A FLOOD EVENT

THE 1987 APRIL FOOLS FLOOD IN MAINE: A HYDRO-METEOROLOGICAL ACCOUNT

1. The Meteorological Assessment
2. The Hydrological Assessment

Bruce W. Budd (1)
NWSFO, Portland ME

ABSTRACT

Heavy rains combined with snowmelt on March 31 and April 1, 1987 caused major flood conditions on many rivers in Maine and New Hampshire. In the capitol of Maine at Augusta, the Kennebec River rose 23 ft in 36 hours and crested at 1000 GMT April 2, 1987 at 21 ft above flood stage. The rapid rise of the Kennebec River to unprecedented heights caused the most extensive and costly damage to the river basin communities in recorded history.

The meteorological aspects of this event as it pertains to Maine and New Hampshire are examined in part 1. The impact of this system on the hydrology of the Kennebec River Valley is explored in part 2.

1. THE METEOROLOGICAL ASSESSMENT

1. Surface Features

A surface low-pressure area organized into a 1007-mb central pressure blizzard over Oklahoma on 1200 GMT Mar. 28, 1987. The Low behaving like a stable wave, tracked northeastward into Michigan by 0000 GMT Mar. 30, at which time another Low (1008 mb) formed on the associated cold front in Mississippi. That Low became the second in a series of these Lows over the eastern United States to develop, slightly strengthen, then translate north to northeast along the cold front.

A more significant surface Low (1002 mb) formed over West Virginia by 1800 GMT Mar. 30 and became elongated north to south with two centers as it strengthened and moved slowly eastward. By 1200 GMT Mar. 31, the major surface Low (991 mb) was located in northern Virginia. The light to moderate rain shield had spread to a Quebec City, QE to Bangor, ME line. Rain, which began over New Hampshire and southwest Maine after 0600 GMT Mar. 31 measured on the order of a half an inch in New Hampshire [Concord (CON) .44 in.] and far southwestern Maine [Portland (PWM) .66 in.]. A major influx of mild and saturated air (temperatures and dew points in the mid 40s to mid 50s °F)was advected northward and drawn from the Atlantic Ocean by a moderately strong (15–30 mph) south to southeast surface wind flow.

By 1500 GMT Mar. 31, there was a 990-mb Low over eastern Lake Ontario on the north-south cold front and a 990-mb Low near Washington, D.C. Moderate rain extended along the mid-Atlantic coast and over a good portion of New England. By 0000 GMT Apr. 1, the northern Low of 988 mb was located in Quebec province with a band of moderate rain over eastern New England just ahead of the cold front located north to south from Montpelier (MPV), VT to Bridgeport (BDR), CT (Fig. 1). Higher rainfall amounts (inches) by this time included Rumford, ME 3.05, Augusta (AUG), ME 1.96, PWM 1.97, Mt. Washington (MWN), NH 2.05, and CON 1.71.

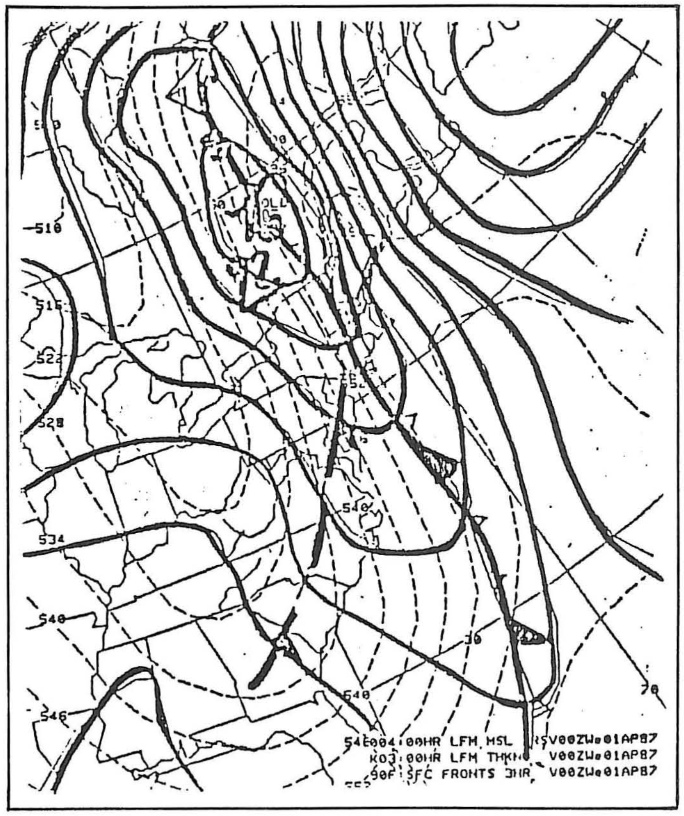

Fig. 1. The LFM surface analysis chart for 0000 GMT April 1, 1987. Isobars (solid lines) 1000–500-mb thickness (dashed lines). Fronts and troughs are shown.

At 0600 GMT Apr. 1, a small Low (1003 mb) was detected near PWM but it was not discernable at 1200. At that time the cold front was positioned from Fort Kent, ME, to PWM and the rain was mostly over in Maine. However, heavy snow fell throughout the day over the New Hampshire and western Maine mountains. Higher cumulative precipitation amounts from the primary reporting stations by 1200 Apr. 1 were Rumford 4.98, AUG 3.20, Bangor (BGR), ME 2.37, Greenville (3B1), ME 2.95, PWM 3.06, and MWN 3.67. By 1800 Apr. 1, a small Low (1006 mb) was located just east of PWM. The cold front had moved into the Gulf of Maine and the rain swath was cut off. The Low was analyzed near Rockland, ME at 0000 GMT Apr. 2 and over New Brunswick province by 1200 GMT Apr. 2. Storm total precipitation for the primary stations were Rumford 5.51, AUG, 3.65, BGR 2.78, 3B1 3.30, PWM 3.41, and MWN 5.29 (Fig. 2).

1.2 Upper Air Features

The mean trough aloft was over the Rockies the week prior to the flood. The northeastern United States enjoyed principally fine, mild weather under a ridge. In Maine and New Hampshire the deep snowpack was steadily eroded as day-

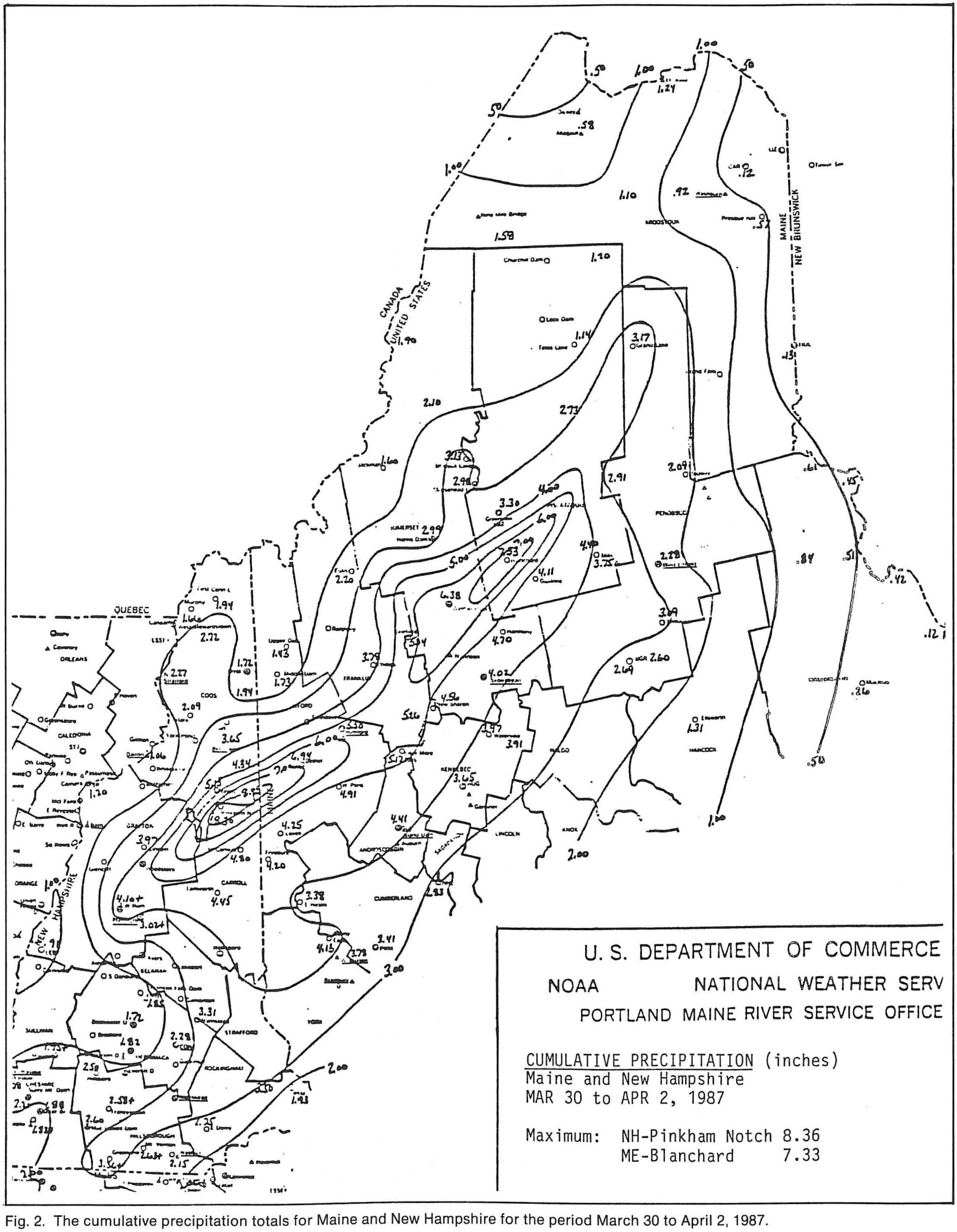

Fig. 2. The cumulative precipitation totals for Maine and New Hampshire for the period March 30 to April 2, 1987.

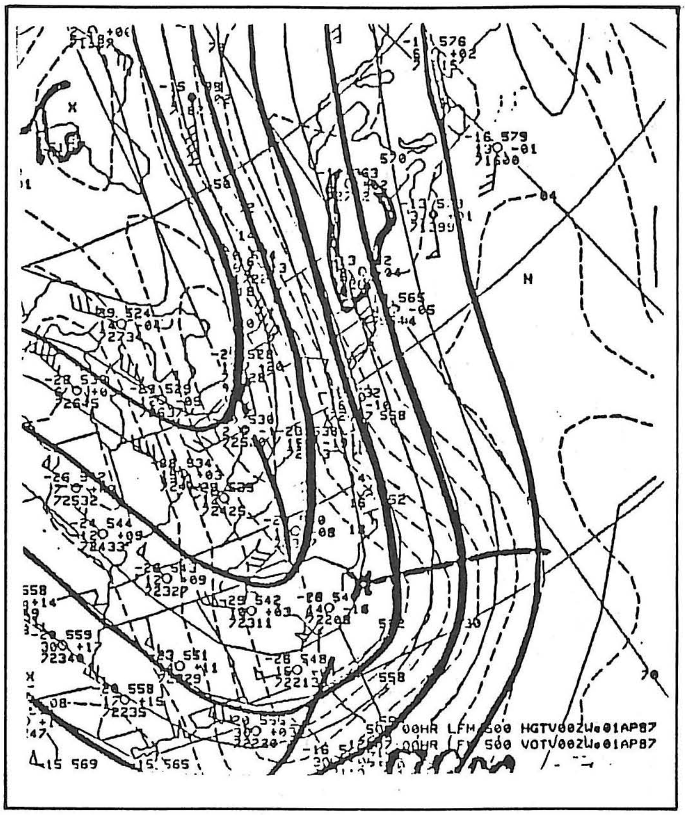

Fig. 3. The 500-mb LFM analysis for 0000 GMT April 1, 1987 showing heights and vorticity.

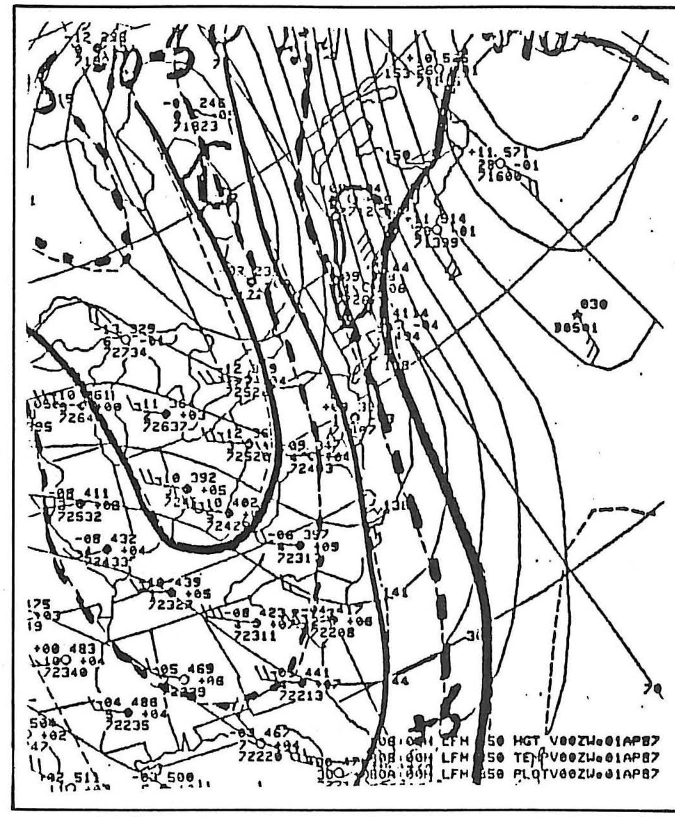

Fig. 4. The 850-mb LFM analysis for 0000 GMT April 1, 1987 showing heights and isotherms.

time temperatures were in the 50s and 60s from Mar. 25 to Mar. 30.

At 500 mb a strong short wave and jet stream maxima over western Canada on Mar. 27 dropped southward, establishing a full-latitude trough over the Rockies by Mar. 29 with a vorticity maximum over New Mexico sponsoring a midwest blizzard. The short-wave was powerful enough to change the position of the mean trough to the eastern United States, thereby forcing the ridge position off the east coast.

By 1200 GMT Mar. 31, there was a sharp negative tilt to the axis of the trough from the western Great Lakes to Alabama. The energy of the jet maxima was maintained around the base of the trough as shown by the vorticity maximum (LFM 20 $\times$ 10^{-5} radians/s) off the S. Carolina coast at 0000 GMT Apr. 1 (Fig. 3). The trough moved northeastward to a position from northern New York State to Delaware by 1200 Apr. 1 with the vorticity maximum off the Virginia coast. South winds at 40 to 50 kt were measured over eastern New England on 1200 GMT Mar. 31. They became south to southeast 75 to 100 kt (Chatam, CHH, MA 90 kt) by 1200 GMT Apr. 1, showing strong evidence of confluence ahead of the trough. The trough then weakened and moved to a position over Maine by 1200 GMT Apr. 2 with a vorticity maxima (LFM 18 $\times$ 10^{-5} rad/s) 250 mi south of Yarmouth, Nova Scotia.

At 850 mb a strong, moist southerly flow (45 kt) had set up by 1200 GMT Mar. 30 over western Pennsylvania and New York with convergence over the Appalachian mountains. Saturated air spread into eastern New York and New England by 0000 GMT Mar. 31. Albany (ALB), NY reported south winds at 50 kt with temperature +5 and dew point +4°C at this time. Southerly winds approximately 60 to 80 kt were occurring over New England by 1200 GMT Mar. 31. A converging wind profile with maximum speeds (Caribou CAR, ME 80 kt) was analyzed over Maine at 0000 GMT Apr. 1 (Fig. 4). High dew points (PWM + 8°C) were supplying excessive moisture to the system at this level. As the cold trough from the west moved into Maine, the temperature dropped to + 1°C at PWM by 1200 GMT Apr. 1 while CAR maintained + 6°C and a south wind at 45 kt.

1.3 Radar

The National Weather Service (NWS) network radar at PWM provided precipitation type, intensity, movement, and maximum top information for this event (not shown). The areal coverage increased on the scope beginning 0900 GMT Mar. 31. The precipitation tops were nearly uniform at 28,000 ft from 1200 Mar. 31 to 0000 GMT Apr. 1, then decreased to the 22,000- to 24,000-ft range for the duration of the event.

Embedded moderate precipitation cells were moving from 210–230 deg at 30–35 kt from 1200 to 1700 GMT Mar. 31. As the winds aloft backed, the direction changed to 190–210 deg at 45–65 kt. From 2000 Mar. 31 to 1200 GMT Apr. 1 the echoes were moving from 180–190 deg at 40–45 kt, then became 160–170 deg at 45–55 kt until 2000 GMT Apr. 1 as the precipitation return on the scope diminished significantly. The southerly flow provided an oceanic airflow trajectory for nearly the entire event.

The radar echo intensities were mostly level 1 with some embedded level 2 echos mostly early in the rain event. In a stratiform event a level 1 echo corresponds to an empirically derived hourly rainfall rate less than 0.1 in., see (2). Likewise, a level 2 echo corresponds to an hourly rainfall rate of $0.1 < 0.5$ in. Actual rainfall rates within the reportable range of the radar (125 nmi) were of the order 0.12 to 0.25 in/hr. Rates in that range should correspond to a much more widespread and continual level 2 coverage than that which was observed on the radar scope.

1.4 Satellite

Satellite imagery was examined for heavy precipitation signatures. Broad-scale features were easily identified. Even a weak short wave over the New Jersey coast in the moist, southerly flow aloft, as shown by the 1200 GMT Mar. 31 LFM analysis, was detected by the colder cloud tops. The cloud-top features of the infrared (IR) satellite imagery (MB enhancement curve, see 3) provided notable information on the precipitation pattern over New England. Imagery from 2100 GMT Mar. 31 to 0600 Apr. 1 were not available for consideration.

Enhancement level 2 (light gray, $-43°$ to $-53°C$) appeared over southern NH and ME by 0700 GMT Mar. 31, coinciding with the onset of rain. Level 3 (dark gray, $-54°$ to $-50°C$) and level 4 (black, $-60°$ to $-63°C$) enhanced areas were over southern New England and off Cape Hatteras. Between 1000 and 1400 GMT Mar. 31, the level 4-enhanced cloud tops moved north to NH and western Maine while an area over New Jersey and southern New England expanded (Fig. 5). From 1500 to 1800 GMT Mar. 31, the level 4 coverage diminished as level 3 predominated. The period 0630 to 1200 GMT Apr. 1 showed the level 3 and 4 over New Hampshire and Maine decreasing in extent while an elongated section of these levels extended 400 mi southeastward over the ocean. Rainfall was decreasing coincidentally. Cloud tops were not as cold over the concerned area from 1300 GMT Apr. 1 until just level 1 and 2 were found over eastern Maine by 0000 GMT Apr. 2.

The tropopause was measured at between 39,000 and 42,000 ft at PWM from 0000 Mar. 31 to 1200 GMT Apr. 1. Level 4 cloud tops were likely in the vicinity of the tropopause, thereby depicting a deep level of atmospheric moisture. Although applicable mainly for convective situations, the rule that rainfall is heaviest when and where cloud tops are still getting colder and the coldest area is growing (4) can also selectively be applied to stratiform situations. The heaviest rains in this case coincided with the coldest cloud tops over the area.

1.5 Evaluation of Guidance

1.51 *Nested Grid Model (NGM) Forecast Charts* The NGM (5) forecast charts and actual analyses were compared for like time periods from 1200 Mar. 29 to 1200 GMT Apr. 2, 1987. From this examined situation it was evident that in nearly every NGM forecast series the 36-hr and 48-hr prognosis exhibited far too much strengthening of the surface (approx. 10 mb too low) and upper air Low systems. The vorticity centers were over-developed and positioned further to the north of the analyzed positions. As a result too much

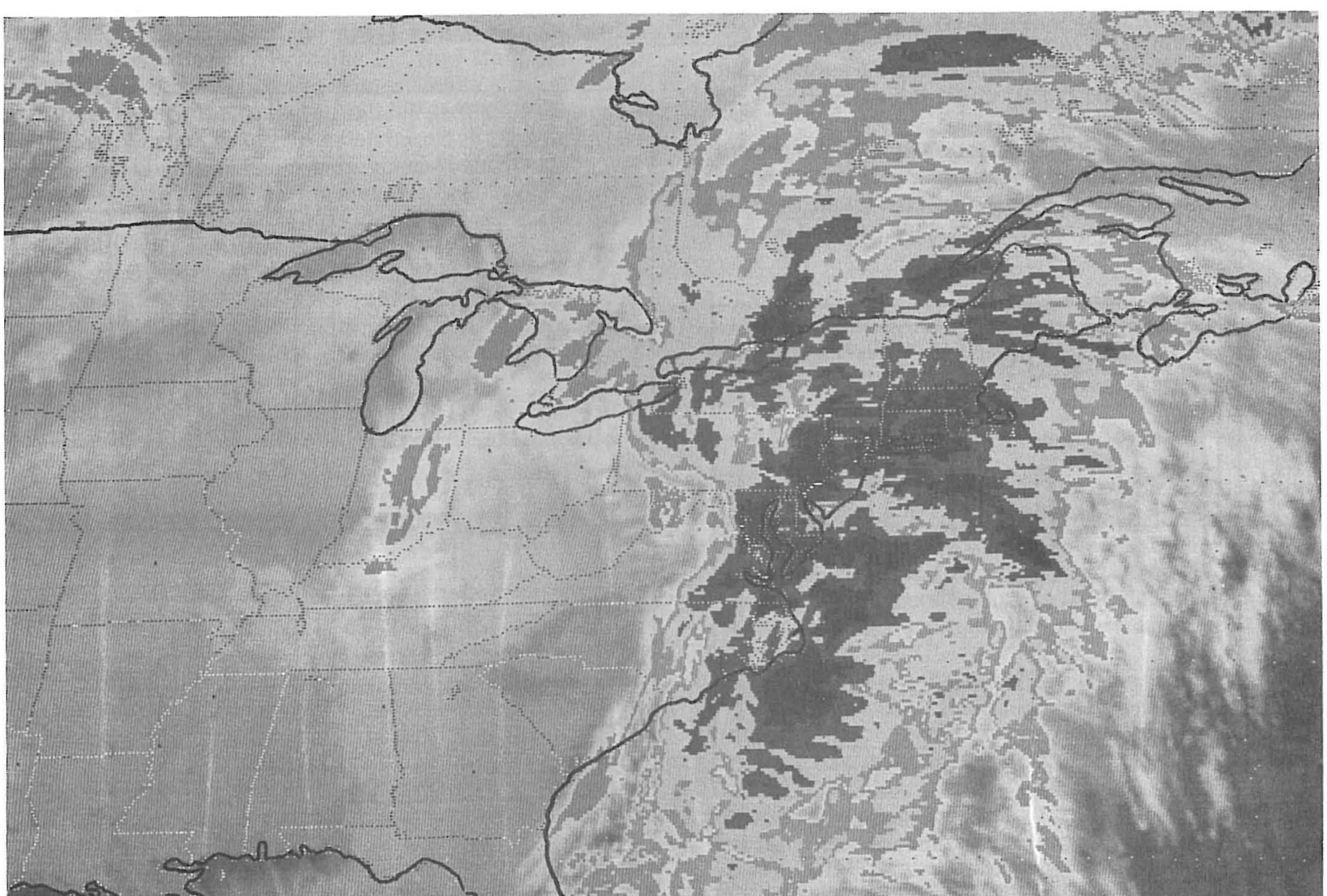

Fig. 5 The IR satellite imagery for 1200 GMT March 31, 1987 using the MB enhancement curve.

warming was depicted by the 850-mb prognosis over the northeast United States prior to the onset of the rain.

The heaviest rainfall was not coincident with the area of strongest positive vorticity advection (PVA) but was located beneath very weak positive or neutral vorticity change farther downstream of the trough axis. Interestingly, the NGM prognosis based on data from 0000 GMT Mar. 31 most closely resembled the actual synoptic situation and had a quantitative precipitation forecast (QPF) that was similar to what occurred.

1.52 *Model Output Statistics (MOS) QPF* The MOS, preferred category, 12-hr QPF for locations in ME and NH were compared to the actual amount of precipitation for like time periods from the 1200 Mar. 29 forecast to the 0000 GMT Apr. 1 forecast. The MOS QPF categories, are: 1 (.01–.24), 2 (.25–.49), 3 (.50–.99), 4 (1.00–1.99), 5 (2.00 or more inches). Three forecast periods (12–24 hr, 24–36 hr, 36–48 hr) were evaluated at each of the six locations for six MOS solutions.

An average deviation of one QPF category was shown for the six locations for the precipitation episode (Fig. 6). With the reliability range of plus or minus one category for this event, the output was not sufficiently close to the actual amounts to have been used with a high degree of confidence. The total deviation was least where the higher amounts of precipitation occurred (PWM 3.41, CON 2.26, AUG 3.65, BGR 2.69) and greatest where a considerably lesser amount of precipitation occurred (LEB 0.83, CAR 0.09).

When considering the sum of the algebraic departures of the forecast category versus the actual category, it was noted that at the locations where the greater amounts of precipitation fell (PWM, CON, AUG, BGR) the forecast sums were nearly zero, except at PWM where the forecast category was consistently too low. At the locations where the least amount of precipitation occurred (LEB, CAR) the categories were consistently too high.

The MOS guidance did not accurately portray the precipitation distribution. Heavier precipitation was confined and focused on a smaller area than that projected by the forecast model. As would be expected, however, the first and second period forecast categories exhibited better accuracy than the third period forecast.

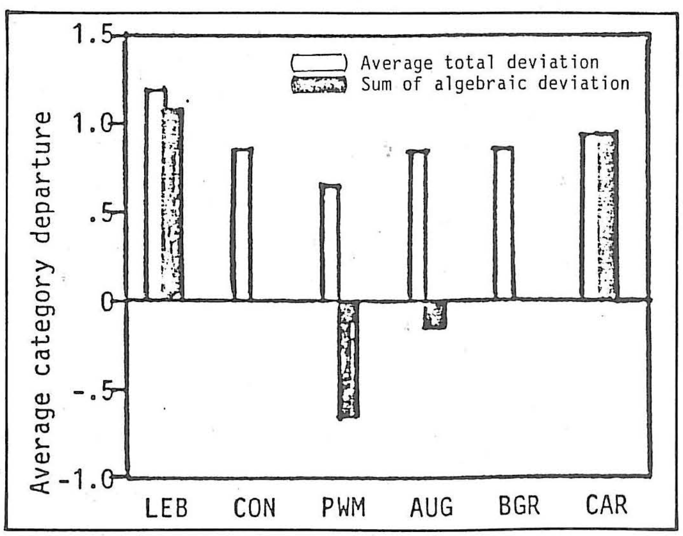

Fig. 6. Depiction of the average total and algebraic deviation of the comparison of MOS, preferred category, 12-hour QPF to actual amount of precipitation. Three forecast periods (12-24 hr, 24-36 hr, 36-48 hr) for six MOS solutions from 1200 GMT March 29 to 0000 GMT April 1, 1987 were evaluated at each of six locations in ME and NH.

1.53 *NGM and LFM QPF Output* QPF amounts for 48 hr from the FOUS bulletins of the LFM and NGM (7) were compared to the actual precipitation amounts which occurred over like time periods from the 1200 Mar. 29 forecast to the 1200 GMT Apr. 1 forecast. The summation of the precipitation was plotted for the seven forecasts at each of the four sites in Maine and New Hampshire; CAR, BGR, PWM, and CON.

At PWM (Fig. 7C), there was remarkably good correlation between the NGM forecast and the actual precipitation from the 0000 Mar. 31 projection to the 1200 GMT Apr. 1 projection. The LFM forecast showed the appropriate trend but the amounts were not sufficient for the seven projections examined. The 1200 GMT Mar. 30 projection grossly underforecast the precipitation at this site and it was similarly dry at BGR and CON. At CON (Fig. 7D), the LFM values were better than the NGM and were sufficiently accurate in which to have had confidence except for the forecasts of 0000 and 1200 GMT Mar. 30.

The forecasts were up to an order of magnitude too high at CAR (Fig. 7A) as the actual precipitation was near 0.10 in. and several total outputs were near 1 in. The NGM and LFM QPF showed about the same limited skill over the forecasts considered. When the actual rainfall was over 2 inches at BGR (Fig. 7B), the models underforecast the amounts by 1 to 2 in. and could not have been used with confidence for these periods.

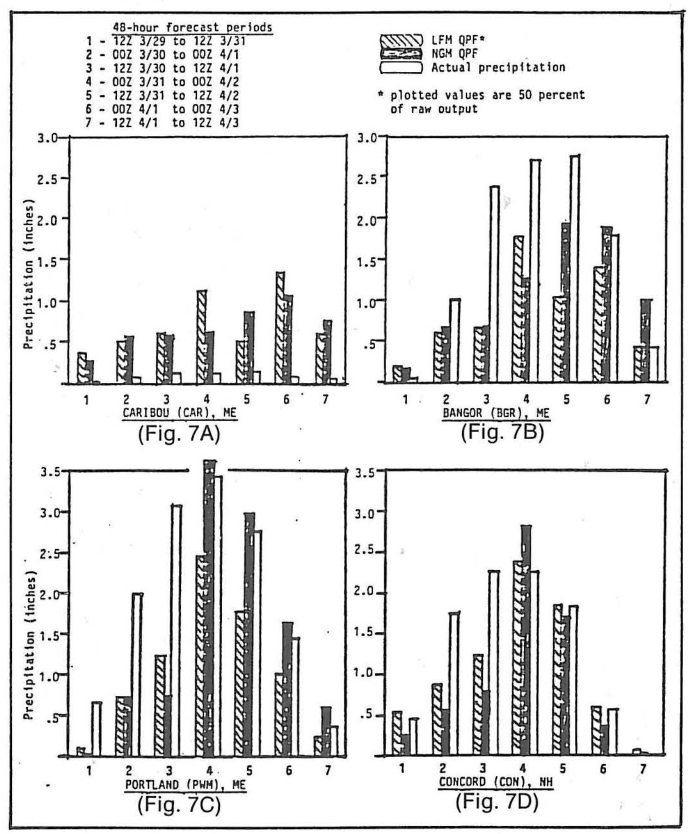

Fig. 7. Comparison of LFM and NGM FOUS QPF amounts to actual precipitation amounts for 48-hour periods from 1200 GMT March 29 to 1200 GMT April 1, 1987.

The greater amounts of precipitation from the system occurred at more suseptible locations than the forecast points based on the topography. In a scheme to estimate the precipitation amount that could occur over the elevated terrain, the QPF values of the forecast points must be included as an important factor.

1.6 Signatures of A Flood Event

There were parallels here to the meteorological description of a synoptic-type flash flood event (Maddox, 8, 9), but there were significant departures from the model which would disqualify this incident as a flash-flood event. The flooding occurred on the east side of a slow-moving, north-south oriented surface front below a convergent area of low-level moisture. The axis of maximum mid-level winds (850 mb) was coincident with the high dewpoint values at this level through the period of maximum rainfall. Confluence ahead of the strong short wave trough at 500 mb was not observed over New England until 1200 GMT Apr. 1 or after the bulk of the rain had fallen in Maine. A large moisture content was present through a deep tropospheric layer and surface temperature and dew points were high for the time of year. However, the heavy rains were not necessarily produced by convective storms since there was signficant vertical wind shear through the clouds.

1.7 SUMMARY

Moist, low, and mid-level convergence coincided with upper level divergence for an extended period, causing widespread upward vertical velocities through the cloud layer. Resultant moderate rain intensities and heavy rain summations triggered extensive flooding in Maine and New Hampshire. The observed radar echo levels were consistently a category low in comparison to the observed rainfall rate. The underestimation in the amount of rain fallen based on the radar echo may be attributed to a beam-pulse receiver that perhaps was not properly tuned. Or, the lower elevation orographic uplift that caused the heavier rains did not leave a higher-level detectable radar signature.

Numerical and graphical guidance provided reliable prognosis through 24 hr. Model QPF values and categories, however, were the least reliable of the measureable parameters. The higher QPF value field was too widespread over ME and NH as compared to the area of greatest precipitation. The maximum QPF values at the selected sites that received the heavier rain were generally not sufficient until the heavier rain was in progress. An effort needs to be made to develop a relationship between QPF values at specific sites and a QPF determination for the elevated topography of Maine and New Hampshire.

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NOTES AND REFERENCES

1. Bruce W. Budd is a forecaster and marine program leader with the National Weather Service at the NWSFO Portland, ME. He received a B.S. in Meteorology from the University of Utah and the M. S. from the Naval Postgraduate School in Monterey, CA.

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2. THE HYDROLOGICAL ASSESSMENT

2.1 Profile of the Kennebec River Basin

The Kennebec River basin is located in west-central Maine encompassing 5,870 mi or 20% of the state (Fig. 8). The Kennebec extends from the mountainous U.S.-Canadian boundary south to the small hills bordering the Maine coast. It is the third largest of the river basins lying wholly within New England with a length of 132 mi and a maximum basin width of 77 mi. The river flows through mostly hilly terrain with mountain peaks over the northern section reaching elevations of 3,000 to 4,000 ft.

The headwaters of the Kennebec are formed by Moosehead Lake and the Moose River (Fig. 9). The major tributaries consist of the Dead, the Carrabassett, the Sandy, and the Sebasticook. Major dams regulate the flow in the mostly uninhabited upper Kennebec River valley. Even though the lower Kennebec is not heavily developed there are a good number of cities and towns located along the river. The headwater and tributaries have a natural storage capacity as deep valleys and dense timberland contain the runoff and slow the flood peaks.

Daily (or more frequent) precipitation readings are taken at 16 locations within the basin and reported to the National Weather Service (NWS) forecast office in Portland (PWM). The river flow is monitored at Wyman Dam in Bingham and Weston Dam in Skowhegan. River stages are available periodically at North Sidney (8 mi upstream from Augusta) and at Augusta (AUG) during flooding episodes. Although readings are made on the various tributaries to the Kennebec, only the gage at the mouth of the Carrabassett River at North Anson (20 mi upstream from Skowhegan) was available to the NWS on a real-time basis.

Destructive flooding occasionally occurs on the river and its tributaries due to any combination of heavy rain, melting snow, and ice jams. The flood flow at Weston Dam in Skowhegan is estimated as 35,000 cubic feet per second (cfs). This value is reached with a return period of less than 2 yr. Destructive flooding has been more common on the Kennebec in recent years. Four of the seven highest flows recorded including the 1936 flood have occurred since 1983. Six out of the seven highest flows have been within the last 14 yr.

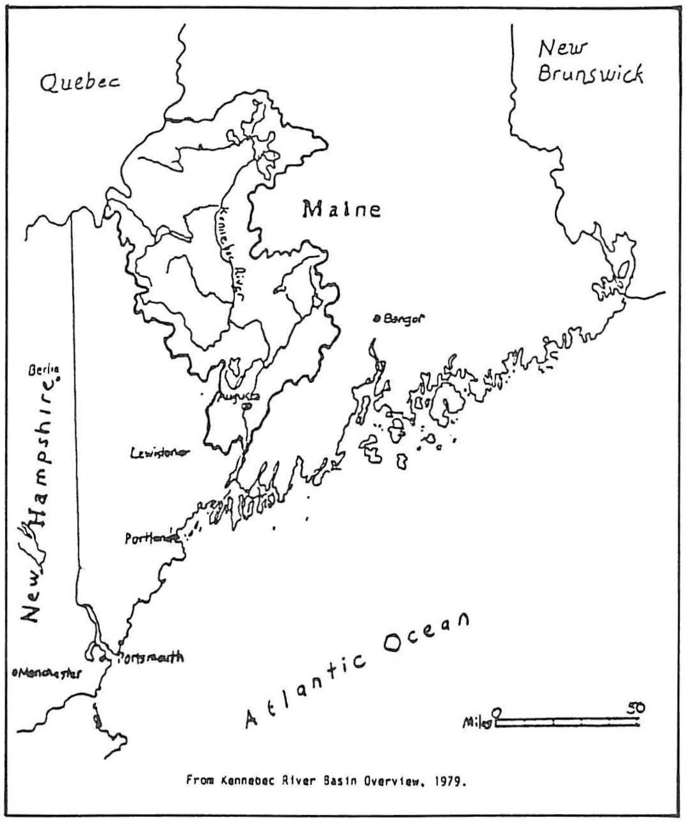

Fig. 8. Location of the Kennebec River Basin.

2.2 Summary of the 1987 Flood

Greater than 100-yr floods occurred on the Kennebec, Carrabassett, Sandy, Sebasticook, and Piscataquis Rivers (Penobscot R. basin) on Apr. 2, 1987. On the Kennebec, the estimated peak flow of 185,000 cfs at Weston Dam (Skowhegan) on Apr. 1 was significantly higher than the 133,500 cfs reported on Mar. 20, 1936, and in subsequent years. The highest flood flow at N. Sidney ws 220,000 cfs, occurring at 0900 AM GMT Apr. 2, 1987, far surpassing prior high water flows of the lower Kennebec and the flood flow of 49,000 cfs.

Hallowell and Gardiner, communities 5 to 10 mi. downstream from Augusta, were hard hit by the flood but their high water marks were just shy of the 1936 standards which were set due to a massive ice-jam downstream. However, the 1987 peak flood flow in excess of 200,000 cfs at Hallowell was greater than the highest flow of about 160,000 cfs in 1936.

The great volume of water of the Kennebec and other rivers, throughout the state in the early days of April, 1987, resulted in an estimated 63 million dollars of damage although, miraculously, there were no reported deaths. The toll included: 137 roads damaged, 13 bridges closed and three washed away; 23 communities evacuated to some degree; 1500 to 1700 homes damaged; and substantial damage to structures along the river. The 130-yr-old Lowe's covered bridge at Guilford on

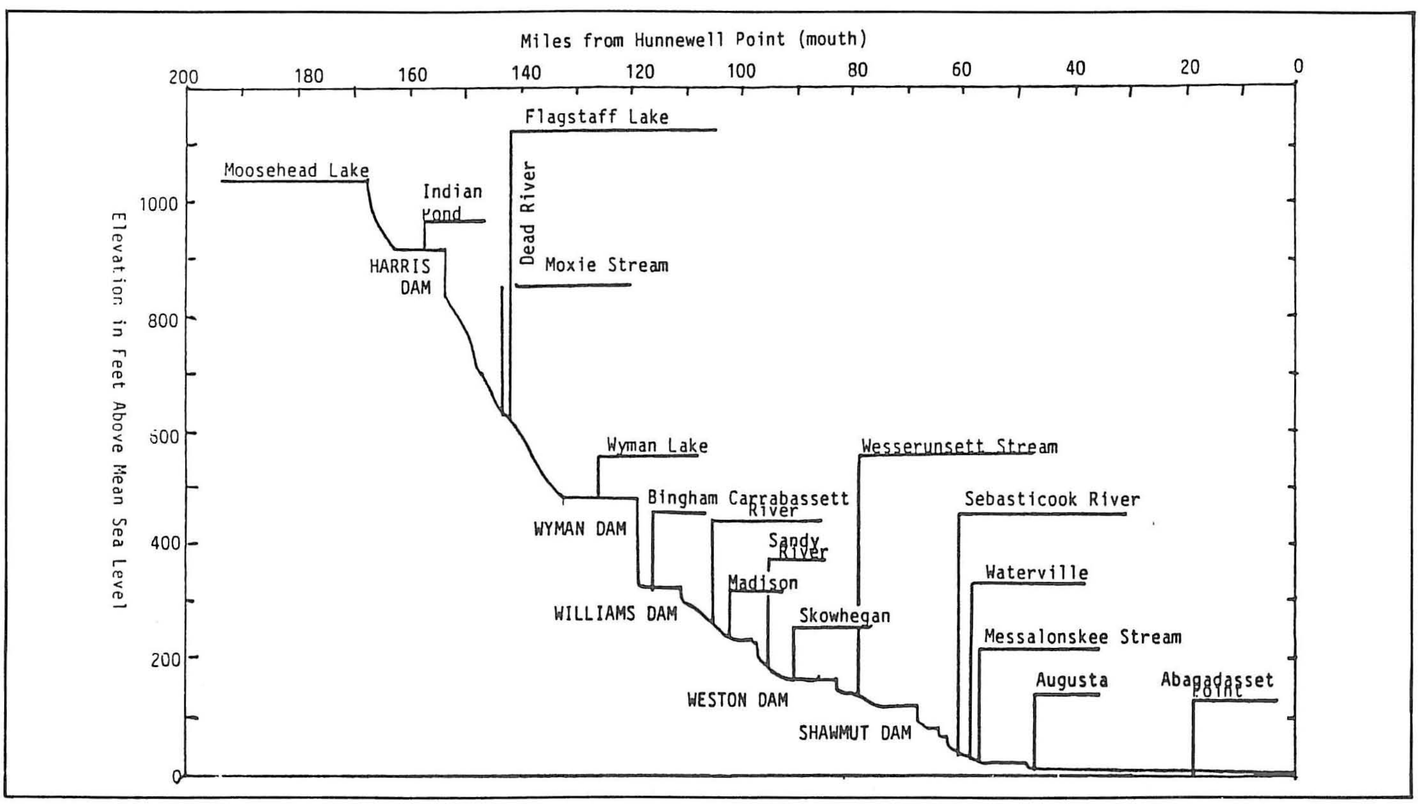

Fig. 9. Profile of the Kennebec River (from Kennebec River Basin Overview, 1979).

the Piscataquis and a 233-yr-old British fort in Winslow on the Kennebec were obliterated. Even though the dollar damage of the 1987 flood on the Kennebec surpassed that of March, 1936, the actual physical destruction was less because the river was not choked full of ice as it was in the previous flood of record.

2.3 Antecedent Conditions to Flooding

Early spring is a climatologically-favored time for flooding in Maine. Ablation of the snow and ice cover due to seasonal warming causes a general increase in the volume of water in rivers. Significant rainfall amounts over river basins at this time of year can easily cause flooding of these swollen rivers. The upper Kennebec River valley with its intercepting bodies of water and regulating dams has a large storage capacity. The mountainous terrain tends to direct runoff quickly into the river valleys. The ground is usually frozen and snow covered in the early spring so that soil moisture, porosity, and vegetative cover are not primary factors in influencing runoff.

In mid-March 1987 the snow was 2 to 3 ft deep over the entire Kennebec River basin. By the end of March, after daytime temperatures in the 50s to mid 60s (°F), the snow had all but disappeared south of Skowhegan. However, amounts less than a foot remained in the upper valleys and amounts more than a foot remained over the wooded areas and higher terrain (Fig. 10). Assuming an average late-season snow density of 0.35, greater than 4 in. of water equivalent over the uplands was available for conversion to runoff.

2.4 Rainfall and Runoff

The onset of rain over the Kennebec River basin occurred during the early morning hours of March 31, then continued moderate to heavy throughout the day and following night, lightening up by sunrise April 1 over the eastern part and changing to light to moderate snow over the western part. Light precipitation throughout the daylight hours April 1 completely ended by midnight. Cumulative rainfall for this 2 day period ranged from 3 to 5 in. over the southern part and headwater region of the basin to 5 to 7 in. over the central area (Fig. 11). Most of this rain fell in a 24-hr period from 1200 GMT March 31 to 1200 GMT April 1. Temperatures and dew points were in the mid 40s to mid 50s (°F) with south and southeast surface winds 15 to 25 mph gusting 30 to 35 mph during the heavier rain period.

On the day after the storm the old snow cover had been virtually eliminated over the central valley region (lightly shaded, Fig. 3) and it was estimated that there had been a 50 to 75% reduction in the central highlands and headwater region. Rainfall was undoubtedly absorbed to some degree by the snow cover over the higher terrain but nearly all the rainfall and melted snow was converted directly to runoff. The rainfall was augmented by an estimated 20 to 80 percent or 1 to 4 in. Runoff from the headwaters and central highlands was in the 4- to 9-in. range and over the central valley it was in the 6- to 11-in. range. Fortunately, the three upstream storage reservoirs, Brassua, Moosehead, and Flagstaff Lakes were in a prespring drawn-down state, so they were able to control the contributing runoff from their watersheds.

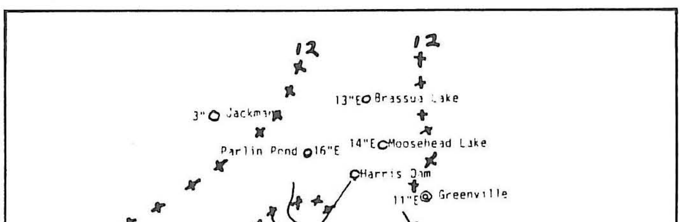

Fig. 10. Snow cover and water equivalent in the Kennebec River Basin on March 30, 1987.

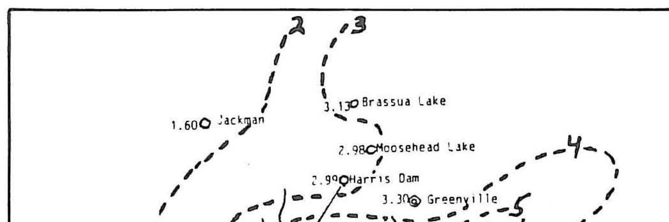

Fig. 11. Precipitation (melted) totals for March 30–April 2, 1987 over the Kennebec River Basin.

2.5 River Response

A composite hydrograph of four sites on the Kennebec River and one on the Carrabassett River (North Anson) are presented in Figure 12. The earliest reaction to the high runoff was on the Carrabassett, the smaller western tributary. The river started rising within 3 hr of the onset of heavier rains at 1200 GMT March 31, nearly 18 ft in approximately 21 hr to a height of 25.87 ft around 4 am April 1. The Kennebec was slower to respond with sharp rises in the river heights beginning 6 to 12 hr after the heavier rain began. Flood flow and stage were exceeded at Weston Dam (Skowhegan) and at the N. Sidney gage around 2200 GMT March 31. Flood stage and flow are not available at N. Anson and Wyman Dam.

A peak flow of 47,930 cfs occurred at 0000 GMT April 1 at Wyman Dam (Bingham). A peak of 48,490 cfs happened again at 0100 GMT April 2 when additional water was released. Although Flagstaff Lake was at capacity, Moosehead Lake and Harris Dam had a reserve and as a result the uppermost portion of the Kennebec did not have the overwhelming volume of water that the remainder of the river received.

At Weston Dam (Skowhegan) the flow increased dramatically from 22,280 cfs at 1200 GMT March 31 to 165,000 cfs at 1200 GMT April 1 and to an estimated peak of 185,000 cfs at 0000 GMT April 2. At N. Sidney the river rose rapidly from 15 ft at 3 March 31 to 37.41 ft at 0000 GMT April 2 and then to 39.31 ft at 4 0900 April 2, nearly 22 ft above flood stage. At Augusta the river crested at 34.0 ft at 1000 GMT April 2 which was 21 ft above the flood stage of 13 ft. The crest at Augusta occurred 10 hr after the peak flow at Skowhegan. The river remained in a flooded state for over 3 days at Skowhegan and for 4½ days in the Sidney-Augusta area.

Because of the reservoirs, the upper basin above Bingham (Wyman Dam) representing 50% of the watershed at Augusta, contributed only about 25% of the peak flow at Augusta. By comparison, the watershed between Bingham and Waterville including the Sandy and Carrabassett tributaries, represented only about 30% of the watershed at Augusta, yet contributed about 60% of the peak flow at Augusta.

On the Piscataquis River between Guilford and Dover-Foxcroft, ME, the gaging station reported a rise from 6.8 ft (4,000 cfs) at 1200 GMT March 31 to a crest of 22.6 1200 GMT ft (33,000 cfs) at 1100 GMT 6 AM April 1 (Fig. 13). This stage was. 11.6 ft above the flood stage of 11 ft, and reports from the site were not available for the 2 days of highest water. The precipitation recording station in Blanchard, at the headwaters of the Piscataquis, received 7.33 in. of rain, which was the greatest amount recorded in the state.

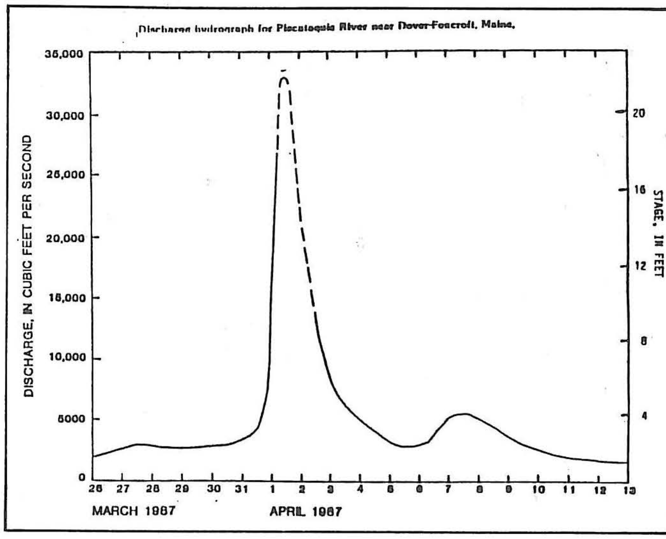

Fig. 13. Discharge hydrograph for the Piscataquie River near Dover-Foxcroft, Maine, March 26–April 13, 1987. (from USGS Open File Report 87-460.)

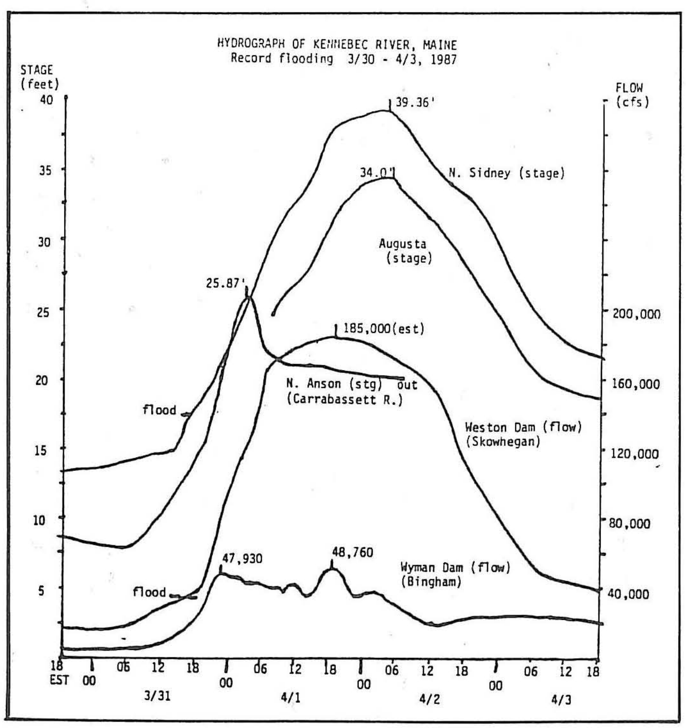

Fig. 12. Hydrograph of the Kennebec River, Maine, March 30–April 3, 1987. This was a record flooding situation.

2.6 Forecasts

According to the zone/county flood guidance prepared by the Northeast River Forecast Center prior to the storm, a rain amount of 1.5 in. for 3 hr or 2 in. for 24 hr were needed to produce flooding. These amounts were reached by midday March 31, then flood warnings were issued by the NWS in Portland for small rivers and steams in western Maine.

Initial forecasts of the river flow at Skowhegan and heights at Augusta were too low, with the crest predicted too early. Early afternoon forecasts on March 31 predicted a maximum flow of 55,000 cfs for the morning of April 1 at Skowhegan and a peak state of 17 ft by 1700 GMT April 1 at Augusta. Subsequent forecasts were revised upward throughout the afternoon and evening. At 1300 GMT April 1 when the full scope of the flooding potential was realized, the maximum flow for Skowhegan was forecast to be 185,000 cfs at midday April 1 and the crest at Augusta was forecast to be 34 ft by early evening April 1. Although the actual crests occurred later than predicted, the forecast values were accurate.

2.7 Recommendations

Could the record flooding have been forecast more accurately at an earlier time? Perhaps, if critical information for composing the forecasts was available and correct at forecast time.

The most significant variable is rainfall (amount, intensity, and distribution). A better scheme is needed for estimating local potential rainfall amount and distribution in a given meteorological situation. The elevated topography of the central Kennebec River basin may have partly contributed to the 50 to 100% increase in the rainfall amount over that which fell over the coastal plain. Perhaps in most any meteorological situation with moderate to strong upslope southeasterly surface winds, the precipitation amount over the slightly elevated terrain is some percentage higher. That value could then be used to enhance the quantitative precipitation forecast.

The precipitation network appears adequate, but all reports need to be received in real time at set intervals. A more complete and timely determination of the snow cover and its water equivalent would be beneficial. From a more complete rainfall and snowmelt estimate, a better runoff determination can be made for the hydrologic model.

In regards to the river gage network on the Kennebec, more real-time observations of river heights or flows available to the NWS are needed. This is especially true for the major tributaries; the Dead, the Carrabassetts, the Sandy, and the Sebasticook. These river gage sites should then become prediction points as well. The April Fools flood of 1987 has left legacy. Hopefully, tools for forecasting another flood on the Kennebec or other rivers in the state will be improved for the next occurrence.

ACKNOWLEDGMENTS

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Folklore

"RED SKIES AT NIGHT, SAILORS DELIGHT"

by Sue Mroz

We are all familiar with the old weatherlore saying, "Red Skies at Night Sailors Delight." But did you know that it may be familiar because its origins can be traced to ancient Greece? That's right! This lore, which is generally true, is credited to the ancient Greek Democritus, a student of Aristotle. As we view the sky at sunset, the longer wave lengths are scattered, producing a pinkish-red hue which is reflected by dust particles and scattered clouds. The fair weather to the west is likely to be with us the next day.

Note: We congratulate Ms. Mroz on her recent graduation from Northern Illinois University with a B.S. in Meteorology.