Technical Memo

WENCK

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To: Scott Ruiter, TLID
Dan Cibulka, Sherburne SWCD

From: Lu Zhang, Wenck Associates, Inc.

Date: October 21, 2020

Subject: Briggs Chain Stabilization

Residents on the Briggs-Julia-Rush Lake Chain experience frequent periods of high water resulting in localized flooding and observance of a No Wake Ordinance. The main goal for this Briggs Lake Chain area is water level stabilization.

Upon reviewing the existing DNR XPSWMM model and water balance of the area, we concluded that Bayou channel flow stage can be highly correlated to the exceedances of the No Wake Zone elevations in the lake chain. The Briggs Lake Chain and the section of Elk River between Bayou channel to Elk Lake outlet acts like a soup bowl that excess water from Elk River will find ways to back into the system causing high water level conditions in the lake chain. We evaluated the following scenarios (Figure 1) with the additional survey data in 2020 and DNR XPSWMM model in this study:

- Existing
- Upstream Wetland B: Impoundment
- Cover Crops
- Additional
    - Upstream Wetland A: Excavation
    - Bayou and Lily Creek Storage
    - County Land Purchase
    - Additional Wetland Storage
    - Elk Lake outlet
- Summary and Recommended Next Steps

Detailed discussion is in the later sections. We also included a section on areas that we have discussed and decided to be less feasible.

Figure 1. Briggs Lake Chain Storage Areas

2019 Monitoring Data

Additional flow and water level data was collected in 2019 to provide more insight on the connectivity of Bayou. Bayou channel elevation varied from 963.06 ft to 967.06 ft in 2019.

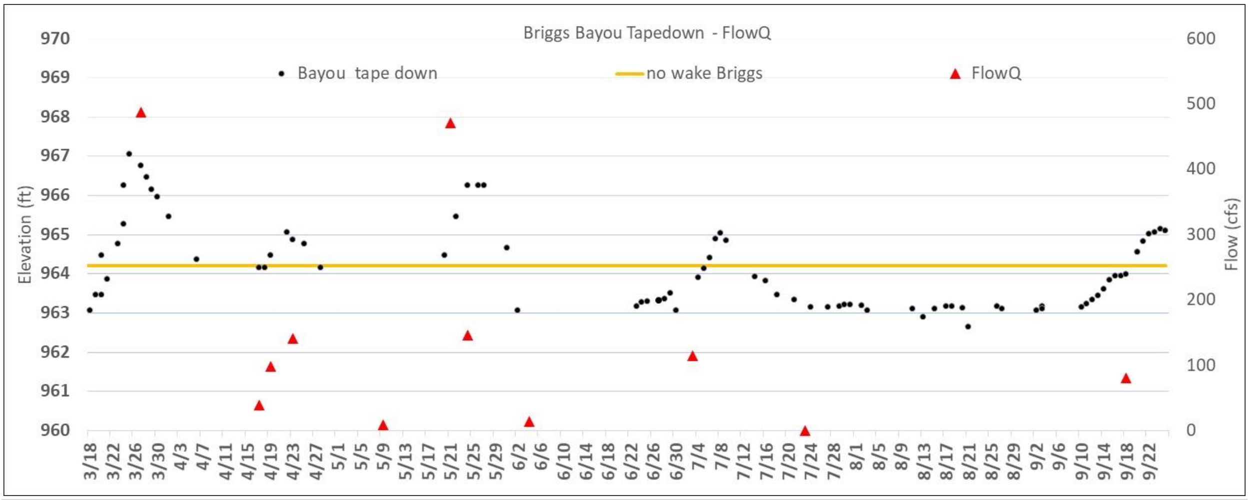


Figure 2. Briggs Lake Chain Bayou Channel Tape-down Measurements in 2019

No observation of the channel being dry in 2019. Figure 2 shows the tape-down monitoring at Bayou bridge. Visually, Bayou stage is correlated with the flow in the channel. Although there is not enough information to determine when the channel will connect/disconnect, 2019 is proven to be the year where the channel is mostly connected, bringing water into Briggs Lake chain.

XPSWMM Model Updates

XPSWMM was the main model used to evaluated 3 out of the 4 scenarios. Elk River XPSWMM model was obtained from the DNR. The model extent covers the entire Elk River reach within Sherburne County, starting from the Sherburne County boundary on the north to Lake Orono.

To provide the model with the correct information, Sherburne County SWCD surveyed the following locations in the spring of 2020:

- Bayou channel: bridge profile, upstream cross-section, downstream cross-section
- Lily Creek: Rush outlet, bridge profile, channel cross-section
- Elk River: Elk Lake outlet cross-section (2X)

The model was updated using the survey information and LiDAR and the major updates include:

- Adding bridge link to Bayou channel and updating channel bottom elevation up and downstream of the bridge using survey information
- Adding bridge link to Lily Creek and updating Rush Lake outlet using survey information
- Adjusting Lily Creek cross-section based on LiDAR data
- Adjusting Elk Lake storage curved based on LiDAR data

Summary of Scenarios

The model used Atlas 14 precipitation data, the 2-, 10-, 100-year rainfall, and 10-day snowmelt depth are summarized as below. In addition, a 1-in event is modeled for the scenarios.

Table 1. Rainfall Depth of Modeled Return Events

Return Event	Depth (in)
1-in 24-hr	1.00
2-yr	2.84
10-yr	3.50
100-yr	6.00

Existing

This is the current condition of the Briggs lake chain system. The model suggests that backwater from Elk River flows into the system through Bayou channel.

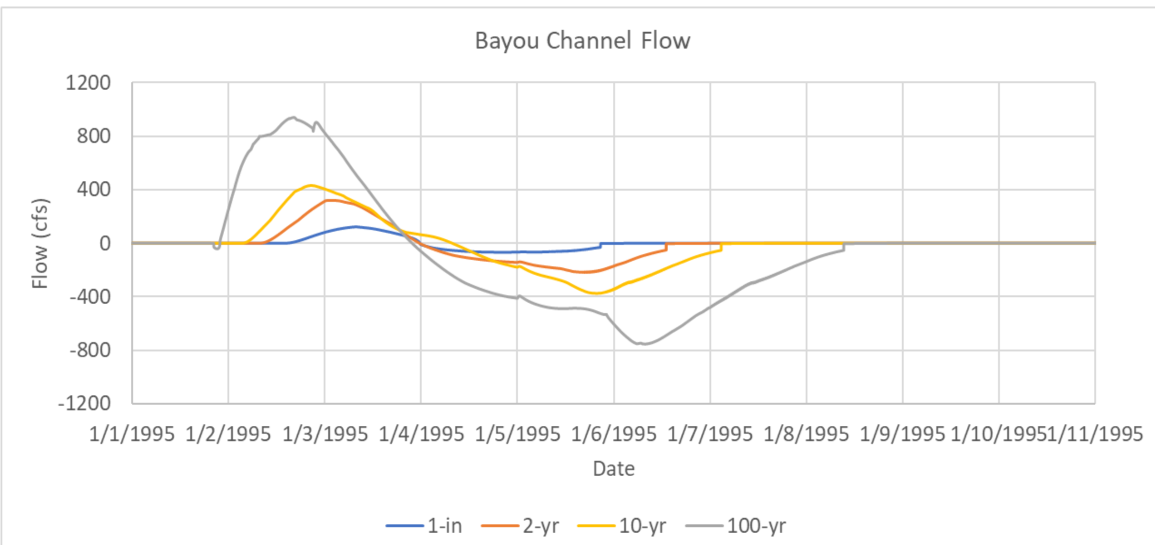


Figure 3. Bayou Channel Flow Under Different Return Events

In Figure 3, the area above the flow 0 axis represents flow going into Briggs Lake from Elk River; the area below the flow 0 axis means flow going into Elk River from Briggs Lake. The graph shows that when storm happens, for the first 3 days, most of the flow will go into Briggs Lake, causing the lake levels to rise and stay high. For the next 2 weeks, the lake levels will gradually drop back as the water leaves the lake chain system.

We calculated the amount of water going to the Briggs Lake Chain for the first 3 days (curve above flow 0 axis) under various return events. The table below summarizes the volume. Considering the volume of the backflow, it is more feasible to find storage for up to the 2-yr event. Therefore, we will evaluate the 1-in 1-hr event and the 2-year event in the following scenarios.

Table 2. Volume of Water Discharged into Briggs Lake Chain and Corresponding Lake Level

Return Event	Depth (in)	Volume (ac-ft)	Max Briggs Lake Level (ft)
1-in 1-hr	1.00	204	965.176
2-yr	2.84	590	966.122
10-yr	3.50	914	966.912
100-yr	6.00	2,281	969.689

The Ordinary High Water Level for Briggs, Julia and Rush is the same at 964.2 ft. The existing condition model results indicated that even when the watershed receives a 1-in rainfall in an hour, the Briggs-Julia-Rush Lake chain will exceed the No Wake Zone elevation by 1 foot. The following scenarios will evaluate both the maximum lake level on Briggs Lake Chain and the duration of high water level in the lake chain.

To compare to the total Elk River discharge, the following graph is generated at County Road 6, upstream from the Bayou channel (Figure 4). The volume of the water discharged from the upstream of Elk River is summarized in the table below:

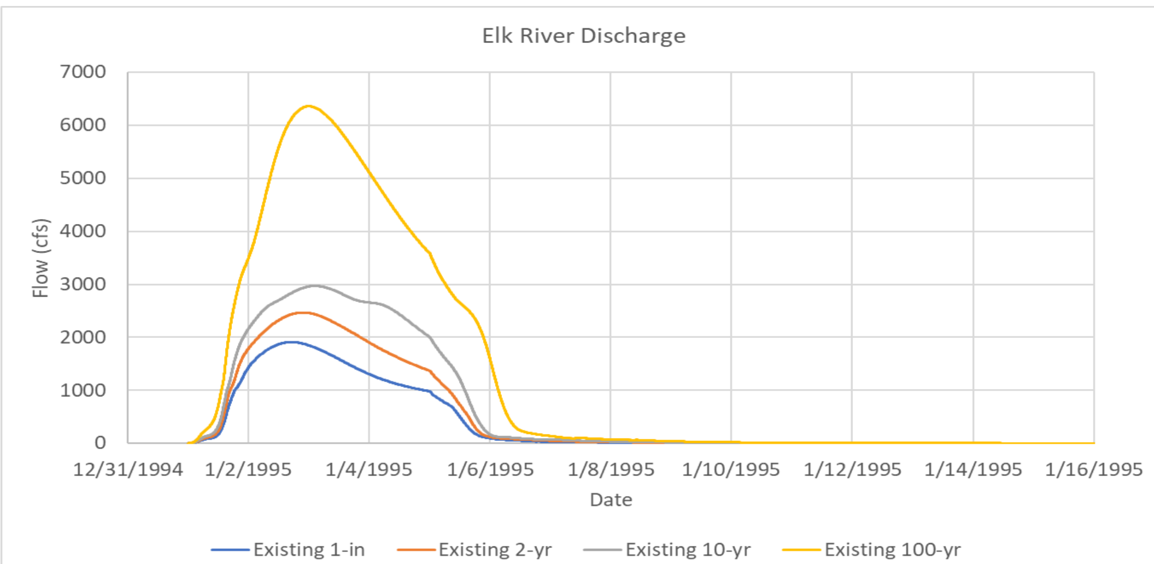


Figure 4. Elk River Discharge at County Road 6 Under Different Return Events

Table 3. Volume of Water Discharged from Upstream at County Road 6 SE

Return Event	Depth (in)	Volume (ac-ft)	% flow going into Bayou
1-in 1-hr	1.00	10,989	1.86
2-yr	2.84	14,929	3.95
10-yr	3.50	19,709	4.64
100-yr	6.00	39,840	5.73

To further examine the Bayou condition, we requested a survey of the Bayou wetland at the junction of the Elk River. However, the land was not accessible. Therefore, we took an alternative route to look at the LiDAR and imaginary information. Shown in Figure 5, at the mouth of the Bayou channel, a sand delta formed through deposition and now functions as a temporary weir. The current highest point at the sand delta is at 964.29 ft. Upon investigating the entire channel LiDAR information, the sand delta appears to be the elevation control of the Bayou channel, meaning that when the Elk River water stage reaches 964.29 ft, water would flow into Bayou channel. This is also the elevation control used in the existing condition XPSWMM model.

However, the sand delta is unstable, the elevation control could change when sand is washed away. Lowering the elevation control will let more water into the Bayou channel. **Potentially, an underground sheet pile weir structure can be put in place at 964.29 ft for a permanent elevation control.**

The purpose of this structure is not to change any conditions in the lake chain area, but stabilization the Bayou channel current condition and prevent changing in the channel shape due to scouring and erosion of the sand delta.

In addition to elevation control, installing a sheet pile weir will help reduce the mobilization of sediments from the sand delta; by controlling the flow, it will also reduce the amount of scouring within the wetland due to potential flow increase in the channel. This has a positive effect on the Briggs Lake Chain water quality as the reduce amount of TSS will also decrease the amount of TP going into the lakes.

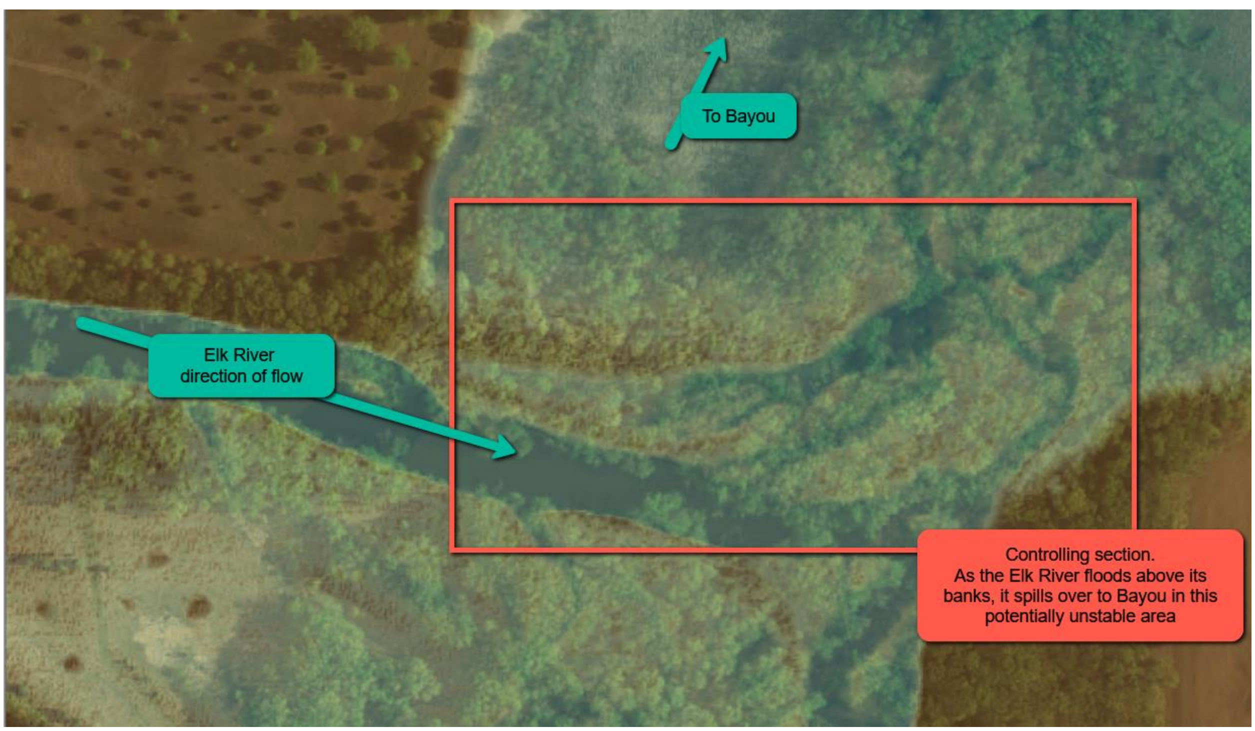


Figure 5. Sand Delta at Mouth of Bayou Channel

The site schematic and estimated cost of the sheet pile weir can be found below:

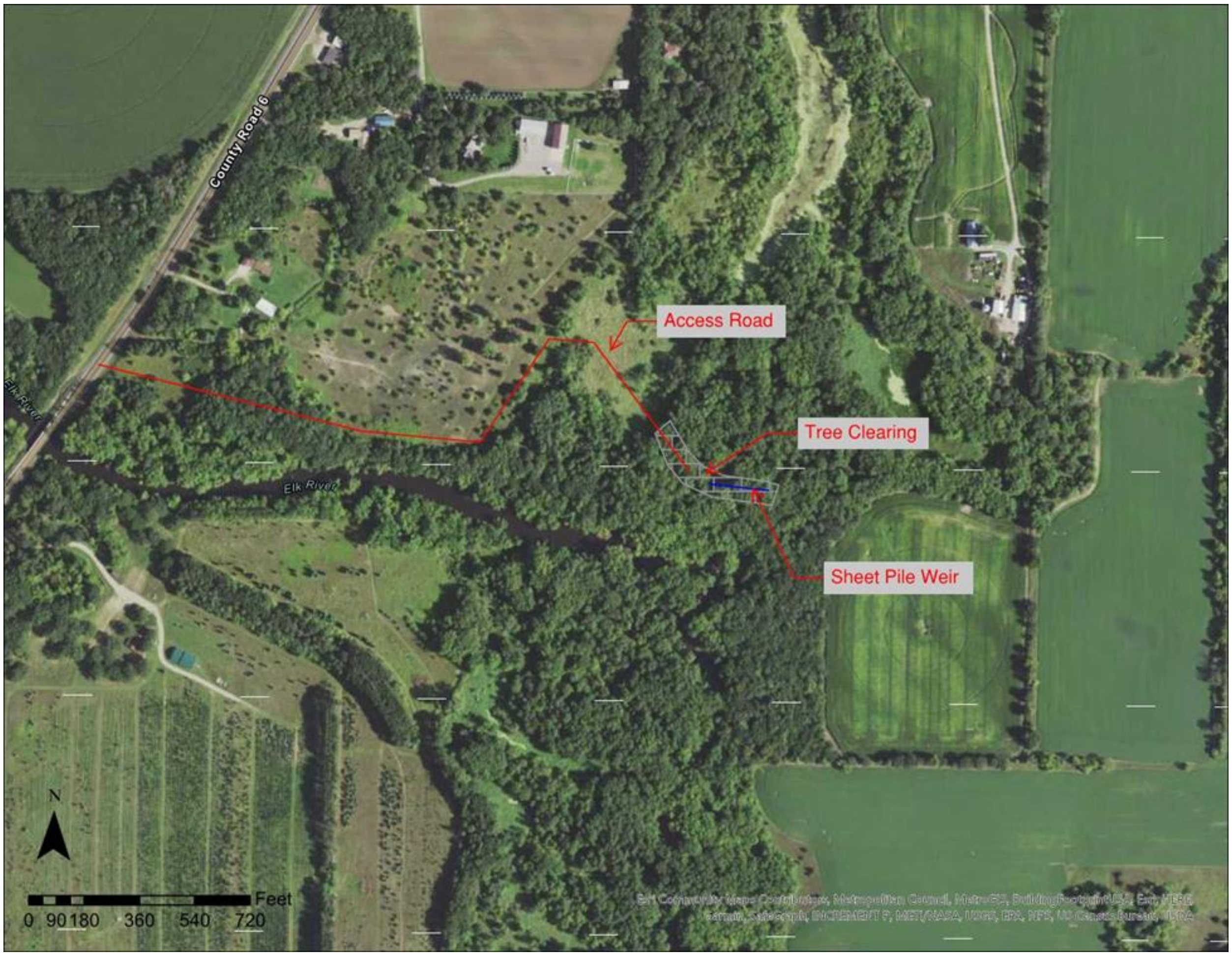


Figure 6. Site Schematic for Sheet Pile Weir

Table 4. Cost Estimate for Sheet Pile Weir

Sheet pile weir					
Item	Description	Unit	Unit Cost	Quantity	Total Cost
1	Mobilization/Demobilization	LS	$ 66,554	1	$ 66,554
2	Tree Clearing & Grubbing	AC	$ 7,000	1	$ 7,000
3	Sheet Pile Weir F&I	SQ FT	$ 80	4000	$ 320,000
4	Geotextile Fabric IV	SQ YD	$ 3	230	$ 690
5	Class III RR	CY	$ 150	200	$ 30,000
6	Access Road	LF	$ 20	2400	$ 48,000
7	Floating Silt Curtain	LF	$ 20	500	$ 10,000
8	Temporary Dewatering	LS	$ 25,000	1	$ 25,000
9	Restoration	LS	$ 10,000	1	$ 10,000
			Total		$ 517,244
	Design/Construction Engineering			20%	$ 103,449
	Permitting/Legal Fee			10%	$ 51,724
	Contigency			30%	$ 201,725
			Total		$ 874,142

Upstream Wetland B: Impoundment

In general, we select wetland restoration sites based on the following criteria:

- Goal of restoration- storage and/or water quality
- Public vs. private parcel
- Distance to flow path
- Type of wetland
- Access availability
- Impact of private land

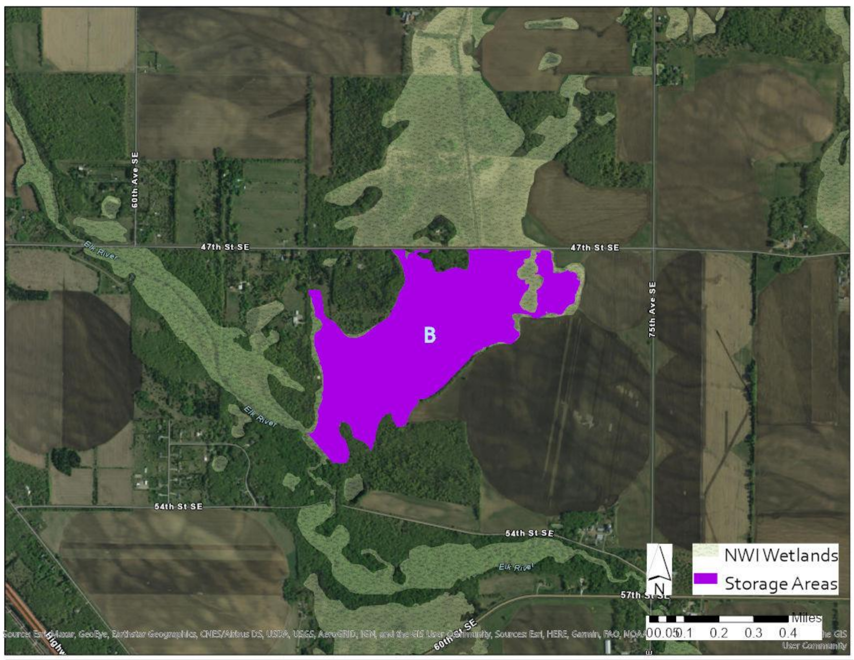


Figure 7. Upstream Wetland B Location

Area B is suggested for impoundment. This area was chosen due to the presence of a large ditched wetland complex feeding into Elk River. While not publicly owned, this area is County Ditch 15, which would presumably give the County access to do work and maintain this ditch. It does not appear to be effectively draining the wetland and is not directly abutted by farmland for most of its reach. This area does have a minor flooding concern given some of the nearby properties have structures close to the wetland's boundary as well as a road running east-west that crosses Ditch 15 in the two locations shown in the figure below. Impoundment may be an option on this county ditch given the large area of the adjacent wetland complex. The polygon shows the potential extent of the basin to impound 2 feet of water and water is let out at the elevation of 984 ft.

Briggs Lake level is summarized in the table below. A discharge graph (Figure 8) is also generated at County Road 6, upstream of Bayou on Elk River. For this scenario, because it is closer to the system, and is blocking water from entering the river, it showed a more significant impact on the Briggs Lake level and Elk River discharge.

Table 5. Lake Level Changes and Stage Reduction of Wetland Impoundment Alternative

Return Event	Max Briggs Lake Level (ft)	Modeled Briggs Max Level (ft)	Stage Reduction (ft)
1-in 1-hr	965.176	965.107	0.069
2-yr	966.122	966.049	0.073
10-yr	966.912	966.827	0.085
100-yr	969.689	969.524	0.165

It is helpful to note that if the storage is within the Briggs Lake Chain, the volume it provides can be deducted direct from the volume diverted into the lake chain (Table 2). However, since the storage is upstream of the lake chain, the storage benefit it provides help reduce the amount of water going into the lake chain, as well as going downstream to Elk Lake (Table 3).

From a water quality perspective, impoundment will allow extra time for additional TSS settling and reduce TSS and TP transport downstream. Shallow impoundment will also provide habitat for wildlife.

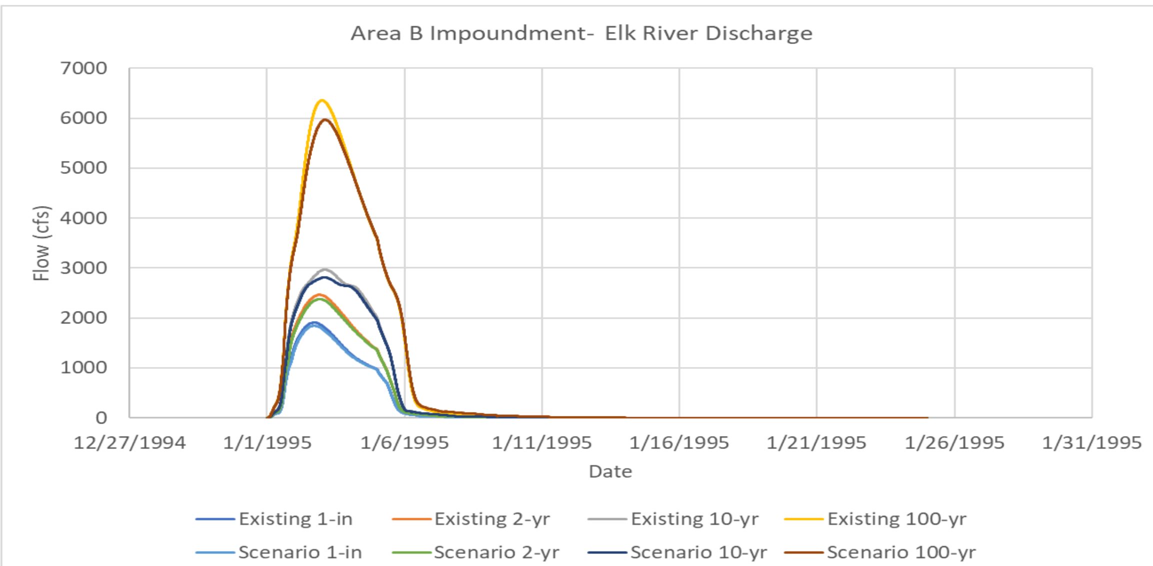


Figure 8. Elk River Discharge for Existing and Wetland B Impoundment Scenario

The potential design would be to have a 4-ft earthen berm constructed along the river side of the impoundment area with a 24" RCP culvert letting out water from the ditch and a 20-ft spillway. Currently, the model shows that 47th St SE (north boundary of the impoundment area) will be impacted by the impoundment under 100-yr storm events. According to LiDAR, the road top elevation is around 986 ft and 100-yr flood elevation in the impoundment area will be 986.35 ft, exceeding the road elevation and causing potential flooding. This can be solved with either a berm at the north boundary of the impoundment area or a road improvement project. Currently, these costs are not included in the estimated cost provided. To assess the necessity of either option would need further investigation and a feasibility study.

In addition, additional information of tile outlet locations will be needed to determine if there is need to cut/re-route tile lines. The impoundment area is composed of private parcels. Landowner communication and potential easement will also need to be considered. The costs of these items are also not included.

Since the wetland impoundment is on a county ditch, it could potentially be further looked at with the multipurpose drainage management plan and/or any upcoming ditch repair assessment. The site schematic and estimated cost of the sheet pile weir can be found below:

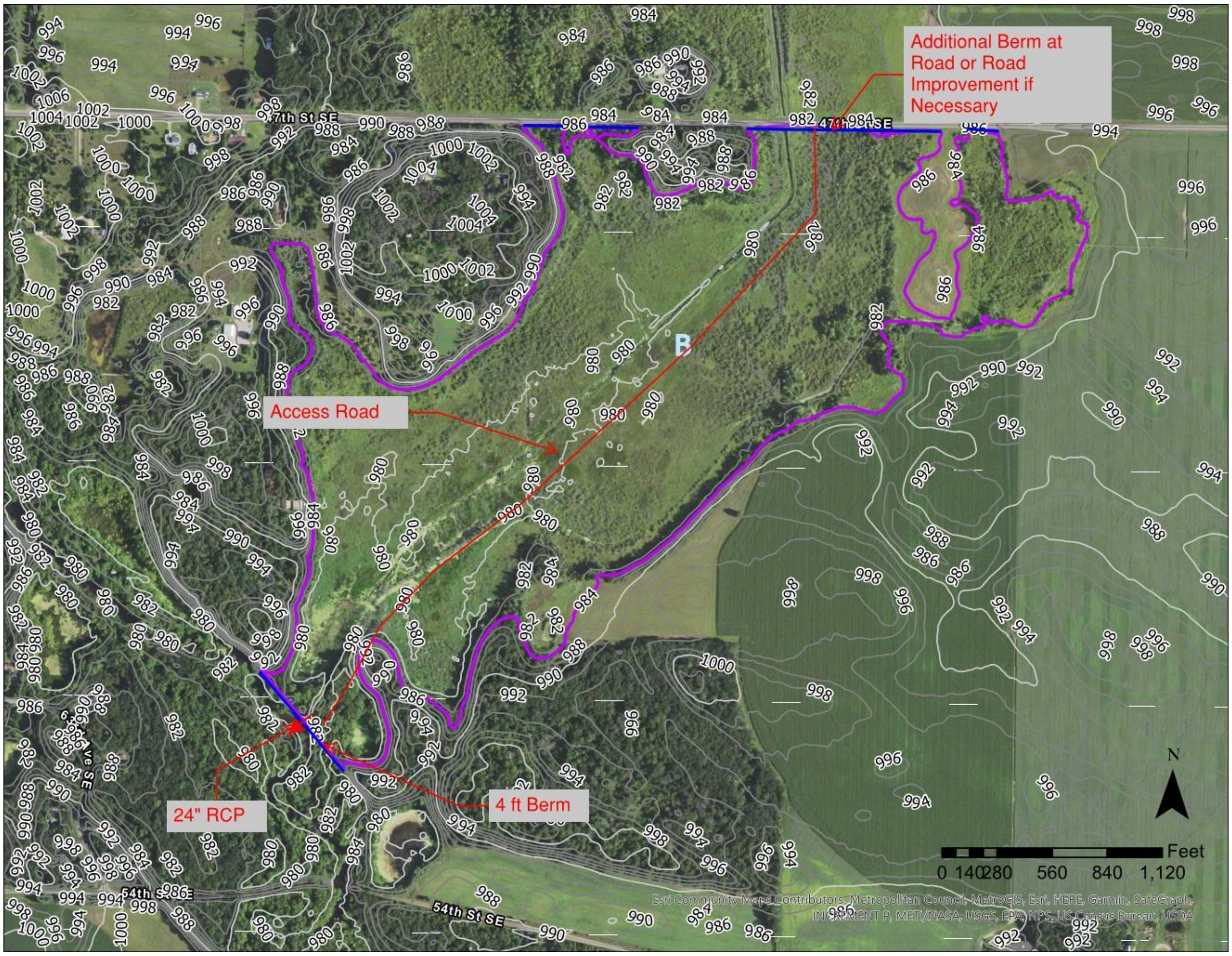


Figure 9. Site Schematic for Wetland Impoundment

Table 6. Cost Estimate for Wetland Impoundment

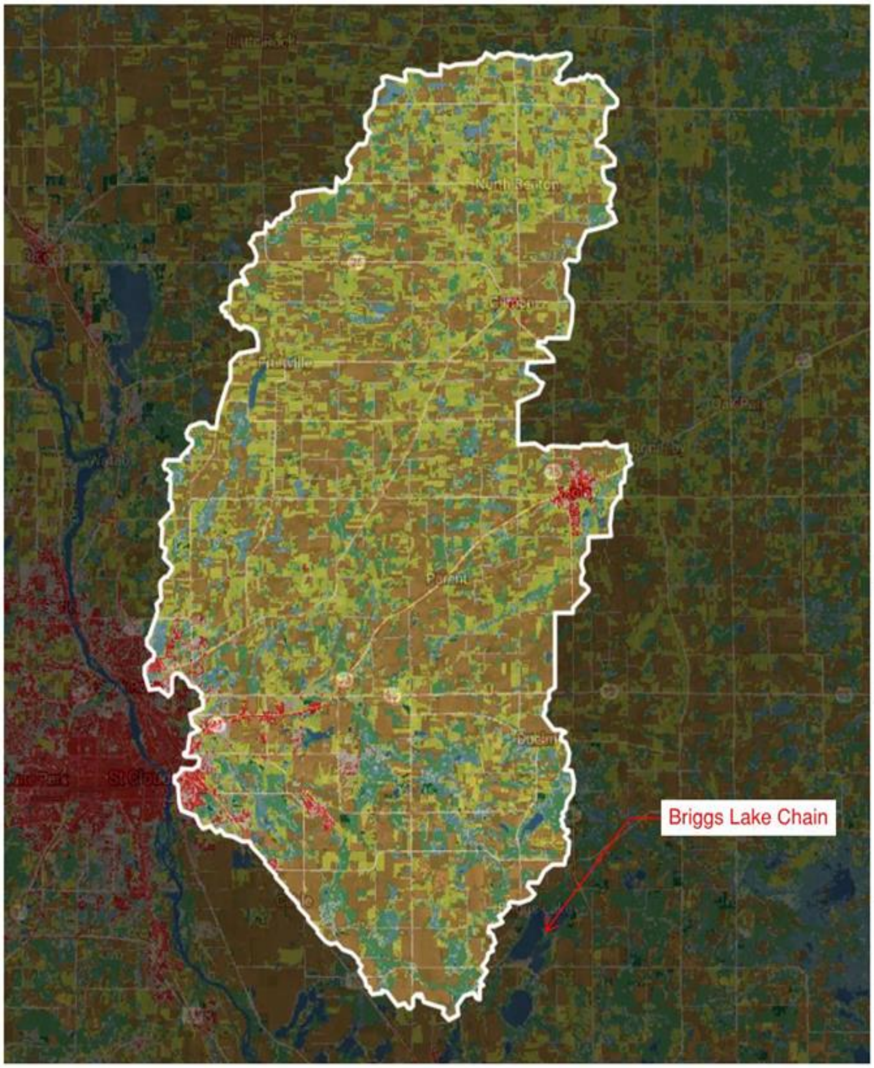
Wetland impoundment					
ITEM NO.	DESCRIPTION	UNITS	Unit Price	QUANTITY	SUBTOTAL
1	Mobilization/Demobilization	LS	$ 40,833	1	$ 40,833
2	Import Berm Material (USCS TYPE CL OR CH) (CV)	CY	$ 30	3100	$ 93,000
3	Temporary Dewatering	LS	$ 25,000	1	$ 25,000
4	Furnish & Install 24" RCP	LF	$ 120	60	$ 7,200
5	Furnish & Install FES with Trash Guard	LS	$ 1,400	1	$ 1,400
6	Geotextile Fabric Type IV	SQ YD	$ 3	140	$ 420
7	Class III RR	CY	$ 150	120	$ 18,000
8	Construction Entrance, Maintained	LS	$ 3,000	1	$ 3,000
9	Access Road	LF	$ 20	4100	$ 82,000
10	Floating Silt Curtain	LF	$ 20	1400	$ 28,000
11	Silt Fence	LF	$ 3	1400	$ 4,200
12	Restoration	LS	$ 10,000	1	$ 10,000
			Total		$ 313,053
	Design/Construction Engineering			20%	$ 62,611
	Permitting/Legal Fee			10%	$ 31,305
	Contigency			30%	$ 122,091
			Total		$ 529,060

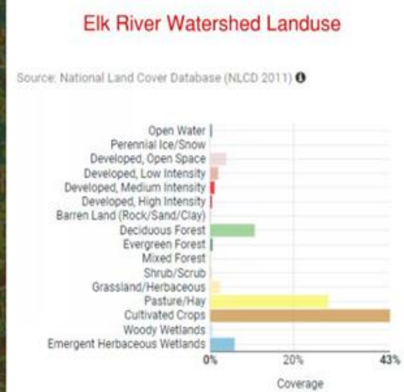
Cover Crops

Cover crop is quickly gaining popularity. It is known for being able to improve soil health. One of the many benefits cover crops can provide is drainage reduction. For example, cereal rye, the most used species in Minnesota, can help reduce soil moisture by uptake, thus potentially reducing the subsurface tile drainage. According to research, the soil moisture percent reduction with cereal rye at the boot stage can vary from 10% to 37% in the upper 60 cm compared to no cereal rye (Krueger et al., 2010; Krueger et al., 2011). In southern Minnesota, researchers observed a tile drainage reduction of 11% over the course of 3 years by using cereal rye (Strock et al., 2004).

To estimate an impact of cover crops in the Elk River watershed up to the Briggs Lake Chain, we utilized the watershed modeling webapp ModelMyWatershed (https://modelmywatershed.org/). The webapp uses a 30-yr Generalized Watershed Loading Function (GWLF) model to estimate runoff and water quality. We delineated the Elk River watershed up to the Briggs Lake Chain (Figure 10). The watershed is 218 square miles in total and 43% crop land (>60,000 acres). A few scenarios were run using the webapp, including existing condition and assumed cover crop coverage of varying percent of the crop land (10-50%). We understand that the higher percent of the cover crop coverage is not easily achievable, but the reduction numbers are provided for reference purposes.

The streamflow depth reduction is not a direct indication on how much impact cover crop has on Briggs Lake Chain, but the reduction indicate less quantity of water being discharged into the lake chain and this will help reduce the overall water level.





Cover Crop Impact on Runoff

Cover crop	Stream Flow (cm)	Surface Runoff (cm)	Subsurface Flow (cm)	ET (cm)	Precip (cm)
Existing	8.54	5.79	2.74	62.45	70.87
10%	8.48	5.71	2.78	62.5	70.87
20%	8.45	5.61	2.82	62.53	70.87
30%	8.41	5.56	2.86	62.56	70.87
40%	8.38	5.47	2.89	62.62	70.87
50%	8.34	5.4	2.93	62.64	70.87

Cover Crop Impact on Water Quality

Cover crop	TN Load (lbs/yr)	TP Load (lbs/yr)	TSS Load (tons/yr)
Existing	363,959	52,474	11,437
10%	357,088	51,250	11,309
20%	350,510	50,070	11,182
30%	344,215	48,937	11,056
40%	338,188	47,846	10,931
50%	332,415	46,798	10,807

Figure 10. Cover Crop Benefit on Elk River Watershed

Reference

Krueger, E., Ochsner, T., Kantar, M., Sheaffer, C., Porter P. 2010. Growth stage at harvest of a winter rye cover crop influences soil moisture and nitrogen. Crop Management. Doi: 10.1094/CM-2010-1014-01-RS

Krueger, E.S., Ochsner, T.E., Porter, P.M., Baker, J.M. 2011. Winter rye cover crop management influences on soil water, soil nitrate, and corn development. Agron. J. 103, 316-323.

Additional Areas Discussed

Upstream Wetland A: Excavation

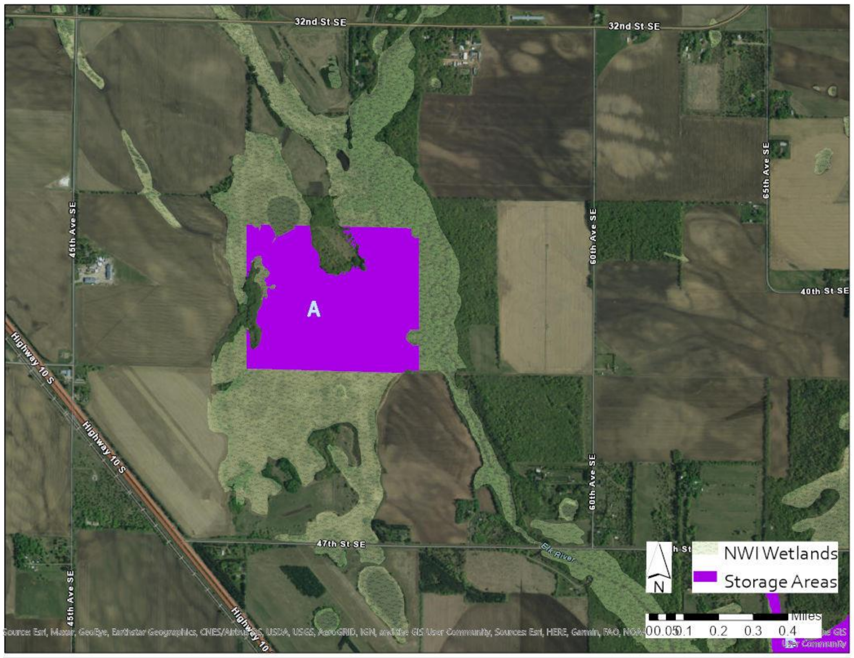


Figure 11. Upstream Wetland A Location

Figure 11 shows the potential excavation area discussed.

This area was chosen due to the intersection of wetland area with publicly owned land that is directly adjacent to Elk River. There are three parcels owned by the DNR here (purple) that are on the mainline channel (also in the geodatabase). The wetland types shown by the NWI include Type 1 (PFOA and PEMA) as well as Type 6 (PSSA). These wetland types allow for excavation within the rule without mitigation, which may help with storage capacity. Excavation is allowed in these community types that does not exceed 6.6 feet (which is considered a conversion to deepwater habitat). Excavation of online flood storage along this reach of Elk River may be achievable.

In the model, we assumed that the excavation would be 4 feet and the bottom elevation is at 984 ft. When the river stage exceeds 984, water will be discharged into the storage area.

Briggs Lake level is summarized in the table below. A discharge graph (Figure 12) is also generated at County Road 6, upstream of Bayou on Elk River. Both the stage reduction at Briggs and peak discharge reduction at County Road 6 is small, or even negative. It is possible that this area is further upstream, so the storage benefit diminishes as the water travels downstream. During the lower flow events, the river stage did not reach 984 long enough for it to have a bigger impact. The reach on Elk River between Wetland A and Bayou could also be contributing significant amount of water that was not captured by the storage.

Table 7. Lake Level Changes and Stage Reduction of Wetland Excavation Alternative

Return Event	Max Briggs Lake Level (ft)	Modeled Briggs Max Level (ft)	Stage Reduction (ft)
1-in 1-hr	965.176	965.175	0.001
2-yr	966.122	966.124	-0.002
10-yr	966.912	966.894	0.018
100-yr	969.689	969.637	0.052

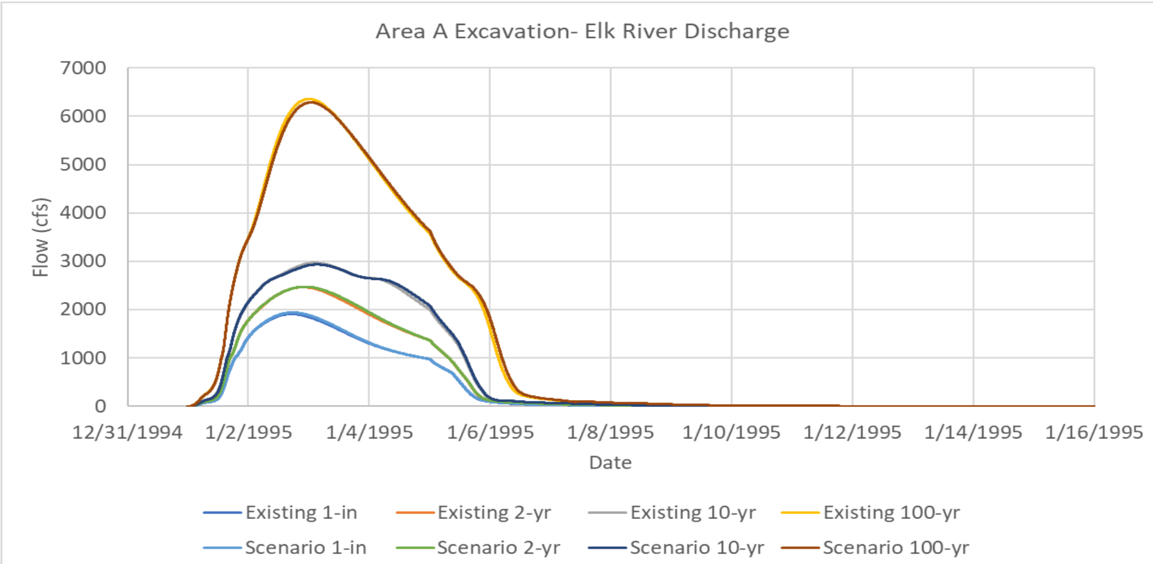


Figure 12. Elk River Discharge for Wetland A Excavation Scenario

Upon further investigation, a few concerns made this a less viable option:

- Similar to Wetland B impoundment, the area is located upstream of the Briggs Lake Chain. The storage is provided is not entirely for the volume of water discharged into Bayou (Table 2).
- The amount of excavation is well above 500 ac-ft. The placement of the material is problematic. The cost of excavation will also make it not worth of benefit.
- If considering impoundment, the DNR parcel boundary is not aligned with the contour and needs re-grading or berm. This will alter the natural drainage and will likely not be approved by the DNR.

Bayou and Lily Creek Storage

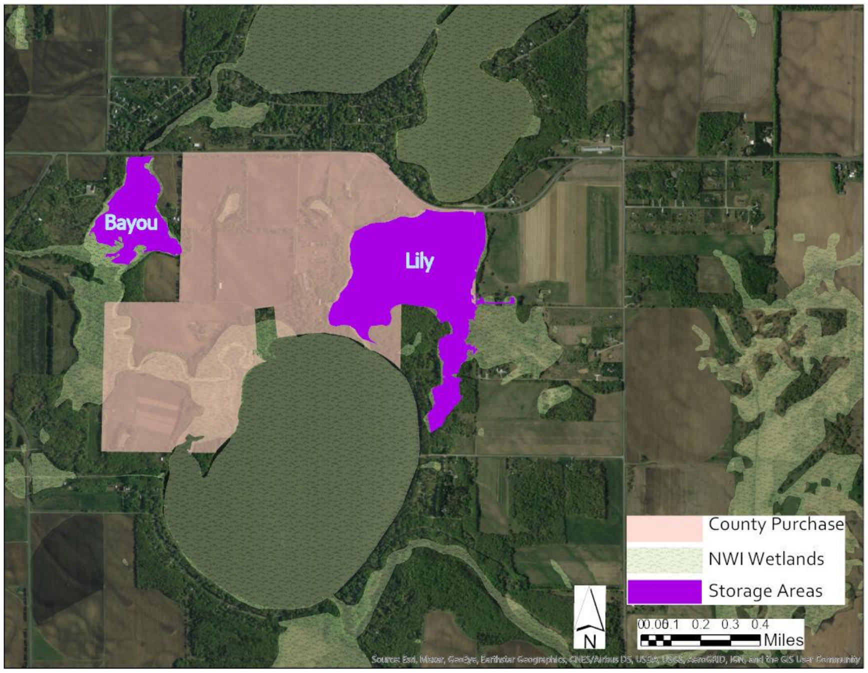


Figure 13. Bayou and Lily Creek Wetland Storage Areas

First assumption for this scenario was made that if a sheet pile weir is constructed at CSAH 16, preventing inflow from the Elk River to Briggs Lake, water would be forced to travel downstream into Elk River. However, the model suggested that water would still back into the system through Lily Creek.

Suggestion was made that storage at both Bayou and Lily Creek wetlands could potentially help reduce the amount water backing into the lake chain system. In addition, in Figure 13, the pink-shaded area upstream of Elk Lake is potentially to be bought by the County. It is mostly agricultural land and wetland.

Upon investigation, the wetland area around Lily Creek and Bayou channel is feasible to impound up to 2 ft of water and letting the discharge into the Briggs Lake Chain at the elevation of 966 ft. However, this will require a similar impoundment at Bayou channel bridge so that water does not simply back into the system through Bayou channel. A backflow preventor is needed at both weirs to allow discharge from the lake chain at elevation lower than 966 ft and prevent building up of lake surface elevations within the lake chains.

This scenario has the potential to impound up to 302 ac-ft of water at the elevation of 966. The effective storage area is highlighted in the graphic below. For Bayou, the weir would be constructed at the bridge crossing at CSAH 16 and for Lily Creek, the weir could be constructed either at the bridge crossing or modified at the existing weir outlet. The needs to be further evaluated in a feasibility study.

As mentioned in the last section, only 1-in 1-hr and 2-yr event was evaluated. The modeled Briggs Lake maximum level is presented in the table below.

Table 8. Lake Level Changes and Stage Reduction of Bayou and Lily Creek Storage

Return Event	Max Briggs Lake Level (ft)	Modeled Briggs Max Level (ft)	Stage Reduction (ft)
1-in 1-hr	965.176	965.083	0.093
2-yr	966.122	966.092	0.03
10-yr	966.912	966.901	0.011
100-yr	969.689	969.691	-0.002

Figure 14 shows the stage comparison before and after impoundment. This option is not ideal as when the channels are blocked and weir is overflown, the build-up stage in the Briggs Lake Chain drops very slowly due to the reduced channel flow capacity. Blocking the channel and provide discharge pipe will cause the lake system to drain very slowly. This response will likely cause the lake levels to stay elevated for an extend period of time, making this option less favorable.

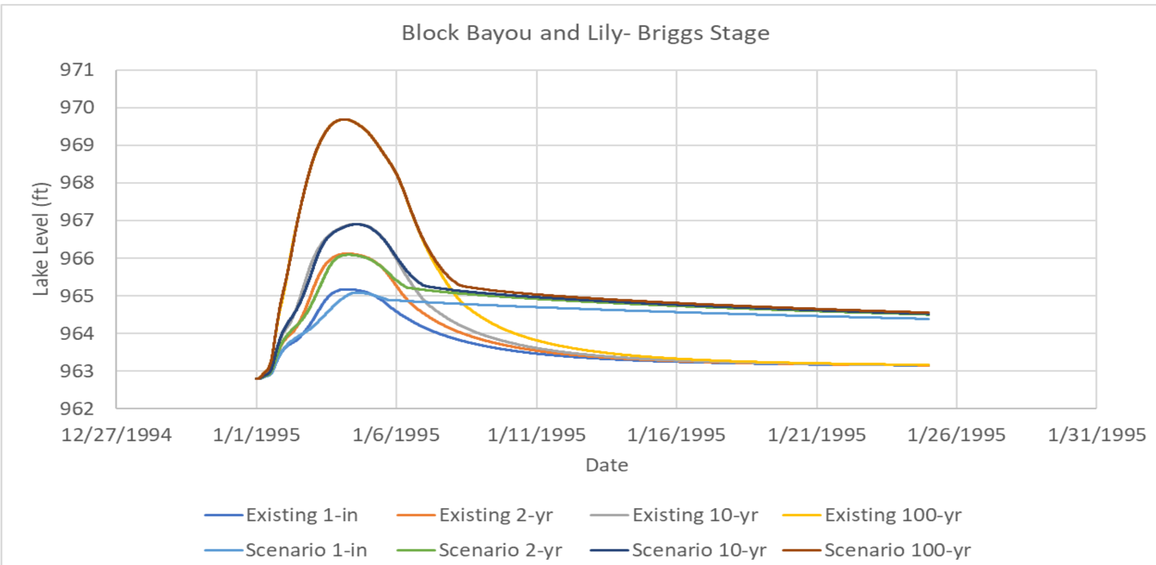


Figure 14. Briggs Stage for Existing and Block Bayou and Lily Scenario

County Land Purchase

Sherburne County plans on purchase land in the Briggs Lake Chain area. This area of land is between Elk Lake and Rush Lake. It is mostly agricultural land and wetland. Upon investigation, the wetland area around Lily Creek is a Type 3 wetland. It is not suited for excavation. For impoundment, it will likely only provide water quality benefit, but no storage benefit. The rest of the area is relatively steep. For storage purposes, the excavation is close to 10 feet, making it impractical.

Figure 15. County Land Purchase Area and Contour

Additional Wetland Storage

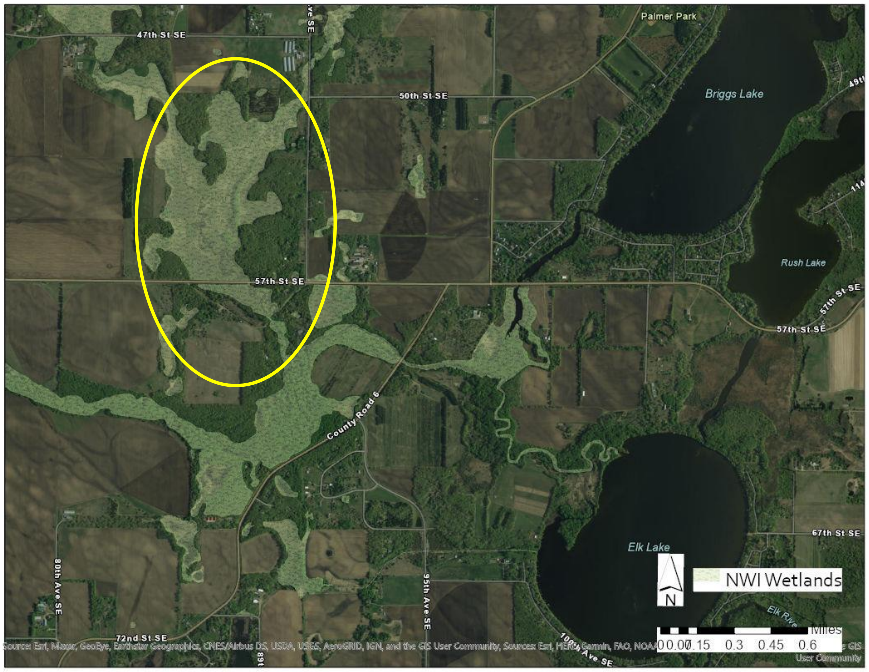


Figure 16. Wetland Area Upstream from Bayou

We also investigated the wetland complex upstream of the system right off Elk River. The aerial imaginary shows a meander channel flowing through the wetland. The channel shape indicates that this is a natural wetland and is in good condition. It is not recommended to alter the hydrology of natural good condition wetlands.

Elk Lake Outlet

One assumption while evaluating the existing condition was that if Elk Lake outlet has less capacity than upstream channels and is potentially restricting the flow. Therefore, we requested cross-sections be surveyed at Elk Lake outlet. We compared Elk Lake outlet cross-section to the channel cross-section at County Road 6 SE upstream from Bayou channel on Elk River (Figure 17).

The channel at County Road 6 SE according to the DNR XPSWMM model is much more incised than the channel at Elk Lake outlet. We calculated the water level channel cross-section. The results indicate that Elk Lake outlet has enough capacity to convey the water and does not appear to be restricting the flow and raising the water level in the system.

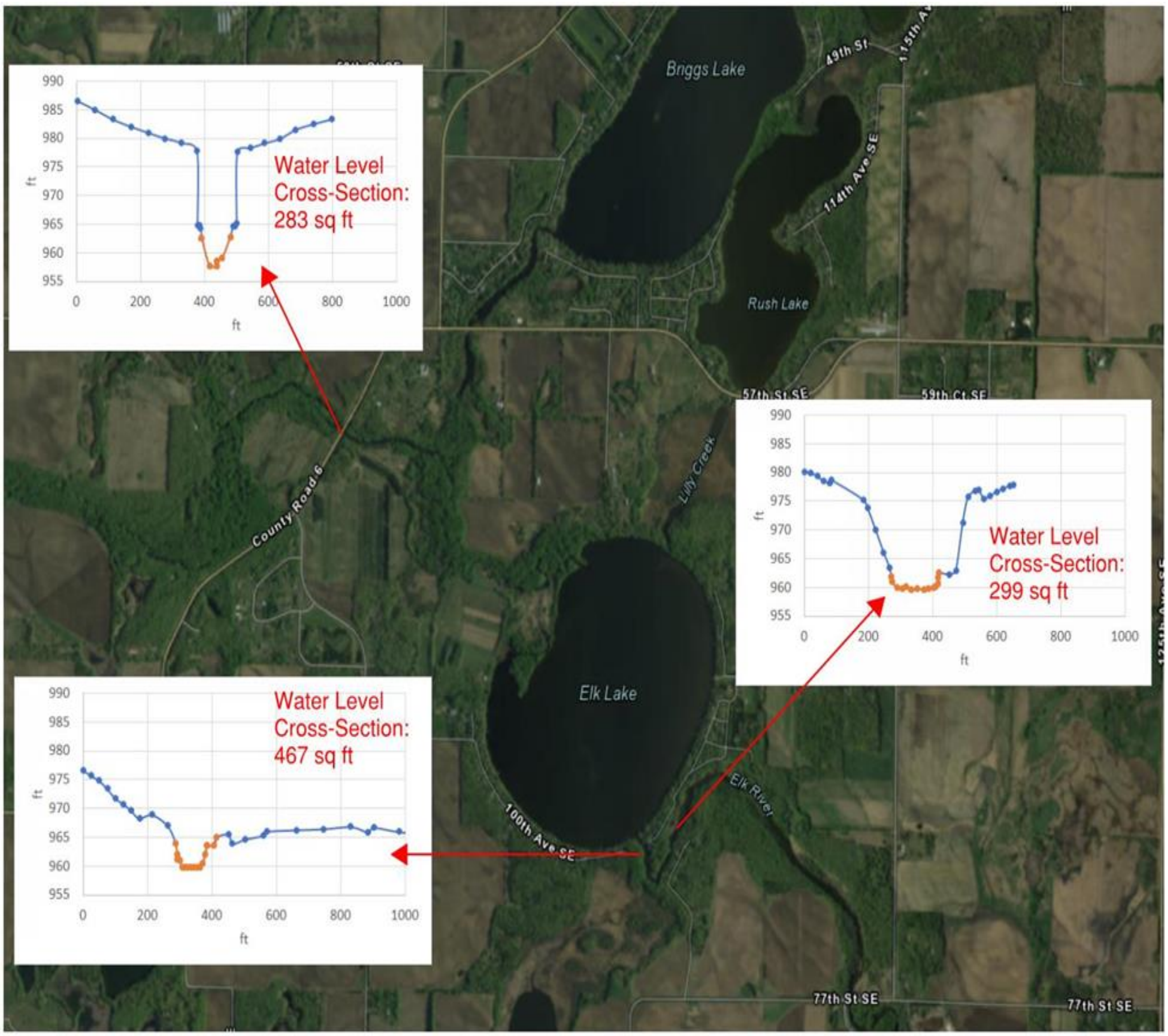


Figure 17. Channel Cross-Sections at Various Locations

Summary and Recommended Next Steps

The table below summarized the alternatives, costs, and benefits.

Table 9. Summary Table of Alternatives

Alternative	Cost	Potential Benefit	Required Up Front Work/Risks	Potential Grants
Sheet Pile Weir at mouth of Bayou Channel	~$880,000	To stabilize Bayou channel inlet, prevent further erosion and scouring; potential TSS/TP reduction	• Area need to be surveyed to determine the condition difference from LiDAR • Model update to assess current condition	
Wetland B Impoundment	>$530,000	Stage reduction in Briggs Lake Chain; potentially improve drainage condition; TSS/TP reduction	• Coordination with DNR • Coordination with drainage authority • Private parcels, work with landowners • Side inlets (if any) need to be determined • Needs feasibility study to refine details	• BWSR • USDA/NRCS WRP, CRP • Potentially FEMA
Cover Crop Implementation	Varies	Streamflow and runoff reduction; TP/TSS/TN reduction	• Benefit will be long-term, and a watershed impact requires significant percent of cover crop implementation on row crop lands • Work with landowners to discuss options of cover crop	• NRCS CSP • NRCS CRP • SWCDs