AREA 30 YR AVG. RAINFALL DISTRIBUTION MAPS

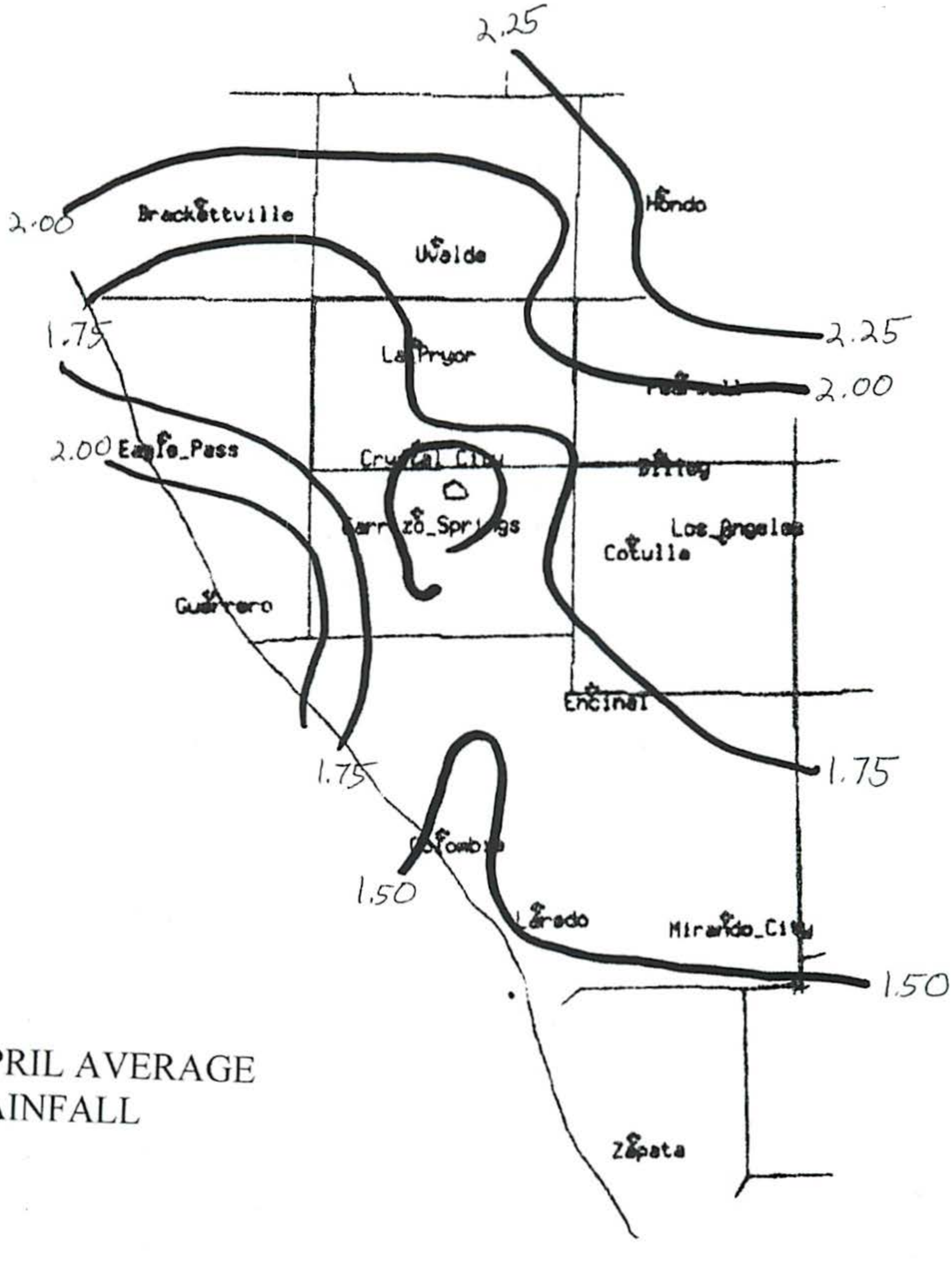
The following set of maps shows the 30-year average rainfall distribution of the SWTREA target area. The contours are in intervals of 1/4 of an inch. A word of caution must be passed forth to the reader. Although the maps are historically accurate for the area, they may not represent the actual amount of rainfall received at any particular location. In other words, each map shows an average rainfall over an entire month, not rainfall over one particular day specific to any one particular location. The maps do not indicate areas where localized flooding occurred for one month either.

The maps clearly indicate a very sharp contrast in rainfall over the target area. Historically, the eastern half of the target area has received more rainfall over the years than the western half. The author believes there are a few meteorological reasons for the difference. One could very reasonably argue that the "sea breeze" during the summer months is the largest culprit for the contrast between the eastern half and the western half of the target area. The sea breeze moves west during the daylight hours. The sea breeze is driven by the sun's energy imparted to the earth's surface and ocean. Why doesn't it continue on through the target area during the day? Generally, the sea breeze begins to enter the eastern portion of the target area (La Salle and Webb Counties) during the late afternoon and early evening hours. Storms develop or already have developed once it moves into the area. As the westward track continues, the sea breeze begins to loose energy and eventually starts to move back east as a "land breeze". Once it moves back east, the lifting forces and energy created by the sea breeze are lost and the storms dissipate. Most of the time, the sea breeze never makes it to the western portion of the target area (Zavala, Dimmit, Zapata, and Uvalde Counties) because those counties in the western half are too far away from the Gulf of Mexico. In other words, by the time the sea breeze and associated storms move into the western half of the target area, the sun is setting or about ready to set so the storms begin to dissipate. It is as if the change in direction occurs precisely on a north-south line at about the La Salle/Dimmit County line.

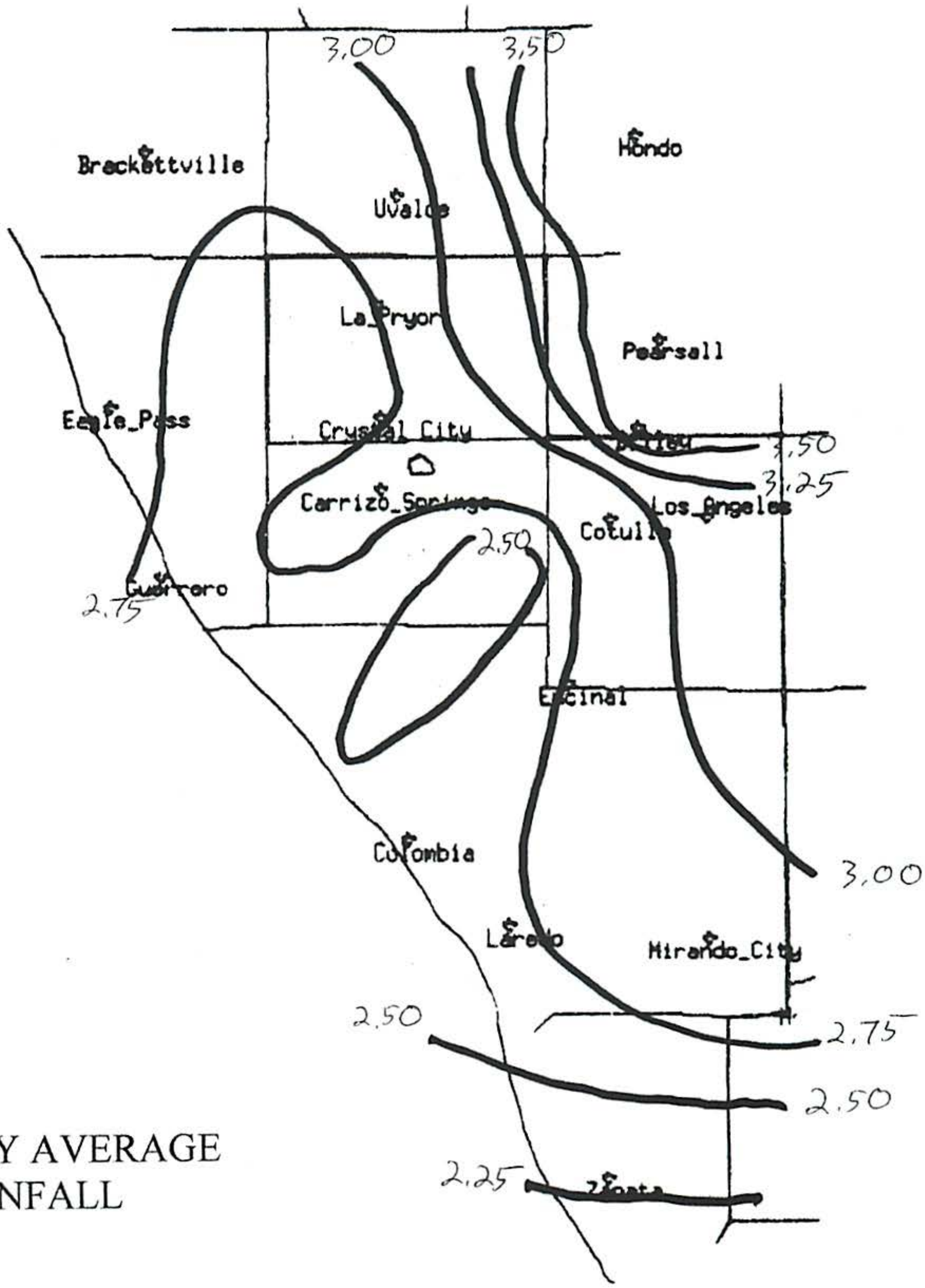
There is also a large difference in rainfall distribution over the northern portion of the target area (Zavala, Dimmit and La Salle Counties) and the southern portion (Webb and Zapata Counties) of the target area. Historically, the northern half of the target area receives more rainfall than the southern half. The difference generally occurs during the months of March, April, May, June, October and November. To a large extent, the months indicated are about the only time south Texas receives any affects from cold fronts or drylines. Indeed cold fronts and drylines can push trough the area "any" time, but the powerful ones generally come through during certain times of the year (spring and fall). As was the case this year, a cold front would begin moving south and stall out just north of the target area. Although the front never made it into the target area, storms still develop along it and move south. Unfortunately, cold front generated storms cannot continue to survive once they move far enough away from the front, they simply lose the dynamical forces the cold front provides to sustain them. We had quite a few instances this year where the cold front would stall north of the area. Storms would develop right along the front and move south but dissipate over Uvalde County as they had reached a distance too far from the front to receive frontal energy. However, not all thunderstorms dissipate when they move too far away from a front. Small or medium size storms generally dissipate at a given distance, but large storms like a supercell or a multi-celled thunderstorm may continue south for a hundred miles as they are not dependent on energy from a front to sustain them once they have reached maturity. We have also seen many large storms move all the way south through the target area this year once they were generated from a front well to the north. Also, the entire target area generally receives more rainfall during the spring and fall but not during the winter and summer. This is typically the case for most of the middle United States because of extreme localized temperature variations and stronger warm or cold frontal activity during these months.



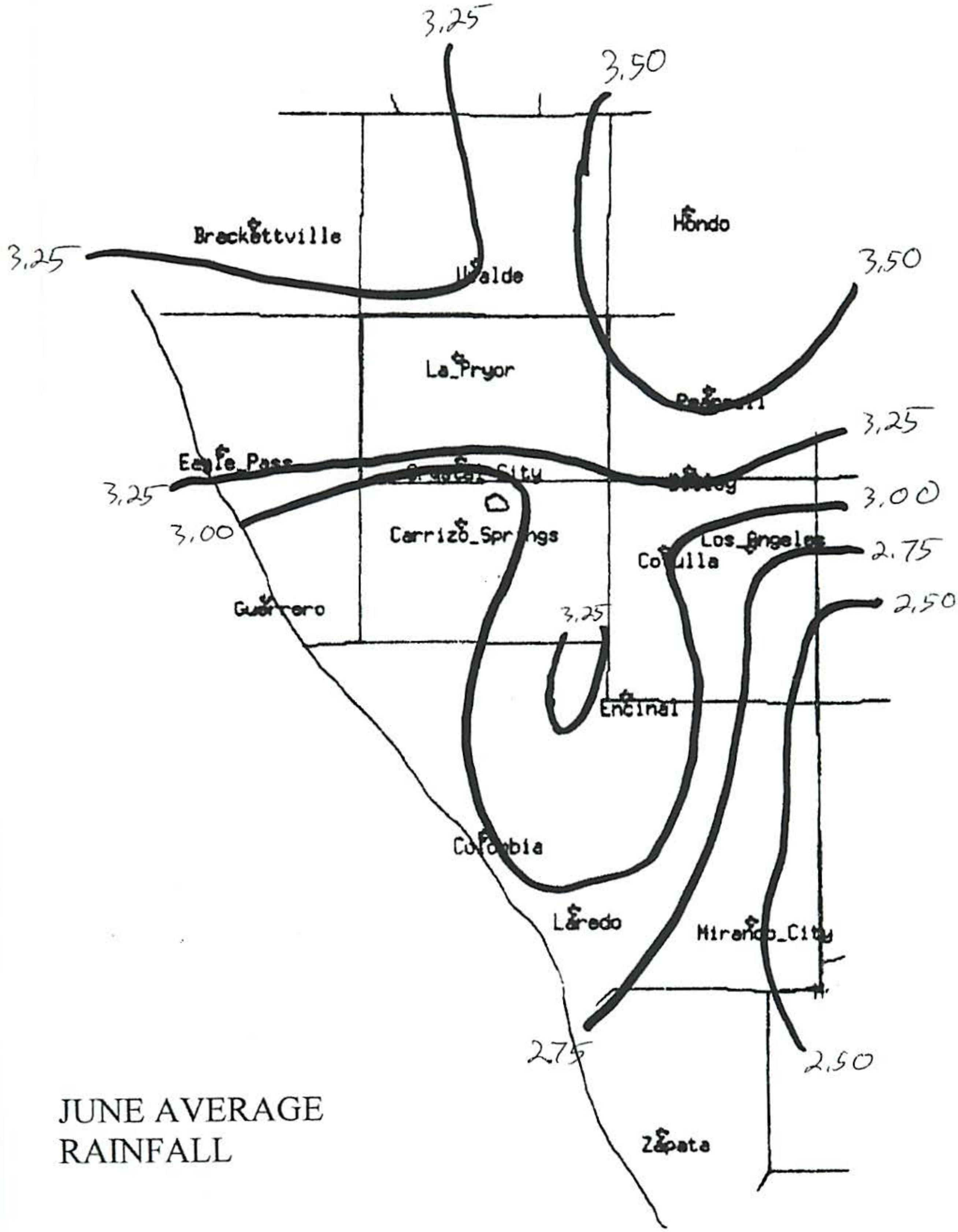
MARCH AVERAGE
RAINFALL



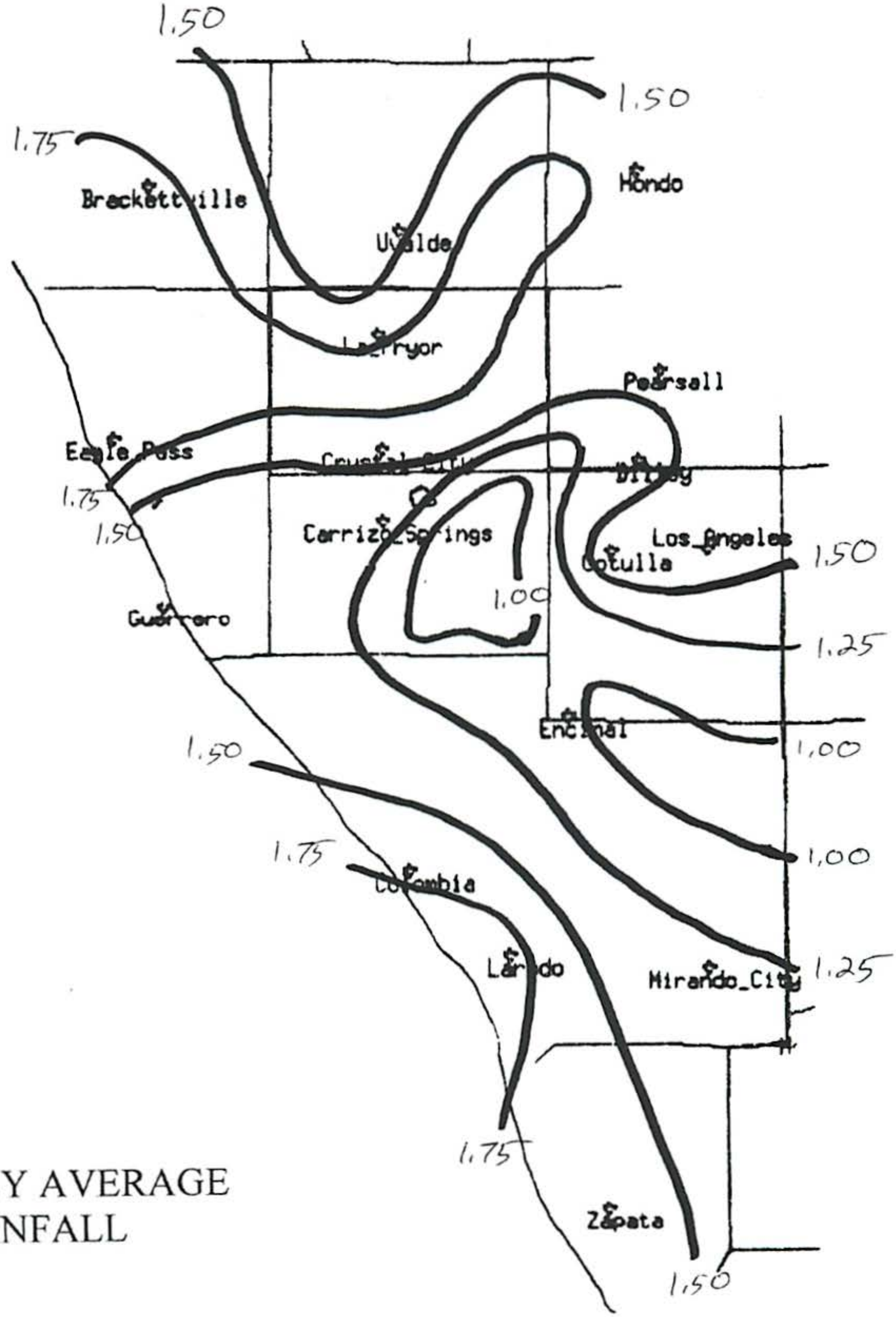
APRIL AVERAGE
RAINFALL



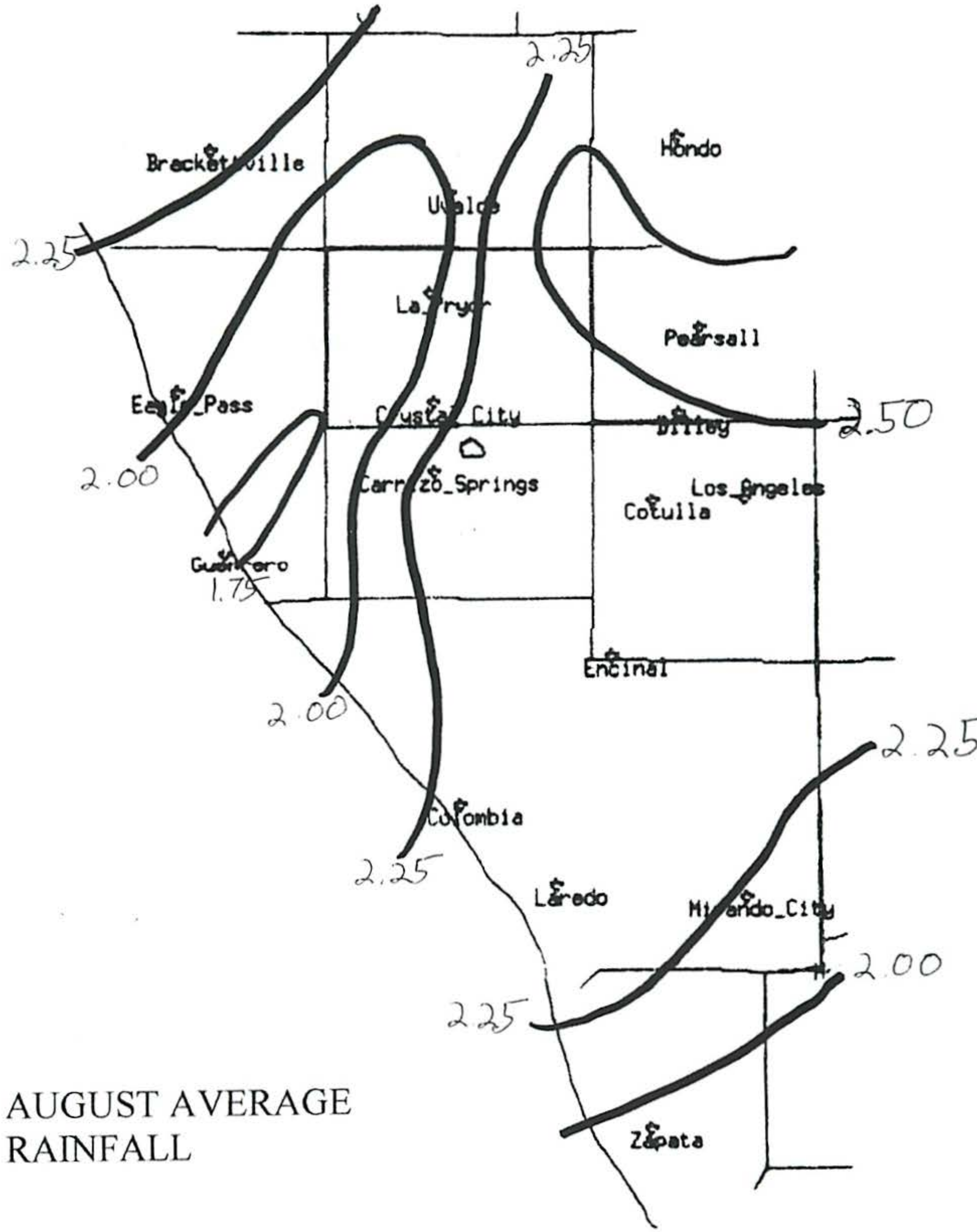
MAY AVERAGE
RAINFALL



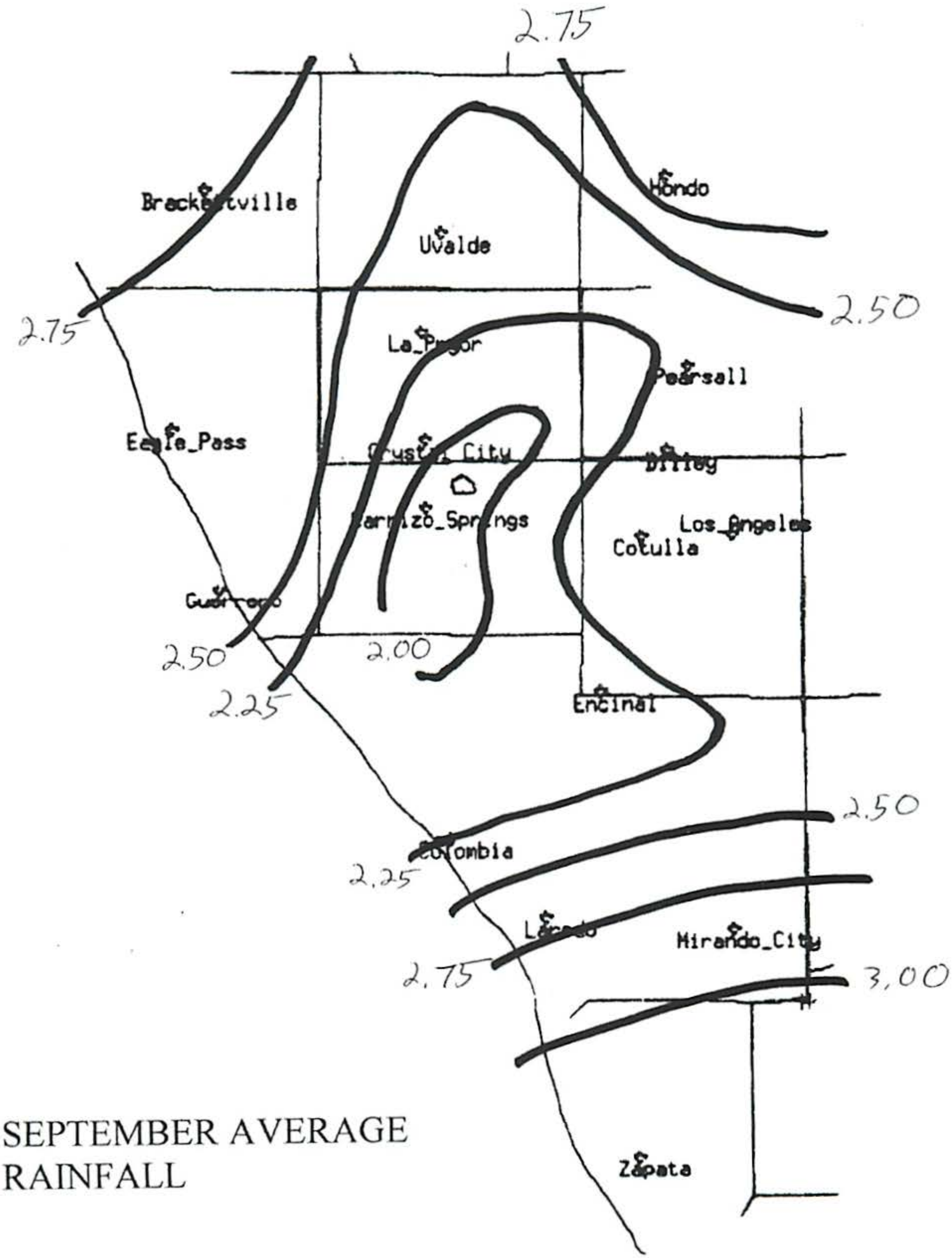
JUNE AVERAGE
RAINFALL



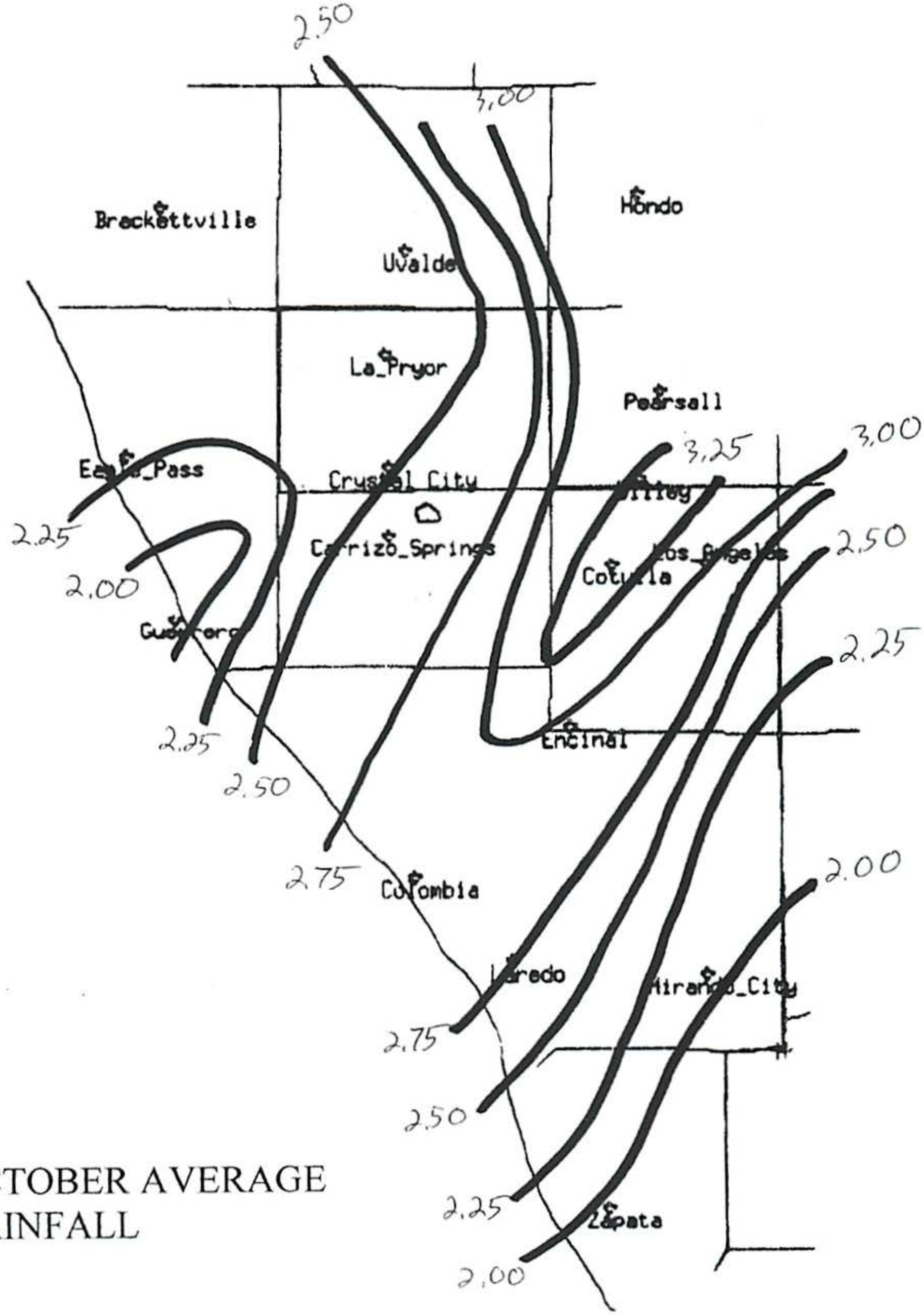
JULY AVERAGE
RAINFALL



AUGUST AVERAGE RAINFALL



SEPTEMBER AVERAGE
RAINFALL



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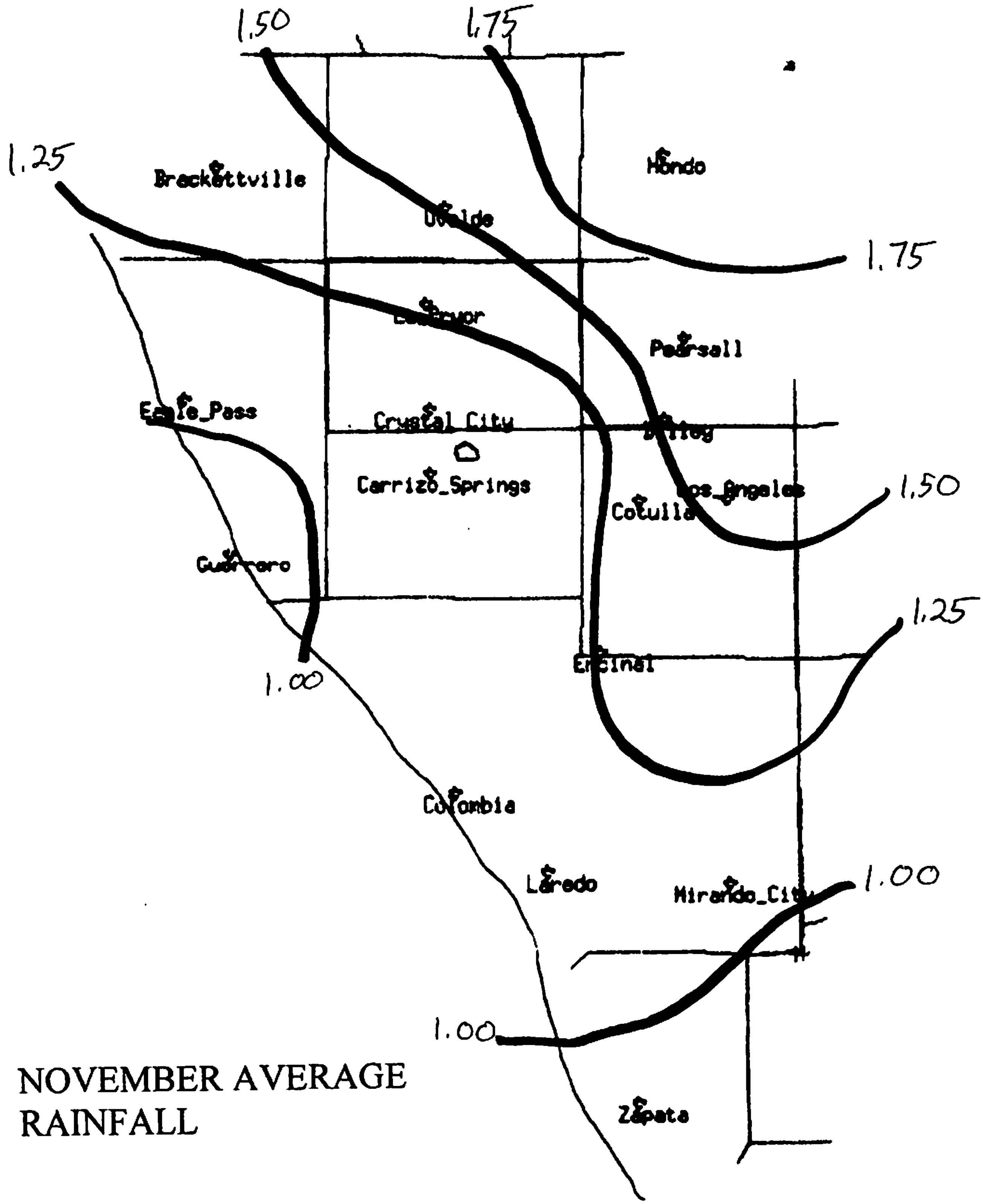
RAINFALL



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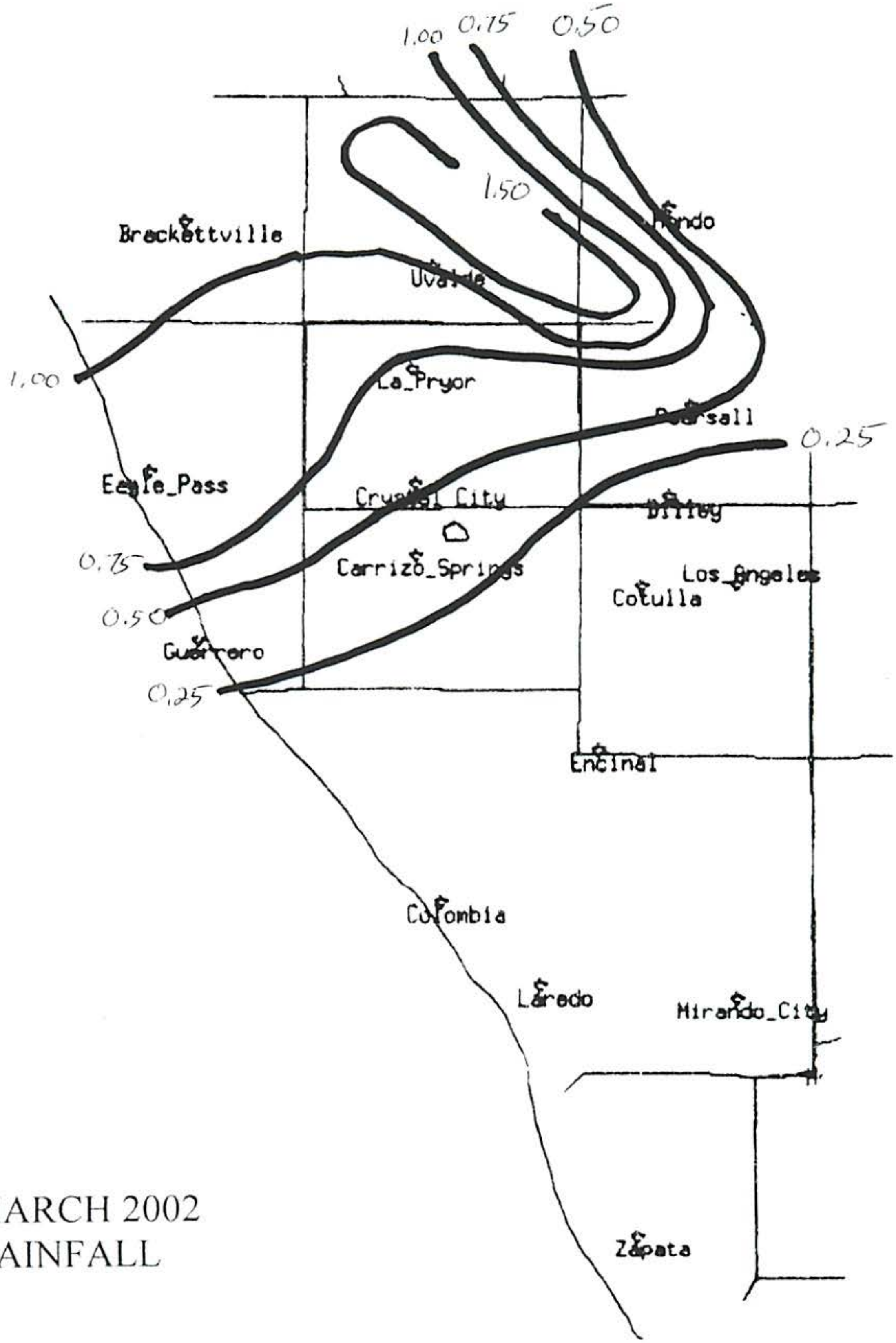
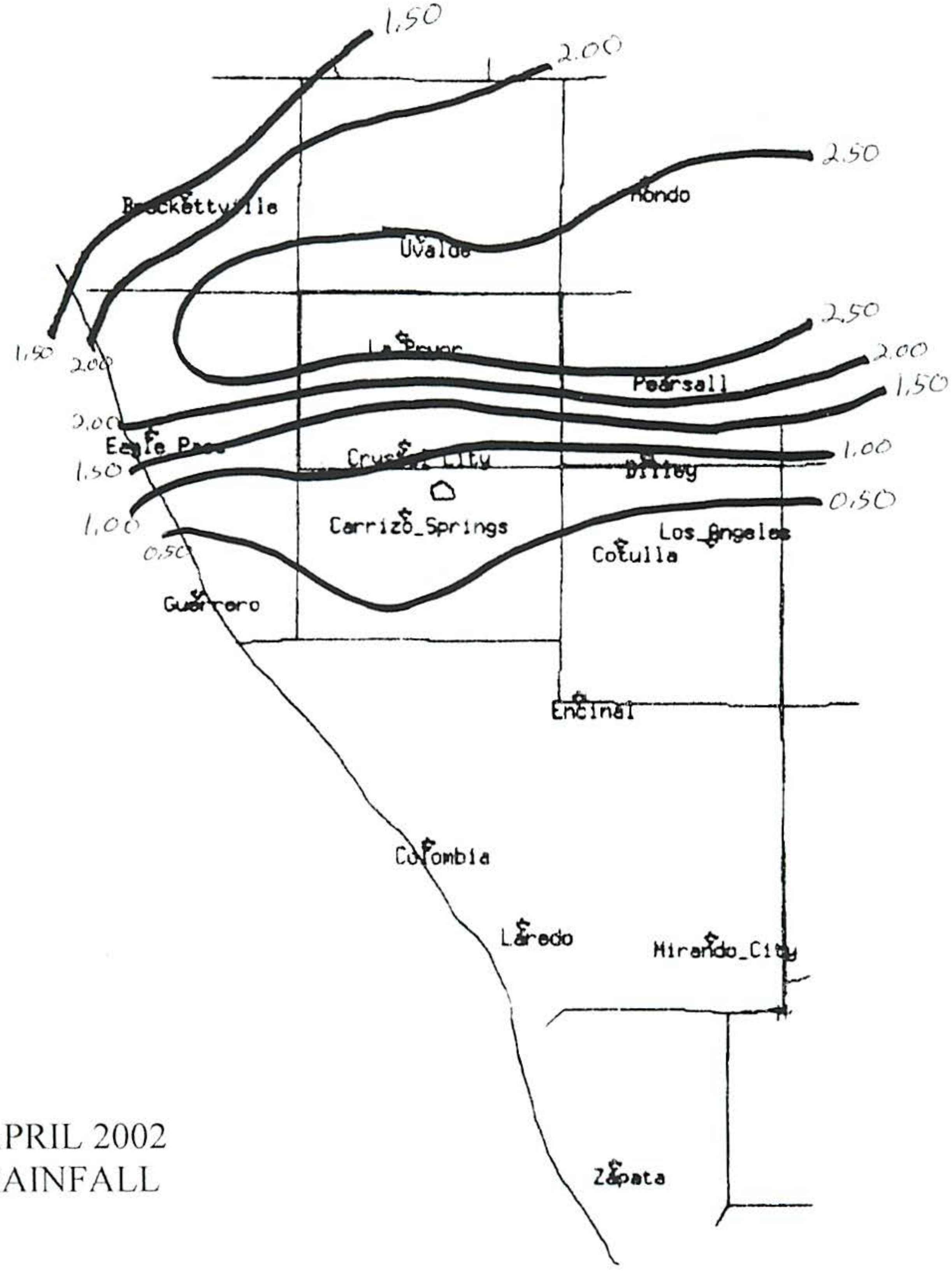
RAINFALL



MARCH 2002
RAINFALL



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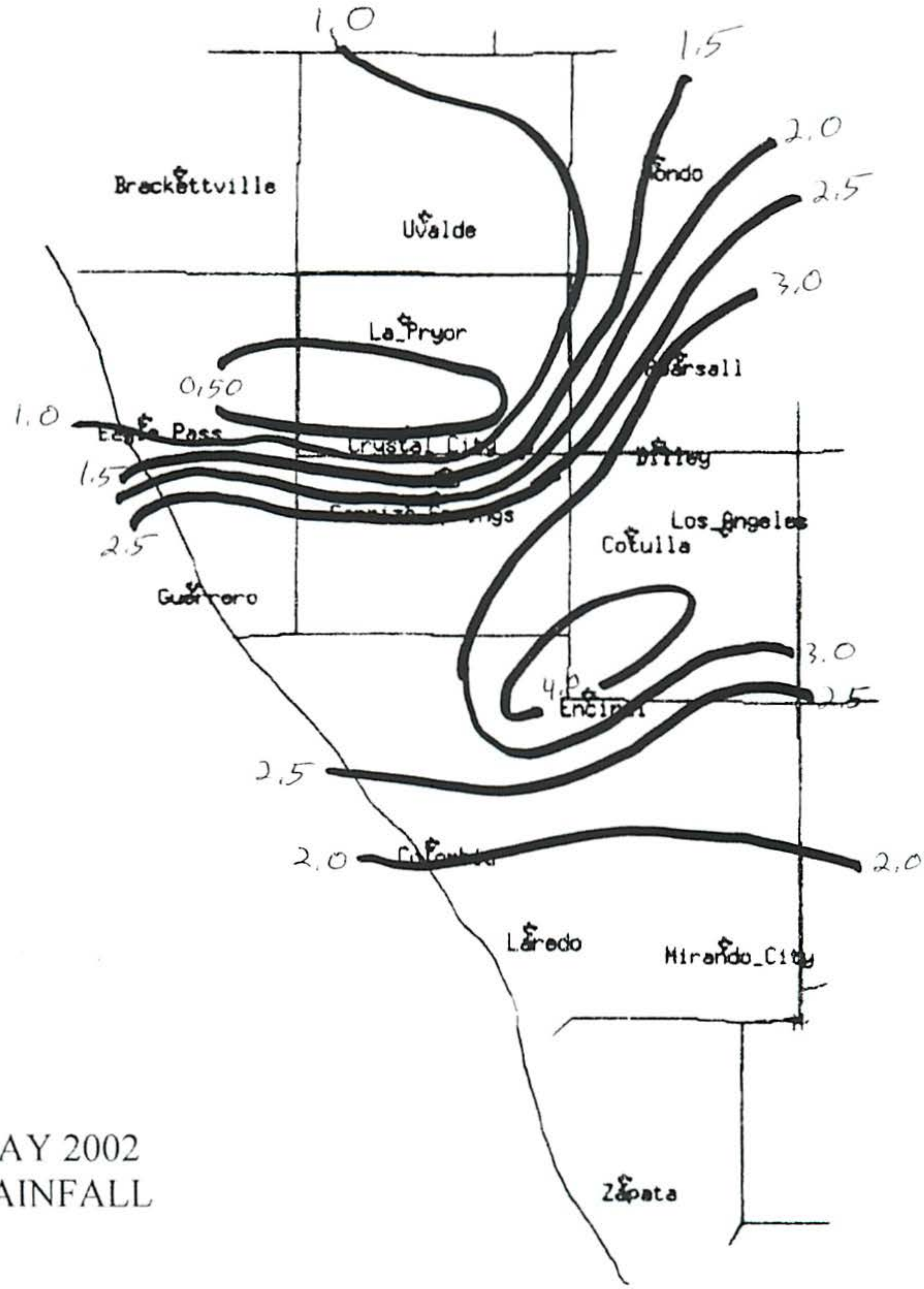
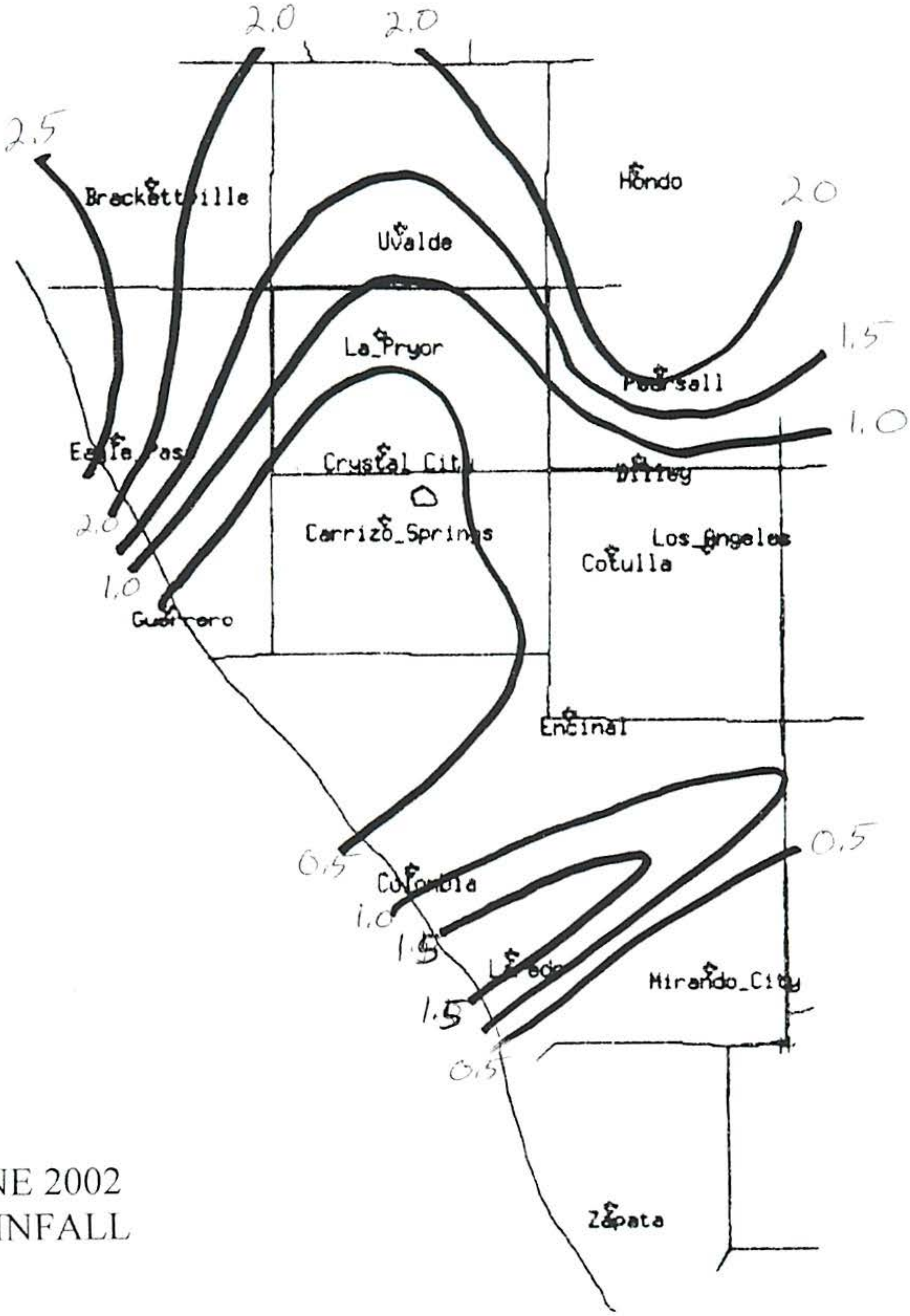
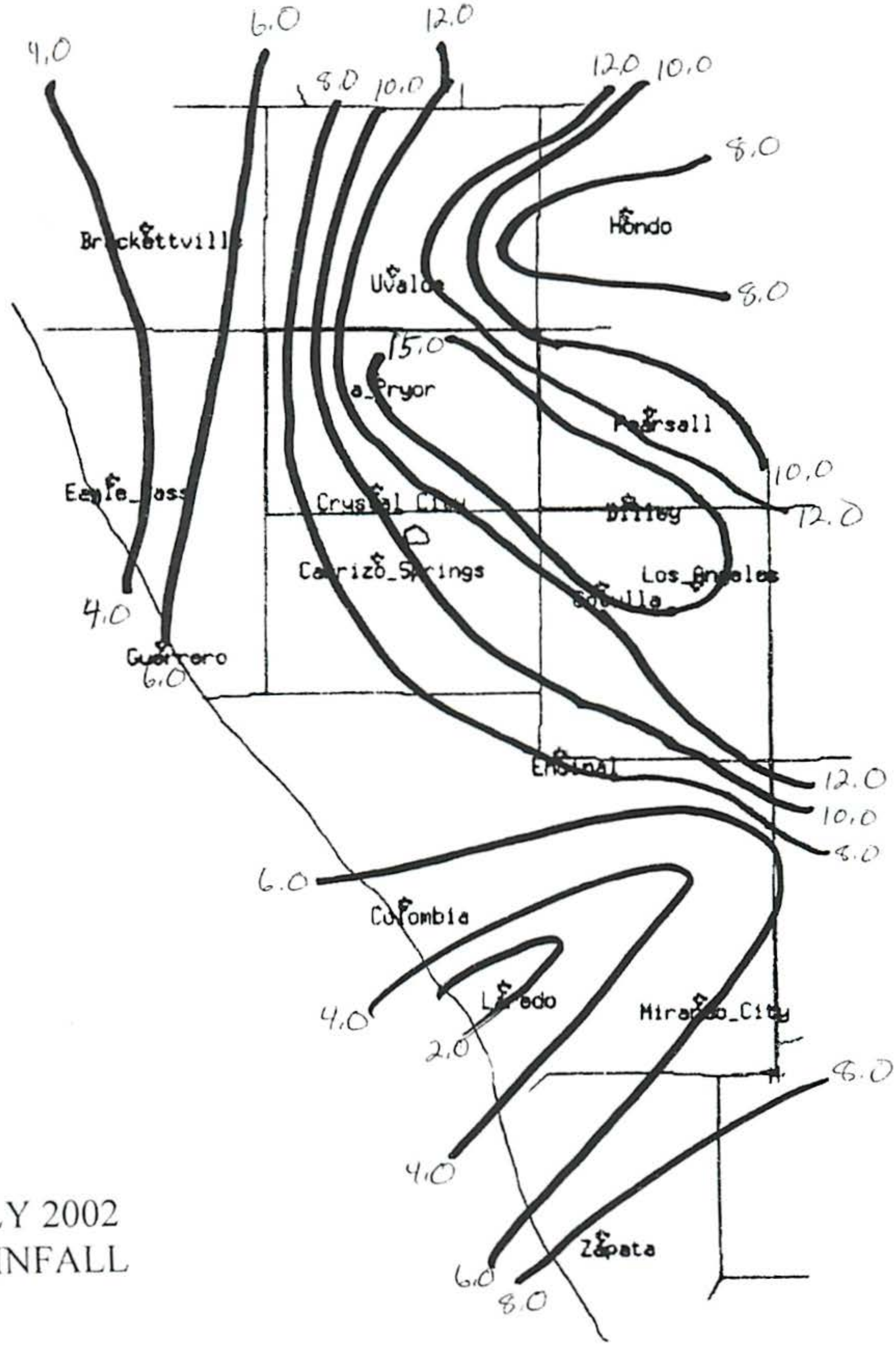
RAINFALL



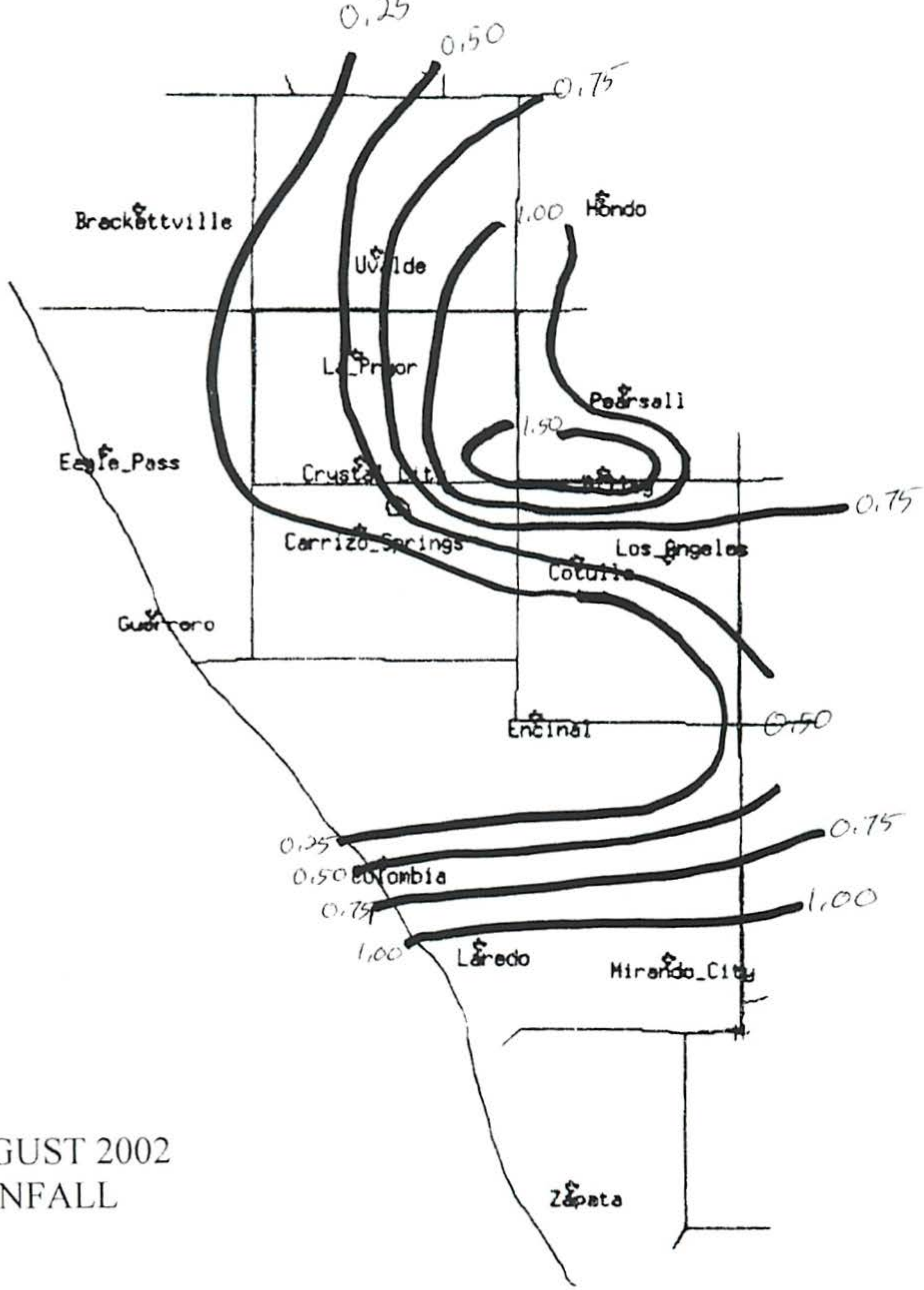
MAY 2002
RAINFALL



JUNE 2002
RAINFALL



JULY 2002
RAINFALL



AUGUST 2002
RAINFALL

VI. USING HYGROSCOPIC SEEDING AGENTS BASED ON CLOUD CHARACTERISTICS AND SEEDING CRITERIA

Over the past nine years, there has been an increasing re-interest in the use of hygroscopic nuclei to modify some types of warm clouds which never raise above the 0°C level within the atmosphere. During the 1960's, the U.S. Navel Ordnance Test Station was involved in the development and application of hygroscopic formulations. The Meteorology Research Inc. conducted another research effort using hygroscopic material in San Angelo, Texas during the period 1971-1974. It was noted from the San Angelo efforts that *"...collision and coalesscence are enhanced by differences in droplet fall rates as well as by improved capture frequencies"*. It is in the processes of collision and coalescence that the use of hygroscopic seeding agents work to provide a helping hand for the formation of raindrops.

The Navy's "salty dog" hygroscopic formulation was utilized by the South Texas Weather Modification Association in 1997 and by the Texas Border Weather Modification Association in 1998 resulting in some interesting and positive results. However, in 1999, the Texas Natural Resource Conservation Commission terminated the use of all hygroscopic seeding agents in the state. The ban was lifted this year and hygroscopic seeding was re-introduced and is now being utilized as one of the primary forms of seeding warm clouds by the SWTREA. Again, the general observation indicates some positive results for rain enhancement when hygroscopic seeding is conducted properly.

The use of hygroscopic seeding agents by the SWTREA is carefully limited to only those clouds that meet certain criteria under certain atmospheric conditions. Based on current thinking, hygroscopic seeding should be used in clouds without an active coalescence or weak coalescence process. South Texas experiences many of these deficient clouds during the summer months when the sea breeze is active. However, even weak sea breeze clouds cannot be enhanced everyday they are present. The thermodynamics of the atmosphere dictates whether or not they will respond to seeding.

A cooperative research effort conducted in Texas regarding the practical use of hygroscopic seeding was carried out during the later half of the 90's. The research focused primarily on developing tools to aid the meteorologist in determining those days when hygroscopic seeding would be useful for cloud modification along with determining geographical areas where hygroscopic seeding would be most beneficial. Atmospheric temperature and dewpoint data was gathered from morning weather balloon launches over southern and western Texas. This thermodynamic data was then inserted into an equation that determines the usefulness of hygroscopic seeding for the given day. Results of the research indicated that areas of west Texas were geographically better suited to hygroscopic seeding that was the case for south Texas. However, the research failed to take into account atmospheric temperature fluctuations that occur between the period of morning and evening. The increase in temperature through the day affects the result of the equation that determines the usefulness of hygroscopic seeding.

Since the sea breeze typically moves into the target area during the late afternoon and evening hours, the temperature and dewpoint data used to compute the coalescence activity was derived from the evening weather balloon launch rather than the morning launch. The SWTREA has used the hygroscopic flares on some sea breeze storms and noted instances where rain enhancement occurred. Had it not been for the hygroscopic flares, it is unlikely that any rain enhancement would have occurred since silver iodide seeding agents are not effective in warm clouds. Hygroscopic flares can also be used to build-up a warm cloud so that a portion of the cloud mass grows above the 0°C level within the atmosphere. Once the cloud has attained this required height, seeding is initiated by silver iodide so that cold cloud rain enhancement may be performed.

VII. CONCLUSIONS

The Southwest Texas Rain Enhancement Association has now completed its fourth year of operations and the second full year of 24-hours a day 7-day per week seeding. This year was a year of ups and downs, with the season starting slowly, then becoming very active. The program performed almost 100 flights during the eight month season. The program has now focused on establishing a long-term weather modification program for the participating counties for many years to come. This year, the SWTREA in many respects again served as a demonstration program to many of the other weather modification projects in Texas by demonstrating effective rain enhancement and hail suppression seeding on any type of storm at any given hour of the day. We look forward to another aggressive seeding season in 2003.

IX. ACKNOWLEDGMENTS

People behind the year 2002 SWTREA project

The SWTREA has now completed its fourth year as a self-sufficient weather modification project. As a result of many hours of consultation, hard work, training and perseverance, we are confident our ability to continue seeding storms in 2003 and beyond will exhibit the same aggressive and determined manner as this year's performance.

Our Association would like to acknowledge the many individuals that guided and encouraged us during the seeding season of 2002. I personally express my utmost thanks to all the tremendous people, many of them listed in this section, who guided me this year on this extraordinary project both professionally and personally. Their brilliance, experience, and dedication were the resources we were able to tap into allowing us to accomplish our goal of continuing our self-sufficient, weather modification project. With immense gratitude we wish to acknowledge and give credit to the following individuals:

The Southwest Texas Rain Enhancement Association Board of Directors:

Bill Martin (Chairman), Chris Hinojosa (Vice-Chairman), Randy Grissom (Secretary), Jay Myers (Chairman Emeritus), Lewis Bracy, Jr. (Advisor), Bill Dillard (Advisor), Joe Finley, Jr., John Galo, Mike Kirk, Chris Meyer, and John Petry.

APPENDICIES

APPENDIX A
HISTORIC PROGRAM OPERATIONAL ACTIVITY SUMMARY
(SEEDING AND RECONNAISSANCE FLIGHTS)

YEAR	RECON FLIGHTS	SEED FLIGHTS	FLIGHT (hours)	SEEDING AGENTS CONSUMED		NO. AIRCRAFT ASSIGNED	
				AgI Flare (gms)	AgI Liquid (gms)	Base	Top
1999	2	55	115	26340	3743	2	0
2000	8	69	99	15040	10322	2	0
2001	21	99	222	37160	10322	3	0
2002	26	67	222	34900	34231	3	0
TOTALS 3 years	57 Flights	290 Flights	658 Hours	113440 Grams AgI	58618 Grams AgI		

APPENDIX B
SWTREA COUNTY WEATHER MODIFICATION PARTICIPATION
(SOUTHWEST AND DEEP SOUTH TEXAS)

	YEAR						
COUNTY	1999	2000	2001	2002			
DIMMIT	X	X	X	X			
LA SALLE	X	X	X	X			
WEBB	X	X	X	X			
UVALDE				X			
ZAPATA		X	X	X			
ZAVALA	X	X	X	X			
TOTALS	4	5	5	6			

APPENDIX C
HISTORIC MONTHLY NUMBER OF SEEDING DAYS FOR RAIN ENHANCEMENT AND/OR HAIL SUPPRESSION

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	YEAR SUM	MAY-OCT TOTAL	NUMBER OF		SEASON DATES
												COUNTIES	AIRCRAFT	
1999	0	0	4	10	9	3	7	3	0	36	36	4	2	5/01-10/31
2000	0	2	8	7	6	11	7	3	3	47	44	5	2	4/12-11/15
2001	0	0	8	10	6	9	10	3	2	48	46	5	3	4/01-11/15
2002	1	3	7	10	6	3	4	5	0	39	35	6	3	3/15-11/15
TOTAL	1	5	27	37	27	26	28	14	5	170	161			

AVERAGE NUMBER OF SEEDING DAYS PER MONTH - ALL YEARS

MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV
0.3	1.3	6.8	9.3	6.8	6.5	7.0	3.5	1.3

5 MONTHS AVG. MAY - OCT:39.8 DAYS

ALL SEASON AVG. APR - OCT: 42.5 DAYS

MAXIMUM NUMBER OF SEEDING DAYS PER MONTH - ALL YEARS

MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV
1	3	8	10	9	11	10	5	3

MAX. DAYS FOR ANY MAY - OCT: 48 DAYS (2001)

MAX. DAYS FOR ANY SEASON: 46 DAYS (2001)

MINIMUM NUMBER OF SEEDING DAYS PER MONTH - ALL YEARS

MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV
0	0	4	7	6	3	4	3	0

MIN. DAYS FOR ANY MAY - OCT: 35 DAYS (2002)

MIN. DAYS FOR ANY SEASON: 36 DAYS (1999)

MONTHLY NUMBER OF SEEDING DAYS FOR HAIL SUPPRESSION

	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	TOTAL
2000	0	0	0	1	1	0	0	0	0	2
2001	0	0	7	3	0	3	2	1	2	18
2002	1	1	2	0	0	0	0	1	0	11

Southwest Texas Rain Enhancement Association
Flight Activity
March, 2002

Flight #	Date	Time	Counties	Seeding Material Used
S-01	3/19/02	6:00PM - 11:00PM	Zavala, Dimmit, and LaSalle Counties	1340 gm Agl, 0gm Salt 17 Burn-In-Place Flares 4.4hr Liquid Generator
S-02	3/19/02	6:00PM - 10:00PM	Zavala, Dimmit, and LaSalle Counties	1530gm Agl, 0gm Salt 24 Burn-In-Place Flares 3.8hr Liquid Generator
R-01	3/29/02	11:45PM - 12:45AM	Zavala and Dimmit	None
R-02	3/30/02	2:30AM - 3:30AM	Zavala and La Salle	None

Total: 4 Flights, 11 hours of flight time.

41 Flares,
8.2 hours of
generator time

Southwest Texas Rain Enhancement Association
Flight Activity
April, 2002

Flight #	Date	Time	Counties	Seeding Material Used
S-3	4/7/2002		Zavala County	1535 gm AgI 14 Burn in Place Flares 2.43hr Liquid Generator
S-4	4/7/2002		Zavala County	937.5 gm AgI 15 Burn-In-Place Flares 0.9hr Liquid Generator
S-5	4/14/2002	202AM - 402AM	Zavala and Dimmit Counties	1062.5 gm AgI 0 Burn-In-Place Flares 2.83hr Liquid Generator
S-6	4/14/2002	514AM - 645AM	Webb County	191.25gm AgI 4 Burn-In-Place Flares 0.35hr Liquid Generator
R-3	4/15/2002	1018AM - 1115AM	Zavala County	None
S-7	4/16/2002	213AM - 345AM	Zavala County	565 gm AgI 1 Burn-In-Place Flare 1.4hr Liquid Generator
R-4	4/16/2002	514PM - 735PM	LaSalle and Webb Counties	None
R-5	4/16/2002	525PM - 700PM	LaSalle County	None

Total: 12 Flights, 22.32 hours of flight time.

77 Flares,
19.70 hours of
Generator time
using 49.25 gallons
of solution.

Southwest Texas Rain Enhancement Association
Flight Activity
May, 2002

Flight #	Date	Time	Counties	Seeding Material Used
R-6	5/9/2002	10:45PM-12:00AM 1.25 hrs	Uvalde County	None
R-7	5/9/2002	10:45PM-12:00AM 1.25 hrs	Uvalde County	None
R-8	5/13/2002	7:18AM-8:20AM 1.03 hrs	Webb County	None
S-8	5/13/2002	1:35PM-3:30PM 1.92 hrs	Zavala and Dimmit Counties	80 gm AgI 2 Burn-In-Place Flares 0hr Liquid Generator
S-9	5/16/2002	11:05PM-12:30AM 1.42 hrs	Webb and Dimmit Counties	1635 gm AgI 24 Burn-In-Place Flares 1.8hr Liquid Generator
S-10	5/16/2002	11:22PM-12:50AM 1.47 hrs	Uvalde and Zavala Counties	1616.25 gm AgI 24 Burn-In-Place Flare 1.75hr Liquid Generator
S-11	5/16/2002	1:03AM-1:50AM 0.78 hrs	Zavala and Frio Counties	200gm AgI 0 Burn-In-Place Flares 0.53hr liquid Generator
S-12	5/16/2002	1:15AM-2:45AM 1.5 hrs	Webb County	250gm AgI 0 Burn-In-Place Flares 0.67hr Liquid Generator
S-13	5/17/2002	4:52PM-8:10PM 3.3 hrs	Webb and Zapata Counties	N/A 24 Burn-In-Place Flares Generator use missing
S-14	5/17/2002	5:30PM-8:28PM 2.97 hrs	Uvalde County	4130gm AgI 24 Burn-In-Place flares 3.3hr Liquid Generator
S-15	5/25/2002	9:39PM-1:05AM 3.43 hrs	Dimmit and Webb Counties	2608.75gm AgI 8 Burn-In-Place 5.25hr Liquid Generator
S-16	5/25/2002	1:41AM-4:45AM 3.07 hrs	Uvalde County	1500gn AgI 0 Burn-In-Place Flares 4.0hr Liquid Generator
R-9	5/27/2002	8:58PM-9:25PM 0.45 hrs	Dimmit County	None
S-17	5/28/2002	9:03AM-11:35AM 2.53 hrs	Dimmit and LaSalle Counties	1031.25gm AgI 0 Burn-In-Place Flares 2.75hr Liquid Generator

R-10	5/28/2002	1:16PM-2:10PM 0.9 hrs	Dimmit County	None
S-18	5/29/2002	4:44PM-6:50PM 2.1 hrs	Zavala and Dimmit Counties	600gm AgI 0 Burn-In-Place Flares 1.6hr Liquid Generator
S-19	5/30/2002	3:21PM-5:00PM 1.65 hrs	Webb County	532.5AgI 4 Burn-In-Place Flares 0.57hr Liquid Generator
S-20	5/30/2002	9:30PM-11:30PM 2.0 hrs	Webb County	80gm AgI 1 Burn-In-Place Flare 0hr Liquid Generator

Total: 18 Flights, 33.02 hours of flight time.

111 Flares,
22.22 hours of
Generator time

Southwest Texas Rain Enhancement Association
Flight Activity
June, 2002

Flight #	Date	Time	Counties	Seeding Material Used
S-21	6/4/2002	10:36PM-1:20AM 2.75 hrs	Zavala and Uvalde Counties	1122.5 gm AgI 14 Burn-In-lace Flares 1.5hr Liquid Generator
S-22	6/4/2002	11:11PM-1:00AM 1.82 hrs	Zavala and Uvalde Counties	1317.5 gm AgI 12 Burn-In-Place Flares 2.23hr Liquid Generator
R-11	6/5/2002	8:04PM-9:15PM 1.18 hrs	Uvalde County	None
S-23	6/6/2002	5:50PM-805PM 2.25 hrs	Uvalde and Dimmit Counties	2196.25 gm AgI 17 Burn-In-Place Flares 2.23hr Liquid Generator
S-24	6/6/2002	6:05PM-10:45PM 4.7 hrs	LaSalle, Dimmit, and Webb Counties	1285 gm AgI 4 Burn-In-Place Flares 3.0hr Liquid Generator
S-25	6/6/2002	7:02PM-11:15PM 4.22 hrs	Webb, Dimmit, and LaSalle Counties	2815 gm AgI 8 Burn-In-Place Flares 5.8hrs Liquid Generator
S-26	6/7/2002	6:55PM-8:30PM 1.58 hrs		218.75 gm AgI 0 Burn-In-Place Flares 0.42hr Liquid Generator
S-27	6/13/2002	3:05PM-5:00PM 1.92 hrs	Uvalde County	218.75 gm AgI 0 Burn-In-Place Flares 0.42hr Liquid Generator
S-28	6/13/2002	8:35PM-11:00PM 2.42 hrs	Uvalde and Zavala Counties	937.5 gm AgI 0 Burn-In-Place Flares 2.5hr Liquid Generator
S-29	6/22/2002	4:20PM-5:30PM 1.16 hrs	LaSalle and Webb Counties	437.5 gm AgI 0 Burn-In-Place Flares 1.1hrs Liquid Generator
S-30	6/26/2002	4:40PM-8:00PM 3.33 hrs	Uvalde, Zavala, Dimmit, and LaSalle Counties	2102.5 gm AgI 46 Burn-in-Place Flares 1.75hrs Liquid Generator
S-31	6/26/2002	7:02PM-9:50PM 2.8 hrs	Dimmit, LaSalle and Webb Counties	1980 gm AgI 24 Burn-In-Place Flares 3.6hrs Liquid Generator
S-32	6/26/2002	8:08PM-9:40PM 1.53 hrs	Dimmit, LaSalle and Webb Counties	745 gm AgI 6 Burn-In-Place Flares 1.77hrs Liquid Generator
S-33	6/27/2002	9:26AM-2:25PM 4.98 hrs	Zavala, Dimmit, and Webb Counties	240gms + generator time 5 Burn-In-Place Flares Generator time unknown

S-34	6/27/2002	10:38AM-4:10PM 5.37 hrs	LaSalle, Webb Zavala, and Dimmit Counties	845 gm Agl 4 Burn-In-Place Flares 3.5hrs Liquid Generator
S-35	6/28/2002	1:41PM-3:40PM 1.98 hrs	LaSalle, Dimmit, Webb, and Zapata Counties	2322.5 gm Agl 24 Burn-In-Place Flares 2.68hrs Liquid Generator
S-36	6/28/2002	1:50PM-3:50PM 2 hrs	Dimmit County	1045 gm Agl 21 Burn-In-Place Flares 1.37hrs Liquid Generators
S-37	6/28/2002	3:25PM-5:50PM 2.42 hrs	Dimmit and Webb Counties	800 gms + generator time 10 Burn-In-Place Flares Generator time unknown
S-38	6/29/2002	1:02PM-4:10PM 3.13 hrs	LaSalle and Dimmit Counties	1572.5 gm Agl 29 Burn-in-Place Flares 1.42hrs Liquid Generators
S-39	6/29/2002	1:13PM-5:00PM 3.78 hrs	Webb and Zapata Counties	1552.5 gm Agl 16 Burn-In-Place Flares 1.82 hrs Liquid Generators
R-12	6/29/2002	2:34PM-4:00PM 1.43 hrs	Zavala and Dimmit Counties	None
S-40	6/30/2002	1:34-5:00Pm 3.43 hrs	LaSalle and Dimmit Counties	977.5 gm Agl 18 Burn-In-Place Flares 1.72 hrs Liquid Generators
S-41	6/30/2002	1:39PM-4:50PM 3.18 hrs	LaSalle, Zavala, and Dimmit Counties	1495 gm Agl 15 Burn-In-Place Flares 1.97hrs Liquid Generators
S-42	6/30/2002	2:29PM-4:50PM 2.35 hrs	Webb County	1742.5 gm Agl 20 Burn-in-Place flares 0.95hrs Liquid Generators

Total: 24 Flights, 65.71 hours of flight time.

292 Flares,
41.33+ hours of
Generator time

Southwest Texas Rain Enhancement Association
Flight Activity
July, 2002

Flight #	Date	Time	Counties	Seeding Material Used
S-43	7/2/2002	8:05PM - 11:15PM	Dimmit and Webb Counties	1295 g AgI 8 BIP Flares 4.37hrs Liquid Generators
R-13	7/2/2002	1:45AM - 2:00AM	None	None
S-44	7/3/2002	12:40PM - 3:05PM	Webb and LaSalle Counties	1202.5 g AgI 12 BIP Flares 1.62hrs Liquid Generators
S-45	7/4/2002	6:20PM - 10:00PM	Webb and Zapata Counties	1385 g AgI 21 BIP Flares 2.57hrs Liquid Generators
R-14	7/5/2002	4:15AM - 5:10AM	None	None
R-15	7/8/2002	7:20PM -7:50PM	None	None
S-46	7/9/2002	1:15PM - 6:30PM	Zapata and Webb Counties	360g Salt 9 Salt Flares no Liquid Generators
R-16	7/10/2002	2:08PM - 3:27PM	None	None
R-17	7/10/2002		None	None
S-47	7/14/2002	8:50AM - 12:10PM	Webb and LaSalle Counties	2800 g AgI 15 BIP Flares 4.0hrs Liquid Generators
S-48	7/29/2002	8:00PM - 12:15AM	Uvalde and Zavala Counties	445 g AgI 0 BIP Flares 2.97hrs Liquid Generators
S-49	7/29/2002	10:22PM - 12:15AM	Zavala, Uvalde and Dimmit Counties	325 g AgI 0 BIP Flares 2.17hrs Liquid Generators
S-49a	7/29/2002	1:50AM - 2:15AM	Relocation flight None	None

Total: 11 Flights

56 Flares,
17.70 hours of
Generator time

Southwest Texas Rain Enhancement Association
Flight Activity
August, 2002

Flight #	Date	Time	Counties	Seeding Material Used
R-18	8/4/2002	5:24PM - 7:55PM 2:21	None	None
R-19	8/5/2002	2:01PM - 4:45PM 2:44	None	None
S-50	8/8/2002	2:10PM - 7:15PM 5:05	Uvalde, Zavala, LaSalle, and Dimmit Counties	832.5 g AgI 0 BIP Flares 5.55hrs Liquid Generators
S-51	8/9/2002	11:52AM - 3:00PM 3:08	Webb and Dimmit Counties	2345 g AgI 24 BIP Flares 2.83hrs Liquid Generators
S-52	8/9/2002	2:42PM - 3:35PM 0:53	LaSalle and Dimmit Counties	90 g AgI 0 BIP Flares 0.6hrs Liquid Generators
R-20	8/9/2002	7:58PM - 10:45PM 2:47	None	None
R-21	8/10/2002	7:02PM - 7:55PM 0:53	None	None
R-22	8/14/2002	6:16PM - 7:30PM 1:14	None	None
S-53	8/29/2002	10:10AM - 4:55PM 4:45	Uvalde, Zavala, Dimmit, LaSalle, and Webb Counties	1147.5 g AgI 9 BIP Flares 5.25hrs Liquid Generators
S-54	8/29/2002	1:31PM - 5:31PM 4:00	Dimmit, Webb, and Zapata Counties	2800 g AgI 15 BIP Flares 4.0hrs Liquid Generators
R-23	8/31/2002	5:33PM - 6:45PM 1:12	None	None

Total: 11 Flights

48 Flares,
18.23 hours of
Generator time

Southwest Texas Rain Enhancement Association
Flight Activity
September, 2002

Flight #	Date	Time	Counties	Seeding Material Used
S-55	9/1/2002	4:28PM - 8:30PM	Webb, Dimmit, and LaSalle Counties	295g AgI 5 Salt Flares 1.98hrs Acetone Generators
S-56	9/4/2002	2:03PM - 5:45PM	LaSalle, Dimmit, and Zavala Counties	1587.5g AgI 15 BIP Flares 2.55hrs Acetone Generators
S-57	9/4/2002	4:12PM - 6:40PM	Webb and Zapata Counties	390g AgI 4 BIP Flares 1.0hr Acetone Generators
R-24	9/5/2002	5:00PM - 7:00PM	None	None
R-25	9/14/2002	7:58PM - 9:25PM	None	None
S-58	9/15/2002	2:45AM - 4:00AM	LaSalle and Dimmit Counties	150g AgI 0 BIP Flares 1.0hr Acetone Generators
S-59	9/19/2002	5:23PM - 7:47PM	Webb and Zapata Counties	210g AgI 0 BIP Flares 1.4hr Acetone Generators

Total: 7 Flights

24 Flares,
7.93 hours of
Generator time

Southwest Texas Rain Enhancement Association
Flight Activity
October, 2002

Flight #	Date	Time	Counties	Seeding Material Used
S-60	10/5/2002	12:55PM - 2:55PM 2:00	Webb and Zapata Counties	80g AgI 1 BIP Flare 0hrs Acetone Generators
S-61	10/7/2002	2:30PM - 6:00PM 3:30	LaSalle, Dimmit, and Webb Counties	830g AgI 6 BIP Flares 2.33hrs Acetone Generators
S-62	10/7/2002	3:15PM - 6:10PM 2:55	LaSalle and Dimmit Counties	1255g AgI 10 BIP Flares 3.03hr Acetone Generators
S-63	10/8/2002	6:45PM - 7:59PM 1:14	LaSalle County	80g AgI 1 BIP Flare 0hrs Acetone Generators
S-64	10/8/2002	10:31PM - 12:45AM 2:14	Zavala County	27.5g Agi 0 BIP Flares 0.18hrs Acetone Generators
S-65	10/9/2002	9:21AM - 11:00AM 1:39	Dimmit and Webb Counties	230g AgI 2 BIP Flares 0.47hr Acetone Generators
S-66	10/9/2002	5:30PM - 8:30PM 3:00	Uvalde and Zavala Counties	560g AgI 0 BIP Flares 3.73hr Acetone Generators
R-26	10/21/2002	2:45AM - 4:00AM 1:15	None	None
S-67	10/22/2002	10:23PM - 12:01AM 1:38	Webb County	655g AgI 6 BIP Flares 1.16hr Acetone Generators

Total: 9 Flights

26 Flares,
10.9 hours of
Generator time

November 2002 saw no seeding flights due to uncooperative weather conditions.

APPENDIX E

HISTORIC SWTREA MONTHLY SEEDING EVENTS BY COUNTIES

2002

County	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	TOTAL
Dimmit	3	1	7	15	2	5	3	3	0	**39**
La Salle	2	2	1	11	2	3	3	3	0	**27**
Uvalde**	0	0	5	7	2	2	0	1	0	**17**
Webb	0	2	7	11	5	3	3	4	0	**35**
Zapata	0	0	1	2	2	1	2	1	0	**9**
Zavala	4	5	4	9	2	2	1	2	0	**29**

TOTAL - ALL YEARS

County	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	TOTAL
Dimmit	3	2	26	34	21	20	24	8	2	**140**
La Salle	2	3	18	34	23	18	15	9	4	**126**
Uvalde**	0	0	5	7	2	2	0	1	0	**17**
Webb	0	3	24	40	24	28	27	12	4	**162**
* Zapata	0	1	2	6	5	7	6	1	0	**28**
Zavala	4	6	15	26	13	14	11	9	8	**106**

* Zapata County was not a participant in the 1999 SWTREA project.

**Uvalde County joined May 1, 2002

NOAA FORM 17-4A (4-81) | U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION | Form Approved OMB No. 0648-0025 Expires 09/30/2004

INTERIM ACTIVITY REPORTS AND FINAL REPORT

This report is required by Public Law 92-205; 85 Stat. 735; 145 U.S.C. 330b. Knowing and willful violation of any rule adopted under the authority of Section 2 of Public Law 92-205 shall subject the person violating such rule to a fine of not more than $10,000, upon conviction thereof.

NOAA FILE NUMBER: 02-1140

[ ] INTERIM REPORT   [x] FINAL REPORT

Complete in accordance with instructions on reverse and forward one copy to:
National Oceanic and Atmospheric Administration
Office of Oceanic and Atmospheric Research
1315 East-West Highway SSMC-3 Room 11554
Silver Spring, MD 20910

REPORTING PERIOD: FROM 03/15/2002 TO 11/15/2002

MONTH	(a) NUMBER OF MODIFICATION DAYS	(b) NUMBER OF MODIFICATION DAYS PER MAJOR PURPOSE				(c) HOURS OF APPARATUS OPERATION BY TYPE		(d) TYPE AND AMOUNT OF AGENT USED				
		INCREASE PRECIPITATION	ALLEVIATE: HAIL	ALLEVIATE: FOG	OTHER	AIRBORNE	GROUND	SILVER IODIDE	CARBON DIOXIDE	UREA	SODIUM CHLORIDE	OTHER
JANUARY												
FEBRUARY												
MARCH	2	0	2	0	0	9	0	2,870	0	0	0	0
APRIL	5	3	2	0	0	13	0	4,291	0	0	0	0
MAY	7	9	6	0	0	27	0	14,263	0	0	0	0
JUNE	10	22	0	0	0	76	0	27,969	0	0	0	0
JULY	6	7	0	0	0	24	0	11,335	0	0	360	0
AUGUST	3	5	0	0	0	18	0	7,215	0	0	0	0
SEPTEMBER	4	5	0	0	0	14	0	2,623	0	0	200	0
OCTOBER	5	8	1	0	0	18	0	3,718	0	0	0	0
NOVEMBER	0	0	0	0	0	0	0	0	0	0	0	0
DECEMBER												
TOTAL	42	59	11	0	0	199	0	74,283	0	0	560	0
TOTALS FOR FINAL REPORT												

DATE ON WHICH FINAL WEATHER MODIFICATION ACTIVITY OCCURRED *(For Final Report only.)* 11/15/2002

CERTIFICATION: I certify that all statements in this report on this weather modification project are complete and correct to the best of my knowledge and are made in good faith.

NAME OF REPORTING PERSON: Jason M. Straub

AFFILIATION: Southwest Texas Rain Enhancement Association

SIGNATURE:

STREET ADDRESS: Box 759

OFFICIAL TITLE: Project Meteorologist

CITY: Cotulla | STATE: TX | ZIP CODE: 78014

DATE: 01/04/2003