Technical Memo:

Date: 11/27/2023

To: Jason Boyle, P.E.
DNR-EWR, Dam Safety Program

Through: Jeff Weiss P.E., CFM
DNR-EWR, LUP, Floodplain Program

From: Salam Murtada, P.E., P.H., CFM
DNR-EWR, LEU, Watershed Group

RE: Effects of proposing additional stop logs on Sturgeon and Side Lakes Water Surface Elevations

Purpose of Study

- Date of Technical Request: 5/3/2021
- County: St Louis County
- Community: French Township
- Source: Sturgeon Lake and Sturgeon River
- HUC 8 Watershed: 09030005

The purpose of this study is to evaluate the effects of adding two additional stoplogs to Sturgeon Lake dam without causing an increase to the peak elevations of the lake. The Sturgeon Lake dam outlet is located approximately 8,200-LF and 4,800 -LF downstream of Little Sturgeon Lake and Side Lake, respectively (Figure 1). For information about the watershed, refer to 'Sturgeon (69-939) / Side (69-933) Lakes, Outlet Analysis' report (Jim Solstad, April 30th, 2007). The land use in the watershed appears to remain the same as was described in the report.

Figure 1: Site Location showing dam and USGS gage

Source of Data

1. 'SturgeonLk' HEC-RAS model, Jim Solstad in 2007. This will be referred to as the '2007 HEC-RAS model'.
2. USGS (04065650), daily peak values (1998 – 2010)
3. Sturgeon Lake Elevations, DNR's Lake Finder (1998 – 2020)
4. Sturgeon (69-939) / Side (69-933) Lakes, Outlet Analysis, Jim Solstad, April 30th, 2007. This will be referred to as the '2007 report'.
5. HEC-DSSVue 2.0.1
6. Other related reports and spreadsheets.

Methodology

This study involved the following steps:

1- The lake levels were compared with the USGS gage discharges for a storm in May of 2008. This is similar to the analysis done in the 2007 report for a storm in July of 1993.

2- The headwater versus tailwater were compared between the 2007 HEC-RAS model and measured values, in order to verify model consistency.

3- The 2007 HEC-RAS model was used to run the following two scenarios:

   a. Adding two additional stoplogs, based on the requisition for technical request.
   b. Adding another three (total five) stoplogs, to get an upper limit.

4- The headwater versus tailwater conditions were evaluated for all scenarios to determine the hydraulic control effects of the Sturgeon Lake dam.
5- Recommendations were made regarding the effects of adding stoplogs and suggested further evaluation of stoplog effects on the lake elevations of Sturgeon Lake.

Discussion

Comparison between stream flow and lake level data:

By plotting the recorded lake elevations for Sturgeon Lake and USGS stream gage discharge for April of 2008 (Figure 2), the graph showed a lag of more than a week between the lake USGS gage discharge peaks. This finding was consistent with the 2007 report, affirming the limited flow capacity of the lake outlet. The additional stoplogs added in 2007 did not change the outcome of that finding.

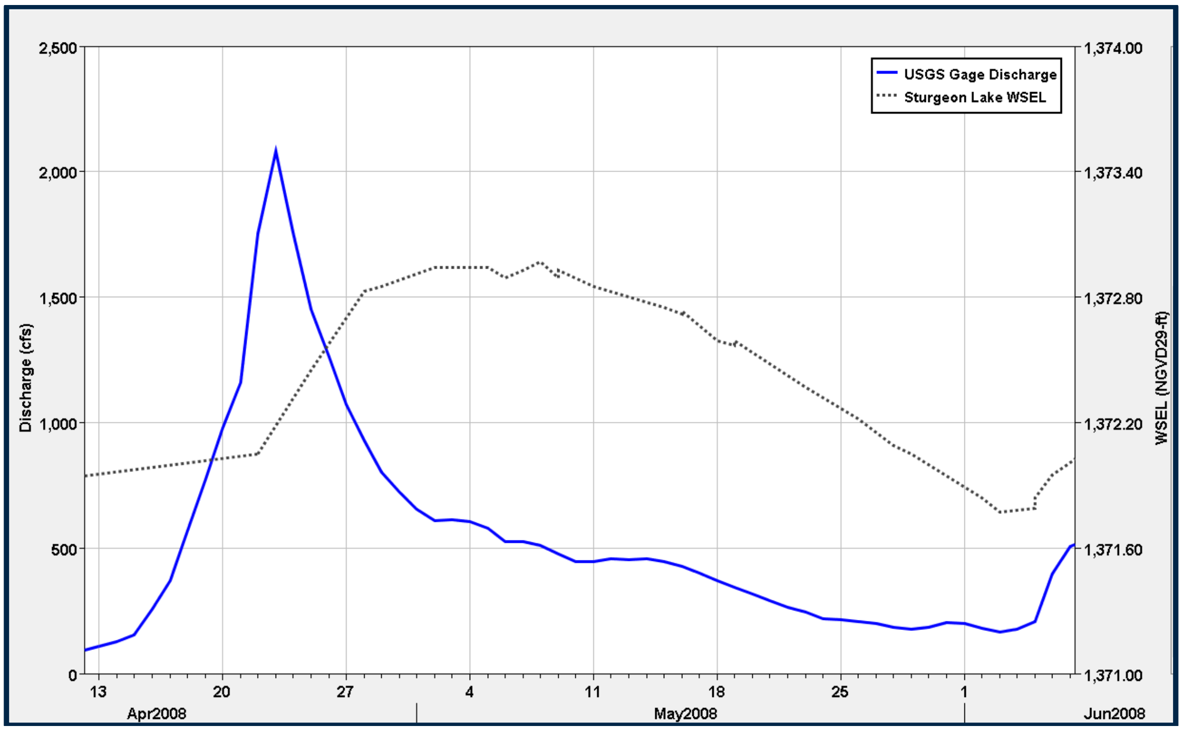

Figure 2: Comparison of stream flow and lake level data for May 2008 storm

Comparison between measured and modeled headwater-tailwater elevations

After plotting the headwater versus tailwater conditions for the modeled and measured values of the pre-2007 conditions (authorized stoplogs), the results showed consistent dam hydraulic effects. At water surface elevation of 1371.0, the headwater and tailwater were equal to where the dam did not exert any hydraulic effects. The lake outlet controlled flows at elevations below the 1371.0-ft. The consistency between modeled and measured results verified a level of confidence for using the model to simulate subsequent scenarios involving the placement of six stoplogs (2007) and two additional stoplogs (2022). Furthermore, a scenario involving the placement of three more stoplogs (total of 5 stoplogs) was also simulated, raising the whole bay to 1371.0 ft.

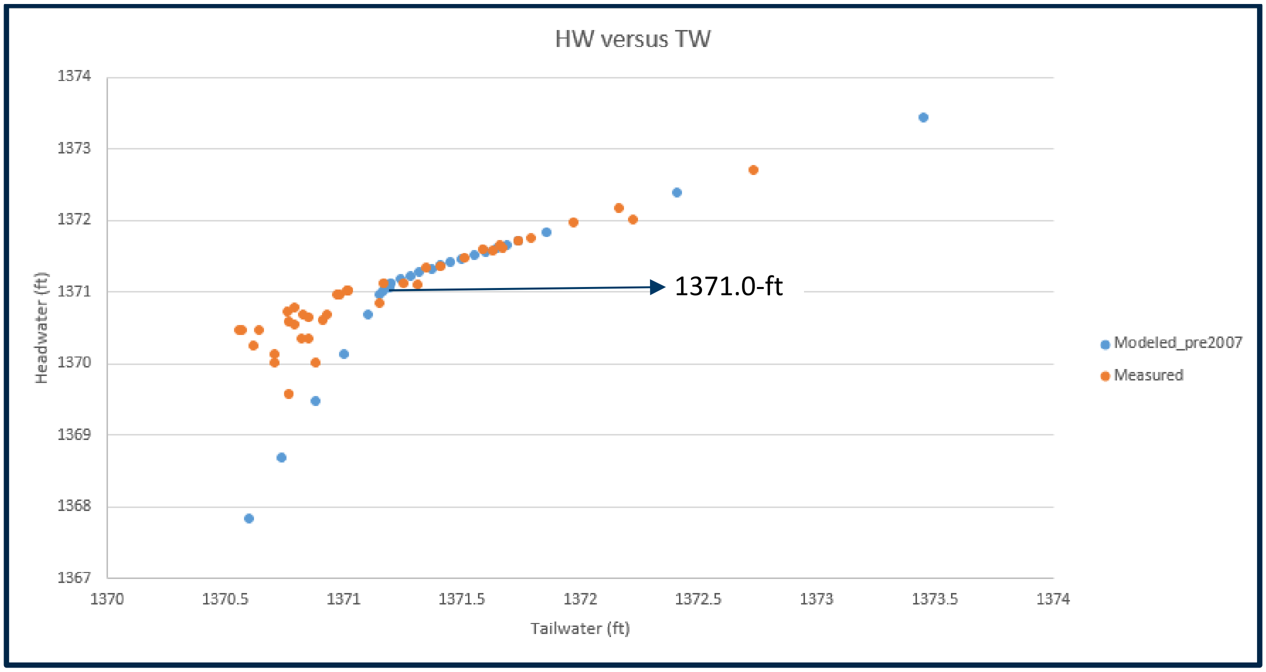

Figure 3: Plotting headwater versus tailwater elevations for measured and modeled pre-2007 conditions

Effects of stoplogs on outlet hydraulic control conditions:

In order to evaluate the effects of stoplogs on the headwater versus tailwater conditions, a total of four scenarios (Figures 4 through 7) were simulated using the 2007 HEC-RAS model. The simulations are summarized in the table below.

Table 1: Summary of stoplog simulated conditions

Scenario	Description	Total stoplogs	Year	Figure	Modeler
Original	Original authorized stoplogs		Pre-2007	4	Jim Solstad
2007 Addition	Additional six stoplogs added to outlet	6	2007	5	Jim Solstad
2007 plus 2	Adding two more stoplogs to 2007 scenario	8	Proposed	6	Salam Murtada
2007 plus 5	Adding five more stoplogs to 2007 scenario	11		7	Salam Murtada

Modeling results for each of these Scenarios is provided in Figures 4 through 7.

For each scenario, the dam eventually becomes submerged, and the tailwater becomes equal to the headwater. The addition of stoplogs in each scenario raises both the elevation and the flow at which the tailwater becomes equal to the headwater. These elevations and flows are noted in each figure and summarized in Table 2.

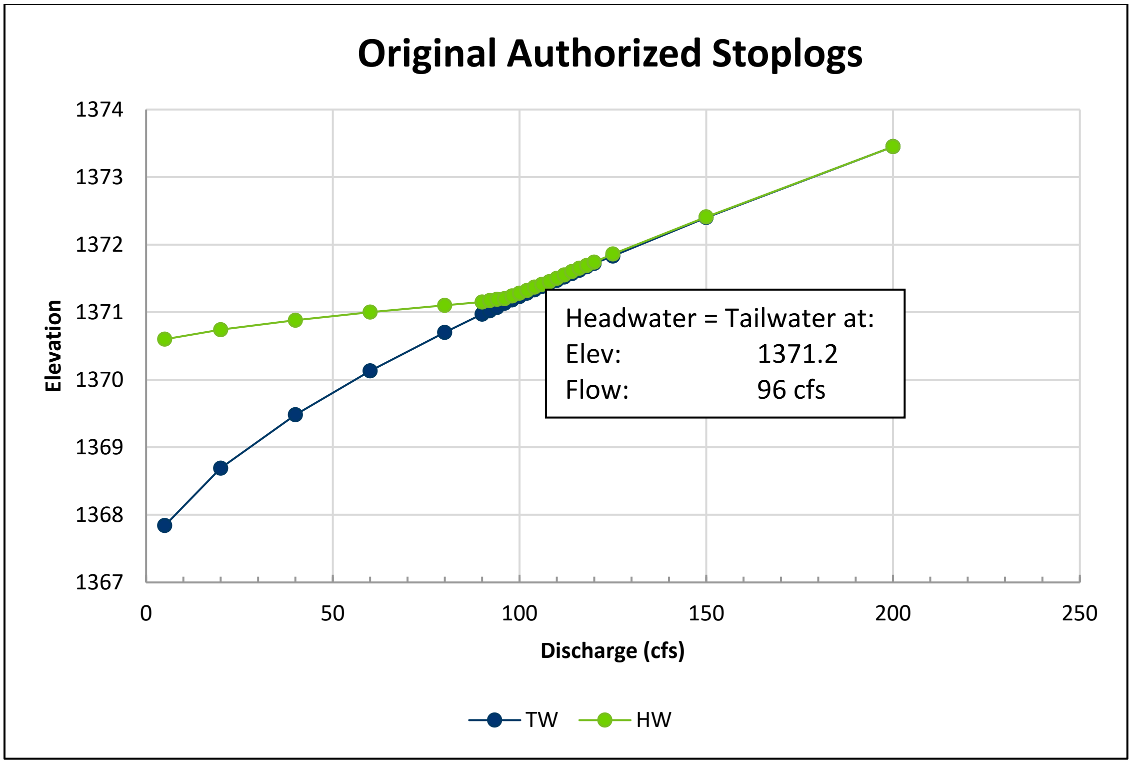

Figure 4: Headwater and Tailwater elevations for original stoplog scenario

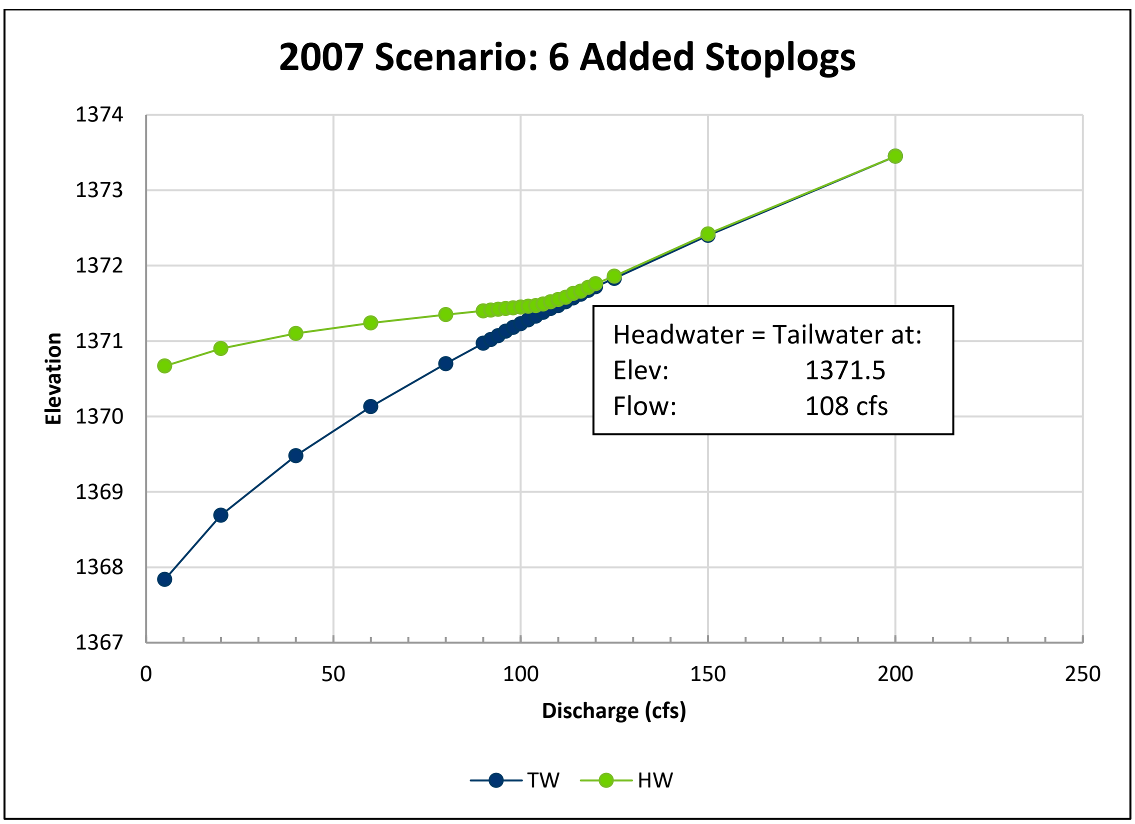

Figure 5 Headwater and Tailwater elevations for the 2007 Scenario with 6 added stoplogs

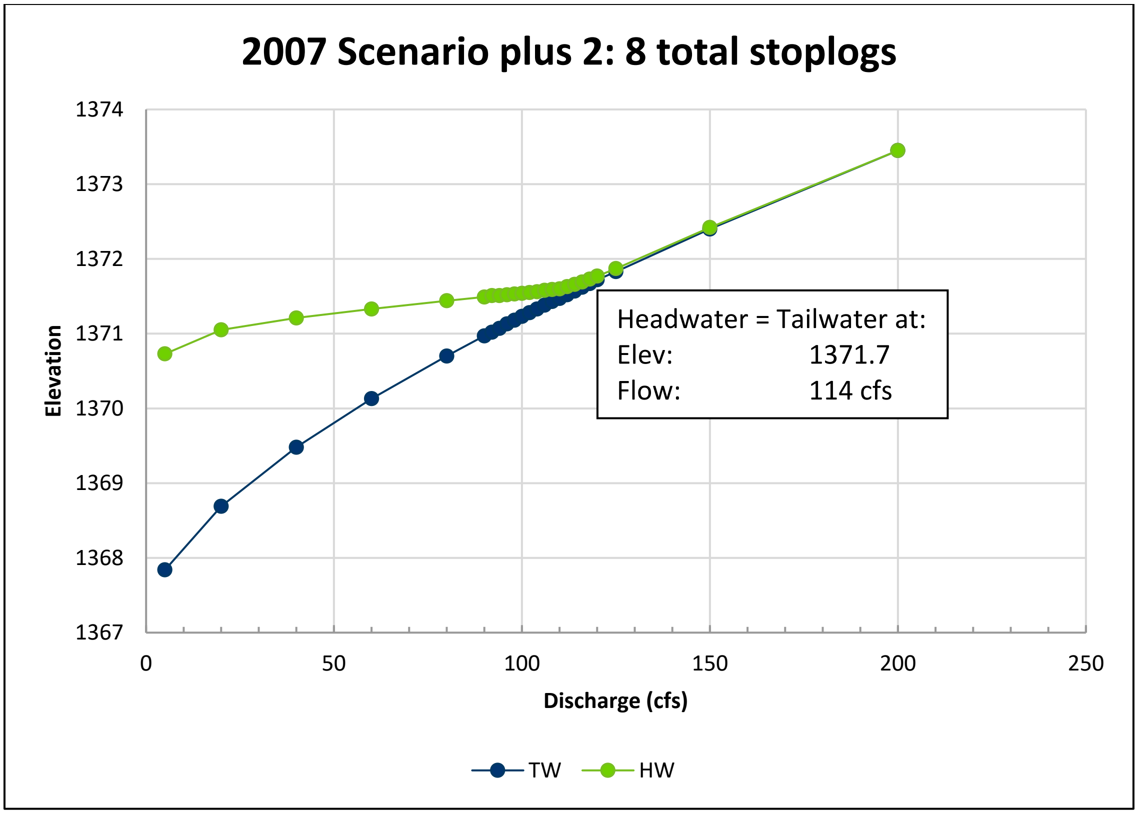

Figure 6: Headwater and Tailwater elevations for the 2007 Scenario plus two additional stoplogs (8 total)

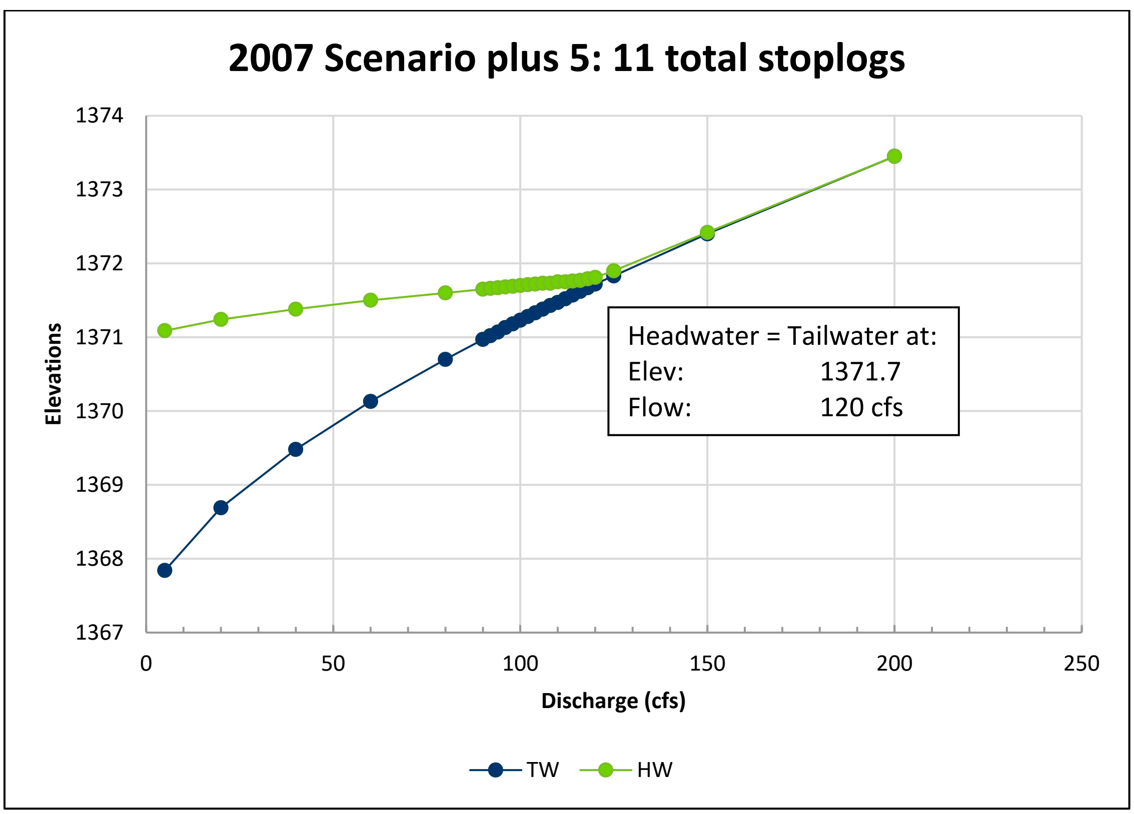

Figure 7: Headwater and Tailwater elevations for the 2007 scenario plus five additional stoplogs (11 total)

Based on Figures 4 through 7, adding stoplogs achieved the following:

1- Stoplogs slightly increased the headwater elevations for lower flows where the dam hydraulic conditions are effective.
2- Stoplogs slightly increased flows that maintain dam effective hydraulic conditions.
3- Stoplogs slightly increased the headwater elevation threshold representing dam effective hydraulic conditions.

To quantify these effects, the headwater elevations were plotted against discharge for the four conditions (Figure 7). Based on the graph, adding additional two stop logs would increase the headwater elevation slightly up to 0.15-ft when compared with the 2007 condition. Adding five stoplogs would raise the headwater elevation by up to 0.25-ft. Table 2 below summarizes the flows and water surface elevations representing the headwater control threshold for the four scenarios.

Table 2: Summary of elevations and flows when tailwater equals headwater

Scenario	Description	HW = TW Elevation (ft)	HW = TW Flow (cfs)
Original	Original authorized stoplogs	1371.2	96
2007 Addition	Additional six stoplogs added to outlet	1371.5	108
2007 plus 2	Adding two more stoplogs to 2007 scenario	1371.7	114
2007 plus 5	Adding five more stoplogs to 2007 scenario	1371.7	120

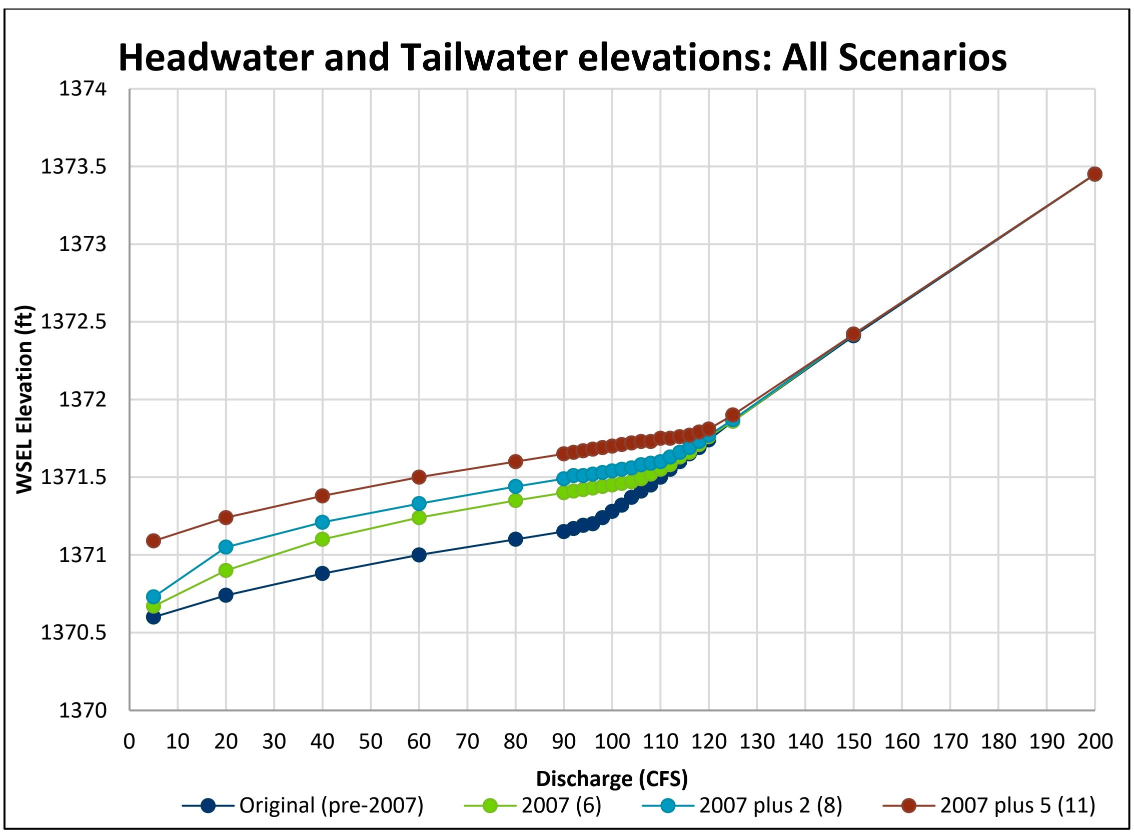

Figure 8: Headwater and Tailwater elevations for all scenarios

Effects of Stoplogs on peak lake elevations:

In order to further evaluate the effects of placing additional stoplogs on the Sturgeon Lake peaks, a hydrologic model, either in HEC-HMS or XPSWMM, can be built for a 48.5 square miles drainage area representing the Sturgeon Lake outlet dam. The 2007 HEC-RAS model can be used to generate different outflow conditions for each scenario, which would be imported into HEC-HMS and used to evaluate any effects on the lake peak elevations. However, routing the generated flow conditions into an unsteady state HEC-RAS model would require getting better survey information for the channel upstream of the outlet.

Results and Conclusions

According to the model results, placing two additional 0.5-ft stoplogs, would slightly increase the headwater elevation by up to 0.15-ft, when compared with the 2007 proposed conditions. Furthermore, it slightly increases the flow threshold of the dam hydraulic control from 108-cfs to 114-cfs.

The peak lake elevations are not expected to be impacted based on the time lag determined for the USGS gage and lake level analysis. However, developing a hydrologic model can further be used to evaluate the stoplogs effects on the Sturgeon lake levels.