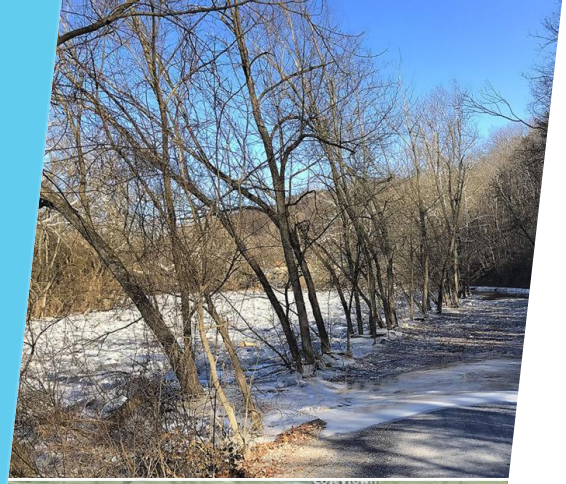
Ice Jam Modeling

Case Study of Conococheague Creek

Washington County, Maryland

November 8, 2018



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FREEZING TEMPERATURES IMPACT CONOCOCHEAGUE CREEK
Ice buildup results in hazardous conditions

HAGERSTOWN, Md. (January 14, 2018) - The Washington County Board of County Commissioners and the Division of Emergency Services would like to advise citizens of the hazardous conditions evolving in Williamsport along the Conococheague Creek.

DES, along with local fire and rescue companies and other County resources, are monitoring the ice buildup on the Conococheague Creek in all areas of Washington County. The area of Kemps Mill Road and Snug Harbor Campground, specifically, are being monitored.

At this time officials are evaluating what actions need to be taken. Please monitor local media, the Washington County and Emergency Services website and social media sites for further updates.

Citizens are advised to refrain from driving through ice or standing water. Encroaching or walking upon ice-covered bodies of water is also discouraged.

Those living within the affected area in need of assistance

January 13-14th Ice Jam Event

- River stage approximately 4.5 feet higher than normal
- Residents lost roadway access to homes
- Structural concerns at Kemps Mill Road Bridge
- Concern of additional flooding

Conococheague Creek January 16, 2018

Project Timeline

JANUARY 2018

Sun	Mon	Tue	Wed	Thu	Fri	Sat
	1	2	3	4	5	6
7	8	9	10	11	12	13
Ice Jam formation 14	RK&K site visit 15	16	17	Deliverables submitted 18	19	20
21	22	23	24	25	26	27
28	29	30	31			

Project Scope

What I heard was something to the effect of:

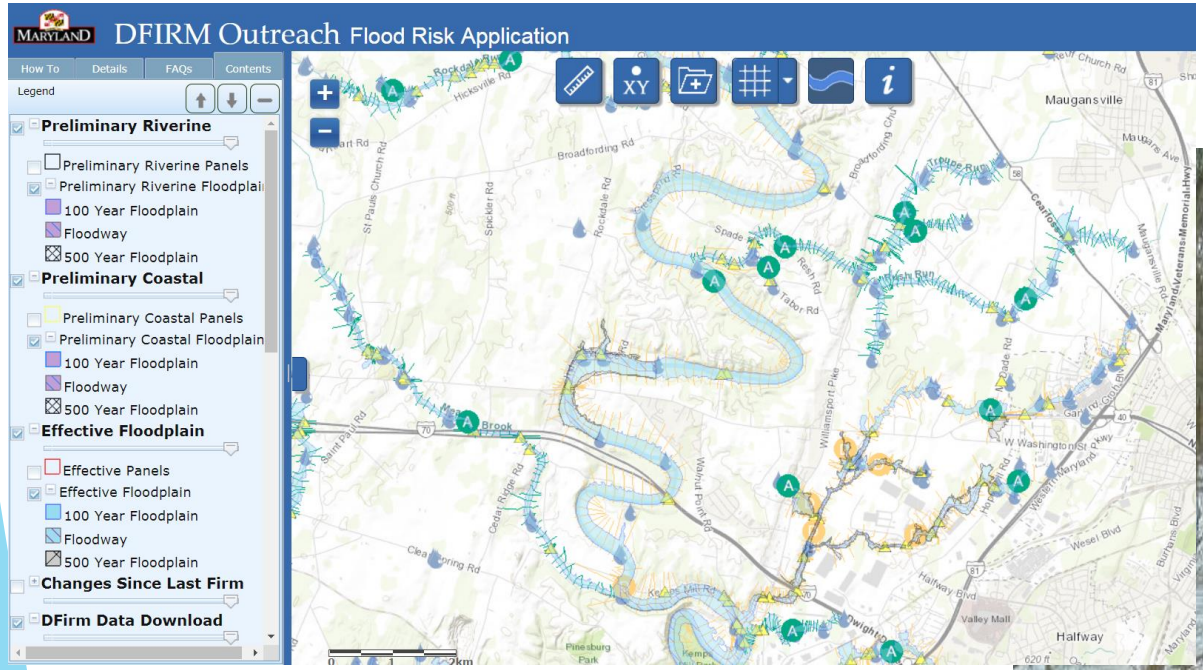
“Tell us what is going to happen based on anticipated weather forecast…as soon as possible”

<u>County Concerns</u>:

- Public Safety
  - Potential future ice build up
  - Potential future flooding due to ice break up/ additional rain
  - Emergency action plan

Available Data

- Upstream USGS Stream Gage
- Local weather gage information
- Detailed HEC-RAS model of Conococheague Creek
- Limited bridge as-built information available



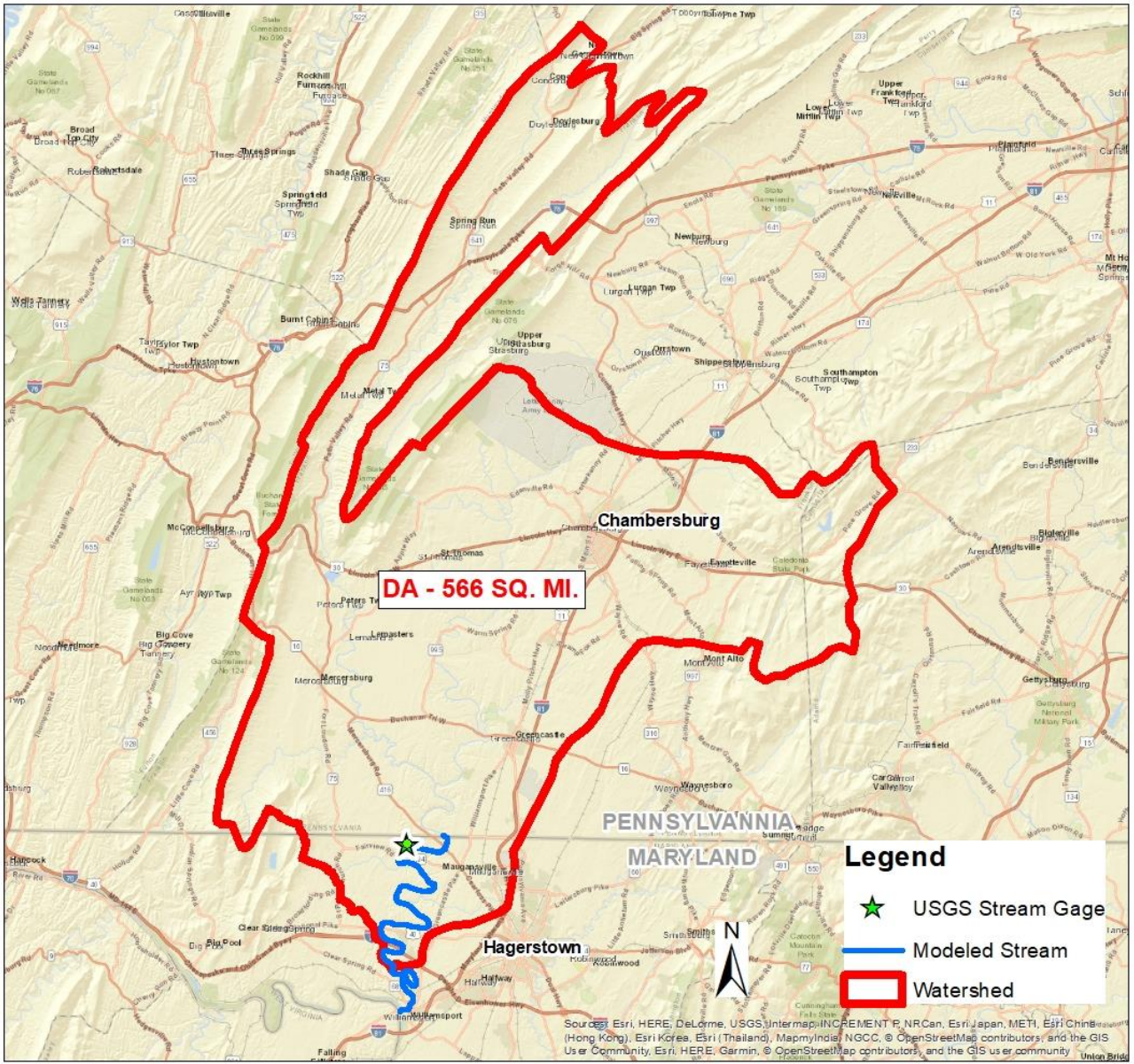
Challenge

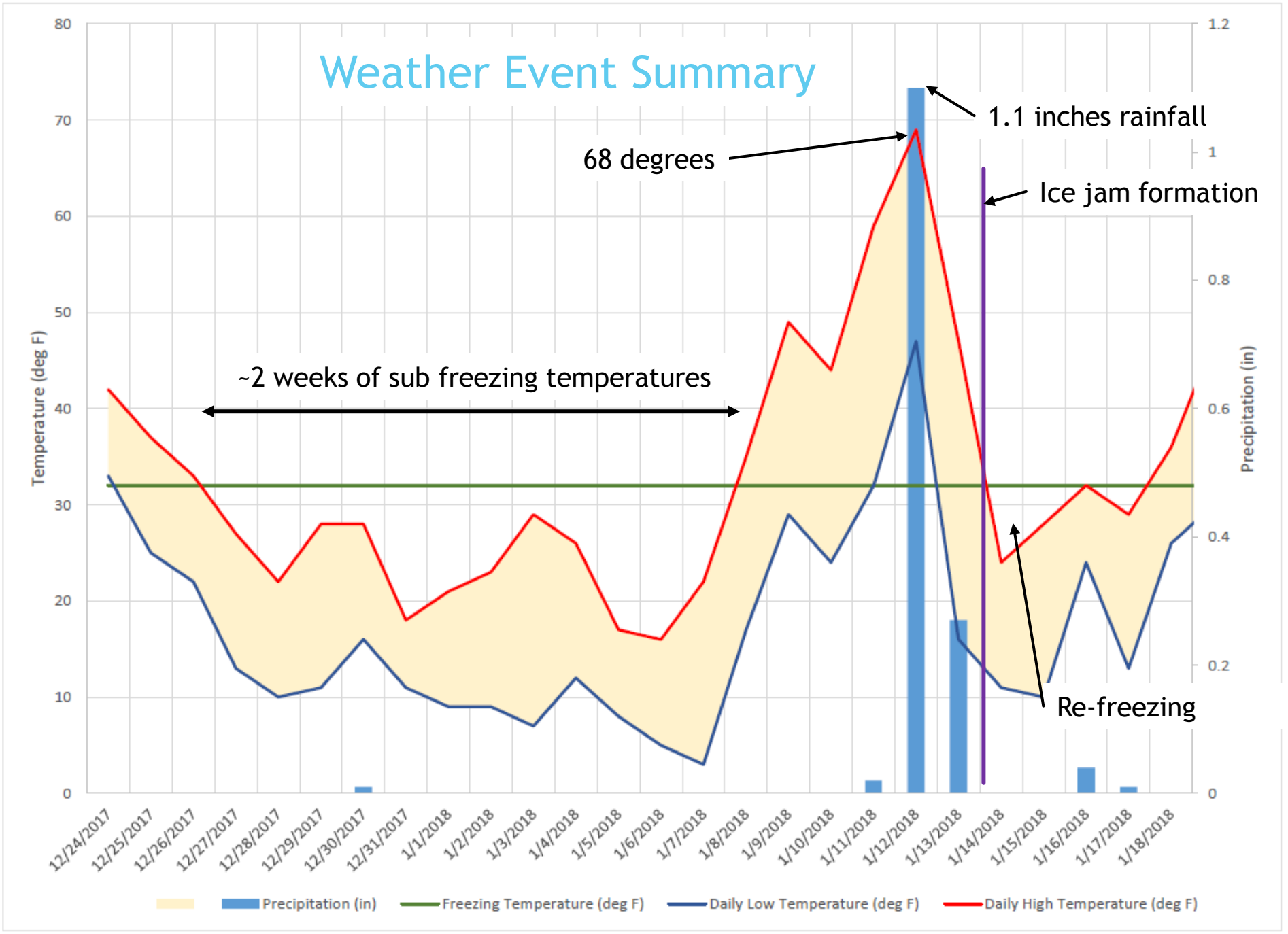
How do we give the County something useful to help manage risk?

Solution

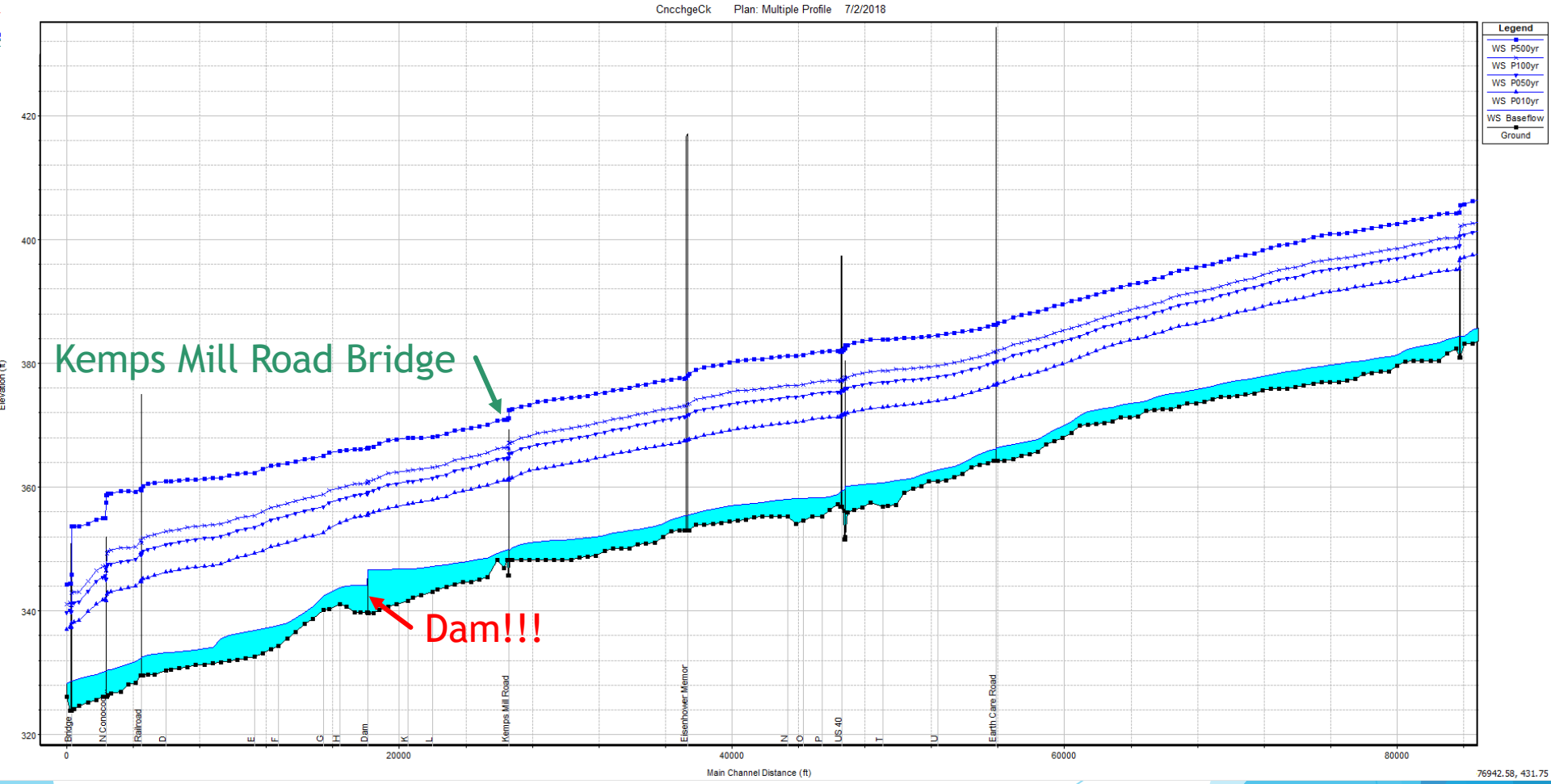
- Use the Ice Jam routine in HEC-RAS to calibrate ice jam parameters to observed measurements
- Run future scenarios in HEC-RAS using calibrated parameters, including “best-predicted” and “worst case”
- Tie scenarios to gage discharge data (rating curves)
- Provide County Emergency Management staff planning information correlating gage discharge to flood elevation

Study Area Watershed




Weather Event Summary
1.1 inches rainfall
68 degrees
Ice jam formation
~2 weeks of sub freezing temperatures
Re-freezing
Temperature (deg F)
Precipitation (in)
80
70
60
50
40
30
20
10
0
1.2
1
0.8
0.6
0.4
0.2
0
12/24/2017
12/25/2017
12/26/2017
12/27/2017
12/28/2017
12/29/2017
12/30/2017
12/31/2017
1/1/2018
1/2/2018
1/3/2018
1/4/2018
1/5/2018
1/6/2018
1/7/2018
1/8/2018
1/9/2018
1/10/2018
1/11/2018
1/12/2018
1/13/2018
1/14/2018
1/15/2018
1/16/2018
1/17/2018
1/18/2018
Precipitation (in)
Freezing Temperature (deg F)
Daily Low Temperature (deg F)
Daily High Temperature (deg F)

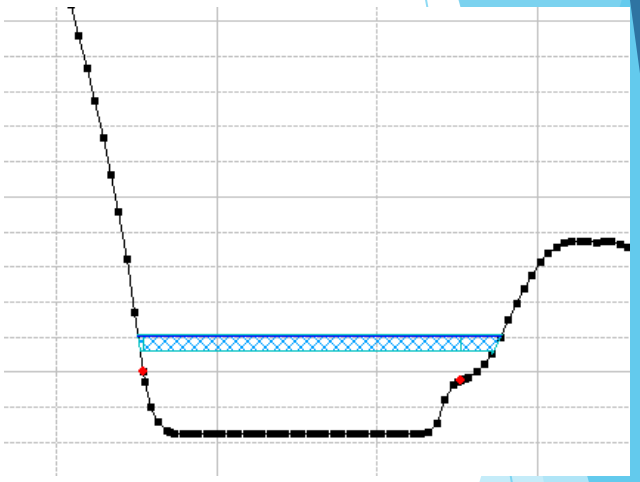
Effective HEC-RAS Model Profile



HEC-RAS Ice Jam Basics

Hydraulic capacity of the channel/floodplain decreases due to ice formation.

Factors include:
- Reduced hydraulic radius/flow area
- Increased roughness/wetted perimeter



HEC-RAS solution simultaneously solves:
- Energy equation for the liquid section
- Force balance equation for the ice

$$\frac{d\left(\overline{\sigma}_x t\right)}{dx} + \frac{2\tau_b t}{B} = \rho' g S_w t + \tau_i \qquad (11\text{-}4)$$

where: $\overline{\sigma_x}$ = the longitudinal stress (along stream direction)

t = the accumulation thickness

τ_b = the shear resistance of the banks

B = the accumulation width

ρ' = the ice density

g = the acceleration of gravity

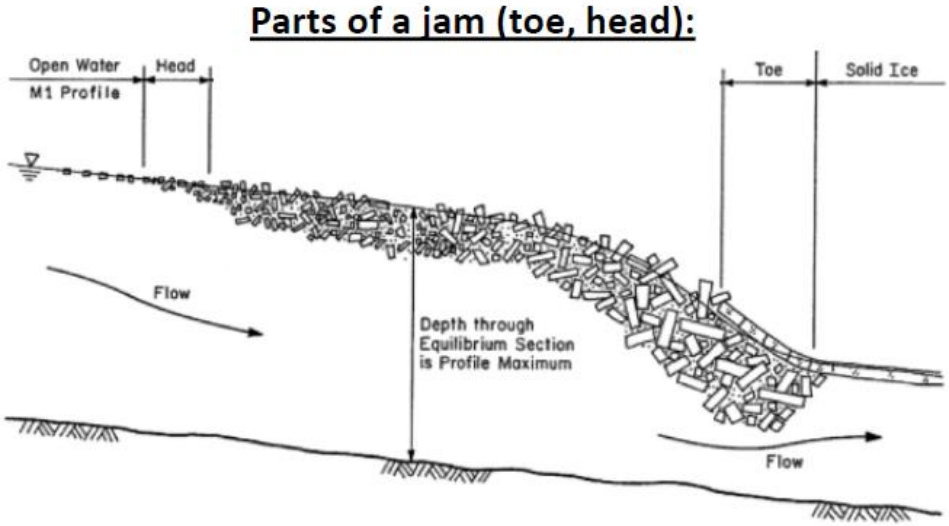
Sw = the water surface slope

τ_i = the shear stress applied to the underside of the ice by the flowing water

HEC-RAS Ice Modeling Limitations

- HEC-RAS does not model melting/freezing conditions. Engineer should evaluate a range of possible ice thickness conditions.

- Location of the Ice Jam Head and Toe are critical parameters – NOT determined by model. If location is unknown, engineer should evaluate a range of possible scenarios.



HEC-RAS Ice Cover Parameters

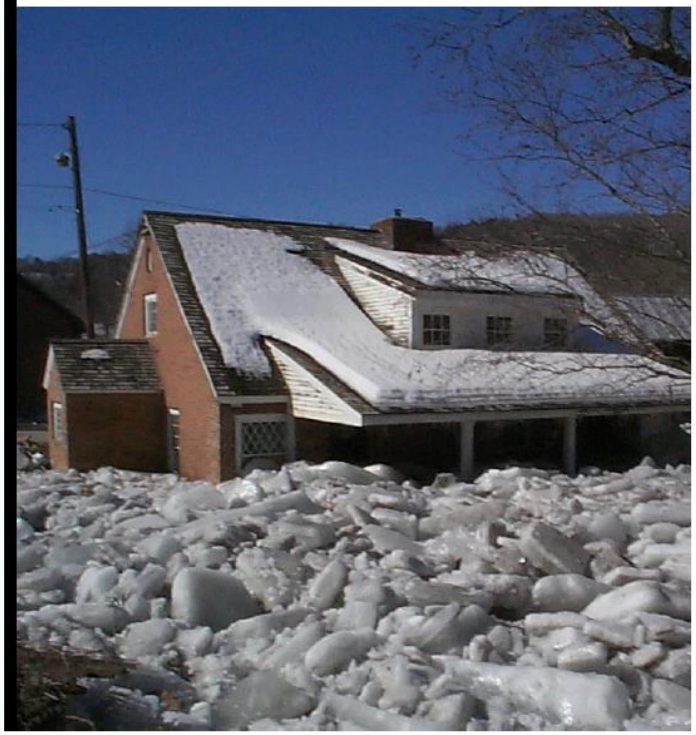
CRREL REPORT 99-11

US Army Corps of Engineers®
Cold Regions Research & Engineering Laboratory

Hydraulic and Physical Properties Affecting Ice Jams

Kathleen D. White

December 1999



Ice Cover Editor

Ice Cover Thickness			Ice Cover Manning's n Values		
LOB	Channel	ROB	LOB	Channel	ROB
1.	1.	1.	0.025	0.025	0.025

Ice Cover Specific Gravity: 0.916

Wide River Ice Jam

☑ Channel ☐ Over Banks

Internal friction angle of jam (degrees): 45.

Ice Jam Porosity (fraction water filled): 0.4

Coefficient K1(lateral to longitude stress in jam): 0.33

Maximum mean velocity under ice cover: 5.

Ice Cohesion: 0

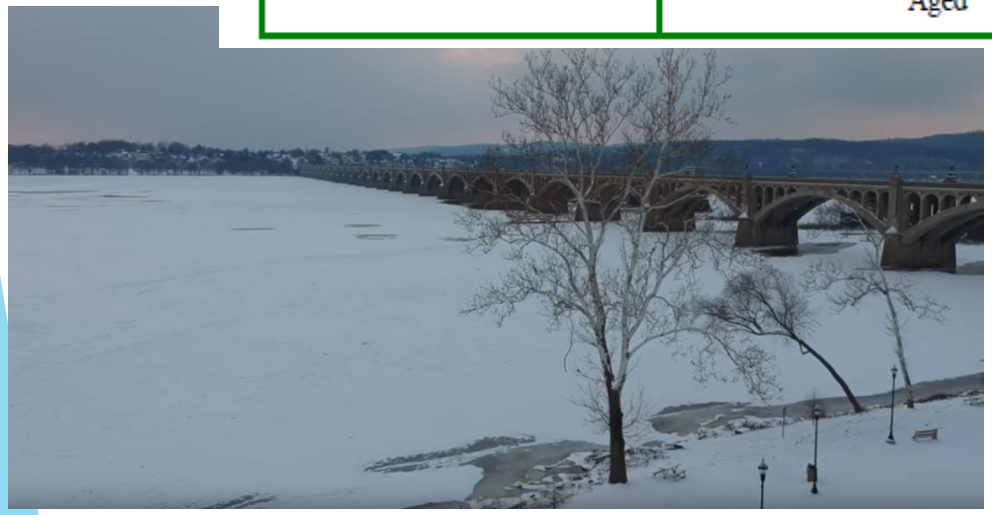
☐ Fixed Manning's n Value (or Nezhikovsky's data will be used)

OK Cancel Help Clear

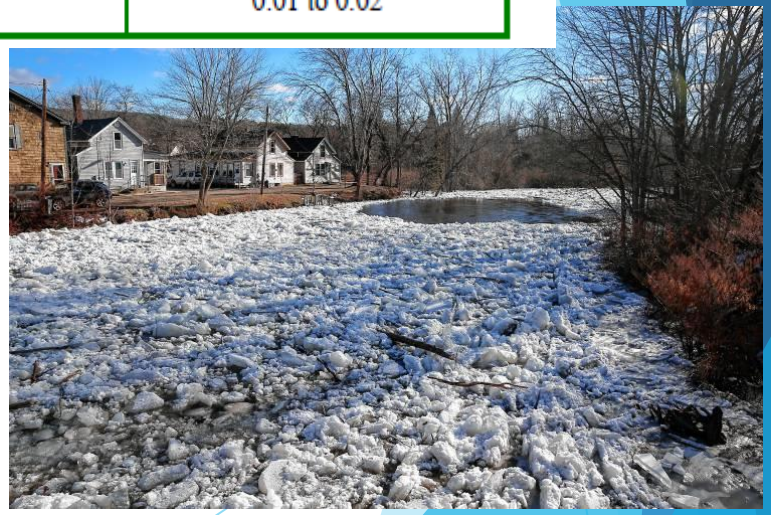
HEC-RAS Ice Cover Parameters

The suggested range of Manning's n values for ice jams

Type of Ice	Condition	Manning's n value
Sheet ice	Smooth	0.008 to 0.012
	Rippled ice	0.01 to 0.03
	Fragmented single layer	0.015 to 0.025
Frazil ice	New 1 to 3 ft thick	0.01 to 0.03
	3 to 5 ft thick	0.03 to 0.06
	Aged	0.01 to 0.02



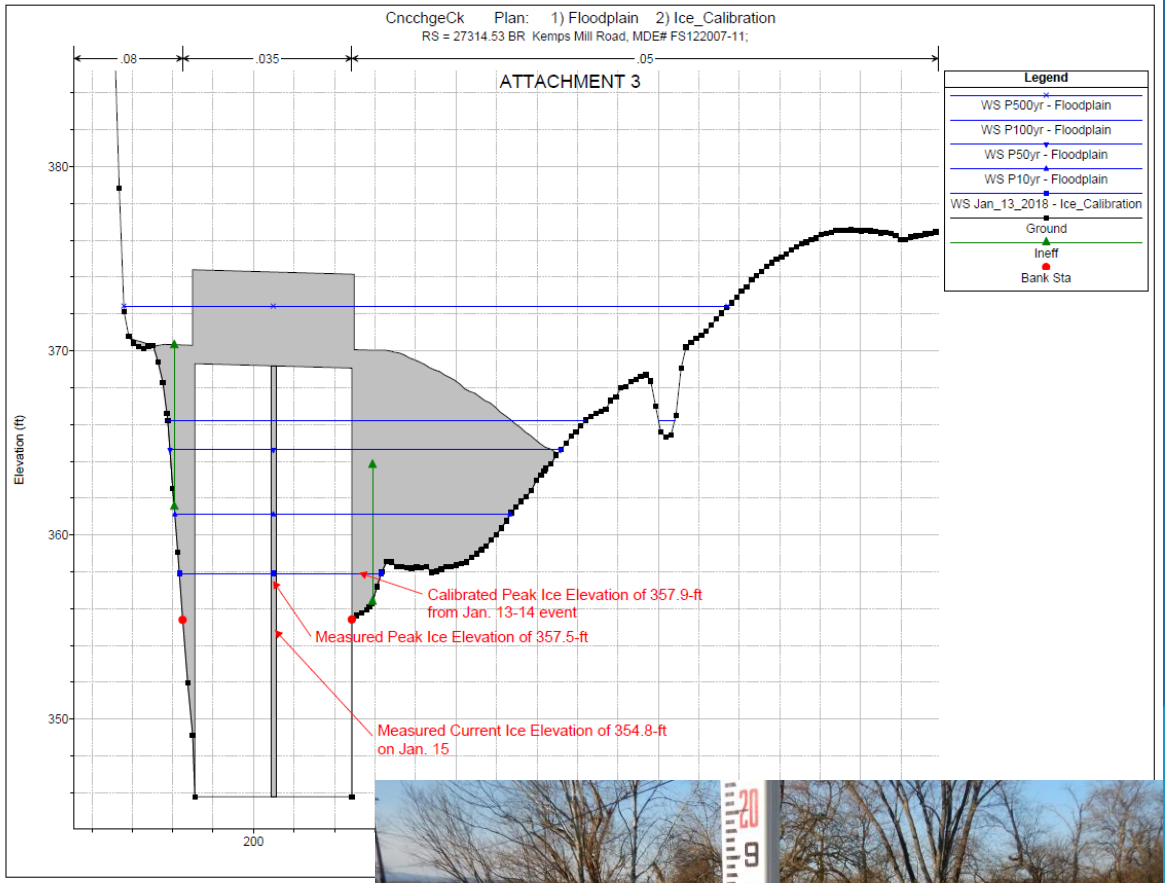
Sheet Ice



Frazil Ice

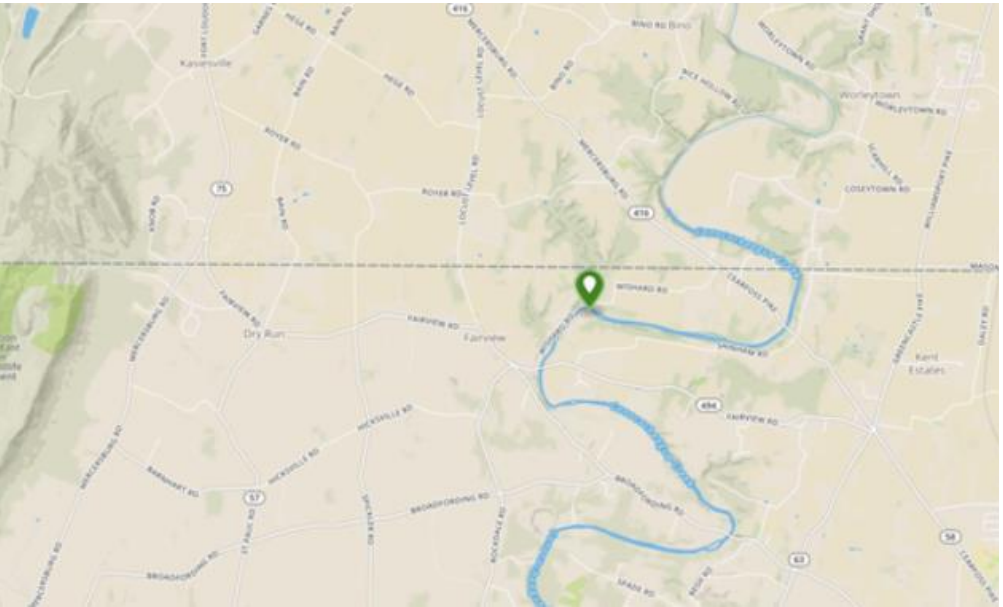
HEC-RAS Model Parameter Calibration

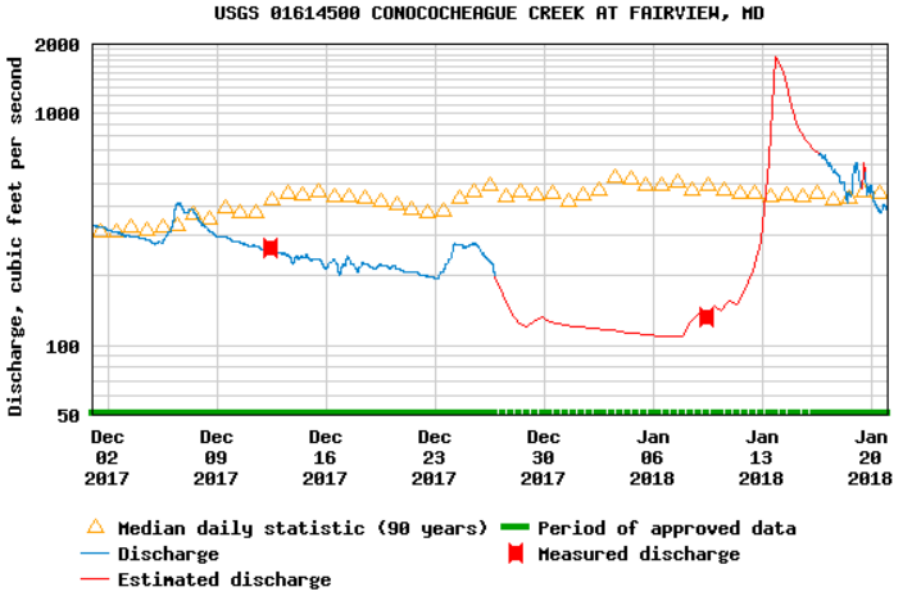
- Used “measure down” and as-builts to determine ice elevation at Bridge (current and peak)
- Measured ice thickness
- Used upstream USGS stream gage peak flow of 2,770 cfs to calibrate model
- HEC-RAS Calibration run was within 0.4-feet of measured peak ice elevation



USGS Gage Correlation Assumptions

- Due to large watershed (566 sq. mi.), difficult to correlate rainfall with runoff (and ice melt contribution). **Time better spent on potential outcomes.**
- Upstream gage was close enough to provide estimates of peak flows (within 10% drainage area), while being far enough away to give Emergency Management Services time to reach to potential flooding (7-8 hours lag time).
- Upstream gage became foundation for monitoring by local officials.





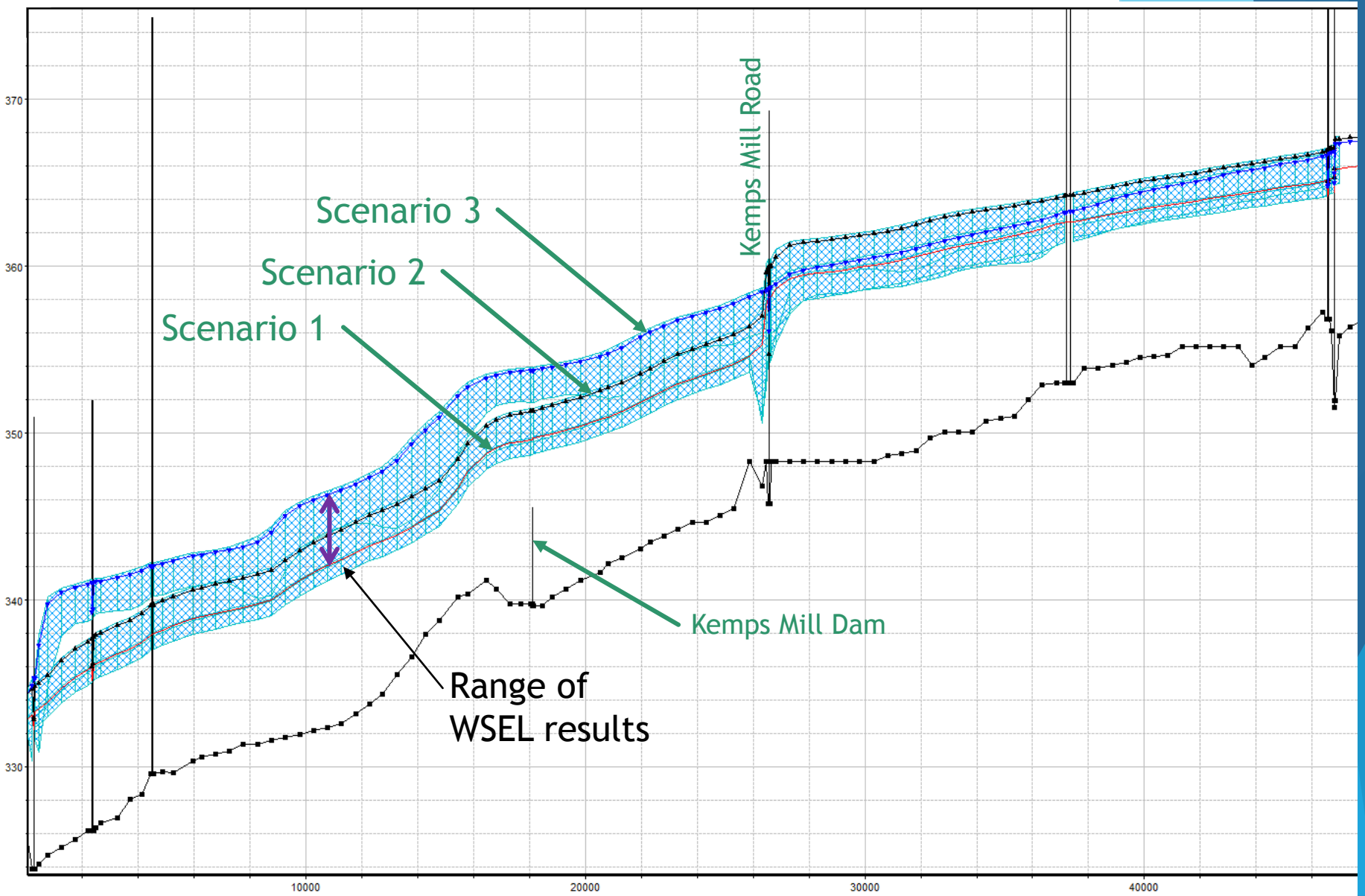
Potential Flooding Scenarios from Ice Jam Breakup

Scenario 1 (Baseline with Ice Jam @ Kemps Mill Dam) – Flooding potential based on an ice jam formation downstream of Kemps Mill Road bridge using the calibrated parameters from the January 13-14 event.

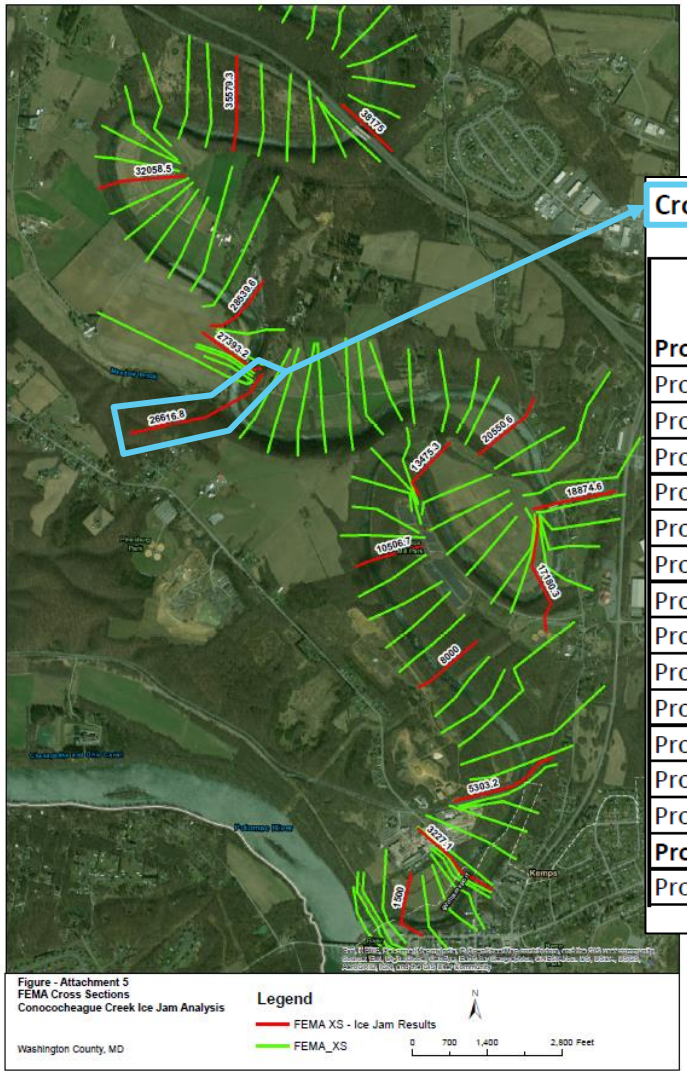
Scenario 2 (Conservative with Ice Jam @ Kemps Mill Dam) – Flooding potential based on conservative ice parameter assumptions (higher ice Manning's n and thicker ice) with ice jam formation downstream of Kemps Mill Road bridge to create a worse-case (but not worst-case) flood scenario.

Scenario 3 (Conservative with Ice Jam Downstream) – Flooding based on conservative ice parameter assumptions with ice jam formation just upstream of the confluence with the Potomac River based on an existing debris jam near the confluence with the Potomac River.

HEC-RAS Flood Scenario Profiles



Deliverables for Onsite Emergency Management



Cross Section 26616.8

Left Bank Elev.= 356.2 Right Bank Elev.= 354.7

Profile ID	Upstream USGS Gage Flow (cfs)	Water Surface Elevation with No Ice (ft)	Estimated Water Surface Elevation with Ice (ft)	Conservative Estimate Water Surface Elevation with Ice (ft)
Profile 1 (Baseflow)	80	348.5	349.4	350.5
Profile 2	200	348.6	349.6	351.1
Profile 3	500	349.2	350.5	352.4
Profile 4	800	349.8	351.2	353.4
Profile 5	1200	350.5	352.1	354.7
Profile 6	2000	351.7	353.4	356.6
Profile 7 (Jan 14 Event)	2770	352.7	354.6	358.2
Profile 8	4000	354.0	356.1	360.1
Profile 9	5300	355.2	357.5	361.7
Profile 10 (2yr Flow)	7604	357.0	359.5	364.0
Profile 11 (5yr Flow)	11500	359.4	362.0	367.0
Profile 12 (10yr Flow)	14500	360.9	363.7	368.9
Profile 13 (50yr Flow)	23800	364.5	367.7	373.5
Profile 14 (100yr Flow)	28600	**366.2**	369.6	374.0
Profile 15 (500 yr Flow)	42600	370.7	374.2	377.8

So….What Happened?

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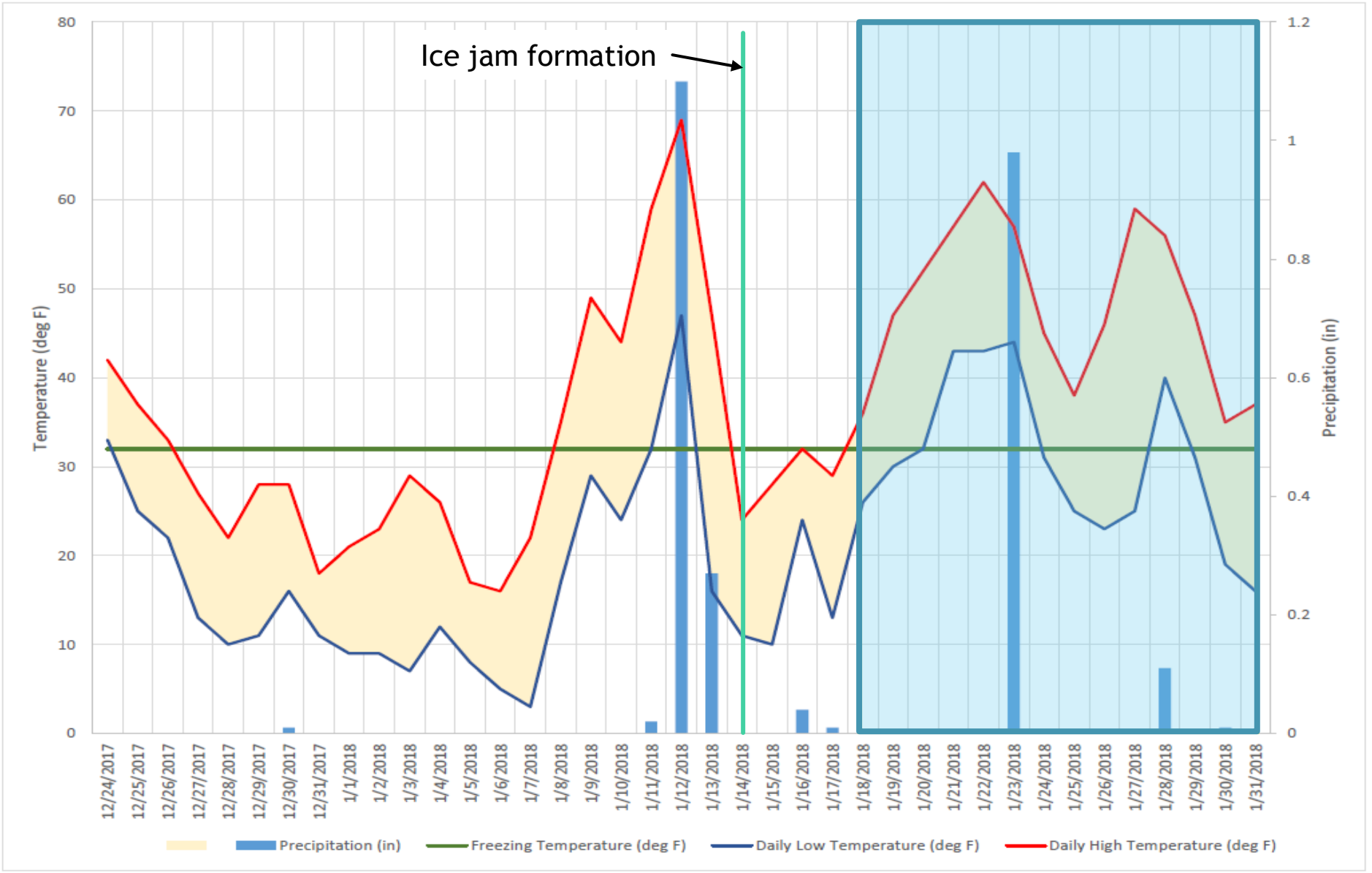
Conococheague Creek ice jam melts away peacefully

Dave McMillion Jan 23, 2018 (0)

In this Herald-Mail file photo, Sharon Mattingly of Hagerstown stands on the Kemps Mill Road bridge to snap a photo of a large ice jam in the Conococheague Creek on Saturday. Standing with Mattingly is her fiancé, David Hutzell. A massive Conococheague Creek ice jam peacefully dissolved into the stream Tuesday afternoon, leaving only a small segment about a quarter-mile long, according to Washington County Emergency Manager Charlie Summers.

Herald-Mail file photo

Post Ice Jam Weather Conditions



Lessons Learned

1. The rating table of potential flooding was difficult to conceptualize by County emergency staff.

2. Time was of the essence. Needed to make assumptions for range of scenarios such as best-predicted and worst-case scenarios.

3. Ice jam flooding is highly weather dependent which cannot be accounted for with HEC-RAS. Can only model flooding based on one ice condition.

4. Availability of USGS gage data, FEMA detailed model, and as-built data was critical to calibrate the HEC-RAS model ice jam parameters.

Questions?

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