Sustainable Rivers Program

Evaluation of Operations Constraints and Opportunities Barren River Reservoir, Kentucky

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Barren River Lake, KY – Sustainable Rivers Program Project

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LRL Water Management has recently completed an evaluation of Barren River Reservoir with support from the Sustainable Rivers Program. The objectives of the evaluation were to 1) leverage the CWMS model to increase operational flexibility at Barren River dam by identifying floodplain locations that constrain operations, 2) compare the existing CWMS hydraulic model to an updated hydraulic model using enhanced terrain data and surveyed cross-sections to understand potential limitations and data sensitivity of the existing model, and 3) determine the impact of increasing maximum release rates on flood storage recovery and the ability to delay the fall drawdown until after fall turnover has occurred. A Powerpoint presentation has been developed to summarize the results of the evaluation and should be viewed in conjunction with this report.

Background

Barren River Dam is located in Allen County in south central Kentucky. The reservoir has the largest drainage area in the Louisville District (940 square miles) and relatively low maximum seasonal release rates compared to other projects within the district (crop season - 3,200 cfs and non-crop season – 4,000 cfs). When the project was initially impounded the normal maximum release rate was 6,000 cfs. Over time, this maximum release rate has been reduced to 4,000 cfs, a 33% loss in release capacity. A maximum release of 4,000 cfs has been use for many years with uncertainty about the impacts of releasing above 4,000 cfs and up to 6,000 cfs. Additionally, the schedule of regulation gives authorization to release up to 6,000 cfs and states "when conditions dictate the need for depletion of reservoir storage at a faster rate, *it may be possible to discharge up to the maximum design rate of 6,000 cfs*. This decision would involve consideration of time of year, current and forecasted weather conditions, and percentage of flood control storage utilized. The decision would be dependent on the notification of downstream interests." Project personnel have identified potentially impacted areas during higher releases, and the CWMS model could help address the benefits and downstream impacts of going to a higher maximum release rate.

Modeling

In order to perform the evaluation, the HEC-ResSim and HEC-RAS models were extracted from the Green River Basin CWMS model. Once these models were extracted, they were trimmed down so that only locations impacted by the operation of Barren River Dam remained. They hydraulic model was terminated approximately 22 miles downstream of the dam to include the areas identified by project personnel.

The initial modeling effort was performed to analyze the impact of releasing higher discharges on flood storage recovery. Significant flood events occurred in both May 2010 and May 2011 when the project was operating at crop season discharges (maximum of 3,200 cfs). HEC-ResSim was used to evaluate how much sooner the project could have returned to the guide curve if the maximum release had been 4,000, 5,000, or 6,000 cfs. A maximum release of 3,200 cfs was simulated for consistency in comparison to the higher maximum releases. During both events the higher release rates resulted in a substantially faster return to the guide curve; 12-20 days sooner with 4,000 cfs, 22-31 days sooner with 5,000 cfs, and 29-39 days sooner with 6,000 cfs. Faster flood storage recovery better prepares the project for potential subsequent events and facilitates recreational usage sooner. These are both positive impacts to the project.

After the initial modeling to determine the effect of flood storage recovery, the possibility of delaying fall drawdown by increasing maximum release rates was evaluated. The period of record from 2000 – 2015 was reviewed and "dry," "average," and "wet" years were identified to test the impacts of the higher release rates over a typical range of hydrologic conditions. The results of the ResSim modeling suggested that by releasing up to 5,000 cfs, fall drawdown could be delayed from October 15th to November 1st and still reach winter pool by December 1st under typical hydrologic conditions. Delaying start of the fall drawdown until November 15th, however, required a release of up to 6,000 cfs to achieve winter pool by December 1st. A review of historical water temperature profiles from 2000-2015 indicate that de-stratification has occurred on or before Nov. 1st in 10 out of the past 15 years. Based on this data and the ResSim routings, fall drawdown could be initiated after reservoir de-stratification approximately 60-70% of the time, with expected downstream ecological benefits and enhanced recreational opportunities.

After the HEC-ResSim modeling was completed, the "off-the-shelf" CWMS hydraulic model was extracted and truncated approximately 22-miles downstream of Barren River dam. These extents encompassed areas of interest identified by project personnel. The original hydraulic model was developed using 10-meter DEMs, assumed channel data, and cross-sectional layout with dam failure scenarios in mind. Steady flows of 3,200, 4,000, 4,700, and 6,000 cfs were simulated in the hydraulic model and the corresponding flood plains were mapped using RAS mapper. The "off-the-shelf" model showed a substantial amount of out of bank inundation at 3,200 cfs, the maximum crop-season release. After the initial inundation mapping, surveyed channel data was incorporated into the model geometry, and improvements in the inundation extents were noted. Finally, the model was revised using updated cross-section layout and 5-foot LIDAR data that became available in 2016 and calibration efforts were performed using the 1) 5-foot LIDAR data, 2) project staff field observations at a discharge of 4,700 cfs and 3) historic aerial photos taken in 1967 when the project was releasing 5,900 cfs. The metadata of the 5-ft LIDAR dataset indicated part of the area was flown in the winter when the project was releasing 4,000 cfs, so the modeled water surface elevations could be calibrated to the low point in the cross-section data. After the model geometry improvements and calibration efforts, there was significant improvement in the inundation extents and confidence that the revised model reach could provide reasonably accurate inundation maps during actual flood events.

Conclusions

The updated hydraulic modeling indicated that a maximum release of 6,000 cfs should not be pursued due to adverse downstream impacts. However, maximum releases of 4,500 cfs to 5,000 cfs are likely feasible. Under these maximum releases, storage recovery could occur 2-4 weeks sooner and the fall drawdown could be initiated on November 1st to obtain positive environmental and recreational benefits. This delay in the fall drawdown would minimize or even prevent the release of hypolimnetic water from the Project. The improvements to the inundation mapping suggest that hydraulic model refinements to the "off-the-shelf" CWMS models may be needed to accurately portray impacts from normal operational scenarios. The district plans to incorporate the revised model geometry back into the CWMS hydraulic model for use with future real-time inundation mapping. LRL will continue to pursue downstream stakeholder interest in working with the Corps to maximize operational flexibility.