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May 07, 2021

Mr. Sam Oliverio
Supervisor
Town of Putnam Valley
265 Oscawana Lake Road
Putnam Valley, NY 10579

RE: Roaring Brook Dam (DEC#213-2775) H&H Analysis and Recommendations Report Memo

Hello Sam,

We have completed a Hydrologic and Hydraulic Analysis and Recommendations Report for Roaring Brook Lake Dam. Please see the Report document enclosed.

If you have any questions regarding the package, please contact Hans Hasnay at (646) 467-6220 & Hans.Hasnay@wsp.com or Alexandra Natchev at (914) 449-9072 & Alexandra.Natchev@wsp.com.

Kind regards,

Hans Hasnay, P.E.

eCc.
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Statement of Purpose

Roaring Brook Lake Dam (NYSDEC ID# 213-2775) is a Class C- High Hazard concrete, gravity dam with a reinforced earth embankment located in the Town of Putnam Valley, Putnam County, New York. WSP has reviewed the Roaring Brook Dam Engineering Assessment, dated December 26th, 2014 completed by Woidt Engineering & Consulting, P.C. and submitted to the NYSDEC for review. The NYSDEC responded on August 4, 2020 with a Notice of Incomplete Application letter stating a PE signature and stamped cover for the Stability Analysis was needed for the Engineering Assessment (EA) to be accepted as complete. Additionally, the NYSDEC concurred with the identified deficiencies of the existing dam and remedial measures from the EA summarized below:

- The dam has inadequate spillway capacity for the 0.5 Probable Maximum Flood (PMF), which is the spillway design storm for a Class C- High Hazard dam. The dam will be overtopped by approximately 1.7ft for about 16 hours during this storm event. Remediation measures consist of a rehabilitation design to have adequate spillway capacity to pass the 0.5 PMF.

- The 18-inch low level outlet (LLO) does not have sufficient capacity to drain 90% of the reservoir within a 14-day period. The outlet valve is also located on the downstream side of the dam, which results in a pressurized pipe throughout the dam. To remediate, it is recommended that the drawdown capacity is investigated such that 90% of the reservoir volume can be removed within 14 days (assuming no inflow).

The NYSDEC assigned a condition rating of "Unsound-Fair" to Roaring Brook Dam until the Application is complete. This condition rating means that the dam is expected to perform adequately under normal loading conditions; however, rare or extreme hydrologic loading conditions may result in an unacceptable performance. The owner of a dam with a condition rating of "Unsound" is also in violation of 6 NYCRR Part 673 and ECL Article 15 Section 0507.

This memo includes our Hydrologic and Hydraulic analysis results (H&H), proposed recommendations for spillway alternatives and a supplemental pumping plan with pumping system required and contact information for the pump supplier to remediate the deficiencies stated above.

Hydrologic and Hydraulic Analysis

Approach and Methodology

The hydrologic and hydraulic analysis submitted in the December 2014 Engineering Assessment Report (*Reference 1)* was recreated from the original HydroCAD model to a HEC-RAS model and confirmed by WSP as being accurate. The NYSDEC Guidelines for Design of Dams (*Reference 2*) requires that the spillway be capable of safely passing the Spillway Design Flood (SDF) with flood routing through the reservoir. Roaring Brook Lake Dam is an existing Class C dam (*Reference 6*) with no freeboard requirement, so the spillway must pass 50% of the PMF (0.5 PMF) without overtopping the dam.

The HEC-RAS model routed the SDF (Spillway Design Flood or Storm) through the reservoir and determined the reservoir response for different dam and spillway geometry options during the SDF. The HEC-RAS model was used to provide the critical reservoir levels during the SDF for the rehabilitated dam, which will be used for the structural design calculations. The model also was used to develop refined geometry to avoid overly conservative designs, potentially saving the Town of Putnam Valley money as this project moves to full design and construction. The elevations were computed using the North American Vertical Datum of 1988 (NAVD88) with new survey data from the March 2021 WSP survey.

Geometry and Dimensions of Proposed Rehabilitation Designs

The existing spillway has a spillway crest of El. 773.8ft with flashboards in place and a varying dam crest of approximately El. 775.1ft to 775.4ft. The existing dam length is approximately 450ft with a spillway length of 28ft. The saddle dam, to the east of the main dam, is approximately 150ft long at a higher crest elevation than the main dam of El. 777.4ft.

The proposed rehabilitation recommendation for the dam consists of adding a parapet wall across the crest of the main dam and saddle dam with the top at EL. 778ft. A berm of equal elevation will be placed at the low areas of the children's beach to prevent water from overflowing the beach and downstream. The existing spillway will remain. A proposed auxiliary spillway will be constructed at the right-side of the main dam looking downstream. This auxiliary spillway will be a 60ft wide, broad-crested spillway with a crest El. 775.5ft and easily connect to the downstream channel.

The analysis consisted of several scenarios that ultimately determined the auxiliary spillway and parapet option above. Parapet walls on the main and saddle dam alone resulted in a Water Surface Elevation (WSE) of 778.08ft, which would require a parapet wall height higher than 778ft to tie-into the topography. The issue with this option was that the topography does not allow for a tie-in elevation of over 778ft. Additionally, widening the spillway an another 100ft, to a total of 128ft, resulted in overtopping of the dam. Although it is possible to increase the service spillway width even wider, it would require more intensive work on the downstream discharge channel.

A combination of the parapet walls at a shorter height and a smaller auxiliary spillway was determined to be the most feasible option. Once it was determined that the WSE during the 0.5PMF was under 778ft, various auxiliary spillway widths and crest elevations were analyzed to ensure no overtopping over the dam, as well as, a reasonable cost-effective width and crest elevation for the auxiliary spillway. The auxiliary spillway crest elevation lower than 775.5ft, even at a wider spillway width of 100ft, did not decrease the WSE enough to justify the lower and wider spillway that would result in an increased cost. An auxiliary spillway crest of lower than 775.5ft would also trigger overflow during the 100-Year flood. This would require additional hardening of the discharge channel, as opposed to the economical, grass-lined channel rehabilitation option downstream of the auxiliary spillway crest of 775.5ft.

For a plan view of the auxiliary spillway and parapet wall configuration, refer to Figure 1 below, and Appendix B for the complete plan view of the site.

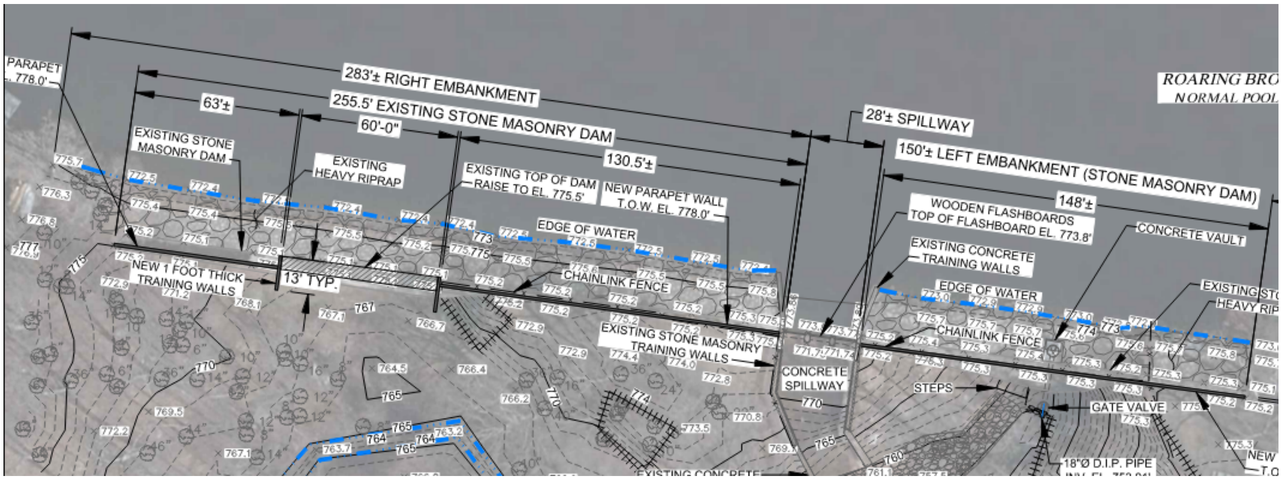


Figure 1: Plan View of Proposed Auxiliary Spillway and Parapet Recommendation

Calculations

The capacity of the existing spillway configuration in the HydroCAD model are checked in the HEC-RAS model with a spillway rating curve and an elevation-storage curve. The elevation-storage curve is from the HydroCAD model, which was developed using bathymetric data from the field survey (*Reference 1*). The spillway rating curve, also known as an elevation-discharge curve, is developed using an equation for the discharge from a sharp-crested weir expressed in terms of total energy head (*Reference 5*). The calculated curve differs from the original HydroCAD curve, which had a constant coefficient.

The discharge for a sharp-crested weir is shown in *Equation 1*.

$$Q = CLH_e^{3/2} \tag{1}$$

Where:

- Q = discharge (cfs)
- C = discharge coefficient
- L = effective spillway crest width (ft)
- H_e = variable energy head on crest (ft)

The information on discharge coefficients, C, for sharp-crested weirs is available from the investigations of the Bureau of Reclamation (1948) and Kindsvater and Carter (1959). These investigations show that the coefficient for free discharge is a function of certain dimensionless ratios that describe the geometry of the channel and the weir (*Reference 5*). The value of C is calculated using the relationships shown in the United States Geological Survey, Chapter A5 (*Reference 5)*. For the existing spillway, the fitted equation for the discharge coefficient is given by *Equation 2*. The reference plot used to derive this fitted equation is shown in Appendix A.

$$C = 0.00561\left(\frac{H_e}{P}\right)^3 - 0.07979\left(\frac{H_e}{P}\right)^2 + 0.46447\left(\frac{H_e}{P}\right) + 3.26204 \tag{2}$$

Where:

- P = height of the weir above the average streambed elevation (ft)
- H_e = variable energy head on crest (ft)

Using *Equations 1* and *2*, a spillway rating curve was developed for the existing spillway configuration. The spillway rating curve for the existing configuration is shown in Figure 2 and Appendix A.

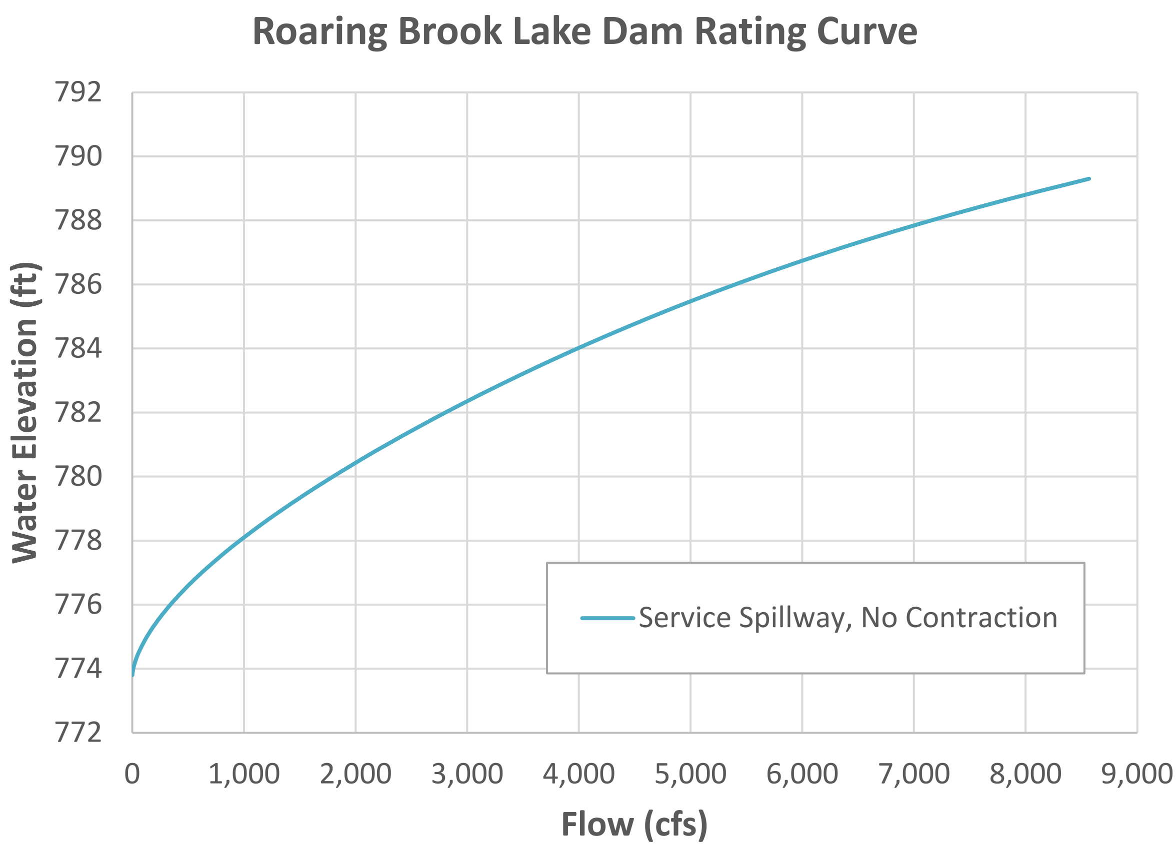


Figure 2: Existing Spillway Rating Curve calculated with a Variable Coefficient

The elevation-discharge curve (spillway rating curve) and the elevation-storage curve are input into HEC-RAS and the model is run for the selected flood events: the 100-year storm return period and the SDF (50% of the PMF for Class C dams). The tables below show the model results for the existing conditions and the proposed auxiliary spillway and parapet wall design for both storm events analyzed. The HEC-RAS model results are shown in Appendix A.

Table 1: HEC-RAS 100-Year Storm Results for Existing Conditions

Existing Conditions							
HEC-RAS Summary Table- 100-Year Storm							
Structure	Crest Elevation (ft)	Length (ft)	Flow (cfs)	WSE (ft)	Overtopping (Ft)	Flow duration (hr)	Flow duration (min)
Saddle Dam	777.4[1]	170	0	775.34	-2.06	0.0	0
Main Dam	775.1[1]	430	0	775.34	0.24	0.0	0
Spillway	773.8	28	193.53	775.34	1.54	24.7	1480

Table 2: HEC-RAS 0.5PMF Results Existing Conditions

Existing Conditions							
HEC-RAS Summary Table- 0.5PMF							
Structure	Crest Elevation (ft)	Length (ft)	Flow (cfs)	WSE (ft)	Overtopping (Ft)	Flow duration (hr)	Flow duration (min)
Saddle Dam	777.4	170	22.66	777.59	0.19	17.8	1070
Main Dam	775.1	430	925.97	777.59	2.49	18.3	1100
Spillway	773.8	28	814.99	777.59	3.79	30.8	1850

Table 3: HEC-RAS 100-Year Storm Results for Parapet Walls at EL. 778ft and Auxiliary Spillway at crest EL. 775.5ft

Proposed Parapet and Aux Spillway							
HEC-RAS Summary Table- 100-Year Storm							
Structure	Crest Elevation (ft)	Length (ft)	Flow (cfs)	WSE (ft)	Overtopping (Ft)	Flow duration (hr)	Flow duration (min)
Saddle Dam	778	170	0	775.34	-2.66	0.0	0
Main Dam	778	370	0	775.34	-2.66	0.0	0
Auxiliary Spillway	775.5	60	0	775.34	-0.16	0.0	0
Spillway	773.8	28	193.53	775.34	1.54	24.7	1480

[1] The main dam crest varies from El. 775.1ft to 775.4ft and the saddle dam crest varies from El. 777.4ft to 777.5ft. The elevation shown in the table is the lowest elevation in the range.

Table 4: HEC-RAS 0.5PMF Results for Parapet Walls at EL. 778ft and Auxiliary Spillway at crest EL. 775.5ft

Proposed Parapet and Aux Spillway							
HEC-RAS Summary Table- 0.5PMF							
Structure	Crest Elevation (ft)	Length (ft)	Flow (cfs)	WSE (ft)	Overtopping (Ft)	Flow duration (hr)	Flow duration (min)
Saddle Dam	778	170	0	777.69	-0.31	0.0	0
Main Dam	778	370	0	777.69	-0.31	0.0	0
Auxiliary Spillway	775.5	60	582.66	777.69	2.19	19.2	1150
Spillway	773.8	28	850.76	777.69	3.89	30.8	1850

In the existing condition during the SDF, the main dam overtops by 2.49ft over 18.3 hours and the saddle dam overtops 0.19ft over 17.8 hours. The proposed option of an auxiliary spillway with parapet walls was investigated because the parapet walls alone yielded a WSE of El. 778.08ft. The parapet walls could not be taller than El. 778ft because of the topography on both sides of the dam abutments. An auxiliary spillway was effective in lowering the WSE below El. 778ft to prevent overtopping the dam. The auxiliary spillway crest elevation was determined by the 100-Year Storm analysis of existing conditions in Table 1 above. The WSE during the 100-Year Storm was El. 775.34ft, which determined that the auxiliary spillway crest elevation would have to be above El. 775.34ft to not overtop during the 100-Year Storm and only be activated during the SDF. This analysis method is used as a cost saving measure to ensure the discharge channel would only have to be grass-lined instead of hardened during the rehabilitation.

In order to pass the required SDF without overtopping the dam, the parapet walls over the main dam crest and saddle dam crest at 778ft elevation would be required along with a 60ft wide auxiliary spillway. The parapet wall on the main dam is maximum 2.9ft high and 0.6ft high on the saddle dam crest. The auxiliary spillway crest would be at approximately the current elevation the dam crest is now, at 775.5ft elevation.

Additional survey will have to be completed to verify the proper tie-in locations for the parapet walls into the existing topography at EL. 778ft. There is a possible low area to be filled on the left abutment, which survey will identify. Please refer to Figure 3 below for the plan view of possible parapet tie-in locations that will need to be verified by additional survey outside the original project boundaries.

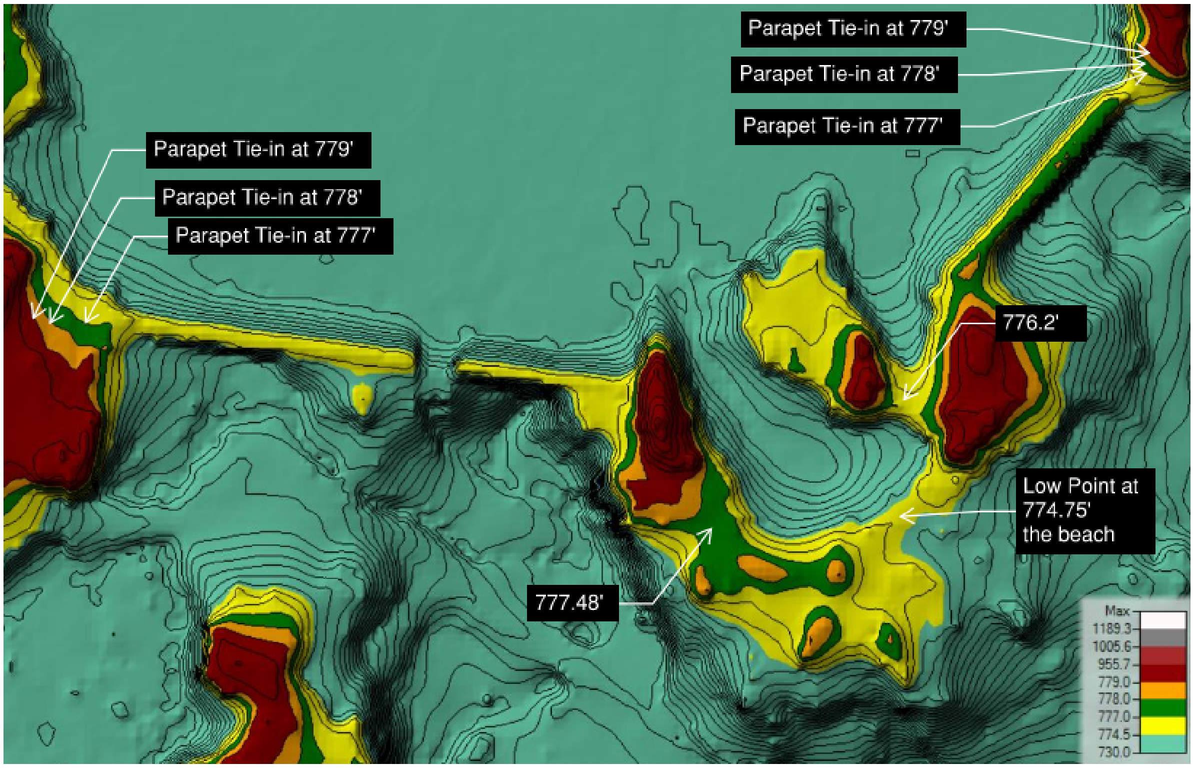


Figure 3: Model schematic of anticipated possible tie-in locations for parapet walls

Additional survey will also be needed on the private property just south of the beach concrete wall and in-between the northern portion of the beach and southern portion of the saddle dam. In the plan view located in Appendix B, we have the additional survey locations identified and the proposed locations at the low areas for proposed placement of fill.

The proposed recommendations above are a simple, cost effective rehabilitation design option that meets the NYSDEC Dam Safety Regulations for a Class C dam.

Emergency Drawdown Pumping Plan Evaluation

Approach and Methodology

Section 7.1 of the NYSDEC Dam Safety Regulations requires Low Level Outlets (LLOs) to discharge 90% of the reservoir storage below the spillway crest within 14 days, assuming no inflow into the reservoir (*Reference 2*). The existing 18-inch LLO through the Roaring Brook Dam is in functioning condition and is operable. There is a valve at the bottom of the dam that was in operating condition during the site visit. A pumping plan has been developed to meet the drawdown requirements for emergency situations.

The calculations are completed in a Microsoft Excel spreadsheet provided in Appendix C.

Assumptions and Justification

1. All elevations are in the NAVD 88 datum.
2. There is no inflow during the drawdown. (*Reference 2*).

3. A period of 3 days is required to install the pumps and for the pumping system to become operational, leaving 11 days duration to drawdown the reservoir.
4. A pipe roughness coefficient (C) equal to 150 for a HDPE pipe is used in the Hazen-Williams equation (*Reference 4*). This is an industry standard value for design purposes.
5. The following K values are used for minor head losses (*Reference 4*):
   - Entrance loss: K = 0.5.
   - Coupling clamp: K=0.04.
   - Gate Valve: K = 0.1.
6. 45° bends: K = 0.2. The downstream water elevation is 755.23, which corresponds to the invert of the drainpipe downstream of the dam.
7. There will be no effect in pump flow as the water level is drawn down. The available trash pumps have discharge capacities that far exceed the head differential at Roaring Brook Dam, therefore the effect of changing suction head will be ignored.

Geometry and Dimensions of Pumping System

1. All elevations are in the NAVD88 Datum.
2. Pipe length is approximately 60 ft (*Reference 8*).
3. Pipe diameter is 18 inches or 1.5 feet. (*Reference 8*).
4. Pipe entrance, exit and other conditions are obtained from (*Reference 4*).
5. Elevation-Volume curve for Roaring Brook Dam was developed using bathymetric data from the field survey (Attachment A).

Calculations

The elevation-storage curve for Roaring Brook Lake is shown in Figure 4. The total storage volume at the spillway crest elevation of 773.8 ft is approximately 1048.3 AC-ft. Therefore 90% of this volume is 943.46 AC-ft, which must be released simultaneously via the 18-inch LLO and temporary pumps during the 11-day pumping period (allowing 3 days for installation of the pumping system).

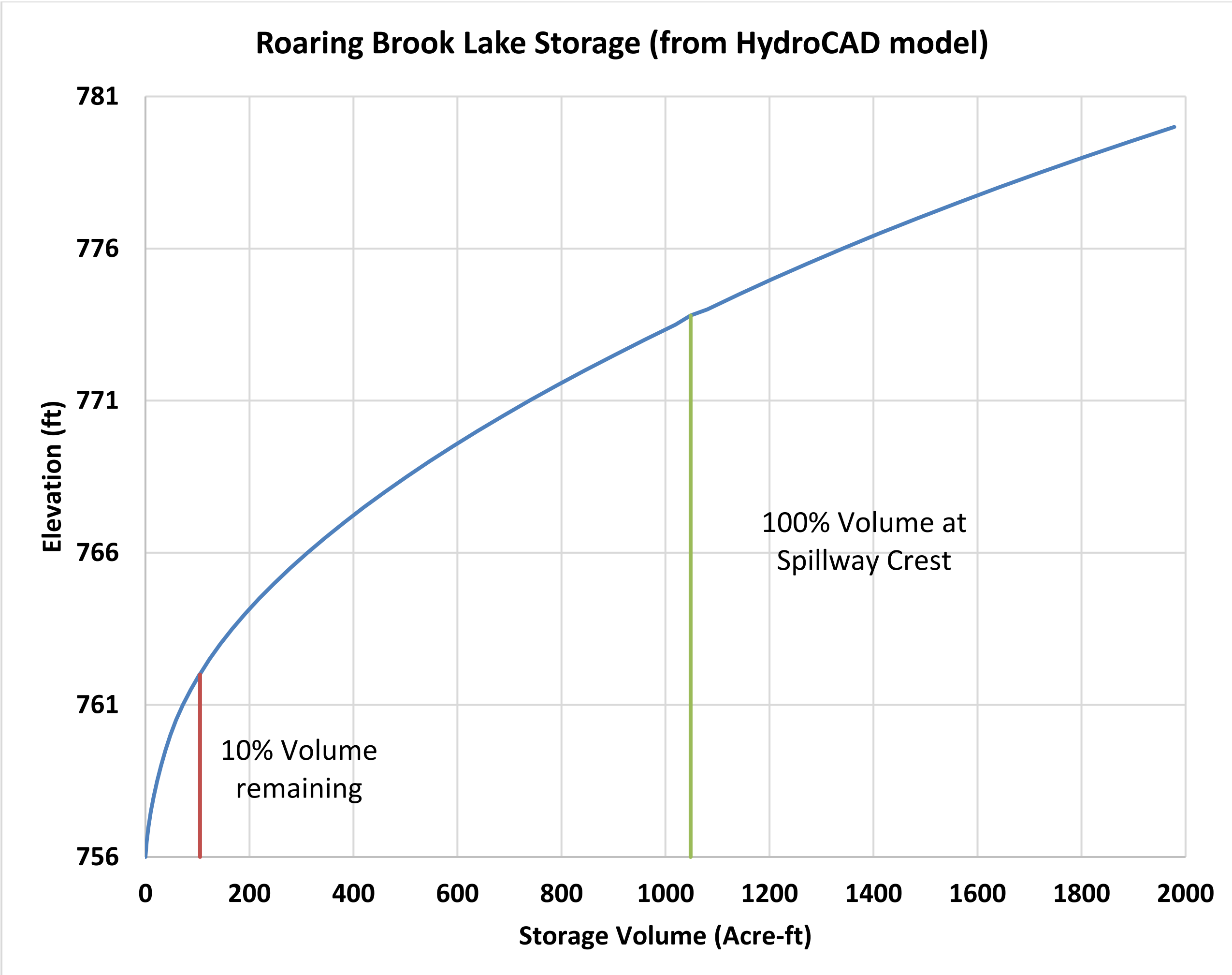


Figure 4: Roaring Brook Lake Storage Volume Data

The discharge capacity is estimated by applying the energy equation between the upstream surface water elevation (reservoir elevation) and the outlet point of the low-level outlet pipe. For steady, viscous flow of an incompressible fluid, the energy equation is written as shown by *Equation 1*.

$$\frac{p_1}{\gamma} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{v_2^2}{2g} + z_2 + h_{L_{major}} + h_{L_{minor}} \tag{1}$$

Where (all units in feet):

$\frac{p}{\gamma}$ = pressure head

$\frac{v^2}{2g}$ = velocity head

z = elevation

$h_{L_{major}}$ = major head losses in pipe (due to friction)

$h_{L_{minor}}$ = minor head losses in pipe (due to bends, valves, tees, etc.)

The Hazen-Williams equation is used to evaluate frictional head losses in the pipe (*Reference 7*). The Hazen-Williams equation is written according to *Equation 2*.

$$v = K_H C R^{0.63} S_f^{0.54} \tag{2}$$

Where:

v = velocity (fps)
K_H = 1.318 for English units
C = pipe roughness coefficient (*Reference 4*)
R = hydraulic radius = A/P (feet)
S_f = friction slope (ft/ft)

Frictional head loss through the pipe is equal to the length times the friction slope, so:

$$h_{L_{major}} = L * S_f \tag{3}$$

From the Hazen-Williams equation:

$$S_f^{0.54} = \frac{v}{K_H C R^{0.63}} \tag{4}$$

So:

$$h_{L_{major}} = L * S_f = L\left(\frac{v}{K_H C R^{0.63}}\right)^{1.85} \tag{5}$$

Because water is open to the atmosphere at the upstream and downstream ends, $\frac{p_1}{\gamma} = \frac{p_2}{\gamma}$ and the terms cancel one another. In addition, the upstream velocity v_1 is approximately zero because of the large size of the reservoir. Thus, the energy equation simplifies to *Equation 6*.

$$z_1 - z_2 = \frac{v^2}{2g} + L\left(\frac{v}{K_H C R^{0.63}}\right)^{1.85} + K\frac{v^2}{2g} \tag{6}$$

A spreadsheet has been developed to estimate the discharge from the low-level outlet pipe beginning at the spillway crest (El. 773.8) and ending at the lake's approximate bottom elevation (El. 756.0). The spreadsheet is set up to satisfy *Equation 6* by using the goal-seek function in Excel to iteratively solve for the velocity parameter on the right side of the equation. The discharge from the pipe is then calculated by multiplying the velocity by the cross-sectional area of the pipe. Flow rates are estimated at incremental time steps corresponding to one-half foot increments between El. 773.8 and El. 756.0. The drain time for each time step is estimated by dividing the discharge from the low-level outlet at the time step by the volume required to lower the reservoir elevation one-half foot. After the elevation closest to 90% of the lake storage is identified, the time to drain 90% of the storage volume of the reservoir is estimated by adding the drain time for each time step.

Discharging the storage of Roaring Brook Lake to a safe level below the base of the dam requires approximately 10.6 days with the assistance of a maximum 5,080 GPM trash pump. The 10.6 days is based on a minimum pumping flow rate of 2,500 GPM from the pump, which will lower the reservoir storage 90%. Detailed results of the reservoir drawdown are presented in Attachment C.

A quotation for delivery and installation of a suitable pumping system has been obtained from Xylem Inc. which is included as Appendix D. Xylem recommend using a Godwin DPC300 Dri-Prime Pump for an emergency drawdown pumping solution. This pump has a capacity of up to 5,080 GPM (with 30-inch hoses) and is capable of handling solids up to 3.7 inches in diameter.

The pump is mounted on a trailer for easy delivery and installation at the dam, and Xylem is located in Feura Bush, NY, approximately 2-hour drive north of Roaring Brook Dam. The estimated delivery time is 1 to 2 days after receipt of order, which is less than the 3 days assumed in the calculation.

Summary and Conclusions

The peak reservoir level in Roaring Brook Lake during the SDF for the existing condition is El. 777.59ft NAVD 88. The dam crest varies from El. 775.1ft to 775.4ft, which would result in maximum 2.49ft of water passing over the non-overflow section during the SDF over 18 hours. This result is higher than the previous analysis in the EA by approximately 0.79ft during this storm event. If the dam crest is left in its existing condition, it remains at risk of overtopping during the SDF and the toe and abutments will be subjected to extreme scour. Additionally, the hardening of both the main dam and saddle dam toe and abutments will likely be more of an expense than the proposed fix and may not be acceptable to NYSDEC regulations. To satisfy the NYSDEC requirements for a Class C dam, the dam crest will have to increase above the WSE during the SDF.

Proposed Spillway and Dam Recommendations

In order to prevent water from overtopping the non-overflow section of the dam during the SDF, we are proposing several improvements:

- A 60-foot-wide Auxiliary Spillway on the right-side of the main dam at a spillway crest elevation of 775.5ft.
- Construct parapet walls across entire dam crest and saddle dam crest at elevation 778ft.
- Place fill in specified low areas around the dam and raise some of the low areas to avoid bypass flows that could impact homes.
- No modifications to existing service spillway.

The plan view of conceptual design is shown in Appendix B.

Emergency Drawdown Pumping Plan Evaluation

The existing LLO outlet through the Roaring Brook Dam is in operating condition. However, according to the EA report (Reference 1), the LLO is only capable of drawing down 90% of the normal storage after 17 days, which does not satisfy NYSDEC requirements (*Reference 2*). A pumping plan has been developed to meet the drawdown requirements for emergency situations.

The NYSDEC Dam Safety Regulations require Low Level Outlets to discharge 90% of the reservoir storage below the spillway crest within 14 days, assuming no inflow into the reservoir (*Reference 2*). Our calculations assume 11 days of continuous pumping, giving 3 days for installation of the pumping system. The required flow rate is 2500 GPM. A product data sheet and quotation for delivery and installation has been received from a local supplier (Xylem Inc.) for a suitable pump with a maximum capacity of up to 5,080 GPM, which is significantly greater than the required minimum flow rate.

References

The following documents are used as sources of information or references:

1. Woidt Engineering & Consulting, P.C., Roaring Brook Lake Dam Engineering Assessment Report, December 2014.
2. New York State Department of Environmental Conservation, *Guidelines for Design of Dams*, 1989.
3. Schaaf & Wheeler Consulting Engineers, *Feasibility of Trash Removal at Pump Stations*, July 2009
4. Mays, Larry W. *Water Resources Engineering*. 1st Edition. John Wiley & Sons, Inc., 2001
5. United States Geological Survey, Chapter A5: Measurement of Peak Discharge at Dams by Indirect Method, Book 3: Applications of Hydraulics, Harry Hulsing, 1968
6. New York State Department of Environmental Conservation, Guidance for Dam Hazard Classification, 2011.
7. Chin, David A. *Water-resources engineering*. 1st ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2000. Print.
8. Heynen Teale Engineers, Roaring Brook Site Plan – Phase I & II Improvements, June 1992.

APPENDICES

APPENDIX A

DISCHARGE COEFFICIENTS FOR SHARP-CREST SPILLWAY & HEC-RAS MODEL RESULTS

Reference 5

springs clear of the weir crest varies somewhat, depending upon the completeness of aeration of the space beneath the downstream nappe, the h/P ratio, and the sharpness of the entrance. The tests made by Bazin indicate that it may occur at an h/L as low as 1.5, or as high as 2.3, for aerated weirs.

The minimum h/L ratio for which the lower nappe will clear the downstream corner of a broad-crested weir is shown on figure 6. If the nappe clears the downstream corner, the weir should be treated as a sharp-crested weir; otherwise it is classified as a broad-crested weir, provided the ratio h/L is greater than 0.10. If h/L is less than 0.10, use figure 23.

Basic equation

The discharge equation for broad-crested weirs is more conveniently expressed in terms of the total energy head, H. The discharge equation is:

$$Q = CbH^{3/2}, \qquad (3)$$

where

Q=discharge,
C=a coefficient of discharge,
b=width of the weir normal to the flow, excluding width of piers, and
H=total energy head $(h+V_1^2/2g)$ referred to the crest of the weir, and V_1 is the mean velocity at the approach section to the weir

TECHNIQUES OF WATER-RESOURCES INVESTIGATIONS

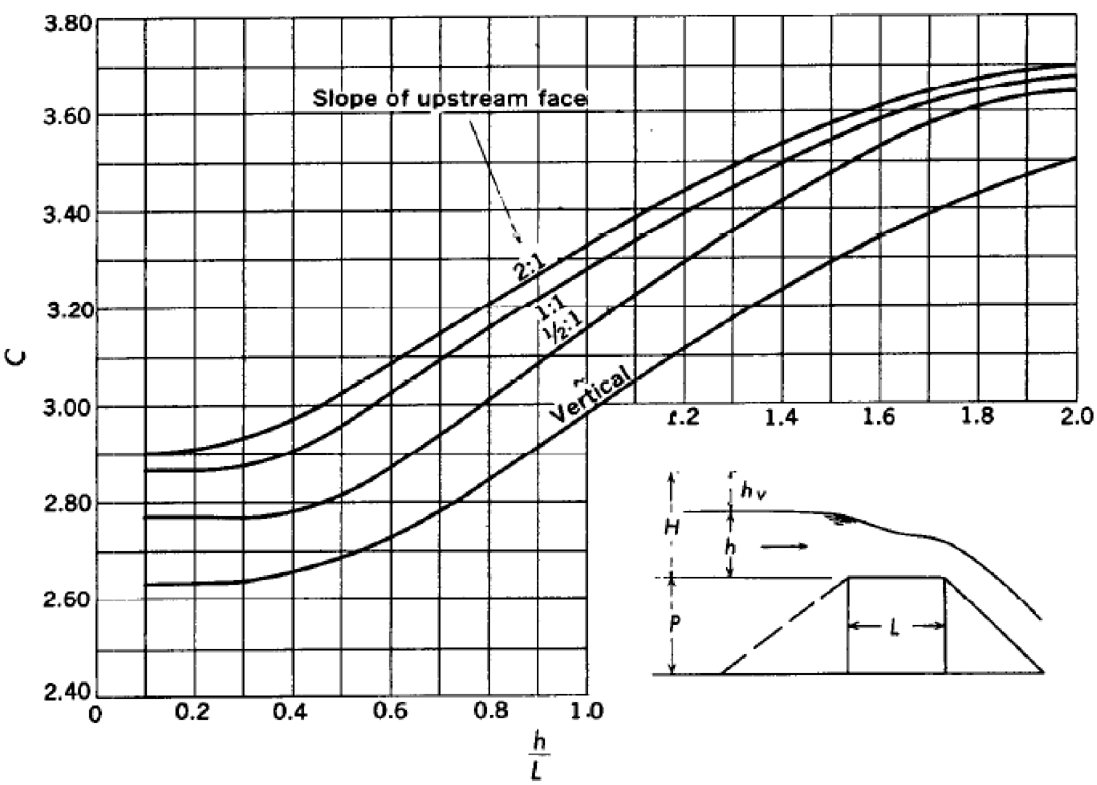


Figure 7.—Coefficients of discharge for full width, broad-crested weirs with downstream slope ≷ 1:1 and various upstream slopes.

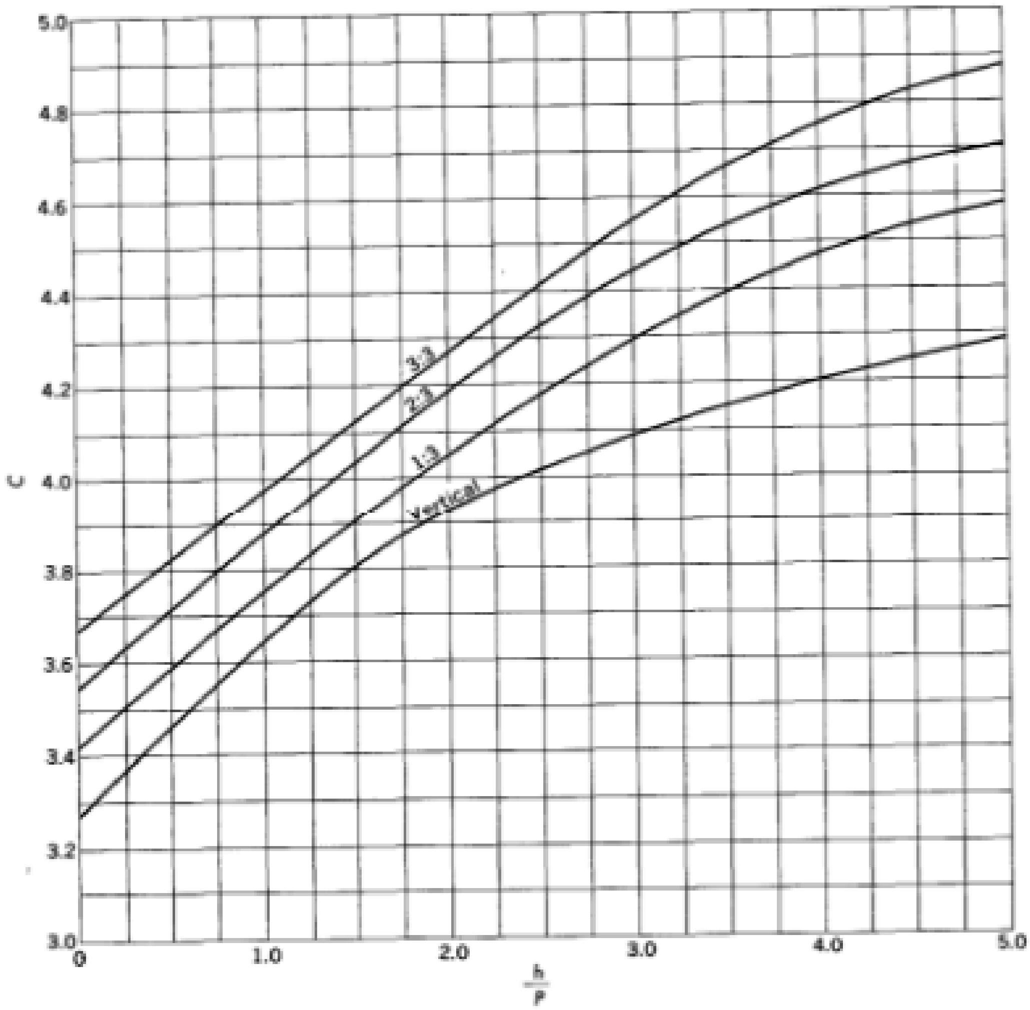


Figure 2.—Discharge coefficients for full width, vertical, and inclined sharp-crested rectangular weirs.

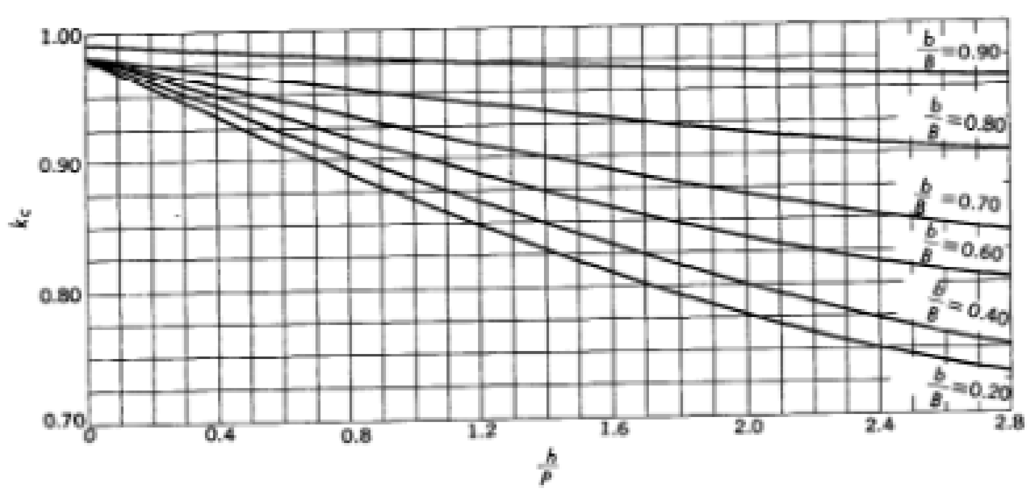
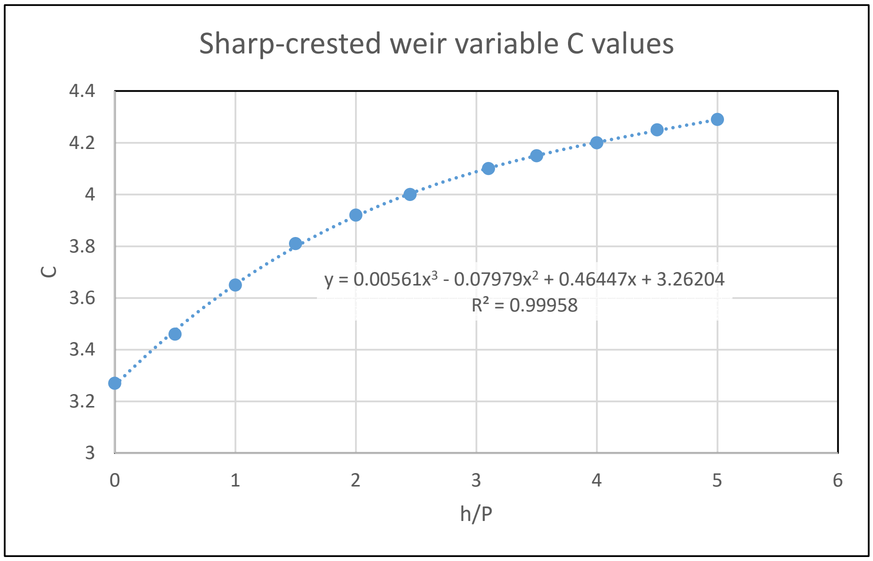


Figure 3.—Definition of adjustment factor, k_c, for contracted sharp-crested weirs.

Values from plot	
h/P	C
0	3.27
0.5	3.46
1	3.65
1.5	3.81
2	3.92
2.45	4
3.1	4.1
3.5	4.15
4	4.2
4.5	4.25
5	4.29



From USGS TWRI Book 3, Chapter A5: Measurement of Peak Discharge at Dams by Indirect Method (Hulsing 1968)

6 TECHNIQUES OF WATER-RESOURCES INVESTIGATIONS

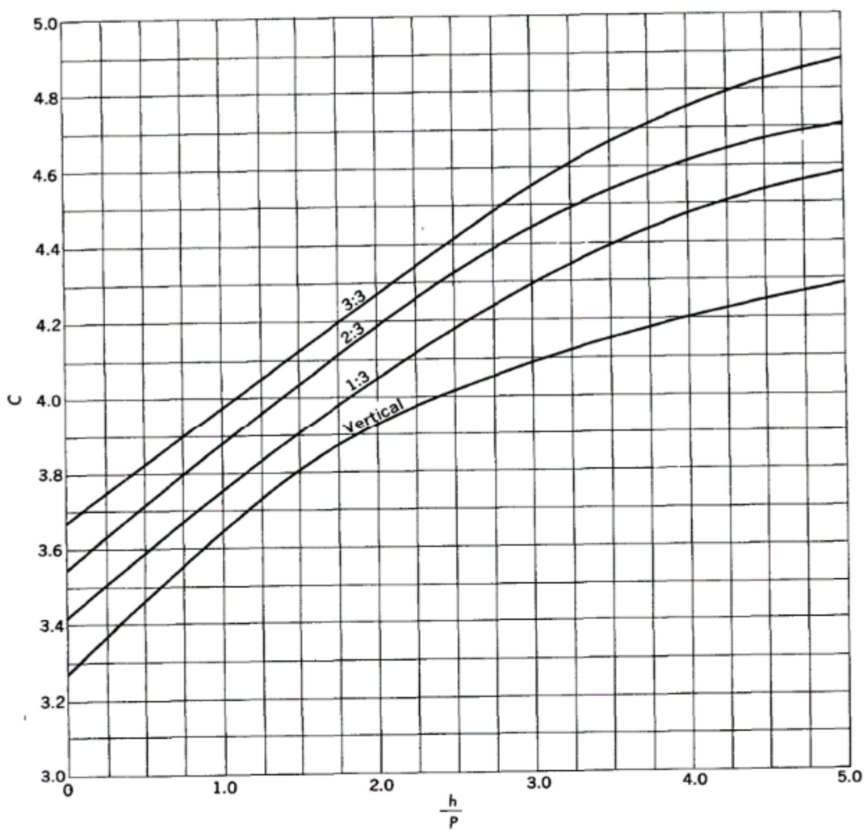
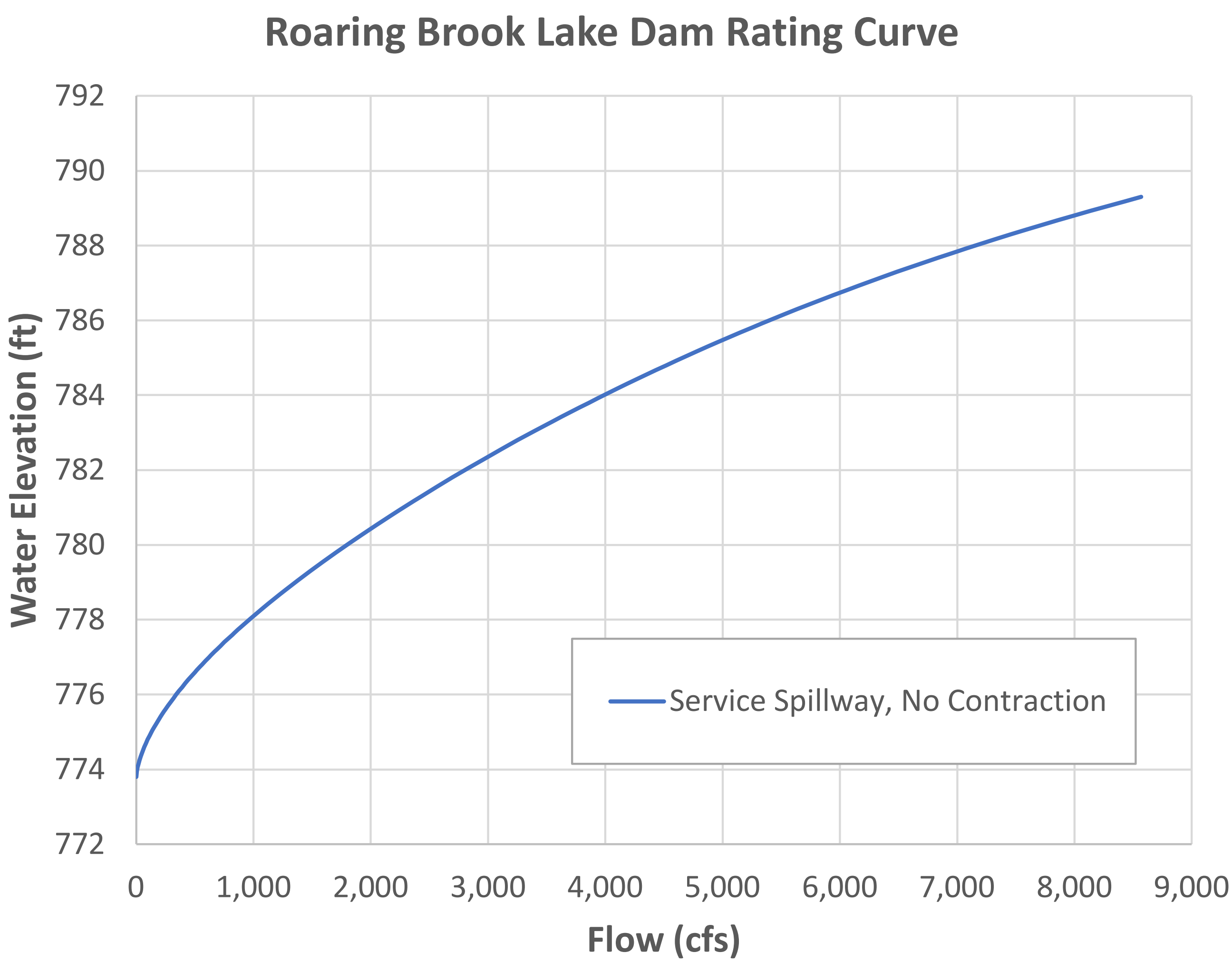


Figure 2.—Discharge coefficients for full width, vertical, and inclined sharp-crested rectangular weirs.

Roaring Brook Lake Dam & Spillway Geometry		Symbols	Values	Units	
Top Dam EL. (Section 1)		-		feet, NAVD88	
Top Dam EL. (Section 2)				feet, NAVD88	
Dam Length (Section 1)		L	0	feet	Part 12D (2014)
Dam Length (Section 2)		L	0	feet	Part 12D (2014)
Spillway Crest EL.		-	773.8	feet, NAVD88	
Net Length of Spillway Crest		L_1	28	feet	
Spillway Coefficient		C	n/a	-	Varies $y = 0.00561x^3 - 0.07979x^2 + 0.46447x + 3.26204$
Dam Coefficient (Section 1)		C	2.6	-	
Dam Coefficient (Section 2)		C	2.6	-	
Abutment contraction coefficient		K_a	0	-	
Pier contraction coefficient		K_p	0	-	
Height of the weir		P	1.75	feet	Height of the weir above the average streambed elevation in a *b* width approach section taken 3-4 *h* upstream from weir.

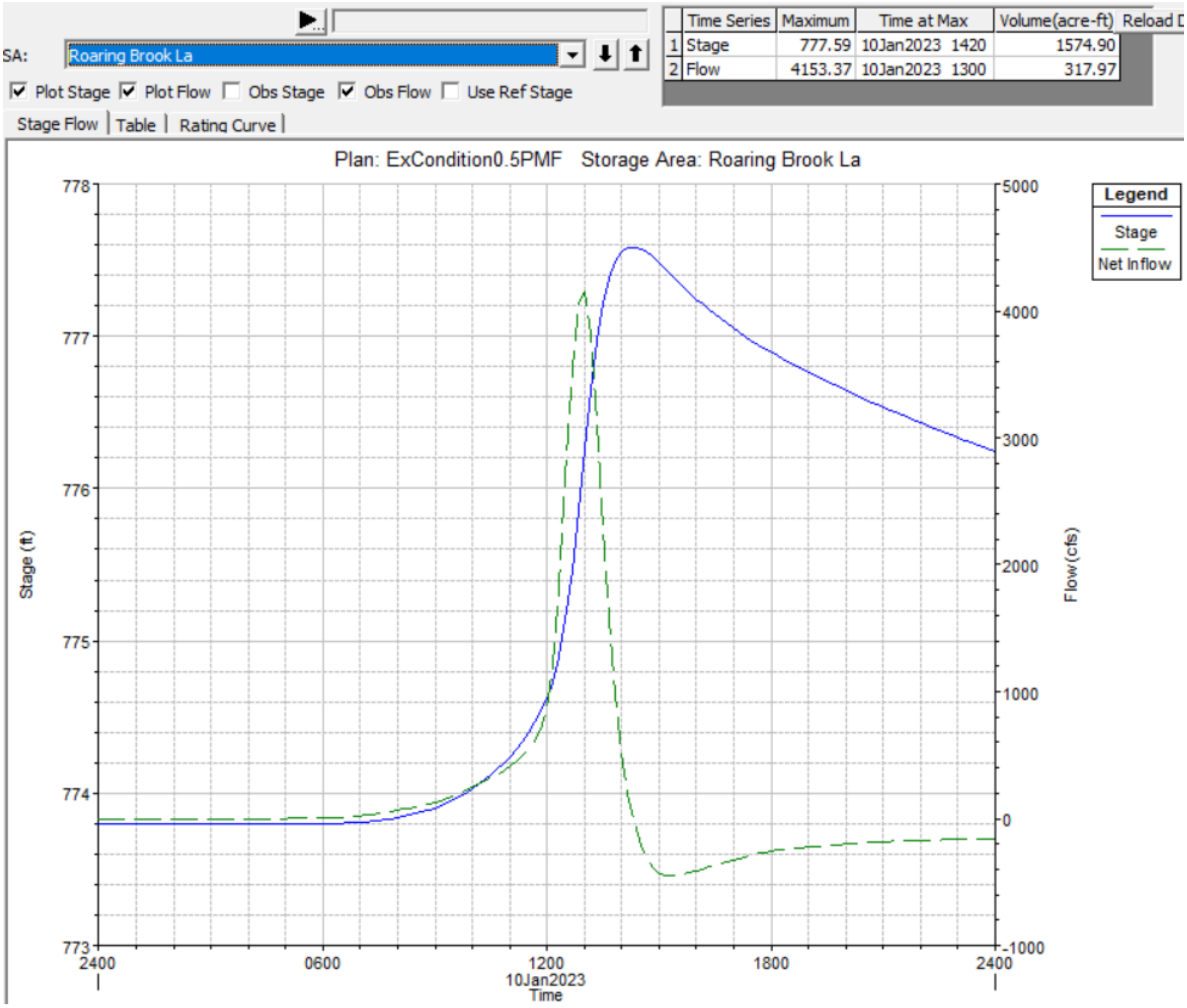
Service Spillway, No Contraction					Dam Crest, Section 1			Dam Crest, Section 2		
Stage [EL.]	h [ft]	L_{eff} [ft]	C	$Q=C_sL_{eff}h^{3/2}$ [cfs]	H_e [ft]	L_{eff} [ft]	$Q=C_sL_{eff}H_e^{3/2}$ [cfs]	H_e [ft]	L_{eff} [ft]	$Q=C_sL_{eff}H_e^{3/2}$ [cfs]
773.80	0	28	3.26	0.0	773.8	0	0.0	773.8	0	0.0
774.00	0.2	28	3.31	8.3	774.0	0	0.0	774.0	0	0.0
774.20	0.4	28	3.36	23.8	774.2	0	0.0	774.2	0	0.0
774.40	0.6	28	3.41	44.4	774.4	0	0.0	774.4	0	0.0
774.60	0.8	28	3.46	69.3	774.6	0	0.0	774.6	0	0.0
774.80	1	28	3.50	98.1	774.8	0	0.0	774.8	0	0.0
775.00	1.2	28	3.54	130.5	775.0	0	0.0	775.0	0	0.0
775.20	1.4	28	3.59	166.3	775.2	0	0.0	775.2	0	0.0
775.40	1.6	28	3.62	205.4	775.4	0	0.0	775.4	0	0.0
775.60	1.8	28	3.66	247.6	775.6	0	0.0	775.6	0	0.0
775.80	2	28	3.70	292.8	775.8	0	0.0	775.8	0	0.0
776.00	2.2	28	3.73	340.9	776.0	0	0.0	776.0	0	0.0
776.20	2.40	28	3.76	391.8	776.2	0	0.0	776.2	0	0.0
776.40	2.60	28	3.79	445.4	776.4	0	0.0	776.4	0	0.0
776.60	2.80	28	3.82	501.7	776.6	0	0.0	776.6	0	0.0
776.80	3.00	28	3.85	560.4	776.8	0	0.0	776.8	0	0.0
777.00	3.20	28	3.88	621.7	777.0	0	0.0	777.0	0	0.0
777.20	3.40	28	3.90	685.4	777.2	0	0.0	777.2	0	0.0
777.40	3.60	28	3.93	751.4	777.4	0	0.0	777.4	0	0.0
777.60	3.80	28	3.95	819.7	777.6	0	0.0	777.6	0	0.0
777.80	4.00	28	3.97	890.1	777.8	0	0.0	777.8	0	0.0
778.30	4.50	28	4.02	1075.6	778.3	0	0.0	778.3	0	0.0
778.80	5.00	28	4.07	1273.7	778.8	0	0.0	778.8	0	0.0
779.30	5.50	28	4.11	1483.6	779.3	0	0.0	779.3	0	0.0
779.80	6.00	28	4.14	1704.8	779.8	0	0.0	779.8	0	0.0
780.30	6.50	28	4.17	1936.7	780.3	0	0.0	780.3	0	0.0
780.80	7.00	28	4.20	2179.2	780.8	0	0.0	780.8	0	0.0
781.30	7.50	28	4.23	2432.0	781.3	0	0.0	781.3	0	0.0
781.80	8.00	28	4.25	2695.1	781.8	0	0.0	781.8	0	0.0
782.30	8.50	28	4.28	2968.8	782.3	0	0.0	782.3	0	0.0
782.80	9.00	28	4.30	3253.4	782.8	0	0.0	782.8	0	0.0
783.30	9.50	28	4.33	3549.7	783.3	0	0.0	783.3	0	0.0
783.80	10.00	28	4.36	3858.3	783.8	0	0.0	783.8	0	0.0
784.30	10.50	28	4.39	4180.5	784.3	0	0.0	784.3	0	0.0
784.80	11.00	28	4.42	4517.5	784.8	0	0.0	784.8	0	0.0
785.30	11.50	28	4.46	4870.8	785.3	0	0.0	785.3	0	0.0
785.80	12.00	28	4.50	5242.4	785.8	0	0.0	785.8	0	0.0
786.30	12.50	28	4.55	5634.3	786.3	0	0.0	786.3	0	0.0
786.80	13.00	28	4.61	6049.0	786.8	0	0.0	786.8	0	0.0
787.30	13.50	28	4.67	6489.0	787.3	0	0.0	787.3	0	0.0
787.80	14.00	28	4.74	6957.5	787.8	0	0.0	787.8	0	0.0
788.30	14.50	28	4.82	7457.7	788.3	0	0.0	788.3	0	0.0
788.80	15.00	28	4.91	7993.2	788.8	0	0.0	788.8	0	0.0
789.30	15.50	28	5.01	8568.1	789.3	0	0.0	789.3	0	0.0

Rating Curve	
Stage [EL.]	$Q=C_sL_{eff}H_e^{3/2}$ [cfs]
773.80	0.0
774.00	8.3
774.20	23.8
774.40	44.4
774.60	69.3
774.80	98.1
775.00	130.5
775.20	166.3
775.40	205.4
775.60	247.6
775.80	292.8
776.00	340.9
776.20	391.8
776.40	445.4
776.60	501.7
776.80	560.4
777.00	621.7
777.20	685.4
777.40	751.4
777.60	819.7
777.80	890.1
778.30	1075.6
778.80	1273.7
779.30	1483.6
779.80	1704.8
780.30	1936.7
780.80	2179.2
781.30	2432.0
781.80	2695.1
782.30	2968.8
782.80	3253.4
783.30	3549.7
783.80	3858.3
784.30	4180.5
784.80	4517.5
785.30	4870.8
785.80	5242.4
786.30	5634.3
786.80	6049.0
787.30	6489.0
787.80	6957.5
788.30	7457.7
788.80	7993.2
789.30	8568.1

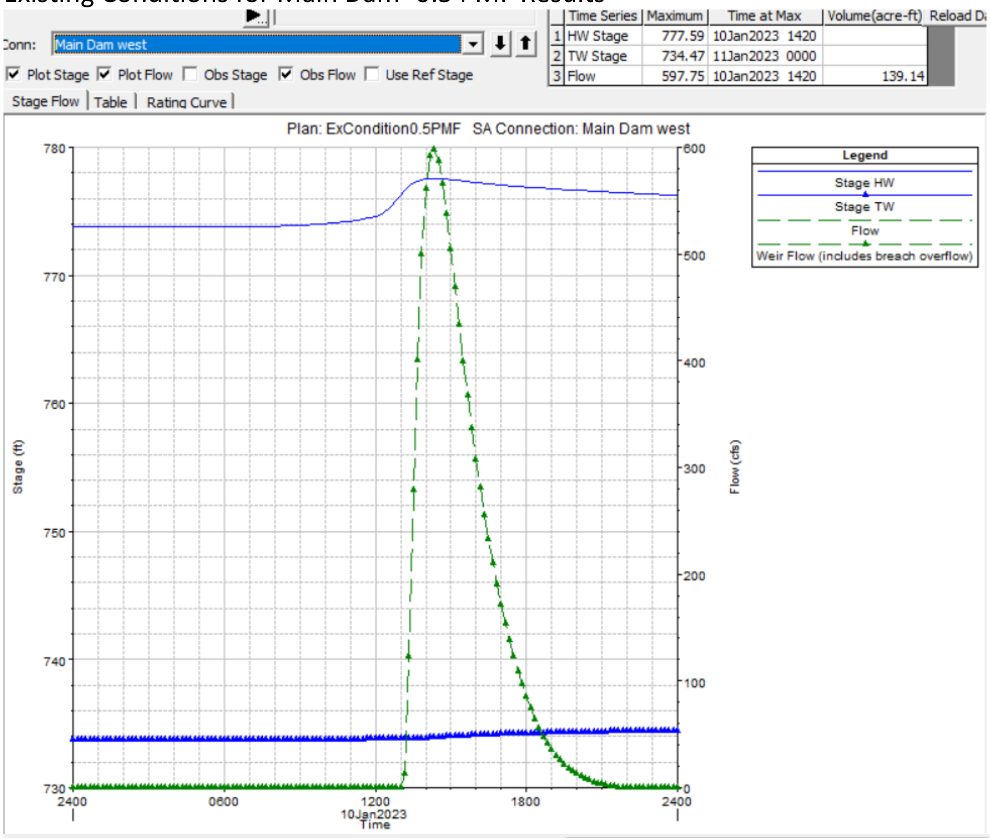

Roaring Brook Lake Dam Rating Curve
792
790
788
786
784
782
780
778
776
774
772
Water Elevation (ft)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
Flow (cfs)
Service Spillway, No Contraction

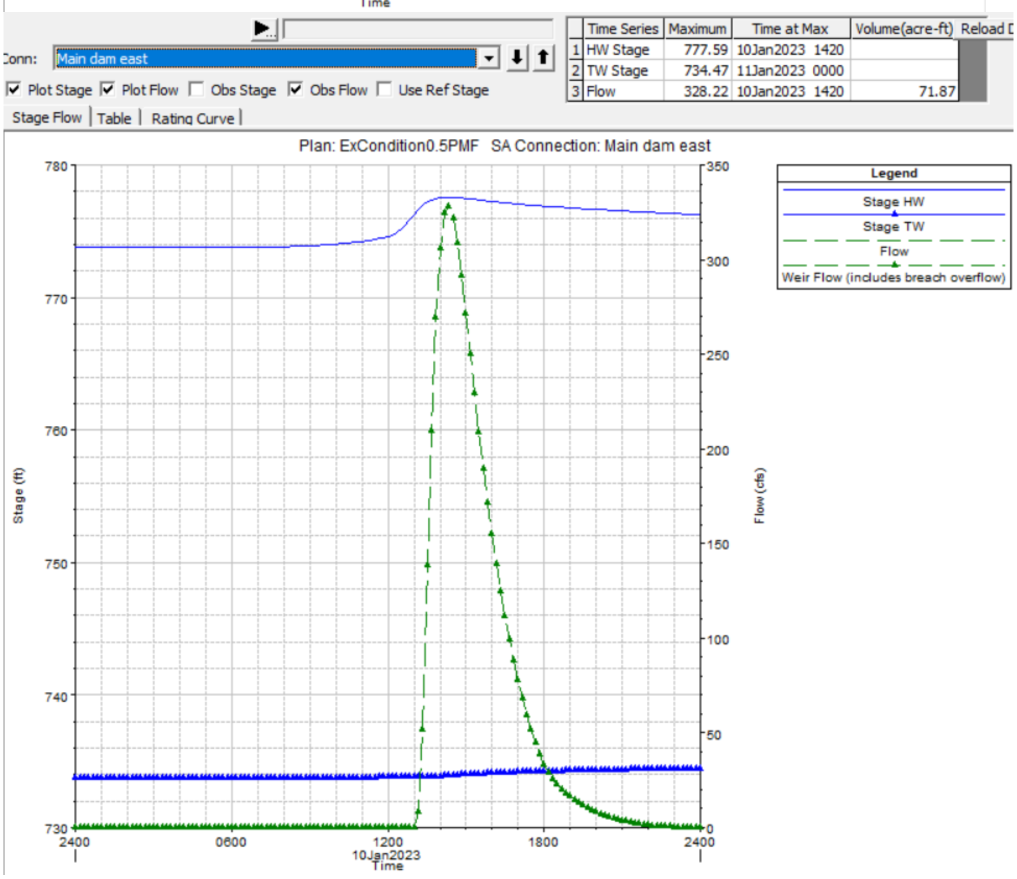
<u>Existing Conditions Analysis Results</u>

Existing Conditions for Roaring Brook Lake Reservoir Storage Area - 0.5 PMF Results

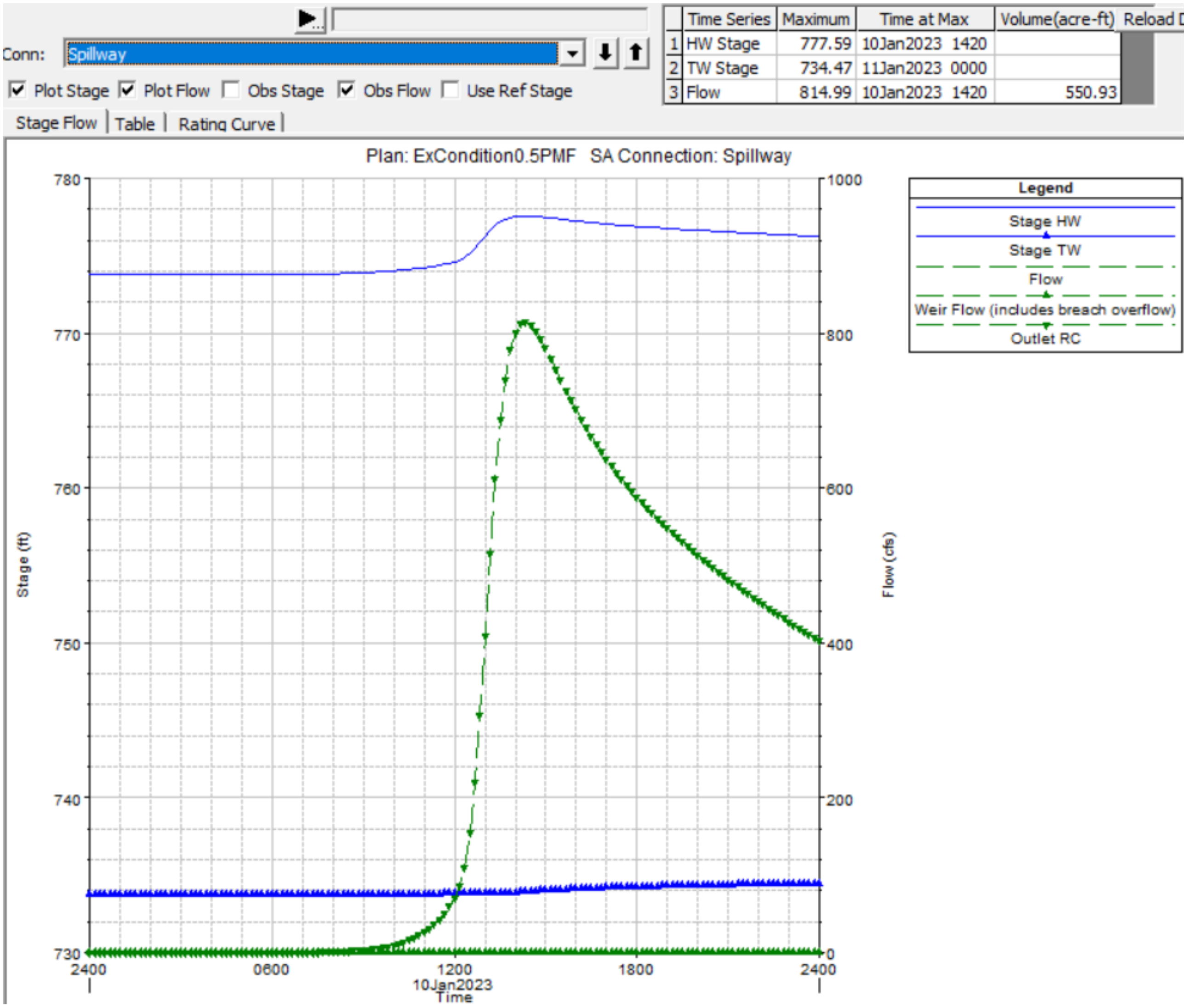


Existing Conditions for Main Dam- 0.5 PMF Results

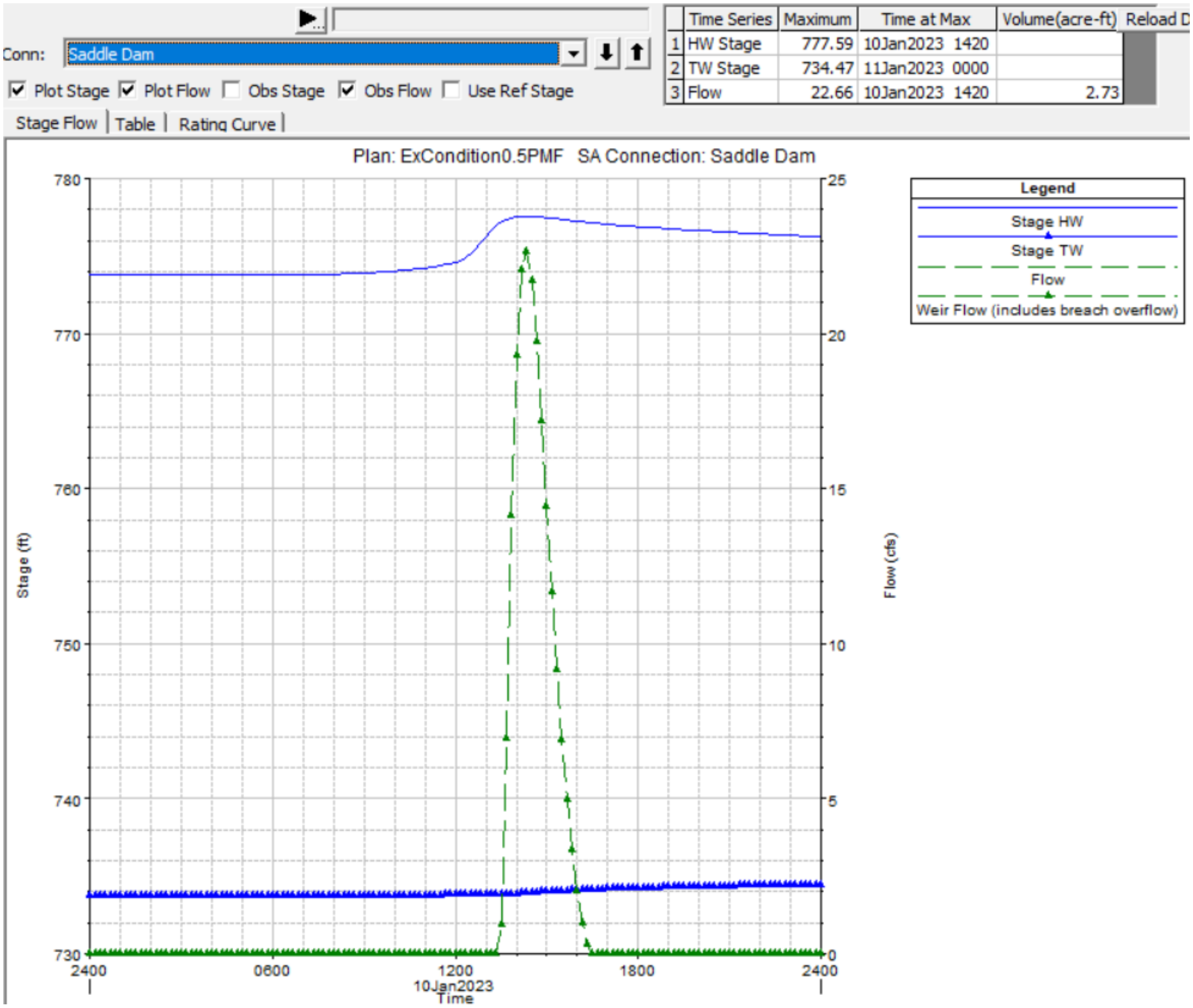




Existing Conditions for Spillway- 0.5 PMF Results

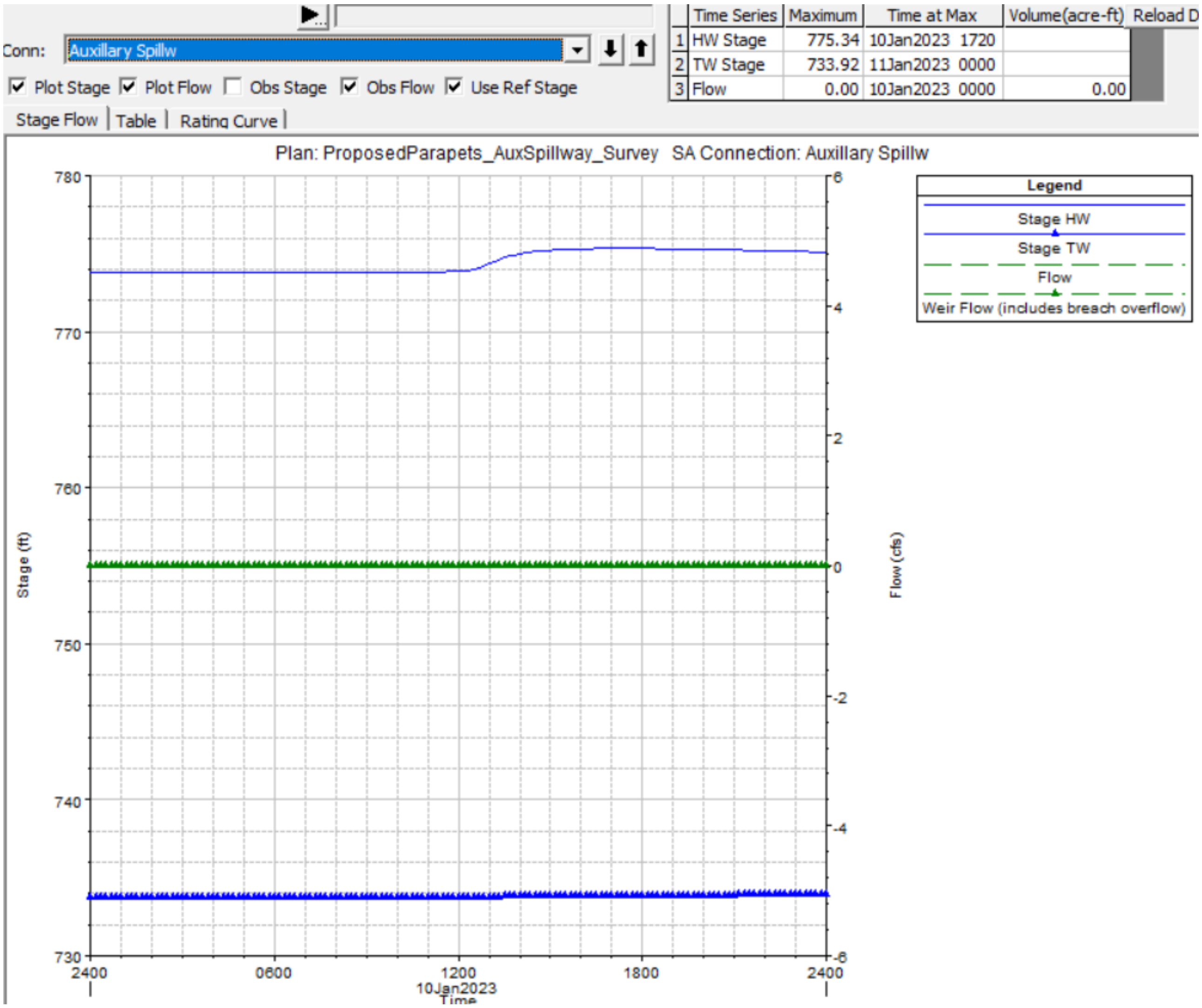


Existing Conditions for Saddle Dam- 0.5 PMF Results

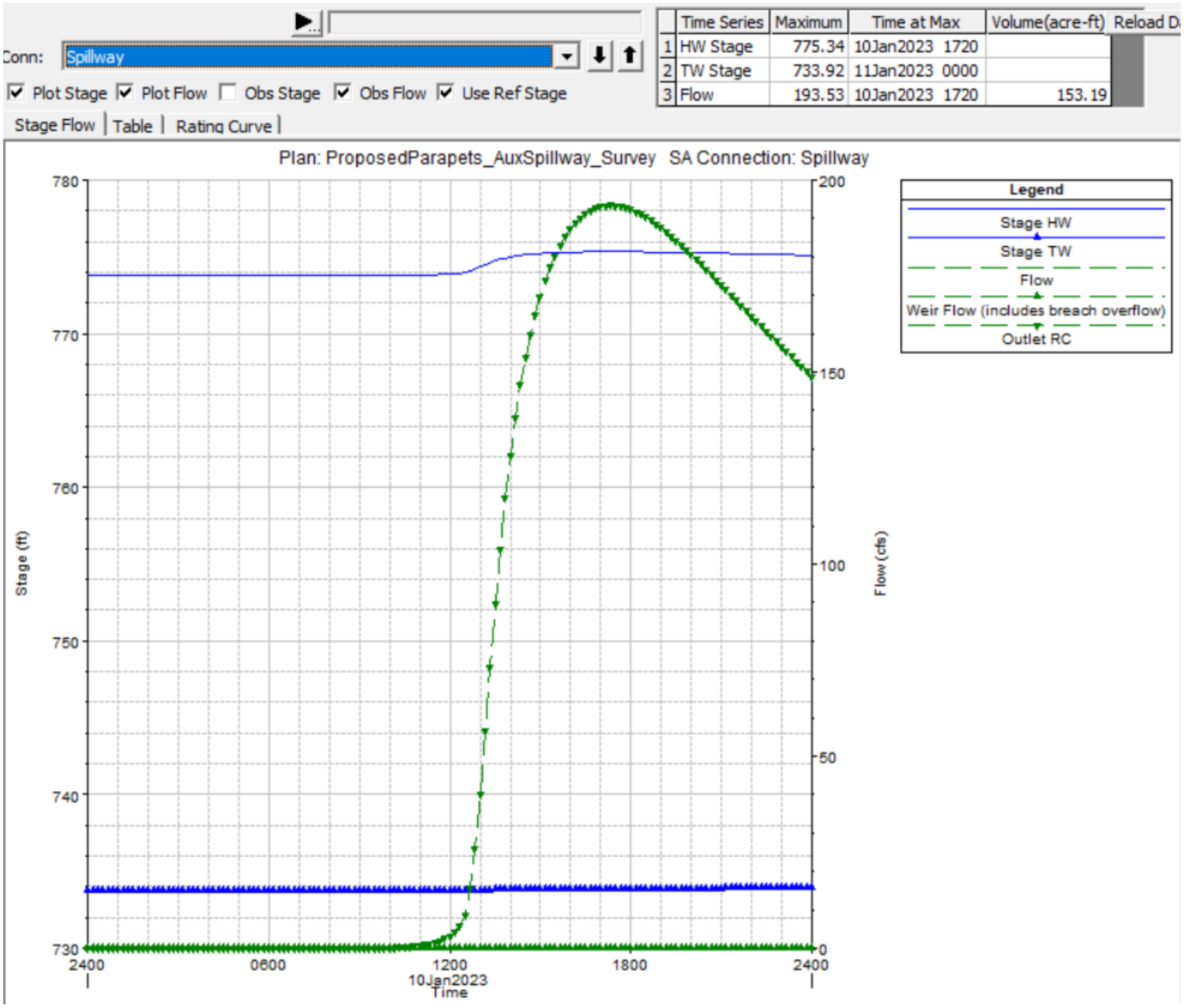


Proposed Analysis Results

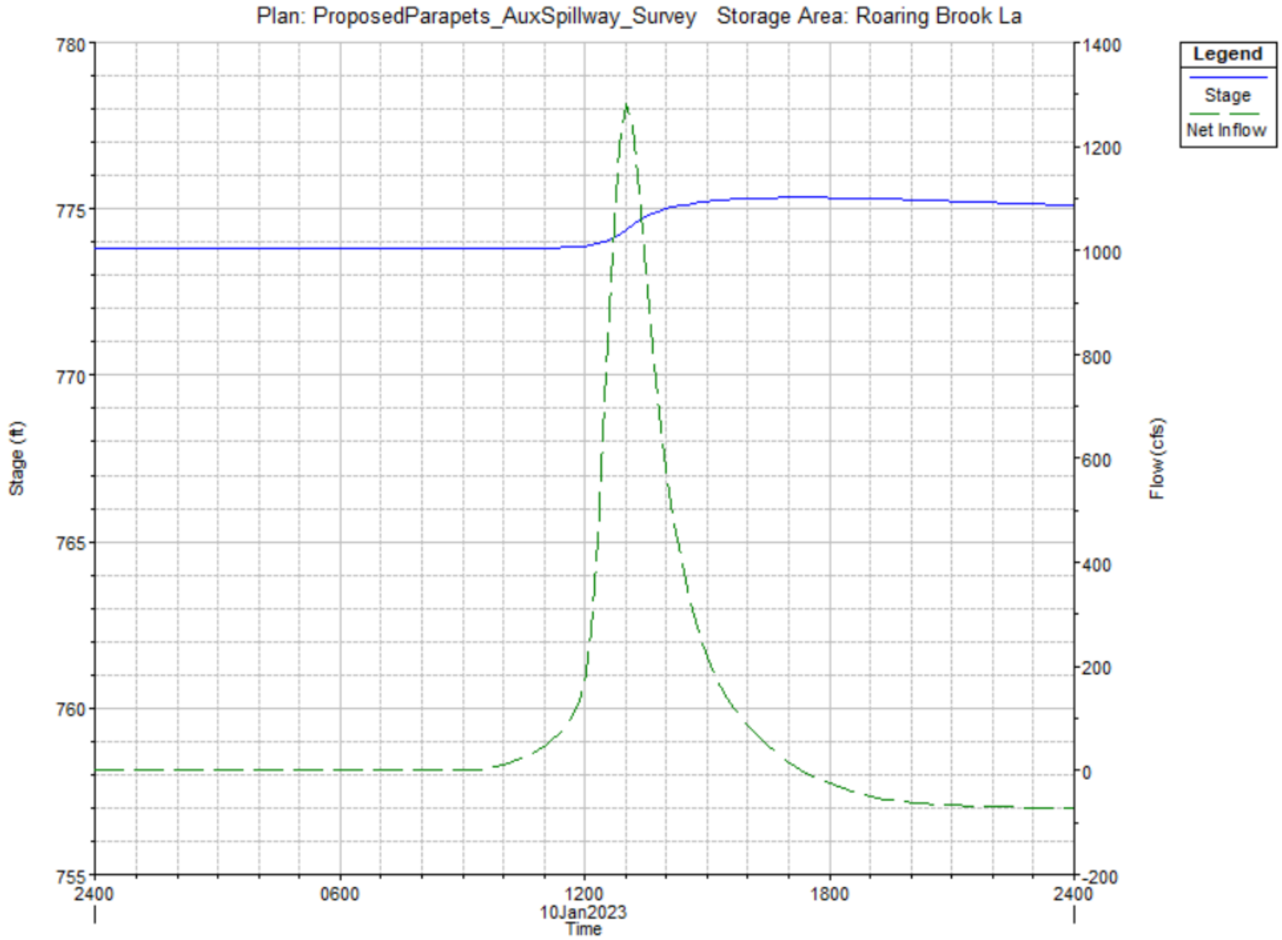
Auxiliary Spillway- 100-Year Storm does not overtop



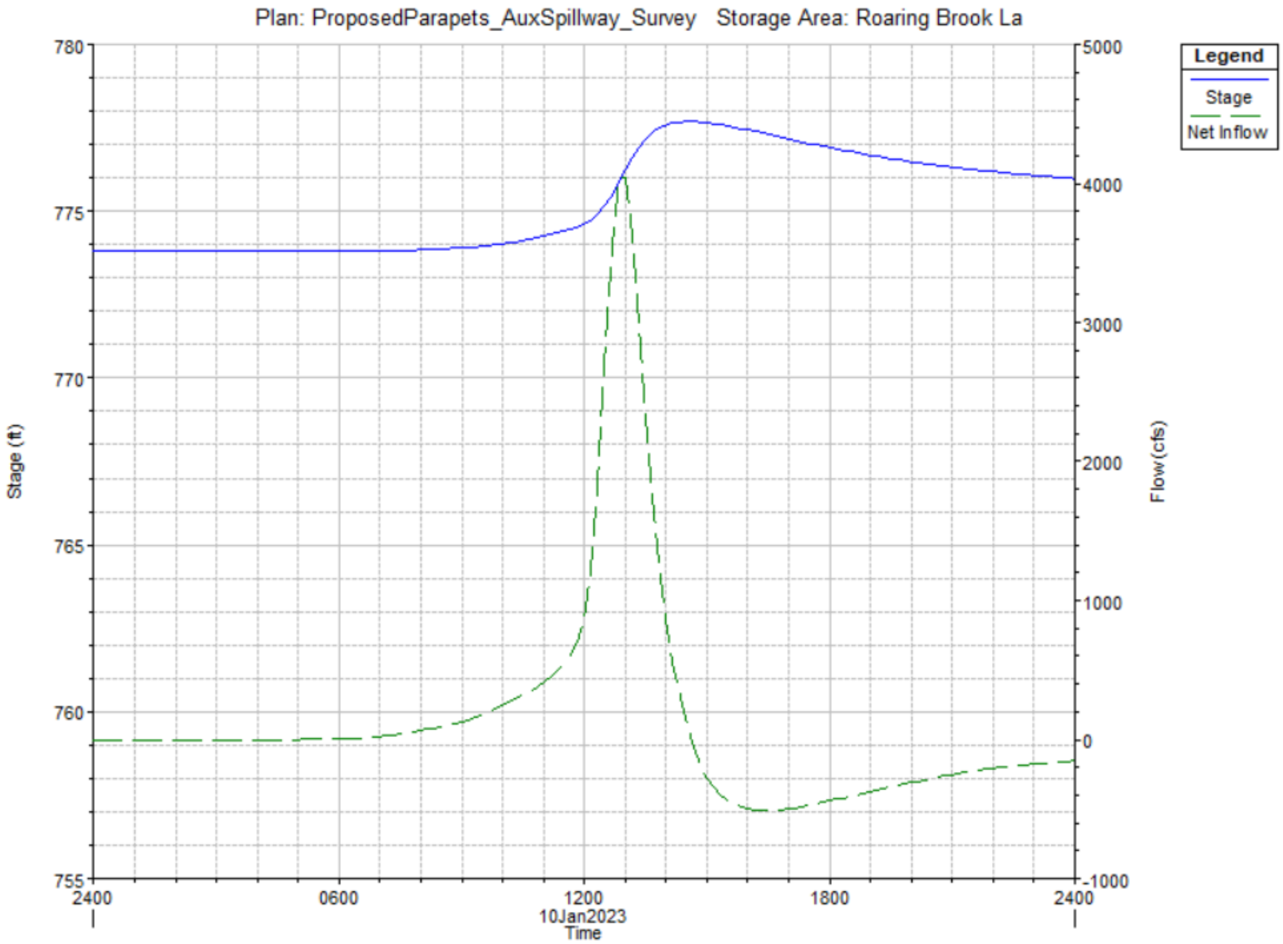
Spillway- 100-Year Storm Results



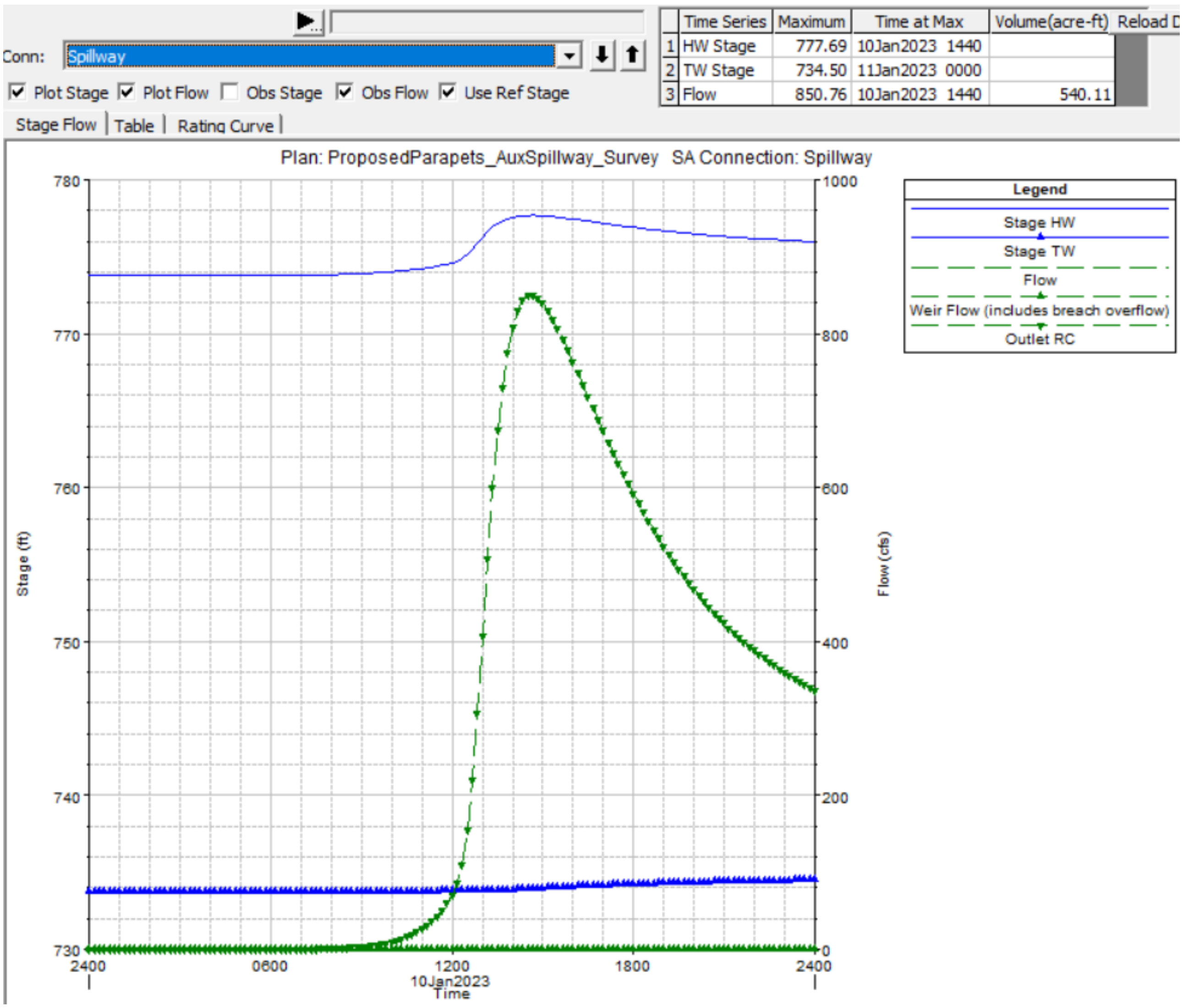
Roaring Brook Lake Reservoir Storage Area- 100-Year Storm result



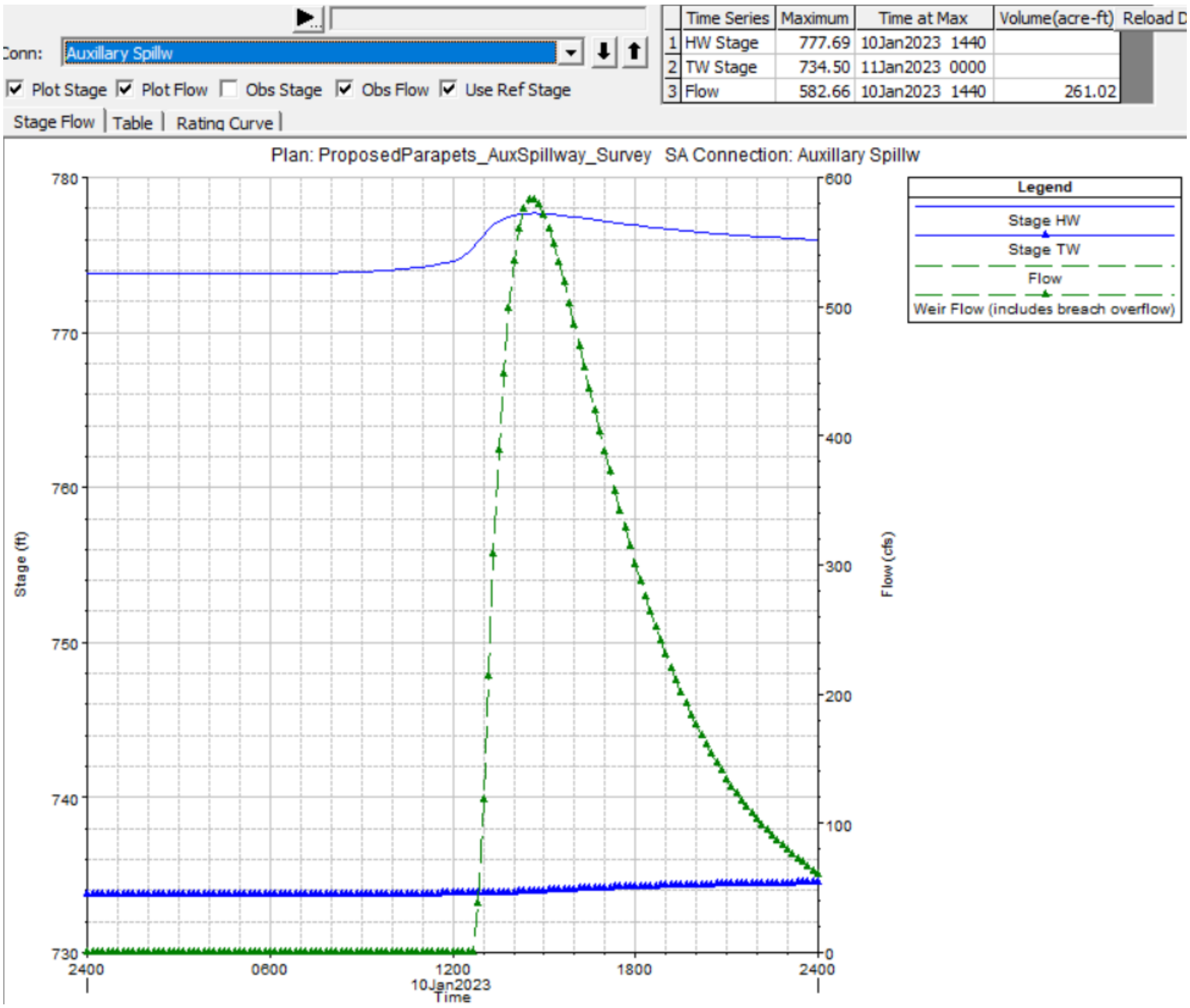
Roaring Brook Lake Reservoir Storage Area- 0.5 PMF result



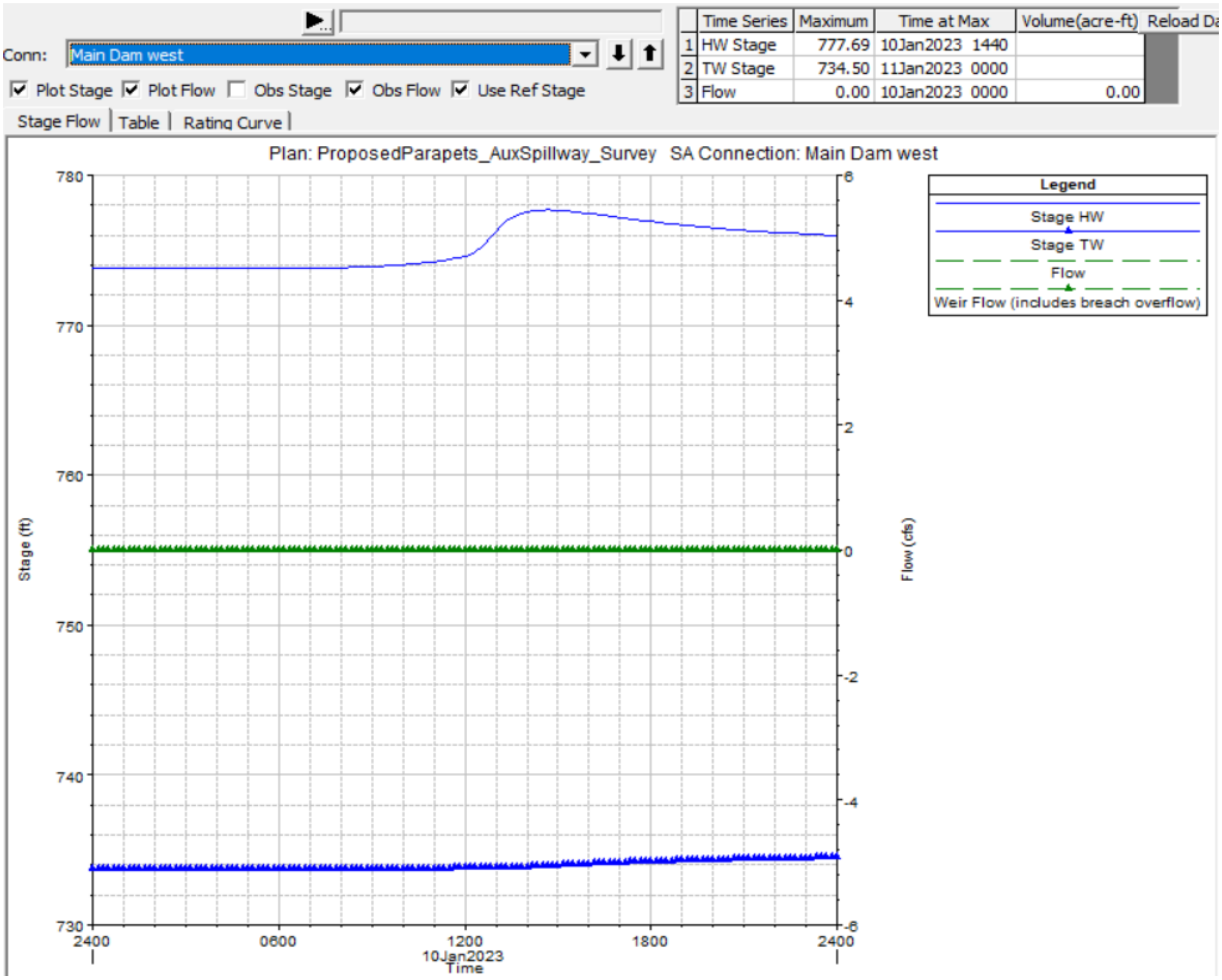
Spillway- 0.5 PMF Results



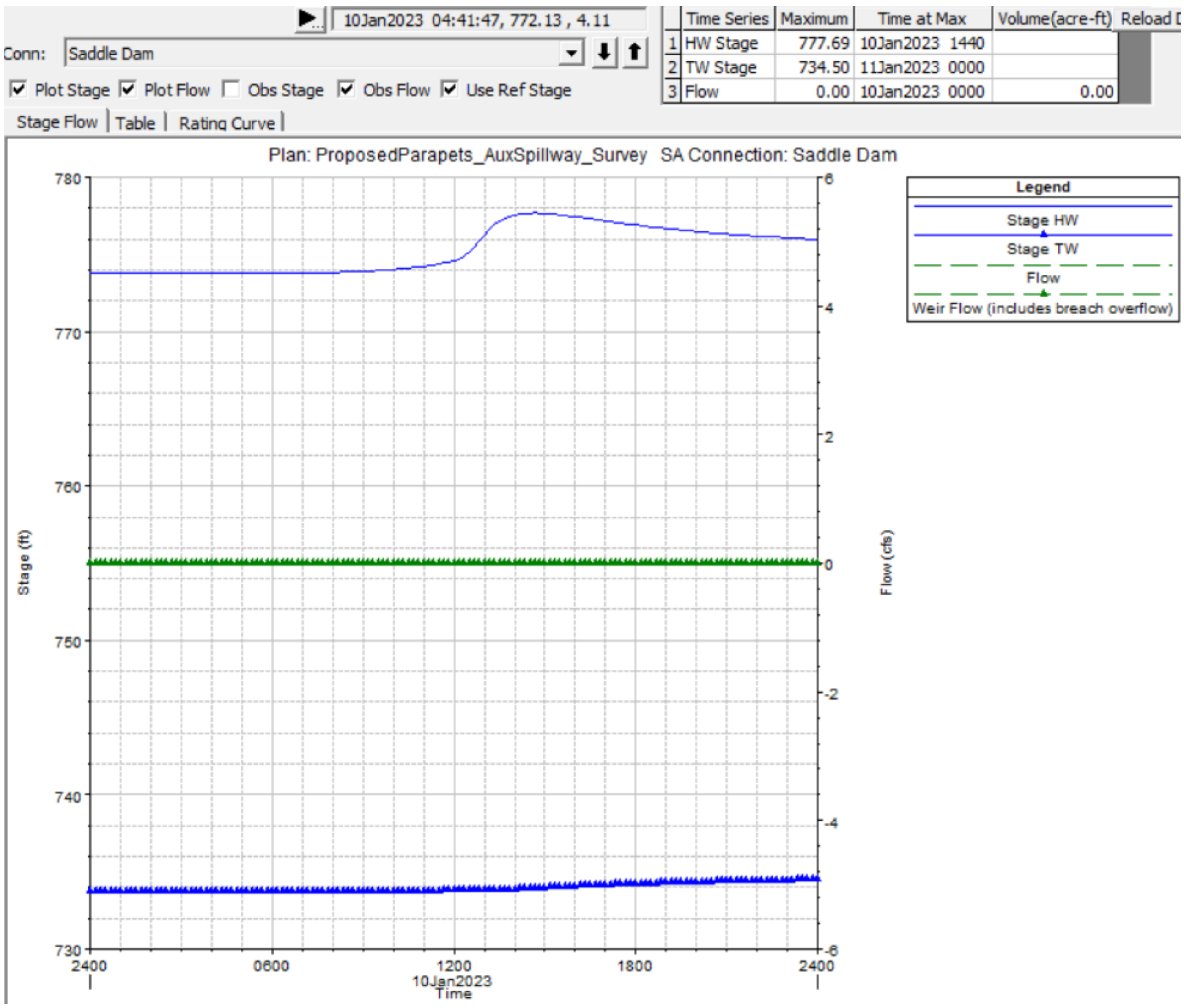
Auxiliary Spillway- 0.5 PMF Results



Main Dam - 0.5 PMF result



Saddle Dam- 0.5 PMF result



APPENDIX B

CONCEPTUAL DESIGN PLAN VIEW

PLAN

NOTES:

1. THIS PLAN WAS PREPARED FROM AN ACTUAL ON THE GROUND FIELD SURVEY CONDUCTED BY WSP DURING MARCH OF 2021.
2. THE HORIZONTAL DATUM SHOWN HEREON REFERENCES THE NEW YORK EAST STATE PLANE COORDINATE SYSTEM NAD83.
3. THE VERTICAL DATUM SHOWN HEREON REFERENCES NAVD 1988.
4. THERE WAS NO UNDERGROUND UTILITY INVESTIGATION COMPLETED FOR THE SITE, ANY UNDERGROUND UTILITY INFORMATION SHOWN HEREON WAS THE RESULT OF FIELD OBSERVATIONS.

NO.	DATE	REVISIONS	APPROVED
A	4/28/21	CONCEPTUAL DESIGN	

WARNING

IT IS A VIOLATION OF SECTION 7209 (2) OF THE NEW YORK STATE EDUCATION LAW FOR ANY PERSON, UNLESS ACTING UNDER THE DIRECTION OF A LICENSED PROFESSIONAL ENGINEER, TO ALTER OR ADD TO THIS DRAWING. ANY ALTERATIONS SHALL BE SEALED BY THE ALTERING ENGINEER AND HAVE THE NOTATION "ALTERED BY" FOLLOWED BY HIS SIGNATURE AND THE DATE OF SUCH ALTERATION, AND A SPECIFIC DESCRIPTION OF THE ALTERATION.

DRAWN	GPB	CHECKED BY	JPO	CAD FILE NUMBER	31403062-D100(M)
DATE	4/26/21	APPROVED BY	AHH		

NEW YORK STATE LICENSED PROFESSIONAL ENGINEER

ROARING BROOK LAKE DAM REHABILITATION PROJECT
TOWN OF PUTNAM VALLEY, NEW YORK

CONCEPTUAL DESIGN PLAN

PREPARED FOR
TOWN OF PUTNAM VALLEY
LOCATED IN THE
TOWN OF PUTNAM VALLEY
PUTNAM COUNTY, NEW YORK

WSP USA
500 SUMMIT LAKE DRIVE
SUITE 450
VALHALLA, NY 10595
(914) 747-1120

DWG-1
SHEET 1 OF 1

APPENDIX C

PUMPING PLAN SPREADSHEET CALCULATIONS

Pipe Properties			
pipe diameter (D) =	1.50	feet	
pipe length (L) =	60	feet	
tailwater elevation (z_2) =	755.23	feet	
pipe material	HDPE		

Hazen-Williams Inputs (constant)		
K_H =	1.318	conversion for English units
C =	150	pipe roughness coefficient
R = A/P =	0.375	hydraulic radius
https://www.engineeringtoolbox.com/hazen-williams-co		

Hydraulic Properties (assumes full pipe flow)		
Area (A) =	1.767	sf
Wetted Perimeter (P) =	4.712	ft
Supplemental Pump	2500	gal/min
	10.8	cfs

Minor Head Loss Coefficients		
location	**description**	**K**
entrance	Square edged	0.50
coupling clamp	coupling	0.04
gate valvue	fully open	0.10
45^{o} bend x1	flow	0.20
Total		0.84

Elevation	Volume	Volume	Step Number	Change in Volume	Average Upstream Water Elevation	Velocity	Energy Equation: left (z_1 - z_2)	Energy Equation: right $\frac{v^2}{2g}+L\left(\frac{v}{K_H C R^{0.63}}\right)^{1.85}+K\frac{v^2}{2g}$	Discharge from Low-Level Outlet Pipe	Time to Reach Next Reservoir Elevation	Cumulative Drawdown Time	% of storage capacity
z	V	V		ΔV	z_1	v			Q	t	t	
(NAVD 88)	(acre-feet)	cf		cf	(feet)	fps			cfs	(sec)	(sec)	
773.80	1048.26	45,662,206										100.0
			1	1,249,301	773.65	22.87	18.42	18.42	51.2	24,377	24,377	
773.50	1019.58	44,412,905										97.3
			2	2,595,305	773.25	22.61	18.02	18.02	50.8	51,087	75,464	
773.00	960.00	41,817,600										91.6
			3	2,530,575	772.75	22.29	17.52	17.52	50.2	50,374	125,839	
772.50	901.91	39,287,025										86.0
			4	2,451,600	772.25	21.97	17.02	17.02	49.7	49,367	175,205	
772.00	845.63	36,835,425										80.7
			5	2,372,670	771.75	21.64	16.52	16.52	49.1	48,345	223,550	
771.50	791.16	34,462,755										75.5
			6	2,293,695	771.25	21.30	16.02	16.02	48.5	47,306	270,856	
771.00	738.50	32,169,060										70.5
			7	2,214,765	770.75	20.96	15.52	15.52	47.9	46,251	317,106	
770.50	687.66	29,954,295										65.6
			8	2,135,790	770.25	20.62	15.02	15.02	47.3	45,177	362,284	
770.00	638.63	27,818,505										60.9
			9	2,056,860	769.75	20.27	14.52	14.52	46.7	44,086	406,370	
769.50	591.41	25,761,645										56.4
			10	1,977,885	769.25	19.91	14.02	14.02	46.0	42,975	449,345	
769.00	546.00	23,783,760										52.1
			11	1,898,955	768.75	19.55	13.52	13.52	45.4	41,844	491,189	
768.50	502.41	21,884,805										47.9
			12	1,819,980	768.25	19.18	13.02	13.02	44.7	40,690	531,879	
768.00	460.63	20,064,825										43.9
			13	1,741,050	767.75	18.80	12.52	12.52	44.1	39,514	571,393	
767.50	420.66	18,323,775										40.1
			14	1,662,075	767.25	18.41	12.02	12.02	43.4	38,313	609,706	
767.00	382.50	16,661,700										36.5
			15	1,583,145	766.75	18.02	11.52	11.52	42.7	37,087	646,794	
766.50	346.16	15,078,555										33.0
			16	1,504,170	766.25	17.62	11.02	11.02	42.0	35,832	682,626	
766.00	311.63	13,574,385										29.7
			17	1,425,240	765.75	17.21	10.52	10.52	41.3	34,549	717,174	
765.50	278.91	12,149,145										26.6
			18	1,346,265	765.25	16.79	10.02	10.02	40.5	33,232	750,407	
765.00	248.00	10,802,880										23.7
			19	1,263,240	764.75	16.36	9.52	9.52	39.7	31,780	782,186	
764.50	219.00	9,539,640										20.9
			20	1,176,120	764.25	15.92	9.02	9.02	39.0	30,181	812,367	
764.00	192.00	8,363,520										18.3
			21	1,089,000	763.75	15.46	8.52	8.52	38.2	28,533	840,900	
763.50	167.00	7,274,520										15.9
			22	1,001,880	763.25	15.00	8.02	8.02	37.3	26,831	867,731	
763.00	144.00	6,272,640										13.7
			23	914,760	762.75	14.51	7.52	7.52	36.5	25,070	892,801	
762.50	123.00	5,357,880										11.7
			24	827,640	762.25	14.02	7.02	7.02	35.6	23,243	916,044	
762.00	104.00	4,530,240										9.9
			25	740,520	761.75	13.50	6.52	6.52	34.7	21,343	937,386	
761.50	87.00	3,789,720										8.3
			26	653,400	761.25	12.96	6.02	6.02	33.7	19,360	956,747	
761.00	72.00	3,136,320										6.9
			27	566,280	760.75	12.41	5.52	5.52	32.8	17,284	974,031	
760.50	59.00	2,570,040										5.6
			28	479,160	760.25	11.82	5.02	5.02	31.7	15,102	989,133	
760.00	48.00	2,090,880										4.6
			29	413,820	759.75	11.21	4.52	4.52	30.6	13,504	1,002,637	
759.50	38.50	1,677,060										3.7
			30	370,260	759.25	10.56	4.02	4.02	29.5	12,551	1,015,188	
759.00	30.00	1,306,800										2.9
			31	326,700	758.75	9.87	3.52	3.52	28.3	11,551	1,026,739	
758.50	22.50	980,100										2.1
			32	283,140	758.25	9.13	3.02	3.02	27.0	10,496	1,037,234	
758.00	16.00	696,960										1.5
			33	239,580	757.75	8.33	2.52	2.52	25.6	9,373	1,046,608	
757.50	10.50	457,380										1.0
			34	196,020	757.25	7.44	2.02	2.02	24.0	8,169	1,054,777	
757.00	6.00	261,360										0.6
			35	152,460	756.75	6.44	1.52	1.52	22.2	6,860	1,061,637	
756.50	2.50	108,900										0.2
			36	108,900	756.25	5.26	1.02	1.02	20.1	5,408	1,067,045	
756.00	0.00	0										0.0

Time to Low Level Outlet	12.35	days
Time to 90% Drianed	10.59	days

APPENDIX D

PUMP RENTAL QUOTATION AND EQUIPMENT SPECIFICATION

RENTAL QUOTE	X	TODAY'S DATE	5-May-21
RENTAL ORDER		BID DATE	
SALE QUOTE		DELIVERY DATE	1-2 Days ARO
SALE ORDER			

CUSTOMER		SHIP TO	
Jeremy Bielby, P.E. WSP		Roaring Brook Dam Westchester County, NY	
PHONE #		FAX #	
PO #		ORDERED BY	
SITE CONTACT		JOB PHONE #	

NOTES

Reservoir Dewatering

(1) Godwin DPC300 12" Dri-Prime Open Diesel Pump
100' suction of suction hose and 100' of discharge pipe

PUMP SYSTEM INFORMATION

Max flow rate as per specifications 2,500 at 16' Elevation Head, 20' TDH
Max Flow Rate to 25,000 gpm/ 30" pump

QUANTITY	DESCRIPTION	WEEKLY UNIT PRICE	WEEKLY TOTAL
	(1) Godwin DPC300 12" Dri-Prime Standard		
1	Godwin 12" QD Dri-Prime Open Diesel Standard	$ 1,500.00	$ 1,500.00
1	Overtie Running (over 48 hrs/week if required)	$ 750.00	$ 750.00
10	12"x10' QD Suction Hose	$ 150.00	$ 1,500.00
1	12" QD Suction Screen	$ -	$ -
1	12" QD 90	$ 45.00	$ 45.00
10	12"x10' QD Pipe	$ 30.00	$ 300.00
		Total Weekly Rental w/ OT Running	**$ 4,095.00**

*Sales tax not included and must be added
*To calculate monthly rental charge, multiply weekly rate by 3
*Weekly rental is based on 48 hrs of run time. Overtime running is 50% extra on diesel powerpack only
*Standby/Backup equipment is offered at 75% of rental rates above
*Critcally Silenced Diesel Pumps are available for $540/each/week additional
***Fuel Consumption 12" Pump approx 4 gal/ hr/pump 180 gal tank**
*Preventative maintenance required every 250 hrs on diesel pumps only (Godwin can provide for an additional charge)

1 Tractor Trailer Loads

Transportation In Bypass	$ 1,250.00
Transportation Out Bypass	$ 1,250.00
TRANSPORTATION BY	GODWIN PUMPS

WEEKLY RENTAL w/ OT	**$ 4,095.00**
FREIGHT IN / OUT	**$ 2,500.00**
SALES TAX	**Plus Tax**
Environemntal Fee	**1%**

Quotations are valid for 60 days
Prices are subject to change without notification

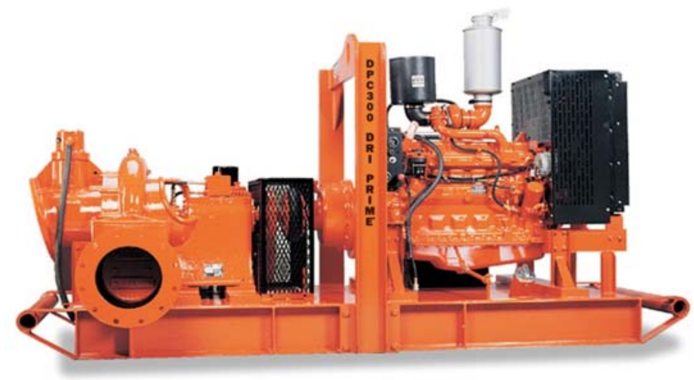
Godwin Pumps ***a xylem brand***
1373 Indian Fields Rd, Feura Bush, NY 12067
Phone - (518)767-2340 Fax - (518)767-2354
Quoted by Seth Morris, P.E. (518)390-4052
Seth.Morris@Xyleminc.com

DPC300 Dri-Prime® Pump

The Godwin Dri-Prime DPC300 pump offers flow rates to 5080 USGPM and has the capability of handling solids up to 3.7" in diameter.

The DPC300 is able to automatically prime to 28' of suction lift from dry. Automatic or manual starting/stopping available through integral mounted control panel or optional wireless-remote access.

Solids handling and portability make the DPC300 the perfect choice for dewatering and bypass applications.



Features and Benefits

- Simple maintenance normally limited to checking fluid levels and filters.
- Dri-Prime (continuously operated Venturi air ejector priming device) requiring no periodic adjustment. Optional compressor clutch available.
- Extensive application flexibility handling sewage, slurries, and liquids with solids up to 3.7" in diameter.
- Liquid lubricated mechanical seal with high abrasion resistant solid silicon carbide faces and limited dry-running capabilities.
- Pedestal-mounted centrifugal pump with Dri-Prime system coupled to a diesel engine or electric motor.
- All cast iron construction (stainless steel construction option available) with cast steel impeller.
- Also available in a critically silenced unit which reduces noise levels to less than 70 dBA at 30'.
- Standard engine John Deere 6068HF285 (T3 Flex). Also available with John Deere 6068HC93 (IT4).

Specifications

Suction connection	12" 150# ANSI B16.5
Delivery connection	12" 150# ANSI B16.5
Max capacity	5080 USGPM †
Max solids handling	3.7"
Max impeller diameter	16.9"
Max operating temp	176°F*
Max pressure	49 psi
Max suction pressure	29 psi
Max casing pressure	74 psi
Max operating speed	1200 rpm

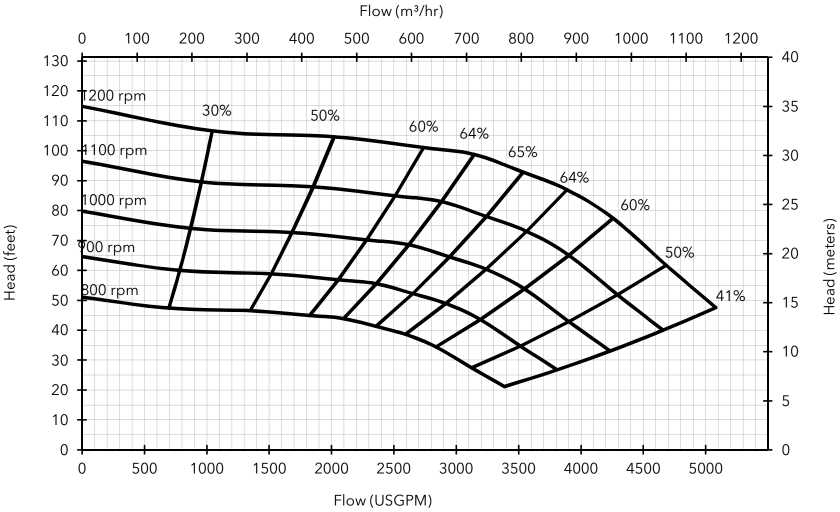
* Please contact our office for applications in excess of 176°F.

† Larger diameter pipes may be required for maximum flows.

Please contact the factory or office for further details. A typical picture of the pump is shown.
All information is approximate and for general guidance only.

godwin
a xylem brand

Performance Curve



Materials

Pump casing & suction cover	Cast iron BS EN 1561 - 1997
Wearplates	Cast iron BS EN 1561 - 1997
Pump Shaft	Carbon steel BS 970 - 1991 817M40T
Impeller	Cast iron BS EN 1561 - 1997
Non-return valve body	Cast iron BS EN 1561 - 1997
Mechanical seal	Silicon carbide face; Viton elastomers; Stainless steel body

Engine option 1

John Deere 6068HF285 (T3 Flex), 156 HP @ 2400 rpm

Impeller diameter 16.9"

Pump speed 1200 rpm driven by 2.0:1 gearbox

Suction Lift Table

Total Suction Head (feet)	**Total Delivery Head (feet)**				
	31	45	58	72	86
	Output (USGPM)				
10	5024	4714	4377	3937	3108
15	4921	4558	4144	3522	1036
20	4403	3885	3108	2072	777
25	2331	2072	1554	1036	-

Fuel capacity: 150 US Gal

Max Fuel consumption @ 2400 rpm: 8.7 US Gal/hr

Max Fuel consumption @ 2000 rpm: 8.0 US Gal/hr

Weight (Dry): 6,250 lbs

Weight (Wet): 7,330 lbs

Dim.: (L) 156" x (W) 55" x (H) 81"

Performance data provided in tables is based on water tests at sea level and 20°C ambient. All information is approximate and for general guidance only. Please contact the factory or office for further details.

Engine option 2

John Deere 6068HC93 (IT4), 157 HP @ 2400 rpm

Impeller diameter 16.9"

Pump speed 1200 rpm driven by 2.0:1 gearbox

Suction Lift Table

Total Suction Head (feet)	**Total Delivery Head (feet)**				
	31	45	58	72	86
	Output (USGPM)				
10	5024	4714	4377	3937	3108
15	4921	4558	4144	3522	1036
20	4403	3885	3108	2072	777
25	2331	2072	1554	1036	-

Fuel capacity: 150 US Gal

Max Fuel consumption @ 2400 rpm: 8.6 US Gal/hr

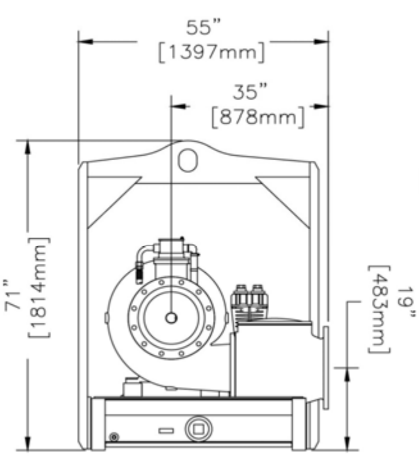
Max Fuel consumption @ 2000 rpm: 7.9 US Gal/hr

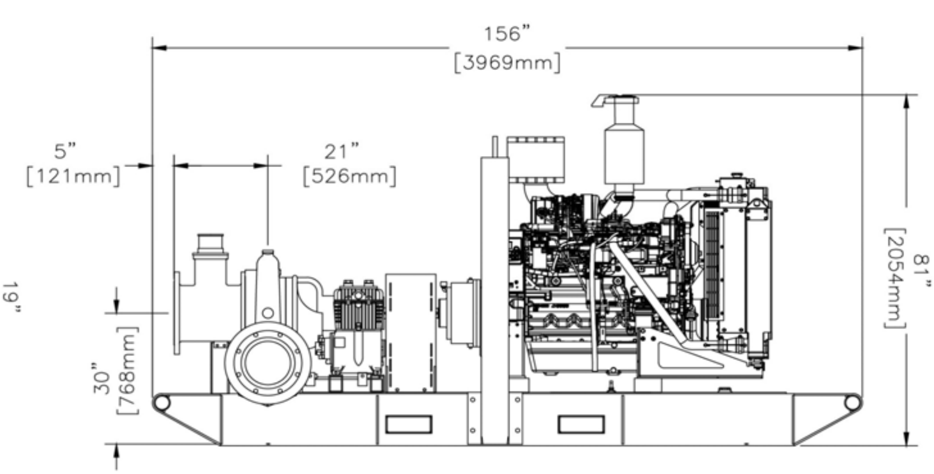
Weight (Dry): 6,550 lbs

Weight (Wet): 7,630 lbs

Dim.: (L) 156" x (W) 55" x (H) 81"

Performance data provided in tables is based on water tests at sea level and 20°C ambient. All information is approximate and for general guidance only. Please contact the factory or office for further details.





Let's Solve Water

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