REVIEW OF NEW PROBABLE MAXIMUM PRECIPITATION VALUES (Effective March 21, 2016) USING THE PMP EVALUATION TOOL

Name of Dam: Woods End Dam, also known as Hidden Valley High School Dam
Inventory Number: 161005
Prepared by: David M. Henderson, PE; Roanoke County Engineer

ORIGINAL HYDROLOGIC DESIGN CALCULATIONS

The original hydrologic calculations were based on a determination of the PMF created by a 24 hour duration storm. See the attached memo, sealed by the original design engineer, dated December 2, 2004 that documents the PMF that was used as the spillway design flood. This information was entered into the PMP Evaluation Tool as the PMF flow of 4,132 cfs. The original design did not include an analysis of either the 6 hour, or 12 hour duration PMP storms.

PMP VALUES FROM HMR51 FOR 6 HOUR, 12 HOUR, AND 24 HOUR STORMS

I determined the PMP for 6 hour, 12 hour, and 24 hour duration storms, using HMR51. Attached are figures that indicate rain amounts for the 3 storm durations for watersheds of 10 square miles. This information was entered into the PMP Evaluation Tool, as the PMP values from HMR.

USE OF THE DCR PMP EVALUATION TOOL

We followed the directions given in the DCR Guidance Document on New Probable Maximum Precipitation (PMP) Implementation and the DCR PMP Evaluation Tool Training Document, February 2016. Accompanying this document in digital form are data files that were used in this analysis.

The digital files consist of:

READ ME file – Contains documentation of file names and contents

Data.zip contains the following:

- **HVDamDrainageArea.shp** – Woods End (Hidden Valley) Dam Drainage Area shapefile projected in NAD 1983 2011 State Plane Virginia South FIPS 4502 Ft US.
- **HiddenValleyHS_Project.shp** - Hidden Valley High School parcels projected in GCS WGS 1984.

Results.zip contains three folders (General, Local, and Tropical) with the following feature classes:

- **Tropical_PMP_Points_1** - The tool's output to a geodatabase containing a point vector file for tropical storms. The attribute table of this file is used in the excel document to calculate the governing PMP values.
- **Local_PMP_Points_1** - The tool's output to a geodatabase containing a point vector file for local storms. The attribute table of this file is used in the excel document to calculate the governing PMP values.
- **General_PMP_Points_1** - The tool's output to a geodatabase containing a point vector file for general storms. The attribute table of this file is used in the excel document to calculate the governing PMP values.

2019 Woods End pmp-2015-calculations – Excel spreadsheet containing Virginia 2015 PMP Watershed Calculation Worksheet (September 2016 version)

EVALUATION
The 2015 PMP Values for 6 hour, 12 hour, and 24 hour storm durations, were all lower than the corresponding values from HMR51.

Based on the memo from the original dam designer, dated December 2, 2004; the design PDF is 4,132 cfs for a 24 hour PMP. The memo further states that this PDF results in 0.4 foot of freeboard.

On the basis of the information stated above, I have completed the Certificate Form: Review of New Probable Maximum Precipitation Values (Effective March 23, 2016) Using the PMP Evaluation Tool

ATTACHMENTS

- Project Memo prepared by Engineering Concepts, Inc., dated December 2, 2004 that documents the original design PMF, using a 24 hour storm duration.
- Figures (3) from the HMR51 for PMP depths for 6 hour, 12 hour, and 24 hour storm durations, and 10 square mile drainage areas.
- Digital files, as described above
- Virginia 2015 PMP Watershed Calculation Worksheet (September 2016 version)
- Certificate Form: Review of New Probable Maximum Precipitation Values (Effective March 23, 2016) Using the PMP Evaluation Tool

PROJECT MEMO

DATE: December 2, 2004
FILE: 00075 DATA CALCS
RE: PMF Flow Capacity

ENGINEERING
CONCEPTS INC.

The purpose of this memo is to relook at the stated capacity of the Hidden Valley High School Dam. The original design report completed in August of 2000 indicated a capacity of 0.41 PMF. Since that time, the construction of the dam has been completed and new information has been reviewed to compare with the original analysis.

A master of science project report was recently prepared on the Hidden Valley High School Dam which took a comprehensive look at the hydrology of the drainage basin, hydraulic performance of the structure, and the sensitivity of various computational methods for calculating flows and capacities at the facility. The report titled "The Effects of Impervious Fraction on Downstream Flood Damages" dated September 9, 2004 was prepared by Matthew Troy Biggs, a masters student in the Department of Civil and Environmental Engineering department at Virginia Tech. The advisors listed for the report are Dr. Kibler and Dr. Loganathan.

The construction of the dam has also been coupled with quarterly stream monitoring focused on water quality during storm events. While the number of sample points and purpose of the data collection do not allow for valid statistical analysis, the monitoring did provide valuable observations of the facility during storm events. In general, the flow depth through the emergency spillway for an estimated 2-year storm was approximately 2' and the flow depth for an estimated 10-year storm was approximately 4'.

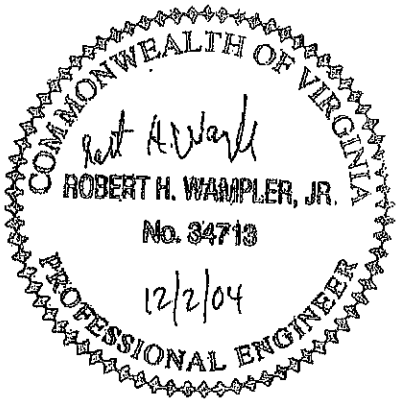
The review of other computational methods and the observation of the facility during storm events indicate that the original stated capacity of the facility was very conservative. For example, the original design report indicated the runoff for a 2-year storm at 417 cfs. Based on observations of the facility, a flow depth of 2' was associated with a 2-year storm and results in a flow of 146 cfs. Using the regression equations by the National Flood-Frequency Program (2000) as a check, a 2-year storm event in this region would be 155cfs. While it is understood that regression equations are very basic and should be used with caution, the flows reflected with the regression equations, observations, and presented in the Master's Study report all indicated flows significantly smaller than estimated in the original design calculations. This is further reflected in other storm frequencies analyzed. A conservative estimate of the facility's capacity was appropriate during the design and approval stage of the project, however a more realistic estimate of the actual performance is desired at this point.

P O. Box 619, Fincastle, VA 24090
Phone 540-473-1253, Fax 540-473-1254

The PMF flow calculated for this analysis is based on a future curve number (CN) value of 85 reflecting the potential conditions of the watershed in the year 2020 during a PMF event. The estimated CN value of the existing watershed is 68. The existing time-of-concentration (Tc) for the watershed is 1.26 hours. Since Tc tends to be shorter during a PMF event, a reduced Tc of 1.00 hours was used in the analysis. Based on the PMP 24-hr depth of 37" for the project site as shown in Hydrometeorological Report No. 51, a hydrograph was developed to model the storm event.

The data used for the capacity analysis related to the outlet structures remained unchanged from the original analysis.

The resultant PMF from this analysis into the facility is 4,132 cfs. The routed PMF through the facility is 4,127 cfs at an elevation of 1124.5'. This results in a freeboard of 0.4' at the low point elevation of the road during a PMF event. Therefore, it is estimated that the facility can pass a PMF with 0.4' of freeboard.



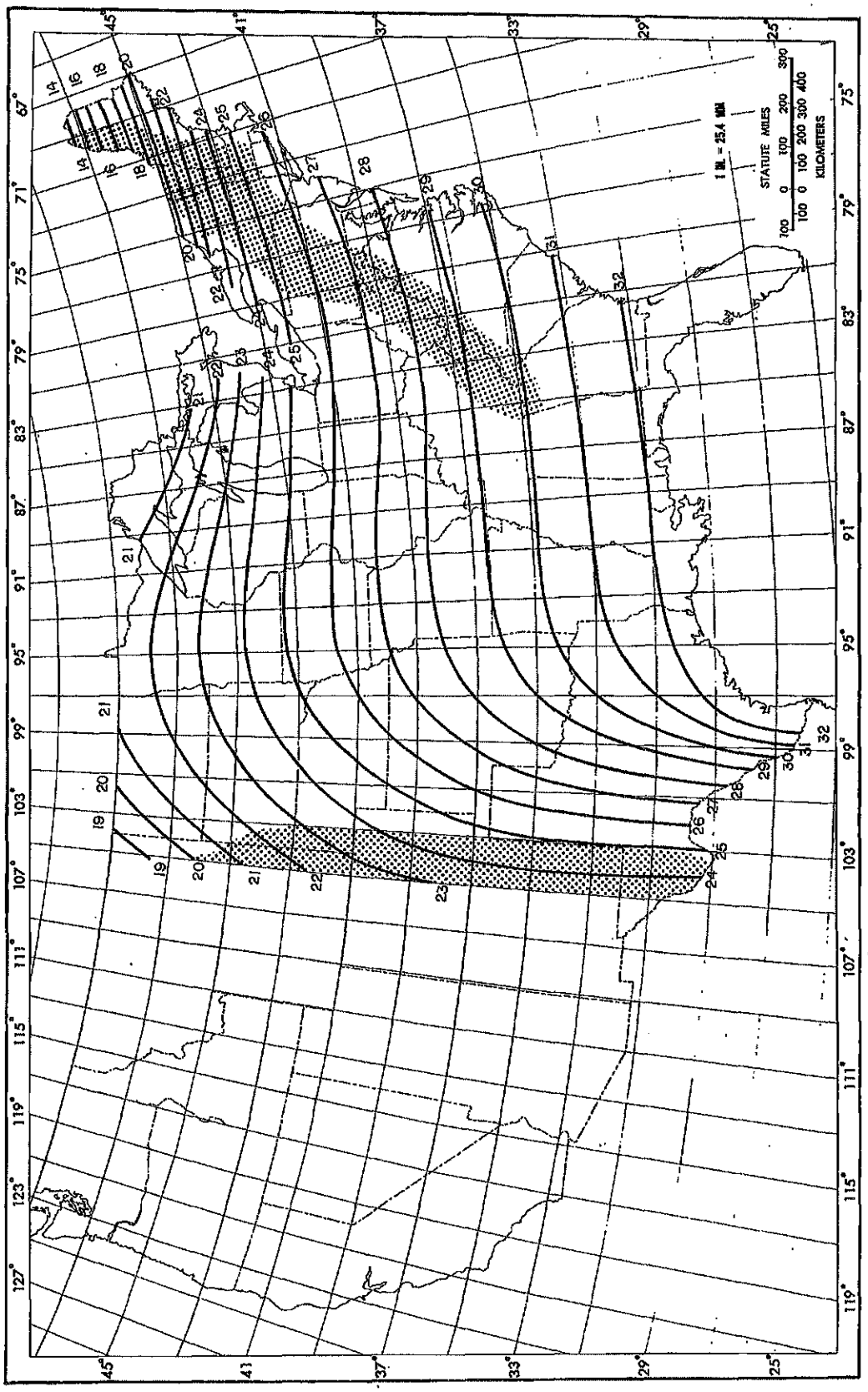


Figure 18.--All-season PMP (in.) for 6 hr 10 mi^2 (26 km^2).

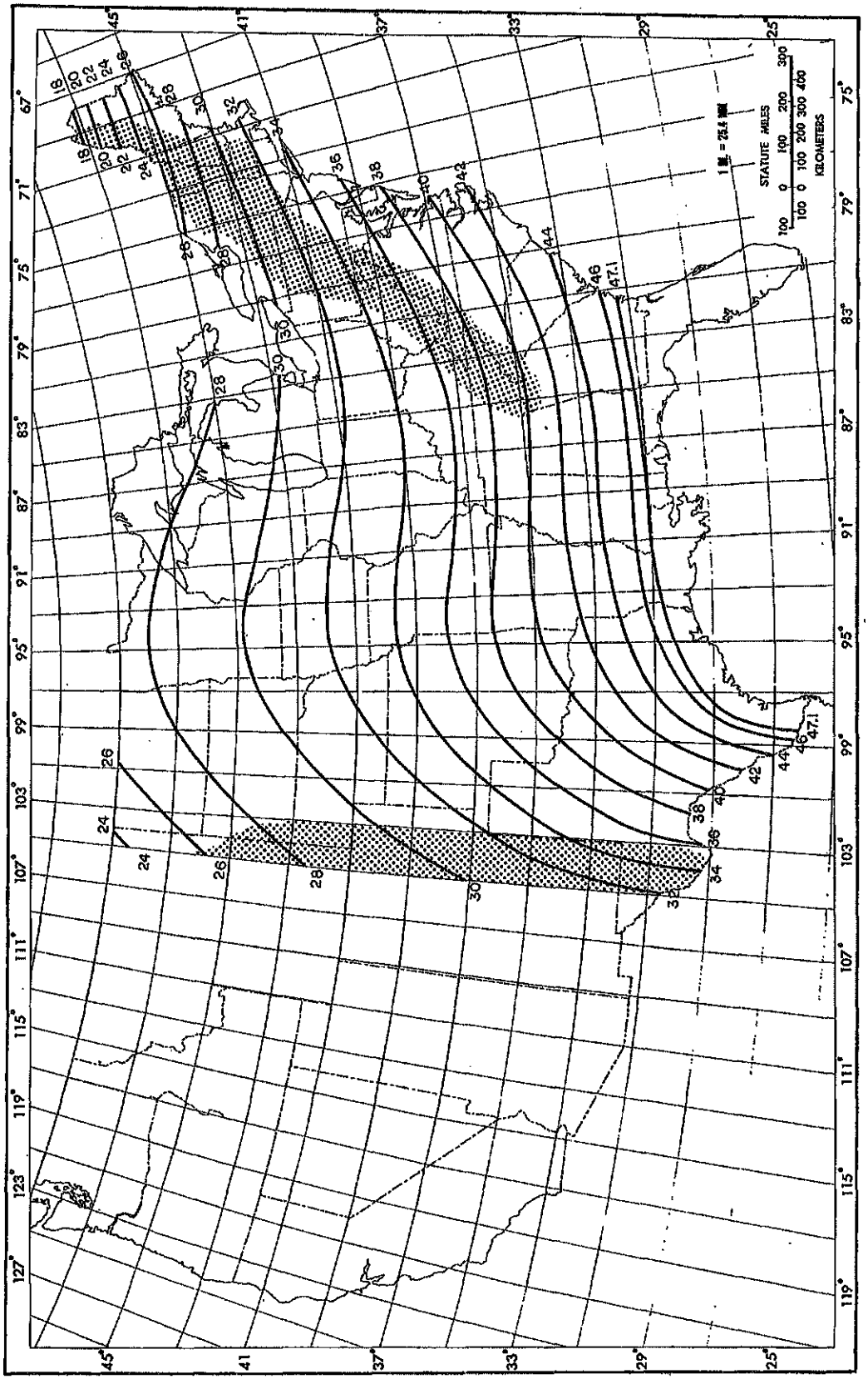


Figure 20.--All-season PMP (in.) for 24 hr 10 mi^2 (26 km^2).

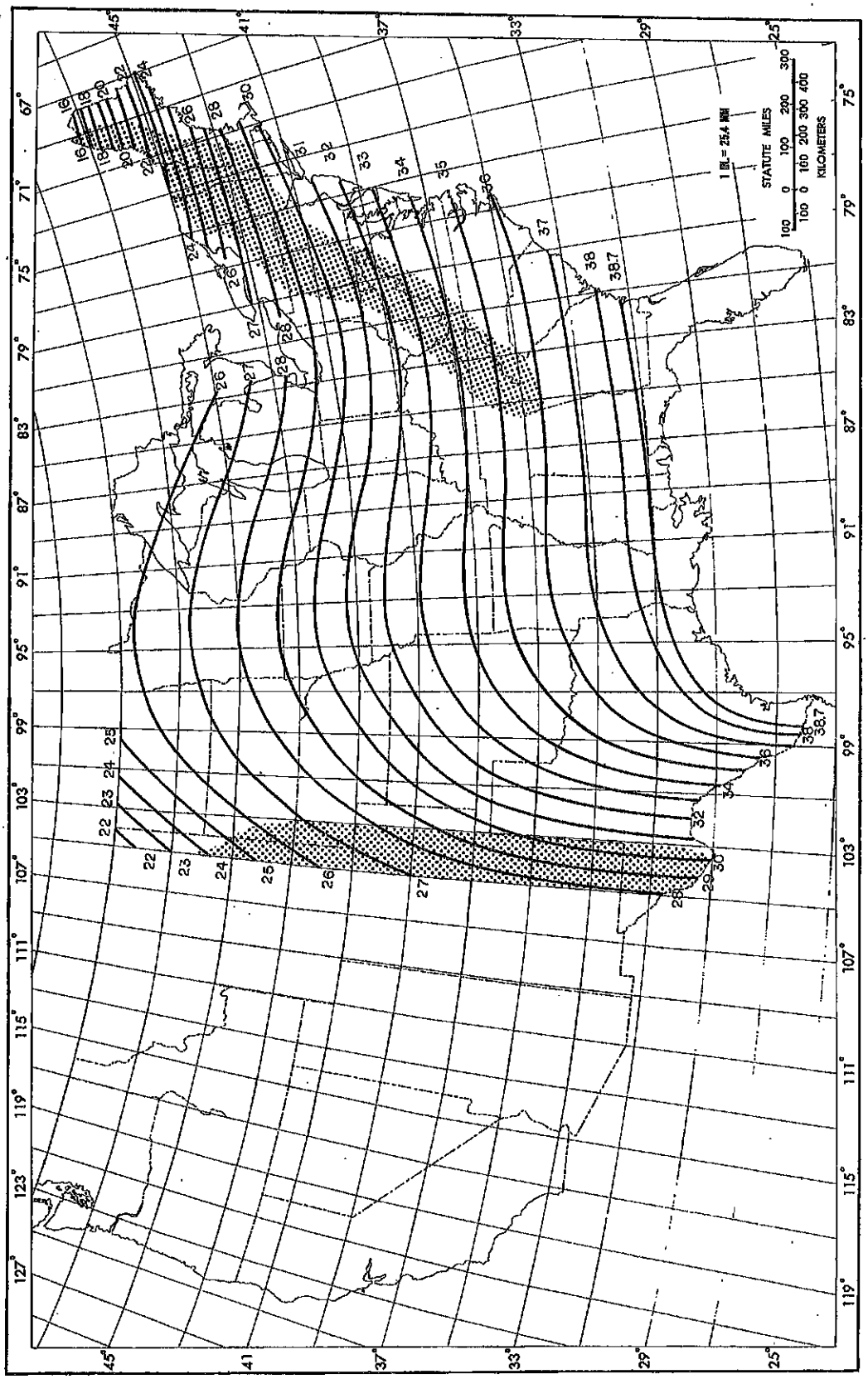


Figure 19.--All-season PMP (in.) for 12 hr 10 mi^2 (26 km^2).

Note : This sheet should be used in consultation with the *Guidance Document on New Probable Maximum Precipitation (PMP) Implementation* (March 23, 2016) and the *Certification Form: Review of New Probable Maximum Precipitation Values (Effective March 23, 2016) Using the PMP Evaluation Tool* .

Virginia 2015 PMP Watershed Calculation Worksheet (SEPTEMBER 2016 version)

Dam: Woods End Dam; Inventory Number 161005
Company: Roanoke County, VA
Engineer: David M. Henderson, County Engineer

Date: 4/16/2019

NOTES

A. PLEASE ENSURE ALL RELEVANT SECTIONS ARE FILLED OUT (PLEASE SCROLL DOWN THROUGH ENTIRE WORKSHEET)
B. PLEASE ENSURE CELLS WITH EMBEDDED CALCULATIONS (CELLS WITH NO BLUE COLOR) ARE REFERENCING THE CORRECT NUMBERS. WHEN ADDING OR DELETING ROWS FOR GRID POINTS, CELLS WITH EMBEDDED CALCULATIONS MAY BE REFERENCING THE WRONG INFORMATION. PLEASE CHECK CALCULATION CELLS!
C. PLEASE ENSURE THAT ALL SUPPORTING DOCUMENTATION AND CALCULATIONS REQUIRED FOR THIS SUMMARY SHEET ARE INCLUDED IN SUBMITTAL (ESPECIALLY INFORMATION FOR SDF CALCULATIONS IN SECTIONS E AND F).

Example Cell	**Cells Requiring User Input are Highlighted in Blue**

Calculation Section A - Drainage Area to Dam

Information obtained from GIS shapefile / watershed boundary analysis or previously completed Dam Failure Analysis

Drainage Area	1218.90	1.905
	Acres	Sq. Miles

Calculation Section B - Original HMR 51/52 Values

Information obtained from previously computed HMR 51/52 program (previously completed Dam Failure Analysis)

6-hr HMR 51/52 PMP Value	28.5	in / 6-hr
12-hr HMR 51/52 PMP Value	34	in / 12-hr
24-hr HMR 51/52 PMP Value	37	in / 24-hr

Calculation Section C - New 2015 PMP Values

Information obtained from new 2015 PMP GIS Evaluation Tool (see the PMP section of the DCR Dam Safety website for more details)

General Storm Events

Grid Pts	Point X	Point Y	Zone	6 Hr. PMP	12 Hr. PMP	24 Hr. PMP	Controlling 6 Hr. Storm	Controlling 12 Hr. Storm	Controlling 24 Hr. Storm
1	-80.05	37.2	5	13.9	16.2	17.8	SPAS_1339_1	SPAS_1339_1	SPAS_1201_1
2	-80.025	37.2	5	14	16.3	17.9	SPAS_1339_1	SPAS_1339_1	SPAS_1201_1
3	-80.05	37.225	5	13.5	15.6	17.2	SPAS_1339_1	SPAS_1339_1	SPAS_1201_1
4	-80.025	37.225	5	13.7	15.9	17.5	SPAS_1339_1	SPAS_1339_1	SPAS_1201_1

Average PMP Values:	13.8	16.0	17.6

Local Storm Events

Grid Pts	Point X	Point Y	Zone	6 Hr. PMP	12 Hr. PMP	24 Hr. PMP	Controlling 6 Hr. Storm	Controlling 12 Hr. Storm	Controlling 24 Hr. Storm
1	-80.05	37.2	5	21.1	23	23.7	SPAS_1406_1	SPAS_1406_1	SPAS_1406_1
2	-80.025	37.2	5	21.2	23.1	23.8	SPAS_1406_1	SPAS_1406_1	SPAS_1406_1
3	-80.05	37.225	5	20.5	22.3	23.1	SPAS_1406_1	SPAS_1406_1	SPAS_1406_1
4	-80.025	37.225	5	20.8	22.6	23.4	SPAS_1406_1	SPAS_1406_1	SPAS_1406_1

Average PMP Values:	20.9	22.8	23.5

Tropical Storm Events

Grid Pts	Point X	Point Y	Zone	6 Hr. PMP	12 Hr. PMP	24 Hr. PMP	Controlling 6 Hr. Storm	Controlling 12 Hr. Storm	Controlling 24 Hr. Storm
1	-80.05	37.2	5	16.7	25.5	25.5	SPAS_1491_1	SPAS_1491_1	SPAS_1491_1
2	-80.025	37.2	5	16.8	25.7	25.7	SPAS_1491_1	SPAS_1491_1	SPAS_1491_1
3	-80.05	37.225	5	16.1	24.6	24.6	SPAS_1491_1	SPAS_1491_1	SPAS_1491_1
4	-80.025	37.225	5	16.4	25	25	SPAS_1491_1	SPAS_1491_1	SPAS_1491_1

Average PMP Values:	16.5	25.2	25.2

Governing PMP Values from Storm Events

	6 Hr. PMP	12 Hr. PMP	24 Hr. PMP
Governing PMP Values for Watershed	**20.9**	**25.2**	**25.2**

Calculation Section D - Comparison Calculations - Original HMR 51/52 Values vs. New 2015 PMP Values

Information for these calculations obtained from data provided in this spreadsheet. Section provides comparison between HMR 51/52 rainfall values and new 2015 PMP rainfall values. Please review options presented below and DCR Dam Safety PMP Guidance Documentation to determine if SDF calculations are required (next section).

Storm Duration, hrs.	HMR 51/52 Value, in/hr	Governing 2015 PMP Value, in/hr	Comparison	Percent Difference, %
6	28.5	20.9	**-7.60**	-26.67%
12	34	25.2	**-8.80**	-25.88%
24	37	25.2	**-11.80**	-31.89%

Section Completion Options

Option A - The Dam in question has no previously completed (or approved) Inundation Study and will only be utilizing the Governing 2015 PMP values for the new Dam Failure Analysis. Calculation Section E and Calculation Section F are not required as the SDF for the Dam in question will be calculated from the new Dam Failure Analysis. This option only applies to Dams with no previously completed (or approved) Inundation Study on file with DCR Dam Safety.

Option B - All three of the new Governing 2015 PMP values decreased when compared to the previously completed HMR 51/52 values (negative values for all three storm

durations in the comparison column above). At this time, revisions to the existing Inundation Maps / EAPs for the Dam in question are optional and not generally required [Please refer to the *Guidance Document on New Probable Maximum Precipitation (PMP) Implementation* for further details, restrictions, and exceptions]. Please fill out information below in Calculation Section E Only. Calculation Section F is not required for this option.

Option C - One or two of the new Governing 2015 PMP values increased when compared to the previously completed HMR 51/52 values (positive values for one or two storm durations in the comparison column above). At this time, revisions to the existing Inundation Maps / EAPs for the Dam in question may be required depending on further analysis of the Dam in question [Please refer to the *Guidance Document on New Probable Maximum Precipitation (PMP) Implementation* for further details, restrictions, and exceptions]. Please fill out information below in Calculation Section E and Calculation Section F as both are required. It must be determined if either of these new increased PMP values have become the controlling storm for the basin in question.

Option D - All of the new Governing 2015 PMP values increased when compared to the previously completed HMR 51/52 values (positive values for all three storm durations in the comparison column above). At this time revisions to the existing Inundation Maps / EAP's for the Dam in question will be required for the Dam in question [Please refer to the *Guidance Document on New Probable Maximum Precipitation (PMP) Implementation* for further details, restrictions, and exceptions]. Please fill out information below in Calculation Section E and Calculation Section F as both are required.

Calculation Section E - Current Flow and SDF for Dam in Question

Information for this calculation section obtained from previously completed Dam Failure Analysis hydrology calculations (HEC-1 or HEC-HMS). Section provides existing controlling storm for Dam in question, existing controlling flow (flow to Dam) from controlling storm for Dam in question, flow existing Dam in question can pass without overtopping, storm event (SDF) existing Dam in question can pass without overtopping, and storm event (SDF) existing Dam in question must pass per Regulations.

Current controlling storm duration for Dam (6, 12, or 24):	only 24 hour storm computed	hour
PMF Flow TO existing Dam during controlling storm duration	4132	cfs
Flow existing Dam can pass without overtopping	4132	cfs
Storm event (SDF) existing Dam can pass without overtopping (calc)	1.00	PMF storm
Storm event (SDF) existing Dam must pass per State DS Regulations	PMF	storm

Calculation Section F - Revised Flow and SDF Calculations for Dam in Question

Information for this calculation section obtained from Calculation Section E and revised Dam Failure Analysis hydrology calculations (HEC-1 or HEC-HMS) (Please see DCR Dam Safety PMP Guidance Document). Section provides information on the revised controlling 6-hr, 12-hr, or 24-hr storm duration (if revisions needed), revised controlling storm for Dam in question (or previous controlling storm if no changes found), revised controlling flow (flow to Dam) from controlling storm for Dam in question, flow existing Dam in question can pass without overtopping (information from Calculation Section E), revised storm event (SDF) existing Dam in question can pass without overtopping, and storm event (SDF) existing Dam in question must pass per Regulations (information from Calculation Section E).

Did controlling storm duration for the Dam change based on revised flow / SDF data?		yes or no
Controlling storm duration for Dam based on Revised Data (6, 12, or 24):		hour
Revised PMF Flow TO existing Dam during revised controlling storm duration		cfs
Flow existing Dam can pass without overtopping (From Calculation Section E)	4132	cfs
Revised Storm event (SDF) existing Dam can pass without overtopping (calc)		PMF storm
Storm event (SDF) existing Dam must pass per State DS Regulations	PMF	storm

Based on the revised flow / SDF values, can the Dam in question now pass the required SDF per State DS Regulations without overtopping?		yes or no

Certification Form: Review of New Probable Maximum Precipitation Values (Effective March 23, 2016) Using the PMP Evaluation Tool

Virginia Department of Conservation & Recreation

Name of Dam (Print): Woods End ; Inventory Number for Dam: 161005 ; Dam in County or City: Roanoke County

CERTIFICATION BY OWNER'S ENGINEER

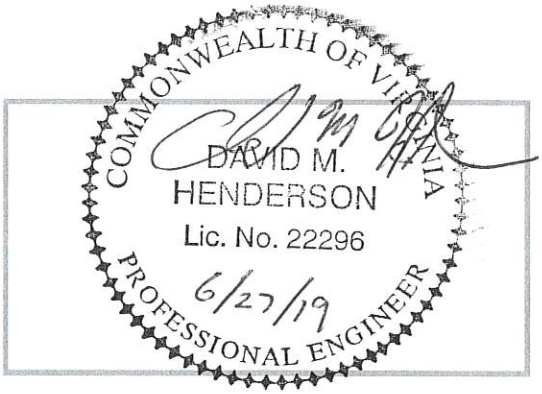
I certify that I have evaluated the new probable maximum precipitation (PMP) values, and have found that one of the following conditions has occurred: (1) each of the governing PMP values for the 6-, 12-, and 24-hour durations have decreased from previously utilized HMR PMP values or (2) the PMP value for the controlling storm has decreased from previously utilized HMR values and still results in the largest outflow from the dam when compared to the other two durations. I therefore find that the original dam break inundation zone map and the emergency action plan/ emergency preparedness plan on file remain protective of public safety. I have attached a completed copy of the *Virginia PMP 2015 Watershed Calculation Spreadsheet* and my supporting calculations to serve as the confirmation record. Further, I have notified the impounding structure owner of my findings.

Signed: _____ David M. Henderson Virginia Number: 0402 022296

Professional Engineer's Signature Print Name

This 27 day of June , 20 19 .

Engineer's Virginia Seal:



CERTIFICATION BY OWNER

I, as the Owner of the impounding structure, certify that my engineer has evaluated the new probable maximum precipitation (PMP) values and advised me of the findings. I recognize that one of the following conditions has occurred: (1) each of the governing PMP values for the 6-, 12-, and 24-hour durations have decreased from previously utilized HMR PMP values or (2) the PMP value for the controlling storm has decreased from previously utilized HMR values and still results in the largest outflow from the dam when compared to the other two durations. In addition, I also certify that the original dam break inundation zone map and the emergency action plan/ emergency preparedness plan on file remain protective of public safety. I agree that should an evaluation be required in accordance with § 10.1-606.3 of the *Code of Virginia* to assess any development proposed within the boundaries of the dam break inundation zone below this impounding structure, that I shall upon notification from the Department of Conservation and Recreation immediately initiate efforts to update the dam break inundation zone map for my impounding structure so that a refined impact of the development may be assessed.

Signed: _____ Richard Caywood

Owner's Signature Print Name

This 27 day of June , 20 19 .

Mail the executed form to the appropriate
Department of Conservation and Recreation
Division of Dam Safety and Floodplain Management
Regional Engineer