

## Reservoir Management Decision Support System for the Connecticut River Watershed

# Appendix A: Modeled Reservoirs for the Connecticut River Watershed Application of HEC-ResSim

August 2013

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<ul> <li>14. ABSTRACT         This report was developed by the US Army Corps of Engineers Hydrologic Engineering Center (CEIWR-HEC) with New England District (CENAE) for assisting in the development of a Decision Support System for the Connecticut River watershed. The Decision Support System uses HEC-ResSim, HEC-EFM, HEC-RAS and estimates of unimpaired stream flows prepared by the U.S. Geological Survey. The Decision Support System will be used to analyze reservoir operating scenarios for a variety of water management purposes, including environmental, hydropower, flood control, water supply, and recreational considerations. This appendix provides detailed information about the modeled reservoirs. The overall Decision Support System is documented in PR-88.     </li> <li>15. SUBJECT TERMS         Hydrology, Decision Support System, HEC-ResSim, watershed, river, Connecticut River, water management, streamflow, Reservoir System Simulation, model, reservoir operation, operation set, data     </li> </ul>								
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## Appendix A: Modeled Reservoirs for the Connecticut River Watershed Application of HEC-ResSim

## August 2013

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PR-88b

Separate from the report for the Decision Support System of the Connecticut River watershed is this reservoir reference appendix document. It contains information about each reservoir modeled in the HEC-ResSim model. Information for each reservoir includes descriptions and sources of all physical and operational parameters in the model. This appendix is to serve as the reference guide in case changes to the model occur. It can also be used for setting up models at the sub-watershed and individual reservoir scale.

## List of Reservoirs

Ball Mountain	
Barkhamsted	
Barre Falls	
Bashan	
Bear Swamp	
Bellows Falls	
Bickford	
Birch Hill	61
Borden Brook	76
Canaan	
Cobble Mountain	
Colebrook	
Comerford	
Conant Brook	
Crescent Street	
Crystal Lake	
Danville	
Deerfield No. 2 Development	
Deerfield No. 3 Development	
Deerfield No.4 Development	
Deerfield No. 5 Development	
First Connecticut Lake	
Forest Lake	
Gardner Falls	
Gilman	

Goose Pond	
Grafton Pond	
Harriman	
Holyoke	
Knightville	233
Lake Francis	257
Lake Groton	
Lake McDonough	
Lake Monomonac	272
Lake Sunapee	
Littleville	
Mare Meadow	
Mascoma	
McIndoes	
Moodus	
Moore	
Nepaug	
New Home Sewing Machine	
North Hartland	
North Springfield	
Northfield	
Otis	
Otter Brook	
Power Canal (Turners Falls)	
Quabbin Windsor	416
Rainbow	428
Red Bridge	435
Searsburg	439
Second Connecticut Lake	456
Lake Shenipsit	464
Sherman	470
Shuttle Meadow	

Silver Lake	
Somerset	
Sugar	
Surry Mountain	
Tighe Carmody	517
Townshend	
Tully	537
Turners Falls	551
Union Village	
Upper Naukeag	573
Vernon	577
Ware Upper and Lower	
West Branch	595
West Springfield Hydro Project	
Whitney Pond	
Wilder	
Woronoco	619

## **Ball Mountain**

#### I. Overview

Ball Mountain Dam is a dam in Jamaica, Windham County, Vermont, in the southeastern part of the state. It was constructed between 1957 and 1961 by the United States Army Corps of Engineers and is owned and operated by the Corps. It is primarily used for flood control but is also used for recreation.

Figure 1 shows the location of Ball Mountain Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Ball Mountain Dam.

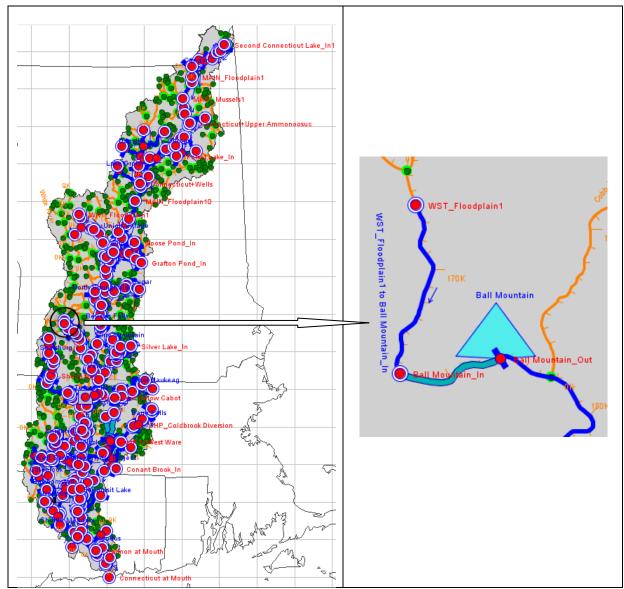


Figure 1: HEC-ResSim Map Display Showing Location of Ball Mountain dam



Figure 2: Photo of Ball Mountain Dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled slide gates, and (2) uncontrolled outlet, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previous ResSim model and the Reservoir Regulation Team website<sup>1</sup>.

<sup>&</sup>lt;sup>1</sup> http://rsgisias.crrel.usace.army.mil/nae/cwms\_map.map\_index

🟹 Reservoir Editor	11	7		X
Reservoir Edit Pool				
Reservoir Ball Mountain	✓ Description			
Physical Operations Observed D	Data			
Ball Mountain	Ball Mountain-Po	ol		
Dam Slide Gates	Linear Interp	olation 🔘 Co	nic Interpolation	Initial Conic Depth (ft)
Uncontrolled Outlet	Elevation	Storage	Area	
	(ft)	(ac-ft)	(acre)	
	0.00	0.00	0.00	
	5.00	17.00	4.00	
	10.00	48.00	8.00	250
	15.00	75.00	12.00	200
	20.00	155.00	16.00	€ 150
	25.00	240.00	20.00	
	30.00	370.00	27.00	Ξ <sub>50</sub> -
	35.00	510.00	34.00	0
	40.00	700.00	41.00	0 40,000 80,000
	45.00	920.00	48.00	Stor (ac-ft)
	50.00	1190.00	55.00	
	55.00	1490.00	62.00	250
	60.00	1850.00	69.00	200
	65.00	2240.00	75.00	€ 150
	70.00	2710.00	87.00	
	75.00	3200.00	100.00	Ξ <sub>50</sub> -
	80.00	3770.00	112.00	0
	85.00	4370.00	125.00	0 400 800 1,200
	90.00	5080.00	138.00	Area (acre)
	95.00	5810.00	151.00	Area (acre)
	100.00	6640.00	165.00	
	105.00	7500.00	182.00	
	110.00	8490.00	200.00 +	
OK Cancel Apply				

Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Ball Mountain					
Ball Mountain	<ul> <li>Description</li> </ul>				K 4 32 of 74 D H
Physical Operations Observed	Data				
Ball Mountain	Ball Mountain-D	Dam			
Dam Slide Gates	Elevation at to	p of dam (ft)		246	.5
Uncontrolled Outlet	Length at top	of dam (ft)		915	.0
	Composite R	elease Cap	acity		
			-		-
	Elevation	Controlled		Total	300
	(ft)	(cfs)	(cfs)	(cfs)	
	0.0	0.0	0.0	0.0 ^	
	10.0	1,950.0	0.0	1,950.0	100-
	20.0			3,900.0 5,175.0 ≡	Ξ <sub>0</sub> <del>7,,,,,</del>
	40.0			6,150.0	0 120,000
	50.0	6,975.0		6,975.0	Flow
	60.0			7,800.0	(cfs)
	70.0			8,550.0	(0.0)
		9,150.0		9,150.0	
	90.0		0.0	9,750.0	
	100.0	10,350.0	0.0	10,350.0	
	110.0	10,800.0		10,800.0	
	120.0	11,175.0	0.0	11,175.0	
	130.0	11,775.0	0.0	11,775.0	
	140.0	12,300.0	0.0	12,300.0	
		12,637.5		12,637.5	
		12,975.0		12,975.0	
		13,312.5		13,312.5	
	180.0	13,650.0	0.0	13,650.0 -	
<u> </u>					
				ОК	Cancel Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

## III. Operations

#### **A. Operation Set**

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Ball Mountain's "ExistingOps" operational zones, which consist of zones of Top of dam (246.5 ft), Surcharge (236.5 ft), Flood Control (211.5 ft), Conservation (25-65 ft), and Inactive zone (5 ft).

Reservoir Editor			and insult	X
Reservoir Edit Operations Zone Rule IF_Block				
Reservoir Ball Mountain			K 4 32 of 74	H
Physical Operations Observed Data				
Operation Set ExistingOps	Description first to	ry; 4/6/05, waiting for ma	rinelli's final input	
Zone-Rules Rel. Alloc. Outages Stor. Credit D	ec. Sched. Projected E	lev		
<ul> <li>Top of dam</li> <li>Slide Gate Ops - Save Dam</li> <li>Surcharge</li> <li>Slide Gate Ops</li> </ul>	Storage Zone Conser Function of Date	vation De	escription Pool elevations up to normal pool.	$\leq    $
🔲 🔲 Min Flow - Flood Pool - Ball Mountain	Data	To a Flouris (A)		
Max Release at Ball Mountain	Date	Top Elevation (ft)		
Connecticut at North Walpole - Linear	01Jan 30Apr	35.0 35.0	▲ 250	
Elood Control	01Mav	25.0	200	
Min Flow - Flood Pool - Ball Mountain	30Jun	25.0		
Max Release at Ball Mountain	01Jul	65.0		
Connecticut at North Walpole - Linear	30Sep	65.0	tio	
Connecticut at Montague - Linear	01Oct	35.0	\$ 100-	
Max ROC Outflow-Increasing				
MAX ROC Outflow-Decreasing			50	
Max Pool Elev ROC				
🔚 Max Outflow equals 21 day max inflow				
🦰 👝 Conservation			Jan Mar May Jul Sep Nov	
🖳 🔚 Min Flow Logic - Ball Mountain				
Max Conservation Release at Ball Mountain				
Connecticut at North Walpole - Linear				
Connecticut at Montague - Linear				
Max ROC Outflow-Increasing				
MAX ROC Outflow-Decreasing			×	
Max Pool Elev ROC	Zone Sort Elevation			
nactive 🦰	Zone Son Elevation			
	,			
			OK Cancel Appl	y

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

## **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## **C.** Rule Descriptions

#### 1. Slide Gate Ops-Save Dam

Figure 7 shows the content of "Slide Gate Ops-Save Dam" rule. This rule represents the maximum allowable release from Slide gates when the pool is in Top of dam zone as a function of pool elevation.

Operation Set ExistingOps	▼ Description first tr	y; 4/6/05, waiting for marii	nelli's final input		
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev					
<ul> <li>Top of dam</li> <li>Slide Gate Ops - Save Dam</li> <li>Surcharge</li> <li>Slide Gate Ops</li> <li>Min Flow - Flood Pool - Ball Mountain</li> <li>Max Release at Ball Mountain</li> <li>Connecticut at North Walpole - Linear</li> <li>Flood Control</li> <li>Min Flow - Flood Pool - Ball Mountain</li> <li>Max Release at Ball Mountain</li> <li>Max RCC Outflow-Increasing</li> <li>Max ROC Outflow-Decreasing</li> <li>Max Outflow equals 21 day max inflow</li> <li>Conservation</li> <li>Min Flow Logic - Ball Mountain</li> <li>Connecticut at North Walpole - Linear</li> <li>Max Conservation Release at Ball Mountain</li> <li>Max ROC Outflow-Increasing</li> <li>Max Conservation Release at Ball Mountain</li> <li>Max ROC Outflow-Increasing</li> <li>Max ROC Outflow-Increasing</li> <li>Max Conservation Release at Ball Mountain</li> <li>Max ROC Outflow-Increasing</li> <li>Max ROC Outflow-Increasing</li> <li>Max ROC Outflow-Decreasing</li> <li>Max Pool Elev ROC</li> </ul>	Operates Release From Rule Name: lide Gate	n: Ball Mountain-Slide Ga Ops - Save Dam Descri col Elevation, Period Aver Interp.: Linear Release (cfs) 0.0 1000.0	ption: rage, 0.0 hr lag, 48.0 hr period	Edit Edit Edit Edit Edit	
👝 Inactive		-	<b>•</b>		

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Slide Gate Ops-Save Dam

#### 2. Slide Gate Ops

Figure 8 shows the content of "Slide Gate Ops" rule. This rule represents the maximum allowable release from Slide gates as a function of pool elevation when pool is in surcharge zone.

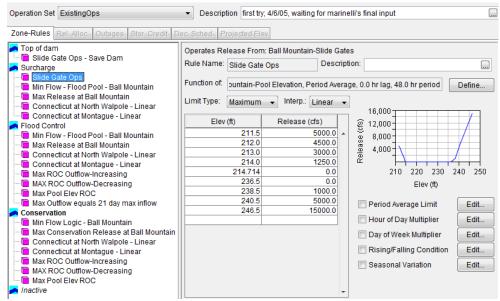


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Slide Gate Ops

#### 3. Min Flow-Flood Pool-Ball Mountain

Figure 9 shows the content of "Min Flow-Flood Pool-Ball Mountain" rule. This rule shows the minimum allowable release from dam during flood control operations.

Operation Set ExistingOps	▼ Description first tr	y; 4/6/05, waiting for marine	lli's final input	)
Zone-Rules Rel. Alloc. Outages Stor. Credit D	ec. Sched. Projected El	ev		
Top of dam     Slide Gate Ops - Save Dam     Slide Gate Ops     Slide Gate Ops     Min Flow - Flood Pool - Ball Mountain     Max Release at Ball Mountain     Connecticut at North Walpole - Linear	Operates Release From Rule Name: Flood Poor Function of: Date Limit Type: Minimum	ol - Ball Mountain Descripti		Define
Connecticut at Montague - Linear  Flood Control  Min Flow - Flood Pool - Ball Mountain  Max Release at Ball Mountain  Connecticut at North Walpole - Linear  Max ROC Outflow-Increasing  MAX ROC Outflow-Decreasing  MAX Pool Elev ROC	Date 01Jan 01Jun 01Oct	Release (cfs) 170.0 90.0 170.0	(sc) 160 (sc) 140 88 120 80 100 Jan Mar May Jul Sep N	lov
Max Outflow equals 21 day max inflow			Period Average Limit	Edit
Max Conservation Release at Ball Mountain     Max Conservation Release at Ball Mountain     Connecticut at North Walpole - Linear     Max ROC Outflow-Increasing     Max ROC Outflow-Decreasing     Max Pool Elev ROC     Inactive			Hour of Day Multiplier     Day of Week Multiplier     Rising/Falling Condition     Seasonal Variation	Edit Edit Edit

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min flow-Flood pool-Ball Mountain

#### 4. Max Release at Ball Mountain

Figure 10 shows the content of "Max Release at Ball Mountain" rule. This rule assigns 5000 cfs as the maximum release from dam.

Operation Set ExistingOps	▼ Description first try;	4/6/05, waiting for marine	lli's final input	
Zone-Rules Rel. Alloc. Outages Stor. Credit D	ec. Sched. Projected Elev			
Top of dam     Silde Gate Ops - Save Dam     Surcharge     Min Flow - Flood Pool - Ball Mountain     Max Release at Ball Mountain     Connecticut at North Walpole - Linear     Flood Control     Min Flow - Flood Pool - Ball Mountain     Max Release at Ball Mountain     Max Roc Outflow-Increasing     Max Roc Outflow-Increasing     Max Pool Flew ROC	Operates Release From: Rule Name: (Release at Function of: Date Limit Type: Maximum Date 01Jan		on: 5,040 5,020 5,020 5,000 4,980 4,980 Jan May Sep	Define
Max Pool Elev ROC     Max Pool Elev ROC     Max Outflow equals 21 day max inflow     Conservation     Max Conservation Release at Ball Mountain     Connecticut at North Walpole - Linear     Max ROC Outflow-Increasing     Max ROC Outflow-Decreasing     Max Pool Elev ROC     MaxCive			Period Average Limit Hour of Day Multiplier Day of Week Multiplier Rising/Falling Condition Seasonal Variation	Edit Edit Edit Edit Edit

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Release at Ball Mountain

#### 5. Connecticut at North Walpole-Linear

Figure 11 shows the content of "Connecticut at North Walpole-Linear" rule. This rule represents the maximum allowable release from dam as a function of previous day stage at North Walpole. The SOP for Ball Mountain was slightly different than the other flood control dams in that it called for an immediate reduction to 2000 cfs when a mainstem stage target was exceeded. Then the SOP says that the outflow will be directed by the Reservoir Regulation Team. The immediate reduction to 2000 cfs was accounted for in the rule and then 2000 cfs was used as the maximum when applying the linear release cutback described in the Simulation/Verification section of the report. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

Operation Set ExistingOps	Description first try; 4/6/05, waiting for marinelli's final input
Zone-Rules Rel, Alloc. Outages Stor. Credit D	Dec. Sched. Projected Elev
<ul> <li>Top of dam</li> <li>Slide Gate Ops - Save Dam</li> <li>Surcharge</li> <li>Slide Gate Ops</li> <li>Min Flow - Flood Pool - Ball Mountain</li> <li>Max Release at Ball Mountain</li> <li>Connecticut at North Walpole - Linear</li> <li>Flood Control</li> <li>Min Flow - Flood Pool - Ball Mountain</li> <li>Max Release at Ball Mountain</li> <li>Connecticut at North Walpole - Linear</li> <li>Flood Control</li> <li>Min Flow - Flood Pool - Ball Mountain</li> <li>Connecticut at North Walpole - Linear</li> <li>Connecticut at North Walpole - Linear</li> <li>Connecticut at North Walpole - Linear</li> <li>Max Release at Ball Mountain</li> <li>Connecticut at North Walpole - Linear</li> <li>Max ROC Outflow-Increasing</li> <li>Max Pool Elev ROC</li> <li>Max Outflow equals 21 day max inflow</li> <li>Conservation</li> <li>Min Flow Logic - Ball Mountain</li> <li>Max Conservation Release at Ball Mountain</li> <li>Max ROC Outflow-Increasing</li> <li>Max ROC Outflow-Decreasing</li> <li>Max ROC Outflow-Decreasing</li> <li>Max ROC Outflow-Decreasing</li> <li>Max ROC Outflow-Decreasing</li> <li>Max Pool Elev ROC</li> <li>Max Pool Elev ROC</li> <li>Inactive</li> </ul>	Operates Release From: Ball Mountain         Rule Name:       t at North Walpole - Linear       Description:         Function of:       Connecticut at North Walpole Stage, Previous Value       Define         Limit Type:       Maximum          Interp.:       Linear          Stage (ft)       Release (cfs)

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at North Walpole-Linear

#### 6. Connecticut at Montague -Linear

Figure 12 shows the content of "Connecticut at Montague-Linear" rule. This rule represents the maximum allowable release from dam as a function of previous day stage at Montague. The SOP for Ball Mountain was slightly different than the other flood control dams in that it called for an immediate reduction to 2000 cfs when a mainstem stage target was exceeded. Then the SOP says that the outflow will be directed by the Reservoir Regulation Team. The immediate reduction to 2000 cfs was accounted for in the rule and then 2000 cfs was used as the maximum when applying the linear release cutback described in the Simulation/Verification section of the report. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

Operation Set ExistingOps	Description first try; 4/6/05, waiting for marinelli's final input
Zone-Rules Rel. Alloc. Outages Stor. Credit D	Dec. Sched. Projected Elev
<ul> <li>Top of dam</li> <li>Slide Gate Ops - Save Dam</li> <li>Surcharge</li> <li>Slide Gate Ops</li> <li>Min Flow - Flood Pool - Ball Mountain</li> <li>Max Release at Ball Mountain</li> <li>Connecticut at North Walpole - Linear</li> <li>Flood Control</li> <li>Min Flow - Flood Pool - Ball Mountain</li> <li>Max Release at Ball Mountain</li> <li>Max Roc Outflow-Increasing</li> <li>MAX ROC Outflow-Decreasing</li> <li>Max Pool Elev ROC</li> <li>Max Outflow equals 21 day max inflow</li> <li>Conservation</li> <li>Min Flow Logic - Ball Mountain</li> <li>Max Conservation Release at Ball Mountain</li> <li>Max ROC Outflow-Increasing</li> <li>Max Conservation Release at Ball Mountain</li> <li>Max Conservation Release at Ball Mountain</li> <li>Max Conservation Release at Ball Mountain</li> <li>Max ROC Outflow-Increasing</li> <li>Max ROC Outflow-Increasing</li> <li>Max Conservation Release at Ball Mountain</li> <li>Max Conservation Release at Ball Mountain</li> <li>Max Conservation Release at Ball Mountain</li> <li>Max ROC Outflow-Increasing</li> <li>Max Pool Elev ROC</li> <li>Inactive</li> </ul>	Operates Release From: Ball Mountain         Rule Name:       cticut at Montague - Linear       Description:         Function of:       Connecticut at Montague Stage, Previous Value       Define         Limit Type:       Maximum          Interp.:       Linear          Stage (ft)       Release (cfs)

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague-Linear

#### 7. MAX ROC Outflow-Increasing

Figure 13 shows the content of "MAX ROC Outflow-Increasing" rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Ball Mountain dam.

Operation Set ExistingOps	Description first try; 4/6/05, waiting for marinelli's final input	
Zone-Rules Rel. Alloc. Outages Stor. Credit D	Dec. Sched. Projected Elev	
Top of dam  Slide Gate Ops - Save Dam Surcharge Surcharge Surcharge Min Flow - Flood Pool - Ball Mountain Max Release at Ball Mountain Connecticut at North Walpole - Linear Connecticut at North Walpole - Linear Max Release at Ball Mountain Min Flow - Flood Pool - Ball Mountain Max Release at Ball Mountain Max Release at Ball Mountain Max Role Outflow-Decreasing Max ROC Outflow-Increasing Max Pool Elev ROC Max Outflow equals 21 day max inflow Conservation Max Conservation Release at Ball Mountain Min Flow Logic - Ball Mountain Max Conservation Release at Ball Mountain Max Conservation Release at Ball Mountain Connecticut at North Walpole - Linear Connecticut at North Walpole - Linear Connecticut at North Walpole - Linear Max Conservation Max Conservation Release at Ball Mountain Max Conservation Release at Ball Mountain Max Conservation Release at Ball Mountain Connecticut at North Walpole - Linear Max Conservation Release at Ball Mountain Min Flow Logic - Ball Mountain Connecticut at North Walpole - Linear Support	Operates Release From: Ball Mountain         Release Rate of Change Limit Max ROC Outflow-Increasing         Description:         Function Of: Release         Type         Increasing         0.0         1,100         4000.0         123456.0         500.0         0.0         123456.0	
Max ROC Outflow-Increasing MAX ROC Outflow-Decreasing MAX Pool Elev ROC Interview	Release (cfs)	

Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – MAX ROC Outflow-Increasing

#### 8. MAX ROC Outflow-Decreasing

Figure 14 shows the content of "MAX ROC Outflow-Decreasing" rule. This rule shows the maximum allowable decreasing release rate of change.

Operation Set ExistingOps	Description first try; 4/6	/05, waiting for marinelli's final input	
Zone-Rules Rel. Alloc. Outages Stor. Credit D	ec. Sched. Projected Elev		
Top of dam     Silde Gate Ops - Save Dam     Surcharge     Silde Gate Ops - Save Dam     Surcharge     Silde Gate Ops     Min Flow - Flood Pool - Ball Mountain     Connecticut at North Walpole - Linear     Connecticut at North Walpole - Linear     Max Release at Ball Mountain     Max Roc Outflow-Increasing     Max ROC Outflow-Decreasing     Max Outflow equals 21 day max inflow     Conservation     Min Flow Logic - Ball Mountain     Max Conservation Release at Ball Mountain     Max ROC Outflow-Decreasing     Max ROC Outflow-Increasing     Min Flow Logic - Ball Mountain     Max Conservation Release at Ball Mountain     Max COC Outflow-Increasing     MAX ROC Outflow-Decreasing     MAX ROC Dutflow-Decreasing     MAX ROC D	Operates Release From: Ba Release Rate of Change Lir Description: Function Of: Type Max Rate of Change (cfs/hr)	MAX ROC Outflow-Decreasing           Constant         Image: Constant im	

Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet – MAX ROC Outflow-Decreasing

#### 9. MAX Pool Elev ROC

Figure 15 shows the content of "MAX Pool Elev ROC" rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

Zone-Rules       Rel: Alloc. Outages       Stor. Credit.       Dec. Sched.       Projected Elev         Image: Top of dam       Stide Gate Ops - Save Dam       Sturcharge       Operates Release From: Ball Mountain         Image: Sturcharge       Stide Gate Ops - Save Dam       Sturcharge       Operates Release From: Ball Mountain         Image: Sturcharge       Sturcharge       Sturcharge       Operates Release From: Ball Mountain         Image: Sturcharge       Sturcharge       Sturcharge       Image: Sturcharge         Image: Sturcharge       Connecticut at North Walpole - Linear       Image: Sturcharge       Image: Sturcharge         Image: Sturcharge       Connecticut at Montague - Linear       Image: Sturcharge       Image: Sturcharge         Image: Max Release at Ball Mountain       Image: Sturcharge       Image: Sturcharge       Image: Sturcharge         Image: Max Roc Outflow-Increasing       Max Change of (ft)       20.0       over       24         Image: Max Conservation       Image: Sturcharge       Max Change of (ft)       20.0       over       24         Image: Max Roc Outflow-Increasing       Max Roc Outflow-Increasing       Max Roc Outflow-Increasing       Image: Sturcharge       Image: Sturcharge         Image: Max Roc Outflow-Increasing       Image: Sturcharge       Image: Sturcharge       Image: Sturcharge <td< th=""><th>Operation Set ExistingOps</th><th>Description first try; 4/6/05, waiting for marinelli's final input</th><th></th></td<>	Operation Set ExistingOps	Description first try; 4/6/05, waiting for marinelli's final input	
<ul> <li>Slide Gate Ops - Save Dam</li> <li>Slide Gate Ops - Save Dam</li> <li>Slide Gate Ops</li> <li< th=""><th>Zone-Rules Rel, Alloc. Outages Stor. Credit D</th><th>ec. Sched. Projected Elev</th><th></th></li<></ul>	Zone-Rules Rel, Alloc. Outages Stor. Credit D	ec. Sched. Projected Elev	
Max Pool Elev ROC	Top of dam  Top of dam  Slide Gate Ops - Save Dam  Surcharge  Slide Gate Ops  Min Flow - Flood Pool - Ball Mountain  Connecticut at North Walpole - Linear  Connecticut at North Walpole - Linear  Connecticut at Montague - Linear  Connecticut at Montague - Linear  Max Release at Ball Mountain  Max Release at Ball Mountain  Max Roc Outflow-Increasing  Max Pool Elev ROC  Max Outflow equals 21 day max inflow  Connecticut at North Walpole - Linear  Max Conservation  Max Conservation  Max Control  Max Coutflow-Increasing  Max Conservation  Max Conservation  Max Conservation  Max Roc Outflow-Increasing  Max Roc Outflow-Increasing  Max Conservation  Max Conservation  Max Conservation  Max Roc Outflow-Increasing  Max Roc Outflow-I	Operates Release From: Ball Mountain Elevation Rate of Change Limit Max Pool Elev ROC Description Function Of: Constant Type Decreasing Instantaneous @ Period Average	

Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet – MAX Pool Elev ROC

#### 10. MAX Outflow equals 21 day max inflow

Figure 16 shows the content of "MAX outflow equals 21 day max inflow" rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

Operation Set ExistingOps	▼ Description first tr	y; 4/6/05, waiting for marine	elli's final input	
Zone-Rules Rel. Alloc. Outages Stor. Credit D	ec. Sched. Projected El	ev		
Top of dam     Slide Gate Ops - Save Dam     Slide Gate Ops - Save Dam     Slide Gate Ops     Min Flow - Flood Pool - Ball Mountain     Max Release at Ball Mountain     Connecticut at North Walpole - Linear     Connecticut at Montague - Linear     Flood Control     Min Flow - Flood Pool - Ball Mountain	Operates Release Fror Rule Name: / equals 2 Function of: ountain-P Limit Type: Maximum Flow (cfs)	1 day max inflow Descript	6,000	Define
Min Flow - Flood Pool - Ball Mountain     Max Release at Ball Mountain     Connecticut at North Walpole - Linear     Connecticut at Montague - Linear     Max ROC Outflow-Increasing     MAX ROC Outflow-Decreasing     Max Pool Elev ROC	5000.0 123456.0	5000.0 5000.0	2,000 0 60,000 120 Flow (cfs)	D,000
Max Outflow equals 21 day max inflow     Conservation     Min Flow Logic - Ball Mountain     Max Conservation Release at Ball Mountain     Connecticut at North Walpole - Linear			Period Average Limit  Hour of Day Multiplier  Day of Week Multiplier  Rising/Falling Condition	Edit Edit Edit
Connecticut at Montague - Linear     Max ROC Outflow-Increasing     MAX ROC Outflow-Decreasing     Max Pool Elev ROC     Inactive		-	Seasonal Variation	Edit

Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet – MAX outflow equals 21 day max inflow

#### 11. Min Flow Logic – Ball Mountain

Figure 17 shows the content of "Min Flow Logic – Ball Mountain" rule. This rule describes a seasonal minimum flow rule from the dam as a function of flow at Ball Mountain.

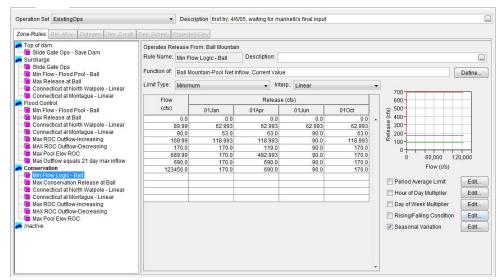


Figure 17: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic – Ball Mountain

#### 12. Max Conservation Release at Ball

Figure 18 shows the content of "Max Conservation Release at Ball" rule. This rule represents the maximum allowable release from Ball Mountain when the pool is in the conservation zone. This rule is unique to Ball Mountain and Townshend.

Top of dam	Operates Release Fi	and the second second second second		
Surcharge	Rule Name: nservat	ion Release at Ball Descriptio	In: Maximum conservation relea	ise (OG)[
Min Flow - Flood Pool - Ball	Function of: Date			Define.
🛅 Max Release at Ball 🛅 Connecticut at North Walpole - Linear	Limit Type: Maximu	im 🖌 Interp.: Step 👻	1,515	
Connecticut at Montague - Linear Flood Control	Date	Release (cfs)	1,510	
Min Flow - Flood Pool - Ball	01Jan	1500.0 🔺		
Max Release at Ball			(£ 1,505 , 1,500 , 1,500 , 1,495	
Connecticut at North Walpole - Linear	2		g 1,500	
Connecticut at Montague - Linear			🚆 1,495	
Max ROC Outflow-Increasing MAX ROC Outflow-Decreasing			ش 1,490	
Max Pool Elev ROC			1,485	
Max Outflow equals 21 day max inflow	<u>.</u>		Jan May Sep	
Conservation			Period Average Limit	Edit
Min Flow Logic - Ball Max Conservation Release at Ball				
Connecticut at North Walpole - Linear			Hour of Day Multiplier	Edit
🔲 Connecticut at Montague - Linear			Day of Week Multiplier	Edit
Max ROC Outflow-Increasing			Rising/Falling Condition	Edit
MAX ROC Outflow-Decreasing Max Pool Elev ROC				
Inactive			Seasonal Variation	Edit

Figure 18: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Conservation Release at Ball

## Barkhamsted

#### I. Overview

Construction of Barkhamsted Reservoir and Saville Dam were completed in 1940. It is owned and operated by the Hartford Metropolitan District Commission(MDC) and serves as the principal drinking water source for the city of Hartford, CT.

Figure 1 shows the location of Saville Dam and Barkhamsted reservoir as it is represented in the HEC-ResSim model, and Figure 2 shows a view from Saville Dam.

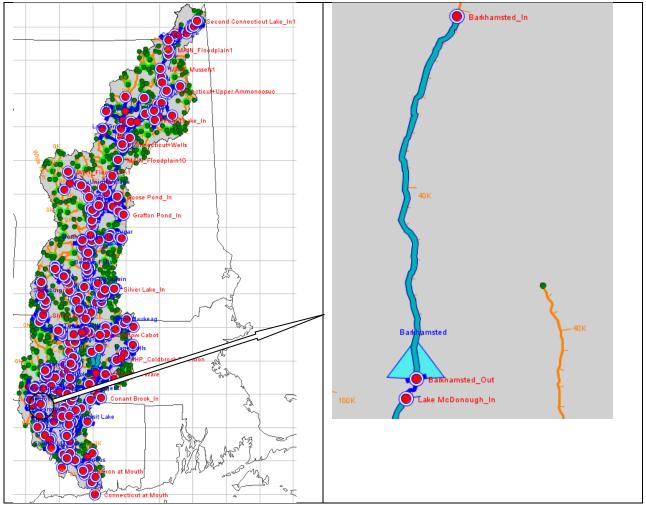


Figure 1: HEC-ResSim Map Display Showing Location of Barkhamsted reservoir



Figure 2: Photo of Barkhamsted reservoir

#### II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure  $3^2$ . The dam consists of one controlled spillway as shown in Figure  $4^3$ .

<sup>&</sup>lt;sup>2</sup> The Metropolitan District Hartford County, Conn. Barkhamsted Reservoir Available Capacity in Million Gallons. 1999.

<sup>&</sup>lt;sup>3</sup> Adamec, K. Farmington Model Documentation. University of Massachusetts, 2009.

eservoir Barkhamsted	<ul> <li>Description</li> </ul>				
Barkhamsted	• Description				K 4 5 of 74 D
hysical Operations Observ	ed Data				
Barkhamsted	Barkhamsted-P	ool			
Dam Spillway	Linear Inte	rpolation 🔘	Conic Interp	olatio	on Initial Conic Depth (ft)
	Elevation	Storage	Area		
	(ft)	(ac-ft)	(acre)		
	490.00	24351.59			
	491.00	25496.28			
	492.00	26671.66			
	493.00	27880.80			
	494.00	29123.70			
	495.00	30400.36			540
	496.00	31680.08		=	€ 520
	497.00	33015.05		- 11	
	498.00	34359.22		- 11	≗ 500
	499.00	35734.08		-11	480
	500.00 501.00	37136.56 38569.72		- 11	80,000 160,000
	501.00	40039.72		-111	Stor (ac-ft)
	503.00	41555.75			olor (ac-li)
	504.00	43090.19		- 1	540
	505.00	44652.25		- 1	
	506.00	46241.93		- 1	€ 520
	507.00	47865.37		- 1	à 500
	508.00	49522.57		- 1	ш зоо
	509.00	51198.18		- 1	480 + + + + + + + + + + + + + + + + + + +
	510.00	52907.55		- 1	2 4 6 8 10
	511.00	54641.47		- 1	Area (undef)
	512.00	56409.14			
	513.00	58210.58			
	514.00	60039.63			
	515.00	61893.24			
	516.00	63774.46			
	517.00	65683.31		Ŧ	

Figure 3: Reservoir Editor -- Physical Tab -- Pool

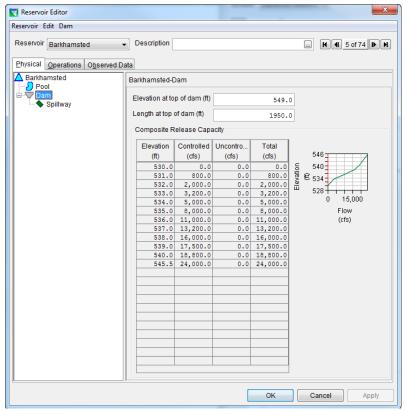


Figure 4: Reservoir Editor -- Physical Tab -- Dam

## III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Barkhamsted's "Existing Ops" operational zones, which consist of the zones Top of Dam (549 ft), Conservation (530 ft), and Inactive (490 ft)<sup>2</sup>.

Reservoir Editor			_	x
Reservoir Edit Operations Zone	e Rule IF_Block			
Reservoir Barkhamsted	<ul> <li>Description</li> </ul>			K 4 5 of 74 D H
Physical Operations Observ	ved Data			
Operation Set Existing Ops	•	Description Fron UM	lass Farmington no	otes: After the Nepaug Dam 📖
Zone-Rules Rel. Alloc. Out	tages Stor. Credit D	ec. Sched. Projected	í Elev	
Conservation	Storage Zone Conserv	vation D	Description	
F Inactive	Function of Date			Define
	Date	Top Elevation (ft)		
	01Jan	530.0	550	
			530	
			€ 520-	
			€ 520 - 550 - 550 -	
			ц 500 490	
			480	
			Jan Ma	r May Jul Sep Nov
Z	Zone Sort Elevation			
			ОК	Cancel Apply

Figure 5: Reservoir Editor -- Operations Tab – Existing Ops OpSet

## **B. Rule Illustrations**

The operation set for Barkhamsted has no operating rules, making it a through flow reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity. There is a water supply time series associated with Barkhamsted described in the Water Supply section of the report.

## **Barre Falls**

#### I. Overview

The Barre Falls Dam is a dam in Barre, Massachusetts on the Ware River. It was constructed between 1956 and 1958 by the US Army Corps of Engineers and is still owned and operated by the Corps. It is primarily used for flood control but is also used for recreation.

Figure 1 shows the location of Barre Falls Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the dam.

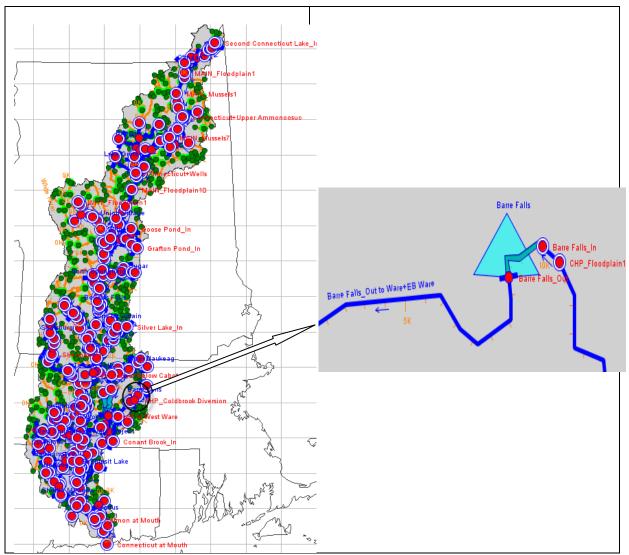


Figure 1: HEC-ResSim Map Display Showing Location of Barre Falls dam



Figure 2: Photo of Barre Falls Dam.

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled Outlet, and (2) uncontrolled spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>4</sup>.

<sup>&</sup>lt;sup>4</sup> http://rsgisias.crrel.usace.army.mil/nae/cwms\_map.map\_index

ervoir Edit Pool				
servoir Barre Falls	<ul> <li>Description</li> </ul>			K 4 50 of 74 🕨
vsical Operations Observed	Data			
Barre Falls	Barre Falls-Pool			
Controlled Outlet	Linear Interpolation	Conic Interpolation	Initial Conic Depth (ft)	
Spillway	Elevation	Oterese	Area	
	(ft)	Storage (ac-ft)	(acre)	
				810
	770.00	0.00	0.00	
	771.00	60.00		800
	773.00	120.00		3 790
	774.00	220.00	80.00 100.00 = 0	780
	775.00	340.00	125.00	770
	776.00	490.00	160.00	
	777.00	670.00	180.00	0 10,000 20,000
	778.00	880.00	215.00	Stor (ac-ft)
	779.00	1120.00	245.00	810
	780.00	1390.00	280.00	800
	781.00	1700.00	200.00	€ 790
	782.00	2050.00		
	783.00	2430.00	390.00	780
	784.00	2850.00	430.00	770
	785.00	3300.00	460.00	
	786.00	3790.00	500.00	
	787.00	4320.00	540.00	Area (acre)
	788.00	4900.00	580.00	
	700.00	5510.00	620.00	

Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor         Reservoir Edit Dam         Reservoir Edit Dam         Reservoir Barre Falls         Description         Physical Operations         Operations         Observed Data         Pool         Dam         Elevation at top of dam (ft)         830.0         Length at top of dam (ft)         825.0	4
Reservoir       Barre Falls       Description       Image: Constraint of the second	4
Physical Operations     Observed Data       Barre Falls     Barre Falls-Dam       Controlled Outlet     Elevation at top of dam (ft)	4 1 1
Physical Operations     Observed Data       Barre Falls     Barre Falls-Dam       Controlled Outlet     Elevation at top of dam (ft)	
Barre Falls     Pool     Controlled Outlet	
Barre Falls     Pool     Controlled Outlet     Controlled Outlet	
Pool     Dam     Controlled Outlet     Elevation at top of dam (ft)     830.0	
Controlled Outlet	
Controlled Outlet	
Controlled Outlet	
Splilway    Length at top of dam (π)	
Composite Release Capacity	
Elevation Controlled Uncontrolled Total	
(ft) (cfs) (cfs) 840	7 I
770.0         0.0         0.0         0.0           771.0         212.0         0.0         212.0           772.0         464.0         0.0         464.0	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	
//3:0 /44:0 0:0 /44:0 0 20.00	
774.0 1,194.0 0.0 1,194.0 0 775.0 1,626.0 0.0 1,626.0 Flow	
776.0 1,818.0 0.0 1,818.0 (cfs)	
778.0 2,070.0 0.0 2,070.0	
780.0 2,256.0 0.0 2,256.0	
785.0 2,634.0 0.0 2,634.0	
790.0 2,894.0 0.0 2,894.0	
793.0 3,000.0 0.0 3,000.0	
807.0 3,000.0 0.0 3,000.0	
808.0 3,000.0 300.0 3,300.0	
809.0 3,000.0 600.0 3,600.0	
OK Cancel	Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

## III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Barre Falls's "Existing Ops" operational zones, which consist of zones of Surcharge (830 ft), Flood Control (807 ft), Conservation (772-776 ft), and Inactive zone (770 ft).

Reservoir Editor	and includes			×	
Reservoir Edit Operations Zone Rule IF_Block					
Reservoir Barre Falls	ion			K 4 50 of 74 D H	)
Physical Operations Observed Data					
Operation Set Existing Ops	<ul> <li>Description</li> </ul>	n			
Zone-Rules Rel. Alloc. Outages Stor. Credi	t Dec. Sched. Pr	ojected Elev			
Surcharge	Storage Zone Co	onservation	Description		
Flood Control     Maximum Controlled Release     ADE Minimum Release	Function of Date			Define	
ABF Minimum Release during FC Ops	Date	Top Elevation (ft)			
Connecticut at Hartford - Linear	01Jan	776.0 🔺	840		
Max ROC Outflow-Increasing	31Mar	776.0	830		
Max ROC Outflow-Decreasing	01Apr 30Nov	772.0	820-		
Max Pool Elev ROC	01Dec	772.0	€ 810-		
Max Outflow equals 21 day max Inflow	01Dec	110.0 =	<u>5</u> 800		
Maximum Controlled Release			5 800- 5 790- 5 790-		
Min Flow Logic - Barre Falls			<u><u></u> <del>–</del> 780–</u>		
Connecticut at Montague - Linear			770		
🖳 🔚 Connecticut at Hartford - Linear			760		
Max ROC Outflow-Increasing			Jan M	far May Jul Sep Nov	
Max ROC Outflow-Decreasing					
	Zone Sort Elevation	on			
			ОК	Cancel Apply	

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

## **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

Reservoir Edit Operations Zone Rule IF_Block         Reservoir Barre Falls       Description         Physical Operations Observed Data         Operation Set Existing Ops         Zone Pulse Rel Alloc Outgreed Stor Orgon
Physical Operations Observed Data Operation Set Existing Ops
Operation Set Existing Ops
Zono Pulos Rol Allon Outogon Stor Crad
Zone-Rules Rel. Alloc. Outages Stor. Cred
<ul> <li>Surcharge</li> <li>Gate Ops to Save Dam</li> <li>Flood Control</li> <li>Maximum Controlled Release</li> <li>ABF Minimum Release during FC Ops</li> <li>Connecticut at Montague - Linear</li> <li>Connecticut at Hartford - Linear</li> <li>Max ROC Outflow-Increasing</li> <li>Max Pool Elev ROC</li> <li>Maximum Controlled Release</li> <li>Maximum Controlled Release</li> <li>Maximum Controlled Release</li> <li>Max Pool Elev ROC</li> <li>Maximum Controlled Release</li> <li>Min Flow Logic - Barre Falls</li> <li>Connecticut at Hartford - Linear</li> <li>Connecticut at Hartford - Linear</li> <li>Max ROC Outflow-Increasing</li> <li>Max ROC Outflow-Decreasing</li> </ul>

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## **C.** Rule Descriptions

#### 1. Gate Ops to Save Dam

Figure 7 shows the content of "Gate Ops to Save Dam" rule. This rule represents the maximum allowable release from controlled outlet as a function of pool elevation when the pool is in surcharge zone.

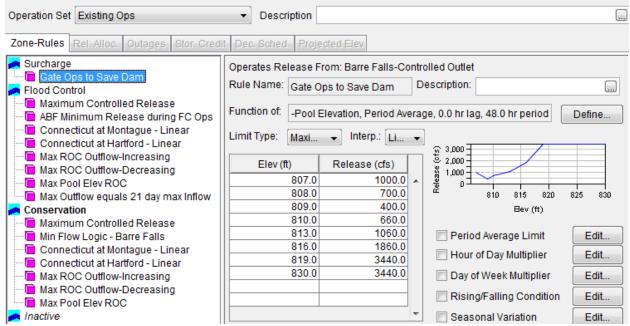


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet –Gate Ops to Save Dam

#### 2. Maximum Controlled Release

Figure 8 shows the content of "Maximum Controlled Release" rule. This rule shows the maximum release from controlled outlet.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>			
Zone-Rules Rel. Alloc. Outages Stor. Cred	it Dec. Sched. Proj	ected Elev		
Surcharge Gate Ops to Save Dam Flood Control Maximum Controlled Release ABF Minimum Release during FC Ops Connecticut at Montague - Linear Max ROC Outflow-Increasing Max ROC Outflow-Increasing Max Pool Elev ROC Max Outflow equals 21 day max Inflow Conservation		Release (cfs)	Description:	Define
Maximum Controlled Release Min Flow Logic - Barre Falls Connecticut at Montague - Linear Connecticut at Hartford - Linear Max ROC Outflow-Increasing Max ROC Outflow-Decreasing Max Pool Elev ROC Anactive			<ul> <li>Period Average Limit</li> <li>Hour of Day Multiplier</li> <li>Day of Week Multiplier</li> <li>Rising/Falling Condition</li> <li>Seasonal Variation</li> </ul>	Edit Edit Edit Edit

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Maximum Controlled Release

#### 3. ABF Minimum Release during FC Ops

Figure 9 shows the content of "ABF Minimum Release during FC Ops" rule. This rule assigns a 30 cfs release from the dam during flood control operations.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>			
Zone-Rules Rel, Alloc. Outages Stor. Cred	it Dec. Sched. Proj	ected Elev		
Surcharge Gate Ops to Save Dam Flood Control Maximum Controlled Release	Operates Release F Rule Name: m Rele			
ABF Minimum Release during FC Ops	Function of: Date	Internet [1.1		Define
Connecticut at Hartford - Linear	Limit Type: Mini Date	✓ Interp.: Li Release (cfs)	© <sup>30.2</sup>	
Max ROC Outflow-Decreasing Max Pool Elev ROC	01Jan	30.0	A 8 29.8	
Max Outflow equals 21 day max Inflow Conservation Maximum Controlled Release			_ & 29.6 J Jan Mar May Jul	i i Sep Nov
Min Flow Logic - Barre Falls			Period Average Lim	
Max ROC Outflow-Increasing			Day of Week Multiple	
Max ROC Outflow-Decreasing Max Pool Elev ROC			Rising/Falling Con	
inactive 🔁		I	Seasonal Variation	Edit

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – ABF Minimum Release during FC Ops

#### 4. Connecticut at Montague-Linear

Figure 10 shows the content of "Connecticut at Montague-Linear" rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

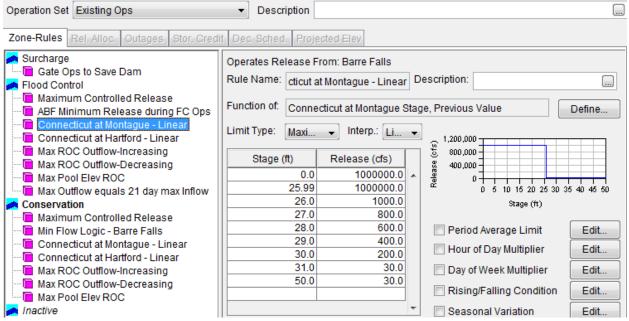


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague-Linear

#### 5. Connecticut at Hartford-Linear

Figure 11 shows the content of "Connecticut at Hartford-Linear" rule. This rule represents the maximum allowable release from dam as a function of previous day stage at Hartford. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

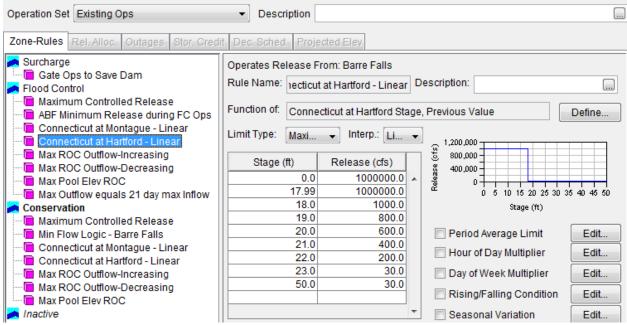


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Hartford-Linear

#### 6. Max ROC Outflow-Increasing

Figure 12 shows the content of "MAX ROC Outflow-Increasing" rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Barre falls dam.

Operation Set Existing Ops	Description	[
Zone-Rules Rel. Alloc. Outages Stor. Credi	Dec. Sched. Projected Elev	
Surcharge Gate Ops to Save Dam Flood Control Maximum Controlled Release	Operates Release From: Barre Falls-Controlled Outlet Release Rate of Change Limit Max ROC Outflow-Increasing	
ABF Minimum Release during FC Ops Connecticut at Montague - Linear Connecticut at Hartford - Linear	Description:	
Max ROC Outflow-Decreasing Max Pool Elev ROC Max Outflow equals 21 day max inflow	Interpolate     Linear       Release (cfs)     Rate Change (cfs/)	
Conservation  Maximum Controlled Release  Min Flow Logic - Barre Falls  Consecting at Marker was biseer	0.0 150.0 600.0 150.0 500.1 50.0 80	
Connecticut at Montague - Linear Connecticut at Hartford - Linear Max ROC Outflow-Increasing Max ROC Outflow-Decreasing Max Pool Elev ROC	123456.0 50.0 60,000 120,000 C C C C C C C C C C C C C C C C C C C	
inactive 🔁	T T T T T T T T T T T T T T T T T T T	

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet –MAX ROC Outflow-Increasing

#### 7. Max ROC Outflow-Decreasing

Figure 13 shows the content of "MAX ROC Outflow-Decreasing" rule. This rule shows the maximum allowable decreasing release rate of change.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>		
Zone-Rules Rel. Alloc. Outages Stor. Credi	t Dec. Sched. Projected Ele	W.	
Surcharge Gate Ops to Save Dam Gate Ops to Save Dam Flood Control Maximum Controlled Release GABF Minimum Release during FC Ops Gonnecticut at Montague - Linear Max ROC Outflow-Increasing Max Pool Elev ROC Max Outflow equals 21 day max Inflow Conservation Maximum Controlled Release Min Flow Logic - Barre Falls Gonnecticut at Montague - Linear Max ROC Outflow-Increasing Max ROC Increasing Max	Operates Release From: Bai Release Rate of Change Lin Description: Function Of: Type Max Rate of Change (cfs/hr)	rre Falls-Controlled Outlet nit Max ROC Outflow-Decreasing Constant • Decreasing • 300.0	

Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – MAX ROC Outflow-Decreasing

#### 8. Max Pool Elev ROC

Figure 14 shows the content of "Max Pool Elev ROC" rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>		
Zone-Rules Rel. Alloc. Outages Stor. Cred	it Dec. Sched. Pro	jected Elev	
Surcharge Gate Ops to Save Dam Gate Ops to Save Dam Flood Control Maximum Controlled Release Gate ABF Minimum Release during FC Ops Gonnecticut at Montague - Linear Max ROC Outflow-Increasing Max ROC Outflow-Decreasing Max Oct Outflow equals 21 day max Inflow Conservation Maximum Controlled Release Max Flow Logic - Barre Falls Connecticut at Mantague - Linear Max ROC Outflow-Increasing Max ROC Increasing Max Pool Elev ROC Anticive	Description	change Limit Max Pool Elev ROC	

Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet –Max Pool Elev ROC

#### 9. Max Outfow equals 21 day max inflow

Figure 15 shows the content of "Max Outflow equals 21 day max inflow" rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

Operation Set Existing Ops	Description			
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev				
<ul> <li>Surcharge</li> <li>Gate Ops to Save Dam</li> <li>Flood Control</li> <li>Maximum Controlled Release</li> <li>ABF Minimum Release during FC Ops</li> <li>Connecticut at Montague - Linear</li> <li>Connecticut at Hartford - Linear</li> </ul>	Operates Release From: Barre Falls         Rule Name:       r equals 21 day max Inflow         Description:         Function of:       >-Pool Inflow, Period Maximum, 0.0 hr lag, 504.0 hr period         Limit Type:       Maxi          Interp.:         Limit Type:       Maxi          Interp.:			
Max ROC Outflow-Increasing     Max ROC Outflow-Decreasing	Elevery (afe) Delevery (afe) 3 80 000			
Max Pool Elev ROC				
Conservation	1000.0 500.0 40,000 80,000 120,000 1000.0 1000.0 Flow (cfs)			
Maximum Controlled Release	123456.0 123456.0			
🗝 🛅 Min Flow Logic - Barre Falls	Period Average Limit Edit	t		
Connecticut at Montague - Linear	Hour of Day Multiplier	t		
Max ROC Outflow-Increasing	Day of Week Multiplier	t		
Max ROC Outflow-Decreasing	Rising/Falling Condition     Edit	t		
👝 Inactive	Seasonal Variation Edit	t		

Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals 21 day max inflow

#### 10. Min Flow Logic-Barre Falls

Figure 16 shows the content of "Min Flow Logic-Barre Falls" rule. This rule describes a seasonal minimum flow rule from controlled outlets as a function of inflow at Barre falls.

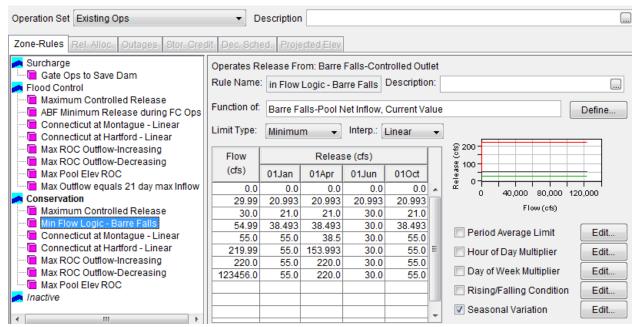


Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic-Barre Falls

### Bashan

### I. Overview

The dam was constructed in 1939 and is used for recreation. It is owned by the state of Connecticut and is under the control of the Department of Environmental Protection. The lake area is 276 acres, about 21% of the its total drainage area. In 2011, funds were allocated to repair the dam and to decrease the risk of the dam overtopping during a flood event.

Figure 1 shows the location of Bashan reservoir as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Bashan Dam.

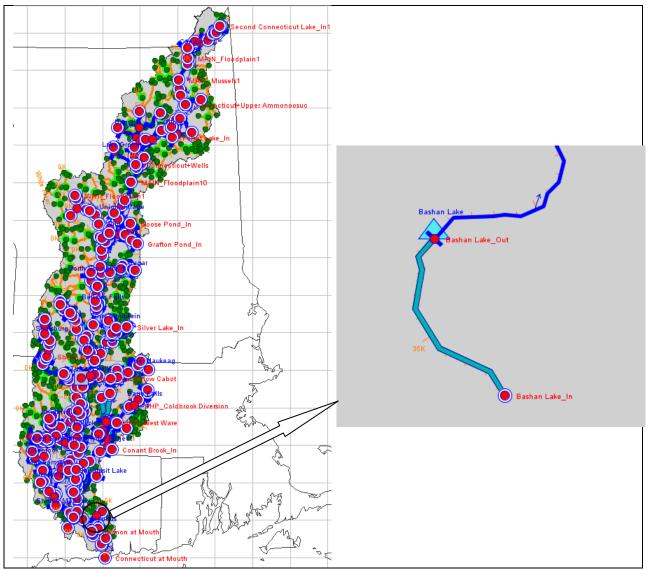


Figure 1: HEC-ResSim Map Display Showing Location of Bashan Dam



Figure 2: Aerial photo of Bashan Lake Dam

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure  $3^5$ . The dam consists of three different outlets: (1) an uncontrolled spillway, (2) an uncontrolled right embankment, and (3) an uncontrolled left embankment as shown in Figure 4. These three uncontrolled were modeled as weirs, with data shown in Table  $1^6$ .

<sup>&</sup>lt;sup>5</sup> Provided by the operators of Bashan

<sup>&</sup>lt;sup>6</sup> WMC Consulting Engineers. Preliminary Design Report. Newington, CT 2012.

Reservoir Edit Pool				
Reservoir Bashan Lake	<ul> <li>Description</li> </ul>			
Physical Operations Observed	Data			
🛆 Bashan Lake	Bashan Lake-Poo	al		
-2 Pool				
🖻 🕎 Dam	Linear Interp	olation 💿 Co	nic Interpolati	on Initial Conic Depth (ft)
spillway				
Right Embankment Steft Embankment	Elevation	Storage	Area	
	(ft)	(ac-ft)	(acre)	
	375.00	0.00		
	376.00	291.00		
	378.00	874.00		
	380.00	1457.00		
	382.00	2040.00		
	384.00	2623.00		
	386.00	3206.00		480
	388.00	3770.00		400
	389.40	4100.00		€ 440
	390.00	4440.00 4590.00		a 400
	390.50	4750.00		
	391.50	4920.00		360 360
	392.00	5080.00		0 20,000 40,000
	392.50	5250.00		Stor (ac-ft)
	393.00	5400.00		
	393.50	5580.00		480-
	394.00	5760.00		
	394.50	5930.00		€ 440
	395.00	6100.00		å 400-
	395.50	6280.00		
	396.00	6460.00		360+++++
	396.50	6650.00		0 100 200
	397.00	6840.00		Area (acre)
	397.50	7020.00		-
	398.00	7200.00		-
	398.50	7400.00		-
	399.00	7580.00		
	400.00	7963.00		
	400.00	41475.50		
	407.50	41473.30		-
				OK Cancel Apply

Figure 3: Reservoir Editor -- Physical Tab -- Pool

💘 Reservoir Editor	-		- 2 -		
Reservoir Edit Dam					
Reservoir Bashan Lake	Description				
Physical Operations Observed D	ata				
A Bashan Lake	Bashan Lake-Da	m			
Dam Spillway	Elevation at top	of dam (ft)		487	.5
Right Embankment	Length at top of	dam (ft)		169	.0
Left Embankment	Composite Rel	ease Capa	city		
	Elevation	Controlled	Uncontrol	Total	]
	(ft)	(cfs)	(cfs)	(cfs)	
	486.0	0.0	0.0	0.0	e 487.2
	486.2	0.0	5.5	5.5	€ 486.6 € 486.0
	486.3	0.0	15.7	15.7	å 486.0
	486.4	0.0	28.8	28.8	
	486.6	0.0	44.3	44.3	0 80 160
	486.8	0.0	61.9	61.9	Flow
	486.9	0.0	81.4	81.4	(cfs)
	487.0	0.0	102.6	102.6	
	487.2	0.0	125.4	125.4	
	487.3	0.0	141.5	141.5	
	487.3	0.0	145.0	145.0 ≡	
	487.3	0.0	148.8	148.8	
	487.4	0.0	150.7	150.7	
	487.4	0.0	152.8	152.8	
	487.4	0.0	161.3	161.3	
	487.4	0.0	161.5	161.5	
	487.4	0.0	165.9	165.9	
	487.4	0.0	165.9	165.9	
	487.4	0.0	168.4	168.4	
	487.4	0.0	170.9	170.9	
	487.4	0.0	173.5	173.5	
	487.5	0.0	176.2	176.2	
	487.5	0.0	178.9	178.9	
	487.5	0.0	181.6	181.6	
	487.5	0.0	184.4	184.4	
	487.5	0.0	187.2	187.2	
				-	
				ОК	Cancel Apply

Figure 4: Reservoir Editor -- Physical Tab -- Dam

	Outlet Elevation (ft)	Weir Coef.	Length (ft)
Spillway	486	3.3	28.9
Right Embankment	487.4	3.3	30.0
Left Embankment	487.3	3.3	30.0

#### Table 1: Weir Data

### III. Operations

### **A. Operation Set**

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 4 shows the definition of Bashan's "Guide Curve" operational zones, which consist of the zones Flood Control (487.5 ft), Conservation (486 ft), and Inactive (400 ft). The zone elevations were based off the top of the elevation-storage curve and the spillway outlet elevation.

Reservoir Editor						
Reservoir Edit Operations Zone Rule IF_Block						
Reservoir Bashan Lake   Description  Reservoir Bashan Lake						
Physical Operations Observed Data						
Operation Set Guide Curve   Description						
Zone-Rules Rel. Alloc. Outages Stor. Credit. Dec. Sched. Projected Elev						
Flood Control Storage Zone Conservation Description						
Function of Date Define						
Date Top Elevation (ft)						
01Jan 486.0 A 480 480 470 -						
460 460						
Jan Mar May Jul Sep Nov						
Zone Sort Elevation						
OK Cancel Apply						

Figure 5: Reservoir Editor -- Operations Tab – Guide Curve OpSet

### **B. Rule Illustrations**

The operation set for Bashan has no operating rules, making it a through flow reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

## Bear Swamp

### I. Overview

Bear Swamp is pump-storage and run-of-river hydropower generating facility (the run-of-river facility is called Fife Brook) on the Deerfield River in Rowe, MA. It is currently owned and operated by Brookfield Renewable Power Inc. and is primarily used for hydropower generation. It is also used to make whitewater releases for whitewater rafting.

Figure 1 shows the location of Bear Swamp Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Bear Swamp dam.

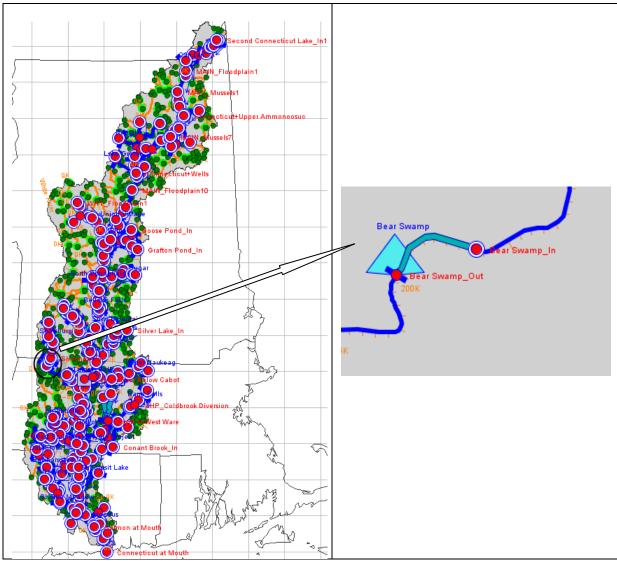


Figure 1: HEC-ResSim Map Display Showing Location of Bear Swamp dam

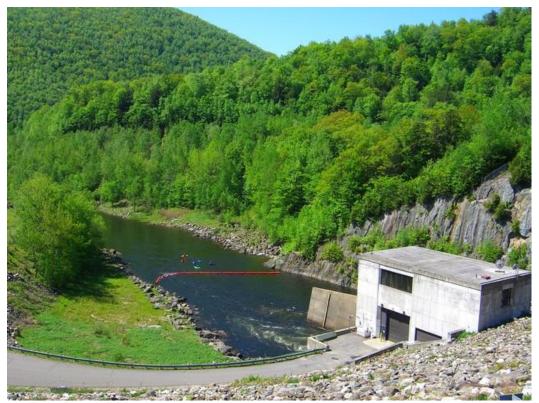


Figure 2: Photo of Bear Swamp Dam

Only the physical and operational characteristics of the river portion of the project are modeled. The pump-storage part of the project was not modeled because it was deemed unnecessary. The pump-storage is operates on the same volume of water, all flow from upstream is passed through the river portion of the project

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>7</sup>. The dam consists of three types of outlets: (1) controlled tainter gate, (2) controlled 30 inch pipe, and (3) power plant as shown in Figure 4.

<sup>&</sup>lt;sup>7</sup> Brookfield Renewable Power Inc. Brookfield – Bear Swamp Pump Storage Project. 2012

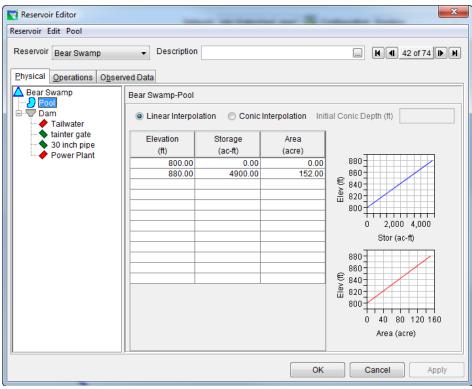


Figure 3: Reservoir Editor: Physical Tab -- Pool

eservoir Edit Dam						
Reservoir Bear Swamp	▼ Descriptio	n			K 4 42 of 74 D	
Physical Operations Obse	rved Data					
A Bear Swamp	Bear Swamp-Dam	ı				
Dam	Elevation at top o	f dam (ft)		880.	0	
🔶 tainter gate	Length at top of o	lam (ft)				
30 inch pipe Power Plant	Composite Release Capacity					
	Elevation	Controlled	Uncontroll	Total	]	
	(ft)	(cfs)	(cfs)	(cfs)	880	
	830.0	384.0	0.0	384.0	5 860	
	832.0	811.6	0.0	811.6		
	833.0	1,384.4	0.0	1,384.4	a <sup>™</sup> 840 <mark>→</mark>	
	834.0	2,085.2	0.0	2,085.2 ≡		
	835.0	2,902.0	0.0	2,902.0	0 50,000	
	836.0	3,290.8	0.0	3,290.8	Flow	
	837.0	4,281.6	0.0	4,281.6	(cfs)	
		5,364.4	0.0	5,364.4		
		6,533.2	0.0	6,533.2		
		7,070.0	0.0	7,070.0		
	841.0	8,378.8	0.0	8,378.8		
		10,368.4	0.0	10,368.4		
		10, 368.4	0.0	10, 368.4		
		13,456.0	0.0	13,456.0		
		15,098.8	0.0	15,098.8		
		16,807.6	0.0	16,807.6		
		17,570.4	0.0	17,570.4 -		

Figure 4: Reservoir Editor: Physical Tab -- Dam

## III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 4 shows the definition of Bear Swamp's "Guide Curve" operational zones, which consist of zones of Top of dam (880 ft), Flood Control (870 ft), Conservation (850 ft), and Inactive zone (800 ft)<sup>1</sup>.

Reservoir Editor Reservoir Edit Operations Zor Reservoir Bear Swamp Physical Operations Obser Operation Set Existing Ops	Description	Description			¥ 1 42 of 74 ► ¥
Zone-Rules Rel. Alloc.	tages       Stor Credit       De         Storage Zone       Conse         Function of       Date         01Jan       01		escriptic	890 880 870 860 850 840 830 820 810 800 790 Jan Mar May Jul 3	Define
				OK Cancel	Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

### **B. Rule Illustrations**

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Guide Curve.

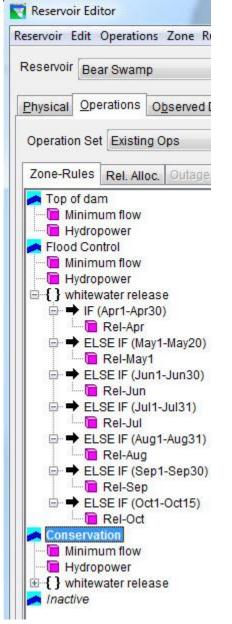


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## **C.** Rule Descriptions

#### 1. Minimum flow

Figure 7 shows the content of "Minimum flow" rule. This rule assigns 125 cfs as a minimum release from 30 inch pipe controlled outlet.

	Operates Release Rule Name: Minin Function of: Date Limit Type: Minin Date	n 🔹 Interp.: [Lin	Des	scription:	 Define
B-{} whitewater release Inactive	01Jan	Release (dfs)	<u>i.0</u> *	126.0 125.0 124.0 Jan Mar May Jul Sep N Period Average Limit	Nov Edit
	<u></u>			Hour of Day Multiplier	Edit
			- 1	Day of Week Multiplier Rising/Falling Condition	Edit

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Minimum flow

#### 2. Hydropower

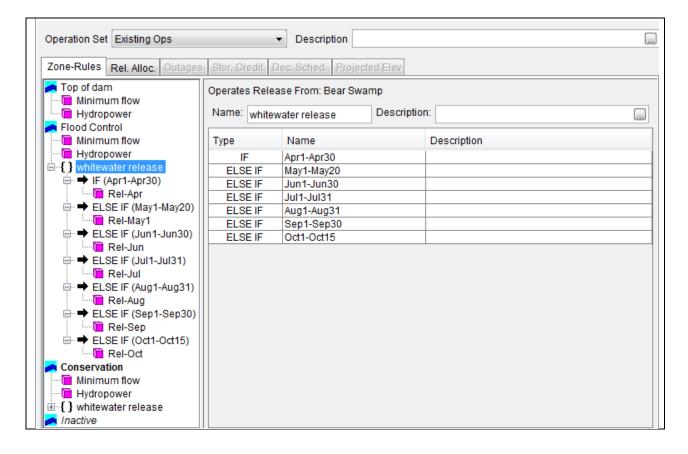
Figure 8 shows the content of "Hydropower" rule. This rule releases 95% of inflow through power plant as per the run-of-river hydropower strategy.

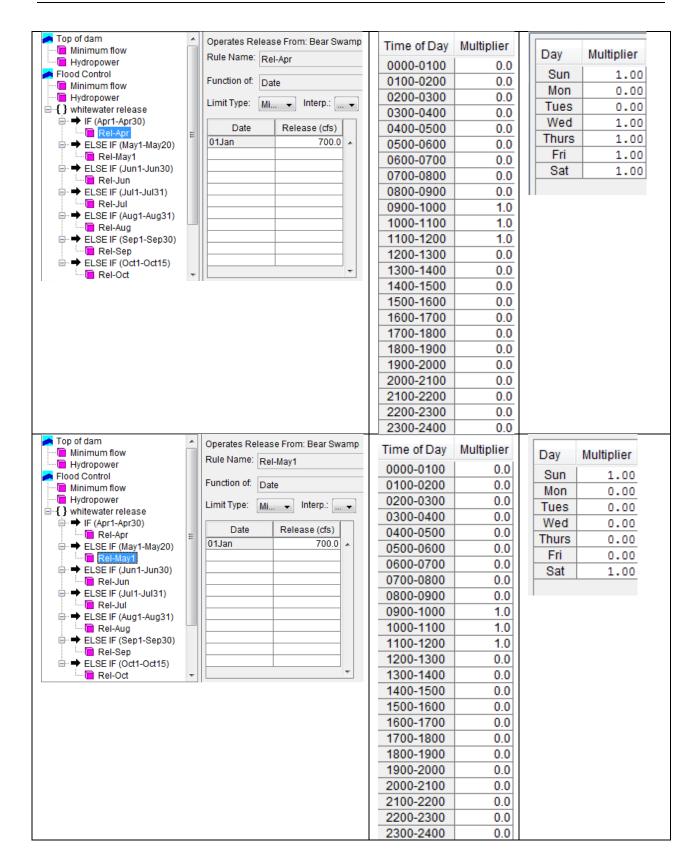
Operation Set Existing Ops	▼ De	escription			
Zone-Rules Rel. Alloc. Outages	Stor. Credit Dec.	Sched. Projected Ele	ev		
<ul> <li>Top of dam</li> <li>Minimum flow</li> <li>Hydropower</li> <li>Flood Control</li> <li>Minimum flow</li> <li>Hydropower</li> <li>{} whitewater release</li> <li>Conservation</li> <li>Minimum flow</li> <li>Hydropower</li> <li>{} whitewater release</li> <li>A minimum flow</li> <li>Hydropower</li> <li>{} whitewater release</li> <li>Inactive</li> </ul>	Rule Name: Hydro	Swamp-Pool Net Inflor	Description w, Current V		 Define
			Ho Da	eriod Average Limit our of Day Multiplier ay of Week Multiplier sing/Falling Condition easonal Variation	Edit Edit Edit Edit Edit

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet –Hydropower

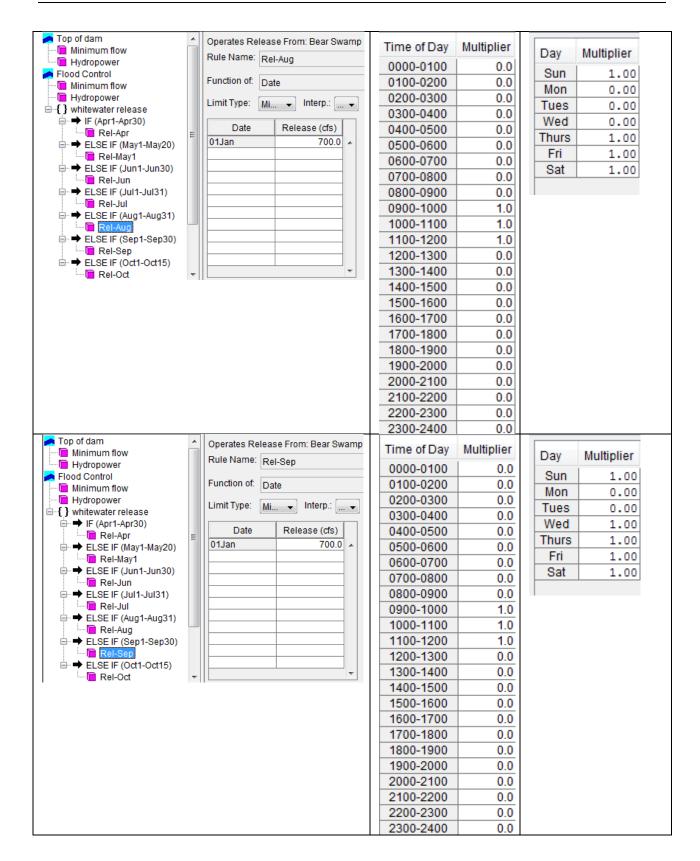
### 3. Whitewater release

Figure 9 shows the content of "Whitewater release" rule. This rule releases 700 cfs through power plant with different schedules during different months of the year.





👝 Top of dam	*	Operates Releas	se From: Bear Swamp	Time of Day	Multiplier	Davis	Markinka
Minimum flow		Rule Name: Re	l-Jun	0000-0100	-	Day	Multiplier
Flood Control					0.0	Sun	1.00
🖳 🛅 Minimum flow		Function of: Da	te	0100-0200	0.0	Mon	0.00
Hydropower		Limit Type: Mi	🗸 Interp.: 🛄 🗸	0200-0300	0.0	Tues	0.00
imitewater release imitewater release imite in iteration				0300-0400	0.0	Wed	1.00
Rel-Apr	-	Date	Release (cfs)	0400-0500	0.0	Thurs	1.00
ELSE IF (May1-May20)	-	01Jan	700.0 🔺	0500-0600	0.0		
Rel-May1				0600-0700	0.0	Fri	1.00
🖻 🕈 ELSE IF (Jun1-Jun30)				0700-0800	0.0	Sat	1.00
ELSE IF (Jul1-Jul31)				0800-0900	0.0		
Rel-Jul				0900-1000	1.0		
ELSE IF (Aug1-Aug31)				1000-1100	1.0		
🔲 Rel-Aug				1100-1200	1.0		
ELSE IF (Sep1-Sep30)				1200-1300	0.0		
■ The Image Provide the Im							
Rel-Oct	-		*	1300-1400	0.0		
				1400-1500	0.0		
				1500-1600	0.0		
				1600-1700	0.0		
				1700-1800	0.0		
				1800-1900	0.0		
				1900-2000	0.0		
				2000-2100	0.0		
				2100-2200	0.0		
				2200-2300	0.0		
				2300-2400	0.0		
A Top of dam	*		se From: Bear Swamp	Time of Day	Multiplier	Day	Multiplier
Hydropower		Rule Name: Re	I-Jul	0000-0100	0.0		
Flood Control		Function of: Da	-	0100-0200	0.0	Sun	1.00
Minimum flow		Function of: Da	te			Mon	0.00
Hydropower		Limit Type: Mi.	👻 Interp.: 🛄 👻	0200-0300	0.0	Tues	0.00
■ IF (Apr1-Apr30)				0300-0400	0.0	Wed	1.00
🔲 🔲 Rel-Apr	=	Date	Release (cfs)	0400-0500	0.0	Thurs	1.00
ELSE IF (May1-May20)		01Jan	700.0	0500-0600	0.0	Fri	1.00
□ Rel-May1 □ ➡ ELSE IF (Jun1-Jun30)				0600-0700	0.0	Sat	1.00
Rel-Jun				0700-0800	0.0	Oat	1.00
ELSE IF (Jul1-Jul31)				0800-0900	0.0		
Rel-Jul				0900-1000	1.0		
ELSE IF (Aug1-Aug31)				1000-1100	10		
🔲 🖻 Rel-Aug				1000-1100	1.0		
■ ➡ ELSE IF (Sep1-Sep30)				1100-1200	1.0		
🔚 Rel-Aug				1100-1200 1200-1300	1.0 0.0		
➡ Rel-Aug ➡ ELSE IF (Sep1-Sep30) ➡ Rel-Sep	Ŧ			1100-1200 1200-1300 1300-1400	1.0 0.0 0.0		
<ul> <li>➡ Rel-Aug</li> <li>➡ ELSE IF (Sep1-Sep30)</li> <li>➡ Rel-Sep</li> <li>➡ ELSE IF (Oct1-Oct15)</li> </ul>	-			1100-1200 1200-1300 1300-1400 1400-1500	1.0 0.0 0.0 0.0		
<ul> <li>➡ Rel-Aug</li> <li>➡ ELSE IF (Sep1-Sep30)</li> <li>➡ Rel-Sep</li> <li>➡ ELSE IF (Oct1-Oct15)</li> </ul>	•			1100-1200 1200-1300 1300-1400 1400-1500 1500-1600	1.0 0.0 0.0 0.0 0.0		
<ul> <li>➡ Rel-Aug</li> <li>➡ ELSE IF (Sep1-Sep30)</li> <li>➡ Rel-Sep</li> <li>➡ ELSE IF (Oct1-Oct15)</li> </ul>	•			1100-1200 1200-1300 1300-1400 1400-1500	1.0 0.0 0.0 0.0		
<ul> <li>➡ Rel-Aug</li> <li>➡ ELSE IF (Sep1-Sep30)</li> <li>➡ Rel-Sep</li> <li>➡ ELSE IF (Oct1-Oct15)</li> </ul>	+			1100-1200 1200-1300 1300-1400 1400-1500 1500-1600	1.0 0.0 0.0 0.0 0.0		
<ul> <li>➡ Rel-Aug</li> <li>➡ ELSE IF (Sep1-Sep30)</li> <li>➡ Rel-Sep</li> <li>➡ ELSE IF (Oct1-Oct15)</li> </ul>	•			1100-1200 1200-1300 1300-1400 1400-1500 1500-1600 1600-1700	1.0 0.0 0.0 0.0 0.0 0.0		
<ul> <li>➡ Rel-Aug</li> <li>➡ ELSE IF (Sep1-Sep30)</li> <li>➡ Rel-Sep</li> <li>➡ ELSE IF (Oct1-Oct15)</li> </ul>	•		 	1100-1200 1200-1300 1300-1400 1400-1500 1500-1600 1600-1700 1700-1800	1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0		
<ul> <li>➡ Rel-Aug</li> <li>➡ ELSE IF (Sep1-Sep30)</li> <li>➡ Rel-Sep</li> <li>➡ ELSE IF (Oct1-Oct15)</li> </ul>	•		 	1100-1200 1200-1300 1300-1400 1400-1500 1500-1600 1600-1700 1700-1800 1800-1900 1900-2000	1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0		
<ul> <li>➡ Rel-Aug</li> <li>➡ ELSE IF (Sep1-Sep30)</li> <li>➡ Rel-Sep</li> <li>➡ ELSE IF (Oct1-Oct15)</li> </ul>	Ŧ		 	1100-1200 1200-1300 1300-1400 1400-1500 1500-1600 1600-1700 1700-1800 1800-1900 1900-2000 2000-2100	1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0		
<ul> <li>➡ Rel-Aug</li> <li>➡ ELSE IF (Sep1-Sep30)</li> <li>➡ Rel-Sep</li> <li>➡ ELSE IF (Oct1-Oct15)</li> </ul>	Ŧ			1100-1200 1200-1300 1300-1400 1400-1500 1500-1600 1600-1700 1700-1800 1800-1900 1900-2000	1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0		



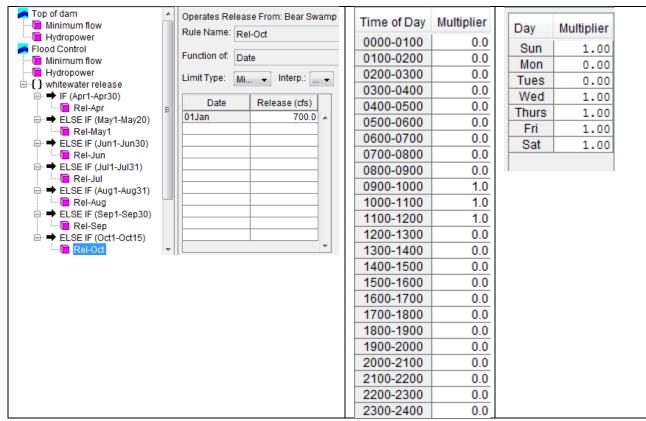


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet –Whitewater release

### **Bellows Falls**

## I. Overview

Bellows Falls dam is located on the mainstem Connecticut River in the towns of Rockingham, VT and Walpole, NH. It is owned and operated by TransCanada Hydro Northeast Inc. for hydropower generation on a run-of-river basis.

Figure 1 shows the location of Bellows Falls dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Bellows Falls dam.

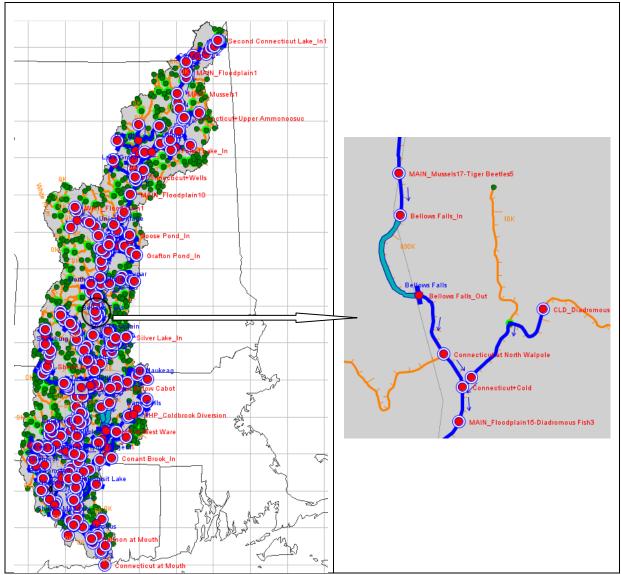


Figure 1: HEC-ResSim Map Display Showing Location of Bellows Falls dam



Figure 2: Photo of Bellows Falls dam.

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>8</sup>. The dam consists of seven types of outlets: (1) controlled Roller gate, and (2) uncontrolled 121 ft Bay-w flashboards, (3) uncontrolled 100 ft Bay-w flashboards, (4) uncontrolled Stanchion-w flashboards, (5) controlled Fish Ladder, (6) Downstream Fish Passage, and (7) power plant as shown in Figure 4.

<sup>&</sup>lt;sup>8</sup> Data provided by TransCanada

Description				
Description				K 4 70 of 74 🕨
1				
Bellows Falls-Pool	1			
Linear Interpo	plation 🔘 Conic	Interpolation	Initial	I Conic Depth (ft)
Elevation	Storage	Area		
		(00.0)	-	
			-A	
			-	
			-	
			Ξ	290
				a 280
284.10	11333.88			€ 280 ≥ 270 ⊒ 260
284.20	11481.82			± 260
284.30	11629.75		- 1	
284.40	11778.10		- 1	250 + + + + + + + + + + + + + + + + + + +
284.50	11926.03			
284.60	12073.97		-	Stor (ac-ft)
284.70	12229.75			290
284.80	12385.12			
284.90	12540.91			₽ 280
285.00	12696.28			€ 280 ≥ 270 ⇒ 260
	12852.07			± 260
				250
				0 600 1,200
	13342.15			
	13505.79			Area (acre)
285.60	13669.01			
285.70	13840.08			
285.80	14011.16			
285.90	14181.82			
	Bellows Falls-Pool      Elevation     (ft)     253.30     283.60     283.70     283.70     283.80     283.90     284.00     284.00     284.00     284.00     284.00     284.00     284.00     284.00     284.00     284.00     284.00     284.50     284.60     284.50     285.00	Bellows Falls-Pool <ul></ul>	Bellows Falls-Pool <ul></ul>	Bellows Falls-Pool           © Linear Interpolation         © Conic Interpolation         Initia           Elevation         Storage (ft)         Area (acre)         Area (acre)           253.30         0.00         •           283.60         10633.06         •           283.70         10773.14         •           283.90         11053.72         •           284.00         11193.80         •           284.10         11333.88         •           284.20         11481.82         •           284.30         11629.75         •           284.60         12073.97         •           284.60         1222.75         •           284.60         1222.75         •           284.60         1228.75         •           284.80         12385.12         •           284.90         12540.91         •           285.10         1262.07         •           285.10         1269.28         •           285.30         13178.93         •           285.60         13669.01         •           285.60         13669.01         •           285.70         13840.08 <td< td=""></td<>

Figure 3: Reservoir Editor: Physical Tab -- Pool

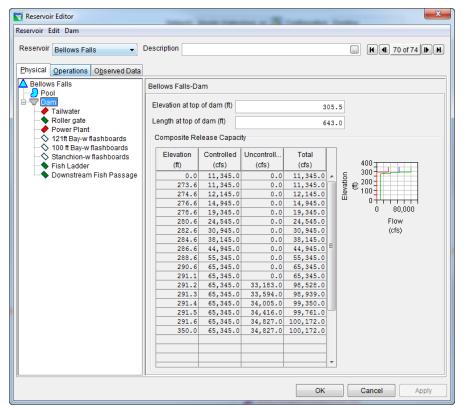


Figure 4: Reservoir Editor: Physical Tab -- Dam

## III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Bellows Falls's "Existing Ops" operational zones, which consist of zones of Flood Control (305.5 ft), FERC Max Pool (291.6 ft), Conservation (291.1 ft), Buffer (289.9 ft), and Inactive zone (288.6 ft)<sup>1</sup>.

Reservoir Editor			-	×
Reservoir Edit Operations Zone Rule IF_Block	:			
Reservoir Bellows Falls    Descri	ption			
Physical Operations Observed Data				
Operation Set Existing Ops	▼ Descriptio	n		
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sched. P	rojected Elev		
<ul> <li>Flood Control</li> <li>Minimum Flow</li> <li>Fish Ladder Release</li> </ul>	Storage Zone Co	nservation	Description	
Downstream Fish Passage Release	Function of Date			Define
	Date	Top Elevation (ft)		
FERC Max Pool	01Jan	291.1	^ 306 304	
Minimum Flow			302	
Fish Ladder Release			200	
Pool Drawdown Rate Limit			€ 300 298- itti 298- itti 296- itti 294-	
			in 100 − − − − − − − − − − − − − − − − − −	
Conservation			a 294	
Minimum Flow			<u><u></u> <u>292</u></u>	
👘 🔚 Fish Ladder Release			292	
📃 🔚 Downstream Fish Passage Release				
👘 🖻 Pool Drawdown Rate Limit			288	r May Jul Sep Nov
🗌 🔚 Hydropower-Release 95% Inflow			Jan Wa	r May Jul Sep Nov
Buffer				
Minimum Flow				
Fish Ladder Release				
Downstream Fish Passage Release				
Hydropower-Release 95% Inflow			-	
A Inactive	Zone Sort Elevatio	n		
			ОК	Cancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

Figure 6 shows a sequential release allocation approach specified for available outlets along Bellows Falls Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The Roller gate gets the remainder of the release until it reaches capacity. After the capacity through the Roller gate is reached, the remainder of the release goes through the Fish ladder gate and Downstream Fish Passage, respectively.

💘 Reservoir Editor		The subscription of the local division of			
Reservoir Edit Operations					
Reservoir Bellows Falls			K ( 70		
Physical Operations Observed Data					
Operation Set Existing Ops	escription				
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. S	ched. Projected Ele	27			
Release Allocation Strategy					
Bellows Falls - Balanced	Release Location:	Bellows Falls-Dam			
Bellows Falls-Dam (1.0) - Sequential	Allocation Type:	Sequential			
<ul> <li>Bellows Falls-Roller gate</li> <li>Bellows Falls-Fish Ladder</li> <li>Bellows Falls-Downstream Fish Passage</li> </ul>	Bellows Falls-Power Plant Bellows Falls-Roller gate Bellows Falls-Fish Ladder Bellows Falls-Downstream Fish Passage				

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

# **B.** Rule Illustrations

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>9</sup>.

Reservoir Editor
Reservoir Edit Operations Zone Rule IF_Block
Reservoir Bellows Falls
Physical Operations Observed Data
Operation Set Existing Ops   De
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched.
Flood Control Minimum Flow Fish Ladder Release Downstream Fish Passage Release Pool Drawdown Rate Limit Max Elev given inflow FIF (inflow<11000 & max elev=291.6) Elev rate of change Elev rate of change FERC Max Pool Fish Ladder Release Downstream Fish Passage Release Pool Drawdown Rate Limit Minimum Flow Fish Ladder Release Downstream Fish Passage Release Pool Drawdown Rate Limit Minimum Flow Fish Ladder Release Downstream Fish Passage Release Pool Drawdown Rate Limit Minimum Flow Fish Ladder Release Downstream Fish Passage Release Pool Drawdown Rate Limit Minimum Flow Fish Ladder Release Downstream Fish Passage Release Pool Drawdown Rate Limit Hydropower-Release 95% Inflow Minimum Flow Minimum Fl

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

\_\_\_\_\_

<sup>&</sup>lt;sup>9</sup> TransCanada. Connecticut River Operational Constraints. 2012.

## **C. Rule Descriptions**

#### 1. Minimum Flow

Figure 8 shows the content of "Minimum Flow" rule. This rule represents the minimum release from dam as a function of flow.

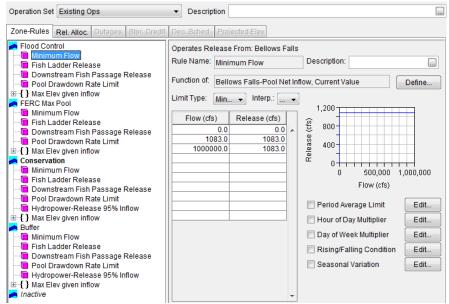


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Minimum Flow

#### 2. Fish Ladder Relaese

Figure 9 shows the content of "Fish Ladder Release" rule. This rule shows the specified release from a fish ladder controlled outlet.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>		
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. Pro	jected Elev	
Flood Control      Minimum Flow      Fish Ladder Release      Downstream Fish Passage Release     Pool Drawdown Rate Limit      Minimum Flow     FERC Max Pool     Minimum Flow     For Downstream Fish Passage Release     Dour Drawdown Rate Limit     Hydropower-Release 95% Inflow     Hydropower-Release 95% Inflow     J Max Elev given inflow     Hydropower-Release 95% Inflow     J Max Elev given inflow	Rule Name: Fish		Fish Ladder Description: Define 0 0 0 0 0 0 0 0 0 0 0 0 0

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Fish Ladder Release

#### **3.** Downstream Fish Passage Release

Figure 10 shows the content of "Downstream Fish Passage Release" rule. This rule shows the specified release from a Downstream Fish Passage controlled outlet.

Operation Set Existing Ops	Description
Zone-Rules Rel. Alloc. Outages Stor. Credit	I Dec. Sched. Projected Elev
Flood Control  Minimum Flow  Fish Ladder Release  Ownstream Fish Passage Release  Pool Drawdown Rate Limit  FERC Max Pool  Max Elev given inflow  FERC Max Pool  Ourstream Fish Passage Release  Downstream Fish Passage Release  Pool Drawdown Rate Limit  () Max Elev given inflow  Conservation  Minimum Flow  Fish Ladder Release  Downstream Fish Passage Release  Pool Drawdown Rate Limit  () Max Elev given inflow  Conservation  Fish Ladder Release  Downstream Fish Passage Release  Downstream Fish Passage Release  Pool Drawdown Rate Limit  Hydropower-Release 95% Inflow  Minimum Flow  Fish Ladder Release  Downstream Fish Passage Release  Down Drawdown Rate Limit  Hydropower-Release 95% Inflow  Hydropower-Release 95% Inflow	Operates Release From: Bellows Falls-Downstream Fish Passage         Rule Name:       Im Fish Passage Release         Function of:       Date         Date       Define         Date       Release (cfs)         01Jan       0.0         01Apr       255.0         15Jun       0.0         9       9         9       9         9       9         9       9         9       9         9       9         150       100         9       9         9       9         9       9         9       9         9       9         150       100         160       100         9       9         9       9         9       9         100       9         101       9         102       9         103       9         104       9         105       9         106       9         107       9         108       9         109       9

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Downstream Fish Passage Relaese

#### 4. Pool Drawdown Rate Limit

Figure 11 shows the content of "Pool Drawdown Rate Limit" rule. This rule describes the maximum elevation rate of change.

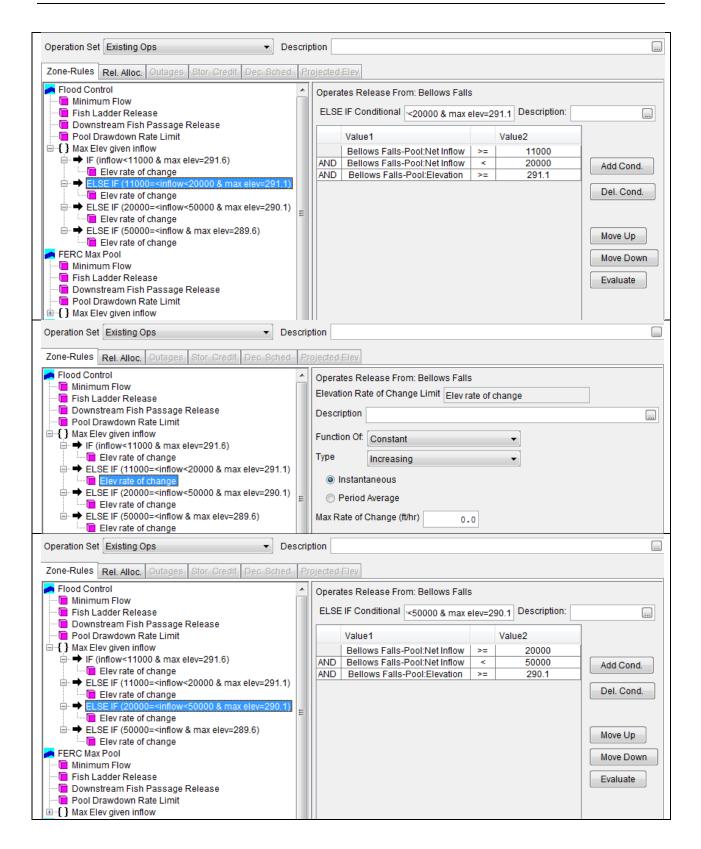
Operation Set Existing Ops	Description
Zone-Rules Rel. Alloc. Outages. Stor. Credit	Dec. Sched. Projected Elev.
Flood Control  Flood Control  Minimum Flow  Fish Ladder Release  Downstream Fish Passage Release  Pool Drawdown Rate Limit  4 Max Elev given inflow  FERC Max Pool  Minimum Flow  Fish Ladder Release  Downstream Fish Passage Release  Pool Drawdown Rate Limit  4 Max Elev given inflow  Conservation  Minimum Flow  Fish Ladder Release  Downstream Fish Passage Release  Pool Drawdown Rate Limit  4 Max Elev given inflow  Conservation  Minimum Flow  Fish Ladder Release  Downstream Fish Passage Release  Pool Drawdown Rate Limit  Hydropower-Release 95% Inflow  Buffer  Minimum Flow  Fish Ladder Release  Pool Drawdown Rate Limit  Hydropower-Release 95% Inflow  Hydropower-Release  Pool Drawdown Rate Limit  Hydropower-Release 95% Inflow  4 Max Elev given inflow  Max Elev given inflow	Operates Release From: Bellows Falls Elevation Rate of Change Limit Pool Drawdown Rate Limit Description Drawdown not to exceed 0.3 ft/hr

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Pool Drawdown Rate Limit

### 5. Max Elev given Inflow

Figure 12 shows the content of "Max Elev given Inlow" rule. This rule shows the maximum elevation rate of change for different range of inflow.

Operation Set Existing Ops    De	scri	ption			
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched.	P	rojected I	Elev		
Flood Control		Operat	es Release From: Bellows I	Falls	
Minimum Flow 		Name	Max Elev given inflow	Description:	
Downstream Fish Passage Release			· Max Elev given milow		
Pool Drawdown Rate Limit		Туре	Name		Description
				x elev=291.6	
IF (inflow<11000 & max elev=291.6) ■ Elev rate of change				00 & max elev=291.1	
➡ ELSE IF (11000= <inflow<20000 &="" elev="291.1)&lt;/p" max=""></inflow<20000>		ELS ELS		00 & max elev=290.1	
Elev rate of change				ax cicv-200.0	
	E				
ELSE IF (50000= <inflow &="" elev="289.6)&lt;/td" max=""><td></td><td></td><td></td><td></td><td></td></inflow>					
Elev rate of change					
Operation Set Existing Ops	scrij	otion			
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched.	Р	ojected E	ev.		
Flood Control					
Minimum Flow	ĥ	L .	es Release From: Bellows F		
Fish Ladder Release		IF Con	ditional <11000 & max elev	=291.6 Description:	
Downstream Fish Passage Release			/-tu-d	Vietue 0	
Pool Drawdown Rate Limit     A Steven inflow			Value1	Value2	
⇒ → IF (inflow<11000 & max elev=291.6)			Bellows Falls-Pool:Net Inflo Bellows Falls-Pool:Net Inflo		
Elev rate of change				20110	Add Cond.
ELSE IF (11000= <inflow<20000 &="" elev="291.1)&lt;/td" max=""><td></td><td></td><td></td><td></td><td>Del. Cond.</td></inflow<20000>					Del. Cond.
➡ ELSE IF (20000= <inflow<50000 &="" elev="290.1)&lt;/p" max=""></inflow<50000>					
Elev rate of change	=				
ELSE IF (50000= <inflow &="" elev="289.6)&lt;/p" max=""></inflow>					Move Up
FERC Max Pool					
Minimum Flow					Move Down
Fish Ladder Release					Evaluate
Downstream Fish Passage Release     Pool Drawdown Rate Limit					
	ecri	ption			
	Join				
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched.	P	rojected E	lev		
Flood Control	*	Operate	es Release From: Bellows F	alls	
Minimum Flow     Fish Ladder Release		Elevatio	n Rate of Change Limit Ele	ev rate of change	
Downstream Fish Passage Release		Descrip			
Pool Drawdown Rate Limit		Descrip			
Image: Book and the second		Functio	n Of: Constant	-	
Elev rate of change		Туре	Increasing	_	
				•	
Elev rate of change		In	stantaneous		
ELSE IF (20000= <inflow<50000 &="" elev="290.1)&lt;/td" max=""><td>Ξ</td><td>© P</td><td>eriod Average</td><td></td><td></td></inflow<50000>	Ξ	© P	eriod Average		
		Max Ra	te of Change (ft/hr)	0.0	
Elev rate of change				0.0	



Operation Set Existing Ops	cription	1	
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched.	Projec	sted Elev	
Flood Control		perates Release From: Bellows Falls	
Fish Ladder Release	E	evation Rate of Change Limit Elev rate of change	
Downstream Fish Passage Release	De	escription	
Pool Drawdown Rate Limit     A Kerner Strengthered S		r. or []	
IF (inflow<11000 & max elev=291.6)	Fu	Inction Of: Constant	
Elev rate of change	Ту	/pe Increasing -	
		Instantaneous	
ELSE IF (20000= <inflow<50000 &="" elev="290.1)&lt;/p" max=""></inflow<50000>		<u> </u>	
Elev rate of change	=	Period Average	
	Ma	ax Rate of Change (ft/hr) 0.0	
Operation Set Existing Ops	cription	n	
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched.	Projec	cted Elev	
A Flood Control	^ OI	perates Release From: Bellows Falls	
Minimum Flow		·	
Fish Ladder Release     Downstream Fish Passage Release		ELSE IF Conditional = <inflow &="" description:<="" elev="289.6" max="" td=""><td></td></inflow>	
Pool Drawdown Rate Limit		Value1 Value2	
A Max Elev given inflow		Bellows Falls-Pool:Net Inflow >= 50000	
➡ IF (inflow<11000 & max elev=291.6)	A	ND Bellows Falls-Pool:Elevation >= 289.6	Add Cond.
Elev rate of change ■ ■ ELSE IF (11000= <inflow<20000 &="" elev="291.1)&lt;/td" max=""><td></td><td></td><td></td></inflow<20000>			
Elev rate of change			Del. Cond.
➡ ELSE IF (20000= <inflow<50000 &="" elev="290.1)&lt;/td" max=""><td>_</td><td></td><td></td></inflow<50000>	_		
Elev rate of change	-		
ELSE IF (50000= <inflow &="" elev="289.6)&lt;/p" max=""></inflow>			Move Up
FERC Max Pool			Move Down
Minimum Flow			Move Down
Fish Ladder Release			Evaluate
Downstream Fish Passage Release     Pool Drawdown Rate Limit			
Operation Set Existing Ops    Des	cription		
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched.	Projec	cted Elev	
Flood Control	^ Or	perates Release From: Bellows Falls	
- I Minimum Flow Fish Ladder Release	E	evation Rate of Change Limit Elev rate of change	
Downstream Fish Passage Release			
Pool Drawdown Rate Limit		escription	
E { } Max Elev given inflow	Fu	Inction Of: Constant	
⇒ IF (inflow<11000 & max elev=291.6) Elev rate of change			
ELSE IF (11000= <inflow<20000 &="" elev="291.1)&lt;/td" max=""><td>I I I</td><td>/pe Increasing •</td><td></td></inflow<20000>	I I I	/pe Increasing •	
Elev rate of change		Instantaneous	
➡ ELSE IF (20000= <inflow<50000 &="" elev="290.1)&lt;/p" max=""></inflow<50000>	=	Period Average	
Elev rate of change ELSE IF (50000= <inflow &="" elev="289.6)&lt;/p" max=""></inflow>			
Elev rate of change	WI C		

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Elev given Inflow

#### 6. Hydropower-Release 95% Inflow

Figure 13 shows the content of "Hydropower-Release 95% Inflow" rule. This rule releases 95% of inflow through power plant as per the run-of-river modeling strategy.

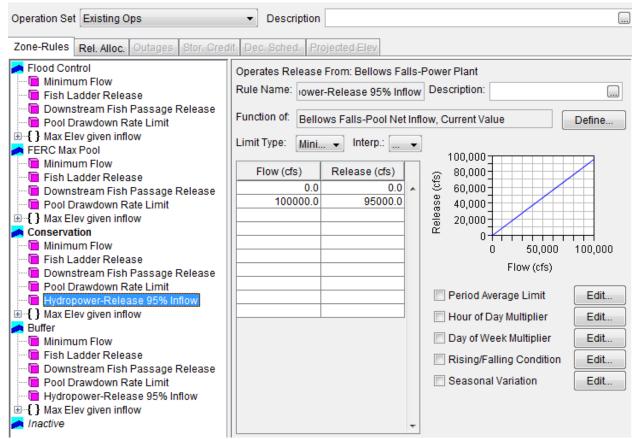


Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Hydropower-Release 95% Inflow

## Bickford

### I. Overview

Bickford dam is a dam on the Ware River by Worcester, MA. Construction of the reservoir was completed in 1970 and the dam is owned by the City of Fitchburg, which uses it for water supply for the city.

Figure 1 shows the location of Bickford Dam as it is represented in the HEC-ResSim model. Figure 2 shows a view from the dam.

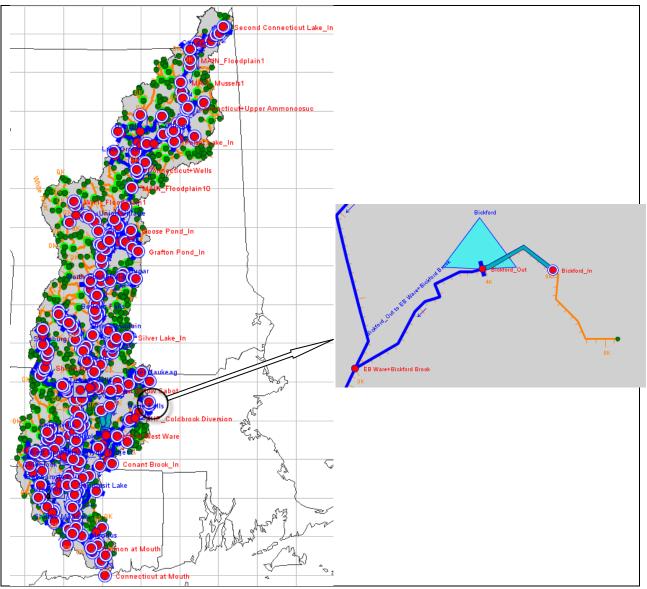


Figure 1: HEC-ResSim Map Display Showing Location of Bickford



Figure 2: View from Bickford Dam

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>10</sup>. The dam consists of a controlled outlet and an uncontrolled spillway as shown in Figure 4.

<sup>&</sup>lt;sup>10</sup> Bickford Dam Phase 1 Report: 1980

👿 Reservoir Editor		hand	$\sim$	X
Reservoir Edit Pool				
	<ul> <li>Description</li> </ul>			K 4 49 of 74 D H
Bickford	Bickford-Pool			
Dam ••••••••••••••••••••••••••••••••••••	Linear Inter	polation 🔘 C	onic Interpolati	on Initial Conic Depth (ft)
Spillway	Elevation	Storage	Area	
	(ft)	(ac-ft)	(acre)	1,060
	1000.00	0.00	0.00	1,040
	1045.00	3029.00	163.00	€
	1051.20	4053.00	167.00	€ 1,020
				<sup>ш</sup> 1,000
				+ + + + + + + + + + + + + + + + + + +
				Stor (ac-ft)
				5.0r (ac-ii)
				₽ 1,040
				€ 1,020
				ش 1,000
				· ++++++++++++++++++++++++++++++++++++
				0 60 120 180
				Area (acre)
L				
			O	K Cancel Apply

Figure 3: Reservoir Editor -- Physical Tab -- Pool

🟹 Reservoir Editor	_	1		×					
Reservoir Edit Dam									
Reservoir Bickford   Description  Description  H 4 49 of 74  H									
Physical Operations Observed Data									
Bickford	Bickford-Dam								
Dam 4-inch pipe to river	Elevation at top of dam (ft)		1051.2	]					
Spillway	Length at top of dam (ft)		900.0						
	Composite Release Capa	city							
	Elevation Controlled	Uncontroll	Total						
	(ft) (cfs)	(cfs)	(cfs)	1 0 10					
	1,003.0 0.0		<u>10.0</u>	€ 1,020-					
	1,045.0 22.0		22.0	§ € 1,020					
	1,046.2 22.		478.1						
	1,046.9 22.0		859.7	0 3,000 6,000					
	1,047.5 22.1	1,288.8	1,311.6	Flow					
	1,048.1 23.		1,824.2	(cfs)					
	1,048.7 23.3		2,390.9						
	1,049.3 23.4		3,007.1						
	1,050.0 23.		3,668.9						
	1,050.6 23.1		4,373.6 5,118.5						
	1,031.2 24.0	5,054.5	3,110.3						
			ОК	Cancel Apply					

Figure 4: Reservoir Editor -- Physical Tab -- Dam

## III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Bickford's "Existing Ops" operational zones, which consist of the zones Flood Control (1051.2 ft), Conservation (1045 ft), and Inactive (1000 ft)<sup>1</sup>.

🟹 Reservoir Editor	hand		×
Reservoir Edit Operations Zone Rule IF_Block			
Reservoir Bickford			
Physical Operations Observed Data			
Operation Set Existing Ops	Description		
Zone-Rules Rel. Alloc. Outages Stor. Credit De	c. Sched. Projected Elev		
Flood Control Conservation Storage Zone Conservation	tion Descri	iption	
Function of Date			Define
Date	Top Elevation (ft)	4.000	
01Jan	1045.0		
		1,050	
		1,040-	
		등 1,030-	
		<u>ដ</u> 1,010-	
		1,000	
		990	
		+ Jan	Mar May Jul Sep Nov
Zone Sort Elevation			
		ОК	Cancel Apply

Figure 5: Reservoir Editor -- Operations Tab – Existing Ops OpSet

## **B. Rule Illustrations**

The operation set for Bickford has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity. There is a water supply timeseries for Bickford that is described in the water supply section of the report.

## **Birch Hill**

### I. Overview

Birch Hill is a dam on the Millers River upstream of Athol. Constructed in 1941 by the US Army Corps of Engineers, it is still owned and operated by the Corps. It is primarily used for flood control but is also used for recreation.

Figure 1 shows the location of Birch Hill Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the dam.

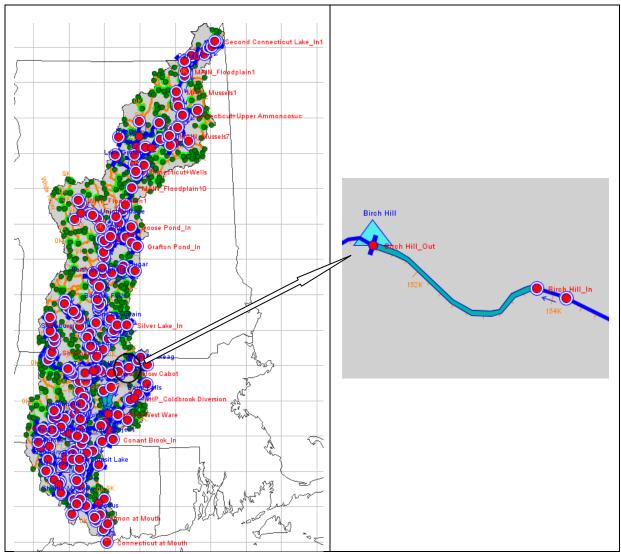


Figure 1: HEC-ResSim Map Display Showing Location of Birch Hill dam



Figure 2: Photo of Birch Hill dam

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled slide gates, and (2) uncontrolled spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>11</sup>.

<sup>&</sup>lt;sup>11</sup> http://rsgisias.crrel.usace.army.mil/nae/cwms\_map.map\_index

eservoir Edit Pool				
Reservoir Birch Hill	<ul> <li>Descrip</li> </ul>	otion		K 4 62 of 74 K
Physical Operations C	D <u>b</u> served Data			
Birch Hill	Birch Hill-Pool			
Dam	Linear Interpol	ation 💿 Conic Int	erpolation Initia	I Conic Depth (ft)
Spillway	Elevation	Storage	Area	
	(ft)	(ac-ft)	(acre)	
	815.00	0.00	0.00	
	816.00	100.00	40.00	
	817.00	200.00	90.00	
	818.00	450.00	140.00	860
	819.00	750.00	190.00	850
	820.00	1000.00	250.00	€ 840
	821.00	1450.00	310.00	
	822.00	1750.00	375.00	Ξ <sub>820</sub>
	823.00	2200.00	450.00	810
	824.00	2750.00	525.00	0 40,000 80,000
	825.00	3200.00	600.00	Stor (ac-ft)
	826.00	3800.00	675.00	
	827.00	4500.00	740.00	860
	828.00	5200.00	820.00	850
	829.00	6000.00	890.00	€ 840
	830.00	6900.00	975.00	à 830 - ₩ 820 -
	831.00	7850.00	1060.00	<sup>□</sup> 820
	832.00	8800.00	1140.00	810
	833.00	9900.00	1230.00	0 1,500 3,000 4,500
	834.00	11100.00	1320.00	Area (acre)
	835.00	12200.00	1420.00	Alea (atie)
	836.00	13700.00	1500.00	
	837.00	15200.00	1600.00	
	838.00	16800.00	1700.00	
	839.00	18500.00	1800.00	<b>~</b>
				Cancel Apply

Figure 3: Reservoir Editor: Physical Tab -- Pool

Birch Hill	Desi	cription			K 4 62 of 74 K
Birch Hill					
- Deol	Birch Hill-Dam				
Dam → Slide Gates → Spillway	Elevation at top Length at top of				
	Composite Rel	ease Capacit	y		
	Elevation	Controlled	Uncontrolled	Total	Γ
	(ft)	(cfs)	(cfs)	(cfs)	860
	815.0	0.0	0.0	0.0	
	817.5	350.0	0.0	350.0	€ 840 820
	820.0	800.0	0.0	800.0	820
	822.5	1,450.0	0.0	1,450.0	- +++++++++++++++++++++++++++++++++++++
	825.0	2,200.0	0.0	2,200.0	0 100,000
	827.5	3,100.0	0.0	3,100.0	Flow
	830.0	4,150.0	0.0	4,150.0 ≡	(cfs)
	832.5	5,300.0	0.0	5,300.0	
	835.0	6,400.0	0.0	6,400.0	
	837.5	7,300.0	0.0	7,300.0	
	840.0	8,100.0	0.0	8,100.0	
	842.5	8,800.0	0.0	8,800.0	d
	845.0	9,450.0	0.0	9,450.0	
	847.5	10,050.0		10,050.0	
	852.0	10,500.0		10,500.0	
	852.9	10,500.0		13,300.0	
	853.0	10,500.0		14,000.0	
	854.0	10,500.0		18,500.0	
	855.0	10,500.0		26,100.0 34,500.0	
	857.0	10,500.0		44,500.0	
				ок	Cancel Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

## III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Birch Hill's "ExistingOps" operational zones, which consist of zones of Excess Surcharge (864 ft), Surcharge Storage (854 ft), Flood Control (852 ft), Conservation (816-825 ft), and Inactive zone (815 ft).

Excess Surcharge Excess Surcharge Exc	Storage Zone	Conservation	Description	
Surcharge Storage	Function of Da	te		Define
Flood Control	Date	Top Elevation (ft)		
Minimum Releases     Control for Athol	01Jan 01Apr	816.0	860-	
Connecticut at Montague - Linear Connecticut at Hartford - Linear Maximum Rate of Increase Maximum Rate of Decrease Max Outflow = Max 21d Inflow Conservation Channel Capacity  Min Flow Logic - Birch Hill Control for Athol Connecticut at Hartford - Linear Connecticut at Hartford - Linear	15Apr 17Apr	825.0 816.0	850 840 830 820 810 Jan Mar May Ju	JI Sep Nov
Maximum Rate of Increase Maximum Rate of Decrease Pool Elevation Rate of Change Inactive	Zone Sort Eleva	*		

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

## **B. Rule Illustrations**

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named ExistingOps. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

Reservoir Editor Reservoir Edit Operations Zone Rule IF_Block	
Ph	vsical Operations Observed Data
0	peration Set ExistingOps
Z	one-Rules Rel Alloc. Outages Stor Credit Dec.
11.7	Excess Surcharge
	Gate Ops to Save Dam Surcharge Storage
	Gate Operation During Surcharge
	Flood Control
1 5	🛅 Channel Capacity
	Minimum Releases
	Connecticut at Montague - Linear
11 3	Connecticut at Hartford - Linear
	Maximum Rate of Increase
	Maximum Rate of Decrease     Pool Elevation Rate of Change
	Max Outflow = Max 21d Inflow
	Conservation
	Channel Capacity
E	{} Min Flow Logic - Birch Hill ⊡ ➡ IF (Jan-Mar)
	⇒ IF (Birch Hill Inflow < 175 cfs)
	Min Q - Birch Hill - Release Inflow
	ELSE (Birch Hill Inflow >= 175 cfs)
	Im I MinQ - Birch Hill - ABF (O-M) → ➡ ELSE IF (Apr-May)
	□ ➡ IF (Birch Hill Inflow < 700 cfs)
	Min Q - Birch Hill - Release Inflow
	ELSE (Birch Hill Inflow >=700 cfs) Imin MinQ - Birch Hill - ABF (A-M)
	ELSE IF (Jun-Sep)
	Hin Flow - Birch Hill (J-S)
	IF (Birch Hill Inflow < 90cfs)
	Image: Birch Hill - Release Inflow ELSE (Birch Hill Inflow >= 90cfs)
	MinQ - Birch Hill - ABF (J-S)
	E ➡ ELSE IF (Oct-Dec)
	☐ { } Min Flow - Birch Hill (O-M) (copy)
	IF (Birch Hill Inflow < 175 cfs) Im IF (Birch Hill - Release Inflow
	ELSE (Birch Hill Inflow >= 175 cfs) ☐ MinQ - Birch Hill - ABF (O-M)
	Control for Athol
	Connecticut at Montague - Linear
	Connecticut at Hartford - Linear
	Maximum Rate of Increase     Maximum Rate of Decrease
	Pool Elevation Rate of Change
	Inactive

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

### **C.** Rule Descriptions

#### 1. Gate Ops to Save Dam

Figure 7 shows the content of "Gate Ops to Save Dam" rule. This rule represents the maximum allowable release from Slide gates when the pool is in Excess Surcharge zone as a function of pool elevation.

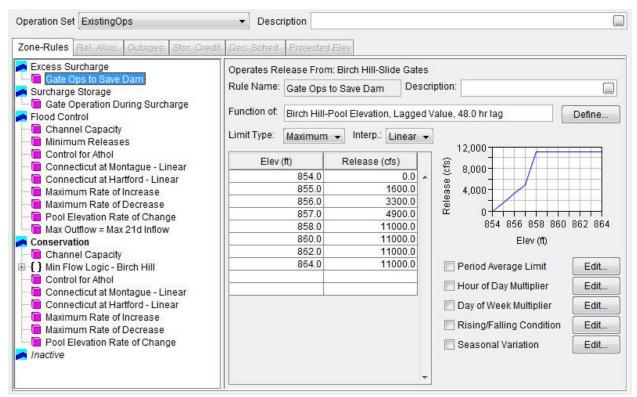


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet –Gate Ops to Save Dam

### 2. Gate Operation During Surcharge

Figure 8 shows the content of "Gate Operation During Surcharge" rule. This rule represents the maximum allowable release from Birch Hill when the pool is in surcharge Storage zone as a function of pool elevation.

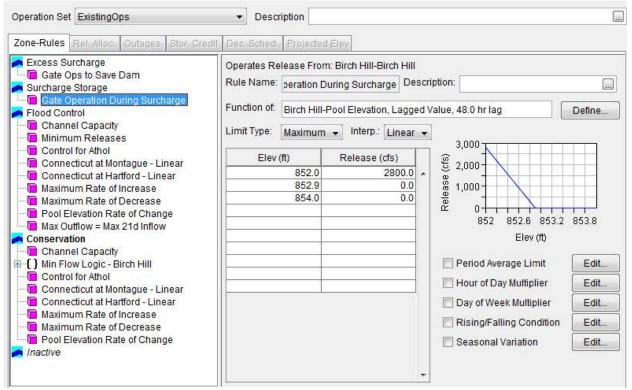


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet –Gate Operation During Surcharge

## 3. Channel Capacity

Figure 9 shows the content of "Channel Capacity" rule. This rule assigns 2000 cfs as a maximum channel capacity.

Zone-Rules Rel Alloc Outages Stor Cr	edit Dec. Sched.	Projected Elev			
<ul> <li>Excess Surcharge</li> <li>Gate Ops to Save Dam</li> <li>Surcharge Storage</li> <li>Gate Operation During Surcharge</li> <li>Flood Control</li> <li>Channel Capacity</li> <li>Minimum Releases</li> <li>Connecticut at Montague - Linear</li> <li>Connecticut at Harford - Linear</li> <li>Maximum Rate of Increase</li> <li>Pool Elevation Rate of Change</li> <li>Max Outflow = Max 21d Inflow</li> <li>Conservation</li> <li>Connecticut at Harford - Linear</li> <li>Max Outflow = Max 21d Inflow</li> <li>Conservation</li> <li>Connecticut at Harford - Linear</li> <li>Max Inflow Logic - Birch Hill</li> <li>Connecticut at Harford - Linear</li> <li>Maximum Rate of Increase</li> <li>Max Inflow Logic - Birch Hill</li> <li>Connecticut at Harford - Linear</li> <li>Maximum Rate of Increase</li> </ul>		1	 2,8 2,8 2,8 2,8 2,8 2,8 2,8 2,8 2,8 2,8	20 - 10 - 00 - 90 -	Edit Edit Edit

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Channel Capacity

## 4. Minimum Releases

Figure 10 shows the content of "Minimum Releases" rule. This rule shows the minimum required release of 90 cfs from the dam during flood control operations.

Zone-Rules Rel, Alloc Outages Stor, Credit	Dec. Sched. Projected Elev	
Zone-Rules Rel Alloc Outages Stor Credit Excess Surcharge Gate Ops to Save Dam Surcharge Storage Gate Operation During Surcharge Flood Control Channel Capacity Minimum Releases Control for Athol Connecticut at Montague - Linear Maximum Rate of Increase Maximum Rate of Decrease Maximum Rate of Change Max Outflow = Max 21d Inflow Conservation	Operates Release From: Birch Hill-Slide Gates Rule Name: Minimum Releases Description:	Define
Channel Capacity Channel Capacity Channel Capacity Control for Athol Connecticut at Montague - Linear Connecticut at Hartford - Linear Maximum Rate of Increase Naximum Rate of Decrease Pool Elevation Rate of Change Inactive	Period Average Limit     Period Average Limit     Period Average Limit     Period Average Limit     Day of Week Multiplier     Rising/Falling Condition     Seasonal Variation	Edit Edit Edit Edit

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet –Minimum Releases

### 5. Control for Athol

Figure 11 shows the content of "Control for Athol" rule. This rule represents the maximum release from the dam as a function of stage at Athol over the previous four days. This rule was taken from a previously created ResSim model of Birch Hill dam.

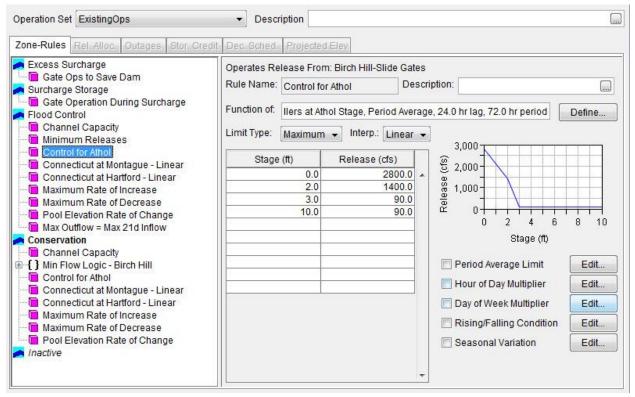


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet –Control for Athol

#### 6. Connecticut at Montague – Linear

Figure 12 shows the content of "Connecticut at Montague-Linear" rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

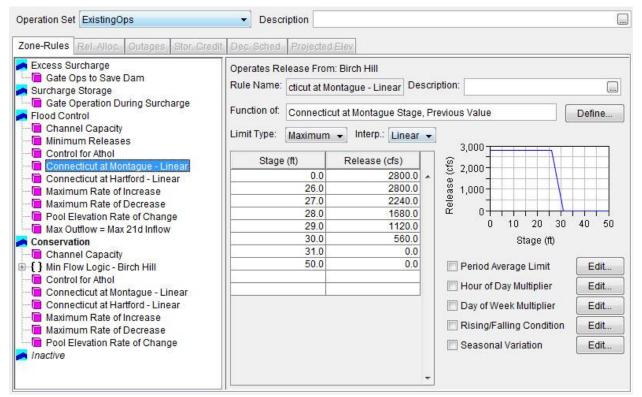


Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague – Linear

#### 7. Connecticut at Hartford – Linear

Figure 13 shows the content of "Connecticut at Montague-Linear" rule. This rule represents the maximum allowable release from dam as a function of previous day stage at Hartford. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

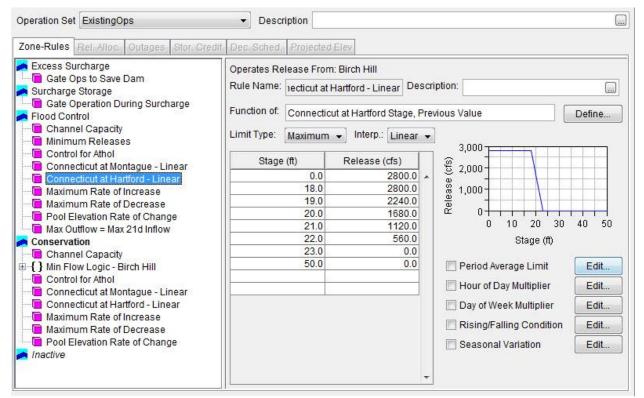


Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Hartford - Linear

### 8. Maximum Rate of Increase

Figure 14 shows the content of "Maximum Rate of Increase" rule. This rule shows the increasing maximum allowable release rate of change rule as a function of release from Birch Hill dam.

Excess Surcharge     Gate Ops to Save Dam     Surcharge Storage     Gate Operation During Surcharge	Release Ra	Operates Release From: Birch Hill-Slide Gates Release Rate of Change Limit Maximum Rate of Increase					
Flood Control	Description						
Channel Capacity           Image: Capacity	Function Of:			•			
Control for Athol	Туре	Increasing		•			
Connecticut at Montague - Linear	Interpolate	Linear		•	550		
Maximum Rate of Increase	Relea	Release (cfs) Rate Change (cfs/hr)			500-		
Maximum Rate of Decrease		0.0 500			· 달 450 -	2	
Pool Elevation Rate of Change Max Outflow = Max 21d Inflow		2000.0	500.0		(450- (400- (1)))) (1))		
		2000.1	200.0		8 350-		
Channel Capacity		123456.0	200.0		E C		
Min Flow Logic - Birch Hill					ළී 300-		
Control for Athol	2				욡 250-		
Connecticut at Montague - Linear	e			11	<sup>2</sup> 200	5 T T 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
Connecticut at Hartford - Linear	2				150		
Maximum Rate of Increase						00 120.000	
Pool Elevation Rate of Change							
					Relea	ise (cfs)	

Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet – Maximum Rate of Increase

### 9. Maximum Rate of Decrease

Figure 15 shows the content of "Maximum Rate of Decrease" rule. This rule shows the maximum allowable decreasing release rate of change rule.

	Tosta as the as an and	A RECEIPTION OF A LAND	
Excess Surcharge     Gate Ops to Save Dam     Surcharge Storage     Gate Operation During Surcharge     Flood Control     Channel Capacity     Minimum Releases     Control for Athol     Connecticut at Montague - Linear     Connecticut at Hartford - Linear     Maximum Rate of Increase     Maximum Rate	Operates Release From: Bli Release Rate of Change Lin Description: Function Of: Type Max Rate of Change (cfs/hr)	Maximum Rate of Decrease	

Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet – Maximum Rate of Decrease

#### **10. Max Pool Elev ROC**

Figure 16 shows the content of "Max Pool Elev ROC" rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

Operation Set ExistingOps	✓ Description	(
Zone-Rules Rel. Alloc. Outages Stor. Cre	edit Dec Sched Projected Elev	
Excess Surcharge C Gate Ops to Save Dam Surcharge Storage Gate Operation During Surcharge Flood Control	Operates Release From: Birch Hill Elevation Rate of Change Limit Pool Elevation Rate of Change Description	
Channel Capacity	Function Of: Constant	
Control for Athol Connecticut at Montague - Linear Connecticut at Hartford - Linear Maximum Rate of Increase Maximum Rate of Decrease Nax Outflow = Max 21d Inflow Conservation Conservation Connecticut at Montague - Linear Connecticut at Hartford - Linear Connecticut at Hartford - Linear Maximum Rate of Decrease Maximum	Type Decreasing  Instantaneous Period Average Max Change of (ft) 5.0 over 24 hours	

Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet – Pool Elevation Rate of Change

### 11. Max Outfow equals 21 day max inflow

Figure 17 shows the content of "Max Outflow equals 21 day max inflow" rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

Zone-Rules Rel. Alloc. Outages Stor. Cred	lit Dec. Sched, Projected	Elev		
Excess Surcharge Gate Ops to Save Dam Surcharge Storage Gate Operation During Surcharge Flood Control Gate Operation Minimum Releases Control for Athol Gonnecticut at Harfford - Linear Connecticut at Harfford - Linear	Operates Release Fron           Rule Name:         x Outflow:           Function of:         th Hill-Poo           Limit Type:         Maximum           Flow (cfs)         0.0           2800.0         2800.0	= Max 21d Inflow Desc	3,000	Define
Maximum Rate of Decrease     Maximum Rate of Decrease     Dool Elevation Rate of Change     Maximum Rate of Decrease     MaxOuthow = Max210 Inflow     Conservation     Conner Capacity     Mar Flow Logic - Birch Hill     Connecticut at Montague - Linear     Connecticut at Hartford - Linear     Maximum Rate of Increase     Maximum Rate of Decrease     Maximum Rate of Decrease     Maximum Rate of Change     Inactive	123456.0	2800.0		Edit Edit Edit Edit Edit

Figure 17: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals 21 day max inflow

#### **12.** *Min flow Logic-Birch Hill*

Figure 17 shows the content of "Min Flow Logic-Birch Hill" rule. This rule shows the minimum release from dam as a function of inflow for different months.

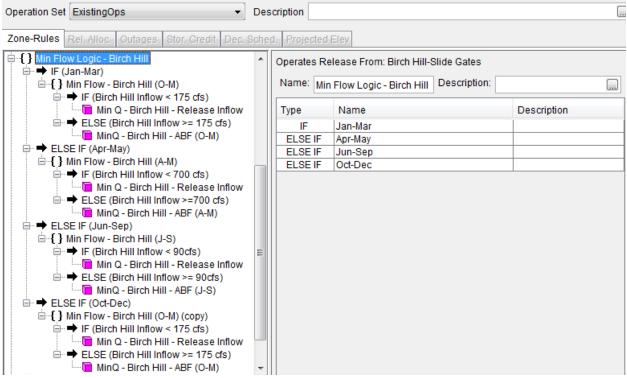


Figure 17: Reservoir Editor: Operations Tab – Existing Ops OpSet –Min Flow Logic-Birch Hill

## Borden Brook

### I. Overview

Borden Brook dam is located in Granville, MA and feeds into the Westfield River. It is owned by the City of Springfield and is used for drinking water supply and hydroelectric power generation. Construction of the dam was completed in 1909.

Figure 1 shows the location of Borden Brook Dam as it is represented in the HEC-ResSim model. Figure 2 shows an aerial view of the reservoir.

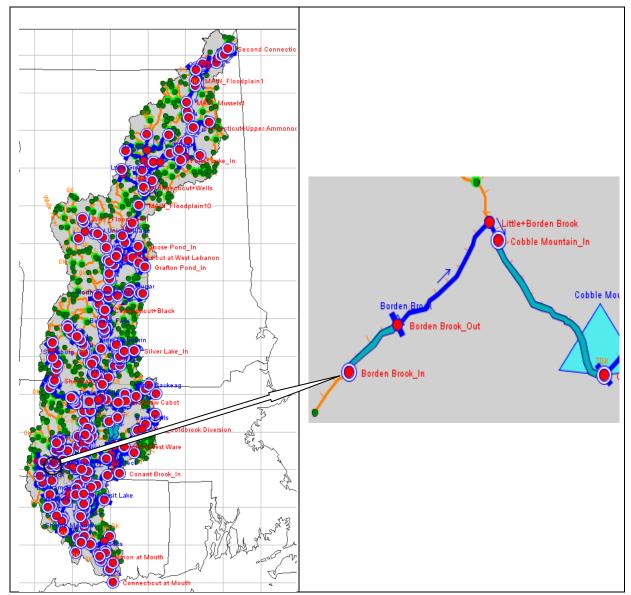


Figure 1: HEC-ResSim Map Display Showing Location of Borden Brook



Figure 2: Aerial photo of Borden Brook Reservoir

# **II.** Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>12</sup>. The dam consists of four types of outlets: (1) uncontrolled spillway, (2) controlled Upper 24-inch outlet, (3) controlled Lower 24-inch outlet, and (4) controlled Low-Level 36-inch outlet as shown in Figure 4.

<sup>&</sup>lt;sup>12</sup> Springfield Water and Sewer Commission. Water Supply System History and Statistics. 1999

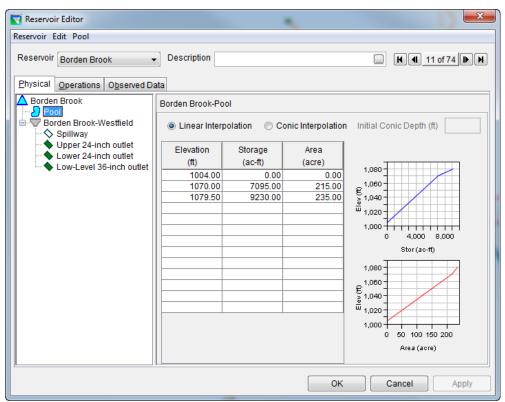


Figure 3: Reservoir Editor -- Physical Tab -- Pool

Reservoir Editor			×
Reservoir Edit Dam			
Reservoir Borden Brook			
Borden Brook	Borden Brook-Borden Broo	k-Westfield	
Borden Brook-Westfield	Elevation at top of dam (ft)	1079	9.5
Upper 24-inch outlet	Length at top of dam (ft)	750	0.0
Low-Level 36-inch outlet	Composite Release Cap		_
	Elevation Controlled (ft) (cfs)	Uncontr Total (cfs) (cfs)	1,080
	1,005.0 0.0	0.0 0.0	
	1,007.0 168.0	0.0 168.0	▲ 5 1,060 5 € 1,040 
	1,009.0 265.0	0.0 265.0	
	1,011.0 356.0	0.0 356.0	1,000 +++++++
	1,013.0 428.0	0.0 428.0	0 3,000
	1,015.0 489.0	0.0 489.0	Flow
	1,017.0 543.0	0.0 543.0	(cfs)
	1,019.0 593.0	0.0 593.0	
	1,021.0 639.0 1,023.0 681.0	0.0 639.0	
	1,025.0 721.0	0.0 721.0	
	1,027.0 759.0	0.0 759.0	
	1,029.0 795.0	0.0 795.0	
	1 021 0 020 0	0 0 0 0 0	•
	J	ОК	Cancel Apply

Figure 4: Reservoir Editor -- Physical Tab -- Dam

## III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Borden Brook's "ExistingOps" operational zones, which consist of the zones Top of dam (1079.5 ft), Conservation (1070 ft), and Inactive (1004 ft)<sup>1</sup>.

Reservoir Editor				×
Reservoir Edit Operations Zone Rule	IF_Block			
Reservoir Borden Brook 🔹	Description		(	H 4 11 of 74 D H
Physical Operations Observed Data	ì			
Operation Set Existing Ops	• D	escription		
	Stor. Credit Dec	Sched. Projected E	lev	
Flood Control	Storage Zone	Conservation	Description	
Conservation Maximum controlled release	Function of Da	ite		Define
Inactive	Date	Top Elevation	1,090	
	01Jan	1070.0	1,080	
			1 060 -	
			() 1,000	
			1,020 1,010	
		<u> </u>	1,000	May Jul Sep Nov
	7		Jan war	May Jul Sep Nov
	Zone Sort Eleva	ation		
			ОК	Cancel Apply

Figure 5: Reservoir Editor -- Operations Tab –Existing Ops OpSet – Guide Curve

## **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops.

🟹 Reservoir Editor
Reservoir Edit Operations Zone Rule
Reservoir Borden Brook 🔹
Physical Operations Observed Data
Operation Set Existing Ops
Zone-Rules Rel. Alloc. Outages
Flood Control Gate Ops to Save Dam Conservation Maximum controlled release Release avg inflow Inactive



## **C.** Rule Descriptions

### 1. Gate Ops to save Dam

Figure 7 shows the content of "Gate Ops to save Dam" rule. This rule increases the minimum release from Dam as a function of pool elevation.

Operation Set Existing Ops	▼ Des	cription	
Zone-Rules Rel. Alloc. Outages S	Stor. Credit Dec. S	ched. Projected E	Elev
<ul> <li>Flood Control</li> <li>Gate Ops to Save Dam</li> <li>Conservation</li> <li>Maximum controlled release</li> <li>Release avg inflow</li> <li>Inactive</li> </ul>	Rule Name: Gate Function of: Bord Limit Type: Min Elev (ft) 1070.0 1076.0 1077.0	e Ops to Save Dam den Brook-Pool Ele 	evation, Previous Value Define
	1078.0 1079.0 1079.5	953.0 1444.0 1934.0	<ul> <li>Period Average Limit Edit</li> <li>Hour of Day Multiplier Edit</li> <li>Day of Week Multiplier Edit</li> <li>Rising/Falling Condition Edit</li> <li>Seasonal Variation Edit</li> </ul>

Figure 7: Reservoir Editor -- Operations Tab – Existing Ops OpSet – Gates Ops to save Dam

#### 2. Maximum controlled release

Figure 8 shows the content of "Maximum controlled release" rule. This rule represents the maximum release from reservoir as a function of date.

Operation Set Existing Ops	▼ Des	cription		
Zone-Rules Rel. Alloc. Outages	Stor. Credit Dec. S	ched. Projected El	ev	
Flood Control     Gate Ops to Save Dam     Conservation     Maximum controlled release	Rule Name: axim	um controlled releas		_
Inactive	Limit Type: Max		4 000	
	Date 01Jan	Release (cfs) 1675.0	1,690 1,680 1,670 1,660 Jan Mar May Jul Sep Nov	
		E	Period Average Limit     Edit     Hour of Day Multiplier     Edit	
			Day of Week Multiplier Edit	
			Seasonal Variation Edit	

Figure 8: Reservoir Editor -- Operations Tab – Existing Ops OpSet – Maximum controlled release

#### 3. Release avg Inflow

Figure 9 shows the content of "Release avg Inflow" rule. This rule represents the maximum release from reservoir as a function of Inflow.

Operation Set Existing Ops	▼ Des	cription			
Zone-Rules Rel. Alloc. Outages S	Stor. Credit Dec. S	ched. Projected I	Ele	V	
Flood Control Gate Ops to Save Dam Conservation Maximum controlled release Release avg inflow	Rule Name: Rele	ease avg inflow		k-Borden Brook-Westfield Description: Lacking informatio e, 0.0 hr lag, 168.0 hr period	on one Define
ja Inactive	Limit Type: Max	🖣 Interp.: 🛄	•	୍ରିଲ 2,000 <del></del>	
	Flow (cfs)	Release (cfs)			
	0.0 2000.0	0.0 2000.0	^		0 2,000
				Flow (ofs)	
				Period Average Limit	Edit
				🔲 Hour of Day Multiplier	Edit
				Day of Week Multiplier	Edit
				Rising/Falling Condition	Edit
			-	Seasonal Variation	Edit

Figure 9: Reservoir Editor -- Operations Tab – Existing Ops OpSet – Release avg inflow

## Canaan

### I. Overview

The Canaan Hydroelectric Project is an existing licensed minor hydroelectric project owned and operated by Public Service of New Hampshire (PSNH). It is located at river mile 370 on the Connecticut River, ten miles below Murphy Dam and 80 miles upstream of Gilman Dam. The project is located in the towns of Canaan, Vermont and Stewartstown, New Hampshire. It was originally constructed by the W.F. Allen Company in 1927; the dam, a concrete gravity structure, was reconstructed in 1943 to replace the timber dam that failed. The purpose of the dam is to impound water for hydroelectic power generation, however, it is currently operated on a strict run-of-river basis.

Figure 1 shows the location of Canon as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the project.

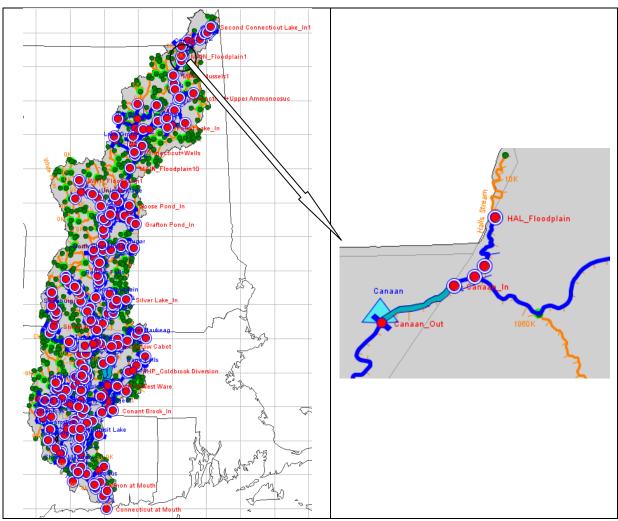


Figure 1: HEC-ResSim Map Display Showing Location of Caanan



Figure 2: Photo of Canaan Hydroelectric project

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>13</sup>. The dam consists of seven types of outlets: (1) uncontrolled Bay#1, (2) uncontrolled Bay#5 (flashboards all in), (3) uncontrolled Bay#5 (flashboards partly cleared), (4) uncontrolled Bay#2, (5) uncontrolled Bay#3, (6) uncontrolled Bay#4, and (7) controlled Tunnel discharge as shown in Figure 4<sup>14</sup>. The power plant has a maximum capacity of 550 cfs and a constant tailwater elevation of 1031.5 feet.

<sup>&</sup>lt;sup>13</sup> NHDam Data Sheet. Canaan. 2003.

<sup>&</sup>lt;sup>14</sup> National Dam Inspection Program. Phase I Inspection Report Canaan. 1980.

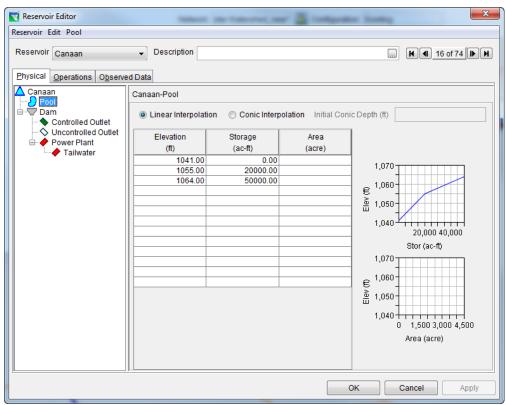


Figure 3: Reservoir Editor -- Physical Tab -- Pool

Reservoir Editor	Tablecon one for	and the second second	X
Reservoir Edit Dam			
Reservoir Canaan	✓ Description		K 1 16 of 74 D D
Physical Operations Observe	ed Data		
🛆 Canaan	Canaan-Dam		
Pool	Elevation at top of dam (ft)		1064.0
Uncontrolled Outlet	Length at top of dam (ft)		275.0
Tailwater	Composite Release Capacity		
	Elevation Controlled		1,070
	(ft) (cfs)	(cfs) (cfs)	
	1,041.0 3,900 1,045.0 3,900		
	1,043.0 3,900		0 \$ € 1,050
	1,055.9 4,291		5 1,040+++++
	1,056.8 4,682	6 1,086.7 5,769.	3 0 15,000
	1,057.7 5,073	8 1,996.4 7,070.	3 _ Flow
	1,058.6 5,465	1 3,073.7 8,538.	8 = (cfs)
	1,059.5 5,856		
	1,060.4 6,247		
	1,061.3 6,638		
	1,062.2 7,030		
	1,063.1 7,421		
	1,069.1 10,030		
	1,005.1 10,000	12,100.0 22,100.	<u> </u>
			-
			<b>v</b>
			OK Cancel Apply

Figure 4: Reservoir Editor -- Physical Tab -- Dam

# III. Operations

# A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Canon Dam's "Existing Ops" operational zones, which consist of the zones Top of dam (1064 ft), Below Top of dam (1063 ft), Conservation (1055 ft), and Inactive (1042 ft)<sup>1</sup>.

Reservoir Editor	1			x
Reservoir Edit Operations Zone Ru	le IF_Block			
Reservoir Canaan	<ul> <li>Description</li> </ul>			K 4 16 of 74 K
Physical Operations Observed D	ata			
Operation Set Existing Ops	▼ Desc	cription		
Zone-Rules Rel. Alloc. Outages	Stor. Credit Dec. Sche	d. Projected Elev		
Top of Dam Below Top of Dam	Storage Zone Conserva	ation Des	cription	
<ul> <li>Min Release</li> <li>Release 95% inflow</li> </ul>	Function of Date			Define
Conservation	Date 01Jan	Top Elevation (ft) 1055.0	1,065-	
📄 🔲 Release 95% inflow	UIJan	1055.0		
			1,060-	
			() () () () () () () () () () () () () (	
			1,045	
			1,045	
			] 1,040 <del> </del>	far May Jul Sep Nov
			Janw	iai may bui bep 1404
			Ŧ	
	Zone Sort Elevation			
			ОК	Cancel Apply

Figure 5: Reservoir Editor -- Operations Tab –Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>15</sup>.

👿 Reservoir Editor
Reservoir Edit Operations Zone Ru
Reservoir Canaan
Physical Operations Observed E
Operation Set Existing Ops
Zone-Rules Rel. Alloc. Outages
Top of Dam Below Top of Dam Min Release Release 95% inflow Conservation Min Release Release 95% inflow
Inactive

Figure 6: Reservoir Editor -- Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>&</sup>lt;sup>15</sup> Public Service of New Hampshire. Canaan Hydroelectric Project: Flow Management and Impoundment & Flow Monitoring Plan. 2010.

# **C.** Rule Descriptions

### 1. Min Release

Figure 7 shows the content of "Min Release" rule. This rule represents the constant minimum release from the dam.

Operation Set Existing Ops	▼ D	escription			
Zone-Rules Rel. Alloc. Outages	Stor. Credit Dec. S	ched. Projected El	ev		
Top of Dam     Below Top of Dam     Below Top of Dam     Below Top of Dam     Min Release 95% inflow     Conservation     Min Release     Release 95% inflow     Inactive	Operates Release Fr Rule Name: Min Rel Function of: Canaar Limit Type: Minimu Flow (cfs)	Interp.: Release Release Release 0.0 0.0	Description: urrent Value Linear +	() () () () () () () () () () () () () (	Define  Define  Edit  Edit  Edit  Edit
				Rising/Falling Condition	Edit
				Seasonal Variation	Edit
			-		

Figure 7: Reservoir Editor -- Operations Tab – Existing Ops OpSet – Min Release

### 2. Release 95% Inflow

Figure 8 shows the content of "Release 95% Inflow" rule. This rule passes 95% of Inflow through power plant as per the run-of-river modeling strategy.

Operation Set Existing Ops	•	Description	n				
Zone-Rules Rel. Alloc. Outages	Stor. Credit De	c. Sched. P	rojected Ele	ev			
<ul> <li>Top of Dam</li> <li>Below Top of Dam</li> <li>Min Release</li> <li>Conservation</li> <li>Min Release</li> <li>Release 95% inflow</li> <li>Conservation</li> <li>In Release</li>     &lt;</ul>	Limit Type: Mini	lease 95% in naan_In Flow imum 👻	flow	Descriptio alue Linear	•	100,000 80,000 40,000 0 50,000 Flow (cfs) Period Average Limit Hour of Day Multiplier Day of Week Multiplier Rising/Falling Condition Seasonal Variation	Define Define 100,000 Edit Edit Edit Edit Edit
					Ψ,		

Figure 8: Reservoir Editor -- Operations Tab – Existing Ops OpSet – Release 95% Infl

## **Cobble Mountain**

## I. Overview

Cobble Mountain dam is located in Granville, MA and feeds into the Westfield River. It is owned by the City of Springfield and is used for drinking water supply for the city.

Figure 1 shows the location of Cobble Mountain Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Cobble Mountain rerservoir.

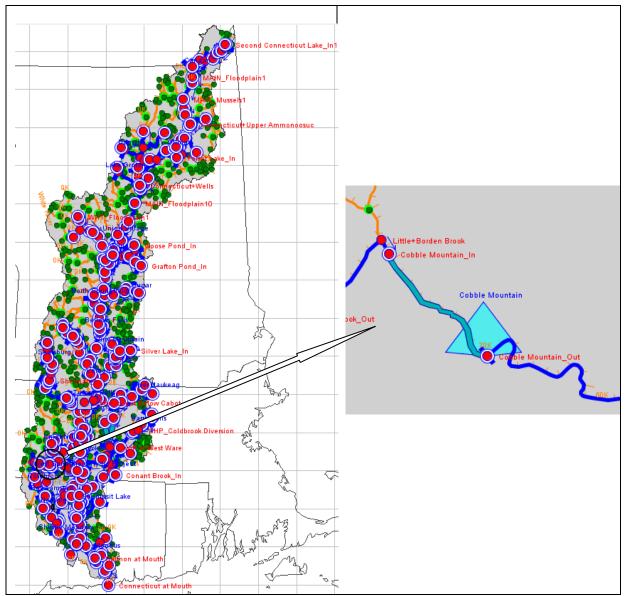


Figure 1: HEC-ResSim Map Display Showing Location of Cobble Mountain dam



Figure 2: Photo of Cobble Mountain reservoir

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>16</sup>. The dam consists of two types of outlets: (1) controlled slide gates, and (2) uncontrolled outlet, as shown in Figure 4.

<sup>&</sup>lt;sup>16</sup> Springfield Water and Sewer Commission. Water Supply System History and Statistics. 1999

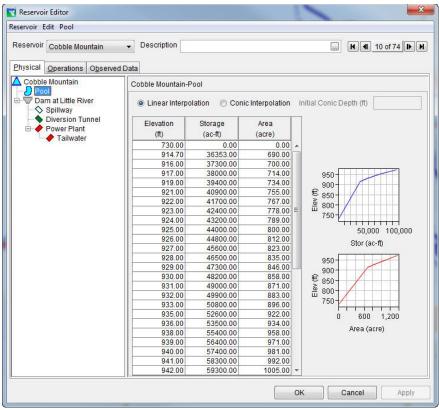


Figure 3: Reservoir Editor: Physical Tab -- Pool

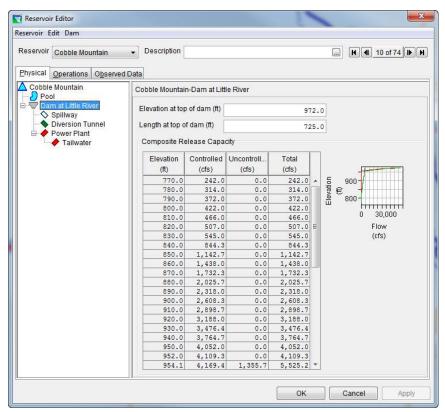


Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Cobble Mountain's "ExistingOps" operational zones, which consist of zones of Flood Control (972 ft), Conservation (940 ft), and Inactive zone (754 ft)<sup>1</sup>.

Reservoir Editor	
Reservoir Edit Operations Zone Rule	IF_Block
Reservoir Cobble Mountain 🔹	Description
Physical Operations Observed Data	a
Operation Set Existing Ops	Description
Zone-Rules Rel. Alloc. Outages S	Stor. Credit Dec. Sched. Projected Elev
Flood Control	Storage Zone Conservation Description
Maximum controlled release	Function of Date Define
	Date Top Elevation 01Jan 940.0 A 950-
	Jan Mar May Jul Sep Nov
	<b>~</b>
	Zone Sort Elevation
	OK Cancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

## **B. Rule Illustrations**

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. There is a water supply timeseries for Cobble Mountain that is described in the water supply section of the report.

💘 Reservoir Editor
Reservoir Edit Operations Zone Rule
Reservoir Cobble Mountain 🔹
Physical Operations Observed Data
Operation Set Existing Ops
Zone-Rules Rel. Alloc. Outages S
Flood Control

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## **C.** Rule Descriptions

#### **1.** Maximum controlled release

Figure 7 shows the content of "Maximum controlled release" rule. This rule shows the maximum release of 1675 cfs from Cobble Mountain.

Zone-Rules Rel. Alloc. Outages Stor. Credit. Dec. Sched. Projected Elev	
Piood Control       Operates Release From: Cobble Mountain-Dam         Imactive       Maximum controlled release       Description:       The maximum flow         Function of:       Date       Interp:       Imactive         Imactive       Date       Release (cfs)       1,680         Other       1,680       Interp:       Imactive         Imactive       Date       Release (cfs)       Imactive         Imactive       Date       Release (cfs)       Imactive         Imactive       Imactive       Imactive       Imactive         Imactive       Imactive <td< td=""><td>v in this Define Edit Edit Edit Edit Edit</td></td<>	v in this Define Edit Edit Edit Edit Edit

Figure 7: Reservoir Editor: Operations Tab - Existing Ops OpSet - Maximum controlled relea

# Colebrook

### I. Overview

Completed in 1969, Colebrook River Dam is owned and operated by the Metropolitan District Commission (MDC), a non-profit municipal corporation chartered to supply drinking water and sewage treatment to Hartford and its surrounding municipalities. During flood conditions, the Corps is responsible for water releases. The primary function of the reservoir is for flood control. The water storage capacity of Colebrook is approximately 10 BG, while the total capacity of the dam is approximately 31.5 BG. Colebrook is FERC licensed to the MDC and authorized for 3,000 KW<sup>17</sup>.

Figure 1 shows the location of Colebrook Dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo from Colebrook Dam.

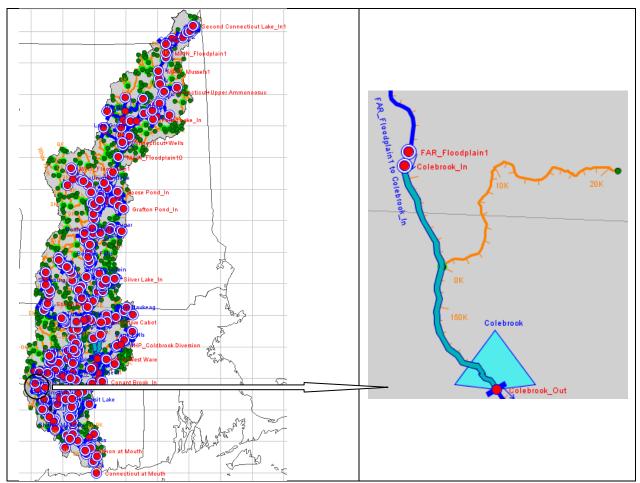


Figure 1 HEC-ResSim Map Display Showing Location of Colebrook dam

<sup>&</sup>lt;sup>17</sup> Adamec, K. *Farmington Model Documentation*. University of Massachusetts, 2009.



Figure 2: Photo of Colebrook dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of three types of outlets: (1) controlled outlet, and (2) uncontrolled outlet, and (3) power plant as shown in Figure 4. All physical and operations data and are from Adamec 2009 and the US Army Corps New England District, either from a previously created ResSim model or the Reservoir Regulation Team website<sup>18</sup>.

<sup>&</sup>lt;sup>18</sup> http://rsgisias.crrel.usace.army.mil/nae/cwms\_map.map\_index

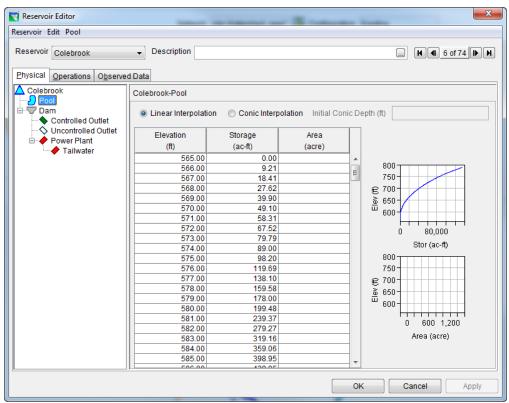


Figure 3: Reservoir Editor: Physical Tab -- Pool

eservoir Edit Dam					
Reservoir Colebrook	<ul> <li>Description</li> </ul>				H d 6 of 74 D H
Physical Operations Observ	ed Data				
Colebrook	Colebrook-Dam				
	COLEDIOOK-Dalli				
Dam Controlled Outlet	Elevation at top of	dam (ft)		790.	0
S Uncontrolled Outlet	Length at top of da	am (ft)		999.	0
🖻 🔶 Power Plant					0
Tailwater	Composite Relea	ase Capacity			
	Elevation	Controlled	Uncontrolled	Total	
	(ft)	(cfs)	(cfs)	(cfs)	780
	637.5	9,999.0	0.0	9,999.0 🔺	
	644.0	10,837.5	0.0	10,837.5	e l
	647.5	11,289.0	0.0	11,289.0	
	657.5	11,820.0	0.0	11,820.0	0 80,000
	667.5	12,228.0	0.0	12,228.0 12,570.0 ≡	Flow
	687.5	12,879.0	0.0	12,879.0	(cfs)
	697.5	13,149.0	0.0	13,149.0	(013)
	714.5	13,549.4	0.0	13,549.4	
	717.5	13,620.0	0.0	13,620.0	
	737.5	14,040.0	0.0	14,040.0	
	757.5	14,388.0	0.0	14,388.0	
	761.0	14,458.4	0.0	14,458.4	
	765.0	14,538.8	4,720.0	19,258.8	
	770.0	14,639.2	19,700.0	34,339.2	
	775.0	14,739.8	42,000.0	56,739.8	
	777.5	14,790.0	53,500.0	68,290.0 +	

Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

# A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Colebrook's "Existing Ops" operational zones, which consist of zones of Top of dam (790 ft), Flood Control (761 ft), Spring & Fall Fisheries Storage (708-714.5 ft), MDC Water Supply (701.2 ft), Operational Inactive (644 ft), and Inactive zone (640 ft).

Reservoir Editor		1 1	-	~	×
Reservoir Edit Operations Zone Rule IF_Blo	ck				
Reservoir Colebrook - Des	cription				6 of 74 🕨 🗎
Physical Operations Observed Data					
Operation Set Existing Ops	- Descriptio	n From UMass Farmin	atan natas: "Du	laa far Oolobro	
			gion notes. Ru	les for Colebro	ok Reservoir
Zone-Rules Rel. Alloc. Outages Stor. C	redit Dec. Sched. F	rojected Elev			
Top of Dam	Storage Zone g & F	all Fisheries Storage	Description		
🛤 Flood Control	Function of Date				Define
Max Release-3000cfs					
DROC	Date	Top Elevation (ft)	800		
	01Jan 21Apr	708.0	780-		
Max Stage at Hartford	29Apr	708.0	760		
Max Pool Elev ROC	30Jun	714.5	€ 740-		
Max Outflow = 21 day Max Inflow	01Jul	708.0	€ 720-		
Spring & Fall Fisheries Storage			- 720 inte 700 - 680		
Max Release-3000cfs			a 680 -		
🛅 Min Seasonal Variation			ш 660-		
DROC			640		
			620		
Max Stage at Hartford				ar May Jul Sej	a Nov
Downstream Control at Simsbury     Max Pool Elev ROC				,	
MDC Water Supply					
Max Release-3000cfs					
Min Seasonal Variation					
IROC					
🖳 🛅 Max Stage at Hartford					
Downstream Control at Simsbury					
Max Pool Elev ROC					
Operational Inactive		-			
Max Release = Inflow					
	Zone Sort Elevation				
		٢	ОК	Cancel	Apply
			UK	Cancel	Apply
uno F. Bosomuoin Editory Operati			uide Cumre		

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>19</sup>. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

🯹 Reservoi	ir Editor			-	
Reservoir E	Edit Ope	erations	Zone	Rule	IF_Blo
Reservoir	Colebr	ook		•	Desc
Physical	<u>O</u> perati	ons (	) <u>b</u> serve	d Dat	а
Operatio	n Set E	xisting	Ops		
Zone-Ru	ules Re	el. Alloc	Outa	ges	Stor. C
	in Flow - I Control ax Relea in Flow - ROC ax Stage ownstre ax Pool I ax Outflo g & Fall ax Relea in Sease ROC ax Stage ownstre ax Relea in Sease ROC ax Stage ownstre ax Relea in Sease ROC ax Stage ownstre ax Relea in Sease ax Relea in Sease ax Relea in Sease ax Relea in Sease ax Relea in Sease	ase-300 Flood at Har am Cor Elev RC w = 21 Fisheri ase-300 onal Va ase-300 onal Va e at Har am Cor Elev RC onal Va e at Har am Cor Elev RC onal Va	00cfs Control htrol at : 0C day Ma es Stop 00cfs riation htrol at : 0C 00cfs riation tford htrol at : 0C 00cfs riation	Simst x Inflo rage Simst	w

Figure 6: Reservoir Editor: Operations Tab – Existing OpSet – Zones and Rules

<sup>&</sup>lt;sup>19</sup> Adamec 2009

Figure 7 shows a sequential release allocation approach specified for available outlets along Colebrook Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The controlled gate gets the remainder of the release.

Reservoir Editor	· ·		-	~	-
Reservoir Edit Operations					
Reservoir Colebrook    Description					
Physical Operations Observed Data					
Operation Set Existing Ops	Description From UM	lass Farmin <u>c</u>	ton notes: "I	Rules for	Colebrook F
Zone-Rules Rel. Alloc. Outages Stor. Credit. Dec. S	Sched. Projected Ele	ΞV			
Release Allocation Strategy					
Colebrook - Balanced	Release Location:	Colebrook-[	Dam		
Colebrook-Dam (1.0) - Sequential	Allocation Type:	Sequential			
Colebrook-Controlled Outlet	Colebrook-Power	Plant			
	Colebrook-Contro	lled Outlet			

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

# **C. Rule Descriptions**

### 1. Min Flow-Flood Control

Figure 8: shows the content of "Min Flow-Flood Control" rule. This rule presents the minimum required release of 50 cfs from the dam during flood control operations.

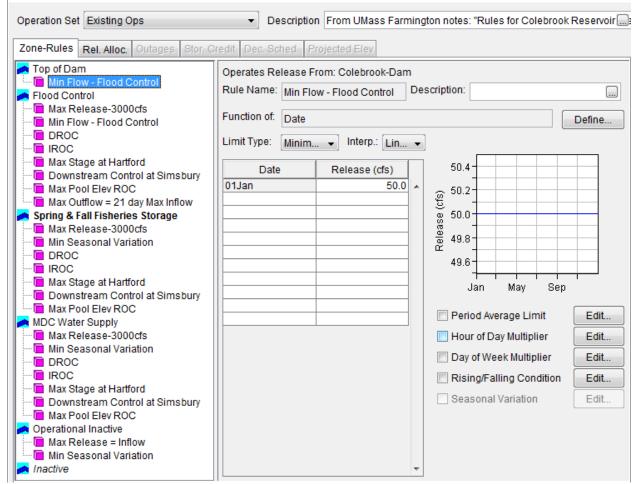


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow-Flood Control

### 2. Max Release-3000cfs

Figure 9 shows the content of "Max release-3000cfs" rule. This rule presents the maximum release of 3000 cfs from dam.

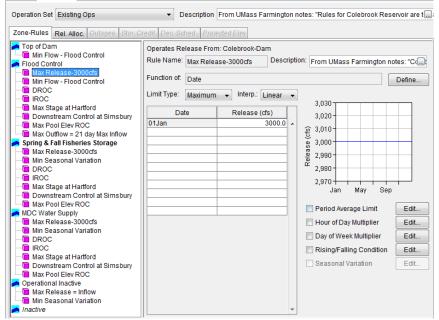


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max release-3000cfs

### 3. DROC

Figure 10 shows the content of "DROC" rule. This rule shows the decreasing maximum allowable release rate of change rule from Colebrook dam.

Operation Set Existing Ops	Description From	UMass Farmington notes: "Rules for Colebrook Reservoir are t
Zone-Rules Rel. Alloc. Outages Stor. C	redit Dec. Sched. Projected I	Elev
Top of Dam Min Flow - Flood Control Flood Control Gloot C	L	

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Decreasing-ROC

# 4. Increasing-ROC

Figure 11 shows the content of "Increasing-ROC" rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Colebrook dam.

Operation Set Existing Ops	<ul> <li>Descriptio</li> </ul>	From UMass Farmington notes: "Rules	for Colebrook Reservoir are t
Zone-Rules Rel. Alloc. Outages Stor. C	redit Dec. Sched. Pr	ojected Elev	
Top of Dam Min Flow - Flood Control Flood Control Max Release-3000cfs Min Flow - Flood Control DROC Max Stage at Hartford Downstream Control at Simsbury Max Pool Elev ROC Max Outflow = 21 day Max Inflow Spring & Fall Fisheries Storage Max Release-3000cfs Min Seasonal Variation DROC Max Stage at Hartford Downstream Control at Simsbury Max Pool Elev ROC Max Stage at Hartford Downstream Control at Simsbury Max Release-3000cfs Min Seasonal Variation Max Pool Elev ROC MDC Water Supply Max Release-3000cfs Min Seasonal Variation DROC MDC Water Supply Max Release at Hartford Downstream Control at Simsbury Max Pool Elev ROC Max Stage at Hartford Downstream Control at Simsbury Max Pool Elev ROC Max Stage at Hartford Downstream Control at Simsbury Max Pool Elev ROC Operational Inactive Max Release = Inflow Min Seasonal Variation Min Seasonal Variation Min Seasonal Variation Min Seasonal Variation Max Release = Inflow	Operates Release Fr Release Rate of Cha Description: Function Of: Type Max Rate of Change	Constant   Increasing	

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Increasing-ROC

### 5. Max Stage at Hartford

Figure 12 shows the content of "Max Stage at Hartford" rule. This rule represents the maximum allowable release from dam as a function of previous day stage at Hartford. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>	From UMass Farmingt	on notes: "Rules for Cole	brook Reservoir are t				
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev								
Zone-Rules       Rel. Alloc.       Outages       Stor. C         Top of Dam       Min Flow - Flood Control       Flood Control         Flood Control       Max Release-3000cfs       Min Flow - Flood Control         DROC       IROC       Max Stage at Hartford         Downstream Control at Simsbury       Max Pool Elev ROC         Max Outflow = 21 day Max Inflow         Spring & Fall Fisheries Storage         Max Stage at Hartford         DROC         Max Release-3000cfs         Max Release-3000cfs         Max Stage at Hartford         DROC         Max Stage at Hartford         DROC         Max Release-3000cfs         Max Release-3000cfs         Max Pool Elev ROC         MDC Water Supply         Max Release-3000cfs         Min Seasonal Variation         DOWD Water Supply         Max Release-3000cfs         Min Seasonal Variation         DROC         Max Release-3000cfs         Max Release-3000cfs         Max Release-3000cfs         Max Release-3000cfs         Max Release-3000cfs         Max Release-3000cfs         Max Pool Elev ROC         Downstream Control at Simsbury     <	Operates Release From Rule Name: Max Stage	m: Colebrook-Dam e at Hartford Desc cut at Hartford Stage, Pre Interp.: Linear Release (cfs) 3000.0 2400.0 1800.0 1200.0 600.0 50.0	3,500           3,000           3,000           2,500           2,000           1,500           1,000           500           0           0           0	Itiplier Edit ultiplier Edit Condition Edit				
Operational Inactive     Max Release = Inflow     Min Seasonal Variation     Inactive			-					

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max stage at Hartford

#### 6. Downstream Control at Simsbury

Figure 13 shows the content of "Downstream Control at Simsbury" rule. This rule shows the maximum allowable flow at the Farmington at Simsbury point downstream.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>	From UMass Farmington not	es: "Rules for Colebrook Reservoir are t
Zone-Rules Rel. Alloc. Outages Stor. C	redit Dec. Sched. Proje	cted Elev	
<ul> <li>Top of Dam</li> <li>Min Flow - Flood Control</li> <li>Flood Control</li> <li>Max Release-3000cfs</li> <li>Min Flow - Flood Control</li> <li>DROC</li> <li>IROC</li> <li>Max Stage at Hartford</li> <li>Downstream Control at Simsbury</li> <li>Max Outflow = 21 day Max Inflow</li> <li>Spring &amp; Fall Fisheries Storage</li> <li>Max Release-3000cfs</li> <li>Min Seasonal Variation</li> <li>DROC</li> <li>IROC</li> <li>Max Stage at Hartford</li> <li>Downstream Control at Simsbury</li> <li>Max Release-3000cfs</li> <li>Min Seasonal Variation</li> <li>DROC</li> <li>IROC</li> <li>Max Release-3000cfs</li> <li>Max Stage at Hartford</li> <li>Downstream Control at Simsbury</li> <li>Max Release-3000cfs</li> <li>Min Seasonal Variation</li> <li>DROC</li> <li>IROC</li> <li>Max Release-3000cfs</li> <li>Min Seasonal Variation</li> <li>DROC</li> <li>IROC</li> <li>Max Stage at Hartford</li> <li>Downstream Control at Simsbury</li> <li>Max Stage at Hartford</li> <li>DROC</li> <li>IROC</li> <li>Max Stage at Hartford</li> <li>DOC</li> <li>Max Stage at Hartford</li> <li>DROC</li> <li>Max Stage at Hartford</li> <li>DROC</li> <li>Max Stage at Hartford</li> <li>DOWnstream Control at Simsbury</li> <li>Max Pool Elev ROC</li> <li>Operational Inactive</li> <li>Max Release = Inflow</li> </ul>	Operates Release From Rule Name:       tream Cont         Function of:       Date         Limit Type:       Maximum         Downstream Location:       Parameter:         Date       01Jan         01Nov	: Colebrook	. Define 9,000 9,0
Min Seasonal Variation		<del>.</del>	Advanced Options

Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Downstream Control at simsbury

#### 7. Max Pool Elev ROC

Figure 14 shows the content of "Max pool Elev ROC" rule. This rule shows the maximum allowable decreasing rate of pool elevation change.

Operation Set Existing Ops	•	Description	From UMass Farmington notes: "Rules for Colebrook Reservoir are t
Zone-Rules Rel. Alloc. Outages Stor. C	redit Dec. S	ched. Proje	ected Elev
Top of Dam Min Flow - Flood Control Flood Control Max Release-3000cfs Min Flow - Flood Control DROC Max Stage at Hartford Downstream Control at Simsbury Max Pool Elev ROC Max Outflow = 21 day Max Inflow Spring & Fall Fisheries Storage Max Release-3000cfs Min Seasonal Variation DROC Max Stage at Hartford Downstream Control at Simsbury Max Pool Elev ROC MDC Water Supply Max Release-3000cfs Min Seasonal Variation DROC MDC Water Supply Max Release-3000cfs Min Seasonal Variation DROC MDC Water Supply Max Release-3000cfs Min Seasonal Variation DROC MDC Water Supply Max Release at Hartford DOWnstream Control at Simsbury Max Pool Elev ROC Max Stage at Hartford Downstream Control at Simsbury Max Pool Elev ROC Max Release = Inflow Max Release = Inflow Min Seasonal Variation Min Seasonal Variation Max Release = Inflow Min Seasonal Variation Min Seasonal Variation	Elevation Ra Description Function Of Type O Instan	ate of Chang Constant Decreasir ntaneous d Average	n: Colebrook ye Limit Max Pool Elev ROC

Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Pool Elev ROC

#### 8. Max Outflow equals 21 day Max Inflow

Figure 15 shows the content of "Max Outflow equals 21 day Max Inflow" rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

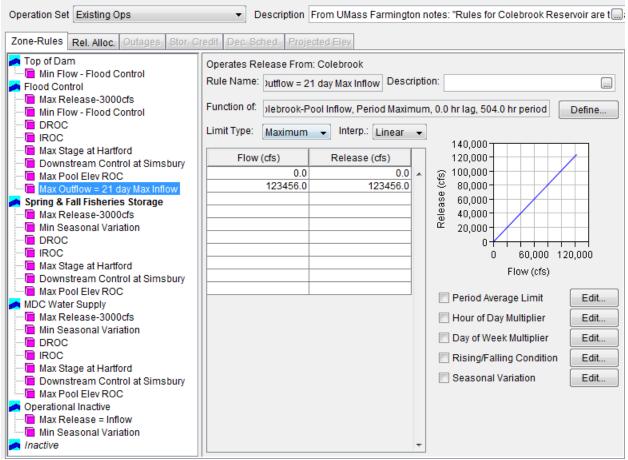


Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals 21 day Max Inflow

#### 9. Min Seasonal Variation

Figure 16 shows the content of "Min Seasonal Variation" rule. This rule shows the minimum release from dam as a function of inflow for different months.

Trail Funda.   Statiges   Statis	Credit Dec. Sched. F	Projected Elev					
Top of Dam Min Flow - Flood Control Flood Control	Operates Release F Rule Name: Min Se		am Description:				(
Max Release-3000cfs	Function of: Otis-D	am Tailwater Flow,	, Current Value				Define
	Limit Type: Minim	um	👻 Ini	erp.: Linear		•	40.000
Max Stage at Hartford	Flow		Release	e (cfs)			12,000
Max Pool Elev ROC	(cfs)	01Jan	16Mar	15May	01Nov		الارمان الارمان الارمان
🔲 间 Max Outflow = 21 day Max Inflow	0.0	99.2820971	50.0	208.3634009	99.2820971		0 0 6,000
Spring & Fall Fisheries Storage	100.0	199.2820971	150.0	308.3634009	199.2820971		<u> </u>
Max Release-3000cfs	500.0	599.2820971	550.0	708.3634009	599.2820971		₩ 4,000
🛅 Min Seasonal Variation	1000.0	1099.282097	1050.0	1208.363401	1099.282097		œ 2,000-
DROC	2000.0	2099.282097	2050.0	2208.363401	2099.282097		0
ROC	5000.0	5099.282097	5050.0	5208.363401	5099.282097		0 3,000 6,000 9,000
🔲 Max Stage at Hartford	10000.0	10099.2821	10050.0	10208.3634	10099.2821		Flow (cfs)
间 Downstream Control at Simsbury							11000 (013)
Max Pool Elev ROC							Period Average Limit
MDC Water Supply							
Max Release-3000cfs							Hour of Day Multiplier Edit.
Min Seasonal Variation							Day of Week Multiplier
DROC							E Day of Week Multiplier
IROC							Rising/Falling Condition Edit.
Max Stage at Hartford							
Downstream Control at Simsbury							Seasonal Variation Edit.
Max Pool Elev ROC							
Operational Inactive							
🔲 🛅 Max Release = Inflow							
🗝 🛅 Min Seasonal Variation							
h Inactive						-	

Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Seasonal Variation

#### 10. Max release=Inflow

Figure 17 shows the content of "Min Flow-Flood Control" rule. This rule releases total inflow from dam when the pool is in Operational Inactive zone.

Operation Set Existing Ops	Description From UMass Farmington notes: "Rules for Colebrook Reservoir are to
Zone-Rules Rel. Alloc. Outages Stor. C	redit Dec. Sched. Projected Elev
<ul> <li>Top of Dam</li> <li>Min Flow - Flood Control</li> <li>Flood Control</li> <li>Flood Control</li> <li>Max Release-3000cfs</li> <li>DROC</li> <li>ROC</li> <li>Max Stage at Hartford</li> <li>Downstream Control at Simsbury</li> <li>Max Pool Elev ROC</li> <li>Max Release-3000cfs</li> <li>Max Stage at Hartford</li> <li>DOWNstream Control at Simsbury</li> <li>Max Release-3000cfs</li> <li>Min Seasonal Variation</li> <li>DROC</li> <li>Max Release-3000cfs</li> <li>Max Release-3000cfs</li> <li>Max Release-3000cfs</li> <li>Max Release-3000cfs</li> <li>Max Release-3000cfs</li> <li>Max Release-3000cfs</li> <li>Min Seasonal Variation</li> <li>DROC</li> <li>Max Release-3000cfs</li> <li>Min Seasonal Variation</li> <li>Max Release-3000cfs</li> <li>Min Seasonal Variation</li> <li>Max Release-3000cfs</li> <li>Min Seasonal Variation</li> <li>Max Release = 1nflow</li> <li>Min Seasonal Variation</li> <li>Min Seasonal Variation</li> <li>Min Seasonal Variation</li> <li>Min Seasonal Variation</li> <li>Max Release = 1nflow</li> <li>Min Seasonal Variation</li> </ul>	Operates Release From: Colebrook         Rule Name:       Max Release = Inflow         Function of:       Colebrook_In Flow, Current Value         Limit Type:       Maximum         Interp:       Linear         Imit Type:       Maximum         Interp:       Linear         Imit Type:       Maximum         Interp:       Linear         Imit Type:       Maximum         Imit Type:       Release (cfs)         0.0       0.0         999999.0       999999.0         Imit Type:       Period Average Limit         Imit Type:       Edit         Imit Type:       Period Average Limit         Imit Type:       Edit         Imit Type:       Seasonal Variation

Figure 17: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow-Flood Control

## Comerford

#### I. Overview

Comerford dam is located on the Connecticut River mainstem in the towns of Monroe, New Hampshire, and Barnet, Vermont. It is owned and operated by TransCanada Hydro Northeast Inc. as part of the 15 Mile Falls project for hydropower generation on a peaking, seasonal storage basis.

Figure 1 shows the location of Comerford dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Comerford dam.

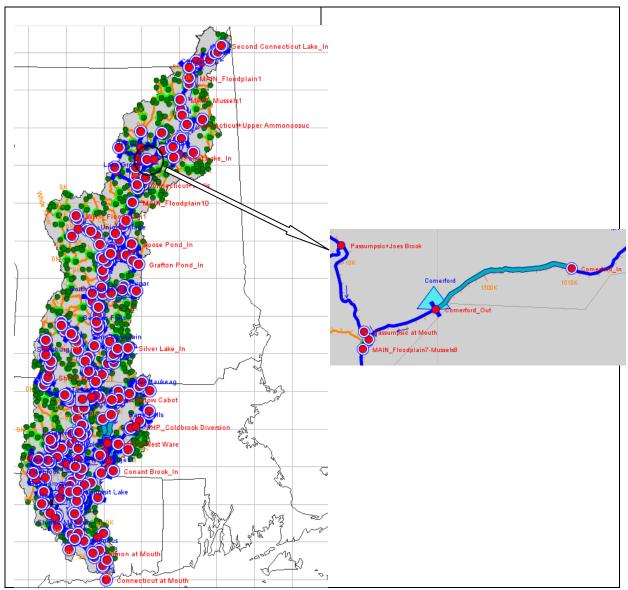


Figure 1: HEC-ResSim Map Display Showing Location of Comerford dam



Figure 2: Photo of Comerford dam.

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>20</sup>. The dam consists of three types of outlets: (1) uncontrolled stanchion Bays, and (2) uncontrolled Flashboard Bays, and (3) power plant as shown in Figure 4.

<sup>&</sup>lt;sup>20</sup> Data provided by TransCanada

eservoir Edit Pool					
Reservoir Comerford	<ul> <li>Description</li> </ul>			H 4 20 of 74 I	Ы
Physical Operations Observed	d Data				
	Comerford-Pool				
Dam Dam	O Linear Inter	polation 🔘 🤇	Conic Interpola	tion Initial Conic Depth (ft)	
Tailwater	Elevation	Storage	Area		
Stanchion Bays	(ft)	(ac-ft)	(acre)		
Flashboard Bays	610.00	0.00	(20.0)		
	610.00	56.20		<u>_</u>	
	610.20	112.40		=	
	610.30	168.60			
	610.40	224.80		660	
	610.50	280.20			
	610.60	336.40		€ 640	
	610.70	392.60		820	
	610.80	448.80			
	610.90	505.00		600++++++++++++++++++++++++++++++++++++	
	611.00	561.20		0 20,000 40,000	
	611.10	618.20		Stor (ac-ft)	
	611.20	675.20			
	611.30	732.20		660	
	611.40	789.30			
	611.50	846.30		€ 640	
	611.60	903.30		à 620	
	611.70	960.30			
	611.80	1017.40		600++++++++++++++++++++++++++++++++++++	
	611.90	1074.40		0 600 1,200	
	612.00	1132.20		Area (acre)	
	612.10	1190.10			
	612.20	1247.90			
	612.30	1306.60			
	612.40	1364.50			
	612.50	1423.10		+	
	0.40.00	1101.00			

Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir       Comerford       Description       Image: Comerford Data         Pool       Pool       Elevation at top of dam (ft)       660.5         Length at top of dam (ft)       2253.0         Composite Release Capacity       Composite Release Capacity         Elevation Bays       Flashboard Bays         640.0 11,750.0       0.0 011,750.0         640.1 11,750.0       11,750.0         640.2 11,750.0       231.0 11,981.0         640.4 11,750.0       231.0 11,981.0         640.4 11,750.0       231.0 11,981.0         640.4 11,750.0       11,981.0         640.5 11,750.0       12,261.0         640.6 11,750.0       12,880.0         641.1 11,750.0       231.0 11,981.0         641.1 11,750.0       12,261.0         641.1 11,750.0       13,059.0         641.1 11,750.0       13,059.0         641.1 11,750.0       13,059.0         641.1 11,750.0       13,059.0         641.1 11,750.0       2,980.0 14,640.0         641.1 11,750.0       2,980.0 14,640.0         641.1 11,750.0       3,260.0 14,956.0         641.1 11,750.0       3,280.0 15,600.0         641.1 11,750.0       4,583.0 16,641.0         641.1 11,750.0       4,583.0	Reservoir Edit Dam	
Comerford Pool Pool Power Plant Stanchion Bays Flashboard Bays Composite Release Capacity Elevation at top of dam (ft) 660.5 Length at top of dam (ft) 2253.0 Composite Release Capacity Elevation Controll Uncontr Total (rt) (cfs) (cfs) (cfs) (650 640.0 11,750.0 0.0 11,750.0 640.1 11,750.0 0.0 11,750.0 640.2 11,750.0 119.0 11,869.0 640.3 11,750.0 231.0 11,981.0 640.4 11,750.0 357.0 12,407.0 640.5 11,750.0 1,085.0 12,283.0 640.9 11,750.0 1,095.0 12,283.0 640.9 11,750.0 1,095.0 12,283.0 641.0 11,750.0 1,095.0 12,283.0 641.1 11,750.0 2,051.0 13,801.0 641.2 11,750.0 2,051.0 13,801.0 641.2 11,750.0 2,281.0 14,956.0 641.1 11,750.0 2,281.0 14,956.0 641.1 11,750.0 2,281.0 14,956.0 641.2 11,750.0 2,281.0 14,956.0 641.1 11,750.0 2,281.0 14,956.0 641.1 11,750.0 2,890.0 14,354.0 641.1 11,750.0 2,890.0 14,956.0 641.1 11,750.0 3,820.0 14,956.0 641.1 11,750.0 3,820.0 15,900.0 641.1 11,750.0	Reservoir Comerford	Description
Power Plant       Elevation at top of dam (ft)       660.5         Stanchion Bays       Stanchion Bays         Flashboard Bays       Composite Release Capacity         Elevation (ft)       2253.0         Composite Release Capacity       Elevation (ft)         Elevation (ft)       (cfs)         640.0 11,750.0       0.0 11,750.0         640.1 11,750.0       0.0 11,750.0         640.2 11,750.0       11,980.1         640.3 11,750.0       231.0         640.4 11,750.0       357.0         640.5 11,750.0       12,020.0         640.6 11,750.0       12,020.0         640.6 11,750.0       12,020.0         640.6 11,750.0       130.90.1         640.6 11,750.0       130.90.1         640.6 11,750.0       1,085.0         640.1 11,750.0       1,085.0         640.2 11,750.0       1,085.0         640.4 11,750.0       1,085.0         640.7 11,750.0       1,085.0         641.1 11,750.0       1,085.0         641.1 11,750.0       1,085.0         641.1 11,750.0       2,081.0       13,081.0         641.1 11,750.0       2,081.0       14,074.0         641.1 11,750.0       3,206.0       14,075.0     <		
Stanchion Bays       Composite Release Capacity         Elevation       Controll       Uncontr       Total         (ft)       (cfs)       (cfs)       (cfs)         630.0       11,750.0       0.0       11,750.0       660         640.1       11,750.0       11,750.0       11,750.0       660         640.2       11,750.0       119.0       11,861.0       630       630         640.3       11,750.0       357.0       12,107.0       640.6       640.6       11,750.0       12,0000       Flow         640.4       11,750.0       357.0       12,107.0       640.6       11,750.0       12,0000       Flow       (cfs)         640.6       11,750.0       875.0       12,261.0       640.6       Flow       (cfs)       660       630       630       630.0       Flow       (cfs)       (cfs)       Flow       (cfs)       (cfs)       641.2       11,750.0       875.0       12,429.0       640.6       640.6       640.6       640.7       13,750.0       13,050.0       641.2       13,750.0       13,050.0       641.2       11,750.0       2,2835.0       640.6       641.2       641.2       641.2       11,750.0       2,282.0       14,074.0	Dam Power Plant	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	Stanchion Bays	
640.2       11,750.0       119.0       11,869.0         640.3       11,750.0       231.0       11,981.0         640.4       11,750.0       357.0       12,107.0         640.5       11,750.0       511.0       12,249.0         640.6       11,750.0       875.0       12,625.0         640.7       11,750.0       1,309.0       13,059.0         640.9       11,750.0       1,309.0       13,059.0         641.0       11,750.0       1,792.0       13,297.0         641.1       11,750.0       2,051.0       13,801.0         641.2       11,750.0       2,324.0       14,074.0         641.4       11,750.0       2,289.0       14,648.0         641.5       11,750.0       3,206.0       14,956.0         641.7       11,750.0       3,521.0       15,600.0         641.8       11,750.0       3,850.0       15,600.0		(ft) (cfs) (cfs) (cfs) 660
640.3       11,750.0       231.0       11,981.0       0       120,000         640.4       11,750.0       357.0       12,107.0       Flow         640.5       11,750.0       511.0       12,261.0       (cfs)         640.6       11,750.0       679.0       12,429.0       (cfs)         640.7       11,750.0       875.0       12,625.0       (cfs)         640.9       11,750.0       1,309.0       13,059.0       (cfs)         641.0       11,750.0       1,547.0       13,297.0       (cfs)         641.1       11,750.0       2,051.0       13,801.0       (cfs)         641.2       11,750.0       2,051.0       13,801.0       (cfs)         641.3       11,750.0       2,051.0       13,801.0       (cfs)         641.4       11,750.0       2,051.0       13,801.0       (cfs)         641.5       11,750.0       2,051.0       13,801.0       (cfs)         641.5       11,750.0       2,898.0       14,648.0       (cfs)         641.6       11,750.0       3,206.0       14,956.0       (cfs)         641.6       11,750.0       3,206.0       14,956.0       (cfs)         641.8       11,750		630.0       11,750.0       0.0       11,750.0       ▲       5       650         640.0       11,750.0       0.0       11,750.0       ▲       5       640         640.1       11,750.0       42.0       11,792.0       ■       630       630
640.6       11,750.0       679.0       12,429.0         640.7       11,750.0       875.0       12,625.0         640.8       11,750.0       1,085.0       12,835.0         640.9       11,750.0       1,309.0       13,059.0         641.0       11,750.0       1,547.0       13,297.0         641.1       11,750.0       1,792.0       13,542.0         641.2       11,750.0       2,051.0       13,801.0         641.3       11,750.0       2,324.0       14,074.0         641.4       11,750.0       2,604.0       14,354.0         641.5       11,750.0       2,898.0       14,648.0         641.6       11,750.0       3,206.0       14,956.0         641.7       11,750.0       3,850.0       15,600.0         641.8       11,750.0       3,850.0       15,600.0		640.3         11,750.0         231.0         11,981.0         0         120,000           640.4         11,750.0         357.0         12,107.0         Flow
640.9       11,750.0       1,309.0       13,059.0         641.0       11,750.0       1,547.0       13,297.0         641.1       11,750.0       1,792.0       13,542.0         641.2       11,750.0       2,051.0       13,801.0         641.3       11,750.0       2,324.0       14,074.0         641.4       11,750.0       2,898.0       14,648.0         641.5       11,750.0       3,206.0       14,956.0         641.6       11,750.0       3,521.0       15,271.0         641.8       11,750.0       3,850.0       15,600.0         641.9       11,750.0       4,193.0       15,943.0		640.6 11,750.0 679.0 12,429.0
641.1       11,750.0       1,792.0       13,542.0         641.2       11,750.0       2,051.0       13,801.0         641.3       11,750.0       2,324.0       14,074.0         641.4       11,750.0       2,604.0       14,354.0         641.5       11,750.0       2,898.0       14,648.0         641.6       11,750.0       3,206.0       14,956.0         641.7       11,750.0       3,521.0       15,271.0         641.8       11,750.0       3,850.0       15,600.0         641.9       11,750.0       4,193.0       15,943.0		640.9 11,750.0 1,309.0 13,059.0
641.4       11,750.0       2,604.0       14,354.0         641.5       11,750.0       2,898.0       14,648.0         641.6       11,750.0       3,206.0       14,956.0         641.7       11,750.0       3,521.0       15,271.0         641.8       11,750.0       3,850.0       15,600.0         641.9       11,750.0       4,193.0       15,943.0		641.1 11,750.0 1,792.0 13,542.0 641.2 11,750.0 2,051.0 13,801.0
641.7         11,750.0         3,521.0         15,271.0           641.8         11,750.0         3,850.0         15,600.0           641.9         11,750.0         4,193.0         15,943.0		641.4         11,750.0         2,604.0         14,354.0           641.5         11,750.0         2,898.0         14,648.0
		641.7 11,750.0 3,521.0 15,271.0 641.8 11,750.0 3,850.0 15,600.0

Figure 4: Reservoir Editor: Physical Tab -- Dam

## III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Comerford's "Existing Ops" operational zones, which consist of zones of Top of dam (660.5 ft), Below Top of dam (650 ft), Conservation (635-648 ft), and Inactive zone (624 ft)<sup>1</sup>.

Reservoir Editor	e .		~~~	×
Reservoir Edit Operations Zone Rule IF_Blo	ck			
Reservoir Comerford    Desc	cription			K 1 20 of 74 H
Physical Operations Observed Data				
Operation Set Existing Ops	▼ Description			
Zone-Rules Rel. Alloc. Outages Stor. C	redit Dec. Sched. Proje	cted Elev		
Top of Dam Provide the second seco	Storage Zone Conserva	tion Desc	ription	
Min Flow	Function of Date			Define
imenter de la Bassispawning	Date	Top Elevation (ft)	665	
Min Flow	01Jan 01Apr	635.0 645.0	660	
im-{} Bass spawning ▲ Inactive	01Jul 01Sep	648.0 648.0		
			€ 650 € 645 5 640 3 640 3 635	
			630 -	
			625	
			_ ← Jan Mar May	Jul Sep Nov
	Zone Sort Elevation			
			ОКСС	ancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

## **B. Rule Illustrations**

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>21</sup>.

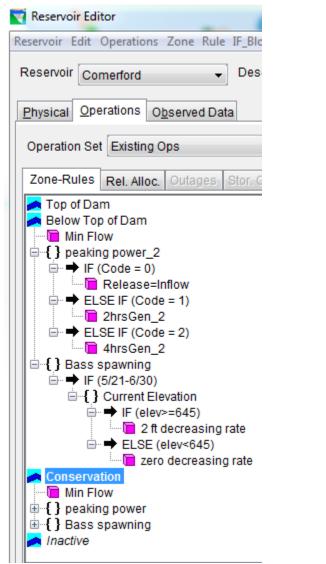


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>&</sup>lt;sup>21</sup> TransCanada. Connecticut River Operational Constraints. 2012.

# **C.** Rule Descriptions

#### 1. Min Flow

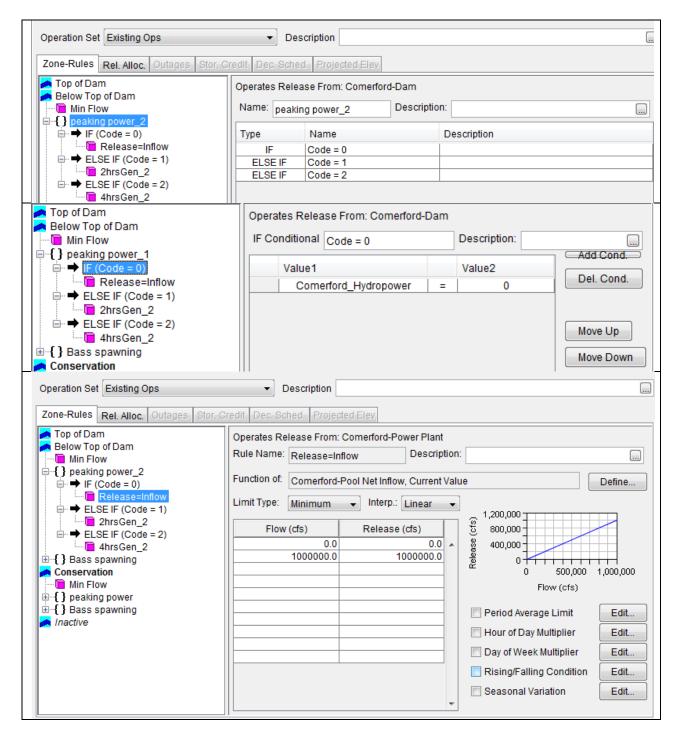
Figure 7 shows the content of "Min Flow" rule. This rule shows the minimum release from dam.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>			
Zone-Rules Rel. Alloc. Outages Stor. C	redit Dec. Sched. Proje	cted Elev		
Top of Dam Below Top of Dam Min Flow → IF (Code = 0) Code = 0) Code = 0 Code = 1) Code = 1) Code = 1) Code = 1) Code = 2) Code = 2)	Operates Release From Rule Name: Min Flow Function of: Date Limit Type: Minimum Date 01Jan 01Apr 01Jun 01Oct	Comerford-Dam Descript Interp.: Step Release (cfs) 1145.0 1635.0 818.0 1145.0	1,600     1,400     9     1,200     9     1,200     9     1,000     9     1,000     9     800	Define
			<ul> <li>Period Average</li> <li>Hour of Day Mul</li> <li>Day of Week Mu</li> <li>Rising/Falling C</li> <li>Seasonal Variation</li> </ul>	tiplier Edit Itiplier Edit Condition Edit

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow

#### **2.** Peaking power\_2

Figure 8 shows the content of "peaking power\_2" rule. This rule represents the peaking power strategy applied for Comerford dam.



Operation Set Existing Ops	✓ Description		
Zone-Rules Rel. Alloc. Outages Stor. C	redit Dec. Sched. Projected Elev		
Top of Dam	Operates Release From: Comerford-Pow ELSE IF Conditional Code = 1	ver Plant Description:	
□···{} peaking power_2 □··· <b>→</b> IF (Code = 0)	Value1	Value2	Add Cond.
■ Release=Inflow ■ ELSE IF (Code = 1) ■ 2hrsGen_2 ■ ELSE IF (Code = 2)	Comerford_Hydropower	= 1	Del. Cond.
☐ 4hrsGen_2 ☐ {} Bass spawning ☐ Conservation			Move Up
Operation Set Existing Ops	✓ Description		
Zone-Rules Rel. Alloc. Outages Stor. C	redit Dec. Sched. Projected Elev		
Top of Dam Below Top of Dam Min Flow Flow Flow Flow ELSE IF (Code = 0) Flow ELSE IF (Code = 1) Flow Flow Conservation Min Flow Flo	Operates Release From: Comerford-Pow Hydropower - Power Guide Curve Rule Description:	PhrsGen_2	ctor (%)
Operation Set Existing Ops	✓ Description		
Zone-Rules Rel. Alloc. Outages Stor. C	redit Dec. Sched. Projected Elev		
<ul> <li>Top of Dam</li> <li>Below Top of Dam</li> <li>Min Flow</li> </ul>	Operates Release From: Comerford-Pow ELSE IF Conditional Code = 2	Description:	
<pre></pre>	Value1 Comerford_Hydropower	Value2 = 2	Add Cond. Del. Cond.
← AhrsGen_2 ⊕ { } Bass spawning Conservation			Move Up

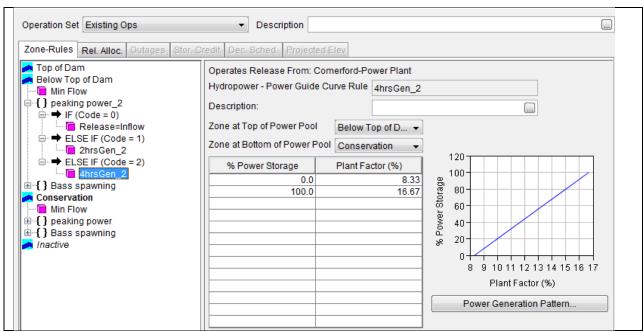


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – peaking power\_2

Figure 9 describes the definition of codes used in the Comerford\_Volume state variable. The code is summing up the current Inflow and previous storage in each time step, compare it to the volume needed for generating 2 and 4 hours power and to the spillway storage minus inactive storage and then decide how much to release.

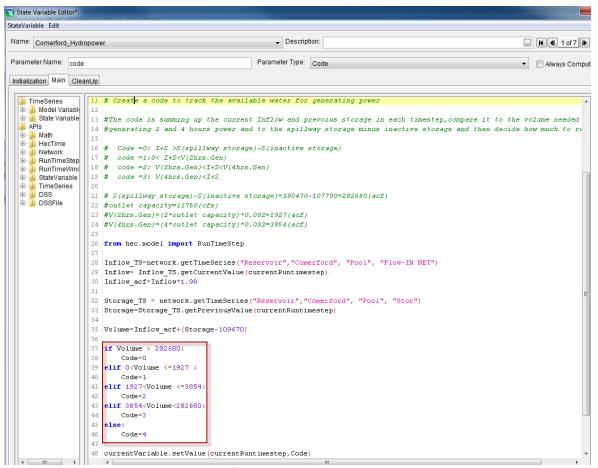


Figure 9: State Variable Editor: Comerford\_Volume

## 3. Bass spawning

Figure 10 shows the content of "Bass spawning" rule. This rule shows the different maximum elevation rate of change for elevations greater and less than 645 feet during 21May-30June.

Operation Set Existing Ops	▼ D	escription			
Zone-Rules Rel. Alloc. Outages Stor. C	redit Dec. Sch	ed. Projected Elev			
Top of Dam Below Top of Dam	Operates Rel	ease From: Comerford-	Power P	lant	
Min Flow	IF Conditiona	al 5/21-6/30	D	escription:	
<pre></pre>	Value			Value2	Add Cond.
	AND	Current Time Step Current Time Step	>=	21May 30Jun	Del. Cond.
<ul> <li>→ IF (elev&gt;=645)</li> <li>2 ft decreasing rate</li> <li>→ ELSE (elev&lt;645)</li> <li>2 ero decreasing rate</li> <li>Conservation</li> <li>Min Flow</li> <li>→ {} peaking power</li> <li>→ {} Bass spawning</li> <li>Inactive</li> </ul>	Logical Ope Value 1 Co Operator Value 2 Co	nstant v			Move Up Move Down Evaluate
Operation Set Existing Ops		escription			
Zone-Rules Rel. Alloc. Outages Stor. C					
selow Top of Dam	·	ease From: Comerford	Descript		
Min Flow Image: The second	Name: Curr		Descript		
⊟…{} Bass spawning □··· ➡ IF (5/21-6/30)	Type	Name elev>=645		Description	
	ELSE	elev<645			
Conservation     Min Flow     How     Hin Flow     Hin Flow					

Zone-Rules Rel. Alloc. Outages Stor. Cred			
Zone-Rules Rel. Alloc. Outages Jator. Cred	dit Dec. Sched. Projected Elev		
Below Top of Dam Min Flow → {} peaking power_2 → {} Bass spawning → IF (5/21-6/30) → {F (elev>=645) ↓ ↓ ↓ f (elev>=645) ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓	Operates Release From: Comerford-Powe         IF Conditional       elev>=645         Value1       Comerford-Pool:Elevation         Comerford-Pool:Elevation       >         Logical Operator:          Value 1       Constant          Operator          Value 2       Constant	er Plant Description: Value2 = 645	 Add Cond. Del. Cond. Move Up Move Down Evaluate
Below Top of Dam Min Flow + } peaking power_2 + } Bass spawning + F (5/21-6/30) - + F (elev>=645) - + F (elev>=645) - + ELSE (elev<645) - + ELSE (elev<645) - + ELSE (elev<645) - + ELSE (elev<645) - + + + + + + + + + + + + + + + + + + +	Description     Descripti	•	

Operation Set Existing Ops	<ul> <li>Description</li> </ul>	
Zone-Rules Rel, Alloc, Outages Stor, C	redit, Dec. Sched. Projected Elev.	
Top of Dam		
Below Top of Dam	Operates Release From: Comerford	
Min Flow	ELSE Conditional elev<645 Description:	
<pre></pre>		
Grant Elevation		
IF (elev>=645)		
□ 2 ft decreasing rate □ → ELSE (elev<645)		
2 zero decreasing rate		
Conservation		
Min Flow		
👝 Inactive		
Operation Set Existing Ops	Description	
Zone-Rules Rel. Alloc. Outages Stor. C	redit Dec. Sched. Projected Elev	
左 Top of Dam	Operates Release From: Comerford	
Below Top of Dam	Elevation Rate of Change Limit zero decreasing rate	
<pre></pre>	Description	
E { Current Elevation	Function Of. Constant	
□ ➡ IF (elev>=645)	Type Decreasing -	
□ 2 ft decreasing rate □ → ELSE (elev<645)	Instantaneous	
🔤 zero decreasing rate	Period Average	
Conservation		
	Max Rate of Change (ft/hr) 0.0	
⊞…{ } Bass spawning		
📩 Inactive		

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Bass spawning

## **Conant Brook**

#### I. Overview

Designed and constructed by the United States Army Corps of Engineers, this dam reduces flooding along the Quaboag, Chicopee, and Connecticut rivers. Construction of the project began in 1964 with completion in 1966. The Conant Brook Dam is located within the Chicopee River watershed. Unlike the other Corps operated flood control dams, Conant Brook is a completely uncontrolled structure..

Figure 1 shows the location of Conant Brook Dam as it is represented in the HEC-ResSim model. Figure 2 shows an aerial photo of the dam.

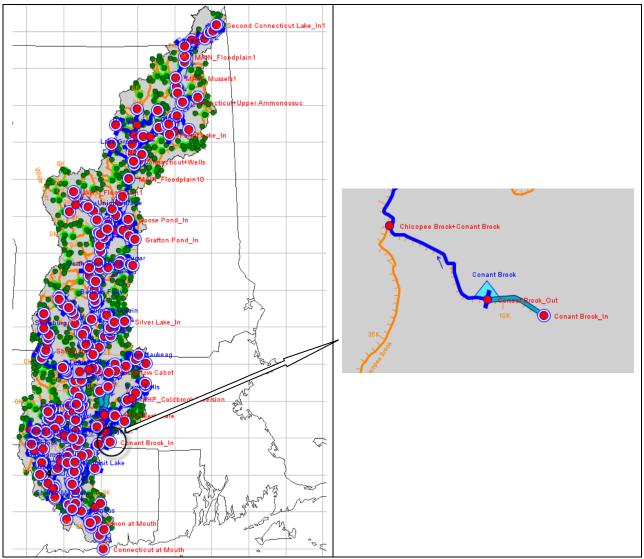


Figure 1: HEC-ResSim Map Display Showing Location of Conant Brook



Figure 2: Aerial photo of Conant Brook Dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of an uncontrolled spillway and uncontrolled 36-inch un-gated conduit as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>22</sup>.

<sup>&</sup>lt;sup>22</sup> http://rsgisias.crrel.usace.army.mil/nae/cwms\_map.map\_index

Physical Operations         Observed Data           Conant Brook         Conant Brook-Pool           Oam         Solution           Solution         Solution           Spillway         Conant Brook-Pool           Image: Spillway         Interpolation           Image: Spillway         Conant Brook-Pool           Image: Spillway         Elevation           Spillway         Spillway           Image: Spillway         Spillway           Image: Spillway         Conant Brook-Pool           Image: Spillway         Conant Brook-Pool           Image: Spillway         Spillway           Image: Spill	Reservoir Edit Pool				
Conant Brook         Conant Brook           Opam         Opam         Interpolation         Initial Conic Depth (ft)           Opam         Opam         Opam         Opam         Initial Conic Depth (ft)           Elevation         Storage         Area         Opam         Opam           (ft)         Gestore         Initial Conic Depth (ft)         Initial Conic Depth (ft)           Elevation         Storage         Area         Opam         Opam           0693.00         0.00         0.00         Initial Conic Depth (ft)         Initial Conic Depth (ft)           0693.00         0.00         1.00         Initial Conic Depth (ft)         Initial Conic Depth (ft)           0700         0.00         0.00         Initial Conic Depth (ft)         Initial Conic Depth (ft)           0700         0.00         0.00         0.00         Initial Conic Depth (ft)         Initial Conic Depth (ft)           0700         0.00         0.00         0.00         Initial Conic Depth (ft)         Initial Conic Depth	Reservoir Conant Brook 🔹	Description			K 4 52 of 74 D
Economic block of           Dam         36-Inch Ungated Conduit           Image: Spillway         Linear Interpolation         Conic Interpolation           Image: Interpolation interpolation         Initial Conic Depth (ff)           Image: Interpolation interpolation interpolation         Initial Conic Depth (ff)           Image: Interpolation interpolation interpolation interpolation         Initial Conic Depth (ff)           Image: Interpolation interpolation interpolation interpolation interpolation interpolation interpolation         Initial Conic Depth (ff)           Image: Interpolation interpolatin interpolation interpolation interpolation interpolati	Physical Operations Observed Data	а			
Dam         Dam           Spillway         Initial Conic Depth (ft)           Elevation         Storage           (ft)         (ac-ft)           693.00         0.00           693.00         0.00           693.00         0.00           693.00         1.00           693.00         0.00           694.00         1.00           699.00         2.00           699.00         20.00           699.00         20.00           699.00         20.00           700.00         24.00           700.00         24.00           700.00         15.00           705.00         100.00           705.00         100.00           705.00         100.00           709.00         21.00           709.00         210.00           709.00         210.00           709.00         210.00           709.00         210.00           700.00         31.00           711.00         270.00           710.00         28.00           710.00         28.00           710.00         28.00           710.00		Conant Brook-Pool			
Elevation         Storage         Area           (ft)         (ac-ft)         (acre)           693.00         0.00         0.00           694.00         1.00         1.00           695.00         4.00         2.00           698.00         16.00         5.00           699.00         20.00         6.00           699.00         20.00         6.00           700.00         24.00         8.00           700.00         24.00         8.00           700.00         24.00         11.00           700.00         15.00         15.00           706.00         125.00         23.00           706.00         125.00         23.00           700.00         240.00         31.00           709.00         210.00         29.00           711.00         240.00         31.00           711.00         270.00         34.00	Dam 36-Inch Ungated Conduit	Linear Interpol	lation 💿 Coni	cInterpolation Init	tial Conic Depth (ft)
1         1	Spillway	Elevation	Storage	Area	]
694.00         1.00         1.00           695.00         4.00         2.00           696.00         8.00         3.00           697.00         12.00         4.00           698.00         16.00         5.00           699.00         20.00         6.00           700.00         24.00         8.00           701.00         28.00         11.00           702.00         40.00         15.00           705.00         100.00         21.00           706.00         125.00         23.00           700.00         24.00         31.00           709.00         210.00         29.00           711.00         240.00         31.00           711.00         270.00         32.00		(ft)	(ac-ft)	(acre)	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		693.00	0.00	0.00	
695.00         4.00         2.00           696.00         8.00         3.00           697.00         12.00         4.00           698.00         16.00         5.00           699.00         20.00         6.00           700.00         24.00         8.00           701.00         28.00         11.00           702.00         40.00         15.00           704.00         80.00         19.00           705.00         100.00         21.00           706.00         125.00         23.00           7070.00         150.00         25.00           709.00         210.00         29.00           700.00         240.00         31.00           711.00         270.00         32.00           711.00         270.00         34.00		694.00	1.00	1.00	760
0000000         00000         00000         00000           6997.00         12.00         4.00         6           699.00         20.00         6.00         5.00           699.00         20.00         6.00         700           700.00         24.00         8.00         11.00           702.00         40.00         15.00         700           704.00         80.00         19.00         700           705.00         100.00         21.00         740           706.00         125.00         23.00         700           708.00         180.00         27.00         700           709.00         210.00         29.00         700           711.00         270.00         31.00         40.80         120.16           Area (acre)         712.00         31.00         34.00         100		695.00	4.00	2.00	
689.00         20.00         6.00           700.00         24.00         8.00           701.00         28.00         11.00           702.00         40.00         15.00           704.00         80.00         19.00           705.00         100.00         21.00           706.00         125.00         23.00           7070.00         150.00         25.00           708.00         180.00         27.00           709.00         210.00         29.00           711.00         270.00         31.00           711.00         270.00         34.00		696.00	8.00	3.00 _	
689.00         20.00         6.00           700.00         24.00         8.00           701.00         28.00         11.00           702.00         40.00         15.00           704.00         80.00         19.00           705.00         100.00         21.00           706.00         125.00         23.00           7070.00         150.00         25.00           708.00         180.00         27.00           709.00         210.00         29.00           711.00         270.00         31.00           711.00         270.00         34.00				4.00	E 720
689.00       20.00       6.00         700.00       24.00       8.00         701.00       28.00       11.00         702.00       40.00       15.00         704.00       80.00       19.00         705.00       100.00       21.00         706.00       125.00       23.00         7070.00       150.00       25.00         708.00       180.00       27.00         709.00       210.00       29.00         711.00       270.00       31.00         711.00       31.00       34.00					
701.00         28.00         11.00           702.00         40.00         15.00           703.00         60.00         17.00           705.00         100.00         21.00           706.00         125.00         23.00           7070.00         150.00         25.00           7070.00         150.00         27.00           7070.00         240.00         31.00           711.00         270.00         32.00           711.00         31.00         34.00					700-
101.00     20.00     11.00       102.00     40.00     15.00       100.00     15.00     10.00       100.00     100.00     17.00       100.00     100.00     19.00       100.00     100.00     21.00       100.00     125.00     23.00       100.00     15.00     25.00       100.00     21.00     29.00       100.00     210.00     29.00       100.00     210.00     31.00       110.00     270.00     32.00       111.00     270.00     32.00       112.00     310.00     34.00					
703.00         60.00         17.00           704.00         80.00         19.00           705.00         100.00         21.00           707.00         150.00         23.00           707.00         150.00         25.00           709.00         210.00         29.00           711.00         270.00         31.00           712.00         310.00         34.00					
704.00         80.00         19.00           705.00         100.00         21.00           707.00         125.00         23.00           707.00         150.00         25.00           708.00         180.00         27.00           709.00         210.00         29.00           711.00         270.00         32.00           712.00         310.00         34.00					Stor (ac-ft)
705.00         100.00         21.00           706.00         125.00         23.00           707.00         150.00         25.00           708.00         180.00         27.00           709.00         210.00         29.00           711.00         270.00         31.00           712.00         310.00         34.00					760
100.00         125.00         23.00           706.00         125.00         23.00           707.00         150.00         25.00           708.00         180.00         27.00           700.00         210.00         29.00           710.00         240.00         31.00           712.00         310.00         34.00					740
708.00         180.00         27.00           709.00         210.00         29.00           710.00         240.00         31.00           711.00         270.00         32.00           712.00         310.00         34.00					£ 140
708.00         180.00         27.00           709.00         210.00         29.00           710.00         240.00         31.00           711.00         270.00         32.00           712.00         310.00         34.00					2 720
709.00         210.00         29.00           710.00         240.00         31.00           711.00         270.00         32.00           712.00         310.00         34.00					<sup>™</sup>
710.00         240.00         31.00         0         40         80         120         16           711.00         270.00         32.00         Area (acre)					
711.00         240.00         31.00           711.00         270.00         32.00           712.00         310.00         34.00					
712.00 310.00 34.00					
					Area (acre)
713.00 345.00 35.00					
713.00 345.00 35.00 714.00 380.00 36.00 +					
		714.00	300.00	50.00 +	

Figure 3: Reservoir Editor -- Physical Tab -- Pool

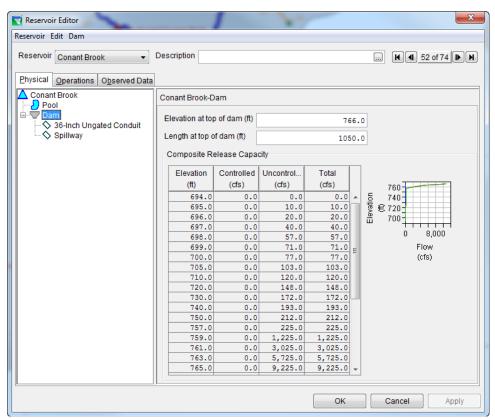


Figure 4: Reservoir Editor -- Physical Tab -- Dam

## III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Conant Brook's "Existing Ops" operational zones, which consist of the zones Flood Control (757 ft), Conservation (696 ft), and Inactive (694 ft).

Reservoir Editor			~		×
Reservoir Edit Operations Zor	ne Rule IF_Block				
Reservoir Conant Brook	✓ Description				4 52 of 74 ▶ ▶
Physical Operations Observed	rved Data				
Operation Set Existing Ops	▼ De	escription			
Zone-Rules Rel. Alloc. Ou	utages Stor. Credit Dec. S	ched. Projected Elev			
Flood Control	Storage Zone Conservation	Descri	iption		
	Function of Date				Define
	Date 01Jan 0	Top Elevation (ft) 69	6	760 750 740 730 720 710 700 690 Jan Mar May Jul	Sep Nov
	Zone Sort Elevation				
				OK Cance	el Apply

Figure 5: Reservoir Editor -- Operations Tab – Existing OpSet

## **B.** Rule Illustrations

The operation set for Conant Brook has no operating rules making it a through flow reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

## **Crescent Street**

#### I. Overview

Crescent Street dam is a dam on the Millers River in Athol, MA. It is owned and operated by the L.S. Starrett Company and is used for hydropower generation.

Figure 1 shows the location of Crescent Street Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the dam.

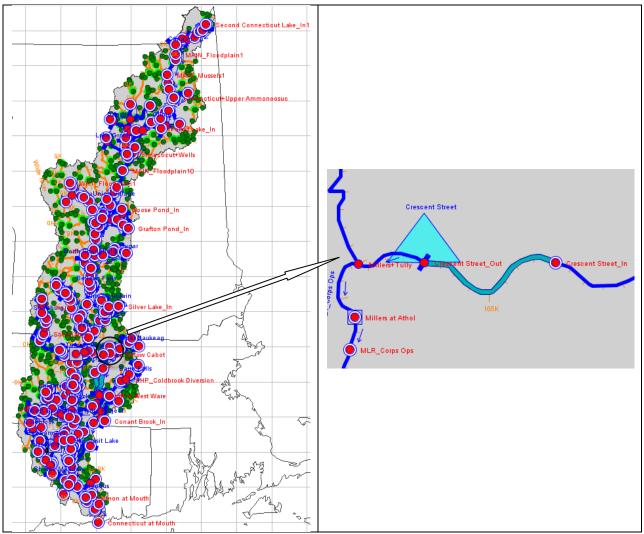


Figure 1: HEC-ResSim Map Display Showing Location of Crescent Street Dam



Figure 2: Photo of Crescent Street Dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>23</sup>. The dam consists of three types of outlets: (1) an uncontrolled Main spillway, (2) an uncontrolled outlet, and (3) a power plant as shown in Figure 4. The power plant has a maximum capacity of 510 cfs. The dam has a constant tailwater elevation of 523.4 feet.

<sup>&</sup>lt;sup>23</sup> National Dam Inspection Program. Phase I Inspection Report. 1972.

teservoir Edit Pool	·			
Reservoir Crescent Street	<ul> <li>Description</li> </ul>			K 4 60 of 74 b H
Physical Operations Observed	Data			
Crescent Street	Crescent Street-P	ool		
Dam Tailwater	Linear Interp	olation 💿 Cor	ic Interpolation	Initial Conic Depth (ft)
Main spillway	Elevation	Storage	Area	
Power Plant Uncontrolled Outlet	(ft)	(ac-ft)	(acre)	
	522.00	100000.00	0.00	
	530.00	100004.00	1.00	550
	538.30	100022.00	3.50	545
	540.00	100025.00	4.00	_ 540
	541.30	100035.00	5.00	€ 535
	549.30	100087.00	8.00	à 530 -
				525 -
				520 + + + + + + + + + + + + + + + + + + +
				Stor (ac-ft)
				545
				540
				€ 535
				≜ 530 -
				<sup>w</sup> 525 -
				520
				0 1 2 3 4 5 6 7 8
				Area (acre)
			ОК	Cancel Apply

Figure 3: Reservoir Editor -- Physical Tab -- Pool

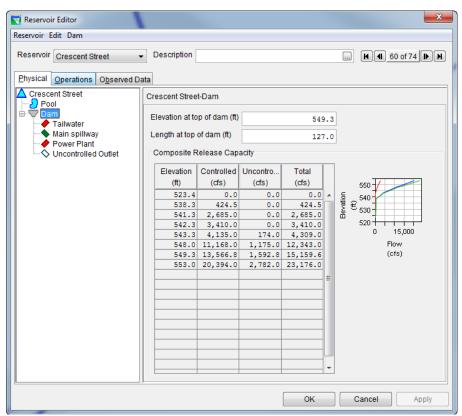


Figure 4: Reservoir Editor -- Physical Tab -- Dam

## III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Crescent Street Dam's "Guide Curve" operational zones, which consist of the zones Top of Dam (549 ft), Flood Control (542.3 ft), Conservation (538.3 ft), and Inactive (523.4 ft)<sup>1</sup>.

Reservoir Editor
Reservoir Edit Operations Zone Rule IF_Block
Reservoir Crescent Street   Description
Physical Operations Observed Data
Operation Set Guide Curve   Description
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev
Top of Dam       Storage Zone Conservation       Description         Flood Control       Function of Date       Define         Date       Top Elevation (ft)
01Jan     538.3       540       540       530       520       Jan Mar May Jul Sep Nov
Zone Sort Elevation
OK Cancel Apply

5: Reservoir Editor -- Operations Tab – Guide Curve OpSet

## **B. Rule Illustrations**

The operation set for Crescent Street Dam has no operating rules, making it a through flow reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity

# Crystal Lake

#### I. Overview

Crystal Lake dam is located in the town of Enfield, NH and flows into the Mascoma River. The dam is maintained and operated by the State of New Hampshire Water Resources Board and is used primarily to provide a recreational lake with some flood control benefits.

Figure 1 shows the location of Crystal Lake as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Crystal Lake.

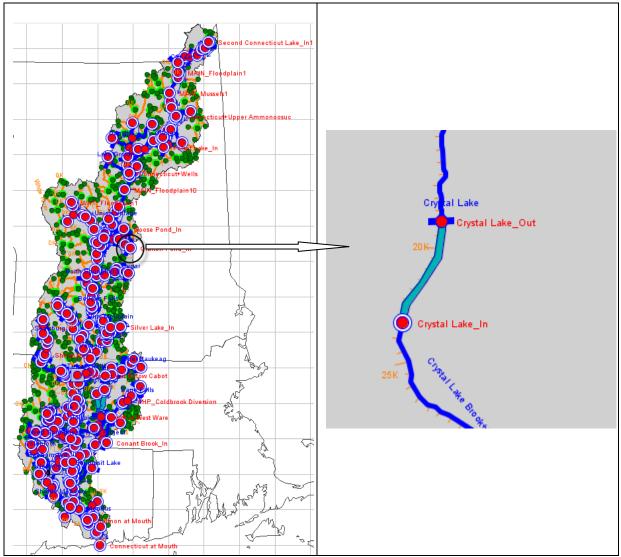


Figure 1: HEC-ResSim Map Display Showing Location of Crystal Lake



Figure 2: Photo of Crystal Lake

#### II. **Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>24</sup>. The dam consists of two types of outlets: (1) uncontrolled stoplogs, (2) uncontrolled spillway as shown in Figure 4<sup>25</sup>.

 <sup>&</sup>lt;sup>24</sup>NHSDam Data Sheet. Crystal Lake. 2006.
 <sup>25</sup> National Dam Inspection Program. Phase I Inspection Report: Crystal Lake Dam. 1978

Reservoir Editor Reservoir Edit Pool			-	
Reservoir Crystal Lake	Description			K 4 27 of 74 D H
	ed Data			
Crystal Lake	Crystal Lake-Pool			
Dam	Linear Interpol	ation 🔘 Conic I	nterpolation Init	ial Conic Depth (ft)
Stoplogs removed	Elevation	Storage	Area	
Spillway	(ft)	(ac-ft)	(acre)	
	887.20	0.00	300.00	
	887.40	69.60	304.80	898
	887.60	139.20	309.60	896
	887.80	208.80	314.40	€ 902-
	888.00	278.40	319.20	€ 892
	888.20	348.00	324.00	888
	888.40	417.60	328.80	886
	888.60	487.20	333.60	0 1,500 3,000
	888.80	556.80	338.40	Stor (ac-ft)
	889.00	626.40	343.20	898
	889.20	696.00	348.00	896
	889.40	765.60	352.80	894
	889.60	835.20	357.60	€ 892
	889.80	904.80	362.40	€ 892
	890.00	974.40	367.20	888
	890.20	1044.00	372.00	886
	890.40	1113.60	376.80	320 360 400 440
	890.60	1183.20	381.60	Area (acre)
	890.80	1252.80	386.40	
	891.00	1322.40	391.20	
	891.20	1392.00	396.00	7
			ОК	Cancel Apply

Figure 3: Reservoir Editor -- Physical Tab -- Pool

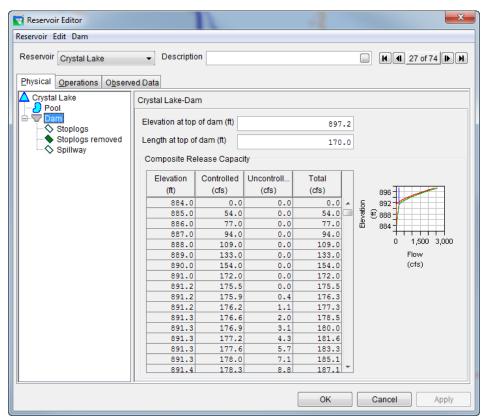


Figure 4: Reservoir Editor -- Physical Tab -- Dam

## III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 4 shows the definition of Crystal Lake's "ExistingOps" operational zones, which consist of the zones Flood Control (897.2 ft), Conservation (887.8-891.8 ft), and Inactive (880.5 ft)<sup>1</sup>.

Reservoir Editor	n l	X
Reservoir Edit Operations Zone	Rule IF_Block	
Reservoir Crystal Lake	✓ Description	K I 27 of 74 D H
Physical Operations Observe	ed Data	
Operation Set Existing Ops	<ul> <li>Description</li> </ul>	
	ges Stor. Credit Dec. Sched. Projected	Elev
Conservation Spring Refill Stoplogs removed Inactive	orage Zone Conservation D Inction of Date Date Top Elevation (ft) 1Jan 887.8 1May 887.8 1Jun 891.8 1Oct 891.8 2Oct 887.8 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	896-
		OK Cancel Apply

Figure 5: Reservoir Editor -- Operations Tab –Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 5 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops.

Reservoir Editor
Reservoir Edit Operations Z
Reservoir Crystal Lake
Physical Operations Obs
Operation Set Existing Op
Zone-Rules Rel. Alloc. (
Flood Control  Stoplogs removed  Conservation  Spring Refill  Stoplogs removed  Inactive

Figure 5: Reservoir Editor -- Operations Tab – Existing Ops OpSet – Zones and Rules

## **C.** Rule Descriptions

#### 1. Stoplogs removed

Figure 6 shows the content of "Stoplogs removed" rule. This rule defines the maximum release from a controlled gate when stoplogs are removed as a function of pool elevation.

Operation Set Existing Ope	S		▼ Desc	ription			
Zone-Rules Rel. Alloc. C	Dutages Sto	r. Credit [	Dec. Sched	. Projecte	d Elev		
Flood Control  Stoplogs removed Conservation  Spring Refill  Stoplogs removed	Operates R Rule Name Function of:	Stoplogs	om: Crystal s removed .ake-Pool E	D	escription:		
Inactive	Limit Type:	Maximur			p.: Linear	•	200
	Elev (ft)	01Jan	30Apr	lease (cfs 01May	110ct	120ct	(j) 160 U 120 W 80
	884.0 885.0 886.0	0.0 54.0 77.0	0.0 54.0 77.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 54.0 77.0	
	887.0 888.0	94.0	94.0 109.0	0.0	0.0	94.0 109.0	884 888 892 896 Elev (ft)
	889.0 890.0 891.0	133.0 154.0 172.0	133.0 154.0 172.0	0.0 0.0 0.0	0.0 0.0 0.0	133.0 154.0 172.0	Period Average Limit
	891.8 893.0	186.0 186.0	186.0 186.0	0.0	0.0 0.0	186.0 186.0	Hour of Day Multiplier     Edit     Day of Week Multiplier     Edit
	894.0 895.0 896.0	186.0 186.0 186.0	186.0 186.0 186.0	0.0 0.0 0.0	0.0 0.0 0.0	186.0 186.0 186.0	Rising/Falling Condition     Edit
	897.0 897.5	186.0 186.0	186.0 186.0	0.0 0.0	0.0	186.0	Seasonal Variation Edit
	•					•	

Figure 6: Reservoir Editor -- Operations Tab – Existing Ops OpSet – Stoplogs removed

#### 2. Spring Refill

Figure 7 shows the content of "Spring Refill" rule. This rule defines the maximum seasonal release as a function of Inflow.

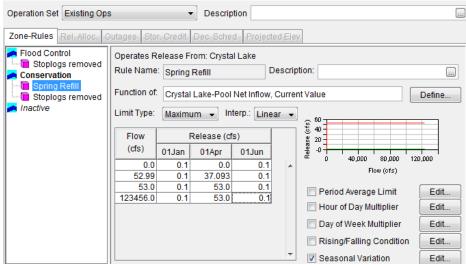


Figure 7 Reservoir Editor: Operations Tab – Existing Ops OpSet – Spring Refill

#### Danville

## I. Overview

Constructed in 1916, Green Mountain Power Corporation (GMP) owns and operates the West Danville Dam and hydroelectric generating facility (Station No. 15) located on Joe's Brook in Caledonia County, Vermont. The dam itself creates Joes Pond.

Figure 1 shows the location of Danville Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Danville Dam.

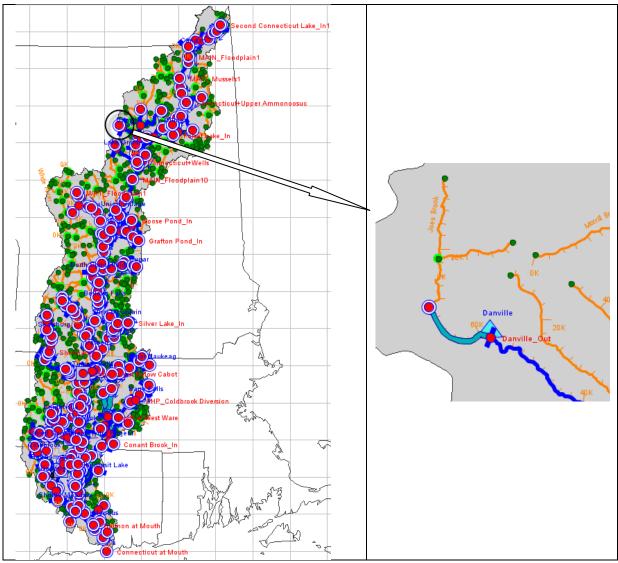


Figure 1 HEC-ResSim Map Display Showing Location of Danville



Figure 2: Photo of Joes Pond, which is impounded by the West Danville Dam

#### **Physical Characteristics** II.

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>26</sup>. The dam consists of two types of outlets: (1) controlled sluice gate, and (2) power plant as shown in Figure 4<sup>1,27</sup>.

 <sup>&</sup>lt;sup>26</sup> National Inventory of Dams database
 <sup>27</sup> Green Mountain Power Corporation. Operating Plan for the West Danville Project. 2005.

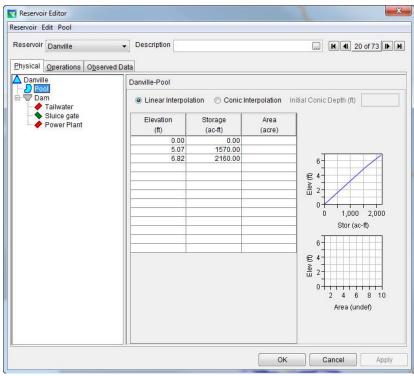


Figure 3: Reservoir Editor -- Physical Tab -- Pool

Reservoir Danville  Physical Qperations Observed  Danville  Pool  Tailwater  Tailwater  Stuice gate  Power Plant	Description           Data           Danville-Dam           Elevation at top of dam           Length at top of dam (ft           Composite Release C           Elevation           (ft)           5.0           5.2           5.4           6.0           6.2           6.4           6.4	apacity Controlled (cfs) 675.0 675.0 678.0 681.0 684.0 687.0 690.0 690.0 692.8	Uncontrolled (cfs) 0.0 0.0 0.0 0.0 0.0 0.0 0.0	14.0 87.0 Total (cfs) 675.0 681.0 684.0 684.0 687.0 682.8	€ € <sup>0.0</sup>
Danville Pool Tailwater Sluice gate	Danville-Dam Elevation at top of dam Length at top of dam (ft Composite Release C Elevation (ft) 50 52 54 56 56 56 60 62 62	apacity Controlled (cfs) 675.0 675.0 678.0 681.0 684.0 687.0 690.0 690.0 692.8	(cfs) 0.0 0.0 0.0 0.0 0.0 0.0	87.0 Total (cfs) 675.0 681.0 681.0 684.0 687.0 687.0 690.0	€ 6.0 5.0 0 300 600 Flow
Pool     Dam     Tailwater     Sluice gate	Elevation at top of dam Length at top of dam (ft Composite Release C Elevation (ft) 50 52 54 56 56 56 60 62 62	apacity Controlled (cfs) 675.0 675.0 678.0 681.0 684.0 687.0 690.0 690.0 692.8	(cfs) 0.0 0.0 0.0 0.0 0.0 0.0	87.0 Total (cfs) 675.0 681.0 681.0 684.0 687.0 687.0 690.0	€ 6.0 5.0 0 300 600 Flow
Tailwater	Length at top of dam (ft Composite Release C (ft) 5.0 5.2 5.4 5.6 5.6 5.6 6.0 6.2 6.2 6.4	apacity Controlled (cfs) 675.0 675.0 678.0 681.0 684.0 687.0 690.0 690.0 692.8	(cfs) 0.0 0.0 0.0 0.0 0.0 0.0	87.0 Total (cfs) 675.0 681.0 681.0 684.0 687.0 687.0 690.0	€ 6.0 5.0 0 300 600 Flow
Sluice gate	Composite Release C Elevation (ft) 5.0 5.2 5.4 5.6 5.6 6.0 6.2 6.2 6.4	apacity Controlled (cfs) 675.0 675.0 681.0 684.0 684.0 687.0 690.0 692.8	(cfs) 0.0 0.0 0.0 0.0 0.0 0.0	Total (cfs) 675.0 681.0 684.0 687.0 687.0 690.0	€ 6.0 5.0 0 300 600 Flow
Power Plant	Elevation (ft) 5.0 5.4 5.6 5.8 6.0 6.2 6.2 6.4	Controlled (cfs) 675.0 678.0 681.0 684.0 687.0 687.0 690.0 692.8	(cfs) 0.0 0.0 0.0 0.0 0.0 0.0	(cfs) 675.0 678.0 681.0 684.0 687.0 690.0	€ 6.0 5.0 0 300 600 Flow
	(ft) 5.0 5.2 5.4 5.6 5.8 6.0 6.2 6.4	(cfs) 675.0 678.0 681.0 684.0 687.0 690.0 692.8	(cfs) 0.0 0.0 0.0 0.0 0.0 0.0	(cfs) 675.0 678.0 681.0 684.0 687.0 690.0	€ 6.0 5.0 0 300 600 Flow
	5.0 5.2 5.4 5.6 5.8 6.0 6.2 6.4	675.0 678.0 681.0 684.0 687.0 690.0 692.8	0.0 0.0 0.0 0.0 0.0 0.0	675.0 678.0 681.0 684.0 684.0 687.0 690.0	€ 6.0 5.0 0 300 600 Flow
	5.2 5.4 5.6 5.8 6.0 6.2 6.4	678.0 681.0 684.0 687.0 690.0 692.8	0.0 0.0 0.0 0.0 0.0	678.0 681.0 684.0 687.0 690.0	0 300 600 Flow
	5.4 5.6 5.8 6.0 6.2 6.4	681.0 684.0 687.0 690.0 692.8	0.0 0.0 0.0 0.0	681.0 684.0 687.0 690.0	0 300 600 Flow
	5.6 5.8 6.0 6.2 6.4	684.0 687.0 690.0 692.8	0.0 0.0 0.0	684.0 687.0 690.0	0 300 600 Flow
	5.8 6.0 6.2 6.4	687.0 690.0 692.8	0.0	687.0 690.0	Flow
	6.0 6.2 6.4	690.0 692.8	0.0	690.0	Flow
	6.2	692.8			
	6.4			092.01	
		COE O	0.0	695.8	(010)
		695.8		695.5	
	6.8	698.5 701.8	0.0	701.8	
	0.0	/01.8	0.0	/01.8	

Figure 4: Reservoir Editor -- Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Danville's "Existing Ops" operational zones, which consist of the zones of Top of dam (6.82 ft), Flood Control (5.3 ft), Conservation (5.07 ft), Min Pool (5 ft), and Inactive zone (4.8 ft)<sup>2</sup>.

		1 ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) (	×			
Reservoir Edit Operations Zone Rule IF_Block						
Reservoir Danville	Reservoir Danville   Description					
Physical Operations Observe	ed Data					
Operation Set Existing Ops	✓ Des	cription				
	ages Stor, Credit Dec. Sch	ed. Projected Elev				
	torage Zone Conservation	Description				
Aquatic Base Flow	unction of Date		Define			
Conservation Bypass Release	Date	Top Elevation (ft)	7.0			
Min pool	, i Jan	5.07	6.5			
			€ 6.0			
			€ 6.0			
			5.0			
		*	Jan Mar May Jul Sep Nov			
Zone Sort Elevation						
			OK Cancel Apply			

Figure 5: Reservoir Editor -- Operations Tab –Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops.

🛒 Reservoir Editor			
Reservoir Edit Operations Z			
Reservoir Danville			
Physical Operations Obs			
Operation Set Existing Op			
Zone-Rules Rel. Alloc. (			
📥 Top of dam			
Flood Control			
Bypass Release			
🔲 Bypass Release			
🔲 🫅 Aquatic Base Flow			
📂 Min pool			
👝 Inactive			

Figure 6: Reservoir Editor -- Operations Tab – Existing Ops OpSet – Zones and Rules

### **C.** Rule Descriptions

#### 1. Bypass Release

Figure 7 shows the content of "Bypass Release" rule. This rule represents a constant 7 cfs release through the sluice gate.

Operation Set Existing Op	s 🔹 🗸	escription					
Zone-Rules Rel. Alloc.	Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev						
Top of dam Flood Control  Sypass Release Conservation  Aquatic Base Flow Conservation  Aquatic Base Flow Min pool Inactive	Operates Release From: Da Rule Name: Bypass Releas Function of: Date Limit Type: Specified Date		7.08 § 7.04				
	01Jan	7.0	x 27.04 37.00 36.96 6.92 Jan Mar May Jul Sep Nov				
			Period Average Limit Edit     Hour of Day Multiplier Edit				
			Day of Week Multiplier				
			Rising/Falling Condition     Edit     Seasonal Variation     Edit				

Figure 7: Reservoir Editor -- Operations Tab – Existing Ops OpSet – Bypass Release

#### 2. Aquatic Base Flow

Figure 8 shows the content of "Aquatic Base Flow" rule. This rule represents the minimum required to be released through power plant.

Operation Set Existing Operation	s 🔹 🗸	escription	
Zone-Rules Rel. Alloc. C	Dutages Stor. Credit Dec. Sc	hed. Projected Elev	
<ul> <li>▲ Top of dam</li> <li>▲ Flood Control</li> <li>▲ Bypass Release</li> <li>▲ Aquatic Base Flow</li> </ul>	Operates Release From: Dar Rule Name: Aquatic Base FI Function of: Date		
Conservation Bypass Release Aquatic Base Flow Min pool	Limit Type: Minimum	Interp.: Linear	
A Inactive	Date 01Jan 14Apr 15Apr 15.lun	Release (cfs) 20.0 20.0 28.0 28.0 28.0	16 Jan Mar May Jul Sep Nov
	16Jun 30Sep 01Oct	14.0 14.0 20.0	Period Average Limit Edit Hour of Day Multiplier Edit
			Day of Week Multiplier     Edit       Rising/Falling Condition     Edit       Seasonal Variation     Edit

Figure 8: Reservoir Editor -- Operations Tab - Existing Ops OpSet - Aquatic Base Flow

## **Deerfield No. 2 Development**

### I. Overview

Deerfield No. 2 Development is located downstream of Shelburne Falls on the Deerfield River and is the closest counting up from confluence with the Connecticut River. It is owned and operated by TransCanada Hydro Northeast Inc. for hydropower generation on a run-of-river basis.

Figure 1 shows the location of Deerfield No. 2 dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo from Deerfield No.2 dam.

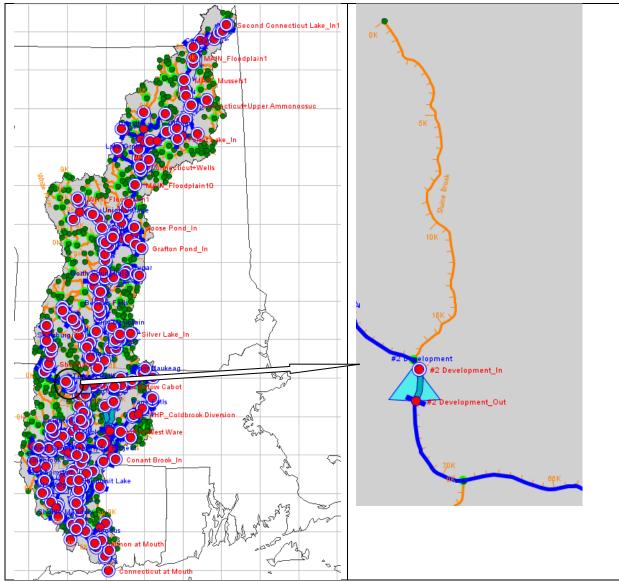


Figure 1: HEC-ResSim Map Display Showing Location of Deerfield No.2

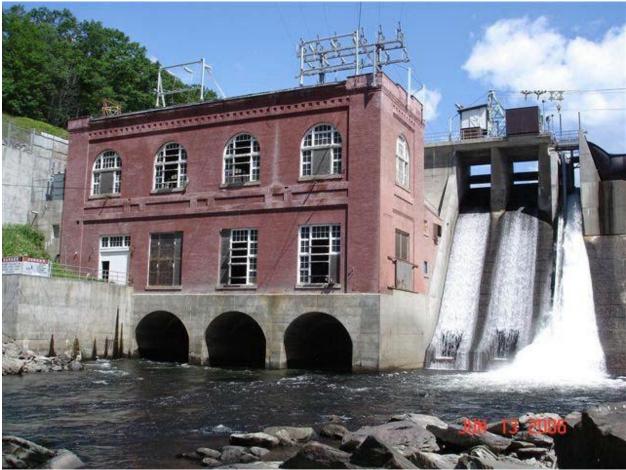


Figure 2: Photo of Deerfield No. 2 Dam

# **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>28</sup>. The dam consists of three types of outlets: (1) controlled spillway, (2) controlled sluice, and power plant as shown in Figure 4 (TransCanada Corporation).

<sup>&</sup>lt;sup>28</sup> Data provided by TransCanada

Reservoir Editor					
Reservoir Edit Pool					
Reservoir #2 Development	Description			K 4 46 of 74 D H	
Physical Operations Observed D	oata				
#2 Development	#2 Development-Pool				
Dam Tailwater	Linear Interpolation	onic Interpolation Initial Coni	ic Depth (ft)		
Power Plant	Elevation	Storage	Area		
Sluice Spillway	(ft)	(ac-ft)	(acre)		
	283.66	100000.00			
	283.76	100060.50			
	283.86	100121.00		296	
	283.96	100181.50		292	
	284.06	100242.00			
	284.16	100302.50		€ 288	
	284.26	100363.00		- 284	
	284.36	100423.50		204	
	284.46	100484.00		100,000 104,000	
	284.56	100544.50		Stor (ac-ft)	
	284.66	100605.00			
	284.76	100665.50		296	
	284.86	100726.00		292	
	284.96	100786.50		e	
	285.06	100847.00			
	285.16	100907.50		<u><u></u> <u>284</u> <u>284</u> <u>284</u></u>	
	285.26	100968.00		284	
	285.36	101028.50		0 100 200	
	285.46	101089.00			
	285.56	101149.50		Area (acre)	
	285.66	101210.00			
	285.76	101270.50			
	285.86	101331.00		+	
<u>I</u>					
OK Cancel Apply					
				Cancer Apply	

Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor					
Reservoir Edit Dam					
Reservoir #2 Development 🗸 Description					
Physical Operations Observed	Data				
A #2 Development	#2 Development-Dam				
Dam Tailwater	Elevation at top of dam (ft)			314.0	6
Power Plant	Length at top of dam (ft)			447.0	D
Spillway	Composite Release Capa	city			
	Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)	
	283.0	1,142.4	0.0	1,142.4	500 200 200 280 0 15.000
	283.6	1,442.4	0.0	1,442.4	≣ € 290
	285.0	2,142.4	0.0	2,142.4	
	290.0	2,142.4	0.0	4,729.9	0 15,000
	298.0	6,642.4	0.0	6,642.4	Flow
	314.6	21,142.4	0.0	21,142.4	(cfs)
OK Cancel Apply					
				UK	Apply Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Deerfield No. 2's "ExistingOps" operational zones, which consist of zones of Top of dam (314.6 ft), Conservation (294.6 ft), Min Pool (283.6 ft), and Inactive zone (283 ft)<sup>1</sup>.

Reservoir Editor						
Reservoir Edit Operations Zone Rule IF_BI	Reservoir Edit Operations Zone Rule IF_Block					
Reservoir #2 Development	scription			46 of 74 🕨 🕅		
Physical Operations Observed Data						
Operation Set ExistingOps	✓ Description					
Zone-Rules Rel. Alloc. Outages Stor.	Credit Dec. Sched. Projected Elev					
Top of dam	Storage Zone Conservation	Description				
Conservation	Function of Date			Define		
Min Flow Logic-#2 Development	Date	Top Elevation (ft)	]			
nactive	01Jan	294.6	315			
			305			
			€ 300- 5 5 5 295- 1 290-			
			285-			
			280			
			Jan Mar May Jul	Sep Nov		
		-	,			
	Zone Sort Elevation					
			OK Cancel	Apply		

Figure 5 Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

Figure 6 shows a sequential release allocation approach specified for available outlets along Buford Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The spillway gets the remainder of the release until it reaches capacity. After the capacity through the spillway is reached, the remainder of the release goes through the sluice gate.

Reservoir Editor				
Reservoir Edit Operations				
Reservoir #2 Development    Description				
Physical Operations Observed Data				
Operation Set ExistingOps   Description				
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev				
Release Allocation Strategy				
Release Location: #2 Development-Dam				
#2 Development-Dam (1.0) - Sequential     Allocation Type:       Sequential				
★ #2 Development-Spillway				
#2 Development-Spillway				
#2 Development-Sluice				

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

### **B. Rule Illustrations**

.

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>29</sup>.

Reservoir Editor				
Reservoir Edit Operations Zone Rule IF_Block				
Reservoir #2 Development				
Physical Operations Observed Data				
Operation Set ExistingOps				
Zone-Rules Rel. Alloc. Outages Stor. Credit				
Top of dam				
Max Power Plant First				
Run of River Hydropower				
i i i i i i i i i i i i i i i i i i i				
Hydropower-Release Inflow     ELSE (Pool Partially Empty)				
Hydropower-Release 95% Inflow				
Min Flow Logic-#2 Development				
in Pool				
🦰 🦰 Inactive				

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>&</sup>lt;sup>29</sup> TransCanada. Deerfield River Operational Constraints. 2012.

# **C.** Rule Descriptions

#### 1. Max Power Plant First

Figure 8 shows the content of "Max Power Plant First" rule. This rule forces the inflow to pass through the power plant first until it reaches the maximum plant capacity.

Reservoir Editor						
Reservoir Edit Operations Zone Rule IF_Block Reservoir #2 Development  Description						
Operation Set ExistingOps Zone-Rules Rel. Alloc. Outages, Stor, Credit.						
Top of dam Max Power Plant First Conservation → [] Run of River Hydropower → IF (Full Pool) ↓ ↓ Hydropower-Release Inflow → ELSE (Pool Partially Empty) ↓ ↓ Hydropower-Release 95% Inflow Min Flow Logic#2 Development Min Pool <i>Inactive</i>	Operates Release From: #2 Development-Power Plant         Rule Name:       Max Power Plant First       Description:         Function of:       #2 Development-Pool Net Inflow, Current Value       Define         Limit Type:       Maximum       Interp.:       Linear         Flow (cfs)       Release (cfs)       800         0.0       0.0       0.0         1142.4       1142.4         123456.0       1142.4         123456.0       1142.4         Hour of Day Multiplier       Edit         Period Average Limit       Edit         Day of Week Multiplier       Edit         Rising/Falling Condition       Edit         Seasonal Variation       Edit					
OK Cancel Apply						

Figure 8 Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Power Plant First

### 2. Run of River Hydropower

Figure 9 shows the content of "Run of River Hydropower" rule. This rule release total inflow through power plant when pool elevation is higher than conservation elevation and 95% of inflow when pool elevation is less than conservation zone as per the run-of-river modeling strategy.

Operation Set ExistingOps	✓ Description	
Zone-Rules Rel. Alloc. Outages Stor.	Credit Dec. Sched. Projected Elev	
<ul> <li>Top of dam</li> <li>Max Power Plant First</li> <li>Conservation</li> <li>→ F (Full Pool)</li> <li>→ Hydropower-Release Inflo</li> <li>→ ELSE (Pool Partially Empty)</li> <li>→ Hydropower-Release 95%</li> <li>Min Flow Logic-#2 Development</li> <li>Min Pool</li> <li>Inactive</li> </ul>	Operates Release From: #2 Development IF Conditional Full Pool Value1 #2 Development-Pool:Elevation	nt-Power Plant       Description:
Operation Set ExistingOps Zone-Rules Rel. Alloc. Outages Stor	Description     Credit Dec. Sched. Projected Elev	
Top of dam     Max Power Plant First     Conservation         → IF (Full Pool)         → ELSE (Pool Partially Empty)         → ELSE (Pool Partially Empty)         → Hydropower-Release 95%     Min Flow Logic-#2 Development     Min Pool	Operates Release From: #2 Development Rule Name: ydropower-Release Inflow Function of: #2 Development-Pool Net I Limit Type: Mi Interp.:	Description:
< III +		0 2,000 4,000 6,000 8,000 10,000 Flow (ofs) Period Average Limit Edit Hour of Day Multiplier Edit Day of Week Multiplier Edit Rising/Falling Condition Edit

Operation Set ExistingOps	▼ Description	
Zone-Rules Rel. Alloc. Outages Stor	. Credit Dec. Sched. Projected Elev	
Top of dam Max Power Plant First	Operates Release From: #2 Develop ELSE Conditional Pool Partially Em	
<ul> <li>☐ Run of River Hydropower</li> <li>☐ IF (Full Pool)</li> <li>☐ Hydropower-Release Inflo</li> <li>☐ ELSE (Pool Partially Empty)</li> <li>☐ Hydropower-Release 95%</li> <li>☐ Min Flow Logic-#2 Development</li> <li>☑ Min Pool</li> <li>☑ Inactive</li> </ul>		ipty
Operation Set ExistingOps	✓ Description	
Zone-Rules Rel. Alloc. Outages Stor	Credit Dec. Sched. Projected Elev	
Top of dam Max Power Plant First	Operates Release From: #2 Develop	
Conservation	Rule Name: Iower-Release 95% Inf	low Description:
IF (Full Pool)	Function of: #2 Development-Pool N	Net Inflow, Current Value Define
Hydropower-Release Inflo → ► ELSE (Pool Partially Empty)	Limit Type: Mi 🗸 Interp.:	ଳ 9,000 <del>]                                     </del>
Min Flow Logic-#2 Development	Flow (cfs) Release (cfs)	
Min Pool	0.0 0.0 ^	
		Flow (cfs)
		Period Average Limit Edit
		Hour of Day Multiplier
		Day of Week Multiplier
	<b></b>	Rising/Falling Condition     Edit     Seasonal Variation     Edit

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Run of River hydropower

### 3. Min Flow Logic#2 Development

Figure 10 shows the content of Min Flow Log#2 Development. This rule represents the minimum flow of 200 cfs from Deerfield #2.

Operation Set ExistingOps	▼ D	escription		
Zone-Rules Rel. Alloc. Outages Stor	. Credit Dec. S	ched. Projected Elev		
Top of dam Max Power Plant First Conservation H Run of River Hydropower H F (Full Pool)	Rule Name: 0	ase From: #2 Development w Logic-#2 Development D vate	escription:	
<ul> <li>Hydropower-Release Inflo</li> <li>ELSE (Pool Partially Empty)</li> <li>Hydropower-Release 95%</li> </ul>		linimum 🗸 Interp.: Linea	r ▼ 202.0 ∯ 201.0 200.0	]
Min Flow Logic-#2 Development Min Pool	Date 01Jan	Release (cfs)	φ 200.0	
			Jan Mar May Jul Sep Nov	Edit
			Hour of Day Multiplier	Edit
				Edit Edit
4 III >			Seasonal Variation	Edit

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic #2 Development

### **Deerfield No. 3 Development**

#### I. Overview

Deerfield No. 3 Development is located on the Deerfield River upstream from Selburne Falls, MA. It is owned and operated by TransCanada Hydro Northeast Inc for hydropower generation on a run-of-river basis.

Figure 1 shows the location of Deerfield No. 3 dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Deerfield No. 3 dam

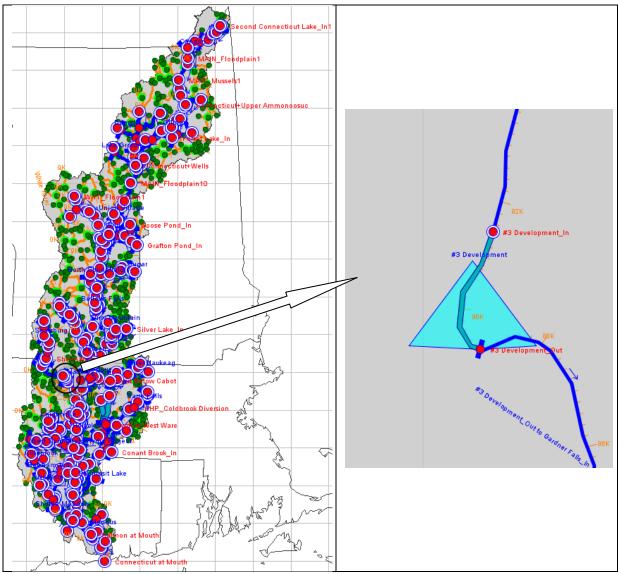


Figure 1: HEC-ResSim Map Display Showing Location of Deerfield No. 3



Figure 2: Photo of Deerfield No. 3 Development

### II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>30</sup>. The dam consists of four types of outlets: (1) controlled sluice, (2) controlled old fish gate, (3) uncontrolled flashboard spillway, and (4) power plant as shown in Figure 4.

<sup>&</sup>lt;sup>30</sup> Data provided by TransCanada

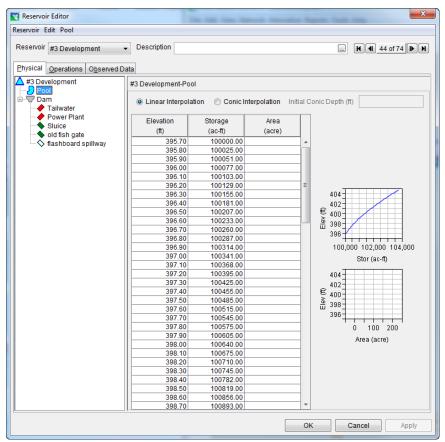


Figure 3: Reservoir Editor: Physical Tab -- Pool

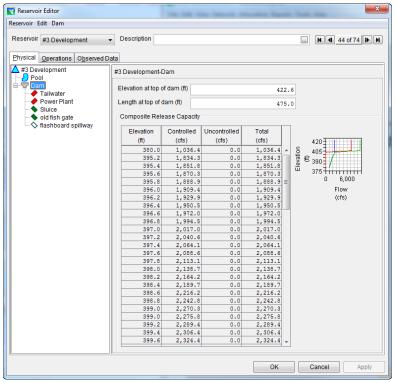


Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Deerfield No. 3's "ExistingOps" operational zones, which consist of zones of Top of dam (422.6 ft), conservation (402.6 ft), Min Pool (399.6 ft), and Inactive zone (370 ft)<sup>1</sup>.

Reservoir Editor		_			×
Reservoir Edit Operations Zone Rule IF_Block					
Reservoir #3 Development	۱ 			K	<b>4</b> of 74 ► ►
Physical Operations Observed Data					
Operation Set ExistingOps	<ul> <li>Description</li> </ul>				
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. Proj	ected Elev			
Top of dam	Storage Zone Co	nservation	De	escription	
Conservation Cons	Function of Date				Define
Min Flow Logic - #3 Development	Date	Top Elevation (ft)		120	
👝 Inactive	01Jan	402.6	<b>^</b>	430	
				410	
				400	
			5	390-	
			ы Барала С Парала	380	
			3	370	
			3	360 + + + +	
			-	Jan Mar May Ju	I Sep Nov
	Zone Sort Elevatio	n			
	]				
			C	OK Canc	el Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

Figure 6 shows a sequential release allocation approach specified for available outlets along Buford Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The sluice gate the remainder of the release until it reaches capacity. After the capacity through the sluice is reached, the remainder of the release goes through the old fish gate.

Reservoir Editor	The last time thematic internation Papersi.							
Reservoir Edit Operations								
Reservoir #3 Development								
Physical Operations Observed Data								
Operation Set ExistingOps	Description							
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. S	Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev							
Release Allocation Strategy								
#3 Development - Balanced #3 Development-Dam (1.0) - Sequential #3 Development-Power Plant #3 Development-Sluice #3 Development-old fish gate	Release Location:       #3 Development-Dam         Allocation Type:       Sequential         #3 Development-Power Plant       #3 Development-Sluice         #3 Development-old fish gate       #3 Development-old fish gate							

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

#### **B. Rule Illustrations**

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>31</sup>.

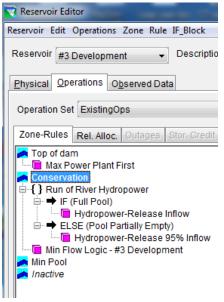


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>&</sup>lt;sup>31</sup> TransCanada. Deerfield River Operational Constraints. 2012.

# **C.** Rule Descriptions

#### 1. Max Power Plant First

Figure 8 shows the content of "Max Power Plant First" rule. This rule forces the inflow to pass through the power plant first until it reaches the maximum plant capacity.

Reservoir #3 Development	on
Physical Operations Observed Data	
Operation Set ExistingOps	Description
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. Projected Elev
<ul> <li>Top of dam</li> <li>Max Power Plant First</li> <li>Conservation         <ul> <li>↓ Run of River Hydropower</li> <li>↓ IF (Full Pool)</li> <li>↓ Hydropower-Release Inflow</li> <li>↓ ELSE (Pool Partially Empty)</li> <li>↓ Hydropower-Release 95% Inflow</li> <li>♪ Min Flow Logic - #3 Development</li> <li>Min Pool</li> <li>↓ Inactive</li> </ul> </li> </ul>	Operates Release From: #3 Development-Power Plant         Rule Name:       Max Power Plant First       Description:         Function of:       #3 Development-Pool Net Inflow, Current Value       Define         Limit Type:       Maxi •       Interp.:       •         Flow (cfs)       Release (cfs)       •       •         -1000.0       0.0       •       •         0       0.0       0.0       •         123456.0       1022.4       1022.4         123456.0       1022.4       •         •       •       •       •         •       •       •       •         •       •       •       •         •       •       •       •         •       •       •       •         •       •       •       •         •       •       •       •         •       •       •       •         •       •       •       •         •       •       •       •         •       •       •       •         •       •       •       •         •       •       •       •

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Power Plant First

### 2. Run of River Hydropower

Figure 9 shows the content of "Run of River Hydropower" rule. This rule release total inflow through power plant when pool elevation is higher than conservation elevation and 95% of inflow when pool elevation is less than conservation zone as per the run-of-river modeling strategy.

Operation Set       ExistingOps         Zone-Rules       Rel. Alloc.       Outages       Stor. Credit.         Top of dam       Top of dam       Stor. Credit.         Top of dam       Max Power Plant First         Conservation       Image: Conservation         F (Full Pool)       Full Pool)         Hydropower-Release Inflow         ELSE (Pool Partially Empty)         Image: Hydropower-Release 95% Inflow         Min Flow Logic - #3 Development         Min Pool         Inactive	Description   Dec. Sched. Projected Elev     Operates Release From: #3 Development-Power Plant   IF Conditional Full Pool   Value1   Value2   #3 Development-Pool:Elevation   >=   402.6   Move Up   Move Down   Fvaluate
Operation Set       ExistingOps         Zone-Rules       Rel. Alloc.       Outages-Stor. Credit         Top of dam       Top of dam         Top of dam       Max Power Plant First         Conservation       -{}         +       F (Full Pool)         +       F (Full Pool)         +       Hydropower-Release Inflow         +       FLSE (Pool Partially Empty)         -       Hydropower-Release 95% Inflow         Min Flow Logic - #3 Development       Min Pool         Inactive       Inactive	Description     Dec. Sched. Projected Elev      Operates Release From: #3 Development-Power Plant      ELSE Conditional Pool Partially Empty Description:

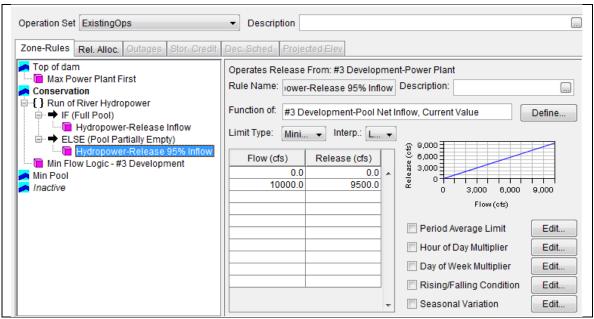


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Run of River hydropower

#### 3. Min Flow Logic#3 Development

This rule represents seasonal minimum flow as represented in Figure 10.

Operation Set ExistingOps	▼ D	escriptio	n				
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched	I. Proje	cted Elev	/			
Top of dam Max Power Plant First Conservation H Run of River Hydropower	Operates R Rule Name			Developn evelopme		iption: Seas	sonal min rules which are accounting for
	Function of: Limit Type:	#3 De Minim			et Inflow, ( erp.: Line	Current Valu ear 🗸	
Hydropower-Release 95% Inflow     Min Flow Logic - #3 Development     Min Pool	Flow (cfs)	01Jan	F 01Apr	Release (o	ts) 15Sep	16Nov	
A Inactive	0.0	0.0		0.0	100.0 100.0	0.0	∝ 0 40,000 80,000 120,000 Flow (cfs)
	123456.0	100.0	100.0	100.0	100.0	<u>100.0</u> ≡	Period Average Limit     Edit     Hour of Day Multiplier     Edit
							Day of Week Multiplier
	•		I	1			Rising/Falling Condition     Edit     Seasonal Variation     Edit

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic #3 Development

### **Deerfield No.4 Development**

#### I. Overview

Deerfield No. 4 Development is located directly downstream of the Highway 2 bridge on the Deerfield River. It is owned and operated by TransCanada Hydro Northeast Inc. for hydropower generation on a run-of-river basis.

Figure 1 shows the location of Deerfield No. 4 dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Deerfield No. 4 dam.

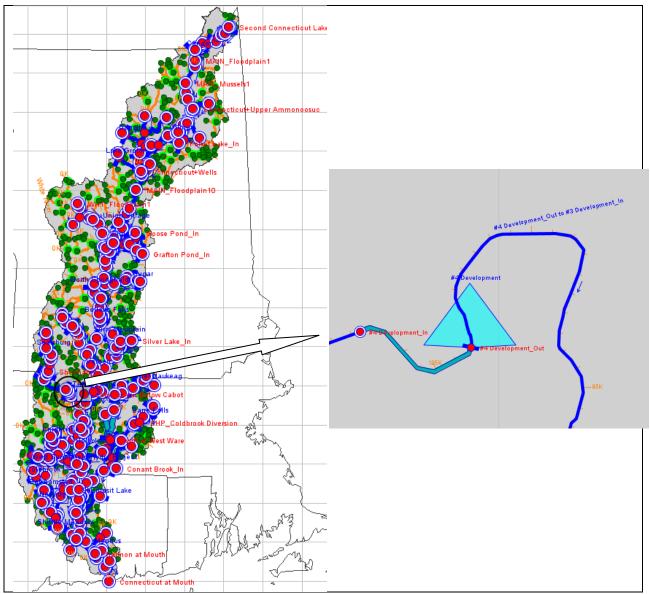


Figure 1: HEC-ResSim Map Display Showing Location of Deerfield No.4

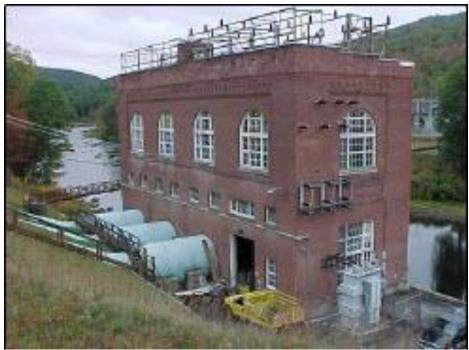


Figure 2: Photo of Deerfield No. 4 Development

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure  $3^{32}$ . The dam consists of five types of outlets: (1) controlled fish gate, (2) controlled sluice No.1&2, (3) controlled sluice No.3, (4) uncontrolled flashboard spillway, and (5) power plant as shown in Figure 4.

<sup>&</sup>lt;sup>32</sup> Data provided by TransCanada

ervoir Edit Pool						
servoir #4 Development	- Description					K 4 43 of 74 🕨
untent en un la company						
ysical Operations Observed I	Data					
#4 Development	#4 Development-Poo	bl				
Dam Tailwater	Linear Interpola	tion 💿 Conic Inter	polation Initia	al Con	ic Depth	(ft)
Power Plant	Elevation	Storage	Area			
🔸 fish gate	(ft)	(ac-ft)	(acre)			
sluices No.1 & 2	464.70	100000.41	(dere)	- 1	47	4
sluice No.3	464.80	100000.41			473	2
flashboard spillway	464.90	100041.41			€ 47	
	465.00	100082.41		=		- /
	465.10	100123.41			a 46 □ 46	- /
	465.20	100205.43		- 1	46	
	465.30	100248.43		- 1	40	4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
	465.40	100291.43		- 1		
	465.50	100334.43		- 1		Stor (ac-ft)
	465.60	100377.43		- 1	47-	4
	465.70	100420.45			47:	2
	465.80	100465.45			€ 47	0
	465.90	100510.45			€ 471 30 461 111 461	8
	466.00	100555.45			ш <sup>46</sup>	
	466.10	100600.45			46	
	466.20	100645.47			40	0 100 200
	466.30	100692.47				
	466.40	100739.47				Area (acre)
	466.50	100786.47		-		

Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir #4 Development	<ul> <li>Description</li> </ul>				)	K € 43 of 74
Physical Operations Observed	Data					
4 Development	#4 Development-D	am				
Pool					_	
Tailwater	Elevation at top of	f dam (ft)		489.	6	
Power Plant	Length at top of d	am (ff)		160.	_	
fish gate	2 chight actop of a			100.	U	
- 🔶 sluices No.1 & 2	Composite Rele	ase Capacity				
	Elevation	Controlled	Uncontrolled	Tatal		
🎰 🛇 flashboard spillway				Total		490
	(ft)	(cfs)	(cfs)	(cfs)	_	
	462.7	1,208.8	0.0	1,208.8	Elevation (ff)	480
	462.9	1,210.8	0.0	1,210.8	e ₹	470
	463.3	1,223.8	0.0	1,223.8	Ξ	460
	463.5	1,240.8	0.0	1,240.0		0 40,000
	463.7	1,285.8	0.0	1,285.8		Flow
	463.9	1,311.8	0.0	1,311.8		(cfs)
	464.1	1,340.8	0.0	1,340.8		
	464.3	1,372.8	0.0	1,372.8		
	464.5	1,406.8	0.0	1,406.8		
	464.6	1,431.3	0.0	1,431.3		
	464.7	1,441.8	0.0	1,441.8		
	464.9	1,479.8	0.0	1,479.8		
	465.3	1,517.8	0.0	1,517.8		
	465.5	1,600.8	0.0	1,600.8		
	465.7	1,646.8	0.0	1,646.8		
	465.9	1,692.8	0.0	1,692.8		
	466.1	1,738.8	0.0	1,738.8		
	466.3	1,787.8	0.0	1,787.8		
	466.5	1,838.8	0.0	1,838.8		
	466.7	1,890.8	0.0	1,890.8 -		

Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Deerfield No. 4's "ExistingOps" operational zones, which consist of zones of Top of dam (489.6 ft), conservation (469.6 ft), Min Pool (464.6 ft), and Inactive zone (419.6 ft)<sup>1</sup>.

Reservoir Editor
Reservoir Edit Operations Zone Rule IF_Block
Reservoir #4 Development  Description
Physical Operations Observed Data
Operation Set ExistingOps   Description
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev
Top of dam       Imax Power Plant Fire         Imax Power Plant Fire       Storage Zone       Conservation         Imax Power Plant Fire       Function of       Date       Define         Imax Power Plant Fire       Imax Power Plant Fire       Imax Power Plant Fire       Define         Imax Power Plant Fire       Imax Power Plant Fire       Imax Power Plant Fire       Imax Power Plant Fire         Imax Power Plant Fire       Imax Power Plant Fire       Imax Power Plant Fire       Imax Power Plant Fire         Imax Power Plant Fire       Imax Power Plant Fire       Imax Power Plant Fire       Imax Power Plant Fire         Imax Power Plant Fire       Imax Power Plant Fire       Imax Power Plant Fire       Imax Power Plant Fire         Imax Power Plant Fire       Imax Power Plant Fire       Imax Power Plant Fire       Imax Power Plant Fire         Imax Power Plant Fire       Imax Power Plant Fire       Imax Power Plant Fire       Imax Power Plant Fire         Imax Power Plant Fire       Imax Power Plant Fire       Imax Power Plant Fire       Imax Power Plant Fire         Imax Power Plant Fire       Imax Power Plant Fire       Imax Power Plant Fire       Imax Power Plant Fire         Imax Power Plant Fire       Imax Power Plant Fire       Imax Power Plant Fire       Imax Power Plant Fire         Imax Power Plant Fire <t< td=""></t<>
Zone Sort Elevation
OK Cancel Apply

Figure 5: Reservoir Editor: Operations Tab –Existing Ops OpSet – Guide Curve

Figure 6 shows a sequential release allocation approach specified for available outlets along Buford Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The fish gate the remainder of the release until it reaches capacity. After the capacity through the fish gate is reached, the remainder of the release goes through sluice No. 1, 2, and 3 respectively.

Reservoir Editor	In its tax based streams light
Reservoir Edit Operations	
Reservoir #4 Development	
Physical Operations Observed Data	
Operation Set ExistingOps	scription
Zone-Rules Rel. Alloc. Outages Stor, Credit Dec.	Sched. Projected Elev
Release Allocation Strategy	
#4 Development - Balanced	Release Location: #4 Development-Dam
	Allocation Type: Sequential
#4 Development-fish gate #4 Development-sluices No.1 & 2	#4 Development-Power Plant
↓ #4 Development-sluice No.1 & 2	#4 Development-fish gate
	#4 Development-sluices No.1 & 2
	#4 Development-sluice No.3

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

### **B. Rule Illustrations**

.

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>33</sup>.

Reservoir Editor
Reservoir Edit Operations Zone Rule IF_Block
Reservoir #4 Development
Physical Operations Observed Data
Operation Set ExistingOps
Zone-Rules Rel. Alloc. Outages Stor. Credit
<ul> <li>Top of dam</li> <li>Max Power Plant First</li> <li>Conservation</li> <li>Conservation</li> <li>Conservation</li> <li>Conservation</li> <li>Conservation</li> <li>Conservation</li> <li>Hydropower</li> <li>Hydropower-Release Inflow</li> <li>Statistical Statistics</li> <li>Hydropower-Release 95% Inflow</li> <li>Hydropower-Release 95% Inflow</li> <li>Min Flow Logic - #4 Development</li> <li>Min Pool</li> <li>Inactive</li> </ul>

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>&</sup>lt;sup>33</sup> TransCanada. Deerfield River Operational Constraints. 2012.

# **C.** Rule Descriptions

#### 1. Max Power Plant First

Figure 8 shows the content of "Max Power Plant First" rule. This rule forces the inflow to pass through the power plant first until it reaches the maximum plant capacity.

Operation Set ExistingOps	<ul> <li>Description</li> </ul>			
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. Proje	cted Elev		
Top of dam     Max Power Plant First     Conservation    {} Run of River Hydropower	Rule Name: Max P		ent-Power Plant Description: tinflow, Current Value	Define
Hydropower-Release Inflow     ELSE (Pool Partially Empty)     Hydropower-Release 95% Inflow	Limit Type: Maxi	✓ Interp.: Li Release (cfs)		
Min Flow Logic - #4 Development Min Pool Inactive	-1000.0 0.0 1204.8	0.0	(31,200 300 300 300 300 300 400 0 0 60,000	120,000
	123456.0	1204.8	Flow (cfs)	
			<ul> <li>Period Average Limit</li> <li>Hour of Day Multiplier</li> </ul>	Edit
			Day of Week Multiplier	Edit
			Rising/Falling Conditio     Seasonal Variation	n Edit Edit

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Power Plant First

### 2. Run of River Hydropower

Figure 8 shows the content of "Run of River Hydropower" rule. This rule release total inflow through power plant when pool elevation is higher than conservation elevation and 95% of inflow when pool elevation is less than conservation zone as per the run-of-river modeling strategy.

Operation Set ExistingOps	Description
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. Projected Elev.
<ul> <li>Top of dam</li> <li>Max Power Plant First</li> <li>Conservation</li> <li>-{ } Run of River Hydropower</li> <li>→ FF (Full Pool)</li> <li>→ FF (Full Pool)</li> <li>→ FELSE (Pool Partially Empty)</li> <li>→ Hydropower-Release 95% Inflow</li> <li>Min Flow Logic - #4 Development</li> <li>Min Pool</li> <li>Inactive</li> </ul>	Operates Release From: #4 Development-Power Plant IF Conditional Full Pool Value1 Add Cond. Add Cond. Del. Cond. Move Up Move Down Evaluate
Operation Set       ExistingOps         Zone-Rules       Rel. Alloc.       Outages       Stor. Credit         Top of dam <ul> <li>Max Power Plant First</li> <li>Conservation</li> <li>+ IF (Full Pool)</li> <li>- Hydropower-Release Inflow</li> <li>- ELSE (Pool Partially Empty)</li> <li>- Hydropower-Release 95% Inflow</li> <li>Min Flow Logic - #4 Development</li> <li>Min Pool</li> <li>Inactive</li> </ul>	Description     Description     Dec Sched. Projected Elev      Operates Release From: #4 Development-Power Plant Rule Name: ydropower-Release Inflow     Description:     Function of: #4 Development-Pool Net Inflow, Current Value     Define Limit Type: Mini     Interp.: Li      Flow (cfs)     Release (cfs)         0.0         0.0         10000.0         10000.0         Period Average Limit     Edit     Day of Week Multiplier     Edit     Rising/Falling Condition     Edit     Seasonal Variation

Operation Set ExistingOps	▼ Description	
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. Projected Elev	
Top of dam     Max Power Plant First     Conservation     F (Full Pool)     Hydropower-Release Inflow     Hydropower-Release 95% Inflow     Hydropower-Release 95% Inflow     Min Flow Logic - #4 Development     Min Pool     Inactive	Operates Release From: #4 Development-Power Plant ELSE Conditional Pool Partially Empty Description:	,
Operation Set ExistingOps Zone-Rules Rel. Alloc. Outages Stor. Credit.	Description     Dec. Sched. Projected Elev	
Top of dam Max Power Plant First Conservation If (Full Pool) Hydropower-Release Inflow ELSE (Pool Partially Empty) Hydropower-Release 95% Inflow Min Flow Logic - #4 Development Min Pool Inactive	Operates Release From: #4 Development-Power Plant         Rule Name:       rower-Release 95% Inflow       Description:         Function of:       #4 Development-Pool Net Inflow, Current Value         Limit Type:       Mini  Interp.:       I  Imit Type:         Flow (cfs)       Release (cfs) <ul> <li>0.0</li> <li>0.0</li> <li>0.0</li> <li>0.0</li> <li>0.0</li> <li>0.0</li> <li>9500.0</li> <li>Interp.:</li> <li>Imit Type:</li> <li>Imit Type:</li></ul>	Edit Edit Edit Edit

Figure 8 Reservoir Editor: Operations Tab – Existing Ops OpSet – Run of River hydropower

### 3. Min Flow Logic#4 Development

This rule represents seasonal minimum flow as represented in Figure 9.

Operation Set ExistingOps		escription	1								
Zone-Rules Rel. Alloc. Outages Stor. Credit: Top of dam Max Power Plant First Conservation ↓ Run of River Hydropower ↓ F (Full Pool) ↓ Hydropower-Release Inflow ↓ ELSE (Pool Partially Empty) ↓ Hydropower-Release 95% Inflow ↓ Hydropower-Release 95% Inflow ↓ Min Flow Logic #4 Development ↓ Min Pool ↓ Inactive	Operates Relea Rule Name: w	se From: #4 Logic - #4 De	Developr evelopme	nt Desc			min rules	which ar	e acc	ounting for smolt passage fro	m 01Ap[
	Limit Type: Min							120	Define		
	(cfs)	01Jan 1.0 0.0 1.0 60.0	01Apr 60.0 60.0	01Jun 60.0 60.0	16Jun 0.0 60.0	15Sep 60.0 60.0	01Oct 60.0 60.0	16Nov 0.0 60.0		40 2 0 40,000 80,000 12 Flow (cfs)	20,000
	100 125 123456	i.0 100.0	100.0 100.0 100.0	100.0 125.0 125.0	100.0 125.0 125.0	100.0 125.0 125.0	100.0 100.0 100.0	100.0 100.0 100.0	=	Period Average Limit Hour of Day Multiplier	Edit Edit
									-	Day of Week Multiplier     Rising/Falling Condition     Seasonal Variation	Edit Edit

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic #4 Development

# **Deerfield No. 5 Development**

### I. Overview

Deerfield No. 5 Development is located in the town of Monroe, MA on the Deerfield River. It is owned and operated by TransCanada Hydro Northeast Inc. for hydropower generation on a run-of-river basis.

Figure 1 shows the location of Deerfield No. 5 dam as it is represented in the HEC-ResSim model .Figure 2 shows the photo of Deerfield No.5 dam.

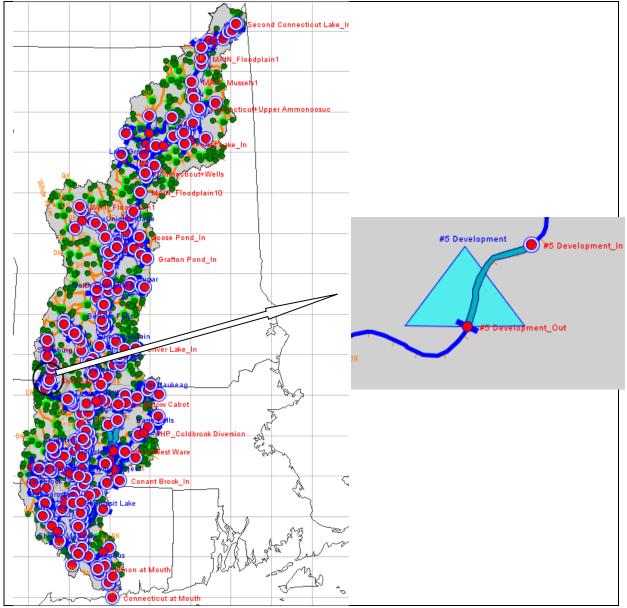


Figure 1: HEC-ResSim Map Display Showing Location of Deerfield No.5



Figure 2: Photo of Deerfield No.5 Development

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>34</sup>. The dam consists of five types of outlets: (1) controlled sluice gate, (2) controlled spillway, (3) controlled Flap gate, (4) controlled flood gate, and (5) power plant as shown in Figure 4.

<sup>&</sup>lt;sup>34</sup> Data provided by TransCanada

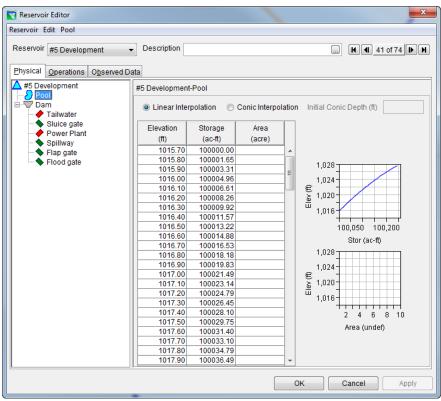


Figure 3: Reservoir Editor: Physical Tab -- Pool

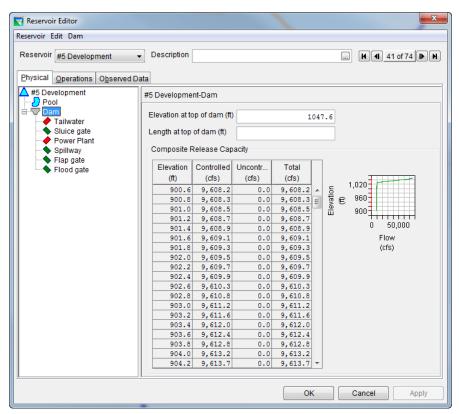


Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Deerfield No. 5's "ExistingOps" operational zones, which consist of zones of Top of dam (1047.6 ft), Conservation (1027.6 ft), Min Pool (1017.6 ft), and Inactive zone (970 ft)<sup>1</sup>.

🟹 Reservoir Editor				)	×
Reservoir Edit Operations Zone Rule IF_Block					
Reservoir #5 Development   Description  Physical Operations Observed Data				Ka	41 of 74 🕨 🗎
Operation Set ExistingOps	Description				
	Dec. Sched. Projec	ted Elev			
A Top of dam	Storage Zone con	servation	Description		
Conservation	Function of Date				Define
➡ ➡ IF (Full Pool) ➡ ➡ IF (Full Pool) ➡ ➡ Hydropower-Release Inflow	Date	Top Elevation (ft)	1,050		
➡ ► ELSE (Pool Partially Empty) ➡ ➡ Hydropower-Release 95% Inflow	01Jan	1027.6	1,040		
Min Flow Logic - #5 Development 🚰 Min Pool			1,030- € 1,020-		
Min Flow Logic - #5 Development			€ 1,020 u 1,010 ite 1,000 990		
			980		
			960	Mar May Jul Se	n blau
			Jan K	nar may Jun Se	ρινον
	Zone Sort Elevation	n			
			ОК	Cancel	Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

Figure 6 shows a sequential release allocation approach specified for available outlets along Buford Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The spillway the remainder of the release until it reaches capacity. After the capacity through the spillway is reached, the remainder of the release goes through sluice gate, Flap gate, and Flood gate respectively.

Description			
ched. Projected Elev			
Release Location: #5 Development-Dam			
Allocation Type: Sequential			
#5 Development-Power Plant			
#5 Development-Spillway			
#5 Development-Sluice gate			
#5 Development-Flap gate			

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

### **B. Rule Illustrations**

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>35</sup>.

Reservoir Editor				
Reservoir Edit Operations Zone Rule IF_Block				
Reservoir #5 Development				
Physical Operations Observed Data				
Operation Set ExistingOps				
Zone-Rules Rel. Alloc. Outages Stor. Credi				
Top of dam				
Max Power Plant First				
🗧 🚺 Run of River Hydropower				
IF (Full Pool)				
■ Hydropower-Release Inflow ■ ➡ ELSE (Pool Partially Empty)				
🔲 🗎 Hydropower-Release 95% Inflow				
Min Flow Logic - #5 Development				
Min Pool				
A Inactive				

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

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<sup>&</sup>lt;sup>35</sup> TransCanada. Deerfield River Operational Constraints. 2012.

## **C.** Rule Descriptions

#### 1. Max Power Plant First

Figure 8 shows the content of "Max Power Plant First" rule. This rule forces the inflow to pass through the power plant first until it reaches the maximum plant capacity.

Operation Set ExistingOps	▼ Description	
Zone-Rules Rel. Alloc. Outages Stor, Credit	Dec. Sched. Projected Elev	
Top of dam Max Power Plant First conservation ↓ Run of River Hydropower ↓ F (Full Pool) ↓ Hydropower-Release Inflow ↓ ELSE (Pool Partially Empty) ↓ Hydropower-Release 95% Inflow Min Flow Logic - #5 Development Min Pool ↓ Min Flow Logic - #5 Development Min Flow Logic - #5 Development Min Flow Logic - #5 Development	Operates Release From: #5 Development-Power Plant         Rule Name:       Max Power Plant First         Description:         Function of:       #5 Development-Pool Net Inflow, Current Value         Limit Type:       Minimu  Interp.:         Limit Type:       Minimu  Interp.:         Flow (cfs)       Release (cfs)         0.0       0.0         1667.25       1667.25         123456.0       1667.25	
	Elow (cfs)	J

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Power Plant First

#### 2. Run of River Hydropower

Figure 9 shows the content of "Run of River Hydropower" rule. This rule release total inflow through power plant when pool elevation is higher than conservation elevation and 95% of inflow when pool elevation is less than conservation zone as per the run-of-river modeling strategy.

Operation Set ExistingOps	Description	(
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. Projected Elev	
Top of dam Max Power Plant First conservation	Operates Release From: #5 Development-Power Plant IF Conditional Full Pool Description:	
<ul> <li>☐ { Run of River Hydropower</li> <li>☐ ↓ [F (Full Pool)]</li> <li>☐ Hydropower-Release Inflow</li> <li>☐ ELSE (Pool Partially Empty)</li> <li>☐ Hydropower-Release 95% Inflow</li> <li>☐ Min Flow Logic - #5 Development</li> <li>✓ Min Pool</li> </ul>	Value1 Value2 #5 Development-Pool:Elevation >= 1027.6	Add Cond. Del. Cond.
Inactive Min Flow Logic - #5 Development Minactive		Move Up Move Down Evaluate

Operation Set ExistingOps	- Description	
Zone-Rules Rel. Alloc. Outages Stor. Credit.	Dec. Sched. Projected Elev	
Top of dam Max Power Plant First conservation ↓ Run of River Hydropower ↓ F (Full Pool) ↓ ↓ F (Full Pool) ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓	Operates Release From: #5 Development-Power Plant         Rule Name:       ydropower-Release Inflow       Description:         Function of:       #5 Development-Pool Net Inflow, Current Value         Limit Type:       Minimu         Interp.:         Flow (cfs)       Release (cfs)         0.0       0.0         10000.0       10000.0         4,000       0         3,000       6,000         Flow (cfs)       Period Average Limit         Hour of Day Multiplier       Day of Week Multiplier         Day of Week Multiplier       Rising/Falling Condition	Define 9,000 Edit Edit Edit Edit
Operation Set ExistingOps	Description	
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. Projected Elev	
Top of dam Max Power Plant First conservation → IF (Full Pool) Hydropower-Release Inflow → ELSE (Pool Partially Empty) Hydropower-Release 95% Inflow Min Flow Logic - #5 Development Min Flow Logic - #5 Development Anactive	Operates Release From: #5 Development-Power Plant ELSE Conditional Pool Partially Empty Description:	

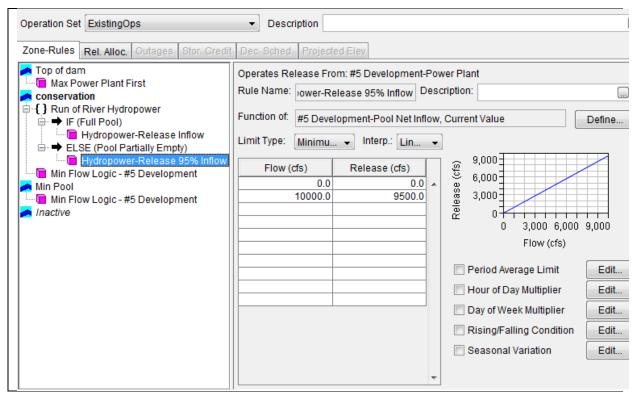


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Run of River hydropower

#### **3.** Min Flow Logic #5 Development

This rule represents a minimum release based on inflow as represented in Figure 10.

Operation Set ExistingOps	✓ Description	
Zone-Rules Rel. Alloc. Outages Stor. Cred	Dec. Sched. Projected Elev.	
Top of dam Max Power Plant First conservation -{} Run of River Hydropower +} IF (Full Pool) 	Operates Release From: #5 Development Rule Name: w Logic - #5 Development Description: Function of: #5 Development-Pool Net Inflow, Current Value Limit Type: Minimum Interp.: Linear	Edit Edit Edit Edit Edit

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic #5 Developmen

# **First Connecticut Lake**

#### I. Overview

First Connecticut Lake dam is located 8 miles upstream of Pittsburg, NH on the mainstem Connecticut River. It is owned and operated by TransCanada Hydro Northeast Inc. as a storage reservoir to make releases to its downstream hydro facilities.

Figure 1 shows the location of Second Connecticut Dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo from Second Connecticut Dam.

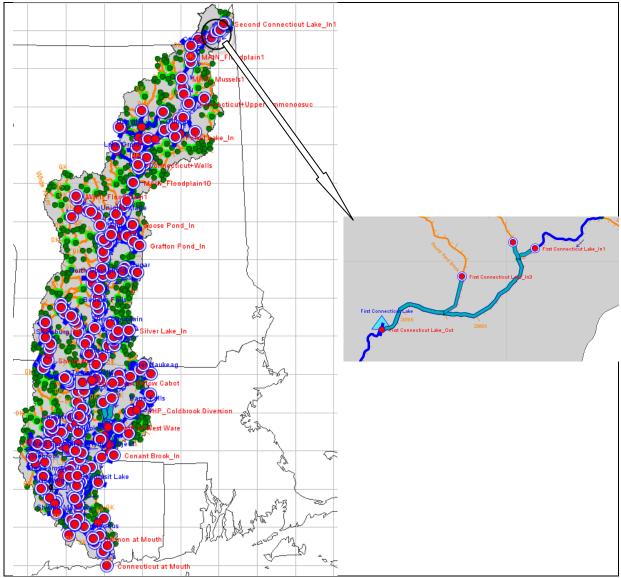


Figure 1: HEC-ResSim Map Display Showing Location of First Connecticut Dam

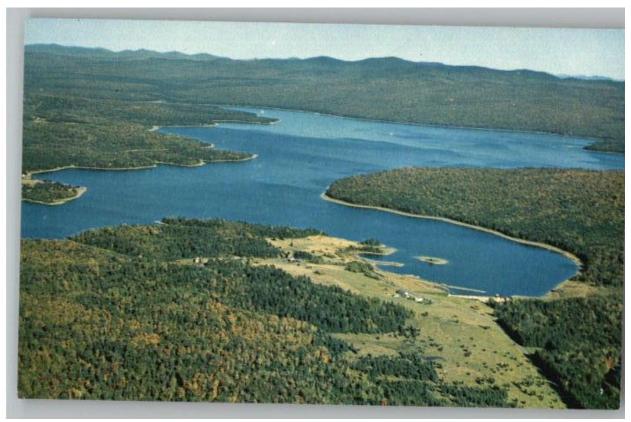


Figure 2: Photo of First Connecticut Lake

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>36</sup>. The dam consists of four types of outlets: (1) controlled outlet, (2) uncontrolled spillway, (3) controlled Log way, and (4) controlled Fish Pipe as shown in Figure 4.

<sup>&</sup>lt;sup>36</sup> Data provided by TransCanada

eservoir Edit Pool					
Reservoir First Connecticut Lake	<ul> <li>Description</li> </ul>				K 4 14 of 74 🕨
Physical Operations Observed	Data				
First Connecticut Lake	First Connecticut La	ke-Pool			
Dam Controlled Outlet	Linear Interpola	ation 💿 Conic In	terpolation	Initial (	Conic Depth (ft)
	Elevation	Storage	Area		
Logway	(ft)	(ac-ft)	(acre)		
Fish Pipe	1610.00	0.00	, /		
	1610.10	186.40		=	
	1610.20	374.90		-	1,640
	1610.30	563.30			€ 1,630
	1610.40	753.70			€,
	1610.50	944.10			a 1,620
	1610.60	1134.50			<sup>1,610</sup>
	1610.70	1325.00			+++++++++++++++++++++++++++++++++++++++
	1610.80	1515.40			0 40,000 80,000
	1610.90	1707.80			Stor (ac-ft)
	1611.00	1900.20			
	1611.10	2092.60			1,640
	1611.20	2286.90			€ 1,630
	1611.30	2481.30			
	1611.40	2675.70			ā 1,620
	1611.50	2872.10			1,610
	1611.60	3068.40			+++++++++++++++++++++++++++++++++++++++
	1611.70	3264.80			0 1,500 3,000 4,500
	1611.80	3461.20			Area (acre)
	1611.90	3659.50			
	1612.00	3857.90			
	1612.10	4056.20		-	

Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor eservoir Edit Dam	~					×
Reservoir First Connecticut Lake	<ul> <li>Description</li> </ul>					K I 14 of 74 D H
Physical Operations Observed	Data					
First Connecticut Lake	First Connecticut	Lake-Dam				
Dam Controlled Outlet	Elevation at top	of dam (ft)		1641	.0	
Spillway	Length at top of	dam (ft)		1117	.0	
Fish Pipe	Composite Rel	ease Capacity	1			
	Elevation	Controlled	Uncontrolled	Total		
	(ft)	(cfs)	(cfs)	(cfs)		
	1,601.5	0.0	0.0	0.0 🔺	B	1,635 € 1,620 1,605
	1,604.0	253.6	0.0	253.6	/ati	₽ 1,620 <mark>- /</mark>
	1,604.1	278.8	0.0	278.8	Ш.	1,605
	1,622.0	2,094.7	0.0	2,094.7	_	
	1,636.0	5,407.0	0.0	5,407.0		0 10,000
	1,636.5	5,530.0		5,930.0		Flow
	1,637.0	5,673.0		6,773.0		(cfs)
	1,637.5	5,799.5		7,799.5		
	1,638.0	5,926.0		9,026.0		
	1,638.5			10,576.0		
	1,639.0			12,026.0		
	1,639.5	6,359.5		13,759.5		
	1,640.0	6,493.0	8,900.0	15,393.0		
				•		
				ок		Cancel Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

#### **A. Operation Set**

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of First Connecticut Dam's "Existing Ops" operational zones, which consist of zones of Top of Dam (1641 ft), Below Top of Dam (1640 ft), Conservation (1617.262-1637.493 ft), and Inactive zone (1600 ft). The Conservation Pool Elevation curve was created from 10 years of weekly average pool elevation<sup>1</sup>.

Reservoir Editor			~~~	×
Reservoir Edit Operations Zone Rule IF_Blo	ck			
Reservoir First Connecticut Lake  Descriptions Observed Data	cription			H 14 of 74 D H
Operation Set Existing Ops	<ul> <li>Description</li> </ul>			
Zone-Rules Rel. Alloc. Outages Stor. C	redit Dec. Sched. Project	ed Elev		
Top of Dam Below Top of Dam Min Flow Conservation	Storage Zone Conservati	on Description	n	Define
Min Flow	Date 01Jan 10Jan	Top Elevation (ft) 1628.97 1627.544	1,645	
	20Jan 31Jan 10Feb 20Feb	1625.744 1623.779 1621.872 1620.051	1,635 1,630 € 1,625 § 1,620	
	28Feb 10Mar 20Mar	1618.967 1617.934 1617.262	0 1,620 0 1,620 1,615 □ 1,610 1,605	
	31Mar 10Apr 20Apr	1617.893 1619.457 1624.046	1,600 1,595 Jan Mar Ma	ay Jul Sep Nov
	30Apr 10May 20May	1628.466 1633.231 1635.862		
	20ne Sort Elevation	1636.969 1627.264		
			ОК	Cancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

# **B. Rule Illustrations**

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>37</sup>.

Reservoir Editor
Reservoir Edit Operations Zone R
Reservoir First Connecticut Lake
Physical Operations Observed
Operation Set Existing Ops
Zone-Rules Rel. Alloc. Outage
Top of Dam Below Top of Dam Min Flow Conservation Min Flow Inactive

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

\_\_\_\_\_

<sup>&</sup>lt;sup>37</sup> TransCanada. Connecticut River Operational Constraints. 2012.

# **C.** Rule Descriptions

#### 1. Min Flow

Figure 7 shows the content of "Min Flow" rule. This rule represents the minimum release from dam as a function of date.

Operation Set Existing Ops		<ul> <li>Descriptio</li> </ul>	n		
Zone-Rules Rel. Alloc. Outage	s Stor. Credi	Dec. Sched. Proj	jected Elev		
Top of Dam Below Top of Dam Min Flow Conservation Min Flow Inactive	Operates Re Rule Name:		Interp.: Step Release (cfs)	■ 100 million	Define      D
				Ψ.	

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow

## Forest Lake

#### I. Overview

Forest Lake is a dam located in Whitefield, NH on the Johns River. It is owned and operated by the New Hampshire Water Division and is primarily used for water supply and recreation.

Figure 1 shows the location of Forest Lake Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Forest Lake reservoir.

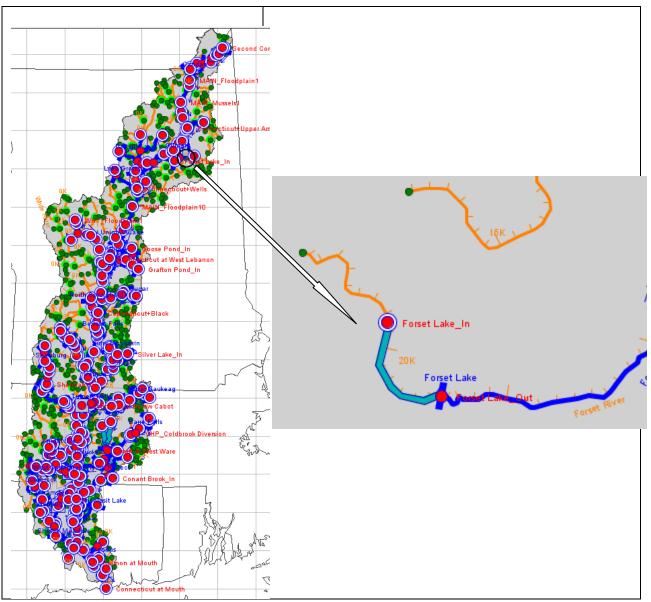


Figure 1: HEC-ResSim Map Display Showing Location of Forest Lake Dam



Figure 2: Photo of Forest Lake reservoir.

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>38</sup>. The dam consists of two types of outlets: (1) an uncontrolled concrete spillway, and (2) an uncontrolled stoplog bay as shown in Figure 4.

<sup>&</sup>lt;sup>38</sup> National Dam Safety Program. Forest Lake Dam Operation & Maintenance Plan. 2007.

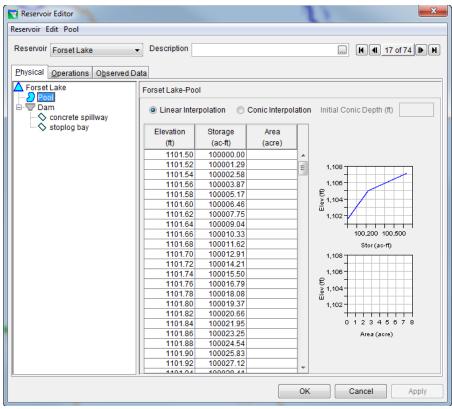


Figure 3: Reservoir Editor: Physical Tab -- Pool

eservoir Edit Dam			
Reservoir Forset Lake	<ul> <li>Description</li> </ul>		K 4 17 of 74 D H
Physical Operations Observed	1 Data		
A Forset Lake	Forset Lake-Dam		
Dam Concrete spillway	Elevation at top of dam (ft)	110	07.1
stoplog bay	Length at top of dam (ft)	10	03.0
	Composite Release Cap	acity	
	Elevation Controll U	ncontr Total	
	(ft) (cfs)	(cfs) (cfs)	1,108.0 = 1,107.0
	1,105.0 0.0	0.0 0.0 ^	E 1,107.0 E 1,106.0 E 1,105.0
	1,105.0 0.0 1,105.0 0.0	1.4 1.4 4.0 4.0 ≡	
	1,105.1 0.0	7.3 7.3	
	1,105.1 0.0	11.2 11.2	0 1,500
	1,105.1 0.0	15.6 15.6	Flow
	1,105.1 0.0	20.6 20.6	(cfs)
	1,105.1 0.0	25.9 25.9	
	1,105.2 0.0	31.7 31.7	
	1,105.2 0.0	37.8 37.8	
	1,105.2 0.0	44.2 44.2	
	1,105.2 0.0	51.3 51.3	
	1,105.2 0.0	58.8 58.8	
	1,105.3 0.0	66.7 66.7	
	1,105.3 0.0	74.9 74.9	
	1,105.3 0.0	83.5 83.5	
	1,105.3 0.0	92.5 92.5	
	1,105.3 0.0	101.9 101.9 -	

Figure 4: Reservoir Editor: Physical Tab -- Dam

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Forest Lake Dam's "Guide Curve" operational zones, which consist of zones of Top of Dam (1107.1 ft), Conservation (1105 ft), and Inactive zone (1102 ft)<sup>1</sup>.

Reservoir Editor				
Reservoir Edit Operations Zo	one Rule IF_Block			
Reservoir Forset Lake	✓ Description			K 4 17 of 74 D H
Physical Operations Obs	erved Data			
Operation Set Guide Curve	•	Description		
Zone-Rules Rel. Alloc. C	outages Stor. Credit [	Dec. Sched. Projecte	d El	Elev
Top of Dam Conservation	Storage Zone Conse	rvation	Des	escription
inactive 📩	Function of Date			Define
	Date	Top Elevation (ft)		
	01Jan	1105.0	-	1,108
				1,106
				€ 1,105
				i 🗑 1,104
				± 1,103
				1,102
			Ŧ	1,101 <del>             </del> Jan Mar May Jul Sep Nov
	Zone Sort Elevation			_
			_	
				OK Cancel Apply

Figure 5 Reservoir Editor: Operations Tab – Guide Curve OpSet

#### **B. Rule Illustrations**

The operation set for Forest Lake Dam has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

# **Gardner Falls**

#### I. Overview

Gardner Falls dam is located in Shelburne Falls, MA on the Deerfield River. It is owned and operated by Consolidated Edison and is operated as a run-of-river hydropower generating facility.

Figure 1 shows the location of Gardner Falls dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Gardner Falls dam.

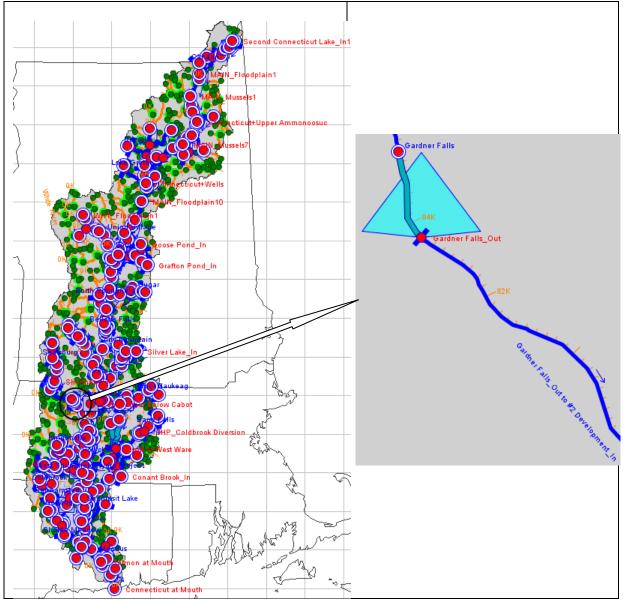


Figure 1: HEC-ResSim Map Display Showing Location of Gardner Falls Dam



Figure 2: Photo of Gardner Falls dam

#### **Physical Characteristics** II.

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>39</sup>. The dam consists of two types of outlets: (1) uncontrolled outlet and (3) power plant as shown in Figure 4<sup>1,40</sup>. The capacity of the power plant was made to be the maximum release specified in the NID database so that the dam would modeled completely as run-of-river with some actual physical information.

 <sup>&</sup>lt;sup>39</sup> National Inventory of Dams database (NID)
 <sup>40</sup> http://www.lowimpacthydro.org/lihi-certificate-80-ferc-no.-gardner-falls-project-maine.html

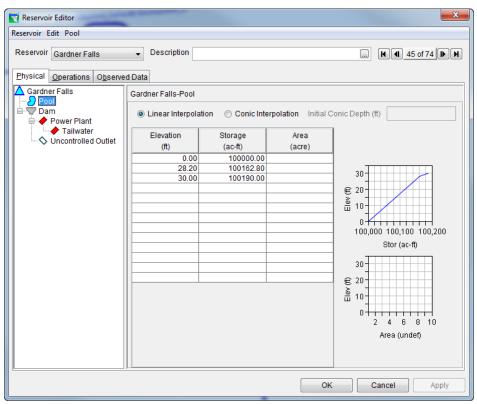


Figure 3: Reservoir Editor: Physical Tab – Pool

Reservoir Editor	-					X
Reservoir Edit Dam						
Reservoir Gardner Falls	✓ Description					K ◀ 45 of 74 ► H
Physical Operations Observe	d Data					
Gardner Falls	Gardner Falls-Dar	n				
ia▼ Dam ia◆ Power Plant	Elevation at top o	f dam (ft)		30.0		
Tailwater	Length at top of o	lam (ft)		337.0		
Uncontrolled Outlet	Composite Rele	ase Capacity			_	
	Elevation	Controlled	Uncontrolled	Total		
	(ft)	(cfs)	(cfs)	(cfs)		45
	0.0	99,999.0	0.0	99,999.0 🔺	5	30
	30.0	99,999.0	0.0	99,999.0	Elevation (ff)	15
	31.0	99,999.0	478.5	100,477.5	Шe	
	32.0	99,999.0		101,352.4		0 80,000
	33.0	99,999.0		102,485.4		Flow
	34.0	99,999.0 99,999.0		103,827.0 105,348.8 =		(cfs)
	36.0	99,999.0		107,031.5		(015)
	37.0	99,999.0		108,860.9		
	38.0	99,999.0		110,826.2		
	39.0	99,999.0	12,919.5	112,918.5		
	40.0	99,999.0	15,131.5	115,130.5		
<u> </u>	1					
				ОК		Cancel Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Gardner Falls's "Guide Curve" operational zones, which consist of Top of Dam (30 ft), Conservation (28.2 ft), and Inactive zone (20 ft)<sup>1</sup>. There was no specified inactive zone so 10 feet below top of dam was arbitrarily chosen.

Reservoir Editor
Reservoir Edit Operations Zone Rule IF_Block
Reservoir Gardner Falls   Description  M 45 of 74  M
Physical Operations Observed Data
Operation Set Guide Curve   Description
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev
Top of Dam Storage Zone Conservation Description
Function of Date Define
Date Top Elevation (ft)
30
Jan Mar May Jul Sep Nov
Zone Sort Elevation
OK Cancel Apply

Figure 5: Reservoir Editor: Operations Tab –Guide Curve OpSet – Guide Curve

#### **B. Rule Illustrations**

The operation set for Garner Falls has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity. This was modeled this way because no real operation information was found.

## Gilman

#### I. Overview

Gilman dam is located directly downstream of the town of Dalton, NH on the mainstem Connecticut River. It is owned and operated by Ampersand Gilman Hydro LP for run-of-river hydropower generation.

Figure 1 shows the location of Gilman Dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo of Gilman Dam.

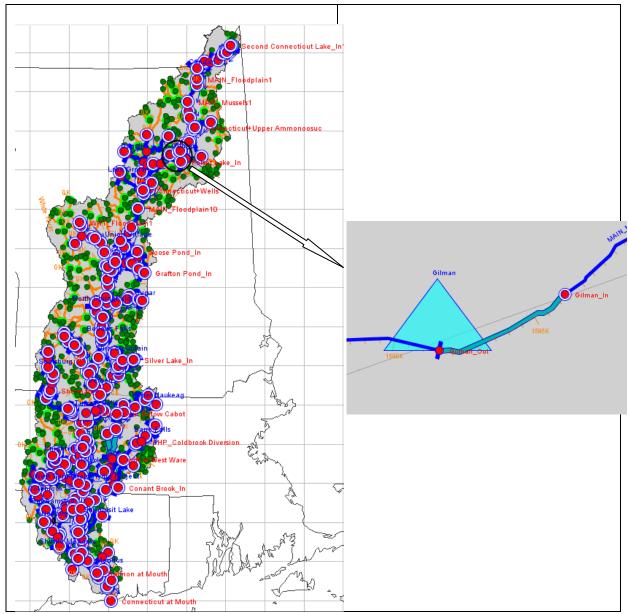


Figure 1: HEC-ResSim Map Display Showing Location of Gilman

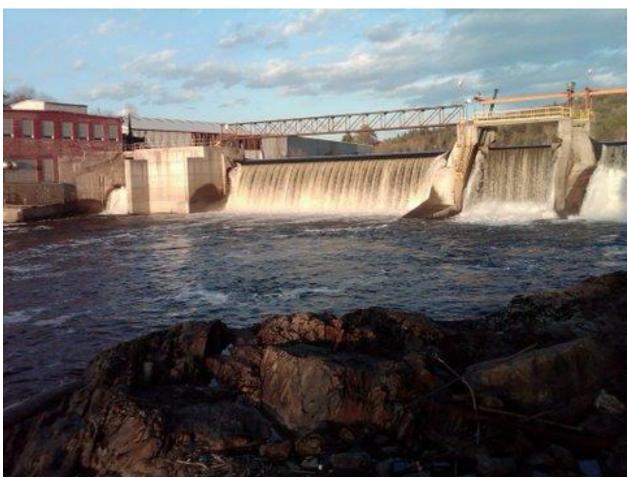


Figure 2: Photo of Gilman Dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>41</sup>. The dam consists of two types of outlets: (1) controlled outlet, and (2) power plant as shown in Figure 4.

<sup>&</sup>lt;sup>41</sup> NHSDam Data Sheet. Gilman. 2009.

👿 Reservoir Editor	-	a family an	a	×
Reservoir Edit Pool				
Reservoir Gilman +	Description			K 4 18 of 74 D H
Physical Operations Observed Da	ata			
Gilman	Gilman-Pool			
Dam	Linear Interpolati	ion 💿 Conic Inte	rpolation Initial	Conic Depth (ft)
Controlled Outlet	Elevation	Storage	Area	
Controlled Outlet	(ft)	(ac-ft)	(acre)	
	813.00	100000.00		900
	833.30	1000200.00		880
	890.00	1097000.00		
				€ 860
				820
				1,000,000 1,100,000
				Stor (ac-ft)
				900
				880
				€ 860 <u> <u> </u> <u> </u> <u> </u> <u> </u> <u> </u> 840 <u> </u> </u>
				± ± ± ± ± ± ± ± ± ± ± ± ± ± ± ± ± ± ±
				820
				0 1,500 3,000 4,500
				Area (acre)
·				OK Cancel Apply

Figure 3: Reservoir Editor: Physical Tab -- Pool

Physical Operations Observed Data Gilman Pool Power Plant Controlled Outlet	Description Iman-Dam Elevation at top of d composite Rele				
Physical Operations Observed Data Gilman Pool Power Plant Controlled Outlet	Iman-Dam Elevation at top o				
Gilman Pool Pour Power Plant Controlled Outlet	Elevation at top o .ength at top of d				
Pool Power Plant Power Plant Controlled Outlet	Elevation at top o .ength at top of d				
Dam     Dam     Power Plant     A     Tailwater     Controlled Outlet	ength at top of d				
Tailwater     Controlled Outlet				841.	4
	Composite Rele	am (ft)		324.	5
		ase Capacity			
	Elevation	Controlled	Uncontrolled	Total	
	(ft)	(cfs)	(cfs)	(cfs)	840
	820.0	11,400.0	0.0	11,400.0	- Б <b>Т</b>
	828.3	11,400.0	0.0	11,400.0	
	828.5	11,610.0	0.0	11,610.0	≝ <sub>820</sub>
	830.0	13,200.0	0.0	13,200.0	0 15,000
	833.3	16,252.5	0.0	16,252.5	
	834.0	16,900.0	0.0	16,900.0	Flow (cfs)
	837.0 839.5	19,400.0	0.0	19,400.0 21,600.0	(((s)
	840.0	21,600.0 22,073.7	0.0	22,073.7	
	841.4	23,400.0	0.0	23,400.0	
	041.4	20,400.0	0.0	23,400.0	
				-	-

Figure 4: Reservoir Editor: Physical Tab -- Dam

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Gilman's "Existing Ops" operational zones, which consist of zones of Top of dam (850 ft), conservation (833.3 ft), and Inactive zone (814 ft)<sup>42</sup>.

Reservoir Editor		2	~~	×
Reservoir Edit Operations Zone R	ule IF_Block			
Reservoir Gilman	✓ Description		(	K 4 18 of 74 D D
Physical Operations Observed	Data			
Operation Set Existing Ops	▼ Description	on		
Zone-Rules Rel. Alloc. Outage	s Stor. Credit Dec. Sched. Pro	jected Elev		
Top of Dam	Storage Zone Conservation	Description		
Conservation	Function of Date			Define
Inactive Release=95%Inflow	Date 01Jan	Top Elevation (ft) 833.3	850 845 840 € 835 835 830 830 825 830 825 815 810	May Jul Sep Nov
				Canaal
			ОК	Cancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

<sup>&</sup>lt;sup>42</sup> Water Quality Certification. 1989.

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops.

Reservoir Editor
Reservoir Edit Operations Zone R
Reservoir Gilman
Physical Operations Observed
Operation Set Existing Ops
Zone-Rules Rel. Alloc. Outage
Top of Dam
Below Top of Dam
Conservation
Release=95%Inflow
inactive

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## **C.** Rule Descriptions

#### 1. Release=95%Inflow

Figure 7 shows the content of "Release=95%Inflow" rule. This rule release the minimum of 95% of Inflow from dam as per the run-of-river modeling strategy.

Operation Set Existing Ops	Description
Top of Dam     Below Top of Dam     Conservation     Release=95%Inflow     Conservation     Release=95%Inflow     Inactive	Operates Release From: Gilman Rule Name: Release=95%Inflow Description: Function of: Gilman-Pool Net Inflow, Current Value Define
	Limit Type:       Minimum       Interp.:       Linear         Flow (cfs)       Release (cfs)       60,000         100000.0       95000.0       0         0       50,000       100,000         Flow (cfs)       Flow (cfs)       Edit         0       Flow (cfs)       Edit         0       Seasonal Variation       Edit
igure 7 Reservo	ir Editor: Operations Tab – Existing OpSet – Release=95%Inf

## Goose Pond

#### I. Overview

Goose Pond dam is a dam located in the town of Canaan and feeds into the Mascoma River. It is owned and operated by the State of New Hampshire and is used to store spring runoff to maintain normal flow on the Mascoma River for hydropower generation by other facilities. It is also used for recreation.

Figure 1 shows the location of Goose Pond Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Goose Pond dam.

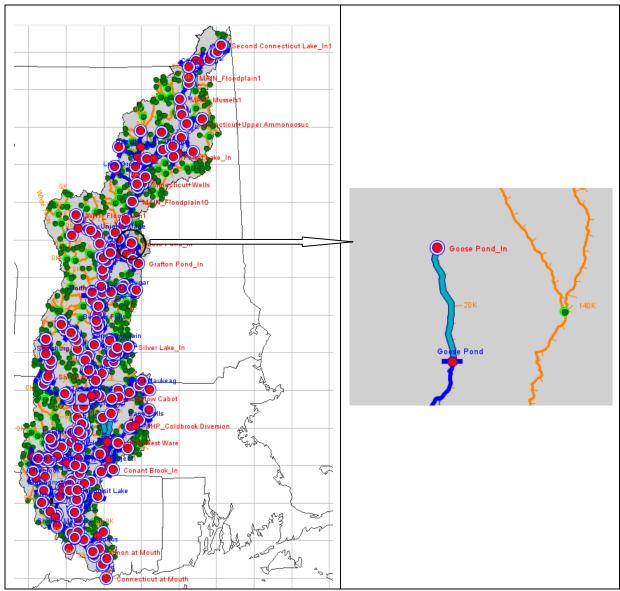


Figure 1: HEC-ResSim Map Display Showing Location of Goose Pond Dam



Figure 2: Photo of Goose Pond dam.

## **II.** Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>43</sup>. The dam consists of four types of outlets: (1) controlled slide gates, (2) controlled flashboard gate, (3) uncontrolled broad-crested weir, and (4) controlled slide gates as shown in Figure 4.

<sup>&</sup>lt;sup>43</sup> National Dam Safety Program. Goose Pond Dam Operation & Maintenance Plan. 2008.

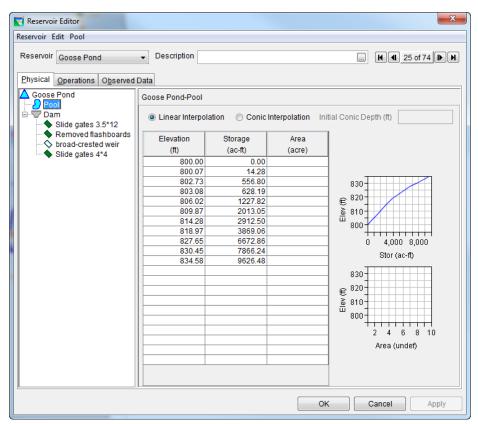


Figure 3: Reservoir Editor: Physical Tab -- Pool

leservoir Edit Dam								
Reservoir Goose Pond   Description								
Physical Operations Observed Data								
Coose Pond	Goose Pond-Da	m						
Dam Slide gates 3.5*12	Elevation at top	of dam (ft)		834.6				
Removed flashboards broad-crested weir	Length at top of	dam (ft)		1240.0				
Slide gates 4*4	Composite Re	lease Capac	ity					
	Elevation (ft)	Controlled (cfs)	Uncontroll (cfs)	Total (cfs)	-1			
	811.8	0.0	0.0	0.0	E 830-			
	811.8	0.6	0.0	0.6	830 = 820 = 820			
	811.9	1.8	0.0	1.8	- <u>1</u>	4		
	812.0	3.2	0.0	3.2	- 810+			
	812.0	5.0	0.0	5.0	0			
	812.1	7.0	0.0	7.0		Flow		
	812.2	9.2	0.0	9.2		(Cfs)		
	812.2	11.6	0.0	11.6				
	812.3	14.1	0.0	14.1				
	812.4	16.9	0.0	16.9				
	812.5	19.7	0.0	19.7				
	812.5	22.8	0.0	22.8				
	812.6	26.0	0.0	26.0				
	812.7	32.7	0.0	32.7				
	812.8	32.7	0.0	36.3				
	812.9	40.0	0.0	40.0				
	813.0	43.7	0.0	43.7				
	813.0	47.7	0.0	47.7 -				

Figure 4: Reservoir Editor: Physical Tab -- Dam

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Goose Pond Dam's "ExistingOps" operational zones, which consist of zones of Top of dam (834.6 ft), Flood Control (833 ft), Conservation (824.4-829 ft), and Inactive zone (803.6 ft)<sup>1</sup>.

Reservoir Edit Operations Zone Rule IF_Block         Reservoir Goose Pond       Description         Physical Operations Observed Data         Operation Set Existing Ops       Description         Zone-Rules Rel_Alloc: Outages Stor. Credit Dec. Sched. Projected Elev         Top of dam         Flood Control    Storage Zone Conservation Description
Physical Operations Observed Data         Operation Set Existing Ops         Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev         Top of dam         Storage Zone
Operation Set Existing Ops       Description         Zone-Rules       Rel. Alloc.       Outages         Storage       Zone       Projected Elev         Top of dam       Storage       Conservation
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev
Top of dam
Fall Drawdown Release Function of Date Define
Image: Spring Refile       Date       Top Elevation (ft)         Image: Spring Refile       Date       Top Elevation (ft)         Image: Spring Refile       Date       Top Elevation (ft)         Image: Spring Refile       Dillan       824.4         Other       829.0         OSep       829.0         Other       824.4         Other       824.4         Other       829.0         Other       829.0         Other       824.4         Other       824.4         Other       829.0         Othow       824.4         Other       829.0         Other       824.4         Other       826.4         Other       80.5         Other       90.5         Other       90.5         Other       90.5         Other
OK Cancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops.

Reservoir Editor
Reservoir Edit Operations Zone Rule IF_Block
Reservoir Goose Pond
Physical Operations Observed Data
Operation Set Existing Ops -
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec
<ul> <li>Flood Control</li> <li>Fall Drawdown Release</li> <li>Spring Refill</li> <li>Flash Boards</li> <li>Flash Boards</li> <li>Flease over the flashboards</li> <li>ELSE IF (elevation&gt;831.13)</li> <li>relaese while flashboards are removed</li> <li>Conservation</li> <li>Fall Drawdown Release</li> <li>Spring Refill</li> <li>Flash Boards</li> <li>Flash Bo</li></ul>

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## **C.** Rule Descriptions

#### 1. Fall Drawdown Release

Figure 7 shows the content of "Fall Drawdown Release" rule. This rule defines the maximum release from reservoir as a function of pool elevation.

Operation Set Existing Ops		▼ Des	scription				
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.							
Top of dam Flood Control Fall Drawdown Release Spring Refill	Rule Name	E Fall Draw	n: Goose Po down Relea		riptio	on:	
Flash Boards     Conservation     Fall Drawdown Release     Foring Dafill	Function of Limit Type:	0003010	ond-Pool Ele	-	ous •	Value [	Define
Spring Refill ∃ Flash Boards	Elev	F	Release (cfs	)		8 60,000	
📥 Inactive	(ft)	01Jan	01Oct	01Nov			
	803.6	123456.0	123456.0	123456.0		<sup>6</sup> 800 805 810 815 820 82	5 830 835
	824.4	123456.0	123456.0	123456.0		Elev (ft)	
	824.5	123456.0	250.0	123456.0			
	829.5	123456.0	123456.0	123456.0		Period Average Limit	Edit
	834.6	123456.0	123456.0	123456.0		Hour of Day Multiplier	Edit
						Day of Week Multiplier	Edit
						Rising/Falling Condition	Edit
					-	Seasonal Variation	Edit

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Fall Drawdown Release

#### 2. Spring Refill

Figure 8 shows the content of "Spring Refill" rule. This rule represents the seasonal maximum release from reservoir as a function of Inflow.

Operation Set Existing Ops		•	Description					
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.								
<ul> <li>Top of dam</li> <li>Flood Control</li> <li>Fall Drawdown Release</li> </ul>	Operates Re Rule Name:				escription	:		
Spring Refill     Flash Boards	Function of:	Goose P	ond-Pool N	Vet Inflow,	Current Va	alue		Define
Conservation Eall Drawdown Release	Limit Type:	Maximur	n 🔻	Interp.:	Linear	•	ු 60 <del></del>	-
Spring Refill I show the second se	Flow		Releas	e (cfs)			(i) 60 0 40 2 20	_
🛤 Inactive	(cfs)	01Jan	01Mar	01Apr	01May			_
	0.0	1.0	0.0	0.0	1.0		40,000 80,000 120,	000 '
	15.99	1.0	11.193	11.193	1.0		Flow (cfs)	
	62.99	1.0 1.0	16.0 16.0	11.2 44.093	1.0 1.0		Period Average Limit	Edit
	63.0	1.0	16.0	63.0	1.0		Period Average Limit	Eait
	123456.0	1.0	16.0	63.0	1.0		Hour of Day Multiplier	Edit
							Day of Week Multiplier	Edit
							Rising/Falling Condition	Edit
						-	Seasonal Variation	Edit

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Spring Refill

## 3. Flash Boards

Figure 9 shows the content of "Flash Boards" rule. This rule represents the seasonal maximum flow from reservoir based on Inflow.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>							
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec	. Sched. Projecte	d Elev						
<ul> <li>Top of dam</li> <li>Flood Control</li> <li>Fall Drawdown Release</li> </ul>	Operates Release From: Goose Pond           Name:         Flash Boards							
<ul> <li>Fall Drawdown Release</li> <li>Spring Refill</li> <li>Flash Boards</li> <li>→ IF (827.3=<elevataion=<831.13)< li=""> <li>→ IF (elevation&gt;831.13)</li> <li>→ ELSE IF (elevation&gt;831.13)</li> <li>→ release while flashboards are removed</li> <li>Conservation</li> <li>Fall Drawdown Release</li> <li>Spring Refill</li> <li>{} Flash Boards</li> <li>Inactive</li> </elevataion=<831.13)<></li></ul>	Type IF ELSE IF	Name 827.3= <elevataion= elevation&gt;831.13</elevataion= 	<831.13	Description 3				
Operation Set Existing Ops	Description							
Zone-Rules Rel, Alloc. Outages Stor, Credit Dec. S	ched. Projected E	lev						
<ul> <li>Top of dam</li> <li>Flood Control</li> <li>Fall Drawdown Release</li> </ul>	_	From: Goose Pond-l .3= <elevataion=<831< td=""><td></td><td></td><td></td></elevataion=<831<>						
Spring Refill     Flash Boards     Flash Boards     F (827.3= <elevataion=<831.13) f="" flashboards<="" over="" release="" td="" the=""><td></td><td>Pond-Pool:Elevation</td><td>&gt;=</td><td>Value2 827.3</td><td></td></elevataion=<831.13)>		Pond-Pool:Elevation	>=	Value2 827.3				
➡ ELSE IF (elevation>831.13) ➡ relaese while flashboards are removed	AND Goose F	ond-Pool:Elevation	<=	831.13	Add Cond.			

Operation Set Existing Ops	Description	
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec.	Sched. Projected Elev	
📩 Top of dam	Operates Release From: Goose Pond	
👝 Flood Control		
Fall Drawdown Release	Rule Name: ease over the flashboards Description:	
E Spring Refill	Function of: Goose Pond-Pool Elevation, Current Value	Define
☐ { Flash Boards ☐ ➡ IF (827.3= <elevataion=<831.13)< p=""></elevataion=<831.13)<>	Goose Polid-Pool Elevation, Cultent value	Deline
release over the flashboards	Limit Type: Specified 🗸 Interp.: Linear 🗸	
ELSE IF (elevation>831.13)		
relace while flashboards are removed	Elev (ft) Release (cfs) 💮 800	
Conservation	827.37 2.22 × 3 600	
Fall Drawdown Release	827.44         6.27           827.51         11.52           827.58         17.73	
🛛 🔲 Spring Refill	827.51 11.52 0 200	
🗄 { } Flash Boards		
inactive 🔁	021.03 24.70	9.5 831
	827.79 41.04 Elev (ft)	
	827.86 50.15	
	827.93 59.83 Period Average Limit	Edit
	828.0 70.08	
	828.07 80.85 Hour of Day Multiplier	r Edit
	828.14 92.11 Day of Week Multiplie	er Edit
	828.21 103.86 828.28 116.07 Rising/Falling Condit	tion Edit
	828.35 128.72 Seasonal Variation	Edit
	828.49 155.3	
	828.56 169.2	
	828.63 183.49 -	
Operation Set Existing Ops	Description	
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec.	Sched. Projected Elev	
A Top of dam	Operates Release From: Goose Pond	
A Flood Control		
🔚 🔚 Fall Drawdown Release	ELSE IF Conditional elevation>831.13 Description:	
E Spring Refill		
E-{} Flash Boards	Value1 Value2	
➡ IF (827.3= <elevataion=<831.13)< p=""></elevataion=<831.13)<>	Goose Pond-Pool:Elevation > 831.13	
Felease over the flashboards     FLSE IF (elevation>831.13)		Add Cond.
ELSE IF (elevation > 83 1.13)		

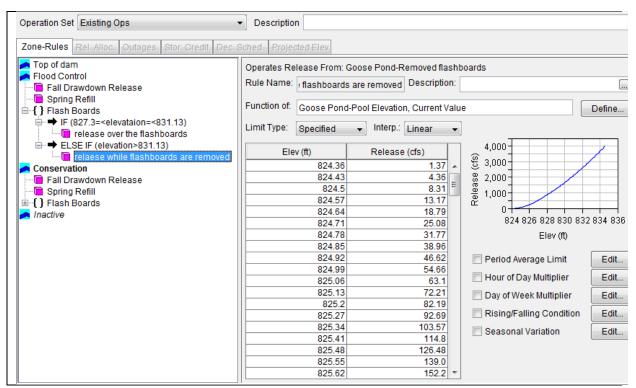


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Flash Boards

# **Grafton Pond**

#### I. Overview

The Grafton Pond Dam lies on a tributary of the Mascoma River close to Enfield Center, NH. The dam is owned and operated by the New Hampshire Water Resources Board. It is primarily used to maintain the level of Grafton Pond for recreation but also has some flood control benefits.

Figure 1 shows the location of Grafton Pond as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Grafton Pond dam.

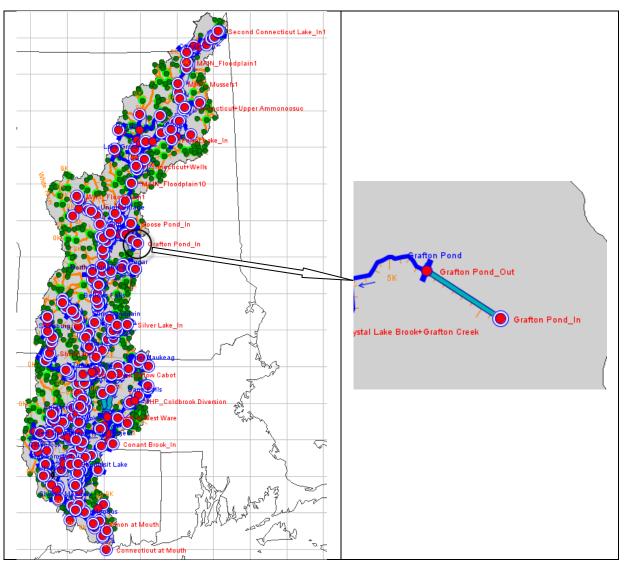


Figure 1: HEC-ResSim Map Display Showing Location of Grafton Pond



Figure 2: Photo of Grafton Pond dam

#### **Physical Characteristics** II.

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>44</sup>. The dam consists of three types of outlets: (1) controlled slide gates, (2) uncontrolled spillway-over TOD, and (3) uncontrolled lower spillway as shown in Figure  $4^{45}$ .

 <sup>&</sup>lt;sup>44</sup> NHDam Data Sheet. Grafton Pond. 2009.
 <sup>45</sup> National Dam Safety Program. Grafton Pond Operation and Maintenance Plan. 1978.

leservoir Edit Pool								
Reservoir Grafton Pond - Description								
Physical Operations Observed Data								
	Data							
Grafton Pond	Grafton Pond-Po	ol						
E-T Dam								
Slide Gates	Linear Inter	polation 🔘 Co	nic Interpolation	Initial Conic Depth (ft)				
Spillway-over TOD								
Solution of the second sec	Elevation	Storage	Area					
• •••••••	(ft)	(ac-ft)	(acre)					
	1210.51	100.00	0.00					
	1210.59	100.53	12.00 🗉					
	1210.67	101.07	24.00					
	1210.75	101.60	36.00					
	1210.83	102.13	48.00	1,250				
	1210.91	102.67	60.00	£ <sup>1,240</sup>				
	1210.99	103.20	72.00	€ 1,230 1,230				
	1211.07	103.73	84.00	± 1 220				
	1211.15	104.27	96.00					
	1211.23	104.80	108.00	1,210				
	1211.31	105.33	120.00					
	1211.39	105.87 106.40	132.00 144.00	Stor (ac-ft)				
	1211.47	106.40	144.00	1,250				
	1211.63	106.93	168.00	1,240				
	1211.03	107.47	188.00	€ 1,240				
	1211.79	108.53	192.00	€ 1,230 ↓ 230				
	1211.87	100.07	204.00	<sup>Ⅲ</sup> 1,220				
	1211.95	109.60	216.00	1,210				
	1212.03	110.13	228.00	0 4,000 8,000				
	1212.00	110.67	240.00	Area (acre)				
	1212.19	111.20	252.00					
	1212.27	111.73	264.00					
	1212.35	112.27	276.00					
	1212.43	112.80	288.00					
	1212.51	113.33	300.00 👻					

Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor						X
Reservoir Edit Dam						
Reservoir Grafton Pond -	Description					K 4 26 of 74 K
Physical Operations Observed Da	ita					
Grafton Pond	Grafton Pond-I	Dam				
Pool	Elevation at to	op of dam (f	)	1245	.25	
Spillway-over TOD	Length at top	of dam (ft)		28	4.8	
Iower spillway	Composite F	Release Ca	pacity			
	Elevation	Controll	Uncontr	Total	]	
	(ft)	(cfs)	(cfs)	(cfs)		1,250
	1,225.0	0.0	0.0	0.0 🔺	8	1,240
	1,225.1	0.2	0.0	0.2 =	Elevation	€ 1,230
	1,225.2	0.7	0.0	0.7	Ē	
	1,225.2	1.4	0.0	1.4	-	1,220 + + + + + + + + + + + + + + + + + +
	1,225.3	2.2	0.0	2.2		
	1,225.4	3.1	0.0	3.1		Flow
	1,225.5	4.1	0.0	4.1		(cfs)
	1,225.6	5.2	0.0	5.2		
	1,225.6	6.4 7.7	0.0	6.4		
	1,225.8	9.0	0.0	9.0		
	1,225.9	10.4	0.0	10.4		
	1,226.0	11.9	0.0	11.9		
	1,226.0	13.4	0.0	13.4		
	1,226.1	15.0	0.0	15.0		
	1,226.2	16.7	0.0	16.7		
	1,226.3	18.4	0.0	18.4		
	1,226.4	20.1	0.0	20.1		
	1,226.4	22.0	0.0	22.0		
	1,226.5	23.8	0.0	23.8		
	1,226.6	25.7	0.0	25.7		
	1,226.7	27.7	0.0	27.7 -		
[]						
				ОК		Cancel Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Grafton Pond's "ExistingOps" operational zones, which consist of zones of Top of dam (1245.25 ft), Flood Control (1244.5 ft), Conservation (1239.5-1241.5 ft), and Inactive zone (1223.5 ft)<sup>1</sup>.

Reservoir Editor				X							
Reservoir Edit Operations Zone Rule	EIF_Block										
Reservoir Grafton Pond   Description  M   26 of 74  M											
Physical Operations Observed Data											
Operation Set Existing Ops   Description											
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev											
Top of dam Flood control	Storage Zone Cor	nservation	Description								
Conservation	Function of Date			Define							
inactive 🔁		Top Elevation									
	01Jan 01Mar	1239.5 × 1239.5	<u> </u>	1,245							
	01Jun	1239.5		1,240							
	120ct	1241.5	. €								
	01Nov	1239.5	tion	1,235							
			Elevation (ft)	1,230							
				1,225							
			T.	Jan Mar May Jul Sep Nov							
	Zone Sort Elevation	n									
				OK Cancel Apply							

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops.

🟹 Reservoir Editor							
Reservoir Edit Operations Zone Ru							
Reservoir Grafton Pond							
Physical Operations Observed D							
Operation Set Existing Ops							
Zone-Rules Rel. Alloc. Outages							
<ul> <li>Top of dam</li> <li>Flood control</li> <li>Conservation</li> <li>Spring Refill - Grafton Pond</li> <li>Inactive</li> </ul>							

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

#### **C.** Rule Descriptions

#### 1. Spring Refill-Grafton Pond

Figure 7 shows the content of "Spring Refill-Grafton Pond" rule. This rule defines the minimum release from reservoir as a function of Inflow.

Operation Set Existing Ops		▼ D	escription						
Zone-Rules Rel. Alloc. Outages	Stor. Credit	Dec. So	ched. Pro	jected Ele	V				
Top of dam Flood control Conservation	Operates Release From: Grafton Pond Rule Name: pring Refill - Grafton Pond Description:								
Spring Refill - Grafton Pond	Function of: Grafton Pond-Pool Net Inflow, Current Value							e	
	Limit Type:	Minim	um 👻	Interp.:	Linear	•	€ 12		
	Flow	Flow Release (cfs)							
	(cfs)	01Jan	01Mar	01Apr	01May				
	0.0	0.1	0.0 2.793	0.0 2.793	0.1	-	Flow (ofs)		
	4.0	0.1	4.0	2.8	0.1		Period Average Limit	t	
	13.99	0.1	4.0	9.793 14.0	0.1	=	Hour of Day Multiplier Edi		
	123456.0	0.1	4.0	14.0	0.1		Day of Week Multiplier Edi	t	
						Ŧ	Rising/Falling Condition	t	
	4				Seasonal Variation Edi	it			

Figure 7: Reservoir Editor: Operations Tab - Existing Ops OpSet - Spring Refill-Grafton Pond

#### Harriman

#### I. Overview

Harriman dam is located upstream of the town of Readsboro on the Deerfield River. It is owned and operated by TransCanada Hydro Northeast Inc. for hydropower generation on a peaking, seasonal storage basis.

Figure 1 shows the location of Harriman Dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo from Harriman Dam.

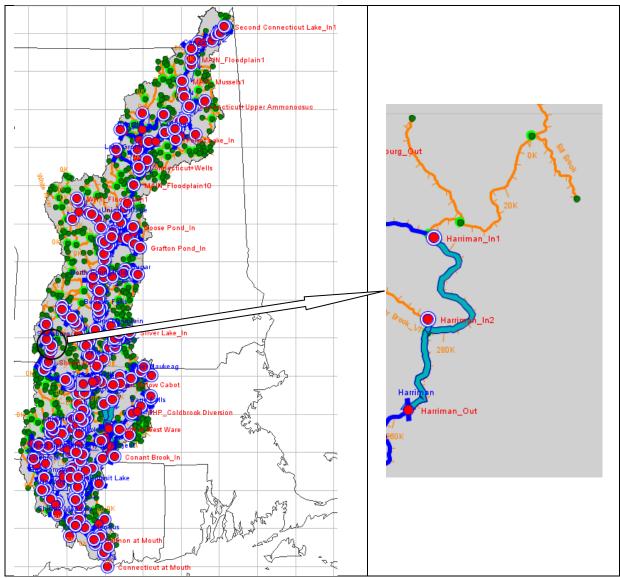


Figure 1: HEC-ResSim Map Display Showing Location of Harriman



Figure 2: Photo of Harriman Dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>46</sup>. The dam consists of four types of outlets: (1) uncontrolled spillway, (2) controlled spillway, (3) Howell Bunger Valve, and (4) power plant as shown in Figure 4.

<sup>&</sup>lt;sup>46</sup> Data provided by TransCanada

Reservoir Editor eservoir Edit Pool			ALC: ALC: ALC: ALC: ALC: ALC: ALC: ALC:					
	Description							
Reservoir Harriman 👻	Description			H 4 39 of 74 H				
Physical Occurrent Data								
Physical Operations Observed Data								
	Harriman-Pool							
⊡	Linear Interpola	ation 💿 Conic Ir	terpolation Initial	I Conic Depth (ft)				
Power Plant			. [	1				
spillway over flashboards	Elevation	Storage	Area					
spillway(flashboards rem	(ft)	(ac-ft)	(acre)					
Howell Bunger valve	1405.66	0.00	465.10 🔺					
	1405.76	47.00	466.20					
	1405.86	94.00	467.30					
	1405.96	141.00	468.30					
	1406.06	188.00	469.40					
	1406.16 1406.26	235.00 281.90	470.50 471.60					
	1406.26	328.90	471.60					
	1406.46	375.90	472.00	1,500				
	1406.56	422.90	474.80	1,480				
	1406.66	471.00	476.00	€ 1,460				
	1406.76	519.00	477.20	à 1,440 □ 1,420				
	1406.86	567.10	478.30	ш 1,420-				
	1406.96	615.20	479.50	1,400 + + + + + + + + + + + + + + + + + +				
	1407.06	663.20	480.70	0 80,000				
	1407.16	711.30	481.90	Stor (ac-ft)				
	1407.26	759.30	483.10					
	1407.36	807.40	484.20	1,500				
	1407.46	855.50	485.40	1,480				
	1407.56	903.50	486.60	€ 1,460				
	1407.66	952.80	487.90	à 1,440 ₩ 1,420				
	1407.78	1002.20	489.30	1,420				
	1407.86	1051.50	490.60					
	1407.96 1408.06	1100.80 1150.10	492.00 493.30					
	1408.06	1199.40	493.30	Area (acre)				
	1408.26	1248.80	494.70					
	1408.36	1298.10	490.00					
	1408.46	1347.40	498.70					
	1408.56	1396.70	500.10					
	1408.66	1447.50	501.70					
	1408.76	1498.30	503.20					
	1408.86	1549.00	504.80					
<	1408.96	1599.80	506.40 👻					
				1				
				OK Cancel Apply				

Figure 3: Reservoir Editor: Physical Tab -- Pool

eservoir Edit Dam					
Reservoir Harriman 🗸	Description				K 🖪 39 of 74 🕨 M
Physical Operations Observed Da					
Harriman Pool	Harriman-Dam				
a. Dam	Elevation at top	of dam (ft)		1527.6	
Tailwater     Power Plant					
spillway over flashboards	Length at top of	dam (π)		1250.0	)
spillway(flashboards rem	Composite Rel	ease Capacity	,		
Howell Bunger valve	Elevation	Controlled	Uncontrolled	Total	
	(ft)	(cfs)	(cfs)	(cfs)	1,520
	1,400.0	1,413.2	1.3		5 1,480
	1,410.0	1,413.2	1.3	1,414.5	E 1,480 E 1,440 E 1,440 I 1,400
	1,420.0	1,413.2	1.3	1,414.5	n,400
	1,430.0	1,413.2	1.3	1,414.5	
	1,440.0	1,413.2	1.3	1,414.5	Flow
	1,460.0	1,413.2	1.3	1,414.5	(cfs)
	1,470.0	1,413.2	1.3	1,414.5	
	1,480.0	1,413.2	1.3	1,414.5	
	1,490.0	1,413.2	1.3	1,414.5	
	1,491.8	1,415.9	1.3	1,417.2	
	1,491.9	1,416.5	2.0	1,418.5	
	1,491.9	1,419.7	4.7	1,424.4	
	1,492.0	1,420.5	5.3	1,425.9	
	1,492.1	1,425.9	8.9	1,434.8	
	1,492.1	1,430.7	12.7	1,443.3	
	1,492.2	1,431.9	13.6	1,445.5	
	1,492.2	1,437.2	17.3	1,454.5	
	1,492.3	1,438.5	23.3	1,457.1	
	1,492.4	1,445.2	24.4	1,469.6	
	1,492.4	1,451.6	28.7	1,480.3	
	1,492.5	1,453.2	30.0	1,483.2	
	1,492.5	1,459.6	35.3	1,494.9	
	1,492.6	1,468.1	42.0	1,510.1	
	1,492.7	1,469.9	43.5	1,513.3	
	1,492.7	1,477.3	49.3	1,526.7 +	

Figure 4: Reservoir Editor: Physical Tab -- Dam

## III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Harriman's "ExistingOps" operational zones, which consist of zones of Top of dam (1527.6 ft), conservation (1497.6 ft), Min Pool (1440-1475 ft), and Inactive zone (1282.1 ft)<sup>1</sup>.

Reservoir Editor						×			
Reservoir Edit Operations Zone Rule IF_Block									
Reservoir Harriman   Description   M   39 of 74   H									
Physical Operations Observed Data	Physical Operations Observed Data								
Operation Set ExistingOps	Operation Set ExistingOps   Description								
Zone-Rules Rel. Alloc. Outages Stor.	Credit Dec. Sched.	Projected Elev							
Top of dam	Storage Zone Con	servation	De	scription					
Conservation	Function of Date					Define			
Image: Second Stability	Date	Top Elevation (ft)		4.550					
Hydropower_Harimann_Z2 removal of flashboards in winter	01Jan	1497.6	^	1,550					
in Pool 🦰				1,500					
Haximum Drawdown Rate How The second stability			6						
Min flow in Bypass			Elevation	1,400					
Inactive			E e	1,350					
				1,300					
				1,250	May Jul Se	n Nov			
			Ŧ	Jan Mai	May Jul Je	p 1404			
	Zone Sort Elevation								
					Canaal	Anniu			
				ОК	Cancel	Apply			

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

Figure 6 shows a sequential release allocation approach specified for available outlets along Harriman Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The spillway gets the remainder of the release until it reaches capacity. After the capacity through the spillway is reached, the remainder of the release goes through the Howell Bunger Valve.

Reservoir Editor	A							
Reservoir Edit Operations								
Reservoir Harriman								
Physical Operations Observed Data								
Operation Set ExistingOps	Operation Set ExistingOps   Description							
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. S	Sched. Projected Elev							
Release Allocation Strategy								
Harriman - Balanced Harriman-Dam (1.0) - Sequential Harriman-Power Plant Harriman-spillway(flashboards removed) Harriman-Howell Bunger valve	Release Location: Harriman-Dam Allocation Type: Sequential Harriman-Power Plant Harriman-spillway(flashboards removed) Harriman-Howell Bunger valve							

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

## **B. Rule Illustrations**

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>47</sup>.

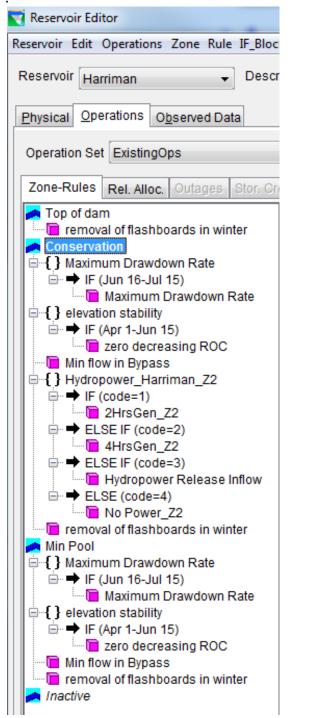


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>&</sup>lt;sup>47</sup> TransCanada. Deerfield River Operational Constraints. 2012.

# **C.** Rule Descriptions

### 1. Removel of flashboards in winter

Figure 8 shows the content of "removal of flashboards in winter" rule. This rule represents the releases through spillways when the flashboards are removed in winters.

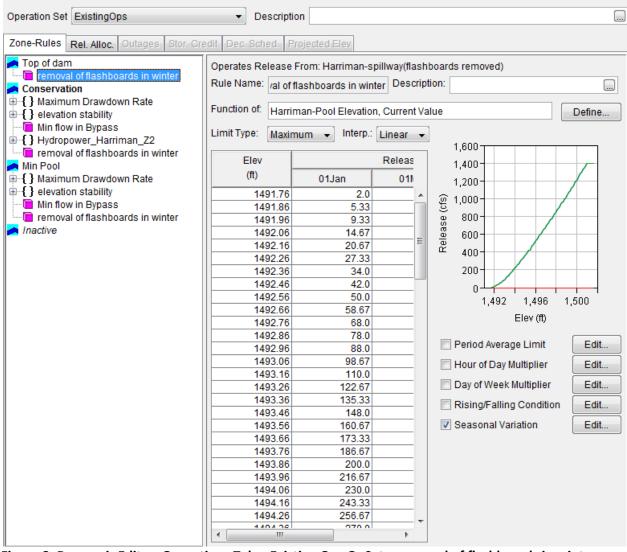


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – removal of flashboards in winter

## 2. Maximum Drawdown Rate

Figure 9 shows the content of "Maximum Drawdown Rate" rule. This rule limits the maximum change of elevation during 16Jun-15Jul.

Operation Set ExistingOps	-	Description			
Zone-Rules Rel. Alloc. Outages Stor. C	redit Dec	Sched. Projected Elev			
interfection of dam	Operate	s Release From: Harriman	-spillw	ay(flashboards removed)	
removal of flashboards in winter Conservation	Name:	Maximum Drawdown Rate	Desc	cription:	
Aximum Drawdown Rate		Maximum Brawdown (Call		•	
➡ IF (Jun 16-Jul 15) ■ Maximum Drawdown Rate	Туре	Name		Description	
Maximum Drawdown Rate     English elevation stability	IF	F Jun 16-Jul 15			
Min flow in Bypass					
Hydropower_Harriman_Z2     removal of flashboards in winter					
Min Pool					
Aximum Drawdown Rate					
<ul> <li>elevation stability</li> <li>Min flow in Bypass</li> </ul>					
removal of flashboards in winter					
nactive					
Operation Set ExistingOps	•	Description			
Zone-Rules Rel. Alloc. Outages Stor. Cr	edit Dec.	Sched. Projected Elev			
Top of dam	Operates	Release From: Harriman-	spillwa	y(flashboards removed)	
	IF Cond	itional Jun 16-Jul 15		Description:	
Aximum Drawdown Rate					
IF (Jun 16-Jul 15) IF (Jun 16-Jul 15) Imaximum Drawdown Rate	V	/alue1	>=	Value2	
<pre></pre>	AND	Current Time Step Current Time Step	<=	16Jun 15Jul	
Min flow in Bypass					
Hydropower_Harriman_Z2					
Alin Pool					
Maximum Drawdown Rate					Add Cond.
Image: The second stability           Imag					ridd obind.
📄 removal of flashboards in winter					Del. Cond.
👝 Inactive					

Operation Set ExistingOps	Description	)					
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev							
<ul> <li>Top of dam</li> <li>Top of dam</li> <li>removal of flashboards in winter</li> <li>Conservation</li> <li>{ Maximum Drawdown Rate</li> <li>IF (Jun 16-Jul 15)</li> <li>Maximum Drawdown Rate</li> <li>{ elevation stability</li> <li>Min flow in Bypass</li> <li>{ Hydropower_Harriman_Z2</li> <li>removal of flashboards in winter</li> <li>Min Pool</li> <li>{ elevation stability</li> <li>I maximum Drawdown Rate</li> <li>{ elevation stability</li> <li>I move and the stability</li> <li>Maximum Drawdown Rate</li> <li>{ elevation stability</li> <li>Maximum Drawdown Rate</li> <li>{ elevation stability</li> <li>Maximum Drawdown Rate</li> <li>{ elevation stability</li> <li>Min flow in Bypass</li> <li>removal of flashboards in winter</li> </ul>	Operates Release From: Harriman         Elevation Rate of Change Limit         Maximum Drawdown Rate         Description         Function Of:         Constant         Type         Decreasing         Instantaneous         Instantaneous         Period Average         Max Change of (ft)         1.0						

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Maximum Drawdown Rate

## 3. Elevation Stability

As Figure 10 shows this rule represents zero rate of change during Apr 1-Jun 15 for Harriman.

Operation Set ExistingOps	▼ De	scription			[.		
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev							
Top of dam	Operates Re	lease From: Harrim	an				
Conservation	Name: ele	vation stability	Descripti	on:			
elevation stability	Туре	Name		Description			
IF (Apr 1-Jun 15)	IF	Apr 1-Jun 15					
Min flow in Bypass							
Hydropower_Harriman_Z2 removal of flashboards in winter							
Min Pool Maximum Drawdown Rate							
Min flow in Bypass							
A Inactive							

Operation Set ExistingOps	✓ Description	
Zone-Rules Rel. Alloc. Outages Stor. C	it Dec. Sched. Projected Elev	
Top of dam	Operates Release From: Harriman	
Conservation	IF Conditional Apr 1-Jun 15 De	escription:
		alue2
zero decreasing ROC	AND Current Time Step >= AND Current Time Step <=	01Apr 15Jun
<ul> <li>Min flow in Bypass</li> <li>Hydropower_Harriman_Z2</li> <li>removal of flashboards in winter</li> </ul>		
📥 Min Pool		
Aaximum Drawdown Rate     elevation stability		Add Cond.
Min flow in Bypass Temoval of flashboards in winter Inactive		Del. Cond.
Operation Set ExistingOps	- Description	
Zone-Rules Rel. Alloc. Outages Stor. C	it Dec. Sched. Projected Elev	
Top of dam Top of dam Top of dam	Operates Release From: Harriman	
A Conservation	Elevation Rate of Change Limit zero decreasin	ig ROC
Haximum Drawdown Rate Haximum Drawdown Rate Haximum Stability	Description	
IF (Apr 1-Jun 15) IF (apr 1-Jun 15)	Function Of: Constant	•
Min flow in Bypass      Hydropower_Harriman_Z2	Type Decreasing	-
🔤 removal of flashboards in winter 🔁 Min Pool	<ul> <li>Instantaneous</li> <li>Period Average</li> </ul>	
Haximum Drawdown Rate How The stability	Max Rate of Change (ft/hr)	
Min flow in Bypass	0.0	
A Inactive		

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – elevation stability

## 4. Hydropower\_Harriman\_Z2

This rule represents power strategy applied for Harriman reservoir. The content of the rule is shown in Figure 11 as per the peaking hydropower modeling strategy.

Operation Set ExistingOps	- Doc	cription			[
Operation Set ExistingOps	• Dest				<u></u>
Zone-Rules Rel. Alloc. Outages Stor. Cre	edit Dec. Sched	I. Projected Elev			
nop of dam	Operates Rele	ase From: Harriman			
removal of flashboards in winter	Name: Index	power_Harriman_Z2	Descriptio	n:	
Conservation     Anximum Drawdown Rate	Hydro	power_Harriman_22	Descriptio		
<pre></pre>	Туре	Name	(	Description	
Min flow in Bypass	IF	code=1		•	
Hydropower_Harriman_Z2	ELSE IF	code=2			
IF (code=1) □ IF (code=1) □ 2HrsGen Z2	ELSE IF	code=3			
	ELSE	code=4			
4HrsGen_Z2					
➡ ➡ ELSE IF (code=3)					
Hydropower Release Inflow → ELSE (code=4)					
No Power_Z2					
Operation Set ExistingOps	▼ Desc	ription			
Operation Set ExistingOps	+ Dest				()
Zone-Rules Rel. Alloc. Outages Stor. Cre	edit Dec. Sched	. Projected Elev			
Top of dam	Operates Relea	ase From: Harriman			
removal of flashboards in winter Conservation	IF Conditional	code=1	Des	cription:	
Aaximum Drawdown Rate		0000-1		•	1
elevation stability	Value1		Val	ue2	
Min flow in Bypass	Ha	arimann_Volume	=	1	1
□ → IF (code=1)					
2HrsGen_Z2					
ELSE IF (code=2)					
HrsGen_Z2 → ELSE IF (code=3)					
Hydropower Release Inflow					Add Cond.
ELSE (code=4)					
No Power_Z2					Del. Cond.
	<u> </u>				
Operation Set ExistingOps	▼ Des	cription			
Zone-Rules Rel. Alloc. Outages Stor. Cri	edit Dec. Sched	d. Projected Elev			
👝 Top of dam	Operates Rele	ase From: Harriman	-Power Plan	t	
removal of flashboards in winter	Hvdropower - I	Power Guide Curve R	Rule 2HreCo	an 72	
Conservation			2111300	an_22	
	Description:				
Min flow in Bypass	Zone at Top of	Power Pool Con	nservation 🤜	·	
☐ ↓ Hydropower_Harriman_Z2 ☐ ↓ F (code=1)	Zone at Botton	n of Power Pool Min	Pool -		
2HrsGen_Z2	% Power S	torogo Plant P	Factor (%)	1	
ELSE IF (code=2)	70 FOWERS		0.0		
4HrsGen_Z2		100.0	8.33	-	
⇒ ELSE (code=4)				_	
No Power_Z2				-	

Operation Set ExistingOps	Description						
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sched. Projected Elev						
Top of dam	Operates Release From: Harrima	in-Power F	Plant				
	ELSE IF Conditional code=2		Description:				
	Value1		Value2				
Min flow in Bypass	Harimann_Volume	=	2				
Hydropower_Harriman_Z2     Hydropower_Harriman_Z2     Hydropower_Harriman_Z2							
E 2HrsGen_Z2							
ELSE IF (code=2)							
Hydropower Release Inflow     ELSE (code=4)				Add Cond.			
No Power_Z2				Del. Cond.			
Operation Set ExistingOps	✓ Description						
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sched. Projected Elev						
A Top of dam	Operates Release From: Harrima	in-Power F	Plant				
removal of flashboards in winter Conservation	Hydropower - Power Guide Curve						
Conservation     English Addition	Description:						
elevation stability				)			
Min flow in Bypass		onservatio	n 🔻				
IF (code=1)	Zone at Bottom of Power Pool	n Pool	•				
		t Factor (%					
HrsGen_Z2	0.0		8.33 6.67				
➡ ELSE IF (code=3) Hydropower Release Inflow							
ELSE (code=4)							
No Power_Z2							
Operation Set ExistingOps	<ul> <li>Description</li> </ul>						
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sched. Projected Elev						
Top of dam removal of flashboards in winter	Operates Release From: Harrim	an-Power I	Plant				
A Conservation	ELSE IF Conditional code=3		Description:				
⊕{ } Maximum Drawdown Rate     ⊕{ } elevation stability	Value1 Value2						
Min flow in Bypass	Harimann_Volume	_					
E→ Hydropower_Harriman_Z2 Hydropower_Harriman_Z2 Hydropower_Harriman_Z2							
2HrsGen_Z2							
ELSE IF (code=2) HrsGen Z2							
ELSE IF (code=3)							
Hydropower Release Inflow ➡ ELSE (code=4)				Add Cond.			
No Power_Z2				Del. Cond.			

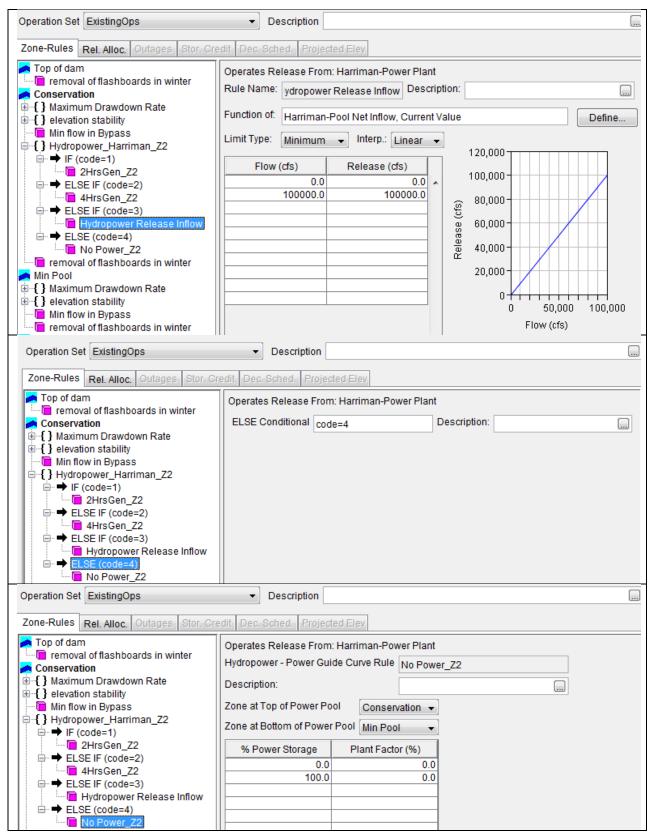


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Hydropower\_Hariman\_Z2

Figure 12 describes the definition of codes used in the Harriman\_Volume state variable. The code is summing up the current Inflow and previous storage in each time step, compare it to the volume needed for generating 2 and 4 hours power and to the spillway storage minus inactive storage and then decide how much to release.

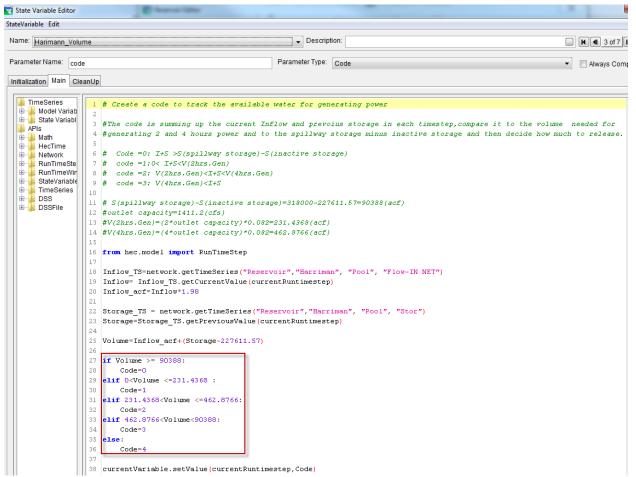


Figure 12: State Variable Editor: Harriman\_Volume

### 5. Min Flow in Bypass

Figure 13 shows the content of Min Flow in Bypass. This rule represents the seasonal minimum flow releases required from Harriman.

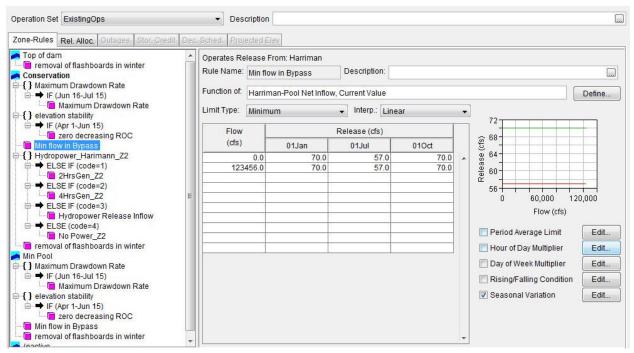


Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min flow in Bypass

# Holyoke

## I. Overview

Holyoke dam is located in the City of Holyoke, MA and is the most downstream dam on the mainstem Connecticut River. It is owned and operated by the Holyoke Water Power Company and is used for hydropower generation.

Figure 1 shows the location of Holyoke Dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo from dam.

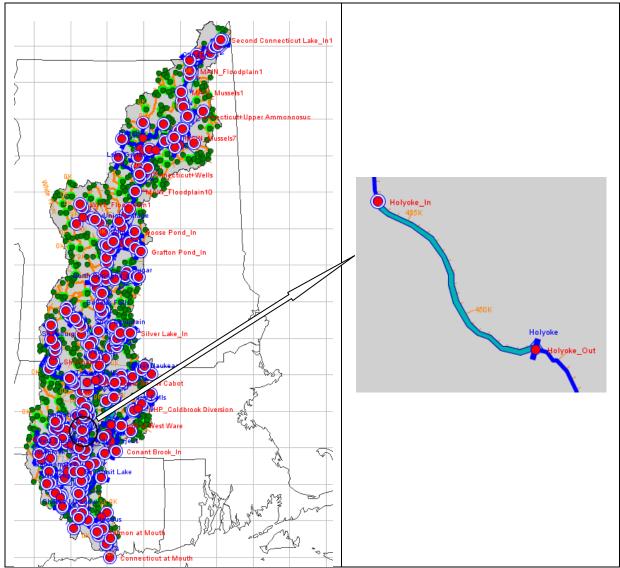


Figure 1: HEC-ResSim Map Display Showing Location of Holyoke dam



Figure 2: Photo from Holyoke dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>48</sup>. The dam consists of five types of outlets: (1) controlled Bascule Gate, (2) controlled Bypass pipe, (3) controlled Canal System, (4) controlled Spillway with gates, and (5) power plant as shown in Figure 4.

<sup>&</sup>lt;sup>48</sup>Data provided by UMASS

💘 Reservoir Editor Reservoir Edit Pool	-		Contractor (	×
Reservoir Holyoke	Description			K (1) 69 of 74 D H
Holyoke	Holyoke-Pool			
Dam	Linear Interpolation	Conic Interpol	ation Initial Conic	Depth (ft)
Bascule Gate Bypass pipe Canal System Spillway with gates Power Plant	Elevation (ft) 59.00 99.60 100.40 100.60 103.10 120.30	Storage (ac-ft) 100000.00 126000.00 126500.00 127600.00 135400.00	Area (acre) 0.00 2290.00 2290.00 2292.00 2300.00	120 100 80 60 100,000 120,000 140,000 Stor (ac-ft) 120 100 80 00 100 00 100 00 100 00 100 00
			Ok	Cancel Apply

Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor	_	-	- 3-	-		X	
Reservoir Edit Dam							
Reservoir Holyoke  Description Bescription Reservoir Observed Data							
	Holyoke-Dam						
Dam Tailwater	Elevation at top of	f dam (ft)		117.8	в		
Bascule Gate	Length at top of d	am (ft)		1770.0	b		
Bypass pipe     Canal System     Spillway with gates	Composite Rele	ase Capacity					
Power Plant	Elevation	Controlled	Uncontrolled	Total			
• • • • • • • • • • • • • • • • • • • •	(ft)	(cfs)	(cfs)	(cfs)	1	20	
	70.0	14,250.0	0.0	14,250.0 🔺	5 1	00-	
	80.0	14,338.0	0.0	14,338.0	TE @	80-	
	85.0	17,053.6	0.0	17,053.6	Ê	co	
	94.5	22,148.0	0.0	22,148.0 ≡		60 <del>- 1 1 1 1 1 1 1 1 1</del> 350,000	
	95.0	22,497.1	0.0	22,497.1			
	96.0	23,287.0	0.0	23,287.0		Flow	
	97.0	24,179.0	0.0	24,179.0		(cfs)	
	98.0	25,150.9 26,190.9	0.0	25,150.9 26,190.9			
	99.6	26,846.0	0.0	26,846.0			
	100.0	28,254.8	0.0	28,254.8			
	100.4	30,873.2	0.0	30,873.2			
	101.0	34,635.3	0.0	34,635.3			
	102.0	12 177 6	0.0	12 177 6			
				ОК		Cancel Apply	

Figure 4: Reservoir Editor: Physical Tab -- Dam

## III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 6 shows the definition of Holyoke's "ExistingOps" operational zones, which consist of zones of Flood Control (120.3 ft), Conservation (100.6 ft), and Inactive zone (68 ft)<sup>1</sup>.

Reservoir Editor	-		_	X
Reservoir Edit Operations				
Reservoir Holyoke - Desc	ription			K (1) 69 of 74 (1) H
Physical Operations Observed Data				
Operation Set Existing Ops	▼ Descriptio	n		
Zone-Rules Rel. Alloc. Outages Stor. C	redit Dec. Sched.	Projected Elev		
Flood Control	Storage Zone Con	servation	De	escription
Bascule Gate	Function of Date			Define
Conservation Bypass Pipe releases	Date	Top Elevation (ft)		130
<ul> <li>Normal high pool spillway gates</li> <li>Hydropower-Release 95% Inflow</li> </ul>	01Jan	100.6	^	120
inactive 🔁			E	
			Elevation (ft)	90
			Ē	
			Ŧ	Jan Mar May Jul Sep Nov
	Zone Sort Elevation			
				OK Cancel Apply

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

## **B. Rule Illustrations**

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>1</sup>.

Reservoir Editor
Reservoir Edit Operations
Reservoir Holyoke
Physical Operations Observed Data
Operation Set Existing Ops
Zone-Rules Rel. Alloc. Outages Stor. C
<ul> <li>Flood Control</li> <li>Bypass Pipe releases</li> <li>Canal Flows</li> <li>Conservation</li> <li>Bypass Pipe releases</li> <li>Normal high pool spillway gates</li> <li>Hydropower-Release 95% Inflow</li> <li>Inactive</li> </ul>

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

Figure 8 shows a sequential release allocation approach specified for available outlets along Bellows Falls Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The Bypass pipe gets the remainder of the release until it reaches capacity. Then the flow passes through the Canal System. After the capacity through the Canal System is reached, the remainder of the release goes through the Bascule gate and spillway with gates, respectively.

Reservoir Editor	and and a local sector of the local sectors
Reservoir Edit Operations	
Reservoir Holyoke	
Physical Operations Observed Data	
Operation Set Existing Ops    Descri	ption
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched.	Projected Elev
Release Allocation Strategy	
Holyoke - Balanced	Release Location: Holyoke-Dam at Connecticut River
Holyoke-Dam at Connecticut River (1.0) - Sequential     Holyoke-Power Plant	Allocation Type: Sequential
<ul> <li>Holyoke-Bypass pipe</li> <li>Holyoke-Canal System</li> <li>Holyoke-Bascule Gate</li> <li>Holyoke-Spillway with gates</li> </ul>	Holyoke-Power Plant Holyoke-Bypass pipe Holyoke-Canal System Holyoke-Bascule Gate Holyoke-Spillway with gates

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

## **C.** Rule Descriptions

#### 1. Bypass Pipe release

Figure 9 shows the content of "Bypass Pipe release" rule. This rule represents a specified release from Bypass pipe controlled outlet.

Operation Set Existing Ops	▼ De:	scription	
Zone-Rules Rel. Alloc. Outages Stor.	. Credit Dec. S	ched. Projected Ele	ev.
Flood Control  Bypass Pipe releases  Bascule Gate Canal Flows	Operates Rel Rule Name:	ease From: Holyoke- Bypass Pipe release	
	Function of:	Date	Define
Bypass Pipe releases	Limit Type:	S 🗸 Interp.: 🚬	
Hydropower-Release 95% Inflow	Date	Release (cfs)	(£ 120
	01Jan	0.0	
	31Mar 01Apr	0.0	ل ملاحظ المحالي المحالي Jan Mar May Jul Sep Nov
	30Nov	150.0	San Ioan Ioay Sui Sep Noo
	01Dec	0.0	Period Average Limit Edit
			Hour of Day Multiplier Edit
			Day of Week Multiplier
			Rising/Falling Condition
		*	Seasonal Variation Edit

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Bypass Pipe release

### 2. Bascule Gate

Figure 10 shows the content of "Bascule Gate" rule. This rule represents the seasonal minimum release from Bascule gate controlled outlet.

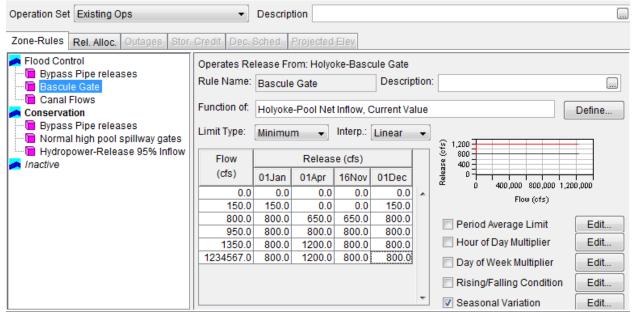


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Bascule Gate

#### 3. Canal Flows

Figure 11 shows the content of "Canal Flows" rule. This rule represents the seasonal minimum release from Canal System controlled outlet.

Operation Set Existing Ops		▼ Des	cription						[
Zone-Rules Rel. Alloc. Outages Sto	r. Credit De	c. Sched	Project	ed Elev					
Flood Control Bypass Pipe releases Canal Flows Canal Flows Box Conservation Bypass Pipe releases	Operates F Rule Nam Function o Limit Type	e: Cana f: Holyc	I Flows ke-Pool I	Vet Inflow	_ `	ription: Value			 Define
Normal high pool spillway gates Hydropower-Release 95% Inflow Inactive	Flow (cfs)		R	elease (c	fs)		•	@ 6,000	
	0.0 400.0 950.0 951.0 1351.0 2951.0	01Jan 400.0 400.0 400.0 400.0 400.0 400.0	01Apr 0.0 0.0 1.0 400.0 2000.0	01Aug 0.0 0.0 1.0 400.0 400.0	01Sep 0.0 0.0 1.0 400.86 2000.3	400.0 400.0	*	(1) 4,000 2,000 0 0 80,000 160,0 Flow (cfs)	000
	2951.0 3951.0 15601.0 17200.0 17201.0 17601.0 18201.0 18202.0 18601.0 21601.0 23201.0	400.0 400.0 400.0 400.0 400.0 400.0 400.0 400.0 400.0 400.0 400.0 400.0	2000.0 2000.0 2000.0 2001.0 2267 2667 2668 2934 4934 6000.0	400.0 400.0 1679.2 1680.0 2000.0 2600.0 2601.0 3000.0 6000.0	2000.3 3000.0 3000.0 3000.0 3000.0 3000.0 6000.0 6000.0 6000.0 6000.0	400.0 400.0 400.0 400.0		Period Average Limit Hour of Day Multiplier Day of Week Multiplier Rising/Falling Condition Seasonal Variation	Edit Edit Edit Edit Edit

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Canal Flows

### 4. Normal high pool spillway gates

Figure 12 shows the content of "Normal high pool spillway gates" rule. This rule makes no releases from Spillway with gates controlled outlet.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>			
Zone-Rules Rel. Alloc. Outages Stor. C	Credit Dec. Sched. Proje	ected Elev		
Flood Control Bypass Pipe releases Bascule Gate Canal Flows Conservation		: Holyoke-Spillway with gai I spillway gates Descripti		Define
Bypass Pipe releases Normal high pool spillway gates Hydropower-Release 95% Inflow Inactive	Limit Type: Maximum Date 01Jan	Interp.: Linear     Release (cfs)     0.0	1.0 (0.8 (0.0 0.0 0.0 0.2 0.0 Jan Mar May Jul Sep N	
			<ul> <li>Hour of Day Multiplier</li> <li>Day of Week Multiplier</li> <li>Rising/Falling Condition</li> </ul>	Edit Edit Edit Edit

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Normal high pool spillway gates

### 5. Hydropower-Release 95% Inflow

Figure 13 shows the content of "Hydropower –Release 95% Inflow" rule. This rule releases the 95% of inflow through power plant as per the run-of-river modeling strategy.

Operation Set Existing Ops	<ul> <li>Descrip</li> </ul>	tion			
Zone-Rules Rel. Alloc. Outages Stor.	Credit Dec. Sched.	Projected Elev			
Flood Control Bypass Pipe releases Bascule Gate Canal Flows Conservation	Operates Release Rule Name: Iower Function of: Holyo		wD	escription:	 Define
Bypass Pipe releases     Normal high pool spillway gates     Hydropower-Release 95% Inflow     Inactive	Limit Type: Mini Flow (cfs) 0.0 100000.0	Release (cfs)		(i) 90,000 60,000 30,000 0 0 0 0 0 0 0 0 0 0 0 0	90,000
			T	<ul> <li>Period Average Limit</li> <li>Hour of Day Multiplier</li> <li>Day of Week Multiplier</li> <li>Rising/Falling Condition</li> <li>Seasonal Variation</li> </ul>	Edit Edit Edit Edit Edit

Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Hydropower-Release 95% Inflow

# Knightville

## I. Overview

Knightville Dam is located on the North Branch of the Westfield River near the town of Knightville in Hampshire County, Massachusetts, USA. The U.S. Army Corps of Engineers constructed the dam in 1941 and is still owned and operated by the Corps. It is primarily used for flood control but also for recreation.

Figure 1 shows the location of Knightville Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the dam.

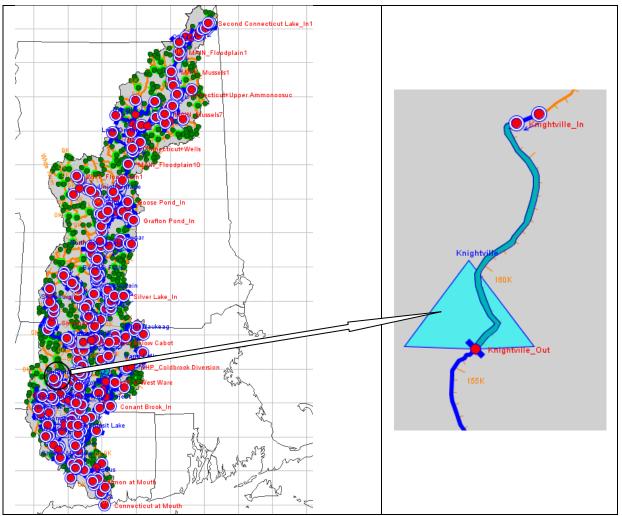


Figure 1: HEC-ResSim Map Display Showing Location of Knightville dam



Figure 2: Photo of Knightville Dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled slide gates, and (2) uncontrolled spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>49</sup>.

<sup>&</sup>lt;sup>49</sup> http://rsgisias.crrel.usace.army.mil/nae/cwms\_map.map\_index

servoir Edit Pool				
eservoir Knightville	<ul> <li>Description</li> </ul>			K 4 9 of 74 🕨 I
hysical Operations Observed	rved Data			
Knightville	Knightville-Pool			
Dam Slide Gates	Linear Interpola	tion 💿 Conic Inte	erpolation Initial C	Conic Depth (ft)
Spillway	Elevation	Storage	Area	
	(ft)	(ac-ft)	(acre)	
	480.00	0.00	0.00	
	490.00	73.00	12.00	
	492.00	113.00	14.00	
	494.00	153.00	16.00	600
	496.00	195.00	20.00 =	⇔ 560
	498.00	244.00	25.00	
	500.00	294.00	30.00	à 520 <b>-</b>
	502.00	384.00	36.00	480
	504.00	475.00	45.00	
	506.00	592.00	55.00	20,000 40,000
	508.00	710.00	65.00	Stor (ac-ft)
	510.00	872.00	75.00	
	512.00	1035.00	87.00	600
	514.00	1235.00	100.00	a 560
	516.00	1435.00	115.00	
	518.00	1705.00	125.00	<u>a</u> 520
	520.00	1975.00	145.00	480
	522.00	2317.00	160.00	+++++++++++++++++++++++++++++++++++++++
	524.00	2660.00	185.00	0 400 800
	526.00	3045.00	205.00	Area (acre)
	528.00	3430.00	220.00	
	530.00	3857.00	230.00	
	532.00	4285.00	240.00	
	534.00	4802.00	255.00 -	
				·

Figure 3: Reservoir Editor: Physical Tab -- Pool

eservoir Edit Dam					
Reservoir Knightville	<ul> <li>Description</li> </ul>				H 4 9 of 74 D H
Physical Operations Ob	served Data				
Knightville	Knightville-Dam				
Dam Slide Gates	Elevation at top of	f dam (ft)		630.	.0
Spillway	Length at top of o			1200.	. 0
	Composite Rele				
	Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)	
	480.0	0.0	0.0	0.0 🔺	500 500 500 500 500 500 500 500
	490.0	1,066.0	0.0	1,066.0	E 540
	500.0	2,860.0	0.0	2,860.0	⊕ 480 <b>-</b>
	510.0	4,260.0	0.0	4,260.0	0 120,000
	520.0	5,160.0	0.0	5,160.0	Flow
	540.0	5,900.0		5,900.0 6,540.0 ≡	(cfs)
	540.0	6,666.0		6,666.0	(015)
	610.0	6,666.0		6,666.0	
	611.0	6,666.0		8,666.0	
	612.0	6,666.0		10,666.0	
	613.0	6,666.0		13,666.0	
	614.0	6,666.0	10,000.0	16,666.0	
	615.0	6,666.0	14,000.0	20,666.0	
	616.0	6,666.0		25,666.0	
	617.0	6,666.0		30,666.0	
	618.0	6,666.0		37,666.0	
	619.0	6,666.0		44,166.0	
	620.0 621.0	6,666.0 6,666.0		52,166.0 60,666.0 -	

Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Knightville's "ExistingOps" operational zones, which consist of zones of Surcharge (630 ft), Flood Control (610 ft), Conservation (481-505 ft), and Inactive zone (480 ft).

Reservoir Editor						
Reservoir Edit Operations Zone Rule IF_Block						
Reservoir Knightville   Description  Reservoir Knightville  Reservoi						
Physical Operations Observed Data						
Operation Set Existing Ops	Description					
Zone-Rules Rel. Alloc. Outages Stor. Credit D	ec. Sched. Projected Elev					
Surcharge	Storage Zone Conservation	Description				
Minimum ABF Release	Function of Date	Define				
Connecticut at Montague - Linear Connecticut at Hartford - Linear Westfield at Huntington - Linear Downstream control at Westfield Flood Control Maximum Release from Controlled Outlets Minimum ABF Release Connecticut at Montague - Linear Connecticut at Hartford - Linear Westfield at Huntington - Linear Uestfield at Montague - Linear Uestfield at Montague - Linear Uestfield at Huntington - Linear	Date         Top Elevation (ft)           01Jan         505.0           30Apr         505.0           01May         481.0           30Nov         481.0           01Dec         505.0           01Dec         505.0           01Dec         505.0	640 620 680 580 560 540 540 480 480 480 Jan Mar May Jul Sep Nov				
Downstream control at Westfield     Max Flow ROC-Increasing     ABF Maximum rate of decrease     AF Maximum rate of pool level drop     Inactive	Zone Sort Elevation	OK Cancel Apply				

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

Reservoir Editor	🟹 Reservoir Editor
Reservoir Edit Operations Zone Rule IF_Block	Reservoir Edit Operations Zone Rule IF_Block
Reservoir Knightville	Reservoir Knightville    Description
Physical Operations Observed Data	Physical Operations Observed Data
Operation Set Existing Ops	Operation Set Existing Ops   Desc
Zone-Rules       Rel. Alloc.       Outages       Stor. Credit       E         Surcharge       Gate Ops to Save Dam       Maximum Release from Controlled Outlets       Minimum ABF Release         Minimum ABF Release       Connecticut at Montague - Linear       Connecticut at Hartford - Linear         Westfield at Huntington - Linear       Downstream control at Westfield         Flood Control       Maximum Release from Controlled Outlets         Minimum ABF Release       Connecticut at Montague - Linear         Downstream control at Westfield       Minimum ABF Release         Connecticut at Hartford - Linear       Montague - Linear         Montage - Linear       Connecticut at Montague - Linear         Montage - Linear       Ouvestfield at Huntington - Linear         Downstream control at Westfield       Max Flow ROC-Increasing         ABF Maximum rate of decrease       ABF Maximum rate of decrease         ABF Maximum rate of pool level drop       Max Outflow equals 21 day max Inflow         Maximum Release from Controlled Outlets       Min Flow Logic - Knightville	Zone-Rules       Rel. Alloc.       Outages.       Stor. Credit       Dec. Sched            • • • IF (Pool elev >= 582 ft)         • • • • IF (Pool elev >= 576 & <582 ft)         • • • • ELSE IF (Pool elev >= 576 & <582 ft)         • • • • ELSE IF (Pool elev >= 570 & <576 ft)         • • • ELSE IF (Pool elev >= 570 & <576 ft)         • • • • ELSE IF (Pool elev >= 520 & <570 ft)         • • • • ELSE IF (Pool elev >= 555 & <562.5)         • • • • ELSE IF (Pool elev >= 555 & <562.5)         • • • • • • • ELSE IF (Pool elev >= 547.5 & <555)         • • • • • • • • • • • • • • •
Connecticut at Montague - Linear Connecticut at Hartford - Linear Westfield at Huntington - Linear Downstream control at Westfield Max Flow ROC-Increasing ABF Maximum rate of decrease Context at the structure of the structure o	Pelse in (roof elev>=510 & <515)     Restrict releases for pool 510-515     Pelse if (Pool elev>= 505 & <510 ft)     Restrict release for pool 505-510     Pelse if (Pool elev>=500 & <505 ft)     Restrict release for pool 500-505     Pelse (Pool elev <500 ft)     Restrict release for pool <500 ft     Pelse (Pool elev <500 ft)     Restrict release for pool <500 ft     Pelse (Pool elev <500 ft)     Pelse (Pool elev <500
inactive	

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## **C. Rule Descriptions**

#### 1. Gate Ops to Save Dam

Figure 7 shows the content of "Gate Ops to Save Dam" rule. This rule represents the maximum allowable release from Slide gates as a function of pool elevation when the pool is in Surcharge zone.

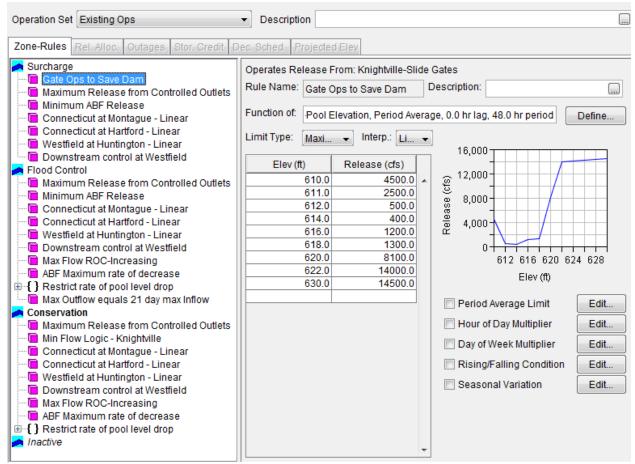


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet –Gate Ops to Save Dam

## 2. Maximum Release from Controlled Outlets

Figure 8 shows the content of "Maximum Release from Controlled Outlets" rule. This rule represents the maximum allowable release from Slide gates.

Operation Set Existing Ops	Description
Zone-Rules Rel, Alloc. Outages. Stor. Credit. I	Dec. Sched. Projected Elev
<ul> <li>Surcharge</li> <li>Gate Ops to Save Dam</li> <li>Maximum Release from Controlled Outlets</li> <li>Minimum ABF Release</li> <li>Connecticut at Montague - Linear</li> <li>Connecticut at Hartford - Linear</li> <li>Westfield at Huntington - Linear</li> <li>Downstream control at Westfield</li> <li>Flood Control</li> <li>Maximum Release from Controlled Outlets</li> <li>Minimum ABF Release</li> <li>Connecticut at Montague - Linear</li> <li>Connecticut at Montague - Linear</li> <li>Connecticut at Hartford - Linear</li> <li>Downstream control at Westfield</li> <li>Max Flow ROC-Increasing</li> <li>ABF Maximum rate of decrease</li> <li>Astimum Release from Controlled Outlets</li> <li>Min Flow Logic - Knightville</li> <li>Connecticut at Hartford - Linear</li> <li>Westfield at Huntington - Linear</li> <li>Min Flow Logic - Knightville</li> <li>Connecticut at Hartford - Linear</li> <li>Westfield at Huntington - Linear</li> <li>Max Flow ROC-Increasing</li> <li>ABF Maximum rate of decrease</li> <li>ABF Maximum rate of decrease</li> <li>ABF Maximum rate of decrease</li> </ul>	Operates Release From: Knightville-Slide Gates         Rule Name:       se from Controlled Outlets       Description:         Function of:       Date       Define         Date       Release (cfs)       4,540         01Jan       4500.0       4,520         9       4,500       4,500         9       4,500       4,480         4,480       4,480       4,480         4,460       Jan       May         9       9       9         9       9       9         9       9       9         9       9       9         9       9       9         9       9       9         9       9       9         9       9       9         9       9       9         9       9       9         9       9       9         9       9       9         9       9       9         9       9       9         9       9       9         9       9       9         9       9       9         9       9       9

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Maximum Release from Controlled Outlets

## 3. Minimum ABF Release

Figure 9 shows the content of "Minimum ABF Release" rule. This rule represents the minimum required release from dam during flood control operations.

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Minimum ABF Release

### 4. Connecticut at Montague-Linear

Figure 10 shows the content of "Connecticut at Montague-Linear" rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

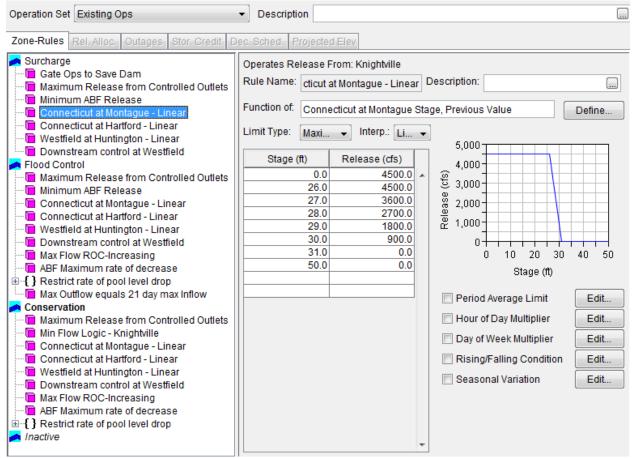


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague-Linear

### 5. Connecticut at Hartford-Linear

Figure 11 shows the content of "Connecticut at Hartford-Linear" rule. This rule represents the maximum allowable release from dam as a function of previous day stage at Hartford. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

	Description	
Rel. Alloc.       Outages       Stor. Credit.         Surcharge       Gate Ops to Save Dam       Maximum Release from Controlled Outlets         Minimum ABF Release       Connecticut at Montague - Linear         Connecticut at Hartford - Linear       Westfield at Huntington - Linear         Downstream control at Westfield       Flood Control         Maximum Release from Controlled Outlets       Minimum ABF Release         Connecticut at Hartford - Linear       Westfield at Huntington - Linear         Downstream control at Westfield       Flood Control         Maximum Release from Controlled Outlets       Minimum ABF Release         Connecticut at Hartford - Linear       Westfield at Huntington - Linear         Downstream control at Westfield       Max Flow ROC-Increasing         MAF Haximum rate of decrease       Restrict rate of pool level drop         Max Outflow equals 21 day max Inflow       Conservation         Maximum Release from Controlled Outlets       Min Flow Logic - Knightville         Connecticut at Montague - Linear       Connecticut at Hartford - Linear         Westfield at Huntington - Linear       Westfield at Huntington - Linear	Dec. Sched.       Projected Elev         Operates Release From: Knightville         Rule Name:       necticut at Hartford - Linear       Description:         Function of:       Connecticut at Hartford Stage, Previous Value         Limit Type:       Maxi  Interp.:       Li           Stage (ft)       Release (cfs)         0.0       4500.0         18.0       4500.0         19.0       3600.0         21.0       1800.0         22.0       900.0         23.0       0.0         50.0       0.0         Stage (ft)       Release (cfs)         0.0       4500.0         19.0       3600.0         21.0       1800.0         23.0       0.0         50.0       0.0         Stage (ft)       Period Average Limit	Uefine Define 40 50 Edit Edit Edit

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague-Linear

### 6. Westfield at Huntington-Linear

Figure 12 shows the content of "Westfield at Huntington-Linear" rule. This rule represents the maximum allowable release from dam as a function of previous day stage at Huntington. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

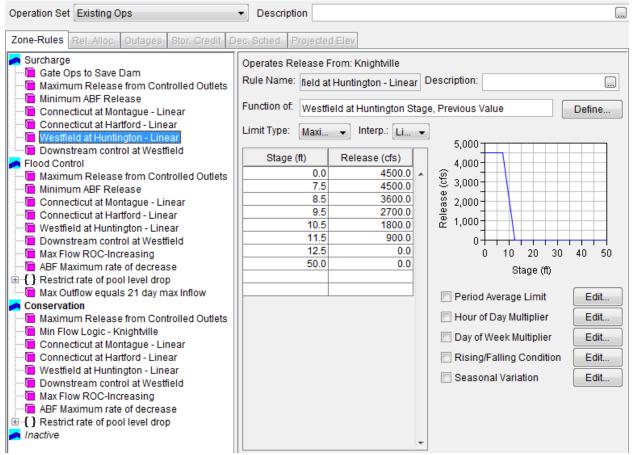


Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Westfield at Huntington-Linear

### 7. Downstream control at Westfield

Figure 13 shows the content of "Downstream control at Westfield" rule. This rule represents the maximum allowable flow at the downstream point Westfield at Huntington.

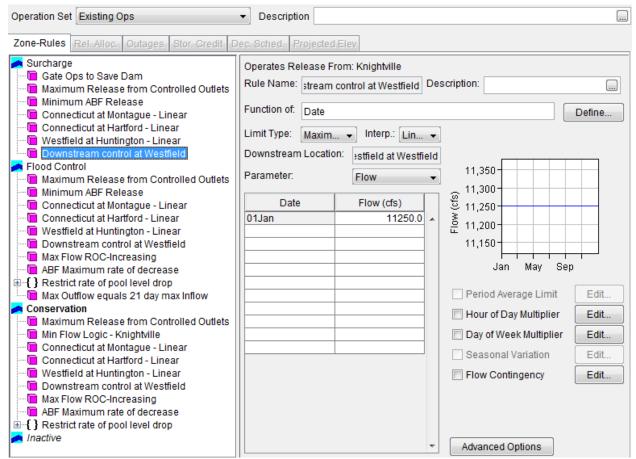


Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Downstream controlat Westfield

### 8. Max Flow ROC-Increasing

Figure 14 shows the content of "Max Flow ROC-Increasing" rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Knightville dam.

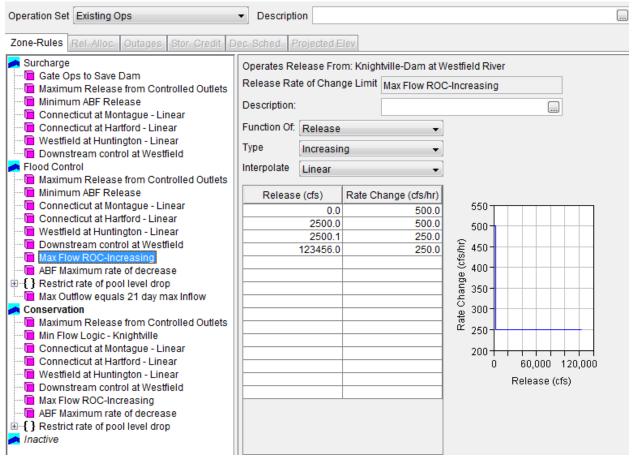


Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet –Max Flow ROC-Increasing

## **9.** ABF Maximum rate of decrease

Figure 15 shows the content of "ABF Maximum rate of decrease" rule. This rule shows the maximum allowable decreasing release rate of change.

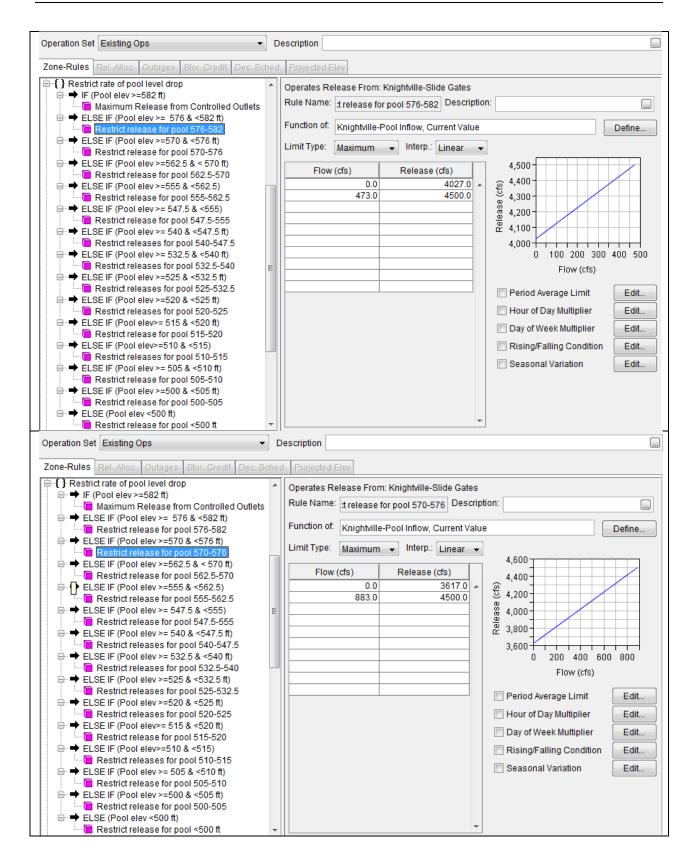
Operation Set Existing Ops	Description				
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev					
Connecticut at Montague - Linear Connecticut at Hartford - Linear Westfield at Huntington - Linear Downstream control at Westfield	Operates Release From: Kni Release Rate of Change Lin Description: Function Of: Type Max Rate of Change (cfs/hr)	ightville-Slide Gates nit ABF Maximum rate of decrease Constant • Decreasing • 1500.0			

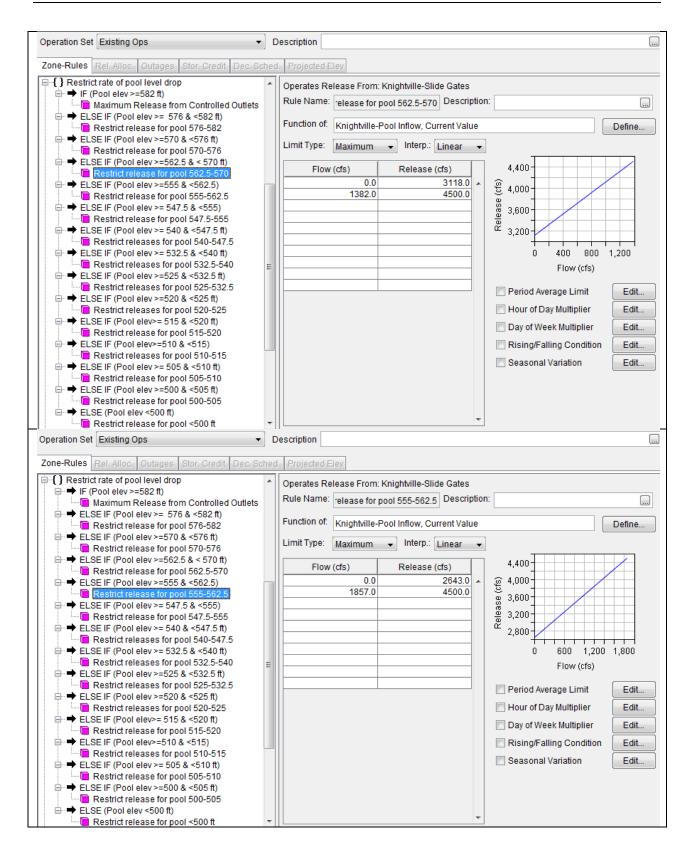
Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet –ABF Maximum rate of decrease

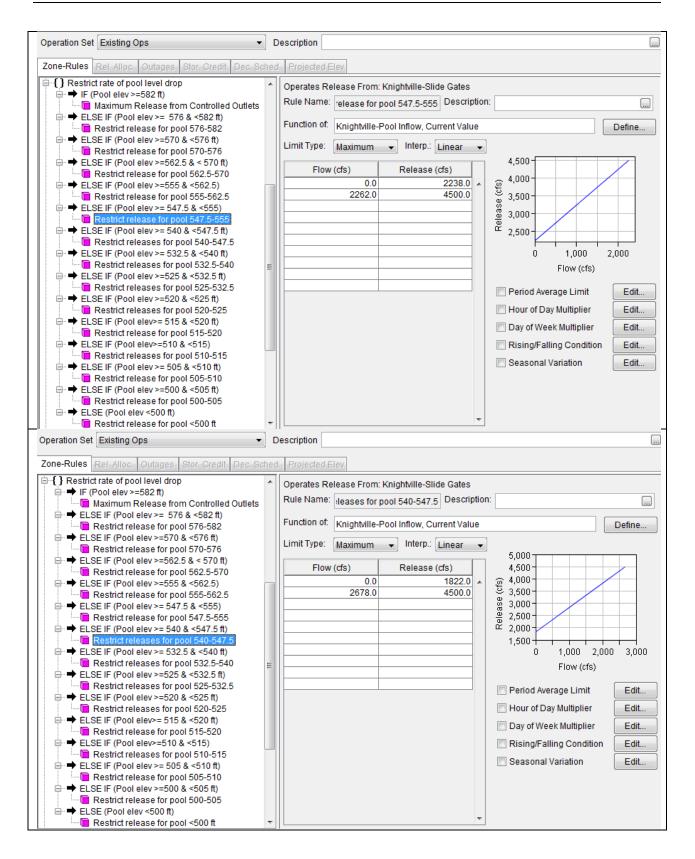
# 10. Restrict rate of pool level drop

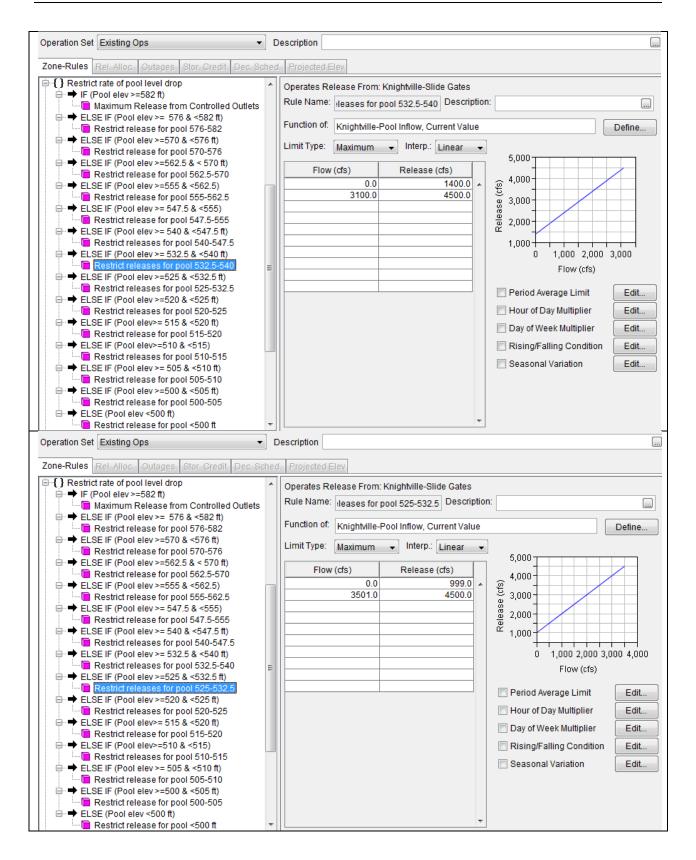
Figure 16 shows the content of "Restrict rate of pool level drop" rule. It shows the maximum allowable release as a function of Inflow for different ranges of pool elevations.

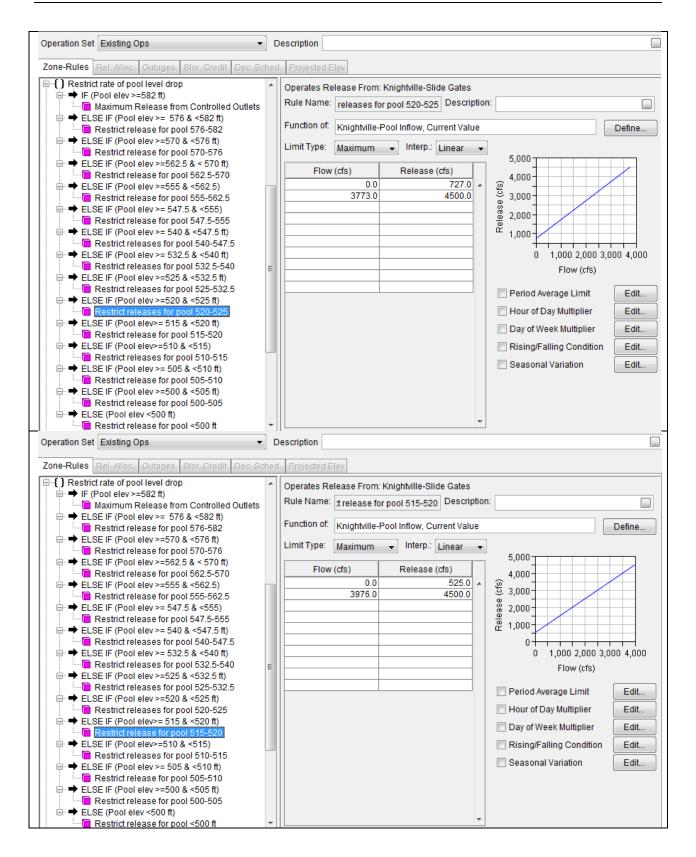
Operation Set Existing Ops	Descri	iption		
Zone-Rules Rel, Alloc. Outages Stor. Credit Dec. St	ched.	Projecte	d Elev	
<ul> <li>Restrict rate of pool level drop</li> <li>IF (Pool elev &gt;=582 ft)</li> <li>Maximum Release from Controlled Outlets</li> <li>ELSE IF (Pool elev &gt;= 576 &amp; &lt;582 ft)</li> <li>Restrict release for pool 576-582</li> <li>ELSE IF (Pool elev &gt;=570 &amp; &lt;576 ft)</li> <li>Restrict release for pool 570-576</li> <li>ELSE IF (Pool elev &gt;=562.5 &amp; &lt;570 ft)</li> <li>Restrict release for pool 562.5-570</li> <li>ELSE IF (Pool elev &gt;=555 &amp; &lt;562.5)</li> <li>Restrict release for pool 555-562.5</li> <li>ELSE IF (Pool elev &gt;= 547.5 &amp; &lt;555)</li> <li>Restrict release for pool 547.5-555</li> <li>ELSE IF (Pool elev &gt;= 540 &amp; &lt;547.5 ft)</li> <li>Restrict releases for pool 525.540</li> <li>ELSE IF (Pool elev &gt;= 532.5 &amp; &lt;540 ft)</li> <li>Restrict releases for pool 525.540</li> <li>ELSE IF (Pool elev &gt;= 525 &amp; &lt;522.5 ft)</li> <li>Restrict releases for pool 525.540</li> <li>ELSE IF (Pool elev &gt;= 515 &amp; &lt;520 ft)</li> <li>Restrict releases for pool 520.525</li> <li>ELSE IF (Pool elev &gt;= 515 &amp; &lt;520 ft)</li> <li>Restrict releases for pool 510.515</li> <li>ELSE IF (Pool elev &gt;= 505 &amp; &lt;510 ft)</li> <li>Restrict releases for pool 510.515</li> <li>ELSE IF (Pool elev &gt;= 505 &amp; &lt;510 ft)</li> <li>Restrict release for pool 505.510</li> <li>ELSE IF (Pool elev &gt;= 500 &amp; &lt;505 ft)</li> <li>Restrict release for pool 505.510</li> <li>ELSE IF (Pool elev &gt;= 500 &amp; &lt;505 ft)</li> <li>Restrict release for pool 505.510</li> <li>ELSE IF (Pool elev &gt;= 500 &amp; &lt;505 ft)</li> <li>Restrict release for pool 505.510</li> <li>ELSE IF (Pool elev &gt;= 500 &amp; &lt;505 ft)</li> <li>Restrict release for pool 500.505</li> <li>ELSE IF (Pool elev &gt;=500 &amp; &lt;500 ft)</li> <li>Restrict release for pool 500 ft</li> <li>Max Outflow equals 21 day max Inflow</li> </ul>	м Ш Т	· .	Name           Pool elev >= 582 ft           F         Pool elev >= 576 & <582 ft           F         Pool elev >= 570 & <576 ft           F         Pool elev >= 552.5 & < 570 ft           F         Pool elev >= 555 & <562.5           F         Pool elev >= 547.5 & <555           F         Pool elev >= 540 & <547.5 ft           F         Pool elev >= 525 & <532.5 ft           F         Pool elev >= 520 & <525 ft           F         Pool elev >= 515 & <520 ft           F         Pool elev >= 515 & <520 ft           F         Pool elev >= 510 & <515           F         Pool elev >= 505 & <510 ft	Prevent pool from dro

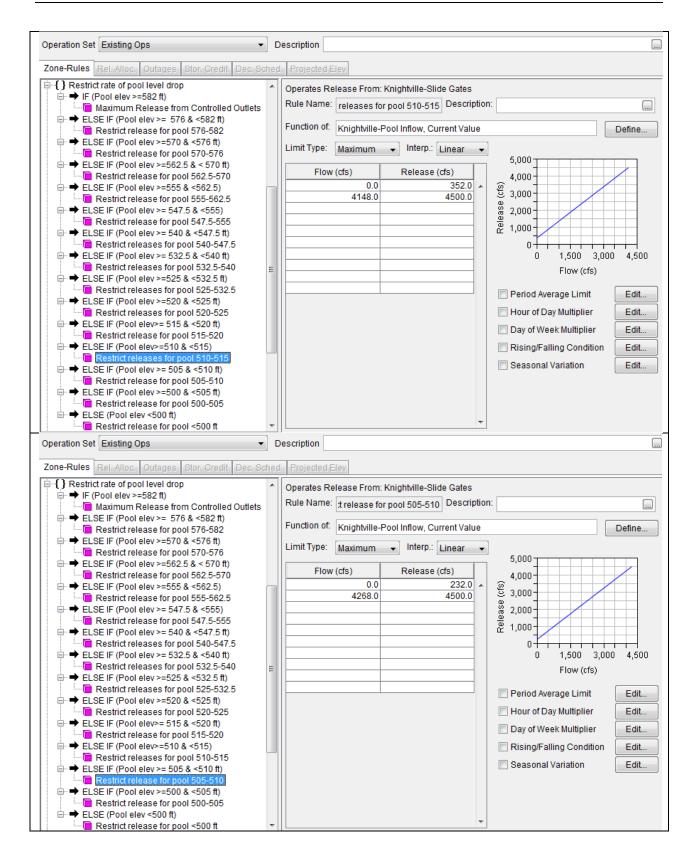












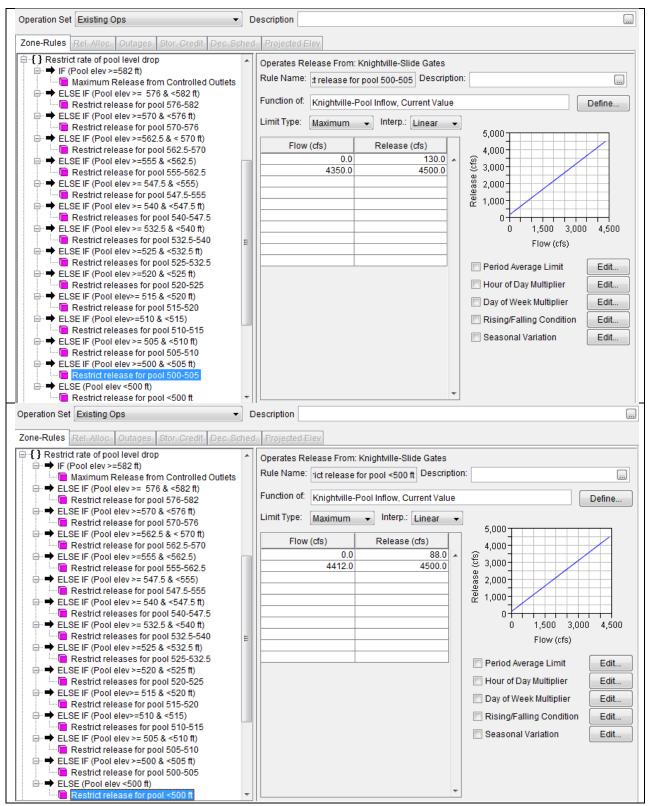


Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet – Restrict rate of pool level drop

#### 11. Max Outflow equals 21 day max Inflow

Figure 17 shows the content of "Max Outflow equals 21 day max Inflow" rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

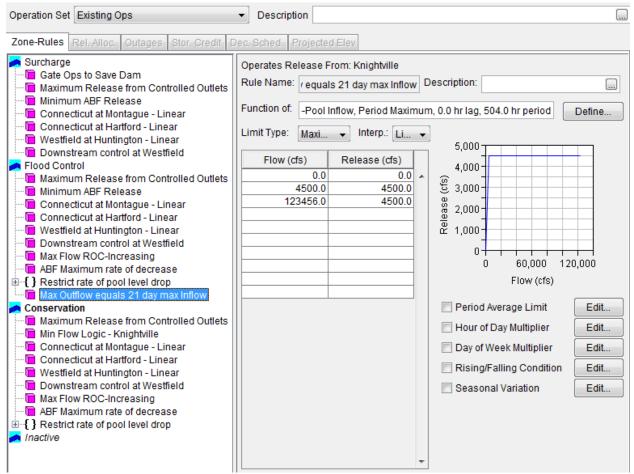


Figure 17: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals 21 day max Inflow

#### **12.** *Min Flow Logic - Knightville*

Figure 18 shows the content of "Min Flow Logic - Knightville" rule. This rule describes required seasonal minimum flows from controlled outlets as a function of inflow at Knightville.

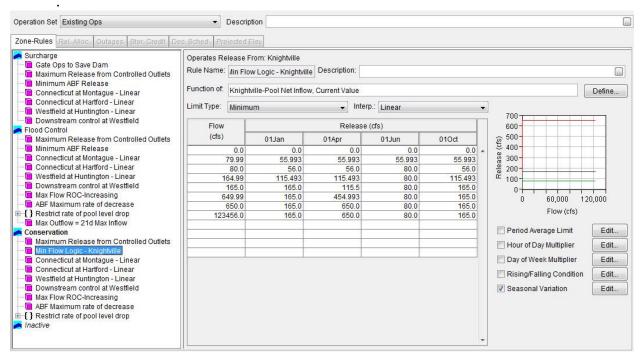


Figure 18: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic - Knightville

## Lake Francis

#### I. Overview

Lake Francis (Murphy) dam is located in the town of Pittsburg, NH. It is owned and operated by TransCanada Hydro Northeast Inc. as a storage reservoir to make releases to its downstream hydro facilities.

Figure 1 shows the location of Lake Francis as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Lake Francis.

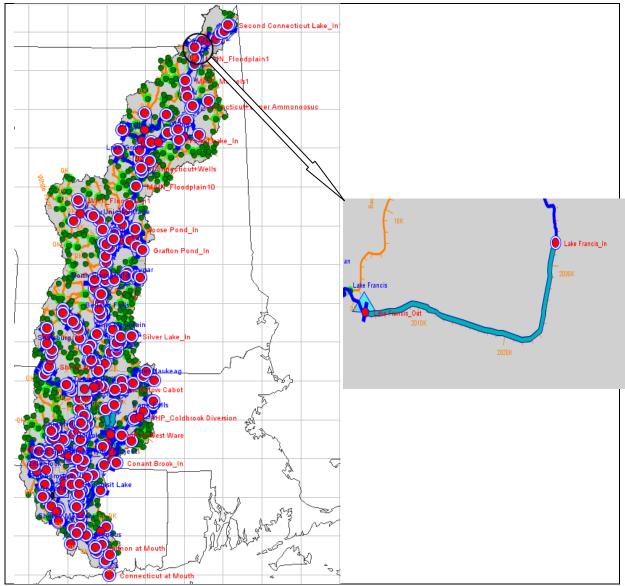


Figure 1: HEC-ResSim Map Display Showing Location of First Connecticut Dam



Figure 2: Aerial photo of Lake Francis

## **II.** Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>50</sup>. The dam consists of seven types of outlets: (1) uncontrolled Bay#1, (2) uncontrolled Bay#5(flashboards all in), (3) uncontrolled Bay#5(flashboards partly cleared), (4) uncontrolled Bay#2, (5) uncontrolled Bay#3, (6) uncontrolled Bay#4, and (7) controlled Tunnel discharge as shown in Figure 4.

<sup>&</sup>lt;sup>50</sup> Data provided by TransCanada

🟹 Reservoir Editor	1 .				X				
Reservoir Edit Pool									
Reservoir Lake Francis   Description  M  15 of 74  M									
Physical Operations Observed Data									
A Lake Francis	Lake Francis-Pool								
Dam Dam S Bay #1(stoplogs in)	Linear Interpolation	n 💿 Conic Interpolat	ion Initial Conic E	)epth (ft	)				
Bay #5( flashboards all in)	Elevation	Storage	Area						
Bay #5( flashboards partly cleared)	(ft)	(ac-ft)	(acre)						
Bay #2(stoplogs in)	1305.00	0.00	()						
Bay #3(stoplogs in)	1305.10	2.00		-	1,400				
Tunnel discharge	1305.20	4.00			1,380				
	1305.30	7.90		-					
	1305.40	9.90			€ 1,360				
	1305.50	11.90			à 1,340 Ⅲ 1,320				
	1305.60	13.90			1,320				
	1305.70	15.90			1,300 + + + + + + + + + + + + + + + + + +				
	1305.80	17.90			0 60,000 120,000				
	1305.90	23.80			Stor (ac-ft)				
	1306.00	25.80			1,400				
	1306.10	29.80			1,380				
	1306.20	31.70			€ 1,360				
	1306.30	35.70			€ 1,300_ à 1,340				
	1306.40	39.70							
	1306.50	43.60		_	1,520				
	1306.60	45.60		_	1,300				
	1306.70	49.60		_	0 1,500 3,000 4,500				
	1306.80	53.60		_	Area (acre)				
	1306.90	57.50		-					
	1307.00	61.50		-					
4 III >	1307.10	65.50		-					
				OK	Cancel Apply				

Figure 3: Reservoir Editor: Physical Tab -- Pool

🝸 Reservoir Editor	1	-	_		X				
Reservoir Edit Dam									
Reservoir Lake Francis   Description  Mul 15 of 74									
Physical Operations Observed Data									
Lake Francis	Lake Francis-Dam								
Bay #1(stoplogs in)	Elevation at top of dam (f	)		1400.	0				
Bay #5( flashboards all in)	Length at top of dam (ft)			2200.	0				
Bay #5( flashboards partly cleared)									
Bay #2(stoplogs in)	Composite Release Ca	bacity							
Bay #3(stoplogs in)	Elevation Co	ntrolled Ur	controlled	Total					
Tunnel discharge	(ft)	(cfs)	(cfs)	(cfs)					
	1,302.4	505.0	0.0	505.0	S 1,380				
	1,302.5	570.0	0.0	570.0 =	E 1,380 E 1,350 1,320 1,320				
	1,302.6	630.0	0.0	630.0	ê 1,320 <b>- 1</b>				
	1,302.7	695.0	0.0	695.0	1111111111				
	1,302.8	755.0	0.0	755.0	0 10,000				
	1,302.9	810.0	0.0	810.0	Flow				
	1,303.0	870.0	0.0	870.0	(cfs)				
	1,303.1	925.0	0.0	925.0					
	1,303.2	975.0	0.0	975.0					
	1,303.3	1,030.0	0.0	1,030.0					
	1,303.4	1,080.0	0.0	1,080.0					
	1,303.5	1,130.0	0.0	1,130.0					
	1,303.6	1,175.0	0.0	1,175.0					
	1,303.7	1,220.0	0.0	1,220.0					
	1,303.8	1,265.0	0.0	1,265.0					
	1,303.9	1,310.0	0.0	1,310.0					
	1,304.0	1,350.0	0.0	1,350.0					
	1,304.1	1,385.0	0.0	1,385.0 -					
۰ III ا									
				OK	Cancel Apply				

Figure 4: Reservoir Editor: Physical Tab -- Dam

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of First Connecticut Dam's "Existing Ops" operational zones, which consist of zones of Top of dam (1400 ft), Below Top of dam (1399 ft), Conservation (1340.492-1379.249 ft), and Inactive zone (1305 ft). The Conservation Pool Elevation curve was created from 10 years of weekly average pool elevation<sup>1</sup>.

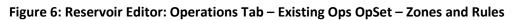
Reservoir Editor		2	×
Reservoir Edit Operations Zone R	ule IF_Block		
Reservoir Lake Francis Physical Operations Observed	Description		
Operation Set Existing Ops	▼ Descript	ion	
Zone-Rules Rel. Alloc. Outage	s Stor. Credit Dec. Sched. Pr	ojected Elev	
Top of Dam Below Top of Dam Difference Tunnel discharge Conservation	Storage Zone Conservation Function of Date	Description	Define
Inactive	Date01Jan10Jan20Jan31Jan10Feb20Feb28Feb10Mar20Mar31Mar10Apr20Apr30Apr10May20May31May10 lup20ne Sort Elevation	Top Elevation (ft) 1373.0 1364.677 1361.059 1356.638 1352.036 1351.095 1346.959 1342.767 1340.492 1343.364 1348.508 1355.169 1364.752 1370.713 1375.007 1377.125 1229.250 *	1,400 1,380 1,360 1,340 1,320 1,300 Jan Mar May Jul Sep Nov
			OK Cancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named  $Existing^{51}$ .

Reservoir Editor							
Reservoir Edit Operations Zone R							
Reservoir Lake Francis							
Physical Operations Observed I							
Operation Set Existing Ops							
Zone-Rules Rel. Alloc. Outage							
🛃 Top of Dam							
A Below Top of Dam							
Min Flow							
🔚 🔚 Tunnel discharge							
Conservation							
Min Flow							
inactive 🔁							



## **C.** Rule Descriptions

#### 1. Min Flow

Figure 7 shows the content of "Min Flow" rule. This rule represents the minimum release from dam as a function of date.

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow

<sup>&</sup>lt;sup>51</sup> TransCanada. Connecticut River Operational Constraints. 2012.

## 2. Tunnel discharge

Figure 8 shows the content of "Tunnel discharge" rule. This rule represents the maximum release from the Tunnel discharge gate as a function of pool elevation.

Operation Set Existing Ops	▼ Descript	lion							
Zone-Rules Rel. Alloc. Outage	s Stor. Credit Dec. Sched. P	rojected Elev							
Top of Dam     Below Top of Dam     Min Flow     Tunnel discharge	Operates Release From: Lake Francis-Tunnel discharge Rule Name: Tunnel discharge Description:								
Conservation	Function of: Lake Francis-Poo	ol Elevation, Current Value	Define						
Min Flow Inactive	Limit Type: Maximum	✓ Interp.: Linear ✓							
	Elev (ft)	Release (cfs)	4,000 (9) 3,000						
	1302.4		8 2,000						
	1302.0	630.0							
	1302.5	□ 0							
	1302.9		Elev (ft)						
	1303.0		Period Average Limit Edit						
	1303.3		Period Average Limit     Edit     Hour of Day Multiplier     Edit						
	1303.4	4 1080.0	Day of Week Multiplier						
	1303.5		Rising/Falling Condition						
	1303.7		Seasonal Variation Edit						
	1303.8								
	1304.0								
	1304.1	1 1385.0 -							

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Tunnel discharge

## Lake Groton

#### I. Overview

Lake Groton dam is a dam located in Groton, VT at the headwaters of the Wells River. It is owned and operated by the State of Vermont Department of Water Resources and is used primarily for recreational purposes.

Figure 1 shows the location of Lake Groton Dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo of Lake Groton Dam.

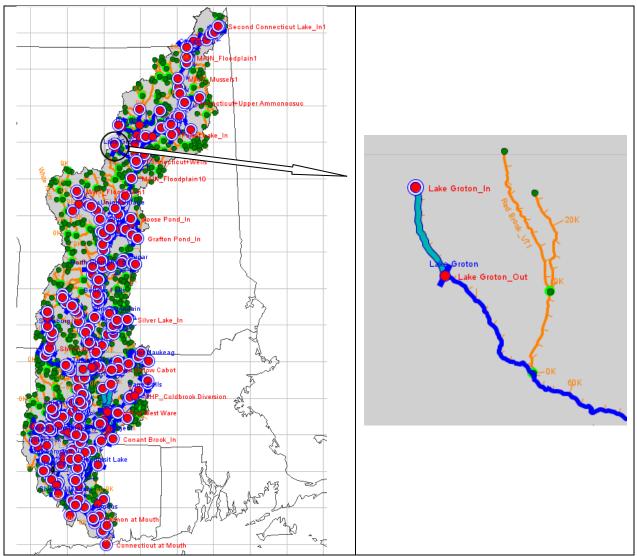


Figure 1: HEC-ResSim Map Display Showing Location of Somerset



Figure 2: Photo of Lake Groton Dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>52</sup>. The dam consists of four types of outlets: (1) uncontrolled spillway, (2) uncontrolled stop log spillway, (3) uncontrolled Core wall+ Embankment, and (4) uncontrolled Island as shown in Figure 4.

<sup>&</sup>lt;sup>52</sup> State of Vermont Dam Inventory. 2010.

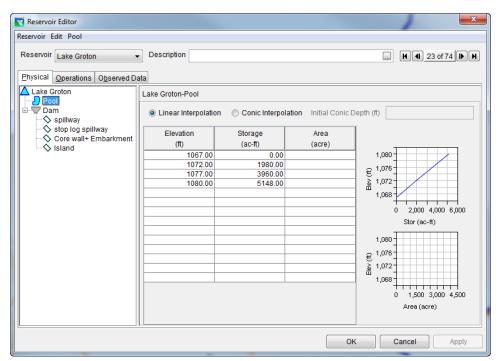


Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor eservoir Edit Dam			<b>X</b>							
Reservoir Lake Groton	Description		K 4 23 of 74 D H							
Physical Operations Observed Data										
Lake Groton	Lake Groton-Dam									
Dam Spillway	Elevation at top of dam (ft)	108	30.0							
stop log spillway	Length at top of dam (ft)	59	98.0							
Sisland	Composite Release Capacity									
	Elevation Controlled	Uncontrolled Total								
	(ft) (cfs)	(cfs) (cfs)	1,086							
	1,077.0 0.0	0.0 0.0	g 1,083							
	1,077.5 0.0	70.0 70.0	E 1,083 E 1,080 E 1,080							
	1,078.0 0.0	235.0 235.0	L 1,077							
	1,078.5 0.0	456.0 456.0								
	1,079.0 0.0	722.0 722.0	0 25,000							
	1,079.5 0.0	1,025.0 1,025.0	Flow							
	1,080.0 0.0	1,361.0 1,361.0	(cfs)							
	1,080.5 0.0	2,271.0 2,271.0	-							
	1,081.0 0.0	3,707.0 3,707.0								
	1,081.5 0.0	5,412.0 5,412.0								
	1,082.0 0.0	7,473.0 7,473.0								
	1,082.5 0.0	9,973.0 9,973.0								
	1,083.0 0.0	12,982.0 12,982.0								
	1,083.5 0.0	16,508.0 16,508.0 20,573.0 20,573.0								
	1,084.0 0.0	20,5/3.0 20,5/3.0 25,201.0								
	1,085.0 0.0	30,419.0 30,419.0								
	1,085.5 0.0	36,246.0 36,246.0								
	1,00010 010	00,21010 00,24010								
			-							
		ОК	Cancel Apply							
		OK	Apply							

Figure 4: Reservoir Editor: Physical Tab -- Dam

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Lake Groton's "Guide Curve" operational zones, which consist of zones of Top of dam (1080 ft), conservation (1077 ft), Min Pool (1076-1077 ft), and Inactive zone (1070 ft)<sup>1</sup>.

Reservoir Editor	×								
Reservoir Edit Operations Zone Rule IF_Block									
Reservoir Lake Groton   Description  M  23 of 74  H									
Physical Operations Observed Data									
Operation Set Guide Curve   Description									
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev									
Top of Dam     Storage Zone Conservation     Description									
Min Release Function of Date	Define								
Image: Second	ay Jul Sep Nov								
OK C	Cancel Apply								

Figure 5: Reservoir Editor: Operations Tab –Guide Curve OpSet – Guide Curve

## **B. Rule Illustrations**

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Guide Curve.

💘 Reservoir Editor
Reservoir Edit Operations Z
Reservoir Lake Groton
Physical Operations Obs
Operation Set Guide Curv
Zone-Rules Rel. Alloc. (
👝 Top of Dam
Conservation
🛄 🛅 Min Release
Min Pool
🔚 🛅 Min Release
inactive 🔁

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## **C.** Rule Descriptions

#### 1. Min release

Figure 7 shows the content of "Min release" rule. This rule represents a seasonal minimum flow as a function of Inflow.

-Rules Rel. Alloc.	Outages Stor	. Credit	Dec. Scr	ied. Proj	ected Elev	1			1	
p of Dam onservation	Operates R	perates Release From: Lake Groton								
Min Release	Rule Name:	Min Rel	ease		Descrip	tion:				
Pool	Function of:	Lake Cr	oton-Po	ol Not Infl	W. Curren	t Value		Define		
lin Release		Lake Gi	01011-1 0	ornetinit	w, curren	t value		Denne		
active	Limit Type:	Minimu	n		erp.: Line	ar	•	12		
	Flow		F	Release (	cfs)			(¥) 8		
	(cfs)	01Jan	30Apr	01May	310ct	01Nov				
	0.0		0.0	0.0	0.0	0.0		a 0 <del>                       </del> 0 400,000 800,000		
	10.0	0.0	0.0	10.0	10.0	0.0		Flow (cfs)		
	1000000.0	0.0	0.0	10.0	10.0	0.0		FIGOR (CIS)		
								Period Average Limit Edit		
								Hour of Day Multiplier		
								Day of Week Multiplier		
								Rising/Falling Condition		
							÷	Seasonal Variation Edit		

## Lake McDonough

#### I. Overview

Lake McDonough dam is located directly downstream of Barkhamsted Reservoir that feeds into the Farmington River. It is owned and operated by The Metropolitan District of Hartford, Connecticut (MDC) and is used for recreation.

Figure 1 shows the location of Lake McDonough as it is represented in the HEC-ResSim model, and Figure 2 shows a photo for Lake McDonough.

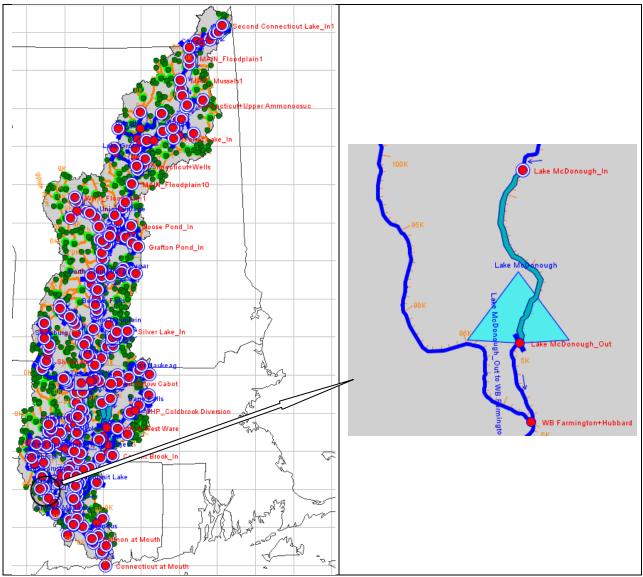


Figure 1: HEC-ResSim Map Display Showing Location of Lake McDonough



Figure 2: Aerial photo of Lake McDonough

#### **Physical Characteristics** II.

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>53</sup>. The dam consists of a controlled outlet as shown in Figure  $4^{54}$ .

<sup>&</sup>lt;sup>53</sup> MDC 1999 <sup>54</sup> Data from UMASS

Reservoir Editor Reservoir Edit Pool			-	X
Reservoir Lake McDonough				
Lake McDonough	Lake McDonoug	h-Pool		
Dam	Linear Inter	polation 🔘 C	onic Interpolation	n Initial Conic Depth (ft)
	Elevation	Storage	Area	
	(ft)	(ac-ft)	(acre)	
	362.00	100000.00		420
	363.00	100001.53		€ 400
	364.00	100003.07	-	2
	365.00	100006.14	=	ä 380 -
	366.00	100009.21		
	367.00	100015.34		360 <del>                       </del> 100,000 104,000 108,000
	368.00	100024.55		
	369.00	100030.69		Stor (ac-ft)
	370.00	100046.03		420
	371.00	100061.38		420-
	372.00	100079.79		€ 400
	373.00	100101.27		аларанананананананананананананананананан
	374.00	100125.82		± 380 -
	375.00	100159.58		
	376.00	100190.27		360 + + + + + + + + + + + + + + + + + + +
	377.00	100230.17		
	378.00	100273.13		Area (acre)
	370.00	100310 16	•	
			ОК	Cancel Apply

Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor			-	X
Reservoir Edit Dam				
Reservoir Lake McDonough	Description			K 4 3 of 74 K
Physical Operations Observed Da	ata			
Lake McDonough	Lake McDonough-Da	m		
Dam Controlled Outlet	Elevation at top of d	am (ft)	420.5	]
	Length at top of dan	n (ft)	950.0	
	Composite Releas	e Capacity		
		trolled Uncontrol	Total	
		cfs) (cfs)	(cfs)	420
	362.0	0.0 0.0	0.0 9,999.0	
	420.3 5,		5,555.0	.9 ₩ ₩ ₩ 380
				360
				0 5,000 10,000 Flow
				(cfs)
			ОК	Cancel Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Lake McDonough's "Existing Ops" operational zones, which consist of zones of Top of Dam (420.5 ft), Conservation (410-417.5 ft), and Inactive zone (362 ft)<sup>2</sup>.

Reservoir Editor	. (	2	
Reservoir Edit Operations Zone Ru	ule IF_Block		
Reservoir Lake McDonough	▼ Description		
Physical Operations Observed D			
Operation Set Existing Ops			for recreation, "From Memorial Day to Labor 🛄
Zone-Rules Rel. Alloc. Outages	s Stor. Credit Dec. Sched. Pro	jected Elev	
Top of Dam	Storage Zone Conservation	Description	
📥 Inactive	Function of Date		Define
	Date	Top Elevation (ft)	
	01Jan 14Mar	410.0	
	14Mar 15Mar	410.0 417.5	420
	03Sep	417.5	
	310ct	410.0	€ 400- 5 390- 380- ₩ 380-
			e 380
			370
			360
			Jan Mar May Jul Sep Nov
		<b>.</b>	
	Zone Sort Elevation		
			OK Cancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet

## **B. Rule Illustrations**

The operation set for Lake McDonough has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

#### Lake Monomonac

#### I. Overview

Lake Monomonac dam is located in the town of Winchendon, MA on the Monomonac River that flows into the Millers River. The Town of Winchendon owns and operates the dam and is used primarily for recreational purposes.

Figure 1 shows the location of Upper Lake Monomonac Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Lake Monomonac.

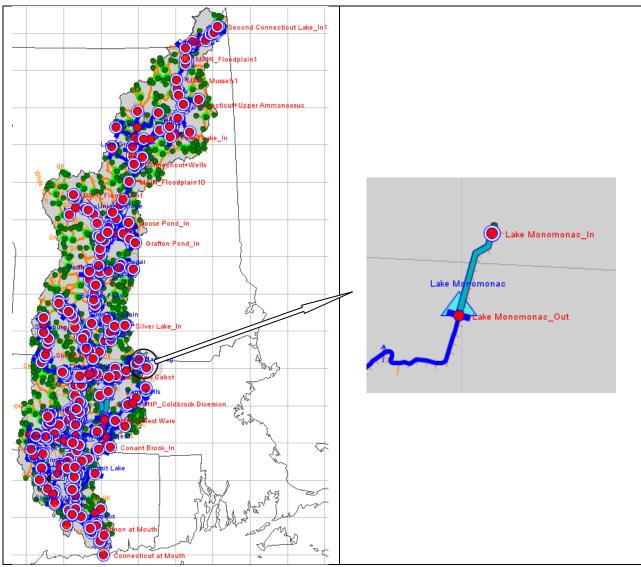


Figure 1: HEC-ResSim Map Display Showing Location of Lake Monomonac Dam



Figure 2: Photo of Lake Monomonac

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>55</sup>. The dam consists of two types of outlets: (1) an uncontrolled outlet, and (2) a controlled outlet as shown in Figure 4.

<sup>&</sup>lt;sup>55</sup> C.T. Male Associates, P.C. Lake Monomonac Dam.

🟹 Reservoir Editor				×
Reservoir Edit Pool				
Reservoir Lake Monomonac	<ul> <li>Description</li> </ul>			K 4 57 of 74 b H
Physical Operations Observed	Data			;
Lake Monomonac	Lake Monomonac	-Pool		
Dam	Linear Interp	olation 🔘 C	onic Interpolation	Initial Conic Depth (ft)
Controlled Outlet	Elevation	Storage	Area	
	(ft)	(ac-ft)	(acre)	
	1044.00	6440.00		1,050
	1047.60	8650.00		£1,048
	1048.30	9080.00		€ 1.048 ∎ 1.046
	1048.80	9387.00		
	1049.50	9694.00		1,044
	1049.80	10001.00		6,000 7,500 9,000 10,500
	1050.30	10308.00		Stor (ac-ft)
				1,050
				€1,048
				€ a 1,046
				1,044
				0 1 2 3 4 5 6 7 8
				Area (acre)
			ОК	Cancel Apply

Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor		x
Reservoir Edit Dam		
Reservoir Lake Monomonac	<ul> <li>Description</li> </ul>	
Physical Operations Observed D	ata	
Lake Monomonac	Lake Monomonac-Dam	
Dam	Elevation at top of dam (ft)	1048.3
Controlled Outlet	Length at top of dam (ft)	333.0
	Composite Release Capacity	y
		ontr Total fs) (cfs) 1,053
	1,045.0 0.0	1,000
	1,046.0 30.0	0.0 0.0 0.0 30.0 0.0 70.0 1,047 1,047 1,044
	1,047.0 70.0	0.0 70.0
	1,047.3 99.0	0.0 99.0 = 1,044
	1,047.6 99.0	0.0 55.0
		317.0 416.0 Flow 672.0 771.0 (cfs)
	· · · · · · · · · · · · · · · · · · ·	106.0 1,205.0
		606.0 1,705.0
		165.0 2,264.0
	1,050.5 99.0 2,8	832.0 2,931.0
	1,051.0 99.0 3,5	
		428.0 4,527.0
		20.01 5 479 01
		OK Cancel Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Lake Monomonac Dam's "Guide Curve" operational zones, which consist of zones of Flood Control (1048.3 ft), Conservation (1045-1047 ft), and Inactive zone (1041 ft)<sup>1</sup>.

Reservoir Editor					3
Reservoir Edit Operations Z	one Rule IF_Block				
Reservoir Lake Monomona	c 👻 Description			K 4 57 of 74 D	4
Physical Operations Obs	erved Data				
Operation Set Guide Curve	9 ▼	Description			וו
Zone-Rules Rel. Alloc. C	Dutages Stor. Credit [	Dec. Sched. Projecte	ed E	Elev	
Flood Control	Storage Zone Conse	rvation	De	escription	
inactive	Function of Date			Define	
	Date	Top Elevation (ft)		7	
	01Jan	1045.0			
	31Mar	1045.0	-0.000	1,048	
	01Apr	1047.0	-11	1.046	
	30Sep 01Oct	1047.0 1045.0	Ε		
	31Dec	1045.0		÷£ 1,044	
	51000	1040.0		E 1,040 E 1,045 E 1,044 A 1,043 A 1,043	
				1,042	
				1,041	
				1,040	
			Ŧ	Jan Mar May Jul Sep Nov	
	Zone Sort Elevation				
				OK Cancel Apply	

Figure 5: Reservoir Editor: Operations Tab – Guide Curve OpSet

## **B. Rule Illustrations**

The operation set for Lake Monomonac Dam has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

## Lake Sunapee

#### I. Overview

Lake Sunapee dam is located in the town of Sunapee, NH on the Sugar River. It is owned and operated by the Town of Sunapee and is used for powering the town's water works pumping station as well as recreational purposes.

Figure 1 shows the location of Lake Sunapee Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Lake Sunapee.

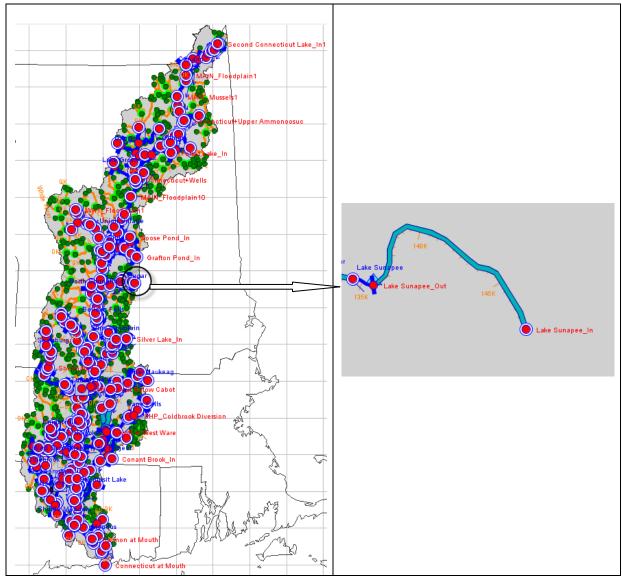


Figure 1: HEC-ResSim Map Display Showing Location of Lake Sunapee Dam



Figure 2: Photo of Lake Sunapee

#### **Physical Characteristics** II.

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>56</sup>. The dam consists of four types of outlets: (1) controlled Gates, (2) controlled sluice gate, (3) uncontrolled outlet, and (4) power plant as shown in Figure 4<sup>57</sup>.

 <sup>&</sup>lt;sup>56</sup> NHDams Data Sheet. Lake Sunapee Dam. 2010
 <sup>57</sup> Operations & Maintenance Plan. Lake Sunapee Dam. 2008.

Reservoir Editor				×
Reservoir Edit Pool				
Reservoir Lake Sunapee	✓ Description			<b>H 4</b> 29 of 74 <b>D H</b>
Physical Operations Observed	d Data			
Lake Sunapee	Lake Sunapee-Pool			
Dam Tailwater	Linear Interpolation	Conic Interpolation	on Initial Conic D	)epth (ft)
Gates	Elevation	Storage	Area	
sluice gate	(ft)	(ac-ft)	(acre)	
Uncontrolled Outlet	1075.50	0.00		1
	1090.50	16340.00		1,110
	1091.50	18382.50		
	1092.50	22467.50		€ 1,100 à 1,090
	1094.50	30637.50		ه 1,090 ه
	1095.50	34722.50		1,080
	1096.50	38807.50		
	1100.00	55147.50		50,000 100,000
	1105.00	75572.50		Stor (ac-ft)
	1110.00	95997.00		
				1,110
				€ 1,100 à 1,090
				1,080
				2 4 6 8 10
				Area (undef)
				OK Cancel Apply

Figure 3: Reservoir Editor: Physical Tab -- Pool

servoir Edit Dam					
eservoir Lake Sunapee	<ul> <li>Description</li> </ul>				K 4 29 of 74 D
hysical Operations Observ					
7000000	1				
Lake Sunapee	Lake Sunapee-Dam	1			
	Elevation at top of	fam (ff)			-
Tailwater		Jann (it)		1094	.5
Gates	Length at top of da	m (ft)		139	.0
sluice gate	Composite Relea	co Conocity			
Power Plant	Composite Relea	se Capacity			
♦ Oncontrolled Outlet	Elevation	Controlled	Uncontrolled	Total	
	(ft)	(cfs)	(cfs)	(cfs)	1,125
	1,084.7	421.0	0.0	421.0 🔺	
	1,090.5	769.0	0.0	769.0	E € 1,110 1,095 1,095
	1,091.5	869.0	90.0		L,080
	1,092.5	966.0	255.0	1,221.0	0 25,000
	1,093.5	1,061.0	468.0	1,529.0 1,873.0 ≡	Flow
	1,094.5	1,153.0	720.0	1,955.8	(cfs)
	1,095.5	1,195.0	1,044.0	2,239.0	(00)
	1,096.5	1,225.0	1,519.0	2,744.0	
	1,097.5	1,252.0	2,088.0	3,340.0	
	1,098.5	1,279.0	4,197.0	5,476.0	
	1,099.5	1,304.0	6,278.5	7,582.5	
	1,100.5	1,329.0	8,360.0	9,689.0	
	1,102.5	1,376.0	14,146.4	15,522.4	
	1,103.5	1,541.0	41,658.0	43,199.0	
	1,115.5	1,631.0	41,658.0	43,289.0	
	e		10 050 0	10.074.0	

Figure 4: Reservoir Editor: Physical Tab -- Dam

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Lake Sunapee's "Guide Curve" operational zones, which consist of zones of Maximum pool elevation (1099.2 ft), Top of Dam (1094.5 ft), Conservation (1090.5 ft), and Inactive zone (1075.5 ft)<sup>2</sup>.

💌 Reservoir Editor	×						
Reservoir Edit Operations Zone Rule IF_Block							
Reservoir Lake Sunapee   Description	H 1 29 of 74 H						
Physical Operations Observed Data							
Operation Set Guide Curve   De	scription						
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sch	ed. Projected Elev						
Maximum release in nooding condition	ne Conservation Description						
Top of Dam	Date Define						
A Conservation	1 1 0 0						
01Jan	1,095						
	€ 1,090						
	€ 1,090						
	1,080						
	1,075						
	Jan Mar May Jul Sep Nov						
	-						
Zone Sort I	Elevation						
	OK Cancel Apply						

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Guide Curve.

🟹 Reservoir Editor					
Reservoir Edit Operations Zone Rule IF_Block					
Reservoir Lake Sunapee 🔹 Descrip					
Physical Operations Observed Data					
Operation Set Guide Curve					
Zone-Rules Rel. Alloc. Outages Stor. Cred					
👝 Maximum pool elevation					
Maximum release in flooding condition					
Top of Dam					
Maximum release in flooding condition					
Conservation					

Figure 6: Reservoir Editor: Operations Tab – Guide Curve OpSet – Zones and Rules

# **C.** Rule Descriptions

#### 1. Maximum release in flooding condition

Figure 7 shows the content of "Maximum release in flooding condition" rule. This rule represents 750 cfs as a maximum release when the pool elevation is higher than conservation elevation.

Operation Set Guide Curve	Description	
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. Projected Elev	
Maximum pool elevation Maximum release in flooding condition Top of Dam Maximum release in flooding condition Conservation Inactive	Operates Release From: Lake Sunapee         Rule Name:       lease in flooding condition       Description:         Function of:       Date       Define         Limit Type:       Maximum <ul> <li>Interp.:</li> <li>Linear              </li> <li>O1Jan</li> <li>750.0</li> <li>3an Mar May Jul Sep Nov</li> <li>Period Average Limit</li> <li>Edit</li> <li>Day of Week Multiplier</li> <li>Edit</li> <li>Seasonal Variation</li> <li>Edit</li> </ul>	_
	· · ·	

Figure 7: Reservoir Editor: Operations Tab – Guide Curve OpSet – Maximum release in flooding condition

# Littleville

## I. Overview

Littleville Dam is a dam on the Westfield River in Hampden County, Massachusetts. It was constructed in 1965 by the US Army Corps of Engineers and is still owned and operated by the Corps. It is primarily used for flood control purposes but is also used for recreation.

Figure 1 shows the location of Littleville Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the dam.

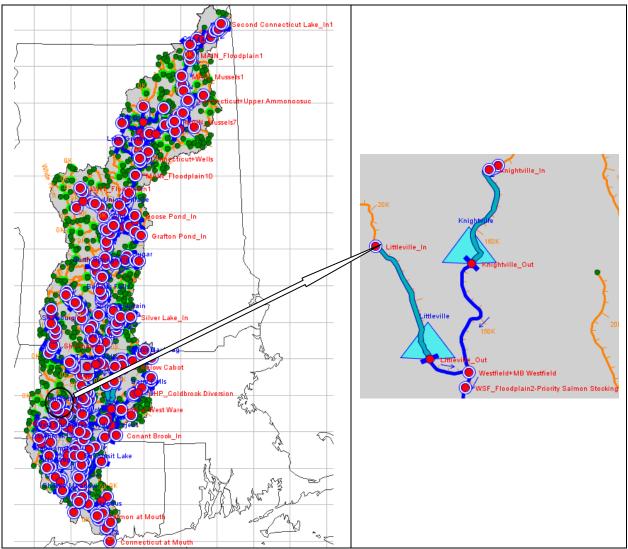


Figure 1: HEC-ResSim Map Display Showing Location of Littleville dam

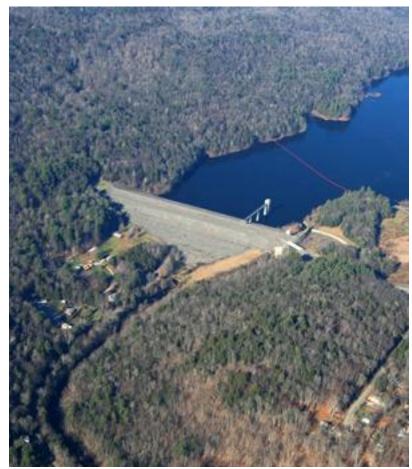


Figure 2: Photo of Littleville Dam

# **II.** Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled slide gates, and (2) uncontrolled spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both personal correspondence and the Reservoir Regulation Team website<sup>58</sup>.

<sup>&</sup>lt;sup>58</sup> http://rsgisias.crrel.usace.army.mil/nae/cwms\_map.map\_index

eservoir Edit Pool				
Reservoir Littleville	- Desci	ription		K 4 8 of 74 b H
Physical Operations (	D <u>b</u> served Data			
🛆 Littleville	Littleville-Pool			
Dam	Linear Interpola	ation 🔘 Conic In	terpolation Initial	Conic Depth (ft)
Spillway	Elevation	Storage	Area	
	(ft)	(ac-ft)	(acre)	
	432.00	0.00	0.00	
	435.00	15.00	6.00	
	440.00	25.00	12.00	560
	445.00	75.00	19.00	E ⊕ 520
	450.00	150.00	25.00	€ 520 à 480
	455.00	230.00	38.00	
	460.00	400.00	50.00	440
	465.00	700.00	67.00	0 15,000 30,000
	470.00	1200.00	85.00	
	475.00	1700.00	100.00	Stor (ac-ft)
	480.00	2200.00	120.00	
	485.00	2800.00	138.00	560
	490.00	3600.00	155.00	€ 520
	495.00	4400.00	175.00	± 3 480
	500.00	5300.00	195.00	
	505.00	6200.00	220.00	440-
	510.00	7300.00	243.00	0 200 400 600
	515.00	8500.00	268.00	
	518.00	9400.00	275.00	Area (acre)
	519.00	9714.00	280.00	
	520.00	10028.00	283.00	
	521.00	10143.00	285.00	
				OK Cancel Apply

Figure 3: Reservoir Editor: Physical Tab -- Pool

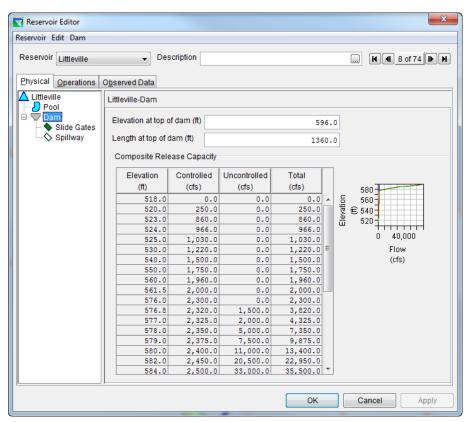


Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 4 shows the definition of Littleville's "ExistingOps" operational zones, which consist of zones of Surcharge (596 ft), Flood Control (576 ft), Conservation (518.5 ft), and Inactive zone (518 ft).

Reservoir Editor			X
Reservoir Edit Operations Zone Rule IF_Block	(		
Reservoir Littleville   Descri  Physical Operations Observed Data	ption		
Operation Set Existing Ops Zone-Rules Rel Alloc Outages Stor. Cre	Description	ey	
Surcharge     Gate Ops to Save Dam     Max release from controlled outlets     Minimum ABF Release     Connecticut at Montague - Linear     Ownstream control at Westfield     Flood Control     Max release from controlled outlets     Minimum ABF Release     Connecticut at Hartford - Linear     Westfield at Huntington     Downstream control at Westfield     Flood Control     Max release from controlled outlets     Minimum ABF Release     Connecticut at Montague - Linear     Westfield at Huntington     Downstream control at Westfield     Maximum rate of increase     Maximum rate of decrease     Maximum rate of pool level drop     Max Outflow = Max 21d Inflow     Conservation     Max release from controlled outlets     Min Flow Logic - Littleville     Connecticut at Hartford - Linear     Westfield at Huntington     Max release from control at Westfield     Maximum rate of decrease     Maximum rate of increase     Maximum rate of decrease     Maximum rate of pool level drop     Max outflow = Max 21d Inflow     Conservation     Max release from control at Westfield     Maximum rate of increase     Maximum rate of increase     Maximum rate of decrease     Maximum rate of decrease	Storage Zone Conservation Function of Date	Op Elevation (ft)	C Define Define 0 0 0 0 0 0 0 0 0 0 0 0 0
			OK Cancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

Reservoir Editor	Reservoir Editor
eservoir Edit Operations Zone Rule IF_Bloc	Reservoir Edit Operations Zone Rule IF_Block
Reservoir Littleville 🗸 Descr	Reservoir Littleville    Descriptio
Physical Operations Observed Data	Physical Operations Observed Data
Operation Set Existing Ops	Operation Set Existing Ops
Zone-Rules       Rel. Alloc.       Outages       Stor. Cr         Surcharge       Gate Ops to Save Dam       Max release from controlled outlets         Minimum ABF Release       Connecticut at Montague - Linear         Connecticut at Hartford - Linear       Westfield at Huntington         Downstream control at Westfield         Flood Control         Max release from controlled outlets         Minimum ABF Release         Connecticut at Montague - Linear         Connecticut at Hartford - Linear         Minimum ABF Release         Connecticut at Hontague - Linear         Connecticut at Hartford - Linear         Westfield at Huntington         Downstream control at Westfield         Maximum rate of increase         Maximum rate of decrease         Maximum rate of pool level drop         Max release from controlled outlets         Min Flow Logic - Littleville         Connecticut at Montague - Linear         Min Flow Logic - Littleville         Connecticut at Hartford - Linear         Westfield at Huntington         Max release from controlled outlets         Min Flow Logic - Littleville         Connecticut at Montague - Linear         Westfield at Huntington         Downstream control at Westfield </td <td>Zone-Rules Rel. Alloc. Outages Stor. Credit Restrict rate of pool level drop File (Pool level &gt;= 573.5 ft) Restrict release for pool &gt; 573.5 ft ELSE IF (Pool level &gt;= 568.5 &amp; <math>&lt; 573.5</math>) Restrict release for pool 568.5-573 ELSE IF (Pool level &gt;= 563.5 &amp; <math>&lt; 568.5</math>) Restrict release for pool 563.5-568 Restrict release for pool 558.5-563 ELSE IF (Pool level &gt;= 558.5 &amp; <math>&lt; 563.5</math>) Restrict release for pool 553.5-558 ELSE IF (Pool level &gt;= 548.5 &amp; <math>&lt; 553.5</math>) Restrict release for pool 548.5-553 ELSE IF (Pool level &gt;= 548.5 &amp; <math>&lt; 553.5</math>) Restrict release for pool 548.5-553 ELSE IF (Pool level &gt;= 548.5 &amp; <math>&lt; 548.5</math>) Restrict release for pool 543.5-548 ELSE IF (Pool level &gt;= 538.50 &amp; <math>&lt; 543.5</math>) Restrict release for pool 538.5-543 ELSE IF (Pool level &gt;= 533.5 &amp; <math>&lt; 538.5</math>) Restrict release for pool 533.5-538 ELSE IF (Pool level &gt;= 533.5 &amp; <math>&lt; 533.5</math>) Restrict release for pool 523.5-538 ELSE IF (Pool level &gt;= 523.5 &amp; <math>&lt; 533.5</math>) Restrict release for pool 523.5-538 ELSE IF (Pool level &gt;= 523.5 &amp; <math>&lt; 533.5</math>) Restrict release for pool 523.5-538 ELSE IF (Pool level &gt;= 523.5 &amp; <math>&lt; 533.5</math>) Restrict release for pool 523.5-538 ELSE IF (Pool level &gt;= 523.5 &amp; <math>&lt; 533.5</math>) Restrict release for pool 523.5-538 ELSE IF (Pool level &gt;= 523.5 &amp; <math>&lt; 533.5</math>) Restrict release for pool 523.5-538 ELSE IF (Pool level &gt;= 523.5 &amp; <math>&lt; 533.5</math>) Restrict release for pool 523.5-538 ELSE IF (Pool level &gt;= 523.5 &amp; <math>&lt; 533.5</math>) Restrict release for pool 523.5-538 Restrict release for poo</td>	Zone-Rules Rel. Alloc. Outages Stor. Credit Restrict rate of pool level drop File (Pool level >= 573.5 ft) Restrict release for pool > 573.5 ft ELSE IF (Pool level >= 568.5 & $< 573.5$ ) Restrict release for pool 568.5-573 ELSE IF (Pool level >= 563.5 & $< 568.5$ ) Restrict release for pool 563.5-568 Restrict release for pool 558.5-563 ELSE IF (Pool level >= 558.5 & $< 563.5$ ) Restrict release for pool 553.5-558 ELSE IF (Pool level >= 548.5 & $< 553.5$ ) Restrict release for pool 548.5-553 ELSE IF (Pool level >= 548.5 & $< 553.5$ ) Restrict release for pool 548.5-553 ELSE IF (Pool level >= 548.5 & $< 548.5$ ) Restrict release for pool 543.5-548 ELSE IF (Pool level >= 538.50 & $< 543.5$ ) Restrict release for pool 538.5-543 ELSE IF (Pool level >= 533.5 & $< 538.5$ ) Restrict release for pool 533.5-538 ELSE IF (Pool level >= 533.5 & $< 533.5$ ) Restrict release for pool 523.5-538 ELSE IF (Pool level >= 523.5 & $< 533.5$ ) Restrict release for pool 523.5-538 ELSE IF (Pool level >= 523.5 & $< 533.5$ ) Restrict release for pool 523.5-538 ELSE IF (Pool level >= 523.5 & $< 533.5$ ) Restrict release for pool 523.5-538 ELSE IF (Pool level >= 523.5 & $< 533.5$ ) Restrict release for pool 523.5-538 ELSE IF (Pool level >= 523.5 & $< 533.5$ ) Restrict release for pool 523.5-538 ELSE IF (Pool level >= 523.5 & $< 533.5$ ) Restrict release for pool 523.5-538 ELSE IF (Pool level >= 523.5 & $< 533.5$ ) Restrict release for pool 523.5-538 Restrict release for poo

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

# **C. Rule Descriptions**

#### 1. Gate Ops to Save Dam

Figure 7 shows the content of "Gate Ops to Save Dam" rule. This rule represents the maximum allowable release from Slide gates as a function of pool elevation when the pool is in Surcharge zone.

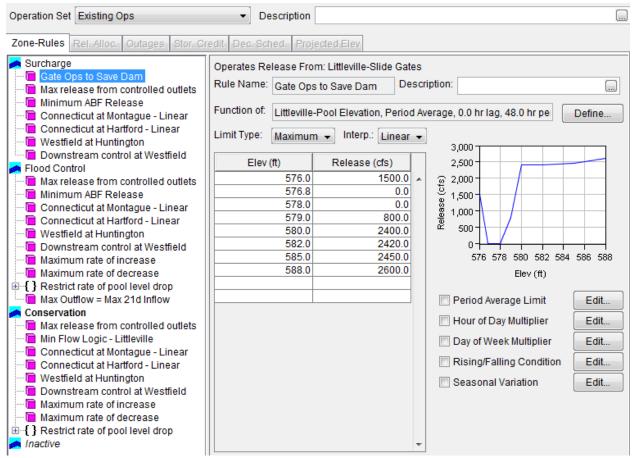


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet –Gate Ops to Save Dam

# 2. Max release from controlled outlets

Figure 8 shows the content of "Max release from controlled outlets" rule. This rule represents the maximum allowable release from Slide gates.

Operation Set Existing Ops	✓ Description	
Zone-Rules Rel. Alloc. Outages Stor. C	Credit Dec. Sched. Projected Elev	
Surcharge Gate Ops to Save Dam Max release from controlled outlets Minimum ABF Release Connecticut at Montague - Linear Westfield at Huntington Downstream control at Westfield Flood Control Max release from controlled outlets Minimum ABF Release Connecticut at Montague - Linear Connecticut at Hartford - Linear Westfield at Huntington Downstream control at Westfield Maximum rate of increase Maximum rate of decrease Restrict rate of pool level drop Max release from controlled outlets Max release from controlled outlets Maximum rate of decrease Max release from controlled outlets Max release from controlled outlets Min Flow Logic - Littleville Connecticut at Hartford - Linear Westfield at Huntington Max release from controlled outlets Min Flow Logic - Littleville Connecticut at Montague - Linear Westfield at Huntington Maximum rate of increase Maximum rate of increase	Function of:       Date       Defin         Limit Type:       Maximum         Interp.:       Linear           Date       Release (cfs)       1,515         01Jan       1500.0       1,505         1,505       1,500       1,495         1,495       1,495       1,495         1,485       1,490       1,485         Jan Mar May Jul Sep Nov       Period Average Limit       Edited and the set of the s	() dit dit dit

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet –Max release from controlled outlets

## 3. Minimum ABF Release

Figure 9 shows the content of "Minimum ABF Release" rule. This rule represents the minimum required release from slide gates during flood control operations.

Operation Set Existing Ops	Description	
Zone-Rules Rel. Alloc. Outages Stor. C	Credit Dec. Sched. Projected Elev	
<ul> <li>Surcharge</li> <li>Gate Ops to Save Dam</li> <li>Max release from controlled outlets</li> <li>Connecticut at Montague - Linear</li> <li>Connecticut at Hartford - Linear</li> <li>Westfield at Huntington</li> <li>Downstream control at Westfield</li> <li>Flood Control</li> <li>Max release from controlled outlets</li> <li>Minimum ABF Release</li> <li>Connecticut at Montague - Linear</li> <li>Westfield at Huntington</li> <li>Downstream control at Westfield</li> <li>Flood Control</li> <li>Max release from controlled outlets</li> <li>Minimum ABF Release</li> <li>Connecticut at Hartford - Linear</li> <li>Westfield at Huntington</li> <li>Downstream control at Westfield</li> <li>Maximum rate of increase</li> <li>Restrict rate of pool level drop</li> <li>Max Outflow = Max 21d Inflow</li> <li>Conservation</li> <li>Max release from controlled outlets</li> <li>Min Flow Logic - Littleville</li> <li>Connecticut at Hartford - Linear</li> <li>Westfield at Huntington</li> <li>Max Outflow = Max 21d Inflow</li> <li>Connecticut at Montague - Linear</li> <li>Westfield at Huntington</li> <li>Max release from controlled outlets</li> <li>Min Flow Logic - Littleville</li> <li>Connecticut at Montague - Linear</li> <li>Westfield at Huntington</li> <li>Maximum rate of increase</li> <li>Maximum rate of increase</li> <li>Maximum rate of decrease</li> <li>Restrict rate of pool level drop</li> <li>Maximum rate of decrease</li> <li>Restrict rate of pool level drop</li> <li>Maximum rate of decrease</li> </ul>	Operates Release From: Littleville-Slide Gates         Rule Name:       Minimum ABF Release       Description:         Function of:       Date         Limit Type:       Minimum Interp.:       Linear I         Date       Release (cfs)       25.0         01Jan       25.0       25.0         24.9       24.9       24.9         24.8       24.9       24.9         Date       Period Average Limit       Hour of Day Muttiplier         Day of Week Multiplier       Day of Week Multiplier       Seasonal Variation	Edit Edit Edit

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Minimum ABF Release

#### 4. Connecticut at Montague-Linear

Figure 10 shows the content of "Connecticut at Montague-Linear" rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

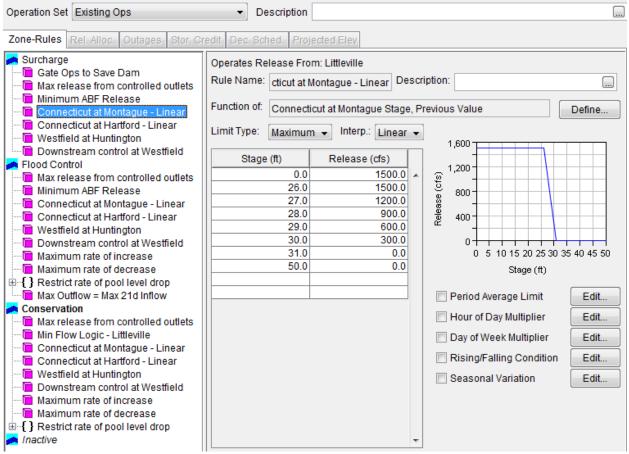


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet –Connecticut at Montague-Linear

#### 5. Connecticut at Hartford-Linear

Figure 10 shows the content of "Connecticut at Hartford-Linear" rule. This rule represents the maximum allowable release from dam as a function of previous day stage at Hartford. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

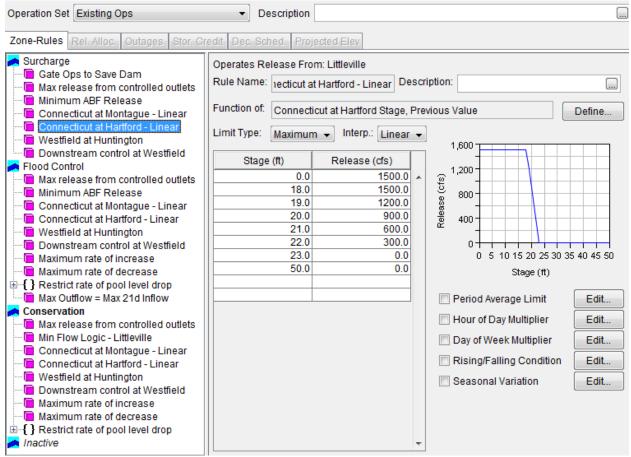


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Hartford-Linear

#### 6. Westfield at Huntington

Figure 12 shows the content of "Westfield at Huntington" rule. This rule represents the maximum allowable release from dam as a function of previous day stage at Huntington. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

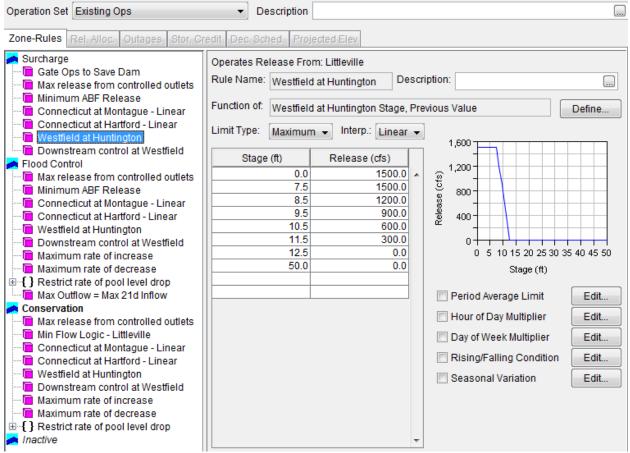


Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet –Westfield at Huntington

#### 7. Downstream control at Westfield

Figure 13 shows the content of "Downstream control at Westfield" rule. This rule represents the maximum allowable flow at the downstream point Westfield at Huntington.

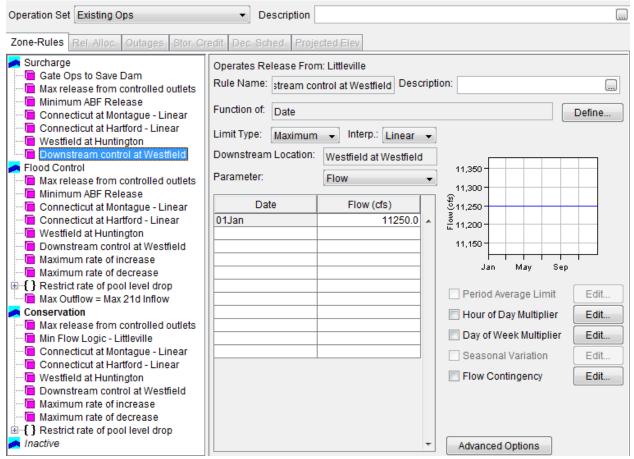


Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Downstream control at Westfield

## 8. Maximum rate of increase

Figure 14 shows the content of "Maximum rate of increase" rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Littleville dam.

Operation Set Existing Ops	▼ De	escription			)
Zone-Rules Rel. Alloc. Outages Stor. Cr	edit Dec. Sch	ned. Projecte	d Elev		
Surcharge  Gate Ops to Save Dam  Max release from controlled outlets  Minimum ABF Release Connecticut at Montague - Linear  Westfield at Huntington Downstream control at Westfield Flood Control Max release from controlled outlets Minimum ABF Release Connecticut at Montague - Linear Minimum ABF Release Connecticut at Hartford - Linear Connecticut at Hartford - Linear Westfield at Huntington Downstream control at Westfield Maximum rate of increase Maximum rate of decrease Connecticut at Montague - Linear Max release from controlled outlets Maximum rate of decrease Connecticut at Montague - Linear Max release from controlled outlets Maximum rate of decrease Connecticut at Montague - Linear Max release from controlled outlets Max release from control at Westfield Max release from control at Westfield Maximum rate of decrease Mestfield at Huntington Downstream control at Westfield Maximum rate of decrease	Operates Re Release Rat Description: Function Of: Type Interpolate	elease From: L e of Change L	A Elev ittleville-Slide Gates imit Maximum rate of incr Rate Change (cfs/hr) 300.0 300.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0	ease 300 (uly 250 200 200 150 200 150 200	3,000 4,500 e (cfs)
📥 Inactive					

Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet –Maximum rate of increase

## **9.** Maximum rate of decrease

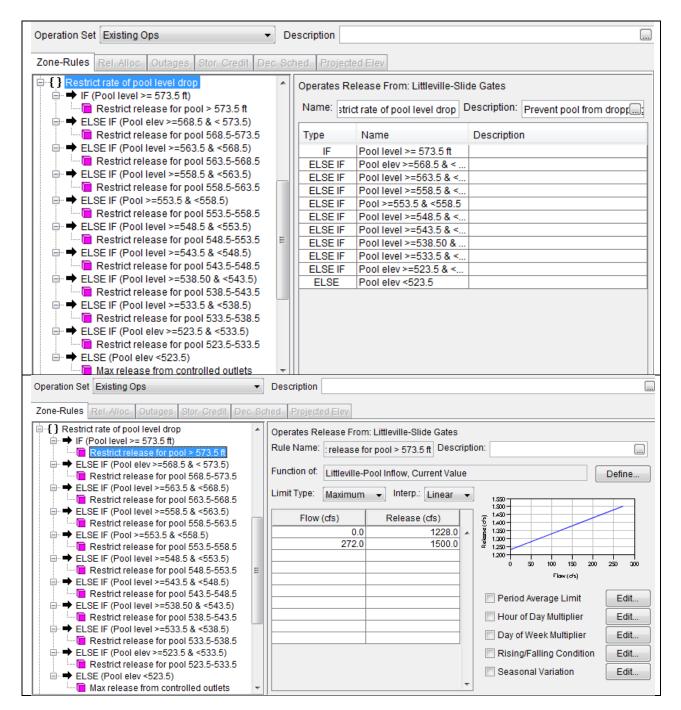
Figure 15 shows the content of "Maximum rate of decrease" rule. This rule shows the maximum allowable decreasing release rate of change.

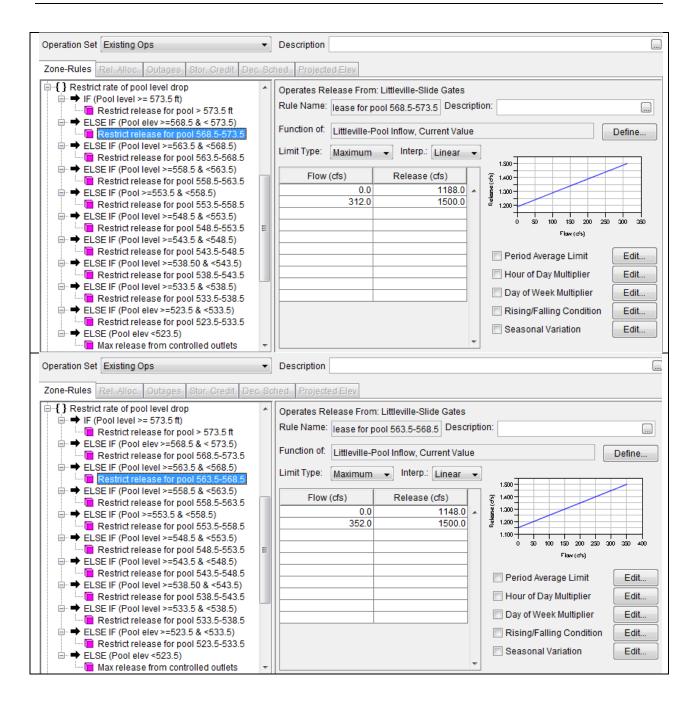
Operation Set Existing Ops	<ul> <li>Description</li> </ul>		
Zone-Rules Rel, Alloc. Outages Stor. Cr	redit Dec. Sched. Projected	Elev	
Surcharge Gate Ops to Save Dam Max release from controlled outlets Minimum ABF Release Connecticut at Montague - Linear Westfield at Huntington Downstream control at Westfield Flood Control Max release from controlled outlets Minimum ABF Release Connecticut at Montague - Linear Connecticut at Hartford - Linear Westfield at Huntington Connecticut at Hartford - Linear Westfield at Huntington Downstream control at Westfield Maximum rate of increase Maximum rate of decrease Max release from controlled outlets Min Flow Logic - Littleville Connecticut at Hartford - Linear Max release from controlled outlets Minimum rate of decrease Maximum rate of decrease Maximum rate of not level drop Max Outflow = Max 21d Inflow Conservation Max release from controlled outlets Min Flow Logic - Littleville Connecticut at Hartford - Linear Mestfield at Huntington Max release from control at Westfield Maximum rate of increase Maximum rate of increase Maximum rate of decrease Max	Operates Release From: Litt Release Rate of Change Lin Description: Function Of: Type Max Rate of Change (cfs/hr)	deville-Slide Gates nit Maximum rate of decrease Constant • Decreasing • 500.0	

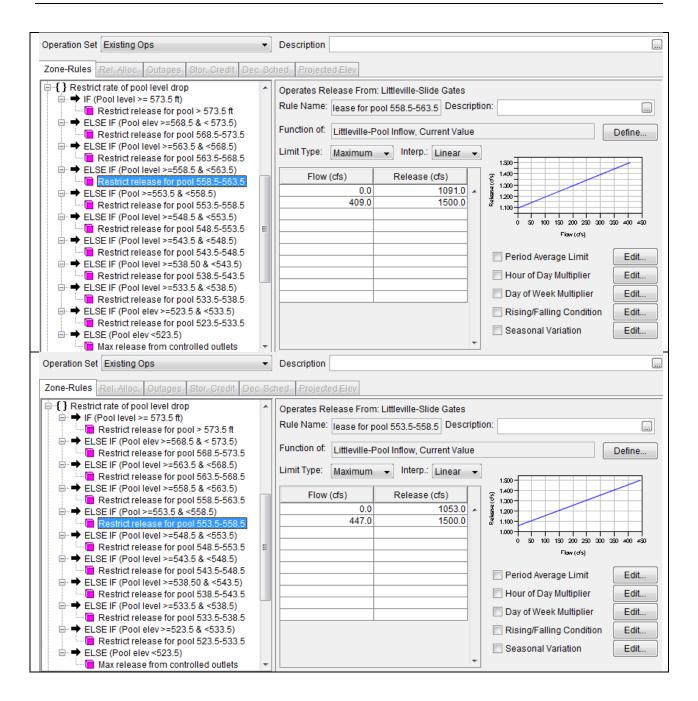
Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet –Maximum rate of decrease

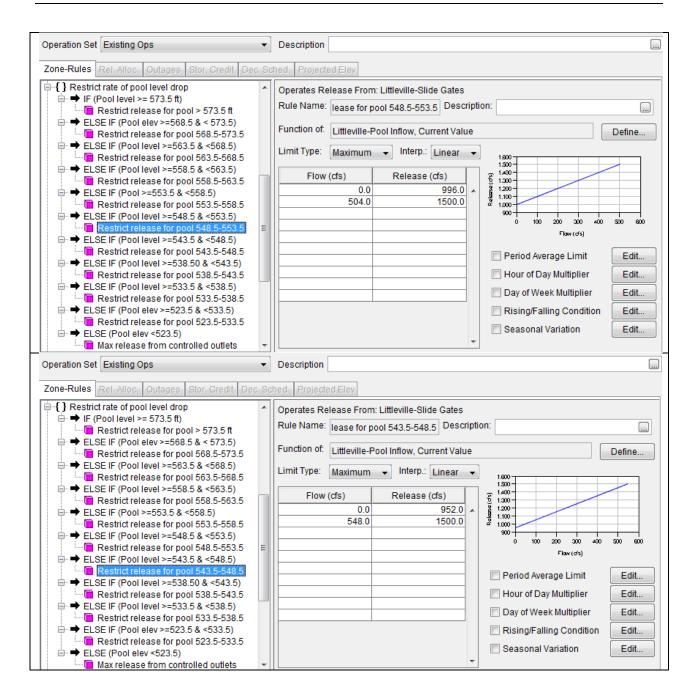
#### 10. Restrict rate of pool level drop

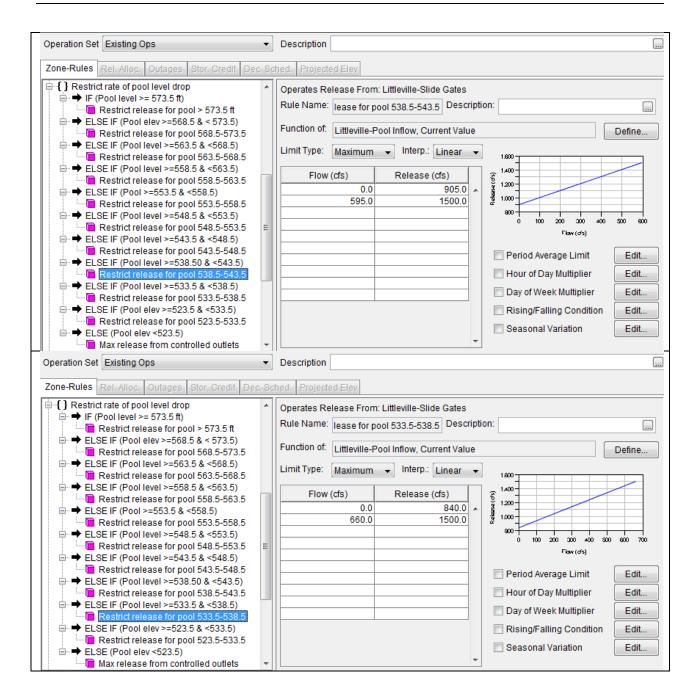
Figure 15 shows the content of "Restrict rate of pool level drop" rule. It shows the maximum allowable release as a function of Inflow for different ranges of pool elevations.











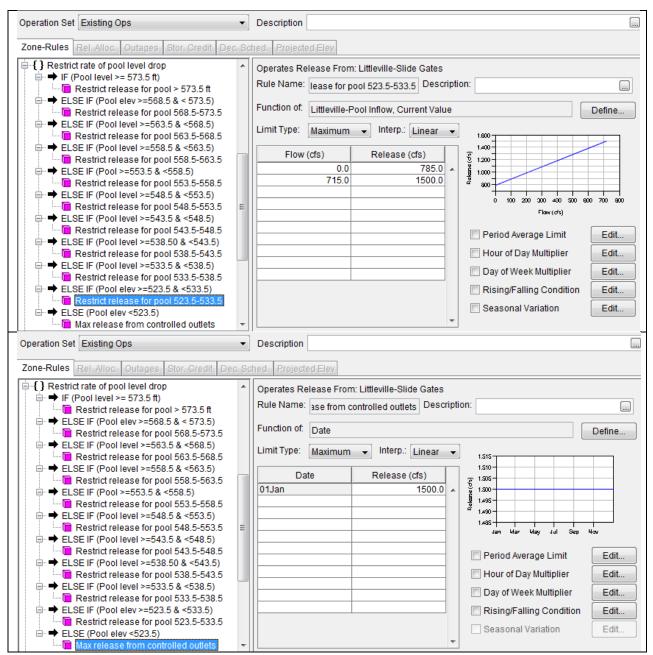


Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet –Restrict rate of pool level drop

#### 11. Max Outflow equals 21 day max Inflow

Figure 17 shows the content of "Max Outflow equals 21 day max Inflow" rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

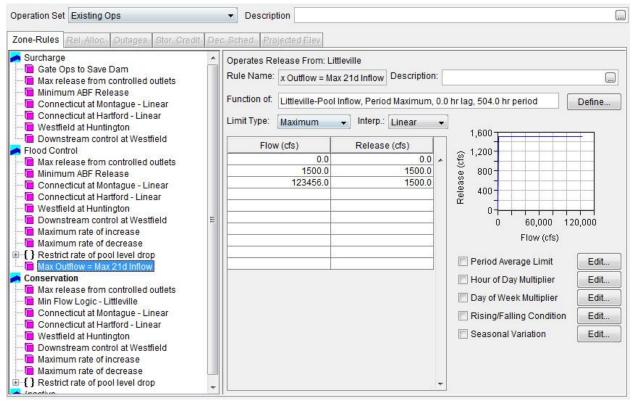


Figure 17: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals 21 day max Inflow

#### **12.** *Min Flow Logic - Littleville*

Figure 18 shows the content of "Min Flow Logic - Littleville" rule. This rule describes required seasonal minimum flows from controlled outlets as a function of inflow at Littleville.

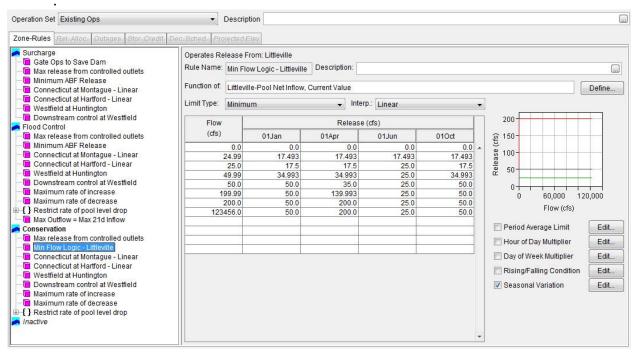


Figure 18: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic - Littleville

## Mare Meadow

### I. Overview

Mare Meadow dam is on the Mare Meadow River in Worcester County, Massachusetts. It is owned by the City Of Fitchburg and is primarily used for drinking water supply for the city.

Figure 1 shows the location of Mare Meadow Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the dam.

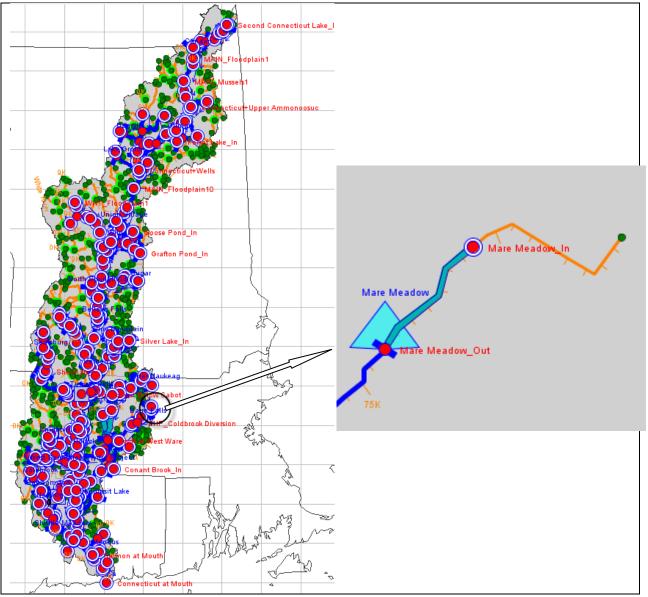


Figure 1: HEC-ResSim Map Display Showing Location of Mare Meadow



Figure 2: Aerial photo of Mare Meadow reservoir.

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>59</sup>. The dam consists of a controlled outlet and an uncontrolled spillway as shown in Figure 4.

<sup>&</sup>lt;sup>59</sup> Provided by UMASS

Reservoir Editor				X
Reservoir Edit Pool				
Reservoir Mare Meadow -	Description			K 4 48 of 74 b b
Physical Operations Observed Da	ata			
Mare Meadow	Mare Meadow-Pool			
Dam 20 CIP Reservoir Drain	Linear Interpolation	Conic Interpolation	Initial Conic Depth	(ft)
Spillway	Elevation	Storage	Area	
	(ft)	(ac-ft)	(acre)	
	1020.00	0.00	0.00	1,070
	1060.50	4849.00	283.00	1,060
	1063.60	5800.00	300.00	€ 1,050
	1066.50	6700.00	315.00	€ 1,050 à 1,040 ш 1,030 1,020
				0 3,000 6,000
				Stor (ac-ft)
				1,070
				€ 1,050 ≥ 1,040 = 1,030
				3 1,040 ± 1,030 ±
		· · ·		1,020
				0 100 200 300
				Area (acre)
[ <b>I</b> ]	J			
			ОК	Cancel Apply

Figure 3: Reservoir Editor: Physical Tab -- Pool

🟹 Reservoir Editor					×
Reservoir Edit Dam					
Reservoir Mare Meadow -					K 4 48 of 74 D H
Physical Operations Observed Da	ita				
Are Meadow	Mare Meadow-Dam				
Dam 20 CIP Reservoir Drain	Elevation at top of dar	m (ft)		1066.5	
Spillway	Length at top of dam	(ft)		830.0	
	Composite Release	Capacity			<u></u>
	Elevation	Controlled	Uncontrolled	Total	
	(ft)	(cfs)	(cfs)	(cfs)	1,070
	1,040.0	0.0	0.0	0.0 8	g 1,060
	1,060.5	17.0	0.0	17.0	E 1,060 € 1,050 1,040
	1,063.6	17.0 17.0	700.0	2,017.0	1,040
	1,000.5	17.0	2,000.0	2,017.0	0 1,000 2,000
					Flow
					(cfs)
				ОК	Cancel Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

## III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Mare Meadow's "Existing Ops" operational zones, which consist of zones of Flood Control (1066.5 ft), Conservation (1060.5 ft), and Inactive zone (1020 ft)<sup>1</sup>.

Reservoir Editor		×
Reservoir Edit Operations Zo	one Rule IF_Block	
Reservoir Mare Meadow	✓ Description	K 4 48 of 74 b H
Physical Operations Obs	erved Data	
Operation Set Existing Ope	B Description	
Zone-Rules Rel, Alloc. C	utages Stor. Credit Dec. Sched. Proje	jected Elev
Flood Control	Storage Zone Conservation	Description
inactive 🛃	Function of Date	Define
	Date Top Elevation (ft)	1 070
	01Jan 1060	1,060
		€ 1,050
		Jan Mar May Jul Sep Nov
	Zana Sat Elevation	Jan Mar May Jul Sep Nov
	Zone Sort Elevation	
		OK Cancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet

## **B. Rule Illustrations**

The operation set for Mare Meadow has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

## Mascoma

## I. Overview

Mascoma Lake dam is located 3 miles upstream of the city of Lebanon on the Mascoma River. It is currently owned and operated by the New Hampshire Water Resources Board and is used for several purposes: water supply for the City of Lebanon, recreation, and some flood control.

Figure 1 shows the location of Mascoma dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Mascoma dam.

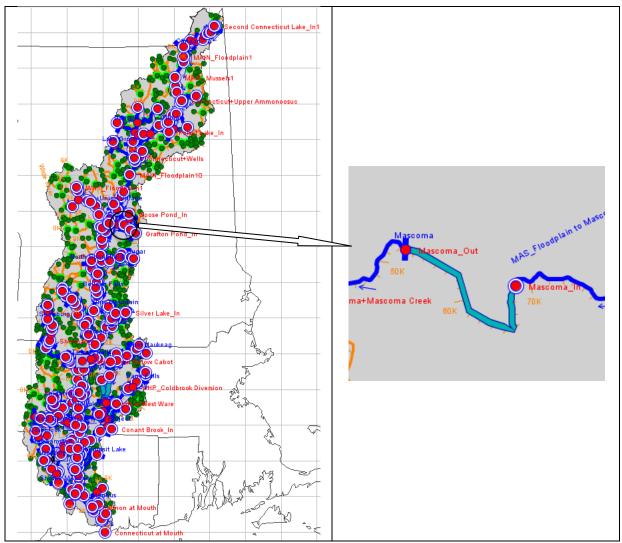


Figure 1: HEC-ResSim Map Display Showing Location of Mascoma Dam



Figure 2: Photo of Mascoma dam.

#### II. **Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>60</sup>. The dam consists of three types of outlets: (1) controlled slide gates, (2) controlled Obermeyer gate on aux spillway, and (3) uncontrolled Main Spillway, as shown in Figure 4<sup>61</sup>.

 <sup>&</sup>lt;sup>60</sup> NHDams Data Sheet. Mascoma Dam. 2010
 <sup>61</sup> Phase 1 Report. Mascoma Dam. 1978.

eservoir Edit Pool					
Reservoir Mascoma 🗸 Des	cription				K 4 64 of 74 D H
Physical Operations Observed Data					
Mascoma	Mascoma-Pool				
Dam     Slide Gates	Linear Inter	polation © 0	Conic Interpol	ation	n Initial Conic Depth (ft)
Obermeyer Gate on aux spillway	Elevation	Storage	Area		
🏧 🛇 Main Spillway	(ft)	(ac-ft)	(acre)		
	742.00	0.00			
	742.50	333.33			
	743.00	666.67			
	743.50	1000.00			
	744.00	1333.33			770
	744.50	1666.67			
	745.00	2000.00			€ 760
	745.50	2633.20		=	5
	746.00	3266.40		1	a 750
	746.50	3899.60		1	740
	747.00	4532.80		1	0 15,000 30,000
	747.50	5166.00		1	
	748.00	5799.20		1	Stor (ac-ft)
	748.50	6432.40			770
	749.00	7065.60		1	
	749.50	7698.80		1	€ 760
	750.00	8332.00		1	2
	750.50	8885.78			a 750-
	751.00	9439.56			740
	751.50	9993.33			2 4 6 8 10
	752.00	10547.11			
	752.50	11100.89			Area (undef)
	753.00	11654.67			
	753.50	12208.44			
	754.00	12762.22			
	754.50	13316.00			
• • • • • • •	755.00	13869.78		+	
	755 50	14400 56			

Figure 3: Reservoir Editor: Physical Tab – Pool

Reservoir Mascoma 🗸 Des	cription					4 1 64 of 74 D H	
Physical Operations Observed Data							
Mascoma	Mascoma-Dar	n					
Dam Slide Gates	Elevation at te	op of dam (ft)	)	758.02	]		
<ul> <li>Obermeyer Gate on aux spillway</li> </ul>	Length at top	of dam (ft)		575.0	575.0		
Main Spillway	Composite F	Release Cap	acity				
	Elevation	Controlled	Uncontr	Total			
	(ft)	(cfs)	(cfs)	(cfs)			
	742.0	0.0	0.0	0.0	76 75 🕀 Elevation 74	0	
	742.5	0.0	0.0	0.0	Te € 75	0-	
	743.0	1.6	0.0	1.6	<u>b</u>		
	743.5	23.9	0.0	23.9	- 74	0 + + + + + + + + + + + + + + + + + + +	
	744.0	59.2	0.0	59.2			
	744.5	104.0	0.0	104.0 ≡		Flow	
	745.0	156.3	0.0	156.3		(cfs)	
	745.5	251.7 383.3	0.0	251.7 383.3			
	746.0	539.9	0.0	539.9			
	740.5		0.0	717.6			
	747.5	913.6	0.0	913.6			
	748.0		0.0	1,126.4			
	748.5	1,354.7	0.0	1,354.7			
	749.0		0.0	1,581.8			
	749.5		120.9	1,926.8			
	750.0		372.5				
	750.5	2,264.0	744.0	3,008.1			
	751.0		1,166.7	3,666.7			
	751.5		1,635.5	4,376.5			
	752.0						
	752.5			5,956.2			
	753.0	3,495.8	3,320.0	6,815.8 +			
4		0.050.0					

Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Mascoma Dam's "ExistingOps" operational zones, which consist of zones of Flood Control (758.02 ft), Conservation (748-751 ft), and Inactive zone (742 ft)<sup>62</sup>.

Reservoir Editor				×			
Reservoir Edit Operations Zone Rule IF_B							
Reservoir Mascoma 👻 Des	scription			● 64 of 74 ► ►			
Physical Operations Observed Data							
Operation Set Existing Ops	▼ Descrip	tion					
Zone-Rules Rel. Alloc. Outages Stor.	Credit Dec. Sched.	Projected Elev					
Flood Control	Storage Zone Cor	servation	Description				
Max controlled Fall-Winter release	Function of Date			Define			
Spring Whitewater Release Min Flow Logic - Mascoma	Date	Top Elevation (ft)	700				
inactive	01Jan	748.0	760				
	15Apr 01Jun	748.0	756				
	110ct	751.0	754- € 752-				
	01Nov	748.0	5 752				
			₹ 748				
			отремания и простория и простори и простори и простор				
			744				
			742				
			Jan Mar May Ju	I Sep Nov			
	Zone Sort Elevation	1					
			OK Cano	el Apply			

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

<sup>&</sup>lt;sup>62</sup>http://www2.des.state.nh.us/rti\_home/station\_information\_display.asp?WID=fivebasins&ID=MCAN3&NAME=M ascoma+Lake

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>63</sup>.

Reservoir Editor
Reservoir Edit Operations Zone Rule IF_E
Reservoir Mascoma 🔹 De
Physical Operations Observed Data
Operation Set Existing Ops
Zone-Rules Rel, Alloc, Outages Stor.
Flood Control  Spring Whitewater Release  Max controlled Fall-Winter release  Conservation  Spring Whitewater Release  Min Flow Logic - Mascoma  Inactive

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

# **C.** Rule Descriptions

#### 1. Spring Whitewater release

Figure 7 shows the content of "Spring Whitewater Release" rule. This rule defines a seasonal maximum release from reservoir as a function of Inflow.

Operation Set Existing Ops	•	Description					
Zone-Rules Rel. Alloc. Outages Stor.	Credit Dec. S	Sched. Proje	ected Elev				
Flood Control	Operates Re			Description:			
Max controlled Fall-Winter release	Function of:						
<ul> <li>Spring Whitewater Release</li> <li>Min Flow Logic - Mascoma</li> <li>Inactive</li> </ul>	Limit Type:	Maximum		erp.: Linear	•	[	Define
	Flow Release (cfs)			1200.00 5 300.00 10 400.00	0	-	
	(cfs)	01Jan 1234567.0	11Apr 500.0	13Apr 1234567.0	-	o <del>               </del>	200.000
	500.0	1234567.0 1234567.0	1000.0	1234567.0 1234567.0 1234567.0	Î	0 200,000 300,000 1. Flaw(d/s)	200.00
	1234567.0		1000.0	1234567.0	Peri	iod Average Limit	Edit
						ur of Day Multiplier of Week Multiplier	Edit
						ing/Falling Condition	Edit
4 III >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>					▼ 🔽 Sea	asonal Variation	Edit

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Spring Whitewater Release

<sup>&</sup>lt;sup>63</sup> Mascoma Lake Operating Guide. 1985.

#### 2. Max controlled Fall-Winter release

Figure 8 shows the content of "Max controlled Fall-Winter release" rule. This rule limits the maximum release from Dam to 2000 cfs during 15Apr-31May.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>								
Zone-Rules Rel. Alloc. Outages. Stor. Credit. Dec. Sched. Projected Elev.									
Flood Control  Spring Whitewater Release  Conservation  Spring Whitewater Release  Min Flow Logic - Mascoma  Inactive	Operates Release From: Ma Rule Name: Itrolled Fall-Wi Function of: Date Limit Type: Maximum Date 01Jan 15Apr 01Jun	Release         Cfs           1234567.0         1234567.0           1234567.0         1234567.0	1 400,000 1 200,000 1 200,000	Edit Edit Edit Edit					
۰ III ۲		<b>T</b>	Seasonal Variation	Edit					

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max controlled Fall-Winter release

#### 3. Min Flow logic-Mascoma

Figure 9 shows the content of "Min Flow logic-Mascoma" rule. This rule represents the seasonal minimum flow from reservoir as a function of Inflow.

Operation Set Existing Ops	•	Descrip	otion				
Zone-Rules Rel. Alloc. Outages Stor.	Credit Dec.	Sched.	Projected	Elev			
Flood Control Spring Whitewater Release Max controlled Fall-Winter release	Operates R Rule Name				Descriptio	n:	
Conservation Spring Whitewater Release Min Flow Logic - Mascoma	Function of Limit Type:	mascor		et Inflow, ( Interp.: [	Current Val	ue •	Define
	Flow (cfs)	01Jan	Relea: 01Apr	se (cfs) 01Jun	01Oct		
	0.0	0.0 52.493	0.0 52.493	0.0 52.493	0.0 52.493		0 40.000 80.000 120.000 Flaw(d%)
	75.0 149.99	52.5 104.993		75.0 75.0	52.5 104.993	E	Period Average Limit Edit
	150.0 609.99	150.0 150.0		75.0	150.0		Hour of Day Multiplier     Day of Week Multiplier     Edit
	610.0 123456.0	150.0 150.0	610.0 610.0	75.0 75.0	150.0 150.0		Rising/Falling Condition
4 III +						Ŧ	Seasonal Variation Edit

Figure 9: Reservoir Editor: Operations Tab - Existing Ops OpSet - Min Flow logic-Mascoma

# McIndoes

### I. Overview

McIndoes dam is located on the mainstem Connecticut River between Monroe, NH and Barnet, VT. It is owned and operated by TransCanada Hydro Northeast Inc. as part of the 15 Mile Falls project for hydropower generation on run-of-river basis.

Figure 1 shows the location of McIndoes dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of McIndoes dam.

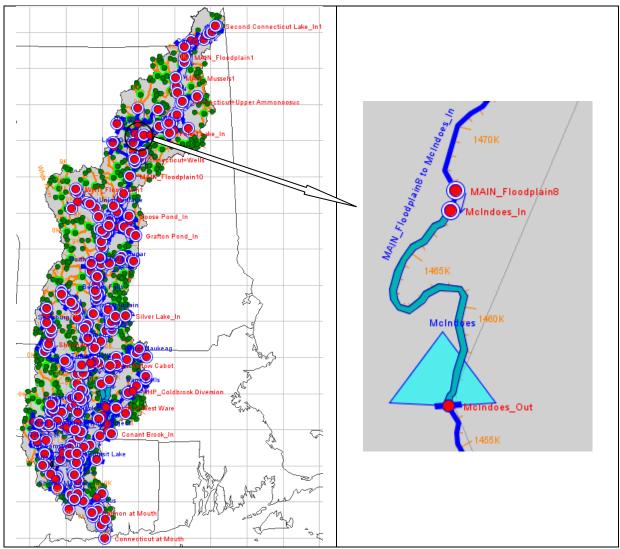


Figure 1: HEC-ResSim Map Display Showing Location of McIndoes dam

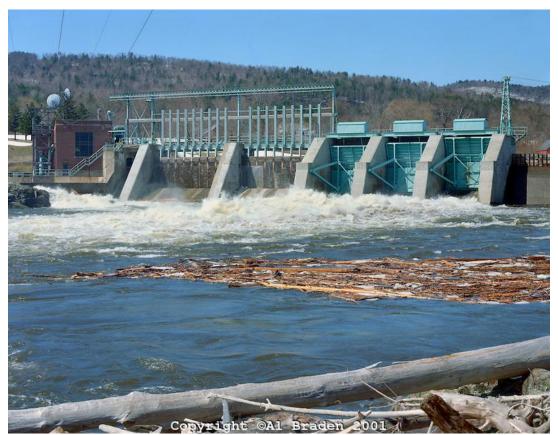


Figure 2: Photo of McIndoes Dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>64</sup>. The dam consists of six types of outlets: (1) uncontrolled outlet, (2) controlled skimmer gate, (3) controlled tainter gate, (4) controlled needle flashboard, (5) controlled pin flashboard, (6) and power plant as shown in Figure 4.

<sup>&</sup>lt;sup>64</sup> Data provided by TransCanada

i-	Description				
Reservoir McIndoes	<ul> <li>Description</li> </ul>				K 4 22 of 74 b H
Physical Operations Observed	Data				
McIndoes	McIndoes-Pool				
Pool	McHiddes-Foor				
⊡♥ Dam □♦ Power Plant	Linear Inter	polation 💿 (	Conic Interpola	ation	Initial Conic Depth (ft)
Tailwater	Elevation	Storage	Area		
Uncontrolled Outlet	(ft)	(ac-ft)	(acre)		
skimmer gate	430.00	0.00			
needle flashboard	430.10	1.32			
pin flashboard	430.20	2.73		Ξ	
	430.30	4.05			
	430.40	5.45			460
	430.50	6.78			æ 450
	430.60	8.18			€ <sup>450</sup> à 440
	430.70	9.50			
	430.80	10.91			430
	430.90	12.23			
	431.00	13.64			
	431.10	16.78			Stor (ac-ft)
	431.20	20.00			
	431.30	23.14			460
	431.40	26.36			€ 450
	431.50 431.60	29.50 32.73			€ <sup>450</sup> à 440
	431.00	35.87			
	431.70	39.09			430
	431.80	42.23			
	431.50	45.45			
	432.10	50.33			Area (acre)
	432.20	55.29			
	432.30	60.17			
	432.40	65.12			
	432.50	70.00			
	102.00	71.00		Ŧ	

Figure 3: Reservoir Editor: Physical Tab -- Pool

eservoir Edit Dam	
Reservoir McIndoes	✓ Description
Physical Operations Observed I	Data McIndoes-Dam
Dam 	Elevation at top of dam (ft) 460.0
<ul> <li>Tailwater</li> <li>Uncontrolled Outlet</li> </ul>	Length at top of dam (ft) 730.0
skimmer gate	Composite Release Capacity
<ul> <li>needle flashboard</li> <li>pin flashboard</li> </ul>	Elevation         Controlled         Uncontr         Total           (ft)         (cfs)         (cfs)         460
↓ pin itability and	
	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
	442.0 25,980.0 0.0 25,980.0 0 40.000
	444.0 28,180.0 0.0 28,180.0 = Flow
	445.5 30,130.0 0.0 30,130.0 (cfs)
	446.0 30,780.0 0.0 30,780.0
	446.5 31,530.0 0.0 31,530.0
	447.0 32,280.0 0.0 32,280.0 447.5 33,030.0 0.0 33,030.0
	448.0 33,780.0 0.0 33,780.0
	448.5 35,792.5 0.0 35,792.5
	449.0 38,105.0 0.0 38,105.0
	449.5 40,367.5 0.0 40,367.5
	450.0 42,930.0 0.0 42,930.0
	450.5 45,817.5 0.0 45,817.5
	451.0 48,705.0 0.0 48,705.0
	451.5 52,292.5 0.0 52,292.5
	452.0 55,580.0 0.0 55,580.0 452.5 58,230.0 0.0 58,230.0
	453.0 60,580.0 0.0 60,580.0

Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 4 shows the definition of McIndoes's "Existing" operational zones, which consist of zones of Top of dam (460 ft), Below Top of dam (459 ft), Conservation (451 ft), Bottom of Conservation (447.5 ft), and Inactive zone (436 ft)<sup>1</sup>.

Reservoir Editor		2 1	~~	×
Reservoir Edit Operations Zone R	ule IF_Block			
Reservoir McIndoes	Description			K € 22 of 74 ► H
Physical Operations Observed	Data			
Operation Set Existing Ops	✓ Descripti			
Zone-Rules Rel. Alloc. Outage	s Stor. Credit Dec. Sched. Pr	ojected Elev		
Top of Dam	Storage Zone Conservation	Description		
Min Flow	Function of Date			Define
Conservation	Date	Top Elevation (ft)	]	
Release=95%Inflow	01Jan	451.0 🔺	460	
Employed Constant release Bottom of Conservation			455	
Inactive				
			(1) 450 uopper 445	
			E 445	
			ـــــــــــــــــــــــــــــــــــــ	
			440	
			435-	
			Jan Mar M	ay Jul Sep Nov
		-		
	Zone Sort Elevation			
			ОК	Cancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing<sup>65</sup>.

e	servoir Edit Operations Zone Rule IF_Block
R	eservoir McIndoes
	Physical Operations Observed Data
	Operation Set Existing Ops 🔹
	Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. S
	👝 Top of Dam
ŀ	A Below Top of Dam
l	🔲 Min Flow
l	E { } Constant release
l	➡ IF (440= <elev<443 &="" flow="">=20000)</elev<443>
I	Release=800 cfs
l	➡ ELSE IF (443= <elev<446 &="" flow="">=20000)</elev<446>
l	Release=900 cfs
l	
l	
l	■
l	➡ ELSE IF (451= <elev<454 &="" flow="">=20000)</elev<454>
l	Release=1200 cfs
l	➡ ELSE IF (440= <elev<443 &="" flow<20000)<="" p=""></elev<443>
l	Release=1200 cfs
l	➡ ELSE IF (443= <elev<446 &="" flow<20000)<="" p=""></elev<446>
l	Release=1300 cfs
l	ELSE IF (446= <elev<449 &="" flow<20000)<="" td=""></elev<449>
l	Release=1400 cfs
l	ELSE IF (449= <elev<451 &="" flow<20000)<="" p=""></elev<451>
l	Release=1500 cfs
l	➡ ELSE IF (451= <elev<454 &="" flow<20000)<="" p=""></elev<454>
l	Release=1600 cfs
	👝 Conservation
l	- 🛅 Min Flow
I	Release=95%Inflow
	🗄 -{ } Constant release
	👝 Bottom of Conservation
1	👝 Inactive

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

\_\_\_\_

<sup>&</sup>lt;sup>65</sup> TransCanada. Connecticut River Operational Constraints. 2012.

Figure 7 shows a sequential release allocation approach specified for available outlets along Bellows Falls Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The skimmer gate gets the remainder of the release until it reaches capacity. Then the flow passes through tainter gate. After the capacity through the tainter gate is reached, the remainder of the release goes through the needle flashboard and pin flashboard, respectively.

Reservoir Editor										
Reservoir Edit Operations										
Reservoir McIndoes										
Physical Operations Observed Data										
Operation Set Existing Ops	Description									
Zone-Rules Rel. Alloc. Outages Stor, Credit Dec	Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.									
Release Allocation Strategy										
McIndoes - Balanced	Release Location: McIndoes-Dam									
☐ ↓ ↓ McIndoes-Dam (1.0) - Sequential	Allocation Type: Sequential									
McIndoes-skimmer gate	McIndoes-Power Plant									
McIndoes-tainter gate	McIndoes-skimmer gate									
McIndoes-pin flashboard	McIndoes-tainter gate									
	McIndoes-needle flashboard McIndoes-pin flashboard									
	Monuves-pin nashuvaru									

Figure 7: Reservoir Editor: Operations Tab – Existing OpSet – Release Allocation

# **C.** Rule Descriptions

#### 1. Min Flow

Figure 8 shows the content of "Min Flow" rule. This rule represents the minimum allowable release from dam.

Operation Set Existing Ops	•	Description				
Zone-Rules Rel. Alloc.	utages Stor. Credit Dec. S	Sched. Proje	cted Elev			
Zone-Rules Rel. Alloc.	Operates Release From: M Rule Name: Min Flow Function of: Date Limit Type: Minimum			2210.0 4420.0 1105.0 2210.0	4,500 4,000 3,500 2,500 1,500 Jan May Sep Period Average Limit Hour of Day Multiplier Day of Week Multiplier Rising/Falling Condition Seasonal Variation	Edit Edit Edit Edit
4				-		

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow

### 2. Constant release

Figure 9 shows the content of "Constant release" rule. It shows the minimum allowable release for different combinations of Inflow and elevation.

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Constant release

#### 3. Release=95% Inflow

Figure 10 shows the content of "Release=95% Inflow" rule. It releases 95% of Inflow as a minimum release from power plant as per the run-of-river modeling strategy.

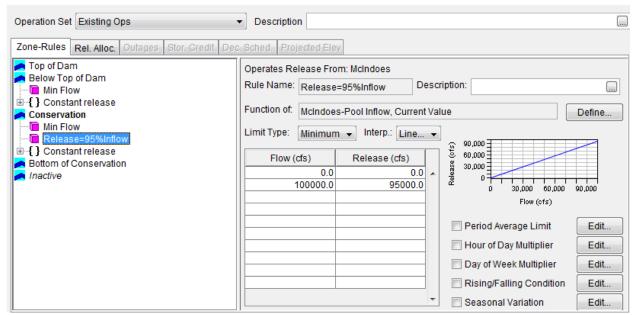


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release=95% Inflow

### Moodus

#### I. Overview

Moodus reservoir and dam is located on the Moodus River in East Haddam, CT. The dam is owned by the State of Connecticut. It is primarily used for recreation and some local flood protection.

Figure 1 shows the location of Moodus reservoir as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Moodus reservoir.

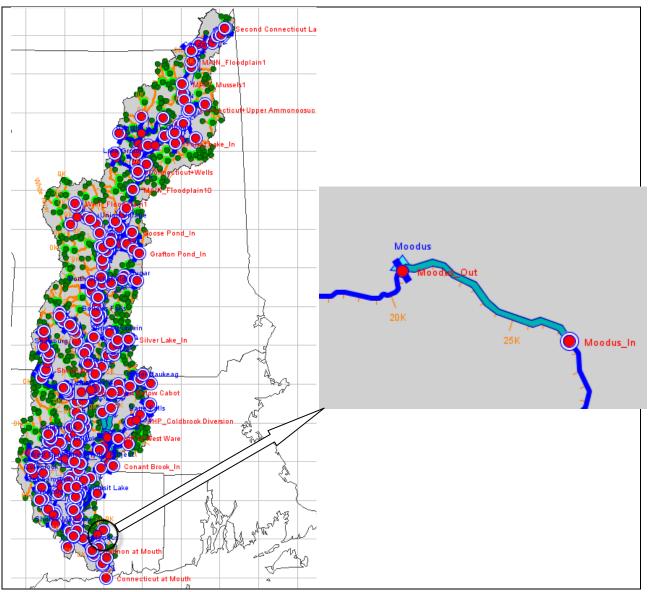


Figure 1: HEC-ResSim Map Display Showing Location of Moodus



Figure 2: Photo of Moodus reservoir

# **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>66</sup>. The dam consists of an uncontrolled spillway and outlet as shown in Figure  $4^{67}$ .

 <sup>&</sup>lt;sup>66</sup> Provided by the operators of Moodus
 <sup>67</sup> WMC Consulting Engineers. Moodus Reservoir Dam. Newington, CT 2006.

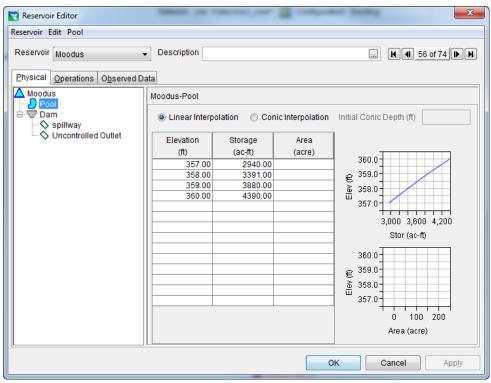


Figure 3: Reservoir Editor: Physical Tab -- Pool

🛒 Reservoir Editor	-		~ <u>a</u> .		×				
Reservoir Edit Dam									
Reservoir Moodus -	Description				K 4 56 of 74 K H				
Physical Operations Observed Da	ata								
Moodus Pool	Moodus-Dam								
Dam Dam Spillway	Elevation at to	p of dam (ft)		362	.0				
Uncontrolled Outlet	Length at top	of dam (ft)		275	.0				
	Composite Release Capacity								
	Elevation	Controlled	Uncontrol	Total					
	(ft)	(cfs)	(cfs)	(cfs)					
	357.0	0.0	0.0	0.0	163 56 560 360 367				
	357.3	0.0	54.2	54.2	1 € € 360				
	357.6		153.4	153.4	₩ 357				
	357.9	0.0	281.8	281.8	0 2,000				
	358.2	0.0	433.8	433.8					
	358.5	0.0	606.2	606.2 796.9	Flow				
	358.8	0.0	796.9	1,004.3	E (cfs)				
	359.4	0.0	1,227.0	1,227.0					
	359.7	0.0	1,464.1	1,464.1					
	360.0	0.0	1,714.7	1,714.7					
	360.5	0.0	1,782.0						
	361.0	0.0	1,905.0	1,905.0					
	362.0	0.0	2,252.9	2,252.9					
	363.0	0.0	2,703.5						
	364.0	0.0	3,237.1	3,237.1					
					<b>T</b>				
[L]									
	OK Cancel Apply								

Figure 3 Reservoir Editor: Physical Tab -- Dam

# III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 4 shows the definition of Moodus's "Guide Curve" operational zones, which consist of zones of Flood control (360 ft), Conservation (357 ft), and Inactive zone (342.5 ft).

Reservoir Editor										
Reservoir Edit Operations Zone Rule IF_Block										
Reservoir Moodus   Description  Met 56 of 74  Met 56										
Physical Operations Observed Data										
Operation Set Guide Curve   Description										
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev										
Flood Control Storage Zone Conservation Description										
Function of Date Define										
Date Top Elevation (ft)										
01Jan 357.0 ^ 362 360										
€ 354 5 352 5 350 5 350 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5										
342										
Jan Mar May Jul Sep Nov										
· · · · · · · · · · · · · · · · · · ·										
Zone Sort Elevation										
OK Cancel Apply										

Figure 4 Reservoir Editor: Operations Tab – Guide Curve OpSet

### **B. Rule Illustrations**

The operation set for Moodus has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

### Moore

### I. Overview

Moore dam is located on the mainstem Connecticut River in the towns of Littleton, NH, and Waterford, VT. It is owned and operated by TransCanada Hydro Northeast Inc. as part of the 15 Mile Falls project for hydropower generation on a peaking, seasonal storage basis.

Figure 1 shows the location of Moore dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo from Moore dam.

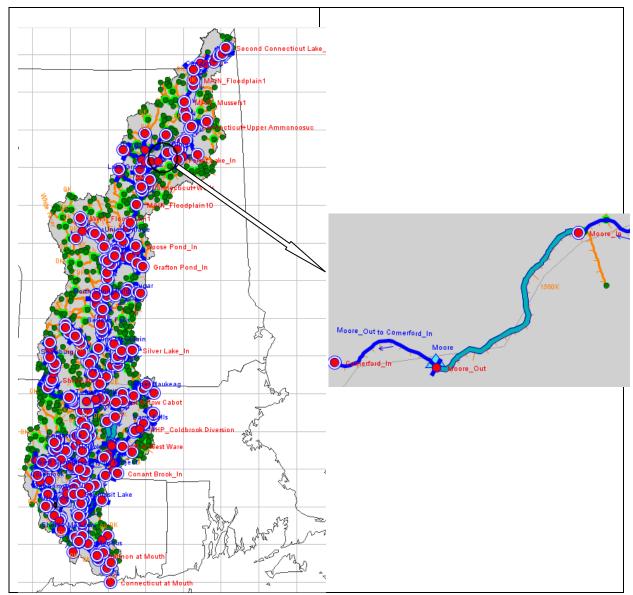


Figure 1 HEC-ResSim Map Display Showing Location of Moore



Figure 2: Photo of Moore dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>68</sup>. The dam consists of four types of outlets: (1) controlled skimmer gate, (2) controlled tainter gate, (3) uncontrolled stanchion Bays, and (4) power plant as shown in Figure 4.

<sup>&</sup>lt;sup>68</sup> Data provided by TransCanada

servoir Edit Pool					
eservoir Moore	<ul> <li>Description</li> </ul>				H 19 of 74
hysical Operations Observe	d Data				
Moore	Moore-Pool				
Dam 	Linear Interplace	oolation 🔘 C	onic Interpolatio	on Initial Con	ic Depth (ft)
🔶 🔶 Tailwater	Elevation	Storage	Area		
skimmer gate	(ft)	(ac-ft)	(acre)		
<ul> <li>Tainter gate</li> <li>stanchion Bays</li> </ul>	769.00	0.00			
Stanchion Bays	769.10	222.30		=	
	769.20	444.60			
	769.30	666.90		820	
	769.40	889.30			
	769.50	1111.60		€ 800-	
	769.60	1333.90			
	769.70	1556.20		₩ 780-	
	769.80	1778.50		760-	
	769.90	2001.70		Ó	80,000 160,000
	770.00	2224.00			Stor (ac-ft)
	770.10	2449.60			
	770.20	2675.20		820-	
	770.30	2900.80		-	
	770.40	3126.40		€ 800-	
	770.50	3352.10		8 780	
	770.60	3577.70		ш ""-	
	770.70	3803.30		760+	<u> </u>
	770.80	4028.90			2 4 6 8 10
	770.90	4254.50			Area (undef)
	771.00	4480.20			
	771.10	4709.10			
	771.20	4938.00			
	771.30	5166.10			
	771.40	5395.00		<b>T</b>	

Figure 3: Reservoir Editor: Physical Tab -- Pool

servoir Edit Dam					
Reservoir Moore	✓ Description				K 4 19 of 74 🕨 I
hysical Operations Observe	ad Data				
Moore	Moore-Dam				
Pool	MOOIe-Dalli				
Dam Dam	Elevation at top of	of dam (ft)		820.	0
Tailwater	Length at top of o	dam (ft)	2920.0		
<ul> <li>skimmer gate</li> <li>Tainter gate</li> </ul>	Composite Rele	ease Capac	ity		
Stanchion Bays				<b>T</b> -1-1	
			Incontro	Total	
	(ft)	(cfs)	(cfs)	(cfs)	820
	775.0 1	7,664.0	0.0	17,664.0 🔺	
	779.0 1	7,664.0	0.0	17,664.0	₩ E E
	779.2 1		0.0	17,709.0 =	<u>a</u> 780 <b>(</b>
	779.4 1	7,754.0	0.0	17,754.0	- +++++++++++++++++++++++++++++++++++++
	779.6 1	7,829.0	0.0	17,829.0	0 80,000
	779.8 1		0.0	17,904.0	Flow
	780.0 1	7,988.0	0.0	17,988.0	(cfs)
	780.2 1			18,090.0	
	780.4 1			18,189.0	
	780.6 1	8,324.0		18,324.0	
	780.8 1	8,459.0	0.0	18,459.0	
	781.0 1	-		18,609.0	
	781.2 1	-		18,729.0	
	781.4 1			18,894.0	
	781.6 1	-		19,059.0	
	781.8 1	9,239.0	0.0	19,239.0	
	782.0 1	-		19,374.0	
	782.2 1	-		19,614.0	
	782.4 1			19,779.0	
	782.6 2	· · ·		20,019.0	
	782.8 2	0,214.0	0.0	20,214.0 -	

Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Moor's "Existing" operational zones, which consist of zones of Top of dam (820 ft), Below Top of Dam (809 ft), Conservation (779.8-806.5 ft), and Inactive zone (769 ft). The Conservation Pool Elevation curve was created from 10 years of weekly average pool elevation<sup>1</sup>.

Reservoir Editor										
Reservoir Moore   Description  M 19 of 74										
Physical Operations Observed Data										
Operation Set Existing										
	ages Stor. Credit Dec.	Sched. Projected B	lev							
Top of Dam Below Top of Dam	Storage Zone Conser	vation	Description							
<pre>Image: Image: Ima</pre>	Function of Date			Define						
Release into fish trap	Date 01Jan	Top Elevation (ft)		830-						
Conservation	10Jan	805. 803.	1	820						
Heaking power     Release into fish trap	20Jan 31Jan	801. 800.	_	_ 810-						
	10Feb	797.	9	€ 800- ter 790-						
👝 Inactive	20Feb 28Feb	793.	_	itg 790-	$ \times / -$					
	10Mar	786.	3	±± 180 –	V					
	20Mar 31Mar	781.	-	770-						
	31Mar 10Apr	779.	-	760-						
	20Apr	791.		Ja	n Mar May J	ul Sep Nov				
	30Apr	799.	4							
	10May	804.	-							
	20May	805.	-							
	31May 10Jun	806. 806.	_							
	rosun	800.								
	Zone Sort Elevation									
			[	OK	Can	cel Apply				
			l	U.S.		C. C				

Figure 5: Reservoir Editor: Operations Tab – Existing OpSet – Guide Curve

Figure 6 shows a sequential release allocation approach specified for available outlets along Harriman Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The skimmer gate and tainter gate gets the remainder of the release, respectively.

📢 Reservoir Editor	The local division of							
Reservoir Edit Operations								
Reservoir Moore								
Physical Operations Observed Data								
Operation Set Existing	escription							
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. S	Sched. Projected Elev							
Release Allocation Strategy								
Moore - Balanced Moore-Dam (1.0) - Sequential Moore-Power Plant Moore-skimmer gate Moore-Tainter gate	Release Location: Moore-Dam Allocation Type: Sequential Moore-Power Plant Moore-skimmer gate Moore-Tainter gate							

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

# **B. Rule Illustrations**

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing<sup>69</sup>.

💘 Reservoir Editor
Reservoir Edit Operations Zone Rule IF_Block
Reservoir Moore
Physical Operations Observed Data
Operation Set Existing
Zone-Rules Rel. Alloc. Outages Stor. Credit
Top of Dam Below Top of Dam Hin Flow IF (Inflow>=320) Min Flow-320 cfs ELSE (Inflow<320) Min Flow = Inflow

#### Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

\_\_\_\_

<sup>&</sup>lt;sup>69</sup> TransCanada. Connecticut River Operational Constraints. 2012.

# C. Rule Descriptions

#### 1. Min flow

Figure 8 shows the content of "Min Flow" rule. This rule sets the minimum flow to 320 cfs for the inflows greater than 320 cfs and inflow for the inflows less than 320 cfs.

Operation Set Existing		<ul> <li>Desc</li> </ul>	ription			[.		
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev								
Top of Dam		Name:	Min Flow		escription:			
i→ [] Min Flow i→ IF (Inflow>=320)		Туре	Name		Description			
Image: Big ELSE (Inflow<320)		IF ELSE	Inflow>=320 Inflow<320					
Min Flow = Inflow								
Operation Set Existing		Descri	iption					
		Dec. Sche						
<ul> <li>Top of Dam</li> <li>Below Top of Dam</li> </ul>			rom: Moore-Dam	Deer	intin n.			
i≕{} Min Flow □ ··· → IF (Inflow>=320)		ional Inflo	w>=320	Desc	ription:	)		
In Flow-320 cfs Inflow<320)		ilue1 Moore-Po	ol:Net Inflow >=	Value2	320			
Min Flow = Inflow						[]		
Operation Set Existing			ription	_				
Zone-Rules Rel. Alloc. Outages S	Stor. Credit	Dec. Sch						
A Below Top of Dam			From: Moore-Dam	Descr	iption.			
	Function		10W-520 CIS					
	Limit Typ	Date	n 👻 Interp.: 📘	in		Define		
Min Flow = Inflow Image: The second secon					324			
Release into fish trap	01Jan	Date	Release (cfs) 32		<sub>6</sub> 322			
Conservation					(£ 322 a) 320 a) 320 a) 318			
🗄 📲 Peaking power					8 318			
Release into fish trap					316			
inactive					Jan Mar May J	ul Sep Nov		
Operation Set Existing		<ul> <li>Descr</li> </ul>	iption					
	tor. Credit	Dec. Sche	d. Projected Elev					
🚧 Top of Dam 者 Below Top of Dam		Operates Release From: Moore-Dam						
	ELSE Co	onditional	Inflow<320		)escription:			
Min Flow-320 cfs     ELSE (Inflow<320)								
Min Flow = Inflow								

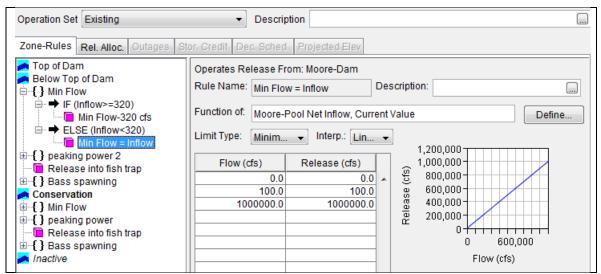
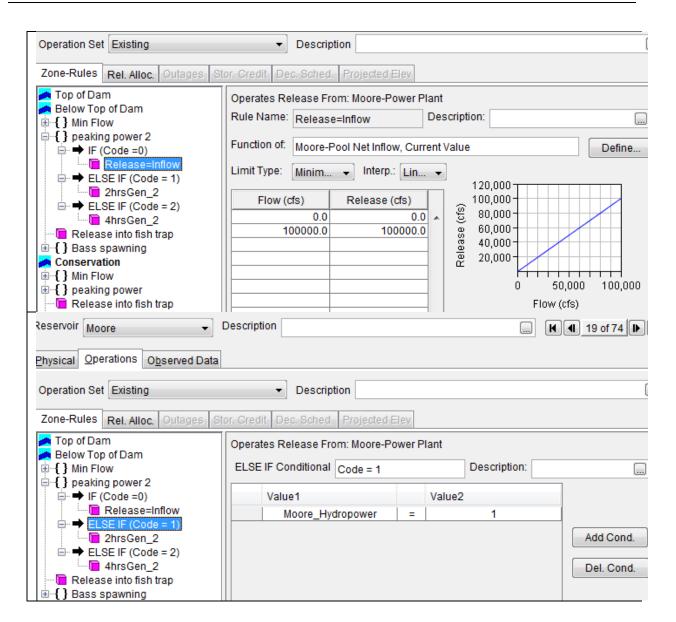


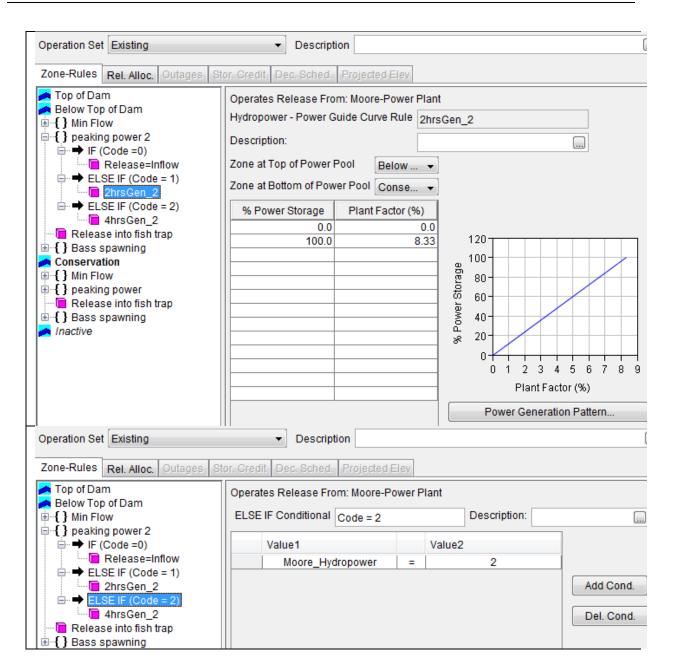
Figure 8: Reservoir Editor: Operations Tab – Existing OpSet – Min Flow

#### 2. Peaking power 2

This rule represents the peaking power strategy applied for Moore reservoir. The content of the rule is shown in Figure 9.

Operation Set Existing   Description					
Zone-Rules Rel. Alloc. Outages St	or. Credit Dec.	Sched. Projected E	lev		
✓ Top of Dam ✓ Below Top of Dam ⊕ { Min Flow	Operates Rele Name: peak	ease From: Moore-Da ing power 2	_	scription:	
□{} peaking power 2 □→ IF (Code =0)	Туре	Name		Description	
	IF ELSE IF	Code =0 Code = 1			
	ELSE IF	Code = 2			
	 	Description			 (
Zone-Rules Rel. Alloc. Outages St	or. Credit Dec.	Sched. Projected E	lev		
A Top of Dam	Operates Rele	ease From: Moore-Da	m		
in flow in	IF Conditiona	Code =0		Description:	
► → IF (Code =0)	Value1	-		Value2	
ELSE IF (Code = 1)	Mo	ore_Hydropower	=	0	
□ 2hrsGen_2 □ ➡ ELSE IF (Code = 2)					Add Cond.
← ● 4hrsGen_2 ← ■ Release into fish trap					Del. Cond.





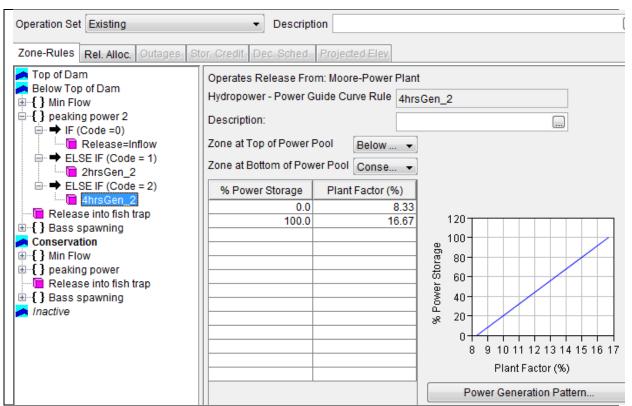


Figure 9: Reservoir Editor: Operations Tab – Existing OpSet –peaking power 2

Figure 10 describes the definition of codes used in the Moore\_Volume state variable. The code is summing up the current Inflow and previous storage in each time step, compare it to the volume needed for generating 2 and 4 hours power and to the spillway storage minus inactive storage and then decide how much to release.

Variable Edit	
ne: Moore_Hydropower	Description:
meter Name: code	Parameter Type: Code 🗸 🖉 Always Con
Alization Main CleanUp Alization Main CleanUp TimeSeries APIs APIs APIS	
	33         else:           34         Code=4           35
	35 36 • •
Insert in Script	Compile Script

Figure 10: State Variable Editor: Moor\_Volume

### 3. Release into fish trap

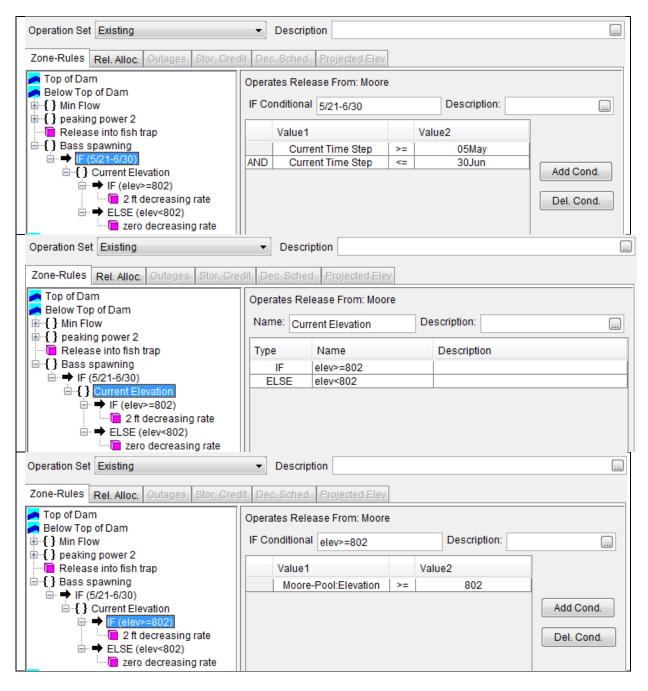
Figure 11 shows the content of "Release into fish trap" rule. This rule represents a 500 cfs release from Apr1-Jun15.

Operation Set Existing	▼ Descri	ption			
Zone-Rules Rel. Alloc. Outages S	tor. Credit Dec. Sched	I. Projected Elev			
<ul> <li>Top of Dam</li> <li>Below Top of Dam</li> <li>Below Top of Dam</li> <li>Hin Flow</li> <li>I peaking power 2</li> <li>I F (Code = 0)</li> <li>Release=Inflow</li> <li>ELSE IF (Code = 1)</li> <li>2hrsGen_2</li> <li>ELSE IF (Code = 2)</li> <li>4hrsGen_2</li> <li>Release into fish trap</li> <li>{ Bass spawning</li> <li>Conservation</li> <li>{ Min Flow</li> <li>Peaking power</li> <li>Release into fish trap</li> <li>{ Bass spawning</li> </ul>	Operates Release Fi Rule Name: Release Function of: Date Limit Type: Minim Date 01Jan 31Mar 01Apr 15Jun 16Jun	e into fish trap	elease (cfs)		Define
nactive				Period Average Limit Hour of Day Multiplier	Edit
				Day of Week Multiplier	Edit
				Rising/Falling Condition	Edit
				Seasonal Variation	Edit

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release into fish trap

#### 4. Bass spawning

Figure 12 shows the content of "Bass spawning" rule. It shows a decreasing maximum rate of elevation change of 2 ft/hr when the pool elevation is greater than 802 ft and a decreasing maximum rate of elevation change of zero ft/hr when the pool elevation is less than 802 ft during May21-Jun30.



Operation Set Existing	Description
Zone-Rules Rel. Alloc. Outages Stor. Cred	lit Dec. Sched. Projected Elev
Top of Dam Below Top of Dam Below Top of Dam Generation Strap Bass spawning Bass spawning F (5/21-6/30) F (5/21-6/30) F (5/21-6/30) F (5/21-6/30) F (5/21-6/30) F (5/21-6/30) F (6lev>=802) F (6lev>=802)	Operates Release From: Moore Elevation Rate of Change Limit 2 ft decreasing rate Description Function Of: Constant Type Decreasing Instantaneous Period Average Max Rate of Change (ft/hr) 2.0
Operation Set Existing	Description
Zone-Rules Rel. Alloc. Outages Stor. Cred Top of Dam Below Top of Dam Characteristic field of the store of	iti Dec. Sched.       Projected Elev         Operates Release From: Moore         ELSE Conditional       elev<802
Operation Set Existing	Description
Zone-Rules Rel. Alloc. Outages Stor. Cred	dit Dec. Sched. Projected Elev
Top of Dam Below Top of Dam Gravit Conservation Below Top of Dam Gravit Conservation Below Top of Dam Below Top of Dam For Conservation Conservatio	Operates Release From: Moore Elevation Rate of Change Limit zero decreasing rate Description Function Of: Constant Type Decreasing Instantaneous Period Average Max Rate of Change (ft/hr) 0.0

Figure 12: Reservoir Editor: Operations Tab – Existing OpSet – Bass spawning

# Nepaug

#### I. Overview

Nepaug dam is located in the town of New Hartford, CT on the Nepaug River that feeds into the Farmington River. It is owned and operated by the The Metropolitan District of Hartford, Connecticut (MDC) and is used for water supply for the City of Hartford as well as the City of New Britain.

Figure 1 shows the location of Nepaug Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Nepaug Dam.

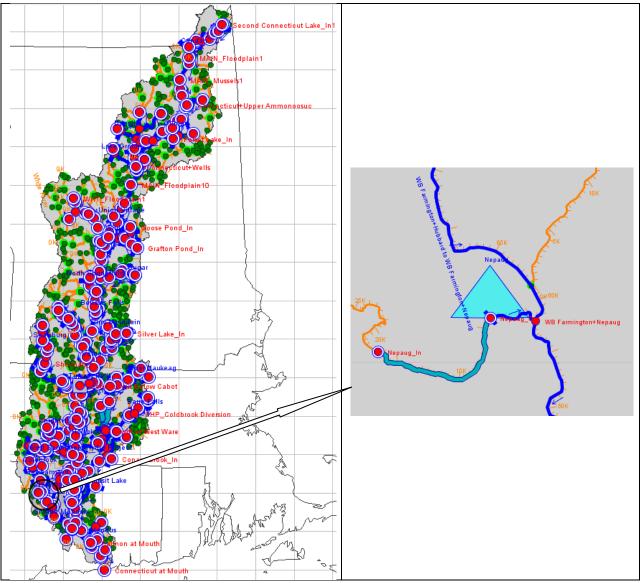


Figure 1: HEC-ResSim Map Display Showing Location of Nepaug



Figure 2: Photo of Nepaug Dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure  $3^{70}$ . The dam consists of an uncontrolled outlet as shown in Figure  $4^{71}$ .

<sup>&</sup>lt;sup>70</sup> MDC 1999.

<sup>&</sup>lt;sup>71</sup> Data provided by UMASS

tion ool ar Interp ion 104.00 120.00 125.00 135.00 140.00 151.00 151.00 152.00 153.00 155.00 150.00 155	Storage (ac-ft)           0.00           613.78           1227.55           2148.22           3068.88           4296.44           5984.32           7310.08           7761.21           8227.68           8712.56           9215.86           9740.64           10277.69           10836.23           11410.11           11999.33           12610.04	ic Interpolation Area (acre)	ion A	□ ■ 4 of 74 ■ Initial Conic Depth (ft)
ar Interp ion 104.00 120.00 125.00 135.00 140.00 145.00 150.00 151.00 153.00 154.00 155.00 155.00 155.00 156.00 157.00 156.00 157.00 158.00 159.00 160.00 161.00	Storage (ac-ft)           0.00           613.78           1227.55           2148.22           3068.88           4296.44           5984.32           7310.08           7761.21           8227.68           8712.56           9215.86           9740.64           10277.69           10836.23           11410.11           11999.33           12610.04	Area		500 480 € 460 ≩ 440
ar Interp ion 104.00 120.00 125.00 135.00 140.00 145.00 150.00 151.00 153.00 154.00 155.00 155.00 155.00 156.00 157.00 156.00 157.00 158.00 159.00 160.00 161.00	Storage (ac-ft)           0.00           613.78           1227.55           2148.22           3068.88           4296.44           5984.32           7310.08           7761.21           8227.68           8712.56           9215.86           9740.64           10277.69           10836.23           11410.11           11999.33           12610.04	Area		500 480 € 460 ≩ 440
ar Interp ion 104.00 120.00 125.00 135.00 140.00 145.00 150.00 151.00 153.00 154.00 155.00 155.00 155.00 156.00 157.00 156.00 157.00 158.00 159.00 160.00 161.00	Storage (ac-ft)           0.00           613.78           1227.55           2148.22           3068.88           4296.44           5984.32           7310.08           7761.21           8227.68           8712.56           9215.86           9740.64           10277.69           10836.23           11410.11           11999.33           12610.04	Area		500 480 € 460 ≩ 440
ion 104.00 120.00 125.00 135.00 140.00 145.00 151.00 151.00 153.00 154.00 155.00 155.00 155.00 155.00 155.00 156.00 157.00 158.00 159.00 160.00 160.00 160.00 161.00	Storage (ac-ft)           0.00           613.78           1227.55           2148.22           3068.88           4296.44           5984.32           7310.08           7761.21           8227.68           8712.56           9215.86           9740.64           10277.69           10836.23           11410.11           11999.33           12610.04	Area		500 480 € 460 ≩ 440
ion 104.00 120.00 125.00 135.00 140.00 145.00 151.00 151.00 153.00 154.00 155.00 155.00 155.00 155.00 155.00 156.00 157.00 158.00 159.00 160.00 160.00 160.00 161.00	Storage (ac-ft)           0.00           613.78           1227.55           2148.22           3068.88           4296.44           5984.32           7310.08           7761.21           8227.68           8712.56           9215.86           9740.64           10277.69           10836.23           11410.11           11999.33           12610.04	Area		500 480 € 460 ≩ 440
404.00 420.00 425.00 430.00 445.00 445.00 450.00 451.00 453.00 454.00 455.00 455.00 455.00 456.00 457.00 458.00 459.00 460.00 460.00 461.00	(ac-ft) 0.00 613.78 1227.55 2148.22 3068.88 4296.44 5984.32 7310.08 7761.21 8227.68 8712.56 9215.86 9740.64 10277.69 10836.23 11410.11 11999.33 12610.04			480 € 460 à 440
104.00           122.00           125.00           135.00           135.00           145.00           151.00           151.00           155.00           155.00           155.00           155.00           155.00           155.00           155.00           155.00           155.00           155.00           155.00           155.00           155.00           156.00           157.00           158.00           159.00           160.00           161.00	0.00 613.78 1227.55 2148.22 3068.88 4296.44 5984.32 7310.08 7761.21 8227.68 8712.56 9215.86 9740.64 10277.69 10836.23 11410.11 11999.33 12610.04	(acre)		480 € 460 à 440
120.00 125.00 130.00 135.00 140.00 145.00 150.00 151.00 153.00 154.00 155.00	613.78 1227.55 2148.22 3068.88 4296.44 5984.32 7310.08 7761.21 8227.68 8712.56 9215.86 9740.64 10277.69 10836.23 11410.11 11999.33 12610.04			480 € 460 à 440
425.00 430.00 435.00 440.00 445.00 150.00 151.00 153.00 153.00 154.00 155.00 155.00 155.00 156.00 157.00 158.00 159.00 160.00 160.00 161.00	1227.55 2148.22 3068.88 4296.44 5984.32 7310.08 7761.21 8227.68 8712.56 9215.86 9740.64 10277.69 10836.23 11410.11 11999.33 12610.04			480 € 460 à 440
130.00           135.00           140.00           145.00           150.00           151.00           151.00           152.00           153.00           155.00           155.00           155.00           155.00           155.00           156.00           157.00           158.00           159.00           160.00           160.00           161.00	2148.22 3068.88 4296.44 5984.32 7310.08 7761.21 8227.68 8712.56 9215.86 9740.64 10277.69 10836.23 11410.11 11999.33 12610.04			480 € 460 à 440
135.00 140.00 145.00 150.00 151.00 152.00 153.00 155.00 155.00 155.00 155.00 156.00 158.00 159.00 160.00 161.00	3068.88 4296.44 5984.32 7310.08 7761.21 8227.68 8712.56 9215.86 9740.64 10277.69 10836.23 11410.11 11999.33 12610.04			480 € 460 à 440
440.00 445.00 150.00 151.00 152.00 153.00 153.00 155.00 155.00 156.00 158.00 158.00 159.00 160.00 161.00	4296.44 5984.32 7310.08 7761.21 8227.68 8712.56 9215.86 9740.64 10277.69 10836.23 11410.11 11999.33 12610.04			480 € 460 à 440
445.00 150.00 151.00 152.00 153.00 153.00 154.00 155.00 156.00 157.00 158.00 158.00 159.00 160.00 161.00	5984.32 7310.08 7761.21 8227.68 8712.56 9215.86 9740.64 10277.69 10836.23 11410.11 11999.33 12610.04			480 € 460 à 440
150.00 151.00 152.00 153.00 154.00 155.00 155.00 155.00 158.00 158.00 159.00 160.00 161.00	7310.08 7761.21 8227.68 8712.56 9215.86 9740.64 10277.69 10836.23 11410.11 11999.33 12610.04			480 € 460 à 440
152.00 153.00 154.00 155.00 156.00 157.00 158.00 159.00 160.00 161.00	8227.68 8712.56 9215.86 9740.64 10277.69 10836.23 11410.11 11999.33 12610.04			480 € 460 à 440
153.00 154.00 155.00 156.00 157.00 158.00 159.00 160.00 161.00	8712.56 9215.86 9740.64 10277.69 10836.23 11410.11 11999.33 12610.04			480 € 460 à 440
154.00 155.00 156.00 157.00 158.00 159.00 160.00 161.00	9215.86 9740.64 10277.69 10836.23 11410.11 11999.33 12610.04			480 € 460 à 440
155.00 156.00 157.00 158.00 159.00 160.00 161.00	9740.64 10277.69 10836.23 11410.11 11999.33 12610.04			480 € 460 à 440
156.00 157.00 158.00 159.00 160.00 161.00	10277.69 10836.23 11410.11 11999.33 12610.04			€ 460 <u>à</u> 440
457.00 458.00 459.00 460.00 461.00	10836.23 11410.11 11999.33 12610.04			<u>à</u> 440
458.00 459.00 460.00 461.00	11410.11 11999.33 12610.04			<u>à</u> 440
459.00 460.00 461.00	11999.33 12610.04			
61.00				ш 420 <mark>-</mark>
	40000.00		Ξ	400 + + + + + + + + + + + + + + + + + +
162 00	13229.96			0 20,000 40,000
	13862.15		_	Stor (ac-ft)
163.00	14506.61		_	500
				480
				€ 460
67.00	17194.95			
168.00	17894.66			<sup>III</sup> 420
169.00	18600.50			400++++++
				0 100 200
				Area (acre)
75.00	23044.24			
76.00	23820.67			
77.00	24612.44			
78.00	25413.42			
			_	
			_	
			-	
195.50	40147.20			
	-		-	
	68.00 69.00 70.00 71.00 72.00 73.00 74.00 75.00 76.00 77.00 78.00 79.00 80.00 81.00 82.00 82.50	65.00         15829.30           66.00         16507.52           67.00         17194.95           68.00         17894.66           69.00         18600.50           70.00         19315.55           71.00         20042.88           72.00         20776.34           73.00         21522.08           74.00         22277.02           75.00         23044.24           77.00         24612.44           78.00         25413.42           79.00         26223.61           80.00         27046.07           81.00         27874.67           82.00         28712.47           82.50         29135.98	65.00         15829.30           66.00         16507.52           67.00         17194.95           68.00         17894.66           69.00         18600.50           77.00         19315.55           71.00         20042.88           72.00         20776.34           73.00         21522.08           74.00         22277.02           75.00         23044.24           76.00         24612.44           77.00         24612.44           77.00         26223.61           80.00         27046.07           81.00         27874.67           82.00         28712.47           82.50         29135.98	65.00         15829.30           66.00         16507.52           67.00         17194.95           68.00         17894.66           69.00         18600.50           77.00         19315.55           71.00         20042.88           72.00         20776.34           73.00         21522.08           74.00         22277.02           75.00         23044.24           76.00         23820.67           77.00         24612.44           78.00         25413.42           79.00         26223.61           80.00         27046.07           81.00         27874.67           82.00         28712.47           82.50         29135.98           95.50         40147.20

Figure 3: Reservoir Editor: Physical Tab -- Pool

eservoir Edit Dam						
Reservoir Nepaug	<ul> <li>Description</li> </ul>					▲ 4 of 74 ► ►
Physical Operations Observed	Data					
Nepaug	Nepaug-Dam					
Dam Controlled Outlet	Elevation at to	p of dam (ft)		495.	5	
	Length at top of	of dam (ft)		600.		
	Composite R	elease Capa	city			
	Elevation	Controlled	Uncontrol	Total		
	(ft)	(cfs)	(cfs)	(cfs)	496	
	482.5	0.0	0.0	0.0 🔺	492 in (10 492 488 € 488 484	
	483.5	0.0	600.0	600.0	j 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
	484.5	0.0	1,750.0	1,750.0	84 - 184 -	
	485.5	0.0	3,200.0	3,200.0		0 15,000
	486.5	0.0	5,000.0	5,000.0		
	487.5	0.0	7,200.0	7,200.0 ≡		Flow
	494.5	0.0	23,000.0	23,000.0		(cfs)
				v		

Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

# A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Nepaug's "Existing Ops" operational zones, which consist of zones of Top of Dam (495.5ft), Conservation (482.5ft), and Inactive zone (417.5ft)<sup>2</sup>.

Reservoir Editor			~~~	
Reservoir Edit Operations Zone Rule IF_Block				
Reservoir Nepaug				K (1 4 of 74 ) )
Physical Operations Observed Data				
Operation Set Existing Ops	Description Fron U	JMass Farmington no	otes: "Water for drink	ting equal to 30% of 57 MGE
Zone-Rules Rel. Alloc. Outages Stor. Credit Der	. Sched. Projected Ele	2V/		
Top of Dam Conservation	Storage Zone Conse	rvation	Description	
A Inactive	Function of Date			Define
	Date	Top Elevation (ft)		
	01Jan	482.5	500 490	
			480-	
			€ 470 ⊆ 460	
			€ 470 € 460 ote 460 te 450 au 440	
			a 440-	
			430-	
			410	
			👻 Jan Ma	ar May Jul Sep Nov
	Zone Sort Elevation			
			ОК	Cancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet

### **B. Rule Illustrations**

The operation set for Nepuag has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

# **New Home Sewing Machine**

#### I. Overview

New Home Sewing Machine dam is on the Millers River in Orange, MA. The dam is owned by the Chase Industrial Supply Company, Inc. and used is for hydropower generation.

Figure 1 shows the location of New Home Sewing Machine dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of New Home Sewing Machine dam.

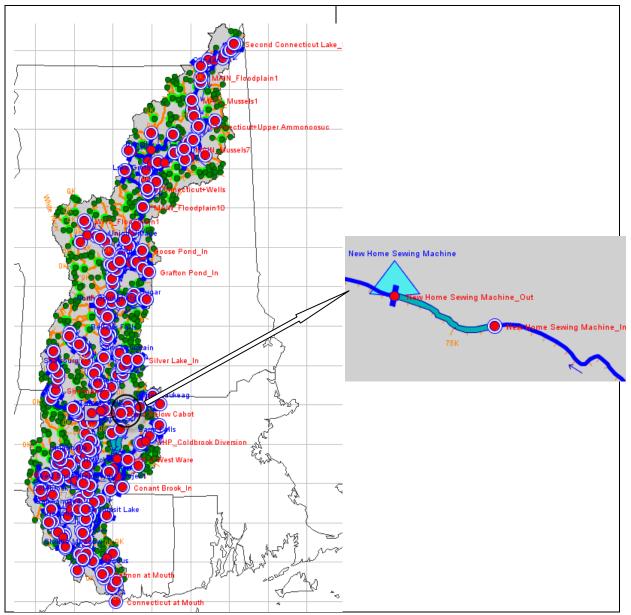


Figure 1: HEC-ResSim Map Display Showing Location of New Home Sewing machine dam



Figure 2: Photo of New Home Sewing Machine dam

#### **Physical Characteristics** II.

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>72</sup>. The dam consists of five types of outlets: (1) controlled Dam Embankment, (2) controlled outlet, (3) power plant 1,(4) power plant 2, and (5) power plant 3 as shown in Figure  $4^{73}$ .

 <sup>&</sup>lt;sup>72</sup> National Dam Inspection Program. Phase I Inspection Report. 1980.
 <sup>73</sup> Mini-Watt Hydroelectric LLC. Stream Flow Compliance Plan. 2009.

Reservoir Editor	100	and the links state,	mer 🚡 Carlage	×
Reservoir Edit Pool				
Reservoir New Home Sewing 🔻	Description			H 4 59 of 74 D H
Physical Operations Observed Da	ita			
New Home Sewing Machine	New Home Sewing Mach	ine-Pool		
Dam Tailwater	Linear Interpolation	Conic Interpolation	n Initial Conic Dep	oth (ft)
Power Plant 1	Elevation	Storage	Area	
Controlled Outlet	<b>(</b> ft)	(ac-ft)	(acre)	510
Power Plant 2	490.00	100000.00		505
Power Plant 3	502.25	100530.00		€ 500
	509.08	100825.50		495
				490
				100,000 100,500
				Stor (ac-ft)
				510
				505
				€ 500
				€ 500
				490-
				Area (acre)
			C	OK Cancel Apply

Figure 3: Reservoir Editor: Physical Tab -- Pool

📷 Reservoir Editor		-	anne, mr 2	Collector	×
Reservoir Edit Dam					
Reservoir New Home Sewing	<ul> <li>Description</li> </ul>				H 1 59 of 74 D H
Physical Operations Observed D	ata				
A New Home Sewing Machine	New Home Sewing	Machine-Dam			
Pool					
Dam Tailwater	Elevation at top of o	lam (ft)		509.	08
Power Plant 1	Length at top of dar	m (ff)		80	
Dam Embankment				50	.0
Controlled Outlet	Composite Release	se Capacity			
Power Plant 2	Elevation	Controlled	Uncontrolled	Total	
Power Plant 3	(ft)	(cfs)	(cfs)	(cfs)	600
	10.8	653.0 653.0	0.0	653.0 A	
	12.0	653.0	0.0	653.0	\$€200
	15.6	653.0	0.0	653.0 =	
	17.8	653.0	0.0	653.0	0 12,000
	18.9	653.0	0.0	653.0	Flow
	19.9	653.0	0.0	653.0	(cfs)
	20.8	653.0	0.0	653.0	
	21.3	653.0	0.0	653.0	
	21.9	653.0	0.0	653.0	
	22.2	653.0	0.0	653.0	
	22.5	653.0	0.0	653.0	
	22.6	653.0	0.0	653.0	
	22.7	653.0	0.0	653.0	-
				ОК	Cancel Apply
	_	_			

Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 4 shows the definition of New Home Sewing machine's "Existing Ops" operational zones, which consist of zones of Top of dam (509.08 t), Flood Control (497.3 ft), Conservation (493 ft), and Inactive zone (491 ft)<sup>1</sup>.

Reservoir Editor				-	x
Reservoir Edit Operations Zone Rule IF_Block					
Reservoir New Home Sewing   Description				H 4 59 of 74	
Physical Operations Observed Data					
Operation Set Existing Ops	<ul> <li>Description</li> </ul>				
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec	: Sched. Proje	cted Elev			
Top of dam Flood Control	Storage Zone	Conservation	Description		
Max power Release 3 Max power Release 2	Function of D	ate		Defi	ne
	Date	Top Elevation (ft)	510	) <del>_</del>	_
Fish Beakage	01Jan	493.0	508	3	
Conservation Max power Release 3			506	L	
Max power Release 2			€ 502 900 U E 502 910 U E 500 910 U E 500 9100 U E 500 910 U E 500 9100 9100 U E 500 9100 U E 500 9100 U E 500 910000000000000000000000000000000000	2	
∰ ••{} Min Flow			tex 498		
Fish Beakage			494		
nactive			490		
				Jan Mar May Jul Sep Nov	
			Ŧ		
	Zone Sort Elev	vation			
			ОК	Cancel	Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Guide Curve.

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

# **C.** Rule Descriptions

#### 1. Max power Release 3

Figure 7 shows the content of "Max power Release 3" rule. It assigns 600 cfs as a maximum allowable release from power plant 3.

Operation Set Existing Ops	Description
Zone-Rules Rel, Alloc, Outages Stor, Credit, Der	Sched Projected Elev
Top of dam     Flood Control     Max power Release 3     Max power Release 2     Max power Release 1     Min Flow     → IF (inflow<152)     Release=inflow	Operates Release From: New Home Sewing Machine-Power Plant 3 Rule Name: Max power Release 3 Description: Function of: Date Limit Type: Maximu Interp.: Line  606
→ ELSE (inflow>152)         → ELSE (inflow>152)         → Fish         → Ieakage         Conservation         Max power Release 3         → Max power Release 2	Date         Release (cfs)           01Jan         600.0           600         600           600         600           598         598           Jan Mar May Jul Sep Nov         Jan Mar May Jul Sep Nov
Max power Release 1	Period Average Limit Edit
Fish leakage	Hour of Day Multiplier Edit Day of Week Multiplier Edit
	Rising/Falling Condition Edit
	Seasonal Variation Edit
	<b></b>

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max power Release 3

#### 2. Max power Release 2

Figure 8 shows the content of "Max power Release 2" rule. It assigns 600 cfs as a maximum allowable release from power plant 2.

Operation Set Existing Ops	Description	
Zone-Rules Rel Alloc Outages Stor, Credit Dec. Sched, Projected Elev		
Top of dam Flood Control Max power Release 3 Max power Release 1 Max power Release 1 Min Flow → IF (inflow<152) Release=inflow → ELSE (inflow>152) Fish Ieakage Conservation Max power Release 3 Max power Release 3 Max power Release 1 Max power Release 2 Max power Release 1 Max power Release 2 Max power Release 2 Max power Release 2 Max power Release 1 Max power Release 2 Max power Release 1 Max power Release 2 Max power Release 1 Max power Release 1 Max power Release 2 Max power Release 1 Max power Re	Operates Release From: New Home Sewing Machine-Power Plant 2         Rule Name:       Max power Release 2         Description:       Image: Comparison of	

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max power Release 2

### 3. Max power Release 1

Figure 9 shows the content of "Max power Release 1" rule. It assigns 600 cfs as a maximum allowable release from power plant 1.

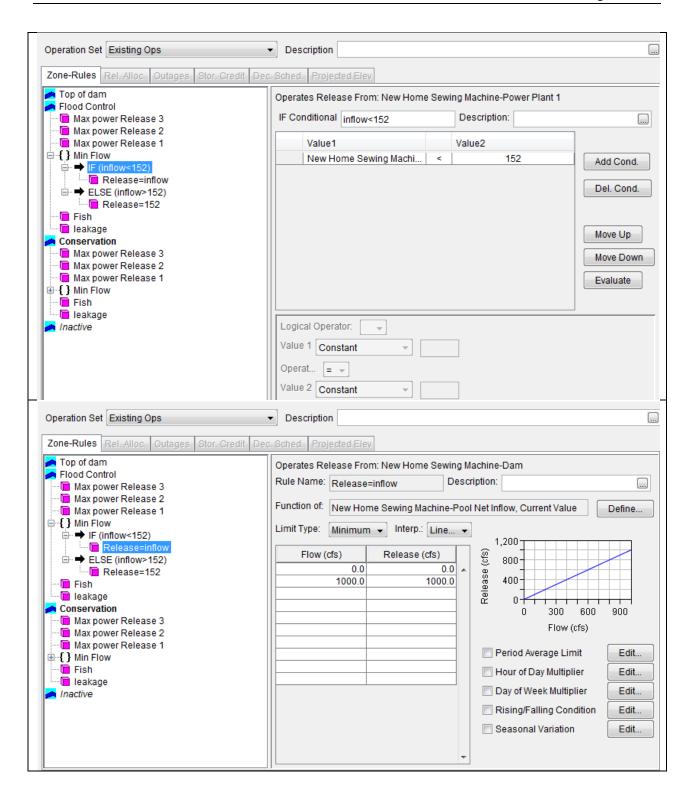
Operation Set Existing Ops	Description	
Zone-Rules Rel, Alloc, Outages Stor, Credit Dec	c. Sched. Projected Elev	
Top of dam Flood Control Max power Release 3 Max power Release 2 Max power Release 1 Flood Control Max power Release 1 Fish Release=152 Fish Max power Release 3 Max power Release 3 Max power Release 2 Max power Release 1 Fish	Limit Type: Maximu  Interp.: Line  Date Release (cfs) 01Jan 600.0  Second	Edit Edit Edit Edit

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max power Release 1

#### 4. Min Flow

Figure 10 shows the content of "Min Flow" rule. It releases inflow when inflow is less than 152 cfs and 152 cfs when inflow is greater than 152 cfs.

Zone-Rules Rel, Alloc. Outages Stor, Credit Dec			ne Sewing Mach	ine-Power Plant 1	
Flood Control	Name: Min	Flow	Description:		
Max power Release 2 Max power Release 1 Max power Release 1 High fillow High fillow High fillow High fillow High fillow High fillow High fillow High fillow Max power Release 3 Max power Release 3 Max power Release 2 Max power Release 3 Max power Release 1 High fillow High	Type IF ELSE	Name inflow<152 inflow>152		Description	



Operation Set Existing Ops	Description
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec	c. Sched. Projected Elev
Top of dam	Operates Release From: New Home Sewing Machine-Dam
Max power Release 3 Max power Release 2 Max power Release 1 Min Flow → F (inflow<152) Release=inflow → ELSE (inflow>152) Release=152 Fish	ELSE Conditional inflow>152 Description:
<ul> <li>Ieakage</li> <li>Conservation</li> <li>Max power Release 3</li> <li>Max power Release 2</li> <li>Max power Release 1</li> <li>Min Flow</li> <li>Fish</li> <li>Ieakage</li> <li>Inactive</li> </ul>	
	Description
Zone-Rules Rel. Alloc. Outages Stor, Credit Dec	c. Sched. Projected Elev
Top of dam Flood Control	Operates Release From: New Home Sewing Machine-Dam
Max power Release 3	Rule Name: Release=152 Description:
Max power Release 2	Function of: Date Define
	Limit Type: Minimum 🖌 Interp.: Line 🗸
<ul> <li>Inactive</li> </ul>	Date       Release (cfs)         01Jan       152.0         152.0       152.0         151.0       151.0         150.0       150.0

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow

### 5. Fish

Figure 11 shows the content of "Fish" rule. It shows the minimum release from dam for Fish.

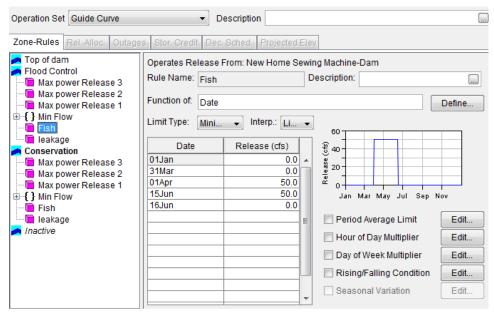


Figure 11: Reservoir Editor: Operations Tab – Guide Curve OpSet – Fish

#### 6. leakage

Figure 12 shows the content of "leakage" rule. It shows the minimum release from dam for leakage.

Operation Set Guide Curve	▼ D	escription			Ì		
	s Stor. Credit Dec	Sched. Projected B	Elev				
<ul> <li>Top of dam</li> <li>Flood Control</li> <li>Max power Release 3</li> <li>Max power Release 2</li> <li>Max power Release 1</li> <li>Fish</li> <li>Fish</li> <li>Conservation</li> <li>Max power Release 3</li> <li>Max power Release 3</li> <li>Max power Release 1</li> <li>Min Flow</li> <li>Fish</li> <li>Ieakage</li> <li>As power Release 1</li> <li>Ieakage</li> <li>Inactive</li> </ul>	Operates Release Rule Name: Ieaka Function of: Date Limit Type: Mini Date 01Jan		Description:	Define Define Nov Edit Edit Edit Edit Edit Edit			
Figure 12: Reserve	oir Editor:	Operations	Tab – Guide	Curve	OpSet	-	leakage

# North Hartland

### I. Overview

North Hartland Dam is a dam in Hartland, Windsor County, Vermont. It was constructed in 1961 by the US Army Corps of Engineers and is still owned and operated by the Corps. It is primarily used for flood control purposes but is also used for recreation.

Figure 1 shows the location of North Hartland Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the dam.

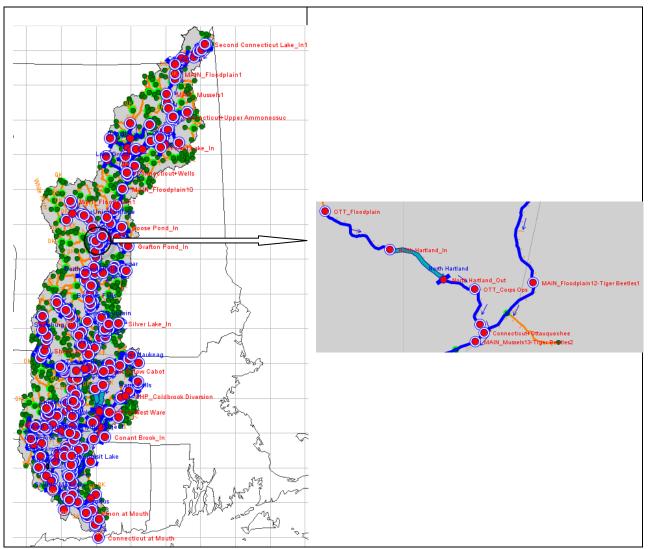


Figure 1: HEC-ResSim Map Display Showing Location of North Hartland dam



Figure 2: Photo of North Hartland Dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled slide gates, and (2) uncontrolled outlet, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>74</sup>.

<sup>&</sup>lt;sup>74</sup> http://rsgisias.crrel.usace.army.mil/nae/cwms\_map.map\_index

eservoir Edit Pool				
Reservoir North Hartland	<ul> <li>Description</li> </ul>			K 4 28 of 74 🕨 H
Physical Operations Ob	served Data			
North Hartland	[]			
	North Hartland-Pool			
⊡▼ Dam 	Linear Interpolation	<ul> <li>Conic Interpolat</li> </ul>	ion Initial Conic De	pth (ft)
Spillway	Elevation	Storage	Area	
	(ft)	(ac-ft)	(acre)	
	390.00	0.00	0.00	
	395.00	50.00	10.00	
	400.00	100.00	30.00	
	405.00	250.00	50.00	
	410.00	500.00	80.00	
	415.00	625.00	130.00	
	420.00	1250.00	170.00	
	425.00	2350.00	215.00	560
	430.00	3400.00	255.00	520
	435.00	4825.00	280.00	€ 480
	440.00	6225.00	305.00	>
	445.00	7875.00	330.00	
	450.00	9525.00	355.00	400
	455.00	11450.00	380.00	0 60,000 120,000
	460.00	13350.00	410.00	Stor (ac-ft)
	465.00	15550.00	430.00	Stor (ac-it)
	470.00	17650.00	450.00	560
	475.00	20000.00	495.00	520
	485.00	24950.00	505.00	€ 480 ▲ 440
	485.00	27525.00	540.00	A40
	495.00	30325.00	560.00	400
	500.00	33100.00	595.00	····
	505.00	36250.00	620.00	0 600 1,200
	510.00	39400.00	650.00	Area (acre)
	515.00	42825.00	685.00	. ,
	520.00	46200.00	715.00	
	525.00	50300.00	815.00	
	530.00	54375.00	915.00	
	535.00	59250.00	975.00	
	540.00	64100.00	1030.00	
	545.00	69500.00	1085.00	
	546.50	71100.00	1100.00	
	550.00	74900 00	1140.00	

Figure 3: Reservoir Editor: Physical Tab -- Pool

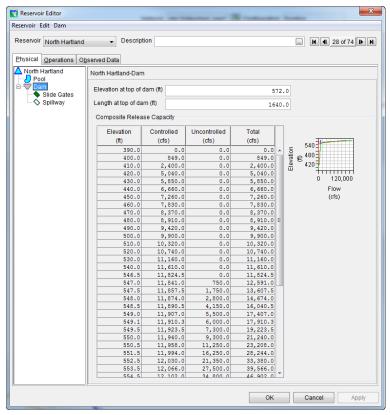


Figure 4: Reservoir Editor: Physical Tab -- Dam

## III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of North Hartland's "ExistingOps" operational zones, which consist of zones of Top of dam (572 ft), Flood Control (546.5 ft), Conservation (426 ft), and Inactive zone (390 ft).

Reservoir Editor		<b>X</b>
Reservoir Edit Operations Zone Rule IF_Block		
Reservoir North Hartland 🗸 Descrip	tion	K 4 28 of 74 D H
Physical Operations Observed Data		
Operation Set Existing Ops	✓ Description	
Zone-Rules Rel, Alloc. Outages Stor. Cred	lit Dec. Sched. Projected Elev	
<ul> <li>Top of dam</li> <li>Gate Ops to Save Dam</li> <li>Flood Control</li> <li>Maximum Controlled Release</li> </ul>	Storage Zone Conservation	Description
ABF minimum controlled Release     ABF minimum release     Connecticut at North Walpole - Linear     Connecticut at Montague - Linear	Date Top Elevation (ft) 01Jan 426.0	580
Max ROC-Increasing MAX ROC-Decreasing MAX rate of pool drawdown Max rate of pool drawdown		560 540 520
Conservation     Maximum Controlled Release     Min Flow Logic - North Hartland     Connecticut at North Walpole - Linear		€ 500- 5480- te 460- 440- 420- 400-
Connecticut at Montague - Linear     Max ROC-Increasing     MAX ROC-Decreasing     MAX ROC-Decreasing     Max rate of pool drawdown		380 Jan Mar May Jul Sep Nov
A Inactive	Zone Sort Elevation	
		OK Cancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

🟹 Reservoir Editor
Reservoir Edit Operations Zone Rule IF_Block
Reservoir North Hartland 👻 Descrip
Physical Operations Observed Data
Operation Set Existing Ops
Zone-Rules Rel. Alloc. Outages Stor. Cred
<ul> <li>Top of dam</li> <li>Gate Ops to Save Dam</li> <li>Flood Control</li> <li>Maximum Controlled Release</li> <li>ABF minimum release</li> <li>Connecticut at North Walpole - Linear</li> <li>Connecticut at Montague - Linear</li> <li>Max ROC-Increasing</li> <li>MAX ROC-Decreasing</li> <li>Max outflow equals 21 day Max Inflow</li> <li>Conservation</li> <li>Maximum Controlled Release</li> <li>Min Flow Logic - North Hartland</li> <li>Connecticut at Montague - Linear</li> <li>Max ROC-Increasing</li> <li>Maximum Controlled Release</li> <li>Min Flow Logic - North Hartland</li> <li>Connecticut at Montague - Linear</li> <li>Max ROC-Increasing</li> <li>Max ROC-Increasing</li> <li>Max ROC-Increasing</li> <li>Max ROC-Increasing</li> <li>Max ROC-Increasing</li> <li>Max ROC-Increasing</li> <li>Max rate of pool drawdown</li> </ul>

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

# **C.** Rule Descriptions

### 1. Gate Ops to Save Dam

Figure 7 shows the content of "Gate Ops to Save Dam" rule. This rule represents the maximum allowable release from Slide gates as a function of pool elevation when the pool is in Top of dam zone.

Operation Set Existing Ops	▼ Description							
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev								
<ul> <li>Top of dam</li> <li>Gate Ops to Save Dam</li> <li>Flood Control</li> <li>Maximum Controlled Release</li> <li>ABF minimum release</li> <li>Connecticut at North Walpole - Linear</li> <li>Connecticut at Montague - Linear</li> <li>Max ROC-Increasing</li> <li>MAX ROC-Decreasing</li> <li>Max outflow equals 21 day Max Inflow</li> <li>Conservation</li> <li>Maximum Controlled Release</li> <li>Min Flow Logic - North Hartland</li> <li>Connecticut at North Walpole - Linear</li> <li>Max ROC-Increasing</li> <li>Max Conservation</li> <li>Maximum Controlled Release</li> <li>Min Flow Logic - North Hartland</li> <li>Connecticut at North Walpole - Linear</li> <li>Max ROC-Increasing</li> <li>Max ROC-Increasing</li> <li>Max ROC-Increasing</li> <li>Max ROC-Increasing</li> <li>Max ROC-Increasing</li> <li>Max rate of pool drawdown</li> <li>Inactive</li> </ul>	Operates Release Fro           Rule Name:         Gate Operator           Function of:         rtland-Poerator           Limit Type:         Maximu           Elev (ft)         546.5           547.0         547.5           548.0         548.0           549.1         550.5           552.5         553.5           555.5         555.5           555.5         555.5           555.5         556.5           557.20         572.0	s to Save Dam De	escription: verage, 0.0 hr lag, 48.0 hr perio Define	t t				

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet –Gate Ops to Save Dam

#### 2. Maximum Controlled Release

Figure 8 shows the content of "Maximum Controlled Release" rule. This rule represents the maximum allowable release from Slide gates.

Operation Set Existing Ops	Description
Zone-Rules Rel. Alloc. Outages Stor. Cr	edit. Dec. Sched. Projected Elev
<ul> <li>Top of dam</li> <li>Gate Ops to Save Dam</li> <li>Flood Control</li> <li>Maximum Controlled Release</li> <li>ABF minimum release</li> <li>Connecticut at North Walpole - Linear</li> <li>Max ROC-Increasing</li> <li>MAX ROC-Decreasing</li> <li>Max rate of pool drawdown</li> <li>Max Outflow equals 21 day Max Inflow</li> <li>Conservation</li> <li>Maximum Controlled Release</li> <li>Min Flow Logic - North Hartland</li> <li>Connecticut at North Walpole - Linear</li> <li>Max ROC-Increasing</li> <li>Max ROC-Decreasing</li> <li>Max rate of pool drawdown</li> <li>Inactive</li> </ul>	Date         Release (cfs)           01Jan         6000.0           5300         5300           Jan         5300           Jan         5300           Jan         Kar

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Maximum controlled Release

#### 3. ABF minimum release

Figure 9 shows the content of "ABF minimum release" rule. This rule represents the minimum required release from slide gates during flood control operations.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>	
Zone-Rules Rel. Alloc. Outages Stor. Cre	edit Dec. Sched. Projected Elev	
<ul> <li>Top of dam</li> <li>Gate Ops to Save Dam</li> <li>Flood Control</li> <li>Maximum Controlled Release</li> <li>AF-minimum release</li> <li>Connecticut at North Walpole - Linear</li> <li>Max ROC-Increasing</li> <li>MAX ROC-Decreasing</li> <li>Max rate of pool drawdown</li> <li>Max outflow equals 21 day Max Inflow</li> <li>Consecticut at North Walpole - Linear</li> <li>Max mum Controlled Release</li> <li>Max mum Controlled Release</li> <li>Max mum Controlled Release</li> <li>Min Flow Logic - North Hartland</li> <li>Connecticut at Montague - Linear</li> <li>Max ROC-Increasing</li> <li>Max Max Collect at North Walpole - Linear</li> <li>Max ROC-Increasing</li> <li>Max ROC-Increasing</li> <li>Max rate of pool drawdown</li> <li>Inactive</li> </ul>	Limit Type: Minimum  Interp.: Step  Date Release (cfs) 01Jan 220.0 31May 220.0 01Jun 110.0 30Sep 110.0 01Oct 220.0 Period Average Limit Hour of Day Multiplier Day of Week Multiplier Rising/Falling Condition	Edit Edit Edit Edit Edit

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet –ABF minimum release

### 4. Connecticut at North Walpole-Linear

Figure 10 shows the content of "Connecticut at North Walpole-Linear" rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at North Walpole. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

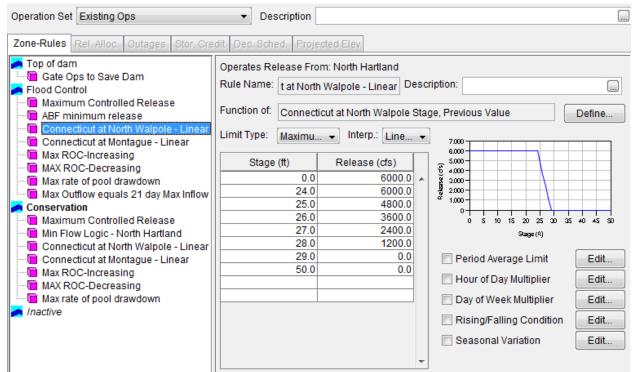


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet –Connecticut at North Walpole-Linear

#### 5. Connecticut at Montague-Linear

Figure 11 shows the content of "Connecticut at Montague-Linear" rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

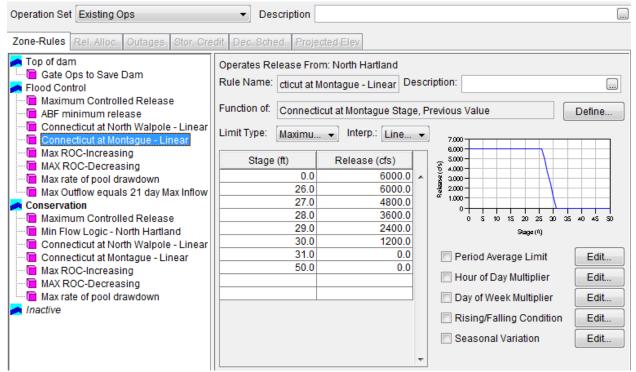


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet –Connecticut at Montague-Linear

#### 6. Max ROC-Increasing

Figure 12 shows the content of "Max ROC-Increasing" rule. This rule shows the maximum allowable increasing release rate of change as a function of release from North Hartland dam.

Operation Set Existing Ops	▼ Desc	ription						 
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sched	1. Projecte	ed Elev					
Top of dam  Consection  Consection  Maximum Controlled Release  ABF minimum release  Connecticut at North Walpole - Linear  Max ROC-Increasing  Max rate of pool drawdown  Max Outflow equals 21 day Max Inflow  Conservation  Maximum Controlled Release  Min Flow Logic - North Hartland  Connecticut at Montague - Linear  Max ROC-Increasing  Max rate of pool drawdown  Max ACC-Increasing  Max rate of pool drawdown  Max ROC-Increasing  Max rate of pool drawdown  Max ROC-Increasing  Max rate of pool drawdown  Max rate of pool drawdown  Max rate of pool drawdown  Max ROC-Increasing  Max rate of pool drawdown	Release Rate Description: Function Of: F Type I Interpolate I Release	of Change Release ncreasing Linear	North Hartland Limit Max RO(	C-Increas • •	Rate Change (cfs/hr)	550 500 450 350 300 250 200 150 0	() () () () () () () () () () () () () (	

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet –Max ROC-Increasing

#### 7. Max ROC-Decreasing

Figure 13 shows the content of "Max ROC-Decreasing" rule. This rule shows the maximum allowable decreasing release rate of change.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>							
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.								
<ul> <li>Top of dam</li> <li>Gate Ops to Save Dam</li> <li>Flood Control</li> <li>Maximum Controlled Release</li> <li>ABF minimum release</li> <li>Connecticut at North Walpole - Linear</li> <li>Connecticut at Montague - Linear</li> <li>Max ROC-Increasing</li> <li>Max rate of pool drawdown</li> <li>Max outflow equals 21 day Max Inflow</li> <li>Conservation</li> <li>Max Min Flow Logic - North Hartland</li> <li>Connecticut at North Walpole - Linear</li> <li>Max Max Concreasing</li> <li>Max Ax ROC-Decreasing</li> <li>Max Max Controlled Release</li> <li>Min Flow Logic - North Hartland</li> <li>Connecticut at North Walpole - Linear</li> <li>Max ROC-Increasing</li> <li>Max ROC-Increasing</li> <li>Max ROC-Increasing</li> <li>Max Rot of pool drawdown</li> <li>Inactive</li> </ul>	Operates Release From: No Release Rate of Change Lin Description: Function Of: Type Max Rate of Change (cfs/hr)							

Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet –Max ROC-Decreasing

### 8. Max rate of pool drawdown

Figure 14 shows the content of "Max rate of pool drawdown" rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet –Max rate of pool drawdown

#### 9. Max Outflow equals 21 day Max Inflow

Figure 15 shows the content of "Max Outflow equals 21 day Max Inflow" rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

Operation Set Existing Ops	Description							
Zone-Rules Rel. Alloc. Outages Stor. Credit. Dec. Sched. Projected Elev.								
Top of dam Gate Ops to Save Dam Flood Control Maximum Controlled Release ABF minimum release Connecticut at North Walpole - Linear Connecticut at North Walpole - Linear Max ROC-Increasing Max ROC-Increasing Max rate of pool drawdown Conservation Maximum Controlled Release Min Flow Logic - North Hartland Connecticut at Montague - Linear Max ROC-Increasing Maximum Controlled Release Min Flow Logic - North Hartland Connecticut at Montague - Linear Max ROC-Increasing Max ROC-Increasing Max ROC-Increasing Max ROC-Increasing Max ROC-Decreasing Max ROC-Decreasing Max rate of pool drawdown Inactive	Flow (cfs)         Release (cfs)           0.0         0.0           6000.0         6000.0           123456.0         6000.0           0         40000           0         0.000.0           0         6000.0           123456.0         6000.0           0         40000           0         40000           0         40000           1000         0           1000         0           1000         0           1000         0           1000         0           1000         120000							

Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet –Max Outflow equals 21 day Max Inflow

#### 10. Min Flow Logic-North Hartland

Figure 16 shows the content of "Min Flow Logic-North Hartland" rule. This rule describes required seasonal minimum flows from controlled outlets as a function of inflow at North Hartland.

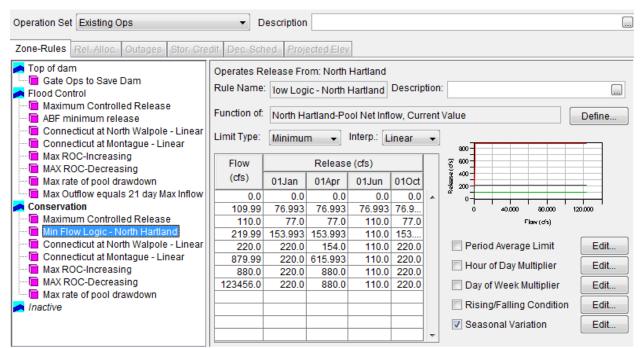


Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet –Min Flow Logic-North Hartland

# North Springfield

### I. Overview

North Springfield is a dam on the Black River in Central Vermont. It was constructed in 1960 by the US Army Corps of Engineers and is still owned and operated by the Corps. It is primarily used for flood control purposes but also for recreation.

Figure 1 shows the location of North Springfield Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the dam.

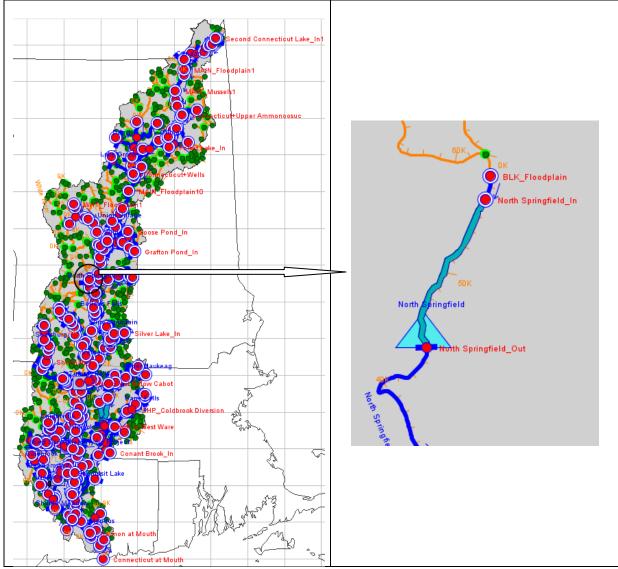


Figure 1: HEC-ResSim Map Display Showing Location of North Springfield dam



Figure 2: Photo of North Springfield dam.

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled slide gates, and (2) uncontrolled spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>75</sup>.

<sup>&</sup>lt;sup>75</sup> http://rsgisias.crrel.usace.army.mil/nae/cwms\_map.map\_index

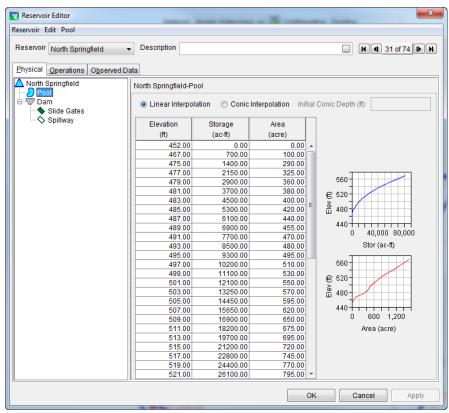


Figure 3: Reservoir Editor: Physical Tab -- Pool

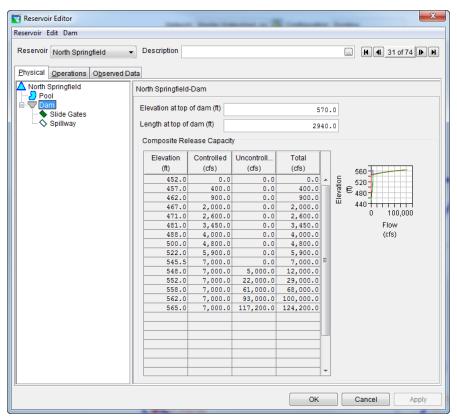


Figure 4: Reservoir Editor: Physical Tab -- Dam

## III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of North Springfield's "ExistingOps" operational zones, which consist of zones of Top of dam (570 ft), Flood Control (545.5 ft), Conservation (467 ft), and Inactive zone (452 ft).

Reservoir Editor	×					
Reservoir Edit Operations Zone Rule IF_Block						
Reservoir North Springfield   Description  Description  M   31 of 74  H						
Physical Operations Observed Data						
Operation Set Existing Ops    Desc	ription					
Zone-Rules Rel. Alloc. Outages Stor, Credit Dec. Sched	Projected Elev					
Top of dam Gate Ops During Surcharge Flood Control Downstream Channel Capacity ABF Minimum Release Connecticut at North Walpole - Linear MAX ROC-Increasing Control rate of pool elevation drop Max Outflow equals Max 21day Inflow Conservation Connecticut at North Walpole - Linear Max Outflow equals Max 21day Inflow Conservation Connecticut at North Walpole - Linear Max Outflow equals Max 21day Inflow Connecticut at North Walpole - Linear Max Outflow equals Max 21day Inflow Connecticut at North Walpole - Linear Max ROC-Increasing Connecticut at Montague - Linear MAX ROC-Increasing Connecticut at Montague - Linear MAX ROC-Increasing Connecticut at Montague - Linear MAX ROC-Increasing Control rate of pool elevation drop Inactive Zone Sort Elevation	te Define Top Elevation (ft) 467.0 560 540 520 520 480 480 480 480 480 400 400 40					
	OK Cancel Apply					

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

😴 Reservoir Editor
Reservoir Edit Operations Zone Rule IF_Bloc
Reservoir North Springfield - Descri
Physical Operations Observed Data
Operation Set Existing Ops
Zone-Rules Rel. Alloc. Outages Stor. Cre
<ul> <li>Top of dam</li> <li>Gate Ops During Surcharge</li> <li>Flood Control</li> <li>Downstream Channel Capacity</li> <li>ABF Minimum Release</li> <li>Connecticut at North Walpole - Linear</li> <li>Connecticut at Montague - Linear</li> <li>MAX ROC-Increasing</li> <li>MAX ROC-Decreasing</li> <li>Control rate of pool elevation drop</li> <li>Max Outflow equals Max 21day Inflow</li> <li>Conservation</li> <li>Downstream Channel Capacity</li> <li>Min Flow Logic - N Springfield</li> <li>Connecticut at North Walpole - Linear</li> <li>Connecticut at North Walpole - Linear</li> <li>MAX ROC-Increasing</li> <li>Connecticut at North Walpole - Linear</li> <li>Connecticut at North Walpole - Linear</li> <li>Connecticut at Montague - Linear</li> <li>MAX ROC-Increasing</li> <li>Control rate of pool elevation drop</li> </ul>
< Þ

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## **C.** Rule Descriptions

### 1. Gate Ops During Surcharge

Figure 7 shows the content of "Gate Ops During Surcharge" rule. This rule represents the maximum allowable release from Slide gates as a function of pool elevation when the pool is in Top of dam zone.

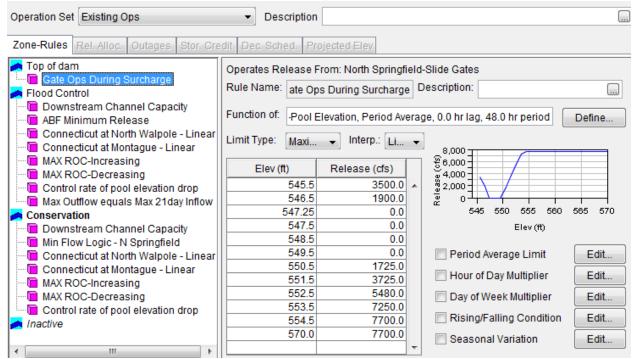


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Gate Ops During Surcharge

#### 2. Downstream Channel Capacity

Figure 8 shows the content of "Downstream Channel Capacity" rule. This rule represents the maximum allowable release from dam.

Operation Set Existing Ops	Description						
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev							
Top of dam Gate Ops During Surcharge Flood Control Downstream Channel Capacity ABF Minimum Release	Operates Release From: North Springfield-Slide C Rule Name: Istream Channel Capacity Descript Function of: Date						
Connecticut at North Walpole - Linear MAX ROC-Increasing MAX ROC-Decreasing Control rate of pool elevation drop Max Outflow equals Max 21day Inflow Conservation Downstream Channel Capacity	Limit Type: Maxi  Interp.: Li Date Release (cfs) 01Jan 3.5 01Jan 3.6 3.5 3.5 3.4 3.4 3.4 3.5 3.5 3.5 3.4						
Min Flow Logic - N Springfield Connecticut at North Walpole - Linear MAX ROC-Increasing MAX ROC-Decreasing Control rate of pool elevation drop Inactive		eriod Average Limit Edit our of Day Multiplier Edit ay of Week Multiplier Edit ising/Falling Condition Edit easonal Variation Edit					

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Downstream Channel capacity

### **3.** ABF Minimum Release

Figure 9 shows the content of "ABF Minimum Release" rule. This rule represents the minimum required release from slide gates during flood control operations.

Operation Set Existing Ops   Description								
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.								
<ul> <li>Top of dam</li> <li>Gate Ops During Surcharge</li> <li>Flood Control</li> <li>Downstream Channel Capacity</li> <li>ABF Minimum Release</li> <li>Connecticut at North Walpole - Linear</li> <li>Connecticut at Montague - Linear</li> <li>MAX ROC-Increasing</li> <li>MAX ROC-Decreasing</li> <li>Control rate of pool elevation drop</li> <li>Max Outflow equals Max 21day Inflow</li> <li>Conservation</li> <li>Downstream Channel Capacity</li> </ul>	Operates Release I Rule Name: ABF M Function of: Date Limit Type: Mini Date 01Jan 31May 01Jun 30Sep 01Oct	▼ Interp.: Li Release (cfs) 160.0 160.0 80.0 80.0	Description:					
Min Flow Logic - N Springfield Connecticut at North Walpole - Linear Connecticut at Montague - Linear MAX ROC-Increasing MAX ROC-Decreasing Control rate of pool elevation drop Inactive	010ct	160.0	<ul> <li>Period Average Limit</li> <li>Hour of Day Multiplier</li> <li>Day of Week Multiplier</li> <li>Rising/Falling Condition</li> <li>Seasonal Variation</li> </ul>					

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – ABF Minimum Release

#### 4. Connecticut at North Walpole-Linear

Figure 10 shows the content of "Connecticut at North Walpole-Linear" rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at North Walpole. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

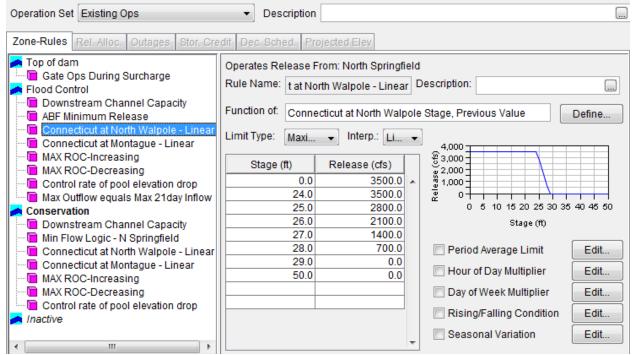


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at North Walpole-Linear

#### 5. Connecticut at Montague-Linear

Figure 11 shows the content of "Connecticut at Montague-Linear" rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

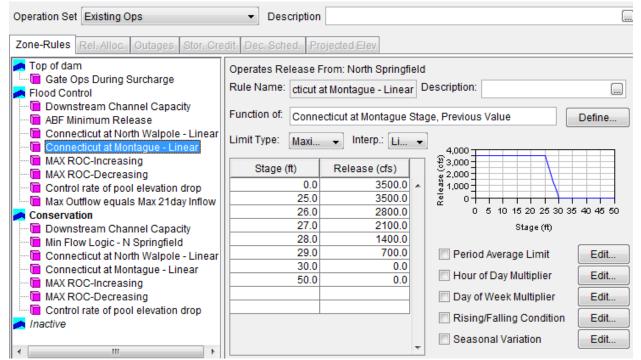


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague-Linear

#### 6. MAX ROC-Increasing

Figure 12 shows the content of "MAX ROC-Increasing" rule. This rule shows the maximum allowable increasing release rate of change as a function of release from North Springfield dam.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>						
Zone-Rules Rel, Alloc. Outages Stor, Credit Dec. Sched. Projected Elev							
Top of dam     Gate Ops During Surcharge     Flood Control     Downstream Channel Capacity     ABF Minimum Release     Connecticut at North Walpole - Linear     MAX ROC-Increasing     MAX ROC-Decreasing     MAX ROC-Decreasing     Max Outflow equals Max 21day Inflow     Conservation     Downstream Channel Capacity     Min Flow Logic - N Springfield     Connecticut at North Walpole - Linear     Min Flow Logic - N Springfield     Connecticut at North Walpole - Linear     Min Flow Logic - N Springfield     Connecticut at North Walpole - Linear     Min Flow Logic - N Springfield     Connecticut at Montague - Linear     MAX ROC-Increasing	Operates Release From: North Springfield-D         Release Rate of Change Limit         MAX ROC-Inc         Description:         Function Of:         Release         Type         Increasing         Interpolate         Linear         Release (cfs)         Rate Change (cfs/hr)         0.0         3000.0         3000.0         123456.0         200.0						
MAX ROC-Decreasing Control rate of pool elevation drop							
		Release (cfs)					

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – MAX ROC-Increasing

#### 7. MAX ROC-Decreasing

Figure 13 shows the content of "MAX ROC-Decreasing" rule. This rule shows the maximum allowable decreasing release rate of change.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>	
Zone-Rules Rel. Alloc. Outages Stor. Cred	dit Dec. Sched. Projected E	lev,
Top of dam Gate Ops During Surcharge Flood Control Downstream Channel Capacity Flood Control Downstream Channel Capacity MAX ROC-Increasing MAX ROC-Increasing Connecticut at North Walpole - Linear MAX ROC-Increasing Control rate of pool elevation drop Max Outflow equals Max 21day Inflow Conservation Conservation Connecticut at North Walpole - Linear Connecticut at North Walpole - Linear Connecticut at North Walpole - Linear Connecticut at Montague - Linear MAX ROC-Increasing MAX ROC-Increasing MAX ROC-Decreasing Control rate of pool elevation drop Inactive	Operates Release From: No Release Rate of Change Lin Description: Function Of: Type Max Rate of Change (cfs/hr)	

Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – MAX ROC-Decreasing

### 8. Control rate of pool elevation drop

Figure 14 shows the content of "Control rate of pool elevation drop" rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

Zone-Rules       Rel. Alloc.       Outages       Stor. Credit.       Dec. Sched.       Projected Elev.         Top of dam       Operates Release From: North Springfield       Operates Release From: North Springfield         Elevation Rate of Change Limit       Control rate of pool elevation drop	Operation Set Existing Ops	▼ Description	)
Gate Ops During Surcharge     Flood Control     Elevation Rate of Change Limit Control rate of pool elevation drop	Zone-Rules Rel. Alloc. Outages Stor. Cr	editi Dec. Sched. Projected Elev	
Description     Descripti	Gate Ops During Surcharge     Flood Control     Downstream Channel Capacity     ABF Minimum Release     Connecticut at North Walpole - Linear     MAX ROC-Increasing     MAX ROC-Increasing     Max Outflow equals Max 21day Inflow     Conservation     Downstream Channel Capacity     Min Flow Logic - N Springfield     Connecticut at Montague - Linear     MAX ROC-Increasing     MAX Control rate of pool elevation drop     MAX ROC-Increasing     Max Outflow equals Max 21day Inflow     Conservation     Downstream Channel Capacity     Min Flow Logic - N Springfield     Connecticut at Montague - Linear     MAX ROC-Increasing     MAX ROC-Increasing     MAX ROC-Increasing     MAX ROC-Increasing     MAX ROC-Increasing     Control rate of pool elevation drop     Inactive	Elevation Rate of Change Limit Control rate of pool elevation drop Description Function Of: Constant Type Decreasing  Instantaneous Period Average Max Change of (ft) 10.0 over 24 hours	

Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet – Control rate of pool elevation drop

### 9. Max Outflow equals Max 21 day Inflow

Figure 15 shows the content of "Max outflow equals Max 21 day Inflow" rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>							
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev								
<ul> <li>Top of dam</li> <li>Gate Ops During Surcharge</li> <li>Flood Control</li> <li>Downstream Channel Capacity</li> <li>ABF Minimum Release</li> <li>Connecticut at North Walpole - Linear</li> <li>MAX ROC-Increasing</li> <li>MAX ROC-Decreasing</li> <li>Control rate of pool elevation drop</li> <li>Max Outflow equals Max 21day Inflow</li> <li>Conservation</li> <li>Downstream Channel Capacity</li> <li>Min Flow Logic - N Springfield</li> <li>Connecticut at Montague - Linear</li> <li>MAX ROC-Increasing</li> <li>Max Outflow equals Max 21day Inflow</li> <li>Conservation</li> <li>Downstream Channel Capacity</li> <li>Min Flow Logic - N Springfield</li> <li>Connecticut at Montague - Linear</li> <li>MAX ROC-Increasing</li> <li>MAX ROC-Decreasing</li> <li>MAX ROC-Decreasing</li> <li>Control rate of pool elevation drop</li> <li>Inactive</li> </ul>	Operates Release F Rule Name: w equi Function of: -Pool Limit Type: Maxi Flow (cfs) 0.0 3500.0 123456.0	als Max 21day Inflow	v Description num, 0.0 hr l v 4,000 ⊗ 2,000 v 2,000	ag, 504.0 hr period	Edit Edit Edit Edit Edit			

Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals Max 21 day Inflow

#### 10. Min Flow Logic-N Springfield

Figure 16 shows the content of "Min Flow Logic-N Springfield" rule. This rule describes required seasonal minimum flows from controlled outlets as a function of inflow at North Springfield.

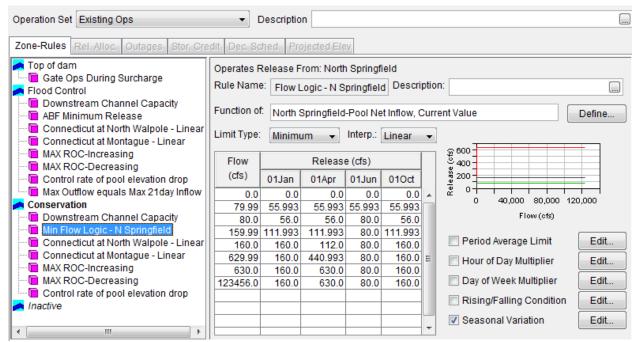


Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic-N Springfield

# Northfield

## I. Overview

Northfield (full name Northfield Mountain) is a pump storage project located on the mainstem Connecticut River above Turners Falls. It is owned and operated by FirstLight Power Resource and is operated for hydropower generation in connection with the Turners Falls project, another FirstLight Power resources project.

Figure 1 shows the location of Northfield Mountain dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the Northfield Mountain project.

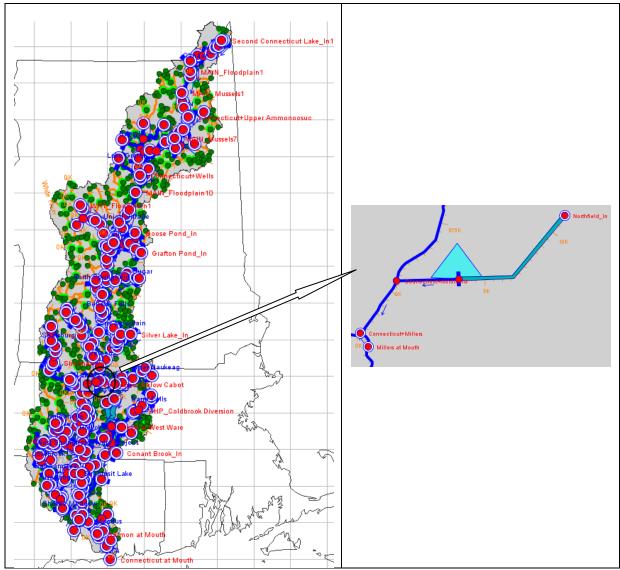


Figure 1: HEC-ResSim Map Display Showing Location of Northfield dam



Figure 2: Photo of Northfield Mountain project

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>76</sup>. The dam consists of two types of outlets: (1) pump, and (2) Northfield Station, as shown in Figure 4.

<sup>&</sup>lt;sup>76</sup> All physical and operational data from ResSim model developed by Gomez and Sullivan Engineers, P.C.

servoir Edit Pool							
Reservoir Northfield	Description North	hfield Mountain Pumped	l Storage Project		K 4 74 of 74 D		
Physical Operations Obser	ved Data						
Northfield	Northfield-Pool						
🖹 🖓 Dam 🔤	Linear Interpolation	Conic Interpolation	Initial Conic Depth	(ft)			
🔶 Tailwater							
Pumps	Elevation	Storage	Area				
Tailwater	(ft)	(ac-ft)	(acre)				
Northfield Station	920.00	0.00			1,000		
Taliwater	921.00	88.00			980		
	922.00	177.00		=	€ 960		
	923.00	269.00					
	924.00	363.00			920		
	925.00	459.00					
	926.00	558.00			0 8,000 16,000		
	927.00	658.00			Stor (ac-ft)		
	928.00	760.00					
	929.00	865.00			1,000		
	930.00	972.00			980		
	931.00	1081.00			€ 960		
	932.00	1192.00			€ 960		
	933.00	1306.00			920		
	934.00	1422.00		_			
	935.00	1540.00		_	0 200 400 600		
	936.00	1660.00		_	Area (acre)		
	937.00	1781.00					

Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor		-	fightening, sur-	🚡 Contigonition	X
Reservoir Edit Dam					
Reservoir Northfield		hfield Mountain I	Pumped Storage Pro	oject	
▲ Northfield	Northfield-Dam				
Dam Dam Tailwater	Elevation at top of dam (f	t)		1010	0.0
Pumps → Tailwater → Northfield Station	Length at top of dam (ft)	pacity		30	0.0
Tailwater		Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)	1,000
	938.0 1,000.5	20,000.0	0.0	20,000.0 20,000.0	
					≝ 940 0 12,000
					Flow (cfs)
OK Cancel Apply					
					, and the states of the states

Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Northfield's "ExistingOps" operational zones, which consist of zones of Flood Control (1010 ft), FERC Max Pool (100.5 ft), and Inactive zone (938 ft)<sup>1</sup>.

Reservoir Editor	Tablecci I	na takata, na 🕻	Card	×		
Reservoir Edit Operations						
Reservoir Northfield	escription Northfield Mount	ain Pumped Storage Proje	ct	H I 74 of 74		
Physical Operations Observed Data						
Operation Set Existing Ops   Description						
Zone-Rules Rel, Alloc, Outages, Stor, Credit, Dec, Sched, Projected Elev						
Flood Control	Storage Zone FERC Max	Pool Descrip	tion FE	ERC max pool		
■ No Gen if Pump > 0 ■ {} Pump if TF > 177.5'	Function of Date			Define		
IF (TF > 177.5' and NF < 995') IF (TF > 177.5' and NF < 995')	Date	Top Elevation (ft)		4.020		
Inactive □	01Jan		Elevation (ft)	1,020 1,010 1,000 990 980 970 960 950 940 930 Jan Mar May Jul Sep Nov		
OK Cancel Apply						

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

## **B. Rule Illustrations**

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>1</sup>.

💘 Reservoir Editor
Reservoir Edit Operations
Reservoir Northfield
Physical Operations Observed Data
Operation Set Existing Ops
Zone-Rules Rel. Alloc. Outages Stor
Flood Control FERC Max Pool No Gen if Pump > 0 ↓ Pump if TF > 177.5' ↓ F (TF > 177.5' and NF < 995') ↓ Pump Schedule ↓ Power Guide Curve ↓ Inactive

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

# **C.** Rule Descriptions

#### 1. No Gen if Pump>0

Figure 7 shows the content of "No Gen if Pump>0" rule. This rule represents that when water is pumped then no water is released from Northfield.

Operation Set Existing Ops	-	Description					
Zone-Rules Rel. Alloc. Outages Stor. Credit: Dec. Sched. Projected Elev							
Flood Control FERC Max Pool No Gen if Pump > 0 Pump if TF > 177.5' Power Guide Curve Inactive	Operates Release Fro Rule Name: No Gen	if Pump > 0 D d-Pool Net Inflow, Pre	esc evior	ription:	•		
			Ŧ	Seasonal Variation Edit			

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – No Gen if Pump>0

# 2. Pump if TF>177.5'

Figure 8 shows the content of "Pump if TF>177.5" rule. This rule shows that if Turner falls pool elevation is less than 175' and Northfield pool elevation is less than 995'then water is pumped.

Operation Set Existing Ops	✓ Description	(		
Zone-Rules Rel. Alloc. Outages Sto	. Credit Dec. Sched. Projected Elev			
Flood Control FERC Max Pool No Gen if Pump > 0	Operates Release From: Northfield Name: Pump if TF > 177.5' Description: Pump only if Turners Fall.			
Pump if TF > 177.5' IF (TF > 177.5' and NF < 995')	Type Name	Description		
Pump Schedule	IF  TF > 177.5' and NF < 995'			
👝 Inactive				
✓ IIII ► IIII ► IIII ► IIIII ► IIIII ► IIIII ► IIIII ► IIIII ► IIIIII	Description			
	r. Credit Dec. Sched. Projected Elev			
Flood Control	Operates Release From: Northfield			
FERC Max Pool     Image: No Gen if Pump > 0	IF Conditional TF > 177.5' and NF < 995'	Description:		
□{} Pump if TF > 177.5' □ ➡ IF (TF > 177.5' and NF < 995')	Value1	Value2 Add Cond.		
Pump Schedule		> 177.5 < 995		
A Inactive		- 333		
		Move Up		
		Move Down		
		Evaluate		
	Logical Operator:			
	Value 1 Constant			
	Volue 2 Occested			
۰ III ا	Value 2 Constant			

Operation Set Existing Ops	<ul> <li>Descrip</li> </ul>	otion					(
Zone-Rules Rel. Alloc. Outages Stor	. Credit Dec. Sched	. Projected Elev					
Flood Control	Operates Release I	From: Northfield-Pun	nps				
™ 🛅 No Gen if Pump > 0	Pump Rule: Pump	Description: During the period when a fix				<b>(()</b> ;	
□{} Pump if TF > 177.5' □+→ IF (TF > 177.5' and NF < 995')	Target Fill Elevation	Daily Pumping Period					
Pump Schedule	Option Storage 2	Option Fixed Hour Range 🗸				•	
Power Guide Curve Inactive	Zone Existing Ops - FERC 🔻		Date	Begin	End	No. Units	
			01Jan	2200	0500	4	
			01Apr	2200	0500	3	
			16Jun	2200	0500	4	-
							Ŧ
	Pumping Strategy	Use full pump capa	a 👻 Pur	nping Bias	B	eginning of P	•
	Source Reservoir:	Turners Falls	<b>-</b>	Whole Ho	ur Pumpi	ng Option	
۰ III ۲	Minimum Pumping	No Required Min	→ Min	. Pump Un	it Hrs		

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet –Pump if TF>177.5'

#### 3. Power Guide Curve

Figure 9 shows the content of "Power Guide Curve" rule. This rule shows the 9.6 hours of power generation in a day.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>	
Zone-Rules Rel. Alloc. Outages Stor	Credit Dec. Sched. Projected Elev	
Flood Control FERC Max Pool No Gen if Pump > 0 Pump if TF > 177.5' Pump Schedule Power Guide Curve Inactive	Operates Release From: Northfield-Northfield Hydropower - Power Guide Curve Rule Power Description: Zone at Top of Power Pool FERC • Zone at Bottom of Power Pool Inactive • % Power Storage Plant Factor (%) 0.0 0.0 ^ 100.0 40.0 ===================================	er Guide Curve
Figure 9: Reservoir Editor:	Operations Tab – Existing Ops	OpSet – Power Guide Curv

## Otis

### I. Overview

Otis dam is located in the towns of Otis and Tolland, MA on the west Branch of the Farmington River. It is owned and operated by the Massachusetts Department of Conservation and Recreation (DCR) and is used primarily for recreation.

Figure 1 shows the location of Otis dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Otis dam.

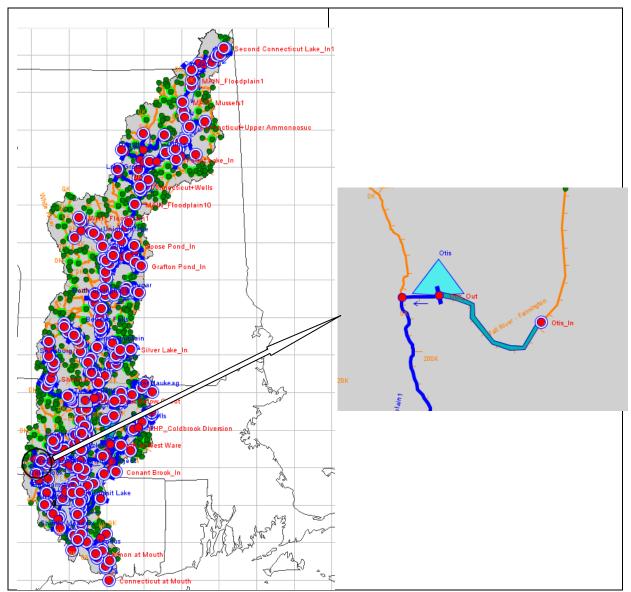


Figure 1: HEC-ResSim Map Display Showing Location of Otis dam



Figure 2: Photo of Otis dam

# **II.** Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>77</sup>. The dam consists of two types of outlets: (1) controlled outlet, (2) uncontrolled spillway as shown in Figure 4.

<sup>&</sup>lt;sup>77</sup> Data from UMASS

Reservoir Editor Reservoir Edit Pool			$\sim$	×
Reservoir Otis  Physical Operations Observed D  Otis  Dom Dam	Otis-Pool	nolation © C	onic Internol	ation Initial Conic Depth (ff)
Controlled Outlet	Elevation (ft) 1391.00 1420.60 1425.28	Storage (ac-ft)           0.00           22000.00           24600.00           4600.00	Area (acre)	$ \begin{array}{c} 1,430 \\ 1,420 \\ 1,410 \\ 1,390 \\ 0 \\ 1,390 \\ 1,420 \\ 1,420 \\ 1,420 \\ 1,420 \\ 1,420 \\ 1,420 \\ 1,420 \\ 1,400 \\ 1,390 \\ 0 \\ 40 \\ 80 \\ 120 \\ 160 \\ Area (acre) \end{array} $
OK Cancel Apply				

Figure 3: Reservoir Editor: Physical Tab -- Pool

🟹 Reservoir Editor Reservoir Edit Dam	
Physical     Operations     Observed	Description     M      7 of 74
Otis	Otis-Dam Elevation at top of dam (ft) 1425.28
Controlled Outlet	Length at top of dam (ft) 630.0 Composite Release Capacity
	$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$
	OK Cancel Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

## III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Otis's "Existing Ops" operational zones, which consist of zones of Top of dam (1425.28 ft), conservation (1412.4-1420.6 ft), Min Pool, and Inactive zone (1400 ft)<sup>1</sup>.

Reservoir Editor	X
Reservoir Edit Operations Zone Rule IF_Block	
Reservoir Otis   Description	
Physical Operations Observed Data	
Operation Set Existing Ops	d Toll(
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev	
Top of Dam Minimum Release Storage Zone Conservation Description Form UMass Farmington notes:	Fro
Conservation Function of Date Defi	ne
Date Top Elevation (ft)	
01Jan 1412.4 1,430	
15Mar 1412.4 1,425	-
16Mar 1420.6 1,420	
200ct 1420.6 € 1,420	
210ct 1412.4 § 1,415	-
200ct 1420.6 210ct 1412.4 □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □	
1,400	
1,395 1 i i i i j Jan Mar May Jul Sep Nov	-
· · · · · · · · · · · · · · · · · · ·	
Zone Sort Elevation	
OK Cancel	Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops (Adamec, University of Massachuset, Amherst).

Reservoir Editor
Reservoir Edit Operations Zor
Reservoir Otis
Physical Operations Obser
Operation Set Existing Ops
Zone-Rules Rel. Alloc. Ou
Top of Dam

Figure 6: Reservoir Editor:	<b>Operations Tab</b> –	<b>Existing Ops OpSet</b>	- Zones and Rules
-----------------------------	-------------------------	---------------------------	-------------------

# **C.** Rule Descriptions

#### 1. Minimum Release

Figure 7 shows the content of "Minimum Release" rule. This rule represents a seasonal rule for minimum release from Otis reservoir.

Operation Set Existing Ope	•	Description From UMass	Farmington notes: Located in Ot	is and Toll(
Zone-Rules Rel. Alloc. C	outages Stor. Credit De	c. Sched. Projected Elev		
Top of Dam	Operates Release From Rule Name: Minimum F Function of: Date Limit Type: Minimum Date 01Jan		2.020 2.010 2.010 2.000 1.990 Jan May Sep Period Average Limit Hour of Day Multiplier Day of Week Multiplier Rising/Falling Condition Seasonal Variation	Edit Edit Edit Edit

Figure 7: Reservoir Editor: Operations Tab - Existing Ops OpSet - Minimum Release

# **Otter Brook**

### I. Overview

Otter Brook dam is a dam on Otter Brook that flows into the Ashuelot River in New Hampshire. It was constructed in 1958 by the US Army Corps of Engineers and is still owned and operated by the Corps. It is primarily used for flood control but also for recreation.

Figure 1 shows the location of Otter Brook Dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo from Otter Brook dam.

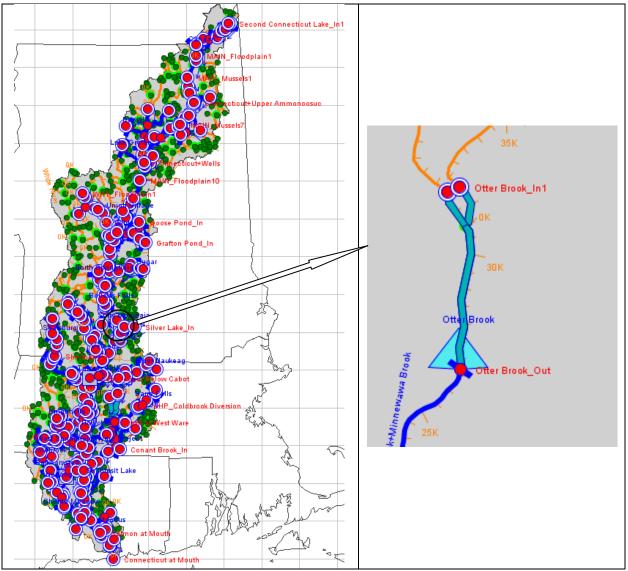


Figure 1: HEC-ResSim Map Display Showing Location of Otter Brook dam



Figure 2: Photo of Otter Brook Dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled slide gates, and (2) uncontrolled spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>78</sup>.

<sup>&</sup>lt;sup>78</sup> http://rsgisias.crrel.usace.army.mil/nae/cwms\_map.map\_index

Reservoir Editor		Sumary Start	anne, mr 3	
Reservoir Edit Pool				
	Description			K 4 35 of 74 D D
Physical Operations Observed D	ata			
Otter Brook	Otter Brook-Pool			
Dam	Linear Interpol	ation 💿 Conic	Interpolation Initial	Conic Depth (ft)
Spillway	Elevation	Storage	Area	
	(ft)	(ac-ft)	(acre)	120
	0.00	0.00	11.00 🔺	120
	2.00	20.00	16.00	80
	4.00	40.00	22.00	
	6.00	60.00	27.00	ê 40-
	8.00	80.00	32.00	
	10.00	90.00	40.00	
	12.00	100.00	47.00	0 15,000
	14.00	120.00	55.00	Stor (ac-ft)
	16.00	130.00	62.00	120
	18.00	140.00	70.00	
	20.00	150.00	76.00	a 80
	22.00	310.00	83.00	
	24.00	480.00	90.00	± 40
	26.00	670.00	96.00	
	28.00	870.00	103.00	
	30.00	1080.00	113.00	
	32.00	1320.00	123.00	Area (acre)
	34.00	1580.00	133.00 +	
			Ok	Cancel Apply

Figure 3: Reservoir Editor: Physical Tab -- Pool

🛒 Reservoir Editor		Interest	All Calendra	()eer 🗿 🗠	-	X
Reservoir Edit Dam						
Reservoir Otter Brook	Description					K (1) 35 of 74 (1) H
Physical Operations Observed Da	ata					
Otter Brook	Otter Brook-Dam					
Dam Slide Gates	Elevation at top	of dam (ft)		119.0		
Spillway	Length at top of	dam (ft)		1288.0		
	Composite Rel	ease Capacit	/			
	Elevation	Controlled	Uncontrolled	Total		
	(ft)	(cfs)	(cfs)	(cfs)		120
	0.0	0.0	0.0	0.0	5	80-
	0.5	75.0	0.0	75.0	Elevation (ff)	40
	1.0	150.0	0.0	150.0	Ē	
	2.0	255.0	0.0	255.0		0 40,000
	2.3	300.0	0.0	300.0		·
	3.0	330.0 360.0	0.0	330.0 360.0		Flow (cfs)
	4.0	420.0	0.0	420.0		(UIS)
	5.0	480.0	0.0	480.0		
	6.0	540.0	0.0	540.0		
	7.0	585.0	0.0	585.0		
	8.0	630.0	0.0	630.0		
	9.0	675.0	0.0	675.0		
	10.0	720.0	0.0	720.0 👻		
				ОК		Cancel Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

## III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Otter Brook's "ExistingOps" operational zones, which consist of zones of Surcharge-near TOD (119 ft), Surcharge (109 ft), Flood Control (89 ft), Conservation (20 ft), and Inactive zone (0 ft).

Reservoir Editor		×
Reservoir Edit Operations Zone Rule IF_Block		
Reservoir Otter Brook    Descrip	tion	K 4 35 of 74 b H
Physical Operations Observed Data		
Operation Set ExistingOps	✓ Description	
Zone-Rules Rel. Alloc, Outages Stor, Cred	lit Dec. Sched. Projected Elev	
Surcharge - near TOD	Storage Zone Conservation	Description Pool elevations up to nc
Surcharge	Function of Date	Define
Max Release at Otter	Date Top Elevation	140
Connecticut at Montague - Linear	01Jan 20.0	120
Flood Control		
Max Release at Otter		
Connecticut at Montague - Linear		
ROC Decrease Flood - Otter		0
Pool Decreasing ROC		-20
Conservation Min Flow Logic - Otter		Sali Mai May Sui Sep 1400
Max Conservation Release at Otter		
Connecticut at Montague - Linear		
ROC Decrease Flood - Otter		
Pool Decreasing ROC	Zone Sort Elevation	
		OK Cancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

🟹 Reservoir Editor		
Reservoir Edit Operations Zone Rule IF_Block		
Reservoir Otter Brook 🗸 Descrip		
Physical Operations Observed Data		
Operation Set ExistingOps		
Zone-Rules Rel. Alloc. Outages Stor. Cre		
A Surcharge - near TOD		
Slide Gate Ops - Save Dam		
Min Flow - Flood Pool - Otter		
Max Release at Otter		
☐ Slide Gate Ops		
🔲 🔲 Connecticut at Montague - Linear		
Max Flow at Keene		
🔁 Flood Control		
🔚 🔚 Min Flow - Flood Pool - Otter		
Max Release at Otter		
🔲 🫅 Max Flow at Keene		
Connecticut at Montague - Linear		
ROC Increase Flood - Otter		
ROC Decrease Flood - Otter		
-		
Max Outflow equals Max 21 day Inflow		
Min Flow Logic - Otter		
Max Conservation Release at Otter		
Max Flow at Keene		
Connecticut at Montague - Linear		
ROC Increase Flood - Otter		
🔲 🔲 ROC Decrease Flood - Otter		
Pool Decreasing ROC		
nactive 🔁		

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

### **C.** Rule Descriptions

#### 1. Slide Gate Ops-Save Dam

Figure 7 shows the content of "Slide Gate Ops-Save Dam" rule. This rule represents the maximum allowable release from Slide gates as a function of pool elevation when the pool is in Surcharge-near TOD zone.

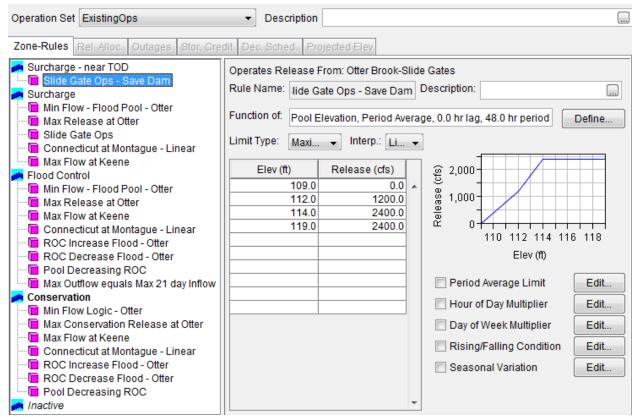


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Slide Gate Ops-Save Dam

#### 2. Min Flow-Flood Pool-Otter

Figure 8 shows the content of "Min Flow-Flood Pool-Otter" rule. This rule shows the required minimum release from dam during flood control operations.

Operation Set ExistingOps   Description					
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sched. Proj	ected Elev			
Surcharge - near TOD Slide Gate Ops - Save Dam Surcharge Min Flow - Flood Pool - Otter Max Release at Otter Slide Gate Ops Connecticut at Montague - Linear Max Flow at Keene Flood Control Min Flow - Flood Pool - Otter Max Release at Otter	Operates Release Fr Rule Name: in Flow Function of: Date Limit Type: Minimu Date 01Jan	- Flood Pool - Otter D	≥ 25.2- (x) 25.1- (x) 25.0- (x) 25.0- (		Define
Max Flow at Keene     Connecticut at Montague - Linear     ROC Increase Flood - Otter     ROC Decrease Flood - Otter     Pool Decreasing ROC     Max Outflow equals Max 21 day Inflow     Conservation			Jan M	ar May Jul Sep N Average Limit	Edit
Min Flow Logic - Otter     Max Conservation Release at Otter     Max Flow at Keene     Connecticut at Montague - Linear     ROC Increase Flood - Otter     ROC Decrease Flood - Otter     Pool Decreasing ROC     Inactive			Day of V	Day Multiplier Veek Multiplier Falling Condition al Variation	Edit Edit Edit

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow-Flood Pool-Otter

#### 3. Max Release at Otter

Figure 9 shows the content of "Max Release at Otter" rule. This rule shows the maximum allowable release from dam.

Operation Set ExistingOps	Description
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit. Dec. Sched. Projected Elev.
Surcharge - near TOD Silde Gate Ops - Save Dam Surcharge Min Flow - Flood Pool - Otter Max Release at Otter Max Connecticut at Montague - Linear ROC Increase Flood - Otter Pool Decreasing ROC Max Outflow equals Max 21 day Inflow Conservation Max Flow at Keene Connecticut at Montague - Linear Max Flow at Keene Connecticut at Montague - Linear Max Flow at Keene Connecticut at Montague - Linear ROC Increase Flood - Otter ROC Increase Flood - Otter Pool Decrease Flood - Otter Pool Decrease Flood - Otter	Operates Release From: Otter Brook         Rule Name:       Max Release at Otter       Description:       Maximum release rate from Ott(
Inactive	<b>•</b>

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Release at Otter

#### 4. Slide Gate Ops

Figure 10 shows the content of "Slide Gate Ops" rule. This rule represents the maximum allowable release from Slide gates as a function of pool elevation when the pool is in Surcharge zone.

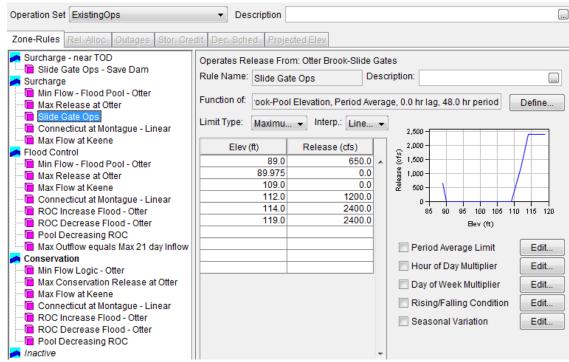


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Slide Gate Ops

#### 5. Connecticut at Montague-Linear

Figure 11 shows the content of "Connecticut at Montague-Linear" rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

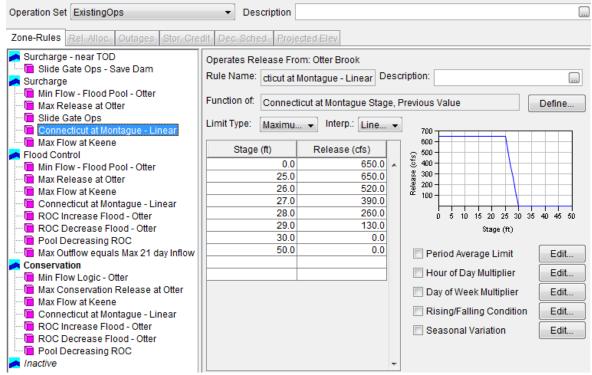


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague-Linear

#### 6. Max Flow at Keene

Figure 12 shows the content of "Max Flow at Keene" rule. This rule represents the maximum allowable flow downstream at the point Ashuelot+Otter Brook.

Operation Set ExistingOps	▼ Description			
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sched. Projec	ted Elev		
Surcharge - near TOD  Slide Gate Ops - Save Dam  Surcharge  Min Flow - Flood Pool - Otter  Max Release at Otter  Otter	Operates Release From Rule Name: Max Flow Function of: Date		ption:	Define
Slide Gate Ops Connecticut at Montague - Linear Max Flow at Keene Flood Control Min Flow - Flood Pool - Otter Max Release at Otter	Limit Type: <u>Maximum</u> Downstream Location: Parameter:	Interp.: Step     Ashuelot+Otter Brook     Flow	2,520 2,510 5 2,500	
Max Flow at Keene     Connecticut at Montague - Linear     ROC Increase Flood - Otter     ROC Decrease Flood - Otter	Date 01Jan	Flow (cfs)	2,490 Jan Mar May Jul Sep	Nov
Pool Decreasing ROC     Max Outflow equals Max 21 day Inflow     Conservation     Min Flow Logic - Otter     Max Conservation Release at Otter     Max Flow at Keene     Connecticut at Montague - Linear			Period Average Limit Hour of Day Multiplier Day of Week Multiplier Seasonal Variation	Edit Edit Edit Edit
ROC Increase Flood - Otter     ROC Decrease Flood - Otter     Pool Decrease Rood - Otter     Pool Decreasing ROC     Inactive			Flow Contingency     Advanced Options	Ealt

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max flow at Keene

#### 7. ROC Increase Flood-Otter

Figure 13 shows the content of "ROC Increase Flood-Otter" rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Otter Brook dam.

Operation Set ExistingOps	✓ Description	
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sched. Projected Elev	
Surcharge - near TOD Slide Gate Ops - Save Dam Surcharge Min Flow - Flood Pool - Otter Slide Gate Ops Connecticut at Montague - Linear Max Flow at Keene Flood Control Max Flow at Keene Flood Control Max Flow at Keene Connecticut at Montague - Linear ROC Decrease Flood - Otter ROC Decrease Flood - Otter Nax Onservation Max Flow at Keene Connecticut at Montague - Linear ROC Decrease Flood - Otter Max Conservation Max Flow at Keene Connecticut at Montague - Linear ROC Decrease Flood - Otter Nax Flow at Keene Connecticut at Montague - Linear ROC Decrease Flood - Otter ROC Decrease Flo	Operates Release From: Otter Brook         Release Rate of Change Limit         ROC Increase Floor         Description:         Function Of:         Release         Type         Increasing         Interpolate         Step         Release (cfs)         Rate Change (cfs/hr)         0.0         500.0         100.0         500.1         50.0         123456.0         50.0         Interpolate	od - Otter

Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – ROC Increase Flood-Otter

#### **8.** *ROC Decrease Flood-Otter*

Figure 14 shows the content of "ROC Decrease Flood-Otter" rule. This rule shows the maximum allowable decreasing release rate of change.

Operation Set ExistingOps	<ul> <li>Description</li> </ul>		
Zone-Rules Rel. Alloc. Outages Stor. Cre	edit Dec. Sched. Projected E	lev	
Surcharge - near TOD Surcharge - near TOD Min Flow - Flood Pool - Otter Max Release at Otter Max Release at Otter Max Flow at Keene Flood Control Min Flow - Flood Pool - Otter Max Release at Otter Max Release at Otter Max Release at Otter Max Role at Keene Connecticut at Montague - Linear ROC Increase Flood - Otter ROC Decrease Flood - Otter Max Conservation Max Conservation Release at Otter Max Conservation Release at Otter Max Conservation Release at Otter Max Concrease Flood - Otter Max Conservation Release at Otter Max Conservation Release at Otter ROC Increase Flood - Otter Max Conservation Release at Otter Max Conservation Release at Otter Max Conservation Release at Otter ROC Increase Flood - Otter ROC Increase Flood - Otter ROC Decrease Flo	Description: Function Of: Type Max Rate of Change (cfs/hr)	er Brook nit ROC Decrease Flood - Otter Constant Decreasing 200.0	

Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet – ROC Decrease Flood-Otter

#### 9. Pool Decreasing ROC

Figure 15 shows the content of "Pool Decreasing ROC" rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

Operation Set ExistingOps	Description	)
Zone-Rules Rel. Alloc. Outages Stor. Cre	edit. Dec. Sched. Projected Elev	
Surcharge - near TOD  Slide Gate Ops - Save Dam  Surcharge  Min Flow - Flood Pool - Otter  Max Release at Otter  Kax Release at Otter  Kax Flow at Keene  Flood Control  Max Flow at Keene  Connecticut at Montague - Linear  ROC Increase Flood - Otter  ROC Decrease Flood - Otter  Max Conservation Release at Otter  Max Conservation Release at Otter  Max Conservation Release at Otter  ROC Increase Flood - Otter  Max Conservation Release at Otter  Kax Conceticut at Montague - Linear  ROC Increase Flood - Otter  ROC Decrease Flood - Otter  Nax Conservation Release at Otter  ROC Decrease Flood - Otter  ROC Decrease Fl	Operates Release From: Otter Brook Elevation Rate of Change Limit Pool Decreasing ROC Description Function Of: Constant Type Decreasing Instantaneous Period Average Max Change of (ft) 10.0 over 24 hours	

Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet – Pool Decreasing ROC

#### 10. Max Outflow equals Max 21 day Inflow

Figure 16 shows the content of "Max outflow equals Max 21 day Inflow" rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

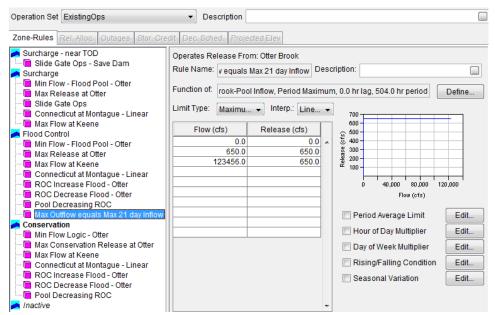


Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals Max 21 day Inflow

#### 11. Min Flow Logic-Otter

Figure 17 shows the content of "Min flow Logic-Otter" rule. This rule provides seasonal minimum releases from Otter Brook as a function of inflow.

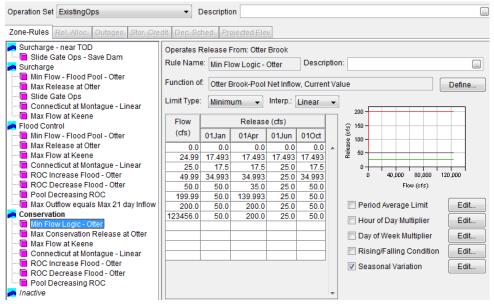


Figure 17: Reservoir Editor: Operations Tab - Existing Ops OpSet - Min Flow Logic-Otter

# **Power Canal (Turners Falls)**

### I. Overview

Power Canal dam is one of the outlet canals from Turners Falls that is used for hydropower generation. It is part of the Turners Falls project but is modeled separately in the ResSim model because Gomez and Sullivan Engineers P.C., modeled it in this fashion.

Figure 1 shows the location of Power Canal Dam as it is represented in the HEC-ResSim model.

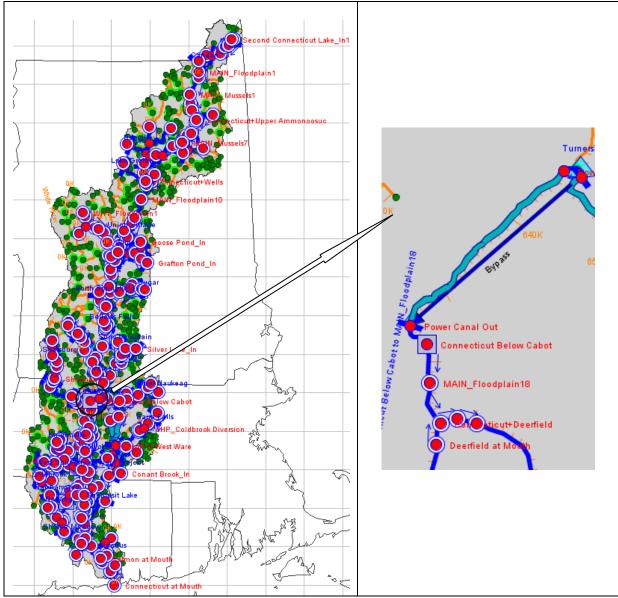


Figure 1: HEC-ResSim Map Display Showing Location of Power Canal dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 2. The dam consists of three types of outlets: (1) controlled Canal Fishways, and (2) Station No.1, and (3) Cabot Station as shown in Figure 3.

👿 Reservoir Editor				
Reservoir Edit Pool				
Reservoir Power Canal				
Physical Operations Observed Da	ita			
Power Canal	Power Canal-Pool			
□▼ Dam Tailwater	Linear Interpola	ation 💿 Conic In	terpolation Initi	ial Conic Depth (ft)
Station No. 1	Elevation	Storage	Area	
Cabot Station	(ft)	(ac-ft)	(acre)	175.0
Tailwater	171.50	402.89		174.0
Canal Fishways	172.50 173.50	433.88 464.88		
	174.50	495.87		€ 173.0
				171.0
				420 450 480
				Stor (ac-ft)
				175.0
				174.0
				€ 173.0
				€ 173.0
				474.0
				0 150 300 450
				Area (acre)
			C	OK Cancel Apply
-		-		

Figure 2: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor Reservoir Edit Dam	
Reservoir Power Canal	Description
Power Canal Pool Tailwater Station No. 1 Cabot Station Tailwater Canal Fishways	Power Canal-Dam         Elevation at top of dam (ft)         Length at top of dam (ft)         Composite Release Capacity         Elevation       Controlled         (ft)       (cfs)         0.0       16,524.0         173.0       16,524.0         175.0       16,524.0         190.0       16,524.0         190.0       16,524.0         0.0       16,524.0
	OK Cancel Apply

Figure 3: Reservoir Editor: Physical Tab -- Dam

# III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 4 shows the definition of Power Canal's "ExistingOps" operational zones, which consist of zones of Flood Control (174 ft), Normal Pool (173.5 ft), and Inactive zone (173.5 ft).

Reservoir Editor				<b>X</b>
Reservoir Edit Operations				
Reservoir Power Canal 🗸 De	scription			K 4 73 of 74 D H
Physical Operations Observed Data				
Operation Set Existing Ops	▼ Descri	ption		
Zone-Rules Rel. Alloc. Outages Stor.	Credit Dec. Sched	I. Projected Elev		
<ul> <li>Flood Control</li> <li>Fishway Releases</li> <li>Cabot Releases (script)</li> <li>Station No. 1 Releases (script)</li> </ul>	Storage Zone Con Function of Date	nservation		Description
Conservation Fishway Releases Cabot Releases (script) Station No. 1 Releases (script) Inactive	Date 01Jan   Zone Sort Elevatio	Top Elevation (ft) 173.5 173.5	*	174.1 174.0 173.9 173.8 173.7 173.6 173.5 173.4 Jan Mar May Jul Sep Nov
				OK Cancel Apply

Figure 4: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

Figure 5 shows a sequential release allocation approach specified for available outlets along Power canal Dam. The available outlets are given an order of priority for release. The Cabot Station gets the release first until it reaches release capacity. The Station No.1 gets the remainder of the release until it reaches capacity. After the capacity through the Station No.1 is reached, the remainder of the release goes through the Canal Fishways.

Reservoir Editor	tanun im Salestan, anr 📓 Calipania Inc.
Reservoir Edit Operations	
Reservoir Power Canal	
Physical Operations Observed Data	
Operation Set Existing Ops    Des	scription
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sch	ned. Projected Elev
Release Allocation Strategy	
Power Canal - Balanced Power Canal-Dam (1.0) - Sequential Power Canal-Cabot Station Power Canal-Station No. 1 Power Canal-Canal Fishways	Release Location:       Power Canal-Dam         Allocation Type:       Sequential         Power Canal-Cabot Station       Power Canal-Station No. 1         Power Canal-Canal Fishways       Power Canal-Canal Fishways

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

## **B. Rule Illustrations**

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops.

🟹 Reservoir Editor				
Reservoir Edit Operations				
Reservoir Power Canal 🗸 De				
Physical Operations Observed Data				
Operation Set Existing Ops				
Zone-Rules Rel. Alloc. Outages Stor				
Flood Control				
Fishway Releases				
Cabot Releases (script)				
Station No. 1 Releases (script)				
Fishway Releases				
Cabot Releases (script)				
Station No. 1 Releases (script)				
inactive				

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## **C.** Rule Descriptions

#### 1. Fishway Release

Figure 7 shows the content of "Fishway Release" rule. It shows the sum of Cabot ladder attraction flow and fishway flow, spillway ladder fishway flow (not attraction flow which releases from spillway gates), and Cabot log sluice for downstream fish passage. Gatehouse ladder attraction flow and fishway flow release to the canal and are available for generation so are not included here. Values of 386 cfs include the cabot and spillway ladders, values of 586 cfs include those two ladders plus the Cabot log sluice, and values of 200 cfs include the log sluice only.

Operation Set Existing Ops	▼ Descr	iption			
Zone-Rules Rel. Alloc. Outages Sto	r. Credit Dec. Sche	d. Projected Elev			
Flood Control Cabot Releases Cabot Releases (script) Station No. 1 Releases (script) Normal Pool Fishway Releases Cabot Releases (script) Station No. 1 Releases (script) Station No. 1 Releases (script) Inactive		From: Power Canal-C vay Releases	Description:	Sum of Cabot ladder	Define
			- Sea	asonal Variation	Edit

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Fishway Release

### 2. Cabot Release(script)

Figure 8 shows the content of "Cabot Relesea" rule. This script calculates the Power Canal's inflow and subtracts the seasonal fishways flow to determine how much flow should be released through Cabot Station. 1400 cfs corresponds to the minimum flow to run one unit at Cabot; 13,728 cfs is Cabot's capacity.

Oper	ration Set Existing Ops	✓ Des	scription			
Zone	e-Rules Rel. Alloc. Outages Sto	or. Credit Dec. Sched.	Projected Elev			
🔁 Fl	lood Control	Operates Release Fro	om: Power Canal-Cabot Station			
	Fishway Releases					
l (	Cabot Releases (script)	Script Operation Rule	Cabot Releases (script)			
<b>(</b>	Station No. 1 Releases (script)	Description	This script calculates the Power Canal's inflow and subtracts the seasonal fishways flov			
13	# create new Operation Value (Op)					
14	opValue = OpValue()					
15						
16	# This script calculates the Powe					
17	# fishways flow to determine how					
18	# 1400 cfs corresponds to the min	imum flow to run one uni	it at Cabot; 13,728 cfs is Cabot's capacity.			
19						
20 21	# Calculate the power canal's eff					
21			Canal", "Pool", "Flow-IN NET").getCurrentValue(currentRuntimestep) Mer Canal", "Canal Fishways-Fishway Releases", "Flow-SPEC").getCurrentValue(currentRuntimeste			
23	effective inflow = canal inflow -		er canar, "canar Fishways-Fishway Releases", "FIGW-SPEC").getturrentvarde(Gurrentvarde)			
24	effective_fiffiow - canaf_fiffiow -	TISHWAY_DUCTION				
25						
26	#cabot capacity = 13728					
27						
28	# set type and value for OpValue					
29						
192	# OpRule.RULETYPE MAX - maximum flow					
30	# OpRule.RULETYPE_MAX - maximum	: flow				
	# OpRule.RULETYPE_MAX - maximum # OpRule.RULETYPE_MIN - minimum					
30 31 32	<pre># OpRule.RULETYPE_MIN - minimum # OpRule.RULETYPE_SPEC - specif:</pre>	n flow				
30 31 32 33	<pre># OpRule.RULETYPE_MIN - minimum # OpRule.RULETYPE_SPEC - specif: if effective_inflow &lt; 1400:</pre>	n flow ied flow				
30 31 32 33 34	# OpRule.RULETYPE_MIN - minimum # OpRule.RULETYPE_SPEC - specify if effective_inflow < 1400: opValue.init(OpRule.RULETYPE_	n flow ied flow				
30 31 32 33 34 35	<pre># OpRule.RULETYPE_MIN - minimum # OpRule.RULETYPE_SPEC - specify if effective_inflow &lt; 1400:</pre>	n flow ied flow SPEC, O)				
30 31 32 33 34 35 36	<pre># OpRule.RULETYPE_MIN - minimum # OpRule.RULETYPE_SPEC - specif: if effective_inflow &lt; 1400:</pre>	n flow ied flow SPEC, O)				
30 31 32 33 34 35 36 37	<pre># OpRule.RULETYPE_MIN - minimu # OpRule.RULETYPE_SPEC - specifi if effective_inflow &lt; 1400:</pre>	a flow ed flow SPEC, 0) SPEC, effective_inflow)				
30 31 32 33 34 35 36 37 38	<pre># OpRule.RULETYPE_MIN - minimum # OpRule.RULETYPE_SPEC - specif: if effective_inflow &lt; 1400:</pre>	a flow ed flow SPEC, 0) SPEC, effective_inflow)				
30 31 32 33 34 35 36 37 38 39	<pre># OpRule.RULETYPE_MIN - minimum # OpRule.RULETYPE_SPEC - specifi if effective_inflow &lt; 1400: opValue.init(OpRule.RULETYPE_ elif effective_inflow &lt;= 13728: opValue.init(OpRule.RULETYPE_ else: opValue.init(OpRule.RULETYPE_</pre>	a flow ed flow SPEC, 0) SPEC, effective_inflow)				
30 31 32 33 34 35 36 37 38	<pre># OpRule.RULETYPE_MIN - minimu # OpRule.RULETYPE_SPEC - specifi if effective_inflow &lt; 1400:</pre>	a flow ed flow SPEC, 0) SPEC, effective_inflow) SPEC, 13728)				

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Cabot Relesae

### **3.** Station No.1 Releases(script)

Figure 9 shows the content of "Station No.1 Releases" rule. This script calculates the Power Canal's inflow and subtracts the seasonal fishways flow to determine how much flow should be released through Station No. 1. 1400 cfs corresponds to the minimum flow to run one unit at Cabot; 13,728 cfs is Cabot's capacity.

Operation Set Existing Ops	
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.	
Flood Control Operates Release From: Power Canal-Station No. 1	
Fishway Releases     Script Operation Rule Station No. 1 Releases (script)	
Clating No. 4 Delegaço (agrip)	
Vernet Deel	ubtracts the seasonal fishways flow to determine how much flow should be released through Station No. 1. 1400 cfs corres
13 # create new Operation Value (OpValue) to return	
14 opValue = OpValue()	
15	
16 # This script calculates the Power Canal's inflow and subtracts the	
17 # fishways flow to determine how much flow should be released throug 18 # 1400 cfs corresponds to the minimum flow to run one unit at Cabot;	
18 # 1400 cfs corresponds to the minimum flow to run one unit at Cabot; 19	13,728 CIS 18 Capot's capacity.
20 # Calculate the power canal's effective inflow (inflow - fishway rel	
20 ** Calculate the power canal's effective inflow (inflow = fishway fer 21 canal inflow = network.getTimeSeries("Reservoir", "Power Canal", "Poo	
	Canal Fishways-Fishway Releases", "Flow-SPEC").getCurrentValue(currentRuntimestep)
23 effective inflow = canal inflow - fishway outflow	and Honways Honway Keleases , How Sile ).gecearchevalae(carrenevalere)
24	
25 #cabot minflow = 1400	
26 #cabot capacity = 13728	
27	
28 # set type and value for OpValue	
29 # type is one of:	
30 # OpRule.RULETYPE_MAX - maximum flow	
31 # OpRule.RULETYPE_MIN - minimum flow	
32 # OpRule.RULETYPE_SPEC - specified flow	
<pre>33 if effective_inflow &lt; 1400:</pre>	
34 opValue.init (OpRule.RULETYPE_SPEC, effective_inflow)	
35 elif effective_inflow > 13728:	
36 opValue.init(OpRule.RULETYPE_SPEC, effective_inflow - 13728)	
37 else:	
38 opValue.init(OpRule.RULETYPE_SPEC, 0)	
39	
40 # return the Operation Value.	
41 # return "None" to have no effect on the compute	
42 return opValue	

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Station No.1 Releases(script)

# **Quabbin Windsor**

#### I. Overview

The Quabbin Windsor dam is a very large project located on the Swift River that feeds into the Chicopee River. It is owned and operated by the Massachusetts Water Resources Authority (MWRA) and is used for water supply for the City of Boston.

Figure 1 shows the location of Quabbin Windsor dam as it is represented in the HEC-ResSim model. Figure 2 show a photo of Quabbin Windsor dam.

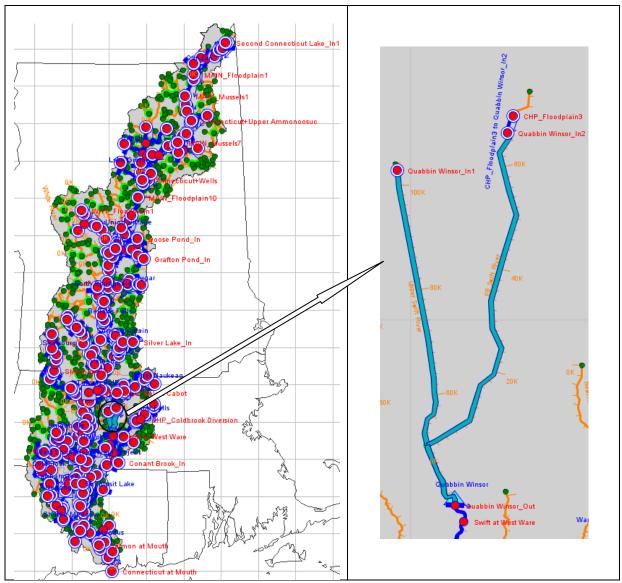


Figure 1: HEC-ResSim Map Display Showing Location of Quabbin dam



Figure 2: Photo of Quabbin Windsor dam.

## **II.** Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>79</sup>. The dam consists of three types of outlets: (1) controlled Bypass to Swift River, (2) uncontrolled spillway, (3) uncontrolled Auxillary Spillway as shown in Figure 4.

<sup>&</sup>lt;sup>79</sup> Phase I Report. 1978.

Reservoir Editor								
Reservoir Quabbin Winsor				K 4 65 of 74 D M				
Quabbin Winsor	Quabbin Winsor-Poo		erpolation Initial Co	onic Depth (ft)				
<ul> <li>Bypass to Swift River</li> <li>Spillway</li> <li>Auxillary Spillway</li> </ul>	Elevation (ft)	Storage (ac-ft)	Area (acre)	]				
	386.00 434.00 446.00 456.00 466.00 476.00 486.00 491.38 496.00 506.00 511.00 516.00 521.00 521.00 531.00 534.00	0.00 30400.00 64500.00 10990.00 250700.00 353300.00 41800.00 481800.00 64000.00 728000.00 82100.00 922000.00 1030000.00 115000.00 122000.00	0.00 ▲ 1900.00 5200.00 6900.00 9300.00 11300.00 12880.00 14500.00 16980.00 18300.00 21960.00 23300.00 24160.00	Stor (ac-ft) 520 480 440 400 0 15,000				
536.00         1270000.00         24700.00         Area (acre)           OK         Cancel         Apply								

Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor		-	e talente, e		X					
Reservoir Edit Dam										
	<ul> <li>Description</li> </ul>									
Physical Operations Observed D	ata									
Cuabbin Winsor Pool Quabbin Winsor-Dam										
Evaporation Elevation at top of dam (ft) 556.1										
Bypass to Swift River Spillway	Length at top of d	am (ft)		2640.	0					
Auxillary Spillway	Composite Rele	ase Capacity			1					
	Elevation	Controlled	Uncontrolled	Total						
	(ft)	(cfs)	(cfs) 0.0	(cfs)	- 540					
	471.1	0.0		0.0 🔺	5 540					
	471.1         0.0         0.0         0.0         ▲           480.0         185.0         0.0         185.0         €         €         510           485.0         244.0         0.0         244.0         ■         480         480									
490.0 290.0 0.0 290.0										
	495.0 330.0 0.0 330.0 0 50									
	500.0	366.0	0.0	366.0	Flow					
	505.0	399.0	0.0	399.0	(cfs)					
	510.0	429.0	0.0	429.0						
	515.0	457.0	0.0	457.0						
	520.0	483.0	0.0	483.0						
	525.0	509.0	0.0	509.0 532.0						
	530.0	532.0 560.0	0.0	560.0						
	536.0	560.0	0.0	560.0						
				ОК	Cancel Apply					

Figure 4: Reservoir Editor: Physical Tab -- Dam

Figure 5 shows the monthly evaporation factors that were accounted for Quabbin Windsor, due to the large size of the reservoir.

servoir Edit Evaporation			
eservoir Quabbin Winsor	Description		
hysical Operations Observed	Data		
Quabbin Winsor	Quabbin Winsor-Pool-Evapor	ation	
Pool			
Evaporation	Monthly Total Evaporation	1	
Dam	Month	Evap(in)	
Bypass to Swift River	Jan	0.00	
Spillway	Feb	0.00	1.6
Auxillary Spillway	Mar	0.10	
	Apr	0.30	€ <sup>1.2</sup>
	May	1.40	ğ 0.8
	Jun	1.70	(i) 1.2 de 0.8 W 0.4
	Jul	1.60	
	Aug	1.30	0.0+ F++++
	Sep	1.10	Jan May Sep Jan
	Oct	0.50	
	Nov	0.30	
	Dec	0.00	
	© Evaporation Time Series		
		OK	Cancel

## III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Quabbin's "ExistingOps" operational zones, which consist of zones of, Flood Control (556 ft), Conservation (536.05 ft), Min Water Supply Intake (434 ft), and Inactive zone (380 ft)<sup>1</sup>.

Reservoir Editor	a mante materiara ( na 🗿 contigar								
Reservoir Edit Operations Zone Rule IF_Block									
Reservoir Quabbin Winsor   Description  M   65 of 74  M									
Physical Operations Observed Data									
Operation Set Existing Ops									
Zone-Rules Rel, Alloc. Outages Stor. Credit Dec. Sched.	Projected Elev								
Flood Control	Storage Zone Conservation	Description							
Conservation     Baintain Navigation on Connecticut River at Montague	Function of Date	Define							
Min Water Supply Intake Inactive	Date Top Elevation (ft)	560							
	01Jan 536.05	^ 540- 520-							
		500- € 480-							
		5 460- 5 440- 1 420- 1 420-							
		380							
		360 +							
		<b>•</b>							
۰ m	Zone Sort Elevation								
		OK Cancel Apply							

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

## **B. Rule Illustrations**

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>1</sup>. Quabbin, the largest reservoir in the basin and one of the major water supply sources for the City of Boston, had its water withdrawals estimated from a combination of monthly pool levels and annual water supply volumes from 2006 to 2009, provided by the Massachusetts Water Resources Authority's (MWRA) website and the Massachusetts Department of Environmental Protection (MADEP), which showed the pool is allowed to fluctuate seasonally. Gauged records of discharges from Quabbin and SYE flows gave some indication of the total volume that was diverted from the reservoir for water supply. These different facets were used to crudely estimate a withdrawal time series for the model period of record. The main goal was to remove a significant percentage of the total volume released from Quabbin into the Swift River. It is worth noting that in the mid 1980s, significant reductions in water supply demand as well as fixes to the system such as repairing leaking pipes began to be implemented that reduced the withdrawals from Quabbin. This is reflected in the water supply time series for Quabbin.

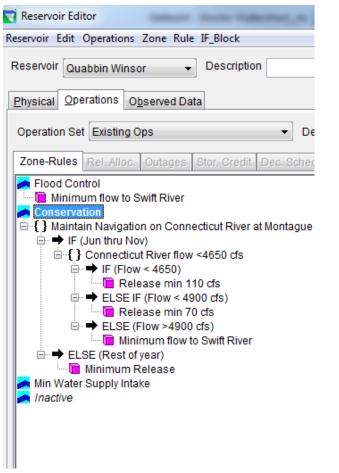


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

# **C.** Rule Descriptions

#### 1. Minimum flow to Swift River

Figure 7 shows the content of "Minimum flow to Swift River" rule. This rule shows a minimum flow from dam to swift river.

Operation Set Existing Ops    De	scription War Depart	tment memos from th	ne 1920's give a 1-June-through-30-	Novembe
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched	. Projected Elev			
Flood Control Flood Control Conservation Conservation { Maintain Navigation on Connecticut River at Montague Min Water Supply Intake Inactive	Operates Release I	→ Interp.: Li Release (cfs)	Description:	Define
	30Jun 01Jul 31Dec	94.0 30.0 30.0	Jan Mar May Jul Sep N Period Average Limit Hour of Day Multiplier Day of Week Multiplier Rising/Falling Condition Seasonal Variation	Edit Edit Edit Edit Edit

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Minimum flow to Swift River

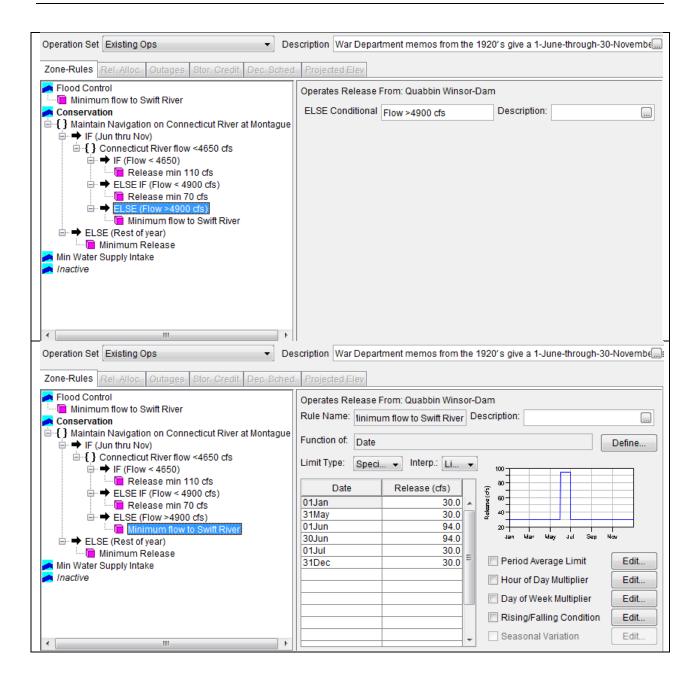
## 2. Maintain Navigation on Connecticut River at Montague

Figure 8 shows the content of "Maintain Navigation on Connecticut River at Montague" rule. This rule shows a minimum release from dam as a function of Inflow during Jun-Nov.

Operation Set Existing Ops    De	scripti	on War D	epartment memos	from	the 1920's give a 1-	June-throug	h-30-Novembe	
Zone-Rules Rel, Alloc. Outages Stor, Credit. Dec. Sched	I. Pro	jected Ele	V					
Flood Control	Operates Release From: Quabbin Winsor-Dam							
Conservation  Gamma Gam		IF Conditional Jun thru Nov			Description:	Description:		
		Value1			Value2		Add Cond.	
i⊟{} Connecticut River flow <4650 cfs			rent Time Step rent Time Step	>=	01Jun 30Nov	[	Del. Cond.	
Release min 110 cfs     ELSE IF (Flow < 4900 cfs)			rent nine otep		501407			
🔚 Release min 70 cfs						ſ	Move Up	
							Move Down	
ELSE (Rest of year) ☐ Minimum Release							Evaluate	
Min Water Supply Intake		jical Opera	ator:				Lindato	
			stant -		]			
< Þ	Val	ue 2 Con	stant –		]			
	escript	ion War [	Department memos	s from	the 1920's give a 1	1-June-throu	gh-30-Novembe	
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched	d. Pro	jected El	2V/					
Flood Control	Ope	rates Rel	ease From: Quabbi	in Win	sor-Dam			
Conservation		me: eticu	t River flow <4650	cfs D	escription:			
☐	Тур	be	Name		Description			
		IF	Flow < 4650					
🔚 Release min 110 cfs		LSE IF ELSE	Flow < 4900 cfs Flow >4900 cfs					
ELSE IF (Flow < 4900 cfs) □ Release min 70 cfs								
ELSE (Rest of year)								
Minimum Release Min Water Supply Intake								
nactive								
· · · · · · · · · · · · · · · · · · ·								

Operation Set Existing Ops	scription War Department memos from the 1920's give a 1-June-through-30-Novembe						
Zone-Rules Rel, Alloc. Outages Stor, Credit Dec, Sched	Projected Elev						
Flood Control	Operates Release From: Quabbin Winsor-Dam						
Minimum flow to Swift River	IF Conditional Flow < 4650 Description:						
Conservation     Maintain Navigation on Connecticut River at Montague	Add Cond.						
IF (Jun thru Nov) IF (Jun thru Nov) IF (Jun thru Nov)	Value1 Value2						
	Connecticut at Montague:Flow < 4650 Del. Cond.						
🔚 Release min 70 cfs	Move Up						
ELSE (Rest of year)	Move Down						
	Evaluate						
nactive	Logical Operator: 👻						
	Value 1 Constant -						
	Ope 👻						
• III • •	Value 2 Constant						
Operation Set Existing Ops 🔹 🗸	scription War Department memos from the 1920's give a 1-June-through-30-Novembe						
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched	Projected Elev						
Flood Control	Operates Release From: Quabbin Winsor-Dam						
Minimum flow to Swift River Conservation	Rule Name: Release min 110 cfs Description:						
A Maintain Navigation on Connecticut River at Montague	Function of: Date Define						
IF (Jun thru Nov) IF (Jun thru Nov) IF (Jun thru Nov)							
	Limit Type: Mini V Interp.: Li V						
➡ ➡ ELSE IF (Flow < 4900 cfs)	Date Release (cfs)						
Release min 70 cfs      ELSE (Flow >4900 cfs)	110.0 A B 109.5						
Minimum flow to Swift River	Jan Mar May Jul Sep Nov						
Image: Image							
📥 Min Water Supply Intake	Period Average Limit Edit						
nactive	Hour of Day Multiplier						
	Day of Week Multiplier						
	Rising/Falling Condition Edit						
۰ III ا	Seasonal Variation Edit						

Operation Set Existing Ops	escrip	tion War Depa	tment memos from th	e 1920	's give a 1-June-thro	ough-30-Novembe			
Zone-Rules Rel. Alloc. Outages. Stor. Credit. Dec. Sche	d. Pr	ojected Elev							
Flood Control	Ор	Operates Release From: Quabbin Winsor-Dam							
Minimum flow to Swift River		ELSE IF Conditional Flow < 4900 cfs Description:							
☐ → { } Maintain Navigation on Connecticut River at Montague → F (Jun thru Nov)	<u>ا</u>	Value1			Value2	Add Cond.			
E → IF (Flow < 4650)			ut at Montague:Flow	>=	4650	Del, Cond,			
Release min 110 cfs	AN	ID Connectio	ut at Montague:Flow	<	4900				
ELSE IF (Flow < 4900 cfs) ■ Release min 70 cfs									
						Move Up			
ELSE (Rest of year)						Move Down			
Minimum Release Min Water Supply Intake						Evaluate			
nactive	L	ogical Operator:							
	V;	alue 1 Constan	t						
		pe 📮							
×	V;	alue 2 Constan	t –						
Operation Set Existing Ops  ▼ Description War Department memos from the 1920's give a 1-June-through-30-Novemb∈									
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sche	d. Pr	ojected Elev							
Flood Control			From: Quabbin Winso						
Conservation	11	e Name: Relea	ise min 70 cfs	Descri	ption:				
🖨 🌩 IF (Jun thru Nov)	Fur	nction of: Date				Define			
<ul> <li>☐ { } Connecticut River flow &lt;4650 cfs</li> <li>☐ ➡ IF (Flow &lt; 4650)</li> </ul>	Lim	nit Type: Mini	✓ Interp.: Li •	•					
Release min 110 cfs → ➡ ELSE IF (Flow < 4900 cfs)		Date	Release (cfs)	18	۵٫۰				
Release min 70 cfs	01.	Jan	70.0	- 6i	- 0.0				
ELSE (Flow >4900 cfs) ☐ Minimum flow to Swift River					92 Jan Mar May Jul	Sep Nav			
ELSE (Rest of year) ☐ Minimum Release									
Min Water Supply Intake					Period Average Lim				
					Hour of Day Multipli Day of Week Multipl				
					Rising/Falling Cond				
4					Seasonal Variation	Edit			



Operation Set Existing Ops	scription War Department memos from the 1920's give a 1-June-through-30-Novembe
Zone-Rules Rel. Alloc. Outages Stor, Credit Dec. Sched	Projected Elev
Flood Control	Operates Release From: Quabbin Winsor-Dam
Conservation     Conservation     A Maintain Navigation on Connecticut River at Montague	ELSE Conditional Rest of year Description:
IF (Jun thru Nov) IF (Jun thru Nov) IF (Jun thru River flow <4650 cfs	
← ← ELSE IF (Flow < 4900 cfs)	
➡ ELSE (Flow >4900 cfs)	
🦾 🛅 Minimum Release 🗾 Min Water Supply Intake	
nactive	
	scription War Department memos from the 1920's give a 1-June-through-30-Novemb
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched	
Minimum flow to Swift River	Operates Release From: Quabbin Winsor           Rule Name:         Minimum Release   Description:
🖃 {} Maintain Navigation on Connecticut River at Montague	Function of: Date Define
□- → IF (Jun thru Nov) □-{} Connecticut River flow <4650 cfs	Limit Type: Mini V Interp.: Li V
i → IF (Flow < 4650) Release min 110 cfs	302
ELSE IF (Flow < 4900 cfs) □ Release min 70 cfs	Date         Release (cfs)           01Jan         30.0
	296
	Jan Har Hay Jul Sep Hov
Min Water Supply Intake	Period Average Limit Edit
- macine	Hour of Day Multiplier Edit
	Rising/Falling Condition Edit
4 III >	Seasonal Variation Edit

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Maintain Navigation at Connecticut River at Montague

### Rainbow

#### I. Overview

Rainbow Dam is located in the town of Rainbow, CT on the Farmington River. It is owned and operated by the Farmington River Power Company and is used for hydropower generation.

Figure 1 shows the location of Rainbow Dam as it is represented in the HEC-ResSim model. Figure 2 shows the photo of Rainbow Dam.

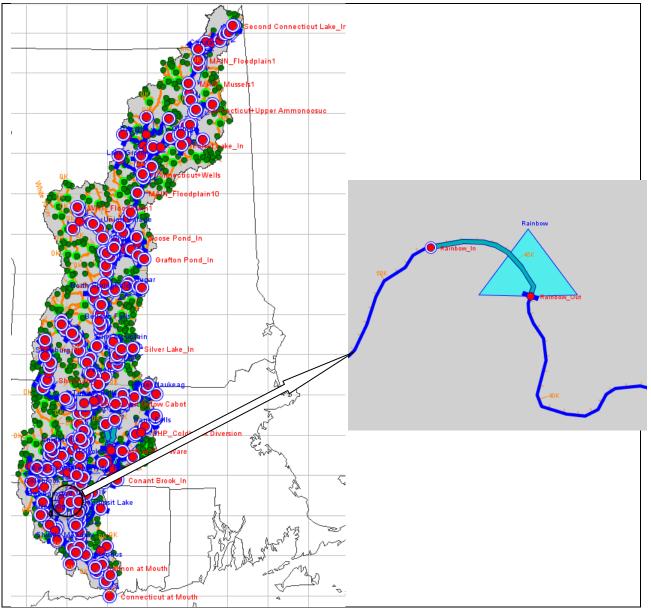


Figure 1: HEC-ResSim Map Display Showing Location of Rainbow



Figure 2: Photo of Rainbow Dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>80</sup>. The dam consists of three types of outlets: (1) controlled sluice gates, (2) controlled spillway, and (3) power plant as shown in Figure 4.

 $<sup>^{\</sup>rm 80}$  Data provided by UMASS

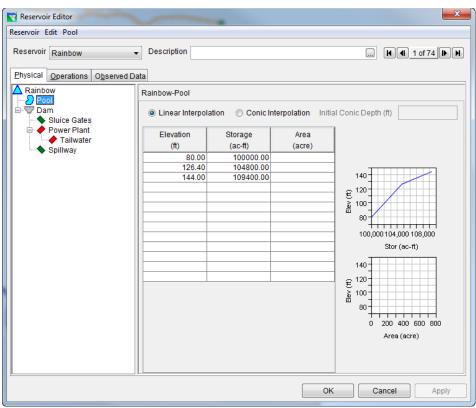


Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor			×
Reservoir Rainbow	Description		
Rainbow Pool	Rainbow-Dam		
Dam Sluice Gates	Elevation at top of dam (ft)	1	44.0
Power Plant	Length at top of dam (ft)	4	100.0
Spillway	Composite Release Capa	city	
	Elevation Controlled	Uncontroll Total	
	(ft) (cfs)	(cfs) (cfs)	140
	82.1 5,000.	0 0.0 5,000.	
	100.0 5,537.	0 0.0 5,537.	
	126.4 6,329.	0 0.0 6,329.	
	132.4 6,539.		
	133.1 10,921.		
	134.0 16,530.		
	134.4 26,530.		
	138.0 49,030.		
	138.4 68,030.		
	143.0 111,030.		
	144.0 129,030.	0 0.0 129,030.	<u>0</u>
			-
			-
			-
			-
L			
		OK	Cancel Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

## III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Raibow's "Existing Ops" operational zones, which consist of zones of Top of dam (144 ft), Conservation (132.4 ft), and Inactive zone (86 ft).

Reservoir Editor	L		at the	×
Reservoir Edit Operations Zo	one Rule IF_Block			
Reservoir Rainbow	<ul> <li>Description</li> </ul>			
Physical Operations Obse	erved Data			
Operation Set Existing Ops	•	Description		
Zone-Rules Rel. Alloc.	utages Stor. Credit De	c. Sched. Projected Ele	ev	
Top of Dam	Storage Zone Conserva	tion Des	cription	
Min Flow	Function of Date			Define
Release=95%Inflow	Date	Top Elevation (ft)	150-	
	01Jan	132.4	150	
			130-	
			€ 120	
			€ 120- 5€ 110- 110-	
			<u>له</u> 100-	
			90-	
			] 80 <del>     </del> Jan Mar May	Jul Sep Nov
			+	
Image: Image	Zone Sort Elevation			
			ок	ancel Apply
				ancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops.

Reservoir Editor
Reservoir Edit Operations Zone Rule I
Reservoir Rainbow
Physical Operations Observed Data
Operation Set Existing Ops
Zone-Rules Rel. Alloc. Outages S
Top of Dam Min Flow Conservation Min Flow Release=95%Inflow Anactive

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

# **C.** Rule Descriptions

#### 1. Min Flow

Figure 7 shows the content of "Min flow" rule. This rule represents the minimum release from Dam as a function of date.

Reservoir Editor Reservoir Edit Operations Zone Rule IF	Black		×
Reservoir Rainbow	Description		
Operation Set Existing Ops	Descriptio     Dec. Sched. Pro	n	
<ul> <li>Top of Dam</li> <li>Min Flow</li> <li>Conservation</li> <li>Min Flow</li> <li>Release=95%Inflow</li> <li>Inactive</li> </ul>	Operates Release From: F Rule Name: Min Flow Function of: Date Limit Type: Minimum Date 01Jan 01Apr 01Jul 15Sep 16Nov	Rainbow-Dam Description: Interp.: Step Release (cfs) 121.0 231.0 121.0	Define      Define      240     200     200     30     160     120     Jan Mar May Jul Sep Nov      Period Average Limit     Hour of Day Multiplier     Edit     Day of Week Multiplier     Edit     Day of Week Multiplier     Edit     Seasonal Variation     Edit
			OK Cancel Apply

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow

#### 2. Release=95%Inflow

Figure 8 shows the content of "Release=95%Inflow" rule. This rule represents the minimum release from Rainbow as a function of inflow as per the run-of-river modeling strategy.

Reservoir Editor		x
Reservoir Edit Operations Zone Rule If	_Block	
Reservoir Rainbow	Description	H I of 74 D
Physical Operations Observed Data		
Operation Set Existing Ops	Description	
Zone-Rules Rel. Alloc. Outages St	or. Credit Dec. Sched. Projected Elev	
Top of Dam	Operates Release From: Rainbow Rule Name: Release=95%Inflow Description:	
Min Flow Release=95%Inflow	Function of: Rainbow-Pool Inflow, Current Value	Define
jan Inactive	Limit Type: Minimum 👻 Interp.: Linear 👻	
	Flow (cfs) Release (cfs)	90,000 0,000 0,000
	100000.0 95000.0	
		0 50,000 100,000 Flow (cfs)
		Period Average Limit Edit
		Hour of Day Multiplier     Edit     Day of Week Multiplier     Edit
		Rising/Falling Condition Edit
		Seasonal Variation Edit
	-	
	]	
		OK Cancel Apply

Figure 8 Reservoir Editor: Operations Tab – Existing Ops OpSet – Release=95%Inflow

# **Red Bridge**

### I. Overview

Red Bridge dam is located in the towns of Wilbraham and Ludlow, MA on the Chicopee River. It is owned and operated by Essential Power LLC and is operated as run-of-river hydropower generating facility.

Figure 1 shows the location of Red Bridge dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Red Bridge dam.

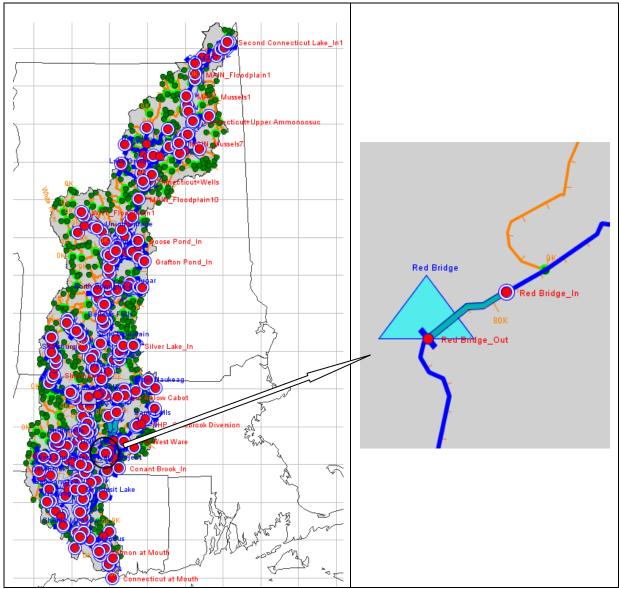


Figure 1: HEC-ResSim Map Display Showing Location of Red Bridge Dam



Figure 2: Photo of Red Bridge dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>81</sup>. The dam consists of two types of outlets: (1) uncontrolled outlet and (3) power plant as shown in Figure 4<sup>1,82</sup>. The capacity of the power plant was made to be the maximum release specified in the NID database so that the dam would modeled completely as run-of-river with some actual physical information

<sup>&</sup>lt;sup>81</sup> National Inventory of Dams database (NID)

<sup>&</sup>lt;sup>82</sup> http://www.lowimpacthydro.org/lihi-certificate-96-red-bridge-project-ma.html

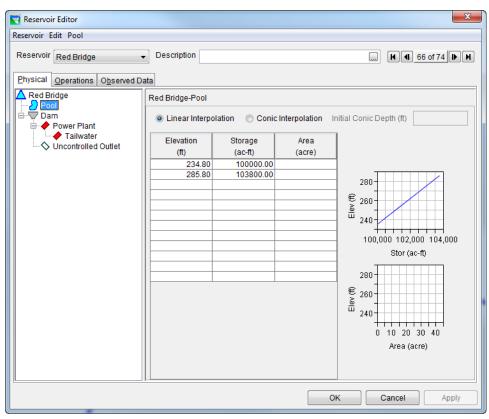


Figure 3: Reservoir Editor: Physical Tab – Pool

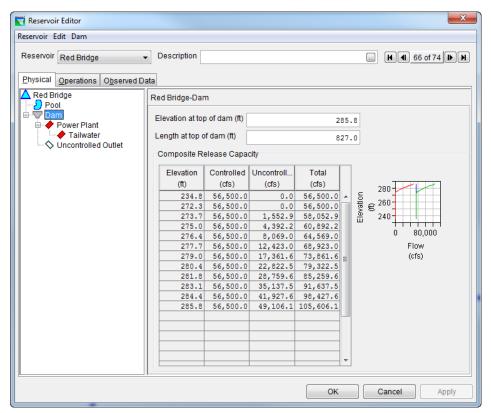


Figure 4: Reservoir Editor: Physical Tab -- Dam

## III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Red Bridge's "Guide Curve" operational zones, which consist of Top of Dam (285.8 ft), Conservation (271.3 ft), and Inactive zone (235.8 ft)<sup>2</sup>.

Reservoir Editor
Reservoir Edit Operations Zone Rule IF_Block
Reservoir Red Bridge   Description
Physical Operations Observed Data
Operation Set Guide Curve   Description
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev
Image: Conservation     Storage Zone     Conservation
A Inactive Function of Date Define
Date Top Elevation (ft)
01Jan 271.3 A 280 280 280 280 280 280 280 280 280 280
€ 270
230
· · · · · · · · · · · · · · · · · · ·
Zone Sort Elevation
OK Cancel Apply

Figure 5: Reservoir Editor: Operations Tab –Guide Curve OpSet – Guide Curve

## **B. Rule Illustrations**

The operation set for Red Bridge has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity. This was modeled this way because no real operation information was found.

# Searsburg

#### I. Overview

Searsburg dam is located on the Deerfield River upstream of Harriman. It is owned and operated by TransCanada Hydro Northeast Inc. for hydropower generation on a peaking, seasonal storage basis.

Figure 1 shows the location of Searsburg Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo from Searsburg Dam.

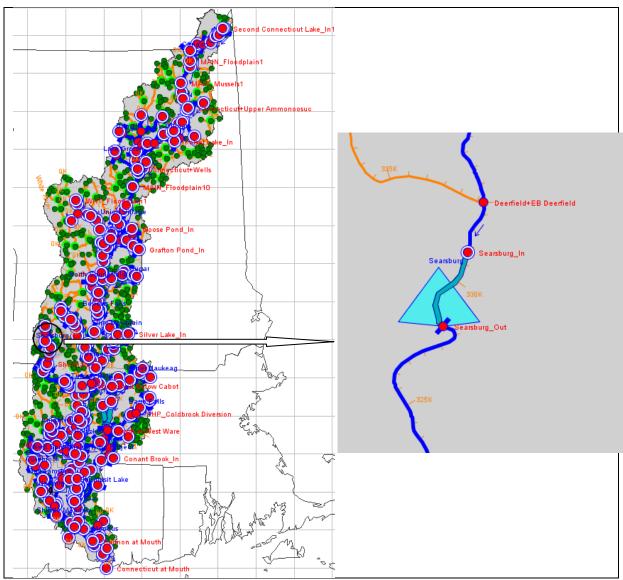


Figure 1: HEC-ResSim Map Display Showing Location of Searsburg dam

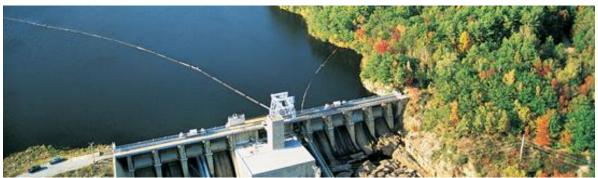


Figure 2: Photo of Searsburg Dam

## II. Physical Characteristics

.

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>83</sup>. The dam consists of five types of outlets: (1) controlled sluice, (2) controlled waste gate, (3) uncontrolled spillway over 5ft flashboards, (4) spillway over clear crest, and (5) power plant as shown in Figure 4.

<sup>&</sup>lt;sup>83</sup> Data provided by TransCanada

servoir Edit Pool				
eservoir Searsburg 🗸	Description			K 4 38 of 74 D
hysical Operations Observed Da	ta			
Searsburg	Searsburg-Pool			
Dam Dam ◆ Tailwater	Linear Interpolation	Conic Interpo	lation Initial C	Conic Depth (ft)
Power Plant	Elevation	Storage	Area	
sluice	(ft)	(ac-ft)	(acre)	
waste gate			(acre)	
	1731.66	100000.00		
spillway over clear crest	1731.76 1731.86	100000.74 100001.49		
	1731.80	100001.49		= =
	1732.06	100002.23		
	1732.16	100003.72		
	1732.26	100004.46		
	1732.36	100005.21		-
	1732.46	100005.95		1,760
	1732.56	100006.69		
	1732.66	100007.44		€ 1,750
	1732.76	100008.26		
	1732.86	100009.09		â 1,740
	1732.96	100009.92		
	1733.06	100010.74		
	1733.16	100011.57		
	1733.26	100012.40		Stor (ac-ft)
	1733.36	100013.22		1,760
	1733.46	100014.05		
	1733.56	100014.88		€ 1,750
	1733.66	100015.70		
	1733.76	100016.61		<u> <u> <u> </u> <u> </u></u></u>
	1733.86	100017.52 100018.43		1,730
	1733.96	100018.43		600 1,200 1,800
	1734.00	100019.34		Area (acre)
	1734.10	100020.25		Alea (acie)
	1734.20	100022.07		
	1734.46	100022.98		
	1734.56	100023.88		
	1734.66	100024.79		
	1734.76	100025.79		
	1734.86	100026.79		
	1734.96	100027.79		
	1735.06	100028.79		
	1735.16	100029.79		<b>*</b>

Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor		-	ar Statut	
eservoir Edit Dam				
Reservoir Searsburg	Description			K 4 38 of 74 D H
locaraburg				
Physical Operations Observed D	ata			
A Searsburg				
Pool	Searsburg-Dam			
🗄 🖳 🔽 Dam	Elevation at top of dam (ft)		1784.66	]
Tailwater			1704.00	]
<ul> <li>Power Plant</li> <li>sluice</li> </ul>	Length at top of dam (ft)		475.0	
waste gate	Composite Release Cap	acity		
spillway over 5 ft flashboa		-		
spillway over clear crest	Elevation Contro		Total	
	(ft) (cfs	) (cfs)	(cfs)	1,780
	1,731.7	287.0 0.0	287.0 🔺 👌	1,780 € 1,760 1,740
		329.5 0.0	329.5 tex	€ ','** +
		372.0 0.0	372.0 ≡ 🗒	1,740
		414.5 0.0	414.5	0 12,000
		457.0 0.0	457.0	
		499.5 0.0	499.5	Flow
		542.0 0.0 584.5 0.0	542.0	(cfs)
		584.5 0.0 627.0 0.0	627.0	
		669.5 0.0	669.5	
		712.0 0.0	712.0	
		754.5 0.0	754.5	
		797.0 0.0	797.0	
	1,734.3	839.5 0.0	839.5	
	1,734.5	882.0 0.0	882.0	
	1,734.7	924.5 0.0	924.5	
		967.0 0.0	967.0	
		009.5 0.0	1,009.5	
		052.0 0.0	1,052.0	
		094.5 0.0	1,094.5	
		137.0 0.0 179.5 0.0	1,137.0	
		222.0 0.0	1,222.0	
		264.5 0.0	1,222.0	
		307.0 0.0	1,307.0	
		349.5 0.0	1,349.5	
		392.0 0.0	1,392.0	
	1,737.1 1,	434.5 0.0	1,434.5	
		477.0 0.0	1,477.0	
		519.5 0.0	1,519.5	
		562.0 0.0	1,562.0	
· · · · · · · · · · · · · · · · · · ·	1,737.9 1,	604.5 0.0	1,604.5	
	]			
			ОК	Cancel Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Searsburg's "ExistingOps" operational zones, which consist of zones of Top of dam (1784.66 ft), conservation (1754.66 ft), Min Pool (1743.66-1746.66 ft), Buffer Inactive (1720 ft), and Inactive zone (1704.6 ft)<sup>1</sup>.

🟹 Reservoir Editor	-	-	-	×
Reservoir Edit Operations Zone Rule IF_E	llock			
Reservoir Searsburg 🗸 De	scription			K d 38 of 74 D H
Physical Operations Observed Data				
Operation Set ExistingOps	<ul> <li>Description</li> </ul>	۱		
Zone-Rules Rel. Alloc. Outages Stor.	Credit Dec. Sched. Pro	jected Elev		
👝 Top of dam 🛅 Max Power Plant First	Storage Zone conservat	tion	Descript	tion
conservation	Function of Date			Define
Max CC Minimum Flow Bypass	Date 01Jan	Top Elevation	(ft) 54.66	1,790
<ul> <li>{ } smelt spawning</li> <li>{ } peaking power_Searsburg_Z2</li> <li>[ ] removal of flashboards in winter</li> </ul>			54.00	1,780
Min Pool				€ 1,760
Minimum Flow Bypass				1,760 1,750 1,750 1,740 1,740 1,730
<ul> <li>Fremoval of flashboards in winter</li> <li>Buffer Inactive</li> </ul>				1,720
			_	1,700 Jan Mar May Jul Sep Nov
	Zone Sort Elevation			
			[	OK Cancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

Figure 6 shows a sequential release allocation approach specified for available outlets along Harriman Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The sluice gets the remainder of the release until it reaches capacity. After the capacity through the sluice is reached, the remainder of the release goes through the waste gate and the rest is passing through the spillway over the clear crest.

🟹 Reservoir Editor	Salari in Carolina, and
Reservoir Edit Operations	
Reservoir Searsburg	
Physical Operations Observed Data	
Operation Set ExistingOps	Description
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. S	Sched. Projected Elev
Release Allocation Strategy	
Searsburg - Balanced	Release Location: Searsburg-Dam
Searsburg-Dam (1.0) - Sequential	Allocation Type: Sequential
Searsburg-sluice Searsburg-waste gate Searsburg-spillway over clear crest	Searsburg-Power Plant Searsburg-sluice Searsburg-waste gate Searsburg-spillway over clear crest

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

# **B.** Rule Illustrations

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops (TransCanada Corporation).

Reservoir Editor
Reservoir Edit Operations Zone Rule IF_Blo
Reservoir Searsburg 🗸 Des
Physical Operations Observed Data
Operation Set ExistingOps
Zone-Rules Rel. Alloc. Outages Stor. C
<ul> <li>Top of dam</li> <li>Max Power Plant First</li> <li>removal of flashboards in winter</li> <li>conservation</li> <li>Max CC</li> <li>Minimum Flow Bypass</li> <li>IF (1 April-15 Jun)</li> <li>decresing rate of change</li> <li>ELSE IF (16 Jun-15 Jul)</li> <li>Max drawdown</li> <li>ELSE IF (16 Jun-15 Jul)</li> <li>Max drawdown</li> <li>Peaking power_Searsburg_Z2</li> <li>IF (code=0)</li> <li>Hydropower Release Inflow</li> <li>ELSE IF (code=1)</li> <li>2HrsGen_Z2</li> <li>ELSE IF (code=3)</li> <li>Hydropower Release Inflow</li> <li>ELSE IF (code=4)</li> <li>No power</li> <li>removal of flashboards in winter</li> <li>Max CC</li> </ul>
Minimum Flow Bypass
<ul> <li>➡ IF (1 April-15 Jun)</li> <li>➡ decressing rate of change</li> <li>➡ ELSE IF (16 Jun-15 Jul)</li> <li>➡ Max drawdown</li> </ul>
Buffer Inactive

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

# **C.** Rule Descriptions

#### 1. Max Power Plant First

Figure 8 shows the content of "Max Power Plant First" rule. This rule forces the inflow to pass through the power plant first until it reaches the maximum plant capacity.

Zone-Rules       Rel. Alloc.       Outages       Stor. Credit       Dec. Sched.       Projected Elev         Top of dam       Operates Release From: Searsburg-Power Plant       Rule Name:       Max Power Plant First       Description:         Top of dam       Operates Release From: Searsburg-Power Plant       Rule Name:       Max Power Plant First       Description:         Top of dam       Function of:       Searsburg-Pool Net Inflow, Current Value       Defin         Type Simult Spawning       Interp.:       Linear       300									
Max Power Plant First       Coperates Release From: Searsburg-Found Se	Zone-Rules Rel. Alloc. Outages Stor. Credit. Dec. Sched. Projected Elev.								
Flow (cfs)       Release (cfs)         Min Pool       0.0       0.0         Minimum Flow Bypass       287.04       287.04         Smelt spawning       123456.0       287.04         Buffer Inactive       0       0         Inactive       0       0         Flow (cfs)       123456.0       287.04         Duffer Inactive       0       0         Flow (cfs)       100									

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Power Plant First

### 2. Removal of flashboards in winter

Figure 9 shows the content of "removal of flashboards in winter" rule. This rule represents the releases through spillways when the flashboards are removed in winters.

one-Rules Rel. Alloc. Outages Stor.	Credit Dec. Sche	d. Projected Elev								
Top of dam	Operates Relea	se From: Searsburg-	spillway over clear o	crest						
Max Power Plant First	Rule Name: (al	Rule Name: val of flashboards in winter Description:								
conservation										
Max CC	Function of: Searsburg-Pool Elevation, Current Value Define									
Minimum Flow Bypass	Limit Type: Ma	aximum	<ul> <li>Interp.: Line</li> </ul>		1					
-{ } smelt spawning	Linit Type. Ma	aximum		ar 🔻	14.000					
Paking power_Searsburg_Z2	Elev		Release (cfs)							
	(ft)	041			12,000					
Min Pool Max CC		01Jan	01May	010ct	10,000					
Max CC Minimum Flow Bypass	1644		0.0	0.0	8,000					
-{} smelt spawning	1644		0.0	22.0						
- removal of flashboards in winter	1644		0.0	74.0	8 6,000 4,000					
Buffer Inactive	1644		0.0	104.0	a 4,000					
Inactive	1644		0.0	136.0	2,000					
	1644		0.0	172.0						
	1644	1.7 214.0	0.0	214.0	0+7++++++++++++++++++++++++++++++++++++					
	1644	1.8 260.0	0.0	260.0						
	1644		0.0	309.0	Elev (ft)					
	1645		0.0	363.0						
	1645		0.0	422.0	Period Average Limit					
	1645		0.0	486.0	Hour of Day Multiplier Edit					
	1645		0.0	556.0 703.0	Day of Week Multiplier					
	1645		0.0	703.0	E Day of week multiplier					
	1645		0.0	781.0	Rising/Falling Condition Edit					
	1645		0.0	861.0	Seasonal Variation Edit.					
	1645		0.0	944.0						
	1645	5.9 1030.0	0.0	1030.0						
	1646	5.0 1120.0	0.0	1120.0						
	1646		0.0	1220.0						
	1646		0.0	1320.0						
	1646	5.3 1420.0	0.0	1420.0						
	1646	6.4 1620.0	0.0	1620.0						

Figure 9 Reservoir Editor: Operations Tab – Existing Ops OpSet – removal of flashboards in winter

#### 3. Max CC

Figure 10 represents the content of "Max CC" rule. This rule limits the channel capacity to 340 cfs.

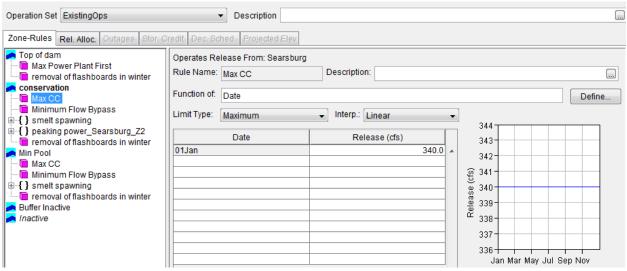


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max CC

#### 4. *Minimum Flow Bypass*

Figure 11 shows the content of "Minimum Flow Bypass" which shows a seasonal minimum flow as a function of Inflow.

Operation Set ExistingOps		<ul> <li>Desc</li> </ul>	ription					
Zone-Rules Rel. Alloc. Outages Stor	. Credit Dec.	Sched.	Projected B	lev				
Top of dam Max Power Plant First removal of flashboards in winter conservation	Operates R Rule Name: Function of:	Minimun	n Flow Byp	ass	Description: Current Valu		in Ta	ailrace from April to mid May is 175 cfs ti
Max CC  Minimum Flow Bypass   Small spawning	Limit Type:	Minimun	-		erp.: Linea		•	
Pedaling power_oceasions      removal of flashboards in winter     Min Pool     Max CC	Flow (cfs)	01Jan 0.0	20Apr 30.0	elease (c 16May 0.0	fs) 01Jun 0.0	010ct 0.0		
Minimum Flow Bypass 	35.0 55.0 175.0	35.0 55.0 55.0	60.0 85.0 175.0	35.0 55.0 55.0	35.0 35.0 35.0	35.0 55.0 55.0	^	0 60,000 120,000
Buffer Inactive Inactive Inactive	123456.0	55.0	175.0	55.0	35.0	55.0		Flow (cfs)  Period Average Limit Edit
								Hour of Day Multiplier     Edit     Day of Week Multiplier     Edit
					I			<ul> <li>Rising/Falling Condition</li> <li>Edit</li> <li>Seasonal Variation</li> <li>Edit</li> </ul>
							Ŧ	

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Minimum Flow Bypass

### 5. Smelt Spawning

Figure 12 describes the content of "smelt spawning" rule. Based on this rule during Apr1-Jun 15 maximum rate of elevation change is zero, and during Jun 16-Jul 15 the maximum rate of change is one ft/hr.

Operation Set ExistingOps	✓ Description			[.				
Zone-Rules Rel. Alloc. Outages Stor	Credit Dec. Sched. Projected Elev							
<ul> <li>Top of dam</li> <li>Max Power Plant First</li> <li>removal of flashboards in winter</li> <li>conservation</li> </ul>	Operates Release From: Searsburg Name: smelt spawning	Description:						
Max CC Minimum Flow Bypass ↓ Smelt spawning ↓ → IF (1 April-15 Jun) ↓ ⊕ decresing rate of change	Type Name IF 1 April-15 Jun ELSE IF 16 Jun-15 Jul		Description					
Deration Set ExistingOps	Description							
Zone-Rules Rel. Alloc. Outages Stor								
Top of dam	Operates Release From: Searsburg							
Max Power Plant First	IF Conditional 1 April-15 Jun	Description:						
conservation     Max CC     Minimum Flow Bypass     organization	Value1 Current Time Step	>=	Value2 01Apr	Add Cond.				
S smelt spawning     F (1 April-15 Jun)     G decresing rate of change     → ELSE IF (16 Jun-15 Jul)     G Max drawdown	AND Current Time Step	<=	15Jun	Del. Cond.				
Operation Set ExistingOps	▼ Description							
Zone-Rules Rel. Alloc. Outages Stor	Credit Dec. Sched. Projected Elev							
Top of dam	Operates Release From: Searsburg Elevation Rate of Change Limit decre	cing rate of change						
removal of flashboards in winter conservation Max CC	Description	sing rate of change	5					
Minimum Flow Bypass	Function Of: Constant		•					
→ IF (1 April-15 Jun)	Type Decreasing		•					
ELSE IF (16 Jun-15 Jul)	<ul> <li>Instantaneous</li> <li>Period Average</li> </ul>							
removal of flashboards in winter	Max Rate of Change (ft/hr)	0.0						
Operation Set ExistingOps	Description							
Zone-Rules Rel. Alloc. Outages Stor.	Credit Dec. Sched. Projected Elev							
Top of dam	Operates Release From: Searsburg							
removal of flashboards in winter	ELSE IF Conditional 16 Jun-15 Jul	Descri	iption:					
Max CC	Value1 Current Time Step	>=	Value2 16Jun	Add Cond.				
<ul> <li>→ IF (1 April-15 Jun)</li> <li>→ IF (1 April-15 Jun)</li> <li>↓ Gecresing rate of change</li> </ul>	AND Current Time Step	<=	15Jul	Del. Cond.				
ELSE IF (16 Jun-15 Jul)								

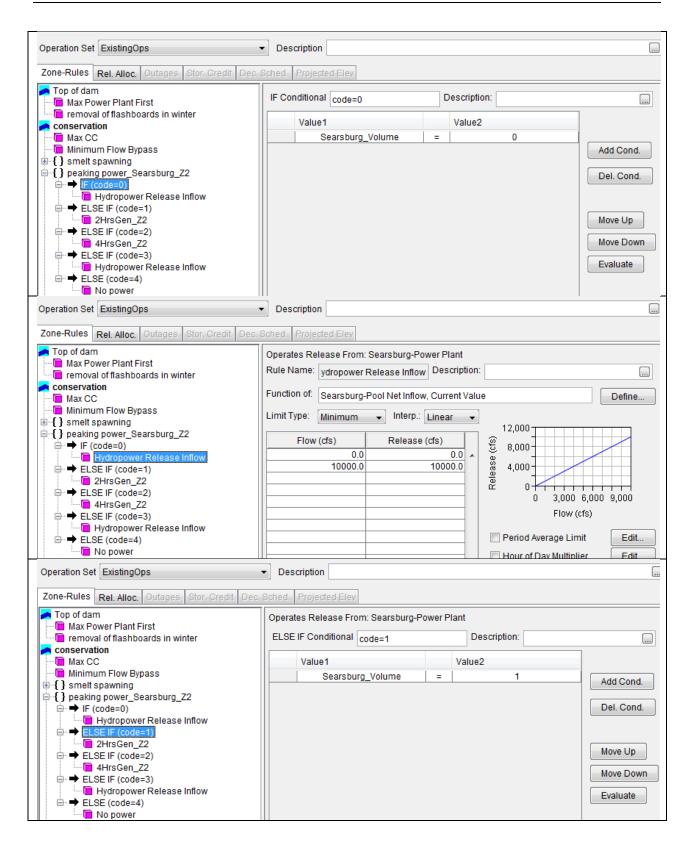
Operation Set ExistingOps	✓ Description	)
Zone-Rules Rel. Alloc. Outages Stor	Credit Dec. Sched. Projected Elev	
<ul> <li>Top of dam</li> <li>Max Power Plant First</li> <li>removal of flashboards in winter</li> <li>conservation</li> </ul>	Operates Release From: Searsburg Elevation Rate of Change Limit Max drawdown	
Max CC	Function Of: Constant	
<ul> <li>☐ { smelt spawning</li> <li>☐ ↓ IF (1 April-15 Jun)</li> <li>☐ decresing rate of change</li> </ul>	Type Decreasing -	
	<ul> <li>Instantaneous</li> <li>Period Average</li> </ul>	
removal of flashboards in winter	Max Rate of Change (ft/hr) 1.0	

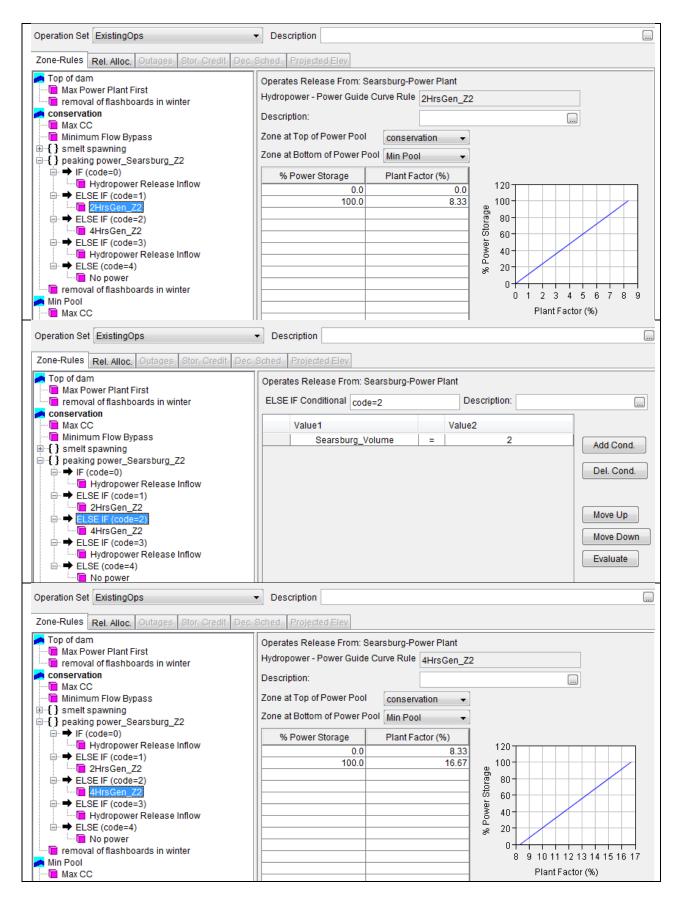
Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Smelt Spawning

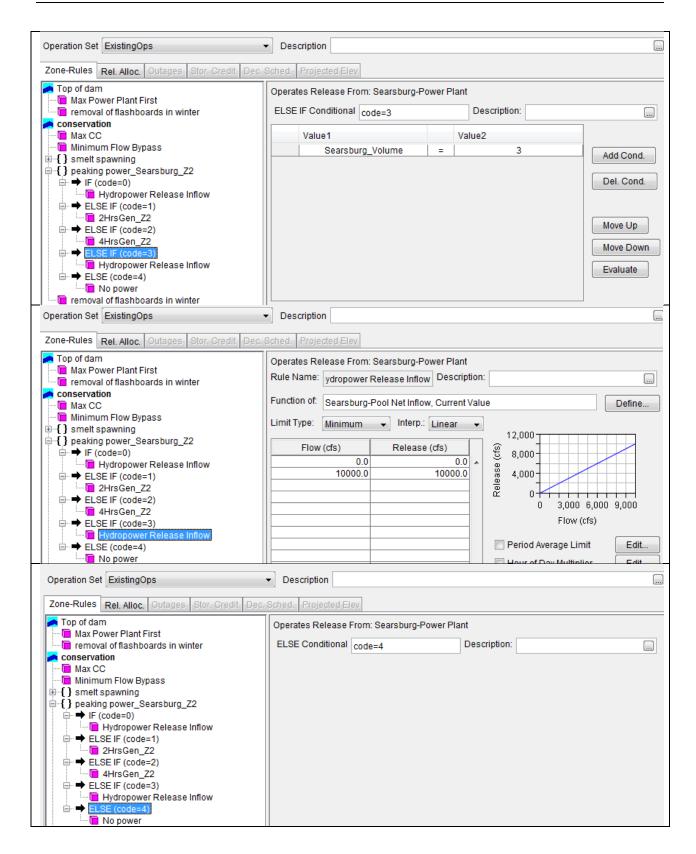
### 6. Peaking power\_Searsburg\_Z2

This rule represents power strategy applied for Searsburg reservoir. The content of the rule is shown in Figure 11 as per the peaking hydropower modeling strategy.

Operation Set ExistingOps	<ul> <li>Description</li> </ul>			
Zone-Rules Rel. Alloc. Outages Stor, Credit Dec.	Sched. Project	ed Elev		
Top of dam Max Power Plant First	Name: ding p	oower_Searsburg_Z2 D	escription:	
Temoval of flashboards in winter	Туре	Name	Description	
Max CC	IF	code=0		
Minimum Flow Bypass	ELSE IF	code=1		
	ELSE IF	code=2		
<pre>peaking power_Searsburg_Z2</pre>	ELSE IF	code=3		
➡ ➡ IF (code=0)	ELSE	code=4		
Hydropower Release Inflow				
ELSE IF (code=1)				
2HrsGen_Z2				
ELSE IF (code=2)				
HrsGen_Z2				
ELSE IF (code=3)				
Hydropower Release Inflow				
ELSE (code=4)				
No power				
removal of flashboards in winter				
in Pool 🦰				
Max CC				
Minimum Flow Bypass				
⊞{} smelt spawning				
removal of flashboards in winter				
A Buffer Inactive				
📂 Inactive				







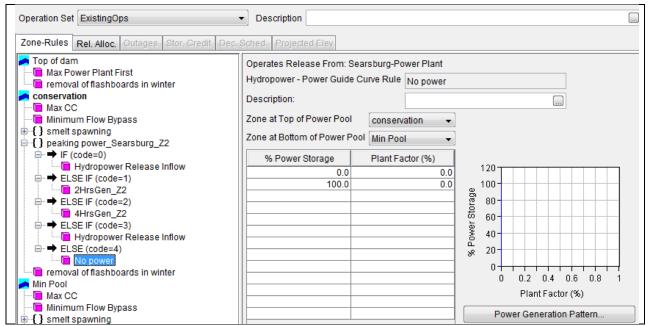


Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Hydropower\_Searsburg\_Z2

Figure 14 describes the definition of codes used in the Searsburg\_Volume state variable. The code is summing up the current Inflow and previous storage in each time step, compare it to the volume needed for generating 2 and 4 hours power and to the spillway storage minus inactive storage and then decide how much to release.

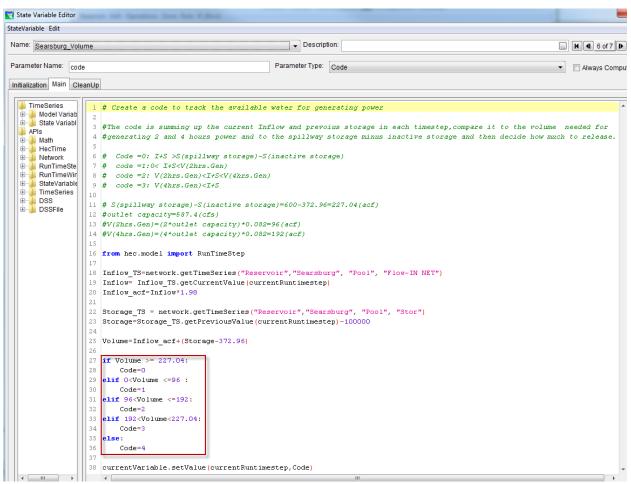


Figure 14: State Variable Editor: Searsburg\_Volume

## Second Connecticut Lake

#### I. Overview

Second Connecticut Lake dam is located 8 miles south of the Canadian border on the mainstem Connecticut River. It is owned and operated by TransCanada Hydro Northeast Inc. as a storage reservoir to make releases to its downstream hydro facilities.

Figure 1 shows the location of Second Connecticut Dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo from Second Connecticut Dam.

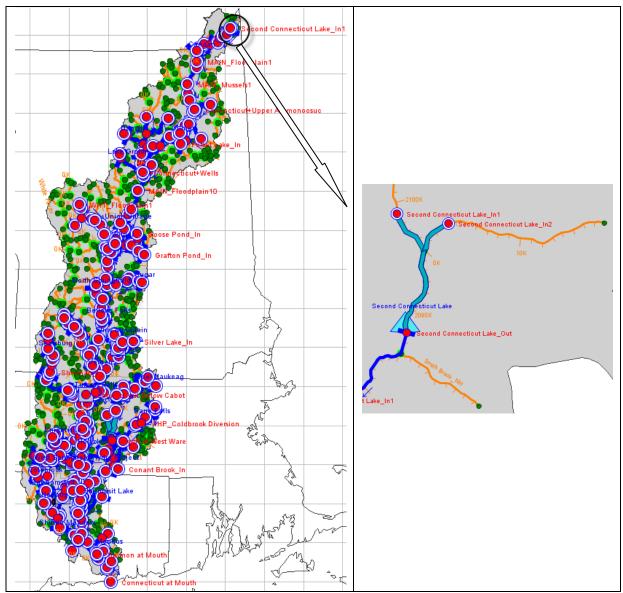


Figure 1: HEC-ResSim Map Display Showing Location of Second Connecticut Dam



Figure 2: Photo of Second Connecticut Dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>84</sup>. The dam consists of four types of outlets: (1) controlled Log way, (2) uncontrolled spillway, (3) controlled Fish Pipe, and (4) controlled Waste way as shown in Figure 4.

<sup>&</sup>lt;sup>84</sup> Data provided by TransCanada

eservoir Edit Pool					
Reservoir Second Connecticut	<ul> <li>Description</li> </ul>				K ◀ 13 of 74
Physical Operations Observed	Data				
Second Connecticut Lake	Second Connecticut	Lake-Pool			
Dam Log Way	Linear Interpola	ation 🔘 Conic Inte	erpolation Initi	al Conic Depth (ft)	
Spillway	Elevation	Storage	Area		
Fish Pipe	(ft)	(ac-ft)	(acre)		
Wasteway	1858.00	0.00	(/		
	1858.10	79.30		1,876	
	1858.20	160.70		≡ 1,872	
	1858.30	242.00		€ 1,868	
	1858.40	321.30			
	1858.50	402.60		à 1,864	
	1858.60	484.00		1,000	
	1858.70	563.30		1,856+	
	1858.80	644.60		- 0	8,000 16,000
	1858.90	724.00			Stor (ac-ft)
	1859.00	805.30		1,876	
	1859.10	888.60		1,872	
	1859.20	971.90		€ 1,868	
	1859.30	1055.20		à 1,864	
	1859.40	1136.50		± 1,804 ± 1,860	
	1859.50	1211.80		1,000	
	1859.60	1303.10			
	1859.70	1386.40			1,500 3,000 4,500
	1859.80	1469.80			Area (acre)
	1859.90	1553.10			
	1860.00	1638.30			
	1860 10	1723.60		<b>T</b>	

Figure 3: Reservoir Editor: Physical Tab -- Pool

🟹 Reservoir Editor	/				×
Reservoir Edit Dam					
Reservoir Second Connecticut	✓ Description				K d 13 of 74 D D
Physical Operations Observed	Data				
Second Connecticut Lake	Second Connection	cut Lake-Dam			
Dam Log Way	Elevation at top of	of dam (ft)		1875	
Spillway Fish Pipe	Length at top of (	Jam (ft)		118	
Wasteway	Composite Rel	ease Capacity			
	Elevation	Controlled	Uncontrolled	Total	1
	(ft)	(cfs)	(cfs)	(cfs)	
	1,852.0	0.0	0.0	0.0 🔺	E 1,870 € 1,860
	1,856.0	109.1	0.0	109.1	👮 € 1,860-
	1,861.5	263.1	0.0	263.1	
	1,862.0	282.7	0.0	282.7	
	1,862.5	313.3	0.0	313.3 =	0 3,000 6,000
	1,863.0	348.9	0.0	348.9	Flow
	1,863.5	389.5	0.0	389.5	(cfs)
	1,864.0	434.1	0.0	434.1	
	1,864.5	483.8	0.0	483.8	
	1,865.0	536.4	0.0	536.4	
	1,865.5	592.0	0.0	592.0	
	1,866.0	649.2	0.0	649.2	
	1,866.5	709.4	0.0	709.4	
	1,867.0	772.5	0.0	772.5	
	1,867.5	838.7	0.0	838.7	
	1,868.0	906.9	0.0	906.9	
	1,868.5	976.6	0.0	976.6	
	1 950 0	1 0/0 2	0 0	1 040 2	L
				ОК	Cancel Apply
	-				

Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Second Connecticut Dam's "Existing Ops" operational zones, which consist of zones of Top of dam (1875 ft), Below Top of dam (1874 ft), Conservation (1861.248-1867.215 ft), Operational Inactive (1860 ft), and Inactive zone (1859 ft). The Conservation Pool Elevation curve was created from 10 years of weekly average pool elevation<sup>1</sup>.

Reservoir Editor	1-		- L.	×
Reservoir Edit Operations Zone Rule If	F_Block			
Reservoir Second Connecticut 🔻	Description			K I <u>13 of 74</u>
Physical Operations Observed Data				
Operation Set Existing Ops	✓ Descripti	on		
	or. Credit Dec. Sched. P	rojected Elev		
Top of Dam	Storage Zone Conserva	tion Descri	ption	
Min Flow Conservation	Function of Date			Define
Min Flow Operational Inactive	Date	Top Elevation (ft)	1,876	
⊞ -{ } Seasonal Min	01Jan 10Jan	1865.711 1865.661	1,874	
inactive 🔁	20Jan	1865.495	1,872	
	31Jan	1865.269	- 1.870-	
	10Feb	1864.533	= € 1,070	
	20Feb	1864.384	E € 1,870 U 1,868 E 1,866 E 1,866 U 1,864 U 1,864	
	28Feb	1862.902		
	10Mar	1861.887	<u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u></u>	
	20Mar	1861.248	1,862	
	31Mar	1862.034	1,860	
	10Apr	1863.308	1,858	
	20Apr	1865.289	Jan M	Mar May Jul Sep Nov
	30Apr	1866.577		
	10May	1866.733		
	20May	1866.634		
	31May	1866.418	_	
	10Jun	1866.72	<u> </u>	
	Zone Sort Elevation			
			ОК	Cancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>85</sup>.

Reservoir Editor
Reservoir Edit Operations Zone Rule
Reservoir Second Connecticut 🔻
Physical Operations Observed Data
Operation Set Existing Ops
Zone-Rules Rel. Alloc. Outages
Top of Dam Below Top of Dam Min Flow Conservation Min Flow Operational Inactive Generational Inactive Fly Seasonal Min Fly Se

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>&</sup>lt;sup>85</sup> TransCanada. Connecticut River Operational Constraints. 2012.

# **C.** Rule Descriptions

#### 1. Min Flow

Figure 7 shows the content of "Min Flow" rule. This rule represents the minimum release from dam as a function of date.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>	n	
Zone-Rules Rel. Alloc. Outages St	or. Credit Dec. Sched. Pro	pjected Elev	
Top of Dam Below Top of Dam Min Flow Conservation Min Flow Operational Inactive Hereit Seasonal Min Inactive	Operates Release From: S Rule Name: Min Flow Function of: Date Limit Type: Minimum Date 01Jan 01Jun 01Oct	Second Connecticut Lake-Dar Description: Interp.: Step Release (cfs) 45.0 45.0  	n Define

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow

### 2. Seasonal Min

Figure 8 shows the content of "Seasonal Min" rule. It represents a minimum release of 22.5 cfs for inflows greater than 22.5 cfs in summer and 45 cfs for inflows greater than 45 cfs in the rest of the year.

Operation Set Existing Ops   Description						
Zone-Rules Rel. Alloc. Outages Sto	or. Credit Dec. Sch	hed. Projected Ele	ev			
<ul> <li>Top of Dam</li> <li>Below Top of Dam</li> </ul>	Name: Seasona	al Min	Description:			
Min Flow Conservation	Туре	Name		Description		
Min Flow Appendional Inactive		Summer Not Summer				
Gerssonal Min     Gersso						
Operation Set Existing Ops	• D	escription				
	or. Credit Dec. Sci	hed. Projected Ele	ev			
Top of Dam Below Top of Dam	IF Conditional	Summer	Desc	cription:		
Min Flow Conservation	Value1		V	/alue2		
🔚 Min Flow		irrent Time Step irrent Time Step	>=	01Jun 30Sep	Add Cond.	
Operational Inactive  Seasonal Min   F (Summer)  Linactive Min Rule  ELSE (Not Summer)  Inactive Min Rule 2  Anactive					Del. Cond.	
Operation Set Existing Ops	▼ D	escription				
	or. Credit Dec. Sc	hed. Projected El	ev			
👝 Top of Dam	· ·	e From: Second Co				
Min Flow	Rule Name: Inac	ctive Min Rule	Descrip	ition:		
Min Flow	Function of: Sec	ond Connecticut L	ake-Pool Net	Inflow, Current Value	Define	
Operational Inactive Image: Content of the second secon	Limit Type: Mini	imum 👻 Inte	erp.: Linear	<b>•</b>		
→ F F (Summer)     inactive Min Rule     → ELSE (Not Summer)     inactive Min Rule 2     inactive	Flow (cfs	i) Rel 0.0 22.5 00000.0	22	0.0 2.5 2.5 2.5 0 40,000	80,000	
				Flow (		

Operation Set Existing Ops	▼ Description	]
Zone-Rules Rel. Alloc. Outages Sto	or, Credit Dec. Sched. Projected Elev	
Top of Dam Below Top of Dam Min Flow Conservation Min Flow Operational Inactive Seasonal Min Seasonal Min H (Summer) Inactive Min Rule ELSE (Not Summer) Inactive Min Rule 2 Anactive	Operates Release From: Second Connecticut Lake ELSE Conditional Not Summer Description:	
Operation Set Existing Ops	Description	
<ul> <li>Top of Dam</li> <li>Below Top of Dam</li> <li>Min Flow</li> <li>Conservation</li> <li>Min Flow</li> <li>Operational Inactive</li> <li>         I Seasonal Min     </li> <li>         I F (Summer)     </li> <li>         I Inactive Min Rule     </li> <li>         ELSE (Not Summer)     </li> <li>         Inactive Min Rule 2     </li> <li>         Inactive Min Rule 2     </li> </ul>	Operates Release From: Second Connecticut Lake         Rule Name:       Inactive Min Rule 2         Function of:       Second Connecticut Lake-Pool Net Inflow, Current Value         Limit Type:       Minimum Interp.:         Flow (cfs)       Release (cfs)         0.0       0.0         45.0       45.0         100000.0       45.0         0       40,000       80,000         Flow (cfs)       Flow (cfs)	]

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Seasonal Min

## Lake Shenipsit

#### I. Overview

Lake Shenipsit Dam is located in the town of Rockville, CT on the Hockanum River. It is owned and operated by the Connecticut Water Company and used as water supply for the town of Rockville.

Figure 1 shows the location of Lake Shenipsit Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Lake Shenipsit.

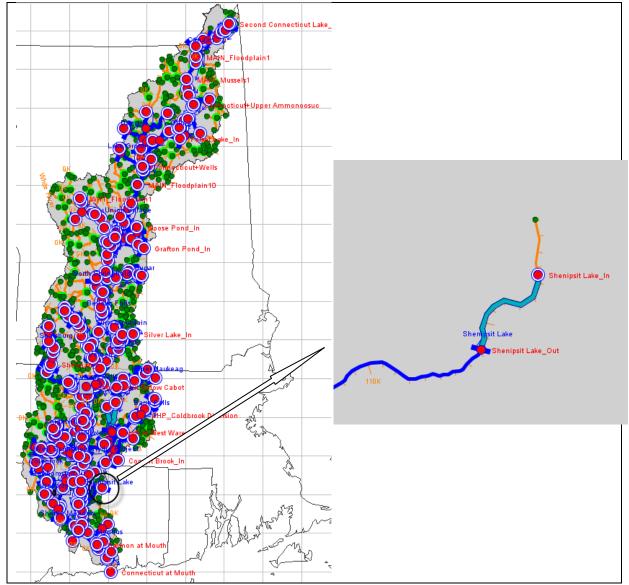


Figure 1: HEC-ResSim Map Display Showing Location of Lake Shenipsit Dam



Figure 2: Photo of Lake Shenipsit

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>86</sup>. The dam consists of two types of outlets: (1) uncontrolled outlet, and (2) controlled water to treatment plant gate as shown in Figure 4.

<sup>&</sup>lt;sup>86</sup> Data provided by Connecticut Water Company.

Reservoir Editor		-			×
Reservoir Shenipsit Lake					K 4 53 of 74 D H
Shenipsit Lake Dom Dam Controlled Outlet	Shenipsit Lake-Pool	tion 💿 Conic Inf	erpolation Ini	ial Conic	Depth (ft)
water to treatment plant	Elevation (ft)	Storage (ac-ft)	Area (acre)		
	480.00 485.00 490.00 500.00 505.00 510.00 511.20 515.00 517.30 520.00	0.00 5300.00 6600.00 10500.00 12800.00 14800.00 15500.00 17900.00 13300.00 21000.00	0.00 320.00 355.00 400.00 520.00 575.00 585.00 660.00 685.00 740.00	Elev (ft) III Elev (ft) A A A A A A A A A A A A A A A A A A A	220 100 100 100 100 100 100 100
				•	Area (acre)
			0	ĸ	Cancel Apply

Figure 3: Reservoir Editor: Physical Tab -- Pool

eservoir Edit Dam Reservoir Shenipsit Lake	<ul> <li>Description</li> </ul>					K € 53 of 74 ► H
Physical Operations Observed D	ata					
Shenipsit Lake	Shenipsit Lake-D	am				
Dam Dam	Elevation at top	of dam (ft)		517.3	3	
<ul> <li>water to treatment plant</li> </ul>	Length at top of	dam (ft)		400.0	D	
	Composite Rel	ease Capacit	у			
	Elevation	Controlled	Uncontrolled	Total	]	
	(ft)	(cfs)	(cfs)	(cfs)		520
	490.0	10.5	0.0	10.5	E	510
	511.2	10.5	0.0	10.5	Elevation	Ê 500
	512.0	10.5	96.0	106.5	ll ∮	490
	512.2	10.5	120.0	130.5		+++++++++++++++++++++++++++++++++++++++
	513.2	10.5	410.0	420.5		0 10,000
	514.2	10.5	800.0	810.5		Flow
	515.2	10.5	1,100.0	1,110.5 ≡		(cfs)
	516.2	10.5	1,700.0	1,710.5		
	517.2	10.5	2,200.0	2,210.5		
	518.2	10.5		3,110.5		
	519.2	10.5		5,010.5		
	520.2	10.5		7,610.5		
	521.2	10.5		10,410.5		
	522.2	10.5		13,210.5		
	523.2	10.5	16,350.0	16,360.5		
					_	

Figure 4: Reservoir Editor: Physical Tab -- Dam

### **B.** Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 4 shows the definition of Shenipsit's "Existing Ops" operational zones, which consist of zones of Top of dam (517.3 ft), Flood control (512 ft), Conservation (511 ft), and Inactive zone (490 ft)<sup>1</sup>.

Reservoir Editor	1 1			· 2		X
Reservoir Edit Operations Zone Rule IF	_Block					
Reservoir Shenipsit Lake 🗸 [	Description					53 of 74 🕨 🕨
Physical Operations Observed Data						
Operation Set Existing Ops	✓ Description	1				
	or. Credit Dec. Sched. Pro	jected Elev				
Top of Dam	Storage Zone Conservation	n	Description	n		
Dam release	Function of Date					Define
<ul> <li>Conservation</li> <li>Dam release</li> <li>Water to treatment plant</li> <li>Inactive</li> </ul>	Date 01Jan	Top Elevatio	n (ft) 511.0	515 - 510 -		
				€ 505 500 495 490 485		
	Zone Sort Elevation			Jan	Mar May Jul Se	sp Nov
			(	ОК	Cancel	Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet

## **B. Rule Illustrations**

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Guide Curve.

Reservoir Editor
Reservoir Edit Operations Zone Rule I
Reservoir Shenipsit Lake 🔻
Physical Operations Observed Data
Operation Set Existing Ops
Zone-Rules Rel. Alloc. Outages S
📕 📥 Top of Dam
Flood Control
Dam release
water to treatment plant
Dam release
🔲 🔲 water to treatment plant
📩 Inactive

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

### **C.** Rule Descriptions

#### 1. Dam release

Figure 6 shows the content of "Dam release" rule. This rule represents the minimum release from Dam as a function of date.

Operation Set Existing Ops	✓ Descriptio	n	
Zone-Rules Rel. Alloc. Outages St	or. Credit Dec. Sched. Pro	pjected Elev	
Top of Dam Flood Control Dam release Dam release Dam release Dam release Dam release Treatment plant Inactive	Operates Release From: S Rule Name: Dam release Function of: Date Limit Type: Minimum Date 01Jan 01Feb 01Mar 01Jun 01Jun 01Jun 01Jun 01Jun 01Jun 01Aug 01Sep 01Oct 01Nov 01Dec	·	Define      2,000     1,600     1,200     0     1,200     0

Figure 6 Reservoir Editor: Operations Tab – Existing Ops OpSet – Dam release

### 2. Water to treatment Plant

Figure 7 shows the content of "Water to treatment" rule. This rule represents the minimum release from "water to treatment plant" gate.

Operation Set Existing Ops	▼ Descriptio	n	
Zone-Rules Rel. Alloc. Outages St	or. Credit Dec. Sched. Pr	ojected Elev	
Top of Dam Flood Control Water to freatment plant Conservation Dam release Water to treatment plant Nater to treatment plant Inactive	Operates Release From: S Rule Name: water to trea Function of: Date Limit Type: Minimum Date 01Jan	Shenipsit Lake-water to treat tment plant Description Interp.: Linear Release (cfs) 10.53	n: Define

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – water to treatment plant

### Sherman

#### I. Overview

Sherman dam is located on the Deerfield River between Readsboro and Monroe. It is owned and operated by TransCanada Hydro Northeast Inc. for hydropower generation on a peaking, weekly storage basis.

Figure 1 shows the location of Sherman dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Sherman dam.

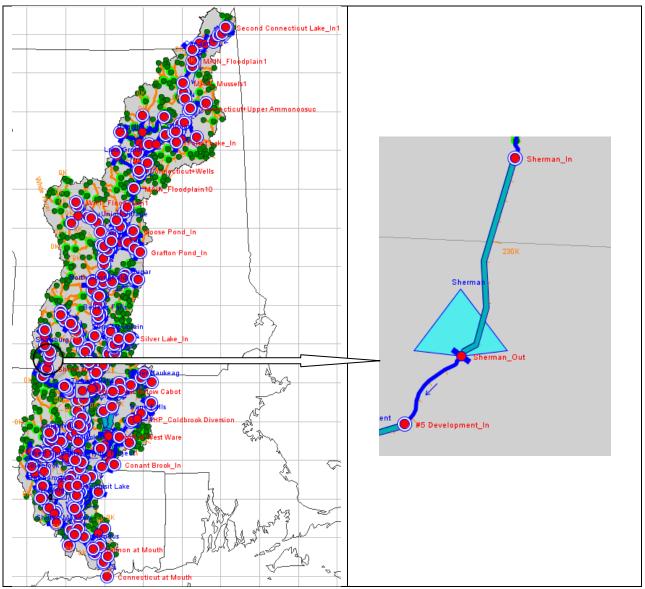


Figure 1: HEC-ResSim Map Display Showing Location of Sherman

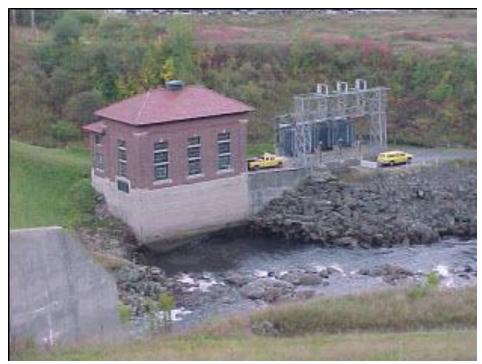


Figure 2: Photo of Sherman dam

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>87</sup>. The dam consists of three types of outlets: (1) controlled spillway, (2) uncontrolled outlet, and power plant as shown in Figure 4.

<sup>&</sup>lt;sup>87</sup> Data provided by TransCanada

servoir Edit Pool				
leservoir Sherman	<ul> <li>Description</li> </ul>			K 4 40 of 74 🕨
hysical Operations Observed	Data			
Sherman	Sherman-Pool			
Dam				
Dam → Dam	Linear Interpolation	on 💿 Conic Interp	olation Initial C	conic Depth (ft)
Power Plant				
Spillway	Elevation	Storage	Area	
Uncontrolled Outlet	(ft)	(ac-ft)	(acre)	
	1083.66	100000.00		1,110
	1083.76	100009.50		
	1083.86	100019.01		
	1083.96	100028.51		à 1,090
	1084.06	100038.02		1,080
	1084.16	100047.52		100,000 102,500 105,000
	1084.26	100057.02		
	1084.36	100066.53		Stor (ac-ft)
	1084.46	100076.03		4 4 4 0
	1084.56	100085.54		1,110
	1084.66	100095.04		€ 1,100
	1084.76	100104.96		
	1084.86	100114.88		凿 1,090
	1084.96	100124.79		1,080
	1085.06	100134.71		600 1,200 1,800
	1085.16	100144.63		
	1085.26	100154.55		Area (acre)
	1085 36	100164.46		

Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor				X
Reservoir Edit Dam				
Reservoir Sherman	Description		]	
Physical Operations Observed Da	ata			
A Sherman	Sherman-Dam			
□ □ → Dool □ · · · · · · Dom □ · · · · · · · · · · · · · · · · · · ·	Elevation at top of dam (ft)		1127.6	
Power Plant	Length at top of dam (ft)		810.0	
Spillway				
Uncontrolled Outlet	Composite Release Capa	ity		
	Elevation Controll	d Uncontrolled	Total	
	(ft) (cfs)	(cfs)	(cfs)	1,130
	1,098.6 1,28			1,120
	1,103.7 1,28			1,110
	1,103.8 1,28	8.8 14.0	1,302.8	1,100
	1,103.9 1,28	8.8 44.0	1,332.8	120,000
	1,104.0 1,28		1,372.8	0 120,000
	1,104.1 1,28		1,422.8	Flow
	1,104.2 1,28		1,479.8	(cfs)
	1,104.3 1,28		1,545.8	
	1,104.4 1,28		1,617.8	
	1,104.5 1,28		1,696.8	
	1,104.6 1,28		1,782.8	
	1,104.7 1,28		1,873.8	
	1,104.0 1,20		2 072 0	
	4			
			ОК	Cancel Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Sherman's "Existing Ops" operational zones, which consist of zones of Top of dam (1127.6 ft), Conservation (1107.6 ft), Min Pool (1098.6 ft), and Inactive zone (997.6 ft)<sup>1</sup>.

Reservoir Editor	2				L				x
Reservoir Edit Operations Zone Rule I	F_Block								
Reservoir Sherman 👻	Description						K 4	40 of 74	K
Physical Operations Observed Data									
Operation Set Existing Ops	▼ Descripti	on							
Zone-Rules Rel. Alloc. Outages S	tor. Credit Dec. Sched. P	rojected Elev							
Top of dam	Storage Zone Conservat	tion	Descripti	ion					
Conservation Min FLow Logic - Sherman	Function of Date							Define	
<ul> <li>B-{} Hydropower Sherman Z2</li> <li>Min Pool</li> <li>Inactive</li> </ul>	Date 01Jan	Top Elevatio	n (ft) 1107.6	1 1 1 1 1 1	,140 ,120 ,100 ,080 ,040 ,020 ,000 980 Jan t	dar May	/ Jul Sep	) Nov	
					ОК	С	ancel	App	ly

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

Figure 6 shows a sequential release allocation approach specified for available outlets along Buford Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The spillway gets the remainder of the release.

Reservoir Editor	
Reservoir Edit Operations	
Reservoir Sherman	
Physical Operations Observed Data	
Operation Set Existing Ops	Description
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec	Sched. Projected Elev
Release Allocation Strategy	
A Sherman - Balanced	Release Location: Sherman-Dam
Sherman-Dam (1.0) - Sequential     Sherman-Power Plant	Allocation Type: Sequential
Sherman-Spillway	Sherman-Power Plant
	Sherman-Spillway

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

## **B. Rule Illustrations**

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>88</sup>.

•
Reservoir Editor
Reservoir Edit Operations Zone Rule IF_Block
Reservoir Sherman
Physical Operations Observed Data
Operation Set Existing Ops
Zone-Rules Rel. Alloc. Outages Stor, Credit
Top of dam Max Power Plant First Conservation Min FLow Logic - Sherman Hydropower Sherman Z2 Hydropower Release 90% Inflow ELSE IF (code=1) Hydropower Release 90% Inflow ELSE IF (code=2) Hydropower Release 90% Inflow ELSE IF (code=3) Hydropower Release 90% Inflow ELSE (code=4) No Power Min Pool
nactive 🔁

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

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<sup>&</sup>lt;sup>88</sup> TransCanada. Deerfield River Operational Constraints. 2012.

## **C.** Rule Descriptions

#### 1. Max Power Plant First

Figure 8 shows the content of "Max Power Plant First" rule. This rule forces the inflow to pass through the power plant first until it reaches the maximum plant capacity.

Operation Set Existing Ops	Description			
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. Projected	Elev		
Top of dam  Max Power Plant First Conservation  Top of the Logic - Sherman  + Hydropower Sherman Z2  Min Pool	Rule Name: Max Powe	Pool Net Inflow, Current Va		Define
Inactive	Limit Type: Minimum Flow (cfs) -1000.0 0.0 1288.8 123456.0	Interp.:         Linear         ▼           Release (cfs)         0.0         0.0           0.0         1288.8         1288.8	(j. 1,200 800 400 0 60,000 12 Flow (cfs)	20,000
			<ul> <li>Period Average Limit</li> <li>Hour of Day Multiplier</li> <li>Day of Week Multiplier</li> <li>Rising/Falling Condition</li> <li>Seasonal Variation</li> </ul>	Edit Edit Edit Edit

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Power Plant First

#### 2. Min Flow Logic Sherman

This rule represents the minimum release from reservoir as a function of Inflow. The content of the rule is shown in Figure 9.

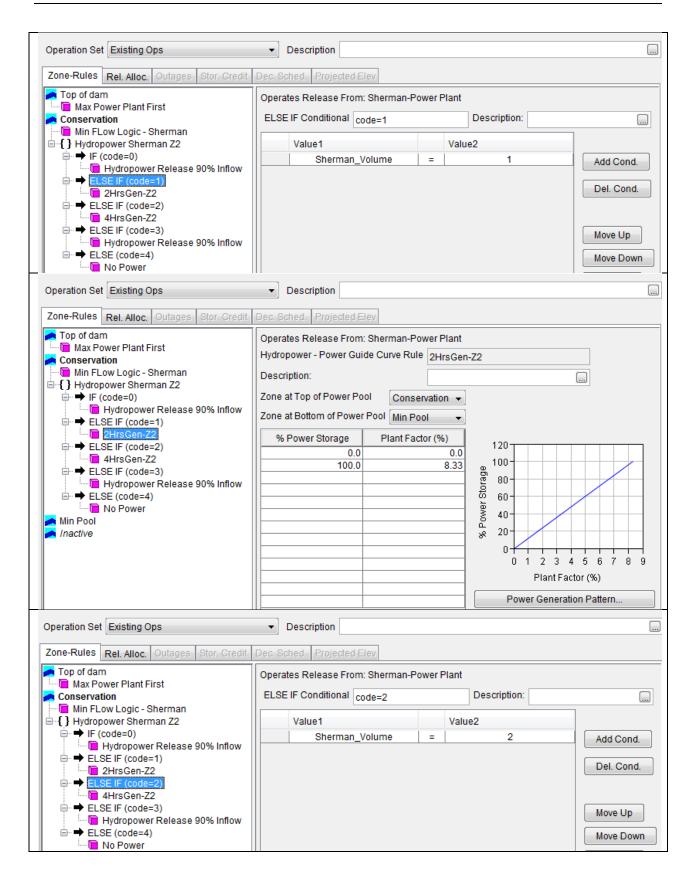
Operation Set Existing Ops	Description
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. Projected Elev
Top of dam Generation Conservation Min FLow Logic - Sherman Generation Min Pool Min Pool Min Pool	Operates Release From: Sherman         Rule Name:       Inin FLow Logic - Sherman       Description:       Min flow rules for downstream plar         Function of:       Sherman-Pool Net Inflow, Current Value       Define         Limit Type:       Minimum <ul> <li>Interp::</li> <li>Linear</li> <li>Flow (cfs)</li> <li>Release (cfs)</li> <li>0.0</li> <li>57.0</li> <li>57.0</li> <li>57.0</li> <li>57.0</li> <li>57.0</li> <li>57.0</li> <li>64</li> <li>64</li></ul>
	Rising/Falling Condition

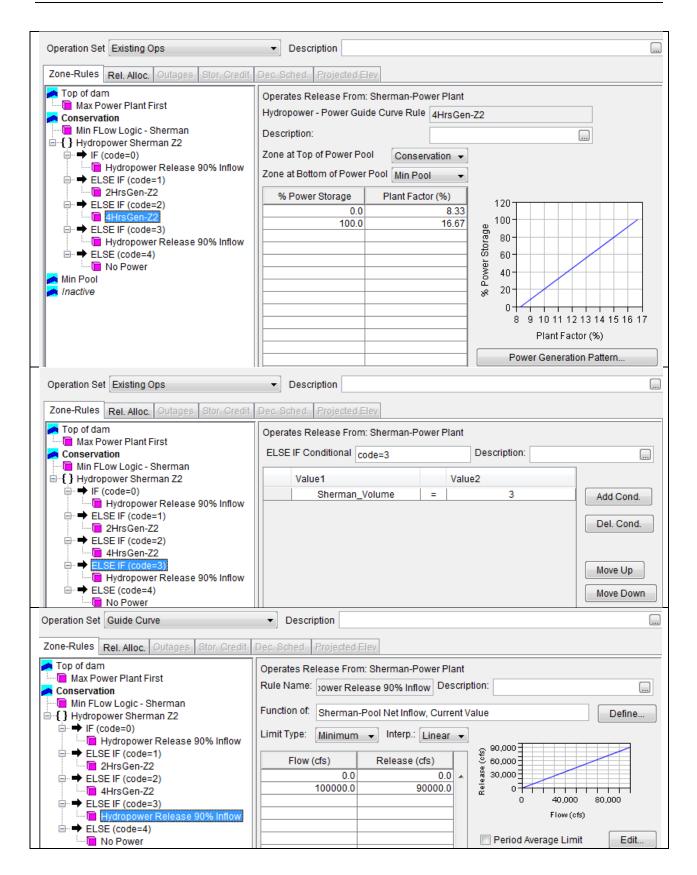
Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic Sherman

## **3.** Hydropower Sherman Z2

This rule represents power strategy applied for Sherman reservoir. The content of the rule is shown in Figure 10.

Operation Set Existing Ops	<ul> <li>Descrip</li> </ul>	tion			
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. F	Projected Elev			
👝 Top of dam	Operates Rele	ease From: Sherman			
🔚 Max Power Plant First					
A Conservation	Name: Hydr	opower Sherman Z2	Descriptio	on:	)
Min FLow Logic - Sherman	-				
Hydropower Sherman Z2	Туре	Name		Description	
➡ IF (code=0)	IF IF	code=0			
➡ Hydropower Release 90% Inflow ➡ ELSE IF (code=1)	ELSE IF	code=1			
2HrsGen-Z2	ELSE IF	code=2			
ELSE IF (code=2)	ELSE IF	code=3			
4HrsGen-Z2	ELSE	code=4			
ELSE IF (code=3)					
Hydropower Release 90% Inflow					
ELSE (code=4)					
No Power					
Operation Set Existing Ops	Descrip	tion			
	, Descrip				
	Dec. Sched. F	Projected Elev			
Top of dam	Operates Rele	ease From: Sherman			
Max Power Plant First	IF Conditiona	l and a O	De	scription:	
Min FLow Logic - Sherman		code=0		Scription.	
Mill PLow Logic - Sherman	Value	1	Ve	lue2	
Hydropower Release 90% Inflow		Sherman_Volume	=	0	Add Cond.
ELSE IF (code=1)					
2HrsGen-Z2					Del. Cond.
ELSE IF (code=2)					
HrsGen-Z2					
ELSE IF (code=3)					Move Up
Hydropower Release 90% Inflow					
ELSE (code=4)					Move Down
No Power					
Operation Set Existing Ops	<ul> <li>Description</li> </ul>	tion			
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. P	rojected Elev			
🛤 Top of dam	Operates Rele	ase From: Sherman-Po	ower Plan	t	
🔚 🛅 Max Power Plant First		ower Release 90% Inflo		-	
A Conservation	Nule Marile. )	ower Release 90% Inflo	Desci	ipuoli.	
Min FLow Logic - Sherman	Function of	Sherman-Pool Net Inflov	N Current	Value	Defea
Hydropower Sherman Z2	anousin or.	sherman-Pool Net INTION	w, Current	value	Define
➡ IF (code=0)	Limit Type:	Ainimum 👻 Interp.:	Linear	•	
Hydropower Release 90% Inflow					
ELSE IF (code=1) □ 2HrsGen-Z2	Flow (d	fs) Release (	(cfs)	(g) 90,000	
ELSE IF (code=2)		0.0	0.0		
HrsGen-Z2	1		90000.0	8 30,000	
ELSE IF (code=3)				ee ee	
Hydropower Release 90% Inflow					),000 100,000
ELSE (code=4)					
No Power				Flow (	cis)





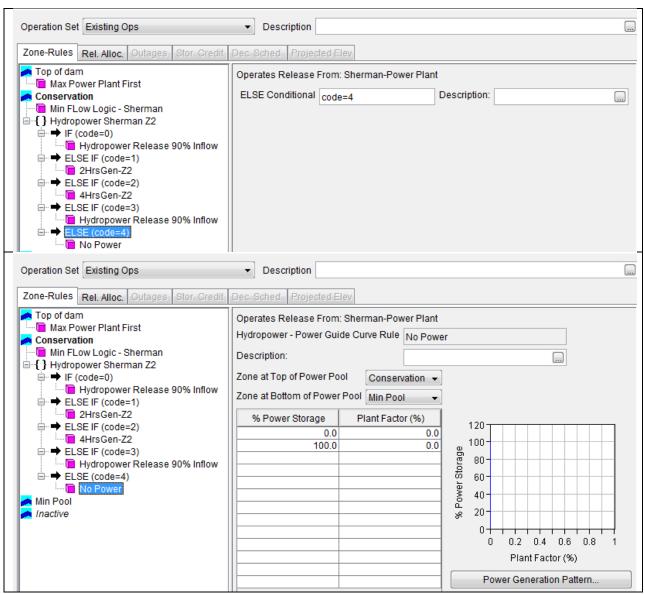


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Hydropower Sherman Z2

Figure 11 describes the definition of codes used in the Sherman\_Volume state variable. The code is summing up the current Inflow and previous storage in each time step, compare it to the volume needed for generating 2 and 4 hours power and to the spillway storage minus inactive storage and then decide how much to release.

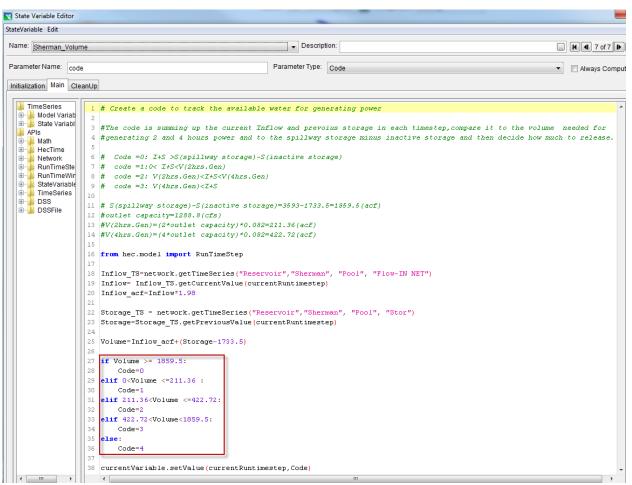


Figure 11: State Variable Editor: Sherman\_Volume

### Shuttle Meadow

#### II. Overview

Shuttle Meadow dam is located on the upper reaches of Willow Brook in the towns of New Britain and Southington, CT. The dam is owned and operated by the two towns and is used for water supply.

Figure 1 shows the location of Shuttle Meadow dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Shuttle Meadow dam.

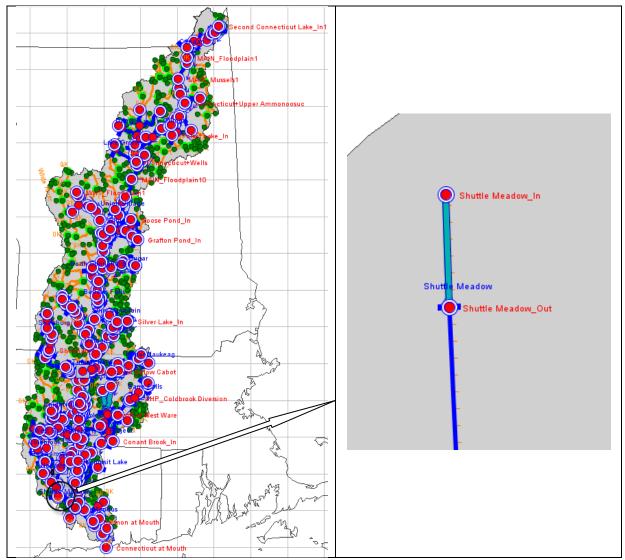


Figure 1: HEC-ResSim Map Display Showing Location of Shuttle meadow



Figure 2: Photo of Shuttle Meadow dam.

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>89</sup>. The dam consists of an uncontrolled spillway as shown in Figure 4.

<sup>&</sup>lt;sup>89</sup> Data provided by the Town of New Britain.

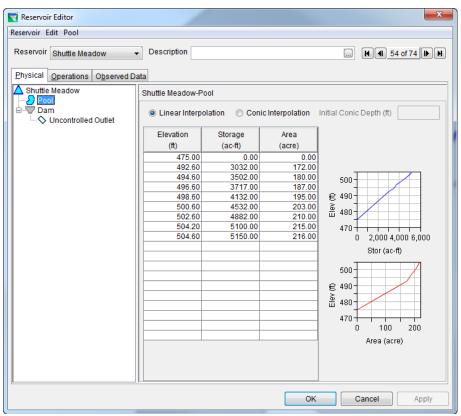


Figure 3: Reservoir Editor: Physical Tab -- Pool

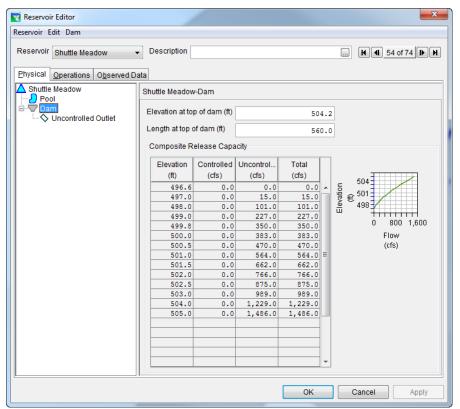


Figure 4: Reservoir Editor: Physical Tab -- Dam

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Shuttle Meadow's "Guide Curve" operational zones, which consist of zones of Flood control (498 ft), Conservation (496 ft), and Inactive zone (480 ft).

👿 Reservoir Editor	×
Reservoir Edit Operations Zo	ne Rule IF_Block
Reservoir Shuttle Meadow	✓ Description
Physical Operations Obse	rved Data
Operation Set Guide Curve	Description
	utages Stor. Credit Dec. Sched. Projected Elev
Flood Control	Storage Zone Conservation Description
nactive 🔎	Function of Date Define
	Date Top Elevation (ft)
	01Jan 490.0
	495- 
	490- 5 490- 5 490- 1 485-
	¥85
	480
	Jan Mar May Jul Sep Nov
	Zees Ood Elaustica
	Zone Sort Elevation
	OK Cancel Apply

Figure 5: Reservoir Editor: Operations Tab – Guide Curve OpSet

## **B. Rule Illustrations**

The operation set for Shuttle meadow has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity. There is a water supply time series for Shuttle Meadow. Daily water withdrawal and return flows for the year 2009 were provided by the New Britain Water District. These daily withdrawals were used to create a water supply time series for the model period of record.

## Silver Lake

#### I. Overview

Silver Lake dam is located in the Town of Harrisville, NH and forms the headwaters of Minnewawa Brook. This dam is owned and operated by the State of New Hampshire Water Resources Board. It is primarily used for recreation with also some flood control benefits.

Figure 1 shows the location of Silver lake dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Silver Lake dam.

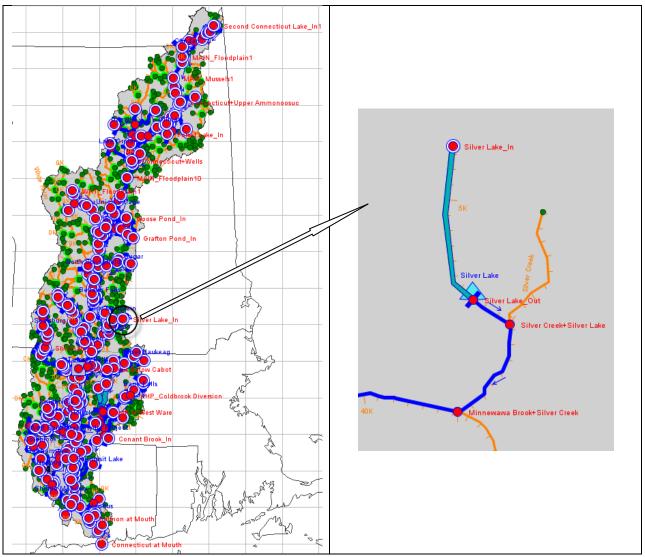


Figure 1: HEC-ResSim Map Display Showing Location of Silver lake



Figure 2: Photo of Silver Lake

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>90</sup>. The dam consists of a controlled and an uncontrolled outlet as shown in Figure 4<sup>91</sup>.

 <sup>&</sup>lt;sup>90</sup> NHDams Data Sheet. Silver Lake. 2007
 <sup>91</sup> New Hampshire Water Resources Board. 1978

📷 Reservoir Editor				X
Reservoir Edit Pool				
Reservoir Silver Lake	✓ Description			K 4 34 of 74 D H
Physical Operations Observed D	)ata			
Silver Lake	Silver Lake-Pool			
Dam Controlled Outlet	Linear Interpolation	Conic Interpolation	ion Initial Conic Dep	oth (ft)
Uncontrolled Outlet	Elevation	Storage	Area	
	(ft)	(ac-ft)	(acre)	
	1312.00	0.00		1,330
	1316.00	1200.00		1,325
	1321.00	2900.00		€ 1,320 <u>1,320</u> <u>1,315</u>
	1326.00 1331.00	4600.00		<u>ت</u> 1,315
	1551.00	0300.00		1,310
				0 2,000 4,000 6,000
				Stor (ac-ft)
				1,330
				1,325
				€ 1,320
				ώ
				1,310 + + + + + + + + + + + + + + + + + + +
				Area (acre)
			ОК	Cancel Apply

Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor						X
Reservoir Edit Dam						
Reservoir Silver Lake	Description					<b>I 3</b> 4 of 74 <b>D</b>
Silver Lake	Silver Lake-Dam					
Dam Controlled Outlet	Elevation at top of	dam (ft)		1324	.5	
Uncontrolled Outlet	Length at top of da	am (ft)		80	.0	
	Composite Relea	ase Capacity				
	Elevation	Controlled	Uncontrolled	Total	]	
	(ft)	(cfs)	(cfs)	(cfs)		1,332
	1,316.8	0.0	0.0	0.0 🔺	5 '	1,328
	1,321.0	230.0	0.0	230.0	Elevation	1,324
	1,322.0	268.0	34.5	302.5	l li	1,320
	1,324.5	363.0	232.0	595.0		
	1,326.0	420.0	1,034.0	1,454.0		
	1,328.0	420.0	2,944.0	3,364.0		Flow
	1,330.0	420.0	5,487.0	5,907.0		(cfs)
				ОК		Cancel Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Bashan's "Guide Curve" operational zones, which consist of zones of Flood Control (1322 ft), Conservation (1318-1321 ft), and Inactive zone (1315 ft)<sup>1</sup>.

Reservoir Editor						x
Reservoir Edit Operations Zone Rule If	F_Block					
Reservoir Silver Lake 🔻	Description					34 of 74 🕨 🗎
Physical Operations Observed Data						
Operation Set Guide Curve	▼ Des	scription				
Zone-Rules Rel. Alloc: Outages St	tor. Credit Dec. Sche	ed. Projected Elev				
Flood Control Storage Z	one Conservation	Descrip	otion			
Inactive Function of	of Date					Define
	Date	Top Elevation		1,323		
01Jan 14May			1318.0	1,323		
15May			1321.0	1,321		
120ct			1321.0	€ 1,320 u 1,319 its 1,318 1,318 1,317 1,317		
130ct			1318.0	E 1,319		
				te 1,318		
				1,317 1,316		
				1,315		
				1,314		
			-	Jan I	Mar May Jul Se	p Nov
Zone Sort	Elevetien.					
Zone Son	Elevation					
				ОК	Cancel	Apply

Figure 5: Reservoir Editor: Operations Tab – Guide Curve OpSet

### **B. Rule Illustrations**

The operation set for Silver Lake has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

### Somerset

#### I. Overview

Somerset dam is located on the East Branch of the Deerfield River, and is the furthest upstream. It is owned and operated by TransCanada Hydro Northeast Inc. as a storage reservoir to make releases to its downstream hydro facilities.

Figure 1 shows the location of Somerset Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo from Somerset dam.

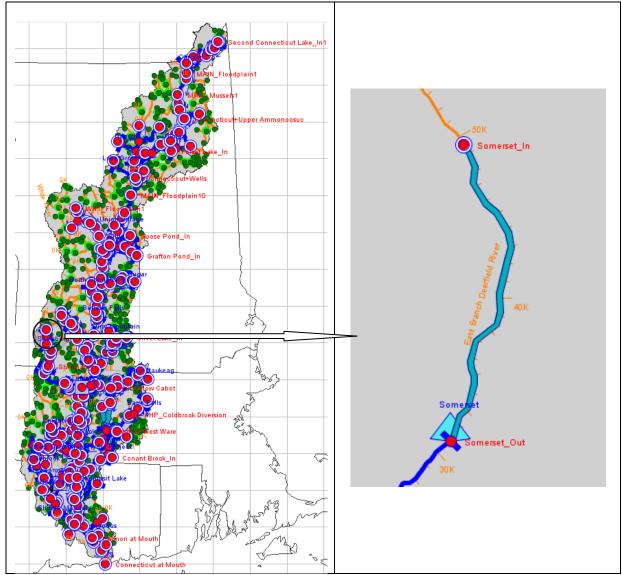


Figure 1: HEC-ResSim Map Display Showing Location of Somerset



Figure 2: Photo of Somerset Dam

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>92</sup>. The dam consists of four types of outlets: (1) controlled outlet, (2) uncontrolled outlet, (3) 14 inch valve, and (4) 42 inch valve as shown in Figure 4.

.

<sup>92</sup> Data provided by TransCanada

ervoir Edit Pool					
servoir Somerset	Description			K 4 37 of 74	
nysical Operations Observed	Data				
Somerset	Somerset-Pool				
Dam Controlled Outlet	Linear Interpolation	Conic Interpolation	nitial Conic Depth (ft)		
Uncontrolled Outlet	Elevation	Storage	Area		
14 inch valve	(ft)	(ac-ft)	(acre)		
42 inch valve	2061.58	1020.80	17		
	2061.68	1036.61			
	2061.78	1052.42		2,140	
	2061.88	1068.24			-
	2061.98	1084.05		2,120	1
	2062.08	1099.86		€ 2,100	-
	2062.18	1115.67		<u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u></u>	
	2062.28	1131.49			-
	2062.38	1147.30		2,060 + + + + + + + +	1
	2062.48	1163.11		0 30,000 60,00	U
	2062.58	1178.92		Stor (ac-ft)	
	2062.68	1194.74		2,140	-
	2062.78	1210.55		2,120	-
	2062.88	1226.36			-
	2062.98	1242.17		5 2,100	-
	2063.08	1257.99		€ 2,100	1
	2063.18	1273.80			-
	2063.28	1289.61		2,060	4
	2063.38	1305.42		600 1,200 1,800	
	2063.48	1321.24		Area (acre)	
	2063.58	1337.05			
	2063.68	1352.86			
	2063.78	1368.67		1	
	2063.88	1384.49		+	

Figure 3: Reservoir Editor: Physical Tab -- Pool

🖥 Reservoir Editor		And in case of		-	×
Reservoir Edit Dam					
Reservoir Somerset	<ul> <li>Description</li> </ul>				
Contractor					
Physical Operations Observed	Data				
A Somerset	Somerset-Dam				
- 2 Pool	Comerser Ban				
	Elevation at top of dan	n (ft)		2166	i. 6
Controlled Outlet	Length atten of dom (	<b>a</b> )			
<ul> <li>4 inch valve</li> </ul>	Length at top of dam (	II.)		2101	0
42 inch valve	Composite Release	Capacity			
	Elevelier	O and the last	University of the	Tatal	
	Elevation	Controlled	Uncontrolled	Total	2,160
	(ft)	(cfs)	(cfs)	(cfs)	
	2,100.0	706.0	0.0	706.0 🔺	
	2,105.0	744.0	0.0	744.0	te € 2,120
	2,107.0	758.4	0.0	758.4	⊕ 2,100 <b>-</b>
	2,110.0	1,014.8	0.0	1,014.8	0 8.000
	2,115.0	1,442.2	0.0	1,442.2	
	2,120.0	1,867.6	0.0	1,867.6	Flow
	2,125.0	2,293.0	0.0	2,293.0	(cfs)
	2,130.0	2,716.4	0.0	2,716.4	
	2,133.6	3,019.5	0.0	3,019.5	
	2,133.6	3,020.4	1.0	3,021.4	
	2,133.6	3,021.2	2.0	3,023.2	
	2,133.6	3,022.1	3.0	3,025.1	
	2,133.6	3,022.9	4.0	3,026.9	
	2,133.6	3,023.8	6.0	3,029.8	
	2,133.6	3,024.6	8.0	3,032.6	
	2,133.6	3,025.5	10.0	3,035.5	
	2,133.7	3,026.3	12.0	3,038.3	
	2,133.7	3,027.2	15.0	3,042.2	
	2,133.7	3,028.0	18.0	3,046.0	
	2,133.7	3,028.9	21.0	3,049.9 -	
				016	
				OK	Cancel Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Somerset's "ExistingOps" operational zones, which consist of zones of Top of dam (2166.6 ft), conservation (2131-2136.6 ft), Min Pool (2107 ft), and Inactive zone (2048.1 ft)<sup>1</sup>.

🟹 Reservoir Editor		Contract, or The Contract	×
Reservoir Edit Operations Zone Rule IF_Bloc	k		
Reservoir Somerset   Descr  Physical Operations Observed Data	iption		
Operation Set ExistingOps	<ul> <li>Description</li> </ul>		
Zone-Rules Rel. Alloc. Outages Stor. Cr	edit Dec. Sched. Projected E	lev	
Top of dam Conservation	Storage Zone Conservation	Description	Define
Max Release at Somerset	Date 01Jan 30Apr 01May 31Jul 01Aug 31Dec	Top Elevation (ft) 2136.6 2131.0 2131.0 2136.6 2136.6 2136.6	2,180 2,160 2,140 2,120 2,100 2,080 2,080 2,060 2,040 Jan Mar May Jul Sep Nov
			OK Cancel Apply

Figure 5 Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

Figure 6 shows a sequential release allocation approach specified for available outlets along Harriman Dam. The available outlets are given an order of priority for release. The controlled outlet gets the release first until it reaches release capacity. The 14 inch valve and 42 incj valve gets the remainder of the release.

🟹 Reservoir Editor	Second and Description of
Reservoir Edit Operations	
Reservoir Somerset	
Physical Operations Observed Data	
Operation Set ExistingOps	Description
Zone-Rules Rel. Alloc. Outages Stor, Credit Dec. S	ched. Projected Elev
Release Allocation Strategy	
Somerset - Sequential Somerset-Dam - Sequential Somerset-Controlled Outlet Somerset-14 inch valve Somerset-42 inch valve	Release Location:       Somerset-Dam         Allocation Type:       Sequential         Somerset-Controlled Outlet       Somerset-14 inch valve         Somerset-42 inch valve       Somerset-42 inch valve

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

#### **B. Rule Illustrations**

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>93</sup>.

🟹 Reservoir Editor
Reservoir Edit Operations Zone Rule IF_Block
Reservoir Somerset
Physical Operations Observed Data
Operation Set ExistingOps
Zone-Rules Rel. Alloc. Outages Stor. Cre
Conservation

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>&</sup>lt;sup>93</sup> TransCanada. Deerfield River Operational Constraints. 2012.

# **C.** Rule Descriptions

#### 1. Loon nesting

Figure 8 shows the content of "loon nesting" rule. This rule limits the maximum and minimum rate of elevation change to one foot per 1440 hours during May15-Jul 15.

Operation Set ExistingOps	✓ Description				
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sched. Projected Elev				
Top of dam     Conservation     Ioon nesting     Ioon F (15 May-15 Jul)     Increasing rate of change     Increasing rate of change     Increasing rate of change	Operates Release From: Somerset Name: Ioon nesting Description:				
	Type Name IF 15 May-15 Jul	Description			
<ul> <li>Seasonal Min Flow Logic - Somerset</li> <li>Max Release at Somerset</li> <li>Max Operating Elev.</li> <li>IF (elev&gt;=2133.55)</li> <li>If (elev&gt;=2133.55)</li> <li>If (aug-Apr)</li> <li>IF (Aug-Apr)</li> <li>ROC Increase - Somerset</li> <li>Min Pool</li> <li>Inactive</li> </ul>					
Operation Set ExistingOps Zone-Rules Rel. Alloc. Outages Stor. Crev	Description     dit Dec. Sched. Projected Elev.		(		
📥 Top of dam	Operates Release From: Somerset	 !			
Conservation	IF Conditional 15 May-15 Jul	Description:			
IF (15 May-15 Jul) □ Increasing rate of change	Value1	Value2	Add Cond.		
decreasing rate of change	AND Current Time Step	>= 15May <= 15Jul	Dei. Cond.		
Max Release at Somerset     Max Operating Elev.     → IF (elev>=2133.55)     □			Move Up		
Ramping Discharge			Move Down		
IF (Aug-Apr) ■ ROC Increase - Somerset ■ ROC Decrease - Somerset	Logical Operator:				
👝 Min Pool	Value 1 Time Series 🔹		Pick Value		
inactive 🔁	Opera 😑 🔻				
	Value 2 Constant 👻				

Operation Set ExistingOps	▼ Description
Zone-Rules Rel. Alloc. Outages Stor. Cred	dit Dec. Sched. Projected Elev
<ul> <li>Top of dam</li> <li>Conservation</li> <li>↓ Ioon nesting</li> <li>↓ IF (15 May-15 Jul)</li> <li>↓ IF (15 May-15 Jul)</li> <li>↓ Ir (elevasing rate of change</li> <li>↓ Seasonal Min Flow Logic - Somerset</li> <li>↓ Max Operating Elev.</li> <li>↓ IF (elevase at Somerset</li> <li>↓ Max Operating Elev.</li> <li>↓ IF (elevase 2133.55)</li> <li>↓ IF (Aug-Apr)</li> <li>↓ IF (Aug-Apr)</li> <li>↓ Roc Increase - Somerset</li> <li>↓ Min Pool</li> <li>↓ Inactive</li> </ul>	Operates Release From: Somerset Elevation Rate of Change Limit Increasing rate of change Description Function Of: Constant Type Increasing Instantaneous Period Average Max Change of (ft) 1.0 over 1440 hours
Operation Set       ExistingOps         Zone-Rules       Rel. Alloc.       Outages       Stor. Cred         Top of dam       Conservation         Conservation       Image: Stor. Cred         Image: Seasonal Min Flow Logic - Comerset       Image: Seasonal Min Flow Logic - Somerset         Image: Seasonal Min Flow Logic - Somerset       Image: Seasonal Min Flow Logic - Somerset         Image: Seasonal Min Flow Logic - Somerset       Image: Seasonal Min Flow Logic - Somerset         Image: Seasonal Min Flow Logic - Somerset       Image: Seasonal Min Flow Logic - Somerset         Image: Seasonal Min Flow Logic - Somerset       Image: Seasonal Min Flow Logic - Somerset         Image: Seasonal Min Flow Logic - Somerset       Image: Seasonal Min Flow Logic - Somerset         Image: Seasonal Min Flow Rel.       Image: Seasonal Min Flow Rel.         Image: Seasonal Min Flow Rel.       Image: Seasonal Min Flow Rel.         Image: Seasonal Min Flow Rel.       Image: Seasonal Min Flow Rel.         Image: Seasonal Min Flow Rel.       Image: Seasonal Min Flow Rel.         Image: Seasonal Min Flow Rel.       Image: Seasonal Min Flow Rel.         Image: Rel Kauge: Rel Kau	Description     Description     Dec. Sched_Projected Elev  Operates Release From: Somerset Elevation Rate of Change Limit decreasing rate of change Description Function Of: Constant Type Decreasing      O Instantaneous     Period Average Max Change of (ft)     1.0 over 1440 hours

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – loon nesting

#### 2. Seasonal Min Flow Logic-Somerset

Figure 9 shows the content of "Seasonal Min Flow Logic-Somerset" rule. This rule represents the seasonal minimum flow from reservoir as a function of Inflow.

Operation Set ExistingOps	•	Descrip	otion						
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sch	ed. Proj	ected Ele	V					
Top of dam     Conservation     ⊖-{} loon nesting     ⊖-→ IF (15 May-15 Jul)	Operates R Rule Name	Min Flov	v Logic - S	Somerset	1		ter Quality	Cer	tification Document (Page 12) states al.
Increasing rate of change     decreasing rate of change     Seasonal Min Flow Logic - Somerset     Max Release at Somerset	Function of: Limit Type:	Somers		let Inflow, ▼	Interp.:	,	1	•	) Define
IF (elev>=2133.55)	Flow (cfs) 0.0	01Jan 100.0	01Mar 30.0	Releas 01May 9.0	e (cfs) 01Aug 12.0	010ct 30.0	01Nov 100.0	*	# 40 # 40,000 80,000 120,000 Flow (cfs)
☐-{} Ramping Discharge → IF (Aug-Apr) ☐ ROC Increase - Somerset ☐ ROC Decrease - Somerset	9.0 12.0 123456.0	100.0 100.0 100.0	30.0 30.0 30.0	9.0 12.0 12.0	12.0 12.0 12.0	30.0	100.0	III	Period Average Limit Hour of Day Multiplier Edit Edit
A Min Pool A Inactive									Day of Week Multiplier     Edit     Rising/Falling Condition     Edit
								Ŧ	Seasonal Variation Edit

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Seasonal Min Flow Logic-Somerset

#### 3. Max Release at Somerset

Figure 10 shows the content of "Max Release at Somerset" rule. This rule represents the seasonal maximum flow from reservoir based on Inflow.

Operation Set ExistingOps	Description						
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev							
Top of dam Conservation ☐-{} loon nesting ☐-→ IF (15 May-15 Jul) ☐-☐ Increasing rate of change	Operates Release From: Somerset Rule Name: Max Release at Somerset Description: Function of: Somerset-Pool Net Inflow, Current Value	Define					
Addressing rate of change     Seasonal Min Flow Logic - Somerset     Max Release at Somerset     Max Operating Elev.	Limit Type: Maximum v Interp.: Linear v Flow Release (cfs)						
<ul> <li>inflow Rel.</li> <li>inflow Rel.</li> <li>□-{} Ramping Discharge</li> </ul>	(cfs) 01Jan 15May 16Jul ઙુ 01	600 2,000					
<ul> <li>➡ IF (Aug-Apr)</li> <li>➡ ROC Increase - Somerset</li> <li>➡ ROC Decrease - Somerset</li> <li>▲ Min Pool</li> </ul>	1000.0         1000.0         123456.0         1000.0           2000.0         2000.0         123456.0         2000.0	Edit Edit					
Inactive	Day of Week Multiplier     Rising/Falling Condition	Edit Edit					

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max release at Somerset

### 4. Max Operating Elev.

Figure 11 shows the content of "Max Operating Elev" rule. This rule makes the release equal to inflow when the pool elevation is higher than 2133.55.

Operation Set ExistingOps	✓ Description	
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sched. Projected Elev	
Top of dam Conservation	Name: Max Operating Elev. Des	cription:
<ul> <li>☐ { } loon nesting</li> <li>☐ ➡ IF (15 May-15 Jul)</li> <li>☐ Increasing rate of change</li> </ul>	Type Name	Description
Gecreasing rate of change     Gecreasing rate of change     Gecreasing rate of change     Gecreasing rate of change     Gecrease at Somerset     Max Release at Somerset     Max Operating Elev     Gecrease - Somerset     Gecrease - Somerset     Gecrease - Somerset     Gecrease - Somerset     Min Pool     Inactive		
Operation Set ExistingOps		
Zone-Rules Rel. Alloc. Outages Stor. Cred		
Conservation	IF Conditional elev>=2133.55	Description:
i{} loon nesting i	Value1	Value2 Add Cond.
Increasing rate of change	Somerset-Pool:Elevation >=	2133.55 Del. Cond.
Gecreasing rate of change     Seasonal Min Flow Logic - Somerset     Max Release at Somerset		
Max Operating Elev.		Move Up
IF (elev≈=2133.55) IF (elev≈=2133.55) Inflow Rel.		Move Down
A Ramping Discharge		Evaluate
🛱 📥 IE (Aug Apr)		Evaluate
⊡ → IF (Aug-Apr)	Logical Operator:	
	Logical Operator:	Pick Value
ROC Increase - Somerset ROC Decrease - Somerset		

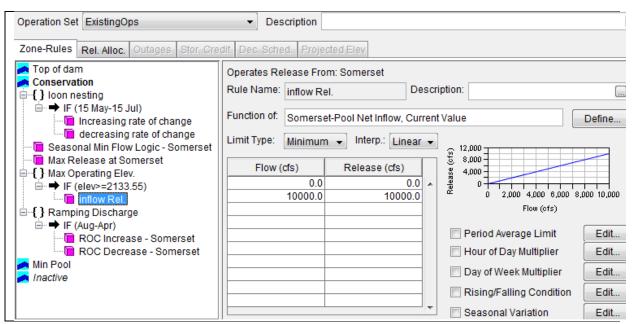


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Operating Elev.

### 5. Ramping Discharge

Figure 12 shows the content of "Ramping Discharge" rule. This rule limits the maximum increasing rate of release change to 4.1667 (cfs/hr) and the maximum decreasing rate of release change to 2.0833 (cfs/hr) during Aug-Apr.

Operation Set ExistingOps	•)	Description					
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec	Sched. Pro	jected Elev				
Top of dam Conservation Conservation		Operates Release From: Somerset Name: Ramping Discharge Description: per Deerfield schematic					
☐ {} Ioon nesting ☐ IF (15 May-15 Jul)		Nam		Desci			
Gereasing rate of change     decreasing rate of change     Gereasing rate of change     Seasonal Min Flow Logic - Somerset	Type	F Aug-/			Des	cription	
Gerasonal min flow Logic - Somerset     Max Release at Somerset     As Release at Somerset     F (elev>=2133.55)     F (elev==2133.55)     F (elev==		Description					
Zone-Rules Rel. Alloc. Outages Stor. Cred			om: Somerset				
Conservation	IF Con	ditional Aug-	Apr		Descri	iption:	
IF (15 May-15 Jul) Increasing rate of change		Value1			Value2		Add Cond.
Gecreasing rate of change     Seasonal Min Flow Logic - Somerset     Max Release at Somerset	AND		Time Step Time Step	>= <=		01Aug 30Apr	
Imax Operating Elev. Imax Operating Elev. Imax Operating Elev.							Move Up
☐ inflow Rel. ☐ { Ramping Discharge ☐ ➡ IF (Aug-Apr)							Move Down
<ul> <li>IF (AUG-ADT)</li> <li>ROC Increase - Somerset</li> <li>ROC Decrease - Somerset</li> </ul>		al Operator:	•				
Min Pool	Value		s 🔻				Pick Value
	Opera Value	<sup>2</sup> Constant	•				

Operation Set ExistingOps	✓ Description
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sched. Projected Elev
<ul> <li>Top of dam</li> <li>Conservation</li> <li>↓ Ioon nesting</li> <li>↓ IF (15 May-15 Jul)</li> <li>↓ IF (15 May-15 Jul)</li> <li>↓ Ir (15 May-15 Jul)</li> <li>↓ Ir (15 May-15 Jul)</li> <li>↓ Ir (15 May-15 Jul)</li> <li>↓ Seasonal Min Flow Logic - Somerset</li> <li>↓ Max Release at Somerset</li> <li>↓ Max Release at Somerset</li> <li>↓ Max Operating Elev.</li> <li>↓ IF (elev&gt;=2133.55)</li> <li>↓ IF (Aug-Apr)</li> <li>↓ Ramping Discharge</li> <li>↓ IF (Aug-Apr)</li> <li>↓ ROC Increase - Somerset</li> <li>↓ Min Pool</li> <li>↓ Inactive</li> </ul>	Operates Release From: Somerset Release Rate of Change Limit ROC Increase - Somerset Description: Function Of: Type Increasing Max Rate of Change (cfs/hr) 4.1667
Operation Set ExistingOps Zone-Rules Rel. Alloc. Outages Stor. Cre	Description
<ul> <li>Top of dam</li> <li>Conservation</li> <li>↓ IF (15 May-15 Jul)</li> <li>↓ IF (creasing rate of change</li> <li>↓ Seasonal Min Flow Logic - Somerset</li> <li>↓ Max Release at Somerset</li> <li>↓ Max Release at Somerset</li> <li>↓ IF (crease - Somerset</li> <li>↓ IF (Aug-Apr)</li> <li>↓ IF (Aug-Apr)</li> <li>↓ ROC Increase - Somerset</li> <li>↓ Min Pool</li> <li>↓ Inactive</li> </ul>	Operates Release From: Somerset         Release Rate of Change Limit         ROC Decrease - Somerset         Description:         Function Of:         Type         Decreasing         Max Rate of Change (cfs/hr)

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Ramping Discharge

## Sugar

### I. Overview

Sugar dam is located on the Sugar River in the town of Newport, NH. It is owned and operated by Sweetwater Hydroelectric, Inc. and is used for hydropower generation.

Figure 1 shows the location of Sugar dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Sugar dam.

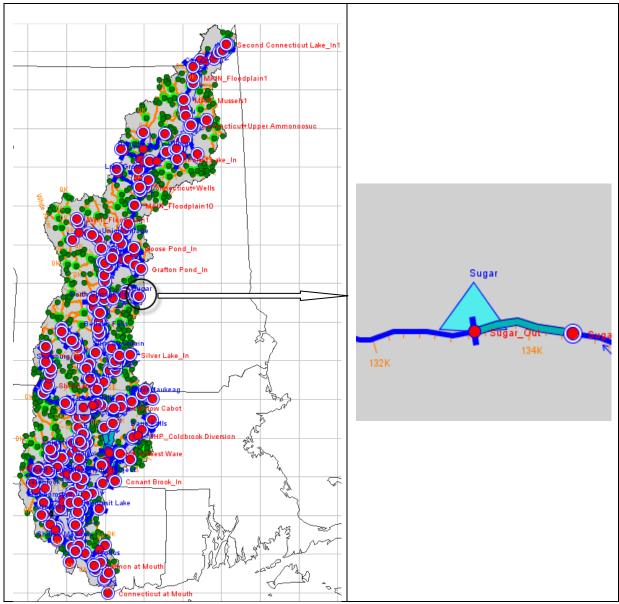


Figure 1: HEC-ResSim Map Display Showing Location of Sugar Dam



Figure 2: Photo of Sugar dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>94</sup>. The dam consists of three types of outlets: (1) controlled Waste Sluice, (2) uncontrolled outlet, and (3) controlled Inlet pipe for pump power generation as shown in Figure 4.

<sup>&</sup>lt;sup>94</sup> NHDams Data Sheet. Sugar River Mill Dam. 2010.

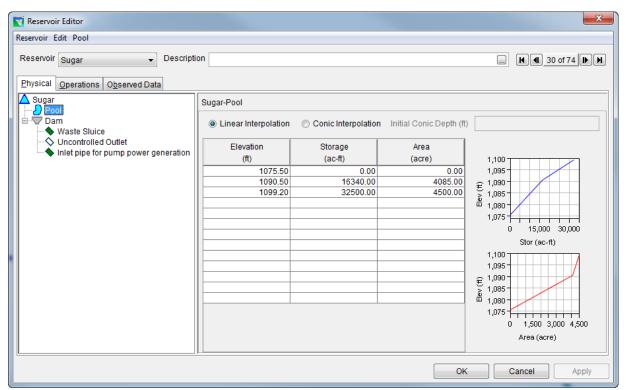


Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor												x
Reservoir Edit Dam												
Reservoir Sugar   Description  Description  M   30 of 74  M												
Physical Operation	ons Observed Data											
Sugar			Sugar-Dam									
Dam Waste S	luice		Elevation a	t top of d	am (ft)				109	5.0		
- S Uncontro		eration	Length at t	op of dan	n (ft)				7	1.0		
	e tot puttip power gen	erauon	Composit	e Releas	e Capac	city						
Elevation Controlled Uncontrolled (ft) (cfs) (cfs)							Uncontrolled (cfs)	Total (cfs)				
			· · · ·	,083.0	(U	0.0	(US) 0.0	(US)	0	E	1,098	
				,090.5		421.0	0.0	421.	_	Elevation	1,092	
				,091.5		461.0	1,061.3	1,522.	3	E -	1,086	
				,092.5		498.0	2,122.5	2,620.		-		
				,093.5		533.0	3,183.8	3,716.			•	
				,094.5		565.0	4,245.1	4,810.			Flow	
				,095.5		595.0	5,306.3	5,901.			(cfs)	
				,096.5		625.0 652.0	6,367.6 7,428.9	6,992. 8,080.				
				,098.5		679.0	8,490.1	9,169.				
				,099.2		696.0	9,233.0	9,929.				
						05010	5,20010	5,525	-			
									_			
									-			
L												
									ок		Cancel Appl	ly

Figure 4: Reservoir Editor: Physical Tab -- Dam

## III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Sugar's "Guide Curve" operational zones, which consist of zones of Flood Control (1094.5 ft), Conservation (1090.5 ft), and Inactive zone (1076 ft).

Reservoir Editor				X
Reservoir Edit Operations Z	one Rule IF_Block			
Reservoir Sugar	✓ Description			K (1) 30 of 74 (1) H
Physical Operations Obs	erved Data			
Operation Set Guide Curve	e ▼ Descripti	on		
Zone-Rules Rel. Alloc. C	Outages Stor. Credit Dec. Sched. Proje	cted Elev		
Flood Control	Storage Zone Conservation	Description		
jan Inactive	Function of Date			Define
	Date	Top Elevation (ft)		
	01Jan		1090.5	1,095
				1,090
				€ 1,085 5 1,085 ₩ 1.080
				L 1,080
				1,075
				Jan Mar May Jul Sep Nov
	Zone Sort Elevation			
				OK Cancel Apply

Figure 5: Reservoir Editor: Operations Tab –Guide Curve OpSet – Guide Curve

### **B. Rule Illustrations**

The operation set for Sugar has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

# Surry Mountain

### I. Overview

Surry Mountain Dam is a dam upstream of Keene, New Hampshire on the Ashuelot River. It was constructed by the US Army Corps of Engineers in 1941 and is still owned and operated by the Corps. It is primarily used for flood control purposes but also for recreation.

Figure 1 shows the location of Surry Mountain Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the dam.

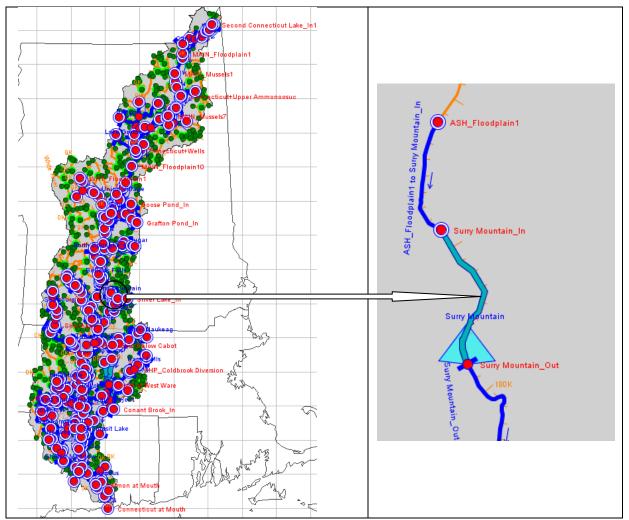


Figure 1: HEC-ResSim Map Display Showing Location of Surry Mountain dam



Figure 2: Photo of Surry Mountain Dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled Broome gates, and (2) uncontrolled spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>95</sup>.

<sup>&</sup>lt;sup>95</sup> http://rsgisias.crrel.usace.army.mil/nae/cwms\_map.map\_index

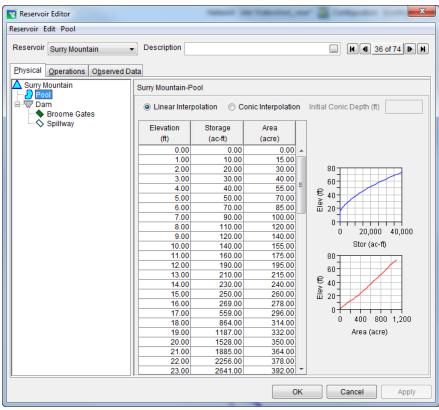


Figure 3: Reservoir Editor: Physical Tab -- Pool

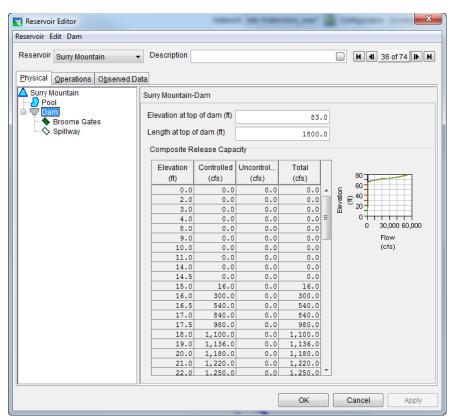


Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Surry Mountain's "ExistingOps" operational zones, which consist of zones of Surcharge-near TOD (83 ft), Surcharge (75 ft), Flood Control (65 ft), Conservation (15-18 ft), and Inactive zone (0 ft).

Reservoir Edit Operations Zone Rule IF_Block         Reservoir Surry Mountain       Description         Physical Operations Observed Data         Operation Set ExistingOps       Description         Zone-Rules ReLAtice Outages Stor. Credit Dec. Sched. Projected Elev         Surcharge       Surcharge         Surcharge       Storage Zone Conservation         Define       Define         Date       Top Elevation (ft)         Otal an       18.0         Otal an       19.0         One clicut at Montague - Linear	Reservoir Editor						x		
Physical Operations Observed Data         Operation Set ExistingOps       Description         Zone-Rules Rel. Alloc. Outages Stor Credit Dec Sched. Projected Elev         Surcharge - near TOD       Broome Gate Ops - Save Dam         Surcharge       Min Flow - Flood Pool - Surry         Max Flow at Keene       Date         Flood Control       Bit Montague - Linear         Max Flow at Keene       Bit Max Flow at Keene         Max Robes at Surry       Bit Max Robes at Surry         Max Robes at Surry       Bit Max Robes at Surry         Max Robes at Surry       Date         Max Rob Acchercesing       Date         Max Flow at Keene       Date         Max Rob Chercesing       Date         Max Rob Chercesing       Date         Max Rob Chercesing       Date         Max Rob Chercesing       Date         Max Pool Elev ROC       Date         Max Pool Elev ROC       Date         Max Pool Elev ROC       Date </td <td colspan="8">Reservoir Edit Operations Zone Rule IF_Block</td>	Reservoir Edit Operations Zone Rule IF_Block								
Operation Set       ExistingOps       Description         Zone-Rules       Rel.Aloc       Outages       Stor Credit       Dec Sched       Projected Elev         Surcharge       Broome Gate Ops - Save Dam       Storage Zone       Conservation       Description       Pool elevations up t(2)         Surcharge       Max Release at Surry       Storage Zone       Conservation       Description       Pool elevations up t(2)         Max Release at Surry       Connecticut at Montague - Linear       Date       Define         Max Flow at Keene       O1Jan       18.0       0<	Reservoir Surry Mountain   Description								
Zone-Rules       Rel. Alloc.       Outages       Stor. Credit.       Dec. Sched       Projected Elev         Surcharge - near TOD       Broome Gate Ops - Save Dam       Storage Zone       Conservation       Description       Pool elevations up t();         Surcharge       Min Flow - Flood Pool - Surry       Max Release at Surry       Connecticut at Montague - Linear       Date       Define         Max Flow at Keene       Storage Zone       Onlow       15.0         Min Flow - Flood Pool - Surry       Max Release at Surry       Otdoe Not Store       90	Physical Operations Observed Data								
Surcharge - near TOD       Broome Gate Ops - Save Dam         Surcharge       Min Flow - Flood Pool - Surry         Max Release at Surry       Connecticut at Montague - Linear         Broome Gate Ops       Storage Zone         Max Flow at Keene       Date         Flood Control       Storage at Surry         Max Flow at Keene       Storage Zone         Min Flow - Flood Pool - Surry       Storage Zone         Max Flow at Keene       Storage Zone         Min Flow - Flood Pool - Surry       Storage Zone         Max Row at Keene       Storage Zone         Min Flow - Flood Pool - Surry       Storage Zone         Max Roc-Increasing       Storage Zone         Max Roc-Increasing       Max Roc-Increasing         Max Roo-Increasing       Max Roo-Increasing         Max Roo-Increasing       Max Roo-Increasing         Max Roo-Increasing       Max Roo-Increasing         Max Roo-Increasing       Max Roo-Increasing         Max Roo-Increasing	Operation Set ExistingOps   Description								
Image: Storage Zone (Conservation)       Description (Pool elevations up t())         Surcharge       Image: Storage Zone (Conservation)       Description (Pool elevations up t())         Image: Storage Zone (Conservation)       Description (Pool elevations up t())         Image: Storage Zone (Conservation)       Description (Pool elevations up t())         Image: Storage Zone (Conservation)       Description (Pool elevations up t())         Image: Storage Zone (Conservation)       Description (Pool elevations up t())         Image: Storage Zone (Conservation)       Description (Pool elevations up t())         Image: Storage Zone (Conservation)       Description (Pool elevations up t())         Image: Storage Zone (Conservation)       Description (Pool elevations up t())         Image: Storage Zone (Conservation)       Description (Pool elevations up t())         Image: Storage Zone (Conservation)       Date (Top Elevation (ft) (Date (Da	Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched.	Projected Elev						
<ul> <li>Surcharge</li> <li>Min Flow - Flood Pool - Surry</li> <li>Max Release at Surry</li> <li>Connecticut at Montague - Linear</li> <li>Flood Control</li> <li>Max Flow at Keene</li> <li>Flood Control</li> <li>Max Release at Surry</li> <li>Connecticut at Montague - Linear</li> <li>MAX ROC-Increasing</li> <li>Max Plow at Keene</li> <li>Max Outflow equals Max 21 day Inflow</li> <li>Conservation</li> <li>Max Role at Montague - Linear</li> <li>Max Outflow equals Max 21 day Inflow</li> <li>Max Role at Montague - Linear</li> <li>Max Plow at Keene</li> <li>Max Outflow equals Max 21 day Inflow</li> <li>Max Rolo Line ROC</li> <li>Max Rolo Line ROC</li> <li>Max Rolo Line ROC</li> <li>Max Role At Keene</li> <li>Max Role At Keene</li> <li>Max Role Iter ROC</li> <li>Max Role At Keene</li> <li>Max Role At Keene</li> <li>Max Role At Keene</li> <li>Max Pool Elev ROC</li> <li>Ma</li></ul>		Storage Zone	Conservation		Description	Pool elevations	s up tc:		
Image: Connecticut at Montague - Linear         Image: Broome Gate Ops         Image: Max Flow at Keene         Image: Consecticut at Montague - Linear         Image: Max Flow at Keene         Image: Consecticut at Montague - Linear         Image: Max Flow at Keene         Image: Consecticut at Montague - Linear         Image: Max Flow at Keene         Image: Max	Surcharge Directory Min Flow - Flood Pool - Surry	Function of	Date			D	efine		
Image: Second Street	🖳 🔲 Connecticut at Montague - Linear				90		_		
<ul> <li>Flood Control</li> <li>Max Flow at Keene</li> <li>Max Release at Surry</li> <li>Connecticut at Montague - Linear</li> <li>MAX ROC-Increasing</li> <li>Max Pool Elev ROC</li> <li>Max Flow at Keene</li> <li>Connecticut at Montague - Linear</li> <li>Max Pool Elev ROC</li> <li>Max Roc-Increasing</li> <li>Max Roc-Increasing</li> <li>Max Roc-Increasing</li> <li>Max Pool Elev ROC</li> <li>Max Roc-Decreasing</li> <li>M</li></ul>				*			_		
Max Flow at Keene         Min Flow - Flood Pool - Surry         Max Release at Surry         Connecticut at Montague - Linear         MAX ROC-Increasing         Max Pool Elev ROC         Max Flow at Keene         Max Roc-Increasing         Max Flow at Keene         Max Flow at Keene         Max Roc-Increasing         Max Flow at Keene         Max Roc-Increasing         Max Pool Elev Roc         Max Pool Elev Roc         Max Roc-Increasing         Max Pool Elev Roc         Inactive		· · ·			70-				
Image: Second Pool - Surry         Image: Max Release at Surry         Image: Connecticut at Montague - Linear         Image: Max Roc-Increasing         Image: Max Roc-Inc									
Image: Max Roc-Increasing				€	50				
Image: Max Roc-Increasing				tio	40		_		
Image: Max Roc-Increasing         Image: Max Roc-Increasing         Image: Max Roc-Increasing         Image: Max Outflow equals Max 21 day Inflow         Image: Max Roc Increasing         Image: Max Roc-Increasing         Image: Max Roc Increasing         Image: Max Roc Increasing <t< td=""><td></td><td></td><td></td><td>evat</td><td>30</td><td></td><td>_</td></t<>				evat	30		_		
<ul> <li>MAX ROC-Decreasing</li> <li>Max Pool Elev ROC</li> <li>Max Outflow equals Max 21 day Inflow</li> <li>Conservation</li> <li>Min Flow Logic - Surry</li> <li>Max Flow at Keene</li> <li>Connecticut at Montague - Linear</li> <li>MAX ROC-Increasing</li> <li>MAX ROC-Decreasing</li> <li>Max Pool Elev ROC</li> <li>Inactive</li> </ul>				μĒ		<b>-</b>	-		
Max Pool Elev ROC Max Outflow equals Max 21 day Inflow Conservation Max Flow at Keene Max Flow at Keene Max Flow at Keene Max ROC-Increasing Max ROC-Increasing Max Pool Elev ROC Inactive							_		
Image: Max Outliow equals Max 21 day Inflow       Image: Conservation       Image: Conservation <t< td=""><td></td><td></td><td></td><td></td><td>0</td><td></td><td>-    </td></t<>					0		-		
Conservation     Min Flow Logic - Surry     Max Flow at Keene     Max Flow at Keene     Max ROC-Increasing     MAX ROC-Decreasing     Max Pool Elev ROC     Max Pool Elev ROC	Max Outflow equals Max 21 day Inflow								
Min Flow Logic - Surry Max Flow at Keene Connecticut at Montague - Linear MAX ROC-Increasing MAX ROC-Decreasing MAX Pool Elev ROC Inactive					Jan Mar Ma	ay Jul Sep Nov	′		
Max Flow at Keene Connecticut at Montague - Linear MAX ROC-Increasing MAX ROC-Decreasing Max Pool Elev ROC Inactive									
MAX ROC-Increasing MAX ROC-Decreasing Max Pool Elev ROC									
MAX ROC-Decreasing Max Pool Elev ROC Inactive	- Connecticut at Montague - Linear								
Max Pool Elev ROC	MAX ROC-Increasing								
A Inactive	MAX ROC-Decreasing								
	Max Pool Elev ROC			-					
Zone Sort Elevation	👝 Inactive			Ť					
ZUIE SUILEIEVALUUI		Zone Sort Fle	evation						
OK Cancel Apply					ок	Cancel	Apply		

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

💘 Reservoir Editor
Reservoir Edit Operations Zone Rule IF_Block
Reservoir Surry Mountain
Physical Operations Observed Data
Operation Set ExistingOps
Zone-Rules Rel. Alloc. Outages Stor. Credit
<ul> <li>Surcharge - near TOD</li> <li>Broome Gate Ops - Save Dam</li> <li>Surcharge</li> <li>Min Flow - Flood Pool - Surry</li> <li>Max Release at Surry</li> <li>Connecticut at Montague - Linear</li> <li>Broome Gate Ops</li> <li>Max Flow at Keene</li> <li>Flood Control</li> <li>Max Flow at Keene</li> <li>Min Flow - Flood Pool - Surry</li> <li>Max Release at Surry</li> <li>Connecticut at Montague - Linear</li> <li>Max Release at Surry</li> <li>Connecticut at Montague - Linear</li> <li>MAX ROC-Increasing</li> <li>Max Pool Elev ROC</li> <li>Max Flow at Keene</li> <li>Connecticut at Montague - Linear</li> <li>Max Pool Elev ROC</li> <li>Max Flow at Keene</li> <li>Connecticut at Montague - Linear</li> <li>Max ROC-Decreasing</li> <li>Max ROC-Increasing</li> <li>Max Flow at Keene</li> <li>Connecticut at Montague - Linear</li> <li>Max ROC-Increasing</li> <li>Max Pool Elev ROC</li> </ul>

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## **C.** Rule Descriptions

#### 1. Broome Gate Ops-Save Dam

Figure 7 shows the content of "Broome Gate Ops-Save Dam" rule. This rule represents the maximum allowable release from Slide gates as a function of pool elevation when the pool is in Surcharge-near TOD zone.

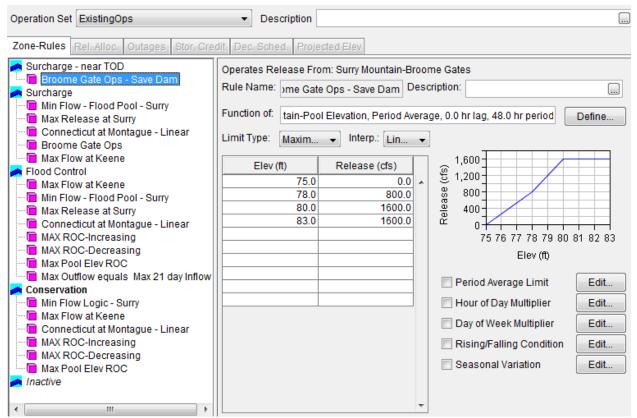


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Broome Gate Ops-Save Dam

### 2. Min Flow-Flood Pool-Surry

Figure 8 shows the content of "Min flow-Flood Pool-Surry" rule. This rule shows the required minimum release from dam during flood control operations.

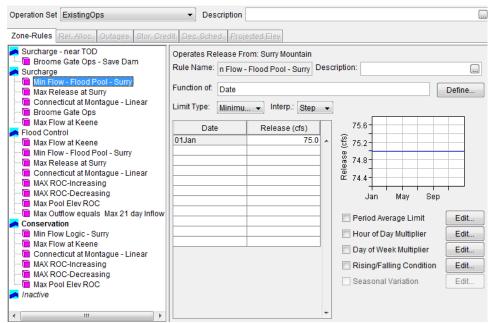


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow-Flood pool-Sury

### 3. Max Release at Surry

Figure 9 shows the content of "Max release at Surry" rule. This rule shows a seasonal maximum allowable release from dam.

Operation Set ExistingOps	<ul> <li>Description</li> </ul>			)
Zone-Rules Rel. Alloc. Outages Stor. Cred	lit Dec. Sched. Proje	ected Elev		
Surcharge - near TOD Broome Gate Ops - Save Dam Surcharge Min Flow - Flood Pool - Surry Min Flow - Flood Pool - Surry Max Release at Surry Flood Control Max Flow at Keene Flood Control Max Flow at Keene Flood Control Max Release at Surry Connecticut at Montague - Linear MaX ROC-Increasing Max ROC-Decreasing Max Flow at Keene Connecticut at Montague - Linear Max ROC-Decreasing Max ROC-Decceasing Max ROC-Decceasing Max ROC-Decce	Operates Release Fri Rule Name: Max Rel Function of: Date Limit Type: Maxim Date 01Jan 01May 01Nov	ease at Surry De	A Scription: Maximum release rate from Otto Define 1,200 1,100 0,000 0,000 1,000 0,0	
✓ III +			<b>*</b>	

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Release at Surry

#### 4. Connecticut at Montague-Linear

Figure 10 shows the content of "Connecticut at Montague-Linear" rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

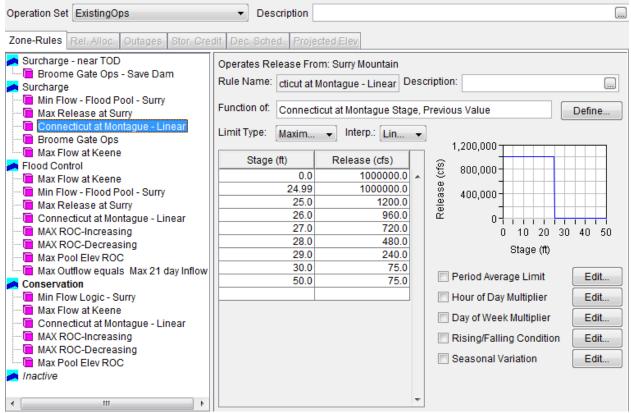


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague-Linear

#### 5. Broome Gate Ops

Figure 11 shows the content of "Broome Gate Ops" rule. This rule shows a seasonal maximum release from Broome gates as a function of pool elevation when the pool is in Surcharge zone.

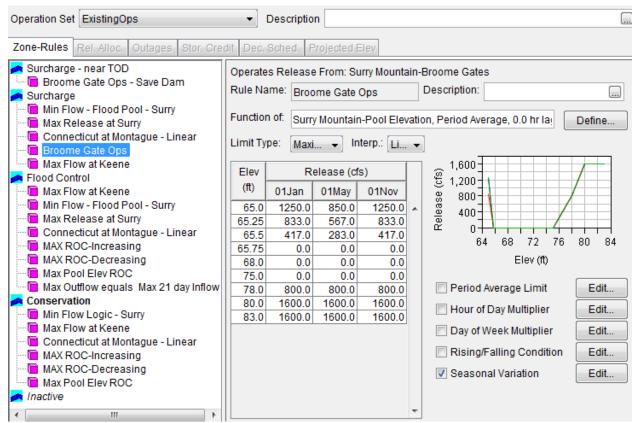


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Broome Gate Ops

### 6. Max Flow at Keene

Figure 12 shows the content of "Max Flow at Keene" rule. This rule represents the maximum allowable flow downstream at the point Ashuelot+Otter Brook.

Operation Set ExistingOps	<ul> <li>Description</li> </ul>			
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sched. Projer	sted Elev		
Surcharge - near TOD  Surcharge  Min Flow - Flood Pool - Surry  Max Release at Surry  Connecticut at Montague - Linear	Operates Release Fro Rule Name: Max Flow Function of: Date	Define		
Broome Gate Ops     Max Flow at Keene     Flood Control     Max Flow at Keene     Min Flow - Flood Pool - Surry     Max Release at Surry     Connecticut at Montague - Linear     MAX ROC-Increasing     MAX ROC-Decreasing	Limit Type: Maxi Downstream Location: Parameter:	Interp.: Step I	ok 2,520 ▼ @ 2,510 ₩ 2,500	
	Date 01Jan	Flow (cfs) 2500.0	2,490 2,480 Jan May Se	p
Max Pool Elev ROC     Max Outflow equals Max 21 day Inflow     Conservation     Min Flow Logic - Surry			<ul> <li>Period Average Limit</li> <li>Hour of Day Multiplier</li> </ul>	Edit
Max Flow at Keene Connecticut at Montague - Linear MAX ROC-Increasing			Day of Week Multiplier Seasonal Variation	Edit
MAX ROC-Decreasing Max Pool Elev ROC			Flow Contingency     Advanced Options	Edit

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Flow at Keene

### 7. Max ROC-Increasing

Figure 13 shows the content of "Max ROC-Increasing" rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Surry Mountain dam.

Operation Set ExistingOps	<ul> <li>Description</li> </ul>	n		[					
Zone-Rules Rel Alloc Outages Stor. Credit Dec. Sched Projected Elev									
Surcharge - near TOD Broome Gate Ops - Save Dam Surcharge Min Flow - Flood Pool - Surry Max Release at Surry		From: Surry Mountain-Da hange Limit MAX ROC-Ir		River					
Connecticut at Montague - Linear     Broome Gate Ops     Max Flow at Keene     Flood Control     Max Flow at Keene	Function Of: Rele Type Incre Interpolate Line	asing -	110						
Min Flow - Flood Pool - Surry     Max Release at Surry     Connecticut at Montague - Linear     MAX ROC-Increasing     Max Pool Elev ROC     Max Outflow equals Max 21 day Inflow     Conservation     Min Flow Logic - Surry     Max Flow at Keene     Connecticut at Montague - Linear     MAX ROC-Increasing     MAX ROC-Increasing     MAX ROC-Decreasing     MAX ROC-Decreasing     MAX ROC-Decreasing	1000 1000 123456	.1 50.0	-001 -00 (cts/µl) -08 (cts/µl) -07 and -03 (cts/µl)	60,000 120,000 Release (cfs)					
Max Pool Elev ROC									

Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max ROC-Increasing

#### 8. Max ROC-decreasing

Figure 14 shows the content of "Max ROC-Decreasing" rule. This rule shows the maximum allowable decreasing release rate of change as a function of release from Surry Mountain dam.

Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max ROC-Decreasing

### 9. Max Pool Elev ROC

Figure 15 shows the content of "Max pool Elev ROC" rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

Operation Set ExistingOps	Description	
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit. Dec. Sched. Projected Elev	
Surcharge - near TOD  Surcharge  Min Flow - Flood Pool - Surry  Max Release at Surry  Max Release at Surry  Max Flow at Keene  Flood Control  Max Flow at Keene  Min Flow - Flood Pool - Surry  Max Release at Surry  Max Roc-Increasing  Max Pool Elev ROC  Max Outflow equals Max 21 day Inflow  Conservation  Max Flow at Keene  Connecticut at Montague - Linear  MAX ROC-Increasing  Max Pool Elev ROC  Max Outflow equals Max 21 day Inflow  Conservation  Max Flow at Keene  MAX ROC-Increasing  Max Pool Elev ROC  M	Operates Release From: Surry Mountain Elevation Rate of Change Limit Max Pool Elev ROC Description Function Of: Constant Type Decreasing Instantaneous Period Average Max Change of (ft) 5.0 over 24 hours	

Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Pool Elev ROC

#### 10. Max Outflow equals Max 21 day Inflow

Figure 16 shows the content of "Max Outflow equals Max 21 day Inflow" rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

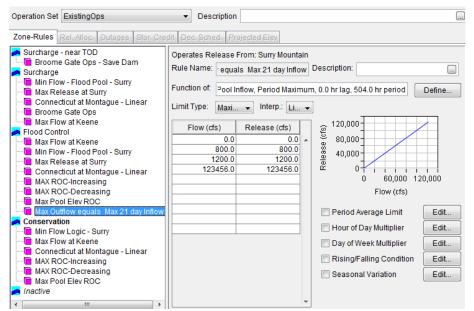


Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals Max 21 day Inflow

#### 11. Min Flow Logic-Surry

Figure 17 shows the content of "Min flow Logic-Surry" rule. This rule provides seasonal minimum releases from Surry Mountain as a function of inflow.

Operation Set ExistingOps	▼ De	escriptior	n					
Zone-Rules Rel, Alloc, Outages Stor, Credit, Dec, Sched, Projected Elev								
Surcharge - near TOD  Broome Gate Ops - Save Dam Surcharge  Min Flow - Flood Pool - Surry  Connecticut at Montague - Linear Broome Gate Ops Max Flow at Keene	Operates Re Rule Name: Function of: Limit Type:	Min Flo	w Logic - lountain-P		Descrip		Value	Define
Flood Control	Flow		Releas	se (cfs)			(£ 300	
Max Flow at Keene	(cfs)	01Jan	01Apr	01Jun	01Oct			
Min Flow - Flood Pool - Surry	0.0	0.0	0.0	0.0	0.0	-		
Max Release at Surry	74.99	52.493	52.493	52.493	52.493		æ 0	
Connecticut at Montague - Linear	75.0	52.5	52.5	75.0	52.5		0 60,000 12	0.000
MAX ROC-Increasing	99.99	69.993		75.0	69.993		Flow (cfs)	
MAX ROC-Decreasing	100.0	100.0	70.0	75.0	100.0		FIDW (CIS)	
Max Pool Elev ROC	399.99		279.993	75.0	100.0		Period Average Limit	Edit
Max Outflow equals Max 21 day Inflow	400.0	100.0	400.0	75.0	100.0		Period Average Limit	Edit
Conservation	123456.0	100.0	400.0	75.0	100.0		Hour of Day Multiplier	Edit
Max Flow at Keene							Day of Week Multiplier	Edit
Connecticut at Montague - Linear								
MAX ROC-Increasing							Rising/Falling Condition	Edit
MAX ROC-Decreasing							Seasonal Variation	Edit
Max Pool Elev ROC								
jan Inactive								
4 III +						Ŧ		

Figure 17: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic -Surry

# Tighe Carmody

### I. Overview

Tighe Carmody dam is located in the town of Southampton, MA on the Manhan River. It is owned and operated by Holyoke Water Works and is used for water supply for the City of Holyoke.

Figure 1 shows the location of Tighe Carmody Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Tighe Carmody dam.

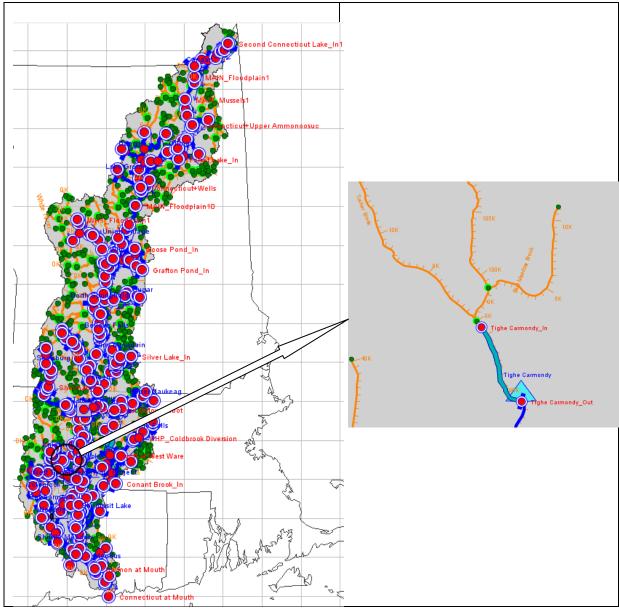


Figure 1: HEC-ResSim Map Display Showing Location of Tighe Carmody



Figure 2: HEC-ResSim Photo of Tighe Carmody Dam

# **II.** Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>96</sup>. The dam consists of two types of outlets: (1) uncontrolled spillway, and (2) controlled Draw-down Conduit as shown in Figure 4.

<sup>&</sup>lt;sup>96</sup> Phase I Report. 1978

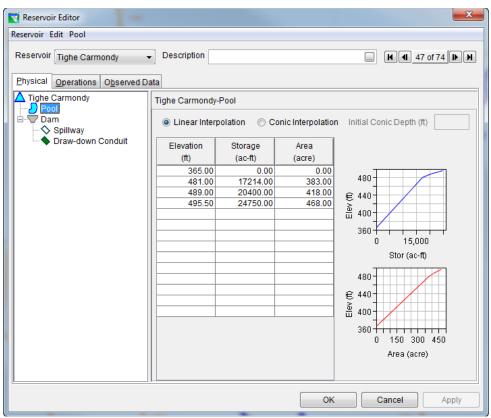


Figure 3: Reservoir Editor: Physical Tab -- Pool

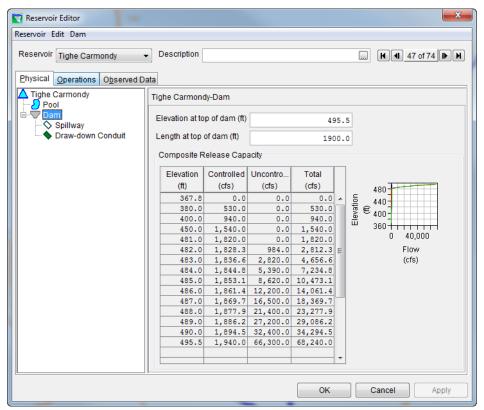


Figure 3 Reservoir Editor: Physical Tab -- Dam

## III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Tighe Carmody's "Existing Ops" operational zones, which consist of zones of Flood Control (495.5 ft), conservation (481 ft), and Inactive zone (365 ft)<sup>1</sup>.

Reservoir Editor	X
Reservoir Edit Operations Zo	ne Rule IF_Block
Reservoir Tighe Carmondy	
Physical Operations Obse	erved Data
Operation Set Existing Ops	Description
	utages Stor. Credit Dec. Sched. Projected Elev
<ul> <li>Flood Control</li> <li>Ops to Save Dam</li> <li>Conservation</li> <li>Minimum release</li> <li>Inactive</li> </ul>	Storage Zone Conservation Description Define
	Zone Sort Elevation
	OK Cancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 5 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. There is a water supply time series associated with Tighe Carmondy which is described in the water supply section of the report.

Reservoir Editor
Reservoir Edit Operations Zon
Reservoir Tighe Carmondy
Physical Operations Obser
Operation Set Existing Ops
Zone-Rules Rel, Alloc. Ou
Flood Control
Minimum release

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

# **C.** Rule Descriptions

### 1. Ops to save Dam

Figure 7 shows the content of "Ops to save Dam" rule. This rule shows when the pool elevation gets to elevation 487 ft the maximum release of 1940 will occur to save the dam.

Operation Set Existing Ops	•	Description			
Zone-Rules Rel. Alloc. Out	ages Stor. Credit Dec	Sched. Projected El	ev		
Flood Control Conservation Minimum release Inactive	Operates Release From Rule Name: Ops to Sa Function of: Tighe Ca Limit Type: Maximum Elev (ft) 481.0 484.0 487.0	ave Dam Des	, Pre	tion: vious Value	Edit Edit Edit Edit

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Ops to save Dam

## 2. Minimum Release

Figure 8 shows the content of "Minimum Release" rule. This rule represents a minimum release of 1 cfs from Tighe Carmody reservoir.

Operation Set Existing Ops	•	Description			
Zone-Rules Rel. Alloc. Out	tages Stor. Credit Dec	c. Sched. Projected El	ev		
Flood Control	Operates Release Fro Rule Name: Minimum Function of: Date		am script	tion:	Define
	Limit Type: Minimum Date 01Jan	Release (cfs) 1.0		1.010 1.005 1.005 0.995 0.995 Jan Mar May Jul Sep	Nov
				Period Average Limit	Edit
				Hour of Day Multiplier	Edit
				Day of Week Multiplier	Edit
				Rising/Falling Condition	Edit
			-	Seasonal Variation	Edit

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Minimum Release

# Townshend

## I. Overview

Townshend dam is a dam located in Townshend, Vermont on the West River. It was constructed in 1961 by the US Army Corps of Engineers and is still owned and operated by the Corps. It is primarily used for flood control purposes but also for recreation.

Figure 1 shows the location of Townshend Dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo from Townshend Dam.

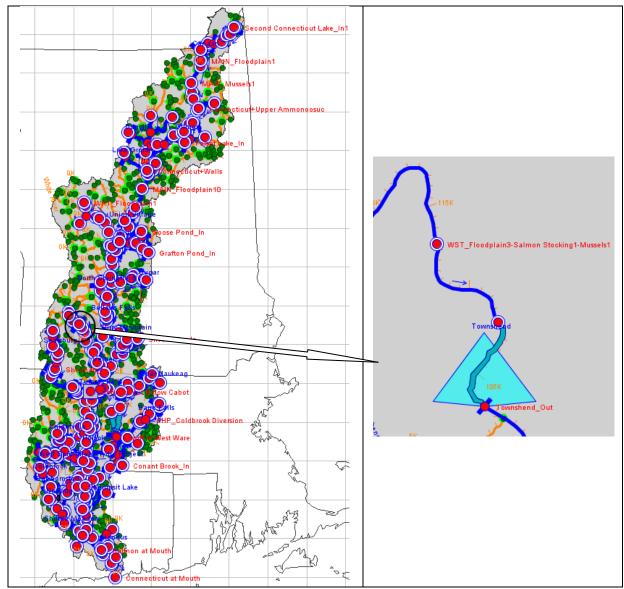


Figure 1 HEC-ResSim Map Display Showing Location of Townshend dam



Figure 2: Photo of Townshend dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled vertical lift gates, and (2) uncontrolled spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>97</sup>.

<sup>&</sup>lt;sup>97</sup> http://rsgisias.crrel.usace.army.mil/nae/cwms\_map.map\_index

eservoir Edit Pool				
Reservoir Townshend	<ul> <li>Description</li> </ul>			
Physical Operations Observed	Data			
Townshend	Townshend-Pool			
Dam	Linear Interpolati	on 💿 Conic Inter	oolation Initial Coni	c Depth (ft)
Spillway	Elevation	Storage	Area	
	(ft)	(ac-ft)	(acre)	
	0.00	100000.00	0.00	
	2.00	100005.00	3.00	
	4.00	100028.00	6.00	
	6.00	100075.00	10.00	
	8.00	100112.00	15.00	120
	10.00	100137.00	20.00	€ 80
	12.00	100175.00	30.00	€ 80
	14.00	100275.00	40.00	a 40-
	16.00	100425.00	55.00	
	18.00	100575.00	70.00	
	20.00	100725.00	85.00	
	21.00	100800.00	95.00	Stor (ac-ft)
	23.00	101050.00	115.00	T
	25.00	101300.00	135.00	120-
	27.00	101550.00	154.00	€ 80
	29.00	101800.00	173.00	€ 80
	31.00	102100.00	192.00	± 40
	33.00	102550.00	211.00	
	35.00	102900.00	230.00	
	37.00	103500.00	248.00	
	39.00	104050.00	266.00	Area (acre)
	41.00	104550.00	284.00	
	43.00	105100.00	302.00	
	45.00	105700.00	320.00	
	47.00	106450.00	340.00	
	49.00	107100.00	360.00 -	

Figure 3: Reservoir Editor: Physical Tab -- Pool

eservoir Edit Dam					
Reservoir Townshend	<ul> <li>Description</li> </ul>				K 4 33 of 74 K
Physical Operations Observed	Data				
Townshend	Townshend-Dam				
Dam Dam	Elevation at top of	dam (ft)		126.0	د د
Spillway	Length at top of d	am (ft)		1700.0	3
	Composite Rele	ase Capacity			
	Elevation	Controlled	Uncontrolled	Total	
	(ft)	(cfs)	(cfs)	(cfs)	120
	2.0	300.0	0.0	300.0 🔺	
	4.0	600.0	0.0	600.0	
	6.0	1,050.0	0.0	1,050.0	
	8.0	1,650.0	0.0	1,650.0 ⊨	0 200,000
	10.0	2,850.0	0.0	2,850.0	
	12.0	3,000.0	0.0	3,000.0	Flow
	14.0	3,900.0	0.0	3,900.0	(cfs)
	16.0	4,800.0	0.0	4,800.0	
	18.0	5,850.0	0.0	5,850.0	
	20.0	7,575.0	0.0	7,575.0	
	22.0	8,400.0	0.0	8,400.0	
	24.0	9,075.0	0.0	9,075.0	
	28.0	9,756.0	0.0	9,756.0	
	30.0	10,500.0	0.0	10,500.0	
	32.0	11,100.0	0.0	11,100.0	
	34.0	11,700.0	0.0	11,700.0	
	36.0	12,150.0	0.0	12,150.0	
	38.0	12,750.0	0.0	12,750.0	
	40.0	13,200.0	0.0	13,200.0	
	42.0	13,800.0	0.0	13,800.0	
	44.0	14,250.0	0.0	14,250.0 *	

Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Townshend's "ExistingOps" operational zones, which consist of zones of Top of dam (126 ft), Surcharge (116 ft), Flood Control (96 ft), Conservation (21 ft), and Inactive zone (0 ft).

Reservoir     Townshend     Description       Physical     Operations     Observed Data       Operation     Set     ExistingOps	✓ Description	
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. Projected Elev	
<ul> <li>Lift Gate Ops - Save Dam</li> <li>Surcharge</li> <li>Min Flow - Flood Pool - Townshend</li> <li>Max Release at Townshend</li> <li>Lift Gate Ops</li> <li>Max Stage at North Walpole - Townshend</li> <li>Max Stage at Montague - Townshend</li> <li>Flood Control</li> <li>Min Flow - Flood Pool - Townshend</li> <li>Max Release at Townshend</li> <li>Max ROC-Increasing</li> <li>Max Stage at North Walpole - Townshend</li> <li>Max Stage at Montague - Townshend</li> <li>Max Stage at Montague - Townshend</li> <li>Max Conservation Release at Townshend</li> <li>Max Conservation Release at Townshend</li> <li>Max ROC-Increasing</li> <li>Max ROC-Increasing</li> <li>Max Conservation Release at Townshend</li> <li>Max ROC-Decreasing</li> <li>Max ROC-Increasing</li> <li>Max ROC-Increasing</li> <li>Max ROC-Increasing</li> <li>Max Conservation Release at Townshend</li> <li>Max ROC-Increasing</li> <li>Max ROC-Increasing<th>Storage Zone Conservation Function of Date       Date     Top Elevation (ft)       01Jan     21.0      </th><th>Description Define</th></li></ul>	Storage Zone Conservation Function of Date       Date     Top Elevation (ft)       01Jan     21.0	Description Define

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

🟹 Reservoir Editor
Reservoir Edit Operations Zone Rule IF_Block
Reservoir Townshend
Physical Operations Observed Data
Operation Set ExistingOps
Zone-Rules Rel. Alloc. Outages Stor. Credit
<ul> <li>Top of dam</li> <li>Lift Gate Ops - Save Dam</li> <li>Surcharge</li> <li>Min Flow - Flood Pool - Townshend</li> <li>Max Release at Townshend</li> <li>Lift Gate Ops</li> <li>Max Stage at North Walpole - Townshend</li> <li>Max Stage at Montague - Townshend</li> <li>Max Stage at Montague - Townshend</li> <li>Max Stage at Montague - Townshend</li> <li>Max Release at Townshend</li> <li>Max Release at Townshend</li> <li>Max Release at Townshend</li> <li>Max Release at Townshend</li> <li>Max Roc-Increasing</li> <li>Max Stage at North Walpole - Townshend</li> <li>Max Stage at North Walpole - Townshend</li> <li>Max Stage at North Walpole - Townshend</li> <li>Max Stage at Montague - Townshend</li> <li>Max Conservation</li> <li>Max Conservation Release at Townshend</li> <li>Max ROC-Increasing</li> <li>Max Conservation Release at Townshend</li> <li>Max ROC-Increasing</li> <li>Max ROC-Increasing</li> <li>Max Conservation Release at Townshend</li> <li>Max ROC-Increasing</li> <li>Max ROC-Decreasing</li> <li>Max ROC-Increasing</li> <li>Max Stage at North Walpole - Townshend</li> <li>Max Stage at Montague - Townshend</li> <li>Max Pool Elev ROC</li> <li>Max Pool Elev ROC</li> <li>Max Pool Elev ROC</li> <li>Inactive</li> </ul>

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## **C.** Rule Descriptions

#### 1. Lift Gate Ops-Save Dam

Figure 7 shows the content of "Lift Gate Ops-Save Dam" rule. This rule represents the maximum allowable release from Lift gates when the pool is in Top of dam zone as a function of pool elevation.

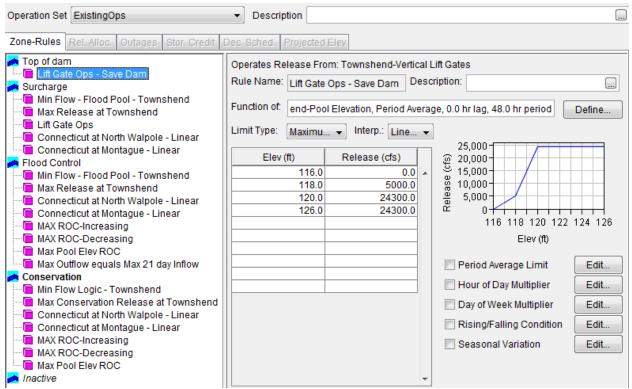


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Lift Gate Ops-Save Dam

#### 2. Min Flow-Flood Pool-Townshend

Figure 8 shows the content of "Min Flow-Flood pool-Townshend" rule. This rule represents the minimum required release from dam during flood control operations.

Operation Set ExistingOps	<ul> <li>Description</li> </ul>			
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. Projected	Elev		
Top of dam     Lift Gate Ops - Save Dam     Surcharge     Min Flow - Flood Pool - Townshend     Max Release at Townshend     Lift Gate Ops     Connecticut at North Walpole - Linear     Flood Control     Min Flow - Flood Pool - Townshend     Max Release at Townshend     Max Release at Townshend     Max Release at Townshend     Max Release at North Walpole - Linear     Connecticut at North Walpole - Linear     Max Rolease at Townshend     Max Release at Townshend     Max Release at Townshend     Max Rolease at North Walpole - Linear     Max ROC-Increasing     MAX ROC-Decreasing	Operates Release Fri Rule Name: - Flood Function of: Date Limit Type: Minimur Date 01Jan 01Jun 01Oct	Pool - Townshend De	280	Define
Max Pool Elev ROC			Period Average Limit	Edit
Conservation  Min Flow Logic - Townshend  Max Conservation Release at Townshend  Connecticut at North Walpole - Linear  MAX ROC-Increasing  MAX ROC-Decreasing  MAX ROC-Decreasing  Max Pool Elev ROC  Anactive			Hour of Day Multiplier Day of Week Multiplier Rising/Falling Condition Seasonal Variation	Edit Edit Edit

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow-Flood pool-Townshend

#### 3. Max Release at Townshend

Figure 9 shows the content of "Max release at Townshend" rule. This rule assigns 9000 cfs as a maximum release from dam.

Operation Set ExistingOps	✓ Description	)
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. Projected Elev	
Connecticut at North Walpole - Linear     Max Release at Townshend     Max Release at Townshend     Max Release at North Walpole - Linear     Connecticut at North Walpole - Linear     Max Release at North Walpole - Linear     Max Release at North Walpole - Linear     Max Release at North Walpole - Linear     Connecticut at North Walpole - Linear     Max ROC-Decreasing     Max Pool Elev ROC     Max Outflow equals Max 21 day Inflow     Conservation     Min Flow Logic - Townshend	Operates Release From: Townshend         Rule Name:       ax Release at Townshend         Date       Defin         Limit Type:       Maximu         Date       9,080         01Jan       9000.0         9,080       9,040         9,000       9,080         01Jan       9000.0         9,080       9,040         9,080       9,040         9,040       9,0	     
Max Conservation Release at Townshend Connecticut at North Walpole - Linear	Day of Week Multiplier     Ed     Rising/Falling Condition     Ed	
Connecticut at Montague - Linear MAX ROC-Increasing MAX ROC-Decreasing Max Pool Elev ROC Inactive	Seasonal Variation	

Figure 9 Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Release at Townshend

### 4. Lift Gate Ops

Figure 10 shows the content of "Lift Gate Ops" rule. This rule represents the maximum allowable release from Lift gates as a function of pool elevation when pool is in surcharge zone.

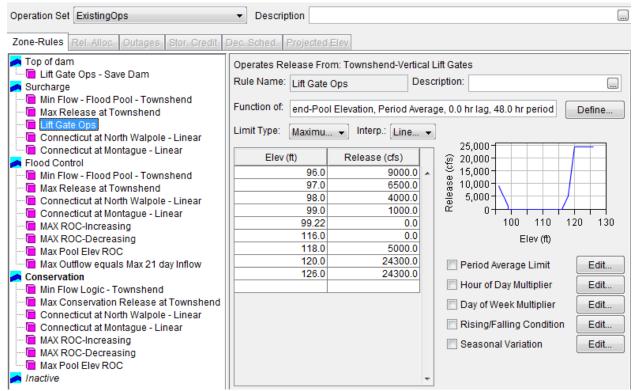


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Lift Gate Ops

### 5. Connecticut at North Walpole-Linear

Figure 11 shows the content of "Connecticut at North Walpole-Linear" rule. This rule represents the maximum allowable release from dam as a function of previous day stage at North Walpole. The SOP for Townshend was slightly different than the other flood control dams in that it called for an immediate reduction to 3000 cfs when a mainstem stage target was exceeded. Then the SOP says that the outflow will be directed by the Reservoir Regulation Team. The immediate reduction to 3000 cfs was accounted for in the rule and then 3000 cfs was used as the maximum when applying the linear release cutback described in the Simulation/Verification section of the report. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

Operation Set ExistingOps	Description
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. Projected Elev.
<ul> <li>Top of dam</li> <li>Lift Gate Ops - Save Dam</li> <li>Surcharge</li> <li>Min Flow - Flood Pool - Townshend</li> <li>Max Release at Townshend</li> <li>Lift Gate Ops</li> <li>Connecticut at North Walpole - Linear</li> <li>Flood Control</li> <li>Min Flow - Flood Pool - Townshend</li> <li>Max Release at Townshend</li> <li>Connecticut at Montague - Linear</li> <li>Flood Control</li> <li>Max Release at Townshend</li> <li>Connecticut at North Walpole - Linear</li> <li>MAX ROC-Increasing</li> <li>MAX ROC-Decreasing</li> <li>Max Outflow equals Max 21 day Inflow</li> <li>Conservation</li> <li>Min Flow Logic - Townshend</li> <li>Connecticut at North Walpole - Linear</li> <li>Connecticut at North Walpole - Linear</li> <li>Max Conservation Release at Townshend</li> <li>Max Conservation Release at Townshend</li> <li>Max Conservation Release at Townshend</li> <li>MAX ROC-Increasing</li> <li>MAX ROC-Increasing</li> <li>MAX ROC-Increasing</li> <li>MAX ROC-Decreasing</li> <li>MAX Pool Elev ROC</li> </ul>	Operates Release From: Townshend         Rule Name:       t at North Walpole - Linear       Description:         Function of:       Connecticut at North Walpole Stage, Previous Value       Define         Limit Type:       Maximu  Interp.:       Line  Interp.:       Interp.:         Stage (ft)       Release (cfs)       8,000       8,000         23.998       9000.0       4,000       2,000         24.0       3000.0       2,000       0       10       20       30       40       50         27.0       2400.0       2,000       0       10       20       30       40       50         31.0       0.0       0.0       0       10       20       30       40       50         31.0       0.0       0.0       0       10       20       30       40       50         31.0       0.0       0.0       0       0       10       20       30       40       50         Stage (ft)       29.0       120.0       30.0       600.0       31.0       0.0       50.0       Stage (ft)       Edit         Hour of Day Multiplier       Edit       Edit       Seasonal Variation       Edit   <

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at North Walpole-Linear

#### 6. Connecticut at Montague-Linear

Figure 12 shows the content of "Connecticut at Montague-Linear" rule. This rule represents the maximum allowable release from dam as a function of previous day stage at Montague. The SOP for Townshend was slightly different than the other flood control dams in that it called for an immediate reduction to 3000 cfs when a mainstem stage target was exceeded. Then the SOP says that the outflow will be directed by the Reservoir Regulation Team. The immediate reduction to 3000 cfs was accounted for in the rule and then 3000 cfs was used as the maximum when applying the linear release cutback described in the Simulation/Verification section of the report. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

Operation Set ExistingOps	Description
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. Projected Elev
<ul> <li>Top of dam</li> <li>Top of dam</li> <li>Lift Gate Ops - Save Dam</li> <li>Surcharge</li> <li>Min Flow - Flood Pool - Townshend</li> <li>Max Release at Townshend</li> <li>Lift Gate Ops</li> <li>Connecticut at North Walpole - Linear</li> <li>Flood Control</li> <li>Min Flow - Flood Pool - Townshend</li> <li>Max Release at Townshend</li> <li>MAX ROC-Increasing</li> <li>MAX ROC-Decreasing</li> <li>Max Outflow equals Max 21 day Inflow</li> <li>Conservation</li> <li>Min Flow Logic - Townshend</li> <li>Max Conservation Release at Townshend</li> <li>Connecticut at North Walpole - Linear</li> <li>Connecticut at North Walpole - Linear</li> <li>Max Conservation Release at Townshend</li> <li>Max ROC-Increasing</li> </ul>	Operates Release From: Townshend         Rule Name:       cticut at Montague - Linear       Description:         Function of:       Connecticut at Montague Stage, Previous Value       Define         Limit Type:       Maximu       Interp.:       Line         Stage (ft)       Release (cfs)       8,000       6,000         22.998       9000.0       4,000       2,000         23.0       3000.0       2,000       0       10       20       30       40       50         28.0       1800.0       29.0       1200.0       0       10       20       30       40       50         31.0       0.0       0.0       0       0       10       20       30       40       50         Stage (ft)       29.0       1200.0       0       10       20       30       40       50         31.0       0.0       0.0       0       0       10       20       30       40       50         31.0       0.0       0.0       0       0       10       20       30       40       50         Stage (ft)       20.0       0       0       10       20       30       40       50

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague-Linear

#### 7. MAX ROC-Increasing

Figure 13 shows the content of "MAX ROC-Increasing" rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Townshend dam.

Operation Set ExistingOps	Description			
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev				
<ul> <li>Top of dam</li> <li>Lift Gate Ops - Save Dam</li> <li>Surcharge</li> <li>Min Flow - Flood Pool - Townshend</li> <li>Max Release at Townshend</li> <li>Lift Gate Ops</li> <li>Connecticut at North Walpole - Linear</li> <li>Flood Control</li> <li>Min Flow - Flood Pool - Townshend</li> <li>Max Release at Townshend</li> <li>Connecticut at North Walpole - Linear</li> <li>Max Role-Increasing</li> <li>Max ROC-Decreasing</li> <li>Max Conservation Release at Townshend</li> <li>Max Conservation Release at Townshend</li> <li>Connecticut at North Walpole - Linear</li> <li>Connecticut at North Walpole - Linear</li> <li>Max Collow equals Max 21 day Inflow</li> <li>Conservation</li> <li>Max Conservation Release at Townshend</li> <li>Max Concecticut at North Walpole - Linear</li> <li>MAX ROC-Increasing</li> <li>MAX ROC-Increasing</li> <li>MAX ROC-Increasing</li> <li>MAX ROC-Decreasing</li> <li>MAX ROC-Increasing</li> <li>Max Pool Elev ROC</li> <li>Inactive</li> </ul>	Operates Release From: Townshend-Dam         Release Rate of Change Limit         MAX ROC-Increasing         Description:         Function Of:         Release         Type         Increasing         Interpolate         Release (cfs)         Rate Change (cfs/hr)         0.0         1000.0         7000.0         123456.0         500.0         123456.0         500         600         <			

Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – MAX ROC-Increasing

### 8. MAX ROC-Decreasing

Figure 14 shows the content of "MAX ROC-Decreasing" rule. This rule shows the maximum allowable decreasing release rate of change from Townshend dam.

Operation Set ExistingOps	<ul> <li>Description</li> </ul>			
Zone-Rules Rel. Alloc. Outages Stor. Credit. Dec. Sched. Projected Elev				
Top of dam Top of dam Lift Gate Ops - Save Dam Surcharge Connecticut at North Walpole - Linear Max Release at Townshend Max Roc-Decreasing Max Conservation Max Conservation Release at Townshend Connecticut at North Walpole - Linear Max ROC-Increasing Max Conservation Release at Townshend Connecticut at North Walpole - Linear Max Conservation Max Conservation Max Conservation Release at Townshend Max Connecticut at North Walpole - Linear Max Conservation Max Conservation Release at Townshend Max Conservation Release at Townshend Max ROC-Increasing MAX ROC-Inc	Operates Release From: To Release Rate of Change Lin Description: Function Of: Type Max Rate of Change (cfs/hr)			

Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet – MAX ROC-Decreasing

### 9. Max Pool Elev ROC

Figure 15 shows the content of "Max Pool Elev ROC" rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

Operation Set ExistingOps	Description	
Zone-Rules Rel, Alloc. Outages Stor. Credit	Dec. Sched. Projected Elev	
<ul> <li>Top of dam</li> <li>Lift Gate Ops - Save Dam</li> <li>Surcharge</li> <li>Min Flow - Flood Pool - Townshend</li> <li>Max Release at Townshend</li> <li>Lift Gate Ops</li> <li>Connecticut at North Walpole - Linear</li> <li>Connecticut at North Walpole - Linear</li> <li>Flood Control</li> <li>Max Release at Townshend</li> <li>Connecticut at North Walpole - Linear</li> <li>Max Role-ase at Townshend</li> <li>Max ROC-Increasing</li> <li>Max ROC-Decreasing</li> <li>Max Outflow equals Max 21 day Inflow</li> <li>Connecticut at North Walpole - Linear</li> <li>Connecticut at North Walpole - Linear</li> <li>Max Pool Elev ROC</li> <li>Max ROC-Increasing</li> <li>MAX Pool Elev ROC</li> <li>Inactive</li> </ul>	Operates Release From: Townshend Elevation Rate of Change Limit Max Pool Elev ROC Description Function Of: Constant Type Decreasing Instantaneous Period Average Max Change of (ft) 10.0 over 24 hours	

Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Pool Elev ROC

### 10. Max Outflow equals Max 21 day Inflow

Figure 16 shows the content of "Max Outflow equals Max 21 day Inflow" rule. This rule represents the maximum release from dam as a function of Inflow.

Operation Set ExistingOps	Description	
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. Projected Elev	
Top of dam     Top of dam     Gate Ops - Save Dam     Surcharge     Gmin Flow - Flood Pool - Townshend     Max Release at Townshend	Operates Release From: Townshend Rule Name: v equals Max 21 day Inflow Description: Function of: vend-Pool Inflow, Period Maximum, 0.0 hr lag, 504.0 hr period Defin	 ne
Lift Gate Ops     Connecticut at North Walpole - Linear     Connecticut at Montague - Linear     Flood Control     Min Flow - Flood Pool - Townshend     Max Release at Townshend     Connecticut at North Walpole - Linear     Connecticut at Montague - Linear     MAX ROC-Increasing     MAX ROC-Decreasing     MAX Pool Elev ROC	Limit Type: Maximu  Interp.: Line  Flow (cfs) Release (cfs) 0.0 0.0 9000.0 9000.0 9000.0 123456.0 9000.0 0 0 60,000 120,000 0 0 60,000 120,000 Flow (cfs)	)
Max Outflow equals Max 21 day Inflow     Mias Outflow equals Max 21 day Inflow     Conservation     Max Conservation Release at Townshend     Max Conservation Release at Townshend     Connecticut at North Walpole - Linear     Connecticut at Montague - Linear     MAX ROC-Increasing     MAX ROC-Decreasing     MAX ROC-Decreasing     Max Pool Elev ROC     MaxCive	Hour of Day Multiplier     Day of Week Multiplier     Rising/Falling Condition	dit dit dit dit

Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals Max 21 day Inflow

### 11. Min Flow Logic-Townshend

Figure 17 shows the content of "Min Flow Logic-Townshend" rule. This rule describes required seasonal minimum flows from controlled outlets as a function of inflow at Townshend.

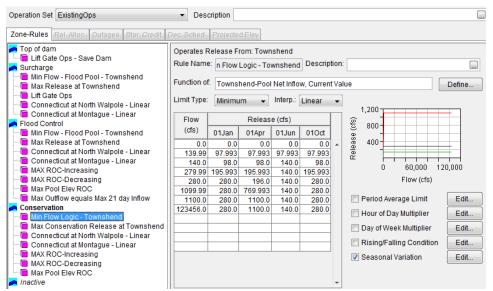


Figure 17: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min flow Logic-Townshend

#### 12. Max Conservation Release at Townshend

Figure 18 shows the content of "Max Conservation Release at Townshend" rule. This rule represents the maximum allowable release from Townshend when the pool is in the conservation zone. This rule is unique to Ball Mountain and Townshend.

Operation Set ExistingOps	▼ Description			
Zone-Rules Rel. Alloc. Outages Stor. Credit	Dec. Sched. Projected Ele	20/		
Top of dam     Lift Gate Ops - Save Dam     Surcharge     Min Flow - Flood Pool - Townshend     Max Release at Townshend     Lift Gate Ops     Connecticut at North Walpole - Linear     Connecticut at Montague - Linear     Flood Control	Operates Release From: Rule Name: on Release Function of: Date Limit Type: Maximum Date		Maximum conservation release	e (OG) Define
Most Connection Place Pla	01Jan	1500.0	(2) 1,505 a) 1,500 a) 1,500 a) 1,495 a) 1,495 b) 1,495 b) 1,495 c) 1,495 c) 1,495 c) 1,495 c) 1,505 c) 1,505 c) 1,505 c) 1,505 c) 1,505 c) 1,505 c) 1,505 c) 1,505 c) 1,505 c) 1,495 c) 1,	
Max Outflow equals Max 21 day Inflow			Period Average Limit	Edit
Min Flow Logic - Townshend     Max Conservation Release at Townshend     Connecticut at North Walpole - Linear     Connecticut at Montague - Linear			Hour of Day Multiplier Day of Week Multiplier Rising/Falling Condition	Edit Edit Edit
MAX ROC-Increasing     MAX ROC-Decreasing     Max Pool Elev ROC     Max Pool Elev ROC     Mactive		-	Seasonal Variation	Edit

Figure 18: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max conservation Release at Townshend

# Tully

## I. Overview

Tully Lake dam is a dam located in Royalston, Massachusetts on the Millers River. It was constructed in 1949 by the US Army Corps of Engineers and is still owned and operated by the Corps. It is primarily used for flood control purposes but also for recreation.

Figure 1 shows the location of Tully Dam as it is represented in the HEC-ResSim model, and Figure 2 shows the photo from Tully dam.

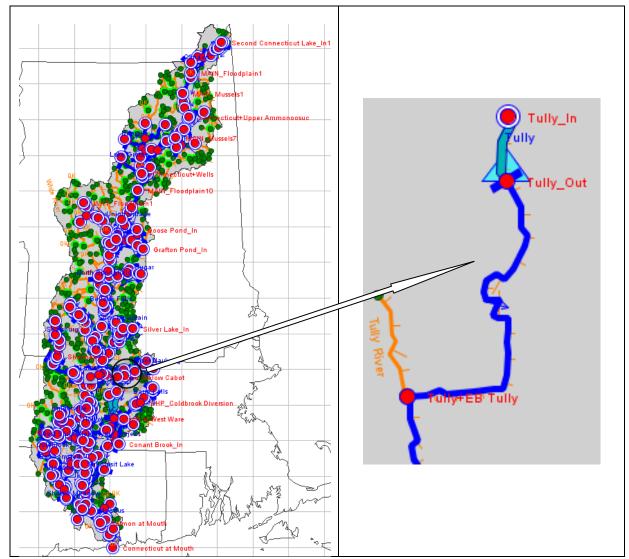


Figure 1: HEC-ResSim Map Display Showing Location of Tully dam



Figure 2: Photo of Tully Lake dam.

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled slide gates, and (2) uncontrolled spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>98</sup>.

<sup>98</sup> http://rsgisias.crrel.usace.army.mil/nae/cwms\_map.map\_index

eservoir Edit Pool				
Reservoir Tully	<ul> <li>Description</li> </ul>			
Physical Operations Obs	erved Data			
	Tully-Pool			
Dam Slide Gates	Linear Interpo	lation 💿 Conic	Interpolation Ir	nitial Conic Depth (ft)
Spillway	Elevation	Storage	Area	
	(ft)	(ac-ft)	(acre)	
	625.00	0.00	0.00	
	626.00	5.00	5.00	
	627.00	10.00	10.00	670
	628.00	15.00	17.00	660
	629.00	20.00	20.00	
	630.00	25.00	23.00 ≡	€ 650 à 640 
	631.00	125.00	32.00	<u><u><u> </u></u></u>
	632.00	200.00	38.00	620
	633.00	225.00	45.00	0 15,000 30,000
	634.00	375.00	55.00	Stor (ac-ft)
	635.00	425.00	65.00	Stor (ac-it)
	636.00	525.00	78.00	670
	637.00	650.00	95.00 112.00	660
	638.00 639.00	825.00 1025.00	140.00	€ 650
	640.00	1225.00	210.00	
	641.00	1500.00	305.00	<sup>III</sup> 630 -
	642.00	1825.00	365.00	620
	643.00	2200.00	420.00	0 600 1,200
	644.00	2600.00	465.00	Area (acre)
	645.00	3025.00	505.00	
	646.00	3475.00	545.00	
	647.00	4025.00	580.00	
	648.00	4575.00	615.00	
			O	K Cancel Apply

Figure 3: Reservoir Editor: Physical Tab -- Pool

eservoir Edit Dam					
Reservoir Tully	- Descriptio	on			
Physical Operations Obse	erved Data				
Tully	Tully-Dam				
Dam	Elevation at top	o of dam (ft)			
Spillway	Length at top o	f dam (ft)			
	Composite R	lease Canaci	itv		
	Compositerto		uy (		-
	Elevation	Controlled	Uncontroll	Total	
	(ft)	(cfs)	(cfs)	(cfs)	680
	625.0	0.0	0.0	0.0 🔺	5 660
	630.0	290.0	0.0	290.0	E 660
	635.0	510.0	0.0	510.0	
	640.0	630.0	0.0	630.0	620 + + + + + + + + + + + + + + + + + + +
	645.0	720.0	0.0	720.0	
	650.0	780.0	0.0	780.0	Flow
	655.0	830.0	0.0	830.0 ≡	(cfs)
	660.0	860.0	0.0	860.0	
	665.0	890.0	0.0	890.0	
	668.0	900.0	0.0	900.0	
	668.9	900.0	825.0 850.0	1,725.0	
	670.0	900.0	2,400.0	3,300.0	_
	671.0	900.0		5,150.0	
	672.0	900.0	6,600.0	7,500.0	
	673.0	900.0	9,500.0	10,400.0	
	674.0	900.0		13,600.0	
	675.0			16,900.0	
	676.0		20,000.0	20,900.0	
	678.0	900.0		29,600.0 -	

Figure 4: Reservoir Editor: Physical Tab -- Dam

## III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Tully's "ExistingOps" operational zones, which consist of zones of Excess Surcharge (684 ft), Surcharge Storage (672 ft), Flood Control (668 ft), Conservation (638-641 ft), and Inactive zone (625 ft).

Reservoir Editor							
Reservoir Tully Des	scription				. K d 61 of 74 D D		
Operation Set ExistingOps							
<ul> <li>Excess Surcharge</li> <li>Gate Operation to Save the Dam</li> <li>Surcharge Storage</li> <li>Gate Operation During Surcharge</li> <li>Flood Control</li> <li>Channel Capacity</li> <li>Minimum Releases</li> <li>Max at Athol - DC</li> <li>Connecticut at Montague - Linear</li> <li>Connecticut at Hartford - Linear</li> <li>Maximum Rate of Increase</li> <li>Max Outflow = Max 21d Inflow</li> <li>Conservation</li> <li>Connecticut at Montague - Linear</li> <li>Max Outflow = Max 21d Inflow</li> <li>Conservation</li> <li>Connecticut at Hartford - Linear</li> <li>Conservation</li> <li>Connecticut at Montague - Linear</li> <li>Connecticut at Montague - Linear</li> <li>Max at Athol - DC</li> <li>Connecticut at Montague - Linear</li> <li>Connecticut at Hartford - Linear</li> <li>Max at Athol - DC</li> <li>Connecticut at Hartford - Linear</li> <li>Maximum Rate of Increase</li> <li>Maximum Rate of Increase</li> <li>Maximum Rate of Decrease</li> <li>Max Pool Elev ROC</li> <li>Inactive</li> </ul>	Storage Zone Cor Function of Date 01Jan 31Mar 08Apr 15Apr 17Apr 01May 30Nov 01Dec   Zone Sort Elevation	Top Elevation (ft) 638.0 638.0 643.0 643.0 641	Elevation (ft)	escription	Define		
				ок	Cancel Apply		

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops.

🟹 Reservoir Editor
Reservoir Edit Operations Zone Rule IF_B
Reservoir Tully De
Physical Operations Observed Data
Operation Set ExistingOps
Zone-Rules Rel. Alloc. Outages Stor.
<ul> <li>Excess Surcharge</li> <li>Gate Operation to Save the Dam</li> <li>Surcharge Storage</li> <li>Gate Operation During Surcharge</li> <li>Flood Control</li> <li>Channel Capacity</li> <li>Minimum Releases</li> <li>Max at Athol - DC</li> <li>Connecticut at Montague - Linear</li> <li>Connecticut at Hartford - Linear</li> <li>Maximum Rate of Increase</li> <li>Max Outflow = Max 21d Inflow</li> <li>Conservation</li> <li>Connecticut at Montague - Linear</li> <li>Max Outflow = Max 21d Inflow</li> <li>Conservation</li> <li>Connecticut at Hartford - Linear</li> <li>Max at Athol - DC</li> <li>Max Outflow = Max 21d Inflow</li> <li>Conservation</li> <li>Connecticut at Montague - Linear</li> <li>Max at Athol - DC</li> <li>Connecticut at Montague - Linear</li> <li>Max at Athol - DC</li> <li>Maximum Rate of Increase</li> <li>Maximum Rate of Increase</li> <li>Maximum Rate of Increase</li> <li>Maximum Rate of Decrease</li> </ul>

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## **C.** Rule Descriptions

#### 1. Gate Operation to Save Dam

Figure 7 shows the content of "Gate Operation to Save Dam" rule. This rule represents the maximum allowable release from Slide gates as a function of pool elevation when the pool is in Excess Surcharge zone.

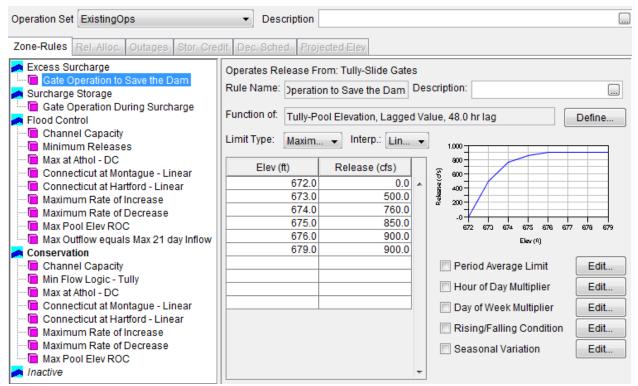


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet –Gate Operation to Save Dam

### 2. Gate Operation During Surcharge

Figure 8 shows the content of "Gate Operation During Surcharge" rule. This rule represents the maximum allowable release from Tully as a function of pool elevation when the pool is in Surcharge storage zone.

Operation Set ExistingOps	<ul> <li>Description</li> </ul>			
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sched. Proj	ected Elev		
<ul> <li>Excess Surcharge</li> <li>Gate Operation to Save the Dam</li> <li>Surcharge Storage</li> <li>Gate Operation During Surcharge</li> <li>Flood Control</li> <li>Channel Capacity</li> <li>Minimum Releases</li> <li>Max at Athol - DC</li> <li>Connecticut at Montague - Linear</li> <li>Connecticut at Hartford - Linear</li> <li>Maximum Rate of Increase</li> <li>Max Pool Elev ROC</li> <li>Max Outflow equals Max 21 day Inflow</li> <li>Conservation</li> <li>Channel Capacity</li> </ul>	Operates Release Fr Rule Name: peration Function of: Tully-P Limit Type: Maxim. Elev (ft) 668.0 668.9 672.0	n During Surcharge ool Elevation, Laggeo V Interp.: Lin Release (cfs) 825.0	Description:	Define 71 6715 672
Min Flow Logic - Tully     Max at Athol - DC     Connecticut at Montague - Linear     Connecticut at Hartford - Linear     Maximum Rate of Increase     Maximum Rate of Decrease     Max Pool Elev ROC     Inactive			Hour of Day Multiplier Day of Week Multiplier Rising/Falling Condition Seasonal Variation	Edit Edit Edit Edit

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet –Gate Operation During Surcharge

### 3. Channel Capacity

Figure 9 shows the content of "Channel Capacity" rule. This rule shows the maximum allowable release from Tully.

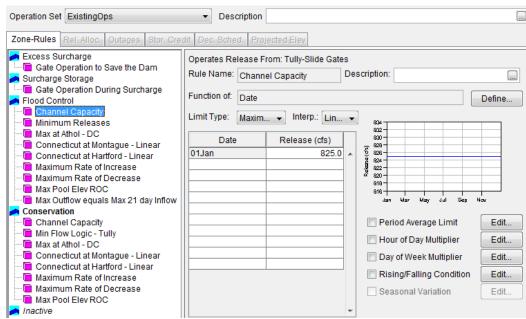


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Channel Capacity

### 4. Minimum Releases

Figure 10 shows the content of "Minimum Releases" rule. This rule shows the minimum required release from dam during flood control operations.

Operation Set ExistingOps	<ul> <li>Description</li> </ul>				
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sched. Pro	ected Elev			
Excess Surcharge     Gate Operation to Save the Dam     Surcharge Storage     Gate Operation During Surcharge     Flood Control     Channel Capacity     Minimum Releases     Max at Athol - DC     Connecticut at Montague - Linear     Connecticut at Hartford - Linear     Maximum Rate of Increase     Max Pool Elev ROC     Max Outflow equals Max 21 day Inflow	Operates Release F Rule Name: Minimu Function of: Date Limit Type: Minim. Date 01Jan	im Releases	Description:		Define
Conservation Channel Capacity Channel Capacity Channel Capacity Channel Capacity Channel Capacity Channel Connecticut at Montague - Linear Connecticut at Hartford - Linear Maximum Rate of Increase Maximum Rate of Decrease Max Pool Elev ROC Inactive			Period Avera Hour of Day Day of Week Rising/Fallin Seasonal Va	Multiplier Multiplier ng Condition	Edit Edit Edit Edit

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet –Minimum Releases

### 5. Max at Athol-DC

Figure 11 shows the content of "Max at Athol-DC" rule. This rule shows the maximum allowable flow at the downstream location Millers at Athol.

Operation Set ExistingOps	Description	)
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sched. Projected Elev.	
Excess Surcharge  Gate Operation to Save the Dam  Surcharge Storage  Gate Operation During Surcharge  Flood Control  Channel Capacity  Minimum Releases  Max at Athol – DO  Connecticut at Montague - Linear  Connecticut at Hartford - Linear  Maximum Rate of Increase  Max Pool Elev ROC  Max Outflow equals Max 21 day Inflow  Conservation  Consecticut at Montague - Linear  Max Pool Elev ROC  Max Outflow cquals Max 21 day Inflow  Conservation  Connecticut at Montague - Linear  Max Athol - DC  Connecticut at Montague - Linear  Max Athol - DC  Max at Athol - DC </td <td>Operates Release From: Tully         Rule Name:       Max at Athol - DC         Function of:       Date         Dimit Type:       Maximu Interp.:         Limit Type:       Maximu Interp.:         Downstream Location:       Millers at Athol         Parameter:       Flow         Date       Flow (cfs)         01Jan       2970.0         Maximu       Period Average Limit         Edit       Day of Week Multiplier         Edit       Seasonal Variation         Edit       Flow Contingency</td> <td></td>	Operates Release From: Tully         Rule Name:       Max at Athol - DC         Function of:       Date         Dimit Type:       Maximu Interp.:         Limit Type:       Maximu Interp.:         Downstream Location:       Millers at Athol         Parameter:       Flow         Date       Flow (cfs)         01Jan       2970.0         Maximu       Period Average Limit         Edit       Day of Week Multiplier         Edit       Seasonal Variation         Edit       Flow Contingency	
inactive	- Advanced Options	

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet –Max at Athol-DC

#### 6. Connecticut at Montague-Linear

Figure 12 shows the content of "Connecticut at Montague-Linear" rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

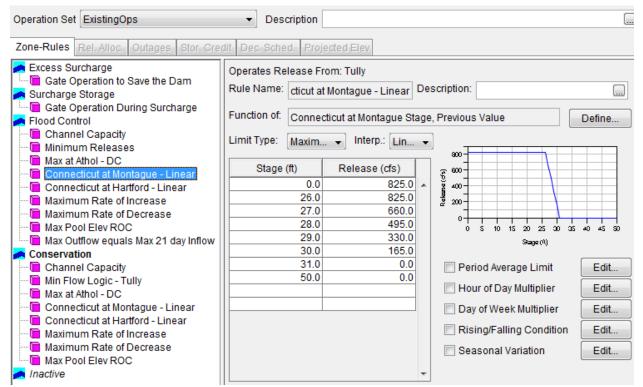


Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet –Connecticut at Montague-Linear

### 7. Connecticut at Hartford-Linear

Figure 13 shows the content of "Connecticut at Hartford-Linear" rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Hartford. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

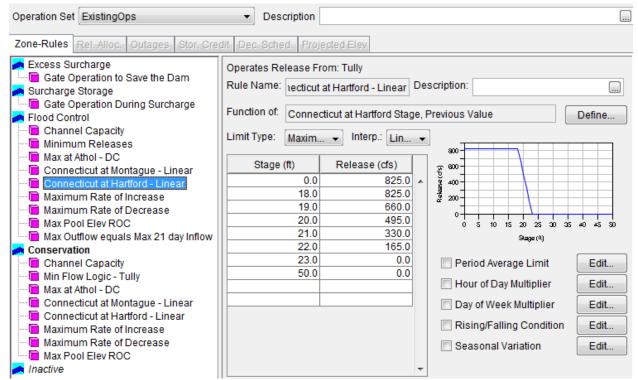


Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Hartford-Linear

### 8. Maximum Rate of Increase

Figure 14 shows the content of "Maximum Rate of Increase" rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Tully.

Operation Set ExistingOps	<ul> <li>Description</li> </ul>			
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sched. Proje	cted Elev		
<ul> <li>Excess Surcharge</li> <li>Gate Operation to Save the Dam</li> <li>Surcharge Storage</li> <li>Gate Operation During Surcharge</li> <li>Flood Control</li> <li>Channel Capacity</li> </ul>	Operates Release Fro Release Rate of Char Description: Function Of: Release	nge Limit Maximum Rate	e of Increase	
Minimum Releases Max at Athol - DC Connecticut at Montague - Linear	Type Increase Interpolate Linear		220	
Maximum Rate of Increase     Maximum Rate of Decrease     Maximum Rate of Decrease     Max Pool Elev ROC     Max Outflow equals Max 21 day Inflow	Release (cfs) 0.0 600.0 600.1	200.0	9 140-	
Conservation Channel Capacity Channel Capacity Min Flow Logic - Tully Max at Athol - DC Connecticut at Montague - Linear Connecticut at Hartford - Linear Maximum Rate of Increase	123456.0	50.0	E ₩ 80- C 60- 40-	120,000
Maximum Rate of Decrease Max Pool Elev ROC			Release (c	fs)

Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet –Maximum Rate of Increase

### 9. Maximum Rate of Decrease

Figure 15 shows the content of "Maximum Rate of Decrease" rule. This rule shows the maximum allowable decreasing release rate of change.

Operation Set ExistingOps	✓ Description		
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sched. Projected E	lev	
Excess Surcharge     Gate Operation to Save the Dam     Surcharge Storage     Gate Operation During Surcharge     Flood Control     Channel Capacity     Max at Athol - DC     Connecticut at Montague - Linear     Maximum Rate of Increase     Max Pool Elev ROC     Max at Athol - DC     Max outflow equals Max 21 day Inflow     Conservation     Min Flow Logic - Tully     Max at Athol - DC     Max at Athol - DC     Max Outflow equals Max 21 day Inflow     Conservation     Max at Athol - DC     Max Double Conservation     Max at Athol - DC     Max Outflow equals Max 21 day Inflow     Conservation     Max at Athol - DC     Max Athol - DC     Max Outflow equals Max 21 day Inflow     Conservation     Max at Athol - DC     Max Ath	Operates Release From: Tu Release Rate of Change Lin Description: Function Of: Type Max Rate of Change (cfs/hr)	Init Maximum Rate of Decrease	

Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet – Maximum Rate of Decrease

Figure 16 shows the content of "Max Pool Elev ROC" rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

Operation Set ExistingOps	Description	
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit. Dec. Sched. Projected Elev.	
Excess Surcharge  Gate Operation to Save the Dam  Surcharge Storage  Flood Control  Channel Capacity  Max at Athol - DC  Connecticut at Montague - Linear  Maximum Rate of Decrease  Max Outflow equals Max 21 day Inflow  Conservation  Connecticut at Montague - Linear  Max Dot Elev ROC  Max d Athol - DC  Consecticut at Montague - Linear  Maximum Rate of Decrease  Max Outflow equals Max 21 day Inflow  Conservation  Connecticut at Montague - Linear  Max Outflow equals Max 21 day Inflow  Conservation  Connecticut at Hartford - Linear  Max at Athol - DC  Connecticut at Montague - Linear  Max at Athol - DC  Connecticut at Hartford - Linear  Max at Athol - DC  Max at Athol - DC  Max of Increase  Max at Athol - DC  Max of Increase  Maximum Rate of Decrease  Maximum Rate of Decrease  Max Pool Elev ROC  Inactive	Operates Release From: Tully Elevation Rate of Change Limit Max Pool Elev ROC Description Function Of. Constant Type Decreasing Instantaneous Period Average Max Change of (ft) 5.0 over 24 hours	

Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet –Max Pool Elev ROC

### 11. Max Outflow equals Max 21 day Inflow

Figure 17 shows the content of "Max Outflow equals Max 21 day Inflow" rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

Operation Set ExistingOps	Description	
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit. Dec. Sched. Projected Elev	
Excess Surcharge     Gate Operation to Save the Dam     Surcharge Storage     Gate Operation During Surcharge     Flood Control	Operates Release From: Tully         Rule Name:       v equals Max 21 day Inflow         Description:         Function of:       Ily-Pool Inflow, Period Maximum, 0.0 hr lag, 504.0 hr period	
Channel Capacity     Minimum Releases     Max at Athol - DC     Connecticut at Montague - Linear     Connecticut at Hartford - Linear     Maximum Rate of Increase     Maximum Rate of Decrease     Max Pool Elev ROC     Max Outflow equals Max 21 day Inflow	Limit Type: Maxim  Interp:: Lin Flow (cfs) Release (cfs) 0.0 825.0 825.0 123456.0 825.0  Flow (cfs) Release (cfs) 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	
Conservation Channel Capacity Min Flow Logic - Tully Max at Athol - DC Connecticut at Montague - Linear Connecticut at Hartford - Linear Maximum Rate of Increase Maximum Rate of Decrease Maximum	Period Average Limit Edi     Period Average Limit Edi     Day of Week Multiplier Edi     Rising/Falling Condition Edi     Seasonal Variation Edi	it it

Figure 17: Reservoir Editor: Operations Tab – Existing Ops OpSet –Max Outflow equals Max 21 day Inflow

#### 12. Min Flow Logic-Tully

Figure 18 shows the content of "Min Flow Logic-Tully" rule. This rule provides seasonal minimum releases from Tully as a function of inflow.

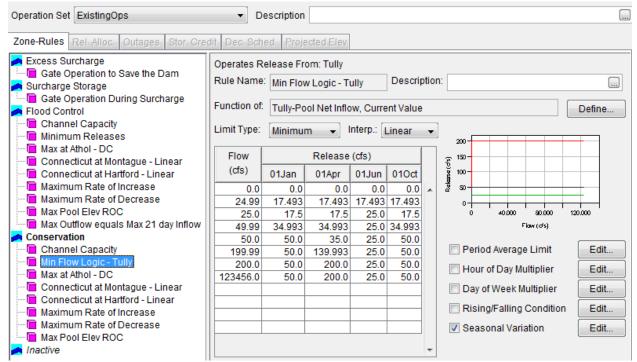


Figure 18 Reservoir Editor: Operations Tab – Existing Ops OpSet –Min Flow Logic-Tully

# **Turners Falls**

### I. Overview

Turners Falls dam is located on the mainstem Connecticut River directly downstream of Northfield Mountain and the confluence with the Millers River. FirstLight Power Resources owns and operates Turners Falls which is used to generate hydropower at two downstream stations (one of those stations is modeled as a separate reservoir, Power Canal). It is also operated in connection with Northfield Mountain, another FirstLight Power Resources project.

Figure 1 shows the location of Turners Falls dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo from Turners Falls dam.

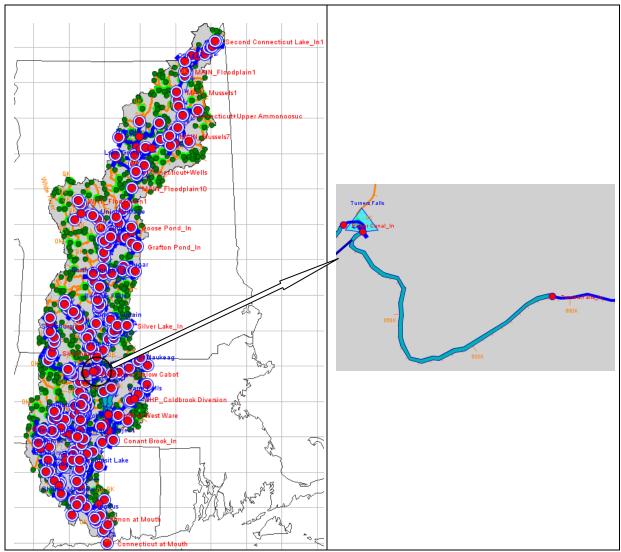


Figure 1: HEC-ResSim Map Display Showing Location of Turners Falls dam



Figure 2: Photo from Turners Falls dam

# **II.** Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>99</sup>. The dam consists of two types of outlets: (1) controlled Gatehouse to Canal, and (2) controlled spillway Gates, as shown in Figure 4.

<sup>&</sup>lt;sup>99</sup> All physical and operational data from ResSim model developed by Gomez and Sullivan Engineers, P.C.

Reservoir Editor		famous and the		
Reservoir Edit Pool				
Reservoir Turners Falls	<ul> <li>Description</li> </ul>			K 1 72 of 74 D H
Physical Operations Observed	Data			
Turners Falls	Turners Falls-Pool			
Gatehouse to Canal	Linear Interpolati	on 💿 Conic Inter	rpolation Initial	Conic Depth (ft)
☐ Tailwater	Elevation	Storage	Area	
Spillway Gates	(ft)	(ac-ft)	(acre)	188
Routing	172.26	0.00		^ 184
_	176.00	4150.00		€ 100
	177.00	5600.00		€ 180
	178.00	7500.00		Ξ 176
	179.00	9200.00 11100.00		172
	180.00	13000.00		0 10,000 20,000
	182.00	14750.00		E Stor (ac-ft)
	183.00	16600.00		188
	184.00	18450.00		184
	185.00	20200.00		
	186.00	22100.00		€ 180-
	186.50	23000.00		🖞 176
				172
				0 150 300 450
				Area (acre)
				Tiea (acie)
<u></u>				·
				OK Cancel Apply

Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor		Testa and	-		<b>X</b>
Reservoir Edit Dam					
Reservoir Turners Falls           Physical         Operations         Observed	Description Data				
Turners Falls	Turners Falls-Dam	1			
Dam Gatehouse to Canal	Elevation at top of	dam (ft)		185.	5
→ Tailwater	Length at top of d	am (ft)		1123.	0
Spillway Gates	Composite Relea				
	Elevation	Controlled	Uncontrolled	Total	
	(ft)	(cfs)	(cfs)	(cfs)	200
	0.0	16,524.0	0.0	16,524.0	
	200.0	16,524.0	0.0	16,524.0	
					• • • • • • • • • • • • • • • • • • •
					0 10,000
					Flow
					(cfs)
	]				
				ОК	Cancel Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Turners Falls's "ExistingOps" operational zones, which consist of zones of Flood Control (185.5 ft), FERC Max Pool (185 ft), Normal pool (181.3 ft), Buffer (179 ft), and Inactive zone (176 ft)<sup>1</sup>.

Reservoir Edit Operations Zone Rule IF_Block Reservoir Turners Falls  Description Description Description Cone-Rules Rel_Alloc_Outages Stor_Credit Dec_Sched_Projected Elev Flood Control Flood Control Flood Control Canal Release (script) Canal Release (	Reservoir Editor	
Physical Operations Observed Data         Operation Set Existing Ops       Description         Zone-Rules Ret Alloc Outages Stor.Credit Dec.Sched Projected Elev         Flood Control         Image: Storage	Reservoir Edit Operations Zone Rule I	IF_Block
Operation Set Existing Ops       Description         Zone-Rules       Rel. Alloc.       Outages       Stor Credit       Description         Flood Control       Storage Zone       Conservation       Description         Canal Release (script)       Canal Release (script)       Storage Zone       Date       Define         Canal Release (script)       Canal Release (script)       Date       Top Elevation (ft)       Image: Storage Zone       Date       Define         Outages       Min Project Release (script)       Canal Release (script)       Date       Top Elevation (ft)       Image: Storage Zone       Image: Storage Zone       Date       Define         Outages       Min Project Release (script)       Canal Release (script)       Image: Storage Zone       Image: Stora	Reservoir Turners Falls 🔹	Description
Zone-Rules       Rel. Alloc.       Outages       Stor. Credit       Dec. Sched.       Projected Elev         Flood Control       Im Bypass Release (script)       Storage Zone       Conservation       Description       Im         Image: Conservation       Canal Release (script)       Canal Release (script)       Date       Top Elevation (ft)       Image: Conservation       Define         Image: Conservation       Canal Release (script)       Canal Release (script)       Canal Release (script)       Canal Release (script)       Image: Conservation       Image: Conservation <td>Physical Operations Observed Data</td> <td></td>	Physical Operations Observed Data	
Flood Control  Flood Contro  Flood Control  Flood Control  Flood Control  Flood C	Operation Set Existing Ops	Description
Image: Storage Zone (Conservation Description D	Zone-Rules Rel. Alloc. Outages St	tor. Credit Dec. Sched. Projected Elev
Date     Top Elevation (ft)       Image: Second Structure     Date       Image: Second Structure     Image: Second Structure       Image: Second Structure	🗄 📲 Min Bypass Release (script)	Storage Zone Conservation Description
FERC Max Pool       Date       Top Elevation (ft)         Image: Second Max Poil       01Jan       181.3         Image: Conservation       Image: Second Max Release       186         Conservation       Image: Second Max Release       186         Image: Conservation       Image: Second Max Release       180         Image: Conservation       Image: Second Max Release       Image: Second Max Release         Image: Conservation       Image: Second Max Release       Image: Second Max Release         Image: Conservation       Image: Second Max Release       Image: Second Max Release         Image: Conservation       Image: Second Max Release       Image: Second Max Release         Image: Conservation       Image: Second Max Release       Image: Second Max Release         Image: Conservation       Image: Second Max Release       Image: Second Max Release <td>Canal Release (script)</td> <td>Function of Date Define</td>	Canal Release (script)	Function of Date Define
Image: Spectrum of the set of the s	FERC Max Pool	196
Canal Max Release   Conservation   Min Bypass Release (script)   Canal Release (script)   Canal Max Release   Buffer   Min Project Release (script)   Canal Release (script)   Canal Max Release   Zone Sort Elevation	Min Project Release (script)	
Canal Max Release Canal Max Release Canal Max Release Canal Max Release (script) Canal Release (script) Canal Max Release Canal Max Releas		€ 182
Canal Max Release Canal Max Release Canal Max Release Canal Max Release (script) Canal Release (script) Canal Max Release Canal Max Releas	Min Project Release (script)	
Image: Solution of the system of the syst	📄 🕞 Canal Max Release	
Canal Release (script)	🗄 📲 } Min Bypass Release (script)	
Zone Sort Elevation	🔚 🔚 Canal Release (script)	
		<b></b>
		Zone Sort Elevation
OK Cancel Apply		OK Cancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

# **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops.

🟹 Reservoir Editor
Reservoir Edit Operations Zone Rule IF_B
Reservoir Turners Falls
Physical Operations Observed Data
Operation Set Existing Ops
Zone-Rules Rel. Alloc. Outages Stor.
<ul> <li>Flood Control</li> <li>Min Bypass Release (script)</li> <li>IF (01Apr - 15Jul)</li> <li>Release 400 cfs or inflow</li> <li>ELSE IF (16Jul - 14Sep)</li> <li>Release 120 cfs or inflow</li> <li>ELSE IF (15Sep - 15Nov)</li> <li>Release 300 cfs or inflow</li> <li>Min Project Release (script)</li> <li>Canal Max Release</li> <li>Conservation</li> <li>Min Bypass Release (script)</li> <li>Canal Max Release</li> <li>Anin Project Release (script)</li> <li>Canal Release (script)</li> <li>Canal Max Release</li> <li>Anin Project Release (script)</li> <li>Canal Max Release</li> <li>Ruffer</li> <li>Min Bypass Release (script)</li> <li>Canal Max Release</li> </ul>

Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## **C.** Rule Descriptions

### 1. Min Bypass Release(script)

Figure 7 shows the content of "Min Bypass Release (script)" rule. This script was created because the available Turners Falls pool inflow parameter includes generation flow from Northfield. This doesn't present too much of a problem with the current low min flow requirements because they are almost always exceeded, but could lead to issues with greater min flow requirements.

Operation Set Existing Ops	•	Description			
Zone-Rules Rel. Alloc. Outages Stor	. Credit Dec. Sche	d. Projected Elev			
Flood Control	·	e From: Turners Falls-B s Release (script) Des		pt was created because the availa	ble Turners Falls pool
← ELSE IF (16Jul - 14Sep)     ← ELSE IF (15Sep - 15Nov)     ← ELSE IF (15Sep - 15Nov)     ← Release 300 cfs or inflow	Type IF ELSE IF ELSE IF	Name 01Apr - 15Jul 16Jul - 14Sep 15Sep - 15Nov		Description	
Operation Set Existing Ops	•	Description			
Zone-Rules Rel. Alloc. Outages Stor.	. Credit Dec. Sche	d. Projected Elev			
Flood Control ☐{ } Min Bypass Release (script) ☐→ IF (01Apr - 15Jul)	Operates Release IF Conditional 0	e From: Turners Falls-By 1Apr - 15Jul	pass Description:		
■ Release 400 cfs or inflow ■ ➡ ELSE IF (16Jul - 14Sep) ■ ■ Release 120 cfs or inflow	Valu	e1		Value2	
ELSE IF (15Sep - 15Nov) ■ Release 300 cfs or inflow	AND	Current Time Step Current Time Step	<	01Apr 16Jul	Add Cond.
15       # Calculate the natural inflow of ctriver_at_pauchaug = network.getT millers_at_mouth = network.getTim         10       ctlocal_at_millers = network.find         20       TF_naturalinflow = ctriver_at_pau         4       #julian_day = currentRuntimestep.         22       # set type and value for OpValue         4       # type is one of:         5       # OpRule.RULETYPE_MIN - maximum         6       # OpRule.RULETYPE_MIN - minimum         7       # OpRule.RULETYPE_MIN - with the optication value.         8       et guide init (opRule.RULETYPE_         9       opValue.init(opRule.RULETYPE_         9       opValue.init(OpRule.RULETYPE_         3       # return the Operation Value.         4       # return the Operation Value.         5       # return in None" to have no effect         7       populae         7       # return opValue	TimeSeries ("Junctic eSeries ("Junction", Junction ("Connectic chaug + millers_at_ dayOfYear() flow eflow ed flow MIN, TF_naturalinfl MIN, 400)	n","Connecticut+Pauchau "Millers at Mouth", "I" uut+Millers").getLocarFi mouth + ctlocal_at_mill	g", "", "Flow").get "Flow").getCurrent owTimeSeries("SYE (	tCurrentValue(currentRuntimestep) tValue(currentRuntimestep)	alue (currentRuntimestep)
Operation Set Existing Ops	•	Description			
Zone-Rules Rel. Alloc. Outages Stor	. Credit Dec. Sche	d. Projected Elev			
Flood Control	Operates Release	e From: Turners Falls-By	pass		
→ IF (01Apr - 15Jul)     Release 400 cfs or inflow     → ELSE IF (16Jul - 14Sep)	ELSE IF Conditio	nal 16Jul - 14Sep	Descriptio	Value2	
Release 120 cfs or inflow		Current Time Step	>=	16Jul	
ELSE IF (15Sep - 15Nov) ■ Release 300 cfs or inflow	AND	Current Time Step	<	15Sep	Add Cond.

13		Value) to return				
14						
15						
16	# Calculate the natural inflow o.	f Turners Falls (not in	cluding pump/gen flow fi	com Northfield).		
17	ctriver at pauchaug = network.ge	tTimeSeries ("Junction",	"Connecticut+Pauchaug",	"", "Flow").get	CurrentValue(currentRuntimestep)	
18	millers at mouth = network.getTim	meSeries ("Junction", "Mi	llers at Mouth", "", "F:	Low").getCurrent	Value(currentRuntimestep)	
19					ONNECTICUT+MILLERS").getCurrentValue(	currentRuntimestep)
20						
21						
22						
23						
24						
25						
26		led flow				
27	_					
28		_MIN, TF_naturalinflow)				
29						
30		_MIN, 120)				
31						
32						
33		t on the compute				
34	return opValue					
Γ.						
O	peration Set Existing Ops	✓ Des	cription			
			-			
7	one-Rules Rel. Alloc. Outages Stor	r. Credit Dec. Sched. F	Incidente d Ellevi			
2	Rel. Alloc.   Outages   Stor	. Credit Dec. Scred. F	Projected Elev			
	Flood Control					
		Operates Release Fro	m: Turners Falls-Bypass	5		
	Min Bypass Release (script)	(] .				
	🖮 🔿 IF (01Apr - 15Jul)	ELSE IF Conditional	15Sep - 15Nov	Description:		
	Release 400 cfs or inflow	[] [	looop lollor			
	🖃 🜩 ELSE IF (16Jul - 14Sep)	Value1			Value2	
	🔚 🔲 Release 120 cfs or inflow		Current Time Step	>=	15Sep	
	ELSE IF (15Sep - 15Nov)					
		AND	Current Time Step	<	16Nov	Add Cond.
	🔤 Release 300 cfs or inflow					
13	# create new Operation Value (OpV	Value) to return				A
14	opValue = OpValue()					
15						
16	# Calculate the natural inflow of	f Turners Falls (not inc	luding pump/gen flow fr	om Northfield).		
17	ctriver at pauchaug = network.get	tTimeSeries ("Junction","	Connecticut+Pauchaug",	"", "Flow").getC	urrentValue(currentRuntimestep)	
18	millers at mouth = network.getTim	meSeries ("Junction", "Hil	lers at Mouth", "", "Flo	ow").getCurrentV	alue (currentRuntimestep)	
19					NNECTICUT+MILLERS").getCurrentValue(c	urrentRuntimestep)
20	TF_naturalinflow = ctriver_at_pau					
21						
22	# set type and value for OpValue					
23						
24		m flow				
25						
26						
20		ica zzow				
27	if TF_naturalinflow < 300:	NTN TE second is first				
	opValue.init (OpRule.RULETYPE	_MIN, IF_naturalinflow)				
29	else:					
30	opValue.init(OpRule.RULETYPE_	_nin, 300)				
31						
32	-					
33		t on the compute				
34	return opValue					-

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Bypass Release (script)

### 2. Min Project Release(script)

Figure 8 shows the content of "Min Project Release (script)" rule. Release 1433 cfs or inflow, whichever is less, from the Turners Falls Project (primarily released from canal). This script was created because the available Turners Falls pool inflow parameter includes generation flow from Northfield. This doesn't present too much of a problem with a min flow of 1433 cfs because it is almost always exceeded, but could lead to issues with greater min flow requirements.

Op	eration Set Existing Ops   Description
Zo	ne-Rules Rel. Alloc. Outages Stor. Gredit. Dec. Sched. Projected Elev
	Min Project Release (script)     Canal Release (script)     Canal Release (script)     Canal Release (script)     Canal Release (script)     Description Release (script)     Release 1433 ds or inflow, whichever is less, from the Turners Falls Project (primarily released from canal). This script was created because the availa
13 14 15	# create new Operation Value (OpValue) to return
16 17 18 19 20	<pre># Calculate the natural inflow of Turners Falls (not including pump/gen flow from Northfield). ctriver_at_pauchaug = network.getTimeSeries("Junction","ConnecticutFauchaug", "", "Flow").getCurrentValue(currentRuntimestep) millers_at_mouth = network.getTimeSeries("Junction", "Hillers at Mouth", "", "Flow").getCurrentValue(currentRuntimestep) ctlocal_at_millers = network.findJunction("Connecticut+Hillers").getCoalFlowTimeSeries("SYE CONNECTICUT+HILLERS").getCurrentValue(currentRuntimestep) TF_naturalinflow = ctriver_at_pauchaug + millers_at_mouth + ctlocal_at_millers</pre>
21 22 23 24 25	# set type and value for OpValue # type is one of: # OpRule.RULETYPE_MAX - maximum flow # OpRule.RULETYPE MIN - minimum flow
26 27 28 29	<pre># 0pRule.RULETYPE_SPEC - specified flow if TF_naturalinflow &lt; 1433:     opValue.init(OpRule.RULETYPE_MIN, TF_naturalinflow) else:</pre>
30 31 32 33	opValue.init(OpRule.RULETYPE_MIN, 1433) # return the Operation Value.
33 34	# return "None" to have no effect on the compute return opValue

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Project Release (script)

## 3. Canal Release(script)

Figure 9 shows the content of "Canal release (script)" rule. When combined usable storage is < 12318 (Northfield's effective storage), only release required fishway flows to the Power Canal.

Opera	ation Set Existing Ops	•	Description
Zone	-Rules Rel. Alloc. Outages Stor.	. Credit Dec. Sched. P	ojected Elev.
	Min Project Release (script) 🔺	Operates Release From	n: Turners Falls-Gatehouse to Canal
	Canal Release (script) Canal Max Release	Script Operation Rule	Canal Release (script)
j FE	RC Max Pool	Description	When combined usable storage is < 12318 (Northfield's effective storage), only release required fishway flows to the Power Canal.
	Min Bypass Release (script)		
13 14	<pre># create new Operation Va. opValue = OpValue()</pre>	lue (Opvalue) to re	urn
15			
16			orthfield's effective storage), only release required fishway flows to the Power Canal
17			","Northfield", "Pool", "Stor").getCurrentValue(currentRuntimestep) ","Turners Falls", "Pool", "Stor").getCurrentValue(currentRuntimestep)
19	combined storage = NF stor		","Turners Falls", "Pool", "Stor").getturrentvalue(durrentvuntimestep)
20			", "Turners Falls", "Pool", "Flow-IN").getCurrentValue(currentRuntimestep)
21			
22	cabot_capacity = 13728		
23	stal_capacity = 2210		
24 25	fishway_outflow = network	.getTimeSeries("Rese	rvoir", "Power Canal", "Canal Fishways-Fishway Releases", "Flow-SPEC").getCurrentValue(currentRuntimestep)
25			
27			
28	# set type and value for (	OpValue	
29	<pre># type is one of:</pre>		
30	<pre># OpRule.RULETYPE_MAX -</pre>		=
31	<pre># OpRule.RULETYPE_MIN -</pre>		
32 33	<pre># OpRule.RULETYPE_SPEC - if combined storage &lt;= 123</pre>		
34	opValue.init(OpRule.R		(outflow)
35	else:		
36	opValue.init(OpRule.R	ULETYPE_MAX, cabot_c	apacity + stal capacity + fishway outflow)
37			
38	# return the Operation Va.		
39	# return "None" to have n	o effect on the comp	ute
40	return opValue		*

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Canal release (script)

### 4. Canal Max Release

Figure 10 shows the content of "Canal Max Release" rule. This rule caps the release to the canal at the capacity of Cabot + Station 1, plus any required fishway flows. It is redundant with the scripted Canal Release rule, but without this rule, the Min Project Release scripted rule somehow causes the canal to receive more flow than its current capacity, leading to spikes in the canal elevation. (The non-scripted version of the min project release rule, called Min Flow below Cabot, does not cause this problem, but its inflow parameter includes generation flow from Northfield, which could lead to issues with greater min flow requirements.)

Operation Set Existing Ops	✓ Description	
Zone-Rules Rel. Alloc. Outages	Stor, Credit Dec, Sched. Projected Elev	
<ul> <li>Flood Control</li> <li>Hin Bypass Release (script)</li> <li>Canal Release (script)</li> <li>Canal Max Release</li> <li>FERC Max Pool</li> <li>Hin Bypass Release (script)</li> <li>Canal Release (script)</li> <li>Canal Release (script)</li> <li>Canal Release (script)</li> <li>Canal Max Release</li> <li>Normal Pool</li> <li>Hin Bypass Release (script)</li> <li>Min Project Release (script)</li> </ul>	Operates Release From: Turners Falls-Gatehouse to Canal         Rule Name:       Canal Max Release       Description:       This rule caps the release         Function of:       Power Canal-Canal Fishways-Fishway Releases Req Flow, Cu         Limit Type:       Maximum  Interp.:       Step          Flow (cfs)       Release (cfs)        16,000          0.0       15938.0        16,000          16,000       16324.0        100 200 300          586.0       16524.0        Flow (cfs)	Define
Canal Release (script) Canal Max Release Buffer Min Bypass Release (script) Min Project Release (script) Canal Release (script) Canal Max Release Anactive	Period Average Limit     Pour of Day Multiplier     Day of Week Multiplier     Rising/Falling Condit     Seasonal Variation	r Edit

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Canal Max Release

# **Union Village**

## I. Overview

Union Village is a dam located in Thetford, Vermomt on the Ompompanuoosuc River. It was constructed in 1950 by the US Army Corps of Engineers and is still owned and operated by the Corps. It is primarily used for flood control but is also used for recreation.

Figure 1 shows the location of Union Village Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo from Union Village Dam.

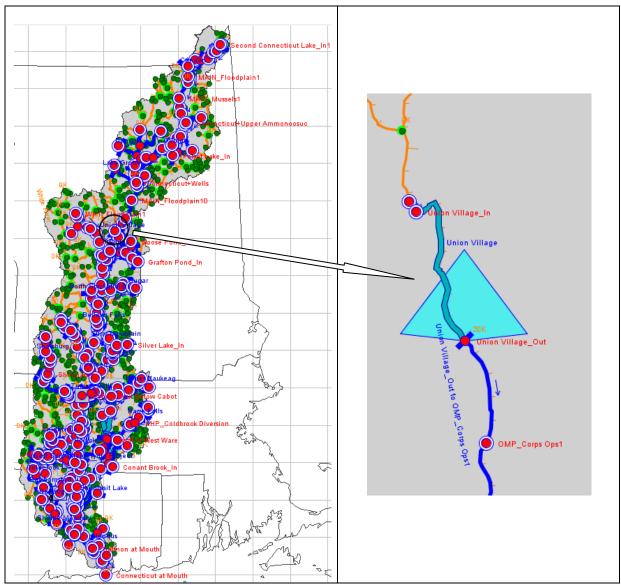


Figure 1: HEC-ResSim Map Display Showing Location of Union Village dam

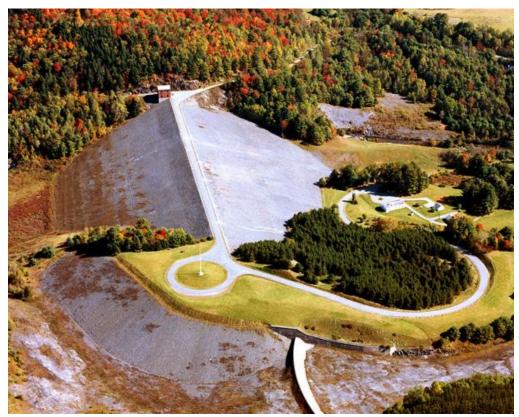


Figure 2: Photo of Union Village dam.

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled Slide gates, and (2) uncontrolled Spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>100</sup>.

<sup>&</sup>lt;sup>100</sup> http://rsgisias.crrel.usace.army.mil/nae/cwms\_map.map\_index

servoir Edit Pool				
eservoir Union Village	<ul> <li>Descript</li> </ul>	lion		K 4 24 of 74 🕨
hysical Operations O	served Data			
Union Village	Union Village-Pool			
Dam	Linear Interpolat	ion 🔘 Conic Inte	rpolation Initial	Conic Depth (ft)
Spillway	Elevation	Storage	Area	
	(ft)	(ac-ft)	(acre)	
	420.00	0.00	0.00	
	425.00	100.00	12.00	
	430.00	200.00	22.00	
	435.00	300.00	33.00	
	440.00	400.00	45.00	600
	445.00	500.00	58.00	560
	450.00	650.00	72.00	€ 520
	455.00	800.00	86.00	€ 320
	460.00	1200.00	97.00	
	465.00	1600.00	115.00	440
	470.00	2100.00	132.00	400+++++++
	475.00	2600.00	148.00	0 30,000 60,000
	480.00	3300.00	168.00	Stor (ac-ft)
	485.00	4000.00	188.00	600
	490.00	5000.00	208.00	560
	495.00	6000.00	232.00	€ 520
	500.00	7250.00	255.00	€ 320
	505.00	8500.00	280.00	à 480 440
	510.00	10000.00	307.00	440
	515.00	11800.00	338.00	400++++++++++++++++++++++++++++++++++++
	520.00	13700.00	372.00	0 300 600 900
	525.00	15700.00	406.00	Area (acre)
	530.00	18000.00	444.00	
	535.00	20500.00	483.00	
	540.00	23000.00	530.00	
	545.00	26000.00	575.00	
	550.00	29000.00	622.00	
	555.00	32300.00	666.00	-

Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor					
Reservoir Edit Dam					
Reservoir Union Village					
Physical Operations C	bserved Data				
Union Village Union Village-Dam					
Elevation at top of dam (ft) 584.0				.0	
Spillway				1100	.0
	Composite Rel	ease Capacity			
	Elevation	Controlled	Uncontrolled	Total	
	(ft)	(cfs)	(cfs)	(cfs)	600
	420.0	0.0	0.0	0.0 🔺	g 540
	430.0	1,000.0	0.0	1,000.0	540 texe € 480 10 420
	440.0	2,170.0	0.0	2,170.0	± 420
	450.0	3,000.0	0.0	3,000.0	
	460.0	3,700.0	0.0	3,700.0	
	470.0	4,250.0	0.0	4,250.0	Flow
	480.0	4,760.0	0.0	4,760.0	(cfs)
	490.0	5,220.0	0.0	5,220.0 5,600.0 ≡	
	510.0	5,600.0	0.0	6,000.0	
	520.0	6,390.0	0.0	6,390.0	
	530.0	6,750.0	0.0	6,750.0	
	540.0	7,090.0	0.0	7,090.0	
	550.0	7,490.0	0.0	7,490.0	
	560.0	7,830.0	0.0	7,830.0	
	564.0	8,000.0	0.0	8,000.0	
	566.0	8,000.0	500.0	8,500.0	
	568.0	8,000.0	10,000.0	18,000.0	
	570.0	8,000.0	19,000.0	27,000.0	
	572.0	8,000.0		38,000.0	
	574.0	8,000.0			
	576.0	8,000.0		66,000.0	
	578.0	8,000.0		84,000.0	
579.0 8,000.0 84,500.0 92,500.0 +					
	J				
				OK	Cancel Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

## III. Operations

## A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Union Village's "ExistingOps" operational zones, which consist of zones of Top of dam (584 ft), Flood Control (564 ft), Conservation (421-440 ft), and Inactive zone (420 ft).

Reservoir Editor					
Reservoir Edit Operations Zone Rule IF_Block					
Reservoir Union Village   Description					
Physical Operations Observed Data					
Operation Set Existing Ops	<ul> <li>Description</li> </ul>				
Zone-Rules Rel. Alloc: Outages Stor. Cred	lit Dec. Sched. Pr	ojected Elev			
Top of dam	Storage Zone Conservation		Description		
Flood Control	Function of Date		Define		
Connecticut at North Walpole - Linear	Date 01Jan	Top Elevation (ft) 440.0	800		
Connecticut at Montague - Linear	31Mar	440.0	580-		
Maximum rate of decrease	01Apr	421.0	560		
Max Rate of Pool Drawdown	14Dec	421.0	€ 520		
Max Outflow equals 21 day Max Inflow	15Dec	440.0	5 500-		
Conservation			g 480		
Channel Capacity below UV Dam			€ 520- 500- 500- 500- 480- ш 460-		
Min Flow Logic - Union Village			440		
Connecticut at North Walpole - Linear		<u> </u>	420		
Maximum rate of increase			400 + + + + + + - +		
Maximum rate of decrease			Jan Mar May Jul Sep Nov		
🔲 🔲 Max Rate of Pool Drawdown					
Zone Sort Elevation					
		(	OK Cancel Apply		
			Cancer Apply		

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

## **B.** Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

Reservoir Editor					
Reservoir Edit Operations Zone Rule IF_Block					
Reservoir Union Village 🗸 Descrip					
Physical Operations Observed Data					
Operation Set Existing Ops					
Zone-Rules Rel. Alloc. Outages Stor. Cre					
<ul> <li>Top of dam</li> <li>Gate Ops to Save Dam</li> <li>Flood Control</li> <li>Channel Capacity below UV Dam</li> <li>Minimum ABF</li> <li>Connecticut at North Walpole - Linear</li> <li>Connecticut at Montague - Linear</li> <li>Maximum rate of increase</li> <li>Maximum rate of decrease</li> <li>Max Rate of Pool Drawdown</li> <li>Max Outflow equals 21 day Max Inflow</li> <li>Conservation</li> <li>Channel Capacity below UV Dam</li> <li>Min Flow Logic - Union Village</li> <li>Connecticut at Montague - Linear</li> <li>Maximum rate of increase</li> <li>Max Rate of Pool Drawdown</li> <li>Max Outflow equals 21 day Max Inflow</li> </ul>					

#### Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## **C.** Rule Descriptions

#### 1. Gate Ops to Save Dam

Figure 7 shows the content of "Gate ops to save Dam" rule. This rule represents the maximum allowable release from slide gates as a function of pool elevation when the pool is in Top of dam zone.

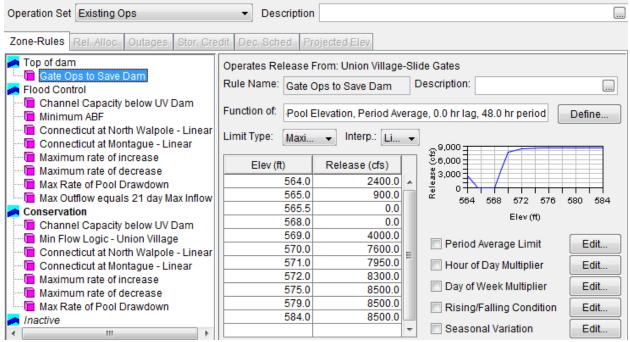


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Gate Ops to Save Dam

### 2. Channel Capacity below UV Dam

Figure 8 shows the content of "Channel Capacity below UV Dam" rule. This rule assigns 2400 cfs as the maximum allowable release from Union Village dam.

Operation Set Existing Ops    Description					
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev					
Top of dam Gate Ops to Save Dam Flood Control Channel Capacity below UV Dam Minimum ABF Connecticut at North Walpole - Linear Maximum rate of increase Maximum rate of decrease Max Rate of Pool Drawdown Max Rate of Pool Drawdown Conservation Channel Capacity below UV Dam Min Flow Logic - Union Village Connecticut at North Walpole - Linear	Operates Release From: Rule Name: el Capacity Function of: Date Limit Type: Maxi ▼ Date Re 01Jan	below UV Dam D	escription:	Define ov Edit	
Connecticut at Montague - Linear			Hour of Day Multiplier           Day of Week Multiplier	Edit	
Maximum rate of decrease Max Rate of Pool Drawdown			Rising/Falling Condition	Edit	
۲ III F		Ψ.	Seasonal Variation	Edit	

Figure 8 Reservoir Editor: Operations Tab – Existing Ops OpSet – Channel Capacity below UV Dam

#### 3. Minimum ABF

Figure 9 shows the content of "Minimum ABF" rule. This rule provides the minimum required release from dam when pool is in flood control zone.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>	1			
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev					
Top of dam Gate Ops to Save Dam Flood Control Channel Capacity below UV Dam Ginimum ABF	Operates Release Rule Name: Minim Function of: Date	From: Union Village num ABF	Description:		 Define
Connecticut at North Walpole - Linear Connecticut at Montague - Linear Maximum rate of increase Max Rate of Pool Drawdown Max Outflow equals 21 day Max Inflow Conservation Channel Capacity below UV Dam	Limit Type: Mini Date 01Jan 31May 01Jun 30Sep	Release (cfs) 130.0 130.0 65.0 65.0	140 (\$120 3) a 100 a se as 80 a as 80 a 80 a 80 a 80 a 80 a 80 a 80 a 80	Mar May Jul Sep N	ov
Min Flow Logic - Union Village Connecticut at North Walpole - Linear Connecticut at Montague - Linear Maximum rate of increase	010ct	130.0	Hour o	Average Limit If Day Multiplier	Edit
Maximum rate of decrease Max Rate of Pool Drawdown Inactive			Rising	Week Multiplier /Falling Condition nal Variation	Edit Edit

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Minimum ABF

#### 4. Connecticut at North Walpole-Linear

Figure 10: shows the content of "Connecticut at North Walpole-Linear" rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at North Walpole. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

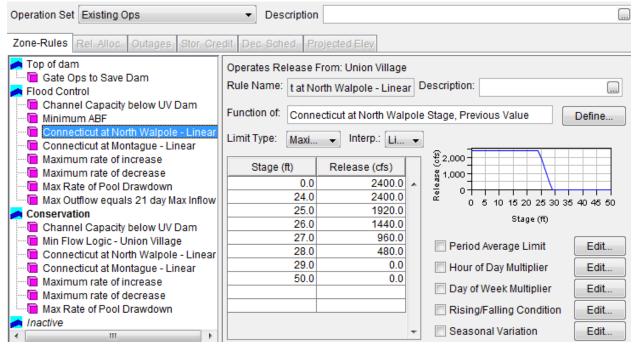


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at North Walpole-Linear

#### 5. Connecticut at Montague-Linear

Figure 11 shows the content of "Connecticut at Montague-Linear" rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

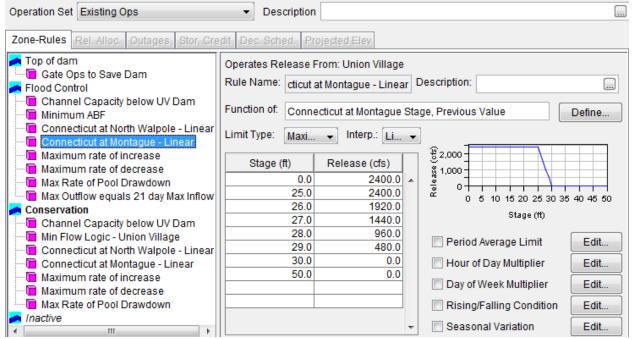


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague-Linear

### 6. Maximum rate of increase

Figure 12 shows the content of "Maximum rate of increase" rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Union Village dam.

Operation Set Existing Ops	Description	)				
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.						
Top of dam Gate Ops to Save Dam Flood Control Channel Capacity below UV Dam Minimum ABF	Operates Release From: Union Village-Slide Gates Release Rate of Change Limit Maximum rate of increase Description:					
Connecticut at North Walpole - Linear     Connecticut at Montague - Linear     Maximum rate of increase	Function Of:     Release       Type     Increasing       300					
Maximum rate of decrease     Max Rate of Pool Drawdown     Max Outflow equals 21 day Max Inflow	Release (cfs) Rate Change (cfs/hr) € 250					
Conservation Channel Capacity below UV Dam	0.0 300.0 mg 200 1800.0 300.0 mg 200					
Min Flow Logic - Union Village Connecticut at North Walpole - Linear Connecticut at Montague - Linear	Release (cfs)         Rate Change (cfs/hr)         and a construction         and a cons					
Maximum rate of increase						
Max Rate of Pool Drawdown Inactive	0 1,000 2,000 Release (cfs)					

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Maximum rate of increase

#### 7. Maximum rate of decrease

Figure 13 shows the content of "Maximum rate of decrease" rule. This rule shows the maximum allowable decreasing release rate of change.

Operation Set Existing Ops   Description	
Zone-Rules Rel. Alloc. Outages Stor. Credit. Dec. Sched. Proj	jected Elev
Top of dam Operates Release Fr	rom: Union Village-Slide Gates Inge Limit Maximum rate of decrease Constant Decreasing

Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Maximum rate of decrease

#### 8. Max Rate of pool Drawdown

Figure 13 shows the content of "Max Rate of pool Drawdown" rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

Operation Set Existing Ops	Description	
Zone-Rules Rel. Alloc. Outages Stor. Cr	redit Dec. Sched. Projected Elev	
Top of dam Gate Ops to Save Dam Flood Control Channel Capacity below UV Dam Minimum ABF Connecticut at North Walpole - Linear Maximum rate of increase Maximum rate of decrease Max Rate of Pool Drawdown Max Outflow equals 21 day Max Inflow Conservation Channel Capacity below UV Dam Min Flow Logic - Union Village Connecticut at North Walpole - Linear Maximum rate of increase Maximum rate of increase Maximum rate of increase Maximum rate of loce case Maximum rate of loce case Maximum rate of decrease Maximum rate of loce case Maximum rate of loce case Max Rate of Pool Drawdown Incetive	Type Decreasing	

Figure 13 Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Rate of pool Drawdown

#### 9. Max Outflow equals 21 day Max Inflow

Figure 14 shows the content of "Max Outflow equals 21 day Max Inflow" rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

Operation Set Existing Ops	<ul> <li>Description</li> </ul>	1			
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sched. Pr	ojected Elev			
<ul> <li>Top of dam</li> <li>Gate Ops to Save Dam</li> <li>Flood Control</li> <li>Channel Capacity below UV Dam</li> <li>Minimum ABF</li> <li>Connecticut at North Walpole - Linear</li> <li>Connecticut at Montague - Linear</li> <li>Maximum rate of increase</li> <li>Maximum rate of decrease</li> <li>Max Rate of Pool Drawdown</li> <li>Max Outflow equals 21 day Max Inflow</li> <li>Conservation</li> <li>Channel Capacity below UV Dam</li> </ul>	Operates Release I Rule Name: v equa Function of: Pool I Limit Type: Maxi Flow (cfs) 0.0 2400.0 123456.0	als 21 day Max Inflov	v C num	Description:	 Define
Min Flow Logic - Union Village				Period Average Limit	Edit
Connecticut at Montague - Linear				Hour of Day Multiplier	Edit
Maximum rate of decrease				Day of Week Multiplier	Edit
Max Rate of Pool Drawdown				Rising/Falling Condition	Edit
Inactive			-	Seasonal Variation	Edit

Figure 14 Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals 21 day Max Inflow

#### **10.** *Min Flow Logic-Union Village*

Figure 15 shows the content of "Min Flow Logic-Union Village" rule. This rule describes seasonal minimum flows from dam as a function of inflow at Union Village.

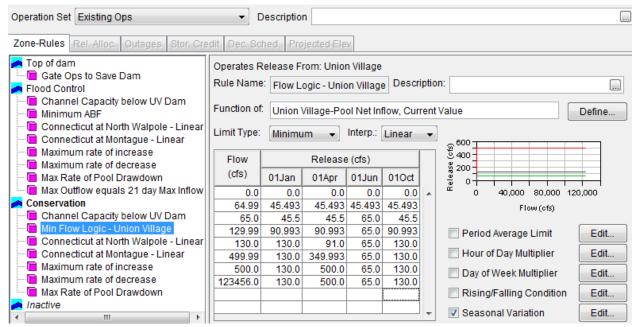


Figure 15 Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic-Union Village

# Upper Naukeag

### I. Overview

Upper Naukeag dam is located by the towns of Winchendon and Ashburnham, MA and feeds into the Millers River. The dam is owned and operated by the towns of Winchendon and Ashburnham and is used for water supply for the two towns.

Figure 1 shows the location of Upper Naukeag Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Upper Naukeag Lake.

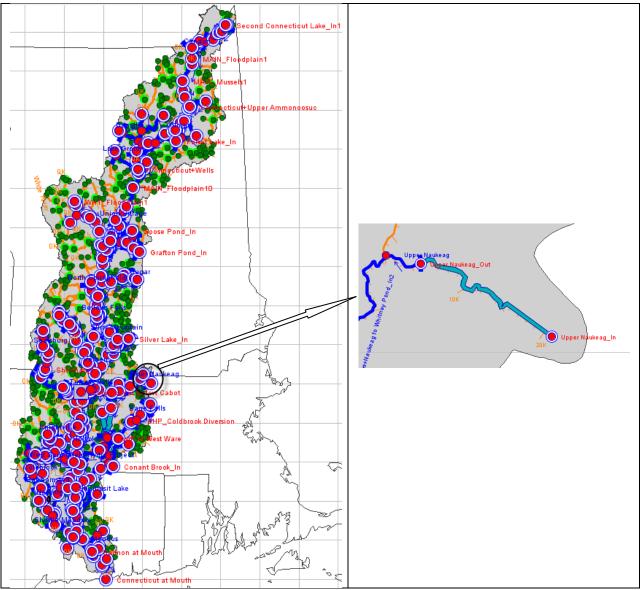


Figure 1: HEC-ResSim Map Display Showing Location of Upper Naukeag Dam



Figure 2: Photo of Upper Naukeag Lake.

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>101</sup>. The dam consists of an uncontrolled outlet as shown in Figure 4.

<sup>&</sup>lt;sup>101</sup> National Inventory of Dams database.

Reservoir Editor				X
Reservoir Edit Pool				
Reservoir Upper Naukeag	✓ Description			K 4 63 of 74 D H
Physical Operations Observed	i Data			
Upper Naukeag	Upper Naukeag-Po	ol		
Dam 	Linear Interpo	lation 🔘 Conic	Interpolation	Initial Conic Depth (ft)
	Elevation	Storage	Area	
	(ft)	(ac-ft)	(acre)	1,136
	1124.00	2798.82		1,132
	1134.00	3100.00		€ ≥ 1,128
				μ <sup>1,120</sup>
				1,124
				2,800 2,900 3,000 3,100
				Stor (ac-ft)
				1,136
				1,132
				€ ≥ 1,128
				1,124
				1,124
				012345678
				Area (acre)
			ОК	Cancel Apply

Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor				x
Reservoir Edit Dam				
Reservoir Upper Naukeag	Description			
Physical Operations Observe	d Data			
Upper Naukeag	Upper Naukeag-Dam			
Dam Dam	Elevation at top of dam (ft)		1134.0	
	Length at top of dam (ft)		300.0	
	Composite Release Cap	acity		
	Elevation Controlled	Uncontro	Total	
	(ft) (cfs)	(cfs)	(cfs)	1,144
	1,134.0 0.0	0.0	0.0 × 5	1.140
	1,135.0 0.0	0.0	0.0	€ 1,136
	1,136.0 0.0	0.0		1,132
	1,137.0 0.0 1,138.0 0.0	0.0	0.0	0 0.3 0.6 0.9
	1,139.0 0.0	0.0	0.0	Flow
	1,140.0 0.0	0.0	0.0	(cfs)
	1,141.0 0.0	0.0	0.0	
	1,142.0 0.0	0.0	0.0	
	1,143.0 0.0	0.0	0.0	
	1,144.0 0.0	0.0	0.0	
			ОК	Cancel Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

# A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Upper Naukeag Dam's "Guide Curve" operational zones, which consist of zones of Flood Control (1134 ft), Conservation (1133 ft), and Inactive zone (1126 ft)<sup>102</sup>.

Reservoir Editor		×
Reservoir Edit Operations Zo	one Rule IF_Block	
Reservoir Upper Naukeag	Description	63 of 74 🕨 🕨
Physical Operations Obse	served Data	
Operation Set Guide Curve	e   Description	
Zone-Rules Rel. Alloc. C	Outages Stor, Credit Dec, Sched, Projected Elev	
Flood Control	Storage Zone Conservation Description	
jan Inactive	Function of Date	Define
	Date Top Elevation (ft)	
	01Jan 1133.0 1,134 1,133	
	€ 1,132 € 1,131	
	1,127	
		- Neu
	Jan Mar May Jul Seg	NUY
	Zone Sort Elevation	
	OK Cancel	Apply

Figure 5 Reservoir Editor: Operations Tab – Guide Curve OpSet

# **B. Rule Illustrations**

The operation set for Upper Naukeag Dam has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacit

<sup>&</sup>lt;sup>102</sup> Water supply records

### Vernon

### I. Overview

Vernon is located on the Connecticut River in the towns of Vernon, VT and Hinsdale, NH. It is owned and operated by TransCanada Hydro Northeast Inc. for hydropower generation on a run-of-river basis.

Figure 1 shows the location of Vernon dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Vernon dam.

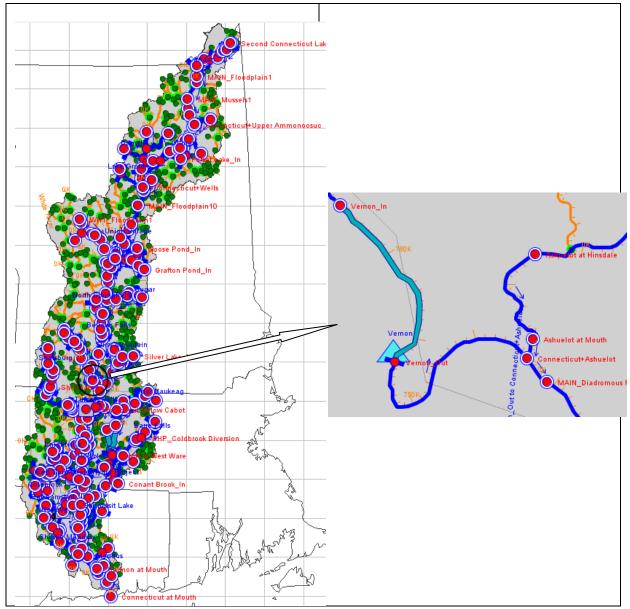


Figure 1: HEC-ResSim Map Display Showing Location of Vernon dam



Figure 2: Photo of Vernon dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>103</sup>. The dam consists of nine types of outlets: (1) controlled Trash sluice gates, (2) controlled Tainter gates-10\*50, (3) controlled Tainter Gates-20\*50, (4) controlled sluice flood gate, (5) controlled Fish ladder, (6) uncontrolled stanchion 42.5 ft- W flashboards, (7) uncontrolled stanchion 50 ft-W flashboards, (8) controlled Fish Pipe+Fish Tube , and (9) power plant as shown in Figure 4.

<sup>&</sup>lt;sup>103</sup> Data provided by TransCanada

eservoir Vernon 👻 Desc	ription			K 4 68 of 74 🕨
	Vernon-Pool			
Dam Tailwater	Linear Interpo	lation 🔘 Coni	c Interpolation	Initial Conic Depth (ft)
Trash sluice gate	Elevation	Storage	Area	7
Tainter Gates - 10x50	(ft)	(ac-ft)	(acre)	
Tainter Gates - 20x50	212.10	0.00	,,	
Sluice flood gate	212.10	200.00		
Fish Ladder	212.20	400.00		
Power Plant	212.30	599.59		
stanchion 42.5 ft-W flashboards	212.50	799.59		
Stanchion 50 ft-W flashboards	212.60	999.59		224
Fish Pipe+Fish Tube	212.70	1204.55		
	212.80	1409.92		€ 220
	212.90	1614.88		€ <sup>220</sup> a 216
	213.00	1819.83		± 216
	213.10	2025.21		212
	213.20	2234.71		0 10,000 20,000
	213.30	2444.21		
	213.40	2654.13		Stor (ac-ft)
	213.50	2863.64		224
	213.60	3073.14		
	213.70	3286.78		€ 220
	213.80	3500.00		<u>a</u> 216
	213.90	3713.64		<u><u> </u></u>
	214.00	3926.03		212
	214.10	4140.50		0 600 1,200
	214.20	4357.85		
	214.30	4574.79		Area (acre)
	214.40	4792.15		
	214.50	5009.09		
	214.60	5226.45		
	214.70	5447.11		
	214.80	5667.77		
	214.90	5888.84	-	-

Figure 3: Reservoir Editor: Physical Tab -- Pool

eservoir Edit Dam			
Reservoir Vernon 👻 De	scription		K 4 68 of 74 D
Physical Operations Observed Data	Vernon-Dam		
Tailwater Trash sluice gate Tainter Gates - 10x50	Elevation at top of dam (ft) Length at top of dam (ft)	228.0	
<ul> <li>Tainter Gates - 20x50</li> <li>Sluice flood gate</li> <li>Fish Ladder</li> <li>Power Plant</li> <li>stanchion 42.5 ft-W flashboards</li> <li>Stanchion 50 ft-W flashboards</li> <li>Fish Pipe+Fish Tube</li> </ul>	Composite Release Capacit           Elevation (ft)         Controlled (cfs)         U           0.0         43,278.0         209.1         43,278.0           209.1         43,278.0         209.6         43,293.2           210.1         43,321.1         210.6         43,357.2           211.1         43,400.0         211.6         43,385.0           212.0         43,471.6         212.1         43,589.2           212.1         43,589.2         212.6         45,101.2           213.1         46,527.2         213.1         46,660.0           213.6         48,877.0         214.1         50,963.8           214.1         51,067.1         214.6         52,793.1           215.1         54,419.3         215.1         54,537.1           215.1         54,537.1         215.6         56,502.1           216.1         58,353.0         216.1         58,353.0	ncontrol Total (cfs) (cfs)	300 200 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
	216.1         58,484.0           216.6         60,672.0           217.1         62,730.6           217.1         62,875.7	0.0 58,484.0 0.0 60,672.0 0.0 62,730.6 0.0 62,875.7 +	

Figure 4: Reservoir Editor: Physical Tab -- Dam

### A. Operation Set

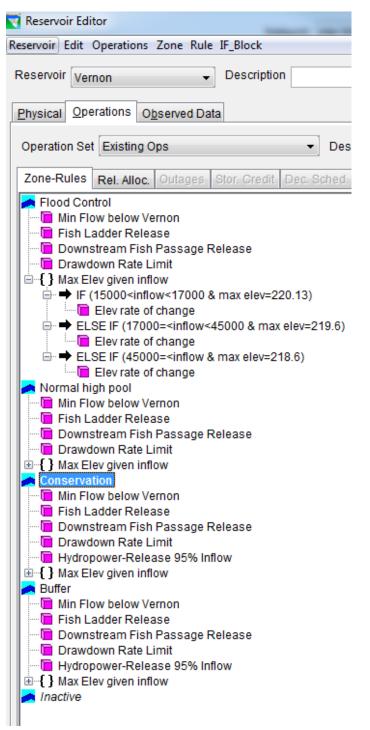
Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Vernon's "ExistingOps" operational zones, which consist of zones of Flood Control (228 ft), Normal high pool (220 ft), Conservation (219.8 ft), Buffer (218.6 ft), and Inactive zone (212 ft)<sup>1</sup>.

Reservoir Editor		×
Reservoir Edit Operations Zone Rule IF_Bloc	k	
Reservoir Vernon   Descr  Physical Operations Observed Data	iption	K 4 68 of 74 D H
Operation Set Existing Ops Zone-Rules Rel. Alloc. Outages Stor. Cr	Description edit. Dec. Sched. Projected Elev	
<ul> <li>Flood Control</li> <li>Im Flow below Vernon</li> <li>Fish Ladder Release</li> </ul>	Storage Zone Conservation	Description
<ul> <li>Downstream Fish Passage Release</li> <li>Drawdown Rate Limit</li> <li>Max Elev given inflow</li> <li>Normal high pool</li> <li>Min Flow below Vernon</li> <li>Fish Ladder Release</li> <li>Downstream Fish Passage Release</li> <li>Drawdown Rate Limit</li> <li>Max Elev given inflow</li> <li>Conservation</li> <li>Min Flow below Vernon</li> <li>Fish Ladder Release</li> <li>Downstream Fish Passage Release</li> <li>Drawdown Rate Limit</li> <li>Hydropower-Release 95% Inflow</li> <li>Fish Ladder Release</li> <li>Downstream Fish Passage Release</li> <li>Downstream Fish Passage Release</li> <li>Downstream Fish Passage Release</li> <li>Min Flow below Vernon</li> <li>Fish Ladder Release</li> <li>Downstream Fish Passage Release</li> <li>Downstream Fish Passage Release</li> <li>Downstream Fish Passage Release</li> <li>Max Elev given inflow</li> </ul>	Date Top Elevation (ft) 01Jan 219.8	230 228 226 224 222 220 220 218 216 214 216 214 210 Jan Mar May Jul Sep Nov
Inactive	Zone Sort Elevation	OK Cancel Apply

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

### **B. Rule Illustrations**

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>104</sup>.



#### Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>&</sup>lt;sup>104</sup> TransCanada. Connecticut River Operational Constraints. 2012.

Figure 7 shows a sequential release allocation approach specified for available outlets along Bellows Falls Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The Trash sluice gate gets the remainder of the release until it reaches capacity. The flow passes through Tainter Gates-10\*50 and then Tainter Gates-20\*50. The next priority is assigned to sluice flood gate. After the capacity through the sluice flood gate is reached, the remainder of the release goes through the Fish pipe+Fish Tube and Fish Ladder, respectively.

Reservoir Editor	a land of S later later	
Reservoir Edit Operations		
Reservoir Vernon		
Physical Operations Observed Data		
Operation Set Existing Ops	Description	
Zone-Rules Rel. Alloc. Outages Stor, Credit Dec. S	Sched. Projected Elev	
Release Allocation Strategy		
Vernon - Balanced	Release Location:     Vernon-Dam       Allocation Type:     Sequential	
<ul> <li>Vernon-Trash sluice gate</li> <li>Vernon-Tainter Gates - 10x50</li> <li>Vernon-Tainter Gates - 20x50</li> <li>Vernon-Sluice flood gate</li> <li>Vernon-Fish Pipe+Fish Tube</li> <li>Vernon-Fish Lodder</li> </ul>	Vernon-Power Plant Vernon-Trash sluice gate Vernon-Tainter Gates - 10x50 Vernon-Tainter Gates - 20x50	
Vernon-Fish Ladder	Vernon-Sluice flood gate Vernon-Fish Pipe+Fish Tube Vernon-Fish Ladder	

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

# **C. Rule Descriptions**

#### 1. Min Flow below Vernon

Figure 8 shows the content of "Min flow below Vernon" rule. This rule shows a minimum release from dam as a function of Inflow.

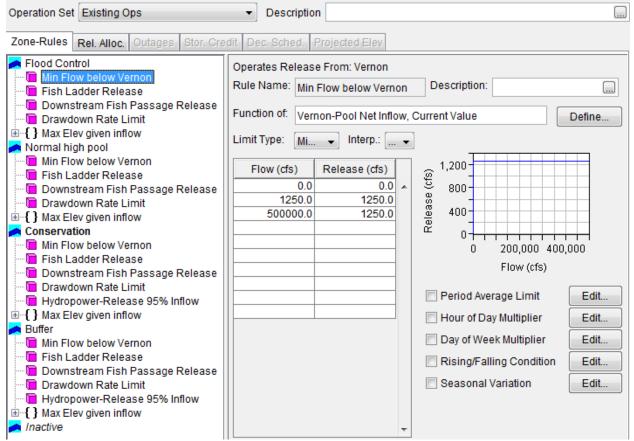


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow below Vernon

#### 2. Fish Ladder Release

Figure 9 shows the content of "Fish Ladder Release" rule. This rule shows the specified release from Fish Ladder gate.

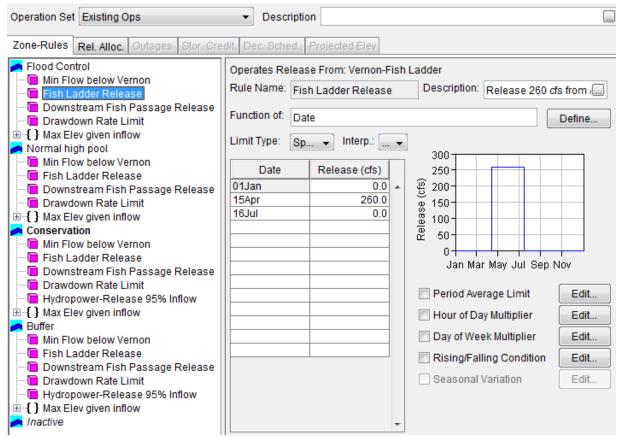


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Fish Ladder Release

### 3. Downstream Fish Passage Release

Figure 10 shows the content of "Downstream Fish Passage Release" rule. This rule shows the specified release from Fish pipe + Fish Tube gate.

Operation Set Existing Ops	<ul> <li>Descriptio</li> </ul>	n		
Zone-Rules Rel. Alloc. Outages Stor. Cre	dit Dec. Sched.	Projected Elev		
<ul> <li>Flood Control</li> <li>Min Flow below Vernon</li> <li>Fish Ladder Release</li> <li>Downstream Fish Passage Release</li> <li>Drawdown Rate Limit</li> <li>{} Max Elev given inflow</li> <li>Normal high pool</li> <li>Min Flow below Vernon</li> <li>Fish Ladder Release</li> <li>Downstream Fish Passage Release</li> <li>Downstream Fish Passage Release</li> <li>Drawdown Rate Limit</li> <li>{} Max Elev given inflow</li> <li>Conservation</li> <li>Min Flow below Vernon</li> <li>Fish Ladder Release</li> <li>Downstream Fish Passage Release</li> <li>Max Elev given inflow</li> <li>Buffer</li> <li>Min Flow below Vernon</li> <li>Fish Ladder Release</li> <li>Downstream Fish Passage Release</li> <li>Max Elev given inflow</li> <li>{} Max Elev given inflow</li></ul>	Rule Name: Im F		se Description: Release 350 d	Define

Figure 10 Reservoir Editor: Operations Tab – Existing Ops OpSet – Downstream Fish Passage Release

#### 4. Drawdown Rate Limit

Figure 11 shows the content of "Drawdown Rate Limit" rule. This rule shows the decreasing elevation rate of change rule.

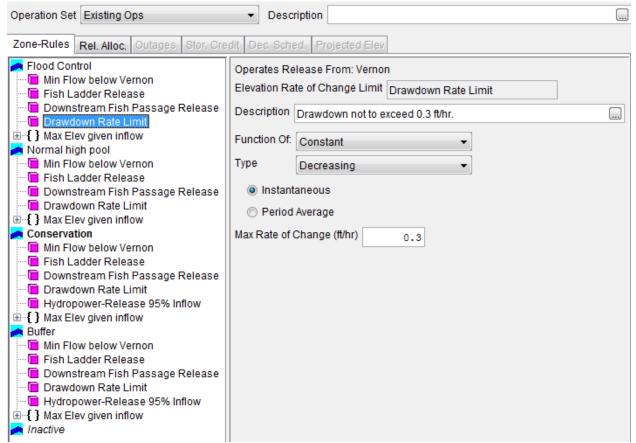
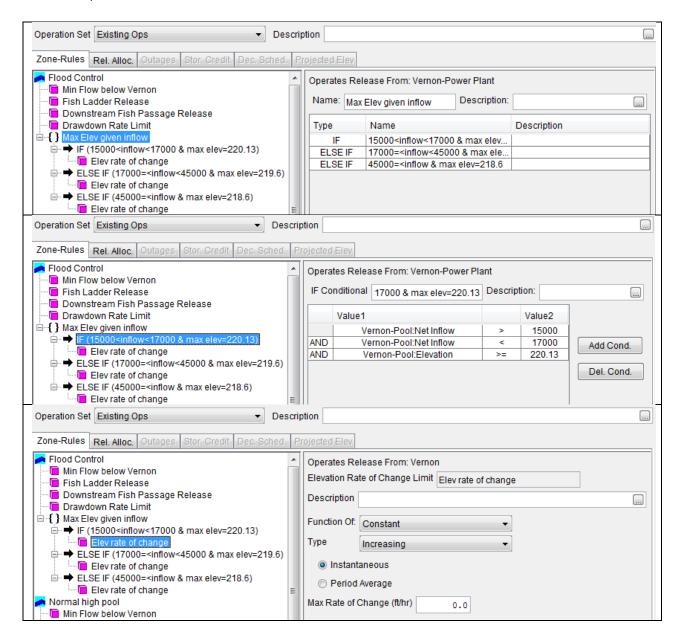


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Drawdown Rate Limit

#### 5. Max Elev given inflow

Figure 12 shows the content of "Max Elev given inflow" rule. For each combination of Inflow and maximum pool elevation shown in the below picture the maximum elevation rate of change equals zero.



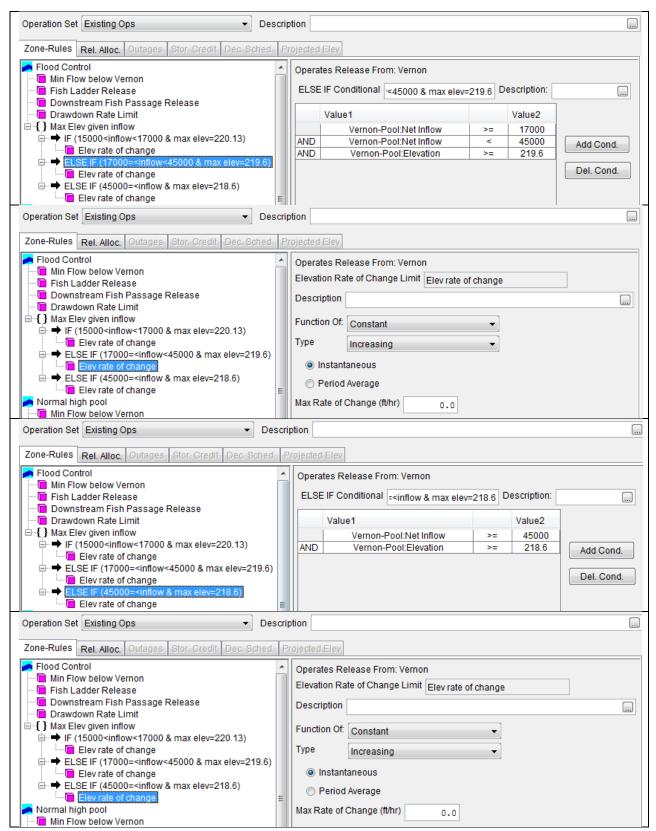


Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Elev given inflow

#### 6. Hydropower-Release 95% Inflow

Figure 13 shows the content of "Hydropower-Release 95% Inflow" rule. This rule passes 95% of Inflow through power plant as per the run-of-river modeling strategy.

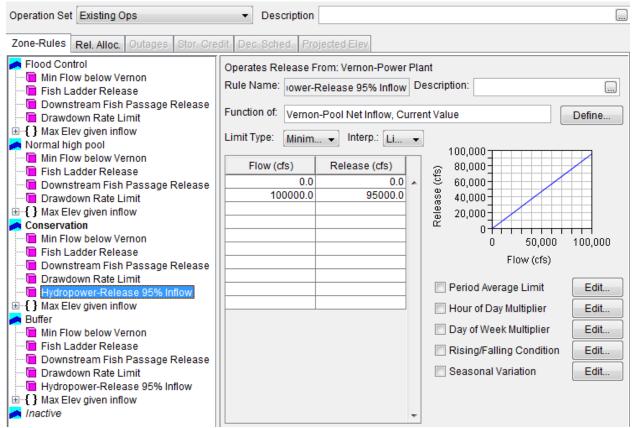


Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Hydropower-Release 95% Inflow

# Ware Upper and Lower

### I. Overview

Ware Upper and Lower are two dams located in Ware, MA on the Ware River. It is owned and operated by Ware River Hydroelectric Company and is used to generate hydropower.

Figure 1 shows the location of Ware upper and lower dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Ware upper dam.

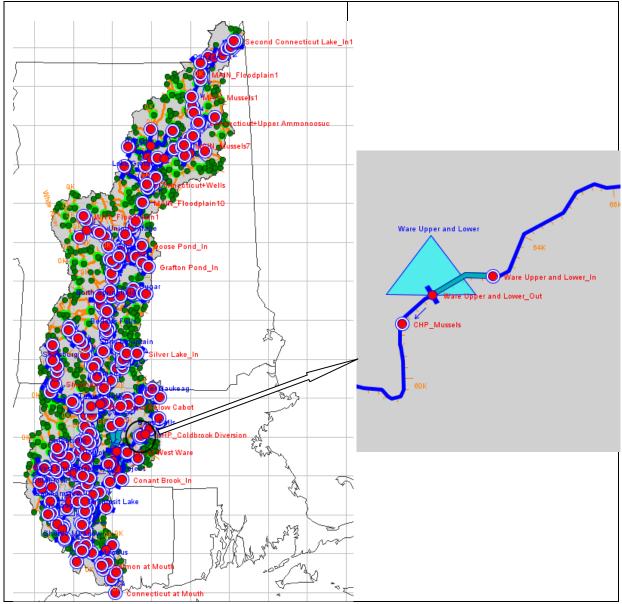


Figure 1: HEC-ResSim Map Display Showing Location of Ware upper and lower Dam

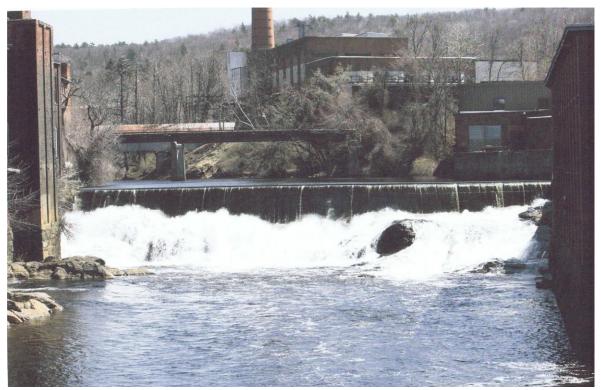


Figure 2: Photo of Ware upper dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>105</sup>. The dam consists of two types of outlets: (1) uncontrolled outlet and (3) power plant as shown in Figure 4<sup>1,106</sup>. The capacity of the power plant was made to be the maximum release specified in the NID database so that the dam would modeled completely as run-of-river with some actual physical information.

<sup>&</sup>lt;sup>105</sup> National Inventory of Dams database (NID)

<sup>&</sup>lt;sup>106</sup> http://www.lowimpacthydro.org.php5-11.dfw1-2.websitetestlink.com/lihi-certificate-47-ware-riverhydroelectric-company-project-ferc-no.-3127-ware-river-massachusetts.html

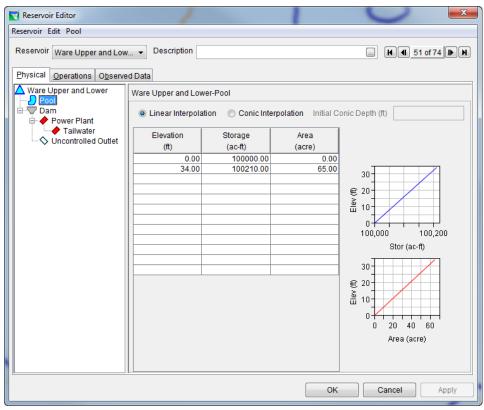


Figure 3: Reservoir Editor: Physical Tab – Pool

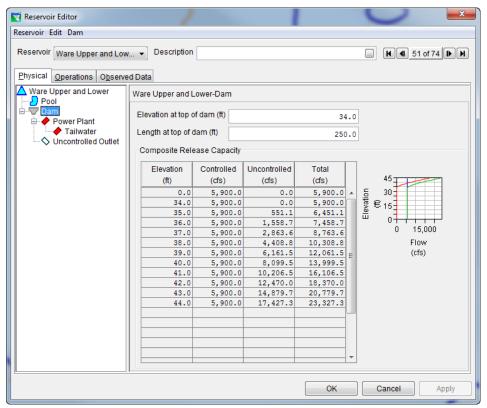


Figure 4: Reservoir Editor: Physical Tab -- Dam

# A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Ware upper and lower's "Guide Curve" operational zones, which consist of Flood Control (34 ft), Conservation (33.9 ft), and Inactive zone (24 ft)<sup>1</sup>. There was no specified inactive zone so 10 feet below top of dam was arbitrarily chosen.

Reservoir Edit Operations Zone Rule IF_Block         Reservoir Ware Upper and Low          Description         Description         Description         Description         Description         Zone-Rules Rel.Alloc. Outages Stor.Credit Dec.Sched. Projected Elev         Storage Zone Conservation         Flood Control         Conservation         Function of Date         Date         Top Elevation (ft)         Olan         33.9          36         34         32         30         34         32         30         34         32         30         34         32         30         34         32         30         34         32         30         34         32         30         32         30         34         32         30         30         32         30         32         30         32         30         32         30         30         32         30         32         30         32         30         32         30         32         30         32         30         30         32         30         32         30         30         32         30         30         32         30         32
Physical       Operations       Observed Data         Operation Set       Guide Curve       Description         Zone-Rules       Rel. Alloc.       Outages       Stor. Credit       Dec. Sched.       Projected Elev         Flood Control       Storage Zone       Conservation       Description       Imactive         Function of       Date       Top Elevation (ft)       36         Oldar       33.9       36         34       32       36
Operation Set     Guide Curve     Description       Zone-Rules     Rel. Alloc.     Outages     Stor. Credit     Dec. Sched.     Projected Elev.       Flood Control     Storage Zone     Conservation     Description     Image: Conservation       Inactive     Function of     Date     Define       Date     Top Elevation (ft)     33.9     36       34     32     34
Zone-Rules       Rel. Alloc.       Outages       Stor. Credit       Dec. Sched.       Projected Elev         Flood Control       Storage Zone       Conservation       Description       Image: Conservation         Inactive       Function of Date       Define       Define         Date       Top Elevation (ft)       33.9       36         34       32       34       32
Flood Control       Storage Zone Conservation       Description         Inactive       Function of Date       Define         Date       Top Elevation (ft)       36         01Jan       33.9       36         34       32       34
Conservation     Storage Zone Conservation     Description       Function of Date     Define       Date     Top Elevation (ft)       01Jan     33.9       36       34       34       32
Date     Top Elevation (ft)       01Jan     33.9
01Jan 33.9 34 32
§ 30
24
22 + + + + + + + + + + + + + + + + + +
· · · · · · · · · · · · · · · · · · ·
Zone Sort Elevation
OK Cancel Apply

Figure 5: Reservoir Editor: Operations Tab –Guide Curve OpSet – Guide Curve

# **B. Rule Illustrations**

The operation set for Ware upper and lower has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity. This was modeled this way because no real operation information was found.

# West Branch

#### I. Overview

West Branch dam (known as Goodwin Dam) is located directly downstream of Colebrook dam on the Farmington River in Hartland, CT. It is owned and operated by The Metropolitan Water District of Hartford, CT (MDC) and is used for drinking water supply and some recreation.

Figure 1 shows the location of West Branch as it is represented in the HEC-ResSim model, and Figure 2 shows a photo for West Branch.

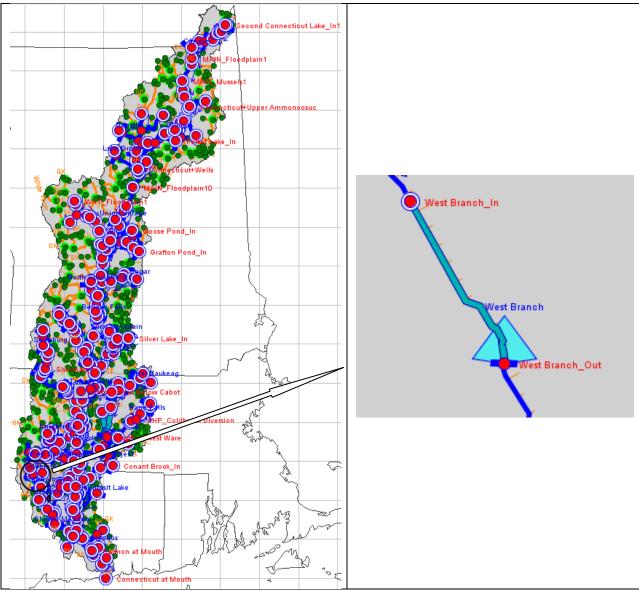


Figure 1: HEC-ResSim Map Display Showing Location of West Branch



Figure 2: Photo of West Branch dam

#### **Physical Characteristics** II.

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>107</sup>. The dam consists of a controlled outlet as shown in Figure  $4^{108}$ .

<sup>&</sup>lt;sup>107</sup> MDC 1999 <sup>108</sup> Data from UMASS

servoir Edit Pool				
eservoir West Branch	<ul> <li>Description</li> </ul>			H 4 2 of 74 D
hysical Operations Observe	d Data			
West Branch	West Branch-Poo	bl		
Dam	Linear Interplace	polation 💿 Co	onic Interpolati	on Initial Conic Depth (ft)
Spillway	Elevation	Storage	Area	
	(ft)	(ac-ft)	(acre)	
	540.00	0.00	(acre)	4
	540.00	2.46		
	542.00	4.91		640
	543.00	7.37		E 040
	544.00	10.13		€ 600
	545.00	12.58		± 560 +
	546.00	15.04		<u> </u>
	547.00	17.49		520
	548.00	19.95		
	549.00	22.40		Stor (ac-ft)
	550.00	24.86		
	551.00	37.75		640
	552.00	50.33		1 4 + + + + + + + 1
	553.00	62.30		€ 600
	554.00	75.49		a 560
	555.00	88.08		
	556.00	100.66		520
	557.00	113.55		320 360 400 440
	558.00	126.13		Area (acre)
	559.00	138.10		
	560.00	150.38		
	561.00	187.20		-
	562.00	220.06		

Figure 3: Reservoir Editor: Physical Tab -- Pool

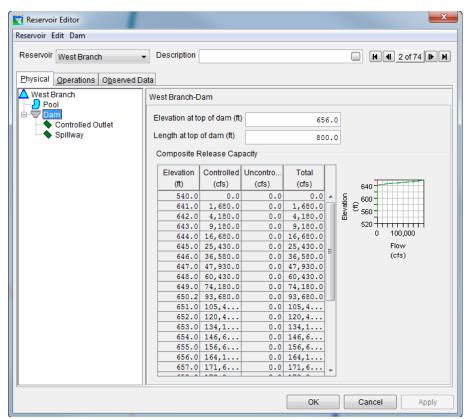


Figure 4: Reservoir Editor: Physical Tab -- Dam

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of West Branch's "Existing Ops" operational zones, which consist of zones of Top of Dam (656 ft), Conservation (641 ft), and Inactive zone (540 ft)<sup>2</sup>.

Reservoir Editor			La	×	
Reservoir Edit Operations Zone Rule IF_Block					
Reservoir West Branch - Description	1			H € 2 of 74 ► H	
Physical Operations Observed Data					
Operation Set Existing Ops   Description From UMass Farmington notes: modeled as run of the river, has same flue					
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev					
Top of Dam	Storage Zone Conserv	ation De	escription From UMass	s Farmington notes: ri	
nactive 🔁	Function of Date			Define	
	Date	Top Elevation (ft)	660		
	01Jan	641.0	640		
			620- € 600-		
			€ 600 - 580 - 199 580 -		
			± 560-		
			540		
			j 520 <del>1 i i</del> Jan Mar Ma	y Jul Sep Nov	
			<b>T</b>		
	Zone Sort Elevation				
OK Cancel Apply					
				Cancel Apply	

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet

# **B. Rule Illustrations**

The operation set for West Branch has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

# West Springfield Hydro Project

### I. Overview

West Springfield is dam located in West Springfield, MA on the Westfield River. It is owned and operated by A&D Hydro, Inc and is used for hydropower generation.

Figure 1 shows the location of West Springfield dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of West Springfield dam.

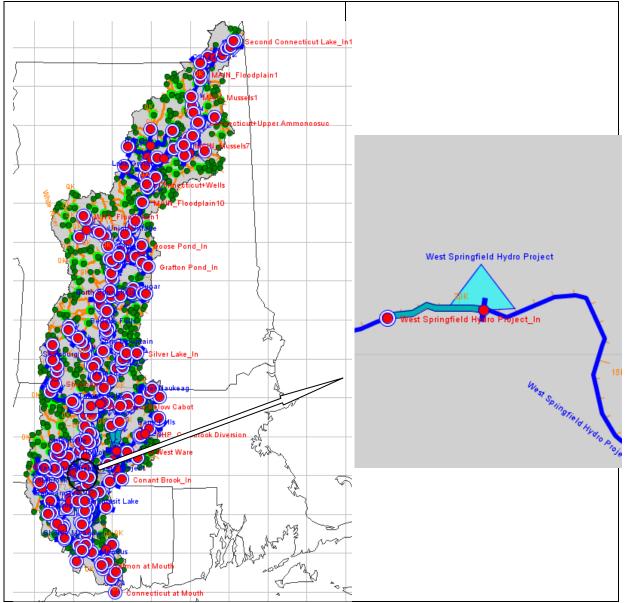


Figure 1: HEC-ResSim Map Display Showing Location of West Springfield Dam



Figure 2: Photo of West Springfield dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>109</sup>. The dam consists of two types of outlets: (1) uncontrolled outlet and (3) power plant as shown in Figure 4<sup>110</sup>. The capacity of the power plant was made to be the maximum release specified in the NID database so that the dam would modeled completely as run-of-river with some actual physical information.

<sup>&</sup>lt;sup>109</sup> National Inventory of Dams database (NID)

<sup>&</sup>lt;sup>110</sup> http://www.lowimpacthydro.org/lihi-certificate-19-west-springfield-project-westfield-river-west-springfield-agawam-ma.-ferc-2608.html

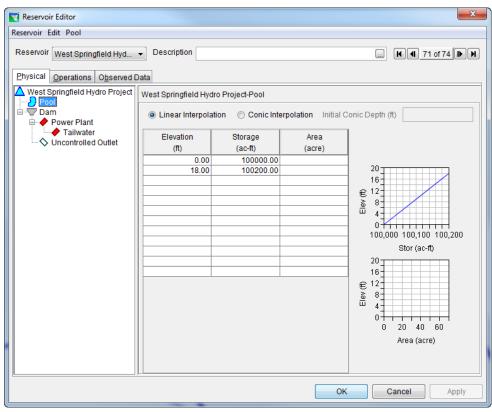


Figure 3: Reservoir Editor: Physical Tab – Pool

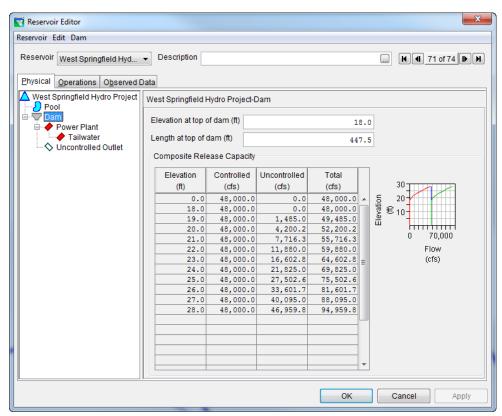


Figure 4: Reservoir Editor: Physical Tab -- Dam

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of West Springfield's "Guide Curve" operational zones, which consist of Flood Control (18 ft), Conservation (17.9 ft), and Inactive zone (8 ft)<sup>1</sup>. There was no specified inactive zone so 10 feet below top of dam was arbitrarily chosen.

Reservoir Editor			
Reservoir Edit Operations Zone Rule IF_Block			
Reservoir West Springfield Hyd  Description			
Physical Operations Observed Data			
Operation Set Guide Curve Only   Description			
Zone-Rules Rel, Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.			
Flood Control Storage Zone Conservation Description			
Function of Date Define			
Date Top Elevation (ft)			
01Jan 17.9 ^ 20 18			
8			
6 6 6 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7			
· · ·			
Zone Sort Elevation			
OK Cancel Apply			

Figure 5: Reservoir Editor: Operations Tab –Guide Curve OpSet – Guide Curve

# **B. Rule Illustrations**

The operation set for West Springfield has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity. This was modeled this way because no real operation information was found.

# Whitney Pond

### I. Overview

Whitney Pond dam is located in the Town of Winchendon, MA at the confluence of the North Branch and Millers River. It is owned and operated by the Town of Winchendon and is used for water supply for the town.

Figure 1 shows the location of Whitney Pond dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Whitney Pond.

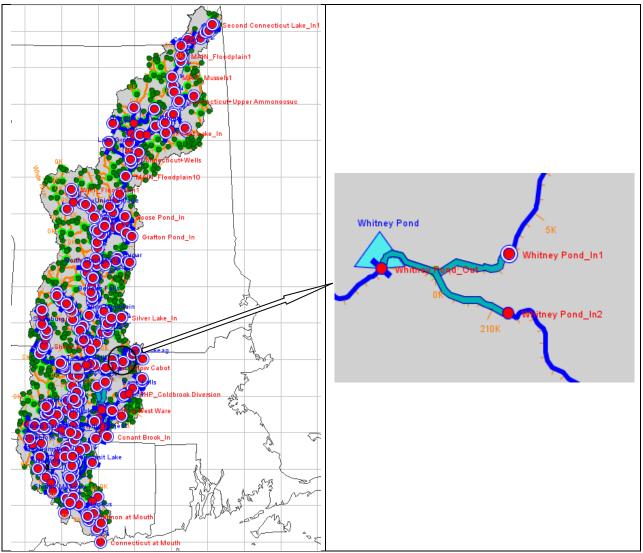


Figure 1: HEC-ResSim Map Display Showing Location of Whitney Pond Dam



Figure 2: Photo of Whitney Pond

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>111</sup>. The dam consists of two types of outlets: (1) an uncontrolled Outlet and an uncontrolled flow over embankment as shown in Figure 4.

<sup>&</sup>lt;sup>111</sup> Phase I National Dam Inspection Program. 1979.

Reservoir Editor Reservoir Edit Pool				X
Reservoir Whitney Pond	<ul> <li>Description</li> <li>ata</li> </ul>			K (1) 58 of 74 (1) M
Whitney Pond → Pool → Dam → Quncontrolled Outlet	Whitney Pond-Po		onic Interpolation	Initial Conic Depth (ft)
◆ flow over embarkment	Elevation (ft) 954.00 960.00 969.00 970.00 970.00 980.00 986.00	Storage (ac-ft) 0.00 72.00 264.00 414.00 640.00 2192.00 4052.00	Area (acre) 0.00 20.00 44.00 56.00 60.00 108.00 280.00 340.00	990 980 970 950 950 950 950 950 990 990 990 990 99
OK Cancel Apply				

Figure 3: Reservoir Editor: Physical Tab -- Pool

Reservoir Editor						×
Reservoir Edit Dam						
Reservoir Whitney Pond	Description					K € 58 of 74 ► H
Physical Operations Observed Da	ata					
Whitney Pond	Whitney Pond-	Dam				
Dam Controlled Outlet	Elevation at to	op of dam (ft)		978	.5	
flow over embarkment	Length at top	of dam (ft)		887.	.0	
	Composite F	Release Cap	acity			
	Elevation		Uncontro	Total		
	(ft)	(cfs)	(cfs)	(cfs)		984
	968.8	0.0	0.0			980 -
	969.3	0.0	68.0 197.0	68.0 197.0	e a	976
	970.8	0.0	551.0			968
	971.8	0.0	1,015.9			0 15,000
	972.8	0.0		1,587.0		Flow
	973.8	0.0	2,293.0	2,293.0		(cfs)
	974.8	0.0	3,133.0			
	975.8	0.0	3,948.0			
	976.8	0.0	4,815.0			
	977.8	0.0	5,755.0 6,410.0			
	978.8	0.0	6,740.0			
	070.0	0.0	6 046 9	6 046 0	Ŧ	
				ОК	C	Apply Apply

Figure 4: Reservoir Editor: Physical Tab -- Dam

# A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Whitney Pond Dam's "Guide Curve" operational zones, which consist of zones of Top of Dam (978.5 ft), Flood Control (970 ft), Conservation (968.8 ft), and Inactive zone (955 ft)<sup>1</sup>.

Reservoir Editor			
Reservoir Edit Operations Z	ne Rule IF_Block		
Reservoir Whitney Pond	Description	K 4 58 of 74 H	
Physical Operations Obs	erved Data		
Operation Set Guide Curve	▼ Description		
Zone-Rules Rel. Alloc. C	utages Stor. Credit Dec. Sched. Pr	rojected Elev	
Top of dam Flood Control	Storage Zone Conservation	Description	
Conservation	Function of Date	Define	
	Date Top Elevation	080	
	01Jan	968.8	
		955	
		Jan Mar May Jul Sep Nov	
	Zone Sort Elevation		
		OK Cancel Apply	

Figure 5: Reservoir Editor: Operations Tab – Guide Curve OpSet

# **B. Rule Illustrations**

The operation set for Whitney Pond Dam has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

# Wilder

### I. Overview

Wilder dam is located in the town of Wilder, VT on the mainstem Connecticut River. It is owned and operated by TransCanada Hydro Northeast Inc. for hydropower generation.

Figure 1 shows the location of Wilder Dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo from Wilder dam.

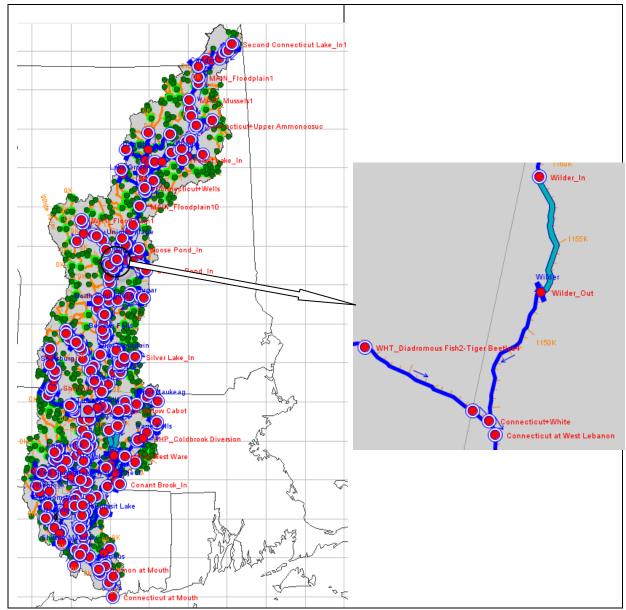


Figure 1: HEC-ResSim Map Display Showing Location of Wilder dam

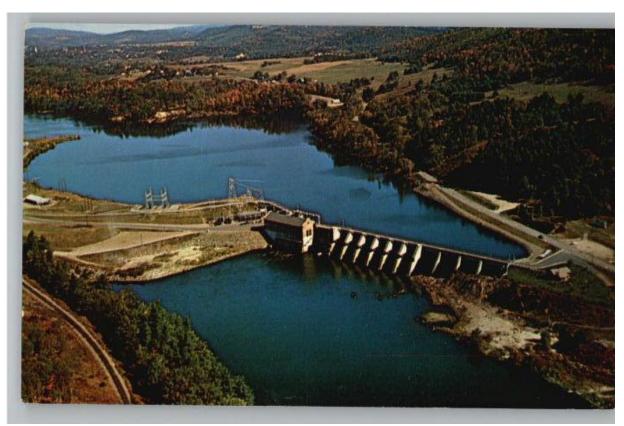


Figure 2: Photo of Wilder dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>112</sup>. The dam consists of six types of outlets: (1) controlled Tainter gates, (2) controlled skimmer gate 10\*10 ft, (3) controlled skimmer gate 15\*20 ft, (4) controlled Fish Ladder, (5) uncontrolled stanchion-stoplogs in, and (6) power plant as shown in Figure 4.

<sup>&</sup>lt;sup>112</sup> Data provided by TransCanada

ervoir Edit Pool				
eservoir Wilder ·	- Description			K 4 67 of 74 🕨
hysical Operations Observed D	ata			
Wilder	Wilder-Pool			
Dam Tailwater	Linear Interpolatio	n 💿 Conic Interpola	tion Initial Conic De	pth (ft)
Tainter gates	Elevation	Storage	Area	
Skimmer gate 10*10 ft	(ft)	(ac-ft)	(acre)	
<ul> <li>Skimmer gate 15*20 ft</li> <li>Fish ladder</li> </ul>	355.00	0.00	100.00	
Power Plant	356.00	106.00	112.00	
stanchion-stoplogs in	357.00	224.00	124.00	
✓ staticition-stopiogs in	358.00	354.00	136.00	390
	359.00	496.00	148.00	380
	360.00	650.00	160.00	£ 270
	361.00	822.00	183.00	€ 370
	362.00	1015.00	206.00	<b>苗 360</b> -
	363.00	1235.00	229.00	350
	364.00	1475.00	252.00	0 15,000 30,000
	365.00	1740.00	276.00	Stor (ac-ft)
	366.00	2025.00	300.00	
	367.00	2505.00	600.00	390
	368.00	3255.00	835.00	380
	369.00	4175.00	1010.00	€ 370
	370.00	5225.00	1090.00	€ 370
	371.00	6360.00	1180.00	⊞ 360 1
	372.00	7585.00	1270.00	350
	373.00	8900.00	1360.00	0 1,500 3,000
	374.00	10305.00	1450.00	Area (acre)
	375.00	11800.00	1540.00	Alea (acie)
	376.00	13410.00	1680.00	
	377.00	15160.00	1820.00	
	378.00	17050.00	1960.00	
	379.00	19080.00	2100.00 +	

Figure 3: Reservoir Editor: Physical Tab -- Pool

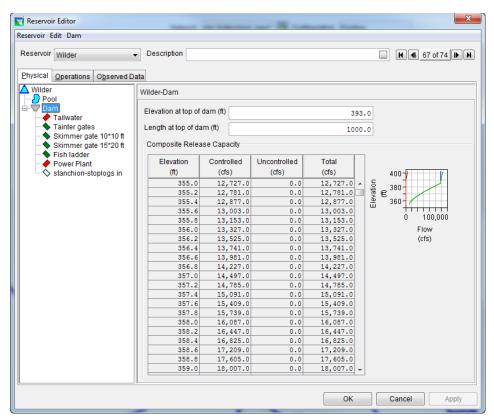


Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Wilder's "ExistingOps" operational zones, which consist of zones of Flood Control (393 ft), FERC Max Pool (385 ft), Conservation (384.5 ft), Buffer (382 ft), and Inactive zone (380 ft)<sup>1</sup>.

Reservoir Editor			-	×		
Reservoir Edit Operations						
Reservoir Wilder   Descri  Physical Operations Observed Data	ption			K 4 67 of 74 K H		
Operation Set Existing Ops   Description  Cone-Rules Rel. Alloc. Outages Stor. Credit. Dec. Sched. Projected Elev.						
Flood Control Min Flow below Wilder Fish Ladder Release Downstream Fish Passage Release	Storage Zone Conse	rvation	Description	Define		
<ul> <li>Pool Drawdown Rate Limit</li> <li>Aax Elev given inflow</li> <li>FERC Max Pool</li> <li>Min Flow below Wilder</li> <li>Fish Ladder Release</li> <li>Pool Drawdown Rate Limit</li> <li></li></ul>	Date 01Jan	Top Elevation (ft) 384	.5 ▲ 394 392 390 € 388 5 386 5 386 384 384 382 380 380 380 378	Mar May Jul Sep Nov		
			ОК	Cancel Apply		

Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Guide Curve

# **B. Rule Illustrations**

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>113</sup>.

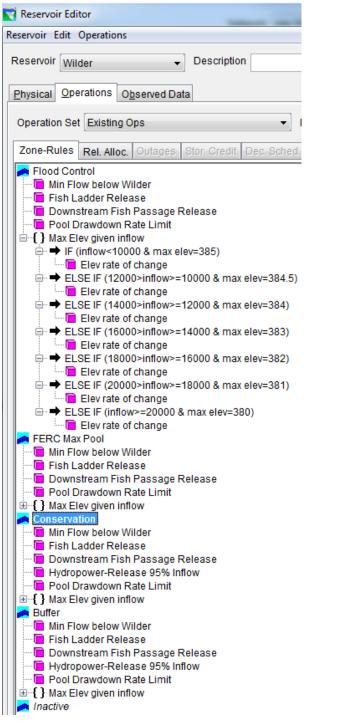


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>&</sup>lt;sup>113</sup> TransCanada. Connecticut River Operational Constraints. 2012.

Figure 7 shows a sequential release allocation approach specified for available outlets along Bellows Falls Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The Tainter gates get the remainder of the release until they reache capacity. Then the flow passes through skimmer gate 15\*20 and 10\*10. After the capacity through the skimmer gates is reached, the remainder of the release goes through the Fish ladder gate.

Reservoir Editor	and the state of the local diversion of the state of the	
Reservoir Edit Operations		
Reservoir Wilder		
Physical Operations Observed Data		
Operation Set Existing Ops	Description	
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. So	Sched. Projected Elev	
Release Allocation Strategy		
Wilder - Balanced	Release Location: Wilder-Dam	
Wilder-Power Plant	Allocation Type: Sequential	
Wilder-Tainter gates     Wilder-Skimmer gate 15*20 ft     Wilder-Skimmer gate 10*10 ft     Wilder-Fish ladder	Wilder-Power Plant Wilder-Tainter gates Wilder-Skimmer gate 15*20 ft Wilder-Skimmer gate 10*10 ft Wilder-Fish ladder	

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

# **C.** Rule Descriptions

#### 1. Min Flow below Wilder

Figure 8 shows the content of "Min Flow below Wilder" rule. This rule shows a minimum release from dam as a function of Inflow.

Operation Set Existing Ops	Description					
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev						
<ul> <li>Min Flow below Wilder</li> <li>Fish Ladder Release</li> <li>Downstream Fish Passage Release</li> <li>Pool Drawdown Rate Limit</li> <li>Max Flow dram inflow</li> </ul>	Operates Release From: Wilder Rule Name: Min Flow below Wilder Description: Function of: Wilder-Pool Net Inflow, Current Value Define Limit Type: Minimum Interp.: Linear Flow (cfs) Release (cfs) 0.0 0.0 0.0 675.0 675.0 500000.0 675.0 Flow (cfs) Period Average Limit Edit Period Average Limit Edit Period Average Limit Edit Day of Week Multiplier Edit Rising/Falling Condition Edit					

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow below Wilder

#### 2. Fish Ladder Release

Figure 9 shows the content of "Fish Ladder Release" rule. This rule shows the specified release from Fish Ladder gate.

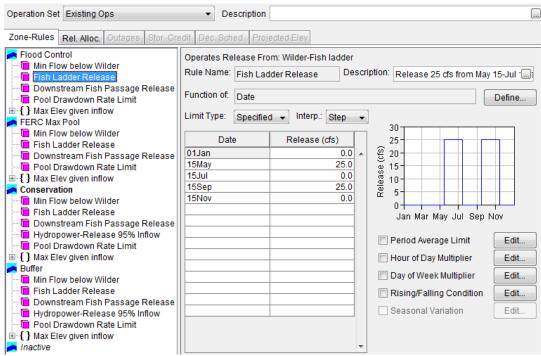


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Fish Ladder Release

# 3. Downstream Fish Passage Release

Figure 10 shows the content of "Downstream Fish Passage Release" rule. This rule shows the specified release from skimmer gate 15\*20 ft.

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Downstream Fish Passage Release

## 4. Pool Drawdown Rate Limit

Figure 11 shows the content of "Pool Drawdown Rate Limit" rule. This rule shows the decreasing elevation rate of change rule.

Operation Set Existing Ops	▼ Description	
Zone-Rules Rel. Alloc. Outages Stor. Cr	edit. Dec. Sched. Projected Elev	
<ul> <li>Flood Control</li> <li>Min Flow below Wilder</li> <li>Fish Ladder Release</li> <li>Downstream Fish Passage Release</li> <li>Pool Drawdown Rate Limit</li> <li>{} Max Elev given inflow</li> <li>FERC Max Pool</li> <li>Min Flow below Wilder</li> <li>Fish Ladder Release</li> <li>Downstream Fish Passage Release</li> <li>Pool Drawdown Rate Limit</li> <li>{} Max Elev given inflow</li> <li>Conservation</li> <li>Min Flow below Wilder</li> <li>Fish Ladder Release</li> <li>Downstream Fish Passage Release</li> <li>Downstream Fish Passage Release</li> <li>Hydropower-Release 95% Inflow</li> <li>Buffer</li> <li>Min Flow below Wilder</li> <li>Fish Ladder Release</li> <li>Downstream Fish Passage Release</li> <li>Max Elev given inflow</li> <li>Buffer</li> <li>Min Flow below Wilder</li> <li>Fish Ladder Release</li> <li>Downstream Fish Passage Release</li> <li>Hydropower-Release 95% Inflow</li> <li>Pool Drawdown Rate Limit</li> <li>{} Max Elev given inflow</li> <li>Hydropower-Release 95% Inflow</li> <li>Pool Drawdown Rate Limit</li> <li>{} Max Elev given inflow</li> </ul>	Operates Release From: Wilder Elevation Rate of Change Limit Pool Drawdown Rate Limit Description Drawdown not to exceed 0.3 ft/hr. Function Of: Constant Type Decreasing • Instantaneous Period Average Max Rate of Change (ft/hr) 0.3	

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Pool Drawdown Rate Limit

#### 5. Hydropower-Release 95% Inflow

Figure 12 shows the content of "Hydropower-Release 95% Inflow" rule. This rule passes 95% of Inflow through power plant. Wilder was modeled as run-of-river even though it has daily peaking operations because the model is a daily time step model.

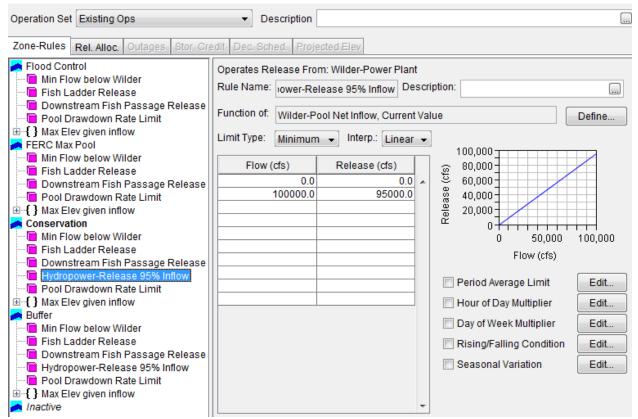


Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Hydropower-Release 95% Inflow

#### 6. Max Elev given Inflow

Figure 13 shows the content of "Max Elev given Inflow" rule. For each combination of Inflow and maximum pool elevation shown in the below picture the maximum elevation rate of change equals zero.

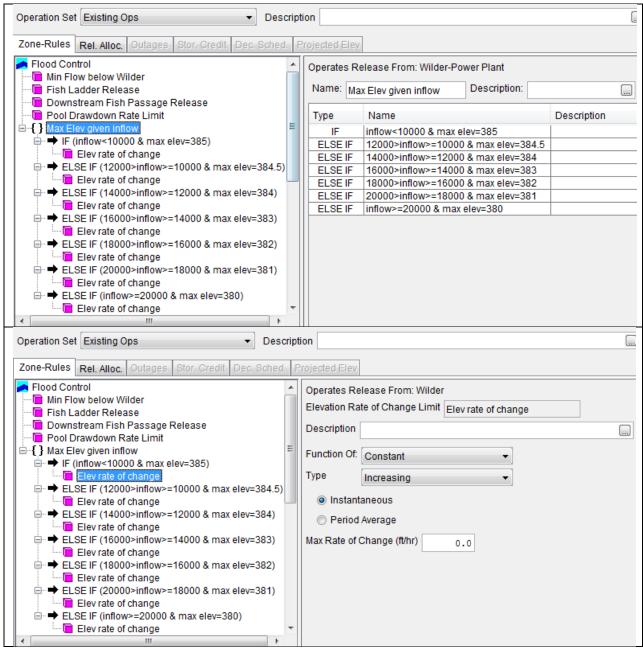


Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Elev given Inflow

### Woronoco

### I. Overview

Woronoco dam is located two miles below Russell, MA on the Westfield River. It is owned and operated by Swift River Hydro Operations Company and is used for hydropower generation.

Figure 1 shows the location of Woronoco Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Woronoco Dam.

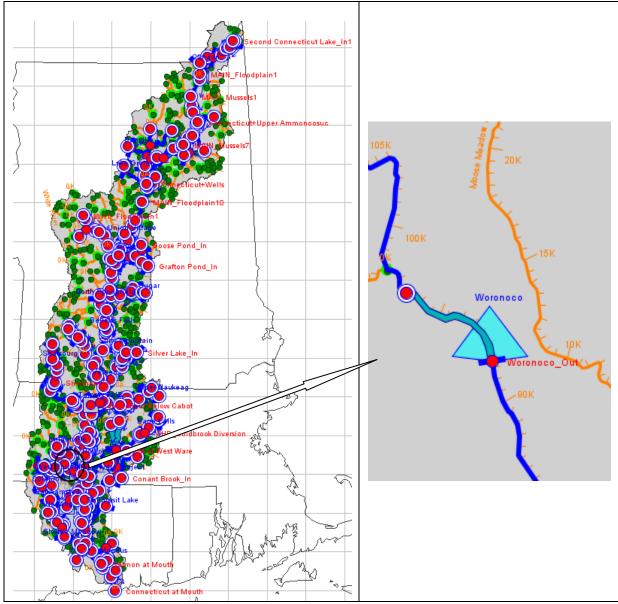


Figure 1: HEC-ResSim Map Display Showing Location of Woronco Dam



Figure 2: Photo of Woronoco dam

# II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>114</sup>. The dam consists of two types of outlets: (1) uncontrolled outlet and (3) power plant as shown in Figure 4<sup>115</sup>. The capacity of the power plant was made to be the maximum release specified in the NID database so that the dam would modeled completely as run-of-river with some actual physical information.

<sup>&</sup>lt;sup>114</sup> National Inventory of Dams database (NID)

<sup>&</sup>lt;sup>115</sup> http://www.swiftriverhydro.com/Woronoco%20Hydro.htm

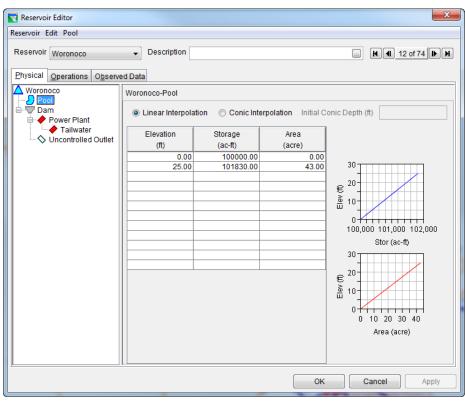


Figure 3: Reservoir Editor: Physical Tab – Pool

Reservoir Editor Reservoir Edit Dam				X	
Reservoir Woronoco	✓ Description			K 12 of 74 D H	
Physical Operations Observe	ed Data				
Woronoco	Woronoco-Dam				
Dam Dam	Elevation at top of dam (ft) 25.0				
Tailwater	Length at top of dam (ft)		622.0		
	Composite Release Capacity				
	Elevation Controll	d Uncontrolled	Total		
	(ft) (cfs)	(cfs) (cfs)	(cfs)	40	
	0.0 10,50	0.0 0.0	10,500.0 🔺	8 <sup>30</sup>	
	25.0 10,50	0.0 0.0	10,500.0	solution = 10 = 10 = 10 = 10 = 10 = 10 = 10 = 1	
	26.0 10,50	0.0 1,013.1	11,513.1		
	27.0 10,50		13,365.5		
	28.0 10,50		15,764.2	·	
	29.0 10,50		18,604.8	Flow	
	30.0 10,50		21,826.8	(cfs)	
	31.0 10,50 32.0 10,50		25,389.5		
	33.0 10,50		29,262.9 33,423.8		
	34.0 10,50		37,853.7		
	35.0 10,50		42,537.0		
			ОК	Cancel Apply	

Figure 4: Reservoir Editor: Physical Tab -- Dam

# III. Operations

# A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Woronco's "Guide Curve" operational zones, which consist of Top of Dam (25 ft), Conservation (24.9 ft), and Inactive zone (15 ft)<sup>1</sup>.

Reservoir Editor				×
Reservoir Edit Operations Zo	ne Rule IF_Block			
Reservoir Woronoco	✓ Description			12 of 74 🕨 🗎
Physical Operations Obse	erved Data			
Operation Set Guide Curve	Only 🔻 🗖	escription		
Zone-Rules Rel. Alloc. O	utages Stor, Credit Dec.	Sched. Projected Elev		
Top of Dam	Storage Zone Conservation	on Description		
inactive 🔁	Function of Date			Define
	Date	Top Elevation (ft)	26	
	01Jan	24.9	24	
			22	
			€ 22 0 20- 18- 18-	
			16	
			14 - 14 Jan Mar May Jul S	Sep Nov
		-		
	Zone Sort Elevation			
			OK Cancel	Apply

Figure 5: Reservoir Editor: Operations Tab –Guide Curve OpSet – Guide Curve

# **B. Rule Illustrations**

The operation set for Woronco has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity. This was modeled this way because no real operation information was found.