HYDRAULIC MODELING OF THE CHANNEL DOWNSTREAM OF THE A-MILL ARTISTS LOFTS HYDROELECTRIC PROJECT FERC No. 14628

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Introduction

This report describes potential changes to the hydraulic function of the channel immediately downstream from the outlet of the A-Mill Artist Lofts Hydroelectric Project (A-Mill) that may occur once the hydroelectric facility is in operation. Hydraulic modeling was carried out for the reach of channel beginning immediately downstream of the outlet of the hydroelectric facility and continuing downstream to just upstream of the reconnection of the channel with the main river as shown in Figure 1. The channel into which the A-Mill outlet empties is the left most of five river channels immediately downstream of the St. Anthony Falls, Figure 2. Moving rightward (westerly) from the outlet channel the next channel largely acts to convey water from Xcel Energy's Hennepin Island Hydroelectric Facility's trashway, the next channel is the outlet channel for the Hennepin Island Hydroelectric Facility, the next is the main river channel below the primary St. Anthony Falls spillway and the right most channel is the outlet to the US. Army Corps of Engineer's Upper St. Anthony Falls Lock, which in addition to providing a navigation channel acts as the discharge channel when the lock is opened to provide addition flood discharge capacity. The channels along the east bank of the river are former discharge channels from historic milling and hydropower production that began in the mid 1800's and as such have been modified and maintained in varying degrees throughout the years. Active channels tend to have bed material consisting of sand and gravel and often exhibit a degree of armoring with larger material such as cobbles and rocks being present. When the channels are not used for any length of the time, they silt up from normal storm water inflows and flood events on the river. As noted above, the A-Mill hydroelectric project will be reactivating the leftmost channel and flushing of some the post 1950's accumulated sediment is to be expected.

A one-dimensional computer model was developed using HEC-RAS for the river reach. Channel bathymetry and bank topography was obtained from a combination of information sources, including multiple site visits, LIDAR, and topographic survey information of portions of the reach obtained in February 2012 by Sunde Land Surveying as well as information obtained during the August 2014 mussel survey of the reach by Ecological Specialists Inc. Generally the channel is nominally two feet deep varying from approximately 1 to 3 feet depending on location. Without a consistent supply of water passing down the channel for the past 60 years, on the surface the river bed material varies but typically consists of approximately equal percentages of silt and sand with a small amount of gravel and larger material. The channel also has several trees and limbs that have fallen into or lay just above the normal water surface. Due to the channels isolation from the main river channel the primary source of fresh water appears to come as a result of the operation of the Upper St. Anthony Falls Lock, which, when it empties as necessary to lock a vessel through, temporarily raises the pool a few inches and some of the water flows back upstream into the channel before flowing back out. Given the varied nature of the substrate and bank material a sensitivity analysis was performed to assess the impact of varying Manning's n and also the channel depth.

[redacted] Modeling

The modeling was conducted using HEC-RAS version 4.1 using the steady state option for analysis. Based on the bed material a Manning's n of 0.025 to 0.03 is probable for the channel however given the logs and limbs that have fallen into the channel the effective Manning's n is probably closer to 0.04 or 0.05. The overbank contains trees and brush and an overbank Manning's n of 0.10 was used. A seven hundred foot long reach was modeled using 13 cross-sections. The channel cross sections were developed from the available information. Limited measurements taken during a site visit on December 15, 2014, once the leaves had fallen allowing better access to the steep side slopes that had previously limited access, confirmed that while the channel width has been estimated in some locations it is likely within 5 to 10 ft. Figure 3 shows the general model layout. The tailwater for the reach was set at the normal water surface level of the intermediate St. Anthony Falls pool, nominally elevation 750.0. The pool is maintained at this elevation throughout the warm weather period, with minor variations due to operation of the Upper and Lower St. Anthony Falls Locks to allow vessels to pass through and gate operations at the Lower St. Anthony Falls Lock and Dam. During the winter period, the US Army Corps of Engineers is allowed to lower the pool by up to 1 foot (to elevation 749.0) if necessary to minimize ice related issues at the gates at the Lower St. Anthony Falls Dam.

While the review below provides values of velocity and potential water surface elevation increases for the maximum discharge capacity of the hydroelectric facility, it is intended for the facility to be operated in a manner to only produce the amount of power necessary to meet the needs of the A-Mill Artist Lofts residents and therefore the facility will likely operate below the maximum capacity for extended periods. The information summarized below also assumes that essentially all water discharged from the A-Mill will be flowing down the left most channel. Should the water in the upstream portion of the channel rise approximately 0.75 feet a small amount of water will pass under the bridge and through the small interconnecting channel between the leftmost channel and the wider channel immediately to its right that presently conveys the water from the trashway at Xcel Energy's Hennepin Island Plant. While the amount of water likely to be conveyed in that direction will likely be limited to a few percent of the total A-Mill discharge at maximum plant capacity and a Manning's n of 0.06, and increasingly smaller amounts will pass in that direction at lower discharges or lower levels of frictional resistance in the left most channel, it none-the-less will reduce the amount of water passing down the left most channel and the upstream water level and the velocities in the channel velocities will exhibit a corresponding decrease.

The modeling results provided in the Appendix indicate that at a maximum plant capacity of 200 cfs the summer time water surface level at the upstream end of the channel may rise by approximately 0.8 foot (to elevation 750.8) above flat pool and the velocities in the channel are likely to typically be slightly more than 2 feet per second or less with a maximum in channel velocity of approximately 2.5 ft/s between cross-sections 300 and 400. Figure 4 shows the projected water surface profile for the entire reach at maximum plant capacity for the channel at a Manning's n of 0.05. Should the U.S. Army Corps of Engineers Lower the pool water elevation in the winter, the result will be a decreased cross-sectional area and increased velocities at some locations in the channel. At the lowest allowable pool elevation of 749.0, the velocities at maximum plant capacity will typically be 3 feet per second or less with a maximum velocity of 4 to 4.5 feet per second at cross-section 300.

Over time, it is likely that much of the silt that has deposited in the channel since the operation of the A-Mill ceased in the 1950's will be conveyed downstream and the channel bed will likely become predominately sand and gravel and more riverine in nature than it presently exists. Although it has been inactive for many years, given the nature of the bed material and the condition of the channel after approximately 70 years of historic operation at significantly higher discharges, the amount of rock in the area and how the channels immediately west of the channel modeled have performed and the relatively low velocities in the channel and a water surface elevation rise of typically less than 0.6 foot for much of the channel, it is anticipated that; when once again subject to routinely flowing water an amount of general sediment movement will occur prior to the channel reaching a new stabilized condition. However, no significant bank erosion is anticipated and the bridges and trails are not expected to be impacted. While no significant adverse impacts are anticipated to occur with the reactivation of the channel, it is recommended that short term monitoring of the channel be done following the startup to verify that no unexpected consequences are occurring or if they do, that mitigation measures can be undertaken in a timely fashion.

Given that access to the channels is generally limited, the depths during operation of the A-Mill facility will typically be less than three to three and a half feet and velocities within the channel will generally be less than 2.5 feet per second during the warm weather period it is unlikely that reactivating the outlet channel will create a significant new safety hazard for park visitors.

2.1 Sensitivity Analyses

To evaluate the impact of the modeling assumptions sensitivity analyses were performed on Manning's n, the channel depth and also the impact that a lower tailwater may have. Manning's n for the channel was varied from 0.03 to 0.06 while the overbank was left at 0.10. For those sections that were difficult to access and obtain accurate channel width measurements, estimates were visually made based on nearby sections. Therefore, to review the possible impact that channel width and depth may have on model results, a uniform reduction in channel depth of 0.5 foot was made for any elevation below 750.0 for all cross-sections and that condition was also evaluated over the Manning's n range of 0.03 to 0.06. To assess the impact of a reduced winter time tailwater, model runs were conducted using a tailwater lowered by 1.0 foot (intermediate pool elevation of 749.0) at Manning's n ranging from 0.03 to 0.06.

The selection of Manning's n naturally impacts the water level of the upstream portion of the leftmost channel; a Manning's n of 0.03 indicates a water level of 750.38 at the upstream-most cross-section while a Manning's n of 0.06 gives a water level of 750.97 for the same location.

The impact of raising the channel bed was undertaken to assess the potential a raised or narrowed cross-section may have on increasing the water level at the upstream end of the reach and if the increased water level would impact the small isolated wetland located in another long retired outlet channel approximately 100 feet southwest of the A-Mill outlet channel. The wetland is located at a slightly higher elevation than the A-Mill outlet channel however when the water level in the left most, or A-Mill, channel gets high enough water from the left most channel may back into the wetland. The modeling conducted for the condition in which the channel bed of the entire model was uniformly raised by 0.5 feet results in an increase in the water level of the upstream segment of the left most channel by approximately 0.3 feet above that projected for the channel modeled in the existing configuration.

A reduction in tailwater to 749.0 during the winter period would lead to an increase in channel velocities and a corresponding increase in headloss along the lower 100 to 200 foot segment of the channel immediately upstream of where it spreads out as it joins intermediate pool. Due to the increase in losses along this segment of the reach the projected water levels in the upstream half of the channel are not notably different than those computed for an intermediate pool water level of 750.0.

[redacted]Discussion

Based on the results of this study, it is anticipated that the water surface elevation at the upstream end of the channel may increase by approximately 0.8 foot when the A-Mill Hydroelectric Facility is operating at full capacity. The impact to the water surface elevation becomes negligible at the downstream end of the left most channel. Due to the intent of the facility, it may often be operating at less than full capacity and during those times when the plant is operating at less than full capacity water surface elevation rises and in stream velocities will be correspondingly lower. For example when operating at 75 % capacity the water surface elevation at the upstream end of the channel may increase by 0.4 to 0.5 feet while at 50% capacity the rise will be approximately 0.2 to 0.3 feet and the typical velocity will be 1.25 ft/s or less. It is expected that the channel will change from a somewhat stagnant pool to an active channel and over time it is anticipated that the silt in the channel will be swept away and the channel will become a more riverine type of habitat.

Appendix

HEC-RAS MODEL OUTPUT