# Hydrologic and Hydraulic Preliminary Design Report

# Route 2 Bridge over Webb River Mexico and Dixfield

## PIN 15620.00 and 15143.00

Allen K. O'Brien 2/04/09

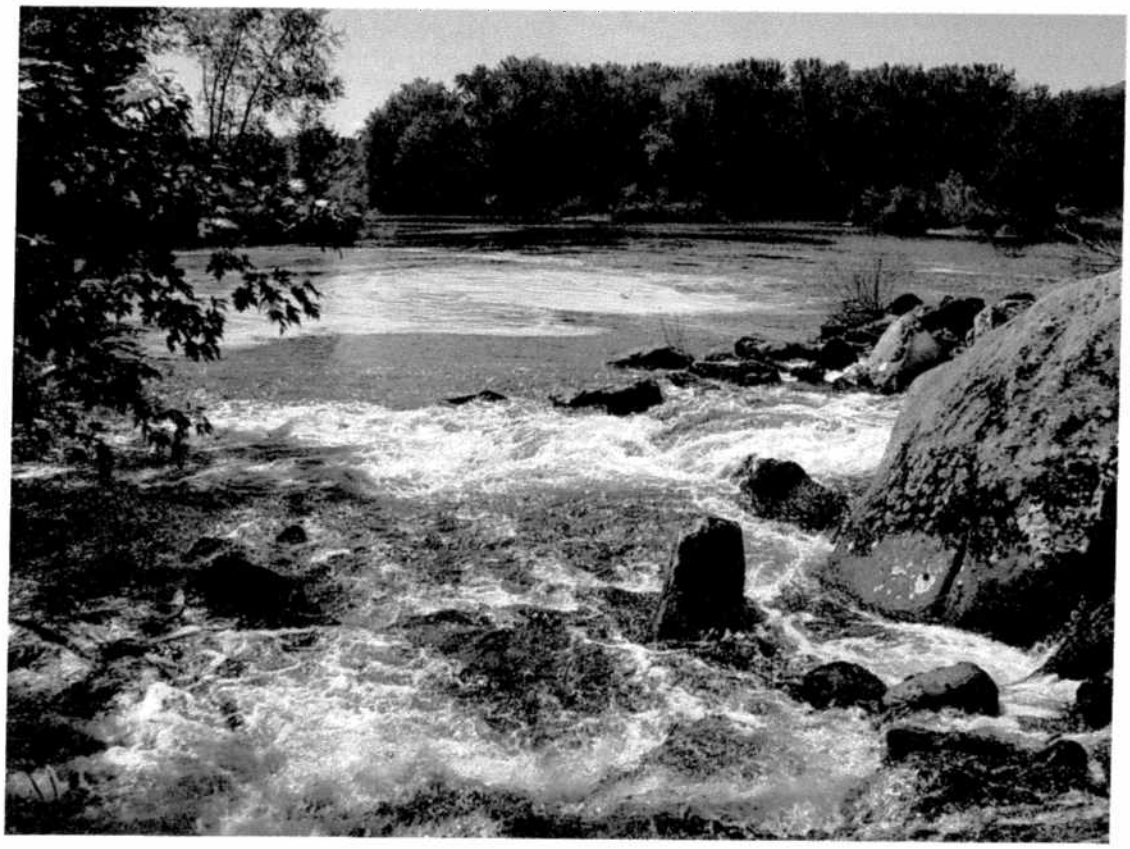
By

*Northstar Hydro, Inc.* and **HNTB, Inc.**

**For Maine Department of Transportation**

**Introduction:**

Route 2 crosses the Webb River at the Mexico/Dixfield town line. Approximately 150' downstream of the bridge, the Webb River joins the Androscoggin River. The reach of the Webb River that passes under the Route 2 Bridge is steep, dropping approximately 10' in 200', a slope of 0.05. This steep slope generates high velocities under most flow conditions. The type of flow is evident with sharp drops, hydraulic jumps, and large boulders/rock comprising the stream bed. However, high flow in the Androscoggin River generates flood elevations that reach back into the Webb River, approximately 250' above the confluence. Thus, flood elevations at the Webb River Bridge are highest when the Androscoggin River is at flood stage, and velocities are highest when only the Webb River is flooding. Hydrologic and Hydraulic analyses were run to simulate flood elevations and velocities under various conditions at the Webb River Bridge. The 100-year flood level on the Androscoggin River is a critical piece of data for hydraulic design of the Webb River Bridge. Research was conducted on former studies and historic flood data to establish reliable information on flood conditions on the Androscoggin River.



Looking downstream from bridge at confluence with Androscoggin River

**Hydrology:**

*Flood Discharges*

Flood discharges for the Webb River Bridge were calculated by MDOT. Flood discharge values are also published in FEMA Flood Insurance Studies of Mexico and Dixfield. MDOT used the USGS regional formula and FEMA used SCS TR20 methodology. Flows computed by the two methods are very similar, within approximately 10%. The drainage area for the Webb River is 133 square miles, with some very steep, hilly topography as well as a lake in the upper watershed. The watershed is primarily undeveloped, with low density residential development along roadways.

| Flood Discharges, cfs | MDOT | FEMA |
|---|---|---|
| 10-yr | 5405 | 4510 |
| 50-yr | 7708 | 6800 |
| 100-yr | 8760 | 7800 |
| 500-yr | 11320 | 10,000 |

It is recommended that MDOT discharge calculations be used for the bridge design to be conservative.

**Hydrology Summary, Webb River at Route 2**

| | |
|---|---|
| Drainage Area | 133 square miles |
| Design Discharge (Q50) | 7708 cfs |
| Check Discharge (Q100) | 8760 cfs |
| Scour Check Discharge (Q500) | 11320 cfs |
| Ordinary Water Height (Q1.1) | 1613 cfs |
| Flood of Record | Discharge not known |

*Coincidence of Peak Flooding on Androscoggin River and Webb River*

Because water levels on the Androscoggin River affect flood levels on the Webb River, it is important to understand whether, in flood conditions, the two rivers experience peak discharge at the same time, or whether the Webb River would reach peak levels and be receding by the time the Androscoggin peaks. The timing of peak flows affects decisions on how to apply backwater elevations when running hydraulic models, as well as determining peak flood velocities.

The March, 1936 flood, generated greater than a 100-yr flow on the Androscoggin River. Flood records for this storm are not available for the Webb River, however, the Swift River in Roxbury has a similar drainage area and location to Webb River, but no lake in its upper watershed. For the Swift River, the 1936 flood peak occurred at about 8:30 a.m. on March 19, 1936 and on the Androscoggin River at midnight on March 19, 16 hours later. When the Swift River peaked, the Androscoggin was at about a 10-yr flow level.

It is likely that the Androscoggin River will at least be high (approx 10-yr) when the Webb River is at peak flow. Regardless of when the Webb River peaks, however, the full backwater from the Androscoggin will still affect the Route 2 bridge at some point, the only issue is whether both rivers experience 100-year levels at the same time, in order to accurately set a 100-year level at the Webb River Bridge.

Because the peaks occur within 24 hours of one another, and because the Androscoggin River peak flow lasts for some time, it will be assumed that both rivers are at simultaneous peak flow for determination of maximum water levels at the Webb River Bridge.

The following photo (MDOT) shows the Webb River Bridge during the 1987 flood, although an exact time is not known. No records of overtopping were found.

Webb River bridge over Webb River - Dixfield - Mexico Nag. Sh 87-2 4-2-87

**Flood Elevations on Androscoggin River:**

Some conflicting information was found regarding the 100-year flood level on the Androscoggin River at it's confluence with the Webb River. However, research and consultation with the Maine Flood Plain Management Program assisted in resolving discrepancies. The following data details available information on historical flooding and on Flood Insurance Study data.

*Historical Data:* The following sources of historical data were reviewed:

USGS Open File Report 92-141, Flood of April, 1987 in Maine.

- Androscoggin River, Dixfield, downstream side of highway bridge, left bank. 415.1

USDI, Geological Survey Water Supply Paper 798, The Floods of March, 1936, Part 1. New England Rivers

- Androscoggin River, Dixfield, Maine, 1.4 miles above, head of second island above highway bridge, left bank 423.7
- Androscoggin River, Dixfield, Maine, Maine Central RR Station, copper plate, left bank, 417.5
- Androscoggin River, Dixfield, Maine, mouth of Webb River, 417.2

Using historic reports and a predictive report to evaluate flow data, the following comparison is given.

| Date | Flow | Frequency | Elev. at Webb R. |
|---|---|---|---|
| April, 1987 flood | 63,900 cfs at Rumford<br>103,000 cfs at Auburn | >100yr[1]<br>75 yr[1] | 415.1 |
| March, 1936 flood | 74,000 cfs at Rumford<br>135,000 cfs at Auburn | >> 100 yr | 417.2 |
| 100-year frequency flood, Rumford[2] | | 60,000 cfs | |

1. Frequency as listed by USGS in OFR 92-141, Flood of April, 1987 in Maine
2. Estimating the Magnitude and Frequency of Peak Flows for Streams in Maine for Selected Recurrence Intervals, U.S.D.I. Geological Survey, WRI 99-4008 in cooperation with Maine DOT.

Published Flood Insurance Studies for Mexico and Dixfield were also consulted to assist in determining flood elevations for the Androscoggin River. The site is on the border of the two towns, so the study for each town was consulted. Unfortunately, the two studies do not have the same elevation listed for the 100-year flood at this location. Only the 100-year flood is listed for Dixfield. The Dixfield study was done after the Mexico study.

| Mexico | Dixfield |
|---|---|
| 10-yr 412 | not given |
| 50-yr 417 | not given |
| 100-yr 418 | 416 |
| 500-yr 424 | not given |

Based on historical records and USGS flow frequency data for the stream gage at Rumford, the 1987 elevation appears to be closer to a 100-year event and the 1936 elevations represent an event of higher frequency.

To resolve conflicting elevations, the Maine Flood Plain Management Program (MFPMP) was consulted and offered the following information. In an email dated 10/28/08 (copy attached), the MFPMP confirmed that updated flood elevations will be published on new county-wide maps in 2009. This work resolved the conflict in elevations at the town line with the following information:

| | |
|---|---|
| 100-year elevation, Androscoggin River at Webb River | 415.4 |
| 100-year elevation, Webb River at Confluence Andros. R. | 415.8 |

The 50-year flood elevation on the Androscoggin can be approximated based on this data as 415.

**Flood Elevations and Velocities at Webb River Bridge**

Hydraulic models boundaries for this bridge study are the Androscoggin River downstream and a section just over 100' upstream of the bridge. The models generate specific flood elevations through the Route 2 Bridge for existing conditions and for proposed conditions, and simulate conditions of backwater and low-water on the Androscoggin River. This photo shows the existing bridge with pier.

Route 2, Webb River Mexico-Dixfield
Northstar/HNTB

Hydraulic models were run for existing and proposed conditions. Two conditions were run, one assuming that the Androscoggin was at flood stage and the other assuming that only the Webb River was experiencing high flow. Model cross sections were taken from project plans that include 1' contours. Supplemental cross section information was taken from the USGS topographic sheet for this location. Computer model HECRAS was used to model flow through the bridge. The following table summarizes model results.

| | Flood Elevations | | Energy Grade Line | Velocity |
|---|---|---|---|---|
| | Downstream | Upstream | Upstream | fps -AVE |
| Without backwater | | | | |
| Existing Bridge with pier | | | | |
| 50-yr | 402.4 | 405.0 | 412.5 | 22.0 |
| 100-yr | 402.8 | 405.4 | 413.7 | 22.9 |
| Proposed Bridge, Stub or Cantilever Abutments | | | | |
| 50-yr | 402.4 | 405.0 | 412.5 | 22.0 |
| 100-yr | 402.7 | 405.4 | 413.6 | 22.9 |
| Proposed Bridge, Integral Abutments | | | | |
| 50-yr | 402.7 | 405.0 | 412.5 | 22.0 |
| 100-yr | 403.6 | 405.4 | 413.6 | 22.9 |
| With Backwater | | | | |
| Existing Bridge with pier | | | | |
| 50-yr | 414.7 | 414.7 | 415.4 | 7.0 |
| 100-yr | 415.0 | 415.0 | 415.9 | 7.7 |
| Proposed Bridge, Stub or Cantilever Abutments | | | | |
| 50-yr | 414.7 | 414.6 | 415.3 | 6.5 |
| 100-yr | 415.1 | 415.0 | 415.8 | 7.2 |
| Proposed Bridge, Integral Abutments | | | | |
| 50-yr | 414.7 | 414.4 | 415.5 | 6.5 |
| 100-yr | 415.1 | 414.6 | 416.0 | 7.2 |

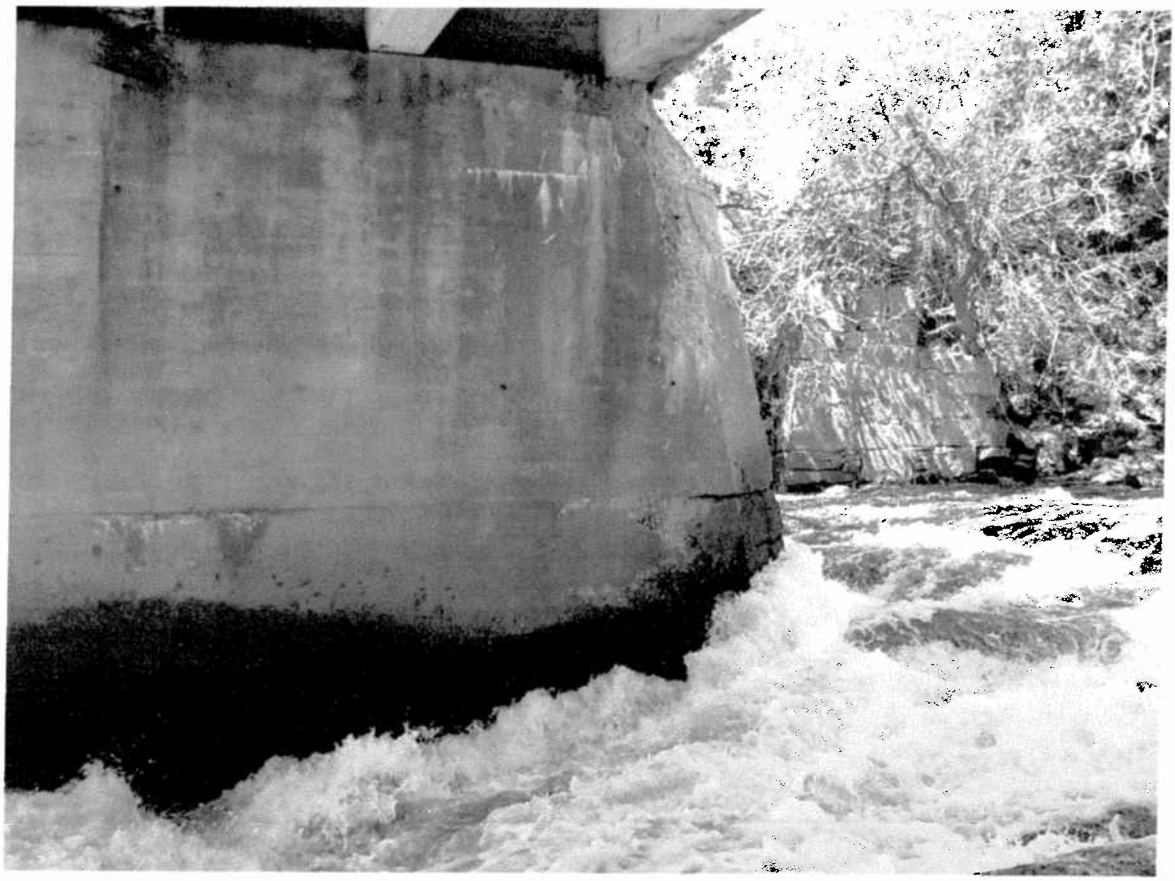
Model output is included in the Appendix.

The models clearly show the effect of backwater – higher elevation, lower velocity. The models also show that the pier has little effect on flood elevation, but stresses on the pier are likely quite high when velocity is over 20 feet per second and flow depths are 7-8'.

| | Existing Bridge | Proposed Bridge |
|---|---|---|
| Headwater at Q50 | 415.4 | 415.3 |
| Headwater at Q100 | 415.9 | 415.8 |
| Velocity at Q50, fps | 22 fps | 22 fps |
| Velocity at Q100, fps | 23 fps | 23 fps |
| Ordinary High Water, Q1.1 | 401.9 | 401.1 |
| Velocity, Q 1.1, fps | 15.6 | 15.6 |
| Clearance at Q50 | 0.4 – 0.9' | 1.0' |

**Scour and Protection of Foundation Components:**

The river bottom is bedrock, with no overburden or unconsolidated material. Although flows are fast and the potential for scour would be high, the rock base provides scour protection at the base of the existing abutments. The following photograph shows fast flow against the existing pier.



The size of material that resists typical flow on the Webb River can by seen by examining the stream bed, i.e. large boulders and bedrock. For the high banks, at the bridge, when flow is impacted by backwater, average velocities are lower.

The existing bridge has dumped riprap around the wingwalls, as shown in the following photograph.

The proposed bridge includes new abutments placed behind the existing abutments. The top of the existing abutments will be cut down, and the new abutments placed in unconsolidated material. Depth and design of the new abutments will be finalized in the next phase of the project. The pier will be removed.

Two areas of potential scour with the new bridge include:

- The area between the old and new abutments
- Wingwalls

Scour analysis indicates potential scour in the area behind the old abutments – at the base of the new abutments. The stub abutment and cantilever abutment proposed concepts include concrete paving in this area, which would provide scour protection. The integral abutment option includes riprap protection for this area. Calculated velocities in this area are 1-2 feet per second during a 100-year storm. However, higher velocities may be possible. The average section velocity is 7 fps.

Scour computations indicate a minimum riprap size of 1'. Riprap around wingwalls should be maintained wherever unconsolidated material is exposed. Final riprap design would be included in final design services.

**Summary:**

Backwater from high flows on the Androscoggin River impacts flood elevations on the Webb River and determines flood elevations at the Route 2 Webb River Bridge. Existing and ongoing studies and historical data for the Androscoggin River were considered to determine 100-year flood level on the Androscoggin River.

From the data available, including the preliminary results of the Oxford County wide flood mapping, the 50- and 100-year flood elevations for the Androscoggin River are recommended to be 415.0 and 415.4 respectively. With proposed bridge configurations and assuming coincidental Androscoggin and Webb River flood stages, the 50-and 100-year flood elevations at the Route 2 Webb River Bridge are recommended to be 415.4 and 415.9 respectively. Due to the many variables for predicting flood elevations at this location, the more conservative existing flood elevations rather than the 0.1' lower computed proposed condition elevations.

Flow velocities during 50-100-year flooding events may range from over 20 feet per second in the lower 7' of the stream cross section below the bridge to approximately 7 feet per second in the upper 3' of the section. Scour protection is required for the area between the old and new piers. Concrete or riprap protection is recommended, with minimum riprap size being 1'.

**References:**

USGS Open File Report 92-141, Flood of April, 1987 in Maine.

USDI, Geological Survey Water Supply Paper 798, The Floods of March, 1936, Part 1. New England Rivers

Federal Emergency Management Agency, Flood Insurance Study of Mexico, Maine. September 7, 2001

Federal Emergency Management Agency, Flood Insurance Study of Dixfield, Maine. February 3, 1981

FHWA HEC 18, Evaluating Scour at Bridges, Fourth Edition

FHWA, HEC 23, Bridge Scour and Stream Instability Countermeasures. March, 2001

Maine Dept. of Transportation, Bridge Design Guide, August, 2003

National Wetland Inventory Maps

U.S.D.I. Geological Survey, Estimating the Magnitude and Frequency of Peak Flows for Streams in Maine for Selected Recurrence Intervals. In cooperation with Maine DOT, WRI 99-4008, Augusta, ME 1999

U.S. Army Corps of Engineers, Model HECRAS, Version 3.1.3, May, 2005

U.S.G.S Topographic Map Series, Dixfield Quadrangle

U.S.D.I., Geological Survey, email from Greg Stewart dated October 15, 2008 referencing Kennebunk River flow data and Spring, 2007 storm flows.

Route 2 Mexico-Dixfield
Webb River Bridge

# Appendix

## Calculations and Reference Material

**From:** Hillier, Timothy [mailto:HillierTS@cdm.com]
**Sent:** Tuesday, October 28, 2008 5:26 PM
**To:** Young, Joseph; Daxikar, Amol
**Cc:** Goetz, Mike; Rooney, Stuart
**Subject:** RE: Hi MSFMP friends!

Joe,

In the updated, county-wide study for Oxford County, the elevation of the Webb River (Flood Profile 128P in the Oxford County FIS) at the confluence with the Androscoggin River is approximately 415.8 ft NAVD. And the elevation of the Adroscoggin (Flood Profile 07P in the Oxford County FIS) at the confluence of the Webb River is approximately 415.4 ft NAVD. Each are within an acceptable tolerance of less than 0.5 feet. Along the Webb River, between the Androscoggin and the US Route 2 Bridge (Webb River Bridge?) the elevations "jump" to 420 ft NAVD largely due to changes in the stream bed.

Community tie-ins were applied in Oxford County. Any apparent changes in BFEs and riverine profiles between the effective community studies and Oxford Countywide study are result of these tie-ins. No updated H&H was performed in this subject area.

I hope this helps. Please let me know if you'd like to discuss further. Thanks,

Tim Hillier
CDM Federal Programs Corporation
**From:** Young, Joseph [mailto:Joseph.Young@maine.gov]
**Sent:** Monday, October 27, 2008 8:56 AM
**To:** Daxikar, Amol; Hillier, Timothy
**Cc:** Goetz, Mike; Rooney, Stuart
**Subject:** FW: Hi MSFMP friends!

**Tim, Amol, anyone,**

**Can you review the comments in the e-mail below and let me know what kind of response is needed?**

**Joseph Young**
**Mapping Coordinator**
**Maine Floodplain Management Program**
**Maine State Planning Office**
**38 State House Station**
**Augusta, ME 04333-0038**
**Voice (207) 287-8051**
**Fax (207) 287-6489**
E-Mail Joseph.Young@maine.gov
Web www.maine.gov/spo/flood

Sign up for our Email Newsletter

http://www.constantcontact.com/safesubscribe.jsp

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**From:** ellen obrien [mailto:ekobrien@fairpoint.net]
**Sent:** Friday, October 24, 2008 11:47 AM
**To:** Baker, Sue; Young, Joseph
**Subject:** Flood Elevs.

I have a technical question:

I am working on a bridge on the border of Mexico and Dixfield, on Route 2. The bridge crosses the Webb River just upstream of its confluence with the Androscoggin River. Backwater from the Androscoggin definitely will affect flood levels at the Webb River Bridge.

The Mexico FIS was done in 1979 and lists the 100-year elevation on the Androscoggin as 418 (flow 78000 cfs) and the Dixfield study (dated 2001) lists the Androscoggin Flood level at the town line as 416 (flow 81,200 cfs). Datum for both studies is NGVD 1929. How do you suggest we resolve the difference?

Thanks..ellen

Ellen K. O'Brien, P.E.
*Northstar Hydro, Inc.*
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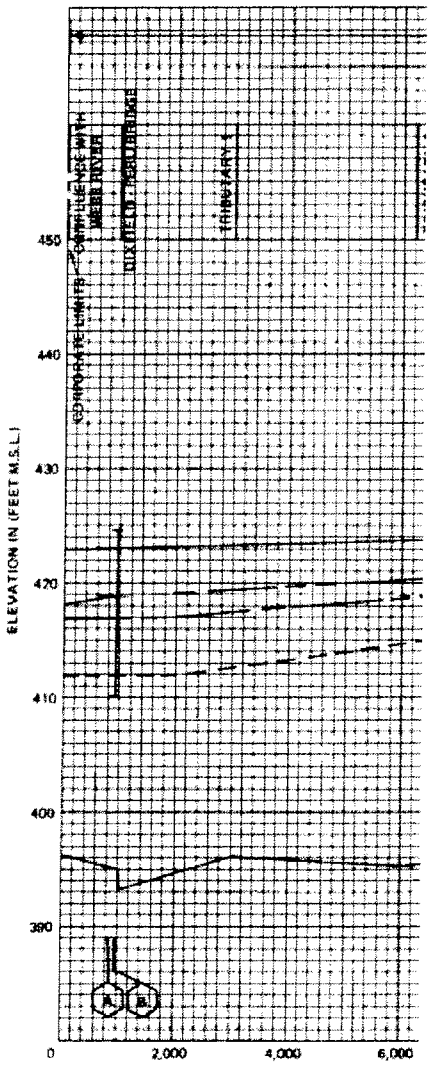
Winthrop, ME 04364
207-377-8043
cell 207-458-2997
ekobrien@fairpoint.net
www.northstarhydro.com

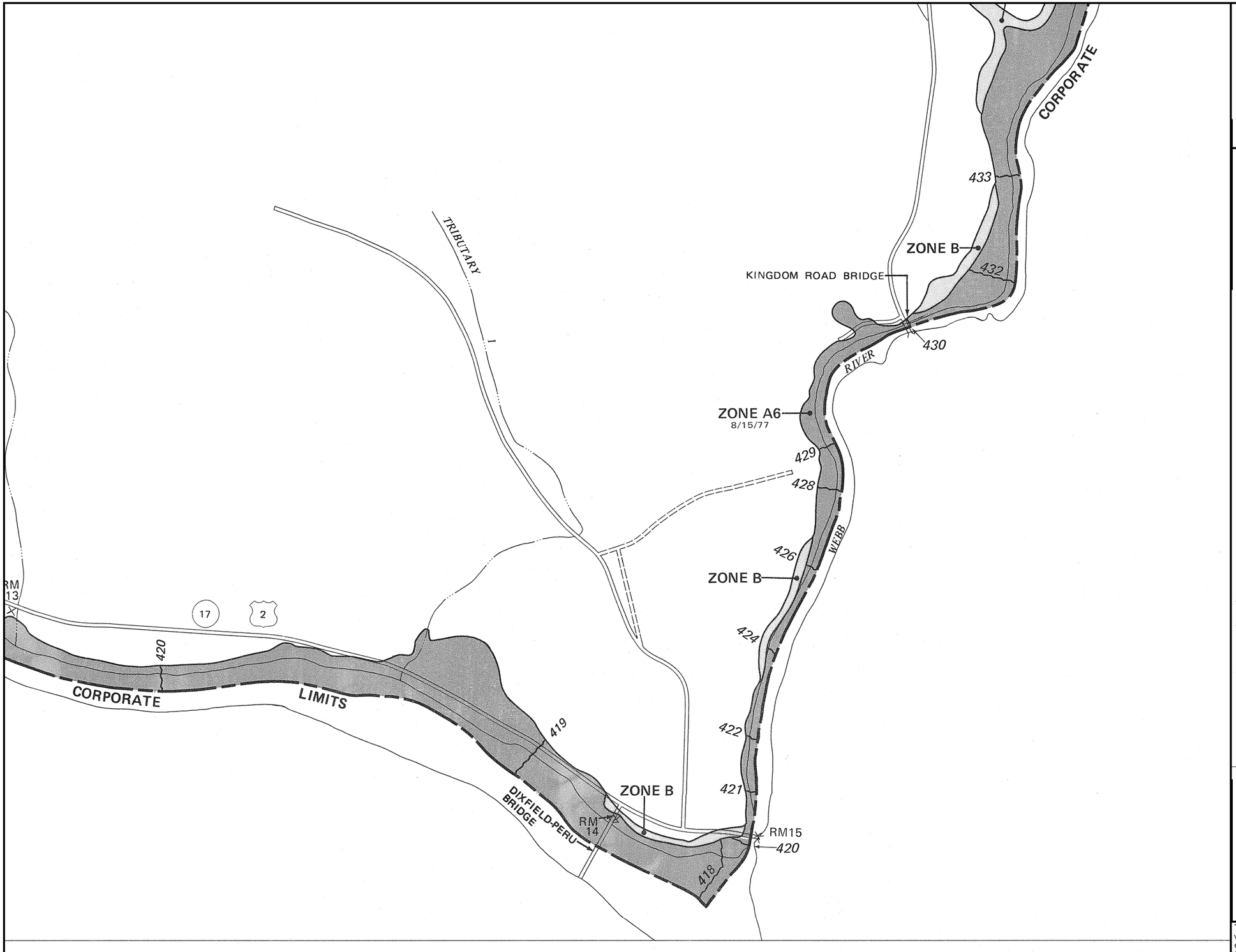
From the Mexico Flood Insurance Study:

Table 1. Summary of Discharges

| Flooding Source and Location | Drainage Area (Square Miles) | Peak Discharges (Cubic Feet per Second) 10-Year | 50-Year | 100-Year | 500-Year |
|---|---|---|---|---|---|
| Androscoggin River | | | | | |
| At Rumford-Peru town line | 2,210 | 51,000 | 68,600 | 78,000 | 98,600 |
| Above Mouth of Swift River | 2,070 | 40,300 | 55,400 | 62,500 | 80,000 |
| Swift River | | | | | |
| At Mouth | 124 | 14,600 | 24,400 | 29,500 | 43,800 |
| Webb River | | | | | |
| At Mouth | 133 | 4,510 | 6,800 | 7,800 | 10,000 |




From Dixfield Flood Insurance Study




FLOOD HAZARD BOUNDARY MAP H-01-04
FLOOD INSURANCE RATE MAP I-01-04

# TOWN OF MEXICO, MAINE

OXFORD COUNTY

**PANEL H&I-04**

**PAGE 2 OF 2 PRINTED**

MAP REVISED:
MAY 15, 1981

COMMUNITY NUMBER:
230095 B

federal emergency management agency
federal insurance administration


surance agent or call the National Flood Insurance Program at (800) 6

APPROXIMATE SCALE

500 0 500 FEE

NATIONAL FLOOD INSURANCE PROGRAM

# FIRM

## FLOOD INSURANCE RATE MAP

TOWN OF
DIXFIELD,
MAINE
OXFORD COUNTY

**PANEL 8 OF 11**

(SEE MAP INDEX FOR PANELS NOT PRINTED)

**COMMUNITY - PANEL NUMBER**
**230092 0008 C**

**MAP REVISED:**
**SEPTEMBER 7, 2001**

Federal Emergency Management Agency

| | | | |
|---|---|---|---|
| **Project Name:** | Mexico Webb River Br | **PIN:** | 15620 |
| **Stream Name:** | Webb River | **Town:** | Mexico |
| **Bridge Name:** | | **Bridge No.** | 2917 |
| **Route No.** | US 2 | **USGS Quad:** | |
| **Analysis by:** | CSH | **Date:** | 1/31/2008 |

# Peak Flow Calculations by USGS Regression Equations (Hodgkins, 1999)

***Enter data in blue cells only!***

| | km$^2$ | mi$^2$ | ac | |
|---|---|---|---|---|
| **A** | 342.59 | 132.274 | 84655.4 | Watershed Area |
| **W** | 32.58 | 12.579 | 8050.7 | Wetlands area (by NWI) |

| | | | |
|---|---|---|---|
| **$P_c$** | | | watershed centroid (E, N; UTM 19N; meters) |
| **DIST** | | | distance from Gulf of Maine line |
| **pptA** | | | mean annual precipitation (inches) |
| **SG** | | | sand & gravel aquifer as percentage of watershed area |

***Enter data in [mi$^2$]***

***Worksheet prepared by:***


Charles S. Hebson, PE
Chief Hydrologist
Maine Dept. Transportation
Augusta, ME 04333-0016
207-287-1105
Charles.Hebson@maine.gov


| | | | |
|---|---|---|---|
| **A (km$^2$)** | 342.590 | **Conf Lvl** | 0.67 |
| **W (%)** | 9.51 | | |

| **Ret Pd** | **Peak Flow Estimate** | | | |
|---|---|---|---|---|
| **T (yr)** | **Lower** | **$Q_T$ (m$^3$/s)** | **Upper** | **$Q_T$ (ft$^3$/s)** |
| 1.1 | | 45.68 | | 1612.9 |
| 2 | 60.90 | 84.71 | 117.83 | 2991.1 |
| 5 | 89.22 | 124.48 | 173.68 | 4395.5 |
| 10 | 108.71 | 153.07 | 215.53 | 5404.9 |
| 25 | 133.17 | 189.95 | 270.94 | 6707.1 |
| 50 | 151.39 | 218.30 | 314.78 | 7708.0 |
| 100 | 170.16 | 248.15 | 361.89 | 8762.3 |
| 500 | 213.33 | 320.68 | 482.04 | 11323.2 |

***Reference:***


Hodgkins, G., 1999.
Estimating the magnitude of peak flows for str
in Maine for selected recurrence intervals
*Water-Resources Investigations Report 99-40*
US Geological Survey, Augusta, Maine


$Q_T = b \times A^a \times 10^{-wW}$

reams

*008*