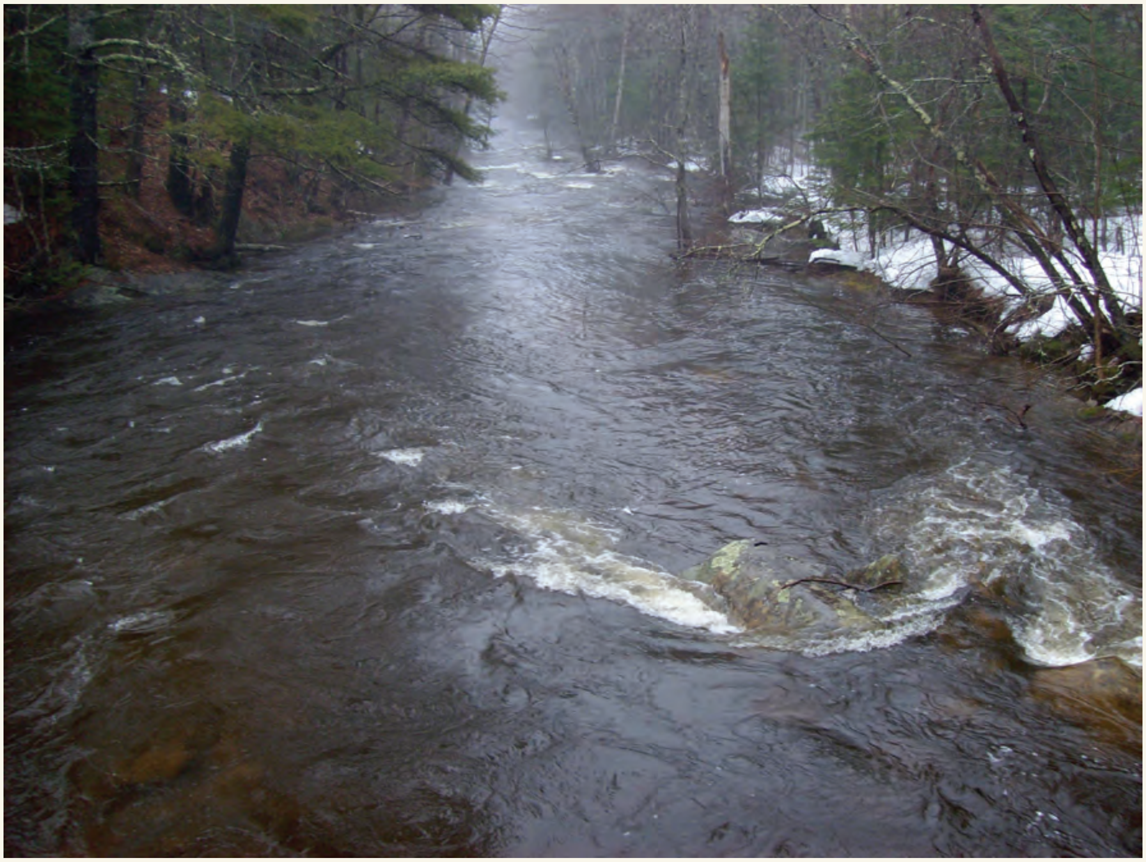
Prepared in cooperation with the Maine Department of Transportation

Modeled Future Peak Streamflows in Four Coastal Maine Rivers



Ducktrap River near Lincolnville, coastal Maine, April 4, 2009

Introduction

To safely and economically design bridges and culverts, it is necessary to compute the magnitude of peak streamflows that have specified annual exceedance probabilities (AEPs). These peak flows are also needed for effective floodplain management. Annual precipitation and air temperature in the northeastern United States are in general projected to increase during the 21st century (Hayhoe and other, 2007). It is therefore important for engineers and resource managers to understand how peak flows may change in the future. This Fact Sheet, prepared in cooperation with the Maine Department of Transportation, presents a summary of modeled changes in peak flows at four basins in coastal Maine on the basis of projected changes in air temperature and precipitation. The full Scientific Investigations Report (Hodgkins and Dudley, 2013) is available at http://pubs.usgs.gov/sir/2013/5080.

Methods

To estimate future peak streamflows at the four basins in this study (fig. 1), historical air temperature and precipitation in the basins were adjusted by different amounts and input to a hydrologic model of each study basin. To encompass the projected changes in climate in coastal Maine by the end of the 21st century, air temperatures were adjusted by four different amounts, from -3.6 ºF (-2 ºC) to +10.8 ºF (+6 ºC) of observed temperatures. Precipitation was adjusted by three different percentage values from -15 percent to +30 percent of observed precipitation. The 20 combinations of adjusted temperature and precipitation values (includes the no-change scenarios) were input to Precipitation-Runoff Modeling System (PRMS) watershed models (Leavesley and others, 2005; Leavesley and others, 1983), and annual daily maximum peak flows were calculated for each combination. Modeled annual

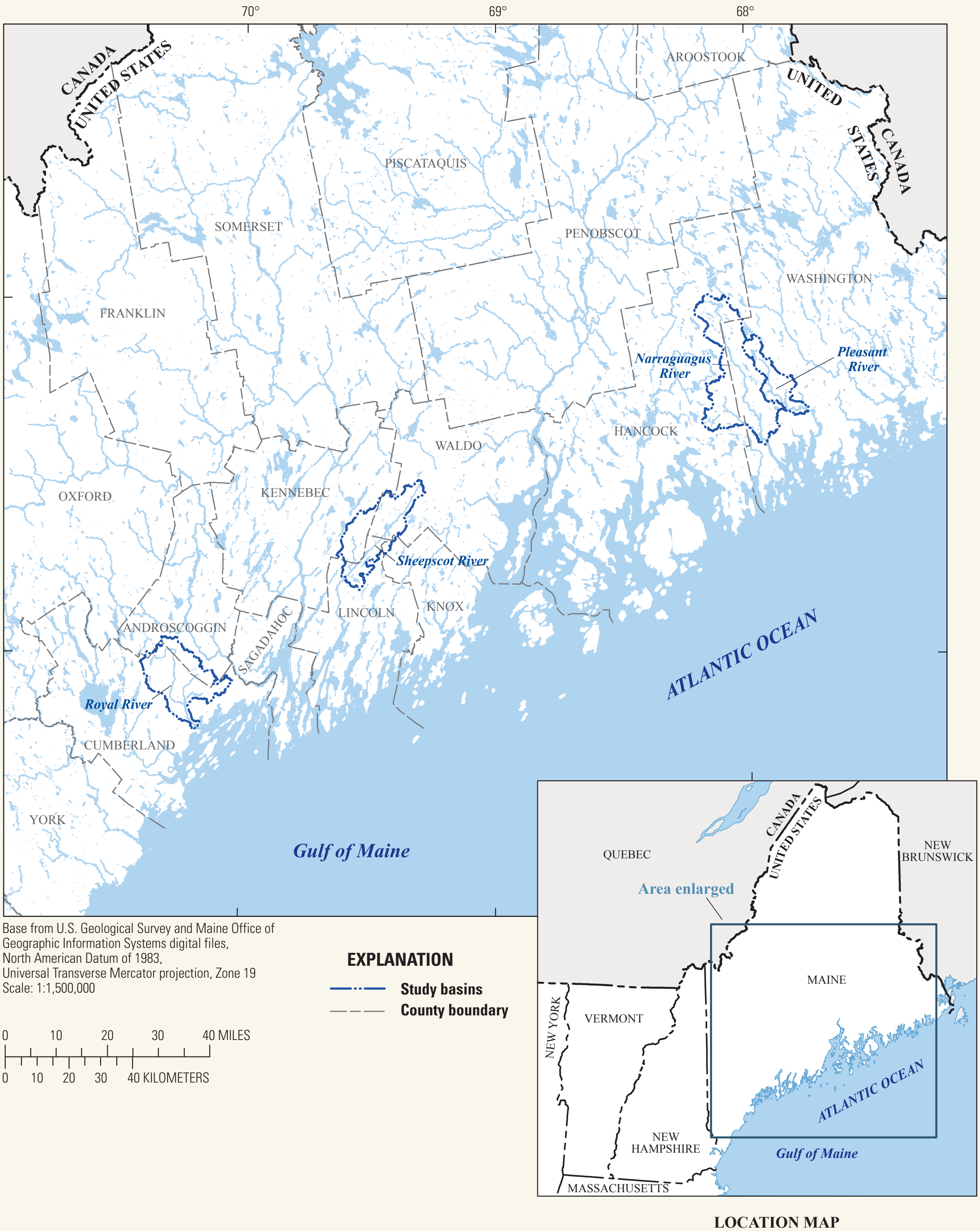


Figure 1. Map showing location of river basins selected for study in coastal Maine.

daily maximum peak flows from the adjusted temperature and precipitation changes were then compared to unadjusted (historical) modeled peak flows. Peak flows with 50-percent and 1-percent AEPs (equivalent to 2-year and 100-year recurrence interval peak flows, respectively) were calculated for the four basins in the study using the modeled annual daily maximum peak flows. Modeled peak flows with 50-percent and 1-percent AEPs and adjusted temperatures and precipitation were compared to unadjusted (historical) modeled values.

Results

Annual daily maximum peak flows increase or decrease at the four study basins, depending on whether temperature or precipitation is adjusted. Increases in air temperature (with no change in precipitation) lead to decreases in peak flows, whereas increases in precipitation (with no change in air temperature) lead to increases in peak flows. As the magnitude of air temperatures increase in the four basins, peak flows decrease by larger amounts. If precipitation is held constant (no change from historical values), 17 to 26 percent decreases in peak flow occur when temperature is increased by 7.2°F. If temperature is held constant, large increases (greater than 25 percent) in peak flow result from a 15-percent increase in precipitation, and very large increases (greater than 50 percent) occur with a 30-percent increase in precipitation. The largest decreases in peak flows at the four basins result from 15-percent decreases in precipitation combined with temperature increases of 10.8°F. The largest increases in peak flows generally result from 30-percent increases in precipitation combined with 3.6 °F decreases in temperatures.

In many cases when temperature and precipitation both increase, small increases or decreases in annual daily maximum peak flows result. For likely changes projected for the northeastern United States for the middle of the 21st century (temperature increase of 3.6 °F and precipitation increases of 0 to 15 percent), peak-flow changes at the four coastal Maine basins in this study are modeled to be evenly distributed between increases and decreases of less than 25 percent.

Changes in peak flows with 50-percent AEPs for adjusted temperatures and precipitation are similar to changes in annual daily maximum peak flow. Changes in peak flows with 1-percent AEPs (table 1) are similar in pattern to changes in annual daily maximum peak flow, but some of the changes

Table 1. One-percent annual exceedance probability peak-flow changes based on changes in precipitation and air temperature.

[Peak-flow changes in percent; light blue shading represents peak flow increases of 25 to 50 percent, blue represents flow increases greater than 50 percent, light orange represents decreases of 25 to 50 percent, orange represents decreases of greater than 50 percent; °F, degrees Fahrenheit]

	Temperature Changes				
	-3.6°F	**No change**	**+ 3.6°F**	**+ 7.2°F**	**+ 10.8°F**
01022260 Pleasant River near Epping, Maine					
-15 percent precipitation change	-4.1	-32.8	-51.4	-56.7	-61.5
No precipitation change	38.5	0.0	-28.6	-34.6	-40.1
+15 percent precipitation change	99.3	40.1	-1.1	-10.3	-14.3
+30 percent precipitation change	162.2	90.1	48.2	28.7	14.1
01022500 Narraguagus River at Cherryfield, Maine					
-15 percent precipitation change	-15.8	-25.1	-36.7	-42.5	-42.4
No precipitation change	9.6	0.0	-11.6	-21.4	-19.7
+15 percent precipitation change	39.6	26.0	10.6	0.0	4.1
+30 percent precipitation change	72.1	55.4	39.0	28.1	32.5
01038000 Sheepscot River at North Whitefield, Maine					
-15 percent precipitation change	-23.5	-26.7	-33.1	-45.4	-50.5
No precipitation change	15.0	0.0	-5.3	-15.5	-17.4
+15 percent precipitation change	51.7	29.0	25.5	12.6	7.8
+30 percent precipitation change	83.9	58.1	57.1	42.2	34.3
01060000 Royal River at Yarmouth, Maine					
-15 percent precipitation change	-31.5	-29.2	-36.6	-43.2	-47.6
No precipitation change	12.6	0.0	-11.3	-14.1	-22.5
+15 percent precipitation change	54.2	50.4	44.0	34.5	12.8
+30 percent precipitation change	110.1	93.8	94.6	94.7	68.9

associated with increasing precipitation are much larger than changes in annual daily maximum peak flow.

The decrease in modeled peak flows with increasing air temperature, given no change in precipitation amount, is likely caused by decreases in winter snowpack (the snow on the ground that accumulates during a winter). Substantial decreases in maximum annual winter snowpack water equivalent (the amount of water in a snowpack if it were melted) are modeled to occur with increasing air temperatures at the four basins in the study. Maximum annual snowpack in coastal Maine is modeled to decrease by about 50 percent with a 3.6 ºF temperature increase, by about 75 percent with a 7.2 ºF temperature increase, and by about 85 percent with a 10.8 ºF temperature increase (assuming no change in precipitation). Decreases in maximum winter snowpack for temperature increases of 7.2 ºF or 10.8 ºF occur regardless of changes in precipitation.

The modeled changes in peak flows (annual daily maximum peak flows and 1-percent and 50-percent AEP peak flows) caused by changing precipitation and air temperatures are consistent with previous studies from other parts of the world. Increased peak flows resulting from increases in precipitation at the four basins in this study are consistent with projections for many parts of the world (Bates and others, 2008). Decreased peak flows from increased temperatures have been shown in some areas of the world where increased temperatures lead to decreased snowpacks and resulting decreased snowmelt runoff (Arora and Boer, 2001; Voss and others, 2002; Hamlet and Lettenmaier, 2007). In some other areas, loss of winter snowpack may lead to increased flood risk because of increased effective watershed areas from elevational shifts in the snow line (Hamlet and Lettenmaier, 2007; Tohver and Hamlet, 2010).

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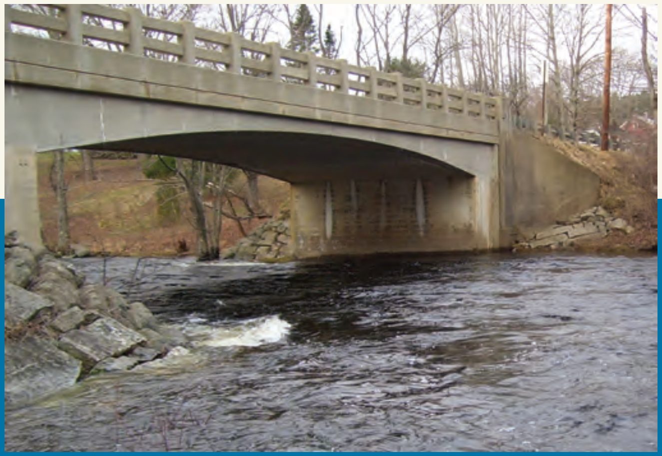

Sheepscot River at North Whitefield, Maine, April 19, 2011

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