EAST GOSHEN TOWNSHIP
CHESTER COUNTY, PENNSYLVANIA
MILLTOWN DAM (DEP ID NO. D15-146)

EAST GOSHEN TOWNSHIP
BOARD OF SUPERVISORS MEETING
MARCH 22, 2016

Gannett Fleming

East Goshen Township
Incorporated 1817
Chester County, Pennsylvania

AGENDA

- Purpose of the Meeting
- Project Location
- Original Design and Construction
- Past Modifications to the Dam
- Operation and Maintenance Costs
- Known Deficiencies and Areas of Risk
- Options for Increasing Conveyance Capacity
- Decommissioning Option
- Partial Breach Options
- Questions and Answers

PURPOSE OF THE MEETING

DEP NOTIFIES EAST GOSHEN TOWNSHIP OF INADEQUATE SPILLWAY CAPACITY AT MILLTOWN DAM UNDER COVER LETTER DATED JUNE 17, 2014

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATERWAYS ENGINEERING AND WETLANDS

June 17, 2014

According to the August 1981 Phase 1 report, the Spillway Design Flood (SDF) is 50 percent of the Probable Maximum Flood (PMF). However, the spillway capacity is 26% of the SDF; meaning the spillway is inadequate to pass the SDF. The discharge capacity or storage capacity, or both, must be capable of safely accommodating the recommended design flood for the dam as classified under chapter 105.91. The design flood must be determined by an incremental dam breach analysis with a minimum required design storm duration of 24 hours. Please provide the Department with an incremental dam breach analysis for review. If you have any questions regarding the incremental breach analysis, contact Ron Mease of our office at 717.772.5947.

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Two copies of the Annual Inspection Report must be submitted to the Department for review and must contain an engineer's original seal and signature. This submission only contained one copy that was not sealed by the professional engineer; we require a resubmittal of two copies properly signed and sealed. Until then, the 2013 annual inspection will be considered incomplete.

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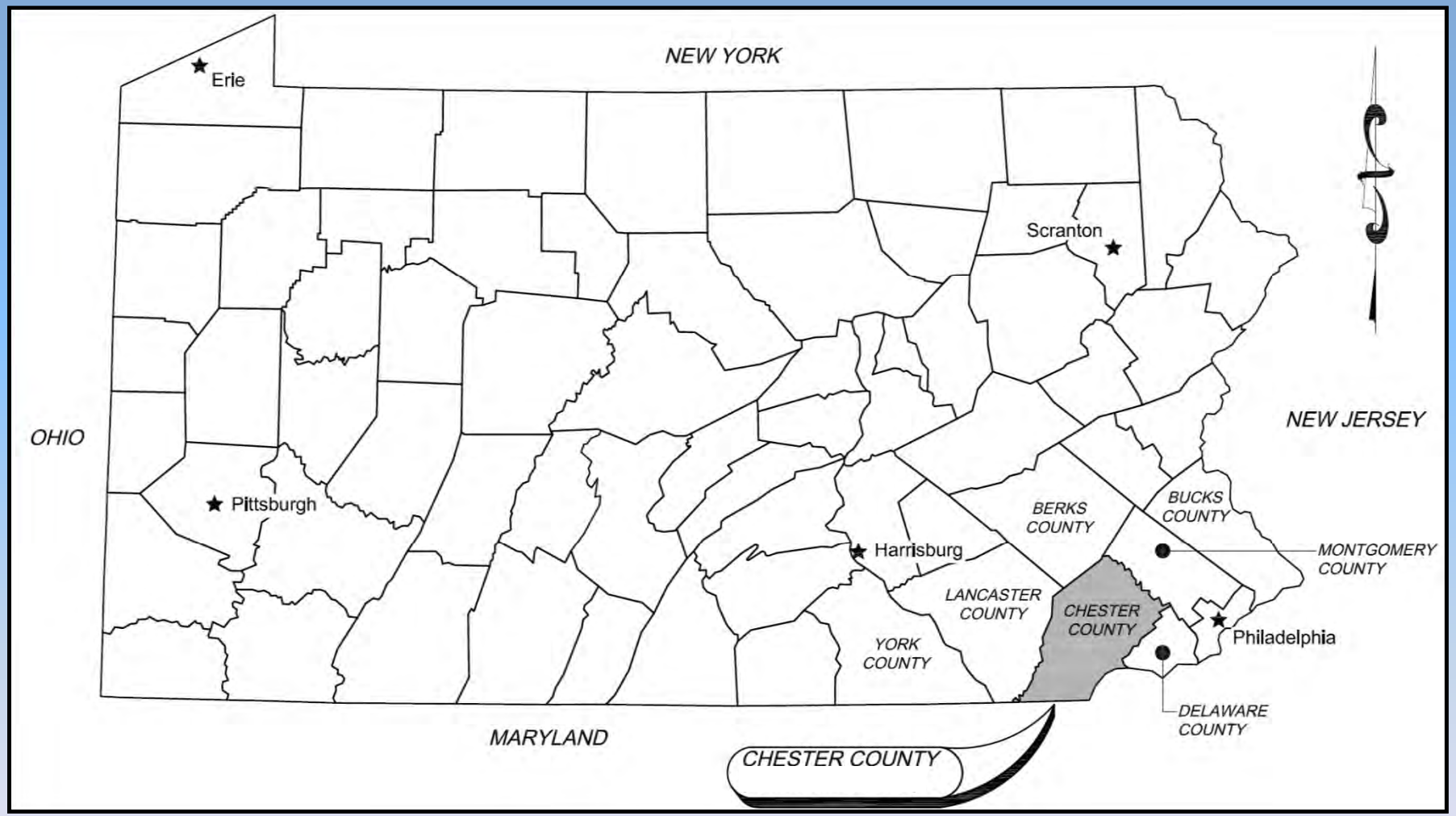
EVALUATE/PRESENT OPTIONS THAT ARE AVAILABLE TO THE TOWNSHIP TO ALLOW THE TOWNSHIP TO MAKE AN EDUCATED AND INFORMED DECISION

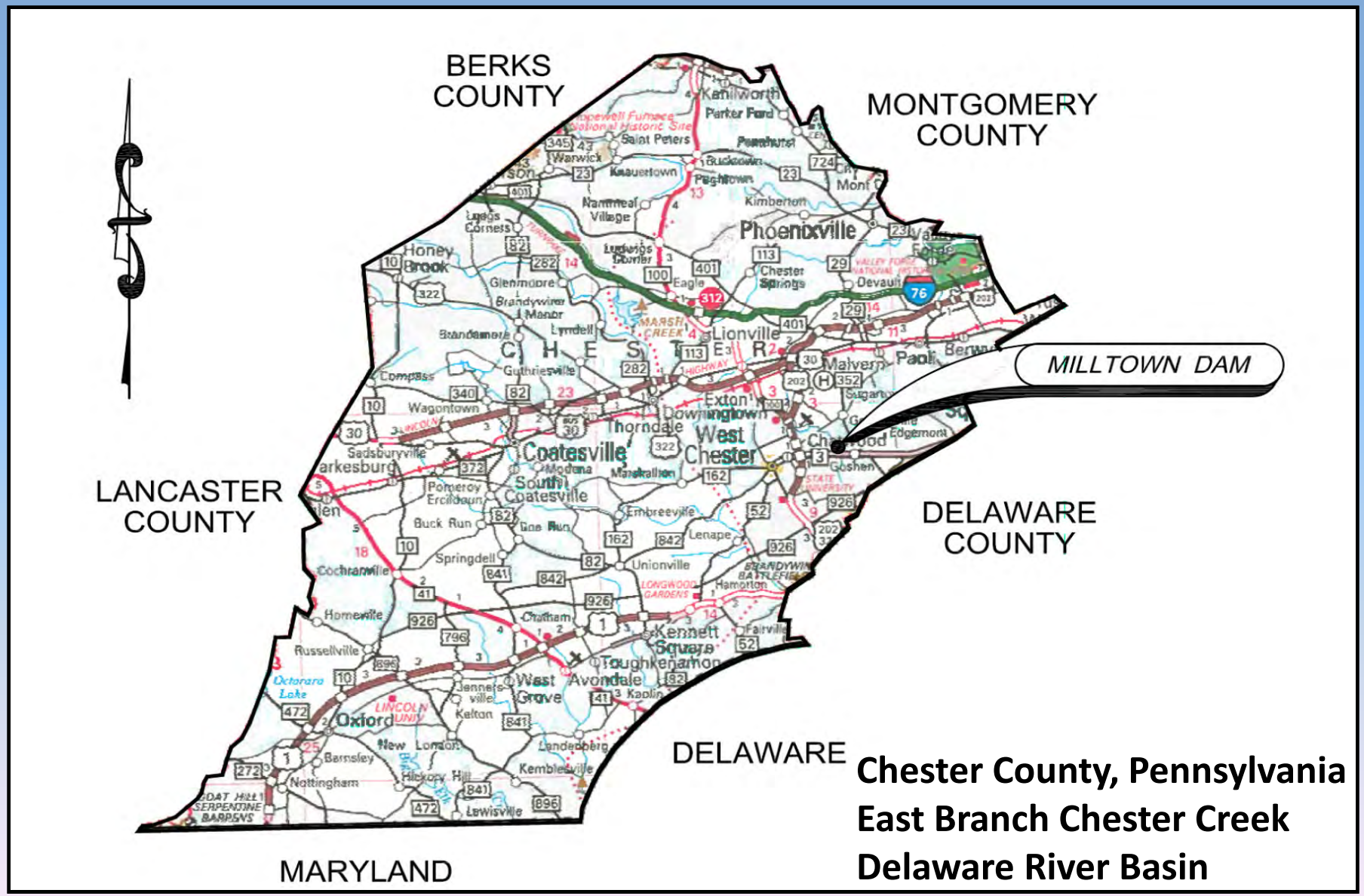
PROJECT LOCATION



MILLTOWN DAM

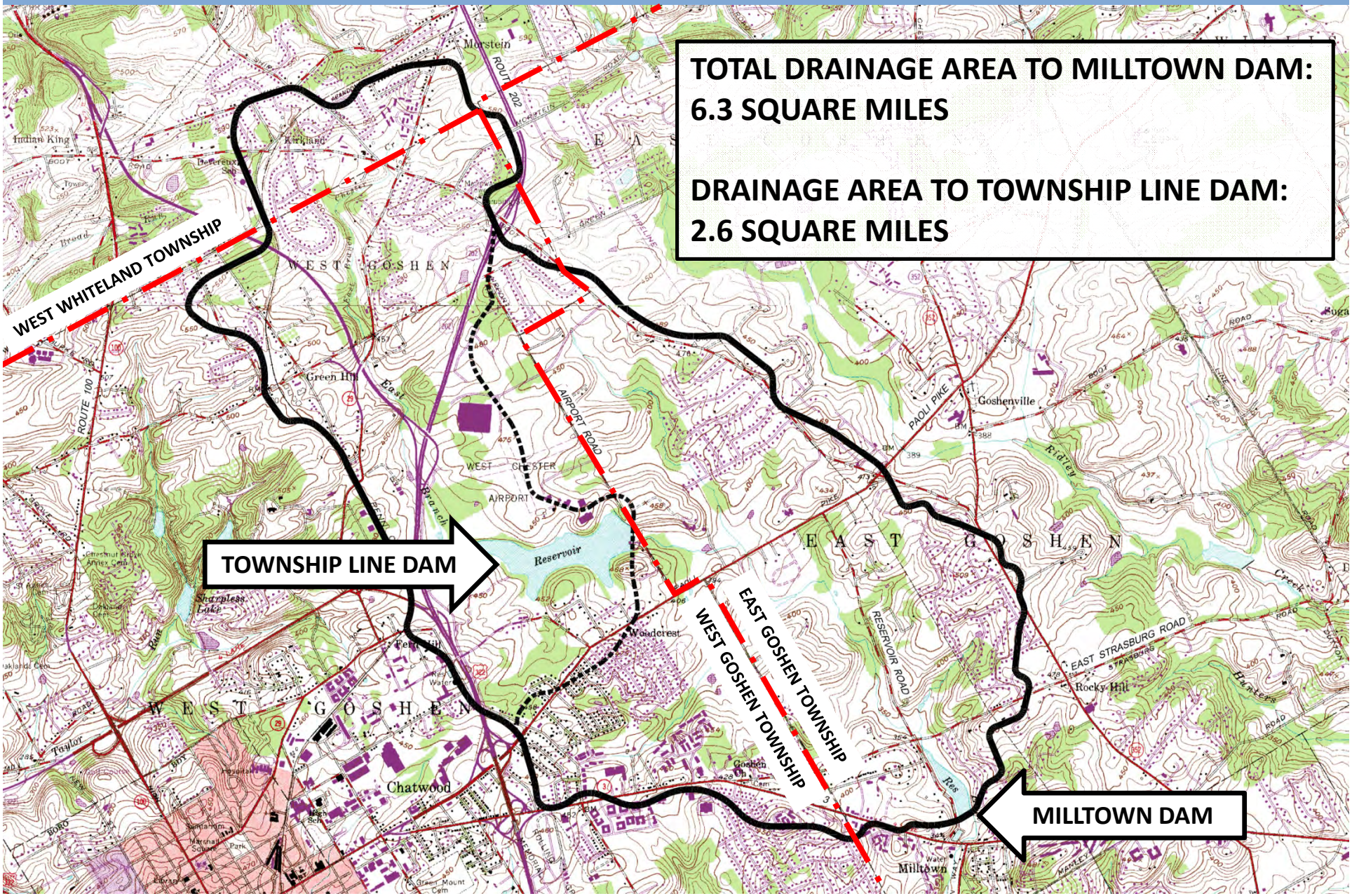
Located in East Goshen Township, Chester County

PROJECT LOCATION



Chester County, Pennsylvania
East Branch Chester Creek
Delaware River Basin

DRAINAGE AREA



MILLTOWN DAM

MILLTOWN DAM

Earth Embankment

350'± in Length (Total Length of Dam)

20'± in Height at Maximum Section

Concrete Core Wall Along Entire Length of Dam

MILLTOWN DAM

Principal Spillway

69-Foot Long Concrete Ogee Spillway with 6-Inch Notch

Spillway Crest El. 342.2 (Notch)

Top of Dam El. 347.5 (Design)

MILLTOWN DAM

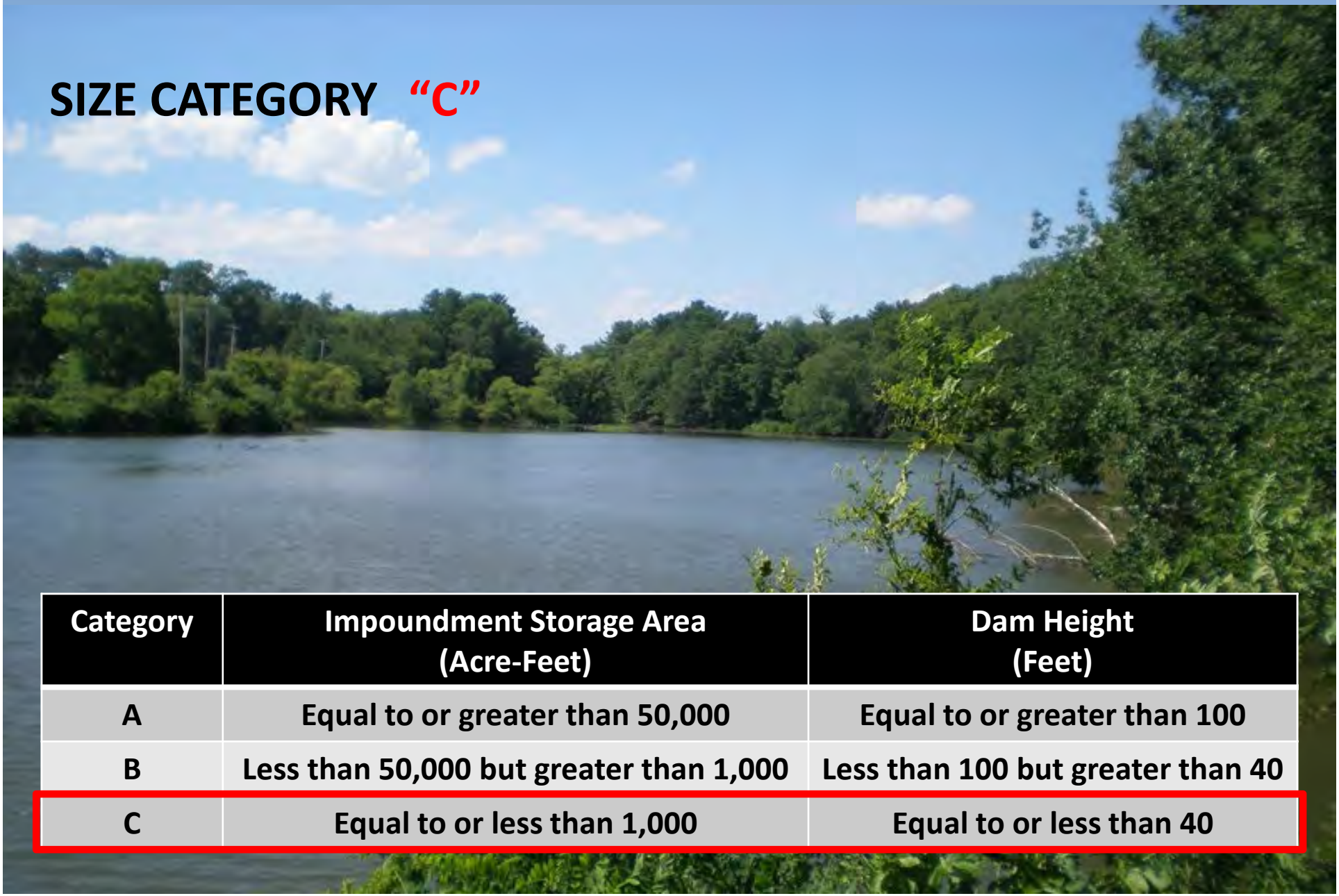
Low Level Dewatering System

16-Inch & 24-Inch CIP Intake Conduits

Valve House situated over a Valve Chamber

24-Inch Discharge Pipe to East Branch Chester Creek

CLASSIFICATION OF DAMS AND RESERVOIRS



SIZE CATEGORY *"C"*

Category	Impoundment Storage Area (Acre-Feet)	Dam Height (Feet)
A	Equal to or greater than 50,000	Equal to or greater than 100
B	Less than 50,000 but greater than 1,000	Less than 100 but greater than 40
C	Equal to or less than 1,000	Equal to or less than 40

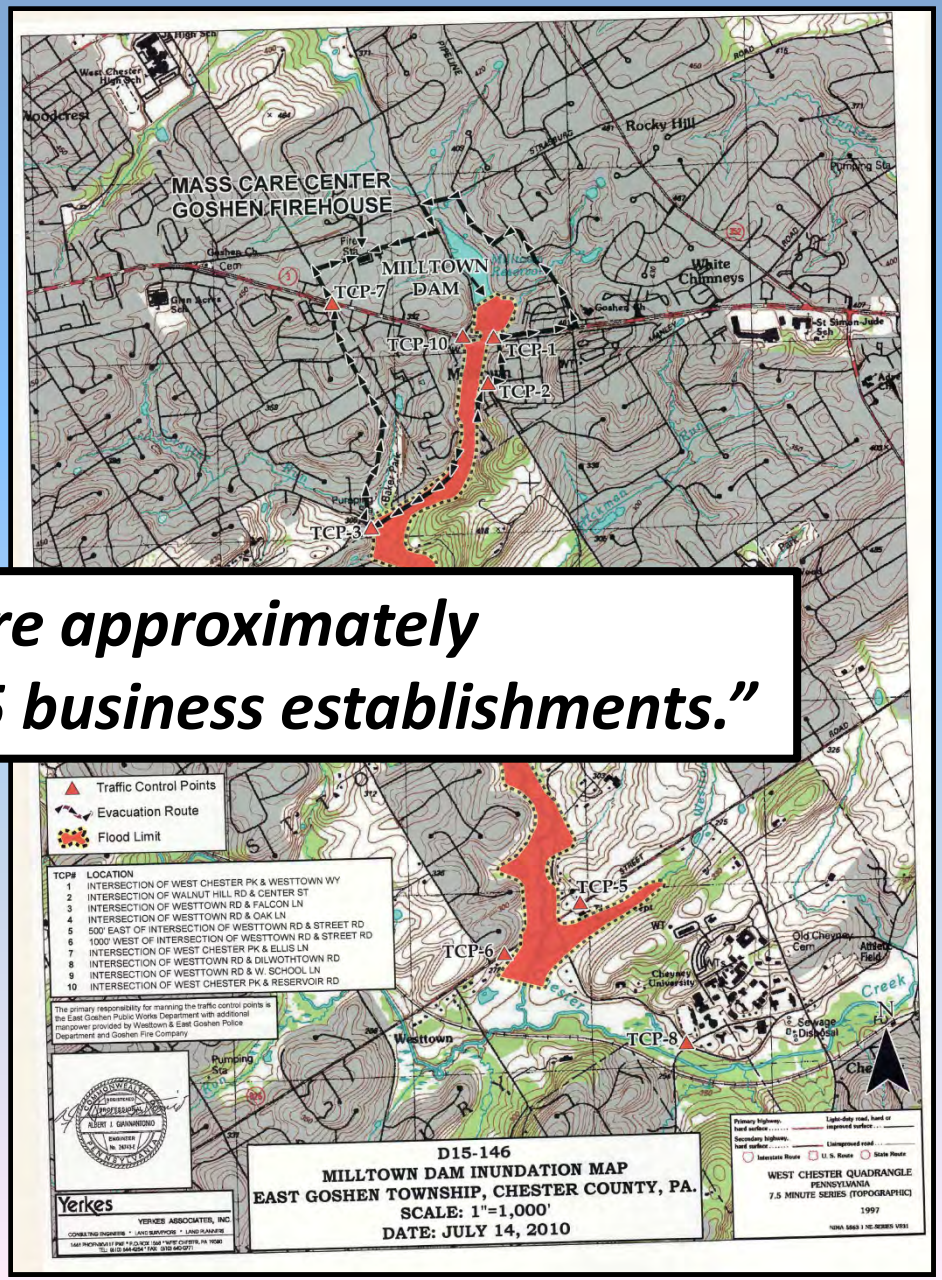
CLASSIFICATION OF DAMS AND RESERVOIRS

HAZARD POTENTIAL CATEGORY "1"

Category	Population at Risk	Economic Loss
1	Substantial - Numerous homes, businesses or schools	Excessive - Residential, Commercial or agricultural damage or substantial public inconvenience
2	Few – Small number of homes or small businesses	Appreciable – Limited residential, commercial or agricultural damage or moderate public inconvenience
3	None expected – No permanent structures for human habitation or employment	Significant damage to private or public property and short duration public inconvenience
4	None expected – No permanent structures for human habitation or employment	Minimal damage to private or public property and no significant public inconvenience

CLASSIFICATION OF DAMS AND RESERVOIRS

EMERGENCY ACTION PLAN
(Approved October 2010)



"Within the inundation area are approximately 100 residents, 39 homes, and 5 business establishments."

DESIGN STORM EVENTS

Probability of Occurrence	Return Period	24-Hour Rainfall Depth
0.5	2 years	3.3”
0.1	10 years	4.8”
0.04	25 years	5.8”
0.02	50 years	6.2”
0.01	100 years	7.5”
0.002	500 years	9.9”

Local Roadway Drainage

Culverts & Bridges

Dams

Probable Maximum Flood

Source: NOAA Atlas 14 for West Chester Station 36-9464

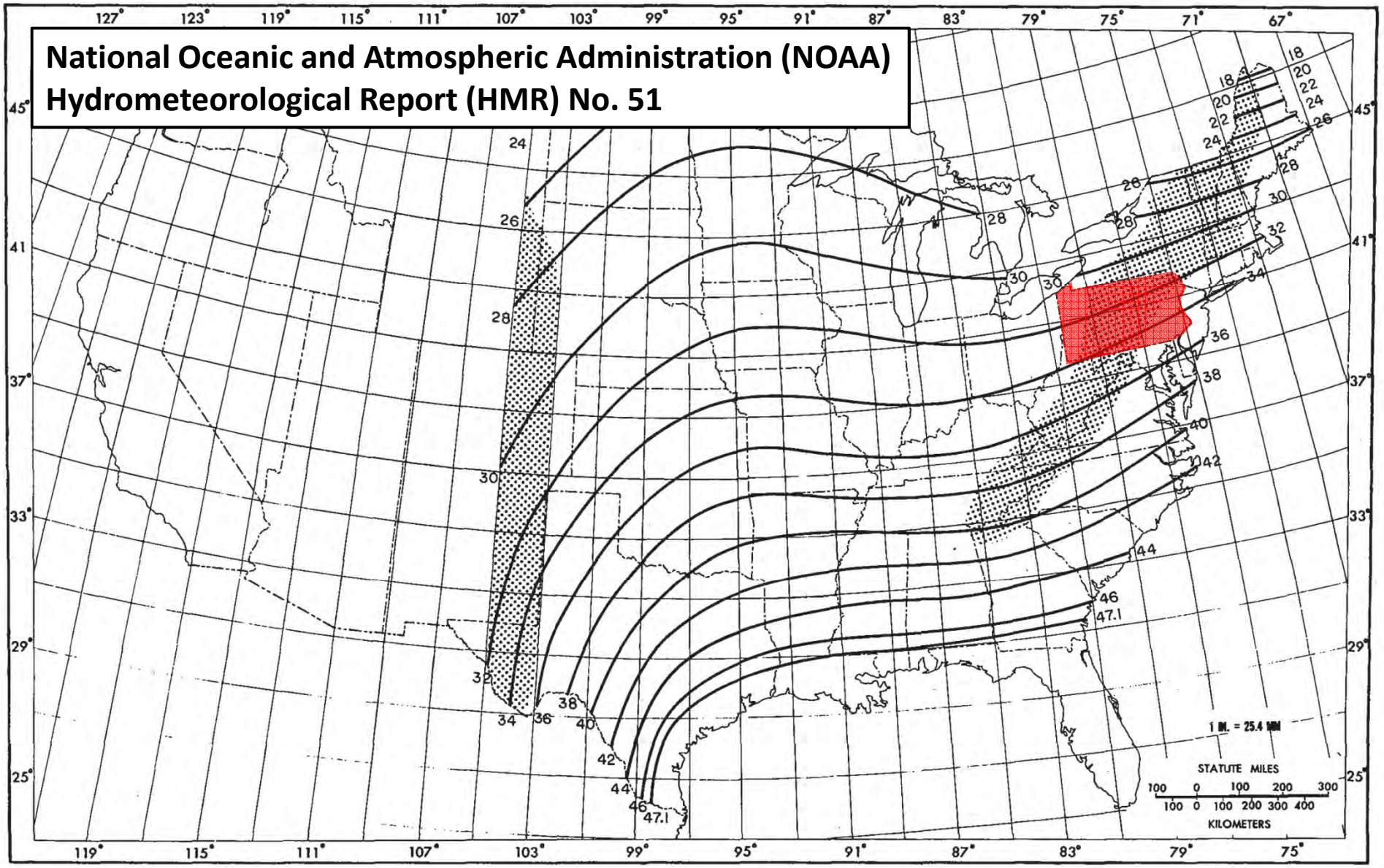
Probable Maximum Flood

The Probable Maximum Flood (PMF) is the flood generated by the Probable Maximum Precipitation (PMP).

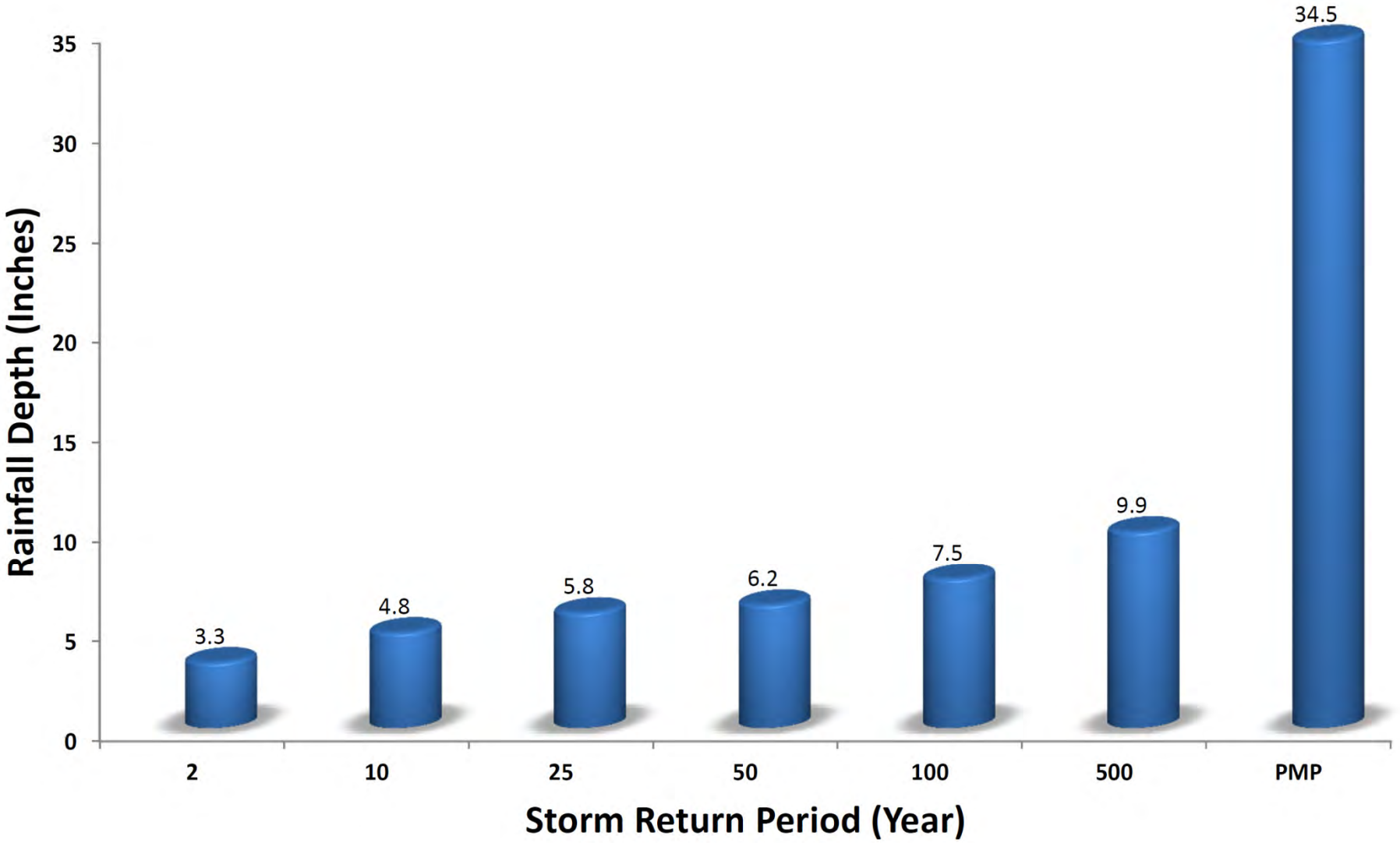
PMP is defined as the "theoretically greatest depth of precipitation for a given duration that is physically possible over a particular drainage area at a particular time of year,"

(American Meteorlogical Society).

PROBABLE MAXIMUM PRECIPITATION



PROBABLE MAXIMUM PRECIPITATION



SPILLWAY DESIGN FLOOD

PA Code, Title 25, Chapter 105 §105.98

The discharge capacity or storage capacity, or both, must be capable of safely accommodating the recommended design flood for the dam as classified under §105.91 (relating to classification of dams and reservoirs). The design flood must be determined by an incremental dam breach analysis. The minimum required design storm duration is 24 hours. When considered appropriate by the Department, engineering judgment may be used to determine the design flood within the design flood range indicated below for dams of Hazard Potential Category 3 or 4. The classification or damage, or both, resulting from dam failure will determine the design flood within the design flood range.

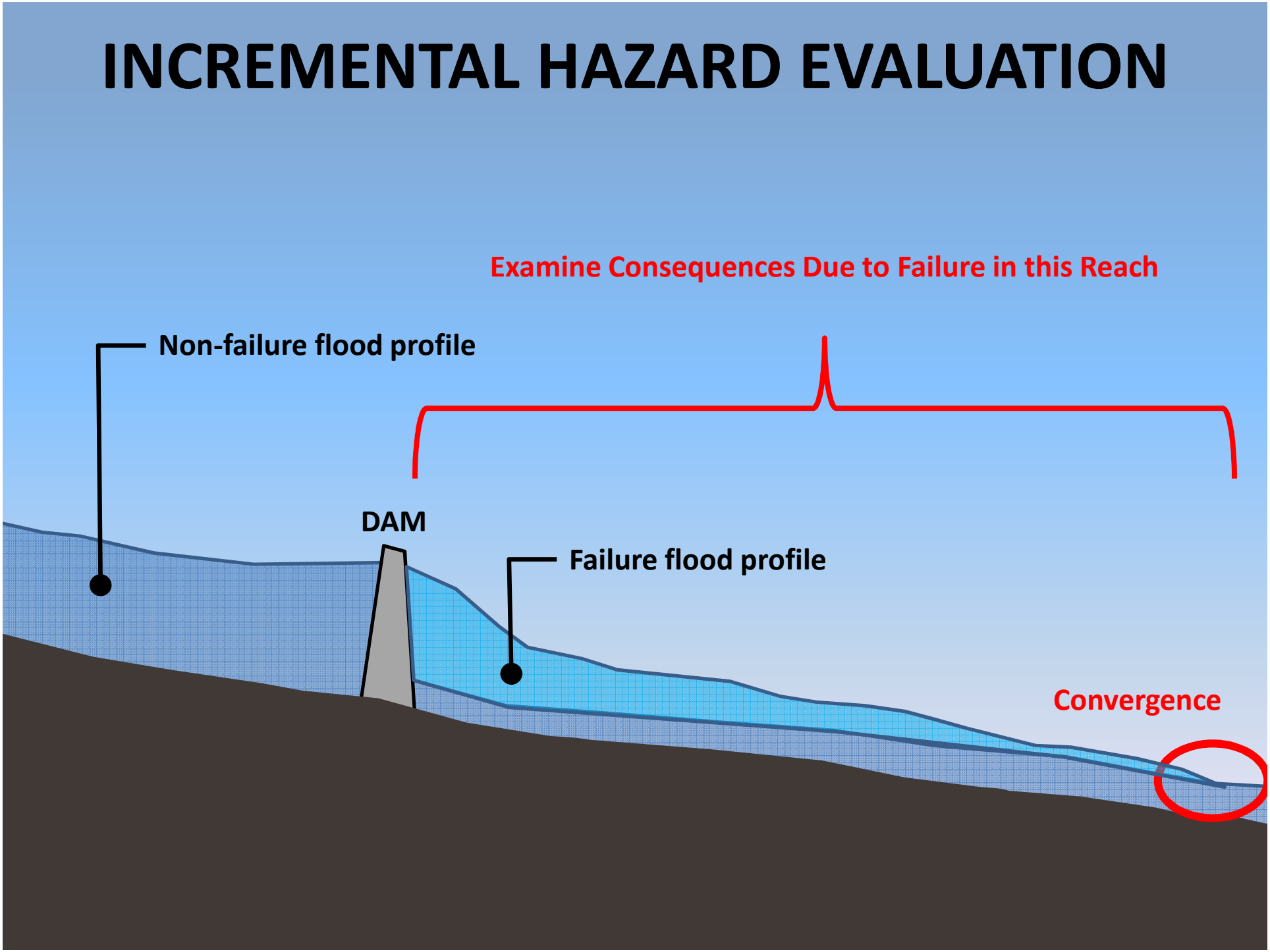
Classification	*Design Flood Range*
A-3, B-3	*½ PMF to PMF*
A-4, B-4, C-3	*100-Year to ½ PMF*
C-4	*50-Year to 100-Year frequency*

Milltown Dam classified as a C-1 High Hazard Structure.
Incremental Dam Breach Analysis performed by DEP in 2014 confirms Spillway Design Flood to be the ½ PMF.

INCREMENTAL HAZARD EVALUATION

The flood flow above which the incremental increase in water surface elevation downstream due to failure of a dam or other water retaining structure is no longer considered to present an unacceptable additional downstream threat.

INCREMENTAL HAZARD EVALUATION



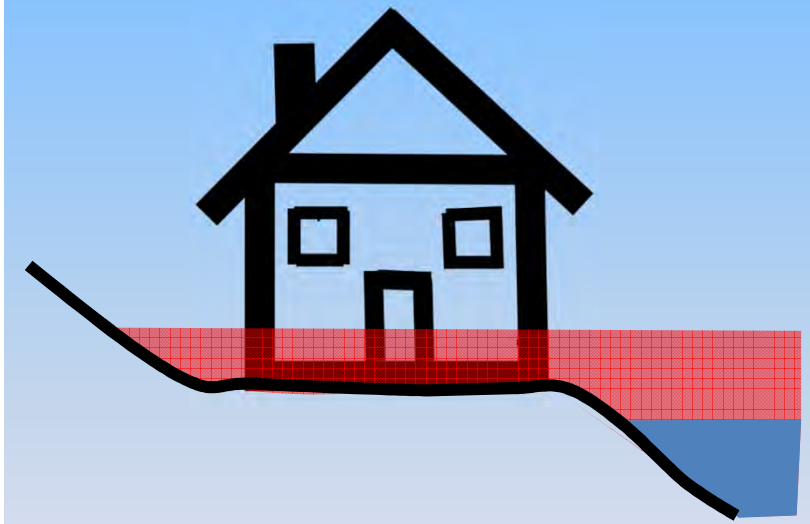
INCREMENTAL HAZARD EVALUATION

No Additional Hazard

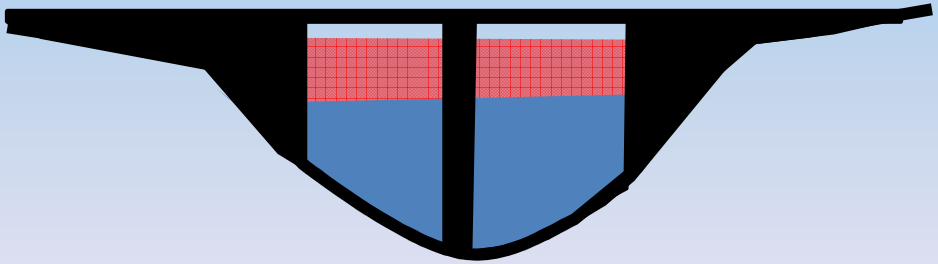
Incremental depth of flooding

INCREMENTAL HAZARD EVALUATION

Additional Hazard



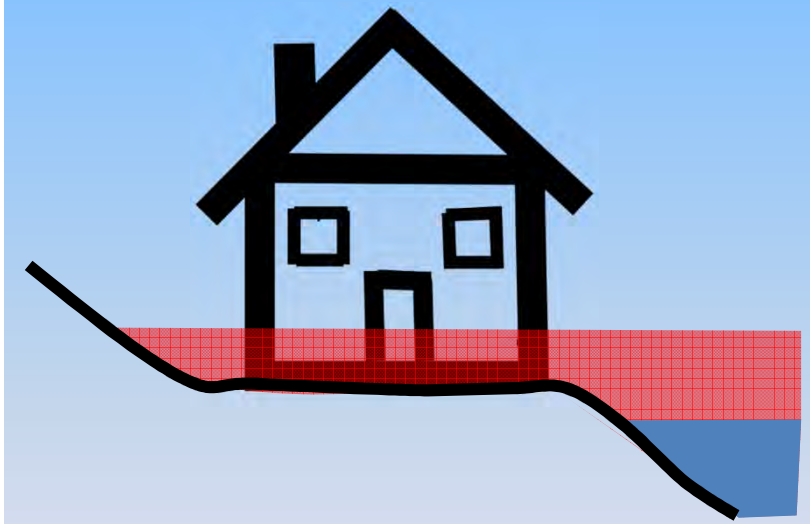
No Additional Hazard



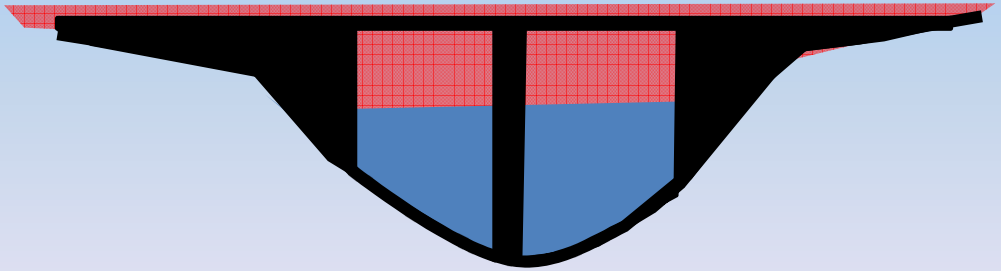
Incremental depth of flooding

INCREMENTAL HAZARD EVALUATION

Additional Hazard

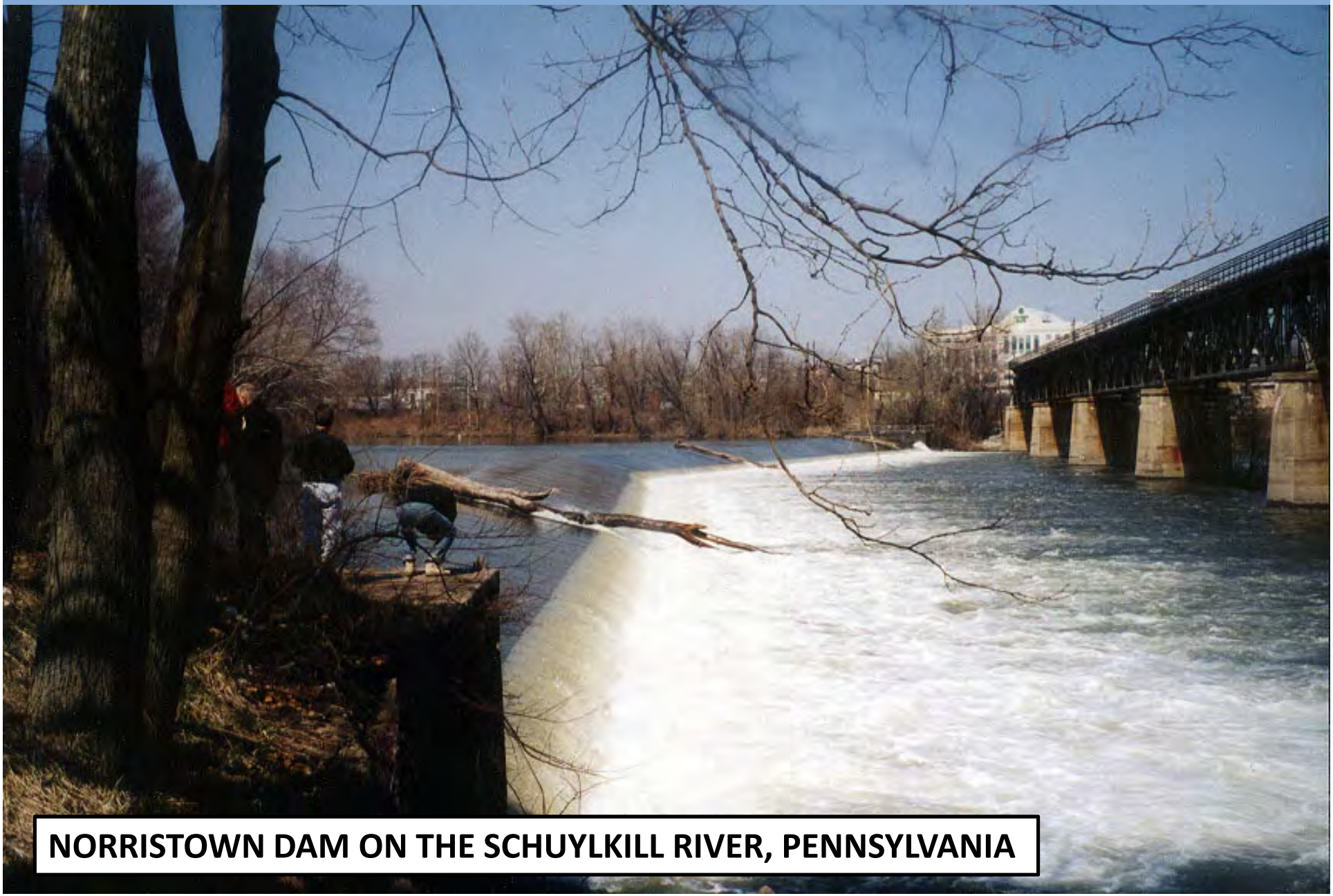


Additional Hazard



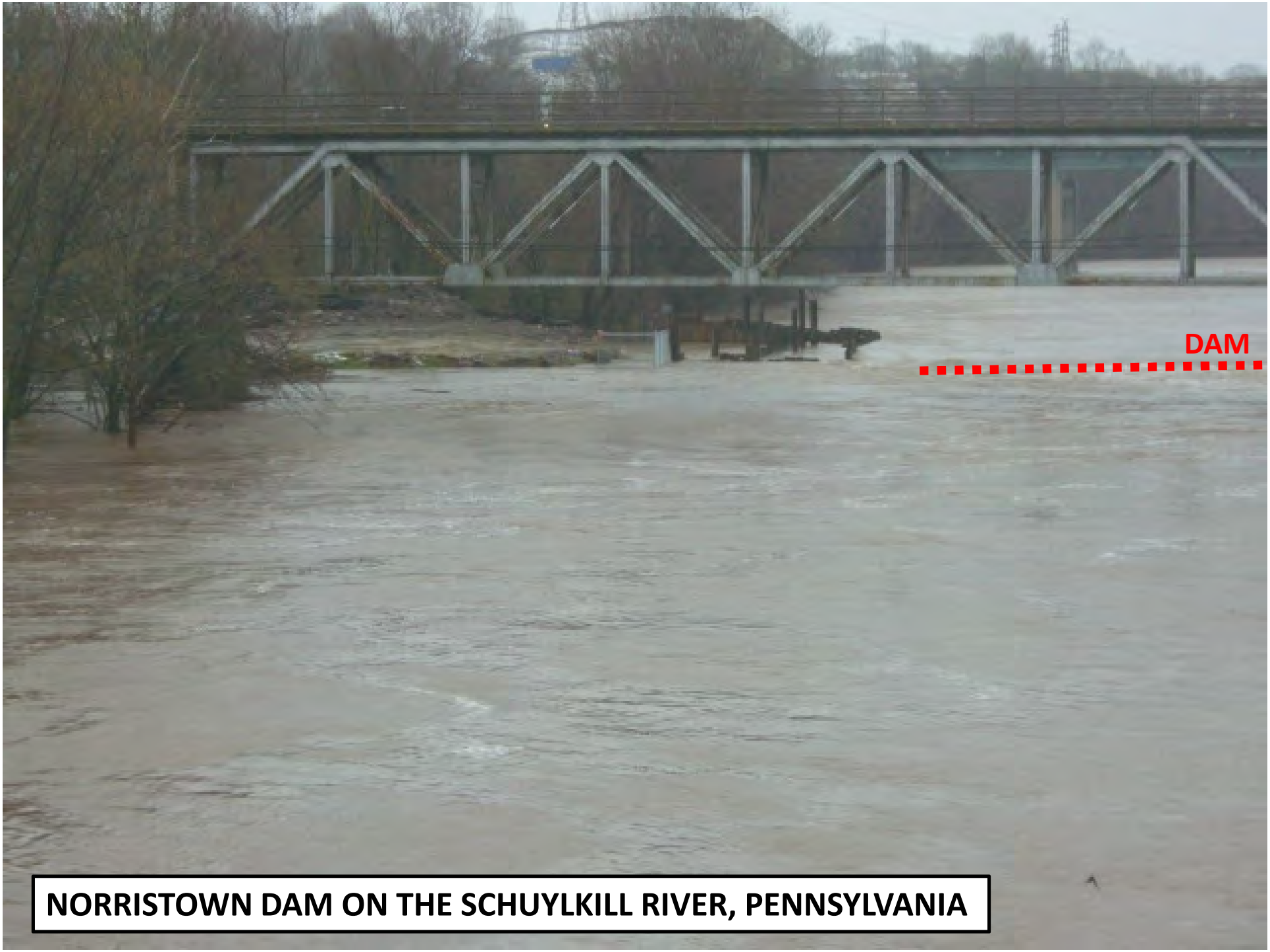
Incremental depth of flooding

INCREMENTAL HAZARD EVALUATION



NORRISTOWN DAM ON THE SCHUYLKILL RIVER, PENNSYLVANIA

NORRISTOWN DAM ON THE SCHUYLKILL RIVER, PENNSYLVANIA



NORRISTOWN DAM ON THE SCHUYLKILL RIVER, PENNSYLVANIA

OWNERSHIP OF THE DAM

Milltown Dam was constructed in 1923-1924 as a water supply reservoir by the Borough of West Chester. Original Dam Permit was issued by DEP on February 22, 1921.

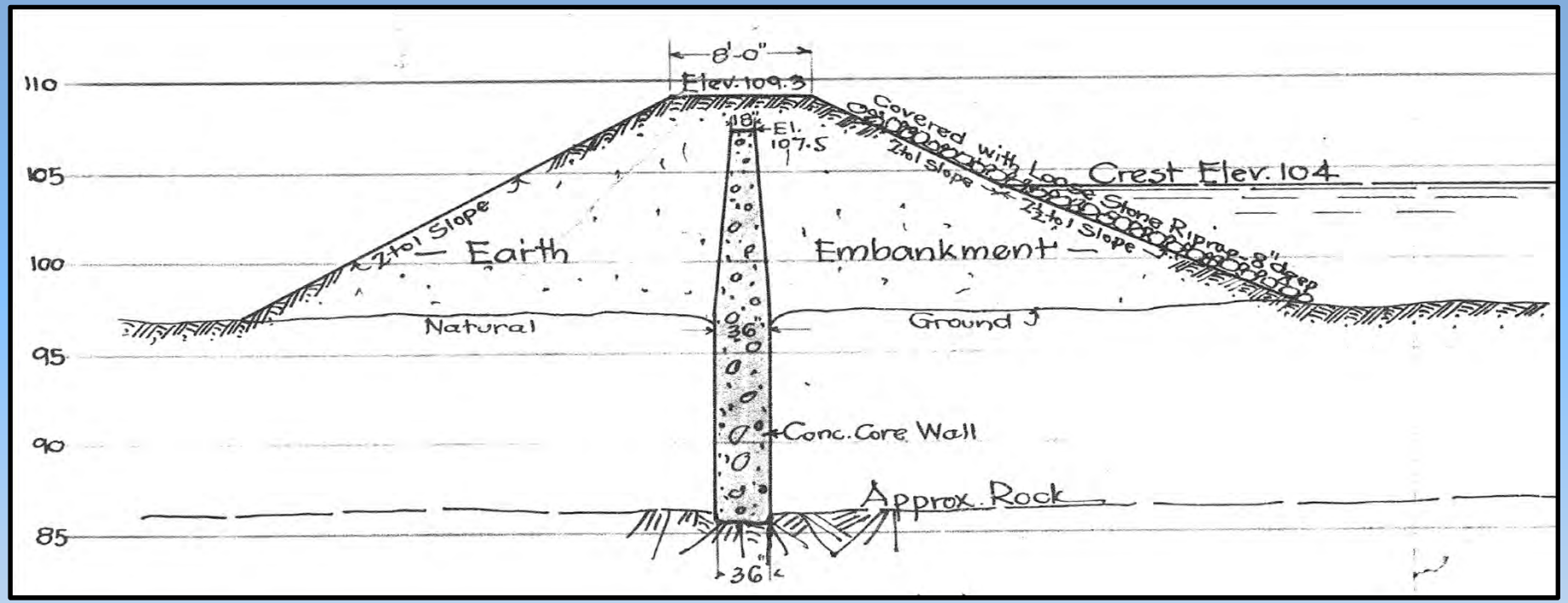
Ownership transferred to West Chester Area Municipal Authority (WCAMA).

By 1961 heavy sedimentation reduces functionality of structure as a water supply reservoir.

In 1984, WCAMA transfers ownership of dam to Mr. Robert Wiggins

In 1985, Mr. Wiggins grants a 19.5± acre parcel containing Milltown Dam to East Goshen Township

ORIGINAL DESIGN & CONSTRUCTION
TYPICAL EMBANKMENT CROSS SECTION



From 1923 Construction Drawings:

Upstream Slope:	**2H:1V Above Normal Pool**
	2.5H:1V Below Normal Pool
Downstream Slope:	**2H:1V**
Top Width:	**8-Feet**
Concrete Core Wall:	**Width Varies from 18-Inches to 36-Inches**


ERIE

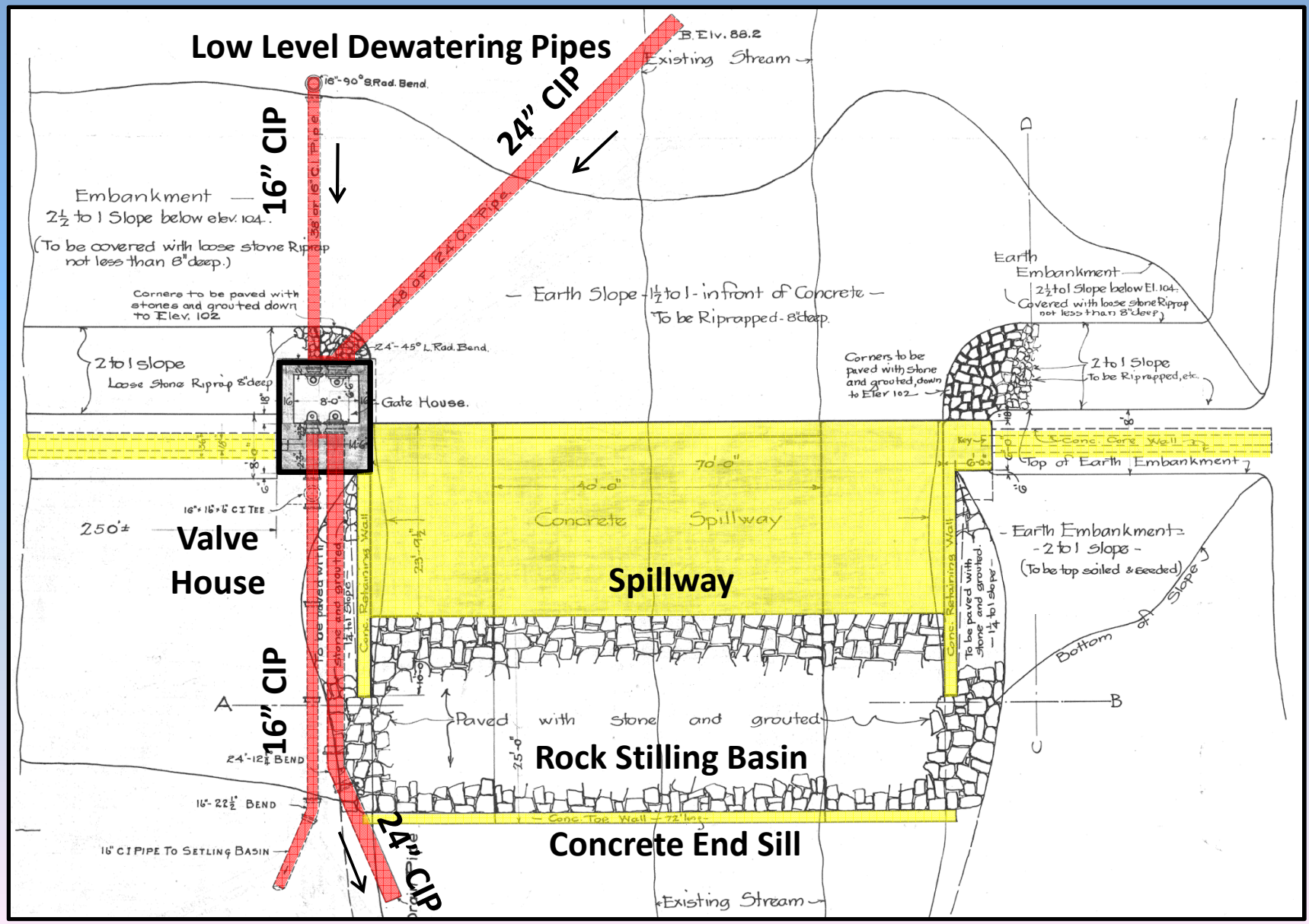
Construction Inspection
July 17, 1923

"Work was in progress… …on excavation for the cut-off wall in the spillway. The foundation approved at this location is 70 feet in length and with an average depth of 15 feet below natural ground surface. The character of this material is a very hard gneissic rock, with tight seams.

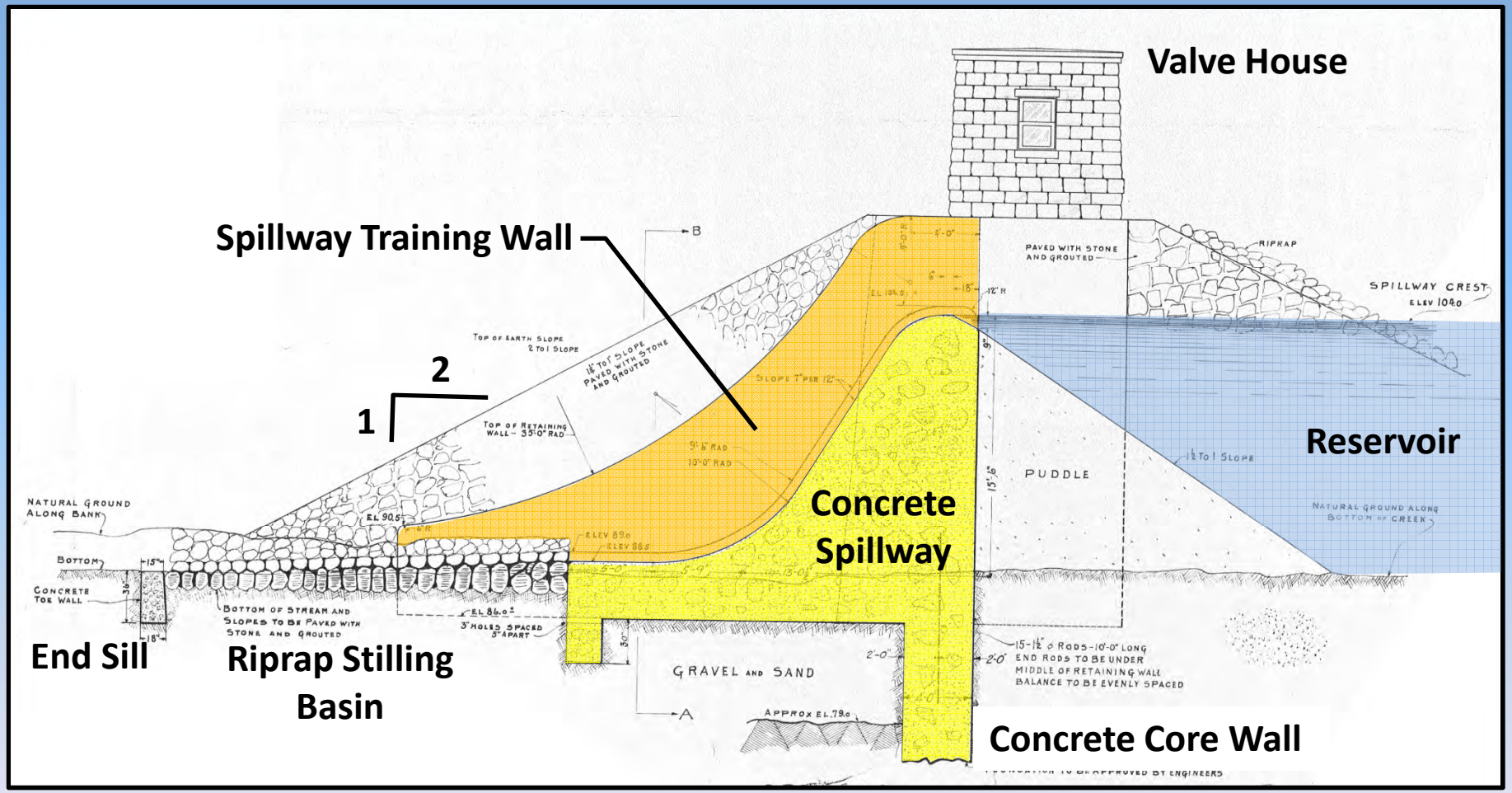
Excavation has been carried through all large boulders and loose seamy stone to what appeared to be bed rock. No seepage was noticed through the upstream side wall, except at where the stream channel intersects the trench."

B.A. Knight, Asst. Engineer

ORIGINAL DESIGN & CONSTRUCTION
PLAN VIEW OF PRINCIPAL SPILLWAY



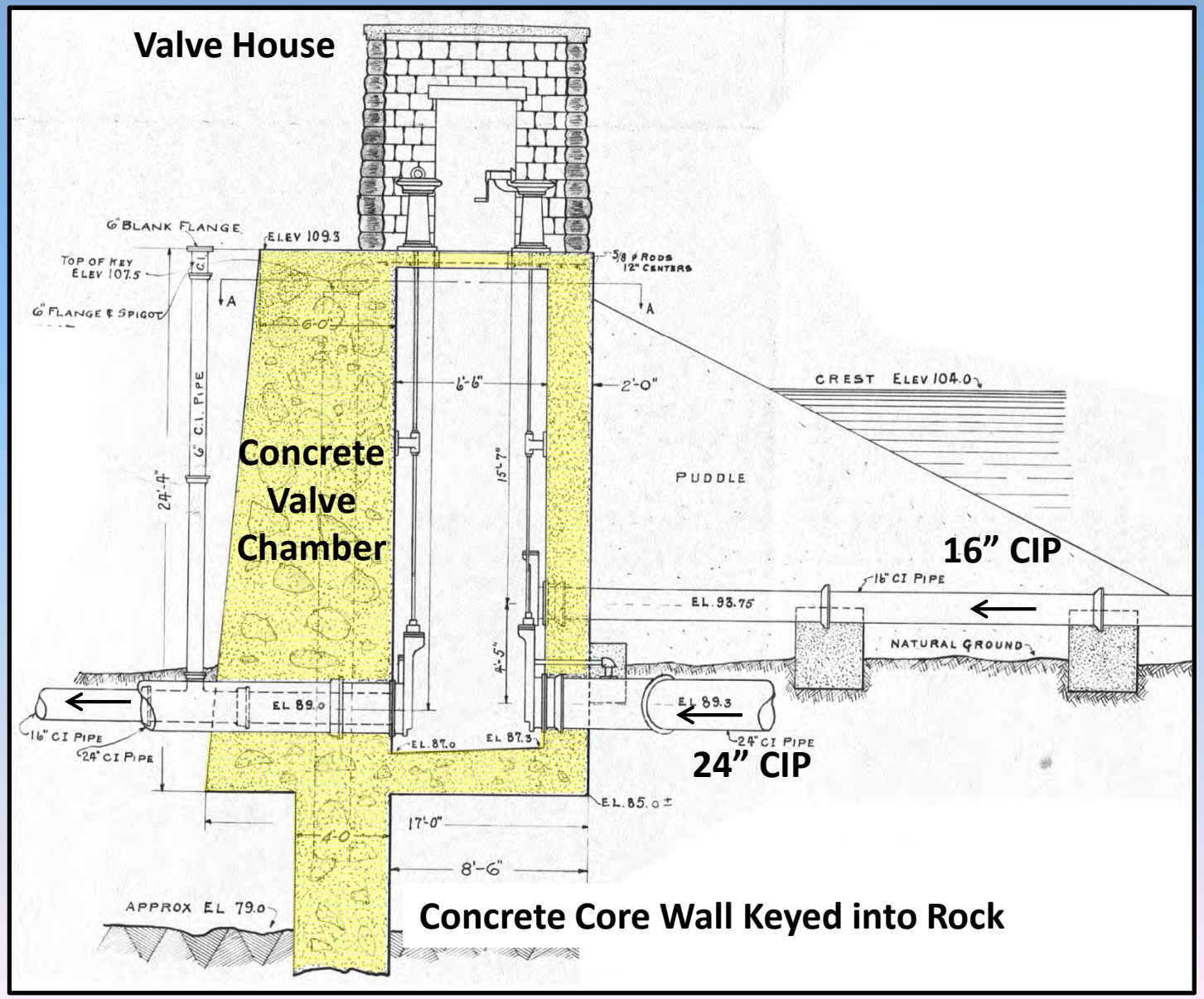
ORIGINAL DESIGN & CONSTRUCTION
TYPICAL SPILLWAY CROSS SECTION



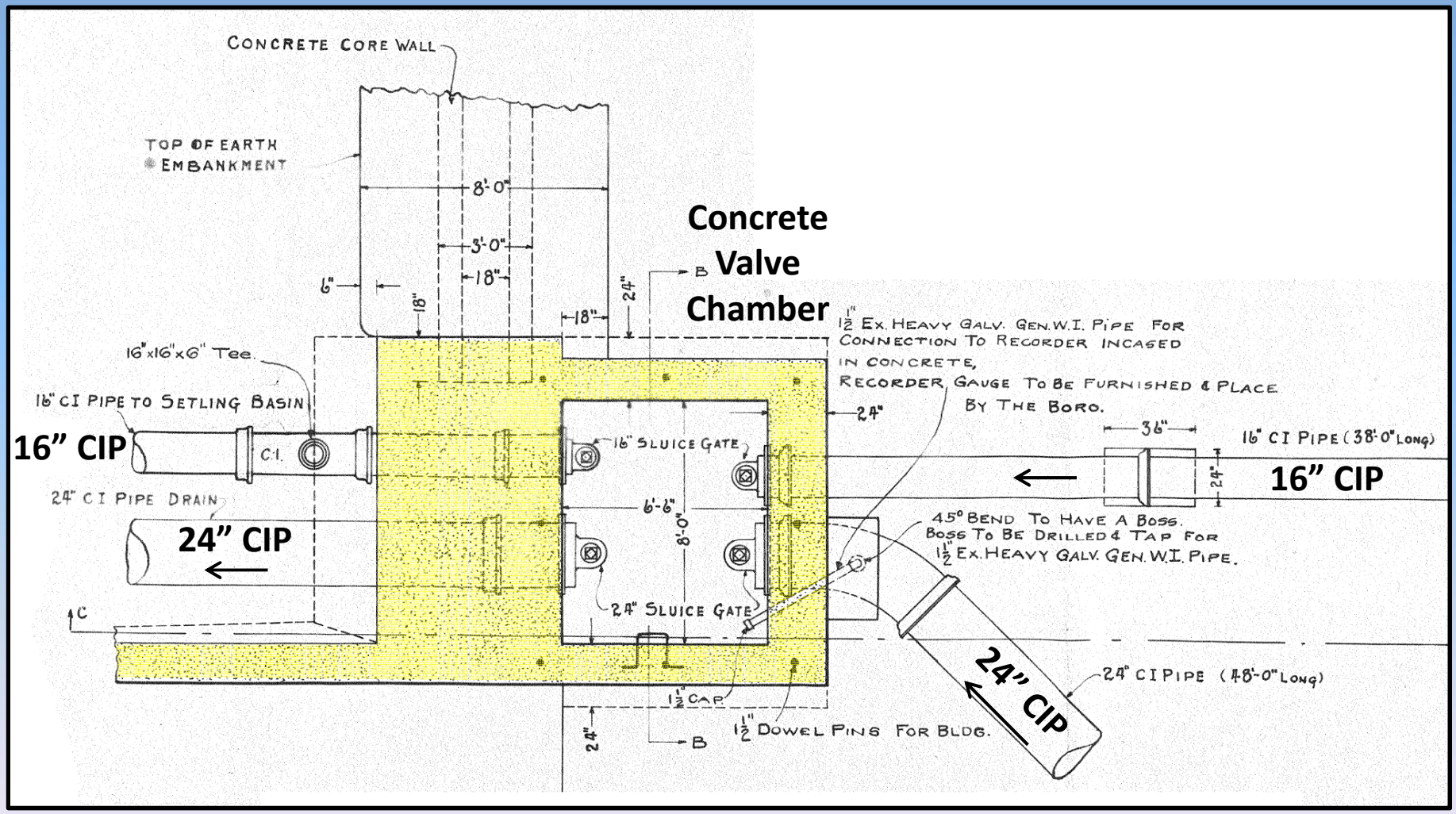
PRINCIPAL SPILLWAY AND LOW FLOW NOTCH

Photograph Taken on August 4, 2015

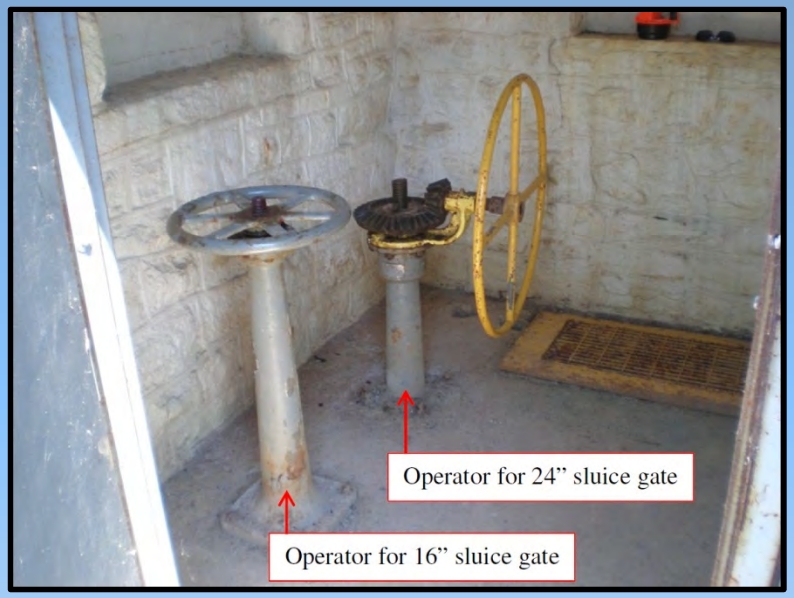
ORIGINAL DESIGN & CONSTRUCTION
VALVE CHAMBER CROSS SECTION

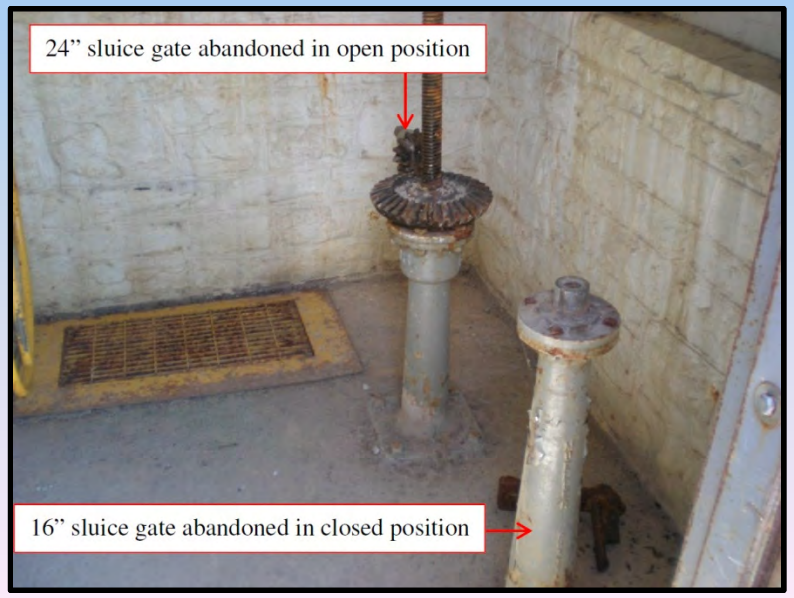


ORIGINAL DESIGN & CONSTRUCTION
VALVE CHAMBER PLAN VIEW



VALVE HOUSE





Photographs Taken on August 4, 2015

PAST MODIFICATIONS

1985 – Spillway and Embankment Rehabilitation Project

1997 – Addition of Trash Racks to Low Level Intake Conduits

2008 – Left Embankment Raised 18-Inches by Adding Riprap

2012 – Slush Grouting of Riprap on Downstream Right Embankment

2013 – Surface Concrete Repairs on Principal Spillway

2015 – Valve Stem and Guides Replaced on 24-Inch Sluice Gate

1985 IMPROVEMENTS

REPAIR WORK
FOR
MILLTOWN DAM

PREPARED FOR:

EAST GOSHEN TOWNSHIP

1580 PAOLI PIKE, WEST CHESTER, PA. 19380
215 - 692 - 7171

PREPARED BY:

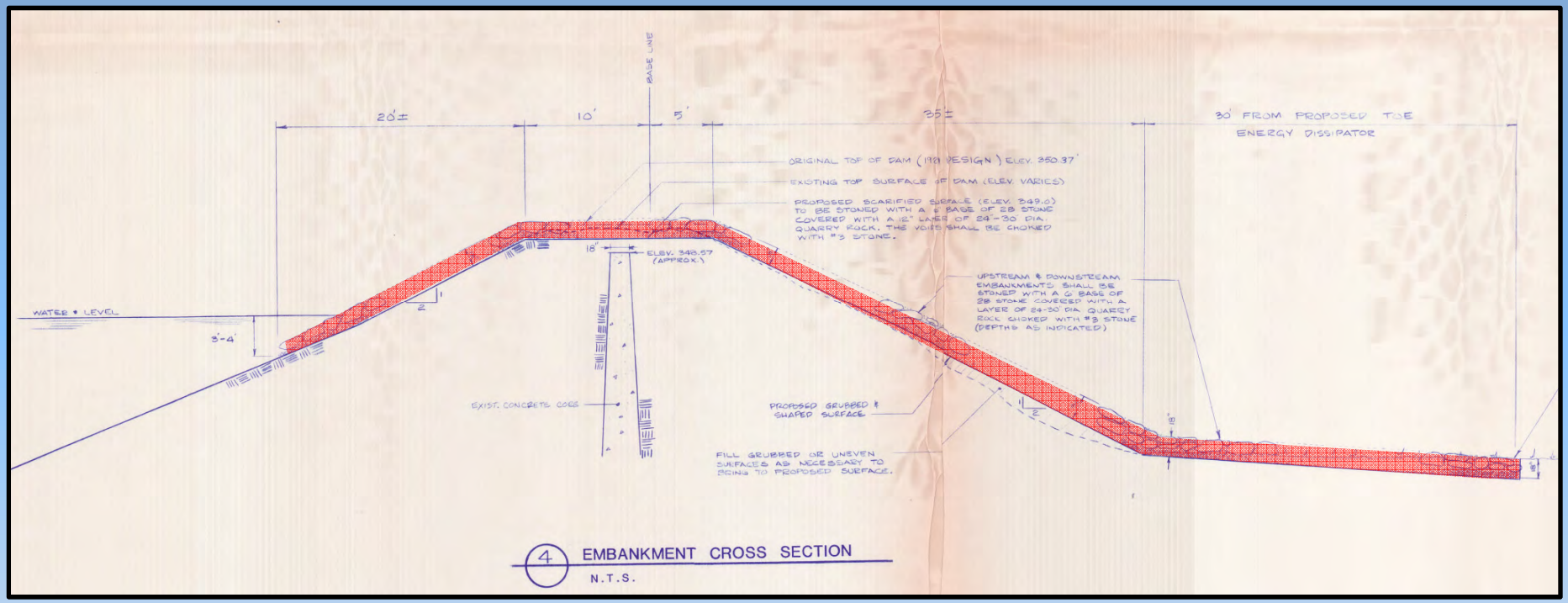
YERKES ASSOCIATES INC.

SITE PLANNERS, LANDSCAPE ARCHITECTS, CONSULTING ENGINEERS, SURVEYORS
1444 PHOENIXVILLE PIKE, W. CHESTER, PA. 19380
215 - 644 - 4254

ISSUED
JAN 3 1985
YERKES ASSOC. INC.

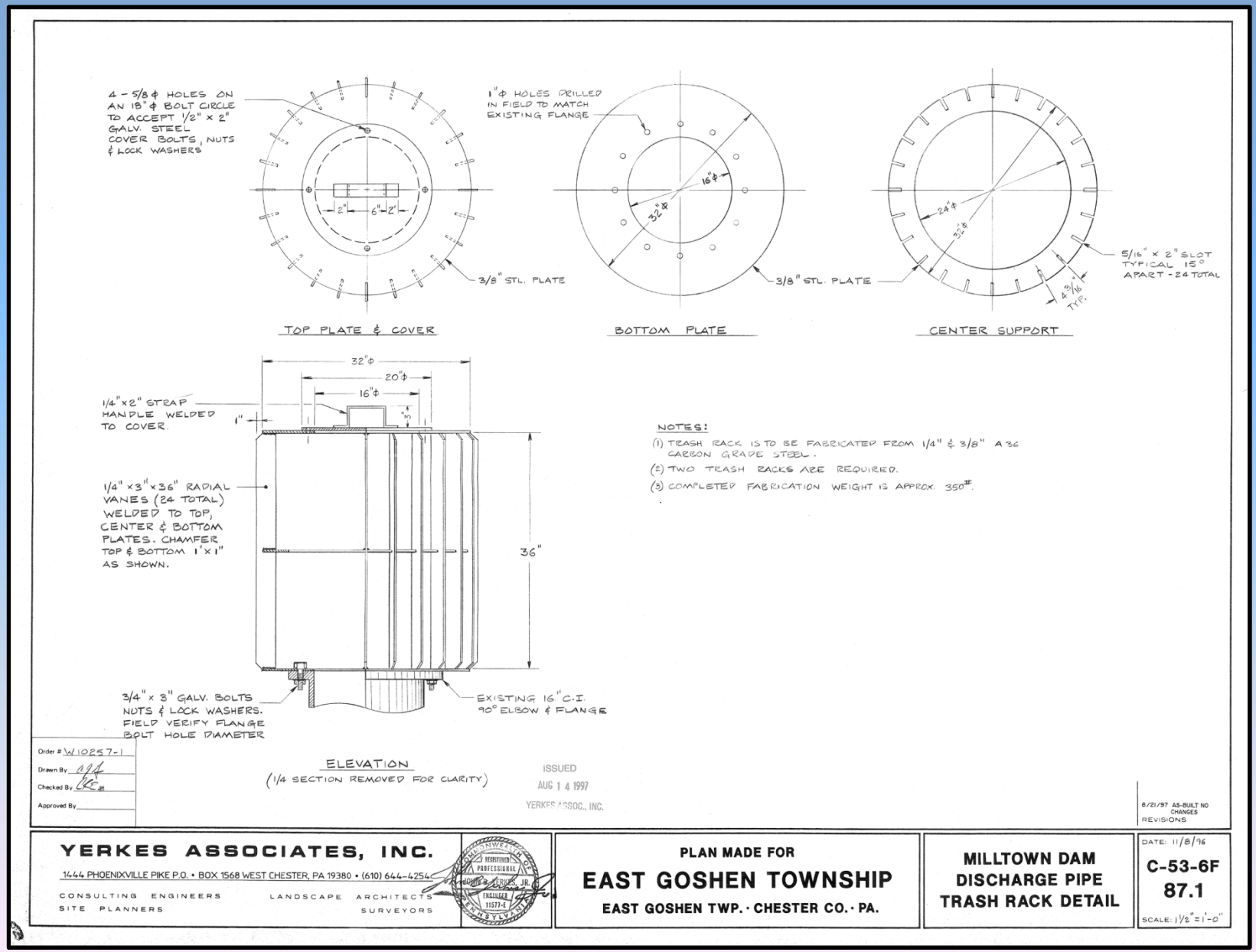
53-74

1985 IMPROVEMENTS



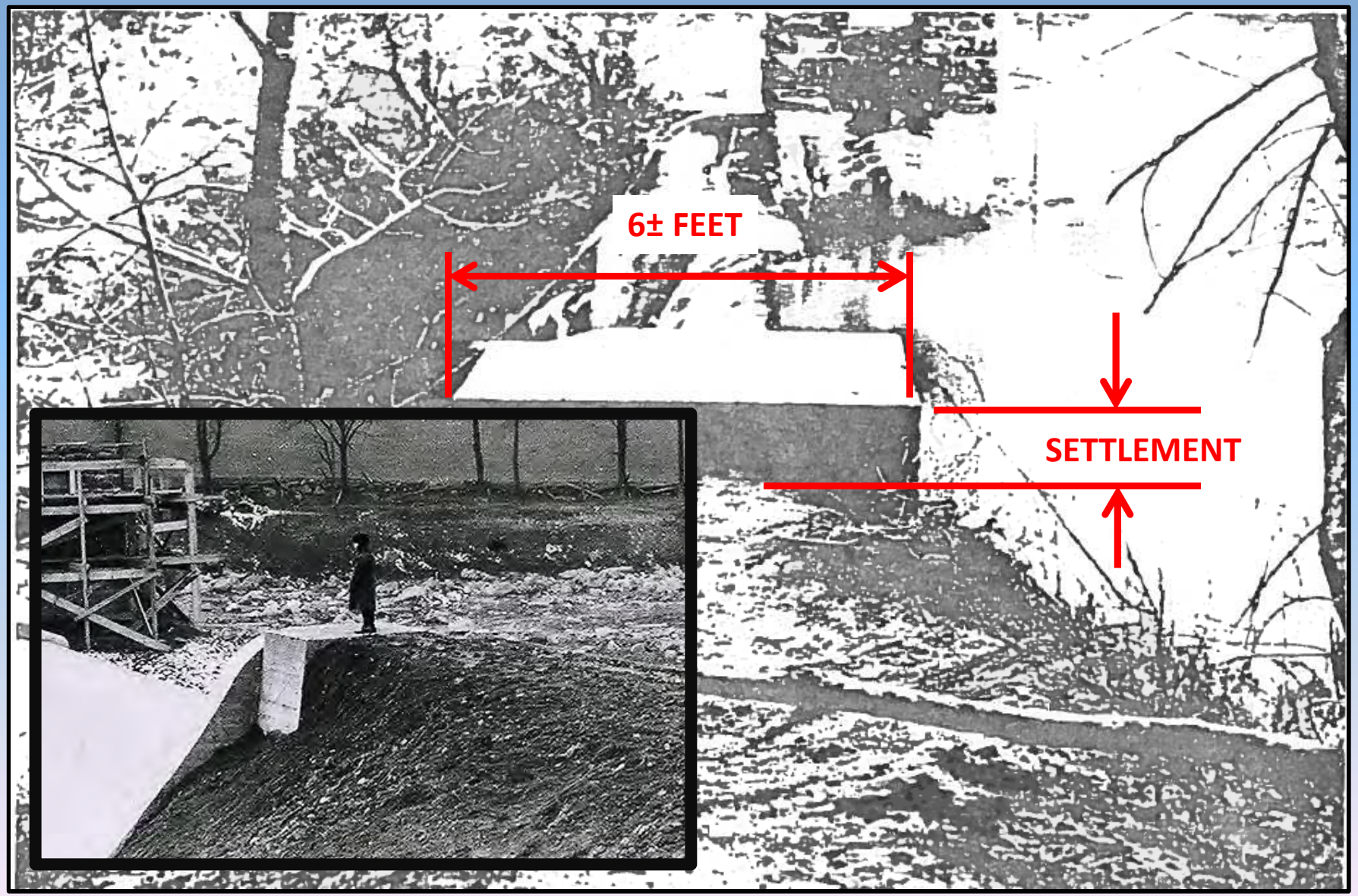
- Surface Embankments with Riprap
- Reconstruct upper Portion of Left and Right Spillway Training Walls
- Reconstruct Principal Spillway Areas Located Outside of Low Flow Notch
- Replace Dislodged Riprap Below Principal Spillway

1997 IMPROVEMENTS




EERE

2008 IMPROVEMENTS



Photograph from 1981 Phase I Report

2008 IMPROVEMENTS

Left Embankment Raised 18” by Adding Riprap

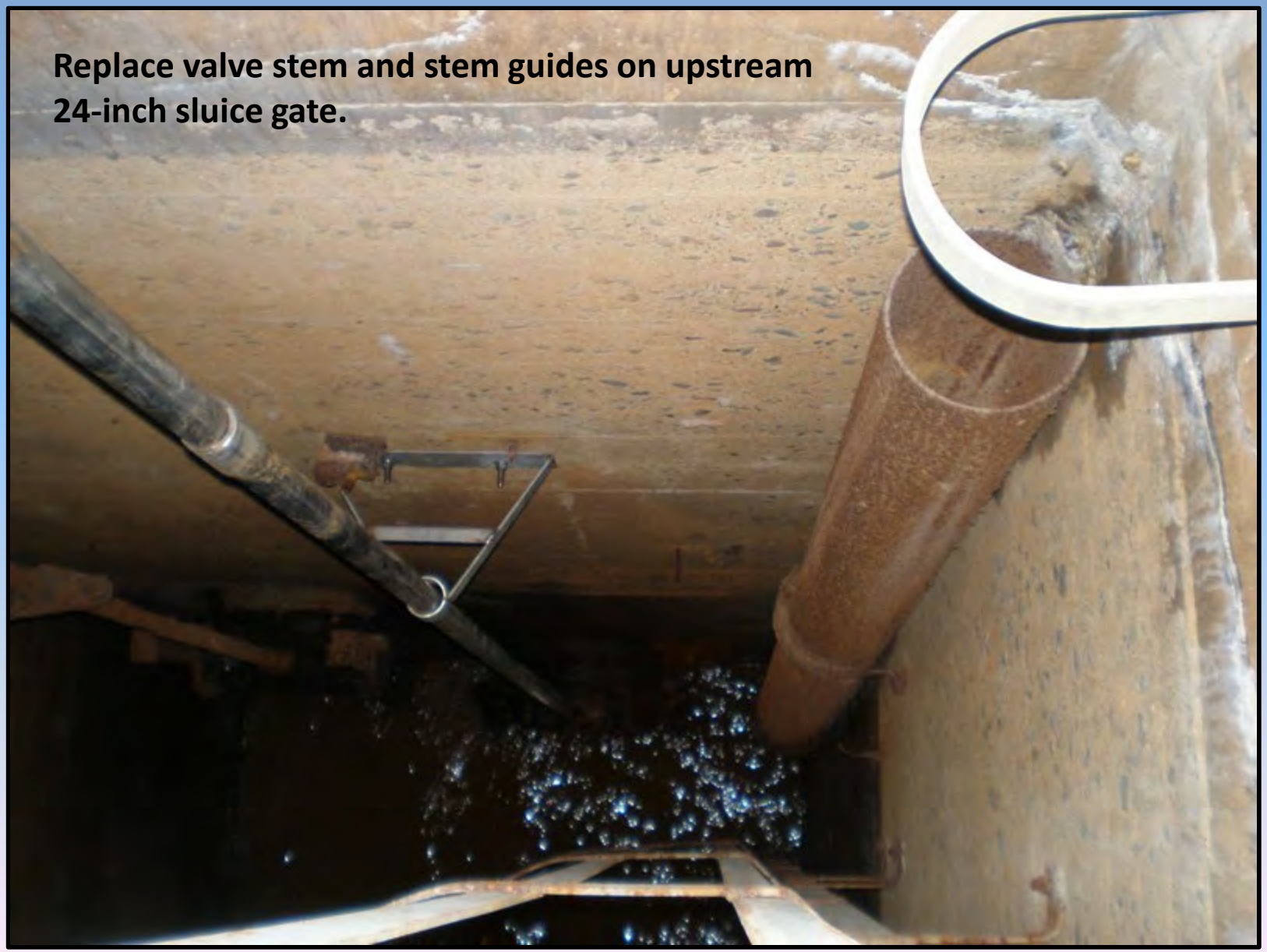
2012 IMPROVEMENTS

Slush Grouting of Riprap on Downstream Right Embankment

2013 IMPROVEMENTS

Application of liquid applied urethane coating to principal spillway surfaces.
CIM 1000 Product by C.I.M. Industries, Inc.

2015 IMPROVEMENTS



OPERATION AND MAINTENANCE COSTS

Table 6-1
Summary of Anticipated Operation and Maintenance Costs
(2015 Base Year Planning Level Costs)

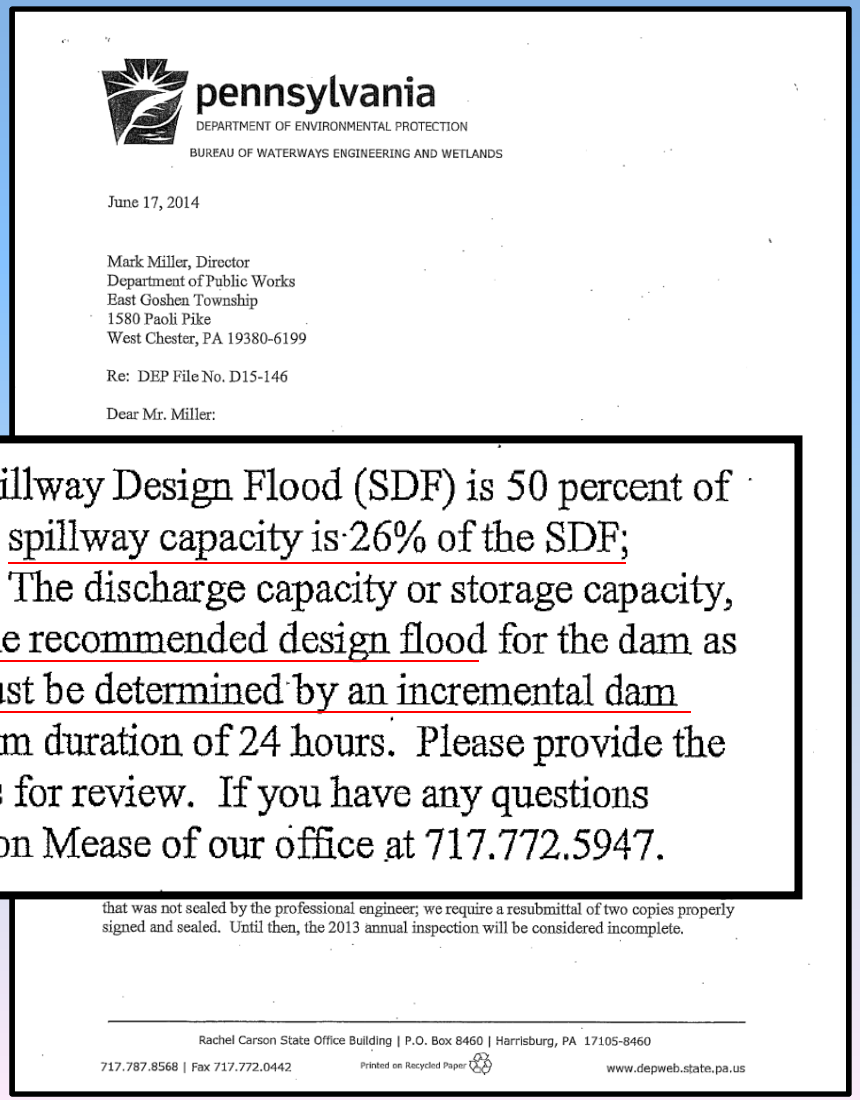
Capital Expenditure Item Description	Assumed Cost
Regulatory Compliance Items	
1. Annual Dam Inspection (Once per Year)	$3,000
2. Update Emergency Action Plan (Once Every 5 Years)	$5,000
3. Outlet Works Inspection (Once Every 10 Years)	$15,000
Routine Operation and Maintenance Items	
1. Site Visits to the Dam (Weekly)	$4,350
2. Weed & Brush Control (Twice per Year)	$2,900
3. Exercise Valves (Four Times per Year)	$500
4. EAP Monitoring (Assume Two Storms per Year)	$950
Present Worth Regulatory/O&M Cost (10-Year Life):*	**$153,500**
Present Worth Regulatory/O&M Cost (20-Year Life):*	**$340,300**
Present Worth Regulatory/O&M Cost (30-Year Life):*	**$567,500**
Deferred Operation and Maintenance Costs	
1. Removal of Vegetation (per 2015 Annual Inspection)	$6,100
2. Repair Chain Link Fence (per 2015 Annual Inspection)	$400
3. Repair Concrete Spalls (per 2015 Annual Inspection)	$1,200
4. Replace Dislodged Riprap below Spillway	$10,000
5. Replace Sluice Gates (2) within Valve Chamber	$90,000
6. Prepare Operation and Maintenance Manual	$10,000
7. Instrumentation and Site Security	$6,000
Total Deferred Operation and Maintenance Costs:	**$123,700**
Total Present Worth O&M Cost (10-Year Life):**	**$277,200**
Total Present Worth O&M Cost (20-Year Life):**	**$464,000**
Total Present Worth O&M Cost (30-Year Life):**	**$691,200**

Notes: *Life Cycle Costs assume a 3% Inflation Rate and a 1% Rate of Return.
**Total Present Worth O&M Cost = O&M Life Cycle Cost+Deferred O&M Cost.

KNOWN DEFICIENCIES

INADEQUATE SPILLWAY CAPACITY

DEP Letter to Township dated June 17, 2014



pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATERWAYS ENGINEERING AND WETLANDS

June 17, 2014

Mark Miller, Director
Department of Public Works
East Goshen Township
1580 Paoli Pike
West Chester, PA 19380-6199

Re: DEP File No. D15-146

Dear Mr. Miller:

According to the August 1981 Phase 1 report, the Spillway Design Flood (SDF) is 50 percent of the Probable Maximum Flood (PMF). However, the spillway capacity is 26% of the SDF; meaning the spillway is inadequate to pass the SDF. The discharge capacity or storage capacity, or both, must be capable of safely accommodating the recommended design flood for the dam as classified under chapter 105.91. The design flood must be determined by an incremental dam breach analysis with a minimum required design storm duration of 24 hours. Please provide the Department with an incremental dam breach analysis for review. If you have any questions regarding the incremental breach analysis, contact Ron Mease of our office at 717.772.5947.

that was not sealed by the professional engineer; we require a resubmittal of two copies properly signed and sealed. Until then, the 2013 annual inspection will be considered incomplete.

Rachel Carson State Office Building | P.O. Box 8460 | Harrisburg, PA 17105-8460
717.787.8568 | Fax 717.772.0442 Printed on Recycled Paper www.depweb.state.pa.us

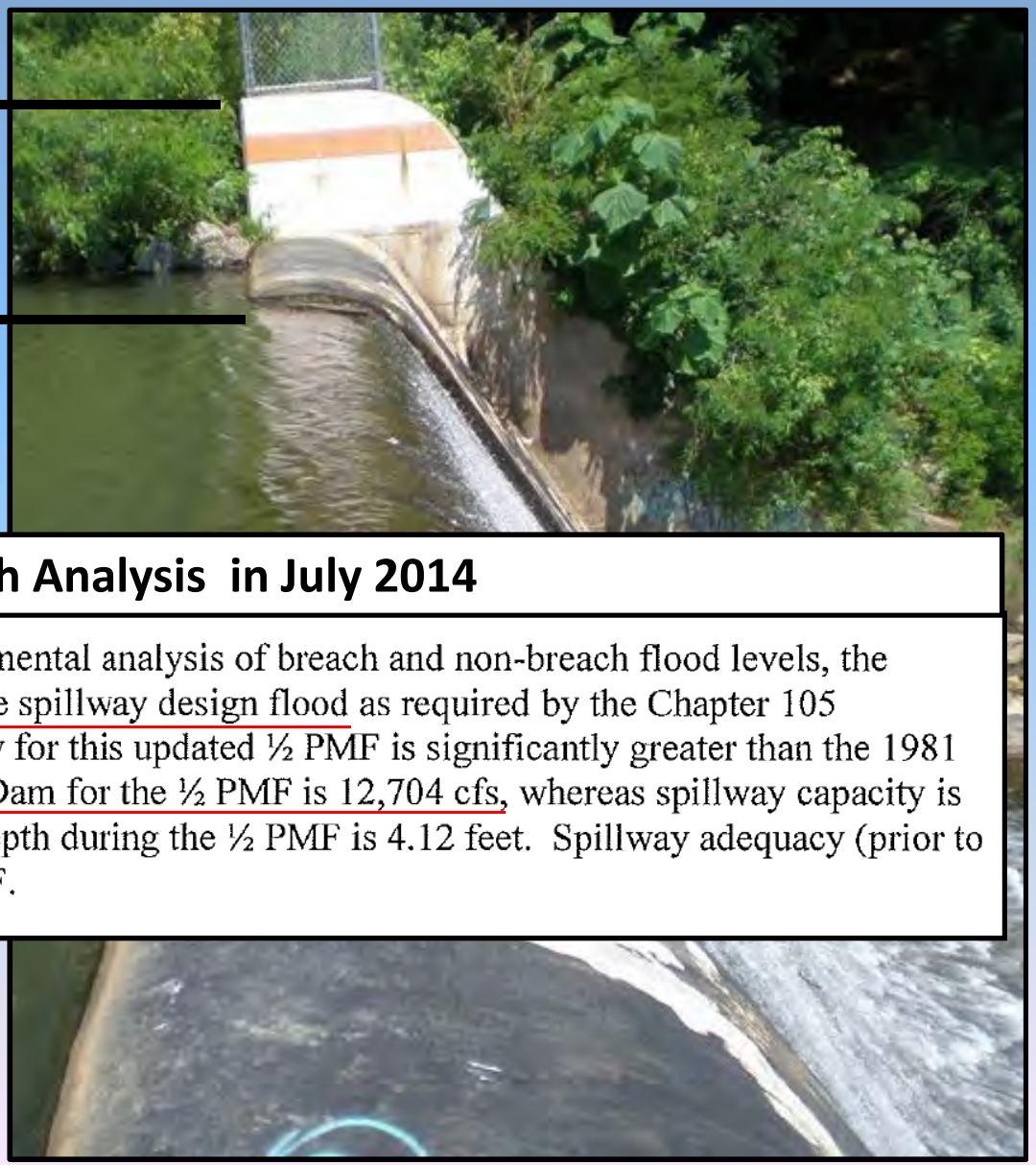
INADEQUATE SPILLWAY CAPACITY

Design Top or Dam El. 347.5

5.3’

Normal Pool El. 342.2

Calculated Spillway Capacity:
3,080± cfs



DEP Conducts Incremental Breach Analysis in July 2014

Based on the results of this “in-house” incremental analysis of breach and non-breach flood levels, the updated ½ PMF appears to be the appropriate spillway design flood as required by the Chapter 105 regulations (Section 105.98). This peak flow for this updated ½ PMF is significantly greater than the 1981 design flood. The peak inflow to Milltown Dam for the ½ PMF is 12,704 cfs, whereas spillway capacity is approximately 3000 cfs. The overtopping depth during the ½ PMF is 4.12 feet. Spillway adequacy (prior to overtopping) was determined to be 0.14 PMF.

SDF (1/2 PMF) = 12,700 cfs
Spillway can pass 0.14 PMF
Dam Overtopped by 4.1 feet

INADEQUATE SPILLWAY CAPACITY

1

PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND, AREA IN SQUARE MILES
TIME TO PEAK IN HOURS

OPERATION	STATION	AREA	PLAN		RATIOS APPLIED TO FLOWS RATIO 1 1.00
HYDROGRAPH AT					
+	AREA1	2.67	1	FLOW	2920.
				TIME	12.83
			2	FLOW	2920.
				TIME	12.83
ROUTED TO					
+	TLDAM	2.67	1	FLOW	992.
				TIME	14.08
			2	FLOW	992.
				TIME	14.08
			** PEAK STAGES IN FEET **		
			1	STAGE	417.01
				TIME	14.08
			2	STAGE	417.01
				TIME	14.08
HYDROGRAPH AT					
+	AREA2	3.67	1	FLOW	2851.
				TIME	13.75
			2	FLOW	2851.
				TIME	13.75
2 COMBINED AT					
+	COMB	6.34	1	FLOW	3821.
				TIME	13.83
			2	FLOW	3821.
				TIME	13.83
ROUTED TO					
+	MTDAM	6.34	1	FLOW	3568.
				TIME	14.25
			2	FLOW	9985.
				TIME	14.67
			** PEAK STAGES IN FEET **		
			1	STAGE	349.52
				TIME	14.25
			2	STAGE	349.52
				TIME	14.20

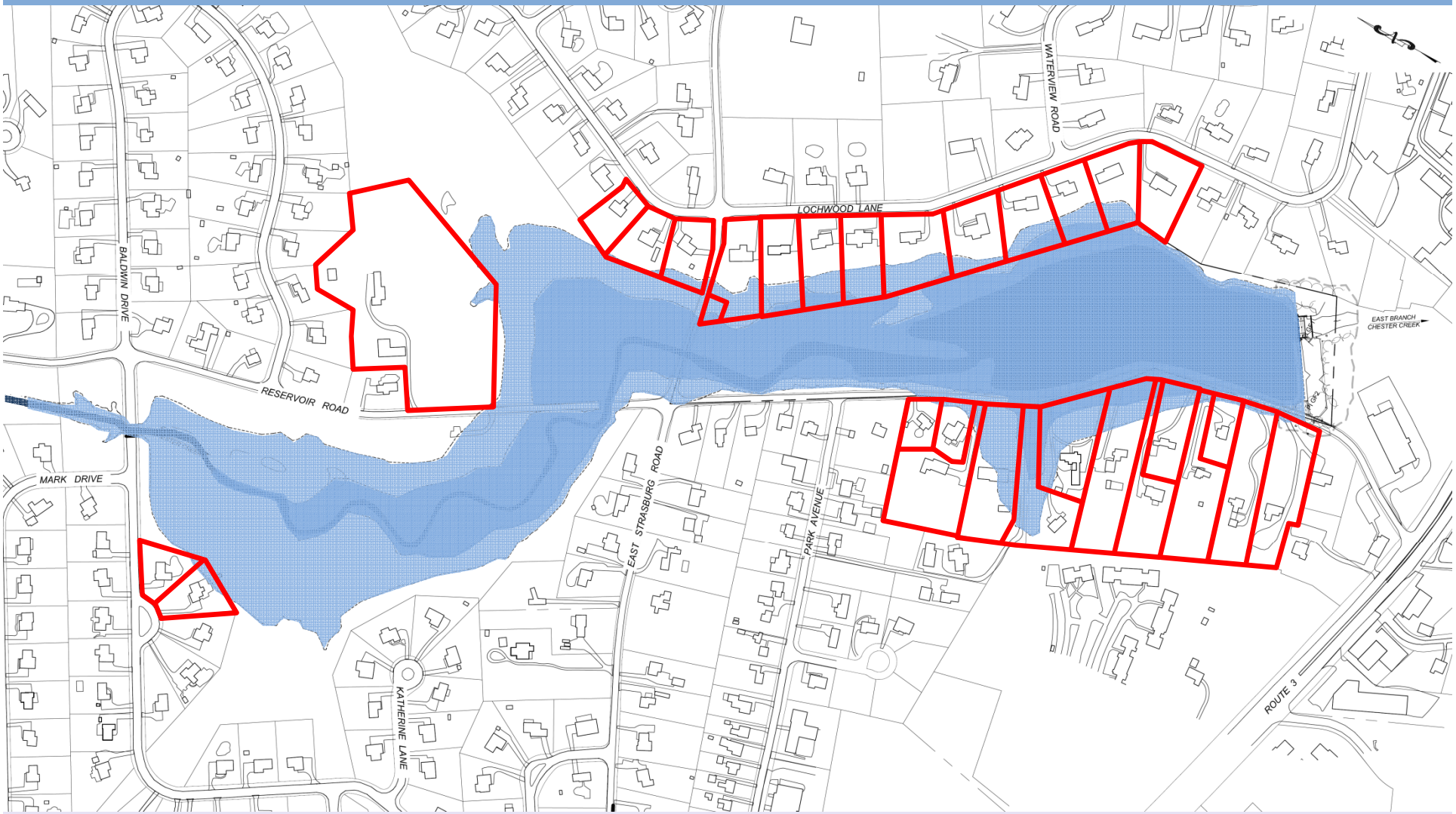
Routing of the 100-Year Storm

Peak Inflow = 3,820 cfs

Peak Outflow = 3,568 cfs

6.5%± Reduction

RESERVOIR INUNDATION AREA



Top of Dam El. 347.5 – 14 Properties impacted

Overtopping depth of 4.1 feet during the Spillway Design Flood – 29 Properties impacted

AREAS OF RISK

ERODIBLE MATERIAL UNDER SPILLWAY AND VALVE VAULT

STEEP SLOPES

RESERVOIR SEDIMENTATION

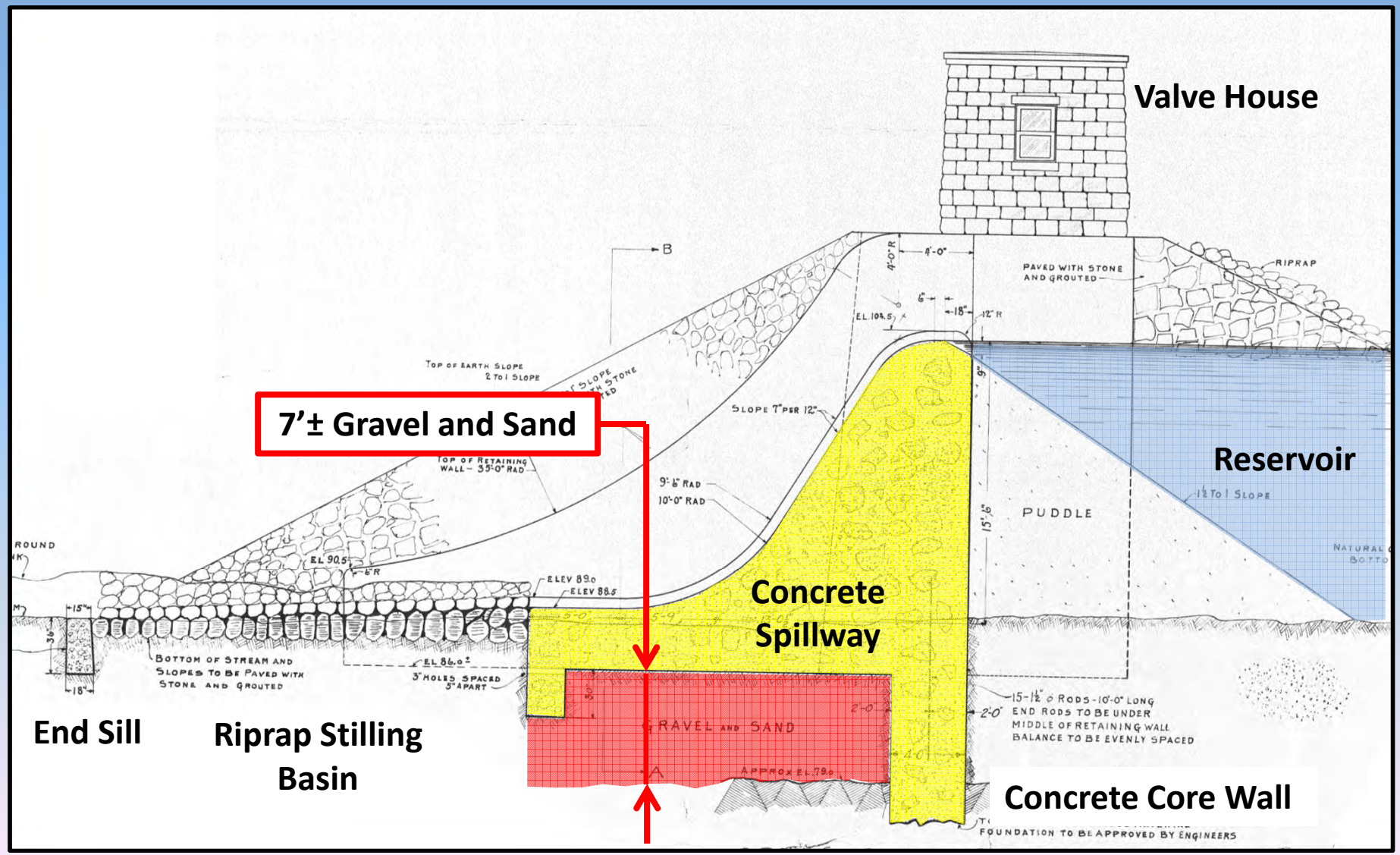
NO INTERNAL SEEPAGE COLLECTION SYSTEM

MAINTENANCE ACCESS TO LEFT EMBANKMENT

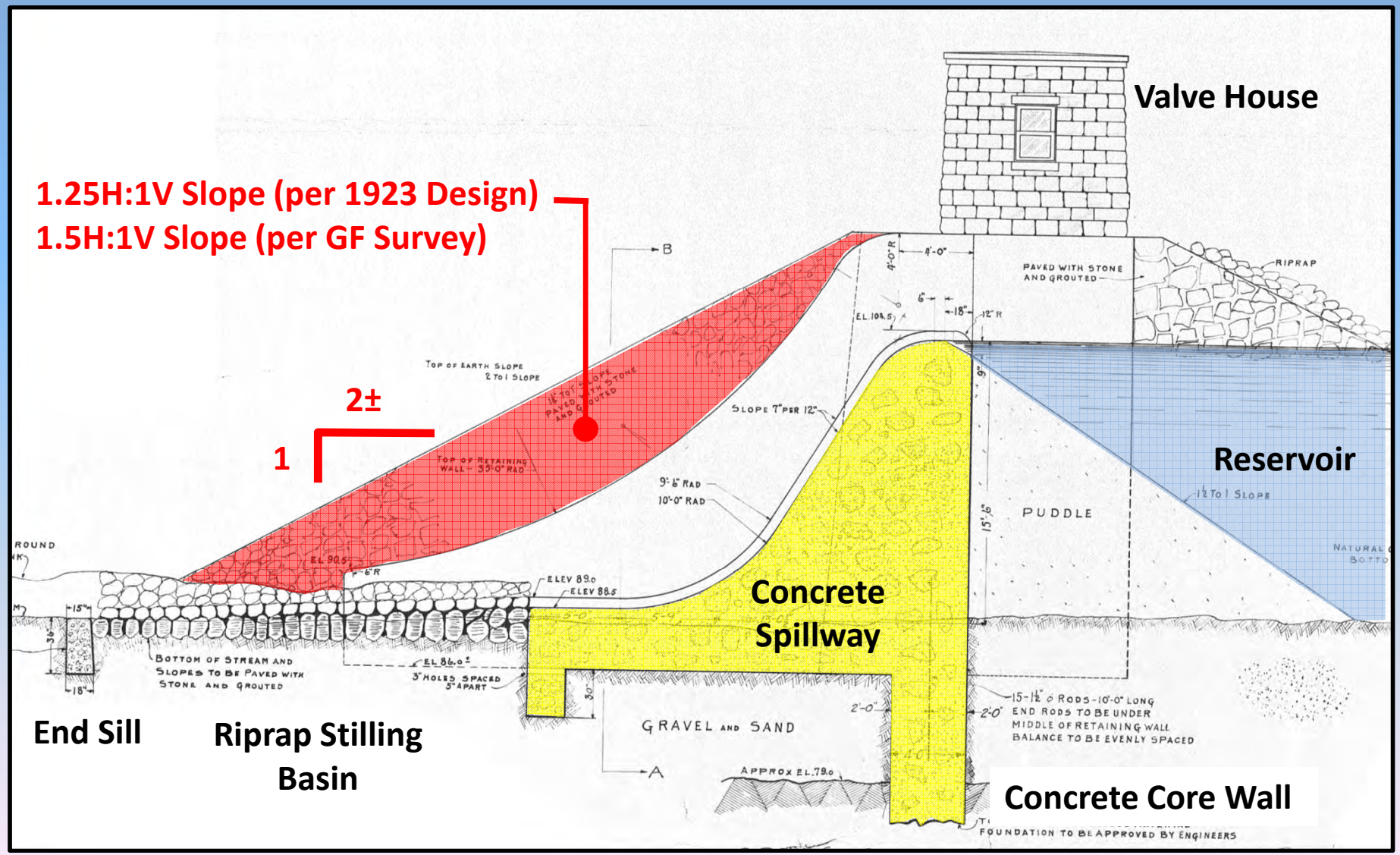
FILL AT CREST OF LEFT EMBANKMENT

ADDITIONAL SITE SECURITY AND PUBLIC SAFETY MEASURES

SPILLWAY AND VALVE VAULT FOUNDED ON ERODIBLE MATERIAL



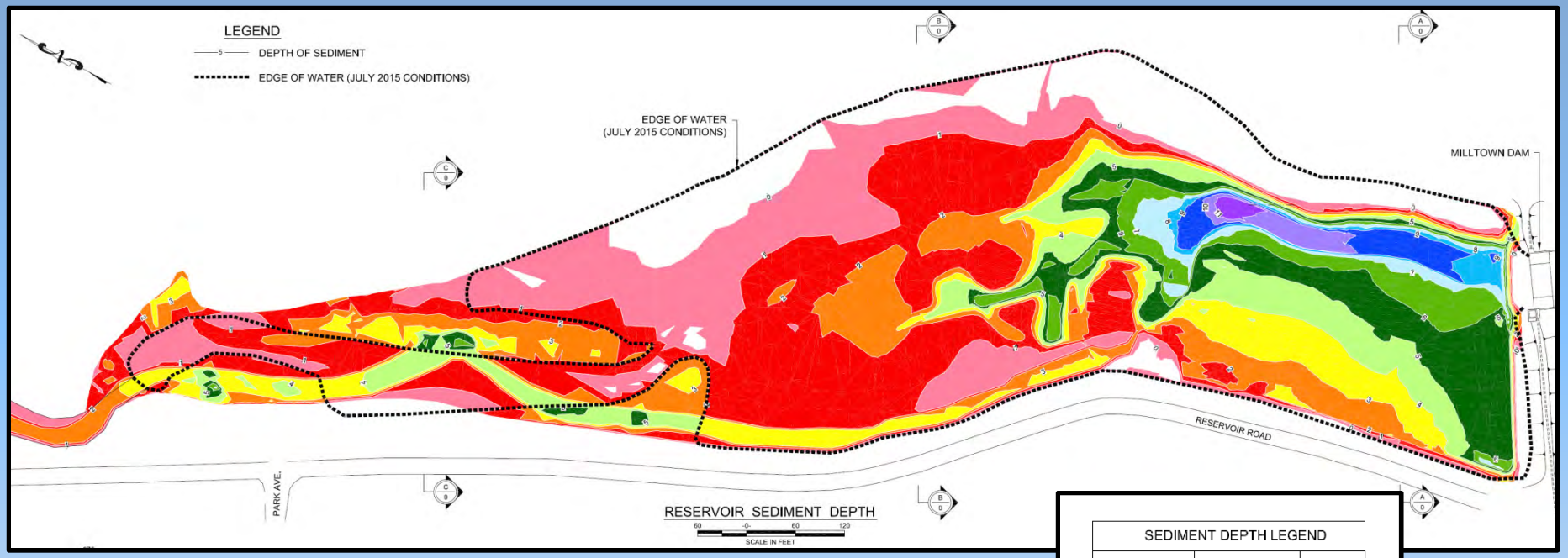
STEEP SLOPES ON DOWNSTREAM EMBANKMENT



STEEP SLOPES ON DOWNSTREAM EMBANKMENT

STEEP SLOPES ON DOWNSTREAM EMBANKMENT

RESERVOIR SEDIMENTATION



SEDIMENT DEPTH LEGEND		
MIN. DEPTH (FEET)	MAX. DEPTH (FEET)	COLOR
0	1.0	
1.0	2.0	
2.0	3.0	
3.0	4.00	
4.0	5.00	
5.00	6.0	
6.0	7.0	
7.0	8.0	
8.0	9.0	
9.0	10.0	
10.0	11.0	
11.0	12.0	

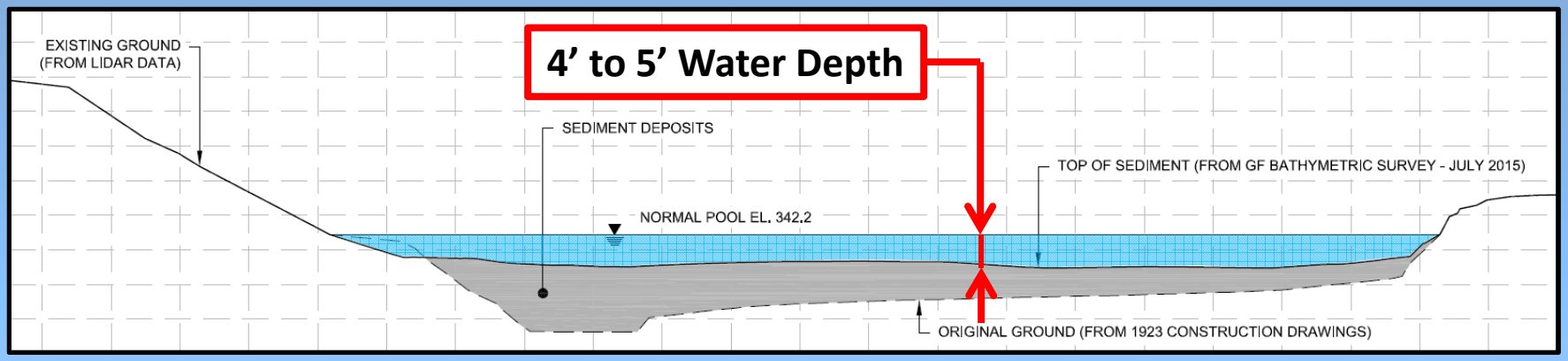
Bathymetric Survey Performed by Gannett Fleming in July 2015

Depth of Sediment as Compared to the Pre-Construction Contours Shown on the 1923 Construction Drawings

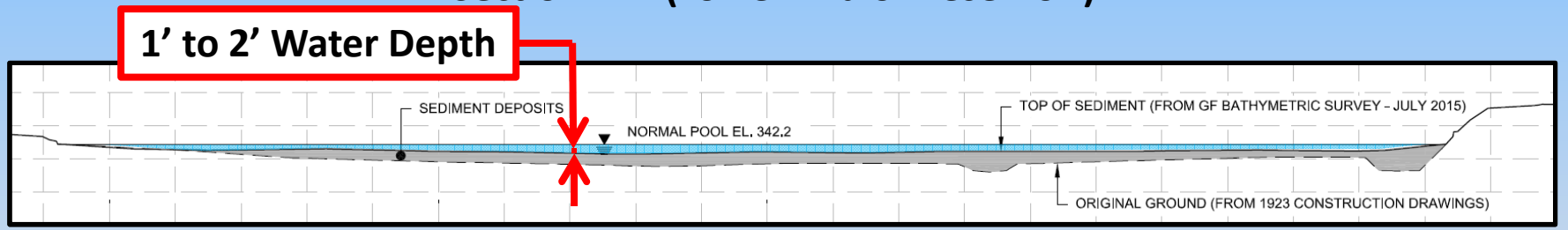
- **Approximately 29 acre-feet of sediment (46,800cy)**


22'±
5,850 Dump Trucks
(Assumes 8cy per load)

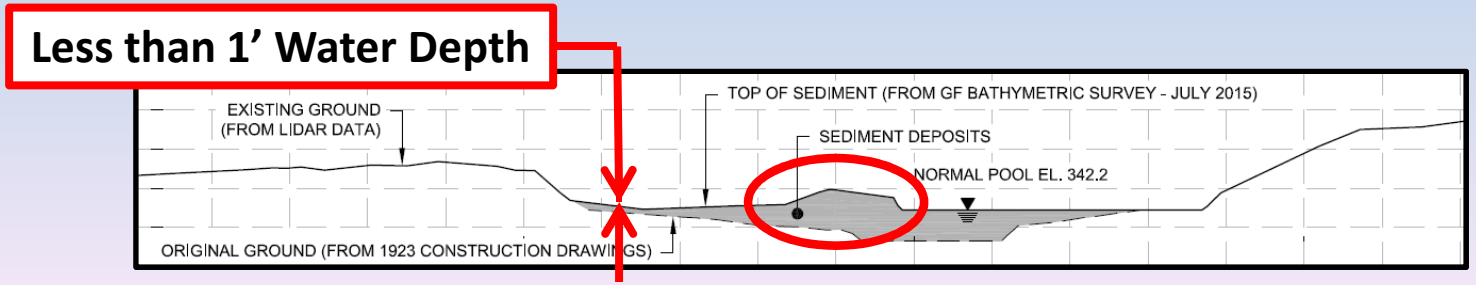
RESERVOIR SEDIMENTATION



Section A-A (Lower End of Reservoir)

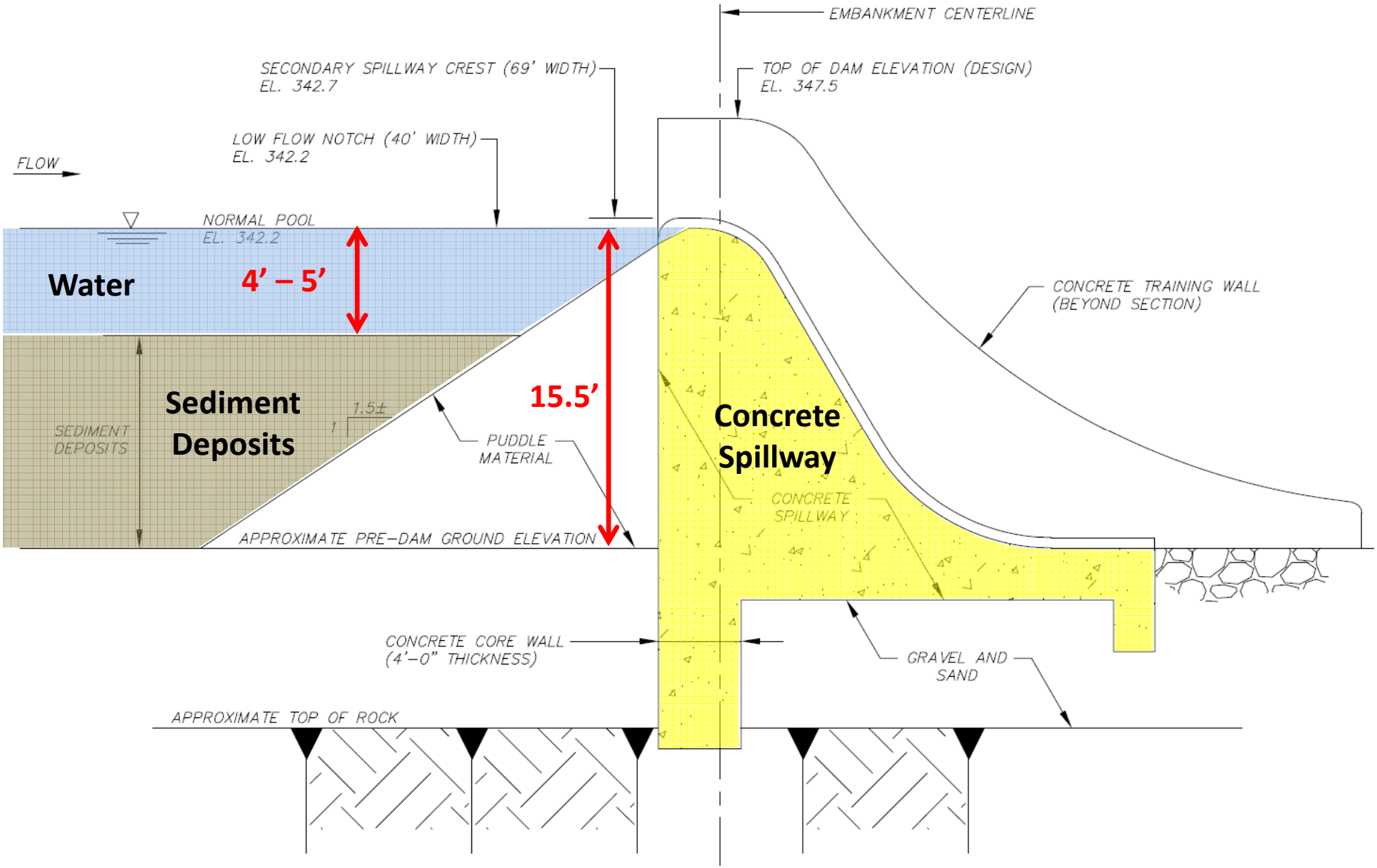


Section B-B (Middle of Reservoir)



Section C-C (Upper End of Reservoir)

BATHYMETRIC SURVEY

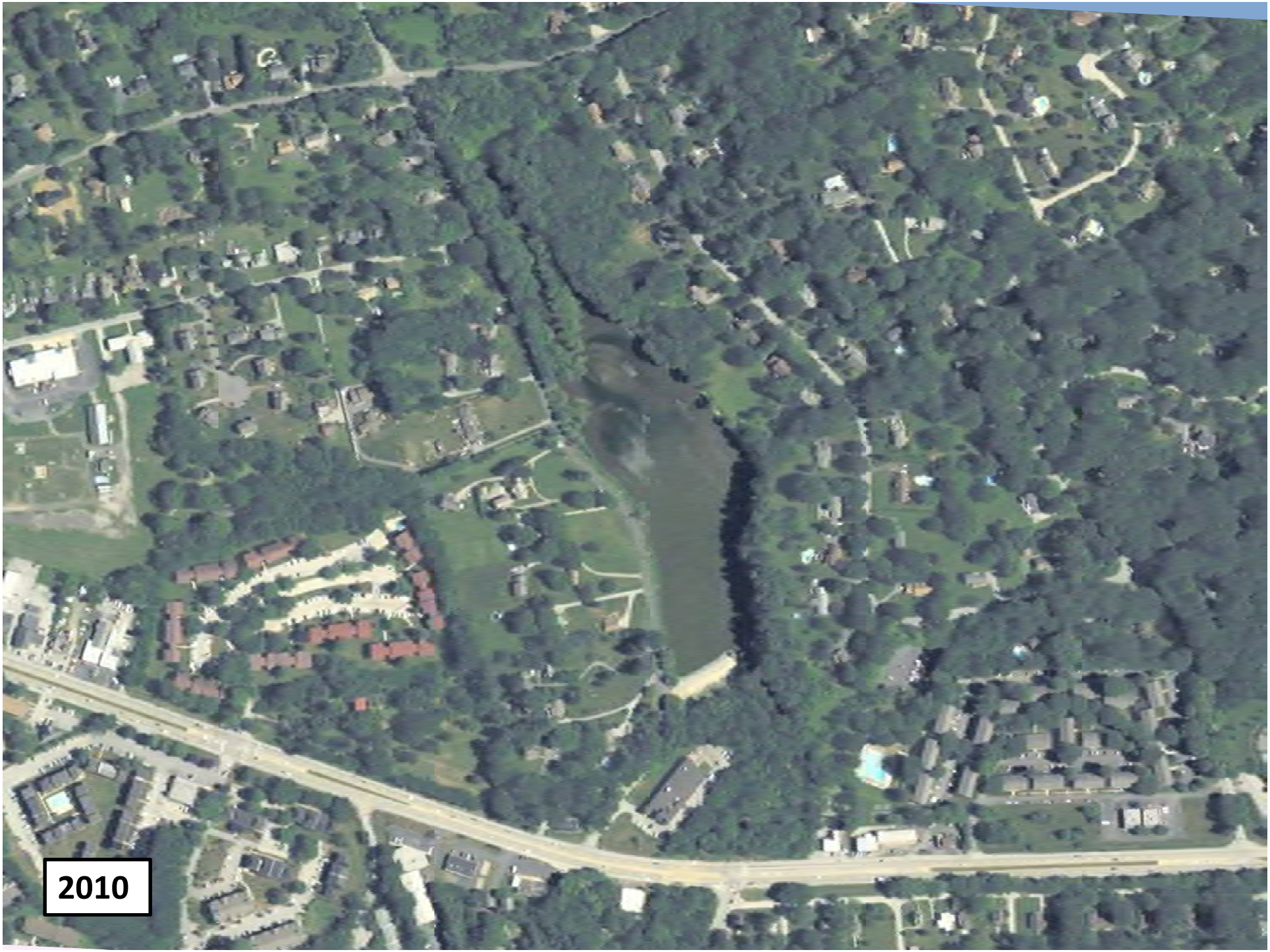



1937


1958


1971


1992

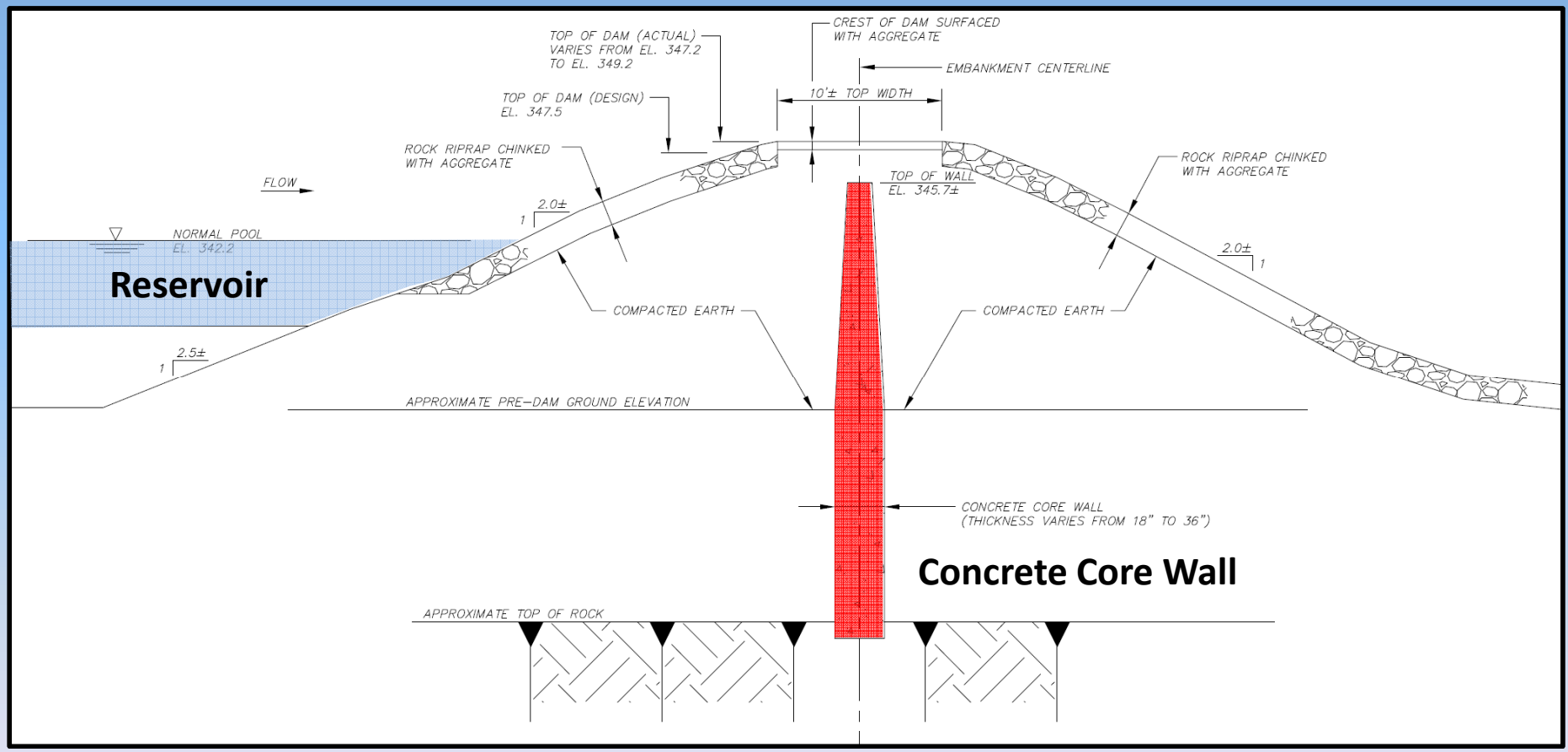

2010

DREDGING OF RESERVOIR

FULL DREDGE (I.E., REMOVAL OF 46,800 CY) AT $75/CY = $3.5 MILLION

PARTIAL DREDGE AT SPILLWAY AND TO CREATE SEDIMENT FOREBAY (15,000 CY)=$1.1 MILLION

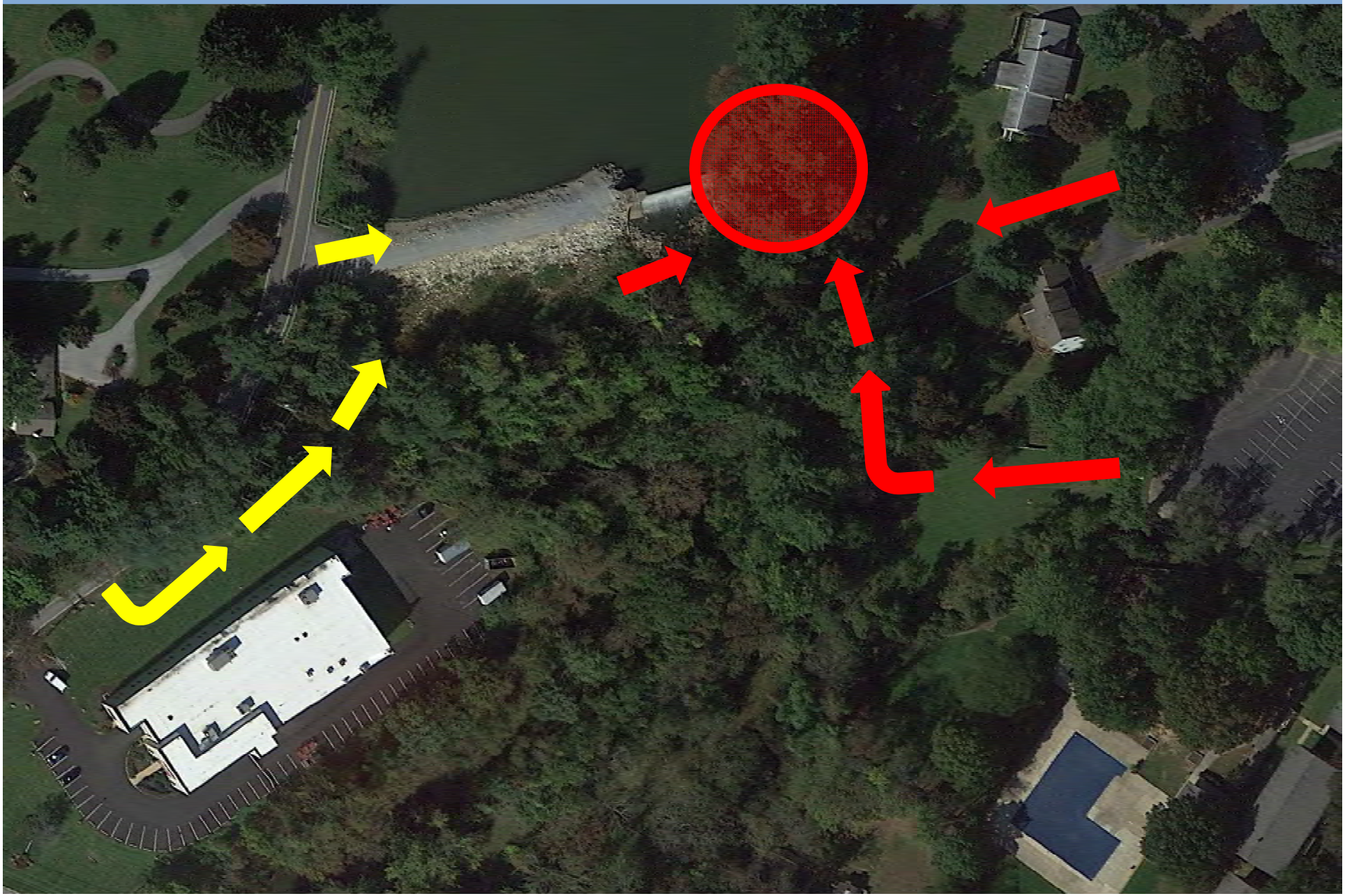
NO INTERNAL SEEPAGE COLLECTION SYSTEM



CONCRETE CORE WALL SERVES AS SEEPAGE CONTROL

NO REPORTS OF SEEPAGE DOWNSTREAM OF DAM

SITE ACCESS TO LEFT EMBANKMENT



OPTIONS TO ADDRESS INADEQUATE SPILLWAY CAPACITY

INCREASE SPILLWAY CAPACITY

- INCREASE HEIGHT OF THE DAM
- INCREASE LENGTH OF THE SPILLWAY
- COMBINATION OF INCREASED DAM HEIGHT AND SPILLWAY LENGTH
- FUSEGATE SYSTEM
- WIDEN SPILLWAY WITH LABYRINTH

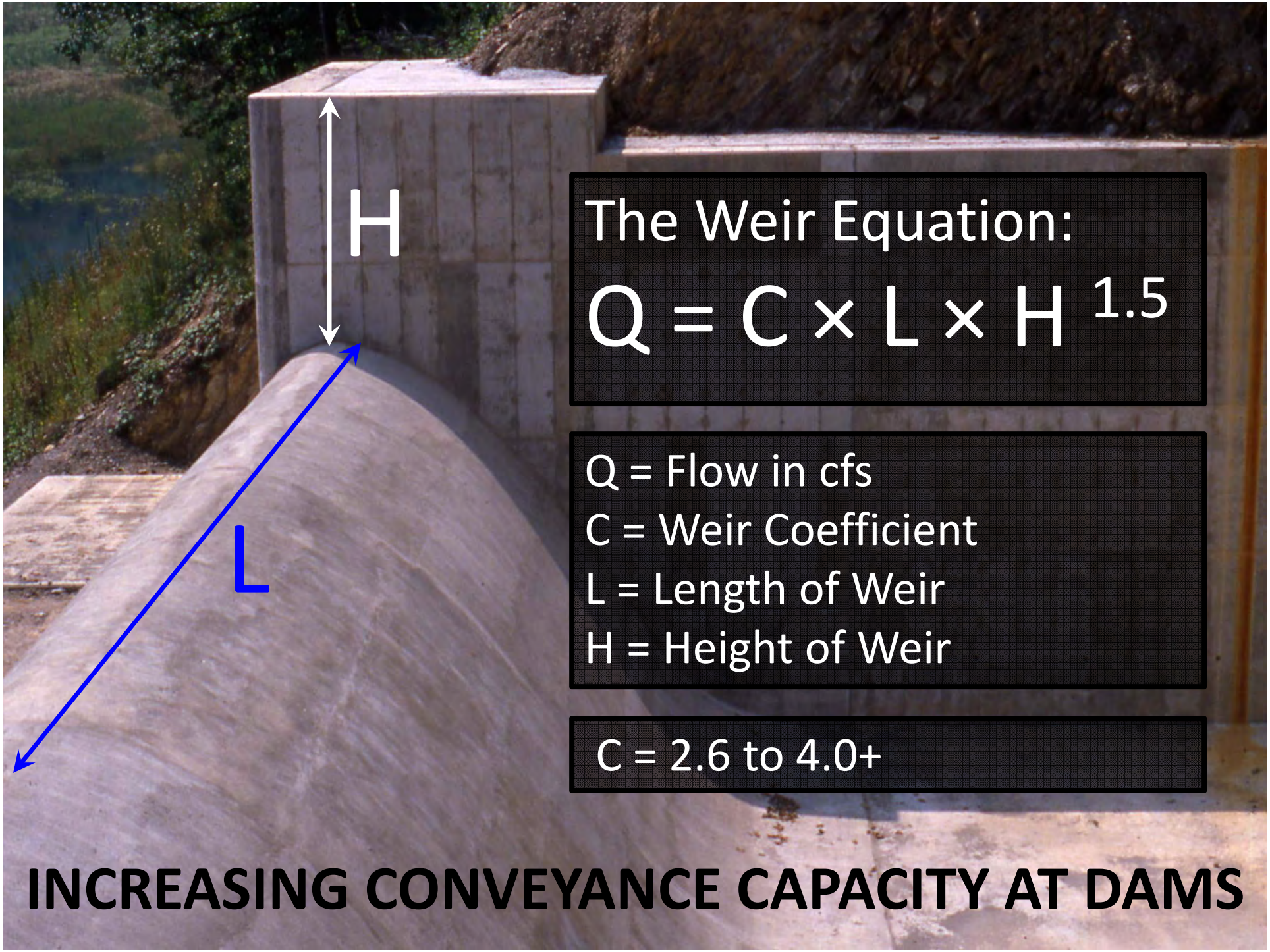
OVERTOPPING PROTECTION

- ARTICULATED CONCRETE BLOCKS (ACB)
- ROLLER-COMPACTED CONCRETE (RCC)

DECOMMISSION DAM

PARTIAL BREACH

- DAM REMAINS A HIGH-HAZARD STRUCTURE
- REDUCE DAM TO A LOW-HAZARD STRUCTURE



The Weir Equation:

$$Q = C \times L \times H^{1.5}$$

Q = Flow in cfs
C = Weir Coefficient
L = Length of Weir
H = Height of Weir

C = 2.6 to 4.0+

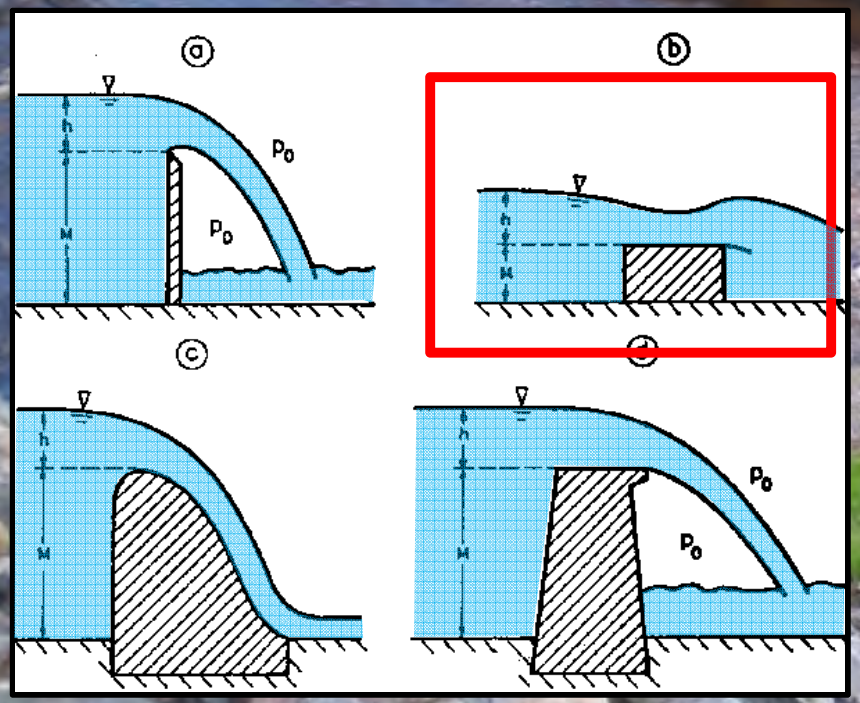
INCREASING CONVEYANCE CAPACITY AT DAMS

INCREASING THE DISCHARGE/WEIR COEFFICIENT (C)

The Weir Equation:

$$Q = C \times L \times H^{1.5}$$

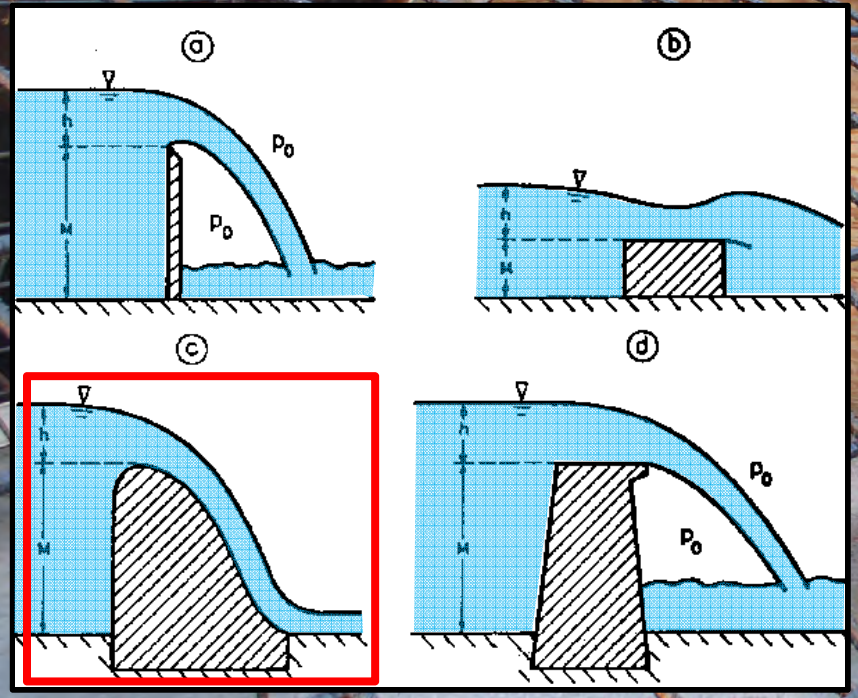
INCREASING THE DISCHARGE/WEIR COEFFICIENT (C)

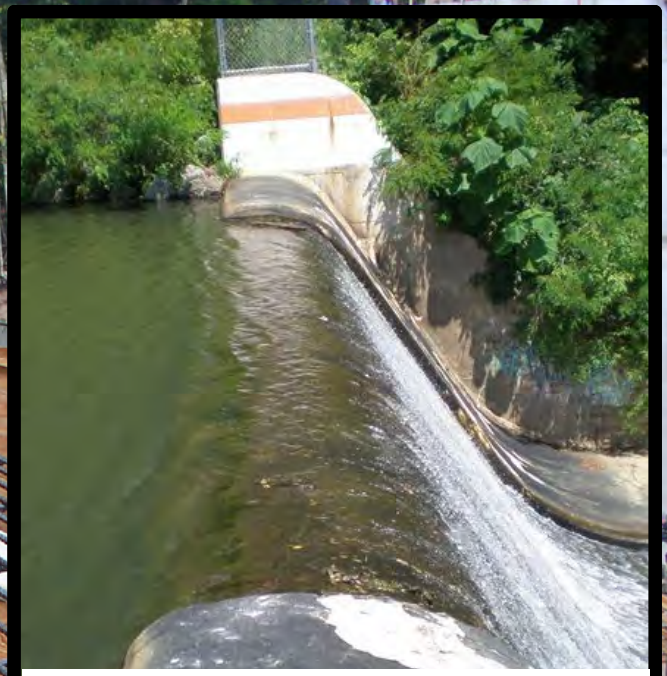


BROAD CRESTED WEIR

C = 2.6 to 3.1+

INCREASING THE DISCHARGE/WEIR COEFFICIENT (C)





MILLTOWN DAM
C = 3.8

OGEE WEIR
C = Up to 4+

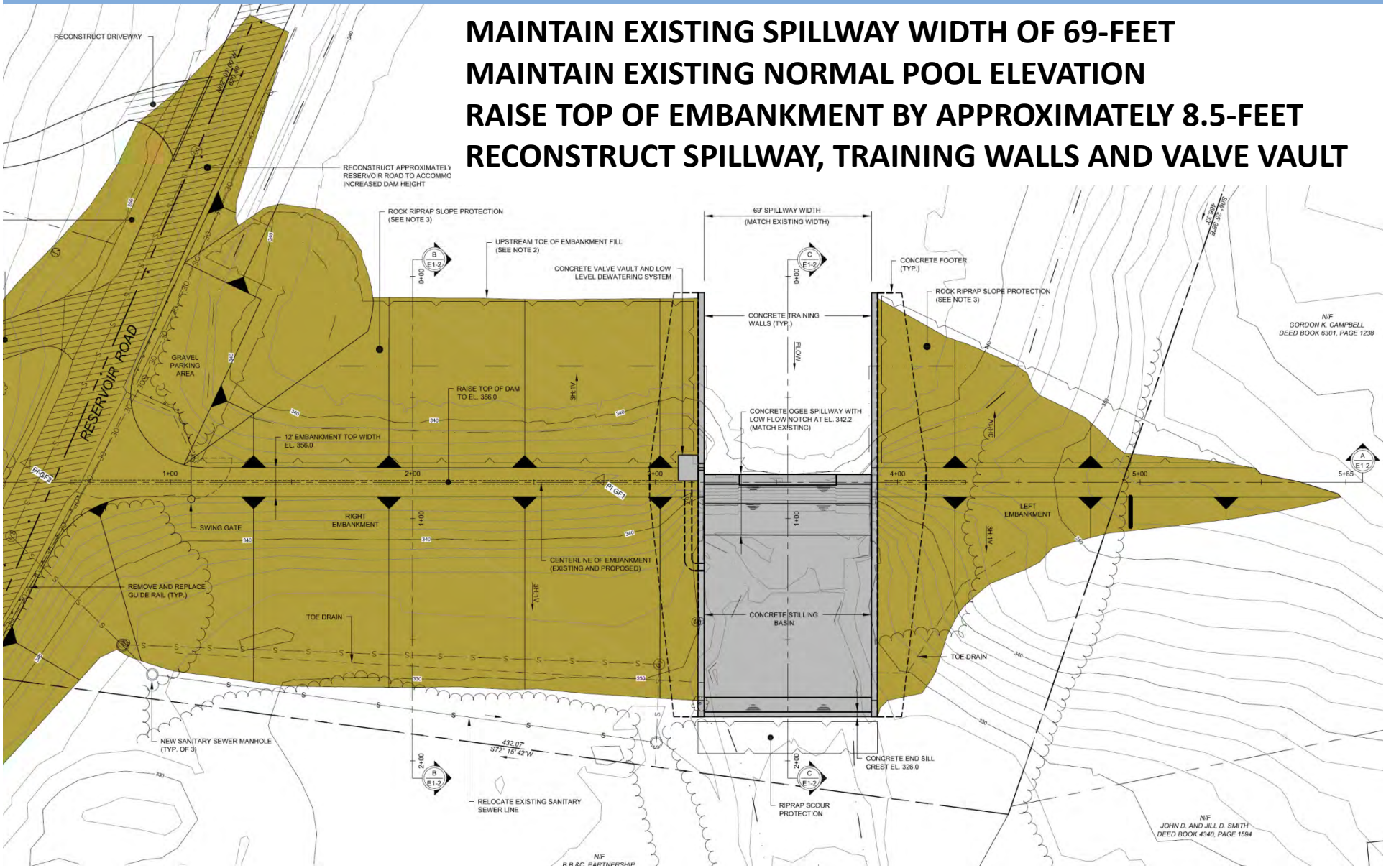
INCREASING THE DEPTH OF FLOW (H)

The Weir Equation:

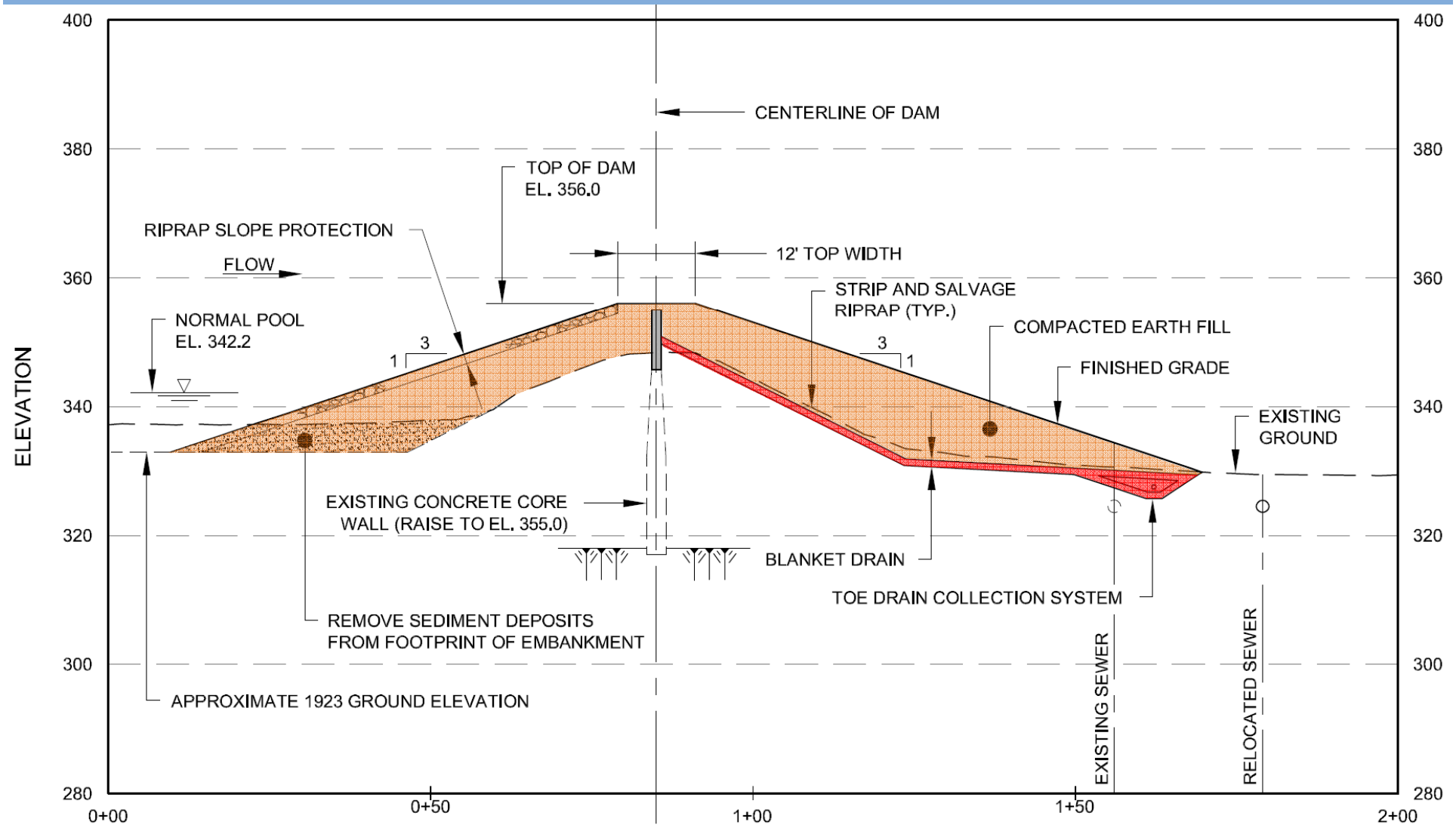
$$Q = C \times L \times H^{1.5}$$

ALTERNATIVE 1
INCREASE EMBANKMENT HEIGHT

MAINTAIN EXISTING SPILLWAY WIDTH OF 69-FEET
MAINTAIN EXISTING NORMAL POOL ELEVATION
RAISE TOP OF EMBANKMENT BY APPROXIMATELY 8.5-FEET
RECONSTRUCT SPILLWAY, TRAINING WALLS AND VALVE VAULT



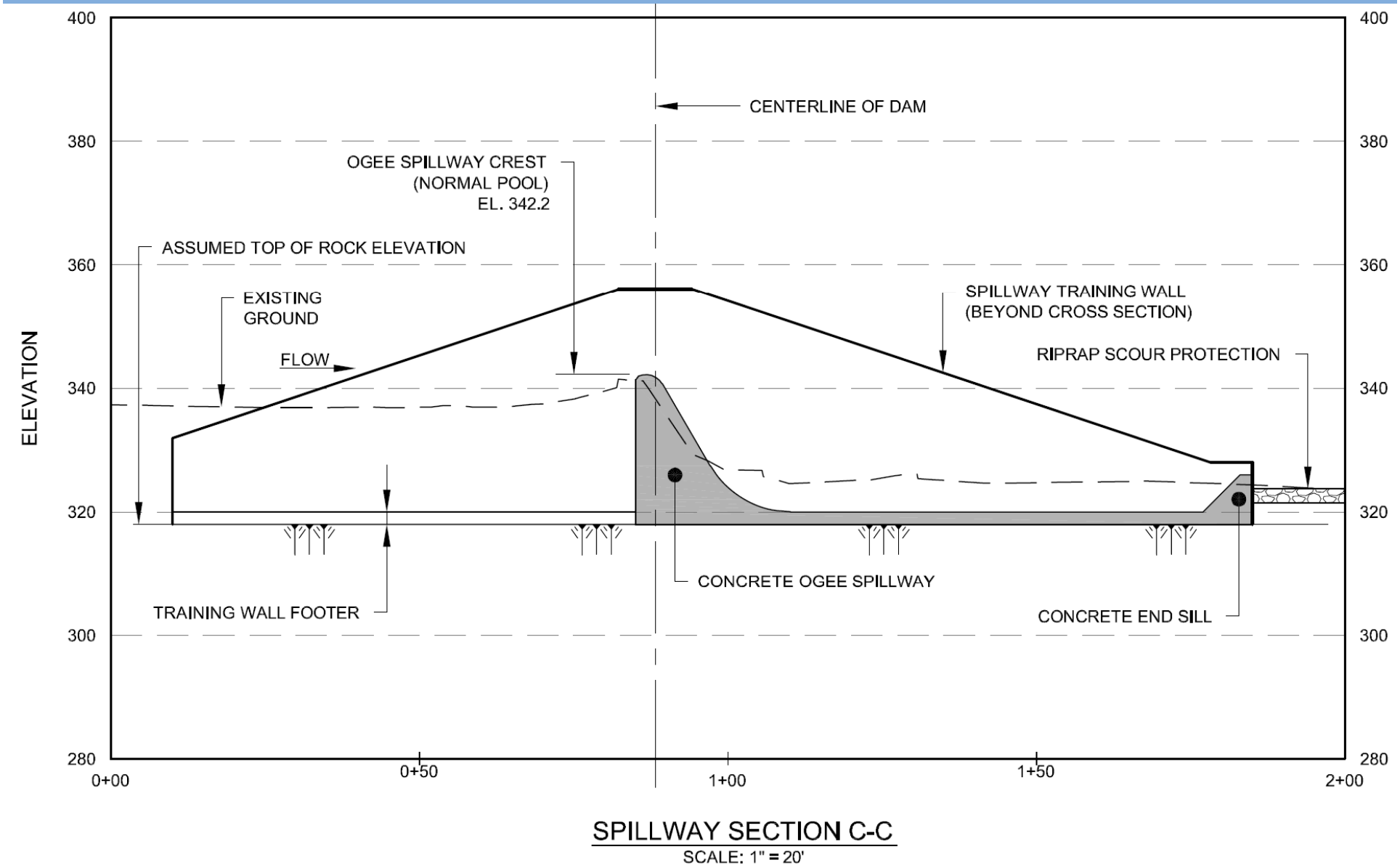
ALTERNATIVE 1
INCREASE EMBANKMENT HEIGHT



EMBANKMENT SECTION B-B

SCALE: 1" = 20'

ALTERNATIVE 1
INCREASE EMBANKMENT HEIGHT



SPILLWAY SECTION C-C

SCALE: 1" = 20'

ALTERNATIVE 1
INCREASE EMBANKMENT HEIGHT

ALTERNATIVE 1
INCREASE EMBANKMENT HEIGHT

ALTERNATIVE 1
INCREASE EMBANKMENT HEIGHT

ALTERNATIVE 1
INCREASE EMBANKMENT HEIGHT

AREA OF RISK	RISK ADDRESSED
Pass Spillway Design Flood	Yes ?? Increased Spillway Height can pass SDF.
Address Erodible Material under Spillway	Yes Spillway Founded on Bedrock
Address Steep Embankment Slopes	Yes New 3H:1V Embankment Slopes
Add Internal Seepage Collection System	Yes Raised embankment provides opportunity for addition of internal drainage system
Access to Left Embankment	Partial Access Created Incorporate Ford Crossing
Fill at Crest of Left Embankment	Yes Top of Embankment Raised
Public Safety (Fencing)	Yes Fencing Added to Training Walls

ALTERNATIVE 1
INCREASE EMBANKMENT HEIGHT

DAM IMPOUNDS ADDITIONAL WATER (8+ ADDITIONAL FEET)

- **Additional embankment stability analysis required due to increased hydraulic loading.**
- **Increased downstream consequences should the dam fail. Breach analysis and emergency action plan will require updating.**
- **Spillway Design Flood may change.**

PROPERTY IMPACTS

- **Permanent easements required from at least five properties to construct and maintain dam.**
- **Flowage easements required from all upstream properties which experience water elevation (47+ properties).**

UTILITY IMPACTS

- **Reservoir Road raised by 6+ feet in vicinity of dam.**
- **Relocation of existing sanitary sewer line downstream of dam.**

DESIGN/CONSTRUCTION COSTS

- **$6.6 Million**

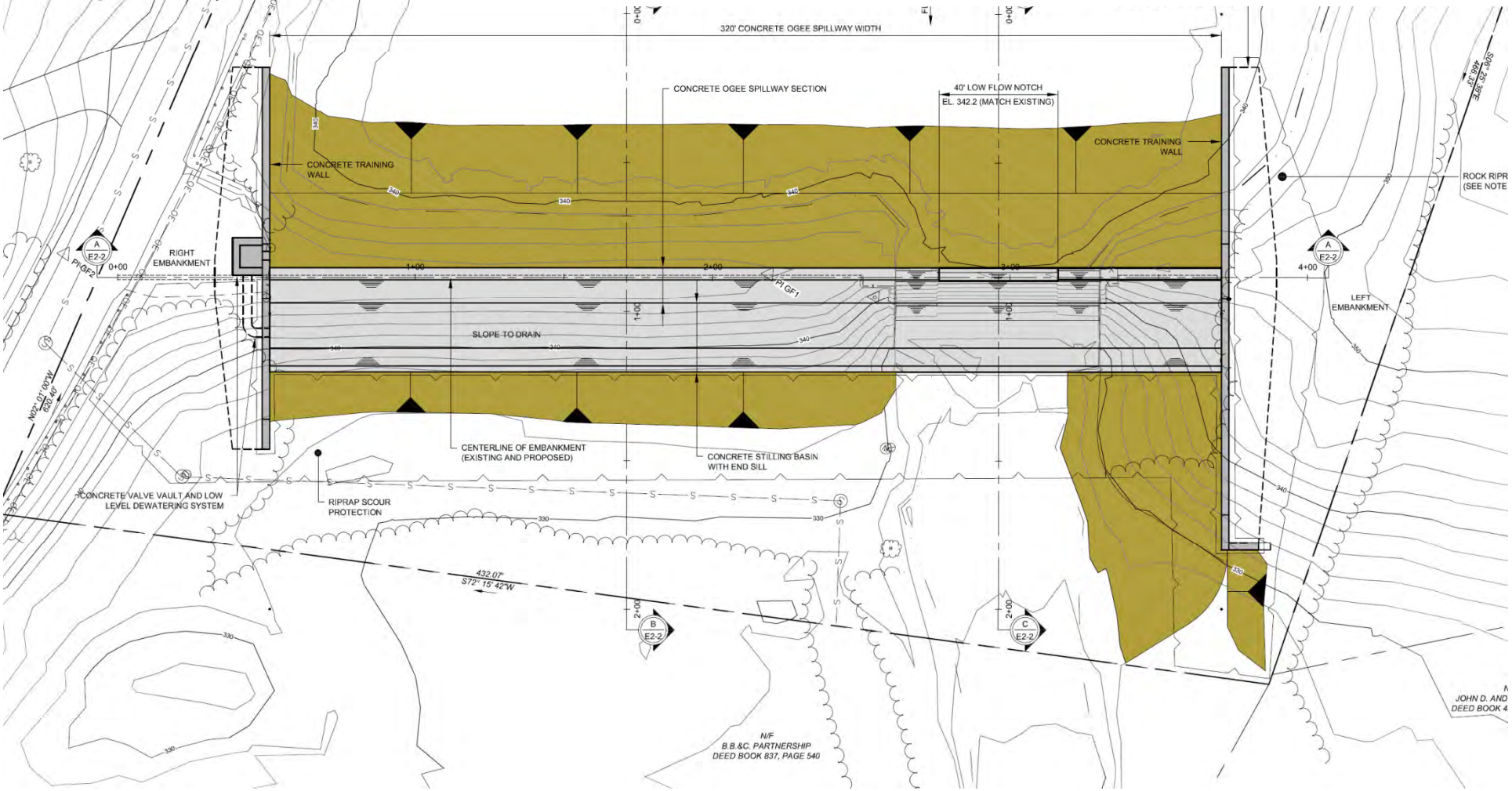
INCREASING THE LENGTH (L) OF THE SPILLWAY

The Weir Equation:

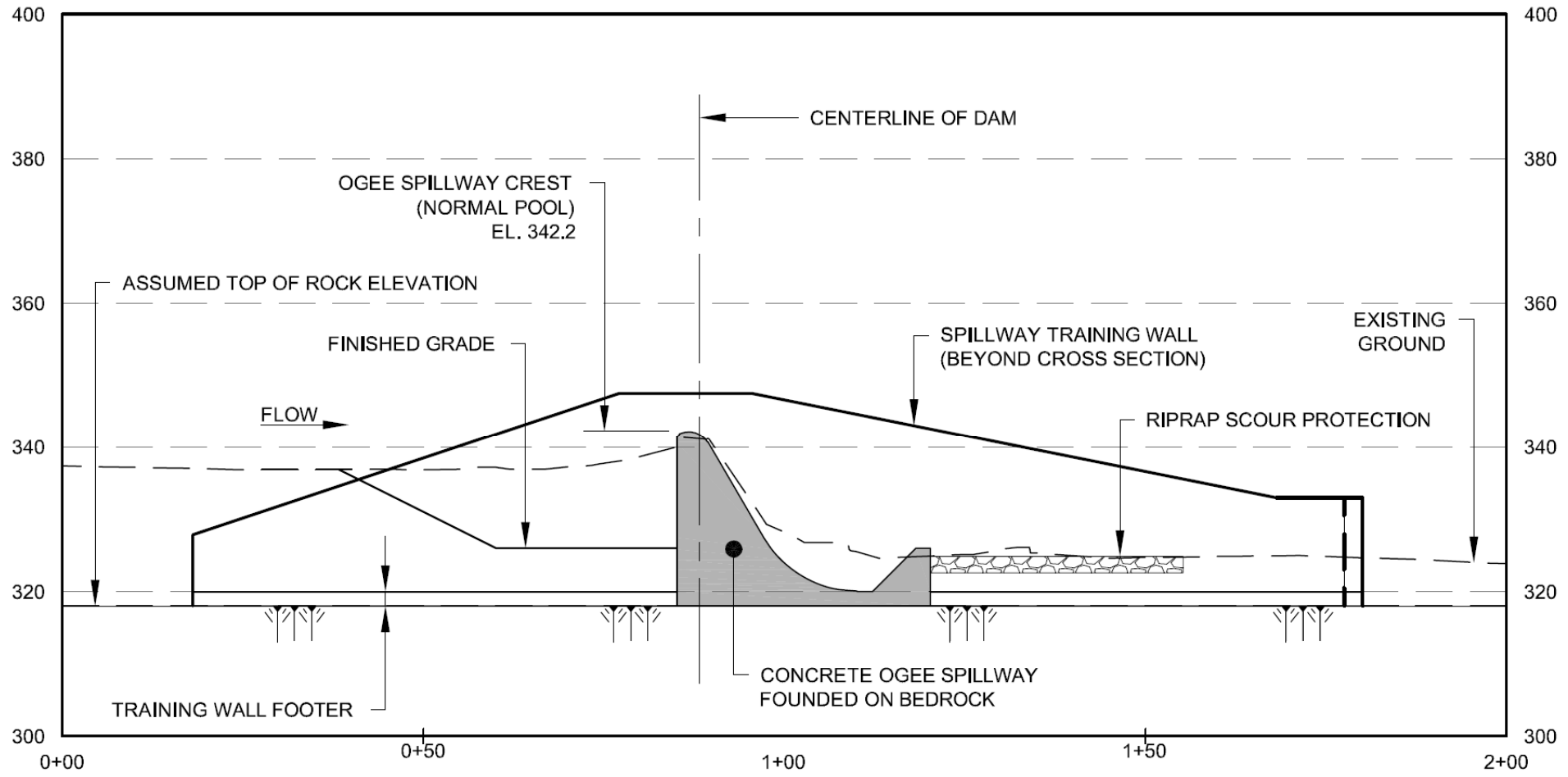
$$Q = C \times L \times H^{1.5}$$

ALTERNATIVE 2
INCREASE SPILLWAY WIDTH

WIDEN SPILLWAY FROM 69-FEET TO 320-FEET
MAINTAIN EXISTING NORMAL POOL ELEVATION
MAINTAIN EXISTING TOP OF DAM ELEVATION
RECONSTRUCT SPILLWAY, TRAINING WALLS AND VALVE VAULT



ALTERNATIVE 2
INCREASE SPILLWAY WIDTH



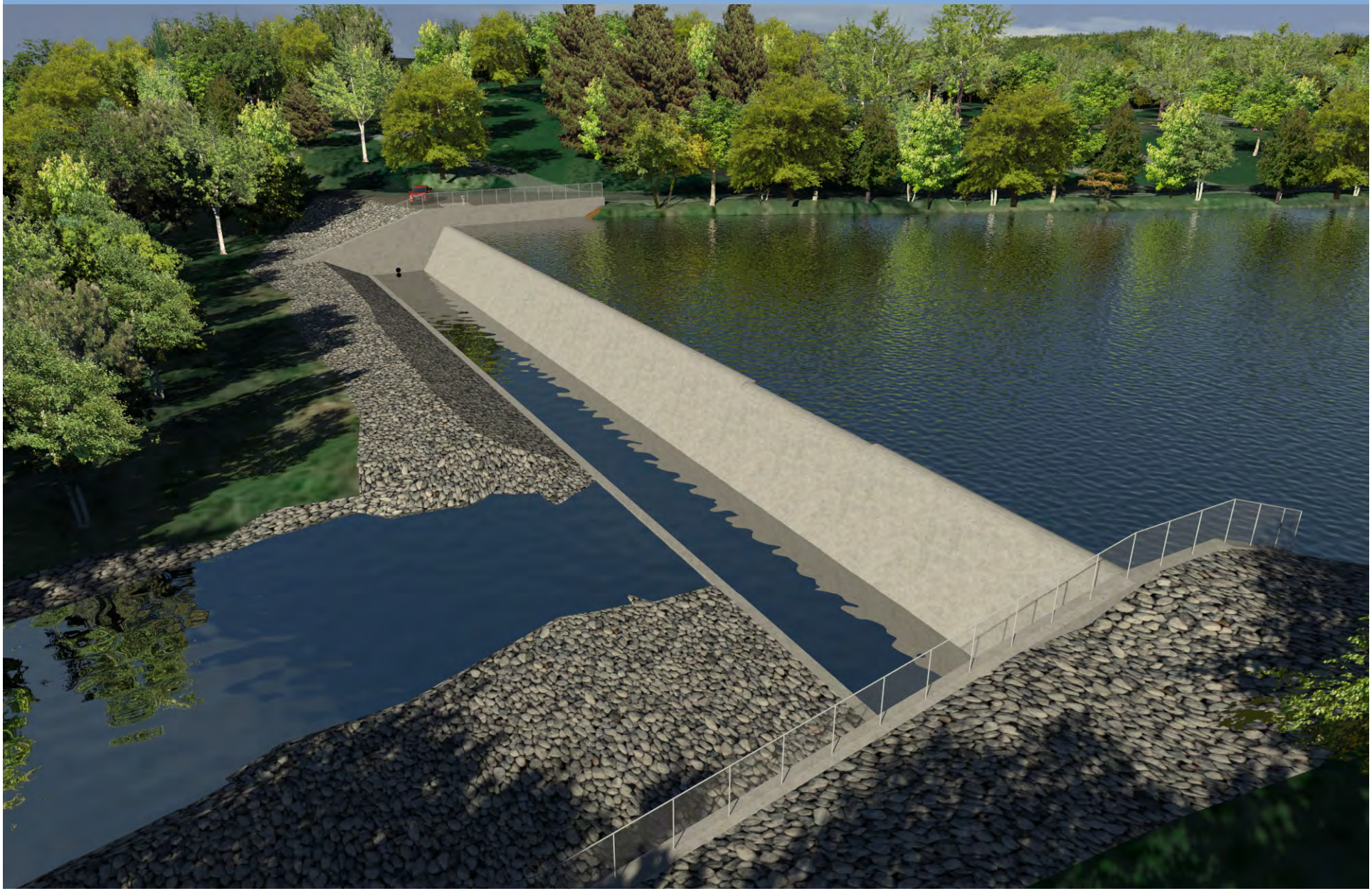
SPILLWAY SECTION C-C

SCALE: 1" = 20'

ALTERNATIVE 2
INCREASE SPILLWAY WIDTH

ALTERNATIVE 2
INCREASE SPILLWAY WIDTH

ALTERNATIVE 2
INCREASE SPILLWAY WIDTH



ALTERNATIVE 2
INCREASE SPILLWAY WIDTH

AREA OF RISK	RISK ADDRESSED
Pass Spillway Design Flood	Yes Increased Spillway Width can pass SDF.
Address Erodible Material under Spillway	Yes Spillway Founded on Bedrock
Address Steep Embankment Slopes	Yes Widened Spillway Eliminates Earth Embankments
Add Internal Seepage Collection System	Not Applicable Internal Drainage Not Required for Concrete Gravity Dam
Access to Left Embankment	Partial Access Created Incorporate Ford Crossing
Fill at Crest of Left Embankment	Yes Left Embankment Eliminated
Public Safety (Fencing)	Yes Fencing Added to Training Walls

ALTERNATIVE 2
INCREASE SPILLWAY WIDTH

HYDRAULIC PERFORMANCE OF MILLTOWN DAM

- Reservoir water surface elevation maintained at top of dam for the spillway design flood (4± foot reduction in water surface).
- Widened spillway will result in increased peak rates of runoff during storm events more frequent that the 100-year storm.
- Note that existing spillway provides marginal reduction in 100-year peak flow rate (3,820 cfs inflow to 3,570 cfs outflow – 6% reduction).

PROPERTY IMPACTS

- No permanent easements required. Temporary construction easements may be required.
- Reduction in upstream water elevations during the spillway design flood. Therefore no flowage easements required.
- Significant amount of material to be spoiled/hauled offsite. Spoiling onsite will be at the expense of open water.

DESIGN/CONSTRUCTION COSTS

- $9.6 Million

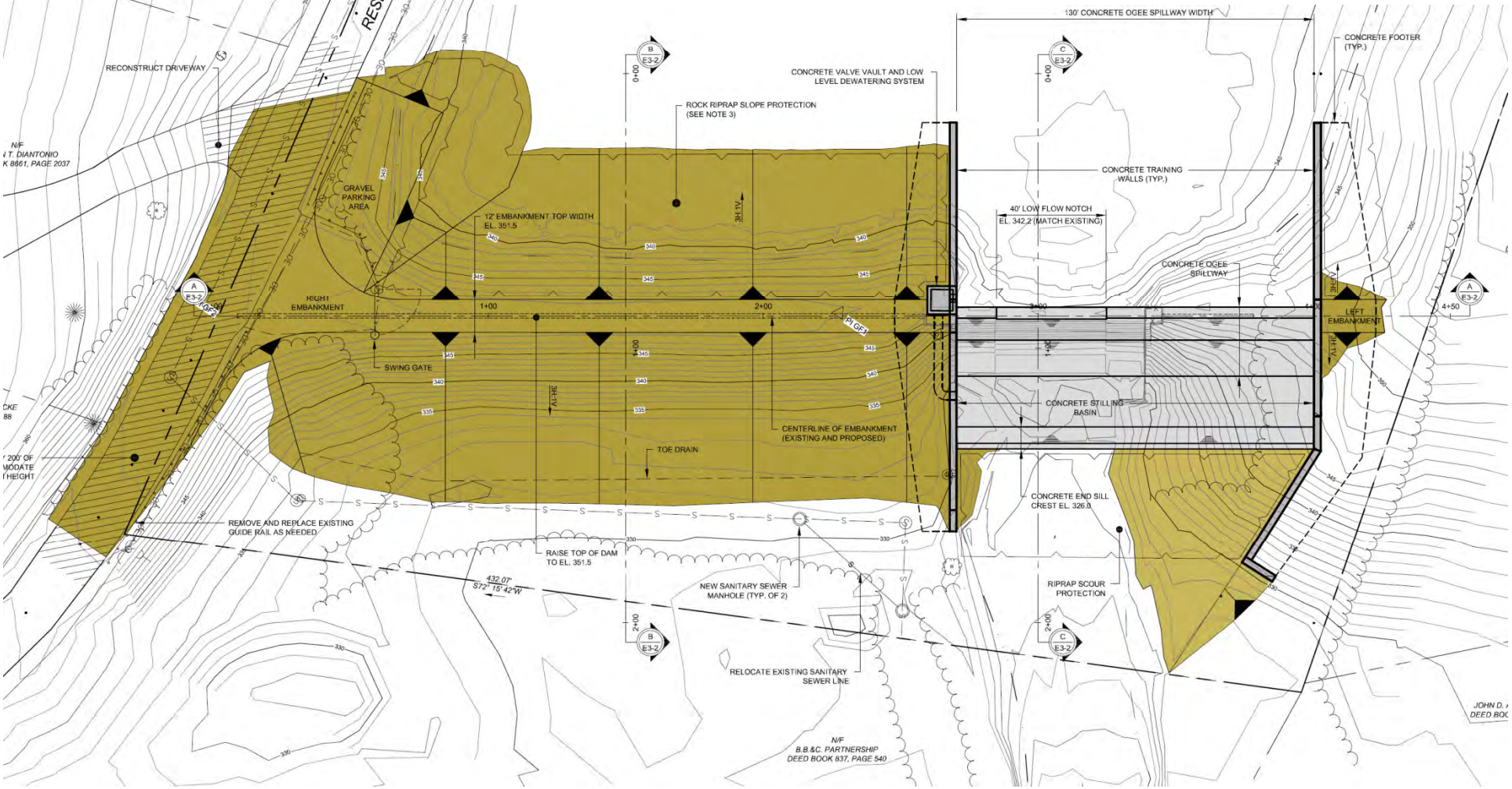
INCREASING THE LENGTH (L) AND THE DEPTH (H) OF THE SPILLWAY

The Weir Equation:

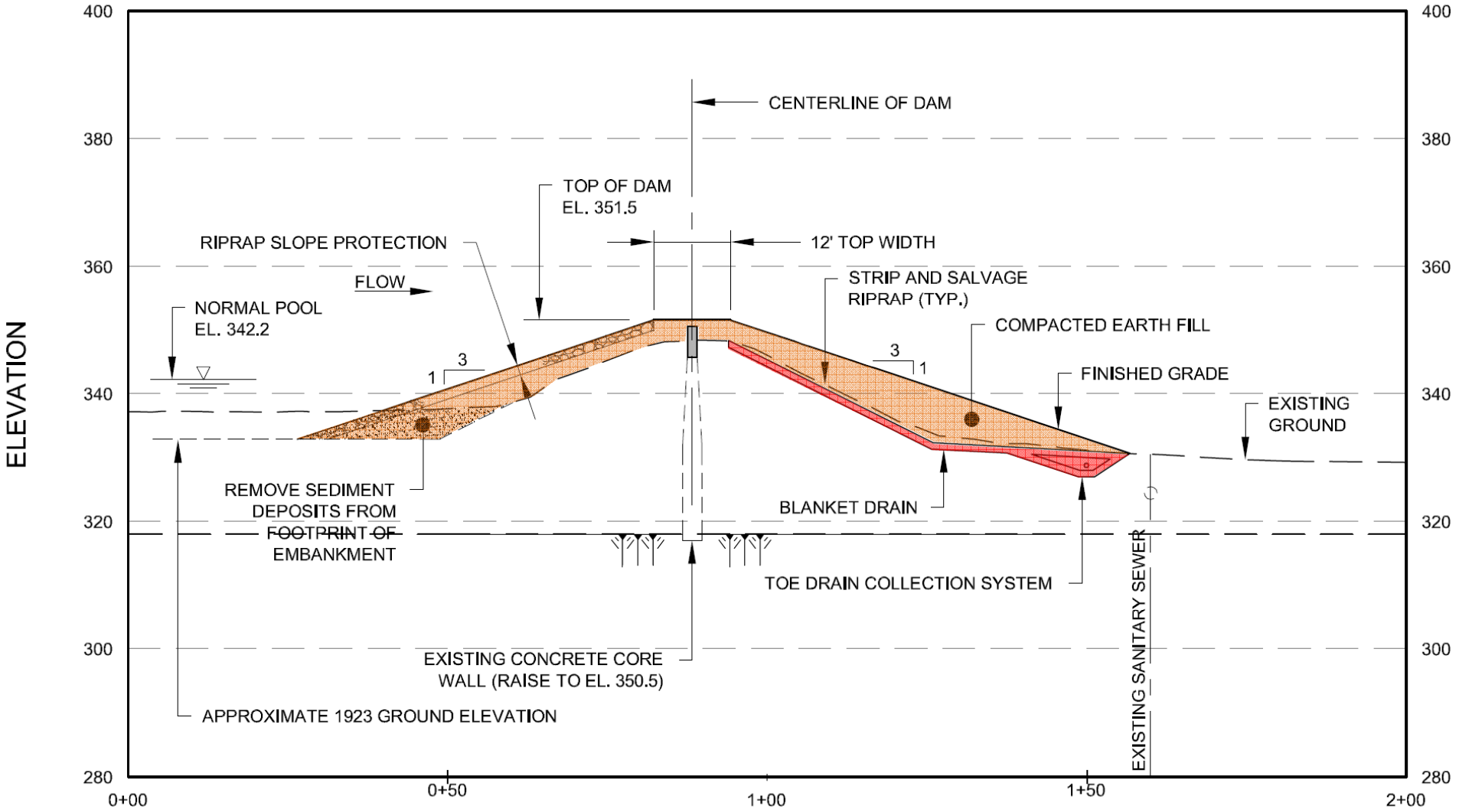
$$Q = C \times L \times H^{1.5}$$

ALTERNATIVE 3
RAISE EMBANKMENT AND WIDEN SPILLWAY

RAISE EMBANKMENT BY APPROXIMATELY 4-FEET
WIDEN SPILLWAY FROM 69-FEET TO 130-FEET
MAINTAIN EXISTING NORMAL POOL ELEVATION
RECONSTRUCT SPILLWAY, TRAINING WALLS AND VALVE VAULT



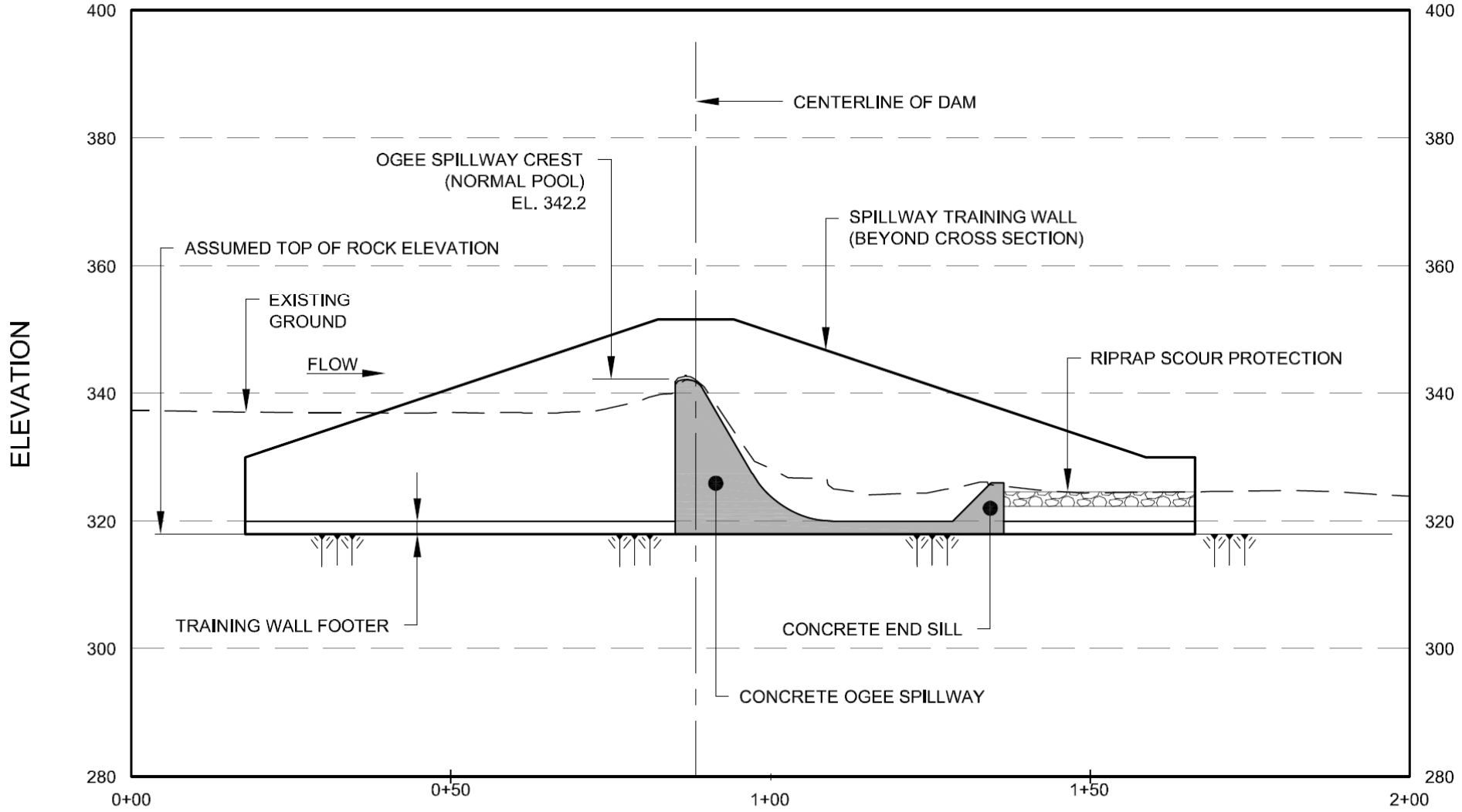
ALTERNATIVE 3
RAISE EMBANKMENT AND WIDEN SPILLWAY



EMBANKMENT SECTION B-B

SCALE: 1" = 20'

ALTERNATIVE 3
RAISE EMBANKMENT AND WIDEN SPILLWAY



SPILLWAY SECTION C-C

SCALE: 1" = 20'

ALTERNATIVE 3
RAISE EMBANKMENT AND WIDEN SPILLWAY

ALTERNATIVE 3
RAISE EMBANKMENT AND WIDEN SPILLWAY

ALTERNATIVE 3
RAISE EMBANKMENT AND WIDEN SPILLWAY

ALTERNATIVE 3
RAISE EMBANKMENT AND WIDEN SPILLWAY

AREA OF RISK	RISK ADDRESSED
Pass Spillway Design Flood	Yes ?? Increased Spillway Width & Height passes SDF.
Address Erodible Material under Spillway	Yes Spillway Founded on Bedrock
Address Steep Embankment Slopes	Yes New 3H:1V Embankment Slopes
Add Internal Seepage Collection System	Yes Raised embankment provides opportunity for addition of internal drainage system
Access to Left Embankment	Partial Access Created Incorporate Ford Crossing
Fill at Crest of Left Embankment	Yes Left Embankment Eliminated
Public Safety (Fencing)	Yes Fencing Added to Training Walls

ALTERNATIVE 3
RAISE EMBANKMENT AND WIDEN SPILLWAY

DAM IMPOUNDS ADDITIONAL WATER (4+ ADDITIONAL FEET)

- Additional embankment stability analysis required due to increased hydraulic loading.
- Increased downstream consequences should the dam fail. Breach analysis and emergency action plan will require updating.
- No increase in the spillway design flood water surface elevation upstream of the dam.
- Widened spillway will result in increased peak rates of runoff during storm events more frequent that the 100-year storm.
- Note that existing spillway provides marginal reduction in 100-year peak flow rate (3,820 cfs inflow to 3,570 cfs outflow – 6% reduction).

PROPERTY IMPACTS

- Temporary/permanent easements required from at least four properties to construct and maintain dam.
- No increase in the spillway design flood elevation. No flowage easements required.

UTILITY IMPACTS

- Reservoir road raised by 2+ feet in vicinity of dam.

DESIGN/CONSTRUCTION COSTS

- $6.8 Million

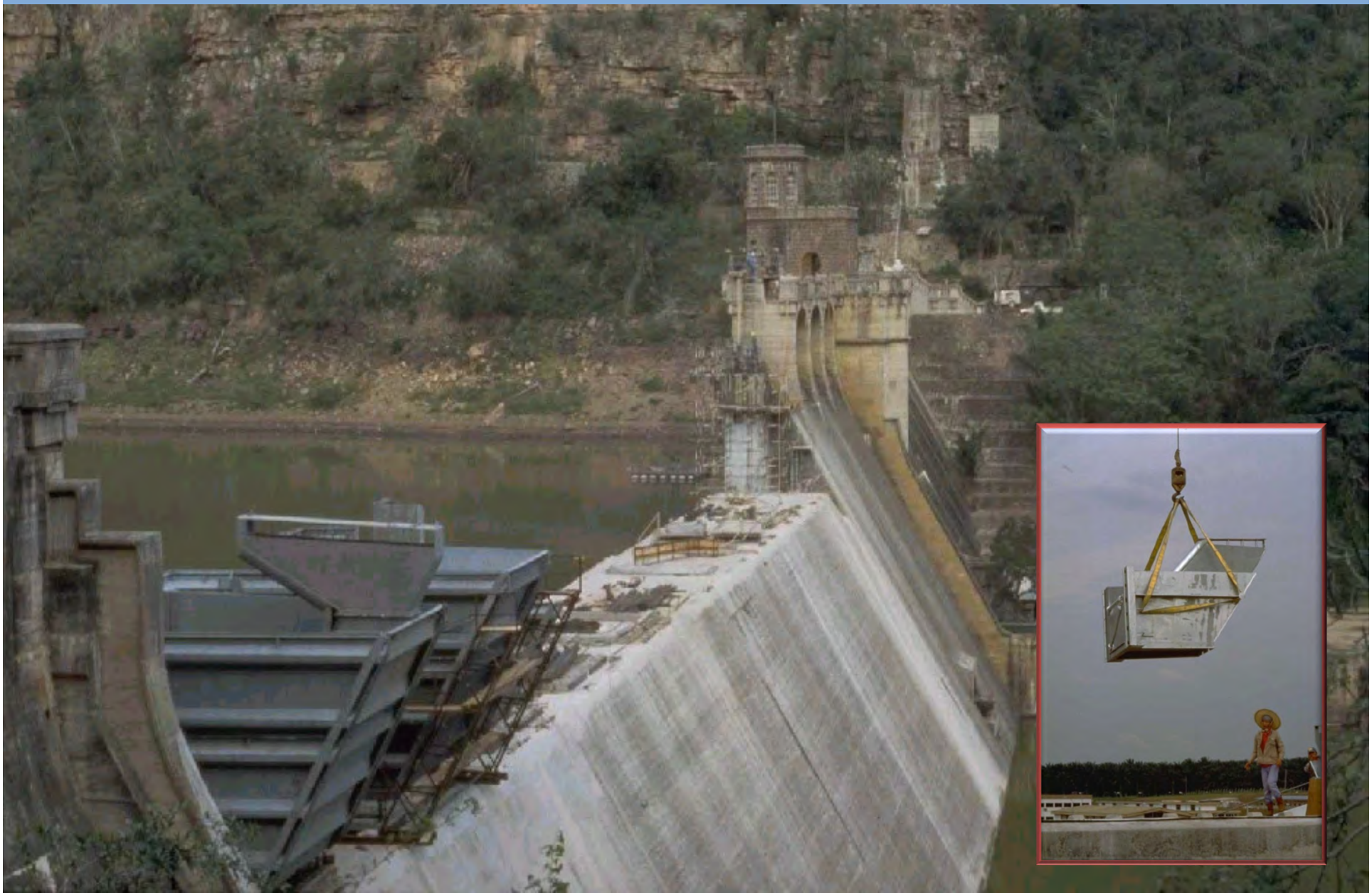
INCREASING THE DEPTH (H) OF THE SPILLWAY

The Weir Equation:

$$Q = C \times L \times H^{1.5}$$

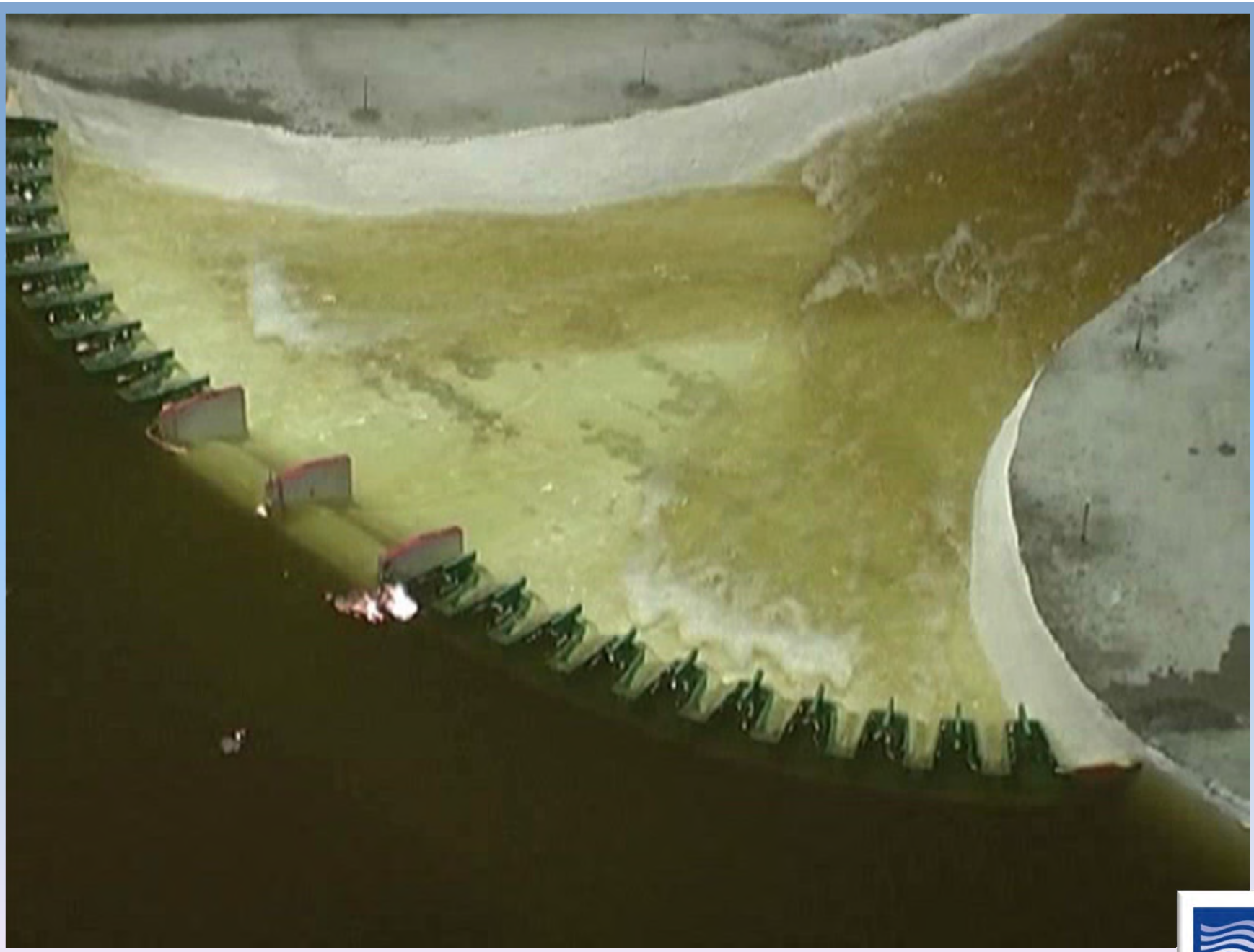
LOWER SPILLWAY CREST AND ADD FUSEGATES TO MAINTAIN NORMAL POOL

ALTERNATIVE 4
FUSEGATES

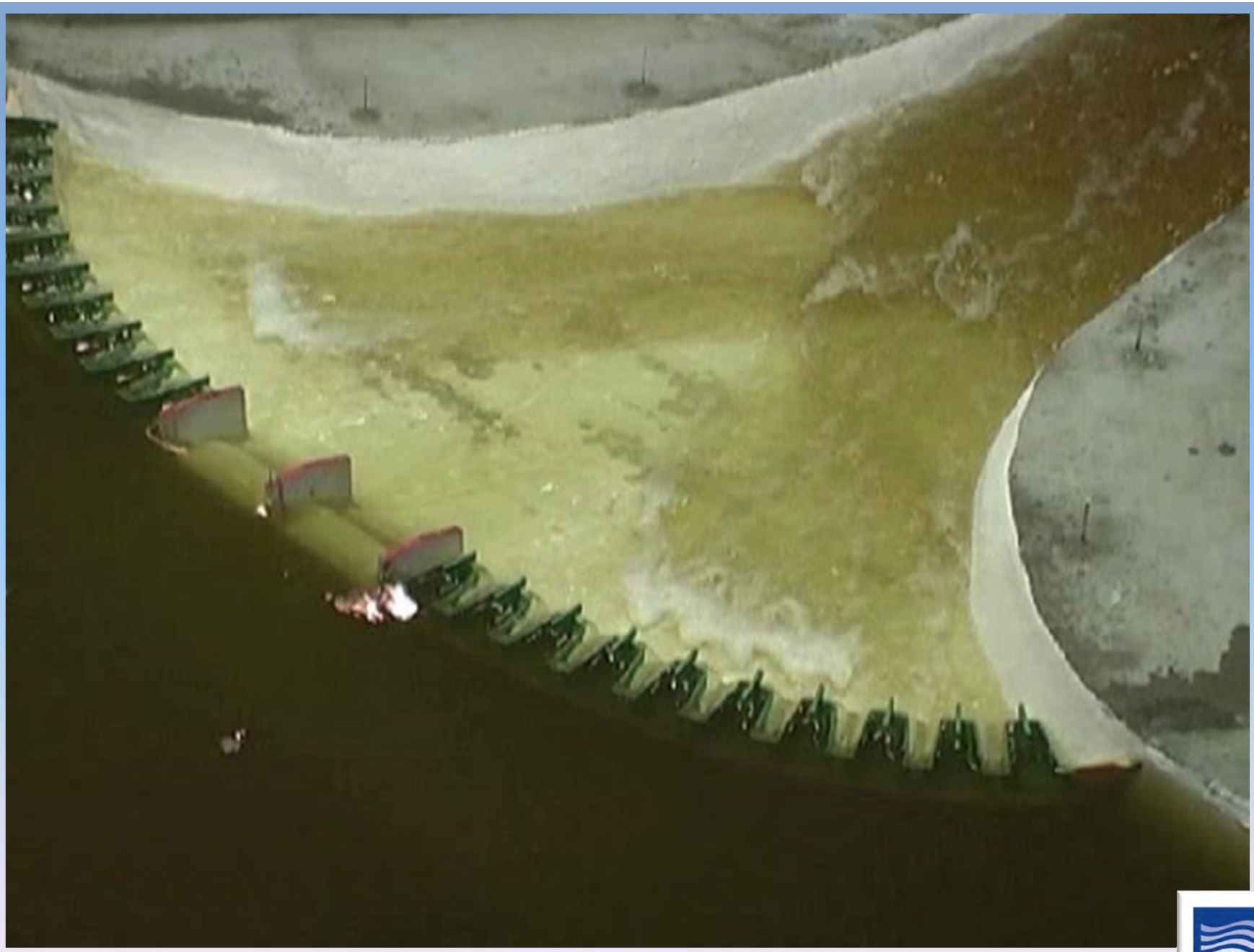


ALTERNATIVE 4
FUSEGATES

MULESHOE DAM
HOLLIDAYSBURG, PENNSYLVANIA

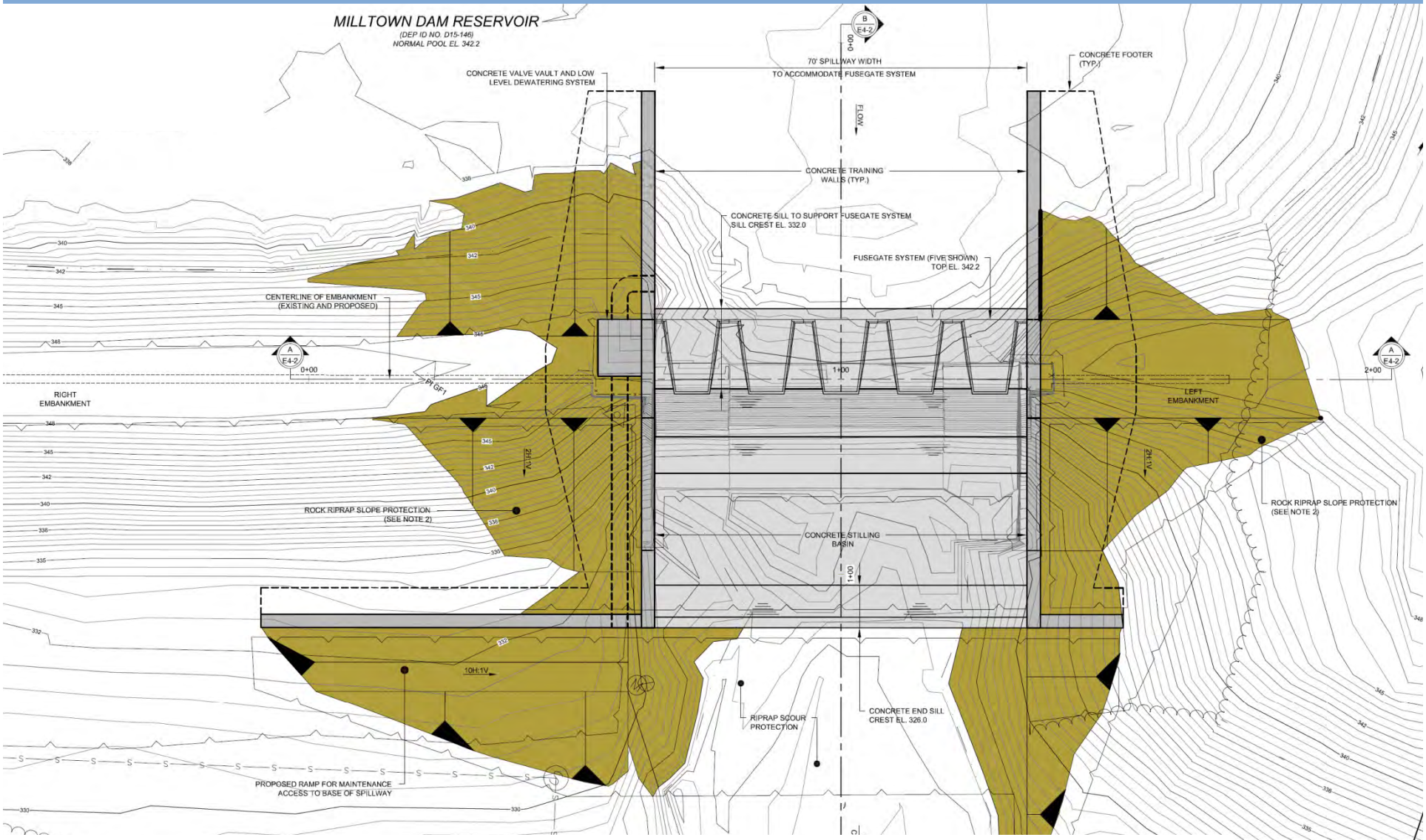


Hydroplus Fuse Gates



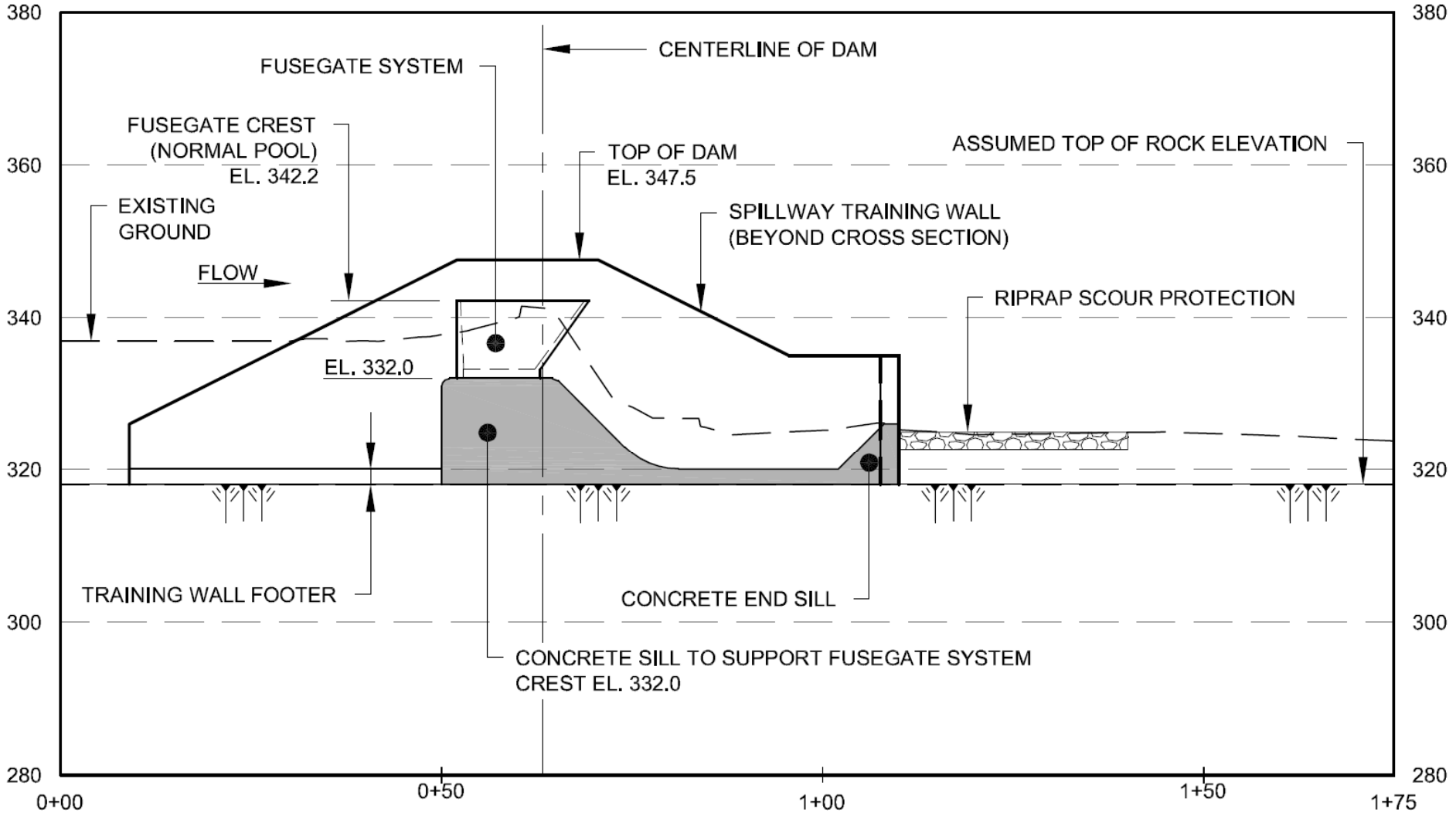
Hydroplus Fuse Gates

ALTERNATIVE 4
FUSEGATES



LOWER SPILLWAY CREST AND INSTALL FUSEGATES TO MAINTAIN NORMAL POOL
RECONSTRUCT SPILLWAY, TRAINING WALLS AND VALVE VAULT

ALTERNATIVE 4
FUSEGATES



SPILLWAY SECTION B-B

SCALE: 1" = 20'

ALTERNATIVE 4
FUSEGATES

ALTERNATIVE 4
FUSEGATES

ALTERNATIVE 4
FUSEGATES

ALTERNATIVE 4
FUSEGATES

AREA OF RISK	RISK ADDRESSED
Pass Spillway Design Flood	Yes Increased Spillway Height Passes SDF.
Address Erodible Material under Spillway	Yes Spillway Founded on Bedrock
Address Steep Embankment Slopes	Partial 1.5H:1V Slopes Eliminated, 2H:1V Slopes Remain
Add Internal Seepage Collection System	No
Access to Left Embankment	Partial Access Created Incorporate Ford Crossing
Fill at Crest of Left Embankment	Yes Left Embankment Reworked
Public Safety (Fencing)	Yes Fencing Added to Training Walls

ALTERNATIVE 4
FUSEGATES

HYDRAULIC PERFORMANCE OF MILLTOWN DAM

- **Reservoir water surface elevation maintained at top of dam for the spillway design flood (4± foot reduction in the SDF water surface).**
- **Negligible change in the performance of the dam for storms more frequent than the 100-year event.**

PROPERTY IMPACTS

- **Small footprint of disturbance. No permanent easements required.**
- **Reduction in upstream water elevations during the spillway design flood. Therefore no flowage easements required.**

OPERATIONAL IMPACTS

- **Fusegates must be replaced following a "tipping" event.**
- **Loss of reservoir until "tipped" gates are replaced.**
- **Maintain area upstream of fusegates free of sediment.**

DESIGN/CONSTRUCTION COSTS

- **$5.8 Million**

INCREASING THE LENGTH (L) OF THE SPILLWAY

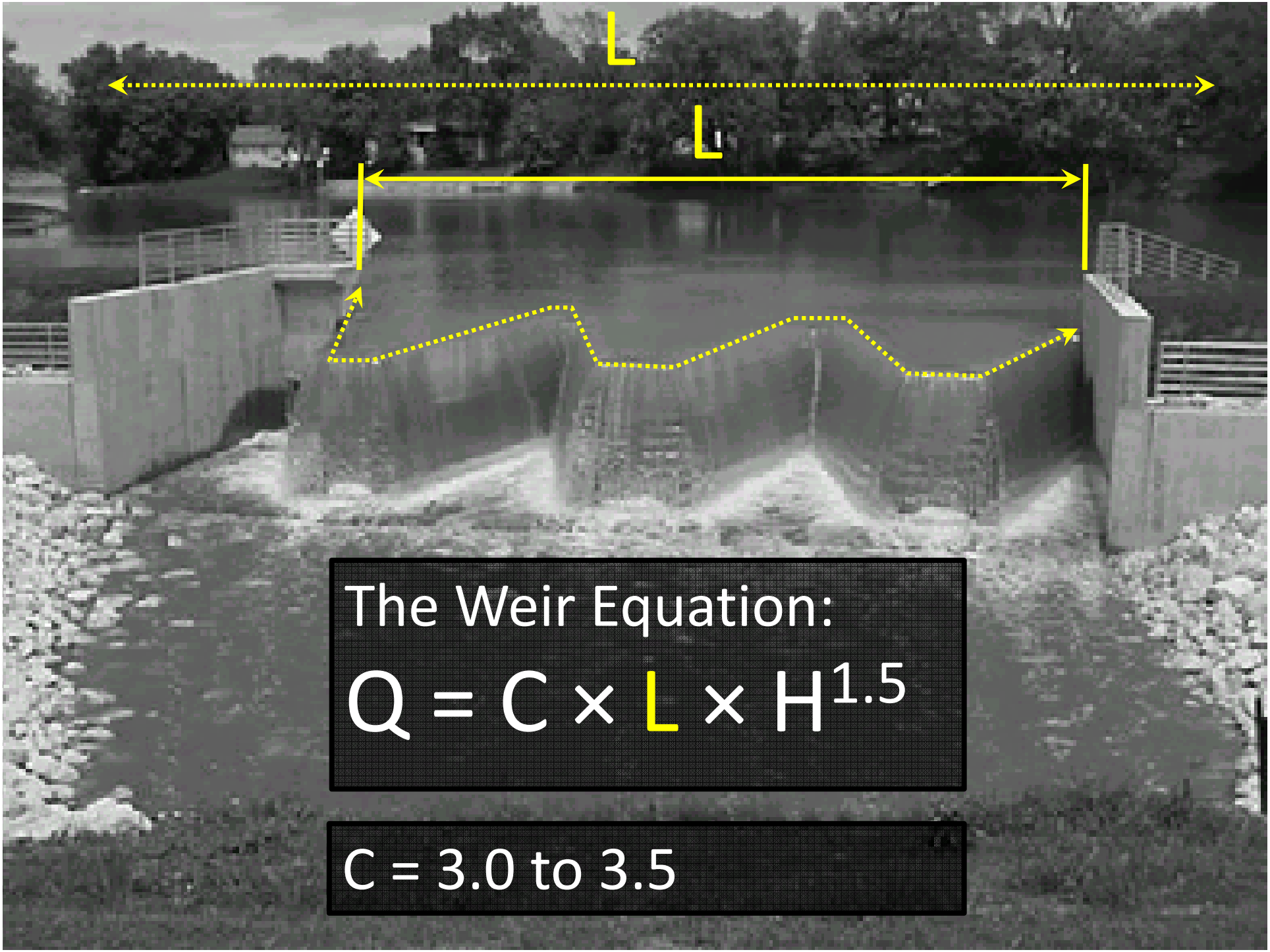
The Weir Equation:

$$Q = C \times L \times H^{1.5}$$

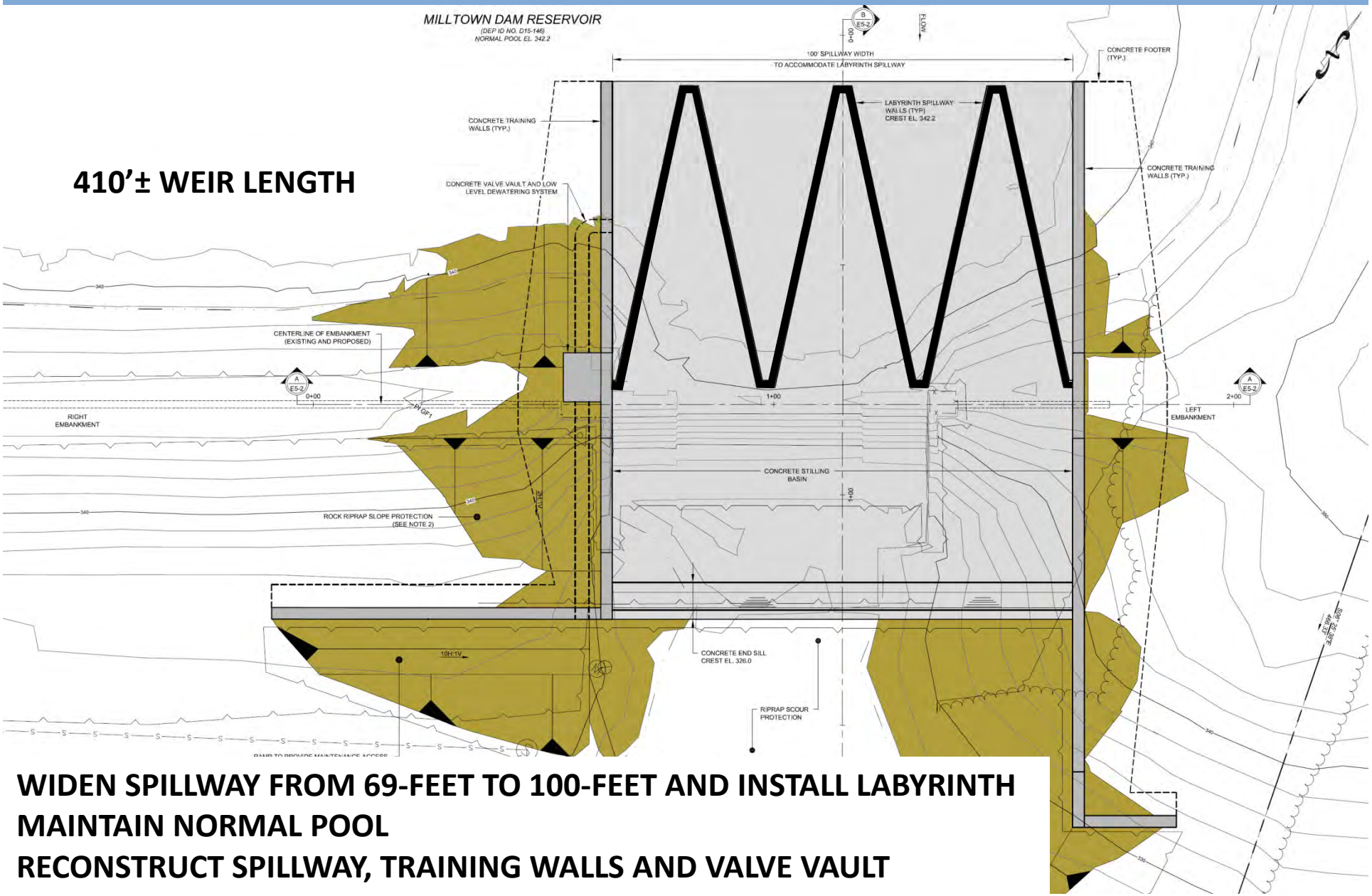
USE LABYRINTH TO MINIMIZE SPILLWAY FOOTPRINT

ALTERNATIVE 5
WIDEN SPILLWAY WITH LABYRINTH

ALTERNATIVE 5
WIDEN SPILLWAY WITH LABYRINTH


L
L'
The Weir Equation:
$Q = C \times L \times H^{1.5}$
C = 3.0 to 3.5

ALTERNATIVE 5
WIDEN SPILLWAY WITH LABYRINTH



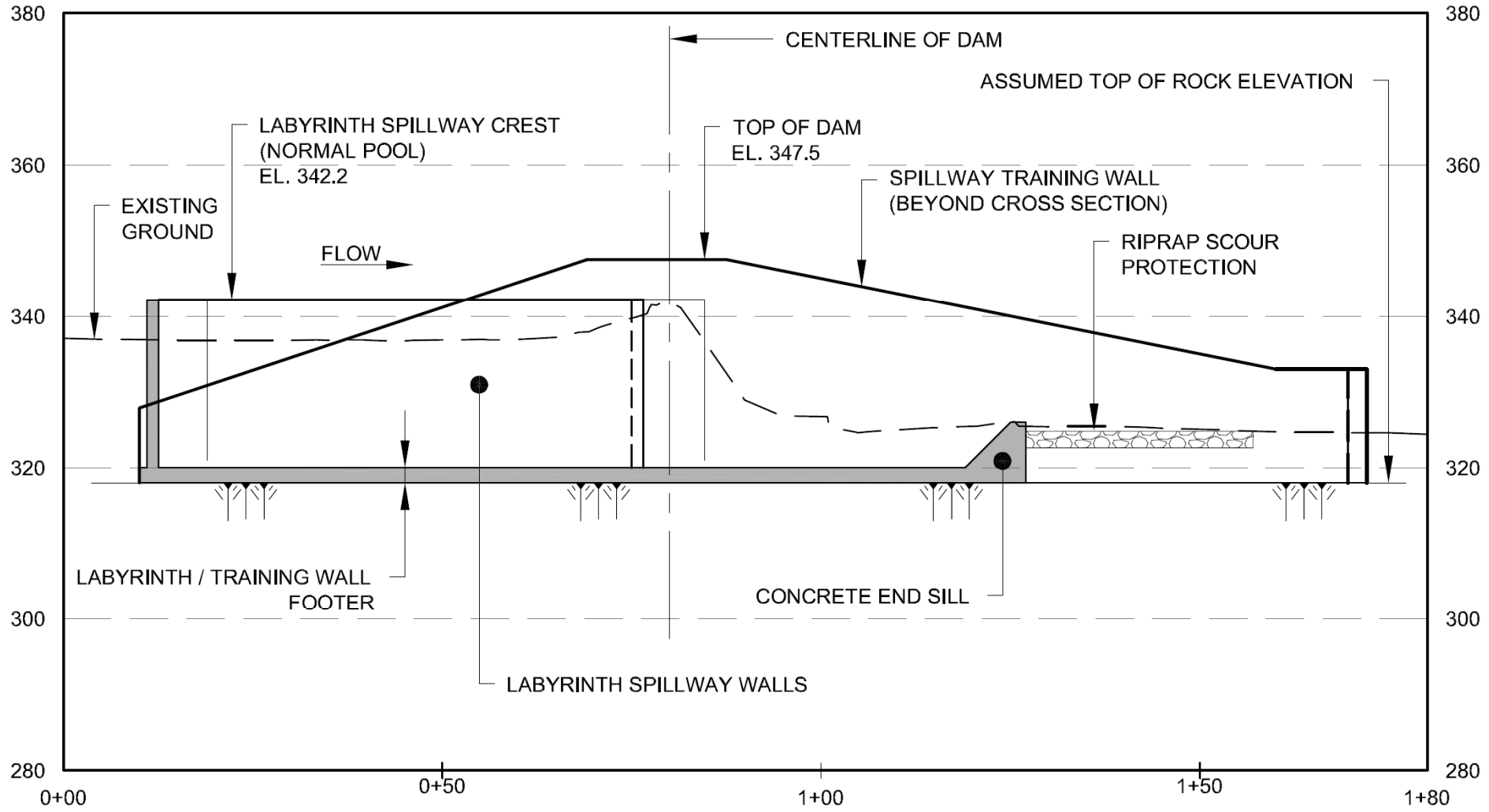
410'± WEIR LENGTH

WIDEN SPILLWAY FROM 69-FEET TO 100-FEET AND INSTALL LABYRINTH

MAINTAIN NORMAL POOL

RECONSTRUCT SPILLWAY, TRAINING WALLS AND VALVE VAULT

ALTERNATIVE 5
WIDEN SPILLWAY WITH LABYRINTH



SPILLWAY SECTION B-B

SCALE: 1" = 20'

ALTERNATIVE 5
WIDEN SPILLWAY WITH LABYRINTH

ALTERNATIVE 5
WIDEN SPILLWAY WITH LABYRINTH

ALTERNATIVE 5
WIDEN SPILLWAY WITH LABYRINTH

ALTERNATIVE 5
WIDEN SPILLWAY WITH LABYRINTH

AREA OF RISK	RISK ADDRESSED
Pass Spillway Design Flood	Yes Increased Spillway Length Passes SDF.
Address Erodible Material under Spillway	Yes Spillway Founded on Bedrock
Address Steep Embankment Slopes	Partial 1.5H:1V Slopes Eliminated, 2H:1V Slopes Remain
Add Internal Seepage Collection System	No
Access to Left Embankment	Partial Access Created Incorporate Ford Crossing
Fill at Crest of Left Embankment	Yes Left Embankment Reworked
Public Safety (Fencing)	Yes Fencing Added to Training Walls

ALTERNATIVE 5
WIDEN SPILLWAY WITH LABYRINTH

HYDRAULIC PERFORMANCE OF MILLTOWN DAM

- **Reservoir water surface elevation maintained at top of dam for the spillway design flood (4± foot reduction in the SDF water surface).**
- **Widened spillway will result in increased peak rates of runoff during storm events more frequent that the 100-year storm.**

PROPERTY IMPACTS

- **Small footprint of disturbance. No permanent easements required. Temporary construction easement may be required.**
- **Reduction in upstream water elevations during the spillway design flood. Therefore no flowage easements required.**

OPERATIONAL IMPACTS

- **Maintain area upstream of the labyrinth free of sediment.**

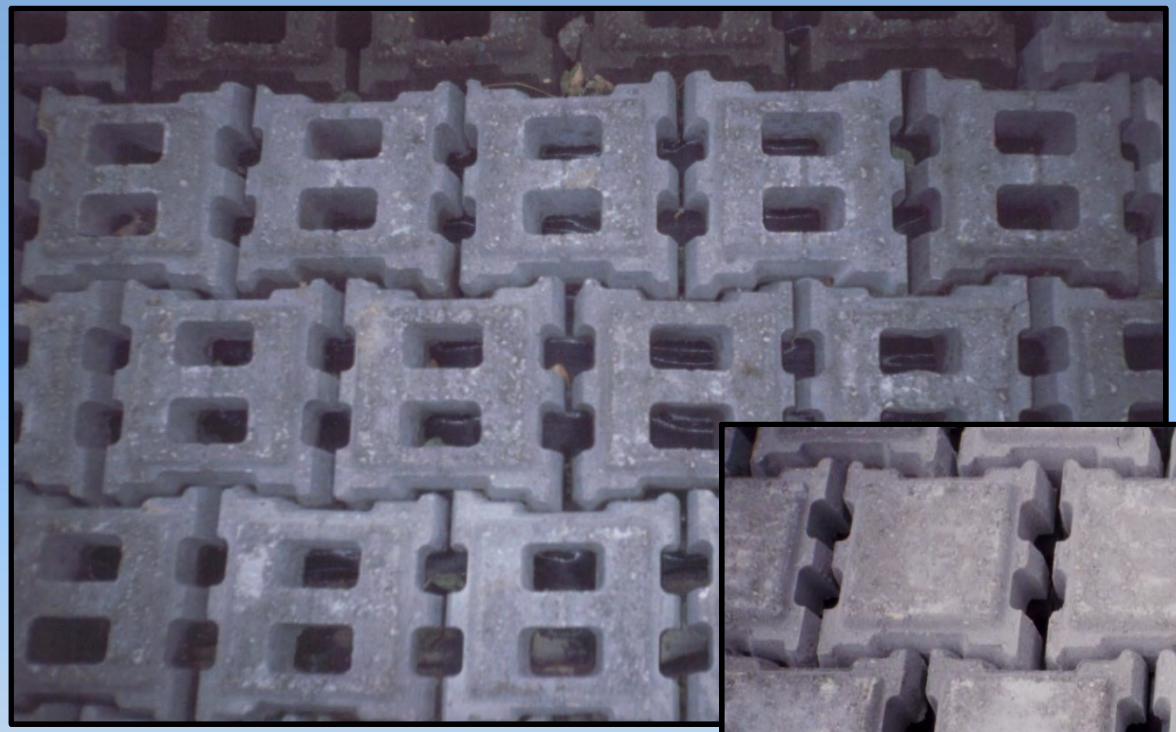
DESIGN/CONSTRUCTION COSTS

- **$6.7 Million**

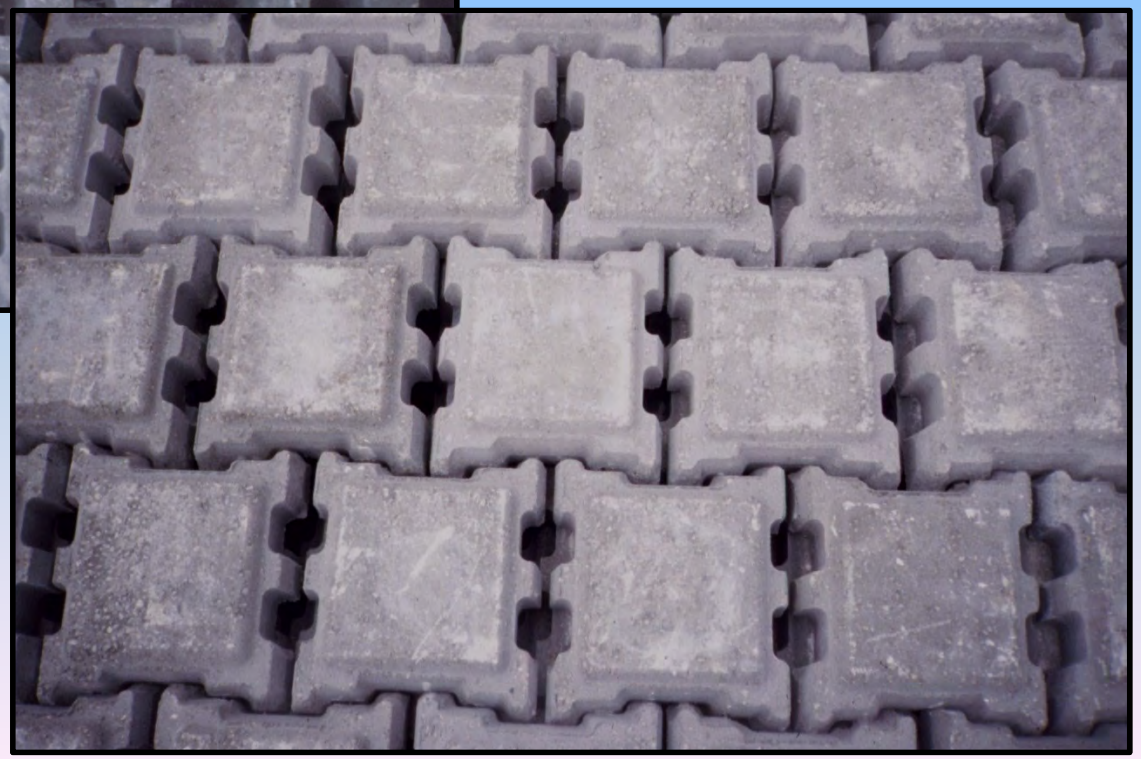
ALTERNATIVE 6
ACB EMBANKMENT OVERTOPPING PROTECTION

SHAVERS CREEK DAM, PENNSYLVANIA

ALTERNATIVE 6
ACB EMBANKMENT OVERTOPPING PROTECTION



OPEN CELL BLOCKS
(20% OPEN AREA)



CLOSED CELL BLOCKS
(10% OPEN AREA)

ALTERNATIVE 6
ACB EMBANKMENT OVERTOPPING PROTECTION


07.08.2010 11:13

ALTERNATIVE 6
ACB EMBANKMENT OVERTOPPING PROTECTION


LAKE NATALIE DAM, PENNSYLVANIA

LAKE NATALIE DAM, PENNSYLVANIA

LAKE NATALIE DAM, PENNSYLVANIA

LAKE NATALIE DAM, PENNSYLVANIA

LAKE NATALIE DAM, PENNSYLVANIA


LAKE NATALIE DAM, PENNSYLVANIA


LAKE NATALIE DAM, PENNSYLVANIA


LAKE NATALIE DAM, PENNSYLVANIA


LAKE NATALIE DAM, PENNSYLVANIA

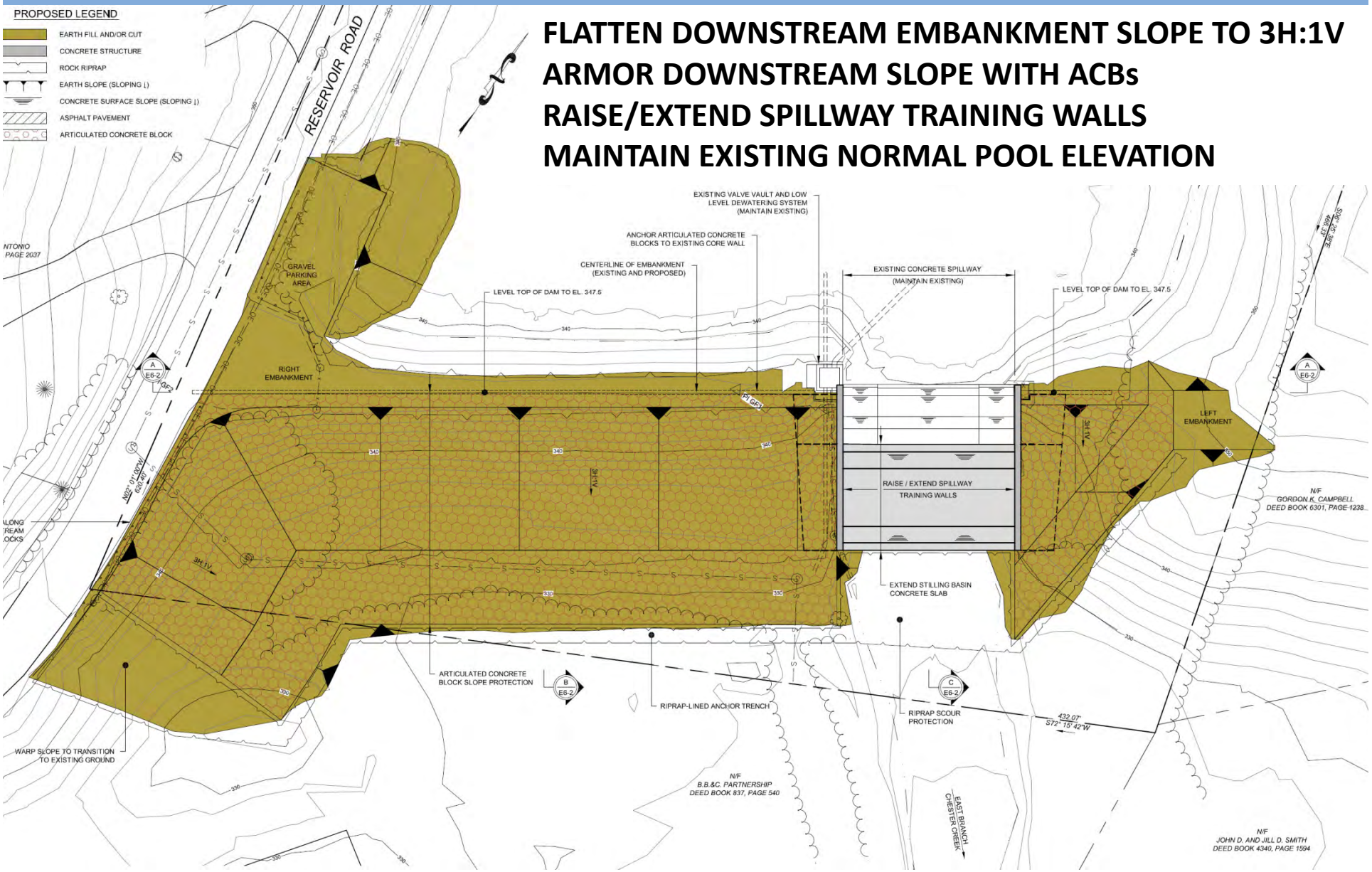
Photo Courtesy of USACE, Jacksonville District

MAXIMUM DESIGN OVERTOPPING DEPTH OF 4-FEET

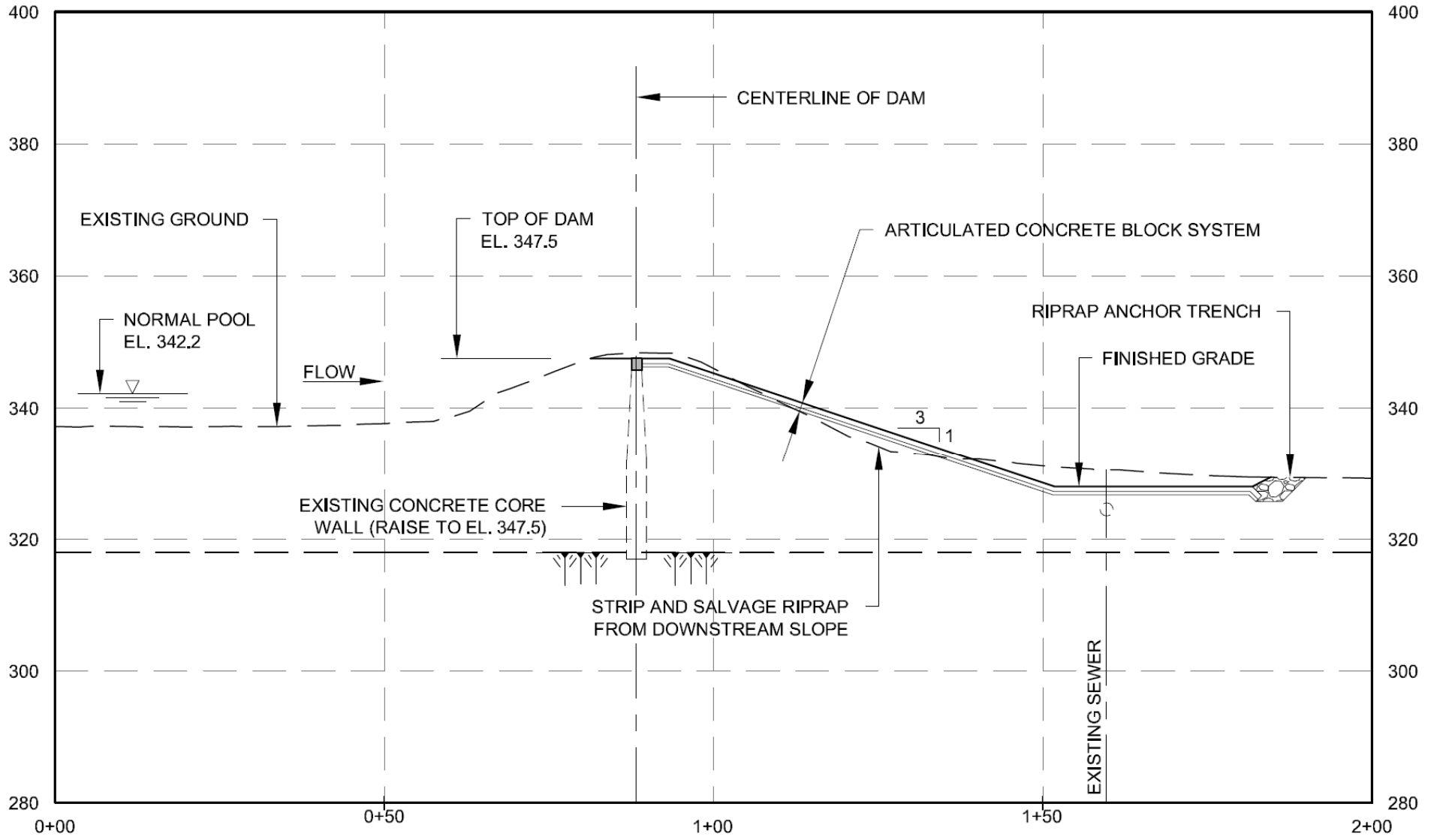
Photo Courtesy of USACE, Jacksonville District

ALTERNATIVE 6
ACB EMBANKMENT OVERTOPPING PROTECTION

FLATTEN DOWNSTREAM EMBANKMENT SLOPE TO 3H:1V
ARMOR DOWNSTREAM SLOPE WITH ACBs
RAISE/EXTEND SPILLWAY TRAINING WALLS
MAINTAIN EXISTING NORMAL POOL ELEVATION



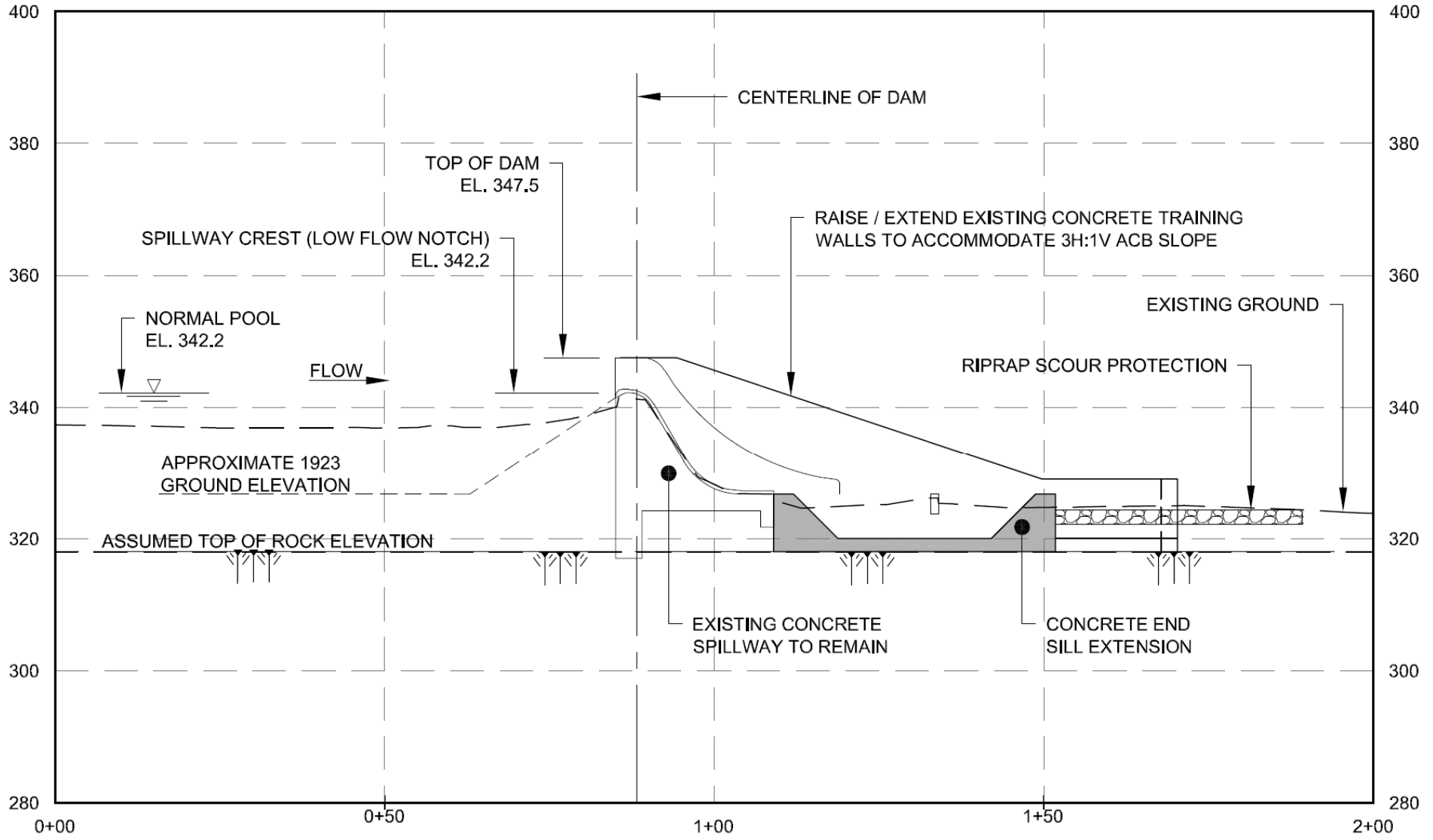
ALTERNATIVE 6
ACB EMBANKMENT OVERTOPPING PROTECTION



EMBANKMENT SECTION B-B

SCALE: 1" = 20'

ALTERNATIVE 6
ACB EMBANKMENT OVERTOPPING PROTECTION



SPILLWAY SECTION C-C

SCALE: 1" = 20'

ALTERNATIVE 6
ACB EMBANKMENT OVERTOPPING PROTECTION

ALTERNATIVE 6
ACB EMBANKMENT OVERTOPPING PROTECTION

ALTERNATIVE 6
ACB EMBANKMENT OVERTOPPING PROTECTION

ALTERNATIVE 6
ACB EMBANKMENT OVERTOPPING PROTECTION

AREA OF RISK	RISK ADDRESSED
Pass Spillway Design Flood	Yes Capacity Increased by Armoring Embankment
Address Erodible Material under Spillway	Partial Erodible Material Encapsulated by New Concrete Stilling Basin
Address Steep Embankment Slopes	Yes Embankment Graded to a 3H:1V Slope
Add Internal Seepage Collection System	No
Access to Left Embankment	Partial Access Created Incorporate Ford Crossing
Fill at Crest of Left Embankment	Yes Core Wall Raised to Top of Dam Elevation
Public Safety (Fencing)	Yes Fencing Added to Training Walls

ALTERNATIVE 6
ACB EMBANKMENT OVERTOPPING PROTECTION

HYDRAULIC PERFORMANCE OF MILLTOWN DAM

- No change in the hydraulic performance of the dam.

PROPERTY IMPACTS

- Easements required from two property owners.
- No change in the SDF elevation. Therefore no flowage easements required.

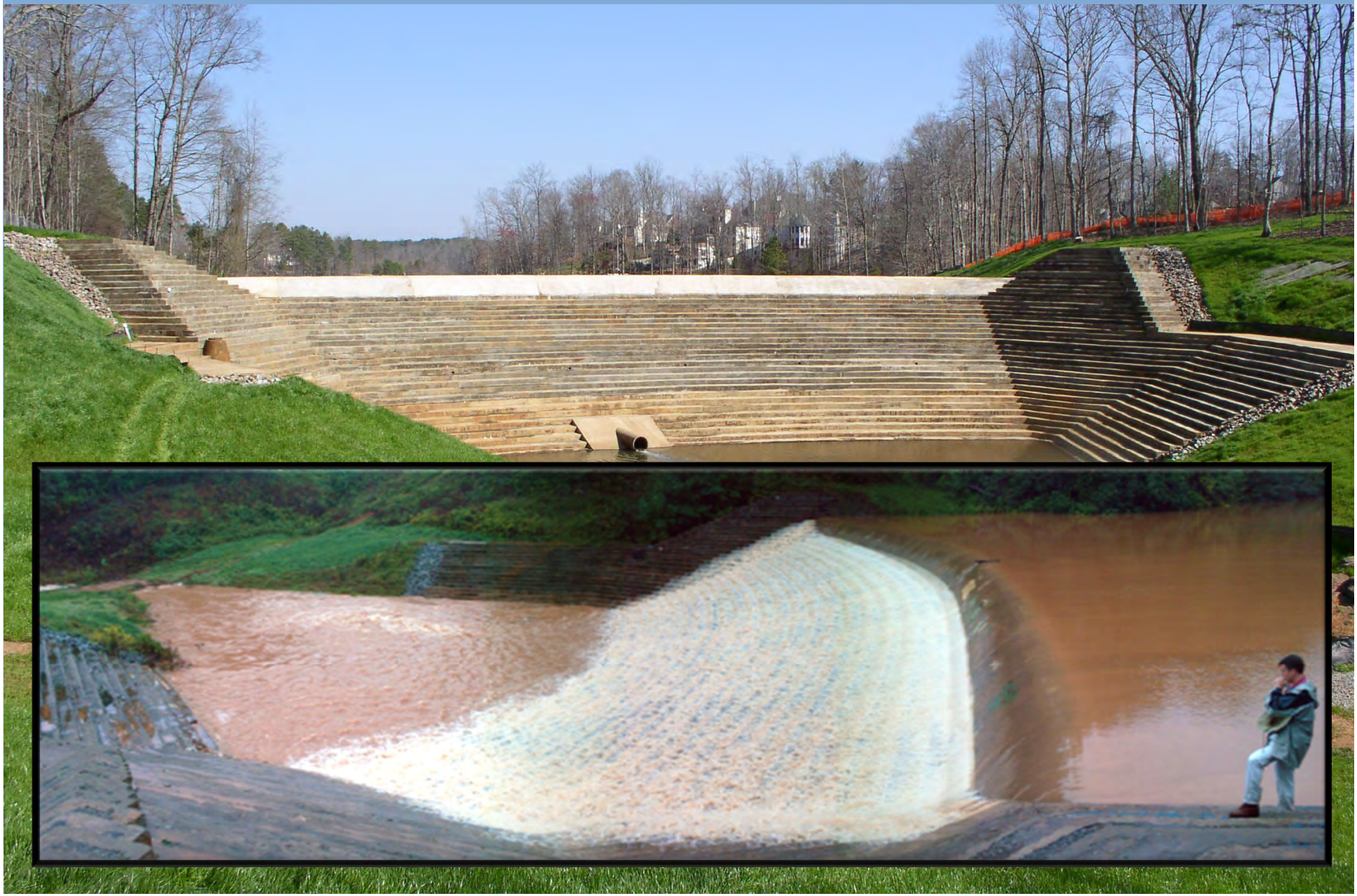
OPERATIONAL IMPACTS

- Existing spillway, training walls and valve vault can remain in place.
- ACBs are approved for overtopping depths of up to four feet. ACBs at Milltown Dam are at their maximum design limit with an overtopping depth of 4.1 feet.
- ACBs can be installed with a full reservoir.

DESIGN/CONSTRUCTION COSTS

- $3.2 Million

ALTERNATIVE 7
RCC EMBANKMENT OVERTOPPING PROTECTION



YELLOW RIVER DAM NO. 15, GEORGIA

Photo Courtesy of Gregg Hudock, Golder Associates

YELLOW RIVER DAM NO. 15, GEORGIA

Photo Courtesy of Gregg Hudock, Golder Associates

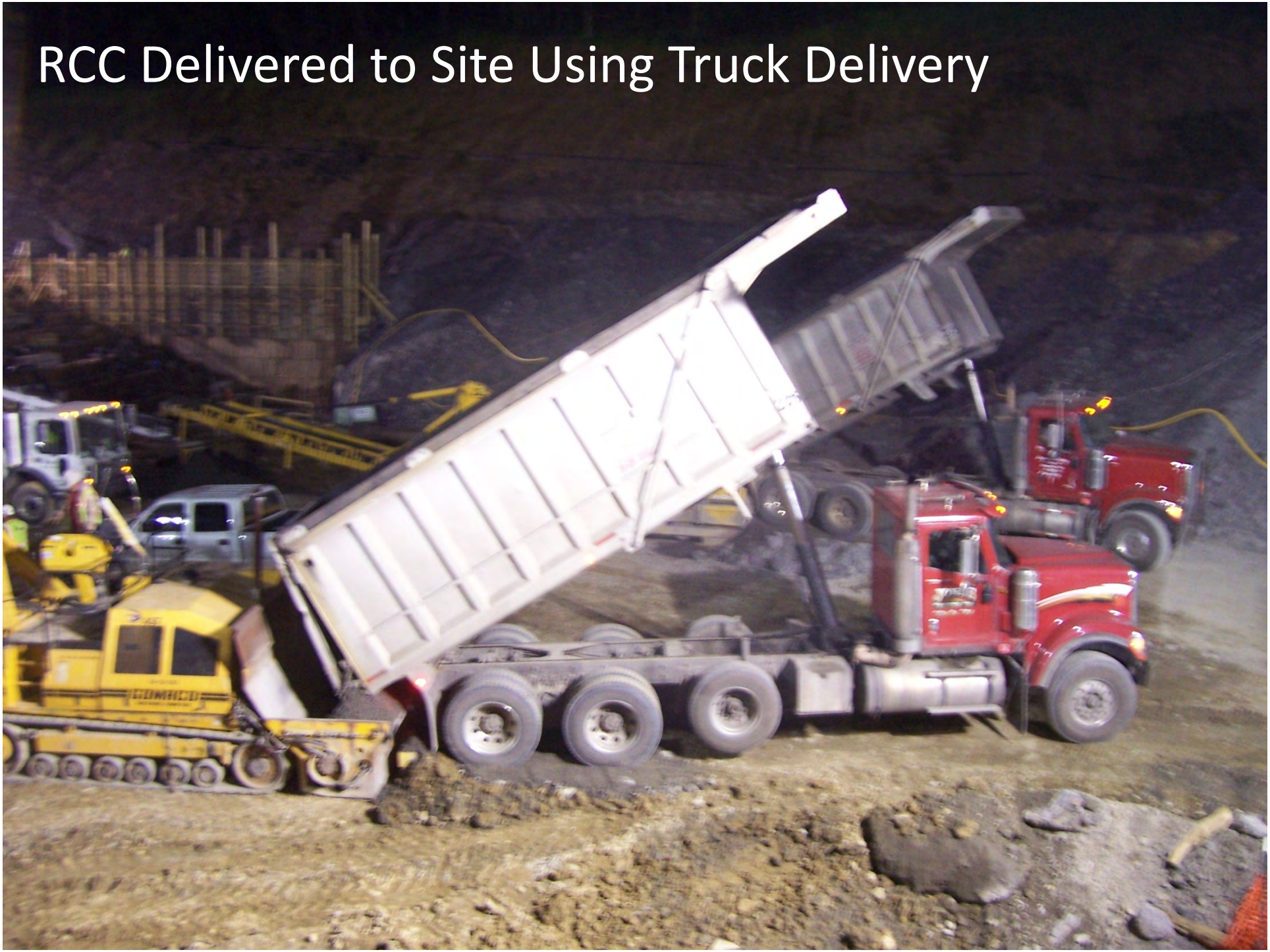

NEW CREEK 14, WEST VIRGINIA

Twin Shaft Batch Plant

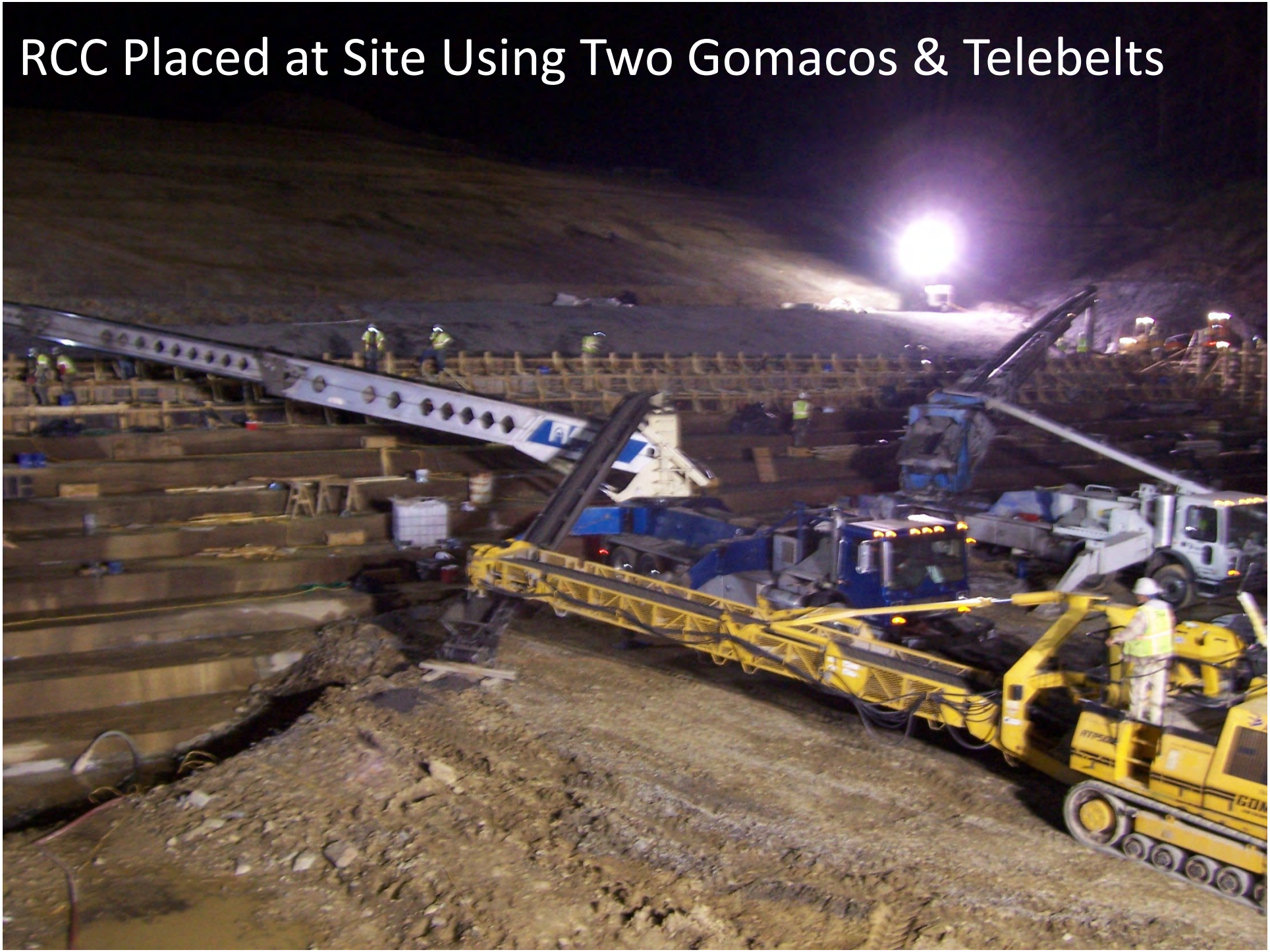
RCC Delivered to Site Using Truck Delivery

RCC Contractor: ***ASI***

RCC Delivered to Site Using Truck Delivery



RCC Placed at Site Using Two Gomacos & Telebelts




~26,000 CY Placed
8-Week Placement Time
6 Nights per Week
~570 CY/Day

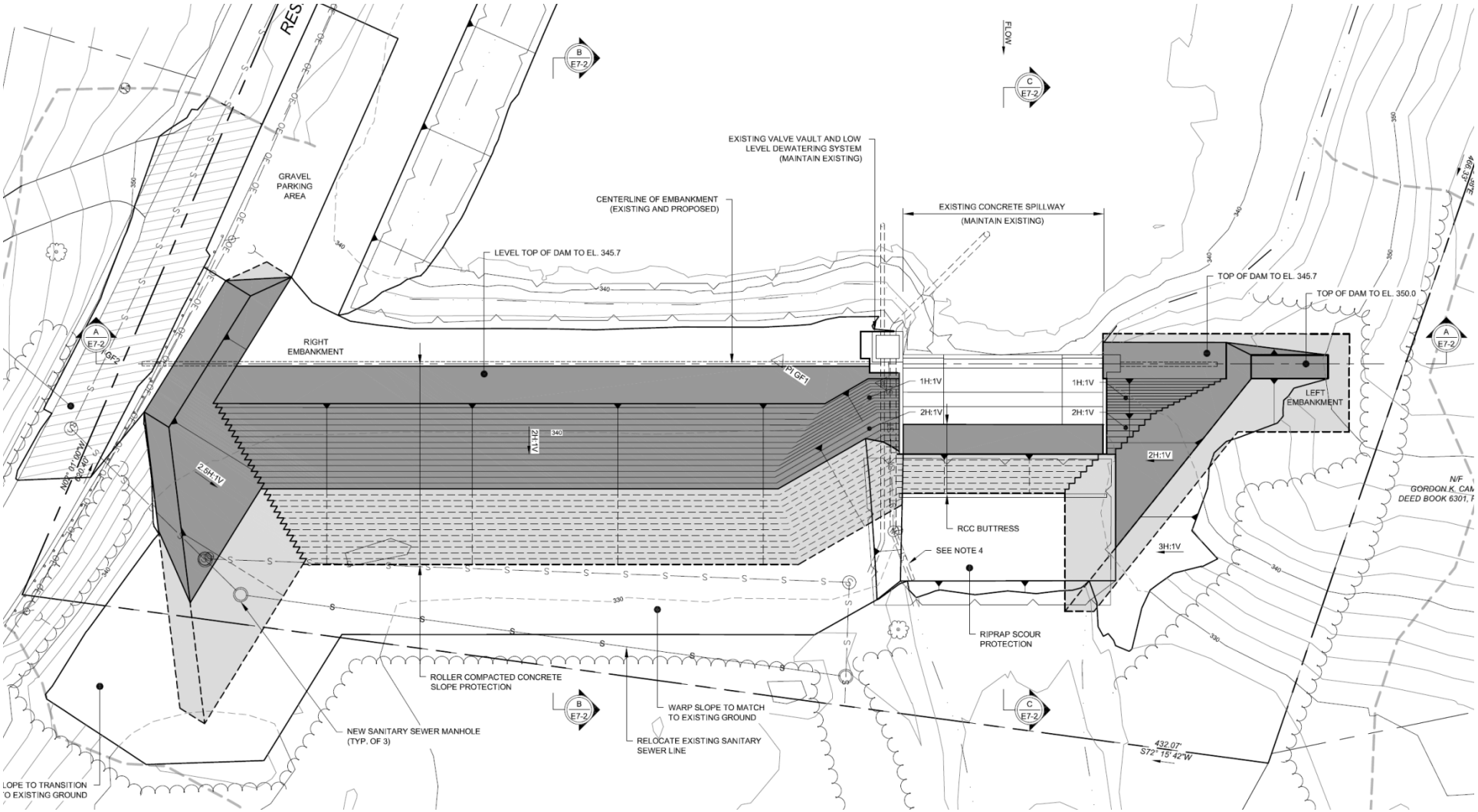

ASI

ALTERNATIVE 7
RCC EMBANKMENT OVERTOPPING PROTECTION

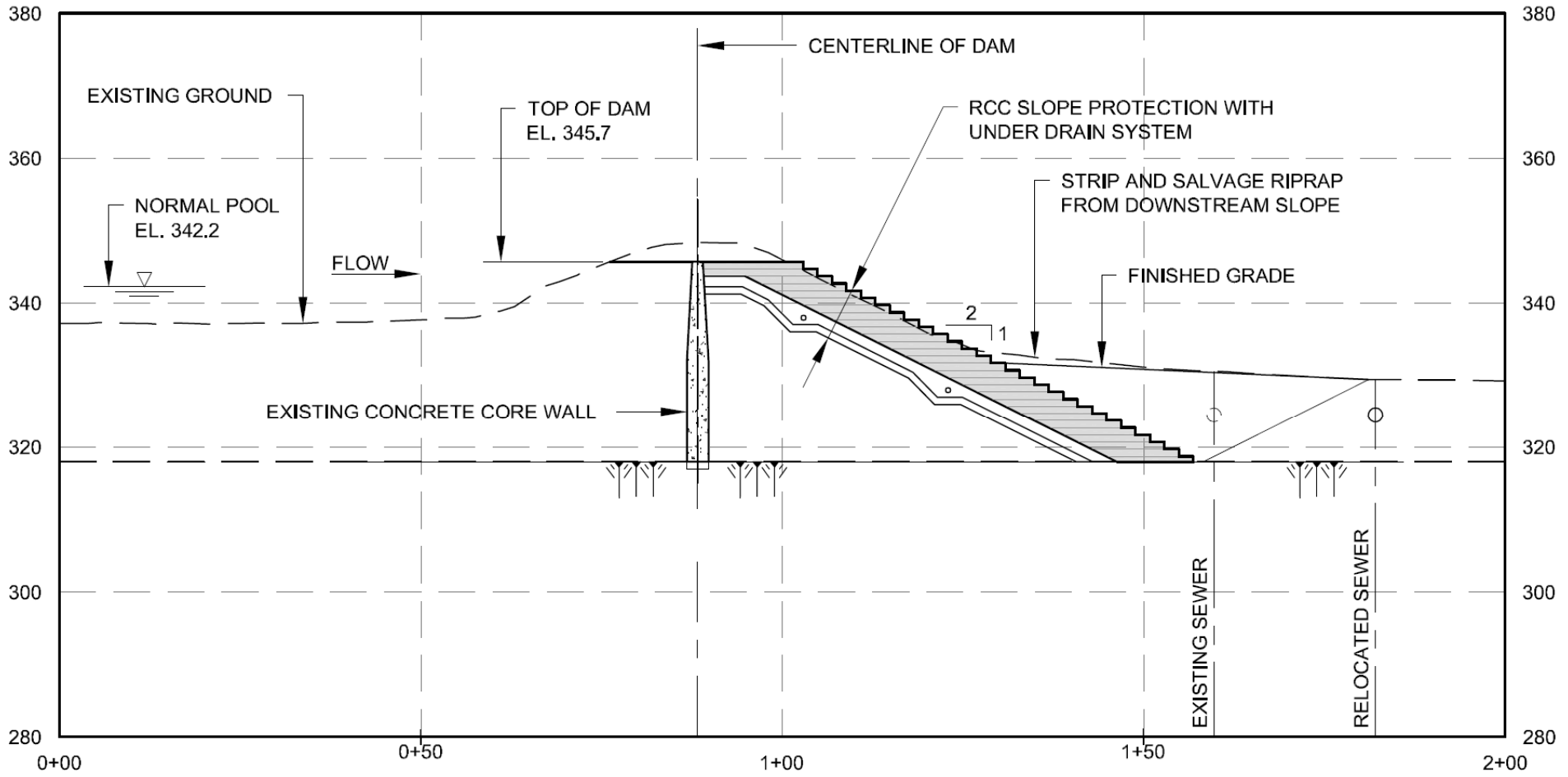
ARMOR DOWNSTREAM SLOPE WITH RCC

LOWER TOP OF DAM BY 1.8-FEET AND RAISE RESERVOIR ROAD BY ONE FOOT

MAINTAIN EXISTING NORMAL POOL ELEVATION



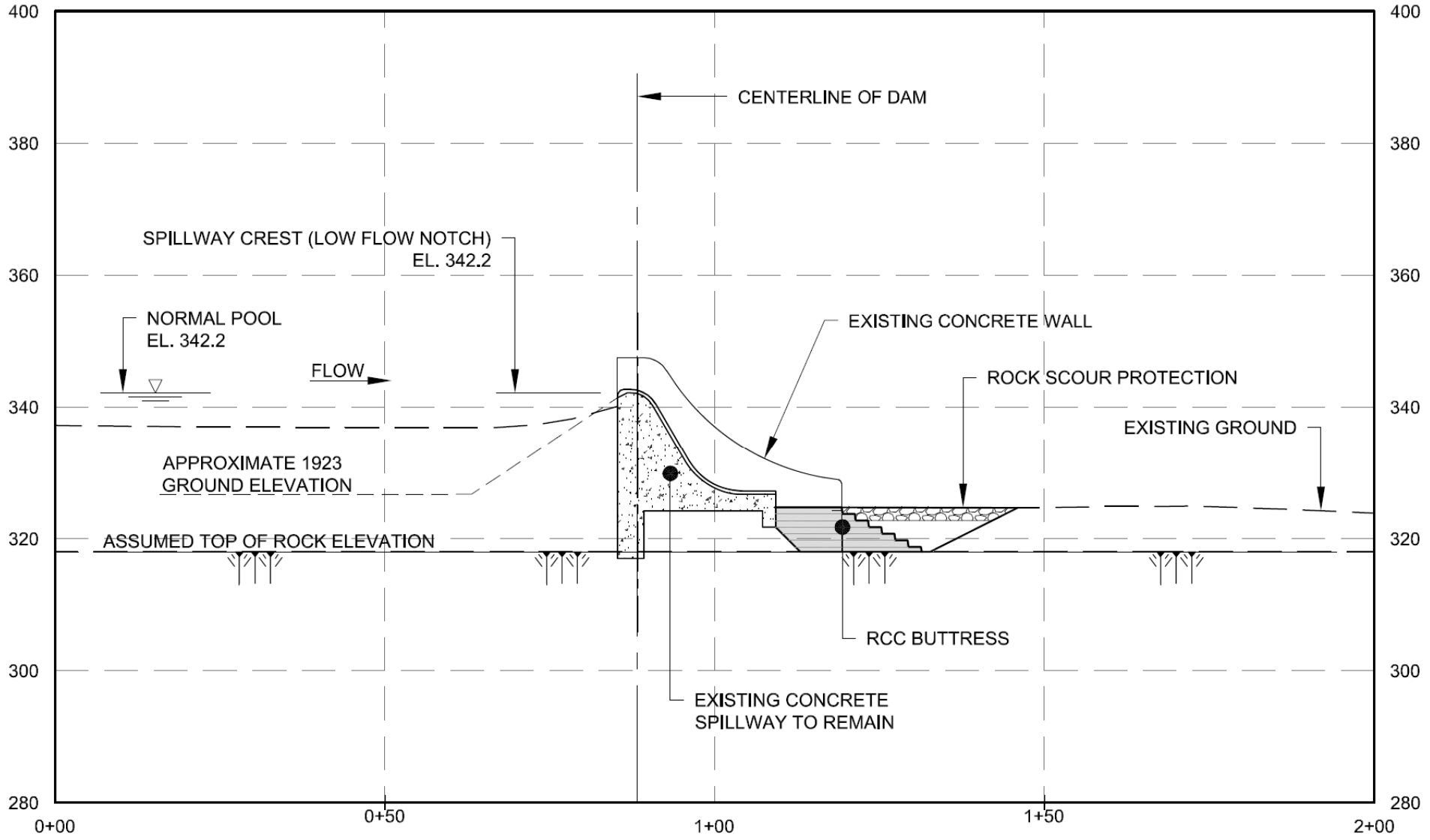
ALTERNATIVE 7
RCC EMBANKMENT OVERTOPPING PROTECTION



EMBANKMENT SECTION B-B

SCALE: 1" = 20'

ALTERNATIVE 7
RCC EMBANKMENT OVERTOPPING PROTECTION



SPILLWAY SECTION C-C

SCALE: 1" = 20'

ALTERNATIVE 7
RCC EMBANKMENT OVERTOPPING PROTECTION

ALTERNATIVE 7
RCC EMBANKMENT OVERTOPPING PROTECTION

ALTERNATIVE 7
RCC EMBANKMENT OVERTOPPING PROTECTION

ALTERNATIVE 7
RCC EMBANKMENT OVERTOPPING PROTECTION

ALTERNATIVE 7
RCC EMBANKMENT OVERTOPPING PROTECTION

ALTERNATIVE 7
RCC EMBANKMENT OVERTOPPING PROTECTION

AREA OF RISK	RISK ADDRESSED
Pass Spillway Design Flood	Yes Capacity Increased by Armoring Embankment
Address Erodible Material under Spillway	Partial Erodible Material Encapsulated by RCC
Address Steep Embankment Slopes	Yes Embankment Stabilized with RCC
Add Internal Seepage Collection System	Yes
Access to Left Embankment	Partial Access Created Incorporate Ford Crossing
Fill at Crest of Left Embankment	Yes Crest of Dam Armored with RCC
Public Safety (Fencing)	Yes Fencing Added to Training Walls

ALTERNATIVE 7
RCC EMBANKMENT OVERTOPPING PROTECTION

HYDRAULIC PERFORMANCE OF MILLTOWN DAM

- Slight change in the hydraulic performance of the dam due to lowering the top of dam by 1.8-feet.

PROPERTY IMPACTS

- Easements required from up to three property owners.
- No increase in the SDF elevation. Therefore no flowage easements required.
- Construction may occur at night.

OPERATIONAL IMPACTS

- Existing spillway, training walls and valve vault can remain in place.
- RCC can pass flows in excess of the Spillway Design Flood.
- RCC can be installed with a full reservoir.

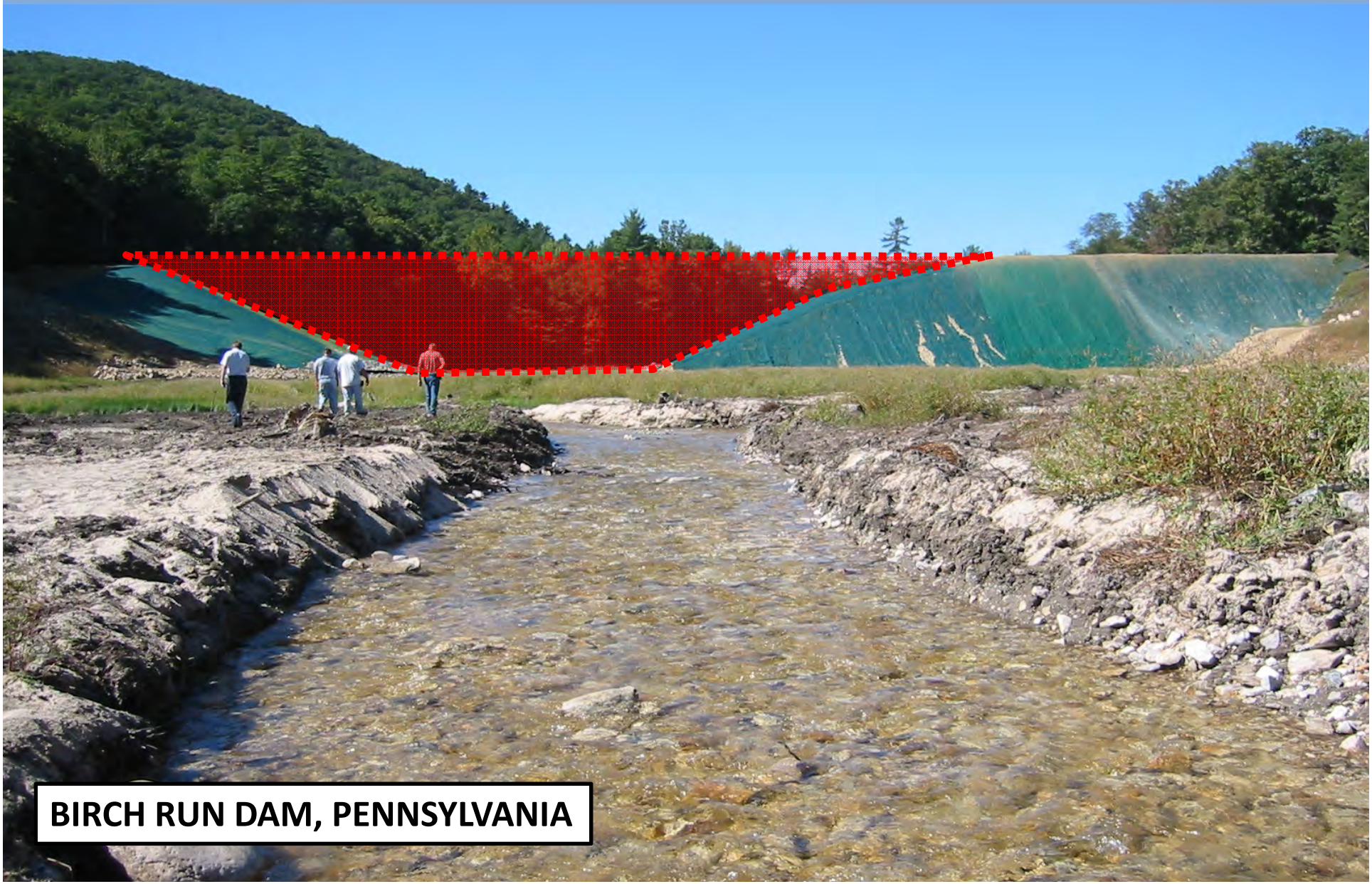
UTILITY IMPACTS

- Reservoir road raised by 1+ foot in vicinity of dam.
- Relocation of existing sanitary sewer line downstream of dam.

DESIGN/CONSTRUCTION COSTS

- $2.6 Million

ALTERNATIVE 8
DECOMMISSION DAM



BIRCH RUN DAM, PENNSYLVANIA


BIRCH RUN DAM, PENNSYLVANIA

BIRCH RUN DAM, PENNSYLVANIA

ALTERNATIVE 8
DECOMMISSION DAM


LOOKING UPSTREAM - 2005
BIRCH RUN DAM, PENNSYLVANIA


LOOKING UPSTREAM - 2015
BIRCH RUN DAM, PENNSYLVANIA

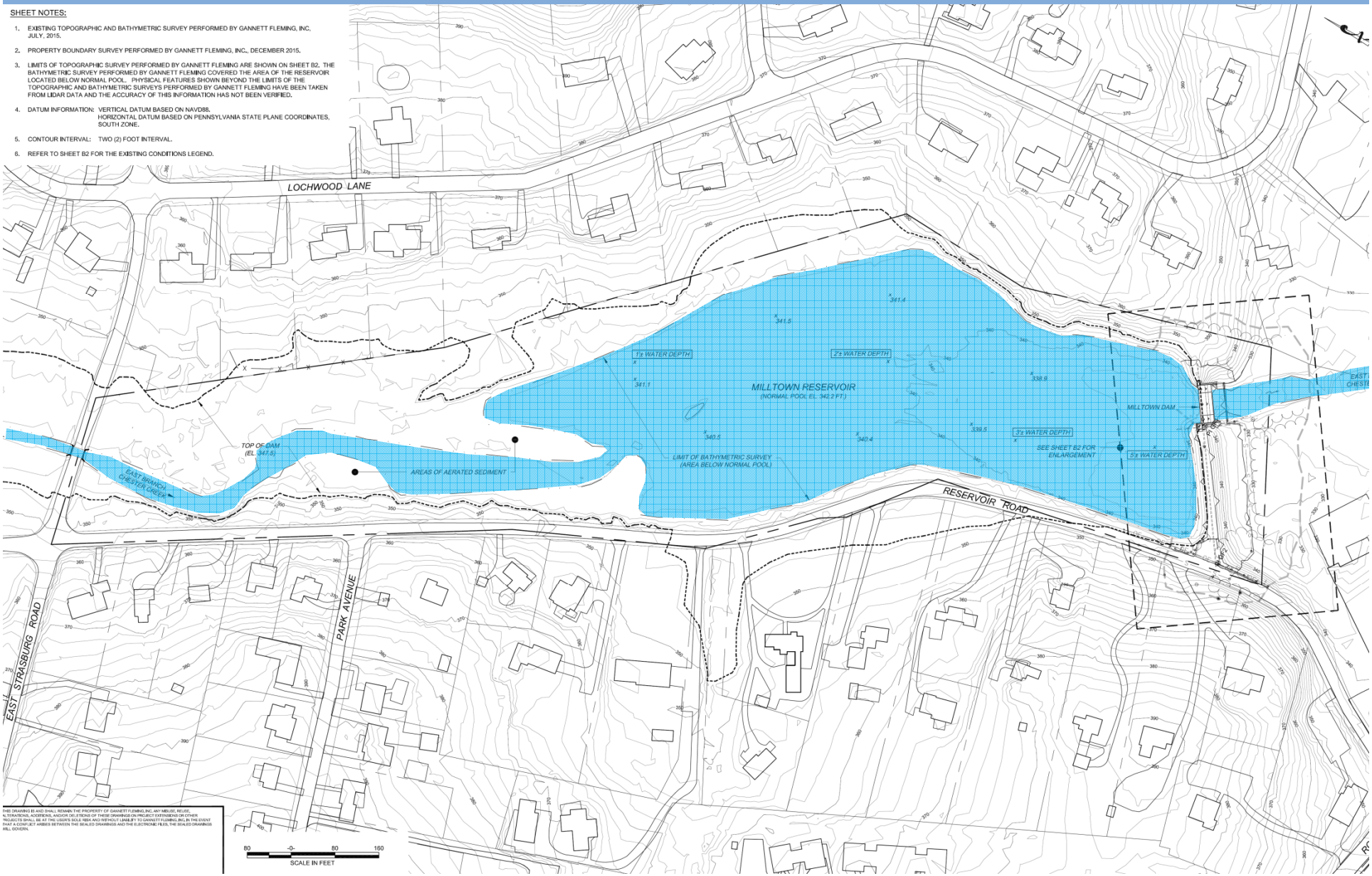

RESERVOIR AREA – POST CONSTRUCTION
BIRCH RUN DAM, PENNSYLVANIA


RESERVOIR AREA
BIRCH RUN DAM, PENNSYLVANIA

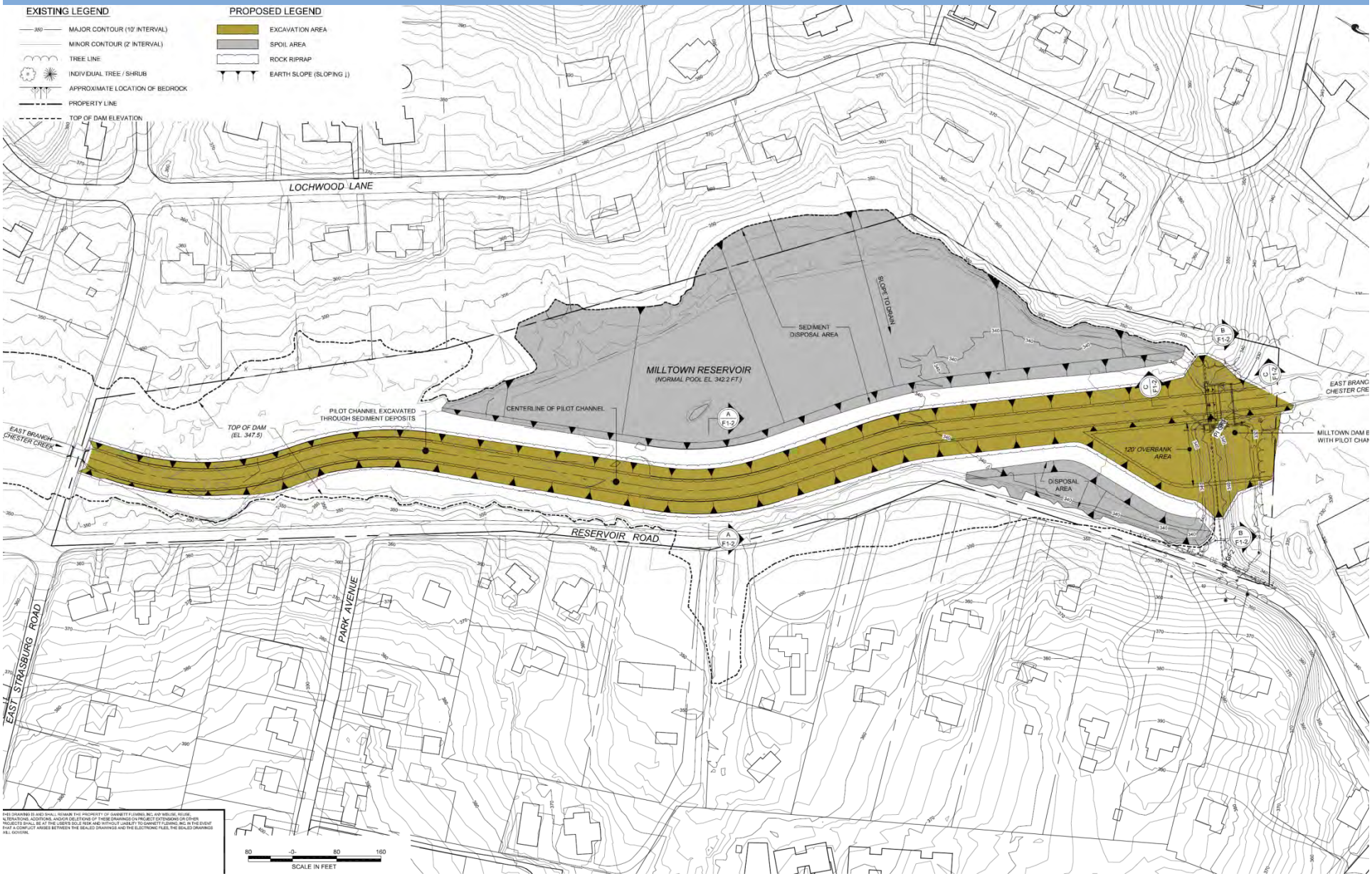

RESERVOIR AREA – 2015
BIRCH RUN DAM, PENNSYLVANIA

RESERVOIR RESTORATION

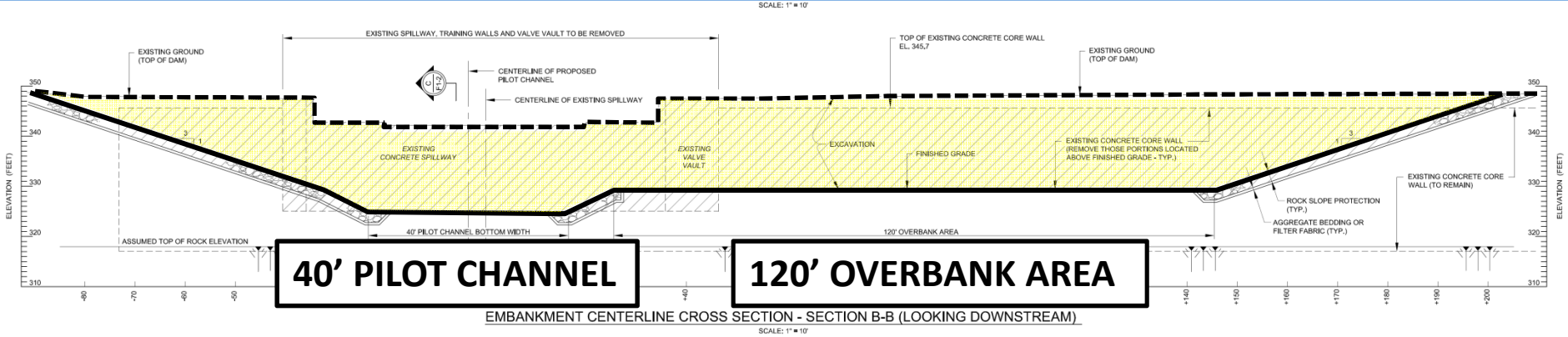
ALTERNATIVE 8
DECOMMISSION DAM



ALTERNATIVE 8
DECOMMISSION DAM



ALTERNATIVE 8
DECOMMISSION DAM



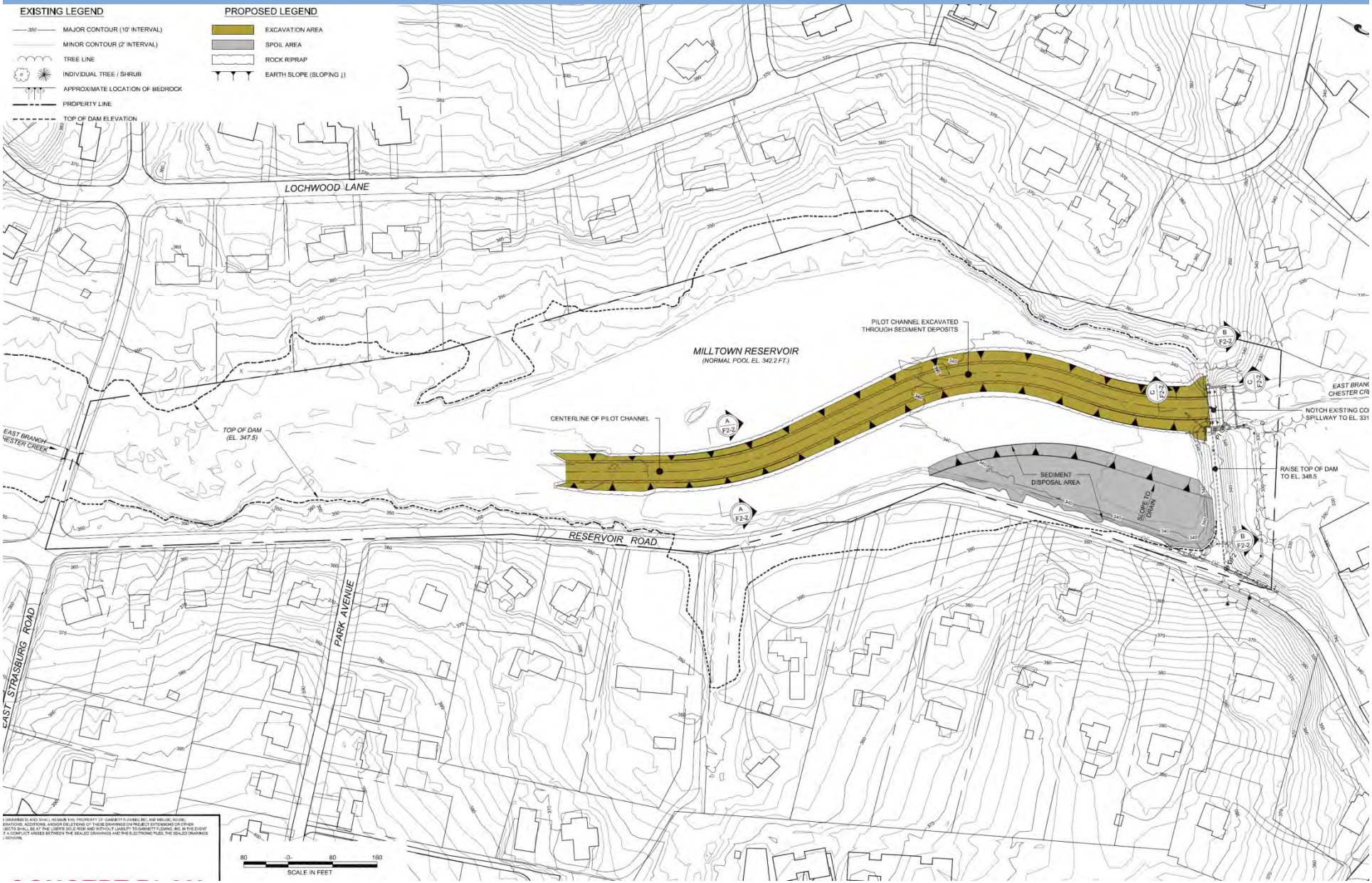
PROFILE ALONG CENTERLINE OF DAM EMBANKMENT
(LOOKING DOWNSTREAM)

ALTERNATIVE 8
DECOMMISSION DAM

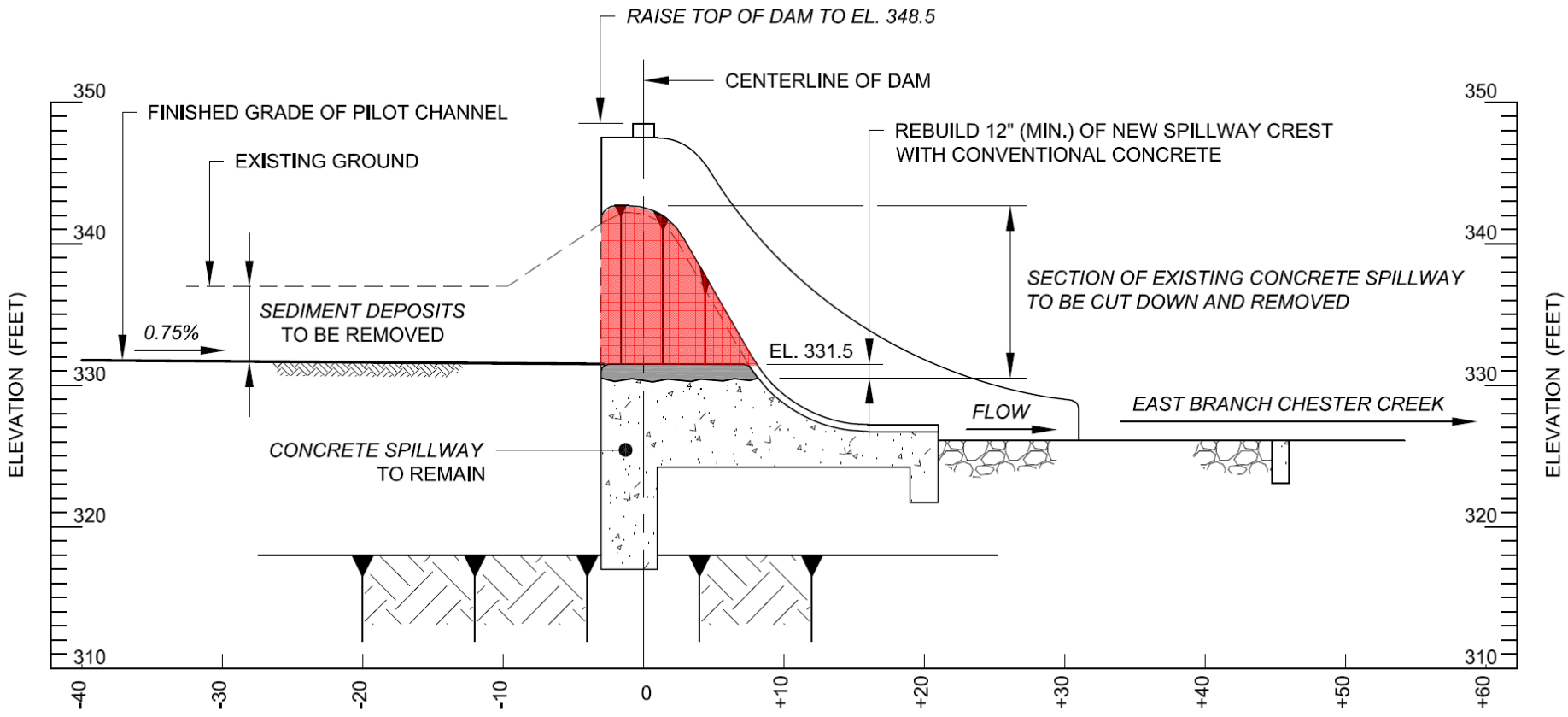
ALTERNATIVE 8
DECOMMISSION DAM

Design/Construction Costs: $3.1 Million

ALTERNATIVE 9
PARTIAL BREACH – REDUCED HAZARD CLASS?



ALTERNATIVE 9
PARTIAL BREACH – REDUCED HAZARD CLASS?



CROSS SECTION THROUGH SPILLWAY WITH PARTIAL BREACH - SECTION C-C

SCALE: 1" = 10'

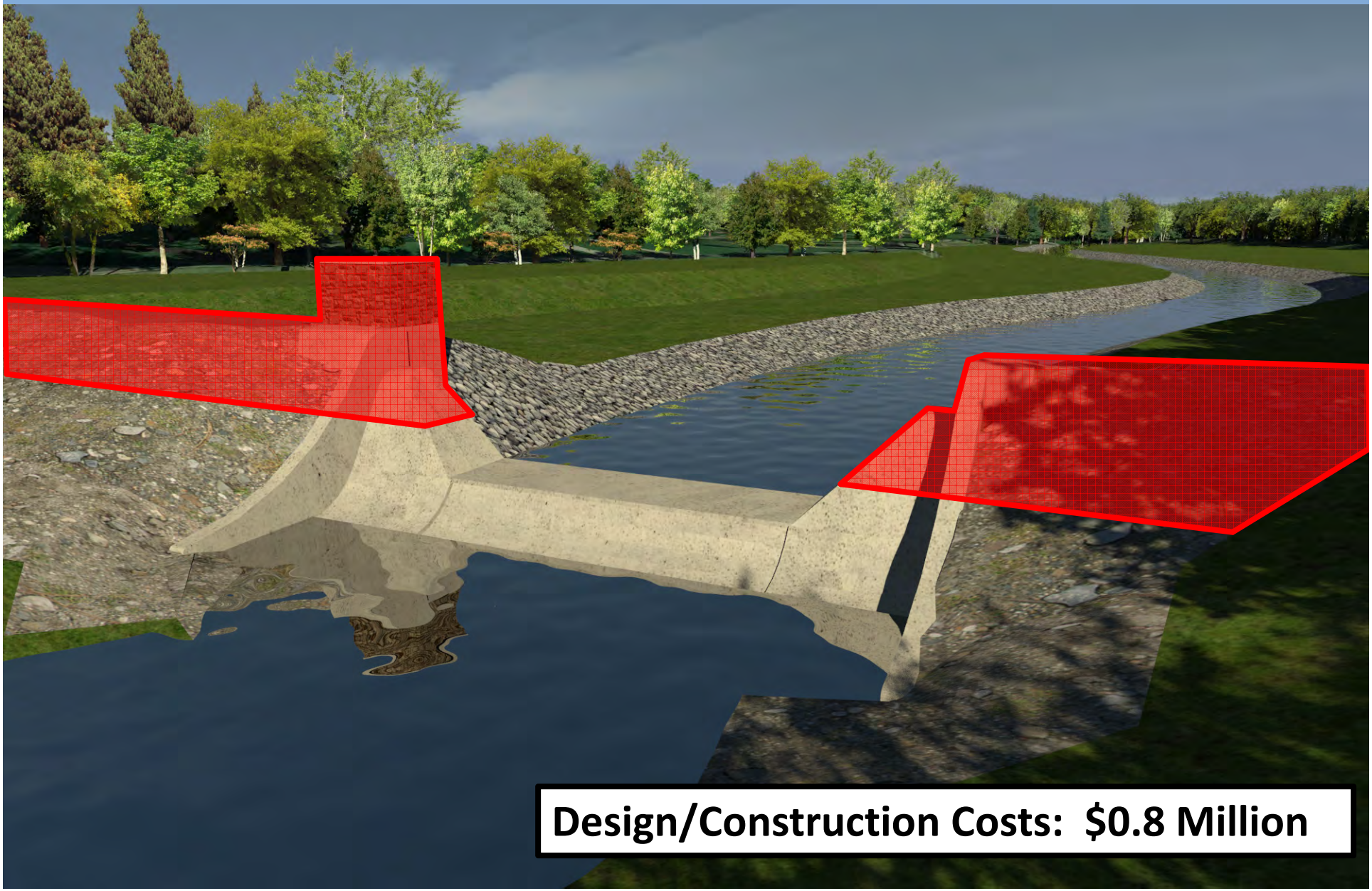
ALTERNATIVE 9
PARTIAL BREACH – REDUCED HAZARD CLASS?

ALTERNATIVE 9
PARTIAL BREACH – REDUCED HAZARD CLASS?

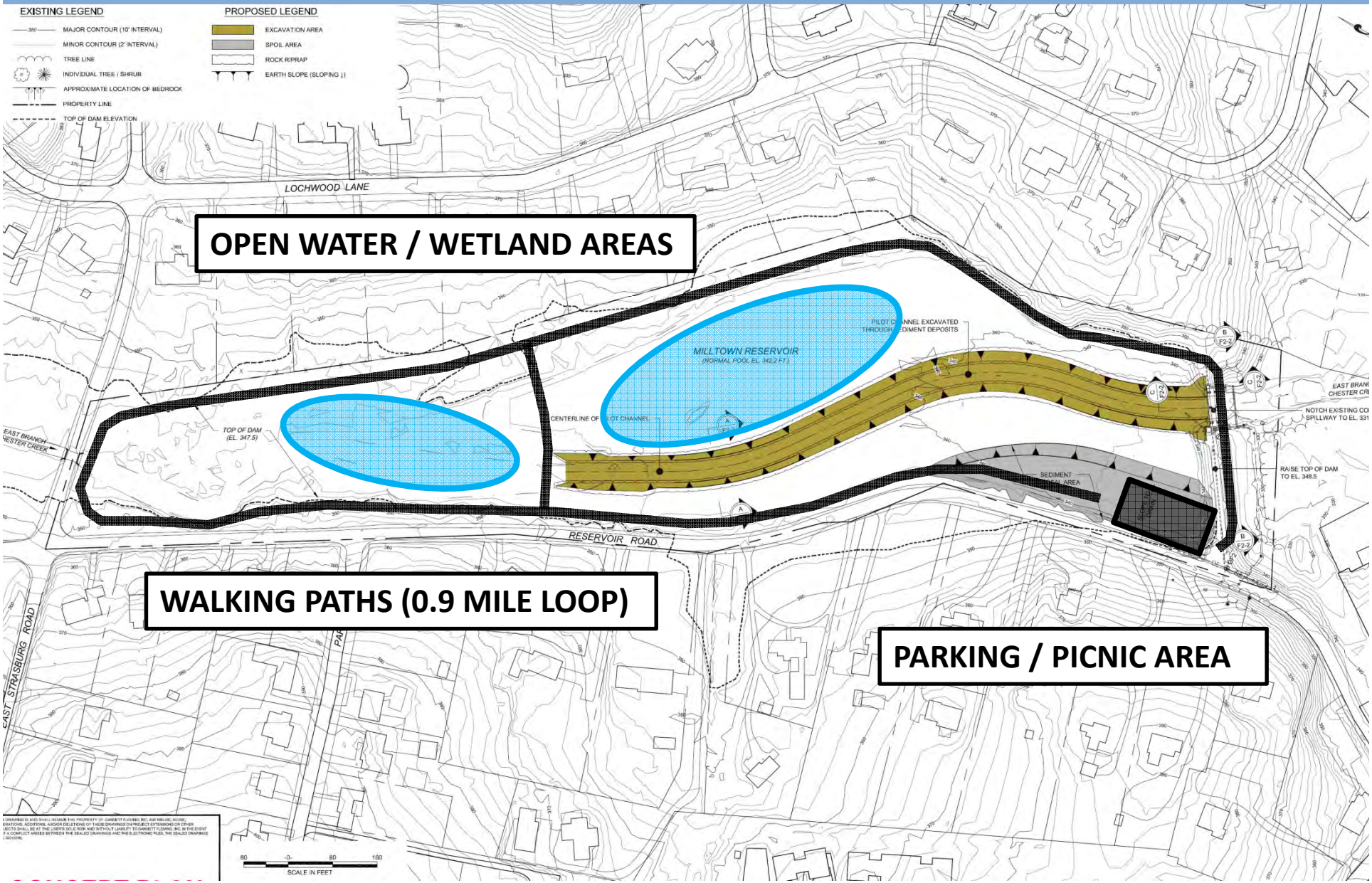
ALTERNATIVE 9
PARTIAL BREACH – REDUCED HAZARD CLASS?

Design/Construction Costs: $1.3 Million

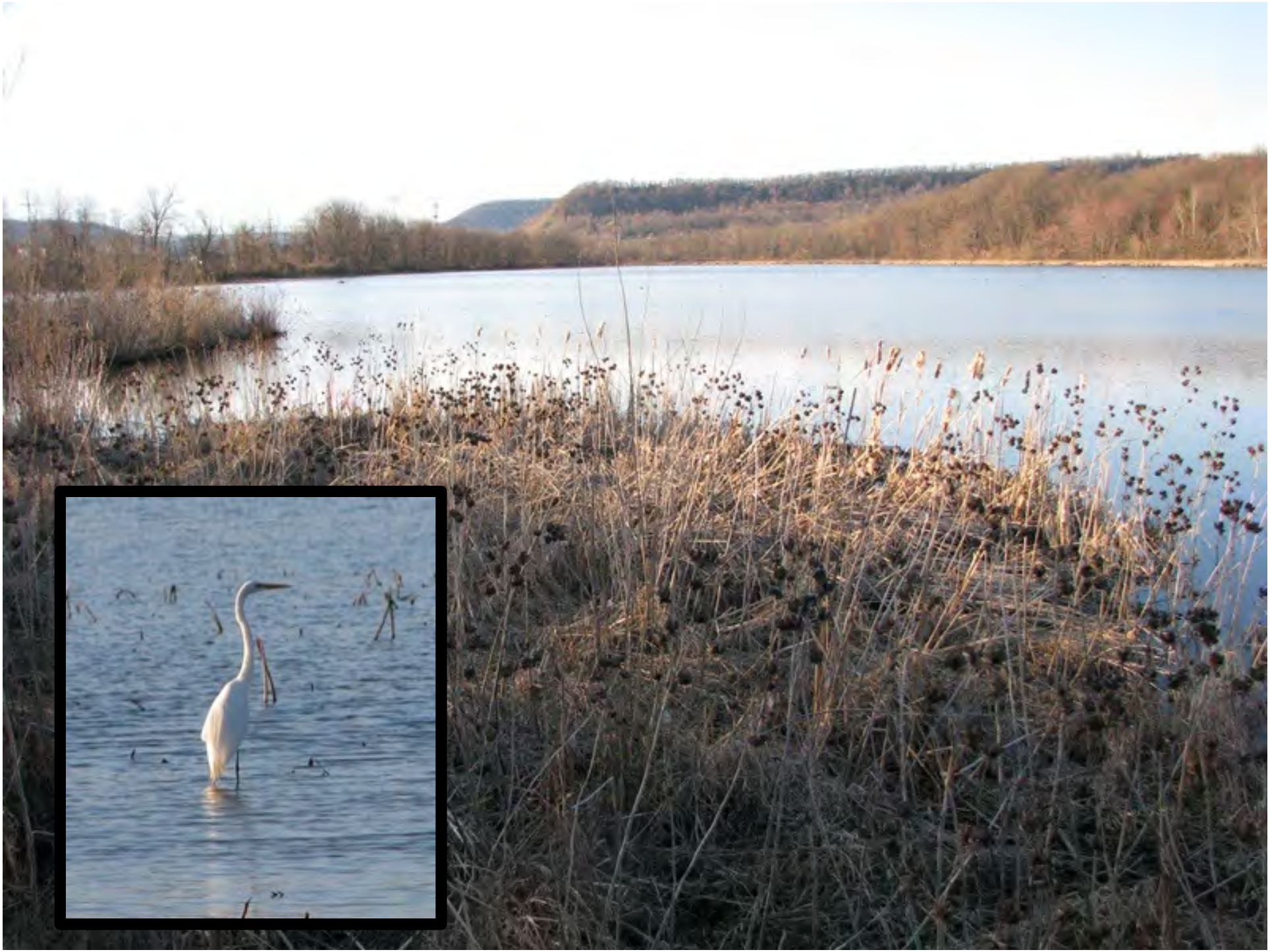
ALTERNATIVE 10
PARTIAL BREACH – REDUCE HAZARD CLASS!



ALTERNATIVES 9 AND 10
RESERVOIR ENHANCEMENT OPPORTUNITIUES



RESERVOIR ENHANCEMENT OPPORTUNITIUES




WETLANDS WILDFLOWER GUIDE


Whose Habitat Is That?

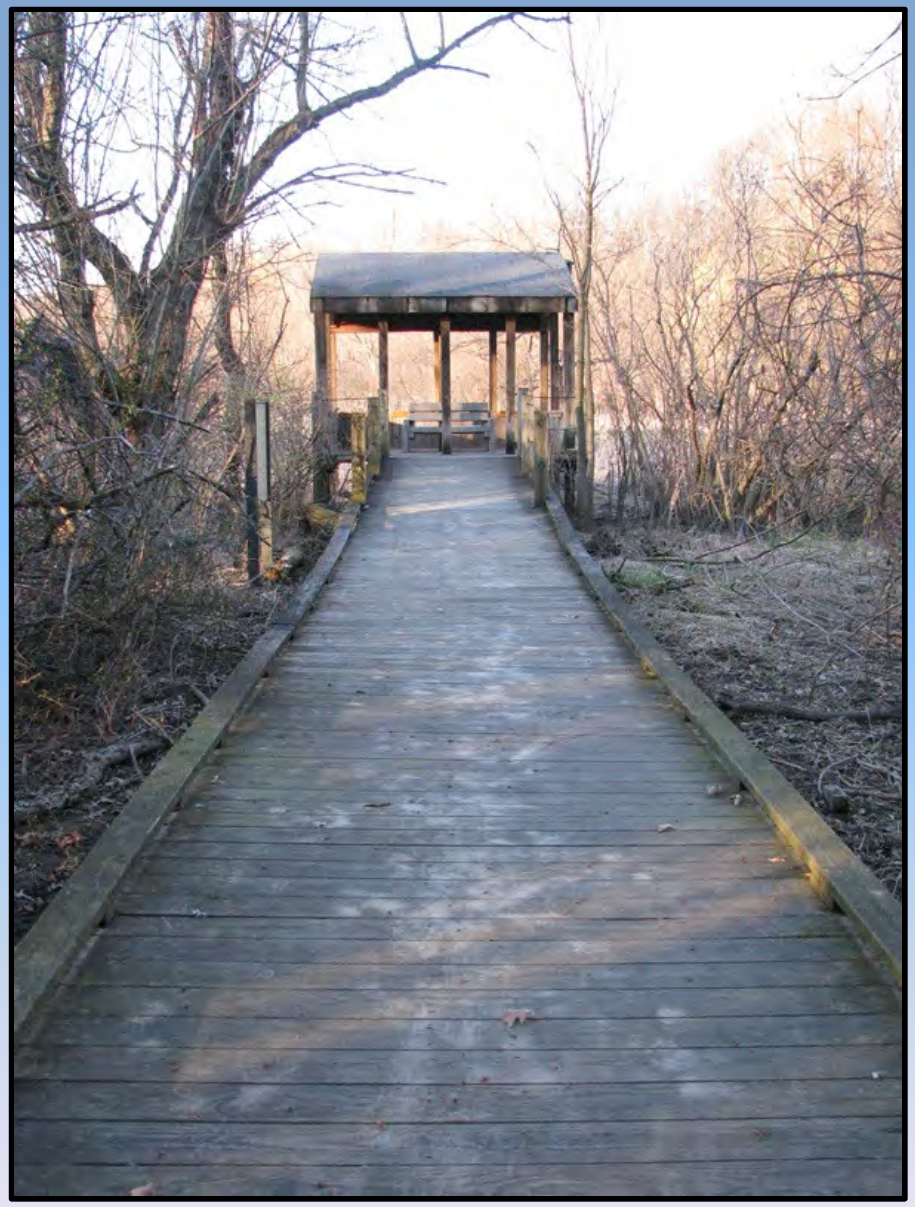


Table 10-3
Summary of 30-Year Life Cycle Costs

Alternative Description	Initial Project Cost[1]	30-Year O&M Costs[2]	Dredging Costs[3]	30-Year Total Cost
Increase Capacity Alternative 1 Increase Spillway Depth	$6.6 Million	$0.6 Million	$1.1 Million	$7.2 to $8.3 Million
Increase Capacity Alternative 2 Increase Spillway Width	$9.6 Million	$0.6 Million	$1.1 Million	$10.2 to $11.3 Million
Increase Capacity Alternative 3 Increase Spillway Width & Depth	$6.8 Million	$0.6 Million	$1.1 Million	$7.4 to $8.5 Million
Increase Capacity Alternative 4 Fusegates	$5.8 Million	$0.6 Million	$1.1 Million	$6.4 to $7.5 Million
Increase Capacity Alternative 5 Widen Spillway with Labyrinth	$6.7 Million	$0.6 Million	$1.1 Million	$7.3 to $8.4 Million
Increase Capacity Alternative 6 ACB Overtopping Protection	$3.2 Million	$0.7 Million	$1.1 Million	$3.9 to $5.0 Million
Increase Capacity Alternative 7 RCC Overtopping Protection	**$2.4 Million**	**$0.7 Million**	$1.1 Million	**$3.1 to $4.2 Million**
Decommissioning Alternative 8 Dam Breach with Restored Channel	$3.1 Million	N/A	N/A	$3.1 Million
Partial Dam Breach Alternative 9 Partial Dam Breach (High Hazard Dam)	$1.3 Million	$0.5 Million	N/A	$1.8 Million
Partial Dam Breach Alternative 10 Partial Dam Breach (Low Hazard Dam)	**$0.8 Million**	**$0.4 Million**	N/A	**$1.2 Million**

QUESTIONS AND ANSWERS