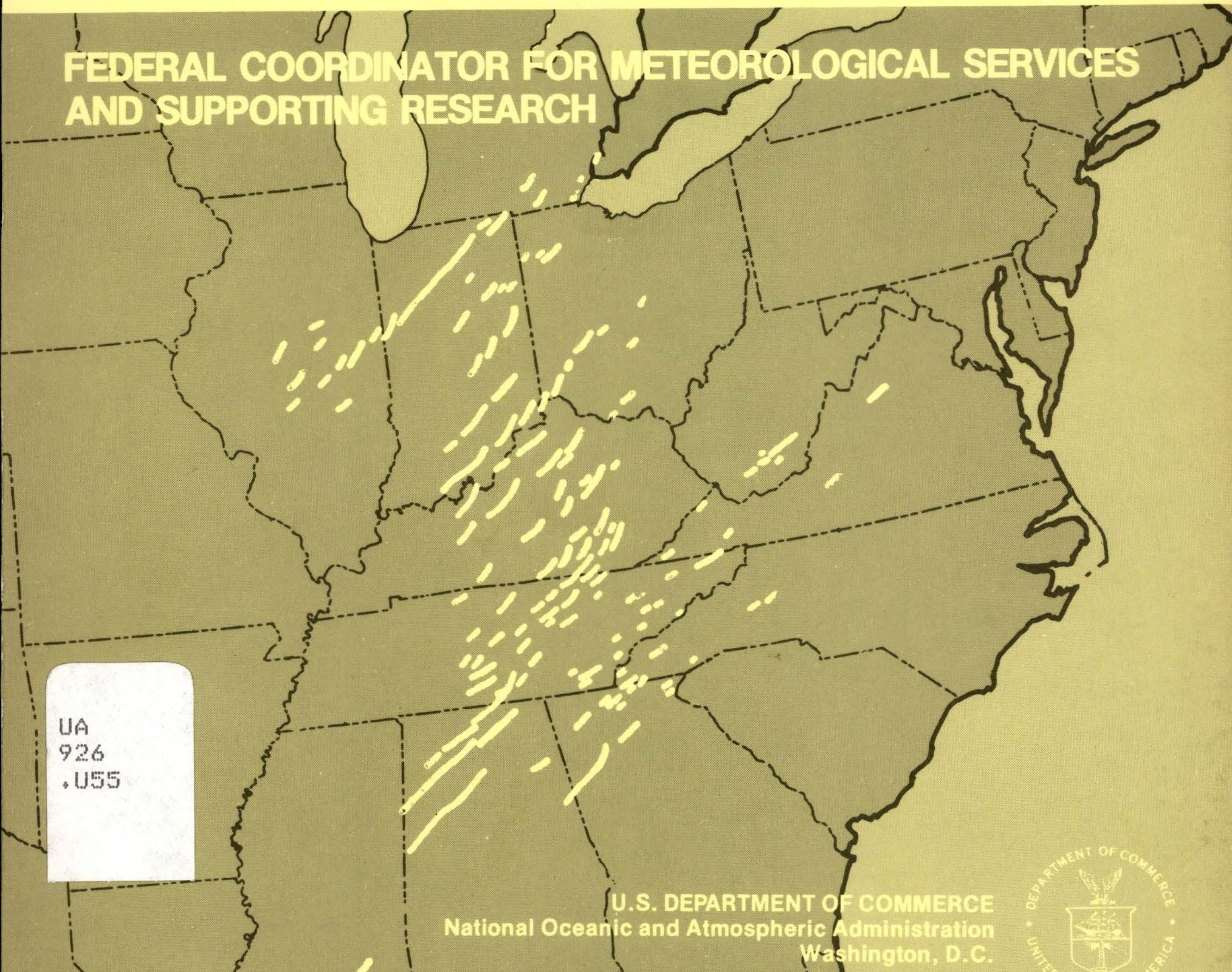
A Federal Plan for Natural Disaster Warning and Preparedness

First Supplement FY 1976 - 1980

JUNE 1975

FEDERAL COORDINATOR FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Washington, D.C.

Cover: Schematic of massive tornado outbreak of April 3-4, 1974. These 148 tornadoes killed 315, injured more than 6,000 and caused over half a billion dollars in damage. T. Theodore Fujita of the University of Chicago, who conducted an exhaustive survey of this outbreak, determined that these storms had a combined path-length of 2,598 miles in the 13 states affected by the outbreak.

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A FEDERAL PLAN FOR

NATURAL DISASTER WARNING AND PREPAREDNESS

FIRST SUPPLEMENT

(FY 1976-1980)

June 1975

Foreword

Natural hazards, such as the massive outbreak of killer tornadoes which struck 13 states early in April 1974, remain an ever-present threat to our Nation's welfare. Disaster surveys have indicated that the Nation's warning and preparedness system has reduced the toll in deaths, injuries, and economic losses from such hazards. However, unmet needs still exist in our monitoring, warning preparation, warning dissemination, and preparedness capabilities.

The Federal Plan for Natural Disaster Warning and Preparedness was published in June 1973. That Plan presented a comprehensive picture of the coordinated plans of 10 Federal agencies to bring about needed improvements to the warning system and preparedness programs. In the months since the Plan was prepared, much progress has been made to improve the system, and applications of recent technological advances promise even greater future improvements.

The June 1973 Plan was well received as a unique source of information on Federal program activities developed to provide responsive natural disaster warnings and preparedness programs for our Nation. After a limited initial distribution, many additional copies were furnished to members of Congress, State offices, universities, and private research interests in response to specific requests. In view of the widespread distribution and interest in the original Plan, this updating supplement has been prepared to maintain the viability of the Plan and insure its continued maximum usefulness. It has been prepared at the request of the Chairman, Federal Committe, by an Ad Hoc Group working under the guidance of the Federal Coordinator. Agencies which assisted in preparation of this supplement are the Departments of Agriculture, Commerce, Defense, Housing and Urban Development, Interior, and Transportation, the National Aeronautics and Space Administration, the National Communications System, the National Science Foundation and the Office of Telecommunications Policy. In addition, the Federal Communications Commission participated as an observer.

This First Supplement to the original Plan is divided into five parts. Part I examines the recent performance of the Nation's disaster warning system and preparedness programs as a means of highlighting unmet needs. Part II is a detailed assessment of improvements made in the system since June 1973 and Part III presents highlights of program plans of the ten participating Federal agencies for fiscal year 1976. Parts IV and V are devoted to future needs for improvements through FY 1980. The FY 1976 programs shown are contained in the President's budget. Follow-on programs for FY 1977 and later years are for planning purposes only. The rate and extent to which they are implemented are dependent on budgetary decisions in the context of the total national needs.

Clayton E. Jensen
Federal Coordinator for Meteorological Services and Supporting Research

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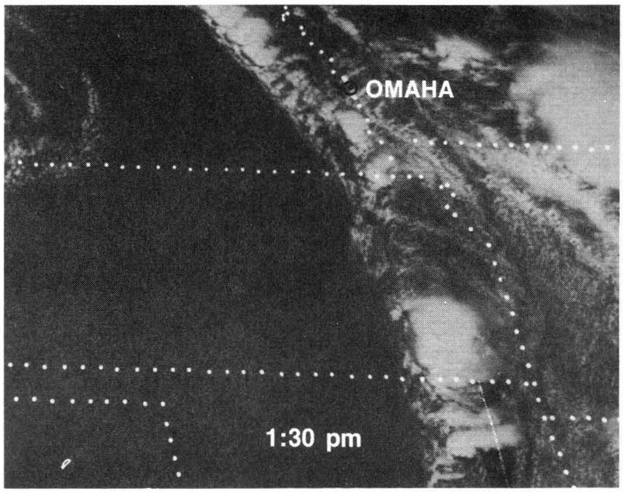
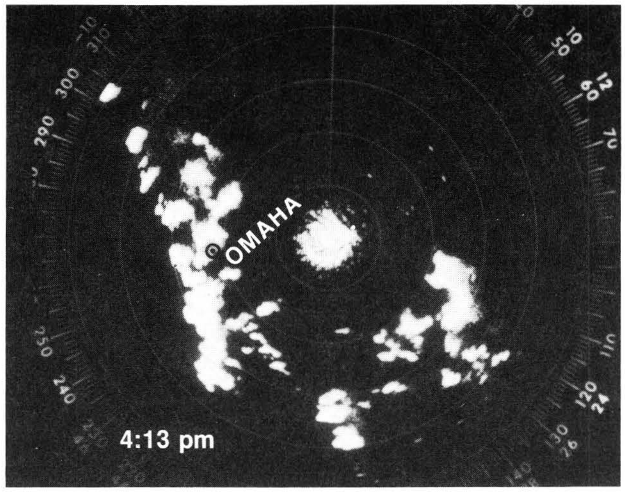


Portion of Synchronous Meteorological Satellite (SMS-2) photo 3 hours before touchdown of Omaha tornado on May 6, 1975. SMS provided 15-minute monitoring of the squall-line as it developed. This photo shows the first thunderstorms to develop in southeast Nebraska.



Tornado-producing squall-line as seen by NOAA's long-range weather radar in Des Moines. A tornado watch was issued as early as 12:37 p.m. CDT and the local warning radar in Omaha contributed to the tornado warning issued at 4:14 p.m. CDT.

Photo of the tornado taken from the AK-SAR-BEN Race Track. Civil Defense officials estimate that 58,000 persons were in the path of this very destructive storm. Three deaths and 141 injuries occurred, with early warnings and effective actions on the part of officials and citizens credited with holding the casualty count so low. (Photo courtesy of Bob Dunn of AK-SAR-BEN Track)

Executive Summary

The Federal Plan for Natural Disaster Warning and Preparedness, June 1973, presented the Federal action programs and plans for fiscal years 1973-78 to satisfy unmet needs in the existing natural disaster warning system and community preparedness programs. This first supplement to the Plan examines the recent performance of the disaster warning system, reports the progress made toward improving the warning system and community preparedness program, and updates the action plans of the ten participating Federal agencies for fiscal years 1975-80 to satisfy identified needs.

RECENT PERFORMANCE OF THE SYSTEM

Major improvements made in our warning system and in community preparedness since June 1973 have contributed toward reducing loss of life and property. Floods, tornadoes, severe storms, and other natural hazards, however, still cause unacceptable death and destruction across the land. The following paragraphs summarize highlights of the performance of the system during some major disasters of the past two years.

TORNADOES AND SEVERE LOCAL STORMS

A record number of 1,109 tornadoes in 1973 caused over half a billion dollars damage, followed in 1974 by the second highest yearly total of 944 tornadoes. The 1974 tornado season was highlighted by the massive outbreak of 148 (the dramatic cover picture shows the tracks of these tornadoes) on April 3-4 that killed 315 people, injured over 6,000, and caused extensive property losses to more than 27,000 families in 13 states. On balance, the system functioned well and is credited with saving many lives and reducing the number of injured. A postdisaster survey of many of the storm-stricken areas served to show both the effectiveness of the system and areas where improvements are still needed in all elements of the warning system. Only two months after the massive April 3-4 outbreak, tornadoes struck sections of Oklahoma, Kansas, and Arkansas. Accurate and timely watches and warnings, buttressed by viable community preparedness plans placed quickly into operation by concerned and knowledgeable community leaders, kept the tolls of dead and injured to a minimum.

The following table vividly illustrates the contribution of an improved warning system and community preparedness program toward reducing the impact of such disasters. It compares the impact of two tornadoes spaced 5 years apart as a function of readiness. In 1968 a tornado swept through Jonesboro, Ark., with devastating effect. Five years later in May 1973, another "twister" roared out of the night across this unfortunate community in northeast Arkansas.

Readiness

1968	1973
No Weather Wire Service	Statewide NOAA Weather Wire
Radio & TV stations did not disseminate watches and warnings	Radio & TV stations did disseminate watches and warnings
No organized spotter network	Organized spotter network in action
No educational programs, emergency operations center, or disaster drill procedures	Extensive educational program, emergency operations center, and disaster drill procedures

Impact

1968		1973
25,000	Population	29,000
34	Deaths	2
458	Injuries	246
82	Hospitalized	21
$8 Million	Damage	$50 Million

TROPICAL STORMS AND STORM SURGES

The massive cyclonic storms of tropical origin termed "hurricanes" which annually threaten the Atlantic and Gulf of Mexico coastal sections of our Nation have been relatively infrequent for more than two years. The lack of such storms and their attendant destruction caused by the high winds, storm surges, and flood-producing rainfall is a blessing. However, an extended period of nonthreatening activity can contribute to lulling inhabitants of high risk areas into a false sense of security. Such unjustified complacency coupled with exploding population growths in certain coastal sections that are highly vulnerable to both storm surge and wind damage greatly increase the potential of a hurricane disaster of catastropic proportions.

During the past two years three tropical storms have impacted the United States, and two of these crossed the U.S. coastline. In 1973 Tropical Storm Delia caused relatively minor damage as it moved inland due primarily to flooding in the coastal sections near Galveston, Tex.; and Tropical Storm Gilda, while not penetrating the U.S. coastline, generated high tides and pounding surfs that caused extensive beach erosion and some property damage from Florida to New Jersey. In 1974 Hurricane Carmen decreased rapidly in intensity as she moved inland near Morgan City, La. Although storm damages exceeded $150 million, there was virtually no loss of lives directly attributable to the storms. In these instances accurate and timely warnings were acted on by an informed and well prepared public to protect lives and property. Several other storms threatened but did not strike the coastal U.S. One major hurricane during this period, "Hurricane Fifi," flattened small coastal communities in Honduras causing over 3,000 deaths and hundreds of millions of dollars of damage to buildings, communications facilities, and agricultural interests. Stronger community preparedness programs in Honduras might have reduced the high death rate due to Hurricane Fifi.

FLOODS Flooding continues as one of our most destructive natural hazards. During the past two years flooding has occurred every month throughout various sections of our country causing more than 150 deaths and over two billion dollars in damages. The disaster warning system and preparedness programs played a major role in reducing the total impact, but the effectiveness of the overall system can be increased by modernized and expanded monitoring networks, application of improved hydrologic models, better warning dissemination facilities, and more emphasis on community preparedness.

Main stem flooding on the Mississippi, which reached historic proportion in March 1973, inundated 16 million acres and caused over one billion dollars in damage. Accurate and timely stage forecasts were effectively used in the safe evacuation of more than 50,000 people from their threatened homes and were the basis for preparedness actions and the operation of water flow control facilities that kept damages from being even higher. In two separate instances on the west coast, warehoused chemicals and cattle herds valued at $4 million were moved to safety on the basis of flood forecasts and warnings. In a separate incident ranchers ignored warnings and lost cattle worth $200,000.

Flash flooding of small streams and tributaries continues to be a major disaster risk, especially because of the large number of deaths they cause. Their slashing onset leaves little time for evacuation and severely limits action to protect property. Our system of watches and warnings works well in some cases but improvements are needed. Better forecasting techniques for alerting areas of potential flash floods and many more automatic alarms and self-help systems for flood prone communities could significantly reduce the annual losses.

WINTER STORMS In January 1975 the most severe blizzard in many years lashed the Midwest with 90 mph winds that piled the heavy snowfall into mountainous drifts. Accurate and timely forecasts and warnings were credited by public officials and the media with saving hundreds of lives. Still, the more than 40 deaths and thousands of livestock lost in the storm point to the need for improved preparedness and education programs.

Another major winter storm paralyzed sections of the Northeast on December 1-2, 1974. Forecast of the storm development and movement were accurate but the effectiveness of warnings was degraded by lack of a capability to accurately forecast specific areas of very heavy snowfall. Better monitoring of precipitation intensities through improved remote sensing and higher resolution numerical forecast models are needed to satisfy this requirement.

OTHER DISASTER AGENTS Other disaster agents seldom make headline news because of their infrequent occurrence or the nonspectacular manner in which they impact our Nation. Nevertheless, the warning system and preparedness programs are important to the areas and interests threatened by frost and freezes, droughts, extreme fire weather, earthquakes, tsunamis, landslides, avalanches, and volcanoes. Agricultural weather advisories are the basis for action by vegetable and fruit growers that save millions of dollars worth of crops each year from unseasonal frosts and freezes. Periodic reports of the drought assessment program contribute to more efficient management of water resources and assist the Department of Agriculture in determining the changes to crop acreage allocations needed to meet national requirements.

Exciting results from field experiments in 1974 suggest that some earthquakes can be predicted using instruments and techniques now available, but additional research into precursor phenomena is required before operational prediction systems can be implemented.

Tsunamis have not caused major damage for several years but the potential threat they pose to industrial and urban developments in coastal areas requires continued effort to develop an effective warning system. Until such a system is available, action to mitigate losses must continue to rely on the delineation of hazardous areas and coastal development practices.

Warnings of snow avalanches that threaten alpinists and skiers are provided in the mountainous western regions. No volcano eruptions have occurred in the U.S. in the past two years, but monitoring networks have detected signs that Mauna Loa is undergoing changes that may lead to eruption.

ASSESSMENT OF PROGRESS SINCE JUNE 1973

Significant progress has been made in meeting the needs identified in the June 1973 Plan. Monitoring capabilities have improved and progress has been made to strengthen warning dissemination and community preparedness. Also, longer term development for better warning dissemination and the study of weather modification are proceeding. Highlights of the improvements during the past two years are:

MONITORING

- Satellites--A two-satellite Geostationary Operational Environmental System (GOES) now provides near continuous monitoring of severe storms and hurricane development and movement over the U.S. and adjacent waters. The GOES system also provides a communications capability to collect data from remote platforms. Also, a geodynamic experimental ocean satellite (GEOS-3) has been launched to test the feasibility of measuring sea surface geometry, wave heights, and other geophysical properties of the earth.

- Weather Radars--Base funding has been obtained in FY 1975 for completion and modernization of the weather radar surveillance system which consists of a network to provide broad area coverage and local warning radars that support forecast and warning services. Procurement and installation actions are underway on five network radars to complete the planned program of 56 as well as for 66 local warning radars, 29 of which will be for new locations and 37 of which will replace obsolete radars. Plans are also proceeding for equipping all 56 network radars with digital video integrators and processors which convert radar returns into digital data as a step toward automation of radar data readout and collection.

- Automation of Hydrologic Observations--A long-term program to automate precipitation and river gages in the hydrologic observing network has begun with the installation of 144 telephone telemetry units and procurement of 73 radio equipped sets for installation in remote areas.

- Flash Flood Alarms--Some 35 flash flood alarms have been installed as part of the planned demonstration project of about 100. Several communities have purchased and installed alarms and in one notable case in Missouri such an alarm was triggered less than 48 hours after installation to give a warning credited with saving lives and much equipment.

- Electronic Tornado Detectors--Promising results have been obtained in the detection of tornadic storms with the new directional electronic tornado detectors. Further field testing and development are planned.

- Earthquake Monitoring--Significant improvements have been made in the capability to monitor solid earth geophysical parameters. Teleseismic systems have been expanded, new networks of local sesimograph systems have been established, and more crustal strain and strong motion systems have been deployed.

WARNING
PREPARATION

- AFOS--The Automation of Field Operations and Services (AFOS) will provide automated capabilities for data storage, retrieval, and processing, and for message preparation. AFOS is a major system effort to streamline and promote more effective application of manpower to warning preparation and dissemination. Prototype equipment for a model field installation has been installed for system experimental and development work and procurement action has been initiated for equipment for the first operational phase of the program.

- Severe Local Storm Forecasts--A new computerized system has been placed in use to produce objective short-range forecasts of the probability of severe local storms.

- Storm Surges--Computer-generated forecasts of extratropical storm surges have been expanded to include two additional east coast cities and the hurricane storm surge model was modified for use on gently-curved coastlines.

- Earthquake Prediction--Analysis of data from an extensive array of monitoring instruments along an active fault zone in California confirm that some earthquakes can be predicted with techniques now available.

WARNING
DISSEMINATION

- NOAA Weather Radio--The number of NOAA Weather Radio stations (VHF/FM) in operation has increased from 65 in 1973 to 77 and 46 additional sets of equipment have been procured for installation through FY 1976.

- NOAA Weather Wire--This primary system for providing detailed weather information and warnings to the mass media has been extended to 9 additional states, making it available now in 35 states.

- NAWAS--The nationwide "hotline" voice circuits of the National Warning System (NAWAS) have now been extended to a total of 218 National Weather Service warning offices.

- DIDS--The first transmitter of the Decision Information Distribution System (DIDS) designed to disseminate warnings to government officials and institutions is undergoing extensive operational testing.

- Support to Press Wire Services--A computer-to-computer link has been installed to eliminate delays in passing forecasts and warnings to United Press International and a similar link to Associated Press is planned.

- Cable TV--Direct outlet transmissions into cable TV have been expanded to 130 CATV systems serving nearly two million people.

- Disaster Warning Satellite--A study has been continued on the feasibility of a disaster warning satellite system which shows promise as a highly efficient follow-on warning system that could be operational by the mid-1980s.

COMMUNITY
PREPAREDNESS

- Coordination of Federal Programs--Increased attention has been directed to interagency coordination of Federal assistance programs to community preparedness planning. Such coordination has been further stimulated by the Natural Disaster Relief Act of 1974.

- Preparedness Specialists--Community preparedness specialists have been assigned to 14 additional National Weather Service Forecast Offices to work through community officials, law enforcement agencies, fire departments, civil meetings, school training sessions, and educational programs on disaster preparedness and to participate with DCPA in a coordinated On-Site Assistance planning effort.

- Public Disaster Education--More than a million copies of publications on disaster safety rules have been distributed during numerous meetings and training sessions for community leaders, school officials, spotter networks, law enforcement offices, and representatives of the mass media.

- Storm Evacuation Maps--A total of 42 maps designed for use in evacuation planning for coastal flooding emergencies have been completed. These maps, covering 6 densely populated sections of the Atlantic and Gulf coasts have been distributed to Federal, State, and community offices involved in preparedness planning.

- Earthquake Risk Mapping--Major advances have been made in development of new analytical methods for mapping and evaluation of earthquake geologic hazards. Initially developed for the San Francisco Bay area, these analytical methods have applications to other earthquake-prone areas.

- Flood Control--Under a continuing program, extensive emergency watershed treatment to protect life and property has been carried out in national, state, and private forest lands damaged by all types of natural disasters.

ENVIRONMENTAL
MODIFICATION

- STORMFURY--A program of modernization of reconnaissance aircraft is continuing in preparation for the conduct of hurricane modification experiments planned for the Pacific in 1977.

- Drought Alleviation--Research and field experiments are being continued in an effort to develop cloud modification technology that will allow operational applications to augment natural water supplies for all purposes. Two significant efforts are the High Plains Cooperative Program and the cumulus cloud experiments being conducted in Florida.

- Lightning and Hail Suppression--Experiments and tests in lightning and hail suppression are continuing in an effort to develop cost effective applications to reduce forest fire losses due to lightning and crop damage by hail.

HIGHLIGHTS OF FY 1976 PROGRAMS

Long-term programs for system improvement will be continued--some such as AFOS will be accelerated, and significant new programs such as SEASAT are planned to begin. Highlights of FY 1976 program plans in each element of the warning system follow.

MONITORING

- Satellites--GOES-A is scheduled for launch in early FY 1976 to provide an in-orbit backup spacecraft to the two-satellite system and plans for equipping NWS offices to receive and use the high quality GOES pictures are scheduled for completion. Also, development and procurement actions will continue for TIROS-N, the third generation polar-orbiting environmental satellite system and action will be initiated to develop requirements and applications of SEASAT data.

- Weather Radar--Equipment will be procured that is needed to continue to obtain weather information from 22 remote radars of the Federal Aviation Administration in the western United States. Also, ancillary equipment will be procured for all network weather radars to automate the integration and processing of radar data.

- Seismic Measurement--Seismograph networks will be expanded, new networks are planned for the eastern United States, and some will be upgraded with the addition of telemetry links to automated processing centers. Also, prototype seismic and tide data platforms designed for data collection through the GOES satellite will be developed and tested.

- Remote Sensing Research--Intense efforts will be continued to develop improved remote sensing capabilities, particularly for monitoring of severe storms. These include a variety of new and improved sensors for satellite systems and further tests and development of groundbased Doppler radar applications.

WARNING
PREPARATION

- AFOS--Plans exist to accelerate implementation of AFOS with the procurement of equipment for installation in 40 NWS field offices and to begin operation of the System Monitoring and Coordination Center.

- Central Guidance--Capacity of the centralized computer systems that provide support and guidance forecasts will be expanded to handle improved, more detailed numerical models and vastly increasing amounts of satellite data available from the new systems.

- Earthquake Prediction--Action will be initiated to establish a prototype earthquake prediction system for southern California. Also, new efforts will be directed to development and refinement of earthquake prediction techniques.

WARNING
DISSEMINATION

- NOAA Weather Radio--A program will be initiated for priority completion of NOAA Weather Radio nationwide. Some 331 stations are planned for installation by FY 1978 that will make warnings available to over 90 percent of the population.

- Disaster Warning Satellite--Plans are underway to undertake system definition studies of a Disaster Warning Satellite System with a view toward possible implementation by the mid-1980s.

- NOAA Weather Wire--Nationwide completion of NOAA Weather Wire is planned to make improved forecast and warning services available to an additional 2,000 radio and TV stations serving 40 million people.

COMMUNITY
PREPAREDNESS

- Planning Assistance--The on-site-assistance effort will be continued with full coordination and participation at national, regional, and local levels.

WEATHER
MODIFICATION

- Precipitation Enhancement--Research and experimental activity designed to establish a feasible cloud seeding technology for increasing water supplies will be continued.

FUTURE NEEDS

There are many multiyear programs that are underway to improve our national warning system and preparedness efforts. These include the automation of field operations and services; modernization and expansion of the weather radar network; continued operation and improvement of the polar orbiting and the geostationary operational environmental satellite systems; and nationwide expansion of the NOAA Weather Radio and the NOAA Weather Wire Service. All have been discussed in the preceding sections and it is assumed that funding levels will be maintained to assure their expeditious completion. In addition to such ongoing programs there are many future improvements needed during the FY 1977-80 period. These are summarized in the following paragraphs.

Further applications of satellite technology to the monitoring of oceanic phenomena and severe storms are important needs for the future. Improvements are also needed in the river and flood forecast and warning service. These include expanded networks of automated river and rainfall gages, new River Forecast Centers for areas not now covered, expanded operations to provide daily service, and development and implementation of improved hydrologic models for all major river basins.

A uniform national seismograph network is needed and significant research and development efforts are required if progress is to be continued on understanding, predicting and controlling seismic events. The responsiveness of all monitoring networks to short-fused disasters can be improved through automation of observing platforms and data collection. Included in the requirements are many additional ocean platforms and buoys, automatic weather stations, tide gages, and open ocean tsunami detectors. Data collection from most of the platforms in remote areas could best be performed by satellite communications links.

Continued research efforts are needed to develop and test improved numerical prediction models for both the atmosphere and the oceans. Major field experiments and tests could provide a basis for better understanding of storms and their potential impact. Models for improved hurricane and storm surge prediction and tsunami run-up must be developed to aid in warning and protection of coastal interests. Better models for severe local storms prediction are also needed to assist in reducing losses of life and property from such hazardous storms.

Improved ocean warnings, prediction and assessment services are needed to support expansive off-shore oil and gas drilling, transportation services, proposed deepwater port terminals, and activities of the general public. Greatly improved marine monitoring capabilities and cadres of specially qualified personnel will be needed to satisfy these new oceanic service requirements.

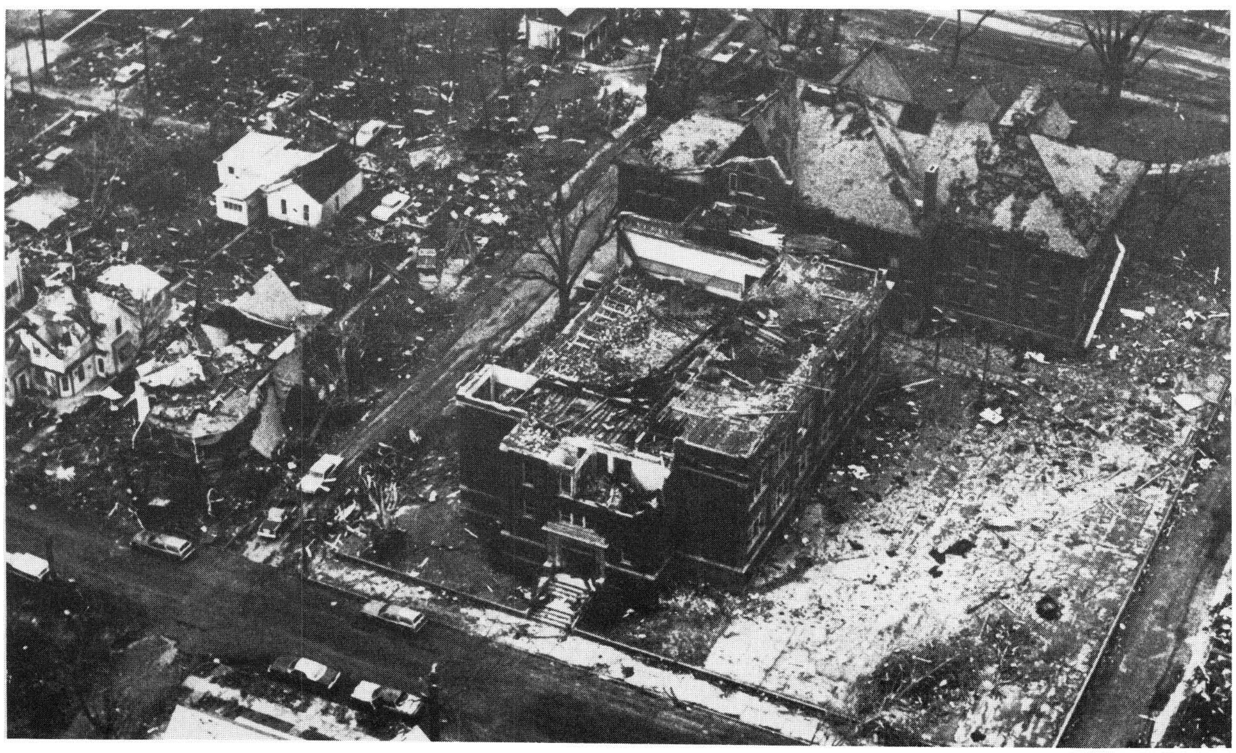
Extension of the agricultural and forestry weather services to areas of the Nation not now served is needed. Environmental studies service centers are required in seven regions and a number of state offices require specially trained meteorologists to satisfy needs of agriculture and forestry industries for specialized forecasts and advisories.

There is an overall need for a United States climate program of global analysis and assessment to support the development of national policy related to the impact of climatic fluctuations upon food production, and the distribution and availability of water and energy resources. Some specifics of the program that relate directly to mitigating the impact of droughts would be the establishment of a center for climatic and environmental assessment, the development of climatic models, and the establishment of a climate diagnostic and early warning capability to provide improved awareness of climate fluctuations and analyses of their potential impact.

By 1979 the warning dissemination system under the current concept of national multipurpose systems will be almost fully exploited with warnings being made available to over 90 percent of the population. Emergency power systems would need to be provided, however, to insure continuous operation of all key elements of this system during critical warning periods. The needs for follow-on activities, such as the development, test, and implementation of a disaster warning satellite system to provide complete nationwide coverage by the mid-1980s is contingent upon system definition studies planned for FY 1976.

Programs for preparedness planning assistance need to be expanded to all communities in disaster-prone areas and much additional effort is needed in risk assessment. In particular, an accelerated earthquake hazards evaluation program is needed and attention must be focused on all areas where a combination of population shifts, urbanization, and land use programs tend to increase the potential for a catastrophic disaster.

Damage from tornadoes of April 3, 1974, in Xenia, Ohio



Monticello, Indiana School struck by tornado on April 3, 1974.

Part I - Recent Performance of Disaster Warning and Preparedness System

Devastating floods, tornadoes, wind storms and other natural hazards pose a continuing threat to our national welfare. In 1974, more than 500 counties were declared disaster areas and damage from natural hazards totalled 1.4 billion dollars. The unprecedented outbreak of 148 tornadoes in early April 1974 left hundreds dead, thousands injured, and 600 million dollars in damage. As recently as this last January, a blizzard left at least 40 dead in the central part of the country even as tornadoes left trails of death and destruction in Mississippi and Alabama.

Recent post-disaster surveys have indicated that the Nation's warning and preparedness system has significantly reduced the disaster toll. However, there are unmet needs in our sub-systems of monitoring, warning preparation, dissemination, and preparedness. The following sections describe system performance during the major disaster events of the past two years, with underlined portions highlighting unmet needs.

TORNADOES AND SEVERE LOCAL STORMS

Weather systems that produce severe convective storms have been extremely active and numerous the past two years. A record 1,109 tornadoes occurred in 1973 and a second-highest yearly total of 944 such storms was reported in 1974. For the first time in history, damage from tornadoes exceeded half a billion dollars in 1973, but even this was eclipsed by the devastation which occurred in less than 24 hours early in April 1974. The massive outbreak of 148 tornadoes which struck on April 3-4 killed 315 people, injured over 6,000, and brought property losses to more than 27,000 families.

The NOAA team which surveyed the performance of the total warning system during this outbreak determined that hundreds, if not thousands, of lives were saved by effective warnings, the actions of radio and television broadcasters, preparedness activities, and proper public response.

In spite of the overall effectiveness of the system, unmet needs were identified. The team recommended the rapid expansion of community preparedness activities, noting that far too few communities have local action plans, spotter networks, or sirens. This was particularly true in areas where tornadoes are very infrequent. The experience of communities in which effective plans, public education, and periodic drills combined to produce a high degree of readiness show that people can survive even when destruction of homes and property is almost unbelievable. The time of devastation of six schools in Xenia, Ohio, fortunately was after pupils were dismissed for the day, since no program had existed for tornado safety education and drills in those schools. Residents of mobile homes were especially vulnerable during the outbreak, and a need exists for widespread use of tie-downs and shelters in mobile home parks. In short, much can be done to strengthen the vital preparedness link in the total system.

Needs were also apparent in monitoring these severe storms. Radar was found to be absolutely essential to the success of the warning program, yet the Nation's long-range and local warning radar network is incomplete. The survey team recommended the rapid completion of the radar program, including the replacement of obsolete local warning sets of World War II vintage. Nearly continuous information from the Advanced Technological Satellite (ATS) proved useful during the outbreak but was limited by its daytime only capability and relatively low resolution. The team urged the rapid exploitation of the more advanced spacecraft instrumentation which has become available since the outbreak. (Synchronous Meteorological Satellites were launched in May 1974 and February 1975, as forerunners of the Geostationary Operational Environmental Satellite (GOES), scheduled for launch in October 1975. The new spacecraft overcame the daytime-only capability and relatively low resolution limitations of the earlier satellites. High resolution images are now being operationally produced 24 hours a day. Provision of ground read-out equipment in forecast offices is well underway and experience is being gained in utilizing this improved imagery.) While radar "hook" echoes were detected with many of the tornadoes, this was not the case with all of the killer storms, and a need exists for a positive method of tornado detection.

Power outages adversely affected some of the warning and radar offices during the outbreak. The survey team recommended that emergency power generators be quickly provided for those offices lacking this equipment.

Dissemination systems operated at peak capacity during the tornado outbreak, and the cooperation of the country's radio and television stations was exemplary. However, the widespread geographical extent of the storms along with their rapid development and movement made the time factor extremely critical. The team concluded that faster dissemination is needed and recommended the rapid expansion of the NOAA Weather Radio program, the completion of the Automation of Field Operations and Services (AFOS) program, and continued efforts to increase the number of subscribers to the NOAA Weather Wire Service. The National Warning System (NAWAS) operated by DCPA was found to be effective for both collecting severe weather reports and disseminating warnings. Local hot lines located in some metropolitan areas were also helpful in dissemination. On the other hand, dial telephone outages and busy signals frustrated some attempts to disseminate warnings and the team urged elimination of this method of warning dissemination in short-fused hazard situations.

The team also recognized the need for improvement in forecast and warning preparation. The potential threat of the storm system was noted well in advance, with the outlook issued early the morning of April 3 containing practically all the tornadoes which occurred in the 24-hour period. Most of the tornadoes were in valid watch areas. However, it was concluded that these watches would have been more effective with greater forecast lead time and that confusion resulted from the sheer number of watches and some overlapping of watch areas. The team recommended the establishment of a techniques development staff at the National Severe Storms Forecast Center to aid in merging the use of new and conventional data into improved forecasts and warnings. Procedures for simplified description of watch areas in outbreak situations were also recommended.

About two months after this disastrous storm outbreak, a smaller tornado outbreak struck sections of Oklahoma, Kansas, and Arkansas. Hardest hit were portions of eastern Oklahoma. Drumright, a community of 4,000 persons, reported 12 dead and $3.5 million in damage, while Tulsa, a city of 350,000 had its first tornado fatality in history and between $20 and $27 million in damages. Illustrating the advantages of fairly complete and integrated phases of the warning and preparedness system, the NOAA Disaster Survey team stated:

> "The outstanding feature of these tornado and flood events was the very outstanding, textbook performance of the preparedness and warning systems displayed by National Weather Service offices, community civil defense organizations, mass news media, amateur radio organizations, police and fire departments, and others.
>
> The real threat of widespread tornadoes and flash flooding was recognized by all Weather Service echelons early in the morning, 12 hours or more in advance of the storms' onslaught. Immediate action was taken to relay this information to the public through the mass news media, civil defense and law enforcement agencies. Many follow-up actions were taken to emphasize the threat, and to set in motion all possible preparatory actions, including urgent requests to review tornado safety rules. Additional personnel were called to duty, hours before the expected storms. Communication systems were tested and augmented. Then, when the threat became more imminent, tornado watches were issued; spotter networks and auxiliary communication systems were activated. When the tornadoes were detected by radar or sighted visually, tornado warnings were given immediate and widespread dissemination--followed by warning sirens in areas where the tornadoes were taking direct aim. The populace in these areas heeded the watches, warnings, and sirens. Protection was taken in storm shelters, basements, interior hallways, and other protected

areas. All persons in the storm areas agree that the warnings saved scores of lives. Mayor LaFortune of Tulsa and others publicly praised the National Weather Service for its magnificent job, attributing the low loss of lives to the warnings and their dissemination by the mass news media."

Numerous other tornado events the past few years reinforce the findings of these survey teams. The Memorial Day weekend (May 26-28) of 1973 saw 97 tornadoes strike poritions of 19 states. One of these hit Jonesboro, Ark., late the night of the 26th, about five years after another tornado had struck the community. Below is a comparison of the readiness and the impact in Jonesboro for the two events:

Readiness

1968	1973
No Weather Wire Service	Statewide NOAA Weather Wire
Radio & TV stations did not disseminate watches and warnings	Radio & TV stations did disseminate watches and warnings
No organized spotter network	Organized spotter network in action
No educational programs, emergency operations center, or disaster drill procedures	Extensive educational program, emergency operations center, and disaster drill procedures

Impact

1968		1973
25,000	Population	29,000
34	Deaths	2
458	Injuries	246
82	Hospitalized	21
$8 Million	Damage	$50 Million

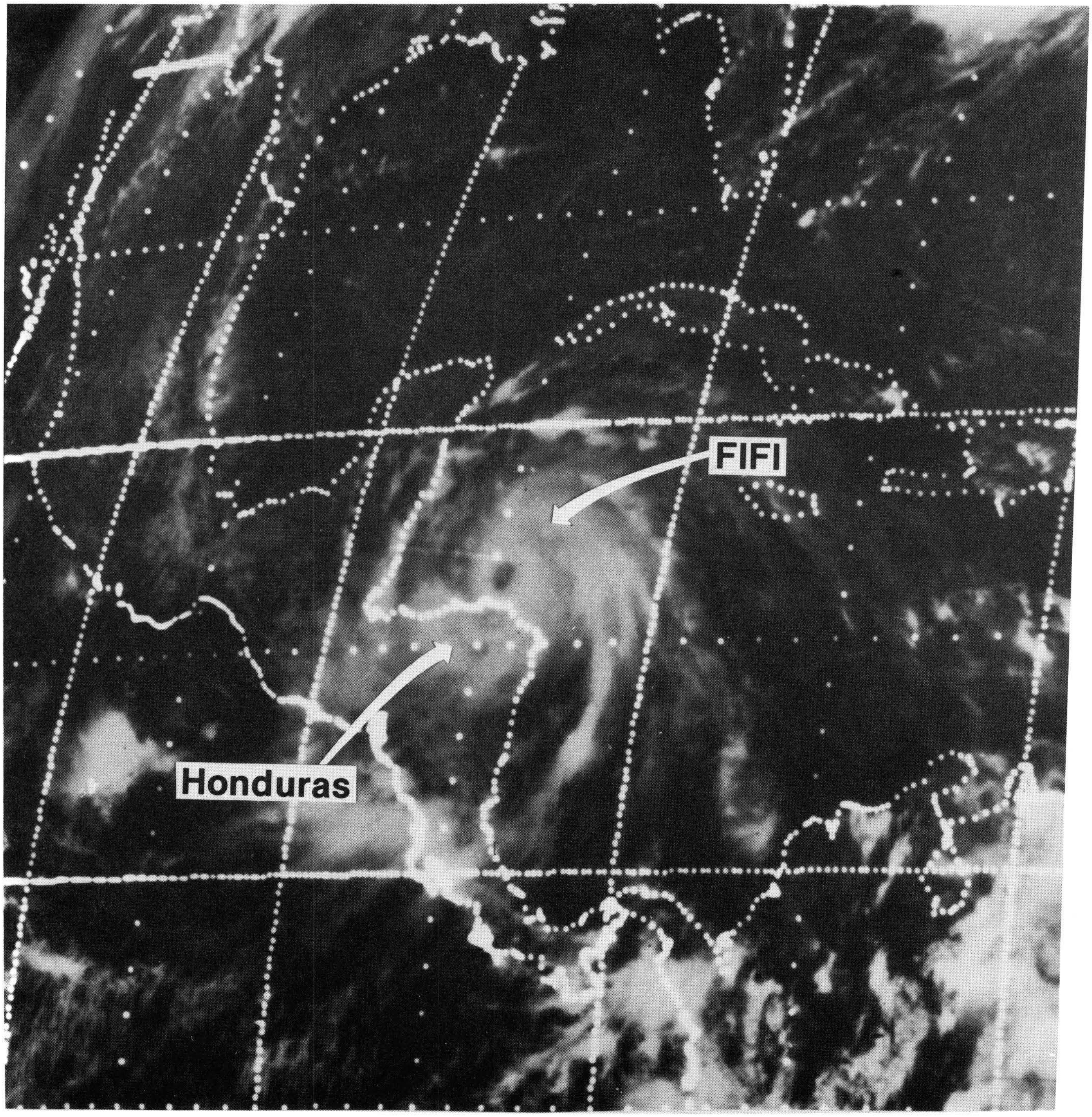
Mandatory tornado drills in Mississippi schools paid off again early this year. Three schools in the Macomb area were badly damaged on January 9, but children and teachers had taken shelter and were spared serious injury. Unfortunately, legislation requiring such drills has been enacted or is pending in only five states (Mississippi, Illinois, Indiana, Kansas, and Ohio).

Survey findings that improvements are needed in tornado forecast techniques are borne out by verification statistics. While considerable variation is noted from year to year, about 40 percent of the tornado watch areas verify (i.e., have one or more storms occur within the area). About one-third of all reported tornadoes occur in valid watch areas, although 56 percent of tornadoes causing deaths have been in or close (within 25 miles) to a valid watch area. Watch areas average about 26,000 square miles, slightly larger than West Virginia, and this results in alerting far more people than is desirable.

TROPICAL STORMS AND STORM SURGES

Despite the fact that the past two hurricane seasons were below normal in numbers of Atlantic hurricanes and in storms directly affecting the United States mainland, disasters in other countries served to stress the need for continued attention to our hurricane warning and preparedness activities. Torrential rains from Hurricane Fifi left at least 3,000 dead in Honduras in October 1974, while Darwin, Australia suffered 45 deaths and damage of $250 million when an intense tropical cyclone hit there during December 1974. On the Atlantic and gulf coasts, the number one killer from natural disasters is the hurricane storm surge. Growing population in these regions, coupled with the fact that many of these same areas have not been affected by a major hurricane in a number of years, make it imperative that public education and community preparedness activities be strengthened. At the same time, we need to improve our monitoring and increase our understanding of tropical storms and the associated storm surges so that we can reduce overwarning and increase advisory lead time, thereby reducing the disaster potential of these storms. Current hurricane storm surge models can be applied only to straight-line coastal segments. New models are needed that will simulate flooding in vulnerable bays and estuaries.

Hurricane Carmen, the only named tropical cyclone to strike the United States in 1974, was the most intense Atlantic hurricane since Camille in 1969. Fortunately, this storm weakened somewhat just before its September 8 landfall on the Louisiana coast and more rapid weakening followed landfall. Highest sustained wind measured over Louisiana was 75 knots at Morgan City. Rainfall amounts over land were mostly 6 inches or less, while reported storm tides ranged up to six feet along the Louisiana coast. Responding to frequent and relatively accurate advisories--the 24-hour landfall forecast was in error by 40 nautical miles--more than 75,000 people, mostly in Louisiana and Mississippi, evacuated low-lying areas ahead of the hurricane. The only fatality caused directly by Carmen was an electrocution by a fallen power line. A turn toward the northwest as the hurricane reached the coast south of New Orleans spared that city considerable damage. About $90 million of the $150 million in damages in Louisiana



Hurricane FIFI as seen by NOAA's Synchronous Meteorological Satellite (SMS-1) at 10:00 a.m. (EDT), September 18, 1974, a few hours before she made landfall. This is a 2-mile resolution picture taken on the visible band. SMS-1 was launched by NASA on May 17, 1974.

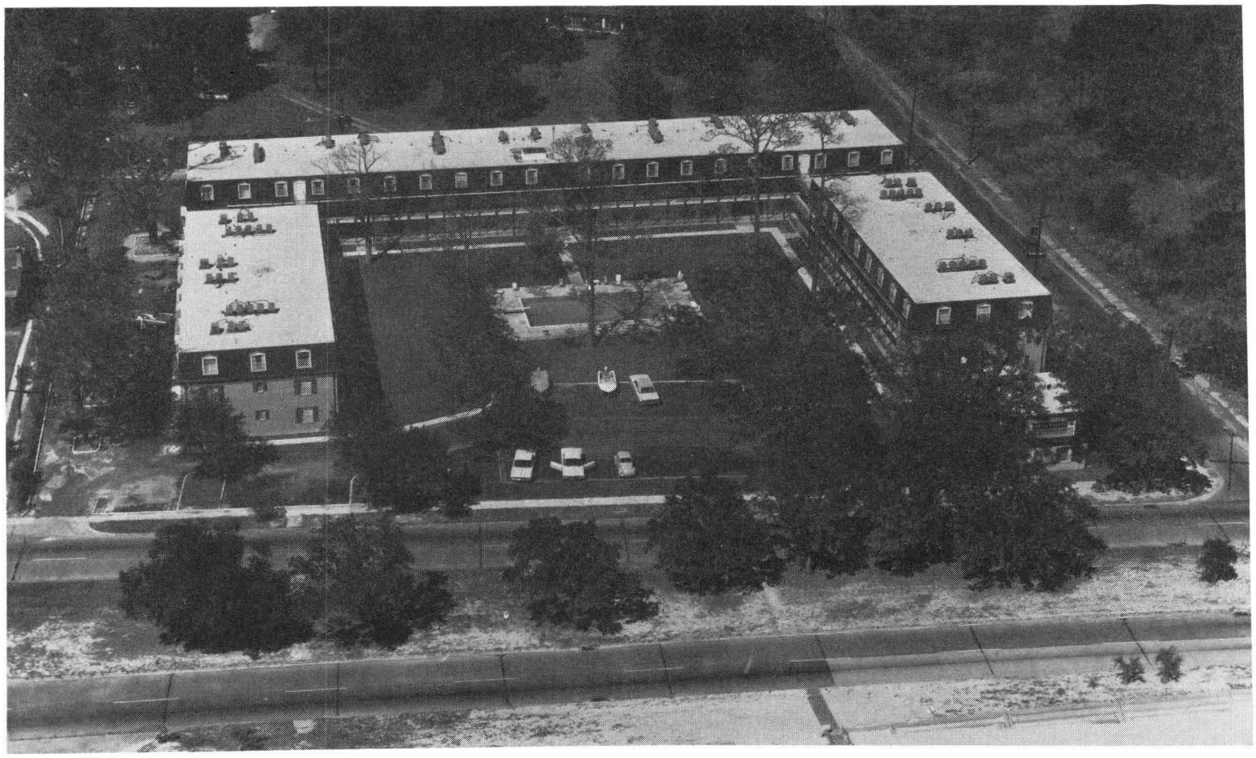
was due to crop losses. Some losses were also sustained by offshore oil installations and the shrimp industry. Carmen caused damage in excess of two million dollars in Puerto Rico, mainly due to flash flood and a tornado caused by the developing storm.

In the only significant storm landfall of 1973 in the United States, Tropical Storm Delia brought sustained winds of 40 to 50 knots and gusts to 60 knots from Freeport to Galveston, Tex. Taking an erratic path, Delia reached the coast near Galveston on September 3, looped, then moved back onshore in the same area 24 hours later. Tides of 5 to 7 feet above mean sea level in Galveston Bay caused flooding of the Baytown area and an estimated three million dollars in losses to homeowners. Only minor losses were reported from marine interests, but 8 to 10-inch rains over southeast Texas and southwest Louisiana caused an additional three million dollars damage to crops. These agricultural losses were raised to an estimated $15 million when a strong tropical depression became nearly stationary over the same area 5 days later and dropped an additional 15 inches of rain on southeast Texas. There were five deaths indirectly attributed to Delia in the Houston-Galveston area.

While remaining well-offshore, Tropical Storm Gilda generated pounding surf which caused considerable beach erosion and some property damage from Florida to New Jersey from October 20-27, 1973.

A subtropical storm which formed in the eastern Gulf of Mexico moved across the Florida peninsula on June 25, 1974. This storm packed sustained winds of 30 to 40 knots with gusts to 45-55 knots. This storm and the tropical depression which crossed the coast two days later produced 20 inches of rain in the Tampa Bay area and 10 inches or more over much of west central Florida. There were 3 deaths by drowning while damage from tidal and rain-induced flooding has been estimated at $10 million.

Analysis of existing capabilities in hurricane forecasting indicates that warnings are normally issued for about 275 miles of the U.S. coast when only about 75 miles will actually experience hurricane conditions. For the last five years, the mean 24-hour displacement error for all official forecasts was 102 nautical miles. The mean 24-hour landfall forecast error for 23 storms in the past five years was 47 nautical miles, but these showed considerable variation, ranging up to 140 miles. These verification statistics indicate the need for better forecasts of hurricane movement. Forecasting changes in intensity of tropical storms is also frequently critical, and improved numerical forecast models will assist in both movement and intensity prediction. Also critical is forecasting hurricane-induced flooding. Development of new or improved storm surge numerical forecast models will help alleviate the loss of life and property.



(Before)

(After)

Apartment complex in Pass Christian, Miss., flattened by storm surge from Hurricane Camille, August 1969. (Photos courtesy of Chauncey T. Hinman.)

Some of the uncertainty in hurricane forecasting follows directly from errors in determining current intensity and center position of the storm. During the past several years, satellite imagery and interpretation have improved the accuracy and timeliness in the positioning of hurricanes as well as estimating intensities and development trends. Nevertheless, recent studies of aircraft reconnaissance and satellite monitoring show uncertainties in initial storm positioning are still on the order of 15 to 30 nautical miles and existing systems may be slow to detect rapid storm intensification. To provide improved monitoring and take full advantage of advanced forecast models, improvements in satellite techniques and aircraft reconnaissance systems have been recommended by an interagency group working under the auspices of the Federal Coordinator for Meteorological Services and Supporting Research.

FLOODS Causing more than 150 deaths and well over two billion dollars in damage the past two years, flooding remains one of our most serious natural hazards. Severe flooding occurred in some part of the country every month during the past two years. A record flood on the Mississippi River and many of its branches began in March 1973, and persisted in some areas into June. During 1974 alone, 59 flash flood events caused 62 deaths and more than 30 million dollars in damages. In addition to the toll from river and stream flooding, very high water levels in the Great Lakes have aggravated flooding potential from storm surges, seiches, and wave action. The warning and preparedness system has definitely reduced the loss of lives and property from flooding, but improvements are still needed in monitoring networks, forecast and warning procedures, dissemination channels, and preparedness activities. The following sections discuss in more detail the events of the past two years in flooding along the Nation's major rivers, flash flooding of smaller streams, and shoreline flooding along the Great Lakes.

River Flooding

The major flood event of 1973 was the historic flood on the Mississippi. By the end of March, the river was above flood stage from Iowa to Louisiana, some 1,300 miles. Nearly 16 million acres were inundated and more than 50,000 people forced from their homes. This flooding caused more than one billion dollars in damage, pushing the damage toll for 1973 to nearly $1.7 billion, an annual amount exceeded only in 1972, when the Agnes and Rapid City disasters occurred.

June of 1973 saw severe flooding affect many streams from New England into the Carolinas. Communities in New England suffered 11 deaths and nearly $64 million in damage. That same month, floods in three river basins in Texas cost 10 lives and over $100 million.

Rescue from James River, Va., July 1973
(National Guard Association Photo)

Historic Mississippi River flood of April 1973 in Hannibal, Mo.
(National Guard Association Photo)

In 1974, the January floods in the far Northwest were the most costly, with damages estimated between $200 and $300 million in California, Oregon, Washington, and Idaho. Despite the severity of this flooding, which drove thousands from their homes, only six lives were lost to drowning.

Flood forecasts for the Nation's major rivers and tributaries are generally quite good and have contributed to saving lives and property. Recent examples from flooding on the West Coast back this up. Using accurate NOAA forecasts, operators of the Oroville Dam were able to "hold back" on releases which otherwise would have been required for flood prevention, thereby saving some $880,000 in hydroelectricity potential. Flood forecasts made 36 hours in advance permitted two West Coast companies to save $750,000 worth of chemicals stored near the lower Columbia River. Six thousand cattle worth about $3 million were removed to safety from the Eel River Delta in California following the receipt of timely flood forecasts. In another instance, cattle worth $200,000 were lost, despite three specific warnings they were in danger.

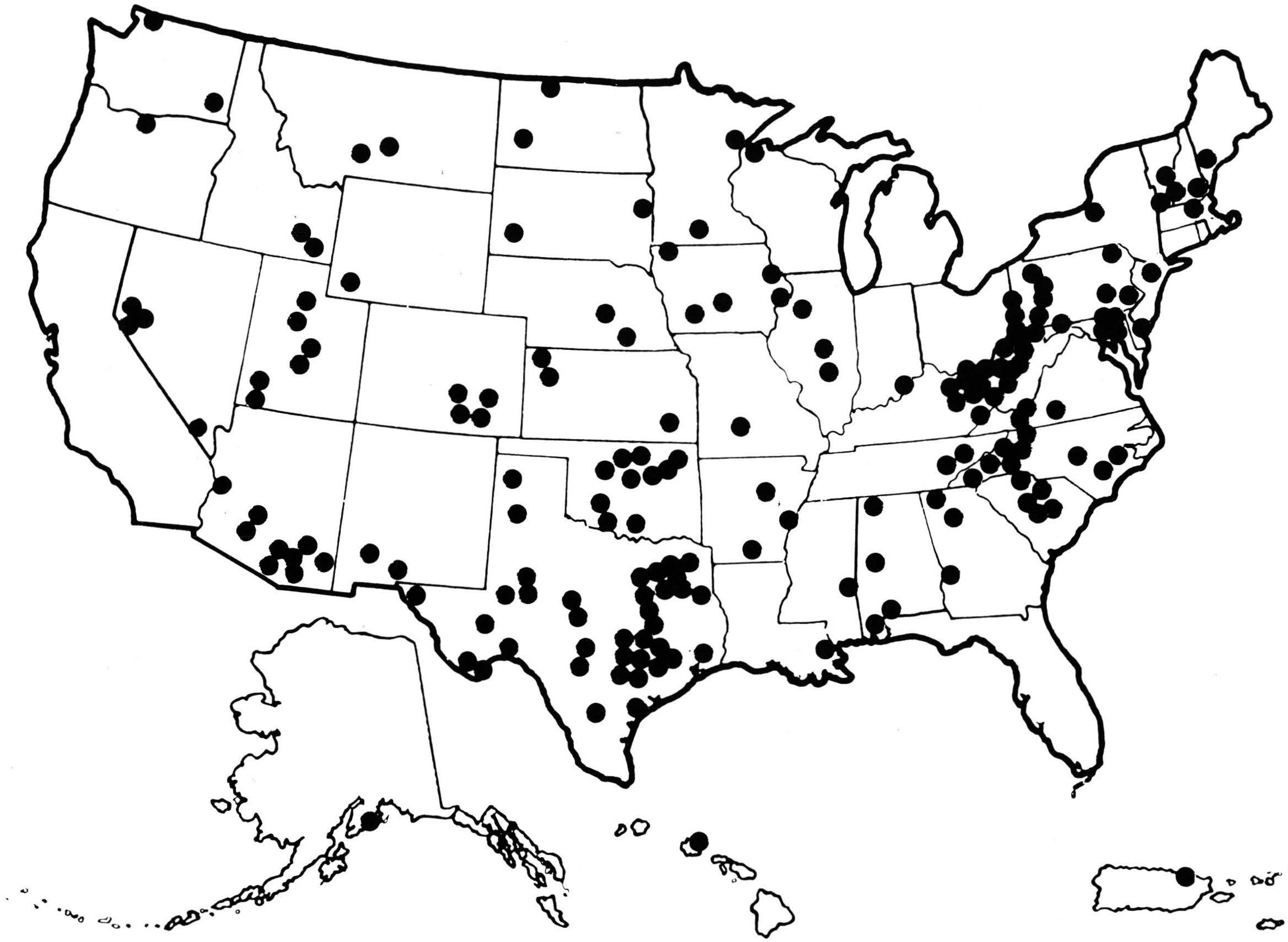
There are unmet needs in warnings for major tributaries, particularly for those on which time between rainfall and flooding is relatively short. In these cases, faster collection of reports and preparation of warnings are needed. Flooding caused by ice jams needs better forecast techniques, as do the problems associated with snowmelt flooding. A hydrologic forecast model is now available which has produced quite accurate and more rapid forecasts for the Lower Mississippi River. Additional personnel in NOAA River Forecast Centers will speed required fitting of this model to other basins.

Flash Flooding

Flooding of small streams and tributaries in which only a few hours elapse between rainfall and overflow is termed flash flooding. In such cases, there is not sufficient time to collect stage and rainfall information, transmit this data to River Forecast Centers, prepare the forecasts, and finally disseminate effective warnings to concerned areas. Most recent surveys indicate at least 10,000 communities in the United States are potential victims of flash flooding. The map on page 26 shows the locations of major flash flood events in the period 1971-74.

The 59 significant flash flood events reported in 1974 affected 24 states and Puerto Rico. The 62 deaths which resulted occurred in Nevada, Arizona, New Mexico, Texas, Oklahoma, South Dakota, Iowa, Missouri, Arkansas, Pennsylvania, New Jersey, Hawaii, and Puerto Rico.

SIGNIFICANT FLASH FLOODS
1971-1974



Flash flood watches, based on forecasts of heavy rains and generally issued for fairly large areas, were in effect prior to many of the flash floods during the past two years. Flash flood warnings for specific localities, issued after rainfall has been measured or estimated and the streams have usually already begun to rise, were effective in some cases, but by no means enough. Improvements needed in the flash flood warning program include better precipitation forecasts, installation of equipment to rapidly provide quantitative radar estimates of rainfall intensity, expansion of the number of communities protected by flash flood alarms and/or self-help forecast schemes, better dissemination systems, and increased public awareness and readiness. Flash flood alarms have been installed in 35 locations, including two municipally-owned alarms in Tulsa, Okla. An alarm installed in southeast Missouri this past winter provided a vital warning credited with saving lives and property only two days after it was commissioned. In many cases, flash flood alarms are not feasible due to stream configuration and community location. In many of these, a self-help forecast scheme provided by NOAA's River Forecast Centers and utilizing community networks and officials gives warnings in time to be effective. In certain locations, a combination of alarm and forecast scheme provides the optimum warning system. To date, self-help forecast schemes have been provided for about 150 communities.

Great Lakes Shoreline Flooding

Record high levels existing on the Great Lakes a few years ago have subsided somewhat, but water levels remain abnormally high. This has resulted in aggravating the shoreline flooding and erosion due to storm surges (primarily associated with strong winds produced by winter storms) and increasing the potential for damage from seiches and wind waves. A number of instances of shoreline flooding have occurred the past two years, with the most significant in the southwestern end of Lake Erie and the Saginaw Bay area of Lake Huron. Warnings of this flooding were timely and, in at least one instance, prompted evacuation of threatened families. (An additional problem involved in flooding due to winter storm surges in that area is the heavy snow which frequently occurs with the flooding and hampers evacuation efforts.)

Objective guidance forecasts of wind waves and storm surge are now available for the Great Lakes. An objective technique exists for forecasting seiches on Lake Michigan, but such procedures are not yet available for predicting this relatively rare event in other areas. Research aimed at producing such procedures is needed.

WINTER STORMS

What has been called "The Blizzard of the Century" in the upper Midwest struck on January 10-12, 1975. Up to 2 feet of snow fell in Minnesota with a foot or more in Nebraska, the Dakotas, and Iowa. Winds as high as 90 mph piled snow in monumental drifts. While this storm caused over forty deaths and the loss of livestock by the thousands, a greater tragedy was averted by early warnings issued by the National Weather Service (NWS) and the widespread dissemination provided by mass media and governmental communication channels.

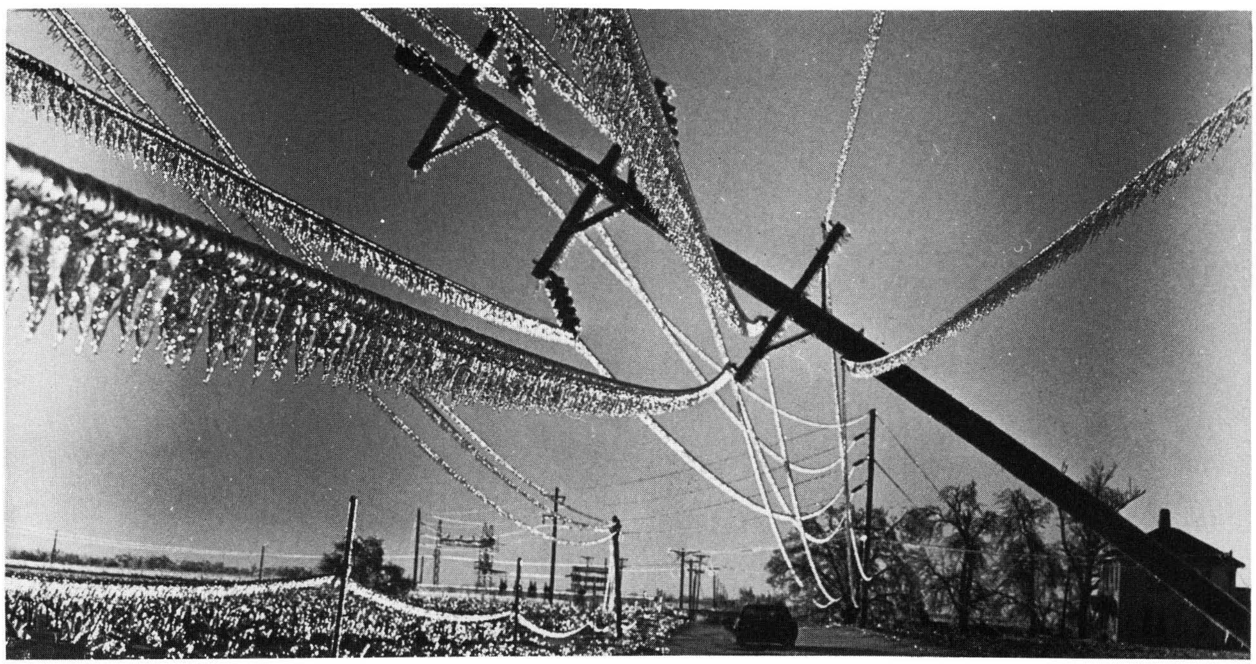
Most areas were advised well in advance to prepare for a bad storm. To quote the headline from the January 13 edition of the St. Paul Pioneer Press: ". . .NWS Warnings May Have Saved Hundreds of Lives." However, the hundreds of stranded travelers and massive livestock losses point to weaknesses in preparedness and education activities.

A post-analysis of this winter storm showed that the mathematical models prepared by the computers at the National Meteorological Center contributed to early warnings with an excellent forecast of movement and intensification of the storm. Numerical guidance has proven to be of major value in handling the dozens of winter storms which have affected some portion of the Nation the past two winter seasons. However, there remain definite limitations to forecasting the smaller-scale extreme conditions associated with these storms. For example, the big storm which lashed the eastern part of the country on December 1-2, 1974, was handled very well by the numerical models and an excellent job was done in forecasting the high winds, heavy rains, and temperature changes connected with this system. The forecast fell short, however, in defining the very heavy snow areas.

Recognizing the limitations in being able to observe and forecast the relatively narrow bands of heavy snow, freezing rain, and other phenomena accompanying these winter storm systems, NOAA issues "Winter Storm Watches" as far in advance as practicable and prepares shorter period warnings for the specific elements expected. Better monitoring, such as from newer satellite systems, and higher-resolution numerical forecast models, are needed to improve winter storm warnings.

FROST AND FREEZE

Sunday night, January 12, 1975, temperatures dipped into the teens and lower 20's in the Rio Grande Valley of southern Texas. The following night, temperatures were almost as low. Yet damage to citrus crops was considered minimal and at least 8,000 acres of vegetables were saved by flood irrigation in the Edinberg-McAllen area. The protective measures to alleviate the crop losses followed excellent forecasts and warnings issued by the NWS Office at Brownsville.



Winter storms cause deaths, damage and untold misery each year. (Snow picture courtesy Chicago's American; ice picture courtesy Illinois Rural Electric News)

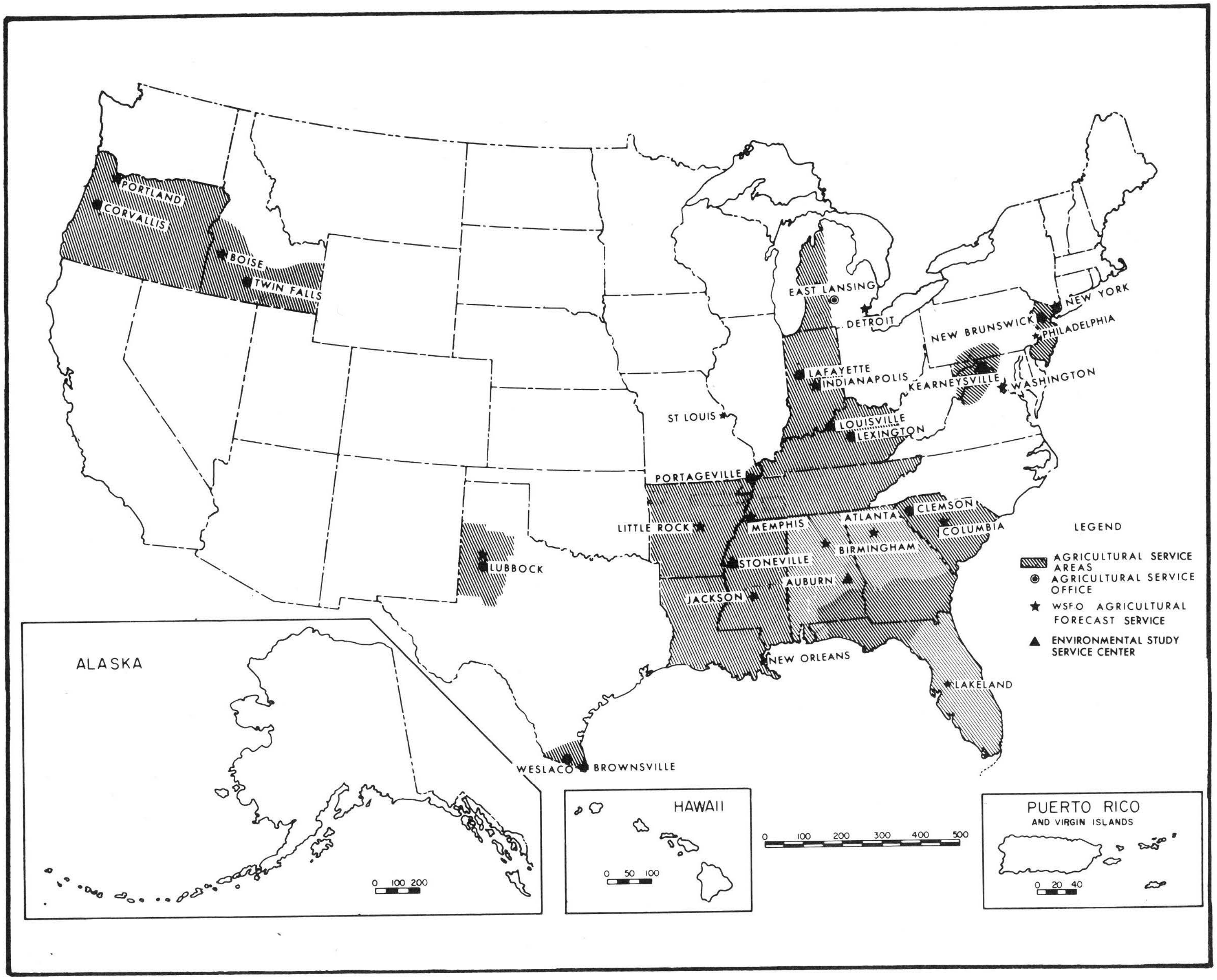
An Agricultural Weather Advisory issued the evening of January 6 alerted citrus and vegetable interests that very cold arctic air poised over northwestern Canada was starting to drift slowly southward. On Thursday, January 9, a morning advisory indicated that cold temperatures were possible on the weekend. As the cold air approached, forecasts became more specific. Utilizing data from a network of special observing stations and cloud information from satellite imagery, the agricultural meteorologists in Brownsville prepared and disseminated very accurate forecasts of both minimum temperatures and duration of below freezing readings.

Provision of this type of service is considered routine to those responsible NWS stations that are staffed and equipped to provide specialized agricultural weather services. In October of 1973, an early freeze with temperatures dropping into the middle teens affected the fruit growing regions of Michigan. Growers were given sufficient warning to enable them to save about half the grape crop and over one third of the apples still on the trees. When the earliest freeze of record hit Kentucky tobacco fields on October 3, 1974, growers had taken advantage of agricultural weather advisories issued as early as September 30 and saved an estimated $10 million by forced harvesting of plants still in the fields.

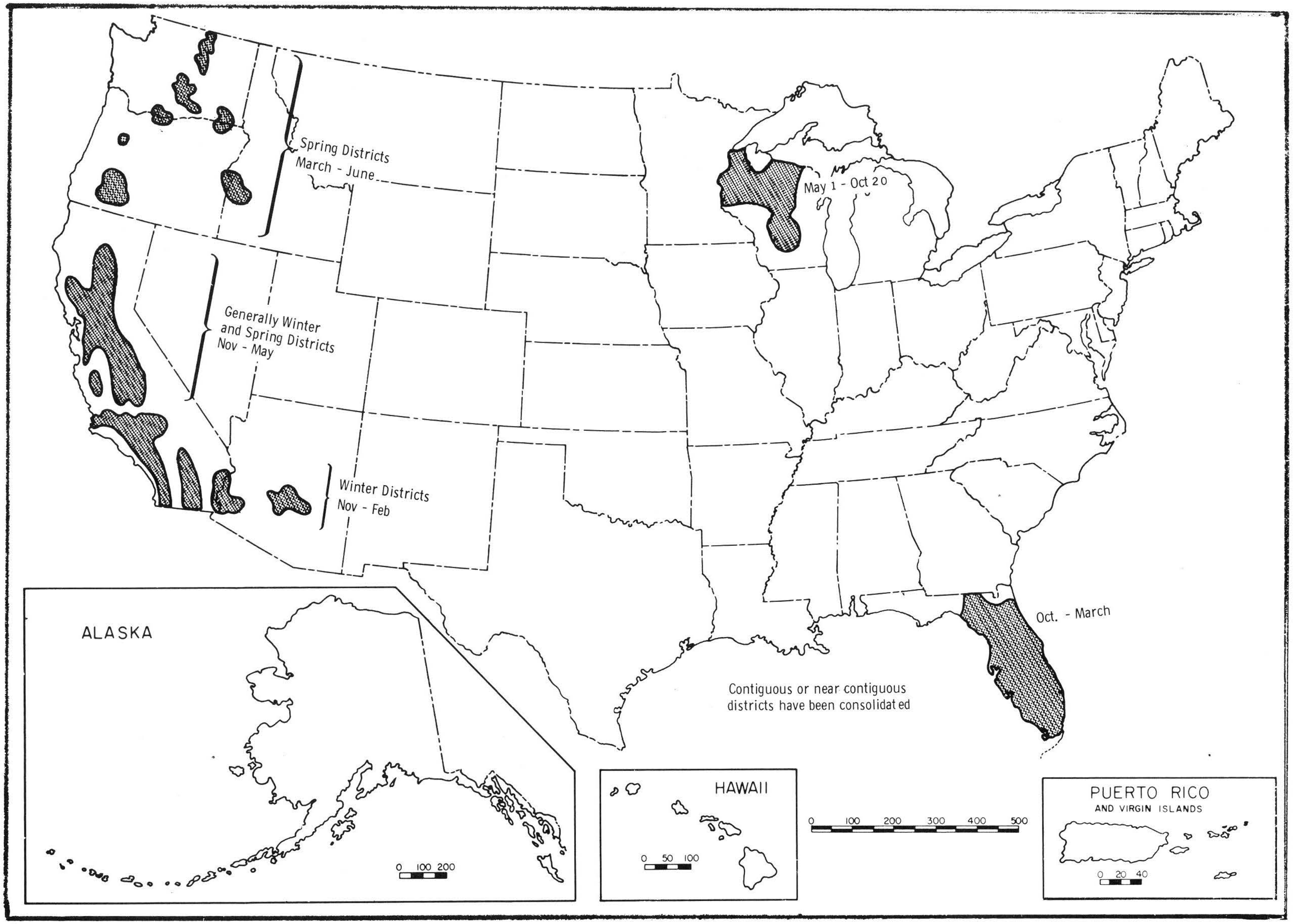
These few examples point up the value of the specialized agricultural weather service in providing frost and freeze warnings for the use of agricultural interests. And yet, this service is not available to all the Nation's farmers. Only 19 states, or portions of states, are provided with specialized agricultural weather services, which require specially-trained meteorologists, denser-than-normal observing networks, and unique forecasting techniques. (See maps on pages 31 and 32.) In some areas, dissemination of advisories and warnings is not made routinely to all who can benefit from these messages. Newly available technology, such as in the high-resolution infrared images from the latest satellites, needs to be exploited so that a truly real-time advisory service is provided all our Nation's agricultural interests.

DROUGHT NOAA's Environmental Data Service and the Department of Interior's U.S. Geological Survey (USGS) continued the past two years with their respective programs to assess the Nation's water resources and drought conditions. Periodic reports on conditions were made through the period and disseminated both in the Weekly Weather and Crop Bulletin and in regular briefings to Department of Agriculture officials.

In early 1973, the only area of significant drought was western Washington and Oregon. The Palmer Index, formerly termed the Palmer Drought Index, was used during the spring to assess the impact of the excess moisture in the Corn Belt on planting of corn and soy beans. On



AGRICULTURAL WEATHER SERVICE



FRUIT-FROST PROGRAM

the basis of this assessment, the Department of Agriculture decided that more acres should be put into production to compensate for expected lower yields due to late planting. During May and June, the drought in the Pacific Northwest spread into Idaho, Montana and California. In some areas it was the worst in 30 years, causing damage in orchards and reducing wheat production. A major impact was felt in the forests of the Northwest. By mid-August, 11,000 men were mobilized to combat over 70 major forest fires. During the fall, the drought was broken, as above-normal moisture was reported in that area. By April 1974, the areas of concern had become southern Florida and from west Texas through the southern sections of New Mexico and Arizona. By the first of June, the drought in the southwest covered all of New Mexico and Arizona, the northwest third of Texas, eastern Colorado, and Utah. Damage to wheat was high in Texas and New Mexico. As the dryness spread northward, it adversely affected row crops but provided excellent harvest conditions in the central Great Plains. Unusually dry, hot weather in late June and July caused significant damage across much of the Corn Belt and aggravated the drought in Kansas, southeast Nebraska, and southwest Iowa. By early August, the drought area had spread to cover most of the western States, while the drought in southern Florida was broken. During the early fall, the drought broke in Texas and Oklahoma and conditions had improved in Montana. However, most western States remained dry. By early 1975, the drought had intensified in the Dakotas and western portions of the central Plains but early spring snows eased the situation in the Dakotas.

Recent food shortages serve to emphasize the need to find ways to alleviate the adverse affects of drought. Improved assessment, including better techniques of prediction of climatic and crop fluctuations, and more research into precipitation augmentation are two promising avenues to ameliorate the effects of drought.

EXTREME FIRE WEATHER

Calendar year 1973, the latest for which full statistics are available, saw more than 91 thousand wildfires in the Nation's protected timberland and watersheds. Extremely serious in much of the western part of the country, it was termed the worst in many years in Montana and the worst since 1967 in parts of Idaho. It was also a severe year in Minnesota, with fire suppression costs more than double that of the previous year. Over 200 fires each burned areas greater than 1,000 acres during the year, including 62 major fires which destroyed a total of more than 310,000 acres.

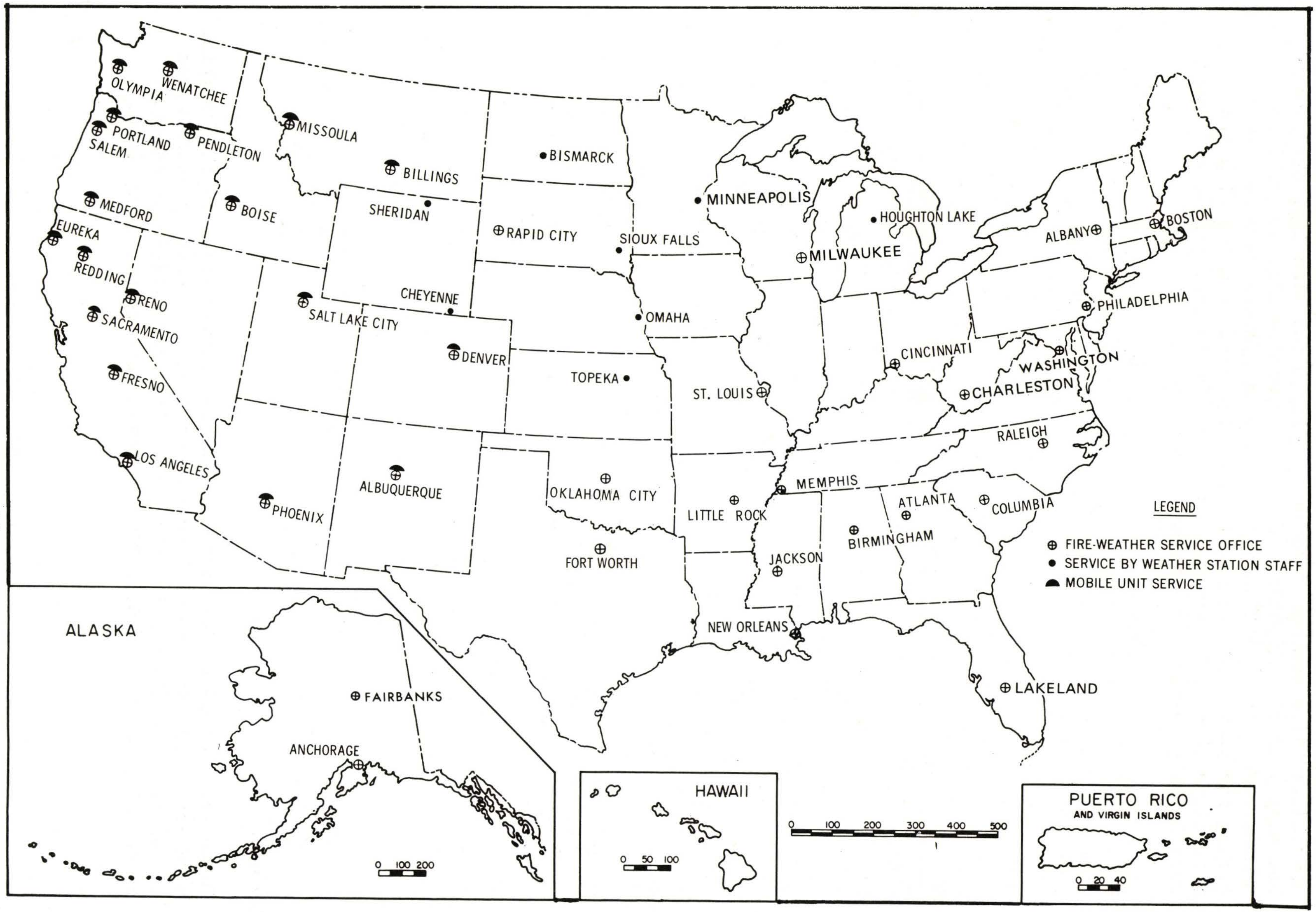
Federal and state fire control officials have spoken highly of NOAA's specialized fire weather forecasts utilized for planning, deployment and supply of fire-fighting crews, and operationally on the fire scenes. More than 55 thousand fire weather forecasts were issued during the year. As requested, specially-trained meteorologists were dispatched in mobile vans to 56 of the largest fires, and spent many hours providing "on-the-spot" services.

While most of the fire weather offices in the western portion of the Nation are adequately staffed with fire weather forecasters, increased service is required in Alaska, and in the southern, north central and northeastern parts of the country (see map on page 35). The mobile vans used in western States frequently require long, exhausting travel by the forecaster before arrival at the fire scene. Air transport of these units has been recommended by interagency task teams.

The development of better forecasting techniques is an urgent requirement, especially for local thermal and terrain-induced circulations and dry lightning storms. These lightning storms start about 40 percent of the forest fires that occur in western United States.

EARTHQUAKES Recent scientific advances indicate that reliable predictions of the time, place, and magnitude of damaging earthquakes may be feasible within a few years for some earthquake-prone areas. Field measurements, laboratory experiments, and theoretical studies of earthquake forerunners are being carried out by the U.S. Geological Survey (USGS) in order to establish a firm physical basis for prediction. The research includes monitoring and analysis of strain accumulation and release, and investigation of the behavior of rocks under conditions similar to those in the crust and upper mantle.

In California, where the greatest hazard to life and property from earthquakes exists, the USGS operates an experimental earthquake-prediction system astride a highly seismic part of the San Andreas fault near Hollister in central California. This system is composed of a dense network of seismometers, tiltmeters, magnetometers, and devices for recording horizontal strain, fault creep, and water level changes in wells. Some elements of the system are telemetered to USGS facilities in Menlo Park, Calif., thus permitting the real-time monitoring of geophysical signals. The immediate objectives of the experimental system are to establish the physical characteristic of the fault zone and to develop efficient methods for recording and interpreting the changes that occur within the earth prior to earthquakes. A long-term goal is to test hypotheses, such as the dilatancy model, that have been proposed to explain the time of occurrence of earthquakes.



OFFICES PARTICIPATING IN FIRE WEATHER PROGRAM

Within the past year, premonitory changes within the earth's crust in the test area were detected repeatedly in association with earthquakes. A magnitude 5.2 earthquake on Thanksgiving Day, 1974 near Hollister was preceded by changes in the magnetic field, tilt, and seismic wave velocity anomalies; this was the first United States earthquake for which multiple premonitory signals have been recorded. Twelve other earthquakes within the test area have shown significant changes in the direction of tilt of the land surface. These observations provide exciting confirmation that at last some of the more simple type earthquakes can be predicted and suggest that the necessary instruments and techniques for prediction are now under development or exist.

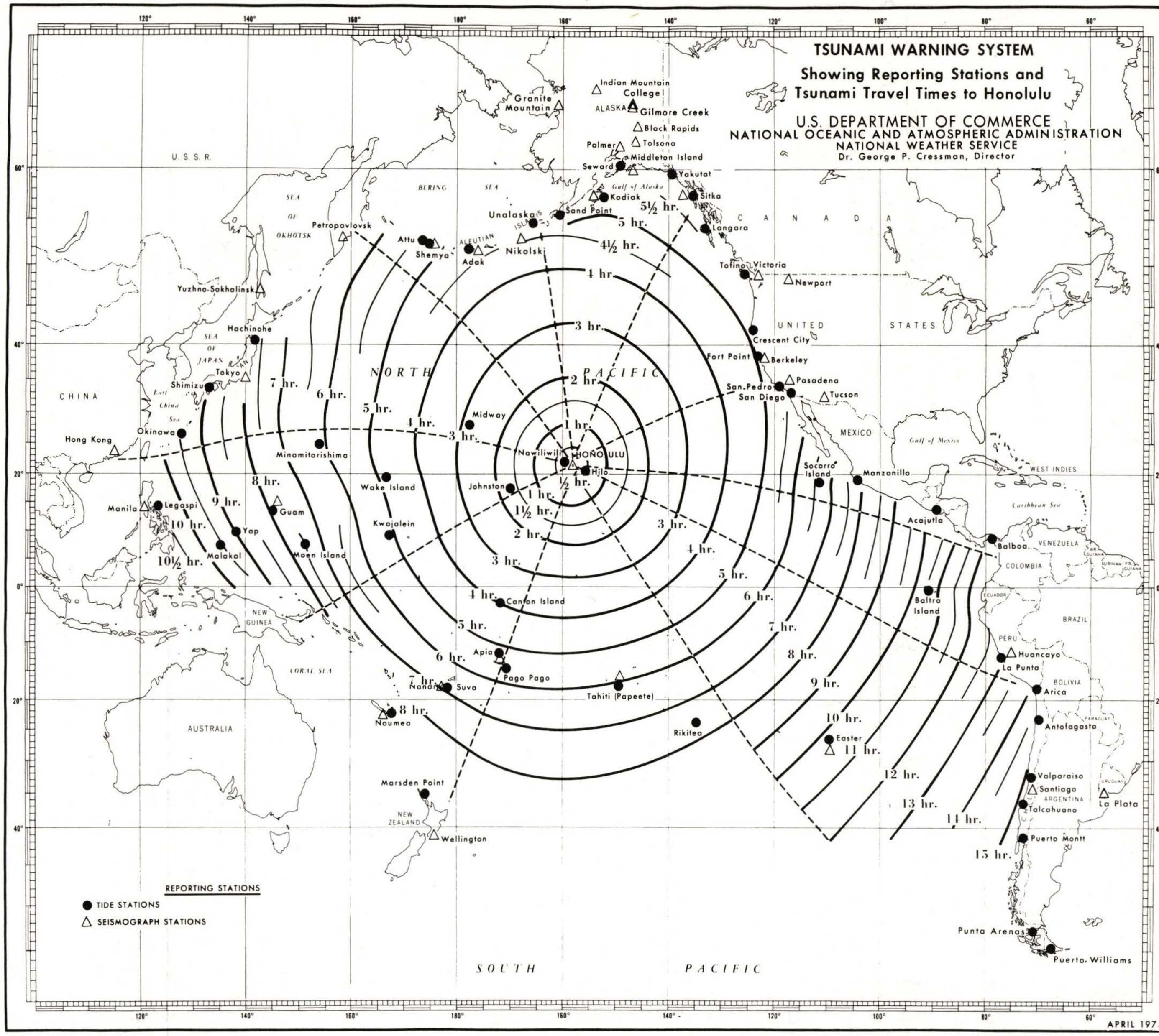
Considerable additional research into precursory phenomena is required before operational prediction systems can be deployed to protect the urban areas of California. The applicability of the Central California results needs to be tested in other, geologically more complex, regions. Deployment of a second experimental system is planned in a similar area of high seismicity in southern California along the San Jacinto fault. After the instrumentation and analytical techniques have been validated by these prototype earthquake prediction systems, coverage could be extended to the heavily populated regions of San Francisco and Los Angeles. It is estimated that this could be accomplished within five years if sufficient funding is made available.

The National Academy of Sciences (NAS), under contract with the Federal Disaster Assistance Administration (FDAA), is conducting a study to assess the social, political, economic, behavioral, and legal consequences of an earthquake prediction capability. The study should provide advice for policy formulation regarding procedures for the review of earthquake predictions, and the issuance of warnings of impending damaging earthquakes.

TSUNAMIS No major tsunamis have caused damage to the United States or its possessions in the past two years, but increasing urbanization and development of coastal areas have considerably expanded the disaster potential from this hazard.

The NWS Honolulu Observatory at Ewa Beach serves as the center of the Tsunami Warning System. The operational aspects of the Center involve the location of possible tsunami sources; detection of a Pacific-wide tsunami; and dissemination of this information to various selected areas in the Pacific Basin.

In general, potential tsunami sources are seismic areas in the Pacific. Moreover, large shallow earthquakes with faulting near or under water become prime candidates for the generation of Pacific-wide tsunamis. Since 1948, the most destructive tsunamis were generated by large



Tsunami Warning System

earthquakes of Richter magnitude greater than 7.0, but not all quakes of this intensity will produce a tsunami. Therefore, every earthquake which surpasses a threshold magnitude of 6.5 is investigated, and watches or warnings issued as appropriate.

The Warning Center has issued watches or warnings on two recent occasions which point up improvements needed in the Tsunami Warning System. An earthquake near Lima, Peru on October 3, 1974 produced a minor tsunami and caused the issuance of a tsunami watch by the Warning Center. Messages from the nearest tide gages took approximately 45 minutes to reach the Observatory, and the hand-compilation of incomplete data by our tsunami specialists meant further time expended. The watch was not issued until more than three hours had elapsed after the quake, time for a tsunami to travel several hundred miles. Four months later, on February 2, 1975, an earthquake near Attu in the western Aleutian Islands triggered the issuance of a tsunami warning for the western Aleutians and a watch for the rest of that island chain. Some residents were evacuated to higher ground and public credibility suffered when no tsunami materialized. Communications to the tide station at Shemya were disrupted and the warning was left in force until the projected disturbance would have reached Adak.

These two occasions highlight the need for more rapid and reliable tsunami forecasts, which in turn will require improved monitoring systems, communications channels, automated data handling, and modeling research. Better sensors are required and the bathymetry of the ocean floor needs to be more adequately incorporated into our forecast methods.

LANDSLIDES AND AVALANCHES

Although no individual landslides or active areas of slides have caused great loss of life or property damage in the past two years, the cumulative economic effects have continued to be quite large. The annual cost of slope failures has never been accurately documented but the estimated figure is usually at the level of several hundred million dollars.

Federal programs, primarily under the U.S. Geological Survey, are continuing in an effort to improve needed understanding of landslide mechanisms and to develop a useful warning system. Until such a system is available, the most effective technique of mitigating losses will be continued reliance on the delineation of hazardous areas and development practices. In 1973, San Mateo County, Calif., adopted guidelines for development that rely extensively on USGS maps of geological hazards including a map showing landslide susceptibility. This useful extension of landslide hazard delineation is based on integration of landslide data and related slope and geologic materials data.

Snow avalanches are common occurrences in the steep mountain areas of the United States: roughly 10,000 avalanches per winter are observed and recorded. Inevitably, a certain number of avalanche accidents occur each winter. These involve persons at home, persons at work, and especially, persons at play. The accompanying table summarizes the statistics on avalanches and avalanche accidents in the United States for the past several winters. These statistics show also that two groups of recreationists--skiers (both alpine and cross country) and mountaineers--are especially prone to the danger of avalanches.

United States Avalanche Statistics

Winter	Total number of avalanches	People				Vehicles		Damage* to		
		Caught	Buried	Injured	Killed	Caught	Damaged*	Build-ings	Ski lifts	Miscel-laneous
1971-72	6,975	168	63	17	5	21	4	11	2	12
1972-73	9,965	92	35	3	5	11	1	4	2	2
1973-74	11,782	159	92	13	13	54	16	11	2	7

*Annual property damage is roughly $250,000.

The U.S. Forest Service (USFS) has been working the past several years to increase required public awareness of avalanches. Avalanche lectures, films, training sessions, and the National Avalanche School have been part of this education effort. In addition, two continuing programs--the Westwide Avalanche Network and the avalanche warning program--are designed (1) to gather avalanche data over the western United States, and (2) to warn the public when the avalanche hazard becomes high in any given area.

In 1966 the Forest Service established the Westwide Avalanche Network that has now grown to over 60 sites in the 11 western-most states and Alaska. These stations are located at ski areas and mining operations and along mountain highways. The weather and avalanche data taken at these widespread sites are collected at the Rocky Mountain Forest and Range Experiment Station in Fort Collins, Colo.; here the data are stored and computerized for quick recall. The purposes of this data collection effort are: (1) to provide accurate avalanche statistics for the U.S. (as shown in the table above, for example); (2) to provide the basic weather, snow, and avalanche information needed for day-to-day avalanche control at the field sites themselves; (3) to generate long-term records needed to develop an avalanche danger rate scheme (a high priority research topic); and (4) to serve as a day-by-day source of information for issuing avalanche warnings to the public.

VOLCANOES Federal programs undertaken to minimize damage caused by volcanoes focus mostly on the Island of Hawaii where Kilauea and Mauna Loa pose a threat to the lives and property of more than 40,000 people.

Forecasts and Warnings

The staff of the USGS Hawaiian Volcano Observatory continues to monitor the ongoing eruption on the upper east rift of Kilauea. Special attention is now being directed towards the populated Puna district on the lower east rift of the volcano in the event that the eruptive activity shifts to that area. Ground deformation is monitored by (1) conducting precise leveling surveys to detect vertical ground displacements, (2) making laser altimeter measurements to detect horizontal ground displacements, and (3) recording ground tilt associated with swelling of the volcano as the lava moves prior to eruption. Microearthquakes associated with volcanic activity are monitored by a network of short-period seismographs providing data which are transmitted by VHF radio or by cable to the Observatory.

In May 1974, it was first noted that Mauna Loa, dormant since its spectacular 1950 eruption, is becoming restless. Geodimeter measurements in August 1974, indicated that the volcanic ediface is undergoing significant inflation, a process that will likely lead to eruption. At the request of the USGS, NOAA's National Ocean Survey is now releveling the precise network to the tip of Mauna Loa. Hundreds of earthquakes are being recorded daily and a recently recorded swarm consisted of over one thousand earthquakes in one day. Seismic and ground deformation networks are being expanded and improved in the Mauna Loa area, although badly needed high-power helicopter support is not yet available.

In the Cascade Range of the Pacific Northwest, eleven volcanoes, extending from Mt. Shasta to Mt. Baker, threaten 100,000 people with potential ash eruptions and volcanic mudflows. Although the eruptive potential of these volcanoes is not known, at least two volcanoes (Lassen and St. Helens) have erupted within the past 120 years. Studies of ancient ash layers using mineralogy and chemical data obtained from the USGS TRIGA reactor provide a key for evaluating the threat posed by future activity. A program of volcano surveillance has been initiated in which seismicity, ground deformation and temperature are monitored on Lassen Peak, Mt. Saint Helens, and Baker Peak. This surveillance system, coupled with special volcano hazards studies on Mt. Saint Helens and Mt. Shasta, marks the first step toward developing a warning system that will indicate which, if any, of the Cascade volcanoes are showing signs of returning to activity.

Research

In collaboration with the Department of Housing and Urban Development the USGS has completed a volcano hazards study of the entire Island of Hawaii to assist in establishing FHA loan participation guidelines and to assist officials and citizens of the County of Hawaii concerned with land-use policy.

Picture from NOAA-2 provided first evidence of volcanic eruption in Galapagos Islands, December 10, 1973.

One of the first one-half-mile resolution pictures received May 26, 1974, from Synchronous Meteorological Satellite (SMS-1). Seen are a squall line moving along the U.S. gulf coast, thunderstorm activity over Brazil, a cloud spiral associated with an extratropical disturbance west of the southern tip of South America, and the snow-capped Rockies. (NASA photo)

Part II - Assessment of Progress Since June 1973

Progress has been made in meeting those needs summarized in the original disaster warning and preparedness plan published in June 1973. Monitoring needed for effective disaster warning and risk assessment has been strengthened, and significant progress has occurred in warning dissemination and community preparedness. Also, the longer-term development of systems to assist in warning preparation and the study of weather modification and control are proceeding on schedule. In the following sections this progress is assessed in more detail.

MONITORING During the past two years, there have been several improvements in our capability to monitor natural hazards:

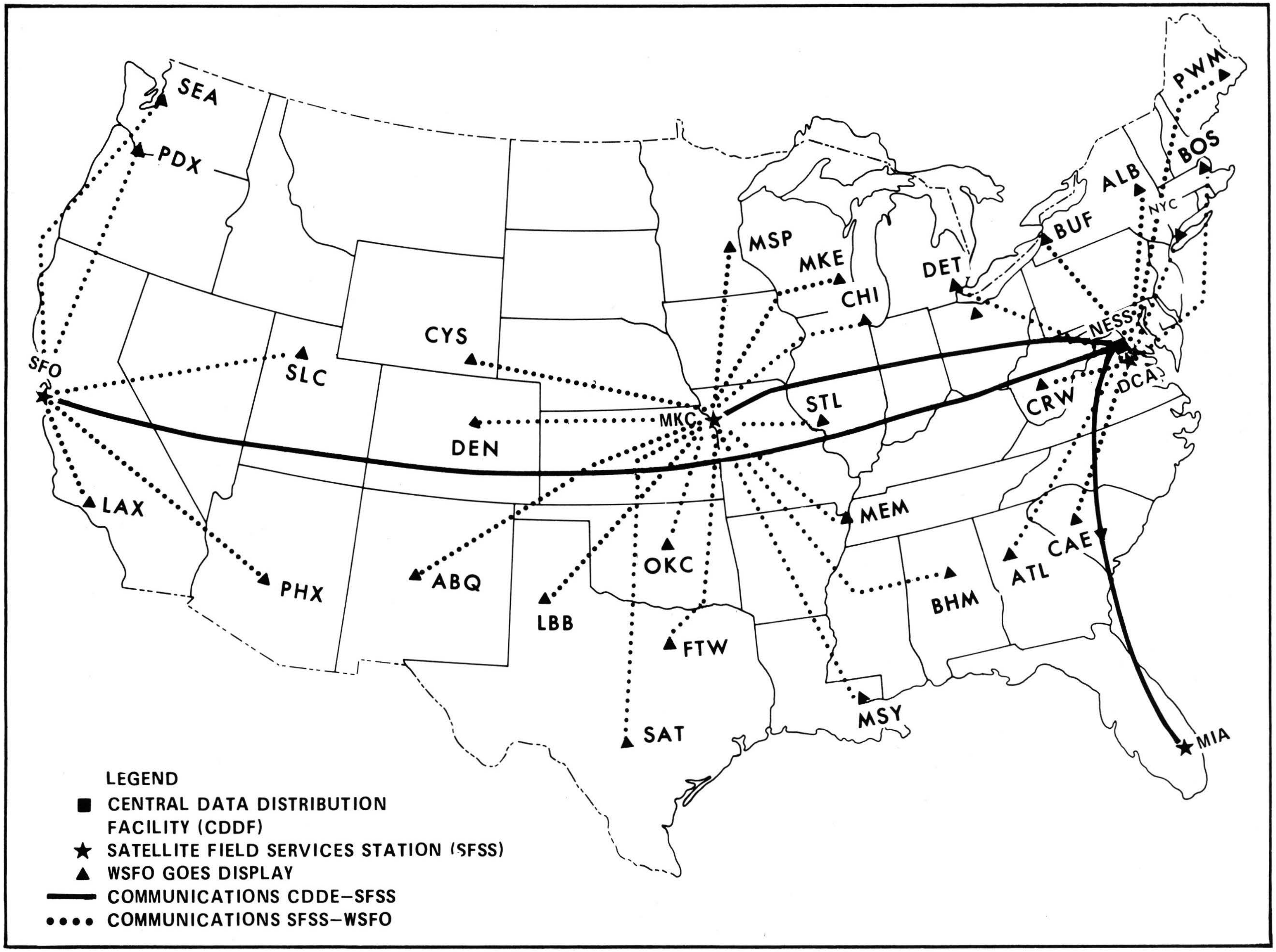
- A two-satellite system in geostationary orbit that provides near continuous monitoring of the U.S. and adjacent waters has been inaugurated. The system includes the capability of collecting environmental data from remote platforms.
- Launch of GEOS-3 (Geodynamic Experimental Ocean Satellite)
- Base funding has been obtained and steps taken to complete by 1979 the long-range weather radar surveillance and to provide a modern local warning radar capability for areas prone to severe weather.
- A beginning has been made on the Automatic Hydrologic Observation System (AHOS), with 144 telephone telemetry units and 44 radio-equipped sets installed and 73 radio-equipped sets purchased for installation during the next year.
- One-third of the demonstration project of 99 flash flood alarms has been installed.
- Research continued into automatic identification of the presence of tornadic storms; research results obtained with the new azimuth-sector-indicating electronic detectors are promising.
- Expansion and improvements in the earthquake and tsunami monitoring networks have been accomplished.

Atmospheric and Hydrologic Monitoring Systems

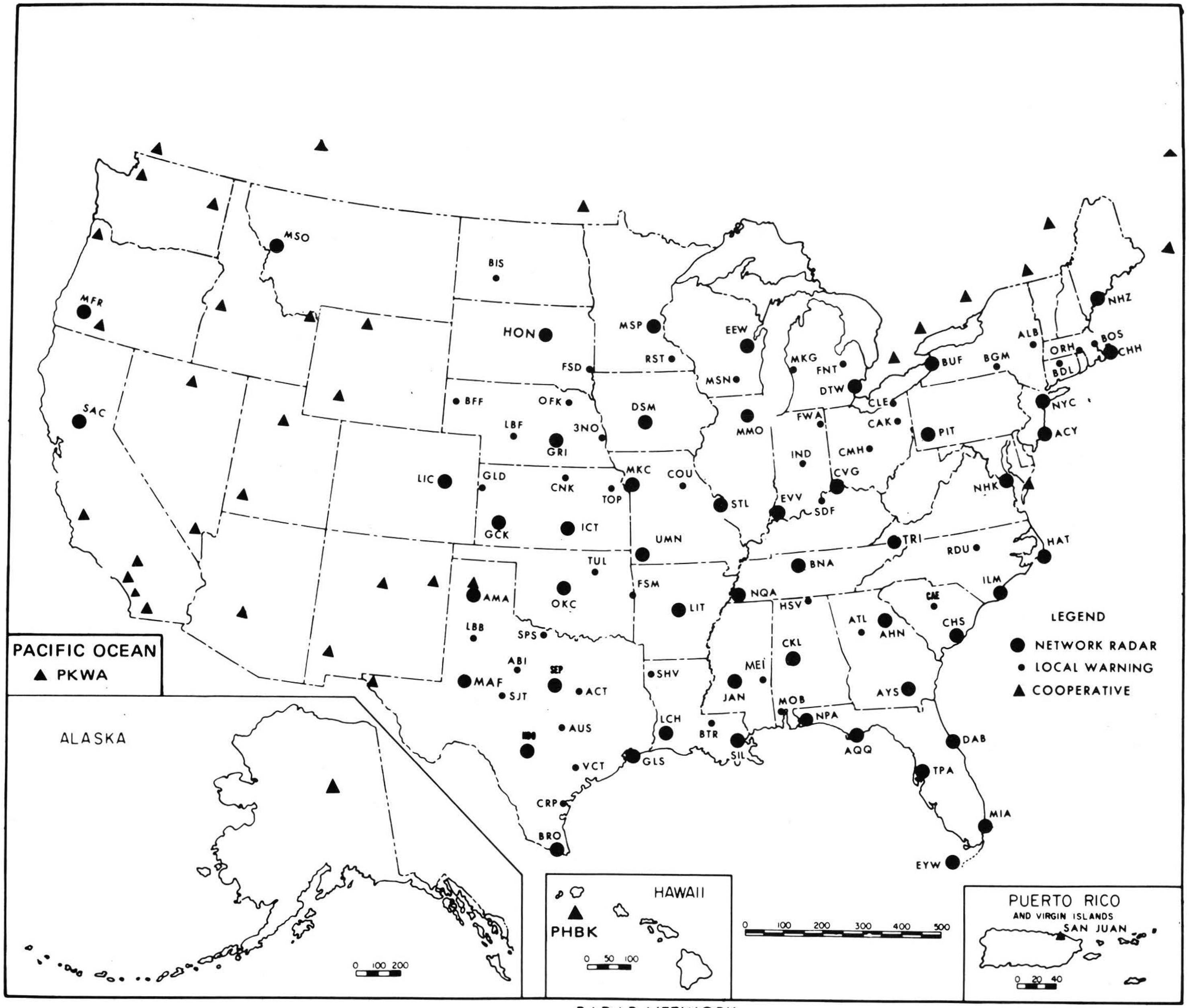
While satellite information has been available for several years, a giant step forward was taken with the launch of SMS-1 in May 1974 and SMS-2 in February 1975. These improved satellites, the first two of the GOES (Geostationary Operational Environmental Satellite) system, provide higher resolution, round-the-clock coverage with both visible and infra-red channels. With imagery available in near real-time, this advanced satellite data has improved NOAA's capability to monitor hurricanes and the development of severe local storms, to determine limited winds in data-sparse areas, and has even assisted in short-period forecasts on the duration of heavy snowfall. The purchase of the necessary photorecorders to equip all NOAA forecast offices and national centers has been completed and this equipment has been installed in 29 of 45 locations. Four Satellite Field Services Stations (SFSSs) have been established and collocated with important NWS facilities at Kansas City, San Francisco, Miami, and Washington, D.C. These stations are manned 24 hours per day with satellite meteorologists who provide satellite imagery, analyses, and advice to NWS personnel. In addition, meteorologists specifically trained in satellite data interpretation are now in place at numerous NWS Forecast Offices. Specialists in interpreting the satellite data have been assigned to 29 stations. The GOES system also includes communications equipment to collect and relay observational data from a variety of ground-based sensors. Work has also begun on the development of a third-generation polar orbiting spacecraft, TIROS-N, with NOAA, NASA, and the Department of Defense collaborating on this project.

The Nation's system of long-range network radars and the shorter-range local warning radars is being completed and modernized. Three network radars have been procured. Construction has begun on new network radar sites in east Texas and in southern Virginia and will begin soon in southern New York. Site surveys have started for network radars in western Nebraska and eastern North Dakota. Twenty-seven local warning radars procured in FY 1974 are being installed or will be installed as site surveys are finished. Another 19 of these sets have been ordered with delivery expected to begin in FY 1976. The radar system, when completed by 1979, will consist of 56 network radars (an increase of 5), and 66 local warning radars (29 new locations and replacements for 37 obsolete sets). Work is also proceeding on improving the network radars. Forty-seven of these units will be provided with digital video integrators and processors (DVIP), as a step in the eventual automation of the radar data collection.

More rapid collection of river and rainfall data is a must for improved flood warning, and the AHOS will assist in this collection. During the last two years, NOAA has procured 190 AHOS-T (telephone telemetry)



GOES PICTURE INSTALLATIONS



RADAR NETWORK

units and installed 144 of them. Also, 73 AHOS-S units equipped with radios for use with GOES communication systems have been purchased. These will be installed and commissioned during the next year.

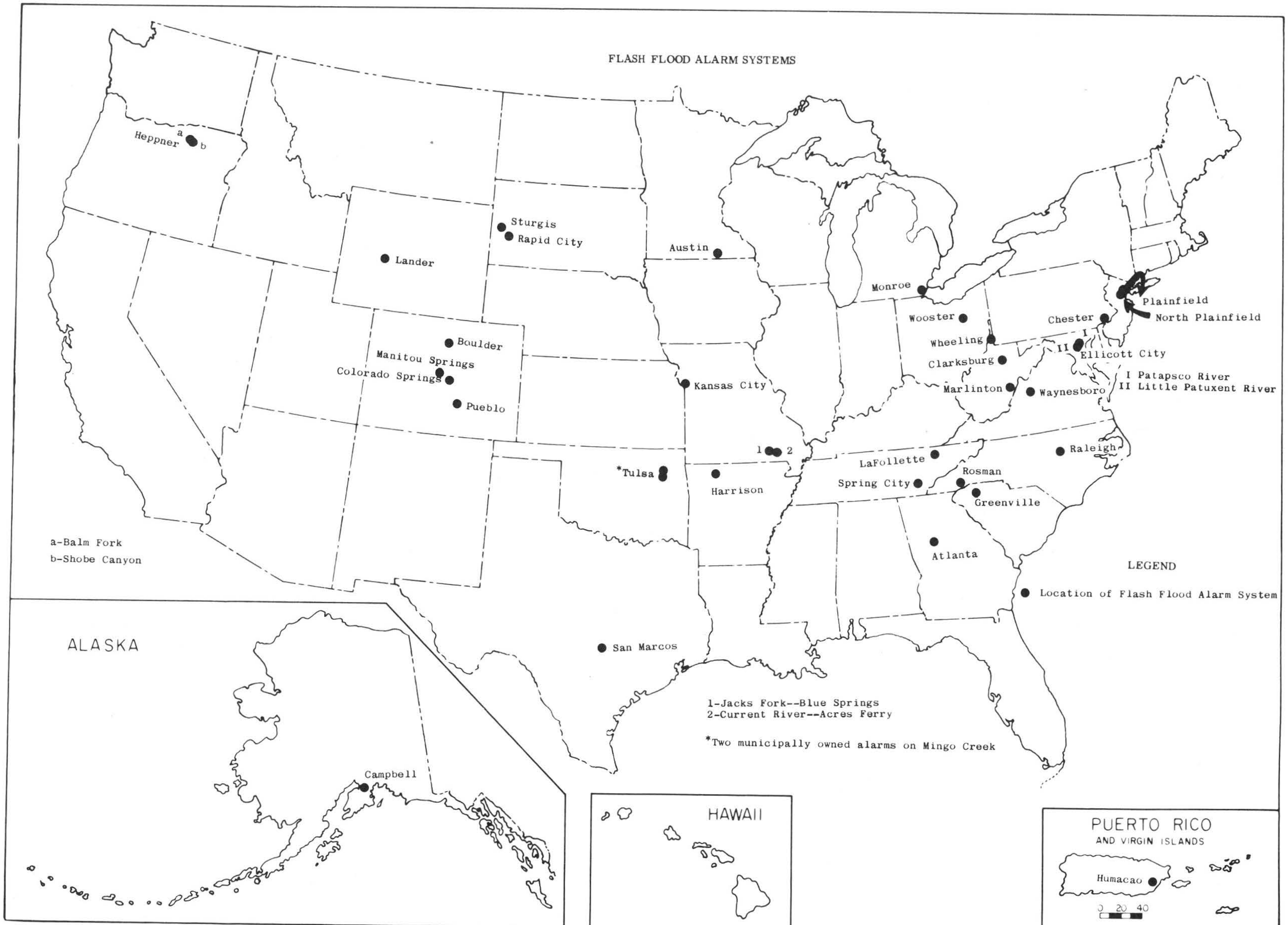
Flash floods pose a special problem, as noted in Part I. As a demonstration project, NOAA will purchase and install a total of 99 flash flood alarms which will sound an alarm in the affected community whenever the upstream river stage reaches some pre-determined danger level. Sixty-five telemetered alarms have been purchased. Of these, 35 have been installed and the remainder will be commissioned by August 1975. Thirty-four alarms, designed for use in remote areas where land-lines are impractical, will be radio-equipped and are scheduled for procurement early in FY 1976.

NOAA is continuing work which shows promise of providing the positive, around-the-clock detection of tornadoes that is needed. Devices to measure the electromagnetic output of thunderstorms have been placed in selected locations the past few tornado seasons and gathered a large amount of information. Post-analysis of this information indicates that generally, the higher the electromagnetic "burst-rate" from a particular storm, the more intense the storm. It is hoped that further research will lead to the development of an operationally useful detector. Another promising technique of detection lies in Doppler radar, which is capable of measuring "toward" and "away" velocity components of precipitation particles moving in small-scale circulations. Tornadic storms have been observed to be associated with intense small scale circulations, and detection of these will improve the warning system. Utilizing two Doppler radar sets, it has even been possible to measure the full three-dimensional velocity field in regions of precipitation.

As a significant beginning toward improved monitoring of fire hazard, the National Fire Danger Rating System (NFDRS) has been implemented in all National Forests and most other federally managed lands. Some state forest fire protection agencies have also implemented the System. The calculation of fire behavior conditions has been automated in a time-share computer system that is available nationwide to all fire protection activities. Fire hazard can thus be monitored and adequate protection action programmed on a national basis through the computer system which has been dubbed AFFIRMS (Automated Forest Fire Information Retrieval and Management System).

Solid Earth Monitoring Systems

In September 1973, the earthquake research programs of NOAA and the USGS were administratively merged. The combined program under the USGS constitutes the single largest research and data-gathering effort in earthquake hazard reduction in the United States and includes the



Flash Flood Alarm Systems

major efforts of the Federal Government in earthquake-related studies in seismology, geology, geophysics, as well as important efforts in soils engineering. The new USGS program includes seismic-engineering data gathering and research conducted for the National Science Foundation (NSF), which has the principal Federal responsibility for earthquake-engineering research. At the same time, NOAA has continued the national and international data services in all of the Solid Earth Sciences, including earthquake and seismic data, keeping very close contact with USGS as well as the academic and industrial communities in the fields.

The USGS operates or helps maintain a variety of systems that monitor earthquakes, crustal changes associated with earthquakes, and earthquake effects. These systems include:

- National and international networks for observation and reporting of teleseismic data from potentially damaging earthquakes. (Included are the Worldwide Network of Standard Seismographs--jointly funded by NSF and USGS--and the USGS seismologic and geomagnetic observatories, seismograph stations, and National Earthquake Information Service. NOAA continues to operate the seismographic and geomagnetic observatories at Honolulu, Hawaii and at Palmer and Adak, Alaska.)

- Local seismograph networks for delineation of active faults and for earthquake prediction research in areas of significant seismicity.

- Crustal movement monitoring using geodetic surveys, tiltmeters, creepmeters, strainmeters, or magnetometers.

- Instrumentation for research in strong-motion seismology and earthquake engineering.

Progress in these systems since June 1973 is summarized in the following paragraphs.

Teleseismic systems--Telemetry links have been established between several seismologic observatories and stations and the National Earthquake Information Service to provide real-time coverage. The threshold of detection of United States earthquakes has been improved by addition of stations in some areas.

Local seismograph systems--New networks for detection of small earthquakes were established in South Carolina (the site of the destructive 1886 Charleston earthquake), Puerto Rico, and the Mojave Desert of eastern California. Substantial upgrading of existing networks in southern California, Puget Sound area, Nevada seismic zone, Wasatch Fault zone, Mississippi Valley, and Alaska also has been made. Improvements consisted of new stations, addition of telemetry links, and improvement of automatic data processing capabilities.

Crustal strain systems--Two types of instruments--borehole tiltmeters and proton magnetometers--have proved to be of great value in analyzing earthquake occurrence and crustal strain. Tiltmeters distributed at sites along 80 Km of the most active segment of the San Andreas fault in central California detected anomalous changes in tilt that could be associated with 13 different earthquakes. Magnetometers deployed in the same area recorded a magnetic anomaly that signalled the magnitude 5.2 Hollister Thanksgiving Day earthquake, the first United States earthquake for which multiple precursors were observed.

Strong-motion systems--The USGS-managed cooperative national strong-motion network contains about 1,200 accelerographs, a substantial increase above the 700 instruments reported in 1973. Although most of the strong-motion instruments are deployed in the western states, additions were made in the eastern United States, Alaska, and Puerto Rico.

Data Services--The data services which support research and engineering aspects of earthquake hazard reduction are in NOAA's Environmental Data Service. These files are especially important since the forecast of future earthquake activity and their effects rely heavily on the historical record. The archive includes an extensive magnetic tape file of about 100,000 earthquakes which have occurred since 1900 in the U.S. and other parts of the world, drawn from all available sources. Another tape file contains comprehensive information on the seismic effects (intensity) on people and things and the damage incurred in the United States since 1928, supplemented by data on the effects of major earthquakes prior to 1928. In addition, a magnetic tape file containing digitized "strong-motion" records of about 400 events is maintained.

The Environmental Data Service also maintains a film file of over 3,000,000 seismograms written by the Worldwide Standard Seismograph stations and others in over 60 countries and territories, plus a complete film file of all the "strong-motion" seismograph records written by the instruments of the national network since its inception in 1932.

These files grow by 5 to 10 percent per year and are maintained in current status, in large measure through the addition of material now supplied by the USGS networks and academia, with the inclusion of additional data supplied by other central sources such as the International Seismological Service, United Kingdom; the Bureau Central International Seismologique, France; the Japan Meteorological Agency and others.

Satellites are also being used for monitoring solid earth phenomena. The tectonic plate motion portion of the overall NASA Earth and Ocean Physics Applications Program has three purposes: (1) to develop and demonstrate new techniques for measuring very accurately the position of stations on the earth's surface and their motion with respect to one another, (2) to evaluate these techniques with the user community for their future application on an operational basis, and (3) to obtain significant geophysical data for the scientific and applications users.

There are three specific experiments being conducted in this program. Two distinct measurement techniques are used in these experiments. The satellite laser ranging techniques uses satellites equipped with retroreflectors. Light beamed from tracking stations to the satellite is reflected back to the station where it is recorded. By tracking satellites in this manner from different stations, precise positions of the stations relative to each other can be ascertained. Repeating this process periodically will enable the determination of crustal motion from the changes in position of the stations. Mobile tracking stations have been developed to provide the flexibility to determine the position or motion basically anywhere on the earth and with minimum capital investment cost. The other measurement technique, Very Long Baseline Interferometry (VLBI), utilizes existing radio antenna stations to track very distant radio stars. Recording at different stations the signals emitted from these stars makes it possible to compute the relative positions of the stations after an observation period of a few hours. The main advantage of these space techniques compared to conventional ones is that the achieved accuracy is not nearly as dependent upon the length of the baseline to be measured. Hence, we can measure regional and global scale distances of hundreds to thousands of kilometers with the prescribed accuracy to monitor the plate motions.

The San Andreas Fault Experiment is a regional scale laser tracking experiment. The plate which cradles most of the Pacific Ocean is sliding northward relative to the plate on which North America rides and at rates that differ along the fault and are only approximately known. The scraping of one plate by another generates a number of earthquakes. The San Andreas Fault Experiment is being conducted in collaboration with USGS, the Lamont-Doherty Geophysical Observatory of Columbia University, and the University of California, San Diego. Currently, two mobile satellite laser ranging stations are located at Quincy in the Plumas National Forest in northern California and on Otay Mountain, 15 miles southeast of San Diego. Another station is being located at Bear Lake, Utah, to measure distortions in the western region of the plate.

The Astronomical Radio Interferometric Earth Surveying experiment employs the Very Long Baseline Interferometry technique to make regional scale measurements of crustal motion. The regions over which these measurements will be made in the initial phase are located in the Los Angeles Basin.

The Pacific Plate Motion Experiment, a global scale activity, will extend this Very Long Baseline Interferometry approach to Alaska and to Hawaii on the Pacific Plate.

Ocean Monitoring Systems

Since June 1973, the tsumani warning system has been strengthened by the addition of seismograph stations at Yakutat, Alaska, and Petropavlovsk and Yuzhno-Sakhalinsk, USSR, and tide stations at San Diego, Calif.; Langara Is., Canada; Kuzhiro, Japan; and Socorro I., Mexico. Progress has been made in obtaining needed USSR tsunami data, and an exchange of Soviet and United States tsunami specialists has begun. Under an agreement with NOAA, the USGS has completed development of interface equipment to transmit seismic data via the GOES satellite.

GEOS-3, the Geodynamic Experimental Ocean Satellite, was launched April 9, 1975. The primary objective of the program is to determine the feasibility and utility of measuring sea surface geometry and wave height with an in-orbit satellite radar altimeter. Other geophysical properties of the earth such as gravity field, polar motion, earth rotation variations, and investigations of continental drift theory, tectonic plate and fault motion will be conducted.

WARNING PREPARATION

Among improvements in our capability to prepare warnings of natural hazards during the past two years are:

- The beginnings of AFOS, the NWS program to automate its field operations and services.
- The development of a computer-based short-period objective probability forecast of severe local storms.

- The programming of a second generation fine-mesh boundary layer model.

- The extension of extra-tropical storm surge forecasts to two additional cities on the east coast.

- The modification of the hurricane surge model to accommodate gently curving coastlines.

- Significant advances toward reliable earthquake prediction.

- Initiation of an avalanche warning program.

Warning preparation covers a wide variety of activities, including research to improve knowledge of disaster phenomena, development and improvements of forecast techniques, message composition, and the display and handling of data.

NOAA's National Weather Service has a significant automation effort underway to promote more effective application of manpower to warning preparation and dissemination. This effort, the Automation of Field Operations and Services (AFOS), will be phased in over the next four to five years. The aim is to apply modern methods of data handling, display, and communications to the needs of field offices to provide more effective forecast and warning services. An AFOS Experimental Facility which can simulate a Weather Service Forecast Office (WSFO), Weather Service office (WSO), or River Forecast Center (RFC) has been installed at NWS Headquarters for experimental, evaluation, and development work. Computer programs have been developed to speed the preparation, editing, and transmission of warning messages. The National Meteorological Center (NMC) is interconnected by a communications link with this equipment as an integral part of the Experimental Facility. Procurement of initial equipment for operational installation at three WSFOs, two WSOs, one RFC, the Systems Monitoring and Coordination Center and completion of the NMC interface is underway.

One of the major research efforts within NWS is addressed to the development of automated techniques for predicting severe local storms. Included in this development was a new computer program for producing objective forecasts of the probability of severe local storms 2-6 hours in advance (implemented May 1974) and the programming of a second generation boundary layer model on a fine mesh grid (100 Km spacing). A computer-generated forecast of extra-tropical storm surges along the east coast was expanded to include two additional cities (Willet Point, N.Y., and Charleston, S.C.). The hurricane storm surge model (SPLASH) has been modified to accommodate a gently curved coastline and is now operational from the Texas-Mexico border to Long Island, N.Y. Presently, efforts are being made to extend SPLASH (Special

Program to List Amplitudes of Surges from Hurricanes) from Long Island to the Maine-Canadian border. However, until new research breakthroughs are realized, we will still be in the position of applying the SPLASH models to coastal features (e.g., bays) for which they are not designed.

A significant step toward the goal of earthquake forecasting was reached on Thanksgiving Day, 1974, when an earthquake of magnitude 5.2 occurred between the San Andreas and Calaveras faults near Hollister in central California, where a dense array of seismometers, tiltmeters, and magnetometers is deployed. USGS scientists had anticipated the earthquake from marked changes observed over the preceding weeks in deformation of the earth's surface and in the magnetic field. Retrospective analysis of seismic wave velocity data from the area indicated an anomaly generally coincident in time with the other geophysical signals. This was the first time that such a variety of precursory signals had been observed for a single earthquake in the United States.

During 1974, 12 other earthquakes in the test area were preceded by significant changes in tilt of the earth's surface. These observations, together with the Thanksgiving Day event, confirm that some earthquakes can be predicted with presently available geophysical instrumentation and analytical techniques.

In the winter of 1973-74, an avalanche warning program was formally begun as a joint effort between the U.S. Forest Service and the National Weather Service. The program is designed to broadcast avalanche warnings over radio and television during periods of high avalanche hazard. Briefly, the program works as follows: The Forest Service avalanche forecaster maintains daily contact by telephone with field observers to obtain current avalanche, weather, and snowpack conditions. Coupled with a mountain weather forecast from the NWS, the avalanche forecaster must decide when conditions are dangerous enough to issue an avalanche warning. When this decision is made, the warning is issued by means of teletypewriter through the NWS and is instantly transmitted over the NOAA Weather Wire Service to the area's radio and TV stations and newspapers. When the hazard has abated after several days (weeks, sometimes), the warnings are terminated. Warning programs are now operational for the Colorado Rockies, the Wasatch Range in Utah, the Sawtooth Range in Idaho, the California Sierras, and the Washington Cascades.

WARNING DISSEMINATION

Dissemination of hazard warnings has been strengthened during the past two years. Specifically:

- The Disaster Relief Act of 1974 has resulted in increased coordination among Federal agencies in the issuance of disaster warnings.
- NOAA Weather Radio has expanded from 65 to 77 stations and more are being rapidly installed.
- NOAA Weather Wire Service (NWWS) has been extended into 9 additional states, making this service available through 35 states.
- Heavy duty Weather-by-Phone systems have been added in 8 additional locations, with these systems now available in 39 cities.
- Use of NAWAS (National Warning System) has expanded and 218 NWS warning offices now have drops on this DCPA-operated system.
- The first DIDS (Decision Information Distribution System) transmitter has been installed and tested by DCPA.
- The developmental phase of AFOS is progressing rapidly and procurement initiated on equipment for the first operational phase.
- Cable TV and computer-to-computer forecast distribution are becoming important dissemination channels.
- Investigations of the potentials of a Disaster Warning Satellite System (DWSS) are continuing.

Telephone, teletypewriter, and radio systems of warning dissemination have all been expanded the past two years, and increased coordination among Federal agencies has contributed to strengthening of dissemination. Available computer technology is also beginning to be exploited in efforts to speed warnings to the public.

Federal coordination in the dissemination of warnings was deemed essential in the Disaster Relief Act of 1974. Section 202(a) of this Act states that "The President shall insure that all appropriate Federal agencies are prepared to issue warnings of disasters to State and local officials." This authority, by executive order, has been redelegated to the Secretary of Housing and Urban Development.

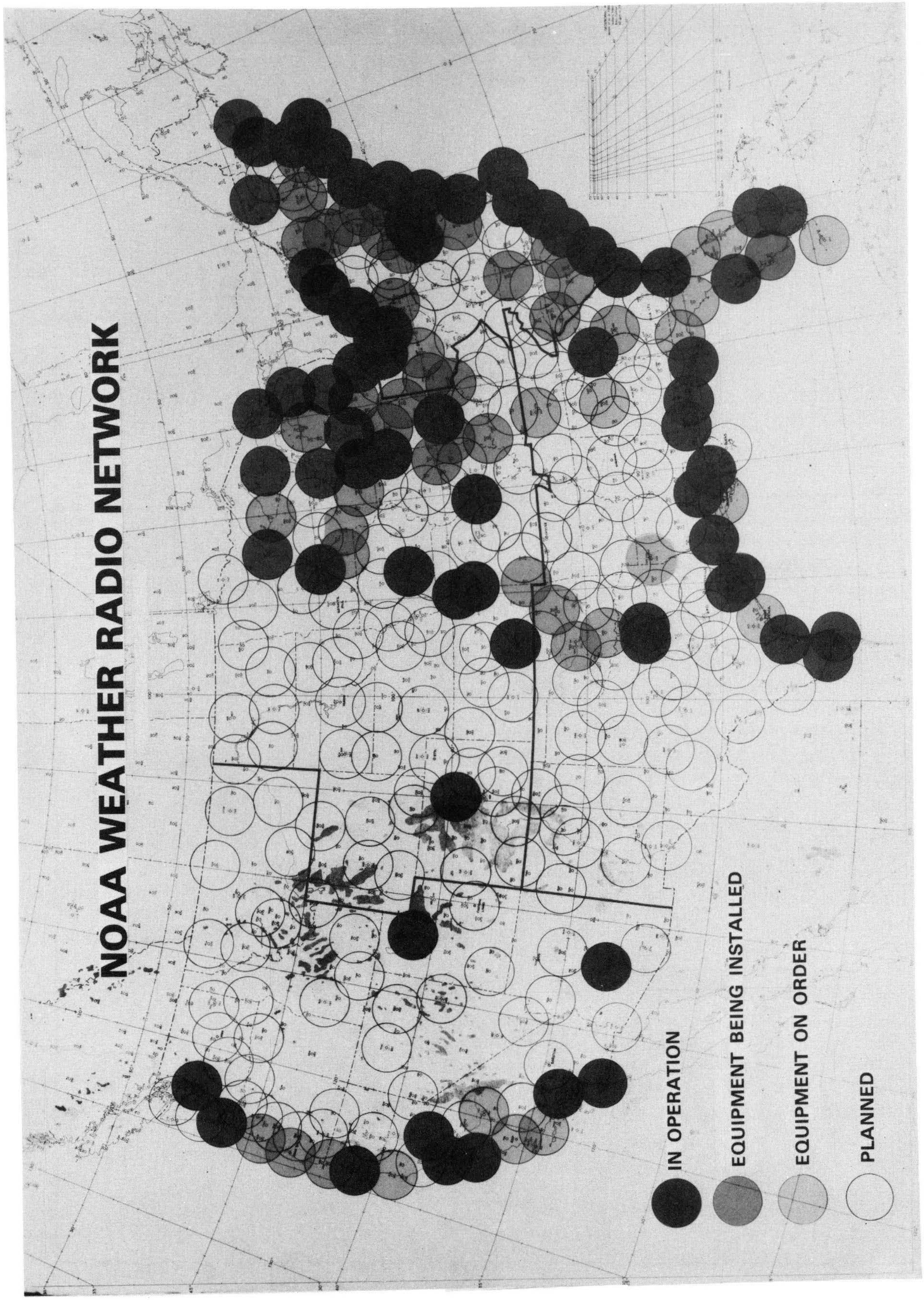
It is the intent of the Secretary of Housing and Urban Development to delegate certain disaster warning authorities to the Departments of Commerce, Interior, and Agriculture, subject to the concurrence of the agencies involved. The purpose of these delegations is to authorize these agencies to provide technical assistance to State and local governments, pursuant to Section 202(b); to utilize the services of any Federal communications systems, pursuant to Section 202(c); and, to enter into agreements with private or commercial communications systems, pursuant to Section 202(d).

NOAA and DCPA are coordinating their efforts to expand and improve the use of sirens for natural disaster warnings. Communities are being encouraged to permit the National Weather Service to directly sound sirens in the event of a tornado. Communities are also being encouraged to collocate the siren activation control with the point of receipt of warning and to delegate the authority to sound sirens so no delay will occur when tornado warnings are received. The agencies also are working with the Federal Communications Commission to update state Emergency Broadcast System (EBS) plans in order to permit better use of the broadcast media.

The past two years have seen the number of NOAA Weather Radio stations increase from 65 to 77, and others are being rapidly installed. These stations, operating at 162.4 or 162.55 MHz, provide continuous radio broadcasts out to about 40 miles from the transmitter site. An important policy statement issued by the Office of Telecommunications Policy on January 13, 1975, announced that "The National Oceanic and Atmospheric Administration (NOAA) Weather Radio will be the only Federally sponsored radio transmission of warning information to receivers optionally available to the general public." A total of 331 transmitters will complete the program and put disaster warnings within range of 95 percent of the Nation's citizens. Those warning offices which were equipped with this system during the massive tornado outbreak of April 1974, were able to rapidly disseminate tornado warnings and all-clear information to their listening areas. An important feature of the NOAA Weather Radio is the warning alarm which will automatically turn on special receivers located in schools, hospitals, disaster action agencies, and local governmental offices. There are several inexpensive receivers now on the market. In addition, some manufacturers are including a "weather button" as part of their regular FM radios.

NOAA Weather Wire Service (NWWS), the teletypewriter circuit which delivers "hard copy" warnings to the mass news media for relay to the public, is now complete in 35 states, an increase of 9 states in the past two years. This service will be extended through the conterminous 48 states in FY 1976.

Automatic weather-by-phone systems have been increasing during the past two years. There are now 39 heavy duty systems in operation, compared with 31 in June 1973. Nine of these are "multiple service," providing marine, extended forecasts, etc., in addition to regular forecasts.


NOAA WEATHER RADIO NETWORK
IN OPERATION
EQUIPMENT BEING INSTALLED
EQUIPMENT ON ORDER
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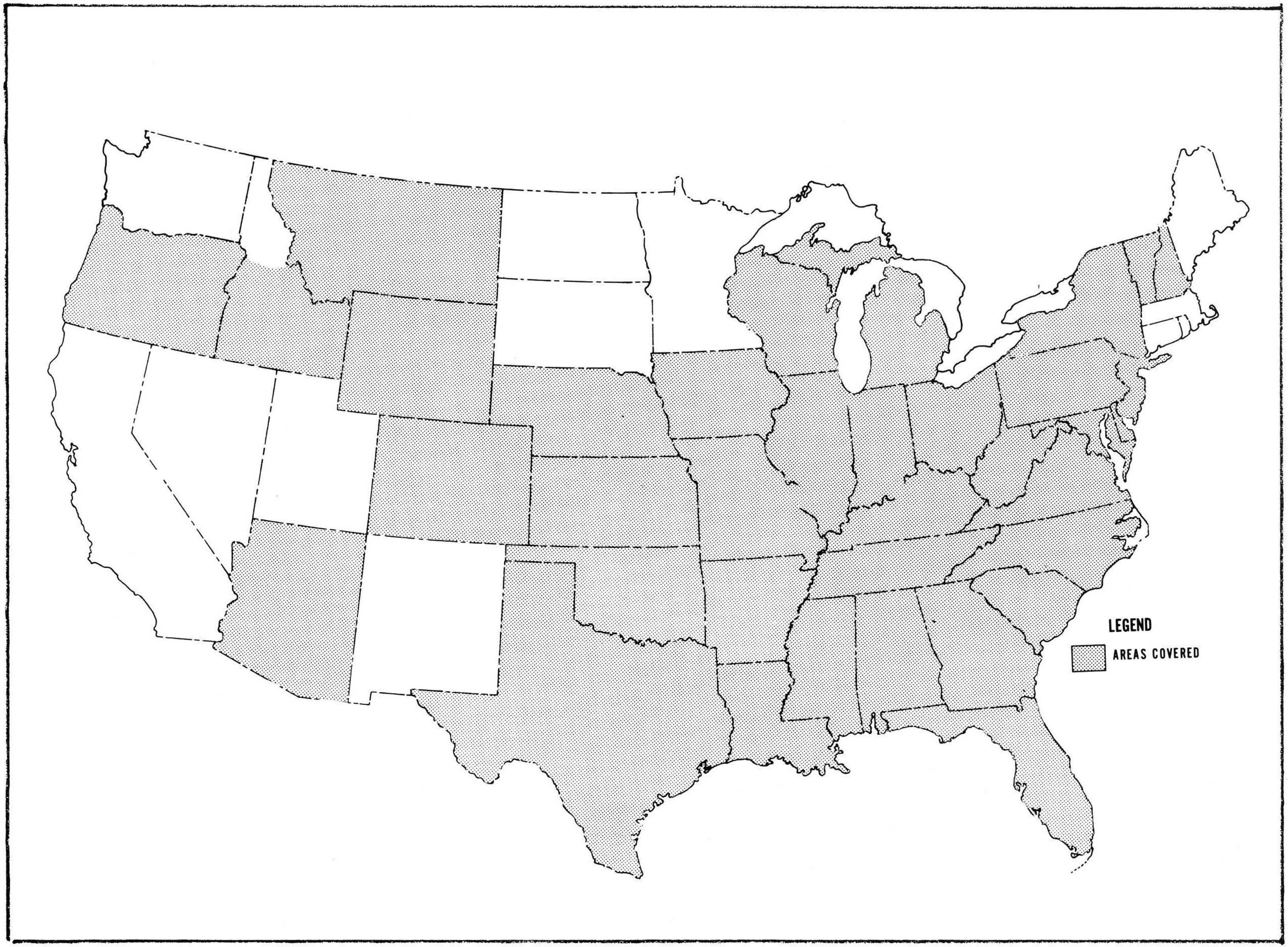
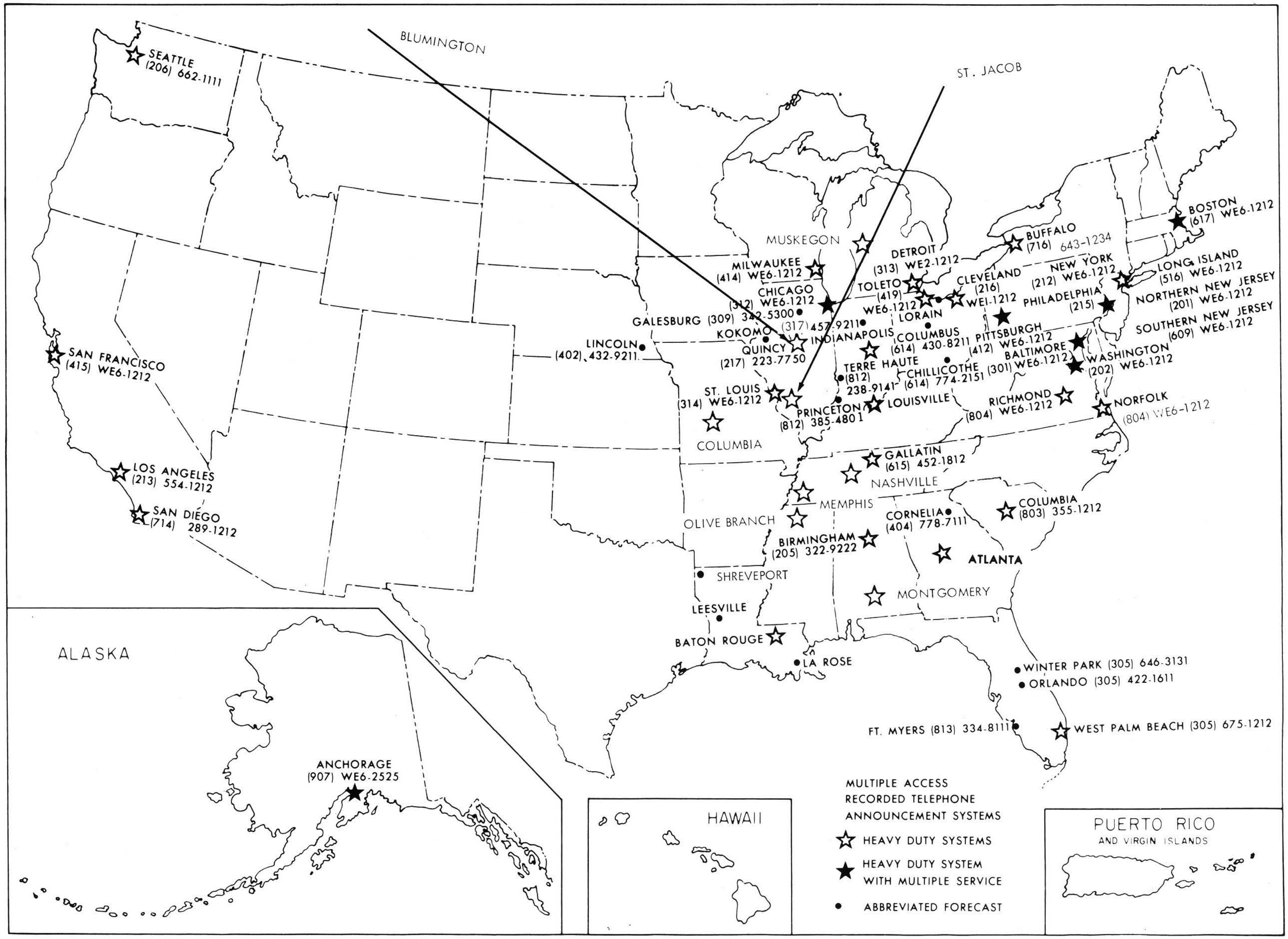


NOAA Weather Wire Service



MULTIPLE-ACCESS RECORDED TELEPHONE ANNOUNCEMENT SYSTEMS

DIDS is DCPA's low frequency radio system consisting of 10 high-powered transmitters designed to provide nationwide attack warnings to government offices and institutions. The first DIDS transmitter facility has been completed at Edgewood (Aberdeen), Md. This transmitter covers a 10-state area and commenced test transmissions in the summer of 1974. For use in these operations, 375 voice receivers have been installed in agencies and departments of Federal, State, and local government. An additional 1,000 receivers will be installed in the summer of 1975, including commercial radio and television stations and the NWS offices operating NOAA Weather Radio.

Procedures to disseminate severe weather warnings over DIDS have been developed. Hardware for interfacing DIDS with the NWS offices is being evaluated preparatory to testing these procedures. The locations of the existing and projected transmitters are shown on the map on page 61.

The AFOS program, described in the section on Warning Preparation, will give NWS the capability of transmitting warnings more rapidly to radio and television stations for relay to the public. AFOS will also permit better utilization of cable television as a medium of warning dissemination. While parts of the AFOS program are still developmental, initial implementation is expected by the end of calendar year 1976.

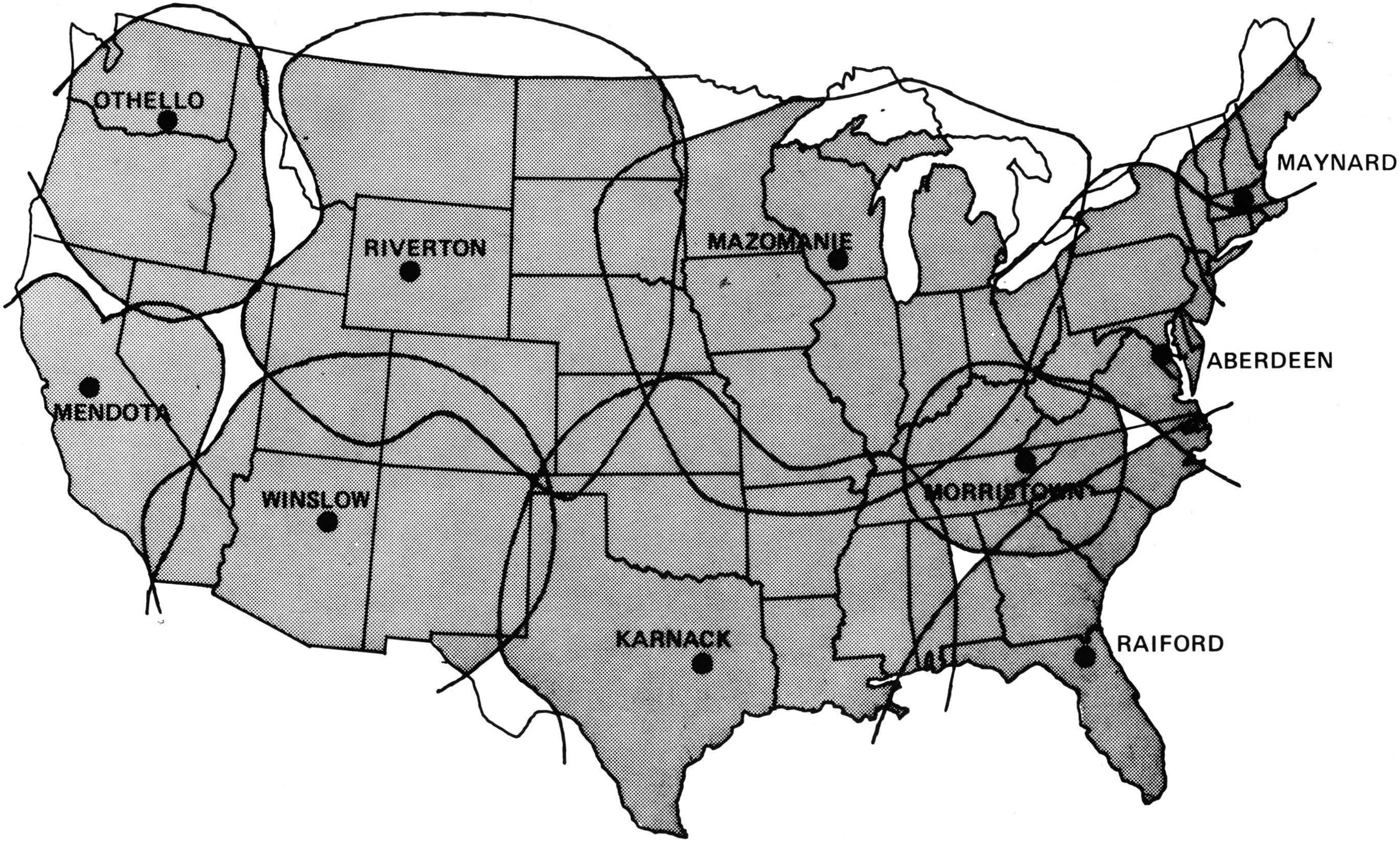
For the past year, forecasts and warnings issued by NWS offices have been passed to United Press International on a computer-to-computer link, reducing the time required for dissemination. A similar link will be established with Associated Press later this year.

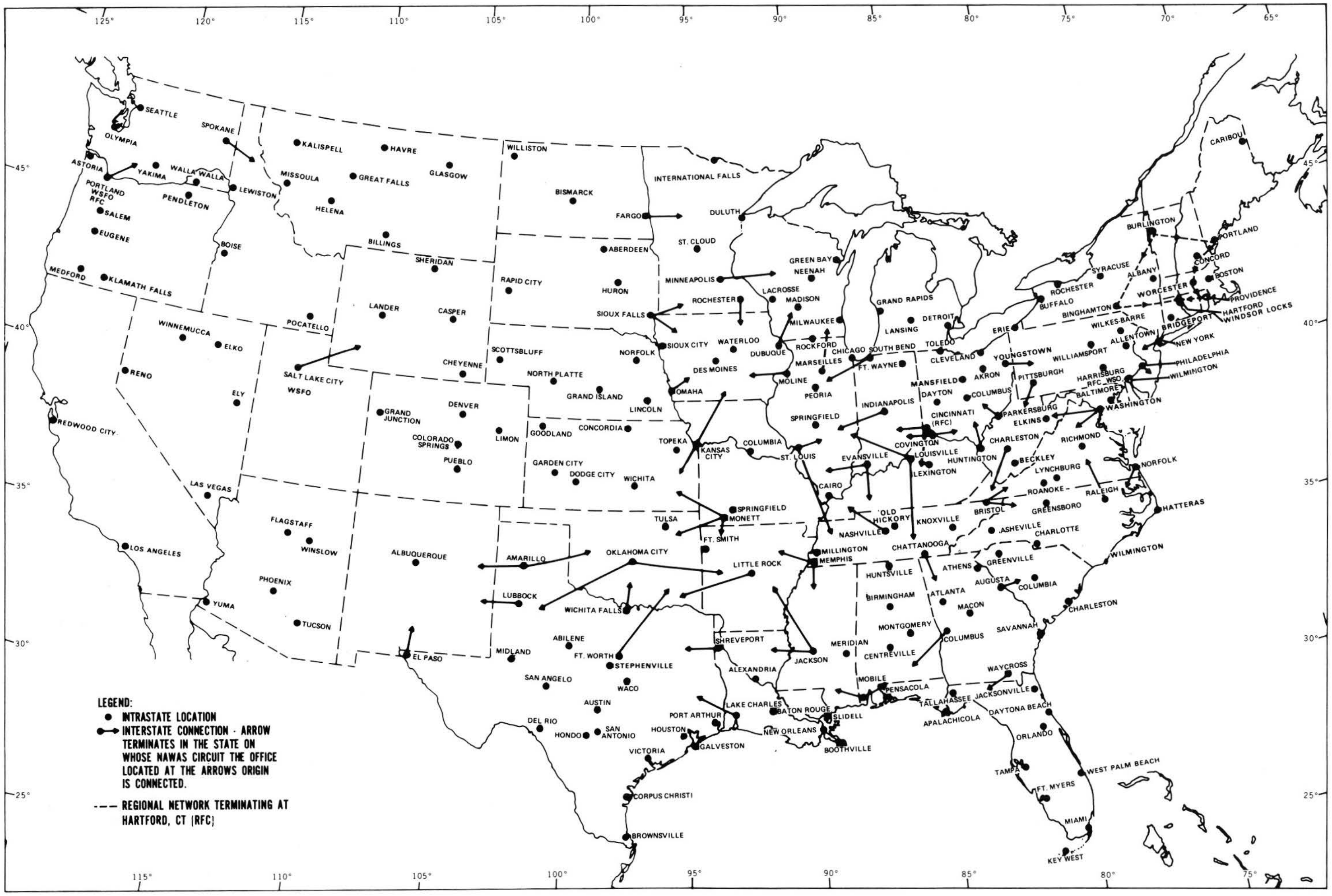
The record tornado outbreak in April 1974 pointed up the value of DCPA's National Warning System (NAWAS) in both dissemination and feedback to NWS warning offices. Two hundred eighteen of these offices now have drops on this hot-line telephone system, including 62 offices with drops in more than one state.

Cable television has become more important as a warning dissemination medium the past few years. Currently, more than 130 CATV systems serving nearly two million people continuously display zone and local forecasts issued by NWS offices. This method is particularly adapted to alerting the public during longer term warning situations, as in times of hurricanes, winter storms, or heavy rains. For short-fused warnings, as for tornadoes, some CATV systems have provided for warnings broadcast from a community "command post" to override all channels, thus insuring that all viewers on the cable receive the warning. This override system worked quite well in northcentral Kansas when tornadoes struck Salina and Clay Center in September 1973. Cable systems are especially selective, since they are usually set up on a community basis, but have the limitation that generally only 30-60 percent of the families subscribe to the service.

DIDS TRANSMISSION COVERAGE

High Reliability Service





NATIONAL WEATHER SERVICE NAWAS LOCATIONS

COMMUNITY PREPAREDNESS

In the past two years, progress toward improved preparedness has been strengthened by:

- Increased coordination between NOAA, DCPA, and other Federal agencies involved in assisting communities in readiness activities.

- The addition of 14 trained community preparedness meteorologists in National Weather Service forecast offices.

- Concerted efforts toward improved tornado readiness, including the annual SKYWARN program and emphasis on tornado safety in schools.

- Agreement with 250 Radio Emergency Associated Citizens Teams to cooperate with NWS warning programs.

- The distribution of millions of copies of hazard safety publications.

- Continued progress in preparing storm evacuation maps for communities along the Atlantic and gulf coasts.

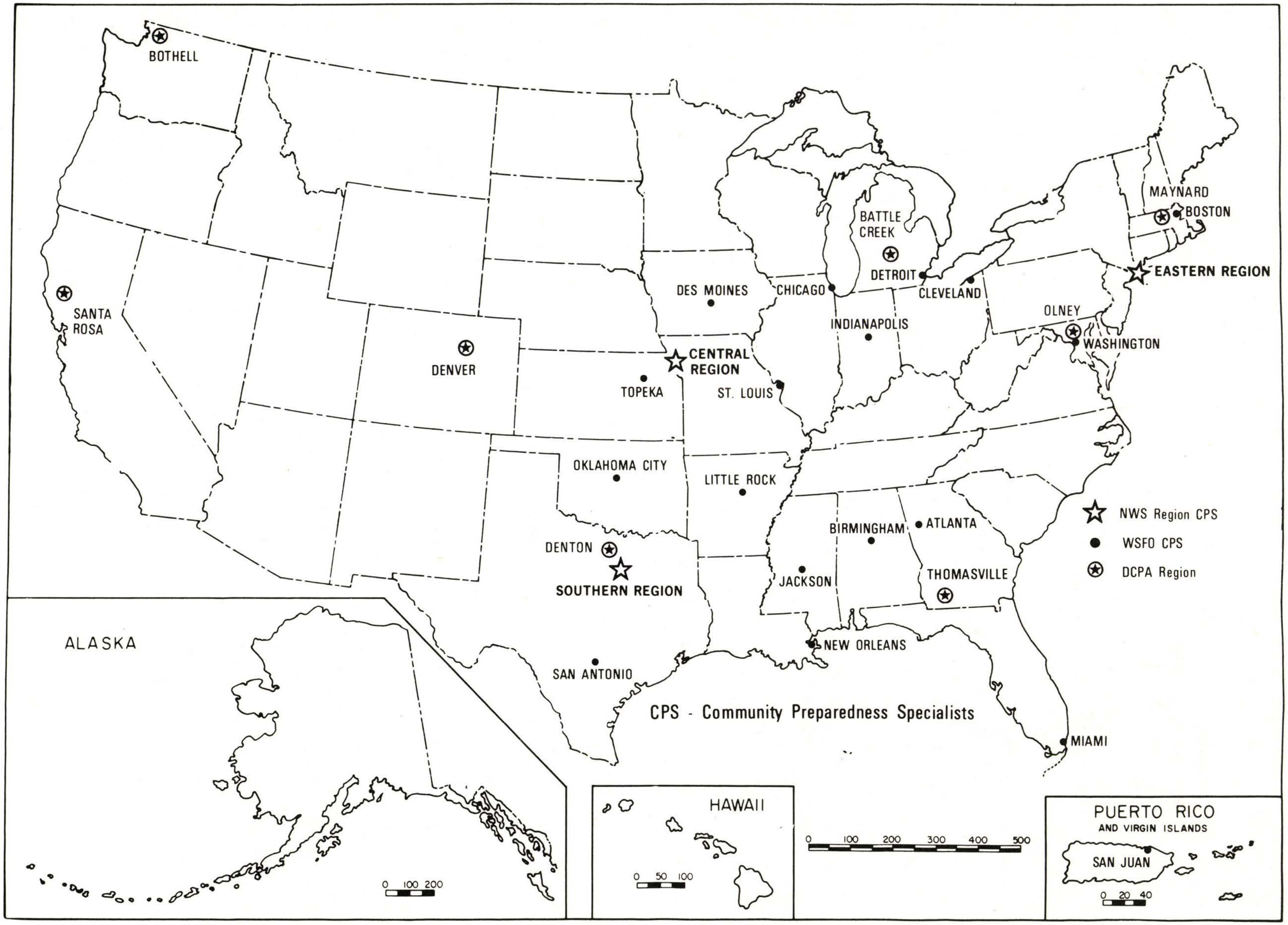
- Progress in earthquake hazards mapping and risk assessment.

- Public education in avalanche safety.

- Countless meetings and training sessions for community leaders, school officials, spotter networks, state and local law enforcement officers, and mass media representatives.

Natural disasters continue to take an inordinate number of lives and cause thousands of injuries every year despite advances in technology and skill in forecasting and warning. Post-disaster surveys show that effective local preparedness plans and an educated citizenry contribute to low death and injury rates. Unfortunately, many of our Nation's communities have not adequately planned for natural disasters.

Federal community preparedness programs are designed to improve this situation by assisting communities in adequate risk assessment and preparedness activities. The past two years have seen increased stress on interagency coordination and cooperation in this area. A prime example is the cooperation between NOAA and DCPA, recently strengthened by an agreement which defines each agency's role in community preparedness.



FOCAL POINTS FOR COMMUNITY PREPAREDNESS ASSISTANCE

NOAA's community preparedness efforts, managed by the National Weather Service, are designed to provide the link between warnings and the response by local officials and citizens. Community preparedness personnel have recently been added to 14 field offices and a headquarters staff assigned to provide technical assistance, guidance, and coordination for this program.

Following the April 3-4, 1974, tornado outbreak, the NWS community preparedness effort accented and accelerated tornado preparedness. Because of the school buildings devastated, particular emphasis was placed on safety education in schools and encouraging tornado drills. Five states in tornado-prone areas have recently made tornado drills mandatory in schools or have legislation pending which requires such drills. A publication, "Tornado Safety Rules in Schools" has been prepared and given widespread distribution.

About two years ago, DCPA began surveying schools in sections of the southeastern U.S. to determine the shelter areas that provide the best available protection from tornadoes. These surveys, which were primarily conducted through contracts with universities in the concerned states, advised interested school officials (i.e., those who granted permission for the surveys) as to the best area for shelter in the event of a tornado. The program was accelerated during the past year and about 7,500 schools were surveyed by April 1975. The survey has been completed in Kentucky (with about 1,500 of the state's 1,800 schools participating) and by this summer will be finished in Alabama, Mississippi, and North Carolina. In an effort to accelerate school preparedness in other states, a team of architects and engineers involved in this program has recently provided, through contract with NWS, a slide presentation with commentary on "The Safest Places in Schools." This information will assist school officials in determining the safest areas that children and staff can occupy during a tornado threat.

In February, the NWS launched SKYWARN '75, this year's tornado preparedness program. In addition to hundreds of meetings arranged by local warning offices with community leaders and representatives from radio, television, and newspapers, major preparedness meetings were held this year in four Ohio cities. More than 50 cities in 26 states have held such meetings since the program was started in 1971. Tornado frequency, community preparedness, and safety programs are emphasized. To assist local offices in their preparedness activities, slides and script on tornado readiness have been prepared and distributed to NWS field offices. A tornado documentary film stressing the advantages of community preparedness is being prepared by NWS.

Mobile homes struck by tornado in Salina, Kansas - September 25, 1973.
80 residents had taken shelter; four who didn't were injured.
(Credit: Darras Delamaide, Salina Journal)

Preparedness for other natural hazards is not being ignored. NOAA has also developed slide training packages covering general community preparedness and flood warnings. A revised publication on Winter Storms has been prepared, Spanish versions of several flood publications have been released, and millions of copies of existing natural hazard publications have been reprinted and distributed.

Hurricane preparedness conferences have also been held this year in nine major cities along the East and Gulf coasts. The primary objectives are to create a public awareness of the hurricane threat and to insure the continuing help of the media in delivery to the public of warnings, watches, and hurricane safety information. The warning films, Tornado and Flood continue to receive widespread use in the community preparedness effort and a major hurricane film will be produced in the near future.

As part of the hurricane preparedness program, NOAA's National Ocean Survey continues on a project to publish by 1986 approximately 200 storm evacuation maps for urban areas that are vulnerable to hurricane generated storm surges along the Atlantic and Gulf coasts. These maps show emergency evacuation routes, areas subject to flooding in distinctive color tones, elevations which might afford "safety islands" for storm evacuees and other related geographical and statistical data; they are distributed to Federal, State, and local officials and to community emergency preparedness committees. Forty-two maps have been issued to date covering coastal areas in parts of Louisiana, Alabama, Mississippi, Texas, South Carolina, Georgia, Virginia, New York, and New Jersey. In the planning stage are maps along the coast of Florida, additional areas in Louisiana and part of Massachusetts. Long-range planning through 1980 includes approximately 60 additional maps covering parts of Florida, Texas, South Carolina, and Georgia.

For emergency communications, more than 250 REACT (Radio Emergency Associated Citizen Teams) groups were contacted in the past year to enlist possible assistance to NWS and civil defense groups during natural disaster emergencies.

Such things as volunteer spotter networks, flash flood programs, improved local communications, local preparedness plans, sirens, tornado drills--all these have paid off when tornadoes or other natural disasters struck. NOAA and DCPA working in cooperation with other Federal, State, and local agencies have done much in the past two years to assist communities with their preparedness plans. While restrictions on travel have limited the community preparedness effort, countless contacts have been made with local officials, schools, spotter networks, radio and television stations and others concerned with public safety.

Major advances have been made in methods for mapping and evaluation of earthquake geologic hazards. During the past several years, USGS earthquake hazards studies in the San Francisco Bay region have been aimed toward development of seismic zonation techniques utilizing existing geologic and geophysical data. Methodologies recently were summarized for the identification of active faults, estimation of regional attenuation of strong shaking, and qualitative delineation of relative shaking response of geologic units in the Bay Region. Techniques for determining the liquefaction potential and landslide susceptibility on a regional scale within the San Francisco Bay area also have been developed. These analytical methods have application to other earthquake-prone regions and can be used as a basis for land-use planning and engineering actions to substantially reduce earthquake hazards.

Identification and delineation of earthquake geologic hazards is proceeding in several major urban areas of high or moderate seismic risk in the western United States. A substantial effort was initiated in the Los Angeles region that will apply the techniques developed in San Francisco to the more highly populated southern California region. Similar earthquake hazard evaluation programs have been started on a smaller scale for the Puget Sound, Wash., and Salt Lake City, Utah, areas.

Assessment of earthquake problems in the eastern United States has been difficult because of the much lower earthquake frequency of the region, although the hazards may be as severe as in the western United States because of the greater areal shaking effects of eastern earthquakes. The USGS recently published a regional map for the eastern United States that documents the sectors of highest earthquake activity and their relation to known geologic structures and tectonic provinces. This map provides a preliminary framework for better defining the earthquake risk in the East. A more detailed analysis of the seismicity and structure of the central Mississippi Valley region--the site of several major historic earthquakes--has been started.

Considerable progress has been made in estimating the maximum expectable earthquake size and frequency, and in techniques for predicting ground motion parameters. In addition, USGS scientists have validated a promising new method for identifying large earthquake events in sediments. Application of the technique to the young sedimentary rocks of earthquake-prone regions will aid the determination of earthquake recurrence intervals, which presently is restricted to the historic seismic record.

Avalanche warnings issued by the Forest Service and disseminated by the National Weather Service have generally been well received by the public. The news media have been cooperative in broadcasting the warnings, and newspapers in Colorado have run several feature articles on avalanches. All this is helping to accomplish the goal of increasing general avalanche awareness among the public--a major ingredient in reducing the annual avalanche toll. This increased awareness has resulted in positive reaction on the part of both the general public and segments of industry. Work crews from public utility and mining corporations have changed or cancelled work plans in response to avalanche warnings. Government work crews and large-scale mountain cloud seeding projects have also been affected. In at least two known cases, large mining companies shut down operations altogether due to warnings prior to avalanches. In other cases, trans-mountain highways were closed and public outings cancelled. Mountain clubs and cross country skiers are inquiring in increasing numbers about avalanche conditions in the mountain west. Resumption of normal winter activity follows cancellation of most avalanche warnings.

ENVIRONMENTAL MODIFICATION

Progress toward modification of the environment the past two years has remained primarily research-oriented or in preparatory activities. Included were:

- NOAA preparations for the 1977 STORMFURY experiment to beneficially modify hurricanes.
- Bureau of Reclamation's program to develop and test seeding techniques in High Plains.
- Cooperative field effort in summer of 1973 to test precipitation augmentation in cumulus over southern Florida.
- Lightning suppression experiments in Colorado and Alaska.
- Emergency flood prevention activities by the Forest Service.
- National Hail Research Experiment under the auspices of the National Science Foundation.

Several Federal agencies are engaged in research into the modification of our environment to reduce disaster losses. Much of this activity is in the realm of weather modification research, with emphasis on reducing the disaster potential of hurricanes and drought.

A major objective is research into effective methods for moderating the destructive force of hurricane winds without decreasing the rainfall essential to man's activities in many regions. Project STORMFURY is aimed at determining the feasibility of altering the dynamics of hurricanes by seeding the storm's cloud systems with silver iodide. Theoretical considerations, verified by computer modeling, indicate that seeding should expand the diameter of the eyewall and lead to a reduction of maximum wind velocity. Studies have indicated that a 15% reduction in maximum wind speeds could result in average savings of approximately $100 million in the U.S. annually due to decreased property damage. Results from storms seeded to date are encouraging, although experimentation has been hampered by the scarcity of storms acceptable for seeding in the Atlantic and Caribbean. Due to the poor condition of the aircraft and instrumentation, NOAA decided in FY 1973 to discontinue the field experimental phase of Project STORMFURY until safe, well-instrumented aircraft were available. Under the present plans, operations will be resumed during the summer of 1977 in the Pacific where there is a much greater incidence of storms suitable for experimentation. The procurement of new aircraft and instrumentation began in FY 1974 and continued in FY 1975.

Drought is a short-term recurring problem in many areas, although records of precipitation show several periods of up to 5 years duration occurring in the southern Great Plains during the last century. Major changes in world climate could possibly cause droughts of even longer duration and greater severity.

A January 1972 report to the Congress on Disaster Preparedness, prepared by the Office of Emergency Preparedness, states that "Drought-protection methods fall into three categories: (1) those passive procedures that are taken well in advance of drought danger and that are designed to avoid losses; (2) those Federal, State, and local alleviation programs that shield an area from the effects of drought by early preparation (storage, conservation, and reuse of water; improvement of water supplies; weather modification to induce increased precipitation; and avoidance of high water use activities in particularly hazardous areas); and (3) those emergency measures that provide relief after drought conditions become severe (economic and material assistance to sustain the inhabitants and emergency measures to supply water by piping or hauling or by weather modification to end the drought).

Current independent scientific assessments of rain stimulation characterize it as an emerging technology with limited rather uncertain capabilities but important promise. These assessments stress the need for better information about crucial scientific uncertainties and about the economic and social alternatives that make for long-term solutions. At the same time, these assessments have not questioned the appropriateness of applying rain stimulation in its present imperfected state when pressing need is recognized that justifies the acceptance of the existing uncertainties. The distress of drought is the foremost of these pressing needs.

The drought-alleviating effectiveness of rain stimulation depends primarily upon the natural occurrence of seedable clouds. During droughts, such clouds occur less frequently than normal. However, climatic studies have shown that extended droughts are interrupted by periods when clouds come and some rain falls, but less than normal. Such periods occur characteristically once each 7-10 days, and offer reasonable opportunities for rain stimulation. These opportunities should not be expected to break the drought, but it is reasonable to expect that they may alleviate it and reduce the agricultural damage that would otherwise occur.

The usefulness of such an effort will depend not only on success in augmenting rainfall, but also on the condition of the crops on which it falls. Some crops may be at least partially salvaged, others not. Some substitute crops may yet be planted, or prospects for later crops greatly improved, if more rainfall occurs.

While there are still many uncertainties in weather modification as revealed by current research efforts, it appears that sufficient progress has been made to justify its use as a tool to alleviate drought conditions, and possibly diminish the adverse effects of climate extremes, especially on a short-term basis.

In the central part of the Nation, the Bureau of Reclamation has been planning the High Plains Cooperative Program, aimed at developing and evaluating improved techniques for seeding more types of clouds, particularly groups of clouds, in the spring and summer months. This is expected to lead to the establishment of a practical working technology capable of increasing precipitation to stabilize and augment agricultural economies and help to ameliorate the adverse effects of drought.

Meanwhile, NOAA has been working to develop convective cloud modification technology so that it can be used operationally by state and local agencies to augment water supplies in Florida and in other areas having similar meteorological conditions. Potential benefit-to-cost ratios of at least 30 to 1 are projected. Results of experiments conducted by NOAA's Experimental Meteorology Laboratory involving the seeding of individual cumulus clouds in southern Florida showed a threefold increase in rain in showers from seeded clouds under certain meteorological conditions. Additional observations and studies have indicated the possibility of economically significant increases in rainfall by bringing about the merger of several clouds. A major field effort involving ten NOAA, university, and other Federal agency groups was conducted during the summer of 1973 which involved randomized multiple cloud seeding of suitable cumulus clouds. Detailed documentation concerning the clouds, convective events and precipitation were maintained by the ground stations and participating aircraft. Analysis of the 1973 experimental data shows increased precipitation locally from the seeded clouds within the experimental area but the limited number of experimental days is insufficient to demonstrate increased rainfall in the total experimental area.

The Bureau of Land Management and Forest Service Research conducted a lightning suppression test in interior Alaska in the summer of 1973. Results of the test, which used silver iodide seeding techniques, were favorable, but it did not prove cost effective for operational use in Alaska.

NOAA's Atmospheric Physics and Chemistry Laboratory conducted lightning suppression tests in Colorado from 1971 to 1973. Aircraft flying at the bases of thunderclouds measured electric field decay following seeding with chaff fibers. All the storms which met certain seedability criteria were examined to look for lightning discharges and the results show a remarkable decrease in lightning activity following chaff seeding. No differentiation was made between lightning types (e.g., cloud-to-cloud, cloud-to-ground), but for seeded thunderstorms, the lightning count decreased from an average of 12.5 to 3.5 strokes per storm, or to one lightning stroke every 7 minutes as opposed to one stroke every 2 minutes before seeding. The following table summarizes the results.

	Number of Lightning Discharges	
Average of 11 seeded clouds	Before Seeding 12.5	After Seeding 3.5
Average of 21 control clouds	Before Seedability Threshold 11.8	After Seedability Threshold 15.5

The National Hail Research Experiment (NHRE), conducted under the auspices of the National Science Foundation, is now going into its fourth year. The primary goal of this experiment is to demonstrate a workable method of suppressing hail damage at a cost which is small compared with the damage produced by the hail. Basic to the achievement of this goal is the development of an operational capability to predict the occurrence of hail, the associated rainfall, and their potential modification by seeding. Such a capability will allow more rapid evaluation of hail suppression efforts, better operational procedures for the user community, and improved ability to transfer hail suppression techniques to other geographical areas.

The experiment includes selected physical experiments designed to improve the predictive capability, model development, and a statistical experiment as a test of the hail suppression effort in northeast Colorado. Much useful information on severe storms has been accumulated the past three years.

Under authority of Section 216 of the Flood Control Act of 1950, the Forest Service received funds early in FY 1974 to carry out emergency watershed treatment to protect life and property. Areas treated included National Forest lands in Alabama, Arkansas, Georgia, Mississippi, and Tennessee, as well as State and private forest lands in Illinois and Missouri.

Also, early in FY 1974, monies were made available for work on State and private forest land in Mississippi and on National Forest land in Arkansas, North Carolina, Georgia, Vermont, and New Hampshire.

Concurrently, work was being completed on areas damaged in Tropical Storm Agnes in New York, Pennsylvania, and Maryland, and the Black Hills flood in South Dakota.

With funds appropriated under P.L. 92-67, further work was carried out on the Rocky Burn Fire in Oregon and for flooding in Vermont.

The latter half of FY 1974 brought no letup in the need for emergency treatment of forested watersheds damaged or destroyed by fire, floods, and tornadoes. As a result, the Forest Service was involved in disaster emergency activities in New Mexico, California, Oregon, Washington, Alabama, Tennessee, North Carolina, Mississippi, Georgia, Kentucky Ohio, West Virginia, Indiana, and Illinois. Actions, in cooperation with the Soil Conservation Service (SCS), State Foresters, and other agencies, involved areas both within major declared areas and within areas covered under existing Department of Agriculture authorities.

Part III - Highlights of FY 1976 Program

In continuation of the progress reported since June 1973 to improve the natural disaster warning and preparedness system, further significant improvements are planned for FY 1976. Long-term programs begun in prior years will be continued; some, such as AFOS, will be greatly accelerated; and new programs such as SEASAT are planned.
The programs provided for in the FY 1976 budget focus on needed improvements identified in the NACOA Report on the Agnes Floods, particularly modernization and streamlining of the data collection, processing, and warning preparation functions, and faster, more thorough warning dissemination. Also significant research efforts will be directed to the solution of many long-standing problems in the detection, prediction, and early warning of short-lived, violent, and destructive storms. The components of this research program will include ground-based studies, aircraft field work, modeling studies based on numerical prediction techniques, and satellite system development. The following sections describe highlights of the planned FY 1976 programs.

MONITORING In addition to continuing other ongoing programs, significant accomplishments are planned in FY 1976 in the following monitoring capabilities:

- Launch GOES-A, the first NOAA funded geostationary satellite.
- Continue development and procurement of TIROS-N, the third generation polar-orbiting environmental satellite, and initiate research on requirements and applications of SEASAT data.
- Provide equipment needed to continue to obtain weather information from 22 remote radars of the FAA in the western United States.
- Procure RADAPs (Radar Data Processing System) and DVIPs (Digital Video Integrators and Processors) to integrate and process radar data.
- Modernize existing seismograph networks in the United States and install additional ones in the northeast.
- Test the prototype GOES seismic and tide data platforms.
- Continue research for development of improved remote sensors to support further study and modeling of severe storms.

GOES-A, the first NOAA funded geostationary environmental satellite, is scheduled for launch during the first half of FY 1976. The original launch date, mid FY 1975, was delayed to allow design improvements to correct weaknesses identified in the SMS-1 spacecraft systems. GOES-A will be a stored-in-orbit spare to insure continued operation of the 2-GOES system in the event of failure of either of the SMS spacecraft. Procurement actions are continuing for follow-on spacecraft at intervals based on normal projected life spans to insure no disruption in the vital support this program provides to the detection and tracking of hurricanes over ocean areas and monitoring the development and movement of severe storms and tornadoes over the United States. Photorecorders for GOES data will be put in operation at the remaining 16 WSFOs to complete the originally planned network of 45 WSFO/GOES facilities.

During FY 1976 NOAA will continue procurement of spacecraft and parts needed to insure no disruption in the polar-orbiting ITOS system which provides global data as part of the basic support to large scale analyses and forecast guidance for the disaster warning system. In addition, major procurement actions are planned for the ground data handling systems and spacecraft bus and instruments for TIROS-N, the third generation satellite system, which will provide significant contributions to improved warning capability through more accurate sensors and a means for global data collection and location from remote platforms.

As part of NASA's Earth and Ocean Physics Application Program the SEASAT mission is the first major step in developing and demonstrating a global ocean dynamics monitoring system. The SEASAT objectives include mapping the global ocean geoid, charting ice fields and leads, measuring precise sea-surface topography and the global monitoring of wave height, directional spectra, surface winds, current patterns and ocean temperature. The key features of an operational system are to be demonstrated including global sampling, near-real time data processing and dissemination and user feedback for operational programming. The SEASAT spacecraft is tentatively scheduled for launch in the second quarter of calendar year 1978. The FY 1976 NOAA budget request will provide funds to develop techniques for applying data from the NASA SEASAT program to NOAA missions. NOAA, the principal user of SEASAT data, will use these data to develop a comprehensive theoretical and experimental description of the structure and dynamics of the ocean and atmosphere as a total system for use in refinement of numerical models to provide more accurate predictions of storms, storm surges, tidal conditions, and state of the sea, plus additional operational forecasts not directly related to disasters.

Within the ground-based portion of the NASA Severe Storm Research Program, efforts will be continued to specify sensor characteristics and physical measurement concepts for detecting and locating tornado origins and activity. In studying the characteristic features of severe storms, much reliance will be placed on the new Atmospheric and Oceanographic Information Processing System (AOIPS), a mini-computer system being configured for the management, display, enhancement, and time-series presentation of meteorological data from all sources. Plans call for the development of microwave radiometer and radar technology for global surveillance of storms to obtain essential descriptive data such as precipitation rate profiles, cloud liquid water content, cloud structure, and surface wind velocities.

In the NASA aircraft field project work, flights will be continued to study characteristics of storm-producing cloud systems. Measurements will be made of the growth and decay of overshooting cloud domes, temperature differences between the dome and the surrounding anvil, and other significant meteorological phenomena near the cloud base. Damage surveys in the vicinity of storms under study will be conducted by instrumented aircraft. Work will be continued on the development of a Cloud-Top Scanning Radiometer, its integration with a high-altitude aircraft, and the analysis of the acquired data. Also, new sensing equipment, such as an Airborne Infrared Doppler Lidar system will be developed for observing tornado-scale phenomena from WB-57F aircraft. These instruments will be studied for possible NASA participation in the two NOAA-managed national severe storm projects, STORMFURY (hurricane modification) and SESAME (Severe Environmental Storms and Mesoscale Experiment).

In its modeling efforts, NASA will continue studies of storm properties through analytical solutions for the movement, growth, and behavior of thunderstorms, tornadoes, and hurricanes. After validating these solutions with aircraft and satellite data, the numerical solutions will be applied to studies of storm structure.

In NASA's satellite-related work, effort will be focused upon defining the use of an Advanced Atmospheric Sounding and Imaging Radiometer and will utilize the telescope and other technology of the SMS/GOES Visible and Infrared Spin-Scan Radiometer (VISSR) and the VISSR Atmospheric Sounder (VAS). Development of the instrument is underway in the Advanced Applications Flight Experiments (AAFE) Program. The AASIR will be flown on the Severe Storm Satellite (STORMSAT) which is planned to be launched about 1978, and will be positioned over the middle of the North American continent. Three-axis stabilization is required on the spacecraft in order to provide the longer dwell times ("on-target" times) needed to obtain data which best describes the severity of the observed storms.

While no new funding is requested for NOAA's Tsunami Warning System, a tide station is programmed for Salina Cruz, Mexico, and the prototype GOES seismic and tide data platform will be tested.

To supplement relatively sparse weather radar data in the mountainous regions of the western United States, NOAA has long relied on data from ARTCC radars operated by the Federal Aviation Administration. Automation of the air traffic control functions now planned by FAA would eliminate the weather data which are vital to accurate warnings of severe thunderstorms and flash floods in the area. NOAA is planning to install equipment needed to insure the continued availability of these important data.

The USGS in cooperation with various universities and the Nuclear Regulatory Commission, will establish a seismograph network to detect local earthquakes in the northeastern United States. The network will consist of about 80 seismograph stations in 10 states and will be capable of locating earthquakes of magnitude 3.5 or greater. Data from the network will be useful in assessing the possible activity of faults in the northeastern United States.

Existing local seismograph networks in other parts of the United States will be upgraded, with emphasis on addition of stations and telemetry links in southern California and Puerto Rico, in order to improve capability for detecting and locating small earthquakes. Improved data management techniques and introduction of automatic computer processing of data is planned for the central and southern California networks.

WARNING PREPARATION

Future improvements in the speed and accuracy with which warnings are prepared and issued are centered in plans for automation of field operations and services of the NWS and USGS and those sponsored by the National Science Foundation. Highlights are as follows:

- Accelerate the automation of field operations and services of the National Weather Service of NOAA.
- Expand the memory and core storage capacity of the computers of the National Meteorological Center.
- Initiate action to establish an experimental earthquake prediction system for southern California.
- Continue efforts to refine and develop hurricane storm surge computer models.

- Continue work to automate message handling at the National Tsunami Warning Center.

- Direct new efforts to refine and develop earthquake control and prediction techniques under study by USGS and NSF.

NOAA plans to accelerate implementation of AFOS, the program to automate field operations and service functions. The plan is to procure equipment for installation in 27 weather service forecast offices, 31 weather service offices, four national centers, four river forecast centers, and to initiate operation of the System Monitoring and Coordination Center. This is a major step toward complete implementation of the system by FY 1981, which will provide nationwide improvement in the warnings of impending disasters and the speed and efficiency with which they are issued.

NOAA's basic weather analysis and prediction programs which support the disaster warning functions depend on centralized high speed computer and data processing equipment at the National Meteorological Center. Improved and more complex computer models and vastly increased amounts of more detailed and accurate data from the newer satellites are becoming available. The more complex models and increased volume of data require faster computer processing to be of maximum utility. To accomplish this, NOAA plans to increase the main memory and disk storage capacity of the two large computers at Suitland, Md., by fifty percent. This expanded capability will permit more programs to be operated concurrently and will provide faster access to data bases in support of the warning system. Efforts to speed tsunami warning preparation will focus on automating message handling at the Tsunami Warning Center in Honolulu.

A major contribution to storm surge modeling was made with the development and implementation of the SPLASH (Special Program to List Amplitudes of Surges from Hurricanes) model. But, since the SPLASH models do not realistically simulate hurricane-induced flooding in bays and estuaries, NWS and NOAA's Environmental Research Laboratories are embarked on a joint research and development program to meet this need.

As a first step toward establishment of an experimental earthquake prediction system for southern California, the USGS will deploy dense arrays of seismometers and tiltmeters along the highly active San Jacinto fault, with telemetry links to USGS facilities at the California Institute of Technology in Pasadena. This experimental system will test the applicability of current earthquake prediction techniques used in the central California test area to the southern California region.

Basic research into earthquake source mechanics, crustal models, and possible earthquake precursors will be increased.

The USGS and the National Science Foundation plan to support studies into the economic, social, and political implications of earthquake prediction. Procedures for the review of scientific predictions and for the issuance of warnings of impending damaging earthquakes will be developed.

WARNING DISSEMINATION

The NACOA Report on the Agnes Floods singled out the high priority need for improving NOAA's capability to disseminate warnings. Three major program actions are planned in FY 1976 to expand the warning dissemination systems:

- Begin a program for priority completion of NOAA Weather Radio nationwide.
- Complete the NOAA Weather Wire Service in the conterminous States.
- Undertake system definition studies of a Disaster Warning Satellite System (DWSS).

A 1975 policy statement by the Office of Telecommunications Policy designated the NOAA Weather Radio system as the single Federally-sponsored system for direct broadcast of warnings to the homes, and expressed the need for its priority expansion. Current NOAA plans for a network of about 331 stations will be expedited in FY 1976 with the installation of transmitters serving 46 additional locations, as a first major step toward completion of the planned network by FY 1979. Also, in carrying out the OTP policy statement on home warnings and in compliance with the Natural Disaster Act of 1974 (PL 93-282), plans are being developed to use the NOAA Weather Radio network as a supplemental system for the dissemination of attack warnings by the Defense Civil Preparedness Agency (DCPA).

The NOAA Weather Wire Service is the primary means for delivering forecasts and warnings to the mass media for broadcast to the public. In FY 1976, NOAA plans to complete NWWS in the remaining 13 states not now served to make this important service available to an additional 2,000 radio and TV stations serving 40 million people.

It is planned that NASA in cooperation with NOAA will undertake systems definition studies of DWSS in FY 1976. These studies will provide preliminary designs and specifications of the satellite and its associated ground equipment. Schedules and resource requirements for the development and implementation of DWSS will also be generated. Should the decision be made to proceed into the flight phase, it is expected that a prototype mission could be launched in 1981, and that DWSS could be fully operational in 1986.

COMMUNITY PREPAREDNESS

Preparedness activities will continue to be stressed in FY 1976 in consonance with the Natural Disaster Act of 1974. Highlights of planned program activities will include:

- Continuation of the DCPA On-Site Assistance Effort with coordination and participation by other Federal agencies.

- Maintenance of NOAA's Community Preparedness and Public Education Efforts.

- New initiatives in earthquake hazard assessments in special seismic zones and nationwide to support safe siting of nuclear power reactors.

During FY 1976, DCPA in coordination with NOAA and other agencies will conduct about 250 on-site assistance projects distributed geographically throughout the U.S. Continued emphasis will be placed on communities in natural disaster-prone areas. Among other things, this effort will focus on flash flood warning systems and the Federal assistance available for installing them in vulnerable communities. The FDAA will assist by giving maximum publicity to the program through continuing relations with State Civil Defense Directors.

NOAA Community Preparedness efforts will continue in FY 1976. In cooperation with other Federal, State, and local agencies, mandatory tornado drills in schools will be encouraged and hurricane preparedness planning for hurricane winds, floods, and maximum potential storm surge will be recommended along the entire gulf and Atlantic shorelines. Public safety and education programs to make the public aware of the proper response to all natural disasters will be expanded. Efforts will be maintained to encourage rapid dissemination of weather warnings and assist communities to develop and exercise local preparedness plans.

USGS assessment of earthquake hazards in the Salt Lake City, Utah, area will be increased substantially. Emphasis will be on the evaluation of the tectonic framework and seismic risk of the Wasatch fault zone; delineation of active faults in the urban areas along the Wasatch Front; and study of the expectable shaking response of geologic units to large earthquakes.

As part of a national program to facilitate the safe siting of nuclear power reactors, the USGS will begin studies to develop advanced techniques for prediction of ground motion from earthquakes under varied geologic conditions. Theoretical, laboratory, and field investigations are planned to determine the effects of geology and hydrology on levels of strong shaking. The results will be useful for seismic microzonation and therefore will be applicable to land-use planning and engineering design to help mitigate earthquake effects.

ENVIRONMENTAL MODIFICATION

Experimental tests and research programs in weather modification are planned to continue, with some increased effort in FY 1976. Highlighted are:

- Project Skywater and the High Plains Cooperative Program of the Bureau of Reclamation.
- NOAA's summer field experiments in Cumulus Modification in Florida.
- Continuation of aircraft instrument procurement, installation, and check-out in preparation for project STORMFURY.

The Bureau of Reclamation, as the principal water resources management and development agency in the Department of Interior, has primary interest in the area of precipitation management, and conducts a comprehensive research program to develop cloud seeding techniques which can be utilized to augment water supplies, particularly in water-short areas of the Nation. Project Skywater, as the research program is known, represents expertise and capability in-being for weather modification activity that are currently devoted to investigation for advancing the effectiveness of this technology. Research in seeding the warm cloud systems which prevail over the Plains States in summer, however, is not as advanced as in the case of cold orographic-type seeding. To accelerate warm cloud research, the Bureau redirected its various efforts in the Plains States toward a new coordinated, cooperative experiment in 1974. Completion of this major Project Skywater effort, scheduled for 1981, is expected to establish a feasible cloud seeding technology for confidently increasing water supplies in the High Plains.

Another summer of field experiments over Florida is planned by NOAA, with assistance again provided by universities and other agencies. This work, devoted to testing the feasibility of enhancing precipitation from tropical cumulus, will add to the experimental data collected in 1973.

NOAA plans to continue the program to modernize the Research Facilities Center aircraft in preparation for Project STORMFURY. Procurement, installation, and check-out of equipment is planned, with procurement including an initial set of meteorological research instruments, a second P-3D data system, and three aircraft radars.

Part IV - Future Needs

As noted earlier in this supplement, many Federal programs to strengthen our warning and preparedness system are multi-year in nature. The following sections discuss agency assessment of expected progress and needs in the FY 1977-80 period.

MONITORING Many of the programs begun in the past two years are expected to bring about significant improvements in our monitoring of natural hazards by the end of this decade. Highlights include:

- The completion of the long-range and local warning radar networks by 1979.
- The modification of FAA radars to provide continued coverage in the mountainous areas of the west.
- The expansion of data-collection from remote sensors through satellite communications systems. Included are the collection of river and rainfall reports, environmental data from ocean platforms and buoys, automatic weather stations, tide gages and seismology stations.
- The completion of systems to place satellite imagery in all forecast offices and considerable experience in the interpretation and use of this data.
- Completion of the flash flood alarm demonstration project and rapid expansion, through community funding, of the number of alarms.
- Global monitoring and assessment of the impact of climatic fluctuations on national and international resources.
- Implementation of Radar Data Processing Systems (RADAP) at long-range radar stations.
- Implementation of Digital Video Integrators and Processors (DVIPs) at long-range weather radar stations.
- Improved and expanded marine observations for defining storms approaching the shoreline.

- Automation of selected fire danger assessment locations for determining weather and fuel moisture conditions.

- The initial planning for Project SESAME--a severe storm mesoscale experiment planned for the late seventies.

- First measurements of the three-dimensional velocity fields in thunderstorms by using three Doppler weather radars in a coordinated system.

Other needed improvements in our monitoring systems are dependent upon current research or new funding, and assessment of future progress is somewhat difficult. Included in this category are:

- The development of operational tornado detectors.

- The establishment of a uniform national seismograph network.

- Expanded use of airborne gamma radiation methods for rapid assessment of flood potential in critical snow-covered basins.

- Development of satellite imagery techniques for quantizing results for input to forecast models.

- The possible modification of NWS weather radar to permit Doppler identification of the location of strong winds and tornadoes.

WARNING PREPARATION

Highlights of Federal efforts to improve the preparation of hazard warnings in the next few years are centered around completion of automated systems of data handling and forecast preparation and the development of more sophisticated models of prediction. Among improvements sought or expected are:

- The completion, by FY 1981, of the AFOS program.

- The development of mesoscale atmospheric prediction models, specifically through operation of project SESAME and efforts of the severe local storms application development group.

- The development of coastal run-up models for tsunamis.

- The establishment of experimental earthquake prediction systems in central and southern California to be later expanded into operational systems covering San Francisco and Los Angeles.

- The implementation, by 1980, of the NWS Hydrologic Forecast Model at all RFCs.
- The development of new hurricane storm surge prediction models.
- Risk assessment analyses which relate the impact of climate variations to socio-economic programs and events.
- The development of resource/climate models to quantify the effects of weather and climate on crops, energy, and other resources.
- The development of a next generation hydrologic model to incorporate estimation theory principles to maximize forecasts.
- Completion of River Forecast Center coverage in the U.S.
- The provision of increased manpower devoted to avalanche prediction and warning preparation to extend this service to other areas needing such warning services on a routine basis.

WARNING DISSEMINATION

The completion, in FY 1976, of the NOAA Weather Wire Service throughout the conterminous 48 states will provide the foundation for distributing hazard warnings through mass media outlets. This is a significant step forward, but will still prove to be too slow in some short-fused warning situations. The expansion of the NOAA Weather Radio stations nationwide, with 331 stations in operation by FY 1979, will greatly improve this situation and make warnings directly available to local action officials and 95 percent of the general public. Continued interagency cooperation will result in the rapid transmission of all hazard warnings to concerned areas.

Investigations will be continued on the feasibility of a Disaster Warning Satellite as a follow-on system for possible implementation by the mid 1980s. Systems definition studies planned for FY 1976 will determine the cost effectiveness of the satellite approach. A decision to proceed would permit the development of a prototype satellite system to be undertaken in FY 1977.

COMMUNITY PREPAREDNESS

The assignment of NWS community preparedness specialists to 28 additional WSFOs, now expected in FY 1977, will do much to strengthen the community preparedness effort. These specialists, working in cooperation with personnel of

DCPA and other state and local agencies, will encourage the preparation of local preparedness plans for natural disasters, cooperate with local authorities in conducting natural disaster drills, and establish and train tornado spotter networks and flash flood observer networks. Working with the news media, the community preparedness specialist will supplement a public education program designed to inform the populace of safety measures that will protect life and property from the ravages of natural hazards.

Another very important function in preparedness is a continuing risk assessment for the various natural hazards. For example, an expanded and accelerated earthquake hazards evaluation program is needed for all urban areas of high and moderate seismic risk. In particular, studies of eastern U.S. cities in Seismic Risk Zone 3 should be started, and methodologies of earthquake hazards mapping applicable to the eastern states must be developed.

ENVIRONMENTAL MODIFICATION

By the end of FY 1977, NOAA expects to complete the required modernization of its Research Facilities Center aircraft and begin the field experiment phase of Project STORMFURY. Field experiments in tropical cumulus modification will continue until sufficient data is available to make evaluations of operational usefulness. Future progress in o other environmental modification activities, such as in earthquake prevention, will depend upon current research.

A continuing review is necessary of legislation dealing with modification activities if we are to reap the optimum results from available modification techniques. For example, present Federal laws do not specifically provide for the use of weather modification technology as a means for coping with drought disasters. In the past, when critical drought periods occurred, the application of small-scale cloud seeding efforts to alleviate the drought could best be described as too little and too late. To be most effective, weather modification should be utilized during more favorable periods to improve water supplies and soil moisture in drought-prone areas in order to ameliorate the effects of drought should it occur.

Part V - Program Plans

OBJECTIVES VS. FEDERAL PROGRAM CHANGES FY 1975-80

OBJECTIVE	FY 1975 PROGRAM CHANGES	FY 1976 PROGRAM CHANGES	FY 77-80 PROGRAM ESTIMATES	REMARKS
MONITORING				
GOES Provide near-continuous observations of severe storm development and data collection and transmission using GOES system.	NOAA Continue procurement of GOES B and C spacecraft (0/7325K). (Note: The increase is offset by decreases of -2152K in the GOES A launch vehicle and services program.) Polar-orbiting spacecraft sounding data and high latitude imagery will supplement GOES data. (0/5173K)	NOAA Launch GOES A and prepare for launch of GOES B and C as required.	NOAA Maintain the 2 GOES System.	The prototypes for GOES, NASA's Synchronous Meteorological Satellites, were launched in May 1974 (SMS 1) and February 1975 (SMS 2) and are providing operational data from their locations at 75°W and 115°W longitude. GOES A will be stored in orbit as a spare to replace either SMS in event of failure.
Polar-orbiting Satellite Provide improved satellite information services based on quantitative data from third generation polar-orbiting satellite with improved resolution and accuracy through the Advanced Very High Resolution Radiometer, the TIROS-N Operational Vertical Sounder, the Space Environmental Monitor, and a data collection system.	NOAA Begin procurement of ground equipment, data handling systems, and spacecraft for the third generation polar-orbiting satellite system (0/1365K).		NASA TIROS N launch projected in 1978.	NOAA, NASA, and DOD are collaborating on planning the design and development of the spacecraft and sensors.
SEASAT NASA research satellite will provide capability to measure global ocean dynamics and physical characteristics including directional wind field, wave spectra, sea surface temperature, sea surface topography and geodal height.		NOAA Initiate program to support research related to requirements, processing, analysis, and application of SEASAT data. (5/730K) NASA Continue work on SEASAT spacecraft.	NOAA Complete and refine tasks associated with sea truth testing, ocean surface wind and wave models, software models for marine geodesy, determination of sea level, sea slope and sea surface temperatures. NASA Continue SEASAT program for planned launch in mid-1978.	

OBJECTIVES VS. FEDERAL PROGRAM CHANGES FY 1975-80

OBJECTIVE	FY 1975 PROGRAM CHANGES	FY 1976 PROGRAM CHANGES	FY 77-80 PROGRAM ESTIMATES	REMARKS
Satellite Input to Warning Offices Equip and staff 48 more NWS Forecast Offices to receive and use satellite environmental information in providing warning services.	NOAA Buy 18 photorecorders to complete equipment purchase. Install and begin operations in 16 WSFOs, including 3 in Alaska/ Annualise operations of all equipment installed to date. (All FY 1975 program increases were through reprogramming.)	NOAA Complete installation and begin operation of equipment to provide high-quality GOES pictures in all WSFOs and Centers.	NOAA Provide staff as resources become available.	
Tsunami Monitoring Improve the capability to issue tsunami warnings promptly by automating the seismic network for rapid collection of data.			NOAA Automate seismographs and tide gages with data telemetered to Honolulu Observatory and automate data evaluation and issuance of warnings at the observatory	
Develop a capability to provide quantitative tsunami warnings for Hawaii by using open ocean tsunami detectors.			NOAA Procure and deploy 4 open ocean tsunami detectors and develop coastal run-up models.	
Fire Danger Rating System Complete the implementation of Fire Danger Rating System on all Federal and State protected lands.	USFS Extension of the system to include all risk components and all automation of all calculations (75K)	USFS No change	USFS Automate selected fire weather-fire hazard observation sites (250K)	

OBJECTIVES VS. FEDERAL PROGRAM CHANGES FY 1975-80

OBJECTIVE	FY 1975 PROGRAM CHANGES	FY 1976 PROGRAM CHANGES	FY 77-80 PROGRAM ESTIMATES	REMARKS
<u>Radar</u> Complete the expansion and modernization of the weather radar surveillance program by providing:			<u>NOAA</u> Complete Radar Plan Implementation by 1979.	
1. 5 long-range network radars to fill major gaps in the network	<u>NOAA</u> Begin procurement and installation of network radar for S. New York. (0/420K)	<u>NOAA</u> Radars to become operational in S. Virginia, S. New York, east Texas.	<u>NOAA</u> Install radars in eastern N. Dakota, northwest Nebraska.	
2. 66 local warning radars for 29 new operating locations and to replace 37 obsolete radar sets.	<u>NOAA</u> Procure 19, install 4 and begin operating 4 local warning radars (12/1381K).	Procure 14, install 26 local warning radars.	Procure 6, install final 36.	
3. 53 digital video intetrators and processors (DVIPs).	Procure and install 47 digital video integrator and processors. (0/265K)	Procure and install 6 DVIPs.		
4. 75 RADAP/RADIT units to process and transmit digitized radar data.		Procure RADAP units for 56 network and 15 local warning radars.	Procure RADAP/RADIT combination.	
5. 47 additional radar remote receivers for a total of 106.		Procure 8 receivers.	Procure 39 receivers.	
6. 27 FAA radars with modifications and equipment for remoting to NWS facilities.		Procure and install equipment at 22 sites. (0/1925K)	Begin operations and maintenance at 22 sites, procure equipment and install at 5 additional sites.	
7. Dopplerization of NWS local warning radars.			$150K is required to develop, test, and evaluate the modification of one local warning radar to provide Doppler information on the local wind fields. Depending on these tests, up to an estimated $40K will be needed per local warning radar to achieve Doppler capability.	

OBJECTIVES VS. FEDERAL PROGRAM CHANGES FY 1975-80

OBJECTIVE	FY 1975 PROGRAM CHANGES	FY 1976 PROGRAM CHANGES	FY 77-80 PROGRAM ESTIMATES	REMARKS
Hydrologic Data Collection Develop a hydrologic data collection network of about 10,000 river and rainfall stations. Under AHOS (Automatic Hydrologic Observing Stations), some 2,500 of which will be automated for data collection through the GOES satellites and another 2,500 automated using ground communications.	NOAA Procure 73 radio sets for use with GOES Satellite and 90 telephone telemetry set. Continue installation of prior year telemetry sets. Begin testing of radio sets.	NOAA Procure approximately 100 telephone sets. Continue installation, with about 300 telephone and 44 radio sets installed at end of fiscal year.	NOAA Complete AHOS procurement continue installation work.	Level funding FY 75 and 76, with major AHOS buys planned for FY 77 and FY 80.
Provide improved snow-cover and potential flood evaluations by developing instrumentation to measure water equivalent of snow on the ground by gamma radiation methods.			Expand use as required.	Experimental program near U.S.-Canadian border in 1974 showed feasibility of technique and data was used operationally early in 1975.
Develop the observational network needed to support preparation of forecasts of river-water temperature.			NOAA Install sensors and increase implementation rate to 100/year until the network is complete.	Water temperatures are used in predicting ice formations and actions as well as in thermal pollutions of rivers.
Electronic Tornado Detector Provide a capability for remote detection of tornadoes in all Weather Service Offices with warning responsibility in areas where tornadoes occur with significant frequency.	NOAA Continue field testing and evaluation of directional electromagnetic tornado detection equipment.	NOAA Continue test and evaluation.	NOAA Provide operational system dependent upon evaluation.	

OBJECTIVES VS. FEDERAL PROGRAM CHANGES FY 1975-80

OBJECTIVE	FY 1975 PROGRAM CHANGES	FY 1976 PROGRAM CHANGES	FY 77-80 PROGRAM ESTIMATES	REMARKS
Remote Sensing Develop improved capability for remote sensing of the atmosphere and ocean using optical, radio, and acoustic techniques applicable to NOAA's storm detection and warning.	NOAA Conduct field experiment to evaluate potential for monitoring gravity wave initiation of severe storms. Continue field testing and evaluation of directional electromagnetic tornado detection equipment. Develop prototype optical Doppler system and conduct field observations of vortex phenomena. Continue developmental work in multiple-Doppler radar operations. (0/650K)	NOAA Continue development and field testing required to achieve operational capabilities with new remote sensing techniques.	NOAA Continue development of new methods to measure and monitor meteorological parameters required to detect severe storms. Instrument a meteorological tower to calibrate and evaluate remote sensors. Continue development of applications to move remote sensing technology from the laboratory to operational prototype systems for field use in severe storm investigations.	
Emergency Power Provide full standby power source for emergency use at all operational offices of the NOAA National Weather Service.			NOAA Procure 356 emergency power generators and complete installation by 1980.	

OBJECTIVES VS. FEDERAL PROGRAM CHANGES FY 1975-80

OBJECTIVE	FY 1975 PROGRAM CHANGES	FY 1976 PROGRAM CHANGES	FY 77-80 PROGRAM ESTIMATES	REMARKS
<u>WARNING PREPARATION</u>				
<u>AFOS</u> Implement automation of field operations and services at all NWS forecast offices and the coordination center for more effective application of man-power to warning preparation, especially during emergencies.	<u>NOAA</u> Procure and install automatic equipment and develop software for 3 WSFOs, 1 RFC, 2 WSOs, and 1 Systems Monitoring and Coordination Center. (8/2180K)	<u>NOAA</u> Procure and install equipment for 40 weather offices. (5/12,460K)*	<u>NOAA</u> Complete procurement of equipment and proceed with installation.	<u>NOAA</u> Field implementation will be completed in FY 1981. *Does not include $1.3M deferred. Deferral and prior year increment will be used to procure equipment for 4 National Centers, 4 River Forecast Centers, and 18 WSOs.
<u>SESAME</u> Improve short-range forecasts and warnings by undertaking field research to identify and understand the processes and controlling parameters of mesoscale and local severe storm outbreaks.			<u>NOAA</u> Undertake a Severe Environmental Storms and Mesoscale Experiment (Project SESAME) to collect comprehensive mesoscale data sets needed for the development and verification of mesoscale prediction models.	
<u>River and Flood</u> Implement the new NWS Hydrologic Forecast Model at all RFCs.	<u>NOAA</u> In progress.	<u>NOAA</u> In progress.	<u>NOAA</u> Complete by 1980.	
Provide complete nationwide coverage by opening new RFCs in the Great Lakes and Great Plains areas.			<u>NOAA</u> Open new RFCs - 1977. Assume limited forecast responsibility 1978. Furnish complete service 1979.	

OBJECTIVES VS. FEDERAL PROGRAM CHANGES FY 1975-80

OBJECTIVE	FY 1975 PROGRAM CHANGES	FY 1976 PROGRAM CHANGES	FY 77-80 PROGRAM ESTIMATES	REMARKS
River and Flood (Cont'd) Provide extended service forecasting capability at all River Forecast Centers			NOAA Complete extended coverage at 10 more RFCs.	
Provide Improved Flash Flood Warning Capability.	NOAA Install 20 additional flash flood alarms in the demonstration project.	NOAA Continue installation of alarms.	NOAA Complete installation of the 99 flash flood alarms in the demonstration project. Develop and implement program to provide assistance to communities in siting and installing flash flood alarms.	NOAA Of some 2,500 communities seriously threatened by flash floods, about half could effectively use flash flood alarms or self help systems. As a demonstration project, NOAA is buying and installing 99 flash flood alarms (65 over telephone lines and 34 via radio). In each case, the community concerned agrees to pay communications and utility charges and to monitor the alarm around-the-clock. 33 of the telemetered alarms have been installed and the remainder of them will be commissioned by Aug. 1975. The radio alarms will be purchased in July 1975 and commissioned by Jan. 1977.
Avalanche Warnings Provide an improved avalanche warning service.	USFS Improve prediction and implement the System west-wide where required.			

OBJECTIVES VS. FEDERAL PROGRAM CHANGES FY 1975-80

OBJECTIVE	FY 1975 PROGRAM CHANGES	FY 1976 PROGRAM CHANGES	FY 77-80 PROGRAM ESTIMATES	REMARKS
<u>NSSFC Tornado Research</u> Significantly expand and accelerate research and development in operationally oriented severe storm prediction techniques especially for forecasting severe storms in the 0-6 hour period.			<u>NOAA</u> Establish applications development group at NSSFC. Recruit personnel, start research and development of techniques and establish a data bank of past severe storm incidents. (6/273K)	
<u>Agriculture and Fire Weather</u> Provide expanded agricultural weather services to additional agricultural areas and expand fire weather forecast activities where present services are inadequate.			Complete expansion of fire weather and agricultural weather forecast activities through WSFOs by cross-utilization, specialized training of existing staff, internal reprogramming from AFOS manpower savings, or increases in positions. As resources become available, establish Environmental Studies Service Centers (ESSCs) to provide meteorological Extension Advisory Services to the Agricultural Community. Automation of the collection and dissemination of fire weather products is planned as is contractual research in both fire weather and agricultural meteorology.	One ESSC (Auburn, Ala.) has been operating since July 1973. A second was established at Stoneville, Miss., in Jan. 1975, and a third is being set up at College Station, Tex. A total of 11 ESSCs will complete the program.

OBJECTIVES VS. FEDERAL PROGRAM CHANGES FY 1975-80

OJECTIVE	FY 1975 PROGRAM CHANGES	FY 1976 PROGRAM CHANGES	FY 77-80 PROGRAM ESTIMATES	REMARKS
Earthquake Prediction Develop the physical understanding and instrumental means required for forecasting the time, place, and magnitude of earthquakes.	USGS Research and experimentation on earthquake prediction and control	Continuation		
Hurricane Storm Surge Improve hurricane storm surge predictions by developing prediction models having broader application capabilities.			NOAA Develop new numerical models for predicting hurricane storm surge in areas of irregular coastline, broken coast features, and where nonlinear effects are important.	
Tsunami Risk Assessment Provide detailed tsunami risk assessment planning information and quantitative tsunami warnings for Port Valdez, Alaska, (TAPS terminal).			NOAA Undertake studies to provide computation of wave run-up for the port area, design criteria for shore structures, design of harbor warning system, and recommended operational procedures in the event of a tsunami.	NOAA Port Valdez is located in an area vulnerable to tsunamis caused by both deep ocean earthquakes and local landslides.

OBJECTIVES VS. FEDERAL PROGRAM CHANGES FY 1975-80

OBJECTIVE	FY 1975 PROGRAM CHANGES	FY 1976 PROGRAM CHANGES	FY 77-80 PROGRAM ESTIMATES	REMARKS
WARNING DISSEMINATION				
NWWS Complete coverage of NOAA Weather Wire Service to all conterminous states in U.S.	NOAA NWWS operational in 35 states.	NOAA Complete coverage in states of: NV, UT, NM, ME, MA, CT, RI, MN, ND, SD, ID(N), WA, CA (49/1455K)		FY 1976 increases will complete the program with service available in the conterminous 48 states.
VHF-FM Weather Transmission Complete the planned network of 331 stations to provide nationwide coverage of VHF/FM NOAA radio continuous broadcasts of weather forecasts and warnings.	NOAA Install NOAA Weather Radio at 10 locations, bringing total stations operating to 77.	NOAA Install equipment at 46 locations. Continue negotiations of purchase/lease arrangements for remainder of locations. (0/3560K)	NOAA FY 76 1/4 Install equipment at 23 sites. FY 77 Install equipment at 87 sites. FY 78 Install equipment at 50 sites. FY 79 Install equipment at final 48 locations.	Equipment for 56 stations installed in FY 74 and 75 was purchased using re-programmed funds. FY 1976 increases will buy out the program and maintain it in future years under a combination purchase/lease contractual arrangement.
Weather-by-Phone Expand the availability of automatic telephone forecasts to major metropolitan areas nationwide as rapidly as possible.	NOAA Funding by TELCO. Statewide trial in Illinois as a test function (zero K).	NOAA Funding by TELCO. (Zero K).	NOAA Funding by TELCO expansion on nationwide basis as much as possible.	NOAA Persuade the various telephone companies to solicit sponsors for this service, and to expand their own funds to provide this service as a profit-making enterprise.

OBJECTIVES VS. FEDERAL PROGRAM CHANGES FY 1975-80

OBJECTIVE	FY 1975 PROGRAM CHANGES	FY 1976 PROGRAM CHANGES	FY 77-80 PROGRAM ESTIMATES	REMARKS
<u>DIDS</u> Provide a low cost radio warning system known as the Decision Information Distribution System (DIDS) to disseminate attack warning to selected Federal agencies, local governments and institutions, home of selected officials and emergency services key personnel, the broadcast stations, and by interface, over the NOAA Weather Radio System to private homes. Use DIDS whenever practicable to disseminate natural disaster warnings. Test interface of DIDS with the National Weather Service disaster warning operations.	<u>DCPA</u> Continue to operate the first DIDS transmitter located at Edgewood, Md. Conduct special tests. Continue the general weather announcements and time announcements now being made over DIDS. Continue to operate the 375 voice receivers now deployed and now operational in a 10-state area. FY 75 increased $500K over FY 74. DCPA and NOAA are developing procedures for dissemination of attack warnings over NOAA Weather Radio.	<u>DCPA</u> Continue operation of the first transmitter and the 375 voice receivers. Add 1,000 voice receivers. Conduct operational test of the 1,000 voice receivers deployed in specific geographical areas prone to natural disasters and other emergencies. FY 76 decreased $179K from FY 75. DCPA and NOAA will finalize and implement procedures for disseminating attack warnings by NOAA Weather Radio.	Continue to operate the first DIDS transmitter and the 1,375 voice receivers. Evaluate operations and the results of special tests. Expand the system within the 10-state area of coverage and beyond this area of coverage.	
<u>NAWAS</u> Provide additional DCPA National Warning System Circuits, in Weather Service Offices and communities. Provide interstate connections to Weather Service Offices for speeding the warning process when tornadoes cross state boundaries.	<u>DCPA</u> Only 38 out of a planned 200 cities and counties were added to the National Warning System due to a freeze on U.S. Army Communications Command leasing funds. The program is funded through the Dept. of the Army. This was a decrease of $40K from the FY 74 effort.	<u>DCPA</u> Add 77 National Weather Service Stations to the DCPA National Warning Systems giving them a total of 356 stations on the system. Add a total of 123 cities and counties to the National Warning System. The program is funded through Dept. of Army. This increase FY 75 funds by $80K.	<u>DCPA</u> Continue to add a total of 200 cities and counties to the National Warning System each fiscal year.	
<u>Future Dissemination System</u> Conduct investigations and studies needed to develop for mid 1980s a low cost national warning system that will make warnings available in all homes.	<u>NOAA/NASA</u> Continued work following initial jointly-funded feasibility study which showed a Disaster Warning Satellite System (DWSS) was technologically feasible.	<u>NOAA/NASA</u> Undertake system definition studies for a DWSS.	<u>NOAA/NASA</u> Further developmental work contingent on outcome of FY 1976 studies. Favorable outcome could lead to prototype launch in 1981.	

OBJECTIVES VS. FEDERAL PROGRAM CHANGES FY 1975-80

OBJECTIVE	FY 1975 PROGRAM CHANGES	FY 1976 PROGRAM CHANGES	FY 77-80 PROGRAM ESTIMATES	REMARKS
COMMUNITY PREPAREDNESS AND RISK ASSESSMENT				
Complete the planned program to assign specialists to each WSFO to provide Assistance to communities in natural disaster preparedness planning.			NOAA Complete manning the program by assigning Community Preparedness Specialists to 28 WSFOs, 2 Regional Headquarters, and 4 training positions.	20 specialists (19 at WSFOs, 1 at Southern Regional Headquarters) are currently assigned to the program.
Improve disaster preparedness programs of communities Provide guidance, encouragement and planning assistance to localities to upgrade local disaster plans with greater emphasis on preparedness and particular attention to warning capability.	DCPA Defense Civil Preparedness Agency will continue to send On-Site Assistance Teams to local governments to (1) assess existing capabilities, (2) to survey local needs, and (3) develop action plans to meet requirements identified. This effort involves most DCPA programs and no funds are programmed specifically for On-Site Assistance Teams.	Continue to send On-Site-Assistance teams to assist local governments.	Continue to send On-Site-Assistance teams to assist local governments.	
Improve disaster preparedness plans and programs of States and communities by continued implementation of Federal agency programs:				
a. FDAA grant program under PL 93-288 for the development and maintenance of State disaster plans.	FDAA $250,000 outright grant available to each State. This is a one time grant.	FDAA $25,000 matching grants available to each State to improve and maintain plans.		
b. Defense Civil Preparedness Agency On-Site Assistance program for local governments to (1) assess existing capabilities, (2) to survey local needs, and (3) develop action plans to meet requirements identified.				

OBJECTIVES VS. FEDERAL PROGRAM CHANGES FY 1975-80

OBJECTIVE	FY 1975 PROGRAM CHANGES	FY 1976 PROGRAM CHANGES	FY 77-80 PROGRAM ESTIMATES	REMARKS
Conduct earthquake vulnerability analyses and damage assessment studies for high risk metropolitan areas as an essential first step in hazard reduction and preparedness planning.	USGS Studies completed for San Francisco Bay and Los Angeles areas ($340,000). Studies in progress for Puget Sound, Wash., and Salt Lake City, Utah areas ($330,000). Above studies were under contract from FDAA.	Unknown at this time.		
Complete earthquake response planning for metropolitan areas of high seismic risk under PL 91-606 authorization for matching funds	FDAA Approved planning contracts with the State of California for response plans in the San Francisco and Los Angeles areas ($250,000). Plans will be complete in 1975.	FDAA Planning contracts will be negotiated for Puget Sound and Salt Lake City areas under PL 93-288, the Disaster Relief Act of 1974.		
Determine the public policy implications of a credible earthquake prediction capability. The assessment should include the social, political, economic, behavioral and legal consequences that would ensure from this capability.	National Academy of Sciences (NAS) The committee on seismology, NAS, established a panel on Earthquake Prediction to make a scientifc assessment of the state-of-the-art. A special panel of the Advisory Committee on Emergency Planning (ACEP), NAS, under contract to FDAA, will provide advice to FDAA on the Public Policy Implications of Earthquake Prediction ($70,000 supplement of $10,000).	Continuation.		
	National Science Foundation (NSF) NSF has established an earthquake task force and will fund studies on the Technology Assessments of earthquake prediction.	Continuation.		
Develop a capability to provide assessments of the impact of variations of environmental factors on national and global socioeconomic problems through development of statistical models and assessment of natural phenomena.	NOAA Establish an EDS Center for Climatic and Environmental Assessment (CCEA) to assess the impact of climate variations on crop production. This includes the development of crop yield models and risk analyses assessments.	NOAA Increase CCEA personnel 13 to 20 people. Expand CCEA studies to energy and living marine resources.	NOAA Begin a major initiative encompassing climatic monitoring, analysis and assessments directed toward conservation of energy resources and increased production and more efficient management of food grains.	

OBJECTIVES VS. FEDERAL PROGRAM CHANGES FY 1975-80

OBJECTIVE	FY 1975 PROGRAM CHANGES	FY 1976 PROGRAM CHANGES	FY 77-80 PROGRAM ESTIMATES	REMARKS
ENVIRONMENTAL MODIFICATION				
Conduct Project STORMFURY in the Pacific to test the hypothesis that the maximum surface winds in hurricanes can be reduced by at least 10 to 15 percent by cloud seeding.	NOAA Continue modernization of Research Facilities Center aircraft. Procure (a) second P-3D aircraft, (b) remainder of data system for first P-3D, (c) long lead items for data system for second P-3D, (d) long lead P-3D spares. (0/9210K)	NOAA FY 76 - Procure (a) second P-3D data system, (b) radars for two P-3Ds and NASA CV 990, (c) initial set of meteorological research instrumentation. Install and check out equipment purchased. (0/5488K)	NOAA FY 76 1/4 - FY 77 Complete modernization. Procure balance of radar systems, seeding systems, research instruments, spares. Install and check out equipment. (24/4930K) Begin STORMFURY field experiments.	Alternative plan, calling for use of civilian research aircraft for STORMFURY, necessitated by AF inability to obtain AWRS and radars within cost and schedule constraints of original NOAA plan. Alternate plan has been coordinated with NASA.
Continue tropical cumulus modification experiment to test the feasibility of precipitation enhancement from tropical cumulus clouds.		NOAA Summer field experiments in Florida.	NOAA Continue field experiments and evaluations.	Level funding.
Conduct research into the use of cloud seeding to augment precipitation during the growing season in the High Plains.	DOI High Plains Cooperative Program (HIPLEX).	DOI Begin field experiments.	DOI Continue field experiments and evaluation.	Level funding after FY 1976.
Conduct research into lightning prevention for forest fire protection.	USFS Phasing down present research approach. (-$150K)	USFS -$75K	USFS Maintain level funding.	
Implement flood prevention progress in small watersheds.	USFS Complete implementation of flood prevention program on 11 small watersheds managed by the Forest Service. ($400K)		USFS Level funding for balance of the period.	