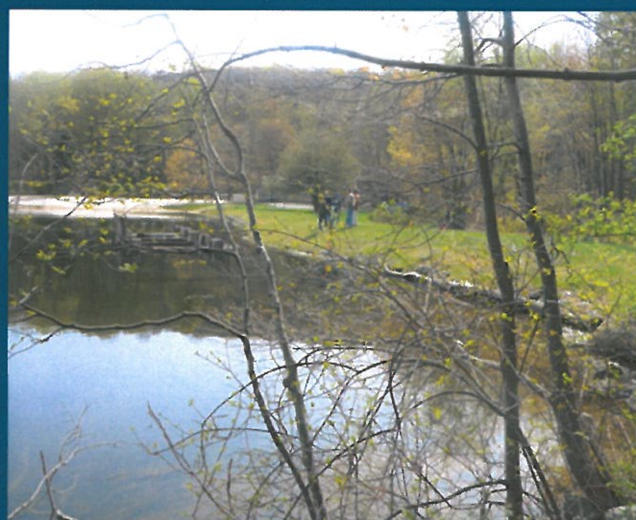
Seven Hills Lake Dam Presentation



February 24, 2011

PRESENTATION OVERVIEW

- Regulatory Obligations
- Project Characteristics
- Investigations and Studies to Date
- Evaluation of Dam
- Evaluation of Low Level Outlet
- Evaluation of Spillway
- Budget Estimates for Remedial Measures

REGULATORY OBLIGATIONS

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NYSDEC Part 673 : Dam Safety Regulations

NYSDEC	Regulation	Timing
673.3 (a)	Owner to operate dam in a safe condition	At all Times
673.6 (b) (i)	Inspection and Maintenance Plan to include notifications of deficiencies	I&M Plan due on Aug 19, 2010
673.8 (b)	Owner to certify that current Inspection and Maintenance Plan is in place	By Jan 31,2011
673.12 (d) (4)	Safety Inspection Report to include identification of deficiencies and schedule for corrective action (excluding studies)	As identified in I&M Plan (every four years)
673.13 (f)	Engineering Assessment to identify deficiencies and schedule for corrective action	By Aug 19, 2015

PROJECT CHARACTERISTICS

General

Upstream View of Dam

Dam Height : 15 ft

Reservoir Volume : 115 MG

Regulated under NYSDEC Part 673

Hazard Classification : B

PROJECT CHARACTERISTICS

Appurtenant Works


Drop Inlet Spillway

Spillway

- Drop Inlet Type
- Effective Crest Length : 85 ft
- Twin box culverts, each 5 feet by 8 feet


Twin Box Culverts

Low Level Outlet

- 2 No. 24" Sluice Gates

INVESTIGATIONS AND ANALYSES

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Studies to Date

- Site inspections to observe project condition
- Hydrology studies to determine design floods
- Hydraulic studies to determine capacities of spillway and low level outlet
- Dam break studies to confirm hazard classification
- Conceptual options for remedial work
- Stability analysis for existing condition and remedial work options

INVESTIGATIONS AND ANALYSES

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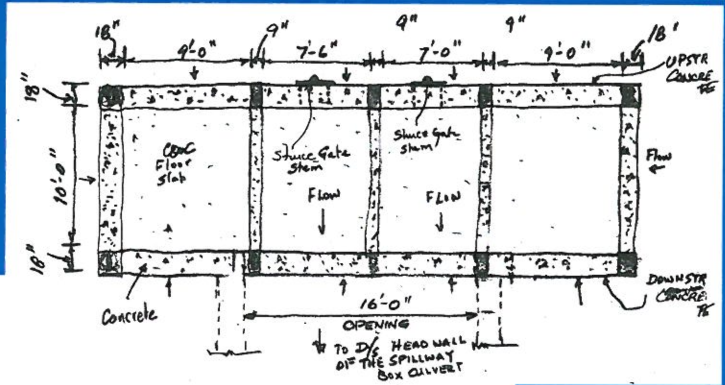
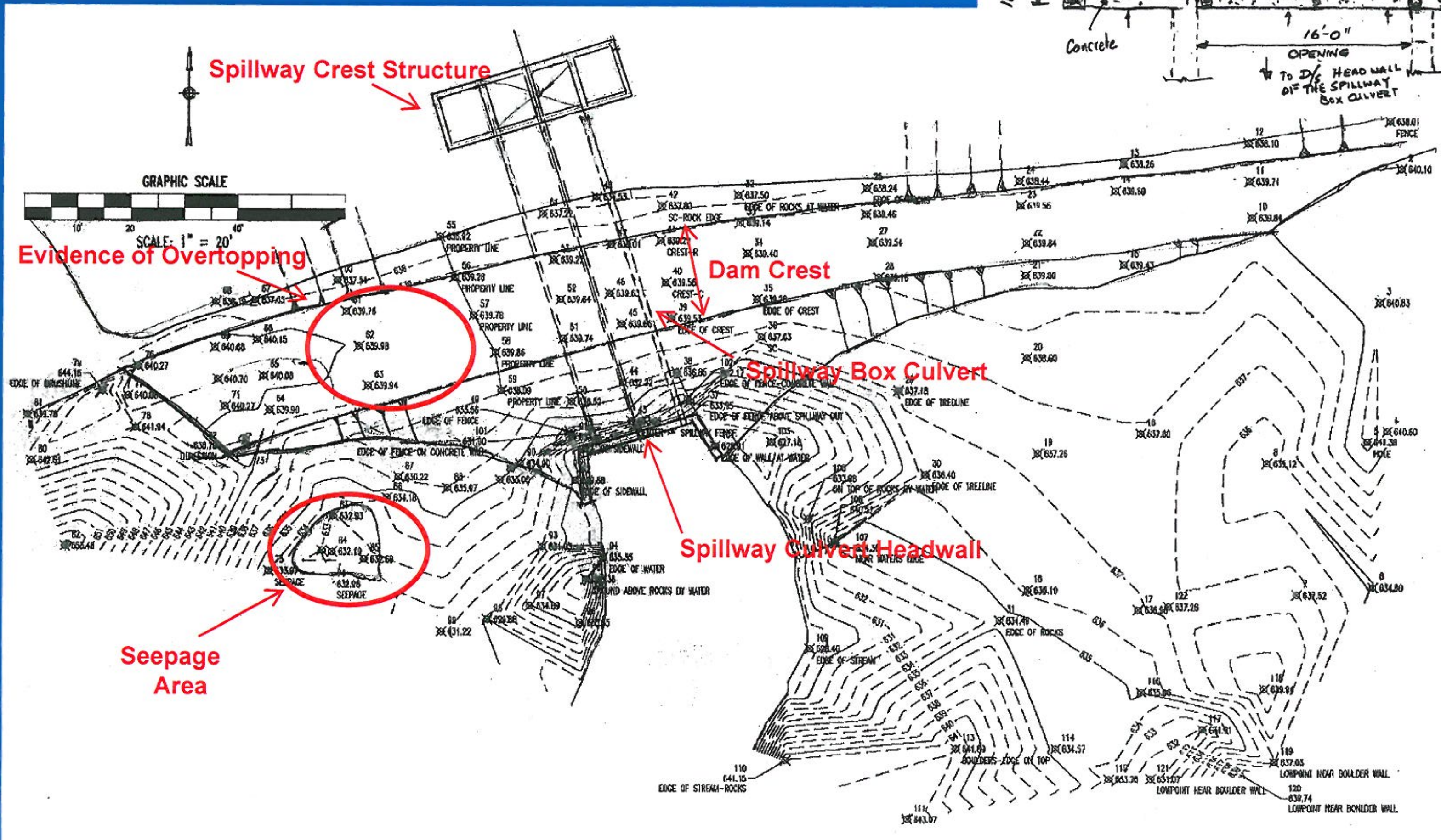
Typical Site Inspection Data

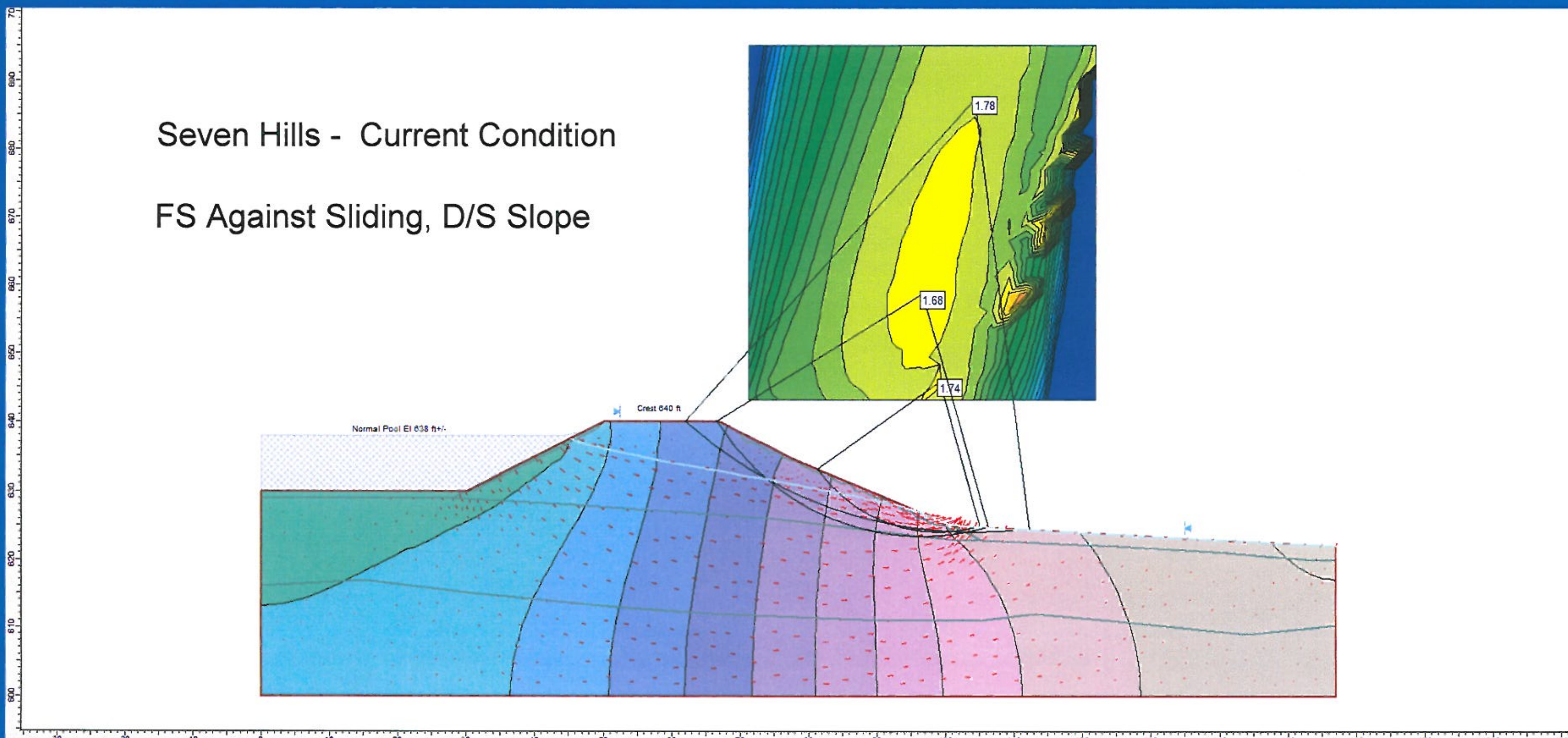




EVALUATION OF DAM

Evaluation

- Generally dam is in good condition
- Dam is stable - Steady Seepage Factor of Safety = 1.68



EVALUATION OF DAM

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Issues

Indications of overtopping at right of spillway

Erosion at spillway culvert outlet walls

Seepage near right abutment

EVALUATION OF DAM

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Remedial Measures

Issue	Proposed Remedial Work
Overtopping of dam	Increase spillway capacity (see later)
Seepage at downstream toe of dam	For minor foundation seepage: -Place filter material at seepage areas For seepage through dam: -Reconstruct dam section
Erosion at Spillway Culvert Headwall	Place rip-rap at eroded areas

EVALUATION OF LOW LEVEL OUTLET

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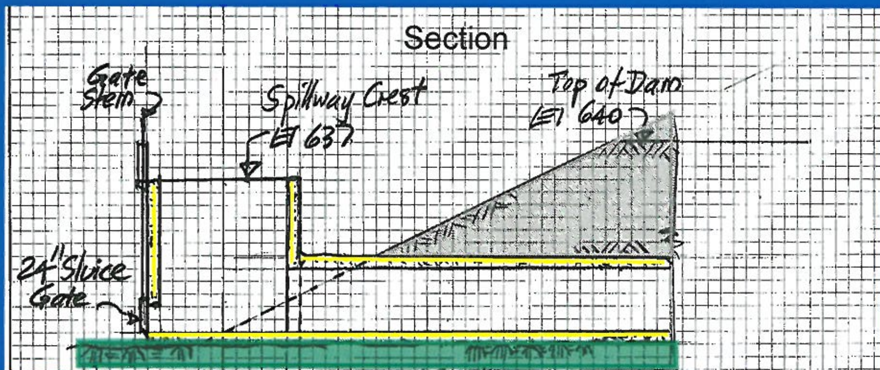
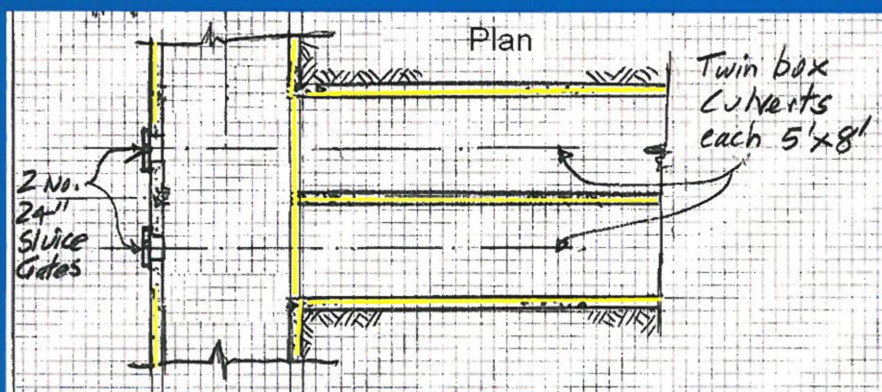
Outlet Facilities





2 No. 24" sluice gates

Note misaligned gate stem

EVALUATION OF LOW LEVEL OUTLET

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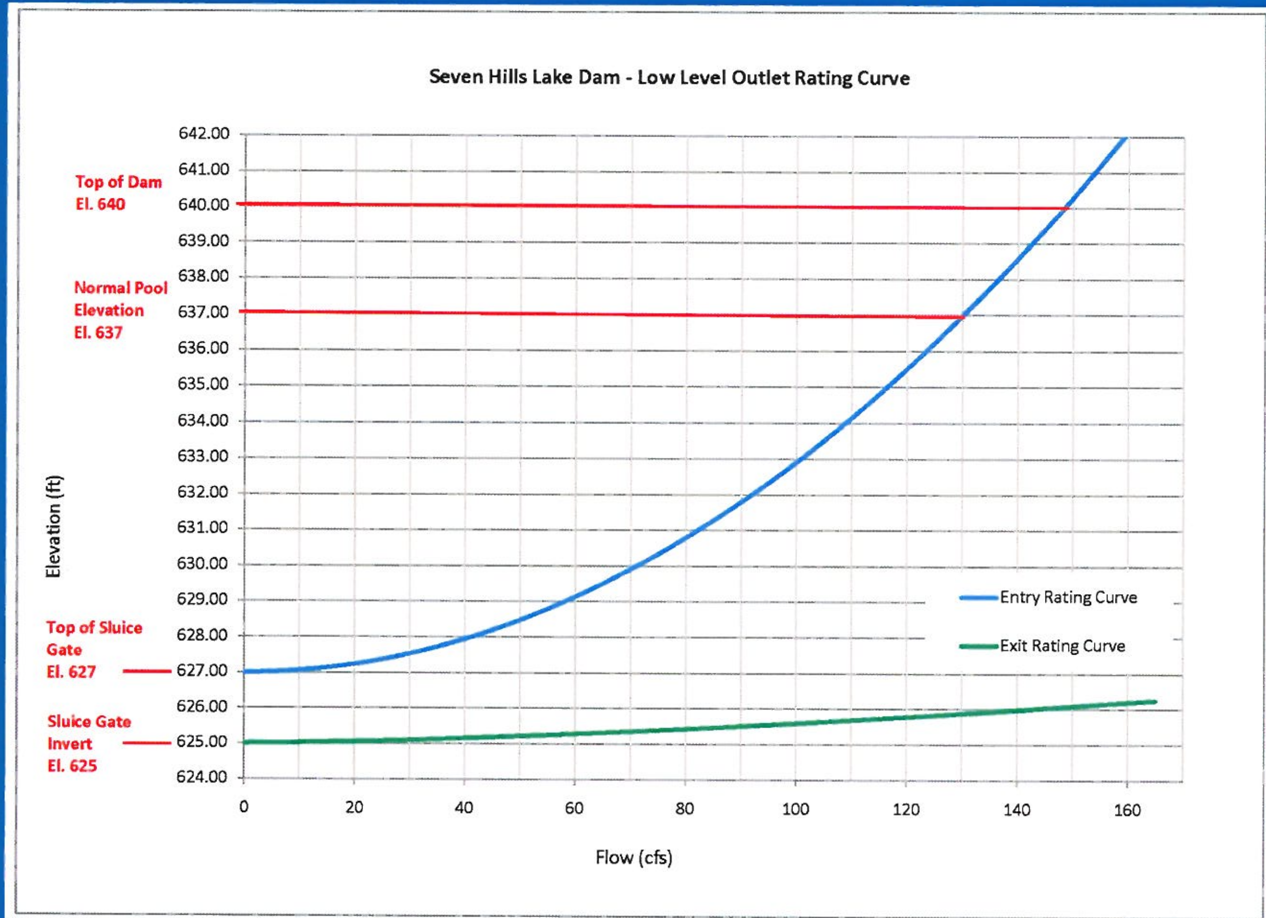
Discharge Capacity



Capacity at Normal Pool = 130 cfs

EVALUATION OF LOW LEVEL OUTLET

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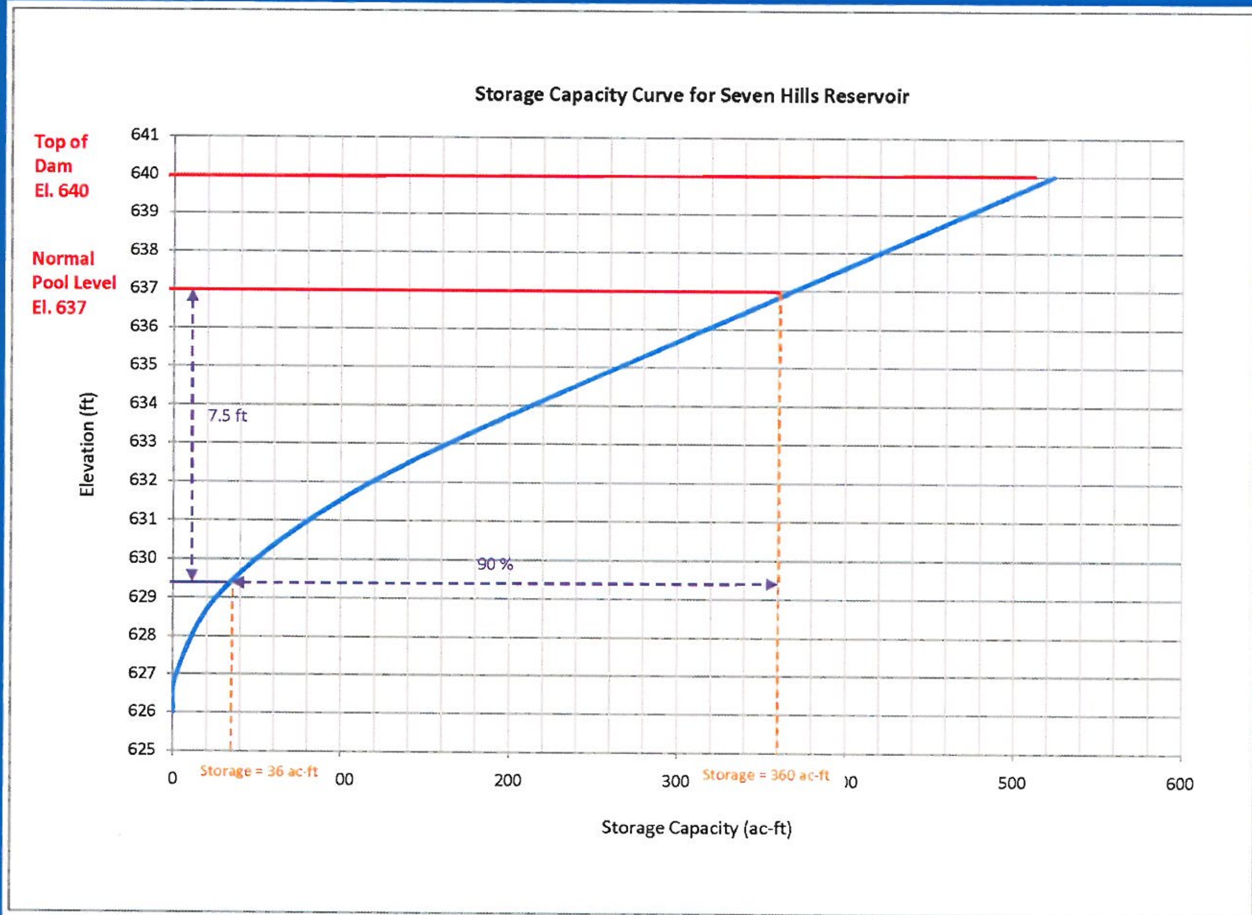
Ability to Draw Down Reservoir



Both outlets can draw down reservoir in 2 days

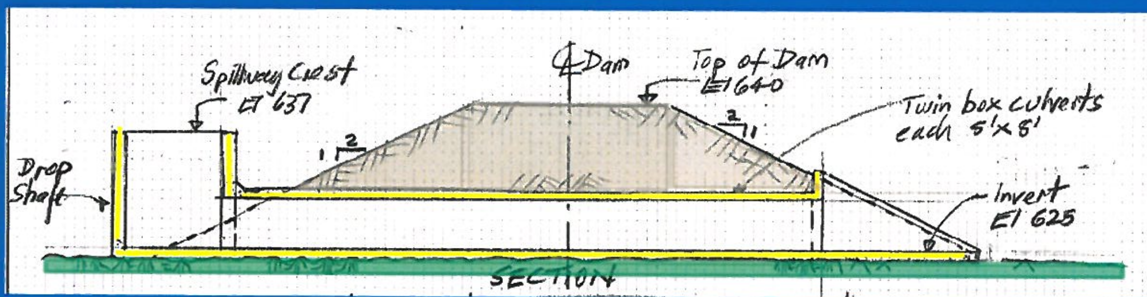
EVALUATION OF LOW-LEVEL OUTLET

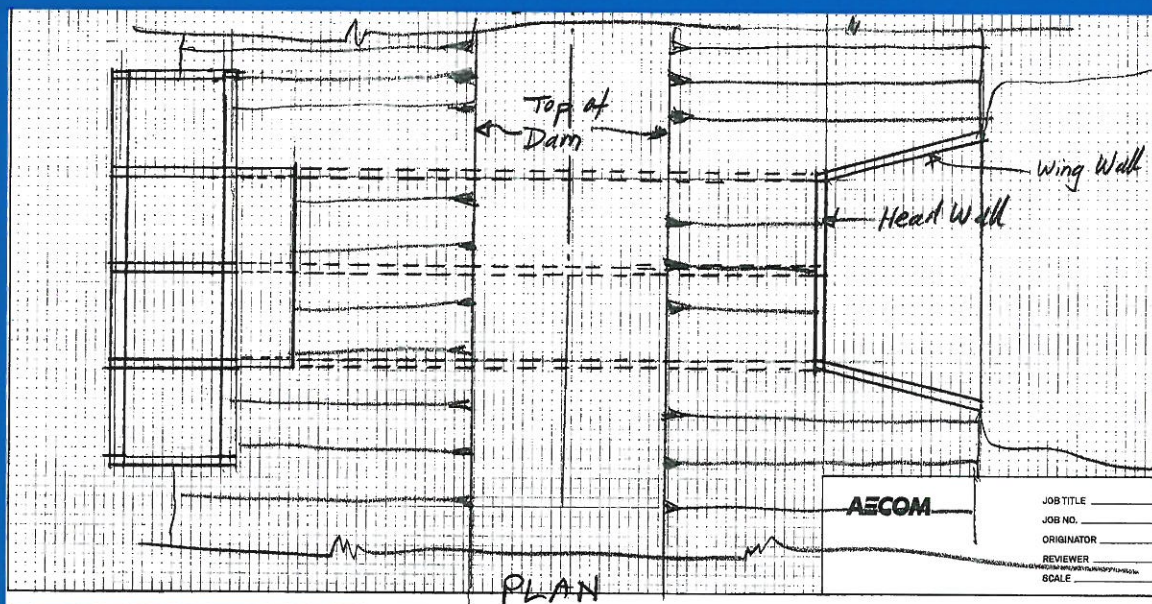
- Issues
  - Condition of gates unknown
  - Operating stem out of alignment

- Remedial Measures
  - Replace gates, including stems and lifting frames
  - This will require emptying the reservoir

EVALUATION OF SPILLWAY

Existing Works





Crest structure

- Rectangular box structure
- Effective Crest Length = 85 feet
- Crest Level = El 637

Drop Inlet

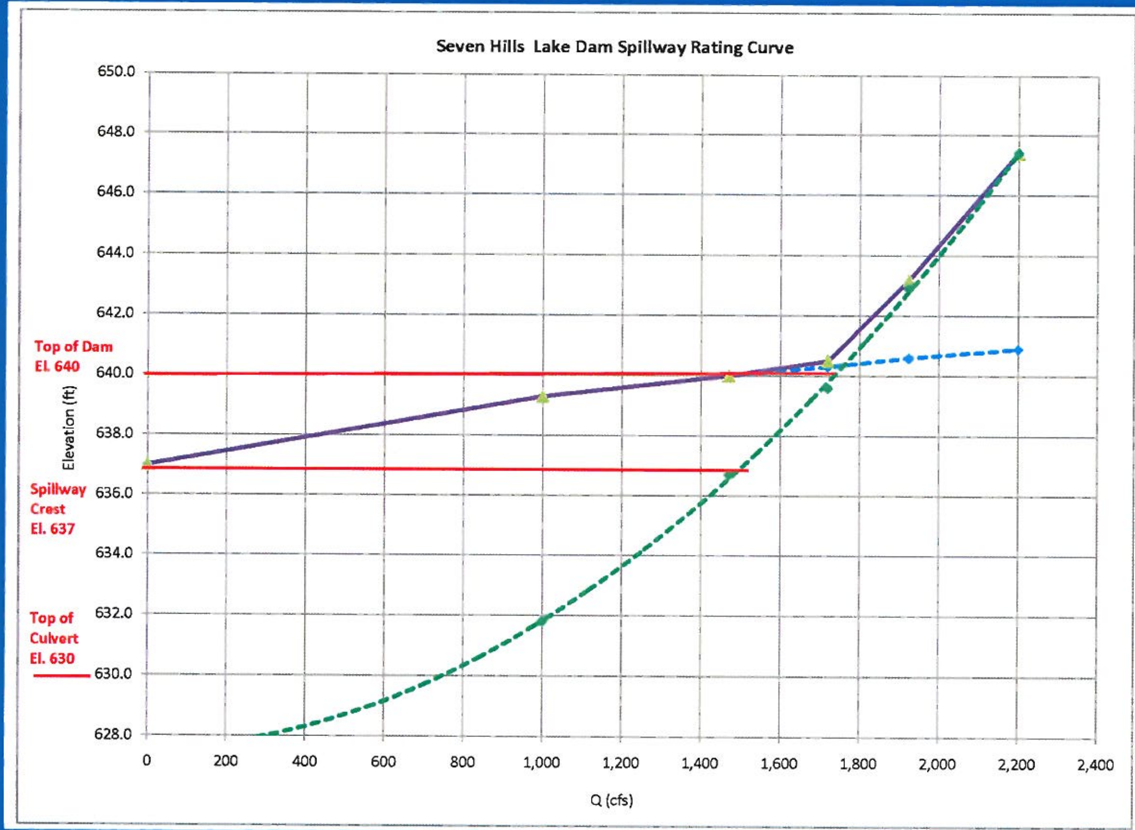
- Rectangular shaft

Culvert beneath Dam

- Twin box culverts each 5 feet by 8 feet
- Invert Level = El 625

EVALUATION OF SPILLWAY

Capacity



Crest Control

- $Q = CLH_{cr}^{(3/2)}$
- $C= 3.5$

Culvert Control

- $Q = KH_{cu}^{(1/2)}$

EVALUATION OF SPILLWAY

Required Capacity

5.3 Existing Dams - Design Flood

Existing dams that are being rehabilitated should have adequate spillway capacity to pass the following floods without overtopping:

Hazard Classification	Spillway Design Flood (SDF)
A	100 year
B	150% of 100 year
C	50% of PMF

The Service Spillway Design Flood (SSDF) for existing dams is the same as shown for the new dams on Table 1.

New York State Requirements - NYSDEC Guidelines for Design of Dams 1989

EVALUATION OF DESIGN FLOOD

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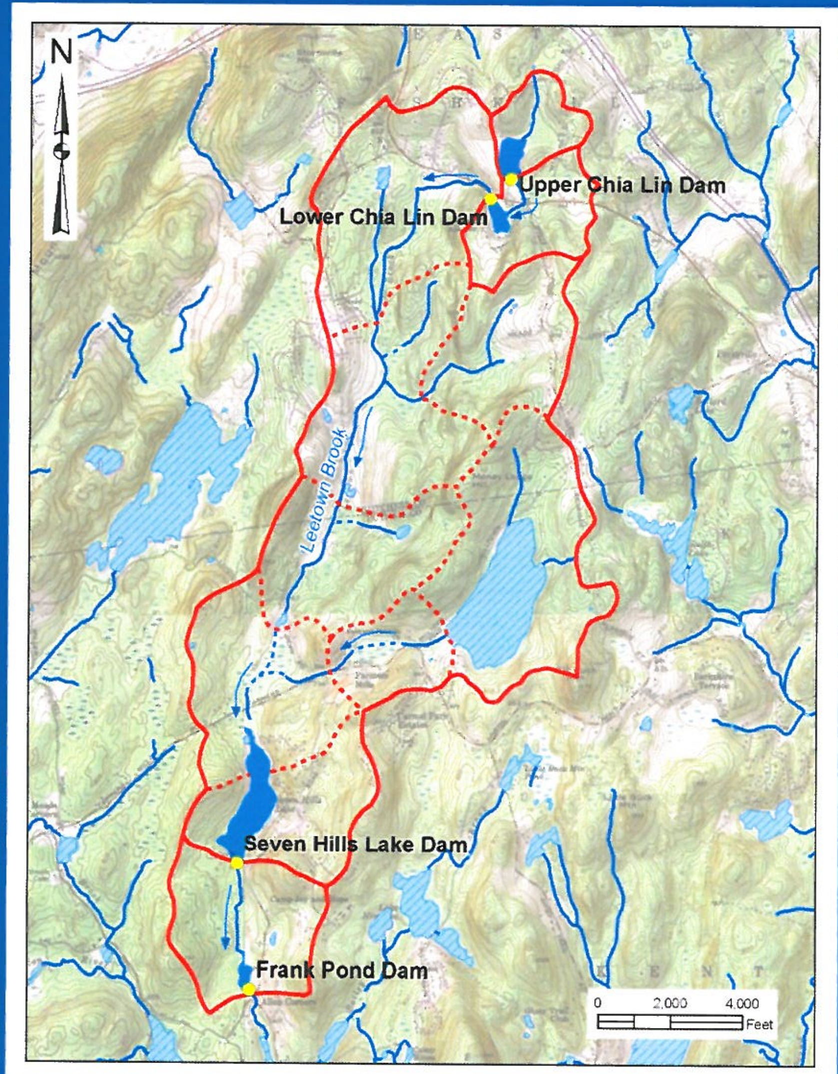
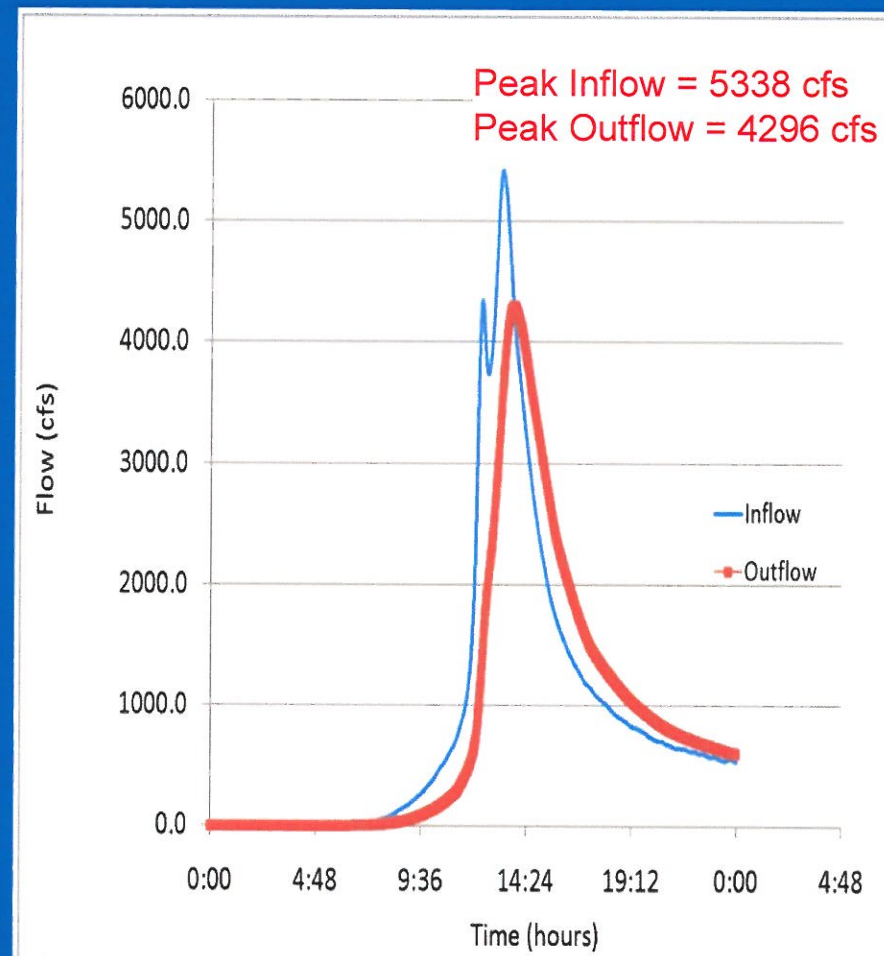
100 - yr Flood





EVALUATION OF SPILLWAY

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Other Return Period Floods

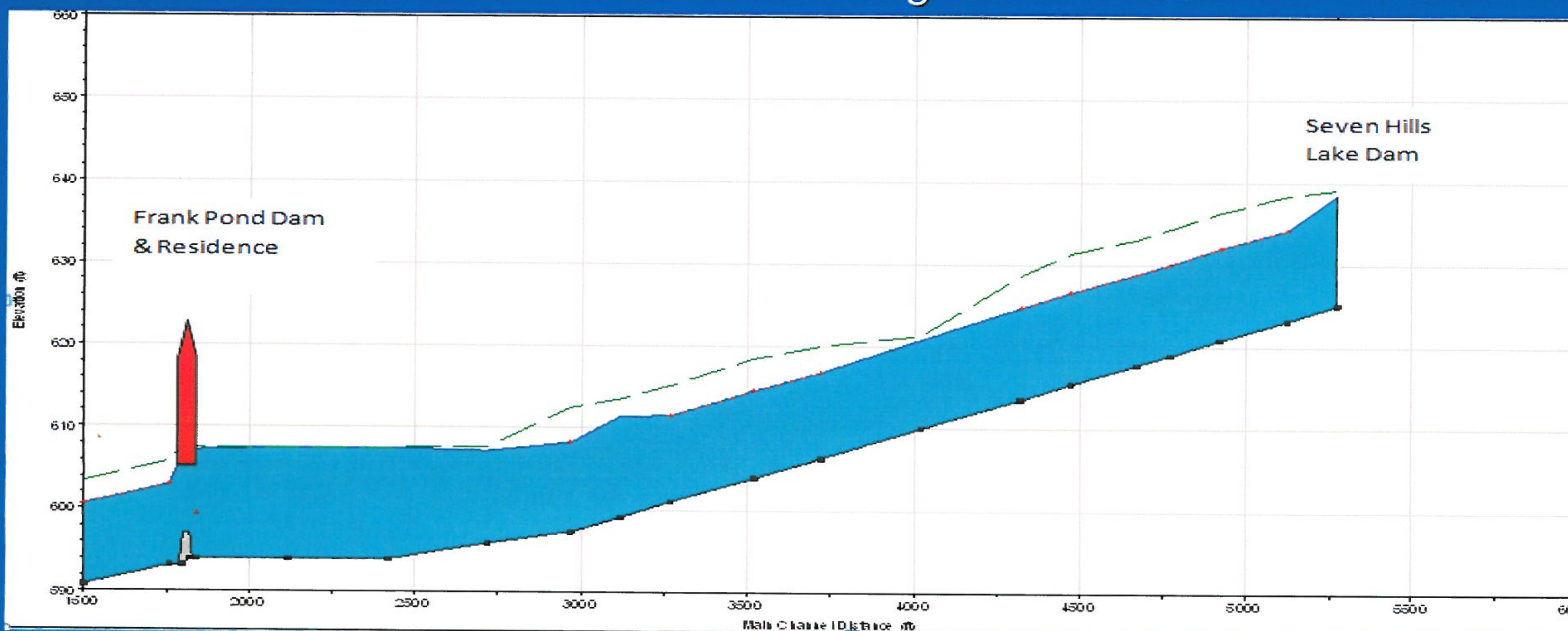
Flood	Peak Inflow (cfs)	Peak Outflow (cfs)	Max. Res. Level (ft)
10 yr	1,970	1,410	El 639.9
25 yr	3,110	2,270	El 640.9
50 yr	4,270	3,220	El 641.7
100 yr	5,340	4,300	El 642.5
150% 100 yr	8,130	6,770	El 644.0

EVALUATION OF SPILLWAY

Impact of Dam Overtopping

- Dam collapse for high overflow
- Large flood wave passes down valley
- Threat to house(s) downstream, particularly at Frank Pond Dam downstream

This is the reason for Class B Hazard Rating at Seven Hills



Downstream Effects of 25-Yr Flood Dam Break at Seven Hills Lake Dam

EVALUATION OF SPILLWAY

Remedial Options

- Raise dam
  - Maximum raise possible = 5 feet
  - Spillway capacity increase to 2000 cfs
  - Improves but not solves deficiency

- Raise dam and replace existing spillway
  - Need to triple the conduit area
  - Much of dam fill would need to be excavated and subsequently replaced
  - Very high cost

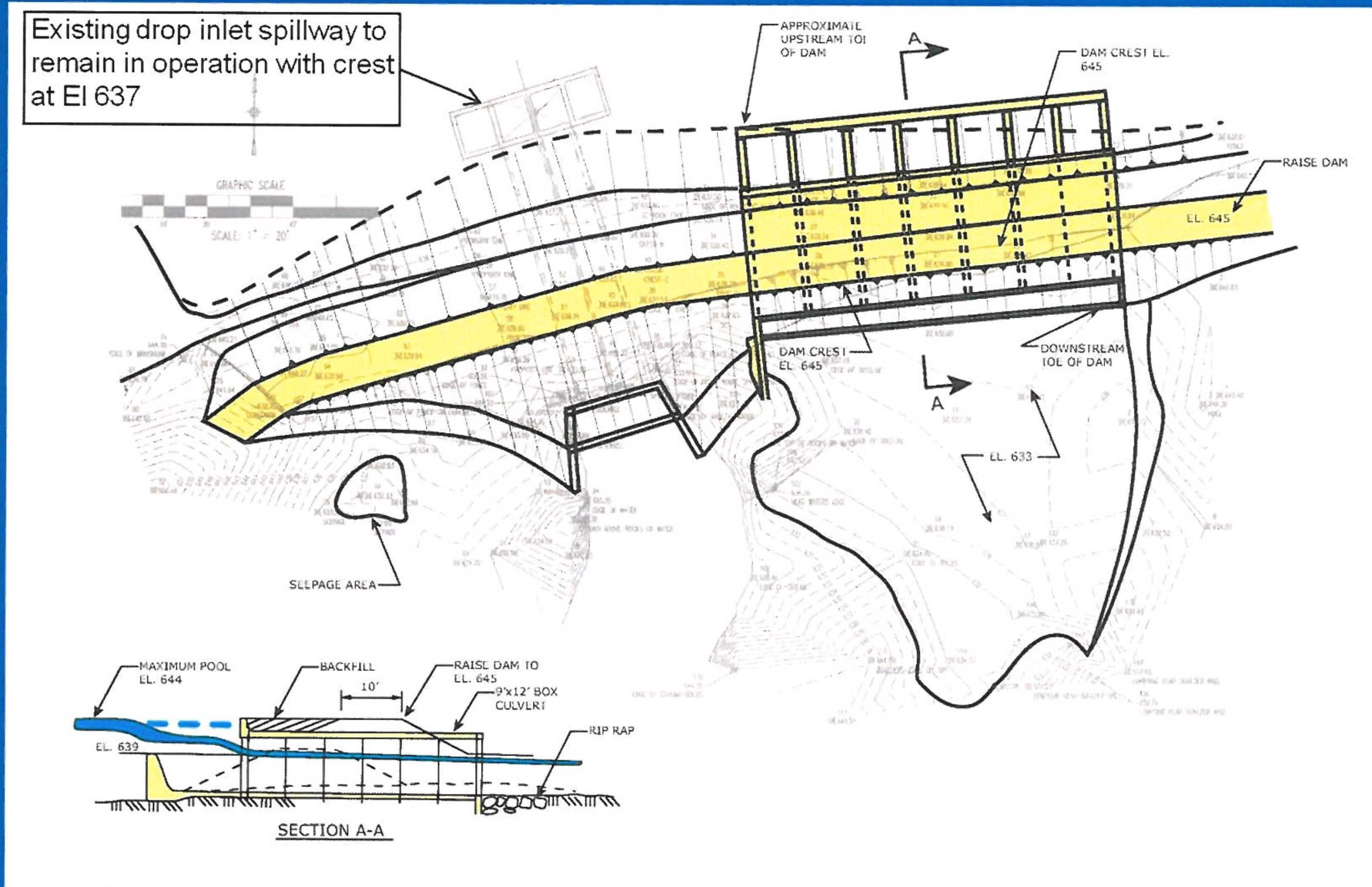
- Raise dam and add auxiliary box culverts
  - Promising option, referred to as Option 1

- Raise dam and add articulated concrete mat
  - Promising option, referred to as Option 2

OPTIONS TO INCREASE SPILLWAY CAPACITY

AECOM

Option 1- Raise Dam and Add Auxiliary Box Culverts



OPTIONS TO INCREASE SPILLWAY CAPACITY

NYC Environmental Protection

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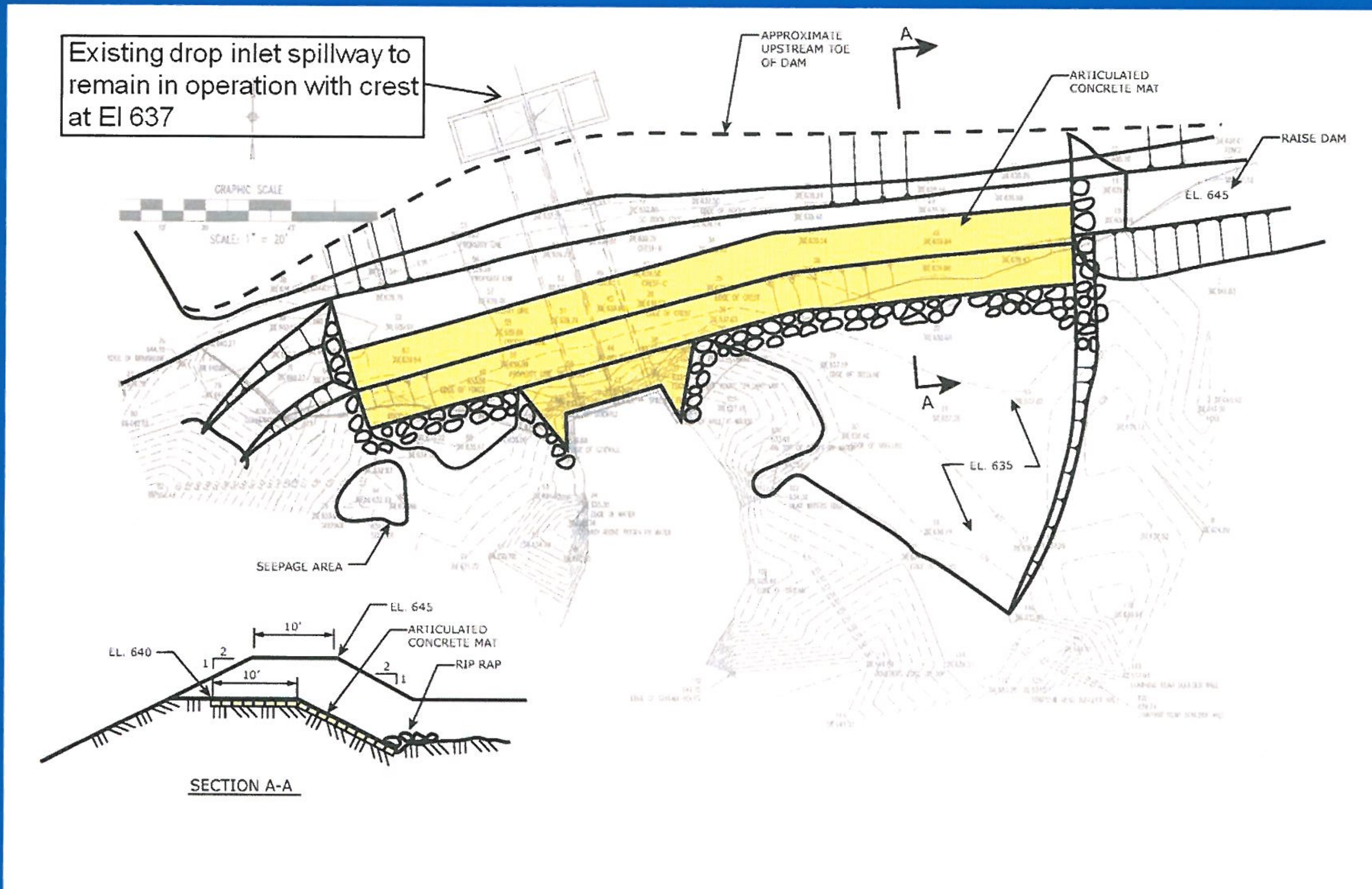
Option 2 – Raise Dam and Add Articulated Concrete Mat



BUDGET ESTIMATES FOR REMEDIAL MEASURES

AECOM

- Dam Seepage Area
  - For minor foundation seepage---------------------------------$11,600
  - For reconstruction of dam section---------------------------$73,300

- Low Level Outlet
  - Replace Gates--$53,300

- Increase Spillway Capacity
  - Option 1 (Auxiliary Box Culverts)-------------------------$3,085,700
  - Option 2 (Articulated Concrete Mat)----------------------$787,700

BUDGET ESTIMATES FOR REMEDIAL MEASURES

AECOM

Dam Seepage Area – Minor Foundation Seepage

Item Description	Quantity	Unit	Unit Price	Total Direct Cost
Direct Costs				
Excavation (including haul to disposal area)	0	CY	$ 80.00	$ -
Fill Placement (including borrow and haul)	0	CY	$ 80.00	$ -
Filter Material (crushed stone)	20	CY	$ 200.00	$ 4,000
Filter Material (geotextile and geogrid)	400	SF	$ 2.00	$ 800
			Total Direct Cost:	$ 4,800
Indirect Project Costs:				
Mobilization/Demobilization			0%	$ -
General Conditions			0%	$ -
			Total Indirect Cost:	$ -
Add-Ons:				
Miscellaneous Items			10%	$ 480
Contractor Markup (OH&P)			21%	$ 1,109
Contractor Bonds/Insurance			10%	$ 639
Project Contingency			50%	$ 3,514
			Total Construction Cost	$ 10,542
Engineering Services			10%	$ 1,054
			TOTAL	**$ 11,596**

BUDGET ESTIMATES FOR REMEDIAL MEASURES

NYC AECOM

Dam Seepage Area – Reconstruction of Dam Section

Item Description	Quantity	Unit	Unit Price	Total Direct Cost
Direct Costs				
Excavation (including haul to disposal area)	150	CY	$ 80.00	$ 12,000
Fill Placement (including borrow and haul)	150	CY	$ 80.00	$ 12,000
Filter Material (crushed stone)	0	CY	$ 200.00	$ -
Filter Material (geotextile and geogrid)	0	SF	$ 2.00	$ -
			Total Direct Cost:	$ 24,000
Indirect Project Costs:				
Mobilization/Demobilization			10%	$ 2,400
General Conditions			15%	$ 3,960
			Total Indirect Cost:	$ 6,360
Add-Ons:				
Miscellaneous Items			10%	$ 3,036
Contractor Markup (OH&P)			21%	$ 7,013
Contractor Bonds/Insurance			10%	$ 4,041
Project Contingency			50%	$ 22,225
			Total Construction Cost	$ 66,675
Engineering Services			10%	$ 6,668
			TOTAL	**$ 73,343**

BUDGET ESTIMATES FOR REMEDIAL MEASURES

AECOM

Low Level Outlet – Replace Gates

Item Description	Quantity	Unit	Unit Price	Total Direct Cost
Direct Costs				
Dewatering and Maintaining Reservoir Level	1	LS	$ 5,000.00	$ 5,000
Removal of Existing Two Sluice Gates				
Laborer (Crew of 2 x 1 week)	80	MH	$ 65.00	$ 5,200
Supply New Sluice Gates	2	EA	$ 5,000.00	$ 10,000
Installation of Two New Sluice Gates				
Laborer (Crew of 2 x 1 week)	80	MH	$ 65.00	$ 5,200
			Total Direct Cost:	$ 25,400
Indirect Project Costs:				
Mobilization/Demobilization			5%	$ 1,270
General Conditions			0%	$ -
			Total Indirect Cost:	$ 1,270
Add-Ons:				
Miscellaneous Items			5%	$ 1,334
Contractor Markup (OH&P)			21%	$ 5,881
Contractor Bonds/Insurance			10%	$ 3,388
Project Contingency			30%	$ 11,182
			Total Construction Cost	$ 48,454
Engineering Services			10%	$ 4,845
			TOTAL	**$ 53,300**

BUDGET ESTIMATES FOR REMEDIAL MEASURES

AECOM

Increase Spillway Capacity – Option 1

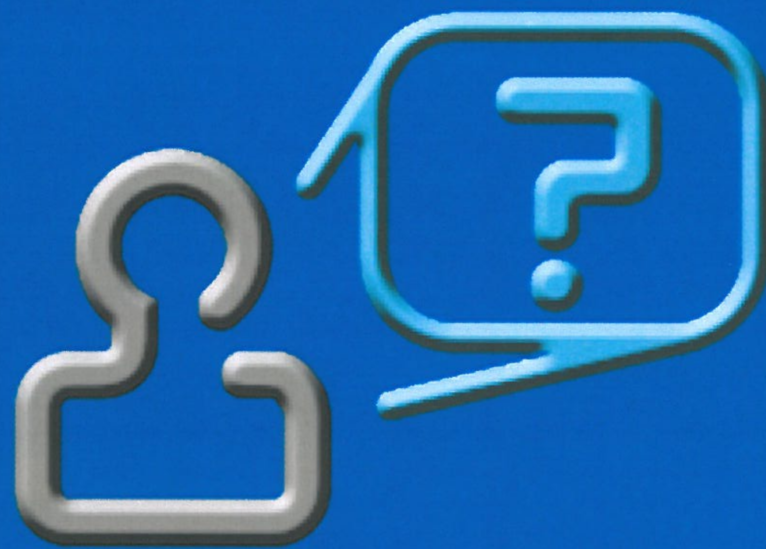
Item Description	Quantity	Unit	Unit Price	Total Direct Cost
Direct Costs				
Excavation (including haul to disposal area)	800	CY	$ 80.00	$ 64,000
Fill Placement (including borrow and haul)	2400	CY	$ 80.00	$ 192,000
Rip-rap Protection	275	CY	$ 150.00	$ 41,250
Cast-in-Place Reinforced Concrete	475	CY	$ 1,500.00	$ 712,500
Surface Preparation		SF	$ 10.00	$ -
Filter Material (crushed stone)	0	CY	$ 200.00	$ -
Filter Material (geotextile and geogrid)	0	SF	$ 2.00	$ -
Articulated Concrete Mat	0	SF	$ 15.00	$ -
			Total Direct Cost:	$ 1,009,750
Indirect Project Costs:				
Mobilization/Demobilization			10%	$ 100,975
General Conditions			15%	$ 166,609
			Total Indirect Cost:	$ 267,584
Add-Ons:				
Miscellaneous Items			10%	$ 127,733
Contractor Markup (OH&P)			21%	$ 295,064
Contractor Bonds/Insurance			10%	$ 170,013
Project Contingency			50%	$ 935,072
			Total Construction Cost	**$ 2,805,217**
Engineering Services			10%	$ 280,522
			TOTAL	**$ 3,085,738**

BUDGET ESTIMATES FOR REMEDIAL MEASURES

AECOM

Increase Spillway Capacity – Option 2

Item Description	Quantity	Unit	Unit Price	Total Direct Cost
Direct Costs				
Excavation (including haul to disposal area)	250	CY	$ 80.00	$ 20,000
Fill Placement (including borrow and haul)	250	CY	$ 80.00	$ 20,000
Rip-rap Protection	375	CY	$ 150.00	$ 56,250
Cast-in-Place Reinforced Concrete	0	CY	$ 1,500.00	$ -
Surface Preparation	4500	SF	$ 10.00	$ 45,000
Filter Material (crushed stone)	200	CY	$ 200.00	$ 40,000
Filter Material (geotextile and geogrid)	4500	SF	$ 2.00	$ 9,000
Articulated Concrete Mat	4500	SF	$ 15.00	$ 67,500
			Total Direct Cost:	$ 257,750
Indirect Project Costs:				
Mobilization/Demobilization			10%	$ 25,775
General Conditions			15%	$ 42,529
			Total Indirect Cost:	$ 68,304
Add-Ons:				
Miscellaneous Items			10%	$ 32,605
Contractor Markup (OH&P)			21%	$ 75,318
Contractor Bonds/Insurance			10%	$ 43,398
Project Contingency			50%	$ 238,688
			Total Construction Cost	$ 716,063
Engineering Services			10%	$ 71,606
			TOTAL	**$ 787,669**



APPENDIX

Additional Topics

- Flood Hydrology
- Hydraulics
- Dam Break
- Stability Analysis

Critical Hydrologic Parameters

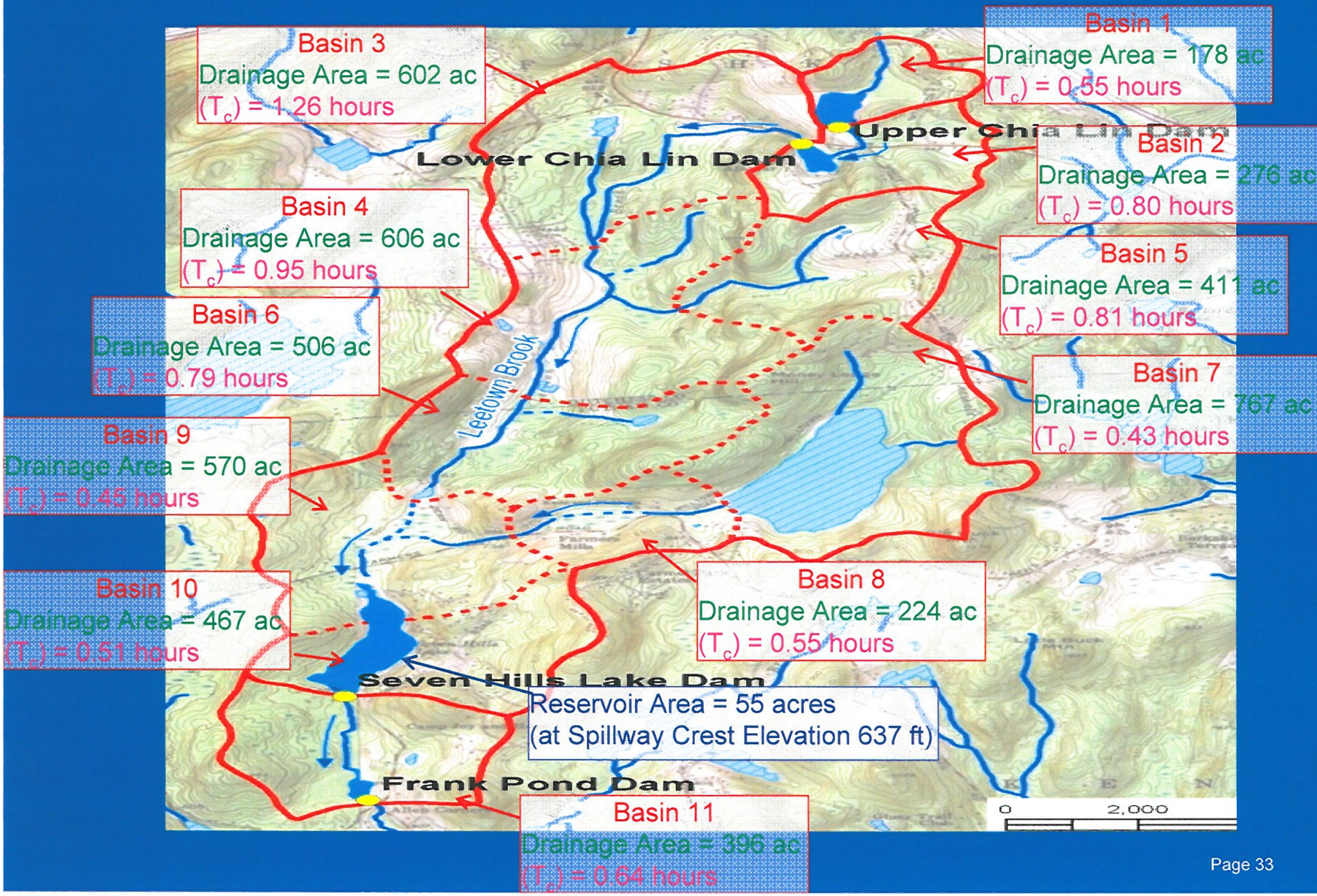
- Drainage Area
  - Time of Concentration (T_c)
  - Lag Time (T_L)
    - Lag Time = T_c/1.67

- Rainfall
  - Rainfall distribution curves obtained from Cornell website (http://precip.eas.cornell.edu/)

- Reservoir Development
  - Spillway Rating Curve
  - Reservoir Capacity Curve

- Losses
  - Initial Abstraction (I_a)
    - Accounts for surface wetting of vegetation and filling of depressions
    - I_a = 0.2*[(1000/CN)-10]
  - CN
    - Runoff Curve Number
    - Based on soil characteristics

FLOOD HYDROLOGY



FLOOD HYDROLOGY

Seven Hills Basin 10: CN and Initial Abstraction (I_a)

http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

1. Runoff curve number

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN [1/] Table 2-2	CN Figure 2-3	CN Figure 2-4	Area ☐acres ☐mi² ☐%	Product of CN x area
Charlton, B	Brush, poor condition	67			148	9,880
Chatfield, B	Brush, poor condition	67			103	6,891
Muck/loam, D	Brush, poor condition	83			9	741
Hollis/Chatfield, C	Brush, poor condition	77			157	12,078
Leicester/ Udothents, C	Brush, poor condition	77			9	9,880
Reservoir	Water	100			42	4,200
				Totals ➡	467	34,475

[1/] Use only one CN source per line

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{34,475}{467} = 74$; Use CN ➡ 74

FLOOD HYDROLOGY

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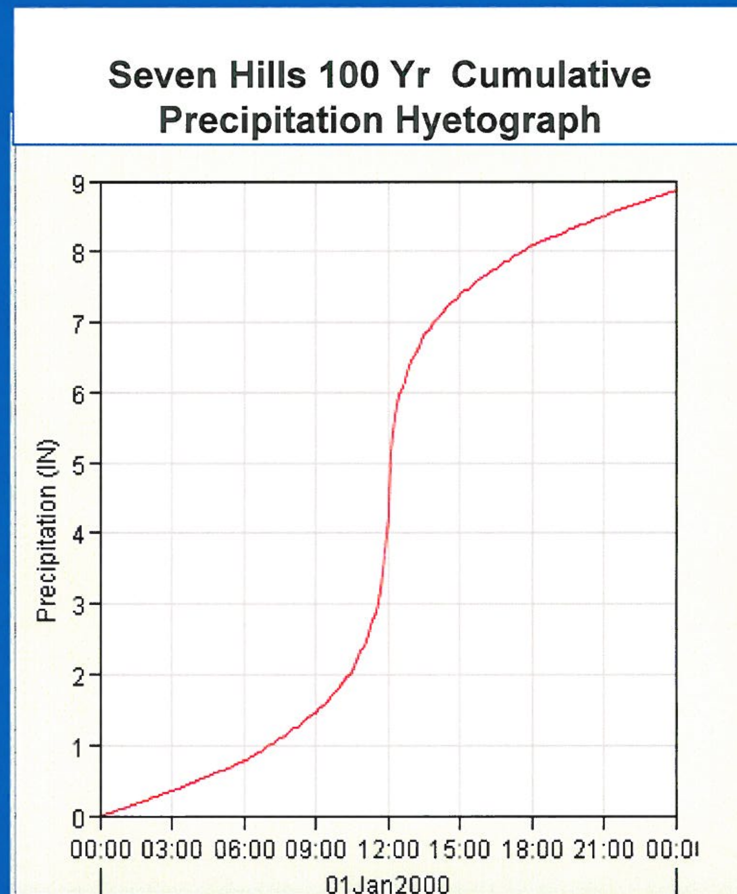
Seven Hills Dam : Rainfall

- Source
  - NYSDEC Recommendation
    - http://precip.eas.cornell.edu/
    - Provides current data about extreme precipitation events for New York and New England
- Data obtained
  - Dimensionless Accumulation Data for 100 Yr 24 Hour Storm
  - Total Cumulative Precipitation for 24 Hour 100 Year Storm = 8.76 inches
- Procedure
  - Develop Hyetograph using HEC-HMS



FLOOD HYDROLOGY

NYC Environmental Protection

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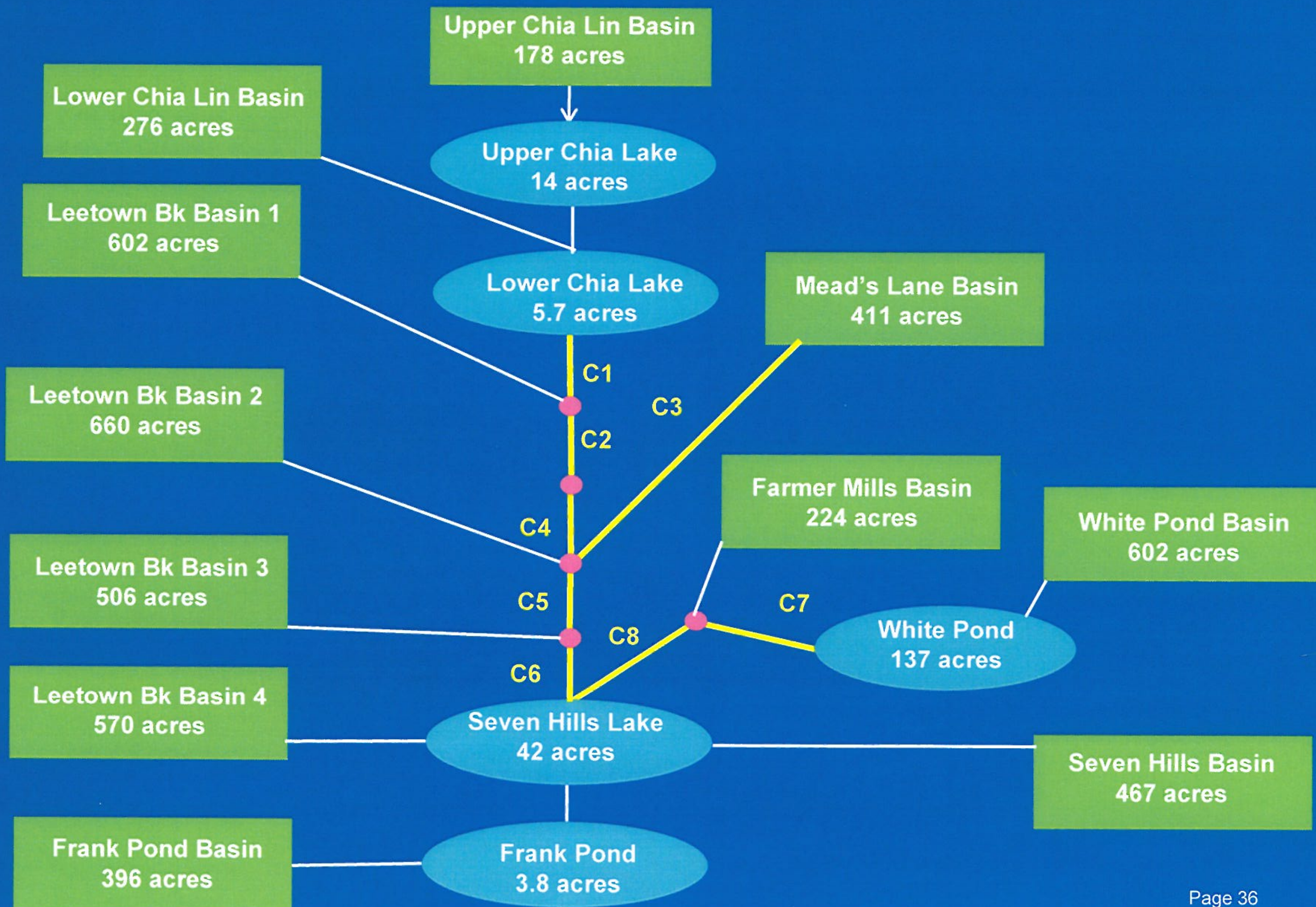
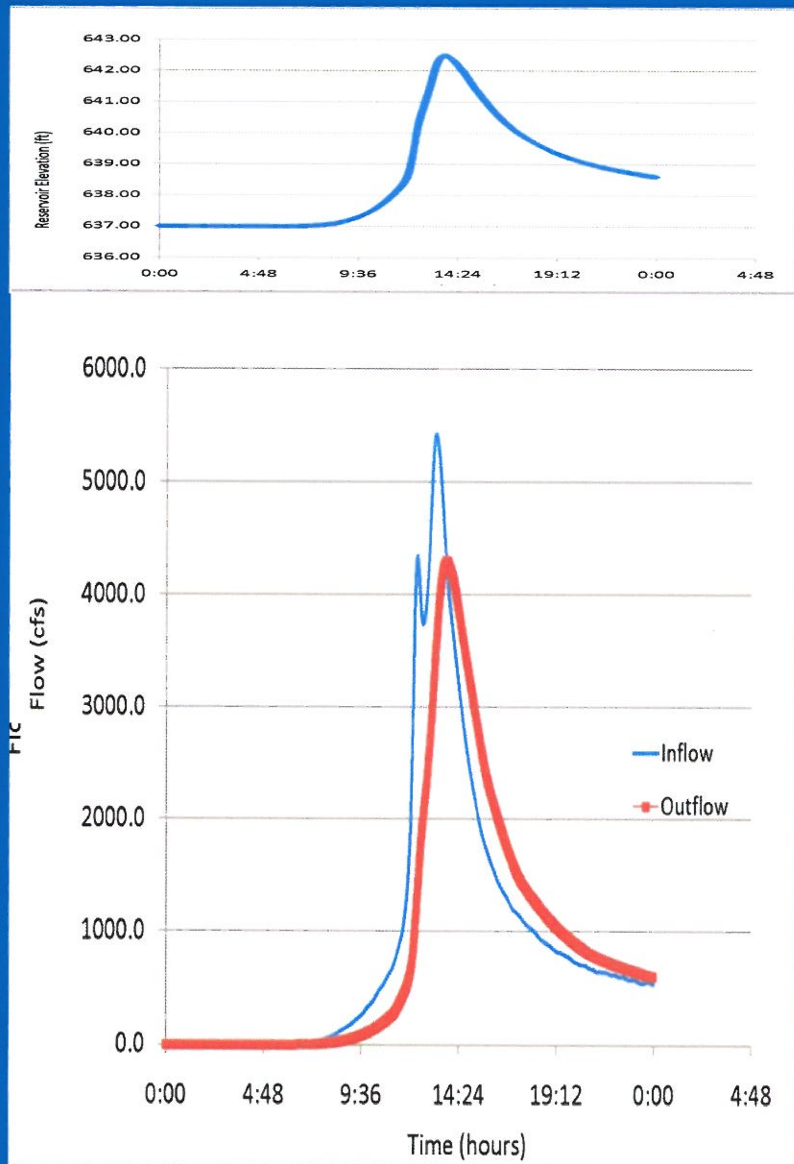
Seven Hills HEC-HMS Catchment Model

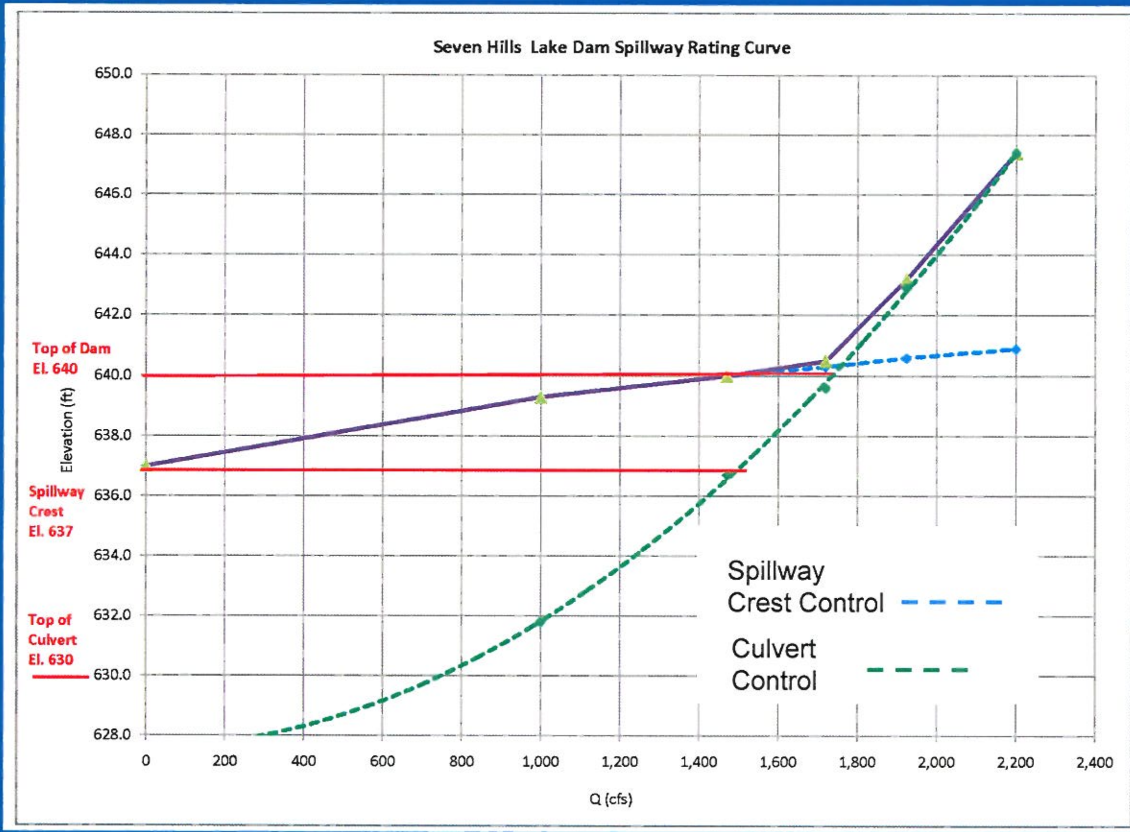


FLOOD HYDROLOGY

100 Yr Hydrograph (HEC-HMS)



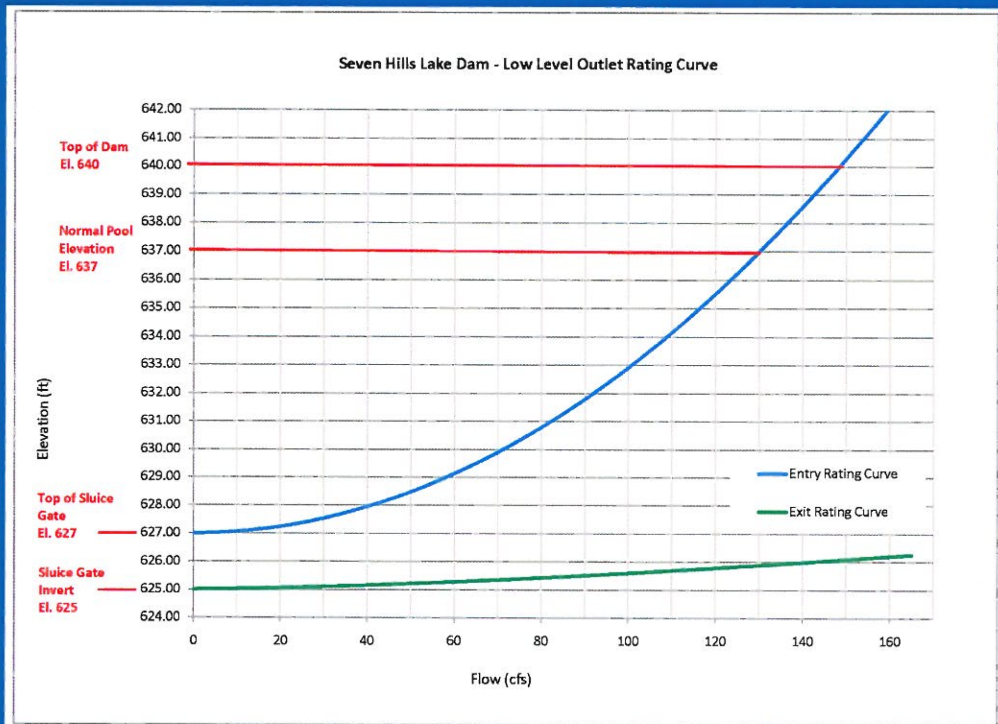
Spillway Rating Curve



- Spillway
  - Basic Spillway Assumptions
    - Total Length = 85 ft
    - 18 inch thick wall, represented as a sharp crested weir (C=3.33)
    - Height = 10 ft
    - $Q=CLH^{(3/2)}$
  - Discharge
    - Spillway discharges into twin concrete culverts
    - Head loss in the culverts will eventually become larger than the vertical height of the shaft and the crest will become submerged
    - The twin culvert would eventually become the hydraulic control

HYDRAULICS

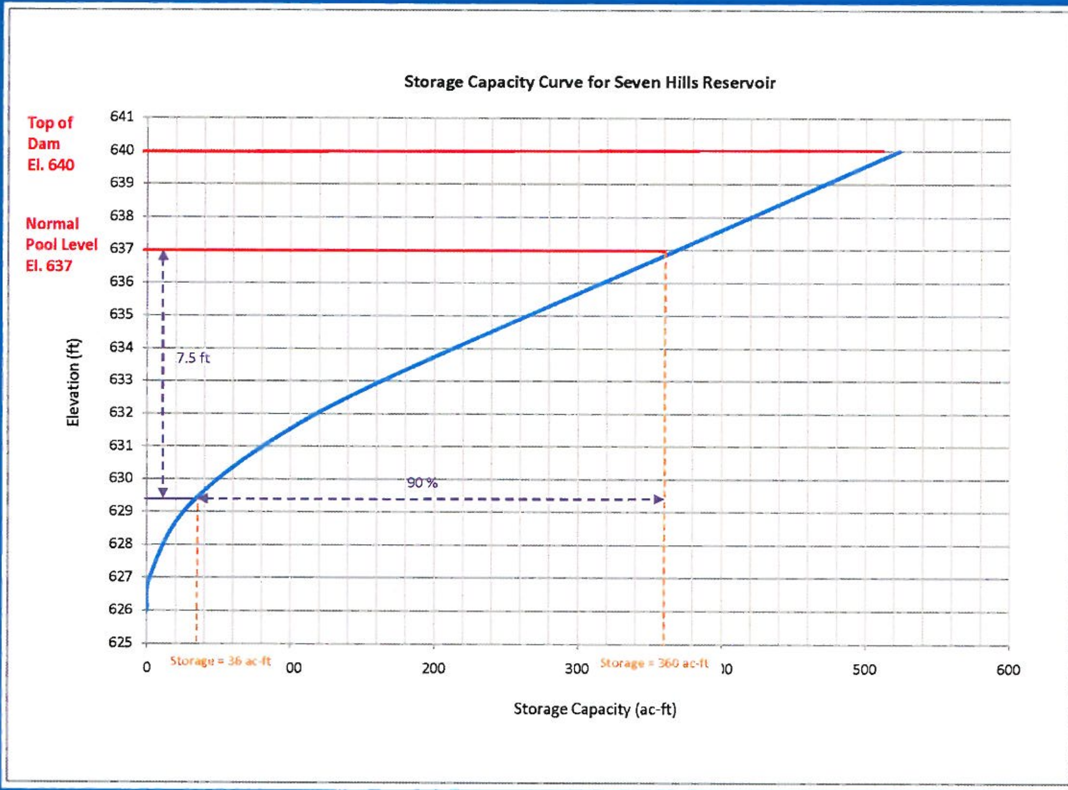
Low Level Outlet Rating Curve



- Low Level Outlet
  - Basic Assumptions
    - Diameter = 24 inches
    - L= 18 ft
    - n= 0.013
  - $H = H_{L\ entrance} + H_{L\ exit} + H_{L\ valve} + HL_{friction}$
  - Coefficients
    - $K_{L\ entrance} =$ 0.25
    - $K_{L\ exit} =$ 1.00
    - $K_{L\ valve} =$ 0.20
  - Conclusions
    - Low Level Outlet can draw down reservoir in approximately 2 days

EVALUATION OF LOW LEVEL OUTLET

Ability to Drawdown Reservoir



- Requirements
  - 90% of the reservoir must be drawdown in 14 days
- Reservoir Drawdown
  - 90% of the total volume is equal to a drawdown of approximately 7.5 feet
  - Required drawdown rate = 7.5 ft/14 days = 0.5 ft/day
- Capability
  - The low level outlet can draw the reservoir down completely in 2 days.

DAM BREAK STUDIES

NYC Environmental Protection | AECOM

Breach Formation Parameters – FERC Engineering Guides

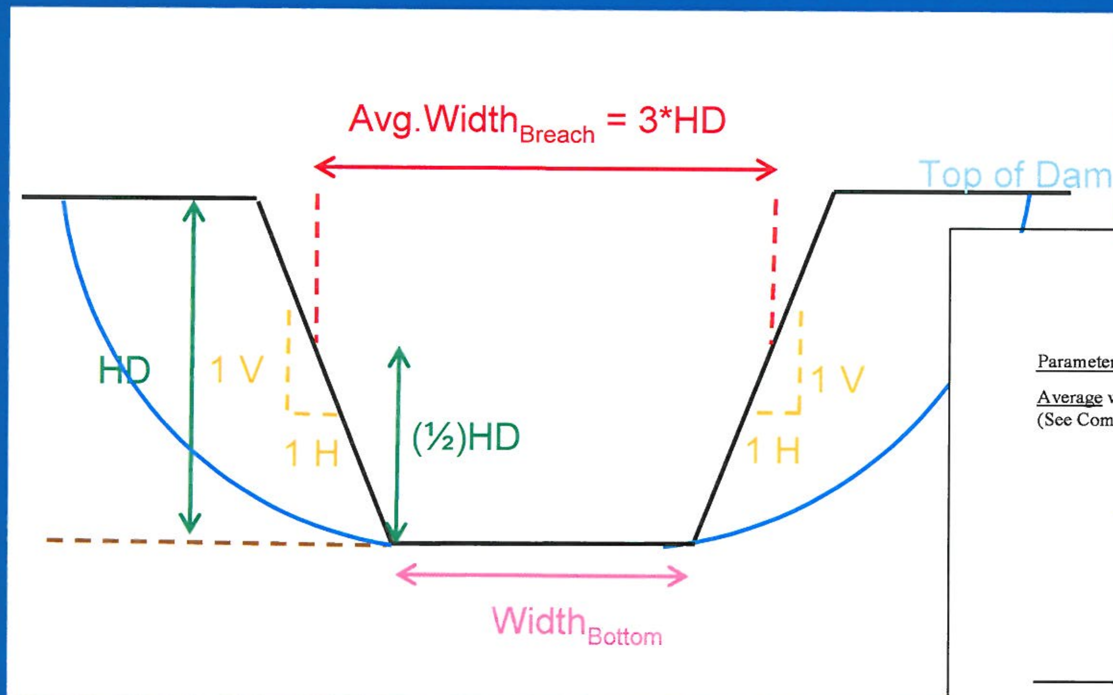


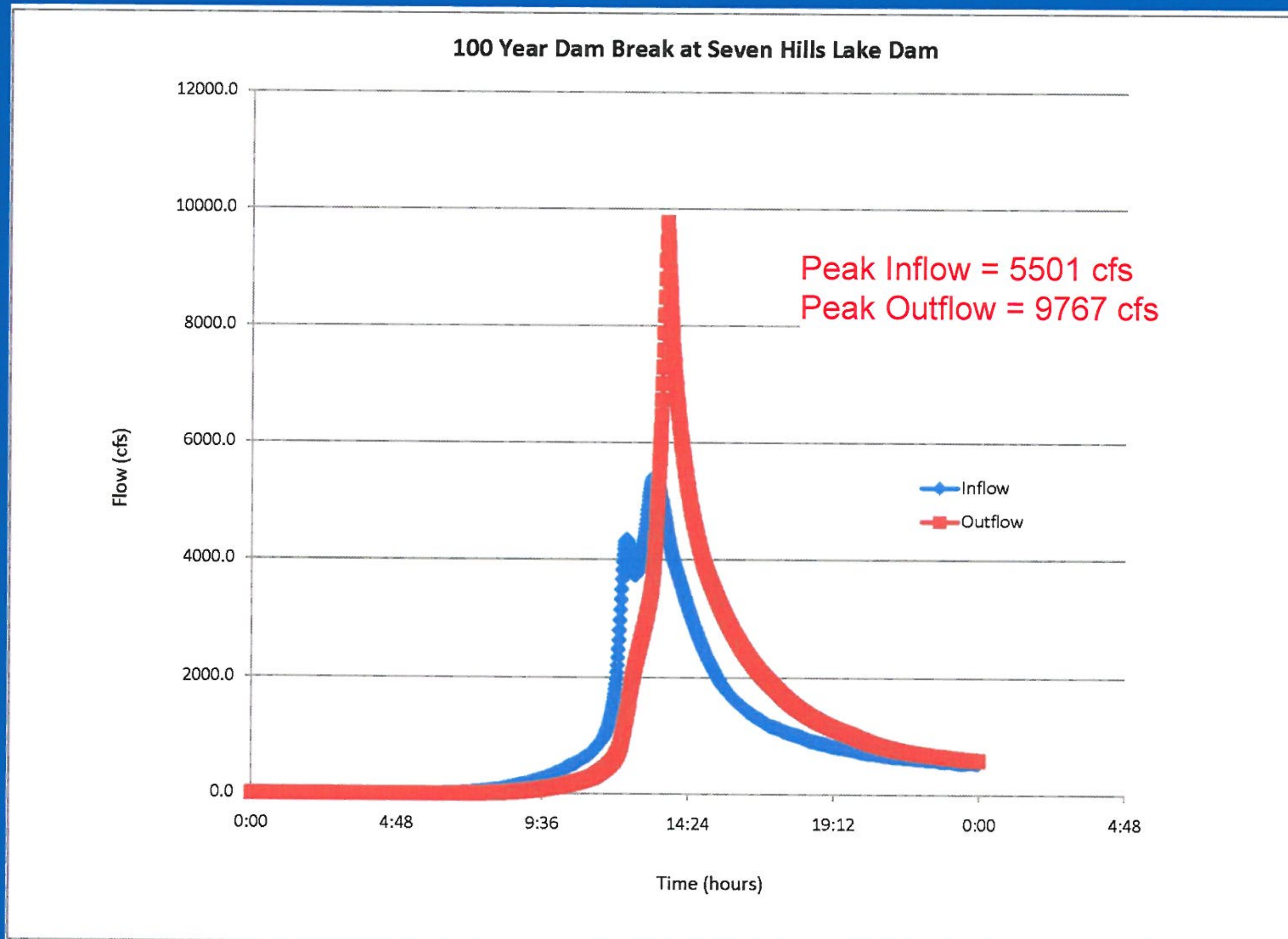
TABLE 1
SUGGESTED BREACH PARAMETERS
(Definition Sketch Shown in Figure 1)

Parameter	Value	Type of Dam
Average width of Breach (BR) (See Comment No. 1)*	$\overline{BR}$ = Crest Length	Arch
	$\overline{BR}$ = Multiple Slabs	Buttress
	$\overline{BR}$ = Width of 1 or more Usually $\overline{BR} \le 0.5$ W	Masonry, Gravity Monoliths,
	HD ≤ $\overline{BR}$ ≤ 5HD .... (usually between .... 2HD & 4HD)	Earthen, Rockfill, Timber Crib
	$\overline{BR}$ ≥ 0.8 x Crest .... Length	Slag, Refuse
Horizontal Component of Side Slope of Breach (Z) (See Comment No. 2)*	0 ≤ Z ≤ slope of valley walls . . .	Arch
	Z = O	Masonry, Gravity Timber Crib, Buttress
	¼ ≤ Z ≤ 1	Earthen (Engineered, Compacted)
	1 ≤ Z ≤ 2	Slag, Refuse (Non-Engineered)
Time to Failure (TFH) (in hours) (See Comment No. 3)*	TFH ≤ 0.1	Arch
	0.1 ≤ TFH ≤ 0.3	Masonry, Gravity, Buttress
	0.1 ≤ TFH ≤ 1.0	Earthen (Engineered, Compacted) Timber Crib
	0.1 ≤ TFH ≤ 0.5	Earthen (Non Engineered Poor Construction)
	0.1 ≤ TFH ≤ 0.3	Slag, Refuse

DAM BREAK STUDIES

NYC Environmental Protection AECOM

- 100 Yr



DAM BREAK STUDIES

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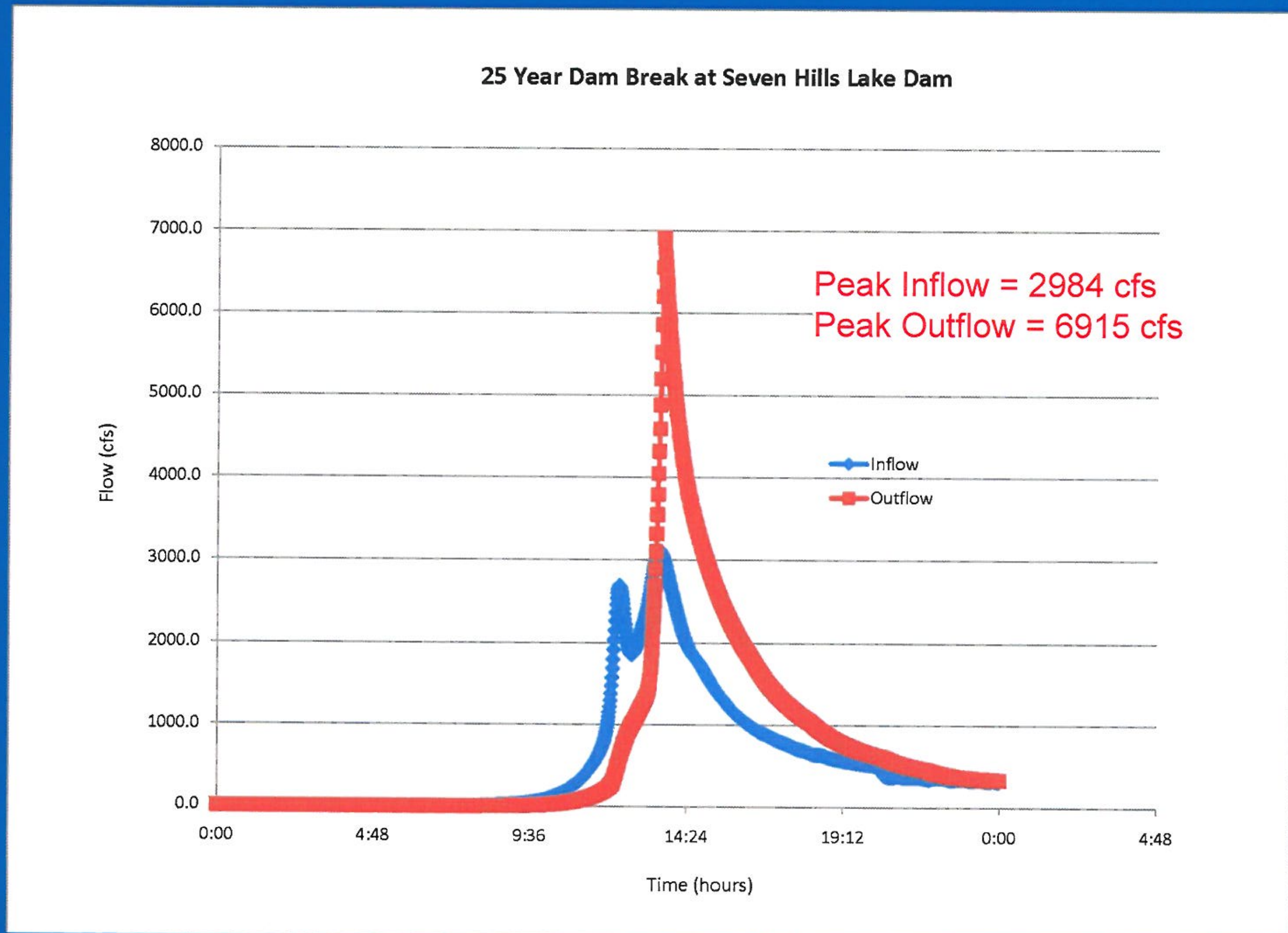
- 25 Yr



DAM BREAK STUDIES

NYC Environmental Protection AECOM

Impact of Dam Break at Seven Hills on Frank Pond Dam

	Frank Pond Dam Spillway Crest El 597 Top of Dam El 604			Frank Pond Dam during Dam Break at Seven Hills Lake Dam		
	Inflow (cfs)	Outflow (cfs)	Maximum Res Elev.	Inflow (cfs)	Outflow (cfs)	Maximum Res Elev.
Sunny Day	-	-	-	3,453	2,614	604.87
2-yr	604	594	601.16	-	-	-
10-yr	1,465	1,431	603.49	-	-	-
25-yr	2,365	2,349	604.63	6,743	5,954	607.26
50-yr	3,360	3,334	605.46	-	-	-
100-yr	4,499	4,462	606.29	9,589	8,705	608.77

Major Consequences

- Sunny Day Dam Break - minor (0.9 ft) overtopping of Frank Pond Dam
- 25yr Flood - minor (0.6 ft) overtopping of Frank Pond Dam
- 25 yr Flood with Dam Break at Seven Hills - severe (3.3 ft) over topping of Frank Pond Dam
- 100yr Flood - 2.3 ft overtopping of Frank Pond Dam
- 100 yr Flood with Dam Break at Seven Hills - severe (4.8 ft) overtopping of Frank Pond Dam

STABILITY ANALYSES

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AECOM

Approach & Guidelines

- **Embankment Dams**
  - USACE Code

    EM-1110-2-1902, January 1989. 'Stability of Earth and Rockfill Dams'
  - Loading Cases & Factors of Safety

II	Sudden drawdown from maximum pool	1.0‡‡
III	Sudden drawdown from spillway crest or top of gates	1.2‡‡
IV	Partial pool with steady seepage	1.5
V	Steady seepage with maximum storage pool	1.5
VI	Steady seepage with surcharge pool	1.4
VII	Earthquake (Cases I, IV, and V with seismic loading)	1.0

  - Software

    Slide v. 6.005 (July 2010) & Phase2 v. 7.016 by Rocscience, Toronto

STABILITY ANALYSES

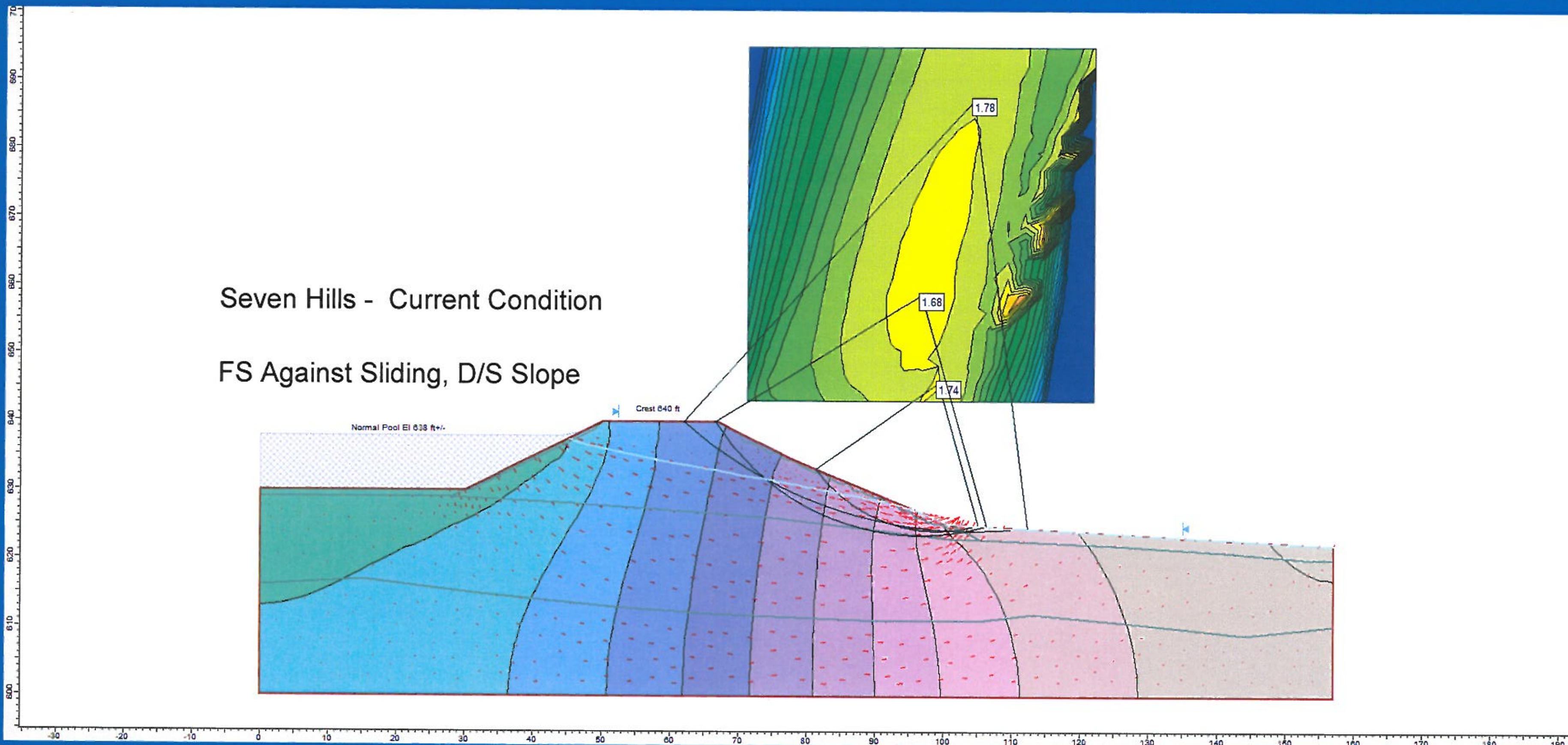
NYC Environmental Protection AECOM

Assumptions made in the Stability Analyses:

1. Geometry of dams, et cetera was taken from AECOM inspection reports and other on file data
2. Local geology and subsurface conditions were assumed based on personal observations of the dam sites and available local surface geology maps and data
3. Shear strength parameters of all formations and fill materials were assumed and consistent with dam construction practice and most likely available borrow materials
4. Foundation, fill and sediment permeabilities were assumed based on experience elsewhere
5. No particular weakness/failure plane was assumed exists in the foundation of any of the dams analyzed. No preexisting shear zones/surfaces were assumed existed in the local rock formation
6. No foundation and/or fill dispersive and piping potential was assumed to exist
7. Reasonable boundary conditions were assumed and introduced in the models consistent with these type of analyses and based on experience on similar projects elsewhere
8. FEA ground water and seepage analyses, a basis to stability, were based on hydrologic input data and reasonable boundary condition assumptions

STABILITY ANALYSES

Existing condition



STABILITY ANALYSES

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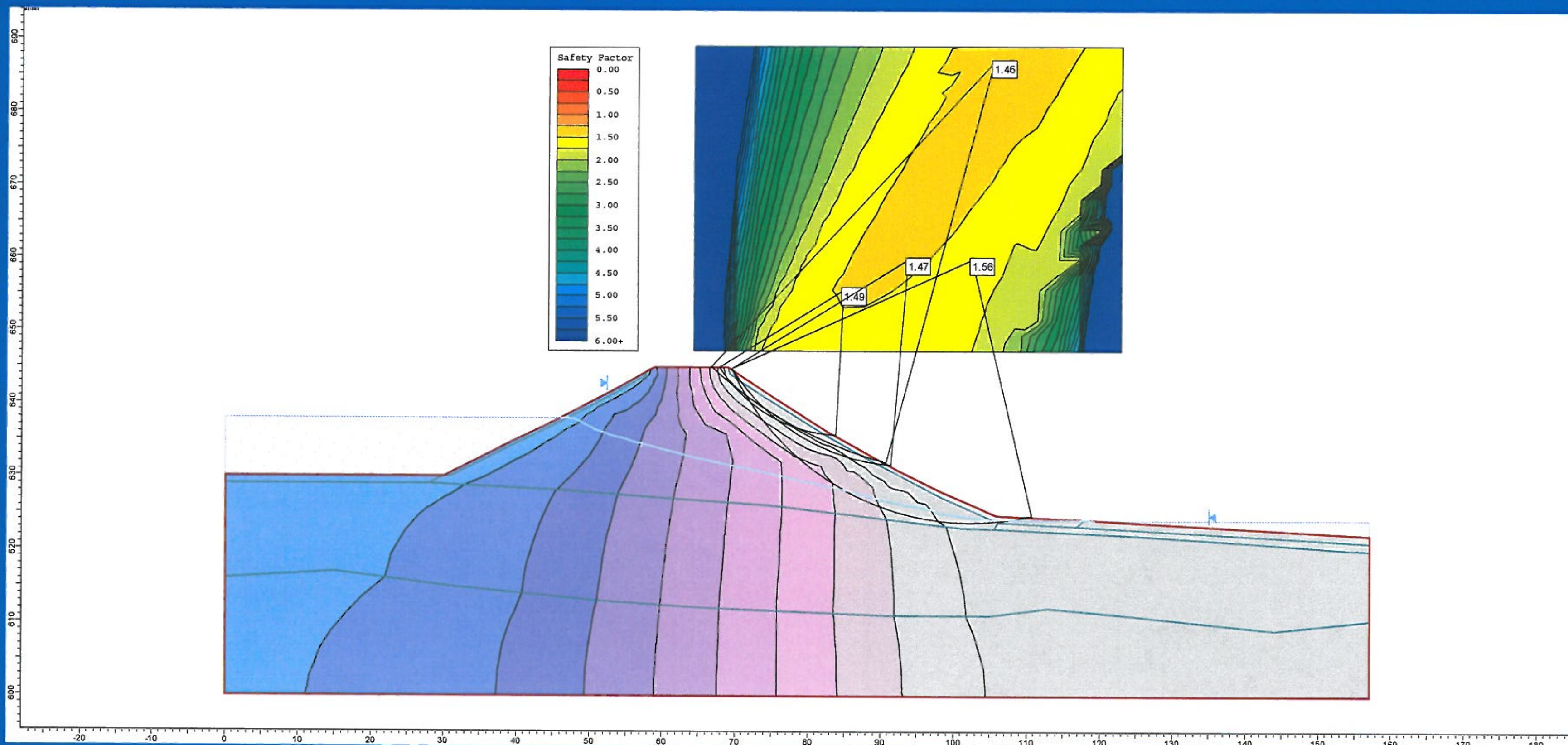
Seven Hills - Option 1 (Raised Dam to El 645 ft)



Downstream Slope Stability Raised Dam Option with Crest Elevation at 645 ft. Steady State Normal Pool at El 638 ft

STABILITY ANALYSES

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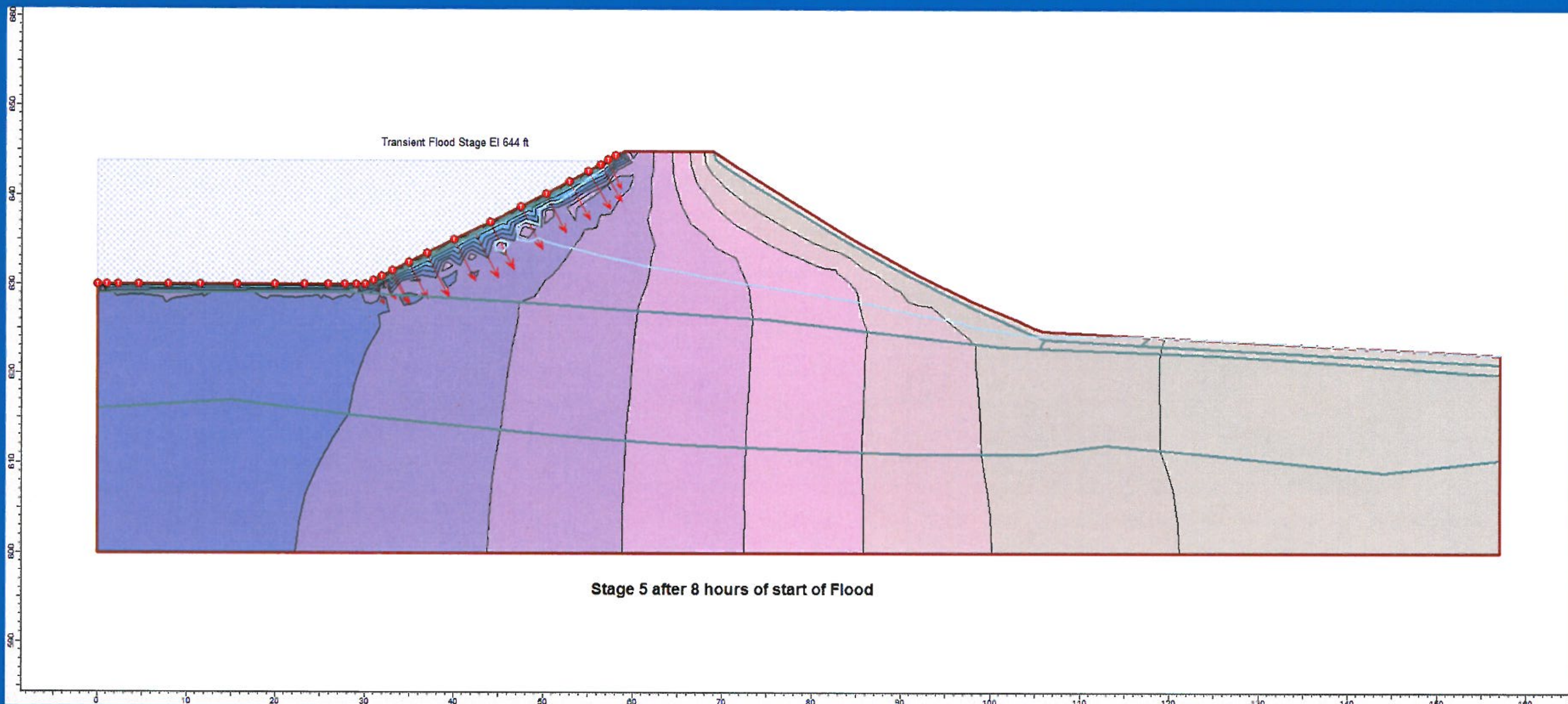
Seven Hills - Option 1 (Raised Dam)



Seepage Transient - Flood Stage to El 644, 150% in 100-year

STABILITY ANALYSES

NYC Environmental Protection

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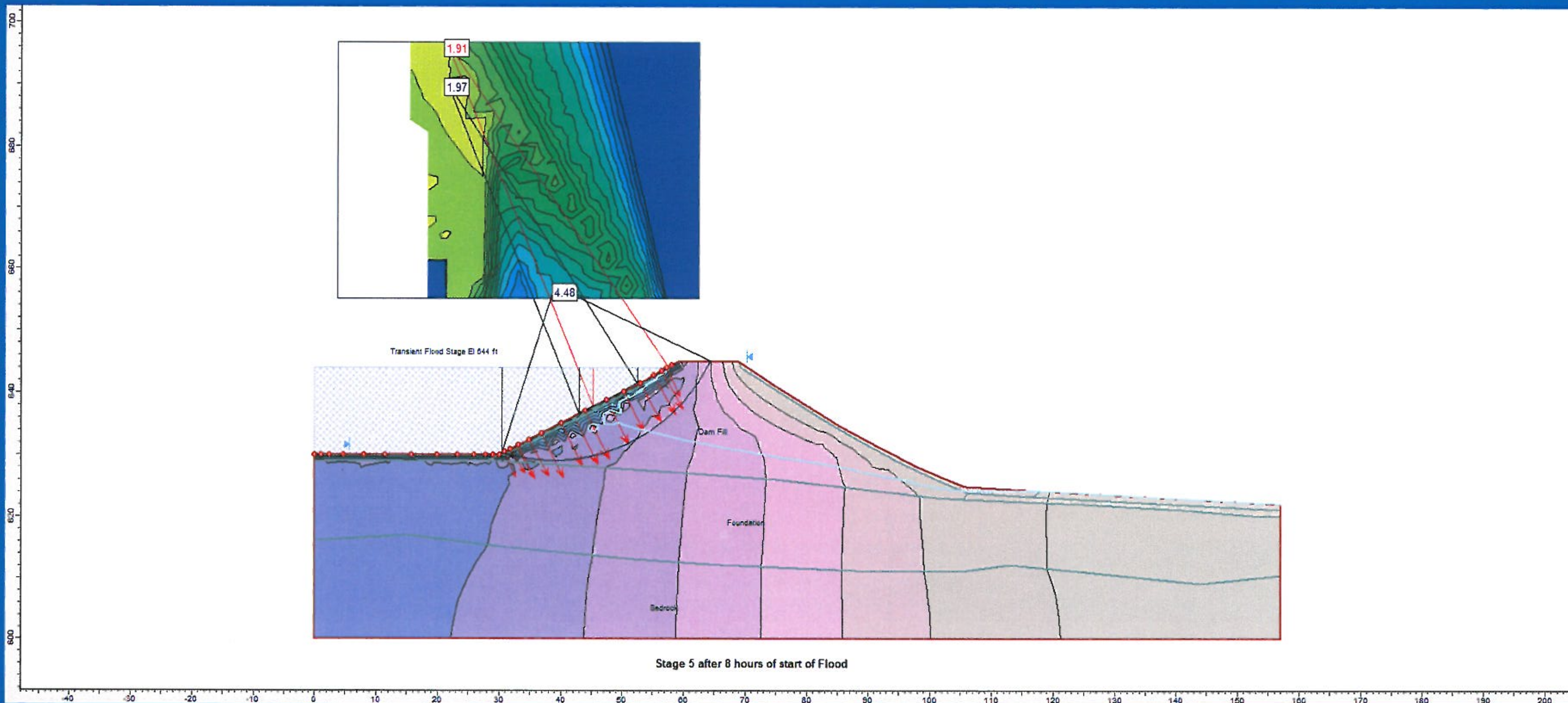
Seven Hills - Option 1 (Raised Dam)



Upstream Stability Flood Stage to El 644, Transient Seepage, 150% in 100-year

STABILITY ANALYSES

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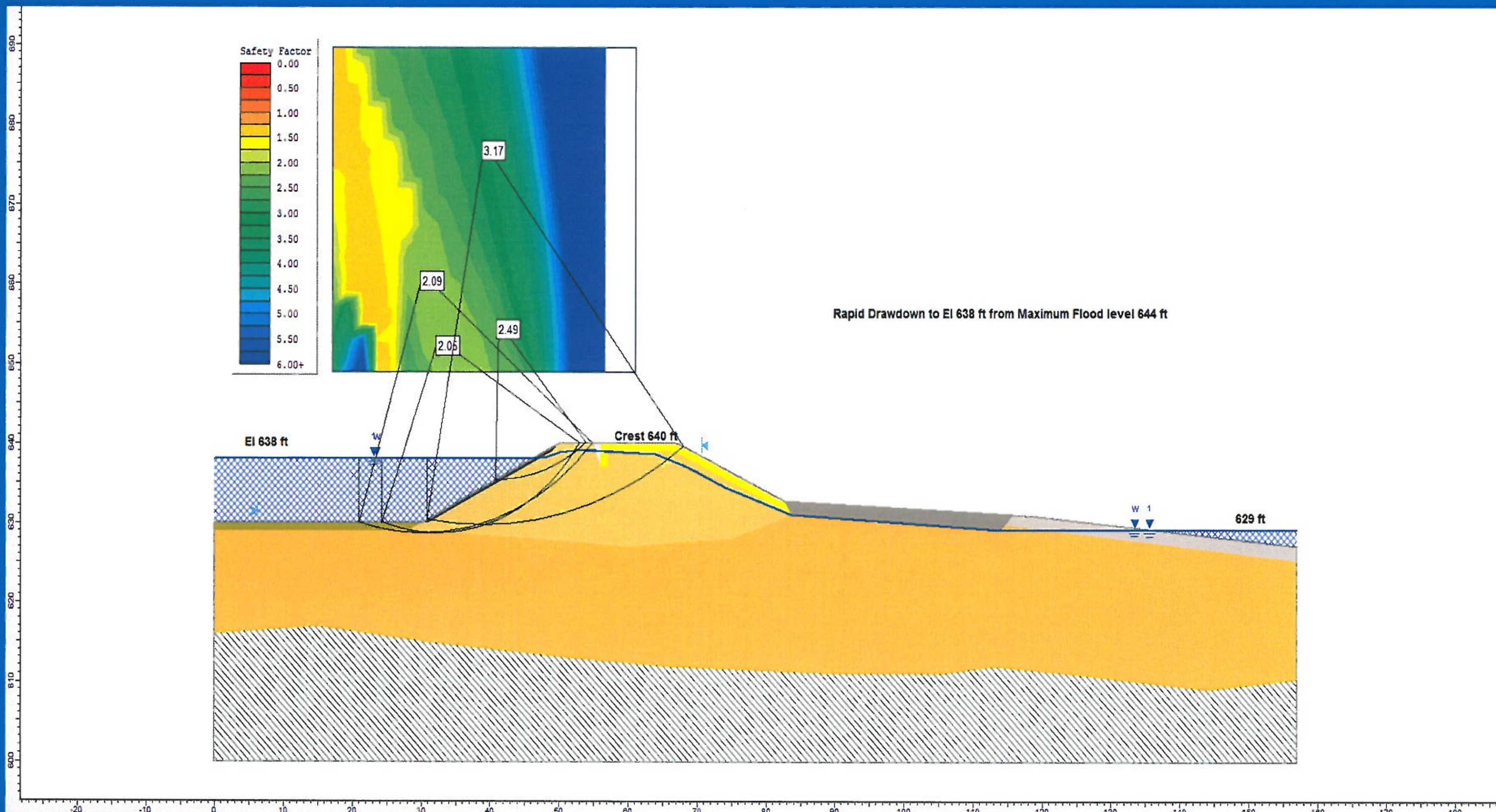
Seven Hills - Option 2 (Overflow Spillway)



Upstream Stability after Rapid Drawdown

STABILITY ANALYSES

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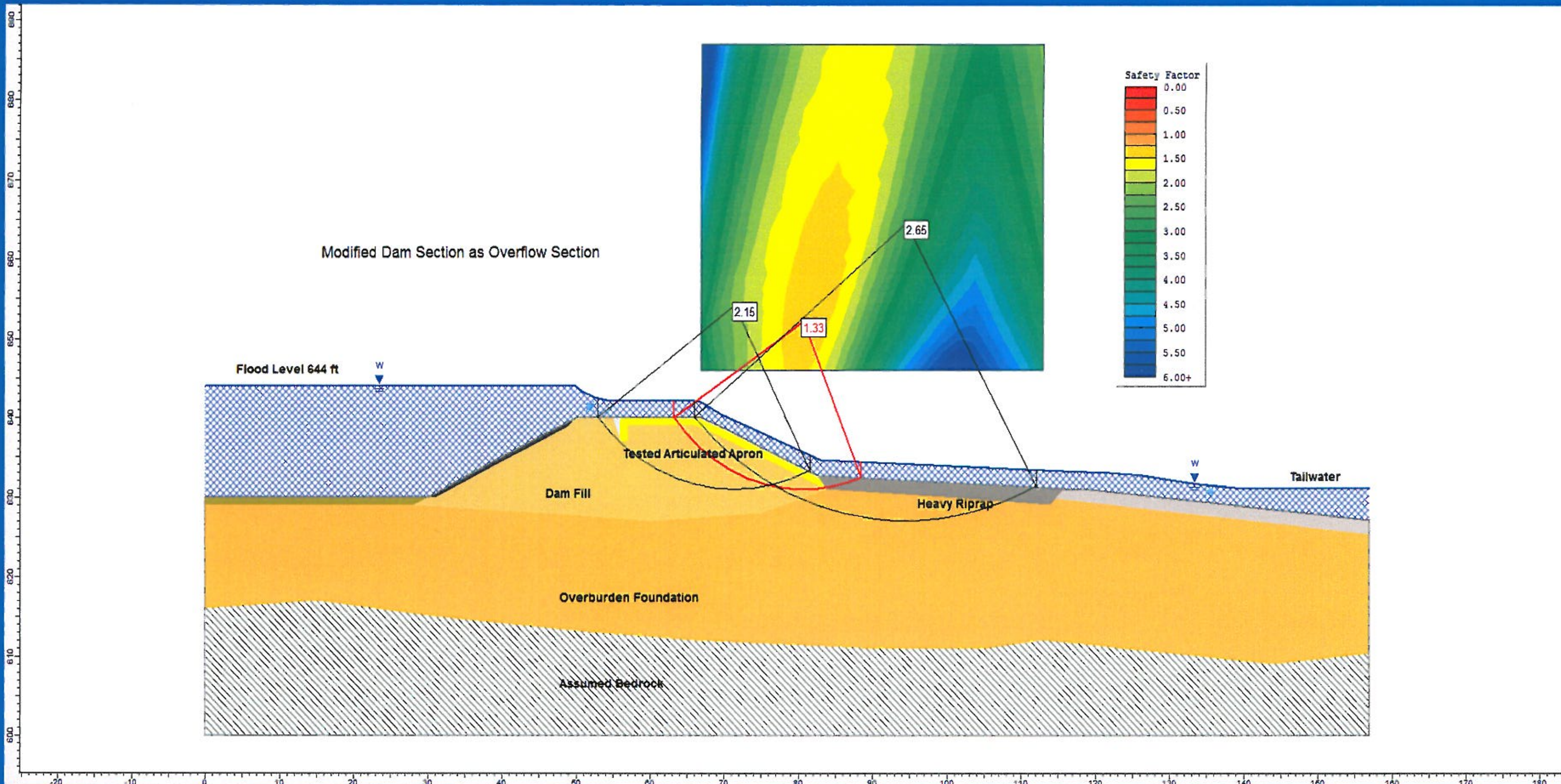
Seven Hills - Option 2 (Overflow Spillway)



STABILITY ANALYSES

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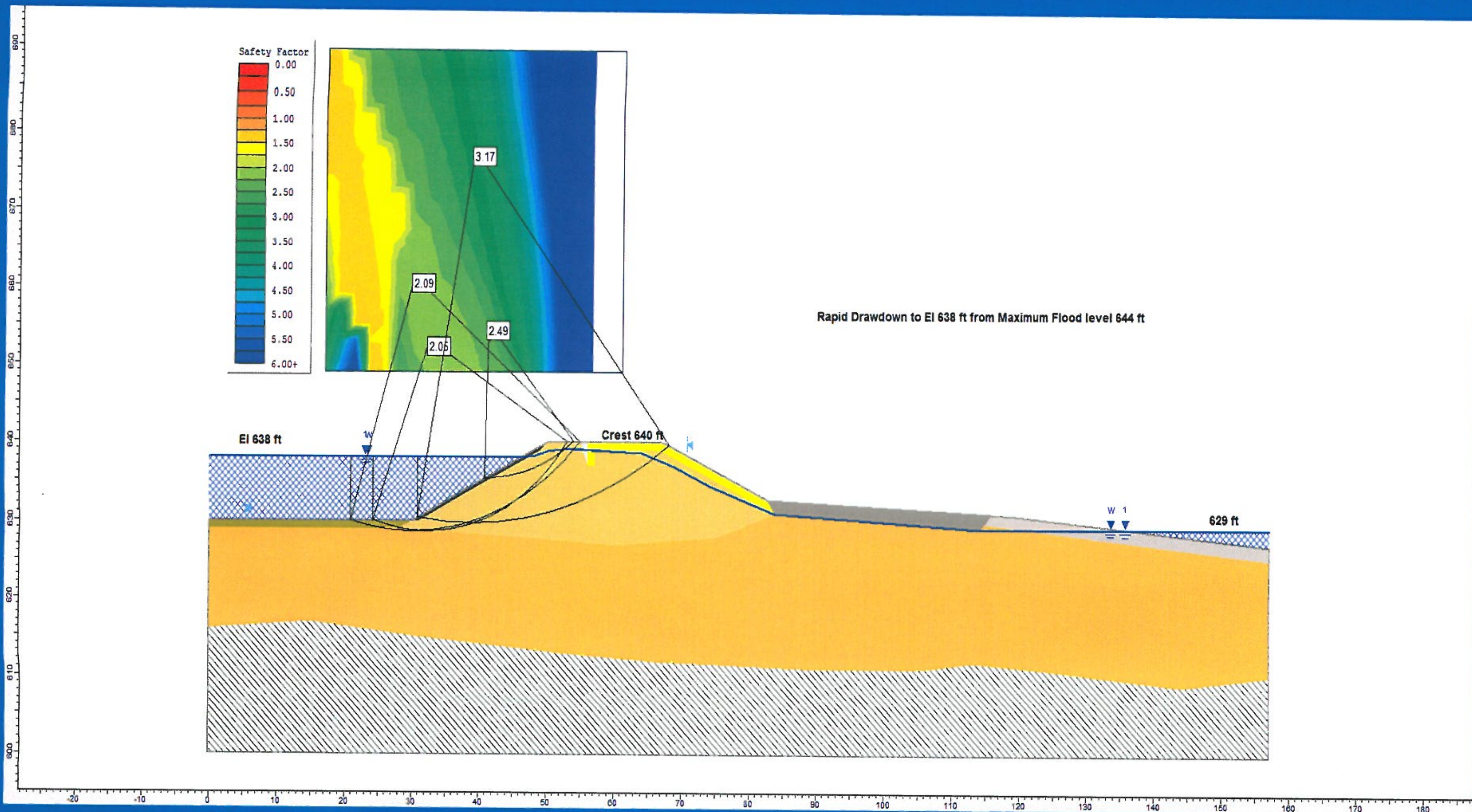
Seven Hills - Option 2 (Overflow Spillway)



Upstream Stability after Rapid Drawdown