NEW YORK STATE | NY Power Authority

KATHY HOCHUL
Governor

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Chairman

JUSTIN E. DRISCOLL
Acting President and Chief Executive Officer

July 10, 2023

Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

RE: Crescent Hydroelectric Project (P-4678) and
Vischer Ferry Hydroelectric Project (P-4679)
Response to FERC Additional Information Request Concerning Update on Reduction and Mitigation of Ice Jam Efforts on the Mohawk River/Barge Canal

Dear Secretary Bose:

The Power Authority of the State of New York (Power Authority or NYPA) filed its Final License Applications for the Crescent Hydroelectric Project and the Vischer Ferry Hydroelectric Project (Projects) with the Federal Energy Regulatory Commission (FERC or Commission) on May 25, 2022. The Commission issued an Additional Information Request (AIR) on August 1, 2022, (Final License Application), the Power Authority provided its response on October 28, 2022. On December 22, 2022, the Power Authority submitted a letter seeking a 90-day delay in the Commission's issuance of the Ready for Environmental Analysis (REA) Notice to facilitate ongoing settlement discussions; and provided a brief update on NYPA's ongoing efforts to reduce and mitigate ice jams on the Mohawk River/Barge Canal.

On January 19, 2023, the Commission issued an AIR relative to the ice jam mitigation work at Vischer Ferry, specifically, the details of NYPA's preferred alternative, including the length of each of the crest gates and the computational modeling results of the preferred alternative. On March 16, 2023, NYPA provided a summary of its simulations for various crest gate modification alternatives and a description of its preferred alternative (P-1), which would include installing 27-inch pneumatic actuated crest gates at Dams D and E and a combination of 27-inch and 48-inch pneumatic crest gates at Dam F of the Vischer Ferry dam. The gates are anticipated to operate in concert with ice-breaking vessels during the winter months and improve management of riverine floods during the summer months. However, NYPA did not provide the modeling results of this preferred alternative. On March 31, 2022, NYPA provided the Commission with a copy of the June 2021 Clarkson University study entitled "A Numerical Model Study on Ice Jam Flooding in the Lower Mohawk River".

On May 11, 2023, the Commission issued a subsequent AIR requesting "*the modeling results of the preferred alternative for the 2018 winter ice-jam event, similar to the modeling results presented in the Ice-Jam Report ("A Numerical Model Study on Ice Jam Flooding in the Lower*

Mohawk River") (i.e., flow and ice conditions during the ice-breaking stage with ice thicknesses of 0.15 meter and 0.3 meter, and a comparison of ice thicknesses and water depths between the baseline and preferred alternative during the ice-breakup stage)."

In response to the Commission's AIR of May 11, 2023, NYPA confirms that additional modeling has been performed that validates NYPA's preferred selection of installing 27-inch pneumatically actuated crest gates (crest gates) on Dams D and E, and a combination of 27-inch and 48-inch crest gates on Dam F. The top elevation of the proposed crest gates is anticipated to be the same as the existing fixed flashboards currently installed for navigation purposes each year.

At NYPA's request, Clarkson University (Clarkson), performed additional modeling of dam modification alternatives, since its June 2021 study, including a variety of pneumatically actuated and hydraulically operated crest gate configurations on Dam D. The configuration of crest gates on Dam E and F remained basically the same for all model runs.

Please see attached letter dated June 30, 2023 from Clarkson University responding to the Commission's specific question included in the May 11, 2023 AIR. Attached to Clarkson's letter is an updated report entitled "Effect of Vischer Ferry Dam Modification Alternatives on Ice Jam Flooding". This report provides the results of proposed modification alternatives for the Vischer Ferry Dam configurations with the ice-breaking operation in the channel to enhance the transport capacity of the breakup ice run.

Project Status - NYPA is currently in the process of procuring an Engineer of Record (EOR) to provide detailed design engineering services for the project and anticipates a contract award by August 2023.

Please contact me if you have any further questions.

Sincerely,

Robert A. Daly
Director, Licensing
New York Power Authority

CC: Jody Callihan

Clarkson

CIVIL AND ENVIRONMENTAL
ENGINEERING DEPARTMENT
8 Clarkson Avenue
Potsdam, New York 13699
315-268-6517/6529

June 30, 2023

Brian Platt
Resilience Director (RTC)
New York Power Authority
149 Northern Concourse, Suite #400
Syracuse, New York 13212

RE: Vischer Ferry Dam Modification Project
Response to FERC's May AIR Letter

Dear Brian,

On May 11, 2023, the Federal Energy Regulatory Commission (the Commission) issued an Additional Information Request (AIR) requesting the modeling results of the preferred alternative for the 2018 winter ice-jam event, similar to the modeling results presented in the previous Ice Jam Report issued June 2021 (i.e., flow and ice conditions during the ice-breaking stage with ice thicknesses of 0.15 meter and 0.3 meter, and a comparison of ice thicknesses and water depths between the baseline and preferred alternative during the ice-breakup stage).

On behalf of NYPA, Clarkson University (Clarkson), has performed additional modeling of dam modification alternatives (since the June 2021 study was submitted to the Commission on March 31, 2022), including a variety of pneumatically actuated and hydraulically operated crest gate configurations on Dam D. The configuration of crest gates on Dam E and F remained the same for all model runs.

Response to the Commission's specific question included in the May 11, 2023 AIR is addressed below for each of the two ice flow stages studied. The two stages are the pre-breakup stage (Stage 1) and the breakup ice run stage (Stage 2).

Stage 1 – Pre-Breakup Stage - Clarkson's initial report entitled "A Numerical Model Study on Ice Jam Flooding in the Lower Mohawk River" originally issued in June 2021 and filed with the Commission on July 30, 2021 and again on March 31, 2022, presented the preliminary evaluations of potential mitigations to reduce the risks of ice jam flooding. The report indicated that pre-breakup ice-breaking and controlled operation at Vischer Ferry Dam are more effective than other measures. The ice-breaking operation was assumed to be conducted a couple of days before the breakup. The ice thicknesses of 0.15 meter and 0.3 meter referred to in that report represent the typical thicknesses before the breakup for a mild winter and a cold winter, respectively. In addition, the ice-breaking zone described in the March 31, 2022 response was only between Vischer Ferry Dam and the Knolls area. This ice-breaking operation was evaluated before NYPA implemented the ice-breaking operation from Lock 7 to the Western Gateway Bridge (located downstream of Lock 8) during the 2020-21 winter.

Following field observations and feedback from ice breaker staff, the December 2022 report (updated June 30, 2023) considers the initiation of the ice-breaking operation at the beginning of the freeze-up period and continues as needed throughout the winter until either a mid-winter or spring breakup occurs when ice can be flushed over Dam D by opening the proposed crest gates. In the analyses, the ice-breaking zone is extended from Lock 7 to Lock 8 because of an additional 2± feet of water depth facilitated by the installation of the proposed 27-inch crest gates on Vischer Ferry Dam, which would typically remain in the closed (up) position throughout the winter. Currently, the ice breaker stops at the Western Gateway Bridge, approximately 8.6 miles upstream of Lock 7 (Vischer Ferry Dam), or 2.4 miles downstream of Lock 8, due to insufficient water depth for the ice breaker/tug. Currently, with the fixed flashboards removed after navigation season each year, there is typically insufficient flow depth over Vischer Ferry Dam to effectively flush ice over the dam. With periodic ice breaking in the channel during the winter, an ice thickness of 0.08 meters (3 inches), calculated based on the calibrated freezing degree-day method with 2022 field data, is used to evaluate the effectiveness of flushing ice fragments from the ice-breaking operation by strategically opening the 27-inch crest gates on Dam D.

Stage 2 – Breakup Ice Run Stage - The evaluation and analysis of the preferred alternative (P-1) in the December 2022 report (updated June 30, 2023) is presented with a series of comparisons of ice thickness, ice accumulations, water depths, typical river flow and peak water levels between the baseline and the preferred alternative during the breakup ice run stage. Additional alternatives, by varying the crest gate height, are also evaluated and discussed. The comparisons of the outcomes indicate that Alternative P-1 provides favorable ice jam flooding mitigation and satisfies the minimum flow requirement past Vischer Ferry Dam.

To supplement the information provided previously, a new report entitled "Effect of Vischer Ferry Dam Modification Alternatives on Ice Jam Flooding", originally issued in December 2022, and subsequently updated on June 30, 2023, is attached for your use. This report provides the results of proposed modification alternatives for the Vischer Ferry Dam configurations with the ice-breaking operation in the channel to enhance the transport capacity of the breakup ice run.

Please contact me if you have any further questions.

Sincerely,

Hung Tao Shen
Distinguished Research Professor
in Hydraulic Engineering

Fengbin Huang
Research Assistant Professor

Effect of Vischer Ferry Dam Modification Alternatives on Ice Jam Flooding

A report for Ice Jam Mitigation Panel
Reimagine the Canals Task Force

Submitted to
New York Power Authority

Fengbin Huang and Hung Tao Shen

Department of Civil and Environmental Engineering
Clarkson University
Potsdam, NY 13699-5710

DECEMBER 2022

(Updated June 30, 2023)

Abstract

Breakup ice jams in the Lower Mohawk River often result in significant discharge and water level changes causing inundation of low-lying areas along the river. Ice breaking and a modified Vischer Ferry Dam configuration and operation are effective measures to alleviate the ice jam flooding potential. This report evaluates three potential modification alternatives for the Vischer Ferry Dam configuration using the calibrated January 2018 ice jam event as the baseline case. The ice-breaking operation has been implemented since the winters of 2021-22 to enhance the transport of the breakup ice runs.

The analysis concluded that breaking the sheet ice throughout the winter is essential to a successful ice jam mitigation strategy. The suspension of generation at the powerhouse provides extra flow depth to facilitate the ice transport over the Dam. Operational improvements and modifications to the Vischer Ferry Dam cannot offer reasonable ice jam mitigation risk benefits without performing sheet ice breaking during the winter.

The proposed modification alternatives for the Vischer Ferry Dam configuration by replacing the fixed flashboards with pneumatically actuated crest gates on Dams D, E and F, and was analyzed for Dam D crest gates fully lowered during the operational period. The analysis showed that the proposed dam modification alternatives, combined with ice breaking and suspending powerhouse generation to supplement river flow over Dam D, can reduce the ice jam-related flood risk compared to the existing fixed dam crest configuration. The study found that the ice jam mitigation benefits of each alternative analyzed, specifically 27-inch, 48-inch and 72-inch-high crest gates on Dam D are similar but not equal.

Alternative P-1 (27-inch-high pneumatic crest gates on Dam D) significantly reduces ice jam severity upstream of the Vischer Ferry Dam. By opening crest gates on Dam D and suspending powerhouse discharge to provide additional flow allows the ice floes to flush out of the dam pool. The likelihood of ice jam formation in the typical ice jamming locations of Freeman's Bridge and Rexford-Knolls remains, but the ice jamming and accumulations are temporary. This is due to the increased discharge towards and over Dam D triggered by the operation.

Alternative P-2 (48-inch-high pneumatic crest gates on Dam D) provides similar improvements on ice conditions when compared to Alternative P-1, but with a slightly greater water level reduction. The increased benefits are associated with the ability to increase water surface gradient and the corresponding increased discharge capacity. Alternative P-2 increases the ice transport capability of the river and the Vischer Ferry Dam.

Alternative P-3 (72-inch-high pneumatic crest gates on Dam D) further improves ice jam mitigation potential upstream of the Vischer Ferry Dam compared to Alternative P-2. The increased benefits are associated with the increased water surface gradient of the 72-inch-high crest gates fully lowered and the corresponding increased discharge capacity to transport ice floes passing Knolls. Alternative P-3 may lead to ice jamming in the pool, but the backwater to Stockade is substantially reduced.

Two regulatory conditions are considered in the present analysis: the required minimum discharge past the Vischer Ferry Project of 5.7 m^3/s (200 cfs), and the water level reduction at the Vischer

Ferry Dam within a 24-hour period should not be more than 6 inches. The proposed Alternative P-1 satisfies the minimum discharge in both the pre-breakup and breakup stages. During the pre-breakup stage, alternatives P-2 and P-3 result in a greater than 6 inches of water level reduction at the Dam due to the larger crest gate opening and low river flows. During the breakup stage, the 6-in maximum water level reduction at the Dam is temporarily violated due to the ice accumulation and release, albeit less than 24 hours. The maximum drawdown below the top of crest gates in Alternatives P-1, P-2, and P-3 is 3 in, 15 in, and 18 in, respectively. Alternative P-1 provides the most favorable benefits for ice jam flooding mitigation while satisfying regulatory criteria.

Additional evaluations with the reductions of the 27-inch high crest gates by 6, 15, and 21 inches showed that all three alternatives effectively reduce upstream ice jam potential and water level. All three crest gate openings (when opened) can mitigate the ice jam flooding in Stockade District and satisfy the current regulatory criteria at Vischer Ferry Dam. However, ice jams can still form at Knolls and in the head pond.

All evaluations indicate the risk of the temporary thickening of ice floe accumulation in the Stockade area that causes the flooding remains, although significantly reduced. The ice thickness and coverage upstream of Lock 8 impact the ice discharge from the breakup ice runs past Stockade into the Vischer Ferry Pool. Once the ice discharge exceeds the transport capacity in the Stockade area, temporary thickening of ice accumulation will occur due to the reduction of the effective channel width between the Stockade and Maritime Center.

Acknowledgments

The writers would like to thank Howard Goebel, Ken Kemp, Brian Platt, Andrew Sumner of the New York Power Authority, and John Garver of Union College for valuable input and discussions throughout the entire period of this study.

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Unit Conversion

Length:
1 in = 0.0254 m
1 ft = 0.3048 m
1 mi = 1.60934 km

Area:
1 in^2 = 645.16 mm^2
1 ft^2 = 0.092903 m^2

Volume:
1 ft^3 = 0.02831681 m^3

Temperature:
$T°C = (5/9)(T°F - 32°)$

Force:
1 lb = 4.448 N

1. Introduction

Breakup ice jams in the Lower Mohawk River often result in severe obstruction to the river flow, causing water level changes and inundation of low-lying areas along the river. The sheet ice-breaking operation during the winter and the operation of the proposed modification of the Vischer Ferry Dam could be effective measures to reduce the ice jam flooding potential. This report summarizes a numerical model study on the potential reduction of ice jam flooding with these measures using a comprehensive river ice model (Shen 2010). The calibrated January 2018 ice jam event (Huang and Shen, 2021) is used as the baseline case in this study.

The Lower Mohawk River is a complex system with significant slope variations, river width changes, channel split around islands, bridge crossings, and bends. Ice jam flooding along the Mohawk River is a highly complex phenomenon related to ice cover breakup, ice transport, and jam formation and release. The study reach is the 58-km (36-mile) reach of the Lower Mohawk River extending from Fonda to Vischer Ferry Dam, including a stretch of the Schoharie Creek and the floodplain areas, as shown in Figure 1. The datum of the vertical and horizontal survey is referenced to NAVD 88 and NAD 83, respectively. All elevations in this report and the model are referenced to NAVD 88. Figure 1 also shows the gauging stations along the river, which provide water level and discharge data.

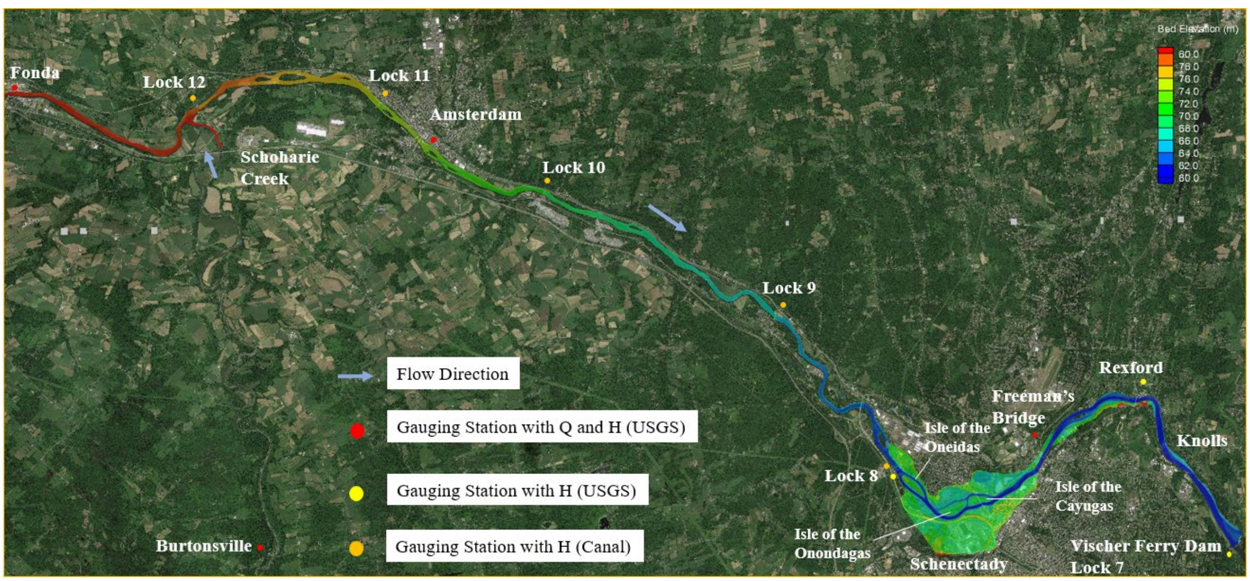


Figure 1. Model domain with bed elevation (NAVD 88 Datum).

The model upstream boundary conditions are the Fonda and Schoharie Creek inflow and ice discharges. The ice discharge from upstream was negligible for most of the past breakup events. For the January 2018 breakup event, there was no ice discharge from upstream. The downstream boundaries at Lock 7 include the Vischer Ferry Dam, which is part of the Vischer Ferry Hydroelectric Project, as shown in Figure 2. The outflow boundary conditions are discharges through the Vischer Ferry Hydroelectric Project and over the Vischer Ferry Dam based on the rating curve (Huang and Shen, 2021). The Vischer Ferry Hydroelectric Project includes a powerhouse with four generating units with a total flow capacity of 189.73 m^3/s (6,700 cfs), three regulation gates[1], each with a discharge capacity of 70.79 m^3/s (2,500 cfs), and a debris sluice. The total discharge capacity of the Vischer Ferry Hydroelectric Project is 402.1 m^3/s (14,200 cfs). Table 1 and Table 2 summarize the available data sources.

Table 1. USGS gaging stations.

USGS Station	Station Number	Stage (Gage Height)		Discharge		Water Temperature	
		Starting Date	End Date	Starting Date	End Date	Starting Date	End Date
Fonda	1349527	10/1/2014	Present	10/1/2015	Present	-	-
Amsterdam	1354083	1/16/2015	Present	1/16/2015	Present	-	-
Lock8 Downstream	1354330	12/14/2011	Present	-	-	12/11/2018	Present
Freeman's Bridge	1354500	1/6/2011	Present	8/6/2011	Present	-	-
Rexford	1355475	6/27/2014	Present	-	-	12/14/2018	Present
Vischer Ferry Dam	1356000	11/1/2014	Present	-	-	-	-
Schoharie Creek	1351500	10/1/2007	Present	10/1/1986	Present	-	-

Table 2. Canal Corporation gaging stations in the study reach.

Station	Stage	
	Starting date	End date
Lock 12 upstream	4/16/2015	Present
Lock 12 downstream	4/16/2015	Present
Lock 11 upstream	4/16/2015	Present
Lock 11 downstream	4/16/2015	Present
Lock 10 upstream	4/16/2015	Present
Lock 10 downstream	4/16/2015	Present
Lock 9 upstream	4/17/2015	Present
Lock 9 downstream	4/17/2015	Present
Lock 8 upstream	4/17/2015	Present

[1] Six regulation gates exist but only three are currently operational.

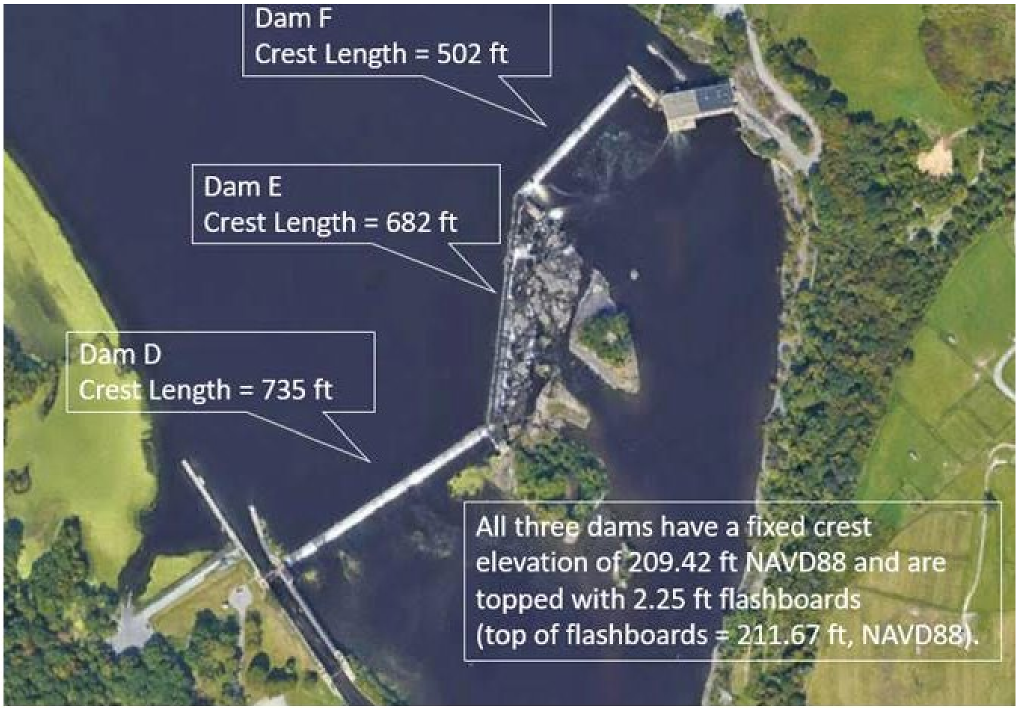


Figure 2. Vischer Ferry Dam – Existing Conditions

Four Vischer Ferry Dam modification alternatives are proposed by NYPA, as shown in Table 3. The main difference between these alternatives is the different permanent crest heights and two types of control structures with varying heights at Dam D to maintain the current impoundment elevation. Alternatives P-1, P-2, and P-3 include the 27-inch, 48-inch, and 72-inch crest gates, while alternative P-4 uses the 72-inch high hydraulic crest gate. Piers of differing numbers and sizes are required to support the crest gates and gates. The crest gates on Dam D will regulate the flow and ice discharges over the Dam to minimize the ice jam flooding potential along the river. A preliminary report in October 2022 (Huang and Shen 2022) showed Alternative P-4 increases the ice jam formation potential at the Dam due to the considerable hydraulic obstruction of the need for numerous wide gate piers. Therefore, Alternative P-4 is not considered in this report.

Figure 3 shows the design options for Dam D and crest gate arrangements at the Vischer Ferry Dam. The top elevation of the crest gates is equal to that of the existing Dam with fixed seasonal 27-inch flashboards (El. 211.67)[2]. Dam F consists of two 27-inch high crest gates, except for a section of 48-inch high crest gate near the north end to be used for fish passage and debris sluicing.

Figure 4 shows the finite element mesh grid with the crest gates on Dam D used in the model. Table 3 summarizes the crest gate and pier parameters. The width of the pier is insignificant compared to the crest gate width. Therefore, the effect of the pier size on the flow and ice transport

[2] All elevations refer to NAVD 88 unless otherwise stated. The conventional Datum for the Canal System is Barge Canal Datum (BCD), which is 1.58 feet higher than NAVD88.

would be negligible. The pier geometry is not included in the mesh. However, their resistance to the flow and ice movement is included in the model.

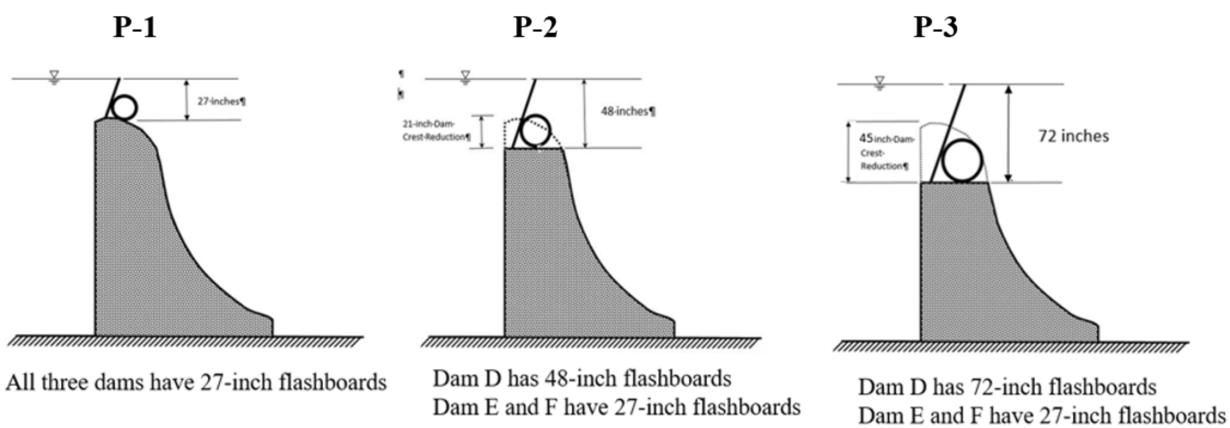
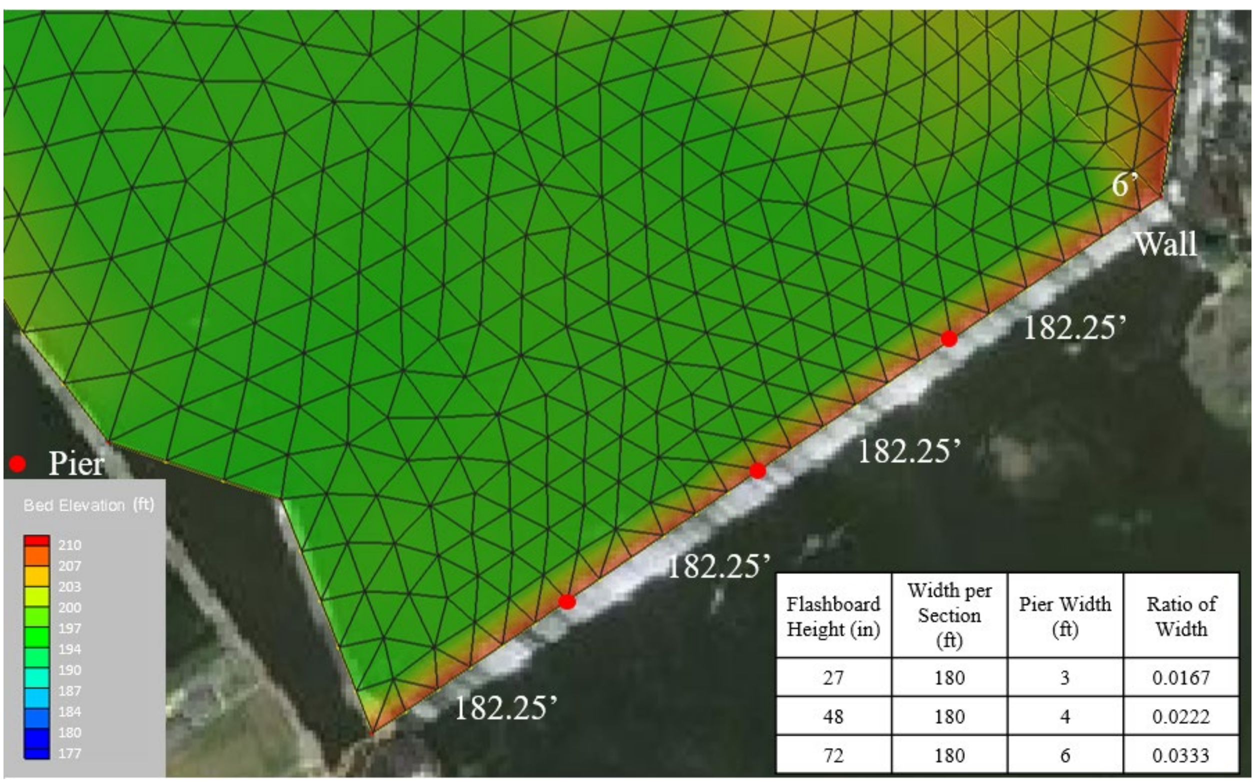


Figure 3. Three design options with pneumatic actuated crest gates installed on Vischer Ferry Dam.



Flashboard Height (in)	Width per Section (ft)	Pier Width (ft)	Ratio of Width
27	180	3	0.0167
48	180	4	0.0222
72	180	6	0.0333

Figure 4. Mesh grid at Dam D – Alternative P-1, P-2, and P-3 Crest Gates.

ALTERNATIVE NUMBER	DAM	CREST GATE DESCRIPTION	CREST GATE CONFIGURATION	TOTAL GATE WIDTH	TOTAL PIER & WALL WIDTH	TOTAL DAM LENGTH
P-1	D	27" High Pnuematically Actuated Crest Gate	4 Sections 180' with 3 Piers @ 3' and 6' of crest wall	720	15	735
P-2	D	48" High Pnuematically Actuated Crest Gate	4 Sections 180' with 3 Piers @ 4' and 3' of crest wall	720	15	735
P-3	D	72" High Pnuematically Actuated Crest Gate	3 Sections @ 180' plus 1 Section @ 160' with 3 Piers @ 6' and 17' of crest wall	700	35	735
P-4	D	72" High Hydraulically Actuated Crest Gate	7 Sections @ 95' with 8 Piers @ 8' and 6' of crest wall	665	70	735
P-1, P-2, P-3, P-4	E	27" High Pnuematically Actuated Crest Gate	3 Sections @ 220 ' with 2 piers @ 3' and 16' of crest wall	660	22	682
P-1, P-2, P-3, P-4	F	27" High Pnuematically Actuated Crest Gate	2 Sections @ 200' with 1 pier @ 3' and 3' of crest wall	400	6	502
		27" High Pnuematically Actuated Crest Gate	1 Section @ 20' for Fish Bypass with 2 piers @ 3'	20	6	
		48" High Pnuematically Actuated Crest Gate	1 Section @ 60' for Trash Sluice with 1 Pier @ 4' and 6' of crest wall	60	10	

Table 3. Modification Alternatives at Vischer Ferry Dam (Provided by WSP & A. Sumner).

2. Evaluation of Vischer Ferry Dam Modifications

Since the 2020-21 winter season, sheet ice-breaking operations have been implemented to break an open channel in the ice cover upstream of Vischer Ferry Dam, between Lock 7 and Western Gateway Bridge, to enhance the transport of breakup ice runs. Flow regulation at Vischer Ferry Dam by crest gates will further enhance the ice-breaking operation and the ice jam mitigation. Furthermore, the future winter strategy is anticipated to maintain the water level at the top of the crest gates with the crest gates fully closed. This full-pond condition will allow the ice-breaking operation to extend to Lock 8 and improve the ice transport by increasing the water surface gradient and the discharge past Dam D after all sections of Dam D crest gates are fully lowered. The typical low discharge, ranging between 56.6 m^3/s (2000 cfs) and 113.3 m^3/s (4000 cfs), throughout the winter, leads to insufficient flow depth over Dam D to flush the broken ice fragments. Temporarily suspending generation at the Vischer Ferry Hydroelectric Project can provide additional flow depth to convey the ice fragments over Dam D.

The three proposed alternatives presented in Figure 3 (P-1, P-2, and P-3) have the same Dam E and F configurations with crest gates up during winter but with different configurations on Dam D. The initial top elevations of Dam D, E, and F are the same with crest gates up. Alternative P-1 allows the operation of 27-inch high crest gates on Dam D. Alternative P-2 allows the operation of 48-inch high crest gates on Dam D. Alternative P-3 allows the operation of 72-inch high crest gates on Dam D.

The January 2018 ice jam event that inundated Stockade District is the baseline case for the Vischer Ferry Dam mitigation evaluation because it was the only event with sufficient field data for proper model calibration. This event has a recurrence period of about two years (Avery, 2022). Figure 5 shows the observed discharge at Fonda, Amsterdam, and Freeman's Bridge. The evaluation of the mitigation alternatives at the Vischer Ferry Dam consists of two stages, i.e., the pre-breakup stage with the ice-breaking operation and the breakup ice run stage during the breakup event. Stage 1 analyzes the ice and flow conditions with the ice-breaking operation during the pre-breakup period between January 1 and January 12, 2018. Stage 2 analyzes the ice run and jam conditions during the breakup event that occurred on January 13. The dam operation with different design alternatives is examined to allow the ice floes from the ice-breaking operation and the breakup ice run from upstream to pass the Dam.

Simulations are conducted for the three alternative configurations of Vischer Ferry Dam, shown in Table 3 and Figure 3, to evaluate the effectiveness in reducing ice jam formation and flooding potential. The operational strategy is to fully open (lower) the crest gates to flush ice over Dam D. In both stages 1 and 2, the simulation ends once the ice condition in the channel reaches a stable condition and ice transport over the Dam stops, or after the arrival of the peak discharge in stage 2. The following paragraphs provide details on the operations simulated in stages 1 and 2:

- Stage 1- Pre-breakup Period (January 1 to 12, 2018)

At the beginning of the run, all crest gates are fully raised, and the water level at the Dam is at the top of the crest gates. An ice breaker is deployed to break a track in the ice cover along the main flow path from Vischer Ferry Dam to Lock 8. The crest gates on Dam D, as described in Table 3, are fully opened for 2 hours to pass the ice fragments over Dam D. The Vischer Ferry Hydroelectric project generation is suspended.

- Stage 2 - Breakup Period

The crest gates are fully raised at the beginning of Stage 2. The initial water level remains at the top of the crest gates since the water level can be restored to the full pond level by fully closing the crest gates after the completion of Stage 1. The generation at the Vischer Ferry Hydroelectric project is suspended. The crest gates are lowered to the fully open position[3] starting at 3 am before the peak discharge approaches the Vischer Ferry Dam at 10 am, January 13, 2018. This intervention with the opening of the crest gates is expected to facilitate the ice movement passing the Knolls and over the Vischer Ferry Dam so that the ice jam flooding during the breakup period would be reduced. The crest gates on Dam E and F remain fully raised during the simulation.

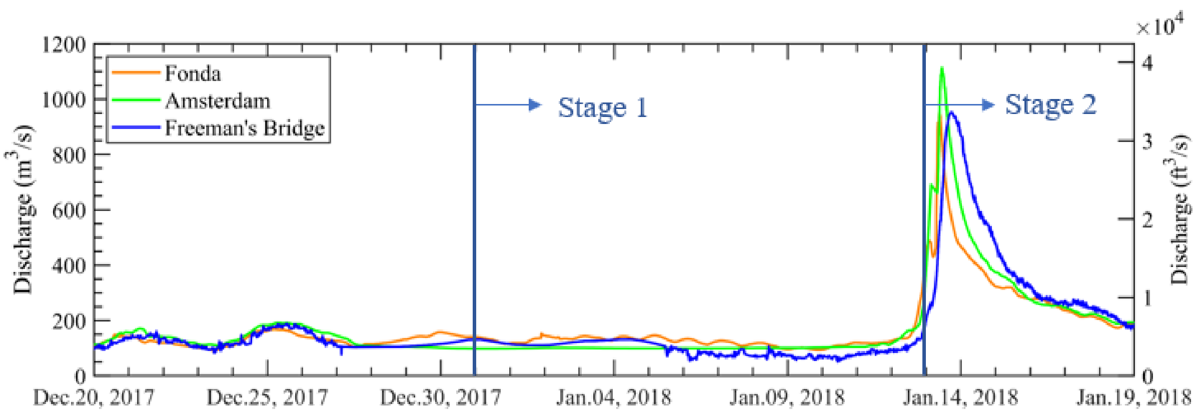


Figure 5. Observed discharges at Fonda, Amsterdam, and Freeman's Bridge.

[3] In this study, the duration of the crest gates operation is assumed to be 2 hours. This duration may be refined in the future.

2.1 Ice-breaking channel between Lock 7 and Lock 8

The Ice Jam Mitigation Panel proposes an ice-breaking path from Vischer Ferry Dam to Lock 8 to break up the sheet ice, as shown in Figure 6. The ice-breaking operation starts at the beginning of the ice-cover period and continues as needed throughout the winter until the breakup.

The freezing degree-day method (Shen and Yapa, 1985) for ice cover thickness is calibrated with the 2022 field data, as shown in Figure 7. The thickness of ice fragments in the ice-breaking channel is calculated to be 0.08 m (3 in) with periodic ice breaking in the channel during the winter.

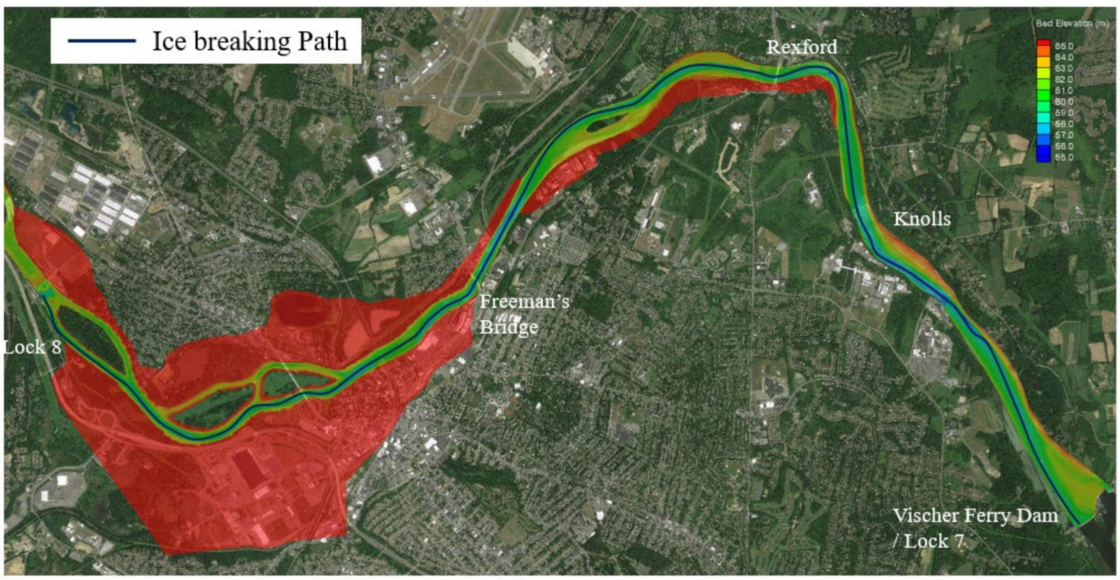


Figure 6. Ice-breaking path between Lock 7 and Lock 8. The red zone outside the river channel represents the floodplain coverage of the March 1914 breakup ice jam event, equivalent to the 500-year riverine damages (Avery, 2022).

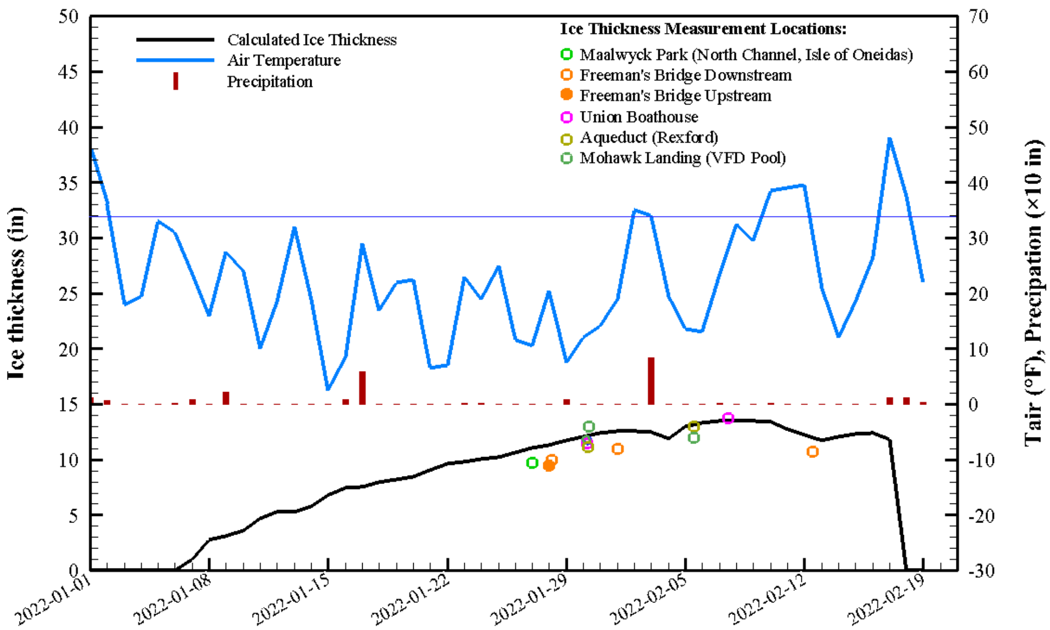


Figure 7. Calibrated ice thickness variation by degree-day method.

2.1.1 Stage 1 – Pre-breakup operations

Ice-breaking operation during the ice-covered period will produce an open channel of about 70% of the channel width by breaking the sheet ice in the main channel. Sheet ice remains on the right and left of the main channel. In the winters of 2021-22 and 2022-23, the ice breaker was deployed to break up the sheet ice once the ice cover formed in the head pond. Figure 8 to Figure 10 show the flow and ice conditions during the sheet ice-breaking operation.

Alternative P-1 (27-inch high crest gates): Figure 8 shows the ice fragment distribution during stage 1. Ice fragments can smoothly pass Dam D. No ice accumulation at Knolls or ice stoppage at Dam D. This is due to the moderate ice flow rate and mild water surface gradient at low discharge conditions. The force acting on the ice fragments is relatively uniform. Powerhouse discharge suspensions create sufficient flow depth for ice flow over Dam D.

Alternative P-2 (48-inch high crest gates): Ice fragments in the head pond can pass Dam D after fully lowering the crest gates. The channel contraction downstream of Knolls slows the ice movement. Ice fragments from upstream accumulate at Knolls but still can bleed downstream due to the increased water surface gradient, as shown in Figure 9. Ice fragments accumulate from Dam D to the downstream of Knolls after the discharge over Dam D decreases. Periodically raising and lowering the crest gates to restore pond level and discharge capability over Dam D would flush out the loose ice fragments to reduce the ice accumulation.

Alternative P-3 (72-inch high crest gates): In this case, the larger opening at Dam D leads to a steeper water surface slope than Alternative P-2 and enables flushing out more ice fragments at the early stage. Ice floes can pass the Knolls contraction to Vischer Ferry Dam. However, ice fragments accumulate from Dam D to the downstream of Knolls after the discharge over Dam D decreases, as shown in Figure 10. Periodically raising and lowering the crest gates can flush out the ice accumulations in the head pond.

Alternatives P-1 and P-3 benefit the downstream transport of ice fragments. Alternative P-1 results in slow and steady ice transport past Dam D. Alternative P-3 leads to fast ice transport past Dam D, due to the steeper water surface gradient. Alternative P-2 also provides benefits from the downstream transport of ice fragments. However, ice accumulation may occur at the contraction at Knolls when ice discharge exceeds ice transport capacity.

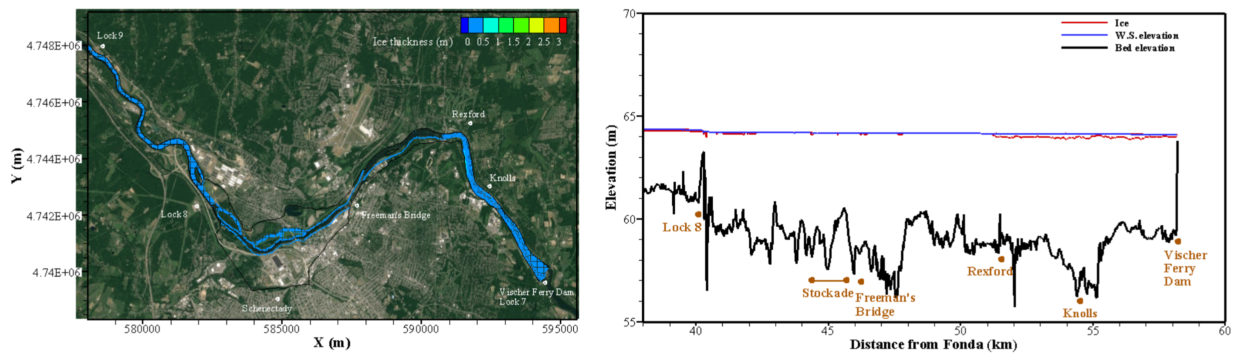


Figure 8. Simulated flow and ice conditions during the ice-breaking stage between Lock 7 and Lock 8– Alternative P-1.

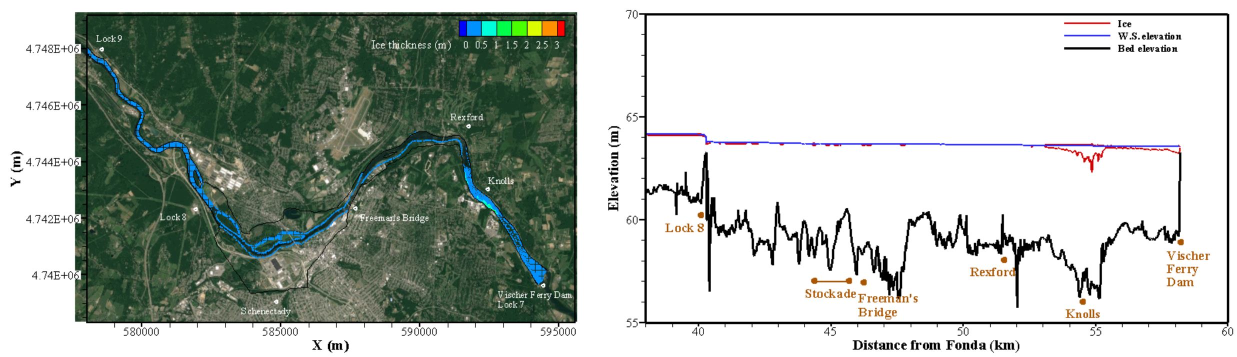


Figure 9. Simulated flow and ice conditions during the ice-breaking stage between Lock 7 and Lock 8– Alternative P-2.

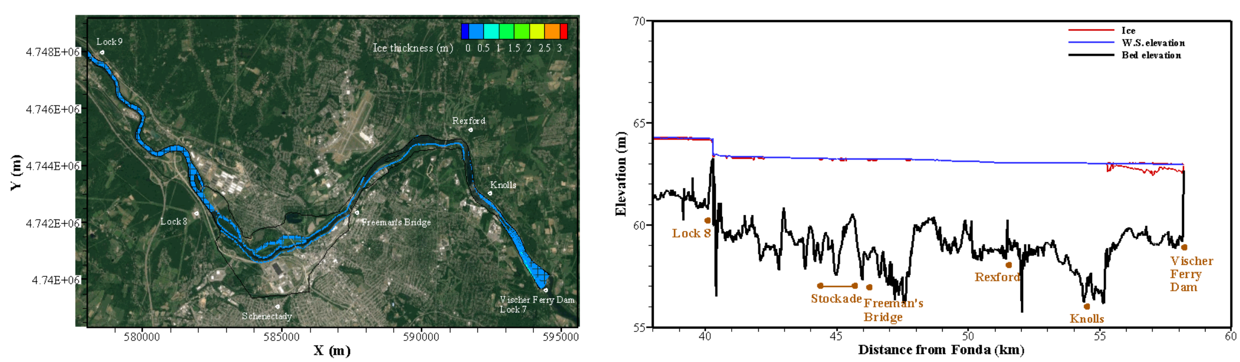


Figure 10. Simulated flow and ice conditions during the ice-breaking stage between Lock 7 and Lock 8– Alternative P-3.

2.1.2 Stage 2 – Interventions at Dam D during breakup ice run

Figure 11 through Figure 13 show the comparisons of simulated ice thickness between the baseline case and Alternatives P-1 to P-3. Figure 14 through Figure 16 show the comparisons of simulated flood depth between the baseline case and Alternatives P1-P3.

Alternative P-1: An open channel is established from the ice-breaking operation since the ice fragments can pass the Dam without accumulation. The peak ice discharge leads to a temporary thickening of ice floe accumulation in the Stockade area due to the narrow channel width, which causes minor flooding. The subsequent incoming peak ice discharge results in a temporary ice accumulation at Knolls and temporary ice jamming at Dam D. The breakup ice run can eventually pass Dam D, as shown in Figure 11, and the peak water level at Stockade is reduced. However, minor flooding occurs due to the thickening of the ice floe accumulation downstream of the Stockade area during the breakup ice run, as shown in Figure 14. The peak ice discharge, originating from the ice cover breakup upstream of Lock 8, exceeds the channel ice transport capacity of the reach between Stockade and Rexford. However, the ice jam flood is significantly reduced as most ice floes can flow unimpeded over the Vischer Ferry Dam. In addition, the suspension of the powerhouse discharge increases the flow discharge and ice transport capacity over Dam D.

Alternative P-2: Ice floes remain in the pool from ice-breaking operation past Dam D when the increasing water discharge arrives. Similar to Alternative P-1, temporary ice thickening in the Stockade and Knolls and temporary ice jamming in the pool occur, but to a lesser degree. Most ice floes can pass Dam D, as shown in Figure 12. Lowering the 48-inch high crest gates at Dam D promotes the ice discharge past the Stockade. However, the thickening of ice accumulation still occurs in the narrow reach near Freeman’s Bridge during the breakup ice run, resulting in flooding upstream, as shown in Figure 15.

Alternative P-3: Ice floes in the pool from ice-breaking operation pass Dam D when the high water discharge arrives. The breakup ice run can pass the Dam at the early stage, and the ice run past the Knolls contraction is easier than in Alternative P-2 due to the larger water surface gradient. The peak ice run leads to the ice jam formation in the pool, as shown in Figure 13. But the backwater of the jam to Stockade is significantly reduced. Similar to Alternatives P-1 and P-2, the thickening of ice accumulation still occurs in the reach near Freeman’s Bridge with minor flooding in Stockade District, as shown in Figure 16.

In summary, Alternative P-3 provides an increased gradient with the 72-inch high crest gates and the corresponding increased discharge capacity and associated velocities to transport ice floes past the most jam-prone location at Knolls. However, the high peak ice discharge may exceed the ice transport capacity through the head pond since the peak ice discharge lags the peak water discharge, which may cause ice accumulation in the head pond.

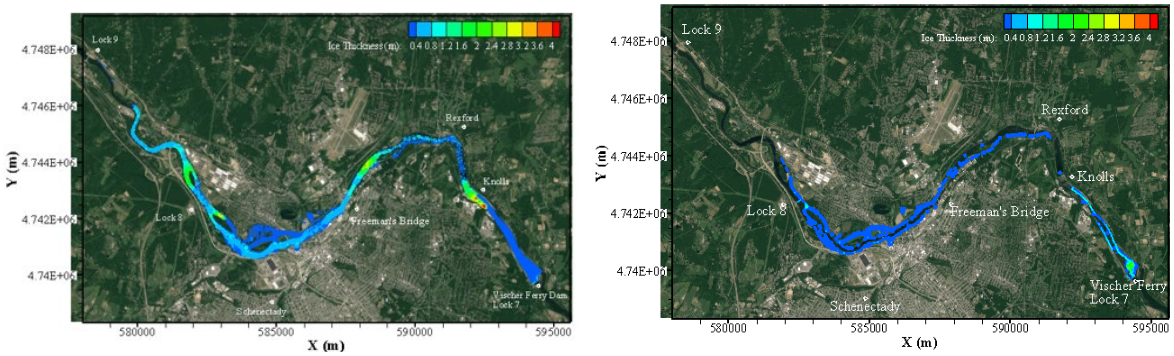


Figure 11. Comparison of Simulated ice thickness between Baseline and Alternative P-1 – breakup ice run. Left – Baseline; Right - Alternative P-1.

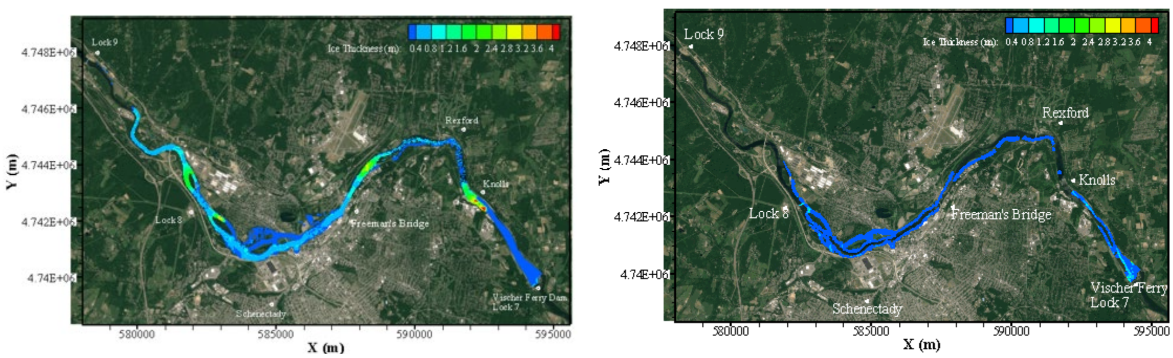


Figure 12. Comparison of Simulated ice thickness between Baseline and Alternative P-2 – breakup ice run. Left – Baseline; Right - Alternative P-2.

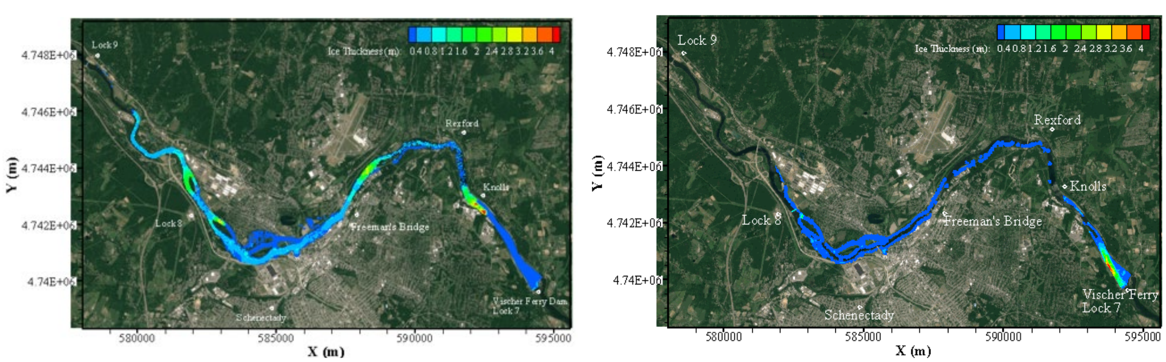


Figure 13. Comparison of Simulated ice thickness between Baseline and Alternative P3 – breakup ice run. Baseline; Right - Alternative P-3.

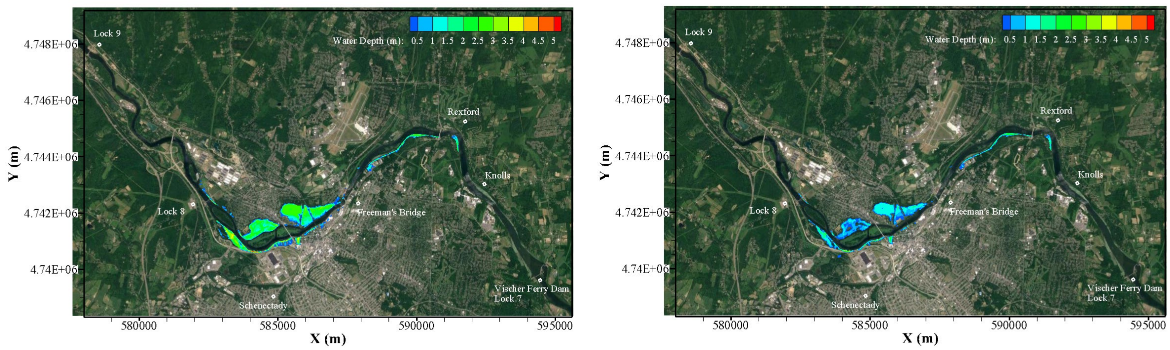


Figure 14. Comparison of Simulated flood depth between Baseline and Alternative P1 – breakup ice run. Left – Baseline ; Right - Alternative P-1.

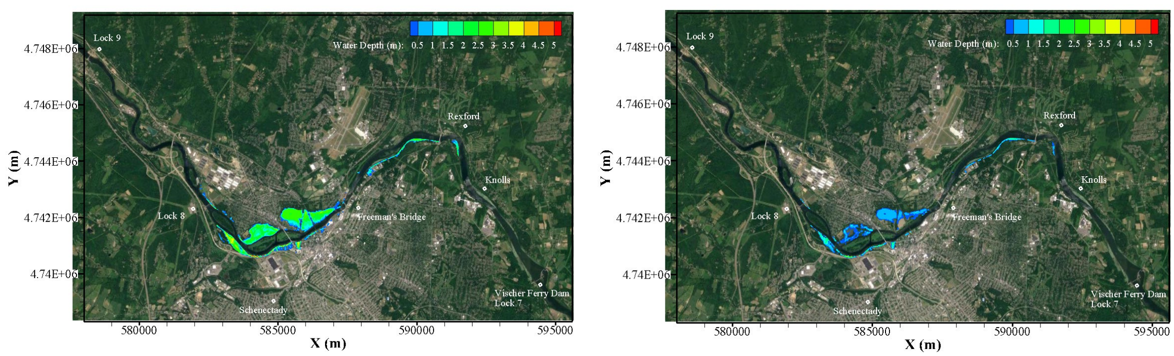


Figure 15. Comparison of Simulated flood depth between Baseline and Alternative P2 – breakup ice run. Left – Baseline ; Right - Alternative P-2.

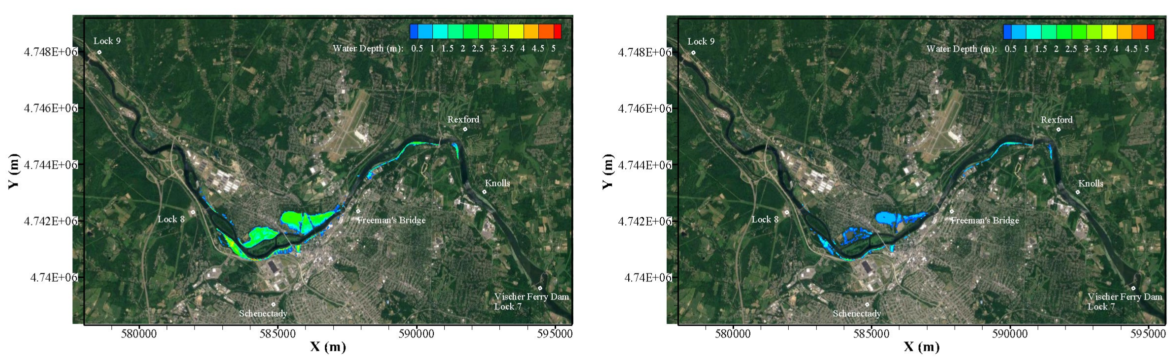


Figure 16. Comparison of Simulated flood depth between Baseline and Alternative P3 – breakup ice run. Left – Baseline; Right - Alternative P-3.

2.1.3 Summary

Comparison of the simulated peak water surface profiles for the three mitigation alternatives, as shown in Figure 17, are summarized in Table 4. Ice breaking between Lock 7 and Lock 8 provides a path for the breakup ice run. All alternatives result in the reduction of peak water levels and reduced flood inundation. The water level at Stockade District remains lower than the no-damage elevation of 223 feet. Alternative P-3 with 72-inch high crest gates fully open provides the lowest peak water level in the Stockade District. The larger opening of the crest gates leads to more flooding reduction. Powerhouse discharge suspensions create extra flow depth for ice to pass over the Dam, especially for Alternative P-1. The ice fragments remaining in the pool from the ice-breaking operation have little effect on the breakup ice run because the increased breakup flow discharge can flush out most ice fragments in the pool before the breakup ice run arrival. During the breakup period, flooding can occur in the Stockade area due to the temporary thickening of ice floe accumulation in the reach between the Stockade and Maritime Center from the breakup ice run. However, the flood area and depth are substantially reduced compared to the baseline case. Table 4 shows the maximum drawdown below the top of the crest gates of Alternatives P-1, P-2, and P-3 are 3 in, 15 in, and 18 in, respectively.

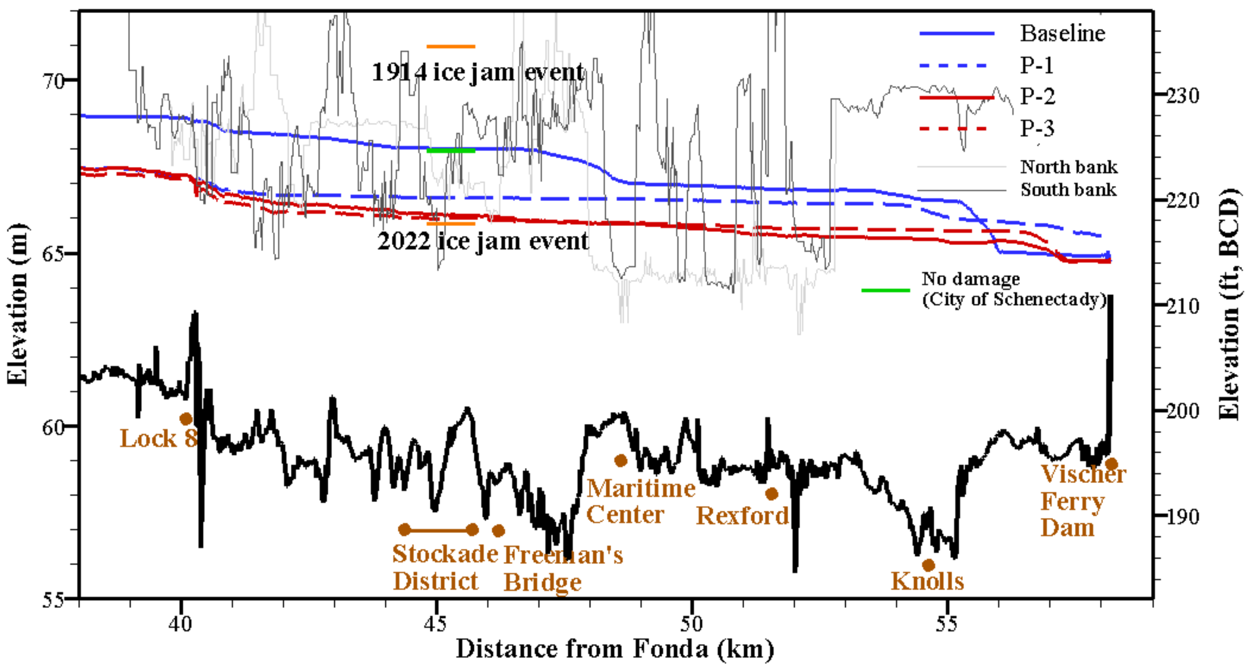


Figure 17. Comparison of simulated peak water level profiles between the Baseline case and Alternatives P-1 through P-3. Note: No Damage elevation of approximately 223 ft (NAVD88)/ 224.58 ft (BCD) represents the grade elevation at the foundation wall, provided by the City of Schenectady to NYPA in informal email communication. Some basements may be flooded at this elevation, but additional topographic elevation is needed if this approximate value is to be refined.

Table 4. Breakup operation with the ice-breaking channel between Lock 7 and Lock 8 for Alternatives P-1 to P-3.

	Reduction of peak water level at Stockade (ft)	Reduction of Inundation for the entire floodplain (%)	Reduction of Inundation at Stockade (%)	Maximum water level drawdown at VFD below the top of crest gates (in)	Minimum water level at VFD (ft, BCD)
2018 Jan. Event Calibration/Baseline	0/223.0	0	0	-	210.86
Alternative P-1	-4.42	31.7	78.0	3	212.98
Alternative P-2	-6.05	51.0	86.3	15	212.02
Alternative P-3	-6.41	54.2	86.3*	18	211.76

* *Flood depth in Alternative P-3 is less than that in Alternative P-2.*

2.1.4 Discussion

The FERC licensing requires the minimum flow downstream of the Vischer Ferry Project as 5.7 m^3/s (200 cfs) through the generating units, trash sluice gates, or spilled over the Dam. This requirement is satisfied for all three alternatives in the ice-breaking and breakup periods because the suspension of powerhouse discharge leads to sufficient flow over the crest gates or the dam crest. Another potential requirement is that the pond level is maintained within 6 inches of the existing dam crest level year around. This requirement is assumed to be applied for future operations with crest gates installed. Under normal operations, the water level will be maintained at/near the top of the crest gates. The amount of allowable drawdown will be further investigated in the next phase of work and discussed between FERC and NYPA. Table 5 summarizes the evaluations of the minimum water level for each alternative. Figure 18 and Figure 19 show the water level variations at Vischer Ferry Dam during Stages 1 and 2, respectively.

Alternative P-1: During Stage 1, the water level at Vischer Ferry Dam remains above the minimum requirement after fully opening the crest gates. The maximum drawdown below the top of the crest gates is 5 in, as shown in Figure 18. During Stage 2, the water level at Vischer Ferry Dam generally increases due to the arrival of the increasing flow discharge on the rising limb, except for a short period of drawdown caused by the crest gate operations. The water level at the Dam later decreases to slightly above the minimum requirement during the ice accumulations and releases at Knolls and in the pool for 9 hours while the peak ice run enters the head pond and passes the Dam. The jams substantially reduce the discharge to the head pond and the water level at the Dam. The jam in the head pond upstream of Dam D diverts the flow to Dam E and Dam F, which enables the water level at Vischer Ferry Dam to remain above the minimum requirement. The maximum drawdown below the top of the crest gates is 3 in, as shown in Figure 19 and Table 4. The subsequent release of ice accumulations leads to the increasing water level at the Dam. The water level at the Dam gradually decreases as the inflow discharge decreases on the recession limb.

Alternative P-2: During Stage 1, the water level at Vischer Ferry Dam remains below the minimum requirement due to low inflow discharge after fully opening the crest gates. The maximum drawdown below the top of the crest gates is 12 in, as shown in Figure 18. During Stage 2, the water level at the Dam decreases below the minimum requirement shortly after the peak flow passes the Dam. The maximum drawdown below the top of the crest gates is 15 in, as shown in Figure 19 and Table 4. Peak ice run leads to ice accumulations at Knolls and in the pool, which reduces the discharge to the head pond and further decreases the water level at Vischer Ferry Dam. Fluctuations in the water level during the release of ice accumulations exist. The water level at Vischer Ferry Dam gradually decreases as the inflow discharge decreases on the recession limb. It is noted that raising the crest gates will restore the water level in the pool once the ice accumulations release past Dam D after the breakup event.

Alternative P-3: During Stage 1, the water level at Vischer Ferry Dam remains below the minimum requirement due to low inflow discharge after fully opening the crest gates. The maximum drawdown below the top of the crest gates is 20 in, as shown in Figure 18. During Stage 2, the water level at the Dam decreases below the minimum requirement shortly after fully opening the crest gates. The duration of the water level lower than the minimum requirement was about 17 hours. The maximum drawdown below the top of the crest gates is 18 in, as shown in Figure 19 and Table 4. The peak ice run led to ice accumulation in the pool, which reduced the discharge to the Dam and the water level at the Dam. Fluctuations in the water level are due to the ice release and accumulation at the Dam. The jam formation in the head pond against Dam D diverts the flow to Dam E and Dam F. The water level at Vischer Ferry Dam remains high and stable. If a cold weather period is forecasted after the breakup event, it is recommended to alternatively raise and lower the crest gates to flush out the jam in the pool and maintain the full pond level. This operation will reduce the potential of ice jamming in the second breakup event.

In summary, the water level at Vischer Ferry Dam satisfies the minimum requirement in both stages 1 and 2 with Alterative P-1. The water level at Vischer Ferry Dam remains lower than the minimum requirement due to low inflow discharge during Stage 1 with both alternatives P-2 and P-3. During Stage 2, Alternative P-2 leads to the water level being lower than the minimum requirement because of the increased flow and ice discharge capacity. Alternative P-3 satisfies the minimum water level requirement due to the ice jam formation at Dam D but is more likely to violate the requirement if the ice jam is released. Fully raising the crest gates after the completion of the operations will restore the full pond level. A separate simulation run indicates that it takes about 6, 8, and 12 hours, corresponding to Alternatives P-1, P-2, and P-3, respectively, to fill the pool to reach the water level at the top of the crest gates after the powerhouse suspension, based on the 2018 Stage 1 discharge condition. The duration to restore the full pond level varies depending on the inflow discharge and will be shorter on the recession limb of the post-breakup event.

Table 5. Minimum water level requirement evaluation.

	Is the water level maximum requirement of 6-inch drawdown satisfied?	
	Stage 1	Stage 2
Alternative P-1	Yes.	Yes.
Alternative P-2	No, due to low inflow discharge. The water level remains lower than the minimum requirement shortly after the crest gates are fully lowered.	Temporarily lower for 38 hours
Alternative P-3	No, due to low inflow discharge. The water level remains lower than the minimum requirement shortly after the crest gates are fully lowered.	Temporarily lower for 17 hours. The water level above the minimum requirement starting from the later stage of the breakup event was due to the ice jam formation at the Dam.

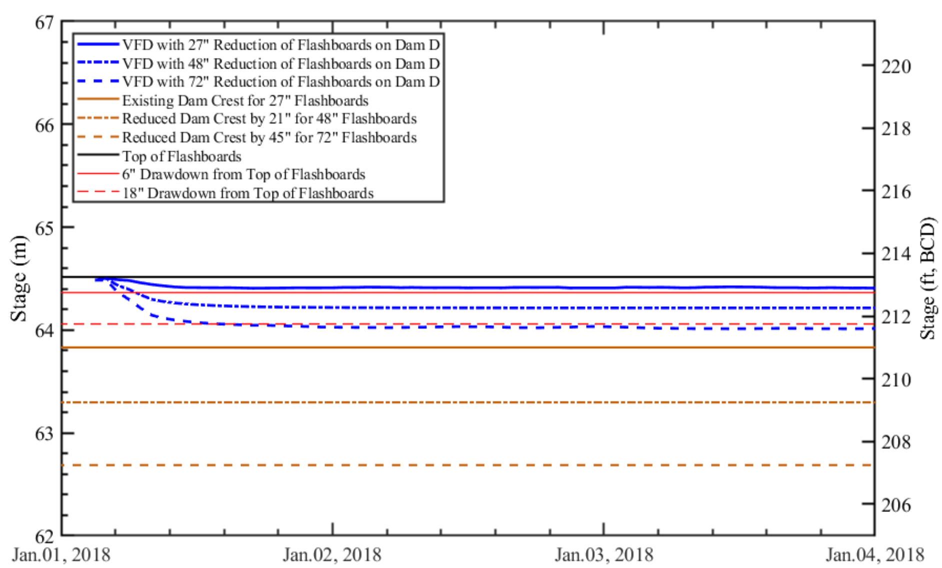


Figure 18. Simulated water level variations at Vischer Ferry Dam with Alternative P-1 to P-3 during Stage 1.

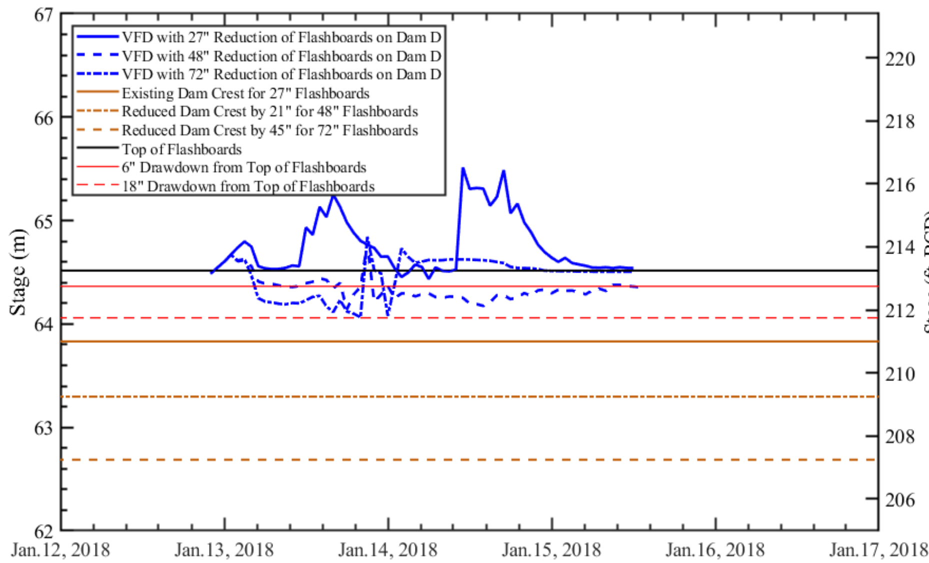


Figure 19. Simulated water level variations at Vischer Ferry Dam Alternative P-1 to P-3 during Stage 2.

Additional evaluations of reducing the 27-inch high crest gates by 6, 15, and 21 inches are conducted to minimize the duration of the minimum water level requirement violation. Both Stage 1 and Stage 2 are simulated. These simulations indicate that the ice fragment from the ice-breaking operation can move past Dam D without ice accumulations after lowering the crest gates by 6, 15, and 21 inches, respectively.

Figure 20 to Figure 22 show the simulated ice thickness and flood depth of these three additional cases during Stage 2. The ice condition and flood inundation are similar in these three cases. The front of the breakup ice run can pass Dam D but stop with the arrival of the peak ice discharge. Ice jams form at Knolls and in the pool due to insufficient ice transport over Dam D. The temporary thickening of ice accumulation in the Stockade area due to the reduction of effective channel width causes flooding. The temporary thickening of ice accumulation and downstream jamming caused minor flooding at Stockade. The relatively small reductions of the crest gates by 6, 15, and 21 inches, respectively, allow to flush out the ice fragments from the ice-breaking operation and reduce the ice jam flooding potential in the Stockade area during the breakup. However, ice jams form at Knolls and in the pool due to the insufficient ice transport capacity of Dam D.

Figure 23 and Figure 24 show the simulated water level variation at Vischer Ferry Dam for these three additional cases. With the reduction of crest gates by 6, 15, and 21 inches, the water level at Vischer Ferry Dam remains above the minimum required water level during stages 1 and 2. The temporary generation suspension at the powerhouse provides favorable flow conditions at Vischer Ferry Dam. During the breakup ice run, the fluctuation in water level at Vischer Ferry Dam is due to the formation and release of the ice jams at Knolls and in the head pond. The water level recovers to a relatively stable condition when the ice jams reach the equilibrium state. At the end of the breakup ice run, the crest gates can be fully raised to minimize further development of the jam, followed by an ice breaker and operation of the crest gates to clear the ice accumulation after the breakup event.

Figure 25 shows these three alternatives provide similar outcomes for ice jam mitigation and water level reduction. Table 6 shows that a larger reduction of the crest gate height provides greater peak water level and flood inundation reductions. However, a larger reduction of the crest gate height leads to a larger drawdown at the Dam. The maximum water level drawdown below the top of the crest gates for different crest gate height reductions is summarized in Table 6.

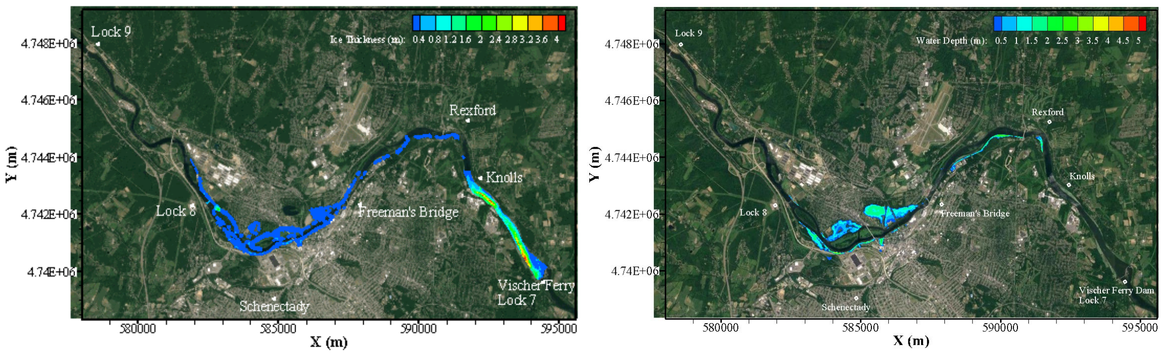


Figure 20. Simulated ice thickness and flood depth – Reduction of crest gates by 6 inches.

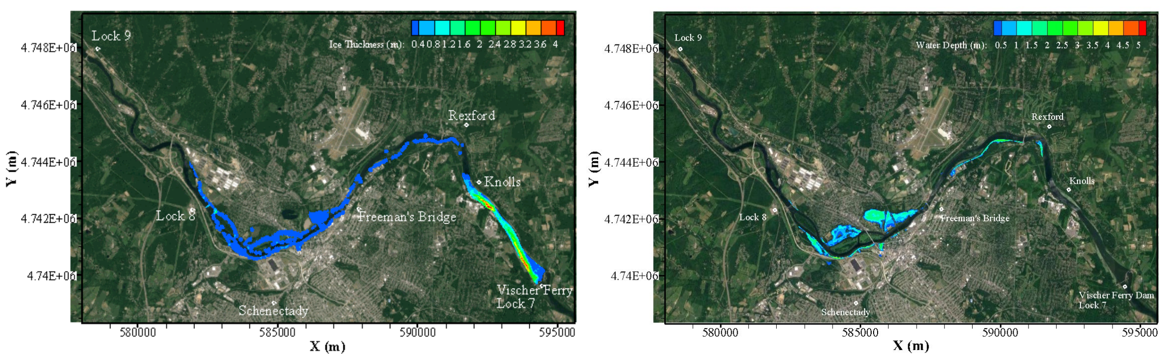


Figure 21. Simulated ice thickness and flood depth – Reduction of crest gates by 15 inches.

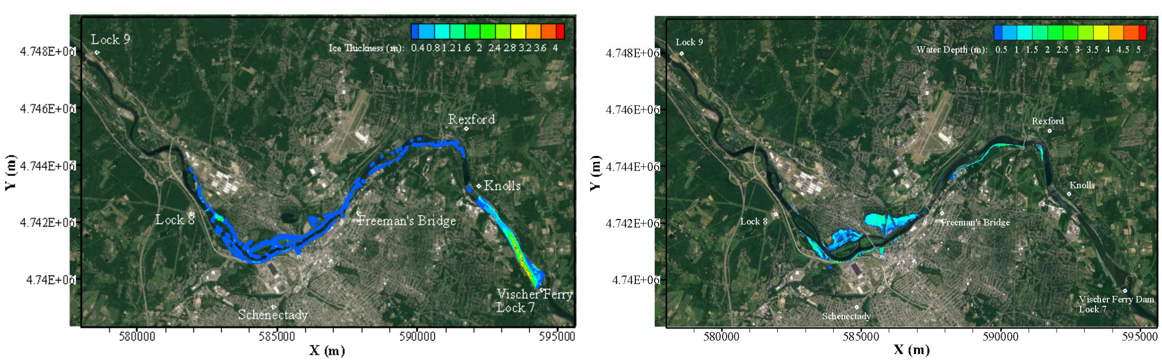


Figure 22. Simulated ice thickness and flood depth – Reduction of crest gates by 21 inches.

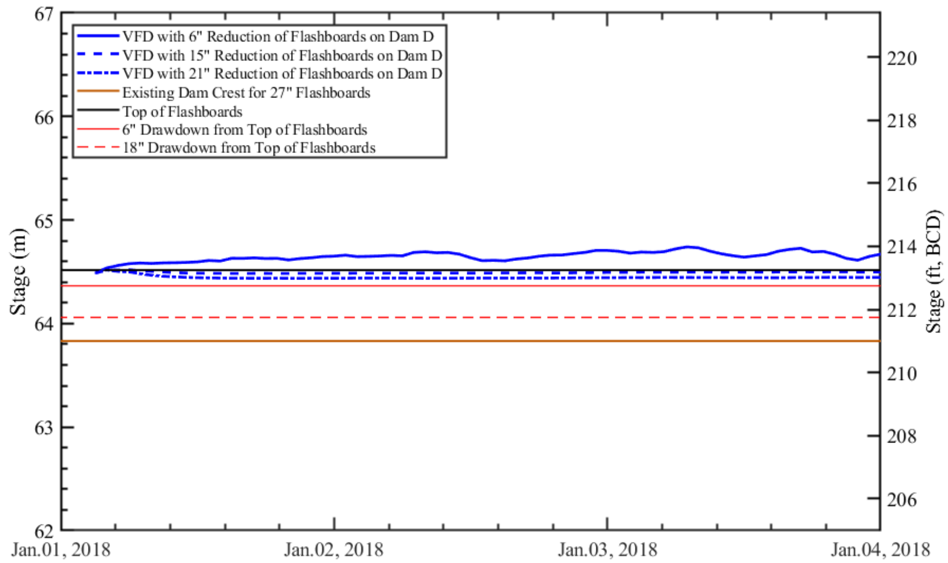


Figure 23. Simulated water level variations at Vischer Ferry Dam with smaller reductions of the crest gates during Stage 1.

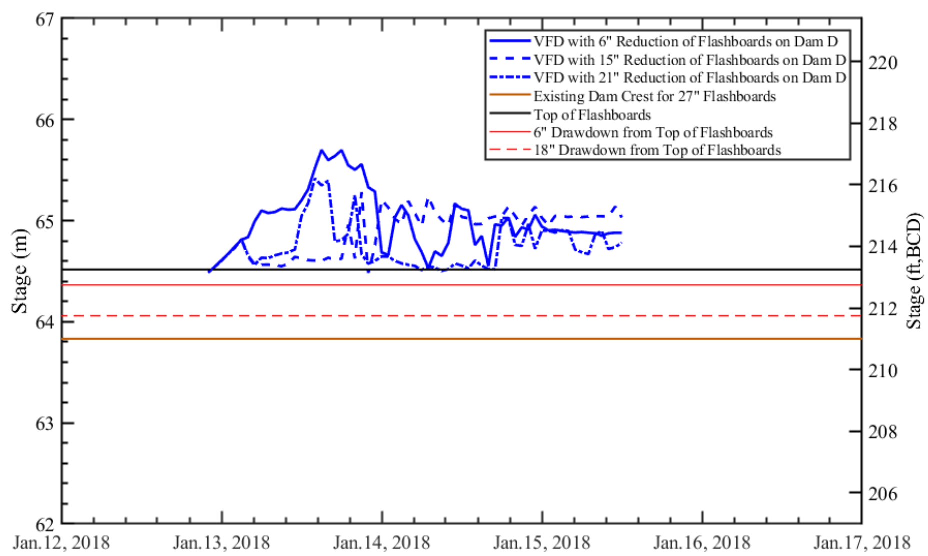


Figure 24. Simulated water level variations at Vischer Ferry Dam with small reductions of the crest gates during Stage 2.

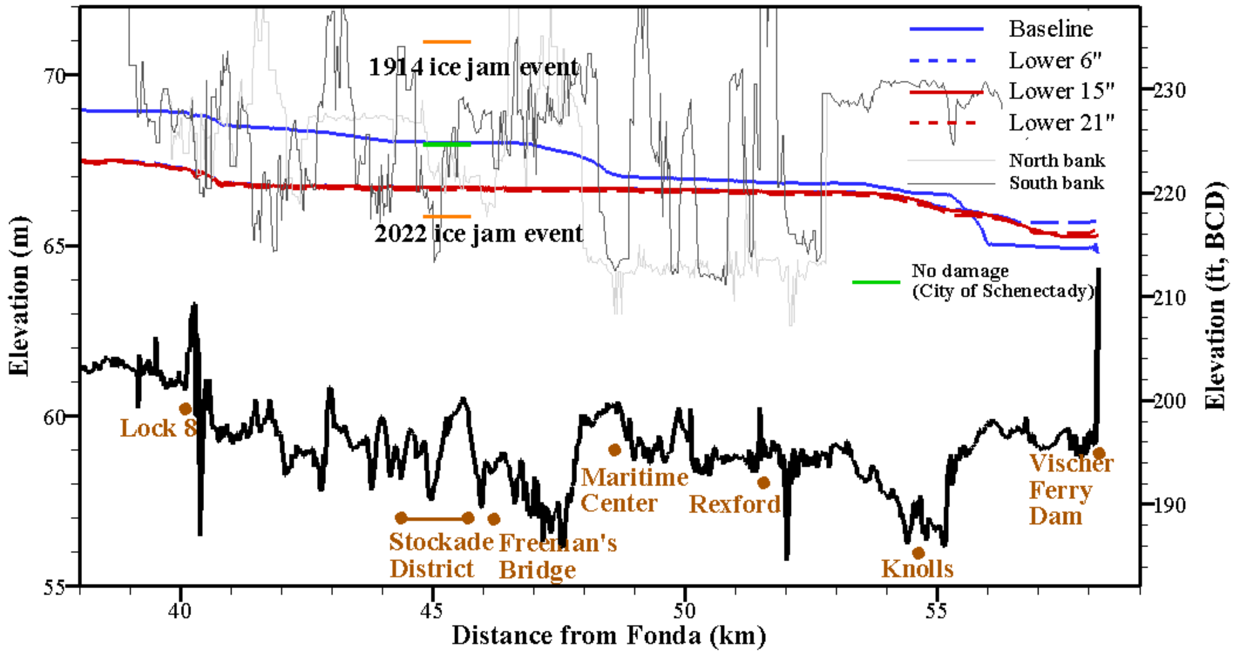


Figure 25. Comparison of simulated peak water level profiles between the baseline case and reduction of the crest gates by 6, 15, and 21 inches, respectively.

Table 6. Breakup operation with the ice-breaking channel between Lock 7 and Lock 8 for all of the alternatives.

Crest gates lowered by (in)	Reduction of water level at Stockade (ft)	Reduction of inundation for the entire floodplain (%)	Reduction of inundation at Stockade District (%)	Maximum water drawdown at VFD below the top of crest gates (in)	
				Stage 1	Stage 2
6	-4.13	28.7	78.0	-6*	1
15	-4.14	28.4	75.9	1	1
21	-4.34	30.7	78.0	3	1
27 (P-1)	-4.42	31.7	78.0	5	3
48 (P-2)	-6.05	51.0	86.3	12	15
72 (P-3)	-6.41	54.2	86.3	20	18

Note: The January 2018 ice jam event with inundation at Stockade District is the baseline for calculating the peak water level and inundation reduction.
* The 6-inch reduction of the crest gates doesn't cause the water level reduction at Vischer Ferry Dam.

3. Summary and Conclusions

This report presents a river ice model study evaluating the effectiveness of Vischer Ferry Dam modification alternatives and the in-channel ice-breaking during the winter to minimize ice jam flooding risk in the lower Mohawk River. The analysis shows that ice breaking throughout the winter is essential to reduce the ice run mass and increase the ice transport capacity during a breakup event. The proposed Vischer Ferry Dam modifications will enhance the ice-breaking operation by reducing ice fragments in the channel before the breakup and promoting ice transport over the Dam during the breakup ice run. During the pre-breakup period, the combination of sheet ice breaking, suspension of the powerhouse discharge, and flow regulation at Vischer Ferry Dam to flush ice fragments over the Dam would establish an open channel in anticipation of the breakup ice run. The typical low-flow discharge in winter ranges between 2,000 cfs and 4,000 cfs. The suspension of the powerhouse discharge can provide sufficient flow depth, approximately 1.75 feet, to convey the ice fragments over the Dam. The model evaluation shows that each proposed dam modification alternative resulted in different degrees of peak water level and flood inundation reduction.

The requirement of a minimum discharge of 5.7 m^3/s (200 cfs) passing the Vischer Ferry Project can be satisfied with the mitigations in both stages. However, the minimum water level reduction within 6 inches at the Vischer Ferry Dam may be violated with the proposed alternatives P-2 and P-3 due to low inflow discharge during the ice-breaking operation. Alternative P-1 generally satisfies the minimum water level required in both stages. Alternatives P-2 and P-3 will lead to a more than 6 inches reduction of water level at the Dam during the breakup period with maximum drawdown by 15 in and 18 in, respectively. Once the ice accumulations are released over the Dam, raising the crest gates will restore the pool level. Alternative P-3 provides the most ice mitigation outcome and ice jam risk reduction. However, the resulting water level reduction exceeds the allowable drawdown, and ice jam forms at Vischer Ferry Dam. Alternative P-2 also results in the violation of the allowable drawdown. Therefore, Alternative P-1 is considered the preferred alternative with favorable ice jam flooding mitigation and satisfaction of the minimum requirement on the water level at Vischer Ferry Dam.

Additional evaluations with smaller reductions of the crest gates by 6, 15, and 21 inches showed the effective reduction of upstream ice jam potential and water levels. The requirement of a minimum discharge passing the Vischer Ferry Project can be satisfied in both stages. These three reductions of the crest gates meet the minimum water level requirement in both stages. However, ice jam formations can still occur at Knolls and in the head pond.

Since the evaluation of the mitigation alternatives is based on the January 2018 breakup event, factors and conditions that could occur in a different event should be considered in selecting the alternative in the final design. The 1996 breakup event was a very severe ice jam flooding event, with an unusually thick ice cover of over 15 in., and an exceptionally high breakup discharge of 92,600 cfs (Lederer and Garver 1999). In 2018, two breakup events occurred in the winter. First, on Jan. 24-25, a breakup ice run from Schoharie Creek into the Mohawk created an ice jam against the refrozen ice jam from the January 13 breakup event. Another breakup event occurred in late February. In the 2020-21 winter, the attempt to extend the ice-breaking operation to Lock 8 failed due to the shallow water depth downstream of Lock 8, resulting from the low discharge condition associated with the non-navigation season removal of the fixed crest gates. These are just a few examples showing that a mitigation alternative with more flexible operational capability is desirable, which is especially important with potentially more extreme flow and ice conditions associated with climate change in the future.

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