State of Maine

Department of Environmental Protection

Department of Defense, Veterans and Emergency Management,

Maine Emergency Management Agency

Report to the
Joint Standing Committee on Natural Resources

Pursuant to Resolve, Chapter 80
First Regular Session, 123rd Legislature
Resolve, To Study Flood Control and Water Storage

February, 2008

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Executive Summary

Section 1:

Section 1 of Resolve 80 of the 123rd Legislature, 1st Regular Session directs the Department of Environmental Protection and the Department of Defense, Veterans and Emergency Management, Maine Emergency Management Agency, referred to in this resolve as "the agencies", to:

> "undertake a study of current state and federal laws regarding flood control and water storage by hydropower facilities, water level regimes of regulated storage reservoirs, the impact of those laws and regimes on flood control and any other consideration the agencies determine to be necessary to effectuate the purpose of the study."

To fulfill this requirement, the agencies convened a committee including representatives of state government agencies, environmental advocacy groups, federal and state government scientific partners, and the operators of the storage dam at Flagstaff Lake to examine the effects of a reduced drawdown level at Flagstaff Lake. A list of participating agencies is included in Appendix A. The National Weather Service, Northeast River Forecast Center developed a methodology to examine how a five-foot drawdown limit on the Lake would have changed the flood flows and flood stages of multiple historical flood events.

The results of this study indicate a measurable relationship between reduced storage capacity at Flagstaff Lake at this five-foot drawdown level and increased flows and flood stages downstream on the Kennebec River.

Section 2:

Section 2 of Resolve 80 concerns dam operation and notification in small river basins (such as the Mousam River in York County) which unlike the Kennebec Basin, for example, have a very limited reservoir storage capacity. Section 2 directs MEMA to:

> "review and submit a report on the criteria and procedures by which the water levels of dams and flood control structures in the State are modified in emergency circumstances and the procedures for notifying downstream properties of those water level modifications."

To examine this issue, MEMA studied existing dam safety statutes and planning standards, as well as USGS, FEMA and MEMA reports of flooding during May 2006 and April of 2007.

MEMA concludes that, unlike in larger basins, there is very limited opportunity in small basins to reduce flood damages through dam operation. However, there is an opportunity for improvement in dam safety coordination, education and planning protocols, many of which steps are already underway. There is also a critical need for additional flood warning and monitoring stream gages in southern Maine, and other small basins across the State.

Text of: **RESOLVE Chapter 80**
SIGNED on 2007-06-14 - First Regular Session - 123rd Legislature

Resolve, To Study Flood Control and Water Storage

Sec. 1. Study of flood control and water storage. Resolved: That the Department of Environmental Protection and the Department of Defense, Veterans and Emergency Management, Maine Emergency Management Agency, referred to in this resolve as "the agencies," shall undertake a study of current state and federal laws regarding flood control and water storage by hydropower facilities, water level regimes of regulated storage reservoirs, the impact of those laws and regimes on flood control and any other consideration the agencies determine to be necessary to effectuate the purpose of the study. The purpose of the study is to identify ways to reduce the threat of flooding in the State. In conducting the study, the agencies shall invite the participation of interested stakeholders, including, but not limited to, representatives of hydropower facilities, environmental groups and municipal officials. By January 15, 2008, the agencies shall submit a report related to the study under this section, along with any necessary implementing legislation, for presentation to the Joint Standing Committee on Natural Resources. The Joint Standing Committee on Natural Resources is authorized to submit legislation related to the report to the Second Regular Session of the 123rd Legislature; and be it further

Sec. 2. Review of criteria for water level modification. Resolved: That the Department of Defense, Veterans and Emergency Management, Maine Emergency Management Agency shall review and submit a report on the criteria and procedures by which the water levels of dams and flood control structures in the State are modified in emergency circumstances and the procedures for notifying downstream properties of those water level modifications. The report must include an assessment of the effectiveness of those procedures in connection with the major rain events that occurred in May 2006 and April 2007. The report must be submitted to the Joint Standing Committee on Natural Resources by January 15, 2008.

Section 1: Study of Flood Control and Water Storage

RESOLVE Chapter 80

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Sec. 1. Study of flood control and water storage. Resolved: That the Department of Environmental Protection and the Department of Defense, Veterans and Emergency Management, Maine Emergency Management Agency, referred to in this resolve as "the agencies," shall undertake a study of current state and federal laws regarding flood control and water storage by hydropower facilities, water level regimes of regulated storage reservoirs, the impact of those laws and regimes on flood control and any other consideration the agencies determine to be necessary to effectuate the purpose of the study. The purpose of the study is to identify ways to reduce the threat of flooding in the State. In conducting the study, the agencies shall invite the participation of interested stakeholders, including, but not limited to, representatives of hydropower facilities, environmental groups and municipal officials. By January 15, 2008, the agencies shall submit a report related to the study under this section, along with any necessary implementing legislation, for presentation to the Joint Standing Committee on Natural Resources…

A. Relevant State and Federal Laws

The Clean Water Act, and related state law, requires that waters be classified and then assigned designated uses that are to be achieved and maintained. The principal tools used to achieve and maintain designated uses are the waste water discharge permit, the wetlands fill permit, and the water quality certification [citations omitted]. In the case of hydropower generating and storage facilities, the State of Maine has asserted its authority to issue water quality certificates to facilities that are licensed by the Federal Energy Regulatory Commission (FERC). States are given the opportunity to issue water quality certificates in Section 401 of the Clean Water Act to any applicant for "a Federal license or permit to conduct any activity, including but not limited to, the construction or operation of facilities which may result in any discharge . . . " A water quality certificate can be issued only when the state determines that the hydropower project will comply with state water quality standards. A certificate may impose conditions on the proposed project. The conditions of a certification must be included in any federal license or permit that is issued.

Maine's water classification creates four classes (AA, A, B, and C) for fresh water rivers and streams and one class (GPA) for lakes. The designated uses of Class GPA waters are:

- drinking water after disinfection
- fishing
- agriculture
- recreation in and on the water

- industrial process and cooling water supply
- navigation
- habitat for fish and other aquatic life
- hydroelectric power generation, except as prohibited under Title 12, section 403 [except in Class AA waters which prohibit dams]

Flood protection is not a designated use of Maine's waters.

An important point about designated uses is that they must all be achieved and maintained, which means in effect that the most sensitive use will govern limitations imposed on permits or certifications. This is a frequent misunderstanding about designated uses. One use cannot occur at the expense of another. So even if flood protection became a designated use of one or all of Maine's classifications, the State could not make a decision that would allow for aquatic life to be violated in order to provide for flood protection on a routine basis. Emergencies and matters of public safety are notwithstanding this protection of aquatic life.

The Clean Water Act and related state laws then provide narrative and numeric criteria that are designed to achieve and maintain the designated uses. Maine's classification system provides for a tiered approach to aquatic life, where a Class A water body is required to support a more sensitive population of aquatic organisms than is a Class C water body. These criteria are summarized in Table I.

Table I: Maine Water Classification System

	Numeric Criteria		**Narrative Criteria**	
	Dissolved Oxygen	**Bacteria (*E. coli*)**	**Habitat**	**Aquatic Life (Biological)**
Class AA	as naturally occurs	as naturally occurs	free flowing and natural; no dams or discharges	as naturally occurs
Class A	7 ppm or 75% saturation	as naturally occurs	Natural; "equal to or better discharges", dams allowed	as naturally occurs
Class B	7 ppm or 75% saturation	64 cfu/100 ml geometric mean	Unimpaired; well-treated discharges, dams allowed	support all aquatic species indigenous to the receiving water; no detrimental changes to the resident biological community
Class C	5 ppm or 60% saturation; 6.5 ppm 30-day avg.	126 cfu/100 ml geometric mean	habitat for fish and other aquatic life; well-treated discharges, dams allowed	maintain the structure and function of resident biological community
Class GPA	not applicable	29 cfu/100 ml geometric mean	Natural; no new discharges; dams allowed	As naturally occurs, except maintain the structure and function of the resident biological community in existing hydropower impoundments

There are a variety of ways in which these criteria are evaluated in a permitting decision. A full description of these is beyond the scope of this discussion.

There are three outcomes in a water quality certification decision for a hydropower storage or generating facility that requires a federal license being able to meet water quality standards while simultaneously providing flood protection, given existing state and federal law. They are:

- A proposed operating regime (flow or water level) is protective of aquatic life and all other uses as well as providing flood protection downstream, so the state could issue a water quality certificate.

- A proposed operating regime is protective of aquatic life, and additional releases or flows are provided for when snowpack or precipitation will create flooding conditions. This exception is provided for the limited instances when flooding will occur.[1]

- A proposed operating regime violates water quality standards so an applicant and the State undertake a Use Attainability Analysis (UAA) provided for in the Clean Water Act and state law to create a subcategory of designated uses. Such a subcategory is in effect a lower standard than presently exists in state law and would allow impacts to water quality that would otherwise not be allowable. There is guidance in federal regulations as to the criteria and information needed to conduct a UAA.[2]

B. Summary of Decisions and Litigation to Date Regarding Flagstaff Dam

- 2003: DEP approved a water quality certification for Flagstaff Storage Project with a drawdown of 24 feet. Exception provided for "when excessive snowpack or precipitation requires an additional drawdown in order to maintain the historic level of flood protection."

- 2003: FERC issued a new license incorporating this drawdown in the DEP certification.

- 2004: BEP granted NGO appeal of DEP's certification and denied-certification without prejudice where "the Board makes no findings or conclusions regarding the allowable winter drawdown."

- 2004: FPL appealed board decision to state and federal court. FERC stayed the new license pending outcome of state appeal. Federal court appeal has also

[1] The certificates issued to the Union Water Power Company in 2001 for the operation of the Upper and Middle Dams provided for additional releases of water from Richardson Lake under specified snowpack conditions to provide for historic flood protection on the Androscoggin River.
[2] The State conducted a UAA for the operation of Great Lakes Hydro America Storage Project located at Seboomook and Ragged Lakes. This UAA was approved by the Board of Environmental Protection and the 122nd Legislature in 2005.

been stayed pending outcome of state appeal.

- 2006 – 07: BEP denial upheld in Kennebec County Superior Court and Maine Supreme Court. Maine Supreme Court holds that BEP decision is valid and that Department's determination that a 24-foot drawdown met water quality standards was incorrect. The U.S. Supreme Court recently declined to hear FPL's appeal of the Maine Supreme Court's decision. FPL's federal court appeal is now expected to go forward.

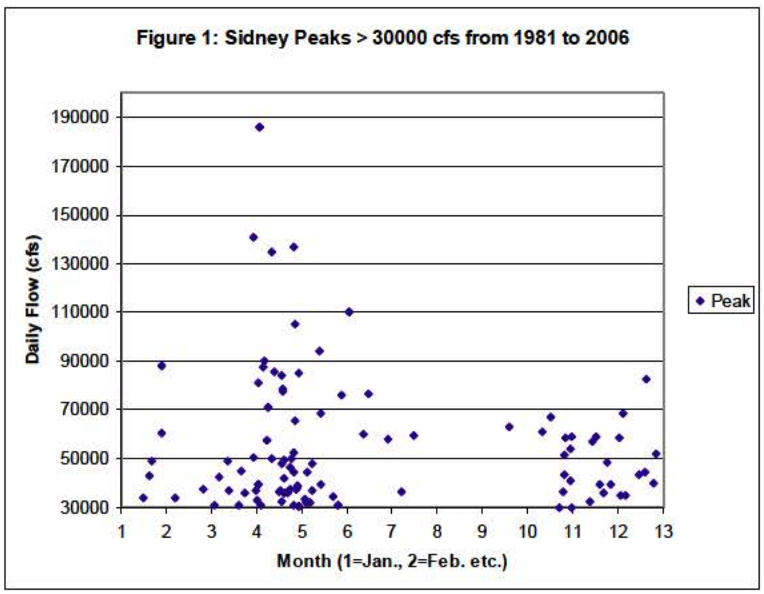
  Flagstaff Storage Project does not have certification from the State and will continue to operate under the terms of its 1979 FERC license until certification is issued or waived. FERC may not issue a new license until the State either issues or waives certification.

C. Study: Effects of Drawdown at Flagstaff Lake on Downstream Flood Flows

1. Background:

Patterns of spring riverine flooding:

Historically, more major riverine floods in Maine have occurred during the spring run-off period, roughly March through May. In Figure 1, a chart prepared by the USGS shows flows over 30,000 cubic feet per second on the Kennebec River at Sidney, from 1981 through 2006. From this graphic, it can be seen that both the numbers of events, and the higher values "cluster" in those spring months.



Riverine flooding is more common in these months due to several factors:

- Abundant rainfall
- Frozen ground that can absorb little or no rainfall
- Lack of vegetation to take up water
- Rapidly melting snowpack
- Presence of ice jams

When spring flooding occurs, it is due to some combination of these factors.

It should be noted that because the activity of ice jams is very difficult to predict, ice as a factor in flooding was not considered in designing this study. The study focused on flow alone.

The pattern of operation of Maine's storage dams in order to produce electricity coincides with the optimal timing to mitigate spring flooding. Hydroelectric producers have developed operational protocols to release water (and thereby generating electricity) over winter and early spring months, in order to "catch" runoff from rain and snowmelt and refill the reservoirs in later spring. This allows water to be released over the drier summer months for recreational, agricultural, environmental and hydroelectric generation purposes. (See Appendix B for an overview of typical river basin management by storage dam operators).

These storage dams are generally licensed, and both drawdowns and downstream flows regulated, in such a way as to meet designated and existing uses of these rivers per state and federal law. These restrictions occur throughout the calendar year and could impact flooding depending on basin characteristics, management needs and requirements of state and federal law to maintain water quality standards. However, these protocols have a disproportionate effect on flooding in the spring, since the majority of events and most severe riverine floods in Maine occur during the spring run-off period (see Figure 1).

To put the economic impact of major flooding into perspective, the Maine Floodplain Management Program, State Planning Office has estimated the cost in current dollars of two major floods in Maine:

> The 1987 Flood did approximately $100,000,000 in damages in 1987. That is 1987 dollars. In 2006 dollars that calculates to $171 million in damages. While many think the 1987 flood was the worse flood Maine has had, it was the 1936 flood that gets the prize. The damages in 1936 totaled a whopping $25 million in 1936 dollars or $352 million in 2006. That is more than twice as expensive as the 1987 flood.[3]

Planning and operational coordination:

The River Flow Advisory Commission (Title 37-B MRSA §1131) provides a platform for the ongoing coordination among parties in Maine with an interest in hydrologic matters. The Commission, comprised of state, federal and private sector agencies, typically meets once in the spring to review spring flood potential. In years of unusual spring flood potential, additional meetings may be held.

In times of low water conditions and drought, the Commission partners with water utilities and additional environmental and regulatory organizations to function as a Drought Task Force. The Task Force provides situational analysis on which State drought response policies and decisions can be based.

[3] http://www.maine.gov/spo/flood

Although the Commission's formal meetings are few, coordination is year round among Commission member agencies. In particular, the National Weather Service, river basin managers and the USGS are in constant communication throughout the year, sharing information on river flow issues. This partnership, though not unique to Maine, is uniquely strong and effective in Maine.

The Commission is referenced here because of its membership from the scientific community and the existing excellent working relationships among all members. These factors were instrumental in conducting the study documented in this report.

2. Methodology:

Computer-based river models for the major river basins in Maine have been developed at the Northeast River Forecast Center (NERFC) in Taunton, Massachusetts. These models use data supplied from a variety of sources to predict flooding, based on such factors as projected and actual rainfall, snow pack and outflow from storage reservoirs.

The Gray and Caribou National Weather Service Forecast Offices use the resulting information (as well as models developed at the St. John River Forecast Center in Fredericton NB, Canada for river basins common to Canada and Maine) to issue flood watches, warnings, and river forecasts for the major river basins in the State.

Flood Forecast Terminology:

Minor Flooding - minimal or no property damage, but possibly some public threat.
Moderate Flooding - some inundation of structures and roads near stream. Some evacuations of people and/or transfer of property to higher elevations.
Major Flooding - extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations.
Record Flooding - flooding which equals or exceeds the highest stage or discharge at a given site during the period of record keeping.
Note: all three of the lower flood categories (minor, moderate, major) do not necessarily exist for a given forecast point. For example, at the level where a river reaches flood stage, it may be considered moderate flooding. However, at least one of these three flood categories must start at flood stage.
Flood Stage - an established gage height for a given location above which a rise in water surface level begins to create a hazard to lives, property, or commerce. The issuance of flood (or in some cases flash flood) warnings is linked to flood stage. Not necessarily the same as bankfull stage.

Source: National Weather Service: National Weather Service Manual 10-950

These models are used in real-time to forecast an imminent flood event. They can also be used hypothetically, to create a projected river flow or stage level based on simulated conditions. This use of the model assists, for example, in developing scenarios for emergency exercises. An overview of the factors used in flood forecast modeling is included in Appendix C.

The NERFC used existing models to compare all historical statistical flood events on the Kennebec for the evaluation period 1981 through 2006 to those same events if a 5-foot drawdown had been in effect on Flagstaff Lake. Average daily discharge and pool height for Flagstaff, Wyman and Harris Station were provided by FPL Energy, the owner and operator of these dams.

The simulated flows and stages generated by the model run were compared against historical records at Wyman, North Sidney and Augusta (USGS gage sites). Each flood event was analyzed to determine the change in flow, stage and duration of flooding.

The full presentation made of this study by NERFC to the study group is included in Appendix D.

3. Findings:

General findings

Based on their analysis, the NERFC concluded that a 5-foot drawdown limit at Flagstaff Lake would likely cause an increase in flood level and duration at locations downstream on the Kennebec River. Flood events would also occur more frequently (see below).

Of the 31 events modeled for the forecast point at North Sidney, 21 (68%) showed a higher water level and 24 (77%) showed an increase in duration. These percentages were higher during the months of spring run-off.

The Figures 2 and 3 show changes in peak stages and in the length of flooding event at The North Sidney forecast point.

Effect on recurrence Interval

“Recurrence interval” is an important benchmark for risk management for all natural hazards. This benchmark captures the statistical probability of an event of a certain magnitude occurring in any given year. Recurrence intervals are used to calculate flood risk for floodplain management and development, infrastructure design and flood insurance rate purposes.

Recurrence intervals for flooding are calculated based on the statistical occurrence of a particular rate of flow in a particular river basin. For example, a 100-year flow (familiarly referred to as the “100-year flood”) means that statistically there is 1% chance in any given year of this flow occurring. This does not mean that a flow of this magnitude will happen only every 100 years, just that statistically one every 100 years is likely. The lower the recurrence interval, the more likely an event is to happen in any given year.

The USGS, using the model data produced by the NERFC, found measurable changes in flood recurrence intervals. In simplest terms this means that large flood events would occur more frequently.

The model data demonstrates that were Flagstaff Lake to be limited to a 5 foot drawdown, what is now a 100-year flood event would become a 64-year event. This change, from a 100 year to 64 year event, means that this event becomes roughly one and a half times more likely to occur than under the existing operation of Flagstaff Lake where average drawdowns are in the excess of 24 feet.

Similarly, the 500-year event would become a 200-year event. To put this in perspective, the 1987 flood in the Kennebec basin is an example of a 500-year event. With a 5-foot drawdown limitation, the chances of this event recurring in any given year would increase from .02% to .05%, making this event 2 and a half times more likely.

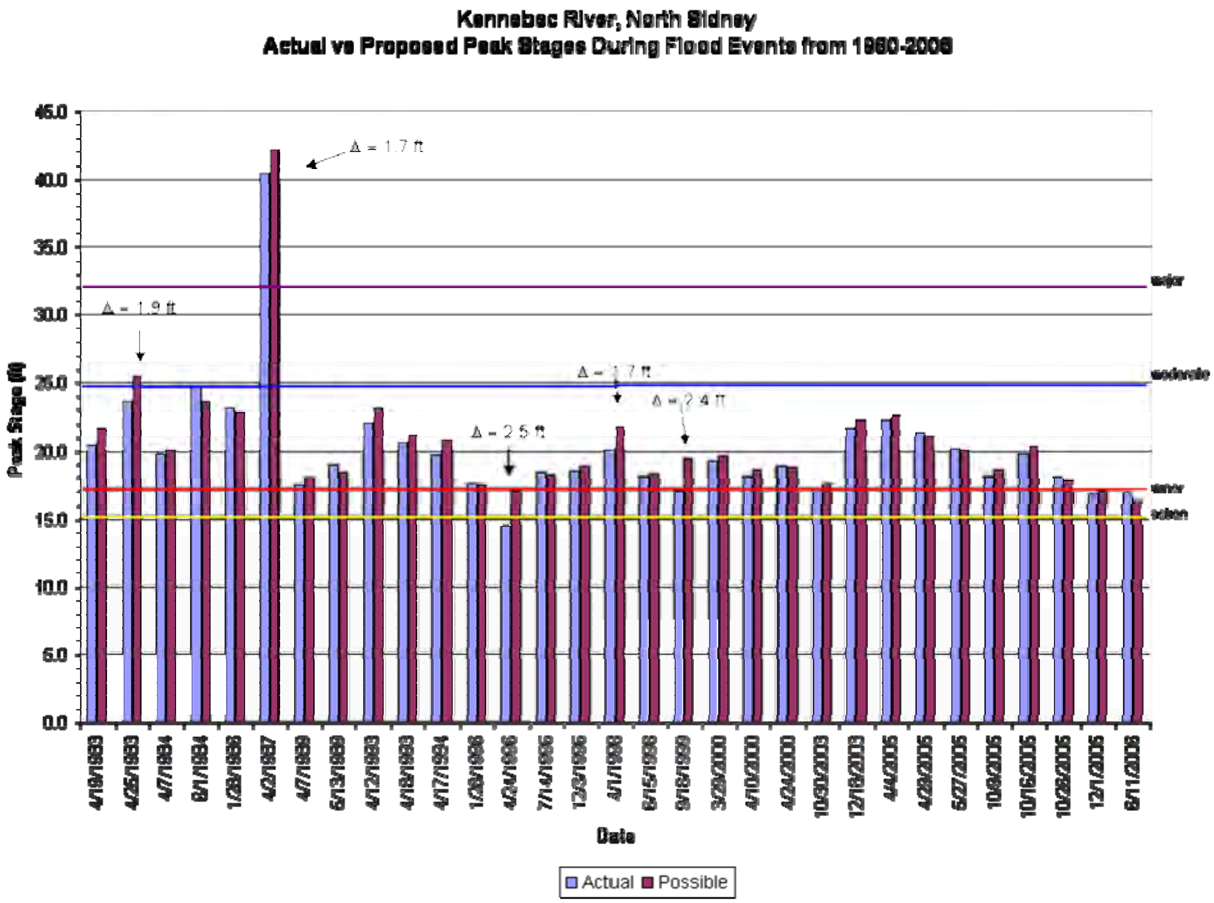


Figure 2: Source: NERFC Model. Blue or lighter line is HISTORICAL water level of these events; Red or dark line represents POSSIBLE level.

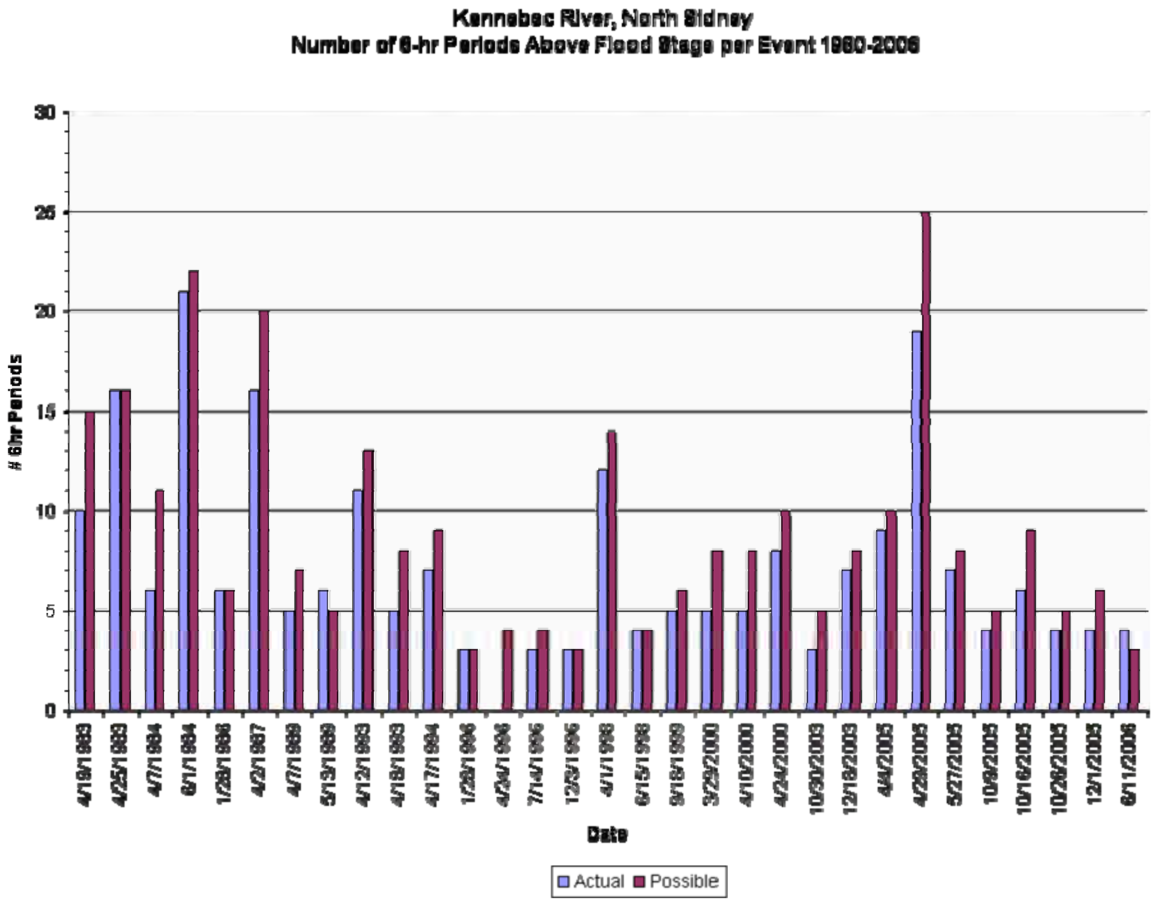


Figure 3: Source NERFC Model. Blue or lighter line is HISTORICAL duration of these events; Red or dark line represents POSSIBLE duration.

The recurrence intervals at North Sidney and Augusta calculated by the USGS from NERFC model data are included in Appendix E.

The calculated recurrence intervals also indicate that higher water levels would result using the 5-foot drawdown scenario. For example, in North Sidney:

- The 10-year event produces 2.5% more water, and the water is almost 5 inches higher.
- The 100 year event produces almost 5% more water, and the water is approximately a foot higher.
- The event that occurs every 2 years produces water almost 3 inches higher.

To put that 3 inches of water into perspective, just downstream in Augusta that 3 inches of water is sufficient, according to city officials, to tip water into the basements of buildings that would not otherwise be affected.

Effect on impact of flooding event

The impact of a flooding event can be indicated either by an increase in flow (amount of water, usually expressed in cubic feet per second, or cfs), stage (height of water) or increased duration of inundation.

Using data from the model, specifically values at North Sidney, it can be calculated that 77% of the modeled events would have seen a longer duration of flooding with a 5-foot drawdown at Flagstaff Lake. 68% of the events would have seen a higher stage. These percentages are displayed in Table 2. (Detailed data from the NERFC model, showing the dates of historical flooding at Augusta, actual flood stage and duration, and possible stage and duration of those events as projected by the model, is included in Appendix F,)

For March through May, encompassing the spring run-off, the percentage rises to 82% of events having a longer duration and 76% having a higher stage.

Table 2: Projected Change in Stage and Duration, Kennebec River at North Sidney

	Duration of Event			Flood Stage		
All Dates	Greater Duration	24	77%	Higher Stage	21	68%
	No Change	5	16%	No Change	0	0%
	Lesser Duration	2	6%	Lower Stage	10	32%
Total Events		31				
June-January	Greater Duration	10	71%	Higher Stage	8	57%
	No Change	4	29%	No Change	0	0%
	Lesser Duration	0	0%	Lower Stage	6	43%
Total Events		14				
March-May	Greater Duration	1	82%	Higher Stage	13	76%
	No Change	2	6%	No Change	0	0%
	Lesser Duration	0	12%	Lower Stage	4	24%
Total Events		15				

An increase in flow or stage (more water) translates to more inundated land area and property. A longer duration of the flooding event requires a longer period of emergency response time, and may increase damages to both private property and public infrastructure from a longer exposure to water and current. Prolonged flooding and flooded buildings can also increase long-term risks to health. All these factors can translate to higher response costs and greater financial loss due to damages.

An economic analysis of the cost of the changes that would occur from the modeled drawdown of five feet was beyond the time frame of this report.

While a small percentage of the events modeled showed either no change or a slight decrease in flow or duration as compared to the actual historical event, the percentage of events showing an increase in flow or duration is significant. In addition, the NERFC noted in their study summary that the largest differences were seen during the spring melt season.

4. Summary of Results

This study showed that a drawdown level of 5 feet at Flagstaff Lake would increase flood flows, increase duration of single events and decrease recurrence intervals.

The study group, in reviewing the methodology and resulting modeled data, determined that this method of analysis was viable for examining additional alternate drawdown scenarios. Therefore, further refined analysis of the interaction of hydroelectric storage, flood protection and water quality standards at Flagstaff Lake, is readily possible with this now existing hydrologic model and data set.

5. Limitations of Study

While this analysis looked at a 26-year period of record, it looked only at one drawdown scenario, at one storage reservoir. This analysis did not evaluate different drawdown scenarios. Nor did it look at altered drawdowns at other storage dams in the Kennebec Basin. These additional levels of complexity would have been beyond the time frame for this study.

In addition, the data presented do not indicate whether the rainfall that triggered each event fell primarily in a regulated or non-regulated area of the overall drainage basin.

6. Opportunities for Future Research

Having developed this methodology, the NERFC can now model different scenarios for the Kennebec River based on different Flagstaff Lake storage levels.

However, as noted above, changing any additional parameters, such as differing levels at other storage locations, would require significantly more complex modeling to be developed.

D. Conclusions

MEMA and DEP feel that this study has demonstrated that objective, scientific analysis methods can greatly inform the discussion of the necessary balance between water quality and public safety concerns.

Going forward, both agencies, and the scientific partners who participated in this demonstration study, are prepared to support that ongoing discussion in any way requested.

Section 2: Review of criteria for water level modification

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A. Challenges in Small River Basin Flooding

Small river basins provide unique challenges in flooding situations. Basins such as the Mousam and Little Ossipee in York County, and the Salmon Falls basin shared by York County and New Hampshire, respond quickly to concentrated local rainfall amounts. When conditions such as snowpack and frozen ground exist, they exacerbate the problem. Water levels rise rapidly, with limited opportunity to warn the public and take emergency action.

Small-basin reservoirs, if they exist, have limited storage capacity when compared to the large storage reservoirs on major rivers, such as the Kennebec. Though the reservoirs can have some impact on peak flood flow, the overall impact, as a percentage of the flow, lessens as the flood flow increases. Conversely, the lesser the natural flood flow, the greater opportunity there is for dam operation to mitigate peak flows.

Dam operators on these river systems must balance public safety needs with the need to maintain operational integrity of their dams. Those public safety interests may be both upstream and downstream of the dam.

B. Relevant State and Federal Laws

Emergency action planning for dams directly influences public safety activities such as public warning and evacuation decisions. Both state and federal laws have a bearing on dam safety planning in Maine.

Federal laws and Federal Energy Regulatory Commission (FERC) rules govern safety and planning issues for FERC-licensed hydroelectric and storage projects. State law governs all other dams in the state of Maine. Title 37-B MRSA §1111 through §1130, defines the dam safety program for the State of Maine. This section of the statute covers design criteria, dam inspections, enforcement and emergency planning requirements. The state statute does not govern routine operation of dams. It addresses operation only as it relates to or affects the condition of the dam.

At the present time, Maine has identified 879 dams in the State. Of these, 178 are regulated by FERC, and 701 fall under the State's dam safety jurisdiction. Of these, 104 are classified as high or significant hazard dams (see sidebar), requiring Emergency Action Plans (EAPs) to be developed according to State law.

Federal and State emergency planning requirements for dams are reviewed below.

C. Planning Protocols

1. Federal

FERC Emergency Action Plan (EAP) guidance sets out planning requirements for owners of licensed hydroelectric projects. EAPs are required only for dams classified as high hazard potential (37 in the State). FERC planning guidance calls for coordination with local public safety officials. FERC high-hazard dam owners are required for licensure to conduct an annual emergency exercise with local public officials and departments.

2. State

State law (Title 37-B MRSA §1127) sets out planning requirements for dams that fall under state jurisdiction. This section states:

> Within 6 months after the determination of classification, the owner of a dam under the commissioner's jurisdiction that is classified as high or significant hazard potential shall prepare an emergency action plan, which must be updated every 2 years. Such emergency action plans must be reviewed for adequacy by the department. Emergency plans must follow a model plan supplied by the department. All emergency action plans must be available and on file at the appropriate local and county government offices and at the department.

Of the 104 high and significant hazard dams over which the State has jurisdiction, most are in compliance with this statute. After a two-year concerted focus on bringing dam owners into

Dam Hazard Potential Definitions
Title 37-B MRSA §1111

Hazard potential: The possible adverse incremental consequences that result from the release of water or stored contents due to failure of the dam or misoperation of the dam or appurtenances. The hazard potential classification of a dam does not reflect in any way on the current condition of the dam and its appurtenant structures.

High hazard potential: Failure or misoperation will probably cause loss of human life;
Significant hazard potential: Failure or misoperation results in no probable loss of human life but can cause major economic loss, environmental damage or disruption of lifeline facilities or affect other concerns.
Low hazard potential: Failure or misoperation results in no probable loss of human life and low economic and environmental losses. Losses are principally limited to the owner's property

planning compliance, only 12 remain out of compliance, almost all of which are working with MEMA and County EMAs on completing their plans.

Although MEMA strongly recommends in planning guidance and EAP workshops that the EAP be regularly exercised, there is no statutory requirement for these plans to be exercised.

MEMA and County EMA Directors provide oversight and technical assistance for EAP development. County EMAs put a great deal of effort into the field coordination of dam safety planning and exercise; their efforts are limited only by their agencies' resources.

Likewise, MEMA's ability to provide technical assistance to dam owners is limited by the State resources available under the Dam Safety Program. Currently, MEMA has one licensed Dam Inspector, and one part-time administrative support position in the program.

MEMA guidance recommends that the EAP identify steps to be taken at three levels of emergency conditions:

- Failure is imminent or has occurred
- Potential failure situation is developing
- Non-failure emergency condition (such as high water conditions)

All these steps should be site-specific, and should be coordinated with local public officials. Examples of recommended actions when developing a plan include:

- Keep the EAP simple and realistic
- Specify the conditions that trigger emergency actions
- Include a Notification Flow Chart (who will be notified in case of a failure)
- Ensure EAP meets with the approval of all stakeholders and coordinates with the Town Emergency Operations Plan
- Conduct and evaluate ongoing EAP exercises and development of the EAP

As previously noted, there is no statutory requirement for exercising EAPs.

D. Case Study: York County Flooding

In May of 2006 and April of 2007, significant flooding occurred in York County, Maine. Both these events were characterized by extremely heavy regional rainfall amounts in southern Maine. Severe flooding occurred county-wide, in low-lying areas, along ponds and small streams and in the Mousam, Little Ossipee and Salmon Falls River Basins.

1. USGS research:

The US Geological Survey, in cooperation with the Federal Emergency Management Agency (FEMA) analyzed peak flows and recurrence intervals on the Mousam and Little

Ossipee and documented their conclusions in USGS Open File Report 2007-1146.[4] The recurrence intervals for this event were summarized as follows:

- Mousam River near West Kennebunk: between 100 and 500 years
- Little Ossipee River near South Limington: between 100 and 500 years.

The USGS report documents heavy 24-hour rainfall amounts between April 15 and April 16 as 7.58 inches in Sanford, 4.97 inches in Hollis and 4.60 in Cornish. This may have been augmented by as much as 1.5 inches by water released from the snowpack in these areas. In short, this was a rainfall event of historically severe proportions.

While most dams in this region are so-called "run-of-river" dams[5] with no storage capacity, USGS noted that the Mousam River basin has some reservoirs with limited storage capacity, which could potentially affect peak flows to a limited degree. The role of these reservoirs in this event, including dam operation, was not a part of their initial analysis. However, FEMA has contracted with the USGS to do a broader analysis of these basins, including dam operation. This study is underway and is projected to be completed in late 2008.

However, initial data indicates that dam operation likely had little effect on the overall impact, because of the overall high flows.

2. FEMA research and outreach:

As part of their work in the State following the April 2007 event, FEMA personnel researched and documented historical flooding events and population growth in the Mousam and Salmon Falls river basins.

Using this research, FEMA conducted informational meetings in several York County communities hard-hit by flooding in 2006 and 2007. The goal of these meetings was to facilitate a fact-based discussion about flood risk, and the factors affecting that risk, using the extraordinary nature of these events to begin the discussion.

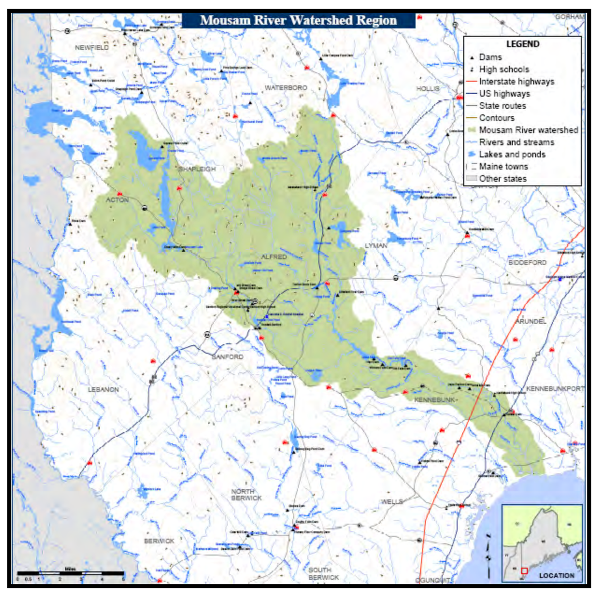

Figure 4: Mousam River Watershed Region
Source: FEMA

The Mousam River basin (see Figure 4) encompasses Shapleigh, Waterboro, Acton, Alfred, Sanford, Lyman and Kennebunk. This

[4] USGS: Estimated Magnitudes and Recurrence Intervals of Peak Flows on the Mousam and Little Ossipee Rivers for the Flood of April 2007 in Southern Maine, Open-File Report 2007-1146, available online at: http://pubs.usgs.gov/of/2007/1146/

[5] A "run-of-river" dam utilizes the power of the water flowing over the dam, but has no capacity to hold water back. In a high-water event, a run-of-river dam has no effect on downstream water levels

basin includes some 14 dams, mostly run-of-river. The Salmon Falls basin encompasses parts of eight York County towns: Acton, North Berwick, Berwick, South Berwick, Eliot, Shapleigh, Lebanon and Sanford.

The Salmon Falls River forms the border between New Hampshire and York County, Maine. The operation of dams located in New Hampshire has the potential to affect conditions in Maine. The FEMA research identified 13 functional dams on this river, again, mostly run-of-river.

All the communities in these river basins have seen a significant growth in population, and an even higher increase in the number of housing units since 1960. Acton, for example, saw a 425% increase in population between 1960 and 2006, and a 745% increase in the number of housing units. Development in and of itself is not considered to be a major causative factor in increased flooding in these events. However, increased development means more lives and property are at risk, and the community is therefore as a whole more vulnerable to floods.

The results of FEMA's research and outreach, conducted in conjunction with York EMA and MEMA, are not yet quantifiable. However, there has been a great deal of interest from a number of York County towns in projects that will reduce community vulnerability to flooding. For example, the town of Kennebunk has applied for, and has been approved for a $1.5 million FEMA grant that will allow them to elevate or buy out private structures in a neighborhood hard-hit by flooding in 2006 and 2007. This is an example of a creative community response to a level of risk that has been demonstrated by recent events and historical research to be very high.

3. Local Coordination:

In the matter of coordination, small basin dam operation differs from the large basin, major hydroelectric projects such as those referenced in Section 1 of this report. The large basin projects are, with few exceptions in the State of Maine, all owned and operated by one entity within the basin. This means that operational coordination occurs as a matter of internal protocol, which has the effect of optimizing public safety. These are FERC-regulated projects, with regular exercise required for licensing purposes. And finally, the coordination fostered by the River Flow Advisory Commission (see Section 1) is in play year-round, not just during high water events.

The Mousam and Salmon Falls basins feature smaller dams with various owners, some regulated by FERC and some by the States of New Hampshire and Maine. The coordination here can be recommended, but will likely occur only if facilitated by an outside entity, such as emergency management at the county or state level.

After the serious flooding in York County in 2006, the York County Emergency Management Agency began a coordination initiative among dam owners, town officials, the National Weather Service and utilities along the Mousam River. The goal of this initiative, the Mousam River Coordination Group, is to improve information exchange, both in high water situations and in routine dam operation, that can affect interests all along the river.

In the early stages of a potential flood event, the York County Emergency Management Agency initiates conference calls or meetings to ensure that all parties are coordinating their dam operations, and sharing information and concerns.

York EMA's establishment of the Mousam River Coordination Group provides the framework for watershed-based emergency planning. However, because there is no uniform requirement for this planning and coordination to take place, its continuation is dependent on the resources allocated to the facilitation of the group, primarily by the EMA.

A similar coordination effort will be of value for the Salmon Falls River, but is complicated by the shared jurisdiction between New Hampshire and Maine. Several of the dams that affect Maine are owned and operated by the State of New Hampshire. MEMA has initiated discussions with New Hampshire to improve the coordination of basin management; however, this initiative is still in its initial stages.

4. Planning Improvements:

MEMA's Dam Inspector and York EMA have separately observed that the dam EAPs currently in place focus far more on the scenario of a dam breach than on dam operation and public safety coordination during high water events. This is despite planning guidance that recommends development of emergency actions not just for a dam breach, but for other situations such as high flow as well.

At the same time, the detail needed for an effective dam EAP, including information about inundation areas, and buildings and infrastructure at risk, is also invaluable information in any flooding scenario. This suggests that there is an opportunity to improve overall emergency planning in many communities, simply by making a better link between dam EAPs and local and regional all-hazard emergency plans.

Basin groups such as the Mousam River Coordination Group provide a venue to discuss these matters, and to align basin-wide emergency plans. Emergency management practice and history show clearly that plans must be exercised in order to become institutionalized. This coordination, planning and exercise is labor-intensive. County EMAs in other parts of the state, less well resourced than York County, may not have the internal resources to successfully undertake this coordination.

MEMA can assist in several ways:

- Improve planning guidance, models and training modules to demonstrate the critical interconnection between dam EAPs and all-hazard community emergency plans.
- Provide planning and exercise technical assistance to regional planning and coordination groups

- Assist County EMAs by documenting “best practices” in small basin coordination
- Use FEMA, USGS and other available research as a basis for public education on flood risk and mitigation

However, as previously noted, MEMA’s ability to assist is constrained by the level of resources available to the Dam Safety program.

5. Stream gaging:

Automated stream gages provide real-time data on stream flow, as well as water and air temperature and precipitation (depending on instrumentation installed). The stream gage monitoring network in Maine is operated by the USGS, in cooperation with MEMA and other River Flow Advisory Commission agencies (see Appendix G). The USGS derives the funding for the network through a combination of 100% federal funds, funds from state and local partners matched by federal funds, and FERC-licensee funding for specific locations.

During a flood event, stream gaging on small basins makes it possible to assess how fast waters are rising, and therefore take timely, appropriate action. There are currently no stream gages on the Mousam or Little Ossipee Rivers. Reports from the MEMA Dam Inspector, who was on site in York County during the flood events in 2006 and 2007, reference taking hourly manual measurements of water levels at impoundment reference points in order to measure the rate of rise on the river. These manual measurements then had to be individually communicated to partner agencies. When adequate stream gaging is in place, these measurements are typically registered automatically every 15 minutes and are immediately available in real time to all operational partners and the public.

In addition, stream gaging provides data not only on particular events but also over time. This provides a basis to develop appropriate design standards for roads, bridges, culverts and dams. Without gaging, hundreds of hours of field work were required by the USGS to measure and document high water marks, in order to calculate the magnitude of the flood flows for 2006 and 2007.

The USGS is currently working with the Maine Department of Transportation (DOT) to deploy stream gaging on a number of small basins in the State, probably including some sites in York County. Installation of potentially 10 new gages is planned. Since funding is being provided by DOT, these gages will be located at sites most useful for long-term analysis of infrastructure issues, not necessarily those most useful for flood monitoring.

State appropriations for the stream gage network have been essentially flat-funded over the past five years. Other local sources of funding have so far not been forthcoming. Federal allocations to the USGS for the Maine network have not substantially increased over the last 8 years. While the DOT-funded gages will be a welcome addition to the network, a shortfall will remain in flood warning and monitoring stream gaging in the small basins in southern Maine.

E. Statewide Implications

With what we know so far about the sheer magnitude of water that inundated York County in 2006 and 2007, it is unlikely that any changes in dam operation could have significantly reduced the impact of those events. We look forward to the USGS report scheduled for release later this year, which will take a more in-depth look at the 2007 event, including dam operation. If any changes are deemed advisable based on that report, MEMA and York EMA will work with dam operators and local officials to make those changes.

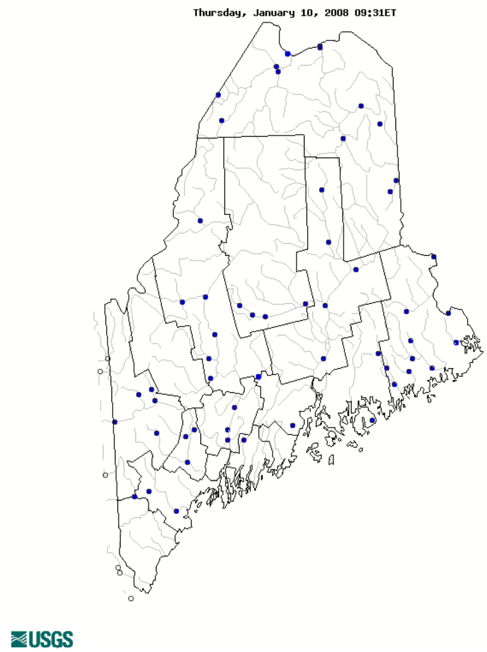

Figure 5: Stream gage locations in Maine. Source: USGS

Improved local coordination and better response planning will result in a more seamless response. In York County, it will be important for the State, primarily MEMA, to continue to support the County EMA in this effort, particularly in regard to facilitating coordination with New Hampshire. It will also be critically important for MEMA to support other County EMAs in small basin coordination across the state.

The single factor, however, that could have the most impact on operational decision making in small river basins is accurate real-time hydrologic information, which can be provided most effectively by automated stream gaging.

F. Other Opportunities

Community vulnerability to flooding can be reduced in a number of ways. Emergency preparedness (planning, training and exercise) generally results in a faster, more coordinated response, which in turn can save lives and avert some property damage. Sensible development strategies, including floodplain management and mitigation projects can reduce the amount of property at risk. Better data and understanding of the flood risk may also lead to giving the communities better tools for reducing the flood insurance premium rates, through the Community Rating System (CRS). And lastly, when structures such as dams are a factor in the river basin, dam design, condition and operation may reduce flood risk.

FEMA research in York County is documented above. A second FEMA study going on statewide will provide an enhanced planning and educational base for all Maine towns at risk for flooding. FEMA is interviewing local officials in towns across the state, documenting vulnerable populations and property at risk in flood-prone areas. The resulting data will be map-based, and published on a public Internet site. This data will complement research sponsored by the Maine Floodplain Management Program (MFMP) at the State Planning Office, documenting historical Maine floods[6].

MEMA, the MFPM and County EMAs will be able to draw on this information to encourage better local planning, coordination and development, and as an educational tool for the public to better understand the level of risk in their communities. For example, it will allow for a better assessment of current development standards and any need to rework those standards. A clear understanding of risk is critical to good local decision-making before and during the flood, and to finding creative local solutions to reduce vulnerability.

G. Work Points

York County's experiences in 2006 and 2007 provided a number of work points for improving small basin management there and elsewhere in the State. MEMA has identified the following internal work points to improve small basin management and overall emergency coordination:

- Improve EAP and all-hazard planning guidance to clarify the importance of local and regional coordination both during flooding events and during non-emergency operations.
- Work with County EMAs to determine areas where regional basin coordination groups are advisable
- Work with County EMAs to form and exercise regional basin coordination groups, where needed
- Identify advisable changes in dam operations protocols based on the forthcoming USGS report on the 2007 York County flood event; support York EMA in facilitating any needed changes based on that report.

It is also critical to continue to work to identify additional resources to increase stream gaging on small basins. The data provided by additional gaging would be immeasurably valuable not just during flooding emergencies, but also for long-term development and infrastructure design.

[6] See this report online at http://www.maine.gov/spo/flood

Appendix A: Participating Agencies

The following agencies participated in the process for completing the study outlined in Section 1 of this report, and provided valuable review and comment on this report:

- Department of Environmental Protection
- Department of Defense, Veterans and Emergency Management, Maine Emergency Management Agency
- Department of Conservation, Maine Geological Survey
- State Planning Office, Maine Floodplain Management Program
- Kennebec County Emergency Management Agency
- Somerset County Emergency Management Agency
- FPL Energy Maine Hydro LLC
- Kennebec Water Power Company
- USGS, Maine Water Science Center
- National Weather Service, Forecast Office, Gray, Maine
- National Weather Service, Northeast River Forecast Center
- Appalachian Mountain Club
- Maine Rivers
- Natural Resources Council of Maine
- Trout Unlimited

The following agencies assisted in the data gathering and review for Section 2 of this report:

- Department of Defense, Veterans and Emergency Management, Maine Emergency Management Agency; Dam Safety and Mitigation programs
- State Planning Office, Maine Floodplain Management Program
- York County Emergency Management Agency
- USGS, Maine Water Science Center
- Federal Emergency Management Agency (FEMA)

Appendix B: Overview of River Basin Management[7]

History of River Basin Development

The industrialization of Maine during the middle of the nineteenth century relied upon the water power available at many sites along the State's rivers and streams. The most favorable sites were those combining the greatest hydraulic head and volume of flow. Around these locations grew many of Maine's largest and most prosperous communities such as Lewiston, Rumford, Waterville and Augusta. All of the early river-based industries faced a common problem: the lack of sustained flows during annual dry periods.

Precipitation in Maine is reasonably well distributed throughout the calendar year. However, on the headwaters of major rivers the precipitation usually falls as snow from December through March. During April and May, the water from the winter snows combines with the spring rains to produce 50 percent of the annual runoff. The annual ratio of spring flow to late-summer flow can range from fifty-to-one to several thousand-to-one. Such extremes can cause potentially destructive flooding when there is a high flow or the curtailment of industrial operations during periods of very low flow.

Loss of production during dry periods prompted downstream mill owners to construct headwater storage dams. Generally, enough water can be stored behind these dams to sustain flows at desired levels throughout the year. The continued operation of the headwater storage dams results in important economic, ecological, and recreational benefits in the watersheds they serve.

Headwater Reservoirs

Reservoirs behind headwater storage dams usually fill during the spring runoff period. As runoff gradually diminishes during the summer period, water is drawn from the reservoirs at a rate calculated to maintain downstream flows at uniform levels. The rate of draw represents a balance among the needs of the downstream users of the water.

After the passing of the recreational season on the lakes and rivers, the river manager plans the winter "run". This "run" is based on the volume of water remaining in storage and the existing runoff rate. With this knowledge, the manager sets flows at a level that allows the reservoirs to reach targeted low levels in early spring.

The manager continually monitors the conditions of the river basin. These include the volume of water in storage, precipitation, temperature, water content of snow, stream flows and ground cover conditions. As these conditions vary, the manager adjusts the amount of water drawn from the reservoirs to maintain the desired flow downstream. For example, more water may be drawn in a dry month than during a wet month.

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[7] Adapted from "When the Rivers Rise: Flood Awareness for Maine Public Officials", MEMA, 1993.

The lowest reservoir levels usually are attained about the first day of spring. In this low-water condition, the reservoirs can intercept and hold many billions of cubic feet of water. Without this capability, the water would be added to the high flows existing on the lower reaches of the river.

There is usually a large watershed area below the headwater storage dams. Runoff from this area, which has little or no available flow regulation, contributes to downstream flows.

One must look at each reservoir to see its actual effect on flood abatement. If a storm system that causes flooding concentrates its precipitation downstream of the reservoir system, the system will only slightly alleviate the flow in the river. However, if precipitation is concentrated in the reservoir catchment area, the reservoir system can potentially reduce downstream flooding.

Downstream Hydroelectric Dams

Downstream hydroelectric dams are operated as either "run-of-river" or "cycled" projects. A run-of-river project uses the flow available in the river, without modification, for generating power. A cycled project fluctuates the flow of the river over the course of a daily, weekly or annual cycle. During periods of peak electrical demand, the project generates power with a flow greater than the river flow. This results in a slight draw from the impoundment behind the dam. Conversely, during periods of low electrical demand, the project would generate with a flow less than the river flow, refilling the impoundment. The average flow for the cycle will equal the run-of-river flow for the same period.

The ability of a downstream, run-of-river hydroelectric dam to reduce the impact of flooding is minimal. Impoundments behind these dams are generally much smaller than those behind storage dams. Most of these dams would fill in a matter of hours with the arrival of flood flows even if water were drawn down in advance.

Appendix C: Overview of Flood Forecast Modeling[8]

Computer-based river models for the major river basins in Maine have been developed at the Northeast River Forecast Center in Taunton, Massachusetts. These models use data supplied from a variety of sources. The Gray and Caribou National Weather Service Forecast Offices use the resulting information (as well as models developed at the St. John River Forecast Center in Fredericton NB, Canada) to issue flood watches, warnings, and river forecasts for the State.

These models are used real-time to characterize an imminent flood event, and can also be used hypothetically, to create a projected forecast based on simulated conditions.

Variables in a Flood Forecast Model

Many factors affect the amount of runoff that contributes to river flow in a basin. These factors include:

Rainfall: The amount, duration, intensity, and distribution of rainfall over the basin.

Soil type in the basin: Less absorbent soils such as clays result in more runoff and higher flows.

Soil moisture at the time the rainfall begins: Higher initial soil moisture results in more runoff.

Vegetation and season: runoff is much less during growing season. On a typical summer afternoon, a mature oak or maple tree can absorb and emit 50 to 100 gallons of moisture into the atmosphere.

Topography: A river will rise faster and have a higher flood crest in mountainous terrain than in flat terrain.

State of the ground: Rain falling on frozen ground runs off faster than if the ground were not frozen.

Conditions of the snowpack (if present): Rain falling on snow is initially absorbed by the snow and will not contribute to runoff until the snow can no longer absorb the rain. As the temperature climbs, however, the snowpack can rapidly release water that contributes to higher flows.

Interception by ponds and lakes: Runoff flowing into ponds, lakes and reservoirs raises the level of these bodies of water, potentially dampering out flood peaks

[8] Adapted from "When the Rivers Rise: Flood Awareness for Maine Public Officials", MEMA, 1993

downstream. The effect of this interception by a storage reservoir is affected by the level the lake is drawn down behind the reservoir dam.

Urbanization: More blacktop and concrete result in more runoff.

Appendix D: Northeast River Forecast Center Presentation

Flagstaff Lake Study

Northeast River Forecast Center

November 2007

1

Methods

- Try to determine potential impact of 5 ft drawdown limitation at Flagstaff Lake
- Evaluation period 1980-2006
- Average daily discharge and pool height for Flagstaff, Wyman and Harris Station provided by FPL
- Historical precipitation and temperature time series created from NCDC data

2

Methods cont.

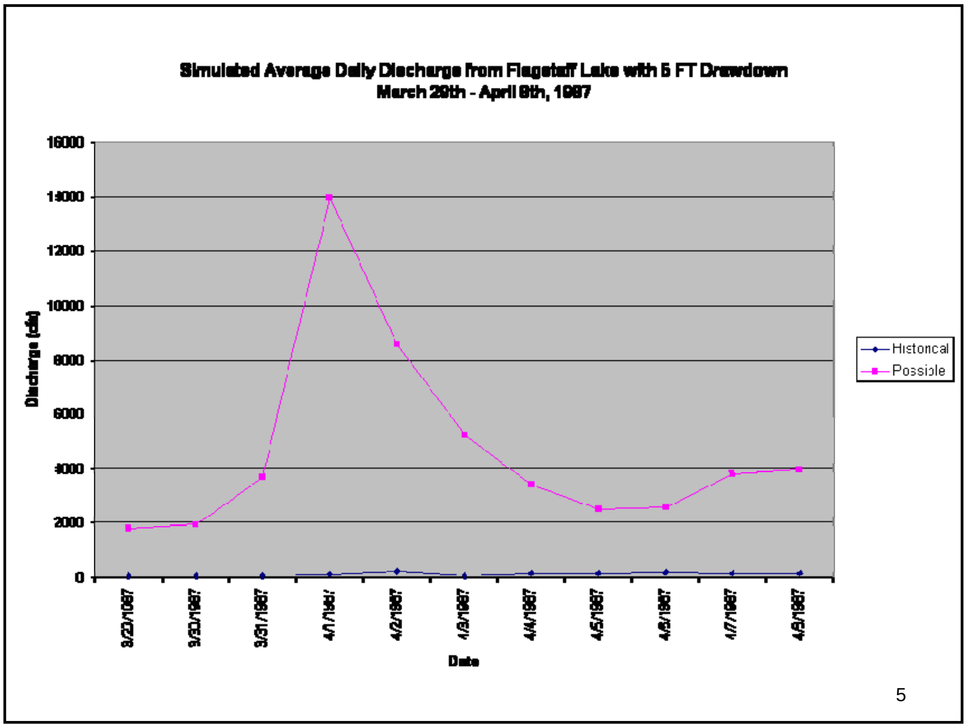
- Using Joint Reservoir model, historical temperature and precipitation data and I-O=ΔS, calculated inflow to Flagstaff Lake.
- 5-ft drawdown rule curve input into Res-J model to provide simulated outflow time series.
- Simulated time series input into calibration decks for the Kennebec River.

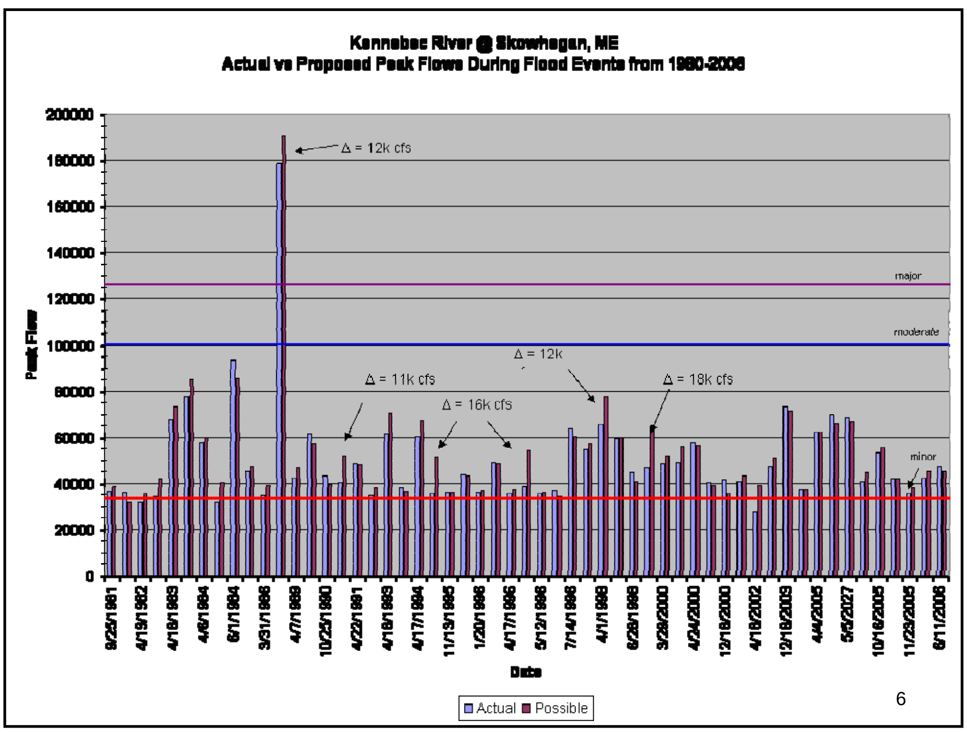
3

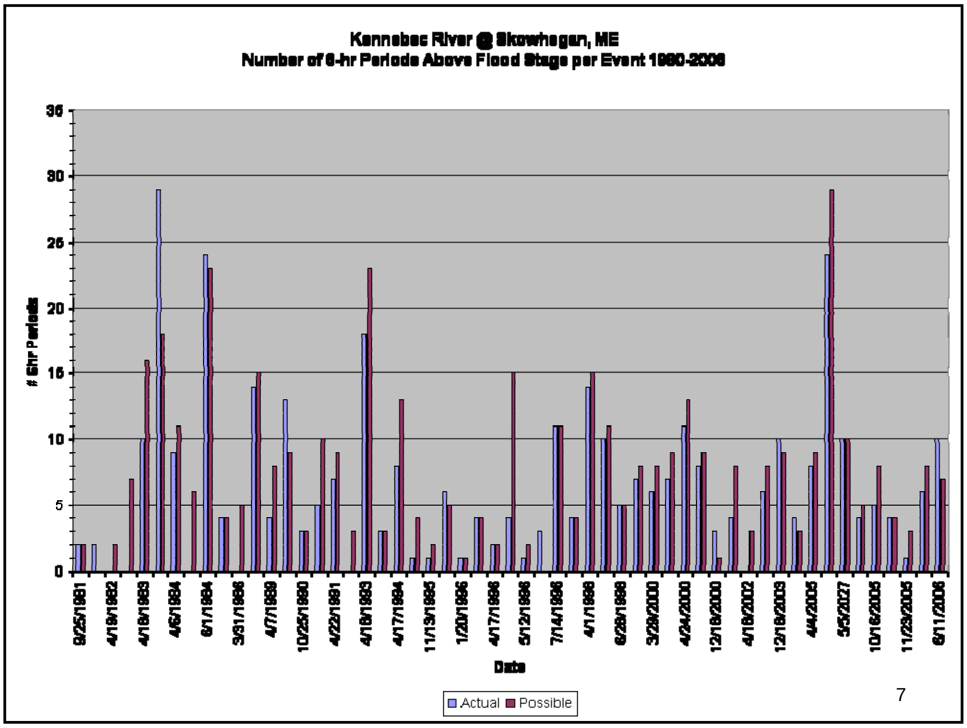
Methods cont.

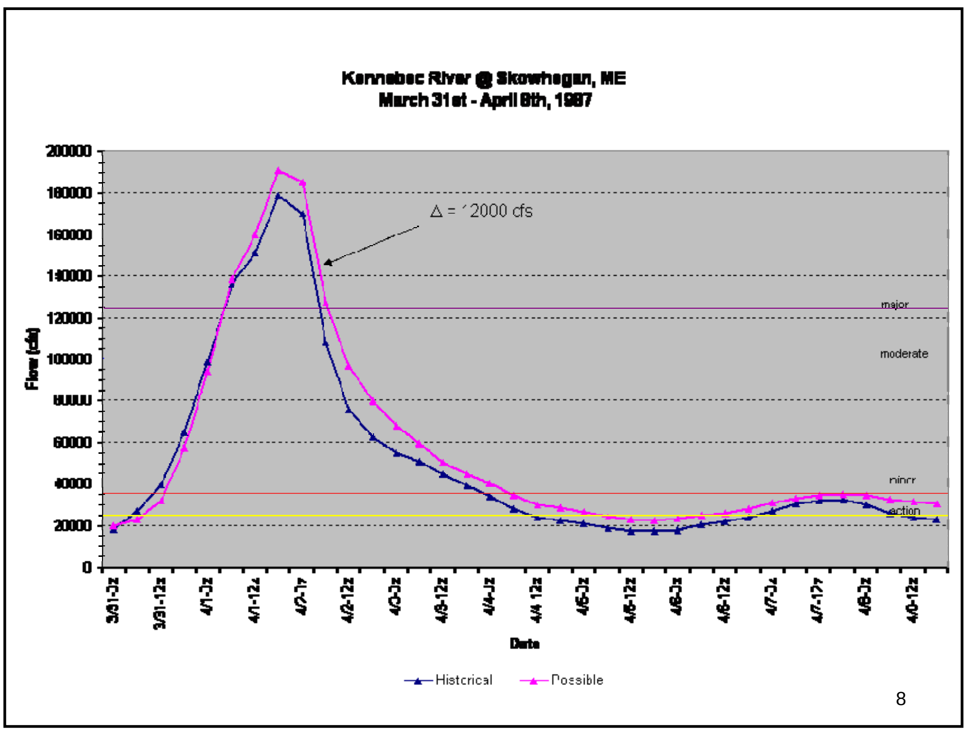
- Simulated flow/stages output from Kennebec calibration decks compared against historical records at Wyman, North Sidney and Augusta.
- No records for Skowhegan, used original calibrated flow time series to compare against the potential flow.
- Each flood event analyzed to determine change in flow/stage and duration of flooding.

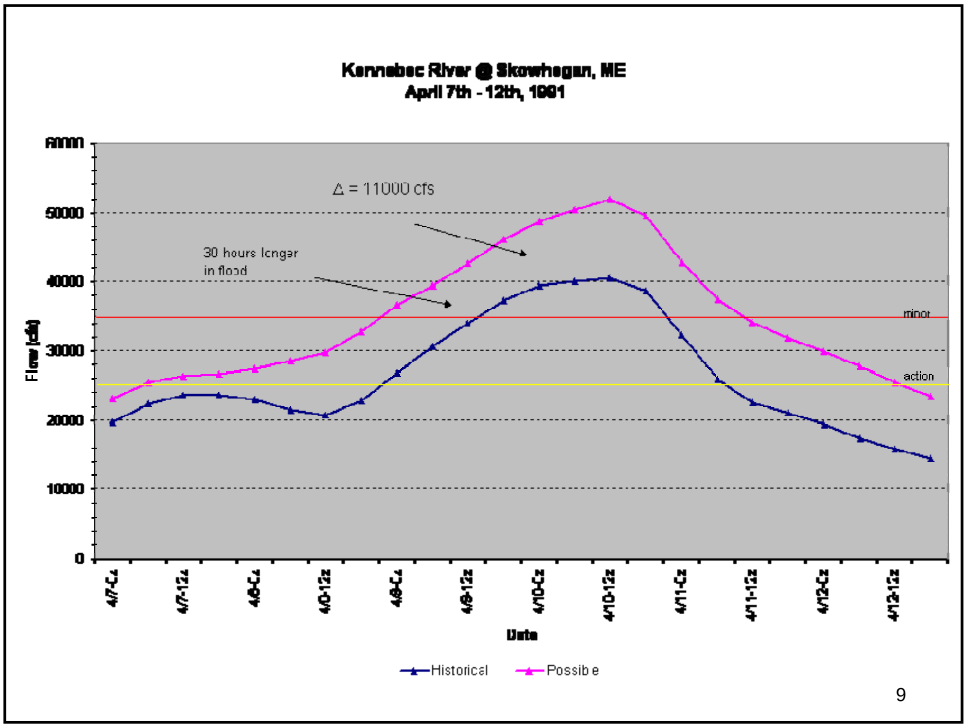
4

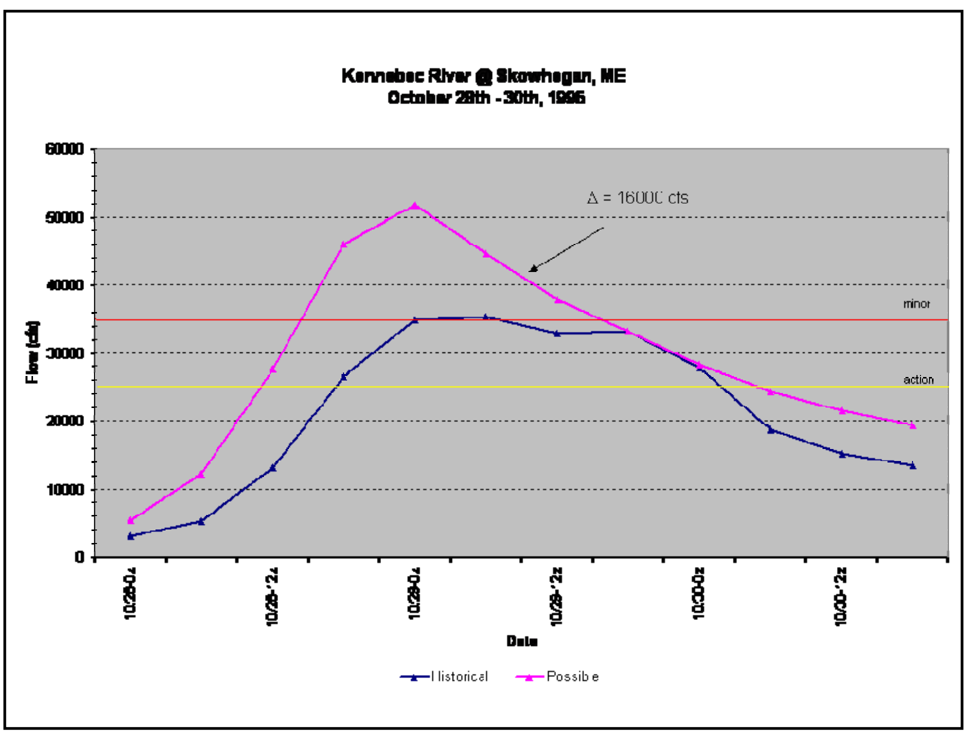

Simulated Average Daily Discharge from Flagstaff Lake with 5 FT Drawdown
March 29th - April 8th, 1987
Discharge (cfs)
Date
Historical
Possible
5

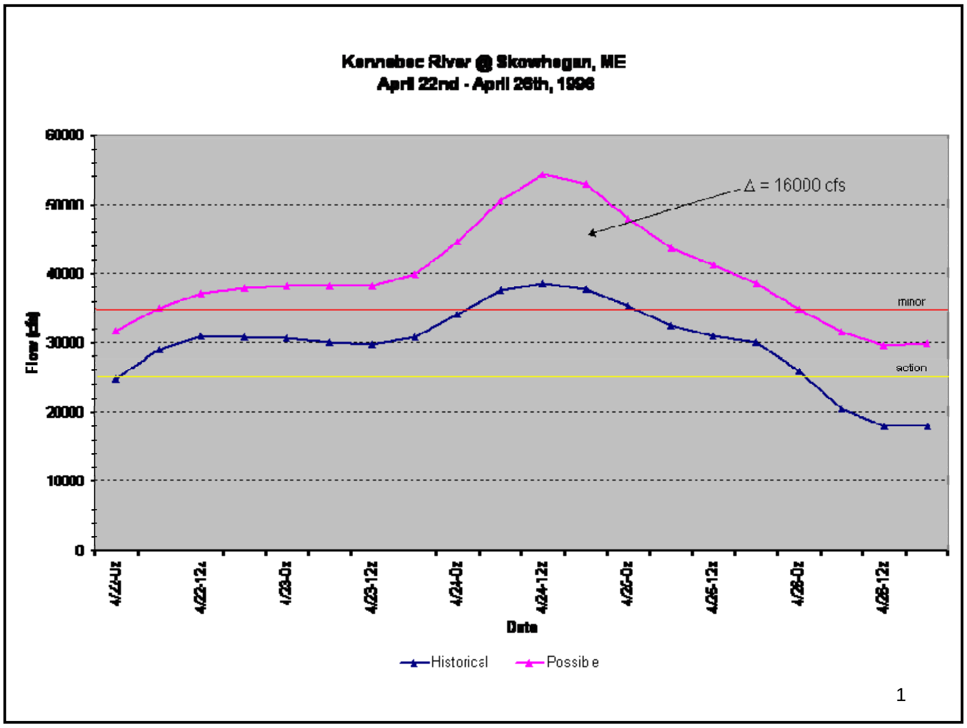

Kennebec River @ Skowhegan, ME
Actual vs Proposed Peak Flows During Flood Events from 1980-2006
Peak Flow
Date
Δ = 12k cfs
Δ = 11k cfs
Δ = 16k cfs
Δ = 12k
Δ = 18k cfs
major
moderate
minor
Actual
Possible
6

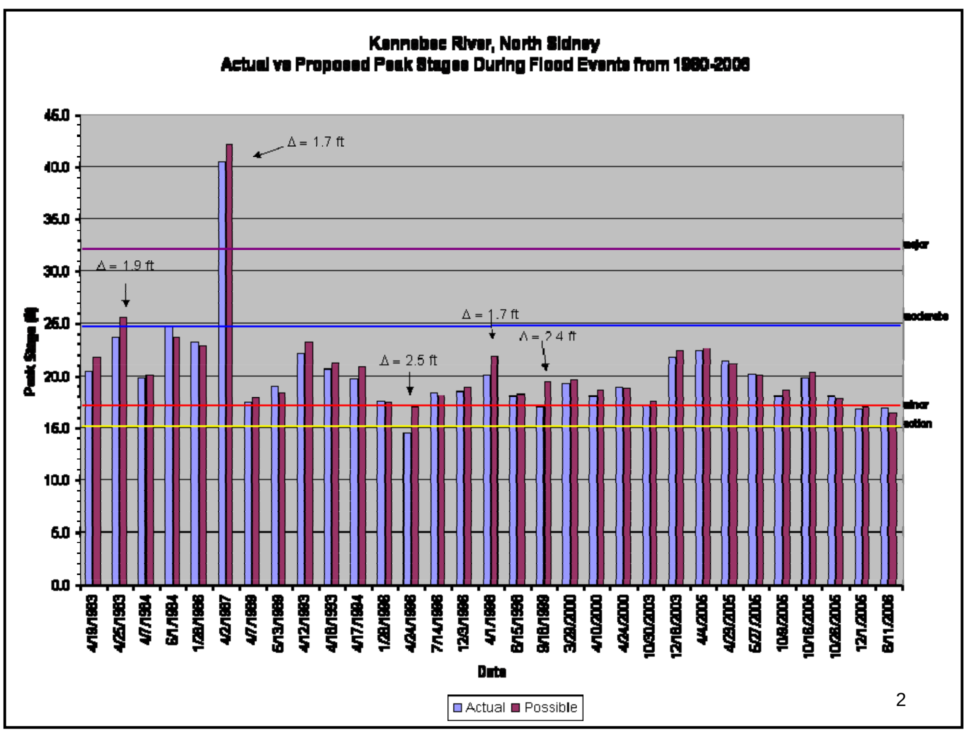

Kennebec River @ Skowhegan, ME
Number of 6-hr Periods Above Flood Stage per Event 1980-2006
6hr Periods
Date
Actual
Possible
7

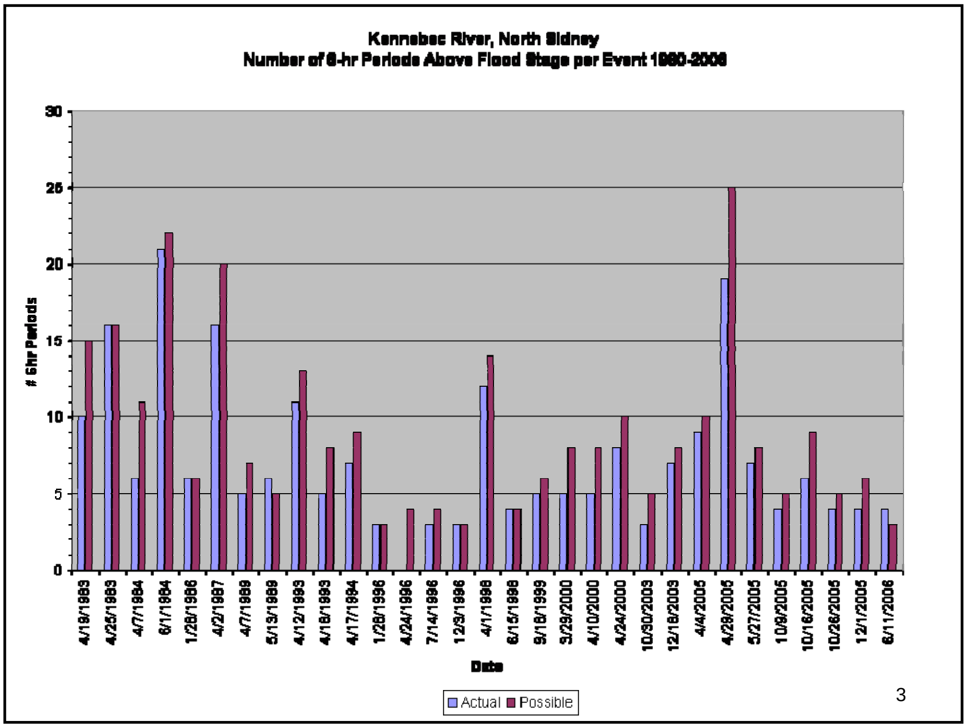

Kennebec River @ Skowhegan, ME
March 31st - April 9th, 1987
Flow (cfs)
Date
Historical
Possible
8

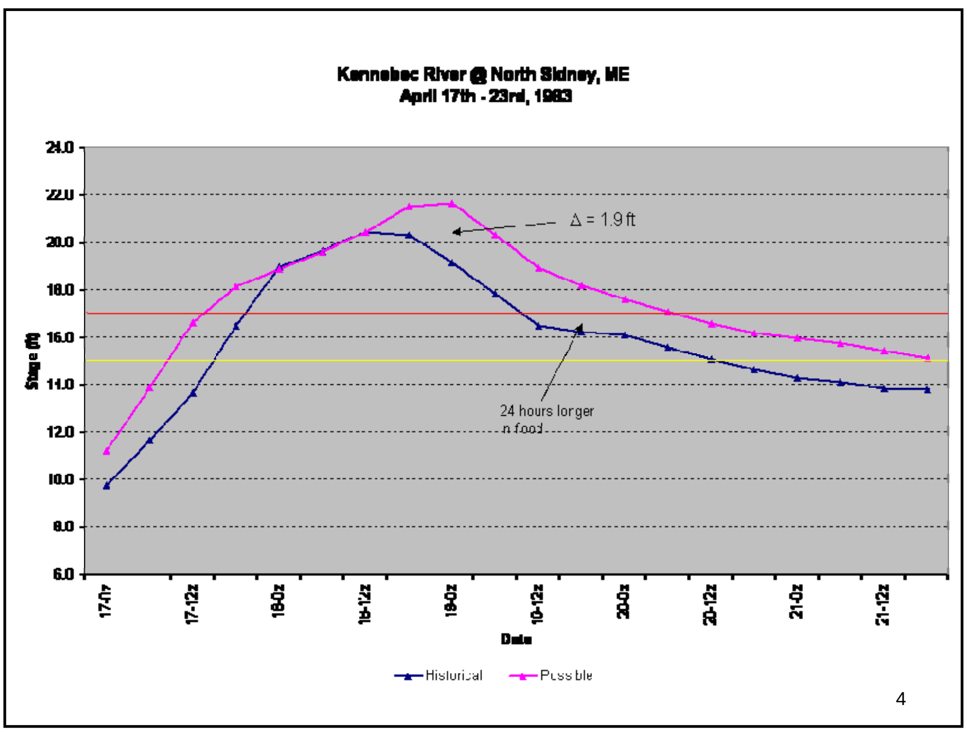

Kennebec River @ Skowhegan, ME
April 7th - 12th, 1991
Δ = 11000 cfs
30 hours longer
in flood
minor
action
Flow (cfs)
Date
Historical
Possible
9

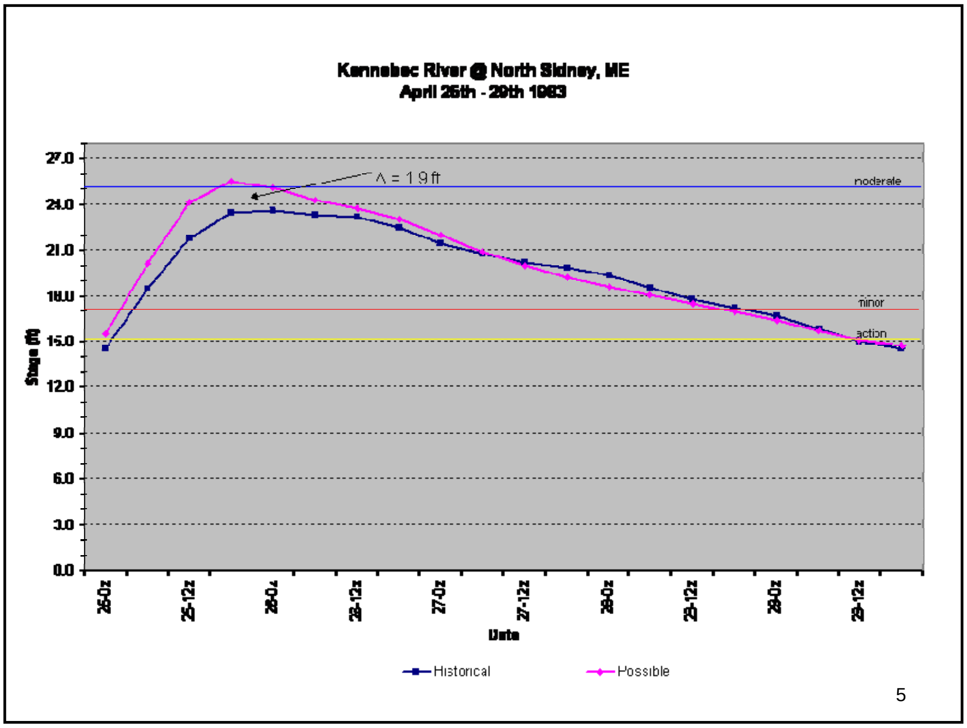

Kennebec River @ Skowhegan, ME
October 28th - 30th, 1996
Δ = 16000 cfs
minor
action
Flow (cfs)
Date
Historical
Possible

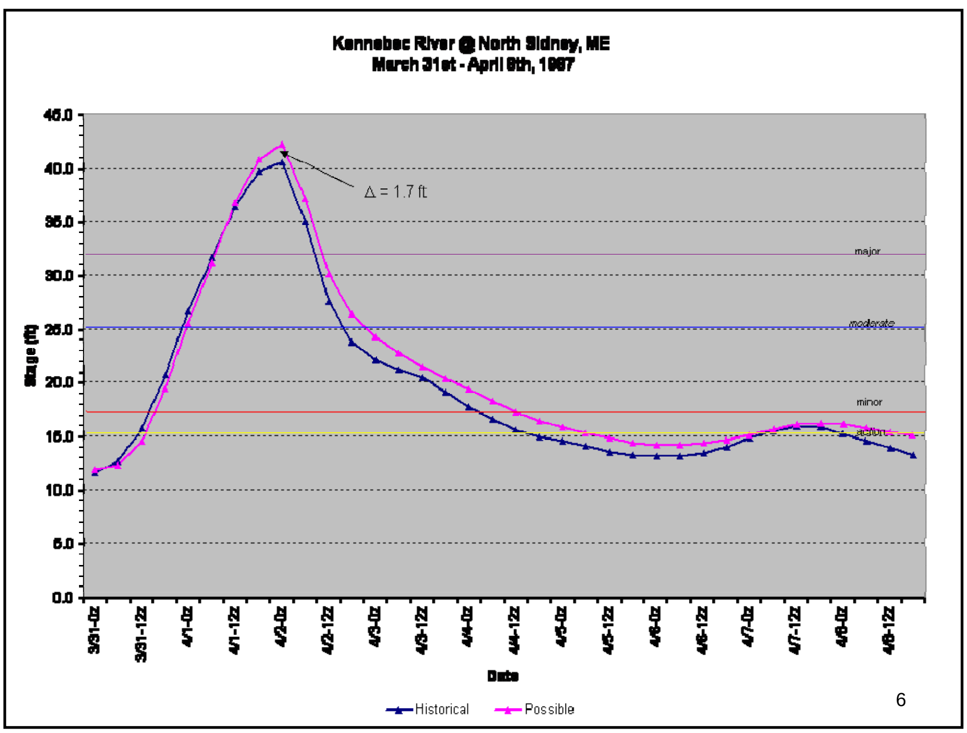

Kennebec River @ Skowhegan, ME
April 22nd - April 26th, 1996
Δ = 16000 cfs
minor
action
Flow (cfs)
Date
Historical
Possible
1


Kennebec River, North Sidney
Actual vs Proposed Peak Stages During Flood Events from 1980-2006
Δ = 1.7 ft
Δ = 1.9 ft
Δ = 1.7 ft
Δ = 2.4 ft
Δ = 2.5 ft
major
moderate
minor
action
Peak Stage (ft)
Date
Actual
Possible
2


Kennebec River, North Sidney
Number of 6-hr Periods Above Flood Stage per Event 1980-2006
6hr Periods
Date
Actual
Possible
3


Kennebec River @ North Sidney, ME
April 17th - 23rd, 1983
Stage (ft)
Δ = 1.9 ft
24 hours longer
Date
Historical
Possible
4


Kennebec River @ North Sidney, ME
April 25th - 29th 1983
Δ = 1.9 ft
moderate
minor
action
Stage (ft)
27.0
24.0
21.0
18.0
15.0
12.0
9.0
6.0
3.0
0.0
25-0z
25-12z
26-0z
26-12z
27-0z
27-12z
28-0z
28-12z
29-0z
29-12z
Date
Historical
Possible
5


Kennebec River @ North Sidney, ME
March 31st - April 8th, 1987
Δ = 1.7 ft
major
moderate
minor
action
Stage (ft)
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
3/31-0z
3/31-12z
4/1-0z
4/1-12z
4/2-0z
4/2-12z
4/3-0z
4/3-12z
4/4-0z
4/4-12z
4/5-0z
4/5-12z
4/6-0z
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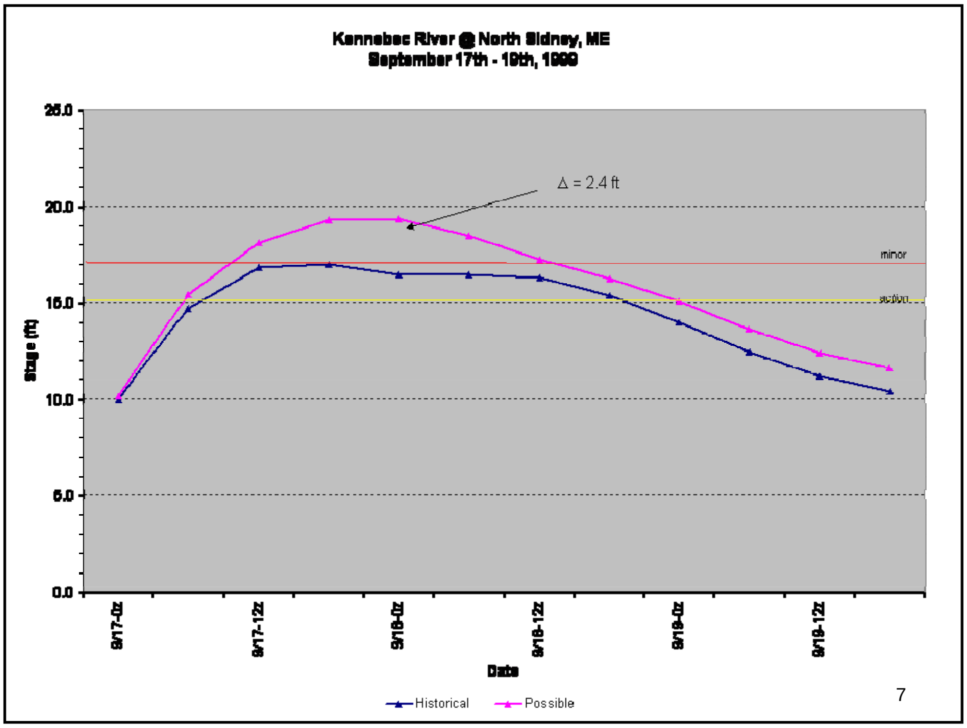
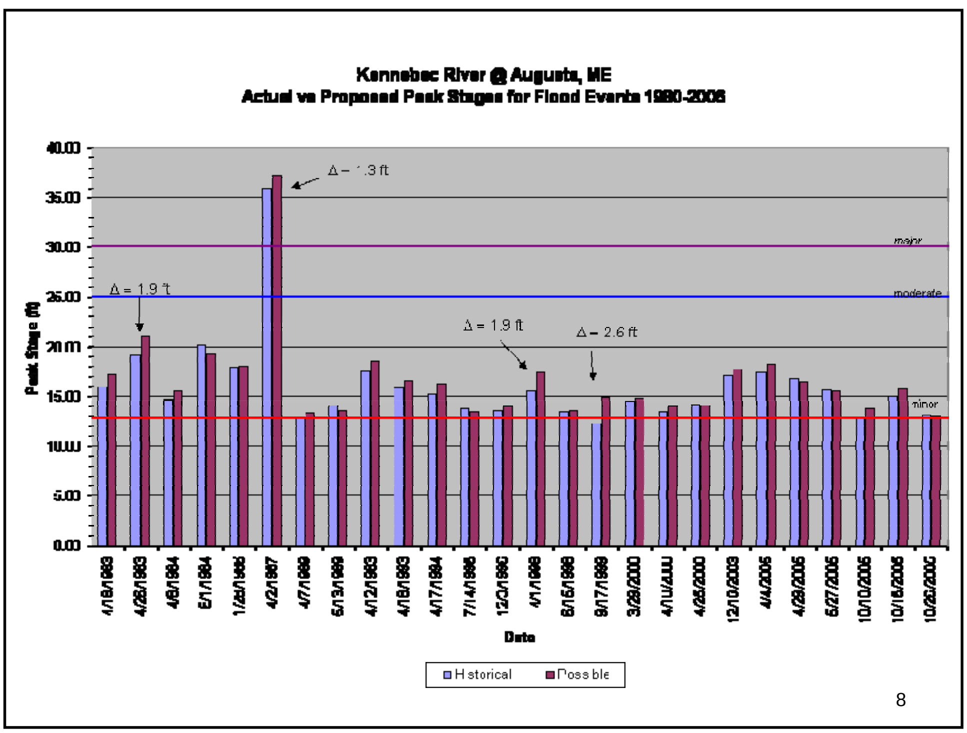
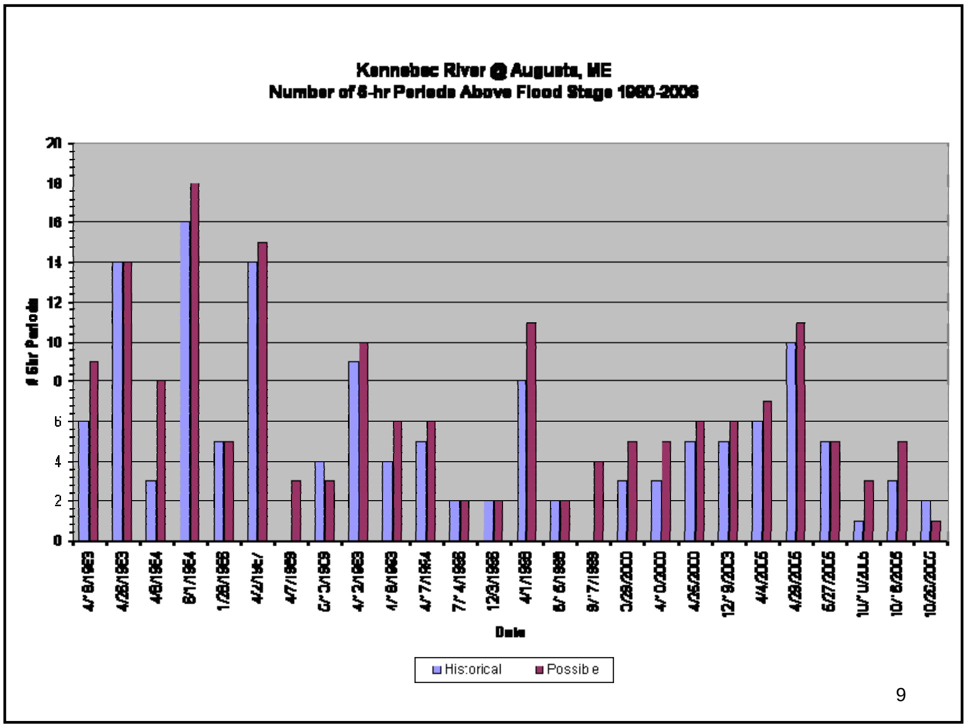
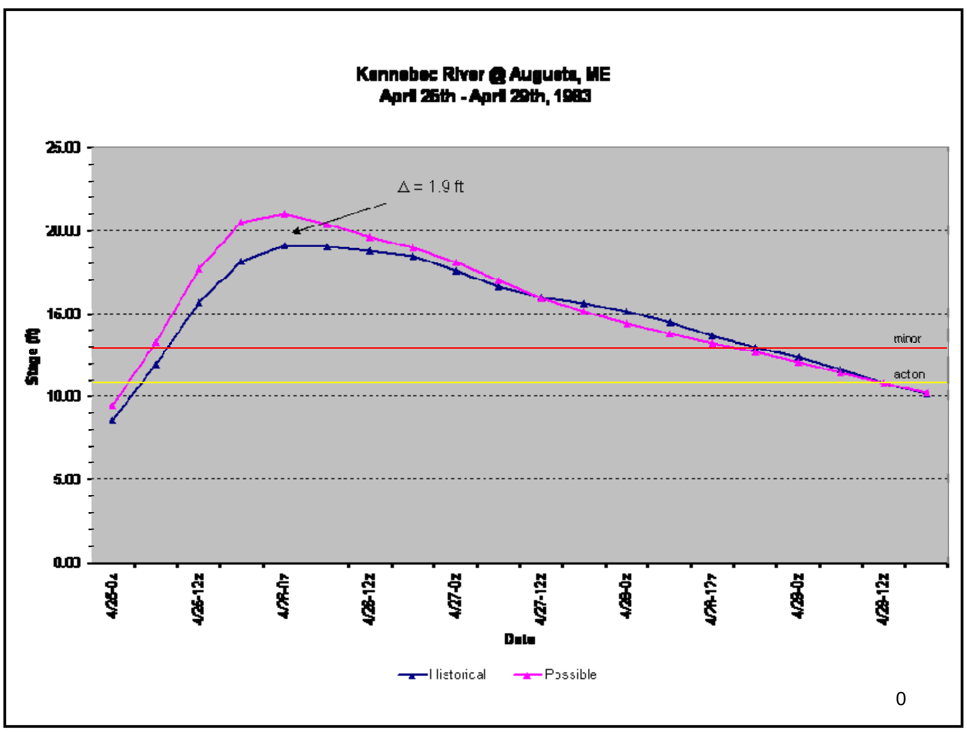
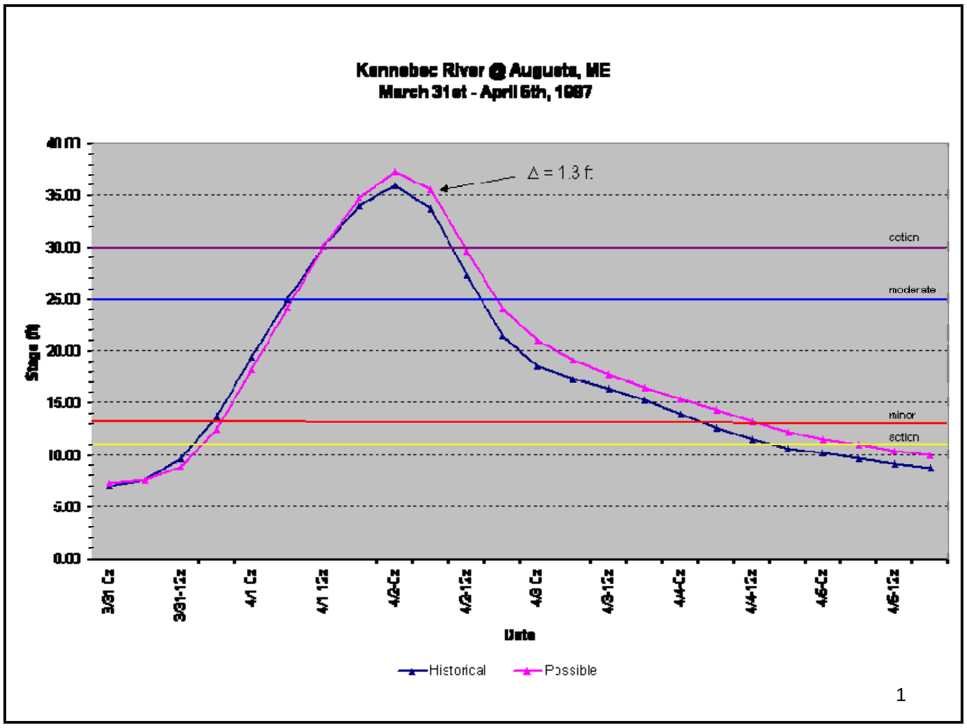
4/8-0z
4/8-12z
Date
Historical
Possible
6

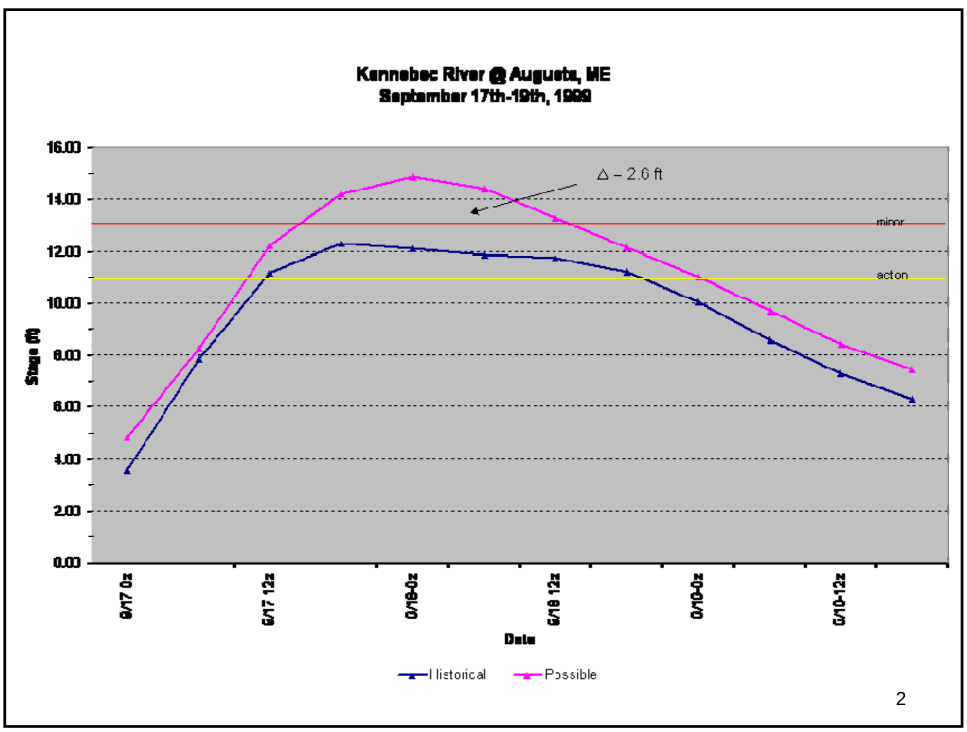

Kennebec River @ North Sidney, ME
September 17th - 19th, 1999
Stage (ft)
Date
Δ = 2.4 ft
minor
action
Historical
Possible
7

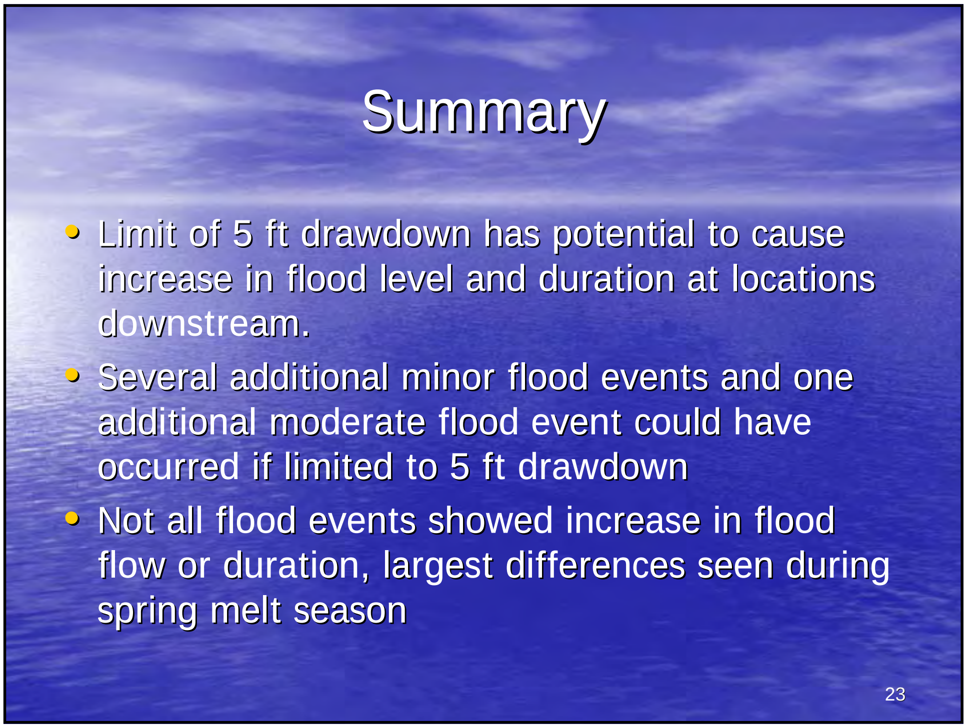

Kennebec River @ Augusta, ME
Actual vs Proposed Peak Stages for Flood Events 1980-2006
Peak Stage (ft)
Date
Δ = .3 ft
Δ = 1.9 ft
Δ = 1.9 ft
Δ = 2.6 ft
major
moderate
minor
H storical
Poss ble
8


Kennebec River @ Augusta, ME
Number of 6-hr Periods Above Flood Stage 1960-2006
6hr Periods
Date
Historical
Possible
9


Kennebec River @ Augusta, ME
April 25th - April 29th, 1983
25.00
20.00
15.00
10.00
5.00
0.00
Δ = 1.9 ft
minor
action
Stage (ft)
Date
Historical
Possible
0


Kennebec River @ Augusta, ME
March 31st - April 5th, 1987
Δ = 1.3 ft
action
moderate
minor
action
Stage (ft)
Date
Historical
Possible
1


Kennebec River @ Augusta, ME
September 17th-19th, 1999
Δ – 2.0 ft
minor
action
Stage (ft)
Date
Historical
Possible
2


Summary
Limit of 5 ft drawdown has potential to cause increase in flood level and duration at locations downstream.
Several additional minor flood events and one additional moderate flood event could have occurred if limited to 5 ft drawdown
Not all flood events showed increase in flood flow or duration, largest differences seen during spring melt season
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Appendix E: Recurrence Intervals

USGS calculations from NERFC model

Recurrence Interval	Probability	Sidney (cfs)			Sidney Gage Height (ft)			Augusta Gage Height (ft)		
		Actual	Modeled	% Differ-ence	Actual	Modeled	Differ-ence	Actual	Modeled	Differ-ence
1.11-year	0.9	31540	33320	5.34%	12.26	12.57	0.31	8.51	8.83	0.32
2-year	0.5	65180	66610	2.15%	17.84	18.07	0.23	14.33	14.57	0.24
5-year	0.2	94260	96220	2.04%	22.36	22.64	0.28	19.04	19.33	0.29
10-year	0.1	110800	113700	2.55%	24.69	25.08	0.39	21.47	21.88	0.41
25-year	0.04	128800	133300	3.38%	27.25	27.87	0.62	24.14	24.79	0.65
50-year	0.02	140300	146300	4.10%	28.84	29.63	0.79	25.80	26.62	0.82
100-year	0.01	150500	158200	4.87%	30.19	31 2	1.01	27.21	28.26	1.05
200-year	0.005	159500	169000	5.62%	31.37	32.6	1.23	28.44	29.72	1.28
500-year	0.002	170100	182000	6.54%	32.76	34.26	1.5	29.89	31.45	1.56

Appendix F: Changes in Flood Stage and Duration

Kennebec River at North Sidney, ME
Flood Events From 1981-2006 (Flood Stage = 17 ft)
Sorted by Month of Occurrence

	Actual			Possible			Difference		
Date of Peak Flow	Peak Flow (cfs)	Peak Stage (ft)	# 6 hour Periods Above Flood Stage	Peak Flow (cfs)	Peak Stage (ft)	# 6 hour Periods Above Flood Flow	(Possible - Actual) (cfs)	(ft)	# 6 hour periods
3/29/2000	69,068	18.0	4	72,384	18.5	5	3,316	0.5	1
4/19/1983	107,376	23.6	16	121,680	25.5	16	14,303	1.9	0
4/25/1983	47,058	14.5	0	62,522	17.0	4	15,464	2.5	4
4/7/1984	83,301	20.2	7	82,596	20.1	8	-705	-0.1	1
4/2/1987	76,668	19.2	5	79,246	19.6	8	2,578	0.4	3
4/7/1989	80,635	19.8	6	82,527	20.0	11	1,892	0.3	5
4/12/1993	96,314	22.0	11	104,118	23.1	13	7,805	1.1	2
4/18/1993	86,768	20.7	5	90,314	21.2	8	3,545	0.5	3
4/17/1994	80,138	19.7	7	87,751	20.8	9	7,613	1.1	2
4/24/1996	98,476	22.4	9	100,569	22.6	10	2,093	0.3	1
4/1/1998	62,543	17.0	5	78,118	19.4	6	15,576	2.4	1
4/10/2000	85,332	20.5	10	93,531	21.6	15	8,199	1.2	5
4/24/2000	91,920	21.4	19	89,978	21.1	25	-1,942	-0.3	6
4/4/2005	75,223	18.9	6	71,051	18.3	5	-4,172	-0.6	-1
4/29/2005	62,171	16.9	4	58,946	16.4	3	-3,225	-0.5	-1
5/13/1989	240,049	40.5	16	253,291	42.2	20	13,243	1.7	4
5/27/2005	80,576	19.8	6	84,418	20.3	9	3,842	0.6	3
6/1/1984	103,789	23.1	6	102,105	22.9	6	-1,684	-0.2	0
6/15/1998	63,430	17.1	3	66,062	17.5	5	2,632	0.4	2
6/11/2006	94,098	21.7	7	98,564	22.4	8	4,466	0.6	1
7/14/1996	115,050	24.6	21	107,358	23.6	22	-7,692	-1.1	1
9/18/1999	65,608	17.5	5	68,550	17.9	7	2,942	0.5	2
10/30/2003	61,160	16.8	4	62,466	17.0	6	1,306	0.2	2
10/9/2005	69,365	18.0	4	68,069	17.8	5	-1,296	-0.2	1
10/16/2005	71,840	18.4	3	74,278	18.8	3	2,437	0.4	0
10/26/2005	74,420	18.8	8	73,906	18.7	10	-514	-0.1	2
12/3/1996	69,352	18.0	4	70,633	18.2	4	1,282	0.2	0
12/18/2003	69,299	18.0	5	72,554	18.5	8	3,255	0.5	3
12/1/2005	71,267	18.3	3	70,176	18.2	4	-1,091	-0.2	1
1/28/1986	66,077	17.5	3	65,613	17.5	3	-464	-0.1	0
1/28/1996	82,935	20.1	12	94,697	21.8	14	11,762	1.7	2

Appendix G: River Flow Advisory Commission

The River Flow Advisory Commission was created in statute (Title 37-B MRSA §1131) in part to "facilitate communication of river flow data between dam operators, river basin managers, state agencies, the United States Geological Survey and the National Weather Service during floods and droughts…".

The Commission, which includes representation from several state and federal agencies and river basin managers, has been in practical existence since the early 1980s. The Commission meets annually in the early spring to discuss snow pack and precipitation forecasts, and to assess the potential for spring flooding. However, Commission members exchange information throughout the year, both in weather events, and to conduct research and leverage project resources.

The State of Maine appropriates approximately $132,000 per year, which provides matching funds to the USGS for the operation of the state hydrologic monitoring network. The network is comprised of stream gages, ground-water monitoring wells and precipitation monitors. Real-time readings from network instrumentation are available around the clock on the Internet, for the public's information as well as for use by emergency officials. .

Commission members include:

- US Geological Survey, Maine Water Science Center (co-chair)
- Maine Emergency Management Agency (co-chair)
- Atlantic Salmon Sea Run Commission
- Department of Agriculture, Food and Rural Resources
- Department of Environmental Protection
- Department of Conservation, Maine Geological Survey
- Department of Marine Resources
- Department of Inland Fisheries and Wildlife
- Department of Human Services
- FPL Energy Maine Hydro LLC
- Domtar, Inc.
- Brookfield Power
- National Weather Service Forecast Office, Caribou
- National Weather Service Forecast Office, Gray
- SAPPI Fine Paper
- Senator George Mitchell Center for Environmental Research
- Kennebec Water Power Company

The Commission's statutory make-up also includes a member of the public; that seat is currently filled by a member of the business community in a flood-prone area.