US Army Corps
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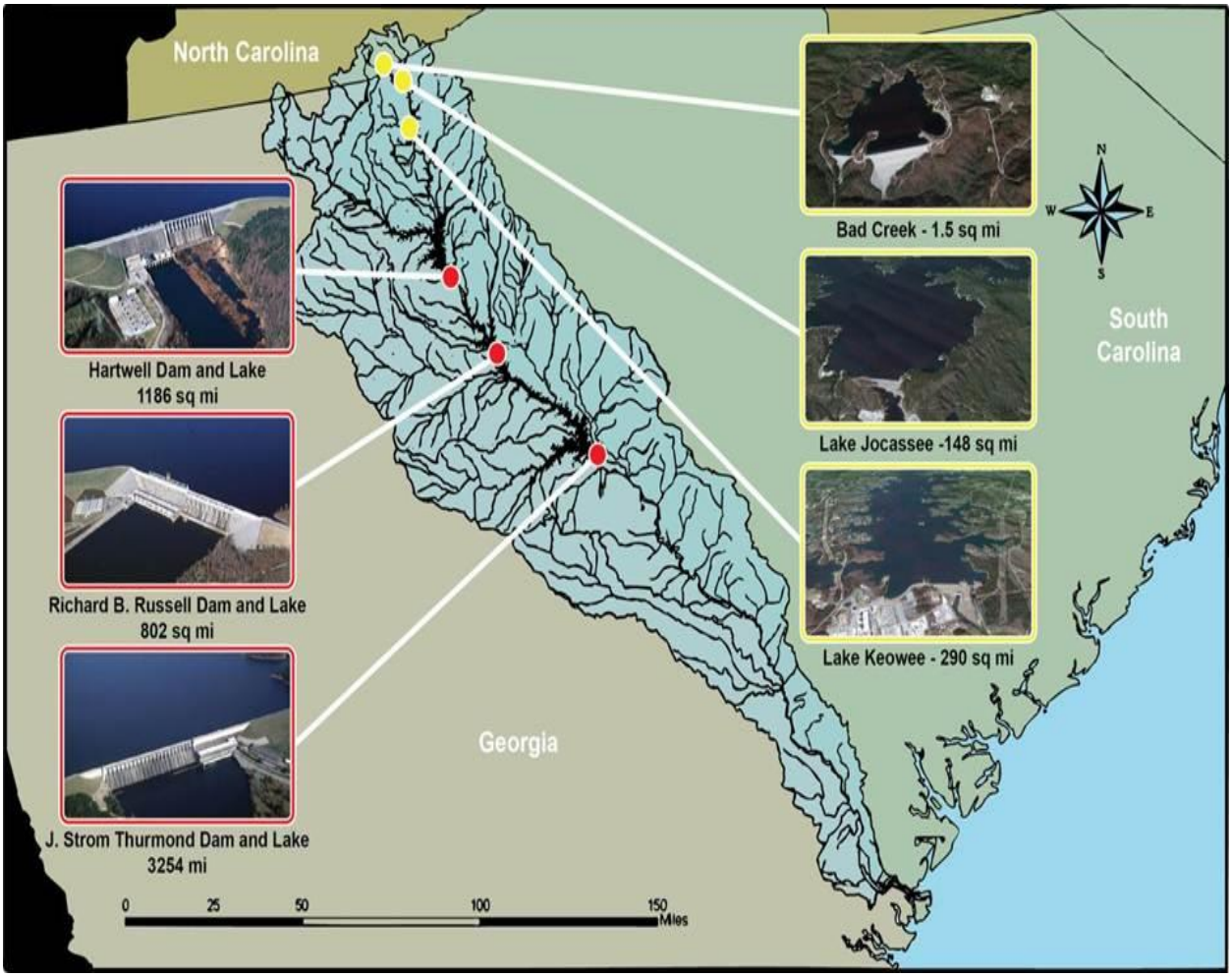
Savannah District

PMF Analysis for Savannah River Multipurpose Projects



May 2016

PMF Analysis

for Savannah River Multipurpose Projects

The purpose of this analysis is to validate that the existing spillway capacities and gate operating schedules of the Hartwell, Russell, and Thurmond multipurpose projects on the Savannah River meet current dam safety criteria. The original design of Hartwell and Thurmond were based on Spillway Design Flood (SDF) criteria which is no longer used. Currently, the Corps of Engineers uses the Probable Maximum Flood (PMF) in the design of spillway capacities of large dams.

The U.S. Army Corps of Engineers, Savannah District (CESAS), collaborated with the Corps' Hydrologic Engineering Center (HEC) to develop computer models to perform an analysis of the effects of a PMF design storm.

The first element of the study was for HEC to identify the precipitation patterns that would produce a Probable Maximum Storm event. Due to the size and length of the basin, HEC developed several storms centered and oriented on different parts of the basin. This enabled the District to validate the PMF design capability at each multipurpose project.

HEC then developed an hourly version of HEC-HMS (a rainfall-runoff model used to simulate hydrologic processes on dendritic watershed systems) and applied these storms to determine which orientations would produce the largest inflows to the Savannah River projects.

HEC then developed an hourly configuration of HEC RES-SIM (the Corps' reservoir simulation model). This version of the RES-SIM model included all of the rules and gate regulation curves that CESAS uses in their 1996 Reservoir Regulation Manuals. HEC used the outputs from the different centering positions of the PMF storms in HEC-HMS as inflows to RES-SIM. Each multipurpose project was tested to determine which inflows would produce the highest pool, and whether the gate operation would be sufficient to prevent overtopping of the gates. The RES-SIM analysis was prepared under the assumption that the PMF begins at the top of their flood pools at 665 FT-MSL, 480 FT-MSL, and 335 FT-MSL at Hartwell, Russell, and Thurmond, respectively.

The maximum design-induced surcharge elevations are 674.0 FT-MSL, 490 FT-MSL, and 346 FT-MSL at Hartwell, Russell, and Thurmond, respectively. The maximum design-induced surcharge elevation is the elevation of the top of the gates at their full open position. The original spillway design established the size of the gates and their maximum opening that defined the top of the induced surcharge pools. Typically, the top of the induced surcharge pool is set at or slightly above the maximum gate opening which prevents potential failure of the gates from overtopping.

Table 1 compares the original SDF criteria to the results of the 2015 PMF analysis. The results indicate that the 2015 PMF analysis is consistent with the original SDF criteria confirming that the peak pool elevations would not exceed the maximum induced surcharge pool elevations. The peak pool elevations from the PMF analysis are slightly below the peak pool elevations in the original SDF analysis at all three projects. This analysis confirms that the Savannah River multipurpose projects have adequate gate capacity and operating guidance to manage the PMF storm event.

Table 1: Comparison of Peak Elevations of Original SDF and PMF

	Original Spillway Design Flood Criteria			2015 PMF Analysis		
	Peak Elevation	Peak Inflow	Peak Outflow	Peak Elevation	Peak Inflow	Peak Outflow
Hartwell	674.00 FT-MSL	875,000 CFS	565,000 CFS	671.40 FT-MSL	778,000 CFS	546,747 CFS
Russell	490.00 FT-MSL	1,035,210 CFS	801,500 CFS	485.88 FT-MSL	707,000 CFS	703,675 CFS
Thurmond	346.00 FT-MSL	1,280,000 CFS	1,055,000 CFS	344.54 FT-MSL	1,236,450 CFS	1,048,244 CFS

Figure 1 illustrates how the PMF storm would affect the Hartwell Pool elevation and how the PMF peak pool elevation compares to the maximum induced surcharge elevation. The maximum induced surcharge elevation is 674 FT-MSL. The PMF peak pool elevation is 671.4 FT-MSL. The PMF peak pool elevation is 2.6 FT-MSL below the maximum design-induced surcharge elevation. Therefore, the Hartwell project has adequate gate capacity and operating guidance to manage a PMF storm event.

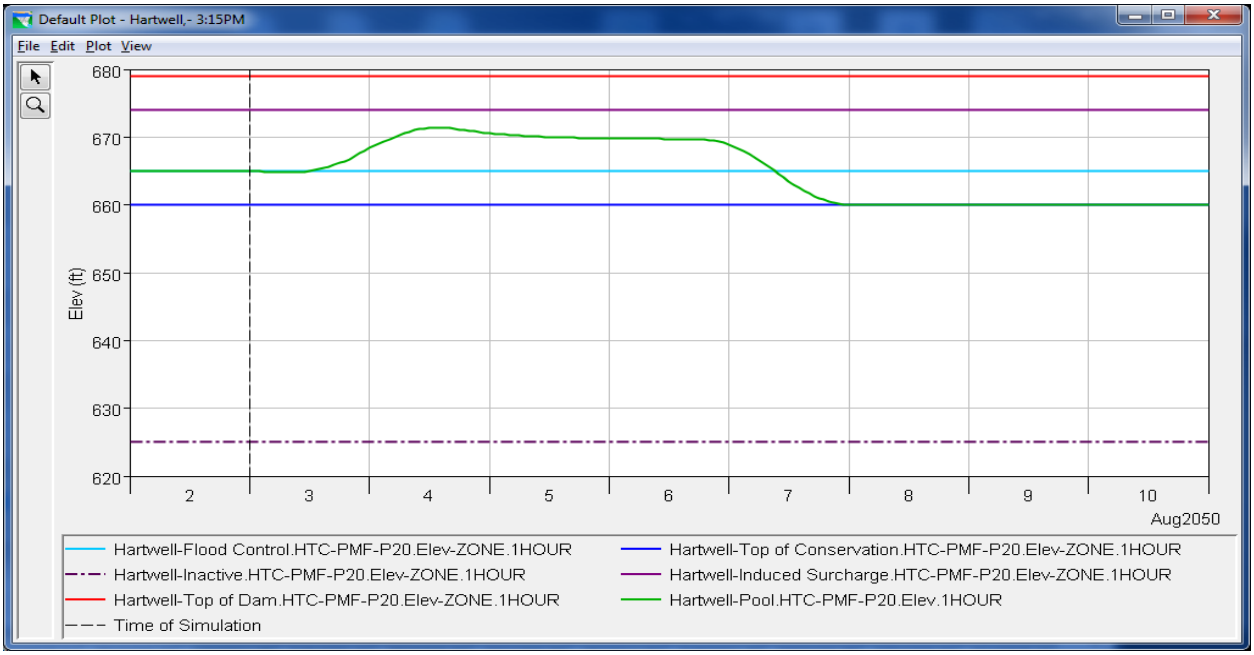


Figure 1: PMF Compared to Maximum Design-Induced Surcharge Elevation at Hartwell

Figure 2 illustrates how the PMF storm would affect the Russell Pool elevation and how the PMF peak pool elevation compares to the maximum induced surcharge elevation. The maximum design-induced surcharge elevation is 490 FT-MSL. The PMF peak pool elevation is 485.88 FT-MSL. The PMF peak pool elevation is 4.12 FT-MSL below the maximum design-induced surcharge elevation. Therefore, the Russell project has adequate gate capacity and operating guidance to manage a PMF storm event.

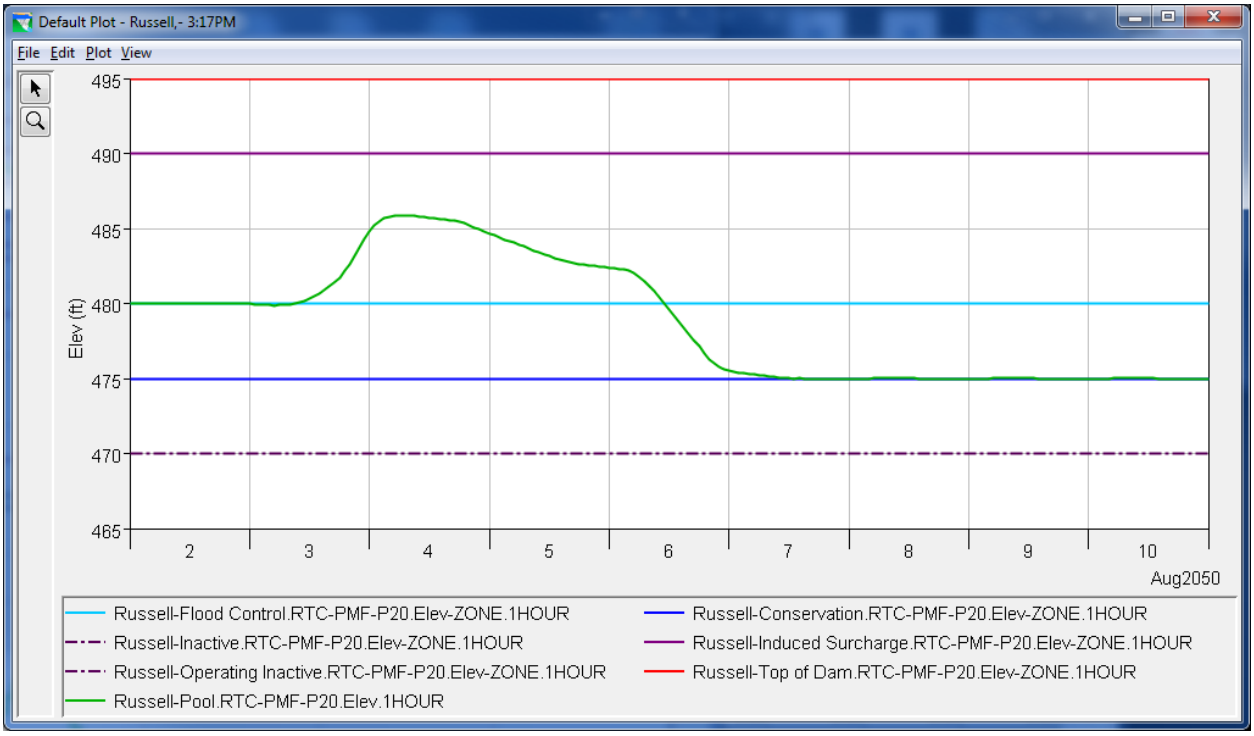


Figure 2: PMF Compared to Maximum Design-Induced Surcharge Elevation at Russell

Figure 3 illustrates how the PMF storm would affect the Thurmond Pool elevation and how the PMF peak pool elevation compares to the maximum induced surcharge elevation. The maximum design-induced surcharge elevation is 346 FT-MSL. The PMF peak pool elevation is 344.54 FT-MSL. The PMF peak pool elevation is 1.46 FT-MSL below the maximum design-induced surcharge elevation. Therefore, the Thurmond project has adequate gate capacity and operating guidance to manage a PMF storm event.

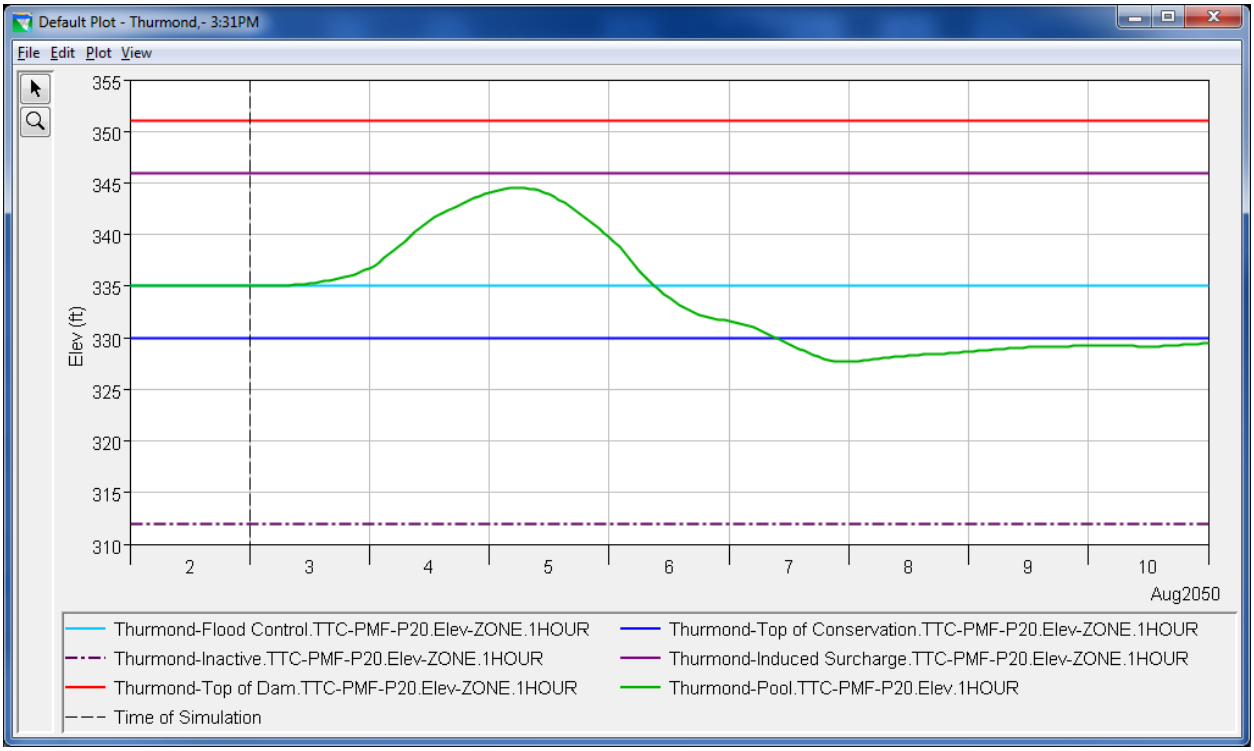


Figure 3: PMF Compared to Maximum Design-Induced Surcharge Elevation at Thurmond

Figure 4 illustrates how the operation of the Corps of Engineers' three multipurpose projects would affect the flow at Augusta, Georgia.

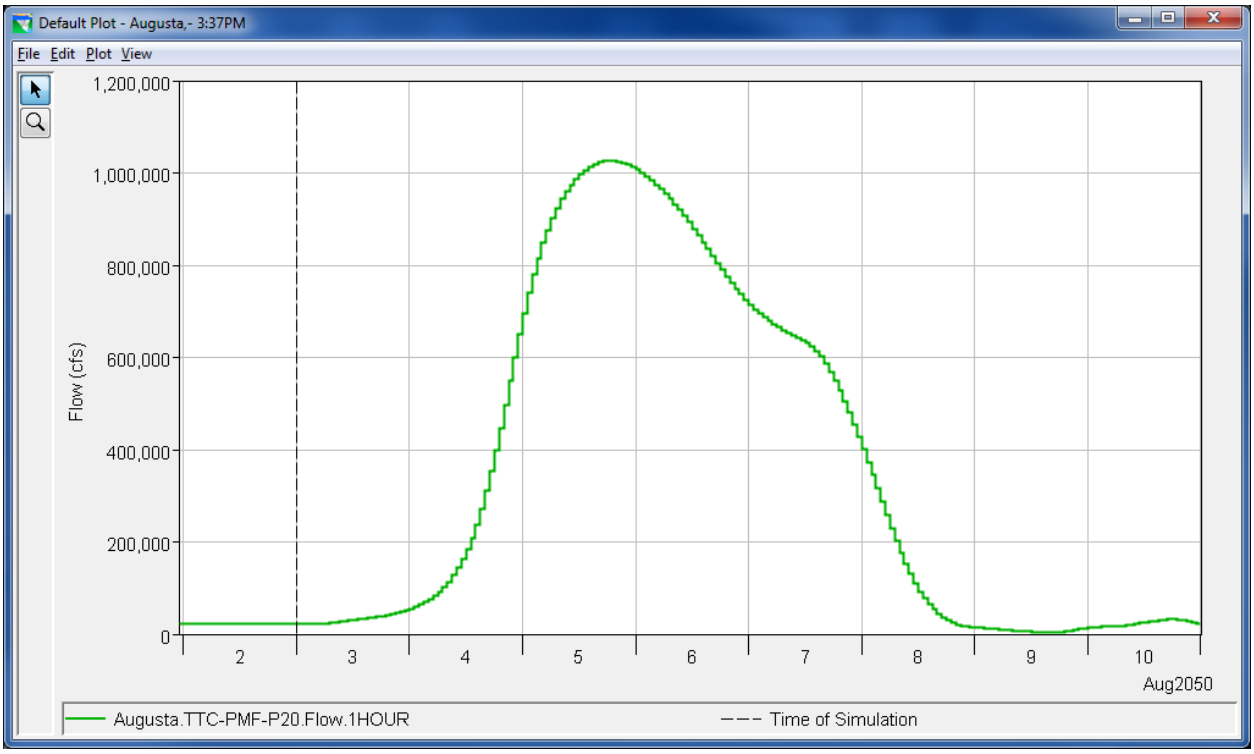


Figure 4: PMF Flow Impacts at Augusta, Georgia

Conclusions of the PMF Analysis

The 2015 PMF analysis enabled Savannah District to validate that the three Savannah River multipurpose projects meet current USACE design criteria, HMR-51/52. If the projects were designed today, a PMF design storm would be used to design the flood capacity of these USACE reservoir projects.

The existing flood storage at the three Savannah River Projects -- Hartwell, Russell, and Thurmond -- combined with the existing operational rules associated with flood management of the system are sufficient to manage the PMF storm without overtopping the gates. During a PMF event, substantial volumes of water would temporarily rise into the induced surcharge zones requiring releases over the spillway. It is important to keep in mind that while the dams have the capacity to manage the PMF storm without failure, the peak flow of 1,026,395 cfs would occur at Augusta. The Augusta Levee is only capable of protecting Augusta from floods less than 550,000 cfs. If the three dams were not present, a PMF would produce 1,261,723 cfs at Augusta.

This analysis focused on the PMF event and the ability of the Corps' Savannah River multipurpose projects to operate without failure during this event. The analysis indicates that no alteration of the existing gate regulation curves or induced surcharge storage pools is needed to prevent failures at the projects.

December 2015 Storm Event

In December 2015, a series of non-tropical winter storm events passed across the Savannah River basin affecting all three multipurpose projects. These storm events equated to roughly a 25-year event (4 percent chance of exceedance in any given year).

When the series of winter storm events began on December 14th, the pool elevations were at or near their guide curve. For the Hartwell Project, the guide curve pool elevation was 656 FT-MSL and the actual pool elevation was at 656.9 FT-MSL. For the Thurmond Project, the guide curve pool elevation was at 326 FT-MSL and the actual pool elevation was 325.84 FT-MSL. The guide curve pools on December 15th were nearly 4-feet below the summer full pool elevations of 660 FT-MSL and 330 FT-MSL at Hartwell and Thurmond, respectively. The seasonally transitioning guide curve provided an additional 4-feet of flood storage at both Hartwell and Thurmond for the series of storm events that began on December 14th. For the Russell Project, the guide curve pool elevation was 475 FT-MSL and the actual pool elevation was a few inches below guide curve. The Russell Project's guide curve does not vary seasonally. The flood control storage, which includes the additional 4-feet at both Hartwell and Thurmond from the seasonally transitioning guide curves, was nearly 100 percent available.

Runoff from the storms caused the Corps reservoirs to enter flood control operations. Lake levels rose to the top of all three project's flood control pools and into the induced surcharge pool at Thurmond. Hartwell's lake levels rose to 664.85 FT-MSL, just 0.15 feet from the top its flood control pool. Russell's lake levels rose to 479.79, just 0.21 feet from the top of its flood control pool. Thurmond's lake levels ascended beyond the top of its flood control pool and one foot into the induced surcharge pool. The local inflows below Thurmond in addition to a maximum release of 45,688 cfs from Thurmond Dam resulted in a peak stream flow at Augusta of 54,000 cfs. This is roughly twice the downstream channel capacity of 30,000 cfs. The Corps was required to open Thurmond's spillways 1.5 feet to prevent overtopping of the gates.

The City of Augusta/Richmond County, Georgia, and North Augusta, Aiken County, South Carolina all experienced flooding from this event. The City of North Augusta begins to flood at some locations even when streamflows are less than the channel capacity. This is due to encroachment on the flood plain.

The December 2015 storm revealed that the flood control pools for the Corps' three multipurpose projects (with the 4-foot winter drawdowns at Hartwell and Thurmond) have the capacity to store slightly less than a 25-year storm event without making use of induced surcharge. The Corps observed that releases from a 25-year storm event will flood portions of Augusta and North Augusta. A larger storm would have resulted in more flooding in those areas. If the storm had struck during a time when the reservoir levels were at full summer pool, additional downstream flooding and increased flood risks would have occurred.