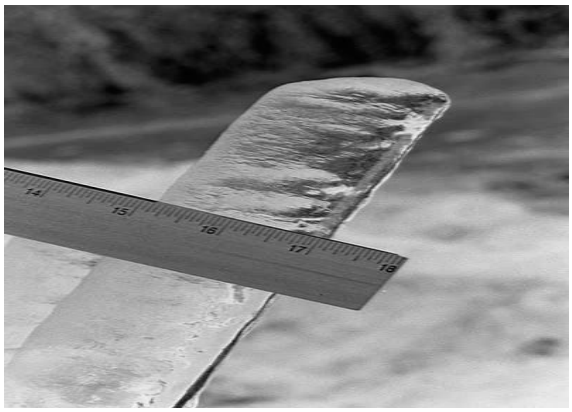
Service Assessment

THE ICE STORM AND FLOOD OF JANUARY 1998



June 1998

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
Eastern Region
Bohemia, NY

Cover: top left photograph – view from the front door of NWSFO GYX
top right photograph – view of ice accretion on a tall piece of grass
bottom photographs – Black River at Watertown, NY

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U.S. DEPARTMENT OF COMMERCE
William M. Daley, Secretary

National Oceanic and Atmospheric Administration
D. James Baker, Administrator

National Weather Service
John J. Kelly, Jr., Assistant Administrator

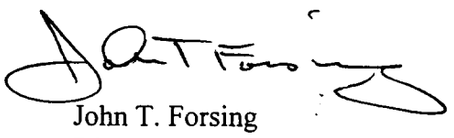
National Weather Service, Eastern Region Headquarters
John T. Forsing, Director

PREFACE

The primary purpose of this Service Assessment is to document the National Weather Service's (NWS's) performance in fulfilling its mission of providing accurate forecasts and timely warnings prior to, during, and after **The Ice Storm and Flood of January 1998**. The extent and magnitude of this storm is unprecedented in New England history. The NWS's products and services, used by emergency managers, media, and others, are key to public safety during such an extreme event.

The Service Assessment Team collected data and information from affected NWS offices. The Team also surveyed a wide range of NWS users to determine their level of satisfaction and the utility of NWS products and services.

The Team is indeed most grateful to the many people who took time from other activities to assist in assessing the NWS's performance during this event.



John T. Forsing
Director, Eastern Region
National Weather Service

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ACRONYMS AND ABBREVIATIONS

ACOE	Army Corps of Engineers
AES	Atmospheric Environment Service - Canada
AP	Associated Press
AFOS	Automation of Field Operations and Services
ALY	NWSFO Albany, New York
ASOS	Automated Surface Observing System
AWIPS	Advanced Weather Interactive Processing System
BOX	NWSFO Taunton (Boston), Massachusetts
BTV	NWSO Burlington, Vermont
BUF	NWSFO Buffalo, New York
CJIS	Criminal Justice Information System
CRREL	Cold Regions Research Laboratory
CWA	County Warning Area
DOD	Department of Defense
DOT	Department of Transportation
EAS	Emergency Alert System
EMA	Emergency Management Agency
EMWIN	Emergency Management Weather Information Network
EOC	Emergency Operations Center
ER	Eastern Region
ERH	Eastern Region Headquarters
FAA	Federal Aviation Administration
FLARE	Flood Analysis and River Emulator
GYX	NWSFO Gray (Portland), Maine
HAS	Hydrometeorological Analysis and Support
HCM	Hydrometeorological Coordination Message
HMD	Hydrometeorological Discussion
HPC	NCEP, Hydrometeorological Prediction Center
HSA	Hydrologic Service Area
HSD	Hydrologic Services Division
HTB	Heated Tipping Bucket
IWIN	(NWS) Interactive Weather Information Network
MAP	Mean Areal Precipitation
MAT	Mean Areal Temperature
MPH	Miles Per Hour
MSD	Meteorological Services Division
NAWAS	National Warning System
NCEP	National Centers for Environmental Prediction
NERFC	Northeast River Forecast Center - NWS
NEXRAD	Next Generation Radar (WSR-88D)
NGM	Nested Grid Model

NOAA	National Oceanic and Atmospheric Administration
NWR	NOAA Weather Radio
NWS	National Weather Service
NWSO	NEXRAD Weather Service Office
NWSFO	NEXRAD Weather Service Forecast Office
NWSRFS	NWS River Forecast System
NWWS	NOAA Weather Wire Services
NYSEMO	New York State Emergency Management Office
NYSPIN	New York Statewide Police Information Network
OEM	Office of Emergency Management
OH	Office of Hydrology
PMDSPD	NCEP Prognostic Discussion
PW	Precipitable Water
QPF	Quantitative Precipitation Forecast
QPFPFD	NCEP Quantitative Precipitation Forecast Discussion
RFC	River Forecast Center - NWS
ROSA	Remote Observation System Automation
RVF	River Forecast
SAA	Snow Accumulation Algorithm
SAME	Specific Area Message Encoder
SDM	Senior Duty Meteorologist
SH	Service Hydrologist
SWE	Snow Water Equivalent
UTC	Universal Coordinated Time
VLETS	Vermont Law Enforcement Telecommunications System
WCM	Warning Coordination Meteorologist
WHFS	WFO Hydrologic Forecast System
WMO	World Meteorological Organization
WFO	Weather Forecast Office
WSR-88D	Weather Surveillance Radar-1988 Doppler

SERVICE ASSESSMENT TEAM

Following a major storm in which there has been a loss of life or extensive damage, a service assessment team may be assigned by the NWS to provide an objective appraisal of products and services, and to make findings and recommendations for improving the service. Such a team was assembled to survey **The Ice Storm and Flood of January 1998**.

TEAM MEMBERS

Team Leaders

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The Team would like to thank the following field personnel for their invaluable post storm information, reports, and local assessments:

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Robert Thompson, Meteorologist in Charge
Dave Vallee, Service Hydrologist

NCEP, Hydrometeorological Prediction Center, Camp Springs, MD
Wes Junker, Lead Forecaster

EXECUTIVE SUMMARY

Event Overview

A catastrophic ice storm and flood event struck northern New England and northern New York during the first two weeks of January 1998. Heavy rain associated with a warm moist airmass overspread a shallow but dense layer of cold air producing ice accumulations in excess of three inches. The heavy rainfall, exceeding four inches in some areas, combined with significant runoff from the melting snowpack to produce record flooding. The ice coated all outdoor surfaces, destroying the electric power infrastructure, toppling trees, collapsing outdoor structures, and threatening the lives of a large, distributed population. The flooding exacerbated the icing problems by forcing the evacuation of more than 1,000 homes and forcing the closure of numerous roads. A record crest was observed on the Black River at Watertown, NY, where the river crested two feet above the previous flood of record.

Conservative damage estimates approach one-half billion dollars. More than three million people in four states and two Canadian provinces were without electricity. In Maine, 80% of the state's population lost electrical service, some for more than two weeks. Residents were forced to find alternative means of heating their homes, pumping water, traveling, and communicating. Tens of thousands of trees were downed or severely damaged. Agricultural losses exceeded one million dollars as farmers were unable to milk their cows without electricity. National Guard units were activated and many counties in Maine (16), New York (6), Vermont (6), and New Hampshire (9) were declared federal disaster areas. Despite its severity, duration, and scope, only seven fatalities were directly attributed to the event.

NWS employees also suffered through this event. More than 25 employees at the NEXRAD Weather Service Forecast Office (NWSFO) Gray (Portland), ME (GYX), and the NEXRAD Weather Service Office (NWSO) Burlington, VT (BTV), lost power to their homes. One employee remained without electrical service for 16 days. Despite the hazardous driving conditions, many employees risked personal danger to reach their office and maintain essential services. When the emergency generators at NWSFO GYX and NWSO BTV failed, surrounding offices successfully implemented backup plans. Extra coverage required by the backup offices was done by employees working overtime.

NWS Products and Services

The affected NWS offices - NWSFOs GYX, Albany, NY (ALY), Buffalo, NY (BUF), Taunton (Boston), MA (BOX), NWSO BTV, and the Northeast River Forecast Center (NERFC) - provided excellent products and services to their users before, during, and after the event. The first alert of the impending ice storm, in the form of Special Weather Statements, was issued up to three days in advance of the event. These statements were followed by Winter Storm Watches which highlighted the threat of a significant ice storm. The Watches clearly stated the threat from downed trees and power lines which could result in widespread power outages. As forecasters became more confident that the icing event would develop, Winter Storm Warnings were issued. The Warnings provided 12 to 39-hours of lead-time before the severe icing

developed. The flood threat was also well advertised by the NWS. Flood Potential Statements were issued up to two and a half days before the flooding materialized. These statements were followed by Flood Watches and Warnings. River Flood Warnings provided eight to 24-hours lead-time before the onset of flooding and up to 36-hours before the flood crests were reached.

Follow up statements provided timely updates on the ongoing event. In cooperation with emergency management officials, NWS offices continued to issue warnings after the ice storm had ended. These statements addressed carbon monoxide poisoning dangers, instructions for rescue by areal surveillance, the threat from falling debris, road closures, and instructions for claiming federal disaster relief.

HPC (Hydrometeorological Prediction Center) forecasts of the precipitation preceding the two most significant days of precipitation were excellent. In particular, the locations of the most significant rainfall amounts were well forecast.

Coordination and Dissemination

NWS forecasts and warnings were well coordinated among the affected offices. The NERFC coordinated Quantitative Precipitation Forecasts (QPFs) and data collection with the NWSFOs and NWSO. Contingency plans were discussed with Eastern Region Headquarters (ERH) when it appeared that normal backup assignments might not work if multiple office outages occurred simultaneously. When backup was required for NWSFO GYX and NWSO BTV, products and services were issued by backup offices without interruption. The regional generator technician was dispatched in anticipation of power outages and extensive use of office generators.

External coordination was superb. Conference calls were held with emergency managers and emergency operations centers. Products were faxed to dispatch centers that were unable to receive information through normal channels. Interviews were conducted with the media which effectively passed critical information to the public. NWSFO GYX provided frequent updates to the Maine congressional delegations which helped to speed federal disaster relief to the state.

All normal means of dissemination were used throughout the event. The use of the amateur radio network was critical. The interruption in telephone services due to downed wires made normal means of communications extremely difficult. At one point, the only means of communications with NWSO BTV was through amateur radio operators. Vital real-time reports of precipitation, river levels, and damage were relayed to backup offices through the amateur radio network.

User Response

A survey of a cross section of users was conducted after the event to determine the effectiveness and quality of NWS products and services. The survey indicated that NWS customers were pleased with the service they had received. Based on NWS forecasts, utility companies requested extra staffing and equipment before the storm began. Frequent updates during and after the event assisted repair crews with recovery operations. Emergency management officials stated that they

were able to deploy key personnel before the severe icing began due to the early warning. States of Emergency were declared based on forecasts. Businesses and schools closed, minimizing the traffic on debris-covered roads. This allowed clean up crews to clear roads faster. The NWS's distribution of state-endorsed statements addressing carbon monoxide poisoning and emergency telephone numbers for people in dire need was lauded by emergency management officials. The media was very complimentary of NWS products and services.

Maine and New Hampshire emergency management officials noted the difficulty in receiving some NWS products through the Interactive Weather Information Network (IWIN). The recent change to World Meteorological Organization (WMO) product identifiers was the reason for the problem. This problem also affects distribution of products over the Associated Press (AP) wire. The New Hampshire Office of Emergency Management (OEM) indicated that they require more detail in zone forecasts for defining the location of the most severe icing. Some emergency managers were confused by the terminology used in River Flood Warnings and Statements.

Data Acquisition and Availability

The lack of reliable and timely precipitation measurements during this event hindered warning and forecast operations. Some of the data loss can be attributed to power and telephone interruptions. The inability of the Automated Surface Observing System (ASOS) Heated Tipping Bucket (HTB) gage to accurately measure freezing precipitation also contributed to the lack of reliable precipitation data. Observations from cooperative observers and SkyWarn spotters were used extensively throughout the event. Data from nearby areas of Quebec helped NWSO BTV determine the extent of sub-freezing temperatures advecting into their county warning area (CWA). Precipitation accumulation estimates from WSR-88Ds were consistently underestimated.

Equipment Outages

While most equipment was functioning normally during the event, a number of outages did occur.

The majority of equipment outages were ASOS related. With the exception of the widespread power outages, this is typical of what occurs with many winter storms that produce mixed precipitation. The additional workload on the electronics maintenance staff and the operational staff was significant. At one non-commissioned site, the data loss was 73% during the two-week period. Federal Aviation Administration (FAA) ASOS systems located at small airports do not have a source of backup power that would mitigate many of the problems that occur with power loss.

The streamflow gaging network provided adequate data, however, there were a few locations where data was missing due to mechanical and communications problems.

Telephone and electrical service were interrupted to NWSFO GYX and NWSO BTV. The backup generators at both offices failed. Vibrations from the prolonged use of the generators caused critical parts to become loose.

All WSR-88Ds in the affected area were operational except the Department of Defense (DOD) radar near Montague, NY (KTYX).

Assessment of Modernized Technologies and Equipment

NWSFO ALY was able to use estimates from the Snow Accumulation Algorithm (SAA) which proved to be far superior to the standard algorithm currently used by the WSR-88D. The Advanced Weather Interactive Processing System (AWIPS) and associated Satellite Broadcast Network worked very well at NWSFO BOX and the NERFC. The increased system integration and interactive capability of AWIPS allowed for efficient model runs which resulted in faster delivery of river stage forecasts. AWIPS allowed forecasters to overlay hydrometeorological data on multiple workstations enhancing the efficiency and effectiveness of forecasts.

Backup

The loss of the backup generator at NWSFO GYX and NWSO BTV required backup plans to be implemented. Products and services continued without interruption.

FINDINGS AND RECOMMENDATIONS

OFFICE DESCRIPTION AND IMPACT OF THE EVENT

Finding I-1: The extent and magnitude of the destruction caused by the ice storm and flood event of January 1998 is unprecedented in New England history.

Recommendation I-1: None.

Finding I-2: The NWS offices involved in this event (NWSFOs ALY, BOX, BUF, GYX, NWSO BTV, and NERFC) did an outstanding job of providing timely and accurate forecasts and warnings to their users. The personnel at these offices surmounted a wide array of personal and professional hardships to get the job done.

Recommendation I-2: These offices deserve proper recognition for outstanding public service.

SUMMARY OF WATCH AND WARNING SERVICES

Finding II-1: In cooperation with emergency management officials, NWSFO GYX continued issuing warning products for non-weather hazards after the main storm had passed. These subsequent warnings and safety statements saved lives in the days immediately following the disaster.

Recommendation II-1: Other NWS offices, when faced with large disaster events, should consider emulating the NWSFO GYX philosophy of continuing warnings until public safety threats have passed.

Finding II-2: The Mean Areal Temperatures (MATs) computed for use in the NWS River Forecast System (NWSRFS) snowmelt model had a consistent cold bias for this event. The MATs are based on the NGM model guidance temperatures.

Recommendation II-2: This situation can be remedied by having the RFC HAS Forecaster mosaic MATs similar to the way they mosaic QPFs. This would allow for better consistency of meteorological data in the hydrologic models.

Finding II-3: Precipitation type is a critical part of QPF input for the RFC forecast models. Uncertainties of precipitation type and ice accumulation hampered river stage forecasting.

Recommendation II-3: Real-time precipitation measurements are vital for accurate river stage forecasting. Resources must be protected to maintain and increase the cooperative observer network and increase the frequency of reports.

Finding II-4: HPC did an excellent job identifying the areas where the heaviest precipitation would fall. However, HPC discussions concentrated more on the potential for flooding than the threat of freezing rain.

Recommendation II-4: HPC should explore whether a more complete guidance package is needed for all types of winter weather in the 6-60 hour time range.

SUMMARY OF COORDINATION AND DISSEMINATION

Finding III-1: QPFs are normally issued for 24-hour periods once per day by the Weather Forecast Offices (WFOs) in the NERFC forecast area. During this event, the NERFC requested additional QPFs from the WFOs with up to 36-hour durations. This greatly enhanced the operations of the RFC.

Recommendation III-1: RFCs should coordinate with WFOs for more frequent updates of QPF, and extension of the QPF duration during significant flood events.

Finding III-2: NWSFO GYX included elected officials in the coordination process. In particular, U.S. Senators and Representatives and the Governor of Maine were briefed as often as possible. This helped speed the process of getting Maine declared a federal disaster area.

Recommendation III-2: Other NWS offices should coordinate with elected officials on the federal level when federal disaster declarations appear likely.

Finding III-3: When the generator power was restored at NWSO BTV, the NOAA Weather Radio (NWR) clock in the Specific Area Message Encoder (SAME) unit defaulted to Dec 31/Jan 1.

Recommendation III-3: NWR SAME instructions should be written in the office duty manual concerning procedures for programming the clock. A simple reminder to check the clock periodically and especially after a power outage should suffice to clear this problem. Ideally, a hardware modification to provide a battery backup for the SAME clock would eliminate this reset procedure.

Finding III-4: Flood Statements and Short Term Forecasts were not being received by all New York State county dispatch centers.

Recommendation III-4: NWSFO ALY must coordinate with offices issuing products for New York State to ensure the schedule that drives the New York Statewide Police Information Network (NYSPIN) is up to date.

Finding III-5: There were many requests from emergency management, river regulation agencies, and response officials to fax copies of local products. The decision was made to provide the service during this event, but it will not always be possible nor desirable due to the resulting increase in staff workload.

Recommendation III-5: The NWS must increase efforts to publicize the Emergency Management Weather Information Network (EMWIN), IWIN, NOAA Weather Wire Service (NWWS), and NWS Internet homepages as sources of written copies of NWS products.

Finding III-6: The complexity and widespread nature of the event required numerous coordination calls between NERFC and the Hydrologic Service Areas (HSAs). Initiation of early contacts led to improved services.

Recommendation III-6: Conference coordination calls between RFCs and HSAs should be implemented to better incorporate hydrologic and meteorologic input into hydrologic forecast procedures. The HAS function would coordinate calls prior to the onset of a significant hydrometeorological event.

Finding III-7: There was little feedback from the Hydrometeorological Coordination Message (HCM) issued by NERFC. NERFC did not know whether or not HSAs were using the HCM.

Recommendation III-7: RFCs should establish an acknowledgment system for the HCM product with the WFOs they serve.

USER RESPONSE

Finding IV-1: Internet has become a very important system for distributing NWS products to the public and to local emergency managers. The NWS IWIN site does not appear to properly interpret zone coding for many NWS products. Consequently, many products are listed as unavailable on the official NWS IWIN site.

Recommendation IV-1: Product headers and coding on NWS products must be interpreted properly in order for IWIN to post the product. A review of missing products to determine that IWIN is properly interpreting the headers is necessary.

Finding IV-2: The AP plays a major role in distributing NWS products to the broadcast and print media. This event revealed products are either not available or labeled incorrectly in the AP system. The Maine State Forecast product sent through the AP print media circuit was incorrectly labeled by the AP as the New Hampshire State Forecast during the storm. Consequently, newspapers looking for the AP product labeled the Maine State Forecast would have been unable to find the product.

Recommendation IV-2: NWS Headquarters should work more closely with the major companies that distribute NWS products to ensure that they are adequately prepared whenever the NWS plans to make changes to product headers.

Finding IV-3: Some emergency management personnel did not understand the format used by the NWS to convey river crest information in River Flood Statements and Warnings.

Recommendation IV-3: As part of their spotter training sessions, Warning Coordination Meteorologists (WCM) must include examples of River Flood Statements and Warnings and explain their content.

SUMMARY OF DATA ACQUISITION AND AVAILABILITY

Finding V-1: Permission was not given by the National Centers for Environmental Prediction (NCEP) Senior Duty Meteorologist (SDM) to attempt a second upper air release at NWSFO GYX on two occasions during the storm. The upper air data was critical to local forecasters for determining the depth of the below freezing temperatures.

Recommendation V-1: Should field forecasters determine that a second upper air release is necessary, and the SDM refuses permission, a request should be made through proper management channels for the decision to be overturned.

Finding V-2: The lack of real-time information on ice accretions, particularly during the overnight hours when spotter's reports are scarce, makes forecasting ice accretions difficult and adversely affects the quality of the forecast. In this storm, many spotters were without power and there was great danger in venturing outside at night due to the darkness.

Recommendation V-2: Efforts to develop new sources of ice accretion data, such as Cold Regions Research Laboratory's (CRREL's) research with the ASOS freezing rain sensor, should be supported and implemented.

Finding V-3: Other than at the 7 a.m. cooperative data collection time, there was not enough precipitation data to calculate accurate Mean Areal Precipitation (MAPs) for inclusion in RFC forecast models.

Recommendation V-3: Cooperative reporting criteria need to be revised to support modernized RFC forecast operations for obtaining data every six hours.

Finding V-4: Lack of real-time operational reservoir information hampered river forecast procedures at Mount Morris Dam, Hinckley Reservoir, Delta Dam, and the Great Sacandaga Lake.

Recommendation V-4: Provide real-time reservoir data and releases to HSAs and RFCs. This data should be transmitted via Remote Observation System Automation (ROSA) using SHEF code.

Finding V-5: Routine data exchange with Canada helped NWSO BTV determine the extent of freezing temperatures advecting into their CWA.

Recommendation V-5: Pursue exchange of mesonet data between the U.S. and Canada.

Finding V-6: This is the second time in three years that significant rapid snowmelt occurred in the Northeast in January before the normal spring snowmelt and before the scheduled snow surveys. During January 1996 and January 1998 record flooding occurred due to snowmelt runoff.

Recommendation V-6: Snow water equivalent (SWE) data must be available when the snowmelt flood potential is high. Operational requirements, such as snowmelt flood potential assessments, should be primary requirements for activating SWE measurements. This should include cooperative observer data, snow course data, and remotely sensed SWE data.

EQUIPMENT OUTAGES

Finding VI-1: The majority of equipment outages during this event were ASOS related. With the exception of the problems caused by the widespread power outages, this is typical of what occurs with many winter storms that produce mixed precipitation. The additional workload on the electronics maintenance staff and the operational staff was significant.

Recommendation VI-1: Efforts to improve the reliability of ASOS equipment during winter storms must be given a high priority.

Finding VI-2: The ASOS HTB does not provide reliable water equivalency of freezing, frozen and/or mixed precipitation data. The lack of automated precipitation data, and combined at critical times with the lack of supplemental spotter reports, had a negative impact on operations during the ice storm.

Recommendation VI-2: Efforts to replace the ASOS HTB with an "all weather" precipitation gage that provides reliable measurements of water equivalency for liquid, freezing, frozen and/or mixed precipitation should be accelerated.

Finding VI-3: The power sensor warning alarms at NWSFO GYX worked properly during the storm. Unfortunately, with no commercial power available and with the backup generator unstable, ear-piercing alarms were activated every few seconds during the day and evening shifts on Saturday. Such alarms are extremely annoying and add stress to an already stressful situation.

Recommendation VI-3: Install a mechanism that would allow the forecaster to temporarily deactivate the alarms.

Finding VI-4: Falling trees and power lines made travel very hazardous during and after the event. Personnel had difficulty getting to work, requiring on-duty personnel to work many hours of overtime. Generator failures left two offices completely in the dark for up to fourteen hours.

Recommendation VI-4: Long-term planning is vital to continuing operations at NWS offices affected by prolonged significant weather events. Long-term planning should include arranging for temporary sleeping quarters at a nearby motel/hotel or campus center. Otherwise, cots should

be obtained for personnel to sleep at the office. An office food cache should be available for emergencies, including canned foods that do not require heating. Flashlights should be placed in convenient locations.

Finding VI-5: NWSFO GYX was without power for about 14 hours. Fortunately, temperatures were relatively mild for the time of year and there was no possibility of damage from frozen pipes. However, if the power outage had lasted longer and temperatures had been colder, the threat of damage would have been a concern.

Recommendation VI-5: Have a contingency plan available to protect the office and its equipment for cases of extended total power outages in sub-freezing temperatures.

Finding VI-6: A series of mechanical and electronic failures at several river gages hampered data collection which affected river stage forecasts during the event. River gages are maintained and operated by several cooperating agencies.

Recommendation VI-6: NWS offices must maintain an up to date contact list associated with each gage so forecasters can quickly determine who is responsible for maintenance of the gage. Commercial telephone outages should be assumed with every weather disaster. The WCM must recruit and train spotters, amateur radio operators, and emergency management personnel to serve as a manual backup to automated gage data and report information on ice-jams.

Finding VI-7: The backup generators at NWSO BTV and NWSFO GYX failed during the event. Both failed due to connections which became loose due to the vibration of the generator.

Recommendation VI-7: Generators should be continuously operated for a 48-hour period, once a year.

ASSESSMENT OF MODERNIZED TECHNOLOGIES AND EQUIPMENT

Finding VII-1: Current AWIPS capabilities make it difficult for RFCs to look at river forecasts before they issue the product and compare them to their previous forecasts.

Recommendation VII-1: The Office of Hydrology (OH) should develop a river forecast companion to help graphically compare current forecasts to those previously issued.

Finding VII-2: Stage III precipitation processing did not work for the NERFC during the event.

Recommendation VII-2: The NERFC needs to use this event as a case study for reviewing Stage III precipitation processing and make recommendations of improvement to OH.

Finding VII-3: The WFO Hydrologic Forecast System (WHFS) in the NWSFO BOX AWIPS was a helpful tool in hydrologic evaluation and product formulation for this event.

Recommendation VII-3: The operational implementation of WHFS should be a priority for offices once they receive AWIPS. OH and ERH should coordinate with field sites to streamline operational implementation of WHFS. WHFS for meteorologists and hydrometeorological technicians should be conducted as soon as possible after AWIPS is implemented.

Finding VII-4: Precipitation estimates from the conventional WSR-88D precipitation algorithm were inadequate. Estimates from the U.S. Bureau of Reclamation SAA were excellent.

Recommendation VII-4: The Service Assessment Team recommends that the Bureau of Reclamation SAA be given high priority for presentation to the NEXRAD Technical Advisory Committee for consideration for approval as an operational algorithm.

BACKUP OPERATIONS

Finding VIII-1: Extended telephone communication outages are likely during major weather events.

Recommendation VIII-1: Alternate means of communication during telephone outages must be identified.

APPENDIX A - HYDROMETEOROLOGICAL SUMMARY

A strong arctic high pressure system built across Ontario and Quebec on January 4 and pushed an arctic front across New England. Temperatures behind the front ranged from well below 0°F over portions of Quebec to the low 20s across northern New York and Maine. Temperatures were above freezing behind the front by 7 a.m. January 5. The front stalled and provided the focus for an excessive freezing rain event during the next four days as two separate impulses lifted across the area. By 7 a.m. January 7, a 500 millibar circulation moving across Texas had induced the development of a surface low over the Gulf Coast states. This low then lifted northward into the Ohio Valley region during the next 24-hours as its associated upper trough responded to a strong shortwave moving into the northern Plains.

On the east side of this low, a long fetch of strong southerly winds emanating from the Gulf of Mexico and the Atlantic Ocean, pumped unseasonably warm moist air into the Northeast. The strong dynamics and abundant moisture overrunning the front led to one to two inches of freezing rain across portions of northern New York, New Hampshire and Vermont, and northern and central Maine during the 24-hour period ending at 7 a.m. January 8. South of the front during the same time period over two inches of rain fell in northern New York and upwards of three to four inches of rain fell in the Tug Hill Plateau region of New York State.

The rainfall of January 7-9 was the most in recorded history across western and central New York for this time of year. The entire region had between 2.5 and 4 inches in a 48-hour period. Figure 1 shows the storm total precipitation for the event.

Another inch or more of freezing rain fell during the ensuing 24-hours as the unseasonably warm and moist air continued to be lifted over the frontal boundary. The last day of significant precipitation was during the 24-hours ending at 7 a.m. January 10 when up to a half-inch of precipitation was observed over northern Maine and portions of Quebec.

Rainfall accelerated the melting of the snowpack across northern New York and Vermont and in the Tug Hill Plateau. However, the ground was completely bare prior to the main event in many sections in western New York. The rain, therefore, fell on saturated but unfrozen ground across the west. This still was enough to create significant flooding and to send rivers and creeks into flood. The situation was even more critical east of Lake Ontario in the Black River Basin where some snowmelt aggravated the problem. The Black River rose to all-time record levels.

NCEP Model Forecasts for the Event

Overall, the NCEP numerical models did a good job predicting the event. Each model forecast that the arctic front would push southward across New England and then would stall, allowing it to become the focus for a prolonged period of overrunning precipitation. Each also correctly predicted that a potent low-level jet would be advecting abnormally high amounts of moisture northeastward into the front suggesting the event would be a significant one. All three operational models also started predicting that a stripe of quarter inch or greater precipitation amounts would occur across southern Ontario, Quebec, and northern New England during the 24-hour period ending at 7 a.m. January 6. Starting with the model runs from 7 a.m. January 5, each model and model run also did a good job of predicting the QPF across New England during the 24-hour period ending 7 a.m. January 7.

The one day the models appeared to have a forecast problem was for the 24-hour period ending 7 a.m. January 8. The longer range model guidance (36-60 hour) and (24-48 hour) generally predicted the stripe of moderate to heavy precipitation associated with the frontal boundary too far south. However, the 12-36 hour model guidance correctly shifted the band to the north with the AVN model doing an excellent job predicting the 0.50 inch and 1.00 inch or greater amount over New England. The models did an outstanding job of predicting the heavy precipitation during the 24-hour period ending 7 a.m. January 9 and did a good job of predicting that the event would start to taper off during the following 24-hours. The models clearly predicted that there would be a significant rain and freezing rain event across New England.

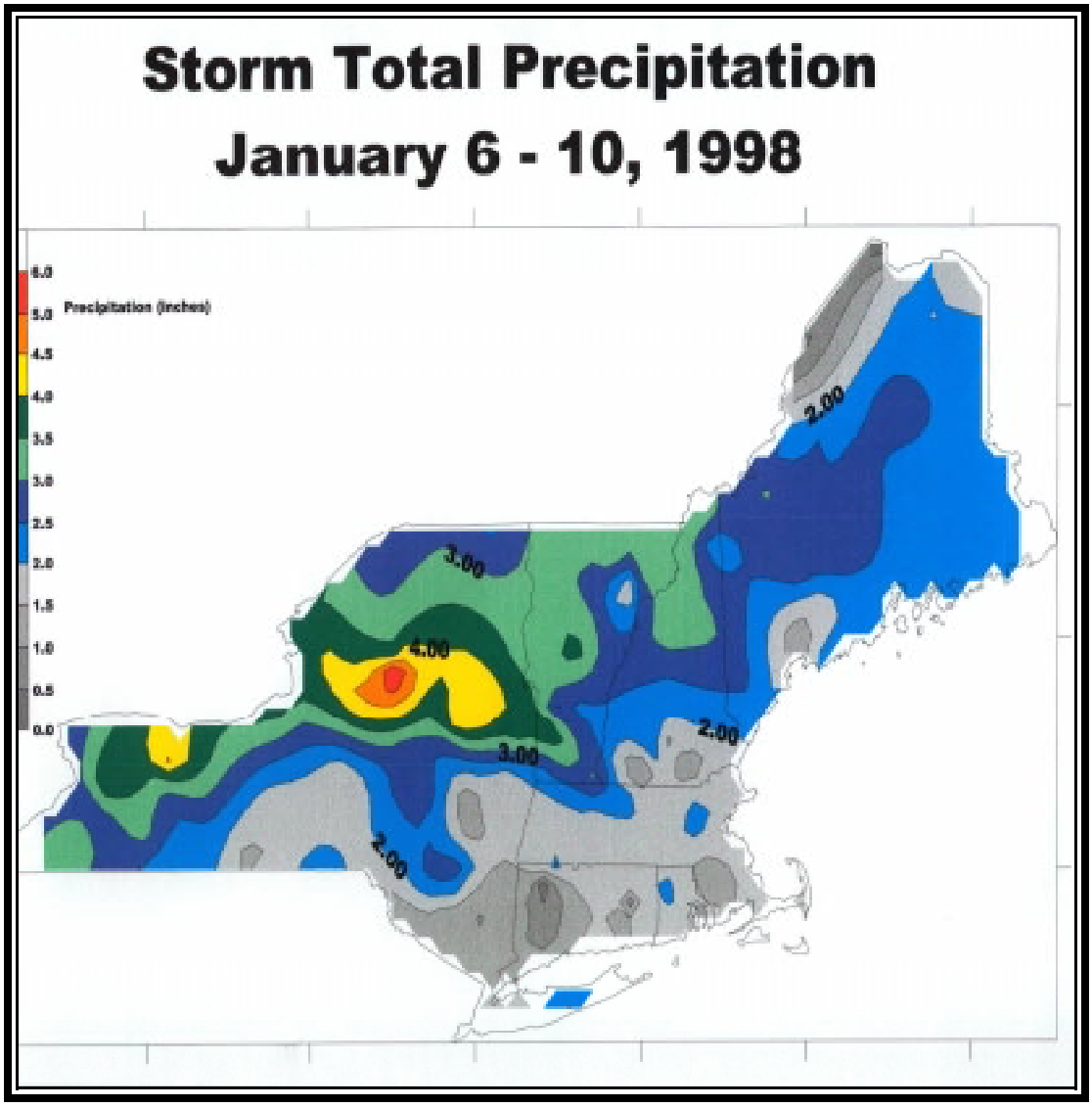

Figure 1 - Storm Total Precipitation for NERFC Forecast Area

APPENDIX B - OFFICE SUMMARIES

National Weather Service Northeast River Forecast Center (NERFC) Taunton, Massachusetts

OFFICE DESCRIPTION AND IMPACT OF THE EVENT

In early January, watersheds across the entire NERFC forecast area, with the exception of basins in Maine, were very moist and primed for flooding. During a normal winter, much of the area would have both frozen ground and a snowpack. This was not the case, however, during the time of this event.

December 1997 was a snowy month across the Northeast, but the ground did not freeze and there were frequent warmup episodes which produced subsequent snowmelt. A significant snowfall occurred prior to Christmas across all of the areas which were flooded in January. However, a warmup in the days prior to the flooding melted much of the snow across New York State. The only substantial snowpack left by the time the floods started in New York was in the headwaters of the Black River and Hudson River basins. A significant snowpack was still on the ground in the upper Connecticut and Lake Champlain drainage basins and in all of northern New England.

The snowmelt prior to the flood event resulted in saturated soils and brought minor to moderate rises to many rivers. When the heavier, more intense rainfall, arrived on January 7, the ground was saturated with little antecedent storage left in the soil. As a result, the heavy rainfall was almost total runoff. In locations where a snowpack still existed, strong southerly winds combined with high relative humidity and heavy rainfall to produce ideal snowmelt runoff conditions. Rapid snowmelt before and during the start of the rain event was a significant factor that contributed to the record flooding in the Black River basin.

The flooding in the NWSFO BUF HSA was the most severe during the event. Rapid snowmelt was occurring just prior to and in the beginning of the event which resulted in very moist soil conditions and high base flow values. When the heavy rainfall started, widespread flooding broke out on the smaller creeks in western New York and in the larger Genesee River basin. While the Army Corps of Engineers (ACOE) flood control reservoir at Mount Morris Dam controlled much of the flow coming from the upper Genesee River, the local runoff from the Genesee River at Avon was significant enough to bring the lower reaches of the river near Rochester, NY, above flood stage.

The most significant flood occurred in the Black River basin in the Tug Hill Plateau region of New York State. The heavy rainfall (up to four inches storm total) combined with saturated ground from snowmelt resulted in the highest river stages ever recorded at Watertown, NY. The peak stage at Watertown was approximately 2.5 feet above the rating table for the location cresting at 16 feet (local datum). The NERFC river forecast provided 36-hours of lead-time to the record flood stage.

Flooding in the NWSFO ALY HSA was mostly a combination of swollen rivers primed by snowmelt and heavy rainfall. By the time the rainfall started in the NWSFO ALY HSA, significant runoff was already occurring, resulting in minor flooding at most NERFC forecast

points. However, significant flooding did occur in many headwater basins to the Hudson and Mohawk Rivers.

The NWSO BTV HSA had a very unusual problem during the flood event. Cold air in the mountain valleys kept temperatures well below freezing which resulted in severe icing. The higher elevations remained above freezing. The heavy rain, combined with the melting snow in the mountains, produced significant small stream flooding with the larger rivers recording significant within bank rises.

Hydrologic problems in the NWSFO BOX HSA were confined to minor flooding on the lower Connecticut River basin. The flooding was driven by rainfall combined with snowmelt from the headwaters in Vermont and New Hampshire.

SUMMARY OF FORECAST SERVICES

The NERFC normally issues one set of River Forecasts (RVFs), a Hydrometeorological Discussion (HMD) and flash flood guidance for each HSA after 1200 UTC. The HCM is usually issued twice daily during normal operations. During the five day period of the event, product frequency increased significantly. Fifty-five RVFs, and 22 HCMs were issued. The RFC maintained 24-hour operations for five days.

QPFs are used as primary input to the NERFC river forecasting operations and during routine situations are issued once a day for a 24-hour period. During the flood event, the NERFC requested and received QPFs three times a day for a 36-hour period. The additional QPFs increased the HSA workload, but allowed the RFC to provide better forecasts. In certain cases, the QPFs did not align along HSA boundaries. In those instances, the RFC HAS Forecaster developed a mosaic of the forecasted QPF.

During the event, NCEP model guidance was used to support the QPFs from HSAs. While the model and office produced QPFs had difficulty forecasting some of the heavy rainfall that fell in the Tug Hill Plateau and Adirondack regions of New York, it did a fine job of pinpointing locations of the heavy rainfall. In other locations where the flooding was not as severe, the QPFs were overestimated. Implementation of a probabilistic QPF forecast process will allow a more accurate representation of uncertainty.

SUMMARY OF COORDINATION AND DISSEMINATION

NERFC coordinated this event very well before, during, and after the flooding. The HCM was used to coordinate with surrounding field offices throughout the entire flooding episode. Primary coordination with NWSFOs and NWSOs centered on QPF and data collection. More than 50 coordination calls were logged during the event. Operationally, coordination calls were made to the New York and New England Districts of the North Atlantic Division of the ACOE. The coordination calls with the ACOE focused around reservoir operations on the Genesee River at Mount Morris Dam and for the river regulation system in the upper Connecticut River basin. Coordination calls were also initiated for the Hudson River/Black River Regulating District to regulate operations of the Stillwater Reservoir in the upper Black River.

Coordination with the HSAs and reservoir operators was mostly positive during the event. This was due to two factors. First, since AWIPS was recently brought on line at NERFC, they were

able to produce more rapid turn-around on forecasts, based upon HSA input of hydrometeorological data and QPF. An example of this was the early coordination with the NWSFO BUF HSA that allowed forecasters to realize that record flooding would occur on the Black River basin as early as 7:00 a.m. January 8. Second, the NERFC participated in a significant internal/external coordination effort with HSAs and external users prior to the event.

The pro-active event coordination and the implementation of new technologies at the NERFC provided the necessary information and aided to understand local reservoir regulation. This resulted in forecasts having a higher level of accuracy.

USER RESPONSE

The NERFC does not issue forecasts directly to the public. Their forecasts are issued to servicing HSAs who issue public hydrologic products. Internally, the HSAs were generally pleased with the forecast guidance provided by the RFC. One problem was the lack of real-time hydrologic data that made forecasting for a few locations difficult.

Response from external users was quite positive. The NERFC usually deals with larger basin wide regulating agencies and other federal and state agencies. The New York District of the ACOE was very pleased with the coordination from the NERFC and due to their "heads-up" coordination, were able to implement regulation adjustments to reduce the flood crest downstream of the Mount Morris Dam on the Genesse River.

The New England District of the ACOE also coordinated with the NERFC and let them know that the NERFC river forecasts for the Connecticut River basin, though accurate in height, were off by 12-hours in their timing. This was due to the impact of a number of hydroelectric operations that had gone into Phase 1 Emergency Operations. These forecasts could have been more accurate if the coordination calls to the New England Power Company Turner's Falls facility had been made before the initial forecast run.

SUMMARY OF DATA ACQUISITION AND AVAILABILITY

Most precipitation reports are received by 7 a.m. With limited hourly and 6-hourly gaging networks in place, forecasting was very difficult for the 1 p.m., 7 p.m., and 1 a.m. forecast periods. With limited data at these time periods, the MAP data used by the river forecast models underestimated the precipitation amounts. This forced forecasters to add river modification information to the model to better estimate the MAPs for specific time periods.

The streamflow gaging network in the NERFC service area consists of a variety of data sources. The gages that provided adequate data to the NERFC are those which have backup or multiple data communications pathways to the NERFC. These gage locations are usually equipped with a GOES DCP and a LARC, a telemetered data acquisition and retrieval system. The gage locations that did not provide adequate data to the NERFC during the event were either not telemetered or had equipment problems.

EQUIPMENT OUTAGES

No significant equipment outages were observed at the NERFC. Most of the equipment problems were with remote gaging networks. The problems were either due to equipment outages requiring maintenance or due to communications systems damaged from the ice storm.

ASSESSMENT OF MODERNIZED TECHNOLOGIES AND EQUIPMENT

NWSRFS Interactive Forecast Program release 9 was in operation at the NERFC during the event. Running NWSRFS on AWIPS provided a clear advantage over the previously used Pathfinder system. The increased computer power of the AWIPS hardware allowed for significantly faster model runs resulting in a quicker river forecast turn-around. In addition, the dual monitor system allowed the forecaster to monitor numerous tasks at the same time. Hydrologic products from HSAs could be monitored while data processing was being checked and forecasts were being made. Furthermore, AWIPS D2D proved to be an invaluable tool during the flood.

The ability to monitor current observations, satellite loops, radar loops, and the most current meteorological model data all at one workstation, greatly enhanced the efficiency and effectiveness of the hydrometeorological operations at the NERFC.

The Stage III precipitation processing was not used during the event because of it's consistently poor performance.

National Weather Service Forecast Office (NWSFO) Albany, New York (ALY) County Warning Area (CWA)

OFFICE DESCRIPTION AND IMPACT OF THE EVENT

Widespread flooding of small streams and mainstem rivers occurred across upstate New York January 8-14, 1998. The flooding resulted in significant damage to more than 180 homes, the evacuation of 185 people, and numerous road closures throughout the northern portion of NWSFO ALY's CWA. December snowstorms set the stage for the flooding by leaving a snowpack of a foot or more throughout the Adirondack Mountains and in the Schoharie, Mohawk, and Hudson valleys. The impacted area experienced rainfall up to 4.5 inches January 7-9. Above freezing temperatures combined with the rain to accelerate the melting of the snowpack. The combination of the rainfall and the melting snow resulted in the widespread flooding.

SUMMARY OF WATCH AND WARNING SERVICES

NWSFO ALY first alerted the public to the threat of flooding by issuing a Flood Potential Statement, Monday, January 5, more than two and a half days before the flooding began. A River Statement was issued Tuesday afternoon highlighting the potential for flooding and ice jams along the mainstem rivers of upstate New York. Subsequent statements mentioned the threat of flooding through Friday, January 9, as well as the potential for the issuance of a Flood Watch.

NWSFO ALY issued an excellent Winter Storm Watch on Wednesday morning, January 7. The Winter Storm Watch highlighted the potential for significant icing across northern portions of New York and Vermont. This Watch provided users with sufficient notice before significant icing began. As the likelihood of a significant ice storm became more apparent, a Winter Storm Warning was issued at 10:10 a.m. Wednesday. The Warning highlighted the forecast of a long duration freezing rain event, which could cause widespread power outages. The Warning also advised that alternate heating sources should be identified. Shortly after the Winter Storm Warning was issued, a Flood Watch was issued. The Flood Watch provided up to 17 hours of lead-time before the onset of significant flooding.

NWSFO ALY began issuing flood flooding at 12:50 a.m., January 8. The first warning provided almost four hours of lead-time before the first report of significant flooding was received. Over the next six days, NWSFO ALY issued numerous Flood Statements and River Flood Warnings. These products were of excellent quality and provided vital information to users. The last flood warning expired on January 14 when the Schroon River went below flood stage.

SUMMARY OF COORDINATION AND DISSEMINATION

Coordination between NWSFO ALY and surrounding offices was handled very well. NWSO BTV was asked for input on the need for the Winter Storm Watch and Warning for northern New York and Vermont. NWSFO ALY also coordinated river forecasts with the NERFC. NERFC furnished useful support during the event. Overall, coordination with external users went well. It was discovered that some emergency managers do not understand the format the NWS uses to disseminate river stage forecasts. No significant problems occurred with the dissemination system.

USER RESPONSE

A survey of a sample of NWSFO ALY's users indicated that they were pleased with the office's products and services. The New York State Emergency Management Office (NYSEMO) stated that the timely watches and warnings provided them with sufficient lead-time to deploy key people across northern New York ahead of the brunt of the storm. NYSEMO was pleased with the NWS's distribution of state-endorsed Public Information Statements which addressed the carbon monoxide poisoning threat resulting from make-shift home heating systems. NYSEMO also thanked the NWS for disseminating special emergency phone numbers for people in dire need to call for state assistance. NYSEMO noted that service could be improved by cutting down on the number of product corrections. They also requested that the warning and watch thresholds be mentioned in NWS products.

The Ulster County Emergency Manager was disappointed with the NWR service that covers his area. He said there were times when "hours old" information was broadcast, specifically the message broadcast regarding crests that would occur "this afternoon" when in fact it was already "tonight" and the crests were past. He was very complimentary of the actual forecasts and stage predictions.

The Saratoga County Emergency Manager was very pleased with the forecasts and information provided by the NWS, with the one exception being that he was confused by the terminology used in the warning products.

Emergency managers from Washington, Fulton, Rensselaer, and Schenectady Counties were all complimentary of NWS products and services.

SUMMARY OF DATA ACQUISITION AND AVAILABILITY

Collection of hydrologic data proved to be a challenge for NWSFO ALY during this event. At least two river gages were inoperable before the event began. Maintenance associated with these gages is the responsibility of other agencies. In one case, the agency did not realize that the gage belonged to them.

At least four gages malfunctioned during the event. Supplemental information from one of these gages was obtained from a U.S. Geological Survey field crew. Attempts to poll several other gages were frustrated by poor long distance service, especially to the Mid-Hudson region and Connecticut.

Amateur radio operators were of great assistance in providing river level information. Emergency networks were established in New York and Vermont. Volunteers operated the amateur radio station in NWSFO ALY from the afternoon of January 8 through late January 10. This provided a link to mobile observers, delivering up to date information on river levels and flooding. At the same time, they relayed the latest flood forecasts and information from the NWS to the emergency management community.

EQUIPMENT OUTAGES

The problems with collecting river gage data, as previously stated, was the only problem NWSFO ALY had with equipment.

ASSESSMENT OF MODERNIZED TECHNOLOGIES AND EQUIPMENT

WSR-88D precipitation estimates based on the standard precipitation algorithm were underestimated throughout the event. However, the SAA that NWSFO ALY is beta-testing for the Operational Support Facility, National Severe Storms Laboratory, and the U.S. Bureau of Reclamation, provided excellent precipitation estimates. During an event in November, NWSFO ALY discovered that the SWE products from the SAA worked well for low-topped convection and stratiform rain events. This discovery prompted the NWSFO ALY forecasters to use the SWE estimates as input into the local hydrologic application - Flood Analysis and River Emulator (FLARE). FLARE is used for small basin areas that are not forecast by the NERFC. As a result, excellent river crest forecasts were prepared and included in warnings.

BACKUP OPERATIONS

The severe icing which occurred across northern New England, made it difficult for personnel at the NWSO BTV to get back and forth to work. With the potential of not being able to get relief into the NWSO BTV office, NWSFO ALY was prepared to backup NWSO BTV's products and services. ERH held a conference call with the affected offices to discuss contingency plans for each office. The Meteorologist in Charge of NWSFO ALY prepared a supplemental shift schedule which could be implemented when needed. When NWSO BTV's emergency generator failed Friday morning, (commercial power was lost earlier in the week), NWSFO ALY went into backup mode. NWSFO ALY was in backup from 7 to 11 a.m. Friday. Phone service was also interrupted at the NWSO BTV office. NWSFO ALY used amateur radio operators, who set up a high frequency link to the Burlington Red Cross, to exchange critical information with the NWSO BTV office.

National Weather Service Forecast Office (NWSFO) Buffalo, New York, (BUF), County Warning Area (CWA)

OFFICE DESCRIPTION AND IMPACT OF THE EVENT

The NWSFO BUF staff faced two significant forecast challenges during the January 7-12, 1998, event. The storm produced record breaking rainfall amounts for western New York for the time of year, that, combined with a severe freezing precipitation episode, resulted in record flooding on the Black River and historic ice accumulations. As the storm departed the region, the wind increased and a few inches of lake-effect snow fell across the area, creating a significant hazard to repair crews working on the ice-laden power and telephone lines.

A total of twelve counties were significantly affected by the flooding, severe icing, and/or high winds and, of these, state and federal declarations were proclaimed for seven of them. A State of Emergency was also declared for several counties due to flooding. Following the event, a Presidential Disaster Declaration was issued for two counties, Jefferson and Lewis. The National Guard was activated to protect lives and property and to assist with the clean-up.

Two storm-related fatalities were reported in Jefferson County. More than 1,000 homes were evacuated in six counties due to flooding, with more than 700 evacuated in Niagara County alone as water levels reached the first floor in some residences. Dozens of roads and bridges were closed, including the New York State Thruway. Tens of thousands of residents lost power due to severe ice accumulations and were forced to move into shelters for food and heat. Power was not restored in many areas for up to two weeks.

The flooding resulted from heavy rainfall, melting snow, and a saturated ground. Rainfall across the region measured 1.5 to 3.5 inches in the first 24-hours of the event and 2.5 to 5 inches in 48-hours. Snow cover in upstate New York before the event ranged from 12 to 24 inches and snow spotters reported as much as three inches of liquid equivalent in a 12 inch snow pack.

The snowmelt increased the runoff in the Black River valley and the flood of record in Watertown was exceeded by nearly two feet. Near record flooding occurred along the Black and Oatka Creeks in the Genesee River valley, affecting the Rochester area. Water rose above flood stage along portions of the Allegheny and Genesee Rivers, as well as along Buffalo area creeks. Some of the flooding reported was the worst in more than 10 years.

Severe icing brought down trees and power lines in the eastern Lake Ontario counties of Jefferson and Lewis Counties, with ice accumulations greater than three inches reported in northern Jefferson County. Power outages due to ice also occurred in Allegany, Livingston, Ontario, and Wyoming Counties.

SUMMARY OF WATCH AND WARNING SERVICES

Nearly 90 unscheduled watches, warnings, advisories, and statements were issued over a ten day period in addition to regularly scheduled forecast products.

A Winter Weather Advisory for freezing rain was issued at 3:07 a.m. on Sunday morning, January 4, for central and northern New York. The advisory was in effect for Sunday afternoon

and Sunday night, though later advisories would extend the period into Monday afternoon. Lead-time for the onset of precipitation was approximately 8-10 hours. These products mentioned a light ice accumulation on trees and power lines and the potential for hazardous travel.

The first mention of a potentially significant ice storm later in the week came in the State Forecast Discussion issued on Tuesday afternoon, January 6. A Winter Storm Watch for significant ice accumulation was issued at 10:35 p.m. later the same day for Jefferson and Lewis Counties. This was 22-hours before the onset of heavy freezing rain in northern Jefferson County. The watch was upgraded to a Winter Storm Warning at 3:34 p.m. Wednesday, January 7, which provided at least five hours of lead-time prior the onset of the freezing rain and more than twelve hours of lead-time before the severe icing began.

Two Flood Potential Statements were issued on Tuesday, January 6. The first was issued at 1:55 p.m. for the eastern Lake Ontario region and the second was issued at 2:10 p.m. for the Genesee Valley, Finger Lakes, Buffalo area, and Southern Tier regions. These statements and subsequent updates provided more than a 36-hour lead-time to area flooding. A Flood Watch for the entire CWA was issued at 10:30 a.m. on Wednesday, January 7, and was based upon anticipated rainfall. The first Flood Warnings were issued for western New York creeks at 9:16 p.m., providing three to six hours of lead-time. Warnings for eight gaged rivers and streams were issued between 7 and 9 a.m. on Thursday, January 8, with lead-times ranging from two to ten hours. A Flood Warning for all small streams, urban areas, and lowlands was issued at 9:50 a.m. Thursday. A Flood Statement issued at 10:32 a.m. Thursday forecast especially severe and near record flooding along the Black River at Watertown in the eastern Lake Ontario region. This statement preceded the observed crest by 48-hours and the record level of 16 feet was accurately forecast approximately 30-hours prior to the crest.

As the storm departed over the weekend, strong west winds began to blow on Friday night, January 9, and continued through Monday, January 12. With wind gusts expected to reach 45 MPH and realizing the effect of the wind on the repair crews dealing with ice laden power lines, Wind Advisories were issued beginning Friday evening. These issuances correctly conveyed the hazard posed by the wind to responders and to the general public.

In addition, a Lake Effect Snow Watch was issued Friday afternoon, January 9, for Saturday. There was a potential for locally heavy snow reaching seven inches in Jefferson and Lewis Counties, further hampering recovery efforts and placing a hardship on residents. The heavy snow did not materialize. However, Lake Effect Snow Advisories were issued early Saturday morning, January 10, for up to four inches accumulation Saturday night and Sunday which did occur in a few outlying areas. The lead-time of the watch was about 30-hours and the advisory about 16-hours.

SUMMARY OF COORDINATION AND DISSEMINATION

Coordination between NWSFO BUF and the NERFC was extremely effective. Close telephone coordination during the critical runoff period assisted NWSFO BUF in issuing timely and accurate flood forecasts. Having the NERFC staff available during the overnight hours as a result of expanded RFC coverage was critical.

The primary method of dissemination to state and local emergency management officials is NYSPIN. The system appears to have worked well, though it was discovered that Flood Statements and Short Term Forecasts were not being received at all county dispatch centers. The problems were circumvented by issuing the Flood Statements under both FLS and FLW headers and the Short Term Forecasts under both NOW and SPS AFOS PIL headers. NAWAS was used as a confirmation that NWS products were being received through NYSPIN.

NWR was crucial in getting up-to-date weather information to telephone and power repair crews. The Watertown NWR was off the air from Saturday morning, January 10, until around noon on Monday, January 12, and again for a few hours the following day due to an outage of the telephone line. It was noted by state officials that the outage of this NWR signal was a major loss in the overall dissemination efforts.

Telephone briefings were conducted throughout the event with emergency management and response officials to assist with evacuation, road closure, and river flow and dam regulation decisions. Several products were faxed to officials in the field who could not easily retrieve the hard copies from the dispatch centers. Dozens of interviews were conducted with media personnel which effectively passed critical information to the general public.

NWS aviation products were used by a power company to plan helicopter inspections of downed power lines. Several products issued during the event included information requested by state and local officials to assist in emergency services and response.

During the recovery efforts, Public Information Statements were issued that mentioned carbon monoxide dangers and that publicized telephone numbers residents could use to seek financial assistance. These statements were distributed on NWWS and read on NWR.

USER RESPONSE

Response from the users was extremely positive. Users commented that service provided by NWSFO BUF was timely and accurate. Many were appreciative of the high volume of real-time observations and reports and these were used extensively to make decisions regarding evacuations, river releases, and repair crew assignments.

Following the event, a radio station manager contacted the local office to inquire how to best receive NWS forecasts and warnings. She said these products were far superior to those her station was receiving from the private vendors.

SUMMARY OF DATA ACQUISITION AND AVAILABILITY

No problems were noted regarding reception of standard NWS data products. Canadian radar data was also available and used. Precipitation and river gage readings were available without any reported loss of data as were the first order stations and buoy observations.

Supplemental data sources were used extensively and included both automated and manual observations and reports. The primary automated sources were DOT road sensors and SchoolNet/Automated Weather Source observations, which were made available through media agreements. Manual observations were provided by the cooperative observer and snow spotter networks and were heavily relied upon for critical rainfall, temperature, and river level data.

EQUIPMENT OUTAGES

The WSR-88D at Montague was down throughout the entire event. The Watertown NWR was down for more than 48-hours during the event. This was due to downed telephone lines. Telephone company officials acknowledged the high priority of restoring service, but it was too dangerous to work on the telephone lines while the electrical lines were still down.

DOT road sensor data was lost in the Watertown area due to the loss of electricity. This had only a minor impact on local NWS operations.

ASSESSMENT OF MODERNIZED TECHNOLOGIES AND EQUIPMENT

It was noted early in the event that the NWSFO BUF WSR-88D was underestimating rainfall, based on rain gage reports. With adjustments made for this error, the WSR-88D reflectivity information was invaluable to the forecaster. The reflectivity data used in conjunction with satellite imagery allowed forecasters to accurately predict the chance of thunderstorms with locally heavy rain on Friday, January 9.

BACKUP OPERATIONS

NWSFO BUF was prepared to provide backup service to NWSO BTV if the primary backup office was unable to perform the function. However, this service did not become necessary.

National Weather Service Office (NWSO) Burlington, Vermont, (BTV) County Warning Area (CWA)

OFFICE DESCRIPTION AND IMPACT OF THE EVENT

From January 4-9, 1998, significant icing occurred across northwest Vermont and northern New York. The geography of the region played a major role in the distribution and concentration of the freezing rain. The Green Mountains of Vermont acted as a barrier, trapping the low level cold air in northwest Vermont and westward across northern New York. Heavy rainfall produced ice accumulations of 1.5 to 3 inches, although some areas in the St. Lawrence Valley region exceeded three inches. The heavy rain combined with melting snow to produce significant small stream flooding. Large rises were also observed on many rivers.

Wednesday night, January 7, into early Friday morning, January 9, trees, tree limbs, utility poles and utility lines came down across the region. Numerous roads were closed due to debris in the streets. Blue sparks were being reported as lightning when in reality they were falling power transformers and utility lines. Tens of thousands of trees were downed or severely damaged by the icing.

In the NWSO BTV CWA, only two deaths were directly attributed (1 hypothermia and 1 fall victim) to the storm. Four other deaths occurred indirectly from the storm (all from carbon monoxide poisoning). Damage estimates were $12 million for Vermont and $5 million for New York (excluding NY utilities). NY State Electric and Gas Corporation required more than 2,000 new poles in their effort to restore power to the region. Utility workers from as far away as Hawaii were called in to help restore power.

Travel was severely hampered by this event. Many roads were closed due to a combination of ice and rising water. The Burlington International Airport was without power during portions of Friday forcing all but one airline to cancel flights for the day.

Many businesses were forced to close. Banks without power were unable to serve customers, including via ATMs. Several newspapers, such as the Plattsburgh Press Republican, Ogdensburg Journal, and Massena Courier Observer had portions of or complete editions not printed due to power outages. The last time the Ogdensburg Journal was not printed due to loss of power was in the 1940's.

Another direct impact on the area was the inability of farmers to milk their cows with losses estimated in the millions of dollars. Also, State Forest Agents indicated many maple trees were severely damaged. In the immediate Burlington area, 25-40% of trees planted on greenbelts next to roads were destroyed or damaged. The preliminary costs to replace these is $3 million.

By Friday morning, a State of Emergency was declared in both New York and Vermont. Across the four northwest counties of Vermont, at least 35,000 customers were without power, while 60,000 to 80,000 customers were without power in northern New York. At least six radio stations were knocked off the air during this time period. Numerous emergency shelters were opened. Most schools were closed.

About 500 National Guard troops were called up in Vermont and northern New York to help with the recovery operations and cleanup of downed trees. They also assisted in the rescue of people from flooded areas along the Missisquoi River in Franklin County, VT. This was the largest disaster mobilization call-up since the 1973 flood.

Many staff members continued to report for work on scheduled shifts despite personal and family hardships at home. Power interruptions leading to loss of heat and water in some cases was experienced by nearly all staff members at home and some families moved in temporarily with co-workers and friends. Some were without power for more than three days and one remained without phone service for nearly one month following the storm. A few staff members even risked traveling tree and power line littered roadways during local travel bans and curfews to continue their shift responsibilities. The office electronic staff spent several hours clearing debris from the radar access road before assistance was offered by the Vermont National Guard.

SUMMARY OF WATCH AND WARNING SERVICES

NWSO BTV provided excellent products and services to their users. As early as Tuesday afternoon, January 6, a Special Weather Statement from NWSO BTV highlighted that "the potential is there for a significant ice storm...beginning on Wednesday." This statement emphasized the threat of falling trees and power lines resulting in a loss of electricity. The statement also indicated the potential for flooding on Thursday. Information contained in these outlook statements resulted in over 36-hours of lead-time.

Short Term Forecasts contained excellent information and were issued regularly during the event. Routine and special statements included call-to-action safety reminders prepared by the NWS and emergency management offices.

Flood Potential Statements were issued well in advance of any flooding in the NWSO BTV CWA. The first statement was issued with 48-hours of lead-time. Subsequent Flood Warnings, Flood Statements, and River Flood Statements were timely and effective.

SUMMARY OF COORDINATION AND DISSEMINATION

With the exception of the period during which NWSO BTV was without power, the normal means of dissemination were fully utilized. This included the Vermont Law Enforcement Telecommunications System (VLETS), Low Band Radio Links with Vermont Emergency Management as well as both Clinton and Essex, NY County Emergency Management, and amateur radio via voice and packet. With the exceptions noted below, all means of coordination and dissemination worked properly during the event.

On Wednesday, January 7, the transmission signal from NWR transmitter station KIG-60 was operating under reduced power. This reduced power state inhibited the Emergency Alert System (EAS) tones from being properly received and utilized by commercial radio stations. The diesel generator was providing power for the office until a relay switch which regulates the flow of diesel fuel became inoperative. With neither commercial nor generator power the office was non-operational including NWR. Thus, during this period, no routine NWR or EAS broadcasts were initiated by NWSO BTV. When the generator power was restored, the clock in the SAME unit defaulted to Dec. 31/Jan. 1. This was not discovered and rectified until Saturday, January

10. This condition inhibited the EAS signals from being delivered to automated commercial broadcast stations.

SkyWarn was officially activated on Thursday, January 8. Reports concerning icing and rising rivers/flooding were received via two meter voice communications throughout the event, except during the power outage period. During the period of no power, the WCM communicated with amateur radio operators via a handheld radio plugged into his automobile cigarette lighter slot. The support provided by the amateur radio operators was excellent. The NWSO BTV office provided forecasts via fax and packet radio to the Clinton and Essex County EOCs. The WCM was able to relay forecasts to Clinton County, NY, from his home packet station to relieve the office of extra responsibility.

The ASOS anemometer cups iced up at a few locations including at the Burlington International Airport. Coordination between NWSO BTV and the Burlington FAA Tower was frequent via the tower hotline telephone throughout the event and cooperation with an airline official allowed NWSO BTV's electronic technicians to use the airlines hydraulic lift to clear the ice from the ASOS wind tower which could not be lowered because of the weight of the ice.

USER RESPONSE

Emergency managers, state and local government officials, the media, and private businesses were contacted for their assessment of NWS products and services. All indicated that NWSO BTV provided timely and accurate products and services throughout the event.

The urgency and magnitude of emergency management personnel and resource mobilization, evacuation and shelter operations, search and rescue operations, and clean-up and repair operations were partially based on updated weather information from the NWS. Local officials used NWS forecasts to declare States of Emergency, which led to closures of schools and offices. At least one major bank closed all branch offices in northwest Vermont, minimizing traffic on dangerous ice and debris-clogged highways before and during local declarations of emergency and curfews.

Major utility company representatives were stationed at emergency management offices and were provided with updated NWS weather information through the law enforcement telecommunications systems and direct telephone and fax communications. Based on NWS forecasts, utility officials quickly expanded their interstate search for available repair crews and necessary replacement hardware.

SUMMARY OF DATA ACQUISITION AND AVAILABILITY

Routine surface and river observations were available during the event, but there were several exceptions where data was incomplete, delayed, or missing. A surprising amount of routine Canadian data remained available from the devastated areas of Quebec, providing necessary information about the extent and magnitude of sub-freezing temperatures advecting into the precipitation areas in the U.S. Shortly following the event, the Quebec Weather Centre of the Canadian Atmospheric Environment Service (AES) began to accurately assess the extent of ice along the Canadian border and to document the scope and extent of the record precipitation event. Sharing of data between the NWS and AES allowed the Quebec Weather Centre to produce detailed graphics as to the extent and magnitude of the icing.

EQUIPMENT OUTAGES

Data interruptions were most often related to interruptions in electrical power or telephone communications that were directly or indirectly affected by the ice storm; however, a few equipment failures unrelated to power and communication failures were noted.

Contract observer observations at Massena, NY, were manually logged and routinely phoned to the NWS for AFOS entry during the several days of lost electrical power at that airport. Telephone communications failures prevented the relay of observations from at least four ASOS sites and one Automated Weather Observing System site for varying periods, and the access of river gage readings from at least three sites for varying periods. Telephone communications failures also interrupted surface data receipt from more than a half dozen cooperative automated data-logger sites. Wind direction and speed at as many as three reporting ASOS sites were believed to be inaccurate at times due to the accumulation of ice on these sensors.

Receipt and processing of data from the cooperative observer network and SkyWarn spotters was also subject to telephone service interruptions and the short term total power failure at the NWSO BTV office. Amateur radio SkyWarn data proved quite valuable and continued to be collected by NWSO BTV's WCM using power from his car battery, even during the office power interruption and radio resets. The cooperative, SkyWarn, and amateur radio data collectives were invaluable in maintaining sufficient real-time data for accurate warnings, statements, and forecasts.

The NWS Eastern Region Network worked very well, providing a continuous stream of high resolution satellite imagery and gridded model data.

The KTYX WSR-88D DOD radar at Montague, NY, was not available during the event.

ASSESSMENT OF MODERNIZED TECHNOLOGIES AND EQUIPMENT

The NWSO BTV WSR-88D radar data was routinely available during the event and provided good guidance regarding precipitation location and fair estimates of precipitation intensity. Poor estimates of quantitative measurement of accumulated precipitation were due to topographic blockage, overshooting of low height precipitation production, and multiple bright-banding from at least two freezing levels. Wind profile data helped to define the local depth of the most shallow temperature inversion.

BACKUP OPERATIONS

During Friday, January 9, NWSO BTV was without commercial and backup power. At that time, NWSFO ALY assumed backup between the hours of 7:30 a.m. and 10:30 a.m. NWSFO ALY issued well written statements covering the NWSO BTV CWA. These issuances were received on VLETS which receives products from the NWWS. NWSO BTV's backup generator problem was corrected as a result of a maintenance agreement with a company that provided quick and efficient service.

During the time that NWSO BTV was totally without power, the amateur radio operators were able to relay reports into the NWS office via the one phone line which remained operational. The NWSFO ALY spotter phone numbers were provided to SkyWarn net controllers to provide for the efficient relay of information. In addition, the Multifunction Acquisition and Reporting

System helped relay reports via high frequency radio. During the entire event, cellular telephone communications were not an effective substitute for wired telephone systems. Cellular phone companies were not prepared for the volume of calls attempted and cellular calls could not be completed.

National Weather Service Forecast Office (NWSFO) Gray (Portland), Maine, (GYX), County Warning Area (CWA)

OFFICE DESCRIPTION AND IMPACT OF THE EVENT

Extreme winter weather conditions impacted the NWSFO GYX CWA from January 5-25, 1998. The most significant event within this 20 day period occurred across most of New Hampshire and a large part of central and southern Maine from January 7-9. On those days, two inches of ice accreted on all outdoor surfaces, destroying much of the commercial power infrastructure, toppling trees and man-made structures, and leading to a chain reaction of public safety hazards. On January 13, an arctic front ushered bitterly cold air and gusty winds into the area, further aggravating the threat to life and property and hampering recovery efforts.

The ice storm knocked out power to close to one million people, some for more than two weeks. In Maine, 80% of the state's population lost electrical service. The widespread loss of commercial power forced people to find alternative ways to heat their homes, pump water, travel, and communicate. Thanks to intensive coordination efforts by the NWSFO GYX staff, emergency managers, commercial broadcast stations, power companies, and key political figures were constantly kept apprised of the threat.

Close interagency contact reaped many benefits. By mobilizing utility repair crews ahead of time, the duration of recovery operations was reduced to three weeks instead of a month or more. Elected officials were better prepared to ask for a federal disaster declaration. Close collaboration with commercial broadcasters helped the public prepare for and survive the aftermath of this great storm.

Despite the magnitude of the storm, only three people died directly from it (hypothermia victims). Five other deaths occurred indirectly from the storm (three carbon monoxide poisonings, one roof collapse victim, and one tree cleanup victim). Damage estimates as of mid-May were $320 million in Maine, and $16 million in New Hampshire.

The NWSFO GYX staff suffered great personal hardship during this event as 24 of the 30 employees lost power to their homes. Despite this hardship, NWSFO GYX employees reported to work, often at great personal risk. Several of them drove over downed power lines and around fallen trees. Employees reported seeing trees, branches, and utility poles fall down directly in front of, beside, or behind them as they drove to the office. Unwavering dedication to the NWS public safety mission was displayed by the entire NWSFO GYX staff during this trying time.

SUMMARY OF WATCH AND WARNING SERVICES

In addition to routine product issuances, NWSFO GYX issued more than 75 special statements during the disaster event period. At the request of emergency managers, NWSFO GYX continued issuing Winter Storm Warnings after the ice storm ended to address non-weather threats to the public. The practice of continuing NWS warnings beyond the storm for falling debris and carbon monoxide poisoning is a highly unusual practice, in fact, no policy actually requires this extra action. The NWSFO GYX management displayed excellent judgement in deciding to provide this extra level of warning service.

Winter Weather Advisories were first issued for the initial stages of the storm on Sunday, January 4. These advisories continued in effect for two days through Tuesday afternoon, January 6. Another advisory was posted early Wednesday morning for freezing drizzle, along with a Winter Storm Watch for the potential for "significant" icing on Thursday. At 3:00 p.m. Wednesday, January 7, a Winter Storm Warning was issued for Wednesday night and Thursday, for "damaging accumulations of ice with resulting downed trees and power lines." Although it is difficult to know exactly when the warning criteria (½ inch of ice accretion) was reached, watches were issued with over 24-hours of lead-time and warnings with more than 12-hours lead-time before initial problems began to occur. If one uses the onset of widespread power outages as the time of event occurrence, lead-times expand to 51-hours for the watch and 39-hours for the warning.

On Monday, January 12, NWSFO GYX alerted their users that an arctic front was approaching and would pass through the area Tuesday afternoon. Gusty winds with this front would raise the threat of falling debris, and bone-chilling temperatures behind the front would raise the threat of hypothermia and slow recovery efforts. Though the front actually arrived Tuesday evening, the public and emergency responders had a full day to anticipate its impact.

Subsequent watches, warnings, and advisories were issued from Wednesday, January 14, through Thursday, January 22, as recovery operations continued. Another ice storm that took out power to 75,000 customers along the Maine coast on Friday, January 23, was covered with an advisory. Fortunately repair crews had not yet left the state, and service was restored in less than 24 hours.

SUMMARY OF COORDINATION AND DISSEMINATION

All NWSFO GYX NWR transmitters were off the air on at least two occasions during the event. A four hour communications line outage occurred at the office on Saturday, January 10. Around 9:10 p.m. Saturday night the office's emergency power generator developed a mechanical problem, causing a 12-hour outage. A separate longer term (approximately 72-hour) outage occurred from Saturday evening through Tuesday at the Ellsworth transmitter, when both commercial and emergency power failed. The Ellsworth transmitter is a primary entry point for EAS warnings.

Emergency managers used the Internet to obtain some of their weather information. Unfortunately, recent WMO communication header changes caused some products to be overwritten in the IWIN system, and many products that were available were listed as not available. Loss of the NETCAST system was perceived as detrimental to Internet dissemination. The WMO product header changes also caused missing or improperly identified products for AP customers. Non-standard punctuation and capitalization of NWS products caused some problems with certain print media customers, who had to retype NWS text to make it look "normal."

Internally, forecasts and warnings meshed well with surrounding offices, and contingency plans were discussed with ERH when it appeared that normal backup assignments might not work if multiple office outages occurred simultaneously. Arrangements were made ahead of time to have a special generator technician available to go to either NWSO BTV or NWSFO GYX as necessary.

External coordination was lauded by customers. In particular, the NWSFO GYX office was praised for "constant personal contact" and useful "backchannel" communication. Of special note is the fact that the NWSFO GYX staff took the effort to reach out to elected officials, including U.S. Senators and Congressman, to keep them apprised of the situation.

USER RESPONSE

A variety of customers were interviewed during the last week of January, to allow them time to recover from their storm-related tasks.

Central Maine Power requested extra staffing and equipment from other states before the storm, based on NWSFO GYX's forecasts, to assist in the massive power restoration effort. NWSFO GYX provided frequent updates to assist crews in the recovery operation.

Channel 6 TV made necessary arrangements for extra staffing well ahead of the event in anticipation of broadcasting emergency information for an extended period of time. The Channel 6 representative indicated that the warnings after the event advising of the danger from falling trees and carbon monoxide poisoning were excellent. The representative also stated, “on a scale of 1 to 10, I'd rate NWS service for this storm as an 11!"

The Penobscot Emergency Management Agency (EMA) representative was impressed with the frequency of personal contact with the NWSFO GYX WCM. He indicated that he was contacted twice a day during the event. The Office of the Director, Maine EMA, specifically mentioned how helpful the constant personal NWS contact was. It was stated that the "backchannel" communication from both the WCM and the SH was a great help and much appreciated. It was also noted that when NWSFO GYX went into service backup, the Maine EMA was notified of that fact, and informed which NWS offices were supplying critical backup services. The Maine DOT indicated an overall satisfaction with NWS products and services. However, it was noted that it is difficult to get Maine and New Hampshire State Forecasts from IWIN and EMWIN, now that they both share the same WMO product identifier. The New Hampshire OEM indicated that advance warning allowed the OEM to adjust work schedules, but because forecasts were non-specific as to where the icing would occur (New Hampshire was in the transition zone) no pre-positioning of supplies or personnel was accomplished.

SUMMARY OF DATA ACQUISITION AND AVAILABILITY

Data loss was clearly related to precipitation type. In marine areas, where rain fell, none of the observing sensors failed. In those areas where freezing rain or drizzle occurred, from 46-73% of the observations were missing. Part of this was due to sensor freeze-up while widespread power outages with no power backup accounted for the rest.

Upper air observation reliability was good during the event. However, on two occasions when the first instrument release was unsuccessful, the NCEP SDM refused to approve a second release. This decision prevented NWSFO GYX forecasters from obtaining low level temperature profiles that would have augmented local forecast and warning operations.

Except for the communication and power outages at NWSFO GYX on January 10-11, the WSR-88D radar worked well. Some forecasters felt the precipitation amounts were underestimated,

but the system required no maintenance and provided useful information on the location, movement, and intensity of precipitation.

EQUIPMENT OUTAGES
Numerous ASOS outages were noted. The office backup generator failed Saturday night and was off-line until late Sunday morning.

ASSESSMENT OF MODERNIZED TECHNOLOGIES AND EQUIPMENT
The WSR-88Ds located at Gray, ME, and Hodgdon, ME, underestimated precipitation amounts.

Significant problems occurred with the ASOS network. The lack of reliable precipitation measurements during this event hindered warning and forecast operations, especially during late night and early morning hours when supplemental spotter reports were not available. Even momentary power interruptions at FAA ASOS sites without battery backup resulted in missing precipitation accumulation data. Unavailable and/or unreliable precipitation data made it difficult to estimate ice accumulations. The equipment fail rate for some ASOS locations was excessive. Equipment failures resulted primarily from a combination of sensor icing, power failures and communications circuit failures.

BACKUP OPERATIONS
NWSFO GYX required service backup twice during the event. In both instances, all products were issued in a timely fashion, and no service complaints were received.

The first request for service backup occurred Saturday at 6:45 a.m. when NWSFO GYX lost all voice and data communications. Data communications were restored at 11:05 a.m. However, the battery backup power for phone company equipment at NWSFO GYX was depleted at that time and voice communication was not restored until the phone company hooked up a generator to their equipment at NWSFO GYX at about 2 p.m. During the outage period, a cellular phone was used to communicate with NWSFO BOX, Maine EMA, and the New Hampshire OEM. With data communications restored, some model forecast data became available, and with emergency agencies notified of the cellular phone number, NWSFO GYX took back service responsibility at 12:30 p.m. Saturday.

The second request for backup came Saturday evening at 9 p.m. when the backup generator failed and NWSFO GYX lost all power. NWSFO BOX had been notified earlier in the day that the backup generator was not functioning properly and might fail at any moment. Due to the potential for imminent failure, the evening update package had been prepared and the preliminary files were sent to NWSFO BOX via AFOS. NWSFO BOX sent out the evening update, and prepared and sent out the early morning release and the morning update. Generator power was restored to NWSFO GYX Sunday morning at 10:00 a.m. and NWSFO GYX assumed service responsibility for the afternoon package.

National Weather Service Forecast Office (NWSFO) Taunton (Boston), Massachusetts (BOX), County Warning Area (CWA)

OFFICE DESCRIPTION AND IMPACT OF THE EVENT

The extreme southern extent of the serious icing affected portions of Cheshire and northwest Hillsborough Counties in the southern New Hampshire portion of NWSFO BOX's CWA from January 7-9.

Steady rain fell from Wednesday night, January 7 into Friday, January 9. At elevations ranging from 1,100 feet to 2,500 feet, the rain froze on contact, creating major buildups of ice. By Saturday, ice accretions ranged from one to two inches Thousands of trees and power lines were felled, some of which landed on houses and crashed through windshields of moving vehicles. Power was lost to most of the affected communities before daybreak Thursday.

This event presented a difficult challenge for emergency management officials as well as forecasters. First, the seriousness of the event was not known by many officials, including NWSFO BOX, until as late as Friday morning, about 24-hours after most power was lost. The New Hampshire OEM did not activate their Emergency Operations Center (EOC) until 8:30 a.m. Friday, and their 24-hour operations did not cease until the State of Emergency was lifted on Friday, January 16. According to several local emergency managers that were interviewed, the delay can be attributed to the highly localized nature of the problem.

Second, one typically thinks of the lower valleys as being the areas in which cold air drains, leading to freezing rain potential. In this case, the damage occurred in a very specific elevation zone, below and above which there was no damage.

SUMMARY OF WATCH AND WARNING SERVICES

River Flood Watches and Warnings were issued for several points along the Connecticut River. Lead-times for the River Flood Warning ranged from 30 minutes to 26.5 hours.

Feedback from NERFC indicated that the QPF information was accurate and timely. A 36-hour QPF resulted in accurate river stage guidance.

This was the first operational event involving the use of the WHFS application in AWIPS to evaluate hydrologic data and issue watches, warnings, and statements. The extensive effort by the NWSFO BOX SH to locally customize the software proved beneficial during this event.

A Winter Weather Advisory was issued at 10:40 a.m. Wednesday, January 7 for Cheshire and Hillsborough Counties in southern New Hampshire and northern Worcester County in central Massachusetts. The main concern at that time regarded travel. Ice accretion to the point of warning criteria was expected to occur north of the NWSFO BOX CWA. At 4:50 p.m., the Winter Weather Advisory was expanded to included southern Worcester County and extended overnight. The Advisory was subsequently extended through Thursday morning with a 9:35 p.m. issuance Wednesday evening. The Wednesday evening statement noted that areas of freezing rain "will form a layer of ice on cars...power lines...trees...and roads." The advisory was allowed to expire 11 a.m. Thursday, January 8.

Reports of localized damaging ice and the anticipation of additional significant rainfall prompted NWSFO BOX to issue a Winter Storm Warning for ice for Cheshire and Hillsborough Counties Friday at 9 a.m. Although additional significant ice accreted during the day Friday after the warning issuance, localized icing had become severe enough to down branches and trees by early Thursday morning. This was more than 24-hours before the Winter Storm Warning was issued but during a time when a Winter Weather Advisory was in effect.

There were no spotter reports of damaging ice accumulation until Friday, when NWSFO BOX initiated a number of calls to communities in northeast Cheshire County and northwest Hillsborough County. However, a New Hampshire Department of Transportation (DOT) fax report of statewide conditions at 5 a.m on Thursday, January 8, referenced fallen trees in the northern part of District 4 (Cheshire/Sullivan County border area). More extensive references of fallen trees appeared in the fax report at 8 p.m. on Thursday and in subsequent faxes.

The localized icing which was severe enough to bring down branches, trees, and power lines commenced very early Thursday morning in Cheshire and Hillsborough Counties when a Winter Weather Advisory was in effect. Pockets of damaging ice accretion continued through Thursday and Thursday night after the Winter Weather Advisory had expired. Still more damaging ice accretion occurred on Friday after the Winter Storm Warning was issued. Unlike a more typical synoptic scale winter storm event, warning criteria was met only in localized areas (e.g. in the more extreme instances no icing on one side of a hill and warning criteria ice accretion on the other side of the same hill.)

SUMMARY OF COORDINATION AND DISSEMINATION

When the Winter Weather Advisory was issued January 7, NWSFO BOX contacted the New Hampshire and Massachusetts OEMs by phone. When NWSFO BOX issued the Winter Storm Warning for Cheshire and Hillsborough Counties on Friday morning, they utilized the National Warning System (NAWAS) to contact the New Hampshire and Massachusetts State Warning Points. In addition, they used the "Snap-Page" pager system to notify the Duty Officers at the New Hampshire OEM. Also, they gave a briefing to the Massachusetts OEM via phone. Other telephone notifications included the Federal Emergency Management Agency Region I Headquarters and the American Red Cross. All of the aforementioned coordination contacts occurred between 9:10 a.m. and 9:40 a.m. on January 9.

NWSFO BOX has a link to the New Hampshire State Police computer system via the Massachusetts Criminal Justice Information System (CJIS) computer. On occasion, they write messages to states other than Massachusetts to try to obtain information. This was not utilized.

Internal coordination went very well, particularly during times when NWSFO BOX was backing up NWSFO GYX.

USER RESPONSE

After the event, NWSFO BOX made several calls to emergency officials. Those with whom they spoke did not have any unfavorable comments about NWSFO BOX's performance. Two representatives from the New Hampshire DOT were interviewed after the storm. One person stated that weather forecasts were too vague and needed better timing for their use. This person also felt that they had to wait too long between updates and when they really needed new

information, it was not available. A second representative from the DOT noted that they had received good service from two private weather vendors in the past, but the contracts had not been renewed.

The Public Service of New Hampshire was also interviewed after the storm. They noted that the magnitude and ending times of this storm were not understood ahead of time.

SUMMARY OF DATA ACQUISITION AND AVAILABILITY

NWSFO BOX received virtually no reports from more than one hundred spotters located in Cheshire and Hillsborough Counties. This prompted an emergency mailing to the nearly 1,800 spotters in and around NWSFO BOX CWA, reiterating the wintertime (and summertime) reporting criteria and the importance of their reports.

The NWSFO occasionally heard from their Jaffrey, NH, spotter who mentioned "some icing" but did not mention power outages or any damage. New Hampshire DOT faxes indicated fallen tree limbs and trees in Cheshire County as early as 5 a.m. on Thursday, January 8, and again, with more specificity as to location, at 8 p.m. Thursday. No reports were received from emergency managers or via NAWAS, or CJIS.

EQUIPMENT OUTAGES

Aside from a few ASOS outages, equipment functioned well.

ASSESSMENT OF MODERNIZED TECHNOLOGIES AND EQUIPMENT

Typically, in low-level cold season stratiform rain and low-topped convection, the WSR-88D overshoots precipitation echoes at extended ranges. It is difficult to determine precipitation intensity from the KBOX WSR-88D in southwest New Hampshire since the beam at 0.5 degree elevation angle is over 9,000 ft at the extreme northern areas of Cheshire and Hillsborough Counties in New Hampshire.

AWIPS and the Satellite Broadcast Network worked well.

BACKUP OPERATIONS

NWSFO BOX performed service backup for NWSFO GYX on Saturday morning, January 10, and again from Saturday night at 8:30 p.m. until 1:00 p.m. Sunday, January 11. Overall, the service backup proceeded smoothly. There was no degradation in products and services to the NWSFO GYX CWA.

Several problems were uncovered during the backup operations. The FAA sites, Augusta, Houlton, Utica, and Massena normally send their observations through the NWSFO GYX AFOS dissemination system. There is no established backup for these offices to disseminate their observations when the host AFOS system is down. In this instance, Augusta and Houlton personnel called their observations into NWSFO BOX, which in turn entered them into AFOS. Since the NWS Telecommunications Gateway is not configured to receive these observations directly from the FAA, it is necessary for the observations to be entered through an AFOS computer. Until ASOS has been commissioned at these sites, a backup dissemination procedure should be established. NWSFO BOX staff noted that personnel at Augusta and Houlton were very cooperative in feeding observations for AFOS entry.

It would be helpful for NWSFO BOX to have a complete listing of airport telephone numbers for the NWSFO GYX CWA. Also, phone numbers and passwords for ASOS sites should be exchanged between NWSFOs BOX and GYX.

This was the first time NWSFO BOX had to assume backup responsibilities since AWIPS was installed. All five workstations were needed to accomplish primary and backup operations. NWSFO BOX realized that five workstations will not be enough to dedicate one forecaster to each program (i.e., aviation, marine, public) during backup operations. Backup operations in the AWIPS era must be addressed by each office.

National Centers for Environmental Prediction, Hydrometeorological Prediction Center (HPC)

Summary of Products and Services

HPC short range cloud and weather packages began predicting freezing rain and sleet across portions of Ontario, Quebec and New England on the 48-hour cloud and weather forecast depiction chart valid 12 UTC January 5. The HPC forecast packages correctly depicted that there would be freezing rain during a portion of each day from January 5-10 across portions of northern New England and southern Canada.

Despite the excellent guidance predicting there would be a prolonged period of freezing rain across portions of northern New England and southern Canada, the emphasis of discussions during the early part of the storm were on the heavy rains and flash flooding that were expected across the Gulf States. One exception is the forecast discussion (PMDSPD) that accompanied the 48-hour forecast valid 12 UTC January 5. This discussion mentioned that an arctic front would sag southward across New England and that icy conditions were expected to develop to the north of the front late Sunday night as a southwesterly flow overran the front. HPC did not start emphasizing the potential for a major ice storm until the QPF (QPFPFD) discussion issued at 2 p.m. January 7. After that time, a number discussions highlighted the storm's potential. For example, the QPFPFD issued at 2 a.m. January 8 highlighted that "a major ice event appears on tap for portions of Maine where liquid equivalents could exceed an inch during the period." During this period, several heavy snow discussions mentioned the potential for freezing rain but most were on or after January 7. One stated that "freezing rain could make things messy across portions of Maine." Another emphasized that an inch of liquid equivalent was expected across portions of Maine during the 12-hour period from 7 p.m. January 8 to 7 a.m. January 9.

HPC forecasts of the precipitation preceding the two most significant days of precipitation were excellent. The subjective QPF from 36-60 hour model guidance valid 12 UTC January 5 predicted liquid equivalent values of .50-1.00" across the same areas of northern New England and southern Canada where the first shot of significant icing occurred. Subsequent subjective QPF's valid during this event underestimated the precipitation, predicting .25-.50" amounts across Northern New England where .40-.70" amounts were generally observed. Only light precipitation was observed across northern New England for the 24-hour period valid 7 a.m. January 7.

The heaviest precipitation across New England occurred during the two day period from 7 a.m. January 7 through 7 a.m. January 9. The first QPFPFD that covered these two days was issued at 6 a.m. January 6. It stated "Precipitation should be heavier across New England on Day 2....A plume of very high PWs (precipitable water) is starting to push into the Carolinas. Moisture associated with this plume should lead to PWs well above normal along the front." HPC subjective forecasts generally underpredicted the 2" or greater amounts that were observed across north-central Maine during the two day period but still suggested that a significant freezing rain event was likely. HPC QPF forecast when taken together with the corresponding clouds and weather forecasts during the two day period suggested there would be a serious ice storm over portions of north-central Maine and northern New Hampshire.

HPC also started issuing Storm Summaries for the heavy rainfall event at 12:30 p.m. January 6. Summaries were then issued every 12-hours through 1 a.m. January 9. Like the other HPC products, the summaries concentrated primarily on the heavy rains and flash flooding in the Southeast until the summary issued at 12:45 a.m. January 8 which stated "In addition....a significant accumulation of freezing rain and sleet is likely across Maine today....Please refer to the latest statements....watches...and warnings from local National Weather Service Offices." However, the next statement again concentrated on the heavy rainfall and flooding across North Carolina and Virginia instead of the ice storm that was going on in the Northeast. The final Storm Summary issued at 1 a.m. January 9 then stated "Winter Storm Warnings are in effect for severe icing conditions in portions of northern New York, northern Vermont, northern New Hampshire and interior Maine. A devastating ice storm has already occurred...with widespread power outages and roads blocked by fallen trees."